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Riken-BNL Workshop on Hard Parton Physics in High-Energy Nuclear Collisions
March 1,1999

Hard Parton Physics at the Tevatron $\longrightarrow$ Results from DØ

The focus of this talk was to show Run 1 results from the DØ experiment at Fermilab that may be applicable to RHIC. The analyses discussed are tests of QCD and are summarized below. The full talk is available at http://www.rhic.bnl.gov/afs/rhic/star/doc/www/conf/index.html. All the results shown are either published or can be obtained from the DØ results pages at http://www-d0.fnal.gov/public/d0_physics_v2.html and then go to "Publications","Summer 98 Results" or to Physics Groups "QCD" (then either "Approved Plots" or the "Working Groups"). The preceding talk by Prof. G. Blazey should be consulted for details on jet triggering, algorithms, corrections, and calibrations.

Dijet Angular and Mass Distributions:

The dijet angular distribution provides a direct test of QCD is insensitive to parton distribution functions (pdf). The value measured is $\frac{1}{N}\frac{dN}{d\chi}$ where $\chi = e^{2|\eta^{\star}|}$ and $\eta^{\star}$ is η of c.o.m. system. This variable flattens out the distribution to facilitate comparison with NLO QCD predictions, which were done using Jetrad (Nucl Phys. B**403** (1993) 633). The data are also compared to a prediction with a compositeness scale Λ_c, and lead to a limit on quark compositeness of $\Lambda_c > 1.9$ TeV. See Fig. 1.

The dijet mass spectrum provides constraints on the pdfs and limits on quark compositeness. The dijet mass is calculated assuming the jets are massless. The 95% lower limits on the compositeness mass scale obtained are $\Lambda^{+} > 2.7$ TeV and $\Lambda^{-} > 2.4$ TeV. See Fig. 2.

Jet Shapes:

Jets have structure due to gluon radiation and fragmentation. We measure the radial E_T distribution in jets with cone-size $R = 1.0$, $\rho(r) = 1/N[\Sigma(E_T(r)/E_T(R))]$, as a function of the distance r from the jet axis and compare to NLO QCD predictions at the parton level. This is the first order a jet shape prediction can be made. The run 1A analysis was published (PLB **357** (1995) 500) and there was a subsequent theory paper (hep-ph/9510420). The data show that jets narrow with increasing jet E_T and going from central to forward jets and are insensitive to differences in axis definitions. Herwig Monte Carlo describes the data well whereas the NLO QCD predictions vary considerably with jet axis and clustering definitions. See Figs. 3 and 4.

Color Coherence:

In QCD theory, there is interference of soft gluon radiation emitted along color connected particles. This color coherence is studied to determine the details of hadronic final state to see if these effects can survive hadronization. Also the relative importance of perturbative vs. non-perturbative contributions is measured. In the multijets analysis (PLB **414** (1997) 419), events with 3 or more jets are chosen and the angular distribution of the softer 3rd jet is measured around the 2nd highest E_T jet. The data show a clear enhancement of events in the event plane (i.e. plane defined by direction of 2nd jet and beam axis, $\beta = 0, \pi$) and a depletion in the transverse plane ($\beta = \pi/2$). The data differ from Isajet, which has no color coherence (CC) effects, and from Pythia when angular ordering (AO) is turned off. The NLO QCD prediction from Jetrad and Herwig (has CC) agree best with the data. See Fig. 5.

In the $W+$ jets analysis (preliminary), the leading E_T jet opposite in ϕ to the W is selected in the event. The multiplicity of calorimeter towers above 250 MeV in a ring around the jet and W from $.7 < R < 1.5$ is measured. Around the W the angular distribution of soft gluons is expected to to be uniform, whereas around the jet there is expected to be structure. This enhancement of multiplicity around the jet compared to the W is seen in the data. Monte Carlo models which include CC effects and QCD predictions (hep-ph/9612351) in which the parton cascade is evolved much further than traditional QCD (MLLA calculation) agree well with the data. See Fig. 6.

Direct Photons:

Direct photons can be used as probes for hard parton interactions w/o fragmentation effects. Used as a test of NLO QCD, they give information on the contribution from higher order corrections, especially multiple soft gluon emission (i.e. k_T effects)
gluon pdfs and also matrix elements. The analysis based on Run 1A data sample is published (PRL **77** (1996) 5001) and the Run 1B results are preliminary. The inclusive cross section is consistent with QCD predictions (PRD **42** (1990) 61), but data from all experiments show a trend away from predictions - especially at low p_T. The γ-jet angular distribution agrees well with the same NLO predictions. The di-photon p_T spectrum shows deviation from NLO (PRD **46** (1992) 2018) at low p_T. Predictions which add in multiple gluon emission, Pythia or resummed-QCD (hep-ph/9704258), are consistent with data. See Fig. 7 and 8.

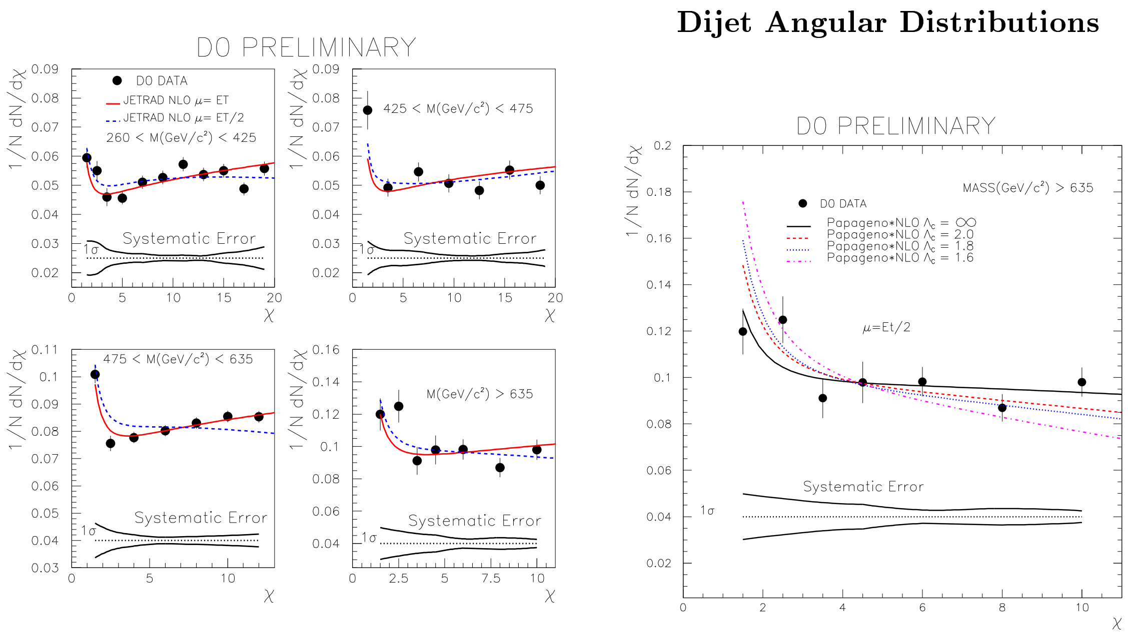

Figure 1: (A) The dijet angular distribution vs. χ is shown over 4 regions of dijet mass and compared to NLO QCD predictions using JETRAD. (B) The data are shown compared to predictions with various values of the compositeness scale, Λ_c.

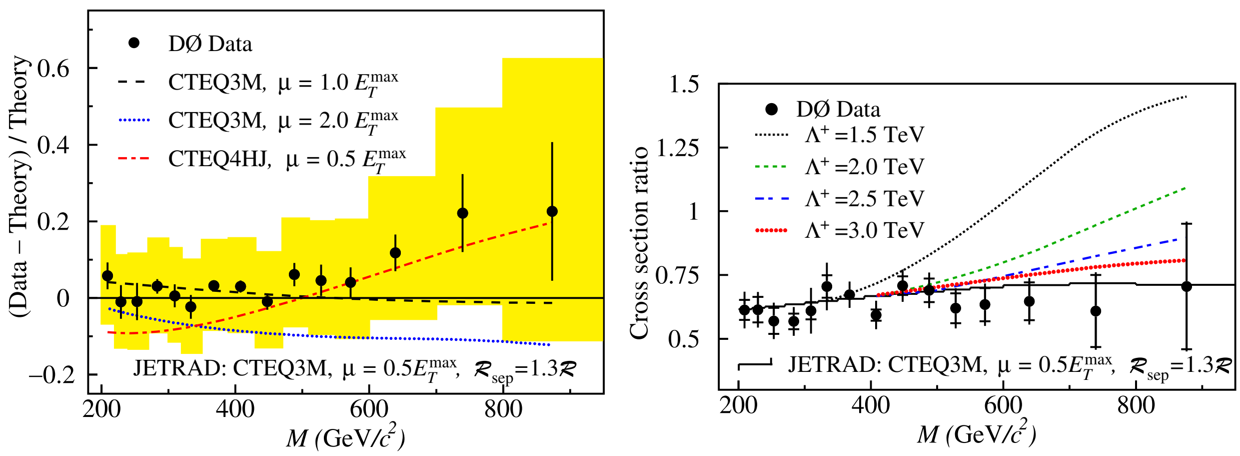

Figure 2: (A) The difference between the dijet mass distribution data and theory are shown vs. the dijet mass. Also shown are the differences between the nominal pdf and μ-scale and other settings (lines). The shaded region indicated the errors on the data. (B) The ratio of the dijet mass spectra for $|\eta|_{jet} < 0.5$ and $0.5 < |\eta|_{jet} < 1.0$ and the NLO prediction at the nominal settings and scaled to different compositeness values.

D0 Jet Shape - CENTRAL

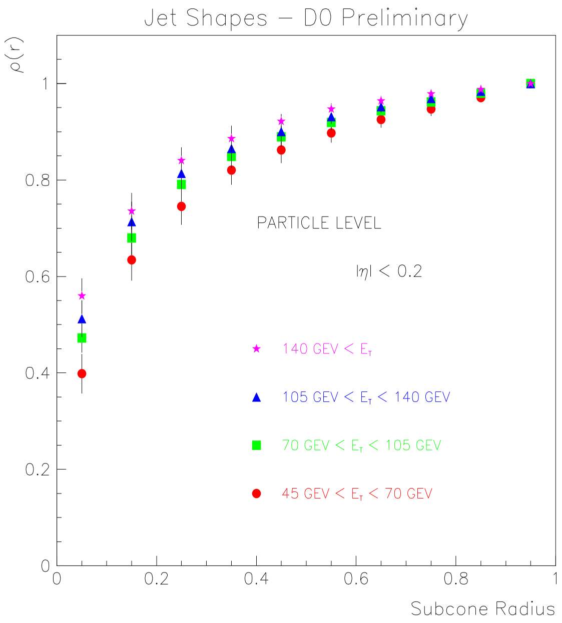

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Figure 3: The measured integrated jet E_T as a function of distance from jet axis, corrected for detector effects, is shown in the central region for 4 values of jet E_T.

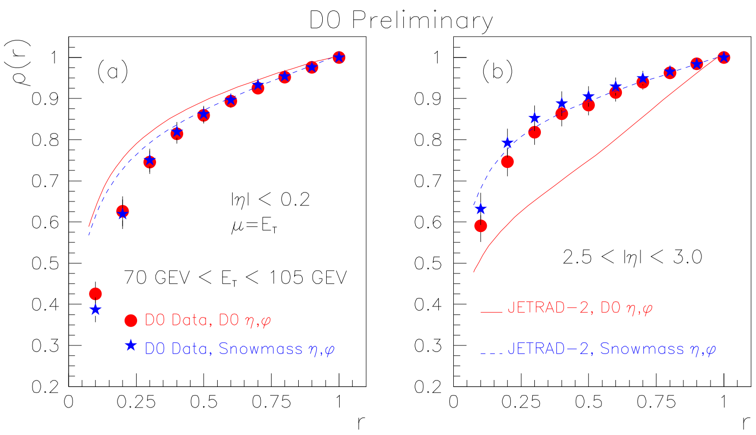

Figure 4: The data are shown for jets in the central (a) and forward (b) regions, using two different jet axis definitions, compared to the NLO prediction using the two different definitions.

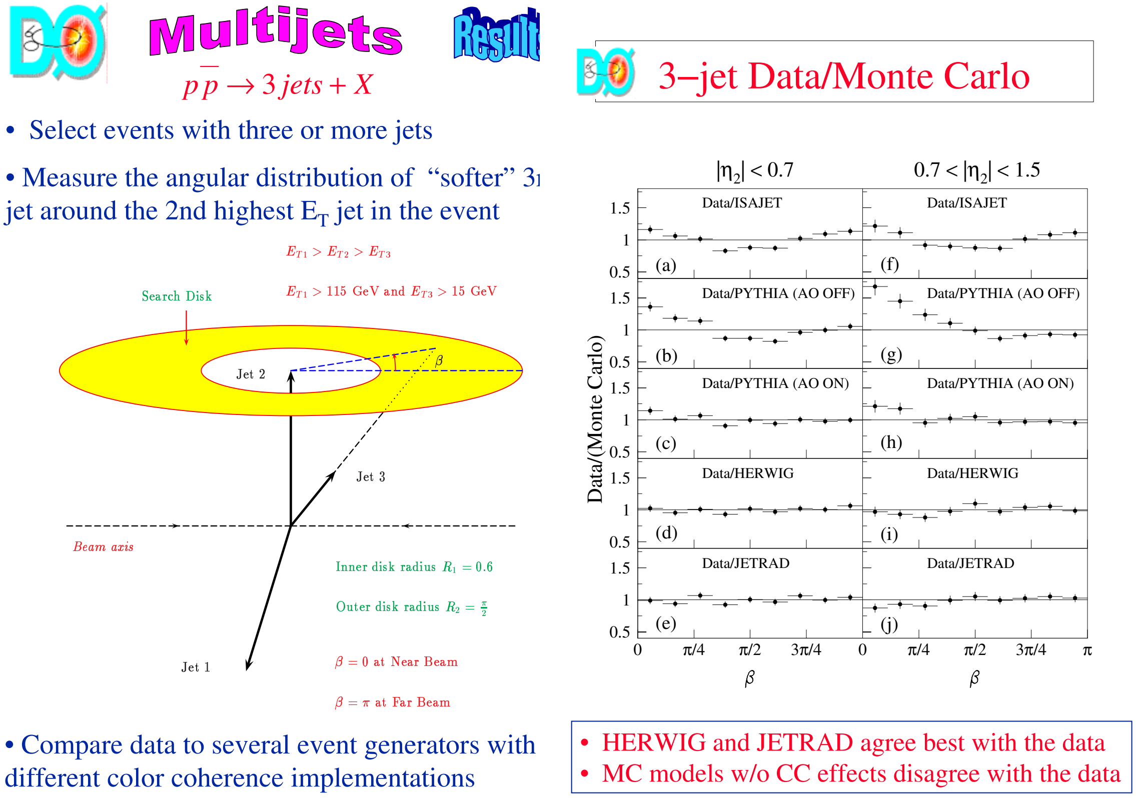

Figure 5: (A) Explanation of coordinate system used in analysis. (B) Ratio of observed β distributions relative to the MC predictions for two η regions. MC models that don't have color coherence effects are seen to disagree with the data.

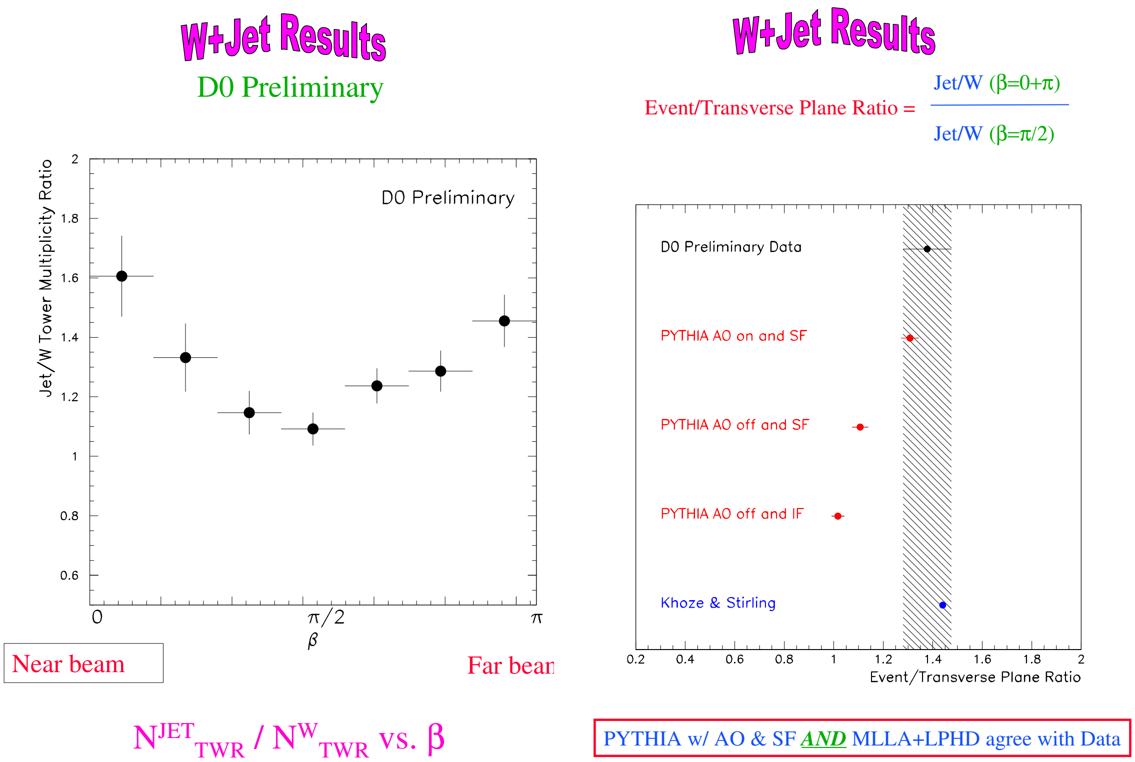

Figure 6: (A) The ratio of calorimeter tower multiplicity around the jet and the W as a function of the angle β. (B) The ratio of event plane to transverse plane of jet/W tower multiplicity for the data, Pythia with various color coherence implementations and for a MLLA QCD calculation.

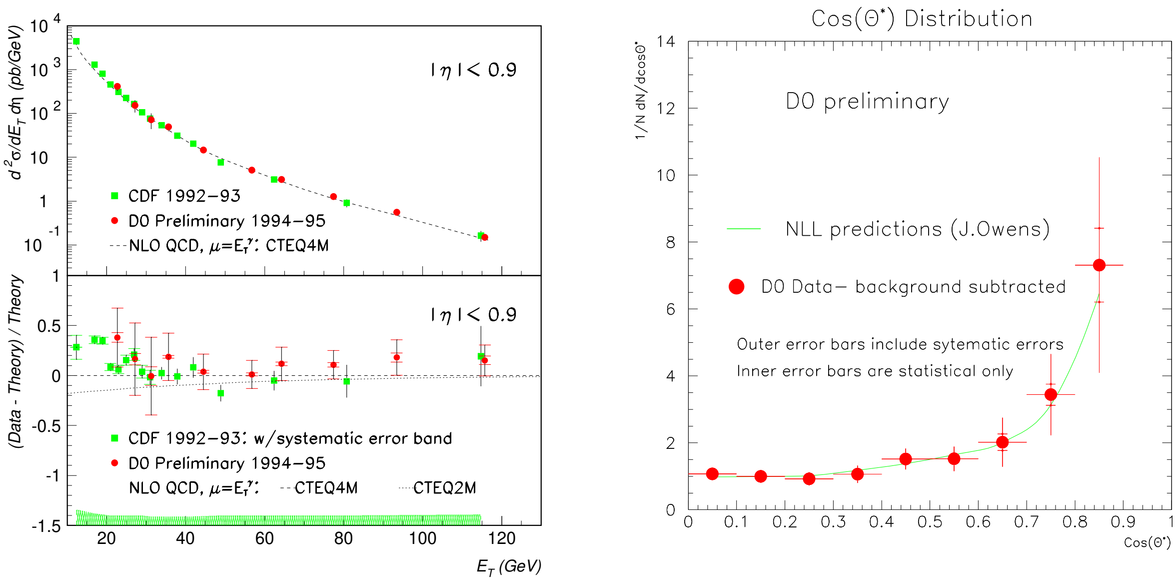

Figure 7: (A) The direct-γ cross section from DØ and CDF, compared to NLO QCD (Baer *et al*). (B) The γ+jet angular distribution (Run 1A).

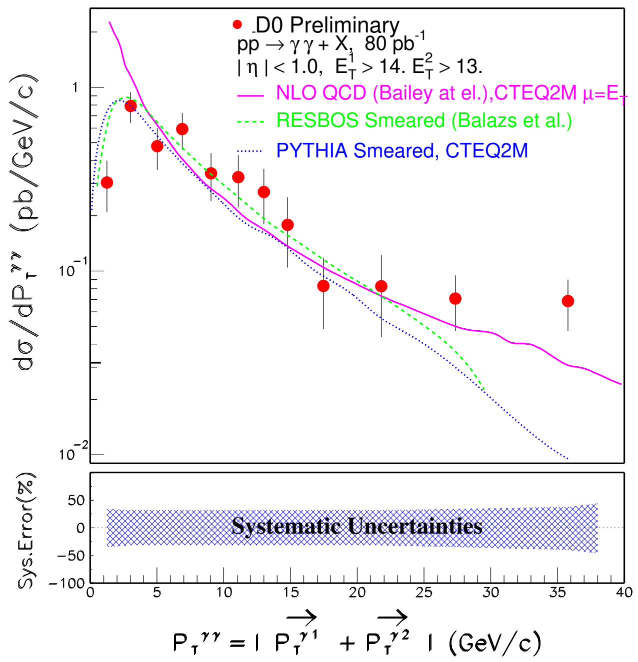

Figure 8: The di-photon p_T spectrum (Run 1B).