SUBJET STRUCTURE OF JETS AT DØ

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We present a preliminary study of jet structure in $\overline{p}p$ collisions at $\sqrt{s} = 1.8$ TeV using data taken with the DØ detector during the 1994-95 Tevatron run. We measure the average number $<N_{sub}>$ and radial distributions of subjets within a jet, and compare to the predictions of HERWIG 5.8, a parton-shower Monte Carlo event generator.[1]

1 Introduction

In leading order perturbative QCD, jets are formed from the final state of a hard body 2-to-2 scatter of partons. Jets are pencil-thin at this order, consisting of a single parton carrying the full jet transverse energy E_T in a definite direction in $\eta - \phi$ space. Next-to-leading order calculations predict jets containing two partons. A two parton jet will have its E_T distributed in $\eta - \phi$ space, giving structure to the jet. Similarly, higher order radiation and non-perturbative hadronization further contribute to jet structure. Using a cone jet algorithm, DØ has studied the E_T flow over various subcones within each jet.[2] For the analysis presented here, we use the k_T jet algorithm, a variation of the Durham jet algorithm modified for hadron-hadron collisions.[3] We study jet structure by rerunning the k_T jet algorithm within jets to resolve subjets.[4] This method is used to directly compare calorimeter cells, hadrons and partons, and is expected to have small hadronization and detector corrections.[5]

In the k_T jet algorithm, all 4-vectors in the event are merged together successively starting with the pair with the smallest relative p_T, stopping when no pair is within a distance $D = 1.0$ in $\eta - \phi$ space. The remaining 4-vectors are called jets. To resolve subjets within a jet, the algorithm is rerun on all 4-vectors within the jet. Merging stops when all 4-vector pairs (i,j) have

$$d_{i,j} = min(E_{T,i}^2, E_{T,j}^2)(\Delta\eta_{i,j}^2 + \Delta\phi_{i,j}^2) > y_{cut} E_{T,jet}^2$$

The resolution parameter $0 \leq y_{cut} \leq 1$ defines the minimum relative transverse momentum between any two subjets inside the jet. For $y_{cut} = 1$, the number of subjets within any jet always equals one and increases as $y_{cut} \rightarrow 0$.

2 Data Analysis

Inclusive jet events were reconstructed by preclustering calorimeter cells within a radius 0.2 in $\eta - \phi$, then clustering using the k_T jet algorithm. Subjets were resolved within jets with $275 < E_T^{jet} < 350$ and $|\eta_{jet}| < 0.5$ at a series of y_{cut} values. Figure 1 shows that $<N_{sub}>$ increases by $\sim 70\%$ as y_{cut} is decreased three orders of magnitude and $<N_{sub}> \approx 1.25$ at $y_{cut} = 10^{-2.0}$. HERWIG subjets at the parton level (after parton showering) account for $\geq 70\%$ of the subjets observed in DØ data jets. $<N_{sub}>$ increases only slightly when the analysis is redone in HERWIG at the particle level, showing that hadronization effects are small for these y_{cut}, although this may be model dependent. When the detector simulation is included, HERWIG agrees with the DØ data quite well, quantifying the effects of showering in the DØ calorimeter.

Choosing $y_{cut} = 10^{-2.0}$ forces the subjets in these high E_T jets to be seperated by distances ≥ 0.2 in $\eta - \phi$ space and $E_T^{sub} > 27$ GeV. Figure 2 shows the $< N_{sub} >$ resolved within a distance ΔR from the jet axis. On average, there is approximately one subjet resolved within $\Delta R \leq 0.25$, and very few additional subjets for $\Delta R > 0.7$. For jets with two subjets, it is most likely that one subjet carries most of the jet E_T near the jet axis, and the second subjet is much softer and further from the jet axis. This interpretation is confirmed by Figure 3, which is Figure 2 weighted by the subjet E_t fraction.

$$<\rho(\Delta R)>= \frac{\sum_{i=1}^{N_{sub}(r \leq \Delta R)} E_{T,i}}{\sum_{i=1}^{N_{sub}(r \leq 1.0)} E_{T,i}}$$

reaches a plateau at smaller ΔR than $<N_{sub}>$, with subjets at $\Delta R > 0.25$ contributing $< 10\%$ to the total jet E_T.

In conclusion, HERWIG with the detector simulation agrees well with the DØ data. In HERWIG, particle and parton level jets agree well with each other, but have less (more) subjets than the jets at the calorimeter level, for distances ΔR greater (less) than 0.2, and have relatively more (less) E_T concentrated in the jet core.

References

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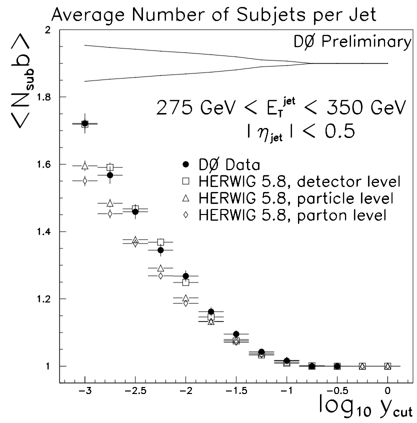

Figure 1: Average number of subjets per central high E_T jet vs. resolution variable y_{cut}. The error bars are statistical, and the $\pm 1\sigma$ systematic error band is an estimate of the effects of multiple interactions and energy scale correction error, added in quadrature.

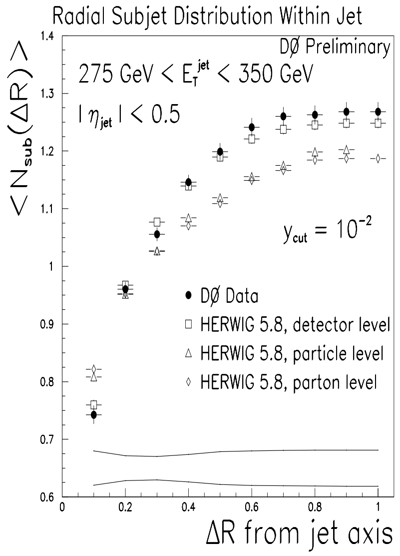

Figure 2: Average number of subjets per jet within a radius ΔR around the jet axis. The error bars are statistical, and the systematic error band is $\pm 1\sigma$.

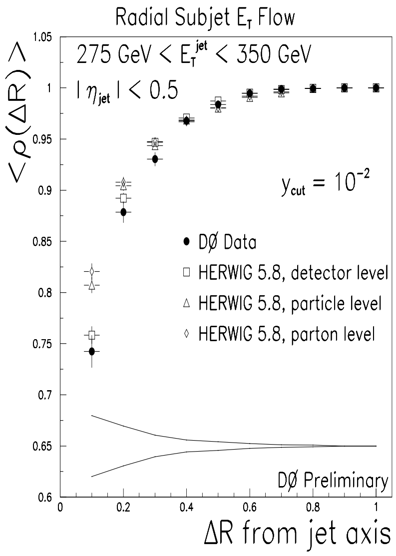

Figure 3: The average E_T fraction carried by subjets within a radius of ΔR around the jet axis. The error bars are statistical, and the systematic error band is $\pm 1\sigma$.