

Precision QCD measurements from CMS

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Recent measurements of jet events are presented which test QCD with unprecedented precision. The measurements are based on Run 2 data collected with the CMS detector at the LHC. The data are compared to various theoretical predictions and Monte Carlo event generators after correcting for detector effects. Such studies can improve experimental understanding of jets and jets substructure.

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1. Introduction

In high-energy proton-proton collisions, processes governed by the strong interaction are dominant. Quantum chromodynamics (QCD), the gauge theory describing the strong interaction between quarks and gluons, has a great testing ground at the LHC, providing rich jet data in a previously unexplored region. In this document, recent jet related measurements performed with the data collected by the CMS [1] experiment are presented.

2. Multijet correlation measurement

Multijet events and the modeling of their characteristics play an important role in precision measurements, as well as in searches for new physics. The understanding of the structure of multijet final states is therefore crucial for analyses of those events. A recent measurement has been published by CMS [2] related to collinear (small-angle) and large-angle radiation as well as momentum distributions in multijet production. In the analysis two different topologies of three-jet events and Z+2jet events are used. Events are categorized by using two observables, one of which is the transverse momentum ratio to distinguish the soft from hard radiation and the second one is the angular separation to define a collinear and a large-angle radiation. Reasonable agreement with parton shower and matrix element calculations is observed within the available phase space, except the hard radiation region ($p_{T3}/p_{T2} > 0.6$). In Figure 1, the p_{T3}/p_{T2} distribution is shown for the angular radiation of ΔR_{23} .

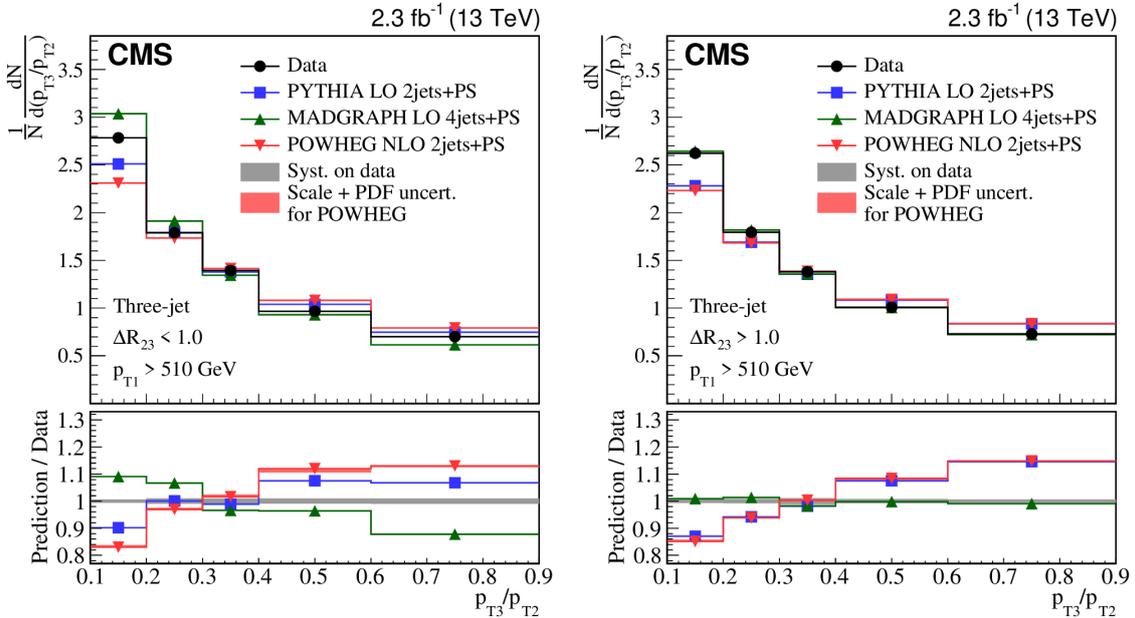


Figure 1: Comparison of p_{T3}/p_{T2} for three-jet events with the theoretical predictions for small-angle radiation ($\Delta R_{23} < 1.0$) (left) and for large-angle radiation ($\Delta R_{23} > 1.0$) [2].

3. Inclusive jet production dependence on distance parameter

The anti- k_T algorithm, the commonly used jet clustering algorithm at CMS, requires the distance parameter R which corresponds to the radius of the jet in the $y - \phi$ plane, where y and ϕ are the rapidity and azimuthal angle, respectively. The amount of energy clustered into the jet is controlled by the distance parameter R and various contributions having dependence on R . The measurement of a jet production cross section as a function of R gives the opportunity to examine the theoretical modeling of the perturbative and nonperturbative (NP) effects in parton evolution. The CMS Collaboration has recently published [3] the inclusive jet cross section measurement for each R parameter, relative to $R = 0.4$, covering $R = 0.1 - 1$ in intervals of 0.1. The unfolded results are compared to leading order (LO) and higher order (NLO, NNLO) predictions with different parton shower and with and without NP corrections. In Figure 2, the ratio of differential cross sections of inclusive jets with respect to AK4 jets is shown. NLO prediction using POWHEG+PYTHIA [4, 5] (CUETP8M1 tune) describes the data at high p_T however some deviations at low p_T are observed for larger jet radii.

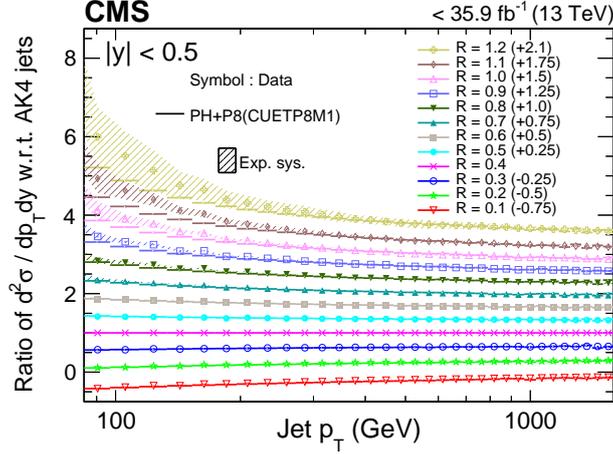


Figure 2: Ratio of the differential jet cross sections for different sizes with respect to AK4 jets in the region $|y| < 0.5$ [3].

4. Z/γ +jet cross section measurements

The differential cross sections of Z + jets and γ + jets production and their ratio are measured as a function of the vector boson p_T by using the data recorded by the CMS experiment [6]. In order to explicitly study the collinear Z emission, the Z +jet cross section is also given as a function of the distance between the Z boson and the closest jet. Due to the sensitivity of higher order electroweak corrections at high boson p_T region, Z/γ ratio plays a crucial role for the background estimations in beyond SM physics searches. In the analysis, the vector boson is required to have $p_T > 200$ GeV, η or $|y| < 1.4$. The unfolded data is compared with predictions from LO and NLO calculations from MADGRAPH5 aMC@NLO, as well as the NLO QCD+EW calculation from SHERPA + OPENLOOPS. Furthermore, a comparison of γ +jets measurement with with NLO JetPhox predictions is performed. Figure 3 shows the comparison of differential cross section ratio

of Z + jets to γ + jets as a function of the vector boson p_T with the theory predictions. Overall, a good agreement is observed between the data and the theory for both the γ and Z boson final states, although in some regions of phase space a few tens of percent deviations are observed. In general, the perturbative NLO corrections exhibit a better agreement with the measurements.

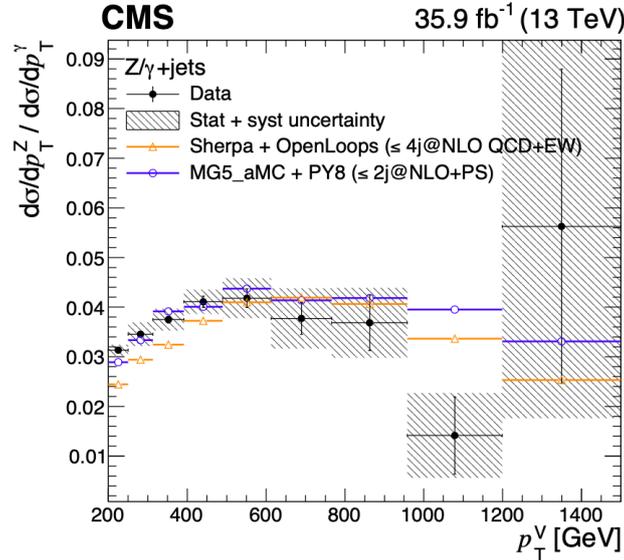


Figure 3: Comparison of differential cross section ratio of Z + jets to γ + jets as a function of the vector boson p_T with the theory predictions [6].

References

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