PROCEEDINGS OF SCIENCE

Measurement of single and multi-jet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with ATLAS

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Single and multiple jet cross sections have been measured in proton-proton collisions at a centre-of-mass energy of 7 TeV using the ATLAS detector. The anti-k_t algorithm is used to identify jets. Inclusive single-jet differential cross sections are presented as functions of jet transverse momentum and rapidity. Dijet cross sections are presented as functions of dijet mass and rapidity. The measurements extend the previously measured kinematic region to higher rapidities, and to both higher and lower values of transverse momentum. Additionally, measurements are presented of multijet cross sections, and of the azimuthal correlation between dijets. Measurements of dijets separated by large intervals of rapidity are also presented, where a veto is applied based on the presence of further jets with the rapidity interval.

All the results are compared to several perturbative QCD predictions, which are in general in good agreement with measurements.

The 2011 Europhysics Conference on High Energy Physics-HEP 2011,
July 21-27, 2011
Grenoble, Rhône-Alpes France

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PoS(EPS-HEP2011)278

1. Measuring jets with the ATLAS detector

A detailed description of the ATLAS detector and performances can be found in Ref. [1]. The jets are measured with the ATLAS calorimetric system, which has high granularity, covers a wide angle in pseudo-rapidity η ($|\eta| < 4.9$), and it is completely hermetic in the azimuthal angle ϕ[1]. Three different trigger systems have been used to perform the measurements reported in this proceeding: (1) minimum bias trigger scintillator used to measure the jets with p_T< 60 GeV, (2) central jet trigger system used to measure jets in the rapidity region $|y| < 2.8$, (3) forward jet trigger system used to extend the measurements to $|y| < 4.4$. The anti-k_t jet algorithm have been selected to reconstruct the jets. Given the fact that different clustering parameters R make the jets differently sensitive to the hadronization, underlying event and pile-up, the ATLAS Collaboration used two different values for the distance parameter R=0.4 and R=0.6 in the measurements reported in this proceeding. A jet calibration procedure has been used to correct the measurements for detector effects such as: the non linearity due to the different calorimetric response to electromagnetic and hadronic showers, the energy loss in non instrumented material, and the bending of charge particles in the magnetic field, and the measured cross sections are unfolded to the particle level[2]. A detail description of the jet reconstruction and calibration developed by the ATLAS collaboration can be found in Reference [2]. The non collision backgrounds have been studied and suppressed with a dedicated quality selection strategy.

2. Measured jet cross sections

The inclusive single jet and dijet cross sections: the inclusive jet and dijet cross sections measure the p_T and the dijet mass M cross sections in different rapidity regions respectively. The inclusive jet measurement is performed in the p_T range 20 GeV - 1.5 TeV, and it extends to a wide rapidity range ($|y| < 4.4$).

In the measurement of the dijet mass cross section, the first two jets, ordered in descending p_T, are used to measure the dijet invariant mass M, and the angular variable $|y|_{\max} = \max(|y_1|, |y_2|)$. The leading jet p_T is required to be above 30 GeV, and the second above 20 GeV. They both are selected in the rapidity range $|y| < 2.8$. The dijet mass cross section cover a range from 70 GeV to 2 TeV in the central rapidity region ($|y|_{\max} < 0.3$), and a range from 500 GeV to 4 TeV in the very forward region.

These two cross sections (the inclusive single jet cross section is shown in Figure 1(top-left)) have been compared with pure next to leading order (NLO) predictions, corrected for the non-perturbative effects, and with POWHEG Monte Carlo simulations, which perform a NLO prediction coherently interfaced with parton shower, hadronization and underlying event simulations. The

[1] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the center of the detector and the z-axis along the beam pipe. The x-axis points from the IP to the center of the LHC ring, and the y-axis points upward. Cylindrical coordinates (r,ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe, referred to the x-axis. The pseudo-rapidity η is defined in terms of the polar angle θ with respect to the beam-line as $\eta = \frac{1}{2}\ln\tan(\theta/2)$. When dealing with massive jets and particles, the rapidity $y = \frac{1}{2}\ln\frac{E+p_z}{E-p_z}$ is used.

[2] Particle-level jets in the Monte Carlo simulation are identified using the anti-k_t jet algorithm and are built from stable particles, which are defined as those with a proper lifetime longer than 10 ps.

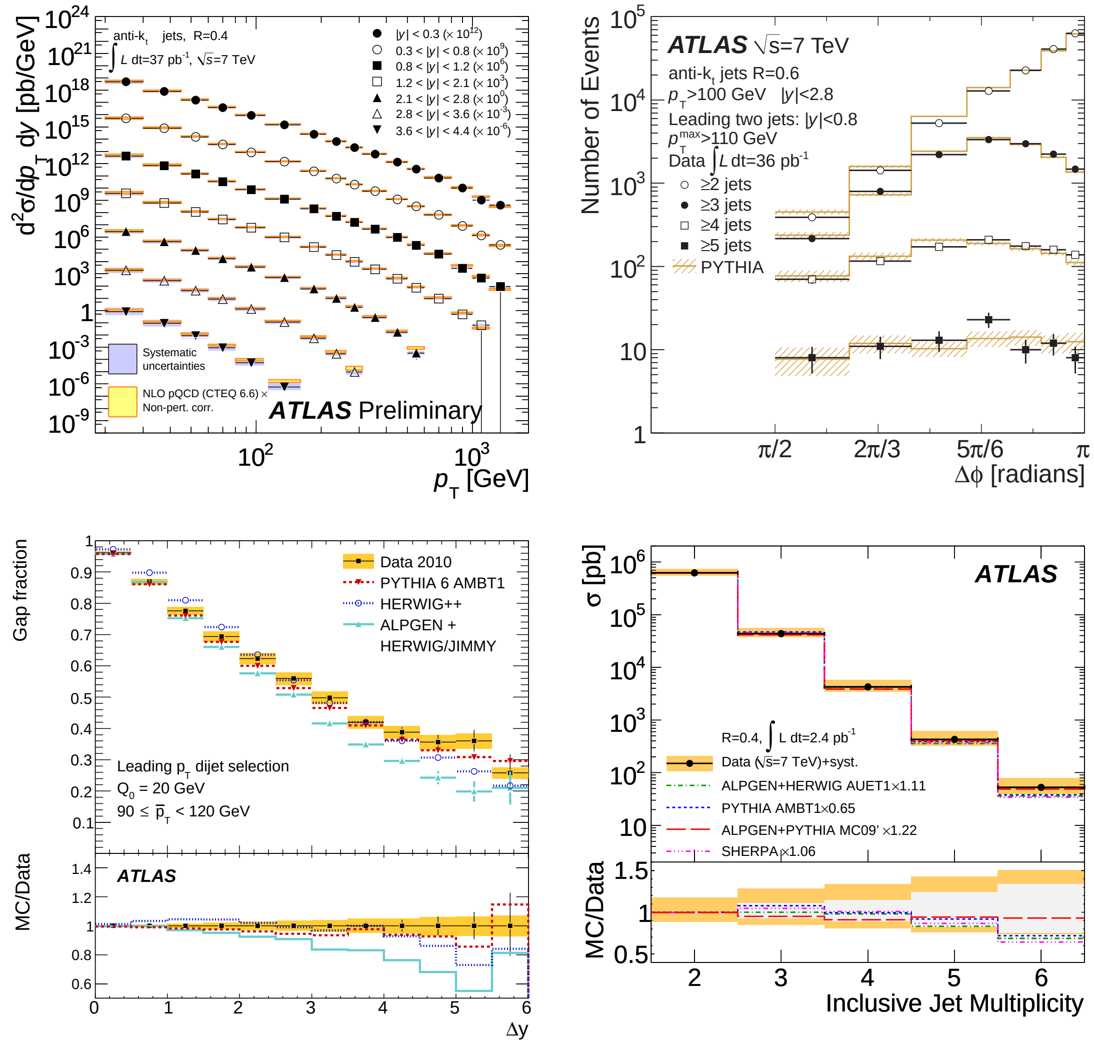

Figure 1: (top-left) Inclusive jet double-differential cross section for jets identified using the anti-k_t jet algorithm with $R = 0.4$. The data are compared to NLO calculations to which non-perturbative corrections have been applied (Ref. [3]).
(top-right) The $\Delta\phi$ distributions for events with at least 2, 3, 4, and 5 jets with $p_T > 100$ GeV, compared with the PYTHIA simulations (Ref. [4]).
(bottom-left) Gap fraction as a function of Δy bounded by the two leading p_T jets. The data,in black, are compared with several Monte Carlo predictions (Ref. [5]).
(bottom-right) Total inclusive jet cross section as a function of multiplicity. The data are compared to several leading-order Monte Carlo simulations normalized to the measured inclusive two-jet cross section (Ref. [7]).

comparisons, done for R=0.4 and R=0.6, show a good theoretical description of the inclusive single jet and dijet productions, as described in detailed in Reference [3].

Dijet system - azimuthal de-correlation: Distributions in $\Delta\phi$ test perturbative QCD calculations for multiple jet production without requiring the measurement of additional jets. The relative differential cross section is defined as $1/\sigma \cdot d\sigma/d\Delta\phi$ where the normalization σ is the inclusive dijet cross section , integrated over the same phase space used in the measurement. The azimuthal decorrelation $\Delta\phi$ is defined as the absolute value of the difference in azimuthal angle between the jet with the highest p_T in each event and the jet with the second-highest p_T in the event. The measurement of the azimuthal de-correlation in the presence of at least two, three, four, five jets with p_T>100 GeV is shown in Figure 1(top-right). The measured unfolded distributions in Reference [4], show a good agreement with the NLO predictions, corrected for the non-perturbative effects, and with several Monte Carlo generators, such as PYTHIA, SHERPA, and HERWIG.

Dijet production with a veto on additional central jet activity: A veto on additional hadronic activity in the rapidity interval bounded by the dijet system (named gap-veto) suppresses the contributions from colour octet exchange in the jet production and can be used to search for evidence of colour singlet exchange. As an example, Figure 1(bottom-right) shows the fraction of events with a gap as a function of the Δy distance of the two leading p_T jets. The measurements in Reference [5], are compared with several theoretical predictions: LO Monte Carlo simulations (PYTHIA, HERWIG++, ALPGEN+HERWIG+JIMMY), NLO Monte Carlo simulations (POWHEG+PYTHIA, POWHEG+HERWIG), and parton-level event simulation that provides an all-order description of wide-angle emissions of similar transverse momentum (HEJ). The accuracy of this measurement already demanded a better theoretical understating of the QCD in this regime, as reported in Reference [6].

Multi jet cross sections: The study of multi-jets production cross sections is fundamental to test the validity of the Monte Carlo predictions for those processes that constitute important background contributions in many searches for new physics. Figure 1(right) presents the total inclusive cross section as a function of the jet multiplicity. The cross sections have been compared with the several LO Monte Carlo (PYTHIA, ALPGEN+HERWIG+JIMMY, ALPGEN+PYTHIA, SHERPA), showing an overall good agreement. The detailed discussion of the results can be found in Reference [7].

3. Conclusion

In these proceedings, precise jet cross section results are reported based on the 2010 ATLAS proton-proton data at $\sqrt{s} = 7$ TeV. The measurements include inclusive jet, dijet and multi-jet production which are used to investigate the dynamics of the strong interaction in many different limits. The theory predictions are in general in good agreement with measurements although further theoretical developments are needed in some of the measured limits of the phase space.

References

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