Jet results from CMS

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Abstract

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Jet Results from CMS

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Abstract. Production of jets, measured with high experimental precision, allow for important tests of different theoretical predictions. These proceedings present a short overview of the recent jet results obtained with the CMS experiment at the LHC.

Introduction

A high cross section of the jet production at the LHC results in enormous events yield that can be used for precise experimental measurements. Jet rates, normalized cross sections, correlation between jets and multidifferential jet cross sections, measured in proton-proton collisions, provide significant input for theoretical models and improve our understanding of the standard model. Parton density functions, strong coupling constant, modelling of hard interaction, parton shower algorithms and multiple interactions, fragmentation and hadronization, QED radiation - this is still not a full list of important physics topics that can be addressed with jet results.

Precision measurement requires not only significant number of data events, but also well understood detector performance, proper simulation of the detector response and robust jet reconstruction algorithm. The anti-kt algorithm \cite{1} that is used by CMS, to be run on the particles reconstructed using particle-flow algorithm \cite{2}, demonstrated a good performance and reliable treatment of underlying events. The jets at CMS are corrected for pileup (multiple beam interactions in single event) and also subject of different corrections. Still the energy scale uncertainty remains the dominant systematic uncertainty in all the jet-related measurements. These proceedings present only a short overview of the recent jet results from CMS.

Inclusive jet production cross section

The most general measurement that can be done with jets is the inclusive jet production cross section measurement. A huge jets yield at the LHC allows to perform an accurate double differential cross section measurement with fine binning, as demonstrated in Fig. 1 left, where inclusive jet cross section at $\sqrt{s} = 8$ TeV, unfolded for detector effects, double-differential in jet $p_T$ and $y$ is compared to theoretical predictions \cite{3, 4}. The NLO predictions are corrected for non-perturbative effects. The data are well described by the predictions over many orders of magnitude in cross section and for jet $p_T$ up to 2.5 GeV.

To better explore the comparison of the data to different theoretical predictions, the ratio of the data to the prediction with CT10 PDF is shown together with five investigated PDF sets in Fig. 1 right. The total experimental systematic uncertainties are shown as band around one. The theory predictions describe the data generally well, the results from different PDF sets differ from each other mainly at high $p_T$. The best description of the data is obtained with predictions based on the CT10 PDF set.

Similar results were recently obtained by CMS at $\sqrt{s} = 2.76$ TeV \cite{5}. Figure 2 left shows that the data are well described by the predictions over many orders of magnitude in cross section in slightly different kinematic regime than in the previous measurement. The ratio of cross sections obtained at different $\sqrt{s}$ provides even more precise comparison to the theory, because many correlated uncertainties cancel for both measurement and predictions.
FIGURE 1. Left: inclusive jet cross section measurement from CMS. Right: the ratio of cross sections to the theory predictions for one representative $y$-bin.

FIGURE 2. Left: inclusive jet cross section measurement from CMS at $\sqrt{s} = 2.76$ TeV. Right: the ratio of cross sections measured at different $\sqrt{s}$ for one representative $|y|$ bin.
Figure 2 right shows the ratio of the two measurements and demonstrates that at low jet $p_T$ the predictions deviate from the observed behaviour by 1-1.5 $\sigma$.

**Dijet production cross section and kinematics**

Study of multijet production is not only a natural continuation of the inclusive jet studies, it also allows to study correlations in jet kinematics that are extremely sensitive to NLO effects.

In Fig. 3 dijet cross section at $\sqrt{s} = 8$ TeV, unfolded for detector effects, double-differential in jet $p_T$ and $y$, is well described by the predictions [6]. The ratio of the data to the prediction with NNPDF PDF is shown together with other investigated PDF sets in Fig. 3 right. The theory predictions describe the data generally well, the conclusions based on this comparison are consistent with previously shown inclusive jet results.

![Figure 3](image-url)  
**FIGURE 3.** Left: inclusive dijet cross section measurement from CMS at $\sqrt{s} = 8$ TeV. Right: the ratio of cross sections to predictions for one representative $|y|$ bin.

Figure 4 presents the azimuthal correlation between two leading in $p_T$ jets from CMS [7]. In the right plot the data are compared to fixed order prediction only in restricted $\Delta \phi$ range, since there is no prediction at fixed-order that can describe the whole region. The predictions are calculated for three jets NLO production, which is not valid at $\pi$, corresponding to LO dijet production, and also not valid after $\pi/2$, since here we would require NNLO prediction. In the region between $\pi/2$ and $2\pi/3$ the predictions do not describe data, since the three jets NLO calculations become effectively only LO in this regime. In the region where predictions are expected to work, the data are well described.

The same data are compared in Figure 4 left to predictions of different models, that reasonably describe the measurements over the whole $\Delta \phi$ range. The small observed differences are discussed in detail in Ref. [7].

**Extraction of $\alpha_s$**

All jet measurements can be used to extract the value of the strong coupling constant, $\alpha_s$. The predictions show high sensitivity to the $\alpha_s$, thus allowing to use fits to measured distributions with $\alpha_s$ as a fit parameter, to extract its best value. Figure 5 left shows a summary of running $\alpha_s$ measurements for all published CMS results and results from Tevatron and HERA experiments. For CMS the measurements include the inclusive jets, ratio of the three- to two- jet production cross sections, studies of three-jet mass and $t\bar{t}$ production. Overall all data demonstrate consistent values of $\alpha_s$, that agree well with the CMS measurement [3], with $\alpha_s(M_Z) = 0.1185^{+0.0042}_{-0.0042}$, where the $\alpha_s(M_Z)$ values are evolved to the corresponding energy scale $Q$ using the two-loop solution to the renormalization group equation within HOPPET.

The summary of the $\alpha_s(M_Z)$ values measured in different experiments compared to the world average in Fig. 5 right. Within the uncertainties all the measurements agree between each other and with the average value.
FIGURE 4. The normalized dijet cross section differential in $\Delta\phi_{DiJet}$ for seven $p_T^{max}$ regions, scaled by multiplicative factors for presentation purposes. For $\pi > \Delta\phi_{DiJet} > \pi/2$ the data are compared to predictions from fixed-order calculations in pQCD in the left plot, and to different models in the right plot for the whole $\Delta\phi$ region.

FIGURE 5. Left: the strong coupling $\alpha_s(Q)$ (solid line) and its total uncertainty (band) as determined in Ref. [3, 4]. Results from HERA and Tevatron experiments are also shown. Right: an overview of $\alpha_s(M_Z)$ measurements using hadrons.
Summary

Extremely interesting results from the LHC Run I data have contributed a lot to our understanding of underlying physics processes. Increasing luminosity and center-of-mass energy in the LHC Run II should allow for even more precise measurements in further extended kinematic regimes.

References

REFERENCES