# on e+e- Higgs/EW/Top Factories, October 5-7, 2022, in Hamburg


# Report of Contributions

Contribution ID: **9** Type: **not specified**

# Opening & Introduction

*Wednesday, 5 October 2022 09:00 (25 minutes)*

**Presenters:** HEINEMANN, Beate (DESY and University of Freiburg (Germany)); SCHWANENBERGER, Christian (CMS (CMS Fachgruppe TOP)); JAKOBS, Karl

**Session Classification:** Plenary

Contribution ID: **10** Type: **not specified**

# Physics case of an e+e- Higgs factory

*Wednesday, 5 October 2022 09:25 (20 minutes)*

**Presenter:** MCCULLOUGH, Matthew (CERN)

**Session Classification:** Plenary

Contribution ID: **11** Type: **not specified**

# From Snowmass to the ECFA Higgs Factory Study

*Wednesday, 5 October 2022 12:30 (20 minutes)*

**Presenter:** REINA, Laura (Florida State University)

**Session Classification:** Plenary

Contribution ID: **12** Type: **not specified**

# News and input to ECFA study from circular and linear Higgs Factories

*Wednesday, 5 October 2022 09:45 (40 minutes)*

**Presenters:** SIMON, Frank (Max-Planck-Institute for Physics); TIAN, Junping (The University of Tokyo)

**Session Classification:** Plenary

Contribution ID: **13** Type: **not specified**

# News and input to ECFA study from linear Higgs Factories

**Presenter:** TIAN, Junping (The University of Tokyo)

**Session Classification:** Plenary

Contribution ID: **14** Type: **not specified**

# Physics landscape at the start of a Higgs factory

*Wednesday, 5 October 2022 11:00 (25 minutes)*

**Presenter:** ROLOFF, Philipp (CERN)

**Session Classification:** Plenary

Contribution ID: **15** Type: **not specified**

# Precision theory requirements, developments & prospects for e+e-

*Wednesday, 5 October 2022 11:25 (25 minutes)*

**Presenter:** FREITAS, Ayres (University of Pittsburgh)

**Session Classification:** Plenary

Contribution ID: **16** Type: **not specified**

# Interplay of indirect and direct searches at a Higgs factory

*Wednesday, 5 October 2022 11:50 (25 minutes)*

**Presenter:** HEINEMEYER, Sven (IFCA (CSIC, Santander))

**Session Classification:** Plenary

Contribution ID: **17** Type: **not specified**

# Open study questions

*Wednesday, 5 October 2022 12:15 (15 minutes)*

**Presenter:** LIST, Jenny (FTX (FTX-SLB))

**Session Classification:** Plenary

Contribution ID: **18** Type: **not specified**

# Spare - redistribute time …?

**Session Classification:** Plenary

Contribution ID: **19** Type: **not specified**

# Highlights & Plans WG1-PREC

*Friday, 7 October 2022 11:00 (20 minutes)*

**Presenter:** MEYER, Andreas (DESY)

**Session Classification:** Plenary

Contribution ID: **20** Type: **not specified**

# Highlights & Plans WG1-GLOB

*Friday, 7 October 2022 11:20 (20 minutes)*

**Presenter:** GROHSJEAN, Alexander (CMS (CMS Fachgruppe TOP))

**Session Classification:** Plenary

Contribution ID: **21** Type: **not specified**

# Highlights & Plans WG1-SRCH

*Friday, 7 October 2022 11:40 (20 minutes)*

**Presenter:** ZARNECKI, Aleksander Filip (Faculty of Physics, University of Warsaw)

**Session Classification:** Plenary

Contribution ID: **22** Type: **not specified**

# Highlights & Plans WG1-FLAV

*Friday, 7 October 2022 12:00 (20 minutes)*

**Presenter:** MARZOCCA, David (INFN Trieste)

**Session Classification:** Plenary

Contribution ID: **23** Type: **not specified**

# Highlights & Plans WG1-HTE

*Friday, 7 October 2022 12:20 (20 minutes)*

**Presenter:** HAYS, Chris (Oxford University)

**Session Classification:** Plenary

Contribution ID: **24** Type: **not specified**

# Path towards a Higgs Factory

*Friday, 7 October 2022 14:20 (30 minutes)*

**Presenter:** MNICH, Joachim (DESY)

**Session Classification:** Plenary

Contribution ID: **25** Type: **not specified**

# Timeline and Next Steps of the ECFA Higgs Factory Study

*Friday, 7 October 2022 14:00 (20 minutes)*

**Presenter:** ROBSON, Aidan (University of Glasgow)

**Session Classification:** Plenary

Contribution ID: **26** Type: **not specified**

# Closing & Farewell

*Friday, 7 October 2022 14:50 (15 minutes)*

**Presenter:** JAKOBS, Karl (University of Freiburg)

**Session Classification:** Plenary

Contribution ID: **27** Type: **Parallel session talk**

# The geometric SMEFT

*Thursday, 6 October 2022 17:11 (17 minutes)*

The effective field theory approach to the Standard Model, the SMEFT, has been used to study LHC data with ever increasing theoretical precision and sophistication recently. The explosion in the number of parameters in the SMEFT as a function of operator mass dimension, and the technical challenge or reformulating SM predictions consistently into the SMEFT were very serious problems for years. I will discuss how these challenges have been overcome
using an understanding that the projection of curved scalar field spaces generated by the Higgs - in the Geometric SMEFT.

**Primary author:** TROTT, Michael (NBI)

**Presenter:** TROTT, Michael (NBI)

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **28** Type: **Parallel session talk**

# A Tale of Two Portals: Testing Light, Hidden New Physics at Future e+e– Colliders

*Wednesday, 5 October 2022 16:40 (15 minutes)*

We investigate the prospects for producing new, light, hidden states at a future $e^+e^-$ collider in a Higgsed dark $U(1)_D$ model, (the Double Dark Portal model). The simultaneous presence of both vector and scalar portal couplings immediately modifies the SM $e^+e^- \to Zh$ process at leading order in each coupling. After accounting for current constraints, we demonstrate that a future Higgs factory will have leading sensitivity to the two portal couplings in production, decay, and radiative return processes. Besides exotic Higgs decays, we highlight the importance of direct dark vector and scalar production tagged from the recoil mass method.

**Primary author:** YU, Felix (JGU Mainz)

**Co-authors:** LIU, Jia (Peking U.); WANG, Xiaoping (Beihang U.)

**Presenter:** YU, Felix (JGU Mainz)

**Session Classification:** WG1: joined HTE & SRCH session

**Track Classification:** WG1-HTE+SRCH - Physics Potential: Higgs, top and EW joint with FIP and direct searches

Contribution ID: **29** Type: **Parallel session talk**

# Probing new physics with a LUXE-type experiment at future Higgs factories

*Wednesday, 5 October 2022 14:20 (15 minutes)*

The proposed LUXE (LASER Und XFEL Experiment) at DESY, Hamburg, using the 16.5 GeV electron beam from the European XFEL, aims to probe QED in the non-perturbative regime created in collisions between high-intensity laser pulses and high-energy electron or photon beams. This setup also provides a unique opportunity to probe physics beyond the Standard Model by leveraging the large photon flux generated at LUXE, probing axion-like-particles (ALPs) at a reach comparable to FASER2 and NA62. In this contribution we will explore the sensitivity of a LUXE-type experiment using the electron beam of future Higgs factories instead of the EU.XFEL one.

**Primary author:** WING, Matthew (UCL)

**Presenter:** MELONI, Federico (ATLAS (ATLAS SM and Beyond))

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **30** Type: **Parallel session talk**

# Higgs self-coupling projections for future e+e- colliders

*Thursday, 6 October 2022 16:49 (17 minutes)*

Establishing the shape of the Higgs potential is invaluable in paving a path forward for understanding the principles behind the Higgs mechanism. As the Higgs self-couplings are directly related to the Higgs potential, their measurements are crucial to either verify the SM mechanism for electroweak symmetry breaking sector or uncover new physics.
The physics programmes at future $e^+e^-$ colliders provide access to the trilinear Higgs self-coupling, $\lambda_{HHH}$. At Higgs factories, it can only be indirectly accessed via model-dependent fits. More direct information on the $\lambda_{HHH}$ can be obtained from double-Higgs production available at sufficiently high center-of-mass energies. For such a measurement, precision is key, however, small production cross sections pose challenges and set high standards on the analysis techniques. Recent improvements in analysis techniques have been achieved and are expected to improve the Higgs self-coupling projections.
In this contribution, we review current state-of-the-art projections for the Higgs self-coupling measurement at future $e^+e^-$ colliders and discuss key aspects of improvement, focusing on flavour-tagging, b-jet reconstruction, and kinematic fitting.

**Primary authors:** TORNDAL, Julie (FTX (FTX Fachgruppe SLB)); LIST, Jenny (FTX (FTX-SLB))

**Presenter:** TORNDAL, Julie (FTX (FTX Fachgruppe SLB))

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **32** Type: **Parallel session talk**

# New BSM Higgs bosons: e+e- collider physics potential

*Wednesday, 5 October 2022 17:19 (20 minutes)*

We discuss the mounting evidence for a 95 GeV Higgs boson, as well as interesting excesses in the searches for heavier Higgs bosons at $\sim 400$ GeV. We show how these excesses can described in the Two Higgs Doublet Model plus real singlet (N2HDM), or in the Next-to-Minimal Supersymmetric Standard Model (NMSSM). We discuss the physics potential of future $e^+e^-$ colliders to analyze these scenarios.

**Primary authors:** GROHSJEAN, Alexander (CMS (CMS Fachgruppe TOP)); SCHWANENBERGER, Christian (CMS (CMS Fachgruppe TOP)); WEIGLEIN, Georg (T (Phenomenology)); HEINEMEYER, Sven (IFCA (CSIC, Santander)); BIEKOETTER, Thomas (T (Phenomenology)); MOORTGAT-PICK, Gudrid (University of Hamburg / DESY); PAASCH, Steven (FLC (FTX Fachgruppe SLB)); LI, Cheng (FTX (FTX Fachgruppe SLB))

**Presenter:** HEINEMEYER, Sven (IFCA (CSIC, Santander))

**Session Classification:** WG1: joined HTE & SRCH session

**Track Classification:** WG1-HTE+SRCH - Physics Potential: Higgs, top and EW joint with FIP and direct searches

Contribution ID: **33** Type: **Parallel session talk**

# Triple Higgs couplings of the 2HDM at the ILC and CLIC

*Wednesday, 5 October 2022 17:02 (15 minutes)*

We analyze the parameter space allowed in the Two Higgs Doublet Model (2HDM) with respect to all current experimental and theoretical constraints. We show the allowed ranges for the various triple Higgs couplings, depending on the Yukawa type of the model. We discuss the accessibility of BSM triple Higgs couplings at the ILC and CLIC.

**Primary authors:** ARCO GARCIA, Francisco (Instituto de Física Teórica (IFT-UAM)); HEINEMEYER, Sven (IFCA (CSIC, Santander)); HERRERO, Maria Jose

**Presenter:** ARCO GARCIA, Francisco (Instituto de Física Teórica (IFT-UAM))

**Session Classification:** WG1: joined HTE & SRCH session

**Track Classification:** WG1-HTE+SRCH - Physics Potential: Higgs, top and EW joint with FIP and direct searches

Contribution ID: **34** Type: **Parallel session talk**

# (g-2)_mu and SUSY: ILC and CLIC Physics Opportunities

*Wednesday, 5 October 2022 16:25 (20 minutes)*

The electroweak (EW) sector of the Minimal Supersymmetric Standard Model (MSSM) can account for a variety of experimental data. The lightest SUSY particle (LSP), the lightest neutralino, is a perfect Dark Matter (DM) candidate. The EW spectrum can easily explain the discrepancy between the experimental value of the anomalous magnetic moment of the muon, $(g-2)_\mu$, and its SM prediction. Taking these constraints as well as LHC searches into account, we derive upper limits on the lighter part of the MSSM spectrum of $\leq 650$ GeV. We discuss how this parameter space can be tested at the ILC and CLIC, as well as the complementarity with DM direct detection experiments.

**Primary authors:** SAHA, Ipsita; CHAKRABORTI, Manimala (AstroCeNT, Warsaw); HEINEMEYER, Sven (IFCA (CSIC, Santander))

**Presenter:** HEINEMEYER, Sven (IFCA (CSIC, Santander))

**Session Classification:** WG 1 - Global

**Track Classification:** WG1-GLOB - Physics Potential: Global interpretations

Contribution ID: **36** Type: **Parallel session talk**

# Precise predictions for the trilinear Higgs coupling in arbitrary models

*Thursday, 6 October 2022 16:27 (17 minutes)*

The trilinear coupling of the 125-GeV Higgs boson, $\lambda_{hhh}$, is one of the most important quantities to investigate in the future. It controls the shape of the Higgs potential, and in turn it determines the strength of the electroweak phase transition. It can also exhibit large deviations from its SM predicition, even in scenarios where New Physics is hidden from direct observation (e.g. scenarios with alignment), and the experimental bounds on it are already sufficiently strong to exclude significant parts of (otherwise unconstrained) parameter spaces of Beyond-the-Standard-Model (BSM) theories. It is therefore crucial to have accurate predictions for $\lambda_{hhh}$ for the wide range of BSM models currently investigated.

In this talk, I will present a new public tool, providing predictions for $\lambda_{hhh}$, expressed in terms of the coupling modifier $\kappa_\lambda$, to full one-loop order within arbitrary renormalisable QFTs. This framework allows computing one-, two-, and three-point functions at one loop in an automated way, and furthermore offers a high level of flexibility in the application of pre- or user-defined renormalisation conditions. I will review the main elements of the calculation and demonstrate features of the new program. Finally, I will discuss possible applications and extensions of this tool.

**Primary authors:** BAHL, Henning (None); BRAATHEN, Johannes (T (Phenomenology)); GABELMANN, Martin (T (Phenomenology)); WEIGLEIN, Georg (T (Phenomenology))

**Presenter:** GABELMANN, Martin (T (Phenomenology))

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **37** Type: **Parallel session talk**

# New constraints on extended Higgs sectors from the trilinear Higgs coupling

*Thursday, 6 October 2022 16:05 (17 minutes)*

Investigating the trilinear Higgs coupling $\lambda_{hhh}$ is crucial to determine the structure of the Higgs potential and to probe possible signs of physics beyond the Standard Model (SM). Focusing on the Two-Higgs-Doublet Model as a concrete example, I will discuss the calculation of the dominant two-loop contributions to $\lambda_{hhh}$, and I will show that this coupling can, in certain regions of parameter space, be significantly enhanced with respect to its SM prediction. Taking into account all relevant corrections up to the two-loop level, I will demonstrate that the current experimental bounds on $\lambda_{hhh}$ already rule out significant parts of otherwise unconstrained parameter space of the model. Finally, I will present a benchmark scenario illustrating the interpretation of the current results and future measurement prospects on $\lambda_{hhh}$.

**Primary authors:** WEIGLEIN, Georg (T (Phenomenology)); BAHL, Henning (None); BRAATHEN, Johannes (T (Phenomenology))

**Presenter:** BRAATHEN, Johannes (T (Phenomenology))

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **39** Type: **Parallel session talk**

# Searches for light scalars at LHC and interpretation of the findings

*Wednesday, 5 October 2022 17:43 (15 minutes)*

LHC has discovered a light boson h(125), residual of EWSB in the SM and no heavy particle. More generally, one can assume that scalars due to BSM symmetry breaking mechanisms are likely to be the lightest particles produced at LHC and the only new particles reachable at future lepton colliders. From a systematic survey of LHC data, I conclude that there are 4 likely candidates, all reaching a global evidence above 4 s.d. Confronted to the most popular models, it turns out that models with triplets, as initially proposed by Georgi and Machacek (GM) in 1985, are able to interpret these candidates. Its major prediction, based on unitarity requirements, is an upper bound, 700 GeV, on the masses of all these scalars, therefore accessible to LHC and at future e+e- TeV Linear Colliders (LC) proposed by the community of particle physics. This model needs to be extended in several ways, which are naturally embedded within a SUSY version of GM, SGM, which offers a promising scenario for a global and calculable theory describing particle physics and cosmology. Quantitative predictions are given for e+e- cross sections of the relevant processes. Promising searches for HL-LHC are briefly described.

**Primary author:** RICHARD, Francois (IJCLab Orsay)

**Presenter:** RICHARD, Francois (IJCLab Orsay)

**Session Classification:** WG1: joined HTE & SRCH session

**Track Classification:** WG1-HTE+SRCH - Physics Potential: Higgs, top and EW joint with FIP and direct searches

Contribution ID: **40** Type: **Parallel session talk**

# Dark sector in Two Higgs Doublet extensions with a Complex Scalar Singlet [zoom]

*Wednesday, 5 October 2022 16:25 (15 minutes)*

Extension of the Two Higgs Doublet model augmented with a complex scalar singlet (2HDMS) is a well motivated candidate for Beyond Standard Model (BSM) Physics. In this talk, we focus on the dark matter (DM) phenomenology of 2HDMS and investigate cases where the singlet doesnot obtain a vacuum expectation value (vev) and act as the DM candidate. We also consider the case where the singlet develops a vacuum expectation value (vev) and the pseudoscalar component is the DM candidate. We perform a parameter scan to study the impact of relic density and direct detection scenarios on the model parameter space for both cases. Some representative benchmarks are chosen for the former case and potential signals at future e+e- colliders are presented.

**Primary authors:** Mr LI, Cheng (DESY); Prof. MOORTGAT-PICK, Gudrid (DESY and UHH); DUTTA, Juhi (UNI/TH (Uni Hamburg, Institut fuer Theoretische Physik)); Ms ZIEGLER, Julia (UHH); Ms SHEIKH FARAH, Tabira (UHH)

**Presenter:** DUTTA, Juhi (UNI/TH (Uni Hamburg, Institut fuer Theoretische Physik))

**Session Classification:** WG1: joined HTE & SRCH session

**Track Classification:** WG1-HTE+SRCH - Physics Potential: Higgs, top and EW joint with FIP and direct searches

Contribution ID: **41** Type: **Parallel session talk**

# Stau searches and measurement prospects at future Higgs factories

*Wednesday, 5 October 2022 14:50 (15 minutes)*

The direct pair-production of the tau-lepton superpartner, stau, is one of the most interesting channels to search for SUSY. First of all the stau is with high probability the lightest of the scalar leptons. Secondly the signature of stau pair production signal events is one of the most difficult ones, yielding the 'worst' and thus most general scenario for the searches.
The most model-independent limits on the stau mass come from LEP.
LHC exclusion reach extends to higher masses, but under strong model assumptions.
Future electron-positron colliders are ideally suited for stau searches: featuring increased luminosity and centre-of-mass energy and improved technologies, with respect to previous electron-positron colliders, and profiting from cleaner environment, initial state being known, and trigger-less operation of the detectors, with respect to hadron colliders.
The capability of a future electron-positron collider for determining stau exclusion/discovery limits in a model-independent way, together with an overview of the current state-of-the-art and prospects on stau-properties measurements, are shown in this contribution.
The studies used the full detector simulation and reconstruction procedures of the International Large Detector concept (ILD) at the ILC, all SM and machine induced backgrounds are included. The applicability to other projects will be discussed.

**Primary authors:** BERGGREN, Carl Mikael (FLC (FTX Fachgruppe SLB)); LIST, Jenny (FTX (FTX-SLB)); NUNEZ PARDO DE VERA, Maria Teresa (FS-EC (Experimente Control))

**Presenter:** NUNEZ PARDO DE VERA, Maria Teresa (FS-EC (Experimente Control))

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **42** Type: **Poster**

# Higgs physics studies with ILC

*Thursday, 6 October 2022 17:30 (2 hours)*

With technically mature design and well understood physics program, ILC is a realistic option for realization of a Higgs factory. With a unique physics reach of a linear collider, ILC will significantly complement projections for HL-LHC. Energy staged data collection, employment of beam polarization and capability to reach a TeV center-of-mass energy enable unique precision measurements of various Higgs couplings including its self-coupling. These precision measurements will allow to probe BSM indirectly beyond the reach of direct search at the LHC. This talk will address the simulation studies based on the ILD detector concept for the Higgs physics program at the ILC.

**Primary authors:** BOZOVIC JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade (RS)); KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern)); TIAN, Junping (The University of Tokyo)

**Presenters:** MILUTINOVIC-DUMBELOVIC, Gordana (VINCA Institute of Nuclear Sciences, University of Belgrade); MILUTINOVIC-DUMBELOVIC, Gordana (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **43** Type: **Parallel session talk**

# Identification of charged leptons in jets at future Higgs factories.

*Thursday, 6 October 2022 14:45 (15 minutes)*

An important goal at future Higgs factories are precise measurements of the 125 GeV Higgs boson properties. As the Higgs boson predominantly decays to $b\bar{b}$, the precise reconstruction of heavy flavor jets is crucial. A source of uncertainty for these jets is missing momentum from semi-leptonic decays $b \to \ell\nu X$. Recent work has shown the possibility of correcting this missing neutrino momentum. For this, the charged lepton from the decay needs to be successfully reconstructed and identified. While particle flow detector concepts with their high granularity offer ideal conditions to identify leptons inside jets, the excellent hardware needs to be matched with corresponding reconstruction algorithms. In this work, we use the detailed simulation of the ILD detector concept to investigate how to exploit the information provided by a particle flow detector to identify single electrons and muons in a dense environment and how this improves the reconstruction of $H \to b\bar{b}$ decays.

**Primary author:** REICHENBACH, Leonhard (FTX (Technol. zukuenft. Teilchenph. Experim.))

**Co-author:** LIST, Jenny (FTX (FTX-SLB))

**Presenter:** REICHENBACH, Leonhard (FTX (Technol. zukuenft. Teilchenph. Experim.))

**Session Classification:** WG 2: Physics Analysis Methods

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **44** Type: **Parallel session talk**

# ErrorFlow: Jet Error Estimation for Kinematic Fitting in Particle Flow Detectors at Future Higgs Factories

*Thursday, 6 October 2022 15:15 (15 minutes)*

Constrained fits improve the kinematic reconstruction of the final state in many Higgs, top and electroweak physics studies. This is a powerful tool, particularly at $e^+e^-$ colliders where the initial state four-momentum is known and can be employed to constrain the final state. An accurate estimate of the measurement uncertainties, particularly for composed objects like jets, is a crucial ingredient to kinematic fitting. Detectors optimized for particle-flow reconstruction provide a detailed estimation of the covariance matrices for individual particle flow objects in addition to an excellent four-momentum measurement. These can be combined to derive an estimate of the individual covariance matrix of the four-momentum of each jet by an algorithm called ErrorFlow. This contribution will present the improvements by the application of ErrorFlow in the $ZH$ versus $ZZ$ separation at $\sqrt{s}$=250 GeV, using the full simulation of the International Large Detector as an example of a highly-granular ParticleFlow optimized detector concept.

**Primary authors:** LIST, Jenny (FTX (FTX-SLB)); RADKHORRAMI, Yasser (FLC (FTX Fachgruppe SLB))

**Presenter:** RADKHORRAMI, Yasser (FLC (FTX Fachgruppe SLB))

**Session Classification:** WG 2: Physics Analysis Methods

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **45** Type: **Parallel session talk**

# Prospects of time-of-flight particle identification at the future Higgs factories

*Wednesday, 5 October 2022 15:12 (18 minutes)*

One of the important aspects of the future Higgs factory is particle identification, which is important for precision measurements and plays a crucial role for flavour physics. Recent technology developments of Si sensors, e.g. LGADs, enable time resolutions below 50 ps. This allows to use measurement of the time-of-flight as a tool for particle identification of $\pi^{\pm}$, $K^{\pm}$ and $p$ up to roughly 5 GeV momentum. Time-of-flight particle identification serves as a great complementary tool for dE/dx in gaseous detectors and the only available particle identification tool in fully Si detector designs. In this talk we will discuss the latest developments of the time-of-flight particle identification tool, its physics applications at the future Higgs factory and the potential impact on the detector design using International Large Detector (ILD) at the International Linear Collider (ILC) as an example case.

**Primary author:** DUDAR, Bohdan (FTX (FTX Fachgruppe SLB))

**Co-authors:** LIST, Jenny (FTX (FTX-SLB)); EINHAUS, Ulrich (FTX (Fachgruppe SLB))

**Presenter:** DUDAR, Bohdan (FTX (FTX Fachgruppe SLB))

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **46** Type: **Parallel session talk**

# Dark Photon Searches at Future $e^+e^-$ Colliders

*Thursday, 6 October 2022 16:50 (15 minutes)*

In theories where dark matter is explained by the existence of a 'dark sector', interacting with the visible sector of the standard model via gravitation, the photon of the dark sector, the dark photon $(A_D)$, might be the only visible manifestation of the dark sector due to kinetic mixing with the (ordinary) photon. The strength of the mixing is given by a mixing parameter $(\epsilon)$. This is the same parameter governing both the production cross-section and the decay of the $A_D$ back to SM particles. Detectors at future e+e- colliders will have excellent momentum resolution and equally excellent track-finding efficiency. These are the features needed to probe for the expected signal of a $A_D$, namely a quite small, and quite narrow resonance: If $(\epsilon)$ is large enough to yield a detectable signal, its decay width will be smaller than the detector resolution, but so large that the decay back to SM particles is prompt. This study investigates the dependency of the limit on the mixing parameter and the mass of the $A_D$ using the $A_D \to \mu^+\mu^-$ decay mode in the presence of standard model background, using fully simulated signal and background events in the ILD detector at the ILC Higgs factory.

**Primary authors:** BERGGREN, Carl Mikael (FLC (FTX Fachgruppe SLB)); LIST, Jenny (FTX (FTX-SLB)); HOSSEINI SENVAN, Sepideh (FTX (FTX Fachgruppe SLB)); MOORTGAT-PICK, Gudrid (University of Hamburg / DESY)

**Presenter:** HOSSEINI SENVAN, Sepideh (FTX (FTX Fachgruppe SLB))

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **48** Type: **Parallel session talk**

# Enabling precision electroweak measurements at high energy e+e-colliders with detector-based center-of-mass energy measurements

*Thursday, 6 October 2022 16:00 (15 minutes)*

One of the challenges for future e+e- colliders is adequate control of the center-of-mass energy, and the associated luminosity spectrum. For linear colliders at all energies and for circular colliders at center-of-mass energies above 200 GeV one can not rely on resonant beam depolarization and must use collision data driven methods. The contribution will focus on progress related to this issue based on reconstruction of di-muon events that leverages a precise tracker momentum scale calibration, and will discuss a few of the electroweak measurements such as the W and Z masses and widths and the left-right asymmetry that are made feasible particularly at a linear collider. The talk will also address associated detector performance requirements.

**Primary author:** WILSON, Graham (University of Kansas)

**Presenter:** WILSON, Graham (University of Kansas)

**Session Classification:** WG 1 - Precision

**Track Classification:** WG1-PREC - Physics Potential: Precision

Contribution ID: **49** Type: **Parallel session talk**

# Benchmarking FIMP signatures at future Higgs factories

*Wednesday, 5 October 2022 14:35 (15 minutes)*

Feebly interacting massive particles (FIMPs) are characterised by very weak couplings and can be mediators to the dark sector or dark matter (DM) candidates themselves. In the latter case, the DM abundance is determined by the *freeze-in* mechanism (in contrast to *freeze-out* for WIMPs). Many FIMP scenarios are difficult to be constrained at the LHC and future e+e- Higgs factories seem to be a good place to look for them.

Typically, benchmark points (BPs) for studing collider sensitivity to Beyond the Standard Model (BSM) scenarios are selected in the model parameter space, providing predictions on the experimental signatures expected in a given experiment. We propose a different, more experiment-focused approach. A set of BPs is selected here to cover a range of experimental signatures, rather than a range of BSM model parameters.

The available space of physical FIMP parameters strongly depends on the particle type, coupling structure, and hence also the production scenario, which leads to particular signatures. Therefore, BPs are defined in the space of physical FIMP properties, directly related to the level of experimental sensitivity, for a given production channel and/or a signature. If FIMP is a mediator, this can be e.g. its mass, lifetime or branching ratios.

**Primary author:** KLAMKA, Jan (University of Warsaw)

**Co-author:** ZARNECKI, Aleksander Filip (Faculty of Physics, University of Warsaw)

**Presenter:** KLAMKA, Jan (University of Warsaw)

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **50** Type: **Parallel session talk**

# SUSY at future colliders: Will e^+e^- colliders be relevant?

*Wednesday, 5 October 2022 15:05 (15 minutes)*

A study of the prospects for discovering or excluding SUSY at various proposed future colliders is presented. The study is based on scanning the relevant parameter space of (weak-scale) SUSY parameters. In particular, I concentrate on the properties most relevant to evaluate the experimental prospects: mass differences, lifetimes and decay-modes. The observations are then confronted with estimated experimental capabilities, including - importantly - the detail of simulation these estimates are based upon. Conclusions on realistic prospects are presented, and the answer to the question in the title is found to be “Yes”.

**Primary author:** BERGGREN, Carl Mikael (FLC (FTX Fachgruppe SLB))

**Presenter:** BERGGREN, Carl Mikael (FLC (FTX Fachgruppe SLB))

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **51** Type: **Parallel session talk**

# Generative Models for Fast Simulation of Electromagnetic and Hadronic Showers in Highly Granular Calorimeters

*Wednesday, 5 October 2022 18:00 (15 minutes)*

Simulation in High Energy Phyiscs (HEP) places a heavy burden on the available computing resources and is expected to become a major bottleneck for the upcoming high luminosity phase of the LHC and for future Higgs factories, motivating a concerted effort to develop computationally efficient solutions. Methods based on generative machine learning methods hold promise to alleviate the computational strain produced by simulation, while providing the physical accuracy required of a surrogate simulator.

In this contribution, we provide an overview of a growing body of work focused on simulating showers in highly granular calorimeters, which is making significant steps towards realistic fast simulation tools based on deep generative models. Progress on the simulation of both electromagnetic and hadronic showers will be reported, with a focus on the high degree of physical fidelity and computational performance achieved. Additional steps taken to address the challenges faced when broadening the scope of these simulators, such as those posed by multi-parameter conditioning, will also be discussed.

**Primary author:** EREN, Engin (FLC (FTX Fachgruppe SFT))

**Presenter:** EREN, Engin (FLC (FTX Fachgruppe SFT))

**Session Classification:** WG 2: Physics Analysis Methods

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **52** Type: **Parallel session talk**

# Heavy Neutrinos at Future Linear e+e- Colliders

*Thursday, 6 October 2022 16:20 (15 minutes)*

Neutrinos are probably the most mysterious particles of the Standard Model. The mass hierarchy, oscillations and the nature of their antiparticles are currently being studied in many experiments. Moreover, in models of New Physics, baryon asymmetry or dark matter density 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 could be produced at future e+e- colliders.

We studied the possibility of observing decays of heavy neutrinos in qql final state at future e+e- machines for a wide range of collision energy, starting from 250 GeV up to 3 TeV. The analysis is based on the WHIZARD event generation and fast detector simulation with DELPHES. Dirac and Majorana neutrinos with masses from 100 GeV to 3.2 TeV are considered. Estimated limits on the production cross section and on the neutrino-lepton coupling are compared with the current limits coming from the LHC running at 13 TeV and future hadron colliders. The obtained results are stricter than other estimates published so far. The potential of future colliders to discriminate between Dirac and Majorana nature of the new heavy lepton is also discussed.

**Primary authors:** ZARNECKI, Aleksander Filip (Faculty of Physics, University of Warsaw); MEKALA, Krzysztof (University of Warsaw); REUTER, Juergen (T (Phenomenology))

**Presenter:** MEKALA, Krzysztof (University of Warsaw)

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **53** Type: **Poster**

# Di-Higgs with missing transverse momentum at FCC-hh

*Thursday, 6 October 2022 17:30 (2 hours)*

The determination of the Higgs self-coupling from di-Higgs events with very high precision is one of the clearest benchmarks for the FCC-hh. Its potential has been well established already in several final states. In this talk studies into final states of the di-Higgs system which involve neutrinos are presented. The benefit of studying yet another di-Higgs final state is two-fold: First, any additional events included will add further precision to the measurement. Second, specifically neutrino channels will help to shed light on an experimental aspect for the FCC-hh which has not been well investigated yet: a robust reconstruction of the missing transverse momentum (ETMiss) is crucial for such analyses. It is is clear that ETMiss reconstruction at the FCC-hh will be extremely challenging due to the high pile-up environment, with average interactions per bunch crossing of the order of 1000. In particular, bbWW, bbττ and bbZZ signals are analysed in the final state with 2 light charged leptons in addition to ETMiss, using cut-based as well as multivariate techniques. Their expected sensitivity is extracted, and the impact of different scenarios for systematic uncertainties, such as the worsening of the ETMiss resolution, is assessed.

**Primary author:** STAPF, Birgit (ATLAS (ATLAS Higgs Physics))

**Co-authors:** GALLO-VOSS, Elisabetta (CMS (CMS-Experiment)); TACKMANN, Kerstin (BELLE (BELLE Gruppe)); LAUDAMUS, Kevin (CMS (CMS Fachgruppe HIGGS))

**Presenter:** STAPF, Birgit (ATLAS (ATLAS Higgs Physics))

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **54** Type: **Parallel session talk**

# Probing the CP properties of Higgs bosons via transverse polarization at $e^+e^-$ collider

*Wednesday, 5 October 2022 15:12 (14 minutes)*

In the CP-violating 2HDM, the CP-violating Higgs to fermions couplings can make an additional loop contribution on the Higgs to gauge bosons couplings. In order to address this aspect, we consider a generic model which has the effective CP-violation structure of the Higgs to gauge bosons couplings. We explore the effect of CP-violation term via the process $e^+e^- \to HZ, Z \to \mu^+\mu^-$, where the angular distribution of muon pair can be sensitive to the CP-violation structure. In particular, the transverse polarization of the initial beams can be applied to single out the effect of CP-violating term compared to the unpolarized or longitudinally polarized beams. We discuss the set-up and the results for the differential cross section and the asymmetries with respect to the CP-odd observables with transverse polarization, at the future $e^+e^-$ collider with center-of-mass energy 250 GeV.

**Primary authors:** LI, Cheng (FTX (FTX Fachgruppe SLB)); MOORTGAT-PICK, Gudrid (University of Hamburg / DESY)

**Presenter:** LI, Cheng (FTX (FTX Fachgruppe SLB))

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **55** Type: **Parallel session talk**

# Prospects of $B_c^+ and B^+ \to \tau\nu$ decays at FCC-ee

*Wednesday, 5 October 2022 15:15 (25 minutes)*

The Z-pole operation at FCC-ee presents an unprecedented opportunity for heavy flavor physics, as the production of $5\times10^{12}$ Z bosons will result in about $8\times10^{11}$ b-quark pairs. Among all species of B hadrons produced at FCC-ee, the purely leptonic decays of the $B_c^+$ and $B^+$ mesons are clean experimental probes to measure the off-diagonal CKM elements $|V_cb|$ and $|V_ub|$, and are highly sensitive to test BSM models such as charged Higgs bosons and leptoquarks. A complete feasibility study of the $B_C^+$ to $\tau^+\nu_\tau$ measurement at FCC-ee is performed and its phenomenological impact on various new physics scenarios is explored. Recent developments have also been made in the measurement of the $B^+$ to $\tau^+\nu_\tau$ decay, demonstrating the feasibility of this measurement with a precision comparable to that of $B_c^+$. This set of work also showcases the FCC-ee analysis workflow fully based on common software tools from EDM4hep through to final analysis.

**Presenter:** ZUO, Xunwu (Karlsruhe Institute of Technology)

**Session Classification:** WG 1 - FLAV

**Track Classification:** WG1-FLAV - Physics Potential: Heavy flavours

Contribution ID: **56** Type: **Parallel session talk**

# Probing new U(1) gauge symmetries via exotic Z⟶Z′γ decays

*Thursday, 6 October 2022 17:05 (15 minutes)*

New U(1) gauge theories involving Standard Model (SM) fermions typically require additional electroweak fermions for anomaly cancellation. We study the non-decoupling properties of these new fermions, called anomalons, in the Z–Z′–γ vertex function, reviewing the connection between the full model and the effective Wess-Zumino operator. We calculate the exotic Z⟶Z′γ decay width in U(1)B–L and U(1)B models, where B and L denote the SM baryon and lepton number symmetries. For U(1)B–L gauge symmetry, each generation of SM fermions is anomaly free and the exotic Z⟶Z′BLγ decay width is entirely induced by intragenerational mass splittings. In contrast, for U(1)B gauge symmetry, the existence of two distinct sources of chiral symmetry breaking enables a heavy, anomaly-free set of fermions to have an irreducible contribution to the Z⟶Z′Bγ decay width. We show that the current LEP limits on the exotic Z⟶Z′Bγ decay are weaker than previously estimated, and low-mass Z′B dijet resonance searches are currently more constraining. We present a summary of the current collider bounds on U(1)B and a projection for a TeraZ factory on the Z⟶Z′Bγ exotic decay, and emphasize how the Z⟶Z′γ decay is emblematic of new anomalous U(1) gauge symmetries.

**Primary author:** YU, Felix (JGU Mainz)

**Presenter:** YU, Felix (JGU Mainz)

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **57** Type: **Poster**

# Kinematic Fitting at future e+e- Higgs Factories

*Thursday, 6 October 2022 17:30 (2 hours)*

The well-known initial state of e+e- colliders can be exploited in physics analyses by fits of the measured quantities to kinematic constraints, called kinematic fitting. Compared to LEP, though, the detector precision increased dramatically, while initial-state radiation and beamstrahlung make the initial-state somewhat less well known, making new developments mandatory. This contribution will present recent developments in MarlinKinfit, which are ready to be provided also via Key4HEP. This includes the treatment of photon radiation, improved minimisation engines, so-called “soft” constraints as well as the usage of sophisticated covariance matrix estimates for the measured quantities, thereby exploiting the high-granularity of particle flow detectors.

**Primary author:** LIST, Jenny (FTX (FTX-SLB))

**Presenter:** LIST, Jenny (FTX (FTX-SLB))

**Session Classification:** Poster Session

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **59** Type: **Parallel session talk**

# Three-loop massive form factors

*Thursday, 6 October 2022 16:18 (15 minutes)*

In this talk three-loop QCD corrections to heavy quark form factors are presented. They constitute the virtual corrections for various processes as, e.g., top quark production in $e^+e^-$ annihilation or Higgs decay into heavy quarks. A semi-numerical method is discussed, which is based on expansions around singular and regular kinematical points. They are matched at intermediate values of the squared partonic center-of-mass energy $s$ which allows to cover the whole kinematic range. The method permits a systematic increase of the precision by varying the expansion depth and the choice of the intermediate matching points. Results are presented for various choices of external currents.

**Primary author:** STEINHAUSER, Matthias (KIT)

**Presenter:** STEINHAUSER, Matthias (KIT)

**Session Classification:** WG 1 - Precision

**Track Classification:** WG1-PREC - Physics Potential: Precision

Contribution ID: **60** Type: **Poster**

# New physics searches with the ILD detector at the ILC

*Thursday, 6 October 2022 17:30 (2 hours)*

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 poster gives an overview of recent ILD studies on new particle searches at the ILC. 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.

**Primary authors:** BERGGREN, Carl Mikael (FLC (FTX Fachgruppe SLB)); KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern))

**Presenter:** BERGGREN, Carl Mikael (FLC (FTX Fachgruppe SLB))

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE+SRCH - Physics Potential: Higgs, top and EW joint with FIP and direct searches

Contribution ID: **61** Type: **not specified**

# The Software Eco-System

*Thursday, 6 October 2022 09:00 (22 minutes)*

**Presenter:** MADLENER, Thomas (FLC (FTX Fachgruppe SFT))

**Session Classification:** Plenary

Contribution ID: **62** Type: **not specified**

# Generators: Back to the Future

*Thursday, 6 October 2022 09:22 (22 minutes)*

**Presenter:** SIODMOK, Andrzej Konrad (Jagiellonian University)

**Session Classification:** Plenary

Contribution ID: **63** Type: **not specified**

# Simulation: Going Fast, Full and Fully Fast

*Thursday, 6 October 2022 09:44 (22 minutes)*

**Presenter:** SAILER, Andre (CERN)

**Session Classification:** Plenary

Contribution ID: **64** Type: **not specified**

# Reconstruction: Imaging the Events

*Thursday, 6 October 2022 10:06 (22 minutes)*

**Presenter:** BRONDOLIN, Erica (CERN)

**Session Classification:** Plenary

Contribution ID: **65** Type: **not specified**

# ECFA Detector Roadmap and Implementation Plan

*Thursday, 6 October 2022 11:15 (30 minutes)*

**Presenter:** SEFKOW, Felix (DESY)

**Session Classification:** Plenary

Contribution ID: **66** Type: **not specified**

# Tracking and Vertexing for Higgs Factories

*Thursday, 6 October 2022 11:45 (30 minutes)*

**Presenter:** DANNHEIM, Dominik (CERN)

**Session Classification:** Plenary

Contribution ID: **67** Type: **not specified**

# Calorimetry and Particle ID for Higgs Factories

*Thursday, 6 October 2022 12:15 (30 minutes)*

**Presenter:** KRUEGER, Katja (DESY (FTX Fachgruppe DTA))

**Session Classification:** Plenary

Contribution ID: **68** Type: **not specified**

# Summary on Generators

*Friday, 7 October 2022 09:00 (25 minutes)*

**Presenter:** PRICE, Alan (University of Siegen)

**Session Classification:** Plenary

Contribution ID: **69** Type: **not specified**

# Summary on Simulation & Reconstruction

*Friday, 7 October 2022 09:25 (20 minutes)*

**Presenter:** EINHAUS, Ulrich (FTX (Fachgruppe SLB))

**Session Classification:** Plenary

Contribution ID: **70** Type: **not specified**

# Plans for WG2

*Friday, 7 October 2022 09:45 (9 minutes)*

**Presenter:** AZZI, Patrizia (INFN)

**Session Classification:** Plenary

Contribution ID: **71** Type: **not specified**

# WG3 - Highlights and plans on tracking and PID

*Friday, 7 October 2022 09:54 (18 minutes)*

**Presenter:** MARCHIORI, Giovanni (APC Paris - CNRS/IN2P3 and Université de Paris)

**Session Classification:** Plenary

Contribution ID: **72** Type: **not specified**

# WG3 - Highlights and plans on calorimetry

*Friday, 7 October 2022 10:12 (18 minutes)*

**Presenters:** FOUZ, Mary-Cruz (CIEMAT); FOUZ IGLESIAS, Mary-Cruz (CIEMAT)

**Session Classification:** Plenary

Contribution ID: **73** Type: **not specified**

# Highlights & Plans WG1-FLAV

**Session Classification:** Plenary

Contribution ID: **74** Type: **not specified**

# Highlights & Plans WG1-HTE

**Session Classification:** Plenary

Contribution ID: **75** Type: **Parallel session talk**

# Noble Liquid Calorimetry for an FCC-ee Experiment

*Thursday, 6 October 2022 17:12 (18 minutes)*

Noble liquid calorimetry is a well proven technology that successfully operated in numerous particle physics detectors (D0, H1, NA48, NA62, ATLAS, ⋯). Its excellent energy resolution, linearity, stability, uniformity and radiation hardness as well as good timing properties make it a very good candidate for future hadron and lepton colliders. Recently, a highly granular noble liquid sampling calorimeter was proposed for a possible FCC-hh experiment. It has been shown that, on top of its intrinsic excellent electromagnetic energy resolution, noble liquid calorimetry can be optimized in terms of granularity to allow for 4D imaging, machine learning and - in combination with the tracker measurements - particle-flow reconstruction. This talk will discuss the ongoing R&D to adapt noble liquid sampling calorimetry for an electromagnetic calorimeter of an FCC-ee experiment with a focus on signal extraction, noise mitigation and cryostat material budget. In addition to that, performance studies realized with the FCCSW full simulation framework and first electrical tests of a readout electrode prototype will be presented.

**Primary author:** FRANCOIS, Brieuc (CERN)

**Presenter:** FRANCOIS, Brieuc (CERN)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **77** Type: **Poster**

# Higgs Self Couplings Measurements at Future proton-proton Colliders

*Thursday, 6 October 2022 17:30 (2 hours)*

The Higgs boson trilinear and quartic self-couplings are directly related to the shape of the Higgs potential; measuring them with precision is extremely important, as they provide invaluable information on the electroweak symmetry breaking and the electroweak phase transition.
\\In this paper, we perform a detailed analysis of double Higgs boson production, through the gluon-gluon fusion process, in the most promising decay channels $b\bar{b}\gamma\gamma$, $b\bar{b}\tau\tau$, and $b\bar{b}b\bar{b}$ for several future colliders: the HL-LHC at 14 TeV and the FCC-hh at 100 TeV, assuming respectively 3 $ab^{-1}$ and 30 $ab^{-1}$ of integrated luminosity.\\
In the HL-LHC scenario, we expect an upper limit on the di-Higgs cross section production of 0.76 at 95\% confidence level, corresponding to a significance of 2.8 $\sigma$.
In the FCC-hh scenario, depending on the assumed detector performance and systematic uncertainties, we expect that the Higgs self-coupling will be measured with a precision in the range 4.8-8.5\% at 95\% confidence level.\\

**Primary author:** CAPUTO, Claudio (UCLouvain)

**Co-authors:** TALIERCIO, Angela (Northwestern); VISCHIA, Pietro (UCLouvain); MASTRAPASQUA, Paola (UCLouvain); DE FILIPPIS, Nicola (Politecnico and INFN, Bari (Italy)); BHAT, Pushpa (Fermilab)

**Presenter:** MASTRAPASQUA, Paola (UCLouvain)

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **78** Type: **Parallel session talk**

# Light mediator searches with mono-photon signature

*Thursday, 6 October 2022 16:35 (15 minutes)*

With mono-photon signature, high energy $e^+e^-$ colliders offer unique possibility to look for processes with fully invisible final state, pair-production of dark matter particles in particular. Most studies in the past focused on scenarios assuming heavy mediator exchange. However, scenarios with light mediator exchange are still not excluded by existing experimental data, if the mediator coupling to Standard Model particles is very small. Results on the expected sensitivity of the 500 GeV ILC and the 3 TeV CLIC to scenarios with both heavy and light mediator exchange were presented recently based on a novel approach, where the experimental sensitivity is defined in terms of the mediator mass, width and
coupling to the electrons.Included in this contributions are new results on the sensitivity of the 250 GeV Higgs Factory to dark matter pair-production via light mediator exchange.

**Primary authors:** KALINOWSKI, Jan (University of Warsaw); KOTLARSKI, Wojciech (TU Dresden); MEKALA, Krzysztof (University of Warsaw); ZARNECKI, Aleksander Filip (Faculty of Physics, University of Warsaw); Mr ZEMBACZYNSKI, Kamil (University of Warsaw)

**Presenter:** ZARNECKI, Aleksander Filip (Faculty of Physics, University of Warsaw)

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **79** Type: **Parallel session talk**

# High spatial resolution pad and pixelated TPC technology R&D for the e+e- collider

*Wednesday, 5 October 2022 14:36 (18 minutes)*

Time Projection Chamber (TPC) could be used as a central high spatial resolution tracking detector at future electron-positron colliders such as ILC, CEPC or FCC-ee. A large worldwide community of physicists is working to realize EWK precision physics program at the future e+e- Higgs Factory. In the ILD detector concept, a large volume TPC is embedded in a magnetic field of B=3.5T, the requirements for the TPC are a continuous tracking with very high efficiency and a single hit resolution of better than 100μm in the transverse direction. The TPC performance of the spatial resolution and dE/dx have been measured using three different readout modules (GEMs, Resistive Micromegas and GridPix) in a magnetic field of B=1.0T at DESY. In the conventional readout the pad size is ~1mmx6mm and in the pixelated readout it is about 55μmx55μm. During Tera-Z operation at the high luminosity, the pixelated readout can reach better spatial resolutions with higher detection efficiency. To improve the particle identification using dE/dx and dN/dx, the cluster counting method shows significant potential, but a high readout granularity is needed. In this talk, we will present the updated results and plans of TPC technology potential extending to other e+e- colliders.

**Primary authors:** Dr QI, Huirong (Institute of High Energy Physics, CAS); Mrs CHANG, Yue (Insitute of High Energy Physics, CAS)

**Co-authors:** TITOV, Maxim (CEA Saclay, Irfu); KAMINSKI, Jochen (University of Bonn); Prof. SUGIYAMA, Akira (Saga University); ON BEHALF OF LCTPC INTERNATIONAL COLLABORATION GROUP

**Presenter:** Dr QI, Huirong (Institute of High Energy Physics, CAS)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **80** Type: **Parallel session talk**

# Toward a vertex detector suited to a future Higgs factory based on CMOS pixel sensors

*Wednesday, 5 October 2022 14:00 (18 minutes)*

Small electrode CMOS Pixel Sensors (CPS) developed at IPHC-Strasbourg provide one the most promising approaches for vertexing and tracking devices suited to a Higgs Factory. Two different R&D CMOS processes are currently pursued based on 180 (mature) and 65 (recent) nm feature sizes respectively.

The 180 nm process is used to develop the MIMOSIS sensor for the MicroVertex Detector (MVD) of the CBM experiment at FAIR/GSI. It features in particular 5 µm and 5 µs spatial and time resolutions, while being adapted to hit densities near 100 MHz/cm² translating into 2 Bpbs output flow. The first full scale prototype of MIMOSIS, composed of 500,000 pixels, was fabricated with two variants of in-pixel circuitry and
several different doping profile of their epitaxial layer.

In parallel, the 65 nm technology of TPSCo with pixel pitch of 15 and 25 µm respectively is being explored to achieve smaller pixels adapted to in-pixel low power and signal processing functionalities.

Beam test results for both 180 and 65 nm will be presented and complemented by prominent aspects of the next step of the prototyping, in particular multi-reticle sensors exploiting the stitching technique as well as bending technique in partnership with the ALICE-ITS3 groups.

**Primary authors:** Dr BESSON, Auguste (IPHC/Unistra); Dr EL BITAR, Ziad

**Presenter:** Dr EL BITAR, Ziad

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **81** Type: **Parallel session talk**

# Prospects for the measurement of top-quark couplings

*Wednesday, 5 October 2022 14:00 (14 minutes)*

In this work the prospects for measurements of the top-quark couplings at future colliders are presented. Projections are presented for the high luminosity phase of the Large Hadron Collider and a future Higgs/electroweak/top factory electron-positron collider. Results are presented for the expected bounds on Wilson coefficients of the relevant SMEFT operators from a global fit to the top-quark physics sector.

**Primary author:** Dr MIRALLES, Victor (INFN Roma1)

**Co-authors:** DURIEUX, Gauthier (CERN); GUTIÉRREZ CAMACHO, Abel (IFIC); MANTANI, Luca; MIRALLES LOPEZ, Marcos (IFIC (CSIC-UV)); MORENO LLÁCER, María (IFIC, (CSIC - Univ. of Valencia)); PONCELET, René; VRYONIDOU, Eleni; VOS, Marcel (IFIC (UVEG/CSIC) Valencia)

**Presenter:** Dr MIRALLES, Victor (INFN Roma1)

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **82** Type: **Parallel session talk**

# From strange to top: activities of the Top/QCD/HF physics group of ILD

*Thursday, 6 October 2022 15:15 (25 minutes)*

The process ee->qq with qq=ss,cc,bb,tt plays a central role in the physics programs of high energy electron-positron colliders operating from the O(100GeV) to O(1TeV) center of mass energies. Furthermore, polarised beams as available at the International Linear Collider (ILC) are an essential input for the complete measurement of the helicity amplitudes that govern the production cross section. Quarks, specially the heaviers, are likely messengers to new physics and at the same time they are ideal benchmark processes for detector optimisation. All four processes call for superb primary and secondary vertex measurements, a high tracking efficiency to correctly measure the vertex charge and excellent hadron identification capabilities. Strange, charm and bottom production are already available below the ttbar threshold.
This contribution will cover the most relevant and latest activities of the ILD concept group on physics studies related to heavy quarks, using detailed simulation and realistic analysis tools to determine the full potential of ILC on this area. Some of the topics to be discussed will be the top-quark mass measurements, top and less heavy quarks electroweak couplings or BSM searches at ILC with the ILD.

**Primary authors:** IRLES, Adrian (IFIC CSIC/UV); KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern)); POESCHL, Roman (LAL Orsay)

**Presenter:** IRLES, Adrian (IFIC CSIC/UV)

**Session Classification:** WG 1 - FLAV

**Track Classification:** WG1-FLAV - Physics Potential: Heavy flavours

Contribution ID: **83** Type: **Parallel session talk**

# Simulation of selected top-quark processes at FCC-ee and their interpretation in terms of effective field theories

*Thursday, 6 October 2022 14:50 (25 minutes)*

Experiments at future circular colliders such as the FCC-ee are expected to improve electroweak and top-quark physics in an unrivaled way. This talk gives an overview on the sensitivity of selected top-quark pair production observables taking into account dimension-six extensions of the Standard Model and following an optimal-observable analysis. Relevant observables and their parameterizations as function of the dimension-six operator strength are given.

Carrying out these generator-level studies to reconstructed objects in the FCC-ee environment requires for an adequate event selection and definition of the relevant objects of the process under study. Here, the semileptonic and dileptonic decay channels of $t\bar{t}$ production are taken into account and recently improved methods for missing momentum component entanglement at lepton colliders are presented on reconstructed events.

**Primary author:** ROEHRIG, Lars

**Co-authors:** Prof. KRÖNINGER, Kevin; Dr MADAR, Romain; Prof. MONTEIL, Stéphane

**Presenter:** ROEHRIG, Lars

**Session Classification:** WG 1 - FLAV

**Track Classification:** WG1-FLAV - Physics Potential: Heavy flavours

Contribution ID: **84** Type: **Parallel session talk**

# Event shapes and jet substructure at past and future lepton colliders

*Thursday, 6 October 2022 16:36 (15 minutes)*

Jet substructure is an important tool in analyses at the currently running LHC experiments. These observables, and likewise related event shapes, can be expected to play an important role at future colliders, both in the study of QCD effects as well as in the tagging of jet properties to identify signal enhanced phase space regions in various analyses. In this talk I will present examples for such applications, using resummed results for event shapes and jet substructure at $e^+e^-$ colliders. These predictions are obtained using the Sherpa event generator framework, both for Monte Carlo simulations as well as in conjunction with analytic resummation in the CAESAR framework.

**Primary author:** REICHELT, Daniel (Durham University, IPPP)

**Presenter:** REICHELT, Daniel (Durham University, IPPP)

**Session Classification:** WG 1 - Precision

**Track Classification:** WG1-PREC - Physics Potential: Precision

Contribution ID: **85** Type: **Poster**

# Search for non-Standard Model interactions of the top quark at ILC

*Thursday, 6 October 2022 17:30 (2 hours)*

Top quarks and in general heavy quarks are likely messengers to new physics. The scrutiny of these particles properties must be completed by the measurement of electroweak qqbar production at high energies, in particular for the top-quark. The International Linear Collider will offer favorable low-background environment of e+e- annihilation combined with a high-energy reach.
This talk will review the opportunities for precision measurements of the top and heavy quarks properties at the International Linear Collider, including the search for BSM contributions and CP violation in the top sector.

**Primary author:** IRLES, Adrian (IFIC CSIC/UV)

**Presenter:** IRLES, Adrian (IFIC CSIC/UV)

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **86** Type: **Parallel session talk**

# Photo-production at NLO QCD

*Thursday, 6 October 2022 17:12 (15 minutes)*

Photo-production is a non-negligible contribution to cross-sections at lepton—proton and lepton—lepton colliders, amounting to in fact over half of the QCD cross section. In this talk I will discuss the framework in the Sherpa event generator that allows the calculations of both unresolved and resolved photon contributions. I will show comparisons of simulated events at MC@NLO accuracy with data from the LEP and HERA experiments. I will present results for different sensitive observables for a future e+e- collider, motivating further investigations of the hadronic structure of the photon. Finally, I will discuss how these simulations will help in understanding the QCD background as well as the underlying event and allow for more tests of QCD at future lepton colliders.

**Primary author:** Mr MEINZINGER, Peter (IPPP, Durham Uni)

**Presenter:** Mr MEINZINGER, Peter (IPPP, Durham Uni)

**Session Classification:** WG 1 - Precision

**Track Classification:** WG1-PREC - Physics Potential: Precision

Contribution ID: **87** Type: **Parallel session talk**

# Measuring the Higgs Trilinear Self-Coupling at the FCC-ee

The determination of the Higgs self-couplings are of primary importance in particle physics and cosmology. Here we will report on our investigation of the measurement of the Standard Model Higgs trilinear self-coupling parameter at the FCC-ee using single Higgs production channels, via its production cross section. We have introduced several Higgs boson production channels at $\sqrt{s} = 240, 365$ GeV, used improved Monte Carlo samples and a new orthogonal categorization of events. We used inclusive Higgsstrahlung (leptonic and hadronic) and exclusive vector boson fusion channels in a combined analysis to extract the sensitivity on the respective cross sections as well as on the trilinear self-coupling. We show that the signal strength modifiers used to estimate the precision on the Higgsstrahlung and vector boson fusion production cross sections could be measured with sub-percent and percent precision at the FCC-ee under the assumption that the decay of the Higgs boson follows the Standard Model expectation. In a similar manner, we extracted the Higgs boson trilinear self-coupling $\kappa_\lambda$ using one-loop corrections to the leading order Feynman diagrams of Higgsstrahlung and vector boson fusion. Results are obtained assuming all couplings except for $\kappa_\lambda$ are set to the Standard Model values.

**Primary authors:** Mr HARRINGER, Nico (CNRS/IN2P3 - LLR, École polytechnique); Dr SALERNO, Roberto Salerno (CNRS/IN2P3 - LLR, École polytechnique); LEMMON, Roy (Daresbury Laboratory (GB)); Dr SASIKUMAR, Swathi (Max-Planck-Institute for Physics)

**Presenter:** Dr SASIKUMAR, Swathi (Max-Planck-Institute for Physics)

**Session Classification:** WG1: joined HTE & GLOB session

**Track Classification:** WG1-HTE+GLOB - Physics Potential: Higgs, top and EW joint with Global Interpretations

Contribution ID: **88** Type: **Parallel session talk**

# High level reconstruction for Higgs factories

*Thursday, 6 October 2022 14:15 (15 minutes)*

LCFIPlus, a combined package for vertex finding, jet clustering and flavor tagging is a software package used as a standard tool for the jet analysis of linear colliders since 2012. As the author is one of the original developers, the overview of the software and performance on the ILD is presented. The recent development in our group, yet not finished, to improve the performance of vertex finding, flavor tagging and particle flow for Higgs factories using DNN techniques are also reviewed.

**Primary author:** SUEHARA, Taikan (Kyushu University)

**Presenter:** SUEHARA, Taikan (Kyushu University)

**Session Classification:** WG 2: Physics Analysis Methods

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **89** Type: **Poster**

# An overview of the International Large Detector (ILD) for a future electron-positron collider

*Thursday, 6 October 2022 17:30 (2 hours)*

The International Large Detector (ILD) is a detector designed primarily for the International Linear Collider (ILC), a high-luminosity linear electron-positron collider with an initial center-of-mass energy of 250 GeV, extendable to 1 TeV.
The ILD concept is based on particle flow for overall event reconstruction, which requests outstanding detector capabilities including superb tracking, very precise detection of secondary vertices and high-granularity calorimetry. In the past years the design has focused on building subdetector technological prototypes scalable to the full ILD size, studying their integration into a coherent detector, benchmarking the ILD performance and preparing for an optimization of the overall ILD size and costing. The current status has been made public in an ILD Interim Design Report (IDR, 2020) of interest for any future e+e–collider detector. The poster will summarize the main IDR results.
Recently, the ILD group has been considering widening its activities to explore synergies with studies at other Higgs factories. A new strategy of the ILD group currently under discussion may also be presented.

**Primary author:** KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern))

**Presenter:** BEHNKE, Ties (DESY)

**Session Classification:** Poster Session

**Track Classification:** WG3 - Detector R&D

Contribution ID: **90** Type: **Poster**

# The International Large Detector: Tracking system

*Thursday, 6 October 2022 17:30 (2 hours)*

The International Large Detector (ILD) is a detector designed primarily for the International Linear Collider (ILC), a high-luminosity linear electron-positron collider with an initial center-of-mass energy of 250 GeV, extendable to 1 TeV. This poster will present the current design of its tracking system; a precision vertex detector positioned very close to the interaction point is followed by a hybrid tracking layout, realized as a combination of silicon tracking with a time projection chamber. Open options and critical aspects, as well as prospects for enhanced capabilities in the future will also be presented.

**Primary author:** KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern))

**Presenters:** TITOV, Maxim (CEA Saclay, Irfu); COLAS, Paul (CEA Saclay, IRFU)

**Session Classification:** Poster Session

**Track Classification:** WG3 - Detector R&D

Contribution ID: **91** Type: **Poster**

# The International Large Detector: Calorimeter system

*Thursday, 6 October 2022 17:30 (2 hours)*

The International Large Detector (ILD) is a detector designed primarily for the International Linear Collider (ILC), a high-luminosity linear electron-positron collider with an initial center-of-mass energy of 250 GeV, extendable to 1 TeV. This poster will present the current design of its calorimeter system; a highly granular calorimeter in an overall design philosophy called particle flow, developed for optimal global event reconstruction. Open options and critical aspects, as well as prospects for enhanced capabilities in the future will also be presented.

**Primary author:** KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern))

**Presenter:** JEANS, Daniel (KEK)

**Session Classification:** Poster Session

**Track Classification:** WG3 - Detector R&D

Contribution ID: **92** Type: **Poster**

# Very forward calorimeters at ILC/ILD

*Thursday, 6 October 2022 17:30 (2 hours)*

Detectors at future e+e- colliders need special calorimeters in the very forward region for a fast estimate of instantaneous and precise measurement of the integrated luminosity. In ILD detector concept, two such calorimeters are foreseen, LumiCal and BeamCal. Both are designed as sandwich calorimeters with very thin sensor planes to keep the Molière radius small, facilitating measurement of the high-energy electron showers. Silicon sensor prototypes and dedicated FE ASICs have been developed and produced matching the timing and dynamic range requirements. The status of the calorimeter prototype performance in the recent beam tests at DESY will be presented, against the expected performance obtained from simulation.

**Primary authors:** BOZOVIC JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade (RS)); KAWAGOE, Kiyotomo (FLC (Forschung an Lepton Collidern))

**Presenter:** BOZOVIC JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade (RS))

**Session Classification:** Poster Session

**Track Classification:** WG3 - Detector R&D

Contribution ID: **93** Type: **Poster**

# Measurement of the Higgs to diphoton branching fraction at 3 TeV CLIC

Here we address the results of a full simulation of experimental measurement of the Standard Model Higgs boson decaying to a pair of photons at 3 TeV center-of-mass energy at the Compact Linear Collider (CLIC). Since photons do not couple to Higgs boson at a tree level, any deviation of the Higgs to photons coupling may indicate a New Physics. We show that the product of the Higgs production cross-section in W+W− fusion and BR (H → γγ) as the observable for determination of the Higgs to photons coupling, can be measured with a relative statistical precision of 5.5%, assuming the integrated luminosity of 5 ab−1 and unpolarized beams.

**Primary author:** Ms VUKASINOVIC, Natasa (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Co-authors:** Dr BOZOVIC-JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade); Mr KACAREVIC, Goran (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Presenter:** Mr KACAREVIC, Goran (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Session Classification:** WG 1 - Higgs/ Top/ EW

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **94** Type: **Parallel session talk**

# Parton showers from old to new paradigms

*Thursday, 6 October 2022 16:54 (15 minutes)*

I will present recent developments on accurate (QCD) parton showers at the NLL level and I will outline new approaches based on amplitude level evolution which have led to improved algorithms, links to hadronization models, and touch further aspects such as electroweak evolution.

**Primary author:** PLATZER, Simon (University of Graz)

**Presenter:** PLATZER, Simon (University of Graz)

**Session Classification:** WG 1 - Precision

**Track Classification:** WG1-PREC - Physics Potential: Precision

Contribution ID: **95** Type: **Parallel session talk**

# ARC - a novel RICH detector for a future e+e- collider

*Thursday, 6 October 2022 16:00 (18 minutes)*

Particle identification is a highly desirable attribute of an experiment at a future e+e- collider. For example, high luminosity operation at the Z pole will provide opportunities for precise flavour-physics measurements, for which hadron identification is mandatory. The ability to tag the quark flavour of jets, for instance from Higgs decays, will also be greatly enhanced by high quality hadron identification. The Aerogel RICH Cellular (ARC) detector is a novel RICH system consisting of a dual aerogel-gas radiator system that would provide hadron identification over the required momentum range. Crucially, the ARC is a compact and low-mass detector that can be conveniently integrated into the layout of many of the experiment designs that are being considered for FCC-ee and the ILC. The current status of the ARC design will be presented, and its expected physics performance will be discussed.

**Primary authors:** WILKINSON, Guy (University of Oxford (GB)); TAT, Martin (University of Oxford); FORTY, Roger (CERN)

**Presenter:** TAT, Martin (University of Oxford)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **96** Type: **Poster**

# Studies of di-Higgs production at the FCC-hh in the bbZZ(llvv) final state

*Thursday, 6 October 2022 17:30 (2 hours)*

The FCC-hh is a proposed circular hadron collider at an energy of 100 TeV. The total integrated luminosity is expected to be around 30 $ab^{-1}$. With such a large dataset, 400 times more double-Higgs events are expected than with the full HL-LHC dataset, allowing to measure the Higgs self-coupling with high precision. As a consequence, also rarer final states, which are not within reach of the (HL)-LHC, have good prospects at the FCC-hh. One such final state is the bbZZ(ll$\nu\nu$) channel, which has only an Branching Ratio of 0.12\%. With a regular cut-based analysis the potential of this channel is very limited.
This study implements a multivariate analysis using neural networks to see if it is a feasible channel that can be used to help to improve the Higgs self-coupling measurement.
Upper limits on the di-Higgs production cross-section are derived in order to assess the potential of this channel.

**Primary author:** LAUDAMUS, Kevin (CMS (CMS Fachgruppe HIGGS))

**Co-authors:** STAPF, Birgit (ATLAS (ATLAS Higgs Physics)); GALLO-VOSS, Elisabetta (CMS (CMS-Experiment)); TACKMANN, Kerstin (BELLE (BELLE Gruppe))

**Presenter:** LAUDAMUS, Kevin (CMS (CMS Fachgruppe HIGGS))

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **97** Type: **Parallel session talk**

# Long-Lived Particles at the FCC-ee

*Wednesday, 5 October 2022 14:00 (20 minutes)*

Many physics problems such as neutrino masses and the nature of dark matter predict particles with long lifetimes as an important possibility in the search for new phenomena. When produced at colliders, these long-lived particles (LLPs) have a distinct experimental signature: they can decay far from the collision point, or even completely pass through a detector before decaying. Since most of the trigger and reconstruction algorithms are optimized for short-lived particles, searches for LLPs can be challenging, usually requiring dedicated methods and sometimes also dedicated hardware to spot them. In the context of FCC-ee, crucial physics cases connected to LLPs will collect very high statistics in very clean experimental conditions. In this presentation, I will consider the high luminosity Z run and highlight three interesting physics cases that can produce LLPs at the FCC-ee: Heavy Neutral Leptons, Axion-Like Particles, and exotic Higgs boson decays.

**Primary authors:** ALIMENA, Juliette (CERN); GONZALEZ SUAREZ, Rebeca (Uppsala University (SE)); KULKARNI, Suchita

**Presenter:** ALIMENA, Juliette (CERN)

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **98** Type: **Poster**

# The IDEA detector concept

This talk will describe how the IDEA detector concept can address the main physics requirements for a detector at FCC-ee. The main associated R&D efforts will be reported. Potential improvements with an even thinner solenoid based on MgB2 wires and/or the addition of a crystal EM calorimeter will be discussed.

**Primary authors:** BEDESCHI, Franco (INFN); GIACOMELLI, Paolo (INFN Bologna)

**Track Classification:** WG3 - Detector R&D

Contribution ID: **99** Type: **Parallel session talk**

# Silicon Detector R&D for IDEA

*Wednesday, 5 October 2022 14:18 (18 minutes)*

Current R&D on silicon detectors considered for the IDEA concept is described. In particular recent results from the ARCADIA project and the ATLASpix3 sensors. Additional work on LGADs and vertex detector mechanics will also be described.

**Primary authors:** ANDREAZZA, Attilio (INFN Sezione di Milano); BEDESCHI, Franco (INFN)

**Presenter:** NEUBUSER, Coralie (TIFPA-INFN, Trento)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **102** Type: **Parallel session talk**

# Dual Readout fiber calorimeter and crystal EM calorimeter for the IDEA detector

*Thursday, 6 October 2022 16:54 (18 minutes)*

The status of the current R&D on an optical fiber based Dual Readout calorimeter will be discussed, including results from test beams at DESY and CERN. Plans for the construction of a new prototype with full containment of the hadronic shower will be shown.
A crystal EM calorimeter addition to the IDEA detector is also discussed, including both simulated performance improvements and future planned R&D.

**Primary authors:** BEDESCHI, Franco (INFN); LUCCHINI, Marco Toliman (Università & INFN, Milano-Bicocca (IT)); FERRARI, Roberto (INFN); Dr GAUDIO, Gabriella (INFN); Prof. SANTORO, Romualdo (Universita' dell'Insubria); VIVARELLI, Iacopo (Sussex University)

**Presenter:** VIVARELLI, Iacopo (Sussex University)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **103** Type: **Parallel session talk**

# R&D on a drift chamber with cluster counting and on micro-rWell chambers for the IDEA detector

*Wednesday, 5 October 2022 14:54 (18 minutes)*

The drift chamber proposed for the IDEA detector concept and the associated R&D in progress will be described. In particular current work on the cluster counting technique will be reported, including results from recent test beams at CERN.

The muon system for the IDEA detector is discussed. In particular current and future R&D on chambers based on the micro-rWell techique are described, including recent test beam results.

**Primary authors:** Dr GIANNI, Bencivenni (INFN); BEDESCHI, Franco (INFN); GIACOMELLI, Paolo (INFN Bologna); DE FILIPPIS, Nicola (Politecnico and INFN Bari); Dr GRANCAGNOLO, Franco (INFN)

**Presenter:** DE FILIPPIS, Nicola (Politecnico and INFN Bari)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **104** Type: **Parallel session talk**

# A Particle Identification Framework for Future Higgs Factories

*Thursday, 6 October 2022 15:00 (15 minutes)*

The particle physics community has concluded that the next collider should be a Higgs factory with the ability to also produce a large number of W and Z bosons. In the ongoing discussions it has become increasingly clear that particle identification including charged hadron ID is a key feature that enables a number of analyses and improves many. A number of different PID systems - from the simple muon ID to gaseous dE/dx and dN/dx to calorimeter shower shapes and time of flight (and more) - are being envisioned for the proposed FHF detector concepts. It is desirable to assess their impact and the effect of combining them in a common tool to enable fair comparisons.

This talk presents a new modular approach to a generic PID framework for the different possible FHFs. It discusses implementation questions, performance measures and possible physics applications, exampling the International Large Detector (ILD) concept for the International Linear Collider (ILC).

**Primary author:** EINHAUS, Ulrich (FTX (Fachgruppe SLB))

**Presenter:** EINHAUS, Ulrich (FTX (Fachgruppe SLB))

**Session Classification:** WG 2: Physics Analysis Methods

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **106** Type: **Parallel session talk**

# Physics potential for $\sigma$xBR(H $\rightarrow$ ZZ$^*$) measurement at CLIC

*Thursday, 6 October 2022 14:33 (15 minutes)*

CLIC is a linear $e^+e^-$ collider designed to reach center-of-mass energies ranging from 350 GeV, 1.4 TeV up to 3 TeV. Individual measurements of Higgs couplings in various Higgs production and decay channels are subject of a global fit in order to achieve the ultimate statistical precision of the cumulative CLIC data. In this talk we discuss the $\sigma$xBR(H $\rightarrow$ ZZ$^*$) measurement at all CLIC energy stages, in a full simulation of detector and experimental conditions.

**Primary author:** Ms VUKASINOVIC, Natasa (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Co-authors:** Dr BOZOVIC-JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade); Dr MILUTINOVIC-DUMBELOVIC, Gordana (VINCA Institute of Nuclear Sciences, University of Belgrade); Dr KACAREVIC, Goran (VINCA Institute of Nuclear Sciences, University of Belgrade); Dr RADULOVIC, Mirko (Faculty of Science, University of Kragujevac); Dr STEVANOVIC, Jasna (Faculty of Science, University of Kragujevac)

**Presenter:** Ms VUKASINOVIC, Natasa (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Session Classification:** WG 1 - Higgs/ Top/ EW

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak

Contribution ID: **107** Type: **Parallel session talk**

# Implementation of large imaging calorimeters

*Thursday, 6 October 2022 16:18 (18 minutes)*

The next generation of collider detectors will make full use of Particle Flow algorithms, requiring full imaging calorimeters. The latter have been developed during the past 15 years by the CALICE collaboration and are now reaching maturity. The state-of-the-art and the remaining challenges will be presented for all investigated readout types. 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. At the time of conference new results obtained in recent (2021/22) beam tests with a technological prototype of a highly granular silicon tungsten electromagnetic calorimeter standalone and combined with the CALICE analogue hadron calorimeter (SiPM on Tile) will be available. Further, the design of experiments addressing the requirements and potential of imaging calorimetry will be discussed. Promising techniques for dedicated devices inverse APD or segmented crystal calorimeters will also be highlighted. Recently, 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.

Prototypes of electromagnetic and hadronic imaging calorimeters developed 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. 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, in comparison 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. Granular calorimeters are also an ideal testing ground for the application of machine learning techniques. We will outline how these techniques are applied to CALICE data and in the CALICE simulation framework.

**Primary author:** POESCHL, Roman (None)

**Presenters:** POESCHL, Roman (None); POESCHL, Roman (LAL Orsay)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **109** Type: **Poster**

# The Semi-Digital Hadron Calorimeter (SDHCAL) for future Higgs Factories

*Thursday, 6 October 2022 17:30 (2 hours)*

The Semi-Digital Hadron Calorimeter (SDHCAL) is a highly segmented sampling hadronic calorimeter. using large Glass Resistive Plate Chambers (GRPC) as active medium with embedded readout Printed Circuit Board (PCB) hosting 1 $cm^2$ copper pads (read independently) on one side and ASIC readout chips (HARDROC) on the other side.

A technological prototype of ~1m3 developed within the CALICE collaboration have shown excellent results in energy resolution and shower separation. Refined analysis techniques are still being developed. Latest developments address improving spatial uniformity and use of the particle incidence angle in the energy reconstruction.

Experiments at future Higgs Factories can require length-scalable GRPCs (maximum 3 meters). To design such detectors, all aspects had to be rethink : gas distribution, PCB with latest HARDROC chip, DAQ interface board, holding cassette and new way to manufacture and assemble the absorber plates.

A new phase of R&D is focused on exploiting time precision, turning the SDHCAL on a 5D device, leading to better shower reconstruction and better showers separation. Multigap RPC (MRPC) can provide excellent time resolution of 50-100 ps. This requires new readout chips, PETIROC ASIC with its internal TDC, and new PCB. Developments related to the MRPC and the needed electronic are ongoing.

**Primary authors:** Dr GRENIER, Gerald (IP2I, CNRS, Univ Lyon 1 (FR)); Dr FOUZ, Mary-Cruz (CIEMAT); LAKTINEH, imad (IPNL)

**Presenter:** Dr FOUZ, Mary-Cruz (CIEMAT)

**Session Classification:** Poster Session

**Track Classification:** WG3 - Detector R&D

Contribution ID: **110** Type: **Parallel session talk**

# Optimisation of a SIlicon-Tungsten ECAL resolutions for Higgs Factory

*Thursday, 6 October 2022 16:36 (18 minutes)*

Higgs Factories detector will require high precision highly granular ECAL.
The Silicon-Tungsten ECAL is optimised for the particle flow with cell size of 5×5 mm².
We propose here a revisitation of the Silicon-Tungsten ECAL parameters to optimise the energy, timing, position and angle resolutions for given cost (amount of tungsten, number of layers) based on detailed simulations.

**Primary author:** BOUDRY, Vincent (LLR –CNRS, École polytechnique, Institut Polytechnique de Paris)

**Presenter:** BOUDRY, Vincent (LLR –CNRS, École polytechnique, Institut Polytechnique de Paris)

**Session Classification:** WG 3: R&D

**Track Classification:** WG3 - Detector R&D

Contribution ID: **112** Type: **Parallel session talk**

# Higgs Naturalness at a HTE factory

*Thursday, 6 October 2022 16:00 (20 minutes)*

The nature of electroweak symmetry breaking and the Higgs bosons are likely paths to physics beyond the standard model. Neutral naturalness, symmetry based constructions for addressing the electroweak hierarchy problem/puzzle, have garnered increasing interest as LHC bounds on new colored states have increased. These models often predict new electroweak states along with a rich Higgs sector. I provide an overview of ways an HTE factory can explore these scenarios including the direct production of new states and exotic Higgs decays.

**Primary author:** VERHAAREN, Chris (Brigham Young University)

**Presenter:** VERHAAREN, Chris (Brigham Young University)

**Session Classification:** WG 1 - Searches

**Track Classification:** WG1-SRCH - Physics Potential: Feebly interacting particles, direct low mass searches

Contribution ID: **113** Type: **Parallel session talk**

# Electroweak precision (Z/W) measurements at future e+e- colliders

*Wednesday, 5 October 2022 16:30 (25 minutes)*

**Presenter:** BLONDEL, Alain (Universite de Geneve (CH) and CNRS (France))

**Session Classification:** WG 1 - Precision

Contribution ID: **114** Type: **Parallel session talk**

# Top quark threshold and QCD measurements at future e+e- colliders

*Wednesday, 5 October 2022 17:05 (20 minutes)*

**Presenter:** SIMON, Frank (Max-Planck-Institute for Physics)

**Session Classification:** WG 1 - Precision

Contribution ID: **115** Type: **not specified**

# Theory precision calculations for future e+e- colliders: status and prospects

*Wednesday, 5 October 2022 17:35 (20 minutes)*

**Presenter:** REUTER, Juergen (T (Phenomenology))

**Session Classification:** WG 1 - Precision

Contribution ID: **116** Type: **not specified**

# Luminosity Spectra for lepton colliders

*Wednesday, 5 October 2022 16:45 (15 minutes)*

**Presenter:** OHL, Thorsten (Universität Würzburg)

**Session Classification:** WG 2: Physics Analysis Methods

Contribution ID: **117** Type: **not specified**

# TBA

**Session Classification:** WG 2: Physics Analysis Methods

Contribution ID: **118** Type: **not specified**

# QCD for Lepton Colliders

*Wednesday, 5 October 2022 17:00 (20 minutes)*

**Presenter:** REICHELT, Daniel (Durham University, IPPP)

**Session Classification:** WG 2: Physics Analysis Methods

Contribution ID: **119** Type: **not specified**

# QED Status and Benchmarking Event Generators for Lepton Colliders

*Wednesday, 5 October 2022 17:20 (25 minutes)*

**Presenter:** PRICE, Alan (University of Siegen)

**Session Classification:** WG 2: Physics Analysis Methods

Contribution ID: **120** Type: **not specified**

# Progress in DELPHES

*Wednesday, 5 October 2022 17:45 (15 minutes)*

**Presenter:** SELVAGGI, Michele (CERN)

**Session Classification:** WG 2: Physics Analysis Methods

Contribution ID: **121** Type: **not specified**

# Reconstruction with KEY4HEP

*Thursday, 6 October 2022 14:00 (15 minutes)*

**Presenter:** SMIESKO, Juraj

**Session Classification:** WG 2: Physics Analysis Methods

Contribution ID: **122** Type: **not specified**

# PID with Cluster Counting

*Thursday, 6 October 2022 14:30 (15 minutes)*

**Presenter:** DE FILIPPIS, Nicola (Politecnico and INFN Bari)

**Session Classification:** WG 2: Physics Analysis Methods

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **123** Type: **Poster**

# Status of the CALICE AHCAL - a highly granular SiPM-on-tile hadron calorimeter

*Thursday, 6 October 2022 17:30 (2 hours)*

The Analogue Hadron Calorimeter (AHCAL) developed by the CALICE collaboration is a scalable technology for a highly granular hadron sampling calorimeter, made from steel absorber plates and 3*3 cm^2 plastic scintillator tiles individually read out by silicon photomultipliers (SiPMs). The tiles are individually wrapped in ESR reflector foil. The SPIROC2E front-end chips are integrated into the active layers of the calorimeter. They are designed for minimal power consumption by rapidly cycling the power according to the beam structure of a linear electron-positron collider. The AHCAL provides hit times with a resolution of ~1 ns. In 2017 and 2018, a new large prototype with 38 active layers of 72*72 cm^2 size was built. The prototype was assembled using techniques suitable for mass production. The calorimeter was commissioned at DESY and took muon, electron and pion data at the CERN SPS. In 2022, for the first time data were recorded together with the CALICE SiW ECAL technological prototype.

Further AHCAL hardware developments focus on two areas: 1) an alternative readout ASIC (KLauS) that supports continuous readout, needed for a detector at a circular collider, and 2) “Megatiles” as alternative scintillator geometry.

The contribution gives an overview of AHCAL status and ongoing developments.

**Primary authors:** KRUEGER, Katja (DESY (FTX Fachgruppe DTA)); KVASNICKA, Jiri (FTX (FTX Fachgruppe DTA))

**Presenter:** KVASNICKA, Jiri (FTX (FTX Fachgruppe DTA))

**Session Classification:** Poster Session

**Track Classification:** WG3 - Detector R&D

Contribution ID: **124** Type: **not specified**

# Implications of Flavour anomalies for Higgs/EW/top factories

*Wednesday, 5 October 2022 14:00 (25 minutes)*

**Presenters:** SELIMOVIC, Nudzeim (University of Zurich); SELIMOVIC, Nudzeim (University of Zurich)

**Session Classification:** WG 1 - FLAV

Contribution ID: **125** Type: **not specified**

# Prospects for b → s nu nubar at Higgs/EW/top factories

*Wednesday, 5 October 2022 14:50 (25 minutes)*

**Presenter:** WIEDERHOLD, Aidan (University of Warwick)

**Session Classification:** WG 1 - FLAV

Contribution ID: **126** Type: **not specified**

# Lattice QCD progresses and bottlenecks at the dawn of Higgs/EW factory

*Thursday, 6 October 2022 14:00 (25 minutes)*

**Presenter:** JUETTNER, Andreas (CERN/University of Southampton)

**Session Classification:** WG 1 - FLAV

Contribution ID: **127** Type: **not specified**

# Heavy Flavours, CKM, and rare decays measurements: some detector requirements

*Thursday, 6 October 2022 14:25 (25 minutes)*

**Presenter:** MONTEIL, Stephane (Univertité Clermont Auvergne)

**Session Classification:** WG 1 - FLAV

Contribution ID: **128** Type: **Poster**

# Particle Flow reconstruction in IDEA with Pandora

*Thursday, 6 October 2022 17:30 (2 hours)*

The aim of the project is to adopt the Pandora framework to build a Neural Network based algorithm that, from a given collection of energy deposits in the dual readout calorimeter, is able to completely reconstruct a jet in the IDEA detector.

**Primary authors:** FARILLA, Ada (INFN); D'ONOFRIO, Adelina (INFN); DI MICCO , Biagio (Universita' Roma 3); BIGLIETTI, Michela (INFN); DI NARDO, Roberto (Universita' Roma 3)

**Presenter:** AZZI, Patrizia (INFN)

**Session Classification:** Poster Session

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **129** Type: **not specified**

# Prospects for rare B decays and flavour anomalies at Belle-II

*Wednesday, 5 October 2022 14:25 (25 minutes)*

**Presenters:** GLAZOV, Alexander (DESY); GLAZOV, Alexander (BELLE (BELLE II Experiment))

**Session Classification:** WG 1 - FLAV

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **130** Type: **Poster**

# IDEA Detector in DD4HEP

*Thursday, 6 October 2022 17:30 (2 hours)*

Implementation of the Idea Detector in DD4HEP

**Primary author:** CAPRIOTTI, Lorenzo (INFN Bologna)

**Presenter:** CAPRIOTTI, Lorenzo (INFN Bologna)

**Session Classification:** Poster Session

**Track Classification:** WG2 - Physics Analysis Methods

Contribution ID: **131** Type: **Parallel session talk**

# Fixing the SMEFT Lagrangian with data from e+e- Higgs factories

*Wednesday, 5 October 2022 16:45 (20 minutes)*

**Presenter:** PESKIN, Michael E.

**Session Classification:** WG 1 - Global

Contribution ID: **132** Type: **Parallel session talk**

# Overview of the Snowmass SMEFT fit results

*Wednesday, 5 October 2022 17:05 (20 minutes)*

**Presenter:** MIRALLES, Victor (IFIC-UV)

**Session Classification:** WG 1 - Global

Contribution ID: **133** Type: **not specified**

# Mapping EFT on concrete models

*Wednesday, 5 October 2022 17:25 (20 minutes)*

**Presenter:** CEPEDELLO, Ricardo (University of Würzburg)

**Session Classification:** WG 1 - Global

Contribution ID: **134** Type: **Parallel session talk**

# Global fits in concrete models with Gambit

*Wednesday, 5 October 2022 17:45 (20 minutes)*

**Presenter:** GONZALO, Tomas

**Session Classification:** WG 1 - Global

Contribution ID: **135** Type: **Parallel session talk**

# Differential top cross section and ttV measurements at the LHC and HL-LHC prospects

*Wednesday, 5 October 2022 14:36 (14 minutes)*

**Presenter:** JUNG, Andreas Werner

**Session Classification:** WG1: joined HTE & GLOB session

Contribution ID: **136** Type: **Parallel session talk**

# Prospects for constraining or discovering top FCNC at the LHC and at e+e- colliders

*Wednesday, 5 October 2022 14:18 (14 minutes)*

**Presenter:** DURIEUX, Gauthier (CERN)

**Session Classification:** WG1: joined HTE & GLOB session

Contribution ID: **137** Type: **Parallel session talk**

# Introduction

*Thursday, 6 October 2022 14:00 (3 minutes)*

**Presenters:** HAYS, Chris (Oxford University); MALTONI, Fabio (Université catholique de Louvain); KOENEKE, Karsten (Uni Freiburg)

**Session Classification:** WG 1 - Higgs/ Top/ EW

Contribution ID: **138** Type: **Parallel session talk**

# Diboson measurements, including anomalous couplings, at future e+e- colliders

*Thursday, 6 October 2022 14:50 (15 minutes)*

**Presenter:** GU, Jiayin

**Session Classification:** WG 1 - Higgs/ Top/ EW

Contribution ID: **139** Type: **Parallel session talk**

# Prospects for aTGC / EFT constraints at the LHC and at e+e- colliders

*Thursday, 6 October 2022 15:15 (15 minutes)*

**Presenter:** RAHAMAN, Rafiqul

**Session Classification:** WG 1 - Higgs/ Top/ EW

Contribution ID: **141** Type: **Parallel session talk**

# CP-sensitive top-quark measurements

*Wednesday, 5 October 2022 14:54 (14 minutes)*

**Presenter:** VOS, Marcel (IFIC (UVEG/CSIC) Valencia)

**Session Classification:** WG1: joined HTE & GLOB session

Contribution ID: **142** Type: **Parallel session talk**

# Measurements to improve hadronization models

*Thursday, 6 October 2022 14:04 (25 minutes)*

**Presenter:** Prof. KRAUSS, Frank (Durham University)

**Session Classification:** WG 1 - Higgs/ Top/ EW

Contribution ID: **143** Type: **Poster**

# Measurement of the Higgs to diphoton branching fraction at 3 TeV CLIC

*Thursday, 6 October 2022 19:13 (17 minutes)*

Here we address the results of a full simulation of experimental measurement of the Standard Model Higgs boson decaying to a pair of photons at 3 TeV center-of-mass energy at the Compact Linear Collider (CLIC). Since photons do not couple to Higgs boson at a tree level, any deviation of the Higgs to photons coupling may indicate a New Physics. We show that the product of the Higgs production cross-section in W+W− fusion and BR (H → γγ) as the observable for determination of the Higgs to photons coupling, can be measured with a relative statistical precision of 5.5%, assuming the integrated luminosity of 5 ab−1 and unpolarized beams.

**Primary author:** KACAREVIC, Goran (Vinca Institute of Nuclear Sciences)

**Co-authors:** BOZOVIC JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade (RS)); VUKASINOVIC, Natasa (VINCA Institute of Nuclear Sciences, University of Belgrade)

**Presenter:** BOZOVIC JELISAVCIC, Ivanka (VINCA Institute of Nuclear Sciences, University of Belgrade (RS))

**Session Classification:** Poster Session

**Track Classification:** WG1-HTE - Physics Potential: Higgs, top, and electroweak