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

M. Erlebach, O. Biebel, M. Binder, T. Christiansen, J. Elmsheuser, F. Fiedler, A. Grohsjean, P. Haefner, T. Nunnemann, D. Schaile, P. Schieferdecker, R. Ströhmer, and B. Tiller

We simulated $p\bar{p}$ 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.
In our analysis [1] we have determined 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, one needs a jet reconstruction algorithm. The standard algorithm at DØ is the Cone Algorithm, but in our simulation we used 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 basics of the algorithm including the definition of its cut-off parameter d_{Cut} and the scaling parameter D can be found in last year's annual report [2].

The output of the k_T 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. 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. Figure 1 represents the 3-jet ratio for parton and hadron jets.

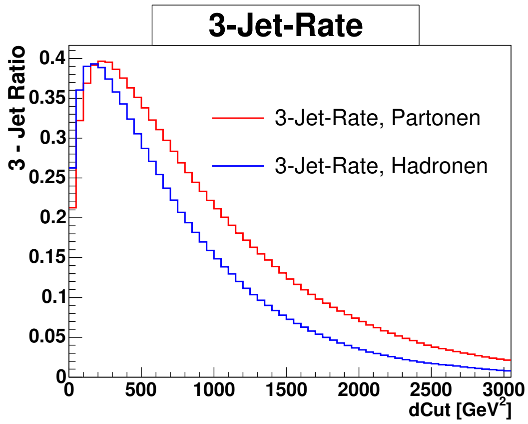

Fig. 1: 3-jet-ratio versus cut-off parameter d_{Cut}, determined from parton and hadron jets.

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. As the 3-jet ratios on parton and hadron level are very similar, the hadronic corrections are close to unity.

At hadron colliders with high luminosity (Tevatron) several $p\bar{p}$ events can occur in a single bunch crossing. These events, which are called *pile-up events*, cannot be separated by the detector and therefore blur the results. The pile-up correction for the parton level, which is close to unity, is shown in figure 2. On hadron level, this correction is slightly higher and scales up to a factor of 1.5 for high values of the cut-off parameter.

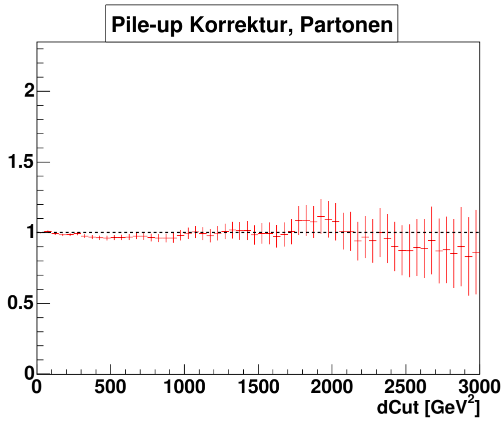

Fig. 2: pile-up corrections on parton level

To compare measured 3-jet rates to theory, we used the NLOJet++ program [3] for the determination of NLO (next-to-leading order) 3-jet rate predictions.
Figure 3 illustrates a very good agreement of the jet-rates from PYTHIA and NLOJet++ at large d_{Cut}, with NLOJet++ scaled by 1.6 to account for missing higher order terms. Note that only jet ratios on parton level are regarded in this figure.

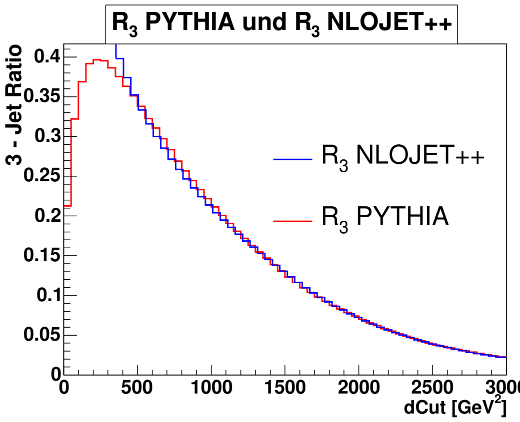

Fig. 3: 3-jet ratio from PYTHIA and NLOJet++

References

[1] M. Erlebach, diploma thesis, LMU München, 2004
[2] M. Erlebach *et al.*,Annual report 2003, p. 40
[3] Z. Nagy, Phys.Rev.Lett. **88** (2002) 122003