Fermi National Accelerator Laboratory

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CDF

Recent Results on QCD at the Tevatron (CDF and DØ)

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RECENT RESULTS ON QCD AT THE TEVATRON (CDF and D0)

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ABSTRACT

In the last run the Tevatron collider delivered an integrated luminosity of 29.9 pb^{-1} to CDF and D0. We describe here some preliminary result from analyses of relevant QCD processes in the 1992-93 data from the two experiments.

1. Introduction

Recent developments on both the experiments and the theory offer now at the Tevatron collider the possibility to test QCD predictions at the level of 10–20 %. On the experimental side upgrades of the CDF detector[1] and the new D0 detector[2] provide data with better energy resolution and higher statistics, along with extended sensitivity and better background separation for direct photons. On the theoretical side Next-to-Leading Order (NLO) calculations are now available for all the processes of major interest, while Parton Distribution Functions (PDF's) are being strongly constrained from latest NMC and CCFR results in the region $x \geq 0.01$ ($Q^2 \geq 5$ GeV^2).[3]

2. QCD with Jets

The comparison of inclusive jet production cross section to QCD NLO calculations can be used to test the validity of the latter. Possible discrepancies may indicate the need for higher-order corrections, or be an hint for new physics, like quark substructure. The range of the inclusive jet cross-section measurement at CDF has been extended to E_T values as low as 15 GeV. The agreement with 1988-89 data is very good in the region of overlap (35-200 GeV), while statistical errors are less than 5%. The measured cross section is also in good agreement with the NLO calculation over 10 orders of magnitude (fig. 1a). While the D0 measurement has a much lower statistics in the central region, thanks to the wider angular acceptance of the detector D0 has also measured the inclusive jet cross-section in the region $2 < |\eta| < 3$ (fig. 1b). Jet events with large total transverse energy are an important tool to test the validity of shower Monte Carlos. These in turn are necessary to study higher order QCD effects in the lack of complete Next-to-Next-to-Leading Order calculations, and the background from QCD to many rare processes. CDF has collected a substantial sample of events with $\sum E_T > 320$ GeV. In fig. 2a the uncorrected $\sum E_T$ spectrum for this sample is compared to a Leading Order prediction from HERWIG[4] 5.3 plus the CDF detector simulation. The data is well described by the MC, except at very high $\sum E_T$. Another aspect of jet physics which is covered by the Tevatron experiments is the associated production of W bosons and jets. By fitting the jet multiplicity for different values of jet E_T in W+(n jets) events D0 is able to extract the ratio of W+(1 jet) over

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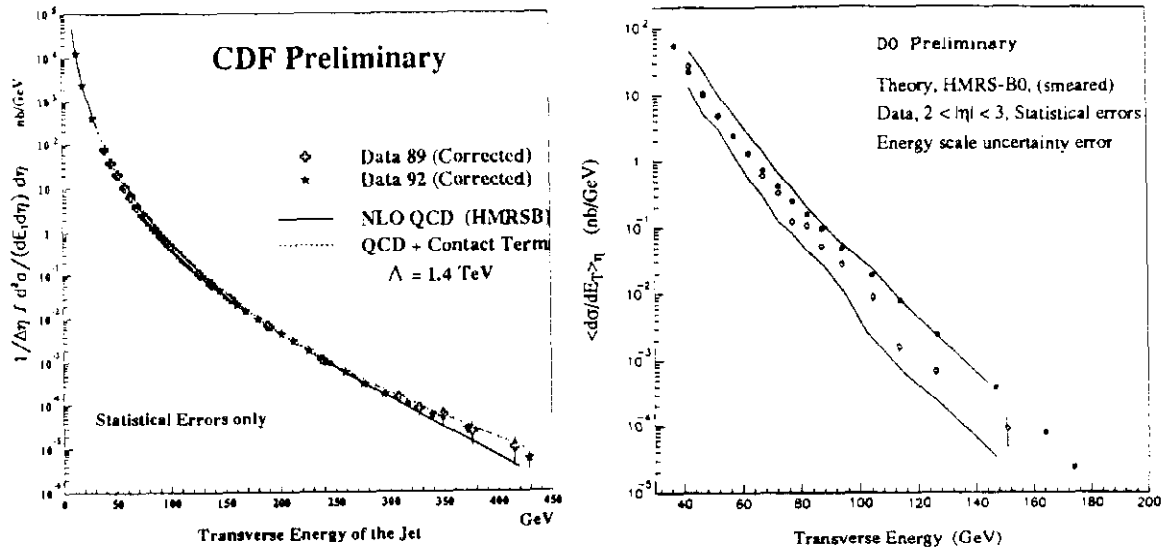
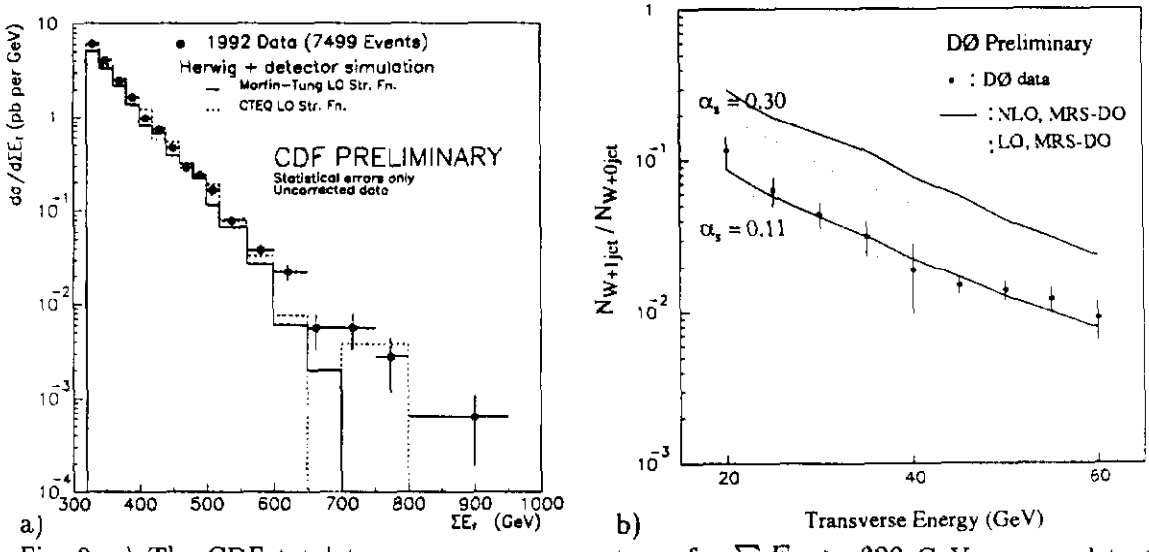


a) b)

Fig. 1. a) Comparison of the inclusive Jet E_t spectrum from CDF '89 and '92 data to QCD. The solid line is the NLO calculation, while the dashed line is NLO plus a contact term. b) Inclusive Jet cross section from D0 in the region $2 < |\eta| < 3$: open dots are data, solid dots are theory points (NLO calculation with KMRS B0 PDF), while the solid lines indicate the systematic uncertainty

W+(0 jets) event rate as a function of the jet E_T, which can discriminate between various values of α_s: compared to a NLO simulation data seem to prefer $\alpha_s = 0.11$ (fig. 2b).



a) b)

Fig. 2. a) The CDF total transverse energy spectrum for $\sum E_T > 320$ GeV compared to the Monte Carlo prediction from HERWIG, normalized to the number of events. b) N [W+(1 jet)] / N[W+(0 jets)] vs. $E_T min$ at D0.

3. QCD with Photons

Photons directly produced in hard collisions are of particular interest, because their production mechanism is very sensitive to the gluon structure function at low x, and their energy measurement is free from the fragmentation systematics. Photons are identified as

isolated clusters of EM energy with no matching track, the main background coming from isolated π^0's. Shower profile (CDF) and conversion (CDF,D0) methods are employed to separate photons from background. The addition of the Central PreRadiator (CPR) in the CDF detector has improved the γ/background separation at high-P_t with respect to the last run, while a Neural Net isolation trigger extended the sensitivity at low-P_t. This results in improved statistics and better background rejection than in the '89 run, and the inclusive photon cross section now spans over six orders of magnitude. The direct photon inclusive-P_t cross section measurement, is one of the best tests of new PDF fits (fig. 3a).

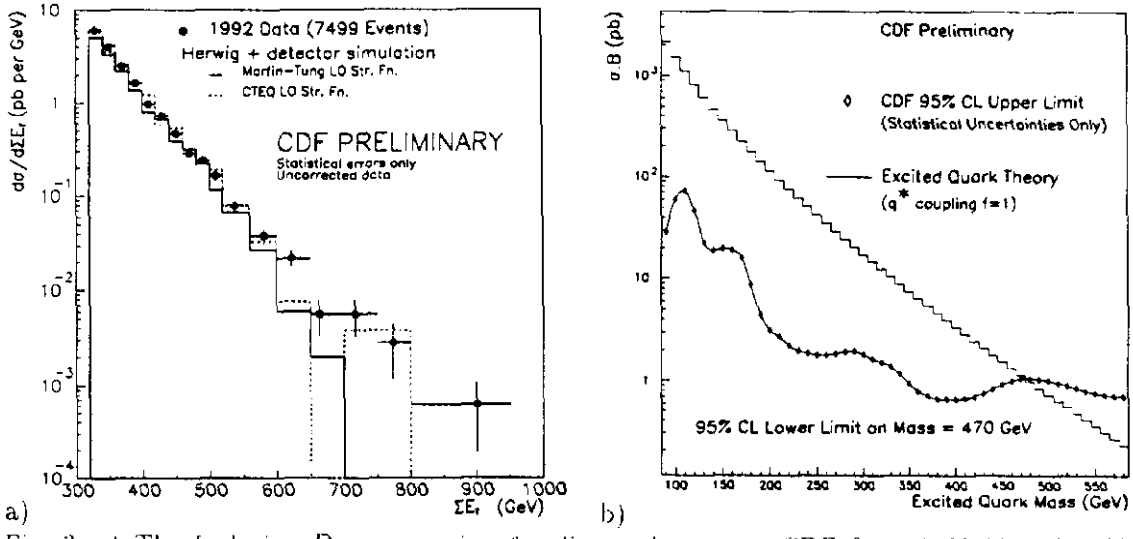


Fig. 3. a) The Inclusive P_t cross-section for direct photons at CDF from 1988-89 and 1992-93 runs, compared to QCD on a linear scale; the default theory is NLO with KMRS B0. Substantially improved agreement with the new CTEQ PDF's is evident. b) The 95 % Confidence Level limit on the q^* cross section as set by the CDF γ + jet measurement superimposed to the theoretical calculation.

A careful study of the γ+jet invariant mass distribution (fig. 3b) has allowed CDF to set a lower limit on the excited quark mass[6] at 470 GeV.

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