T 88: Top quarks: associated production

Time: Thursday 16:30–19:00 Location: L-4.001

T 88.1 Thu 16:30 L-4.001

$t\bar{t}$+Z production in the Z → $b\bar{b}$ channel at the CMS experiment — Ulrich Husemann, Matthias Schröder, and •Jan van der Linden — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

The production of $t\bar{t}$+Z is a direct probe of the weak coupling of the Z boson to the top quark. Contributions of BSM interactions, changing the coupling of the Z boson to the top quarks, might be identified by studying this process. The $t\bar{t}$+Z process has already been successfully measured in final states with two or more charged leptons. In these multi-lepton analyses also first effective field theory interpretations have been performed.

A measurement of the $t\bar{t}$+Z process in an additional phase space region targeting the Z → $b\bar{b}$ decay is performed. This can improve the sensitivity to the coupling of the top quark to the Z boson.

The analysis also builds the ground work for a combined measurement of the $t\bar{t}$+Z and $t\bar{t}$+H processes in the Z → $b\bar{b}$ and H → $b\bar{b}$ final states for LHC Run-II data. This is especially interesting, as these two processes share similar kinematic features and production probabilities, and are therefore inherently hard to separate from each other. The analysis strategy devised explicitly aims at distinguishing the $t\bar{t}$+H and $t\bar{t}$+Z contributions in the analyzed region as much as possible.

In this talk an overview of the analysis strategy and methods for an enhanced $t\bar{t}$+H and $t\bar{t}$+Z separation is given.

T 88.2 Thu 16:45 L-4.001

Measurement of ttZ with hadronically decaying Z bosons — •Valerie Scheurer — DESY

In the Standard Model of particle physics the coupling of top quark and Z boson is an important quantity to probe for possible deviations that hint to new physics. This coupling can be measured in the associated production of top quark pairs with a Z boson. This process has been observed with leptonically decaying Z bosons. However in the region of high Z boson p_{T}, where the deviation is expected to be strongest, this measurement is not sensitive. In that region the measurement of ttZ with a hadronically decaying Z boson can provide additional sensitivity due to the large branching ratio of that process. However the background in that region is very high. Signal and background are separated using a dedicated deep neural network. The development and application of this technique is the topic of this talk.

T 88.3 Thu 17:00 L-4.001

Studies on the measurement of the $t\bar{t}Z$ production cross section in the dilepton channel — Otmar Biebel[1], •Florian Fischer[1], and Thomas McCarthy[2] — [1]Ludwig-Maximilians-Universität München — [2]Max-Planck-Institut für Physik, München

In the Standard Model of Particle Physics, the coupling of the Z boson to top quarks is precisely predicted via the weak interaction. As its value is experimentally not yet well constrained, several possible extensions of the Standard Model predicting modifications to this coupling could not be ruled out nor confirmed so far. Therefore a more accurate understanding of electroweak processes could significantly benefit from a precise measurement of this coupling at the LHC.

A process that is particularly sensitive to this coupling is the associated production of top-antitop quark pairs with a Z boson. Analyses targeting final states with three or four leptons offer the benefit of a very high signal purity. However, they suffer from low branching ratios. In contrast, the dileptonic channel currently being considered targets events in which the Z boson decays leptonically but the $t\bar{t}$ system decays to a fully hadronic final state.

Multivariate techniques are employed to improve the discrimination between signal events and the two dominant backgrounds: the production of top-antitop quark pairs, and the associated production of Z bosons with jets. For the studies presented in this talk, LHC Run 2 data collected by the ATLAS detector between 2015 and 2018 at a centre-of-mass energy of 13 TeV, as well as simulated data normalised to an integrated luminosity of 139 fb^{-1}, have been used.

T 88.4 Thu 17:15 L-4.001

Studies on the reconstruction of the Z boson for a measurement of the $t\bar{t}Z$ production cross section at ATLAS — Otmar Biebel, Florian Fischer, and •Maximilian Riepe for the ATLAS-Collaboration — Ludwig-Maximilians-Universität, München

In top quark physics, the production of top-antitop quark pairs in association with a Z boson is of great relevance since measuring this cross section provides direct sensitivity to the coupling between the top quark and the Z boson. The precise determination of this coupling allows testing many models of physics beyond the Standard Model which expect a significantly varied top-Z-coupling.

In this talk, studies on the improvements of the reconstruction of the Z boson will be presented, using LHC Run 2 data recorded by the ATLAS experiment in the years 2015 to 2018 at a centre-of-mass energy of 13 TeV and Monte Carlo simulations normalized to an integrated luminosity of 139 fb^{-1}. Special emphasis will be put on the suppression of combinatorial effects in decay channels with multiple leptons in the final state as this directly impacts the performance of the unfolding technique used in a differential cross section measurement.

T 88.5 Thu 17:30 L-4.001

Separation of Signal and Background in $t\bar{t}\gamma$ Processes using Deep Neural Networks in Single Lepton Final States at $\sqrt{s}$ = 13 TeV in ATLAS — •Steffen Korn, Thomas Peiffer, Arnulf Quadt, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

Through the associated production of the $t\bar{t}\gamma$ process, the strength of the electromagnetic coupling of the top quark and the photon can be measured. The measurement of this fundamental parameter of the Standard Model (SM) also serves as a probe to new physics beyond the SM. First evidence for this process was found by CDF at the Tevatron at $\sqrt{s}$ = 1.96 TeV. The process was later observed by ATLAS and CMS at $\sqrt{s}$ = 7 and 8 TeV with increased precision. Due to the similar topology between signal and background processes and a signal to background ratio of approximately 1:1 in the single lepton channel, deep neural networks (DNN) are used to improve the separation of signal and background processes. The separation of $t\bar{t}\gamma$ signal processes from background processes in proton-proton collisions data, taken between 2015 and 2018 with the ATLAS detector, is presented. Signal and background processes are hereby grouped into multiple different classes using a deep multi-class neural network. The performance of different DNN architectures based on a one-vs-one and a one-vs-many training approach and their effect on the event selection and the sensitivity of the analysis is presented.

T 88.6 Thu 17:45 L-4.001

Measurement of top quark charge asymmetry in $t\bar{t}\gamma$ production in the ATLAS experiment — •Amartya Rej, Ivor Fleck, and Carmen Diez Pardos for the ATLAS-Collaboration — Universitaet Siegen, Germany

Top quarks pairs ($t\bar{t}$) produced via initial quarks at the LHC are emitted in slightly different directions depending on its charge, referred to as charge asymmetry (A_c). The asymmetry is due to QCD interference contributions at next-to-leading order accuracy and it is very sensitive to New Physics models. Such asymmetry was observed at the Tevatron experiment, where quark anti-quark ($q\bar{q}$) annihilation was the dominant mode of $t\bar{t}$ production. The asymmetry is diluted at the LHC owing to the very large fraction of gluon fusion initiated $t\bar{t}$ production. However, recently its evidence has been found by the ATLAS experiment.

In $t\bar{t}$ production in association with a photon ($t\bar{t}\gamma$), the fraction of top quark pairs produced via $q\bar{q}$ annihilation increases with respect to $t\bar{t}$ production and also leading order QED interference contributes to the charge asymmetry. Hence a larger value of charge asymmetry is expected to be found in this process with higher sensitivity to New Physics models. Still, this process has a tiny cross-section compared to $t\bar{t}$ production, one of the dominant background processes. Thus the background discrimination becomes more challenging. In this presentation, the ongoing effort for the charge asymmetry measurement in $t\bar{t}\gamma$ production in the ATLAS experiment will be presented highlighting the analysis methods and related challenges.

T 88.7 Thu 18:00 L-4.001

Constraining top-quark couplings combining top-quark and

B decay observables — Stefan Bissmann, Johannes Erdmann, •Cornelius Grunwald, Gudrun Hiller, and Kevin Kröninger — TU Dortmund, Fakultät Physik, Deutschland

Over the last years the Standard Model Effective Field Theory (SMEFT) gained a lot of popularity in model-independent searches for physics beyond the Standard Model in the top-quark sector. Various efforts are being made to interpret measurements of top-quark production and decay observables in the context of SMEFT, aiming towards a global fit of dimension-six operators affecting the top quark. In this talk, a new approach is presented, combining measurements from top-quark and B physics observables to constrain the Wilson coefficients of dimension-six operators that modify the couplings of the top quark to the gauge bosons. Considering the $t\bar{t}\gamma$ cross section together with the $\bar{B} \to X_s\gamma$ branching fraction, the ingredients required for a consistent combination of observables from different energy scales are discussed and the benefits of this approach for the resulting constraints on the Wilson coefficients are demonstrated.

T 88.8 Thu 18:15 L-4.001

Effective Field Theory for $t\bar{t}\gamma$ at $\sqrt{s} = 13$ TeV — •Binish Batool[1], Carmen Diez Pardos[2], and Ivor Fleck[3] for the ATLAS-Collaboration — [1]binish.batool@cern.ch — [2]carmen.diez.pardos@cern.ch — [3]fleck@hep.physik.uni-siegen.de

The cross section measurement for the production of top anti-top quark pair in association with a photon ($t\bar{t}\gamma$) probes the electroweak coupling of top quark and photon. The high energy and luminosity of LHC data could provide an opportunity to look for possible deviations from the standard model (SM). These deviations are interpreted by employing model dependent and model independent, such as Effective Field Theory, approaches. This talk is about the later one, where three, dimension-six operators, namely O_{tG}, O_{tB}, O_{tW} are investigated. The sensitivity of the total and differential $t\bar{t}\gamma$ cross sections towards these operators, is investigated and expected limits for the full run2 data at $\sqrt{s} = 13$ TeV, on the operators are given.

T 88.9 Thu 18:30 L-4.001

Search for $t\bar{t}t\bar{t}$ production in same-sign dilepton and multilepton final states at the LHC with the ATLAS detector using the full Run-2 dataset — •Ö. Oğul Öncel, Niklas W. Schwan, and Markus Cristinziani — Universität Bonn

Production of $t\bar{t}t\bar{t}$ in proton–proton collisions is a rare process predicted by the Standard Model with an expected cross section of around 0.01 pb. Many BSM theories, such as Top Compositeness and 2HDM, predict an enhancement of the $t\bar{t}t\bar{t}$ cross section. In addition, $t\bar{t}t\bar{t}$ can also be used to measure the top-quark Yukawa coupling, another important quantity for probing new physics.

A search for this process in the same-sign dilepton and multilepton channels using ATLAS data collected at the LHC during 2015–2018 with 139.4 fb^{-1} integrated luminosity and at a centre-of-mass energy of 13 TeV, is presented. The main challenges are the small cross section, irreducible background contaminations from $t\bar{t}Z$, $t\bar{t}W$, $t\bar{t}H$, as well as sizeable backgrounds due to charge mis-identification and photon conversion. Particular focus is given to the multi-variate techniques used in signal extraction, which has led to significant improvement in the signal sensitivity.

T 88.10 Thu 18:45 L-4.001

Signal extraction with ANNs for $t\bar{t}t\bar{t}$ production in the same–sign dilepton and multilepton channels at the LHC with the ATLAS detector — Ö. Oğul Öncel, •Niklas W. Schwan, and Markus Cristinziani — Universität Bonn

Artificial Neural Networks (ANNs) have become an increasingly popular multivariate method in particle physics. They are used in a wide range of applications such as vertex reconstruction, particle identification, calorimeter energy estimation and jet tagging.
In this talk, ANNs are considered for improving the signal extraction in the $t\bar{t}t\bar{t}$ analysis carried out by the ATLAS collaboration in the same-sign dilepton and multilepton channels; using the data collected during 2015–2018 with 139.4fb^{-1} integrated luminosity and at a centre-of-mass energy of 13 TeV. The $t\bar{t}t\bar{t}$ events are produced in proton–proton collisions at the LHC with a cross section of around 0.01pb. The dominant background processes are the irreducible contributions from $t\bar{t}Z$ and $t\bar{t}H$ production, as well as background stemming from charge misidentification and photon conversion.
The performance of the ANNs will be compared to the Boosted Decision Tree method currently being used in the analysis. Different kinds of architectures are considered such as Feedforward and Recurrent Neural Networks which can take advantage of the high jet and lepton multiplicities of the signal process. Studies on how the Neural Network distinguishes between $t\bar{t}t\bar{t}$ and background events will be presented.