Measurement of the t-channel single top-quark production with the ATLAS detector

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1 Introduction

At the LHC, single top-quark production can occur in three processes. The dominant process, the t-channel exchange of a virtual W boson, has a predicted top-quark production cross section of 41.9 pb and top-antiquark cross section of 22.7 pb [1]. The difference between the top-quark and -antiquark cross sections is directly related to the difference of the up-quark and the down-quark density functions (PDF) of the proton. This report presents measurements of the cross-sections of single top-quark and single top-antiquark production, $\sigma_t(t)$ and $\sigma_t(\bar{t})$ in the t-channel, and a measurement of the cross-section ratio $R_t \equiv \sigma_t(t)/\sigma_t(\bar{t})$ [3] at a center-of-mass energy of $\sqrt{s} = 7\,\text{TeV}$ with $4.7\,\text{fb}^{-1}$ of data recorded by the ATLAS detector [2] in 2011. The measurements of $\sigma_t(t)$, $\sigma_t(\bar{t})$ and R_t are sensitive to the PDFs of the u-quark and the d-quark in the momentum fraction (x) regime of $0.02 < x < 0.5$.

2 Measurement of the t-channel cross-section ratio

The single top signal includes a b quark and a W boson, that decays leptonically, from the top decay as well as additional jets. The main backgrounds to the single-top quark final state are multijet events, W boson production in association with jets, and top pair production ($t\bar{t}$), that are reduced by the event selection. Lepton candidates, e or μ, are required to be well reconstructed and isolated and to have $p_{\text{T}} > 25$ GeV and $|\eta| < 2.5$. Only jets with $p_{\text{T}} > 25$ GeV and $|\eta| < 4.5$ are considered. Jets containing bottom quarks are tagged in the region $|\eta| < 2.5$ using a neural network technique. The final event selection requires exactly one charged lepton, two jets or three jets, and missing transverse energy $E_{\text{T}}^{\text{miss}} > 30$ GeV. The multijet background contribution is reduced by requiring the W transverse mass $m_{\text{T}}(W) > 30$ GeV.

The multijet background is estimated using a data-driven method and performing a binned maximum likelihood fit to the $E_{\text{T}}^{\text{miss}}$ distribution. The kinematic distributions for the W+jets background are taken from Monte Carlo samples, while the

overall normalisation and the flavour composition are derived from data when extracting the result of the analysis. The $t\bar{t}$ background and other smaller backgrounds are normalised to their theory predictions.

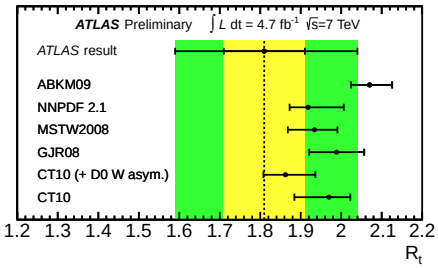

Figure 1: Measurement of R_t with its statistical (yellow band) and total (green band) uncertainty compared to the calculated values for different NLO PDF sets [3].

The analysis is performed in four independent channels: l^+ and l^- for two and three jets. In each channel a neural network combines a maximum of 19 variables into one discriminant. The variables with the most discriminating power are the reconstructed top-quark mass $m_{l\nu b}$ and the pseudorapidity of the untagged jet $|\eta(\text{u-jet})|$. The effects of systematic uncertainties on the measurement, that affect the normalisation of the individual backgrounds, the signal acceptance and the shape of the individual predictions, are taken into account with pseudo-experiments. Thus, uncertainties on the object modeling, the Monte Carlo generators, the PDFs, the background normalisation to data, and integrated luminosity are considered in the measurement.

To extract the signal content of the selected sample, we perform a simultaneous maximum likelihood fit to all four NN output distributions. The measured t-channel single top-quark production cross section is $\sigma_t(t) = 53.2 \pm 1.7\,(\text{stat.}) \pm 10.6\,(\text{syst.})\,\text{pb}$, while the top-antiquark production cross section is $\sigma_t(\bar{t}) = 29.5 \pm 1.5\,(\text{stat.}) \pm 7.3\,(\text{syst.})\,\text{pb}$. This results into a measured cross-section ratio of $R_t = 1.81 \pm 0.10\,(\text{stat.})\,^{+0.21}_{-0.20}\,(\text{syst.})$. The measured value of R_t is compared to the predictions obtained with different PDF sets in Figure 1.

References

[1] N. Kidonakis, Phys. Rev. D **83** (2011) 091503.

[2] ATLAS Collaboration, 2008 JINST 3 S08003.

[3] ATLAS Collaboration, ATLAS-CONF-2012-056 (2012). https://cdsweb.cern.ch/record/1453783.