# Measurements of Jet Production in pp Collisions with the ATLAS Detector

*Adam Yurkewicz* on behalf of the ATLAS Collaboration

Northern Illinois University, DeKalb, IL, United States of America

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Differential jet cross sections are measured in inclusive jet, dijet, and multijet events at a center-of-mass energy of 7 TeV using information from the ATLAS calorimeters and tracking detectors. The inclusive jet measurements use jets with transverse momenta from 20 GeV to 1.5 TeV, and the dijet measurements extend up to masses of 5 TeV. Measurements using jets builts from charged tracks are only sensitive to the charged-particle content of the jet, but allow measurements at low transverse momenta. A wide range of QCD-based calculations is compared with measurements, testing the predictions of QCD in a new kinematic regime.

## 1 Introduction

At the Large Hadron Collider, jet production is the dominant high transverse-momentum ($p_T$) process. Jet cross sections are one of the main observables in high-energy physics, providing precise information about the structure of the proton, and allowing tests of predictions from QCD calculations.

This note summarizes several of the measurements of inclusive jet, dijet, and multijet differential cross sections made using the ATLAS detector with up to 4.8 fb$^{-1}$ of data collected in 2010 and 2011. The measured jets cover a large $p_T$ and rapidity range. At high rapidities and high dijet masses, this allows tests of QCD in new kinematic regimes. At low $p_T$, the measurements are more sensitive to non-perturbative effects from hadronization and the underlying event. Measurements of jets reconstructed from charged tracks allow comparisons to theoretical models down to 4 GeV in $p_T$.

All measurements are made using jets reconstructed with the anti-$k_T$ jet-finding algorithm [1], and are corrected for detector effects using Monte Carlo simulations. Results presented here use jets with distance parameter $R = 0.6$ (cited results also use R=0.4 jets).

## 2 Inclusive Jet and Dijet Production

Measurements of inclusive jet and dijet differential cross sections are made over a large kinematic range and compared to MC predictions [2, 3]. In order to compare the data to the predictions, the measured jets are corrected for all detector inefficiencies and resolutions using an iterative unfolding procedure. They are then compared to “particle-level” jets built from stable particles using MC simulations. The dominant systematic uncertainty comes from the knowledge of the

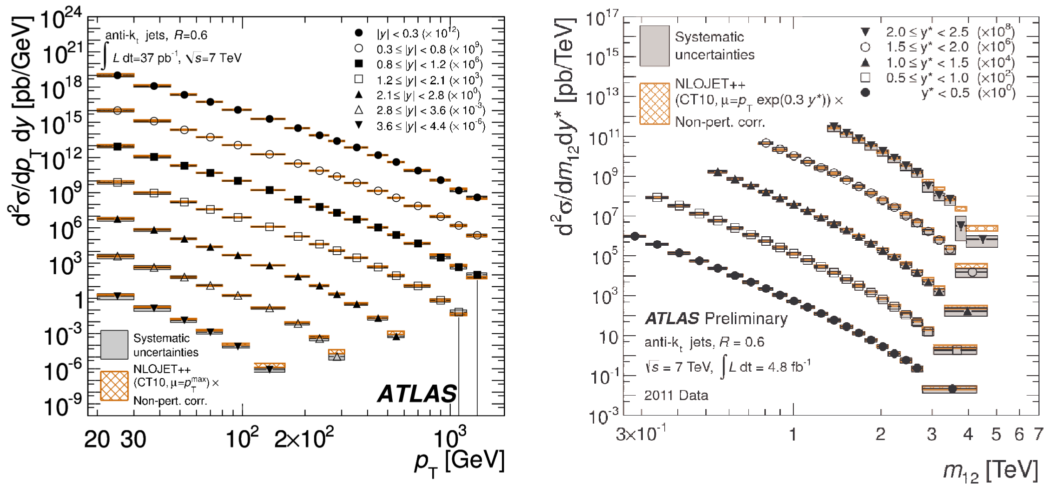


Figure 1: The double differential cross sections for the inclusive jet measurement (using 37 pb$^{-1}$ of data) as a function of $p_T$ in bins of rapidity (left) and for the dijet measurement (using 4.8 fb$^{-1}$ of data) as a function of mass in bins of y* (defined in text) compared to NLO predictions (right).

jet energy scale. This uncertainty is less than 2.5(4.6)% for jets with $p_T$ >60(20) GeV in the central region and rises to ≈12% at low $p_T$ in the forward region. Uncertainties from the jet reconstruction efficiency, jet resolution, and pileup are also included. The uncertainty on the luminosity measurement is 3.4%.

Cross section measurements are compared to NLO pQCD predictions from NLOJET++, corrected for non-perturbative effects, and also to NLO predictions from the POWHEG generator. Comparisons using several different PDF sets are made. Figure 1 shows the double differential cross sections for the inclusive jet cross section measurement as a function of $p_T$ in bins of rapidity, and for the dijet cross section measurement as a function of dijet mass, binned in half the absolute rapidity difference between the two leading jets, y* $= |y_1 - y_2|/2$. Good agreement is observed between the observed cross sections and the predictions from the Monte Caro simulations.

# 3 Multijet Production

Measurements of multijet differential cross sections [4] are used for shape comparisons to leading-order simulations as well as comparisons to next-to-leading order perturbative calculations. Measurements are corrected using a bin-by-bin unfolding procedure with MC simulation. Systematic uncertainties on the unfolding procedure are derived from comparisons to unfolding factors calculated using other MC simulations, and by varying the jet resolution and energy scale within their uncertainties.

The dominant systematic uncertainty comes from the jet energy scale uncertainty. For this measurement, additional contributions which may alter the jet energy scale are considered including a difference in the admixture of light-quark and gluon jets relative the MC simulation, the presence of nearby jets, and the presence of additional proton-proton interactions. Uncer-

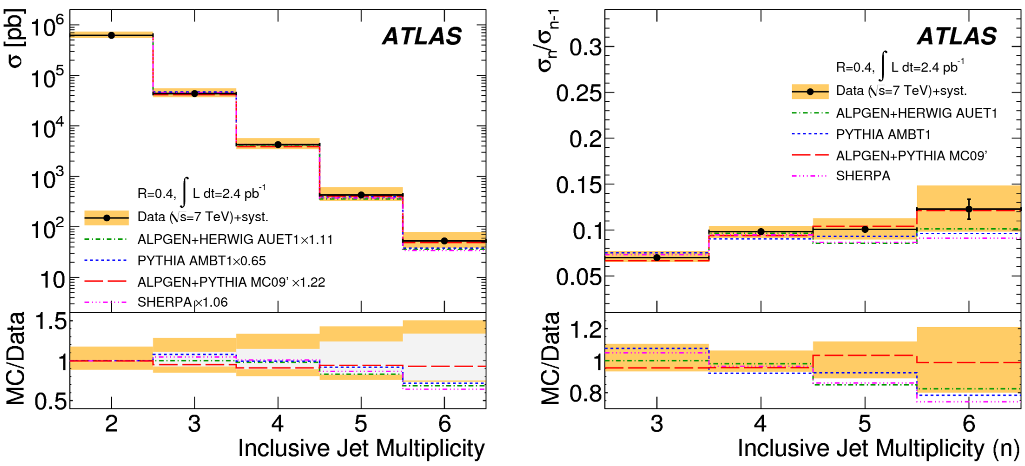


Figure 2: The total inclusive jet cross section as a function of jet multiplicity (left) and the ratio of n-jet to (n-1)-jet cross sections. The data are compared to several MC simulations, which have been normalized to the measured two-jet cross section (right). Jets with $p_T$ >60 GeV are counted.

tainties from the jet reconstruction efficiency, jet resolution, and pileup are included in the total systematic uncertainty.

Figure 2 shows the total inclusive jet cross section as a function of jet multiplicity and the ratio of n-jet to (n-1)-jet cross sections. The data are compared to several MC simulations, which have been normalized to the measured two-jet cross section. The simulations agree with the measured results across the full jet multiplicity spectrum.

Other differential distributions, including the $p_T$ spectra of jets, have also been made. The MC predictions show significant differences between leading order calculations. The measurements are also compared to NLO pQCD calculations corrected for non-perturbative effects. The calculations describe the data well, except in the lowest $p_T$ bin.

## 4 Measurements with Jets from Tracks

Measurements with jets reconstructed from charged tracks allow comparisons to MC simulations at very low $p_T$ [5], a region inaccessible with jets reconstructed in the calorimeters. Events are recorded with a minimum-bias trigger. Charged tracks with $p_T$ >400 MeV are used as input to the anti-$k_T$ jet finder. Jet properties are studied for jets with $|y| < 1.9$. Five quantities are measured: $\frac{d^2\sigma_{jet}}{dp_{Tjet}dy_{jet}}$; $\frac{1}{N_{jet}}\frac{dN_{jet}}{dN^{ch}_{jet}}$; $\frac{1}{N_{jet}}\frac{dN_{ch}}{dz}$; $\frac{1}{N_{jet}}\frac{dN_{ch}}{dp_T^{rel}}$; and $\rho_{ch}(r)$.

Figure 3 shows the cross section for charged particle jets as a function of $p_T$ for jets with $|y| < 0.5$, and the multiplicity of particles per jet over the full measured rapidity range in bins of $p_T$, compared to several MC predictions. None of the compared tunes or models agrees with all quantities measured within their uncertainties. Difficulty in modeling the transition between soft and perturbative physics is indicated by disagreements between data and all MC

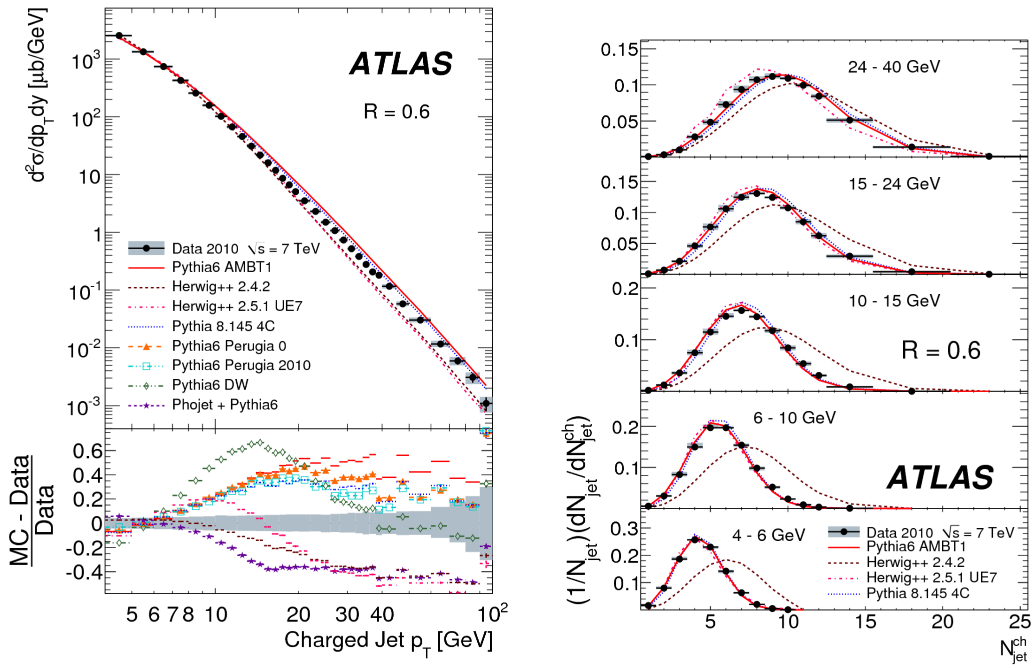


Figure 3: The cross section for charged particle jets as a function of $p_T$, with $|y| < 0.5$ (left), and the multiplicity of particles per jet, over the full measured rapidity range, in bins of $p_T$ (right), compared to several MC predictions.

distributions in the 10–20 GeV range.

# 5 Conclusions

ATLAS measurements of jet cross sections in inclusive jet, dijet, and multijet events at a center-of-mass energy of 7 TeV cover a large, new kinematic range. Detailed understanding of the detector performance has precisely determined systematic uncertainties, in particular those arising from the jet energy scale. Comparisons to MC simulations show good agreement.

Measurements of jets reconstructed from charged tracks allow comparisons to many different MC event generators and tunes in an interesting kinematic regime. No tune or model is able to reproduce the charged jet measurements, and they can be used to improve future simulations.

# References


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