PROCEEDINGS OF SCIENCE

Top-quark-antiquark production in association with a photon in the electron-muon channel at a center-of-mass energy of 13 TeV with the ATLAS detector

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The cross-section of top-quark-antiquark pair production in association with a photon is important in order to determine the electromagnetic coupling of the top-quark with high precision. It is also of great significance to test deviations from the Standard Model, such as anomalous dipole moments of the top-quark. Furthermore, such cross-section can be interpreted in effective field theories which would allow for probing effects of higher-dimensional operators of the Standard Model fields. The inclusive and differential cross-sections of top-quark production in association with a photon in the electron-muon channel at $\sqrt{s}$ = 13 TeV with the ATLAS detector at the LHC are measured. The measurements are performed in a fiducial volume. The fiducial inclusive cross-section is extracted using a profile likelihood fit, while the fiducial differential cross-section is measured at parton level as a function of various observables, such as the photon transverse momentum and angular variables related to the photon and the leptons. The measurements are compared to the most recent next-to-leading-order theory calculation and state-of-the-art Monte Carlo simulations. The results are found to be in good agreement with the predictions within uncertainties.

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1. Introduction

The study of the production of a top-quark pair in association with a photon ($t\bar{t}\gamma$) plays an important role in understanding and also testing the validity of the predictions of the Standard Model such as the top-photon electroweak coupling and the charge of the top-quark. It is also important for new physics models that are beyond the Standard Model, e.g., in testing the anomalous dipole moments of the top-quark and probing effects of higher-dimensional operators predicted in effective field theories.

The measurements of the combined $t\bar{t}\gamma/tW\gamma$ process which are presented here are based on the measurements recently conducted [1] by ATLAS. The measurements are performed using 139 fb^{-1} of collision data which are collected by the ATLAS detector [2] at the LHC at $\sqrt{s} = 13$ TeV.

2. Analysis strategy

Events with exactly one electron and one muon with transverse momentum $p_{\mathrm{T}} > 25$ GeV, exactly one photon with $p_{\mathrm{T}} > 20$ GeV, at least two jets with $p_{\mathrm{T}} > 25$ GeV, of which at least one is b-tagged, and a $\Delta R > 0.4$ between the photon and the lepton, are selected. The electron-muon channel has the advantage (compared to the other decay channels) of being pure which is manifested by having 84% signal events ($t\bar{t}\gamma/tW\gamma$) while the background processes being categorized based on the origin of the reconstructed photon represent the remaining 16%.

The measurements are performed in a fiducial volume at parton level such that events with exactly one electron and one muon with $p_{\mathrm{T}} > 25$ GeV, exactly one photon with $p_{\mathrm{T}} > 20$ GeV, exactly one b-jet and one $\bar{b}$-jet with $p_{\mathrm{T}} > 25$ GeV, and $\Delta R > 0.4$ between all partons in the event, are selected.

The fiducial inclusive cross-section is extracted using a binned Maximum Likelihood Fit to the S_{T} distribution. The S_{T} observable is defined as the scalar sum of all transverse momenta in the event, including leptons, photons, jets and missing transverse momentum.

To examine distributions even further at a finer level, the fiducial differential (absolute and normalised to unity) cross-sections are measured as functions of photon kinematic variables, angular variables related to the photon and the leptons, and angular separations between the two leptons in the event, using the Iterative Bayesian Unfolding method.

3. Results

The results reported below represent the most recent measurements of the combined $t\bar{t}\gamma/tW\gamma$ process in the electron-muon channel [1] with the ATLAS detector at the LHC. On one hand, the fiducial inclusive cross-section is measured to be $\sigma_{\mathrm{fid}} = 39.6 \pm 0.8\,(\mathrm{stat})\,^{+2.6}_{-2.2}\,(\mathrm{syst})$ fb, which is found to be in good agreement with the next-to-leading-order theory prediction [3]. The fitted distribution of S_{T} observable is shown in Figure 1. On the other hand, the shape of the measured fiducial differential cross-sections is well described by the next-to-leading-order calculation, while the leading order Monte Carlo simulation fails to describe such shape for some observables, such as the azimuthal angle between the two leptons. Examples of the absolute and normalised differential cross-sections are shown in Figure 2. The systematic uncertainties of the fiducial inclusive and differential measurements are dominated by the background and signal modeling.

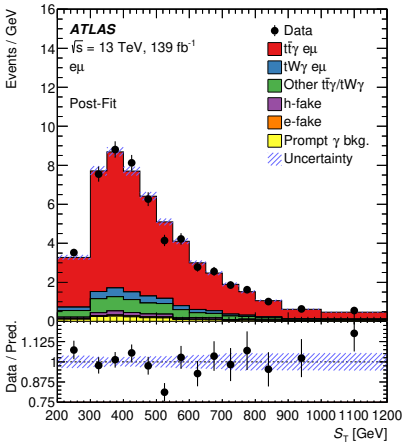

Figure 1: The post-fit distribution of the S_T observable where underflow and overflow events are included in the first and last bins of the distribution, respectively [1].

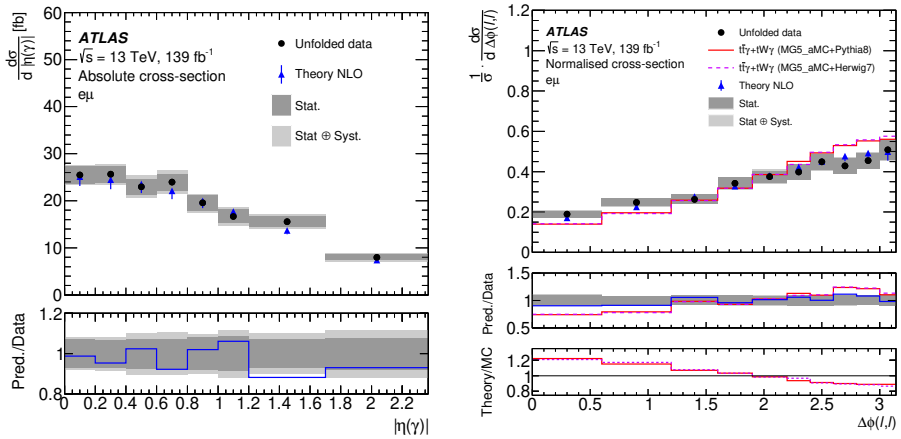

Figure 2: Left plot is the absolute differential cross-section measured in the fiducial phase space as a function of the absolute pseudorapidity of the photon, while right plot is the normalised differential cross-section measured in the fiducial phase space as a function of the azimuthal angle between the two leptons [1] where data are compared with the NLO calculation [3] and the MadGraph5_aMC@NLO simulation interfaced with Pythia 8 and Herwig 7.

References

[1] ATLAS Collaboration, *Measurements of inclusive and differential cross-sections of combined $t\bar{t}\gamma$ and $tW\gamma$ production in the $e\mu$ channel at 13 TeV with the ATLAS detector*, *JHEP* **09** (2020) 049 [arXiv:2007.06946 [hep-ex]].

[2] ATLAS Collaboration, *The ATLAS Experiment at the CERN Large Hadron Collider*, *JINST* **3** (2008) S08003.

[3] G. Bevilacqua, H. B. Hartanto, M. Kraus, T. Weber and M. Worek, *Hard photons in hadroproduction of top quarks with realistic final states* *JHEP* **10** (2018) 158 [arXiv:1803.09916 [hep-ph]].