T 35: Higgs Boson: Associated Production 1

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

T 35.1 Tue 16:15 T-H20

Higgs Boson Mass Reconstruction in the ttH Multi-lepton Channel Using ATLAS data — Igor Boyko[1], •Adam Herold[2], Nazim Huseynov[1], Jan Kybic[2], André Sopczak[2], Petr Urban[2], and Cyrus Walther[3] — [1]JINR Dubna — [2]CTU in Prague — [3]TU Dortmund

This study deals with the reconstruction of the Higgs boson mass in the 2lSS + $1\tau_{\text{had}}$ channel in ttH production. Based on the reconstructed mass, the goal is to separate the signal from background productions such as the ttZ production. The data created by the full ATLAS detector simulation are used to develop two neural networks. First, a classification neural network that organizes the data by assigning detected particles to corresponding positions in the channel. Second, a regression neural network that reconstructs the mass of the Higgs boson. The developed neural network is tested and is shown to outperform the Missing Mass Calculator technique.

T 35.2 Tue 16:30 T-H20

Investigation of ttH(bb) Events with Very High Higgs Boson Momentum at ATLAS Detector — •Doga Elitez, Lucia Masetti, Eftychia Tzovara, Asma Hadef, and Alexander Basan — Johannes Gutenberg-Universität Mainz, Mainz, Deutschland

The coupling of the Higgs boson to the top quark is very sensitive to effects of the physics beyond the Standard Model (BSM) and the most favorable production mode for direct measurement of the top Yukawa coupling is the Higgs production in association with a pair of top quarks ($t\bar{t}H$). The decay to two bottom quarks ($H \to b\bar{b}$) has the largest branching fraction of about 58%. This analysis aims at events in which one of the top quarks decays semi-leptonically and produces an electron or a muon plus several jets. The so-called ultra boosted topology targets events containing a Higgs boson produced at very high transverse momentum, which is contained in a single small-R jet. This topology is not included in the current high p_T (boosted) Higgs boson selection and requires a dedicated analysis. In this talk, methods to improve background rejection and event reconstruction to increase the sensitivity above the current p_T range are presented, along with the challenges of combining the different channels.

T 35.3 Tue 16:45 T-H20

Measurement of the $t\bar{t}H$ production cross-section with $H \to b\bar{b}$ in the boosted topology with the ATLAS detector — •Eftychia Tzovara, Lucia Masetti, Doga Elitez, Asma Hadef, and Alexander Basan — JGU Mainz, Germany

Studying the coupling of the Higgs boson to the top quark is of particular interest, since it could be sensitive to effects of physics beyond the SM. The Higgs production in association with a top-quark pair is the most favourable process for a direct measurement of the top Yukawa coupling. The decay to two b-quarks has the largest branching ratio, while it allows for the reconstruction of the Higgs boson kinematics. The analysis presented here aims at events in which one of the top quarks decays semi-leptonically, producing an electron or a muon, and the other one hadronically. In the single-lepton channel, there is a specific boosted region, targeting events with a Higgs boson produced at high transverse momentum p_T.

Due to the highly complex final state and the large SM backgrounds, the reconstruction of the Higgs boson becomes a complicated task. The ultimate goal is to constrain the background events of the boosted channel in order to maximise the statistical significance of the measurement. For this purpose, multivariate techniques are used to discriminate between signal and background events, in particular from $t\bar{t}$+jets production. For the first time, the signal strength is also measured differentially in bins of the Higgs boson p_T. Finally, the measurement of the $t\bar{t}H(b\bar{b})$ cross-section, using the full LHC run-2 data, as well as further improvements on the boosted channel, will be presented.

T 35.4 Tue 17:00 T-H20

Improvements of the MVA classifiers for the $t\bar{t}H(b\bar{b})$ analysis in the dilepton channel with full Run2 data in the CMS experiment — •Angela Giraldi and Maria Aldaya — DESY, Hamburg, Germany

In the Standard Model (SM), the Higgs boson couples to fermions with a Yukawa-type interaction and a strength proportional to the fermion mass. The associated production of a Higgs boson with a top-quark pair ($t\bar{t}H$) is therefore the best direct probe of the top-Higgs Yukawa coupling, a vital element to verify the SM nature of the Higgs boson. In the SM, the Higgs boson decays into b-quark-antiquark pair with the largest branching fraction, and is thus experimentally attractive as a final state. The dominant background contributions arise from $t\bar{t}$+jets production, and in particular the $t\bar{t}b\bar{b}$ background is irreducible with respect to $t\bar{t}H$,$H \to b\bar{b}$. To better enhance the sensitivity, the signal is extracted exploiting multivariate analysis (MVA) techniques.

This talk focuses on the analysis of the $t\bar{t}H$,$H \to b\bar{b}$ process in final states with two leptons using proton-proton data collected by the CMS experiment at the LHC during 2016-2018 at $\sqrt{s} = 13$ TeV. The possibility to critically increase the sensitivity to the $t\bar{t}H$ signal is investigated using machine learning approaches. Detailed studies on the optimization and performance of MVA discriminants trained using Artificial Neural Networks are presented in this final state.

T 35.5 Tue 17:15 T-H20

Adversarial Machine Learning Methods for Modelling Uncertainty Reduction in the Bottom Anti-Bottom Higgs Decay Channel of Higgs-associated Top Quark Pair Production with ATLAS at 13 TeV — Arnulf Quadt, •Chris Scheulen, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August Universität Göttingen

The bottom anti-bottom Higgs decay channel of Higgs-associated top quark pair production offers direct access to measurements of the top Yukawa coupling and Higgs-p_{T} differential cross section, which are sensitive to potential new physics. To incorporate improvements such as developments in b-tagging and event simulation, a legacy analysis of the $t\bar{t}H(H \to b\bar{b})$ process in the full ATLAS Run 2 Dataset of $\mathcal{L} = 139\,\text{fb}^{-1}$ is currently ongoing.

Modelling differences between Monte Carlo samples of the dominant $t\bar{t}$ + jets background process were found to be one of the most significant sources of uncertainty in previous analysis rounds. Along with investigating and mitigating the source of these modelling differences via generator studies of new $t\bar{t}$ + jets background simulation setups or improving event classification performance to decrease background contamination in signal regions, the usage of adversarial machine learning techniques to select robust features could decrease the impact of background modelling systematics on the fit performance. This talk will present ongoing efforts concerned with developing such adversarial machine learning approaches.

T 35.6 Tue 17:30 T-H20

Performance Tests of tH(bb) Signal and Background Separation Using a Binary Classifier Neural Network with ATLAS Data — Igor Boyko[1], Nazim Huseynov[1], Oksana Koval[1], •Marcel Patzwahl[2], and André Sopczak[2] — [1]JINR Dubna — [2]CTU in Prague

The production of a Higgs boson in association with a single top quark is a strongly suppressed process in the Standard Model (SM). In the current ATLAS data set of $140\,\text{fb}^{-1}$, the SM expected production rate is below the experimental sensitivity. Thus, observing such a tH production would indicate new physics. The absolute ttH coupling strength was already measured and the tH process can in addition measure the relative sign of the ttH coupling. Therefore, observing the tH process gives an important additional insight into the physics of the Higgs mechanism. Owing to the low production rate, it is particularly important to enhance the signal sensitivity, and a Neural Network (NN) is used. The resulting significance is studied by varying the NN structure. Based on simulated data, the performances of these different NN structures were tested and results are expressed as area under the ROC curve to quantify the signal and background separation.

T 35.7 Tue 17:45 T-H20

Higgs Boson Mass Reconstruction in the tH Multi-lepton Channel Using ATLAS Data — Igor Boyko[1], Adam Herold[2], Nazim Huseynov[1], Lars Kolk[3], Jan Kybic[2], André Sopczak[2], Petr Urban[2], and •Cyrus Walther[3] — [1]JINR Dubna — [2]CTU in Prague — [3]TU Dortmund

The Higgs boson mass is reconstructed in single top production in as-

sociation with a Higgs boson, tH, using a regression neural network approach. The reconstruction of the Higgs boson mass is expected to show discrimination to background processes. A focus lies on the lepton association. For the lepton association, a classification neural network is used. Hyperparameter optimization, as well as feature importance studies, are applied in order to increase the neural network performance. For the Higgs boson mass reconstruction, a hyperparameter optimization is also performed. The performance of the network is tested on tH signal and tZ background simulations.

T 35.8 Tue 18:00 T-H20

Associated production of a Higgs boson and a single top quark from t-channel production (tHq) in channels with hadronically decaying tau leptons at ATLAS — •Tanja Holm and Ian C. Brock — Physikalisches Institut Universität Bonn

Associated Higgs boson production gives us the opportunity to study its couplings to fermions and bosons. An especially interesting but challenging channel is the associated production with a single top quark, as it allows one to probe the relative coupling to both kind of objects. The downside to this is a small predicted cross-section and a complicated final state including jets from light quarks or gluons, jets containing b-hadrons, missing E_T and leptons. The decay into tau leptons which subsequently decay hadronically was chosen as it has a relatively high Higgs decay branching ratio, while having a lower background than hadronic processes with higher branching ratios. This talk will discuss the search for this channel in the Run 2 LHC dataset by ATLAS.