Determination of the 3-Jet Ratio in $p\bar{p}$ Events

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We simulate $p\bar{p}$ events at a center-of-mass energy of $\sqrt{s} = 1.96$ TeV with the PYTHIA Monte Carlo generator. Right after the collision between p and $\bar{p}$, two partons emerge from the hard process, immediately begin to radiate gluons and quarks and create a parton shower. After further fragmentation, the partons recombine and form sprays of highly energetic particles, the jets.

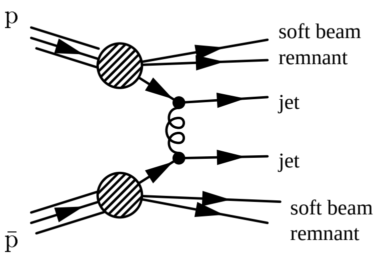

Fig. 1: $p\bar{p}$ scattering

In our analysis we determine the 3-jet-ratio, which is the number of 3-jet events divided by the number of all events. The 3-jet-ratio is directly proportional to the strong coupling constant α_s.

In order to recombine particles into jets, we need a jet reconstruction algorithm. The standard algorithm at D0 is the Cone Algorithm, but in our simulation we use the k_T jet algorithm. This algorithm has some advantages compared to the cone algorithm. It is infared and collinear safe, less dependent on hadronic corrections, doesn't create overlapping jets, and the size of the jets is dynamic. The k_T clustering algorithm starts with a list of energy preclusters, formed from final state partons and hadrons, which are the particles after hadronization. The angular separation between the preclusters is obtained from their difference in pseudorapidity, $\Delta\eta$, and azimuthal angle, $\Delta\phi$, by $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$. The three basic steps of the algorithm are as follows:

1. For each object i in the list, the algorithm defines $d_{i,i} = p_{T,i}^2$, where p_T is the momentum transverse to the beam. For each pair i and j of objects it defines the distance function $d_{i,j} = \min(p_{T,i}^2, p_{T,j}^2)\frac{\Delta R_{i,j}^2}{D^2}$. D is the resolution parameter.

2. If the minimum of all $d_{i,i}$ and $d_{i,j}$ is $d_{i,j}$, and $d_{i,j}$ is smaller than cut-off parameter dCut, objects i and j are replaced by a new pseudo-particle k by adding the four-vectors of the particles, before the algorithm goes back to step 1. If the minimum is $d_{i,i}$, and $d_{i,i}$ is smaller than dCut, i is defined as a jet and is removed from the list of objects. If $d_{i,i}$ is larger than dCut, the algorithm stops.

3. The algorithm returns to step 1 as long as there is an object left in the list.

The output of this algorithm is a list of jets, separated by $\Delta R > D$ from each other. As the particles, which are produced in the $p\bar{p}$ events, have been separated into two groups, final-state partons at the end of the shower and long-lived particles, the algorithm produces a list of jets for each group: parton and hadron jets. To apply QCD calculations it is necessary to determine the extent of the hadronic corrections in order to assess the differences between parton and hadron jets.

Once the jets are extracted by the jet algorithm, the 3-jet-ratio can be determined by dividing all events with 3 jets through the total number of events.

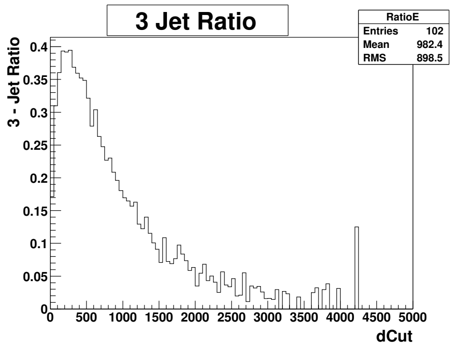

Fig. 2: 3-jet-ratio versus cut-off parameter dCut, determined from parton jets

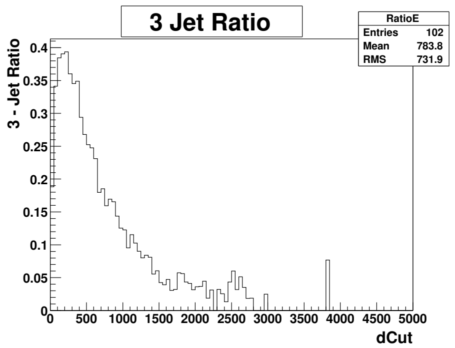

Fig. 3: 3-jet-ratio versus cut-off parameter dCut, determined from hadron jets

Note that figure 2 represents the 3-jet-ratio for the parton jets. The corresponding ratio for the hadron jets is illustrated by figure 3. The two ratios are similar so that hadronization correctures will be close to unity.

To compare measured 3-jet rates to theory, we use the NLOJet++ program [3] for the determination of NLO (next-to-leading order) 3-jet rate predictions.

References

[1] D. Elvira, Jet measurements at D0 using a k_T algorithm, hep-ex/0209073, September 2002

[2] K. Chiyoko Frame, Implementation and calibration of a k_T jet finding algorithm for use in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$TeV at the D0 collider detector, FERMILAB-THESIS-1999-10, 1999

[3] Z. Nagy, Three-jet cross sections in hadron-hadron collisions at next-to-leading order, hep-ph/0110315, September 2003