ATLAS physics highlights

91st PRC meeting

Sonia Carra`, on behalf of the DESY-ATLAS group Hamburg, May 4-5, 2021







ATLAS group (as the COVID-19 era continues)



Overview of Group Activities

Involvement in current and future ATLAS detector and computing aspects:

- detector operation
 - \rightarrow monitoring and calibration of current detector
- detector upgrade
 - \rightarrow design and assembly of future ITk detector
- software and computing
 - \rightarrow software development, Monte Carlo simulation, distributed computing

Expertise in wide range of physics object performance and high- quality data analyses

- physics object performance
 - \rightarrow identification and calibration of jets, b-jets, electrons and photons
- data analysis
 - \rightarrow from Standard Model precision measurements to

Beyond Standard Model searches

— Focus of this talk

Leadership roles in many areas

New ATLAS physics results

Since November 2020

The group is involved in many analyses, new public results in many the sectors:

Standard Model:

- Extracting PDFs from V+jets data
- Measurement of WW production with jets
- Higgs couplings interpretations
- Search for rare Higgs decays
 H→IIγ
- ttH(H->bb)

Beyond the Standard Model:

- Search for Dark Matter produced in the Higgs + MET final state
- Search for RPV SUSY with leptons and many jets
- Search for long-lived particles that stopped in the detector material
- Combination of searches for invisible
 Higgs
- Search for sbottom and dark matter pair production with 2 b-jets

Standard Model Sector WW+jets

Motivation

- First jet-inclusive WW + ≥1 jets measurement at the LHC (only up to 1 jet considered in in previous measurement)
- First measurement of jet kinematics in WW production

Motivations:

- The measurement can be combined with complementary measurement without jets, to improve the precision of the inclusive WW cross section (anti-correlation of jet uncertainties)
- **Probe for BSM physics:** anomalous triple-gauge-boson couplings



Analysis strategy

Selecting WW $\rightarrow e^{\pm}\mu^{\scriptscriptstyle \mp}$ events

- at least one jet (30 GeV)
- no b-jet (20 GeV)



Top background dominant:

- precise top background estimate with data-driven method
- two control regions with 1 b-jet and 2 b-jets
 → measure number of tt events and b-tagging
 efficiency in each analysis bin

$$\begin{array}{ccc} N_{1b} + N_{2b} & \rightsquigarrow \sigma_{t\bar{t}} \cdot \varepsilon_{\text{sel.}} \\ N_{2b}/N_{1b} & \leadsto \varepsilon_{b} \end{array} \right\} \underset{\text{bkg. in SR}}{\longrightarrow} N_{0b}$$



Fiducial cross section



σ fid = 258 ± 4 (stat.) ± 25 (syst.) fb

- Total uncertainty of 10%
- Measured fiducial differential cross section in good agreement with theoretical predictions

EFT models for anomalous coupling also tested, result compatible with SM

Differential distribution



Many differential distribution provided

 \rightarrow Excellent agreement up to high lepton p_{T} and up to 5 jets

Future: full Run-2 measurement for 0-jet selection and combination

Higgs Sector Search for $H \rightarrow II\gamma$

Search for $H \rightarrow II\gamma$

Motivation

- First ATLAS search for Higgs boson decaying to $II\gamma$ with $m_{ee} < 30$ GeV
- Extremely rare decay in the SM: 5% of $H \rightarrow \gamma \gamma BR \rightarrow 0.01\%$
- **Probe for coupling modifications** introduced by possible extensions to the SM
- In the future, this channel can be a probe for CP-violation in the Higgs sector

Submitted to PLB arXiv:2103.10322



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Search for H→IIγ

Event selection and merged ee reconstruction

- Considering both $ee\gamma$ (first time in Run-2) and $\mu\mu\gamma$ final states
- Leptons collimated at small m_n
- Collimated ee pair can end up in the same electromagnetic cluster
- \rightarrow Dedicated object reconstruction and calibration for merged ee
- Dedicated identification

• Dedicated energy calibration:

kinematic behaviour of merged ee in calorimeter resembles a **photon converting** in the material, used for calibration

• Dedicated efficiency estimate

Event selection:

- 9 categories with different S/B:
 - 3 channel for lepton selection
 - (µµ, ee, merged electrons)
 - \circ 3 kinematic selection (VBF, high/low Higgs p_T)





Search for $H \rightarrow II\gamma$

Results

Result:

- **Observed significance:** 3.2 σ (expected 2.1 σ)
- Best-fit signal strength: 1.5 ± 0.5 times SM
- Cross-section times BR for $m_{\ell \ell}$ < 30 GeV: 8.7^{+2.8}_{-2.7} fb

First evidence for the decay of the Higgs boson into a pair of leptons and a photon



DESY.

Weighted sum of all categories

Beyond Standard Model Long lived stopped particles

Search for long lived stopped particles

Motivation

- Supersymmetry model, considering **long lived particles** (LLP): long lived gluino due to squark large mass
- LLP produced in pp collision, binds with SM quarks and gluons \rightarrow form R-hadron
- LLP can stop inside the detector before decaying
- Unconventional signature: search for jets in events without collisions
- Challenging due to the non-standard final state: specialised techniques for analysis strategy and background estimate





Search for long lived stopped particles

Analysis strategy

Backgrounds:

- cosmic rays, inducing energetic jets
 - cosmics-enriched control regions to extract jet pT template
- beam-induced background (BIB)
 - beam protons interacting with upstream collimators, residual gas or the beam pipe itself
 - jet pT template is derived from BIB sample

Signal regions

- events with jet pT > 150 GeV
- shape fit of leading jet pT

Data in agreement with background prediction



Search for long lived stopped particles

Result

- Data compatible with SM

 → limits on SUSY particles mass
 and lifetime
- Interpretation for three supersymmetric particles mass scenario
- Sensitive to lifetime from 100 ns up to 1 year
- Gluino mass up to 1.4 TeV is excluded



Conclusion



- ATLAS DESY group continues to play an important role in ATLAS detector operation, ITk project, computing, simulation, measurements and searches for new phenomena
- New public results in many sectors, Standard Model and beyond
- Three ATLAS highlights presented today:
 - measurement of WW + jets
 - search for $H \rightarrow II\gamma$
 - BSM physics with long lived stopped particles



Run: 339387 Event: 812083095 2017-10-28 09:47:43 CEST

 $H \rightarrow II\gamma$ events

Many more data analyses ongoing, stay tuned for new results!

1