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Quark and Gluon Jets at CDF

Naor Wainer
for the CDF Collaboration

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

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CDF Collaboration
Presented by Naor Wainer
Fermilab
Batavia, Illinois 60510, USA

ABSTRACT

Jet shapes at $\sqrt{s} = 1.8$ TeV have been measured by CDF at the Fermilab Tevatron Collider. The jet shape is mainly formed by parton emission before hadronization. The jet shapes may also be used to differ between quark and gluon jets. Two approaches are tried. Jet shape variables are input to a feed forward neural network trained on QCD Monte Carlos. We observe a variation of the quark content of jets as a function of jet transverse energy. The second approach consists of constructing a likelihood function, based on Monte Carlo predictions, with the Mellin moments of the momentum of charged tracks in jets. Differences are found between gluon-like jets in 2-jet events and quark-like jets in photon-jet events.

1. Jet Shape

In this paper the jet shape is defined as the normalized transverse momentum flow of tracks inside a jet of cone R where $R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$, η is pseudorapidity and ϕ is the azimuthal angle. Jets have transverse energy E_t. Transverse is calculated w.r.t. the beam axis. In previous papers[1] we have shown that the measured jet shape agrees with NLO QCD calculations and with the Herwig Monte Carlo. We pursue this analysis farther by showing that both Pythia and Isajet Monte Carlos predict quite accurately the shape (Fig. 1a). We try to separate the QCD shower contribution to the shape from the fragmentation contribution in the Monte Carlos. The shape obtained from showered partons in Herwig agrees to the data, while the shape obtained from Feynman-Field fragmentation without gluon radiation in Isajet diverges from the data (Fig. 1b). Thus, we conclude that parton emission is the dominant process in forming the jet shape. One may try to use jet shape variables to classify quark and gluon jets, based on Monte Carlo predictions.

2. Neural Network Quark-Gluon Separation

A feed-forward Neural Network (NN) is used to discriminate between quark and gluon jets[2]. Of the 8 variables chosen, 3 sample the jet shape described above. The others are the charge multiplicity, the second moments of the η and ϕ distributions of the jet, and the P_t of the leading track and its distance r from the jet axis in η-ϕ space. The NN was trained on Pythia quark and gluon jets.

The NN outputs one variable, *qgval*, which is larger for quark jets then for gluon jets. In Fig. 2 we show the evolution of <*qgval*> with measured jet E_t. It

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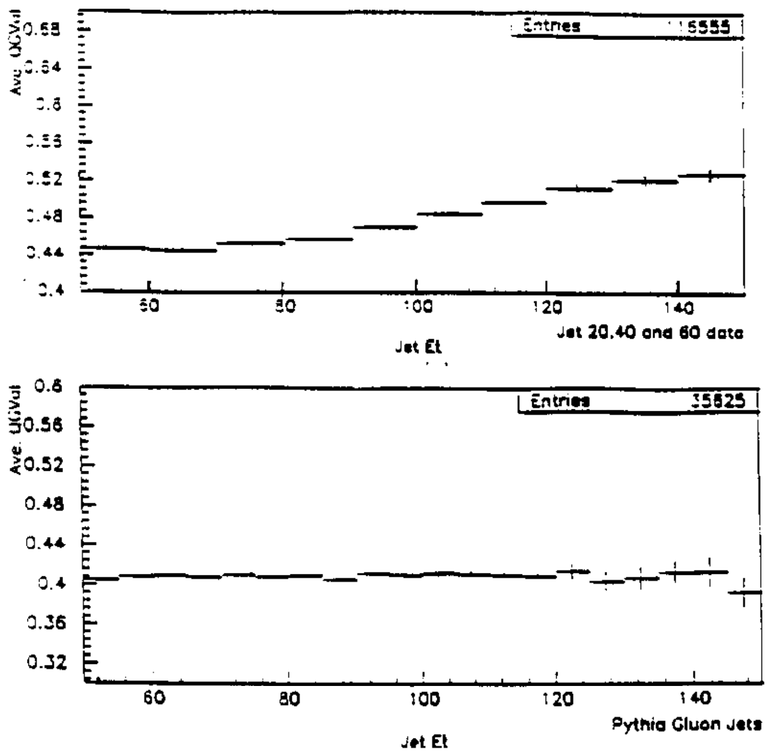

Figure 2: Neural Network output for different jet energies. The average *qgval* increases with energy, suggesting an increasing number of quark jets in the data.

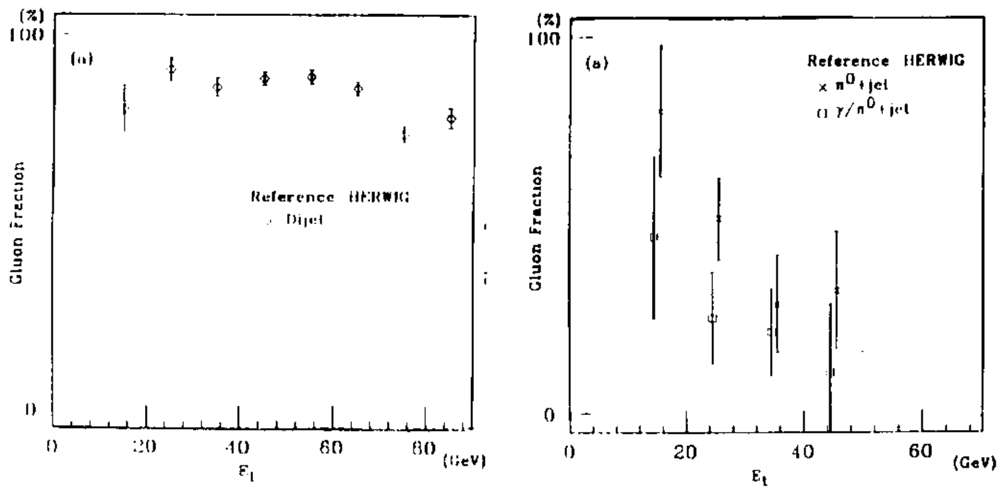

Figure 3: The fraction of gluon jets in 2-jet and γ-jet events.

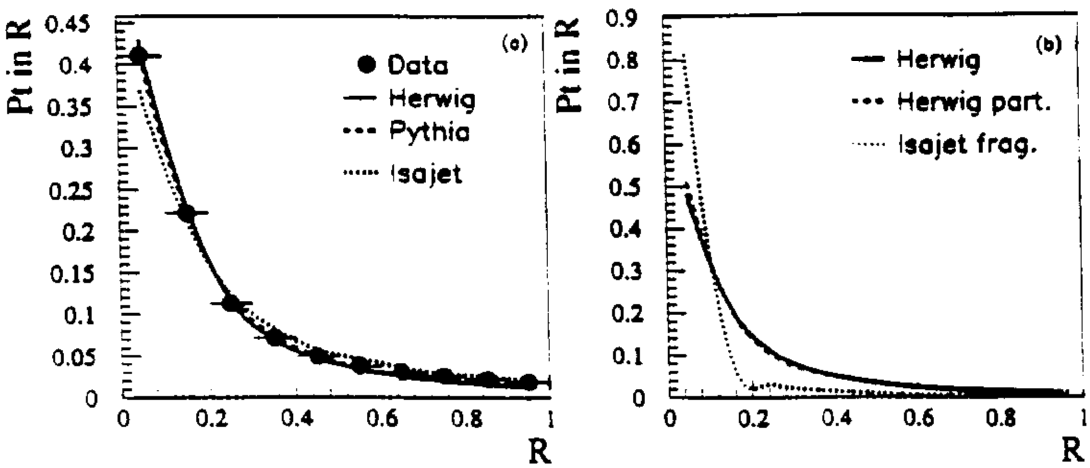

Figure 1: Jet Shape for data and Monte Carlos. a) The MC's are shown after detector simulation. b) The MC's are shown without detector simulation.

is noticeable that the fraction of quark jets grows with jet E_t, while <*qgval*> is independent of jet E_t for a single species.

3. Dynamic Likelihood Quark-Gluon Separation

Another approach is to use Mellin transforms of the momentum of charged particles inside a jet[3] . A likelihood function is constructed with these transforms. We rely on distributions calculated from Herwig and Pythia quark and gluon jets to derive probabilities for a jet to be a quark or a gluon jet.

In Fig 3. we display the gluon jet fractions in 2 jet events and in γ-jet events, which are expected to be quark enriched. As expected, 2-jet events on average contain more gluon-like jets than γ events.

6. References

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