Azimuthal decorrelation of jets widely separated in rapidity in pp collisions at $\sqrt{s} = 13$ TeV

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The azimuthal angular decorrelation between the two jets with the largest rapidity separation is sensitive to dynamical effects that emerge in the high energy limit of quantum chromodynamics (QCD). Azimuthal angular distributions provide an ideal testing ground for Balitski–Fadin–Kuraev–Lipatov (BFKL) resummation effects, which is related to an all orders resummation of large logarithms of energy in this limit related to multiple parton splittings in QCD. At leading order (LO) in α_s, the two jets are produced back-to-back on the transverse plane and are perfectly balanced in transverse momentum p_T. However, when accounting for higher order corrections in the perturbative expansion, there will be extra radiation between the outward-most jets, which induces less correlation in the transverse plane than in the LO case. The decrease of azimuthal angular correlation as the rapidity separation increases must be sufficient to show the effect of enhanced radiation predicted by BFKL.

It is possible to further characterize the hard processes involving scattering of partons by increasing the collision energy in hadron-hadron collisions. At high centre-of-mass energies, the semi-hard region $\Lambda^2_{QCD} \ll Q^2 \ll s$ can be reached, where pre-asymptotic BFKL effects could manifest in the data. In such a collision, the struck partons manifest themselves in the final state as a collimated sprays of particles that we call a jet. Jet production carries large logarithmic terms in the semi-hard region and these terms need to be resummed in the parton structure function or in the partonic cross section.

To further investigate these large logarithmic effect, Mueller–Navelet (MN) [1] suggested looking at the process of dijet production in as large

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an interval of rapidity as possible and to assess the increase of the cross-section within the BFKL framework [2, 3]. In a kinematic region where semi-hard parton interactions become important, azimuthal decorrelation will increase with increments in the rapidity separation between the outermost jets $\Delta y = |y_1 - y_2|$, where y_1 and y_2 are rapidities of the most forward and the most backward jets [4]. Our plan for the Snowmass 2021 process is to define new variables that are sensitive to mini-jets emission between the two MN jets that are sensitive to BFKL dynamics at NLL [5, 6, 7, 8], in addition to the standard azimuthal angle decorrelation variables that have been explored by the Tevatron and LHC experiments.

On the experimental side, the CMS Collaboration has published a measurement of the azimuthal decorrelation of the most-forward and backward jets in the event with $p_T > 35$ GeV and $\Delta y < 9.4$ in pp collisions at $\sqrt{s} = 7$ TeV [4]. Analytical BFKL calculation at next-to-leading logarithmic (NLL) accuracy with an optimised renormalisation scheme and scale and next-to-leading order (NLO) impact factors are found to be consistent with the CMS measurement for the measured jet observables at $\Delta y > 4$. However, approaches inspired on the Dokshitzer–Gribov–Lipatov–Altarelli–Parisi (DGLAP) evolution equations are also able to describe most features of the data on similar Δy intervals. Thus, a judicious choice of observables that can better discriminate between DGLAP evolution and BFKL evolution need to be further investigated. At increasing collision energies, possible manifestations of BFKL signatures are expected to be more pronounced, so the analysis was devoted to study the NLL-BFKL framework.

For the Snowmass process, we would like to define and perform new measurements of azimuthal angular decorrelations in MN jet events. It will be fundamental to test the dependence of the $\Delta\phi$ correlations as a function of the outermost jets p_T, in addition to the Δy scan. The region of applicability of the BFKL formalism is expected to occur in cases where the outermost jets have similar p_T. At the same time, we are interested in studying the radiation pattern between the jets presented in the form of "mini-jets" between the outermost jets. Indeed, as the rapidity interval increases there is more phase space available for extra radiation to be emitted, so it is natural for the average jet multiplicity to increase. The number of mini-jets as well as the emission pattern in y–ϕ space could potentially be used in addition to the azimuthal angular decorrelation to further characterize MN dijet events. The main focus will be given in the definition of more "exclusive" observables that exploit the two-jet angular correlations between the mini-jets and the outermost jets in y–ϕ space, together with a measurement of $\langle\cos(\Delta\phi)\rangle$ between the outermost jets. The study is tailored for MN jet events with low jet $p_T > 20$ GeV, given the availability of low pileup data collected by the CMS detector in pp collisions at $\sqrt{s} = 13$ TeV. A strong collaboration between experimentalists and theorists is fundamental in order to define a set of robust variables sensitive to BFKL dynamics.

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