JET PRODUCTION AT LARGE RAPIDITY INTERVALS

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ABSTRACT

During the 1992–93 collider run of the Fermilab Tevatron the DØ experiment accumulated a large sample of events with jets in the final state. Since DØ has the ability to trigger on jets out to a pseudorapidity of 3.2, we were able to collect events containing jets with large rapidity intervals. Such events may not be well described by LO or NLO QCD perturbative calculations due to the increased importance of additional gluon radiation which tends to decorrelate the leading jets in the event. These contributions can be included by using BFKL theory to resum the leading powers of the rapidity interval to all orders in α_s. We present the first experimental measurement of jet-jet ϕ correlations as a function of the rapidity interval of the η ordered jets. We compare these results to JETRAD, HERWIG and BFKL resummation predictions.

1. Introduction

Theoretical QCD calculations of jet final states resulting from $\bar{p}p$ collisions have historically been dominated by fixed order expressions. Leading order (LO) and next-to-leading order (NLO) calculations[1,2] have so far provided an adequate description of the measured cross sections.[3] As new regions of phase space are explored limitations of this approach may be encountered. If there is more than one scale present in the process the perturbative calculation will contain logarithms of the ratios of these quantities; these logarithms may become large. An appropriate choice of the renormalization scale can absorb one of these scales into the parton distribution function, but the others will remain in the perturbative expansion. Such scales arise when low E_T jets with large rapidity intervals are produced at the Tevatron.

DelDuca and Schmidt,[4] and independently Stirling,[5] have developed techniques based on the theory of Balitsky-Fadin-Kuraev-Lipatov[6] (BFKL) to resum these large logarithms. BFKL theory resums to all orders in α_s soft gluon emissions that arise in these cases. Their calculation leads to a term e^y appearing in the partonic cross section where y is the rapidity interval between the two jets most separated in rapidity. This indicates that this emission should increase exponentially as a function of y. Such emissions would tend to decorrelate the two leading jets. In the case of fixed order

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calculations little or no decorrelation would be seen. In LO, the jets are always correlated but in NLO, the presence of one additional parton will induce some decorrelation, weakly dependent on y.

We have investigated this decorrelation by analyzing azimuthal angle distributions between jets in events with large rapidity intervals in collider data and compared them to predictions from BFKL resummation, HERWIG[7] and JETRAD[8] (a NLO Monte Carlo) . We calculated $\pi - \Delta\phi$ where $\Delta\phi$ is the difference in azimuth between the jets with the largest rapidity interval $\Delta\eta = \eta_1 - \eta_2$. We plotted $\xi =< \cos(\pi - \Delta\phi) >$ as a function of $\Delta\eta$. Complete correlation would correspond to ξ = constant for all $\Delta\eta$; decorrelation would be indicated by a deviation from the constant. Unfortunately, calculations are not currently available using the cuts we applied to the data, forcing us to compare HERWIG and JETRAD to each separately. Efforts are underway to produce calculations compatible with our data.

2. Detector and Event Selection

The DØ detector was used for this study. As it is described in detail elsewhere,[9] only the portions relevant to this analysis will be described here. DØ has a uranium–liquid argon sampling calorimeter covering the pseudorapidity region $|\eta| < 4.0$ and 2π in ϕ. It has fine longitudinal and transverse segmentation providing good jet energy and position resolution.

The trigger consists of three levels. The first (L0) requires hits in beam-beam scintillation counters signalling the presence of an inelastic collision. The second level (L1) looks for localized energy deposits in 0.2×0.2 ($\Delta\eta \times \Delta\phi$) towers in the calorimeter. The third level (L2) implements a cone based jet-finding algorithm ($R = 0.7$) using calorimeter cell information. Jets were triggered on out to $\eta = 3.2$. For this analysis, one tower above 7 GeV at L1 and 1 jet above 30 GeV at L2 were required.

Jet energy scale corrections were applied offline and spurious jets removed before a minimum E_T cut of 20 GeV was applied. Of the remaining jets, the one most forward will be referred to as jet 1 and the one furthest away in rapidity from jet 1 will be referred to as jet 2. One of these two 'tagging' jets was required to be above 50 GeV to remove any trigger bias.

3. Results

Currently the BFKL calculation is available using symmetric cuts where both tagging jets were required to be above the same threshold. The comparison between HERWIG, JETRAD and the BFKL resummation calculation are shown in Figure 1 for $E_{t1,2} > 30$ GeV. Here we see that the resummation theory predicts a much stronger decorrelation effect than seen in HERWIG or JETRAD; these show reasonable agreement possibly due to the radiation suppressing effects of the symmetric cuts. Experimental data should be able to distinguish between these predictions.

In Figure 2 the comparison between HERWIG, JETRAD and collider data for the cuts described in Section 2 are shown. Here we see that there is good agreement between HERWIG and the data. In contrast, there is a difference in the shape of the distribution for JETRAD which predicts too little decorrelation for these selection criteria.

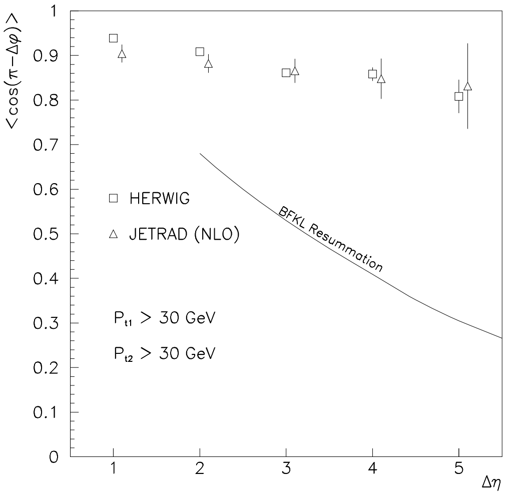

Fig. 1. $< cos(\pi - \Delta\phi) >$ v. $\Delta\eta$ for symmetric 30/30 GeV E_t cuts.

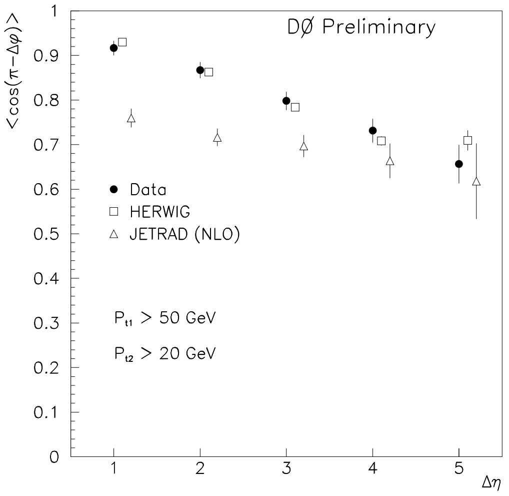

Fig. 2. $< cos(\pi - \Delta\phi) >$ v. $\Delta\eta$ for asymmetric 50/20 GeV E_t cuts.

4. Conclusions

We have examined jet-jet correlations in jets produced with large rapidity intervals using the DØ detector at the Tevatron. These events show a decorrelation in azimuth between the extreme η jets which increases with increasing $\Delta\eta$. These effects are described well by HERWIG but NLO calculations show a weaker trend. Theoretical predictions based on BFKL theory are not directly comparable at this time, but comparisons between this calculation and HERWIG and NLO predictions with similar event selection criteria show a much stronger decorrelation effect for the resummation theory than HERWIG or NLO.

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