PROCEEDINGS OF SCIENCE

Measurement of differential top-quark-pair production cross sections in the lepton+jets channel with CMS

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A measurement is presented of normalised differential top-quark-pair cross sections in the lepton+jets decay channel (e+jets and μ+jets). The analysis is based on data of pp collisions at a centre-of-mass energy of 8 TeV at the LHC recorded by the CMS experiment in 2012, corresponding to 12.1 fb^{-1}. The cross sections are measured as a function of kinematic variables of the $t\bar{t}$ system, the top quarks and their decay products (charged leptons and b jets). The results are compared to standard-model predictions from Monte-Carlo event generators and approximate next-to-next-to-leading-order calculations. A good description of the data is observed.

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1. Introduction

The large centre-of-mass energy and luminosity at the LHC allow for a detailed investigation of top-quark-pair ($t\bar{t}$) production properties, including differential cross sections. Such distributions are a test of the standard model (SM), especially of perturbative QCD, and allow to constrain QCD parameters such as parton-distribution functions (PDFs). Furthermore, they are also relevant for scenarios beyond the SM because firstly $t\bar{t}$ events often constitute a major background in these searches and secondly these distributions are sensitive to potential new physcis effects themselves.

Already at a centre-of-mass energy of $\sqrt{s} = 7\,\text{TeV}$, using data up to $5\,\text{fb}^{-1}$, first measurements [3, 4, 5] of normalised differential $t\bar{t}$ cross sections have been performed by the CMS [1] and ATLAS [2] experiments. Here, an update of the measurement by CMS in the lepton+jets decay channel is presented, using data of pp collisions at a centre-of-mass energy of 8 TeV at the LHC recorded in 2012, corresponding to $12.1\,\text{fb}^{-1}$. More details of this analysis are presented in Ref. [6]. A complementary measurement in the dileptonic decay channel is presented elsewhere [7].

2. Event Selection, Reconstruction and Cross-Section Determination

The measurement is based on a high-purity $t\bar{t}$-event selection according to the decay topology in the lepton+jets channel. Single isolated electron or muon triggers are used. Events are required to have exactly one well-isolated and identified electron or muon with a transverse momentum of $p_T > 30\,\text{GeV}$ and a pseudorapidity range of $|\eta| < 2.1$ and at least four jets with $p_T > 30\,\text{GeV}$ and $|\eta| < 2.4$, two out of which are required to be identified as originating from b quarks. This results in 39,019 (36,822) selected events in data in the muon (electron)+jets channel. From simulation, the $t\bar{t}$ signal fraction is estimated to be 80% with major backgrounds originating from $t\bar{t}$ events of other decay channels (12%), single-top-quark events (4%) and W+jets events (2%). The background is subtracted from the selected events as estimated from the simulation.

The reconstruction of kinematic properties of the top-quark pair is performed with a kinematic fit constraining the reconstructed W-boson masses to 80.4 GeV and requiring equal reconstructed top- and antitop-quark masses.

The reconstructed distributions are corrected for detector effects such as inefficiencies and migration using a regularised unfolding. The detector response matrix is estimated from the MADGRAPH [8] $t\bar{t}$ signal simulation with data-driven corrections for the trigger and lepton-selection efficiencies. For the $t\bar{t}$-system and top-quark quantities, the distributions are unfolded to parton level and extrapolated to the full phase space, whereas the lepton and b-jet distributions are unfolded to the stable-particle level in the visible phase space.

The differential cross sections are finally normalised using the in-situ determined inclusive cross section, reducing systematic uncertainties that are correlated across all bins. The remaining uncertainties of between 3 and 10% (depending on the exact quantity and bin) are dominantly from model variations such as the MADGRAPH matching scale and the hard-scattering scale Q^2.

3. Results and Conclusions

As an example, the resulting normalised differential cross sections for the top-quark p_T and $t\bar{t}$ invariant mass distribution are shown in Fig. 1. The distributions of further quantities (rapidity of

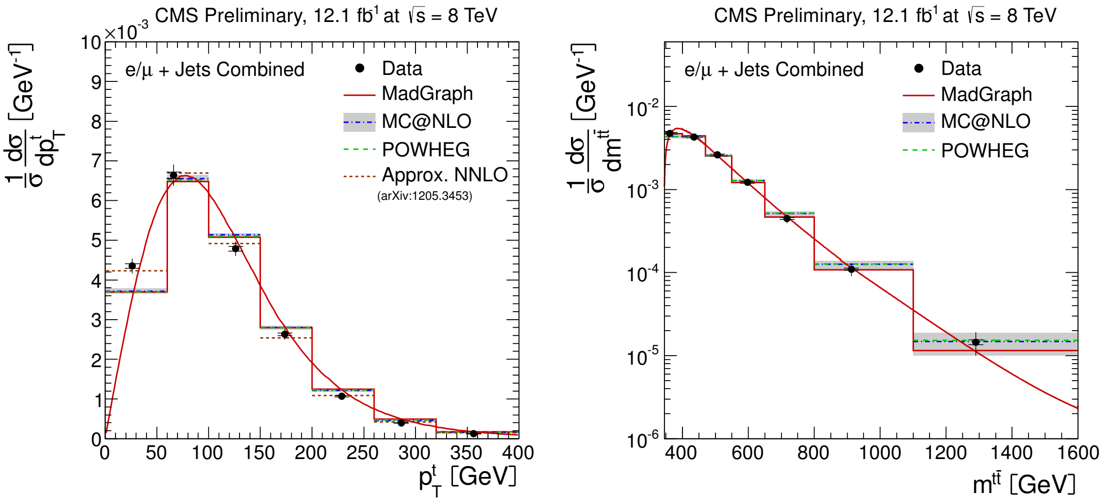

Figure 1: Normalised differential $t\bar{t}$ cross sections as a function of the p_T of the top quark (left) and the invariant mass of the $t\bar{t}$ system (right).

the top quark and the $t\bar{t}$ system; p_T of the $t\bar{t}$ system, the charged lepton and b jets; and pseudorapidity of the charged lepton and b jets) are shown in Ref. [6].

The results are compared to different model predictions from Monte-Carlo event generators. The top-quark quantities are additionally compared to approximate next-to-next-to-leading-order (NNLO) calculations [9]. Generally, a good agreement is observed between data and the various SM predictions. The top-quark-p_T distribution is measured slightly softer than the Monte-Carlo predictions, but the higher-order approximate NNLO calculation describes the data well. The results agree with those obtained in the dileptonic channel [7] and show qualitatively the same agreement between data and predictions as the ones at 7 TeV [3].

To conclude, top-quark-pair physics seems to be well-described within the SM and no signs of new physics are observed at the current level of precision.

References

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