Tevatron Jet Results at High E_T and High Rapidity

Presented

by

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for the

CDF and DØ Collaborations

Inclusive Jet Cross Section

Di-Jet Triply Differential Cross Section

Di-Jet Angular Distributions

Inclusive Jet Cross Section

Measurement of the inclusive differential cross section for jet production in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV.

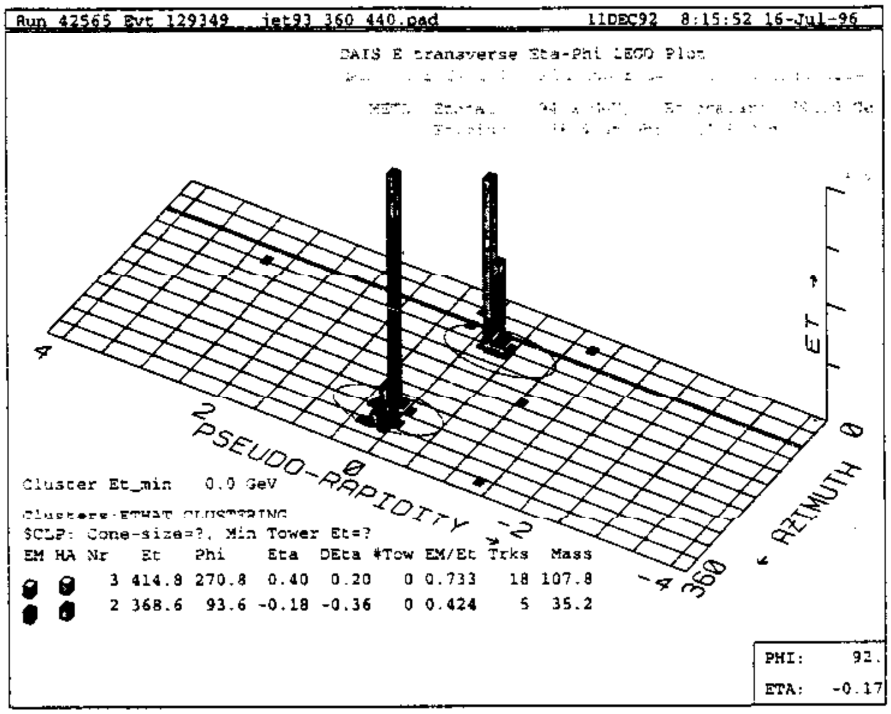
The data provides information about details of the parton density functions (pdf) and the strong coupling constant, α_s.

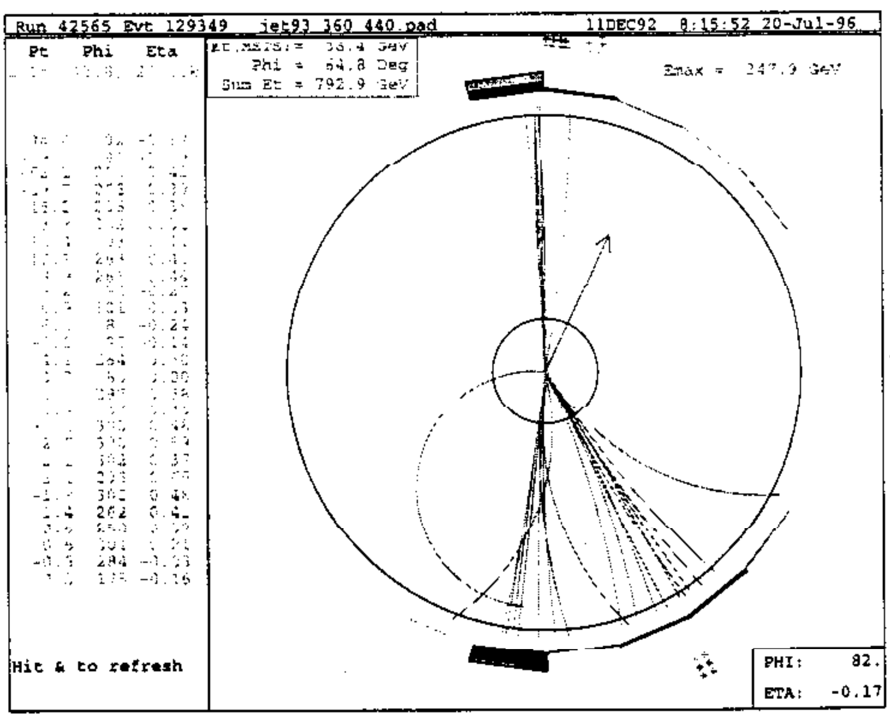
High statistics measurement with small systematic uncertainties provides a powerful test of QCD over a wide range of Jet E_T.

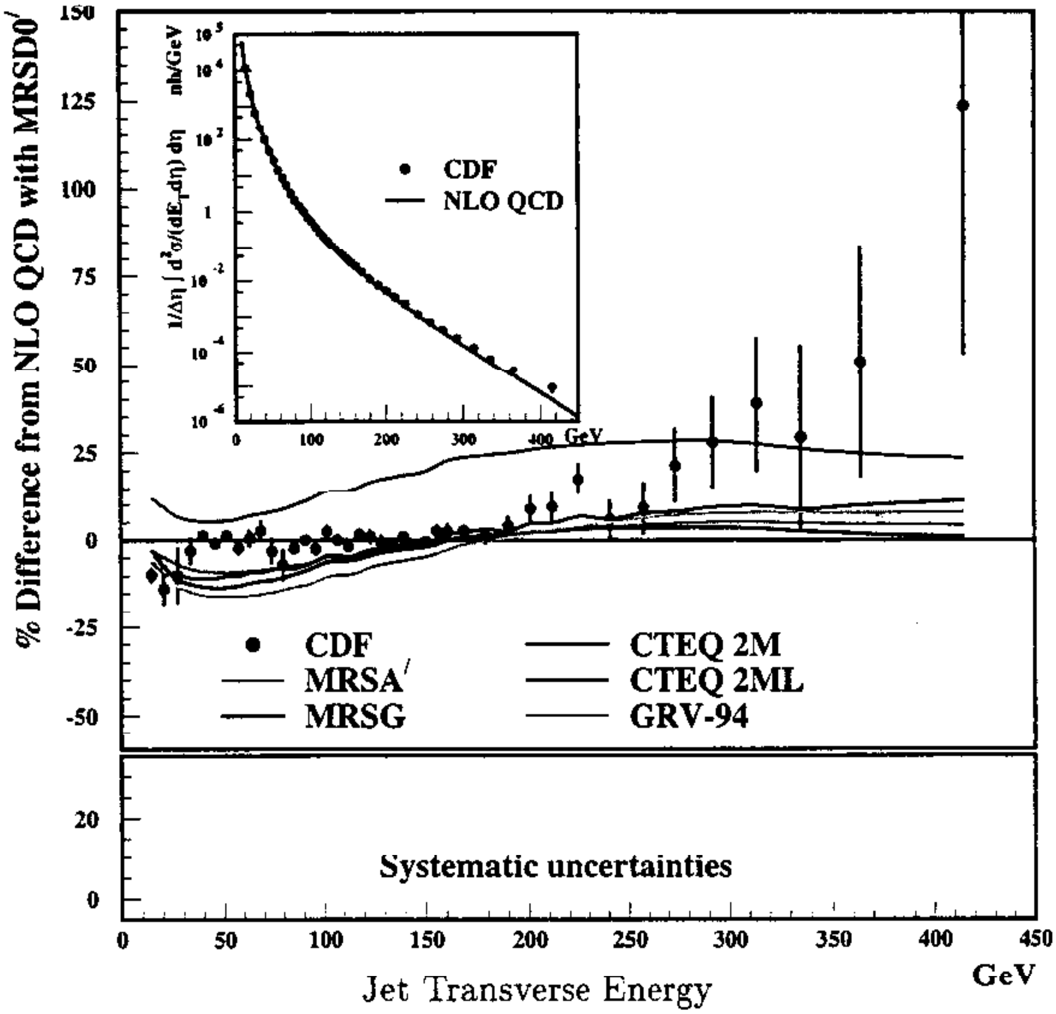
Highest E_T bins correspond to a distance scale of $\mathcal{O}(10^{-17}\text{cm})$ which extends searches for new physics.

Theory calculations are available at $\mathcal{O}(\alpha_s^3)$ which include the possibility of a third jet in the final state and reduces the theoretical uncertainties to 10 - 20%

Event with High E_T Jets



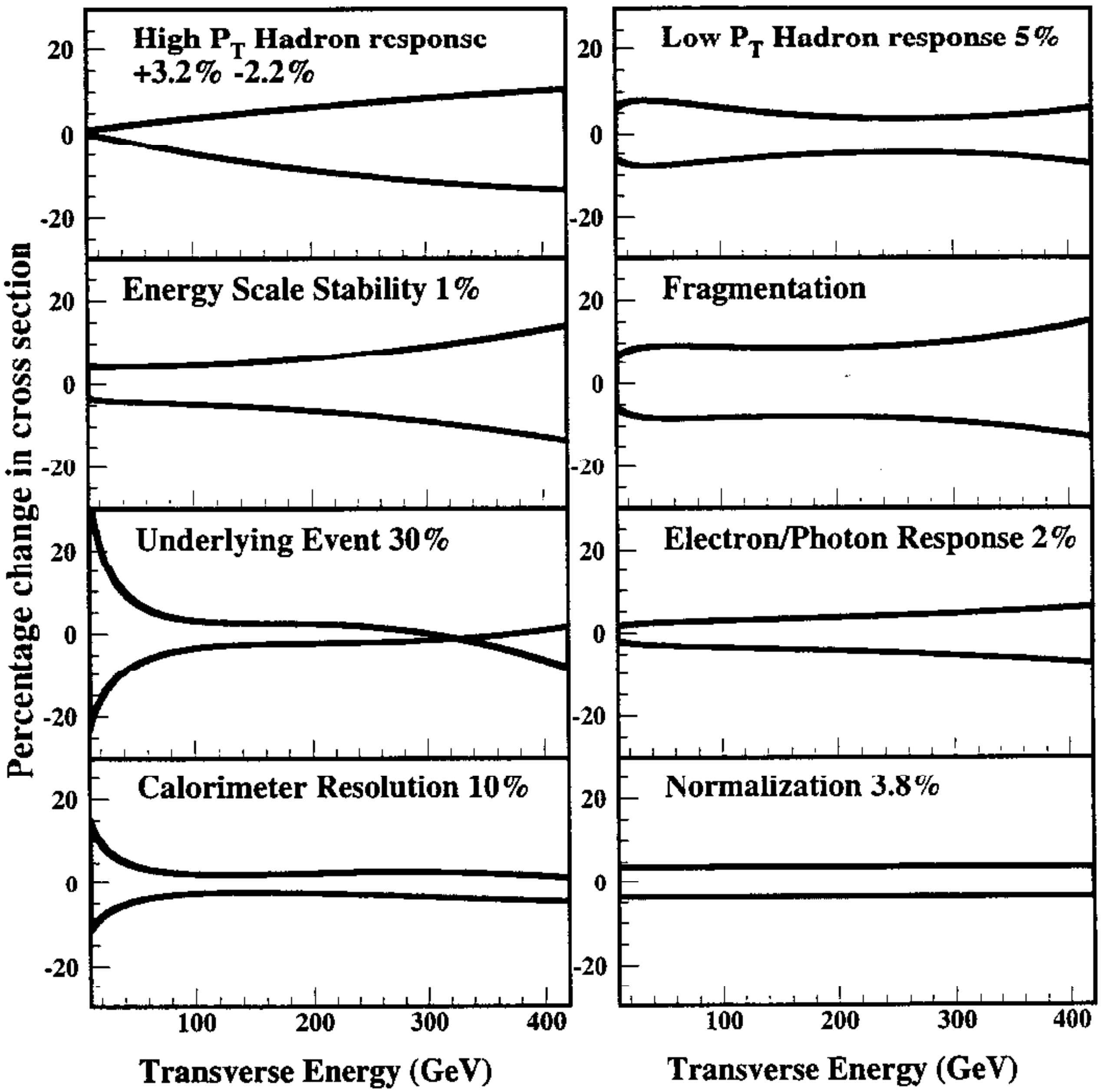




There is an excess of data at high E_T when compared to the expectation from NLO QCD using the MRS D0′ parton parameterization..

Predictions using different pdfs are shown by the curves.

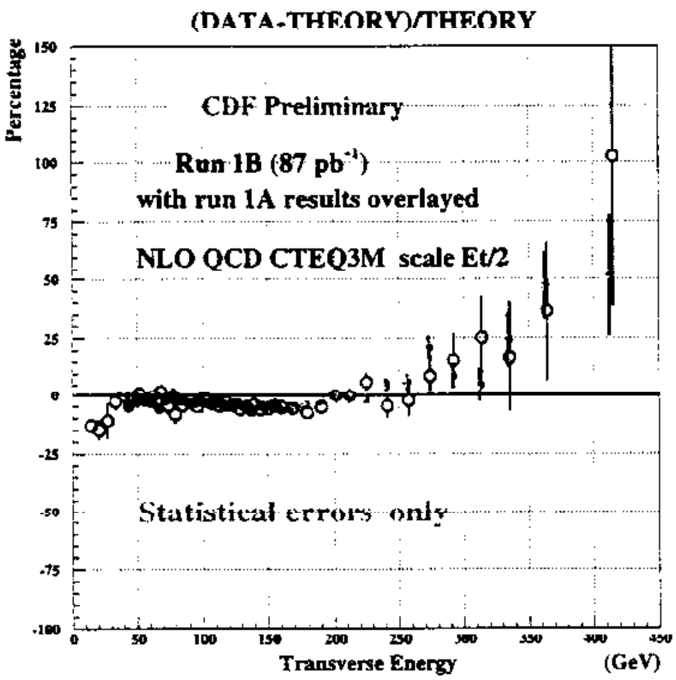
Systematic Errors for the CDF Measurement



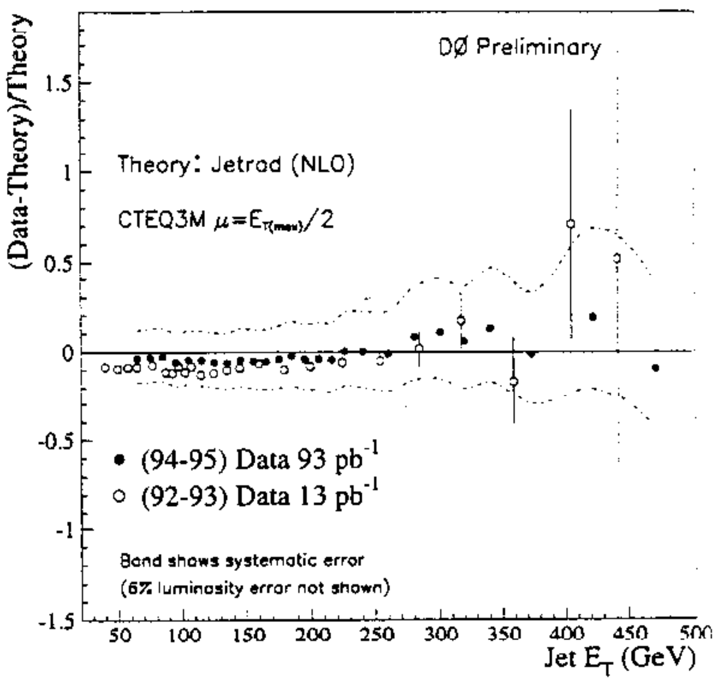
Percentage change in the inclusive jet cross section when the different systematic errors are changed by ±1 standard deviation from nominal values.

Preliminary Results from Ib Data

$0.1 < |\eta| < 0.7$



$|\eta| < 0.5$

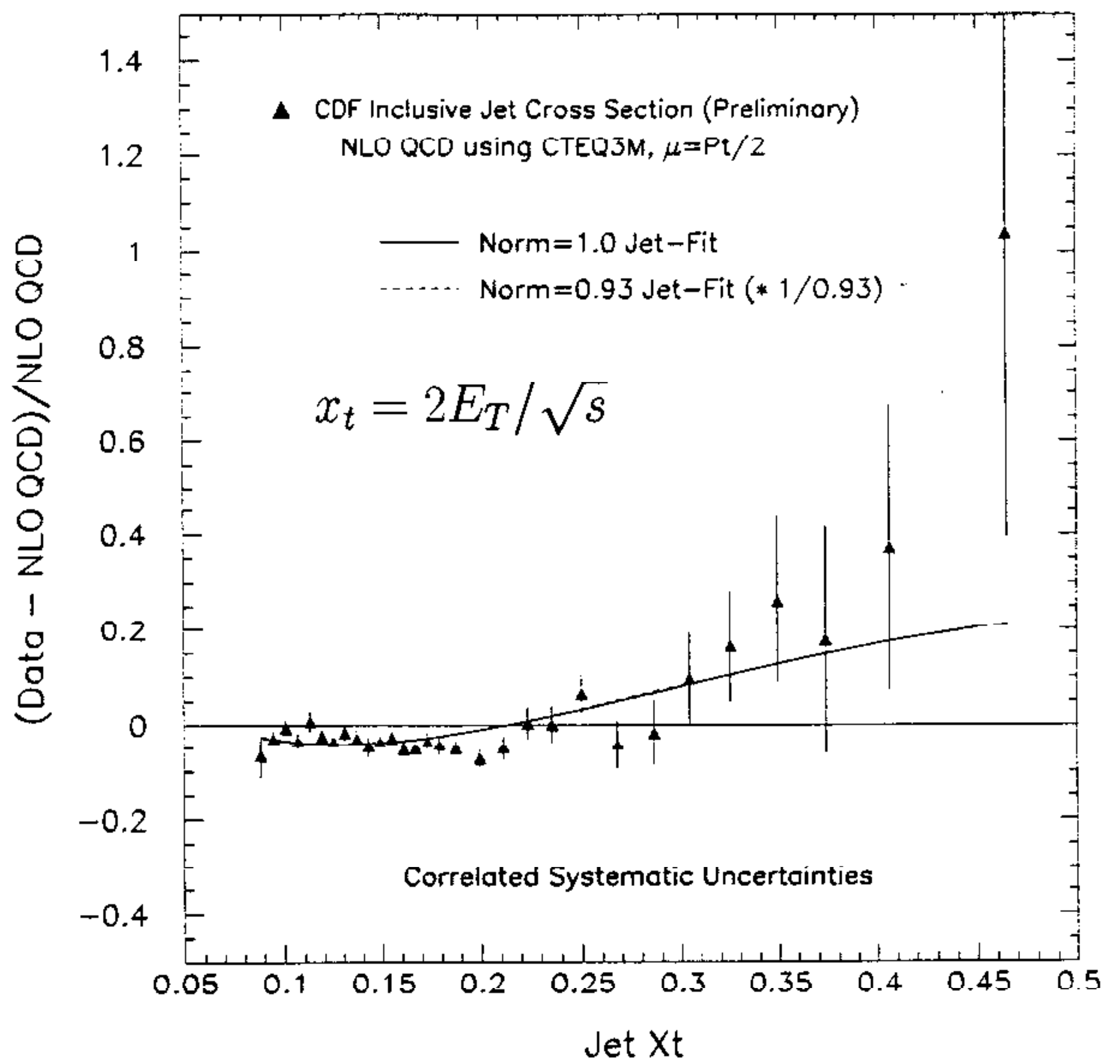


The run Ib data set contains about four times the data from run Ia.

Results from run Ia are confirmed by the run Ib data with reduced statistical errors.

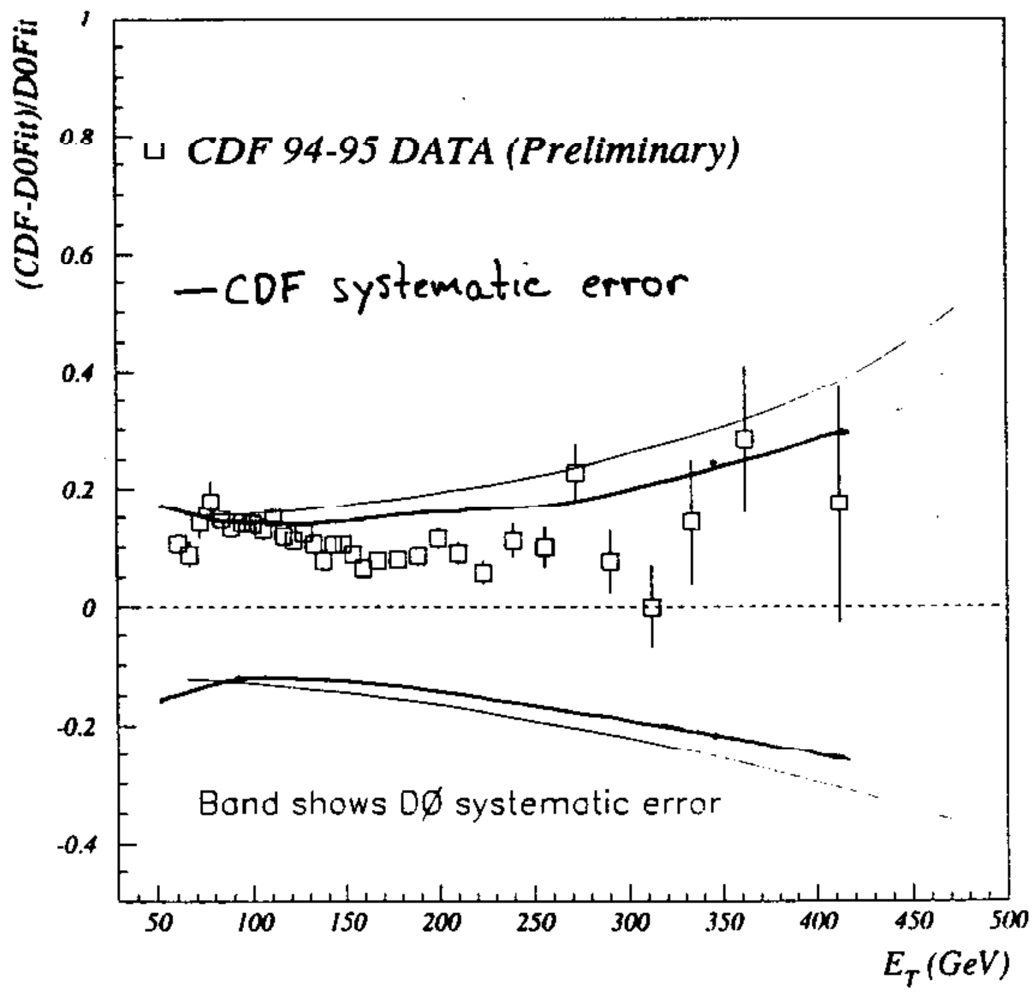
See R. Hirosky's talk "Jet and Dijet Production at the Tevatron" for a discussion of the effect on the choice of parameters on the theory predictions.

Inclusive jet results from both CDF and DØ are used as input to global fitting packages where the data constrains the pdfs at high x.



The CTEQ group has modified the parameterization of the gluon distribution resulting in better agreement at high E_T.

CDF Ib Data Compared With Fit to DØ Data



DØ analysis for $0.1 < |\eta| < 0.7$.

Results from the two experiments are within systematic errors.

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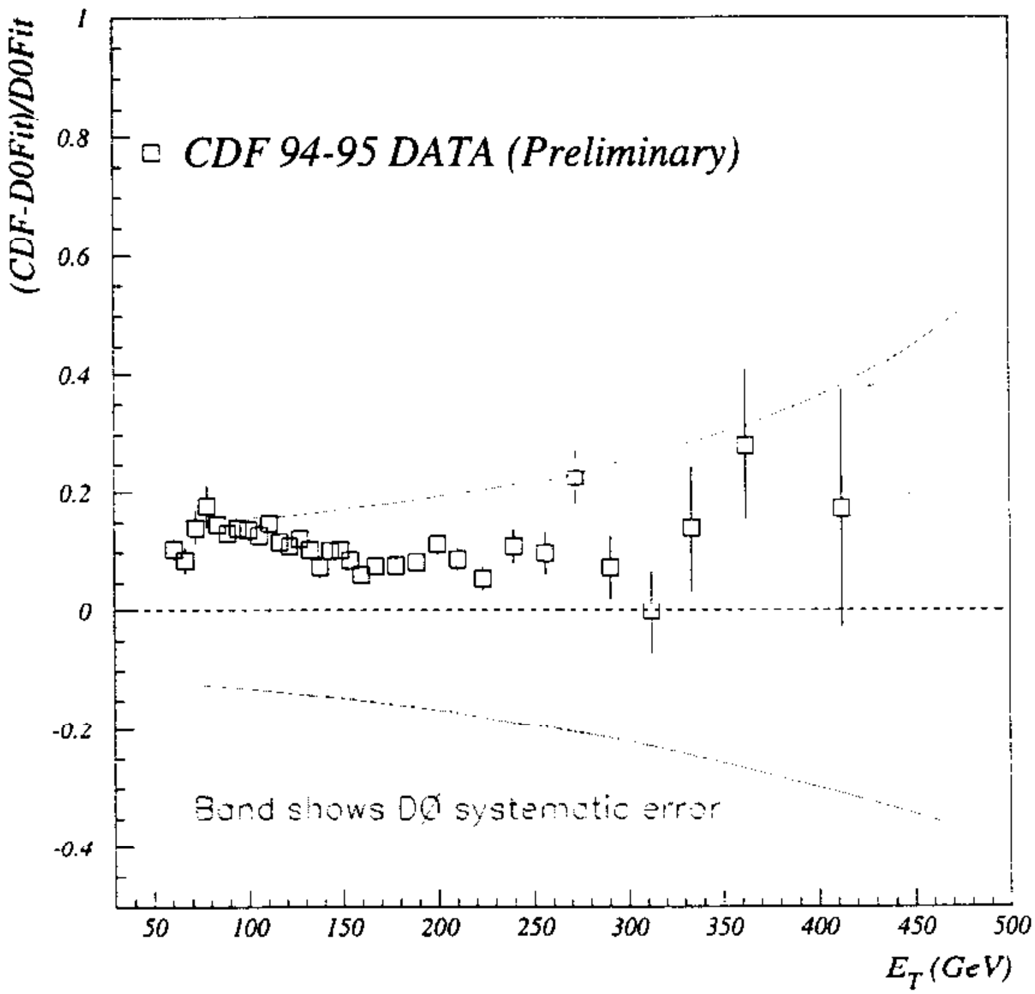

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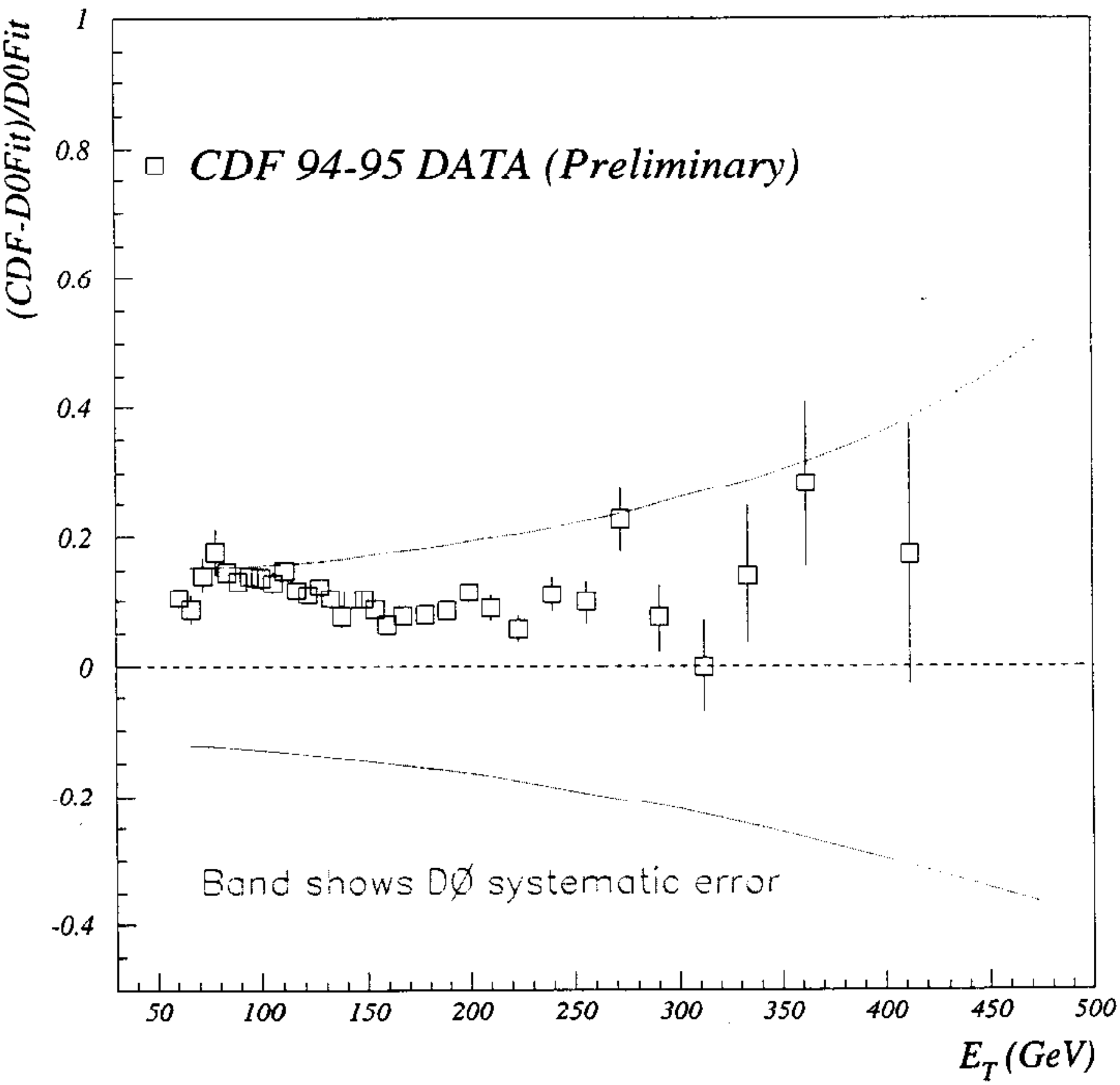
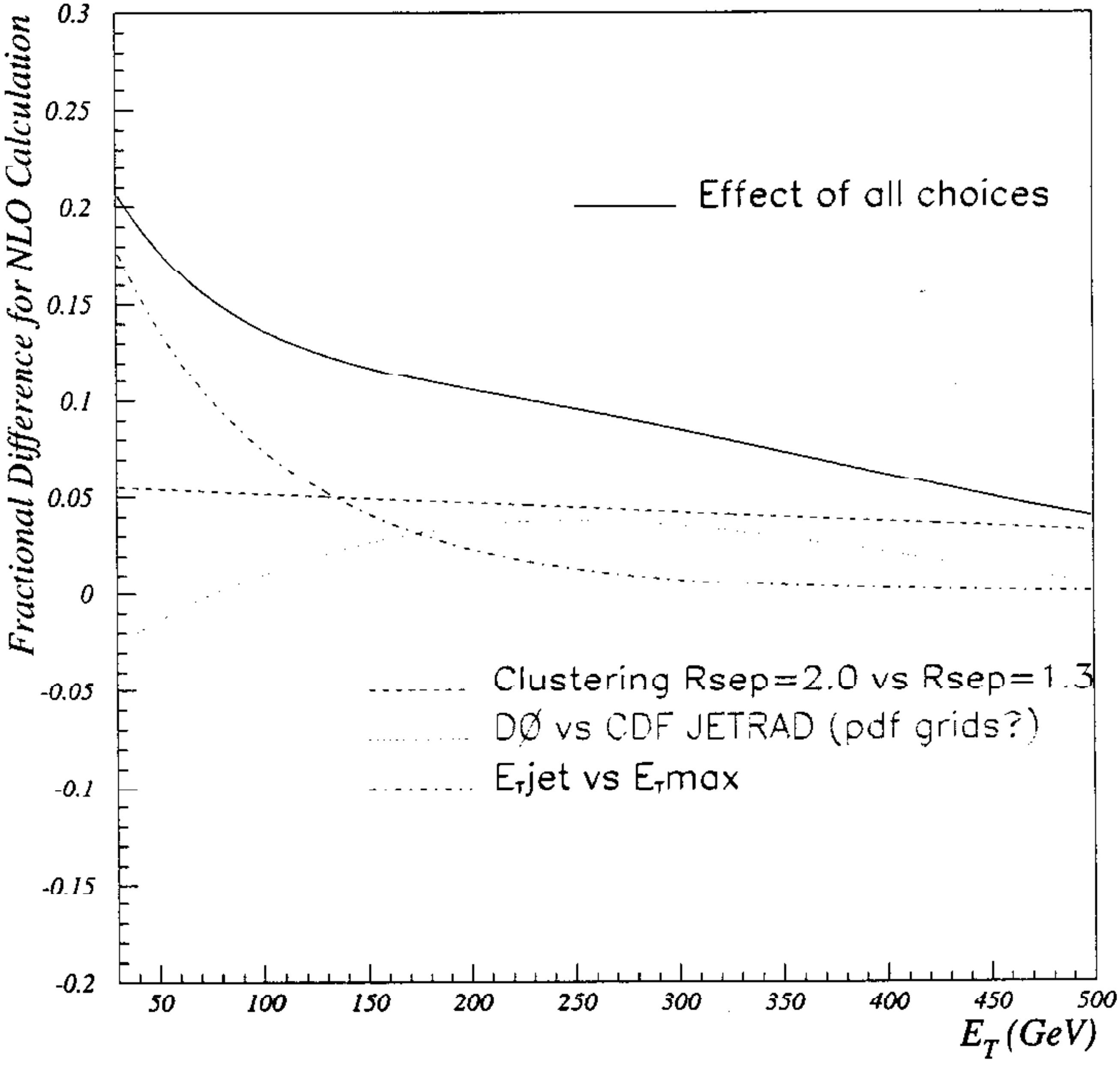
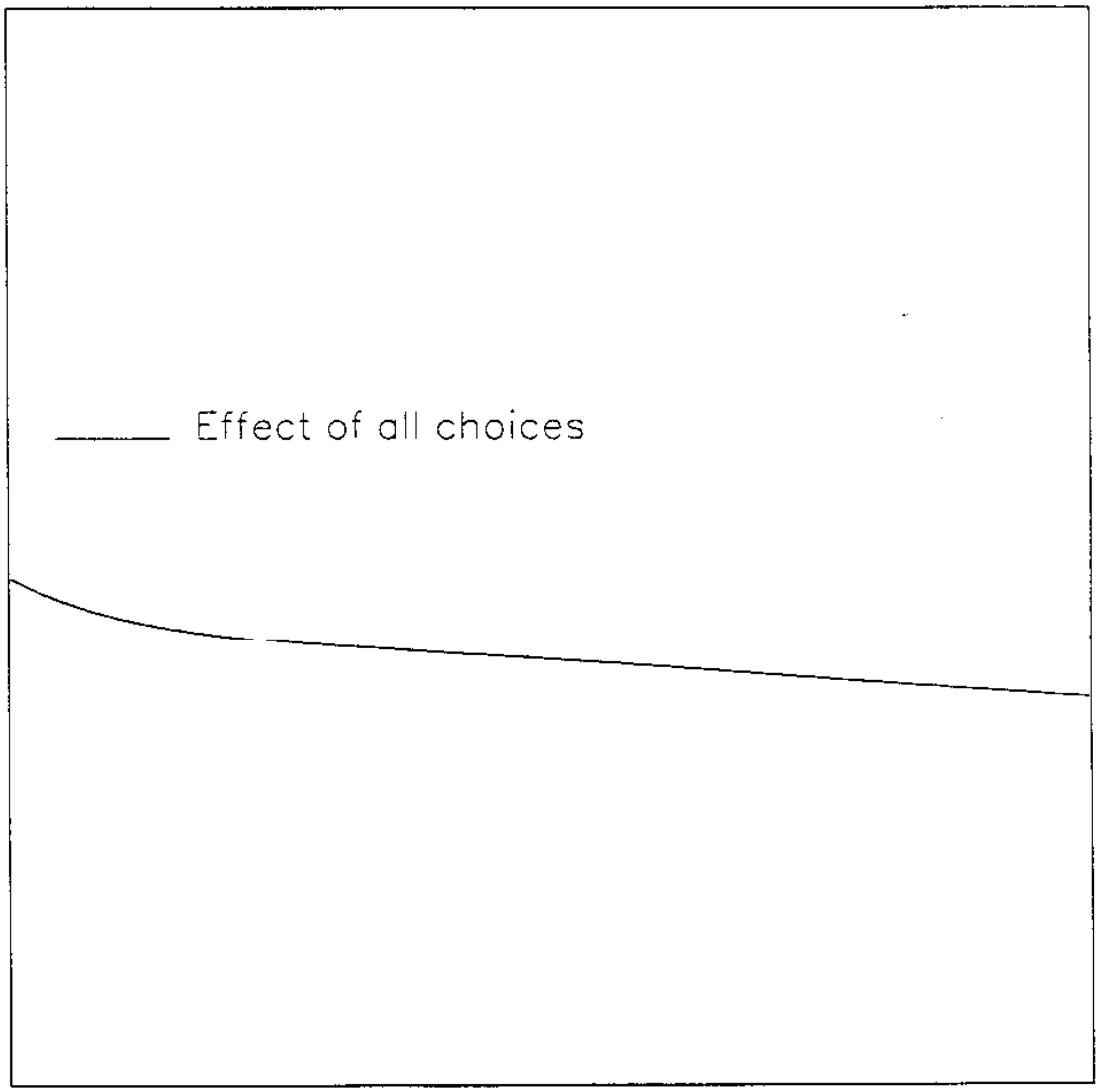

(CDF-D0Fit)/D0Fit
CDF 94-95 DATA (Preliminary)
Band shows DØ systematic error
E_T (GeV)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
50
100
150
200
250
300
350
400
450
500



Fractional Difference for NLO Calculation
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
50
100
150
200
250
300
350
400
450
500
$E_T\,(GeV)$
Effect of all choices
Clustering Rsep=2.0 vs Rsep=1.3
DØ vs CDF JETRAD (pdf grids?)
$E_T$jet vs $E_T$max


Effect of all choices

Inclusive Di-Jet Differential Cross Section

$$\frac{d^3\sigma}{dE_T d\eta_1 d\eta_2}$$

E_T Transverse energy of leading jet
η_1 Pseudorapidity of leading jet
η_2 Pseudorapidity of next to leading jet

One or more of the two leading jets is required to be within the central region.

The central "trigger" jet is used to measure the E_T of the event.

If there are two energetic central jets both combinations contribute.

The "probe" jet satisfies $E_T > 10\text{GeV}$.

There are no restrictions on any additional jets.

Separate E_T distributions are made when the probe jet sits in different η intervals.

$0.1 < \|\eta_2\| < 0.7$	$0.7 < \|\eta_2\| < 1.4$
$1.4 < \|\eta_2\| < 2.1$	$2.1 < \|\eta_2\| < 3.0$

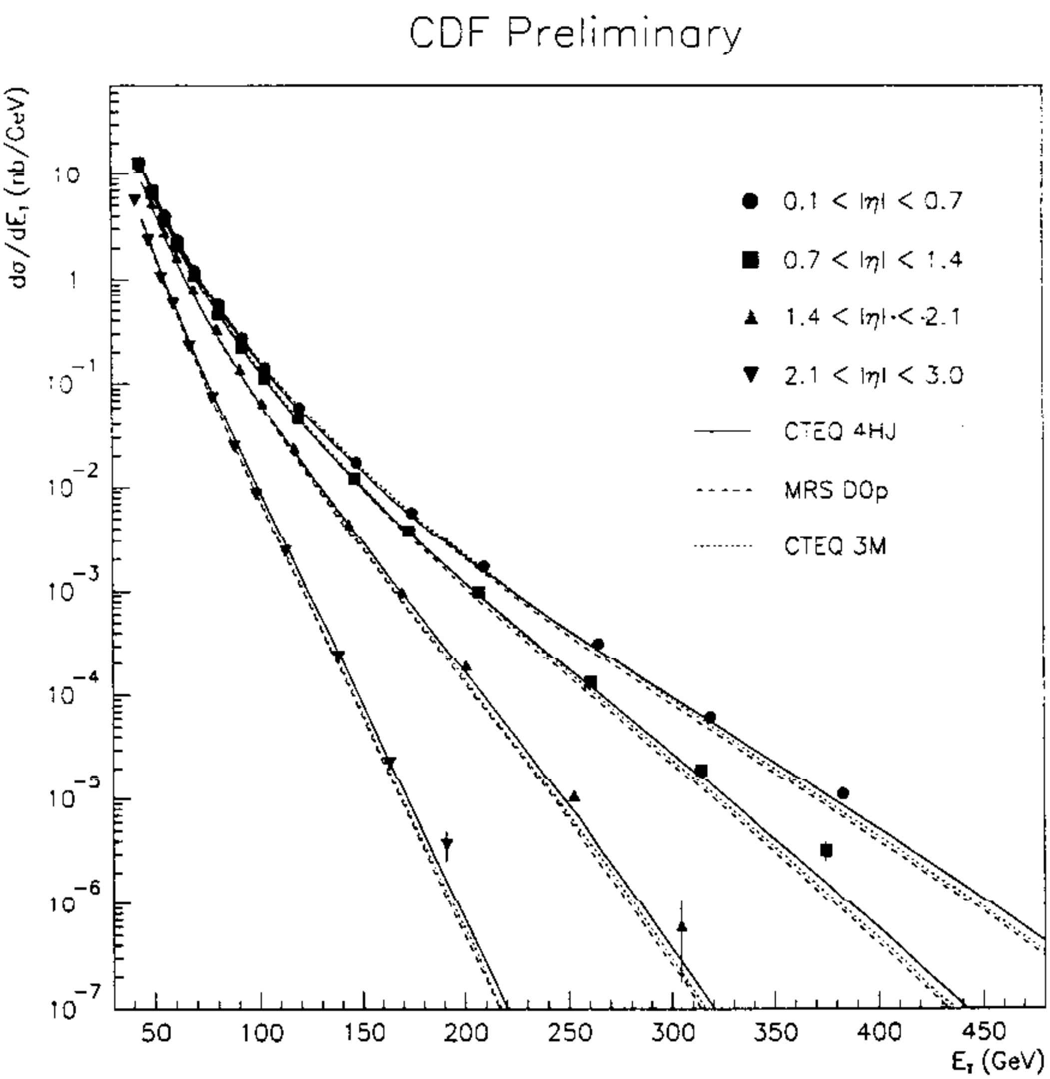
In leading order η_1 and η_2 are related to the parton momentum fractions.

$$x_1 = \frac{E_T}{\sqrt{s}}(\mathrm{e}^{\eta_1} + \mathrm{e}^{\eta_2})$$

$$x_2 = \frac{E_T}{\sqrt{s}}(\mathrm{e}^{-\eta_1} + \mathrm{e}^{-\eta_2})$$

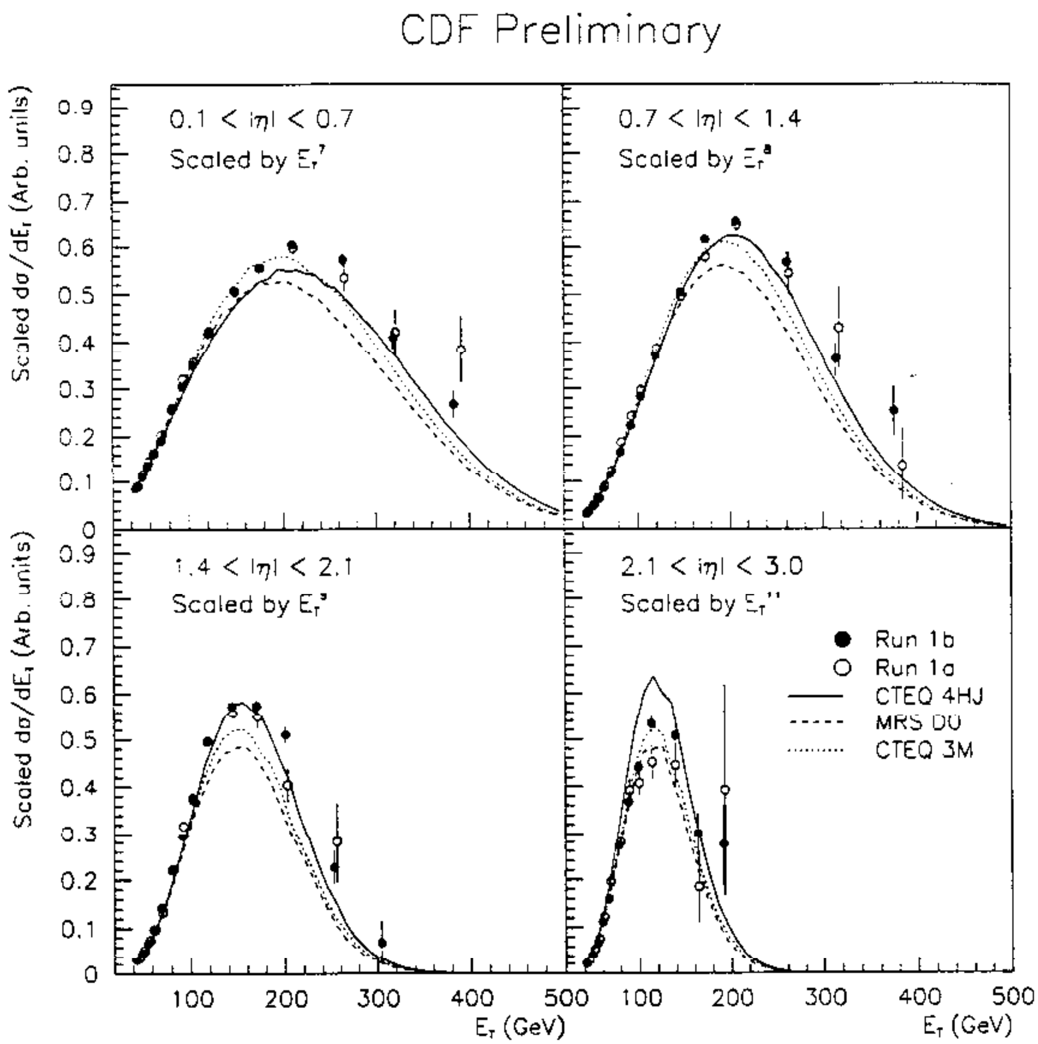
For fixed E_T and η_1 one can probe different momentum fractions by requiring that the next leading jet lie in different η intervals.

Inclusive Di-jet Differential Cross Section From Run Ib (87 pb^{-1})



Error bars represent the statistical error. The systematic error is under study.

The cross section was scaled by E_T^n and normalized by different factors for each η range.



For large η and high E_T a large fraction (25-60%) of events have four or more jets with $E_T > 10$ GeV while theory is $\mathcal{O}(\alpha_s^3)$.

Error bars represent the statistical error. The systematic error is under study.

For NLO the parton momentum fractions can be determined from

$$x_1 = \frac{E_{T1}}{\sqrt{s}}\left(e^{\eta_1} + \frac{E_{T2}}{E_{T1}}e^{\eta_2} + \frac{E_{T3}}{E_{T1}}e^{\eta_3}\right)$$

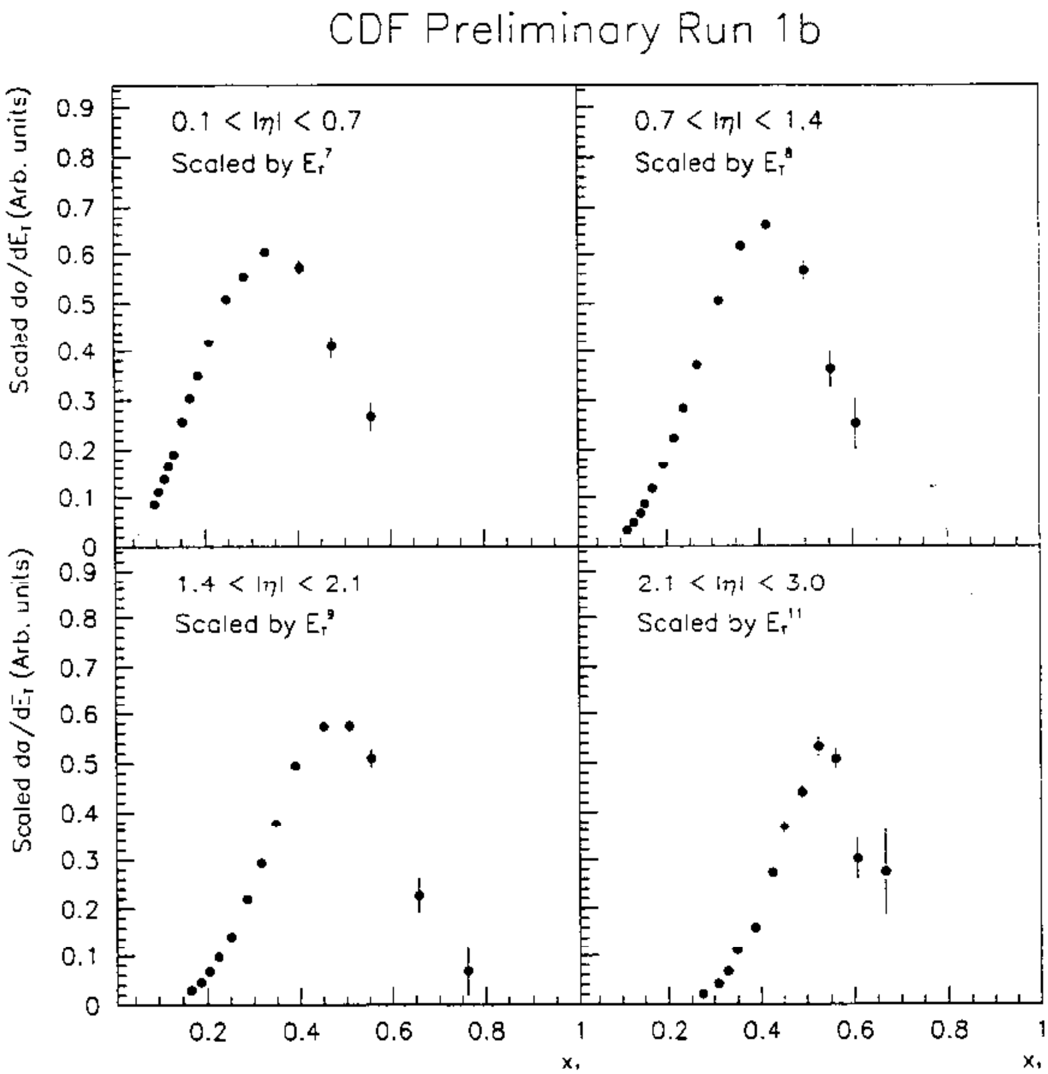
$$x_2 = \frac{E_{T1}}{\sqrt{s}}\left(e^{-\eta_1} + \frac{E_{T2}}{E_{T1}}e^{-\eta_2} + \frac{E_{T3}}{E_{T1}}e^{-\eta_3}\right)$$

For each E_T bin the average value for the factor in brackets is calculated and multiplied by the corrected E_T to determine x.

The factors have been ordered so that x_1 is always the maximum.

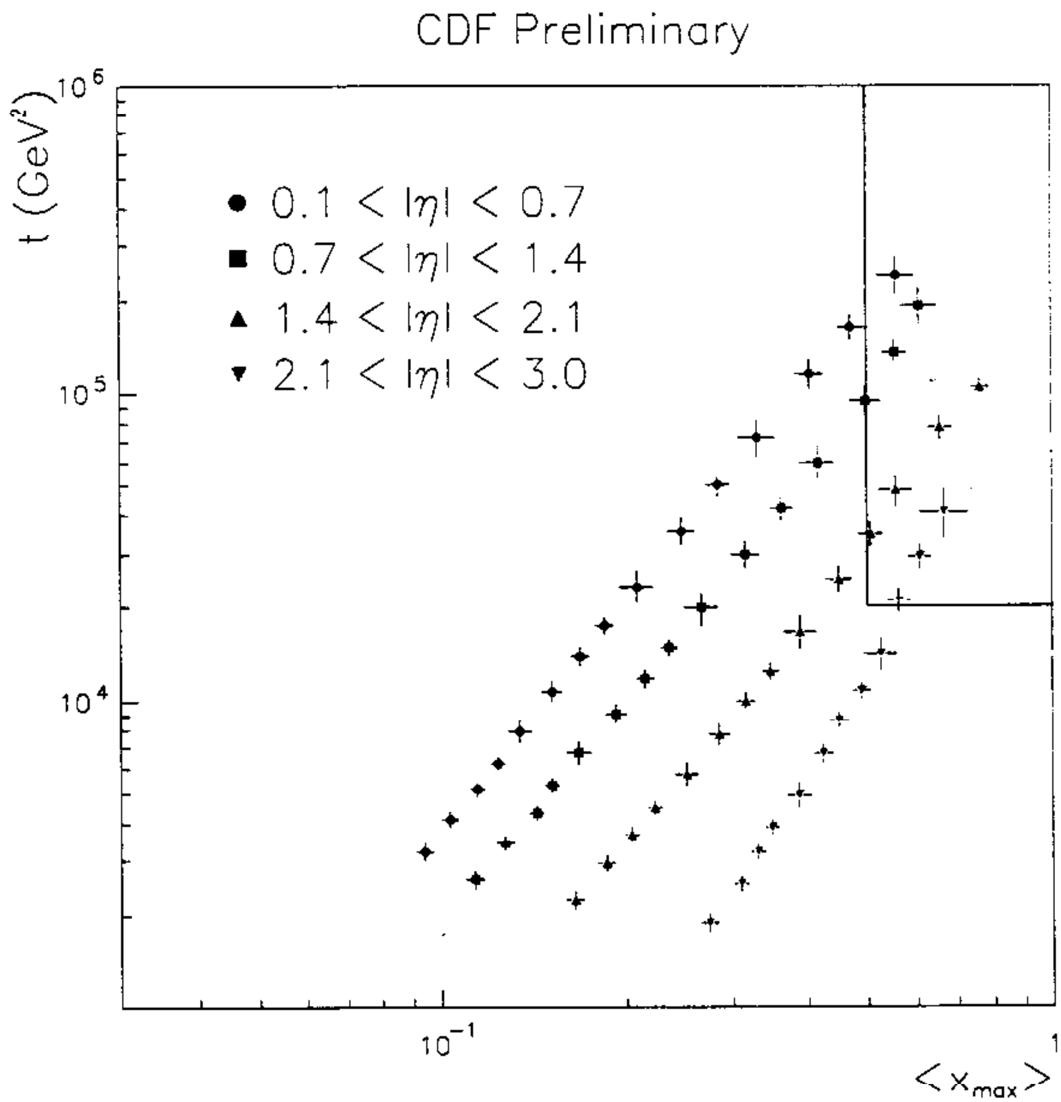
For a 2 body process

$$\begin{aligned} Q^2 &\sim -\hat{t} \\ &= \frac{\hat{s}}{2}(1 - \cos\theta^*) \\ &= 2E_T^2 \cosh^2\eta^*(1 - \tanh\eta^*) \end{aligned}$$



Error bars represent the statistical error. The systematic error is under study.

We have data in the high Q^2 and high x region.



Error bars represent *only* the statistical error on the average of E_T.

Di-jet Angular Distributions

Measurement of the distribution of the scattering angle between the di-jet and proton beam, in the CMS system, provides a fundamental test of QCD and is a sensitive probe of new physics.

The distributions result from the dynamics of hard scattering of quarks and gluons and is expected to be fairly insensitive to the momentum distributions of the partons.

Di-jet angular distributions can help identify whether the excess in the data at high E_T is a signal of new physics.

The di-jet mass is calculated from

$$M_{jj}^2 = 2 \cdot E_{T1} \cdot E_{T2} \cdot (\cosh(\Delta\eta) - \cos(\Delta\phi))$$

In order to allow an easier comparison with theory the angular distribution is plotted in the variable χ defined as

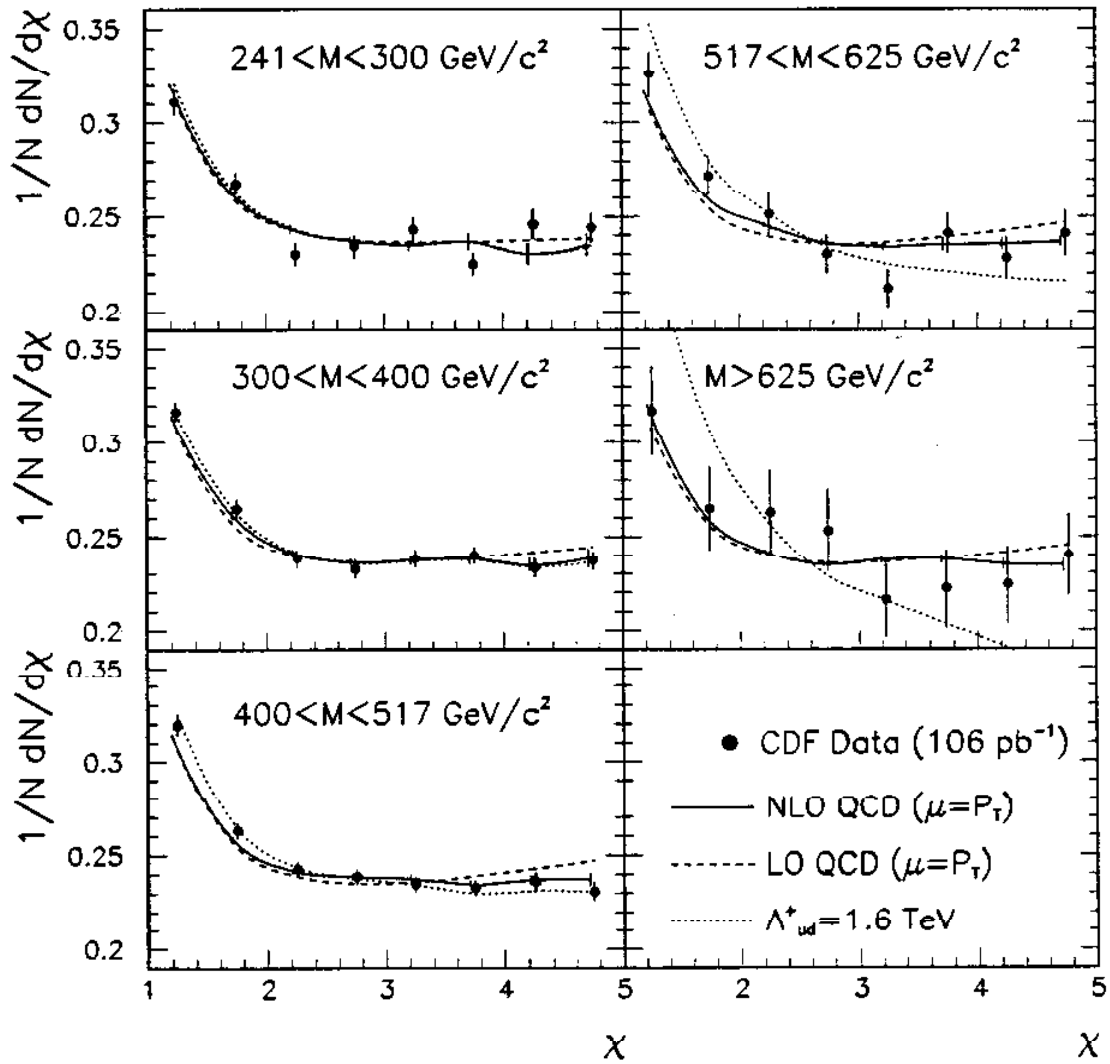
$$\chi = \frac{1 + \cos\theta^*}{1 - \cos\theta^*} = e^{|\eta_1 - \eta_2|}$$

where θ^* is the center of mass scattering angle.

The quantity χ uses only angles and is less sensitive to the energy scale of the detector.

Two dominant sources of systematic error arise from multiple interactions and the energy scale dependence on η.

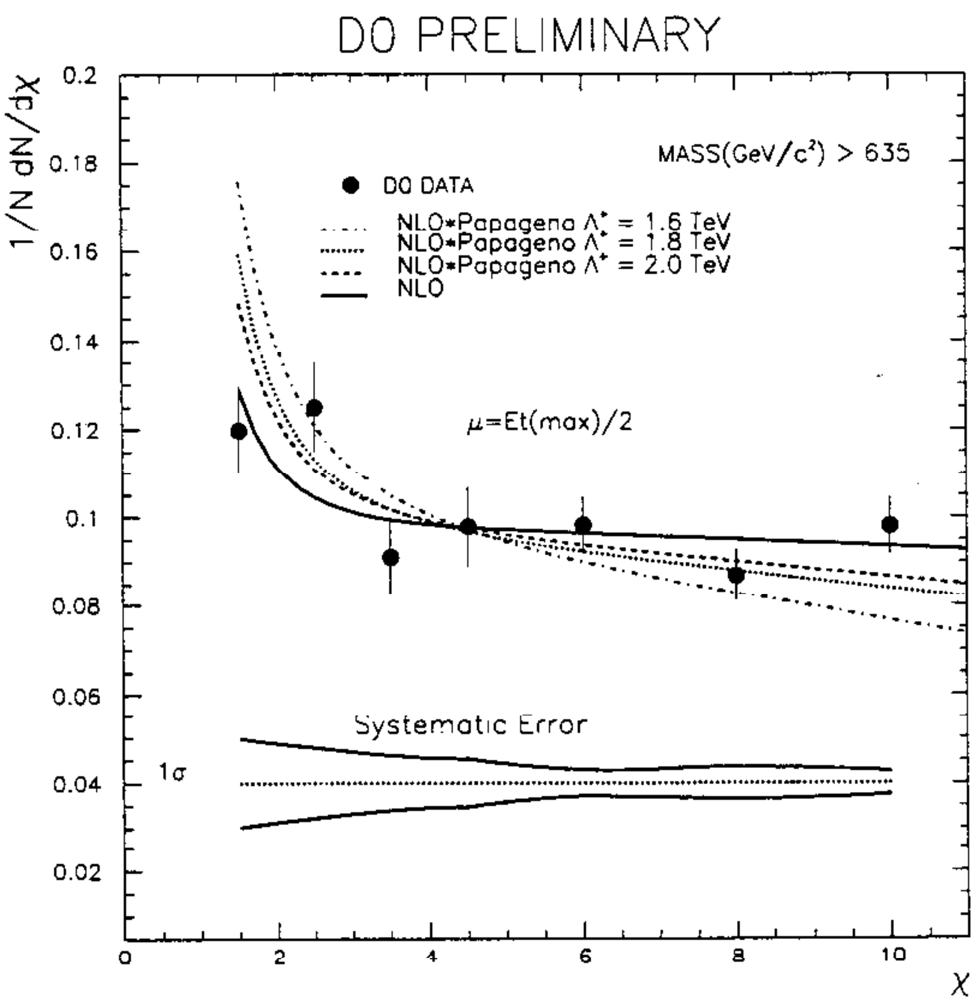
The data is in good agreement with NLO QCD calculations.



Data excludes (at the 95% CL) a contact interaction scale of $\Lambda^+_{ud} \leq 1.6$ TeV and $\Lambda^-_{ud} \leq 1.4$ TeV.

For a model where all quarks are composite $\Lambda^+ \leq 1.8$ TeV and $\Lambda^- \leq 1.6$ TeV.

The DØ measurements are at higher χ values.



Conclusions

Inclusive jet cross section results has stimulated theoretical activity at understanding the comparison of the data with QCD predictions.

Modification of the gluon distribution parameterization leads to an improved fit at high E_T.

The CDF and DØ inclusive jet data agree within systematic errors.

Looking at the effects of changing input parameters on the theory predictions.

Preliminary results for the inclusive di-jet differential cross section has been presented.

Large η allows one to explore higher x. Have data in the high x and high Q^2 region.

At large η and high E_T a large fraction of events have four or more jets while MC calculations are only available at $\mathcal{O}(\alpha_s^3)$.

Di-jet angular distributions are consistant with NLO QCD calculations and limits have been determined for the contact interaction scale.