

## T 65: Top quarks: differential cross sections

Time: Wednesday 16:30–19:00

Location: H-HS VIII

T 65.1 Wed 16:30 H-HS VIII

**Top-antitop energy asymmetry in jet-associated top-quark pair production at ATLAS** — ●ALEXANDER BASAN, PETER BERTA, LUCIA MASETTI, and EFTYCHIA TZOVARA — Johannes Gutenberg University Mainz

The top quark is particularly well suited to probe the standard model (SM) and many extensions thereof at the electroweak symmetry-breaking scale and beyond.

At hadron colliders, the  $t\bar{t}$  production is symmetric at leading order perturbation theory under the exchange of the top- and anti-top-quark, while interferences at higher orders create an asymmetry. This charge asymmetry can provide sensitive probes for many models beyond the standard model like massive color-octet states, extra dimensions, flavor violating gauge bosons and axiglons. Within the framework of effective field theories (EFT), the charge asymmetry is especially sensitive to four-quark operators and one operator that modifies the top-gluon interaction.

In inclusive jet-associated top-quark pair production the asymmetry arises already at leading order in quark-gluon interactions. Furthermore, the  $t\bar{t}j$  final states allow the definition of a new observable, the energy asymmetry, expressed in terms of the distribution of the energy difference  $E_t - E_{\bar{t}}$ .

This talk presents the measurement strategy in lepton+jets events with a high  $p_T$  hadronically decaying top quark at ATLAS with a center of mass energy of  $\sqrt{s} = 13$  TeV as well as expected sensitivities to the Wilson coefficients.

T 65.2 Wed 16:45 H-HS VIII

**Bestimmung der Energie-Asymmetrie im Top-Quark-Paarsystem mit einem zusätzlichen Jet mit dem CMS-Experiment** — DARIUS BÜHLER, THORSTEN CHWALEK, NILS FALTERMANN, THOMAS MÜLLER, ●JOHANN RAUSER und SIMON WEISSER — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Mit dem aufgenommenen Datensatz von Run 2 eröffnet sich am LHC die Möglichkeit, die Eigenschaften des Top-Quarks mit noch höherer Präzision zu vermessen. Von besonderem Interesse sind hierbei Asymmetrien im Top-Quark-Paarsystem, da Abweichungen von der Theorie-Erwartung ein Indiz auf Physik jenseits des Standardmodells sein können. Bisherige Analysen am Tevatron und am LHC mit den Daten von Run 1 fokussierten sich auf Rapiditäts-Asymmetrien; ein Effekt, der sich mit steigender Schwerpunktsenergie verringert.

Die Energie-Asymmetrie ist eine speziell auf den LHC zugeschnittene Observable im Kanal der Top-Quark-Paarproduktion mit einem zusätzlichen Jet. Diese verspricht bei einer Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV einen signifikant messbaren Effekt. Im Vortrag wird die Messung der Energie-Asymmetrie am CMS-Experiment vorgestellt.

T 65.3 Wed 17:00 H-HS VIII

**Measurements of observables sensitive to color reconnection in  $t\bar{t}$  dilepton events** — ●SHAYMA WAHDAN<sup>1</sup>, DOMINIC HIRSCHBÜHL<sup>1</sup>, WOLFGANG WAGNER<sup>1</sup>, THORSTEN KUHLE<sup>2</sup>, ANDREA KNUE<sup>3</sup>, FREDERIC DELIOT<sup>4</sup>, TETIANA MOSKALETS<sup>4</sup>, and CLEMENT HELSENS<sup>5</sup> — <sup>1</sup>Wuppertal — <sup>2</sup>DESY — <sup>3</sup>Freiburg — <sup>4</sup>Saclay CEA — <sup>5</sup>CERN

The color reconnection (CR) modelling uncertainty could become one of the dominant sources of systematic uncertainties in the top mass determination. Ongoing top-quark mass analyses use the PYTHIA 8 MC generator for parton showering and hadronization. PYTHIA 8 comes with several alternative CR models which should be explored to estimate the CR modelling uncertainty. At the same time, the models should be confronted with collision data to test their validity. Only models which are in agreement with data in general are suitable to define the corresponding modelling uncertainty. An investigation to find the most discriminating observable between these models has been done in  $t\bar{t}$  dilepton events. The sensitive observables use tracks associated to the vertex of the hard scattering (primary vertex). The selected tracks are still diluted with pile-up tracks and tracks of secondary particles. Therefore, a pile-up model is developed to subtract the pile-up contribution. The observables are then unfolded to the particle level.

T 65.4 Wed 17:15 H-HS VIII

**Regressionsbasierte Rekonstruktion der Top-Quark-Kinematik bei Top-Quark-Paarproduktion für das CMS-Experiment.** — ●DARIUS BÜHLER, THORSTEN CHWALEK, NILS FALTERMANN, THOMAS MÜLLER, JOHANN RAUSER und SIMON WEISSER — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Im Laufe des Run 2 am LHC wurde eine hohe Zahl von Top-Quark-Paaren erzeugt, weshalb sich dieser Produktionsmechanismus für Präzisionsmessungen der Eigenschaften des Top-Quarks eignet. Mögliche Abweichungen dieser Eigenschaften von den Vorhersagen des Standardmodells könnten wichtige Hinweise auf neue Physik liefern. Für die Vermessung verschiedener Eigenschaften – beispielsweise von Asymmetrien im Top-Quark-Paarsystem – ist eine möglichst genaue Kenntnis der Kinematik von Top-Quark und Top-Antiquark erforderlich.

Klassische Rekonstruktionsansätze basieren auf der Zuordnung von im Detektor gemessenen Objekten, in diesem Fall Leptonen und Jets, zu den nach dem Zerfall des Top-Quark-Paares erwarteten Teilchen. Die rekonstruierte Kinematik der Top-Quarks ergibt sich durch Addition der Vierervektoren der entsprechenden Detektorobjekte.

Im Vortrag werden Studien zu einem anderen Ansatz am CMS-Experiment vorgestellt, der auf der Regression von Top-Quark- und Top-Antiquark-Kinematik mittels neuronaler Netze aufbaut. Dabei wird die Geometrie herkömmlicher neuronaler Netze durch spezielle Strukturen erweitert, die auch in modernen Verfahren der Bildanalyse Anwendung finden.

T 65.5 Wed 17:30 H-HS VIII

**Measurements of differential cross sections for  $t\bar{t}$  production at  $\sqrt{s} = 13$  TeV with the CMS experiment** — MARIA ALDAYA, OLAF BEHNKE, ●HENRIETTE PETERSEN, MYKOLA SAVITSKYI, RAFAEL SOSA, and SEBASTIAN WUCHTERL — Deutsches Elektronen Synchrotron (DESY)

Precision tests of the Standard Model are of utmost importance in particle physics, not only in terms of testing existing theories but also in probing the realm of new physics. The top quark is of particular interest in this context as its heavy mass can link it to production- and decay-modes of new processes at higher energy scales. In this talk measurements of differential cross sections for  $t\bar{t}$  production at  $\sqrt{s} = 13$  TeV will be presented. The analysis is based on data obtained with the CMS experiment during 2016, 2017 and 2018 in Run 2 of the LHC which corresponds to an integrated luminosity of  $137 \text{ fb}^{-1}$ . In this period of time more than 100 million  $t\bar{t}$  events have occurred and as such this facilitates unprecedented precision in measurements of kinematic spectra and topologies in these events. The analysis is performed using the dileptonic decay channel. We perform differential measurements of the  $t\bar{t}$  production cross section in bins of kinematic properties of the visible decay products,  $t\bar{t}$  system and top quark.

In this talk the general analysis strategy will be presented. This constitutes an overview of the event selection, kinematic reconstruction of the  $t\bar{t}$  system, cross section unfolding procedure and the first results for full Run 2 differential cross sections compared to MC predictions based on NLO QCD models matched to parton showers.

T 65.6 Wed 17:45 H-HS VIII

**Measurement of multi-differential cross sections for the production of top quark pairs plus additional jets in pp collisions at  $\sqrt{s}=13$  TeV.** — MARIA ALDAYA, OLAF BEHNKE, HENRIETTE PETERSEN, MYKOLA SAVITSKYI, ●RAFAEL E. SOSA RICARDO, and SEBASTIAN WUCHTERL — Deutsches Elektronen-Synchrotron DESY.

Measurements of multi-differential cross sections for top quark pair ( $t\bar{t}$ ) production in pp collisions at a centre-of-mass energy of  $13 \text{ TeV}$  using events containing two opposite-sign leptons will be presented. The analyzed dataset was recorded with the CMS detector during the years 2016, 2017 and 2018, corresponding to an integrated luminosity of  $137 \text{ fb}^{-1}$ . The  $t\bar{t}$  cross sections are measured double and triple-differentially as a function of the  $t\bar{t}$  system kinematics, the top quark and of additional jets in the event.

This talk comprises an overview of the analysis starting with the event selection, kinematic reconstruction of the  $t\bar{t}$  system and the cross section unfolding procedure. First cross section results will be compared to MC predictions based on NLO QCD matched to parton show-

ers.

T 65.7 Wed 18:00 H-HS VIII

**Measurement of the dileptonic  $t\bar{t}$  differential cross section in a BSM phase space at CMS** — LUTZ FELD, ●DANILO MEUSER, JOHANNES SCHULZ, and MARIUS TEROERDE — I. Physikalisches Institut B, RWTH Aachen University

Measurements of the  $t\bar{t}$  production cross section yield important precision tests of the Standard Model (SM), while also probing scenarios for physics beyond the SM (BSM). Although the dileptonic channel has the lowest branching ratio of all  $t\bar{t}$  decay channels, its sensitivity is large due to small contributions from other SM processes, making this channel a great candidate for precision measurements of the  $t\bar{t}$  process.

This analysis aims to measure the  $t\bar{t}$  cross section in a phase space where additional contributions from BSM scenarios could be present. It is based on the data set recorded by CMS in the years 2016 to 2018 at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of  $137.2 \text{ fb}^{-1}$ . The BSM scenarios considered include supersymmetric and dark matter models, where, similarly to the dileptonic  $t\bar{t}$  channel, two leptons, b jets and undetected particles are produced. Unlike previous measurements, where the differential cross sections were mainly measured as a function of kinematic variables of the leptons or top quarks, this analysis focuses on observables related to the neutrinos, like the missing transverse momentum, to separate BSM from SM  $t\bar{t}$  events.

T 65.8 Wed 18:15 H-HS VIII

**Differential Measurement of the Associated Production of a Single Top Quark and a Z Boson at the CMS Experiment** — ●DAVID WALTER — DESY, Hamburg, Germany

The top quark is the heaviest particle of the standard model (SM) and can be produced through strong interactions in top quark-antiquark pairs, or polarised as a single top quark (or antiquark) via the electroweak interaction. The associated production of a single top quark and a Z boson ( $pp \rightarrow tZq$ ) includes the  $tZ$  coupling as well as the coupling of three vector bosons (WWZ) and is therefore a unique process to study the couplings of heavy particles in the SM. As early as 2018, the CMS Collaboration observed the SM production of  $tZq$  in its final state with three leptons. It was found to be in agreement with the SM prediction. In an ongoing analysis, a differential cross section measurement is being pursued. This can give more detailed insight into the modeling of the process in the SM while some of the distributions are

also sensitive to beyond SM effects.

In this presentation, the analysis strategy is outlined. This includes the reconstruction of the leptons and jets as well as of the composite objects from the Z boson and the top quark. Furthermore, a multiclass neural network to isolate the signal from various background processes is shown. Based on this, first results of the signal extraction are presented. A maximum likelihood unfolding procedure is discussed to obtain results that are corrected for detector effects and effects of the hadronization process.

T 65.9 Wed 18:30 H-HS VIII

**Differential cross-section measurement of the  $tZq$  process with the ATLAS detector** — ●NILIMA AKOLKAR, CHRIS BOEVER, and IAN BROCK — Physikalisches Institut, University of Bonn

The associated production of a single top quark with a Z boson ( $tZq$ ) is a rare process confirmed by the ATLAS Collaboration in 2019. This process is of special interest, as it allows one to probe the couplings of the Z boson to the quark sector and to W bosons simultaneously.

This talk will focus on the differential cross-section measurement of the  $tZq$  process, analyzed in the trilepton decay channel. The data used was collected with the ATLAS detector during Run 2 of the LHC, corresponding to an integrated luminosity of  $139 \text{ fb}^{-1}$ . The  $tZq$  differential cross-section is measured using two different methods of unfolding and the preliminary results will be presented in the talk.

T 65.10 Wed 18:45 H-HS VIII

**Measurement of the jet mass distribution in boosted top quark decays at CMS** — JOHANNES HALLER, ROMAN KOGLER, ●ALEXANDER PAASCH, and DENNIS SCHWARZ — Institut für Experimentalphysik, Universität Hamburg

The top quark plays an essential role in particle physics and precision measurements of its mass allow consistency tests of the standard model. While most measurements of the top quark mass rely on the reconstruction of its decay products as distinct objects, this analysis targets the boosted regime where the decay products are reconstructed in a single large jet, using the exclusive cone (XCone) algorithm. The differential  $t\bar{t}$  cross section is measured as a function of the jet mass for transverse momenta larger than 400 GeV. The distribution is sensitive to the value of the top quark mass, enabling a measurement in the boosted regime. Studies are presented for a measurement in the lepton+jets channel, using data recorded by the CMS experiment in 2016, 2017 and 2018 at a center of mass energy of 13 TeV.