EPS-HEP2021 conference

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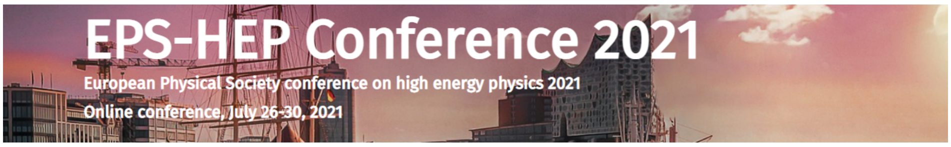
Zoom



Book of Abstracts

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Accelerator Roadmap

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Discussion

T06: QCD and Hadronic Physics / 9

χ_c and χ_b meson produciton in high multiplicity events

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Recently studies of the heavy J/ψ and D-mesons by ALICE and STAR collaborations revealed a pronounced dependence of the cross-section on multiplicity of co-produced charged particles, and one of the possible explanations of this phenomenon is the enhanced contribution of multipomeron configurations. In this talk we present our theoretical results for the production of P-wave quarkonia

(χ_c and χ_b mesons) in proton-proton collisions. We expect that, due to different quantum numbers, the χ_c and χ_b meson production cross-section does not get contributions from 3-pomeron fusion, and for this reason the multiplicity dependence of the cross-section should be significantly milder than that of J/ψ and D-mesons. We expect that the experimental confirmation of this result could constitute an important test of our understanding of multiplicity enhancement mechanisms in the production of different quarkonia states. We also present detailed production cross-sections in kinematics of ongoing experiments at LHC and RHIC.

This presentation is partially based on our recent publication [Eur.Phys.J.C 80 (2020) 6, 560] and arXiv submission https://arxiv.org/abs/2012.08284

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UTFSM

T06: QCD and Hadronic Physics / 10

Single-diffractive production of heavy mesons in pp and pA collisions

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In this talk we present our theoretical results for the single-diffractive production of open heavy flavor mesons and non-prompt charmonia in pp and pA collisions. Using the color dipole framework, we found that this mechanism constitutes 0.5-2 per cent of the inclusive production of the same mesons. In Tevatron kinematics our theoretical results are in reasonable agreement with the available experimental data. In LHC kinematics we found that the cross-section is sufficiently large and could be accessed experimentally. We also analyzed the dependence on multiplicity of co-produced hadrons and found that it should be significantly slower than that of inclusive production of the same heavy mesons. If this expectation will be confirmed experimentally, this could constitute important contribution to our understanding of multiplicity enhancement mechanisms in the production of different quarkonia states. We also analyzed this process in pA collisions and found that the cross-section per nucleon decerases by up to a factor of two compared to pp production due to nuclear saturation effects.

This presentation is partially based on our recent publication Phys.Rev.D 102 (2020) 7, 076020 [arXiv:2008.12446 [hep-ph]]

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T10: Searches for New Physics / 11

Lorentz invariance violation (LIV) in some basic phenomena in quntum physics

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Lorentz symmetry is one of the cornerstone of both general relativity and the standard model of particle physics . We study the violation of Lorentz symmetry in some basic phenomena in quantum physics. Using the Green's function, and the source 4-current, the differential equation of 4-vector of electromagnetic potential is solved and the modified coulomb potential is obtained by some researchers. Using modified Coulomb potential, we find the corrections due to LIV on the spectrum of Hydrogen and Helium atoms. We also investigate the consequence of LIV on Stark, Zeeman and Spin orbit effects and obtain upper bounds for the LIV coefficients.

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T06: QCD and Hadronic Physics / 12

All loop causal representation of scattering amplitudes

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The loop-tree duality (LTD) has become a novelty
alternative to bootstrap the numerical evaluation of
multi-loop scattering amplitudes.
It has indeed been found that Feynman integrands,
after the application of LTD, displays a representation
containing only physical information, the so-called
causal representation.
In this talk, I discuss the all causal representation
of multi-loop Feynman integrands, recently found in terms
of features that describe a loop topology, cusps,
and edges.
Likewise, in order to elucidate the numerical stability
in the LTD integrands, we present applications that
involve the numerical evaluation of four-loop integrals
with the presence of several kinematic invariants.

Collaboration / Activity:

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T07: Top and Electroweak Physics / 14

LUXE: A new experiment to study non-perturbative QED in electron-LASER and photon-LASER collisions

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The LUXE experiment (LASER Und XFEL Experiment) is a new experiment in planning at DESY Hamburg using the electron beam of the European XFEL. LUXE is intended to study collisions between a high-intensity optical LASER and 16.5 GeV electrons from the XFEL electron beam, as well as collisions between the optical LASER and high-energy secondary photons. The physics objective of LUXE are processes of Quantum Electrodynamics (QED) at the strong-field frontier, where the electromagnetic field of the LASER is above the Schwinger limit. In this regime, QED is non-perturbative. This manifests itself in the creation of physical electron-positron pairs from the QED vacuum, similar to Hawking radiation from black holes. LUXE intends to measure the positron production rate in an unprecedented LASER intensity regime. An overview of the LUXE experimental setup is given, in the context within the field of high-intensity particle physics. The foreseen detector systems and their sensitivity are presented. Finally, the prospects for studying BSM physics are also discussed.

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LUXE Collaboration

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T11: Quantum Field and String Theory / 15

Non-singular vortices with positive mass in 2+1-dimensional Einstein gravity with AdS$_3$ and Minkowski background

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We find numerically static vortex solutions where the scalar and gauge fields have a non-singular profile under Einstein gravity in an AdS$_3$ background. Vortices with different winding numbers n, VEV v and cosmological constant Λ are obtained. These vortices have positive mass and are not BTZ black holes as they have no event horizon. The mass is determined in two ways: by subtracting the numerical values of two separate asymptotic metrics and via an integral that is purely over the matter fields. The mass of the vortex increases as the cosmological constant becomes more negative and this coincides with the core of the vortex becoming smaller (compressed). We then consider the vortex with gravity in asymptotically flat spacetime for different values of the coupling $\alpha = 1/(16\pi G)$. At the origin, the spacetime has its highest curvature and there is no singularity. It transitions to an asymptotic conical spacetime with angular deficit that increases significantly as α decreases. For comparison, we also consider the vortex without gravity in flat spacetime. For this case, one cannot obtain the mass by the first method (subtracting two metrics) but remarkably, via a limiting

procedure, one can obtain an integral mass formula. In the absence of gauge fields, there is a well-known logarithmic divergence in the energy of the vortex. With gravity, we present this divergence in a new light. We show that the metric acquires a logarithmic term which is the $2+1$ dimensional realization of the Newtonian gravitational potential when General Relativity is supplemented with a scalar field.

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T11: Quantum Field and String Theory / 16

The Higgs field in brane-worlds

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The problematic huge hierarchy between the usual 4-dimensional Planck mass scale of gravity and the ElectroWeak symmetry breaking scale can interestingly disappear at some point-like location along extra space-like dimensions where the effective gravity scale is reduced down to the TeV scale. Field theories with point-like particle locations (3-dimensional brane-worlds) or point-like interactions deserve special care. In particular it can be shown that, in contrast with usual literature, brane-scalar fields –like the Standard Model Higgs boson –interacting with fermions in the whole space (bulk) do not need to be regularized if rigorous 4- or 5-dimensional treatments are applied: standard regularization introduces a finite width wave function for scalar fields localized along extra dimensions. The variational calculus of least action principle must also be applied strictly to derivate the fermion (Kaluza-Klein) masses and couplings, in particular by distinguishing the natural and essential boundary conditions: the higher-dimensional model –based in particular on extra compact spaces of type interval or circle (orbifold) –must be defined either completely through the action expression [necessity then for new specific brane terms bilinear in the fermion fields] or partially from additional so-called essential boundary conditions. Besides, the correct action integrand definition requires to introduce improper integrals in order to remain compatible with the fermion wave function discontinuities induced by point-like Higgs interactions. These presented new brane-Higgs treatments have phenomenological impacts and in particular the relaxing of previously obtained strong bounds on Kaluza-Klein masses, induced by flavour changing reactions generated through exchanges of the Higgs field.

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T02: Cosmology / 17

A Multiple-Scales Approach to the Averaging Problem in Cosmology

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The Universe is homogeneous and isotropic on large scales, so on those scales it is usually modelled as a Friedmann-Lemaître-Robertson-Walker (FLRW) space-time. The non-linearity of the Einstein field equations raises concern over averaging over small-scale deviations form homogeneity and isotropy, with possible implications on the applicability of the FLRW metric to the Universe, even on large scales. In this talk I will present a technique, based on the multiple-scales method of singular perturbation theory, to handle the small-scale inhomogeneities consistently. I will obtain a leading order effective Einstein equation for the large-scale space-time metric, which contains a back-reaction term. The derivation relies on a series of consistency conditions, that ensure that the growth of deviations from the large-scale space-time metric do not grow unboundedly; criteria for their satisfiability are discussed, and it is shown that they are indeed satisfied if matter is non-relativistic on small scales. The analysis is performed in harmonic gauge, and conversion to other gauges is discussed. I will also estimate the magnitude of the back-reaction term relative to the critical density of the Universe in the example of an NFW halo. In this example, the back-reaction term can be interpreted as a contribution of the energy-density of gravitational potential energy, averaged over the small-scale, to the total energy-momentum tensor.

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T10: Searches for New Physics / 18

Heavy Z' Bosons in the Secluded $U(1)'$ Model at Hadron Colliders

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We study Z' phenomenology at hadron colliders in an $U(1)'$ extended MSSM. We choose a $U(1)'$ model with a secluded sector, where the tension between the electroweak scale and developing a large enough mass for Z' is resolved by incorporating three additional singlet fields into the model.

We perform a detailed analysis of the production, followed by decays, including into supersymmetric particles, of a Z' boson with particular emphasis on its possible discovery. We select three different scenarios consistent with the latest available experimental data and relic density constraints, and concentrate on final signals involving $2\ell+ \not{E}_T$,$4\ell+ \not{E}_T$ and $6\ell+ \not{E}_T$. Including the SM background from processes with two, three or four vector bosons, we show the likelihood of observing a Z' boson is not promising for the HL-LHC at 14 TeV, but optimistic for 27 and 100 TeV.

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Collaboration / Activity:

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T02: Cosmology / 19

Three different effects of the same quantum nature

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In the model of low-energy quantum gravity by the author the cosmological redshift and additional dimming of remote objects may be interpreted as results of scattering of photons on gravitons of the background. A tentative detection of a diffuse cosmic optical background by the New Horizons mission may be connected with non-forehead collisions of photons with gravitons, too. The conjecture about the local quantum-gravitational nature of the redshift may be verified in a ground-based laser experiment partly using advanced LIGO technologies.

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T10: Searches for New Physics / 21

Blast from the past: Constraints on the dark sector from the BEBC WA66 beam dump experiment

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We derive limits on millicharged dark states, as well as particles with electric or magnetic dipole moments, from the number of observed forward electron scattering events at the Big European Bubble Chamber in the 1982 CERN-WA-066 beam dump experiment. The dark states are produced by the 400 GeV proton beam primarily through the decays of mesons produced in the beam dump, and the lack of excess events places bounds extending up to GeV masses. These improve on bounds from all other experiments, in particular CHARM II.

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Collaboration / Activity:

BEBC WA66 BeamDump (historical

T10: Searches for New Physics / 22

Casimir effect and Lorentz invariance violation (LIV)

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From nanoscience to high energy physics and cosmology, fluctuation-induced phenomena are accepted as underlying mechanism of some most interesting features of the physical world. The Casimir effect is one of the most direct manifestations of the existence of the vacuum quantum fluctuations, discovered by H. B Casimir in 1948, and experimentally confirmed about one decade later by M. J. Sparnnaay. While the first application of Casimir effect has been developed for the electromagnetic fields, but all quantum fields should demonstrate this phenomenon. Moreover, the Casimir effect has been suggested as an experimentally powerful tool for investigating new physics beyond the standard model. On the other hand, Lorentz invariance is one of the main and basic concepts in high energy physics. Recent studies in Standard Model Extension (SME) at high energies indicate that this symmetry may be violated. Such an extension of the Standard Model (SME) has been applied to several scenarios to evaluate the breakdown of symmetries.
In this work using the corrections due to LIV on the electric and magnetic fields, we calculate the corrections imposed by LIV on Casimir effect (force). This may provide a direct probe to test LIV in nature. Finally using the accuracy of the experimental measurements, we impose some upper bounds on the LIV parameter.

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presenter

T04: Neutrino Physics / 23

Latest results of the R2D2 project: a possible future neutrino double beta decay experiment

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The search for neutrinoless double beta decay could cast light on one critical piece missing in our knowledge i.e. the nature of the neutrino mass. Its observation is indeed the most sensitive experimental way to prove that neutrino is a Majorana particle. The observation of such a potentially rare process demands a detector with an excellent energy resolution, an extremely low radioactivity and a large mass of emitter isotope. Nowadays many techniques are pursued but none of them meets all the requirements at the same time. The goal of R2D2 is to prove that a spherical high pressure TPC could meet all the requirements and provide an ideal detector for the $0\nu\beta\beta$ decay search. The prototype has demonstrated an excellent resolution with Argon and the preliminary results with Xenon are already very promising. In the proposed talk the R2D2 results obtained with the first prototype will be discussed as well as the project roadmap and future developments.

Collaboration / Activity:

R2D2

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T02: Cosmology / 24

Quality tests for the Heavy QCD axion

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Heavy QCD axion models are motivated by the so-called "quality problem", the sensitivity of the QCD axion to misaligned contributions to its potential.
In this talk I will show that despite the absence of axion relics today, these models can generically produce a large amount of gravitational waves, a non-vanishing theta angle and, in some cases, both signals simultaneously.
Therefore, I will argue that GW observatories (e.g. LIGO-VIRGO-KAGRA, LISA) and future neutron and proton EDM experiments are good laboratories to search for the Heavy QCD axion.

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Collaboration / Activity:

T01: Astroparticle and Gravitational Waves / 26

Cosmology in the dark: How compact binaries formation impact the gravitational-waves cosmological measurements

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Information about the mass spectrum of compact stars can be used to infer cosmological parameters from gravitational waves (GW) in the absence of redshift measurements obtained from electromagnetic (EM) observations. This method will be fundamental in measuring and testing cosmology with GWs for current and future ground-based GW detectors where the majority part of sources are detected without an associated EM counterpart.
In this talk, I will discuss the prospects and limitations of this approach for studying cosmology. I will show that, even when assuming GW detectors with current sensitivities, the determination of the Hubble constant is strongly degenerate with the maximum mass for black hole production.
I will discuss how assuming wrong models for the underlying population of black hole events can bias the Hubble constant estimate up to 40\%. I will then show how, when taking into account uncertainties on the population of black holes, it is possible to constrain the Hubble constant to a 10% accuracy and the maximum mass of black hole production to a value of 5% by combining 1000 GW event without and observed EM counterpart.

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T06: QCD and Hadronic Physics / 27

Spectral Clustering for Jet Physics

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Machine learning (ML) is pushing through boundaries in computational physics.
Jet physics, with it's large and detailed dataset, is particularly well suited.
In this talk will cover the work done in https://arxiv.org/abs/2104.01972
on the application of an unusual ML technique, Spectral Clustering, to jet formation.

Spectral clustering differers from much of ML as it has no "black-box" elements.
Instead, it is based on a simple, elegant algebraic manipulation.
This allows us to inspect the way the algorithm is interpreting the data, and apply physical intuition.

Infrared-collinear (IRC) safety is of critical importance to jet physics.
IRC safety requires that jets formed are insensitive to collinear splitting and soft emissions.
Spectral clustering is shown to be possible to apply in an IRC safe way, and the conditions for this are noted.

Finally, the capacity of spectral clustering to handle different datasets is shown.
Its excellent performance, both in terms of multiplicity and mass peaks is demonstrated.
In particular we show great performance on two datasets from the extended Higgs sector, alongside the semileptonic top.
The reasons for its flexibility are discussed, and potential developments offered.

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CMS

T01: Astroparticle and Gravitational Waves / 28

GW190521 as a boson-star merger

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In September 2020, Advanced LIGO-Virgo reported a short gravitational-wave signal (GW190521) interpreted as a quasi-circular merger of black holes, one at least populating the pair-instability supernova gap. In this talk I will show that GW190521 is consistent with numerically simulated signals from head-on collisions of two (equal mass and spin) horizonless vector boson stars (aka Proca stars) and provide estimate the mass of the corresponding ultralight vector boson. This provides the first demonstration of close degeneracy between these two theoretical models, for a real gravitational-wave event.

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Collaboration / Activity:

LIGO Scientific Collaboration

T11: Quantum Field and String Theory / 31

The string theory swampland in the Euclid, SKA and Vera Rubin observatory era

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We explore the ability of future cosmological surveys to put constraints on string theory, through the Swampland program. String theory is sometimes thought to be unfalsifiable due to the incredibly large amount of low energy effective versions that can be derived in its framework. However, it is well known that constructing consistent solutions in a de-Sitter background is tremendously difficult. This led to speculative conditions on the possible shape of the potential of a dark energy scalar field. This postulate is referred to as the "de-Sitter conjecture" and low-energy effective theories that do not satisfy it are said to live in the Swampland. Future experiments, such as the Vera Rubin Observatory, Euclid or SKA, will set strong constraints on the form of dark energy and we investigated their potential conflict with the Swampland theoretical conditions. In particular, we show that the expected constraints on the equation of states of dark energy might be in strong contradiction with the de-Sitter conjecture and could therefore put string theory under pressure. Our study is carried out for many different quintessence potentials and a very wide range of initial conditions.

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Collaboration / Activity:

PhD Student

T04: Neutrino Physics / 32

Measuring TeV neutrinos with FASERnu in the LHC Run-3

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The FASERν detector at the LHC has been designed to study neutrinos at the highest man-made energies. The detector will be located 480 m downstream of the ATLAS interaction point, and will take data starting in 2022. With FASERν, the three-flavor neutrino cross-sections will be measured in the currently unexplored energy range between 360 GeV and 5 TeV. In particular, tau-neutrino and electron-neutrino cross sections will be measured at the highest energy ever.

In 2018 we performed a pilot run with the aims of measuring particle fluxes at the proposed detector location and of possibly detecting neutrino interactions for the first time at the LHC. We installed a 30-kg lead/tungsten emulsion detector and collected data of 12.2 fb^{-1}. The analysis of this data has yielded several neutrino interaction candidates, excluding the no-signal hypothesis at the 2σ level. We have also studied the charged particle flux (mainly muons) in regard to the characterization of the unprecedented collider neutrino beamline.

During Run-3 of the LHC starting from 2022, we will deploy an emulsion detector with a target mass of 1.1 tons, coupled with the FASER magnetic spectrometer. This would yield roughly 1,300 ν_e, 9,000 ν_μ, and 30 ν_τ interacting in the detector. Here we present the status and plan of FASERν, as well as the neutrino detection in the 2018 data.

Collaboration / Activity:

FASER Collaboration

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T04: Neutrino Physics / 33

On the sources of CP violation in the Lepton sector

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The phenomenon of Neutrino Oscillation has been very well confirmed by a plethora of data; we are now entering a precision era in which the mixing angles and mass differences are going to be measured with unprecedented precision by ongoing and planned experiments. However, the new measurements could reveal that the standard three flavor scenario is not enough for a complete description of oscillations and a new paradigm beyond the standard physics in the lepton sector must be invoked.
In this talk I will discuss how to test that all CP violating asymmetries are described in terms of the single leptonic Jarlskog invariant as predicted in the absence of new physics effects.

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Collaboration / Activity:

neutrino physics

T01: Astroparticle and Gravitational Waves / 34

High Energy Physics Astroparticle Experiments to Improve the Radiation Health Risk Assessment in Space Missions

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In the near future all the space agencies are working to restart the human exploration of the space outside the Low Earth Orbit (LEO). Manned space missions in this and the next decade will see the presence of humans on the Moon and Mars surface. One of the main showstopper to be investigated for a safe exploration and colonization is the ionizing radiation biological effects that can compromise the health of astronauts/space-workers.
In this important task a principal roles could and do be done by the astroparticle experiments presently operating in space. Such experiments are a source of information crucial to improve the

knowledge of radiobiology effects in space. In this talk a review of the past and present astroparticle experiments will be presented and will be highlighted some of the possible contributions and improvements in the space radiobiology research field.

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Collaboration / Activity:

AMS / SPRB

T06: QCD and Hadronic Physics / 35

Measurement of Exclusive pi+pi- and rho0 Meson Photoproduction at HERA

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Exclusive photoproduction of $\rho^0(770)$ mesons is studied using the H1 detector at the ep collider HERA. A sample of about 900000 events is used to measure single- and double-differential cross sections for the reaction $\gamma p \to \pi^+\pi^- Y$. Reactions where the proton stays intact ($m_Y = m_p$) are statistically separated from those where the proton dissociates to a low-mass hadronic system ($m_p < m_Y < 10$ GeV). The double-differential cross sections are measured as a function of the invariant mass $m_{\pi\pi}$ of the decay pions and the squared 4-momentum transfer t at the proton vertex. The measurements are presented in various bins of the photon-proton collision energy $W_{\gamma p}$. The phase space restrictions are $0.5 < m_{\pi\pi} < 2.2$ GeV, $|t| < 1.5$ GeV^2, and $20 < W_{\gamma p} < 80$ GeV. Cross section measurements are presented for both elastic and proton-dissociative scattering. The observed cross section dependencies are described by analytic functions. Parametrising the $m_{\pi\pi}$ dependence with resonant and non-resonant contributions added at the amplitude level leads to a measurement of the $\rho^0(770)$ meson mass and width at $m_\rho = 770.8^{+2.6}_{-2.7}$ (tot) MeV and $\Gamma_\rho = 151.3^{+2.7}_{-3.6}$v (tot) MeV, respectively. The model is used to extract the $\rho^0(770)$ contribution to the $\pi^+\pi^-$ cross sections and measure it as a function of t and $W_{\gamma p}$. In a Regge asymptotic limit in which one Regge trajectory $\alpha(t)$ dominates, the intercept $\alpha(t{=}0) = 1.0654^{+0.0098}_{-0.0067}$ (tot) and the slope $\alpha'(t{=}0) = 0.233^{+0.067}_{-0.074}$ (tot) GeV^{-2} of the t dependence are extracted for the case $m_Y{=}m_p$.

Eur.Phys.J.C80 (2020), 1189

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H1 collaboration

T06: QCD and Hadronic Physics / 36

Measurement of charged particle multiplicity distributions in DIS at HERA and its implication to entanglement entropy of partons

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Charged particle multiplicity distributions in positron-proton deep inelastic scattering at a centre-of-mass energy $\sqrt{s} = 319$ GeV are measured. The data are collected with the H1 detector at HERA corresponding to an integrated luminosity of 136 pb^{-1}. Charged particle multiplicities are measured as a function of photon virtuality Q^2, inelasticity y and pseudorapidity η in the laboratory and the hadronic centre-of-mass frames. Predictions from different Monte Carlo models are compared to the data. The first and second moments of the multiplicity distributions are determined and the KNO scaling behaviour is investigated. The multiplicity distributions as a function of Q^2 and the Bjorken variable x_{Bj} are converted to the hadron entropy S_{hadron}, and predictions from a quantum entanglement model are tested.

Eur.Phys.J.C 81 (2021), 212

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Collaboration / Activity:

H1 collaboration

T06: QCD and Hadronic Physics / 37

Jet-based TMD measurements with H1 data

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Recently, jet measurements in DIS events close to Born kinematics have been proposed as a new probe to study transverse-momentum-dependent (TMD) PDFs, TMD fragmentation functions, and TMD evolution. We report measurements of lepton-jet momentum imbalance and hadron-in-jet correlations in high-Q^2 DIS events collected with the H1 detector at HERA. The jets are reconstructed with the kT algorithm in the laboratory frame. These are two examples of a new type of TMD studies in DIS, which will serve as pathfinder for the Electron-Ion Collider program.

Collaboration / Activity:

H1 collaboration

First author:

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T05: Heavy Ion Physics / 38

Search for collective behaviour and multiparton interactions in ep scattering at HERA

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Collective behaviour of final-state hadrons is studied in ep scattering using the H1 and ZEUS detectors at HERA. Measurements of two- and four-particle azimuthal correlations in both DIS and photoproduction are presented. Ridge yields are extracted from fits to two-particle correlations with H1 data. Comparisons of the magnitudes and signs of the first- and second-harmonic of two-particle correlations are made with ZEUS data. Four-particle cumulant correlations are observed to be positive.
The results do not indicate the kind of collective behaviour observed at RHIC and the LHC in high-multiplicity hadronic collisions. The possibility of multiparton interactions are studied in photoproduction with ZEUS. Comparisons of PYTHIA predictions with the measurements strongly indicate the presence of multiparton interactions from hadronic fluctuations of the exchanged photon.

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Collaboration / Activity:

H1 collaboration

T06: QCD and Hadronic Physics / 39

Comparison of pp and $p\bar{p}$ differential elastic cross sections and observation of the exchange of a colorless C-odd gluonic compound

Author: Christophe Royon[1]

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We describe an analysis comparing the $p\bar{p}$ elastic cross section as measured by the D0 Collaboration at a center-of-mass energy of 1.96~TeV to that in pp collisions as measured by the TOTEM Collaboration at 2.76, 7, 8, and 13 TeV using a model-independent approach. The TOTEM cross sections, extrapolated to a center-of-mass energy of $\sqrt{s} = 1.96$ TeV, are compared with the D0 measurement in the region of the diffractive minimum and the second maximum of the pp cross section.
The two data sets disagree at the 3.4σ level and thus provide evidence for the t-channel exchange of a colorless, C-odd gluonic compound, also known as the odderon.

We combine these results with a TOTEM analysis of the same C-odd exchange based on the total cross section and the ratio of the real to imaginary parts of the forward elastic strong interaction scattering amplitude in pp scattering.
The combined significance is larger than 5σ and is interpreted as the first observation of the exchange of a colorless, C-odd gluonic compound.

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Collaboration / Activity:

D0 / TOTEM

T07: Top and Electroweak Physics / **40**

Searches for quartic anomalous coupling at the LHC with intact protons

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We will discuss the sensitivity to quartic anomalous couplings between photons and W/Z bosons at the LHC using intact protons in the final state. This allows obtaining a negligible background for 300 fb−1 of data and improves the sensitivities to anomalous couplings by two or three orders of magnitude compared to standard methods. We will also discuss the sensitivity to axion-like particles that also improves by two orders of magnitude.

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Collaboration / Activity:

Phenomenology

T03: Dark Matter / **43**

Search for a Dark Photon with the PADME experiment

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In spite of the variety of attempts to create dark matter at accelerators, up-to-now, none of the conducted experiments has produced any evidence.
This elusiveness of dark-matter has then triggered innovative and open-minded approaches spanning a wide range of energies with high-sensitivity detectors [1].
In this scenario is inserted the Positron Annihilation into Dark Matter Experiment (PADME) ongoing at the Laboratori Nazionali di Frascati of INFN. PADME is searching a Dark Photon signal [2] by studying the missing-mass spectrum of single photon final states resulting from positron annihilation events on the electrons of a fixed target. Actually, the PADME approach allows to look for any new particle produced in e^+e^- collisions through a virtual off-shell photon such as long lived Axion-Like-Particles (ALPs), proto-phobic X bosons, Dark Higgs …
After the detector commissioning and the beam-line optimization, PADME collaboration collected in 2020 about 5×10^{12} positrons on target at 430 MeV. These data are now under study in order to tune all analysis tools.
In the talk, it will be given an overview of the scientific program of the experiment and the performance of the detector will be presented showing Standard Model channels study ($\gamma\gamma$ events, Bremsstrahlung).

References
[1] M. Battaglieri et al., e-Print: 1707.04591 [hep-ph].
[2] M. Raggi and V. Kozhuharov, Adv. High Energy Phys. 509, (2014) 959802.

Collaboration / Activity:

PADME

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T12: Detector R&D and Data Handling / 45

Usage of PEN as self-vetoing structural material in the LEGEND experiment

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PEN is an industrial polyester plastic interesting for the physics community as a new type of wavelength shifting plastic scintillator. Recently, PEN structures with good radio-purity and attenuation length have been successfully produced using the injection compression molding technology. This opens the possibility for usage of PEN as optically active structural components in low-background experiments such as the LEGEND-200 experiment. The ongoing R&D on PEN will be outlined with focus on the evaluation of the optical properties of PEN. In addition, the ongoing efforts for further application of PEN in the LEGEND-1000 experiment will be presented.

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Collaboration / Activity:

LEGEND and PEN group

T01: Astroparticle and Gravitational Waves / 47

Neural networks for TeV cosmic electrons identification on the DAMPE experiment

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The past decades have witnessed the deployment of a new generation of cosmic ray (CR) observatories with unprecedented sensitivity and complexity, pushing towards ever-higher energies. To face the challenges of the multi-TeV domain, such instruments must be accompanied by equally powerful analysis techniques, able to exploit as much information as available. For example, the machine learning tool set may provide the needed techniques. We present a neural network optimised for the identification of multi-TeV electrons on DAMPE, a calorimetric spaceborne CR observatory with among other objectives the measurement of cosmic electrons up to 10 TeV. This constitutes a particularly challenging endeavour due to both the soft electron spectrum and the large proton background. The developed neural network significantly outperforms the more traditional cut-based approach, achieving a much lower proton contamination in the multi-TeV domain with a high signal efficiency, and retains its accuracy when transposed from Monte Carlo to real data.

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Collaboration / Activity:

DAMPE Collaboration

T06: QCD and Hadronic Physics / 48

NNPDF4.0: The Structure of the Proton at 1% Precision

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We present a new release of the NNPDF family of global analyses of the proton's parton distribution functions: NNPDF4.0. It includes a wealth of new experimental data from HERA and the LHC, from dijet cross-sections and isolated photons to single-top and top-quark pair differential distributions. The NNPDF4.0 methodology benefits from improved machine learning algorithms, in particular automated hyperparameter optimisation and stochastic gradient descent for neural network training, which has been validated extensively by means of closure tests and future tests. We demonstrate the stability of the results with respect to the choice of parameterisation basis. We compare NNPDF4.0

with its predecessor NNPDF3.1 as well as to other recent global fits, and study its phenomenological implications for representative collider observables. We assess the impact of representative datasets on specific PDF flavour combinations, such as the dijet and top quark data on the gluon, the Drell-Yan and neutrino DIS data on strangeness, and electroweak measurements on charm and quark flavour separation.

Collaboration / Activity:

Theoretical Particle Physics

First author:

Email:

T07-T09: Combined: Top, Electroweak and Higgs Physics / 50

Parton Distributions in the SMEFT from high-energy Drell-Yan tails

Author: Maeve Madigan[1]

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The high-energy tails of charged- and neutral-current Drell-Yan (DY) processes provide important constraints on the light quark and anti-quark parton distribution functions (PDFs) in the large-x region. On the other hand, a hypothetical short-distance new physics would smoothly distort the high-energy tails as described by the Standard Model Effective Field Theory (SMEFT). In this work, we assess for the first time the interplay between PDF and EFT effects in the high-mass Drell-Yan at the LHC. We determine to which extent EFT signals that would manifest themselves in the tails of the Drell-Yan distributions could be reabsorbed into the large-x (anti-)quark PDFs, and present a strategy aimed at disentangling possible New Physics effects from proton structure modifications. We quantify the impact that a consistent joint determination of the PDFs and Wilson coefficients has in two motivated short-distance new physics scenarios: 1) electroweak oblique corrections and 2) four-fermion interactions possibly behind the LHCb anomalies in R(K(*)). Finally, we present dedicated projections for the High-Luminosity LHC and evaluate its ultimate potential to constrain the EFT parameters, while taking into account potential modifications of the proton structure.

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Collaboration / Activity:

Theoretical Particle Physics

T10: Searches for New Physics / 51

FASER: Forward Search Experiment at the LHC

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The FASER experiment is a new small and inexpensive experiment that is being placed 480 meters downstream of the ATLAS experiment at the CERN LHC. The experiment will shed light on currently unexplored phenomena, having the potential to make a revolutionary discovery. FASER is designed to capture decays of exotic particles, produced in the very forward region, out of the ATLAS detector acceptance. This talk will present the physics prospects, the detector design, and the construction progress of FASER. The experiment has been successfully installed and will take data during the LHC Run-3.

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Collaboration / Activity:

FASER Collaboration

T14: Outreach, Education and Diversity / **52**

The importance of visual representation

Authors: Erica Brondolin[1]; Noemi Caraban[None]

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Science communication is a field that has been evolving over the years. Visual communication has proved to be a critical allied for communication and outreach. The democratisation of technology, the development of 4G / 5G, and social media establishment pushed visual communication as a vital tool for any communication strategy. In large research organizations such as CERN, the archive of images, articles, and videos are not only part of their heritage and memory, it is also a communication tool. A healthy image database open to everyone is key to facilitate assets for user-generated content. In a knowledge-intensive organization, it is important to balance the audiovisual archive needs as technologies evolve and the demand for content creation. With images, diversity can be shown without explaining it. I want to go through my experience at CERN as a videographer and photographer from 2013 to 2020, during the explosion of social media and user-generated content, and talk about the importance of creating images for others to be used on their articles, press assets, presentations and their social media publications. I would like to set **the example of the work done with the WIT group at CERN and the importance of being involved in diverse groups to make them part of the conversation.** WIT members will explain how important these images are for their communication strategy and their social media impact.

Collaboration / Activity:

media content creator / CERN

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T14: Outreach, Education and Diversity / 53

LA-CoNGA physics: an open science education collaboration between Latin America and Europe for High Energy Physics

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The communities of astrophysics, astronomers and high energy physicists have been pioneers in establishing Virtual Research and Learning Networks (VRLCs)[1] generating international productive consortiums in virtual research environments and forming the new generation of scientists. In this talk we will discuss one in particular: LA-CoNGA Physics (Latin American alliance for Capacity buildiNG in Advance physics) [2].

LA-CoNGA physics aim to support the modernization of the university infrastructure and the pedagogical offer in advanced physics in four Latin American countries: Colombia, Ecuador, Peru and Venezuela. This virtual teaching and research network is composed of 3 partner universities in Europe and 8 in Latin America, high-level scientific partners (CEA, CERN, CNRS, DESY, ICTP), and several academic and industrial partners. The project is co-funded by the Education, Audiovisual and Culture Executive Agency (EACEA) of the European Commission.

Open Science education and Open Data are at the heart of our operations. In practice LA-CoNGA physics has created a set of postgraduate courses in Advanced Physics (high energy physics and complex systems) that are common and inter-institutional, supported by the installation of interconnected instrumentation laboratories and an open e-learning platform. This program is inserted as a specialization in the Physics masters of the 8 Latinamerican partners in Colombia, Ecuador, Peru and Venezuela. It is based on three pillars: courses in high energy physics theory/phenomenology, data science and instrumentation.

In the current context, VRLCs and e-learning platforms are contributing to solve challenges, such as distance education during the COVID19 pandemic.

[1] http://www.oecd.org/sti/inno/international-distributed-research-infrastructures.pdf
[2] http://laconga.redclara.net

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Collaboration / Activity:

LA-CoNGA physics & ATLAS

T04: Neutrino Physics / 55

Testing the neutrino mass generation mechanism at the future colliders

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The generation of the neutrino mass is an essential observation from the neutrino oscillation experiments. This indicates a major revision of the Standard Model which initiated with the massless neutrinos. A possible interesting scenario is the seesaw mechanism where SM gauge singlet Right Handed Neutrinos are introduced. Another interesting aspect is the extension of the SM with $SU(2)_L$ triplet fermions. Alternatively a general $U(1)$ extension of the SM is also an interesting idea which involves three generations of the SM singlet RHNs to generate the tiny neutrino mass through the seesaw mechanism. Additionally such models can contain a Z' boson which could be tested at the colliders through the pair production of the RHNs.

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Collaboration / Activity:

HEP-PH

T10: Searches for New Physics / 56

Probing the minimal $U(1)_X$ model at future electron-positron colliders via the fermion pair-production channel

Author: Arindam Das[1]

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The general $\mathrm{U}(1)_X$ extension of the Standard Model (SM) is a well motivated scenario which has a plenty of new physics options. Such a model is anomaly free which requires to add three generations of the SM singlet right-handed neutrinos (RHNs) which naturally generates the light neutrino masses by the seesaw mechanism.This offers interesting phenomenological aspects in the model. In addition to that the model is equipped with a beyond the SM (BSM) neutral gauge boson, Z' which interacts with the SM and BSM particles showing a variety of new physics driven signatures. After the anomaly cancellation the $\mathrm{U}(1)_X$ charge of the particles are expressed in terms of the SM Higgs doublet and the SM Higgs singlet which allows us to study the interaction of the fermions with the Z'.In this paper we investigate the pair production mechanism of the different charged through the photon, Z and Z' boson exchange processes at the electron-positron (e^-e^+).The angular distributions, forward-backward $(\mathcal{A}_{\mathrm{FB}})$, left-right $(\mathcal{A}_{\mathrm{LR}})$ and left-right forward-backward $(\mathcal{A}_{\mathrm{LR,FB}})$ asymmetries of the different charged fermion pair productions show substantial deviation from the SM results.

Collaboration / Activity:

HEP-PH

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T12: Detector R&D and Data Handling / 57

Online DAQ and slow control interface for the Mu2e experiment

Authors: Antonio Gioiosa[1]; Simone Donati[2]; Luca Morescalchi[3]; Franco Spinella[3]; Elena Pedreschi[3]; Richard Bonventre[4]; Flumerfelt Eric[5]; Glenn Horton-Smith[None]; Gianantonio Pezzullo[6]; Vivian O'Dell[7]; Lorenzo Uplegger[7]; Ryan A. Rivera[None]

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[4] *BNL*

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The muon campus program at Fermilab includes the Mu2e experiment that will search for a charged-lepton flavor violating processes where a negative muon converts into an electron in the field of an aluminum nucleus, improving by four orders of magnitude the search sensitivity reached so far.
Mu2e's Trigger and Data Acquisition System (TDAQ) uses {\it otsdaq} as its solution. Developed at Fermilab, {\it otsdaq} uses the {\it artdaq} DAQ framework and {\it art} analysis framework, under-the-hood, for event transfer, filtering, and processing.
{\it otsdaq} is an online DAQ software suite with a focus on flexibility and scalability, while providing a multi-user, web-based, interface accessible through a web browser.
A Detector Control System (DCS) for monitoring, controlling, alarming, and archiving has been developed using the Experimental Physics and Industrial Control System (EPICS) open source Platform.
The DCS System has also been integrated into {\it otsdaq}.

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Collaboration / Activity:

Post doc

T09: Higgs Physics / 58

mb(mH): extracting the bottom quark mass from Higgs precision measurements

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A new method is presented to extract the bottom quark mass from collider data on Higgs production and decay rates. We find a value for the bottom quark MSbar mass at the scale of the Higgs boson mass of mb(mh) = 2.6 +/- 0.3 GeV from recent measurements of Higgs coulings by the ATLAS and CMS experiments at the CERN LHC. This result is compatible with the prediction of mb(mh) from the evolution of the world average for mb(mb) and thus provides further evidence for the scale evolution, or "running" of the bottom quark mass. Future precision measurements of Higgs decay rates are expected to improve this result considerably. We assess, in particular, the potential of the complete HL-LHC program and of a future "Higgs factory" electron-positron collider.

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Collaboration / Activity:

interpretation of LHC data

T04: Neutrino Physics / 59

Visible Decay of Astrophysical Neutrinos at IceCube

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Neutrino decay modifies neutrino propagation in a unique way; not only is there flavor changing as there is in neutrino oscillations, there is also energy transport from initial to final neutrinos. The most sensitive direct probe of neutrino decay is currently IceCube which can measure the energy and flavor of neutrinos traveling over extragalactic distances. For the first time, we calculate the flavor transition probability for the cases of visible and invisible neutrino decay, including the effects of the expansion of the Universe, and consider the implications for IceCube. As an example, we demonstrate how neutrino decay addresses a tension in the IceCube data.

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Collaboration / Activity:

BNL

T07: Top and Electroweak Physics / 60

SMEFT analysis of vector boson scattering and diboson data from the LHC Run II

Authors: Giacomo Magni[1]; Juan Rojo[2]; Raquel Gomez-Ambrosio[3]; Jake Jacob Ethier[1]

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We present a systematic interpretation of vector boson scattering (VBS) and diboson measurements from the LHC in the framework of the dimension-six Standard Model Effective Field Theory (SMEFT), based on our results available at https://arxiv.org/abs/2101.03180.
We try to understand what is the interplay between VBS and diboson measurements in order to constrain 16 independent directions in the dimension-six EFT parameter space, finding that VBS provides complementary information on several operators relevant for the description of the electroweak sector.
Finally we also quantify the ultimate EFT reach of VBS measurements via dedicated projections for the High Luminosity LHC. Our results motivate the integration of VBS processes with Higgs measurements in future global SMEFT interpretations of particle physics data.

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Collaboration / Activity:

VU, Nikhef

T07-T09: Combined: Top, Electroweak and Higgs Physics / 61

Combined SMEFT interpretation of Higgs, diboson, and top quark data from the LHC

Author: Juan Rojo[1]

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We present an extensive global interpretation of Higgs, diboson, and top quark production and decay measurements from the LHC in the framework of the Standard Model Effective Field Theory (SMEFT) at dimension six. We constrain simultaneously 36 independent directions in its parameter space, and compare the outcome of the global analysis with that from individual and two-parameter fits. Our results are obtained by means of state-of-the-art theoretical calculations for the SM and the EFT cross-sections, and account for both linear and quadratic corrections in the EFT expansion. We demonstrate how the inclusion of NLO QCD and quadratic effects is instrumental to accurately map the posterior distributions associated to the fitted Wilson coefficients. We assess the interplay and complementarity between the top quark, Higgs, and diboson measurements, deploy a variety of statistical estimators to quantify the impact of each dataset in the parameter space, and carry out fits in BSM-inspired scenarios such as the top-philic model. Our results represent a stepping stone in the ongoing program of model-independent searches at the LHC from precision measurements, and pave the way towards yet more global SMEFT interpretations extended to other high-pT processes as well as to low-energy observables.

Collaboration / Activity:

Theoretical Particle Physics

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T01: Astroparticle and Gravitational Waves / 62

Supernova bounds on axion-like particles coupled with nucleons and electrons

Authors: Pierluca Carenza[1]; Maurizio Giannotti[2]; Alessandro Mirizzi[3]; Giuseppe Lucente[4]; Joerg Jaeckel[5]; Francesca Calore[6]

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We investigate the potential of core-collapse supernovae (SNe) to constrain axion-like particles (ALPs) coupled to nucleons and electrons. ALPs coupled to nucleons can be efficiently produced in the SN core via nucleon-nucleon bremsstrahlung and, for a wide range of parameters, leave the SN producing a large ALP flux. For ALP masses exceeding 1 MeV, these ALPs would decay into electron-positron pairs, generating a positron flux. For Galactic SNe the annihilation of the created positrons with the galactic electron background would contribute to the 511 keV annihilation line. Using the observation of this line by the spectrometer SPI (SPectrometer on INTEGRAL), we obtain stringent constraints for the electron-ALP coupling, excluding the range $10^{-18} < g_{ae} < 10^{-11}$ for $g_{ap} < 10^{-9}$. Furthermore, ALP decays and subsequent electron-positron annihilations in the extra-galactic medium would yield a contribution to the cosmic X-ray background. Using this allows to set constraints down to the level $g_{ae} \sim 10^{-21}$.

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Collaboration / Activity:

.

T10: Searches for New Physics / 63

Charged Higgs production as probe for extra top Yukawa couplings

Author: Tanmoy Modak[1]

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We discuss the possibility of probing additional top Yukawa couplings via charged Higgs boson (H+) production at the Large Hadron Collider. The context is general Two Higgs Doublet Model (g2HDM). We show that additional top Yukawa couplings ρtc and ρtt in g2HDM can be searched via cg⟶bH+⟶bt̄b process at the LHC with evidence may emerge as early as in the Run 3 data. A discovery may shed light on the observed baryon asymmetry of the Universe.

Reference

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Collaboration / Activity:

single author

T10: Searches for New Physics / 65

Mass Unspecific Supervised Tagging (MUST) for boosted jets

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Jet identification tools are crucial for new physics searches at the LHC and at future colliders. We introduce the concept of Mass Unspecific Supervised Tagging (MUST) which relies on considering both jet mass and transverse momentum varying over wide ranges as input variables —together with jet substructure observables —of a multivariate tool. This approach not only provides a single efficient tagger for arbitrary ranges of jet mass and transverse momentum, but also an optimal solution for the mass correlation problem inherent to current taggers. By training neural networks, we build MUST-inspired generic and multi-pronged jet taggers which, when tested with various new physics signals, clearly outperform the variables commonly used by experiments to discriminate signal from background. These taggers are also efficient to spot signals for which they have not been trained. Taggers can also be built to determine, with a high degree of confidence, the prongness of a jet, which would be of utmost importance in case a new physics signal is discovered.

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Collaboration / Activity:

Particle physics

T03: Dark Matter / 66

The DarkMESA Experiment

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At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will go into operation within the next years. In the extracted beam operation (150 MeV, 150 μA) the P2 experiment will measure the weak mixing angle in electron-proton scattering in 10,000 hours operation time. Therefore, the high-power beam dump of this experiment is ideally suited for a parasitic dark sector experiment — DarkMESA.
The experiment is designed for the detection of Light Dark Matter (LDM) which in the simplest model couples to a massive vector particle, the dark photon γ'. It can potentially be produced in the P2 beam dump by a process analogous to photon bremsstrahlung and can then decay in Dark Matter (DM) particle pairs $\chi\overline{\chi}$. A fraction of them scatter off electrons or nuclei in the DarkMESA calorimeter.
In a first stage 1,000 high density PbF_2 Cherenkov radiators from a previous experiment will be used. In further stages Pb-glass is added incrementally.
Within a MadGraph and Geant4 simulation the accessible parameter space was estimated. The experimental setup was optimized and further concepts were investigated.
DarkMESA-Drift is such an additional approach. A directional Time Projection Chamber (TPC) filled with CS_2 at low pressure serves as DM detector. With the nuclear recoil threshold being in the keV range the accessible parameter space can be extended.

Collaboration / Activity:

MAGIX-Collaboration

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T04: Neutrino Physics / 67

Status of the Short-Baseline Near Detector at Fermilab

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The Short-Baseline Near Detector (SBND) will be one of three liquid Argon Time Projection Chamber (LArTPC) neutrino detectors positioned along the axis of the Booster Neutrino Beam (BNB) at Fermilab, as part of the Short-Baseline Neutrino (SBN) Program. The detector is currently in the construction phase and is anticipated to begin operation in the second half of 2022. SBND is characterised by superb imaging capabilities and will record over a million neutrino interactions per year. Thanks to its unique combination of measurement resolution and statistics, SBND will carry out a rich program of neutrino interaction measurements and novel searches for physics beyond the Standard Model (BSM). It will enable the potential of the overall SBN sterile neutrino program by performing a precise characterisation of the unoscillated event rate, and by constraining BNB flux and neutrino-Argon cross-section systematic uncertainties. In this talk, the physics reach, current status, and future prospects of SBND are discussed.

Collaboration / Activity:

SBND

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T01: Astroparticle and Gravitational Waves / **68**

Searching for binary black holes in the Milky Way and its neighborhood with LISA

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In 2034, within the rapidly changing landscape of gravitational-wave astronomy, the Laser interferometer Space Antenna will be the first space-based detector that will observe the gravitational spectra in the millihertz frequency band. It has recently been proposed that numerous LIGO/VIRGO sources will also be detectable by LISA. LISA will be able to detect binary black holes from our Milky Way galaxy and its neighbourhood, evolving from their early inspiral stages. Interestingly, the sources that appear to be circular in the LIGO band may be eccentric in the LISA band, depending on the earlier stages of their evolution. We aim to explore the gravitational waves emitted from black hole binaries in our Milky Way galaxy and its neighbourhood, as they are expected to be observable with LISA. Here, I will present models that combine simulation of Milky Way-like galaxy formation, and specifically, the Latte simulation from the Feedback in relativistic environments (FIRE-2) project, with the new binary population synthesis code POSYDON to investigate the detectability of inspiraling binary black hole populations in both the LISA and the LIGO frequency bands, as a function of eccentricity and their horizon distances, using a Monte-Carlo approach. Furthermore, I will discuss how one can disentangle different formation channels of these binaries using LISA, and estimate the rate and observable properties with which these binaries form in the Milky Way galaxy and other nearby galaxies.

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Collaboration / Activity:

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T01: Astroparticle and Gravitational Waves / **69**

Magnetic-field influence on beta-processes in core-collapse supernova

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Neutrinos play a significant and sometimes even dominant role in all phases of the supernova explosion. The dominant neutrino processes in a core-collapse supernova are beta-processes, which are responsible for the energy exchange between neutrinos and the matter and change a chemical composition of a matter. We investigate an influence of a magnetic field on beta-processes under conditions of a supernova matter. For realistic magnetic fields reachable in astrophysical objects, we obtain simple analytical expressions for reaction rates of beta-processes as well as energy and momentum transferred from neutrino and antineutrinos to the matter. In our analysis we use results of one-dimensional simulations of a supernova explosion performed with the PROMETHEUS-VERTEX code. We found that, in the magnetic field with the strength $B \sim 10^{15}$ G, the quantities considered are modified by several percents only and, as a consequence, the magnetic-field effects can be safely ignored, considering neutrino interaction and propagation in a supernova matter. The work is supported by the Russian Science Foundation (Grant No. 18-72-10070).

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Collaboration / Activity:

no

T10: Searches for New Physics / **72**

Triggering long-lived particles in HL-LHC and the challenges in the first stage of the trigger system

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Triggering long-lived particles (LLPs) at the first stage of the trigger system is very crucial in LLP searches to ensure that we do not miss them at the very beginning. The future High Luminosity runs of the Large Hadron Collider will have an increased number of pile-up events per bunch crossing. There will be major upgrades in hardware, firmware and software sides, like tracking at level-1 (L1). The L1 trigger menu will also be modified to cope with pile-up and maintain the sensitivity to physics processes. In our study we found that the usual level-1 triggers, mostly meant for triggering prompt particles, will not be very efficient for LLP searches in the 140 pile-up environment of HL-LHC, thus pointing to the need to include dedicated L1 triggers in the menu for LLPs. We consider the decay of the LLP into jets and develop dedicated jet triggers using the track information at L1 to select LLP

events. We show in our work that these triggers give promising results in identifying LLP events with moderate trigger rates.

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Collaboration / Activity:

N/A

T07: Top and Electroweak Physics / 73

The full electroweak $\mathcal{O}(\alpha)$ corrections to $\gamma\gamma \to \ell^-\ell^+$

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We present high-precision predictions for $\ell^-\ell^+$ production ($\ell = \mu, \tau$) at $\gamma\gamma$ collisions by considering a complete set of one-loop-level scattering amplitudes, i.e., full electroweak (EW) $\mathcal{O}(\alpha)$ corrections together with soft and hard QED radiation. We perform detailed numerical discussion of the one-loop EW radiative corrections, particularly the pure QED and Weak corrections, and then discuss the production rates in terms of different polarization modes of initial photons. We observe an improvement up to two-times for the case of oppositely polarized photons. It is found that the considered corrections enhance the Born cross section within ten percent of total relative correction for both production channels. Our results indicate that the full EW corrections must be included to improve a percent level accuracy.

Collaboration / Activity:

High-precision predictions

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T06: QCD and Hadronic Physics / 74

ITMD factorization and its applications

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I would like to review recently introduced factorization called Improved Transverse Momentum Dependent factorization which applies in the regime of QCD when the saturation effects become relevant and when one has hard final state. Furthermore I would like to present an application of this formalism to phenomenological predictions of jet production in pA and eA.

Collaboration / Activity:

QCD

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T09: Higgs Physics / 75

Higgs-plus-jet differential distributions as stabilizers of the high-energy resummation

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We investigate the inclusive hadroproduction of a Higgs boson in association with a jet, featuring large transverse momenta and separated by a large rapidity distance. We propose this reaction, that can be studied at the LHC as well as at new-generation colliding machines, as a novel probe channel for the manifestation of the Balitsky-Fadin-Kuraev-Lipatov (BFKL) dynamics. We bring evidence that high-energy resummed distributions in rapidity and transverse momentum exhibit a solid stability under higher-order corrections, thus offering us a faultless chance to gauge the feasibility of precision calculations of these observables at high energies. We come out with the message that future, exhaustive analyses of the inclusive Higgs-boson production, would benefit from the inclusion of high-energy effects in a *multi-lateral* formalism where distinct resummations are concurrently embodied. We propose these studies with the aim of inspiring synergies with other Communities, and pursuing the goal of widening common horizons in the exploration of the Higgs-physics sector.

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Collaboration / Activity:

ECT*/FBK & TIFPA-Trento

T05: Heavy Ion Physics / 76

First steps towards the quantum simulation of jet quenching

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The leading order α_s effect in jet quenching corresponds to the broadening of the jet's transverse momentum, due to the multiple interactions with the underlying medium. A complete understanding of momentum broadening is critical for the success of jet quenching phenomenology.

In this talk, we introduce a strategy to quantum simulate single particle momentum broadening in a QCD background medium. We argue that it is, in principle, possible to extract the jet quenching parameter $\hat{q}$ from such an algorithm. More importantly, this corresponds to the first step towards simulating full medium induced parton showers, which is far beyond the capabilities of classical computers.

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Collaboration / Activity:

IGFAE

T04: Neutrino Physics / **77**

The ESSnuSB/HIFI Design Study

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The ESS 5 Megawatt linac will be the world's most powerful accelerator, enabling with its 1016 2 GeV protons per second the production of the world's most intense flux, not only of neutrons, but also of neutrinos and muons. This opens unique opportunities for High Intensity Frontier fundamental physics. An EU supported Design Study of an ESS neutrino Super Beam (ESSnuSB) is under way since 2018 with the participation of physicists from 15 European institutions of the use of the neutrino beam for long baseline neutrino oscillations. Within this study is being designed the upgrade of the linac required to increase its power to 10 MW by the provision of extra H- pulses between the proton linac pulses, of a ca 400 circumference accumulator ring to compress the 3ms long linac pulses to 1.3µs, of a set of four high power neutrino targets with focusing horns and a kiloton near and a megaton far water Cherenkov neutrino detector, the latter at a distance of 540 km at the location of the second neutrino oscillation maximum. The publication of the ESSnuSB Design Study report is approaching and highlights among achieved design results will be presented. More recently a study of the use of the intense muon flux produced together with neutrinos has been started, aiming at a design of, in the first stage, a Muon Cooling Test Facility to be followed by the study of a nuSTORM low-energy facilty, a Neutrino Factory and ultimately a Muon Collider Higgs Factory. The plan for this High Intensity Frontier Initiative (HIFI) design work will be presented.

Collaboration / Activity:

ESSnuSB

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T10: Searches for New Physics / 78

Minimal and non-minimal Universal Extra Dimension models in the light of LHC data at 13 TeV

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Universal Extra Dimension (UED) is a well-motivated and well-studied scenario. One of the main motivations is the presence of a dark matter (DM) candidate namely, the lightest level-1 Kaluza-Klein (KK) particle (LKP), in the particle spectrum of UED. The minimal version of UED (mUED) scenario is highly predictive with only two parameters namely, the radius of compactification and cut-off scale, to determine the phenomenology. Therefore, stringent constraint results from the WMAP/PLANCK measurement of DM relic density (RD) of the universe. The production and decays of level-1 quarks and gluons in UED scenarios give rise to multijet final states at the Large Hadron Collider (LHC) experiment. We study the ATLAS search for multijet plus missing transverse energy signatures at the LHC with 13 TeV center of mass energy and 139 inverse femtobarn integrated luminosity. In view of the fact that the DM RD allowed part of mUED parameter-space has already been ruled out by the ATLAS multijet search, we move on to a less restricted version of UED namely, the non-minimal UED (nmUED), with non-vanishing boundary-localized terms (BLTs). The presence of BLTs significantly alters the dark matter as well as the collider phenomenology of nmUED. We obtain stringent bounds on the BLT parameters from the ATLAS multijet plus missing transverse energy search.

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Collaboration / Activity:

Personal

T11: Quantum Field and String Theory / 79

Non-Hermiticity: a new paradigm for model building in particle physics

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Non-Hermitian quantum theories have been applied in many other areas of physics. In this talk, I will review recent developments in the formulation of non-Hermitian quantum field theories, highlighting features that are unique compared to Hermitian theories. I will describe their crucial discrete symmetries and how continuous symmetry properties are borne out, including Noether's theorem 1, the Goldstone theorem [2] and the Englert-Brout-Higgs mechanism [3,4]. As examples, I will describe non-Hermitian deformations of QED, the Higgs-Yukawa theory [5] and flavour oscillations [6], illustrating the potential implications of non-Hermitian model building for the neutrino sector [5]. Together, these results pave the way for a systematic programme for building non-Hermitian extensions of the Standard Model of particle physics.

1 J. Alexandre, P. Millington, D. Seynaeve, Phys. Rev. D 96, 065027 (2017).
[2] J. Alexandre, J. Ellis, P. Millington, D. Seynaeve, Phys. Rev. D 98, 045001 (2018).
[3] J. Alexandre, J. Ellis, P. Millington, D. Seynaeve, Phys. Rev. D 99, 075024 (2019).
[4] J. Alexandre, J. Ellis, P. Millington, D. Seynaeve, Phys. Rev. D 101, 035008 (2020).
[5] J. Alexandre, C. M. Bender, P. Millington, J. High Energy Phys. JHEP11(2015)111.
[6] J. Alexandre, J. Ellis, P. Millington, Phys. Rev. D 102, 125030 (2020).

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Collaboration / Activity:

N/A

T03: Dark Matter / 81

Dark matter from evaporating Black Holes

Author: Isabella Masina[None]

Primordial black holes might have existed in the early Universe and, via their evaporation mechanism (completed before Big Bang Nucleosynthesis), they might have released stable particles beyond the Standard Model. We discuss the possibility that such particles might constitute all or a fraction of the dark matter observed today, also considering the bounds on warm dark matter. If sufficiently light, stable particles from primordial black holes evaporation might provide a significant contribution to dark radiation.

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Collaboration / Activity:

-

T03: Dark Matter / 82

Directional Dark Matter Search with NEWSdm

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In spite of the extensive search for the detection of the dark matter (DM), experiments have so far yielded null results: they are probing lower and lower cross-section values and are touching the so-called neutrino floor. A way to possibly overcome the limitation of the neutrino floor is a directional sensitive approach: one of the most promising techniques for directional detection is nuclear emulsion technology with nanometric resolution. The NEWSdm experiment, located in the Gran Sasso underground laboratory in Italy, is based on novel nuclear emulsion acting both as the Weakly Interactive Massive Particle (WIMP) target and as the nanometric-accuracy tracking device. This would provide a powerful method of confirming the Galactic origin of the dark matter, thanks to the cutting-edge technology developed to readout sub-nanometric trajectories. In this talk we discuss the experiment design, its physics potential, the performance achieved in test beam measurements and the near-future plans. After the submission of a Letter of Intent, a new facility for emulsion handling was constructed in the Gran Sasso underground laboratory which is now under commissioning. A Conceptual Design Report is in preparation and will be submitted in Summer 2021.

Collaboration / Activity:

NEWSdm Coll.

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T12: Detector R&D and Data Handling / 83

Performance of the Multigap Resistive Plate Chambers of the Extreme Energy Events Project

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The muon telescope of the Extreme Energy Events (EEE) Project is made by 3 Multigap Resistive Plate Chambers (MRPC). The whole EEE array is composed of 61 telescopes installed in Italian High Schools, built and operated by students and teachers, constantly supervised by researchers.
The unconventional working sites are a unique test field for checking the robustness and the low ageing features of the MRPC technology for particle tracking and timing purposes. The MRPCs are fluxed with a standard mixture (98% C₂H₂F₄ - 2% SF₆), of greenhouse gases (GHG) phasing out of production.
In order to reduce GHG emissions, without affecting MRPC excellent performance, the EEE Collaboration is currently studying alternative mixtures environmentally and economically sustainable.MRPCs achieved performance in terms of resolution (time and space), efficiency, tracking capability and stability will be discussed and compared to specifications and preliminary results obtained by using new gas mixtures.

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Collaboration / Activity:

EEE Collaboration

T12: Detector R&D and Data Handling / 84

Application of Quantum Machine Learning to High Energy Physics Analysis at LHC Using Quantum Computer Simulators and Quantum Computer Hardware

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Machine learning enjoys widespread success in High Energy Physics (HEP) analysis at LHC. However the ambitious HL-LHC program will require much more computing resources in the next two decades. Quantum computing may offer speed-up for HEP physics analysis at HL-LHC, and can be a new computational paradigm for big data analysis in High Energy Physics.

We have successfully employed Variational Quantum Classifier (VQC) method, Quantum Support Vector Machine Kernel (QSVM-kernel) method and Quantum Neural Network (QNN) method for two LHC flagship analyses: ttH (Higgs production in association with two top quarks) and H->mumu (Higgs decay to two muons, the second generation fermions).

We will present our experiences and results of a study on LHC High Energy Physics data analysis with IBM Quantum Simulator and Quantum Hardware (using IBM Qiskit framework), Google Quantum Simulator (using Google Cirq framework), and Amazon Quantum Simulator (using Amazon Braket cloud service). The work is in the context of a Qubit platform. Taking into account the present limitation of hardware access, different quantum machine learning methods are studied on simulators and the results are compared with classical machine learning methods (BDT, classical Support Vector Machine and classical Neural Network). Furthermore, we do apply quantum machine learning on IBM quantum hardware to compare performance between quantum simulator and quantum hardware.

The work is performed by an international and interdisciplinary collaboration with the Department of Physics and Department of Computer Sciences of University of Wisconsin, CERN Quantum Technology Initiative, IBM Research Zurich, Fermilab Quantum Institute, BNL Computational Science Initiative, State University of New York at Stony Brook, and Quantum Computing and AI Research of Amazon Web Services.

This work pioneers a close collaboration of academic institutions with industrial corporations in a High Energy Physics analysis effort.

Although the era of efficient quantum computing may still be years away, we have made promising progress and obtained preliminary results in applying quantum machine learning to High Energy Physics. A PROOF OF PRINCIPLE.

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Collaboration / Activity:

quantum ML application to HEP

T09: Higgs Physics / 85

Resurrecting bbh with Machine Learning Magic

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The associated production of a $b\bar{b}$ pair with a Higgs boson could provide an important probe to both the size and the phase of the bottom-quark Yukawa coupling, y_b. However, the signal is shrouded by several irreducible background processes. We show that the analysis of kinematic shapes provides us with a concrete prescription for separating the y_b-sensitive production modes from both the irreducible and the QCD-QED backgrounds in the $b\bar{b}\gamma\gamma$ final state. We draw a page from game theory and use Shapley values to make Boosted Decision Trees interpretable in terms of kinematic measurables and provide physics insights into the variances in the kinematic shapes of the different channels that help us complete this feat. Adding interpretability to the machine learning algorithm opens up the black-box and allows us to pick and interpret upon kinematic variables that matter most in the analysis. We resurrect the hope of constraining the size and, possibly, the phase of y_b using kinematic shape studies of $b\bar{b}h$ production with the full HL-LHC data and at FCC-hh.

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Collaboration / Activity:

DESY

T08: Flavour Physics and CP Violation / 86

BaBar B ->D*lnu amplitude analysis confronting latest lattice data

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We present comparisons between the results obtained in the BaBar B ->D*lnu amplitude analysis (PRL 123, 091801 (2019)) in the light of new non-zero recoil lattice data from MILC. We also discuss prospects for probing right-handed currents from a joint lattice + BaBar fit, in a manner independent of the |Vcb| normalization issue.

Collaboration / Activity:

BABAR

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T08: Flavour Physics and CP Violation / 87

Rare and forbidden decays of D0 meson.

Author: Fabio Anulli[1]

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We report the observation of the rare charm decay $D^0 \to K^-\pi^+e^+e^-$, a search for nine lepton-number-violating and three lepton-flavor-violating neutral charm decays of the type $D^0 \to h^-h^{'-}\ell^+\ell^{'+}$, and $D^0 \to h^-h^{'+}\ell^+\ell^{'-}$, and a search for seven lepton-number-violating decays of the type $D^0 \to X^0e^{\pm}\mu^{\mp}$, where h and h' represent a K or π meson, ℓ and ℓ' an electron or muon, and X^0 a π^0, K^0_S, K^{*0}, ρ^0, ϕ, ω, or η meson. The results, which greatly improve on previously available data, are based on 468 fb^{-1} of e^+e^- collision data collected at or close to the $\Upsilon(4S)$ resonance with the BaBar detector at the SLAC National Accelerator Laboratory.

Collaboration / Activity:

BABAR

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T07: Top and Electroweak Physics / 90

Study of e^+e^- annihilation into hadrons at low energies with ISR at BABAR

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The measurement of exclusive e^+e^- to hadrons processes is a significant part of the physics program of BABAR experiment, aimed to improve the calculation of the hadronic contribution to the muon $g-2$ and to study the intermediate dynamics of the processes. We present the most recent studies performed on the full data set of about 470 fb^{-1} collected at the PEP-II e+e− collider at a center-of-mass energy of about 10.6 GeV. In particular, we report the results on e^+e^- annihilation into three pions and into states with six and seven pions or kaons, in an energy range from production threshold up to about 4 GeV.

Collaboration / Activity:

BABAR

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Plenary Session 1 / 92

LHC Collider Status and Future

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Plenary Session 1 / 93

Highlights from the CMS Experiment

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Plenary Session 1 / 94

Highlights from the ATLAS Experiment

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Collaboration / Activity:

Plenary Session 1 / 95

Standard Model Theory

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Plenary Session 2 / 96

Highlights from the LHCb Experiment

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Plenary Session 2 / 97

Highlights from the ALICE Experiment

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Plenary Session 2 / 98

Beyond Standard Model Theory

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Plenary Session 2 / 99

Quantum Field and String Theory

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Plenary Session 3 / 100

Multi-messenger Astroparticle Physics

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Plenary Session 3 / 101

Dark Matter and Axion Searches

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Plenary Session 3 / 102

Gravitational Waves

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Plenary Session 3 / 103

Observational Cosmology

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Plenary Session 4 / 104

Highlights from the BELLE II Experiment and Flavour Physics in e+e-

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Plenary Session 4 / 105

Highlights from Neutrino Physics Experiments

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Plenary Session 4 / 106

Quark and Lepton Flavour Theory

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Plenary Session 4 / 107

Future Collider Projects

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Plenary Session 4 / 108

Conference Summary

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Review Stream 1 / 109

Higgs Measurements

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Review Stream 1 / 110

Higgs Theory

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Review Stream 2 / 111

Emergence of Quark-Gluon Plasma Phenomena

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Collaboration / Activity:

Review Stream 2 / 112

High-energy QCD Matter Theory

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Review Stream 1 / 113

Standard Model Measurements

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Review Stream 1 / 114

Searches for Exotica

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Review Stream 2 / 115

Cosmic Messengers

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Review Stream 2 / 116

Cosmology and Dark Matter Theory

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Review Stream 1 / 117

Calculational Techniques in Particle Theory

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Review Stream 1 / 118

Rare Decays and CP violation

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Review Stream 2 / 119

Neutrino Physics with Particle Beams

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Review Stream 2 / 120

Neutrino Theory

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Review Stream 2 / 121

Future Astroparticle Facilities

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T12: Detector R&D and Data Handling / 122

RADiCAL - Ultracompact Radiation-hard Fast-timing EM Calorimetry

Authors: Randy Ruchti[1]; Bradley Cox[2]; Renyuan Zhu[3]; Yasar Onel[4]; Robert Hirosky[2]; Alexander Ledovskoy[2]; Mitchell Wayne[1]; Colin Jessop[1]; Adriaan Heering[1]; Yuri Musienko[5]; Mark Vigneault[1]; Yuyi Wan[1]; C Hu[3]; L Zhang[3]; Paul Debbins[4]; Ugur Akgun[4]

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To address the challenges of providing high performance EM calorimetry in future experiments under high luminosity and difficult radiation and pileup conditions, R&D is being conducted on promising optical-based technologies that can inform the design of future detectors, with emphasis on ultra-compactness, excellent energy resolution and spatial resolution, and especially fast timing capability.

The strategy builds upon the following concepts: use of dense materials to minimize the cross sections and lengths (depths) of detector elements; maintaining Molière Radii of the structures as small as possible; use of optical techniques that can provide high efficiency and fast response while keeping optical paths as short as possible; and use of radiation resistant, high efficiency photosensors.

High material density is achieved by using thin layers of tungsten absorber interleaved with active layers of dense, highly efficient crystal or ceramic scintillator. Scintillator approaches under investigation include rare-earth 3+ activated materials Ce3+ and Pr3+ for brightness and Ca co-doping for improved (faster) fluorescence decay time.

Light collection and transfer from the scintillation layers to photosensors is enabled by the development and refinement of new waveshifters (WLS) and their incorporation into radiation hard quartz waveguide elements. WLS developments include the fast organic dyes of the DSB1 type, ESIPT (excited state intermolecular proton transfer) dyes having very low optical self-absorption, and inorganic materials such as LuAG:Ce, having high radiation resistance.

Optical waveguide approaches include thick-wall quartz capillaries containing WLS cores for: (1) energy measurement; (2) with WLS materials strategically placed at the location of the EM shower maximum to provide timing of EM showers, and (3) with WLS shifter elements placed at various depth locations to provide depth segmentation and angular measurement of EM shower development.

Light from the wave shifters is detected by pixelated, Geiger-mode photosensors.
These include small pixel (5-7 micron) silicon photomultiplier devices (SiPM) operated at low gain and cooled (typically -35℃ or below), and potentially via large band-gap devices such as GaInP.

Underway or in planning are bench, beam and radiation tests of individual components and modular elements. Recent results and program plans will be presented.

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Collaboration / Activity:

RADiCAL EM Calorimetry

T06: QCD and Hadronic Physics / 124

Study of scalar meson production in three body η_c decays at BABAR

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We perform Dalitz plot analysis of η_c decays to $\eta' K^+K^-$, $\eta'\pi^+\pi^-$, and $\eta\pi^+\pi^-$, where the η_c is produced in two-photon interactions. We measure the parameters of $K_0^*(1430)$ and $K_0^*(1950)$ and observe production of $\sigma(600)$, $f_0(1400)$ and $f_0(1710)$ resonances. We observe new resonances decaying to $\pi^+\pi^-$ in the $\eta'\pi^+\pi^-$ and $\eta\pi^+\pi^-$, decay modes of the η_c meson. We also compare rates of production of glueball candidates $f_0(1500)$ and $f_0(1710)$ in η and η' final states. Data have been collected by the BABAR experiment at the PEP-II e^+e^- and correspond to an integrated luminosity of about 470 fb^{-1}.

Collaboration / Activity:

BABAR

First author:

Email:

T08: Flavour Physics and CP Violation / 126

Tests of the Standard Model by means of $\Upsilon(3S)$ meson decays with the $BABAR$ detector

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The $BABAR$ detector collected a sample of 122 million $\Upsilon(3S)$ mesons, corresponding to an integrated luminosity of 28 fb^{-1}, operating the PEP-II e^+e^- collider at a center-of-mass energy of about 10.355 GeV. This sample is the largest ever collected at that energy and provides unique opportunities to test several aspects of the Standard Model.
We report on a precision measurement of the ratio $R_{\tau\mu} = BF(\Upsilon(3S) \to \tau^+\tau^-)/BF(\Upsilon(3S) \to \mu^+\mu^-)$. The result is in agreement with the Standard Model prediction and its uncertainty is almost an order of magnitude smaller than the only previous measurement reported by the CLEO collaboration. We also present a search for the Lepton Flavour Violating decays $\Upsilon(3S) \to e^\pm\mu^\mp$, unobservable in the SM, but predicted to be enhanced in several new physics extensions.

Collaboration / Activity:

BABAR

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T03: Dark Matter / 127

Search for self-interacting dark matter with the BABAR detector

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A new class of dark matter models introduces a dark sector with new Dirac fermions charged under an additional U(1) gauge group. The corresponding gauge boson, the dark photon A', has a MeV-GeV mass and couples to the Standard Model photon (and Z) via kinetic mixing. Fermionic bound

states ("darkonium" Υ_D) could form if the dark sector coupling constant is strong enough. We present a search for dark sector bound states (Υ_D) in $e^+e^- \to \gamma\Upsilon_D$, $\Upsilon_D \to A'A'A'$, $A' \to X^+X^-$ ($X = e, \mu, \pi$) decays for 0.02 GeV $\leq m_{A'} \leq 1.0$ GeV, 1 GeV $\leq m_{\Upsilon_D} \leq 10$ GeV using the full data sample collected by the $BABAR$ detector.

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Collaboration / Activity:

BaBar

T06: QCD and Hadronic Physics / 130

Renormalization of the flavor-singlet axial-vector current and its anomaly at N^3LO in QCD

Author: Long Chen[1]

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The renormalization constant Z_J of the flavor-singlet axial-vector current with a non-anticommuting γ_5 in dimensional regularization is determined to order α_s^3 in QCD with massless quarks. The result is obtained by computing the matrix elements of the operators appearing in the axial-anomaly equation between the vacuum and a state of two (off-shell) gluons to 4-loop order. Furthermore, through this computation, the equality between the $\overline{\mathrm{MS}}$ renormalization constant $Z_{F\tilde{F}}$ associated with the operator $\left[F\tilde{F}\right]_R$ and that of α_s is verified explicitly to hold true at 4-loop order.

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Collaboration / Activity:

yes

T12: Detector R&D and Data Handling / 131

Tile Multiple Readout and Beyond for FCC.

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Dual-Readout Compensated Calorimetry with Tile Sensors Friday, March 19, 2021 2:40 PM (20 minutes) We discuss techniques and materials to develop optimize the energy resolution in the long-term performance of calorimeters as required by the challenging environment of future colliders and high intensity experiments. We extend the Dual Readout/Cerenkov compensation by using 2 tile types, one sensitive to to e-m showers, such as quartz, aerogel, Teflon AF or other low index Cerenkov tiles, and scintillator tiles, sensitive to low energy particles such as neutrons, nuclear fragments. The many advantages over fiber calorimeters for dual readout are discussed.

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Collaboration / Activity:

FCC

T12: Detector R&D and Data Handling / 132

Very Forward Calorimetry at the FCC.

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The success of any particle detector at a collider experiment depends on its ability to measure both the trajectories and energies of particles exiting the interaction point. Especially important and difficult is measuring the trajectories and energies of particles in the very forward region - particles that exit the detector with very shallow angles compared to the beam line. The difficulty with measuring these particles with high precision is related to the high radiation this area is exposed to, making robust instrumentation a challenge. This area becomes more important with increasing beam energy.

We propose a radiation hard, precise, and highly resolved tracking calorimeter that addresses all of these challenges. The design uses highly segmented radiation resistant quartz tiles coupled to replaceable radiation resistant photomultiplier tubes. Charged particles entering the quartz array will generate Cherenkov light in proportion to their energy, and this light will be measured with photomultiplier tubes. Tracks can be drawn between coinciding signals, and trajectories measured. Neutral particles will leave no initial track in the quartz, but layers of absorber between the quartz tiles will initiate a shower, making it possible to measure all types of particles and energies using this detector. Neural nets can be used to identify particles and tracks. Our simulations show that this detector has excellent tracking, excellent electromagnetic energy resolution, and excellent hadronic energy resolution. Its radiation tolerant materials make it well suited for high radiation environments, but its energy resolution properties mean it can used in varying geometries at any location around the interaction point.

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Collaboration / Activity:

FCC

T12: Detector R&D and Data Handling / 133

New radiation-hard scintillators for FCC detectors

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Future circular and linear colliders as well as the Large Hadron Collider in the High-Luminosity era have been imposing unprecedented challenges on the radiation hardness of particle detectors that will be used for specific purposes e.g. forward calorimeters, beam and luminosity monitors.
We performed research on the radiation-hard active media for such detectors, particularly calorimeters, by exploring intrinsically radiation-hard materials and their mixtures.The initial samples that we probed were thin plates of Polyethylene Naphthalate (PEN) and Polyethylene Terephthalate (PET) and thin sheets of HEM. The previous studies indicate towards promising performance under high radiation conditions. We will report on the necessary process of mixing the PEN and PEN for optimized scintillation and signal timing properties preserving the high radiation resistance.
Recently we developed a new plastic scintillator material. The scintillation yield of SX sample was compared to a BGO crystal using a setup with 90Sr source and a Hamamatsu R7525-HA photomutiplier tube (PMT). The SX was measured to yield roughly 50% better light production compared to the BGO crystal.sample SX was irradiated at the CERN PS radiation facility with 24 GeV/c protons. The samples received a fluence of 1.2 x 1015 p/cm2 which corresponds to 4 x 105 Gy radiation doses. The comparison of the transmission spectra of SX sample before and after the irradiation exhibits a loss of roughly 7% light transmission after 4 x 105 Gy proton irradiation

Collaboration / Activity:

FCC

First author:

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T04: Neutrino Physics / 134

RES-NOVA: archaeological Pb-based observatory for Supernova neutrino detection

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RES-NOVA is a new proposed experiment for the hunt of neutrinos from core-collapse supernovae (SN) via coherent elastic neutrino-nucleus scattering (CEνNS) using an array of archaeological lead (Pb) based cryogenic detectors. The high CEνNS cross-section on Pb and the ultra-high radiopurity of archaeological Pb enable the operation of a high statistics experiment equally sensitive to all neutrino flavors. Thanks to these unique features, RES-NOVA will be as sensitive as the currently

running neutrino observatories, while running a detector with a total active volume of only (60 cm)^3. RES-NOVA will be able to reconstruct the SN neutrino parameters with great accuracy (at the 10% level) and it will be sensitive to SN bursts from the entire Milky Way Galaxy with >5 σ statistical significance. The expected detector performance and sensitivity will be presented.

Collaboration / Activity:

RES-NOVA

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T05: Heavy Ion Physics / 135

Geometrical scaling for strange and multi-strange hadrons in pp and A-A collisions at relativistic energies

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Color Glass Condensate is a powerful theoretical tool that is able to describe the dynamical properties of partons in the QCD non-perturbative regime, characterized by strong color fields and high parton density.
A previous study, performed for a wide range of energies measured at the Relativistic Heavy Ion Collider (RHIC) and at the Large Hadron Collider (LHC), has shown that observables characteristic for the dynamics of the collision, i.e. the mean transverse momentum ($< p_T >$), the slope of the $< p_T >$ dependence on the mass of the particles and the average transverse flow velocity obtained from the simultaneous fits of the p_T spectra of the detected particles with the Boltzmann-Gibbs Blast Wave expression, scale rather well as a function of the square root of the ratio of the particle density over unit of rapidity and the overlapping area of the colliding nuclei ($\sqrt{\frac{dN/dy}{S_\perp}}$), the relevant scale in the gluon saturation picture.
This study was extended to strange and multi-strange hadrons, for both proton-proton (pp) and heavy-ion (A-A) collision systems. The dependence of the $< p_T >$ and its slope as a function of particle mass on $\sqrt{\frac{dN/dy}{S_\perp}}$, for K_0^S, Λ, Ξ^- and Ω^-, are presented. The comparison with the results obtained for non-strange light flavor hadrons is discussed.

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Collaboration / Activity:

PhD student

T07-T09: Combined: Top, Electroweak and Higgs Physics / 136

Indirect CP probes of the Higgs–top-quark interaction: current LHC constraints and future opportunities

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Co-authors: Philip Bechtle [2]; Sven Heinemeyer [3]; judith katzy [4]; Tobias Klingl [5]; Krisztian Peters [6]; Matthias Saimpert [6]; Tim Stefaniak [1]; Georg Weiglein [1]

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The CP structure of the Higgs boson in its coupling to the particles of the Standard Model is amongst the most important Higgs boson properties which have not yet been constrained with high precision. In this study, all relevant inclusive and differential Higgs boson measurements from the ATLAS and CMS experiments are used to constrain the CP-nature of the top-Yukawa interaction. The model dependence of the constraints is studied by successively allowing for new physics contributions to the couplings of the Higgs boson to massive vector bosons, to photons, and to gluons. In the most general case, we find that the current data still permits a significant CP-odd component in the top-Yukawa coupling. Furthermore, we explore the prospects to further constrain the CP properties of this coupling with future LHC data by determining tH production rates independently from possible accompanying variations of the $t\bar{t}H$ rate. This is achieved via a careful selection of discriminating observables. At the HL-LHC, we find that evidence for tH production at the Standard Model rate can be achieved in the Higgs to diphoton decay channel alone.

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Collaboration / Activity:

Phenomenological study

T04: Neutrino Physics / 137

T2K status and plans

Authors: Neil McCauley[1]; Stephen Dolan[None]

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Tokai-to-Kamioka (T2K) is a long baseline neutrino experiment which uses the proton beam at the Japan Particle Accelerator Research Centre (JPARC) to produce a beam of muon neutrinos and antineutrinos. T2K determines neutrino oscillation parameters of interest by comparing the measured

neutrino rate and spectrum at a near detector complex, located at JPARC, and at Super-Kamiokande, a water-Cherenkov detector, located 295 km away.

The T2K experiment performs world-leading measurements of the PMNS oscillation parameters \Delta_m^{2}{32}, sin^2(\theta{23}) and the CP violating phase \delta_{CP}, providing an exclusion at 3σ for some values of this parameter.

T2K is now undergoing major improvements and refurbishment. The Super-Kamiokande detector has been loaded with 0.02% of Gadolinium in 2020, enabling enhanced neutron tagging. An upgrade of the ND280 near detector, located 2.5 degrees off-axis, is scheduled for installation in 2022. The WAGASCI near detector, installed in 2018 and located 1.5 degrees off-axis, is also collecting statistics and a joint analysis at different off-axis angles is being prepared.

The T2K collaboration is working on an updated oscillation analysis to improve the control of systematic uncertainties and enable future inclusion of improved near and far detector data. A new beam tuning has been developed, based on an improved NA61/SHINE measurement which used a replica of the T2K target and which includes a refined modeling of the materials in the beam line. New selections have been developed as well; ND280 selections now include proton and photon tagging, and the muon-neutrino samples at Super-Kamiokande now includes pion tagging. The collaboration has also developed a more robust model of systematic uncertainties for the nuclear effects in neutrino-nucleus interactions, notably for the Spectral Function approach and for pion tagging.

This talk will review the latest measurements of oscillation parameters from T2K, the status of the new selection and systematic developments and the plans for upcoming data runs from T2K.

Collaboration / Activity:

T2K

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T04: Neutrino Physics / 138

T2K latest results on neutrino-nucleus cross sections

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A detailed understanding of neutrino(ν)-nucleus interactions is essential for the precise measurement of neutrino oscillations at long baseline experiments, such as T2K. The T2K near detector complex, designed to constrain the T2K flux and cross section models, also provides a complementary program of neutrino interaction cross-section measurements. Through the use of multiple target materials (carbon, water, argon, iron, lead), and the ability to sample different neutrino spectra (with detectors located on- and off-axis with respected to the flux), T2K is able to investigate atomic number and energy dependence of interaction cross sections in single experiment. An overview of the T2K measurement strategy, adopted to reduce the model dependence, and the most recent results, as well as future planned analyses, will be presented.

Collaboration / Activity:

T2K

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T12: Detector R&D and Data Handling / 140

TPC Development by the LCTPC Collaboration for the ILD Detector at ILC

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A large, worldwide community of physicists is working to realise an exceptional physics program of energy-frontier, electron-positron collisions with the International Linear Collider (ILC). The International Large Detector (ILD) is one of the proposed detector concepts at the ILC. The ILD tracking system consists of a Si vertex detector, forward tracking disks and a large volume Time Projection Chamber (TPC) embedded in a 3.5 T solenoidal field. The TPC is designed to provide 220 three dimensional points for continuous tracking with a single-hit resolution better than 100 μm in rφ, and about 1 mm in z. An extensive research and development program for a TPC has been carried out within the framework of the LCTPC collaboration. A Large Prototype TPC in a 1 T magnetic field, which allows to accommodate up to seven identical Micropattern Gaseous Detector (MPGD) readout modules of the near-final proposed design for ILD, has been built as a demonstrator at the 5 GeV electron test-beam at DESY. Three MPGD concepts are being developed for the TPC: Gas Electron Multiplier, Micromegas and GridPix. Successful test beam campaigns with different technologies have been carried out. Fundamental parameters such as transverse and longitudinal spatial resolution and drift velocity have been measured. In parallel, a new gating device based on large-aperture GEMs have been produced and studied in the laboratory. In this talk, we will review the track reconstruction performance results and summarize the next steps towards the TPC construction for the ILD detector.

Collaboration / Activity:

LCTPC collaboration

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T04: Neutrino Physics / 141

Correlating Muon $g-2$ Anomaly with Neutrino Magnetic Moments

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We have analyzed new contributions to the muon anomalous magnetic moment in a class of models that generates a naturally large transition magnetic moment for the neutrino (needed to explain the XENON1T electron recoil excess). These models are based on an approximate $SU(2)_H$ symmetry that suppresses the neutrino mass while allowing for a large neutrino transition magnetic moment. We have shown that the new scalars present in the theory with masses around 100 GeV can yield the right sign and magnitude for the muon $g-2$ which has been confirmed recently by the Fermilab collaboration. Such a correlation between muon $g-2$ and the neutrino magnetic moment is generic in models employing leptonic family symmetry to explain a naturally large $\mu_{\nu_\mu \nu_e}$. We have also outlined various other experimental tests of these models at colliders. Results will be presented.

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Collaboration / Activity:

Nil

T12: Detector R&D and Data Handling / 142

Performance of a highly compact electromagnetic calorimeter for future electron-positron colliders

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The FCAL Collaboration is presently designing and testing electromagnetic sampling calorimeters foreseen for the forward region of future detectors at electron-positron colliders. Two calorimeters, LumiCal and BeamCal, are foreseen for a precise and instant measurement of the luminosity, respectively. For the integrated luminosity, obtained from the rate of low angle Bhabha scattering events, a precision of better than 10^−3 is required from the physics program. The precise measurement of electromagnetic showers on top of background favours highly compact calorimeter designs. BeamCal sensors have to withstand high radiation doses.
The performance of a LumiCal silicon-tungsten prototype was studied in several test-beam campaigns at DESY using electrons with energies between 1 and 5 GeV. The results demonstrate an effective Moliere radius of about 8mm, a shower position resolution of 0.44mm and excellent linearity of the response. The results are in a good agreement with the MC simulation.
Recently, a dedicated multi-channel ultra-low power ASIC for the LumiCal readout was used in test-beam studies for the first time. Preliminary results will be presented. In addition, an ASIC with a dual readout scheme for the BeamCal is being developed.
Also, results on radiation hardness studies of different sensor candidates will be reported.

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Collaboration / Activity:

FCAL Collaboration

T07: Top and Electroweak Physics / 143

Two-loop QCD corrections to Wbb production at hadron colliders

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I will present an analytic computation of the two-loop QCD corrections to ud->Wbb process for an on-shell W-boson using the leading colour and massless bottom quark approximations. The computation involves integration-by-parts reduction of the unpolarised squared matrix element using finite field reconstruction techniques and identifying an independent basis of special functions that allows an analytic subtraction of the infrared and ultraviolet poles.

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Collaboration / Activity:

Theory

T11: Quantum Field and String Theory / 144

The strong CP problem, the infinite volume limit, and cluster decomposition

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While CP violation has never been observed in the strong interactions, the QCD Lagrangian admits a CP-odd topological interaction proportional to the so called theta angle, which weighs the contributions to the partition function from different topological sectors. The observational bounds are usually interpreted as demanding a severe tuning of theta against the phases of the quark masses, which constitutes the so-called strong CP problem. In this talk we challenge this view and argue that in an infinite spacetime the theta angle drops out of correlation functions, so that it becomes unobservable and the CP symmetry is preserved. We arrive at this result either by using instanton computations or by constraining the dependence of the partition function on the spacetime volume and the fermion masses by imposing cluster decomposition and compatibility with the index theorem. We further show that in large but finite spacetime volumes, cluster decomposition can be satisfied up to volume-suppressed corrections without the need to sum over topological sectors, and the resulting partition functions lead again to no CP violation.

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Collaboration / Activity:

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T02: Cosmology / 145

Cosmological bubble friction in local equilibrium

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In first-order cosmological phase transitions, the asymptotic velocity of expanding bubbles is of crucial relevance for predicting observables like the spectrum of stochastic gravitational waves, or for establishing the viability of mechanisms explaining fundamental properties of the universe such as the observed baryon asymmetry. In these dynamic phase transitions, it is generally accepted that subluminal bubble expansion requires out-of-equilibrium interactions with the plasma which are captured by friction terms in the equations of motion for the scalar field. This has been disputed in works pointing out subluminal velocities in local equilibrium arising either from hydrodynamic effects in deflagrations or from the entropy change across the bubble wall in general situations. We argue that both effects are related and can be understood from the conservation of the entropy of the degrees of freedom in local equilibrium, leading to subluminal speeds for both deflagrations and detonations. The friction effect arises from the background field dependence of the entropy density in the plasma, and can be accounted for by simply imposing local conservation of stress-energy and including field dependent thermal contributions to the effective potential. We illustrate this with explicit calculations of dynamic and static bubbles for a first-order electroweak transition in a Standard Model extension with additional scalar fields.

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Collaboration / Activity:

Technical University of Munich

T04: Neutrino Physics / 146

Study of tau neutrino production with nuclear emulsion at CERN-SPS

Author: Alina Tania Neagu[None]

The data on tau neutrino is very scarce, only a few experiments have detected its interactions. At FNAL beam dump experiment DONUT, tau neutrino interaction cross-section was directly measured with a large systematical (~50%) and statistical (~30%) errors. The main source of systematical error is due to a poor knowledge of the tau neutrino flux. The effective way for tau neutrino production is the decay of Ds mesons, produced in proton-nucleus interactions. The DsTau experiment at CERN-SPS has been proposed to measure an inclusive differential cross-section of a Ds production with a consecutive decay to tau lepton in p-A interactions. The goal of experiment is to reduce the systematic uncertainty to 10% level. A precise measurement of the tau neutrino cross section would enable a search for new physics effects such as testing the Lepton Universality (LU) of Standard Model in neutrino interactions. The detector is based on nuclear emulsion providing a sub-micron spatial resolution for the detection of short length and small "kink"decays. Therefore, it is very suitable to search for peculiar decay topologies ("double kink") of Ds→τ →X. After successful pilot runs and data analysis, CERN had approved the DsTau project as a new experiment NA65 in 2019. During the

physics runs, 2.3×10^8 proton interactions will be collected in the tungsten target, and about 1000 Ds⟶τ decays will be detected. In this talk, the results from the pilot run will be presented and the prospect for physics runs in 2021-2022 will be given.

Collaboration / Activity:

DsTau Coll.

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T06: QCD and Hadronic Physics / 147

Photon identification with the ATLAS detector

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Good photon identification capabilities are important for many aspects of the ATLAS physics programme, including measurements of fundamental properties of the hard interaction in final states with one or more photons, possibly produced in association with jets or gauge bosons. The identification of prompt photons and the rejection of background coming mostly from photons from hadron decays relies on the high granularity of the ATLAS electromagnetic calorimeter. Several methods are used to measure with data the efficiency of the photon identification requirements, covering a broad energy spectrum. At low energy, photons from radiative Z decays are used. In the medium energy range, similarities between electrons and photon showers are exploited using Z->ee decays. At high energy, inclusive photon samples are used. The results of these measurements performed with pp collisions data at sqrt(s)=13 TeV in 2015-2018 corresponding to an integrated luminosity of 140 fb-1 are presented. The impact on the photon identification of the pile-up, especially large in the second part of 2017 data taking, is also discussed.

Collaboration / Activity:

ATLAS

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T06: QCD and Hadronic Physics / 148

Precision measurements of jet production at the ATLAS experiment

Authors: ATLAS Collaboration[None]; mario campanelli[1]; mario campanelli[1]

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Measurements of jet production are sensitive to the strong coupling constant, high order perturbative calculations and parton distribution functions. In this talk we present the most recent ATLAS measurements in this area at a centre-of-mass energy of sqrt(s) = 13 TeV. We present measurements of variables probing the properties of the multijet energy flow and of the Lund Plane using charged particles. We will also present new measurements sensitive to the strong coupling constant. All of the measurements are corrected for detector effects and are compared to the predictions of state-of-the-art Monte Carlo event generators.

Collaboration / Activity:

ATLAS

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T06: QCD and Hadronic Physics / 149

Hadronic Reconstruction Techniques at ATLAS

Authors: ATLAS Collaboration[None]; Nathan Lalloué[1]

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The reconstruction and calibration of hadronic final states is an extremely challenging experimental aspect of measurements and searches at the LHC. This talk summarizes the latest results from ATLAS for jet and missing energy reconstruction and calibration. New approaches to jet inputs better utilize relationships between calorimeter and tracking information to significantly improve the reconstruction of jet substructure. Additionally, a full suite of in-situ measurements of the jet energy scale and jet energy resolution for ATLAS's new particle flow jets yield the lowest uncertainties yet in the high pileup conditions of the LHC Run 2. Finally, new machine learning approaches for various aspects of reconstruction will be discussed.

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Collaboration / Activity:

ATLAS

T06: QCD and Hadronic Physics / 150

Measurement of prompt photon production and W/Z boson production in association with jets at ATLAS

Authors: ATLAS Collaboration[None]; Heberth Torres[1]

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The production of prompt isolated photons and W/Z-boson
in association with jets are an important test of perturbative QCD prediction and also yield information about the parton distribution functions of the proton.
In this talk, we present the latest measurements of prompt photon production using proton-proton collision data collected by the ATLAS experiment at $\sqrt{s}$=13 TeV. This includes the differential cross-section measurements of isolated di-photon production. We also present a measurement that probes the event topologies of prompt isolated photons produced in association with two hadronic jets. Latest results of differential cross-sections measurements for Z-boson production in association jets will be also presented including association with heavy flavour. Each measurement is corrected for detector inefficiency and resolution and the results are compared to state-of-the-art theory predictions, indicating several interesting discrepancies. If available, studies on the modelling of various processes in the state-of-art MC generators and fixed-order predictions will be presented.

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Collaboration / Activity:

ATLAS

T06: QCD and Hadronic Physics / 151

Measurements of diffractive physics and soft QCD at ATLAS

Author: ATLAS Collaboration[None]

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In this talk we present various measurements of diffractive physics and soft QCD processes performed using data collected by the ATLAS experiment at the LHC. Single diffractive processes (pp->pX) are studied reconstructing the particles from the dissociative system (X) with the ATLAS detector, while the intact proton is reconstructed and measured in a forward detector. If available, this talk will also present the underlying event measurements using strange particles as probes. Also in this talk, we present, If available, studies of correlation phenomena in order to study the dynamics of hadronization formation.

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Collaboration / Activity:

ATLAS

T06: QCD and Hadronic Physics / 153

Determination of proton parton distribution functions using ATLAS data

Authors: ATLAS Collaboration[None]; Claire Gwenlan[1]

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We present fits to determine parton distribution functions (PDFs) using inclusive W/Z-boson measurements from the ATLAS experiment at the LHC. The ATLAS measurements are used in combination with deep-inelastic scattering data from HERA. We also present the results of PDF fits that use W/Z+jets measurements from ATLAS in addition to the measurements listed above. An improved determination of the sea-quark densities at high Bjorken, x, is seen, while confirming a strange-quark density similar in size to the up- and down-sea-quark densities in the range x < 0.02 found by previous ATLAS analyses. If available, PDF fits including inclusive W and Z boson production, ttbar production, W+jets and Z+jets production, inclusive jet production and direct photon production will also be presented.

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Collaboration / Activity:

ATLAS

T07: Top and Electroweak Physics / 154

Search for tttt production in 13 TeV proton-proton collission with the ATLAS detector at the LHC

Authors: ATLAS Collaboration[None]; Rachel Lindley[1]

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The methodology and results are presented for the search for four-top production at the ATLAS detector. An integrated luminosity of 139 fb-1 of proton-proton collision data at sqrt(s) = 13 TeV was analyzed to measure the cross section of the four-top production, specifically for decays containing 1 lepton or 2 oppositely-charged leptons. For these largely hadronic decay channels, signal regions were defined by high jet and b-tagged jet multiplicity.
Within these regions, a multivariate discriminant provided further isolation of the four-top-quark signal from backgrounds, in particular the dominant background resulting production of top-quark pair plus jets. A reweighting technique was applied to ensure that the backgrounds were accurately modelled to avoid biasing the multivariate discriminant in regions of high jet multiplicity.The analysis measured a cross section value of 26 (+17/-15) fb, or an observed (expected) discrepancy of 1.9 (1.0) standard deviations from the background-only hypothesis.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 156

Measurements of the inclusive and differential production cross sections of a top-quark-antiquark pair in association with a Z boson at $\sqrt{s} = 13$ TeV with the ATLAS detector

Author: ATLAS Collaboration[None]

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The production of a top-quark-antiquark pair in association with a Z boson (ttZ) is a rare process that directly probes the neutral coupling of the top quark to the electroweak gauge bosons. A better understanding of this process also benefits precision measurements of other Standard Model processes and beyond the Standard Model searches where ttZ is an important background. The ttZ process became accessible only recently owing to the large centre-of-mass energy and luminosity of the Large Hadron Collider. This poster will present measurements of the inclusive and differential ttZ production cross sections at a centre-of-mass energy of 13 TeV with the ATLAS detector. These measurements use the full set of data collected during Run 2 of the LHC from 2015 to 2018, corresponding to a total integrated luminosity of 139 fb^{-1}. Overall, the unfolded data and the inclusive cross section, measured to be $\sigma_{t\bar{t}Z} = 0.99 \pm 0.05$~(stat.)~$\pm\, 0.08$~(syst.)~pb, are in good agreement with the theoretical predictions.

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Collaboration / Activity:

ATLAS

T07: Top and Electroweak Physics / 157

Calibration of flavour tagging algorithms in ATLAS on ttbar and Z+jets final states

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The correct identification of b-initiated jets (b-jets) against c-initiated (c-jets), hadronic tau-initiated (tau-jets) and u-, d-, s-initiated jets (light-jets) is primordial for ATLAS Collaboration searches and precision measurements e.g. ttbar and single-top measurements, supersymmetry, Higgs boson. In consequence, the ATLAS Collaboration has developed several so-called b-tagging algorithms to discriminate b-jets against the other types, trained on ttbar and Z' samples. Expected performance is evaluated on MC events, but due to some inaccuracies in the simulation, it might differ from the performance in real data events. These algorithms are calibrated to account for differences between data and simulated events in the b-tagging efficiency for b-jets and mistagging efficiency in c- and light-jets.

The b-jet efficiency calibration is performed on two-lepton ttbar events in order to exploit the large purity of this final state in b-jets. The c-jet mistag rate is measured on one-lepton

ttbar events, which allow the presence of an hadronically decaying W-jet enriched in c-jets. Both calibrations adopt a combinatorial likelihood approach to retrieve the efficiency of the jet for a given flavour. Finally, due to the large light-jet rejection of b-tagging algorithms, the calibration of light jets mistag rate is performed on a Z+jet sample since ttbar doesn't allow for a pure enough light-jet sample.

This poster presents an overview of the DL1r b-tagging algorithm and the calibration techniques explained above. Results in the form of data-MC scale-factors are obtained for b-efficiency and c- and light-jet mistagging rate with 140 fb^{-1} of data recorded by the ATLAS detector from 2015 to 2018.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 158

Measurements of differential cross-sections for top-quark pair production in association with additional jets in highly boosted events using the ATLAS detector

Authors: ATLAS Collaboration[None]; Jonathan Jamieson[1]

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Top anti-top (tt) pair production at the Large Hadron Collider (LHC) is often observed in the presence of additional high energy radiation. Similarly the abundant tt production at the LHC allows us to probe high transverse momentum (p_{T}) top quarks. This poster compares the latest measurements, using data recorded by the ATLAS detector from 2015 to 2018, with different QCD predictions showcasing how suited current theories are to estimating complex, multi-scale, and above leading order tt processes. Single and double-differential $t\bar{t}$ cross-section measurements as functions of various event kinematic properties are presented. Results are derived from proton-proton collisions, at a centre-of-mass energy of 13 TeV, using events with a high p_{T} large-R jet, one muon or electron and at least two b-tagged jets in the final-state.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 159

Measurements of $W^+W^-+\geq 1$ jet production cross sections with the ATLAS detector

Authors: ATLAS Collaboration[None]; Jack Cameron MacDonald[1]

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Measurements of cross sections for the production of pairs of oppositely charged -bosons (WW) provide an important test of the Standard Model (SM), in particular electroweak theory and perturbative quantum chromodynamics. WW production can additionally be a dominant background for measurements of Higgs boson production, and in searches for physics beyond the SM. In contrast to most previous measurements that have focused on WW production in the absence of hadronic jets due to the higher obtainable precision, here a measurement of WW production in association with at least one hadronic jet is presented. This is motivated by an expected improved precision of fully inclusive WW production cross sections in a future combined measurement, and additionally by an enhanced sensitivity to the linear effects of dimension-6 effective field theory operators with respect to the jet veto case. In this measurement, fiducial and differential cross sections are obtained using data collected in sqrt (s) = 13 TeV pp collisions at the ATLAS detector, corresponding to an integrated luminosity of 139 fb-1. Events are selected with exactly one electron and one muon of opposite charge and at least one hadronic jet with a transverse momentum of pT > 30 GeV and a pseudo-rapidity of |eta| < 4.5. Background contributions are estimated using a combination of simulation and data-driven techniques. The dominant background from ttbar events is precisely estimated using a data-driven method that significantly reduces experimental and modeling uncertainties. Differential results are used to place constraints on a dimension-6 effective field theory coefficient.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 160

Combining ATLAS and CMS measurements of top quark production and W boson polarisation for LHC pp collisions at sqrt{s} = 7 and 8 TeV

Authors: ATLAS Collaboration[None]; Veronique Boisvert[None]

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Measurements of the inclusive top-quark pair production cross section and of the W boson polarisation in top quark decays are presented. The most precise results performedd by the ATLAS and CMS collaborations using all the proton-proton collisions data produced at the LHC at center-of-mass energies of 7 and 8 Te. The combined results provide both lower uncertainties than the individual measurements and stringent comparisons with the standard model predictions at NNLO in perturbative QCD.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 162

Recent measurements of the top-quark mass and Yukawa coupling using the ATLAS and CMS detector at the LHC

Author: ATLAS Collaboration[None]

The top quark mass is one of the fundamental parameters of the Standard Model that must be determined experimentally. Single measurements of the top quark mass have reached a precision well below the %-level. Different methods - based on a direct reconstruction of the top quark decay or an extraction from (differential) top quark production cross sections - provide complementary handles on the experimental systematic uncertainties. An overview is given of the most recent ATLAS and CMS measurements of the top -quark mass, its running and of the top quark Yukawa coupling.

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Collaboration / Activity:

ATLAS

T07: Top and Electroweak Physics / 163

Results on Rare and BSM top quark interactions from ATLAS and CMS

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The remarkably large integrated luminosity collected by the ATLAS and CMS detector at the highest proton-proton collision energy provided by LHC allows to probe the presence of new physics that might enhance extremely rare processes in the SM. Examples of such studies are presented using data collected in Run2 pp collisions at a center-of-mass of 13 TeV. These involve direct searches for top quark anomalous couplings (altered tWb vertex), Flavour Changing Neutral Currents (FCNC) like interactions between a top quark and an up- or c-quark mediated by either a Z or a gluon , as well as CP violating interactions.

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Collaboration / Activity:

ATLAS

T07: Top and Electroweak Physics / 164

Evidence for four-top-quarks production with the ATLAS detector at the Large Hadron Collider

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Results are presented of searches in ATLAS for four-top-quark production. This rare process, with a predicted cross section of 12 fb in the Standard Model, has not been observed yet by experiment. The analysis is based on data from proton–proton collisions at a centre-of-mass energy of 13 TeV collected with the ATLAS detector during run 2 of the CERN Large Hadron Collider, and corresponding to an integrated luminosity of 139 inverse fb. The search is performed in several final states, either with multiple or same-sign leptons or with one or two leptons and a large jet and b-jet multiplicity. Background models are carefully constructed and validated, for top quark pair production with additional gauge bosons and (b-)jets and other background processes. The signal strength is extracted with a fit to distributions of several sensitive observables. The combination of the searches yields 4.7 sigma evidence for four-top-quark production.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 165

Testing the Standard Model in boosted top quark production with the ATLAS experiment at the LHC

Authors: ATLAS Collaboration[None]; Peter Berta[1]

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Measurements in boosted top quark production test the Standard Model in a previously unexplored regime with a strongly enhanced sensitivity to high-scale new phenomena. Dedicated techniques have been developed to reconstruct and identify boosted top quarks. In this contribution measurements of the ATLAS experiment are presented of the differential cross section and asymmetries in this extreme kinematic regime. The measurements are interpreted within the Standard Model Effective Field Theory, yielding stringent bounds on the Wilson coefficients of two-light-quark-two-quark operators.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 167

Measurements of single top quark production cross sections with the ATLAS detector at the LHC

Authors: ATLAS Collaboration[None]; Rui Zhang[None]

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The inclusive cross section for production of a single top quark production in association with a W boson is measured in both the dilepton and in the lepton+jets final state. Events are are selected requiring two (one) charged leptons and one or two (at least three) jets with at most two (one) jets (jet) identified as containing b hadrons. Multivariate discriminants are constructed to separate the tW signal from the dominant top-quark pai$\bar{r}$ background. Measurements use data from LHC proton-proton collisions recorded during Run2 at both 13 and 8 TeV center-of-mass energy

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ATLAS

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T07: Top and Electroweak Physics / 168

Measurements of top quark pair production cross sections with the ATLAS detector at the LHC

Author: ATLAS Collaboration[None]

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Comprehensive measurements of inclusive and differential cross-sections for top-quark production are presented. The cross section for production of top-quark-antiquark pair is measured in the dilepon, lepton+jets and all-hadronic channels as function of kinematic properties the top quarks and of their final decay products, also including final states featuring top quarks with high transverse momenta compared to the top quark mass.
Measurements use data from LHC proton-proton collisions recorded during the entire Run2 at both 13 and 5 TeV center-of-mass energy.
The differential measurements are compared quantitatively to several setups of next-to-leading order matrix-element generators combined with parton-shower generators.

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Collaboration / Activity:

ATLAS

T07: Top and Electroweak Physics / 169

Measurements of W and Z boson production at ATLAS

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Precision measurements of the production cross-sections of W/Z boson at LHC provide important tests of perturbative QCD and information about the parton distribution functions for quarks within the proton. We present measurements of the transverse momentum distribution of the vector boson at 13 TeV. If available differential measurements in the side band of the Z-mass peak are also presented. The measurements are corrected for detector inefficiency and resolution and compared with state-of-the-art theoretical calculations.

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Collaboration / Activity:

ATLAS

T07: Top and Electroweak Physics / 170

Recent observation and measurements of vector-boson fusion and scattering with ATLAS

Author: ATLAS Collaboration[None]

Measurements that exploit the weak vector-boson scattering and weak vector-boson fusion are fundamental tests of the gauge structure of the Standard Model and are sensitive to anomalous weak boson self interactions. In this talk, we present recent results in this contest performed by the ATLAS experiment using proton-proton collisions at sqrt(s)=13 TeV. Measurements of Zjj final states produced via weak-boson fusion are shown, differential cross-section measurements are presented as well as reinterpretation in terms of an effective field theory to constrain new physics beyond the Standard Model. If available, new results on weak-boson production will also be shown.

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Collaboration / Activity:

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T07: Top and Electroweak Physics / 171

Photon-photon fusion measurements at ATLAS

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Photon-photon fusion is a rare process at hadron and ion colliders. It is particularly interesting as a remarkably clean interaction with little (if any) remnant activity from the interacting particles. In this talk we present the status of photon-photon fusion measurements at the ATLAS detector. We present differential measurements of the light-by-light scattering process, $\gamma\gamma \to \gamma\gamma$, in lead-lead collisions. In addition, we present photon-photon fusion measurements that contain two charged leptons in the final state. The scattered proton is detected by the ATLAS Forward Proton spectrometer while the leptons are reconstructed by the central ATLAS detector. Finally, we highlight the observation of photon-induced WW production.

Collaboration / Activity:

ATLAS

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T07: Top and Electroweak Physics / 172

Measurements of multi-boson production at ATLAS

Authors: ATLAS Collaboration[None]; Jessica Metcalfe[1]

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Measurements of multiple electroweak bosons production at the LHC constitute an important test of the Standard Model. They are sensitive to the properties of electroweak-boson self-interactions and provide a test of the electroweak theory and of the perturbative quantum chromodynamics. In this talk, we present recent results from the ATLAS experiment for multi-boson production in proton-proton collisions at sqrt(s) =13 TeV. The differential cross-section measurement of WW production in association with jets is presented. We also present the measurement of differential cross-sections of four-lepton events, containing two same-flavour, opposite-charge electron or muon pairs.. The data are corrected for detector inefficiency and resolution and are compared to theoretical predictions. The measurements are reinterpreted in terms of an effective field theory to constrain new physics beyond the Standard Model. If available new results on other final states will be also presented

Collaboration / Activity:

ATLAS

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T08: Flavour Physics and CP Violation / 174

ATLAS results on exotic heavy hadrons

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Recent results from the ATLAS experiment on searches and measurements on exotic heavy hadrons will be presented.
Studies of the pentaquarks with hidden charm in the Lambda_b decays in proton-proton collisions at 7 - 8 TeV will be discussed.
New results on the heavy tetraquarks in the Run 2 data at 13 TeV will also be reported.

Collaboration / Activity:

ATLAS

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T08: Flavour Physics and CP Violation / 175

ATLAS measurements of CP violation with beauty mesons

Author: Radek Novotny[1]

[1] *UNM*

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The ATLAS experiment has performed measurements of mixing and CP violation in the neutral B meson systems.
This talk will focus on the latest results from the ATLAS collaboration on CP violation in the B_s^0 —> J/psi phi decays.
Standard Model predicts the CP violating mixing phase, phi_s, to be very small and its SM value is very well constrained,
while in many new physics models large phi_s values are expected. Latest measurements of phi_s and several other parameters
describing the B_s^0 —> J/psi phi decays will be reported.

Collaboration / Activity:

ATLAS

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T08: Flavour Physics and CP Violation / 176

ATLAS results on charmonium production and B_c production and decays

Author: Tatiana Lyubushkina[1]

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Recent results from the proton-proton collision data taken by the ATLAS experiment on the charmonium production and on the B_c production and decays will be presented. The measurement of J/psi and psi(2S) differential cross sections will be reported as measured on the whole Run 2 dataset. The measurement of the differential ratios of the B_c+ and B+ production cross sections at 8 TeV will also be discussed. New results on the B_c decays to J/psi Ds(*) final states obtained with the Run 2 data at 13 TeV will be shown.

Collaboration / Activity:

ATLAS

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T03: Dark Matter / 177

Searches for dark matter with the ATLAS detector

Authors: ATLAS Collaboration[None]; Jonathan Bossio[1]

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The presence of a non-baryonic Dark Matter (DM) component in the Universe is inferred from the observation of its gravitational interaction. If Dark Matter interacts weakly with the Standard Model (SM) it could be produced at the LHC. The ATLAS experiment has developed a broad search program for DM candidates, including resonance searches for the mediator which would couple DM to the SM, searches with large missing transverse momentum produced in association with other particles (light and heavy quarks, photons, Z and H bosons) called mono-X searches and searches where the Higgs boson provides a portal to Dark Matter, leading to invisible Higgs decays. The results of recent searches on 13 TeV pp data, their interplay and interpretation will be presented. Prospects for HL-LHC will also be discussed.

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T03: Dark Matter / 178

Search for invisibly decaying Higgs bosons produced in vector boson fusion with ATLAS in Run 2

Authors: ATLAS Collaboration[None]; Arthur Linss[1]

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Dark matter is one of the remaining puzzles of the Standard Model. This poster presents preliminary results of a search for dark matter candidates in invisible Higgs boson decays with the ATLAS experiment using 139 fb-1 of proton-proton collision data. The search targets vector boson fusion Higgs boson production, which is expected to be the most sensitive channel. This presentation highlights the background estimates for V+jets and multijet processes, the event categorisation, limit setting as well as the interpretation of the result in terms of Higgs portal models.

Collaboration / Activity:

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T03: Dark Matter / 179

Search for Dark Matter produced in association with a Standard Model Higgs boson decaying to b-quarks using the full Run 2 collision data with the ATLAS detector

Author: ATLAS Collaboration[None]

This poster presents a search for Dark Matter produced in association with a Higgs boson decaying to b-quarks using the data corresponding to an integrated luminosity of 139 fb-1 collected with the ATLAS detector in pp collisions at √s=13 TeV at the Large Hadron Collider. The targeted Events typically contain large missing transverse momentum and either two b-tagged small-radius jets or a single large-radius jet associated with two b-tagged subjects. No significant deviation from Standard Model expectations is observed. The results are interpreted in two benchmark models with two Higgs doublets extended by either a heavy vector boson Z'or a pseudoscalar singlet a and which provide a dark matter candidate χ. Significant improvements in sensitivity have been achieved with respect to previous results owing to optimized event selections as well as advances in the object identification, such as the use of the likelihood-based significance of the missing transverse energy and variable-radius track jets. In the case of the Two-Higgs-Doublet model with an additional vector boson Z', the observed limits extend up to a Z'mass of 3.1 TeV at 95 % confidence level for a mass of 100 GeV for the Dark Matter candidate. For the Two-Higgs-Doublet model with an additional pseudoscalar a, masses of a are excluded up to 520 GeV and 240 GeV for tan β = 1 and tan β = 10 and a Dark Matter mass of 10 GeV, respectively. In addition, limits on the visible cross sections are set and range from to 0.05 fb to 3.26 fb, depending on the missing transverse momentum and b-quark jet multiplicity requirements.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 180

Search for non-resonant HH production in the bbyy final state : Higgs self-coupling constraints

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Abstract: Since the Higgs boson discovery in 2012, measuring its properties and couplings with high precision is a priority for ATLAS and CMS. The Higgs coupling to itself is providing a direct probe on the EWSB and is a precision test of the electroweak theory but has not been observed yet. Measuring the total and differential (mHH) cross-sections of two Higgs boson production is the current way to probe the trilinear coupling component. The low cross-section (31 fb at 13 TeV) at SM requires large integrated luminosity. But new physics might enhance non-resonant HH production by modifying the Higgs self-coupling. This poster focuses on the attempt to observe di-Higgs production through the decay of one H -> bb (largest branching ratio) and the other one H -> γγ benefiting from its excellent di-photon resolution to maximise background rejection. The bbγγ final state is one of the most promising decay channel. The poster will present the recent analysis developments to maximise the statistical power of the dataset which includes the overall Run-2 data (139/fb) collected by the ATLAS detector. The upper limit on the cross section and the measurement of of the Higgs self coupling parameter will be presented.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 181

Searches for non-resonant Higgs boson pair production at sqrt(s) = 13 TeV with ATLAS detector at the LHC

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Abstract: Since the discovery of the Higgs boson in 2012, many of its properties have been measured. However, one of its important properties yet to be measured is the Higgs self-coupling, which probes the Standard Model Higgs potential. One way to measure the trilinear Higgs self-coupling is through the observation and measurement of non-resonant Higgs pair production. In this poster the searches for non-resonant Higgs pair production, using proton-proton collision data of LHC Run-2 recorded by the ATLAS detector, will be presented.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 182

Search for the Decay of the Higgs Boson to Charm Quarks with the ATLAS Experiment

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A direct search for the Standard Model Higgs boson decays to a pair of charm quarks is presented, probing the Higgs boson Yukawa couplings to the second generation of fermions. This analysis makes use of the full LHC Run 2 dataset collected with the ATLAS detector, corresponding to an integrated luminosity of 139 fb-1 of proton collisions at a centre-of-mass energy of 13 TeV. Higgs boson production in association with a W or Z boson is targeted, where only leptonic W/Z boson decays are considered. The analysis is then divided in three channels according to the reconstructed lepton multiplicity. Both charm and bottom jet tagging algorithms are used to identify the signature of the Higgs boson decays to charm quarks, while reducing contamination from Higgs boson decays to bottom quarks. This search is expected to improve the constraint on the Higgs boson decays to charm quarks cross-section previously presented by ATLAS, using an integrated luminosity of 36 fb-1 of proton collisions at the same centre-of-mass energy.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 183

Study of the CP properties of the top-quark Yukawa Interaction in ttH and tH events with H → γγ

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This poster presents the search for CP-violation in the top Yukawa coupling using ttH and tH production modes in the diphoton decay channel (H → γγ). The analysis is based on the 139 fb−1 of proton-proton colli- sion data at center-of-mass energy √s = 13 TeV recorded with the ATLAS detector at the Large Hadron Collider. Two separate sets of selections are introduced to capture the full hadronic and leptonic decay of the tt sys- tem each. This search is performed using a simultaneous fit to the mγγ distribution in analysis categories defined to enhance signal over continuum background and also to separate the CP even and CP odd signal hypotheses. The expected significance for ttH signal is 4.4σ. The observed significance is 5.2σ. The expected and observed limits for tH production are 11.7× and 11.6× the Standard Model prediction, respectively. Two-dimensional contours of κt cos(α) and κt sin(α) are derived. A CP-mixing angle above 43◦ (63◦ expected) is excluded at 95% confidence level, and CP-odd hypothesis is rejected at the 3.9σ level.

Collaboration / Activity:

ATLAS

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T09: Higgs Physics / 184

Measurement of the ttH production cross-section with a collimated H->bb decay in pp collisions at a centre-of-mass energy of 13 TeV with the ATLAS detector

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A measurement of the Higgs boson production cross section in association with a top-quark pair (ttH) and the subsequent Higgs boson decay into a b-quark pair is presented. The events used for this analysis are characterised by one or two electrons or muons. Also in the single-lepton channel, the "boosted topology" was studied, targeting events with a Higgs boson and possibly a hadronically decaying top quark produced at a transverse momentum above 300 GeV. The analysed data was collected in pp collisions with the ATLAS detector at the LHC, with an integrated luminosity of 139 fb-1 and at a centre-of-mass energy of 13 TeV, corresponding to the full run-2 dataset (2015–2018). The signal strength, defined as the ratio of the measured ttH signal cross section to the Standard Model expectation, is measured, assuming a Higgs boson mass of 125 GeV. For the first time, the signal strength is measured differentially, as a function of the Higgs boson transverse momentum, in the simplified template cross section framework. Results for the inclusive and differential cross section will be presented.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 186

Background Modelling in the ATLAS H to yy Differential Cross Section Analysis

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Differential cross section measurements are an important part of the efforts to precisely measure the Higgs boson properties, providing model-independent measurements of kinematic and event observables. This poster presents the H to yy differential cross section analysis using the full Run-2 data set taken between 2015 and 2018 at the ATLAS experiment. The analysis uses analytical functions to extract the signal yield in its signal + background fit to data, subsequently unfolding the fitted yields to the particle level. The background fit function is chosen from a list of considered functional

forms by evaluating the potential measurement bias for each function using MC simulated samples. An emphasis is put on the explanation of the background modelling strategy and the estimation of the potential bias introduced to the measurement by the background model choice.

Collaboration / Activity:

ATLAS

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T09: Higgs Physics / 187

Measurement of the Higgs boson coupling to tau leptons in proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector at the LHC

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The Standard Model decay of the Higgs boson to leptons has been observed in the decay to a pair of tau leptons. A measurement of the coupling of the Higgs boson to a pair of tau leptons is presented. The coupling strength is measured using Higgs boson decays into two tau leptons in multiple Higgs production channels. The sensitivity of the analysis is improved using machine-learning techniques. The analysis uses proton-proton collision data recorded at a center-of-mass energy $\sqrt{s}$ = 13 TeV with the ATLAS detector at the LHC.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 188

Effective Field Theory interpretation of the combined Higgs boson measurements with the ATLAS experiment

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The experimental study of the Higgs boson at the Large Hadron Collider is rapidly progressing over the past decade. The hunt for the elusive boson is now evolving to measure kinematics properties of the Higgs boson interacting with other particles. These detailed measurements provides an opportunity to study novel physical phenomena which occur at energies which are much large than those reached by particle collisions at the LHC. The Standard Model Effective Field Theory (SMEFT) lays the theoretical foundation that predicts how these signatures look like in the ATLAS detector. This sets the stage to consistently scrutinise deviation of the data with respect to Standard Model prediction. The latest combined Higgs measurements measure kinematic regions defined in the simplified

template cross-section framework in the decay channels of H->\gamma\gamma, H->ZZ^*->4l, and H->b\bar{b} using the full Run-2 proton-proton collision dataset at \sqrt{s} = 13 TeV collected with the ATLAS detector in the years 2015-2018. There are a large number of SMEFT operators that affect these measurements, however many operators have similar effects on the measurement and the challenge is therefore to identify the set of directions that can be constrained. In this work, we have identified ten linear combinations of SMEFT operators that can be probed with the analyzed data.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 189

Searches for Higgs boson pair production with the full LHC Run-2 dataset in ATLAS

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The latest results on the production of Higgs boson pairs (HH) in the ATLAS experiment are reported, with emphasis on searches based on the full LHC Run 2 dataset at 13 TeV. In the case of non-resonant HH searches, results are interpreted both in terms of sensitivity to the Standard Model and as limits on kappa_lambda, i.e. a modifier of the Higgs boson self-coupling strength. Searches for new resonances decaying into pairs of Higgs bosons are also reported. Prospects of testing the Higgs boson self-coupling at the High Luminosity LHC (HL-LHC) will also be presented.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 190

Search for rare decays of the Higgs boson with the ATLAS detector

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The Standard Model predicts several rare Higgs boson decay channels, among which are decays to a Z boson and a photon, H⟶Zγ, and to a low-mass lepton pair and a photon H⟶ℓℓγ. The observation of these decays could open the possibility of studying the CP and coupling properties of the Higgs boson in a complementary way to other analyses. Results based on 139 fb−1 of pp collision data collected at 13 TeV will be presented.

Collaboration / Activity:

ATLAS

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T09: Higgs Physics / 191

Studies of the CP properties of the Higgs boson at the ATLAS experiment

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Studies of the CP properties of the Higgs boson in various production modes and decay channels are presented. Limits on the mixing of CP-even and CP-odd Higgs states are set by exploiting the properties of diverse final states.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 192

Combined measurements of Higgs boson production and decays with the ATLAS detector

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The most precise measurements of Higgs boson cross sections, using the framework of simplified template cross sections, are obtained from a combination of measurements performed in the different Higgs boson decay channels using pp collision data with a center-of-mass energy of 13 TeV. This talk presents the combined measurements, as well as their interpretations in terms of Higgs coupling modifiers and their ratios, also taking into account results of searches for H->invisible decays as well as off-shell Higgs boson production. It also presents interpretations in generic 2HDM models and in the hMSSM, and in the framework of an Effective Field Theory.

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Collaboration / Activity:

ATLAS

T07-T09: Combined: Top, Electroweak and Higgs Physics / 193

Higgs boson production in association with top quarks with the ATLAS detector

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The measurement of Higgs boson production in association with one or two top quarks is essential to understand the top-quark couplings to the Higgs boson. This talk presents the analyses using Higgs boson into several final states, using pp collision data collected at 13 TeV.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 194

Higgs boson coupling to second generation fermions with the ATLAS detector

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Searches for Higgs boson decays to two second-generation quarks or leptons, based on 13 TeV pp collision data, are presented, as well as indirect constraint of the Yukawa coupling of the Higgs boson to the charm quark.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 195

Measurements and interpretations of Higgs boson production using decays to two b-quarks with the ATLAS detector

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Testing the couplings of the Higgs boson to quarks is important to understand the origin of quark masses. The talk presents Simplified Template Cross Section measurements for Higgs boson production in association with a vector boson using decays to two b quarks using pp collision data collected at 13 TeV, along with an interpretation in an Effective Field Theory framework. A search for vector-boson fusion production in the same Higgs decay channel will also be presented.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 196

Measurements of Higgs boson production in decays to two tau leptons with the ATLAS detector

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Testing the couplings of the Higgs boson to leptons is important to understand the origin of lepton masses. This talk presents measurements of Higgs boson production in Higgs boson decays to two tau leptons based on pp collision data collected at 13 TeV.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 197

Measurements and interpretations of Simplified Template Cross Sections and differential and fiducial cross sections in Higgs boson decays to two W bosons with the ATLAS detector

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The Higgs boson decay to two W bosons has the largest bosonic branching fraction and can be used to perform some of the most precise measurements of the Higgs boson production cross sections. This talk will present cross section measurements using pp collision data collected at 13 TeV, including those for the different Higgs boson production processes in the Simplified Template Cross Section framework.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 198

Measurements and interpretations of Simplified Template Cross Sections, differential and fiducial cross sections in Higgs boson decays to four leptons with the ATLAS detector

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Higgs boson decays to four leptons can be selected with a very high purity and are very well suited for measurements of Higgs boson properties, despite the small H⟶ZZ⟶4l branching ratio. This talk will present measurements of differential cross sections, as well as cross section measurements for the different Higgs boson production processes in the Simplified Template Cross Section framework using pp collision data collected at 13 TeV.

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Collaboration / Activity:

ATLAS

T09: Higgs Physics / 199

Measurements and interpretations of Simplified Template Cross Sections, differential and fiducial cross sections in Higgs boson decays to two photons with the ATLAS detector

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Higgs boson decays to two photons can be selected with high efficiency, and the very good invariant mass resolution allows a robust subtraction of the backgrounds. This talk will present measurements of Simplified Template Cross Sections, differential and fiducial cross sections, as measured in the diphoton decay channel by the ATLAS detector using the full Run 2 dataset of pp collision data collected at 13 TeV at the LHC, and their respective interpretations in the context of an Effective Field Theory.

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Collaboration / Activity:

ATLAS

T06: QCD and Hadronic Physics / 200

Simultaneous extraction of fragmentation functions of light charged hadrons with mass corrections

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We describe a simultaneous determination of unpolarized FFs of charged pions, charged kaons, and protons/antiprotons from single-inclusive hadron production in electron-positron annihilation (SIA) data at next-to-leading order and next-to-next-to-leading order accuracy in perturbative QCD. We include data for identified light charged hadrons as well as for unidentified light charged hadrons, and show that these data have a significant impact on both size and uncertainties of the fragmentation functions. We examine the inclusion of higher-order perturbative QCD corrections and finite-mass effects. We compare the new SGKS20 FFs with other recent FFs available in the literature and find in general reasonable agreement, but also important differences for some parton species. We show that theoretical predictions obtained from our new FFs are in very good agreement with the analyzed SIA data, especially at small values of z.

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Collaboration / Activity:

SGKS20

T07-T09: Combined: Top, Electroweak and Higgs Physics / 201

Probing the CP structure of the top quark Yukawa coupling: Loop sensitivity vs. on-shell sensitivity

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The question whether the Higgs boson is connected to additional CP violation is one of the driving forces behind precision studies at the Large Hadron Collider. In this work, we investigate the CP structure of the top quark Yukawa interaction—one of the most prominent places for searching for New Physics—through Higgs boson loops in top quark pair production. We calculate the electroweak corrections including arbitrary CP mixtures at next-to-leading-order in the Standard Model Effective Field Theory. This approach of probing Higgs boson degrees of freedom relies on the large $t\bar{t}$ cross section and the excellent perturbative control. In addition, we consider all direct probes with on-shell Higgs boson production in association with a single top quark or top quark pair. This allows us to contrast loop sensitivity versus on-shell sensitivity in these fundamentally different process dynamics. We find that loop sensitivity in $t\bar{t}$ production and on-shell sensitivity in $t\bar{t}H$ and tH provide complementary handles over a wide range of parameter space.

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Collaboration / Activity:

none

T03: Dark Matter / 202

Axion-Photon Conversion in Magnetospheres: The Role of the Plasma

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The most promising indirect search for the existence of axion dark matter uses radio telescopes to look for narrow spectral lines generated in the magnetospheres of neutron stars. Unfortunately, a large list of theoretical uncertainties has prevented this search strategy from being accepted as robust. In this talk I will present a novel end-to-end pipeline that traces individual photon trajectories from their point of genesis in the magnetosphere to asymptotic distances. This method allows one assess many of the outstanding uncertainties, including: (1) do refraction and reflection induce strong inhomogeneous features in the flux, (2) can refraction induce premature axion-photon de-phasing, (3) what is the expected width of the line, (4) does the flux have a strong time-dependence, and (5) can these radio photons be efficiently absorbed.

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Collaboration / Activity:

none?

T04: Neutrino Physics / 203

DUNE The Deep Underground Neutrino Experiment

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The Deep Underground Neutrino Experiment (DUNE) is a next-generation long-baseline neutrino experiment. Its main physics goals are the precise measurement of the neutrino oscillation parameters, in particular the violation of the charge-parity symmetry and the neutrino mass hierarchy, measuring proton decay and BSM physics searches. DUNE consists of a Far Detector (FD) complex with four multi-kiloton liquid argon detectors, and a Near Detector (ND) complex located close to the neutrino source at Fermilab (USA). Here we present an overview of the DUNE experiment, its detectors, and physics capabilities.

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Collaboration / Activity:

DUNE

T04: Neutrino Physics / **204**

ProtoDUNE Physics and Results

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ProtoDUNE-SP and ProtoDUNE-DP are large-scale single-phase and dual-phase prototypes of DUNEs far detector modules, operated at the CERN Neutrino Platform. ProtoDUNE-SP has finished its Phase-1 running in 2020 and has successfully collected test beam and cosmic ray data. In this talk, we will discuss the first results of ProtoDUNE-SP Phase-1's physics performance, ProtoDUNE-DPs design and progress and future ProtoDUNE plans.

Collaboration / Activity:

DUNE

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T12: Detector R&D and Data Handling / **205**

The DUNE Near Detector

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The Deep Underground Neutrino Experiment (DUNE) is an upcoming long-baseline neutrino experiment which will study neutrino oscillations. Neutrino oscillations will detected at the DUNE far detector 1300 km away from the start of the beam at Fermilab. The DUNE near detector (ND) will be located on-site at Fermilab, and will be used to provide an initial characterization of the neutrino beam, as well as to constrain systematic uncertainties on neutrino oscillation measurements. The detector suite consists of a modular 50-ton LArTPC (ND-LAr), a magnetized 1-ton gaseous argon time projection chamber (ND-Gar) surrounded by an electromagnetic calorimeter, and the System for on-Axis Neutrino Detection (SAND), composed by magnetized electromagnetic calorimeter and inner tracker. In this talk, these detectors and their physics goals will be discussed.

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Collaboration / Activity:

DUNE

T04: Neutrino Physics / 206

Search for light sterile neutrinos with the KATRIN experiment

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I will report on the light sterile neutrino search from the first science runs of the KATRIN experiment. Beta-decay electrons from a high-purity gaseous molecular tritium source are analyzed by a high-resolution MAC-E filter down to 40 eV below the endpoint at 18.57 keV. The analysis of the spectral shape of the spectrum near the endpoint leads to an improvement over the previous direct measurement of the neutrino mass, with a published new upper limit of 1.1 eV at 90% C.L. Analyzing the shape of the whole spectrum down to 40 eV below the endpoint, we find no significant distortion compared to the standard model expectation. Therefore, exclusion bounds on the sterile mass and mixing are reported. These new limits supersede the Mainz results and improve the Troitsk bound. The reactor and gallium anomalies are further constrained.

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Collaboration / Activity:

CEA - Saclay - Irfu

T04: Neutrino Physics / 207

Latest results from the CUORE experiment

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The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for $0\nu\beta\beta$ decay that has been able to reach the one-tonne mass scale. The detector, located at the LNGS in Italy, consists of an array of 988 TeO2 crystals arranged in a compact cylindrical structure of 19 towers. CUORE began its first physics data run in 2017 at a base temperature of about 10 mK and in April 2021 released its 3rd result of the search for $0\nu\beta\beta$, corresponding to

a tonne-year of TeO2 exposure. This is the largest amount of data ever acquired with a solid state detector and the most sensitive measurement of 0νββ decay in 130Te ever conducted, with a median exclusion sensitivity of 2.8×10^25 yr. We find no evidence of 0νββ decay and set a lower bound of 2.2 ×10^25 yr at a 90% credibility interval on the 130Te half-life for this process. In this talk, we present the current status of CUORE search for 0νββ with the updated statistics of one tonne-yr. We finally give an update of the CUORE background model and the measurement of the 130Te 2νββ decay half-life, study performed using an exposure of 300.7 kg·yr.

Collaboration / Activity:

CUORE

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T07-T09: Combined: Top, Electroweak and Higgs Physics / 208

Heavy states and electroweak effective approaches

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The existence of a mass gap between the Standard Model (SM) and possible new states encourages us to use effective field theories. Here we consider the non-linear realization of the electroweak symmetry breaking: the electroweak effective theory (EWET), also known as Higgs effective field theory (HEFT) or electroweak chiral Lagrangian (EWChL). At short distances a resonance Lagrangian which couples the SM states to bosonic and fermionic resonances is assumed. After integrating out the resonances and assuming a well-behaved high-energy behavior, we estimate or constrain most of the bosonic low-energy constants in terms of only resonance masses. Current fits of these low-energy constants allow us to constrain the high-energy resonance masses.

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Collaboration / Activity:

Theoretical Physics

T09: Higgs Physics / 209

Hbb dead or alive?

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Hbb associated production is often advocated as an ideal proxy to measure the bottom-quark Yukawa coupling yb. However, large irreducible background exists, which make the extraction of yb very challenging, if not impossible. I will discuss some recent calculations which showed how gluon-fusion, VH and VBF production conspire to kill our sensitivity on yb from Hbb at the LHC.

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Collaboration / Activity:

Theory

T04: Neutrino Physics / **210**

QED corrections to neutrino nucleus scattering

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As neutrino physics marches towards its goal of percent-level determinations of oscillation parameters, the corresponding theory of neutrinos scattering off nuclei (detector material) must be improved and developed to a sub-percent level of precision. Large logarithms, e.g. $\log(E_\nu/m_e)$, and coherent enhancements, i.e. $Z\alpha/v$, can enhance QED corrections significantly. In this talk I will discuss Coulomb corrections in detail and comment on the importance of radiative corrections for coherent elastic neutrino nucleus scattering (CEvNS).

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Collaboration / Activity:

Not applicable?

T03: Dark Matter / **211**

Dark Matter in the Type Ib Seesaw Model

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We study the connection between the two indications of physics beyond the Standard Model (SM): the masses and mixing of neutrinos and the existence of dark matter (DM). To have a more testable connection, we consider a minimal type Ib seesaw model instead of the traditional type I seesaw model. In the minimal type Ib seesaw model, the effective neutrino mass operator involves two different Higgs doublets and two right-handed neutrinos which form a single heavy Dirac pair. To account for DM, we consider neutrino portal couplings to a dark fermion and a dark scalar. We explore the parameter space of the extended model consistent with both oscillation data and DM relic abundance. Within this framework, we show how DM can be directly related to laboratory experiments when the heavy Diracneutrino mass is around 1~100 GeV.

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Collaboration / Activity:

N/A

T10: Searches for New Physics / 212

METNet: A combined missing transverse momentum working point using a neural network with the ATLAS detector

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In order to suppress pile-up effects and improve resolution, ATLAS employs a suite of working points for missing transverse momentum (p_T^{miss}) reconstruction, and each is optimal for different event topologies and different beam conditions. A neural network (NN) can exploit various event properties to pick the optimal working point on an event-by-event basis and also allows to combine complementary information from each of the working points. The resulting regressed p_T^{miss} (METNet) offers improved resolution and pile-up resistance across a number of different topologies compared to the current p_T^{miss} working points. Additionally, by using the NN's confidence in its predictions, a machine learning-based p_T^{miss} significance ('METNetSig') can be defined. This poster presents simulation-based studies of the behaviour and performance of METNet and METNetSig for several topologies compared to current ATLAS p_T^{miss} reconstruction methods.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 213

Search for gluino-mediated stop pair production in events with b-jets and large missing transverse momentum

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A search for supersymmetry involving the pair production of gluions decaying via stop quarks into the lightest neutralino is reported. The search uses LHC proton-proton collision data at the center-of-mass energy sqrt(s)=13 TeV with an integrated luminosity of 139 inverse fb collected with the ATLAS detector in 2015-2018. The search is performed in events containing large missing transverse momentum and several energetic jets, at least three of which must be identified as originating from b-quarks. The analysis considers two final states, one of which is required to have at least one lepton, while the second search region imposes a veto on leptons. Expected exclusion limit for gluino and neutralino masses is evaluated using simplified signal models.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 214

Search for higgsinos with R-parity violating decays in a final state with one lepton and many jets in sqrt(s) = 13 TeV pp collisions with the ATLAS detector

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Natural supersymmetry (SUSY) suggests light higgsinos possibly within the discovery reach of Run-2 of the LHC. This poster presents the lat- est result of a search for R-parity violating (RPV) SUSY in final states with one lepton and high jet and b-jet multiplicities. In a target model supersymmetric higgsinos are produced in pairs and decay via an RPV coupling to three quarks. The $t\bar{t}$ process is the main background source and estimated using a data-driven model that predicts higher jet and b-jet multiplicities used in the search.

Machine learning techniques are introduced to reach sensitivity to elec- troweakino production, extending the data-driven background estimation to the shape of the machine learning discriminant. This search repre- sents the first LHC result to obtain sensitivity to electroweak production

of SUSY particles promptly decaying to quarks, as predicted in baryon-number-violating RPV models.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 215

Search for doubly and singly charged Higgs bosons decaying into vector bosons in multi-lepton final states with the ATLAS detector using proton-proton collisions at 13 TeV

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This poster presents a search for charged Higgs bosons decaying into WW or ZW bosons, involving experimental signatures with two leptons of the same charge, or three or four leptons with a variety of charge combinations, missing transverse momentum and jets. Some focus will be given on the same-charge leptons channel signature. A data sample of proton–proton collisions at a centre-of-mass energy of 13 TeV recorded with the ATLAS detector at the Large Hadron Collider between 2015 and 2018 is used. The data correspond to a total integrated luminosity of 139/fb. The search is guided by a type-II seesaw model that extends the scalar sector of the Standard Model with a scalar triplet, leading to a phenomenology that includes doubly and singly charged Higgs bosons. Two scenarios are explored, corresponding to the pair production of doubly charged H++ (or H−) bosons, or the associated production of a doubly charged H++ boson and a singly charged H+ boson. No significant deviations from the Standard Model predictions are observed. H++ bosons are excluded at 95% confidence level up to 350 GeV and 230 GeV for the pair and associated production modes, respectively.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 217

Search for heavy Higgs bosons decaying into two tau leptons with the ATLAS detector using pp collisions at sqrt(s) = 13 TeV

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A search for heavy neutral Higgs bosons is performed using the LHC Run-2 data, corresponding to an integrated luminosity of 139/fb of proton-proton collisions at sqrt(s) = 13 TeV recorded with the

ATLAS detector. The search for heavy resonances is performed over the mass range 0.2–2.5 TeV for the tau+ tau- decay with at least one tau-lepton decaying into final states with hadrons. The data are in good agreement with the background prediction of the Standard Model. In the Mh125 scenario of the Minimal Supersymmetric Standard Model, values of tan(beta)>8 and tan(beta)>21 are excluded at the 95% confidence level for neutral Higgs boson masses of 1.0 and 1.5 TeV, respectively, where tan(beta) is the ratio of the vacuum expectation values of the two Higgs doublets.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 218

Search for a resonance in the di-Higgs channel decaying into yybb with the ATLAS detector

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In 2012, the ATLAS and CMS experiments jointly discovered the Higgs boson, a key particle of the Standard Model of particle physics. This discovery raised new questions, in particular about the mass hierarchy. The existence of new particles could help answering this problem, a Higgs-like resonance being one of them. Various theories beyond the Standard Model predict the existence of such new scalar particles that can decay in two Higgs bosons. Among the different decay channels, the decay of the first Higgs boson into a pair of photons and the second Higgs boson into a pair of b-quarks is one of the most promising since it benefits from the good diphoton resolution for the first one and the high branching ratio of the second one. This poster presents this search with 139/fb of data collected by the ATLAS detector in 2015-2018. Limits on the production cross-section for a new particle over the mass range 251-1000 GeV are set, improving by up to a factor five the expected limit of the 36/fb result.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 219

Search for light charged Higgs boson in t -> H+b (H+ -> cb) decays with the ATLAS detector at LHC

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A search for light charged Higgs boson (m_H+ = 60-160 GeV) in t to bH+ is presented. The analysis focuses on top-quark pair events in which one top quark decays to Wb, with the W boson decaying leptonically, and the other top quark decays to bH+, with H+ decaying subsequently to a charm and a bottom quark (H+ to cb). The search is based on pp collisions at sqrt(s) = 13 TeV recorded by the ATLAS detector at the LHC and uses an integrated luminosity of 139/fb. The process results in the lepton-plus-jets final state, characterized by an isolated electron or muon and at least four jets. The search exploits the high b-jet multiplicity in signal events and employs a neural network discriminant that uses the kinematic differences between the signal and the background, which is dominated by a top-quark pair production.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 221

Search for W'→tb decays in the hadronic final state with the ATLAS detector

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A search for W'production with decay to a top quark and a bottom quark in proton-proton collisions at √s=13 TeV with the ATLAS detector is presented. The hadronic decay of the top quark is identified using DNN-based boosted-object techniques. The dominant background is obtained by a data-driven method with small systematic uncertainties. The results are presented as upper limits on the W' production cross-section times the top-bottom channel branching ratio for several W'masses ranging from 1.5 to 6 TeV.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 222

Search for exotic decays of the Higgs boson to long-lived particles in pp collisions at √s=13 TeV using displaced vertices in the ATLAS inner detector

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A novel search for exotic decays of the Higgs boson to pairs of long-lived neutral particles, each decaying to a bottom quark pair, is performed using 139 fb-1 of √s=13 TeV proton-proton collision data collected with the ATLAS detector at the LHC. Events consistent with the production of a Higgs boson in association with a leptonically decaying Z boson are analyzed. Long-lived particle (LLP) decays are reconstructed from inner detector tracks as displaced vertices with high mass and track multiplicity relative to Standard Model processes. The analysis selection requires the presence of at least two displaced vertices, effectively suppressing Standard Model backgrounds. The residual background contribution is estimated using a data driven technique. No excess over Standard Model predictions is observed, therefore upper limits are set on the branching ratio of the Higgs boson to LLPs. Branching ratios of 10% are excluded at a 95% confidence level for LLP mean proper lifetimes cτ as small as 4 mm and as large as 110 mm. For LLP masses below 40 GeV, these results represent the most stringent constraint in this lifetime regime.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 223

ATLAS Searches for Resonances Decaying to Boson Pairs

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Many extensions to the Standard Model predicts new particles decaying into two bosons (W, Z, photon, or Higgs bosons) making these important signatures in the search for new physics. Searches for such diboson resonances have been performed in final states with different numbers of leptons, photons, as well as jets and b-jets where new jet substructure techniques are used to disentangle the hadronic decay products in highly boosted configuration. This talk summarises recent ATLAS searches with Run 2 data collected at the LHC and explains the experimental methods used, including vector- and Higgs-boson-tagging techniques.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 224

Exploring the frontier of R-parity-violating supersymmetry with the ATLAS detector

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Supersymmetry models in which R-parity violation occurs predict a wide range of experimental signatures at the LHC, including many high-multiplicity final states without large missing transverse momentum. These models are motivated by the hierarchy problem and for some parameters naturally explain the lightness of the standard model neutrinos. Searches for RPV SUSY signatures require dedicated signal regions and innovative techniques to estimate the challenging backgrounds. This talk will highlight the latest results of searches conducted by the ATLAS experiment which target supersymmetric particles produced via both strong and electroweak processes in R-parity violating scenarios.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 227

Searches for electroweak production of supersymmetric particles with the ATLAS detector

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The direct production of electroweak SUSY particles, including sleptons, charginos, and neutralinos, is a particularly interesting area of search at the LHC, as considerations on dark matter and the naturalness of the Higgs mass motivate the existence of light electroweakinos. The small production cross sections lead to difficult searches, despite relatively clean final states. This talk will highlight the most recent results of searches performed by the ATLAS experiment for supersymmetric particles produced via electroweak processes, including analyses targeting small mass splittings between SUSY particles, with a focus on searches that target models on which R-parity is conserved. Sophisticated analysis techniques, including machine learning, are employed to increase the sensitivity for these processes.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 228

Searches for strong production of supersymmetric particles with the ATLAS detector

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Supersymmetry (SUSY) provides elegant solutions to several problems in the Standard Model, and searches for SUSY particles are an important component of the LHC physics program. Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the gluons and third generation quarks with masses light enough to be produced at the LHC. This talk will present the latest results of searches conducted by the ATLAS experiment which target gluino and squark production, including stop and sbottom, in a variety of decay modes, focusing on decay modes in which R-parity is conserved and therefore the lightest SUSY particle is a stable dark matter candidate.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 229

Searches for exotic decays of the Higgs boson with the ATLAS detector

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Exotic decays of the Higgs boson provide a unique window for the discovery of new physics, as the Higgs boson may couple to hidden-sector states that do not interact under the Standard Model gauge transformations. Models predicting exotic Higgs boson decays to pseudoscalars can explain the galactic centre gamma-ray excess, if the additional pseudoscalar acts as the dark matter mediator. In addition, theories beyond the Standard Model may predict lepton-flavor violating (LFV) decays of the Higgs boson. This talk presents recent ATLAS searches for decays of the 125 GeV Higgs boson to new particles, and searches for LFV decays of the Higgs boson. These searches use LHC collision data at sqrt(s) = 13 TeV collected by the ATLAS experiment in Run 2.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 230

Searches for additional Higgs bosons at ATLAS

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The discovery of the Higgs boson with the mass of about 125 GeV completed the particle content predicted by the Standard Model. Even though this model is well established and consistent with many measurements, it is not capable to solely explain some observations. Many extensions addressing such shortcomings introduce additional Higgs-like bosons which can be either neutral, singly-charged or even doubly-charged, or additional resonances with masses larger or smaller than that of the SM Higgs boson. The current status of searches for these particles based on the full LHC Run 2 dataset of the ATLAS experiment at 13 TeV are presented.

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ATLAS

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T10: Searches for New Physics / 231

Searches for BSM physics using challenging and long-lived signatures with the ATLAS detector

Authors: ATLAS Collaboration[None]; Louie Corpe[1]

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Various theories beyond the Standard Model predict unique signatures that are difficult to reconstruct and for which estimating the background rate is also a challenge. Signatures from displaced decays anywhere from the inner detector to the muon spectrometer, as well as those of new particles with fractional or multiple values of the charge of the electron or high mass stable charged particles are all examples of experimentally demanding signatures. The talk will focus on the most recent results using 13 TeV pp collision data collected by the ATLAS detector. Prospects for the HL-LHC will also be shown.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 232

Searches for vector-like quarks with the ATLAS Detector

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Vector like quarks appear in many theories beyond the Standard Model as a way to cancel the mass divergence for the Higgs boson. The talk will focus on the most recent results using 13 TeV pp collision data collected by the ATLAS detector. This presentation will address the analysis techniques, in particular the selection criteria, the background modeling and the related experimental uncertainties. The results and the complementarity of the various searches, along with the phenomenological implications, will be discussed.

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ATLAS

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T10: Searches for New Physics / 233

Searches for new physics with leptons using the ATLAS detector

Authors: ATLAS Collaboration[None]; Daniele Zanzi[1]

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Many theories beyond the Standard Model predict new phenomena, such as Z', W'bosons or heavy neutrinos, in final states with isolated, high-pt leptons (e/mu/tau). Searches for new physics with such signatures, produced either resonantly or non-resonantly, including a general search using multilepton final states are performed using the ATLAS experiment at the LHC. Lepton flavor violation (LVF) is a striking signature of potential beyond the Standard Model physics. The search for LFV with the ATLAS detector is reported in searches focusing on the decay of the Z boson into different flavour leptons (e/mu/tau). The recent 13 TeV pp results will be reported.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 234

Searches for leptoquarks with the ATLAS detector

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Leptoquarks (LQ) are predicted by many new physics theories to describe the similarities between the lepton and quark sectors of the Standard Model and offer an attractive potential explanation for the lepton flavour anomalies observed at LHCb and flavour factories. The ATLAS experiment has a broad program of direct searches for leptoquarks, coupling to the first-, second- or third-generation particles. This talk will present the most recent 13 TeV results on t he searches for leptoquarks and contact interactions with the ATLAS detector, covering flavour-diagonal and cross-generational final states.

Collaboration / Activity:

ATLAS

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T10: Searches for New Physics / 235

Searches and techniques for boosted resonances (non-diboson) with the ATLAS detector

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Many new-physics signatures at the LHC produce highly boosted particles, leading to close-by objects in the detector and necessitating jet substructure techniques to disentangle the hadronic decay products. This talk presents the latest ATLAS results for searches for heavy W'and Z'resonances in top-bottom, di-top and 4-top final states using 13 TeV data. It will explain the techniques used, including new top-tagging techniques using machine learning and the use of large-radius jets containing electrons.

Collaboration / Activity:

ATLAS

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T05: Heavy Ion Physics / 236

Measurements of collective behavior in pp, Xe+Xe, and Pb+Pb collisions with the ATLAS detector

Authors: ATLAS Collaboration[None]; Somadutta Bhatta[None]

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This talk presents ATLAS measurements of collective, flow phenomena in a variety of collision systems, including pp collisions at 13 TeV, Xe+Xe collisions at 5.44 TeV, and Pb+Pb collisions at 5.02

TeV. A new measurement of vn-[pT] correlations in Xe+Xe and Pb+Pb collisions is presented for harmonics n=2, 3, and 4. The correlation between the event-wise average transverse momentum ([pT]) and the harmonic flow (vn) carries important information about the initial-state geometry of the Quark-Gluon Plasma. Additionally, the potential quadrupole deformation in Xe+Xe is predicted to produce an initial state with enhanced shape and size fluctuations, and result in non-trivial change in the correlation. A measurement of the sensitivity of two-particle correlations in pp collisions to the presence of jets is presented. By rejecting particles associated with low-pT jets, this data can distinguish the role that semi-hard processes play in the collective phenomena observed in pp collisions.

Collaboration / Activity:

ATLAS

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T05: Heavy Ion Physics / **237**

Di-muons production from two-photon scattering in Pb+Pb collisions with the ATLAS detector

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Relativistic heavy ion beams are accompanied by a large flux of equivalent photons, giving rise to a set of photon-induced processes. These can lead to photon-photon interactions in both ultraperipheral collisions, where the nuclei do not overlap, as well as in hadronic processes accompanied by the production of hot, dense matter. The latter provides a potentially sensitive electromagnetic probe of the quark-gluon plasma. This talk presents a series of measurements of such processes performed by the ATLAS Collaboration. New measurements of exclusive di-muon production, which provide detailed constraints on the nuclear photon flux and its dependence on impact parameter and photon energy. In particular, the study of the di-muon cross sections in the presence of forward neutron production, provides an additional experimental handle on the impact parameter range sampled in the observed events. The same process of dileptons produced via two-photon scattering in non-ultra-peripheral (non-UPC) nucleus-nucleus collisions first measured by ATLAS and STAR showed an unexpected centrality-dependent broadening of the angular correlation between the two leptons and/or of the two-lepton p_{T} distribution. Full statistic of run 2 dataset allow new features to be observed in the data, both in the yields of the pairs as well as in their angular distributions. Differential measurements of the dependence of the pair-distribution on the transverse-momentum and rapidity of the two muons, as well as the dependence on the event centrality will be presented, and the possible physics implications will be discussed.

Collaboration / Activity:

ATLAS

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T05: Heavy Ion Physics / **238**

Two-particle azimuthal correlations in photo-nuclear ultra-peripheral Pb+Pb collisions at 5.02~TeV with ATLAS

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The ultra-peripheral collisions (UPCs) of relativistic heavy ion beams lead to a diverse set of photon-nucleus interactions. The measurements of particles and their interaction produced in photo-nuclear reactions can shed light on the QCD dynamics of novel, extremely asymmetric colliding systems, with energies between those available at RHIC and the LHC. Understanding the hadronic fluctuation spectrum of the photon in this fashion is also critical for maximizing the precision of measurements at a future Electron Ion Collider facility. This talk presents a measurement of two-particle long-range azimuthal correlations in photo-nuclear collisions using 1.73~nb^{-1} of 5.02~TeV~Pb+Pb data collected in 2018 by ATLAS with a dedicated photo-nuclear event trigger. Candidate photo-nuclear events are selected using a combination of the single-sided zero-degree calorimeter activity and reconstructed pseudorapidity gaps constructed from calorimeter clusters and charged-particle tracks. Correlation functions are constructed using charged-particle tracks, separated in pseudorapidity. A template fitting procedure is utilized to subtract the non-flow contribution. Elliptic and triangular flow coefficients are presented as a function of charged-particle multiplicity and transverse momentum, and significant non-zero values of the flow coefficients are observed. The results are compared to flow coefficients obtained in pp and p+Pb collisions in similar multiplicity ranges.

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Collaboration / Activity:

ATLAS

T05: Heavy Ion Physics / 239

Measurement of light-by-light scattering in ultra-peripheral Pb+Pb collisions with the ATLAS detector

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In ultra-relativistic heavy-ion collisions, one expects copious rates of $\gamma + \gamma$ processes through the interaction of the large electromagnetic fields of the nuclei which can lead to light-by-light scattering via loop diagrams. This process was directly observed for the first time in UPCs at the LHC by ATLAS. Final measurements of light-by-light scattering with full run 2 dataset with substantially reduced uncertainties will be presented. This process provides a precise and unique opportunity to investigate extensions of the Standard Model such as axion-like particles.

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Collaboration / Activity:

ATLAS

T05: Heavy Ion Physics / 240

Measurements of jet suppression and modification in heavy-ion collisions with ATLAS

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Measurements of jet suppression and modification in heavy-ion collisions provide powerful and broad information on the dynamics of the hot, dense plasma formed in relativistic nucleus-nucleus collisions. In this talk we present measurements of jet energy loss and modification which are performed using the high-statistics Pb+Pb collision data at 5.02 TeV recorded during 2018 with the ATLAS detector at the LHC. These data can provide insight into the path length or system size dependence of energy loss, fluctuations in the energy loss process, the modification of parton fragmentation, and the re-distribution of lost energy.

This talk will first present a broad measurement of the single jet yields as a function of the azimuthal angle with respect to the 2nd, 3rd, and 4th event planes in Pb+Pb collisions. The azimuthal anisotropies for jets are reported as a function of jet p_{T} and centrality. This talk will also present a measurement of the fully unfolded dijet momentum balance in high-statistics Pb+Pb and pp data. The balance distributions are presented as a function of centrality and leading jet p_{T}, exploring a significantly higher kinematic range than Run 1 results. Finally, the talk presents a measurement of Z-tagged charged hadron yields, which feature an opportunity to understand the energy loss, and its redistribution by the medium, for low-p_{T} partons in a calibrated way.

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T05: Heavy Ion Physics / 241

Recent heavy-flavor measurements with the ATLAS detector

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Measurements of open heavy-flavor hadron production in heavy-ion collisions provide a powerful tool to study both initial-state effects on heavy-quark production and final-state interactions between heavy-quarks and the quark-gluon plasma (QGP). These measurements are performed with the ATLAS detector at the LHC and capitalize on the large statistics of the Run 2 Pb+Pb dataset. This talk presents published results on the azimuthal anisotropy (v_2 and v_3) of muons from heavy-flavor decays in Pb+Pb collisions, as well as new results on the nuclear modification factor (R_{AA}) for heavy-flavor muons, both in the region $p_{\mathrm{T}} > 4$ GeV. In both measurements, muons from charm and bottom hadrons are statistically separated using the transverse impact parameter with respect to the

primary collision vertex. Muons from both charm and bottom hadrons are found to have significant azimuthal anisotropies in Pb+Pb collisions, with larger anisotropies for muons from charm hadrons than for muons from bottom hadrons. Muons from both sources are also observed to be strongly suppressed with respect to the pp baseline, in a way that depends on the mass of the parent hadron at low to moderate muon p_{T}. The simultaneous measurement of multiple observables (v_2, v_3, and R_{AA}) for both charm and bottom with the same detector and technique is particularly crucial in providing constraints on state of the art theoretical predictions.

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Collaboration / Activity:

ATLAS

T10: Searches for New Physics / 245

Searching for millicharged particles in future proton-proton collisions at the LHC

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We report on the expected sensitivity of dedicated scintillator-based detectors at the LHC for elementary particles with charges much smaller than the electron charge. Having secured the necessary funding, we plan to construct two detectors, including a novel slab detector configuration, for the LHC Run 3. The dataset provided by a prototype scintillator-based detector has been used to characterise the performance of these detectors and provide an accurate background projection. With the Run 3 dataset, we expect sensitivity to new particles with masses between 10 MeV and 45 GeV for charges between 0.003e and 0.3e, depending on their mass. We also consider upgraded detectors for the HL-LHC dataset, for which we expect sensitivity to masses between 10 MeV and 80 GeV for charges between 0.0018e and 0.3e, depending on their mass.

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T13 - Accelerator for HEP / 246

The SHERPA experiment

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The SHERPA ("Slow High-efficiency Extraction from Ring Positron Accelerator") project aim is to develop an efficient technique to extract a positron beam from one of the accelerator rings composing the DAΦNE accelerator complex at the Frascati National Laboratory of INFN, setting up a new beam line able to deliver positron spills of O(ms) length, excellent beam energy spread and emittance.
The most common approach to slowly extract from a ring is to increase betatron oscillations approaching a tune resonance in order to gradually eject particles from the circulating beam.
SHERPA proposes a paradigm change using coherent processes in bent crystals to kick out positrons from the ring, a cheaper and less complex alternative 1. This non-resonant technique, already successfully used and still developed mainly in hadron accelerators, will provide a continuous multi-turn extraction of a high quality beam [2, 3, 4, 5].
Realizing this for sub-GeV leptons is challenging, however would provide the world's first primary positron beam obtained with crystal extraction. An immediate application of this new extracted beam line would be the PADME ("Positron Annihilation into Dark Matter Experiment") experiment [6], currently strongly limited by the duty cycle. Using the proposed extraction, PADME could increase the statistics by a factor 10^4 and its sensitivity by a factor 10^2.
This technology can be applied in general for both negative and positive leptons, including muons, providing a know how that can be applied for several accelerating machine aspects in the next future, as collimation, extraction and beam splitting, contributing to a general improvement in the particle accelerator field.
In the talk will be given an overview of the whole experiment, describing in particular the crystal extraction principle, the accelerator optics studies, the crystal prototype and the characterization apparatus. First simulation and experimental results will be reported.

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T04: Neutrino Physics / 247

The DUNE Near Detector Complex as a Beam Dump Facility

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Two of the greatest mysteries that particle physics faces today are the fact that neutrinos have mass and the existence of dark matter. Upcoming experiments are on the horizon attempting to unveil more about both of these, but there is the possibility that we can learn about both in one environment. The Deep Underground Neutrino Experiment, a next-generation experiment planned for the

US in the late 2020s and beyond, will have a suite of near detectors designed to better understand neutrino fluxes and interactions, however, it has capabilities for discovering beyond-the-Standard-Model physics as well. In this talk, I will demonstrate how this complex can be seen as a sort-of "Beam Dump"facility, enabling searches for new particles, such as heavy neutrinos, dark Higgs bosons, and axion-like particles.

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T03: Dark Matter / 248

The Light Dark Matter eXperiment, LDMX

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The constituents of dark matter are still unknown, and the viable possibilities span a very large mass range. Specific scenarios for the origin of dark matter sharpen the focus on a narrower range of masses: the natural scenario where dark matter originates from thermal contact with familiar matter in the early Universe requires the DM mass to lie within about an MeV to 100 TeV. Considerable experimental attention has been given to exploring Weakly Interacting Massive Particles in the upper end of this range (few GeV –~TeV), while the region ~MeV to ~GeV is largely unexplored. Most of the stable constituents of known matter have masses in this lower range, tantalizing hints for physics beyond the Standard Model have been found here, and a thermal origin for dark matter works in a simple and predictive manner in this mass range as well. It is therefore a priority to explore. If there is an interaction between light DM and ordinary matter, as there must be in the case of a thermal origin, then there necessarily is a production mechanism in accelerator-based experiments. The most sensitive way, (if the interaction is not electron-phobic) to search for this production is to use a primary electron beam to produce DM in fixed-target collisions. The Light Dark Matter eXperiment (LDMX) is a planned electron-beam fixed-target missing-momentum experiment that has unique sensitivity to light DM in the sub-GeV range. This contribution will give an overview of the theoretical motivation, the main experimental challenges and how they are addressed, as well as projected sensitivities in comparison to other experiments.

Collaboration / Activity:

LDMX

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T03: Dark Matter / 250

Dark Matter with DAMA/LIBRA

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The recent results of DAMA/LIBRA–phase2 experiment deep underground at Gran Sasso are presented. The improved experimental configuration with respect to the phase1 allowed a lower software energy threshold. The DAMA/LIBRA–phase2 data confirm the evidence of a signal that meets all the requirements of the model independent Dark Matter annual modulation signature, at high C.L. The model independent DM annual modulation result is compatible with a wide set of DM candidates. In this talk we summarize some of them and perspectives for the future will be outlined.

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DAMA coll.

T05: Heavy Ion Physics / 251

Anisotropic flow decorrelation in heavy-ion collisions at RHIC-BES energies with 3D event-by-event viscous hydrodynamics

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In the RHIC Beam Energy Scan program, gold nuclei are collided with different collision energies in the range from few to 62.4 GeV. The goals of the program are to explore the onset of QGP creation, locate the critical point of QCD and study dense baryon matter.
In this talk, we report on the first application of 3D Monte Carlo Glauber (GLISSANDO2) and TrENTO p=0 initial states for 3D event-by-event viscous fluid dynamic (vHLLE) + cascade modelling of Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 27$ and 62.4 GeV, which is the upper region of RHIC BES energies. The initial states are extended into both the longitudinal direction and for finite baryon density using simple ansätze. The full energy and baryon charge counting in the initial states is implemented. We show the reproduction of basic hadronic observables - pseudorapidity distributions of charged hadrons and net protons, transverse momentum spectra and elliptic flow, at both collision energies and with both initial states. We compare it to the existing results obtained with UrQMD initial state. Furthermore, we show the results for rapidity decorrelation of elliptic flow r_2 at $\sqrt{s_{\mathrm{NN}}} = 27$ and 200 GeV from the same setup of hydrodynamic calculations with the 3D Monte Carlo Glauber and UrQMD initial states. We discuss the features of the initial states responsible for the magnitude of the observed flow decorrelation, and the effect of the final-state hadronic cascade.
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Collaboration / Activity:

theory

T03: Dark Matter / 252

Circular polarisation of gamma rays as a probe of dark matter-cosmic ray electron interactions

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Dark Matter (DM) constitutes most of the matter in the presently accepted cosmological model for our Universe. However, despite the increased sensitivity of direct and indirect DM searches, and the latest LHC run at 13 TeV centre of mass energy, no signal from DM particles has been detected so far, leading to exclusion limits on the parameter space of DM models. Conventional indirect searches look for an excess in the electromagnetic emission from the sky that cannot be attributed to known astrophysical sources, but polarisation is so far not being explored.

In this talk, I will argue that the photon polarisation is an important feature to understand new physics interactions. In particular, circular polarisation can be generated from Beyond the Standard Model (BSM) interactions if they violate parity and there is an asymmetry in the number of particles which participate in the interaction. I will consider a simplified model for fermionic (Majorana) DM and study the circularly polarised gamma rays below 10 GeV from DM cosmic ray electron interactions. I will study the differential flux of positive and negative polarised photons from the Galactic Centre and show that the degree of circular polarization can reach up to 90%. Finally, I will discuss the detection prospects of this signal in future experiments.

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Collaboration / Activity:

Article

T04: Neutrino Physics / 254

Final results of GERDA on the search for neutrinoless double beta decay

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The GERDA (GERmanium Detector Array) collaboration operated high-purity Ge detectors enriched in ^{76}Ge at LNGS to search for neutrinoless double beta decay ($0\nu\beta\beta$). An observation would imply both the Majorana nature of neutrinos and the violation of lepton number conservation, with important consequences for the neutrino mass scale, and the matter-antimatter asymmetry in the Universe. The operation of high resolution Ge detectors in an active liquid Ar shield combined with a powerful pulse shape discrimination allowed the collection of a background-free data set. With a total exposure of 127.2 kg yr, a lower limit on the half-life of $0\nu\beta\beta$ in ^{76}Ge of $T_{1/2} > 1.8 \times 10^{26}$ yr at 90% C.L was set, a world-leading constraint in the search for $0\nu\beta\beta$. In this talk I will give an overview of the experimental techniques exploited to reach the final result.

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Collaboration / Activity:

GERDA collaboration

T12: Detector R&D and Data Handling / 255

Precision luminosity measurement with proton-proton collisions at the CMS experiment in Run 2

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Precision luminosity calibration is critical to determine fundamental parameters of the standard model and to constrain or to discover beyond-the-standard-model phenomena at LHC. The luminosity determination at the LHC interaction point 5 with the CMS detector, using proton-proton collisions at 13 TeV during Run 2 of the LHC (2015–2018), is reported. The absolute luminosity scale is obtained using beam-separation ("van der Meer") scans. The dominant sources of systematic uncertainty are discussed. When applying the van der Meer calibration to the entire data-taking period, a substantial contribution to the total uncertainty in the integrated luminosity originates from the measurement of the detector linearity and stability. The reported integrated luminosity in 2015–2016 is among the most precise luminosity measurements at bunched-beam hadron colliders.

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T06: QCD and Hadronic Physics / 256

New physics results with the CMS Precision Proton Spectrometer

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The Precision Proton Spectrometer (PPS) is a new subdetector of CMS introduced for the LHC Run 2, which provides a powerful tool for advancement of BSM searches.The talk will present the new results on exclusive diphoton, Z+X, and diboson production explored with with PPS, illustrating the unique sensitivity which can be achieved using proton tagging. The upcoming Run 3 will bring new opportunities for measurements with PPS, which will also be discussed.

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T07: Top and Electroweak Physics / 259

Probing EFT in canonical and associated top quark productions in CMS

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Top quark production can probe physics beyond the SM in different ways. The Effective Field Theory (EFT) framework allows searching for BSM effects in a model independent way. CMS experiment is pioneering EFT measurements that move towards using full potential of the data in the most global way possible. This talk covers various analysis strategies pursued in CMS for constraining top quark EFT couplings with the focus on the latest results.

Collaboration / Activity:

CMS

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T07: Top and Electroweak Physics / 261

Measurement of top-quark properties with the ATLAS and CMS detectors at LHC

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The remarkably large integrated luminosity collected by the ATLAS and CMS detectors at the highest proton-proton collision energy provided by LHC allows to use the large sample of top quark events to explore properties of the top quark production and decay and to probe the presence on new physics that might break well established symmetries. The angular properties are explored by illustrating the simultaneous measurement of the all three components of the top-quark and antiquark polarisation vectors in t-channel single-top-quark production, the measurement of normalised differential cross sections for single-top t-channel production as a function of the direction cosines of the momentum of the charged lepton in the top quark rest frame, the measurement of the helicity of the W boson from the top decays . The angular differential cross sections in single-top t-channel events are used to extract the complex Wilson coefficient of the dimension-six O_{tW} operator in the framework of an effective field theory. Measurements of the top sector of the CKM matrix and of the ttbar forward backward asymmetry enrich the exploration of top quark decay and production. Finally a measurement that tests the universality of the couplings of the different generations of leptons to the electroweak gauge bosons is illustrated.

Collaboration / Activity:

CMS

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T07: Top and Electroweak Physics / 262

CMS results of top quark electroweak production, including associated productions

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Latest CMS measurements of single top quark, inclusive and/or differential is presented. The talk also covers single top production in association with additional bosons.

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T07: Top and Electroweak Physics / 263

Inclusive and differential ttbar cross-section measurements at CMS

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Latest CMS measurements of top quark pair production, inclusive and/or differential is presented. Boosted regime is included in this talk.

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T07: Top and Electroweak Physics / 264

Associated production of tt and heavy flavor at CMS

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A comprehensive set of inclusive and differential measurements of top quark pair production in association with light, c- and b-jets is presented and results are compared to theory predictions. The status of the search for four top quark production, to which the LHC experiments are starting to be sensitive, and that has important BSM re-interpretations, is also reported.

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T07: Top and Electroweak Physics / 265

Measurement of top-quark electroweak couplings in associated top quark production with vector bosons with ATLAS and CMS detector

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A comprehensive set of inclusive and differential measurements of top quark pair production in association with EWK bosons (W, Z or γ) , including searches for rare single top production processes (tZq) is presented.

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T12: Detector R&D and Data Handling / 266

Overview of the HL-LHC Upgrade for the CMS Level-1 Trigger

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The High-Luminosity LHC will open an unprecedented window on the weak-scale nature of the universe, providing high-precision measurements of the standard model as well as searches for new physics beyond the standard model. Such precision measurements and searches require information-rich datasets with a statistical power that matches the high-luminosity provided by the Phase-2 upgrade of the LHC. Efficiently collecting those datasets will be a challenging task, given the harsh environment of 200 proton-proton interactions per LHC bunch crossing. For this purpose, CMS is designing an efficient data-processing hardware trigger (Level-1) that will include tracking information and high-granularity calorimeter information. Trigger data analysis will be performed through sophisticated algorithms such as particle flow reconstruction, including widespread use of Machine Learning. The current conceptual system design is expected to take full advantage of advances in FPGA and link technologies over the coming years, providing a high-performance, low-latency computing platform for large throughput and sophisticated data correlation across diverse sources.

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T06: QCD and Hadronic Physics / 267

Vector boson associated with jets in CMS

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The study of the associated production of vector bosons and jets constitutes an excellent enviroment to check numerous QCD predictions. Total and differential cross sections of vector bosons produced in association with jets have been studied in pp collisions using CMS data. Differential distributions

as function of a broad range of kinematical observables are measured and compared with theoretical predictions.

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T07: Top and Electroweak Physics / 268

Vector boson associated with heavy-flavor jets in CMS

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The associated production of vector bosons and jets originating from heavy-flavour (c or b) quarks is a large background source in measurements of other standard model processes, Higgs boson studies, and many searches for physics beyond the standard model. The study of events with a vector boson accompanied by heavy-flavour jets is crucial to refine the theoretical calculations in perturbative QCD, as well as to validate associated Monte Carlo predictions. Differential cross sections are measured as a function of several kinematic observables with the CMS detector.

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T07: Top and Electroweak Physics / 269

Multiboson production in CMS

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This talk reviews recent measurements of multiboson production using CMS data. Inclusive and differential cross sections are measured using several kinematic observables.

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T07: Top and Electroweak Physics / 270

Vector boson scattering in CMS

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Vector boson scattering is a key production process to probe the electroweak symmetry breaking of the standard model, since it involves both self-couplings of vector bosons and coupling with the Higgs boson. If the Higgs mechanism is not the sole source of electroweak symmetry breaking, the scattering amplitude deviates from the standard model prediction at high scattering energy. Moreover, deviations may be detectable even if a new physics scale is higher than the reach of direct searches. Latest measurements of production cross sections of vector boson pairs in association with two jets in proton-proton collisions at sqrt(s) = 13 TeV at the LHC are reported using a data set recorded by the CMS detector. Differential fiducial cross sections as functions of several quantities are also measured.

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T07: Top and Electroweak Physics / 272

CMS Inclusive vector bosons results including Drell-Yan measurements in a wide mass range

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Recent inclusive W,Z measurements and differential results on DY dilepton productions in a wide range of invariant masses are presented, making use of CMS proton collision data at 13 TeV.

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T06: QCD and Hadronic Physics / 273

Recent jet measurements in CMS

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Measurement of inclusive jet cross sections in proton collisions at 5 and 13 TeV with the CMS experiment are presented. Measurements are performed as a function of the jet transverse momentum pT and jet rapidity. Jets are reconstructed using the anti-kT clustering algorithm with different size parameters in a wide phase space region in jet pT and jet rapidity. The measured jet cross sections are corrected for detector effects and compared with the predictions from perturbative QCD.

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CMS

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T06: QCD and Hadronic Physics / 275

Jet substructure measurements in CMS

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Various measurements related to the study of hadronic jets substructure in proton collisions at 13 TeV with the CMS experiment are presented. The differential jet production cross section as a function of the jet mass and transverse momentum is shown in events with a Z boson plus jet topology, with and without the soft radiation within a jet removed by a jet grooming algorithm. Measurement of jet substructure observables describing the distribution of particles within quark- and gluon-initiated jets, are carried out with both dijet and Z plus jet event samples. The cross section of hadronically decaying W/Z bosons identified using jets with a large cone radius at large transverse momenta together with jet substructure identification criteria, are also presented.

Collaboration / Activity:

CMS

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T06: QCD and Hadronic Physics / 276

Double parton scattering and exclusive hadron productions in CMS

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Double parton scattering (DPS) is investigated using a states of a Z boson and jets, and of four jets, with CMS proton collisions data at 13 TeV. Final state distributions are studied as functions of several observables that exploit correlations between the jets, and the Z boson, with sensitivity to different aspects of the underlying event, parton shower, and matrix element calculations. Values of the effective DPS cross section are calculated and discussed. The central exclusive production of charged hadron pairs in pp collisions at a center- of-mass energy of 13 TeV is also examined with the CMS experiment. Differential cross sections as functions of the polar scattering angle of the incoming protons and several squared four-momenta are measured in a wide region of scattered proton transverse momenta. The dynamics of nonresonant continuum is determined and compared to models.

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CMS

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T12: Detector R&D and Data Handling / 277

The Phase-2 upgrade of the CMS Outer Tracker

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The Large Hadron Collider at CERN will undergo a major upgrade in the Long Shutdown 2 from 2025-2027. The so-called High Luminosity LHC (HL-LHC) is expected to deliver peak instantaneous luminosities of about $5-7.5\times10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ and an integrated luminosity of about $3000-4500$ fb^{-1} during ten years of operation. In order to fully exploit the delivered luminosity and to cope with the demanding operating conditions, the whole silicon tracking system of the CMS experiment will have to be replaced. The Phase-2 Outer Tracker (OT) will have an increased radiation hardness, a higher granularity, and will be able to cope with larger data rates. In addition, the OT will provide tracking information to the Level-1 trigger. To achieve this, each module will consist of two closely spaced sensors, which are connected to the same readout chips. The readout chips correlate data from both sensors for a rough transverse momentum measurement. This novel concept allows to keep trigger rates at a sustainable level without sacrificing physics potential. Furthermore, the Phase-2 OT will use evaporative $\mathrm{CO_2}$ cooling and a DC-DC conversion based powering scheme to keep the material budget small. In this contribution, the design of the CMS Phase-2 Outer Tracker, highlights about research and development activities, and the present status of the project will be presented.

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T12: Detector R&D and Data Handling / 278

Upgrade of the CSC Muon System for the CMS Detector at the HL-LHC

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Co-author: CMS

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The Large Hadron Collider (LHC) will be upgraded in several phases to significantly expand its physics program. After the current long shutdown from 2018-2021 (LS2) the accelerator luminosity will be increased to 2 – 3 * 10^34cm−2s−1 exceeding the design value of 1 * 10^34cm−2s−1 allowing the CMS experiment to collect approximately 100 fb−1/year. A subsequent upgrade in 2022-23 will increase the luminosity up to 5 * 10^34cm−2s−1. The CMS muon system must be able to sustain a physics program after the LS2 shutdown that maintains sensitivity to electroweak scale physics and for TeV scale searches similar to what was achieved up to now For the Cathode Strip Chamber (CSC) muon detectors. The on chamber front-end readout electronics portion of the CSC electronics upgrade has now been completed. The design of the upgraded CSC electronics will be discussed as well as the status of the commissioning of the upgraded CSC system. In view of the operating conditions at HL-LHC, it is vital to asses the detector performance for high luminosity. Accelerated aging tests are being performed to study the behavior of the CSC detectors under conditions which are nearly an order of magnitude beyond the original design values. The status of this irradiation campaign and results will be presented.

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T12: Detector R&D and Data Handling / 280

Status and plans for the CMS High Granularity Calorimeter upgrade project

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The CMS Collaboration is preparing to build replacement endcap calorimeters for the HL-LHC era. The new high-granularity calorimeter (HGCAL) is, as the name implies, a highly-granular sampling calorimeter with approximately six million silicon sensor channels (~1.1 cm^2 or 0.5 cm^2 cells) and

about four hundred thousand channels of scintillator tiles readout with on-tile silicon photomultipliers. The calorimeter is designed to operate in the harsh radiation environment at the HL-LHC, where the average number of interactions per bunch crossing is expected to exceed 140. Besides measuring energy and position of the energy deposits the electronics is also designed to measure the time of their arrival with a precision on the order of 50 ps. In this talk, the reasoning and ideas behind the HGCAL, the current status of the project, the many lessons learnt so far, in particular from beam tests, and the challenges ahead will be presented.

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CMS

T12: Detector R&D and Data Handling / 281

Strategy for high-precision luminosity measurement with the CMS detector at the HL-LHC

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The high-luminosity upgrade of the LHC (HL-LHC) is foreseen to reach an instantaneous luminosity a factor of five to seven times the nominal LHC design value. The resulting, unprecedented requirements for background monitoring and luminosity measurement create the need for new high-precision instrumentation at CMS, using radiation-hard detector technologies. This contribution presents the strategy for bunch-by-bunch online luminosity measurement based on various detector technologies. The potential of the exploitation of the tracker endcap pixel detector, the outer tracker, the hadron forward calorimeter, the barrel muon detectors and the 40 MHz scouting system is discussed together with the concept of a standalone luminosity and beam-induced background monitor using Si-pad sensors.

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CMS

T12: Detector R&D and Data Handling / 282

Fast Beam Condition Monitor of the CMS experiment at the HL-LHC

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To achieve the challenging target of 1% precision on luminosity determination at the high-luminosity LHC (HL-LHC) with instantaneous luminosity up to 7.5 × 10^{34} cm^{−2} s^{−1}, the CMS experiment will employ multiple luminometers with orthogonal systematics. A key component of the proposed system is a stand-alone luminometer, the Fast Beam Condition Monitor (FBCM), which is fully independent from the central trigger and data acquisition services and able to operate during all times at 40 MHz providing bunch-by-bunch luminosity measurement with 1 s time granularity. FBCM is foreseen to be placed inside the cold volume of the Tracker as it utilizes silicon-pad sensors exploiting the zero-counting algorithm of hits for luminosity measurement. FBCM will also provide precise timing information with a few ns precision enabling the measurement of beam induced background. We report on the optimisation of the design and the expected performance of FBCM.

Collaboration / Activity:

CMS

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T12: Detector R&D and Data Handling / 283

Optimisation of the CMS tracker endcap pixel detector as a precision luminometer and background monitor at the HL-LHC

Authors: CMS[None]; Ashish Sehrawat[None]

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The High Luminosity upgrade of the LHC (HL-LHC) places unprecedented requirements for background monitoring and luminosity measurements. The CMS Tracker Endcap Pixel Detector (TEPX) will be adapted to provide high-precision online measurements of bunch-by-bunch luminosity and beam-induced background. The implementation of dedicated triggering and readout systems, the real-time clustering algorithm on an FPGA and the expected performance are discussed. The innermost ring of the last layer (D4R1) will be operated independently from the rest of TEPX enabling beam monitoring during the LHC ramp and during unqualified beam conditions. The system optimisation and the dedicated timing and trigger infrastructure for D4R1 are also presented.

Collaboration / Activity:

CMS

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T10: Searches for New Physics / 284

Heavy Neutrinos at Future Linear e+e- Colliders

Author: Krzysztof Mekala[1]

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Neutrinos are probably the most mysterious particles of the Standard Model. The mass hierarchy and oscillations, as well as the nature of their antiparticles, are currently being studied in experiments around the world. Moreover, in many models of the New Physics, baryon asymmetry or dark matter density in the universe are explained by introducing new species of neutrinos. Among others, heavy neutrinos of the Dirac or Majorana nature were proposed to solve problems persistent in the Standard Model. Such neutrinos with masses above the EW scale could be produced at future linear e+e- colliders, like the Compact LInear Collider (CLIC) or the International Linear Collider (ILC).

We studied the possibility of observing production and decays of heavy neutrinos in qql final state at the ILC running at 500 GeV and 1 TeV and the CLIC running at 3 TeV. The analysis is based on the WHIZARD event generation and fast simulation of the detector response with DELPHES. Dirac and Majorana neutrinos with masses from 200 GeV to 3.2 TeV are considered. Estimated limits on the production cross sections and on the neutrino-lepton coupling are compared with the current limits coming from the LHC running at 13 TeV, as well as the expected future limits from hadron colliders. Impact of the gamma-induced backgrounds on the experimental sensitivity is also discussed. Obtained results are stricter than other limit estimates published so far.

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Collaboration / Activity:

CLIC/ILC

T09: Higgs Physics / 286

Measurements of Higgs boson cross sections and differential distributions in leptonic final states (CMS)

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The latest results obtained with CMS data collected at a centre-of-mass energy of 13 TeV targeting Higgs boson decays in leptonic final states at CMS will be discussed.

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Collaboration / Activity:

CMS

T09: Higgs Physics / 287

Measurements of Higgs boson cross sections and differential distributions in bosonic final states (CMS)

Author: Jonathon Langford[1]

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The latest results obtained with CMS data collected at a centre-of-mass energy of 13 TeV targeting Higgs boson decays into gammagamma, WW, ZZ final states at CMS will be discussed.

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Collaboration / Activity:

CMS

T09: Higgs Physics / 288

Measurements of Higgs production and decay in final states involving quarks (CMS)

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The latests CMS results collected at a centre-of-mass energy of 13 TeV and focusing on Higgs boson production and decay in final states involving quarks (ttH, tH, VH Hbb, VH Hcc) will be discussed.

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T09: Higgs Physics / 289

Measurements of Higgs boson properties and couplings at CMS

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Recent measurements of Higgs boson properties and couplings will be presented.

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CMS

T09: Higgs Physics / 290

Searches for rare Higgs boson decays (CMS)

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Recent measurements of rare SM Higgs boson decays will be presented.

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T09: Higgs Physics / 291

Searches for non-resonant and resonant HH production at CMS

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Recent CMS results on HH, X->HH and X->HY production will be presented.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 292

Searches for Higgs exotic decays and additional (pseudo)scalars at CMS

Author: CMS[None]

Recent CMS searches for additional scalars (pp->a, Maaa) will be presented.

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T09: Higgs Physics / 293

Searches for Higgs invisible (CMS)

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Recent CMS searches for Higgs Invisible decays will be presented.

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Collaboration / Activity:

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T10: Searches for New Physics / 294

Searches for additional Higgs bosons at CMS

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Recent searches for BSM Higgses (both neutral and charged) performed by the CMS experiment at a center of mass of 13 TeV will be presented.

Collaboration / Activity:

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T12: Detector R&D and Data Handling / 295

The Pixel Luminosity Telescope: a silicon sensor detector for luminosity measurement at CMS

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The Pixel Luminosity Telescope is a silicon pixel detector dedicated to luminosity measurement at the CMS experiment. It consists of 48 silicon sensor planes arranged into 16 "telescopes" of three planes each, with eight telescopes arranged around the beam pipe at either end of the CMS detector, outside the pixel endcap at a distance of approximately 1.75 m from the interaction point. The planes in a telescope are positioned such that a particle coming from the interaction point passing through a telescope will produce a hit in each of the three planes of the telescope. The instantaneous luminosity is measured from this rate of triple coincidences, using a special "fast-or" readout at the full bunch-crossing rate of 40 MHz, allowing for real-time, high-precision luminosity information to be provided to CMS and the LHC. The full pixel information, including hit position and charge, is read out at a lower rate and can be used for studies of systematic effects in the measurement. We present the commissioning, calibration, operational history, and performance of the detector during Run 2 (2015-2018) of the LHC, together with lessons learned for future projects.

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Collaboration / Activity:

CMS

T05: Heavy Ion Physics / 297

Influence of scattering versus coherent parton branching on the k_T broadening of QCD cascades in a medium

Authors: Martin Rohrmoser[1]; Etienne Blanco[1]; Robert Straka[2]; Wiesław Płaczek[3]; Krzysztof Kutak[1]

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Heavy ion collisions at high energies can be used as an interesting way to recreate and study the medium of the quark-gluon plasma (QGP).
We particularly investigate how jets produced in hard binary collisions evolve within a tentative medium and in particular how the jet-particle momentum components k_T orthogonal to the jet axis are affected.
We evolved the jets within a medium that contains both, transverse kicks
as well as medium induced coherent radiation within the MINCAS-algorithm 1 following the works of [2,3].
In this framework parton branching occurs simultaneously to scatterings within the medium, leading to the interference effects that reproduce the well known BDMPS-Z emission rates and sizeable k_T broadening.
It is, thus, interesting to study the relative importances of k_T broadening from the coherent splittings and different types of in-medium scatterings.
We find a clear hierarchy of the influences from different scattering effects and deflections during branchings:
While scattering still yields the largest contributions to broadening, the branching effects are comparable in size.
We also observed that the k_T distributions in our results differ considerably from a Gaussian distribution in transverse momentum.

References:
1 K. Kutak, W. Płaczek, R. Straka, Eur.Phys.J. C79 (2019) no.4, 317
[2] J.-P. Blaizot, F. Dominguez, E. Iancu, Y. Mehtar-Tani, JHEP 1301 (2013) 143
[3] J.-P. Blaizot, F. Dominguez, E. Iancu, Y. Mehtar-Tani, JHEP 1406 (2014) 075

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Collaboration / Activity:

jet phenomenology in QGP

T10: Searches for New Physics / 299

Searches for heavy resonances decaying into Z, W, and Higgs bosons at CMS

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We present a summary of searches for new heavy resonances decaying into pairs or triplets of bosons, performed on proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 13 TeV. A common feature of these searches is the boosted topology, where the decay products of the considered bosons (both electroweak W, Z bosons and the Higgs boson) are expected to be highly energetic and close in angle. In cases with hadronic boson decays this leads to massive, large radius jets with substructure. The exploitation of jet substructure techniques (with deep neural networks and others), allows to increase the sensitivity of such searches. Techniques to calibrate such jets discriminant and to estimate total background in data are used. Results are interpreted in the context of multiple scenarios beyond the standard model.

Collaboration / Activity:

CMS

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T10: Searches for New Physics / 301

Search for heavy BSM particles coupling to third generation quarks at CMS

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We present results from searches for resonances with enhanced couplings to third generation quarks, based on proton-proton collision data at a centre-of-mass energy of 13 TeV recorded by CMS. The signatures include single and pair production of vector-like quarks and heavy resonances decaying to third generation quarks. A wide range of final states, from multi-leptonic to entirely hadronic is covered. Jet substructure techniques are employed to identify highly-boosted heavy SM particles in their hadronic decay modes.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 302

Spin polarization as a measure of anomalous gauge-Higgs vertex

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The state of polarization is encoded in the elements of density matrix and for a massive spin-one particle the density matrix can be parametrized in terms of 8 independent parameters called *polarization parameters*. We show how the polarization parameters of the Z boson can be used to study the new physics interaction at the ZZH vertex at future e^+e^- colliders and at the LHC. We analytically calculate the 8 polarization parameters using the spin density matrix of the Z boson and estimate bounds on the anomalous ZZH couplings by constructing angular asymmetries from the Z boson decay leptons, which are related to the polarization observable. Taking into account possible longitudinal beam polarization at two different center of mass energies, we find that oppositely polarized beams at 500 GeV c.m. energy provides tighter bounds on the couplings than the same sign polarized and unpolarized beams. We find that most of the 1σ limits are of the order of a few times 10^{-3} for 14 TeV LHC with integrated luminosity of 1000 fb^{-1} and for 500 GeV e^+e^- colliders with oppositely polarized beams.

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Collaboration / Activity:

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T06-T07: Combined: Top, Electroweak, QCD and Hadronic Physics / 303

Complementarity of Lepton-Charge and Forward-Backward Drell-Yan Asymmetries for Precision Electroweak Measurements and Quark Density Determinations

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Thanks to the large amount of data that is being and will be collected at Run-III and High Luminosity (HL) stage, precision measurements at the LHC are reaching an unprecedented level of statistical

accuracy, whilst PDF uncertainties prevail. We study the impact of future measurements of lepton-charge and forward-backward asymmetries on PDF determination. The numerical results have been obtained employing the open-source platform xFitter and standard profiling procedures. We explore the potential of the combination of charged-current and neutral-current Drell-Yan (DY) asymmetries in regions of transverse and invariant masses near the SM gauge bosons peaks to improve the PDF uncertainties.

Collaboration / Activity:

QCD phenomenology

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T06: QCD and Hadronic Physics / 305

Study of e+e- annihilation to hadrons with SND at VEPP-2000 (12'+3')

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Recent result on e^+e^- annihilation to hadrons below 2 GeV obtained at the SND experiment at the VEPP-2000 collider are presented. In particular, we discuss measurements of the $e^+e^- \to \pi^+\pi^-$ and $e^+e^- \to n\bar{n}$ cross sections, and study of the radiative processes $e^+e^- \to \eta\gamma$, $e^+e^- \to \eta\pi^0\gamma$, and $e^+e^- \to \eta\eta\gamma$.

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Collaboration / Activity:

SND

T10: Searches for New Physics / 306

New physics explanations of a_μ in light of the FNAL muon $g-2$ measurement

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Co-authors: Wojciech Kotlarski [2]; Dominik Stöckinger [3]; Csaba Balazs [1]; Hyejung Stöckinger-Kim [3]; Peter Athron [4]

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The Fermilab Muon $g-2$ experiment reported the results of its Run-1 measurement of the anomalous magnetic moment a_μ^{FNAL}, which is in full agreement with the previous BNL measurement and pushes the world average deviation Δa_μ^{2021} from the Standard Model to a significance of 4.2σ. In this talk I will present an extensive survey of its impact on beyond the Standard Model physics, based on the work in Ref. 1. In this work we used state-of-the-art calculations and a sophisticated set of tools to make predictions for a_μ, dark matter and LHC searches. We examined a wide range of simple models with up to three new fields, that represent some of the few ways that large Δa_μ can be explained. The results show that the new measurement excludes a large number of models and provides crucial constraints on others. Generally, these models provide viable explanations of the a_μ result only by using rather small masses and/or large couplings with chirality flip enhancements, which can lead to conflicts with limits from LHC and dark matter experiments. I will present results for a range of models including scalar leptoquarks and simple models constructed to explain dark matter and g-2 simultaneously.

1 Athron P, Balázs C, Jacob D H, Kotlarski W, Stöckinger D and Stöckinger-Kim H 2021 (Preprint 2104.03691)

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Collaboration / Activity:

BSM Phenomenology

T14: Outreach, Education and Diversity / 307

Why people were on Facebook during your talk (And other lessons in effective communication for scientists)

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Words can inspire, enlighten and motivate; but they can also confuse, frustrate and bore. In this short training, you'll learn how to connect with your audience and explain ideas so that they're not just understood, but have a meaningful impact. Skills covered are:

- Adapting communication goals and strategy to your target audience
- Talking with people who have no idea what you're talking about
- Structuring information into a compelling (and memorable) story
- Staying sharp in high-stress situations

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Collaboration / Activity:

Communication and Outreach

T04: Neutrino Physics / 309

The Singly-Charged Scalar Singlet as the Origin of Neutrino Masses

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We consider the generation of neutrino masses via a singly-charged scalar singlet. Under general assumptions we identify two distinct structures for the neutrino mass matrix. This yields a constraint for the antisymmetric Yukawa coupling of the singly-charged scalar singlet to two left-handed lepton doublets, irrespective of how the breaking of lepton-number conservation is achieved. The constraint disfavours large hierarchies among the Yukawa couplings. We study the implications for the phenomenology of lepton-flavour universality, measurements of the W-boson mass, flavour violation in the charged-lepton sector and decays of the singly-charged scalar singlet. We also discuss the parameter space that can address the Cabibbo Angle Anomaly.

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Collaboration / Activity:

PhD Research Project

T12: Detector R&D and Data Handling / 310

The upgrade of the CMS Electromagnetic Calorimeter for HL-LHC

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The Electromagnetic Calorimeter (ECAL) of the CMS detector has played an important role in the physics program of the experiment, delivering outstanding performance throughout data taking. The High-Luminosity LHC will pose new challenges. The four to five-fold increase of the number of interactions per bunch crossing will require superior time resolution and noise rejection capabilities. For these reasons the electronics readout has been completely redesigned. A dual gain

trans-impedance amplifier and an ASIC providing two 160 MHz ADC channels, gain selection, and data compression will be used in the new readout electronics. The trigger decision will be moved off-detector and will be performed by powerful and flexible FPGA processors, allowing for more sophisticated trigger algorithms to be applied. The upgraded ECAL will be capable of high-precision energy measurements throughout HL-LHC and will greatly improve the time resolution for photons and electrons above 10 GeV. The results in terms of performance achieved with a prototype system in a vertical integration test will be presented.

Collaboration / Activity:

CMS

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T12: Detector R&D and Data Handling / 312

Status and commissioning of the new GE1/1 station for the CMS experiment

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The upgrade of the Large Hadron Collider (LHC), with an increase of its luminosity up to 5-7 × 10^34cm^−2s^−1, will cause a huge growth of the background rates expected by the experiments. For this reason, the Compact Muon Solenoid (CMS) experiment is going through an upgrade project, which includes the installation of a new station, called GE1/1, consisting of 144 Triple-Gas Electron Multiplier detectors (GEM). The combined operation of the new GE1/1 station together with the existing Cathode Strip Chamber (CSC) station ME1/1 is expected to improve muon tracking and triggering performance. The installation of the GE1/1 station is complete and the commissioning phase is ongoing. We will present the status of this commissioning and the first results on the performance of the detectors and electronics. Plans for LHC Run 3 will also be discussed.

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Collaboration / Activity:

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T12: Detector R&D and Data Handling / 313

Overview of the CMS RPC upgrade program

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The Resistive Plate Chambers (RPC) system will be upgraded to sustain the harsher HL-LHC conditions and to help maintain good trigger efficiency and performance of the CMS experiment. The present RPC chambers would continue to operate and a new link system will be installed improving the timing resolutions of the RPC system up to 1.5 ns to cope with the expected higher background. The communication rate with the readout electronics will be increased to 10.24 Gbps. Readout and control electronics will also be upgraded. Boards with customized FPGA will be installed to process data from the experimental cavern and distribute it to the CMS trigger and DAQ systems. Coverage of the RPC system will be increased to a pseudorapidity of 2.4 by installing a new generation of improved RPC chambers (iRPCs), which are equipped with new electronics designed for 2-dimensional readout. The status of the RPC upgrade project will be presented.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 317

Search for electroweak SUSY production in leptonic and hadronic final states with the CMS experiment

Authors: CMS[None]; CMS[None]

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Several searches for supersymmetry produced through electroweak processes have been performed by the CMS Collaboration using the full dataset of proton-proton collisions collected during the Run 2 of the LHC at a center-of-mass energy of 13 TeV. The main features and results of analyses that select events with leptonic and hadronic final states will be presented.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 318

Searches for third generation SUSY particles with the CMS experiment

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Several searches for supersymmetric partners of the top quark and tau lepton have been performed by the CMS Collaboration using the full dataset of proton-proton collisions collected during the Run 2 of the LHC at a center-of-mass energy of 13 TeV. The main features and results of these analyses will be presented.

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CMS

T10: Searches for New Physics / 319

Constraining challenging regions of the SUSY parameter space with the CMS experiment

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Supersymmetric models are characterized by a strong diversity of experimental signatures. Since general-purpose searches have not yet given any clear indication of new physics, dedicated methodologies and tools have been developed to target the regions of the parameter space where the analysis is most challenging and SUSY might still lie undetected. This presentation will describe relevant examples among searches performed by the CMS Collaboration using the full dataset of proton-proton collisions collected during the Run 2 of the LHC at a center-of-mass energy of 13 TeV.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 320

Searches for new physics in CMS in events with jets in the final state

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Many new physics models, e.g., compositeness, extra dimensions, excited quarks, and dark matter mediators, are expected to manifest themselves in final states with jets. This talk presents searches in

CMS for new phenomena in the final states that include jets, focusing on the recent results obtained using the full Run-II data-set collected at the LHC.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 321

Searches for new physics in CMS in events with leptons and photons in the final state

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Many new physics models, e.g., compositeness, extra dimensions, extended Higgs sectors, supersymmetric theories, and dark sector extensions, are expected to manifest themselves in the final states with leptons and photons. This talk presents searches in CMS for new phenomena in the final states that include leptons and photons, focusing on the recent results obtained using the full Run-II data-set collected at the LHC.

Collaboration / Activity:

CMS

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T03: Dark Matter / 322

Dark Matter searches in CMS

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Searches for dark matter at colliders are a powerful complementary probe to elucidate the nature of this hitherto unobserved form of matter. We present CMS searches for dark matter candidate particles and new mediators interacting with them. Various final states, topologies, and kinematic variables are explored utilizing the full Run-II data-set collected at the LHC. Furthermore, we interpret the results of the searches for direct dark matter production as well as visible decays of new mediators in the broader dark matter search landscape.

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 326

Modeling Radiation Damage to Pixel Sensors in the ATLAS Detector

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Silicon pixel detectors are at the core of the current and planned upgrade of the ATLAS detector at the Large Hadron Collider (LHC). As the closest detector component to the interaction point, these detectors will be subjected to a significant amount of radiation over their lifetime: prior to the High-Luminosity LHC (HL-LHC), the innermost layers will receive a fluence of 1-5 10^{15} 1 MeV n_{eq}/cm^2 and the HL-LHC detector upgrades must cope with an order of magnitude higher fluence integrated over their lifetimes. Simulating radiation damage is critical in order to make accurate predictions for current future detector performance. A model of pixel digitization is presented that includes radiation damage effects to the ATLAS pixel sensors for the first time. In addition to a thorough description of the setup, predictions are presented for basic pixel cluster properties alongside early studies with LHC Run 2 proton-proton collision data.

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Collaboration / Activity:

ATLAS Collaboration

T12: Detector R&D and Data Handling / 327

Operational Experience and Performance with the ATLAS Pixel detector at the Large Hadron Collider at CERN

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The tracking performance of the ATLAS detector relies critically on its 4-layer Pixel Detector. As the closest detector component to the interaction point, this detector is subjected to a significant amount of radiation over its lifetime. By the end of the LHC proton-proton collision RUN2 in 2018, the innermost layer IBL, consisting of planar and 3D pixel sensors, had received an integrated fluence of approximately $\Phi = 9 \times 10^{14}$ 1 MeV n_{eq}/cm^2.
The ATLAS collaboration is continually evaluating the impact of radiation on the Pixel Detector. The key status and performance metrics of the ATLAS Pixel Detector are summarised, and the operational experience and requirements to ensure optimum data quality and data taking efficiency will be described, with special emphasis to radiation damage experience. A quantitative analysis of charge collection, dE/dX, occupancy reduction with integrated luminosity, under-depletion effects with IBL, effects of annealing will be presented and discussed, as well as the operational issues and mitigation techniques adopted during the LHC Run2 and the ones foreseen for Run3.

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Collaboration / Activity:

ATLAS Collaboration

T04: Neutrino Physics / 332

Exploring Earth's Matter Effect in High-Precision Long-Baseline Experiments

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A detailed understanding of Earth's Matter effect is inevitable to correctly analyze the data from the upcoming high-precision long-baseline experiments to resolve the remaining fundamental unknowns such as neutrino mass ordering, leptonic CP violation and precision measurements of the oscillation parameters. In this paper, for the first time, we explore in detail the capability of Deep Underground Neutrino Experiment (DUNE) to establish the matter oscillation as a function of $\delta_{\rm CP}$ and θ_{23} by excluding the vacuum oscillation. We find that DUNE is sensitive to Earth's matter effect at more than 2σ C.L. irrespective of the choice of the oscillation parameters. The relative 1σ precision in the measurement of line-averaged constant Earth matter density ($\rho_{\rm avg}$) for maximal CP-violating choices of $\delta_{\rm CP}$ is around 10% to 15% depending on the choice of neutrino mass ordering. If $\delta_{\rm CP}$ turns out to be around -90° or 90° , the precision in measuring ρavg is better in DUNE as compared to what are achievable from the Super-K atmospheric data, combined data from Solar and KamLand, and full exposure of T2K and NOνA. We also observe new interesting degeneracies among $\rho_{\rm avg}$, $\delta_{\rm CP}$, and θ_{23} and notice that the present uncertainty in $\delta_{\rm CP}$ dilutes more the measurement of $\rho_{\rm avg}$ compared to θ_{23} . To lift these degeneracies, we incorporate the prospective data from the upcoming Tokai to Hyper-Kamiokande (T2HK) and T2HK with a second detector in Korea (T2HKK) experiments. With a relatively shorter baseline and high statistics at first oscillation maximum, T2HK offers unprecedented sensitivity to establish genuine CP violation and to measure $\delta_{\rm CP}$, whereas in the T2HKK setup, the second detector in Korea with a roughly four times longer baseline is more sensitive to Earth's matter effect and provides crucial information on $\delta_{\rm CP}$ working at second oscillation maximum. We explore interesting complementarities among these possible setups and

find that the combined data from DUNE and T2HKK can establish Earth's matter effect at more than 5σ C.L. irrespective of the choices of mass ordering, δ_{CP}, and θ_{23}.

Collaboration / Activity:

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T12: Detector R&D and Data Handling / 333

Performance studies for the CMS GE2/1 muon upgrade

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The Large Hadron Collider (LHC) will soon be upgraded to prepare for the high-luminosity phase. To cope with the increase in background rates and trigger requirements, an upgrade is planned to the CMS muon system by installing additional sets of muon detectors based on Gas Electron Multiplier (GEM) technology. The GE2/1 station will consist of 72 GEM chambers, comprised of 288 modules, covering the pseudorapidity range between 1.62 and 2.43. Performance studies for the prototype GE2/1 modules and fully integrated chambers will be presented, together with the plan for a GE2/1 demonstrator chamber to be installed in the cavern before the start of LHC Run-3.

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Collaboration / Activity:

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T12: Detector R&D and Data Handling / 334

Rate capability of large-area triple-GEM detectors and new foil design for the innermost station, ME0, of the CMS endcap muon system

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To extend the acceptance of the CMS muon spectrometer to the region 2.4<|η|<2.8, stations of triple-GEM chambers, called ME0, are planned for the CMS Phase 2 Upgrade. These large-area, micro-pattern gaseous detectors must operate in a challenging environment with expected background particle fluxes up to 150 kHz/cm2. Unlike traditional non-resistive gaseous detectors, the rate capability of large-area triple-GEM detectors is limited not by space charge effects, but by voltage drops on the chamber electrodes due to avalanche-induced currents flowing through the resistive protection circuits. We present a study of the irradiation of large-area triple-GEM detectors with moderate fluxes to obtain a high integrated hit rate. The results show drops as high as 40% of the nominal

detector gas gain, which would result in severe loss of tracking efficiency. We discuss possible mitigation strategies leading to a new design for the GEM foils with electrode segmentation in the radial direction, instead of the "traditional"longitudinal segmentation. The advantages of the new design include maintenance of a uniform hit rate across different sectors, minimization of gain-loss without the need for voltage compensation, and independence of detector efficiency on background flux shape.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 335

Dark Sector searches in CMS

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New physics may have gone unseen so far due to it being hidden in a dark sector. This may result in a rich phenomenology which we can access through portal interactions. In this talk, we present recent results from dark-sector searches in CMS using the full Run-II data-set of the LHC.

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Collaboration / Activity:

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T10: Searches for New Physics / 337

Search for new physics with long-lived and unconventional signatures in CMS

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Many extensions of the standard model predict new particles with long lifetimes or other properties, that give rise to non-conventional signatures in the detector. This talk discusses new techniques to detect such signatures in the CMS detector, and presents recent results from such searches in CMS using the full Run-II data-set of the LHC.

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Collaboration / Activity:

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T07: Top and Electroweak Physics / 338

Improved inclusive cross-section measurement of top quark in association with Z boson at the CMS experiment

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Single top quark production in association with a Z boson (tZq) was recently observed for the first time by both the CMS and ATLAS experiments. This rare process provides experimental access to the coupling of the top quark to the Z boson and is interesting as a probe for several new physics scenarios. We report on an inclusive tZq cross-section measurement that has been improved with respect to the first observations. It employs an optimized lepton identification strategy using boosted decision trees, and a data-driven background rejection method. The analysis improvements together with a larger data set result in a substantially better precision with respect to earlier work, showing the potential for future precision measurements of this rare process.

Collaboration / Activity:

CMS Collaboration, CERN

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T13 - Accelerator for HEP / 339

Studies towards high luminosity at CLIC

Authors: Chetan Gohil[1]; Philip Burrows[2]; Daniel Schulte[3]; Andrea Latina[3]; Jim Ögren[3]; Neven Blaskovic Kraljevic[3]

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We discuss the expected luminosity performance of the Compact Linear Collider (CLIC), which is a future e+e- collider proposed for the CERN site. We will discuss parameter choices and their impact on the luminosity of this collider. Start-to-end tracking simulations of the CLIC beam will be presented. These simulations include a comprehensive set of imperfections, both static and dynamic.

From these simulations we estimate the expected luminosity of the first stage of CLIC at a centre-of-mass energy of 380 GeV. We will also discuss an alternative high-luminosity design of CLIC, which could achieve double the baseline luminosity.

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Collaboration / Activity:

CLIC

T07: Top and Electroweak Physics / 342

Differential cross section measurements of top quark pair production in association with vector bosons at the CMS experiment

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Top quark pair production in association with a vector boson (photon or Z boson) provides an experimental probe for the electroweak couplings of the top quark. To improve the sensitivity to possible new physics modifications of these couplings, the CMS experiment performs differential cross section measurements using proton-proton collisions data collected at 13 TeV. To correct for detector resolution and reconstruction effects, an unfolding procedure is applied to the measured distributions and the results are presented at particle- or parton-level. Comparisons are performed with state-of-the-art theory predictions.

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Collaboration / Activity:

CMS Collaboration

T12: Detector R&D and Data Handling / 343

Performance and calibration of the ATLAS Tile Calorimeter

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The Tile Hadronic Calorimeter (TileCal) covers the central region of the ATLAS experiment. Wavelength-shifting fibres carry the light from active plastic scintillator tiles interspersed with steel absorber

plates to photomultiplier tubes (PMTs). Analogue response of the PMTs are amplified, shaped, and digitized by a front-end electronics system that samples the signal from about 10000 channels every 25 ns and stores the data on detector until a trigger decision is received. The dynamic range of each tile covers from ~30 MeV to ~2 TeV. Each step of the process - from collection of scintillation light to signal reconstruction is monitored and calibrated. During LHC Run-2, high-momentum isolated muons and isolated hadrons were used to calibrate the electromagnetic and hadronic response, respectively. The time resolution was studied with multi-jet events. We shall summarize results of performance studies that address calibration, stability, energy scale, uniformity and time resolution.

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Collaboration / Activity:

ATLAS Collaboration

T12: Detector R&D and Data Handling / 344

The performance and operational experience of ATLAS SemiConductor Tracker in Run-2 at LHC

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The performance of ATLAS SemiConductor Tracker (SCT) in Run-2 at Large Hadron Collider (LHC) has been reviewed during the current long shutdown. The LHC successfully completed its Run-2 operation (2015-2018) with a total integrated delivered luminosity of 156 fb^{-1} at the centre-of-mass pp collision energy of 13 TeV. The LHC high performance provide us a good opportunity for physics analysis. It came with high instantaneous luminosity and pileup conditions that were far in excess of what the SCT was originally designed to meet. The first significant effects of radiation damage in the SCT were also observed during Run-2. This talk will summarise the operational experience and performance of the SCT during Run-2, with a focus on the impact and mitigation of radiation damage effects.

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T12: Detector R&D and Data Handling / 345

Performance of the ATLAS RPC detector and L1 Muon Barrel trigger at 13 TeV

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Resistive Plate Chambers (RPCs) are fast gaseous detectors that are employed by the Level-1 muon trigger system in the barrel region of the ATLAS muon spectrometer. The Level-1 muon trigger system selects muon candidates produced in proton-proton collisions at the Large Hadron Collider (LHC). Muon candidates are associated by the Level-1 system with the correct LHC bunch crossing and assigned to one of the six transverse momentum thresholds. The RPCs are arranged in three concentric double layers and consist of approximately 3700 gas volumes, with a total surface of more than 4000 square meters. They operate in a toroidal magnetic field of approximately 0.5 Tesla and provide up to 6 position measurements along the muon trajectory, with a space-time resolution of about 2 cm x 2 ns. This contribution will discuss performance of the RPC detector and Level-1 muon barrel trigger system measured using proton-proton collision data at a centre-of-mass energy of 13 TeV. New measurements of RPC cluster size, detector efficiency and time resolution will be presented. Trigger efficiency, measured using Z boson decays to a muon pair, and trigger rate measurements will be summarised, as well as the composition of the accepted RPC muon candidates. Measurements of RPC currents as a function of the voltage and of the environmental parameters will be also presented, both with and without beams in the LHC. Similarly, RPC background counting rates are measured as a function of the instantaneous luminosity up to 2x10^{34} cm$^{-2}s^{-1}$. Measurements of the average avalanche charge for background events will be also presented. Results of the extrapolations of the RPC detector response to the expected luminosity of the High Luminosity LHC will be shown. Finally, measurements of the RPC detector response at different high voltage and threshold settings will be discussed, also in the context of expected detector response at the High Luminosity LHC.

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T07: Top and Electroweak Physics / **346**

Measurement of the Differential Cross Section and Spin Asymmetry of the Associated Production of a Single Top Quark and a Z Boson at the CMS Experiment

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The associated production of a single top quark and a Z boson includes the tZ coupling as well as the coupling of three vector bosons (WWZ) and is therefore a unique process to study the couplings of heavy particles in the SM. The top quark in this process is polarized due to its production through the weak interaction. Since the top quark decays before it hadronizes, the spin information is conserved in the leptonic decay products and can be measured. In this poster we document the first differential measurement of the tZq cross section where the full run II data of 137 /fb is used. The tZq cross section is measured at parton and particle level as a function of various kinematic observables including leptons and jets. Therefore a maximum likelihood unfolding procedure is exploited to correct for detector and hadronization effects. Connected to the differential cross section measurement, this poster also presents the first measurement of the spin asymmetry, which is proportional to the top quark polarization, for this process.

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 347

The ATLAS Forward Proton Time-of-Flight Detector System

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The Time-of-Flight (ToF) detectors of the ATLAS Forward Proton (AFP) system are designed to measure the primary vertex z-position of the pp -> pXp processes by comparing the arrival times measured in the ToF of the two intact protons in the final state.

We present the results obtained from a performance study of the AFP ToF detector operation in 2017. A time resolutions of individual channels ranging between 20 ps and 40 ps are extracted, even though the AFP ToF efficiency is below 10%. The overall time resolution of each ToF detector is found to be 20(26) +- 4(5) ps for side A(C). This represents a superb time resolution for a detector operating at few millimeters from the LHC beams. Events from ATLAS physics runs at moderate pile-up taken at the end of 2017 are selected with signals in ToF stations at both sides of ATLAS. The difference of the primary vertex z-position measured by ATLAS and the value obtained by the AFP ToFs is studied. The distribution of the time difference constitutes of a background component from combinatorics due to non-negligible pile-up, and significantly narrower signal component from events where protons from the same interaction are detected in ToF. The fits performed to the distribution of the reconstructed time difference yield the vertex position resolution (of about 6 mm +- 1 mm at best) that is in agreement with the expectation based on single-ToF channel resolutions.

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T07: Top and Electroweak Physics / 348

Precise measurement of the top quark mass with single top events at CMS at $\sqrt{s}$ = 13 TeV

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The t-channel process provides a unique phase space with lower colour reconnection probability as compared to the $t\bar{t}$ which has been exploited to make a precision measurement of the top quark and antiquark mass. Single top quark production via t-channel is the most dominant production process at the LHC. The final state comprises a single top along with a light quark giving rise to at least two jets, (one of which arises from hadronization of b-quark), an isolated high-momentum lepton (electron or muon), and large missing transverse momentum due to an escaping neutrino from the W decay, in the final state. The study is based on proton-proton collision data, equivalent to $35.9\,\mathrm{fb}^{-1}$ integrated luminosity, recorded at $\sqrt{s} = 13$ TeV by the CMS experiment during 2016. Dominant standard model backgrounds are studied in different regions depending on the number of b quark and light-flavour jets in the final state. A multivariate technique relying on boosted decision trees is employed to optimally separate the signal from backgrounds. The top-quark mass is reconstructed using kinematic information of the final state objects such as charged lepton, missing energy and the jets. We obtain the top quark mass by fitting its reconstructed mass distribution using an appropriate combination of parametric shapes. $m_{\mathrm{t}} = 172.13^{+0.69}_{-0.70}$ GeV.

Collaboration / Activity:

Compact Muon Solenoid (CMS)

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T12: Detector R&D and Data Handling / 349

A High-Granularity Timing Detector for the ATLAS Phase-II upgrade

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The increase of the particle flux (pile-up) at the HL-LHC with instantaneous luminosities up to L ~ 7.5 × 10^{34} cm$^{-2}s^{-1}$ will have a severe impact on the ATLAS detector reconstruction and trigger performance.
The end-cap and forward region where the liquid Argon calorimeter has coarser granularity and the inner tracker has poorer momentum resolution will be particularly affected. A High Granularity Timing Detector (HGTD) will be installed in front of the LAr end-cap calorimeters for pile-up mitigation and luminosity measurement.

The HGTD is a novel detector introduced to augment the new all-silicon Inner Tracker in the pseudo-rapidity range from 2.4 to 4.0, adding the capability to measure charged-particle trajectories in time as well as space.
Two silicon-sensor double-sided layers will provide precision timing information for minimum-ionising particles with a resolution as good as 30 ps per track in order to assign each particle to the correct vertex. Readout cells have a size of 1.3 mm × 1.3 mm, leading to a highly granular detector with 3.7 million channels. Low Gain Avalanche Detectors (LGAD) technology has been chosen as it provides enough gain to reach the large signal over noise ratio needed.

The requirements and overall specifications of the HGTD will be presented as well as the technical design and the project status. The on-going R&D effort carried out to study the sensors, the read-out ASIC, and the other components, supported by laboratory and test beam results, will also be presented.

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T12: Detector R&D and Data Handling / 351

ATLAS LAr Calorimeter Commissioning for LHC Run-3

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Liquid argon (LAr) sampling calorimeters are employed by ATLAS for all electromagnetic calorimetry in the pseudo-rapidity region |η| < 3.2, and for hadronic and forward calorimetry in the region from |η| = 1.5 to |η| = 4.9. After detector consolidation during a long shutdown, Run-2 started in 2015 and about 150 fb^{-1} of data at a center-of-mass energy of 13 TeV was recorded. Phase-I detector upgrades began after the end of Run-2. New trigger readout electronics of the ATLAS Liquid-Argon Calorimeter have been developed. Installation began at the start of the LHC shut down in 2019 and is expected to be completed in 2021. A commissioning campaign is underway in order to realise the capabilities of the new, higher granularity and higher precision level-1 trigger hardware in Run-3 data taking. This contribution will give an overview of the new trigger readout commissioning, as well as the preparations for Run-3 detector operation.

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T12: Detector R&D and Data Handling / 352

Machine Learning for Real-Time Processing of ATLAS Liquid Argon Calorimeter Signals with FPGAs

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Within the Phase-II upgrade of the LHC, the readout electronics of the ATLAS LAr Calorimeters is prepared for high luminosity operation expecting a pile-up of up to 200 simultaneous pp interactions. Moreover, the calorimeter signals of up to 25 subsequent collisions are overlapping, which increases the difficulty of energy reconstruction. Real-time processing of digitized pulses sampled at 40 MHz is thus performed using FPGAs.

To cope with the signal pile-up, new machine learning approaches are explored: convolutional and recurrent neural networks outperform the optimal signal filter currently used, both in assignment of the reconstructed energy to the correct bunch crossing and in energy resolution.

Very good agreement between neural network implementations in FPGA and software based calculations is observed. The FPGA resource usage, the latency and the operation frequency are analysed. Latest performance results and experience with prototype implementations will be reported.

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T12: Detector R&D and Data Handling / 353

Development of the ATLAS Liquid Argon Calorimeter Readout Electronics for the HL-LHC

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To meet new TDAQ buffering requirements and withstand the high expected radiation doses at the high-luminosity LHC, the ATLAS Liquid Argon Calorimeter readout electronics will be upgraded. Developments of low-power preamplifiers and shapers to meet low noise and excellent linearity requirements are ongoing in 130nm CMOS technology. In order to digitize the analogue signals on two gains after shaping, a radiation-hard, low-power 40 MHz 14-bit ADCs is developed in 65 nm CMOS. The signals will be sent at 40 MHz to the off-detector electronics, where FPGAs connected through high-speed links will perform energy and time reconstruction through the application of corrections and digital filtering. The data-processing, control and timing functions will be realized by dedicated boards connected through ATCA crates. Results of tests of prototypes of front-end components will be presented, along with design studies on the performance of the off-detector readout system.

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T12: Detector R&D and Data Handling / 356

FELIX and the SW ROD: commissioning the new detector interface for the ATLAS trigger and readout system

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After the current LHC shutdown (2019-2022), the ATLAS experiment will be required to operate in an increasingly harsh collision environment. To maintain physics performance, the ATLAS experiment is undergoing a series of upgrades. A key goal of this upgrade is to improve the capacity and flexibility of the detector readout system. To this end, the Front-End Link eXchange (FELIX) system has been developed. FELIX acts as the interface between the data acquisition; detector control and TTC (Timing, Trigger and Control) systems; and new or updated trigger and detector front-end electronics. The system functions as a router between custom serial links from front end ASICs and FPGAs to data collection and processing components via a commodity switched network. The serial links may aggregate many slower links or be a single high bandwidth link. FELIX also forwards the LHC bunch-crossing clock, fixed latency trigger accepts and resets received from the TTC system to front-end electronics. FELIX uses commodity server technology in combination with FPGA-based PCIe I/O cards. FELIX servers run a software routing platform serving data to network clients. Commodity servers connected to FELIX systems via the same network run the new multi-threaded Software Readout Driver (SW ROD) infrastructure for event fragment building, buffering and detector-specific processing to facilitate online selection. This presentation will cover the design of FELIX and the SW ROD, as well as the results of the installation and commissioning activities for the full system in spring 2021.

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T12: Detector R&D and Data Handling / 357

ATLAS Level-0 Endcap Muon Trigger for HL-LHC

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The design of the Level-0 endcap muon trigger for the ATLAS experiment at HL-LHC and the status of the development are presented. HL-LHC is planned to start the operation in 2027 with an instantaneous luminosity of 7.5 x 10^{34} cm$^{-2}s^{-1}$. In order to cope with the proton-proton collision rate higher than that of LHC, the trigger and readout system needs to be replaced. The new Level-0 endcap muon trigger system is required to reconstruct muon candidates with an improved momentum resolution to suppress the trigger rate with keeping the efficiency. That can be achieved by combining the signals from various subdetectors, thin gap chambers, resistive plate chambers, micromesh gaseous detectors, and scintillator-steel hadronic calorimeters, to form more offline-like tracks. The combined muon track reconstruction was demonstrated with Monte-Carlo simulation samples produced with the condition at HL-LHC. The efficiency was estimated to be greater than 90%, a few percent higher than the current system. The trigger rate was evaluated with proton-proton collision data taken with random trigger overlaid to account for a pileup of 200, which is expected at HL-LHC. The obtained value for momentum threshold of 20 GeV, primary threshold assumed for single muon trigger, is less than 30 kHz, which constitutes less than 3% of the assumed total Level-0 trigger rate of 1 MHz. Hardware implementation is planned with ATCA blades. First prototype of the ATCA blade has a Virtex UltraScale+ (XCVU13P) FPGA with 120 pairs of transceivers, which can be used to receive detector signals, and with huge memory resources suited for track reconstruction. The track reconstruction is based on a pattern matching algorithm using the detector hits and the predefined lists of hits corresponding to tracks. The algorithm with minimal utilisation of the XCVU13P FPGA resource is a major challenge. The track reconstruction firmware for full endcap coverage was provided and the implementation was succeeded with no timing violation by optimised latch circuit locations and logic grouping among Super Logic Regions. The performance was evaluated with the hit inputs from ATLAS GEANT4 full simulation. We achieved an angular resolution of less than 4 mrad, which satisfies the requirement, with less than 40% of the XCVU13P UltraRAM resources. The results constitute an important ingredients in the development of the Level-0 endcap muon trigger for HL-LHC.

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T12: Detector R&D and Data Handling / 358

The phase-1 upgrade of the ATLAS level-1 calorimeter trigger

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The ATLAS level-1 calorimeter trigger (L1Calo) is a hardware-based system that identifies events containing calorimeter-based physics objects, including electrons, photons, taus, jets, and missing transverse energy. In preparation for Run 3, when the LHC will run at higher energy and instantaneous luminosity, L1Calo is currently implementing a significant programme of planned upgrades. The existing hardware will be replaced by a new system of feature extractor (FEX) modules, which will process finer-granularity information from the calorimeters and execute more sophisticated algorithms to identify physics objects; these upgrades will permit better performance in a challenging high-luminosity and high-pileup environment. This talk will introduce the features of the upgraded L1Calo system and the plans for production, installation, and commissioning. In addition, the expected performance of L1Calo in Run 3 will be discussed.

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T12: Detector R&D and Data Handling / 361

Triggering in ATLAS in Run 2 and Run 3

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The ATLAS experiment at the LHC can record about 1 kHz of physics collisions, out of an LHC design bunch crossing rate of 40 MHz. To achieve a high selection efficiency for rare physics events while reducing the significant background rate, a two-level trigger system is used.

The event selection is based on physics signatures, such as the presence of energetic leptons, photons, jets or missing energy. In addition, the trigger system can exploit algorithms using topological information and multivariate methods to carry out the filtering for the many physics analyses pursued by the ATLAS collaboration. In Run 2, around 1500 individual selection paths, the trigger chains, were used for data taking, each with specified rate and bandwidth assignments.

We will give an overview of the Run-2 trigger menu and its performance, allowing the audience to get a taste of the broad physics program that the trigger is supporting. We present the tools that allow us to predict and optimize the trigger rates and CPU consumption for the anticipated LHC luminosities and outline the system to monitor deviations from the individual trigger target rates, and to quickly react to the changing LHC conditions and data taking scenarios.
As an outlook to the upcoming ATLAS data-taking period in Run 3 from 2022 onwards, we present the design principles and ongoing implementation of the new trigger software within the multi-threaded framework AthenaMT together with some outlook to the expected performance improvements.

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T12: Detector R&D and Data Handling / 362

Track and Vertex reconstruction in ATLAS for LHC Run 3 and High-Luminosity phases

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The determination of charged-particle trajectories (tracking) and the identification of primary collision vertices (vertexing) are complex parts of the event reconstruction chain in collider experiments and constitute the building blocks of most high level analysis objects. During the Run 2 data-taking in ATLAS, tracking was by far the most resource intensive step, for an average number of p-p collisions per bunch crossing (pile-up) ranging from 20 up to 60. The complexity of the combinatorial

problem increases dramatically with pile-up and the physics performance degrades as more low-quality tracks with mis-assigned, missing or randomly combined hits are reconstructed.
Averages of around 50 interactions per bunch-crossing are expected during the LHC Run 3, rising to about 200 during the High-Luminosity (HL) phase of the LHC, scheduled to start in about 5 years.
In order to cope with these challenging conditions and to maintain the physics performance reached up to LHC Run 2, a major rewrite of the Run 3 reconstruction software was performed while ATLAS prepares for a replacement of the current ATLAS Inner Detector with a new all-silicon Inner Tracker (ITk) for HL-LHC.
The Run 3 software improvements allowed to dramatically increase the reconstruction speed and pileup robustness. This included replacing the existing ATLAS vertexing with the pioneering use of elements of the ACTS software framework, which will become the backbone of ITk track reconstruction, in production.
In this talk, the improvements achieved for the track and vertex reconstruction to be used in the upcoming LHC Run 3 as well as the latest results on the expected performance of the ITk tracking and of other high-level object identification will be presented.

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T11: Quantum Field and String Theory / 369

Generalizing the Ryu-Takayanagi formula to probe entanglement shadows of BTZ black holes

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We define a generalized entanglement measure in the context of AdS_3/CFT_2. Compared to the ordinary entanglement entropy between spatial degrees of freedom dual to the area of the Ryu-Takayanagi surface, we take into account both entanglement between spatial degrees of freedom as well as between different fields of the boundary CFT. We then calculate this generalized entanglement measure in a thermal state dual to the BTZ black hole in the setting of the D1/D5 system at and close to the orbifold point. We find that the entanglement entropy defined in this way is dual to the length of a geodesic with non-zero winding number. Such geodesics probe the entire bulk geometry, including regions known as entanglement shadows which are not reached by any Ryu-Takayanagi surface. This allows us to describe regions close to the black hole horizon in the one-sided black hole and the wormhole growth in the case of a two-sided black hole from entanglement data in the boundary field theory. Therefore, we propose that entanglement is in fact enough to reconstruct the full BTZ geometry from boundary data.

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T12: Detector R&D and Data Handling / 370

ATLAS toward the High Luminosity era: challenges on electronic systems

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To maximize the physics reach, the LHC plans to increase its instantaneous luminosity to $7.5 \times 10^{34}\text{cm}^{-2}\text{s}^{-1}$, delivering from 3 to 4 ab^{-1} of data at $\sqrt{s}$ =14TeV. In order to cope with this operation condition, the ATLAS detector will require new sets of both front-end and back-end electronics. A new trigger and DAQ system will also be implemented with a single-level hardware trigger featuring a maximum rate of 1 MHz and 10μs latency. Enhanced software algorithms will further process and select events, storing them at a rate of 10 kHz for offline analysis. The large number of detector channels, huge volumes of input and output data, short time available to process and transmit data, harsh radiation environment and the need of low power consumption all impose great challenges on the design and operation of electronic systems. This talk will focus on these challenges, the proposed solutions and the latest results obtained from the prototypes.

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T12: Detector R&D and Data Handling / 371

The ATLAS detector evolution towards the High Luminosity era

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After 9 years of successful operation in proton-proton collisions reaching up to $\sqrt{s}$=13 TeV, the ATLAS detector started in 2018 the preparations for an ambitious physics program, aiming the exploration of very rare processes and extreme phase spaces, an endeavor that will require a substantial increase in the integrated luminosity. To accomplish this purpose, a comprehensive upgrade of the detector and associated systems was devised and planned to be carried out in two phases. ThePhase-I upgrade foresees new features for the muon detector, for the EM calorimeter trigger system and for all trigger and data acquisition chain. For the
Phase-II upgrade, ATLAS will fully replace its inner tracker, install a new timing detector and the calorimeters and muon systems will operate on a free-running readout scheme. This presentation will summarize the expected performance of the aforementioned projects, as well as the new insights gained during the construction phase. This abstract is being submitted by the ATLAS Upgrade

Speaker Committee representative. If approved, the speaker will be selected from ATLAS Collaboration and the conference will be informed.

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T12: Detector R&D and Data Handling / 372

The HL-LHC Upgrade of the ATLAS Tile Hadronic Calorimeter

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The High-Luminosity phase of LHC, delivering five times the LHC nominal instantaneous luminosity, is scheduled to begin in late 2027. The ATLAS Tile Hadronic Calorimeter (TileCal) will need new electronics to meet the requirements of a 1 MHz trigger, higher radiation dose, and to ensure sound performance under high pile-up conditions. Both the on- and off-detector TileCal electronics will be replaced during the shutdown of 2025-2027. PMT signals from every TileCal cell will be digitized and sent directly to the back-end electronics, where the signals are reconstructed, stored, and sent to the first level of trigger at a rate of 40 MHz. This will provide better precision of the calorimeter signals used by the trigger system and will allow the development of more complex trigger algorithms. The TileCal upgrade program has undergone extensive R&D and beam tests. A miniature "demonstrator" module has been tested in actual detector conditions. We will present the results of these studies.

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T12: Detector R&D and Data Handling / 373

Full-system commissioning of TGC frontend electronics for Phase-2 LHC-ATLAS

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The Thin Gap Chambers (TGCs) of the LHC-ATLAS are responsible for triggering muons in the endcap region at the hardware trigger stage. The frontend system of TGC will be upgraded for HL-LHC to send binary hit-map at every bunch crossing (BC) to the backend system. Such an operation requires lots of unique challenges: high-performance hit BC Identification, fine-tuned clock distribution, and the capability of timing calibration. Accommodating these requirements, the primary processor board (PS-Board) is in charge of data processing and reception of control signals distributed by the backend. An independent control module (JATHub) will take responsibility for FPGA configuration and clock phase monitoring of the PS-Boards with an SoC-based design. The timing calibration methodology for fine-tuning the clock phase and signal timing is migrated with highly-extended flexibility in the Phase-2 system, exploiting the experience accumulated through the construction, commissioning, and operation of the existing TGC system. System-level commissioning has been launched at KEK with prototypes of PS-Boards and JATHub and analogue frontend electronics of Amplifier-Shaper-Discriminator (ASD) cards. The full-chain testbed system allows us to demonstrate fundamental functionalities of Trigger, Readout, Control and Calibration: clock phase fine-tuning, signal timing calibration, and hit readout with test pulse injection to ASD channels with adjusted timing parameters.

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T12: Detector R&D and Data Handling / 374

Particle reconstruction performance studies of sMDT detector for the HL upgrade of the ATLAS Muon System

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The expected High Luminosity Large Hadron Collider (HL-LHC) operations require the experiments at the LHC to upgrade the detectors with new technologies to cope with an increased event rate. A new small-diameter Monitored Drift Tube (sMDT) chamber has been developed to upgrade the Muon Spectrometer of the ATLAS experiment. A prototype sMDT chamber has been constructed at the University of Michigan to demonstrate the required performance. In this talk I outline the methodology used to determine the detector tracking resolution and efficiency with cosmic ray muons, which includes a reconstruction of sMDT data and a simulation of the test chamber with Geant4.

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T12: Detector R&D and Data Handling / 376

The New Small Wheel upgrade project of the ATLAS Experiment

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The ATLAS experiment is currently upgrading the first muon station in the high-rapidity region with the construction of new detector structures, named New Small Wheels (NSW), based on large-size multi-gap resistive strips Micromegas technology and small-strip Thin Gap Chambers (sTGC).
The NSW system will be installed in the ATLAS underground cavern during the LHC long shutdown 2 to enter in operation for Run3.
The construction of Micromegas and sTGC series detectors is now close to completion at the construction sites distributed all around the world. At CERN, the final validation and integration of the modules in sectors composing the wheel is well advanced, as well as the installation on the final structure and the commissioning on surface.
In this presentation the motivation of the NSW upgrade and the current status of the project will be reviewed, with particular focus on the main challenges and the measured performance of the system.

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Collaboration / Activity:

ATLAS Collaboration

T12: Detector R&D and Data Handling / 378

Test of ATLAS Micromegas detectors with ternary gas mixture at the CERN GIF++ facility.

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The ATLAS collaboration at LHC has chosen the resistive Micromegas technology, along with the small-strip Thin Gap Chambers (sTGC), for the high luminosity upgrade of the first muon station in the high-rapidity region, the New Small Wheel (NSW) project. Micromegas quadruplets have been constructed at the involved construction sites in France, Germany, Italy, Russia and Greece. At CERN, the final validation and the integration of the modules in Sectors and their commissioning are in progress. The achievement of the requirements for these detectors revealed to be even more challenging than expected. One of the main features being studied is the HV stability of the detectors. Several approaches have been tested in order to enhance the stability, among them the use of different gas mixtures are being studied. A ternary argon-CO2-isobutane mixture has shown to be effective in dumping discharges and dark currents. The presence of isobutane in the mixture required a set of ageing studies, ongoing at the GIF++ radiation facility at CERN, where the expected HL LHC background rate is reached by a 137Cs 14 TBq source of 667 keV photons. Preliminary ageing results and effectiveness of the ternary mixture will be shown.

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Collaboration / Activity:

ATLAS Collaboration

T12: Detector R&D and Data Handling / 379

Electronic integration and commissioning of the New Small Wheel small-strip Thin Gap Chambers

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To enhance the Level-1 muon trigger selectivity and maintain good muon tracking capability under future HL-LHC runs with an instantaneous luminosity of 5-7x10^{34}cm$^{-2}s^{-1}$, the ATLAS experiment plans to replace the present innermost station of Muon Spectrometer in the forward region, Small Wheels, with the New Small Wheel (NSW) detector system during its Phase-I upgrade. The NSW features two novel gaseous detector technologies, Micro Mesh Gaseous Structures (MM) and small-strip Thin Gap Chambers (sTGC). The sTGC is the primary trigger detector for the NSW, which utilizes three different types of readout electrode: pads, strips and wires. It is expected to provide segment measurements with 1 mrad accuracy for Level-1 triggering as well as high precision offline tracking under background rate up to 20kH/cm^2.

The sTGC electronics system employs more than 1.5k Front-end Boards populated with radiation-tolerant ASICs (Application Specific Integrated Circuit), as well as additional FPGA-based custom-made electronics cards to deal with ~400K readout channels. Complex high-speed interconnections among ASICs and electronics cards are designed to simultaneously handle a large volume of trigger and readout data from two separate data paths. The Level-1 readout up to 1 MHz is accomplished via the Front-End Link Interface eXchange (FELIX) system through the optical GBT (GigaBit Transceiver) links. The track segment reconstruction for Level-1 trigger is achieved with custom-made trigger processors hosted by an ATCA-based system.

The sTGC detector system is currently under integration and commissioning at CERN. The validation of connectivity among ~14k readout ASICs and high-speed (up to 4.8 Gbps) links, the calibration of numerous clock phases, channel threshold for optimum detector timing and operation, and the essentiality to address sensitive noise issues due to the large capacitance from sTGC pads, all pose major challenges for the final commissioning. In this presentation we will show the status and progress on the sTGC electronics integration and commissioning, the experiences gained from the establishment of integration procedures and quality control. Performance and validation of the assembled detector system will also be presented.

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Collaboration / Activity:

ATLAS Collaboration

T12: Detector R&D and Data Handling / 381

Tracking performance with the HL-LHC ATLAS detector

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During the High-Luminosity phase of LHC, scheduled to start in 2026, the ATLAS detector is expected to collect more than 3ab−1 of data at an instantaneous luminosity reaching up to 7.5×10^{34} cm$^{-2}s^{-1}$, corresponding to about 200 inelastic proton-proton collisions per bunch crossing. In order to cope with the large radiation doses and to maintain the physics performance reached up to LHC Run 3, the current ATLAS Inner Detector will be replaced with a new all-silicon Inner Tracker (ITk), whose layout has been recently updated to bring the innermost pixel layer at a radius of R=34 mm. In this talk, the latest results on the expected performance of the ITk tracking and of other high-level object identification will be presented.

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T06: QCD and Hadronic Physics / 382

Double parton scattering studies in CMS

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Recent results of the study of double parton scattering with the CMS experiment using states of a Z boson and jets, and of four jets will be presented.

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Collaboration / Activity:

CMS

T06: QCD and Hadronic Physics / 383

Measurement of the Drell-Yan transverse momentum dependence over a wide mass range at 13 TeV from CMS

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The differential cross section measurements of the production of a Drell-Yan pair of opposite-charged leptons (electrons or muons) as a function of pT and phi* in various bins of its invariant mass m as

well as ratios of these cross sections to the on-shell one are presented. The results are obtained using proton-proton collision data recorded with the CMS detector at the LHC. Measurements are compared to state-of-the-art generators also including TMD based predictions.

Collaboration / Activity:

CMS

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T12: Detector R&D and Data Handling / 384

CMS MTD Barrel Timing Layer: Precision Timing at the HL-LHC

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The Compact Muon Solenoid (CMS) detector at the CERN Large Hadron Collider (LHC) is undergoing an extensive Phase II upgrade program to prepare for the challenging conditions of the High-Luminosity LHC (HL-LHC). A new timing detector in CMS will measure minimum ionizing particles (MIPs) with a time resolution of 30-40 ps for MIP signals at a rate of 2.5 Mhit/s per channel at the beginning of HL-LHC operation. The precision time information from this MIP Timing Detector (MTD) will reduce the effects of the high levels of pileup expected at the HL-LHC, bringing new capabilities to the CMS detector. The barrel timing layer (BTL) of the MTD will use sensors that are based on LYSO:Ce scintillation crystals coupled to SiPMs with TOFHIR ASICs for the front-end readout. In this talk we will present motivations for precision timing at the HL-LHC and an overview of the MTD BTL design, including ongoing R&D studies targeting enhanced timing performance and radiation tolerance.

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 385

Precision Timing with Low Gain Avalanche Detectors with the CMS Endcap Timing Layer for HL-LHC

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The MIP Timing Detector (MTD) of the Compact Muon Solenoid (CMS) will provide precision timestamps with 40 ps resolution for all charged particles up to a pseudo-rapidity of $|\eta|=3$. This upgrade will mitigate the effects of pile-up expected under the High-Luminosity LHC running conditions and bring new and unique capabilities to the CMS detector. The endcap region of the MTD, called the Endcap Timing Layer (ETL), will be instrumented with silicon low gain avalanche detectors (LGADs), covering the high-radiation pseudo-rapidity region $1.6 < |\eta| < 3.0$. The LGADs will be read out with the ETROC readout chip, which is being designed for precision timing measurements. We present recent progress in the characterization of LGAD sensors for the ETL and development of ETROC, including test beam and bench measurements.

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Collaboration / Activity:

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T06: QCD and Hadronic Physics / 387

Heavy flavored emissions in hybrid collinear/high energy factorization (12'+3')

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Heavy-flavored emissions have been always considered as an excellent channel to test properties of Quantum chromodynamics (QCD) at present and future colliders. Among different regimes, in which heavy-flavor production can be investigated, we focus our attention on the semi-hard one, where $s >> Q^2 >> \Lambda_{QCD}$ (s is the squared center-of-mass energy, $\{Q^2\}$ a (set of) hard scale(s) characteristic of the process and Λ_{QCD} the QCD mass scale). Here, we build predictions in a hybrid collinear/high-energy factorization, in which the standard collinear description is supplemented by the Balitsky-Fadin-Kuraev-Lipatov resummation of large energy logarithms. The definition and the study of observables sensitive to high-energy dynamics in the context of heavy-flavor physics has the double advantage of (i) allowing to get a stabilization of the BFKL series under higher order corrections and (ii) providing us with an auxiliary tool to investigate heavy-flavor production in wider kinematical ranges. Hence, we propose a scientific program on heavy flavor physics at high energy that starts from the production of open states, with the ultimate goal of considering bound states (such as heavy-light mesons and quarkonia).

In this talk, after a brief overview on the theoretical set-up of high-energy factorization in the case of heavy-quark production, I will present some recent phenomenological analyses involving heavy-quark open states as well as bound states.

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T14: Outreach, Education and Diversity / 388

The IPPOG resource database: particle physics reaching out globally

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The International Particle Physics Outreach Group (IPPOG) has been making concerted and systematic efforts to present and popularize particle physics across all audiences and age groups since almost 25 years. Today the scientific community has in IPPOG a strategic pillar in fostering long-term, sustainable support for fundamental research around the world. One of the main tools IPPOG has been offering to the scientific community, teachers and educators since almost 10 years is the Resource Database (RDB), an online platform containing the collection of high-quality engaging education and outreach materials in particle physics and related sciences. After almost 10 years, a new digital portfolio aiming to greatly broaden the audience type and strengthen the user experience, is being developed including a new RDB, which is currently undergoing a major curation process in order to ensure the resources are up-to-date and of the highest quality. IPPOG wants the new website to become more open to students, teachers, and the general public and the new RDB to become the primary source of particle physics outreach material in the world, which would help to bring particle physics closer to the society.

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Collaboration / Activity:

IPPOG

T06: QCD and Hadronic Physics / 389

Search for contact interactions with inclusive jet production at the LHC at 13 TeV with CMS

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The inclusive jet production cross sections and triple-differential cross sections of top quark-antiquark pair production at the LHC at a center of mass energy of 13 TeV are used together with data of inclusive deep inelastic scattering to extract the parton distributions of the proton and the strong coupling constant. In an additional analysis of the same data, the standard model cross section is extended with effective couplings for 4-quark contact interactions. In particular, left-handed vector-like or axial-vector like colour-singlet exchanges are considered. These would correspond to beyond-the-standard model scenarios with quark substructure, Z' or extra dimensions. For the first time, the Wilson coefficients of contact interactions are extracted simultaneously with the standard model parameters using the LHC data.

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Collaboration / Activity:

CMS

T04: Neutrino Physics / 391

CP-Violating Neutrino Non-Standard Interactions in Long-Baseline-Accelerator Data

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Neutrino oscillations in matter provide a unique probe of new physics. Leveraging the advent of neutrino appearance data from NOvA and T2K in recent years, we investigate the presence of CP-violating neutrino non-standard interactions in the oscillation data. We first show how to very simply approximate the expected NSI parameters to resolve differences between two long-baseline appearance experiments analytically. Then, by combining recent NOvA and T2K data, we find a tantalizing hint of CP-violating NSI preferring a new complex phase that is close to maximal: $\phi_{e\mu}$ or $\phi_{e\tau} \approx 3\pi/2$ with $|\epsilon_{e\mu}|$ or $|\epsilon_{e\tau}|{\sim}0.2$. We then compare the results from long-baseline data to constraints from IceCube and COHERENT.

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Collaboration / Activity:

Theory

T07: Top and Electroweak Physics / 392

Search for vector boson scattering with the semi-leptonic VW signature at CMS

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A search for the electroweak VBS production of a VW pair plus two jets, in the semi-leptonic channel, at a centre-of-mass energy of 13 TeV is reported. The data sample corresponds to the full Run-II CMS dataset of proton-proton collisions at 13 TeV including an integrated luminosity of 137.1 fb−1. Events are analyzed in two energy regimes: either the hadronically decaying W/Z boson is reconstructed as one large-radius jet, or it is identified as a pair of jets with dijet mass near to W/Z mass. Machine learning models are optimized for the signal extraction and the classifiers are interpreted using tools from the explainable machine learning field. The overwhelming background contribution from the single W production plus jets is measured in dedicated control regions implementing a data-driven strategy.

Collaboration / Activity:

CMS

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T08: Flavour Physics and CP Violation / 393

Probing Leptophobic $U(1)_H$ Theories at the J-PARC KOTO

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$K_L \to \pi\nu\nu$ is one of the attractive processes to test new physics beyond the Standard Model (SM). It is drawing attention, thanks to the effort of the KOTO collaboration. In this talk, we briefly study the K_L decay and other relevant flavor violating processes in a class of type-II two Higgs doublet models with extra gauged $U(1)_H$ symmetry. We sort few examples where the source of missing energy in Kaon decays is given by either dark bosons or massive neutrinos. We focus on the setup where effects of the extra gauge boson and of pseudoscalar portals will emerge primarily at the electroweak penguin level of $\Delta F = 1, 2$ processes. We show that J-PARC KOTO most stringent upper limit for the branching ratio of $K_L \to \pi\nu\nu$ leads to important bounds for leptophobic and multi-Higgs $SM \otimes U(1)_X$ theories, at or below the electroweak scale, comparable to the limits provided by hadron colliders.

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Collaboration / Activity:

T07: Top and Electroweak Physics / 394

Prospects for yy->WW at the High-Luminosity LHC

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Photon fusion is a rare and interesting process at proton colliders, with a remarkably clean signature that has little (if any) remnant activity from the interacting particles. A particularly interesting photon-induced process, the production of W-boson pairs (yy->WW), was recently observed using the 139/fb of proton-proton collision data collected by ATLAS at √s=13TeV during LHC Run-2. In this [talk/poster], the prospects for exploiting yy->WW at the High-Luminosity LHC (HL-LHC) will be presented. Photon-fusion analyses will be more difficult at the HL-LHC due to increased pile-up activity, which spoils the clean signature of the photon-fusion process. The expected sensitivity of the HL-LHC yy->WW analysis will be presented, including the impact of planned and possible detector

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ATLAS

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T09: Higgs Physics / 395

CP structure of the tau Yukawa coupling with CMS

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The CMS experiment at LHC has performed the first measurement of the CP structure of the Yukawa coupling between the Higgs boson and tau leptons. The measurement is based on data collected in proton-proton collisions at sqrt(s) = 13 TeV during 2016-18, corresponding to an integrated luminosity of 137 fb^-1. The analysis utilizes the angular correlation between the decay planes of tau leptons produced in Higgs boson decays, where dedicated analysis techniques are used to optimise the reconstruction of tau decay planes. The measured value of CP mixing angle is 4 +/- 17^o, at 68% confidence level. The pure CP-odd hypothesis is excluded by 3.2 standard deviations. The analysis strategies and the results of the measurement are presented.

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Collaboration / Activity:

CMS

T01: Astroparticle and Gravitational Waves / 396

Lunar Gravitational-Wave Antenna

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Gravitational waves excite quadrupolar vibrations of elastic bodies. Monitoring these vibrations was one of the first concepts proposed for the detection of gravitational waves by Joseph Weber. At laboratory scale, these experiments became known as resonant-bar detectors, which form an important part of the history of GW detection. Due to the dimensions of these bars, the targeted signal frequencies were in the kHz range. It was also Weber who suggested to monitor vibrations of Earth and Moon to search for gravitational waves in the mHz band. His Lunar Surface Gravimeter was deployed on the Moon in 1972 by the Apollo 17 crew. A design error made it impossible to carry out the intended search for GWs, but the idea remains intriguing. We have proposed a new concept, the Lunar Gravitational-Wave Antenna (LGWA), based on Weber's idea. LGWA would have a rich GW and multi-messenger science case with galactic binaries and massive black-hole binaries potentially closing the frequency gap between LISA and terrestrial GW detectors. It would also serve as a high-precision geophysical station shedding light on the interior structure of the Moon, the mechanisms of moonquakes, and the Moon's formation history. LGWA's key component is a next-generation, high-sensitivity seismometer to be deployed on the Moon. For its most sensitive realization, LGWA would have to be deployed in a permanent shadow near the north or south pole of the Moon to benefit from the natural cryogenic environment. This would improve the sensitivity of the seismometer and also provide a lower-noise environment due to the absence of thermally induced seismic events that were observed in large numbers by the Apollo seismometers. Powering of the seismic stations and data transfer pose additional challenges for such a deployment.

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Collaboration / Activity:

LGWA

T10: Searches for New Physics / 398

New physics searches with the ILD detector at the ILC

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Although the LHC experiments have searched for and excluded many proposed new particles up to masses close to 1 TeV, there are many scenarios that are difficult to address at a hadron collider. This talk will review a number of these scenarios and present the expectations for searches at an electron-positron collider such as the International Linear Collider. The cases discussed include the light Higgsino, the stau lepton in the coannihilation region relevant to dark matter, and heavy vector bosons coupling to the s-channel in e+e- annihilation. The studies are based on the ILD concept at the ILC.

Collaboration / Activity:

The ILD concept group

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T12: Detector R&D and Data Handling / 399

Charged Hadron Identification with dE/dx and Time-of-Flight at Future Higgs Factories

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The design of detector concepts has been driven since a long time by requirements on transverse momentum, impact parameter and jet energy resolutions, as well as hermeticity. Only rather recently it has been realised that the ability to idenfity different types of charged hadrons, in particular kaons and protons, could have important applications at Higgs factories, ranging from improvements in tracking, vertexing and flavour tagging to measurements requiring strangeness-tagging. While detector concepts with gaseous tracking can exploit the specific energy loss, all-silicon-based detectors have to rely on fast timing layers in front of or in the first layers of their electromagnetic calorimeters. This presentation will review the different options for realising kaon and proton identification, introduce recently developed reconstruction algorithms and present full detector simulation prospects for physics applications using the example of the ILD detector concept.

Collaboration / Activity:

The ILD concept group

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T12: Detector R&D and Data Handling / 400

Kinematic fitting for ParticleFlow Detectors at Future Higgs Factories

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Many physics analyses in Higgs, top and electroweak physics improve the kinematic reconstruction of the final state by constrained fits. This is a particularly powerful tool at e^+e^- colliders, where the initial state four-momentum is known and can be employed to constrain the final state. A crucial ingredient to kinematic fitting is an accurate estimate of the measurement uncertainties, in particular for composed objects like jets. This contribution will show how the particle flow concept, which

is a design-driver for most detectors proposed for future Higgs factories, can — in addition to an excellent jet energy measurement — provide detailed estimates of the covariance matrices for each individual particle-flow object and each individual jet. Combined with information about leptons and secondary vertices in the jets, the kinematic fit enables to correct b- and c-jets for missing momentum from neutrinos from semi-leptonic heavy quark decays. The impact on the reconstruction of invariant di-jet masses and the resulting improvement in ZH vs ZZ separation will be presented, using as example the full simulation of the ILD detector concept. As an outlook, the expected benefit for the Higgs self-coupling measurement from double Higgs production will be discussed.

Collaboration / Activity:

the ILD concept group

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T01: Astroparticle and Gravitational Waves / 401

Neutrino Telescope in Lake Baikal: Present and Nearest Future

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The progress in the construction and operation of the Baikal Gigaton Volume Detector in Lake Baikal is reported. The detector is designed for search for high energy neutrinos whose sources are not yet reliably identified. It currently includes over 2300 optical modules arranged on 64 strings, providing an effective volume of 0.4 km3 for cascades with energy above 100 TeV. We review the construction plan and first results from the partially built detector which is currently the largest neutrino telescope in the Northern Hemisphere and still growing up.

Collaboration / Activity:

Baikal-GVD

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T09: Higgs Physics / 402

A combined fit to the Higgs Branching Ratios at ILD

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We introduce here a new method to measure the Higgs decay branching ratios at future e^+e^- Higgs factories, by directly exploiting class numeration. Given the clean environment at a lepton collider, we build an event sample highly enriched in Higgs bosons and essentially unbiased for any decay mode. The sample can be partitioned into categories using event properties linked to the expected Higgs decay modes. The counts per category are used to fit the Higgs branching ratios in a model independent way. The result of the fit is directly the set of branching ratios, independent from any measurement of a Higgs production mode. Special care is given to an appropriate treatment of the statistical uncertainties. In this contribution, the current status of our implementation of this analysis within the ILD concept detector is presented.

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Collaboration / Activity:

The ILD concept group

T05: Heavy Ion Physics / **404**

Studying of final states in p-Au and p-Pb collisions

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In the framework of PYTHIA8.2 program we considered p-Pb and p-Au heavy ion collisions at the energy of 5.02 TeV and 8 TeV. The advantage of this program is in the combining of several nucleon-nucleon collisions into one heavy ion collision, based on phenomenological treatment of a hadron as a vortex line in a colour superconducting medium, the consistent treatment of the central rapidity region with improvements of Glauber-like model where diffractive excitation processes are taken into account. We have considered the influence of impact parameter correlations on the production cross sections of p-Pb and p-Au processes to estimate the influence of hard and soft subprocesses on basic hadronic final-state properties in proton-ion collisions. Using these characteristics based on semi-hard multiparton interaction model we received the transverse momentum and rapidity distributions of K-meson and Lambda baryon at the energy of 5.02 TeV and 8 TeV.

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Collaboration / Activity:

High energy physics

T04: Neutrino Physics / 405

Constraining ESSnuSB neutrino flux by observing elastic scattering of neutrinos on electrons

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ESSnuSB is a design study for a future experiment which will measure CP violation in the lepton sector at the second neutrino oscillation maximum. Since the experiment will observe muon neutrino to electron neutrino oscillations, it is important to measure interaction cross section of electron neutrinos with water. For this purpose, neutrino flux at near detector site must be precisely known. This poster will show the progress done in constraining the ESSnuSB neutrino flux by considering the elastic scatterings of neutrinos on orbital electrons observed at the near water Cherenkov detector.

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Collaboration / Activity:

ESSnuSB

T04: Neutrino Physics / 406

First Sub-eV Neutrino Mass Limit from the KATRIN Experiment

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The KATRIN experiment is designed to measure the effective electron anti-neutrino mass m_ν with a sensitivity close to 0.2 eV by investigating the energy spectrum of tritium β-decay. After a brief introduction of the experiment, we will focus on the results from our second data taking phase which took place in autumn 2019. For this period, the source activity was increased by a factor of four with respect to the first campaign and around 4.2 million electrons were collected in the region of interest. A fit to this data including all dominant uncertainties yields $m_\nu^2 = 0.26 \pm 0.34$ eV^2. This corresponds to an upper limit of $m_\nu < 0.9$ eV (sensitivity $m_\nu < 0.7$ eV) using the method of Lokhov and Tkachov. Finally, we will give a brief outlook on the upcoming measurement phases.

Collaboration / Activity:

KATRIN

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T01: Astroparticle and Gravitational Waves / 408

Constraining alternative theories of gravity using the latest LIGO-Virgo ringdown observations

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Detections of black hole mergers from the LIGO-Virgo interferometers provide an unprecedented opportunity to glance into unexplored regimes of gravity, where spacetime curvature is several orders of magnitudes larger than the one probed by other experiments. First, the state of the art of black holes ringdown spectral observations will be reviewed. Next, we will show how requiring stringent, yet well-motivated, perturbative parametrisations of beyond- General Relativity effects, allows to extract strong observational constraints on large classes of alternative theories of gravity. Such a boost brings observations close to the regime where corrections from Effective Field Theories of beyond-General Relativity gravity may start to leave a detectable imprint, and translates into a much smaller number of signals needed to detect violations due to an alternative theory of gravity. Finally, we will show what constraints can be placed on a few specific theories, where a self-consistent, non-perturbative prediction can be tested against the data.

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Collaboration / Activity:

Member of LIGO-Virgo-Kagra

T09: Higgs Physics / 409

Recent results in the H->WW channel with CMS

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We present recent results on the cross section measurement of the Higgs boson production using WW decays and the corresponding constraints on the Higgs boson couplings, as well as constraints on new physics models derived from high mass searches. The poster is focused on the recent measurements exploiting the full Run 2 proton-proton collision data collected by the CMS detector.

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Collaboration / Activity:

CMS Collaboration

T01: Astroparticle and Gravitational Waves / **410**

Constraining and comparing short gamma-ray burst beam profiles using gravitational waves

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GRB 170817A was markedly dissimilar to any other detected short gamma-ray burst as it was observed off-axis. This was further made evident by the information gained from the accompanying observation of GW170817. The event has since sparked discussion into the short gamma-ray burst beam profile and how it can link the observed luminosity of GRB 170817A with the rest of the observed on-axis short gamma-ray burst population. By assuming the short gamma-ray burst beam profile is universal across events, we use a fully Bayesian analysis to place constraints on beam profiles associated with cocoon, structured and simple top-hat jet models, as well as the binary neutron star merger rate. The beam profiles are constrained to reconcile the discrepancy between GRB 170817A and the rest of the on-axis population, given the distance and inclination information from GW170817 and the neutron star merger rate inferred from LIGO's first and second observing runs. We further show that these models can be distinguished from one another given a population of future gravitational wave detections of neutron star mergers with and without a counterpart, promised by the observations made by third-generation detectors.

Collaboration / Activity:

Collaboration

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T01: Astroparticle and Gravitational Waves / **411**

Jet-induced high-energy neutrino and electromagnetic counterparts of supermassive black hole mergers

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Supermassive black hole (SMBH) coalescences are ubiquitous in the history of the Universe and often exhibit strong accretion activities and powerful jets. These SMBH mergers are also promising candidates for future gravitational wave detectors such as Laser Space Inteferometric Antenna (LISA). In this work, we investigate the neutrino and electromagnetic counterpart emissions originating from

the jet-induced shocks. We formulate the jet structures and relevant interactions therein, and then evaluate neutrino emission from each shock site. We find that month-to-year high-energy neutrino emission from the postmerger jet after the gravitational wave event is detectable by IceCube-Gen2 within approximately five to ten years of operation in optimistic cases where the cosmic-ray loading is sufficiently high and a mildly super-Eddington accretion is achieved. In addition, based on our model that predicts slowly fading transients with durations of ~1−10 months with a time delay from days to months after the coalescence, we discuss implications for EM follow-up observations after the GW detection.

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Collaboration / Activity:

N/A

T01: Astroparticle and Gravitational Waves / 413

Probing the standard cosmological model with the population of binary black-holes

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Gravitational-wave (GW) detections are rapidly increasing in number, enabling precise statistical analyses of the population of compact binaries. In this talk I will show how these population analyses cannot only serve to constrain the astrophysical formation channels, but also to learn about cosmology. The three key observables are the number of events as a function of luminosity distance, the stochastic GW background of unresolved binaries and the location of any feature in the source mass distribution, such as the expected pair instability supernova (PISN) gap. Given data from LIGO-Virgo observations, I will present constraints in cosmological modifications of gravity. I will also discuss future prospects on measuring H_0 given a possible population of black holes above the PISN gap. These novel tests of the standard cosmological model require GW data only and will become increasingly relevant as GW catalogs grow, specially if multi-messenger events remain elusive.

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University of Chicago

T10: Searches for New Physics / 415

Search for exotic decays of the Higgs Boson using photons with the CMS experiment

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In multiple beyond the SM scenarios, the 125 GeV Higgs boson can decay to light pseudoscalars (a), which each decay into two photons, resulting in a four photon final state. We present a search for exotic decays of the SM Higgs boson in the four photon final state using 131.8 fb-1 of proton-proton collision data collected by the CMS experiment at a center-of-mass energy of 13 TeV. This analysis probes pseudoscalars that range in mass from 15 GeV to 60 GeV and decay into photons that are reconstructed as resolved objects in the CMS electromagnetic calorimeter. Although the branching fraction for $a \longrightarrow \gamma\gamma$ is subdominant, the low backgrounds in 4γ make it an interesting and important final state. These new results, the first in the four photon final state from CMS, set limits on the production cross-section of the SM Higgs boson times the branching ratio of $h \longrightarrow aa \longrightarrow \gamma\gamma\gamma\gamma$ as a function of pseudoscalar mass.

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Collaboration / Activity:

CMS

T04: Neutrino Physics / 416

New physics from oscillations: sensitivity for the DUNE near detector

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We study the capabilities of the DUNE near detector to probe deviations from unitarity of the leptonic mixing matrix, the 3+1 sterile formalism and NSI in detection and production, clarifying the relation and possible mappings among the three formalisms. We add to the current analyses in the literature the use of the charged current events for the $\nu\tau$ appearance channel and the consideration of the energy spectral uncertainty (shape uncertainty) of the background. We find that this plays an important role on the results, and is usually overlooked in the literature. Even with this more conservative and realistic approach, we still obtain an improvement in the sensitivity with respect to the current bounds.

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Collaboration / Activity:

Theory

T05: Heavy Ion Physics / 417

Non-prompt D_s^+ production in pp and Pb–Pb collisions with ALICE

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High-energy heavy-ion collisions produce a state of strongly-interacting matter characterised by high energy density and temperature. In these extreme conditions, according to quantum chromodynamics (QCD) calculations on the lattice, matter undergoes a phase transition to a quark–gluon plasma (QGP) state in which quarks and gluons are deconfined.
The production of strange quarks in heavy–ion collisions is enhanced with respect to other light-flavoured quarks compared to proton–proton collisions. Thus also the production via coalescence of charm and beauty hadrons with strange-quark content is expected to be enhanced with respect to the one of non-strange hadrons in case of hadronisation of heavy quarks via recombination with the light quarks in the medium. In this scenario, measurements of D_s^+ mesons originating from the hadronisation of a charm quark (prompt) and from beauty-hadron decays (non-prompt) offer a unique tool to study the hadronisation mechanism of both charm and beauty quarks in the quark–gluon plasma.
In particular, the production of non-prompt D_s^+ mesons allows the study of the hadronisation of beauty quarks since about half of them originate from B_s^0-meson decays. This makes the non-prompt D_s^+ mesons a sensitive probe to the enhancement of beauty-strange meson production.
In this contribution, the latest results of the ALICE Collaboration on the production of non-prompt D_s^+ mesons in pp and Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$~TeV with Machine-Learning techniques will be presented. Indeed, these measurements could provide important information about the hadronisation of heavy quarks to strange heavy-flavour hadrons relative to that of heavy-flavour hadrons without strange-quark content.
Furthermore, the first measurement of non-prompt D_s^+ nuclear modification factor ($R_{\rm AA}$) in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$~TeV will be presented and compared to the one of prompt D_s^+ and non-prompt D^0 mesons.
Finally, the expected performance for the measurement of non-prompt D_s^+ mesons with ALICE in the LHC Run 3 and 4 will be presented.

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Collaboration / Activity:

ALICE Collaboration

T10: Searches for New Physics / 418

Physics Beyond SM at the HL-LHC with CMS

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The High-Luminosity Large Hadron Collider (HL-LHC) is expected to deliver an integrated luminosity of up to 3000 fb-1. The very high instantaneous luminosity will lead to about 200 proton-proton collisions per bunch crossing ("pileup") superimposed to each event of interest, therefore providing extremely challenging experimental conditions. Prospects for future BSM Physics studies at the HL-LHC at CMS are presented.

Collaboration / Activity:

CMS

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T07: Top and Electroweak Physics / 419

Recent VBS scattering measurement with two vector bosons in the final state

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The full Run II CMS dataset (137.1 fb^{-1}) of proton-proton collisions at a center-of-mass energy of 13 TeV is analyzed, to search for the electroweak VBS production of an opposite sing pair of W bosons plus two jets in the fully leptonic channel. Events are selected requiring two leptons (electrons or muons) and two jets with large pseudorapidity separation and high invariant mass; they are divided into three categories according to the flavor of the final state leptons. Machine learning techniques are employed to deal with the irreducible background from the QCD induced production of W bosons and the overwhelming background from the production of top quarks pair.

Collaboration / Activity:

CMS

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T02: Cosmology / 420

Cosmic Axion Background: the QCD axion as a hot relic

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QCD Axions can be produced in various ways in the Early Universe by scatterings and decays from Standard Model particles, forming thus a Cosmic Axion Background that contributes to the abundance of relativistic relics (N_eff). We review in various setups how this is already constrained by present experiments and how it could be observed by future CMB experiments, in particular focusing on the coupling to quarks and leptons, the bounds on the DFSZ model, and also the connection with the Xenon1T excess.

Collaboration / Activity:

Theory

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T07: Top and Electroweak Physics / 421

Interplay of beam polarisation and systematic uncertainties at future e+e- colliders

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Future high-energy e^+e^- colliders will provide some of the most precise tests of the Standard Model. Statistical uncertainties on electroweak precision observables and triple gauge couplings are expected to improve by orders of magnitude over current measurements.

This provides a new challenge in accurately assessing and minimising the impact of systematic uncertainties. Beam polarisation may hold a unique potential to isolate and determine the size of systematic effects. So far, studies have mainly focused on the statistical improvements from beam polarisation. This study aims to assess, for the first time, its impact on systematic uncertainties.

A combined fit of precision observables, such as chiral fermion couplings and anomalous triple gauge couplings, together with experimental systematic effects is performed on generator-level differential distribution of 2-fermion and 4-fermion final-states. Different configurations of available beam polarisations and luminosities are tested with and without systematic effects, and will be discussed in the context of the existing projections on fermion and gauge boson couplings from detailed experimental simulations.

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Collaboration / Activity:

ECFA Study

T12: Detector R&D and Data Handling / 423

Detector Challenges of the strong-field QED experiment LUXE at the European XFEL

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The LUXE experiment aims at studying high-field QED in electron-laser and photon-laser interactions, with the 16.5 GeV electron beam of the European XFEL and a laser beam with power of up to 350 TW. The experiment will measure the spectra of electrons and photons in non-linear Compton scattering where production rates in excess of 109 are expected per 1 Hz bunch crossing. At the same time positrons from pair creation in either the two-step trident process or the Breit-Wheeler process will be measured, where the expected rates range from 10^-3 to 10^3 per bunch crossing, depending on the laser power and focus. These measurements have to be performed in the presence of low-energy high radiation-background. To meet these challenges, for high-rate electron and photon fluxes, the experiment will use Cherenkov radiation detectors, scintillator screens, sapphire sensors as well as lead-glass monitors for backscattering off the beam-dump. A four-layer silicon-pixel tracker and a compact electromagnetic tungsten calorimeter with GaAs sensors will be used to measure the positron spectra. The layout of the experiment and the expected performance under the harsh radiation conditions will be presented.

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Collaboration / Activity:

LUXE

T10: Searches for New Physics / 424

Probing new physics at the LUXE experiment

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The proposed LUXE experiment at the DESY aims to probe QED at the nonperturbative regime in collisions between high-intensity laser pulses and high-energy electron or photon beams. This setup also provides a unique opportunity to search for physics beyond the standard model. In this talk we show that by leveraging the large photon flux generated at LUXE, one can probe axion-like-particles (ALPs) up to a mass of 350 MeV and with photon coupling of 3x10^-6 GeV^-1. This reach is comparable to FASER2 and NA62. In addition, we will discuss other probes of new physics such as the ALP-electron coupling.

Collaboration / Activity:

LUXE

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T01: Astroparticle and Gravitational Waves / 426

A hybrid simulation of gravitational wave production in first-order phase transitions

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The LISA telescope will provide the first opportunity to probe the scenario of a first-order phase transition happening close to the electroweak scale. In thermal transitions, the main contribution to the GW spectrum comes from the sound waves propagating through the plasma. Current estimates of the GW spectrum are based on numerical simulations of a scalar field interacting with the plasma or on analytical approximations – the so-called sound shell model. In this work we present a novel setup to calculate the GW spectra from sound waves. We use a hybrid method that uses a 1d simulation (with spherical symmetry) to evolve the velocity and enthalpy profiles of a single bubble after collision and embed it in a 3d realization of multiple bubble collisions, assuming linear superposition of the velocity and enthalpy. The main advantage of our method compared to 3d hydrodynamic simulations is that it does not require to resolve the scale of bubble wall thickness. This makes our simulations more economical and the only two relevant physical length scales that enter are the bubble size and the fluid shell thickness (that are in turn enclosed by the box size and the grid spacing). The reduced costs allow for extensive parameter studies and we provide a parametrization of the final GW spectrum as a function of the wall velocity and the fluid kinetic energy.

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Collaboration / Activity:

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T11: Quantum Field and String Theory / 428

Massive Integrability: From Fishnet Theories to Feynman Graphs and Back

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Since the rise of the AdS/CFT duality, integrability has proven to be an important tool to advance our understanding of massless QFT. In this talk we demonstrate that integrability is also present in massive QFT in D>2 spacetime dimensions. We show that large classes of massive Feynman integrals are highly constrained by an infinite dimensional Yangian symmetry. When translated to momentum space, this leads to a novel massive generalization of conformal symmetry. Finally, we argue that these features of Feynman integrals can be understood as the integrability of planar scattering amplitudes in a massive version of the so-called fishnet theory, which is obtained as a double-scaling limit of N=4 super Yang-Mills theory on the Coulomb branch.

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Collaboration / Activity:

-

T04: Neutrino Physics / 430

A simple solution to the LSND, MiniBooNE and muon g-2 anomalies

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We show that one of the simplest extensions of the Standard Model, the addition of a second Higgs doublet, when combined with a dark sector singlet scalar, allows us to: i) explain the long-standing anomalies in the Liquid Scintillator Neutrino Detector (LSND) and MiniBooNE (MB) while maintaining compatibility with the null result from KARMEN, ii) obtain, in the process, a portal to the dark sector, and iii) comfortably account for the observed value of the muon $g-2$. Three singlet neutrinos allow for an understanding of observed neutrino mass-squared differences via a Type I seesaw, with two of the lighter states participating in the interaction in both LSND and MB. We obtain very good fits to energy and angular distributions in both experiments. We explain features of the solution presented here and discuss the constraints that our model must satisfy. We also mention prospects for future tests of its particle content.

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Collaboration / Activity:

LSND, MiniBooNE

T07: Top and Electroweak Physics / 431

Inclusive and differential cross-sections measurements in the single top tW e-mu channel with CMS

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An inclusive and normalised differential cross sections measurements are presented for the production of single top quarks in association with a W boson, in proton-proton collisions at a centre-of-mass energy of 13 TeV. Events containing one muon and one electron in the final state are analysed. For the inclusive measurement, a multivariate discriminant, exploiting the kinematic properties of the events, is used to separate the signal from the dominant ttbar background. For the differential measurements, a fiducial region is defined according to the detector acceptance, and the requirement of exactly one b-tagged jet. The resulting distributions are unfolded to particle-level and compared with predictions calculations at next-to-leading order in perturbative QCD. Within current uncertainties, all predictions agree with the data.

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Collaboration / Activity:

CMS collaboration

T09: Higgs Physics / 432

Measurement of the Higgs boson production in association with top quarks in final states with multileptons using data taken during the Run 2 of the LHC with CMS

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The production of the Higgs boson in association with a pair of top-antitop quarks is studied using final states with multiple leptons in proton-proton collisions collected by the CMS experiment a $\sqrt{s}$ = 13 TeV centre-of-mass energy, during the Run 2 of the LHC. Machine learning and matrix element techniques are used to enhance the sensitivity of the analysis by discriminating signal and backgrounds. The measured production rates are used to determine constraints on the Yukawa coupling of the Higgs boson to the top quark.

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Collaboration / Activity:

CMS

T08: Flavour Physics and CP Violation / 433

Exploring B-physics anomalies at colliders

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The experimental measurements on flavour physics, in tension with Standard Model predictions, exhibit large sources of Lepton Flavour Universality violation. We perform an analysis of the effects of the global fits to the Wilson coefficients assuming a model independent effective Hamiltonian approach, by including a proposal of different scenarios to include the New Physics contributions. A discussion of the implications of our analysis in leptoquark models is included. We conclude with an overview of the impact of the future generation of colliders in the field of B-meson anomalies.

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Collaboration / Activity:

CAPA

T12: Detector R&D and Data Handling / 434

Performance of the CMS muon trigger system in proton-proton collisions at 13 TeV

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During Run 2 (covering 2015–2018) the LHC achieved instantaneous luminosities as high as 2x10^34cm^2s^1 while delivering proton-proton collisions at \sqrt{s}=13 TeV. The challenge for the trigger system of the CMS experiment is to reduce the registered event rate from about 40 MHz to about 1 kHz. In this poster, muon reconstruction and identification algorithms used during Run 2 and their improvements are presented. The new algorithms maintain the acceptance of the muon triggers at the same or even lower rate throughout the data-taking period despite the increasing number of additional proton-proton interactions in each LHC bunch crossing. We will focus on the single and double muon triggers with the lowest sustainable transverse momentum thresholds used by CMS. The efficiency is measured in a transverse momentum range from 8 to several hundred GeV.

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Collaboration / Activity:

CMS collaboration

T03: Dark Matter / **436**

Direct detection of non-galactic light dark matter

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A fraction of the dark matter in the solar neighborhood might be composed of non-galactic particles with speeds larger than the escape velocity of the Milky Way. The non-galactic dark matter flux would enhance the sensitivity of direct detection experiments, due to the larger momentum transfer to the target.

In this note, we calculate the impact of the dark matter flux from the Local Group and the Virgo Supercluster diffuse components in nuclear and electron recoil experiments. The enhancement in the signal rate can be very significant, especially for experiments searching for dark matter induced electron recoils.

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T06: QCD and Hadronic Physics / **439**

Studies of excited heavy flavor states at CMS (12'+3')

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Recent CMS results on spectroscopy of heavy mesons and baryons are reported.

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Collaboration / Activity:

CMS

T08: Flavour Physics and CP Violation / 440

Searches for rare decays at CMS

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Rare decays provide a sensitive laboratory to search for New Physics. Recent CMS results concerning rare decays are presented.

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Collaboration / Activity:

CMS

T06: QCD and Hadronic Physics / 442

Recent study about XYZ particles at BESIII (12'+3')

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In this talk recent XYZ results at BESIII will be reviewed, that includes: Observation of a near-threshold enhancement in the Lambda Lambda-bar mass spectrum from e+ e- -> phi Lambda Lambda-bar at the center-of-mass energies from 3.51 to 4.60 GeV; Observation of e+ e- -> eta psi(2S) at the center-of-mass energies from 4.236 to 4.600 GeV; Cross section measurement of e+ e- -> p pbar eta and e+ e- -> p pbar omega at center-of-mass energies between 3.773 GeV and 4.6 GeV; Search for reaction e+ e- -> chi_cJ pi+ pi- and a charmonium-like structure decaying to chi_cJ pi+/- between 4.18 and 4.60 GeV; Search for the reaction channel e+ e- -> eta_c eta pi+ pi- at center-of-mass energies from 4.23 to 4.60 GeV.

Collaboration / Activity:

BESIII

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T08: Flavour Physics and CP Violation / 443

Leptonic and semileptonic D decays at BESIII

Author: Zhiqing Liu[1]

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BESIII has collected 2.9 and 6.3 fb-1 of e+e- collision data samples at 3.773 and 4.178-4.226 GeV, respectively. We report recent measurements of the (semi)leptonic decays D(s) -> l+nu (l=mu, tau) and D(s) -> X l+nu [X=K(*), rho, eta('), a_0, K_1, and l=e, mu]. The decay constants f_D(s), the semileptonic form factors f(0) and the CKM matrix elements |V_cs(d)| are determined precisely. These results are important to verify the LQCD calculations of f_D(s) and f(0) and the CKM matrix unitarity. Precision tests of lepton-flavor universality with (semi)leptonic D decays are also made.

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Collaboration / Activity:

BESIII

T08: Flavour Physics and CP Violation / 444

Measurements of strong-phase parameters at BESIII

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BESIII has collected 2.9 of e+e- collision data sample at 3.773 GeV. We report recent measurements of strong phase differences in D0 and D0-bar decays of KSpi+pi-, KSK+K-, K-pi+pi+pi- and K-pi+pi0. The obtained parameters are important to reduce the systematic uncertainty in the gamma/phi_3 measurement at LHCb and Belle II.

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Collaboration / Activity:

BESIII

T06: QCD and Hadronic Physics / 446

Light meson spectroscopy at BESIII (12'+3')

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Due to the high production of light mesons J/ψ radiative and hadronic decays, the largest sample of J/ψ events accumulated at the BESIII detector offers a unique laboratory to study the light mesons spectroscopy and search for the light exotic states. In this talk, we shall report the recent progresses on the light meson spectroscopy achieved at BESIII.

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Collaboration / Activity:

BESIII

T08: Flavour Physics and CP Violation / 448

Light hyperon physics at BESIII

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The BESIII experiment at the electron positron collider BEPCII in Beijing is successfully operating since 2008 and has collected large data samples in the tau-mass region, including the world's largest data samples at the J/ψandψ(2S) resonances. The recent observations of hyperon polarizations at BESIII, which opens a new window for searching new physics beyond the SM, also attracts both experimental and theoretical attentions. In this presentation recent results on hyperon physics achieved at BESIII will be highlighted.

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Collaboration / Activity:

BESIII

T06: QCD and Hadronic Physics / 449

Measurements of the R value at BESIII

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The R value, defined as the ratio of the inclusive hadronic cross section and the muon cross section in e+e- collisions, is an important input for the calculation of the Standard Model predictions of the anomalous magnetic moment of the muon a_mu and the running of the QED coupling constant alpha_QED(m_Z) evaluated at Z pole. The BESIII collaboration has collected data with high statistics to measure the R value at more than 130 scan points between 2.0 and 4.6 GeV. In this presentation, the measurement between 2.2324 and 3.6710 GeV is discussed. On average, a total uncertainty of less than 3% is achieved, which is dominated by the systematic uncertainty.

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Collaboration / Activity:

BESIII

T06: QCD and Hadronic Physics / 450

Study of phi(2170) at BESIII (12'+3')

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In e+e- collisions between 2 and 3 GeV, excited states of rho, omega and phi can be produced directly. Especially the resonances around 2GeV like rho(2000), rho(2150) and \phi(2170) are not fully understood yet. Theorists describe the phi(2170) as a traditional s s-bar state, an s s-bar g hybrid, a tetraquark state, a Lambda Lambda-bar bound state, or a phi KK resonance. The predicted decay widths vary strongly depending on the assumed nature of phi(2170). With energy scan data collected by the BESIII collaboration between 2.0 GeV and 3.08 GeV, the properties of phi(2170) are studied systematically in PWAs of its expected decay modes, such as e+e- -> K+K-pi0pi0, phi eta', phi eta, K+K-, and eta' pi+pi-.

Collaboration / Activity:

BESIII

First author:

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T06: QCD and Hadronic Physics / 451

Recent result of nucleon time-like form factors at BESIII

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Nucleons are one of the most fundamental building blocks of ordinary matter, yet their internal structure and dynamics are still not fully understood. Electromagnetic form factors allow to investigate fundamental properties of the nucleon. The BESIII collaboration has studied the time-like form factors of the proton using the energy scan and the ISR technique. The |GE/GM| ratio is obtained with a precision comparable to the investigations of the space-like EMFF in electron proton scattering. The effective form factor of the neutron is measured with highest precision using the scan method. For both nucleons, an intriguing periodic behavior of effective form factors lineshape is observed. In this presentation the latest results on nucleon form factors at BESIII are discussed.

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Collaboration / Activity:

BESIII

T07: Top and Electroweak Physics / 453

Measurement of multileptonic WZ properties with the CMS detector at 13 TeV

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New results are presented corresponding to the measurement of several properties of WZ production in the CMS experiment. The measurements profit from the high purity of the three lepton final state and the whole luminosity of the Run II of the LHC to provide precisions never reached before on this diboson process.

Inclusive and differential cross section measurements are complemented with studies of the asymmetry in the plus and minus charged WZ production, and studies on the gauge boson polarization states. In total they provide an extended picture of the observed properties of the process and their compatibility with SM predictions.

Additionally, an interpretation in terms of new physics as a search for several EFT parameters affecting the WWZ charged triple gauge coupling in WZ production is presented.

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Collaboration / Activity:

CMS Collaboration

T03: Dark Matter / 454

The Cygno Experiment

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The detection of ultra-rare events as the interaction of galactic dark matter (DM) candidate particles or of neutrinos originated from the Sun requires the development of innovative detection techniques. In particular future experiments for direct DM detection requires to extend their sensitivity to masses well below 10 GeV.

The Cygno collaboration plans to build and operate at LNGS a cubic meter demonstrator of a gaseous time projection chamber (TPC), equipped with an optical readout and using a He:CF4 gas mixture kept at atmospheric pressure. The presence of low Z atoms allows to reach a competitive sensitivity to DM masses in the GeV range while the presence of fluorine can be used to set limits on a spin-dependent DM interaction cross-section.

The Cygno TPC is equipped with a Gas Electron Multipliers (GEM) amplification stage of the primary ionization electrons. Light is produced from the GEM while scientific CMOS cameras and fast photodetectors are combined to obtaining a three-dimensional reconstruction of the tracks either due to nuclear or to electron recoils.
The design and the sensitivity of the demonstrator based on advanced Monte Carlo simulations of the radioactivity of the materials and of the LNGS cavern are reported. Pattern recognition algorithms are used to evaluate the identification capability of nuclear recoils against electronic recoils and studied in data from small scale prototypes. Energy measurement and also sensitivity to the source directionality are also evaluated. Therefore, a Cygno TPC would also be able to detect electron recoils originated by solar neutrinos interactions.
The Cygno collaboration plans to demonstrate the scalability of such detector concept to reach a target mass large enough to significantly extend our knowledge about DM nature and solar neutrinos.

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Collaboration / Activity:

CYGNO collaboration

T12: Detector R&D and Data Handling / 455

Challenges & Solutions for Building High Data Rate Archival Software for an Astronomy Experiment

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Ground-based gamma-ray telescopes are built to detect Cerenkov radiation generated by the interaction of the earth's atmosphere and gamma rays coming from different astronomical sources. Major

Atmospheric Cerenkov Experiment (MACE) is a 21m diameter ground-based high energy gamma-ray telescope set up by BARC at Hanle (32.7◦ N, 78.9◦ E, 4270 m asl) in the Ladakh region of North India. The telescope consists of various subsystems like camera and data acquisition system, mirror alignment, telescope control unit, sky monitoring, weather monitoring, calibration system, operator console, data archival, and analysis systems. These subsystems generate data at different rates and the archiving system has to handle this varied data rate, providing sufficient read-write speed for real-time analysis. The camera and data acquisition system generates maximum data at an estimated rate of 1kHz with an average throughput of ~20 MB/sec, which may increase with the increase of hit pixels. Storage of such large data and subsequent analysis has led to the requirement for developing a robust and fault-tolerant data archiving software. In this paper, we present a detailed software architecture, design, implementation, and testing of the Data Archival System (DArS) Software for MACE Telescope. We describe the challenges faced in our previous implementation and how this design has helped us solve the issues. Generic software architecture has been designed which can be adopted for systems with similar functional requirements. The design principles followed provide scalability and maintainability of the software.

Collaboration / Activity:

B.A.R.C , MACE Project

First author:

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T04: Neutrino Physics / 457

New approach to neutrino masses and leptogenesis with Occam's razor

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I will discuss a new Occam's razor setup in the minimal type-I seesaw framework with maximally-restricted texture-zero Yukawa and mass matrices. In this setup, we include charged-lepton mixing parametrized by a single angle, which is predicted to be very close to the quark Cabibbo angle. In this case, compatibility with normally-ordered neutrino masses (currently preferred by data) is achieved and the atmospheric mixing angle is predicted to lie in the second octant. Furthermore, the observed baryon asymmetry of Universe is successfully generated for a leptogenesis scale of the order of 10^{11} GeV, being compatible with vanilla scenarios for Peccei-Quinn axion dark matter where the reheating temperature of the Universe is typically below 10^{12} GeV.

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T02: Cosmology / 458

Early galaxy formation and its implications for 21cm cosmology, dark matter and multi-messenger astronomy

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Galaxy formation in the first billion years mark a time of great upheaval in the history of the Universe: as the first sources of light, these galaxies ended the 'cosmic dark ages' and produced the first photons that could break apart the hydrogen atoms suffusing all of space starting the process of cosmic reionization. As the earliest building blocks, the galaxies that formed in the first billion years also determine the physical properties of all subsequent galaxy populations. I will start by introducing the reionization process and detail the reasons for which the history and topology of reionization remain debated. I will then show how cross-correlations of 21cm data with the underlying galaxy population, in the forthcoming era of 21cm cosmology, will yield tantalising constraints on the average intergalactic medium ionization state as well as the reionization toplogy (outside-in versus inside-out). I will try to give a flavour of how the assembly of early galaxies, accessible with the forthcoming James Webb Space Telescope, can provide a powerful testbed for Dark Matter models beyond "Cold Dark Matter". Finally, I will show the importance of black hole seeding and baryonic feedback in determinging the LISA detectability of merger events from the early universe.

Collaboration / Activity:

SKA, Euclid, LISA

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T05: Heavy Ion Physics / 459

Limits for anomalous magnetic and electric dipole moments of tau leptons from heavy-ion UPCs

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Physics of ultraperipheral ultrarelativistic heavy-ion collisions gives an excellent opportunity to study photon-photon interaction. Vast moving charged particles are surrounded by an electromagnetic field that can be considered as a source of (almost real) photons. The photon flux scales as the square of the nuclear charge, so ^{208}Pb has a considerable advantage over protons as far as the flux of photons is considered. We would like to report our analysis on the possibility to set limits on anomalous magnetic and/or electric dipole moments of τ leptons produced in ultraperipheral heavy ion collisions.

We shall discuss the dependence of $\gamma\gamma \to \tau^+\tau^-$ differential cross section on anomalous magnetic and electric dipole couplings of photons to τ lepton. A similar analysis is done for ultraperipheral Pb+Pb collisions at the LHC. We investigate the sensitivity on a_τ and d_τ, assuming standard LHC detectors using the currently available as well as future datasets. In particular, we propose to use cross section ratios of the $\gamma\gamma \to \tau^+\tau^-$ and $\gamma\gamma \to e^+e^-/\mu^+\mu^-$ processes to probe anomalous magnetic and electric dipole moments. This trick allows to cancel several systematic uncertainties. Due to a short lifetime of τ lepton, the experimental knowledge on a_τ is worse by several orders of magnitude than those for of a_e and a_μ. Our studies show that the currently available sample of the

LHC experiments is already sufficient to improve the sensitivity on a_τ by a factor of two compared to the best LEP2 result. Hence, we consider this analysis as highly interesting and worthwhile to be done in the future.

Published in: Phys. Lett. **B809** (2020) 135682,
M. Dyndal, M. Klusek-Gawenda, M. Schott and A. Szczurek,
"Anomalous electromagnetic moments of τ lepton in $\gamma\gamma \to \tau^+\tau^-$ reaction in Pb+Pb collisions at the LHC"

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Collaboration / Activity:

Theory

T03: Dark Matter / 460

The Dark-PMT: A Novel Direction Light Dark Matter Detector Based on Vertically-Aligned Carbon Nanotubes

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We present the latest results on the development of the Dark-PMT, a novel light Dark Matter (DM) detector. The detector is designed to be sensitive to DM particles with mass between 1 MeV and 1 GeV. The detection scheme is based on DM-electron scattering inside a target made of vertically-aligned carbon nanotubes. Vertically-aligned carbon nanotubes have vanishing density in the direction of the tube axes, therefore the scattered electrons can leave the target without being reabsorbed only if their momentum is parallel to the tubes, which is what happens when the tubes are parallel to the DM wind. This grants directional sensitivity to the detector, a unique feature in this DM mass range. We will report on the construction of the first Dark-PMT prototype, on the establishment of a state-of-the-art carbon nanotube growing facility in Rome, and on the characterizations of the nanotubes performed in Rome with XPS and angular-resolved UPS spectroscopy.

Collaboration / Activity:

Dark-PMT

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T05: Heavy Ion Physics / 461

From Wigner distributions of photons to dilepton production in semicentral heavy ion collisions

Authors: Mariola Kłusek-Gawenda[1]; Antoni Szczurek[2]; Wolfgang Schafer[3]

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Ultrarelativistic Heavy Ions of large charge Z are accompanied by a large flux of Weizsacker–Williams photons. This opens up the opportunity to study a variety of single photon induced nuclear processes, as well as photon-photon processes.

We would like to present a formalism which allows to calculate differential distributions of dileptons produced via photon-photon fusion in semi-central (impact parameter $< 2 \times$ nuclear radius) nucleus-nucleus collisions for a given centrality. In this approach the differential cross section is calculated using the complete polarization density matrix of photons resulting from the Wigner distribution formalism. We will present several differential distributions such as invariant mass of dileptons, dilepton transverse momentum and acoplanarity for different regions of centrality. The results of the calculations will be compared to experimental data of the STAR, ALICE and ATLAS collaborations. Very good agreement with the data is achieved without free parameters in all cases. Additional final state rescattering of leptons in the quark-gluon plasma is not needed. Our new approach based on Wigner distributions of photons gives a much better agreement with experimental data than the previous approaches used in the literature.

M. Kłusek-Gawenda, W. Schaefer and A. Szczurek,
"Centrality dependence of dilepton production via $\gamma\gamma$ processes from Wigner distributions of photons in nuclei,"
Phys. Lett. **B814**, 136114 (2021), [arXiv:2012.11973 [hep-ph]].

Collaboration / Activity:

Theory

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T04: Neutrino Physics / 462

Long Range Interactions in Cosmology: Implications for Neutrinos

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Co-author: Jordi Salvado [2]

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Cosmology is well suited to study the effects of long range interactions due to the large densities in the early Universe. In this talk, I will explore how the energy density and equation of state of a fermion system diverge from the commonly assumed ideal gas form under the presence of scalar long range interactions with a range much smaller than cosmological scales. In this scenario, "small"-scale physics can impact our largest-scale observations. As a benchmark, I will apply the formalism

to self-interacting neutrinos, performing an analysis to present and future cosmological data. I will explore how this fully removes the cosmological neutrino mass bound, opening the possibility for a laboratory neutrino mass detection in the near future. I will also discuss an interesting complementarity between neutrino laboratory experiments and the future EUCLID survey.

Collaboration / Activity:

Based on arXiv:2101.05804

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T02: Cosmology / 463

Long Range Interactions in Cosmology: Implications for Neutrinos

Authors: Ivan Esteban[1]; Jordi Salvado[2]

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[2] *Institute of Cosmos Sciences, University of Barcelona*

Cosmology is well suited to study the effects of long range interactions due to the large densities in the early Universe. In this work, we explore how the energy density and equation of state of a fermion system diverge from the commonly assumed ideal gas form under the presence of scalar long range interactions with a range much smaller than cosmological scales. In this scenario, "small"-scale physics can impact our largest-scale observations. As a benchmark, we apply the formalism to self-interacting neutrinos, performing an analysis to present and future cosmological data. We explore how this fully removes the cosmological neutrino mass bound, opening the possibility for a laboratory neutrino mass detection in the near future. We also discuss an interesting complementarity between neutrino laboratory experiments and the future EUCLID survey.

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Collaboration / Activity:

Based on arXiv:2101.05804

T12: Detector R&D and Data Handling / 464

New ideas on detector technology for the ILC experiments

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Detector concepts are being developed for the foreseen electron-positron International Linear Collider (ILC) in Japan. The detectors are being optimized for precision physics in a range of energies between 90 GeV and 1 TeV. This talk will summarize the required performance of detectors, the proposed implementation and the readiness of different technologies needed for the deployment at ILC.

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Collaboration / Activity:

ILC IDT WG3

T09: Higgs Physics / 465

ILC Higgs physics potential

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Higgs factories based on e+e- colliders have the potential to measure the complete profile of the Higgs boson at a level of precision that goes qualitatively beyond the expect capabilities of the LHC. This talk will review the program of Higgs boson coupling measurements expected from the International Linear Collider, including the most recent updates. These measurements span the range of e+e- CM energies from 250 GeV to 1 TeV, and include precision measurements of the top quark Yukawa coupling and the Higgs self-coupling.

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Collaboration / Activity:

ILC IDT WG3

T09: Higgs Physics / 466

Higgs invisible and rare decays at ILC

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[1] *University of Oregon*

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The operation of an e+e- collider at a CM energy of 250 GeV will yield a large sample of Higgs bosons that are tagged by recoil against an observed Z boson at a fixed laboratory energy. By selecting these Z bosons and looking on the other side of the event, e+e- colliders will be sensitive to essentially all possible rare and exotic Higgs boson decay channels, in most cases down to branching ratios of order 10^{-4}. This includes channels important for theories beyond the Standard Model such as H-> b bbar + (missing energy) and H-> b sbar that are very difficult to observe at the LHC. This talk will review the expectations for the discovery of new decay modes of the Higgs boson at the International Linear Collider.

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Collaboration / Activity:

ILC IDT WG3

T07: Top and Electroweak Physics / **467**

Top quark physics at ILC

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The top quark has not yet been studied in the extremely favorable and low background environment of e+e- annihilation. This talk will review the opportunities for precision measurements of the top quark properties at the International Linear Collider (ILC). These include the archival measurement of the top quark mass, the search for beyond-Standard Model contributions to the top quark electroweak form factors, and the search for CP violation in the top quark couplings.

Collaboration / Activity:

ILC IDT WG3

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T03: Dark Matter / **468**

Probing dark matter with ILC

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The International Linear Collider (ILC) offers a number of unique opportunities for searches for dark matter and dark sector particles. The collider program will offer important capabilities, but also, the ILC will enable new fixed-target experiments using the high-energy electron and positron beams, both beam dump experiments and dedicated experiments using single beams. This talk will describe the expectations for these programs, which address all of the possible dark sector portals.

Collaboration / Activity:

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T08: Flavour Physics and CP Violation / 469

CP violation in the Higgs sector at ILC

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Baryogenesis in the early universe requires a new source of CP violation beyond that in the CKM model. Perhaps the most promising place to look is in the Higgs sector. Though the Standard Model predicts that the couplings of the Higgs boson are exactly CP-conserving, more general models of the Higgs sector give many opportunities for CP violation. This talk will discuss the expectations for searches for these CP-violating couplings in the high-precision study of the Higgs boson at the International Linear Collider (ILC).

Collaboration / Activity:

ILC IDT WG3

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T07: Top and Electroweak Physics / 471

New electroweak challenges and opportunities at the LHeC

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Co-author: Yuji Yamazaki [2]

[1] *UCLouvain*

[2] *Kobe University*

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The Large Hadron-Electron Collider (LHeC) will operate at √s = 1.2 TeV and accumulate about 1/ab of integrated electron-proton luminosity 1. We report here results of a novel study of high energy photon-photon interactions at the LHeC, at the ⊠⊠ center-of-mass energy of up to 1 TeV, opening new frontiers in the electroweak physics. Despite very high *ep* luminosity, the experimental conditions will be very favorable at the LHeC –a negligible event pileup will allow for unique studies of exclusive production via two-photon fusion. We discuss a number of such processes, as ⊠⊠ $\longrightarrow WW$ for example, including estimates of their principal backgrounds. We conclude by evaluating the impact of measurements at the LHeC of such two-photon interactions on testing of the electroweak sector of Standard Model and searches for physics beyond the SM.

1 P. Agostini et al. (LHeC Study Group), *The Large Hadron-Electron Collider at the HL-LHC*, accepted by J. Phys. G; https://arxiv.org/abs/2007.14491.

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Collaboration / Activity:

LHeC/EIC/Virgo

T06: QCD and Hadronic Physics / **472**

Production of fully heavy tetraquarks in proton-proton collisions (12'+3')

Authors: Rafał Maciuła[1]; Wolfgang Schafer[1]; Antoni Szczurek[2]

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[2] *Institute of Nuclear Physics PAN, Krakow and Rzeszow University, Rzeszow*

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We discuss the production mechanism of a new state, a fully charm tetraquark, discovered recently by the LHCb at M = 6.9 GeV in the $J/\psi J/\psi$ channel. Both single parton scattering (SPS) and double parton scattering (DPS) mechanisms are considered. We calculate the distribution in the invariant mass of the four-quark system M_{4c} for SPS and DPS production of $cc\bar{c}\bar{c}$ in the k_t-factorization approach with modern unintegrated gluon distribution functions (UGDFs). The so-calculated contribution of DPS is almost two orders of magnitude larger than the SPS one, but the tetraquark formation mechanism is unknown at present. We construct a simple coalescence model of the tetraquark out of $c\bar{c}\bar{c}$ continuum. Imposing a mass window around the resonance position we calculate the corresponding distribution in $p_{t,4c}$ – the potential tetraquark transverse momentum. The cross section for the $J/\psi J/\psi$ continuum is calculated in addition, again including SPS (box diagrams) and DPS contributions which are of similar size. The formation probability is estimated trying to reproduce the LHCb signal-to-background ratio. The calculation of the SPS $gg \to T_{4c}(6900)$ fusion mechanism is performed in the k_T-factorization approach assuming different spin scenarios (0^+, 0^- and 2^+). The 2^+ and 0^+ assignment is preferred over the 0^- one by a comparison of the transverse momentum distribution of signal and background with the LHCb preliminary data assuming the SPS mechanism dominance. There is no microscopic approach for the DPS formation mechanism of tetraquarks at present as this is a complicated multi-body problem.

We do similar analysis for FCC energy $\sqrt{s}$ = 100 TeV. We predict the production cross section order of magnitude larger than its counterpart for the LHC. We discuss also a possibility to observe the T_{4c} state in the $\gamma\gamma$ channel. The signal-to-background ratio is estimated.

We discuss also production of $c\bar{c}b\bar{b}$ tetraquarks and discuss how the results depend on the mass of such an object.

First part of the presentation will be based on our recent paper:

R. Maciu{\l}a, W. Sch\"afer and A. Szczurek,
"On the mechanism of $T_{4c}(6900)$ tetraquark production",
Phys. Lett. B812 (2021) 136010.

Collaboration / Activity:

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T03: Dark Matter / 473

Status of the LUX-Zeplin Detector

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The nature and origin of dark matter are among the most compelling mysteries of contemporary science. For over three decades, physicists have been trying to detect dark matter particles via collisions on target nuclei. Noble gases, in particular Xenon, have demonstrated leading sensitivities to WIMP-type dark matter due to their excellent radiopurity, chemical inertness, self-shielding, and particle discrimination properties. LUX-ZEPLIN (LZ) is located 1.5 km underground at the Sanford Underground Research Facility in Lead, South Dakota. By utilizing 7 tonnes of active liquid Xenon, the world's largest target mass, in a dual-phase time-projection chamber LZ will achieve a sensitivity of 1.4x10^(−48) cm^2 to 40 GeV WIMPs in a 1000 day exposure. To achieve the backgrounds necessary for this experiment a rigorous radioassay, radon emanation, and cleanliness programs were employed and an active veto detector is built around the TPC. This presentation gives an overview of the LZ experiment, its design goals, and the status of construction and operations.

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Collaboration / Activity:

LZ Collaboration

First author:

Björn Penning

T08: Flavour Physics and CP Violation / 474

CP-Violating Invariants in the SMEFT

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[1] *UNI/TH (Uni Hamburg, Institut fuer Theoretische Physik)*

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In the Standard Model, CP violation in the Electroweak sector is parametrized by the Jarlskog Invariant. This is the flavor invariant sensitive to CP violation with the least number of Yukawa matrices that can be built. When higher dimensional operators are allowed, and the Standard Model Effective Field Theory is constructed, numerous new sources for CP violation can appear. However, the description of CP violation as a collective effect, present in the SM, is inherited by its Effective extension. Here, I will discuss how such a behaviour can be consistently captured, at dimension 6, by flavor invariant, CP violating objects, linear in the Wilson coefficients. Such a description ensures that CP violation in the SMEFT is treated in a basis independent manner. In particular, I claim these are the objects that have to vanish, together with the SM Jarlskog Invariant, for CP to be conserved, and viceversa. The scaling properties of these invariants demonstrates that, while CP is not an accidental symmetry of the Standard Model, its breaking is accidentally small at the renormalizable level. Implications for specific flavor models, such as MFV, will be addressed.

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Collaboration / Activity:

DESY

T06: QCD and Hadronic Physics / **475**

Production of dileptons via photon-photon fusion in proton-proton collisions with one forward proton measurement

Authors: Barbara Linek[None]; Marta Luszczak[1]; Antoni Szczurek[2]

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We discuss mechanisms of dilepton production in proton-proton collisions with rapidity gap in the main detector and one forward proton in the forward proton detectors. This is relevant for LHC measurements by ATLAS+AFP and CMS+PPS. Transverse momenta of the intermediate photons are included and photon fluxes are expressed in terms of proton electromagnetic form factors and structure functions. Differential distributions in $\xi_{1/2}$, M_{ll}, Y_{ll}, $p_{t,ll}$ are shown and the competition of different mechanisms is discussed. Both double-elastic and single-dissociative processes are included in the calculation. We discuss also mechanism with one forward Δ^+ isobar, or other proton resonances in the final state not discussed so far in the literature. The role of several cuts is studied. The rapidity gap survival factor is calculated for each contribution separately. The soft rapidity gap survival factor for the case of single proton measurement is significantly smaller than that for the inclusive case (no proton measurement). The gap survival with and without proton measurement in forward proton detector are compared and the underlying dynamics is discussed. The dependence on the parametrization of the proton structure functions is shown in addition. The gap survival factor for the single-dissociative mechanism due to minijet emission into the main detector are calculated

in addition. The corresponding gap survival factor depends on the invariant mass of the dilepton system as well as the mass of the proton remnant and rapidity of the lepton pair.

A. Szczurek, B. Linek and M. {\L}uszczak, a paper in preparation.

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Collaboration / Activity:

T13 - Accelerator for HEP / 476

The beam-size effect at the EIC and LHeC

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The beam-size effect was discovered at the VEPP-2 collider and later observed at HERA but remained ever since an elusive and poorly studied phenomenon, despite its impact on the electron and positron beam lifetimes at LEP and KEKB, for example. At the Electron-Ion Collider (EIC), due to very small vertical beam sizes, this effect will be even stronger than at HERA and we propose to test its understanding by use of the van der Meer beam scans 1. Such an understanding of the electron-hadron bremsstrahlung is essential for a precise determination of the EIC luminosity, and in that context, we have also studied the impact of the beam-size effect on the bremsstrahlung yields at the future Large Hadron electron Collider (LHeC) [2].

1 K. Piotrzkowski, M. Przybycien, When invariable cross sections change: The Electron-Ion Collider case, Phys. Rev. D 103, L051901 (2021), https://journals.aps.org/prd/abstract/10.1103/PhysRevD.103.L051901
[2] K. Piotrzkowski, M. Przybycien, a publication in preparation

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T10: Searches for New Physics / 477

Unification of Gauge Symmetries … including their breaking

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Co-authors: Andreas Bally [2]; Andrei Angelescu [3]; Simone Blasi [4]

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In this talk, we present a minimal viable scenario that unifies the gauge symmetries of the SM and their breaking sector. Our Gauge-Higgs Grand Unification setup employs 5D warped space with a SU(6) bulk gauge field that includes both a SU(5) grand unified theory (GUT) and a Higgs sector as a scalar component of the 5D vector field, solving the hierarchy problem. By appropriately breaking the gauge symmetry on the boundaries of the extra dimension the issue of light exotic new states, appearing generically in such models, is eliminated and the SM fermion spectrum is naturally reproduced. The Higgs potential is computed at one-loop, finding straightforward solutions with a realistic mh = 125 GeV. The problem of proton decay is addressed by showing that baryon number is a hidden symmetry of the model. The presence of a scalar leptoquark and a scalar singlet is highlighted, which might play a role in solving further problems of the SM, allowing for example for electroweak baryogenesis. Finally, the X and Y gauge bosons from SU(5) GUTs are found at collider accessible masses, opening a window to the unification structure at low energies.

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Collaboration / Activity:

-

T02: Cosmology / 478

Self-interacting neutrinos as a solution(?) to the Hubble tension

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Self-interaction among the neutrinos in the early Universe has been proposed as a solution to the Hubble tension, a discrepancy between the measured values of the Hubble constant from CMB and low-redshift data. However, flavor-universal neutrino self-interaction is highly constrained by BBN and several laboratory experiments such as, tau and K-meson decay, double-neutrino beta decay etc. In this talk, I will discuss about the cosmology if only one or two neutrino states are self-interacting. Such flavor-specific interactions are less constrained by the laboratory experiments. Finally, I will talk about the feasibility of addressing the Hubble tension in the framework of such flavor-specific neutrino self-interaction.

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Collaboration / Activity:

Theory

T01: Astroparticle and Gravitational Waves / 479

Lower Mass Bounds on FIMPs

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Feebly Interacting Massive Particles (FIMPs) are dark matter candidates that never thermalize in the early universe and whose production takes place via decays and/or scatterings of thermal bath particles. If FIMPs interactions with the thermal bath are renormalizable, a scenario which is known as freeze-in, production is most efficient at temperatures around the mass of the bath particles and insensitive to unknown physics at high temperatures. Working in a model-independent fashion, we consider three different production mechanisms: two-body decays, three-body decays, and binary collisions. We compute the FIMP phase space distribution and matter power spectrum, and we investigate the suppression of cosmological structures at small scales. Our results are lower bounds on the FIMP mass. Finally, we study how to relax these constraints in scenarios where FIMPs provide a sub-dominant dark matter component.

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Collaboration / Activity:

research

T13 - Accelerator for HEP / 480

Beam diagnostics at KAHVE Lab proton source and LEBT line

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KAHVE Laboratory, a particle detector, accelerator, and instrumentation research laboratory located at Boğaziçi University Kandilli Campus area at Istanbul, is currently working on the design of a RFQ operating at 800 MHz that will accelerate proton beam up to 2 MeV. As a first part of this linear accelerator, a Microwave Discharge Ion Source operating at 2.45 GHz frequency including 20 keV electrode extraction system has been designed, produced, and tested to generate hydrogen plasma and extract proton beams from this plasma medium. To transmit beams to the RFQ cavity, Low Energy Beam Transport (LEBT) line, a beam pipe including 2 solenoid magnets, 2 steerer magnets and a beam diagnostic box between these electromagnets, has been designed and produced, tested separately for now. The beam diagnostic box, including a Faraday cup, a pepper pot plate and there will be a home-built scintillator screen, is designed to measure the current, emittance and profile of the incoming beam. Currently, there has been an upgrade on the ion source. Instead using solenoid electromagnets in order to extract ions from the thermal hydrogen plasma, a new Microwave Discharge Ion Source system has been designed and constructed with permanent magnets. After this permanent magnet configuration upgrade, since the system is operated on the high voltage platform, a higher system stability would be achieved. Permanent magnet profile tests were completed to check the simulation results, then the production of new ion source system was completed, currently it is in the test phase before integrating to the system. In the session, it will be discussed that the simulation & experimental measurement results, and any other details of the whole system, which is constructed at KAHVELab all with local resources. These projects are supported by Istanbul University Scientific Research Commission Project ID 33250 and TUBITAK Project no: 119M774

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Collaboration / Activity:

KAHVELab

T10: Searches for New Physics / 481

Scalar Leptoquark Pair Production at Hadron Colliders

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I will present precision predictions for scalar leptoquark pair production at hadron colliders. Apart from QCD contributions, included are the lepton t-channel exchange diagrams relevant in the light of the recent B-flavor anomalies. All contributions are evaluated at next-to-leading order in QCD and improved by resummation corrections, in the threshold regime, from soft-gluon radiation at next-to-next-to-leading-logarithmic accuracy. All corrections are found equally relevant. Furthermore, the impact of different sets of parton distribution functions will be discussed. These predictions consist

of the most precise leptoquark cross section calculations available to date and are necessary for the best exploitation of leptoquark LHC searches.

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Collaboration / Activity:

Theory

T04: Neutrino Physics / 482

Modullar Invariance Approch to the Flavour Problem: Fermion Mass Hierarchies and Residual Modular Symmetries

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We will discuss the approach to the flavour problem
based on modular invariance.
In modular-invariant models of flavour,
hierarchical fermion mass matrices may arise
solely due to the proximity of the modulus τ
to a point of residual symmetry.
This mechanism does not require flavon fields, and modular
weights are not analogous to Froggatt-Nielsen charges.
We show that hierarchies depend on the decomposition
of field representations under the residual symmetry group.
We systematically go through the
possible fermion field representation choices which may yield
hierarchical structures in the vicinity of symmetric points,
for the four smallest finite modular groups, isomorphic
to S_3, A_4, S_4, and A_5, as well as for their double covers.
We find a restricted set of pairs of representations for which the
discussed mechanism may produce viable fermion (charged-lepton and quark)
mass hierarchies. After formulating the conditions for obtaining a viable lepton
mixing matrix in the symmetric limit, we construct a model in which both
the charged-lepton and neutrino sectors are free from fine-tuning.

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Collaboration / Activity:

Theoretical Particle Physics

T05: Heavy Ion Physics / 483

The Gluon Exchange Model for diffractive and inelastic collisions

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We propose a new model for a homogeneous description of hadron-hadron and hadron-nucleus collisions, the Gluon Exchange Model (GEM). While technically our model can be regarded as a generalization of the Dual Parton Model by Capella and Tran Thanh Van, it is fundamentally based on the number of exchanged color octets (gluons) and significantly extends the Fock space of states available for the participating protons and nucleons.

In proton-proton collisions we provide an *exact* description of the final state proton and neutron spectrum. What is remarkable is that unlike the original DPM, GEM successfully describes the proton "diffractive peak"at high x_F as a specific case of color octet exchange.

In proton-nucleus reactions we find that the projectile proton diquark cannot survive in more than about half of multiple proton-nucleon processes and consequently *must be very frequently disintegrated*, leading to long transfers of baryon number over rapidity space.

This talk will be partially based on our recent paper, Phys. Lett. **B 816** (2021) 136200, e-Print: 2101.01999 \[nucl-th\]

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Collaboration / Activity:

theory

T04: Neutrino Physics / 484

Tests of Lorentz Invariance at a bi-magic baseline of Protvino-to-ORCA (P2O) experiment.

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Lorentz invariance is one of the fundamental propositions of quantum field theory (QFT). In some string theory models, Lorentz symmetry may break spontaneously at very high energy scales (Planck scale). In the Standard Model Extension (SME) of particle physics, one can study the effects of Lorentz Invariance Violation (LIV) in a perturbative method.

The present and future long-baseline neutrino experiments provides an ideal scope to measure such sub-dominant effects in neutrino oscillations stemming from Planck-suppressed LIV effects. Due to the megatonne volume of ORCA and a long baseline of 2600 km, the Protvino-to-Orca (P2O) is envisaged to provide unparalleled sensitivity to the LIV model parameters even with a modest

beam power and runtime. In this contribution, we present the expected physics potential of the P2O experiment in constraining the LIV parameters.

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Collaboration / Activity:

NA

T03: Dark Matter / **485**

Exploring the Co-SIMP Dark Sector

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A particularly salient aspect of particle dark matter models is the connection between thermal interactions and cosmological abundance. Extending from the famous WIMP paradigm is a rich sector of dark sector models with different number changing mechanisms, all of which realize a relic abundance via interactions with the Standard Model or itself. In this talk I will introduce one of these scenarios: Co-SIMP dark matter, whose key interactions involve both cannibalistic interactions and couplings to the Standard Model. I will discuss the phenomenology and UV completions of this scenario, as well as constraints and prospects for detection.

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Collaboration / Activity:

N/A

T09: Higgs Physics / **486**

Prospects of non-resonant and resonant Higgs pair production at the HL-LHC

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A direct measurement of the Higgs self coupling is very crucial to understand the nature of electroweak symmetry breaking. This requires an observation of production of Higgs boson pair, which suffers from very low event rate even at the current LHC run. In our work, we study the prospects of observing the non-resonant Higgs pair production at the high luminosity run of the 14 TeV LHC (HL-LHC). Here, we choose multiple final states based on the event rate and cleanliness, namely, $b\bar{b}\gamma\gamma$, $b\bar{b}\tau^+\tau^-$, $b\bar{b}WW^*$, $WW^*\gamma\gamma$ and $4W$ channels and do a collider study by employing a cut-based as well as multivariate analyses using the Boosted Decision Tree (BDT) algorithm. We also consider various physics beyond the standard model (BSM) scenarios, for example resonant Higgs pair production, to quantify the effects of contamination when one tries to measure the SM di-Higgs signals. In a later study, we search specifically for the heavy resonant scalars (H/A) via their decay into two SM Higgs boson at the HL-LHC. After performing multivariate analysis using BDT algorithm in various final states, we set upper limits on the production cross-section of heavy scalar times its branching ratio into final state products for different values of heavy scalar masses. Finally, we translate these limits and put strong constraints on the $m_A - tan\beta$ parameter space (where m_A and $tan\beta$ are respectively the mass of the pseudoscalar and the ratio of the vacuum expectation values of the two Higgs doublets) in the context of Minimal Supersymmetric Standard Model (MSSM).

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T10: Searches for New Physics / 487

Implications of the Muon Anomalous Magnetic Moment for 3-3-1 Models

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We explore the implications of g-2 new result to five models based on the SU(3)C×SU(3)L×U(1)N gauge symmetry and put our conclusions into perspective with LHC bounds. We show that previous conclusions found in the context of such models change if there are more than one heavy particle running in the loop. Moreover, having in mind the projected precision aimed by the g-2 experiment at FERMILAB, we place lower mass bounds on the particles that contribute to muon anomalous magnetic moment assuming the anomaly is resolved otherwise. Lastly, we discuss how these models could accommodate such anomaly in agreement with existing bounds.

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Collaboration / Activity:

Ph.D. student

T01: Astroparticle and Gravitational Waves / 489

Cold aberrations and locking of Central Interferometer of Advanced Virgo+

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The target sensitivity of Advanced Virgo for O4 is about 90-120 Mpc for the BNS range. To achieve this, several hardware upgrades are under process. One of the most relevant concerns installation of the Signal Recycling Mirror, which forms an additional marginally stable cavity along with the power recycling cavity already present in Advanced Virgo. Therefore, to compensate for these (cold) optical aberrations, new Central Heating benches were installed by the TCS subsystem.
I will describe the installation and pre-commissioning of CO_2 central heating, which assists the lock of DRMI by compensating for the (cold) optical aberrations, and the procedure followed for locking the Dual Recycled Michelson Interferometer along with the tuning of CO_2 central heating."

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Collaboration / Activity:

EGO-Virgo

T01: Astroparticle and Gravitational Waves / 490

Axion-like Particles from Hypernovae

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It was recently pointed out that very energetic subclasses of supernovae (SNe), like hypernovae and superluminous SNe, might host ultra-strong magnetic fields in their core. Such fields may catalyze the production of feebly interacting particles, changing the predicted emission rates. Here we consider the case of axion-like particles (ALPs) and show that the predicted large scale magnetic fields in the core contribute significantly to the ALP production, via a coherent conversion of thermal photons. Using recent state-of-the-art SN simulations including magnetohydrodynamics, we find that if ALPs have masses $m_a \sim \mathcal{O}(10)\,\mathrm{MeV}$, their emissivity via magnetic conversions is over two orders of magnitude larger than previously estimated. Moreover, the radiative decay of these massive ALPs would lead to a peculiar delay in the arrival times of the daughter photons. Therefore, high-statistics gamma-ray satellites can potentially discover MeV ALPs in an unprobed region of the parameter space and shed light on the magnetohydrodinamical nature of the SN explosion.

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Collaboration / Activity:

None

T01: Astroparticle and Gravitational Waves / 491

Constraining Lorentz-violating gravity with gravitational wave observations

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Models of Lorentz-violating gravity can provide a solution to the puzzle of quantum gravity. By abandoning boost invariance, we can formulate theories which are renormalizable and even asymptotically free in certain cases. At low energies, certain amount of Lorentz violation persists and can percolate onto physical observables, such as the emission rate of gravitational waves from a bounded system.

I will discuss how to constraint the parameter space of Einstein-Aether gravity and Hořava gravity with binary pulsar observations. This singles out a region of the parameter space which points towards a minimal model where only a single parameter remains non-vanishing. I will discuss how the theory then becomes indistinguishable from GR at many levels. Cosmological observables remain as the only possible source of deviations and the only hope to further constraining the theory.

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Collaboration / Activity:

.

T12: Detector R&D and Data Handling / 492

TES Detector for ALPS II

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The Any Light Particle Search II (ALPS II) is a light-shining-through-a-wall (LSW) experiment at DESY, Hamburg, attempting to detect axions and axion-like-particles (ALPs), which can comprise dark matter and solve long-standing problems in physics. ALPS II can convert photons into axions/ALPs in the presence of a magnetic field, in an optical cavity. After passing through an opaque, light-tight barrier, these particles can reconvert to photons in another optical cavity, and be detected. The detection requires a sensor capable of observing the extremely low regenerated photon rates of $\mathcal{O}(10^{-5})$ Hz, necessitating a very low dark rate and high detection efficiency. This can be achieved by using a TES, a Transition Edge Sensor, a cryogenic calorimeter exploiting the drastic temperature dependence of a material's electrical resistance in its transition region around 140 mK. To achieve this, the setup is housed in a dilution refrigerator cooling it down to a temperature of < 25 mK. Being sensitive to low-energy 1064 nm photons also makes the detector susceptible to other particles and backgrounds which can hamper the targeted low dark rate.

We present the setup of the TES detector for ALPS II, its current status, and the analysis of its backgrounds and further improvements in the cryogenic environment to reduce the backgrounds. The viability and outlook of such a detector for the ALPS II experiment will be discussed, including future steps to measure the detection efficiency, etc.

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Collaboration / Activity:

ALPS

T10: Searches for New Physics / 493

Non-Resonant Searches for Axion-Like Particles at the LHC

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We discuss non-resonant ALP-mediated diboson production, a collider probe for axion-like particles (ALPs) which takes advantage of the derivative nature of their interactions with Standard Model particles; here ALPs participate as off-shell mediators of $2 \rightarrow 2$ scattering processes at colliders like the LHC. The power of this novel type of search was first tested by deriving limits on ALP couplings

to gauge bosons via processes like gg → ZZ using Run 2 CMS public data, probing previously unexplored areas of the ALP parameter space. Other non-resonant searches involving the ALP couplings to other electroweak bosons and/or the Higgs particle are presented. LHC experiments are now searching for these processes using the full Run 2 data samples. In addition, new studies on non-resonant ALP-mediated Vector-Boson Scattering (VBS) and preliminary results based on recently published CMS data are presented. Expectations for LHC Run 3 and HL-LHC are derived.

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Collaboration / Activity:

Particle Physics exp. / pheno.

T03: Dark Matter / 494

Search for Axion Dark Matter with the QUAX Haloscopes

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The axion, a pseudoscalar particle originally introduced to solve the "strong CP problem", is a well motivated dark-matter candidate with a mass lying in a broad range from peV to few meV. Axions clustered inside our galaxy may be observed by means of detectors called Haloscopes consisting in a resonant cavity immersed in a static magnetic field that triggers the axion conversion to microwave photons. The QUAX collaboration has put one Haloscope into operation and is installing a second one in the two national INFN laboratories in Legnaro and Frascati, respectively. The first one recently reached the sensitivity to QCD axions with masses around 40 micro-eV. Meanwhile, a rich R&D program is ongoing to improve the detectors sensitivity with superconducting and dielectric resonant-cavities and quantum devices and to extend the axion search beyond the axion-photon interaction with a "ferromagnetic" Haloscope that exploits the coupling of axions to electrons.

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Collaboration / Activity:

QUAX

T10: Searches for New Physics / 495

The IDM and THDMa - current constraints and future prospects

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The THDMa is a new physics model that extends the scalar sector of the Standard Model by an additional doublet as well as a pseudoscalar singlet and allows for mixing between all possible scalar states. In the gauge eigenbasis, the additional pseudoscalar serves as a portal to the dark sector, with a priori any dark matter spin states. The Inert Doublet model is another intriguing new physics model containing a dark matter candidate, which so far has not been investigated by the LHC experiments. I discuss current bounds as well as discovery prospects for both models at current and future colliders.

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Collaboration / Activity:

Phenomenological study

T08: Flavour Physics and CP Violation / 498

Addressing the muon anomalies with muon-flavored leptoquarks

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Significant deviations from SM predictions have been observed in $b \to s\mu^+\mu^-$ decays and in the muon (g-2). Scalar leptoquark extensions of the SM are known to be able to address these anomalies, but generically give rise to lepton flavor violation (LFV) or even proton decay. We propose new muon flavored gauge symmetries as a guiding principle for leptoquark models that preserve the global symmetries of SM and explain the non-observation of LFV. A minimal model is shown to easily accommodate the anomalies without encountering other experimental constraints. This talk is mainly based on arXiv:2103.13991.

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Collaboration / Activity:

None

T03: Dark Matter / 499

Dissecting the inner Galaxy with gamma-ray pixel count statistics

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The nature of the GeV gamma-ray Galactic center excess (GCE) in the data of Fermi-LAT is still under investigation. Different techniques, such as template fitting and photon-count statistical methods, have been applied in the past few years in order to disentangle between a GCE coming from sub-threshold point sources or rather from diffuse emissions, such as the dark matter annihilation in the Galactic halo.
A major limit to all these studies is the modeling of the Galactic diffuse foreground, and the impact of residual mis-modeled emission on the results' robustness.
In Ref.1, we combine for the first time adaptive template fitting and pixel count statistical methods in order to assess the role of sub-threshold point sources to the GCE, while minimizing the mis-modelling of diffuse emission components.
We reconstruct the flux distribution of point sources in the inner Galaxy well below the Fermi-LAT detection threshold, and measure their radial and longitudinal profiles. We find that point sources and diffuse emission from the Galactic bulge each contributes about 10% of the total emission therein, disclosing a sub-threshold point-source contribution to the GCE.

1 arXiv:2102.12497

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Collaboration / Activity:

Theory/Phenomenology

T10: Searches for New Physics / 500

Search for top squarks in final states with two top quarks and several light-flavor jets in proton-proton collisions at CMS

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Traditional searches for supersymmetry at LHC collider experiments have returned null results thus far. The expected, characteristic signature of high missing energy (MET) final states has not been observed. Motivated by this, our analysis searches for "stealthier"SUSY where high MET signatures would not manifest. Two models considered here are Stealth and R-parity violating SUSY and evidence for said models is searched for through top squark pair production at the CMS experiment. Here the top squark decay leaves a final state that contains two top quarks and many light-flavored jets with no additional missing energy. The analysis uses a neural network employing gradient reversal in order to help discriminate signal events from background. The full Run2 dataset is utilized and results are interpreted in the context of the above models. Top squark masses up to 670 (870) GeV are excluded at 95% confidence level for the RPV (stealth) scenario, and the maximum observed

local signal significance is 2.8 standard deviations for the RPV scenario with a top squark mass of 400 GeV.

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Collaboration / Activity:

CMS

T06: QCD and Hadronic Physics / 501

PDF analysis of Z boson polarisation data from LHC and constraints to Higgs boson production cross section by xFitter

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Recent developments of the xFitter PDF analysis package and studies based on it are summarised. The emphasis is given to the PDF analysis of the Z boson polarisation data which provide additional constraint to the gluon distribution for Bjorken x below 0.1. Studies using pseudo data samples corresponding to an integrated luminosity of the LHC Run 3 and high-luminosity HL-LHC show that the PDF uncertainty of the Higgs boson production cross section can be reduced significantly.

Collaboration / Activity:

xFitter

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T01: Astroparticle and Gravitational Waves / 502

Implications for fi rst-order cosmological phase transitions and the formation of primordial black holes from the third LIGO-Virgo observing run

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We place constraints on the normalised energy density in gravitational waves from first-order strong phase transitions and then from the formation of primordial black holes using data from Advanced LIGO and Virgo's first, second and third observing runs. First, adopting a broken power law model, we place 95 % confidence level upper limits simultaneously on the gravitational-wave energy density at 25 Hz from unresolved compact binary mergers and strong first-order phase transitions. We then consider two more complex phenomenological models, limiting at 25 Hz the gravitational-wave background due to bubble collisions and the background due to sound waves at 95 % confidence level for phase transitions occurring at temperatures above 1e8 GeV. We then do a similar search assuming a background sourced by the formation of primordial black holes and unresolved compact binary mergers. For a very generic spectrum describing the primordial black hole background, we place 95% confidence level upper limits on the gravitational-wave energy density at 25 Hz

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T01: Astroparticle and Gravitational Waves / 503

Quantum black holes and ringdown physics with LIGO-Virgo detections

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The gravitational-wave ringdown from black holes gives us direct access to the nature of space-time around them. Thus ringdown signals have the potential to shed some light on the quantum nature of black hole space-times. We present an observational investigation of the hypothesis that the black hole area is quantised in multiples of the Planck area. This hypothesis relies on a recently-proposed heuristic ringdown model built from the Bekenstein-Mukhanov area quantisation conjecture. We test this scenario by combining all the available information from the black hole population included in the GWTC-2 catalog. A time-domain analysis, based on the pyRing software used by the LVK Collaboration, is employed to quantify the evidence for the presence of signatures of the area quantisation in ringdown signals. We also discuss future prospects of effects due to the area quantisation with detections from ground-based detectors at their design sensitivity.

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Collaboration / Activity:

Member of LVK Collaboration

T04: Neutrino Physics / 504

Neutrino quantum decoherence and collective oscillations

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The effect of neutrino quantum decoherence has attracted a growing interest during the last 15 years. The most of already performed studies deal with searches of neutrino quantum decoherence in the terrestrial reactor and solar neutrino experiments. The forthcoming large volume neutrino detectors (e.g., JUNO, Hyper-Kamiokande and DUNE) will provide a new frontier in high-statistics measurements of astrophysical neutrino fluxes that will give, in particular, an opportunity to study the effect of neutrino quantum decoherence also in supernovae fluxes. In 1 we suggested a new mechanism of neutrino quantum decoherence in the supernovae engendered by the neutrino interaction with an external environment and showed that it becomes significant in the region where the collective neutrino oscillations occur. In [2] we studied the influence of the neutrino quantum decoherence of neutrino mass states on bipolar collective neutrino oscillations. In the present work we generalize our study [2] and present new analytical results on the interplay of the neutrino quantum decoherence and the synchronized neutrino collective oscillations. We also discuss the possibility to detect the effect of neutrino quantum decoherence in supernovae neutrino fluxes in the long baseline neutrino experiments.

1 K.Stankevich, A.Studenikin, Neutrino quantum decoherence engendered by neutrino radiative decay, Phys.Rev.D 101, 056004 (2020).
[2] K.Stankevich, A.Studenikin, Collective neutrino oscillations accounting for neutrino quantum decoherence, PoS ICHEP2020, 216 (2021).

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Collaboration / Activity:

Activity

T14: Outreach, Education and Diversity / 505

Science Chatter Hamburg –A #SciComm Project by PIER that Combines Qualification of Early Career Researchers and Outreach Work

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Communicating ongoing research in fields as complex as modern physics to a broader audience is challenging. Nonetheless, this skill becomes increasingly important with a growing number of funding bodies requesting outreach activities to be part of a research project. Institutions dedicated to the interdisciplinary qualification of early career researchers only recently recognized a high demand in trainings for science communication. However, even though PhD students and Postdocs now increasingly attend workshop that cover the basics of science communication, most of them do not engage in outreach activities. Creating their own blog, podcast or video channel appears too time-consuming.

PIER, the strategic partnership between DESY and Universität Hamburg, thus piloted a special project. „Science Chatter Hamburg"is a platform which can be used by researchers from all career stages at DESY and Universität Hamburg to publish their blog posts right now and potentially podcast episodes in the future. For kicking off the blog, a 2-day workshop was offered through the PIER Education Platform in March 2021. Participants in this workshop discussed examples of physics blog posts and which different functions they have. They also learned basics of writing for a broader audience and the technical setup of a modern blog. Most importantly, however, they were given enough time to write their very own blog posts which they directly published at https://science-chatter.blogs.uni-hamburg.de/. Without the need to spend time setting up their own platform, they were rewarded with a link to their published blog posts. Some participants shared this link via their social media platforms or with their international peers and collaborators.

Science Chatter Hamburg thus combines qualification of early career researchers with outreach work. With science communication becoming an increasingly important asset both within and beyond the academic career path, the participants benefit double. Apart from the training, they receive a showpiece and increase their visibility. Last but not least, the public gets the chance to consume authentic points of view from within academic research. This is of note, since evidence suggests that more trust might be given to science when communicated by active researchers instead of professionals in PR departments.

Science Chatter Hamburg is open for contributions from DESY and Universität Hamburg researchers from the PIER research fields particle and astroparticle physics, photon science, nanoscience, infection and structural biology, theoretical physics and accelerator research.

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Collaboration / Activity:

PIER

T05: Heavy Ion Physics / 506

Recent results of D0 mesons azimuthal anisotropy using the CMS detector

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In a relativistic heavy ion collision, heavy flavor (charm and bottom) quarks are mostly created via hard processes at the early stage of collisions. We present the latest results of the azimuthal anisotropy coefficients v_n for prompt and non-prompt D0 mesons in PbPb, pPb, and pp collisions from the CMS experiment. The studies are about collectivity phenomena in smaller systems (pp and pPb), searches for the effects of very strong electromagnetic fields created in the initial stages of ultrarelativistic PbPb collisions, and charm quark energy loss in the quark-gluon plasma.

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 507

Level 1 muon triggers algorithms for the CMS upgrade at the HL-LHC

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In view of the HL-LHC, the Phase-2 CMS upgrade will replace the entire trigger and data acquisition system. The detector readout electronics will be upgraded to allow a maximum L1A rate of 750 kHz, and a latency of 12.5 µs. The upgraded system will be entirely running on commercial FPGA processors and should greatly extend the capabilities of the current system, being able to maintain trigger thresholds despite the harsh environment as well as trigger on more exotic signatures such as long-lived particles to extend the physics coverage. The function of the muon trigger is to identify muon tracks in the experiment and measure their momenta and other parameters for use in the global trigger menu. In addition to the muon detector upgrades that include improved electronics and new sub-detectors, the presence of a L1 track finder in CMS will bring some of the offline muon reconstruction capability to the L1 trigger, delivering unprecedented reconstruction and identification performance. We review the current status of the algorithm developments for a highly efficient L1 muon trigger reconstruction from prompt and displaced muons and the measured performance on emulators and firmware demonstrators

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 508

Trigger primitive generation algorithm in the CMS barrel muon chambers during HL-LHC

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This poster presents an update on the Analytical Method (AM) algorithm for trigger primitive (TP) generation in the CMS Drift Tube (DT) chambers during the High Luminosity LHC operation (HL-LHC or LHC Phase 2). The algorithm has been developed and validated both in software with an emulation approach, and through hardware implementation tests. The algorithm is mainly divided in the following steps: a grouping (pattern recognition) step that finds the path of a given muon, a fitting step to extract the track parameters (position and bending angle), a correlation step that matches the information from the different super-layers and with signal from the Resistive Plate Chambers. Agreement between the software emulation and the firmware implementation, has been verified using different data samples, including a sample of real muons collected during 2016 data taking. This poster also includes an update of the grouping step using a pseudo-bayes classifier.

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Collaboration / Activity:

CMS / Experimentalist

T04: Neutrino Physics / 509

Interplay of neutrino spin and three-flavour oscillations in a magnetic field

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We develop the approach to the problem of neutrino oscillations in a magnetic field introduced in 1 and extend it to the case of three neutrino generations. The theoretical framework suitable for computation of the Dirac neutrino spin, flavour and spin-flavour oscillations probabilities in a magnetic field is given. The closed analytic expressions for the probabilities of oscillations are obtained accounting for the normal and inverted hierarchies and the possible effect of CP violation. In particular, it is shown that the probabilities of the conversions without neutrino flavor change, i.e. $\nu_e^L \to \nu_e^L$ and $\nu_e^L \to \nu_e^R$, do not exhibit the dependence on the CP phase, while the other neutrino conversions are affected by the CP phase. In general, the neutrino oscillation probabilities exhibit quite a complicated interplay of oscillations on the magnetic $\mu_\nu B$ and vacuum frequencies. The obtained results are of interest in applications to neutrino oscillations under the influence of extreme astrophysical environments, for example peculiar to magnetars and supernovas, as well as in studying neutrino propagation in interstellar magnetic fields (see [2]).

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Collaboration / Activity:

JUNO

T04: Neutrino Physics / 510

Constraining the tau-neutrino transition magnetic moment at DUNE's far-detector

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Current limits for the tau-neutrino transition magnetic moment to a sterile neutrino are far weaker than its electron and muon counterparts. This talk addresses possible constraints on the transition magnetic moment between the tau neutrino and an \(\mathcal O(\si{MeV})\) sterile neutrino at the far-detector of DUNE: the proposed neutrino-beam experiment at FermiLab. We compare this with existing limits and limits at proposed neutrino experiments such as SHiP.

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PhD student

T14: Outreach, Education and Diversity / 511

Democratizing LHC data analysis with ADL/CutLang

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Data analysis at the LHC has a very steep learning curve, which erects a formidable barrier between data and anyone who wants to analyze data, either to study an idea or to simply understand how data analysis is performed. To make analysis more accessible, we designed the so-called Analysis Description Language (ADL), a domain specific language capable of describing the contents of an LHC analysis in a standard and unambiguous way, independent of any computing frameworks. ADL has an English-like highly human-readable syntax and directly employs concepts relevant to HEP. Therefore it eliminates the need to learn complex analysis frameworks written based on general purpose languages such as C++ or Python, and shifts the focus directly to physics. Analyses written in ADL can be run on data using a runtime interpreter called CutLang, without the necessity of programming. ADL and CutLang are designed for use by anyone with an interest in, and/or knowledge of LHC physics, ranging from experimentalists and phenomenologists to non-professional enthusiasts. ADL/CutLang are originally designed for research, but are also equally intended for education and public use. This approach has already been employed to train undergraduate students with no programming exprience in LHC analysis in two dedicated schools in Turkey and Vietnam, and is being adapted for use with LHC Open Data. Moreover, work is in progress towards piloting an educational module in particle physics data analysis for high school students and teachers. In this talk, we will introduce ADL and CutLang and present the educational activities based on these practical tools.

Collaboration / Activity:

ADL/CutLang

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T03: Dark Matter / 513

Indirect Dark Matter Searches with the ANTARES and KM3NeT Neutrino Telescopes

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Co-authors: Sergio Navas [2]; Jihad Boumaaza [3]; ANTARES Collaboration [4]; KM3NeT Collaboration [5]

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Neutrino telescopes perform an indirect search for dark matter (DM) through its annihilation into standard model channels yielding neutrinos, for a broad range of WIMP masses. The ANTARES telescope, anchored to the Mediterranean seabed at a depth of about 2500 m, looks for a DM signal from two promising sources with high WIMP density: the Galactic Center and the Sun. We present the latest results of ANTARES on indirect detection for several WIMP masses and channels, and give a future prospect on sensitivities of DM searches with KM3NeT, the next-generation neutrino telescope, currently in deployment in the Mediterranean Sea. These detectors have specific advantages, complementary to other strategies, and can provide a smoking-gun signal in the case of the Sun. The geographical location of ANTARES and KM3NeT is particularly suited for searches in the Galactic Center, allowing for the world-best limits on annihilation cross-section for large WIMP masses.

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Collaboration / Activity:

ANTARES-KM3NeT

T05: Heavy Ion Physics / 514

Multi-partonic medium induced cascades in expanding media

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Going beyond the simplified gluonic cascades, we have introduced both gluon and quark degrees of freedom for partonic cascades inside the medium. We then solve the set of coupled evolution equations numerically with splitting kernels calculated for exponential and Bjorken expanding media to arrive at medium-modified parton spectra for quark and gluon initiated jets respectively. Firstly, we have studied the inclusive jet R_{AA} by including phenomenologically driven combinations of quark and gluon fractions inside a jet. The impact of the rapidity dependence of the jet R_{AA} has been studied in detail. Secondly, we have studied the path-length dependence of jet quenching for different types of expanding media by calculating the jet v_2. Additionally, we have qualitatively studied the sensitivity of the time for the onset of the quenching for the Bjorken profile on jet v_2 and comparison with data from ATLAS.

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Collaboration / Activity:

None

T04: Neutrino Physics / 515

Neutrino spin oscillations in magnetized moving and polarized matter

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We present a detailed analysis of the neutrino spin oscillations in magnetized moving and polarized matter. New phenomena of the resonant amplification of neutrino spin oscillations induced by the transverse component of the matter polarization are considered. In this contribution, a generalization is made in respect to our previous studies [1,2] and the effects of the transversal magnetic field, transversal motion and polarization of matter are simultaneously accounted for. The cases of Dirac and Majorana neutrinos are considered. We also discuss possible effects for neutrino fluxes in astrophysics.
1 P. Pustoshny, V. Shakhov, A. Studenikin, "Neutrino spin and spin-flavor oscillations in matter currents and magnetic fields", PoS EPS-HEP2019 (2020) 429.
[2] P. Pustoshny, A. Studenikin, "Neutrino spin and spin-flavor oscillations in transversal matter currents with standard and non-standard interactions", Phys.Rev. D98 (2018) 113009.

This work is supported by the Russian Foundation for Basic Research under grant No. 20-52-53022-GFEN-a.

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Collaboration / Activity:

None

T04: Neutrino Physics / 516

Neutrino decay processes and flavour oscillations

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The phenomenon of neutrino oscillations emerges due to coherent superposition of neutrino mass states. An external environment can modify a neutrino evolution in a way that the coherence will be violated. Such violation is called quantum decoherence of neutrino mass states and leads to the suppression of flavor oscillations. In our previous paper 1, we presented a new theoretical framework, based on the quantum field theory of open systems applied to neutrinos. Within this framework we proposed and considered a new mechanism of the neutrino quantum decoherence engendered by the neutrino radiative decay in an electron background in an extreme astrophysical environment. In the present study we generalize our approach and consider neutrino radiative decay accounting for the neutrino magnetic moment and milicharge. We also account for the neutrino decay into a hypothetical scalar particle (that can be a familon or another axion-like particle). We show that such decays can also lead to the neutrino quantum decoherence. Using the experimental constraints on neutrino quantum decoherence [2] we estimate the neutrino decay rates.

1 K.Stankevich, A.Studenikin, Neutrino quantum decoherence engendered by neutrino radiative decay, Phys. Rev. D 101 (2020) 056004.

[2] J.A.B.Coelho, W.A.Mann, Decoherence, matter effect, and neutrino hierarchy signature in long baseline experiments, Phys. Rev. D 96 (2017) 093009.

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Collaboration / Activity:

None

T04: Neutrino Physics / 517

Neutrino electromagnetic interactions in elastic neutrino scattering on nucleons and nuclei

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The nonzero neutrino masses open a door for neutrino electromagnetic interactions 1. We study how these interactions may manifest themselves in elastic neutrino-nucleon and neutrino-nucleus scattering processes. Following our approach developed for the case of elastic neutrino-electron [2] and neutrino-proton [3] collisions, in our formalism we account for possible electromagnetic form factors of massive neutrinos: the charge, magnetic, electric, and anapole form factors of both diagonal and transition types. When treating the nucleon electromagnetic vertex, we take into account not only charge and magnetic form factors of a nucleon, but also its electric and anapole form factors. We examine how the effects of the neutrino electromagnetic properties (in particular, charge radii and magnetic moments) can be disentangled from those of the strange quark contributions to the nucleon's weak neutral current form factors. We also study how the neutrino electromagnetic form factors can manifest themselves in coherent elastic neutrino scattering on spin-0 and spin-1/2 nuclear targets.

1 C. Giunti, A. Studenikin, Neutrino electromagnetic interactions: A window to new physics, Rev. Mod. Phys. 87, 531 (2015), arXiv:1403.6344.
[2] K. Kouzakov, A. Studenikin, Electromagnetic properties of massive neutrinos in low-energy elastic neutrino-electron scattering, Phys. Rev. D 96, 099904 (2017), arXiv:1703.00401.
[3] K. Kouzakov, F. Lazarev, A. Studenikin, Electromagnetic neutrino interactions in elastic neutrino-proton scattering, PoS (ICHEP2020) 205.

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Collaboration / Activity:

None

T10: Searches for New Physics / 518

Light Scalar and Lepton Anomalous Magnetic Moments

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Recent precise determination of the electron anomalous magnetic moment (AMM) adds to the long-standing tension of the muon AMM and together strongly point towards physics beyond the Standard Model. Here we present a solution to both anomalies via a light scalar that emerges from a second Higgs doublet and resides in the $\mathcal{O}(10)$-MeV to $\mathcal{O}(1)$-GeV mass range. A scalar of this type is subject to a number of various experimental constraints, however, as we show, it can remain sufficiently light by evading all experimental bounds and has the great potential to be discovered in the near-future low-energy experiments. In addition to the light scalar, our theory predicts the existence of a nearly degenerate charged scalar and a pseudoscalar, which have masses of the order of the electroweak scale. This scenario can be tested at the LHC by looking at the novel process $pp \to H^{\pm}H^{\pm}jj \to l^{\pm}l^{\pm}jj + \not{E}_T$ via same-sign pair production of charged Higgs bosons.

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Collaboration / Activity:

Sudip Jana and Shaikh Saad

T04: Neutrino Physics / 519

Latest 3-flavor neutrino oscillations results from the NOvA experiment

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NOvA is a long-baseline neutrino oscillation experiment. Its large tracking calorimeters can detect and identify muon and electron neutrino interactions with high efficiency. Neutrinos produced by the NuMI beam are detected by a Near Detector, located at Fermilab, and a much larger Far Detector, located 810km away in Ash River, Minnesota. NOvA can measure the electron neutrino and

antineutrino appearance rates, as well as the muon neutrino and antineutrino disappearance rates, in order to constrain neutrino oscillations parameters, including the neutrino mass hierarchy and the CP-violating phase δ_{CP}.
This talk will present NOvA's latest results combining both neutrino data (13.6×10^{20}POT) and antineutrino data (12.5×10^{20} POT).

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Collaboration / Activity:

NOvA

T06: QCD and Hadronic Physics / 520

Hadron physics at KLOE/KLOE-2, results and perspectives (12'+3')

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The KLOE-2 experiment, at the e^+e^- DAΦNE collider in Frascati, acquired an integrated luminosity of about 5 fb^{-1} with an upgraded KLOE apparatus. The whole KLOE/KLOE-2 data sample corresponds to 2.4 $\times 10^{10}$ ϕ and 3.1×10^8 η meson events allowing to develop a wide hadron physics program from rare meson decays to $\gamma\gamma$ fusion and dark forces.

KLOE-2 investigates the $\eta \to \pi^0\gamma\gamma$ decay, an important test of ChPT because of its sensitivity to the p^6 term on both the branching ratio and the M($\gamma\gamma$) spectrum. A preliminary KLOE measurement, based on 450 pb^{-1}, provided a 4 sigma's lower value w.r.t. the most accurate determination of the BR from the Crystal Ball experiment. The new KLOE measurement performed with a larger data sample statistics will be presented.
By using the same five photon final state and
following the many KLOE-2 contributions to Dark Matter (DM) searches, an alternative model, where the dark force mediator is an hypothetical leptophobic B boson, is exploited in the ϕ decay to η-B where B will decay in $\pi^0\gamma$.

Moreover, KLOE-2 has the possibility to investigate π^0 production from $\gamma\gamma$ fusion thanks to two scintillator hodoscopes installed in the DAΦNE beam pipe to tag final-state leptons from $e^+e^- \to \gamma^*\gamma^*e^+e^- \to \pi^0e^+e^-$. The aim is to perform the high precision measurement of the π^0 width to test low-energy QCD dynamics. The status of the $\gamma^*\gamma^* \to \pi^0$ analysis will be reported.

KLOE-2 searches also the
$\phi \to \eta\pi^+\pi^-$, $\mu^+\mu^-$ decays with $\eta \to \gamma\gamma$ and $\eta \to 3\pi^0$. $\phi \to \eta\pi^+\pi^-$ is double suppressed by G–parity and the OZI rule, with an expected BR around 0.35×10^{-6}, while for the $\phi \to \eta\mu^+\mu^-$ decay an upper limit was set as 0.94×10^{-5}. By analyzing those decays with KLOE/KLOE-2 data clear signals are seen for the first time.

Collaboration / Activity:

KLOE-2 collaboration

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T12: Detector R&D and Data Handling / 522

Operation of the CGEM detector

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A ten years extension of the data taking of BESIII experiment, recently approved, motivated an upgrade program both for the leptonic collider BEPCII and for some of the sub-detectors of the spectrometer.
In particular, the current inner drift chamber is suffering from aging and the proposal is to replace it with a detector based on cylindrical GEM technology.
The CGEM detector is made of three coaxial layers of triple GEM. The tracker is expected to restore the efficiency, to improve the z determination and the secondary vertex position reconstruction with respect to the current inner tracker, with a resolution of 130 μm in xy plane and better than 350 μm along the beam direction.
A cosmic telescope instrumented with two out of three layers is in operation in Beijing since January 2020, remotely controlled by Italian groups due to the pandemic situation.
In this presentation, the general status of the project will be presented with a particular focus on the preliminary results from the cosmic data taking and future plans.

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Collaboration / Activity:

BESIII Italian Collaboration

T08: Flavour Physics and CP Violation / 525

Tau physics prospects at Belle II

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e+e− collider. The design luminosity of the machine is 8 × 1035 cm−2s−1 and the Belle II experiment aims to record 50 ab−1 of data, a factor of 50 more than its predecessor. From February to July 2018, the machine has completed a commissioning run and main operation of SuperKEKB has started in March2019. Belle II has a broad τ physics program, in particular in searches for lepton flavour and lepton number violations (LFV and LNV), benefiting from the large cross section of the pair wise τ lepton production in e+e− collisions. We expect that after 5 years of data taking, Belle II will be able to reduce the upper limits on LF and LN violating τ decays by an order of

magnitude. Any experimental observation of LFV or LNV in τ decays constitutes an unambiguous sign of physics beyond the Standard Model, offering the opportunity to probe the underlying New Physics. In this talk we will review the τ lepton physics program of Belle II.

Collaboration / Activity:

Belle II

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T08: Flavour Physics and CP Violation / 528

Search for rare electroweak decay $B^+ \rightarrow K^+$ in early Belle II dataset

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In the recent years, several measurements of B-decays with flavor changing neutral currents (FCNC), i.e. $b \rightarrow s\ell\ell$ transitions, hint at deviations from the Standard Model (SM) predictions.

A search for the flavor-changing neutral current decay $B^+ \rightarrow K^+ \nu\bar{\nu}$ is performed with data sample corresponding to 63 fb^{-1} collected at the Υ(4S) resonance by the Belle II experiment. A novel measurement method is developed, which exploits topological properties of the decay that differ from both generic B-meson decays and light-quark pair-production. This inclusive tagging approach has the benefit of a higher signal efficiency compared to previous searches for this rare decay. As no significant signal is observed, an upper limit on the branching fraction of $B^+ \rightarrow K^+ \nu\bar{\nu}$ = 4.1×10^{-5} is set at the 90% confidence level. We will talk about this novel analysis technique and the result.

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Collaboration / Activity:

Belle II

T08: Flavour Physics and CP Violation / 529

Towards first V_{ub} and V_{cb} measurements at the Belle II experiment

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Precision determinations of V_{ub} and V_{cb} play a central role in precision tests of the CKM sector of the Standard Model and complement direct measurements of CP violation of B meson decays. In this talk, we present first studies towards measurements of $|V_{ub}|$ and V_{cb}, with semileptonic decays using collision events recorded at the $\Upsilon(4S)$ resonance by the Belle II experiment. We report the status

of measuring branching fractions and kinematic properties of inclusive and exclusive $b \to u\ell\bar{\nu}_\ell$ and $b \to c\ell\bar{\nu}_\ell$ decays using untagged and tagged approaches in the full available Belle II data set. In addition, we present a Belle II measurement of the q^2 moments of $B \to X_c\ell\nu$ decay. The q^2 moments of the $b \to c\ell\nu$ transition are particularly powerful for constraining the Heavy Quark Expansion as they can be expressed in terms of a reduced set of matrix elements due to reparametrization invariance.

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Collaboration / Activity:

Belle II

T08: Flavour Physics and CP Violation / **530**

Measurement of the mixing parameter χ_d in semi-leptonic B meson decays at Belle II

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Inclusive semi-leptonic decays of B mesons are an excellent avenue for the study of B\bar{B} mixing, given their large branching fraction. In this talk, we present the measurement of the time integrated mixing parameter, χ_d, using data collected by the Belle II detector. The Belle II experiment is located at the SuperKEKB laboratory in Tsukuba, Japan where electron-positron collisions at the $\Upsilon(4S)$ energy yield a large number of B\bar{B} events. The mixing parameter χ_d is determined by examining the charge of reconstructed lepton pairs in $B \to X\ell\nu$ events. The result is based on 74 fb^{-1} of Belle II reprocessed data.

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Collaboration / Activity:

Belle II

T06: QCD and Hadronic Physics / **532**

Bottomonium results and prospects at Belle II (12'+3')

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The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is an upgrade of the B factory facility at KEK in Tsukuba, Japan. The experiment began operation in 2019 and aims to record a factor of 50 times more data than its predecessor. Belle II is uniquely capable of studying the so-called "XYZ" particles: heavy exotic hadrons consisting of more than three quarks. First discovered by Belle, these now number in the dozens, and represent the emergence of a new category within quantum chromodynamics. We present recent results in new Belle II data, and the future prospects to explore both exotic and conventional bottomonium physics.

Collaboration / Activity:

Belle II

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T08: Flavour Physics and CP Violation / 534

Charm Status and Prospects at Belle II

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The Belle II experiment at the asymmetric e^+e^- collider, SuperKEKB, aims to record 50 ab^{-1} of data over the next decade, a factor of 50 more than Belle. During the first 1.5 years of operations, around 90 fb^{-1} of data were collected. This dataset is used to measure the lifetimes of a few charm hadrons, confirming the expected performance of the Belle II detector, in particular the vertexing, which plays a crucial role in time dependent measurements. Thanks to the performance of the detector and the amount of data that we expect to collect, Belle II will play a crucial role in measuring CP violation and $D^0 - \bar{D}^0$ mixing in many decay channels, especially those having neutral particles in the final state. In this presentation we will also show the sensitivity on mixing and CPV parameters in the golden channel $D^0 \to K_S\pi^+\pi^-$ with a time-dependent Dalitz analysis, and other channels.

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Collaboration / Activity:

Belle II

T06: QCD and Hadronic Physics / 535

Studies of charmonium-like states at Belle II (12'+3')

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The Belle II experiment has accumulated data corresponding to 89.99 fb-1 integrated luminosity in the past 2 years, and is performing very good. Waiting that the full planned data set will be recorded

(50 ab-1), which will allow search for rare processes and will have a tremendous impact in the spectroscopy field, the Phase 3 data set allows to already perform analysis with high precision. We present here the analysis of B -> K J/psi pi pi and B -> K psi(2S): in the former for the first time the evidence for the X(3872) —>Jpsi pi pi has been found at Belle II, which is consistent with the observation at Belle of the same resonant state, performed in 2003.
The re-discovery of the X(3872) based on the early Phase3 data includes the efficiency and resolution study, calibration with B -> K psi(2S), and background check. When higher statistics will be available, Belle II is planning the even more interesting analysis of B—>DD*K, and search for X(3872)→DD*

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Collaboration / Activity:

Belle II

T08: Flavour Physics and CP Violation / 537

Measurements of $B \to D^{(*)}K$ and $B \to D^{(*)}\pi$ related to the determination of γ at Belle II

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he CKM angle γ (ϕ_3) of the unitarity triangle is the only one that is accessible with tree-level decays in a theoretically clean way. The key method to measure γ is through the interference between $B^+ \to D^0K^+$ and $B^+ \to \bar{D}^0K^+$ decays that occurs if the final state of the charm-meson decay is accessible to both the D^0 and $\bar{D}^0$ mesons. The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than its predecessor. With the ultimate Belle II data sample of 50 ab^{-}1, a determination of γ with a precision of 1 degree or better is foreseen. Main operation of SuperKEKB started in March 2019 and results from the full available Belle II data set, which corresponds to approximately 100~fb^{-1}, will be presented. The ratios of decay rates of $\Gamma(B^- \to D^{(*)0}K^-)/\Gamma(B^- \to D^{(*)0}\pi^-)$ and $\Gamma(\bar{B}^0 \to D^{(*)+}K^-)/\Gamma(\bar{B}^0 \to D^{(*)+}\pi^-)$ are measured. In addition, more detailed studies of $B^- \to D(K^0_S\pi^+\pi^-)K^-$, $B^- \to D(K^0_S\pi^0)K^-$ and $B^- \to D^{*0}(D^0\pi^0)K^-$ decays are described; these modes are key to the accurate determination of γ at Belle II.

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Collaboration / Activity:

Belle II

T09: Higgs Physics / 539

Renormalization and non-renormalization of scalar EFTs at higher orders

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For its ability to systematically capture beyond the Standard Model (SM) effects, effective field theory (EFT) has received much attention in phenomenological analyses of e.g. LHC data. In EFT studies, it is essential to identify an operator basis and calculate the anomalous dimensions of the couplings, which encode their scale dependence. In this work, we renormalize the scalar EFT at high orders (5 loop at mass dimension 6 up to 1 loop at mass dimension 12), using the R*-operation. To this end, we explicitly construct the operator bases that are necessary in intermediate steps. Results are presented in the so-called basis of conformal primaries, which exposes interesting non-renormalization and symmetric renormalization structures. The applied method can be extended to more general theories, such as the SM EFT.

Collaboration / Activity:

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T10: Searches for New Physics / 541

Prospects for long-lived particle searches at Belle II

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The Belle II experiment at the asymmetric e^+e^- collider, SuperKEKB, is a substantial upgrade of the Belle/KEKB experiment. Belle II aims to record 50 ab^{-1} of data over the course of the project. During the first physics runs in 2018-2020, around 100 fb^{-1} were collected. Large improvements in the instantaneous luminosity are expected in the coming years. The Belle II detector benefits from a larger tracking detector and improved tracking and vertexing algorithms with respect to Belle, allowing for improvements in the reconstruction of vertices that are displaced from the interaction point. This talk will review the prospects for long-lived particle searches at Belle II. The experiment can be used to search for long lived particles produced directly in the interaction, or in meson and lepton decays.

Tau

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Collaboration / Activity:

Belle II

T04: Neutrino Physics / 543

Short-Baseline neutrino oscillation searches with the ICARUS detector

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The ICARUS collaboration employed the 760-ton T600 detector in a successful three-year physics run at the underground LNGS laboratories studying neutrino oscillations with the CNGS neutrino beam from CERN, and searching for atmospheric neutrino interactions. ICARUS performed a sensitive search for LSND-like anomalous νe appearance in the CNGS beam, which contributed to the constraints on the allowed parameters to a narrow region around 1 eV^2, where all the experimental results can be coherently accommodated at 90% C.L. After a significant overhaul at CERN, the T600 detector has been installed at Fermilab. In 2020 cryogenic commissioning began with detector cool down, liquid Argon filling and recirculation. ICARUS has started operations and is presently in its commissioning phase, collecting the first neutrino events from the Booster Neutrino Beam and the NuMI off-axis. The main goal of the first year of ICARUS data taking will then be the definitive verification of the recent claim by NEUTRINO-4 short baseline reactor experiment both in the ν_μ channel with the BNB and in the ν_e with NuMI. After the first year of operations, ICARUS will commence its search for evidence of a sterile neutrino jointly with the SBND near detector, within the Short Baseline Neutrino (SBN) program. The ICARUS exposure to the NuMI beam will also give the possibility for other physics studies such as light dark matter searches and neutrino-Argon cross section measurements. The proposed contribution will address ICARUS achievements, its status and plans for the new run at Fermilab and the ongoing developments of the analysis tools needed to fulfill its physics program.

Collaboration / Activity:

ICARUS

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T03: Dark Matter / 544

Status of the DEAP-3600 Dark Matter Search at SNOLAB

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The latest results from DEAP-3600 will be presented. DEAP-3600 is a single-phase liquid argon (LAr) dark matter detector operating 2 km underground at SNOLAB in Sudbury, Canada. The detector

consists of 3.3 tonnes of LAr in a spherical acrylic vessel viewed by an array of 255 photomultiplier tubes. DEAP-3600 has been taking data stably since November 2016. Background events that can mimic dark matter particles' signature can be produced in the detector by different sources including beta/gamma interactions in the LAr and acrylic vessel, neutron-induced nuclear recoils and alpha decays. Analysis of the data taken so far demonstrates the power of pulse shape discrimination (PSD) used to suppress background events. This presentation will feature recent DEAP-3600 performance results, the status of the background model, and the most sensitive limit on WIMP dark matter search using a LAr target. This result is reinterpreted with a more general Non-Relativistic Effective Field Theory (NREFT) framework where DEAP-3600 has leading sensitivity for some model parameters. In addition, we also explore how various possible sub-structures in the local dark matter halo may affect the constraints on WIMP-nucleon interactions.

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Collaboration / Activity:

DEAP-3600

T06: QCD and Hadronic Physics / 546

Quarkonium production in pp, p-Pb, and peripheral Pb-Pb collisions with ALICE (12'+3')

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The production of quarkonia, bound states of heavy quark-antiquark pairs, in hadronic collisions is a unique testing ground for our understanding of QCD as the theory of the strong interaction. The hard scattering that produces the heavy-quark pair can be described within perturbative QCD, whereas the evolution of this pair into a colorless bound state involves soft scales. At LHC energies, quarkonia are abundantly produced, and hence can be used to investigate multiple parton interactions. In addition, in pp collisions, quarkonium production serves as a reference for the production in proton-nucleus and nucleus-nucleus collisions, where it becomes sensitive to cold nuclear matter effects (nuclear shadowing of the parton density, energy loss of the $q\bar{q}$ pair while traversing the nucleus, rescattering/break-out effects) and hot nuclear effects (QGP formation). Furthermore in peripheral Pb-Pb collisions, J/ψ photoproduction in coincidence with hadronic interaction can probe the initial state of the heavy-ion collision. ALICE is able to measure quarkonia both at forward ($2.5 < y < 4$) and midrapidity ($|y| < 0.9$) down to zero transverse momentum in all collision systems provided by the LHC, which is a unique feature. In this contribution, final results in pp collisions on J/ψ, ψ(2S), and Υ(nS) production at forward rapidity at $\sqrt{s}$ = 5.02 TeV, and on J/ψ production at midrapidity at $\sqrt{s}$ = 5.02 and 13 TeV will be presented. At midrapidity, the prompt J/ψ production, originating from direct quarkonium production in the collision, and the non-prompt J/ψ production, originating from b-hadron decays are measured separately. Inclusive J/ψ cross section is measured at midrapidity up to 40 GeV/c at $\sqrt{s}$ = 13 TeV, thanks to events triggered according to the energy deposition in EMCAL. Results on the hadron multiplicity dependence of J/ψ production at $\sqrt{s}$ = 5.02 and 13 TeV at both central and forward rapidities, and preliminary results on the multiplicity dependence of ψ(2S) and Υ(1S, 2S) production at forward rapidity at $\sqrt{s}$ = 13 TeV will be shown. In p-Pb collisions, at forward rapidity and $\sqrt{s_{NN}}$ = 8.16 TeV, final results on ψ(2S) yield modification, including its dependence on the event centrality and on Υ production will be presented. Finally, we will show new results based on the full Run 2 Pb-Pb statistics on J/ψ photoproduction in hadronic semi-central collisions at forward rapidity. The comparison of results across different beam energies and with theoretical model calculations will also be discussed.

Collaboration / Activity:

ALICE

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T08: Flavour Physics and CP Violation / 547

A new determination of $|V_{cb}|$ using inclusive q^2 moments of $B \to X_c \ell \bar{\nu}_\ell$ decays

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Precision determination of the CKM matrix element $|V_{cb}|$ are important to test the unitarity of the CKM matrix and to search for loop-level new physics effects. In this talk, we present a new determination of $|V_{cb}|$ using measured q^2 moments from $B \to X_c \ell \bar{\nu}_\ell$ decays provided by the Belle and Belle II collaborations. This new experimental input is the key ingredient to determine the non-perturbative hadronic matrix elements entering the total semileptonic $B \to X_c \ell \bar{\nu}_\ell$ rate in the heavy-quark expansion. Exploiting reparametrization invariance, the number of these non-perturbative parameters can be reduced to 8 at $\mathcal{O}(1/m_b^4)$. The value of these parameters and $|V_{cb}|$ is simultaneously determined, taking into account also the theoretical uncertainties from missing higher order contributions in the heavy quark expansion and corrections from the strong interaction.

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Collaboration / Activity:

Collaborative Research

T03: Dark Matter / 548

An even lighter QCD axion

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We explore whether the axion which solves the strong CP problem can naturally be much lighter than the canonical QCD axion. The Z_N symmetry proposed by Hook, with N mirror and degenerate worlds coexisting in Nature and linked by the axion field, is considered and the associated phenomenology is studied in detail.
On a second step, we show that dark matter can be accounted for by this extremely light axion. This includes the first proposal of a "fuzzy dark matter"QCD axion. A novel misalignment mechanism

occurs –trapped
misalignment–due to the peculiar temperature dependence of the Z_N axion potential, which in some cases can also dynamically source the recently proposed kinetic misalignment mechanism.
The resulting universal enhancement of all axion interactions relative to those of the canonical QCD axion has a strong impact on the prospects of ALP experiments such as ALPS II, IAXO and many others. For instance, even Phase I of Casper Electric could discover this axion.
Based on 2102.00012 and 2102.01082.

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Collaboration / Activity:

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T05: Heavy Ion Physics / 550

Quarkonia measurements in nucleus-nucleus collisions with ALICE

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The production of quarkonia is one of the first proposed probes of the QGP properties in heavy-ion collisions. Since heavy quarks are produced during the early hard partonic collisions, they experience the entire evolution of the fireball. The suppression of quarkonium bound states by the free color charges of the dense deconfined medium, as well as the charmonium regeneration by (re)combination of charm quarks at the QGP phase boundary or through the fireball evolution, are sensitive to the medium properties. Furthermore, a modification of the quarkonium vector states polarization in Pb—Pb collisions with respect to pp collisions may give further insights on quarkonium suppression and regeneration mechanisms in the QGP. In addition, to the study of quarkonia in inelastic heavy-ion collisions, coherent photonuclear production of vector mesons can be studied by the virtue of the strong electromagnetic fields generated by ultrarelativistic heavy ions to infer information on the wave function of the nuclei that are crucial for the understanding of the initial state of heavy-ion collisions.

In this contribution, we will report on the recent ALICE measurements of the nuclear modification factor R_{AA} of J/ψ as a function of centrality/p_{T}, and on final J/ψ v_2 results, at both mid- and forward rapidity, using the full Run 2 Pb—Pb data sample ($\sqrt{s_{\mathrm{NN}}}$=5.02 TeV). The final results on Υ(1S) R_{AA} and v_2, Υ(2S) R_{AA}, and J/ψ v_3 measured at forward rapidity will also be shown. We will also report on the first measurement of the J/ψ polarization in Pb—Pb collisions as a function of p_{T} and of the collision centrality, providing prospects for measurements as a function of the event plane. The aforementioned results will be compared and confronted to theoretical model predictions. Furthermore, we will discuss recent ALICE results on photonuclear production of ρ and J/ψ mesons in ultra-peripheral collisions.

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Collaboration / Activity:

ALICE

T04: Neutrino Physics / 551

Collective effects in neutrino scattering on solid and liquid targets

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Neutrino scattering on liquid and solid targets at low energy transfer can serve both as a tool for searching the BSM physics, for example, such as neutrino electromagnetic interactions 1, and as a test of the Standard Model at low-energy scale [2]. At the same time, the theoretical apparatus for low-energy elastic neutrino scattering on electrons and nuclei bound in liquids and solids must take into account collective effects in the electron and nuclear subsystems of the target. We develop such an apparatus based on the formalism of the density-density and current-current Green's functions. Some numerical illustrations of the roles of the collective effects are provided for the cases of superfluid He-4 1 and graphene [3] targets.

1 C. Giunti and A. Studenikin, Rev. Mod. Phys. 87, 531 (2015) [arXiv:1403.6344 [hep-ph]].
[2] M. Cadeddu, F. Dordei, C. Giunti, K. Kouzakov, E. Picciau, A. Studenikin, Phys. Rev. D 100, 073014 (2019) [arXiv:1907.03302 [hep-ph]].
[3] Y. Hochberg et al., Phys. Lett. B 772, 239 (2017) [arXiv:1606.08849 [hep-ph]].
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Collaboration / Activity:

None

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T06: QCD and Hadronic Physics / 552

Low-mass dielectron measurements with ALICE at the LHC

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Dileptons and photons are unique tools to study the space–time evolution of systems created by QCD in hadronic collisions. They are produced continuously by a variety of sources, in particular prompt and thermal photons and semileptonic heavy-flavour hadron decays, during the entire history of the collision and traverse the medium with negligible final state interaction. So they can carry undistorted information on early stages of the collision.
In this contribution, we will present results from the recent measurements of e^+e^- pair production in pp and p–Pb collisions at the center-of-mass energy $\sqrt{s_{\rm NN}}$ = 5.02 TeV. Charm and beauty cross

sections are extracted to investigate possible cold nuclear matter effects such as shadowing by comparing different nPDFs on the nuclear modification factor R_{pPb}.
Furthermore, our results on dielectrons at low $p_{\mathrm{T,ee}}$ in pp collisions at $\sqrt{s}$ = 13 TeV and new preliminary results of dilepton production from photoproduction in inelastic Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV are presented and compared to expectations from calculations including bremsstrahlung (for pp collisions) and photoproduction (for Pb-Pb collisions).

Collaboration / Activity:

ALICE

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T06: QCD and Hadronic Physics / **553**

Study of the central exclusive production of $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ pairs in proton-proton collisions at $\sqrt{s} = 510$ GeV with the STAR detector at RHIC

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We report on the measurement of the central exclusive production process $pp \rightarrow pXp$ in proton-proton collisions at RHIC with the STAR detector at $\sqrt{s} = 510$ GeV. At this energy, this process is dominated by a double Pomeron exchange mechanism. The tracks of the centrally produced system X were reconstructed in the central detector of STAR, the Time Projection Chamber and the Time of Flight systems, and were identified using the ionization energy loss and the time of flight method. The diffractively scattered protons, moving intact inside the RHIC beam pipe after the collision, were measured in the Roman Pots system allowing full control of the interaction's kinematics and verification of its exclusivity. The preliminary results on the invariant mass distributions of centrally produced $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ pairs measured within the STAR acceptance are presented.

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Collaboration / Activity:

The STAR collaboration

T06: QCD and Hadronic Physics / **554**

Charm cross section and fragmentation fractions in pp collisions with ALICE (12'+3')

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In this contribution, we present the latest measurements of Λ_c^+, $\Xi_c^{+,0}$, $\Sigma_c^{0,++}$, and the first measurement of Ω_c^0 baryons performed with the ALICE detector at midrapidity in pp collisions at $\sqrt{s}$ = 5.02 and 13 TeV. Recent measurements of charm-baryon production at midrapidity by the ALICE Collaboration in small systems show a baryon-over-meson ratio significantly higher than that in e^+e^- collisions, suggesting that the fragmentation of charm is not universal across different collision systems. Thus, measurements of charm-baryon production are crucial to study the charm quark hadronisation in proton-proton collisions and its difference with respect to e^+e^- collisions, which is also relevant for the description of heavy-flavour mesons. In fact, the production cross sections of open heavy-flavour hadrons are usually described within the factorisation approach as the convolution of the parton distribution functions of the incoming protons, the perturbative QCD partonic cross section, and the fragmentation functions which are typically parametrised from measurements in e^+e^- collisions. In addition, the large measured baryon yields are an important contribution for an accurate measurement of the $c\bar{c}$ production cross section at midrapidity in pp collisions at the LHC, which status and progresses are also presented. Furthermore, the new Λ_c^+/D^0ratio measured down to p_T = 0 in p-Pb collisions as well as the nuclear modification factor will be discussed. The measurement of charm baryons in p-nucleus collisions provides important information about Cold Nuclear Matter (CNM) effects. It also helps to understand how the possible presence of collective effects could modify production of heavy-flavour hadrons and the similarities observed among pp, p-nucleus and nucleus-nucleus systems. The results will be compared to models including CNM effects, as well as models assuming the formation of a quark-gluon plasma in p-Pb collisions.

Collaboration / Activity:

ALICE

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T10: Searches for New Physics / 555

Search for scalar top quark pair production in the top corridor region in CMS

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A search for scalar top quark pair production at the LHC with the CMS experiment is presented. This search targets a region of parameter space where the kinematics of top squark pair production and top quark pair production are very similar because of the mass difference between the top squark and the neutralino is close to the top quark mass. The search is performed with the full dataset of proton-proton collisions collected by the CMS experiment during the Run 2 of the LHC, at a centre-of-mass energy of 13 TeV. An algorithm based on a deep neural network is used to separate signal from background.

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Collaboration / Activity:

CMS Collaboration

T08: Flavour Physics and CP Violation / 556

New Physics in $b \to s\,\nu\,\bar{\nu}$ decays ?

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Measurements of various lepton flavor universal observables in $b \to s\,l^+l^-$ transition decays continue to disagree with the standard model expectations. The recent update of R_K measurement from LHCb still indicates 3.1σ deviation from the standard model. Similarly, the measurements of other observables such as R_{K^*}, P_5' and $\mathcal{B}(B_s \to \phi\,\mu^+\,\mu^-)$ continue to show disagreement with standard model predictions. It is well known that there exists a very close relation between $b \to s\,l^+l^-$ and $b \to s\,\nu\bar{\nu}$ decays not only in standard model but also in beyond the standard model physics. In beyond the standard model physics these decay processes are related via $SU(2)_L$ gauge symmetry which relates neutrinos to the left handed charged leptons. Moreover, the B decays with $\nu\bar{\nu}$ final state are theoretically cleaner channels than the corresponding $b \to s\,l^+l^-$ neutral transitions as they do not suffer from hadronic uncertainties beyond the form factors such as the non-factorizable corrections and photonic penguin contributions. Hence, we explore $B_s \to (\phi\,,\eta\,,\eta')\,\nu\,\bar{\nu}$ decays mediated via $b \to s\,\nu\,\bar{\nu}$ transitions using the standard model effective field theory formalism. We give predictions of several observables in standard model and in the presence of various new physics couplings.

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Collaboration / Activity:

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T01: Astroparticle and Gravitational Waves / 557

Construction and verification of analytical approximation of nonequilibrium neutrino distribution function in core-collapse supernova

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The local nonequilibrium neutrino distribution function in a core-collapse supernova is considered and two variants of its analytical approximation are suggested. The proposed analytical approximations are verified using the results of a one-dimensional simulation of neutrino propagation, performed self-consistently with hydrodynamics in Prometheus-Vertex code. It was shown that the approximation, based on a nominal Fermi-Dirac distribution of neutrino spectrum, agrees with results of Prometheus-Vertex simulation only in the inner parts of the supernova. Whereas the approximation based on alpha-fit of neutrino energy distribution, also known as Gamma-distribution, is more general and has no restrictions for application in any part of the supernova. The obtained results could be applied for estimation of various neutrino effects in supernova conditions without their direct inclusion in the explosion simulation. The work is supported by the Russian Science Foundation (Grant No. 18-72-10070).

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Collaboration / Activity:

No

T07-T09: Combined: Top, Electroweak and Higgs Physics / 558

Global properties of SMEFT and HEFT

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We present two works which study global properties of EFT descriptions of physics beyond the Standard Model (BSM).

The first, based on arXiv:2008.08597, considers what BSM physics is amenable to a decoupling SMEFT description. The four scalar degrees of freedom of the Standard Model, the Higgs and the longitudinal components of the Ws and Z, can be viewed one of two ways: "SMEFT" wraps them up in a single Higgs doublet, whereas "HEFT" treats the Higgs and the Goldstones separately. We identify (field redefinition invariant) features of the scalar field space manifold that can only be described by the latter HEFT, and thereby identify two classes of UV completions for which HEFT is required: i) those which contain extra sources of electroweak symmetry breaking, ii) those which contain particles getting all of their mass from electroweak symmetry breaking.

The second, based on arXiv:2001.00017, considers weakly coupled heavy BSM physics that is amenable to a SMEFT description, and its generic pattern of tree-level and loop-level effects in observables. We do this in the high energy limit, where both the Standard Model and the BSM physics have a specific pattern of effects in helicity amplitudes. A main result is to extend non-interference theorems — between SM and weakly coupled BSM physics in certain 2 -> 2 scattering processes — to one-loop order.

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T14: Outreach, Education and Diversity / 559

Sharing ATLAS Science: communicating to the public

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Communicating the science and achievements of the ATLAS Experiment is a core objective of the ATLAS Collaboration. This talk will explore the range of communication strategies adopted in ATLAS communications, with particular focus on how these have been impacted by the COVID-19 pandemic. In particular, an overview of ATLAS'digital communication platforms will be given – with focus on social media –and the effect on target audiences evaluated with best practices are shared.

Collaboration / Activity:

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T14: Outreach, Education and Diversity / 560

Educational Printables: from colouring books to cheat & fact sheetspublic

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The ATLAS Collaboration has developed a variety of printables for education and outreach activities. We present two ATLAS Colouring Books, the ATLAS Fact Sheets, the ATLAS Physics Cheat Sheets, and ATLAS Activity Sheets. These materials are intended to cover key topics of the work done by the ATLAS Collaboration and the physics behind the experiment for a broad audience of all ages and levels of experience. In addition, there is ongoing work in translating these documents to different languages, with one of the colouring books already available in 18 languages. These printables are prepared to complement the information found in all ATLAS digital channels, they are particularly useful in outreach events and in the classroom.

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T14: Outreach, Education and Diversity / 562

ATLAS Open Data –a genuinely collaborative approach for the creation of educational resources

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The ATLAS Open Data project aims to deliver open-access resources for education and outreach in High Energy Physics and related computer sciences. Because the resources -data, software and documentation-target students and instructors, they must be tested by students and instructors before being released. One of the most effective production ways we have found is to promote on-site and remote training schemes such as high-school work experience and summer schools programs, university projects and PhDs qualification tasks. Those programs and alliances allow the construction of a platform that relies on the expertise of ATLAS members and the invaluable contribution of students that help to test and build resources that hundreds of their peers use around the world. We present how multiple training programs inside and outside CERN helped and continue to help create the ATLAS Open Data project and the lessons learnt so far on how to continue implementing this kind of programs.

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ATLAS Collaboration

T14: Outreach, Education and Diversity / 564

The ATLAS public website-Evolution to Drupal 8

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Four years after the deployment of the ATLAS public website using the Drupal 7 content management system, the ATLAS Education & Outreach group has completed its migration to the new CERN Drupal 8 infrastructure. We present lessons learned from the development, usage and evolution of the original web site, and how the choice of technology helped to shape and reinforce our communication strategy. We then discuss tactics for the migration to Drupal 8, including our choice to use the CERN Override theme. This theme was developed by the CERN web team to support clients like ATLAS to develop web sites in the relatively complex and non-intuitive environment of Drupal. Furthermore, CERN has encouraged usage of this theme to mitigate maintenanceand ease future migration. We present the effects this choice has on the design, implementation, and operation of the new site.

Collaboration / Activity:

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T12: Detector R&D and Data Handling / 565

Serial powering and signal integrity characterisation for the TEPX detector for the Phase-2 CMS Inner Tracker

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The High Luminosity Large Hadron Collider (HL-LHC) at CERN is expected to collide protons at a centre-of-mass energy of 14 TeV and to reach the unprecedented peak instantaneous luminosity of $5x10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ with an average number of pileup events of 140. This will allow the ATLAS and CMS experiments to collect integrated luminosities up to 4000 fb^{-1} during the project lifetime. To cope with this extreme scenario the CMS detector will be substantially upgraded before starting the HL-LHC, a plan known as CMS Phase-2 upgrade. The entire CMS silicon pixel detector (IT) will be replaced and the new detector will feature increased radiation hardness, higher granularity and capability to handle higher data rate and longer trigger latency.

The upgraded IT will be composed of a barrel part, TBPX, and small and large forward disks, TFPX and TEPX. The novel scheme of serial powering will be deployed to power the pixel modules and new technologies will be used for a high bandwidth readout system. The TEPX detector has four large disks on each side, extending the coverage up to $|\eta| < 4.0$. Furthermore, the services will be redesigned for the new system. In this contribution the new TEPX detector will be presented, with particular focus on a novel concept to provide both power and data connectivity to the modules through a disk PCB. As TEPX also features the longest serial powering chains in IT, an emphasis on serial powering results will be shown, together with signal integrity and data transmission performance. In TEPX the modules are arranged in five concentric rings. The chains corresponding to the first and third rings have been tested with 5 and 9 quad digital RD53A modules, respectively. Their performance in the disk, while being powered in series, has been compared with the one achievable in stand-alone mode, in terms of noise, threshold uniformity, signal integrity. No degradation of these parameters was observed for these serial power chains and it was possible to establish a simultaneous communication to all the modules. The study will continue with the implementation in the chains of quad modules with sensors, to study the HV distribution, and with the serial power operation of the longest chain in Ring 5, where 12 modules are located.

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Collaboration / Activity:

CMS / tracker phase-2 upgrade

T08: Flavour Physics and CP Violation / 566

NNLO QCD corrections to B-meson mixing

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The flavor mixing parameter $\Delta\Gamma_{12}^{s}$ that governs the lifetime differences of neutral B_s mesons suffers from large uncertainties related to the uncalculated perturbative corrections. In this talk I will present new results on the previously unknown NNLO QCD corrections to the $B_s - \bar{B}_s$ mixing process that lead to a reduction of theoretical errors on $\Delta\Gamma_{12}^{s}$. To this end, we perform a fully analytic evaluation of the current-current correlators at 3 loops, as well as the current-penguin and current-chromomagnetic correlators at 2 loops in the $\Delta B = 1$ effective Hamiltonian. Some interesting aspects of this calculation to be addressed in my talk involve higher-order matching between two effective field theories ($\mathcal{H}_{\text{eff}}^{\Delta B=1}$ and $\mathcal{H}_{\text{eff}}^{\Delta B=2}$), dedicated treatment of evanescent operators in the presence of dimensionally regulated IR divergences, asymptotic expansion of the amplitudes in m_c/m_b up to $\mathcal{O}(m_c^2)$ and the analytic evaluation of the resulting 3-loop on-shell integrals with one mass scale.

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Collaboration / Activity:

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T05: Heavy Ion Physics / 567

Measurement of the jet-particle v_2 in p–Pb and Pb–Pb collisions at $\sqrt{s_{\text{NN}}}$ = 5.02 TeV with ALICE at the LHC

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In heavy-ion collisions, the observed non-zero second-order azimuthal anisotropy coefficient v_2 of particles with high transverse momenta p_{T} is driven by the path-length dependent energy loss of hard partons traveling in the quark-gluon plasma, known as the jet quenching effect. Recent measurements show also a non-zero v_2 value for high-p_{T} charged particles at high multiplicities in small collision systems. The origin of this effect is still debated, and various mechanisms, such as parton energy loss in the cold nuclear matter, hydrodynamic evolution in the final state and initial-state gluon correlations, are proposed to describe the observations. In this contribution, the v_2 measurements of charged particles in jets at midrapidity (|η|<0.8) in 20–60% semicentral Pb–Pb collisions and 0–10% most central p–Pb collisions at $\sqrt{s_{\text{NN}}}$ = 5.02 TeV recorded with the ALICE detector are presented. The particles associated with jets are extracted from the two-particle correlations using a combined fit, and their v_2 are calculated with the scalar product method in Pb–Pb collisions and the central-forward correlation method in p–Pb collisions. The comparisons of the jet-particle and inclusive-particle v_2 in both p–Pb and Pb–Pb collisions will bring new insight into the understanding of the origin of the high-p_{T} azimuthal anisotropy observed in small collision systems.

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T08: Flavour Physics and CP Violation / 568

One-loop corrections to ALPs effective couplings

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The one-loop contributions to Axion-like-particles (ALPs)-SM couplings stemming from effective ALP operators, including all finite one-loop corrections, are presented. This is the first such analysis for most ALP-SM couplings. The complete leading-order (dimension five) effective linear Lagrangian is considered for an off-shell ALP. The results are timely because the level of experimental sensitivity to several ALP-SM couplings has reached a level where one-loop corrections are necessary, and in some cases they are the best tool to constraint some couplings.
For instance, ALP-WW interaction is hardly observed at tree level, but competitive constraints are obtained via its contribution to ALP-γγ interaction at one-loop order. The results are of particular impact on non-resonant LHC and accelerator searches of ALP coupling to γγ, ZZ, Zγ, WW and fermions.

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T05: Heavy Ion Physics / 569

Exploring jet fragmentation using two-particle correlations with Λ and K^0_S as trigger particles in pp and Pb–Pb collisions with ALICE

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Complementary to jet reconstruction, two-particle correlations in $\Delta\eta$ and $\Delta\varphi$ are used to study jets, in particular their particle composition. While in Pb–Pb collisions this is done to characterize the quark–gluon plasma, pp and p–Pb collisions serve as a reference and are of interest on their own for their input into the understanding of particle production mechanisms. Recent ALICE results on the production of strange particles in small systems (pp and p–Pb collisions) reveal the possibility of having similar strange hadron production mechanisms in all collision systems. We present here a study of two-particle correlations triggered with strange hadrons (K^0_S, Λ, $\overline{\Lambda}$) in pp collisions at 13 TeV

and 5.02 TeV and in the most central Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV. The dependence of the per-trigger yields of primary charged hadrons on the transverse momenta of the trigger and associated particles, as well as on the event multiplicity, will be presented for both the near-side and away-side regions. Moreover, the ratios of these yields to the yields extracted from inclusive hadron-hadron correlations and the nuclear modification factor I_{AA} will be discussed. The results are compared among the three hadron species. In addition, a comparison to different Monte Carlo generators is presented, which allows us to better understand the strangeness production in jets.

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Collaboration / Activity:

ALICE

T06: QCD and Hadronic Physics / 570

Extending the ALICE strong-interaction studies to nuclei: measurement of proton-deuteron correlations in pp collisions at $\sqrt{s} = 13$ TeV

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The large data sample of high-multiplicity pp collisions collected by ALICE allows for the precise measurement of the size of the source producing primary hadrons, opening the door to the study of the interaction of different hadron species using femtoscopy techniques. The momentum correlation between (anti)protons and (anti)deuterons measured in pp collisions at $\sqrt{s} = 13$ TeV with ALICE is studied here for the first time. The measured correlation function for ($\bar{\mathrm{p}}$)p–($\bar{\mathrm{d}}$)d pairs is compared with theoretical predictions based on both Coulomb interaction only and Coulomb plus strong interactions, employing the Lednický-Lyuboshitz model and the scattering parameters extracted from p-d scattering experiments. In both cases, the measured correlation function cannot be reproduced by the predictions. This deviation is interpreted as a demonstration of the late formation time of (anti)deuterons in hadron-hadron collisions. This observation is key for the understanding of the production mechanism of light (anti)nuclei, which is an open issue in high-energy physics and has also important consequences for the study of antinuclei formation in the interstellar medium either from collisions triggered by high-energy cosmic rays or by dark matter decays.

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T03: Dark Matter / 571

Photophilic hadronic axion from heavy magnetic monopoles

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We propose a model for the QCD axion which is realized through a coupling of the Peccei-Quinn scalar field to magnetically charged fermions at high energies. We show that the axion of this model solves the strong CP problem and then integrate out heavy magnetic monopoles using the Schwinger proper time method. We find that the model discussed yields axion couplings to the Standard Model which are drastically different from the ones calculated within the KSVZ/DFSZ-type models, so that large part of the corresponding parameter space can be probed by various projected experiments. Moreover, the axion we introduce is consistent with the astrophysical hints suggested both by anomalous TeV-transparency of the Universe and by excessive cooling of horizontal branch stars in globular clusters. We argue that the leading term for the cosmic axion abundance is not changed compared to the conventional pre-inflationary QCD axion case for axion decay constant $f_a > 10^{12}$ GeV.

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T01: Astroparticle and Gravitational Waves / 572

Investigation of three-body nuclear forces via the femtoscopy method in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

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The femtoscopic studies performed by the ALICE Collaboration in pp and p–Pb collisions provide results with unprecedented precision for the short-range strong interactions between several hadron pairs containing nucleons, kaons or hyperons. Three-particle femtoscopy goes one step further and aims to provide the first direct measurement of genuine three-body forces at short distances. The cases of proton-proton-proton and proton-proton-Λ interactions are studied first. Currently, the theoretical models describing these three-body strong interactions are constrained by the binding energies of nuclei and hypernuclei, which are strongly affected by many-body effects. A direct measurement of unbound three-body states is hence crucial to pin down the underlying interaction and also for the resulting equation of state of neutron stars, that strongly depends on this. In this talk, the first femtoscopic p-p-p and p-p-Λ correlation studies are presented. The results are obtained using high-multiplicity pp collisions at $\sqrt{s} = 13$ TeV measured by ALICE. The three-body femtoscopic correlation functions, measured as function of the Lorentz invariant Q_3 kinematic variable, include contributions from the genuine three-body as well as two-body interactions. The formalism of multivariate cumulants is applied to remove the lower order contributions. The latter are estimated with two independent methods: one based on the mixed-event technique and another employing mathematical projectors of two-body correlation functions. In this contribution, the p-p-p and p-p-Λ correlation functions will be shown as well as the corresponding cumulants using the

two methods. These results represent the first ever direct measurement of genuine three-baryon interaction at short distances.

Collaboration / Activity:

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T06: QCD and Hadronic Physics / 573

Understanding baryon and strangeness production using two-particle angular correlations in pp collisions from ALICE

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Correlations between identified particles produced in high-energy nuclear collisions provide a wealth of information about hadronization mechanisms and the evolution of the system. New correlation measurements between long-lived particles (including π, K, p, Λ,Ξ) are used to investigate the particle production and the species dependence of (mini)jet fragmentation. The string/rope model predicts that strangeness is produced in $\mathrm{s\bar{s}}$ pair breaking, therefore, correlations between strange and anti-strange hadrons are expected, and studies of these correlations can provide information on strangeness production mechanisms. In this talk we present measurements of Ξ−π, Ξ−K, Ξ−p, Ξ−Λ, and Ξ−Ξ angular correlations in pp collisions at $\sqrt{s} = 13$ TeV as a function of multiplicity, and discuss the implications for this unique probe on the understanding of strangeness production mechanisms. Furthermore, in previous measurements in pp collisions at $\sqrt{s} = 7$ TeV we observed that correlations between baryons show qualitatively different behavior than those of mesons, and the origin of this difference is still unknown. We will show new results on π, K, p, and Λ correlations from $\sqrt{s} = 13$ TeV pp collisions, which present a challenge to the contemporary models of particle production in elementary systems.

Collaboration / Activity:

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T12: Detector R&D and Data Handling / 574

Latest developments and characterisation results of the MALTA sensors in TowerJazz 180nm for High Luminosity LHC

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The MALTA sensors are Depleted Monolithic Active Pixel Sensors (DMAPS) made using 180nm TowerJazz CMOS technology. These have been iteratively designed towards achieving a high radiation tolerance for applications such as in the outer layers of the HL-LHC's ATLAS Inner Tracker. To date several design enhancements have been implemented to attain a high time resolution (<2ns), granularity as well as achieving excellent charge collection efficiency uniformly across the pixel geometries. This technology promises to drastically cut the production cost of silicon sensors due to their monolithic design, bypassing the costly stage of bump bonding in hybrid sensors. This talk will provide a detailed overview of the comprehensive characterisation studies conducted on the MALTA and Mini-MALTA sensors as well as present newer functionalities being introduced in the latest iteration, the MALTA2.

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Collaboration / Activity:

CERN EP R&D Work Package 1.2

T05: Heavy Ion Physics / 576

Studies of anisotropic flow with event-shape engineering and mean transverse momentum - flow correlations in Pb-Pb, Xe-Xe and pp collisions with ALICE

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Measurements of anisotropic flow (v_n) provide valuable information on the properties of the quark-gluon plasma.
Along with studies of standard flow observables, one can use strong fluctuations of the anisotropic flow for an efficient selection of the events corresponding to a specific initial geometry. Another quantity with unique sensitivity to physical processes in the initial state is the Pearson correlation coefficient of anisotropic flow and the mean transverse momentum, $\rho(v_2^2, [p_\mathrm{T}])$. In particular, recent developments in heavy-ion theory suggest that initial momentum correlations and initial geometry give rise to dramatically different evolution of $\rho(v_2^2, [p_\mathrm{T}])$ with charged-particle multiplicity, mainly at the lowest multiplicity region not accessible in most of the LHC experiments.

In this talk, the selection technique known as Event Shape Engineering has been used to measure the elliptic and triangular flow of inclusive and identified particles (π, K, p, K^0_S, Λ, Ξ) in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV recorded by the ALICE detector. The effect of the event-shape selection is within uncertainties independent of particle species up to $p_{\rm T} \sim 8$ GeV/c, and the origin of this observation is discussed. Next, we present the measurements of $\rho(v_2^2, [p_{\rm T}])$ in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV and Xe–Xe collisions at $\sqrt{s_{\rm NN}} = 5.44$ TeV as a function of centrality, and as a function of charged-particle multiplicity at midrapidity that extends to the lowest multiplicities available. In addition, the results are complemented by the same measurements in pp collisions at $\sqrt{s} = 13$ TeV, where effects related to the initial geometry are suppressed. The measurements are compared to initial state models with and without initial momentum anisotropy and discussed in context of hydrodynamical and pQCD-inspired models. Finally, a new multi-harmonic correlation coefficient $\rho(v_2^2, v_3^2, [p_{\rm T}])$ is presented and discussed as an alternative to resolve between different initial state models in semicentral heavy-ion collisions.

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T11: Quantum Field and String Theory / 577

Four-loop scattering amplitudes journey into the forest

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A crucial challenge in perturbative Quantum Field Theory is the description of quantum fluctuations at high-energy scattering processes by the calculation of multi-loop scattering amplitudes. Aiming for improving the efficiency of these computations, we delve into a new technique based on the Loop-Tree Duality (LTD). We analyse the multiloop topologies that appear for the first time at four loops and manage to assemble them in general expression, the N^4MLT universal topology. Based on the fact that the LTD enables to open any scattering amplitude in terms of convolutions of known subtopologies, we obtained the dual representation of the universal N^4MLT topology and determined the internal causal structure of the entire amplitude. Remarkably, we verified the causal conjecture for the N^4MLT family and present explicit causal representations of selected configurations, allowing a more efficient numerical implementation due to the absence of non-causal singularities.

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T01: Astroparticle and Gravitational Waves / 578

Upper limits on the amplitude of ultra-high-frequency gravitational waves from graviton to photon conversion

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First experimental upper limits for stochastic ultra-high-frequency gravitational waves are obtained using data from existing facilities that have been constructed and operated to detect WISPs (Weakly Interacting Slim Particles). Using the graviton to photon conversion in the presence of their magnetic field, we exclude gravitational waves in the frequency bands from $(2.7-14)\times10^{14}$~Hz and $(5-12)\times10^{18}$~Hz down to a characteristic amplitude of $h_c^{\min}\approx 6\times10^{-26}$ and $h_c^{\min}\approx 5\times10^{-28}$ at 95\% confidence level, respectively. This principle applies to all experiments of this kind, with prospects of constraining (or detecting), for example, stochastic gravitational waves background from light primordial black hole evaporation in the early universe.

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T04: Neutrino Physics / 579

Electromagnetic neutrino: The theory, laboratory experiments and astrophysical probes

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We continue our discussions [1-4] on neutrino electromagnetic properties. In the present talk we start with a short introduction to the derivation of the general structure of the electromagnetic form factors of Dirac and Majorana neutrinos.

Then we consider experimental constraints on neutrino magnetic and electric dipole moments, electric millicharge, charge radii and anapole moments from the terrestrial laboratory experiments (the

bounds obtained by the reactor MUNU, TEXONO and GEMMA experiments and the solar Super-Kamiokande and the recent Borexino experiments). A special credit is done to the most severe constraints on neutrino magnetic moments, millicharge and charge radii [5-9]. The world best reactor [5] and solar [6] neutrino and astrophysical [10,11] bounds on neutrino magnetic moments, as well as bounds on millicharge from the reactor neutrinos [7] are included in the recent issues of the Review of Particle Physics (see the latest Review: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01). The best astrophysical bound on neutrino millicharge was obtained in [12].

In the recent studies [13] it is shown that the puzzling results of the XENON1T collaboration [14] at few keV electronic recoils could be due to the scattering of solar neutrinos endowed with finite Majorana transition magnetic moments of the strengths lie within the limits set by the Borexino experiment with solar neutrinos [6]. The comprehensive analysis of the existing and new extended mechanisms for enhancing neutrino transition magnetic moments to the level appropriate for the interpretation of the XENON1T data and leaving neutrino masses within acceptable values is provided in [15].

Considering neutrinos from all known sources, as well as including all available data from XENON1T and Borexino, the strongest up-to-date exclusion limits on the active-to-sterile neutrino transition magnetic moment are derived in [16] .

A comprehensive analisys of constraints on neutrino electric millicharge from experiments of elastic neutrino-electron interaction and future prospects involving coherent elastic neutrino-nucleus scattering is presented in [17].

We also present results of the recent detailed study [18] of the electromagnetic interactions of massive neutrinos in the theoretical formulation of low-energy elastic neutrino-electron scattering. The formalism of neutrino charge, magnetic, electric, and anapole form factors defined as matrices in the mass basis with account for three-neutrino mixing is presented. Using the derived new expression for a neutrino electromagnetic scattering cross section [18], we further developed studies of neutrino electromagnetic properties using the COHERENT data [8] and obtained [9] new bounds on the neutrino charge radii from the COHERENT experiment. Worthy of note, our paper [9] has been included by the Editors Suggestion to the Phys. Rev. D "Highlights of 2018", and the obtained constraints on the nondiagonal neutrino charge radii since 2019 has been included by the Particle Data Group to the Review of Particle Physics.

The main manifestation of neutrino electromagnetic interactions, such as: 1) the radiative decay in vacuum, in matter and in a magnetic field, 2) the neutrino Cherenkov radiation, 3) the plasmon decay to neutrino-antineutrino pair, 4) the neutrino spin light in matter, and 5) the neutrino spin and spin-flavour precession are discussed. Phenomenological consequences of neutrino electromagnetic interactions (including the spin light of neutrino [19]) in astrophysical environments are also reviewed.

The second part of the proposed talk is dedicated to results of our mostly recently performed detailed studies of new effects in neutrino spin, spin-flavour and flavor oscillations under the influence of the transversal matter currents [20] and a constant magnetic field [21,22], as well as to our newly developed approach to the problem of the neutrino quantum decoherence [23] and also to our recent proposal [24] for an experimental setup to observe coherent elastic neutrino-atom scattering (CEνAS) using electron antineutrinos from tritium decay and a liquid helium target that as we have estimated opens a new frontier in constraining the neutrino magnetic moment.

The discussed in the second part of the talk new results include two new effects that can be summarized as follows:

1) it is shown [20] that neutrino spin and spin-flavor oscillations can be engendered by weak interactions of neutrinos with the medium in the case when there are the transversal matter currents; different possibilities for the resonance amplification of oscillations are discussed, the neutrino Standard Model and non-standard interactions are accounted for;

2) within a new treatment [21] of the neutrino flavor, spin and spin-flavour oscillations in the presence of a constant magnetic field, that is based on the use of the exact neutrino stationary states in the magnetic field, it is shown that there is an interplay of neutrino oscillations on different frequencies. iIn particular: a) the amplitude of the flavour oscillations νLe↔ νLμ at the vacuum frequency is modulated by the magnetic field frequency μB , and b) the neutrino spin oscillation probability

(without change of the neutrino flavour) exhibits the dependence on the neutrino energy and mass square difference Δm2 .

The discovered new phenomena in neutrino oscillations should be accounted for reinterpretation of results of already performed experiments on detection of astrophysical neutrino fluxes produced in astrophysical environments with strong magnetic fields and dense matter. These new neutrino oscillation phenomena are also of interest in view of future experiments on observations of supernova neutrino fluxes with large volume detectors like DUNE, JUNO and Hyper-Kamiokande.

Two other new results discussed in the concluding part of the talk are as follows:

3) a new theoretical framework, based on the quantum field theory of open systems applied to neutrinos, has been developed [23] to describe the neutrino evolution in external environments accounting for the effect of the neutrino quantum decoherence; we have used this approach to consider a new mechanism of the neutrino quantum decoherence engendered by the neutrino radiative decay to photons and dark photons in an astrophysical environment, the corresponding new constraints on the decoherence parameter have been obtained;

4) in [24] we have proposed an experimental setup to observe coherent elastic neutrino-atom scattering (CEνAS) using electron antineutrinos from tritium decay and a liquid helium target and shown that the sensitivity of this apparatus (when using 60 g of tritium) to a possible electron neutrino magnetic moment can be of order about 7×10−13μB at 90% C.L., that is more than one order of magnitude smaller than the current experimental limit.

The best world experimental bounds on neutrino electromagnetic properties are confronted with the predictions of theories beyond the Standard Model. It is shown that studies of neutrino electromagnetic properties provide a powerful tool to probe physics beyond the Standard Model.

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T06: QCD and Hadronic Physics / 580

Photon PDF and Impact from heavy flavors in the CT18 global analysis

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Building upon the most recent CT18 global fit, we present:
1) A new calculation of the photon content of proton based on an application of the LUXqed formalism.
2) The impact of heavy-flavor production data on the CT18 PDFs family.

CT18 Photon PDF: We explore two principal variations of the LUXqed ansatz. In one approach which we designate CT18lux, the photon PDF is calculated directly using the LUXqed formula for all scales, Q. In an alternative realization, CT18qed, we instead initialize the photon PDF in terms of the LUXqed formulation at a lower scale, $Q \approx Q_0$, and evolve to higher scales with a combined QED kernel at $calO(\alpha)$, $calO(\alpha\alpha_s)$ and $calO(\alpha^2)$. Phenomenological implications of these photon PDFs at the LHC are discussed.

Heavy flavors in CT18: We discuss the impact of heavy-flavor production data on the CT18 PDFs family. In particular, we discuss the impact on the CT18 global analysis of the latest charm and bottom production measurements from the H1 and ZEUS collaborations and the differential top-quark pair production cross section measurements from CMS and ATLAS. We discuss tensions and interplays between heavy-quark observables in the global fit and the different pulls on the CT18 gluon.

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T06: QCD and Hadronic Physics / 581

QCD jet production at a high energy muon collider

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After the triumph of discovering the Higgs boson at the CERN Large Hadron Collider, people are getting increasingly interested in studying the Higgs properties in detail and searching for the physics beyond the Standard Model (SM). A multi-TeV lepton collider provides a clean experimental environment for both the Higgs precision measurements and the discovery of new particles. In high-energy leptonic collisions, the collinear splittings of the leptons and electroweak (EW) gauge bosons are the dominant phenomena, which could be well described by the parton picture. In the parton picture, all the SM particles should be treated as partons that radiated off the beam particles, and the electroweak parton distribution functions (EW PDFs) should be adopted as a proper description for partonic collisions of the initial states. In our work, both the EW and the QCD sectors are included in the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) formalism to perturbatively resum the potential large logarithms emerging from the initial-state radiation (ISR). I will show the results of QCD jet production as well as some other typical SM processes at a possible high-energy electron-positron collider and a possible high-energy muon collider obtained using the PDFs.

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T06: QCD and Hadronic Physics / 582

Searching for the odderon in exclusive $pp \to pp\phi$ and $pp \to pp\phi\phi$ reactions at the LHC

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We discuss the possibility to use the exclusive $pp \to pp\phi$ and $pp \to pp\phi\phi$ reactions in identifying the odderon exchange, the charge conjugation C = -1 counterpart of the C = +1 pomeron. The odderon was introduced on theoretical grounds in 1. Results of the TOTEM collaboration suggest that the odderon exchange can be responsible for a disagreement of theoretical calculations and the TOTEM data [2,3]. It is premature to draw definite conclusion. Here we present some recent studies for two related processes where the odderon exchange may show up. We apply recently proposed the tensor-pomeron and vector-odderon model [4]. The first reaction is central exclusive production (CEP) of pairs of ϕ mesons [5]. Here odderon exchange is not excluded by the WA102 experimental data [7] for high $\phi\phi$ invariant masses. The process is advantageous as here odderon does not couple to protons. Comparison with data from the WA102 experiment and predictions for the LHC experiments will be presented. The observation of large $M_{\phi\phi}$ and $Y_{\phi\phi}$ (rapidity distance between the ϕ) seems well suited to identify odderon exchange. We discuss also the $pp \to pp\phi$ reaction [6]. At high energies probably the photon-pomeron fusion is the dominant process. The odderon-pomeron fusion is an interesting alternative. Adding odderon exchange with parameters adjusted for the $\phi\phi$ production improves considerably description of the proton-proton angular correlations measured by the WA102 collaboration [8]. At the low energy we consider also some other subleading processes that turned out to be rather small. A combined analysis of both the K^+K^- and $\mu^+\mu^-$ channels should be the ultimate goal in searches for odderon in single ϕ CEP at the LHC. Predictions for the LHC experiments will be presented.

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T03: Dark Matter / 583

CYGNUS –Directional Identification of Nuclear and Electron Recoils from Dark Matter and Solar Neutrinos

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Recent advances in development of gaseous Time Projection Chambers (TPCs) with ability to reconstruct the direction of ionisation tracks at low energy, opens the possibility of building a nuclear recoil observatory capable of detecting directional signals from WIMP dark matter and coherent elastic neutrino-nucleus scattering (CEvNS) events from solar neutrinos. CYGNUS aims to achieve this through construction of an array of large-scale TPCs, distributed in multiple deep underground laboratories at different latitudes with multiple target nuclei, including He, C, F and S. Such an observatory would allow sensitivity to WIMP-nucleon scattering below the so-called neutrino floor, would open a new window on solar neutrino physics in channels so-far unexplored, and allow exploration of new Beyond the Standard Model (BSM) physics. Simultaneous reconstruction of low energy electron recoil tracks is also feasible to enhance background discrimination but also to open further channels for exploration. With CYGNUS we can envisage a definitive confirmation of the galactic origin of WIMPs and eventually mapping of the local velocity distribution even to low WIMP mass. Smaller pathfinder detectors, backed by simulations of directional sensitivity and background discrimination power, are now being developed and run to allow optimisation of the technologies and the cost-effectiveness of CYGNUS. These devices can nevertheless contribute short-term physics goals, for instance observation of the Migdal effect. Progress towards realisation of CYGNUS, its potential sensitivity in different scenarios, and results of recent R&D will be outlined, including discussion of new results on operation with SF6 negative ion gas with novel charge readout systems designed to achieve directional sensitivity to low mass WIMPs.

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T08: Flavour Physics and CP Violation / 584

Explaining the Cabibbo Angle Anomaly

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The first row of the Cabibbo-Cobayashi-Maskawa (CKM) matrix shows a discrepancy of $\sim 3\sigma$ with unitarity, known as the "Cabibbo Angle Anomaly"(CAA). After reviewing the origin and status of the anomaly, I investigate the various possibilities to explain it in the context of physics beyond Standard Model (BSM) which can be broadly grouped into three categories: modifications of four-fermion contact operators, modifications of the leptonic W vertices and modifications of the W vertices with quarks. In addition, I also discuss the phenomenological implications in the electroweak (EW) precision observables and low energy observables testing lepton flavour universality (LFU) which have to be taken into account in order to asses the viability of these solutions. Then, I review concrete realizations of BSM physics proposed to solve the CAA, which highlight the correlation with other existing anomalies such as $b \to s\ell\ell$ and $\tau \to \mu\nu\nu$, providing interesting predictions to be tested experimentally in the near future.

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T10: Searches for New Physics / 585

Some reflexions on hidden features of SM extensions with scalar triplets

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The Standard Model of particle physics is in remarkable agreement with most experimental data so far. However, a lot of questions remain unanswered, such as the origin of neutrino masses or the need for extra sources of CP violation. Possible solutions rest on scalar sector extensions, popular beyond-the-Standard-Model scenarios, in which the addition of scalar triplets is an attractive possibility. Such models are much studied in the literature, but they still hide some features underneath. In the Higgs-triplet model, in which small neutrino masses may be generated via the type-II seesaw mechanism, the theory can a priori develop a charge-breaking vacuum as the global minimum of the theory, which would spoil electromagnetism. Furthermore, and although not possible with just one triplet, a CP-breaking vacuum is possible with the addition of two triplets, which could lead to interesting leptonic CP-violating effects. However, it also introduces novel and unexpected features in its scalar spectrum. In this work, we briefly present such hidden features.

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T06: QCD and Hadronic Physics / 587

Exclusive $pp \to ppK^{*0}\bar{K}^{*0}$ reaction: $f_2(1950)$ resonance versus diffractive continuum

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We present first predictions of the cross sections and differential distributions for the exclusive reaction $pp \to ppK^{*0}\bar{K}^{*0}$ contributing to the $K^+K^-\pi^+\pi^-$ channel 1. The amplitudes for the reaction are formulated within the tensor-pomeron approach [2]. We consider separately the $f_2(1950)$ s-channel exchange mechanism and the K^{*0} t/u-channel exchange mechanism, focusing on their specificities. First mechanism is a candidate for the central diffractive production of tensor glueball and the second one is an irreducible continuum. We adjust parameters of our model, assuming the

dominance of pomeron-pomeron fusion, to the WA102 experimental data [3]. We find that including the continuum contribution alone one can describe the WA102 data reasonably well. We present predictions for the reaction $pp \to pp(K^{*0}\bar{K}^{*0} \to K^+K^-\pi^+\pi^-)$ for the LHC experiments including typical kinematical cuts. A similar behaviour of the continuum and f_2 production processes makes an identification of a hypothetical tensor-glueball state in this reaction rather difficult. We find from our model a cross sections of $\sigma \cong 17 - 250$ nb for the LHC experiments, depending on the assumed cuts. Absorption effects are included in our analysis. Our predictions can be tested by all collaborations (ALICE, ATLAS, CMS, LHCb) working at the LHC. A measurable cross section for the exclusive process $pp \to pp(K^{*0}\bar{K}^{*0} \to K^+\pi^-K^-\pi^+)$ should provide an interesting challenge to check and explore.

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T10: Searches for New Physics / 588

Status of the MUonE experiment

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The first measurement of the muon anomalous magnetic moment by the Fermilab g-2 experiment has confirmed the previous intriguing result of the BNL experiment. Their combination brings to 4.2σ the discrepancy with the currently accepted prediction of the Standard Model. The dominant theory uncertainty is related to the leading order hadronic vacuum polarization contribution (LO-HVP), determined by a data-driven dispersive approach, using the hadron production cross section in e+e- annihilation. In contrast, a recent ab initio calculation of the LO-HVP contribution, based on Lattice QCD, weakens the discrepancy with the measurement, in some tension with the data-driven estimate.

In this scenario, the novel approach proposed by the MUonE project aims at a third completely independent and competitive determination of the LO-HVP contribution, achievable with an alternative method based on the measurement of the effective electromagnetic coupling in the space-like region at low momentum transfer. We will discuss the possibility of performing this measurement at CERN by a very precise determination of the shape of the differential muon-electron elastic cross section, exploiting the scattering of 160 GeV muons on atomic electrons of a low-Z target. The project status will be presented, in view of the test run on a reduced detector expected to start at the end of 2021.

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T07: Top and Electroweak Physics / 589

Parton shower effects in ttW @ NLO

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We will present our recent calculation of matching NLO QCD corrections to the production of a top-quark pair in association with a W boson using the POWHEG-BOX framework. We compare our results with other Monte Carlo generators for the two same-sign lepton signature commonly used by the experiments. Special focus will be put on the assessment of the importance of subleading electroweak contributions in the modelling of the production process. In addition, We will discuss theoretical uncertainties of our predictions, which are estimated by variations of the renormalization and factorization scales, also matching uncertainties are estimated.

Collaboration / Activity:

theory

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T06: QCD and Hadronic Physics / 590

Measurement of the Z boson production in association with at least two b jets in pp collisions at √s = 13 TeV

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The cross sections of the Z boson production in association with at least two b jets as a function of various kinematic variables are measured in pp collisions at $\sqrt{s}$ = 13 TeV using 137 fb^{-1} of data collected by the CMS experiment at LHC. The Z boson decays to electrons or muons are considered with leading (sub-leading) lepton transverse momentum p_T > 35 (25) GeV and pseudorapidity $|\eta| < 2.4$, and the invariant mass within 71 and 111 GeV. Jets are selected with p_T > 30 GeV and $|\eta| < 2.4$. The results are compared to various QCD calculations.

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T07: Top and Electroweak Physics / 591

Top pair production at NNLO matched to parton showers

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We present the first matched computation of top-quark pair production at next-to-next-to-leading order (NNLO) in QCD with all-order radiative corrections as implemented via parton-shower (PS) simulations. This result has been obtained by constructing the MiNNLOPS method for the production of heavy quarks, which constitutes the first NNLO+PS prediction for reactions with colour charges in the final state in hadronic collisions. Our results are of crucial importance for LHC phenomenology, while also representing an important step towards the NNLO+PS simulation of other hadronic processes with colour charges in the final state.

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T08: Flavour Physics and CP Violation / 592

Pattern of New Physics in the angular analysis of $B_s \to D_s^* (\to D_s\,\pi,\, D_s\,\gamma)\,\tau\,\nu$ decays

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Decoding the exact Lorentz structure of possible new physics in various B decays involving $b \to c\,l\,\nu$ charged current and $b \to s\,l\,l$ neutral current is very crucial. There still exists a long standing discrepancy in the combined measurements of the ratio of branching ratio $R_{D^{(*)}}$ in $B \to D^{(*)}\,l\,\nu$ decays which stands 3σ away from the standard model expectations. In addition, the lepton polarization fraction and longitudinal polarization fraction of D^* meson in $B \to D^*\,\tau\,\nu$ decays also witness considerable deviations from SM expectations. In this context, we perform a detailed angular analysis of $B_s \to D_s^* (\to D_s\,\pi,\, D_s\,\gamma)\,l\,\nu$ decays in a model independent effective field theory formalism. Under the SU(3) favor symmetry both $B \to D^*$ and $B_s \to D_s^{(*)}$ decays exhibit similar properties and hence this decay channel can, in principle provide complementary information regarding the anomalies present in $B \to D^*\,l\,\nu$ decays. We give predictions of various physical observables in standard model and in the presence of various 1D and 2D new physics scenarios.

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T05: Heavy Ion Physics / 593

Measurements of mixed harmonic cumulants in Pb-Pb collisions at 5.02 TeV with ALICE

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Multi-particle cumulants of azimuthal angle correlations are compelling tools to constrain the initial conditions and probe the properties of the quark-gluon plasma created in the ultrarelativistic heavy-ion collisions at the LHC. However, only very few of them have been measured experimentally and supplemented with corresponding theoretical calculations.

Using a newly developed correlation technique, we will present the first measurements of mixed harmonic cumulants in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$~TeV recorded with the ALICE detector. The centrality dependence of correlations between two flow coefficients as well as the correlations between three flow coefficients, both in terms of their second moments, are shown. In addition, a collection of mixed harmonic cumulants involving higher moments of flow amplitudes v_2 and v_3 is measured for the first time, where the characteristic signature of negative, positive and negative signs for the four-, six- and eight-particle cumulants, respectively, is observed. The measurements are compared to the hydrodynamic calculations using iEBE-VISHNU with AMPT and TRENTo initial conditions. It is shown that these new studies on correlations between three flow coefficients as well as correlations between higher moments of two different flow coefficients can tighten constraints on initial-state models and help extract precise information on the dynamic evolution of the hot and dense matter created in heavy-ion collisions at the LHC.

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Collaboration / Activity:

ALICE

T05: Heavy Ion Physics / 594

News from the NA61/SHINE strong-interactions program at CERN SPS

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NA61/SHINE is a multipurpose fixed-target facility at the CERN Super Proton Synchrotron. The main goals of the NA61/SHINE strong-interactions program are to discover the critical point of strongly interacting matter as well as to study the properties of produced particles relevant for the study of the onset of deconfinement - the transition between the state of hadronic matter and the quark-gluon plasma., An analysis of hadron production properties is performed in nucleus-nucleus, proton-proton and proton-nucleus interactions as a function of collision energy and size of the colliding nuclei to achieve these goals.

In this presentation, the NA61/SHINE results from a strong interaction measurement program will be presented. In particular, the latest results from different reactions p+p, Be+Be, Ar+Sc, and Pb+Pb on hadron spectra and fluctuations are planned to be discussed. The NA61/SHINE results will be compared with results from worldwide experiments and with predictions of various theoretical models, like EPOS, PHSD, UrQMD and others. Finally, the motivation, NA61/SHINE plans of the measurements after LS2 and LS3 at the Super Proton Synchrotron energies will be shown.

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T05: Heavy Ion Physics / 595

Measurements of net-charge fluctuations across various colliding systems with ALICE

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Event-by-event fluctuations of conserved quantities such as electric charge, baryon number and strangeness in ultrarelativistic heavy-ion collisions provide insight into the properties of the quark-gluon plasma and the QCD phase diagram. The net-charge fluctuations in finite phase space are usually studied using the ν_{dyn} observable, which is robust against the detection efficiency losses and with a proper multiplicity scaling it becomes equivalent to the strongly intensive quantity Σ. In this talk, the values of ν_{dyn} are explored with ALICE detector in various colliding systems, namely, pp and p-Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV, Pb-Pb at $\sqrt{s_{\mathrm{NN}}} = 2.76$ and 5.02 TeV, and Xe-Xe at $\sqrt{s_{\mathrm{NN}}} = 5.44$ TeV. The observed dependence of ν_{dyn} on charged-particle density shows a regular smooth evolution of net-charge fluctuations from smaller to larger collision systems. Furthermore, the observed negative values of ν_{dyn} indicate the dominance of correlation between the oppositely charged particle pairs as compared to those arising from the like-sign charge pairs. These findings are compared to the predictions of HIJING, EPOS and PYTHIA models. Effect of the kinematical acceptance has also been investigated by examining the ν_{dyn} dependence on the width of the pseudorapidity window within the ALICE acceptance $|\eta| < 0.8$ and in different transverse momentum ranges, whereas the effect of the hadronic resonance decays is studied by comparing the experimental findings with the prediction of HIJING model.

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Collaboration / Activity:

ALICE

T06: QCD and Hadronic Physics / 596

Production of light nuclei in small collision systems measured with ALICE

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The energy densities reached in high-energy hadronic collisions at the LHC allow significant production of light (anti)nuclei. Their production yields have been measured as a function of p_{T} and charged-particle multiplicity in different collision systems and at different center-of-mass energies by ALICE. One of the most interesting results obtained from such a large variety of experimental data is that the dominant production mechanism of light (anti)nuclei seems to depend solely on the event charged-particle multiplicity. Evidence for this comes from the continuous evolution of the deuteron-to-proton and ^{3}He-to-proton ratios with the event multiplicity across different collision systems and energies. The characterization of the light nuclei production mechanism is complemented by measurements of their production yields in jets, where hard QCD processes are dominant, and in the underlying event, which is dominated by soft QCD processes.

In this contribution, recent results on the measurements of light-nuclei production in proton-proton and proton-lead collisions at different center-of-mass energies are shown and discussed in the context of the statistical hadronization and coalescence models. In addition, final results on the deuteron production in jets and new preliminary results on its production in the underlying event measured in proton-proton collisions at 13 TeV are shown.

Collaboration / Activity:

ALICE

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T12: Detector R&D and Data Handling / 597

Detector characterization for Legend-200 experiment

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The LEGEND collaboration is developing an experimental search for the neutrinoless double-beta ($0\nu\beta\beta$) decay of the ^{76}Ge isotope.
Its first phase, LEGEND-200, uses 200 kg of ^{76}Ge-enriched high-purity germanium (HPGe) detectors in an active liquid argon shield and is currently under construction at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy.
Inverted coaxial point-contact (ICPC) detectors are deployed in the experiment. Their peculiar geometry provides an excellent energy resolution in a broad energy range and impressive discrimination

of signal against background events.
LEGEND's search for $0\nu\beta\beta$ requires a precise understanding of the behavior of germanium detectors, requiring extensive detector characterization.
The acceptance tests aim to verify the performance of the delivered detectors meets specifications and to determine their optimal operational parameters.
This talk will provide a review and the first results of the detector characterization program.

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Collaboration / Activity:

Legend

T12: Detector R&D and Data Handling / 598

First results of the newly installed, MAPS based, ALICE Inner Tracking System

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The ALICE Inner Tracking System (ITS) has recently been replaced with a full silicon-pixel detector constructed entirely with CMOS monolithic active pixel sensors. It consists of three inner layers (50 μm thick sensors) and four outer layers (100 μm thick sensors) covering 10 m^2 and containing 12.5 billion pixels with a pixel size of 27 μm x 29 μm. Its increased granularity, the very low material budget (0.35% X_0/layer in the inner barrel) as well as a small radius of the innermost layer combined with a thin beam pipe, will result in a significant improvement of impact-parameter resolution and tracking efficiency at low p_{T} with respect to the previous tracker. The assembly of the full detector and services finished in December 2019. A comprehensive commissioning phase (on surface) was completed in December 2020, including detector calibration, fake-hit rate determination, data transmission tests and preliminary evaluation of the detector efficiency and the sensors alignment, based on reconstruction of cosmic rays tracks. The commissioning of the ITS within the ALICE apparatus has recently started. After a first phase of standalone tests and detector performance optimization, the ITS will be included in the global commissioning activities in summer 2021. In this talk, the first results of the performance of the new ALICE ITS detector, studied during commissioning, will be presented.

Collaboration / Activity:

ALICE

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T04: Neutrino Physics / 599

Improved geoneutrinos observation with Borexino detector

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Geoneutrinos, which are anti-neutrinos emitted from the decays of long-lived radioactive elements inside the Earth, are unique messengers of internal regions of our planet. The Borexino detector, located at Laboratori Nazionali del Gran Sasso in Italy, is able to detect the geoneutrinos through inverse beta decay reaction. This measurement is feasible thanks to the large scintillator target mass and unprecedented radiopurity, the long distance to nuclear reactors and the natural shielding provided by the Gran Sasso rock.

In this talk, the most updated geoneutrino analysis will be presented, including data from December 2007 to April 2019. Thanks to an improved analysis with optimized data selection cuts, enlarged fiducial volume, and sophisticated cosmogenic veto, the dataset exposure is enhanced by a factor of two with respect to the previous Borexino measurement from 2015.

The statistics increase, along with updated analysis techniques, allowed to measure the geoneutrinos flux with unprecedented precision level, also confirming the presence of a mantle signal. Fundamental geological information about our planet is inferred, as the Uranium and Thorium contents of the mantle, and the Earth radiogenic heat. Moreover, the existence of a possible georeactor located at the center of the Earth has been excluded at 95% C.L.

Collaboration / Activity:

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T12: Detector R&D and Data Handling / 601

Status of the Fast Interaction Trigger detector for the ALICE upgrade

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During the second Long Shutdown (LS2) of the LHC, ALICE is installing three new detectors and implementing continuous data readout with online reconstruction and data compression. The changes are needed to benefit from the increased luminosity of the LHC during Run 3 and 4. The ALICE interaction rate will increase by two orders of magnitude, reaching 50 kHz for Pb-Pb and up to 1 MHz for pp collisions.

One of the new ALICE detectors is the Fast Interaction Trigger (FIT). Its main functionality includes generating minimum latency interaction triggers (<425 ns), luminosity monitoring with online feedback to the LHC, precision collision time with a resolution better than 40 ps, determination of the centrality and event plane for heavy-ion collisions, and tagging of diffractive and ultra-peripheral events. The FIT detector consists of three subsystems: two fast Cherenkov arrays with 2 cm thick quartz radiators coupled to modified MCP-PMT photosensors (FT0), a large-area scintillator disc (FV0) implementing a novel light collection system, and a Forward Diffractive Detector (FDD). FDD comprises two plastic scintillator arrays with fast wavelength shifting bars, optical fibre bundles, and PMTs. The FDD arrays are located ~20 m at the opposite sides of the interaction point. A brief

description of the detector and its functionalities will be given together with the installation and commissioning status.

Collaboration / Activity:

ALICE

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T01: Astroparticle and Gravitational Waves / 603

Finding (or not) dark matter in gamma-ray images of the Galactic center with computer vision

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It is now more than a decade since an excess emission in GeV gamma rays in the Galactic centre region has been detected after accounting for well known astrophysical backgrounds from cosmic rays interacting with the interstellar medium. While there was a plethora of attempts over time to unravel the nature of this Galactic Center Excess (GCE), they largely converged to contrast two particular interpretations: a population of faint and unresolved millisecond pulsars and dark matter annihilation. Despite convincing arguments in favour of the conventional astrophysical explanation, it eludes a robust observational confirmation given the available gamma-ray data.

In this talk, we report on our approach based on Bayesian neural networks to perform a detailed gamma-ray analysis of this region in an attempt to address the origin of the GCE. Using simulations of the gamma-ray sky in the Galactic centre region, the network is trained to separate the detected gamma rays into components based on templates of background and GCE emission, which is modelled as a combination of dark annihilation and faint millisecond pulsars. Imperfections in our background model are inspected visually and the model complexity increased iteratively after applying the network to the data.

We confront the performance of the network with a more traditional maximum likelihood fitting approach and demonstrate that the network's prediction for the background templates is comparable to the likelihood method, while having an added advantage of accounting for a millisecond pulsar template in a self-consistent way.

In terms of the GCE, we find that the network is capable of detecting the sub-threshold pulsar population, while the dark matter contribution to the GCE is largely degenerate with other faint components in the region (notably the possible low-latitude part of the Fermi bubbles) and therefore - at the moment - remains challenging to distinguish.

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T12: Detector R&D and Data Handling / 604

The ESS Neutrino Super-Beam Near Detector

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The ESS Neutrino Super-Beam (ESSnuSB) is a proposed long-baseline neutrino oscillation experiment, performed with a high-intensity neutrino beam, to be developed as an extension to the European Spallation Source proton linac currently under construction in Lund, Sweden. The neutrinos would be detected with the near and far detectors of the experiment, the former within several hundred meters of the neutrino production point and the latter within several hundred kilometers. The far detector will consist of a megaton-scale water-Cherenkov detector, and the near detector will consist of a kiloton-scale water-Cherenkov detector in combination with a fine-grained tracking detector and an emulsion detector. The purpose of the near detector is to constrain the flux of the neutrino beam as well as extract the electron-neutrino interaction cross-section in water, thus requiring well performing energy reconstruction and particle flavor identification techniques. These measurements are crucial for the neutrino oscillation study that will be conducted using the far detector.

Year 2021 sees the finalization of the conceptual design of the near detector through a study of the performance of a number of different design options, and a characterization of the neutrino reconstruction and flavor identification performances. In this talk we report on these studies.

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Collaboration / Activity:

ESSnuSB

T14: Outreach, Education and Diversity / 605

LGBTQ+ Inclusivity: How to be an ally

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One of the key ingredients to do good science is the embrace of diversity in all its facets. The LGBTQ+ community faces extra burdens in our daily lives as scientists, making us less likely to stay in academia and achieve visible positions within large experiments.

The LGBTQ CERN group is a CERN-recognized Informal Network seeking to provide a welcoming space for lesbian, gay, bisexual, trans*, intersex, asexual, genderqueer and other LGBTQ+ individuals at CERN, also welcoming friends and allies. This talk will focus on the experiences of the LGBTQ CERN members in our careers in High Energy Physics, and discuss which concrete steps you can take, as an ally, to create a safe, inclusive and supportive scientific work environment.

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T01: Astroparticle and Gravitational Waves / 607

Search for multi-messenger events during LIGO/Virgo era

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Multi-messenger astronomy is a vast and expanding field as electromagnetic (EM) observations are no longer the only way of exploring the Universe. This field had its dawn when new astronomical messengers of non-electromagnetic origin were observed: solar flare, neutrinos, and most recently the detection of gravitational waves (GWs) in 2015. Due to these new messengers, astrophysical triggers with both GWs and EM are no longer a dream of the astronomical community. A breakthrough for GW multi-messenger astronomy came when the LIGO-Virgo network detected a GWs signal of two low-mass compact ob- jects consistent with a neutron star binary (BNS, GRB170817), an event that generated a short gamma ray burst (sGRB), and a kilonova. While GW170817 represents the testimony for BNS mergers being the progenitor of at least some GRBs, a wide range of highly energetic astrophysical phenomena is expected to be accompanied by the emission of GWs and EM. Here we present the unmod- elled method to search for GWs having gamma and radio counterparts using the LIGO/Virgo data and observations of partners'telescopes. We also discuss the most recent results of unmodelled coherent LIGO-Virgo searches targeting astrophysical triggers during the first part of the third observing run (O3a): (i) 105 gamma-ray bursts detected by the Fermi and Swift satellites, and (ii) fast radio bursts detected by CHIME. Finally, a summary of the prospects of unmodelled burst analysis for the second part of the third observing run (O3b) will be given.

Collaboration / Activity:

Ego-Virgo

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T09: Higgs Physics / 608

Two-loop corrections to the Higgs trilinear coupling in classically scale-invariant theories

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The Higgs trilinear coupling provides a unique opportunity to probe the structure of the Higgs sector and the nature of the electroweak phase transition, and to search for indirect signs of New Physics. Classical scale invariance (CSI) is an attractive concept for BSM model building, explaining the apparent alignment of the Higgs sector and potentially relating to the hierarchy problem. A particularly interesting feature of CSI theories is that, at one loop, they universally predict the Higgs trilinear coupling to deviate by 67% from the (tree-level) SM prediction.
In this talk, I will show how this result is modified at two loops. I will present results from the first explicit computation of two-loop corrections to the Higgs trilinear coupling in classically scale-invariant BSM models. Taking as example a CSI variant of a Two-Higgs-Doublet Model, I will show that the inclusion of two-loop effects allows distinguishing different scenarios with CSI, even though the requirement of correctly reproducing the mass of the Higgs boson severely, as well as unitarity, restrict the allowed values of the Higgs trilinear coupling.

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Collaboration / Activity:

Theory

T05: Heavy Ion Physics / 609

Measurement of electroweak-boson production in pp, p-Pb, and Pb-Pb collisions with ALICE at the LHC

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W and Z boson measurements provide a clean probe of the hard scatterings taking place in the initial stages of hadronic collisions. In particular, measurements in pp collisions provide a useful reference to test pQCD calculations, while results in p-Pb and Pb-Pb collisions provide a useful insight in the nuclear parton distribution functions (nPDFs) of the involved nuclei. Such observations are especially important in a phase space region that is poorly constrained by previous experiments, and represent an important reference to properly understand nuclear modification effects in other measurements. In this contribution the most recent measurements on W and Z boson production by the ALICE collaboration are discussed, including invariant production yields and nuclear modification factors. W and Z bosons are measured in ALICE via their leptonic decays in the electron channel at midrapidity ($|\eta_{\rm lab}| < 0.8$) and the muon channel at forward rapidity ($2.5 < \eta_{\rm lab} < 4$). New measurements on W bosons in pp collisions at $\sqrt{s} = 13$ TeV are presented, as well as the latest results on Z and W bosons in p-Pb collisions at $\sqrt{s_{\rm NN}} = 8.16$ TeV and Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. Differential measurements as a function of rapidity and collision centrality are compared to previous experimental results and to the available theoretical calculations, providing constraints on the corresponding models and the considered nPDFs.

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Collaboration / Activity:

ALICE

T05: Heavy Ion Physics / 610

Open charm and beauty production and anisotropy from small to large systems with ALICE

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In this talk, the nuclear modification factor (R_{AA}) and the elliptic flow (v_2) of open heavy-flavour hadrons via their hadronic and semileptonic decays to electrons at midrapidity and to muons at forward rapidity in heavy-ion collisions will be discussed. In particular, the latest results on the centrality dependence of R_{AA} of charmed hadrons, beauty-decay electrons, non-prompt D^0 and the new measurement of non-prompt D_s^+ in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV will be shown. They provide important constraints to the energy loss mechanisms in the medium and their mass dependence, and provide information about the fragmentation of heavy quarks to strange heavy-flavour hadrons. Final and high precision measurements of elliptic flow of heavy-flavour particles provide stringent information about the thermal degrees of freedom of heavy quarks in the QGP, path-length dependence of heavy-quark in-medium energy loss and recombination effects. The elliptic flow of charmed hadrons and of the beauty-decay electrons will help test whether heavy quarks thermalise in the medium. Comparisons with model calculations including the interaction of heavy quarks with the hot, dense, and deconfined medium will be discussed. In this contribution, the final measurements of beauty production using beauty-decay electrons and non-prompt D in pp collisions at $\sqrt{s}$ = 5.02 TeV are also reported. They provide important tests of perturbative QCD calculations.

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Collaboration / Activity:

ALICE

T06: QCD and Hadronic Physics / 611

Production of light isoscalar mesons in pp-collisions via gluon-gluon fusion

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The production of the $f_0(980)$ meson at high energies is not well understood. We investigate two different potential mechanisms for inclusive scalar meson production in the k_t-factorization approach: color-singlet gluon-gluon fusion and color evaporation model. The $\gamma^*\gamma^* \to f_0(980)$ form factor(s) can be constraint from the $f_0(980)$ radiative decay width. The $g^*g^* \to f_0(980)$ form factors are obtained by a replacement of α_{em} electromagnetic coupling constant by α_s strong coupling constant and appropriate color factors. The form factors for the two couplings are parametrized with a function motivated by recent results for scalar quarkonia. The differential cross sections are calculated in the k_t-factorization approach with modern unintegrated gluon distributions. Unlike for quarkonia it seems rather difficult to describe a preliminary ALICE data for inclusive production of $f_0(980)$ exclusively by the color singlet gluon-gluon fusion mechanism. Two different scenarios for flavour structure of $f_0(980)$ are considered in this context. We consider also mechanism of fusion of quark-antiquark associated with soft gluon emission in a phenomenological color evaporation model (CEM) used sometimes for quarkonium production. Here we use k_t-factorization version of CEM to include higher-order contributions. In addition, for comparison we consider also NLO collinear approach with $q\bar{q}q$ and $q\bar{q}g$ color octet partonic final states. Both approaches lead to a similar result. However, very large probabilities are required to describe the preliminary ALICE data. The pomeron-pomeron fusion mechanism is also discussed and results are quantified.

We discuss also inclusive cross section and differential distributions for $f_2(1270)$ tensor meson production via color singlet gluon-gluon fusion in the k_t-factorization approach with unintegrated gluon distribution functions (UGDFs). The process is interesting in the context of searches for saturation effects. The energy-momentum tensor, equivalent to helicity-2 coupling, and helicity-0 coupling are used for the $g^*g^* \to f_2(1270)$ vertex. Some parameters are extracted from $\gamma\gamma \to f_2(1270) \to \pi\pi$ reactions. Different modern UGDFs from the literature are used. The results strongly depend on the parametrization of the $g^*g^* \to f_2(1270)$ form factor. Our results for transverse momentum distributions of f_2 are compared to preliminary ALICE data. We can obtain agreement with the data only at larger $f_2(1270)$ transverse momenta only for some parametrizations of the $g^*g^* \to f_2(1270)$ form factor. No obvious sign of the onset of saturation is possible. At low transverse momenta one needs to include also the $\pi\pi$ final-state rescattering. The agreement with the ALICE data can be obtained by adjusting probability of formation and survival of $f_2(1270)$ in a harsh quark-gluon and multipion environment. The pomeron-pomeron fusion mechanism is in addition discussed and results are quantified.

Finally we discuss also gluon-gluon mechanisms for production of mesons with hidden strangeness, such as η' and ϕ meson, in proton-proton collisions at large energies. The $g^*g^* \to \eta'$ and $g^*g^* \to \phi g$ mechanisms are considered only and the corresponding cross sections are calculated in the k_t-factorization approach. The $F_{\gamma^*\gamma^*\to\eta'}$ and $F_{g^*g^*\to\eta'}$ form factors are calculated from quark-antiquark η' light cone wave function including quark/antiquark transverse momenta. The result for two-photon transition form factor demonstrates that higher twists may survive even to large photon virtualities. The result is compared with the result of a recent leading-twist NLO analysis which uses phenomenological distribution amplitudes fitted to exclusive production of η' in $e^+e^- \to e^+e^-\eta'$ reaction. We calculate transverse momentum distributions of both η' and ϕ mesons in proton-proton collisions for RHIC and LHC energies. The results are compared to experimental data whenever available. The results of the Lund string model are shown for comparison for η' production at LHC energies. It seems that the two-gluon fusion is not the dominant mechanism for both ϕ and η' production, although the situation for η', especially at larger energies, is less clear due to lack of experimental data.

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Collaboration / Activity:

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T06: QCD and Hadronic Physics / 614

Measurement of the primary Lund jet plane density in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

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Precision measurements of jet substructure are used as a probe of fundamental QCD processes. The primary Lund jet plane density is a two-dimensional visual representation of the radiation off the primary emitter within the jet that can be used to isolate different regions of the QCD phase space. A new measurement of the primary Lund plane density for inclusive charged-particle jets in the transverse momentum range of $20 \leq p_{\mathrm{T,jet}}^{\mathrm{ch}} \leq 120$ GeV/c in pp collisions at $\sqrt{s} = 13$ TeV with the ALICE detector will be presented. This is the first measurement of the Lund plane density in an intermediate jet p_{T} range where hadronization and underlying event effects play a dominant role. The projections of the Lund plane density onto the splitting scale k_{T} and splitting angle θ axis are shown, highlighting the perturbative/non-perturbative and wide/narrow angle regions of the splitting phase space. Through a 3D unfolding procedure, the Lund plane density is corrected for detector effects which allows for quantitative comparisons to MC generators to provide insight into how well generators describe different features of the parton shower and hadronization.

Collaboration / Activity:

ALICE

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T05: Heavy Ion Physics / 615

Jet substructure measurements in heavy-ion collisions with ALICE

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Jet substructure measurements, based on the distribution of constituents within a jet, are able to probe specific regions of QCD radiation phase space for jet showers in vacuum. This powerful capability provides new opportunities to study the dynamics of jet quenching in heavy-ion collisions and to help reveal the micro-structure of the quark-gluon plasma. The ALICE experiment is particularly well-suited for jet substructure measurements in heavy-ion collisions, due to its high-precision tracking system and focus on low transverse momentum jets. In this talk, we report several new jet substructure measurements in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV by the ALICE Collaboration. These include the first fully corrected measurements of the groomed jet momentum fraction, z_g, and

the groomed jet radius, $\theta_g \equiv R_g/R$, as well as the N-subjettiness distribution and the fragmentation distribution of reclustered subjets. The measurements will be compared to theoretical calculations and provide new constraints on the physics underlying jet quenching.

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Collaboration / Activity:

ALICE

T06: QCD and Hadronic Physics / 618

Jet substructure measurements in proton-proton collisions with ALICE

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Jets can be used to test our understanding of quantum chromodynamics (QCD). Specifically, jet-substructure observables measured in proton-proton (pp) collisions constrain perturbative (p)QCD calculations, as well as non-perturbative physics effects such as hadronization, and serve as a baseline to compare to measurements in heavy-ion collisions, where a deconfined state of matter is expected to be formed. The significant scale difference between the parton
from the hard-scattering process and the hadrons measured in the detector creates a large phase space for the jet formation and evolution. Consequently, no single measurement can fully constrain the jet behavior, and a suite of observables needs to be studied simultaneously. In this talk we present an overview of recent charged-jet substructure and jet shape measurements from pp collisions in ALICE, including generalized angularities of groomed and inclusive jets, angular distances between different jet axes, and the radial distributions of heavy-flavour jets identified by the presence of a D^0 meson or Λ_c baryon among its constituents. An iterative declustering technique is also used to trace all branching of the charm quark revealing the dead-cone effect for the first time in hadronic collisions. These new results provide new insights into the evolution of jets by comparing our measurements to predictions from different event generators and pQCD calculations.

Collaboration / Activity:

ALICE

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T01: Astroparticle and Gravitational Waves / 619

Enhancement of the IceCube surface instrumentation by a hybrid radio and scintillation detector array

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The IceCube Neutrino Observatory is a cubic kilometer scale detector deployed in the antarctic ice, capable of detecting neutrinos of energies ranging from aprox 10 GeV to PeV and above. In addition to being a powerful neutrino observatory, IceCube is extensively involved in cosmic ray physics. The surface array of IceCube, IceTop, consisting of frozen water tanks equipped with photomultipliers, detects secondary particles like electrons, protons and muons from cosmic ray showers of energies up to 1 EeV. In addition, it is also used to function as a veto for the astrophysical neutrino searches and calibration detector for the IceCube in-ice instrumentation. Despite its great success, the snow accumulation on these surface detectors, contributes to energy uncertainty in the detected signals, and consequently, the shower reconstruction. Moreover, more detailed measurements are needed to understand the astrophysics of the high-energy cosmic-ray sky. Enhancing IceTop with a hybrid array of scintillation detectors and radio antennas will improve cosmic ray detection with IceCube. A lower threshold for air shower measurements, more efficient veto capabilities, a separation of electromagnetic and muonic components due to different detection principles, along with improved calibration by a compensation of the snow accumulation, are expected to be achieved with this enhancement.
Following the success of the first prototype station consisting of three radio antennas and eight scintillation detectors deployed at the South Pole in 2018, the production of detectors for 32 stations is ongoing. The deployment status, calibration methods, and science goals of the enhancement will be discussed in this contribution.

Collaboration / Activity:

IceCube Collaboration

First author:

Email:

T05: Heavy Ion Physics / 620

Measurements of jet quenching via hadron+jet correlations in Pb-Pb and high-particle multiplicity pp collisions with ALICE

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Interactions of high-p_T partons with quark-gluon plasma (QGP) result in jet quenching, which is manifest by the suppression of high-p_T jet yields and the modification of jet substructure and di-jet acoplanarity distributions.
Several jet quenching phenomena can be measured precisely over a wide range of jet p_T using semi-inclusive distributions of charged-particle jets recoiling from a high-p_T trigger hadron, which incorporate data-driven suppression of the large uncorrelated background produced in heavy-ion collisions.

In this talk we report semi-inclusive measurements of hadron-jet acoplanarity in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV and high-particle multiplicity pp collisions at $\sqrt{s} = 13$ TeV. In the Pb-Pb system, where QGP formation is established, narrowing of the acoplanarity is observed relative to a reference distribution from pp collisions. In contrast, pp events with high-particle multiplicity exhibit a broadening of the acoplanarity relative to minimum bias events. In this case, however, qualitatively similar features are also seen in pp collisions generated by PYTHIA, which does not include jet quenching or other QGP effects. We will discuss the current status of these analyses, and prospects to understand the origin of these striking phenomena.

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Collaboration / Activity:

ALICE

T01: Astroparticle and Gravitational Waves / 622

Uncertainties in the solar axion flux and their impact on determining axion model parameters

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The calculation of the solar axion flux has recently generated much attention due to the upcoming helioscope IAXO, studies of plasmon processes, and in context of the Xenon1T anomaly. It has been realised that axions can be powerful tools for studying solar metal abundances and magnetic fields.

However, the feasibility of such studies depends on our ability to accurately predict the solar axion flux. In this talk, I will present an overview of solar models and opacity codes and summarise the statistical and sytematic uncertainties of the solar axion flux calculation from Primakoff, ABC, and plasmon interactions. I will discuss how previous calculations can be improved further e.g. by including electron degeneracy effects. As a direct application, IAXO's ability to distinguish KSVZ axion benchmark models will be analysed as well as its prospects to tackle the solar abundance problem. I will close with an outlook on possible future avenues and ongoing, related work on the "KSVZ model landscape."

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Collaboration / Activity:

n/a

T05: Heavy Ion Physics / 624

Tracking the critical point of strongly interacting matter through proton intermittency analysis in NA61/SHINE

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The search for experimental signatures of the critical point (CP) of strongly interacting matter is one of the main objectives of the NA61/SHINE experiment at CERN SPS. In the course of the experiment, a beam momentum (13A −150A GeV/c) and system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La, Pb+Pb) scan is performed. Local proton density fluctuations in transverse momentum space represent an order parameter of the chiral phase transition and are expected to scale according to a universal power-law in the vicinity of the CP. They can be probed through an intermittency analysis of the proton second scaled factorial moments (SSFMs) in transverse momentum space. Previous such analyses 1 revealed power-law behavior in NA49 Si+Si collisions at 158A GeV/c, the fitted power-law exponent being consistent with the theoretically expected critical value, within errors. Probes of NA61/SHINE systems at the maximum SPS energy revealed no intermittency effect in Be+Be, whereas Ar+Sc analysis is inconclusive due to large uncertainties. The analysis has recently been extended to Pb+Pb collision data at lower energies.

We present a summary of the current status of NA61/SHINE intermittency analysis, and review novel techniques developed and employed to subtract non-critical background and estimate statistical and systematic uncertainties. In particular, the issue of obtaining a reliable estimate of the intermittency index (power-law exponent) ϕ_2 from correlated data is addressed through the use of toy models. Additionally, we use Monte Carlo simulations to assess the statistical significance of the observed intermittency effect.

References:

1 T. Anticic et al, Eur. Phys. J. C 75: 587 (2015).

Collaboration / Activity:

The NA61/SHINE Collaboration

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T10: Searches for New Physics / 625

The forgotten channels: charged Higgs boson decays to a $W^{\pm}$ and a non-SM-like Higgs boson

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The presence of charged Higgs bosons is a generic prediction of multiplet extensions of the Standard Model (SM) Higgs sector. Focusing on the Two-Higgs-Doublet-Model (2HDM), we discuss the charged Higgs boson collider phenomenology in the theoretically and experimentally viable parameter space. While almost all existing experimental searches at the LHC target the fermionic decays of charged Higgs bosons, we point out that the bosonic decay channels — especially the decay into a non-SM-like Higgs boson and a W boson — often dominate over the fermionic channels. We propose several benchmark scenarios with distinct phenomenological features in order to facilitate the design of dedicated LHC searches for charged Higgs bosons decaying into a W boson and a non-SM-like Higgs boson.

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Collaboration / Activity:

none

T09: Higgs Physics / 629

Machine learning augmented probes of light Yukawa couplings from Higgs pair production

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The production of Higgs pairs is one of the most anticipated channels to access at the High-Luminosity LHC. It allows for a measurement of the Higgs trilinear self-interaction. In this work we investigate the possibility to probe the Higgs trilinear coupling through the decomposition of the Higgs pair production into channels based on their topologies. We use interpretable machine learning based on cooperative game theory in order to distinguish them, simplifying the machine learning analysis flow. This procedure ultimately leads to a strong bound on the trilinear coupling. Moreover, we extend the analysis by including the quark-initiated channel, $q\bar{q} \to hh$, which is strongly suppressed in the Standard Model, in order to probe the Higgs coupling to light quarks. We perform a multivariate fit to simultaneously extract the trilinear Higgs and light quark-Higgs couplings. The fit results in a loosened bound on the trilinear coupling by ~ 25\% for models that do not have minimal flavour violation. Furthermore, a similar analysis is preformed for the 100 TeV FCC-hh. We discuss some motivated new physics scenarios where large modifications in the light quark-Higgs couplings are manifest.

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Collaboration / Activity:

Phenomenology

T14: Outreach, Education and Diversity / 631

ALICE virtual visits and masterclasses during the COVID pandemic

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With the onset of the COVID pandemic in 2020 all outreach and educational activities with in-person participation had to stop. The ALICE Collaboration adapted to the new situation and continued reaching out to the public using the multitude of online tools and platforms available. We will focus here on two of our main outreach activities, virtual visits and masterclasses.
With the cancellation of all in-person visits to the underground installations, virtual visits became the only way to explore the experiment. ALICE had already been offering virtual visits for remote audiences with equipment installed in the ALICE Run Control Centre (ARC). We recently acquired dedicated mobile equipment for the virtual visits to the cavern and developed a scenario which includes both the cavern and the ARC as well as a Q&A session. In this way, visitors from many countries have the opportunity to interact with scientists and to see parts of the experiment that they would never be able to see during a real visit.
ALICE has been participating in the International Masterclasses (IMC) programme ever since measurements based on LHC data were introduced in it. The packages used had been developed by simplifying the ALICE event display and were based on ROOT. With the spreading of the COVID pandemic the 2020 IMC programme was interrupted. In 2021, with most activities taking place remotely, it was obvious that web-based versions were needed. The implementation of such versions allowed us to hold remote masterclasses for high-school students, thus ensuring the continuity of this important outreach activity of our community. In addition we reached new countries and also involved high-school teachers in this global effort.

Collaboration / Activity:

ALICE

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T05: Heavy Ion Physics / 633

Simulations of charged hadron and charmed meson production in Pb+Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with HYDJET++ generator

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HYDJET++ is a Monte Carlo event generator merging parametrized soft part inspired by hydrodynamics with hard part containing jets. It has been successful to describe particle production in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV energies. In this poster we present for the first time the particle spectra and collective flow for top LHC energy $\sqrt{s_{NN}} = 5.02$ TeV Pb+Pb collisions. Specifically we used the HYDJET++ model version 2.4 to simulate spectra of charged particles, D^0 and J/ψ mesons and related v_2 and v_3 azimuthal flow harmonics. The particle spectra and flow harominics are studied in different centrality bins ranging from 0-10% up to 30-50% centrality in midrapidity region for charged particles and D^0 mesons and in forward rapidity in case of J/ψ mesons. The simulated results have been compared to experimental data from the ALICE and ATLAS experiments in order to tune the HYDJET++ generator to get the most optimal agreement with the data.

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Collaboration / Activity:

MC generators, phenomenology

T05: Heavy Ion Physics / 635

Constraining transport properties of quark-gluon plasma using non-linear hydrodynamic response

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The primary goal of the ultrarelativistic heavy-ion collision program at the LHC is to study the properties of the quark-gluon plasma (QGP), a state of strongly interacting matter that exists at high temperatures and energy densities. Anisotropic flow, studied using the anisotropy of the momentum distribution of final state particles, is sensitive to the transport properties (i.e., specific viscosities) of the QGP. It v_n contains two components, the linear mode corresponds to the same order initial anisotropy coefficient while the non-linear flow mode is originated from lower-order initial anisotropy. It is commonly known that the lower order flow v_2 and v_3 have the linear response for non-peripheral collisions and therefore can be used directly to constrain the initial state models, while the study of linear and non-linear flow modes of higher-order flow has the potential to improve the accuracy of the extracted transport coefficients of QGP.

In this talk, the latest studies of the non-linear hydrodynamic response of anisotropic flow in Pb–Pb collisions at the LHC will be presented. The new studies using higher-order moments of v_2, as well as the newly proposed correlations between different moments of v_2 and v_3, show an unexpected non-linear response of v_2 and v_3 in the semi-central and semi-peripheral collisions. In addition, the non-linear hydrodynamic response has been explored via the correlations among multiple flow coefficients. These systematic studies using hybrid hydrodynamic iEBE-VISHNU with two different initial conditions, AMPT and TRENTo, and using AMPT and HIJING transport models, show that such non-linear hydrodynamic response has novel sensitivity to the specific viscosities of QGP. The comparisons of state-of-the-art hydrodynamic calculations and the recently available ALICE measurements offer new insights into the transport properties and the dynamical evolution of the QGP.

References:

[1] Z Moravcova, K. Gulbrandsen, Y. Zhou, Physical Review C 103, 024913 (2021)

[2] M. Li, Y. Zhou, W. Zhao, B. Fu, Y. Mou and H. Song, arXiv: 2104.10422

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Collaboration / Activity:

QGP&Flow

T04: Neutrino Physics / 636

Neutrino oscillation physics in JUNO

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Jiangmen Underground Neutrino Observatory, or JUNO, is a future multipurpose neutrino experiment currently being built in China. The data taking with a 20 kt detector, filled with liquid scintillator, will start soon. The main physics goals include estimation of the neutrino mass ordering (NMO) with significance of 3 standard deviations and measurement of neutrino oscillation parameters Δm^2_{32}, Δm^2_{21}, $\sin^2\theta_{12}$ with sub-percent precision. Both these measurements will be done based on the observation of electron antineutrino spectrum from multiple nuclear reactors at an average distance of 53 km.

The talk covers the oscillation physics of the JUNO experiment, which is not limited to the reactor neutrino programme, owing to unprecedented energy resolution and large scale of the detector. The measurement of the solar neutrinos from ^{8}B will enable JUNO to estimate Δm^2_{21} with precision of 20\%, comparable to the current solar experiments. The atmospheric neutrino programme will provide a measurement of the mixing angle $\sin^2\theta_{23}$ and a complementary measurement of NMO. JUNO will be complemented with a satellite detector TAO located at a distance of 30 m from one of the nuclear power plants and will provide a reference measurement of reactor antineutrino spectrum with energy resolution of 2\% at 1 MeV. High energy resolution combined with a short baseline will enable TAO to provide leading constraints on sterile neutrino oscillations in a range of 10^{-2} eV^2 $\leq \Delta m^2_{41}$ $\leq$8 eV^2.

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Collaboration / Activity:

JUNO

T06: QCD and Hadronic Physics / 637

Light flavor particle production across different systems and energies with ALICE

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The study of the production of particles of different masses as a function of event multiplicity is a key tool for understanding the soft QCD processes and hadronization. In this talk, we report ALICE

results on transverse momentum spectra and yields of π, K, p, K^0_S, Λ, Ξ and Ω measured in pp, p-A, and A-A collisions, including the recently published results in Pb-Pb and Xe-Xe collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ and 5.44 TeV, respectively. Particle spectra and ratios as measured in pp and A-A collisions are compared at similar charged-particle multiplicity densities ($\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle$), and, for A-A collisions, at different initial eccentricities. Results on the hadron abundances measured in high-multiplicity pp collisions at $\sqrt{s} = 13$ TeV as a function of event shape will be shown. In addition, to better understand the contribution of the event multiplicity to the observed enhancement of strange particles in pp, two new complementary analyses have been performed. The first classifies events according to the anti-correlation between mid-rapidity multiplicity and the energy deposited in the ALICE Zero Degree Calorimeters. The second exploits the angular correlation between strange and high-p_{T} charged hadrons to distinguish in-jet and out-of-jet strangeness production. Results indicate that strangeness enhancement correlates with the growth of the underlying event, which can be selected by employing a forward-rapidity classifier. Finally, results are discussed in the context of statistical hadronization models as well as pQCD-inspired models.

Collaboration / Activity:

ALICE

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T01: Astroparticle and Gravitational Waves / 638

Unveiling the origin of steep decay in γ-ray bursts

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γ-ray bursts (GRBs) are transient cataclysmic events, whose role became central in the new multi-messenger era. In the present work I propose a novel investigation of the GRB emission mechanism, via time-resolved spectral analysis of the X-ray tails of bright GRB pulses observed with the XRT instrument onboard the Neil Gehrels Swift Observatory, discovering a unique relation between the spectral index and the flux. The investigation of the spectral evolution during the GRB tail is an ideal diagnostic to understand the connection between the emission processes, the cooling processes and the outflow environment. I thoroughly discuss possible interpretations in relation to current available models and I show the incompatibility of our results with the standard high latitude emission. Our results for the first time strongly suggest evidence of adiabatic cooling of the emitting particles, shedding light on fundamental physics of relativistic outflows in GRBs. Finally I discuss the crucial role of future wide-field X-ray telescopes, such as the mission concept Theseus, for the characterisation of the GRB tail emission, highlighting also its importance in the multi-messenger context.

Collaboration / Activity:

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T12: Detector R&D and Data Handling / 640

Performances of a 3D optical readout TPC for the CYGNO experiment

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Gaseous Time Projection Chambers (TPC) with optical readout are an innovative and very promising detection technique to enhance the the sensitivity for light dark matter candidates.

The Cygno experiment is pursuing this technique by developing a TPC operated with gas mixtures at atmospheric pressure equipped with a Gas Electron Multipliers (GEM) amplification stage that produces visible light. Light is collected by as high sensitivity and resolution scientific CMOS camera, while a fast photodetector is used to measure the drift time of the primary ionisation electrons and thus reconstruct the third coordinate of the ionisation track.

In this contribution, we illustrate the technical solutions developed to construct detector prototypes and discuss their performances when exposed to radioactive sources. We present results in terms of electroluminescence yield and charge gain when operated with several gas mixtures based on He-CF4, He-CF4-isobutane, Ar-CF4, and different electric field configurations. We also illustrated the solutions adopted for the DAQ and trigger systems and the performances of an innovative multi-stage pattern recognition algorithm based on advanced clustering techniques. We show how such solutions are essential to identify and select interesting events and how we plan to have them online to cope with the data throughput. Finally, we show the evolution of the project from small size detectors to the current 50 litres prototype which will be installed and tested underground at LNGS this year. A 1 cubic meter demonstrator is expected to be built in 2021/22 and subsequently installed and commissioned at LNGS aiming at a large scale apparatus in a later stage.

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Collaboration / Activity:

CYGNO collaboration

T14: Outreach, Education and Diversity / 644

The REINFORCE citizen-science project and the search for new long-lived particles at the LHC.

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The REINFORCE EU project (link) engages and supports citizens to cooperate with researchers and actively contribute to the development of new knowledge for the needs of science and society. After a brief description of the four demonstrators comprising REINFORCE, we will present in detail the demonstrator titled "Search for new particles at the LHC", which will engage citizen-scientists in searches for new elementary particles produced in the high-energy proton-proton collisions at the LHC of CERN.

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Collaboration / Activity:

ATLAS

T08: Flavour Physics and CP Violation / 645

Measurement of the neutron electric dipole moment in the nEDM and n2EDM experiments

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The electric dipole moment (EDM) of the neutron is a strong probe of CP violation beyond the Standard Model.
In particular, its value could reveal information on baryogenesis.
We report the latest result from the nEDM collaboration, which operates an experiment to measure the neutron EDM at the Paul Scherrer Institute
using Ramsey's method of separated oscillating magnetic fields with ultracold neutrons.
The estimation of systematic effects profited from an unprecedented knowledge of the magnetic field relying on the use of both a 199Hg comagnetometer and an array of optically pumped cesium vapor magnetometers
The total uncertainty is dominated by the statistics and the observe EDM is compatible with zero. A new improved limit, |d|<1.8e-26 e.cm @ 90% CL, was computed.
The systematic precision was improved by a factor 5 with respect to previous experiments opening the way to improved sensitivity in the next generation experiment, n2EDM
which is being build at PSI for an operation starting 2022.

Collaboration / Activity:

nEDM

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T06: QCD and Hadronic Physics / 646

Subleading colour effects and spin correlations in the PanScales showers

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In the context of the PanScales parton shower project I will describe two advances in the development of final-state parton showers with controlled logarithmic accuracy. The first (arXiv:2011.10054) involves simple new algorithms to resolve the long-standing issue of incorrect subleading-colour contributions at leading logarithmic (LL) accuracy in dipole- and antenna-type showers, and also enables the PanScales showers to obtain full-colour NLL accuracy for many observables. The second (arXiv:2103.16526) concerns spin correlations, where we propose a spinor-product based implementation of the well-established Collins algorithm. We verify the logarithmic accuracy of the results with separate purely collinear calculations, using novel spin-sensitive jet observables that are of potential interest also for future experimental measurements.

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Collaboration / Activity:

PanScales

T10: Searches for New Physics / 647

Long-Lived Light Mediators from Higgs Decay at Hadron Colliders

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In this work we study long-lived light mediators which are well-motivated for connecting the dark sector with standard model particles. Experiments like ATLAS and CMS have placed strong bounds on heavy mediators with prompt decay, however the landscape of light long-lived mediators needs attention. Current experimental constraints have pushed the allowed mixing with the SM Higgs boson for scalar, and the kinetic mixing for vector mediators to very small values, indicating long lifetimes. We focus on the pair production of the long-lived mediators from SM Higgs decay in this work. We study the combined projected sensitivity of general purpose detectors like CMS along with dedicated detectors for LLP searches like FASER, MATHUSLA, CODEX-b, in hadron colliders and the prospect of identifying the underlying LLP model and extracting its parameters using such a combination.

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Collaboration / Activity:

IISc

T02: Cosmology / 648

Self-interacting dark matter from late decays and the H0 tension

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The poster presents work done in 2006.16139 where we study dark matter production mechanism based on decays of a messenger WIMP-like state into a pair of dark matter particles that are self-interacting via exchange of a light mediator. A natural by-product of this mechanism is a possibility of a late time transition to subdominant dark radiation component. We provide a simple realization of the mechanism in a Higgs portal dark matter model where we find a significant region of the parameter space that leads to a mild relaxation of the Hubble tension while simultaneously having the potential of addressing small-scale structure problems of ΛCDM.

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Collaboration / Activity:

NCBJ

T13 - Accelerator for HEP / 649

Muon Ionization Cooling Experiment (MICE): Results & Prospects

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A high-energy muon collider could be the most powerful and cost-effective collider approach in the multi-TeV regime, and a neutrino source based on decay of an intense muon beam would be ideal for measurement of neutrino oscillation parameters. Muon beams may be created through the decay of pions produced in the interaction of a proton beam with a target. The muons are subsequently accelerated and injected into a storage ring where they decay producing a beam of neutrinos, or collide with counter-rotating antimuons. Cooling of the muon beam would enable more muons to be accelerated resulting in a more intense neutrino source and higher collider luminosity. Ionization cooling is the novel technique by which it is proposed to cool the beam. The Muon Ionization Cooling Experiment collaboration has constructed a section of an ionization cooling cell and used it to provide the first demonstration of ionization cooling. Here the observation of ionization cooling is described. The cooling performance is studied for a variety of beam and magnetic field configurations. The future outlook for muon ionization cooling demonstrations is discussed.

Collaboration / Activity:

MICE

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T13 - Accelerator for HEP / 651

Analysis of Multiple Coulomb Scattering of Muons in the MICE Liquid H2 Absorber

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It is anticipated that high brightness muon beams will be needed primarily in two types of accelerators, a muon collider and a neutrino factory. The primary challenge posed by using muons for the working particle of an accelerator complex, and the reason they have not been used extensively, is the muon's short life-time (2.2µs at rest) and the relatively long cooling periods required by conventional beam cooling techniques. The Muon Ionization Cooling Experiment (MICE) is a multi-national accelerator physics initiative which has demonstrated Ionization Cooling (IC); a new, rapid beam-cooling technique suitable for the short-lived muon. The performance of IC depends on two key processes - energy loss due to collisional ionization, and Multiple Coulomb Scattering (MCS) - for which accurate models are crucial in parametrizing the method and enabling quantitative design of future muon accelerators. Experimental measurements of MCS of positive straight-track muons with momenta in the range 170-240 MeV/c in liquid H2 are reported in this study.

Collaboration / Activity:

MICE

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T13 - Accelerator for HEP / 653

Normalized Transverse Emittance Reduction via Ionization Cooling in MICE 'Flip Mode'

Author: Paul Jurj[1]

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Low emittance muon beams are central to the development of a Muon Collider and can significantly enhance the performance of a Neutrino Factory. The international Muon Ionization Cooling Experiment (MICE) has recorded several million individual muon tracks passing through a liquid hydrogen or a lithium hydride absorber and has demonstrated the ionization cooling of muon beams.

Previous analysis used a restricted data set, and the beam matching was not perfect. In this analysis, beam sampling routines were employed to account for imperfections in beam matching at the entrance into the cooling channel and enable an improvement of the cooling measurement. A study of the normalized transverse emittance change in the MICE cooling channel set up in a flipped polarity magnetic field configuration is presented. Additionally, the evolution of the canonical angular momentum across the absorber is shown and the characteristics of the cooling effect are discussed.

Collaboration / Activity:

MICE

First author:

Email:

T13 - Accelerator for HEP / 655

Transverse Emittance Change and Canonical Angular Momentum Growth in MICE ʻSolenoid Modeʼwith Muon Ionization Cooling

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Transverse Emittance Change and Canonical Angular Momentum Growth in MICE ʻSolenoid Modeʼ with Muon Ionization Cooling

Emittance reduction of muon beams is an important requirement in the design of a Neutrino Factory or Muon Collider. Ionization cooling, whereby beam emittance is reduced by passing a beam through an energy-absorbing material, requires tight focusing in the transverse plane which is achieved in many designs using solenoid focusing. In solenoid focusing, the beam acquires kinetic angular momentum due to the radial field in the solenoid fringe. Cooling in flip' mode, where the beam-focusing solenoid field changes polarity at the absorber, has already been demonstrated in the Muon Ionization Cooling Experiment (MICE). In this mode the absorber is near to the field flip, so the kinetic angular momentum is zero at the absorber.Solenoid modeʼcooling, where the field polarity does not change across the absorber leading to a beam crossing the absorber with significant kinetic angular momentum, has been considered for the final section of the muon collider design due to potentially stronger focussing that it enables. In this paper, we present the performance of MICE in ʻsolenoid modeʼ.

Collaboration / Activity:

MICE

First author:

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T03: Dark Matter / 657

Annual modulation results from three-year exposure of ANAIS-112

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DAMA/LIBRA observation of an annual modulation in the detection rate compatible with that expected for dark matter particles from the galactic halo has accumulated evidence for more than twenty years. It is the only hint about a positive identification of the dark matter, but it is in strong tension with the negative results of other very sensitive experiments. However, this comparison is model-dependent. By using the same target material than DAMA/LIBRA experiment, NaI(Tl), such a comparison is more direct and almost independent in dark matter particle and halo models. In this talk we will present the performance and prospects of ANAIS-112 experiment, which using 112.5 kg of NaI(Tl) as target, is taking data at the Canfranc Underground Laboratory in Spain since August 2017. Results corresponding to three-year exposure will be presented. These results are compatible with the absence of modulation and in tension with DAMA/LIBRA result. Moreover, they support our goal of reaching a 3σ sensitivity to the DAMA/LIBRA result with about 5 years of data.

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Collaboration / Activity:

ANAIS experiment

T01: Astroparticle and Gravitational Waves / 658

Mass composition modelling at sources of ultra-high energy cosmic rays

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Extragalactic sources are thought to be the origin of the highest energy cosmic rays detected at Earth. In this work, we explore energy-dependent mass compositions of these sources taking a subset of the VCV catalog for distances shorter than z=0.6. We use a power-law spectrum with an exponential cutoff to model individual sources above 10^{18} eV. To be more realistic we use the individual distance and flux weight of the sources, while sharing other properties as the index, Z-dependent rigidity cut and nuclei fraction. We propagate the different nuclei using CRPropa and search for the best stable parameters that fit the features of the spectrum measured by the Pierre Auger Observatory. We show the mass composition at the sources for A = 1, 1 < A ≤ 4, 4 < A ≤ 22, 22 < A ≤ 38 and A > 38.

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Collaboration / Activity:

HEP-PUCP

T04: Neutrino Physics / 659

The ENUBET monitored neutrino beam: a progress report

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The ENUBET experiment, included in the CERN Neutrino Platform effort as NP06/ENUBET, is developing a new neutrino beam based on conventional techniques in which the flux and the flavor composition are known with unprecedented precision ($\mathcal{O}(1\%)$). Such a goal is accomplished monitoring the associated charged leptons produced in the decay region of the ENUBET facility. Positrons and muons from kaon decays are measured by a segmented calorimeter instrumenting the walls of the decay tunnel, while muon stations after the hadron dump can be used to monitor the neutrino component from pion decays. Furthermore, the narrow momentum width (<10%) of the beam provides a precise measurement ($\mathcal{O}(10\%)$) of the neutrino energy on an event by event basis, thanks to its correlation with the radial position of the interaction at the neutrino detector. ENUBET is therefore an ideal facility for a high precision neutrino cross-section measurement at the GeV Scale, that could enhance the discovery potential of the next-generation of long baseline experiments. It is also a powerful tool for testing the sterile neutrino hypothesis and to investigate possible non-standard interactions.

In this contribution the design of the beamline and of the monitoring instrumentation will be shown. A new improved design of the proton target and of the meson transfer line ensures a larger neutrino flux while preserving a purity in the lepton monitoring similar to the one previously achieved. A demonstrator of the instrumented decay tunnel is currently being built and will be exposed to particle beams at CERN in 2022 to prove the effectiveness of the approach. Progress on the full simulation of the ENUBET facility and of the lepton reconstruction, towards the full assessment of neutrino flux systematics, will be also reported, together with the physics potential of the ENUBET beam.

Collaboration / Activity:

NP06/ENUBET

First author:

Email:

T13 - Accelerator for HEP / 660

Towards a Future Circular Higgs and Electroweak Factory

Author: Frank Zimmermann[1]

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A large circular e+e- collider followed by a highest-energy hadron in the same tunnel promises the most far-reaching physics program for the post-LHC era, and such a facility could well serve the particle physics community through the end of the 21st century. Two such projects are presently proposed: The Future Circular Collider, in a global collaboration hosted by CERN, and the combination of Circular Electron Positron Collider and Super Proton-Proton Collider, advanced by IHEP

Beijing. Over the centre-of-mass energy range from 90 to about 365 GeV, covering all known heavy elements of the Standard Model, from the Z resonance to the top-quark threshold, the circular e+e- collider offers a high luminosity and exquisite energy efficiency. The high luminosity is maintained by top-up injection from a full-energy booster synchrotron. On the Z pole and at the WW threshold resonant depolarisation will allow for a precision energy calibration at the ppm level. This presentation will summarize and compare the designs of FCC-ee and CEPC, covering the latest accelerator layouts and beam parameters, R&D plans, ongoing prototyping of key technologies, such as for the SRF system, and possible implementation schedules.

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Collaboration / Activity:

FCC, FCCIS, I.FAST

T04: Neutrino Physics / 661

An Intermediate Water Cherenkov Detector for Hyper-Kamiokande Using the NuPRISM Concept

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The Hyper-Kamiokande (HK) experiment will detect neutrinos produced at an upgraded 1.3 MW J-PARC 30 GeV accelerator with a new water Cherenkov detector that is 8 times larger than Super-Kamiokande. This will allow HK to accumulate neutrino events 20 times faster than the currently operating T2K experiment. To take advantage of the high statistics HK will collect, systematic uncertainties on neutrino production and interaction modelling must be reduced. The Intermediate Water Cherenkov Detector (IWCD) is a 1 kiloton scale water Cherenkov detector to be located ~1 km from the neutrino source at J-PARC to study neutrino production and interactions. The IWCD has the unique feature that it can be moved to different positions relative the beam direction, enabling measurements that probe the relationship between neutrino energy and particles produced in neutrino interactions. I will describe the IWCD design, measurement program and the key technologies that will be deployed in the detector.

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Collaboration / Activity:

Hyper-Kamiokande

T08: Flavour Physics and CP Violation / 663

QCD factorization tests with $\bar{B}^0 \to D^{(*)+}\pi^-$ and $\bar{B}^0 \to D^{(*)+}K^-$ decays at Belle

Author: Shohei Nishida[1]

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We report new results of the branching fractions $\mathcal{B}(\bar{B}^0 \to D^{*+}\pi^-)$ and $\mathcal{B}(\bar{B}^0 \to D^{*+}K^-)$ measured using 772×10^6 B-meson pairs recorded by the Belle experiment. The ratio of the branching fractions is measured in a way that allows for the cancellation of systematic uncertainties arising from the D-meson reconstruction. Furthermore, we report a new high-precision test of QCD factorisation by measuring ratios of $\bar{B}^0 \to D^{*+}h^-$ $(h = \pi, K)$ and $\bar{B}^0 \to D^{*+}\ell^-\bar{\nu}_\ell$ decays at fixed momentum transfers for different particle species. The talk also covers related measurements of $B \to Dh$ decays performed with the full Belle data.

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Collaboration / Activity:

Belle

T08: Flavour Physics and CP Violation / 664

New results on semileptonic B meson decays from the Belle experiment

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Though the Belle experiment has stopped data taking more than a decade ago, new results on semileptonic B meson decays are still being obtained. This is in part due to new experimental tools elaborated for Belle II applied to the Belle data set, such as the FEI (Full Event Interpretation) hadronic and semileptonic tag which enables new measurements of $B \to D^*\ell\nu$, $B \to D^{**}\ell\nu$ and $B \to X\ell\nu$. Other analyses are motivated by the progress in theory such as the measurement of q^2 moments in $B \to X_c\ell\nu$, which allows for a determination of $|V_{cb}|$ up to the order $1/m_b^4$. This talk covers all new semileptonic B decay results obtained with the Belle data set.

Collaboration / Activity:

Belle

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T08: Flavour Physics and CP Violation / 665

New physics searches through τ decays at Belle

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We report the result of a search for $\tau \to \ell\gamma$ ($\ell = e, \mu$) using the full data sample at Belle. Since the observation of neutrino oscillations has unambiguously shown that the lepton flavor is no longer conserved, we can expect lepton flavor violation (LFV) in the charged lepton sector. Though the standard model (SM) does not predict charged LFV decays at an observable rate, $\tau \to \ell\gamma$ is predicted by many new physics scenarios and is thus one of the most promising LFV modes. Consequently, we have obtained the most stringent limit on the branching fraction of $\tau \to \mu\gamma$. In addition, we report the result of a search for tau electric dipole moment (EDM) evaluating τ-τ-γ vertex coupling using the full data sample at Belle. At present, the observed CP violation is insufficient to explain the prevalent matter-antimatter asymmetry in our universe. On the other hand, the EDM of leptons is predicted to be negligibly small in the SM and is expected as a source of CPV in the lepton sector induced by some new physics. We have obtained one order more sensitive result both for the real and imaginary parts of the τ EDM.

Collaboration / Activity:

Belle

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T08: Flavour Physics and CP Violation / 668

Results of Jpsi weak decay searching at BESIII

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Based on the 225 million J/ψ data set accumulated at the 3.097 GeV by the BESIII detector, we show searches for the extremely rare process of J/ψ weak decays. We find no obvious signal event for the processes of $J/\psi \to \bar{D}^0\pi^0, \bar{D}^0\eta, \bar{D}^0\rho^0, D^-\pi^+$ and $J/\psi \to D^-\rho^+$ and present the most stringent constraints of 10^{-6} at 90\% confidence level. Furthermore, the result of $J/psi \to D^-e^+\nu_e + c.c.$ with 10 billion newly collected J/ψ data and some other prospect results are also presented.

Collaboration / Activity:

BESIII

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T10: Searches for New Physics / 669

Search for invisible decays at BESIII

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BESIII has collected 448.2 M $\psi(3686)$ data set and 10 B J/ψ data set. The huge clean data sample provide an excellent chance to search for new physics. We report the search for decay $J/\psi \to \gamma + invisible$, which is predicted by next-to-minimal supersymmetric model. Without significant signal found, we gave around 6.2 times better upper limits than previous CLEO-c's results. In addition, we report the preliminary result of the first search for the invisible decay of Λ. This invisible decay is predicted by the mirror matter model which could explain the 4σ discrepancy in neutron lifetime measurement results from the beam method and bottle method.

Collaboration / Activity:

BESIII

First author:

Email:

T06: QCD and Hadronic Physics / **671**

Charmonium Decays at BESIII (12'+3')

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Although the charmonium spectrum seems to be well investigated, charmonia can still be used as benchmarks to test our QCD predictions, as these states lay in the transition region between perturbative and non-perturbative QCD.Despite the need for experimental confirmations, setbacks arise from limited statistics because of the production processes of all non-vector states. The
properties and many decay channels of some charmonium states (such as hc or eta_c(2S)) are still far from being known.
Since 2009, BESIII has been scanning and investigating the charmonium
region to shed light on open questions. Thanks to its unique J/psi; and psi(2S) data sets, BESIII could overcome statistical limitations.
Recent results on charmonium decays from BESIII are presented.

Collaboration / Activity:

BESIII

First author:

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T03: Dark Matter / **672**

B anomalies and muon g-2 from Dark Matter

Author: Lorenzo Calibbi[1]

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In the light of the recent result of the Muon g-2 experiment and the update on the test of lepton flavour universality R_K published by the LHCb collaboration, we systematically build and discuss a set of models with minimal field content that can simultaneously give: (i) a thermal Dark Matter candidate; (ii) large loop contributions to $b \to s\ell\ell$ processes able to address R_K and the other B anomalies; (iii) a natural solution to the muon g−2 discrepancy through chirally-enhanced contributions.

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Collaboration / Activity:

Theory

T06: QCD and Hadronic Physics / 673

Central exclusive production of pipi, KK and pp pairs with forward proton measured in Roman Pot detectors in proton proton collisions at sqrt(s)=200 GeV with the STAR detector.

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Abstract attached as pdf file.

Collaboration / Activity:

STAR

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T03: Dark Matter / 674

Dark Matter Searches at Belle II, Belle, and BaBar

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The Belle II experiment at the asymmetric e^+e^- collider, SuperKEKB, is a substantial upgrade of the Belle/KEKB experiment. Belle II aims to record 50 ab^{-1} of data over the course of the project. During the first physics runs in 2018-2020, around 100 fb^{-1} of data were collected. These early data include specifically-designed low-multiplicity triggers which allow a variety of searches for light dark matter and dark-sector mediators in the GeV mass range.

This talk will present the very first world-leading physics results from Belle II: searches for the invisible decays of a new vector Z', and visible decays of an axion-like particle; as well as the near-term prospects for other dark-sector searches. Many of these searches are competitive with the data already collected or the data expected in the next few years of operation. In this talk we also review the latest dark sector results from the first generation of B factories: BaBar and Belle.

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Collaboration / Activity:

Belle II

T05: Heavy Ion Physics / 675

Heating triangle singularities in heavy ion collisions

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We predict that triangle singularities of hadron spectroscopy can be strongly affected in heavy ion collisions. To do it we examine various effects on the singularity-inducing triangle loop of finite temperature in the terminal hadron phase.
It appears that peaks seen in central heavy ion collisions are more likely to be hadrons than rescattering effects under two conditions. First, the flight-time of the intermediate hadron state must be comparable to the lifetime of the equilibrated fireball (else, the reaction mostly happens in vacuo after freeze out).
Second, the medium effect over the triangle-loop particle mass or width must be sizeable.
When these (easily checked) conditions are met, the medium quickly reduces the singularity: at T about 150 MeV, even by two orders of magnitude, acting then as a spectroscopic filter.
(To appear in European Physical Journal C)

Collaboration / Activity:

Theory

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T08: Flavour Physics and CP Violation / 678

Unitarity Triangle global fits testing the Standard Model: UTfit 2021 SM update

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Flavour physics represents a unique test bench for the Standard Model (SM). New analyses performed at the LHC experiments are now providing unprecedented insights into CKM metrology and new results for rare decays. The CKM picture can provide very precise SM predictions through global analyses.
We present here the results of the latest global SM analysis performed by the UTfit collaboration including all the most updated inputs from experiments, lattice QCD and phenomenological calculations.
We update our analysis of D meson mixing including the latest experimental results. We also derive constraints on absorptive and dispersive CP violation by combining all available data, and discuss future projections. We also provide posterior distributions for observable parameters appearing in D physics.
Finally we present the perspectives for future UT analyses on the basis of existing extrapolations of experimental results from the Belle-II and LHCb experiments, as well as of expected improvements from Lattice QCD computations.

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Collaboration / Activity:

UTfit Collaboration

T08: Flavour Physics and CP Violation / 679

Unitarity Triangle global fits beyond the Standard Model: UTfit 2021 NP update

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Flavour physics represents a unique test bench for the Standard Model. New analyses performed at the LHC experiments are now providing unprecedented insights into CKM metrology and new results for rare decays. The CKM picture can provide very precise Standard Model predictions through global analyses.
The Unitarity Triangle (UT) analysis can also be used to constrain the parameter space in possible new physics (NP) scenarios. We present an update of the UT analysis beyond the SM by the UTfit collaboration. Assuming NP, all of the available experimental and theoretical information on DeltaF=2 processes is combined using a model-independent parametrisation. We determine the allowed NP contributions in the kaon, D, Bd, and Bs sectors and, in various NP scenarios, we translate them into bounds for the NP scale as a function of NP couplings.

Collaboration / Activity:

UTfit Collaboration

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T01: Astroparticle and Gravitational Waves / 680

CALET on the International Space Station: a precise measurement of the iron spectrum

Author: Caterina Checchia[1]

Co-authors: Francesco STOLZI [2]; Yosui Akaike [3]; on behalf of the CALET collaboration

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The Calorimetric Electron Telescope (CALET) was launched on the International Space Station in 2015 and since then has collected a large sample of cosmic-ray charged particles over a wide energy. Thanks to a couple of layers of segmented plastic scintillators placed on top of the detector, the instrument is able to identify the charge of individual elements from proton to iron (and above). The imaging tungsten scintillating fiber calorimeter provides accurate particle tracking and the lead tungstate homogeneous calorimeter can measure the energy with a wide dynamic range. One of the CALET scientific objectives is to measure the energy spectra of cosmic rays, to shed light on their acceleration and propagation in the Galaxy. After five years of observation, a precise measurement of the iron spectrum is now available in the range of kinetic energy per nucleon from 10 GeV/n to 2 TeV/n. The CALET result will be reported and compared with the findings from other experiments. A description of the analysis and details on the systematic uncertainties will be given.

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Collaboration / Activity:

CALET

T13 - Accelerator for HEP / 684

Muon Collider

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The muon collider offers a unique opportunity to reach high-energy lepton
collisions with high luminosity. Following the Update of the European Strategy

for Particle Physics CERN is hosting a new, forming muon collider collaboration.
The muon collider is also considered in the Roadmap for Accelerator R&D, which is being developed.
The presentation gives a short introduction into the concept and highlights the challenges that have to be addressed together with the plan of the collaboration.

Collaboration / Activity:

Muon Collider Collaboration

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T05: Heavy Ion Physics / 685

System-size dependence of charged- and neutral-particleproduction with ALICE

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Comparing particle production in Pb–Pb and p–Pb collisions with pp collisions provides insight into the longitudinal (and low-x) nature of the hot and dense medium created in heavy-ion collisions. Investigating the system-size dependence of the particle production at the same collision energy is particularly important, as one can then directly study effects of the nuclear geometry. ALICE has unique coverage which can be exploited at forward rapidity. The Forward Multiplicity and the Silicon Pixel Detectors can measure charged particles over a wide range of$-3.4< \eta <5.0$. On the other hand, the Photon Multiplicity Detector can measure neutral-particle production over a kinematic range of $2.3< \eta <3.9$. Results across different colliding systems at forward rapidity will be presented for both charged and neutral particles. The measurements will be compared with model calculations based on different particle-production mechanisms and initial conditions. Finally, we will show the evolution of the width of the pseudorapidity density distribution with centrality and give a lower bound on the Bjorken energy density for different colliding systems.

Collaboration / Activity:

ALICE

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T06: QCD and Hadronic Physics / 686

Underlying Event studies and search for jet modifications in pp and p-Pb collisions with ALICE at the LHC

Authors: ALICE Collaboration[None]; Ahsan Mehmood Khan[None]

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It is well-established that high-multiplicity pp and p–Pb collisions exhibit various signatures associated with the formation of QGP in heavy-ion collisions. In this contribution, we present results obtained using Underlying Event (UE) techniques, used to measure the average number density and the average total transverse momentum (p_{T}) in the Toward, Transverse, and Away regions with respect to the leading trigger particle, but employed in novel ways. A conventional UE analysis is applied in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV to test the similarities between pp and p-Pb collisions. The charged particle multiplicity in the Transverse UE-dominated region, N_{T}, is used as a multiplicity estimator to establish relations between particle production in pp, p-Pb and Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. The results are compared with predictions from QCD-inspired Monte Carlo event generators. Finally, the UE studies are used to search for jet modification by subtracting the UE contributions measured in the Transverse region from the Toward and the Away regions. These studies in terms of N_{T} are powerful tools to search for jet modification patterns from the smallest systems, events with multiplicities lower than the mean for minimum-bias pp collisions, to the largest systems, central heavy-ion collisions, in a coherent way.

Collaboration / Activity:

ALICE

First author:

Email:

T12: Detector R&D and Data Handling / 687

MeV electron- neutrino and antineutrino spectrometer with LiCl and GaCl

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The flavor transition of solar neutrinos is governed by the vacuum MNS mixing parameters and MSW matter effect, however, the transition from matter- to vacuum-dominated energy region, i.e. the upturn, has not been experimentally observed. It left open questions for light sterile neutrinos or non-standard-model interactions. The solar neutrino spectrum predicted by the solar model also bears large experimental uncertainties. Geo-science achieved by neutrino observatories has just started, more data is urged. In this talk, I will introduce our recent experimental study of LiCl and GaCl liquid scintillators. Lithium-7 has shown a high-cross-section low-threshold feature for electron-neutrino detection and energy measurement through charged current interaction. Gallium-71 has shown an interesting delayed-coincidence feature for electron-neutrino detection and energy measurement. Chloride-35 and Lithium-6 have shown that detection of electron-antineutrino with delayed-coincidence technique is possible. We investigated the physical property of LiCl and GaCl on solubility, U, Th, K removal, natural abundance, and attenuation length. We have tried to produce a water-based liquid scintillator including LiCl and GaCl. We find that LiCl aqueous solution is good media for MeV electron- neutrino and antineutrino spectrometer and rather efficient in measuring the upturn, solar sterile neutrinos, and geoneutrinos. Some features are unique and cannot be achieved by a traditional water-Cherenkov or liquid scintillator detector, and some features can cause a compact size for a detector.

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Collaboration / Activity:

None

T07: Top and Electroweak Physics / 689

Search for flavor-changing neutral current interactions of the top quark and the Higgs boson decaying to a b quark-antiquark pair at 13 TeV in CMS

Authors: Jiwon Park[1]; Taejeong Kim[1]

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A search for flavor-changing neutral current interactions between the top quark and the Higgs boson is presented. The search is based on a data sample corresponding to an integrated luminosity of 137 /fb recorded by the CMS experiment at the LHC in proton-proton collisions at the center of mass energy of 13 TeV. Events containing exactly one lepton (electron or muon) and at least three jets, among which at least two are identified as coming from the hadronization of a b quark are analyzed. The analysis further separates events into five categories based on the (b-)jet multiplicity. A deep neural network is used to make the association between the reconstructed objects and the matrix-element partonic final state while boosted decision trees are used to separate the signals and the backgrounds.

Collaboration / Activity:

CMS

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T05: Heavy Ion Physics / 690

System size and energy dependence of resonance production measured with ALICE

Authors: Paraskevi Ganoti[None]; ALICE Collaboration[None]

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Hadronic resonances with different lifetimes are very useful to probe the hadronic phase, the latest stage in the evolution of the system created in heavy-ion collisions. Due to their relatively short lifetimes compared to the duration of the hadronic phase, resonances are good candidates to investigate the interplay between particle rescattering and regeneration. In addition, the measurement of resonances having different masses and strangeness content can contribute to the understanding of strangeness production. Measurements of hadronic resonances $\rho(770)^0$, $\mathrm{K}^*(892)$, $\phi(1020)$, $\Sigma(1385)^{\pm}$, $\Lambda(1520)$, $\Xi(1530)^0$ and $\Xi(1820)$ have been performed with the ALICE detector at the LHC in pp, p–Pb, Pb–Pb and Xe–Xe collisions at different energies. We report on the transverse momentum (p_{T}) spectra and p_{T} integrated yields, complementing our observation with new results on $\Lambda(1520)$ in p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV. In particular, ratios of p_{T}-integrated resonance yields to those of long-lived particles will be discussed as a function of multiplicity in all collision systems at different energies. A critical overview of these results will be given through comparisons to measurements from other experiments and theoretical models.

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Collaboration / Activity:

ALICE

T03: Dark Matter / 691

DarkSide-20k and the Future Liquid Argon Dark Matter Program

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DarkSide run since mid 2015 a 50-kg-active-mass dual phase Liquid Argon Time Projection Chamber (TPC), filled with low radioactivity argon from an underground source and produced world class results for both the low mass ($M_{WIMP} < 20GeV/c^2$) and high mass ($M_{WIMP} > 100GeV/c^2$) direct detection search for dark matter.
The next stage of the DarkSide program will be a new generation experiment involving a global collaboration from all the current Argon based experiments. DarkSide-20k, is designed as a 20-tonne fiducial mass dual phase Liquid Argon TPC with SiPM based cryogenic photosensors, and is expected to be free of any instrumental background for an exposure of >100 ton x years. Like its predecessor DarkSide-20k will be housed at the INFN Gran Sasso (LNGS) underground laboratory, and it is expected to attain a WIMP-nucleon cross section exclusion sensitivity of $7.4 \times 10^{-48}\,cm^2$ for a WIMP mass of $1TeV/c^2$ in a 200 t yr run. DarkSide-20k will be installed inside a membrane cryostat containing more than 700 t of liquid argon and be surrounded by an active neutron veto based on a Gd-loaded acrylic shell. The talk will give the latest updates of the ongoing R\&D and prototype tests validating the initial design.
A subsequent objective, towards the end of the next decade, will be the construction of the ultimate detector, ARGO, with a 300 t fiducial mass to push the sensitivity to the neutrino floor region for high mass WIMPs.

Collaboration / Activity:

DarkSide (GADMC)

First author:

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T06: QCD and Hadronic Physics / 692

$B_s \to D_s^{(\star)}$ Form factors computation in lattice QCD

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In this poster we present the results of a lattice QCD comput-ation at $N_f = 2$ for the processes $B_s \to D_s^{(\star)}$, and their form factors parametrization in the heavy quark limit $\mathcal{G}$, h_{A_1}, h_{A_2} and h_{A_3}. This study is in line with the research of new physics in the B sector, which is motivated by recent tensions reported in lepton flavor universality tests, the so-called B anomalies. Our strategy to deal with systematic effects on lattice calculations reveals promising for forthcoming steps of our work performed with simulations at the physical point.

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Collaboration / Activity:

N/A

T07: Top and Electroweak Physics / 693

Two-loop QED correction to the mu-e elastic scattering

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In this talk we present the analytic evaluation of the two-loop QED correction
to the mu-e elastic scattering, retaining the full dependence on
the muon mass and considering the electron as a massless particle.
We discuss the generation of integrands from Feynman
diagrams as well as the evaluation of the latter by recalling
the analytic expressions of the two-loop master integrals,
recently computed for this kinematics.
Likewise, the renormalisation procedure is discussed in details.
We also comment that this calculation can straightforwardly be applied
to crossing related processes like di-muon production, e+e- -> mu+mu-,
as well as the heavy-quark production in QCD, qqbar -> ttbar.

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Collaboration / Activity:

TBD

T12: Detector R&D and Data Handling / 694

Cryogenic SiPMs for dark matter search with DarkSide-20k

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The Global Argon Dark Matter Collaboration is pursuing the construction, at the Gran Sasso Laboratory (LNGS), of DarkSide-20k a dark matter direct search experiment designed as a 20-tonne fiducial mass Time Projection Chamber (TPC) with SiPM based photosensors, expected to be free of any instrumental background for an exposure of >100 ton x years.
Large-area cryogenic SiPM tile modules (PDM) have been developed with lower radiogenic background and higher photo-detection efficiency (>40%) respect to the PMTs usually adopted in dark matter experiments. Two units made of 25×25 cm^2 arrays of PDMs have been operated and characterized at liquid nitrogen and argon temperatures in small prototype detectors. Several options are currently pursued for transmission of the analog signals to the digitisation electronics at room temperature.
More than 8280 PDMs are needed to fully instrument the DarkSide-20k Liquid Argon TPC. The assembly will take place in NOA, a 700 m^2 clean room under construction at LNGS that will host a dedicated microelectronics packaging facility. The present status of DarkSide-20k with the latest achievements and the future steps and strategies will be presented.

Collaboration / Activity:

DarkSide (GADMC)

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T04: Neutrino Physics / 695

Hyper-Kamiokande experiment

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The Hyper-Kamiokande experiment consists of a 260 kt underground water Cherenkov detector with a fiducial volume more than 8 times larger than that of Super-Kamiokande. It will serve both as a far detector of a long-baseline neutrino experiment and an observatory for astrophysical neutrinos and rare decays.

The long-baseline neutrino experiment will detect neutrinos originating from the upgraded 1.3 MW neutrino beam produced at the J-PARC accelerator 295 km away. A near detector suite, close to the accelerator, will help characterise the beam and minimise systematic errors.

The experiment will investigate neutrino oscillation phenomena (including CP-violation and mass ordering) by studying accelerator, solar and atmospheric neutrinos, neutrino astronomy (solar, supernova, supernova relic neutrinos) and nucleon decays.

In this talk, we will present an overview of the Hyper-Kamiokande experiment, its current status and physics sensitivity.

Collaboration / Activity:

Hyper-Kamiokande

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T12: Detector R&D and Data Handling / 696

ReD: characterisation of a SiPM based Liquid Argon TPC for directional dark matter detection studies

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A double-phase argon Time Projection Chamber (TPC), with an active volume of $5 \times 5 \times 5$ cm^3, has been designed and constructed for the Recoil Directionality (ReD) experiment, within the DarkSide collaboration. The aim of the ReD project is to investigate the directional sensitivity of argon-based TPCs via columnar recombination to nuclear recoils in the energy range of interest (20-200\,keV$_{nr}$) for direct dark matter searches. The key novel feature of the ReD TPC is a readout system based on cryogenic Silicon Photomultipliers (SiPMs), which are employed and operated continuously for the first time in an argon TPC. Over the course of six months, the ReD TPC had been characterised under various operating conditions using γ-ray and neutron sources, demonstrating stability of the optical sensors and reproducibility of the results.
The scintillation gain and ionisation amplification of the TPC were measured to be $g_1 = (0.194 \pm 0.013)$ photoelectrons/photon and $g_2 = (20.0 \pm 0.9)$ photoelectrons/electron, respectively. The ratio of the ionisation to scintillation signals (S2/S1), instrumental for the positive identification of a candidate directional signal induced by WIMPs, has been investigated for both nuclear and electron recoils. At a drift field of 183 V/cm, an S2/S1 dispersion of 12% was measured for nuclear recoils of approximately 60-90 keV$_{nr}$, as compared to 18% for electron recoils depositing 60\,keV of energy. The detector performance discussed in this talk will allow the investigation of a directional effect due to columnar recombination. In addition a phenomenological parameterisation of the recombination probability in liquid argon is presented and employed for modeling the dependence of scintillation quenching and charge yield on the drift field for electron recoils between 50-500 keV and fields up to 1000 V/cm.

Collaboration / Activity:

DarkSide (GADMC)

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T01: Astroparticle and Gravitational Waves / 697

The ANTARES neutrino telescope (on behalf of the ANTARES Collaboration)

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Installed at about 2500 m under the Mediterranean Sea, in front of the southern French coast, the ANTARES detector is the first undersea neutrino telescope and has been collecting data since 13 years in its final configuration. Its main scientific goal is the search for astrophysical high energy neutrinos, either coming from resolved sources, or as a diffuse excess of very high energy events,

or in space-time coincidence with other cosmic messengers such as gravitational waves and electromagnetic signals over the whole energy spectrum.
The good optical properties of sea water yield the reconstruction of neutrino directions with a resolution better than one degree, allowing for all-flavour astronomy. The location of ANTARES, in the Northern hemisphere, also offers a privileged point of view towards the Galactic plane and centre, where interesting high energy candidate sources could be hosted.
In this contribution a general view of the most important scientific achievements of ANTARES will be given, with particular focus on its wide program of multi-messenger research.

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Collaboration / Activity:

ANTARES Collaboration

T12: Detector R&D and Data Handling / 700

SiPM characterisation for cosmic muon veto detector of mini-ICAL

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The prototype detector of Iron CALorimeter (ICAL) experiment at the India-based Neutrino Observatory i.e., mini-ICAL is currently running at IICHEP Madurai, India. An active cosmic muon veto (CMV) detector is going to house the mini-ICAL from top and sides except the front side. CMV consists of 5cm wide extruded plastic scintillators with embedded two WLS fibres to propagate scintillation light and SiPM at both ends of fibres as photosensors for detecting photons. The SiPM will be calibrated using an LED ultrafast driver. A small experimental setup is built to characterise the SiPM along with an extruded scintillator strip to optimise the operating over voltage, threshold of SiPM signals and the veto criteria by observing muon signal and the noise rate in SiPM. These optimisations along with other characteristics of SiPM, e.g. cross-talk, afterpulse, recovery time etc will be presented in this talk.

Collaboration / Activity:

INO collaboration

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T02: Cosmology / 701

Entropy in the early universe

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Due to the quantum origin of primordial perturbations, the early universe is an ideal setup for the interplay between gravity, quantum physics and thermodynamics. In this talk I will discuss results and ongoing work on the role that mutual information between distant regions play in cosmology.

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Collaboration / Activity:

None

T06: QCD and Hadronic Physics / 702

Systematic Uncertainties of the Inverse Amplitude Method

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Effective Field Theories such as HEFT, organized as momentum expansions, are a controllable approximation to strong dynamics only near threshold, as they miss exact elastic unitarity, reducing their predictive power at a higher scale if small separations from the Standard Model are found at the LHC orelsewhere. Unitarized chiral perturbation theory extends their reach to saturation of unitarity but, generally, with unknown systematics. Our contribution follows the derivation of the Inverse Amplitude Method (IAM), a serious unitarization procedure, quantifying the uncertainty introduced at each step. Provided a check for zeroes of the amplitude is performed and, if appropriate, they are taken into account, we find that the IAM extension of EFT partial wave amplitudes can be assigned a limited uncertainty band up to and including the first resonance or structure of the amplitude, and if none appears, up to energies of the order of $4\pi F$, nominal validity limit of the EFT.

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T03: Dark Matter / 703

Dark-matter halo shapes from fits to SPARC galaxy rotation curves

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We fit galactic rotation curves obtained by SPARC from dark matter haloes that are not spherically symmetric, but allowed to become prolate or oblate with a higher-multipole density distribution. This is motivated by observing that the flattening of v(r)=constant is the natural Kepler law due to a filamentary rather than a spherical source, so that elongating the distribution could bring about a smaller chi squared, all other things being equal. We compare results with several different dark matter profiles and the extracted best fits to the ellipticity computed in cosmological simulations of dark matter haloes. The shape distortion can impact our understanding of the local density of dark matter and thus be of interest for the direct detection program.

Collaboration / Activity:

Theory

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T04: Neutrino Physics / 704

JUNO potential in non-oscillation physics

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The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation liquid scintillator experiment being built in Guangdong province in China. JUNO's target mass of 20 kton will be contained in a 35.4 m acrylic vessel, itself submerged in a water pool, under about 650 m of granite overburden. Surrounding the acrylic vessel are 17612 20" PMTs and 25600 3" PMTs. The main goal of JUNO, whose construction is scheduled for completion in 2022, is a 3-4σ determination of the neutrino mass ordering (MO) using reactor neutrinos within six years, as well as a precise measurement of θ_{12}, δM^2_{21}, and δM^2_{31}.
JUNO's large target mass, low background, and dual calorimetry, leading to an excellent energy resolution and low threshold, allows for a rich physics program with many applications in neutrino physics. The large target mass will allow for high-statistics solar-, geo-, and atmospheric neutrino measurements. JUNO will also be able to measure neutrinos from galactic core-collapse supernovae, detecting about 10,000 events for a supernova at 10 kpc, and achieve a 3σ discovery of the diffuse supernova neutrino background in ten years. It can also study non-standard interactions e.g. proton decay, indirect dark matter searches, and probe for lorentz invariance violations. This talk will cover this extensive range of non-oscillation topics on which JUNO will be able to shed light.

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Collaboration / Activity:

JUNO

T05: Heavy Ion Physics / 705

Deep learning jet modifications in heavy-ion collisions

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Jet interactions in a hot QCD medium created in heavy-ion collisions are conventionally assessed by measuring the modification of the distributions of jet observables with respect to the proton-proton baseline. However, the steeply falling production spectrum introduces a strong bias toward small energy losses that obfuscates a direct interpretation of the impact of medium effects in the measured jet ensemble. In this talk, we will explore the power of deep learning techniques to tackle this issue on a jet-by-jet basis.

Toward this goal, we employ a convolutional neural network (CNN) to diagnose such modifications from jet images where the training and validation is performed using the hybrid strong/weak coupling model. By analyzing measured jets in heavy-ion collisions, we extract the original jet transverse momentum, i.e., the transverse momentum of an identical jet that did not pass through a medium, in terms of an energy loss ratio. Despite many sources of fluctuations, we achieve good performance and put emphasis on the interpretability of our results. We observe that the angular distribution of soft particles in the jet cone and their relative contribution to the total jet energy contain significant discriminating power, which can be exploited to tailor observables that provide a good estimate of the energy loss ratio.

With a well-predicted energy loss ratio, we study a set of jet observables to estimate their sensitivity to bias effects and reveal their medium modifications when compared to a more equivalent jet population, i.e., a set of jets with similar initial energy. Then, we show how this new technique provides unique access to the initial configuration of jets over the transverse plane of the nuclear collision, both with respect to their production point and initial orientation. Finally, we demonstrate the capability of our new method to locate with unprecedented precision the production point of a dijet pair in the nuclear overlap region, in what constitutes an important step forward towards the long term quest of using jets as tomographic probes of the quark-gluon plasma.

1 Yi-Lun Du, Daniel Pablos, Konrad Tywoniuk, Deep learning jet modifications in heavy-ion collisions, arXiv:2012.07797 [hep-ph], JHEP. 2021, 206 (2021)

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Collaboration / Activity:

None

T12: Detector R&D and Data Handling / 706

Preparation for ALICE data processing and analysis in LHC Run 3

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After the ALICE Long Shutdown 2 detector upgrades, including a new silicon tracker and a GEM-based readout for the TPC, the experiment will operate during LHC Run 3 at a peak Pb-Pb collision rate of 50 kHz, about 50 times higher than in previous running periods. To maximise the significance of physics signals with low S/B ratios for which triggering is not possible, all events will be read out and written to permanent storage without any selective trigger. In order to minimise the costs and computing time of the online and offline systems, data volume reduction is performed synchronous with data taking on the newly installed Online/Offline facility O2. The facility consists of two types of compute nodes, the First Level Processors (FLP) and the Event Processing Nodes (EPN). Each FLP receives data from parts of individual detectors, performs a first level of data compression by zero suppression as well as calibration tasks, and sends its output to the EPNs over an Infiniband network. Using the EPN's CPU cores and GPUs, data is reconstructed and further compressed. Moreover, data for detector calibration is created. Online data processing is followed by offline reconstruction passes using fully calibrated data producing the input for data analysis (AOD). In addition, large samples of simulated data as input for detector response and performance studies will be produced.

Here we describe the data processing chain and give an overview of the design choices and implementations for the newly developed software frameworks, which can cope with the unprecedented data rates and volumes. The status of the preparation for data processing and analysis in view of the first physics runs in 2022 is presented.

Collaboration / Activity:

ALICE

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T07: Top and Electroweak Physics / **708**

Diboson and top quark pair production cross section measurements at 5.02 TeV in CMS

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We explore a new energy regime, 5 TeV, for the diboson and top quark pair productions in proton-proton collisions using 304/pb of data collected in 2017 by the CMS experiment at the LHC. The diboson, WW, WZ, and ZZ, cross sections are measured analyzing events with two, three or four charged leptons in the final state. The cross sections are compared with NNLO predictions and across other experiments. The top quark pair production measurement is performed using events with one electron and one muon of opposite sign, and at least two jets. To reduce the statistical uncertainty, a combination with the result in the l+jets channel, based on 27.4 1/pb of data collected in 2015 at the same center-of-mass energy, is then performed.

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Collaboration / Activity:

Universidad de Oviedo

T12: Detector R&D and Data Handling / 709

Detection of low-energy X-rays with 1/2 and 1 inch LaBr3:Ce crystals read by SIPM arrays

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LaBr3:Ce crystals are used for radiation imaging in medical physics, with PMT or SIPM readout. An R&D was pursued with 1/2 and 1" crystals to realize compact large area detectors (up some cm^2 area) with SIPM array readout, aiming at high light yields, good energy resolution/linearity and fast time response for low-energy X-raysdetection. This study was triggered by the FAMU experiment at RIKEN-RAL muon facility, that aims at the precise measure of the proton Zemach radius to solve the so-called "proton radius puzzle", triggered by the recent measurements of the proton charge radius at PSI. The goal is the detection of characteristic X-rays around 130 keV. Other applications may be foreseen in medical physics, such as PET and gamma-ray astronomy. A direct and simple readout scheme employing CAEN V1730 fast digitizers was used. Different experimental key factors were studied such as the use of different SIPM arrays for readout from Hamamatsu, Advansid and SENSL, the drift of SIPM gain with temperature, the comparison of performances and intrinsic activity with other available crystals. The temperature gain drift of SIPM was corrected online by the use of custom NIM modules, based on CAEN A7585D power supply chips with temperature feedback. Laboratory tests and beam results will be reported. In laboratory, an energy resolution @ Cs^{137} peak around 3% was obtained. This compares well with the best results obtained with the standard PMT readout.

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Collaboration / Activity:

FAMU / detector R&D

T12: Detector R&D and Data Handling / 710

An Alternative Design for Large Scale Liquid Scintillator Detectors

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Single page abstract attached as a pdf.

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Collaboration / Activity:

SNO+

T03: Dark Matter / 711

Dark matter freeze-in from semi-production

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We study a novel dark matter production mechanism based on the freeze-in through semi-production, i.e. the inverse semi-annihilation processes. A peculiar feature of this scenario is that the production rate is suppressed by a small initial abundance of dark matter and consequently creating the observed abundance requires much larger coupling values than for the usual freeze-in. We provide a concrete example model exhibiting such production mechanism and study it in detail, extending the standard formalism to include the evolution of dark matter temperature alongside its number density and discuss the importance of this improved treatment. Finally, we confront the relic density constraint with the limits and prospects for the dark matter indirect detection searches. We show that, even if it was never in full thermal equilibrium in the early Universe, dark matter could, nevertheless, have strong enough present-day annihilation cross section to lead to observable signals.

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Collaboration / Activity:

Theory

T03: Dark Matter / 713

Towards New Particle Discoveries: the ALPS-II Experiment Shines Soon*

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The version II of the Any Light Particle Search (ALPS) experiment is projected to be one of the most sensitive experiments for axion-like particles. Such particles are a solution to the strong CP problem in quantum chromodynamics (QCD) as well as potential dark matter candidates. Based on theory, the axion-like particles are weakly interacting with matter, making them invisible to regular detectors. However, and fortunately, these "invisible"particles are predicted to be coupled with light, with a certain conversion probability, in the presence of a strong magnetic field. This prediction opened up a way for a potential detection of these particles via optics. ALPS is a light shining through a wall (LSW) experiment where the production of the axion-like particles would be occurring in a pure laboratory setting: a high power laser will shine through a string of 12 superconducting HERA dipole magnets, located in the HERA tunnel at DESY in Hamburg, Germany. At the end of these magnets, a "wall"will block the laser light while the axion-like particles would pass through it towards a second similar set of 12 HERA magnets, which would regenerate a tiny amount of the axion-like particles back to detectable photons. Also, by implementing two high finesse 124 m baseline Fabry-Perot cavities at the production and regeneration sides, ALPS-II could increase its upper limit sensitivity in the coupling factor between the axion-like particles and the photons down to $g_{a\gamma\gamma} = 2 \times 10^{-11}\mathrm{GeV}^{-1}$. I will report on the optics commissioning status and its stages which started at the beginning of this year, on the latest milestones that we have reached, and finally on the science runs and results that we are expecting from our experiment.

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Collaboration / Activity:

ALPS colaboration

T10: Searches for New Physics / 714

New constraints on supersymmetry using neutrino telescopes

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We introduce a new approach to set limits on long-lived charged particles using neutrino telescopes and apply it to data. Towards the horizon, we expect a suppression of low-energy muons and electrons, due to the amount of material they must traverse, to reach the detector. Should the new long-lived charged particle possess a larger mass than the muon, then its energy loss will be suppressed compared to the latter. This results in them being able to reach underground neutrino detectors from the horizon, while appearing as minimally ionizing tracks. The only expected background are low-energy muons produced by neutrinos near the detector.
Using one year of public IceCube data this approach can set a lower mass bound of 320 GeV on the stau, which is predicted in some supersymmetric scenarios. Extending this methodology to ten years of data, we predict that IceCube can set a lower mass bound of 450 GeV, similar to current limits set by collider-based experiments. This opens the possibility of complimentary and competitive studies on new long-lived, charged particles using already existing and upcoming neutrino telescopes.

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Collaboration / Activity:

Technical University Munich

T10: Searches for New Physics / 715

A 96 GeV Higgs Boson in the 2HDMS

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We discuss a ~ 3 σ signal (local) in the light Higgs-boson search in the diphoton decay mode at ~ 96 GeV as reported by CMS, together with a ~ 2 σ excess (local) in the $b\bar{b}$ final state at LEP in the same mass range. We interpret this possible signal as a Higgs boson in the 2 Higgs Doublet Model with an additional complex Higgs singlet (2HDMS). We find that the lightest CP-even Higgs boson of the 2HDMS type II can perfectly fit both excesses simultaneously, while the second lightest state is in full agreement with the Higgs-boson measurements at 125 GeV, and the full Higgs-boson sector is in agreement with all Higgs exclusion bounds from LEP, the Tevatron and the LHC as well as other theoretical and experimental constraints. We derive bounds on the 2HDMS Higgs sector from a fit to both excesses and describe how this signal can be further analyzed at the LHC and at future e^+e^- colliders, such as the ILC. We analyze in detail the anticipated precision of the coupling measurements of the 96 GeV Higgs boson at the ILC.

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Collaboration / Activity:

DESY

T06: QCD and Hadronic Physics / 716

Particle production at midrapidity in correlation with the very forward energy in pp and p-Pb collisions with ALICE ZDC

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The very forward energy detected by the ALICE Zero Degree Calorimeters (ZDC) measures the beam remnants, whose energy decreases as the activity at midrapidity increases. A pseudorapidity gap of nearly 9 units between the ZDC ensures that any correlation between the very forward energy and the midrapidity production originates in the initial scatterings. The measurement of these correlations, done for the first time at LHC energies, provides direct insights into particle production and the initial stages of the collisions. The energy detected in the zero-degree hadronic calorimeters in pp collisions at $\sqrt{s}$ = 13 TeV and in p-Pb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV will be presented and compared with the expectations of several hadronic interaction models. Underlying event (UE) measurements give insight into models implementing impact-parameter dependent multiparton interaction (MPI) production. The novel measurement of the relation between very forward energy and production of large transverse momentum particles at midrapidity provides complementary information to UE analysis.

Collaboration / Activity:

ALICE

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Email:

T10: Searches for New Physics / 717

An unambiguous test of positivity at lepton colliders

Author: Jiayin Gu[None]

The diphoton channel at lepton colliders, $e^+e^-(\mu^+\mu^-) \to \gamma\gamma$, has a remarkable feature that the leading new physics contribution comes only from dimension-eight operators. This contribution is subject to a set of positivity bounds, derived from fundamental principles of Quantum Field Theory, such as unitarity, locality and analyticity. These positivity bounds are thus applicable to the most direct observable – the diphoton cross sections. This unique feature provides a clear, robust, and unambiguous test of these principles. We estimate the capability of various future lepton colliders in probing the dimension-eight operators and testing the positivity bounds in this channel. We show that positivity bounds can lift certain degeneracies among the effective operators and significantly change the perspectives of a global analysis. We also perform a combined analysis of the $\gamma\gamma/Z\gamma/ZZ$ processes in the high energy limit and point out the important interplay among them.

based on 2011.03055

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Collaboration / Activity:

JGU Mainz

T11: Quantum Field and String Theory / 719

Quantum breaking and scrambling: what 2 PI effective action can teach us

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In this talk, after reviewing the concept of quantum breaking, and its relation to scrambling, concepts which proved fundamental for our understanding of composite systems such as condensates, black holes and De Sitter, I will show how to study them within the context of 2PI effective action. To do so I will focus on a simple model of a one dimensional condensate in which a logarithmic timescale emerges.

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Collaboration / Activity:

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T08: Flavour Physics and CP Violation / 720

Tests of CPT symmetry and quantum coherence with entangled neutral kaons at KLOE-2

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In March 2018 the KLOE-2 experiment finished data taking at the upgraded e+e- DAΦNE collider of the INFN Laboratori Nazionali di Frascati. The combined data sample collected by KLOE and KLOE-2 amounts to almost 8 fb^{-1} integrated luminosity and it is the largest existing data sample in the world collected at an e+e- collider at the ϕ meson peak, corresponding to ~2.4×10^{10} ϕ mesons produced.

The entanglement in the neutral kaon pairs produced at the DAΦNE ϕ-factory is a unique tool to test discrete symmetries and quantum coherence at the utmost sensitivity, in particular strongly

motivating the experimental searches of possible CPT violating effects, which would unambiguously signal New Physics.

We will present the final result of measurement of the decoherence and CPT violation parameters in $K_S K_L \to \pi^+\pi^-\pi^+\pi^-$ with an improved accuracy with an improved statistical accuracy of a factor ~2 with respect to literature. Additionally updates on the first direct test of CPT and T symmetries in neutral kaon transitions will be presented.

Collaboration / Activity:

KLOE-2

First author:

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T03: Dark Matter / 721

Dark Matter bound states inside the early Universe plasma

Author: Tobias Binder[1]

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WIMPs at the TeV mass region or above experience long-range force effects, such as the existence of meta-stable bound state pairs (WIMPonium). These bound states contribute to the depletion of the relic abundance and therefore allow for even larger WIMP masses to compensate for the effect. In this talk, I present new next-to-leading order (NLO) zero and finite temperature corrections for unbroken non-Abelian electric dipole transitions between any singlet and adjoint two-particle states. After having proven the gauge invariance, infrared and collinear safety of the derived cross sections from thermal field theory, it is demonstrated that the early Universe plasma environment, which enters at NLO, leads to an enhancement of all rates in the full chemical network of existing bound states. Surprisingly, inside the plasma the hierarchy of rates is generically inverted. I.e. capture into the ground state for example can be the slowest process at relevant times, which is in clear contrast to expectations from the mostly considered LO computation. This gives us a novel understanding of the description of such systems. I also present some implications on the relic abundance.

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Collaboration / Activity:

Project Researcher

T08: Flavour Physics and CP Violation / 722

Flavour Physics and CP Violation at KLOE-2

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KLOE-2 experiment at the upgraded e+e- DAΦNE collider of the INFN Laboratori Nazionali di Frascati collected about 5 fb^{-1} at the center of mass energy of the ϕ-meson. Together with the data set of its predecessor (KLOE) the total acquired data sample of 8 fb^{-1} corresponds to 2.4×10^{10} ϕ-meson produced, which is the largest sample ever collected at the ϕ(1020) at e^+e^- colliders.

The KLOE-2 Collaboration continues the KLOE long-standing tradition of flavour physics precision measurements in the kaon sector and search for Physics Beyond the Standard Model.

In this talk the latest results on K_S rare decays are presented and discussed in the framework of Flavour Physics and CP Violation tests, among these the measurement of K_S semileptonic branching ratios, using 1.7 fb^{-1} KLOE data, and the search for the pure CP-violating $K_S \to 3\pi^0$ decay with the KLOE-2 data set.

Collaboration / Activity:

KLOE-2

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T08: Flavour Physics and CP Violation / **723**

Recent CMS results on B hadron decays with charmonium

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New CMS results on B hadron decays involving a charmonium resonance are presented

Collaboration / Activity:

CMS

First author:

Email:

T01: Astroparticle and Gravitational Waves / **724**

Probing light dark matter particles with astrphysical experiments

Author: Tanmay Kumar Poddar[1]

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Strong bounds from direct detection experiment put stringent limit on the dark matter mass which forces us to go beyond WIMP model of dark matter. In recent years the light mass dark matter

particles gain lots of attention among the particle physicists. In this talk I will discuss about light gauge bosons motivated from U(1) extension of standard model and axions which can be a possible dark matter candidates and its detection in several astrophysical experiments.

First author:

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Collaboration / Activity:

T05: Heavy Ion Physics / **726**

Spectator induced electromagnetic effects on charged meson production in nucleus-nucleus collisions from NA61/SHINE at CERN SPS

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Co-author: Andrzej Rybicki [2]

[1] *IFJ PAN*

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The SPS Heavy Ion and Neutrino Experiment (NA61/SHINE) studies the properties of hadron production in collisions of beam hadrons and nuclei with fixed hadronic and nuclear targets.
In this talk, I will discuss the space-time evolution of the system of strongly interacting matter created in the collision, studied from the modification of charged pion spectra and π^+/π^- ratios by the electromagnetic (EM) field induced by the spectator system as a function of collision centrality. First results on Ar+Sc collisions at 40 A GeV/c ($\sqrt{s_{NN}}$ = 8.76 GeV) will be shown, including the first-ever measurement of spectator induced EM effects in a small peripheral nucleus-nucleus system in the SPS energy range.
These will be compared to Ar+Sc intermediate collisions at 150 A GeV/c($\sqrt{s_{NN}}$ = 16.8 GeV) from NA61/SHINEs and Pb+Pb peripheral collision data at 158 A GeV/c ($\sqrt{s_{NN}}$ = 17.3 GeV) obtained by the NA49 experiment at the CERN SPS. The present implications of the new data from NA61/SHINE for the space-time evolution of the system will be discussed.

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Collaboration / Activity:

NA61/SHINE

T06-T07: Combined: Top, Electroweak, QCD and Hadronic Physics / **727**

Impact of correlations on the PDF uncertainty in the W mass measurement

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We present the results of the recent study published in Phys.Rev.Lett. 126 (2021) 4, 041801, where the PDF uncertainty affecting the MW determination at the LHC is estimated keeping into account the full correlations information from the PDF at the level of the differential distribution used to extract M_W, namely p_T^l.

We find that keeping these correlations into account can reduce significantly the PDF uncertainty (once other sources of uncertainties are under control) so that it should not represent a bottleneck in reaching the ultimate precision in the MW determination at hadron colliders.

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Collaboration / Activity:

theory

T09: Higgs Physics / 728

Parton-Shower Effects in Higgs Production via Vector-Boson Fusion

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We present a systematic investigation of parton-shower and matching uncertainties of perturbative origin for Higgs-boson production via vector-boson fusion. To this end we employ different generators at next-to-leading order QCD accuracy matched with shower Monte Carlo programs, `PYTHIA8`, and `HERWIG7`, and a next-to-next-to-leading order QCD calculation.
We thoroughly analyse the intrinsic sources of uncertainty within each generator, and then compare predictions among the different tools using the respective recommended setups. Within typical vector-boson fusion cuts, the resulting uncertainties on observables that are accurate to next-to-leading order are at the 10% level for rates and even smaller for shapes. For observables sensitive to extra radiation effects, uncertainties of about 20% are found.
We furthermore show how a specific recoil scheme is needed when `PYTHIA8` is employed, in order not to encounter unphysical enhancements for these observables.
We conclude that for vector-boson fusion processes an assessment of the uncertainties associated with an NLO+PS simulation at next-to-leading order matched to parton showers based only on the variation of renormalisation, factorisation and shower scales systematically underestimates their true size.

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Collaboration / Activity:

T12: Detector R&D and Data Handling / 729

The Particle Flow Algorithm in the Phase II Upgrade of the CMS Level-1 Trigger

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The CMS experiment has greatly benefited from the utilization of the particle-flow (PF) algorithm for the offline reconstruction of the data. The Phase II upgrade of the CMS detector for the High Luminosity upgrade of the LHC (HL-LHC) includes the introduction of tracking in the Level-1 trigger, thus offering the possibility of developing a simplified PF algorithm in the Level-1 trigger. We present the logic of the algorithm, along with its inputs and its firmware implementation. We show that this implementation is capable of operating under the limited timing and processing resources available in the Level-1 trigger environment. The expected performance and physics implications of such an algorithm are shown using Monte Carlo samples with hıgh pile-up, simulating the harsh conditions of the HL-LHC. New calorimeter features allow for better performance under high pileup (PU) to be achieved, provided that careful tuning and selection of the prompt clusters has been made. Additionally, advanced pile-up techniques are needed to preserve the physics performance in the high-intensity environment. We present a method that combines all information yielding PF candidates and performs Pile-Up Per Particle Identification (PUPPI) capable of running in the low latency level-1 trigger environment. Demonstration of the algorithm on dedicated hardware relying on ATCA platform is presented.

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 730

Triggering on electrons, photons, tau leptons, Jets and energy sums at HL-LHC with the upgraded CMS Level-1 Trigger

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The High-Luminosity LHC will open an unprecedented window on the weak-scale nature of the universe, providing high-precision measurements of the Standard Model as well as searches for new physics beyond the standard model. The Compact Muon Solenoid (CMS) experiment is planning to

replace entirely its trigger and data acquisition system to achieve this ambitious physics program. Efficiently collecting those datasets will be a challenging task, given the harsh environment of 200 proton-proton interactions per LHC bunch crossing. The new Level-1 trigger architecture for HL-LHC will improve performance with respect to Phase I through the addition of tracking information and subdetector upgrades leading to higher granularity and precision timing information. In this poster, we present a large panel of trigger algorithms for the upgraded Phase II trigger system, which benefit from the finer information to reconstruct optimally the physics objects. Dedicated pile-up mitigation techniques are implemented for lepton isolation, particle jets and missing transverse energy to keep the rate under control. The expected performance of the new trigger algorithms will be presented, based on simulated collision data of the HL-LHC. The selection techniques used to trigger efficiently on benchmark analyses will be presented, along with the strategies employed to guarantee efficient triggering for new resonances and other new physics signals.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 731

The new "MUON G-2" Result and Supersymmetry

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We confront the Minimal Supersymmetric Standard Model (MSSM) with the recent measurement of (g-2)_mu, the Dark Matter (DM) relic density, DM direct detection limits and electroweak SUSY searches at the LHC. We demonstrate that various distinct regions of the parameter space can fulfill all experimental constraints. We present predictions for future pp and e+e- colliders to explore these regions.

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Collaboration / Activity:

theory

T10: Searches for New Physics / 732

The CLIC potential for new physics

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The Compact Linear Collider (CLIC) is a mature option for a future electron-positron collider operating at centre-of-mass energies of up to 3 TeV. CLIC would be built and operated in a staged approach with three centre-of-mass energy stages currently assumed to be 380 GeV, 1.5 TeV, and 3 TeV. A selection of results from recent studies will be presented showing that CLIC has excellent sensitivity to many BSM physics scenarios. New particles can be discovered in a model-independent way almost up to the kinematic limit. Compared with hadron colliders, the low background conditions at CLIC provide extended discovery potential, in particular for the production through electroweak and/or Higgs boson interactions. This includes scenarios with extended scalar sectors, also motivated by dark matter, which can be searched for using associated production processes or cascade decays involving electroweak gauge bosons.

Collaboration / Activity:

CLICdp collaboration

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Email:

T10: Searches for New Physics / 733

Possible indications for new Higgs bosons in the reach of the LHC: N2HDM and NMSSM interpretations

Authors: Sven Heinemeyer[1]; Georg Weiglein[2]; Thomas Biekoetter[2]; Christian Schwanenberger[3]; Alexander Grohsjean[3]

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[2] *T (Phenomenology)*

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In several searches for additional Higgs bosons at the LHC, in particular the CMS search in the $pp \to \phi \to t\bar{t}$ channel and the ATLAS search in the $pp \to \phi \to \tau^+\tau^-$ channel, a local excess at the level of $3\,\sigma$ or above has been observed at a mass scale of $m_\phi \approx$ 400~GeV. We investigate to what extent a possible signal in those channels could be accommodated in the Next-to-Two-Higgs-Doublet Model (N2HDM) or the Next-to Minimal Supersymmetric Standard Model (NMSSM). In a second step we furthermore analyse whether such a model could be compatible with both a signal at $\approx$ 400~GeV and at $\approx$ 96~GeV, where the latter possibility is motivated by observed excesses in searches for the $b\bar{b}$ final state at LEP and the di-photon final state at CMS. The analysis for the N2HDM reveals that the observed excesses at ≈ 400~GeV in the observed excesses at ≈ 400~GeV in the $pp \to \phi \to t\bar{t}$ and $pp \to \phi \to \tau^+\tau^-$ channels point towards different regions of the parameter space, while one such excess and an additional Higgs boson at $\approx$ 96~GeV could simultaneously be accommodated. In the context of the NMSSM an experimental confirmation of a signal in the $t\bar{t}$ final state would favor the alignment-without-decoupling limit of the model, where the Higgs boson at $\approx$ 125~GeV could be essentially indistinguishable from the Higgs boson of the SM. In contrast, a signal in the $\tau^+\tau^-$ channel would be correlated with significant deviations of the properties of

the Higgs boson at $\approx$ 125~GeV from the ones of a SM Higgs boson that could be detected with high-precision coupling measurements.

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Collaboration / Activity:

theory

T06: QCD and Hadronic Physics / 734

A pitfall in applying a non-anticommuting gamma5 in qqbar to > Z+Higgs amplitudes

Authors: Taushif Ahmed[1]; Long Chen[None]; Michal Czakon[None]

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We show how the polarized amplitudes of $b\bar{b} \to Zh$ associated with a non-vanishing b-quark Yukawa coupling and a scalar or pseudoscalar Higgs boson h can be built up solely from vector form factors (FF) of properly grouped classes of diagrams, bypassing completely the need of explicitly manipulating γ_5 in dimensional regularization.

In addition, the FFs of a class of corrections to $q\bar{q} \to ZH$ proportional to the top-Yukawa coupling are obtained analytically to two-loop order in QCD in the heavy-top limit. We address a pitfall that occurs when applying the non-anticommutating γ_5 prescription to this class of contributions that has been overlooked so far in the literature.

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Collaboration / Activity:

Sorry,I do not understand this

T14: Outreach, Education and Diversity / 735

Physics Live on Social Media: Good Practices to Engage New Audiences and Support Education

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Early in 2020, as the Covid-19 pandemic started to hit Europe, scientific outreach and education had to face a new challenge: finding rapidly new ways to engage general public and students. Social media were found to be a useful tool to achieve this goal: thousands of people could be reached directly at home with a few clicks by using a laptop or a mobile phone.
In this talk, it will be discussed how to efficiently organize a series of live events dedicated to schools to be run on Facebook and YouTube and how to, complementary, organize informal lives for Instagram on cutting-edge physics topics to engage a broader and more general audience.
To do so, some useful tools to set up live events will be presented and some guidelines on how to outline them will be summarized. Most of all, it will be discussed how to stimulate and deal with interaction of the audience, a fundamental feature of communication on social media. Finally, some good communication practices to invite people to join the lives will be shown.
The talk will be enriched by practical examples: it will be described how INFN, the Italian National Institute for Nuclear Physics, stood up to this new challenge, by strengthening its communication on Instagram to engage new audiences and by promptly organizing a series of live events on social media for high school students to support the school program and to offer insights on modern physics, from particle and astroparticle physics to cosmology.

Collaboration / Activity:

INFN Communications office

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T13 - Accelerator for HEP / 737

Plasma-Based and Laser Accelerators for High-Energy Physics

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Experiments demonstrated that plasma-based accelerators can produce high energy electrons (e.g., 8 and 42GeV) in short distances (20 and 85cm, respectively). They are very high gradient accelerators (i.e., 50GeV/m) and therefore hold the promise to be more compact and affordable than RF-based linear accelerators. An alternative path investigates the use of dielectric accelerators with high accelerating fields. The challenge for these new accelerators driven by a laser pulse or a relativistic particle bunch is to produce beams with parameters that would make them competitive in terms of luminosity and efficiency. In follow-up to the European strategy of particle physics, an Expert Panel for High Gradient Plasma and Laser accelerators has recently been set up. We present specificities of these accelerators, and discuss various inputs received on how to meet the challenges posed by various HEP applications.

First author:

Email:

Collaboration / Activity:

T04: Neutrino Physics / 738

Joint Determination of Reactor Antineutrino Spectra from 235U and 239Pu Fission using the Daya Bay and PROSPECT Experiments

Author: Jianrun Hu[1]

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The poster presents a joint determination of the reactor antineutrino spectra resulting from the fission of ^{235}U and ^{239}Pu by combining the Daya Bay and PROSPECT experiments. In the Daya Bay experiment, the antineutrinos were generated by six low enriched uranium (LEU) nuclear commercial reactors with 2.9 GW thermal power each and detected by eight antineutrino detectors deployed in two near and one far underground experimental halls. In the PROSPECT experiment, the antineutrinos were generated by an 85 MW thermal power high enriched uranium (HEU) research reactor and detected by a 4-ton ^{6}Li-loaded liquid scintillator (LiLS) detector. The compatibility of the measured prompt energy spectra from both experiments are first evaluated with a dedicated method. With a joint analysis of both experiments' data, the precision of the derived ^{235}U spectrum is improved beyond that individually observed by either experiment, and the degeneracy between derived ^{235}U and ^{239}Pu spectra is reduced below that from Daya Bay alone. Finally, the antineutrino energy spectrum of ^{235}U is unfolded with the Wiener-SVD method, providing a more precise data-based prediction for other reactor antineutrino experiments. This is the first combined measurement from experiments based on LEU and HEU reactors.

Collaboration / Activity:

Daya Bay&PROSPECT Collaboratio

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T04: Neutrino Physics / 739

Joint measurement of the pure-U235 reactor antineutrino spectrum by STEREO and PROSPECT experiments

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STEREO and PROSPECT are very short baseline experiments studying antineutrinos produced by highly-enriched nuclear fuel at the research facilities of Institut Laue-Langevin (Grenoble, France) and Oak Ridge National Laboratory (U.S.A.), respectively. Located at about 10 meters from the reactor cores, they investigate the data-to-prediction deficit called the « Reactor Antineutrino Anomaly » by looking for sterile neutrino oscillations and providing accurate measurements of the U235 antineutrino spectrum.

In this talk I will present a joint analysis performed by the STEREO and PROSPECT collaborations. The two experimental energy spectra have been simultaneously unfolded to provide a reference spectrum in true antineutrino energy for the U235 isotope, achieving the highest precision for pure-U235 experiments. This new experimental reference will be compared to theoretical predictions in order to quantify the observed excess of events around 5 MeV. This measurement proves also to be complementary to the results from experiments using low-enriched nuclear fuel, such as Daya Bay,

where several isotopes contribute to the antineutrino spectrum. In addition, I will present the status of the search for sterile neutrinos with the STEREO detector, including preliminary results with the full collected data set.

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Collaboration / Activity:

STEREO

T03: Dark Matter / 740

Supernova signals of light dark matter

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By virtue of their high temperatures, supernovae can produce large fluxes of MeV-scale dark matter even at couplings stronger than those constrained by cooling. In this region of parameter space, the dark matter can become diffusively trapped by scatterings within the protoneutron star, ultimately escaping with semirelativistic velocity. I will show that this can lead to the formation of a diffuse Galactic flux of supernova-produced dark matter. Furthermore, I will show that this population's high velocity compensates for its low mass and allows it to be detected in direct detection experiments designed for GeV-scale WIMPs. I will conclude with a discussion of the potential to discriminate this dark matter from a cosmological abundance of WIMPs using directionality.

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Collaboration / Activity:

SITP

T08: Flavour Physics and CP Violation / 741

Probing squared four-fermion operators of SMEFT with meson-mixing

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The Standard Model Effective Field Theory (SMEFT) is a universal way of probing New Physics (NP) manifesting as new, heavy particle interactions with the Standard Model degrees of freedom,

that respect the SM gauged symmetries. Higher order terms in the NP interactions possibly lead to large effects, mandatory for meaningful phenomenological studies, such as contributions to neutral meson-mixing, which typically pushes the scale of NP to energy scales much beyond the reach of direct searches in colliders. I discuss for the first time the leading-order renormalization of double-insertions of dimension-6 four-fermion operators that change quark flavor by one unit (i.e., $|\Delta F| = 1$, $F =$ strange-, charm-, or bottom-flavor) by dimension-8 operators relevant for meson-mixing (i.e., $|\Delta F| = 2$) in SMEFT, and consider the phenomenological implications of contributions proportional to relatively large Yukawas. Given the underlying interest of SMEFT to encode full-fledged models at low-energies, this work stresses the need of considering dimension-8 operators in phenomenological applications of dimension-6 operators of SMEFT.

Collaboration / Activity:

not from a large collaboration

First author:

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T10: Searches for New Physics / 742

Analysis of vacuum stability in the $\mu\nu$SSM

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We perform an analysis of the vacuum stability of the neutral scalar potential of the μ-from-ν Supersymmetric Standard Model ($\mu\nu$SSM). As an example scenario, we discuss the alignment without decoupling limit of the $\mu\nu$SSM, for which we demonstrate that large parts of the parameter space are plagued by unphysical minima deeper than the electroweak minimum. In order to estimate the lifetime of the electroweak minimum, we calculate the transition probabilities for the tunneling process into each unphysical minimum. We find that even though the parameter points are metastable, in many cases the lifetime is longer than the age of the universe. In this case a parameter point can still be regarded as valid, emphasizing the importance of accurately taking into account a calculation of the lifetime of metastable configurations. We also find metastable points that are not sufficiently long lived. Thus, the analyse of the vacuum stability of the $\mu\nu$SSM has an important impact on the parameter space of the model.

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Collaboration / Activity:

DESY

T02: Cosmology / 743

Cosmological implications of EW vacuum instability: constraints on the Higgs-curvature coupling from inflation

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The current experimentally measured parameters of the Standard Model (SM) suggest that our Universe lies in a metastable electroweak vacuum, where the Higgs field is prone to vacuum decay to a lower state with catastrophic consequences. Our measurements dictate that such an event has not taken place yet, despite the many different mechanisms that could have triggered it in our past light-cone. The focus of our work has been to calculate the probability of the false vacuum to decay during the period of inflation and use it to constrain the last unknown renormalisable SM parameter ξ, which couples the Higgs field with space-time curvature. More specifically, we derived lower ξ-bounds from vacuum stability in three inflationary models: quadratic and quartic chaotic inflation, and Starobinsky-like power-law inflation. We also took the time-dependence of the Hubble rate into account both in the geometry of our past light-cone and in the Higgs effective potential, which is approximated with three-loop renormalisation group improvement supplemented with one-loop curvature corrections.

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Collaboration / Activity:

PhD student (Theory Group)

T11: Quantum Field and String Theory / 744

Exploring straight infinite Wilson lines in the Self Dual and the MHV Lagrangians

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We investigated the appearance of straight infinite Wilson lines lying on the self-dual plane in the context of the Self Dual sector of the Yang Mills theory and in connection to the Lagrangian implementing the MHV vertices (MHV Lagrangian) according to the Cachazo-SvrcekWitten (CSW) method. The plus helicity field in the MHV Lagrangian was already known to be a straight infinite Wilson line along the complex direction determined by the plus helicity polarization vector (i.e. it lies on the self-dual plane). We showed that this Wilson line expression satisfies the self-dual EOM, when the currents are restricted to the support on the light-cone. Additionally, we show that the minus helicity field is on the other hand given by a similar Wilson line, but with an insertion of the minus helicty gluon field somewhere on the line. Moreover, we discuss that the latter should be a part of a bigger structure, extending beyond the self-dual plane.

Collaboration / Activity:

none

First author:

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T01: Astroparticle and Gravitational Waves / 745

Implications of turbulence dependent diffusion on cosmic ray spectra

Author: Julien Dörner[1]

Co-authors: Patrick Reichherzer [1]; Lukas Merten [2]; Julia Tjus [3]; Horst Fichtner [4]; M.J. Pueschel [5]; Ellen Zweibel [6]

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The propagtion of cosmic rays can be described by diffusive motion in most galactic enviroments. Therfore, a detailed knowlege of the diffusion tensor is necessary. Recent analyses of the energy dependence of the diffusion tensor show a function of the turbulence level b/B, i.e. $\kappa_i \propto E^{\gamma_i}$ with $\gamma_i = \gamma_i(b/B)$, where $i \in \{\|, \perp\}$. (Reichherzer et al, MNRAS 498:5051–5064 (2020))

In this talk we show the implication of this turbulence-dependent diffusion on the radial dependence of the cosmic-ray spectral index and the transition between parallel and perpendicular component. Finally, we interpret the cosmic-ray gradient detected by Fermi in the light of these findings.

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Collaboration / Activity:

n/a

T07: Top and Electroweak Physics / 746

The Bloch Nordsieck (BN) restoration for $l\bar{l} \rightarrow t\bar{t}$

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In nowadays theoretical approach to describe the physics behind scattering experiment we use elementary particles as degrees of freedom. These stand in remarkably agreement with experimental data but encounter an existential dilemma from the quantum field theoretical point of view, since these states are gauge dependent. The solution to this problem for a non-perturbative theory is provided by the Fröhlich-Morchio-Strocchi (FMS) mechanism, where physical states in the electroweak case are composite objects, which reduce to the elementary particles in the limes of low energies. Including this overlooked side of the electroweak sector of the Standard model, we want to show the non-violation of the Bloch-Nordsieck (BN) theorem for the s-channel annihilation l \bar{l} ⟶ t \bar{t}. This process is of particular interest for future NLC experiments, where the electroweak corrections at high energies would be significant according to standard perturbative calculations.

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Collaboration / Activity:

Theory

T12: Detector R&D and Data Handling / 747

Design and commissioning of the FASER trigger and data acquisition system

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The FASER experiment is a new small and inexpensive experiment that is located 480 meters downstream of the ATLAS experiment at the CERN LHC. The experiment will shed light on currently unexplored phenomena, having the potential to make a revolutionary discovery. FASER is designed to capture decays of exotic particles, produced in the very forward region, beyond the ATLAS detector acceptance. The experiment installation was completed at the end of March and the experiment is now getting ready for the LHC Run 3 data-taking. This presentation will focus mostly on the trigger and data acquisition (TDAQ) system of the experiment. TDAQ system is going to combine information from the tracker, scintillators, and calorimeter and will send them to the PC that is going to be located on the ground at the expected physics trigger rate of 650 Hz. The presentation will include information about commissioning of the system on the ground and in the LHC tunnel as well as it will be presenting various tests performed during the commissioning phase including first test runs using cosmic particles.

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Collaboration / Activity:

FASER

T05: Heavy Ion Physics / 748

Pionic depth of the hadron gas after a heavy ion collision

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The final stage of a relativistic heavy-ion collision is a hadron gas. Final-state interactions therein distort the p_t spectrum of particles coming from the phase transition upon cooling the quark-gluon plasma.
Using recent state of the art parametrizations of pion interactions by Ruiz de Elvira and Peláez we provide theoretical computations of the pionic depth of the gas: how likely is it that a given pion rescatters on its way out (we find a high probability around p_t=0.5 GeV, corresponding to the formation of the rho resonance), how many pions make it through as a function of p_t, and what is the thickness of the freeze-out last scattering surface.

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Collaboration / Activity:

Theory

T05: Heavy Ion Physics / 749

Nuclear coalescence and collective behaviour in small interacting systems

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The production of light nuclei in particle collisions can be described as the coalescence of nucleons into nuclei. In most coalescence models used in heavy ion collisions, the probability for coalescence is controlled predominantly by the size of the interaction region, while nucleon momentum correlations may be treated as collective flow or even neglected. Interestingly, recent experimental data on pp collisions at LHC have been interpreted as evidence for such collective behaviour even in small interacting systems. This is contradiction to the standard approach of imposing the coalescence condition only in momentum space for small interacting systems, such as e+e- and dark matter annihilations or pp collisions. We argue however that these data are naturally explained using QCD inspired event generators when taking into account both nucleon momentum correlations and the size of the hadronic emission volume. To consider both effects, we use a per-event coalescence model based on the Wigner function representation of the produced nuclei states. This model reproduces well the size of baryon-emitting source as well as the coalescence factor B2 recently measured in pp collisions by the ALICE collaboration. Finally, we comment on the generalisation to larger interacting systems.

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Collaboration / Activity:

Astroparticle Physics

T01: Astroparticle and Gravitational Waves / 752

Modeling black hole binaries in scalar-tensor theories of gravity

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I will discuss a new formulation of the Einstein equations and scalar tensor theories of gravity–the modified generalized harmonic (MGH) formulation–that allows for the stable, well-posed evolution of black holes in a wide variety of scalar-tensor theories. I will discuss recent progress in numerically modeling binary black hole evolution, and scalar+gravitational wave emission, in the scalar-tensor theory Einstein scalar Gauss-Bonnet gravity.

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Collaboration / Activity:

N/A

T08: Flavour Physics and CP Violation / 753

Form factors for semileptonic B(s) decays

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Determinations of the CKM matrix elements $|V_{ub}|$ and $|V_{cb}|$ or predictions for R-ratios testing lepton flavor universality can be obtained from form factors describing exclusive semileptonic $B_{(s)}$ decays. Using the framework of lattice quantum chromodynamics, we report on our form factor calculations for $B_s \to D_s \ell\nu$, $B_s \to K\ell\nu$, and $B \to \pi\ell\nu$ decays. First scalar and vector form factors with full error budget are presented for the range of momentum transfer directly accessible in our simulations.

Next we show z-parameterization fits to extend q^2 over the kinematically allowed range and use the results to extract CKM matrix elements or predict R-ratios.

Our calculations are based on RBC-UKQCD's set of 2+1 flavor domain wall Iwasaki gauge field configurations featuring three lattice spacings of a^{-1} = 1.78, 2.38, and 2.78 GeV. We simulate up/down, strange, and charm quarks using domain-wall fermions and use the relativistic heavy quark action for the bottom quarks.

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Collaboration / Activity:

RBC-UKQCD

T08: Flavour Physics and CP Violation / 754

BSM $B - \bar{B}$ mixing

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We are presenting our ongoing Lattice QCD study on $B - \bar{B}$ mixing on several RBC/UKQCD and JLQCD ensembles with 2+1 dynamical-flavour domain wall fermions, with a range of inverse lattice spacings from 1.7 to 4.5 GeV and including physical-pion-mass ensembles. We compare various different fitting strategies to extract bag parameters B_{B_d} and B_{B_s} both for the standard-model operator as well as the four BSM operators. On each ensemble, we are simulating a range of heavy-quark masses from below the charm-quark mass towards the bottom-quark mass, with one data point reaching about 75% of m_{η_b}.

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Collaboration / Activity:

RBC/UKQCD & JLQCD

T12: Detector R&D and Data Handling / 756

Enhanced electromagnetic processes in oriented crystals for applications in high-performance calorimetry

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Nowadays, it is well known that the electromagnetic interaction between high-energy particles and matter experiences substantial modifications when the latter consists of a crystalline medium and its lattice axes are almost parallel to the input beam direction. In particular, strong boosts to both the Bremsstrahlung (by electrons and positrons) and the pair production (by photons) cross sections in high-density oriented crystals have been observed in the 10-to-100 GeV regime. This effect proves particularly appealing when it comes to inorganic scintillators, given the possibility to exploit it for the development of high-performance, ultra-compact electromagnetic calorimeters mdash; some applications to future high-energy physics experiments already being under study, e.g. the KLEVER Small Angle Calorimeter. This work provides a detailed discussion of the results obtained by probing a PWO (lead tungstate) oriented sample with 120 GeV/c electrons and positrons at the CERN North Area: in particular, direct measurements of the enhancement in the scintillation light production with respect to the random lattice orientation are presented, and a comparison between the outcomes obtained with electrons and positrons is made. Moreover, output radiation measurements on oriented samples of other commonly used inorganic scintillator such as BGO and YAG have been recently performed in the sub-GeV regime at the MAMI-B facility: an overview on the resulting characterisation is given.

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Collaboration / Activity:

STORM collaboration

T11: Quantum Field and String Theory / 757

Vacuum replicas in field-theory models of Coulomb-gauge QCD

Authors: Pedro Bicudo[1]; Eduardo Garnacho Velasco[2]; Felipe J. Llanes-Estrada[3]; Ribeiro Jose E.[1]; Victor Serrano Herreros[2]; Jorge Vallejo Fernández[2]

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Dynamical symmetry breaking can happen through a Higgs mechanism but also spontaneously within a strongly-enough coupled theory.
We treat a field-theoretical quark model of QCD based on a linear+Coulomb Cornell potential (to account for the longitudinal interaction), together with a transverse interaction (to account for Coulomb gauge gluons) in BCS approximation.
After extracting the well-known BCS ground state on which abundant hadron phenomenology implementing dynamical chiral symmetry breaking has been built, we find two excited replicae of that vacuum, whose nature we study.

Collaboration / Activity:

Theory

First author:

Email:

T07: Top and Electroweak Physics / 758

Soft Gluon Resummation for the Associated Single Top and Higgs Production at the LHC

Authors: Laura Moreno Valero[1]; Anna Kulesza[1]; Vincent Theeuwes[2]

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Processes involving the Higgs boson and the top quark are of high interest in searches for BSM physics because they allow to directly measure the top Yukawa coupling. Although it has a relatively small cross section, the single top and Higgs production process pp → Htj is particularly sensitive to new physics, calling for precise theoretical predictions. For many processes at the LHC, a reduction of theoretical uncertainties can be achieved by means of resummation techniques, accounting for large logarithmic corrections, which originate from soft gluon emissions. In this talk, we discuss extending the precision with which theoretical predictions for the s-channel tHj production are known from NLO (next-to-leading order) to NLO+NLL (next-to-leading logarithmic matched to NLO) accuracy.

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Collaboration / Activity:

Theory (Phenomenology)

T01: Astroparticle and Gravitational Waves / 759

Measurement of the all-electron spectrum through 1 TeV region with the CALET experiment.

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Co-authors: Yosui Akaike [2]; Eugenio Berti [3]; for the CALET collaboration ; Lorenzo Pacini [4]

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The CALorimetric Electron Telescope (CALET) is a space experiment installed aboard the International Space Station (ISS). The instrument has been accumulating data since October 2015, searching for nearby cosmic-ray sources and dark matter signatures with accurate measurements of the cosmic electron+positron spectrum up to the TeV region. The CALET main detector consists of a charge detector, imaging calorimeter and a total absorption calorimeter: the total depth of the instrument for vertical incidence is about 30 radiation lengths. This design offers excellent performances in terms of the reconstruction of: the particle charge up to and above Iron, the primary track with an angular resolution better than 1 degree, the incident energy with a resolution better than 2% for electrons up to 1 TeV and a good proton/electron identification corresponding to a proton rejection factor of about 10^5. In this contribution the analysis steps for the measurement of the electron flux are discussed and, by exploiting the full statistics accumulated by the CALET experiment, the measurement of the electron+positron spectrum is presented.

Collaboration / Activity:

CALET

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T10: Searches for New Physics / 760

Results and future plans of the MoEDAL experiment

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The unprecedented collision energy of the LHC has opened up a new discovery frontier. Unfortunately, signs of new physics have yet to be seen. The LHC's first dedicated search experiment, MoEDAL, started data taking for LHC's Run-2. MoEDAL is designed to search highly ionising particle avatars of new physics using p-p and heavy-ion collisions at the LHC. The planned upgrade for MoEDAL at Run-3 - the MAPP detector (MoEDAL Apparatus for Penetrating Particles) - will extend MoEDAL's physics reach to include feebly interacting and long lived messengers of physics beyond the Standard Model. This will allow us to explore a number of models of new physics, including dark sector models, in a complementary way to that of conventional LHC collider detectors. Further to this, a possible astroparticle extension to MoEDAL, called Cosmic-MoEDAL, will allow the search for magnetic monopoles to be continued from the TeV scale to the GUT scale. The presentation focuses on recent results and plans for the LHC Run 3.

Collaboration / Activity:

MoEDAL

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T03: Dark Matter / 761

eV-threshold Direct Dark Matter Searches

Author: Daniel Baxter[1]

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Over the last decade, significant advancements in semiconductor charge detectors have enabled single-electron resolution and threshold for the first time. These low thresholds significantly enhance detector resolution to well-motivated, but unconstrained, sub-GeV dark matter models. Following an overview of these experimental techniques in silicon and germanium detectors, I will focus on one such detector technology: Skipper CCDs. I will summarize the robust CCD program over the next decade, including recent results from DAMIC at SNOLAB, upcoming experiments including SENSEI and DAMIC-M, and ultimately the 10 kg scale OSCURA detector.

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Collaboration / Activity:

DAMIC

T10: Searches for New Physics / 762

Physics Beyond the Standard Model with the J-PET detector

Author: Elena Perez del Rio[None]

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The Positronium (Ps) system, a bound state of an electron and a positron, is suitable for testing the predictions of quantum electrodynamics (QED), since its properties can be perturbatively calculated to high accuracy and, unlike the hydrogen system, is not affected by finite size or QCD effects at current experimental precision level. This makes the Ps atom a good laboratory to test the Fundamental Symmetries of Physics and also search for new particles not included in the Standard Model (SM) of physics.

On one hand, time reversal (T) and CP symmetry violation have never been observed in pure leptonic systems like the Ps atom, and the current experimental limits for CP and CPT violation in the decays of Ps is currently set at the level of 10^{-3}, while for C violation are at the level of 107. This limits are still six and two orders of magnitude lower than the expected precision of 10^{-9} set by photon-photon interactions. Secondly, experiments searching for invisible decays of the Ps triplet state, the ortho-Positronium (o-Ps), which mainly decays to three photons, are being conducted, since they are sensitive to new physics scenarios, e.g. Mirror Matter (MM), a suitable Dark Matter candidate, proposed to restore parity (P) violation. By performing a high precision measurement of the o-Ps lifetime, the accuracy of the present QED calculations can be tested and a search for the invisible decays of the o-Ps conducted.

These studies are conducted with the novel total-body Positron-Electron Tomograph (PET) scanner at he Jagiellonian University. The J-PET is a large and high precise medical imaging tool, based on the plastic scintillators. The J-PET is a high acceptance multi-purpose detector optimized for the detection of photons from positron-electron annihilation and can be used in a broad scope of interdisciplinary investigation, e.g. medical imaging, life-time measurements, quantum entanglement studies with o-Ps, and tests of discrete symmetries.

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Collaboration / Activity:

J-PET Collaboration

T09: Higgs Physics / 763

NLO production of HH, ZH, and ZZ by gluon fusion, in the high-energy limit

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In this talk I will discuss computations of NLO virtual corrections to four-point gluon-fusion processes; in particular the production of HH, ZH and ZZ. Recently these processes have been computed numerically, but they are not known analytically. I will discuss how one can perform an expansion of these amplitudes in the high-energy limit, and improve the resulting series through the use of Padé approximants.

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Collaboration / Activity:

Theory

T08: Flavour Physics and CP Violation / 764

Probing B-anomalies via dimuon tails at the FCC

Author: Bradley Garland[1]

Co-authors: Sebastian Jaeger [1]; Charanjit Khosa [2]; Sandra Kvedaraitė [3]

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Recent measurements of lepton-universality ratios and $B_s \to \mu^+\mu^-$ decay point to possible new physics contribution to $b \to s\mu^+\mu^-$ transitions. If new physics really is present, then it is possible that it could lie at a scale beyond the kinematical reach of the LHC or even that of a future, more energetic, proton-proton collider. In this instance, the relevant new physics is encapsulated by effective semi-leptonic four-fermion operators and its effects could be indirectly detected in the tails of dilepton invariant mass distributions.

In this talk, I will discuss the sensitivity of a future proton-proton collider to the relevant four-fermion operators when considering an inclusive dimuon final state at a centre of mass energies of 100 TeV. I will present 95% C.L. exclusion bounds on the Wilson coefficients of these operators as well as the values needed for a 5σ rejection of the SM background. Throughout this, I shall also discuss the validity of theses bounds within our EFT approach along with the effect that both NLO QCD and EW corrections to our EFT signal have on the sensitivity.

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Collaboration / Activity:

Theorist

T01: Astroparticle and Gravitational Waves / 765

Study of the cosmic muon rate nearby the Advanced Virgo detector at the end of the O3 run

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Cosmic-ray particles have longly been studied as a potential source of noise for interferometric Gravitational Wave detectors. These particles, mostly muons at sea level, can interact with the detector mirrors releasing charges or inducing thermal effects, which, at the detector output, could be observed as transient excesses of noise, namely glitches. For the Advanced Virgo detector, the rate of these particles is monitored by a muon detector located in the vicinity of the detector central building. We present here the correlation study of the rate of muons with the rate of glitches during a couple of weeks at the end of the third observing run of Advanced Virgo, O3. We also present the correlation of the previous quantities with other environmental effects, showing how the latter dominate the glitch rate and can explain a significant part of its variations.

Collaboration / Activity:

Virgo Collaboration

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T10: Searches for New Physics / 770

Search for heavy neutral lepton production at the NA62 experiment

Author: Christopher John Parkinson[1]

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Searches for heavy neutral lepton production in K+ –> e+N and K+ –> mu+N decays using the data set collected by the NA62 experiment at CERN in 2016-18 are presented. Upper limits on the elements of the extended neutrino mixing matrix $|U_{e4}|^2$ and $|U_{\mu4}|^2$ are established at the levels of 10^{-9} and 10^{-8}, respectively, improving on the earlier searches for heavy neutral lepton production and decays in the kinematically accessible mass range. A search for the K+ –> mu+nuX decays, where X is an new light invisible particle, is also reported.

Collaboration / Activity:

NA62

First author:

Email:

T11: Quantum Field and String Theory / 771

A falling magnetic monopole as a local quench

Author: Nicolò Zenoni[1]

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The AdS/CFT correspondence allows to describe strongly-coupled quantum field theories in terms of weakly-coupled gravitational systems, offering an opportunity to investigate quantum systems at strong coupling far from thermal equilibrium. A simple non-equilibrium process is the quench, representing a system thermalization after the sudden injection of energy. In the case of localized excitation, the quench is holographically realized by the free falling of an object in AdS. This raises the question of how the specifics of the object affect the quench physics.
To gain some insight, I will concentrate on the quenches dual to a falling magnetic monopole and a falling black hole, the latter already studied in the literature. I will show that the holographic energy-momentum tensors have the same functional form, whereas the holographic entanglement entropy is highly sensitive to the bulk details, to the extent that the first law of entanglement entropy is violated in the monopole case.

Collaboration / Activity:

PhD student, UCSC & KU Leuven

First author:

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T08: Flavour Physics and CP Violation / 772

Searches for lepton flavour/number violation in K+ and pi0 decays at the NA62 experiment

Author: Elisa Minucci[1]

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The NA62 experiment at CERN collected a large sample of charged kaon decays into final states with multiple charged particles in 2016-2018. This sample provides sensitivities to rare decays with branching ratios as low as 10^{-11}. Results from searches for lepton flavour/number violating decays of the charged kaon and the neutral pion to final states containing a lepton pair based on this data set are presented.

Collaboration / Activity:

https://na62.web.cern.ch/

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T01: Astroparticle and Gravitational Waves / 773

Gravitational wave echo from relaxion trapping

Authors: Abhishek Banerjee[1]; Eric Madge[2]; Gilad Perez[2]; Pedro Schwaller[3]; Wolfram Ratzinger[3]

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We show that the relaxion coupled to a dark photon can generate a stochastic gravitational wave background in the early Universe. When the electroweak symmetry is restored after reheating, the relaxion starts rolling again until the back-reaction potential wiggles reappear. Depending on the time of barrier-reappearance, Hubble friction alone is insufficient to trap the relaxion in a large portion of the parameter space. Thus, an additional source of friction is required, which can for instance be provided by coupling to a dark photon. The dark photon experiences a tachyonic instability as the relaxion rolls, which slows down the relaxion by back-reacting to its motion, and creates anisotropies in the dark photon energy-momentum tensor, sourcing gravitational waves. We calculate the spectrum of the resulting stochastic gravitational wave background and evaluate its observability by current and future experiments. We further investigate the case that the coherently oscillating relaxion constitutes dark matter and present the corresponding constraints from gravitational waves.

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Collaboration / Activity:

Weizmann Institute of Science

T03: Dark Matter / **774**

NEWS-G: Search for Light Dark Matter with a Spherical Proportional Counter

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The NEWS-G collaboration is searching for light dark matter candidates using a novel detector concept, the spherical proportional counter. Access to the mass range from 0.05 to 10 GeV is enabled by the combination of low energy threshold, light gaseous targets (H, He, Ne), and highly radio-pure detector construction. Initial NEWS-G results obtained with SEDINE, a 60 cm in diameter spherical proportional counter operating at LSM (France), excluded for the first time WIMP-like dark matter candidates down to masses of 0.5 GeV. The construction and on-going commissioning of a new, 140 cm in diameter, spherical proportional counter constructed at LSM using 4N copper with 500 um electroplated inner layer will be presented, along with the new developments in read-out sensor technologies sing resistive materials and multi-anode read-out that allow high gain and high-pressure operation. The detector is scheduled to collect data in SNOLAB (Canada) later this year. The design and construction of ECUME, a 140 cm in diameter spherical proportional counter fully electroformed underground will be discussed. The potential to achieve sensitivity reaching the neutrino floor in light Dark Matter searches, with a next generation detector are also summarised.

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Collaboration / Activity:

NEWS-G

T07-T09: Combined: Top, Electroweak and Higgs Physics / **775**

Importance of top quark loop corrections to WW elastic scattering in HEFT

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We calculate fermion-loop corrections to high energy W^+W^- scattering in the context of a Strongly Interacting Electroweak Symmetry Breaking Sector (EWSBS) using Higgs Effective Field Theory(HEFT). We test the assumption that these corrections are negligible when compared to the boson-loop ones, as it is commonly taken for granted in the literature. While this is correct in most cases, we find that, for some particular regions of the parameter space of effective couplings, fermion-loops can be important: deviations in the couplings of the HEFT from their Standard Model values may lead to fermion-loop corrections as relevant as the boson-loop ones.

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Collaboration / Activity:

VBS

T11: Quantum Field and String Theory / 776

Probing Unified Theories with Reduced Couplings at Future Colliders

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The search for renormalization group invariant relations among parameters to all orders in perturbation theory constitutes the basis of the reduction of couplings concept. Reduction of couplings can be achieved in certain N=1 supersymmetric grand unified theories and few of them can even become finite at all loops. The resulting theories in which successful reduction of couplings has been achieved so far include: (i) a reduced version of the minimal N=1 SU(5) model, (ii) an all-loop finite N=1 SU(5) model, (iii) a two-loop finite N=1 SU(3)^3 model and finally (vi) a reduced version of the Minimal Supersymmetric Standard Model. We present a number of benchmark scenarios for each model and investigate their observability at existing and future hadron colliders. The heavy supersymmetric spectra featured by each of the above models are found to be beyond the reach of the 14 TeV HL-LHC. It is also found that the reduced version of the MSSM is already ruled out by the LHC searches for heavy neutral MSSM Higgs bosons. In turn, the discovery potential of the 100 TeV FCC-hh is investigated and found that large parts of the predicted spectrum of these models can be tested. In this talk we will present results and updates from our recent work (Eur.Phys.J.C 81 (2021) 2,185: arXiv:2011.07900 [hep-ph]).

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Collaboration / Activity:

UNAM,NTUA,UAM,U. Warsaw,IKTP

T12: Detector R&D and Data Handling / 777

Design and construction status of the Mu2e crystal calorimeter

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The Mu2e experiment at Fermi National Accelerator Laboratory searches for the charged-lepton flavor violating neutrino-less conversion of a negative muon into an electron in the field of an aluminum nucleus. The dynamics of such a process is well modelled by a two-body decay, resulting in a mono-energetic electron with energy slightly below the muon rest mass (104.967 MeV). Mu2e will reach a single event sensitivity of about 3x10−17 that corresponds to four orders of magnitude improvement with respect to the current best limit.
The calorimeter requirements are to achieve an energy resolution better than 10% and a timiong resolution better than 500 ps at 100 MeV in order to provide the needed μ/e particle identification, an online trigger filter while aiding the track reconstruction capabilities. It consists of two disks of un-doped CsI crystals, each one read out by two large area UV-extended SiPMs.
In this talk, the status of construction and QC performed on the produced crystals and photosensors, the development of the rad-hard electronics and the most important results of the irradiation tests done on the different components are summarized. The production of electronics is underway and we will summarize the QC test performed on the analog electronics and on the integrated SIPM+FEE units. Construction of the mechanical parts is also progressing well. Status and plans for the final assembly are also described. We expect to start assembly of the disk in summer 2021 assuming that the pandemics status will allow the INFN team to be present at Fermilab.
In the meanwhile, a complete vertical slice test with the final electronics is in progress on the large calorimeter prototype, dubbed Module-0, at the Frascati Cosmic Rays test stand. First calibration and performance results will be shown.

Collaboration / Activity:

Mu2e / calorimeter

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T01: Astroparticle and Gravitational Waves / 779

Mind the gap: What can we learn about stellar astrophysics from gravitational wave detections of binary black holes?

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With the detection of binary black hole (BH) mergers from LIGO/Virgo we have opened up the field of gravitational wave astronomy and created a new window into the Universe. These discoveries bring new and independent information about how very massive stars end their life, and the final remnants they leave behind. In this talk I will discuss the stellar physics that goes into the formation of the most massive stellar mass black holes and how the detection of most massive merging pair of black holes to date, GW190521, with both BHs being in the "PISN mass gap"challenges this picture. I will show what physics goes into the location of this mass gap, and how robust we believe the estimate of the location of the mass gap is. I will then discuss what GW190521 informs us about the location of the mass gap, and the implications for finding both black holes in the mass gap. Finally, I will also discuss how measuring the location of the mass gap allows us to place constraints on uncertain stellar physics, namely the C12(alpha,gamma)O16 nuclear reaction rate and what GW190521 can tell us about this nuclear reaction rate.

Collaboration / Activity:

N/A

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T06: QCD and Hadronic Physics / 780

Proton 3D imaging via transverse-momentum-dependent gluon densities

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In this talk we present exploratory studies of the 3D gluon content of the proton, as a result of analyses on leading-twist transverse-momentum-dependent (TMD) gluon distribution functions, calculated in a spectator model for the parent proton. Our formalism embodies a fit-based parameterization for the spectator-mass density, suited to describe both the small and the moderate-x regime. Particular attention is paid to the T-odd gluon TMDs, which represent a key ingredient in the description of relevant spin-asymmetries emerging when the nucleon is polarized, as the gluon Sivers effect. All these analyses are helpful to shed light on the gluon dynamics inside nucleons and nuclei, which is one of the primary goals of new-generation colliders, as the Electron-Ion Collider, the High-Luminosity LHC and NICA-SPD.

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Collaboration / Activity:

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T12: Detector R&D and Data Handling / 781

Scintillating sampling ECAL technology for the Upgrade II of LHCb

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The aim of the LHCb Upgrade II is to operate at a luminosity in the range of 1 to 2 $\times$ 10^{34} cm^{-2} s^{-1} to collect a data set of 300 fb^{-1}. This will require a substantial modification of the current LHCb ECAL due to high radiation doses in the central region and increased particle densities. The ECAL has to provide good energy and position resolutions in these conditions. Timing capabilities with tens of picoseconds precision for neutral electromagnetic particles and increased granularity with dense absorber in the central region are needed for pile-up mitigation.
An attractive option for the central region is SPACAL technology with radiation-hard scintillating crystal fibers and tungsten absorber, and organic scintillating fibers with lead absorber in the intermediate region. Results from an ongoing R&D campaign to optimise the Upgrade II ECAL are shown. This includes studies of radiation-hard scintillation materials, performance optimisation using detailed simulations and test beam measurements. The presentation also includes an overview of the overall plans for the Upgrade II of the LHCb ECAL.

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Collaboration / Activity:

LHCb ECAL Upgrade II R&D Group

T01: Astroparticle and Gravitational Waves / 783

The performance of the Virgo gravitational-wave detector during the O3 run (04/2019-03/2020) and the impact of the external environment

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The Observation Run 3 (O3) is the longest data-taking period to-date for the LIGO-Virgo global network of ground-based interferometric gravitational-wave (GW) detectors. The GWTC catalog of transient GW events has already been updated for the first six months of the run (O3a: 2019/04/01 -> 2019/19/01) while the analysis of the last five months (O3b: 2019/11/01 -> 2020/03/27, after a one-month commissioning break) is ongoing. This talk will review the performance of the Virgo detector during the O3 run: sensitivity, duty cycle, noise stability and variations. It will in particular focus on the impact of the external environment on this performance: earthquakes, anthropogenic seismic noise, local weather at the EGO site, etc. The experience gained should allow the Virgo Collaboration to improve the robustness of its instrument against external disturbances and to develop improved strategies to mitigate their consequences. This work is ongoing during the current shutdown, besides major detector upgrades, prior to the start of the upcoming O4 run during summer 2022.

Collaboration / Activity:

Virgo

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T01: Astroparticle and Gravitational Waves / 784

Virgo detector characterization and data quality studies: analysis of the O3 data-taking period and ongoing developments to prepare the O4 run

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Detector characterization and data quality studies (referred collectively as "DetChar"in the following) are key inputs to improve the sensitivity of a ground-based interferometric gravitational-wave (GW) detector like Virgo, to optimize the performance of the instrument during data taking periods and to vet GW candidate signals identified in low-latency or offline. DetChar is involved in the whole scientific dataflow, from the raw data recorded by the detector to the final list of GW events to be released publicly. This talk presents the activities of the Virgo DetChar group during the LIGO-Virgo Observing Run 3 (O3, April 2019 –March 2020), summarizes its main findings and concludes by describing the upgrades and improvements that are foreseen to prepare the LIGO-Virgo-KAGRA O4 run that should start during Summer 2022.

Collaboration / Activity:

Virgo

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T07: Top and Electroweak Physics / 785

Top-quark production at approximate N3LO

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I discuss recent theoretical results with soft-gluon corrections for various top-quark production processes through approximate N3LO, including soft anomalous dimensions through three loops. I present numerical results for total cross sections as well as single- and double-differential distributions for top-pair and various single-top processes, including three-particle final states, and I show that soft-gluon corrections are dominant for a large range of collider energies.

Collaboration / Activity:

Theoretical

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T01: Astroparticle and Gravitational Waves / 786

Hyperbolic-like Encounters of Binary Black Holes

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We present results on the encounter of two black holes that are initially on a hyperbolic-like orbit simulated with the numerical relativity code SpEC.
The two black holes either become bound due to the emission of gravitational waves or they escape to infinity. We present trajectories and waveforms for both cases and extract the scattering angle for the latter.

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Collaboration / Activity:

SXS collaboration

T01: Astroparticle and Gravitational Waves / 787

Search for lensing signatures in the gravitational-wave observations from the first half of LIGO-Virgo's third observing run

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The Advanced LIGO and Advanced Virgo detectors are now observing large numbers of gravitational-wave signals from compact binary coalescences, with 50 entries in the latest transient catalogue GWTC-2. With this rapidly growing event rate, our chances become better to detect rare astrophysical effects on these novel cosmic messengers. One such rare effect with a long and productive history in electromagnetic astronomy and great potential for the future of GW astrophysics is gravitational lensing. This presentation covers the first LIGO-Virgo collaboration search for signatures of gravitational lensing in data from O3a, the first half of the third advanced detector observing run.

We study: 1) the expected rate of lensing at current detector sensitivity and the implications of a (non-)observation of strong lensing or a stochastic gravitational-wave background on the merger-rate density at high redshift; 2) how the interpretation of individual high-mass events would change if they were found to be lensed; 3) the possibility of multiple images due to strong lensing by galaxies or galaxy clusters; and 4) possible wave-optics effects due to point-mass microlenses.

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Collaboration / Activity:

LIGO-Virgo Collaboration

T06: QCD and Hadronic Physics / 788

Application of parton showers obtained with the Parton Branching approach to Drell Yan + jets production

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Calculations of Drell-Yan production at next-to-leading (NLO) order have been combined with transverse Momentum Dependent (TMD) distributions obtained with the Parton Branching (PB). For the first time, the predictions show a remarkable agreement with DY measurements across a wide range of DY mass and center of mass energies, from experiments like NuSea, R209, Phenix, CMS and ATLAS. Uncertainties from the TMD fit and from missing higher orders in the calculation are also determined. We also show predictions for Z+jet and multijet measurements, where especially angular correlations, sensitive to TMDs, are well described. We show that the PB TMDs together with a PB TMD parton shower and higher order matrix elements allow a very good description of measurements over a wide kinematic range.

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Collaboration / Activity:

CMS/QCD

T03: Dark Matter / 789

New sensitivity of LHC measurements to Composite Dark Matter

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We present sensitivity of LHC Standard Model (SM) differential cross-section measurements for so-called "stealth dark matter"scenarios occurring in an SU(ND) dark gauge group, where constituents are charged under the SM and ND =2 or 4. The low-energy theory contains mesons which can be produced at the LHC and a scalar baryon dark matter (DM) candidate which cannot. We evaluate the impact of LHC measurements on the dark meson masses. Using existing lattice results, we then connect the LHC explorations to DM phenomenology, in particular considering direct-detection experiments. We show that current LHC measurements constrain DM masses in the 10s of TeV regime. We discuss potential pathways to explore these models further using LHC measurements.

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Collaboration / Activity:

Experiment & Phenomenology

T12: Detector R&D and Data Handling / 790

Tracking and track reconstruction at a muon collider in the presence of beam-induced background

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Among the projects currently under study for the post-LHC generation of particle accelerators the muon collider represents a unique machine, which has the capability to provide very high energy leptonic collisions and to open the path to a vast and mostly unexplored Physics program.
However, on the experimental side, such a great Physics potential is accompanied by unprecedented technological challenges, due to the fact that muons are unstable particles. Their decay products interact with the machine elements and produce an intense flux of background particles that eventually reach the detector and might degrade its performance. Being the closest detector to the beamline, the tracker is the most affected by the beam-induced background. This contribution will outline the measures adopted in order to mitigate the background effects on the track reconstruction and will present the tracking performance in the presence of the beam-induced background. We will discuss considerations on the tracker design, ideas of 5D tracking (position, time, and direction), and strategies using novel tracking algorithms based on the A Common Tracking Software (ACTS) library, which was developed with a focus on hadronic environments with high pile-up - we explore the usage of ACTS to perform the track reconstruction in the presence of the beam-induced background.

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Collaboration / Activity:

Muon Collider Detector&Physics

T03: Dark Matter / 791

Constraining the diffuse supernova axion-like-particle background with high-latitude Fermi-LAT data

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Axions and axion-like particles (ALPs) are thought to be produced along with baryonic matter in a variety of astrophysical processes. Core-collapse supernovae (SNe) have been identified as a promising target to probe the existence of these hypothetical particles, which could make up at least a fraction of the universe's dark matter content.
The cumulative signal from all past SNe events would contain an ALP component and create a diffuse flux with energies $\mathcal{O}(50)$ MeV. Due to their coupling to photons and the related Primakoff process, the diffuse SNe ALP flux is converted into a diffuse gamma-ray flux while traversing the magnetic field of the Milky Way. The spatial morphology of this signal is expected to follow the shape of the Galactic magnetic field lines.
We perform a template-based analysis to constrain the ALP parameter space via the spatial structure of this ALP-induced diffuse gamma-ray flux using Fermi-LAT data from 12 years and an energy range from 50 MeV to 500 GeV. We find an improvement of the upper limit on the ALP-photon coupling constant $g_{a\gamma}$ of about an order of magnitude compared to a previous analysis solely based on the spectral shape of the signal. Our results are robust against variations in the modelling of high-latitude Galactic diffuse emission and systematic uncertainties of the LAT.

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Collaboration / Activity:

CNRS, LAPTh

T03: Dark Matter / 792

Results on Light Dark Matter investigation with CRESST-III

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The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment explores with high sensitivity the parameter space of low mass DM candidates, being the pathfinder in the sub-GeV/c^2 mass range. CRESST employs different high-purity crystals and operate them at mK temperature as cryogenic calorimeters The flexibility in employing detectors made of different materials together with the advanced performance of the thermal sensors allow CRESST-III to establish the most stringent limits on spin-dependent and spin-independent low mass DM interactions.

In this contribution, the current stage of the CRESST-III experiment, together with the most recent dark matter results will be presented. The perspective for the next phase of the experiment will be also discussed.

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Collaboration / Activity:

CRESST

T13 - Accelerator for HEP / 793

Development and use of high gradient RF technology for compact linacs

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The high-gradient linac technology developed by the CLIC study is now being adopted by a wide range of accelerator applications. These range from electron linac applications such as X-ray free electron lasers (XFELs), Inverse Compton Scattering (ICS) sources, beam manipulating components like energy spread linearizers and transverse deflectors through to medical accelerators as well as proton applications like high-gradient low-beta accelerating cavities and large acceptance radio frequency quadrupoles (RFQs). Examples of these applications are presented. The adoption is an important example of technology transfer and is providing a greatly expanded community developing high-gradient technology further.

Collaboration / Activity:

CLIC, CompactLight

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T06: QCD and Hadronic Physics / 794

Transverse momentum dependent splitting functions in the Parton Branching method

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The Parton Branching (PB) approach provides a way to obtain transverse momentum dependent (TMD) parton densities. Its equations are written in terms of splitting functions and Sudakov form factors and can be solved with Monte Carlo methods. Even though the transverse momentum is known in every branching, the PB method currently uses the DGLAP splitting functions, which assume that the parton has no transverse momentum. We propose to extend the PB method by including TMD splitting functions, a concept from high-energy factorization.

We present the evolution equations and the connection to DGLAP evolution equations and BFKL evolution equation. We show their solutions obtained with a Monte Carlo Simulation and show numerically the effects that TMD splitting functions have on the TMD distribution functions.

Collaboration / Activity:

Phenomenology of QCD

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T04: Neutrino Physics / 796

Probing the Earth's Core using Atmospheric Neutrinos at INO

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The Iron Calorimeter (ICAL) detector at the proposed India-based Neutrino Observatory (INO) aims to detect atmospheric neutrinos and antineutrinos separately in the multi-GeV range of energies and over a wide range of baselines. By utilizing its charge identification capability, ICAL can efficiently distinguish μ^- and μ^+ events. Atmospheric neutrinos passing long distances through Earth can be detected at ICAL with good resolution in energy and direction, which enables ICAL to see the density-dependent matter oscillations experienced by upward-going neutrinos in the multi-GeV range of energies. In this work, we explore the possibility of utilizing neutrino oscillations in the presence of matter to extract information about the internal structure of Earth complementary to seismic studies. Using good directional resolution, ICAL would be able to observe 331 μ^- and 146 μ^+ core-passing events with 500 kt·yr exposure. With this exposure, we show for the first time that the presence of Earth's core can be independently confirmed at ICAL with a median $\Delta\chi^2$ of 7.45 (4.83) assuming normal (inverted) mass ordering by ruling out the simple two-layered mantle-crust profile in theory while generating the prospective data with the PREM profile.

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Collaboration / Activity:

INO Collaboration

T05: Heavy Ion Physics / **797**

Secondary nuclei from O-16 fragmentation at the LHC

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Studies of collisions of light systems, like O–O, are planned at the LHC 1. In particular, the translation of initial collision geometry with alpha-clustering in O-16 to triangular modulation of elliptic flow is discussed [2,3]. To date there were no measurements, even at lower collision energies, which demonstrated such fine effects of radial flow. However, numerous measurements of fragmentation of relativistic O-16 were already performed, see, in particular [4]. Therefore, the clustering of O-16 can be revealed by comparing these data to calculations with and without clustering. In the present work we model the fragmentation of O-16 in collisions with light and heavy nuclei by means of a new version of Abrasion-Ablation Monte Carlo for Colliders (AAMCC) model [5] with accounting for pre-equilibrium clustering of spectator matter. AAMCC model is based on Glauber Monte Carlo model [6] in calculating the numbers of participant and spectator nucleons in colliding nuclei. Because of a half-moon shape of spectator matter, it instantaneously dissociates into several independent hot systems defined by minimum spanning tree (MST) clustering algorithm. It is assumed that the excitation energy of each system correlates with its volume and its decays are simulated by means of Fermi break-up model from the Geant4 toolkit [7]. A small contribution to production of forward fragments from electromagnetic dissociation of O-16 is also calculated with RELDIS model [8]. It is demonstrated that in contrast to Pb–Pb collisions, neutron and proton Zero Degree Calorimeters in

the ALICE experiment at the LHC will be less effective in triggering hadronic and electromagnetic interactions of O-16 because of a large number of neutrons and protons remaining in undetected nuclear fragments. As found, the measured production of Li, Be, B and N fragments [4] is described by AAMCC, but the production of carbon is underestimated. At the same time, channels with a single He-4 are overestimated with respect to data [4], but the rates of simultaneous production of two and three He-4 are underestimated. This all indicates that alpha-clustering effects in initial O-16, which give preference to He-4 as fragmentation products of relatively cold spectator matter, have to be taken into account in AAMCC in addition to the considered pre-equilibrium MST clustering.
The work has been carried out with financial support of RFBR within the
project 18-02-40035-mega.

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Collaboration / Activity:

Nuclear fragmentation

T03: Dark Matter / 798

Sub-MeV Dark Matter Searches with EDELWEISS: results and prospects

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The Edelweiss collaboration performs light Dark Matter (DM) particles searches with germanium bolometer collecting
charge and phonon signals. Thanks to the Neganov-Trofimov-Luke effect, a RMS resolution of 0.56 electron-hole pair
was obtained on a massive (33.4g) germanium detector operated underground at the Laboratoire Souterrain de Modane.
This sensitiviy made possible a search for Dark Photons Down to 1 eV and for DM-electron interactions below 1 MeV/c2.
It is the first measurement in cryogenic germanium at such low threshold proving the high relevance of this technology.
This is an important step of the development of the Ge detectors with improved performance in the context of the EDELWEISS-SubGeV program.

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Collaboration / Activity:

Edelweiss

T04: Neutrino Physics / 799

Neutrino Masses and Hubble Tension via a Majoron in MFV

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The recent tension between local and early measurements of the Hubble constant can be explained in a particle physics context. A mechanism is presented where this tension is alleviated due to the presence of a Majoron, arising from the spontaneous breaking of Lepton Number. The lightness of the active neutrinos is consistently explained. Moreover, this mechanism is shown to be embeddable in the Minimal (Lepton) Flavour Violating context, providing a correct description of fermion masses and mixings, and protecting the flavour sector from large deviations from the Standard Model predictions. A QCD axion is also present to solve the Strong CP problem. The Lepton Number and the Peccei-Quinn symmetries naturally arise in the Minimal (Lepton) Flavour Violating setup and their spontaneous breaking is due to the presence of two extra scalar singlets. The Majoron phenomenology is also studied in detail. Decays of the heavy neutrinos and the invisible Higgs decay provide the strongest constraints in the model parameter space.

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Collaboration / Activity:

Universidad Autónoma de Madrid

T12: Detector R&D and Data Handling / 800

Next and Present Generation of the Fast Silicon Timing Sensors for the LHC and the Next Generation of Future Colliders

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The next generation of high energy physics colliders call for major advances in tracking detector technology. In order to cope with the increasingly demanding specifications of HEP experiments an extensive R&D program has been underway within the RD50 Collaboration to develop timing silicon sensors with sufficient radiation tolerance for HL-LHC trackers and beyond. The critical

areas of detectors R&D include HV CMOS sensors, detectors made in the 3D technology and Low Gain Avalanche Detectors (LGADs). We will present the state of the R&D in several silicon detector domains, in particular, LGAD and 3D. We will also comment on the options for detector choices experiments beyond the LHC. Prospects of the fast-timing detectors for particle identification at the future Higgs factories and its implication on future frontier science will be discussed too.

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Collaboration / Activity:

CERN RD50

T04: Neutrino Physics / 801

Explaining the MiniBooNE Excess Through a Mixed Model of Oscillation and Decay

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This talk presents a model of the electron-like excess observed by the MiniBooNE experiment comprising of oscillations involving two new mass states: ν_4, at $\mathcal{O}(1)$ eV, that participates in oscillations, and $\mathcal{N}$, at $\mathcal{O}(100)$ MeV, that decays to $\nu + \gamma$ via a dipole interaction.
Short-baseline oscillation data sets, omitting MiniBooNE appearance data, are used to predict the oscillation parameters. We simulate the production of $\mathcal{N}$ along the Booster Neutrino Beamline via both Primakoff upscattering ($\nu A \to \mathcal{N} A$) and Dalitz-like neutral pion decays ($\pi^0 \to \mathcal{N} \nu\gamma$).
The simulated events are fit to the MiniBooNE neutrino energy and visible scattering angle data separately to find a joint allowed region at 95\% CL.
A point in this region with a coupling of 3.6×10^{-7} GeV^{-1}, $\mathcal{N}$ mass of 394 MeV, oscillation mixing angle of 6×10^{-4} and mass splitting of 1.3 eV^2 has $\Delta\chi^2/dof$ for the energy fit of 15.23/2 and 37.80/2. This model represents a significant improvement over the traditional single neutrino oscillation model.

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Collaboration / Activity:

MiniBooNE

T06-T07: Combined: Top, Electroweak, QCD and Hadronic Physics / 802

Mixed QCD-EW corrections to Drell-Yan at the LHC

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Drell-Yan lepton pair production is a benchmark process at hadron colliders.
From the theoretical side, the inclusion of higher-order radiative corrections is mandatory in order to match the experimental accuracy attainable at the LHC.
QCD radiative corrections are known up to order α_s^3 for inclusive cross sections and up to order α_s^2 for differential observables; EW corrections are known up to order $alpha$.
At this level of precision, the inclusion of mixed QCD-EW corrections becomes relevant.

We report on the first complete computation of the mixed QCD–EW corrections to the neutral- and charged- current Drell–Yan processes. In the former case, the two-loop virtual contribution is computed exactly by using semi-analytical techniques, overcoming the technical problems in the evaluation of the relevant master integrals, and it is compared to an "improved" pole approximation, employed for the charged-current process. The cancellation of soft and collinear singularities is achieved by a formulation of the q_T-subtraction formalism valid in presence of charged massive particles in the final state.

Superseding previously applied approximations, our calculation provides the first result at this order that is valid in the entire range of invariant masses of the charged lepton-anti-lepton pair.

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Collaboration / Activity:

T01: Astroparticle and Gravitational Waves / 803

Neutrino emission from temporarily-absorbed gamma-ray blazars

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Since the discovery of high-energy neutrinos by the IceCube South Pole Neutrino Detector in 2013, the origin of their cosmic flux is still under debate. Every piece of the puzzle that helps to understand their acceleration sites is of great interest, because cosmic neutrinos are key messengers to explore the non-thermal universe where it is opaque to the cosmic rays and photons. IceCube recorded its highest-energy cosmic neutrino alert ever on 2019 July 30, IC-190730A, which quickly became associated with the blazar PKS 1502+106. By analyzing multimessenger observations on this source, we point out that a scenario, in which gamma-ray emission is suppressed during efficient neutrino production, could potentially resolve the apparent contradiction of the blazar models simultaneously producing a detectable neutrino flux and a gamma flare, since at the time of efficient neutrino production the observed gamma-flux drops. We show other examples of possible gamma suppression, TXS 0506+056 and PKS B1424-418. Temporary gamma-suppression could increase the sensitivity of neutrino-blazar coincidence searches due to the short allowed time coincidence between gamma-suppressed periods and neutrinos, enabling the identification of the origin of IceCube's diffuse neutrino flux possibly with already existing data.

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Collaboration / Activity:

IceCube

T04: Neutrino Physics / 804

Sterile Neutrino Search from Daya Bay

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Along with other experiments, the Daya Bay Reactor Neutrino Experiment has searched for light sterile neutrino mixing, using electron antineutrino disappearance. Through comparing a 1230-day sample to prediction, assuming a 3+1 neutrino model, Daya Bay set the most stringent limits to date on the mixing of sterile neutrinos for $2 \times 10^{-4} < \Delta m^2_{41} < 0.3$ eV^2. A joint analysis with the Bugey-3 short-baseline reactor experiment and MINOS/MINOS+ accelerator experiments resulted in the world-leading limits on the $\theta_{\mu e}$ mixing angle for over five orders of magnitude in the sterile mass-squared difference Δm^2_{41}. These results exclude the LSND and MiniBooNE allowed regions at 90% for $\Delta m^2_{41} < 5$ eV^2, weakening the sterile neutrino explanation of their observations. The Daya Bay results, as well as the combined results, will be presented in this poster.

Collaboration / Activity:

Daya Bay collaboration

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T12: Detector R&D and Data Handling / 805

Tracking with ACTS for a Muon Collider detector

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Charged particle trajectory reconstruction at a Muon Collider detector is more similar to the hadron collider environment than an electron collider. The presence of the beam-induced background leaves a large hit multiplicity in the tracking detector that complicates the pattern recognition stage of track reconstruction. The BIB hits increase the possible hit combinations that need to be filtered to create valid track candidates. This is analogous to the problem from pile-up hits in an hadron collider detector. The A Common Tracking Software (ACTS) is a library that implements the tracking algorithms developed by the collider tracking community, with a particular focus on hadronic environments. In addition to clever algorithms, it further tackles the tracking performance issue by heavily optimizing the code and exploring novel computing architectures. Due to the experiment-independent design, ACTS allows other experiments to leverage their complex tracking algorithms in different settings. This contribution will explore the usage of ACTS to perform the track reconstruction for simulated muon collider events with full beam-induced background.

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Collaboration / Activity:

Muon Collider Detector&Physics

T04: Neutrino Physics / 806

Latest Neutrino Oscillation Results from the Daya Bay Experiment

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This talk will present the latest neutrino oscillation results from the Daya Bay experiment, which consists of eight functionally identical detectors in three experimental sites at different baselines from six 2.9 GW_{th} nuclear reactor cores. In 1958 days of operation, Daya Bay has collected the largest sample of inverse beta decay events to date, with close to 4 million candidate events. With improved systematics, Daya Bay has produced a world-leading measurement of the θ_{13} mixing angle and achieved comparable precision for Δm^2_{32} to accelerator experiments. Along with the MINOS/MINOS+ and Bugey-3 experiments, Daya Bay has searched for oscillations to light sterile neutrinos, with no significant signal found. The most stringent limits to date have been placed on the $\theta_{\mu e}$ effective mixing angle over five orders of magnitude in the sterile mass-squared difference Δm^2_{41}, excluding the parameter space allowed by the LSND and MiniBooNE experiments at 90% $\mathrm{CL_S}$ for $\Delta m^2_{41} < 13$ eV^2.

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Collaboration / Activity:

Daya Bay Experiment

T06: QCD and Hadronic Physics / 807

$\gamma\gamma \to \gamma\psi(2S)$ and other studies on charmonium at Belle

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Using $980\mathrm{f}b^{-1}$ of data collected with the Belle detector, the two-photon process $\gamma\gamma \to \gamma\psi(2S)$ is studied for the first time in an effective center-of-mass energy ranging from 3.7 to $4.2\,\mathrm{GeV}$. Evidence is established for a structure in the $\gamma\psi(2S)$ invariant-mass distribution at $3921.3 \pm 2.4 \pm 1.6\,\mathrm{MeV}$, and hint is found for another structure around $4000\,\mathrm{MeV}$. We also report other studies related to charmoniuum or charmoniuum-like states at Belle.

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Collaboration / Activity:

Belle

T06: QCD and Hadronic Physics / 808

Charmed Baryon results from Belle (12'+3')

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Precision hadron spectroscopy helps in understanding how the matter is made around us. The large data sample accumulated by the Belle experiment at the KEKB asymmetric-energy e^+e^- collider provides us a unique opportunity to perform these studies. We report recent results on charmed baryon spectroscopy from Belle, which include a study on the spin and parity of $\Xi_c(2970)$ and Ξ_c^0 decays to $\Xi^0 K^+ K^-$, $\Xi^- \ell^+ \nu_\ell$, ΛK^*, and ΣK^*. The talk may also cover results on non-charmed baryons at Belle.

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Collaboration / Activity:

Belle

T06: QCD and Hadronic Physics / 809

Study on $e^+e^- \to B^{(*)}\bar{B}^{(*)}$ and $\Upsilon(5S) \to \Upsilon(1S, 2S)\eta^{(\prime)}$

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We report the first measurement of exclusive cross sections for $e^+e^- \to B\bar{B}$, $e^+e^- \to B\bar{B}^*$, and $e^+e^- \to B^*\bar{B}^*$ in the energy range from 10.63 to $11.02\,\mathrm{GeV}$. The B mesons are fully reconstructed in a large number of hadronic final states, and the three channels are distinguished using the beam-energy-constrained mass variable. For each channel, the cross section shows an oscillatory behavior, with multiple maxima and minima. The final results on $\Upsilon(5S) \to \Upsilon(1S, 2S)\eta$ and $\Upsilon(5S) \to \Upsilon(1S)\eta'$ branching fractions are also presented. In addition, we report a search for the $\chi_{bJ}(nP)$ bottomonium states at Belle. The P-wave states are reconstructed in decays to the $\Upsilon(1S)$ with the emission of an ω meson. The transitions of the $n = 2$ triplet states provide a unique laboratory to study QCD, as the kinematic threshold for production of an ω and $\Upsilon(1S)$ meson lies between the $J = 0$ and $J = 1$ states. A search for the $\chi_{bJ}(3P)$ states in radiative transitions from $\Upsilon(4S)$ is also performed. All these results are based on data collected by the Belle experiment at the KEKB asymmetric-energy e^+e^- collider.

Collaboration / Activity:

Belle

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T08: Flavour Physics and CP Violation / 810

Study of Lepton Flavor Universality in electroweak penguin B decays

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The electroweak penguin B decays mediated by $b \to s\ell^+\ell^-$ transitions are flavour-changing neutral current processes, and are thus sensitive to new physics because of possible contributions of heavy particles in the quantum loop. We report measurements of lepton flavor universality violation observables R_K and R_{K^*}, and other related decays, based on the full data sample recorded by Belle at the $\Upsilon(4S)$ resonance from e^+e^- collisions produced by the KEKB collider. We also present a search for charged lepton flavor violation and radiative lepton flavor violation in $\Upsilon(1S)$ decays using 158×10^6 $\Upsilon(2S)$ decays collected by the Belle detector.

Collaboration / Activity:

Belle

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T08: Flavour Physics and CP Violation / 811

Latest dark sector searches at the Belle Experiment

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The Belle experiment has accumulated close to $1\,\mathrm{ab}^{-1}$ of data in electron-positron collisions at center-of-mass energies around various $\Upsilon(nS)$ resonances. These data can be used to perform a number of new physics searches in the context of dark sector with an unprecedented precision. We present for the first time the results of a search of the dark photon in B-meson decays, the search for dark matter in bottomonium decays, as well as the latest results in the search for dark forces, via direct production, or in the decay of mesons. These competitive results can be used to severely constrain new physics scenarios.

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Collaboration / Activity:

Belle

T08: Flavour Physics and CP Violation / 812

Study of hadronic B and B_s decays at Belle

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We report the first search for the penguin-dominated process $B_s \to \eta' X_{s\bar{s}}$ using a semi-inclusive method. In absence of a statistically significant signal, we set a 90\% confidence-level upper limit 1.4×10^{-3} on the partial branching fraction where $M(X_{s\bar{s}}) \leq 2.4\,\mathrm{GeV}$. We also report final results for the $B_s^0 \to D_s X$ and $B_s^0 \to \eta\eta'$ decays. These results are obtained using $121.4\,\mathrm{fb}^{-1}$ data collected at the $\Upsilon(5S)$ resonance by the Belle experiment at the KEKB asymmetric-energy e^+e^- collider. Furthermore, we report on measurements involving three-body decays $B^+ \to K^+K^-\pi^+$ and $B^+ \to \pi^+\pi^0\pi^0$ based on the Belle data collected at the $\Upsilon(4S)$ resonance.

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Collaboration / Activity:

Belle

T04: Neutrino Physics / 813

Radiogenic Neutron Background in antineutrino experiments

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This poster presents a novel correlated background present in the antineutrino detection using the inverse beta decay reaction. Spontaneous fissions and (α, n) reactions in peripheral materials of the antineutrino detector, such as borosilicate glass of photomultipliers and electronics boards, produce fast neutrons and prompt gamma rays. If the shielding from the material to the detector target was not thick enough, neutrons and gammas could enter the target volume and could form correlated signals. The background is investigated thoroughly in antineutrino experiments, and the simulation results give a hint that the background could be non-negligible in the oscillation analysis based on neutron capture on hydrogen at Daya Bay.

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Collaboration / Activity:

Daya Bay Collaboration

T09: Higgs Physics / 815

The JHU generator framework: EFT applications in Higgs physics

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The JHUGenerator framework includes an event generator of all anomalous Higgs boson interactions in both production and decay and the MELA library for matrix element analyses. The framework also allows using dimension-six operators of an EFT in on-shell and off-shell production together with triple and quartic gauge boson interactions. One new feature is the JHUGenLexicon interface for relating the anomalous coupling formulation with popular EFT bases. Some of the new features are illustrated along with projections for experimental measurements with the full LHC and HL-LHC datasets.

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Collaboration / Activity:

JHU generator

T05: Heavy Ion Physics / 816

Study of the thermodynamical parameters at kinetic freeze-out in relativistic heavy-ion collisions at RHIC and LHC energy using Tsallis statistics

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The quark-gluon plasma (QGP), produced in relativistic heavy-ion collisions, freeze-out through multi-partonic interactions to final state hadrons. The transverse momentum (p_{T}) spectra study of the produced particles can ighten the thermodynamical properties of the QGP medium. In this work, a detailed study of the p_{T} spectra of the identified charged particles (pions, kaons, protons) and all charged particles in the heavy-ion system are done using the non-extensive Tsallis statistics. The Tsallis parameters q and T measure the degree of deviation of the system from an equilibrium state and the effective temperature at freeze-out conditions, respectively. The present formalism properly describes the nature of the non-exponential behavior of the p_{T} spectra at large transverse momentum ranges which is a drawback of the familiar blast-wave formula.

We present the thermodynamic properties at freeze-out using the experimental data of Au-Au collisions at the Relativistic Heavy Ion Collider (RHIC) energies (from $\sqrt{s_{\mathrm{NN}}} = 7.7$ GeV to 200 GeV) and Pb-Pb collisions at the Large Hadron Collider (LHC) energies ($\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV and 5.02 TeV) in the framework of the Tsallis distribution. The extracted Tsallis parameters are found to be dependent on the particle species, collision energy, centrality, and fitting ranges of the p_{T}. With increases of the collision energies, q increases in a systematic manner whereas T has a decreasing trend. It is

observed that the parameters q, T, changes with increasing p_{T} fitting ranges and at mid p_{T} region the parameter are found to be unchanged which can describe the physics of the systems. It is found that the Tsallis parameters follow mass ordering and the quality of fitting deteriorates with heavier mass particles.

Collaboration / Activity:

Self contribution

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T13 - Accelerator for HEP / 817

Status and perspectives of the SuperKEKB project

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The SuperKEKB electron-positron collider is being commissioned at KEK to study a new physics in the B-meson decays. In order to accomplish the target, the luminosity of 8 x 10^{35} cm^{-2}s^{-1} is necessary. We have applied a novel "nano-beam scheme"to squeeze the beta function at the interaction point (IP) down to 1 mm in the vertical, 60 mm in the HER and 80 mm in the LER in the horizontal direction, respectively. The beta function at the IP is the smallest value for the existing circular colliders in the world. However, the final design value is 0.3 mm which is about 1/3 of the achievement. Recently, we also applied a "crab waist collision scheme"to improve the luminosity in the nano-beam scheme. The status of the commissioning at 2020 run and 2021 run is presented and the performance of nano-beam scheme as well as the crab waist are discussed.

Collaboration / Activity:

SuperKEKB

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T10: Searches for New Physics / 818

Characterising darkjets: Implications of theory scenarios for experimental signatures

Authors: Suchita Kulkarni[None]; Suchita Kulkarni[1]; Marie-Helene Genest[None]; Guillaume Albouy[None]; Harikrishna Nair[None]; Akanksha singh[None]

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Scenarios of strongly interacting dark matter, where confinement in a new non-abelian dark sector leads to composite dark matter candidate are increasingly at the focus of LHC searches. These

scenarios where bound state masses are low compared to the LHC scale lead to exotic darkjet signatures such as semi-visible, emerging jets. With the example of an SU(Nd) gauge group, we present the impact of variation of number of dark flavours, colours, bound state masses, mediator lifetime as well as mediator decay mode along with other theory parameters on the properties of resulting dark jets. With these investigations, we illustrate potential strategies useful for defining inclusive darkjet searches at the LHC.

Collaboration / Activity:

Theory

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Plenary Session 2 / 821

Fermilab muon g-2 result and future perspectives 15'

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Plenary Session 2 / 822

g-2: Theory overview

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Plenary Session 2 / 823

Discussion

T05: Heavy Ion Physics / 825

A large bound state in small systems: ALICE measurement of hypertriton production in pp and p-Pb collisions

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The study of (anti)nuclei production in hadronic collisions has proven to be a powerful tool to investigate the formation mechanism of loosely bound states. The ${}^{3}_{\Lambda}\mathrm{H}$ is a bound state of Λ, proton, and neutron characterised by a Λ separation energy of few keV, which leads to a large wave function. As a consequence, the measured (anti-)${}^{3}_{\Lambda}\mathrm{H}$ production yields in pp and p-Pb collisions can resolve the difference between the Statistical Hadronisation Model (SHM) predictions, which are insensitive to the ${}^{3}_{\Lambda}$H structure, and the coalescence model.

In this talk the first measurements of the production of (anti-)${}^{3}_{\Lambda}$H in pp and p-Pb collisions are presented. In this context, the measurements are compared with the expectations of coalescence and SHM. With the precision of the presented measurements, ALICE is setting tighter constraints to available theoretical models, in particular excluding some configurations of the Statistical Hadronisation and Coalescence models.

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Collaboration / Activity:

ALICE

T13 - Accelerator for HEP / 829

Beam dynamics corrections to the Run-1 measurement of the experiment Muon g-2 at Fermilab

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The Muon g-2 experiment at Fermilab aims to measure the muon anomalous magnetic moment (a_μ) with a final accuracy of 140 part per billions (ppb). The first result on Run-1 dataset were unveiled on April 7, 2021, showing a very good agreement with the previous experimental result at Brookhaven National Laboratory (BNL), improving the uncertainty by achieving a precision of 460 ppb compared to 540 ppb of BNL. Due to the extremely high precision of the experiment four different beam dynamics corrections must be applied to obtain the final value of the anomalous precession frequency. Two corrections are associated with the use of electrostatic quadrupole (ESQ) vertical focusing on the storage ring. A vertically magnetic field is felt by muons passing through the
radial electric field components created by the ESQ system. Due to the vertical betatron motions the muons do not orbit the ring in a plane orthogonal to the vertical magnetic field direction. A correction is necessary to account for an average pitch angle associated with their trajectories. A third correction is caused by muons that escape the ring during the storage time experiencing a biased initial spin phase compared to the parent distribution. Finally, because two high-voltage resistors in the ESQ network had longer than designed RC time constants, the vertical and horizontal centroids of the stored muon beam drifted slightly, during each storage ring fill. This led to the phase-acceptance relationship that requires a correction. I will present this high precision measurement focusing on the beam dynamics corrections to ω_a.

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Collaboration / Activity:

Muon g-2 Collaboration

T14: Outreach, Education and Diversity / 830

Designing particle physics comms for people who don't think about physics: the Urknall Unterwegs module

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The Urknall Unterwegs module, a component of the outreach arm of the German science communication project KONTAKT, is a planned traveling indoor-outdoor exhibition on particle physics. Except it's intended for people who might not much care about physics. These are the people who skip the science centres, the open days at the local lab or institute, or who don't check into science documentaries on TV or YouTube. A team of science communicators, physicists, didactics experts, and lay people (i.e. unassuming test subjects) tried to figure out how best to talk to these people, bring the science to where they are, and make an experience that aims to get them thinking about why it's important to spend time and human effort on particle physics and basic research. We want a diverse group of people young and old to get inspired by how we research the basis of the world around them, while also showing the diversity of particle physics itself and how the field aspires to bring people from around the world together. I'd like to present the thinking behind the module's design and plans for its initial tour, which would begin in Fall 2021 (pandemic conditions permitting).

Collaboration / Activity:

Weltmaschine

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T04: Neutrino Physics / 831

KM3NeT/ORCA overview

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KM3NeT is the Mediterranean distributed deep-sea research infrastructure, hosting the next-generation Cherenkov detectors for the observation and study of neutrinos in the energy range from few GeV up to few PeV. KM3NeT/ORCA (Oscillations Research with Cosmics in the Abyss), the detector aimed at the study of low energy neutrinos (> 1 GeV), is currently under construction off the coast of Toulon in France, at a depth of about 2500 m. In its final configuration, ORCA will include 2070 digital optical modules (DOM) distributed over 115 detection lines. Each DOM contains 31 photomultiplier tubes with a diameter of 3". This megaton-size detector is optimized for studies of atmospheric neutrino oscillations, with the primary goal to determine the neutrino mass ordering. Other measurements planned with ORCA include searches for sterile neutrinos, non-standard interactions, and neutrino oscillation tomography of the Earth.

Currently the configuration with 6 deployed lines (ORCA6) is steadily taking data. The status, current performance, and prospects of the KM3NeT ORCA project will be discussed in the talk.

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Collaboration / Activity:

KM3NeT Collaboration

T10: Searches for New Physics / 833

Dark-SUSY channels to study muon reconstruction performance at the Muon Collider

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In the context of simulation and reconstruction for the Muon Collider, muon reconstruction efficiency has been evaluated to explore the potential for the study of dark-SUSY channels. In dark-SUSY models, supersymmetric particles act as a portal between Standard Model particles and the dark sector. In this analysis, the lightest Minimal Supersymmetric Standard Model neutralino decays, on one hand, directly in a dark photon or, on the other hand, in two dark photons through a dark Higgs boson. A muon pair, with kinematics driven by photon mass, is then expected from each dark photon. Therefore, the final state is characterized by four muons in one channel and eight muons in the other. Preliminary results of the muon reconstruction performance are shown for a possible range of neutralino and dark photon masses at a centre of mass energy of 3 TeV for the time being without the effects of the machine Beam-induced Background.

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Collaboration / Activity:

Muon Collider

T13 - Accelerator for HEP / 834

Measurement of the muon precession frequency in magnetic field for the measurement of the muon magnetic anomaly

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The FNAL Muon g-2 collaboration has performed a measurement of the muon magnetic anomaly to 0.46 ppm, based on the ratio between the observed spin precession frequencies of orbiting positive muons to protons at rest in the same magnetic field. We describe how the muon precession frequency has been measured by fitting the modulation of the rate of high energy positrons detected by the experiment calorimeters. The muon precession measurement has been performed in a blind way, with 11 analyses performed by 6 independent groups, employing comprehensive fit models with up to 25 fit parameters. Additional studies have been completed to estimate several systematic uncertainties due to the detector response. statistical uncertainty of 0.43 ppm has been obtained using about 8.2 billion muon decays recorded at FNAL in 2018, while the systematic uncertainty has been estimated to be 0.06 ppm.

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Collaboration / Activity:

FNAL Muon g-2

T03: Dark Matter / 835

A superconductive axion search experiment

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We propose a new experiment to search for axions in the 30 μeV regime using superconductive cavities in a strong magnetic field. Axions are hypothetical particles that could solve the well known strong CP problem in the standard model of particle physics. Furthermore axions could explain the dark matter content of the universe. Axions are expected to convert to photons in the presence of a strong magnetic field, where the photon frequency depends on the axions mass. For wavelengths in the microwave regime resonators are typically used to enhance the axion signal. In contrast to existing experiments we propose to use a superconducting radio frequency cavity with high quality factor for the first time. In cooperation with the RADES collaboration we plan to setup the experiment within the year. With this innovative approach and by using an existing 14T magnet, the largely unexplored mass region between 20 μeV to 40 μeV could eventually be studied with unprecedented sensitivity.

This talk will present the proposed experiment and its estimated sensitivity in comparison to existing RF cavity based axion search experiments, highlighting the anticipated challenges.

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Collaboration / Activity:

none

T01: Astroparticle and Gravitational Waves / 837

Impact of operators interferences in dark matter direct detection

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The non-relativistic effective theory of WIMP-nucleon interactions depends on 28 coupling strengths. Due to the vast parameter space of the effective theory, most direct detection experiments interpret the results of their searches assuming that only one of the coupling strengths is non-zero. On the other hand, dark matter models generically lead in the non-relativistic limit to several interactions which interfere with one another, therefore, the published limits cannot be straightforwardly applied to model predictions. We present a method to determine a rigorous upper limit on the WIMP-nucleon interaction strength including all possible interferences among operators. We illustrate the method using the null search results from the XENON1T and the PICO collaborations; for some interactions, the limits on the coupling strengths are relaxed up to one order of magnitude. We also present a method that allows to combine the results from different experiments, thus exploiting the synergy between different targets in exploring the parameter space of WIMP-nucleon interactions.

Collaboration / Activity:

TUM, MPP

First author:

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T12: Detector R&D and Data Handling / 838

Muon reconstruction performance and detector-design considerations for a Muon Collider

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A muon collider has a great potential for particle physics giving the possibility to reach the high center-of-mass energy and luminosity of hadron colliders, with a greatly reduced pile up effect.

However, a series of challenges arise mainly from the short muon lifetime and the Beam-induced Background. A complete simulation,based on CLIC's ILCSoft software, is ongoing to understand the performance of the full detector. Concerning the muon system, the iron yoke plates are meant to be instrumented with layers of track sensitive chamber to enhance the muon identification. At the moment, according to CLIC geometry, glass Resistive Plate Chambers with readout cells of 30x30 mm^2 have been adopted both for the barrel and the endcap region. Other possible solutions,based on MicroPattern Gaseous Detectors, will be discussed considering their characteristics and performance.
The results of a preliminary study investigating the muon reconstruction efficiency, Beam-induced Background sensitivity and background mitigation are presented for muon beams collisions at a center-of-mass energy of 1.5 TeV.

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Collaboration / Activity:

Muon Collider

T14: Outreach, Education and Diversity / 839

Make it matter: How to foster interest in particle physics by setting it in meaningful contexts

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Particle physics seems to be abstract and far away from high-school students'daily life. However, research in particle physics is not only relevant for scientists. Technologies developed at CERN have numerous applications, e.g., contributions to cancer therapy in medicine, contributions to art authentication and restoring in cultural heritage, and many others. In short, the fundamental principles of particle physics and its applications are relevant. Experiences in outreach settings show that they are also interesting for high-school students. Yet, there is no solid evidence for high-school students' interest in particle physics.
Fostering interest in physics among high-school students is crucial since it plays an important role in their course and career choices (Blankenburg, Höffler, & Parchmann, 2016). In education research, "*interest*" is defined as the "*subjective value attached to knowledge about an object*" (Krapp & Prenzel, 2011). When investigating high-school students'interest in science, previous studies focused on four aspects: interesting a) contents (e.g., optics), b) contexts (e.g., biological), c) tasks (e.g., conduct an experiment), and d) learning environments (e.g., school). Previous studies agree that when trying to foster interest, the context has a greater influence than the content, task, or learning environment (Häußler, Lehrke, & Hoffmann, 1998; Sjøberg & Schreiner, 2012).
However, since students differ in their preferences, they can be categorized into different interest types (Häußler et al., 1998). When investigating these interest types, previous studies mainly focused on gender differences (Häußler et al., 1998; OECD, 2016; Sjøberg & Schreiner, 2012). For example, girls show a lower interest in the content "*Motion and forces*" than boys (OECD, 2016). However, there are a few contents (e.g., "*The Universe and its history*" (OECD, 2016)) and contexts (e.g., "*The possibility of life outside earth*" (Sjøberg & Schreiner, 2012), or "*The human body*" (Häußler et al.,

1998)) that are extremely and equally interesting for all types of students.
One limitation of previous studies is that they did not include modern physics contents such as particle physics, which might be particularly interesting for all students.
In the framework of a PhD project at CERN, a new study examines which contents and contexts arouse interest in particle physics among today's high-school students. The aim of the project is to identify different types of interest in particle physics while considering clustering variables beyond gender. Moreover, different contexts are compared in order to identify the ones that are equally interesting for all types of students.
The research is conducted in the framework of "*S'Cool LAB*", CERN's Physics Education Research facility. High-school students and teachers contribute to research projects by taking part in different on-site or online learning activities. Typically, they are focused on a particular particle physics content set in different contexts. For example, the X-ray workshop is currently set in the contexts "*Medicine*" (x-ray images), "*Health*" (food irradiation for conservation), and "*Technology*" (airport security).
This contribution introduces the first findings of the interest study. Moreover, recommendations will be given to adapt or create learning activities according to the most promising contexts.

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Sjøberg, S., & Schreiner, C. (2012). Results and Perspectives from the ROSE Project: Attitudinal aspects of young people and science in a comparative perspective. In *Science Education Research and Practice in Europe* (pp. 203-236): Brill Sense.

Collaboration / Activity:

CERN, IR-ECO-TSP

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T09: Higgs Physics / 840

Higgs and double Higgs production at CLIC e+e- energies up to 3 TeV

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The Compact Linear Collider (CLIC) is a mature option for a future electron-positron collider operating at centre-of-mass energies of up to 3 TeV. CLIC would be built and operated in a staged approach with three centre-of-mass energy stages currently assumed to be 380 GeV, 1.5 TeV, and 3 TeV. This presentation provides a full overview of the CLIC Higgs physics potential in both the Higgsstrahlung (e+e- => ZH) and vector-boson fusion (e+e- => Hnunu) production modes at the three CLIC stages. The studies have been performed in full simulation. Latest results include Higgstrahlung at the highest energy, which is of particular interest as contributions from BSM effects to this process grow with energy. Ongoing studies of the Higgs branching ratio to photons at 3 TeV, as wells as ZZ* decay at various energies will also be included. The presentation includes latest results on the extraction of the Higgs self-coupling from double Higgs production at 1.5 TeV and 3 TeV. The Higgs self-coupling is of particular interest for determining the shape of the Higgs potential and for its sensitivity to a variety of BSM physics scenarios. At the higher-energy stages CLIC will produce Higgs boson pairs both via double Higgsstrahlung and via vector-boson fusion. Measurements of these processes lead to a determination of the Higgs self-coupling with a precision around 10%.

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Collaboration / Activity:

CLICdp collaboration

T12: Detector R&D and Data Handling / 841

Design a calorimeter system for the Muon Collider experiment

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A muon collider is being proposed as a next generation facility. This collider would have unique advantages, since clean events as in electron-positron colliders are possible, and high collision energy as in hadron colliders could be reached due to negligible beam radiation losses. The beam-induced background, produced by the muon decays in the beams and subsequent interactions, reaches the interaction region and the detectors and presents unique features and challenges with respect to other machines. As an example, a diffused flux of photons and neutrons passes through the calorimeter system, which thus requires a design to avoid this substantial background. In this talk an overview of the calorimetry at the Muon Collider is given, with a particular focus on the reconstruction and measurement of hadronic jets, that are studied with the full simulation of the detector. R&D for new calorimeter technologies, developed specifically for the Muon Collider, will be also presented.

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Collaboration / Activity:

Muon Collider

T04: Neutrino Physics / 842

The Electron Capture in ^{163}Ho experiment - ECHo

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The Electron Capture in ^{163}Ho experiment, ECHo, is a running experiment for the determination of the neutrino mass scale via the analysis of the end point region of the ^{163}Ho electron capture spectrum. In the first phase, ECHo-1k, about 60 MMCs pixels enclosing ^{163}Ho ions for an activity of about 1Bq per pixel have been operated for several months. The goal of this first phase is to reach a sensitivity on the effective electron neutrino mass below 20 eV/c^2 by the analysis of a ^{163}Ho spectrum with more than 10^8 events. We discuss the characterization of the single pixel performance and the stability over the measuring period. Results from the analysis of the acquired data will be presented with focus on data reduction efficiency and on the procedures to obtain the final high statistics spectrum. A preliminary analysis of the ^{163}Ho spectral shape will be described and the expected sensitivity on the effective electron neutrino mass, on the basis of the properties of the presented spectrum, will be discussed. In conclusion, we will present how the performance obtained by the MMC arrays used during the first phase of the ECHo experiment have led to the design of the MMC arrays for the second phase, ECHo-100K. In ECHo-100k about 12000 MMC pixels each hosting ^{163}Ho for an activity of 10 Bq will be simultaneously operated thanks to the microwave SQUID multiplexing readout. Operating these arrays for three years will allow for reaching a sensitivity on the electron neutrino mass at the 1 eV/c^2 level.

Collaboration / Activity:

ECHo Collaboration

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T07: Top and Electroweak Physics / 843

CP-violating Wtb anomalous couplings and top-quark decay process.

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We consider the top-pair production through pp annihilation, followed by the semileptonic decay of the top-quark. We study the new physics contributions to the Wtb vertex at the Large Hadron Collider. In particular, we estimate the limits on anomalous couplings for the pre-existing data of 13 TeV LHC energy with integrated luminosities of 36.1 fb^{-1} and 140 fb^{-1}. Prediction of limits on anomalous couplings for future hadron colliders, namely, HL-LHC, HE-LHC and FCC-hh is also discussed at the proposed luminosities. In addition, we construct CP-violating asymmetries to study the CP-violating effects arising due to Wtb vertex and give estimates on the sensitivity to CP-violating anomalous couplings.

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Collaboration / Activity:

T12: Detector R&D and Data Handling / 844

Combining Dual-Readout Crystals and Fibers in a Hybrid Calorimeter for the IDEA Experiment

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Crystal calorimetry has a long history of pushing the frontier of high energy resolution measurements for EM particles. Recent technological developments in the fields of crystal manufacturing and photodetector developments (SiPMs) have opened new perspectives on how a segmented crystal calorimeter with dual-readout capabilities could be exploited for particle detectors at future collider experiments. In this contribution, we will discuss how a EM crystal calorimeter can be cost-effectively integrated with the fiber-based calorimeter of the IDEA detector to achieve an energy resolution of $3\%/\sqrt{E}$ for EM particles and $27\%/\sqrt{E}$ for neutral hadrons. We will also show how the extension of the dual-readout method in such a longitudinally segmented hybrid calorimeter can achieve an energy resolution close to 5\% for 50 GeV jets and discuss the potential of such calorimeter in the context of future particle flow algorithms.

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Collaboration / Activity:

IDEA proto collaboration

T04: Neutrino Physics / 845

OSIRIS –An online scintillator radiopurity monitor for the JUNO experiment

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The Jiangmen Underground Neutrino Observatory (JUNO) currently under construction in China, will be the first multi-kton liquid scintillator detector and has a vast potential for new insights into several fields of neutrino and astroparticle physics. To reach its design sensitivity for detecting reactor and solar neutrinos, a radiopure liquid scintillator is required. For IBD measurements, a radiopurity of 10^{-15} g/g is needed for both ^{238}U and ^{232}Th, 10^{-16} g/g for solar measurements.

The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) allows an on-line radiopurity evaluation of the scintillator during the JUNO detector filling over several months. The design of OSIRIS is optimized for tagging ^{214}Bi-^{214}Po and ^{212}Bi-^{212}Po coincidence decays in the decay chains of ^{238}U and ^{232}Th, respectively. OSIRIS will also be able to monitor the ^{14}C and ^{210}Po levels in the scintillator.

To achieve its goals, OSIRIS features a 20 ton liquid scintillator target monitored by 76 intelligent photomultiplier tubes (iPMTs). In this novel design, each iPMT consists of a PMT and its readout electronics mounted on its back. Each hit causing these electronics to trigger is sent to the DAQ as a digitized PMT pulse. A single computer (EventBuilder) is sufficient to combine the data stream into events for further analysis.

For the timing and charge calibration of the detector, two optical systems (LED- and LASER-based) are employed. The energy and position calibration of OSIRIS is performed with height-adjustable radioactive sources within the liquid scintillator. These sources cover the crucial energy range for the detection of Bi-Po signals between 0.66 MeV to 2.5 MeV.

The general design of the OSIRIS detector and its subsystems is presented in this poster.

Collaboration / Activity:

JUNO / PhD student

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T12: Detector R&D and Data Handling / 846

CMS Tracker Alignment: Legacy results from LHC Run-II and Run-III prospects

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The inner tracking system of the CMS experiment, which comprise of Silicon Pixel and Silicon Strip detectors, is designed to provide a precise measurement of the momentum of charged particles and to reconstruct the primary and secondary vertices. The movements of the different substructures of the tracker detectors driven by the operating conditions during data taking, require to regularly update the detector geometry in order to accurately describe position, orientation, and curvature of the tracker modules.

The procedure in which new parameters of the tracker geometry are determined is known as alignment of the tracker. The alignment procedure is performed several times during data taking using reconstructed tracks from collisions and cosmic rays data, and later on, further refined after the data taking period is finished. The tracker alignment performance corresponding to the ultimate accuracy of the alignment calibration for the legacy reprocessing of the CMS Run-II data will be presented. The data-driven methods used to derive the alignment parameters and the set of validations that monitor the performance of physics observables after the alignment will be reviewed. Finally, the prospects for the alignment calibration during the upcoming run of the LHC, where more challenging operation conditions are expected, will be addressed.

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Collaboration / Activity:

CMS

T12: Detector R&D and Data Handling / 847

The Water Cherenkov Test Experiment at CERN

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Water Cherenkov detectors play a crucial role in the study of neutrinos, providing an affordable way to instrument enormous target masses. As neutrino experiments transition from discovery to precision measurement understanding the performance of these detectors becomes more and more important –in the latest T2K oscillation result the Super-Kamiokande detector uncertainty is the largest systematic error on the oscillated event samples. For the next generation experiments Hyper-Kamiokande, ESSnuSB and THEIA, a comprehensive understanding of the detector will be essential.

The Water Cherenkov Test Experiment (WCTE) is a proposed experiment at CERN that will study the response of water Cherenkov detectors to hadron, electron, and muon beams. The aim of the experiment is to test new photosensor technologies such as multi-PMT modules and apply calibration techniques with known particle fluxes to demonstrate a 1% level calibration for GeV scale neutrino interactions. WCTE will also measure Cherenkov light production, pion scattering and secondary neutron production to provide direct inputs to the currently operating T2K and Super-K experiments. This talk describes the WCTE physics program, the detector design and its proposed implementation at the CERN T9 test beam area.

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Collaboration / Activity:

WCTE Collaboration

T03: Dark Matter / 848

DRAKE: Dark matter Relic Abundance beyond Kinetic Equilibrium

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In the usual approach to the determination of the dark matter thermal relic abundance an assumption of local thermal equilibrium is made. In this talk I will discuss how to go beyond this assumption and introduce DRAKE —a numerical precision tool that can trace not only the DM relic density, but also its velocity dispersion and full phase space distribution function. I will review the general motivation for this approach and, for illustration, highlight three concrete classes of models where kinetic and chemical decoupling are intertwined in a way that can impact the value of the relic density by as much as an order of magnitude: i) dark matter annihilation via a narrow resonance, ii) Sommerfeld-enhanced annihilation and iii) 'forbidden' annihilation to final states that are kinematically inaccessible at threshold.

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Collaboration / Activity:

Theory

T03: Dark Matter / 849

Sterile neutrino dark matter in a U(1) extension of the standard model

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We explore the parameter space of a U(1) extension of the standard model — also called the super-weak model 1 — from the point of view of explaining the observed dark matter energy density in the Universe. The new particle spectrum contains a complex scalar singlet and three right-handed neutrinos, among which the lightest one is the dark matter candidate. We explore both freeze-in and freeze-out mechanisms of dark matter production. In both cases, we find regions in the plane of the super-weak coupling g_z versus the mass of the new gauge boson Z' that reproduce the measured dark matter densities. For freeze-out we need to exploit resonant annihilation of dark matter to standard model particles to evade strong constraints on the new gauge coupling. The parameter regions are distinct for the two scenarios and the one for freeze-out will be explored in searches for neutral gauge boson in the near future.

Talk based on:
S. Iwamoto, K. Seller and Z. Trócsányi, "Sterile neutrino dark matter in a U(1) extension of the standard model"[arXiv:2104.11248].

1 Z. Trócsányi, "Super-weak force and neutrino masses,"Symmetry **12** (2020) 107 [arXiv:1812.11189].

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Collaboration / Activity:

astro-particle phenomenology

T08: Flavour Physics and CP Violation / 850

Measurement of the very rare K^+→π^+ νν̄ decay with the NA62 Experiment at CERN

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The decay K^+→π^+ νν̄, with a very precisely predicted branching ratio of less than 〖10〗^(-10), is among the best processes to reveal indirect effects of new physics. The NA62 experiment at CERN SPS is designed to study the K^+→π^+ νν̄ decay and to measure its branching ratio using a decay-in-flight technique. NA62 took data in 2016, 2017 and 2018, reaching the sensitivity of the Standard Model for K^+→π^+ νν̄ by the analysis of the 2016 and 2017 data, and providing the most precise measurement of the branching ratio to date by the analysis of the 2018 data. This measurement is also used to set limits on the branching ratio of a possible K^+→π^+ X decay, where X is a scalar or pseudo-scalar particle. The final result of the K^+→π^+ νν̄ branching ratio measurement and its interpretation in terms of K^+→π^+ X decay from the analysis of the full 2016-2017-2018 data set is presented, and future plans and prospects reviewed.

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Collaboration / Activity:

T10: Searches for New Physics / 851

Analysing Higgs Boson in a flavor violating CMSSM through information theory

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Co-author: Sudhir Kumar Gupta [1]

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Flavor violation in the top sector allows an extra few GeV contribution to the Higgs mass and thereby could reduce the SUSY breaking scale to remain within a few TeV. In this talk we discuss our findings of a detailed investigation on the CMSSM parameter scan particularly in the context of the LHC Higgs observation using the information-theoretic approach and will demonstrate its impact on sparticle masses.

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Collaboration / Activity:

Sudhir Kumar Gupta

T01: Astroparticle and Gravitational Waves / 852

Methods and results on the search for gravitational wave echoes in the post-merger phase after binary black hole coalescences.

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The current Gravitational Wave (GW) surveys of Binary Black Hole (BBH) mergers provide unprecedented probes of the dynamics in extreme gravitational fields and relativistic velocities. It has been proposed that these Compact Objects may have exotic characteristics making them be different from simpler Black Holes (BHs): they would produce repeated GW pulses of widely uncertain morphology (echoes) in the post-merger phase.
We will present a method for searching echoes that is agnostic to the properties of the GW pulses and discuss its discovery potential in terms of echoes' strength. The method is based on a dedicated version of coherentWaveBurst (cWB), an unmodelled GW transient search algorithm, developed in LVC and widely used on LIGO-Virgo-KAGRA data.
The performances in terms of detection and estimation of echoes' characteristics have been investigated on actual data from past LIGO-Virgo observing runs (O1 and O2) by injecting a large set of simulated signals.
Moreover, we will present the new upper limits in echoes detection set by this search on LIGO-Virgo open data and open catalogs of detected CBC.

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Collaboration / Activity:

Virgo - LIGO

T12: Detector R&D and Data Handling / 853

IDEA Dual-Readout Calorimeter Simulation - Status and Plans

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The IDEA Experiment envisaged at future e^+e^- circular colliders (FCCee and CEPC) is currently under design and optimization with dedicated full-simulation investigations. In this talk, we review the main challenges and goals of designing the IDEA fully-projective fiber-based dual-readout calorimeter using the GEANT4 toolkit. Particular attention will be given to geometry design, very-high time-consuming processes, and readout-electronics simulation. Finally, the possibility to store an unprecedented amount of calorimetric information within a new event data model using the EDM4HEP toolkit will be discussed.

Collaboration / Activity:

IDEA proto collaboration

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T12: Detector R&D and Data Handling / 855

Dark matter search for the medical physics: the 3DPi project.

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Detectors filled with noble liquids represent an outstanding technology for the direct dark matter search, both in terms of the radiopurity and the high sensitivity to low energy signals, due to the high scintillation yield. For instance, this allowed the set of the most stringent exclusion limits for WIMPs below 10 GeV/c^{2} with only 50 kg of liquid argon, as done by DarkSide-50 collaboration in 2018. In the next years, the relative cheapness of the argon will allow for a straightforward scaling at high masses, up to 50 tons with DarkSide-20k. In these future detectors, the vacuum technology will be exchanged for the solid-state one; in DarkSide-20k the photodetection will be performed by ~ 80 thousand silicon photomultipliers (SiPMs).
All the R&D employed for the next DarkSide detectors has also converged in medical physics, specifically into the 3DPi project. The project aims to realize the first Time-Of-Flight Positron Emission Tomography (TOF-PET) scanner in liquid argon. The scanner will consist of a cylindrical cryostat fully surrounding the patient, filled with liquid Argon doped with Xenon, in order to suppress the liquid argon triplet state and guarantee a scintillation time of O(10) ns. The scintillation light will be observed by Silicon Photomultipliers, custom-designed by Fondazione Bruno Kessler, who has also developed the photosensor for DarkSide future detectors. The high availability of the argon will allow the build of total body scanners, usually prohibitive in commercial TOF-PET scanners due to the high cost of crystals. In fact, according to the Monte Carlo simulations, the 3DPi scanner will present a 200-fold increase in sensitivity, spatial resolutions comparable to commercial PET scanners and reduce the scanning time from 30 minutes down to less than one minute. Moreover, the Cherenkov light from ionized electrons might further improve the spatial resolution, with the eventual possibility to perform low dose scannings, fundamental for children and pregnant. The 3DPi is the main outcome in the daily life of the DarkSide dark matter search, as it will make the PET scanning available to a much wider range of patients and hospitals.

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Collaboration / Activity:

3DPi

T04: Neutrino Physics / 856

Exploring Long-Range Force of $L_\mu - L_\tau$ Symmetry using Atmospheric Neutrino Experiment

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Flavor-dependent long-range leptonic force mediated by an ultralight and neutral gauge boson Z' associated with $L_\mu - L_\tau$ symmetry constitutes a minimal extension of the Standard Model. We study the physical consequences of such long-range force in the oscillation of terrestrial neutrinos, particularly in ν_μ survival channel. We show that the proposed atmospheric neutrino detector ICAL will be able to put tight constraints on such long-range force due to its capabilities of detecting neutrino and antineutrino separately with wide ranges of energies and baselines. The expected upper limit on the fine structure constant of this long-range force at 3σ is 2.82×10^{-51} using 500 kt·yr exposure of ICAL. We also study the possible impact of the long-range force in the expected measurement of mass ordering at the ICAL in detail.

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Collaboration / Activity:

INO, ICAL

T09: Higgs Physics / 858

Large triple Higgs couplings in the 2HDM

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An important task at future colliders is the investigation of the Higgs-boson sector. Within the framework of the CP conserving Two Higgs Doublet Models (2HDM) type I and II we investigate the allowed ranges for all triple Higgs couplings involving at least one light, SM-like Higgs boson. We will define and explore some benchmark planes that show large values of triple Higgs couplings, still in agreement with all the relevant theoretical and experimental constraints. We find that the SM-type triple Higgs coupling w.r.t. its SM value, $\kappa_\lambda := \lambda_{hhh}/\lambda_{\rm SM}$, can range between ~ -0.5 and ~ 1.5 in type I and between ~ 0 and ~ 1 in type II. We find the coupling λ_{hhH} between $\sim \pm 1.5$ and triple Higgs couplings involving two heavy Higgs bosons, λ_{hHH}, λ_{hAA} and $\lambda_{hH^+H^-}$ can reach values up to $O(10)$, roughly independent of the 2HDM type. Finally, we will comment on the possible phenomenological consequences of this results, focusing on double Higgs production in future e^+e^- colliders.

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Collaboration / Activity:

Higgs physics and BSM physics.

T13 - Accelerator for HEP / 860

The challenges of beam polarization and sub-MeV scale center-of-mass energy calibration at the FCC-ee

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The capability to determine the FCC-ee centre-of-mass energies (ECM) at the ppm level using resonant depolarization (RD) of the beams is essential for the Z line shape measurements, the W mass and the possible observation of the Higgs boson s-channel production.
A first analysis (arXiv:1909.12245) demonstrated the feasibility of this programme for the runs at the Z pole and at the W pair threshold, conditional to careful preparation and a number of further developments. These results are recalled. The particular energy monitoring issues related to the possible run at ECM = mHiggs are considered for the first time. Upcoming challenges towards the ESPP-recommended feasibility study are presented.

Collaboration / Activity:

FCC-ee

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T04: Neutrino Physics / 861

Model-independent test of T violation in neutrino oscillations

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As a function of the baseline L, neutrino oscillation probabilities are linear combinations of $\sin^2(\omega L)$ and $\sin(2\omega L)$, with oscillation frequencies ω that depend on the neutrino energy. Even though the frequencies depend on the oscillation model, in general the presence of L-odd terms in the probability requires the existence of Time Reversal Violation. We propose a χ^2 test of T violation based on fitting oscillation data at a given energy to the functional form of the oscillation probability P(L) with and without the L-odd terms. A large $\Delta\chi^2$ between these two cases would show that L-odd terms are necessary to describe the data, and thus signal the presence of T violation. We use expected number of events at compatible energies in future accelerator neutrino experiments to illustrate that such a test can be applied at planned next-generation experiments. This allows to search for T violation in a largely model independent way, since the argument applies to a wide class of beyond-standard model scenarios.

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Collaboration / Activity:

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T09: Higgs Physics / 862

Prospects for the measurement of σH x BR(H → μμ) at a 3-TeV muon collider

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Co-authors: Chiara Aimè [4]; Paolo Andreetto [5]; Laura Buonincontri [5]; Alessio Gianelle [5]; Sergo Jindariani [6]; Donatella Lucchesi [5]; Nazar Bartosik [7]; Simone Pagan Griso [8]; Nadia Pastrone [9]; Cristina Riccardi [10]; Paola Salvini [11]; Lorenzo Sestini [5]; Ilaria Vai [12]; Anna Colaleo [13]; Angela Zaza [13]; Paola Mastrapasqua [13]; Rosamaria Venditti [13]

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Among the projects currently under study for the next generation of particle accelerators, the muon collider represents a unique machine, which has the capability to provide leptonic collisions at energies of several TeV. The multi-TeV energy regime is as yet unexplored and holds a huge physical potential that will enable a novel research programme ranging from high precision measurements of known standard model processes to high-sensitivity searches for phenomena beyond the standard model. A multi-TeV muon collider will produce huge samples of Higgs bosons that will allow a precise determination of the Higgs boson properties, like its couplings to fermions and bosons and its trilinear and quartic self-couplings with unprecedented precision.
This contribution will present an estimate of the muon collider reach on the production of the process H ⟶ μμ, one of the rarest Higgs boson decays that represents a gateway to the determination of the Higgs boson coupling to the second generation leptons.

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Collaboration / Activity:

Muon Collider

T13 - Accelerator for HEP / 863

Preparing the ILC accelerator project - an International Pre-Lab

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The International Linear Collider (ILC) is a superconducting e^+e^- collider with a centre-of-mass energy of 250GeV, upgradeable in in energy to 500GeV and beyond, and in luminosity by factors of 2 to 4. At 250GeV, it will run as a Higgs factory, the worldwide top priority in future HEP projects. It will be located in the Kitakami mountains in Japan's Tohoku (northwest) region.

In 2020, the International Development Team (ITD) hosted by KEK has been established by ICFA to plan the Preparatory Laboratory (Pre-Lab) for a start in 2022. The Pre-Lab will coordinate further R&D work of critical items and prepare the actual construction of the ILC, with a target to be ready for construction in 2026, and first physics by 2035.

After briefly recalling the ILC accelerator concept we report on the Engineering Design plans for the Pre-Lab phase, and the Technical Preparation plan, which focusses on superconducting technology and nanobeams, plus further R&D on sources, in particular the positron source, and dumps. The status of the International planning for the technical work contained within the Pre-Lab phase will be summarised.

Collaboration / Activity:

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T08: Flavour Physics and CP Violation / 864

New physics analysis of some $b-$baryon decays

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Measurements in the $b \to c\tau^-\overline{\nu}_\tau$ transitions suggest violation of lepton flavor universality. Assuming the flavor anomalies are due to new physics (NP) beyond the Standard Model (SM), we analyse the semileptonic decays of some heavy b-baryons to c-baryons, $B_b \to B_c\tau^-\overline{\nu}_\tau$, which are mediated by $b \to c\tau^-\overline{\nu}_\tau$ transitions. Using a general effective Hamiltonian which includes both SM and NP contributions, we study and discuss the effects of the new contributions on the semileptonic q^2 spectra, such as the differential branching fraction, ratio of branching fractions and forward-backward asymmetry of the charged lepton in various new physics scenarios.

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T10: Searches for New Physics / 865

The HighNESS Project and Future Free Neutron Oscillations Searches at the ESS

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The European Spallation Source ESS, presently under construction, in Lund, Sweden, is a multidisciplinary international laboratory. It will operate the world's most powerful pulsed neutron source. Taking advantage of the unique potential of the ESS, the NNBAR collaboration proposed a two-stage program of experiments to perform high precision searches for neutron conversion in a range of baryon number violation (BNV) channels culminating in an ultimate sensitivity increase for $n \to \bar{n}$ oscillations of three orders of magnitude over the previously attained limit obtained at the Institut Laue-Langevin ILL.
The first stage of this program HIBEAM (High Intensity Baryon Extraction and Measurement) will employ the fundamental physics beamline during the first phase of the ESS operation. This stage focuses principally on searches for neutron conversion to sterile neutrons n' that would belong to a

"dark" sector.
The second stage, NNBAR, will exploit a large beam port, specifically designed in the ESS target station monolith for this experiment, to deliver the maximum possible neutron flux and search directly for $n \to \bar{n}$ oscillations.
Supported by a 3 MEuro Research and Innovation Action within the EU Horizon 2020 program, a design study (HighNESS) is now underway for the design of the ESS second neutron source which will be optimized in order to boost the performance of the NNBAR experiment.
This talk will focus on the HighNESS program and the ongoing developments in the NNBAR collaboration.

Collaboration / Activity:

NNBAR/HIBEAM Collaboration

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T10: Searches for New Physics / 866

Precise LHC limits on the U_1 leptoquark parameter space

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The U_1 leptoquark is the popular candidate to explain the persistent ⊠-anomalies. In this talk, I will discuss the bounds which can be imposed on a U_1 leptoquark model using the latest LHC data. The current LHC data is quite sensitive towards the mass of U_1 and its couplings with the Standard Model second and third-generation fermions. I will discuss some simple scenarios with different couplings that can contribute to the relevant operators and show that the LHC data either rule out or severely constrain these simple U_1 scenarios. I will discuss how a TeV range U_1 can survive the LHC limits (from both dilepton and direct search data) and explain the anomalies. I will also point out some search channels for U_1.

Collaboration / Activity:

N.A

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T12: Detector R&D and Data Handling / 868

The Key4hep turnkey software stack for future colliders

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Detector optimisation and physics performance studies are an integral part for the development of future collider experiments.
The Key4hep project aims at providing a common stack of easy to use software tools for future, or even present, High Energy Physics projects. Key4hep is to a large extent based on software tools that are already very actively used in the community like ROOT, Geant4 and DD4hep or those that are currently under active development like EDM4hep or ACTS. The Key4hep project is, among others, supported by the HEP Software Foundation, CERN, DESY and the AIDAinnova project and has active developers from all large future collider projects: CEPC, CLIC, FCC, and ILC.
In this talk we present an overview on the Key4hep project and describe the ongoing adaptation processes of the different future experiments, thereby showing that Key4hep is a viable long term solution as baseline software for high energy experiments that will facilitate the scientific exchange between these communities in the coming years.

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Collaboration / Activity:

ILC

T08: Flavour Physics and CP Violation / 869

Interplay between dineutrino modes with semileptonic decays

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$SU(2)_L$-invariance links charged dilepton $\bar{q}\,q'\,\bar{\ell}\,\ell$ and dineutrino $\bar{q}\,q'\,\bar{\nu}\,\nu$ couplings. This connection can be established using SMEFT and holds if only SM-like left-handed light neutrinos are present. It allows to perform complementary experimental tests of lepton universality and charged lepton flavor conservation with flavor-summed dineutrino observables. The phenomenological implications are discussed in detail for the branching ratios of rare charm decays $c \to u\,\nu\bar{\nu}$, such as $D^+ \to \pi^+\,\nu\bar{\nu}$, and rare B decays $b \to q\,\nu\bar{\nu}$ with $q = d, s$ decays.

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T13 - Accelerator for HEP / 871

Status and perspectives of the ILC and CLIC studies

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A Higgs factory is considered the highest-priority next collider in the EPPSU 2020 strategy update. Two linear colliders projects, the International Linear Collider (ILC) and the Compact Linear Collider (CLIC), currently under study are among the candidates being considered. Although the linacs accelerating the particles use different RF technologies they share similar challenges, for example related to nanobeams, injectors and positron production. The talk will summarize recent developments and the current status of the two projects, including their baselines parameters, on-going technology and performance studies, near future plans and international planning.

Collaboration / Activity:

HEP colliders

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T08: Flavour Physics and CP Violation / 872

Finite-Width Effects in Three-Body B Decays

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It is customary to apply the so-called narrow width approximation $\Gamma(B \to RP_3 \to P_1P_2P_3) = \Gamma(B \to RP_3) calB(R \to P_1P_2)$ to extract the branching fraction of the quasi-two-body decay $B \to RP_3$, with R and P_3 being an intermediate resonant state and a pseudoscalar meson, respectively. However, the above factorization is valid only in the zero width limit. We consider a correction parameter η_R from finite width effects. Our main results are:
(i) We present a general framework for computing η_R and show that it can be expressed in terms of the normalized differential rate and determined by its value at the resonance.
(ii) We evaluate η_R in the theoretical framework of QCD factorization (QCDF) and in the experimental parameterization (EXPP) for three-body decay amplitudes.In general, $\eta_R^{\rm QCDF}$ and $\eta_R^{\rm EXPP}$ are similar for vector mesons, but different for tensor and scalar resonances. A study of the differential rates enables us to understand the origin of their differences.
(iii) Finite-width corrections to $calB(B^- \to RP)_{\rm NWA}$ obtained in the narrow width approximation are generally small, less than 10\%, but they are prominent in $B^- \to \sigma/f_0(500)\pi^-$ and $B^- \to \overline{K}_0^{*0}(1430)\pi^-$ decays. The EXPP of the normalized differential rates should be contrasted with the theoretical predictions from QCDF calculation as the latter properly takes into account the energy dependence in weak decay amplitudes.
(iv) It is common to use the Gounaris-Sakurai model to describe the line shape of the broad $\rho(770)$ resonance. After including finite-width effects, the PDG value of $calB(B^- \to \rho\pi^-) = (8.3 \pm 1.2) \times 10^{-6}$ should be corrected to $(7.9 \pm 1.1) \times 10^{-6}$ in EXPP and $(7.7 \pm 1.1) \times 10^{-6}$ in QCDF.
(v) For the very broad $\sigma/f_0(500)$ scalar resonance, we use a simple pole model to describe its line shape and find a very large width effect: $\eta_\sigma^{\rm QCDF} \sim 2.15$ and $\eta_\sigma^{\rm EXPP} \sim 1.64$. Consequently, $B^- \to \sigma\pi^-$ has a large branching fraction of order 10^{-5}.
(vi) We employ the Breit-Wigner line shape to describe the production of $K_0^*(1430)$ in three-body

B decays and find large off-shell effects. The smallness of $\eta^{\mathrm{QCDF}}_{K^*_0}$ relative to $\eta^{\mathrm{EXPP}}_{K^*_0}$ is ascribed to the differences in the normalized differential rates off the resonance.

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Collaboration / Activity:

Chung Yuan Christian Universit

T14: Outreach, Education and Diversity / 873

creative approach to engage on scientific topics –Cultural Collisions Online

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We present the results of a first cycle of the unique Cultural Collisions programme run entirely online over one school year 2020/2021 in the South East Europe region. Cultural Collisions is a novel cross-disciplinary science engagement, networking and education programme designed to stimulate the interest of high school students in science by introducing the methods and concepts of art and creativity into their standard science studies. It is based on a unique collaboration of international, national and local partners (scientists, artists and educators), using modern communication tools which in particular facilitate the participation of in city base or rural communities. It provides access to and is supported by science centres and museums through workshops and exhibitions. Cultural Collisions Bosnia and Herzegovina has brought together 11 working groups in 6 different Bosnian cities and has been run entirely online. During a whole school year, a total of 130 students participated in workshops and 556 in complementary events, including virtual visits and public lectures. They were supported by a unique collaboration of their teachers, local artists, local and international scientists, and demonstrated strong interest and enthusiastic engagement. Their commitment and efforts have resulted in an enhancement of their skills, an improved understanding of big science questions, scientific methodology, and an enhanced ability to discover creative solutions to complex problems. Furthermore, the programme demonstrates that the creative approach to engage on scientific topics encourages an increase in the participation of girls. The program is organized by ORIGIN/CMS following the Cultural Collisions methodology of previous successfully disseminated programs in Canada, Germany, Switzerland and Austria.

Collaboration / Activity:

CMS Education & Outreach

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T13 - Accelerator for HEP / 874

From ATF2 to ATF3: the quest for nanobeams and their stabilization

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The ATF2 Final Focus System (FFS) was designed as an energy-scaled version of the ILC FFS, with two main aims: (1) to demonstrate the effectiveness of the local chromaticity correction scheme for achieving an IP vertical beam size as small as 37 nm, and (2) to demonstrate the feasibility of beam orbit stabilization at the nanometer level. To date, an electron vertical beam size as small as 41 nm, essentially satisfying the ATF2 design goal, and stabilization with feedback latency as low as 150 ns, have been achieved. The ATF2 achievements have already verified the minimum technical feasibility of the ILC FFS. However, to maximize the luminosity potential of the ILC, a further investigation of the effects causing the intensity dependence of the IP spot size and optical aberrations, especially with smaller bx*, is crucial. To implement this program and based on the outstanding and unique results achieved by the ATF/ATF2 collaboration, plans for an upgraded beamline, ATF3, are being developed. We summarize the ATF2 results and present the R&D programme that could be pursued with the new ATF3 beamline.

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Collaboration / Activity:

ATF/ATF2 collaboration

T06: QCD and Hadronic Physics / 875

Measurement of 1-jettiness in deep-inelastic scattering at HERA

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A first measurement of the 1-jettiness event shape observable in neutral-current deep-inelastic electron-proton scattering is presented. The 1-jettiness observable τ_b^1 is defined such that it is equivalent to the thrust observable in the Breit frame, following momentum conservation. The data were taken with the H1 detector at the HERA ep collider at a center-of-mass energy of 319 GeV in the years 2003 to 2007 and correspond to an integrated luminosity of about 351pb^{-1}. The triple-differential cross sections are presented as a function of the 1-jettiness τ_b^1, the event virtuality Q^2 and the Bjorken-variable x_{Bj} in the kinematic region $Q^2 > 150$\,GeV^2. The data have high sensitivity to the parton

distribution functions of the proton, the strong coupling constant and to resummation and hadronisation effects. The data are compared to selected predictions.

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Collaboration / Activity:

H1 collaboration

T06: QCD and Hadronic Physics / 876

The Electroweak Hamiltonian in the Gradient Flow Formalism

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Over the last decade, the gradient flow formalism became an important tool for lattice simulations of Quantum Chromodynamics. Most prominently, scale setting strategies based on the gradient flow superseded previous strategies. Moreover, the gradient flow offers remarkable renormalization properties which pave the way for cross-fertilization between perturbative and lattice calculations. In this talk we introduce the gradient flow formalism and outline the perturbative approach. Employing the flowed operator product expansion, we construct the flowed equivalents of the current-current operators of the electroweak Hamiltonian. They allow for simpler transformations between lattice and perturbative schemes and might reduce the uncertainties of theoretical predictions for low-energy flavor observables.

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Collaboration / Activity:

no collaboration

T06: QCD and Hadronic Physics / 879

First inverse moment of the doubly-heavy baryon distribution amplitude from HQET sum rule

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Heavy-quark symmetry (HQS), despite being approximate, allows to relate dynamically many hadron systems.In the HQS-limit doubly-heavy baryons, whose dynamics is determined by a light quark moving in a color field of a static pair of heavy quarks, are similar to heavy mesons with a heavy antiquark being a color source. Non-local interpolation currents are introduced and corresponding matrix elements between the baryon and vacuum state are expressed in terms of light-cone distribution amplitudes. As well known, the first inverse moment of the leading twist B-meson distribution amplitude (DA) is a very important hadronic parameter needed for an accurate theoretical description of B-meson exclusive decays. It is quite natural that a similar moment of doubly-heavy baryons is of importance in exclusive doubly-heavy baryons' decays. We obtain HQET sum rules for the first inverse moment based on the correlation functions containing nonlocal heavy-light operators of doubly-heavy baryons and their local interpolating currents. First estimates of this moment are presented.

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Collaboration / Activity:

Theory

T05: Heavy Ion Physics / 880

Recent LHCb results on charm in the QCD medium

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With full particle ID, precision tracking, and calorimetry, the LHCb detector is able to measure prompt and non-prompt charm production through a variety of decay channels at forward rapidity. These unique abilities allow LHCb to study a wide range of exotic and conventional open and hidden charm states and their interactions in the QCD medium. Here we will discuss recent LHCb results on charm production in pp and pPb collisions, including the first results on chi_c production in nuclear collisions at the LHC, and compare the results with various theoretical models.

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Collaboration / Activity:

LHCb

T01: Astroparticle and Gravitational Waves / 883

GW170817 and AT2017gfo: Multi-messenger Bayesian analysis and constraints on neutron star equation of state

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The joint detection of the gravitational wave GW170817, of the short γ-ray burst GRB170817A and of the kilonova AT2017gfo, generated by the the binary neutron star merger observed on August 17, 2017, is a milestone in multimessenger astronomy and provides new constraints on the neutron star equation of state. Employing a novel specialized pipeline, we perform Bayesian inference on GW170817 and its kilonova counterpart AT2017gfo. GW170817 is analyzed using effective-one-body, phenomenological and post-Newtonian models with different cutoff-frequencies of 1024Hz and 2048Hz. We find that the former choice minimizes systematics on the reduced tidal parameter, while a larger amount of tidal information is gained with the latter choice. We study AT2017gfo using semi-analytical, multi-components models that also account for non-spherical ejecta. Observational data favor anisotropic geometries to spherically symmetric profiles and favor multi-component models against single-component ones. Using the dynamical ejecta parameters inferred from the best-fitting model and numerical-relativity relations connecting the ejecta properties to the binary properties, we constrain the binary mass ratio and the reduced tidal parameter. Finally, we combine the predictions from AT2017gfo with those from GW170817, constraining the radius of a neutron star of 1.4 $M_{\odot}$ to 12.2±0.5 km (1σ level).

Collaboration / Activity:

FSUJena+Virgo/Data analysis

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T06: QCD and Hadronic Physics / 884

Charged hadron production at LHCb

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With a unique geometry covering the forward rapidity region, the LHCb detector provides unprecedented kinematic coverage at low x for charged particles in hadron collisions. The excellent momentum resolution, vertex reconstruction, and particle identification allows precision measurements down to very low pT. This talk will present recent LHCb measurements of prompt charged hadron production in proton-proton and proton-lead collisions. Comparisons with various event generators and nPDF calculations are discussed.

Collaboration / Activity:

LHCb

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T05: Heavy Ion Physics / 886

First LHCb results from PbPb collisions at 5.02 TeV

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The LHCb detector is a full spectrometer at forward rapidity covering a pseudorapidity range of 2<eta<5. With its excellent vertex resolution, particle identification and tracking capability, the LHCb is able to perform precision measurements down to very low transverse momentum. We present first LHCb results on heavy flavor in lead-lead collisions at 5.02 TeV, including photoproduction of J/psi mesons in peripheral and ultra-peripheral collisions, and prompt open charm production, using the datasets collected during 2015 and 2018.

Collaboration / Activity:

LHCb

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T09: Higgs Physics / 887

Higgs boson couplings at muon collider

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Muon collisions at multi-TeV center of mass energies are ideal for studying Higgs boson properties. At these energies the production rates will allow precise measurements of its couplings to fermions and bosons. In addition the double Higgs boson production rate could be sufficiently high to directly measure the parameters of trilinear self-couplings, giving access to the determination of the Higgs potential.
This contribution aims to give an overview of the results that have been obtained so far on Higgs couplings by studying the $\mu^+\mu^- \rightarrow H\nu\bar{\nu}$ and $\mu^+\mu^- \rightarrow HH\nu\bar{\nu}$ processes. All the studies have been performed by fully simulating the signal and physics background samples and by evaluating the effects of the beam-induced background on the detector performances.
Evaluations on Higgs boson couplings sensitivities and most recent results on the uncertainty on double Higgs production cross section, together with the trilinear self-coupling, will be discussed at $\sqrt{s}$ of 3 TeV and extrapolated to 10 TeV.

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Collaboration / Activity:

Muon Collider

T12: Detector R&D and Data Handling / 888

Recent advancements in high-performance analysis and statistical modelling with ROOT

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ROOT is renovating itself at a fast pace in order to allow physicists to address the unprecedented scale of LHC Run 3 datasets and beyond. Thanks to these recent developments, many HEP analyses could be made 5 to 20 times faster, providing turnaround times in the order of minutes rather than hours.

ROOT's RDataFrame, a high-level interface for data analysis and processing in C++ and Python, provides an ergonomic entry point to many of these improvements. It transparently leverages the power of modern multi- and many-core hardware; its declarative design makes it a robust and simple tool to efficiently pipe ROOT data into standard machine learning frameworks; distributed processing is enabled via ad-hoc back-ends capable to connect, for example, to existing Spark or Dask clusters, also enabling scalable deployment on HPC resources.
At the same time RooFit, ROOT's statistical modelling framework, is being upgraded in order to provide state-of-the-art performance on modern CPUs and GPUs.

This contribution will present recent advancements in these areas as well as upcoming enhancements that will make ROOT easier to use, faster out of the box, and adaptable to future workflows.

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Collaboration / Activity:

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T06: QCD and Hadronic Physics / 890

LHCb Fixed-target results and prospects

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Originally conceived for precise luminosity measurements, the gas injection system SMOG currently allows the unique LHCb detector capabilities to be exploited for fixed-target studies in proton-gas collisions at sqrt(s) ~ 100 GeV. The first results obtained with SMOG data are reported: antiproton production with a He target and J/psi , D0 productions in pHe and pAr collisions. The upgraded system SMOG2, which will be used during Run 3 of LHC, will extend the target species available and increase the areal gas density, offering a unique opportunity for measurements related to hadron production, cosmic rays physic and nucleon structure at the LHC. An overview of the SMOG2 system and its prospects is reported along with a selection of interesting physical measurements.

Collaboration / Activity:

LHCb

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T01: Astroparticle and Gravitational Waves / 891

Results from the LHCf Run II in proton-proton collisions at $\sqrt{s}$ = 13 TeV

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The LHCf experiment, at the Large Hadron Collider (LHC), consists of two small independent calorimeters placed 140 metres away, on opposite sides of the ATLAS interaction point (IP1). LHCf has the

capability to measure zero-degree neutral particles, covering the pseudorapidity region above 8.4. By measuring the very-forward particle production rates at the highest energy possible at an accelerator, LHCf aims to improve our understanding of hadronic interactions in air-showers induced by ultra-high-energy cosmic rays in the atmosphere.
This contribution will highlight recent results from Run II measurements with p-p collisions at 13 TeV. First, I will show our neutron energy spectrum measurements, for several pseudorapidity regions, and compare them to the predictions of various hadronic interaction models. From these measurements, we have also extracted the average inelasticity of the collisions, which strongly affects the development of an air-shower. I will then present our ^{0} Feynman-x and transverse momentum spectra, which affect the development of the electromagnetic component of an air-shower, and also compare them to model predictions. Finally, I will discuss the advantages of an ATLAS-LHCf combined analysis, and show a preliminary energy spectrum of very-forward photons produced in diffractive collisions as tagged by ATLAS.

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Collaboration / Activity:

LHCf

T06: QCD and Hadronic Physics / 892

Beauty-hadron spectroscopy at LHCb (12'+3')

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The spectroscopy of conventional hadrons containing a beauty quark is crucial to improve the knowledge of the non-perturbative regime of QCD. The LHCb experiment has been designed to study such hadrons and it is the ideal laboratory to search for as-yet-unobserved beauty baryons, including double heavy hadrons, and to perform precision measurements of already established hadrons. This talk presents the corresponding recent results performed at LHCb.

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Collaboration / Activity:

LHCb

T06: QCD and Hadronic Physics / 894

Recent LHCb results on exotic meson candidates (12'+3')

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Many mesons with additional valence constituents with respect to the conventional quark-antiquark pair have been discovered in the last decades, leading to a renaissance of hadron spectroscopy. Interpretations of such states span from compact objects to hadronic molecules and searches for new exotic meson candidates provide important insights on the quarks binding mechanisms inside hadrons. In this talk the recent LHCb results on this topic are presented.

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Collaboration / Activity:

LHCb

T01: Astroparticle and Gravitational Waves / 896

Propagation of extragalactic cosmic rays in the Galactic magnetic field

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The propagation of extragalactic cosmic rays (EGCRs) in the Galactic magnetic field (GMF) plays a crucial role in understanding the CR signal measured at Earth. Particularly in understanding the transition region from Galactic cosmic rays (GCRs) to EGCRs ($\approx\ 10^{15.5}$ eV–$10^{18.5}$ eV), the GMF is expected to exhibit a range of effects on CRs as this energy range also constitutes a change in propagation regimes from diffusive to ballistic, which are central to understanding the exact nature of this transition.
Using simulation studies with CRPropa3, we study the propagation effects that the GMF have on CRs in the rigidity range 10^{16} V–10^{20} V for both isotropically and anisotropically injected EGCRs. As a result, we find that the GMF neither modifies the flux nor the arrival direction distribution in case of isotropic injection across the entire rigidity range. For injection of dipole-like flux anisotropies as well as for single point sources, we find that the arrival direction distribution is consistent with isotropy below rigidites of 10^{18} V, and the remaining anisotropy for all particles integrated above rigidities of 10^{18} V manifests in the form of dipoles at the 1–10%-level. Flux modification across the entire rigidity range occur dependent on the direction and nature of the anisotropy. We discuss the consequences of these findings to interpretations of observational results in the transition region from GCRs to EGCRs.

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Collaboration / Activity:

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T06: QCD and Hadronic Physics / 898

Recent LHCb results on pentaquark candidates (12'+3')

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The LHCb experiment reported the first observation of pentaquark candidates in 2015, opening a new era in hadron spectroscopy. Since then, other pentaquark candidates, either with hidden-charm or charm-strange quarks content, have been reported by the LHCb collaboration. This talk presents the recent results on pentaquark spectroscopy at LHCb.

Collaboration / Activity:

LHCb

First author:

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T01: Astroparticle and Gravitational Waves / 899

Gravitational-wave signatures of non-integrable extreme-mass-ratio inspirals

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The detection of gravitational waves from extreme-mass-ratio inspirals (EMRIs) with upcoming space-borne detectors will allow for unprecedented tests of general relativity in the strong-field regime. Aside from assessing whether black holes are unequivocally described by the Kerr metric, they may place constraints on the degree of spacetime symmetry. Depending on exactly how a hypothetical departure from the Kerr metric manifests, the Carter symmetry, which implies the integrability of the geodesic equations, may be broken.

In this talk, I will discuss the impact of non-integrability in EMRIs which involve a supermassive compact object with anomalous multipolar structure. After reviewing the particulars of chaotic phenomena in bumpy EMRIs, I will argue that non-integrability is precisely imprinted in the gravitational waveform. Explicit examples of non-integrable EMRIs will be discussed, as well as their role in LISA data analysis.

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Collaboration / Activity:

PostDoctoral Researcher

T12: Detector R&D and Data Handling / 900

The operation and performance of the TOP detector at the Belle II experiment

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The SuperKEKB/Belle II experiment, the successor of the former KEKB/Belle experiment at KEK, has started its physics data taking with the full detector system since March 2019. The Time-of-Propagation (TOP) detector was designed and integrated into the Belle II detector for particle identification in the barrel region. The TOP detector consists of quartz radiators and photodetectors, Micro-Channel-Plate (MCP) PMT, and reconstructs a ring image of Cherenkov photons generated by an incident particle. It measures the timing of each detected photon with an accuracy of less than 100 ps for good K/π separation.

In the operation of the TOP detector, harsh beam-induced background in the high luminosity environment is one of the critical issues to achieve high performance. We have developed various tools to visualize MCP-PMT performance and to identify and fix errors arising from front-end electronics during data taking. The TOP detector provides 85% K efficiency at a 10% π misidentification rate in the data at the early stage of the experiment. In this talk, we will report the operation status and the performance by the summer of 2021.

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Collaboration / Activity:

Belle II Collaboration

T12: Detector R&D and Data Handling / 901

Luminosity measurement at LHCb

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The LHCb detector, designed to measure the decays of heavy hadrons, is a forward-arm spectrometer. Its efficiency can be degraded by collisions with high occupancy: therefore, a technique known as "luminosity levelling" has been used since the start of the LHC Run 1, allowing to control and stabilize the instantaneous luminosity with a precision of 5%. During LHC Runs 1 and 2, this technique employed data from the hardware-based trigger level to determine the instantaneous luminosity. These counters are calibrated in dedicated data taking runs a few times per year. The combination of van der Meer scans and of beam profiles obtained in beam-gas interactions, unique to LHCb, allowed LHCb to obtain in Run 1 the most precise luminosity measurement ever achieved at a bunched hadron collider. During LHC Run 3, the upgraded LHCb detector will see a 5x increase of luminosity. Dedicated luminosity detectors have been designed and are being commissioned for use in Run 3

and Run 4. This talk will review the methods used in Run 1 and introduce the new approach being developed for the coming LHC runs.

Collaboration / Activity:

LHCb

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T05: Heavy Ion Physics / 904

Factorial cumulants from global baryon number conservation

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Many effective models of strong interactions predict the first-order phase transition between the hadronic matter and quark-gluon plasma. One of the main approaches to search for it is based on the study of fluctuations of e.g. net-baryon number, net-charge, or net-strangeness number measured in relativistic heavy-ion collisions. Such fluctuations are often quantified by cumulants or factorial cumulants, which represent the integrated genuine multi-particle correlation functions and have certain advantages over regular cumulants. It is important to study the contribution from effects that may be misinterpreted as fluctuations related to the first-order phase transition. In this talk, the proton, antiproton, and mixed proton-antiproton factorial cumulants originating from the global baryon number conservation will be presented. Our results can be directly tested in experiments. Then, the factorial cumulants from the global baryon number conservation convoluted with short-range correlations will be discussed.

Based on:
M. Barej and A. Bzdak, Phys. Rev. C 102, no.6, 064908 (2020)

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Collaboration / Activity:

Theory of heavy-ion physics

T07: Top and Electroweak Physics / 906

Measurement of the W boson mass at LHCb

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The LHCb experiment covers the forward region of proton-proton collisions, and it can improve the current electroweak landscape by studying the production of W and Z boson in this phase space complementary to ATLAS and CMS. Several preliminary studies have shown the potential of the LHCb experiment to measure the W boson mass with a muon pT based technique, which could yield a statistical precision of 10 MeV if using the full Run 2 dataset. A proof-of-concept measurement of the W boson mass, using only the 2016 dataset, will be presented.

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Collaboration / Activity:

LHCb

T06: QCD and Hadronic Physics / 907

QCD physics measurements at the LHCb experiment

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LHCb is a spectrometer that covers the forward region of proton-proton collisions, corresponding to the pseudo-rapidity range 2<eta<5. In this unique phase space, LHCb can perform tests of perturbative and non-perturbative QCD models, by studying the production of heavy flavor quarks, like charm and top quarks. In this context the production of a Z boson in association with a c-jet can be studied to measure the intrinsic charm content of the proton. Moreover LHCb can test phenomenological models of soft QCD processes, by measuring the production of forward hadrons in pp collisions.

Collaboration / Activity:

LHCb

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T12: Detector R&D and Data Handling / 909

Run-3 offline data processing and analysis at LHCb

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The LHCb detector is undergoing a comprehensive upgrade for data taking in the LHC's Run 3, which is scheduled to begin in 2022. The increased data rate in Run 3 poses significant data-processing and handling challenges for the LHCb experiment. The offline computing and dataflow model is consequently also being upgraded to cope with the factor 30 increase in data volume and associated demands of user-data samples of ever-increasing size. Coordinating these efforts is the charge of the newly created Data Processing and Analysis (DPA) project. The DPA project is responsible for ensuring the LHCb experiment can efficiently exploit the Run 3 data, dealing with the data from the online system with central skimming/slimming (a process known as "Sprucing") and subsequently producing analyst-level ntuples with a centrally managed production system (known as "Analysis Productions") utilising improved analysis tools and infrastructure for continuous integration and validation.It is a multi-disciplinary project involving collaboration between computing experts, trigger experts and physics analysis experts. This talk will present the evolution of the data processing model, followed by a review of the various activities of the DPA project. The associated computing, storage and network requirements are also discussed.

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Collaboration / Activity:

LHCb

T04: Neutrino Physics / 910

New results from the DANSS experiment

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We present new results of the DANSS experiment on the searches for sterile neutrinos. They are based on 4 million inverse beta decay events collected at 10.9, 11.9, and 12.9 meters from the reactor core of the 3.1 GW Kalinin Nuclear Power Plant in Russia. The neutrino spectrum dependence on the fuel composition is also presented. We have also measured the reactor power using the IBD event rate during 38 months with a statistical accuracy 1.5% in 2 days and with the relative systematic uncertainty of about 0.5%. The status of the DANSS upgrade will be presented. This upgrade should allow DANSS to test the Neutrino-4 claim of observation of sterile neutrinos.

Collaboration / Activity:

DANSS

First author:

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T10: Searches for New Physics / 912

The Anomalous Case of Axion EFTs and Massive Chiral Gauge Fields

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Co-authors: Christophe Grojean [2]; Luca Di Luzio [3]; Quentin Rene Christian Bonnefoy [1]; Ayan Paul [1]

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We study axion effective field theories (EFTs), with a focus on axion couplings to massive chiral gauge fields. We investigate the EFT interactions that participate in processes with an axion and two gauge bosons, and we show that, when massive chiral gauge fields are present, such interactions do not entirely originate from the usual anomalous EFT terms. When applied to the case of the Standard Model (SM) electroweak sector, our results imply that anomaly-based sum rules between EFT interactions are violated when chiral matter is integrated out, which constitutes a smoking gun of the latter. As an illustration, we study a UV-complete chiral extension of the SM, containing an axion arising from an extended Higgs sector and heavy fermionic matter that obtains most of its mass by coupling to the Higgs doublets. We assess the viability of such a SM extension through electroweak precision tests, bounds on Higgs rates and direct searches for heavy charged matter. At energies below the mass of the new chiral fermions, the model matches onto an EFT where the electroweak gauge symmetry is non-linearly realised.

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Collaboration / Activity:

Theory

T10: Searches for New Physics / 914

Low Temperature MMC-based X-ray Detectors for IAXO

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The next generation helioscopes babyIAXO and IAXO will search for evidence of axion and axion-like particles (ALPs) produced in the interior of the Sun. A very promising candidate for the focal plane detectors are low temperature metallic magnetic calorimeters (MMCs). Combining good energy resolution and high quantum efficiency, MMC-based detectors would allow to investigate the solar axion spectrum and derive information on axion models by analyzing the resulting X-ray spectrum beyond discovery. We present our detector system composed of a detector module and an amplifier module, both mounted at the mixing chamber plate of a dilution refrigerator kept at about 10 mK. The detector module contains a 64-pixel chip featuring an absorber area of 1 cm^2 which was optimized to match the BabyIAXO X-ray optics. X-ray absorbers made out of 10 µm thick gold ensure a high stopping power for the complete energy range of interest while the expected FWHM energy resolution is around 10 eV. The detector signal is amplified with a two-stage SQUID readout circuit.

The first stage is positioned directly next to the detector whereas the second stage is implemented with a dedicated amplifier module. Moreover, we discuss our strategies to reach a background level of 10^{-7} keV^{-1} s^{-1} cm^{-2} and show ideas of integrating the detector system in the IAXO helioscope mechanical structure.

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Collaboration / Activity:

IAXO Collaboration

T08: Flavour Physics and CP Violation / 915

CP-violating axions

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While the axion was originally introduced to "wash out" CP violation from strong interactions, new sources of CP violation beyond QCD (needed e.g. for the matter-antimatter asymmetry) might manifest themselves via a tiny scalar axion-nucleon component. The latter can be experimentally probed in axion-mediated force experiments, as suggested long ago by J.E. Moody and F. Wilczek. In the present contribution, I will review CP-violating axion searches and report on a recent calculation of the scalar axion-nucleon coupling based on chiral Lagrangian techniques.

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Collaboration / Activity:

Theory

T04: Neutrino Physics / 916

Daya Bay Reactor neutrino flux and spectrum measurement

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This poster will present the measurement on antineutrino flux and the extracted 235U and 239Pu spectra at Daya Bay Reactor Neutrino Experiment. The eight identical detectors, allocated underground in two near sites and one far sites, has operated 1958 days to measure the most precise prompt energy spectrum from six commercial nuclear reactors, each with a thermal power of 2.9GW. The uncertainty of fine-bin total spectrum is analyzed to provide help and constraints for the fine-structure study. The correlation between total and extracted prompt energy spectra is studied in detail based on error propagation.With three unfolding methods, the antineutrino spectra are obtained from both fine-bin and coarse-bin prompt energy spectra. As an alternative to other reactor flux models, a data-driven prediction on reactor antineutrino spectra is provided for other experiments with different fission fractions compared to Daya Bay.

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Collaboration / Activity:

Daya Bay Collaboration

T04: Neutrino Physics / 917

GeV-scale neutrinos at DUNE

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Co-authors: Enrique Fernández-Martínez [2]; Manuel González López [2]; Pilar Coloma [3]; Zarko Pavlovic [4]

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The simplest extension to account for neutrino masses requires the addition of heavy right-handed neutrinos. If these heavy neutrinos have masses up to the GeV escale, they could be produced via mixing at beam-dump experiments in leptonic and semileptonic meson decays. These long lived particles could eventually arrive and decay in the volume of the detector. In this talk, the capability of the DUNE near detector (ND) to look for these heavy neutral leptons is explored. First, the effective operators describing interactions of light mesons and one heavy neutrino will be reviewed. This effective Lagrangian is implemented in a FeynRules model file which is made publicly available so that fully differential event distributions can be simulated. Then, by computing the flux of heavy neutrinos at the ND, we show that DUNE will be able to explore large regions of the allowed parameter space which could explain neutrino masses, through a type-I Seesaw.

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Collaboration / Activity:

Postdoc

T04: Neutrino Physics / 918

Nuclear Effects on Oscillation Parameters using Calorimetric method of Neutrino Energy Reconstruction in NOvA

Authors: PARAMITA DEKA[1]; JAYDIP SINGH[2]; KALPANA BORA[1]

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In current and future long baseline experiments on neutrino oscillation, nuclear effects in neutrino interactions are one of the principal sources of systematic uncertainties. Our present understanding of these effects is still insufficient. Another source of uncertainty is the energy dependence of neutrino oscillation probability which is a nontrivial function of the true incoming neutrino energy. This energy is reconstructed using different methods, which in turn is used in the analysis leading to the extraction of various neutrino oscillation parameters. The extraction of still unknown parameters like the leptonic CP violation phase demands the precision level in these measurements to be very high. The NUMI Off-Axis ν_e Appearance (NOvA), a long baseline neutrino oscillation experiment, is designed to measure $\nu_e(\bar{\nu}_e)$ appearance probability and $\nu_\mu(\bar{\nu}_\mu)$ disappearance probability at Fermilab's NUMI (Neutrinos at the Main Injector) beam. The NOνA consists of two functionally equivalent detectors - the near detector (ND) is located at Fermilab, 1 km from the NUMI beam and the far detector (FD) at a distance of 810 km is sited 14 mrad off-axis to produce a narrow-band beam around the oscillation maximum region ($\sim 2GeV$). In this work, we use the calorimetric method of energy reconstruction of the incoming neutrino energy, both at the ND and FD, and study the role of multinucleon (MN) effects on the sensitivity measurement of various neutrino oscillation parameters in the disappearance channel.

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Collaboration / Activity:

NEUTRINO PHYSICS

T09: Higgs Physics / 919

The h(125) decays to c cbar, b bbar, b sbar, photon photon and gluon gluon in the light of the MSSM with quark flavor violation

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We study the Higgs boson decays h -> c cbar, b bbar, b sbar, photon photon and gluon gluon in the Minimal Supersymmetric Standard Model (MSSM) with general quark flavor violation (QFV), identifying the h with the Higgs boson with a mass of 125 GeV. We compute the widths of the h decays to c cbar, b bbar, b sbar (s bbar) at full one-loop level in the MSSM with QFV. For the h decays to photon photon and gluon gluon we compute the widths at NLO QCD level. We perform a MSSM parameter scan respecting theoretical constraints from vacuum stability conditions and experimental constraints, such as those from K- and B-meson data and electroweak precision data, as well as recent limits on Supersymmetric (SUSY) particle masses and the 125 GeV Higgs boson data from LHC experiments.

From the parameter scan, we find the followings:

(1) DEV(h -> c cbar) and DEV(h -> b bbar) can be very large simultaneously:
DEV(h -> c cbar) can be as large as ~ +/-60% and
DEV(h -> b bbar) can be as large as ~ +/-20%.
Here DEV(h -> X Y) is the deviation of the decay width Gamma(h -> X Y) in the MSSM from the SM prediction:
DEV(h -> X Y) = Gamma(h -> X Y)_MSSM / Gamma(h -> X Y)_SM - 1.

(2) The QFV decay branching ratio BR(h -> b sbar / bbar s) can be as large as about 0.17% in the MSSM. It is almost zero in the SM. The sensitivity of ILC(250 + 500 + 1000) to this decay BR could be about 0.1% at 4 sigma signal significance.

(3) DEV(h -> photon photon) and DEV(h -> gluon gluon) can be large simultaneously: DEV(h -> photon photon) can be as large as about + 4% and DEV(h -> gluon gluon) can be as large as about -15%.

(4) There is a very strong correlation between DEV(h -> photon photon) and DEV(h -> gluon gluon). This correlation is due to the fact that the stop-loop (stop-scharm mixture loop) contributions dominate the two DEVs.

(5) The deviation of the width ratio Gamma(h -> photon photon)/Gamma(h -> gluon gluon) in the MSSM from the SM value can be as large as about +20%.

(6) All of these large deviations in the h decays are due to large scharm-stop mixing and large stop/scharm involved trilinear couplings T_{U23}, T_{U32}, T_{U33} and large sstrange-sbottom mixing and large sstrange/sbottom involved trilinear couplings T_{D23}, T_{D32}, T_{D33}.

(7) ILC can observe such large deviations from SM at high signal significance.

(8) In case the deviation pattern shown here is really observed at ILC, then it would strongly suggest the discovery of QFV SUSY (MSSM with QFV).

Note: This work is based on collaboration with H. Eberl and E. Ginina (HEPHY Vienna).

References:
Phys. Rev. D 91 (2015) 015007 [arXiv:1411.2840 [hep-ph]]
JHEP 1606 (2016) 143 [arXiv:1604.02366 [hep-ph]]
IJMP A34 (2019) 1950120 [arXiv:1812.08010 [hep-ph]]

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Collaboration / Activity:

Vienna SUSY Group

T01: Astroparticle and Gravitational Waves / 920

Latest results from DAMPE

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DArk Matter Particle Explorer (DAMPE) satellite mission is successfully operating and delivering data for more than 5 years since its launch in December 2015. The instrument is a thick calorimeter type detector, targeted at measuring gamma rays and cosmic-ray electrons up to about 10 TeV with excellent energy resolution and cosmic ray ions up to 100 TeV. Precise measurements of electron, proton, and helium cosmic ray spectra have been performed by the collaboration, which is expected to bring new insights into the physics mechanisms behind cosmic rays. In this talk, we give an overview of a mission status and present the latest physics results and data analysis activities.

Collaboration / Activity:

DAMPE

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T06: QCD and Hadronic Physics / 921

Comparison of public codes for Drell-Yan processes at NNLO accuracy

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We present a detailed comparison of predictions computed by four publicly available computer codes for Drell-Yan processes at the LHC and Tevatron colliders. We point out that while there is agreement among the predictions at the next-to-leading order accuracy, the predictions at the next-to-next-to-leading order (NNLO) differ, whose extent depends on the observable. The sizes of the differences in general are at least similar, sometimes larger than the sizes of the NNLO corrections themselves. The talk will be based on arXiv: 2104.02400.

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Collaboration / Activity:

phenomenology

T01: Astroparticle and Gravitational Waves / 922

Searching for High-Energy Neutrinos from Ultra-Luminous Infrared Galaxies with IceCube

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Ultra-luminous infrared galaxies (ULIRGs) have total infrared luminosities that exceed 10^{12} solar luminosities, making them the most luminous objects in the infrared sky. They are mainly powered by starbursts with star-formation rates exceeding 100 solar masses per year, with a possible secondary contribution from an active galactic nucleus (AGN). Both starburst regions and AGN are environments in which hadronic acceleration, and hence neutrino production, is plausible. In this work we present the results of a stacking search for high-energy neutrinos from a representative sample of 75 local ULIRGs using 7.5 years of IceCube data. No significant neutrino excess is found. We therefore report upper limits on the neutrino flux originating from these 75 ULIRGs, and extrapolate these to limits on the full ULIRG source population. We also compare these results with model predictions.

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Collaboration / Activity:

IceCube Collaboration

T12: Detector R&D and Data Handling / 923

Tracking charged particles with O(10 ps) timing precision using 3D trench-type silicon pixels

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One of the great challenges in the next generation of experiments at the future high-luminosity particle colliders will be the event reconstruction, as the large number of interactions occurring at each bunch crossing will create very large occupancies in the innermost detectors. In many of the studies performed for their upgrades, LHC experiments have showed that the addition of track timing measurements with an accuracy of the order of tens of picoseconds per track will restore tracking and vertexing capabilities at the levels we have today. In the last three years the TimeSPOT Collaboration has developed innovative silicon pixels allowing to reach a time resolution better than 20~ps on minimum ionizing particles. This new devices are 3D silicon pixels with trench electrodes, and they achieve such an outstanding time resolution thanks to both a highly uniform electric field inside the pixel and electrons/holes drift velocities close to saturation. Many different types of sensors, with pixel sizes ranging from 27.5 μm x 27.5 μm to 110 μm x 110 μm and arranged in matrices, multi-pixel strips or single-pixel test structures were produced in two batches in 2019 and 2020 by FBK in Trento, Italy. In a first beam test performed at the PSI πM1 beam-line in October 2019, time resolutions of about 20 ps per hit have been measured. In the last year accurate laboratory tests, both with a pulsed laser-based setup, able to precisely measure the sensor response throughout its active area, and with radioactive sources, emulating a test beam setup in the more controlled laboratory environment, have shown that these 3D pixel sensors intrinsically possess a time resolution close to 10 ps, and

presently available front-end electronics represents a limit to their performances. The status of this developments and an outlook of future activities, will be presented at the Conference.

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Collaboration / Activity:

TimeSPOT

T08: Flavour Physics and CP Violation / 924

Automated symbolic calculations of Wilson coefficients in general BSM

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We present a fully automated procedure providing an easy way to perform, systematically, phenomenological analysis in flavour physics for general BSM scenarios. This procedure is model independent and requires as input only the Lagrangian of the theory. Once the Lagrangian has been defined, all tree and loop-level Wilson coefficients are calculated symbolically by MARTY, and from those values flavour observables are computed numerically by SuperIso. We focus in particular on $b \longrightarrow s\gamma$ and the recently measured $b \longrightarrow sll$ observables which are in tension with the SM, and present a few examples of the results for specific new physics scenarios.

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Collaboration / Activity:

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T10: Searches for New Physics / 926

Constraining electroweak and strongly charged long-lived particles with CheckMATE

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Long-lived particles have become a new frontier in the exploration of physics beyond the Standard Model. In this paper, we present the implementation of four types of long-lived particle searches, viz. displaced leptons, disappearing track, displaced vertex (together with muons or with missing energy), and heavy charged tracks. These four categories cover the signatures of a large range of physics models. We illustrate their potential for exclusion and discuss their mutual overlaps in mass-lifetime space for two simple phenomenological models involving either a U(1)-charged or a coloured scalar.

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Collaboration / Activity:

CheckMATE collaboration

T03: Dark Matter / 927

Dark matter and dark radiation from primordial black holes

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Primordial black holes (PBHs) lighter than 10^9 g are at present mostly unconstrained, because they evaporate before Big Bang Nucleosynthesis (BBN). Hence, they can not represent a fraction of dark matter (DM). However, their evaporation products can leave an imprint on the early universe observables. In this talk, we will decribe how the public code BlackHawk has been adapted to compute the Hawking radiation of light PBHs with the addition of a dark sector particle. Depending on this particle mass, it can result in a contribution to warm DM or dark radiation. The first one is further constrained using structure formation thanks to CLASS and the second one contributes to ΔN_{eff}, constrained by BBN and CMB (future) experiments. We conclude by giving the Hawking radiation constraints on light PBHs.

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Collaboration / Activity:

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T05: Heavy Ion Physics / 930

Jet charge in pp collisions with ALICE

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Jet charge is the momentum weighted sum of the electrical charges of jet constituents. This value is sensitive to the charge of the parton that initiates the jet. However, jet charge distributions depend strongly on the choice of parameters for the jet, namely, jet radius, minimum $p_{T,jet}$. This poster presents the measurement of jet charge for proton-proton collisions at $\sqrt{s_{NN}} = 5.02$ GeV. Based on Monte Carlo data generated by PYTHIA8, templates are constructed representing the jet charge distribution at the detector level for different flavours of jet. These templates are generated for various jet radii and momenta. The differences between detector and generator level templates are also presented. In addition, an examination of the systematic uncertainties introduced by using this approach is reported. These studies identify the optimal parameter space for jet charge measurements with the ALICE detector to provide maximum discrimination of jet flavours.

Collaboration / Activity:

ALICE

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T12: Detector R&D and Data Handling / 931

Fast neutron detection with GAGG/SiPM matrix detector

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Co-authors: Kai-Thomas Brinkmann [2]; Oleg Buzanov [3]; George Dosovitskiy [1]; Valery Dormenev [2]; Andrei Fedorov [1]; Vitaly Mechinsky [1]; Vassily Kornoukhov [3]; Dmitriy Kozlov [4]; Vasilli Retivov [5]; Vladimir Vasiliev [3]; Hans-Georg Zaunick [6]; Vladimir Alenkov [3]

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The spectacular progress in the improvement of scintillation properties of Ce doped Gd-based crystalline compounds was demonstrated in the last decade. That makes possible use of these materials for neutron detection, similarly to Li-based inorganic scintillators. Particularly, the materials of interest are compositionally disordered Gd3Al2Ga3O12 (GAGG) garnets, which are tolerant to a different kind of ionizing radiation, exhibit a high light yield of up to ~50000 photons/MeV, have scintillation decay time shorter than 80 ns, time resolution of annihilation □-quanta ~160ps. Their emission band peaks at ~520 nm matching the sensitivity spectrum of the silicon photomultipliers (SiPMs). Recently we demonstrated the response of GAGG based detector to neutrons of Am(Pu)-Be sources [1,2]. Natural gadolinium is a mixture of six stable isotopes, two of which, 155Gd and

157Gd, have a high cross-section of the thermal neutron capture, 61000 and 254000 barns, respectively. Moreover, Gd nuclei possess a set of resonances providing resonance integral ~400 bn. The capture of the neutrons is accompanied by the emission of γ-quanta of different energy, which can be detected in the same scintillation material. The role of the neutron capture by Gd is diminished when their energy reaches a few MeV, and an interaction with 69Ga,71Ga via new channels ((n,p) and (n,α) becomes dominating. Here we report on results of the measurement of neutrons obtained at the bombardment of the Pb 5 cm thick target with a 200 MeV proton beam. The capabilities of the Time-Off-Flight measurement at the short base 0.5m and Pulse Shape Discrimination of the different secondaries were demonstrated. Our results prove the GAGG-based detectors are promising to construct short-flight-base neutron spectrometers utilizing the PSD signals analysis.

1. M Korjik, KT Brinkmann, G Dosovitskiy, V Dormenev, A Fedorov, D Kozlov, Compact and Effective Detector of the Fast Neutrons on a Base of Ce-doped Gd3Al2Ga3O12 Scintillation Crystal., IEEE Transactions on Nuclear Science 66 (1)(2019), 536-540, 7
2. 2. A Fedorov, V Gurinovich, V Guzov, G Dosovitskiy, M Korzhik, V Kozhemyakin, A Lopatik, D Kozlov, V Mechinsky, V Retivov, Sensitivity of GAGG based scintillation neutron detector with SiPM readout, Nuclear Engineering and Technology 52(2020) 2306-2312

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Collaboration / Activity:

Crystal Clear Collaboration

T10: Searches for New Physics / 932

(New) Physics at a multi-TeV Muon Collider

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We discuss the physics potential of a multi-TeV muon collider. We present the results for the main SM processes together with popular BSM models, emphasizing the annihilation and VBF regime at very-high energies. We also discuss some preliminary results about the Effective Vector Boson Approximation and its implementation in MadGraph5_aMC@NLO.

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Collaboration / Activity:

postdoc

T10: Searches for New Physics / 935

The Dark Machines Anomaly Score Initiative: Benchmark Data

and Model Independent Classification for the Large Hadron Collider

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We describe the outcome of a data challenge to detect signals of new physics at the LHC using unsupervised machine learning algorithms conducted as part of the Dark Machines Initiative and the Les Houches 2019 workshop on Physics at TeV colliders. We first define and describe a large benchmark dataset, consisting of $>$ 1 Billion simulated LHC events corresponding to 10 fb^{-1} of proton-proton collisions at a center-of-mass energy of 13 TeV. We then review a wide range of anomaly detection and density estimation algorithms, developed in the context of the data challenge, and we measure their performance in a set of realistic analysis environments. We draw a number of useful conclusions that will aid the development of unsupervised new physics searches during the third run of the LHC, and provide our benchmark dataset for future studies.

Collaboration / Activity:

Dark Machines Initiative

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T05: Heavy Ion Physics / **936**

Quenching effects in the jet spectrum at various cone sizes

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The strong suppression of high-pT jets in heavy-ion collisions is a result of elastic and inelastic energy loss, suffered by the jet multi-prong collection of color charges that are resolved by medium interactions. We develop a novel analytic framework to study the quenched jet spectrum in which we include many energy-loss-related effects, such as resummation of soft and hard medium induced emissions, broadening, elastic scattering, jet fragmentation, cone size, coherence effects, etc. We present the first predictions for the nuclear modification factor and the quantile procedure with cone size dependence. We compare dijet and boson+jet events to unfold the spectrum bias effects and improve quark-, and gluon-jet classification in heavy-ion jets. Besides pointing out its flexibility, we show our formalism relevance in pp jets modeling non-perturbative effects.

The talk is based on arXiv:2101.01742 and arXiv:2103.14676

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Collaboration / Activity:

theory

T14: Outreach, Education and Diversity / 937

Particle Physics for Primary Schools: a Case Study about Science Teaching in K-12 Schools

Authors: Sandra Malvezzi[1]; Cristina Lazzeroni[2]; Andrea Quadri[3]

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We report on an ongoing project aimed to teach particle physics in primary schools, based on an original format developed by C.Lazzeroni and M.Pavlidou at the University of Birmingham (UK). The workshop allows young children (ages 8-11) to learn the world of particles, use creative design to make particle models and engage in creative writing to describe how particles interact with each other.
Early exposure to current results in contemporary science is important since it has been realized in recent years that children make decisions and choices about subjects they like during their primary school years.
We will start from the past and currently planned activities both in UK and in Italy in order to establish a broader framework to describe the conditions for the fruitful interplay between researchers and teachers in order to foster and support science outreach activities in schools.

Collaboration / Activity:

Univ.of Birmingham and INFN

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T12: Detector R&D and Data Handling / 938

New Results from the Silicon Vertex Detector of the Belle II Experiment

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The Silicon Vertex Detector (SVD) consists of four layers of double-sided silicon strip sensors. The SVD is one of the two vertex subdetectors within Belle II.
Since the start of data taking in 2019 at the Super-KEKB collider (KEK, Japan), which has the highest peak-luminosity ever recorded, the SVD is operated reliably and with high efficiency, despite exposure to harsh beam background.
Measurements using data show that the SVD has both high signal-to-noise ratio and hit efficiency, as well precise spatial resolution. Further these properties are stable over time. Recently the simulation has been tuned, using data, to improve the agrement between data and MC for cluster properties.
The good hit-time resolution can be exploited to further improve the robustness against the higher levels of background expected as the instantaneous luminosity increases in the next years of running. First effects of radiation damage on strip noise, sensor currents and depletion voltage have been measured, although they do not have any detrimental effect on the performance of the detector.

Collaboration / Activity:

Belle II - SVD Group

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T06: QCD and Hadronic Physics / 939

Groomed jet mass in lepton collisions at high precision

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We present predictions of the distribution of groomed heavy jet mass in electron-positron collisions at the next-to-next-to-leading order accuracy matched with the resummation of large logarithms to next-to-next-to-next-to-leading logarithmic accuracy. Resummation at this accuracy is possible through extraction of necessary two-loop constants and three-loop anomalous dimensions from fixed-order codes. The talk will be based on published papers on arXiv: 2002.00942 and 2002.05730.

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Collaboration / Activity:

phenomenology

T08: Flavour Physics and CP Violation / 940

Probing New Physics with heavy hadron decays

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The observations of anomalies in exclusive decays of beauty mesons, with
hints toward possible violation of lepton flavour universality, require new analyses of related processes involving other heavy hadrons, to enlarge the set of observables suitable to test the Standard Model (SM) predictions.
I will present results obtained in the study of decay modes of several hadrons containing a heavy quark.

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Collaboration / Activity:

Theory

T01: Astroparticle and Gravitational Waves / 942

Binary systems as dynamical detectors of gravitational waves

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The passage of gravitational waves (GWs) through a binary perturbs the trajectories of the two bodies, potentially causing observable changes to their orbital parameters. In the presence of a stochastic GW background (SGWB) these changes accumulate over time, causing the binary orbit to execute a random walk through parameter space. In this talk I will present a powerful new formalism for calculating the full statistical evolution of a generic binary system in the presence of a SGWB, capturing all six of the binary's orbital parameters. I will show how this formalism can be applied to timing of binary pulsars and lunar laser ranging, thereby setting novel upper limits on the SGWB spectrum in a frequency band that is inaccessible to all other GW experiments.

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Collaboration / Activity:

N/A

T04: Neutrino Physics / 943

Non-standard neutrino interactions in IceCube

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Non-standard neutrino interactions (NSI) arise in various types of new physics. Their existence would change the potential that atmospheric neutrinos encounter when traversing Earth matter and hence alter their oscillation behavior. This imprint on coherent neutrino forward scattering can be probed using high-statistics neutrino experiments such as IceCube and its low-energy extension, DeepCore. Both provide extensive data samples that include all neutrino flavors, with oscillation baselines between tens of kilometers and the Earth diameter.
For DeepCore data samples, event energies reach from few GeV up to the order of 100 GeV - which marks the lower threshold for higher energy IceCube samples, ranging up to 10 TeV.
In DeepCore data the large sample size and energy range allow us to consider not only flavor-violating and -nonuniversal NSI in the $\mu - \tau$ sector, but also those involving the electron flavor.
The effective parameterization used in our analyses is independent of the underlying model and the new physics mass scale. In this way, competitive limits on several NSI parameters have been set in the past. The 8 years of data available now result in significantly improved sensitivities. This improvement stems not only from the increase in statistics but also from substantial improvement in the treatment of systematic uncertainties, background rejection and event reconstruction.

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Collaboration / Activity:

IceCube Collaboration

T14: Outreach, Education and Diversity / 944

The Women in Technology grass roots community at CERN –an example of women networking in a scientific organisation

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The creation of scientific knowledge has transitioned from largely solitary work to collective efforts embedded in large collaborations, placing a new emphasis on social networks as the mechanism linking interdependent scientists across departments and universities. Professional networks have proven to be a key contributor in the career success and their presence becomes even more important for underrepresented communities. In this context, the Women in Technology community at CERN (WIT) was born in the early 2016. At the time, two new members of the IT Department started this grass roots community when realized that women networks from which they had benefited at university and in industry did not exist at CERN, or in the local area.

The main aim of the WIT community is to create a supportive network for exchanging experiences and career advice among women working at CERN. It came on the scene to complement the other professional community networks within he diverse CERN environment, like LGBTQ network and country networks. WIT activites span on different fronts: interviews featuring senior women scientists to inspire the younger generation, social events such as movie screenings and aboratory visits, and a yearly mentoring scheme between more experienced members as mentors and less experienced ones as mentees. Moreover it also strengthens the visibility of women scientists in local schools through outreach lectures and events. The WIT community today comprises more than 500 members, has organised three mentoring yearly programmes and is present in multiple outreach events, both in the local area and world wide through social media.

Women networks, such as WIT, are beneficial to both the network participants and the organisation as a whole: not only do they provide a place to connect and share common experiences but also they can interface with CERN internal programs, such as CERN's official Diversity & Inclusion, transfering the community's ideas and advocating for minoriy'issues. It has to be noted that even if WIT was born in the spirit of supporting women, it actually welcomes members from all genders and all technical fields.

This contribution describes how WIT is structured and the different activities organised by the community; it also highlights how networks like WIT contribute to making an impact on diversity and inclusion in a scientific research organisation like CERN.

Collaboration / Activity:

Women in Technology

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T11: Quantum Field and String Theory / 945

Trace anomaly for Weyl fermions using the Breitenlohner–Maison scheme for γ_*

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Computations of the trace anomaly of chiral fermions have raised a discussion regarding possible unitarity issues at one-loop in four-dimensional theories involving chiral fermions. This was manifested by the claimed existence of an imaginary CP-violating term in the trace of the energy momentum tensor –the Pontryagin density. We revisit this computation using dimensional regularization and standard Feynman diagram techniques. Working in n dimensions and employing the Breitenlohner-Maison scheme of a strictly four-dimensional γ_*, we show that the parity-odd term vanishes, preserving the reality of the trace and thus the unitarity of the Hamiltonian. We further show that the parity-even contribution is half that of a Dirac fermion.

Collaboration / Activity:

Poster

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T14: Outreach, Education and Diversity / 946

How to Engage Public in Science Through Instagram

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In this talk, you will discover how Instagram Stories are a powerful way to tell a story in a short and snappy way and engage the audience along the way. From developing science quizzes to engaging social media campaigns, you will learn the best practices of Instagram's interactive features and make science more inclusive. Based on our experience at CERN, we will accelerate you on a journey to take science outreach in social media to another level.

Collaboration / Activity:

CERN

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T14: Outreach, Education and Diversity / 948

Playing cards as a tool to create public interest in physics

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A novel outreach project is presented that makes use of playing cards –one of the most ubiquitous toys around the world –to communicate physics in a fun, engaging manner. A custom deck of cards has been designed to inspire an interest in physics while being widely appealing to the general public and useful for gameplay, magic and cardistry. In the course of bringing this project to completion, many different social media platforms and channels are explored and used to facilitate communication about the project and physics in general. The project has presented opportunities for unusual collaborations. The cards will soon be in production and have excellent potential for use in outreach events and educational settings.

Collaboration / Activity:

Independent project

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T08: Flavour Physics and CP Violation / 949

Status of the Mu2e experiment at Fermilab

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The Mu2e experiment at Fermilab aims to measure the charged-lepton flavour violating (CLFV) neutrino-less conversion of a negative muon into an electron in the field of a nucleus. The conversion process results in a monochromatic electron with an energy slightly below the muon rest mass (104.97 MeV). The Goal of the experiment is to improve by four orders of magnitude the previous measurement and reach a single event sensitivity of 3 x 10^{-17} on the conversion rate with respect to the muon capture rate.

Although the SM is very well tested in many regimes, it appears likely to be incomplete. In many of the Beyond the Standard Model (BSM) scenarios, rates for CLFV processes are within the reach of the next generation of experiments. In particular, if SUSY particles have masses and couplings within the discovery reach of the LHC, CLFV rates will be observable. On the contrary, many CLFV searches have a sensitivity to new physics that exceeds the LHC, bringing the reach of new mass scales up to 10^4 TeV. In this pursuit, indirect measurements of CLFV will be crucial evidence of new physics.

The experiment goal is achieved by sending a very intense pulsed negative muon beam to an Aluminium target to collect a total of 10^{18} stopped muons in a few years of running. Production and transport of the muons are accomplished by means of a large (25 m length) and sophisticated magnetic system composed of production, transport, and detector solenoids. The magnetic systems allows the very intense beam to be directed on target with a low request on power.

The improvements with respect to previous conversion experiments are based on four elements: the higher muon intensity, the pulsed beam structure, the extinction of out of time particles and the precise electron identification in the detector solenoid. The conversion electron will be reconstructed and separated from the Decay in Orbit (DIO) background by a very high resolution tracking system based on straw technology. The crystal calorimeter system will confirm that the candidates are indeed electrons by performing a powerful mu/e rejection while granting a tracking-independent HLT filter. A Cosmic Ray Veto system surrounds the detector solenoid to make the cosmic based background negligible.

The Mu2e experiment is under construction at the Muon Campus of Fermilab, having received CD-3 approval in July 2016. The construction of the magnetic system is still dominating the critical path of the experiment. In the current schedule, after a long installation and commissioning phase with cosmic rays in the position extracted from the solenoid, the experiment start is foreseen for the beginning of 2024 and will be organised in two phases, a first one at low and a second one at full beam intensity.

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Collaboration / Activity:

Mu2e experiment

T01: Astroparticle and Gravitational Waves / 950

Southern Wide-field Gamma-ray Observatory: status and prospects

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The Southern Wide Field Gamma-ray Observatory (SWGO) is an international R&D project aiming to design and prototype a wide field-of-view gamma-ray facility to monitor the Southern Hemisphere sky in gamma-rays.

SWGO will be placed at a high altitude (above 4.4 km) in South America and aims to provide a good sensitivity for observations from the low energies (~100 GeV) up to the PeV region. Such energy range allows covering a broad physics program, being entirely complementary to the Cherenkov Telescope Array (CTA) and other Northern ground-based observatories, such as HAWC or LHAASO.

In this talk, I will present the current status and plans for SWGO, namely, progress on the detector design concepts being evaluated, array layout options and site procurement. The expected sensitivity of SWGO and its science capabilities will also be addressed.

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Collaboration / Activity:

SWGO

T11: Quantum Field and String Theory / 951

Black hole metamorphosis: what happens after half evaporation?

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Hawking's calculation of particle production by a black hole is based on the semi-classical approximation, in which back-reaction on the metric is not taken into account. This leaves open the question of how the black hole evolves as a result of evaporation. In an attempt to answer it, we construct a simple analogue system, which shares the information storage properties of a black hole such as its Bekenstein-Hawking entropy. We find indications that at the latest after losing half of the mass, a black hole undergoes a metamorphosis leading to a drastic deviation from Hawking evaporation.

As two likely possibilities for the subsequent evolution, it can either become extremely long lived or decay via a new classical instability. The first option would open up a new window for small primordial black holes as viable dark matter candidates.

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T09: Higgs Physics / 952

Precise predictions of the mass of the discovered Higgs boson in supersymmetric scenarios

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The mass of the discovered Higgs boson is one of its most precisely measured properties with an experimental accuracy at the sub-percent level. Besides its coupling behaviour, which conforms so far with the prediction of the Standard Model, the measured Higgs mass value can place strong constraints on extensions of the Standard Model, in particular supersymmetric ones. To fully exploit this experimental accuracy, a very precise prediction of the mass of the Standard Model-like Higgs boson in the respective model is required.

In this talk, I will comment on different methods to calculate the mass and present some recent developments in the effort of improving the predictions within supersymmetric extensions of the Standard Model. In particular, I will consider scenarios with heavy supersymmetric partner particles but relatively light Higgs bosons with and without CP-violation.

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Collaboration / Activity:

Theory

T02: Cosmology / 953

Reconstruction of the neutrino mass as a function of redshift

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In this talk, we present a reconstruction of the neutrino mass as a function of redshift, z, from current cosmological data using both standard binned priors and linear spline priors with variable knots. Using Planck 2018 cosmic microwave background temperature, polarization and lensing data, in combination with distance measurements from baryonic acoustic oscillations and supernovae, we find that the neutrino mass is consistent with $\sum m_\nu(z) = \text{const}$. We obtain a larger bound on the neutrino mass at low redshifts coinciding with the onset of dark energy domination, $\sum m_\nu(z = 0) < 1.46$ eV (95% CL). We comment on how this result can be explained either by the well-known degeneracy between $\sum m_\nu$ and Ω_Λ at low redshifts, or by models in which neutrino masses are generated very late in the Universe. We finally convert our results into cosmological limits for models with post-recombination neutrino decay and comment on neutrino mass detection prospects with the KATRIN experiment.

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Collaboration / Activity:

Lorenz, Löffler, Calabrese

T02: Cosmology / **954**

Primordial gravitational waves revealed by a spinning axion

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A fast-spinning axion can dominate the Universe at early times and generates the so-called kination era. The presence of kination imprints a smoking-gun spectral enhancement in the primordial gravitational-wave (GW) background. Current and future-planned GW observatories could constrain particle theories that generate the kination phase. Surprisingly, the viable parameter space allows for a kination era at the PeV-EeV scale and generates a peaked spectrum of GW from either cosmic strings or primordial inflation, which lies inside ET and CE windows.

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Collaboration / Activity:

Quantum Universe Cluster, UHH

T01: Astroparticle and Gravitational Waves / 955

Very high energy observations of GRBs

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Gamma-ray bursts (GRBs) are transient events releasing a large amount of energy in a short amount of time as electromagnetic radiation. In the past decades, both observational and theoretical efforts were made to understand their inner workings, both in the prompt and afterglow phase. The origin of the GeV emission detected by Fermi-LAT in several GRBs is one of the aspects of GRB physics which is currently not well understood. Observations at very high energies (VHE, E>100 GeV) by Cherenkov telescopes, given their better sensitivity, can provide crucial information to understand the mechanisms behind such high energy components. After almost 15 years of efforts, the MAGIC and H.E.S.S. collaborations finally detected their first bursts, GRB190114C and GRB180720B respectively, opening a new era in the study of GRBs. Such detections proved the presence of a new additional emission component up to TeV energies in the GRB afterglow phase, which can be explained by the synchrotron self-Compton process. Other two GRBs were also detected, GRB190829A by H.E.S.S. and GRB201216C by MAGIC, bringing more information but also revealing a complex picture to explain the origin of the VHE emission. In this context, observations by future facilities as the Cherenkov Telescope Array (CTA) observatory will play a crucial role to increase our understanding of the VHE emission in GRBs. In this contribution I will present the outstanding results accomplished in the last years by Cherenkov telescopes in the observation of GRBs and provide an overview of what can be achieved with future instruments.

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Collaboration / Activity:

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T04: Neutrino Physics / 956

A systematic approach to neutrino masses and their phenomenology

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We propose a model-independent framework to classify and study neutrino mass models and their phenomenology. The idea is to introduce one particle beyond the Standard Model which couples to leptons and carries lepton number together with an operator which violates lepton number by two units and contains this particle. This allows to study processes which do not violate lepton number, while still working with an effective field theory. The contribution to neutrino masses translates to a robust upper bound on the mass of the new particle. We compare it to the stronger but less robust upper bound from Higgs naturalness and discuss several lower bounds. Our framework allows to classify neutrino mass models in just 20 categories, further reduced to 14 once nucleon decay limits are taken into account, and possibly to 9 if also Higgs naturalness considerations and direct searches are considered.

Collaboration / Activity:

Theory

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T04: Neutrino Physics / 957

Simulation of muon-spin rotation for estimation of magnetic field in INO-ICAL

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The India-based Neutrino Observatory (INO) collaboration, a multi-institutional effort to build a 50 kton magnetised Iron Calorimeter (ICAL) for studying neutrino oscillations. The magnetic field in the ICAL, induced by copper coils, will be a crucial input for the track fitting algorithms that reconstruct the four-momenta of atmospheric neutrinos. So far, the magnetic field map is obtained from simulations which may not correspond to the true magnetic field inside the iron plates owing to many factors including approximations in the simulation and the change in the elemental composition of the iron plates etc,. Therefore an alternate non-destructive approach is desirable so that the magnetic field is mapped without disturbing the setup. In this work we present the first results of a simulation study that employs the muon spin-rotation technique to estimate the magnetic field.

Collaboration / Activity:

INO

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T13 - Accelerator for HEP / 959

Status and perspectives of the HL-LHC project

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The HL-LHC project is in the process of transitioning from the R&D phase to the project production and implementation phase. The presentation presents updates from recent prototype tests of strategic accelerator equipment such as Nb3Sn magnets and crab cavities, reports on the progress of the civil engineering efforts currently ongoing at CERN and presents updates on the HL-LHC schedule and start-up plans.

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Collaboration / Activity:

HL-LHC

T03: Dark Matter / 961

String Fragmentation in Supercooled Confinement and implications for Dark Matter

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A strongly-coupled sector can feature a supercooled confinement transition in the early universe. When fundamental quanta of the strong sector are swept into expanding bubbles of the confined phase, the distance between them is large compared to the confinement scale. The flux linking the fundamental quanta then deforms and stretches towards the wall, producing an enhanced number of composite states upon string fragmentation. The composite states are highly boosted in the plasma frame, which leads to additional particle production through the subsequent deep inelastic scattering. I will discuss the modelling of these dynamics and introduce the consequences for the abundance and energetics of particles in the universe and for bubble-wall Lorentz factors. As a case of study, I will show that the composite dark matter relic density is affected by many orders of magnitude.

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T03: Dark Matter / 962

Status and Plans of SuperCDMS SNOLAB

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SuperCDMS SNOLAB is an underground cryogenic experiment currently under construction. The main objective of the experiment is a search for dark matter particles with masses < 10 GeV. Electron or nuclear recoils deposit energy in the germanium and silicon crystals which is collected via phonon and charge sensors. Two different detector designs are utilized: HV(High Voltage) and iZIP(interleaved Z-dependent Ionization and Phonon) detectors. HV detectors with a low threshold and excellent energy resolution will probe dark matter in the sub-GeV range; iZIP detectors, benefiting from their good separation power between electron and nuclear recoil events, are optimized to detect dark matter masses above 3 GeV. An initial HV detector is currently hosted at CUTE, a SNOLAB cryogenic test facility, with plans to take science data in the immediate future.

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Collaboration / Activity:

SuperCDMS collaboration

T08: Flavour Physics and CP Violation / 963

Measurements of the CKM angle gamma at LHCb

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The tree-level determination of the CKM angle gamma is a standard candle measurement of CP violation in the Standard Model. The latest LHCb results from time-integrated measurements of CP violation using beauty to open charm decays are presented. A new combination of all LHCb measurements is also performed. A precision of four degrees is obtained, which dominates the world average.

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Collaboration / Activity:

LHCb

T08: Flavour Physics and CP Violation / 966

Muon $g{-}2$ and $\Delta\alpha$ connection

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The Muon $g-2$ experiment at Fermilab has recently confirmed Brookhaven's earlier measurement of the muon anomalous magnetic moment a_μ. This new result increases the discrepancy Δa_μ with the Standard Model (SM) prediction and strengthens its "new physics" interpretation as well as the quest for its underlying origin. Following the presentations of the new experimental result and the SM prediction of the Muon $g-2$ at this conference, I will focus on some of the latest developments and discuss the connection of the discrepancy Δa_μ to precision electroweak predictions via their common dependence on hadronic vacuum polarization effects. This is particularly relevant for the ongoing comparison between results for hadronic vacuum polarization effect as calculated from hadronic cross section data and from lattice QCD.

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Collaboration / Activity:

Muon g-2 Experiment/Theory

T06: QCD and Hadronic Physics / 967

Recent results in production of open-charm and charmonium states at LHCb (12'+3')

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Collaboration / Activity:

LHCb

T10: Searches for New Physics / 968

Searching for pseudo-Nambu-Goldstone boson dark matter production in association with top quarks

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Pseudo-Nambu-Goldstone bosons (pNGBs) are attractive dark matter (DM) candidates since they are coupled to the Standard Model (SM) predominantly through derivative interactions. Thereby, they

naturally evade the strong existing limits inferred from DM direct detection experiments. Working in an effective field theory that includes both derivative and non-derivative DM-SM operators, we perform a detailed phenomenological study of the Large Hadron Collider reach for pNGB DM production in association with top quarks. Drawing on motivated benchmark scenarios as examples, we compare our results to other collider limits as well as the constraints imposed by DM (in)direct detection experiments and the relic abundance. Furthermore, we explore implications on the viable parameter space of pNGB DM. In particular, we demonstrate that the sensitivity of DM direct detection experiments can be achieved via loop-induced interactions. The search strategies we discuss can serve as a starting point for dedicated experimental analyses by the ATLAS and CMS collaborations.

Collaboration / Activity:

none

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T05: Heavy Ion Physics / 969

Production and ratios of heavy hadrons from large to small collision systems with a coalescence plus fragmentation approach

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Measurements of heavy baryon production in pp, pA and AA collisions from RHIC to top LHC energies have recently attracted more and more attention, currently representing a challenge for the heavy-quark hadronization theoretical understanding.
The Λ_c/D^0 ratio observed in AA collision at RHIC and LHC energies has a value of the order of the unity. The recent experimental measurements in pp collisions at $\sqrt{s} = 5.02\,\mathrm{TeV}$ have shown a ratio of $\Lambda_c/D^0 \sim 0.6$, about one order of magnitude larger than that measured in e^+e^-, ep collisions.
We study the hadronization after the propagation of charm quarks in the quark-gluon plasma (QGP). The propagation is described by means of a relativistic Boltzmann transport approach where the non-perturbative interaction between heavy quarks and light quarks is described by means of a quasi-particle approach.
In this talk we present a coalescence plus fragmentation model for the hadronization and the results obtained in AA collisions for D^0, D_s, Λ_c spectra and the related baryon to meson ratios at RHIC and LHC.
We found a large Λ_c production resulting in a baryon over meson ratio of order O(1). This large production has consequences for the D meson nuclear modification factor, that results dumped in the region of low momenta, as observed in STAR data.
Furthermore we present, for the first time, results for these ratios in pp collisions at top LHC energies assuming the formation of an hot QCD matter at finite temperature even for these systems.
We calculate the heavy baryon/meson ratio and the p_T spectra of charmed hadrons with and without strangeness content: D^0, D_s, Λ_c^+, Σ_c and the recently measured Ξ_c baryon, finding an enhancement in comparison with the ratio observed for e^+e^-, ep collisions; moreover with this approach we predict also a significant production of Ω_c respect to D^0.

1 V. Minissale, S. Plumari and V. Greco, arXiv:2012.12001 [hep-ph].
[2] S. Plumari, V. Minissale, S.K. Das, G. Coci and V. Greco, Eur.Phys.J. C 78 (2018) no.4, 348
[3] F. Scardina, S. K. Das, V. Minissale, S. Plumari, V. Greco, Phys.Rev. C 96 (2017) no.4, 044905

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Collaboration / Activity:

heavy quark hadronization

T08: Flavour Physics and CP Violation / 970

Beauty to open charm final states at LHCb

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The latest studies of beauty meson decays to open charm final states from LHCb are presented. Several first observations and branching fraction measurements using Run 1 and Run 2 data samples are shown. These decay modes will provide important inputs to other analyses, and may be used for future measurements of CP violation.

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Collaboration / Activity:

LHCb

T08: Flavour Physics and CP Violation / 973

Very rare decays at LHCb

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Decays of b-hadrons that are very suppressed in the Standard Model, such as fully leptonic flavour-changing neutral-current transitions or lepton flavour violating decays, are particularly clean probes for New Physics. The LHCb experiment is designed for the study of b-hadron decays and ideally suited for the analysis of very rare decays due to its high trigger efficiency, as well as excellent tracking and particle identification performance. Recent results from the LHCb experiment on very rare decays are presented.

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Collaboration / Activity:

LHCb

T08: Flavour Physics and CP Violation / 975

Lepton flavour universality tests at LHCb

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The coupling of the electroweak gauge bosons of the Standard Model (SM) to leptons is independent of the lepton flavour. Extensions of the SM do not necessarily respect this lepton flavour universality. Semileptonic rare decays of heavy flavour, to which new particles can give sizeable contributions, allow for sensitive tests of lepton flavour universality, and constitute powerful indirect searches for phenomena beyond the SM. Of particular interest are rare b->sll decays that are readily accessible at the LHCb experiment. Recent results from LHCb on lepton flavour universality in rare b->sll decays are discussed.

Collaboration / Activity:

LHCb

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T08: Flavour Physics and CP Violation / 976

Electroweak penguin decays at LHCb

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Rare b->sll decays are flavour-changing neutral-current processes that are forbidden at the lowest perturbative order in the Standard Model (SM). As a consequence, new particles in SM extensions can significantly affect the branching fractions of these decays and their angular distributions. The LHCb experiment is ideally suited for the analysis of these decays due to its high trigger efficiency, as well as excellent tracking and particle identification performance. Recent results from the LHCb experiment in the area of b->sll decays are presented and their interpretation is discussed.

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Collaboration / Activity:

LHCb

T08: Flavour Physics and CP Violation / 977

Radiative b-decays at LHCb

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Radiative b-hadron decays are sensitive probes of New Physics through the study of branching fractions, CP asymmetries and measurements of the polarisation of the photon emitted in the decay. In particular, these measurements help constraining the size of right-handed currents in extensions of the Standard Model. Large samples of radiative b-decays have been collected by the LHCb experiment during Run1 and Run2. We present here the most recent LHCb measurements in this kind of decays.

Collaboration / Activity:

LHCb

First author:

Email:

T14: Outreach, Education and Diversity / 978

How to use your smartphone for outreach

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The best camera is the one you have on you.

In this tutorial, I will discuss how to use a smart phone to communicate your work with a remote audience using the inbuilt camera to produce still images and video content. This can then be edited, if needed, and shared on various social media platforms. Alternatively you can use your phone to directly live-stream and interact with your audience in real-time.

We will explore how to make sure what you are sharing will be accessible and consider which platforms are better for different forms of content. Finally we will look at how to evaluate the different types of feedback from the platforms and the audience.

Collaboration / Activity:

Science Communication

First author:

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T08: Flavour Physics and CP Violation / 979

Measurement of semitauonic b-hadron decays

Author: Stefania Ricciardi[None]

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The semileptonic b-hadron decays with a heavy lepton are sensitive to new couplings like those generated by charged Higgses or Leptoquarks. The B-Factories and LHCb have previously performed various measurements of these decays, using different approaches and techniques. A global average of these measurements shows a discrepancy with the Standard Model expectations, which is above 3 standard deviations. A measurement of the combined ratios BF(B->D tau nu)/BF(B->D mu nu) and BF(B->D*tau nu)/BF(B->D*mu nu) using 3/fb collected by LHCb in Run1, is presented.

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Collaboration / Activity:

LHCb

T07: Top and Electroweak Physics / 983

Experimental challenges towards a full exploitation of the FCC-ee potential

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The European Strategy for Particle Physics ESPP has recommended a financial and technical feasibility of the FCC colliders and their infrastructure to be carried out for its next upgrade around 2025/6. The integral FCC program combines in the same 100km infrastructure a high luminosity Higgs and Electroweak factory e+e- collider, FCC-ee, followed by a 100 TeV hadron collider. With its high luminosity, its clean experimental conditions, and a range of energies that cover the four heaviest particles known today, FCC-ee offers a wealth of physics possibilities, with high potential for discoveries. It is an essential and complementary step towards the 100 TeV hadron collider, and the whole combined program is uniquely rich and powerful. This vision is the backbone of the 2020 ESPP.
The main challenges of the study are now to design the detector systems that can, demonstrably, fully exploit its potential, while being technically feasible and affordable on the project time scale (start of operations around 2040). With 5.1012 Z produced, the TeraZ run offers b,c, ⊠ and QCD physics opportunities, as well as ppm precision challenges on electroweak precision observables and unique searches for extremely rare processes. This breath of opportunities requires very varied and quite specific detector requirements, compared with the higher energy program on Higgs and top physics which is more comparable to the linear collider detector optimization. This variety is clearly in favour of a collider design which foresees four experimental interaction regions. The high precision and varied program is also a considerable challenge for precision calculations.
The opportunities will be reviewed and the most striking detector challenges will be highlighted.

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Collaboration / Activity:

FCC-ee

T08: Flavour Physics and CP Violation / 984

CKM parameter measurement with semileptonic Bs decay at LHCb

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The long standing discrepancy between determinations of the CKM matrix element Vub obtained from exclusive and inclusive semileptonic B decays are at the level of 2-3 standard deviations. This discrepancy continues to challenge our understanding of the semileptonic decays on both the theoretical and experimental sides. Exclusive semileptonic Bs decays are in principle under good theoretical control and provide complementary information with respect to the B-factories in this sector. The first observation of the decay Bs->K mu nu is reported. Using the measurement of the Bs->K mu nu branching fraction relative to the well known Bs->Ds mu nu decay, and the most recent theoretical knowledge of the relevant Bs decays form factors, the ratio of CKM matrix elements Vub/Vcb is extracted, with a precision competitive with the existing measurements. However, the regions of high and low momentum transfer, show inconsistent results. Further investigations are needed to solve the observed discrepancy.

Collaboration / Activity:

LHCb

First author:

Email:

T12: Detector R&D and Data Handling / 985

FCCSW and Key4hep : status and plans

Authors: Gerardo GANIS[1]; Valentin Volkl[2]; Clement Helsens[1]; Emmanuel Perez[1]; Brieuc Francois[1]

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The Future Circular Collider (FCC) is designed to provide unprecedented luminosity and centre-of-mass energies. The physics reach and potential of the different FCC options e^+e^-, pp, ep, is studied with a dedicated software framework, FCCSW, which has been developed and used for the studies published in dedicated Conceptual Design Reports (CDRs) at the end of 2018. Since then a new study phase has started in view of the next European Strategy Update, focusing in particular on detector concept optimisation for the electron-positron machine. On the software-side, this new phase coincided with the start of the common software project Key4hep, of which the FCC community is part

and customer.
The Key4hep project provides a framework, an event data model (EDM4hep) and a set of optimised tools to support the software needs of experiments, in particular in terms of detector optimizations and physics performance. Non FCC-specific parts of FCCSW, including a framework to analyse EDM4hep output using ROOT dataframes, have been or will be migrated to Key4hep and the rest re-based to adapt to the new environment.
In this contribution we will present the current status of this migration process and the overall experience so far. We will also discuss future development plans to optimally support the physics potential studies for FCCee.

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Collaboration / Activity:

FCC

T07-T09: Combined: Top, Electroweak and Higgs Physics / 986

Precision from Diboson Processes at FCC-hh

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Thanks to its high luminosity and center of mass energy, the future FCC-hh collider will allow us to probe processes with clean but rare final states that are unaccessible at the LHC. The study of diboson production processes poses a promising way of indirectly constraining New Physics in the context of the Higgs Boson. Specifically, the diphoton leptonic decay channels of the Wh and Zh production processes are examples for the aforementioned clean but rare final states. I will discuss our study of these channels at the FCC-hh in the SMEFT framework and how doubly differential distributions can be used to gain even better sensitivity to certain higher dimensional EFT operators.

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Collaboration / Activity:

Theory

T12: Detector R&D and Data Handling / 987

Using cluster shape for beam-background suppression in a future muon collider experiment

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The Large Hadron Collider (LHC) is the current highest energy collider, colliding bunches of protons at center-of-mass energy of 13 TeV. In order to further searches for new physics, even higher energies need to be reached. A $\mu^+\mu^-$ collider is a viable alternative, allowing physicists to reach a high center-of-mass energy in a smaller ring than hadron colliders, and with smaller synchrotron radiation than an electron-positron collider. The main challenge is that the muon beams decay rapidly, known as beam-induced background ("BIB"), leading to large multiplicity of hits in the inner tracker. One of the possible discriminants against this beam-induced background is the cluster shape information deposited by muons and BIB, expected to differ between particles originating from the interaction point and BIB. We will present studies implementing a realistic digitization for a muon collider innermost silicon detector and the performance in using cluster shapes as a discriminant.

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Collaboration / Activity:

Muon Collider Detector&Physics

T04: Neutrino Physics / 988

The future of high-energy astrophysical neutrino flavor measurements

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The high-energy cosmic neutrinos seen by IceCube allow us to perform new, powerful tests of high-energy particle physics and astrophysics. In particular, there is vast potential to perform these tests using the high-energy flavor composition, i.e., the proportion of electron, muon, and tau neutrinos in the high-energy neutrino flux. However, presently, these tests are limited by uncertainties in the measurement of flavor in neutrino telescopes and of the neutrino mixing parameters in oscillation experiments. Fortunately, these limitations will be overcome in the next two decades, thanks to new neutrino telescopes—IceCube-Gen2, KM3NeT, Baikal GVD, P-ONE, TAMBO—and new oscillation experiments—JUNO, DUNE, Hyper-Kamiokande. Based on detailed projections of their performance, I will show that in the 2030s flavor will finally become a precision tool for high-energy

neutrino physics and astrophysics. I will showcase two examples: inferring the astrophysical neutrino production mechanism and placing stronger constraints on the neutrino lifetime.

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Collaboration / Activity:

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T06: QCD and Hadronic Physics / 989

Observation of Lambda_b -antiLambda_b production asymmetry (12'+3')

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A precise measurement of the Lambda_b production asymmetry is critical to the measurements of CP violation in the decay of b-baryons at LHCb. In general these production asymmetries cannot be precisely predicted since they require knowledge of non perturbative b-quark hadronisation processes, and so need to be experimentally determined. The semileptonic Lambda_b->Lambda_c mu nu decay offers an excellent tool for precise measurement of such production asymmetry. It has a large branching fraction and a clear experimental signature with the presence of a high transverse momentum muon. Furthermore, it is theoretically clean and the CP violation in the decay can be safely assumed to be negligible. The first observation of the Lb-anti-Lb baryon production asymmetry is presented, together with strong evidence of a dependence of this production asymmetry with the rapidity.

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Collaboration / Activity:

LHCb

T14: Outreach, Education and Diversity / 990

Diversity and Inclusion at Belle II

Authors: Matt Barrett[1]; Elisabetta Prencipe[2]

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The Belle II collaboration has over 1000 people from institutions in 26 countries working together to achieve its physics goals. The collaboration is committed to fostering an open, diverse, and inclusive environment, and created a diversity office to raise awareness of diversity and inclusion issues, promote an inclusive atmosphere within the collaboration, provide a safe and confidential point to contact for collaborators to report any issues, particularly those related to discrimination and harassment, and ensure that persons from underrepresented groups are considered for positions of responsibility within the collaboration. This presentation will discuss diversity and inclusion activities and initiatives at Belle II, and present an analysis of the evolving demographics of the collaboration.

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Collaboration / Activity:

Belle II

T01: Astroparticle and Gravitational Waves / 991

Gravitational waves searches in O3 Advanced LIGO and Advanced Virgo data

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Third Observation (O3) run of Advanced LIGO and Advanced Virgo started in April 2019 and ended in March 2020; reaching sensitivities significantly better than those in the previous observing run. During this period, 56 gravitational-wave candidates were publicly released within hours of detection.
This talk will overview the published science results achieved during the O3 run, focusing on the catalog of the gravitational waves signal due to compact binary coalescences (GWTC-2) and on the main outcomes of follow-up investigations, e.g. tests of general relativity. Among gravitational waves signals reported in GWTC-2, a few have been associated to exceptional scientific case such as binary system with significantly asymmetric mass ratios (GW190412), or intermediate-mass black holes (GW190521), these will be discussed.

Collaboration / Activity:

LVC collaboration

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T05: Heavy Ion Physics / 992

Effect of magnetic field on kaon and antikaon in neutron stars

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The medium modification in energies of kaon and antikaon at zero momentum in strongly magnetized asymmetric nuclear matter are explored using a chiral SU(3) model. The parameters used in this calculation are fitted to nuclear matter saturation properties and with vacuum masses of baryon. We have investigated the possibility of antikaon condensation in neutron star with charge neutrality and $\beta-$equilibrium condition. By considering the effect of anomalous magnetic moments (AMM) in present study it is observed that the density effect is dominating in medium as compared to magnetic field and isospin asymmetry.

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Collaboration / Activity:

no

T04: Neutrino Physics / 993

Determining neutron multiplicity from neutrino interactions with ANNIE

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A hundred meters downstream within the Booster Neutrino Beam at Fermilab lies the Accelerator Neutrino Neutron Interaction Experiment (ANNIE for short), a 26 ton gadolinium-doped water Cherenkov detector, measuring the neutrino interaction cross section in water and the final state neutron multiplicity as a function of momentum transfer. Besides improving the systematic uncertainties of future long-baseline neutrino detectors with its results, ANNIE also serves as a testbed for upcoming technologies in particle experiments: The ongoing Phase-II of the project will see the deployment of novel light sensors, the so called Large Area Picosecond Photodetectors (LAPPDs) for enhanced time resolution below 100 picoseconds while the near future will have an additional detection volume filled with water-based liquid scintillator submereged into the tank. This presentation details the current status of ANNIE during its first Phase-II data taking, show past and present work conducted on LAPPDs and outline future plans for the experiment itself and beyond.

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Collaboration / Activity:

ANNIE

T10: Searches for New Physics / 994

Long-lived particles searches at LHCb

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The unique design of the LHCb detector with a flexible trigger and a precision vertex tracker, offers the possibility to search for long-lived particles with low masses and short lifetimes, in complementarity with other general-purpose detectors at the LHC. Searches have been performed at LHCb, in fully leptonic and semi-leptonic final states. In particular, searches for long-lived particles produced in pairs from an exotic Higgs boson decay, and a search for heavy neutral leptons from a W boson decay, will be presented.

Collaboration / Activity:

LHCb

First author:

Email:

T14: Outreach, Education and Diversity / 995

Diversity & Inclusion in the CMS Collaboration

Authors: CMS[None]; CMS[None]

The CMS Collaboration is one of the largest scientific organizations ever assembled, with over 5000 active members from 229 institutes in 51 countries and regions. The goal of the CMS Diversity Office is to foster a working environment where all members of the Collaboration can thrive; ensuring the collaboration's diverse and inclusive environment is essential for its continued success. In this presentation, we highlight some of the activities of the CMS Diversity Office and present some statistics regarding diversity and inclusion of the CMS Collaboration.

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Collaboration / Activity:

CMS

T10: Searches for New Physics / 996

New constraints on flavour violating supersymmetry

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We present an update on the constraints on general MSSM scenarios with non-minimal sources of flavour violation (NMFV), including all theoretical constraints and the most recent experimental bounds.
Using an MCMC algorithm and the public code SuperIso, we compute various flavour observables and the muon $(g-2)$ and impose the LHC direct search limits.
We present an up-to-date calculation of the relevant observables, in particular those related to $b \to sll$ transitions which manifest tensions with the SM predictions, and show the latest allowed NMFV parameter ranges, in light of the most recent experimental bounds.
We finally discuss and propose a few benchmark scenarios for future BSM searches.

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Collaboration / Activity:

Theory

T03: Dark Matter / 997

Dark matter searches at LHCb

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The LHCb detector at the LHC offers unique coverage of forward rapidities. The detector also has a flexible trigger that enables low-mass states to be recorded with high efficiency, and a precision vertex detector that enables excellent separation of primary interactions from secondary decays. This allows LHCb to make significant (and world-leading) contributions in these regions of phase space in the search for dark matter candidates, such as dark photons, hidden-sector particles, and dark matter candidates produced from heavy-flavour decays. A selection of results from these searches will be presented, alongside the potential for future measurements in these final states.

Collaboration / Activity:

LHCb

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T14: Outreach, Education and Diversity / 998

Education and outreach activities in the Extreme Energy Events Project

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The Extreme Energy Events Project (EEE) is an experiment devoted to the study of Extensive Atmospheric Showers (EAS) through an array of muon telescopes. It was directly born with the intent to involve high school students and teachers in its advanced physics research. Each EEE telescope was built by students and teachers at CERN and most of the telescopes are located inside Italian school buildings where school teams help to monitor and operate the detectors. During the years the EEE project has broadened the telescopes network and its outreach program has been also enriched with new activities. Within the project a large community of researchers, teachers and hundreds of students has been formed, continuously involved in seminars arranged to introduce the young students to data analysis, in meetings to confront their ideas, problems and results, in measurements campaigns where they may also use additional small detectors and help to improve the telescopes performance.

Collaboration / Activity:

The EEE Collaboration

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T08: Flavour Physics and CP Violation / 999

CP violation in charmless 2-body B meson decays at LHCb

Authors: Stefania Ricciardi[None]; Thomas Grammatico[1]

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Measurements of CP asymmetries in charmless two-body B-meson decays can be a powerful way to provide stringent tests of the Standard Model. In particular a longstanding anomaly in the CP asymmetries of B decays to a kaon and a pion, known as the $K\pi$ puzzle, can be a hint of physics beyond the Standard Model. We present new results from the analyses of charmless 2-body B decays with kaons and pions in the final state at LHCb.

Collaboration / Activity:

LHCb

First author:

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T06: QCD and Hadronic Physics / 1000

All-plus helicity off-shell gauge invariant multigluon amplitudes at one loop

Authors: Etienne Blanco[1]; Krzysztof Kutak[2]; Piotr Kotko[3]; Andreas van Hameren[4]

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We calculate one loop scattering amplitudes for arbitrary number of positive helicity on-shell gluons and one off-shell gluon treated within the quasi-multi Regge kinematics. The result is fully gauge invariant and possesses the correct on-shell limit. Our method is based on embedding the off-shell process, together with contributions needed to retain gauge invariance, in a bigger fully on-shell process with auxiliary quark or gluon line.

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Collaboration / Activity:

IFJ-PAN

T04: Neutrino Physics / 1001

Probing Dark Matter Models with Upcoming Neutrino Telescopes

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Next generation of neutrino telescopes currently under construction are drastically improving their ability to constrain the annihilation cross-section of dark matter. In this talk after introducing an angular power spectrum analysis method for future sensitivity of a KM3NeT-like neutrino telescope, we will discuss the implications of results on the various particle dark matter models. Particular attention will be made on the assessment of limits complementing the current direct dark matter detection and gamma ray searches. We will emphasise that future neutrino telescopes will be able to competitively probe significant portions of parameter space and therefore will provide critical complementary information on the dark matter searches.

Collaboration / Activity:

DM Phenomenology

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T06-T07: Combined: Top, Electroweak, QCD and Hadronic Physics / 1002

The impact of mixed QCD-EW corrections on the W-mass measurement

Authors: Raoul Röntsch[1]; Kirill Melnikov[None]; Fabrizio Caola[None]; Federico Buccioni[None]; Arnd Behring[None]; Maximilian Delto[None]; Matthieu Jaquier[None]

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The target precision for W-mass measurements at the LHC is around 0.1 permille, an extremely ambitious goal that requires exceptional theoretical control on vector boson production. I will present the results of a recent calculation of the mixed QCD $\times$ EW corrections to W and Z boson production. I will then discuss the impact of these corrections on the measurement of the W boson mass at the LHC using the transverse momentum of the charged leptons arising from the decay of the W boson.

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Collaboration / Activity:

Theory

T12: Detector R&D and Data Handling / 1004

Future upgrades of ALICE for Run 4

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As ALICE is commissioning the detectors after major upgrades for the upcoming LHC Run 3, further projects are already on their way. R&D for a future upgrade of the Inner Tracking System has demonstrated the feasibility to operate thinned monolithic active pixel sensors bent to radii as small as 18 mm. In addition, it has been confirmed that large-scale wafers can be bent to such radii to form truly cylindrical sensors requiring only the silicon itself in the active area. This technique shall be used to replace the inner tracking layers and achieve unprecedented low material budget, reduced interaction probabilities, and unparalleled vertexing performance. We will discuss the results from the R&D programme and the prospects for the ITS3.

In addition, a novel concept for a Forward Calorimeter (FoCal) consisting of a high-granularity Si-W electromagnetic calorimeter with pad and pixel readout to provide unprecedented spatial resolution, and a hadronic calorimeter with conventional metal-scintillator technology with optical readout. The FoCal covers the pseudorapidity range from 3.4 to 5.8 to measure forward photon production to constrain the gluon PDFs down to very small x. We will show results from the R&D programme and the prospects for physics with the FoCal.

Collaboration / Activity:

ALICE

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T10: Searches for New Physics / 1005

BSM Physics at the LHeC and the FCC-he

Author: Nestor Armesto Perez[1]

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The LHeC and the FCC-he offer fascinating, unique possibilities for discovering BSM physics in DIS, both due to their large centre-of-mass energies and high luminosities. In this talk we will review most recent studies as presented in the 2020 LHeC Conceptual Design Report update 1. We will show the prospects for observing extensions of the Higgs sectors both with charged and neutral scalars, anomalous Higgs couplings and exotic decays. Then we will discuss searches for R-parity conserving and violating supersymmetry both with prompt and long-lived particles, and of feeble interacting particles like sterile neutrinos, fermion triplets, dark photons and axion-like particles. Finally we will address anomalous couplings and searches for heavy resonances like leptoquarks and vector-like quarks, excited fermions and colour-octet leptons.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e-Print: 2007.14491 [hep-ex], to appear in J. Phys. G.

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Collaboration / Activity:

LHeC/FCC-he Study Group

T08: Flavour Physics and CP Violation / 1007

Charmless three-body decays at LHCb

Author: Lais Soares Lavra[1]

Co-author: Stefania Ricciardi

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Short and long-distance dynamics along with a sizeable effective weak phase caused by the interference between tree and penguin amplitudes in charmless 3-body B decays leads to a rich structure of CP violation as a function of the phase space. We present the latest studies with charmless $B \to 3h$ decays at LHCb, including CP asymmetries and branching fractions

Collaboration / Activity:

LHCb

First author:

Email:

T03: Dark Matter / 1008

Shining Light on Dark Matter with Black Holes

Author: Volodymyr Takhistov[None]

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What is dark matter, the mysterious predominant constituent of all matter in the Universe? As I will show, primordial black holes from the early Universe make an attractive non-particle dark matter candidate, with intimate connections to astronomical puzzles like the origin of heavy elements (gold) as well as ongoing boom in gravity wave and multi-messenger astronomy. In fact, primordial black holes from the general formation scenario of bubble multiverse might have already been seen by Subaru Hyper Suprime-Cam.

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Collaboration / Activity:

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T13 - Accelerator for HEP / 1010

The Development of Energy Recovery Linacs

Author: Max Klein[1]

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A summary will be given of the current status and the prospects for energy recovery linac (ERL) technology and its possible application for future ep and e+e- colliders, as well as for low energy particle and nuclear physics. The talk will give an overview of ERL development facilities, current and future, describe key technology challenges and also cover the aspect of sustainability of ERLs. Energy recovery has been recognised as one of the major new, promising accelerator technologies of the future by the recent deliberation on the strategy for particle physics. The presentation is on behalf of an 18 person expert panel on ERL which develops a roadmap on ERL technology developments towards the end of 21, following a mandate by CERN Council and the group of directors of larger laboratories (LDG) associated to CERN.

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Collaboration / Activity:

for LDG (ATLAS, LHeC, PERLE)

T12: Detector R&D and Data Handling / 1011

ALICE 3

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In parallel to the commissioning of the upgraded detector system for Run 3 and the R&D for upgrades planned for Run 4, ALICE is preparing a next-generation heavy-ion experiment for LHC Run 5. It will give us access to novel measurements of electromagnetic and hadronic probes of the QGP at very low momenta that will remain inaccessible in LHC Run 3+4, both because of detector performance and luminosity. We expect new insights from new measurements of multi-charm baryons and exotica as well as from high-precision analyses of dielectron production at very low momenta. The required detector performance shall be achieved through extensive usage of thin silicon sensors for tracking, combining the advantages of extremely low material budget, fast read-out, and high resolution. A modern particle identification system shall complement the tracking system. In combination with a silicon-based time of flight detector, a RICH and preshower detector are studied to provide high-purity measurements of dielectron pairs which probe the conditions in the QGP phase of the collision and help with the background rejection in the heavy-flavour measurements. We will present the physics prospects for heavy-ion physics in LHC Run 5 and beyond and the plans for the apparatus.

Collaboration / Activity:

ALICE

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T06: QCD and Hadronic Physics / 1012

Precision QCD in ep collisions at the LHeC

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The LHeC and the FCC-he are the cleanest, high resolution microscopes that the world can build in the nearer future. Through a combination of neutral and charged currents and heavy quark tagging, they will unfold the parton structure of the proton with full flavour decomposition and unprecedented precision. In this talk we will present the most recent studies on the
determination of proton parton densities as contained in 2020 LHeC Conceptual Design Report update 1. We will also present the results on the determination of the strong coupling constant through the measurement of total and jet cross sections.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e-Print: 2007.14491 [hep-ex], to appear in J. Phys. G.

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Collaboration / Activity:

LHeC/FCC-he Study Group

T05: Heavy Ion Physics / 1015

Electron-Ion Collisions at the LHeC and FCC-he

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The LHeC and the FCC-he will open a new realm in our understanding of nuclear structure and the dynamics in processes involving nuclei, in an unexplored kinematic domain. In this talk we will review the most recent studies as shown in the update of the 2012 CDR 1. We will discuss the determination of nuclear parton densities in the framework of global fits and for a single nucleus. Then we will discuss diffraction, both inclusive and exclusive. Finally we will demonstrate the unique capability of these high-energy colliders for proving the long sought non-linear regime of QCD, saturation, to exist (or to disprove). This is enabled through the simultaneous measurements, of similar high precision and range, of ep and eA collisions which will eventually disentangle non-linear parton-parton interactions from nuclear environment effects.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e Print: 2007.14491 [hep-ex], to appear in J. Phys. G.

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Collaboration / Activity:

LHeC/FCC-he Study Group

T01: Astroparticle and Gravitational Waves / 1016

Instrument science challenges of the Einstein Telescope

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The Einstein Telescope (ET) is a planned third-generation gravitational wave observatory in Europe. The ET observatory is composed of three detectors that together form an equilateral triangle. Each detector consists of two interferometers, one optimised for low frequencies from 3 Hz to 30 Hz and another optimised for high frequencies from 30 Hz to 10 kHz. In order to reach its ambitious sensitive target ET will require significant technology advances compared to current facilities, from cryogenic suspensions to Newtonian noise subtraction. We have recently started the effort towards the technical design of the detectors and the infrastructure. In this talk I will provide a short overview of the unique challenges and plans of ET instrument science activities.

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Collaboration / Activity:

Einstein Telescope

T09: Higgs Physics / 1017

Higgs physics at the LHeC and the FCC-he

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Higgs production cross sections at LHeC (FCC-he) energies are as large (larger than) those at future Z-H e^+e^- colliders. This provides alternative and complementary ways to obtain very precise measurements of the Higgs couplings, primarily from luminous, charged current DIS. Recent results for LHeC and FCC-he 1 are shown and their combination is presented with pp (HL-LHC) cross sections leading to precision comparable to the most promising e^+e^- colliders. We will show the results for the determination of several signal strengths and couplings to quarks, leptons and EW bosons, and discuss the possibilities for measuring the coupling to top quarks and its CP phase, and the search for invisible decays.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e-Print: 2007.14491 [hep-ex], to appear in J. Phys. G.

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Collaboration / Activity:

LHeC/FCC-he Study Group

T06: QCD and Hadronic Physics / 1019

Elucidating the internal structure of hadrons through direct photon production

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The accurate description of the internal structure of hadrons is a very challenging task. In order to compare the predictions with the highly-accurate experimental data, it is necessary to control any possible source of theoretical uncertainties. Thus, we can use the information extracted from final state measurement to constraint our knowledge about the internal structure of hadrons. In this talk, we describe how direct photon production can be exploited to unveil details about the partonic distributions inside protons. In this talk, we explain how to describe NLO QCD plus LO QED corrections to hadron plus photon production at collider, focusing on the accurate reconstruction of the partonic momentum fractions from experimentally accessible observables.

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Collaboration / Activity:

None

T04: Neutrino Physics / 1020

Recent results of the SoLid experiment

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The SoLid experiment intends to search for active-to-sterile anti-neutrino oscillations at the very short baseline (6.3-8.9 m) of the SCK•CEN BR2 research reactor (Mol, Belgium) to address the so-called "Reactor Anti-neutrino Anomaly". This anomaly arose from the reevaluation of the predicted reactor anti-neutrino flux which resulted in a deficit observed by very short baseline experiments. This deficit could be explained by flavor oscillations to a new type of neutrino: the sterile neutrino.

High experimental sensitivity to inverse beta decay interactions can be achieved thanks to the innovative combination of highly segmented PVT scintillator that will serve as neutrino target and to measure the positron with a high neutron-gamma discrimination 6LiF:ZnS(Ag) scintillator. This technology offers precise time and space localization of the IBD signals. The reconstruction of the full topology of the events allows a strong background rejection, necessary given the low overburden at the reactor building and the presence of 214BiPo background from the 238U decay chain in the neutron screens. From the analysis point of view many variables can be reconstructed and exploited with multivariates and boosted decision trees analysis to improve the background rejections.

The detector has been taking a first phase of physics data from 2018 to 2020. In this contribution we will present an overview of the experiment, the background rejections capabilities, the extraction of the reactor anti-neutrino signal and in particular for the first time the physics results with two years of data. The ability to probe the RAA with this result will be investigated. Finally the perspective of a full event topology analysis will be presented on the first opened dataset of 2018.

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Collaboration / Activity:

The SoLid Collaboration

T13 - Accelerator for HEP / 1021

The ERL Facility PERLE at Orsay

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The realisation of the LHeC and the FCC-he at CERN require the development of the energy recovering technique in multipass mode and for large currents
$calO(10)$ mA in the SRF cavities. For this purpose, a technology development facility, PERLE, is under design to be built at IJCLab Orsay, which has the key LHeC ERL parameters, in terms of configuration, source, current, frequency and technical solutions, cryomodule, stacked magnets. In this talk we review the design and comment on the status of PERLE.

Collaboration / Activity:

LHeC/FCC-he Study Group

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T13 - Accelerator for HEP / 1022

The Large Hadron-electron Collider at CERN: Status and Plans

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In this talk the current status and plans are presented on the LHeC, towards the new HEP strategy update in about 5 years time, on physics, with emphasis on the eh-hh relation, on the machine, especially the IR, and further detector developments. The talk also covers FCC-he and refers to a separate presentation of the ERL facility PERLE. It is based on the comprehensive CDR update which is being published in J. Phys. G 1.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e-Print: 2007.14491 [hep-ex], to appear in J. Phys. G.

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Collaboration / Activity:

LHeC/FCC-he Study Group

T04: Neutrino Physics / 1023

Recent astroparticle and exotic physics results from MicroBooNE

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MicroBooNE is an 85-ton active mass liquid argon time projection chamber (LArTPC) at Fermilab. Its excellent calorimetry and resolution, along with its exposure to two neutrino beam lines (BNB and NuMI) make it a powerful detector not just for neutrino physics, but also for Beyond the Standard Model (BSM) physics and astroparticle physics. The experiment has competitive sensitivity to heavy neutral leptons arising in the leptonic decay modes of kaons, and also to scalar bosons that can be produced in kaon decays in association with pions. In addition, MicroBooNE serves as a platform for prototyping searches for rare events in the future Deep Underground Neutrino Experiment (DUNE). This talk will explore the capabilities of LArTPCs for BSM physics and astrophysics and highlight some recent results from MicroBooNE.

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Collaboration / Activity:

MicroBooNE

T01: Astroparticle and Gravitational Waves / 1025

The KM3NeT neutrino telescopes: status and perspectives

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The KM3NeT international collaboration has started to build two underwater neutrino telescopes, located in two deep sites of the Mediterranean Sea. ARCA (Astroparticle Research with Cosmics in the Abyss) in its final configuration will instrument 1 Gton of seawater, using more than 100,000 PMTs with a 3"diameter. ARCA is optimised to detect cosmic neutrinos within an energy range of 1 TeV −10 PeV; it will provide an excellent view of the Southern Sky, including the Galactic Centre. ORCA (Oscillation Research with Cosmics in the Abyss) will be a smaller detector, with an instrumented volume of few Mtons. The photosensors are distributed in a more compact lattice for ORCA, in order to reveal atmospheric neutrinos in the 1 −100 GeV range.

ORCA is running in a 6-line configuration since more than one year. ARCA has recently completed the installation of new strings, bringing the total number of active lines to 6. The 12 DUs of ARCA and ORCA represent the first core towards full construction of KM3NeT, with new deployment campaigns foreseen in the next months and years at the two installation sites.

This talk will focus on the status and the long-term perspectives for the detector completion, together with a description of the main technological solutions adopted. The ARCA and ORCA science program for neutrino astronomy will be presented. Finally, a preliminary analysis of the ARCA 6-line data will be discussed.

Collaboration / Activity:

KM3NeT Collaboration

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T07: Top and Electroweak Physics / 1026

Top physics at the LHeC and the FCC-he

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The LHeC and the FCC-he offer unique prospects for the measurement of top properties in energy frontier, luminous ep scattering. An update of the 2012 Conceptual Design Report was produced last year 1. In this talk we will revisit the determination of the top mass through inclusive measurements. In addition, we will address the possibilities for precise measurements of Wtq and γtq couplings, and competitive searches for FCNC top couplings.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e-Print: 2007.14491 [hep-ex], to appear in J. Phys. G.

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Collaboration / Activity:

LHeC/FCC-he Study Group

T09: Higgs Physics / 1027

Higgs self-coupling measurements in the HL-LHC era: new approaches for the HH->4b final state.

Authors: Jacob Amacker[None]; William Balunas[1]; Lydia Beresford[2]; Daniela BORTOLETTO[1]; Cigdem Issever[3]; James Frost[1]; Jesse Liu[4]; James McKee[None]; Alessandro Micheli[None]; Santiago Paredes Saenz[5]; Michael Spannowsky[6]; Beojan Stanislaus[1]

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Searches for pairs of Higgs bosons will be, in all likelihood, the best tools to precisely measure the Higgs boson self-coupling λ_{hhh} in future colliders. We study various strategies for the $hh \to b\bar{b}b\bar{b}$ search in the HL-LHC era with focus on constraining λ_{hhh}. We implement a machine-learning-based approach to separate signal and background and apply recent advances in machine learning interpretability, compare the traditional 4 b-jet reconstruction to final states with 1 or 2 large-radius jets, and test scenarios with different top-quark Yukawa couplings, among other factors.
Based on arXiv:2004.04240.

Collaboration / Activity:

Phenomenology Study

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T11: Quantum Field and String Theory / 1028

Understanding the Loop Quantum Cosmology and the Concept of Time

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Time is an enigmatic property of the universe which confounded physicists for ages. This property is increasingly dark and cryptic when we deal with metric spaces of the microscopic scales in the universe. There are remarkable theories, in particular, the loop quantum gravity (LQT) which helps us in understanding the cosmology of these microscopic scales. However, the theory possesses considerable complications in explaining the concept of time. We redress the notions of quantum cosmology and the loop quantum gravity. The elegance of the theory in describing the microscopic scales is discussed. We try to emphasise the concept of the time interpreted as far as the notion of quantum gravity is concerned. We aim to review and re-analyse the loop gravity, the perception of the dynamic time and the timeless universe.

Collaboration / Activity:

Birla Science Center & KITP

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T07: Top and Electroweak Physics / 1029

The top quark electro-weak couplings after LHC Run 2

Authors: María Moreno Llácer[1]; Marcos Miralles López[2]; Marcel Vos[2]; Ana Peñuelas[2]; Martin Perello[2]; Víctor Miralles[2]

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As the heaviest particle of the model, with a mass close to the electroweak scale, the top quark is an interesting candidate to look for hints of new physics. The electroweak couplings of the top quarks are specially relevant in many extensions of the Standard Model. Indeed, as the top quark was not produced in the previous generation of electron-positron colliders most of its electro-weak couplings can only be constrained with the data from the Large Hadron Collider. In order to analyze if there is still room for new physics in the electro-weak couplings of the top quark, we perform a global fit to these couplings. Following the Standard Model Effective Field Theory formalism we have constrained the Wilson coefficients of the dimension-six operators that affect the top quark electro-weak couplings. In this work we consider, for the first time, the QCD corrections at NLO for most of the processes included. Furthermore, we have included recently measured processes, such as tZq and $t\gamma q$, and the first differential measurements in $t\bar{t}Z$ and $t\bar{t}\gamma$ production. A special effort is made to understand the uncertainties due to the truncation of the EFT expansion and due to the poorly known correlations among measurements. As the main result, we present a robust set of bounds on the relevant operator coefficients, which represents a significant improvement with respect to previous results.
The results and paper are being finalized and we plan to upload the pre-print in May 2021.

Collaboration / Activity:

Global EFT fits

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T08: Flavour Physics and CP Violation / 1030

LHCb results in charm baryons

Author: Ao Xu[1]

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The LHCb experiment collected the world's largest sample of charmed hadrons during LHC Run 1 and Run 2. With this data set, LHCb is currently providing the world's most precise measurements of properties and production of known charmed baryons, as well as discovering many previously unobserved states. The latest results from the LHCb Collaboration on charmed baryons are presented.

Collaboration / Activity:

LHCb

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T11: Quantum Field and String Theory / 1031

Two-loop renormalisation of non-Abelian gauge theories in $4D$ Implicit Regularisation

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The data collected at the LHC does not indicate significant deviations from the predictions of the Standard Model (SM). Taking into account that precision observables can be predicted already at two and three loops, it is evident the necessity to develop stringent tests of self-consistency of the SM. We compute the two-loop β-function of pure Yang-Mills and quantum chromodynamics using the background field method in a fully quadridimensional setup using Implicit Regularization (IREG). Subtleties related to Lorentz algebra contractions/symmetric integrations inside divergent integrals as well as renormalization schemes are carefully discussed within IREG where the renormalization constants are fully defined as basic divergent integrals to arbitrary loop order. Finally, an algorithm for the automated calculation of the β-function was developed in Mathematica.

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Collaboration / Activity:

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T07: Top and Electroweak Physics / 1032

Precision electroweak measurements at the LHeC and the FCC-he

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The measurements of inclusive deep-inelastic electron-proton scattering (DIS) cross sections at high center-or-mass energies offer a unique opportunity for precision tests of electroweak interactions.

In this talk we revisit electroweak effects in DIS and discuss the combined determination of parameters of electroweak theory together with parton distribution functions of the proton [1,2]. Using simlulated data for the future DIS experiments LHeC and FCC-he, we study the determination of the W, Z and top-quark mass from inclusive measurements. We will show the possibilities for the determination of the vector and axial couplings of light quarks, and outline a unique measurement of the running the effective weak mixing angle. The sensitivity of future inclusive DIS data to generic extensions of the electroweak standard model is further investigated.

1 LHeC Collaboration and FCC-he Study Group, P. Agostini et al., e-Print: 2007.14491 [hep-ex], to appear in J. Phys. G.
[2] Daniel Britzger, Max Klein, Hubert Spiesberger, Eur.Phys.J.C 80 (2020) 9, 831, e-Print: 2007.11799 [hep-ph].

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Collaboration / Activity:

LHeC/FCC-he Study Group

T13 - Accelerator for HEP / 1033

A demonstrator to investigate the feasibility of a Muon Collider

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Following the input of the European Strategy Update released in 2020, an International Collaboration hosted by CERN is being formed to investigate the feasibility and the physics reach of a muon collider in two stages, the first at around 3 TeV, and the second at an energy in excess of 10 TeV. The International Muon Collider Study is organised around three pillars, the design of the colliders at 3 and 10÷14 TeV, the development of prototypes and hardware test facilities for the most critical components, and finally the proposal for a beam test facility whose aim is to produce, capture and provide in a convincing way a demonstration that it is possible to provide sufficient cooling to achieve the performances required for injecting in the collider ring, and measure the cooling and transmission efficiencies. As a first step a full review of past results obtained by collaborations in the different regions is being performed. In parallel, possible options and sites for its construction are being investigated. At CERN we are developing ideas for a campus compatible with the present CERN infrastructure and future developments and that may take advantage of existing beam lines, while not interfering with already approved programs. A first decision has to be taken on the energy at which muons will be produced, which will allow to select between the PS and the SPS complex of accelerators and experimental areas. Also, it would be suitable to design a facility that could possibly evolve in the future into the final collider complex. This paper will describe the status of the discussions and the possible options at stake.

Collaboration / Activity:

International Muon Collider

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T08: Flavour Physics and CP Violation / 1034

Mixing and time-dependent CPV in charm decays at LHCb

Author: Stefania Ricciardi[None]

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LHCb has collected the world's largest sample of charmed hadrons. This sample is used to measure $D^0 - \overline{D}^0$ mixing and to search for CP violation in mixing and interference. New measurements from several decay modes are presented, as well as prospects for future sensitivities.

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Collaboration / Activity:

LHCb

T10: Searches for New Physics / 1036

Data-Driven Background Modelling using Conditional Probabilities

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Constructing a robust background model is one of the main challenges in particle physics data analysis. A common strategy is to simulate the background process, though this is not always possible, and the uncertainties arising from simulation-based background modelling or from limited simulation statistics often limit the physics sensitivity. Two novel data-driven background modelling techniques are presented, which address these issues for a broad class of searches and measurements by providing an almost fully generic background modelling strategy. The first method uses data from a relaxed version of the event selection to estimate a graph of conditional probability density functions of the variables used in the analysis, accounting for all significant correlations. A background model is then generated by sampling events from this graph, before the full event selection is applied. In the second method, a generative adversarial network is trained to estimate the joint probability density function of the variables used in the analysis, conditioned on the variable used to blind the signal region. This training proceeds in the sidebands, and the conditional probability density function is interpolated into the signal region to estimate the background. Results are presented which demonstrate the performance of both methods, and their impacts on two benchmark analyses are discussed.

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Collaboration / Activity:

ExclusiveHiggs

T01: Astroparticle and Gravitational Waves / 1037

Measuring the dark matter environments of black hole binaries with gravitational waves

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Black holes of astrophysical and primordial origin can compress their dark matter environments to extreme densities as they form and grow. This "dark dress" inevitably affects the dynamical evolution of binaries, and imprints a characteristic dephasing onto their gravitational waveforms that could be probed with upcoming interferometers. In this work, we study the prospects for detecting and characterizing the dark matter content of these systems with the Laser Interferometer Space Antenna (LISA). We introduce an analytical model for the dephasing of dark dresses motivated by the interplay between the gravitational wave emission and disruption of the dark matter halo that governs their evolution. We demonstrate that LISA could distinguishing dark dresses from standard black hole binaries and quantify how precisely their parameters could be measured. Through such measurements, future gravitational wave detectors could be a powerful tool for probing the particle nature of dark matter.

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Collaboration / Activity:

None

T12: Detector R&D and Data Handling / 1039

A GPU High Level Trigger 1 for the upgraded LHCb detector

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In 2022 the upgraded LHCb experiment will use a triggerless readout system collecting data at an event rate of 30 MHz. A software-only High Level Trigger will enable unprecedented flexibility for trigger selections. During the first stage (HLT1), a sub-set of the full offline track reconstruction for charged particles is run to select particles of interest. After this first stage, the event rate is reduced by at least a factor 30. Track reconstruction at 30 MHz represents a significant computing challenge, requiring a renovation of current algorithms and the underlying hardware. In this talk,

we present the approach of executing the full HLT1 chain on GPUs. This includes decoding the raw data, clustering of hits, pattern recognition, as well as track fitting. We discuss the design of HLT1 algorithms optimized for many-core architectures. Both the computing and physics performance of the full HLT1 chain will be presented.

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Collaboration / Activity:

LHCb

T10: Searches for New Physics / 1040

Searching for Exotic Signals with the NOvA Experiment

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Two highly segmented NOvA scintillation detectors, separated by 810 km and located in the path of the NuMI neutrino beam produced at Fermilab, are optimized to study the neutrino oscillation phenomenon. At the same time, the larger Far detector (FD) with its 4,000 m2 surface area is capable to search for the exotic low-mass magnetic monopoles, and to monitor flux of the specific high-multiplicity cosmic ray showers, while the smaller Near detector (ND) located 100m underground at Fermilab, is capable to search for the possible presence of the elusive Dark Matter particles in the high-intensity NuMI neutrino beam, and to study the mysterious seasonal variations of multi-muon cosmic flux component. Both ND and FD NOvA detectors serve in combination as a powerful supernova detector, and allow for multi-messenger signal searches in coincidence with LIGO/Virgo gravitational wave events. The survey of the most recent NOvA results on these exciting topics will be presented.

Collaboration / Activity:

NOvA Collaboration

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T12: Detector R&D and Data Handling / 1041

Real-time analysis in Run 3 with the LHCb experiment

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Second stage of high-level trigger at the LHCb, deployed on a CPU server farm, not only selects events but performs an offline-quality alignment and calibration of the detector and uses this information to allow physics analysts to deploy essentially their full offline analysis level selections (including computing isolation, flavour tagging, etc) at the trigger level. This "real time analysis" concept has also allowed LHCb to fully unify its online and offline software codebases. We cover the design and performance of the system which will be deployed in Run 3, with particular attention to the physics performance of the new algorithms.

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Collaboration / Activity:

LHCb

T05: Heavy Ion Physics / **1042**

Measurement of Λ_c^+ production in pp and p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02TeV with the ALICE experiment at the LHC

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Measurements of heavy-flavour meson and baryon production in proton-proton (pp) collisions are crucial to study the charm quark hadronisation mechanisms and the possible difference with respect to e^+e^- collisions. Measurements in p-Pb collisions are also important to investigate the role of the cold nuclear matter (CNM) effects. Furthermore, measurements in both collision systems provide important references to the measurements performed in Pb–Pb collisions. Here charm quarks, which are created at the beginning of the collision and interact with the medium during all the stages of the system evolution, are useful probes of the energy loss and their hadronisation in hadrons. In particular, the measurement of charmed baryon-to-meson ratio Λ_c^+/D^0 is sensitive to the hadronisation mechanisms and could provide further insights about the role of the different mechanisms in e^+e^-, pp, and Pb-Pb collisions.

In this contribution, measurements of the Λ_c^+/D^0 ratio in pp and p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV are presented. The results show an increased Λ_c^+/D^0 ratio compared to that measured in e^+e^- and e–p collisions, which challenges the usual assumption of quark fragmentation being independent of collision system. Furthermore, new results of Λ_c^+ production in p-Pb collisions, measured for the first time down to $p_T=0, are shown. The nuclear modification factor in p-Pb will be discussed, as well as the comparison with theoretical models.

Collaboration / Activity:

ALICE

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T12: Detector R&D and Data Handling / 1043

Real-time alignment procedure at the LHCb experiment

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The LHCb detector at the LHC is a general purpose detector in the forward region with a focus on studying decays of c- and b-hadrons. For Run 3 of the LHC (data taking foreseen from 2022), LHCb will take data at an instantaneous luminosity of 2 × 10^{33} cm−2 s−1, five times higher than in Run 2 (2015-2018). To cope with the harsher data taking conditions, LHCb will deploy a purely software based trigger with a 30 MHz input rate. The software trigger at LHCb is composed of two stages: in the first stage the selection is based on a fast and simplified event reconstruction, while in the second stage a full event reconstruction is used. This gives room to perform a real-time alignment and calibration after the first trigger stage, allowing to have an offline-quality detector alignment in the second stage of the trigger. The detector alignment is an essential ingredient to have the best detector performance in the full event reconstruction. The alignment of the whole tracking system of LHCb is evaluated in real-time by an automatic iterative procedure. The data collected at the start of the fill are processed in a few minutes to update the alignment before running the second stage of the trigger. This in turn allows the trigger output data to be used for physics analysis without a further offline event reconstruction. The motivation for a real-time alignment of the LHCb detector in Run 3 is discussed from both the technical and operational point of view. Specific challenges of this strategy are presented, as well as the working procedures of the framework.

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Collaboration / Activity:

LHCb

T03: Dark Matter / 1044

MIGDAL: Towards an unambiguous observation of the Migdal effect in nuclear scattering

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Despite no experimental confirmation of the Migdal effect in nuclear scattering , it is currently being exploited by several underground direct dark matter experiments to extend limits on WIMPs cross-sections to lower masses. The Migdal in Galactic Dark Matter Exploration (MIGDAL) experiment aims to make the first observation of this process induced by fast neutrons scattering from intensive DT and DD generators allowing to investigate the Migdal effect in a large range of energies of the nuclear recoils.

The characteristic topology of a Migdal event is an arrangement of two tracks sharing the same vertex, one belonging to a nuclear recoil and the other to a Migdal electron. MIGDAL will use an optical TPC filled with a low-pressure CF4 mixed with noble gases to record high-resolution track images and timing information from scintillation and ionisation readout that will be combined to

reconstruct tracks in 3D. Different energy-loss rate distributions of the two tracks will be used to discriminate between signal and background events.

This talk will present the design of the experiment, the result of detailed simulations and estimates of signal and background yields. Up to a few hundred Migdal events are expected to be observed per live day of exposure to neutron beams at the Neutron Irradiation Laboratory for Electronics (NILE) at Rutherford Appleton Laboratory.

Collaboration / Activity:

MIGDAL

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T14: Outreach, Education and Diversity / 1045

The Early Career, Gender & Diversity at LHCb

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LHCb is a collaboration of over 1300 members from 83 institutions based in 19 countries, and representing many more nationalities. We aim to work together on experimental high energy physics, and to do so in the best and most collaborative conditions. The Early Career, Gender & Diversity (ECGD) office exists to support this goal, and in particular has a mandate to support early-career (EC) physicists, thanks also to the recent addition of two EC representatives, to work towards gender equality, and support diversity in the collaboration. The ECGD officers advise the LHCb management and act as LHCb contacts for all matters related to ECGD. They are available for listening to and advising - in a confidential manner - colleagues who have witnessed or have been subject to harassment, discrimination or other inappropriate behaviour. They help raise awareness in the collaboration for topics related to ECGD. In this talk we briefly introduce the ECGD office, discuss what we have learnt from analysis of the collaboration's demographics and responses from a survey that we conducted recently on the impact of covid-19 on our community. Finally, we will share our experience gained over the last years, and we present our vision for the future evolution of the ECGD.

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Collaboration / Activity:

LHCb

T06: QCD and Hadronic Physics / 1046

On next to soft threshold corrections to DIS and SIA processes

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We study the perturbative structure of threshold enhanced logarithms in the coefficient functions of deep inelastic scattering (DIS) and semi-inclusive e^+e^- annihilation (SIA) processes and setup a framework to sum them up to all orders in perturbation theory. Threshold logarithms show up as the distributions $((1-z)^{-1}log^i(1-z))_+$ from the soft plus virtual (SV) and as logarithms $log^i(1-z)$ from next to SV (NSV) contributions. We use the Sudakov differential and the renormalisation group equations along with the factorisation properties of parton level cross sections to obtain the resummed result which predicts SV as well as next to SV contributions to all orders in strong coupling constant. In Mellin N space, we resum the large logarithms of the form $log^i(N)$ keeping $1/N$ corrections. In particular, the towers of logarithms, each of the form $a_s^n/N log^{2n-}(N), a_s^n/N log^{2n-1-}(N) \cdots$ etc for $=0,1,$ are summed to all orders in a_s. We also present the phenomenological impact of NSV corrections for the aforementioned threshold processes and analyse the very impact of NSV terms with respect to the exact and SV corrections.

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Collaboration / Activity:

Not applicable

T14: Outreach, Education and Diversity / 1047

"Warning!": from physics to an interdisciplinary project to discuss with students about the big planetary threats

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The project "Warning! The big planetary threats: knowing them to defend ourselves " aimed to develop interdisciplinary educational paths on the themes of environmental fragility and dangerousness, addressing a wide audience but with a specific focus on young people.
The initiative consisted of 5 debates were scientists presented an in-depth scientific analysis of so-called natural disasters, i.e. phenomena related to climate change, major pandemics, endogenous events (i.e. volcanoes and earthquakes), the fall on the earth's surface of asteroids and space debris and finally to the pollution of the seas, and their consequences. The aim was to foster a "culture of being ready"consisting in the adoption of responsible and scientifically sound behaviors, overcoming a culture dominated by the 'here and now' and therefore little motivated to tackle long-term problems. All the considered phenomena have decidedly complex characteristics: the unpredictability or difficult predictability of their development, the quantification of the risks, the dangerous interconnections among them, the increasingly global nature of their effects and the diversity of their impact according to the social, economic and even cultural situations in the various geographical areas. The debates underlined the importance of internationally supportive initiatives to address these dangers. An interdisciplinary approach was used stressing the importance of the scientific method to face complex problems. Physics was the "fil rouge"accompanying the participants in this journey across many fields of science. The various events took place virtually, allowing the participation of more than 3000 high school students from about 20 schools. To encourage the conscious and direct participation of students in the debate, explanatory material provided in digital form was made available to interested teachers. Students were asked to present their questions to the speakers in advance,

therefore a significant part of the seminars was devoted to answering student questions. “Warning” represented a useful educational support for students and teachers, who were able to attend the events in a ‘virtual classroom’, and integrate topics covered in school programs.

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Collaboration / Activity:

INFN Outreach Activity

T14: Outreach, Education and Diversity / 1049

Outreach at LHCb: Through the online boom and beyond

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Over the past 16 months, the landscape of science communication has radically changed to adapt to a situation of limited mobility and exploding internet usage. Following this trend, the LHCb collaboration has increased its online presence through a wide communication around its latest results, and has built experience in organising virtual visits of the experiment, while pursuing its efforts to strengthen its previous outreach activities. This talk will give an overview of the coverage of recent LHCb results in social and internet-based media through the examples of hadron spectroscopy and the cautious excitement around lepton-flavour universality tests. Different setups for virtual tours of the detector will also be discussed, and updates of the LHCb Masterclass aimed at improving the students experience will be shown. In parallel with this, the collaboration is preparing for the future, and the design of the new LHCb exhibition to be installed on the detector site will be presented.

Collaboration / Activity:

LHCb

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T12: Detector R&D and Data Handling / 1052

GAGG scintillation crystals family for HEP instrumentation

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Homogeneous electromagnetic calorimeters made of crystalline scintillation elements played a crucial role in the discoveries in high-energy physics experiments at colliders during the last three decades 1. Nevertheless, their future application at high luminosity collider facilities (High Luminosity LHC, FCC in hh mode) might become limited by radiation damage effects under the charged and neutral hadrons in the bulk elements. The high luminosity puts in the list of the priorities the combination of the capability for the high time resolution and radiation tolerance as the primary properties of the scintillation material to be exploited. Recently it was demonstrated that compositionally disordered crystalline materials of gallium-aluminum garnets meet these requirements [2]. Their composition may be engineered from ternary to quaternary garnets allowing tuning of the properties of the material for a particular application.
The combination of the scintillation properties, particularly the high light yield up to 50000 photons/MeV, the decay time shorter than 80 ns and a high time resolution better than 160 ps with a modern SiPM photosensor, and outstanding radiation hardness and chemical and mechanical stability make the complex garnet oxides the candidates of choice for a range of various applications in HEP experiments.
In our report we review the last achievements for the properties of multidoped Gd3Al2Ga3O12 - (Gdx-Y1-x)Al2Ga3O12 crystal family produced by the wide-spread Czochralski crystal growth technique. Superior mechanical properties make possible production of different shape scintillation elements to equip heterogeneous detecting units of "Shaslyk"or SPACAL type. Due to its cubic crystalline structure, the crystals of the family may be obtained as a polycrystalline ceramic using various techniques, including 3D printing [3]; this further widens the range of the possible applications.
1. P Lecoq, A Gektin, M Korzhik, Inorganic Scintillators for Detector Systems, Springer, 2016, p.408
2. M Korzhik, G.Tamulaitis, A.Vasil'ev, Physics of the fast phenomena in scintillators. Springer, 2020, p.350
3. G.A. Dosovitskiy et. al, CrystEngComm 19 (2017), 4260-4264

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Collaboration / Activity:

Crystal Clear Collaboration

T10: Searches for New Physics / 1053

Hierarchy in double SU(2) models

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In this work, we provide a simple model in order to compute the probability to obtain a given hierarchy between two scales. In particular, we work in a model with a given gauge symmetry and two scalar doublets. By the Coleman-Weinberg mechanism, the gauge bosons and scalars obtain different masses, corresponding to the light and heavy sectors. We analyze the mass ratio of these sectors in order to discuss the hierarchy between them, and we define a probability associated to this hierarchy. We analyze different cases in which one of the sectors is fixed or both of them have free parameters, and also study the effect of including an interaction between them. We conclude that the probability of obtaining very large hierarchies is not negligible.

Collaboration / Activity:

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T07: Top and Electroweak Physics / 1054

Three-loop standard model Feynman diagrams for the Z-boson EWPOs

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The study of the Z-boson decay was crucial for the success of the LEP experiment. In e^+e^- collisions, with the centre of mass energy matched to its mass, i.e. $\sim$ 91 GeV, a huge number of Z-bosons was produced ($\sim 10^6$). Significant statistics allowed for precise measurements of its decay products along with the Standard Model (SM) parameters. The precision of LEP was so high that quantum corrections had to be taken into account, proving the correctness of SM as a quantum gauge theory.

Future Circular Collider in its lepton mode (FCC-ee) is one of the next-generation colliders along with ILC, CLIC and CEPC. It is planned to be a circular collider with a circumference of 100 km. Operating at the Z resonance it will be able to produce $\sim 10^{12}$ Z-bosons.

This enormous statistics makes FCC a very demanding project from the perspective of theory and it will lead to at least one order of magnitude smaller experimental uncertainties of the electroweak observables (e.g. Z-boson decay width). These experimental errors are one to two orders of magnitude smaller than current theoretical errors and more precise theoretical calculations are needed to meet experimental demands. It means that the 3-loop electroweak corrections to the Z-boson decay are needed.

The complexity of the problem will be presented based on comparisons of diagrams, topologies and integrals at the 3-loop level with the two-loop case. Methods used in the calculation of 3-loop radiative corrections for the Z-boson decay electroweak observables are also discussed.

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Collaboration / Activity:

FCC-ee

T03: Dark Matter / 1055

Closing the window for WIMPy inelastic dark matter with heavy nuclei

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The kinematics of WIMP dark matter-nuclear scattering is drastically altered if the interaction is inelastic, i.e. dark matter is up-scattered to a heavier state with certain mass splitting. With $\mathcal{O}(100)$ keV mass splitting inelastic dark matter will evade the search in most direct detection experiments, where the momentum transfer is limited either by the mass of target nuclei, or by the detector response. We propose a novel way to search for inelastic dark matter with heavy elements. In such experiments, through inelastic scattering on target nuclei dark matter can yield a signal either via nuclear recoil or nuclear excitation. We illustrate this method using results from low-energy gamma quanta searches in low-background experiments with Hf and Os metal samples, and measurements with $CaWO_4$ and $PbWO_4$ crystals as scintillating bolometers. We place novel bounds on WIMPy inelastic dark matter up to the mass splitting of about 640~keV, and provide forecasts for the reach of future experiments.

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Collaboration / Activity:

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T04: Neutrino Physics / 1056

On the Tau flavor of the cosmic neutrino flux

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Observation of high energy cosmic neutrinos by ICECUBE has ushered in a new era in exploring both cosmos and new physics beyond the Standard Model (SM). In the standard picture, although mostly ν_μ and ν_e are produced in the source, oscillation will produce ν_τ {\it en route}. Certain beyond SM scenarios, like interaction with ultralight DM can alter this picture. Thus, the flavor composition of the cosmic neutrino flux can open up the possibility of exploring certain beyond the SM scenarios that are inaccessible otherwise. We show that the τ flavor holds a special place among the neutrino flavors in elucidating new physics. Interpreting the two anomalous events observed by ANITA as ν_τ events makes the tau flavor even more intriguing. We study how the detection of the two tau events by ICECUBE constrains the interaction of the neutrinos with ultralight dark matter and discuss the implications of this interaction for even higher energy cosmic neutrinos detectable by future radio telescopes such as ARA, ARIANNA and GRAND. We also revisit the $3+1$ neutrino scheme as a solution to the two anomalous ANITA events and clarify a misconception that exists in the literature about the evolution of high energy neutrinos in matter within the $3+1$ scheme with a possibility of scattering off nuclei.

We show that the existing bounds on the flux of ν_τ with energy of EeV rules out this solution for the ANITA events. We show that the $3+1$ solution can be saved from both this bound and from the bound on the extra relativistic degrees of freedom in the early universe by turning on the interaction of neutrinos with ultralight dark matter.

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Collaboration / Activity:

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T02: Cosmology / 1057

Fragmentation of the axion field in the early universe

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Axion-like-particle (ALP) is a well-motivated candidate for dark matter, and it has been subject to extensive theoretical and experimental research in recent years. The most popular ALP production mechanism studied in the literature is the misalignment mechanism, where the ALP field has negligible kinetic energy initially, and it starts oscillating when its mass becomes comparable to the Hubble scale. In most of these studies, the ALP field has been assumed to be a homogeneous classical field, and its quantum fluctuations have been ignored. However a non-zero initial velocity can cause exponential growth in the amplitude of fluctuations, and most of the energy density in the homogeneous mode can be converted to axion particles, known as fragmentation. In this talk I will present a semi-analytical study of this process, and describe the necessary ingredients for an efficient fragmentation. I will also mention some observational prospects such as the halo spectrum.

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Collaboration / Activity:

Quantum Universe

T10: Searches for New Physics / 1058

Invisible traces of conformal symmetry breaking

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In our work we study the cosmological phase transition (PT) in a conformal extension of the Standard Model (SM). The model considered is called SU(2)cSM, it extends the SM gauge group by an additional hidden SU(2)$_X$ gauge group, and a scalar doublet (whilist singlet under SM gauge group). The tree-level potential has no mass terms, all the masses are generated via the Coleman-Weinberg mechanism. The new gauge boson X can be considered as a dark matter candidate, also the model may be extended in order to include a mechanism of baryogenesis as well. Due to the large supercooling a strong gravitational waves (GWs) signal can be generated during the PT. \\
We carefully investigate the PT, taking into account recent developments in order to improve existing results and provide meaningful information for the forthcoming LISA searches.
We study the RG improved potential, distinguish between percolation and nucleation temperature of the bubbles, discuss the hydrodynamics, i.e possible runaway, and present resulting GW spectra. We briefly comment on the dark matter phenomenology.

Collaboration / Activity:

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T03: Dark Matter / 1059

Dark Matter from Fragmentation

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Fragmentation of the axion field may produce the observed DM abundance, which makes it possible for ALP DM to appear with lower values of the axion decay constant than those allowed by the conventional misalignment mechanism. Previously, kinetic misalignment has been proposed to open up this parameter space. We find that for a large range of parameters the field becomes fragmented before kinetic misalignment can take place. Additionally, we demonstrate how the initial velocity necessary for fragmentation can be delivered and study how the process may be constrained or tested via cosmological observables such as BBN and structure formation.

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Collaboration / Activity:

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T08: Flavour Physics and CP Violation / 1060

Recent LHCb results on CP violation in beauty decays to charmonia

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The latest results of time-dependent CP Violation in beauty meson decays to charmonia from LHCb are presented, including the CP violating mixing phase phis in Bs → JpsiPhi, using for the first time Jpsi → e+e- . Updates on the measurement of branching ratios are also reported.

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Collaboration / Activity:

LHCb

T04: Neutrino Physics / 1062

Feasibility study of an accelerator neutrino experiment in China

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China has been a stage to a very successful reactor-based neutrino physics program for many years. In this talk, we take a look at the era of Chinese neutrino physics after the conclusion of JUNO and investigate whether there could be a future accelerator-based neutrino experiment in China. We review several notable research laboratory sites that could be considered as candidates for the neutrino source and detector. The physics prospects of these laboratories are then studied in two important physics questions: the precision measurement of the Dirac {\em CP} phase and the search for non-standard neutrino interactions in matter. We finally present a case-study where a neutrino beam conceived by muon decay is sent from the future Super Proton-Proton Collider facility to the China JinPing Laboratory, forming a 1739~km baseline. Our study shows the synergies and limitations of such experiment.

Collaboration / Activity:

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T05: Heavy Ion Physics / 1063

Polarization of lambda hyperons, vorticity and helicity structure in heavy-ion collisions

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Simulations of peripheral Au+Au collisions at NICA energies was performed in the PHSD transport model. The properties of velocity and vorticity fields, hydrodynamic helicity was studied at different impact parameters and energies. The general structure of velocity field follows the “little bang” pattern which may be quantified by the velocity dependence allowing to extract the “Hubble” constant. Quadrupole structures of the vorticity field in transverse reaction plane was obtained. The effect of helicity separation was detected. Calculation of Λ - hyperons polarization is performed in thermodynamic and anomalous models at NICA energies. The polarization of Λ-hyperons at NICA energies was calculated in thermodynamic approximation and anomalous mechanism, based on Chiral Vortical Effect.

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Collaboration / Activity:

P.G. Demidov YSU

T01: Astroparticle and Gravitational Waves / 1064

PLEnuM: A global and distributed monitoring system of high-energy astrophysical neutrinos

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High-energy astrophysical neutrinos, discovered by IceCube, are now regularly observed.
Due to their low flux the observation rate remains small, such that open questions about high-energy neutrino astrophysics and particle physics remain limited by statistics at best, or unanswered at worst. Fortunately, this situation will improve in the next years: new neutrino telescopes will come online, which are currently under planning and construction. In order to answer open questions, we propose the Planetary Neutrino Monitoring System (PLEnuM), a concept for a global repository of high-energy neutrino observations. PLEnuM will reach up to four times the exposure available today by combining the exposures of current and future neutrino telescopes distributed around the world – IceCube, IceCube-Gen2, Baikal-GVD, KM3NeT, and P-ONE. Depending on the declination, spectral index and flavor, PLEnuM will improve the sensitivity to astrophysical neutrinos by up to two orders of magnitude. We present first estimates on the capability of PLEnuM to discover

Galactic and extragalactic sources of astrophysical neutrinos and to characterize the diffuse flux of high-energy neutrinos in unprecedented detail.

Collaboration / Activity:

IceCube, P-ONE, PLEnuM

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T13 - Accelerator for HEP / 1065

Precision measurement of the magnetic field in Run-1 of the Fermilab muon g-2 experiment

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The muon $g-2$ experiment at Fermilab recently announced the measurement of the muon anomalous magnetic moment, a_μ, with a precision of 0.46 ppm 1. The value is in excellent agreement with the previous Brookhaven measurement [2], and the combined average of the two values is in tension with the Standard Model prediction at the 4.2 σ level. The value of a_μ is determined from the ratio of two quantities that are measured in the experiment: ω_a, the anomalous muon spin precession frequency, and $\tilde{\omega_p}'$, the magnetic field weighted by the muon beam distribution. Both quantities must be measured with approximately equal precision in order to achieve the target precision on a_μ. The uncertainty on the run-1 measurement of a_μ is statistically dominated, and the systematic uncertainty contribution from $\tilde{\omega_p}'$ is 0.114 ppm.

In the experiment, a beam of polarized positive muons is injected into a magnetic storage ring with an extremely uniform vertical magnetic field of strength 1.45 T. In order to obtain a precise measurement of a_μ it is crucial to measure the magnetic field that is experienced by the muon beam throughout the experiment. The field in the muon storage region must be measured regularly (every few days) by an in-vacuum field-mapping 'trolley', which drives around the ring and maps out the field gradients. In between trolley runs, a suite of permanently installed NMR probes monitor drifts in the magnetic field over time, which are driven by tiny (ppm-level) changes in the magnet geometry. The final step in the analysis is to weight the magnetic field measurements by the measured muon beam distribution, which is continuously measured by straw tracking detectors.

This talk will cover details of the analysis techniques and results from the run-1 measurement of $\tilde{\omega_p}'$, as well as prospects for future improvements to the measurement.

1 B. Abi et. al. (Muon g−2 Collaboration), Measurement of the Positive Muon Anomalous Magnetic Moment to 0.46 ppm, Phys. Rev. Lett. 126, 141801, 2021

[2] G. W. Bennett et. al., Final Report of the Muon E821 Anomalous Magnetic Moment Measurement at BNL, Phys. Rev. D 73, 072003, 2006

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The muon g-2 collaboration

T03: Dark Matter / 1066

Dark Matter Searches with the IceCube Neutrino Telescope

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The existence of dark matter (DM) has been well-established by repeated experiments probing various length scales. Even though DM is expected to make up 85% of the current matter content of the Universe, its nature remains unknown. Numerous methods have been developed to search for DM—both directly by looking for excess energy created in DM interaction with normal matter and indirectly by looking or DM's effect on normal matter. The IceCube Neutrino Observatory—a cubic-kilometer of instrumented ice located beneath the geographic South Pole, which detects Cherenkov radiation of charged particles produced in neutrino interactions—is well-suited to the latter class of searches. Depending on the nature of DM, IceCube may observe, among other signatures, an excess of neutrinos, a modified directional distribution, or a modified flavor distribution. In this contribution, I will highlight IceCube's recent indirect DM searches and their results.

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Collaboration / Activity:

IceCube Neutrino Observatory

T14: Outreach, Education and Diversity / 1067

Particle therapy masterclass

Authors: on behalf of IPPOG[None]; Yiota Foka[1]

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With the aim to highlight the impact of fundamental research on the broader society, the new Particle Therapy MasterClass (PTMC) package was developed and recently integrated into the International MasterClass 2021 (IMC) online programme, attracting some 37 institutes from 20 countries and more than 1500 students. The PTMC is focusing on the topic of cancer treatment, a particular sensitive topic. The main idea is to show that (a) fundamental properties of particle interactions with matter, which are used to detect them in physics experiments, are also the basis for treating cancer tumours; and (b) the same accelerator technologies are used in both research laboratories and therapy centres.
For the hands-on session, the open source professional Treatment Planning software matRad is used, developed for research and training by DKFZ, the German cancer research institute, Heidelberg.
Ultimately students are shown "what physics has to do with medicine"and what are the various

possibilities that physics and STEM studies may open up for job opportunities in fields that there is lack of expert personnel.

Collaboration / Activity:

IPPOG

First author:

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T10: Searches for New Physics / 1070

Search for additional scalar bosons at the FCC-ee

Authors: Justin Yang[1]; Markus Klute[1]

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As a proposed Higgs factory, the cornerstone of the FCC-ee physics program is the exploration of the Higgs boson at center-of-mass energies of 240 to 365 GeV. Direct and model-independent measurement of its coupling to the Z boson through the study of the Z boson recoil mass spectrum. The recoil mass analysis strategy can be deployed to search for non-SM Higgs boson decays such as Higgs boson to invisible decays or more exotic signatures. The mass spectrum recoiling the Z boson can also be explored in searches for new scalars with coupling to the Z boson. The extremely large FCC-ee data samples especially at lower center-of-mass energy offer excellent sensitivity.

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Collaboration / Activity:

FCC

T07-T09: Combined: Top, Electroweak and Higgs Physics / 1071

SMEFT beyond O(1/Lambda^2)

Author: Adam Martin[1]

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"In this talk I'll talk about truncation errors in the Stadard Model Efftective Field Theory (SMEFT) paradigm —meaning errors from higher terms in the EFT expansion. The main tool I'll use to tackle this type of uncertainty is special operator basis called the "Geometric SMEFT", or geoSMEFT. I will explain the benefits of the geoSMEFT basis and go through some preliminary studies of the impact of O(1/Lambda^4) terms on observables such as Higgs partial width to photons and Z-pole physics."

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Collaboration / Activity:

SMEFT

T01: Astroparticle and Gravitational Waves / 1072

One-Loop Correlators of Charged Fermionic Currents Modified by Electromagnetic Fields and Their Applications

Authors: Alexander Parkhomenko[1]; Ilya Karabanov[1]; Alexandra Dobrynina[2]; Lubov Vassilevskaya[3]

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The non-diagonal correlators of tensor fermionic current with scalar, pseudoscalar, vector and axial-vector ones are considered as examples of the two-point one-loop amplitudes modified by a constant homogeneous magnetic field. The crossed-field limit of this correlators are found. The tensor current is a fermionic part of the Pauli Lagrangian relevant for the electromagnetic interaction of fermions through the anomalous magnetic moment. Under an assumption that this interaction enters the effective QED Lagrangian, the contribution to the photon polarization operator in AMM is calculated. Other examples where a photon is interacting with neutral particles like an axion-like particle are also presented.

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Collaboration / Activity:

Theory

T04: Neutrino Physics / 1073

The Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay

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The observation of neutrinoless double-beta ($0\nu\beta\beta$) decay would unequivocally demonstrate that lepton number conservation is violated and that neutrinos are Majorana particles. Such a discovery would have profound consequences for particle physics and cosmology.

The Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND) collaboration has been formed to pursue a ton-scale ^{76}Ge-based $0\nu\beta\beta$ decay experimental program with discovery potential at a half-life beyond 10^{28} years. LEGEND is building on the success of the predecessor experiments GERDA and Majorana Demonstrator which have achieved both the best energy resolution and lowest background in the field.

The first 200-kg phase (LEGEND-200) is currently under construction at the Gran Sasso underground laboratory (Laboratori Nazionale del Gran Sasso, Italy) and will be commissioned later this year. In this contribution I will present the current status of LEGEND-200 as well as the prospects of the proposed ton-scale phase LEGEND-1000.

The material in this contribution is based upon work supported by the U.S. NSF, DOE-NP, NERSCC and through the LANL & LBNL LDRD programs, and the Oak Ridge Leadership Computing Facility; the Russian RFBR, the Canadian NSERC and CFI; the German BMBF, DFG and MPG; the Italian INFN; the Polish NCN and Foundation for Polish Science; and the Swiss SNF; the Sanford Underground Research Facility, and the Laboratori Nazionali del Gran Sasso.

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Collaboration / Activity:

LEGEND

T01: Astroparticle and Gravitational Waves / 1074

Searching for dark photon dark matter in the third observing run of LIGO/Virgo

Author: Andrew Miller[1]

Co-authors: Huaike Guo [2]; Cristiano Palomba ; Keith Riles ; Fengwei Yang ; Yue Zhang ; Ornella Piccinni

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[2] *Oklahoma university*

We report results from a search for ultralight dark photon dark matter using data from the third observing run of Advanced LIGO and Virgo. This type of dark matter could directly couple to the interferometers and cause a time-dependent quasi-sinusoidal force on the mirrors proportional to the total proton plus neutron number, or just neutron number. We describe two methods to search for this interaction, one that cross correlates data from different detectors, and another that varies the analysis coherence time to account for the expected signal frequency spread and looks for excess power in each detector. We also compare our sensitivity to those from existing direct dark matter experiments for a wide range of dark photon masses.

Collaboration / Activity:

LIGO, Virgo and KAGRA

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Email:

T01: Astroparticle and Gravitational Waves / 1075

Ultra-high-energy cosmic rays from star-forming galaxies constrain the extragalactic magnetic field

Author: Arjen van Vliet[1]

Co-authors: Andrea Palladino [1]; Andrew Taylor [1]; Walter Winter [1]

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The Pierre Auger Observatory (PAO) has recently detected significant correlations between the arrival directions of ultra-high-energy cosmic rays (UHECRs) and positions in the sky of local star-forming galaxies. We interpret these results in terms of the local density of sources and the magnetic fields governing the UHECR propagation 1. We determine the level of UHECR deflections for an ensemble of sources in a random extragalactic magnetic field description as well as a Galactic magnetic field model. In addition, we take into account energy losses with background photon fields as well as spectrum and composition measurements by the PAO. We find that the PAO anisotropy measurement is consistent with large extragalactic magnetic field strengths ($B > 0.6$ nG for a coherence length of 1 Mpc at the 5σ confidence level) in the case of a local density of star-forming galaxies. Larger source densities, on the other hand, allow for weaker extragalactic magnetic fields. However, the acceleration of UHECRs by such abundant sources is more challenging to motivate. Too large source densities and extragalactic magnetic field strengths decrease the expected level of anisotropy and are, therefore, disfavoured as well. This translates to upper limits of $B < 24$ nG and $\rho_0 < 9.0 \cdot 10^{-2}$ Mpc^{-3} at the 90% confidence level.

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1 A. van Vliet, A. Palladino, A. Taylor and W. Winter, arXiv:2104.05732.

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Collaboration / Activity:

DESY Zeuthen

T04: Neutrino Physics / 1076

Meeting the challenges of relic neutrinos

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After some introductory, motivational remarks, our [in collaboration with Bhupal Dev] attempts at confronting these challenges will be discussed in the context of Standard Model and beyond and experimental prospects at existing facilities as well as those being planned in the near future.

[Please note that i am also submitting an abstract for a parallel session talk in the Flavor and CP violation track. If the organizers want to limit me to only one talk my above one in the neutrino session is my top priority for this meeting]

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Collaboration / Activity:

N/A

T13 - Accelerator for HEP / 1078

Power Incident on the ILC Helical Undulator Walls

Author: Khaled Alharbi[1]

Co-authors: Sabine Riemann [2]; Gudrid Moortgat-Pick [3]; Andriy Ushakov [4]

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The positron source of the International Linear Collider (ILC) is based on a superconducting helical undulator passed by the high-energy electron beam to generate photons which hit a conversion target. Since the photons are circularly polarised the resulting positron beam is longitudinally polarised. The power deposition in the undulator walls should be below the acceptable limit of 1 W/m since it is a superconducting undulator and also to fulfill the vacuum requirements. The power deposition of the photon beam in undulator walls was studied and shown that the peak power deposition in the undulator walls is above 20 W/m. To keep the power deposition below the acceptable limit, 22 photon masks must be inserted in the undulator line. In this paper the design of photon masks for an ideal and realistic helical undulator is presented. Furthermore, the effect of adding photon masks on the photon power and polarisation (⊠⊠) at the target plane is discussed.

Collaboration / Activity:

PhD Student

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T10: Searches for New Physics / 1080

Progress in the doubly charged Higgs bosons studies at high energy colliders

Authors: Bartosz Dziewit[1]; Janusz Gluza[2]; Magdalena Kordiaczyńska[1]; Tripurari Srivastava[3]

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We consider the Higgs Triplet Model HTM not restricted by the custodial symmetry and the Minimal Left-Right Symmetric Model MLRSM. The models include scalar triplets with different complexity of scalar potentials and, due to experimental restrictions, completely different scales of non-standard triplet vacuum expectation values. In both models, a doubly charged Higgs boson $H^{\pm\pm}$ can acquire a mass of hundreds of gigaelectronvolts, which can be probed at HL-LHC, future e^+e^-, and hadron colliders.
We analyze the doubly charged Higgs bosons $H^{\pm\pm}$ pair production in e^+e^- and pp colliders with their subsequent decays to four charged leptons.
We take into account a comprehensive set of constraints on the parameters of both models coming from neutrino oscillations, LHC, e^+e^- and low-energy lepton flavour violating data and assume the same mass of $H^{\pm\pm}$. Our finding is that the $H^{\pm\pm}$ pair production in lepton and hadron colliders is comparable in both models, though more pronounced in MLRSM.
We show that the decay branching ratios can be different within both models, leading to distinguishable four lepton signals and that the strongest are 4μ events yielded by MLRSM. We analyze also the associative production of the doubly charged scalar with the Standard Model gauge bosons and both singly and neutral Higgs bosons. We estimate in the context of the present (HL-LHC) and future (FCC-hh) hadron colliders the most promising processes where a single produced doubly charged Higgs boson is involved.

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Collaboration / Activity:

FCC activity

T08: Flavour Physics and CP Violation / 1081

Implications of LHCb Data for Lepton Flavour Universality Violation

Author: Siavash Neshatpour[1]

Co-authors: Tobias Hurth ; Farvah Mahmoudi ; Diego Martínez Santos

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Recently, LHCb has confirmed the evidence for lepton flavour universality violation in the R_K ratio with 3.1σ significance. We present new physics implications within a model-independent approach and make projections for future measurements that indicate that LHCb will be in the position to discover lepton non-universality with the Run 3 data in a single observable. We also present other ratios which are able to differentiate between various new physics scenarios in the near future. Moreover,

we present global fits of rare B-decays within multidimensional fits involving up to all the relevant 20 Wilson coefficients and compare different scenarios via likelihood ratio tests, applying Wilks' theorem.

Collaboration / Activity:

Theory

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T05: Heavy Ion Physics / **1082**

Impact of the initial electromagnetic and glasma fields on heavy quarks and leptons from Z0 decay

Author: Yifeng Sun[1]

Co-authors: Salvatore Plumari [1]; Lucia Oliva [2]; Vincenzo Greco [3]

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Heavy quarks are excellent probes to study the initial stages of heavy ion collisions since they are generated in the early times around 0.1 fm/c together with a thermalization time that is comparable to the lifetime of the QGP phase. Ultra-relativistic heavy ion collisions are expected to generate a huge electromagnetic (e.m.) field that is expected to generate a splitting of the directed flow of charged particles and anti-particles. In this talk we will discuss how the strong initial e.m. field can lead to a large directed flow v1 of neutral particles/anti-particles D0 and anti-D0 of few percent much larger compared to the observed light charged particles v1 and how it can be considered as a possible probe of the formation of the quark-gluon plasma phase.
Moreover, we have found a general formula for all possible charge dependent flow observables that can be generated by the strong electromagnetic fields in non-central relativistic heavy ion collisions. The formula has a very simple form at pT larger than several GeV/c, which can be treated as the signature of charged dependent flow observables induced by e.m. fields. Furthermore, we found that the v1 splitting depends critically on the time evolution of the magnetic field. Based on this study, we finally discuss why the measurement of of leptons from Z0 decay and its correlation to the charmed mesons are better in probing e.m. fields and thus opening a new way to constrain the EM field.
The second topic we want to discuss is the evolution of HQ distribution in the initial glasma fields w.r.t. the standard HQs interaction with the QGP. From the interaction between glasma field and HQs, we find that the field can lead to an initial enhancement of RAA of charm quarks contrary to the pattern of the standard particle interaction; this furthermore leads to the modification on the relation between the elliptic flow v2 and RAA of charmed mesons after the interaction with the QGP.
1 Y. Sun, G. Coci, S. K. Das, S. Plumari, M. Ruggieri and V. Greco, Phys. Lett. B 798, 134933 (2019).
[2] Y. Sun, S. Plumari and V. Greco, Phys. Lett. B 816, 136271 (2021).
[3] Y. Sun, V. Greco and S. Plumari, arXiv: 2104.03742.
[4] L. Oliva, S. Plumari and V. Greco, arXiv: 2009.11066.
[5] S. K. Das, S. Plumari, S. Chatterjee, J. Alam, F. Scardina and V. Greco, Phys. Lett. B 768, 260-264 (2017).

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Collaboration / Activity:

Heavy quark dynamics

T04: Neutrino Physics / 1083

Theia: an advanced optical neutrino detector

Author: Stephane Zsoldos[1]

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Theia is a proposed large-scale novel neutrino detector, designed with the ability to discriminate between Cherenkov and scintillation signals. The design consists of a cylindrical tank viewed by inward-looking PMTs and filled with a novel target, such as water based liquid scintillator (WbLS) or other scintillator, which would allow simultaneous reconstruction of particle direction from the Cherenkov signal, with the energy resolution and low threshold of a scintillator detector. Theia would have a broad physics program ranging from low energy solar to high energy accelerator neutrinos.
In this presentation I will give an overview of the experiment based on a 100kT cylindrical tank filled with WbLS, and its physics sensitivity to various scenarios. I will also discuss a 25kT letterbox Theia detector located in a cavern similar to those under construction for DUNE, at SURF.

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Collaboration / Activity:

Theia

T09: Higgs Physics / 1084

GeoSMEFT and applications [until 12:09, just shortened for agenda purposes]

Author: Tyler Corbett[1]

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I will discuss the geometric formulation of the SMEFT and its applications.

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Collaboration / Activity:

No

T08: Flavour Physics and CP Violation / 1085

Planck Safety and Flavor Physics

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Co-authors: Gudrun Hiller [1]; Daniel Litim [2]; Clara Hormigos-Feliu [1]; Tim Höhne [1]

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We introduce the property of Planck safety as paradigm for model building. Extensions of the SM are constructed featuring vector-like fermions and a flavor matrix scalars. Yukawa interactions interlocking the SM and BSM sector act as flavor portals that allow to address experimental anomalies, while taming Landau poles and stabilizing the Higgs potential up to the Planck scale.

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Collaboration / Activity:

-

T03: Dark Matter / 1086

Cosmological imprints of non-thermalized dark matter

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Non-thermalized dark matter is a cosmologically valid alternative to the paradigm of weakly interacting massive particles. For dark matter belonging to a Z_2-odd sector that also contains a thermalized mediator particle, dark-matter production proceeds via both the freeze-in and super-WIMP mechanism. We highlight their interplay and study the evolution of the resulting dark-matter phase-space distributions in detail. Utilizing our implementation into CLASS, we investigate their cosmological

imprints on the matter power spectrum, constrained, in particular, by Lyman-alpha forest observations. For the explicit example of a colored t-channel mediator model, we map out the entire cosmologically viable parameter space, cornered by bounds from the LHC, big bang nucleosynthesis, and the matter power spectrum on small scales.

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Collaboration / Activity:

none

T07: Top and Electroweak Physics / 1087

Measuring the polarization of boosted, hadronic W bosons with jet substructure observables

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In this work, we present a new technique to measure the longitudinal and transverse polarization fractions of hadronic decays of boosted W bosons. We introduce a new jet substructure observable denoted as p_θ, which is a proxy for the parton level decay polar angle of the W boson in its rest frame. We show that the distribution of this observable is sensitive to the polarization of W bosons and can therefore be used to reconstruct the W polarization in a model-independent way. As a test case, we study the efficacy of our technique on vector boson scattering processes at the high luminosity Large Hadron Collider and we find that our technique can determine the longitudinal polarization fraction to within ± 0.15.

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Collaboration / Activity:

IIT Bombay

T02: Cosmology / 1088

Probing primordial features with the Stochastic Gravitational Wave Background

Author: Jacopo Fumagalli[1]

Co-authors: Lukas Witkowski [1]; Sébastien Renaux-Petel [2]

[1] *IAP*

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High energy embeddings of inflation often lead to departures from the single-field slow-roll paradigm, resulting in features in the primordial scalar power spectrum. Probing these features could, for instance, establish the existence of heavy particles beyond the reach of terrestrial experiments, and even test the inflationary paradigm or point to alternatives to it. To date, observational constraints and prospects for detection have concentrated on the CMB and Large Scale Structure surveys.
In this talk, I will show how features in the primordial spectrum lead to characteristic oscillatory patterns in the stochastic gravitational wave background. This provides a clear target for gravitational wave observatories as well as a challenge for developing dedicated data analysis techniques to look for these unique insights into the physics of the early universe.

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Collaboration / Activity:

Theory / Observation

T01: Astroparticle and Gravitational Waves / 1089

Gravitational Waves as a Big Bang Thermometer

Authors: Carlos Tamarit[1]; Andreas Ringwald[2]; Jan Schütte-Engel[3]

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There is a guaranteed background of stochastic gravitational waves produced in the thermal plasma in the early universe. Its energy density per logarithmic frequency interval scales with the maximum temperature Tmax which the primordial plasma attained at the beginning of the standard hot big bang era. It peaks in the microwave range, at around 80 GHz [106.75/g*s(Tmax)]^(1/3), where g*s(Tmax) is the effective number of entropy degrees of freedom in the primordial plasma at Tmax. We present a state-of-the-art prediction of this Cosmic Gravitational Microwave Background (CGMB) for general models, and carry out calculations for the case of the Standard Model (SM) as well as for several of its extensions. On the side of minimal extensions we consider the Neutrino Minimal SM (νMSM) and the SM-Axion-Seesaw-Higgs portal inflation model (SMASH), which provide a complete and consistent cosmological history including inflation. As an example of a non-minimal extension of the SM we consider the Minimal Supersymmetric Standard Model (MSSM). Furthermore, we discuss the current upper limits and the prospects to detect the CGMB in laboratory experiments and thus measure the maximum temperature and the effective number of degrees of freedom at the beginning of the hot big bang.

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Collaboration / Activity:

Technical University of Munich

T01: Astroparticle and Gravitational Waves / 1090

Anchoring supermassive black hole binaries to active galactic nuclei with the gravitational-wave background

Authors: J. Andrew Casey-Clyde[1]; Chiara Mingarelli[2]; Jenny Greene[3]; Kris Pardo[4]; Morgan Nañez[5]; Andy Goulding[3]

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The nanohertz gravitational wave background (GWB) is believed to be dominated by emission from supermassive black hole binaries (SMBHBs). This population's properties have commonly been investigated using major galaxy mergers as a proxy for SMBHB formation. However, the observation of several dual active galactic nuclei (AGN) strongly suggests a link between AGN and SMBHBs, given that these dual AGN systems will eventually form a bound binary pair. Here we present a complementary model of the SMBHB population using AGN as a proxy for SMBHB systems instead of galaxy mergers. We compare the GWB generated by this AGN-proxy model and its major merger counterparts to the common-spectrum process in the NANOGrav 12.5-yr dataset. Finding the GWB generated by these models to be generally lower, we estimate how many more SMBHB sources are needed to generate a background like the NANOGrav 12.5-yr signal.

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Collaboration / Activity:

NANOGrav

T07: Top and Electroweak Physics / 1091

Status of electroweak higher order corrections to the pseudo observables at the Z-resoncance

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We work on the improvement of theoretical predictions for Standard Model electroweak pseudo-observables at the e^+e^- Z-resonance peak. This study is mandatory for example for the new Future Circular Collider (FCC). The missing higher-order computations involve many Feynman diagrams at three-loop order including all possible Standard Model particles. We make progress in completing the three-loop calculations with a new strategy by exploiting numerical methods to solve a system of differential equations between the master integrals. Which is the main part of the talk.

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Collaboration / Activity:

FCC

T12: Detector R&D and Data Handling / 1095

New radiation-hard scintillators for FCC Detectors

Author: Yasar Onel[1]

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Future circular and linear colliders, as well as the Large Hadron Collider in the High-Luminosity era, have been imposing unprecedented challenges on the radiation hardness of particle detectors that will be used for specific purposes e.g. forward calorimeters, beam, and luminosity monitors. We performed research on the radiation-hard active media for such detectors, particularly calorimeters, by exploring intrinsically radiation-hard materials and their mixtures. The initial samples that we probed were thin plates of Polyethylene Naphthalate (PEN) and Polyethylene Terephthalate (PET) and thin sheets of HEM. The previous studies indicate promising performance under high radiation conditions. We will report on the necessary process of mixing the PEN and PEN for optimized scintillation and signal timing properties preserving the high radiation resistance. Recently we developed a new plastic scintillator material. The scintillation yield of SX sample was compared to a BGO crystal using a setup with 90Sr source and a Hamamatsu R7525-HA photomultiplie tube (PMT). The SX was measured to yield roughly 50% better light production compared to the BGO crystal sample SX was irradiated at the CERN PS radiation facility with 24 GeV/c protons. The samples received a fluence of 1.2 x 1015 p/cm2 which corresponds to 4 x 105 Gy radiation doses. The comparison of the transmission spectra of SX sample before and after the irradiation exhibits a loss of roughly 7% light transmission after 4 x 105 Gy proton irradiation

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Collaboration / Activity:

FCC

T12: Detector R&D and Data Handling / 1097

The dual-readout calorimeter module R&D using innovative 3D metal printing for future e+e- colliders

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Innovative 3D metal printing technology has been recently improved and used widely in various fields for both basic science and high technology. The next generation methodology of the novel calorimeter, dual-readout calorimeter, is one of the candidates to achieve very high energy resolutions for both EM and hadronic particles in future e+e- colliders. Traditionally the module of the dual-readout calorimeter has been built by cutting the copper plates and stacking them. In this presentation, we present the advanced dual-readout calorimeter module R&D by the latest 3D metal printing to achieve a very fine and precise projective structure required for the future e+e- colliders.

Collaboration / Activity:

FCC

First author:

Email:

T08: Flavour Physics and CP Violation / 1098

Updated Predictions for $R(D^{(*)})$ within and beyond the Standard Model and determination of $|V_{cb}|$

Authors: Zoltan Ligeti[1]; Dean Robinson[1]; Michele Papucci[2]; Markus Prim[3]; Xiong Chenglu[3]; Florian Bernlochner [None]; Florian Bernlochner[4]

[1] *LBNL*

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In Heavy Quark Effective Theory (HQET), measured $B \to D^{(*)}\ell\bar{\nu}_\ell$ decay rates for light leptons constrain all $B \to D^{(*)}$ semileptonic form factors, both in and beyond the Standard Model (SM). We update our prior HQET-based analysis, carrying out a global fit including newly available measurements of $B \to D^{(*)}\ell\bar{\nu}_\ell$ decay distributions to predict: the $B \to D^{(*)}\tau\bar{\nu}_\tau$ rates; the lepton universality ratios $R(D^{(*)})$ within and beyond the SM; and determine the CKM matrix element $|V_{cb}|$. The update incorporates a more systematic treatment of certain corrections at order $1/m_c^2$, and discusses the impact of including preliminary lattice QCD information for $B \to D^{(*)}$ form factor ratios from JLQCD.

Collaboration / Activity:

University of Bonn

First author:

Email:

T12: Detector R&D and Data Handling / 1099

The tracking system of the IDEA detector concept for a future e+e- collider

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The IDEA detector concept for future e+e- colliders proposes a tracking system composed by a Si based inner system, an ultra-low mass Drift Chamber central system with Particle Identification capabilities and a Si based outer layer surrounding the drift chamber. The designed tracking system allows to fulfill the high momentum and angular resolutions requirements for the whole momentum range, particularly for low momenta, thanks to the extremely low material budget. Moreover, the use of the Cluster Counting technique allows for particle identification (PID) resolution below 3%, a factor two better than the resolution attainable with traditional dE/dx techniques. Details about the construction of the drift chamber, including both the speculation about new materials for the field wires and new techniques for soldering the wires, the development of an improved layout of the drift cells , and the choice of the gas mixture will be described. The expected tracking system performance together with the Improved PID obtained with the cluster counting technique will be reported.

Collaboration / Activity:

FCC

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T12: Detector R&D and Data Handling / 1100

A proposal of a He based Drift Chamber as central tracker for the IDEA detector concept for a future e+e- collider

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The IDEA detector concept for a future e+e- collider adopts an ultra-low mass Drift Chamber as the central tracking system. It is a He based, 4 m long and 4 m diameter, fully stereo drift chamber with a total material budget of ~ 0.016 X0 in the barrel part and ~ 0.05 X0 in the end-caps. It will be instrumented with readout electronics implementing the Cluster Counting/Timing techniques, allowing for a larger than 3 sigma pi/K separation over most of the momentum range of interest. Details about the novel construction procedures, inspired by the ones developed for the construction of the MEG II drift chamber will be described. The expected tracking system performance, together with the Improved particle identification capabilities obtained by using the cluster counting technique, will be reported.

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Collaboration / Activity:

FCC

T12: Detector R&D and Data Handling / 1101

The preshower and the muon detection system of the IDEA detector for FCC-ee

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The μ-RWELL is a Micro Pattern Gas Detector (MPGD) that inherits some of the best characteristics of existing MPGDs, like GEMs and MicroMegas, while simplifying the detector construction. It also significantly improves the spark protection by incorporating in the design a resistive layer on the anode board. The μ-RWELL 1 is composed of only two elements: the cathode, a simple FR4 PCB with a thin copper layer on one side and the μ-RWELL_PCB, the core of the detector. The μ-RWELL_PCB, realized as a multi-layer circuit by means of standard photo- lithography technology is composed of a well-matrix patterned on an Apical foil acting as amplification element of the detector; a resistive layer, realized with a Diamond-Like-Carbon (DLC) film sputtered on the bottom side of the polyimide foil, as discharge limitation stage; a standard PCB, segmented as strip, pixel, or pad electrodes, for readout purposes. The μ-RWELL, showing excellent spatial performance, good time resolution, and the capability to operate in harsh environments [2], is proposed in different versions in HEP experiments: as device for the upgrade of the LHCb muon system [3] and inside the IDEA detector concept, considered by both the FCC-ee [4] and the CEPC [5,6] colliders, to realize the preshower of the dual readout calorimeter as well as the full muon detection system. Key points of such a technology are the scalability and production by industrial processes which allow cost-effective mass production of the detector: a must in view of the construction, for example, of large muon systems at future HEP Colliders where huge detection surfaces (O(10000)m 2) are expected. I will present the RD status with the latest results achieved and the activities planned until 2024 in terms of detector design, simulation, and test.

Collaboration / Activity:

FCC

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T07: Top and Electroweak Physics / 1106

Electroweak Precision Physics at FCC-ee

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The Future Circular Collider with electron-positron beams (FCC-ee) should provide improvements of the electroweak precision measurement concerning Z, W, H, and their masses by a large factor over the present status. The unparalleled experimental precision would open, via Electroweak loop corrections, a broad discovery potential for new, at least weakly interacting particles up to high energy scales. The Z boson mass and width, as well as the Z to bb partial width, and the forward-backward asymmetries for leptons and quarks can be measured with high precision with the run at the Z pole, where the instantaneous luminosity is expected to be five to six orders of magnitude larger than LEP. As a result, a precise determination of the effective weak mixing angle, as well as of the running electromagnetic coupling can be extracted directly from the data. Considerable improvements of the strong coupling constant determination will be possible with the measurements of the hadronic widths of the Z and W bosons.

Collaboration / Activity:

FCC

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T09: Higgs Physics / 1107

Higgs measurements at the Future Circular Colliders

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Precision measurements and searches for new phenomena in the Higgs sector are among the most important goals in particle physics. Experiments at the Future Circular Colliders (FCC) are ideal to study these questions. Electron-positron collisions (FCC-ee) up to an energy of 365 GeV provide the ultimate precision with studies of Higgs boson couplings, mass, total width, and CP parameters, as well as searches for exotic and invisible decays. Very high energy proton-proton collision (up to 100 TeV) provided by the FCC-hh will allow studying the Higgs self-coupling. There is a remarkable complementarity of the FCC-ee and FCC-hh colliders, which in combination offer the best possible overall study of the Higgs boson properties.

Collaboration / Activity:

FCC

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T04: Neutrino Physics / 1108

Z-Boson Decays into (Heavy) Neutrinos: Dirac or Majorana?

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Recently Z factories have been proposed with the capability to produce more than 10^12 Z bosons. It has been observed that this opens the possibility to observe the decay of the Z into a light neutrino and a heavy neutrino, Z –> vN, down to very small (10^{-11}) light-heavy neutrino mixing angles and up to masses close to the Z mass. The question of whether the heavy neutrino is a Dirac particle (conserving lepton number) or a Majorana particle (leading to violation of lepton number conservation) is raised and analyzed, with the following conclusion: in spite of the fact that it is not possible to distinguish the two hypotheses on an event by event basis, it is possible to build two observables, the charge asymmetry and the polarization analysis, which, given sufficient statistics, would allow a significant determination of the nature of the heavy neutrino.

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T09: Higgs Physics / 1109

Electron Yukawa from s-channel resonant Higgs production at FCC-ee

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Measuring the electron Yukawa is impossible in Higgs boson decays, H -> e+e- , given the smallness of the electron mass that leads to a vanishingly small decay branching fraction. The only direct method to extract the Higgs-electron coupling is through resonant s-channel production in e+e- collisions running at the Higgs pole mass. Such a measurement is possible at the FCC-ee provided one can monochromatize the beams, leading to a center-of-mass energy spread not much larger than the Higgs boson width of ~4 MeV, as well as having a prior accurate and precise knowledge of the Higgs boson mass, within MeV uncertainties. Under such conditions, a study combining 10 different Higgs decay modes indicates that a ~1.3sigma significance for the e+e- -> H process can be reached, above the (much larger) backgrounds, for every 10 ab-1 of integrated luminosity per FCC-ee interaction point (IP). Depending on the number of IPs and years running at the Higgs pole, such a measurement will provide the only means known to access the electron Yukawa.

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Collaboration / Activity:

FCC

T08: Flavour Physics and CP Violation / 1110

Flavor physics at FCC-ee with focus on Bc->tau nu

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Z-pole operation at FCC-ee offers a unique laboratory for flavor physics, with the anticipated production of 10^12 b-quarks and the opportunity for triggerless data-taking in a clean e+e- collision environment. Using new simulation and analysis tools developed for FCC-ee physics and performance studies, theoretically compelling beauty, charm, and tau decay modes are studied in order to evaluate key performance metrics and expected yields. Comparisons with LHCb Upgrade and Belle-II are performed, in order to highlight areas within flavor physics where FCC-ee measurements can be highly impactful.

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FCC

T04: Neutrino Physics / 1113

Distinguishing Dirac vs Majorana Neutrinos at CEνNS experiments

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Coherent Elastic Neutrino Nucleus Scattering (CEνNS) provide a novel window to probe new physics connected with the well established non-vanishing neutrino masses. In this talk we will discuss how in the presence of a transition magnetic moment of neutrinos the CEνNS experiments have the potential to shed light on the nature of neutrinos: Dirac vs Majorana. In particular, we will take the NUCLEUS experiment as an example to demonstrate that through a study of differential energy distribution of the final states the CEvNS experiments can potentially achieve such a feat.

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Collaboration / Activity:

none

T01: Astroparticle and Gravitational Waves / 1114

Hawking radiation of non-standard black holes

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Black Holes of primordial origin (PBHs) can constitute a large fraction of dark matter (DM) in the Universe. If light enough, they can emit a sizeable amount of Hawking radiation, which may be detected by dark matter experiments and be used to set constraints on the fraction of PBHs as DM components. Lately, these constraints have been extended to spinning PBHs, and it is very important to extend such analyses to other black hole metrics, in particular in the perspective of a signal detection. Recent work on black solutions to the Einstein equations have resulted in metrics that are regular at the black hole center, solving the singularity problem.
We will present a generalization of the existing formalism to the generic class of spherically symmetric and static black holes, determining the short-range potentials for the Teukolsky equations for these metrics. Using the public code BlackHawk, we will show how the Hawking radiation is modified for such black holes, and we will in particular focus on the case of polymerized black holes, which are black hole solutions arising from loop quantum gravity.

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Collaboration / Activity:

Theory

T05: Heavy Ion Physics / 1115

Strange hadron effective temperatures in relativistic nuclear collisions

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One of the main goals of the relativistic nuclear collisions studies is to investigate the behavior of nuclear matter under extreme conditions of temperature and energy density. Strange and multi-strange hadrons can provide valuable information related to the properties of the created system and the onset of deconfinement. The energy and centrality dependence of the effective temperatures obtained from the analysis of transverse momentum spectra of charged kaons, φ, Λ, Ξ and Ω produced in Au+Au collisions at the Relativistic Heavy Ion Collider (RHIC) Beam Energy Scan (BES) energies will be presented. These results will be compared with previous results from AGS, SPS and RHIC experiments.

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Collaboration / Activity:

None

T10: Searches for New Physics / 1116

New advances in the minimal potentially realistic SO(10)

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We present new advances in the minimal SO(10) Higgs model where the $45 \oplus 126$ scalars determine spontaneous symmetry breaking down to the Standard model. The comprehensive analysis of all theoretical aspects was performed extending previous results. Computational tools, including full one-loop mass corrections and one-loop scalar beta functions, were developed and allowed us to construct thorough viability constraints. Only two potentially realistic scenarios were identified where one of them seems to be preferred.

Collaboration / Activity:

BSM Phenomenology

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T10: Searches for New Physics / 1117

Why interpretation matters for BSM searches: a case study with Heavy Neutral Leptons at ATLAS

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Even the simplest consistent models of Heavy Neutral Leptons (HNLs) already feature significant complexity, making them impractical for reporting experimental results. In order to keep this complexity manageable, experiments typically interpret their results within simplified models, where e.g. one HNL couples to a single lepton flavor. Unfortunately, such models are in direct contradiction with the observed neutrino oscillation data. This can significantly reduce the impact of these results,

which cannot easily be reused by model builders. In this work, we perform a detailed reinterpretation of the latest ATLAS search for prompt HNLs in W decays within a minimal low-scale seesaw with two HNLs. We show that the exclusion limits obtained using the detailed reinterpretation can differ by *several orders of magnitude* (in either direction) from the limits quoted for the simplified models. Hence naively comparing the mixing angles from a realistic model to the reported limits could lead to *wrongly excluding* entire regions of parameter space! To overcome this issue without requiring experiments to report constraints on all possible HNL models, we propose a simple framework that allows to easily and accurately reinterpret exclusion limits within closely-related models, hence significantly broadening their impact. We outline a number of concrete steps which can be taken by experiments to implement this method with minimal effort, and we discuss its applicability to other models of feebly interacting particles.

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Collaboration / Activity:

Phenomenology

T01: Astroparticle and Gravitational Waves / 1118

HERD: the space-borne High Energy cosmic-Radiation Detection facility

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The China's Space Station, currently under construction, will host the next-generation detector for direct measurements of cosmic rays: HERD. The core of HERD is a thick (3 nuclear interaction lengths and 55 radiation lengths) 3D calorimeter made of about 7500 LYSO cubes. On the top and the four sensitive sides, from outside to the calorimeter, there are a silicon charge detector, a plastic scintillator detector and a scintillating fiber tracker. Thanks to its excellent energy resolution, an acceptance 10 times larger than the present generation missions ($\sim$ 1 m^2 sr), and long lifetime (> 10 years), HERD will be able to perform precise measurements of cosmic ray energy flux and composition towards the "knee"region ($\sim$ 1 PeV). The primary objectives of HERD are the indirect search for dark matter particles and the observation of high energy gamma rays. The HERD science perspectives, design and expected performances in terms of energy sensitivity, spatial and charge resolutions will be presented in this contribution.

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Collaboration / Activity:

HERD Collaboration

T10: Searches for New Physics / 1119

A Meta-Analysis of LHC Results

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We report the results of a meta-analysis conducted to examine possible biases in the uncertainty values published in papers by the LHC experiments. Due to limited availability of computer readable data, we perform this analysis using custom developed python code that extracts the information from the vector graphics source files of the plots in the papers. The aim is to compute the percentages of the data points scattered within 1-sigma and 2-sigma bands of the plots and verify whether the measured percentages agree with statistical norms assuming unbiased estimations of the uncertainties.

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Collaboration / Activity:

Statistical Analysis

T02: Cosmology / 1120

Inflation with strongly non-geodesic motion: theoretical motivations and observational imprints

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A new class of inflationary attractors characterized by a strongly non-geodesic motion has been discovered in the past few years. I will describe how they naturally arise in negatively curved field space, allowing to inflate on potentials that are steep in Planck units. In these scenarios, primordial fluctuations often experience a transient tachyonic instability, akin to the one occurring in axion gauge-field inflation, and which can be described by a single-field effective field theory with imaginary sound speed. Independently of its precise origin, I will show how this leaves a peculiar imprint in the form of primordial non-Gaussianities of flattened type for all higher-order correlation functions, and I will mention links with primordial black holes and specific signatures in the stochastic gravitational wave background.

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Collaboration / Activity:

Theory/observation

T13 - Accelerator for HEP / 1121

Bent Crystals for Investigation of Charmed Baryons Electromagnetic Dipole

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The electric (EDM) and magnetic (MDM) dipole moments of particles are powerful tools to explore fundamental laws of physics. EDM,strongly suppressed in the standard model, offers a perfect "smoking gun"sign of new physics. Baryons'MDM provides insight of QCD models and might probe quark substructure. Study of EDM and MDM is usually carried out analyzing spin precession in a magnetic dipole, but such scheme excludes fast-decaying particles travelling only very short distances (i.e.,few cm). Such is the case for Λ_C and Ξ_C charmed baryons, whose EDM and MDM has still not been directly measured. A chance for this measure is granted by bent crystals. Indeed,spin precession equivalent to hundreds of Tesla dipole may occur for particle crossing a bent crystal in planar channeling state.The crystal-assisted setup exploiting LHCb detectors proposed by SELDOM will be presented, with focus in the design and production of bent crystal suitable for such experiment and compatible with operation in LHC.

Collaboration / Activity:

SELDOM

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T12: Detector R&D and Data Handling / 1123

Plastic scintillator production involving Additive Manufacturing

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Plastic scintillator detectors are widely used in high-energy physics. Often they are used as active neutrino target, both in long and short baseline neutrino oscillation experiments. They can provide 3D tracking with 4π coverage and calorimetry of the neutrino interaction final state combined with a very good particle identification, sub-nanosecond time resolution. Moreover, the large hydrogen content makes plastic scintillator detectors ideal for detecting neutrons.
However, new experimental challenges and the need for enhanced performance require the construction of detector geometries that are complicated using the current production techniques. The solution can be given by additive manufacturing, able to quickly make plastic-based objects of any shape.
The applicability of 3D-printing techniques to the manufacture of polystyrene-based scintillator will be discussed. We will report on the feasibility of 3D printing polystyrene-based scintillator with light output performances comparable with the one of standard production techniques. The latest advances on the R\&D aim at combining the 3D printing of plastic scintillator with other materials such as optical reflector or absorber. The status of the R\&D and the latest results will be presented.

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Collaboration / Activity:

3DprintScint

T11: Quantum Field and String Theory / 1124

Four-dimensional treatment of positivity bounds with gravity

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We formulate Positivity Bounds for scattering amplitudes including exchange of gravitons in four dimensions. We generalize the standard construction through dispersion relations to include the presence of a branch cut along the real axis in the complex plane for the Maldestam variable s. In general, validity of these bounds require the cancellation of divergences in the forward limit of the amplitude. We show that this is possible only if one assumes a Regge behavior of the amplitude at high energies. As a non-trivial fact, a concrete UV behaviour of the amplitude is uniquely determined by the structure of IR divergences. We discuss also possible phenomenological applications of these bounds.

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T12: Detector R&D and Data Handling / 1126

Performance of high-granularity resistive Micromegas at high particle rates and future developments

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We present the latest performance studies of high-granularity resistive Micromegas detectors for tracking applications in high-rate environment.
With the aim of developing resistive Micromegas able to efficiently and reliably work in HEP experiments where particle fluxes as high as 10 MHz/cm^2 are expected, we have built and characterised several prototypes with high-granularity readout plane, with 3 mm^2 size pads, and different resistive protection schemas exploiting a pad-patterned layer or two uniform DLC layers.
We will present the latest results on the detector performance at high rate obtained with tests in laboratory and with particle beams, with a detailed comparison of the resistive schemas and assessment of their potential.
The next step of the project is to make the routing of the readout channels simpler, allowing the construction of larger detectors while keeping the construction process affordable. We are addressing this challenge by the integration of the readout electronics on the back side of the Micromegas board, which leads to a highly integrated device. Preliminary results obtained with the first prototype with embedded APV chip will be presented.

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Collaboration / Activity:

Detector R&D

T14: Outreach, Education and Diversity / 1127

SiTrInEO: A complete silicon tracker for educational experience

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High-energy physics on collider exploits large-scale instruments and infrastructures which are inaccessible for educational purpose. Possibly individual detection elements can be used to discover a given technology, but such simple setups do not illustrate properly the concept of combining various measurements to characterize particles. This is especially true for tracking devices, which requires multi-layer instrument and magnetic field. However, the current technology trend tends to miniaturize sensors and allows the realization of complex systems at the tabletop scale.
The SiTrInEO project (Silicon Tracker for International Education Objective) intends to benefit from these advances in order to offer a small affordable setup allowing students to exercise all aspects of particle tracking. The initiative was started by two universities, KNU-Daegu and Unistra-Strasbourg, and joined by INFN-Frascati.
The instrument concept is based on two pairs of CMOS pixel sensors 1 placed around a small permanent magnetic, which can track and bent low energy electrons (MeV/c range) produced by a standard beta-emitter radioactive sources. The sensors are thinned to 50 µm in order to minimize the largest nuisance process, i.e. multiple scattering.
The development stage relied on existing material and expertise, but was largely conducted by students. The setup uses 3-D printed mechanical support allowing elements to be moved and an affordable DAQ system based on FPGA[2]. Two instruments are now operated quite routinely by students at KNU and Unistra in the context of their academic studies.
This talk will re-trace the simulation work which lead to the design of the instruments and review typical performances achieved. We will also discuss the type of activities conducted by students in the project.

1 I Valin *et al*, 2012 JINST 7 C01102, doi:10.1088/1748-0221/7/01/C01102
[2] E Spiriti *et al*, Nucl.Phys. B 215 (2011)157-161, doi:10.1016/j.nuclphysbps.2011.03.164

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Collaboration / Activity:

Instrumentation training

T10: Searches for New Physics / 1130

Probing muon philic forces at a muon collider

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Experimental anomalies like the muon g-2 and the decay of the B meson $B \to K\mu\mu$ suggest the existence of interactions that predominantly talk to the muon. The muon philic nature of these hypothetical interactions is necessary to avoid experimental constraints on lepton flavor violating processes. Models that explain g-2 feature either light weakly coupled states or heavy strongly coupled new particles. Most explanations for $B \to K\mu\mu$ feature only the latter option. In both cases, we show how a combination of direct and indirect signatures at a muon collider can cover the entire parameter space that explains the aforementioned anomalies in the context of a set of benchmark models.

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Collaboration / Activity:

NA

T04: Neutrino Physics / 1131

Constraining lepton number violating interactions with rare meson decay

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The possibility of new physics in terms of lepton number violating (LNV) interactions is intriguing out of various reasons: LNV could be tightly linked to the generation of neutrino masses of Majorana nature while at the same time having direct implications for the generation of the baryon asymmetry of our Universe. The $K \to \pi\nu\bar{\nu}$ decay is one of the most promising modes to search for physics beyond the Standard Model and is able to probe mass scales higher than other rare meson decays. Motivated by the goal of the NA62 experiment to reach SM precision in $K \to \pi\nu\bar{\nu}$, I will consider the implications of a potential deviation from the SM expectation and estimate the new physics scale associated with potential LNV effects. Finally, I will discuss the potential to discern the Majorana or Dirac nature of neutrinos in rare meson decays.

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Collaboration / Activity:

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T10: Searches for New Physics / 1132

Flavorful leptoquarks at the LHC and beyond: Spin 1

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Evidence for electron-muon universality violation that has been revealed in $b \to s\ell\ell$ transitions in the observables R_{K,K^*} by the LHCb Collaboration can be explained with spin-1 leptoquarks in $SU(2)_L$ singlet V_1 or triplet V_3 representations in the $calO(1-10)$ TeV range. We explore the sensitivity of the high luminosity LHC (HL-LHC) and future proton-proton colliders to V_1 and V_3 in the parameter space connected to R_{K,K^*}-data. Future sensitivity projections based on extrapolations of existing ATLAS and CMS searches are worked out. We find that for $\kappa = 1$ the mass reach for pair (single) production of V_1 can be up to 3 TeV (2.1 TeV) at the HL-LHC and up to 15 TeV (19.9 TeV) at the FCC-hh with $\sqrt{s} = 100$ TeV and $20\,\text{ab}^{-1}$. The mass limits and reach for the triplet V_3 are similar or higher, depending on flavor. While there is the exciting possibility that leptoquarks addressing the R_{K,K^*}-anomalies are observed at the LHC, to fully cover the parameter space pp-collisions beyond the LHC-energies are needed.

Collaboration / Activity:

Ruđer Bošković Institute

First author:

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T01: Astroparticle and Gravitational Waves / 1133

Gravity waves from nonlinear dynamics of axion-likie particles

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Axion-like particles (ALPs) play an important role for inflationary model building, as well as are well motivated dark matter candidates. The out-of-equilibrium initial conditions, combined with their possibly nontrivial potentials, allow for a rich nonlinear dynamics of such fields in the early universe.

We consider the coherent oscillations of an ALP field in a wiggly potential and investigate the scenario when the fluctuations on top of the homogeneous field are amplified via parametric instabilities, leading to the complete fragmentation of the field. If the potential contains several local minima, separated by barriers, transitions between such minima can be induced via bubble nucleation. We investigate such transitions, taking into account the dynamical, nonthermal nature of the process and the impact of fragmentation. The above mentioned processes are accompanied by the production of a stochastic gravitational wave background, possibly within reach of future detectors.

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Collaboration / Activity:

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T10: Searches for New Physics / 1136

Composite resonances at multi-TeV muon colliders

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Composite Higgs models provide a natural solution to the gauge hierarchy problem of the Standard Model. Those models generally predict the existence of multi-TeV composite vector and fermion resonances. In this talk I discuss the possibility of searching for such resonances at a multi-TeV muon collider. Various production and decay channels are discussed, and projections for mass reach are made via fast collider simulation.

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Collaboration / Activity:

None

T12: Detector R&D and Data Handling / 1137

Implementation of large imaging calorimeters

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The next generation of collider detectors will make full use of Particle Flow algorithms, requiring high precision tracking and full imaging calorimeters. The latter, thanks to granularity improvements by 2 to 3 orders of magnitude compared to existing devices, have been developed during the past 15 years by the CALICE collaboration and are now reaching maturity. The state-of-the-art status and the remaining challenges will be presented for all investigated readout types: silicon diode and scintillator for a electromagnetic calorimeter, gaseous with semi-digital readout as well as scintillator with SiPM readout for a hadronic one. We will describe the commissioning, including beam

test results, of large scale technological prototypes and the raw performances such as energy resolution, linearity and studies exploiting the distinct features of granular calorimeters regarding pattern recognition. Beyond these prototypes, the design of experiments addressing the requirements and potential of imaging calorimetry will be discussed. In addition, less established but promising techniques for dedicated devices inverse APD or segmented crystal calorimeters will also be highlighted. In the last year also first results with high resolution timing devices have been obtained. The integration of these devices in the CALICE prototypes is one of the major goals in the coming years.

Collaboration / Activity:

CALICE

First author:

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T12: Detector R&D and Data Handling / 1138

Exploring the structure of hadronic showers and the hadronic energy reconstruction with highly granular calorimeters

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Prototypes of electromagnetic and hadronic imaging calorimeters developed and operated by the CALICE collaboration provide an unprecedented wealth of highly granular data of hadronic showers for a variety of active sensor elements and different absorber materials. In this presentation, we discuss detailed measurements of the spatial and the time structure of hadronic showers to characterise the different stages of hadronic cascades in the calorimeters, which are then confronted with GEANT4-based simulations using different hadronic physics models. These studies also extend to the two different absorber materials, steel and tungsten, used in the prototypes. The high granularity of the detectors is exploited in the reconstruction of hadronic energy, both in individual detectors and combined electromagnetic and hadronic systems, making use of software compensation and semi-digital energy reconstruction. The results include new simulation studies that predict the reliable operation of granular calorimeters. Further we show how granularity and the application of multivariate analysis algorithms enable the separation of close-by particles. We will report on the performance of these reconstruction techniques for different electromagnetic and hadronic calorimeters, with silicon, scintillator and gaseous active elements.

Collaboration / Activity:

CALICE

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T04: Neutrino Physics / 1139

Experimental Evidence of neutrinos produced in the CNO fusion cycle in the Sun with Borexino

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The proton-proton (pp) chain and the carbon-nitrogen-oxygen (CNO) fusion cycle process are two processes understood theoretically how stars converted hydrogen to helium. Neutrinos emitted in such processes are the only direct probe of the deep interior of the Sun. Borexino is a liquid scintillator detector targeted at measuring solar neutrinos. It is hosted by the underground INFN Laboratori Nazionali del Gran Sasso in L'Aquila, Italy and has achieved unprecedented radio purity of liquid scintillator. Since 2015, the Borexino has made a major effort in stabilizing the thermal condition of the detector aimed at measuring the CNO solar neutrinos, including installation of a passive thermal insulation system and an active temperature control system. It was observed that the movement of the Po-210 backgrounds was significantly suppressed and a low rate region in the center was stably present since 2016. After the Po-210 low-rate-region tracking method was improved, an upper limit of the Bi-210, the critical background of the CNO neutrino signal, was determined. Last fall, Borexino published in Nature the results excluding the absence of the CNO neutrino signal with a significance of five sigmas. The results quantify the relative contribution of CNO fusion in the Sun to be of the order of one percent. It is also the first experimental evidence of the CNO cycle process, the primary mechanism for the stellar conversion of hydrogen in the Universe. Additionally, solar models built from heliuseismoeogy (SSM-HZ) and from spectroscopy (SSM-LZ) predicted inconsistent solar metallicities, known as the "solar metallicity problem". The CNO neutrino fluxes depend on the carbon and nitrogen abundances. So this work paves the way towards a direct measurement of the solar metallicity using CNO neutrinos. The details of the detector stabilization, the strategy to track the Po-210 low-rate-region, and the strategy to break the correlation between CNO neutrino signals and its backgrounds will be presented.

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Collaboration / Activity:

Borexino

T01: Astroparticle and Gravitational Waves / 1140

Multimessenger Analysis Strategy for Core-Collapse Supernova Search: Gravitational Waves and Low-energy Neutrinos

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Core-collapse supernovae are fascinating astrophysical objects for multimessenger studies. Gravitational waves (GWs) are expected to play a role in the supernova explosion mechanism, but their modelling is also challenging due to the stochastic nature of the dynamics and the vast possible progenitors, and moreover, the GW detection from these objects is still elusive with the already advanced detectors. Low-energy neutrinos will be emitted enormously during the core-collapse explosion and can help for the gravitational wave counterpart search. In this work we develop a multi-messengers strategy to search for such astrophysical objects by exploiting a global network of both low-energy neutrino and gravitational wave detectors. First, we discuss how to improve the detection potential of the neutrino sub-network by exploiting the temporal behaviour of a neutrino burst from a core-collapse supernova. Then, we combine the information provided by GW and neutrino in a multi-messenger strategy. Our method can better disentangle from noise the low statistical signals

coming from weak (or far) supernovae giving us about 10^3 lower \textit{false-alarm-probability} for recovered signal injections.

Carlo Vigorito, Claudio Casentini, Giulia Pagliaroli, Marco Drago, Odysse Halim, and Viviana Fafone

Collaboration / Activity:

None

First author:

Email:

T04: Neutrino Physics / 1142

NEXT: Measurement of the 136Xe two-neutrino double beta decay half-life with NEXT-White

Author: Pau Novella[1]

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The NEXT (Neutrino Experiment with a Xenon TPC) collaboration aims at the sensitive search of the neutrino-less double beta decay (ββ0ν) of 136Xe at the Laboratorio Subterraneo de Canfranc (LSC). The observation of such a lepton-number-violation process would prove the Majorana nature of neutrinos, providing also handles for an eventual measurement of the neutrino absolute mass. A first large-scale prototype of a high-pressure gas-Xenon electrolumines- cent TPC, NEXT-white, is being operated at the LSC since 2016. This 5-kg ra- diopure detector has already proven the outstanding performance of the NEXT technology in terms of the energy resolution (<1% FWHM at 2.6 MeV) and the topology-based background rejection. NEXT-White has also measured the relevant backgrounds for the ββ0ν search using both 136Xe-depleted and 136Xe- enriched xenon. In this talk, the measurement of the half-life of the two neutrino mode of the double beta decay (ββ2ν) will be presented. For this measurement, two novel techniques in the field have been used: 1) a Richardson-Lucy de- convolution to reconstruct the single and double electron tracks, boosting the background rejection, and 2) a direct subtraction of the ββ backgrounds, mea- sured with 136Xe-depleted data. These techniques allow for background-model- dependent and background-model-independent results, demonstrating the ro- bustness of the ββ2ν half-life measurement and the unique capabilities of NEXT. The physics program of NEXT-White will be completed in late 2021, when the construction of the NEXT-100 detector at the LSC starts. Holding 100 kg of 136Xe and with a background index below 5×10−4 counts/keV/kg/year, this detector will perform the first competitive ββ0ν search within the NEXT roadmap. As validated with NEXT-White, NEXT-100 will reach a sensitivity to the half-life of 6×1025 y after 3 years of data taking.

Collaboration / Activity:

NEXT

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T14: Outreach, Education and Diversity / 1144

AIMS, a few actions and their impact

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The African Institute for Mathematical Sciences is a network of excellence centres for innovative post-graduate training in mathematical sciences in Africa. Established in 2003, today AIMS counts 6 institutes in 5 African countries (Cameroon, Ghana, Rwanda, Senegal, South Africa) and focuses on academics, research, and industry initiative. The students at AIMS follow different academic cursus (mathematical sciences, co-operative education program, climate sciences, machine learning and intelligence). I will present a few actions and the impact that this prominent education network has on the scientific life of some African students.

Collaboration / Activity:

None

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T14: Outreach, Education and Diversity / 1145

Towards an inclusive society by making Astronomy accessible to the blind

Author: Ludovic Petitdemange[None]

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At Guezet the sky is perfectly dark. That's the type of sky the astronomers like to work with at night. Therefore, such conditions are better at Guzet than at the Pic du Midi where observers have to climb steep montains. Every summer, on the Col d'Escot, at an altitude of 1700 meters and from Chalet Beauregard, Astronomers are used to coming there to take advantage of this exceptional place for observation.

This incredible project was born in 2016, Jacques Croiziers, President of the association, followed by six members, have realized that Astronomy should be accessible to all. Indeed, the sky does not belong to a certain category of people. Their primary motivation was to offer an observatory accessible to all people with disabilities and especially the visually impaired people. It is important to show that Science can be accessible. However, the cost is impressive 700 000 euros and requires the contributions of partners including local and national institutions and organisations for the development of the economical region, scientific laboratories with Researchers from different topics. In short, the project supported by Ciel d'Occitanie will allow to join our efforts. The relevant materials suitable for disable people will be identified. In addition, new methods and materials will be developed by the large collaborations allowed by this project. Thank to this observatory, a french group will be able to interact with international projects on the accessibility of Astronomy.

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Collaboration / Activity:

None

T07-T09: Combined: Top, Electroweak and Higgs Physics / 1146

EFT description of lepton magnetic and electric dipole moments

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In my talk I will present a model-independent analysis of the magnetic and electric dipole moments of the muon and electron. The expressions for the dipole moments are given in terms of operator coefficients of the low-energy effective field theory (LEFT) and the Standard Model effective field theory (SMEFT). One-loop renormalization group improved perturbation theory, including the one-loop matching from SMEFT onto LEFT as well as one-loop lepton matrix elements of the effective-theory operators have been used. Semileptonic four-fermion operators involving light quarks give sizable non-perturbative contributions to the dipole moments, which are included in the analysis. Interestingly only a very limited set of the SMEFT operators is able to generate the current deviation of the magnetic moment of the muon from its Standard Model expectation.

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Collaboration / Activity:

T04: Neutrino Physics / 1147

The SuperChooz Pathfinder Exploration

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A new opportunity for a possible flagship experiment in Europe opens by exploiting a unique opportunity that has long been hidden in the Chooz site —Europe's most famous site for reactor neutrino science. The "SuperChooz"project benefits by existence of 2 caverns, formerly hosting the Chooz-A nuclear reactor, built in the 60's, that are becoming vacant upon its dismantling completion. They hold a total volume of up to 50 000m^3, thus directly comparable to the size of SuperKamiokande. Its potential use for for science purposes is under active discussion with EDF and dedicated agreement has just been signed, thus starting the official pathfinder exploration era. The SuperChooz caverns combined with the existing ~1km baseline of the most powerful 2x N4 Chooz PWR nuclear reactors make this site a unique asset world-wide. Experimentally, the challenge is the poor overburden (order 100m underground). However, the novel LiquidO technology, born as byproduct of Double Chooz, heralds the potential for unprecedented active background rejection of up to 2 orders of magnitude, thus providing feasibility potential ground for a hypothetical SuperChooz. The rationale of

the experiment will be highlighted in the talk for the first time —first official released. The project is aimed to address some of the most fundamental symmetries (studies under completion) behind the Standard Model, including a design that may open for key synergies that may boost the sensitivities of other neutrino flagship experiments such as DUNE (US), JUNO (China) and HyperKamiokande (Japan).

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Collaboration / Activity:

SuperChooz

T12: Detector R&D and Data Handling / 1149

Novel LiquidO Neutrino Detection Technology

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Upon the neutrino discovery by Reines & Cowan (1956), they also paved the ground behind much of today's neutrino detection technology. Large instrumented volumes for neutrino detection have been achieved via a key (implicit) principle: detection medium transparency and/or high purity. Much of that technology has yielded historical success, including several Nobel prizes, where the discovery of the neutrino oscillation phenomenon is the latest example. Despite the stunning success, the "transparent technology"like the pioneering liquid scintillator detectors are known to suffer from key limitations such as little (or no) topological particle identification (PID) ability, typically enabling active background rejection. Solving this while keeping the detector scalability has long remained one of the main challenges in the field. Still today, many of those otherwise overwhelming backgrounds can only be reduced via an expensive passive shielding strategy, including the advent for deep underground laboratories. In this talk, we will introduce the novel LiquidO technology (released since mid-2019 by an international proto-collaboration and still under active R&D) whose rationale exploits detection medium extreme opacity, thus breaking with the need for transparency, to yield unprecedented event-wise PID which may reduce dramatically the need for passive shielding.

Collaboration / Activity:

None

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T03: Dark Matter / 1150

The XENON Dark Matter Project

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Understanding the nature of the Dark Matter is one of the biggest challenges in frontier science today. Astrophysical and cosmological observations provide strong evidence for its existence. Several proposed candidates have been put forward over time: one of the most compelling are Weakly Interacting Massive Particles (WIMPs). The XENONnT dark matter program aims at finding direct evidence for the scattering of WIMPs with xenon target nuclei in an ultra-low background dual-phase time projection chamber detector located in the underground National Laboratory of Gran Sasso in Italy.
XENON1T currently achieves the most stringent limits on WIMP (Weakly Interacting Massive Particle) parameters. The technology is evolving rapidly since the last decade and, XENONnT is expected to continue
leading the field.
I will review the current status of the XENON program and the recent Dark Matter results from the XENON1T experiment. The scientific reach of the XENON1T/XENONnT experiments will be completed with the future generation (the DARWIN project) aiming at 40 tons of liquid xenon.

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Collaboration / Activity:

XEXNON

T03: Dark Matter / 1151

The NA64 experiment searching for hidden sectors at the CERN SPS

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NA64 is a fixed target experiment searching for hidden sectors at the CERN SPS. The experiment looks for new particles such as dark photons, axion-like particles, new light X or Z'bosons by colliding 100-150 GeV energy electron beams onto an active target.

We will present the latest NA64 results and conclude with the future prospects of the experiment which will resume data taking this Summer after the 2 years CERN long shutdown.

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Collaboration / Activity:

None

T07: Top and Electroweak Physics / 1152

Top quark contribution to two-loop helicity amplitudes for W/Z boson pair production in gluon fusion

Author: Christian Brønnum-Hansen[1]

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We compute the top quark contribution to the two-loop amplitude for on-shell W/Z boson pair production in gluon fusion. Exact dependence on the top quark mass is retained. For each phase space point the integral reduction is performed numerically and the master integrals are evaluated using the auxiliary mass flow method, allowing fast computation of the amplitude with very high precision. Based on: 2009.03742 and 2101.12095

Collaboration / Activity:

None

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T03: Dark Matter / 1153

COSINUS: a NaI-based experiment for Dark Matter search

Author: Natalia Di Marco[None]

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The COSINUS (Cryogenic Observatory for SIgnals seen in Next-generation Underground Searches) project aims to provide a model-independent cross-check of the long-standing DAMA/LIBRA claim on the observation of dark matter.

The use of sodium iodide (NaI) crystals, operated at cryogenic temperature as scintillating calorimeters, offers both a low energy threshold for nuclear recoils and the possibility to perform signal-to-background discrimination on an event-by-event basis thanks to the dual and independent read-out of both phonon and light signals.

The construction of the COSINUS apparatus will begin in summer 2021 and the data taking will start in 2022.
In this talk we will present the detection principle and the performance together with status and future prospects of the project.

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Collaboration / Activity:

None

T03: Dark Matter / 1154

Operations and Data Taking Status of ADMX

Author: Tatsumi Nitta[None]

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The axion is a hypothetical particle arising from the Pecce-Quinn solution to the Strong CP problem, and an excellent candidate for dark matter. The Axion Dark Matter Experiment (ADMX) is an experiment that searches for axions as a dark matter with a resonant cavity under a strong superconducting magnetic field. In previous operations, ADMX achieved sensitivity to the GUT-inspired DFSZ axion model between 2.66-3.31 eV with yocto Watt level background using a quantum amplifier and dilution refrigerator. The latest run has been in data-taking since 2020. In this run, we have improved our blind axion signal injection, improved our operating efficiency, and have new methods to distinguish true axion signals from the background. I will discuss these advances as well as the current data-taking status.

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Collaboration / Activity:

ADMX

T10: Searches for New Physics / 1155

FASER (the ForwArd Search ExpeRiment)

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The design, expected sensitivity, and current status of the FASER detector are presented. The FASER detector construction was recently completed and it is now undergoing commissioning and preparation for taking data starting in 2022 during Run 3 of the LHC. FASER is dedicated to searching for long-lived particles beyond the standard model. Though extremely rare, such particles may be produced in the high intensity far-forward region of the LHC's proton-proton collisions. These particles may then decay to visible standard model particles within FASER, which is located 480 m downstream of the ATLAS interaction point. This poster depicts a possible mechanism for the production and detection of a Dark Photon with the FASER detector. The motivation for the design of the FASER detector is also presented.

Collaboration / Activity:

FASER

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Email:

T08: Flavour Physics and CP Violation / 1156

Supernova constraints on dark flavoured sectors

Author: Jorge Terol Calvo[1]

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I will present a recent application of the SN 1987A cooling bound to set a constraint on dark flavoured sectors. This is possible thanks to the fact that the protoneutron stars are hot and dense environments where hyperons can be efficiently produced. Therefore a decay of the form $\to nX^0$, where X^0 is a new bosonic dark particle, will be severely constrained. I will explain the ingredients required and the application to flavoured (massless) dark photons, axions and ALPs.

Collaboration / Activity:

None

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Plenary: Welcome and Prize Session / 1158

Welcome from LOC and EPS-HEPP board

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Plenary: Welcome and Prize Session / 1159

The High Energy and Particle Physics Prize - award

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Plenary: Welcome and Prize Session / 1160

The Giuseppe and Vanna Cocconi Prize - award

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Plenary: Welcome and Prize Session / 1161

The Gribov Medal - award

Author: Peter Levai[None]

Plenary: Welcome and Prize Session / 1162

The Young Experimental Physicist Prize - award

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Plenary: Welcome and Prize Session / 1163

The Outreach Prize - award

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T01: Astroparticle and Gravitational Waves / 1164

Galactic cosmic-ray propagation

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I will give an overview of the relevant physics and the challenges of Galactic cosmic-ray transport. In particular, I will address recent developments in numerical modelling and physical developments on this field. Corresponding numerical models aim at reproducing cosmic-ray spectra and also diffuse gamma-ray emission from the Galaxy from high to very-high energies. For these numerical models we witness a transition from analytically prescribed two-dimensional azimuthally-symmetric models to those that use a more realistic description for our Galaxy. Focusing on results computed with the cosmic-ray propagation code PICARD, I will address the new aspects that can be incorporated in such three-dimensional models. This includes, e.g., the impact of observation-driven cosmic-ray source distributions and also the possibility to investigate the effect of anisotropic diffusion with respect to the local magnetic field.

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Collaboration / Activity:

None

T13 - Accelerator for HEP / 1165

High-quality beams from a high-efficiency plasma accelerator at DESY's FLASHForward facility, and beyond

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Plasma accelerators can drastically shrink large-scale future accelerator facilities such as a linear collider. Maintaining high beam quality and accelerating with high energy efficiency is key to delivering high luminosity per wall-plug power. However, this is particularly challenging in a plasma accelerator due to their microscopic size—extreme precision and stability is required. We present recent results from DESY's FLASHForward plasma-accelerator facility, showing preserved energy spread and charge while accelerating with GV/m gradients at record efficiency and stability. Moreover, a new concept for self-correcting plasma acceleration is presented, which may provide orders of magnitude better beam quality and stability for applications in the future.

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Collaboration / Activity:

FLASHForward

T13 - Accelerator for HEP / 1166

Experimental beam tests for FCC-ee

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ossible circular colliders for the post-LHC era at CERN are being explored within the framework of the Future Circular Collider (FCC) feasibility study.
The first stage of the FCC integrated project is the FCC-ee, an ambitious electron-positron collider with a circumference of approximately 100 km.
Certain key concepts of the FCC-ee design can be demonstrated and tested at existing facilities, such as at SuperKEKB at KEK, DAFNE at INFN, KARA at KIT, PETRA III at DESY, VEPP-4M at BINP, and the SwissFEL at PSI. The test of a prototype positron source at PSI, understanding the crab-waist collision scheme at SuperKEKB and DAFNE, testing optics control and emittance tuning techniques at SuperKEKB and PETRA III, and precise beam energy calibration at VEPP-4M will offer invaluable insights for the FCC-ee design optimisation and its operational procedures. The results of these beam tests will be an essential input to the FCC Feasibility Study Report.
This talk will give an overview of possible experimental tests for FCC-ee and highlight already successfully performed studies.

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Collaboration / Activity:

FCC-ee

T13 - Accelerator for HEP / 1167

Perspectives on novel neutrino beams

Author: Kenneth Long[None]

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Neutrino beams today are delivered using technology first developed at CERN in the early 1960s. The next generation of long-baseline neutrino oscillation experiments, DUNE in the US, and Hyper-K in Japan, will exploit enormous detectors of exquisite sensitivity and resolution to deliver enormous data sets with which sensitive searches for the violation of the matter-antimatter symmetry can be made. The statistical weight of these experiments is such that beam-related systematic uncertainties are expexted to play a significant role. To drive the field beyond the sensitivity that will be delivered by DUNE and Hyper-K will require the development and exploitation of novel accelerator techniques. A number of techniques have been proposed to provide the well characterised neutrino beams required to take the field beyond the sensitivity of DUNE and Hyper-K. Such techniques include the creation of neutrino beams from the decay of stored muons and beams in which the neutrino flavour is tagged, and its energy is constrained, by instrumentation in the decay channel. The potential of such approaches will be reviewed and the status of the development of nuSTORM (Neutrinos from Stored Muons) ENUBET (Enanched Neutrino beam from Kaon Tagging) experiments, as well as other initiatives such as NuTAG and ESSnuSB), will be summarised. Synergies between the two programmes and with the R&D required to develop the muon-collider will be presented.

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Collaboration / Activity:

None

T13 - Accelerator for HEP / 1168

Status and Perspectives of High-Field Magnets R&D for Particle Physics

Author: Pierre Vedrine[None]

The CERN Council has endorsed in June 2020 the Update of the European Strategy for Particle Physics. The strategy document contains a strong recommendation to reinforce R&D on key technologies for future accelerators, and in particular high field magnets, including HTS.
To follow up on the implementation of this recommendation, a High Field Magnet Expert Panel (HFM-EP) has been convened under the auspices of the European Large National Laboratories Directors Group (LDG) to create a prioritized R&D roadmap for the High Field Magnets.
The proceedings of the HFM-EP, planned to be endorsed by the CERN council in December 2021, will document this roadmap. They will include the current state-of-the-art and the scientific drivers for High Field Magnets R&D, the progress needed to enable this technology for future facilities, the potential deliverables and demonstrators for the next decade, a prioritized work plan, considering the capabilities and interests of stakeholders, and a range of scenarios for engagement.

We will describe here the status of this work including a technology review about the state-of-the-art, R&D plans, challenges and future opportunities for High Field Magnets for future accelerators.

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T13 - Accelerator for HEP / 1169

Status of the Electron Ion Collider

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The Electron Ion collider will enable collisions of high energy ions with high energy electrons. It will shed light on many open questions of nuclear physics such as the origin of masses of nuclei and nucleons, the origin of nuclear spin, details on the distributions of constituents inside the nuclei, and the questions that emerge from the observed high density of gluons inside the nucleons. On December 19, 2019, the Department of Energy has granted Critical Decision-Zero (CD-0), the acknowledgement of Mission Need of the Electron Ion Collider proposal. On January 9, 2020, Brookhaven National Laboratory was chosen as the site of the new facility. Brookhaven National Laboratory is forming a partnership with Thomas Jefferson Laboratory to design, build and commission the new collider and its detector systems.
The EIC has very ambitious performance parameters that include high luminosity of up to 10^34 cm^-2s^-1, highly polarized beams with P<70%, large range of center of collision center of mass energies between 20 GeV and 140 GeV, large range of ion beams from protons to Uranium and the possibility of up to two detectors and interaction points.
Present plans call for start-up of collider operations in 2030. The design of the new collider is well advanced and recently passed successfully a series of thorough reviews of the conceptual design layout that is documented in a comprehensive conceptual design report.
Scientists from around the world are envisioned to use this exciting facility. There are expectations, that the worldwide science community will contribute to the detector and machine with in-kind contributions. This report will emphasize the status the verification of the design parameters and the accelerator design.

Collaboration / Activity:

None

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T03: Dark Matter / 1170

test

Plenary: EPS Poster Prize / 1171

Poster prize talk: "New measurement of Λ_c^+ production in pp and p-Pb collisions with the ALICE experiment at the LHC"

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Collaboration / Activity:

Plenary: EPS Poster Prize / 1172

Poster prize talk: "Light dark matter searches with DarkMESA"

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Collaboration / Activity:

Plenary: EPS Poster Prize / 1173

Poster prize talk: "Bent crystals for investigation of the charmed baryons electromagnetic dipole"

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Collaboration / Activity:

Plenary: EPS Poster Prize / 1174

Introduction

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Collaboration / Activity:

T14: Outreach, Education and Diversity / 1175

Pandemic as a challenge for International Masterclasses

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International Masterclasses (IMC) is a program under the aegis of the International Particle Physics Outreach Group (IPPOG) to engage high school students and teachers in authentic one-day particle physics analysis experiences at universities and laboratories worldwide. The pandemic of 2020-21 caused IMC to pause and then adjust to be able to reach the participants and excite them about cutting-edge science. This not only addressed immediate issues but also expanded the capacity of IMC to deliver its program in the future. The authors will share what they have learned.

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Collaboration / Activity:

ÖFFENTLICHER ABENDVORTRAG (auf Deutsch / in German) / 1176

Auf der Suche nach der mysteriösen Dunklen Materie

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Zoom webinar

Im Universum muss es 6-mal mehr Materie geben, als die uns bekannte aus Atomen aufgebaute Materie, besagen einhellig alle astrophysikalischen und kosmologischen Messungen: Über 80% der Materie im Universum ist eine uns unbekannte neue Form von Materie, die wir "Dunke Materie" nennen. So ist unsere Galaxie, die Milchstraße, von einem Halo aus Dunkler Materie umgeben. Aus was besteht dann diese Dunkle Materie, wenn nicht aus Atomen?

Die Physiker*innen vermuten, dass es sich dabei um eine neue Art von Elementarteilchen handelt, für die sie mehrere Ideen haben. Weltweit wird mit verschiedenen Techniken nach Signaturen dieser Teilchen gesucht, so auch mit dem ALPS-Experiment am DESY oder mit Experimenten am LHC-Collider am europäischen Teilchenphysikzentrum CERN. Das XENON-Experiment im italienischen Untergrundlabor LNGS 1500m tief unter der Erde will die Dunkle Materie in unserer Milchstraße direkt messen: Es führt eine extrem empfindliche Suche nach der Streuung der Dunkle Materie Teilchen mit Atomen des Edelgases Xenon durch.

Der Vortrag erklärt, welche Messergebnisse die Evidenz für Dunkle Materie belegen, und wie wir mit den Methoden der
(Astro-)Teilchenphysik mit sehr raffinierten Experimenten danach suchen.

First author:

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Collaboration / Activity:

T08: Flavour Physics and CP Violation / 1177

New measurement of radiative decays $K^+ \to e^+\nu\gamma$ and $K^+ \to \pi^0 e^+\nu\gamma$ at the NA62 experiment

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The NA62 experiment at CERN reports new results from studies of radiative kaon decays $K^+ \to e^+\nu\gamma$ ($K_{e2\gamma}$) and $K^+ \to \pi^0 e^+\nu\gamma$ ($K_{e3\gamma}$), using a data sample recorded in 2017–2018. The sample comprises O(10k) $K_{e2\gamma}$ candidates and O(100k) $K_{e3\gamma}$ candidates with sub-percent background contaminations. Preliminary results with the most precise measurement of the $K_{e2\gamma}$ and $K_{e3\gamma}$ branching ratios, determination of structure-dependent $K_{e2\gamma}$ form factors, and T-asymmetry measurement in the $K_{e3\gamma}$ decay, are presented.

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Collaboration / Activity:

Plenary: Welcome and Prize Session / 1178

The High Energy and Particle Physics Prize - talk 1

Author: Torbjörn Sjöstrand[None]

Plenary: Welcome and Prize Session / 1179

The Giuseppe and Vanna Cocconi Prize - talk

Author: Gianpaolo Bellini[None]

Plenary: Welcome and Prize Session / 1180

The Gribov Medal - talk

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Plenary: Welcome and Prize Session / 1181

The Young Experimental Physicist Prize - talk

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Collaboration / Activity:

Plenary: Welcome and Prize Session / 1182

The Young Experimental Physicist Prize - talk

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Collaboration / Activity:

Plenary: Welcome and Prize Session / 1183

The Outreach Prize - talk

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Plenary: Welcome and Prize Session / 1184

The High Energy and Particle Physics Prize - talk 2

Author: Bryan Webber[None]

Plenary Session 4 / 1185

Closing remarks and invitation to EPS-HEP2023

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Collaboration / Activity:

T01: Astroparticle and Gravitational Waves / 1186

PLEnuM: A global and distributed monitoring system of high-energy astrophysical neutrinos

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High-energy astrophysical neutrinos, discovered by IceCube, are now regularly observed.
Due to their low flux the observation rate remains small, such that open questions about high-energy neutrino astrophysics and particle physics remain limited by statistics at best, or unanswered at worst. Fortunately, this situation will improve in the next years: new neutrino telescopes will come online, which are currently under planning and construction. In order to answer open questions, we propose the Planetary Neutrino Monitoring System (PLEnuM), a concept for a global repository of high-energy neutrino observations. PLEnuM will reach up to four times the exposure available today by combining the exposures of current and future neutrino telescopes distributed around the

world – IceCube, IceCube-Gen2, Baikal-GVD, KM3NeT, and P-ONE. Depending on the declination, spectral index and flavor, PLEnuM will improve the sensitivity to astrophysical neutrinos by up to two orders of magnitude. We present first estimates on the capability of PLEnuM to discover Galactic and extragalactic sources of astrophysical neutrinos and to characterize the diffuse flux of high-energy neutrinos in unprecedented detail.

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Collaboration / Activity: