PROCEEDINGS OF SCIENCE

Measurement of the differential cross section of highly boosted top quarks as a function of their transverse momentum in $\sqrt{s}$ = 8 TeV proton-proton collisions using the ATLAS detector

Federica Fabbri* **on behalf of the ATLAS Collaboration**
INFN and University of Bologna
E-mail: federica.fabbri@cern.ch

In this report we present the measurement of the $t\bar{t}$ differential cross section for high p_{T} top quarks as a function of their transverse momentum using pp collisions at $\sqrt{s}$ = 8 TeV collected by the ATLAS detector and corresponding to an integrated luminosity of 20.3 fb^{-1}. The techniques used in the analysis are optimized for the identification and reconstruction of hadronically decaying top quarks with high Lorentz boost and allow to extend the measurement to the TeV region. The observed yield is corrected for detector effects and the differential cross section obtained is compared with several NLO theoretical predictions both in a fiducial region and in the full phase space.

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*Speaker.

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1. Introduction

The top quark is the heaviest fundamental particle known today, for this reason it has the largest coupling with the Higgs boson, and has a crucial role in many new physics model. The study of top quark production has a major role in the physics program of the Large Hadron Collider (LHC) and the large $t\bar{t}$ production rate provide the opportunity to perform precise measurements in kinematic regions never reached before. The goal of the analysis presented here and reported in details in [1] is to measure the $t\bar{t}$ production differential cross section at high top transverse momentum (p_{T}). The differential measurement in this kinematic regime represents a test for Standard Model (SM) predictions and contributes to a more precise determination of the parton distribution function. Moreover a precise measurement of the highly boosted top quarks production rate might reveal signals of physics beyond the SM. The measurement is performed as a function of the p_{T} of the hadronically decaying top quark, using data collected in pp collisions at $\sqrt{s} = 8$ TeV from the ATLAS detector [2] corresponding to an integrated luminosity of $L = 20.3$ fb^{-1}. The differential cross section is evaluated in a fiducial phase space and then extrapolated to the full partonic top quark spectrum (*parton level*).

2. Event Selection and Particle Level Definition

The analysis strategy aims at selecting events with top at high p_{T} in the lepton+jets channel which suffers from relatively small non-$t\bar{t}$ background in this kinematic regime. The targeted event topology, on the side of the leptonic top, should contain one lepton (μ or e) with high momentum, a jet with $R = \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.4$ and missing transverse momentum, indicating the presence of a neutrino. On the hadronic side the three jets deriving from the hadronization of top decay products ($t \to Wb \to q', q, b$) result partially or totally overlapped due to the Lorentz boost of the high p_{T} top quark. The hadronic top must be reconstructed as a Large-R jet (R=1) and identified with techniques based on substructure properties as jet mass and splitting scale ,$\sqrt{d_{12}}$, proportional to the distance between the two sub-jets with highest p_{T} in the Large-R jet. These techniques improve the hadronic top quark purity in high p_{T} region. The events are required to contain at least one jet derived from the hadronization of a b quark. The composition of the final selected sample for data, Monte Carlo signal and background is reported in Table 1. All the backgrounds are evaluated from

	e+jets	μ+jets
$t\bar{t}$ leptons+jets	3883 ± 429	3420 ± 379
$t\bar{t}$ dilepton	199 ± 27	169 ± 24
W+jets	235 ± 54	226 ± 50
Single top	133 ± 22	134 ± 29
Multijet	91 ± 17	3 ± 1
Z+jets	34 ± 18	14 ± 8
Diboson	22 ± 12	18 ± 10
Pretiction	4597 ± 17	3984 ± 17
Data	4145	3603

Table 1: Composition of the selected sample.

MC simulations except for multijet and W+jets samples. The multijet background is estimated with a fully-data driven method (matrix-method technique) while the normalization and heavy-flavor content of the MC simulated W+jets sample is tuned to data in dedicated control regions.

To correct for detector resolution effects while minimizing uncertainties from theoretical inputs, the measured distribution is unfolded to a *particle level* fiducial cross section. The *particle level* objects like jets and missing transverse momentum are defined using only stable particles, with a mean lifetime greater than $0.3 \cdot 10^{-10}$ seconds, in order to have a direct correspondence to the analogue reconstructed objects. A fiducial region, following closely the data event selection, is defined using these objects. Events selected in both leptonic channels are added at the reconstructed level and unfolded to the common lepton+jets phase space at the *particle level*.

3. Unfolding procedure and Systematic

Every distribution measured by an experimental apparatus differs from the real one due to the limited acceptance and resolution of the device. These effects generally result in an overall efficiency detection of the apparatus and in a distortion of the measured spectrum due to bin by bin migrations. The procedure that corrects for these effects is called unfolding. The unfolding process is composed of four steps: first of all the background is subtracted from the data spectrum; then the distribution is multiplied by the acceptance, that corrects for events that pass the reconstructed selection but that fail the *particle level* selection; in the next step the resulting distribution is corrected for the migrations from *particle level* events to reconstructed events by means of a regularized matrix inversion procedure [3]; finally the obtained spectrum is divided by the efficiency correction, defined as the fraction of events passing reconstructed selection among all events passing *particle level* selection. The acceptance, migration matrix and efficiency are reported in Figure 1.

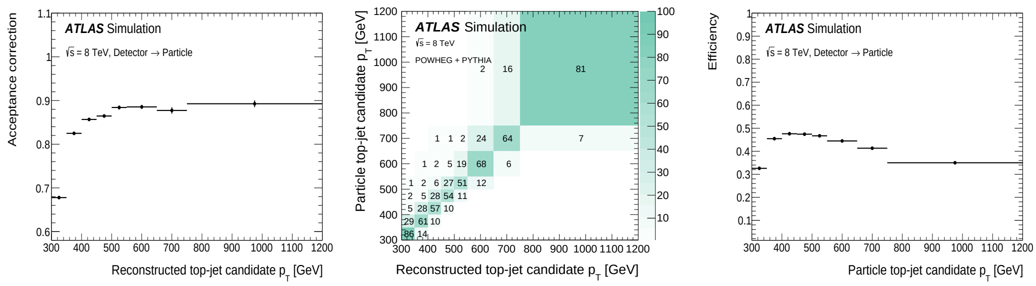

Figure 1: Acceptance (left), Migration Matrix (center) and Efficiency (right) [1].

The systematic uncertainties due to reconstruction processes are evaluated varying the detector-level MC distribution and propagated through the unfolding machinery both at *particle* and *parton* level. The main uncertainties at *particle level* are the jet energy scale (JES) components of the Large-R jet and the data statistics while at *parton level* the signal modeling uncertainty becomes dominant. The total and main uncertainties affecting the measurement are reported in Figure 2.

4. Result

The events selection, objects definition and top quark identification techniques used allow to measure the differential top p_{T} spectrum at the TeV scale, never reached in previous analysis. The measured differential cross section is compared in Figure 3 with different NLO generator predictions, normalized at the NNLO theoretical production cross section both at *particle* and *parton*

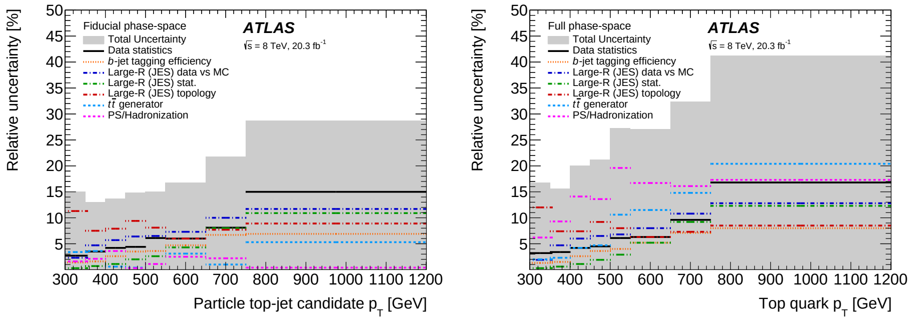

Figure 2: Total, statistical and main systematic uncertainties on the particle (left) and parton (right) differential cross section measurement [1].

level. The MC predictions seem to generally slightly overestimate the measured spectra, but the

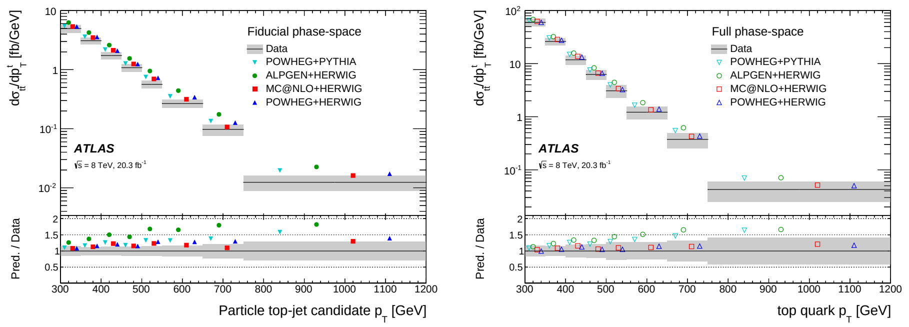

Figure 3: Measured differential cross section compared with several predictions at *particle* (left) and *parton* (right) level [1].

level of agreement between the theoretical expectations and the data can be evaluated only performing a statistical test that account for bin by bin correlations and correlations introduced by the unfolding procedure. The result of the χ^2 test performed on the *particle level* MC distributions and the p-value calculation show that the only prediction that results not compatible with the measurement is ALPGEN+HERWIHG with a p-value of the order of 10^{-5}[1].

References

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