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Measurement of jet properties in CMS

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ABSTRACT

We present measurements of the inclusive jet production at centre-of-mass energies of 8 and 13 TeV, and of multijets at 8 TeV. These measurements allow to constrain PDFs and the strong coupling constant. Two measurements of the azimuthal correlations at 8 and 13 TeV are also presented, testing higher order QCD calculations.

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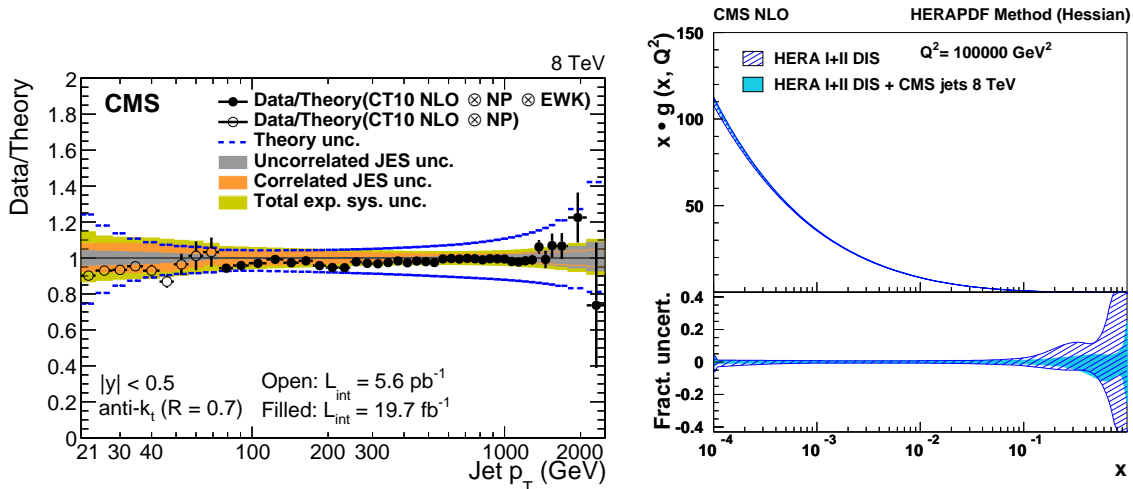


Figure 1: Left: comparison to fixed-order parton-level calculations of the inclusive jet production at 8 TeV. Right: gluon PDF before and after inclusion of inclusive jet data [2].

1 Introduction

We summarise the six most recent jet measurements in CMS [1] at 8 and 13 TeV. Analog measurements at 8 and 13 TeV are presented together.

2 Inclusive jet analyses at 8 and 13 TeV

The double differential cross section as a function of the transverse momentum and the rapidity is given by

$$\frac{d^2\sigma}{dp_T dy} = \frac{1}{\epsilon \mathcal{L}_{int}^{eff}} \frac{N_{jets}}{\Delta p_T \Delta |y|} \quad (1)$$

At 8 TeV [2], the luminosity for the high p_T region is 19.7 fb^{-1} , while for the low p_T region with dedicated low-pile-up runs, it is 5.6 pb^{-1} . The measurement is performed for large cone size jets only with the anti- k_T algorithm [8]. The rapidity coverage is $0 < |y| < 4.7$.

A similar measurement was performed with the first data at 13 TeV [3]. The luminosity is 71 pb^{-1} in the central region ($|y| < 3.0$) and 44 pb^{-1} in the forward region ($3.2 < |y| < 4.7$). The rapidity coverage and binning are kept the same as for the analysis at 8 TeV. The measurement at 13 TeV is performed for two cone size radii: $R = 0.4$ and $R = 0.7$.

The measurements are compared to predictions from MC event generators and from fixed-order parton-level calculations. In general, the uncertainty related to the correction of the jet energy scale is of the order of a percent.

The fixed-order calculation includes the electroweak and non-perturbative QCD corrections. We observe a very good agreement over the two orders of magnitude. The gluon PDF can be constrained with the inclusive jet data, and α_S can be extracted together with the fit of the PDF, as an additional parameter, with a value of $0.1164^{+0.0093}_{-0.0073}$. The measurement and the PDF fit are illustrated in Fig. 1.

The comparison to fixed-order parton-level calculations (not shown here) agrees better for a large cone size radius than for a small cone size radius. This is understood as being related to missing higher order calculations.

The comparison of the measurement with predictions from POWHEG + P8 (NLO + PS) shows very good agreement for both cone sizes at 13 TeV.

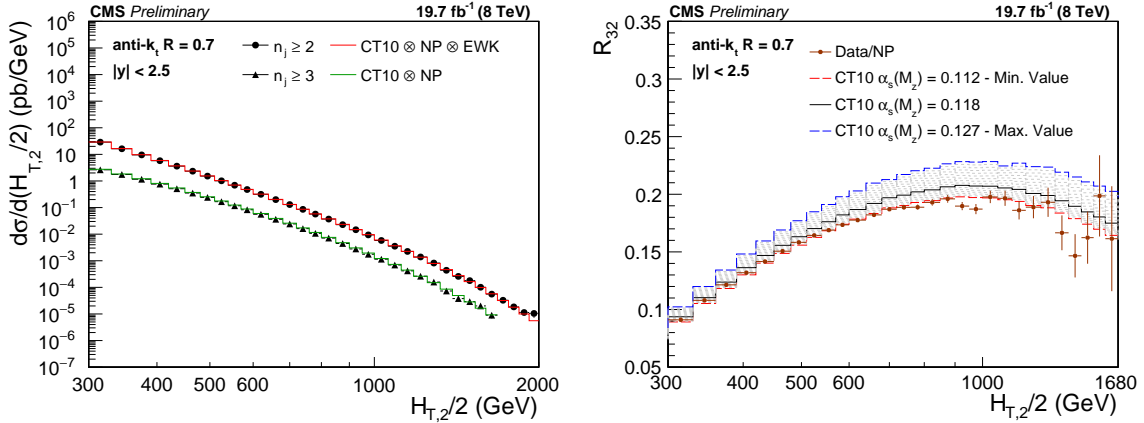


Figure 2: Measurement of the di-jet and tri-jet production at 8 TeV [4].

3 Multijet analysis at 8 TeV

The measurement of the multijet production was performed as a function of $H_{T,n} = \sum_{i=1}^n p_{T,i}$ with all the jets of an event in the considered phase space [4]:

$$\frac{d\sigma}{d(H_{T,2}/2)} = \frac{1}{\epsilon \mathcal{L}_{\text{int}}^{\text{eff}}} \frac{N_{\text{events}}}{\Delta(H_{T,2}/2)} \quad (2)$$

Since $R_{mn} = \frac{\sigma_{m\text{-jet}}}{\sigma_{n\text{-jet}}} \propto \alpha_S^{m-n}$, α_S can be extracted from the ratio of 3 and 2-jet measurements. Some uncertainties cancel in the ratio. The selection consists of jets of $p_T > 150$ GeV in $|y| < 2.5$, clustered with the anti- k_T algorithm with $R = 0.7$. Events where the leading jet would be in the forward region are vetoed. The measurement is shown in Fig. 2 and $\alpha_S = 0.1150^{+0.0088}_{-0.0038}$ is extracted.

4 Dijet triple differential cross section at 8 TeV

The triple differential cross section of the di-jet production at 8 TeV consists in the following measurement [5]:

$$\frac{d^3\sigma}{dp_{T,\text{avg}} dy^* dy_b} = \frac{1}{\epsilon \mathcal{L}_{\text{int}}^{\text{eff}}} \frac{N_{\text{di-jet events}}}{\Delta p_{T,\text{avg}} \Delta y^* \Delta y_b} \quad (3)$$

where

- $p_{T,\text{avg}} = \frac{1}{2}(p_{T,1} + p_{T,2})$ is the average transverse momentum of the di-jet system;
- $y_b = \frac{1}{2}|y_1 + y_2|$ is the *rapidity boost* of the di-jet system;
- $y^* = \frac{1}{2}|y_1 - y_2|$ is the *rapidity separation* of the di-jet system.

Anti- k_T jets with $R = 0.7$ are selected with $p_{T,\text{jet}} > 50$ GeV, $|y_{\text{jet}}| < 3.0$ and $p_{T,\text{avg}} > 133$ GeV.

The different regions of the phase space are then exploited to extract the strong coupling and to constrain PDFs: the central region (small y_b and small y^*) is most suited for α_S extraction at high energy scales; in the boosted region (higher y_b but small y^*), the high- x region of PDFs can be better constrained; finally, in the region of large rapidity separation (small y_b but higher y^*), PDF and detector effects can be better disentangled.

The measurement is compared first to NLO parton-level calculations as well as predictions from MC event generators (HERWIG 7 and PYTHIA 8). In general, predictions are slightly overestimated at high transverse momentum in the boosted region. Eventually, the di-jet data may be used to extract gluon PDFs. This is illustrated in Fig. 3.

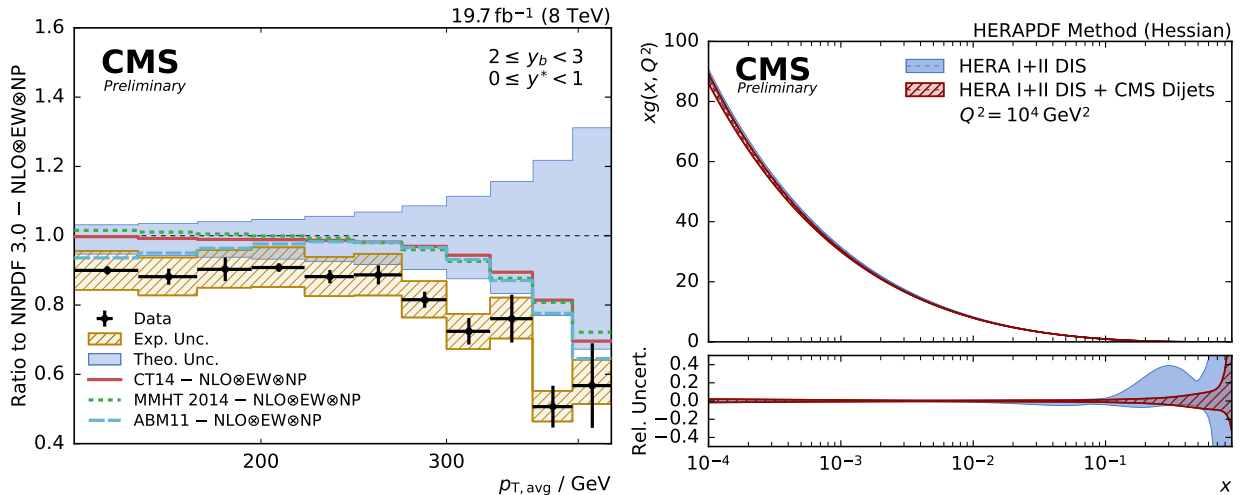


Figure 3: Left: di-jet triple differential cross section in the boosted region. Right: comparisons of the gluon PDF before and after inclusion of di-jet data [5].

5 Azimuthal correlations at 8 and 13 TeV

The azimuthal correlations allow to investigate higher-order QCD corrections: the more extra radiations, the less correlated the two leading jets.

CMS has published two measurements:

1. the measurement of the azimuthal correlations between the two leading jets at 8 TeV with a jet reconstructed with the anti- k_T algorithm of $R = 0.7$ [6];
2. the analog measurement at 13 TeV for a radius of 0.4 [7]; in addition, the same measurement is also performed with minimum jet multiplicities of 3 and 4 jets in order to be more sensitive to higher order effects; finally, correlations between the subleading and the closest third- or fourth-leading jet are measured, also in order to increase the sensitivity to parton showers.

Here, given the large amount of results reported in these analyses, we only show corresponding measurements at 8 and 13 TeV in Fig. 4.

6 Conclusions

In general, the QCD predictions describe well the measurements. With jet data, gluon PDFs can be significantly improved at high x . The value of α_S is also extracted. The azimuthal correlations in multijet events illustrate the importance of higher-order QCD corrections.

References

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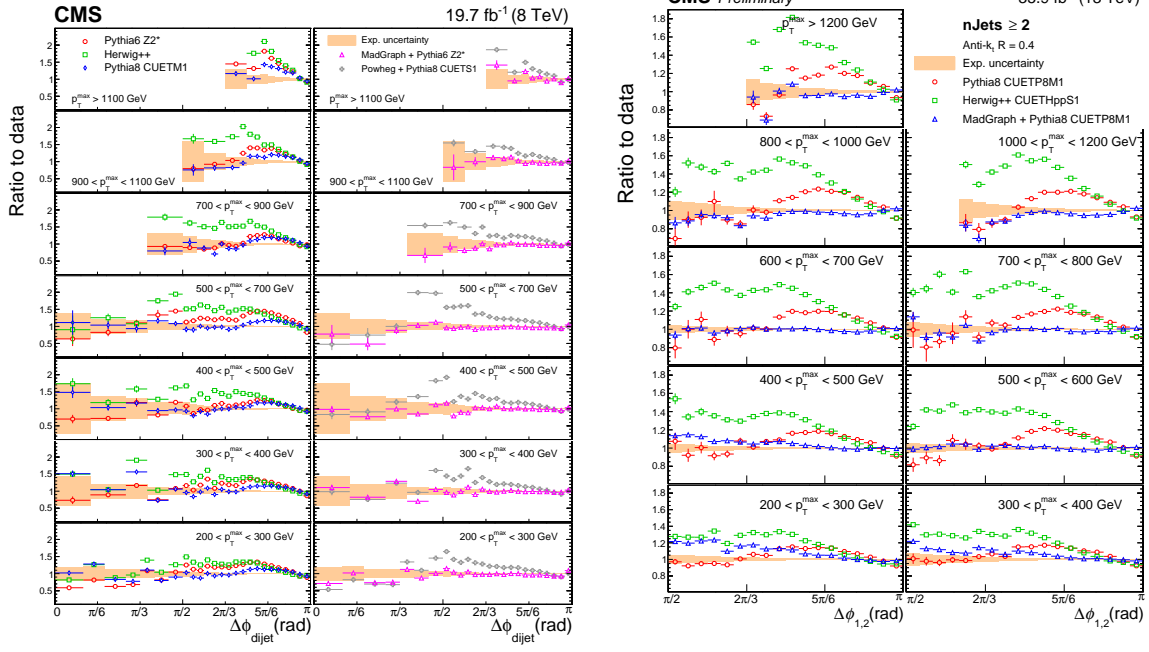


Figure 4: Analog measurements at 8 and 13 TeV (with respective cone size radii) for the azimuthal correlations [7].

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