PROCEEDINGS OF SCIENCE

Inclusive and differential $t\bar{t}$ cross-sections in ATLAS experiment

Petr Jačka, on behalf of the ATLAS experiment

Institute of Physics of the Czech Academy of Sciences,
Na Slovance 1999/2, Prague 8 182 21, Czechia

E-mail: petr.jacka@cern.ch

The latest results of inclusive and differential $t\bar{t}$ cross-section measurements in the ATLAS experiment at CERN are presented. Measurements are based on analyses of $\sqrt{s}$ = 13 TeV proton-proton stable collisions collected by the ATLAS detector, with corresponding integrated luminosities of 36.1 fb^{-1} or 139 fb^{-1}. This includes inclusive cross-section measurements in the dilepton $e\mu$ and the lepton+jets channels, which achieved significant improvements in the precision due to larger data statistics and more sophisticated techniques used. Results of $t\bar{t}$ differential cross-section measurements in three main $t\bar{t}$ system decay channels: dilepton, lepton+jets and all-hadronic resolved, are also presented. The measurement in the all-hadronic resolved channel was performed for the first time in the ATLAS experiment. All differential measurements provide double-differential spectra which allow to determine correlations between variables and which allow stringent tests of the Standard Model.

The Eighth Annual Conference on Large Hadron Collider Physics-LHCP2020
25-30 May, 2020
online

https://pos.sissa.it/

PoS(LHCP2020)067

ATL-PHYS-PROC-2020-059
16 September 2020

1. Introduction

This proceeding summarizes the latest results of inclusive and differential cross-section measurements in the ATLAS experiment [1], which were presented on The Eighth Annual Conference on Large Hadron Collider Physics. All measurements are performed using LHC pp collision data at $\sqrt{s}$ = 13 TeV collected by the ATLAS detector. This paper is organized into four sections focused on four different measurements which are performed in three different $t\bar{t}$ decay channels.

2. Inclusive and lepton differential cross-section measurements in the $e\mu$ channel

The analysis was performed on data collected in 2015 and 2016, corresponding to an integrated luminosity of 36.1 fb^{-1} [2]. The measurement selects events with exactly one electron and one muon with opposite electric charges. The inclusive $t\bar{t}$ cross-section is extracted from event yields in regions with exactly one and two b-tagged jets.

The result of the measurement is a combination of separate measurements with 2015 and 2016 data. The combination reduces the dominant uncertainty related to the integrated luminosity. The measured $t\bar{t}$ cross-section is

$$\sigma^{t\bar{t}} = 826.4 \pm 3.6\,(\text{stat}) \pm 11.5\,(\text{syst}) \pm 15.7\,(\text{lumi}) \pm 1.9\,(\text{beam})\ \text{pb}. \tag{1}$$

The four uncertainties correspond to the statistical, experimental and theoretical systematic, integrated luminosity, and beam energy uncertainty. The total relative uncertainty is 2.4% which is the most precise ATLAS result if combinations are not taken into account.

Lepton differential cross-sections are measured at the particle level in the fiducial phase-space as a function of lepton and dilepton system kinematic variables. They are compared with various NLO+PS generators in combination with various PDF sets. A disagreement is observed for lepton p_{T} and for dilepton system p_{T} and mass. On the other hand, predictions match well rapidity or pseudo-rapidity distributions.

3. Measurement of differential cross-sections in the lepton+jets channel

This measurement is performed in the resolved and boosted topologies covering low and high top quark p_{T} regions, respectively [3]. The differential cross-sections are measured using data collected in 2015 and 2016, corresponding to an integrated luminosity of 36.1 fb^{-1}. Measured distributions are corrected to the particle level fiducial phase-space and the full parton level phase-space.

Measured particle-level spectra are compared with NLO+PS generators. The generators agree with the single-differential measurements over a wide kinematic region for both the resolved and boosted topologies. In general, the agreement with double-differential distributions is poorer.

Figure 1 shows double-differential fiducial cross-section in the resolved channel as a function of p_{T} and mass of the reconstructed $t\bar{t}$ system, which is compared with various Monte Carlo predictions. In general, double-differential cross-sections have high sensitivity to various aspects of Monte Carlo generators. This results in big differences between various predictions and poor agreement with data. The figure demonstrates this property.

PoS(LHCP2020)067

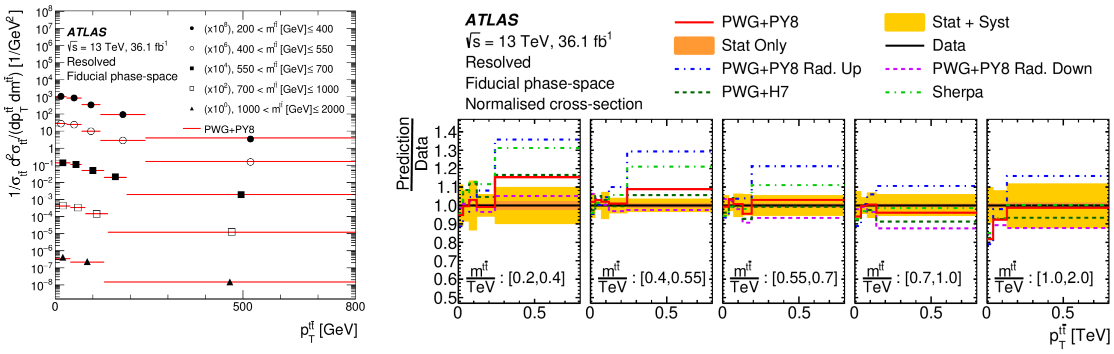

Figure 1: Particle-level normalised differential cross-section (left) as a function of $t\bar{t}$ p_{T} in bins of $t\bar{t}$ mass in the resolved topology compared with the Powheg+Pythia8 prediction. Data points are placed at the center of each bin. The set of ratio plots on the right shows ratios of various predictions to the measured cross-section in different bins of $t\bar{t}$ mass. The error bands represent the statistical and total uncertainty in the data[3].

Parton level spectra are compared with fixed-order NNLO predictions and studies were performed to check sensitivity to electroweak corrections. In general, moving to higher order predictions improves agreement with data. No sensitivity on electroweak corrections was found.

4. Measurement of the $t\bar{t}$ production cross-section in the lepton+jets channel

The analysis is performed using the full Run 2 LHC data sample, corresponding to an integrated luminosity of 139 fb^{-1} [4]. A simultaneous profile likelihood fit is used to extract cross-section from differential variables in three different regions.

The measured value of the inclusive cross-section is

$$\sigma_{\mathrm{inc}}^{t\bar{t}} = 830.4 \pm 0.4\,(\mathrm{stat})^{+38.2}_{-37.0}\,(\mathrm{syst})\,\mathrm{pb} = 830^{+38}_{-37}\,(\mathrm{tot})\,\mathrm{pb}. \tag{2}$$

Uncertainties related to the jet reconstruction and the signal modeling are dominant. The relative total uncertainty of the measurement is 4.6%. This is the most precise ATLAS result in the lepton+jets channel.

5. Measurements of differential cross-sections in the all-hadronic channel

This measurement is performed using a data sample corresponding to integrated luminosity of 36.1 fb^{-1} [5] . Differential cross-sections are measured in the all-hadronic channel and in the resolved topology where all six quarks from the hadronic top decays are reconstructed separately as distinct jets. This is the first ATLAS differential cross-section measurement in this topology.

Measured differential and double-differential cross-sections are unfolded to the fiducial particle level phase-space and to the full parton level phase-space where they are compared with various predictions. Several predictions have a poor agreement with data in a number of variables. This can be exploited to improve top-quark Monte Carlo modeling. Double-differential spectra at the particle level also probe regions with many additional jets which are the regions of interest for many analyses of rare processes.

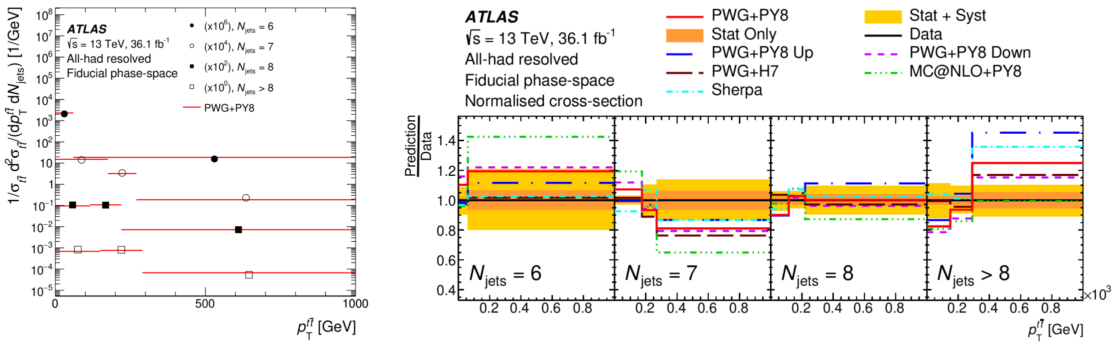

Figure 2: Particle-level double-differential normalised cross-section (left) as a function of the $t\bar{t}$ system transverse momentum in bins of the jet multiplicity, compared with the Powheg+Pythia8 prediction. Data points are placed at the centre of each bin. The ratio of the measured cross-section to different MC predictions is shown on the plot in the right[5].

Figure 2 shows double-differential cross-section in the fiducial phase space as a function of $t\bar{t}$ p_{T} and jet multiplicity. This demonstrates the ability to measure differential cross-sections in the extreme region with eight and more jets in an event. Big differences are observed between various NLO+PS generators as well as between data and predictions. Uncertainties are dominated by the differences in the signal modeling.

6. Summary

The inclusive cross-section measurements were presented in the dilepton $e\mu$ channel and the lepton+jets channel. Both measurements improved precision with respect to previous measurements in the corresponding channel and they are in good agreement with the SM predictions. Differential cross-section measurements cover all three main $t\bar{t}$ decay channels and they include double-differential spectra which provide information about the correlation between variables and probe the ability of the Standard Model predictions to describe distributions in extreme regions. This information can be exploited to improve Monte Carlo predictions. Differential cross-sections were measured for the first time in the all-hadronic resolved channel in the ATLAS experiment. The measurement provides remarkably precise results in this very challenging topology for the reconstruction and it is now well established in the ATLAS experiment.

References

[1] ATLAS Collaboration, 2008 JINST 3 S08003

[2] ATLAS Collaboration, Eur. Phys. J. C 80, 528 (2020), arXiv:1910.08819 [hep-ex]

[3] ATLAS Collaboration, Eur. Phys. J. C 79, 1028 (2019), arXiv:1908.07305 [hep-ex]

[4] ATLAS Collaboration, arXiv:2006.13076 [hep-ex]

[5] ATLAS Collaboration, arXiv:2006.09274 [hep-ex]