T 103: Top physics 4 (tt+X)

Time: Thursday 16:00–18:00 Location: Geb. 30.95: Audimax

T 103.1 Thu 16:00 Geb. 30.95: Audimax

Separation of events with three top quarks from events with four top quarks — Steffen Korn, •Sophia Pennuttis, Arnulf Quadt, and Sreelakshmi Sindhu — Georg-August-Universität Göttingen

The production of three top quarks in the Standard Model is only possible in association with a W boson or a quark, making it challenging to separate the process from the four top production process. Both of these processes are sensitive to the top-Higgs Yukawa coupling, the precise measurement of which is important to identify evidence for physics beyond the Standard model (BSM). Furthermore, their cross-sections could be enhanced by various BSM effects, like flavour-changing neutral currents. While the production process of four top quarks has already been observed by ATLAS and CMS, the measurement of the much rarer three top production has not been possible yet. The ability to separate the two processes is a prerequisite to the observation of three top production in a combined measurement. To achieve this, neural networks are trained on various kinematic variables considering final states with two same sign leptons and those with at least three leptons, using the LHC Run2 and Run3 datasets.

T 103.2 Thu 16:15 Geb. 30.95: Audimax

Classification of $t\bar{t}$+X (heavy flavour) processes at the CMS experiment — •Rufa Kunnilan Muhammed Rafeek[1], Ulrich Husemann[1], Emanuel Pfeffer[1], Jan van der Linden[2], and Michael Wassmer[1] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]Institute of Experimental Particle Physics and Gravity, Ghent University (BE)

Top quark - antiquark pairs ($t\bar{t}$) produced in association with other particles (X) where X can be the Higgs boson, Z/W boson or QCD-initiated heavy flavour jets ($b\bar{b}/c\bar{c}$), plays a significant role in experimental studies at the LHC.
The analysis is challenging as these processes, particularly when the bosons decay into heavy flavour quarks, like for example, $t\bar{t}+H(H\rightarrow b\bar{b})$ and $t\bar{t}+b\bar{b}$ or $t\bar{t}+Z(Z\rightarrow b\bar{b})$, share the same signature and kinematic features. These high jet multiplicity final states create ambiguities in the reconstruction and identification of these processes and thus, it is hard to differentiate them from each other.
The complex task of simultaneously measuring these $t\bar{t}+X$ processes is made by exploring advanced machine learning techniques such as Graph Neural Networks. The primary objective is to distinguish the additional heavy flavour jets, treated as a binary classification task, from the one originating in the $t\bar{t}$-system. This differentiation is crucial for subsequent multi-class event classification, encompassing categories such as $t\bar{t}+b\bar{b}$, $t\bar{t}+H(b\bar{b})$, $t\bar{t}+Z(b\bar{b})$ and $t\bar{t}+c\bar{c}$.
In this talk the current status of such a measurement for the separation of these events, using the $t\bar{t}$ single lepton channel is presented.

T 103.3 Thu 16:30 Geb. 30.95: Audimax

$t\bar{t}$+heavy flavor event classification with graph neural networks at the CMS experiment — •Emanuel Pfeffer[1], Ulrich Husemann[1], Rufa Rafeek[1], Jan van der Linden[2], and Michael Wassmer[1] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]Institute of Experimental Particle Physics and Gravity, Ghent University (BE)

Processes in which a top quark-antiquark pair is produced in association with additional heavy flavor jets are difficult to separate from each other. Such processes include $t\bar{t}$+$b\bar{b}$ and $t\bar{t}$+$c\bar{c}$, where the additional heavy flavor quark-antiquark pair stems from gluon splitting, as well as $t\bar{t}$+H with H $\rightarrow$ $b\bar{b}$ and $t\bar{t}$+Z with Z $\rightarrow$ $b\bar{b}$. Machine learning methods based on graph neural networks are promising techniques for enhancing the classification accuracy of these events in the $t\bar{t}$+heavy flavor phase space. In this talk the latest status of a simultaneous measurement of the production cross section of a top quark-antiquark pair in association with heavy flavor jets in the dileptonic decay channel at the CMS experiment is presented.

T 103.4 Thu 16:45 Geb. 30.95: Audimax

Inclusive cross-section measurements of top-quark pair production in association with charm quarks with the ATLAS experiment — •Matthew Kingston, Arnulf Quadt, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August-Universität Göttingen

The production of top-quark pairs in association with charm quarks is an irreducible background to rare final states such as $t\bar{t}H$ and $t\bar{t}t\bar{t}$, as well as being a particular challenge for QCD modelling due to the uncertainties in the choice of factorisation and renormalisation scales. The first ATLAS measurement of the inclusive total and fiducial cross-section of this process is performed using data corresponding to an integrated luminosity of 140 fb^{-1}, collected by the ATLAS experiment at the LHC between 2015 and 2018 at a centre-of-mass energy of 13 TeV. Measurements are performed in both the dileptonic and semi-leptonic channels, and their combination. A custom heavy-flavour tagging algorithm is used to distinguish jets originating from b and c quarks, based on the standard ATLAS DL1r tagger. This presentation will focus on the work done to understand systematic uncertainties. The measurements of the cross-section as well as of the ratio of $t\bar{t}+\geq 2c$ and $t\bar{t}+1c$ production over inclusive production of $t\bar{t}$+jets are compared with predictions of the state-of-the-art NLO+PS Monte Carlo simulations of $t\bar{t}$ production.

T 103.5 Thu 17:00 Geb. 30.95: Audimax

joint ttZ and tZq measurement — Steffen Korn, •Sebastian Preuth, Arnulf Quadt, Baptiste Ravina, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

Single top (tZq) and top pair production (ttZ) in association with a Z boson are important channels for studying the electroweak sector and potential deviations from Standard Model predictions. The two signals are measured jointly in the reprocessed Run 2 dataset, using an analysis model compatible with a future Run 3 measurement. The dataset, corresponding to a centre-of-mass energy of 13 TeV and an integrated luminosity of 140 fb^{-1}, is used to extract the ttZ and tZq production cross sections and set constraints on the top-Z couplings. The analysis targets final states with three leptons and additional b-jets. To improve the background estimation, which is dominated by diboson production, neural networks are used.

T 103.6 Thu 17:15 Geb. 30.95: Audimax

Prospects for ttW in Run3 — Steffen Korn, •Tobias Moritz, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

The process, where a top-quark anti-top pair is produced in association with a W-boson ($t\bar{t}W$), was first observed by ATLAS and CMS in Run 1 of the LHC. First differential cross-section measurements and precision inclusive measurements only became available with Run 2 of the LHC and show some friction between the theory prediction and the measured cross-section.

$t\bar{t}W$ is one of the heaviest final state that is accessible at the LHC and produced via quark-antiquark annihlation at leading order. The W-boson is emitted by either particle in the initial state. $t\bar{t}W$ has a relatively small cross-section. Nonetheless, it is an important background for other searches at the LHC, as it is one of the few irreducible sources of same-sign lepton pairs.

In order to prepare for a Run 3 analysis of $t\bar{t}W$ new MC samples need to be produced corresponding to the higher center-of-mass energy of $\sqrt{s} = 13.6$ TeV and the upgrades to the ATLAS detector. This talk will present ongoing efforts concerned towards a Run 3 analysis.

T 103.7 Thu 17:30 Geb. 30.95: Audimax

Reinterpretation of the recent ATLAS $t\bar{t}W$ measurement in the framework of the SMEFT — Marcel Niemeyer, Arnulf Quadt, Baptiste Ravina, Elizaveta Shabalina, and •Sreelakshmi Sindhu — II. Physikalisches Institut, Georg-August-Universität Göttingen, Germany

The Standard Model Effective Field Theory (SMEFT) provides a model independent approach to study beyond the Standard Model effects. A search for new physics using the framework of the SMEFT is performed using events with one or two top quarks in association with a boson ($t\bar{t}W$, $t\bar{t}Z$, tZ, $t\bar{t}H$, tH). The simultaneous analysis of these processes gives the opportunity to constrain a large number of dimension six SMEFT operators.

In this analysis, final states with two same sign or three isolated leptons are selected and classified into various regions based on the

number of leptons, jets, b-jets and the total charge of the leptons. Using the event yields in these regions, limits are extracted on the SMEFT operators. This measurement is performed using the proton-proton collision data at $\sqrt{s} = 13$ TeV with an integrated luminosity of 139 fb^{-1}, recorded from 2015 to 2018 with the ATLAS experiment at the Large Hadron Collider at CERN.

T 103.8 Thu 17:45 Geb. 30.95: Audimax

Fitting SMEFT with a CLEW — •Tom Tong — Universität Siegen

Semileptonic charged-current interactions are crucial for exploring the nuances of the Standard Model and its possible extensions. Recent examinations have underscored discrepancies with the SM predictions, particularly in the Cabibbo Angle Anomaly (CAA), which demonstrates a 3 sigma deviation from zero. In this paper, we undertake a rigorous analysis using the SMEFT framework to shed light on potential BSM sources of the CAA. By integrating insights from collider processes (C), low-energy processes (L), and electroweak precision observables (EW), we introduce a holistic CLEW approach. Our analysis underscores the significance of a global CLEW perspective in vetting BSM propositions that align with observations across scales, from the weak to the TeV range. While our initial impetus revolves around the CAA, our findings naturally establish a foundational CLEW framework, poised to significantly influence future SMEFT investigations, especially those sidelining severe phenomenological constraints, including FCNCs and CP violations. We will touch upon preliminary results within the ambit of the U(3)^5 flavor assumption, followed by an in-depth exploration of a flavor-assumption-independent analysis. In this broader analysis, we have incorporated the Akaike Information Criterion (AIC). When combined with the chi-square method, the AIC promotes a model that not only aligns well with experimental data but also circumvents unnecessary complexities, accentuating the challenges and prospective avenues for model-independent global analyses.