T 58: Higgs: associated production

Time: Wednesday 16:30–19:00 Location: H-1.002

T 58.1 Wed 16:30 H-1.002

Optimisation of a deep neural network flavour-tagging algorithm to improve the definition of signal and control regions in the $t\bar{t}H$ ($H \to b\bar{b}$) search. — •Thea Engler, Manuel Guth, Andrea Knue, and Gregor Herten — University of Freiburg, Institute of Physics

The search for the $t\bar{t}H$ ($H \to b\bar{b}$) signal provides direct access to the top-Higgs Yukawa coupling. This channel has four b-jets in the final state and is suffering from large physics background, which makes b-tagging a crucial tool for this analysis. The dominant and most challenging background process is $t\bar{t} + b\bar{b}$. This process also contains four jets however, wherefore a simple b-tagger will not help to discriminate between signal and background. Nonetheless, the two b-jets from the $g \to b\bar{b}$ splitting can be so close that they are identified as one jet. Identification of these gluon splittings would allow to reject the $t\bar{t} + b\bar{b}$ background more efficiently. In this talk, a deep neural network is presented in which the nominal DL1 tagger used by the ATLAS experiment is extended by the $g \to b\bar{b}$ category, and first optimisation studies are shown.

T 58.2 Wed 16:45 H-1.002

Application of Deep Neural Networks to Combinatorial Assignment of Jets in a $t\bar{t}H(b\bar{b})$ Analysis in CMS — •Tobias Lösche — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

A precise determination of the interactions of the Higgs boson with other SM particles is a crucial part of the LHC physics program. When determining the top Yukawa coupling in $t\bar{t}H(b\bar{b})$ events, deep learning plays an integral role. In the single-lepton channel, multivariate approaches using deep neural networks (DNNs) achieve state-of-the-art performance in signal/background classification.

A particular challenge of this analysis is the discrimination of $t\bar{t}H(b\bar{b})$ events from the irreducible $t\bar{t} + b\bar{b}$ background. Considering the combinatorial assignment of jets offers a possible means to deal with this problem and thus further improve performance. To achieve this, multiple DNN architectures were analyzed: An attention-based classifier, able to focus on the different combinations of objects in the event and a graph-based network, inferring relations between objects by learning a meaningful measure of distance between their respective nodes. The results of these analyses will be presented in this talk.

T 58.3 Wed 17:00 H-1.002

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, Peter Berta, Lucia Masetti, and Alexander Basan — Institute of Physics, JGU Mainz, Germany

Studying the coupling of the Higgs boson to the top quark (the heaviest particle in the SM) is of particular interest, since it could be very sensitive to effects of physics beyond the SM (BSM). The most favorable production mode for a direct measurement of the Higgs-top Yukawa coupling is the Higgs production in association with a pair of top quarks, $t\bar{t}H$. The newly observed 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 semileptonically, producing an electron or a muon. In the single-lepton channel, the so-called boosted topology, targets events containing a Higgs boson produced at high transverse momentum.

Due to the highly complex final state and the large Standard Model backgrounds, measuring the signal strength in this process is very challenging. The ultimate goal is to precisely estimate the amount of background events in order to maximise the 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. In this talk, the challenges of this decay channel and the suppression of the background processes will be discussed. Finally, the measurement of the $t\bar{t}H(b\bar{b})$ cross-section, using the full LHC run-2 data collected by the ATLAS detector, will be presented.

T 58.4 Wed 17:15 H-1.002

Assoziierte Produktion eines Top Quarks und eines Higgs-Bosons am CMS-Experiment — Thorsten Chwalek, Nils Faltermann, Kevin Flöh, •Marco Link und Thomas Müller — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Die assoziierte Produktion eines Top-Quarks und eines Higgs-Bosons (tH) ist ein noch nicht beobachteter Standardmodell Prozess mit einem Produktionswirkungsquerschnitt von etwa einem Zehntel des Produktionswirkungsquerschnitts der kürzlich entdeckten Produktion eines Top-Quarkpaars und eines Higgs-Bosons ($t\bar{t}H$). Im Gegensatz zu $t\bar{t}H$ ist tH durch Interferenz sensitiv auf das Vorzeichen der Top-Higgs Kopplung.

Dieser Vortrag konzentriert sich auf die Rekonstruktion von tHq-, tHW-, $t\bar{t}$- und $t\bar{t}H$-Ereignissen im semileptonischen Kanal mit Zerfall des Higgs-Bosons in zwei Bottom-Quarks für die kombinierte Analyse von tH und $t\bar{t}H$ auf den kompletten Run 2 Daten des CMS-Experiments. Die Rekonstruktion verwendet Boosted Decision Trees (BDTs) um die Jets den Quarks zuzuordnen. Zum Schluss werden erste Limits auf den tH-Produktionswirkungsquerschnitt, die Top-Higgs Kopplungskonstante und CP-Verletzung gezeigt.

T 58.5 Wed 17:30 H-1.002

Search for the $t\bar{t}H(H \to b\bar{b})$ process utilising improvements in Deep-Neural-Network-based b-tagging in ATLAS — •Manuel Guth and Andrea Knue — Uni Freiburg, Freiburg

ATLAS and CMS recently discovered the $t\bar{t}H$ production channel using LHC Run 2 data. However the $t\bar{t}H(H \to b\bar{b})$ process is not yet discovered due to its irreducible $t\bar{t}$+$b\bar{b}$ background and corresponding systematic uncertainties. The process allows a direct measurement of the Top-Yukawa coupling which is the strongest fermion-Higgs coupling in the Standard Model and plays therefore an important role in Higgs physics.

The challenging final state with at least 4 b-jets requires an advanced analysis strategy as well as sophisticated b-tagging algorithms.

The data collected during Run 2 with the ATLAS experiment allows to explore Higgs boson properties in the $t\bar{t}H(H \to b\bar{b})$ channel for the first time. Since this channel allows a reconstruction of the Higgs transverse momentum, a simplified cross-section measurement in bins of different Higgs p_{T} is possible. A first study of this measurement will be presented, followed by an outlook to planned improvements based on new b-tagging developments.

T 58.6 Wed 17:45 H-1.002

Improvements of the MVA classifiers for the ttH(bb) analysis in the dilepton channel with full Run2 data in the CMS experiment — Maria Aldaya, •Angela Giraldi, and Marino Missiroli — Deutsches Elektronen Synchrotron (DESY)

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 for the first time in this final state.

T 58.7 Wed 18:00 H-1.002

Towards a measurement of single top-quark production in association with a Higgs boson (tH) in the ditau channel at ATLAS — •Tanja Holm and Ian C. Brock — Physikalisches Institut Universität Bonn, Bonn, Germany

Single top-quark production in association with a Higgs boson sometimes is referred to as the "golden channel" of single top-quark processes due to the opportunities it gives in studying the couplings of the

Higgs boson. Especially interesting is the sign of $\frac{C_F}{C_V}$ which results in the cross-section changing by almost one order of magnitude, as the pair production channel (ttH) is not sensitive to it.
The production of a top-quark in association with a Z boson has been discovered at ATLAS and CMS in the trilepton channel, considering the top-quark and the Z boson to decay leptonically. Because of this a promising channel for the tH search is the multilepton channel where the Higgs decays into two τ. Given that each τ has a 64.6% probability to decay hadronically we search for events containing two hadronic τ decays and events containing one hadronic τ decay.
This talk will discuss the search for the tH production in the hadronic τ channels in ATLAS using the Run 2 data of the LHC.

T 58.8 Wed 18:15 H-1.002

Simplified Template Cross Section measurement in the $t\bar{t}H(H\to b\bar{b})$ channel — Ulrich Husemann, Karim El Morabit, •Peter Krämer, and Matthias Schröder — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Recently, $t\bar{t}H$-production has been observed for the first time and the CMS collaboration has established evidence for $t\bar{t}H$ in the $H\to b\bar{b}$ decay channel. An exciting next step is the exploration of more differential information using the larger datasets available by now.
Simplified Template Cross Sections (STXS) provide a framework designed as a next step of interpreting LHC Higgs data beyond the κ-framework. It defines mutually exclusive regions of phase space for each production mode. For each of these STXS bins, one can build a template based on the Standard Model prediction and fit them to data simultaneously, resulting in a differential measurement of the observable.
Within the recent update of the STXS framework, a binning is defined for $t\bar{t}H$-production for the first time.
In this talk, I will give an overview of STXS in $t\bar{t}H$-production and show studies towards a first STXS measurement of $t\bar{t}H$ in the $H\to b\bar{b}$ channel with the CMS detector.

T 58.9 Wed 18:30 H-1.002

Improvement of the jet-parton assignment in $t\bar{t}H(b\bar{b})$ events using machine-learning techniques — •Felicia Volle, Andrea Knue, and Gregor Herten — Albert-Ludwigs-Universität Freiburg, Deutschland

The associated production of a Higgs boson and a top-antitop-quark pair allows to directly measure the Higgs-top Yukawa coupling, which can be sensitive to Beyond Standard Model physics. In the studies presented, a final state with the Higgs boson decaying into two b-quarks and the $t\bar{t}$ pair decaying into the lepton+jets channel is investigated. This decay channel suffers from irreducible $t\bar{t}$+$b\bar{b}$ background. In order to discriminate signal from background, a good reconstruction of the signal event is of utmost importance.

In the targeted decay channel, at least six jets are expected to be present in the final state. Four of these jets are expected to originate from a b-hadron. Having that many jets in the final state, the correct assignment of the measured jets to their corresponding parton-level object proves difficult. A Boosted Decision Tree has been used in the past in order to identify the correct permutation. The performance of this Boosted Decision Tree is presented and first studies towards using a deep neural network for the assignment will be shown.

T 58.10 Wed 18:45 H-1.002

Measurement of top-quark-antiquark pair production in association with a Higgs boson at CMS — Ulrich Husemann, Philip Keicher, Matthias Schröder, Jan van der Linden, and •Sebastian Wieland — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

The top quark-antiquark pair production in association with a Higgs boson offers a model-independent measurement of the top-Higgs Yukawa coupling. This is of great interest in order to test precisely the couplings of the Higgs boson to fermions predicted by the standard model.

In this talk a multivariate analysis in the semileptonic decay channel of the top quark-antiquark pair and the decay of the Higgs boson into a bottom quark-antiquark pair is presented.

A major challenge to this analysis are the backgrounds. Particularly, top quark-antiquark pair production with additional b quarks provide a final state almost indistinguishable from the signal process. Since this process is also theoretically challenging, different ways of modelling this background will be compared. The focus will be on the comparison of observables sensitive to differences in the background modelling.