Measurement of the Top Quark Pair Production Cross Section in the Single Lepton Channel with the ATLAS Experiment

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1 Introduction

The measurement of the production cross section of top quark pairs $\sigma_{t\bar{t}}$ is the first important ingredient to a rich programme of top physics at the LHC. Already with 35 pb^{-1} of data taken by the ATLAS experiment in 2010, precision measurements of this quantity are possible. They represent an important test of the Standard Model, and also help to understand top events as a dominant background in Higgs and beyond the Standard Model searches. The analysis concentrates on top quark pairs decaying into lepton+jets. This final state is characterized by high statistics and manageable backgrounds. The measurement relies on the excellent tracking, calorimetry and b-tagging abilities of the ATLAS detector.

2 Analysis Strategy

To create a top-enriched data sample, a central, isolated and high p_T lepton, significant missing transverse energy, and at least three central, high-p_T jets are required. In addition, cuts on the transverse leptonic W boson mass are applied to suppress contribution from QCD multijet events.
Two different approaches are used to extract the top quark cross section from this data sample: one relies solely on kinematic differences between $t\bar{t}$ and W+jets events, while the other adds b-jet identification information to further separate signal and background. Both analyses select events with at least 3 jets and split them into subsamples with 3 and ≥ 4 jets (3, 4 and ≥ 5 jets) for the "non-b-tag" ("b-tag") case. Several kinematic variables are combined into a likelihood discriminant for both analyses: aplanarity, lepton charge and pseudorapidity (η) for "non-b-tag"; aplanarity, $H_{T,3p}$ as sum of the transverse momenta of all jets except for the leading two, normalised to the sum of longitudinal momenta of all reconstructed objects, lepton η, average b-tagging algorithm output of the two most b-like jets for "b-tag". Both analyses extract $\sigma_{t\bar{t}}$

from a log-likelihood fit to data. The analysis using b-tagging incorporates systematic uncertainties as nuisance parameters in the fit allowing data to constrain the latter, while the uncertainties for the "non-b-tag" analysis are obtained from ensemble tests. Various analysis strategies, ranging from cut-based analyses to fits to η and angular distributions, as well as 3-jet invariant masses, are used as cross-checks to the main results and are found to be in good agreement with them [1, 2].

3 Results

The analysis without b-tagging yields $\sigma_{t\bar{t}} = 171 \pm 17(\text{stat.})^{+20}_{-17}(\text{syst.}) \pm 6(\text{lumi.})$ pb, and the measured cross section using b-tagging is $\sigma_{t\bar{t}} = 186 \pm 10(\text{stat.})^{+21}_{-20}(\text{syst.}) \pm 6(\text{lumi.})$ pb. The result of this fit is displayed in Fig. 1. Systematic uncertainties are dominated by the b-tagging calibration and the knowledge of the heavy flavour fraction of the W+jets background for the analysis using b-tagging and by the initial and final state radiation modeling and jet energy scale uncertainties for the analysis without b-tagging.

A combination of the "b-tag" result with the result for $\sigma_{t\bar{t}}$ measured in the dilepton channel gives $\sigma_{t\bar{t}} = 180 \pm 9(\text{stat.}) \pm 15(\text{syst.}) \pm 6(\text{lumi.})$ pb [3], with a total uncertainty of 10% after only one year of LHC operation and in excellent agreement with perturbative QCD calculations.

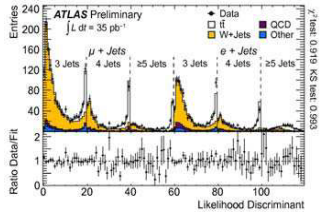

Figure 1: Distribution of the likelihood discriminant D for the analysis using b-tagging. Signal and background contributions are scaled to the results of the fit.

References

[1] ATLAS-CONF-2011-035, `http://cdsweb.cern.ch/record/1337785`

[2] ATLAS-CONF-2011-023, `http://cdsweb.cern.ch/record/1336753`

[3] ATLAS-CONF-2011-040, `http://cdsweb.cern.ch/record/1338569`