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Measurement of the inclusive jet cross section with the ATLAS detector

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Summary. — The data collected in ATLAS at $\sqrt{s} = 7\,\text{TeV}$ in 2010, are being used to perform the measurement of the inclusive jet cross section. The inclusive jet cross section is measured in different rapidity intervals up to very forward regions ($|y| < 4.4$), with transverse momentum in the interval 0.02–1.5 TeV for central rapidities. The systematics of the measurement has been widely investigated, and the impact of the uncertainty on the energy calibration of jets, which is the cause of the dominant uncertainty in the measurement, is discussed.

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1. – Introduction

At the Large Hadron Collider (LHC), jet production is the dominant high transverse-momentum (p_T) process. Jet cross sections serve as one of the main observables in high-energy particle physics, and constitute one of the first measurements performed after the startup of new colliders. The ATLAS Collaboration has published a first measurement of inclusive jet and dijet production at $\sqrt{s} = 7\,\text{TeV}$, using an integrated luminosity of $17\,\text{nb}^{-1}$ [1]. This analysis updates the previous measurement using the full 2010 data sample of $(37.3 \pm 1.2)\,\text{pb}^{-1}$. It more than doubles the kinematic reach in high jet transverse momentum, extending the measurement to the forward region which is currently largely unexplored.

In this analysis jets are identified using the anti-k_t jet algorithm [2]. Two different values are used for the clustering parameter R (0.4 and 0.6), which can be seen intuitively as the radius of a cone jet in the $(\phi; y)$-plane (*i.e.* the azimuthal angle; rapidity plane). The jet cross section measurements are corrected for all experimental effects, and so refer to the ideal truth final state of a proton-proton collision. Inclusive single-jet double-differential cross sections are measured as a function of jet p_T and y in the region $p_T > 20\,\text{GeV}$ and $|y| < 4.4$.

2. – Event and jet selections

The jet cross section measurement uses the full 2010 dataset in proton-proton collisions at $\sqrt{s} = 7\,\text{TeV}$, with the exception of the low-p_T region $20 < p_T < 60\,\text{GeV}$. For low-$p_T$ jets, below the lowest jet trigger threshold, only data taken up to the beginning of June(1) and triggered with an unbiased Minimum Bias trigger are considered. Three different triggers have been used in this measurement: the Minimum Bias Trigger Scintillators (MBTS); the central jet trigger, covering $|\eta| < 3.2$; and the forward jet trigger, spanning $3.1 < |\eta| < 4.9$. For each p_T-bin considered in this analysis, a dedicated trigger threshold is chosen that is fully efficient ($> 99\%$), while having a prescale factor as small as possible.

3. – Jet calibration and uncertainties

The input objects for the jet reconstruction are clusters of calorimetric cells, grouped together with a topological criterion, depending on the significance of the reconstructed signals [3]. These objects are merged in jets by the jet algorithm. Additional energy due to multiple proton-proton interactions in the same bunch crossing is subtracted by applying a correction derived from data. The energy and the position of the jet are corrected for instrumental effects such as dead material and non-compensation. This Jet Energy Scale (JES) correction is calculated using isolated jets in the Monte Carlo simulation as a function of the transverse momentum and pseudorapidity of the jet [4].

The uncertainty on the JES is the dominant uncertainty for the inclusive cross section measurement. In the central barrel region ($|\eta| < 0.8$), the dominant component of the JES uncertainty comes from the calorimeter response to hadrons. This component is obtained by measuring the calorimetric response of single hadrons (in proton-proton collision data and test-beam data) and propagating the uncertainties to the jets response [5]. Additional uncertainties are evaluated using variations of the Monte Carlo simulation. The relative JES uncertainty decreases with increasing jet p_T and is less than 2% for jets with $p_T > 60\,\text{GeV}$.

4. – Data correction and results

Aside from the JES correction, all other corrections for detector inefficiencies and resolutions are performed in a single step using a bin-by-bin correction derived from the Pythia 6.4.21 Monte Carlo simulation with the AMBT1 tune [6]. The systematic uncertainties take into account the contribution from the JES, the error due to the uncertainty on the jet energy and angular resolutions, the uncertainty due to the trigger and jet reconstruction efficiency, the uncertainty in the quality selection efficiency and bias introduced by the bin-by-bin correction when applied to a modified spectrum. The result, compared with the next to leading order prediction(2) obtained by using NLOJET++,with the CTEQ6.6 parton density functions (PDF) and corrected for the non-perturbative effects, such as the hadronization and the underlying event, are shown in fig. 1. The two plots

(1) In the first period of LHC operation, the contributions from additional pile-up events were negligible, providing a well-measured sample of low-p_T jets.

(2) The theoretical uncertainties are estimated as the quadratic sum of uncertainties from the choice of renormalisation and factorisation scales, parton distribution functions, $\alpha_s(MZ)$, and the modeling of non-perturbative effects.

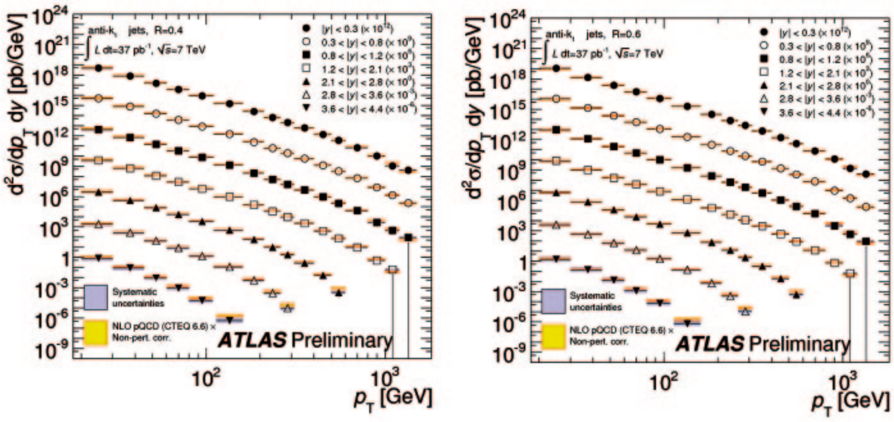

Fig. 1. – Inclusive jet double-differential cross section as a function of jet p_T in different regions of $|y|$ for jets identified using the anti-k_t algorithm with $R = 0.4$ (left) and $R = 0.6$ (right). The data are compared to NLO pQCD calculations to which non-perturbative corrections have been applied. The error bars indicate the statistical uncertainty on the measurement, and the dark-shaded band indicates the quadratic sum of the experimental systematic uncertainties. An additional overall uncertainty of 3.4% due to the luminosity measurement that is not shown. The theory uncertainty are shown in light-shaded band.

show the results for the anti-k_t jet algorithm with $R = 0.4$ and $R = 0.6$. Other prediction, with different PDFs, were tested, and the results are shown in ref. [7]. The advent of the new next to leading order Monte Carlo, interfaced to event generators with parton shower, hadronization and underlying event models, permit a new way to compare the results. The comparison of the measured spectra with the POWHEG results [8] are reported in [7].

5. – Conclusions

The ATLAS detector has been collecting data with high efficiency at $\sqrt{s} = 7\,\text{TeV}$ in proton-proton collisions in 2010. The measurement of the inclusive jet cross section, done with these datasets, shows a good agreement with the theoretical prediction at the next to leading order.

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