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HIGH ΣE_T MULTIJETS AT CDF

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Representing the CDF Collaboration

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HIGH ΣE_T MULTIJETS AT CDF

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REPRESENTING THE CDF COLLABORATION

The CDF collaboration has studied properties of 3-, 4- and 5-jet events with very high total transverse energy. An appropriate set of kinematic variables is described and two calculations based on QCD and with a phase space model. The QCD calculations are in reasonably good agreement with the data.

The Tevatron Collider has produced collisions of antiprotons and protons at a center of mass energy of 1800 GeV. The Collider Detector at Fermilab (CDF) is a general purpose magnetic detector, used to study many aspects of these collisions. This talk presents a study of 3-, 4- and 5-jet events in 105 pb^{-1} collected with an online trigger requirement that the scalar sum of transverse energy ΣE_T be greater than 300 GeV. The inclusive cross section vs. ΣE_T for such events is given in Fig. 1.

Standard event quality cuts were imposed to eliminate bad runs, cosmic rays and multiple interactions. The z-position (along the beam line) of the interaction vertex was required to be withing 60 cm of the detector center. We required ΣE_T calculated offline to be >420 GeV with no significant missing E_T . Individual jets in an event were required to have pseudorapidity,

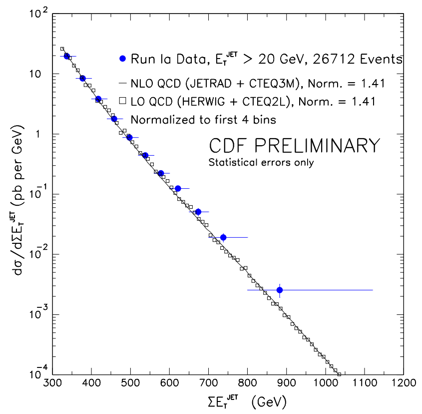

Figure 1: Inclusive jet cross sections from Run 1a

$|\eta| < 3.0$, $E_T > 20$ GeV. The clustering algorithm effectively merged jets with a separation in $\eta - \phi$ space $\Delta R_{ij} < 0.9$.

The data are compared with two QCD models: (a) NJETS[1], a leading order (LO) $2 \rightarrow N$ Monte Carlo calculation without fragmentation, with $< Q >^2 = < P_T >^2$ using the KMRSD0 parton distribution functons (PDF) and (b) HERWIG MC[2] with $2 \rightarrow 2$, gluon radiation, color-coherence, underlying event, detector simulation, $< Q >^2 = stu/(s^2 + t^2 + u^2)$ using the CTEQ1M PDF. As alternate to QCD, we also plot the predictions for phase space.

For N=3, the process $1+2 \rightarrow 3+4+5$ is characterized by variables described in Ref. [3]. For jets 3, 4 and 5 ordered in energy, they are the 3-jet invariant mass, two

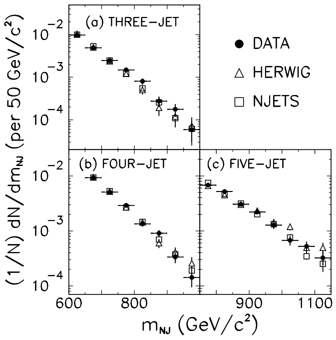

Figure 2: N-jet mass distributions for 3-, 4- and 5-jet events.

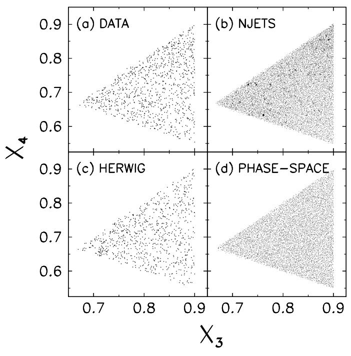

Figure 3: 3-Jet Dalitz Plot.

Dalitz variables, the angle, θ_3, between $\vec{P_1}$ and $\vec{P_3}$ the angle, χ_3, between plane S_{123} containing $\vec{P_1}$, $\vec{P_2}$ and $\vec{P_3}$ and plane S_{345} containing $\vec{P_3}$, $\vec{P_4}$ and $\vec{P_5}$, and the three mass fractions: $f_j = M_j/M_{3J}$, $j = 3,4,5$. The 4-Jet (') and 5-Jet (") events are reduced to the equivalent 3-Jet case by conbining successively, the lowest-mass jet pairs. We required $M_{3J} > 600\mathrm{GeV/c^2}$, $M_{4J} > 650\mathrm{GeV/c^2}$ and $M_{5J} > 750\mathrm{GeV/c^2}$, along with several additional event cuts (leading-jet scattering angle and Dalitz variables) which were imposed to restrict the N-body parameter space to the region for which the ΣE_T requirement is efficient, and to ensure that the jets in the N-jet sample are well-measured.

3-jet

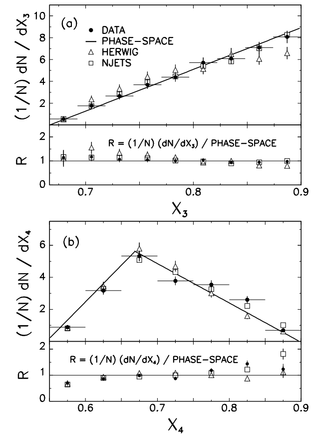

Figure 4: 3-Jet X_3 and X_4 Distributions.

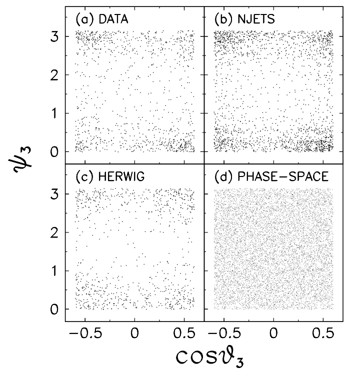

Figure 5: 3-Jet scatter plot for the angular variables.

A full set of kinematic distributions and a complete discussion of the statistical comparisons between data and model predictions is given in Ref. [4]. Here we present a sampling of those results. Figure 2 shows the N-jet invariant mass distributions. Both QCD models reproduce the behavior observed in the data. The phase-space model includes no basis for calculating the N-jet mass distributions.

The distributions for the dimensionless 3-jet parameters are shown in Figs. 2 through 5. The distributions in the Dalitz variables X_3 and X_4 are in good agreement with both QCD models, and are not very different from the phase-space predictions. The distributions in $\cos\theta_3$ and χ_3 are well reproduced by the QCD models, but differ substantially from the flat density predicted by phase-space.

The 4-jet events are reduced to the 3-jet case by combining the two jets in the pair with the lowest invariant mass. In addition to the equivalent 3-jet variables, labelled ('), there are four dimensionless variables describing mass fractions, an energy ratio and the orientation of the two-jet sybsystem. For the 4-jet events, phase

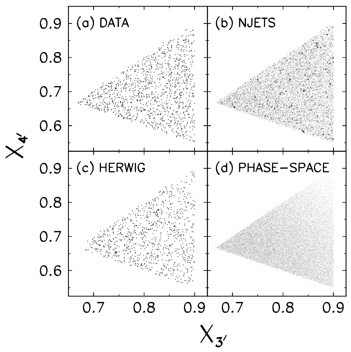

Figure 6: 4-Jet Dalitz Plot

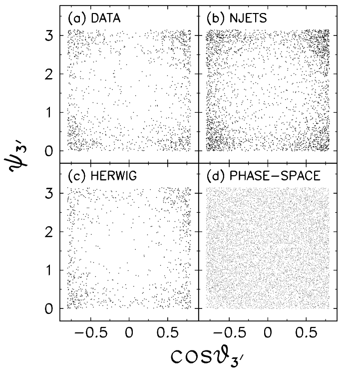

Figure 7: 4-Jet scatter plot for the angular variables.

space shows significant disagreement in the Dalitz variables as well as the angular variables, while the two QCD models give a reasonable discription throughout. More detailed examination of the complete set of distributions, which included properties of the merged jet system, can be found in Ref. [4].

The 5-jet events are successively reduced to the 4-jet and then the 3-jet case by combining at each stage the two jets in the pair with the lowest invariant mass. At the second stage the combined 2-jet system is treated just like the other jets. In addition to the equivalent 3-jet variables, labelled ("), there are two sets of four dimensionless variables describing mass fractions, an energy ratio and the orientation of the two-jet sybsystem. Again, the QCD models show distributions similar to those of the data and the phase-space model does not.

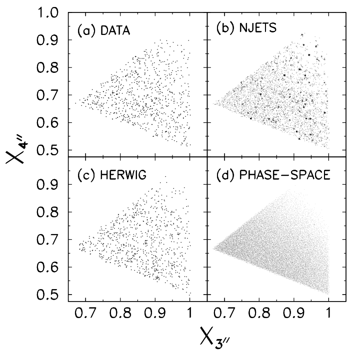

Figure 8: 5-Jet Dalitz Plot

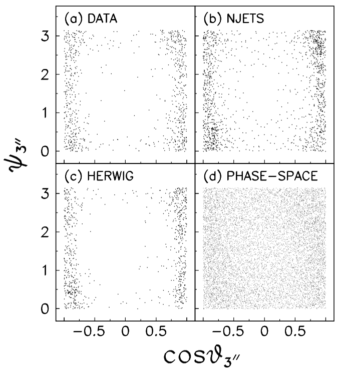

Figure 9: 5-Jet scatter plot for the angular variables.

In order to test the quantitative agreement between each of the QCD models and the experimental data, a χ^2 was formed by combining the sums over bins in all of the 1-dimensional distributions in the kinematic variables. The variance (statistical only) for each bin is assumed to be the sum of the corresponding variances for data and MC.[5] For the NJETS–DATA comparison, the values of $\chi^2/d.f.$ are $46/45 = 1.03$, $93/63 = 1.47$ and $76/63 = 1.21$ for 3-jet, 4-jet and 5-jet samples, respectively. For the HERWIG–DATA comparison, the corresponding numbers are $71/45 = 1.58$, $103/63 = 1.63$ and $96/63 = 1.52$. We also did a direct NJETS–HERWIG comparison for which the results are $93/45 = 2.06$, $108/63 = 1.72$ and $109/63 = 1.73$. While these are not perfect fits, we regard them as reasonable agreement between QCD predictions and the data. They do not suggest the presence of new phenomena.

In summary, we have studied 3-jet, 4-jet and 5-jet events with large total transverse energy. We have defined sets of multijet variables which completely describe the multijet systems. The observed distributions of multi-jet variables have been compared with expectatons from QCD and phase-space predictions. The QCD predictions give reasonable descriptions of all the observed distributions. The phase-space predictions are very different from the observed distributons. We do not see evidence for any deviation from the multijet distributions predicted by QCD that might indicate new phenomena.

Acknowledgments

I am grateful for the efforts of my colleagues at Rutgers, CDF and Fermilab. This work was supported in part by the United States Department of Energy, and by the National Science Foundation. **(Note: The complete set of figures, including some omitted here can be found in http://www.physics.rutgers.edu/~devlin along with a related talk the previous month.)**

References

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2. G. Marchesini and B. Webber, Nucl. Phys. **B310**, 461 (1988).
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4. F. Abe et al. Phys. Rev. Letters **75**, 608 (1995); F. Abe et al., submitted to Phys. Rev. D, FERMILAB-PUB-96/098-E.
5. Since fragmentation is not part of the NJETS calculation, contribuitions from the distributions for individual jet mass fractions were not included in the sums for any of these χ^2 calculations.