T 88: Top Quarks: Production (Exp.) 3

Time: Thursday 16:15–18:30 Location: T-H19

T 88.1 Thu 16:15 T-H19

Studies of modern generators for top-quark pair-production — •Dominic Hirschbühl, Jens Roggel, and Wolfgang Wagner — Bergische Universität Wuppertal, Deutschland

The precise simulation of $t\bar{t}$ processes is crucial for precision tests of the Standard Model and in the search for new physics at the Large Hadron Collider. Several important new event generators for the simulation of $t\bar{t}$ production have been released in the last years. The "$bb4\ell$" generator is a NLO matrix-element generator for $pp \to b\bar{b}\ell^+\ell^{-\prime}\nu\bar{\nu}'$ final states implemented in the POWHEG-BOX. It includes theoretical improvements in the simulation of $t\bar{t}$ processes, which allows the production of $t\bar{t}$ and tW events including interference, off-shell effects, and top-quark decays at NLO. In this talk comparisons of these predictions with unfolded ATLAS data as well as with predictions for different DR and DS models implemented in MG5_aMC@NLO are shown. A second major improvement is the MINNLOPS implementation of the $t\bar{t}$ process in the POWHEG-BOX, which can be used to generate the $t\bar{t}$ production at NNLO. Studies of several parameter variations and an optimised setup for the NNLO generator matched with Pythia8 are presented.

T 88.2 Thu 16:30 T-H19

Machine learning approaches for parameter reweighting in MC samples of top quark production — •Valentina Guglielmi, Katerina Lipka, and Simone Amoroso — DESY, Hamburg, Germany

In high-energy particle physics, complex Monte Carlo simulations are needed to connect the theory to measurable quantities. Often, the significant computational cost of these programs becomes a bottleneck in physics analyses.

In this contribution, we evaluate an approach based on a Deep Neural Network to reweight simulations to different models or model parameters, using the full kinematic information in the event. This methodology avoids the need for simulating the detector response multiple times by incorporating the relevant variations in a single sample.

We test the method on Monte Carlo simulations of top quark pair production, that we reweight to different SM parameter values and to different QCD models.

T 88.3 Thu 16:45 T-H19

Modelling $t\bar{t}$ + jets with the Sherpa fusing approach — •Lars Ferencz[1], Judith Katzy[1], Frank Siegert[2], Stefan Höche[3], Chris Pollard[4], and Johannes Krause[2] — [1]DESY, Hamburg, Germany — [2]IKTP, Dresden, Germany — [3]Fermilab, Chicago, United States — [4]University of Oxford, Oxford, United Kingdom

Analyses interested in measuring the production of a top quark pair in association with a Higgs boson decaying into a $b\bar{b}$ final state rely on the MC modelling or irreducible backgrounds like $t\bar{t} + b\bar{b}$, $t\bar{t} + c\bar{c}$ and $t\bar{t}$+light jets. Recently MCs with massive b-quarks in the $t\bar{t}b\bar{b}$ ME@NLO (so called 4FS) predictions became available and are used for the $t\bar{t}b\bar{b}$ related backgrounds. However, in order to predict the background for the analysis, they need to be combined with calculations of $t\bar{t} + c\bar{c}$ and $t\bar{t}$ + light jets taken from a different calculation based on massless quarks (5FS). This talk will present a method for embedding a $t\bar{t}b\bar{b}$ 4 FS prediction into a multi-leg tt+jets 5 FS prediction using the Sherpa MC generator. This method is called "Sherpa Fusing". This approach would make it possible to predict the various $t\bar{t}$ + jets components like $t\bar{t}$ + light jets, $t\bar{t}$ + c-jets and $t\bar{t}$ + b-jets in a single sample, while ensuring the coverage of the full phase space. This talk will introduce the fusing method and present results comparing the fused predictions to standalone $t\bar{t}$+ jets and $t\bar{t}b\bar{b}$ predictions.

T 88.4 Thu 17:00 T-H19

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 production 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 fiducial cross-sections for a phase space with at least one and at least two additional b-jets at particle-level will be shown and compared. Differential cross-section distributions for several variables in ≥ 3 b-jet and ≥ 4 b-jet regions will also be shown and compared to several theoretical predicions.

T 88.5 Thu 17:15 T-H19

Measurement of the associated production of top-antitop pair with charm jets using the DL1r b-tagging algorithm in the dileptonic final state — •Moritz Habbaba, Arnulf Quadt, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August-Universität Göttingen

Top-antitop pair production production accompanied by a quark-antiquark pair is an important background for many measurements and searches. Top- antitop pair production in association with a bottom-antibottom pair has been measured with relatively good precision inclusively and differentially using powerful b-tagging tools. The b-tagging algorithms have a long and stable history within the analysis tools of particle physics. Dedicated tagging algorithms for charm quarks on the other hand have not been widely used. This work investigates the possibilities of using existing b-tagging tools for c-tagging. The expected signal purity that can be achieved by using DL1r b-tagging algorithm for the purpose of c-jet tagging is investigated. The optimal signal regions in the dilepton ttbar final state are defined and expected uncertainty on the $t\bar{t} + c\bar{c}$ cross section is evaluated.

T 88.6 Thu 17:30 T-H19

Results of differential $t\bar{t}$+$b\bar{b}$ measurement in the lepton+jets channel at the CMS experiment — •Jan van der Linden, Ulrich Husemann, and Emanuel Pfeffer — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Due to the large mass difference between the light bottom quarks and the heavy top quarks, the modeling of the associated production of bottom quarks with a pair of top quarks ($t\bar{t}$+$b\bar{b}$) is very challenging and is still associated with large uncertainties today. 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 event generation methods show significant differences in the modeling of this process, for example in the different treatment of heavy flavors in the parton density functions or the simulation of the additional QCD radiation via parton showering or matrix element simulation.

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

In this talk results of this analysis, using data from the full Run-2 period of the LHC, are discussed.

T 88.7 Thu 17:45 T-H19

Simultaneous measurement of tt+X(bb) processes in the semileptonic channel at the CMS experiment — •Rufa Rafeek, Emanuel Pfeffer, Jan van der Linden, Michael Wassmer, and Ulrich Husemann — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Top quark anti-quark pairs ($t\bar{t}$) are produced in association with other particles (X) where X can be the Higgs boson, Z/W boson or QCD-initiated heavy flavour jets ($b\bar{b}/c\bar{c}$). The measurement of $t\bar{t} + X$ is a direct probe of the coupling of standard model particles like the Higgs and Z boson to the top quark and may reveal new physics effects in

modifications of these couplings.
The analysis is challenging as these processes, particularly when the bosons decay into heavy flavour quarks, like for example, $t\bar{t} + H(H \to b\bar{b})$ and $t\bar{t} + b\bar{b}$ or $t\bar{t} + Z(Z \to b\bar{b})$, 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. Due to this challenge, an attempt to simultaneously measure these $t\bar{t} + X$ processes is made by exploring multivariate analysis strategies.
In this talk, an overview of the ongoing analysis, designed with the full Run-2 data of the LHC using the single lepton channel, is given.

T 88.8 Thu 18:00 T-H19

Graph neural network applications in $t\bar{t}$+heavy flavor studies at the CMS experiment — •Emanuel Pfeffer, Max Erhart, Ulrich Husemann, Rufa Rafeek, Jan van der Linden, and Michael Wassmer — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Graph neural networks are a promising and novel method of artificial intelligence. In contrast to other classes of machine learning, graphs may be better at mapping relationships and dependencies among objects such as jets and at learning interconnections. The application of these networks is particularly interesting in processes consisting a pair of top quarks produced in association with bottom quarks ($t\bar{t}$+$b\bar{b}$) and other indistinguishable processes such as $t\bar{t}$+H with H $\to$ $b\bar{b}$ or $t\bar{t}$+Z with Z $\to$ $b\bar{b}$. Initial studies show promising results in identifying the b jets not originating from the decay of the top quarks in such processes. The graph neural network studies show better results than previous ones based on conventional deep neural networks.
This talk gives an overview of the applications and results of jet assignments in $t\bar{t}$+heavy flavor processes at the CMS experiment using graph neural networks.

T 88.9 Thu 18:15 T-H19

Studies on $t\bar{t}$+$c\bar{c}$/$t\bar{t}$+$b\bar{b}$ separation — •Max Erhart, Ulrich Husemann, Jan van der Linden, Emanuel Pfeffer, and Rufa Rafeek — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Bottom jets and charm jets have very similar signatures and their identification techniques (b-tagging, c-tagging) use similar approaches, thus misidentification between these jets is common. Therefore the production of a top quark pair ($t\bar{t}$) in association with heavy flavor jets, i.e. charm and bottom ($t\bar{t}$+$c\bar{c}$, $t\bar{t}$+$b\bar{b}$), is an important, irreducible background to analyses targeting top quark pairs with additional bottom quark jets such as associated Higgs boson production with a subsequent Higgs boson decay into bottom quarks ($t\bar{t}$+H($b\bar{b}$)). The modeling of the additional bottom or charm jets also suffers from large uncertainties in theroetical calculations due to the difference in mass scale for the large top quark mass and the relatively light bottom or charm quarks.

Due to the similarities of these processes a simultaneous measurement of the production cross section for heavy flavor jets in association with top quarks in the dileptonic final state of the top quarks is being conducted at the CMS experiment.

In this talk an overview of the ongoing analysis and the analysis strategies to separate the $t\bar{t}$+$b\bar{b}$, $t\bar{t}$+H($b\bar{b}$), $t\bar{t}$+Z($b\bar{b}$) and $t\bar{t}$+$c\bar{c}$ processes from one another is given.