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Search for BFKL signatures in CMS

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Abstract

Results by the CMS Collaboration on the measurements of dijet production processes are presented. Such processes are expected to be sensitive to Balitsky-Fadin-Kuraev-Lipatov (BFKL) evolution effects. In particular, the measurements of azimuthal angle correlations between two jets separated by a large rapidity interval at different centre-of-mass energies are discussed. The measurements are corrected for detector effects and compared with the predictions of various Monte Carlo event generators, Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) and BFKL-based calculations.

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Search for BFKL signatures in CMS

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Results by the CMS Collaboration on the measurements of dijet production processes are presented. Such processes are expected to be sensitive to Balitsky-Fadin-Kuraev-Lipatov (BFKL) evolution effects. In particular, the measurements of azimuthal angle correlations between two jets separated by a large rapidity interval at different centre-of-mass energies are discussed. The measurements are corrected for detector effects and compared with the predictions of various Monte Carlo event generators, Dokshitzer– Gribov–Lipatov–Altarelli–Parisi (DGLAP) and BFKL-based calculations.

1 Introduction

Hadronic jet measurements are important probes for investigating the low-x structure of the proton, where x represents the fractional momentum carried by the incoming partons. In the quantum chromodynamics (QCD) prediction, two partons are produced with a back-to-back topology in azimuthal plane. Hence, two jets show a strong correlation in their azimuthal angle which is a sensitive probe for better understanding of the QCD radiation in hard processes in high energy particle collisions. In the Bjorken limit which can be accessible at the large centre-of-mass energies, the scaling variable $x \sim p_T/\sqrt{s}$ is kept fixed near unity whereas the transverse momentum p_T becomes approximately equals to the square of the four-momentum Q^2. Since x is not small, Q^2 tends to infinity. Thus, the calculations can be resummed within the collinear factorization framework with the Dokshitzer–Gribov–Lipatov– Altarelli–Parisi (DGLAP) formalism, where parton emissions are strongly ordered in transverse momentum. In another kinematic regime: $x \rightarrow finite$, $p_T >> \Lambda_{QCD}$ and $\sqrt{s} \rightarrow \infty$, the large rapidity separation between the scattered partons occur, thus the DGLAP dynamics fails at low x. Such processes can be described by the Balitsky–Fadin–Kuraev–Lipatov (BFKL) evolution equations. In the following the measurements searching for the BFKL evolution equation effects are presented. The measurements are performed with data collected in proton-proton collisions by the CMS experiment [1].

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[1] On behalf of the CMS Collaboration

2 Azimuthal decorrelation of jets at $\sqrt{s} = 7$ TeV

The CMS Collaboration reported a measurement of azimuthal angle decorrelation between the most forward and the most backward jets (so-called Mueller-Navelet jets) in proton-proton collisions at $\sqrt{s} = 7$ TeV [2]. In the analysis, jets with transverse momentum, $p_T > 35$ GeV and absolute pseudorapidity, $|y| < 4.7$ are considered. The normalised cross sections are compared with various Monte Carlo generators and analytical predictions based on the DGLAP and BFKL parton evolution equations. In Fig. 1, the azimuthal angle decorrelation of dijets and ratio of its average cosines ($C_n =< \cos(n(\pi - \phi_{dijet})) >$) are shown as a function of rapidity separation between the jets, Δy, reaching up to $\Delta y = 9.4$ for the first time.

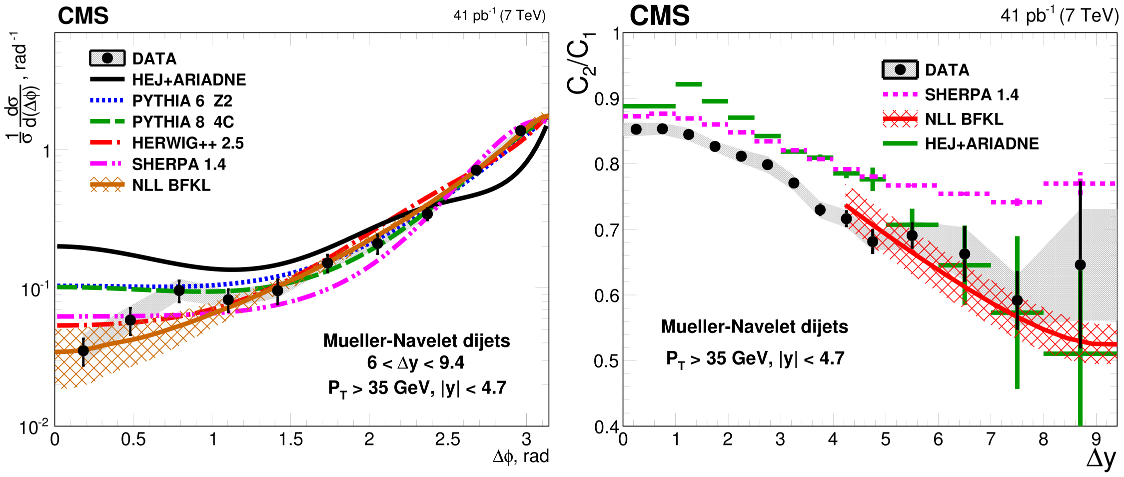

Figure 1: Left: The azimuthal-angle difference distribution measured for Mueller-Navelet jets in the rapidity interval $6.0 < \Delta y < 9.4$. Right: Comparison of the measured ratio C_2/C_1 as a function of rapidity difference Δy to SHERPA, HEJ+ARIADNE and analytical NLL BFKL calculations at the parton level [2].

3 Dijets with large rapidity separation at $\sqrt{s} = 2.76$ TeV

A measurement of inclusive and Mueller-Navelet dijet differential cross sections as a function of rapidity separation between the jets, Δy in pp collisions at $\sqrt{s} = 2.76$ TeV is presented [3]. The present study extends the results of 7 TeV measurement [2] by measuring cross section ratios. The same event selection and jet definition are applied hence a direct comparison of the results is allowed.

The inclusive dijet production cross section, σ^{incl}, is defined as the cross section for events with at least one pair of jets with $p_T > p_{Tmin} = 35$ GeV where p_{Tmin} represents the transverse momentum threshold. The "exclusive" dijet production cross section, σ^{excl}, corresponds to dijet events if only two jets with $p_{Tmin} > 35$ GeV. The Mueller-Navelet cross section, σ^{MN}, denotes the dijet events with the most forward and most backward jets with $p_T > 35$ GeV. Finally, the cross section of events with no extra jets above $p_{Tveto} = 20$ GeV is represented as σ^{excl}_{veto}.

The ratios of the inclusive to the "exclusive" dijet production cross sections, R^{incl}, and to "exclusive" with veto dijet production, R^{incl}_{veto}, are shown in Fig. 2. The results are compared with the predictions of PYTHIA8 (tune 4C) [4], HERWIG++ (tune EE3C) [5] and HEJ+ARIADNE [6] event generators. PYTHIA8 shows an agreement with the data, whereas HEJ+ARIADNE and HERWIG++ significantly overestimate the ratio. In the case of ratio R^{incl}_{veto}, PYTHIA8 gives the best description of the data, however it still fails to model the shape of the Δy dependence.

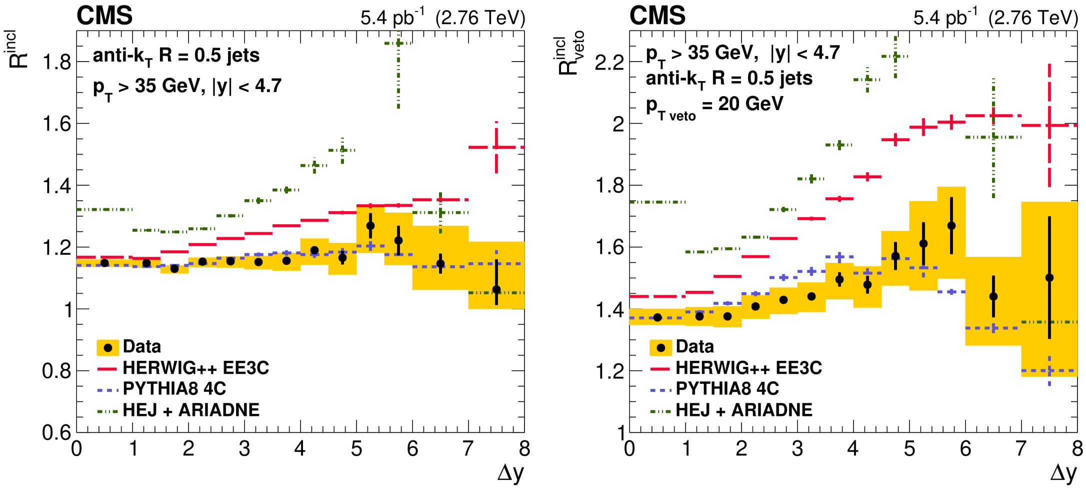

Figure 2: The ratio of differential inclusive dijet cross section to "exclusive" (left) and to "exclusive" with veto dijet production (right). Vertical error bars represent the statistical uncertainties, whereas the systematic uncertainties are indicated as shaded bands [3].

The ratios of the Mueller-Navelet dijet production cross section to “exclusive”, R^{MN}, and to “exclusive” with veto dijet production, R^{incl}_{veto}, are shown in Fig. 3. Generally, only the leading order DGLAP based event generator PYTHIA8 describes the ratios R^{incl} and R^{MN}.

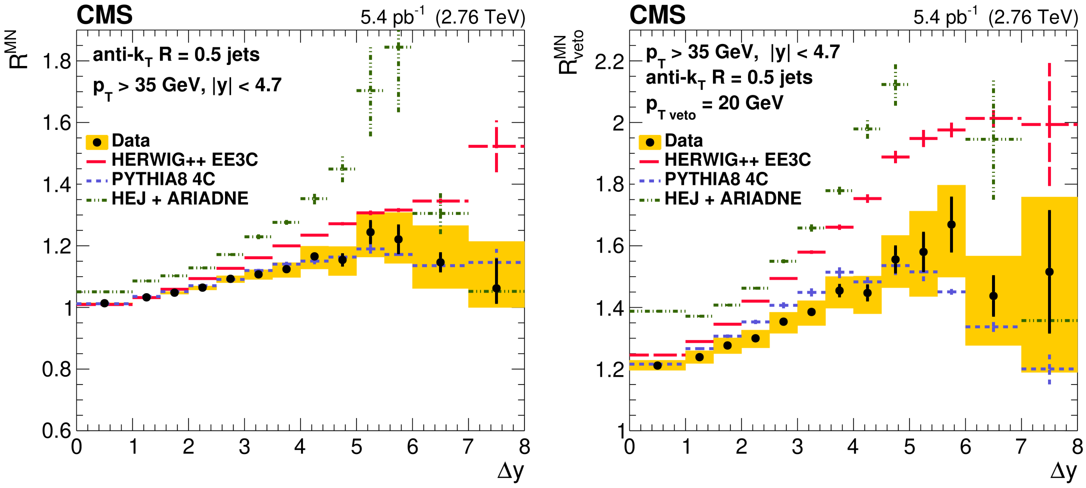

Figure 3: The ratio of Mueller-Navelet dijet cross section to "exclusive" (left) and to "exclusive" with veto dijet production (right). Vertical error bars represent the statistical uncertainties, whereas the systematic uncertainties are indicated as shaded bands [3].

The results of the ratios of R^{incl} and R^{MN} are compared with the previous measurement performed at $\sqrt{s} = 7$ TeV [2] are shown in Fig. 4. A strong rise with Δy is observed at high energies. This can be explained as a reflection of both the increasing available phase space and BFKL dynamics. Due to the increasing phase space volume for hard parton radiation, the ratios show a strong rise with the increasing Δy. As a result of the kinematic limitations on the events with more than two jets with $p_T > 35$ GeV, the ratios decrease at vert large Δy. BFKL calculations at the next-to-leading-logarithm level are needed to compare the results obtained with this analysis.

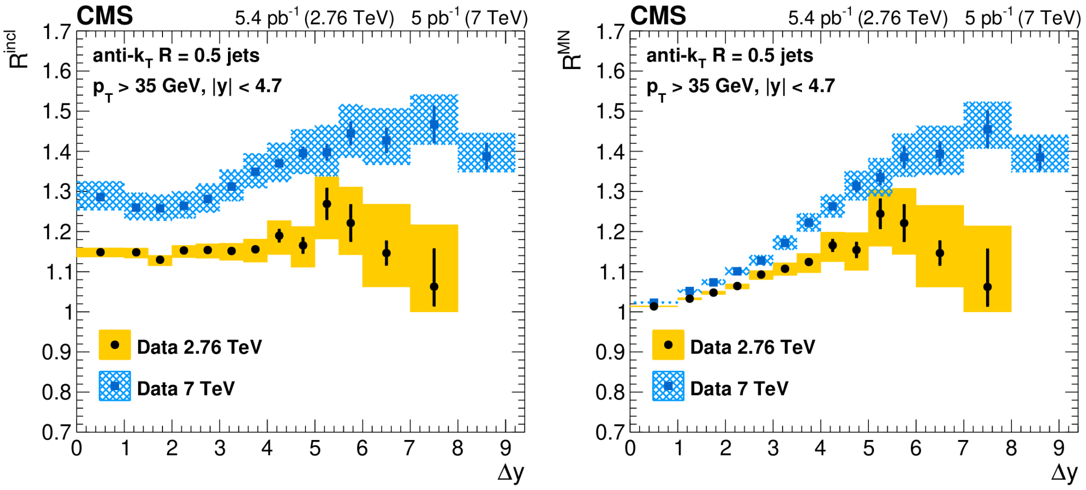

Figure 4: Comparison of ratios of the cross sections for inclusive (left) and MN (right) at the collision energies of 7 TeV and 2.76 TeV [3].

4 Summary

Recent dijet production studies at different centre-of-mass energies performed by the CMS Collaboration are presented. The measurements are compared to various Monte Carlo event generators as well as the predictions based on BFKL calculations. The results on azimuthal angle decorrelations in dijet events, where the two jets are separated by a large rapidity interval, are consistent with the predictions based on BFKL calculations.

References

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