T 79: Top quark production III

Time: Thursday 16:00–18:15 Location: Td

T 79.1 Thu 16:00 Td

Studies of $t\bar{t}$ production with additional heavy flavour jets in p-p collision with the ATLAS detector — •Lucas Klein, Mahsana Haleem, and Raimund Ströhmer — Julius-Maximilians-Universität Würzburg

The production of $t\bar{t}$-pairs with additional jets provides a strong test of quantum chromodynamics (QCD) predictions at high orders. Furthermore, this represents as a significant background to rare SM processes (e.g. $t\bar{t}H$, $t\bar{t}t\bar{t}$), as well as to processes beyond the standard model. The additional jets consisting of b-quarks originating from gluon splitting are particularly interesting in constraining uncertainties in the prediction of the process.

In this talk, we will show studies of $t\bar{t}$-pair production with additional b-jets in the dileptonic top decay channel using full Run 2 ATLAS data from proton-proton collision at $\sqrt{s} = 13\,\text{TeV}$. Events are chosen by requiring an oppositely-charged $e\mu$-pair and at least two b-jets in the final state as a baseline selection. The backgrounds originating from $t\bar{t}$ events with additional light- or c-flavour jets ($t\bar{t}l$, $t\bar{t}c$) misidentified as b-jets in exclusive 3 b-tagged jet and ≥ 4 b-tagged jet regions are estimated using a data-driven method. The additional jet multiplicity and various kinematic distributions in the $t\bar{t}$ predictions will be compared to the data at the particle-level in ≥ 3 b-jet and ≥ 4 b-jet regions.

T 79.2 Thu 16:15 Td

Differential measurement of the $t\bar{t} + b\bar{b}$ cross section in the lepton+jet channel at the CMS experiment — •Jan van der Linden[1], Ulrich Husemann[1], Emanuel Pfeffer[1], and Matthias Schröder[2] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Universität Hamburg

The associated production of bottom quarks with a pair of top quarks ($t\bar{t} + b\bar{b}$) is an important irreducible background for searches of Higgs boson production in association with a pair of top quarks ($t\bar{t}+H$). Due to the large mass difference between the light bottom quarks and the heavy top quarks, the modeling of the $t\bar{t}+b\bar{b}$ process is very challenging and is still today associated with large uncertainties. Past measurements of the inclusive cross section of that process also showed discrepancies between the predicted and measured cross sections, which can be attributed to the challenging modeling. Furthermore, different Monte Carlo simulation methods show significant differences in the modeling of this process.

Hence a measurement of the inclusive, as well as differential, cross section of $t\bar{t} + b\bar{b}$ production is performed at the CMS experiment in the lepton+jet decay channel of the $t\bar{t}$ system. The measurement will provide an important input for the development and tuning of future Monte Carlo generators, to describe the physics of the $t\bar{t} + b\bar{b}$ process more accurately.

In this talk an overview of the ongoing analysis, targeting the full Run-2 period of the LHC, is given.

T 79.3 Thu 16:30 Td

Assignment methods for b jets in $t\bar{t}$+$b\bar{b}$ processes in the lepton+jets channel at the CMS experiment. — •Emanuel Pfeffer, Ulrich Husemann, and Jan van der Linden — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

The associated production of bottom quarks with a top quark-antiquark pair is a large irreducible background in measurements of $t\bar{t}H$ in $H \to b\bar{b}$ decays at the Large Hadron Collider which are important to test the Standard Model and to constrain Physics beyond the Standard Model. Additionally, the process itself is of particular interest due to its multiscale QCD nature. In order to better understand the process, the b jets must be assigned to their origin. In the final state of a $t\bar{t}$+$b\bar{b}$ event it is unknown which b jets originate from top quark decays and which b jets are not associated with the top quarks. Therefore, the question should be answered: Which methods allow for an assignment of the b jets to their origin and how accurate is the assignment? The talk gives an overview of different strategies to assign the b jets and evaluates the accuracies of the methods. These methods range from straightforward observables to sophisticated reconstructions with deep neural networks.

T 79.4 Thu 16:45 Td

Differential measurement of ttbar in association with a photon — •Beatriz Lopes, Alessia Saggio, and Abideh Jafari — DESY, Hambueg, Germany

Precision measurements of top quark production provide a test ground for the Standard Model (SM) predictions and for phenomena beyond the SM.

In this context, the production of $t\bar{t}$ in association with a photon is an important process. It is sensitive to the electroweak top-photon coupling, which can be constrained by cross-section measurements. The results can also be interpreted in the context of Effective Field Theory, where new physics scenarios that predict modifications to the $t - \gamma$ interaction can be constrained.

In this talk, I will present several differential cross-section measurements of this process in the dilepton channel, using lepton, photon and top variables. This measurement is based on data collected by the CMS experiment at the LHC during the full Run 2 (2016-2018).

T 79.5 Thu 17:00 Td

Z boson reconstruction in $t\bar{t}Z$ final states with four charged leptons using deep neural networks at 13 TeV with the ATLAS detector — Steffen Korn, Arnulf Quadt, •Tomke Schröer, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

The production of a top quark in association with a Z boson gives access to the electroweak coupling between the top quark and the Z boson, which provides sensitivity to the third component of the top-quark's weak isospin. In the tetralepton channel, the Z boson and both top quarks decay leptonically. This channel is of major interest as it comes with a high signal purity. In this talk, the application of a deep neural network for the reconstruction of the Z boson is presented. The reconstruction includes the correct assignment of the leptons originating from the Z boson and the origin of the Z boson itself. This is an important aspect since it provides access to the t–Z system. When the Z boson is emitted by one of the top quarks, the structure and strength of the coupling between the top quark and the Z boson can be probed within the framework of the Standard Model Effective Field Theory (SMEFT). Deviations from the Standard Model (SM) prediction would indicate physics beyond the SM.

T 79.6 Thu 17:15 Td

Measurement of the $t\bar{t}Z$ production cross section in the dilepton channel with ATLAS — 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 work 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 $139\,\text{fb}^{-1}$, have been used.

T 79.7 Thu 17:30 Td

Calibration of the prompt lepton veto in a cross-section measurement of top-quark pair production in association with a W boson — •Marcel Niemeyer, Arnulf Quadt, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-

August-Universität Göttingen

The top-quark pair production in association with a W boson is an important background to processes like $t\bar{t}H$ or 4-tops production. Due to higher order electroweak corrections, the process is difficult to model. In consequence, a mismodelling of $t\bar{t}W$ has been observed in previous analyses. Thus, it is of high importance to increase our understanding of it. The analysis is performed in the multi-lepton channel, i.e. 2ℓ (same-sign) and 3ℓ, with a significant contribution from fake backgrounds. To suppress them, a prompt lepton veto is used. Its improvement and calibration will be discussed in this talk.

T 79.8 Thu 17:45 Td

Evidence 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 — Vakhtang Ananiashvili[1], •Ö. Oğul Öncel[1], Niklas Werner Schwan[1], and Markus Cristinziani[2] — [1]Physikalisches Institut, Universität Bonn — [2]Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

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 at $\sqrt{s}$=13 TeV 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.

The recently established evidence 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 backgrounds from the $t\bar{t}Z$, $t\bar{t}H$, and $t\bar{t}W$ processes, as well as sizeable backgrounds due to charge misidentification and photon conversion.

T 79.9 Thu 18:00 Td

Studies on the reconstruction of multiple top quarks in the $t\bar{t}t\bar{t}$ production in same-sign dilepton final states using Boosted Decision Trees with the ATLAS detector — Vakhtang Ananiashvili[1], Peter Johannes Falke[1], •Ö. Oğul Öncel[1], Niklas Werner Schwan[1], and Markus Cristinziani[2] — [1]Physikalisches Institut, Universität Bonn — [2]Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

Recently, ATLAS has established the evidence for the $t\bar{t}t\bar{t}$ process in the same-sign dilepton and multilepton channels, using 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.

The analysis is impacted particularly from large $t\bar{t}Z$, $t\bar{t}H$, and $t\bar{t}W$ backgrounds, as well as small but persistent $t\bar{t}t$ background. This talk presents studies made on the reconstruction of multiple top-quarks in the same-sign dilepton final states of the $t\bar{t}t\bar{t}$ process. The $t\bar{t}t\bar{t}$ process presents significant challenges for top-quark reconstruction in both, hadronic and leptonic decay modes due to the large number of jets, inflating the possible number of combinations, as well as multiple neutrinos in the event that cannot be reconstructed by the detector.

Boosted Decision Trees are employed to reconstruct top-quarks based on an object-level training, in which all possible combinations in an event are evaluated and assigned a score. The performance of the reconstruction is investigated by comparison to Monte-Carlo truth information, and its impact on the analysis sensitivity is evaluated by using this additional information in the statistical analysis.