T 61: Higgs Boson: Decay in Bosons

Time: Wednesday 16:15–18:15 Location: T-H20

T 61.1 Wed 16:15 T-H20

Effective Field Theory interpretation of the $pp \to H \to 4\ell$ Higgs boson decay measurements with the ATLAS detector — •Alice Reed, Sandra Kortner, and Hubert Kroha — Max Planck Institut für Physik (Werner-Heisenberg-Institut), München

An important process for the measurement of the Higgs boson properties is the Higgs boson decay into two Z bosons, which subsequently decay into a $\mu^+\mu^-$ or an e^+e^- pair, $pp \to H \to 4\ell$. In the Standard Model (SM), the Higgs boson is predicted to be a spin-0 particle with a positive CP quantum number. This hypothesis is also favoured by the Run-1 data at the LHC. Still, small admixtures of anomalous and possibly also CP-violating couplings with non-SM tensor structure are not yet excluded.

Such deviations from the SM can be described within the effective field theory (EFT) framework in which the SM is extended by the addition of higher-dimensional operators. In this talk, the EFT interpretation of the measured Higgs boson properties in the 4-lepton decay channel is presented, allowing constraints on several EFT parameters to be determined. Particular emphasis is given to the impact of the these EFT parameters on the acceptance of the four-lepton event selection criteria, which needs to be taken into account in addition to the EFT effects on the production cross section and branching ratio.

T 61.2 Wed 16:30 T-H20

Measurement of $H \to WW^*$ Decays in the $\ell\nu qq$ Final State with a Large-R Jet — •Johannes Hinze, Karsten Köneke, and Benedict Winter — Universität Freiburg

The talk presents a study of $H \to WW^*$ decays at large transverse momenta ($pT(H) > 200$ GeV) with one leptonic ($W \to \mu\nu$ or $W \to e\nu$) and one hadronic W boson decay, where the experimental signature of the hadronic W boson decay is a large-R jet. The lepton provides means to efficiently trigger event candidates and to eliminate background events in particular from multijet events. Further background events, primarily from W+jets events, can be suppressed via W-boson taggers for large-R jets. The measurement benefits from the larger branching fraction in comparison with $\ell\nu\ell\nu$ final states, and from the reduced background levels for large transverse momenta. The measurement will contribute significantly in an area of the phase space that is considered particularly sensitive to possible BSM effects.

T 61.3 Wed 16:45 T-H20

Multivariate Techniques for Measurement of Higgs Bosons in $H \to WW^* \to e\nu\mu\nu$ Decays at ATLAS — •Ahmed Markhoos, Benedict Winter, and Karsten Köneke — University of Freiburg

Since its discovery, the Higgs Boson has been studied in detail at the LHC. The $H \to WW^* \to e\nu\mu\nu$ channel offers sizeable signal and moderate background yields enabling accurate measurements of the total cross-section and of differential cross-sections. The measurements for gluon-fusion production are generally dominated by systematic uncertainties except in the sparsely populated regions of the phase space such as at large transverse momenta.

The talk showcases deep neural networks (DNN) that can enhance the signal purity with respect to the current cut-based selection reducing systematic uncertainties from backgrounds and statistical uncertainties. Additionally, a regression DNN is presented that determines the Higgs Boson transverse momentum, which is elusive due to the presence of neutrinos, and required to measure simplified template cross-sections (STXS).

T 61.4 Wed 17:00 T-H20

Search for Di-Higgs production in the $bb\gamma\gamma$ final state with the ATLAS detector — •Florian Beisiegel, Jochen Dingfelder, and Tatjana Lenz — Physikalisches Institut, Uni Bonn

The discovery of the Higgs boson in 2012 was a great success of modern particle physics since it served as a proof of the Higgs mechanism introduced in 1964. One focus of the current particle physics experiments at the LHC is the measurement of the Higgs properties, such as its coupling strengths to fundamental particles. In addition to the coupling of the Higgs boson to fermions and gauge bosons, the Higgs mechanism predicts Higgs self-coupling. The triple-Higgs self-coupling can be measured in di-Higgs (non-resonant) production. Di-Higgs analyses also facilitate the search for new heavy particles that decay to two Higgs bosons (resonant production).

This talk presents a search for di-Higgs production in the $bb\gamma\gamma$ final state using 139 fb^{-1} of proton-proton collisions at 13 TeV recorded with the ATLAS detector. The analysis aims to measure the non-resonant SM di-Higgs production cross section and the Higgs self-coupling as well as search for resonant di-Higgs production. The focus is put on studies to improve the limits on the non-resonant production cross-section using a 2D fit in $m_{\gamma\gamma}$ and m_{bb}.

T 61.5 Wed 17:15 T-H20

Search for non-resonant Higgs boson pair production in the bbWW final state with leptonic W boson decays at the CMS experiment — Martin Erdmann, •Peter Fackeldey, Benjamin Fischer, and Dennis Noll — III. Physikalisches Institut A, RWTH Aachen University

The measurement of the Higgs boson pair production is a direct test of the electroweak symmetry breaking in the standard model of particle physics (SM) with direct access to the shape of the Higgs potential.

The cross section of the Higgs boson pair production is about a factor of a thousand smaller than that of a single SM Higgs boson, making it a highly challenging search. Physics-inspired deep learning techniques are leveraged for the signal extraction and the control over overwhelming backgrounds, mainly from the top pair production and Drell-Yan processes.

The expected sensitivity of the search for HH $\to$ bbW$_{\text{lep}}$W$_{\text{lep}}$ is presented for the data-taking periods 2016, 2017, and 2018 of the CMS experiment.

T 61.6 Wed 17:30 T-H20

Search for non-resonant di-Higgs production in the semi-leptonic bbWW decay channel at the CMS experiment — Martin Erdmann, Peter Fackeldey, Benjamin Fischer, and •Dennis Noll — III. Physikalisches Institut A - RWTH Aachen University

A measurement of the di-Higgs boson production can directly determine the trilinear Higgs coupling and probe the structure of the Higgs potential.

We present a search for Higgs boson pair production with one Higgs boson decaying into b quarks and the other Higgs boson decaying into W bosons, with one W boson decaying leptonically.

The central challenge of this analysis is a tiny signal among a large amount of background. We approach this task with a Deep Neural Network driven Physics Process Multi-Classification. It utilises a physics motivated architecture, the Lorentz-Boost Network, in conjunction with a Residual Neural Network.

We present expected limits corresponding to the data recorded at the CMS experiment in Run 2.

T 61.7 Wed 17:45 T-H20

Search for non-resonant Higgs boson pair production in the $b\bar{b}b\bar{b}$ final state with the CMS Experiment — Martin Erdmann, Peter Fackeldey, •Benjamin Fischer, and Dennis Noll — III. Physikalisches Institut A, RWTH Aachen University

The non-resonant Higgs boson pair production enables probing the shape of the Higgs potential, in particular the triple Higgs self coupling λ_{hhh}. The decay channel with the highest branching ratio of $\sim 1/3$ has a four-b-quark final state.

This phase space is dominated by QCD-processes, which are challenging to model using Monte Carlo samples. A data-driven modeling is implemented through a Neural Network based reweigthing from a sideband region into the signal region. Through a Neural Network based multi-classification both Di-Higgs production modes, gluon- and vector-boson-fusion, are separated from background processes for the statistical inference.

T 61.8 Wed 18:00 T-H20

Search for non-resonant Higgs boson pair production in lepton+jets final states of the bbWW decay mode at CMS — •Mathis Frahm, Johannes Haller, Matthias Schröder, and Artur Lobanov — Institut für Experimentalphysik, Universität Hamburg

The Higgs boson self-coupling is an important parameter of the Stan-

dard Model, since it is related to the shape of the Higgs potential. At the LHC, this parameter can be probed by measuring the Higgs boson pair production (HH) cross section. In the Standard Model, HH production occurs in processes via Higgs-boson self-coupling and in processes with a fermion loop. Due to destructive interference of these two contributions, the resulting production cross section is small, amounting to only 33 fb at 13 TeV.

In this talk, a search for HH production in lepton+jets finals states of the bbWW decay mode is presented. The analysis is performed on data recorded by the CMS experiment during LHC Run 2 at a center-of-mass energy of 13 TeV, which corresponds to an integrated luminosity of $137.2\,\mathrm{fb}^{-1}$. The analysis utilizes a deep neural network to classify between signal and different background categories. Exclusion limits on the production cross section are derived as a function of the Higgs boson self-coupling strength to set constraints on this parameter.