Tevatron Jet Physics

Presented for the CDF and DØ Collaborations

by

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Tevatron Run II Results

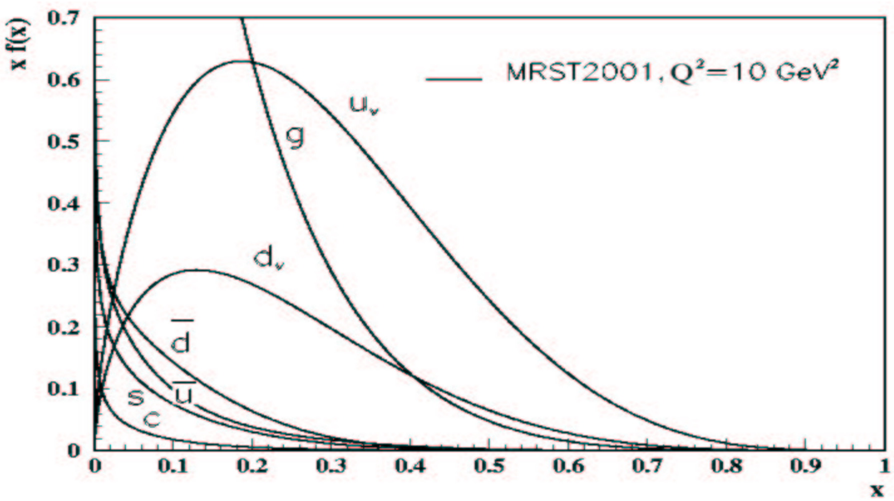
- *Preliminary Results for the Inclusive Jet Cross Section from CDF and DØ*

- *Preliminary Measurement of Dijet Azimuthal Correlations for Central Rapidities by DØ*

- *Preliminary Measurement of the Dijet Cross Section from DØ*

Studying high energy interactions tests our understanding of the Standard Model $\longrightarrow$ *searches for new physics....*

The Tevatron is the world's highest energy collider
Probing distance scales of $\sim 10^{-17}$ cm



Particle structure is parameterized with Parton Density Functions (PDFs)

$\longrightarrow$ *Gives the probability of probing the constituent quarks*

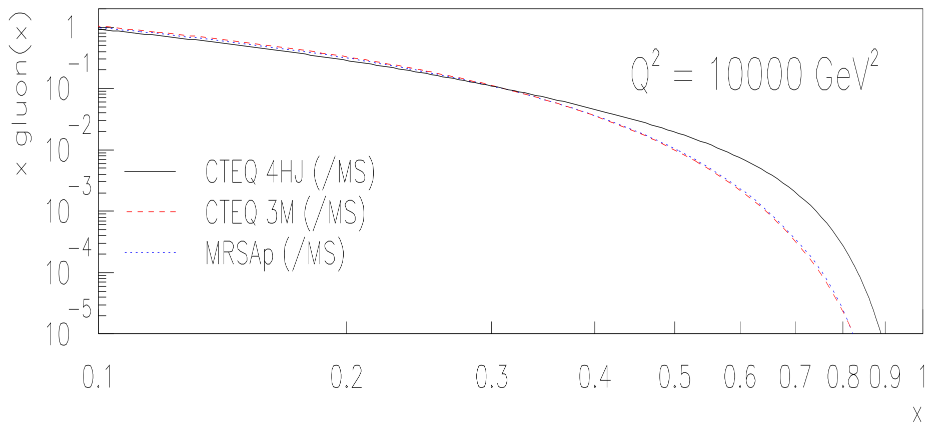
x : momentum fraction carried by struck parton

Q^2 : the square of the momentum transfered to the target $p(\bar{p})$

PDFs are fundamental inputs to calculations describing collider phenomenology

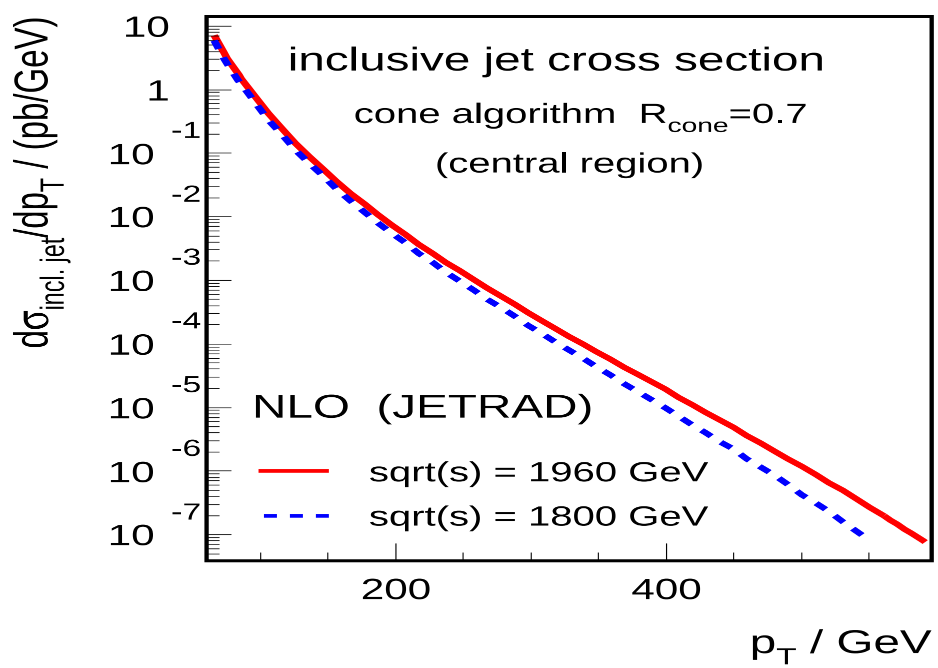
Improved PDFs allow more precise calculations that will be needed not only at the Tevatron but also at the LHC and future experiments

The run I inclusive jet cross section was larger than theory expectations at high E_T



Run I jet data used in fits resulting in new PDFs having an enhanced gluon density at high x

→ *Able to accommodate the rise at high E_T*



Increase center-of-mass energy (1.8 → 1.96 TeV) results in an increased cross section at high E_T.

About 2× at 400 GeV and 5× at 600 GeV

→ *Probing even higher E_T*

Improved Jet Clustering Algorithms

JetClu: *Run I Jet Algorithm*

Not infrared safe (at NNLO)

Preclustering and Ratcheting: $\longrightarrow$ *difficult to implement at the parton/hadron level, depends on the detector geometry*

More difficult to compare to theory and between experiments

MidPoint: *Run II Cone Algorithm*

Uses rapidity, y, instead of pseudorapidity, η and transverse momentum p_T instead of transverse energy, E_T

Infrared safe and well defined

No preclustering, no ratcheting

$\longrightarrow$ *Able to make more direct comparisons with theory and between experiments*

Kt Clustering:

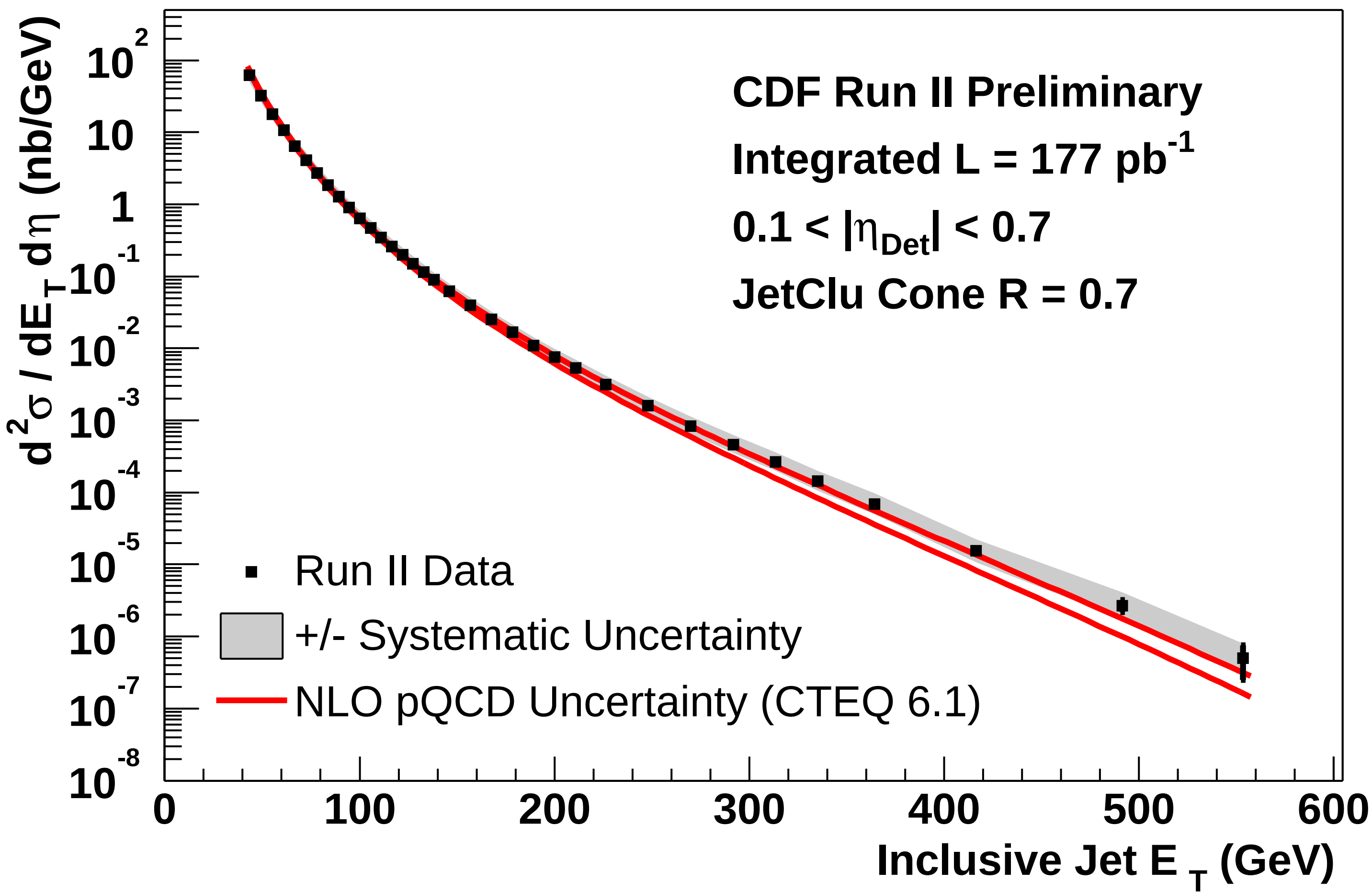
Precluster towers with $P_T > 0.1$GeV

Merge preclusters until all jets are separated by $\Delta R > D$ where D is the scale of the jet.

No use of seeds $\rightarrow$ infrared and collinear safe

Towers uniquely assigned to jets $\rightarrow$ no splitting/merging

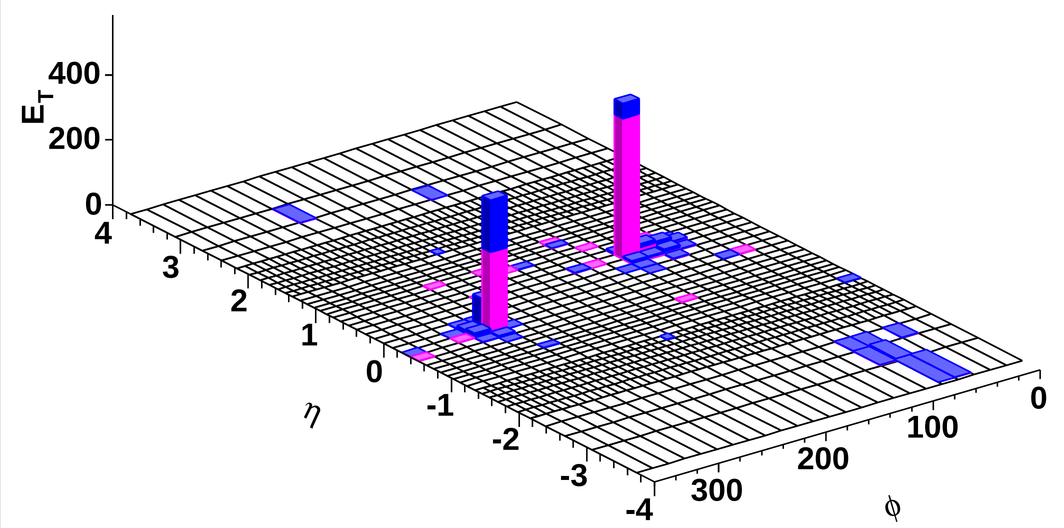
Inclusive Jet Cross Section



→ *Test of QCD over 9 orders of magnitude*

→ *Extends measurement to higher E_T by about 200 GeV*

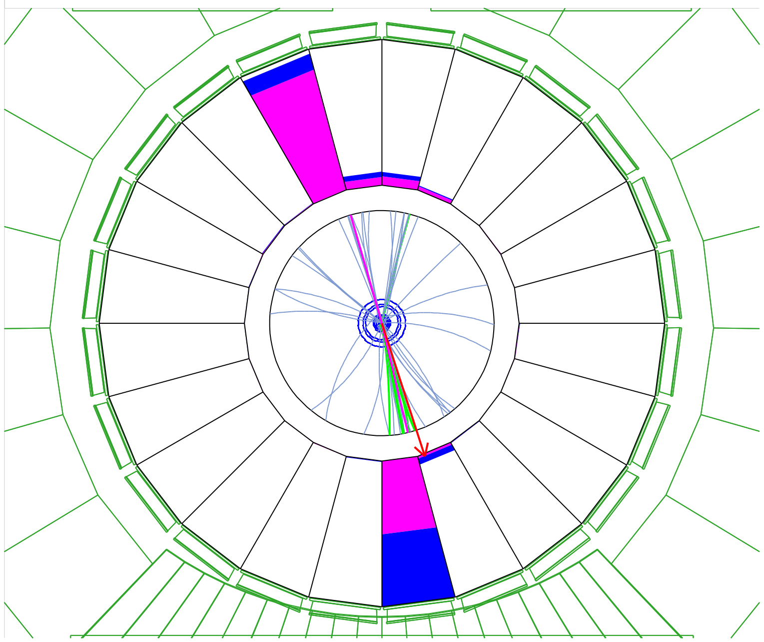
Same unsmearing procedure as used in Run I



CDF Run II Preliminary

```
Jet Et1 = 666 GeV (corr)
          583 GeV (raw)
eta1    = 0.31 (detector)
          0.43 (corr z)

Jet Et2 = 633 GeV (corr)
          546 GeV (raw)
eta2    = -0.30 (detector)
          -0.19 (corr z)
```



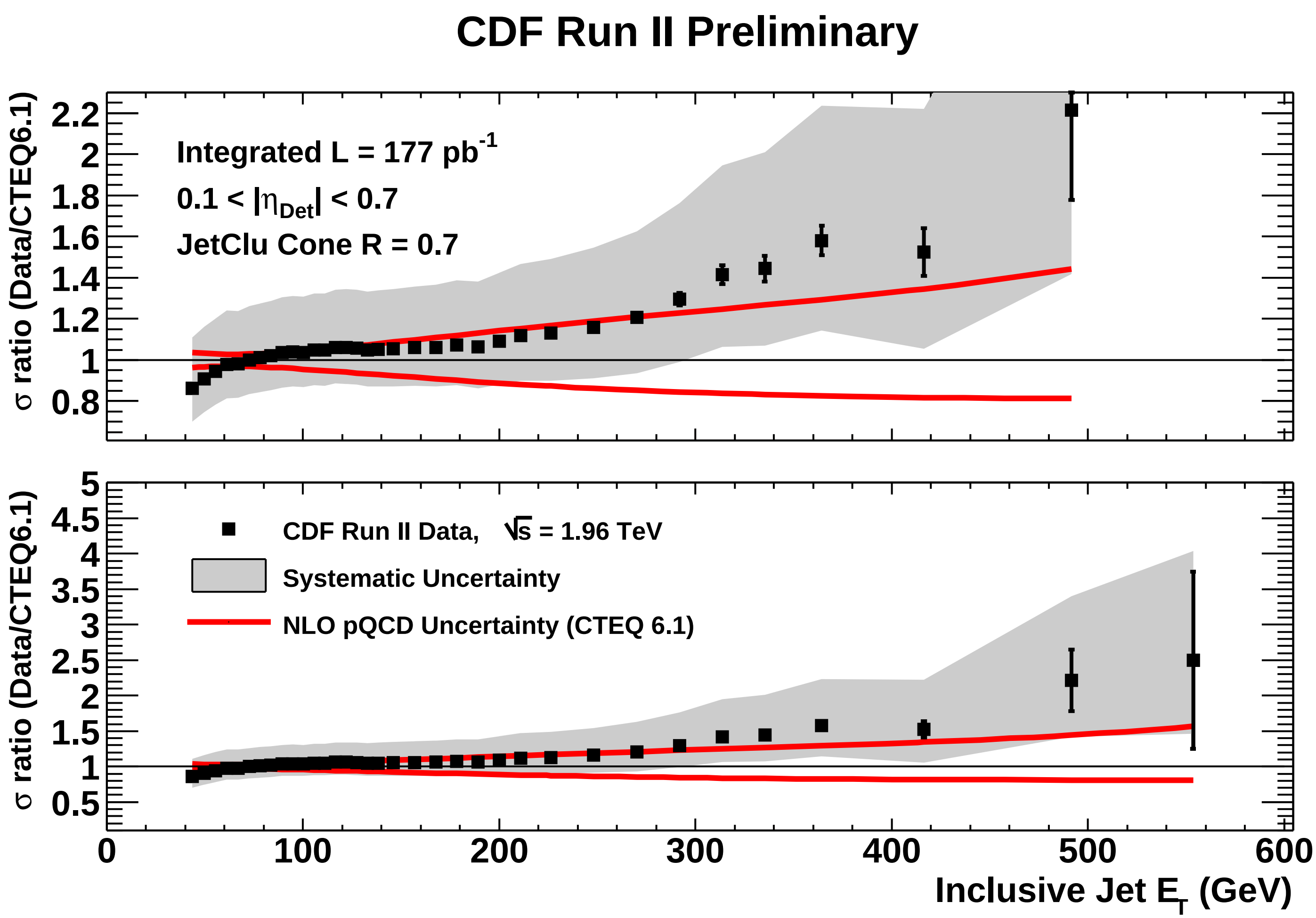
```
Run   152507
Event 1222318

DiJet Mass = 1364 GeV (corr)

z vertex   = -25 cm
```

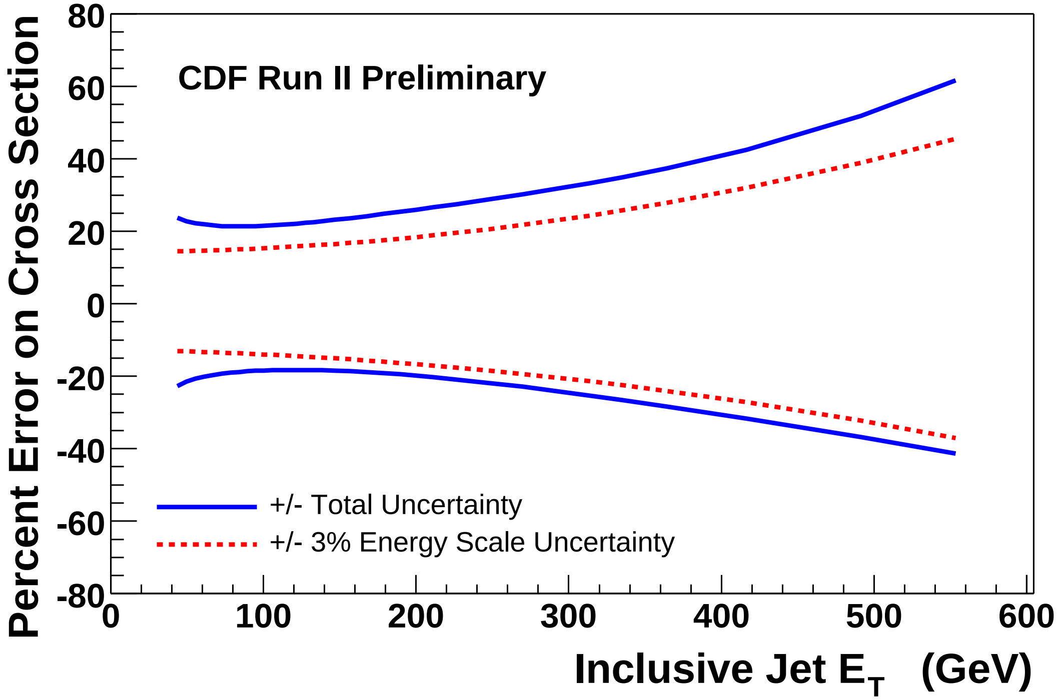
Ratio of Data over Theory

Run I Tevatron Jet data was used in the fit for CTEQ 6.1 which resulted in an enhanced gluon density at high x



Particle level measurement compared with parton level calculation

Uncertainty in the energy scale is the dominant source of systematic error, can expect this to improve...

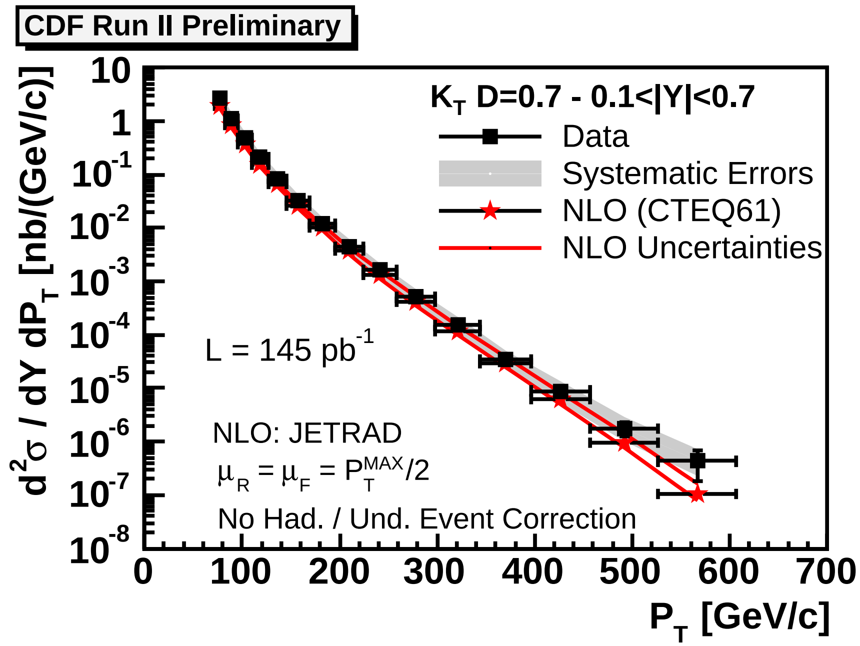


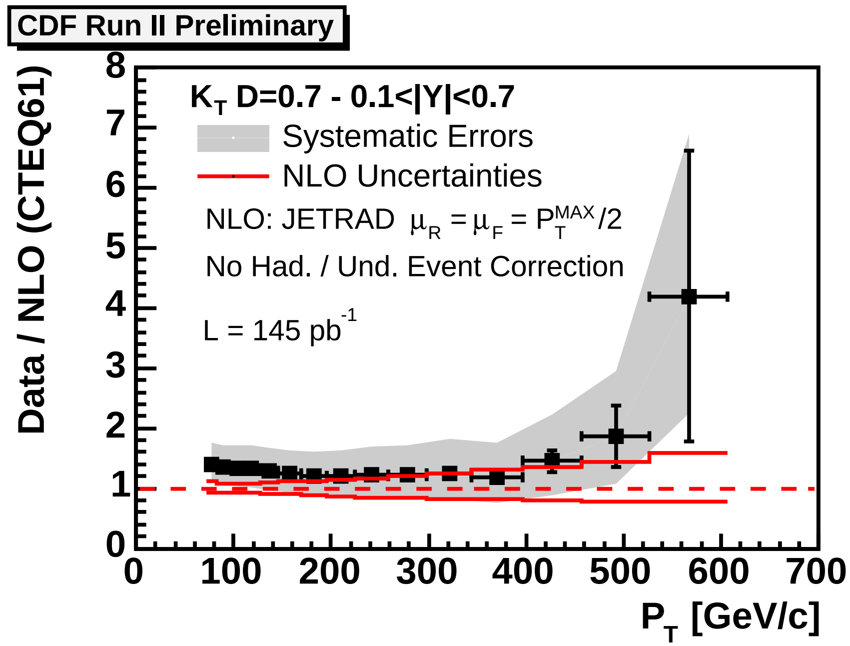
The effect of a 3% energy scale uncertainty contribution to the total systematic error

For a faster falling E_T spectrum, the error on the measured cross section becomes larger

$\rightarrow$ *Errors become larger when measuring forward jets*

Preliminary Results Using the K_T Clustering Algorithm



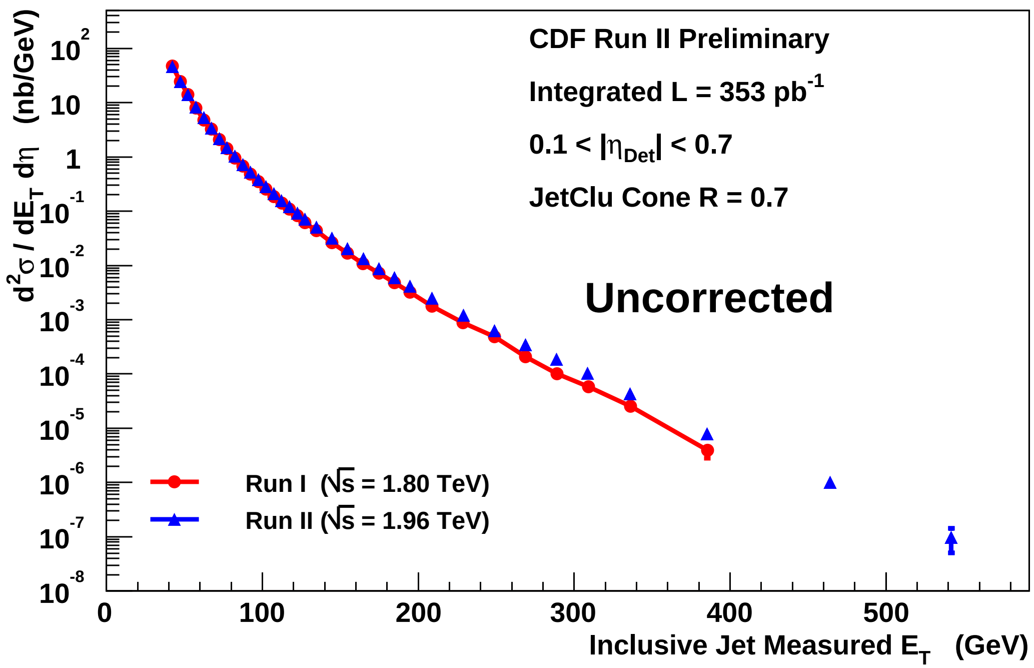


Results compared to JETRAD (NLO) with CTEQ6.1

→ Theory does not include effects from hadronization or the underlying event which tends to "raise" the low E_T region

Uses the Run II detector simulation to determine the jet corrections

We now have even more data available (plot includes 353 pb^{-1})



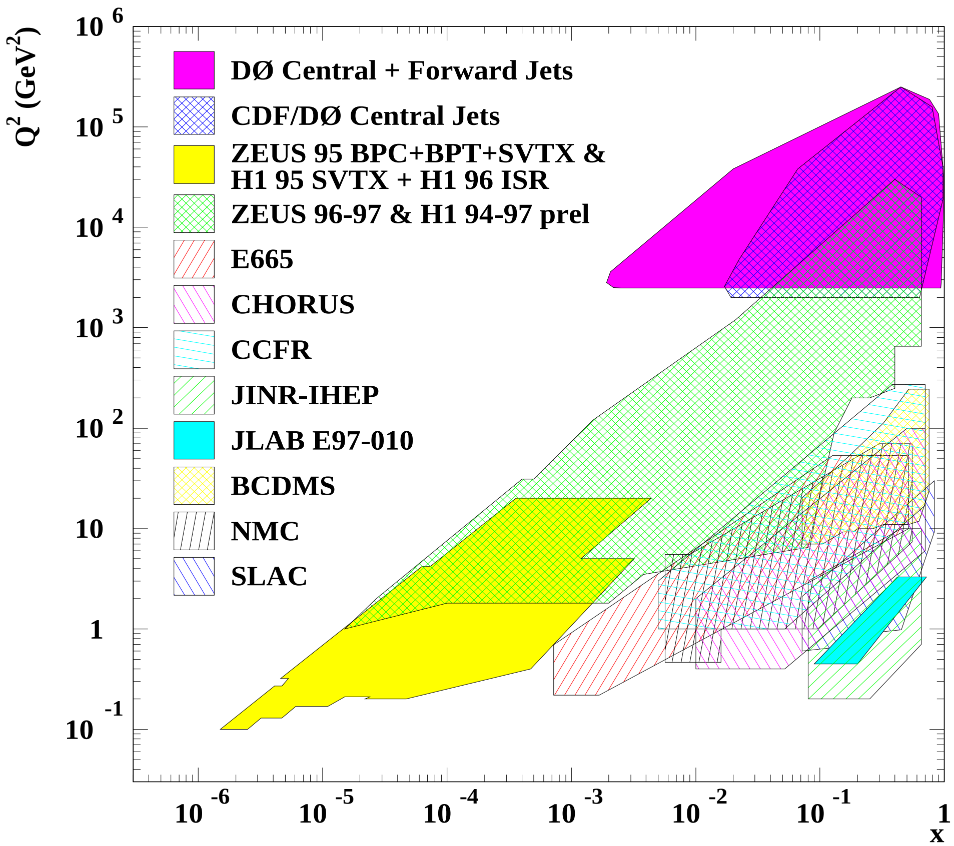
The increased center-of-mass energy enables us to extend our Run I results by about 200 GeV

→ *Able to probe shorter distances with higher precision*

→ *When including more data, rise at high E_T is not as dramatic*

In addition to being able to study the high E_T region we have more data in the low E_T region.

The Tevatron operates in a kinematic region complementing existing and previous experiments and provides unique capabilities



Run I measured region

The parton momentum fraction can be reconstructed from the jet's transverse energy, E_T, and pseudorapidity, η, by

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

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

An approximation of the four momentum transfer, Q^2, in the interaction is

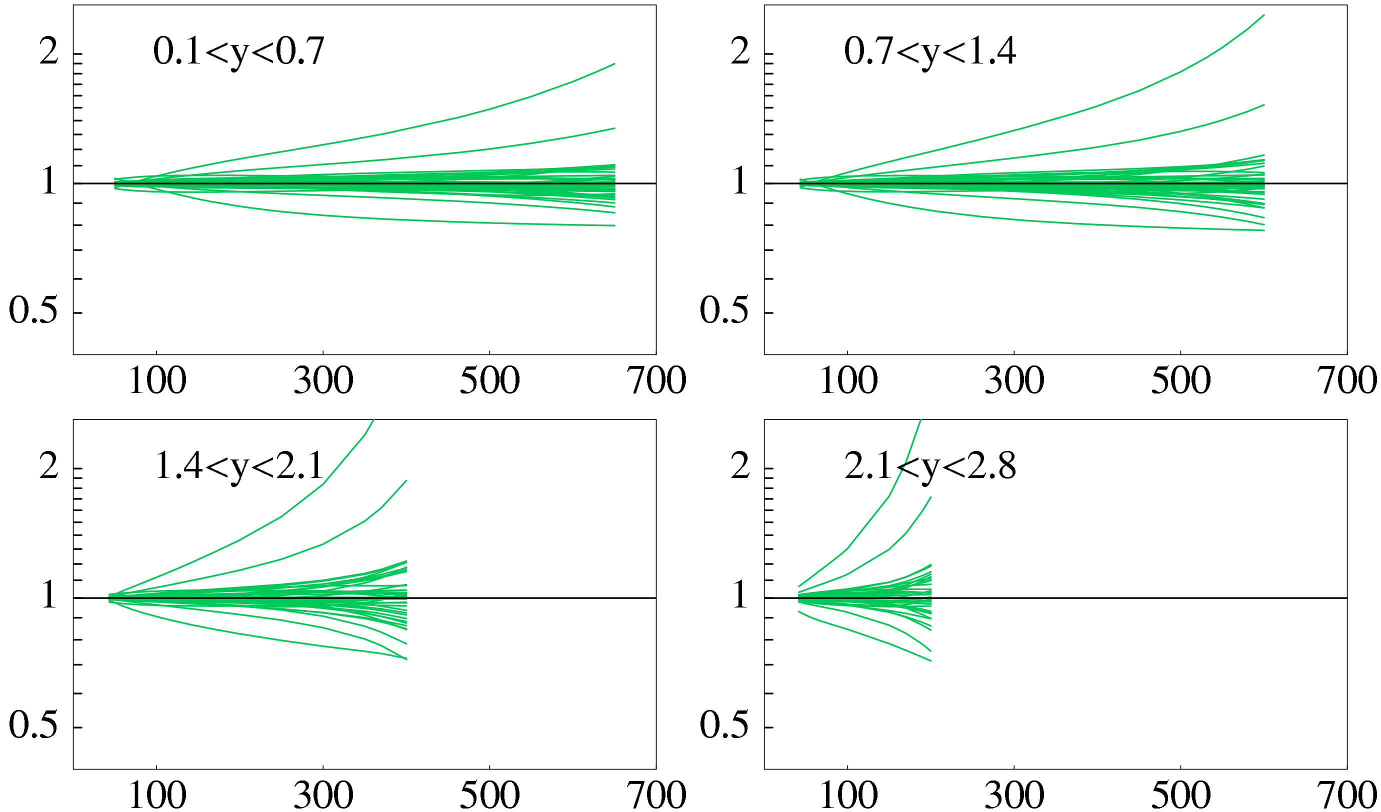
$$Q^2 = 2E_T^2 \cosh^2 \eta^* (1 - \tanh \eta^*)$$

$\rightarrow$ *Best place to study the high x gluon content of the proton*

$\rightarrow$ *Kinematic region can be expanded by measuring jets in the forward region*

Forward jet measurements provide additional input for global QCD fits

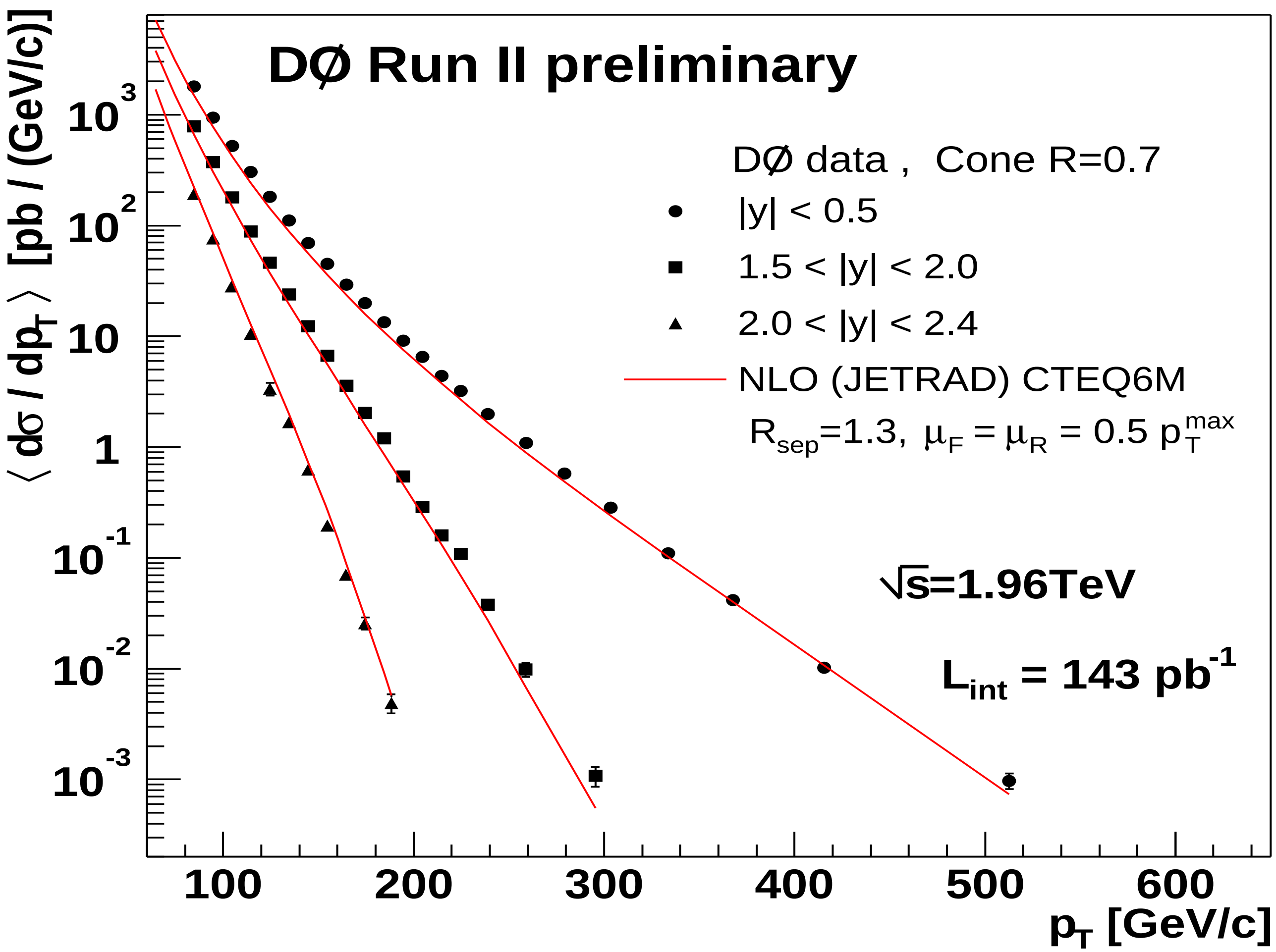
→ *providing better constrained PDFs*



hep-ph/0303013

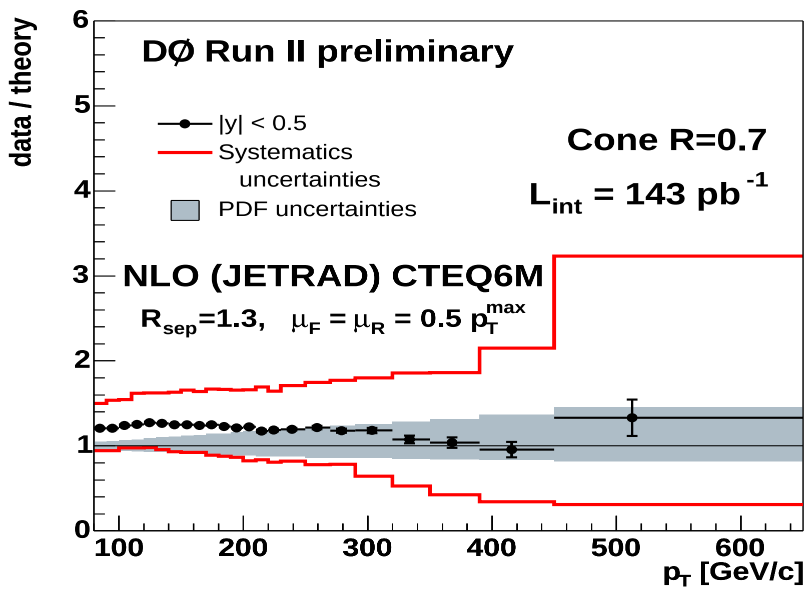
Range of uncertainty of the inclusive cross section in different rapidity regions determined for CTEQ6.1.M

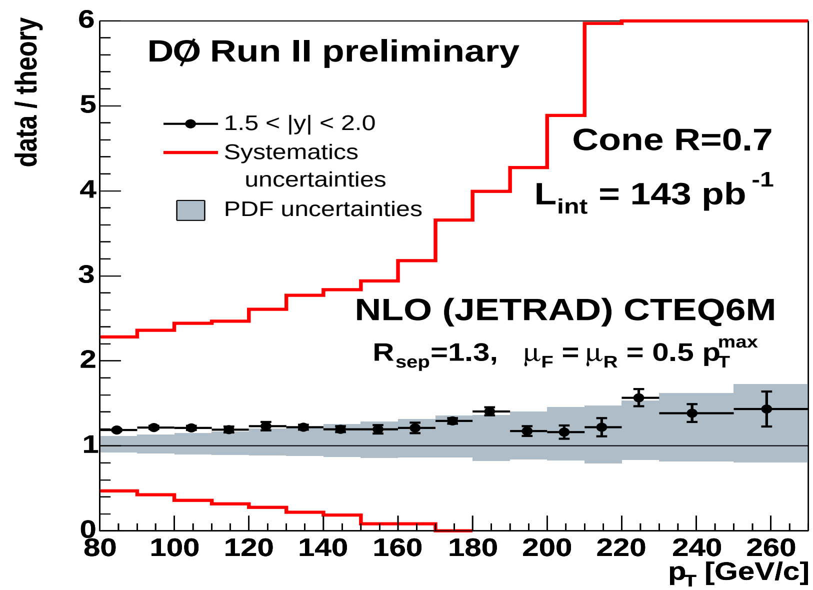
Inclusive Jet Cross Section in Different Rapidity Bins from DØ

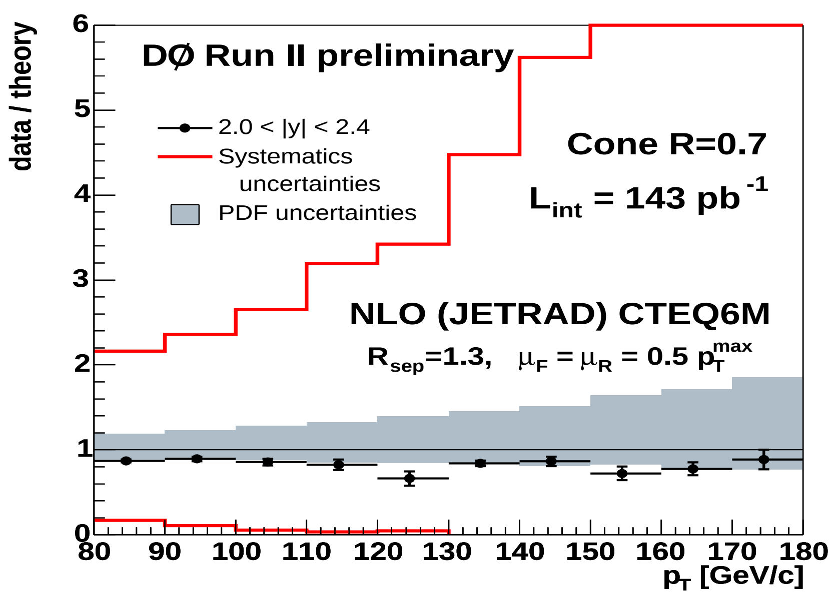


The MC is only used for a showering correction (about 1-2%). Other corrections are determined from the data.

Ratio of Data over Theory





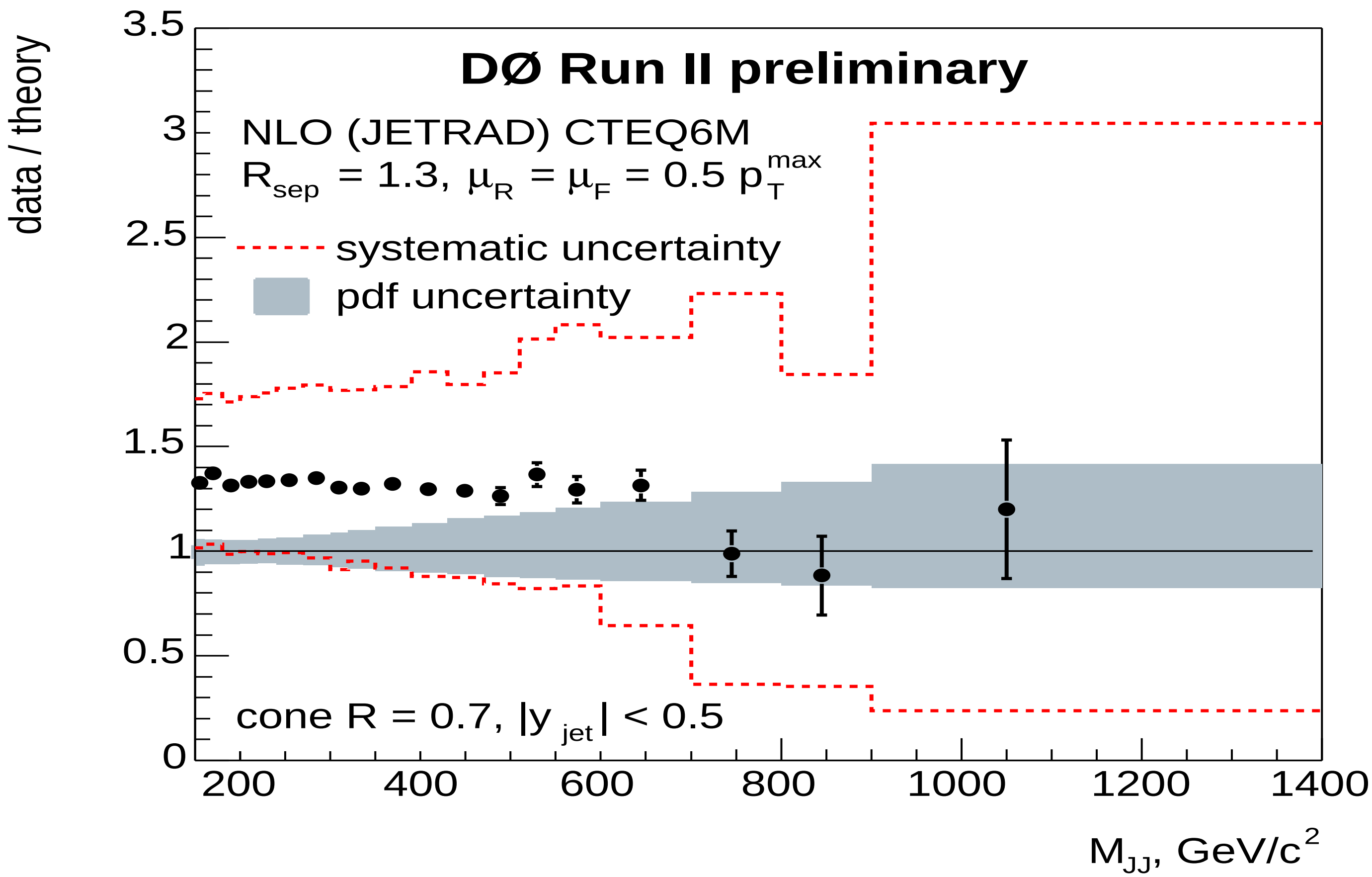


The rapidity-dependent cross section constrains the gluon PDF at medium to high x

Energy scale dominates the experimental uncertainty and work in progress on reducing this error

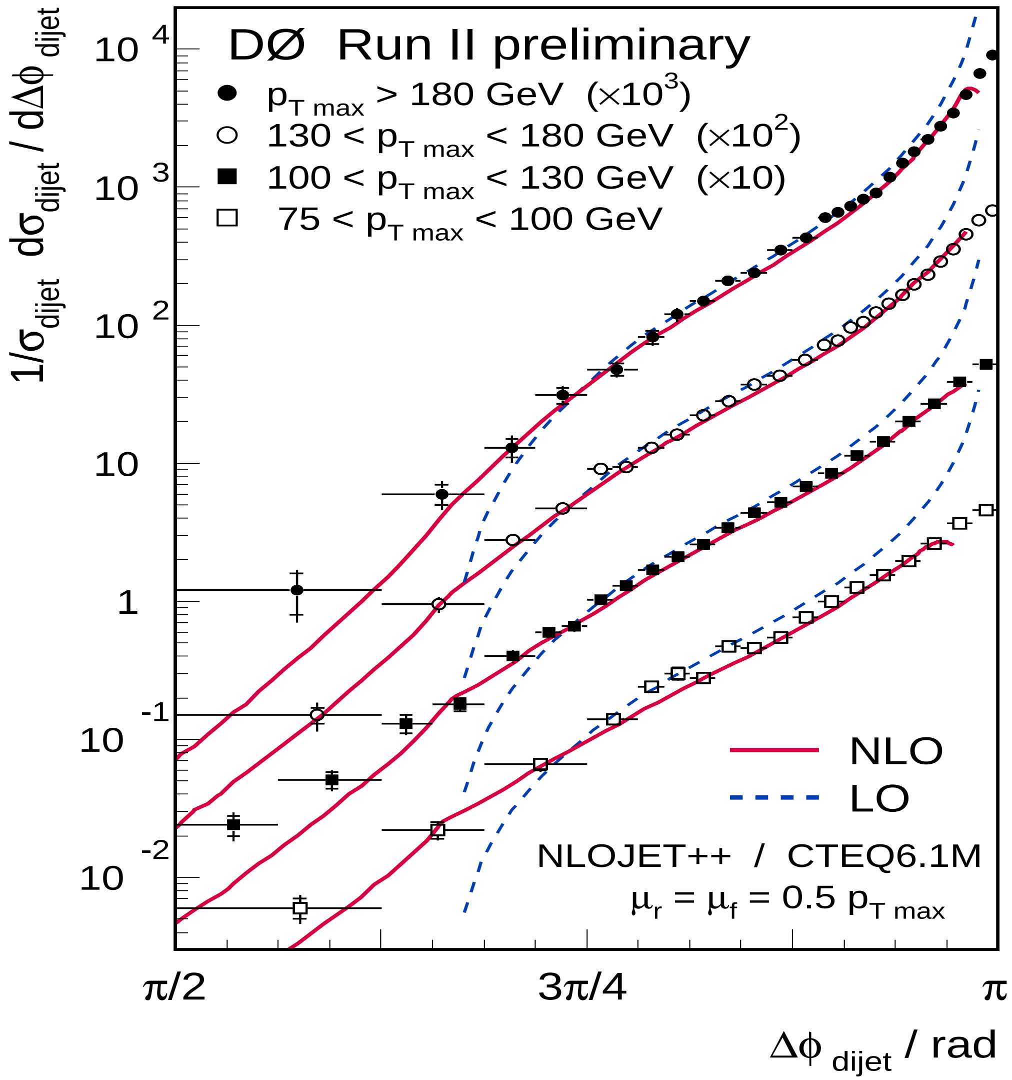
The dijet mass has a greater sensitivity to new phenomena

The analysis has a slight reliance on MC not present for DØ's inclusive measurement



Agreement with theory given the large experimental uncertainty

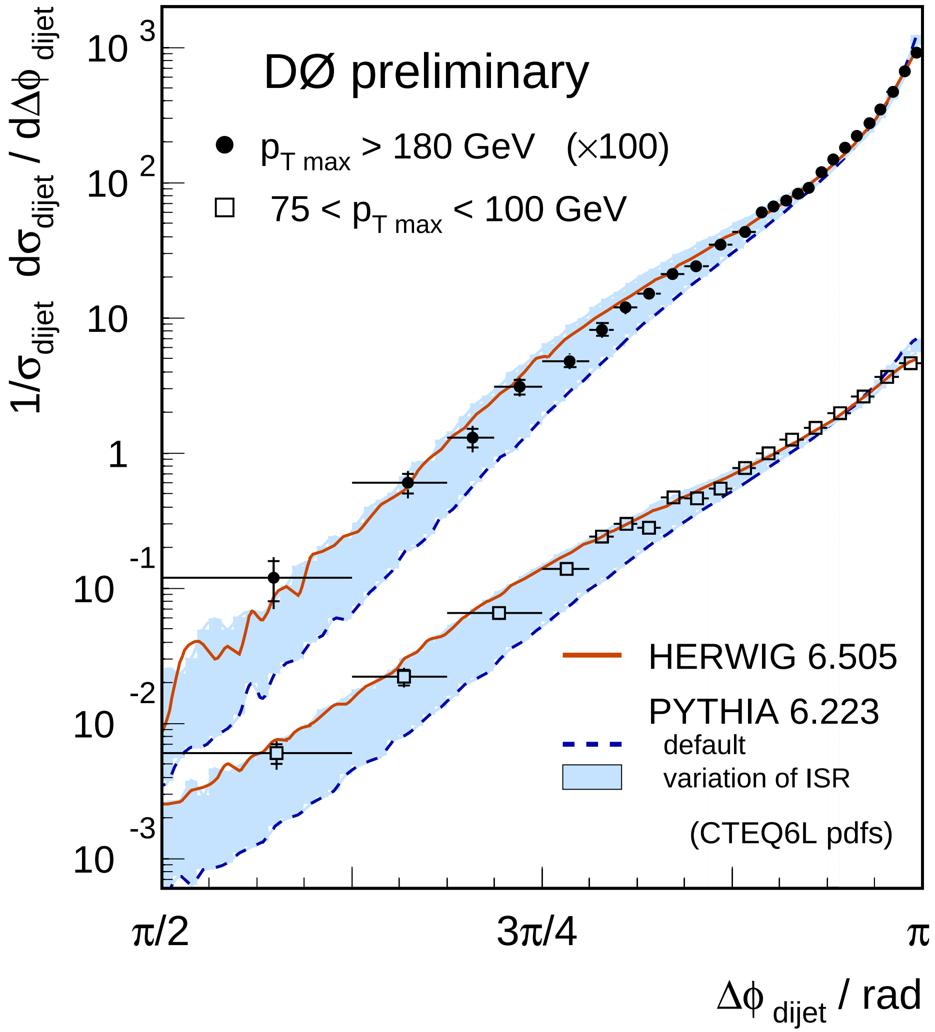
Measurement of the correlations between the two leading jets in multijet production is sensitive to the impact of QCD radiation on jet production



Additional jets produced at higher orders result in a decorrelated angle ($\Delta\phi_{dijet} < \pi$) between the lead jets

Results are compared to pQCD in fixed order α_s (LO and NLO) and to predictions of PYTHIA and HERWIG.

Based on $\mathcal{L} = 150$ pb^{-1}



Results for two of the measured p_T ranges are compared with HERWIG and PYTHIA

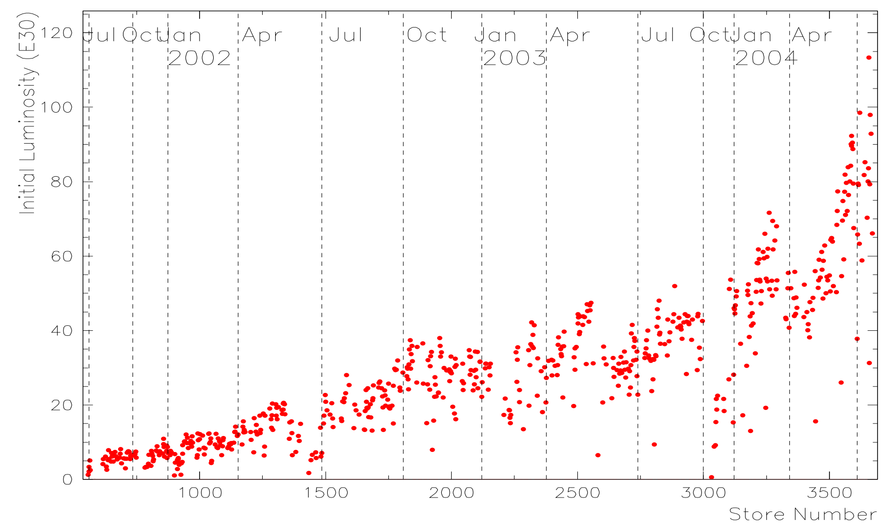
By increasing the initial state radiation, PYTHIA gives a much better description of the data

→ *Illustrates the potential for future efforts to tune the event generators*

MC event generators using parton showers can be tuned to produce the observed correlation over the whole range

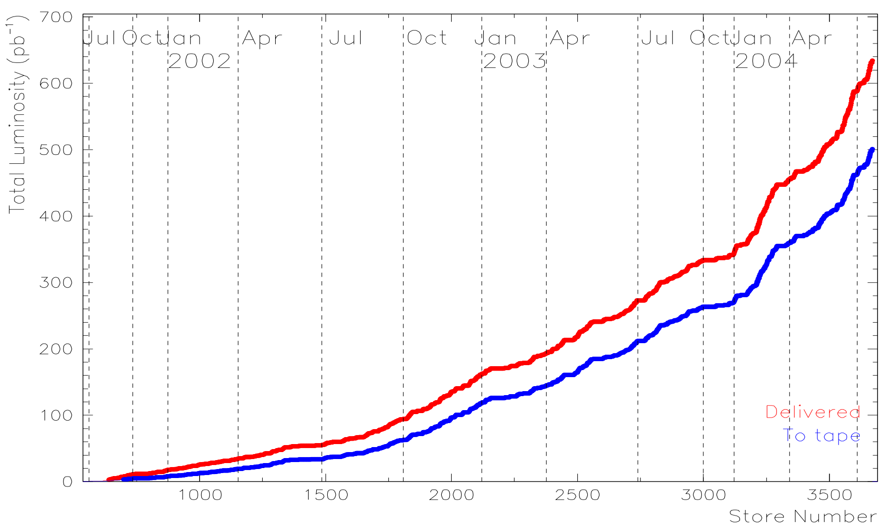
pQCD at NLO provides a very good description of the data

The performance of the Tevatron is rapidly improving



(07/16/2004) Store 3657 set a new luminosity record of $\underline{1.1 \times 10^{32} cm^{-2} s^{-1}}$ as measured at CDF

Tevatron delivered 4.5pb^{-1} in one store!



Both experiments are doing well at collecting physics quality data

Exceeding four times the Run I dataset

Summary

- There has been a lot of work on understanding improved clustering algorithms and both experiments are starting to use them $\rightarrow$ *will eventually allow easier comparison with theory and between experiments*

- Preliminary results have been presented which exceed the Run I data sample by more than a factor of two
...and we now have collected a data sample consisting of more than four times the Run I data sample

- The Tevatron is operating at a higher center-of-mass energy which yields a greater cross section at higher E_T $\rightarrow$ have extended the high E_T measurements by about 200 GeV

- Results are consistent with the QCD predictions

- Expect an improved understanding of the systematic errors