T 24: Higgs Physics III (boson final states)

Time: Tuesday 16:15–17:45 Location: ZHG104

T 24.1 Tue 16:15 ZHG104

Measurement of $H \to \gamma\gamma$ fiducial cross sections with 13.6 TeV CMS data — Caio Daumann, Johannes Erdmann, Florian Mausolf, •Jan Lukas Späh, and Maximilian Wrabetz — III. Physikalisches Institut A, RWTH Aachen University

The Higgs boson is of fundamental importance for the understanding of particle physics. Since its discovery in 2012, it has been studied extensively by the ATLAS and CMS collaborations. The measurement of Higgs boson production cross sections is crucial to study deviations from the standard model in the scalar sector.

In this presentation, the measurement of Higgs boson production cross sections in the diphoton decay channel with the CMS experiment is presented. The data used in this analysis were collected in proton-proton collisions at $\sqrt{s} = 13.6\,\text{TeV}$ in 2022 and correspond to an integrated luminosity of $34.7\,\text{fb}^{-1}$. To reduce extrapolation uncertainties and improve the model independence of the measurement, the cross sections are measured in a fiducial phase space at particle level. Special emphasis is placed on the statistical analysis in this talk. This includes the simulation-based signal modelling, the data-driven background modelling, and the treatment of uncertainties.

This analysis lays the foundation for further measurements of Higgs boson processes in the diphoton decay channel by the CMS collaboration in Run 3 of the LHC and beyond. A brief outlook for future measurements and the potential of such analyses to constrain Higgs boson couplings to light quarks is given.

T 24.2 Tue 16:30 ZHG104

Studies for $\mathbf{H \to \gamma\gamma}$ cross-section measurements with 13.6 TeV CMS data — Caio Daumann, Johannes Erdmann, Florian Mausolf, Jan Lukas Späh, and •Maximilian Wrabetz — III. Physikalisches Institut A, RWTH Aachen University

Precise measurements of Higgs boson production cross-sections are crucial for testing the Standard Model. In this presentation, studies for cross-section measurements of Higgs boson production in the diphoton decay channel, based on proton-proton collision data collected at $\sqrt{s} = 13.6\,\text{TeV}$ by the CMS experiment in 2022 and 2023, are shown. They are performed in a fiducial phase space to reduce extrapolation uncertainties and enhance model independence.
The latest studies for a cross-section measurement of LHC Run 3 data are presented. These include the optimization of the categories for the analysis that are based on the estimated diphoton mass resolution and the decorrelation of that estimate with respect to the invariant diphoton mass.

T 24.3 Tue 16:45 ZHG104

Measurement of differential cross-sections in the $H \to ZZ^* \to 4\ell$ decay channel with the ATLAS Run 3 data — •Elena Cuppini, Alice Reed, Sandra Kortner, Oliver Kortner, and Tae Hyoun Park — Max-Planck-Institut für Physik

The decay of the Higgs boson into two Z bosons, which subsequently decay to four leptons ($H \to ZZ^* \to 4\ell$), offers a clean signature and high signal-to-background ratio for studying the properties of the Higgs boson. The measurement of differential fiducial cross-sections in this decay channel is performed for the first time with the Run 3 proton-proton collision data at a previously unexplored centre-of-mass energy $\sqrt{s} = 13.6\,\text{TeV}$. The data collected with the ATLAS detector during 2022 and 2023 corresponds to an integrated luminosity of $56\,\text{fb}^{-1}$.

The analysis minimises model dependence by employing fiducial phase-space selections that closely match the experimental acceptance, along with corrections for detector effects. Results will be compared to Standard Model predictions, with an emphasis on key differential observables.

Strategies for upcoming differential fiducial cross-section measurements with about three times more Run 3 data from the ATLAS detector collected by the end of 2024 will be discussed.

T 24.4 Tue 17:00 ZHG104

Optimization of machine learning-based measurements of Higgs production processes in the $H \to 4\ell$ decay channel with ATLAS Run 3 data — •Luca Spitzauer, Sandra Kortner, Hubert Kroha, Alice Reed, Elena Cuppini, and Tae Hyoun Park — Max-Planck-Institut für Physik

Cross-section measurements for various Higgs boson production and decay processes are crucial for exploring Higgs boson properties and have high sensitivity to potential physics beyond the Standard Model. The decay of a Higgs boson into a pair of Z bosons, each subsequently decaying into two leptons ($H \to ZZ^* \to 4\ell$), is particularly important for these measurements due to its exceptionally clear signal.

Within the framework of Simplified Template Cross Sections (STXS), exclusive regions of phase space are defined for each Higgs boson production mode. Optimized classification of reconstructed events according to the STXS production regions is essential to enhance signal sensitivity and reduce uncertainties. The previous round of STXS measurements in the $H \to 4\ell$ channel using the Run 2 ATLAS dataset employed a Neural Network classification approach. With the new Run 3 dataset at a center-of-mass energy of 13.6 TeV, we are exploring potential optimizations of this classification using a new Deep Set machine-learning approach.

T 24.5 Tue 17:15 ZHG104

Measurement of gluon fusion and vector-boson fusion Higgs-boson production cross sections in $H \to WW^* \to l\nu l\nu$ decays with the ATLAS detector — •Ahmed Markhoos, Karl Jakobs, and Benedict Winter — University of Freiburg, Freiburg im Breisgau, Germany

As the Higgs boson decay with the second largest branching fraction, the decay to two W bosons ($H \to WW^*$) is not only advantageous due to its sizable signal yield. It also has a relatively clean signature with moderate backgrounds. This allows for accurate measurements of the total and differential cross-sections for Higgs boson production through the gluon-gluon fusion (ggF), vector boson fusion (VBF) and Higgs strahlung modes. Throughout the past decade, this decay channel has been analyzed with improving accuracy, directly testing the Standard Model predictions and measuring the Higgs boson's couplings. In this talk, an overview of the ongoing $H \to WW^* \to l\nu l\nu$ ggF and VBF Simplified Template Cross-Section (STXS) measurement of the full Run 2 ATLAS dataset is presented. The analysis greatly improves on the previously published Run 2 analysis by extending the use of multivariate techniques and considering Higgs-boson decays to light leptons of the same flavor ($e\nu\ e\nu/\mu\nu\ \mu\nu$), which had been disregarded, in addition to different flavor decays ($e\nu\ \mu\nu$). This enables a more granular and precise STXS measurement with a considerably higher sensitivity.

T 24.6 Tue 17:30 ZHG104

Quantum tomography using machine learning to infer incomplete information in $H \to WW \to \ell\nu\ell\nu$ — Carsten Burgard[1], Vince Croft[2], Andre Sopczak[3], •Andrii Vak[3], and Lennart Völz[1] — [1]TU Dortmund University — [2]Leiden University — [3]Czech Technical University in Prague

Potential entanglement originating from the scalar nature of the Higgs boson can translate to variables that could be accessible at collider experiments such as ATLAS at the LHC. The entanglement is mediated through the parity violation from weak decay vertices, affecting for example the angular properties of the dilepton system in $H \to WW \to \ell\nu\ell\nu$ decays. Thus, the analysis of multiple neutrinos in the final state is interesting for quantum tomography measurements. This study uses advanced machine learning methods for regression and inference of missing kinematic information.