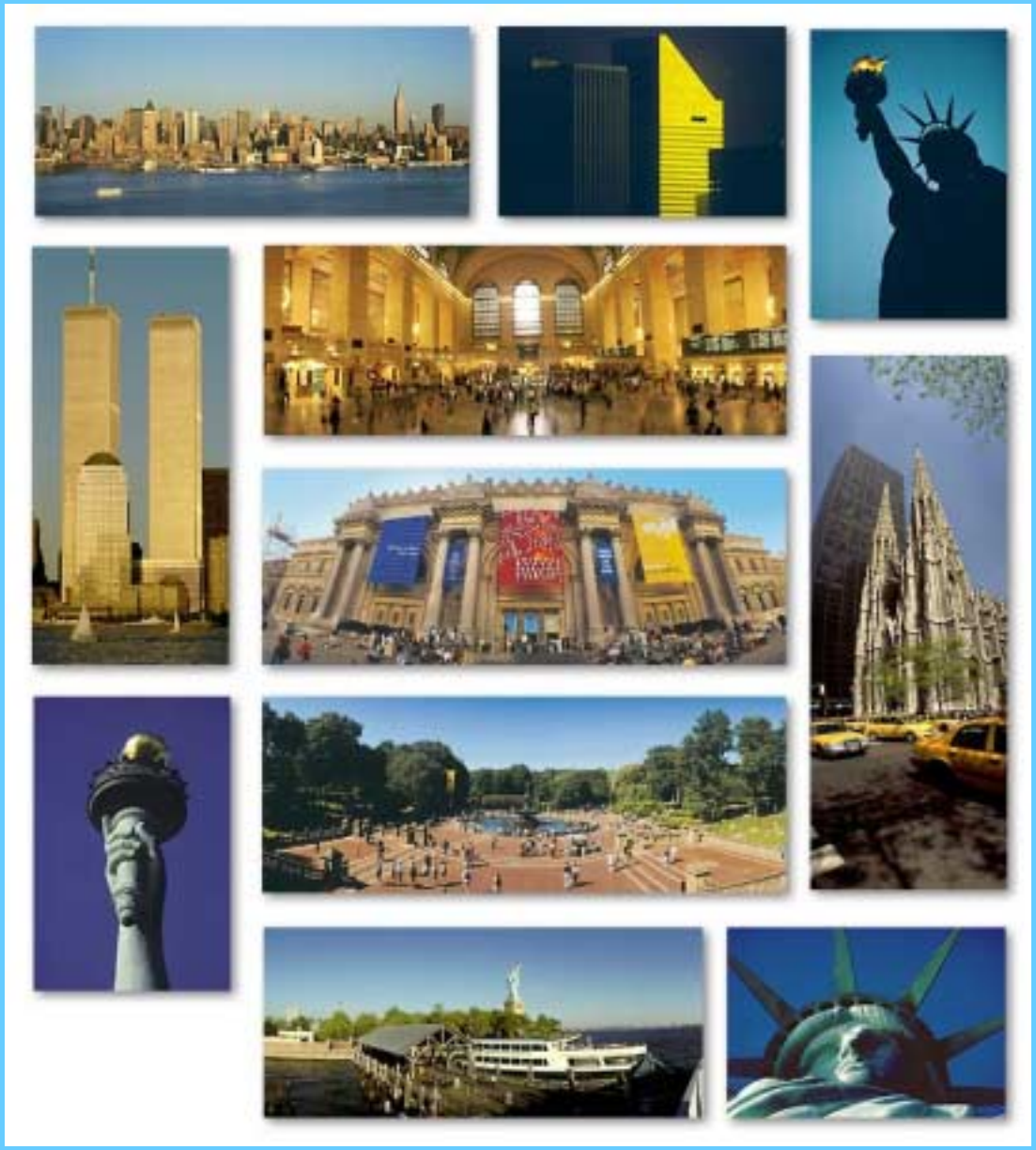
QCD at the TEVATRON

Christina Mesropian

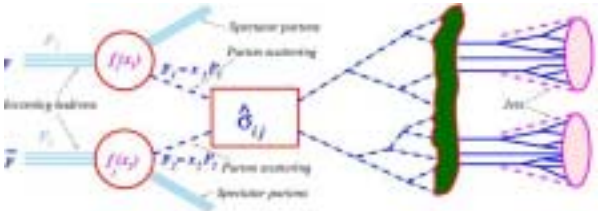
The Rockefeller University



Contents

- Inclusive Jet Cross Section
- Dijet Mass Distribution
- Jet shapes and Energy flow

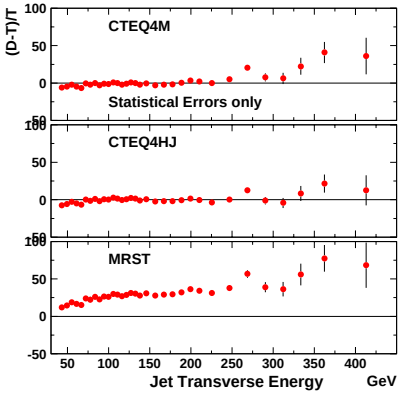
Introduction



probes highest energy scales
search for new physics

Jet Factory

Results from Run I

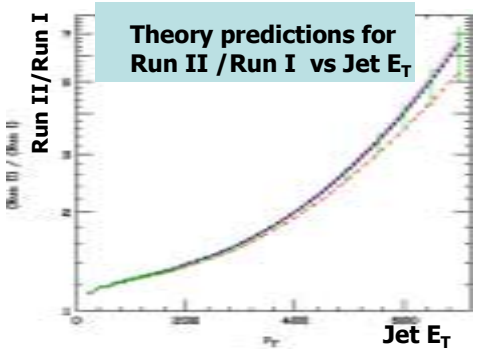


Reevaluation by PDF's groups
CTEQ series:
gluon distribution *g(x)* at high *x*
constrained by Tevatron jet data

Run II

$\sqrt{s}$ = 1.96 TeV

higher σ - factor of 3
for high energy jets

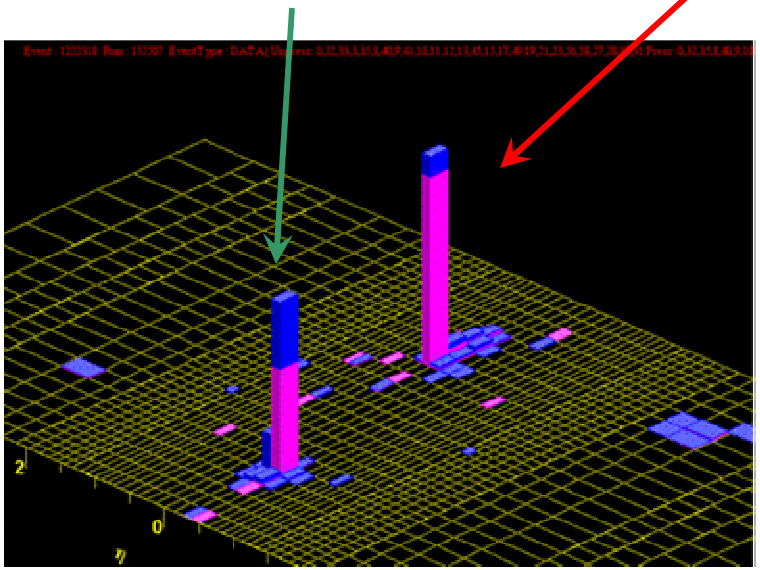


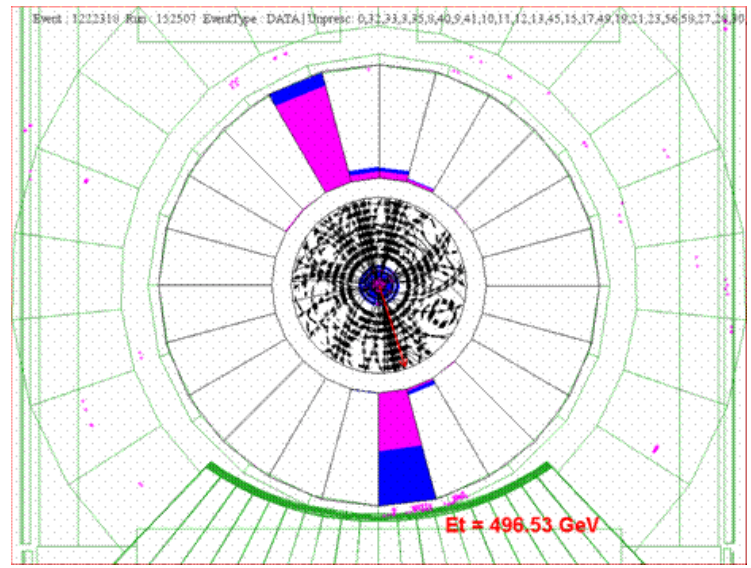
Upgrades at CDF and DØ

Highest Energy Jets in Run II

Jet 2 E_T= 633 GeV (corrected)

Jet 1 E_T= 666 GeV (corrected)





Dijet Mass 1364 GeV/c^2

Run 152507 Event 1222318

Inclusive Jet Cross Section

Data Selection

Data collected from
February 2002 – January 2003

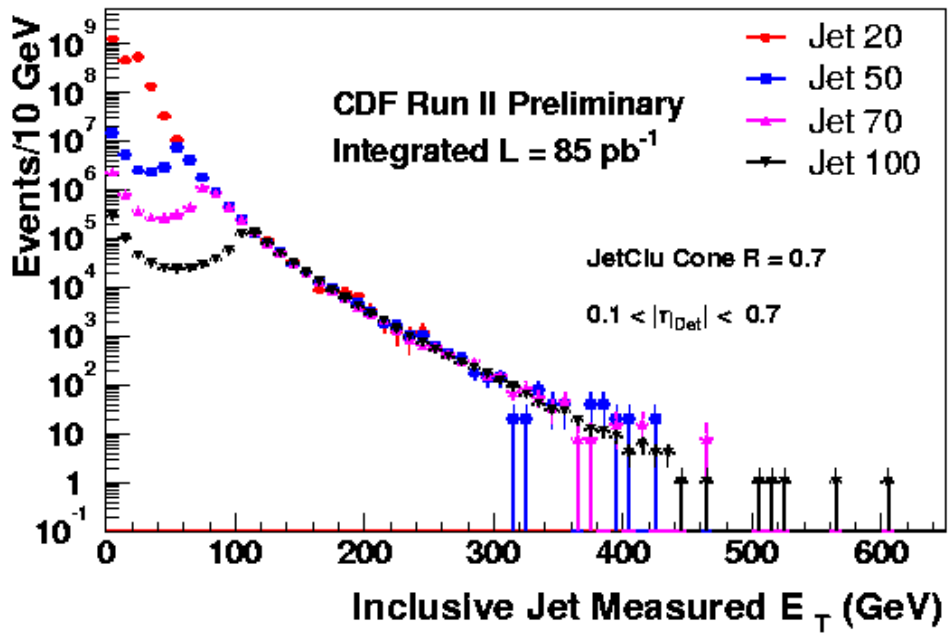
Integrated **L** = 85 pb^{-1}

E_T range of 32-568 GeV

$0.1 < \eta_{jet} < 0.7$

Clean up CUTS

Missing E_T significance
visual scan



Good overlap between different triggers

Data used when triggers are 99% efficient

Inclusive Jet Cross Section

Corrections

Repeat Run I analysis:

jets reconstruction -
iterative jet clustering algorithm ***R=0.7***

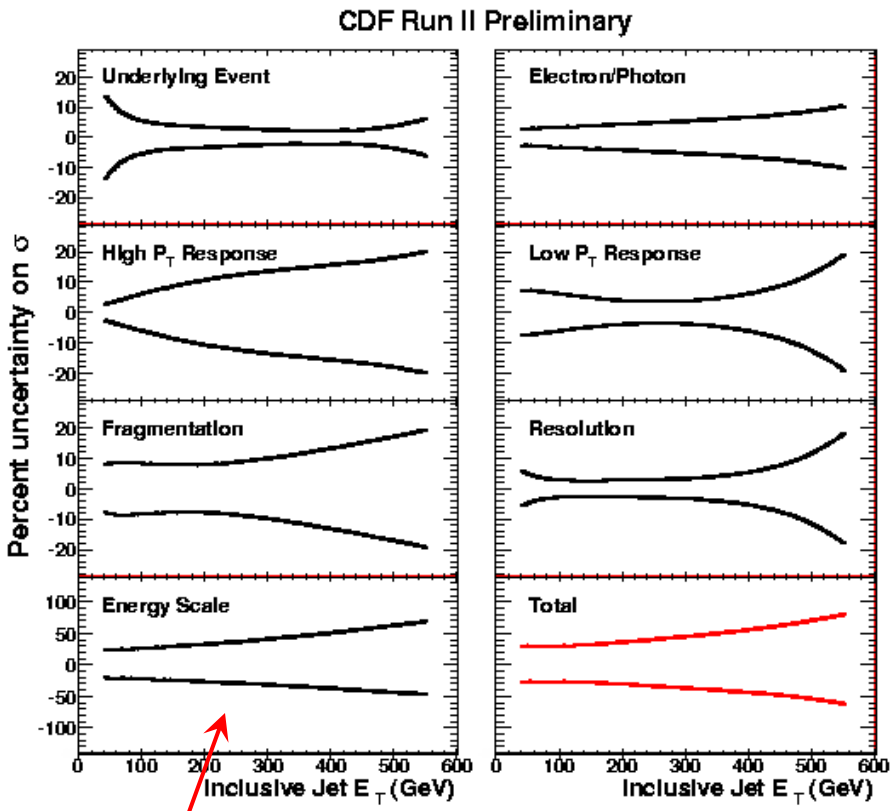
no out of cone corrections

calorimeter scale –
Run I energy scale from γ-jet study

Corrections due to:

calorimeter non-linearity
smearing due to resolution
underlying event /multiple interactions

Luminosity uncertainty 6%



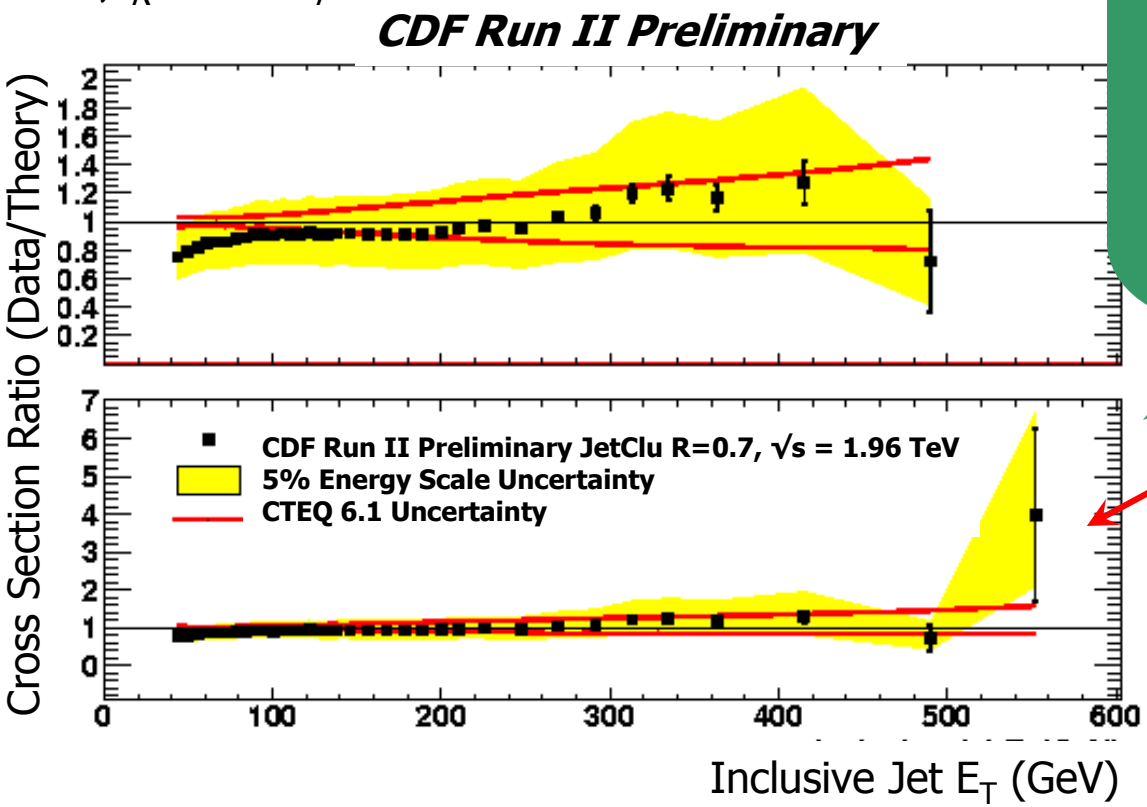
largest uncertainty

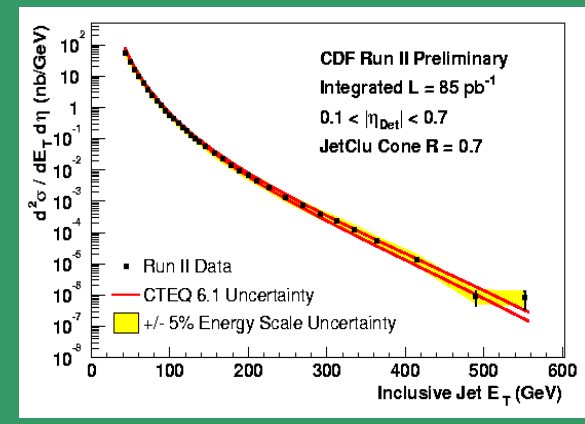
Inclusive Jet Cross Section

Comparison with theory

CTEQ 6.1 PDF set

$\mu_R = 0.5\ E_T$



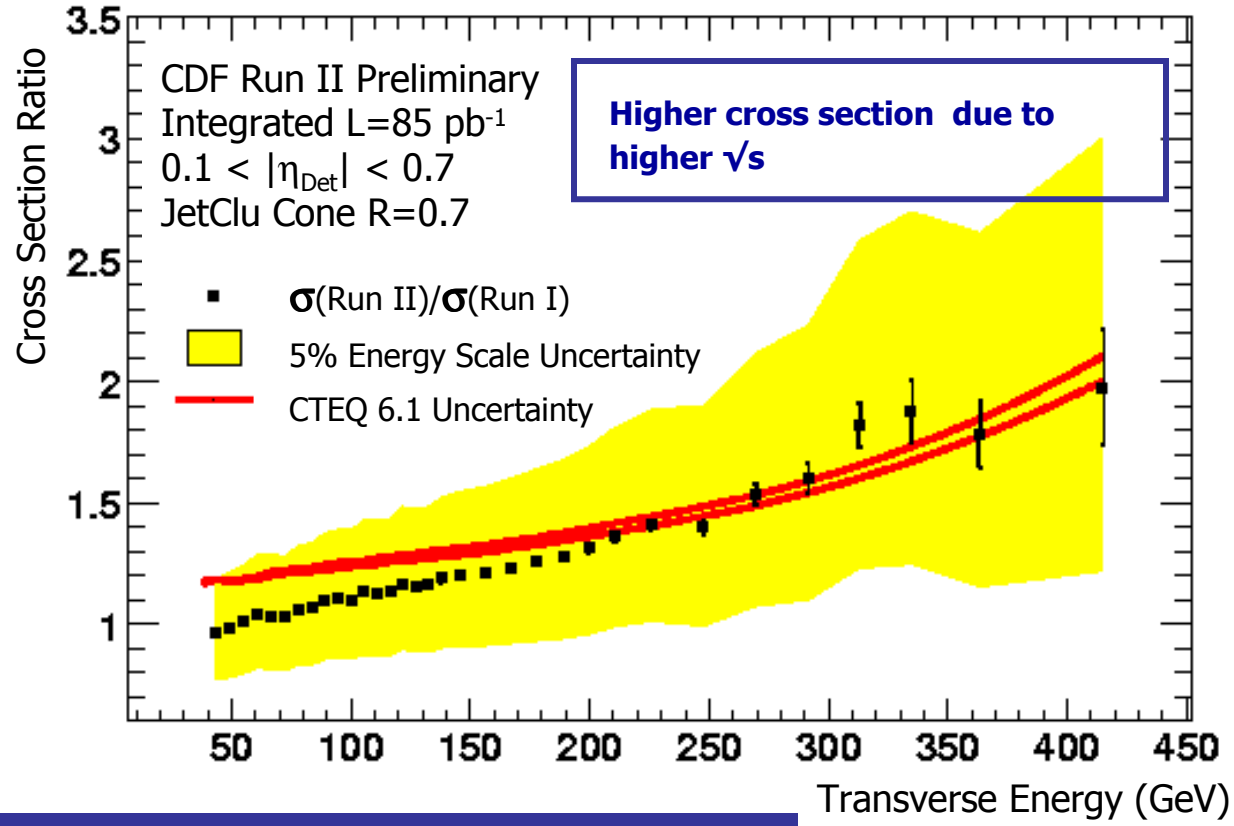


highest E_T jets

Reasonable agreement with theory within uncertainties

Inclusive Jet Cross Section

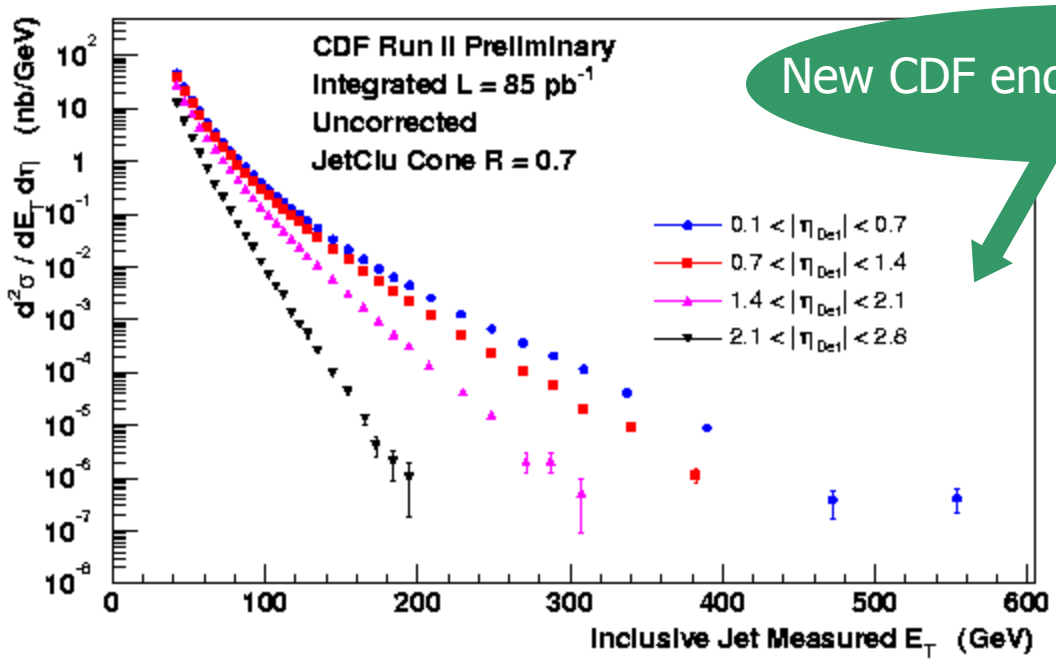
Comparison with Run I



Many systematic uncertainties cancel in ratio:

Dominant uncertainty - Run II jet energy scale ~ 5%

Inclusive Jet Cross Section
for different pseudorapidity η



New CDF endplug calorimeter

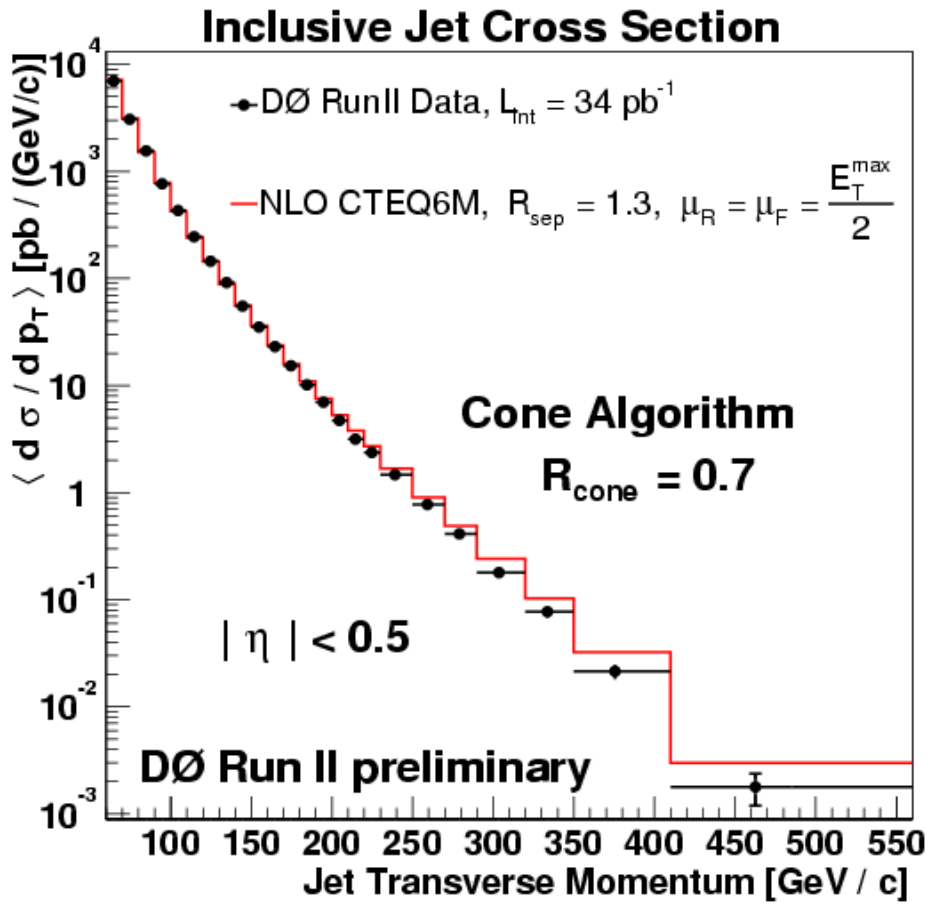
see DØ Run1B results
*Abbott et al., PRD **64**, 032003 (2001)*

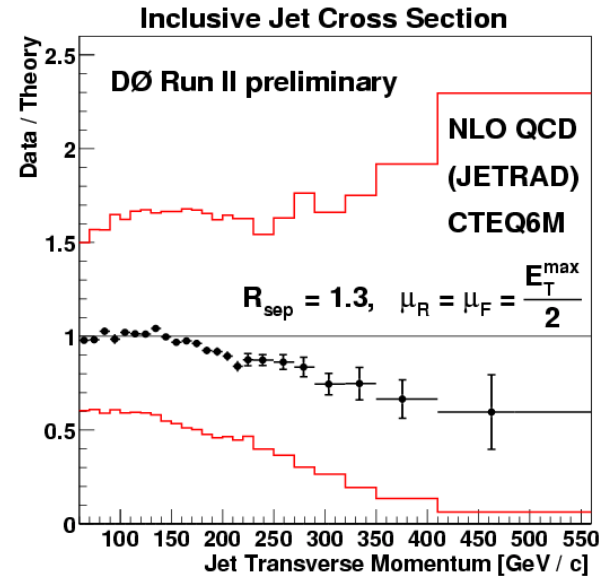
Extends jet cross section measurement to the forward rapidity region

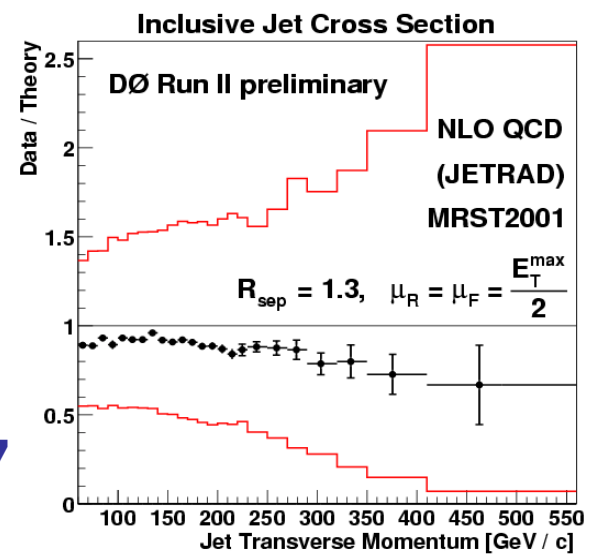
Significance of the results will be determined by the systematic errors

Direct application – global analysis (gluon distributions)

Inclusive Jet Cross Section







Jet reconstruction – cone algorithm with R=0.7

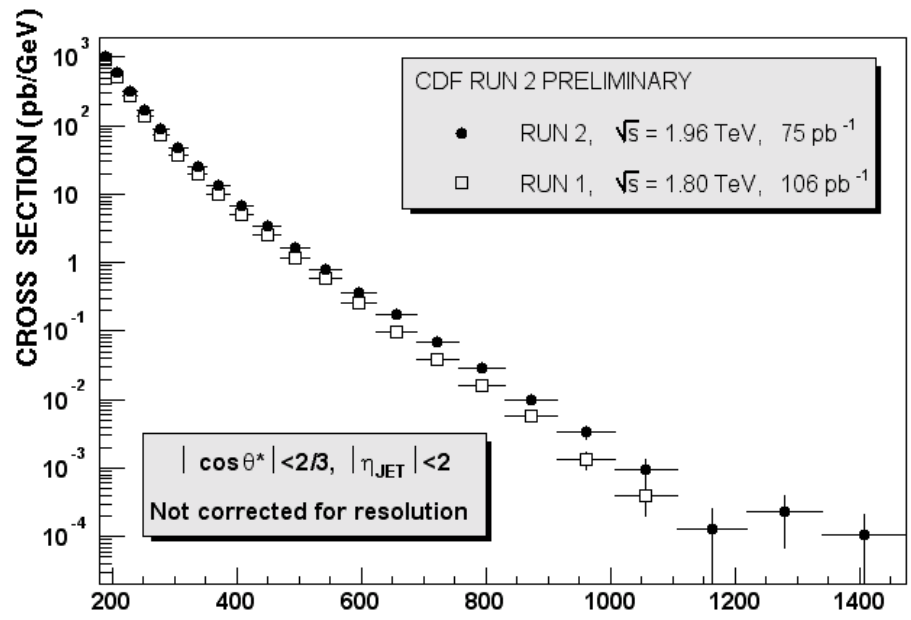
Dijet Mass

$$M = \sqrt{(E_1+E_2)^2-(\vec{P}_1+\vec{P}_2)^2}$$

Used to search for new physics

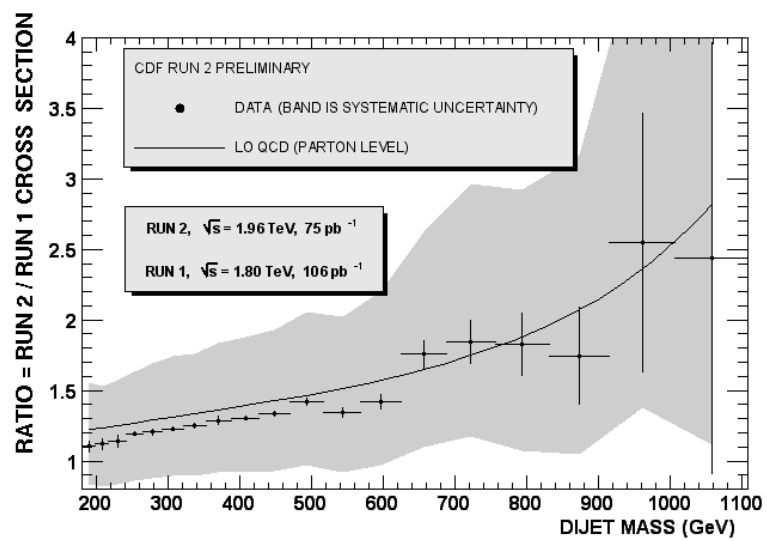
Dijet mass spectrum extends from 180 to 1364 GeV/c^2

75 pb^{-1} of data



same requirements as for Inclusive Jet Cross Section +

Dijet – 2 jets with highest E_T
$|\eta_{jet1}| < 2.0$
$|\eta_{jet2}| < 2.0$
to suppress background - require $|\cos\theta^*|<2/3$

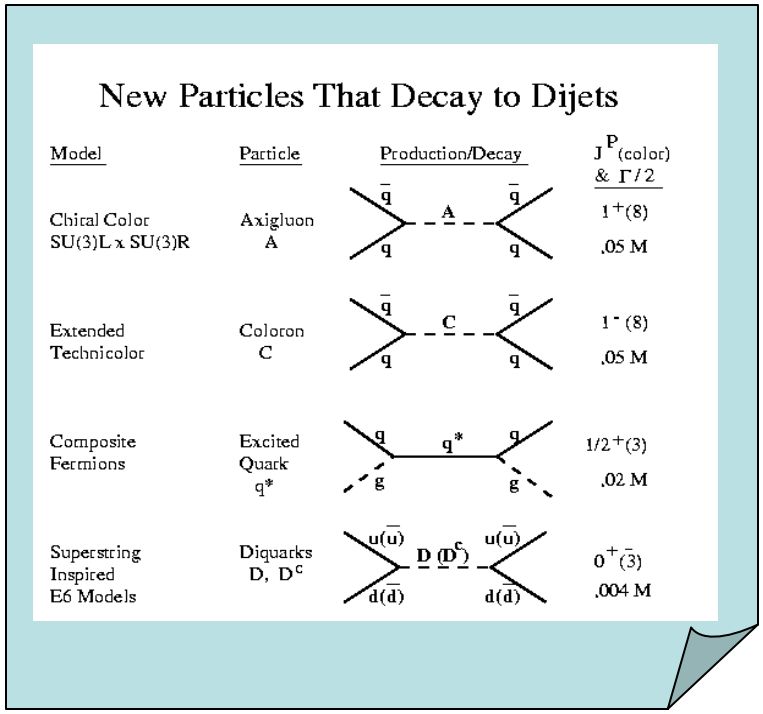


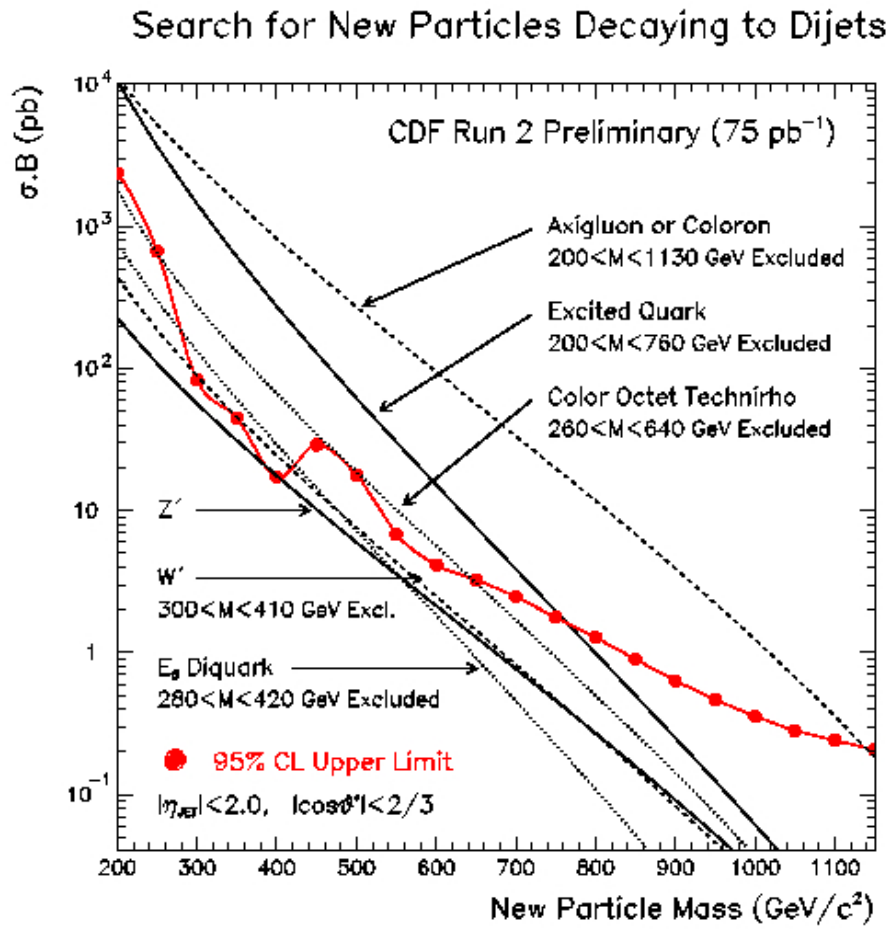
Dijet Mass Spectrum

Search for new physics

looking for resonances

can search for different phenomena with a single measured distribution





DiJet Mass Spectrum

$$\left\langle \frac{d\sigma}{dM_{JJ}} \right\rangle = \frac{N_{evt}}{L} \frac{1}{\varepsilon_{eff}} C_{unsmear} \frac{1}{\Delta M_{JJ}}$$

cut efficiencies

estimated from data

vertex quality: **~78%**

jet quality: **~97%**

cross section

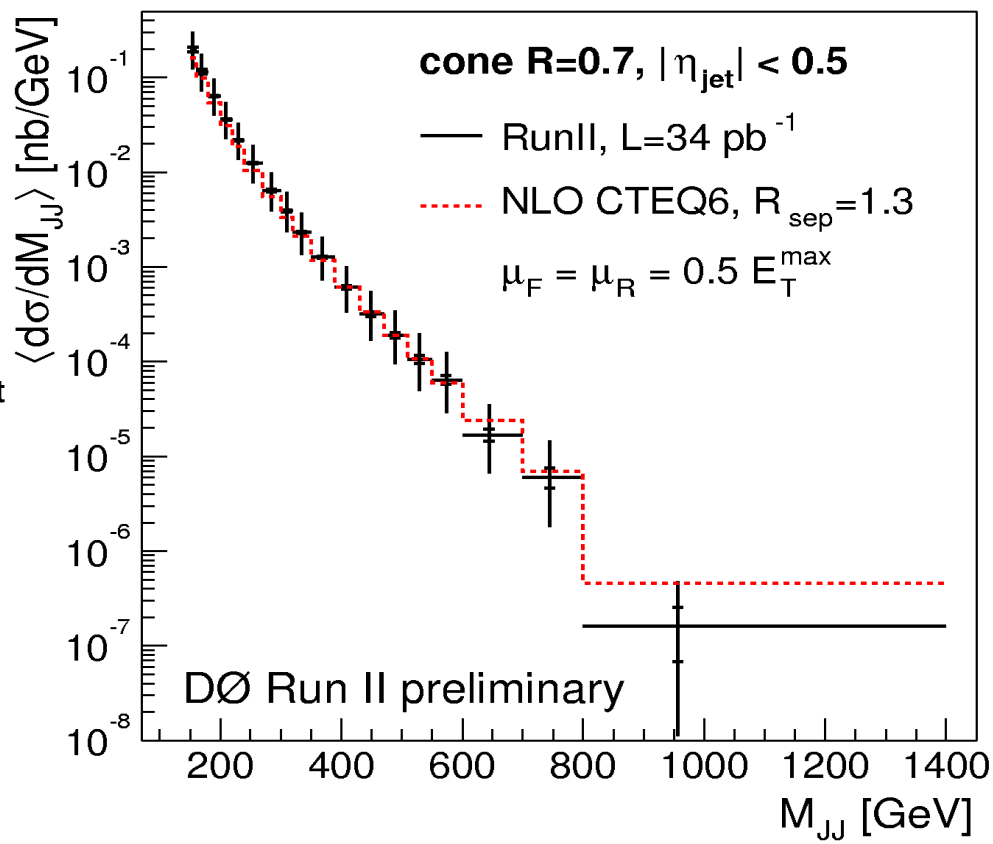
with total error

luminosity error

- **additional 10%**
- **fully correlated bin-to-bin and not shown**

compare to NLO theory

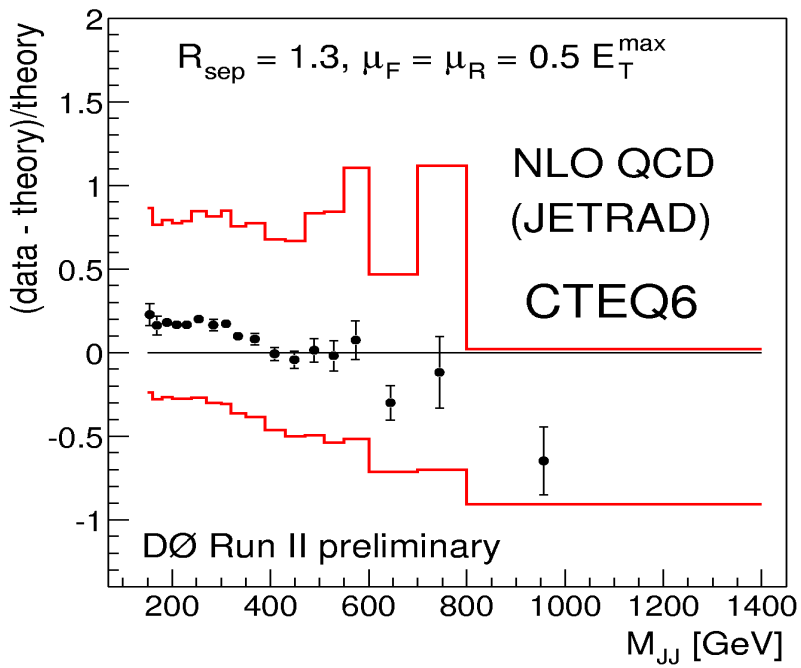
- **CTEQ6 PDF**
- ***R_{sep} = 1.3***

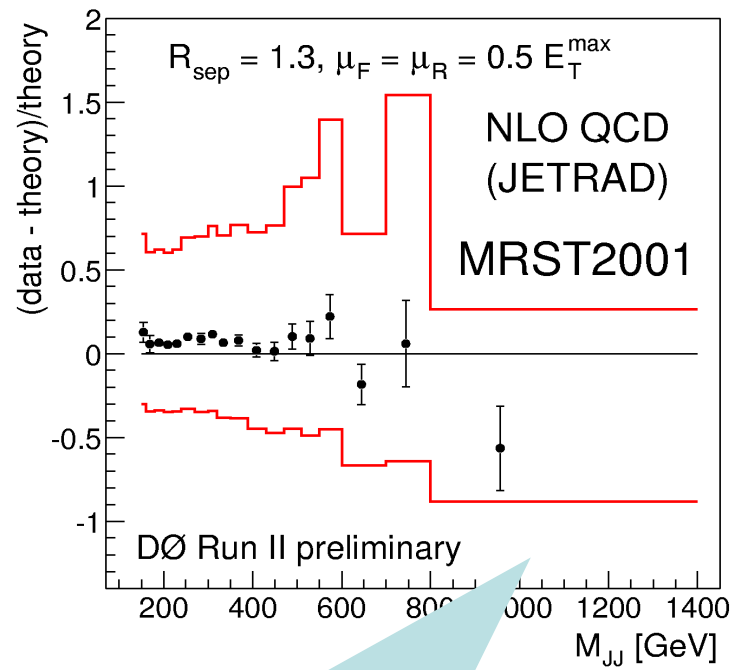


DiJet Mass Spectrum

main uncertainty: jet energy scale, P_T resolution, jet quality
dominated by jet energy scale

150 to 160 GeV:	**+52%**	**- 38%**
800 to 1400 GeV:	**+190%**	**- 73%**

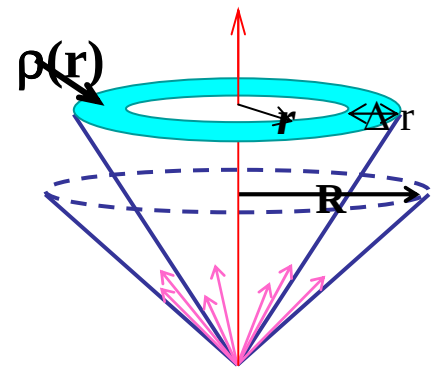




Agrees within uncertainties

10% luminosity uncertainty not included

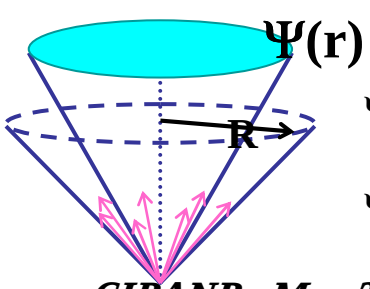
Jet Shapes Studies



$$\rho(r) = \frac{1}{N_{jets}} \frac{1}{\Delta r} \sum_{jets} \frac{E_T(r-\Delta r/2, r+\Delta r/2)}{E_T(0,R)}$$

Method

- Inclusive sample of Dijet events
  ~ 77 pb^{-1} of Run II CDF data
- For jets - cone algorithm *R=0.7*
- Results are *not corrected* to the hadron level
- Measurements are compared to HERWIG/PYTHIA + CDF detector simulation



$$\Psi(r) = \frac{1}{N_{jets}} \sum_{jets} \frac{E_T(0,r)}{E_T^{jets}(0,R)}$$

$$\Psi(r=R) = 1$$

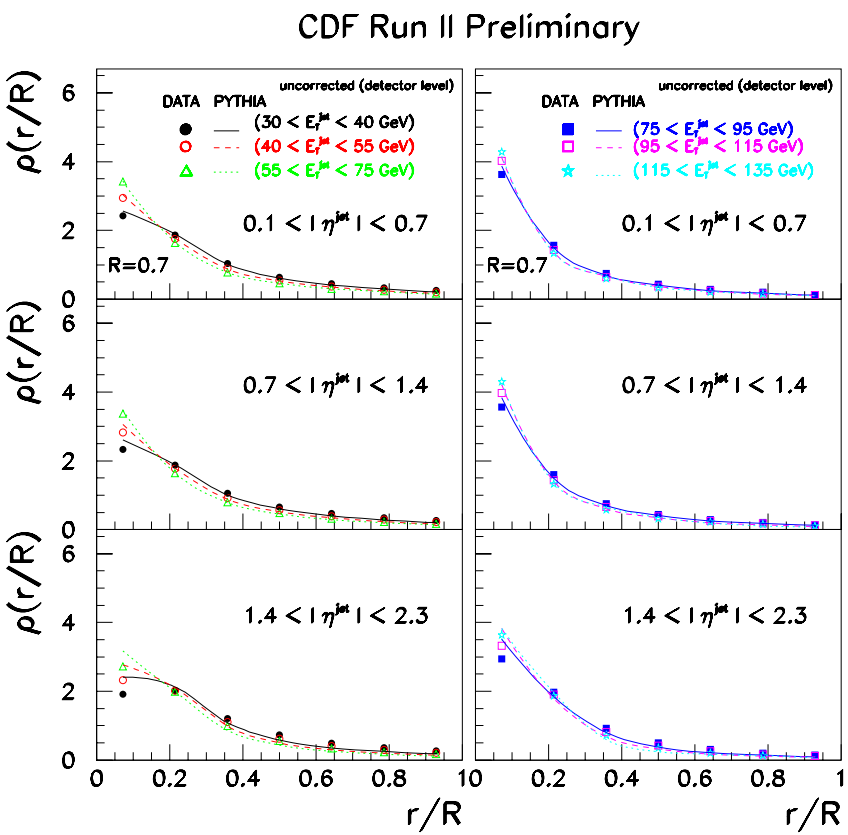
Motivation

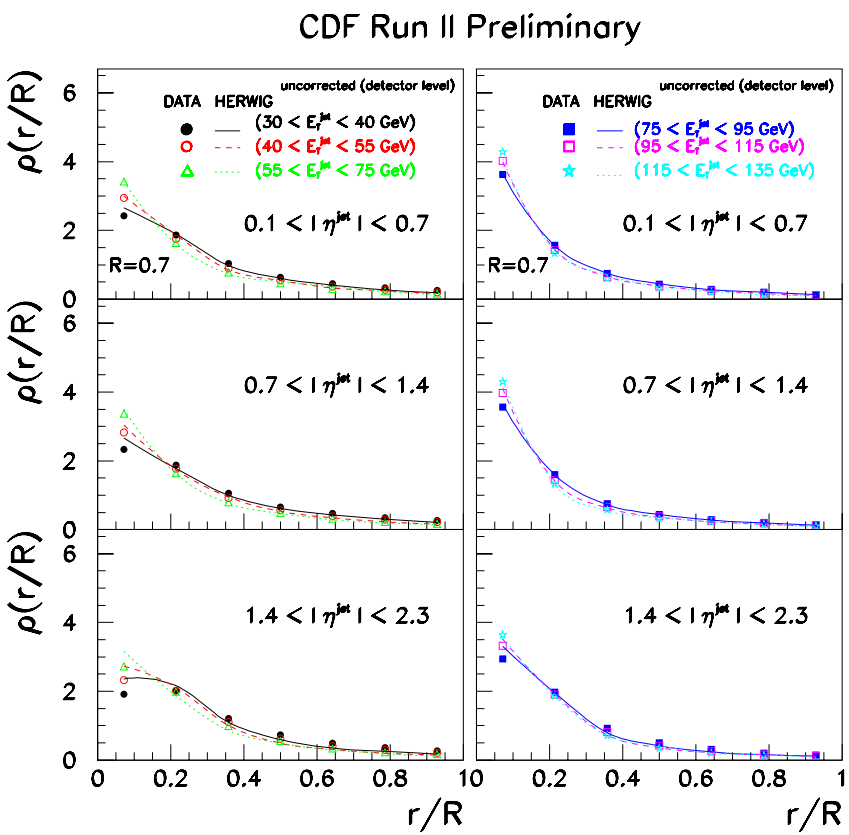
internal structure of jet events

test of parton shower models

comparison with previous CDF result
*Abe et al., PRL **70**, 713 (1993)*

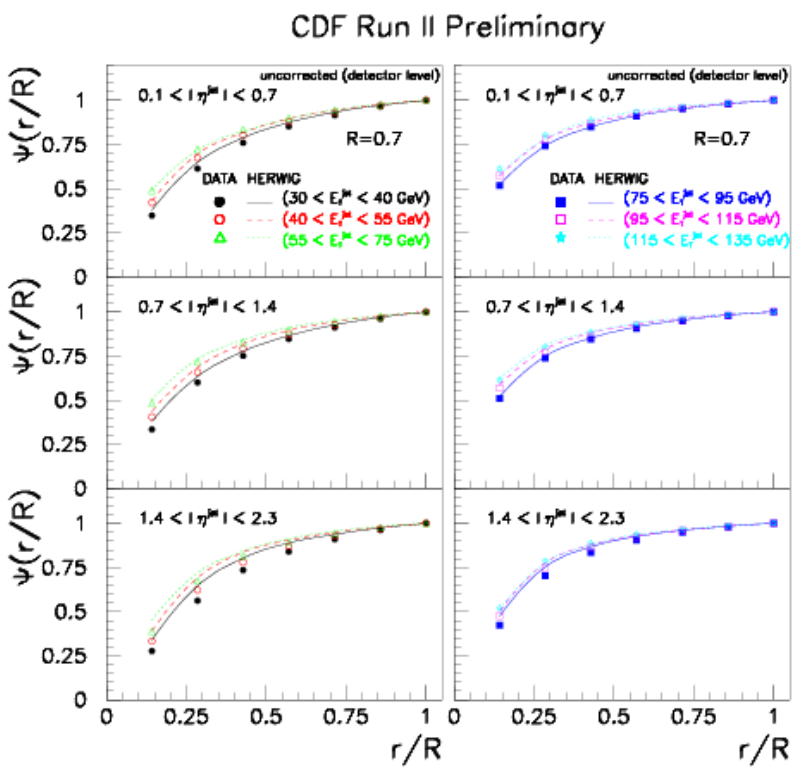
Differential Jet Shapes

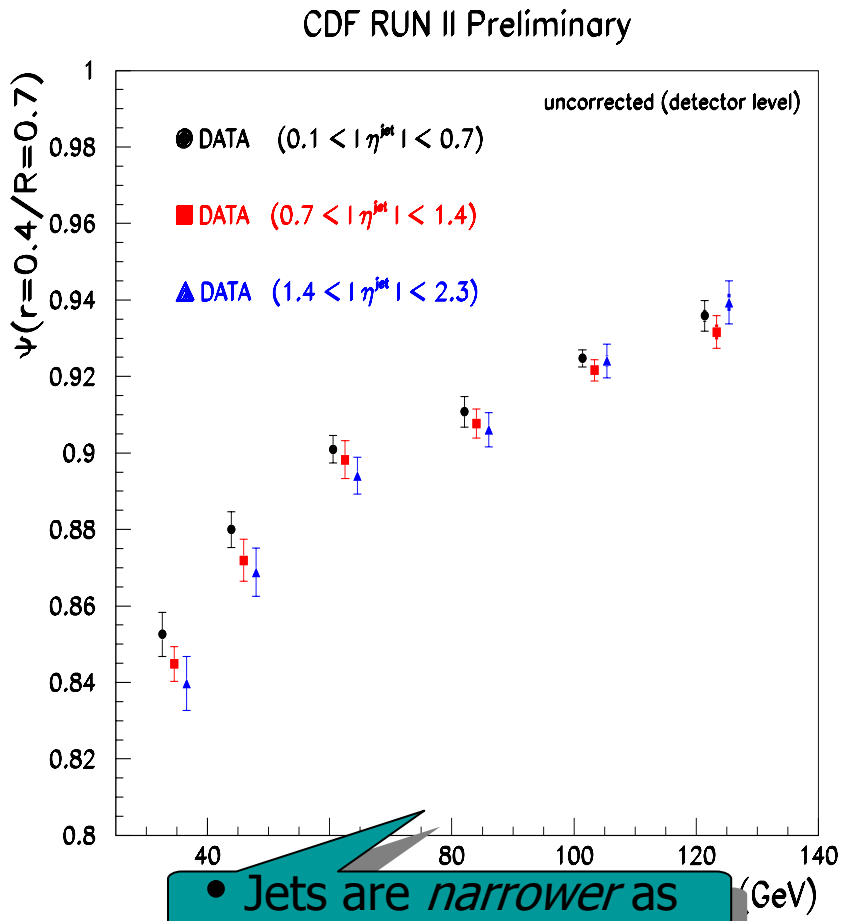




HERWIG predicts jets slightly *narrower* at low E_T and high η

Integrated Jet Shapes





Uncorrected jet shape with calorimeter towers

- Jets are *narrower* as E_T^{jet} increases
  α_s measurement…
- and *broader* at high η

Conclusions

- **Larger kinematic range for jet production**
- **Inclusive jet cross section** extends beyond 550 GeV
  is consistent with NLO QCD predictions
- **Dijet mass spectrum** extends to 1364 GeV
  used for search of new physics:
  upper limits on the cross sections for new particles
- **Studies of internal structure of jet events**
  for E_T from 30-130 GeV
  well modeled by HERWIG/PYTHIA Monte Carlo
- **More interesting results in the future…**