USE OF A $K_\perp$ JET ALGORITHM IN $p\bar{p}$ COLLISIONS AT DØ

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ABSTRACT

The determination of jet multiplicities with algorithms based on '$K_\perp$' type distance parameters at hadron colliders allows a more direct comparison to results from fixed target and e^+e^- experiments and has fewer theoretical ambiguities. We present the results of using such a jet definition to measure the fraction of events with 2, 3, and 4 jets at various momentum transfer (E_T) scales.

1. Introduction

A successive combination jet algorithm similar to those used in e^+e^- physics has been suggested by Ellis and Soper for hadron-hadron physics.[1] The algorithm provides an alternative to the presently used fixed cone algorithm and renders less ambiguity in counting jets. Each particle is assigned to one and only one jet and, therefore, the problem of splitting and merging of jets is avoided.

Because of its similarity to the $K_\perp$ (or Durham) algorithm[2] presently used at e^+e^- colliders, comparisons between hadron-hadron and e^+e^- physics becomes possible. Specifically, we are interested in using jet rates to measure α_S. At leading order, the fraction of events with 3 or more jets, R_3, can be written as*

$$R_3 = \frac{\sigma^{\geq 3jets}(LO)}{\sigma^{\geq 2jets}(LO)} \propto \alpha_S. \tag{1}$$

At the Tevatron, we can measure R_3 over a range of momentum transfer (E_T) scales from 50 to 500 GeV, and therefore, we will be able to probe the running of α_S.

2. The Algorithm

The algorithm suggested by Ellis and Soper clusters particles based on a function of $K_\perp$ type. But unlike the $K_\perp$-algorithm, it does not use a cutoff parameter, y_{cut}. Instead, particles are assigned to a jet if their separation in $\eta - \phi$ space is less than some value

$$R_{ij}{}^2 < D^2 \quad where \quad R_{ij}{}^2 = (\eta_i - \eta_j)^2 + (\phi_i - \phi_j)^2. \tag{2}$$

The recombination procedure is as follows.

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*Representing the DØ Collaboration.

*The NLO calculation for R_3 is expected within the next year.

1. For each pair of particles,i and j, we calculate the function

$$d_{ij} = minimum \left(E_{T,i}{}^2, E_{T,j}{}^2\right) \frac{R_{ij}{}^2}{D^2} \tag{3}$$

   where $D \approx 1^{\dagger}$. Then we define for each particle, i,

$$d_i = E_{T,i}{}^2. \tag{4}$$

2. The minimum d_{min} of all the d_i and d_{ij} is found.

3. If d_{min} is a d_{ij}, particles i and j are merged into a new, pseudo-particle k with

$$\begin{gathered} E_{T,k} = E_k \sin\theta_k, \quad \eta_k = -\ln\left(\tan\frac{\theta_k}{2}\right), \quad and \quad \phi_k = \arctan\frac{P_{x,k}}{P_{y,k}}, \\ with\ four\ vector \quad P_k{}^{\mu} = P_i{}^{\mu} + P_j{}^{\mu}, \quad and \quad \theta_k = \arccos\frac{P_{z,k}}{\mid \vec{P_k} \mid}. \end{gathered} \tag{5}$$

4. If d_{min} is a d_i (i.e. $R_{ij}{}^2 > D^2$ for all j), then the particle is deemed not "mergeable" and it is removed from the list of particles and placed in the list of jets.

5. Return to step 1. Repeat steps 1-5 until all particles have been merged into jets (i.e. $R_{ij}{}^2 > D^2$ for all ij). The result is a list of jets.

6. All jets with E_T below some fraction, f, of the hard scale are dropped ‡. In this analysis, we used $E_{T,max}$ (leading jet E_T) to define the hard scale.

3. Analysis

The algorithm was performed on Herwig Monte Carlo data on partons (parton shower), particles (final state hadrons) and calorimeter cells (DØ detector simulation). Figures 1 and 2 show the fraction of events with 2, 3 and 4 jets as a function of f. The events were generated at 80 Gev E_T for the 2 to 2 process and analysed with $D = .7$. In figure 1, objects were merged as described above and give good agreement for $.2 < f < .4$. In figure 2, merging was done as prescribed by Ellis and Soper[1]:

$$E_{T,k} = E_{T,i} + E_{T,j}, \quad \eta_k = \frac{E_{T,i}\eta_i + E_{T,j}\eta_j}{E_{T,k}}, \quad and \quad \phi_k = \frac{E_{T,i}\phi_i + E_{T,j}\phi_j}{E_{T,k}}. \tag{6}$$

This method gives much less agreement. Thus, the method used in figure 1 was chosen.

Figure 3 shows the 2, 3 and 4 jet fractions for data taken from the first DØ data run (1992-1993) and Herwig Monte Carlo data at the parton shower level. Events are shown with $E_{T,max}$ between 88 and 100 Gev. The data appears to be in fairly good agreement with the Monte Carlo for $.2 < f < .35$, but diverge for larger f.

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†It can be shown that for $D = 1$ and $R_{ij} << 1$, the function d_{ij} is approximately $K_{\perp,ij}$.

‡This was suggested by Mike Seymour and C-P. Yuan independently.

We are investigating alternative ways of defining the hard scale for each event . There is a worry that a bias toward 2 jet events is introduced by using $E_{T,max}$ to set the hard scale. We do see a decrease in R_3 for higher $E_{T,max}$ (figure 4), but at this point, we cannot confirm that it is due to the running of α_S. Studies of this are forthcoming and once confirmed, we will attempt to extract values of α_S for $100 < E_T < 500$ Gev.

References

1. S. D. Ellis, D. E. Soper, *Phys. Rev.* **D48** (1993) 3160.
2. S. Catani et al., *Phys.Lett.* **B285** (1992) 291.
3. S. Catani et al., preprint CERN-TH 6775/93.

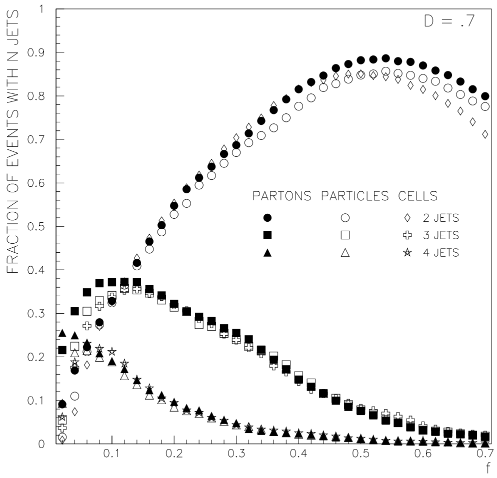

Fig. 1. Herwig data using addition of 4 vectors to merge objects.

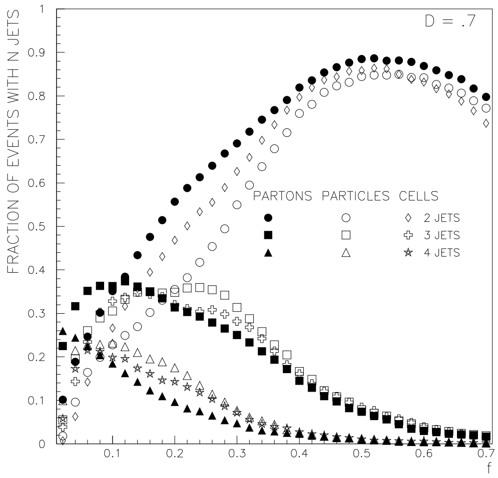

Fig. 2. Herwig data using an E_T weighted scheme to merge objects.

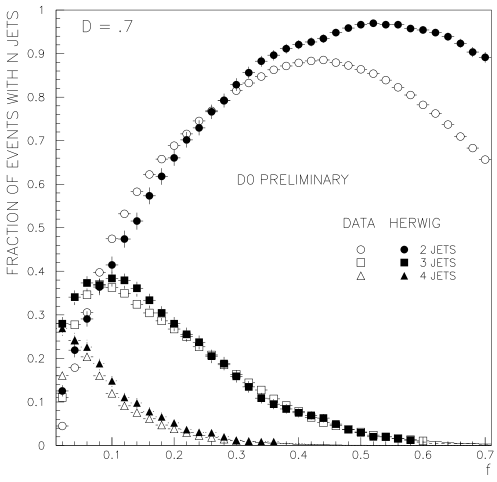

Fig. 3. DØ data and Herwig parton shower data with $88 Gev < E_{T,max} < 100 Gev$.

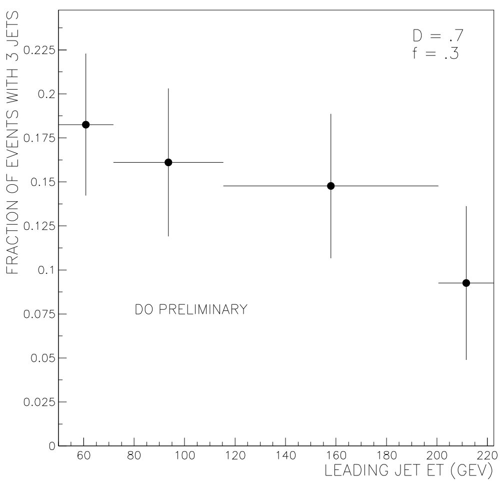

Fig. 4. The fraction of events with 3 jets vs. $E_{T,max}$.