Jet Cross Section Measurements With CMS

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DOI: `http://dx.doi.org/10.3204/DESY-PROC-2012-02/312`

A measurement of inclusive jet production cross section is presented. Data from LHC proton-proton collisions at $\sqrt{s} = 7$ TeV, corresponding to 4.7 fb^{-1} of integrated luminosity, have been collected with the CMS detector. Jets are reconstructed with the anti-k_T clustering algorithm of size parameter $R = 0.7$, extending to rapidity $|y| = 2.5$, and transverse momentum $p_T = 2$ TeV. The measured cross section is corrected for detector effects and compared to perturbative QCD predictions at next-to-leading order, using various sets of parton distribution functions.

1 Introduction

Events with high transverse momentum jets in proton-proton collisions are explained in Quantum Chromodynamics (QCD) in terms of parton-parton scattering, where the outgoing scattered partons manifest themselves as hadronic jets. The inclusive jet and dijet cross sections are calculated precisely in perturbative QCD and can be used to constrain the parton distribution functions. In this Physics Analysis Summary, the measurement of the double-differential inclusive jet (p + p → jet + X) and dijet (p + p → jet + jet + X) production cross sections are reported as a function of the jet transverse momentum or the dijet invariant mass, and jet rapidity at $\sqrt{s} = 7$ TeV [1]. The data are collected with the Compact Muon Solenoid (CMS) detector [2] at the CERN Large Hadron Collider (LHC) during the 2011 run and correspond to an integrated luminosity of 4.7 fb^{-1}, two orders of magnitude larger than the published LHC results from the 2010 run [3],[4],[5]. The measured cross sections are corrected for detector effects and compared to the QCD predictions. The parton transverse momentum fractions $x_T = \frac{2p_T}{\sqrt{s}}$ probed in this measurement cover the range $0.033 < x_T < 0.57$.

2 Jet Reconstruction and Event Selection

Jets are reconstructed using the anti-k_T clustering algorithm [6] with size parameter $R = 0.7$. Each particle is reconstructed with the particle-flow technique [7] which combines the information from several subdetectors. The jet energy corrections are derived using simulated events, generated by PYTHIA6.4.22 (PYTHIA6) [8] and processed through the CMS detector simulation based on GEANT4 [9], and *in situ* measurements with dijet and photon+jet events [10]. An offset correction is also applied to take into account the extra energy clustered in jets due to additional proton-proton interactions within the same bunch crossing (pile-up).

The data samples are collected with single-jet high level triggers (HLT) [11] which require at least one jet in the event to satisfy the condition $p_T > 60$, 110, 190, 270 and 340 GeV, respectively. In order to suppress non-physical jets, they are required to satisfy tight identification criteria: each jet should contain at least two particles, one of which is a charged hadron. Furthermore, the jet energy fraction carried by neutral hadrons and photons should be less than 90%. For the inclusive jet measurement, events are required to contain at least one tight jet with $p_T > 114$GeV, 196GeV, 300GeV, 362GeV, and 507GeV for the five single-jet HLT triggers used respectively. The inclusive measurement is performed in five rapidity regions of $\Delta|y| = 0.5$, up to $|y| = 2.5$. For the dijet measurement, at least two tight reconstructed jets with $p_{T1} > 60$GeV and $p_{T2} > 30$GeV are required. The dijet measurement is performed in five rapidity regions, defined by the maximum absolute rapidity $|y_{\max}| = \max(|y_1|, |y_2|)$ of the two leading jets in the event. The online jets are reconstructed using only calo clusters and non calibrated.

3 Experimental Measurements

The measured double-differential inclusive jet cross section and dijet mass cross sections are defined as $\frac{\mathrm{d}^2\sigma}{\mathrm{d}p_T\mathrm{d}|y|} = \frac{1}{\epsilon\mathcal{L}_{\mathrm{eff}}}\frac{N}{\Delta p_T \Delta|y|}$, and $\frac{\mathrm{d}^2\sigma}{\mathrm{d}M_{\mathrm{JJ}}\mathrm{d}|y_{\max}|} = \frac{1}{\epsilon\mathcal{L}_{\mathrm{eff}}}\frac{N}{\Delta M_{\mathrm{JJ}}\Delta|y_{\max}|}$, respectively, where N is the number of jets in the bin, ϵ is the product of the trigger and event selection efficiencies, $\mathcal{L}_{\mathrm{eff}}$ is the integrated luminosity of the data sample used for the analysis, Δp_T, ΔM_{JJ}, $\Delta|y|$, and $\Delta|y_{\max}|$ are the transverse momentum, invariant mass and rapidity bin widths for inclusive jet and dijet mass, respectively.

The measured spectra are then corrected for detector smearing effects (unfolded to the particle level), using the iterative (D'Agostini) method [12], as implemented in the RooUnfold package [13]. The response matrix is taken from the simulation, and the final statistical errors include the correlations between the bins. Figure 1 shows the unfolded double-differential cross sections as a function of jet p_T and M_{JJ}, compared to the QCD prediction.

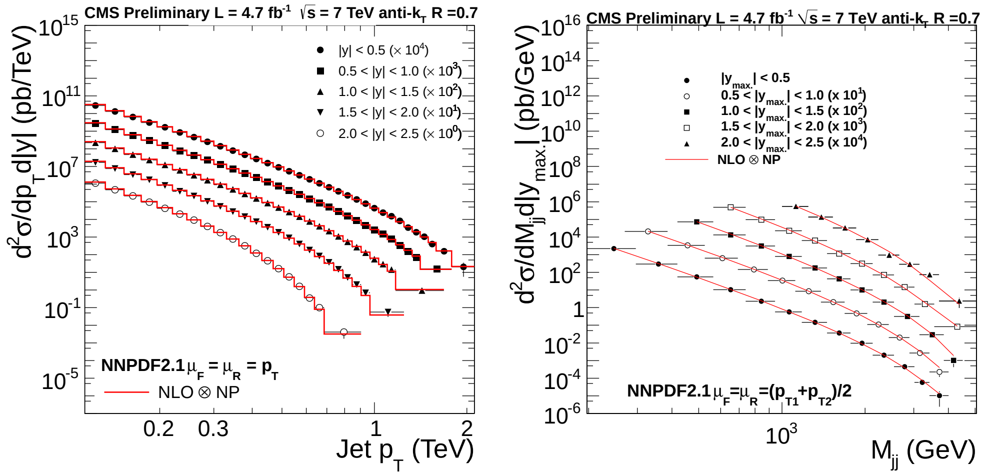

Figure 1: Inclusive jet (left) and dijet (right) cross sections compared to the theory prediction using the central value of the NNPDF PDF set.

4 Theory Predictions

The theoretical predictions for the jet cross sections consist of a next-to-leading-order (NLO) QCD calculation and a nonperturbative correction to account for the multiparton interactions (MPI) and hadronisation effects. The NLO calculations are done using the NLOJet++ program (v2.0.1) within the framework of the fastNLO package (v1.4) [14] The NLO calculation is performed using five different PDF sets: CT10 [15], MSTW2008NLO [16], NNPDF2.1 [17], HERAPDF1.5 [18], and ABKM09 [19] at the corresponding default values of the strong coupling constant $\alpha_S(M_Z) = 0.1180, 0.120$, 0.119, 0.1176, and 0.1179 respectively. The non-perturbative effects are estimated from the simulation, using the event generators PYTHIA6 (tune Z2) and HERWIG++ 2.4.2 [20]. The central value of the non-perturbative correction is calculated from the average of the two models considered, and ranges from 1% to 20%.

5 Measurement-Theory Comparison

In order to reveal the details of the agreement between the CMS data and the theory prediction, the ratio of the two is taken. Figures 2 shows the ratio to the prediction using the central value of the NNPDF PDF set.

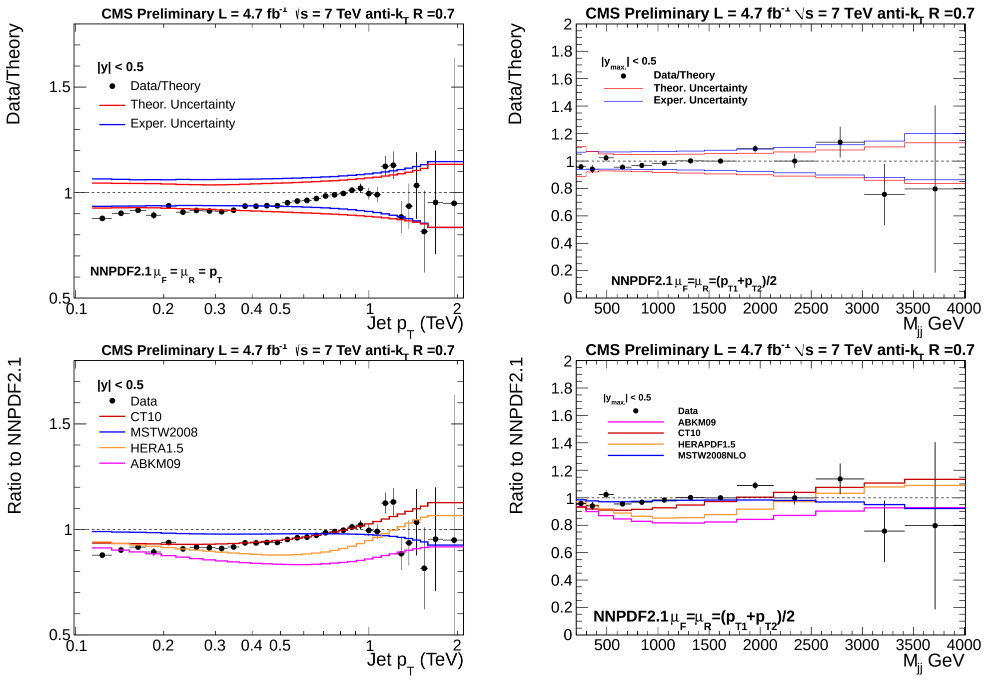

Figure 2: Top:Ratio of inclusive jet (left) and dijet (right) cross sections in $|y| < 0.5$ to the theory prediction of different PDF sets.

The additional curves represent the ratio of the other PDF set's central values. An overall good agreement is observed in all rapidity bins, with the various theory predictions showing differences of otypically 10 to 20%.

6 Summary

A measurement of the double-differential inclusive jet and dijet cross sections has been presented. Using 4.7 fb^{-1} of data from proton-proton collisions at $\sqrt{s} = 7$ TeV collected with the CMS detector, the measurement covers the jet p_T range from 0.1 TeV to 2 TeV, and the dijet mass range from 0.3 TeV to 5 TeV, in five rapidity bins, up to $|y| = 2.5$. Detailed comparisons to perturbative QCD predictions show good agreement with the theoretical predictions from five PDF sets. The size of the experimental uncertainties is comparable to the theoretical uncertainties, and in particular at the limits of the phase space, which allows for these data to be used in the global PDF fits and constrain their uncertainties.

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