Studies of Jet Production at DØ

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(on behalf of DØ Collaboration)

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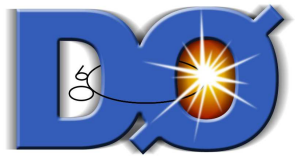


Outlook

Introduction

- Motivation for Jet Physics
- Tevatron
- DØ

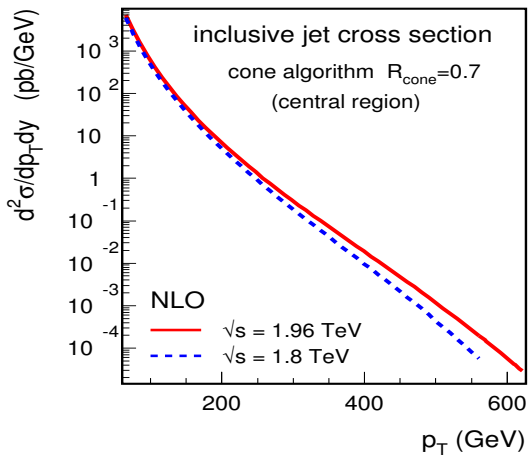
Jet Results at DØ

- Jets
- Inclusive Jet p_{T} Cross-section
- Dijet Cross-section
- Dijet Azimuthal Decorrelations

Summary

Motivation

- Tevatron upgrade extends the reach of jet p_{T}. (Increase in cross-section of 300% for $p_{\mathrm{T}} = 500$GeV jet)



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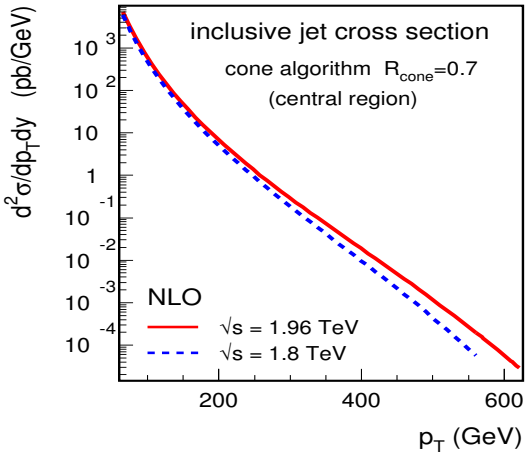
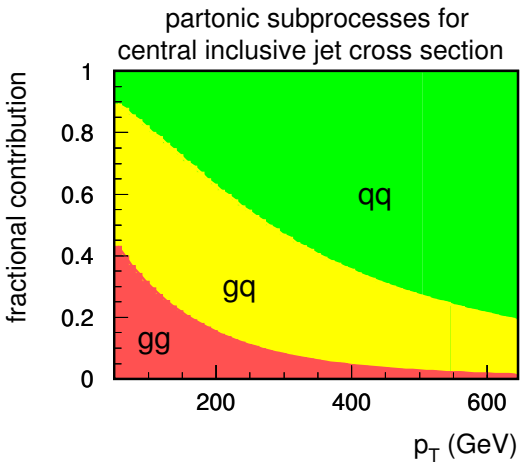
- Inclusive jet cross-section is directly sensitive to strong coupling constant α_S, PDF and pQCD matrix elements
- Sensitivity to gluon PDF





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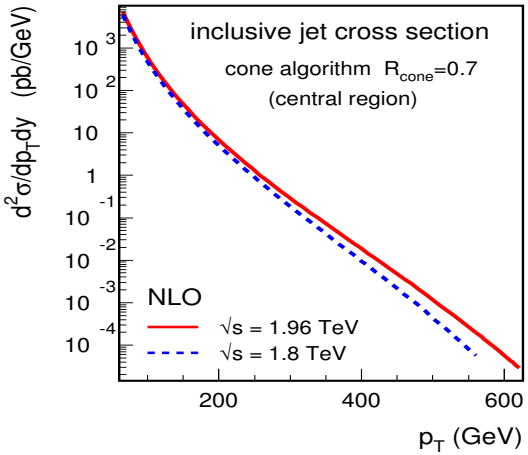

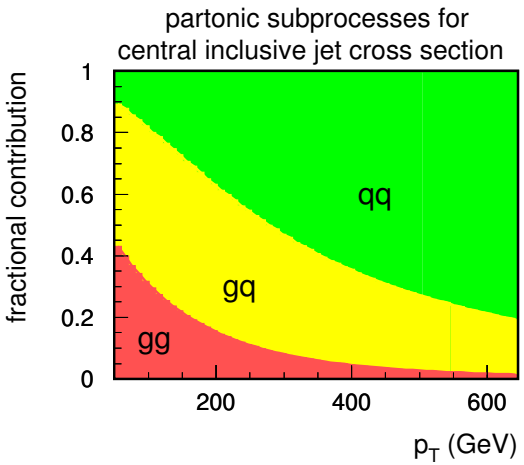

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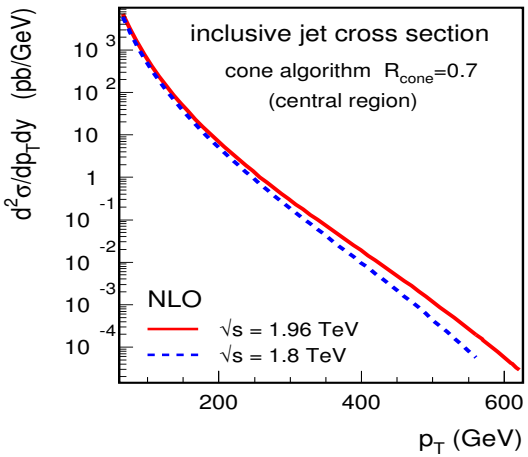
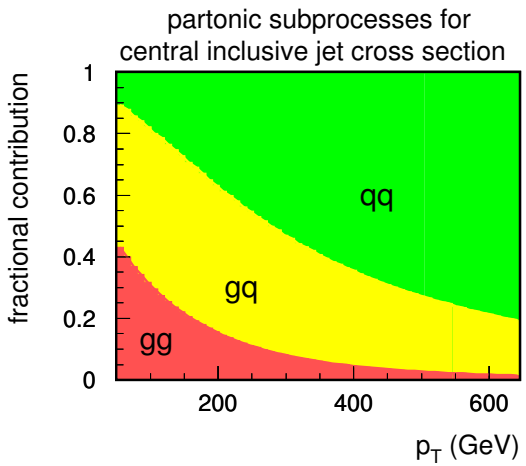
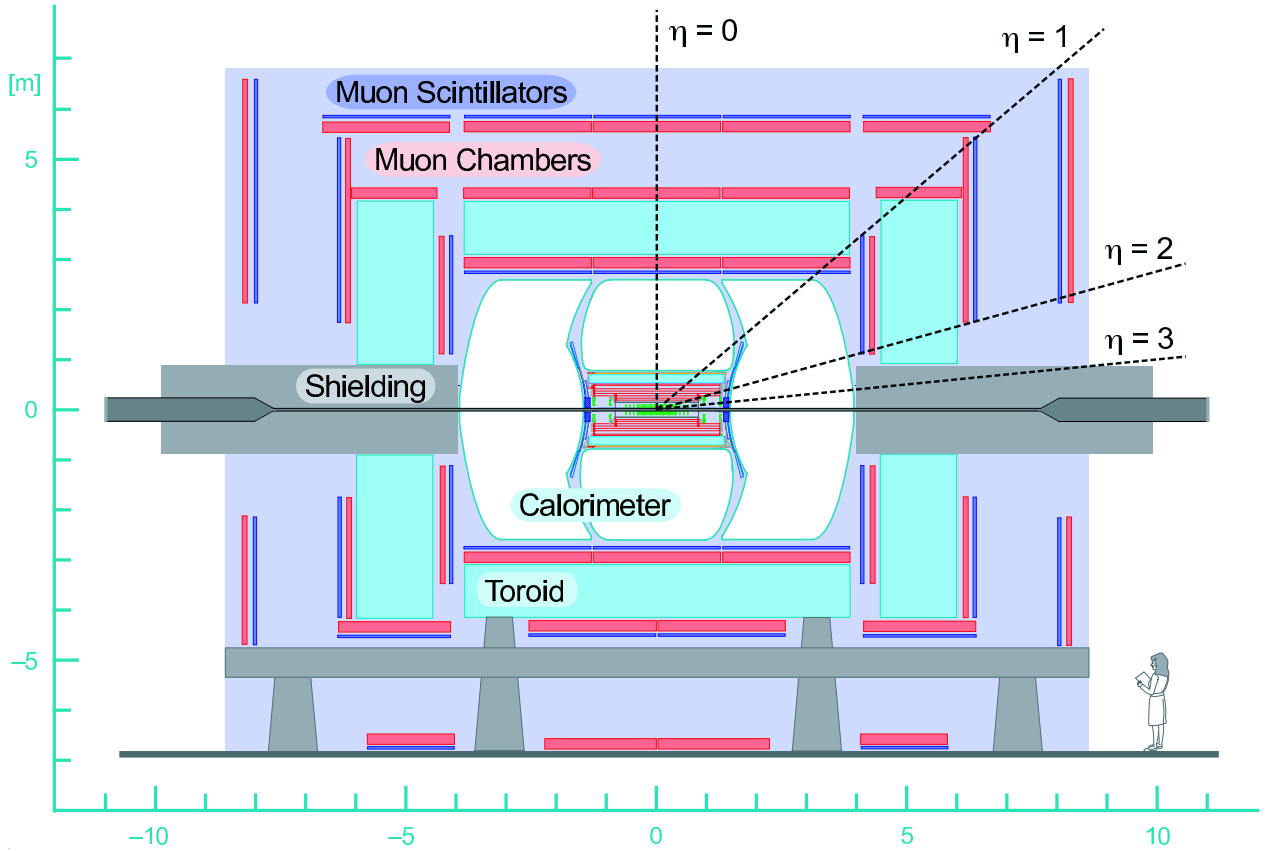
- Place to search for new physics





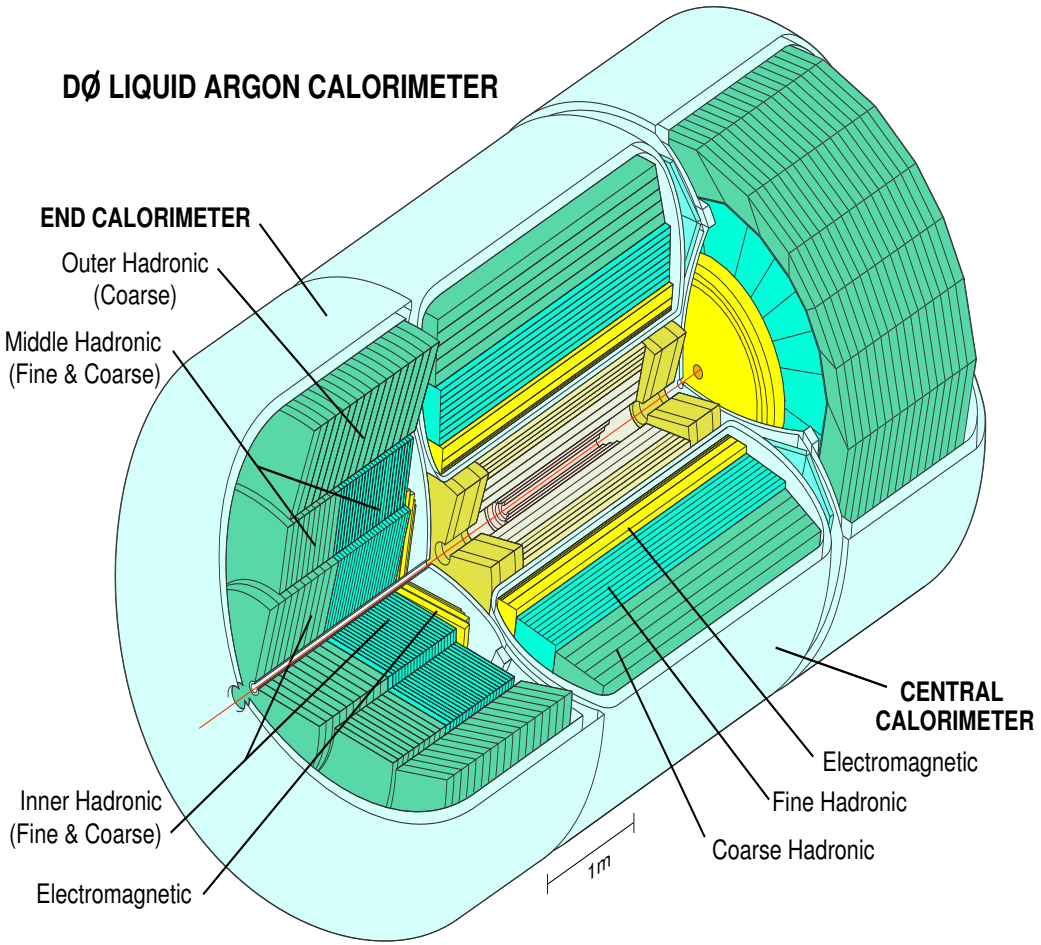
Tevatron and DØ Detector

- $\sqrt{s} = 1.96\text{TeV}$
- Luminosities
  $> 10^{32}\text{cm}^{-2} \cdot \text{s}^{-1}$



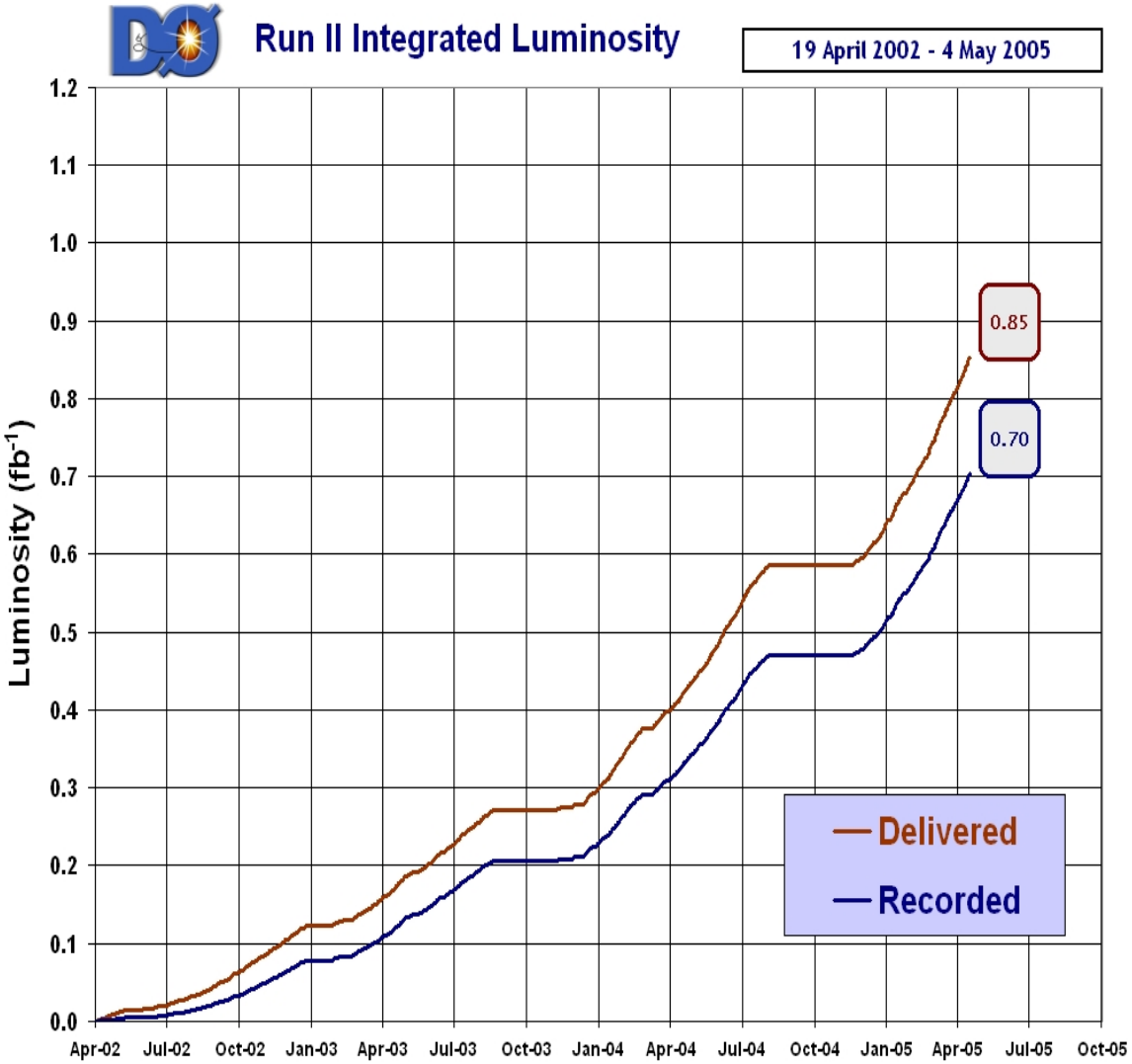
- Upgraded for Run II
  (396 ns bunch spacing)
- New tracking system in 2T magnetic field

DØ Calorimeter



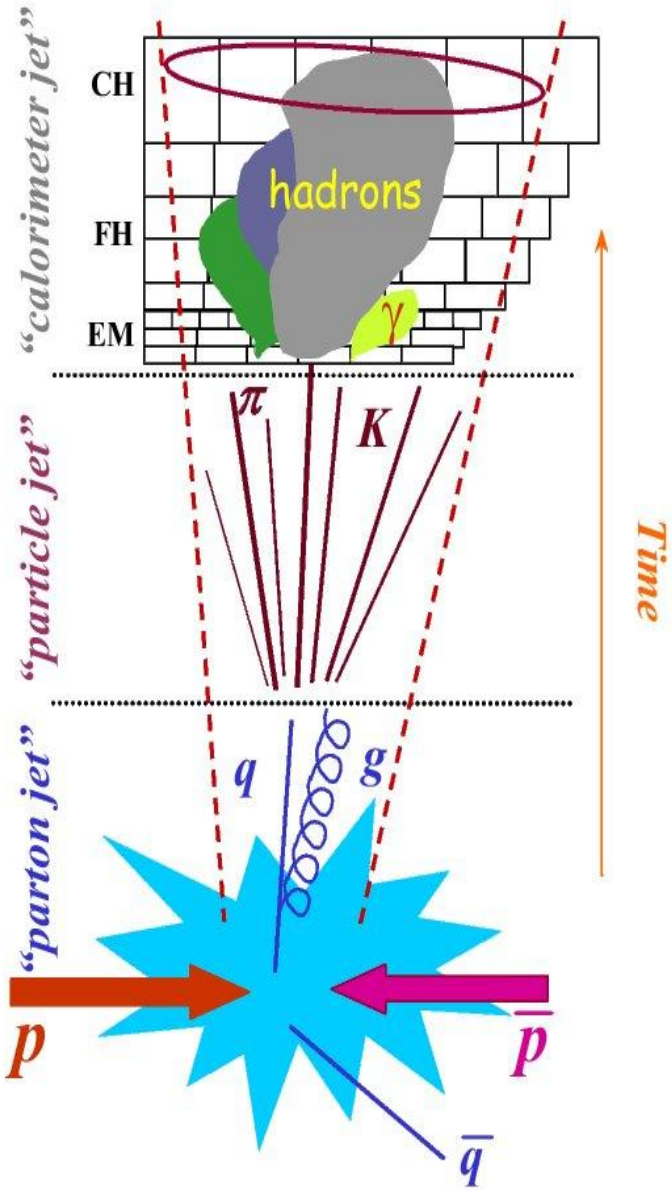
- Uranium-Liquid Argon Calorimeter
- Uniform hermetic coverage
  $| \eta | \leq 4.2$
  $[\eta \equiv -\ln \tan(\theta/2)]$
- Fine segmentation
  (up to $| \eta | < 3.2$)
  $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$

Luminosity



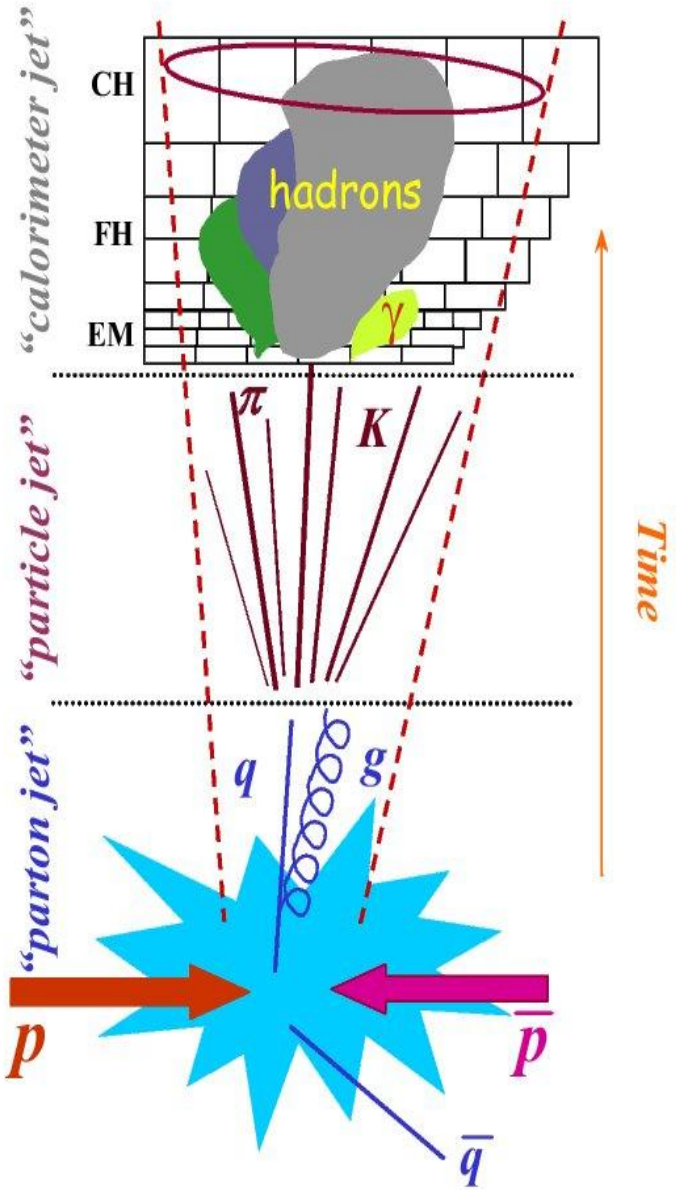
- Presented data collected between 2002 and 2004
- Data taking efficiency is regularly 85-90%
- Atacking 1fb^{-1} in 2005

Jets



- Parton jet
  - hard scattering
  - additional showers

Jets



- Particle jet
  - after hadronization and fragmentation
  - effect of hadronization is soft $\Rightarrow$ allows comparison between particle and parton jets
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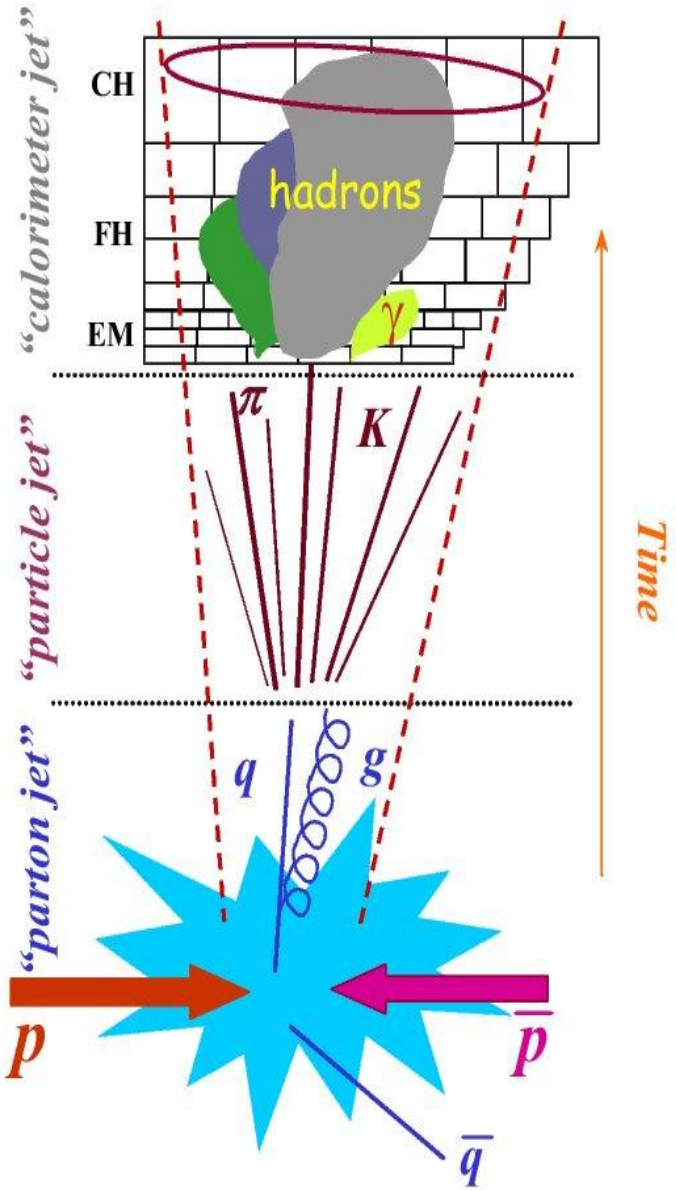

- Calorimeter jet
  - interaction of hadrons with calorimeter
  - collection of calorimeter cell energies
- Particle jet
  - after hadronization and fragmentation
  - effect of hadronization is soft $\Rightarrow$ allows comparison between particle and parton jets
- Parton jet
  - hard scattering
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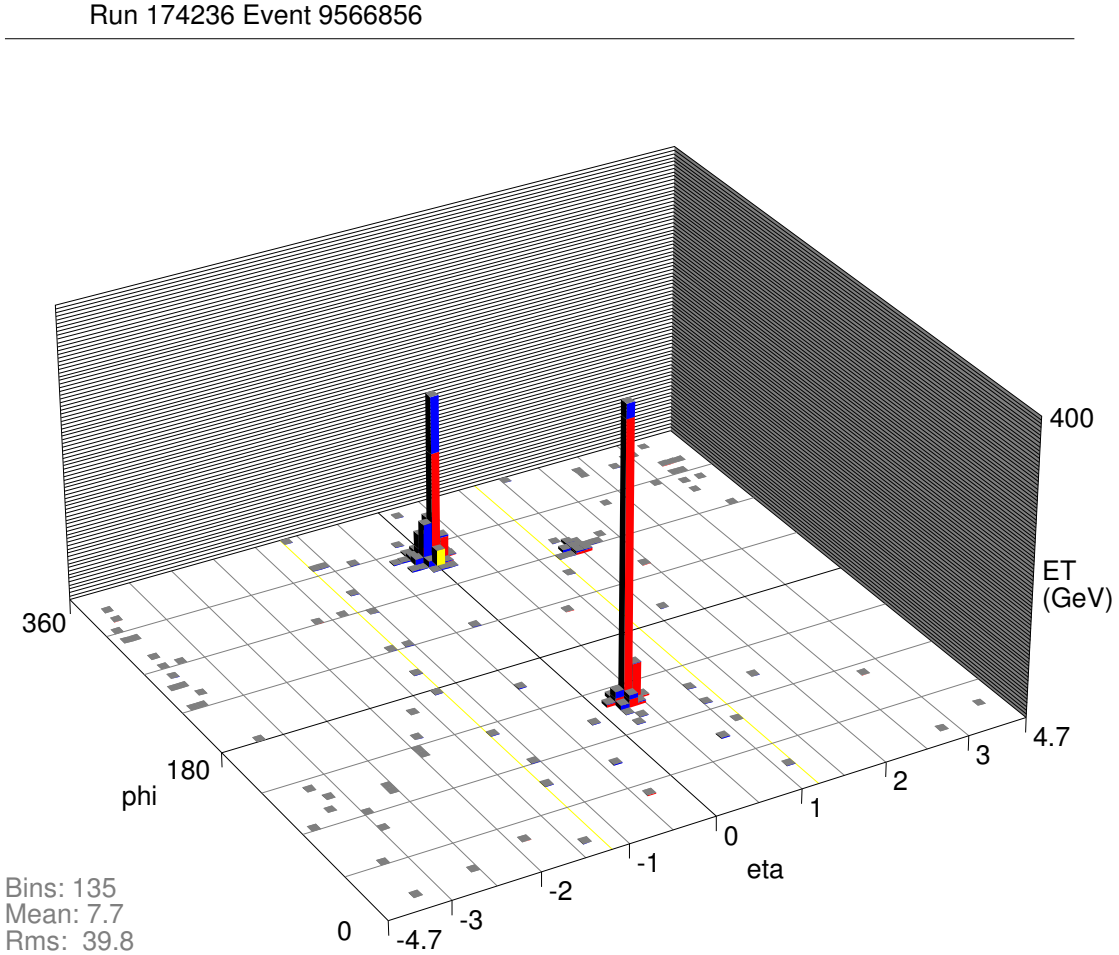
Run II Cone Jet Algorithm

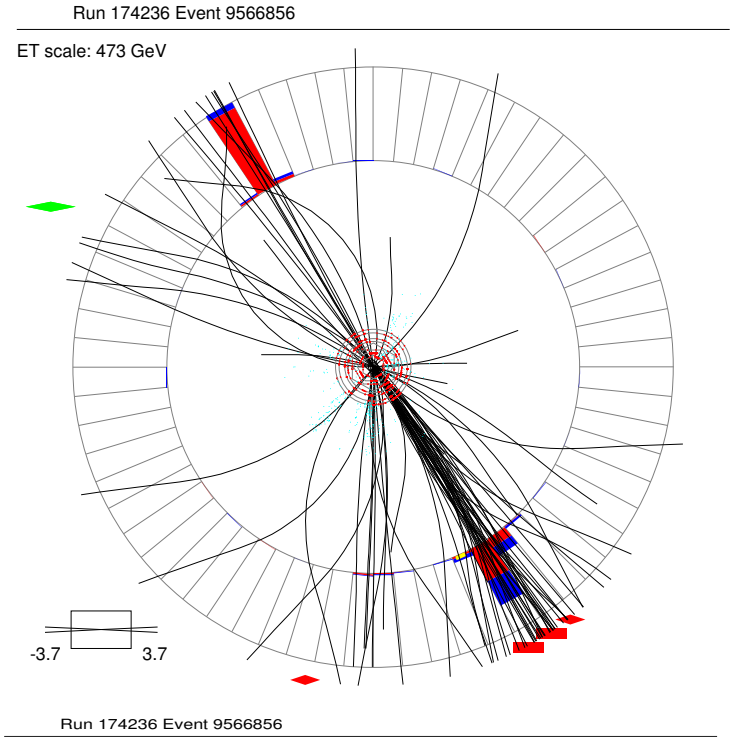
- Uses particles as **seeds**
  - experiment - calorimeter clusters (above given threshold)
  - MC - stable particles
  - pQCD - partons
- Uses 4-vector scheme
  - p_{T} instead of E_{T}
  - rapidity $y = \frac{1}{2} \ln \frac{E+p_z}{E-p_z}$ instead of pseudorapidity η
- Combines 4-vectors within a cone of radius $R_{\mathsf{cone}} = 0.7$ in $y \times \phi$

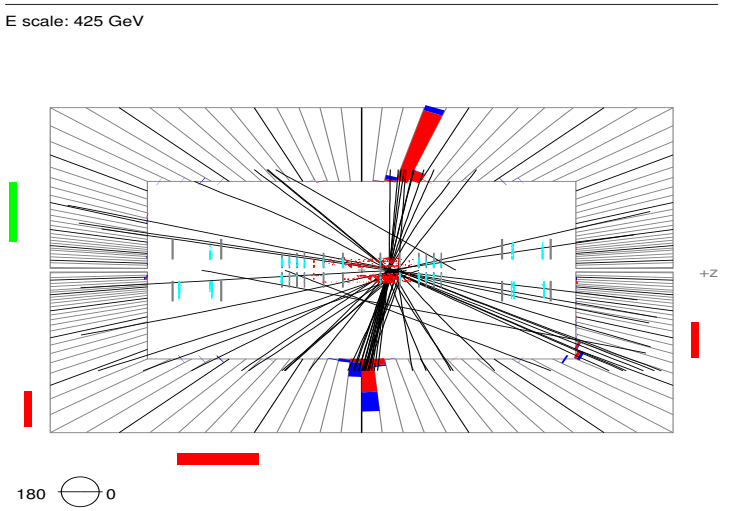
$$\Delta R = \sqrt{\Delta^2 y + \Delta^2 \phi} < R_{\mathsf{cone}}$$

- Calculates jet axis - iterates until the solution is stable
- Adds midpoints between jets as additional seeds $\Rightarrow$ infrared safe
- Removes identical solutions, and treats overlapped jets

Highest p_T Event







mE_t: 20.8
phi_t: 295 deg

Jet Energy Calibration

- Measured energy is corrected to particle level

$$E_{\text{corr}} = \frac{E_{\text{uncorr}} - O}{R \cdot S}$$

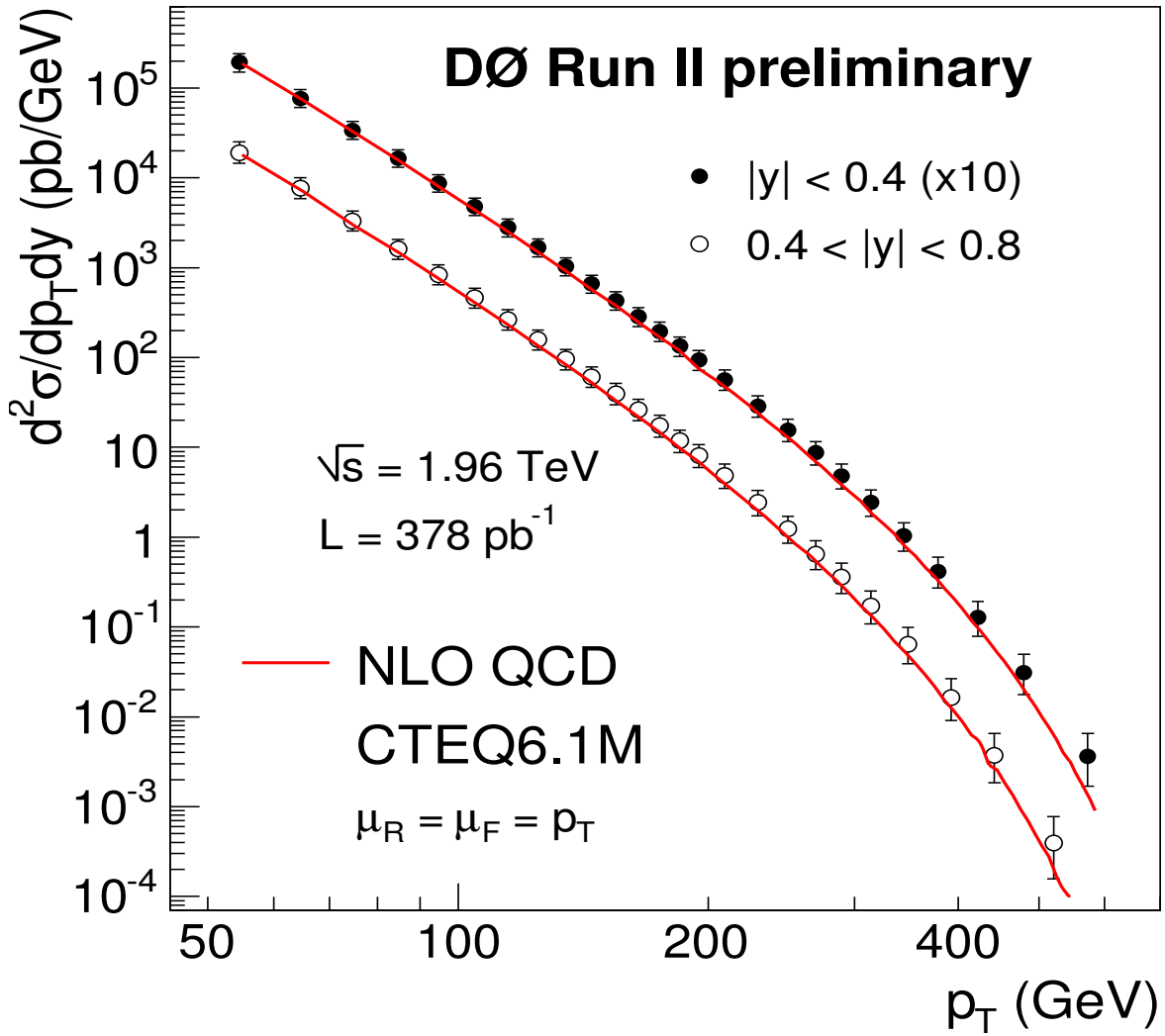
  - Offset (O) is the energy due to previous events, multiple interactions, noise, etc.
  - Response (R) is the calorimeter response to jets (measured in $\gamma +$ jet events)
  - Showering (S) is the correction for fraction of energy outside the jet cone after showering in the calorimeter

- Dominant uncertainty of the measurement

Inclusive Jet Cross-section

- Events selected by inclusive jet triggers in central regions $|\,y\,| < 0.4$ and $0.4 < |\,y\,| < 0.8$
- $L = 378\text{pb}^{-1}$
- Predictions of next-to-leading order (NLO) pQCD are computed using NLOJET++
- CTEQ 6.1M PDFs
- $\mu_\text{r} = \mu_\text{f} = p_\text{T}$

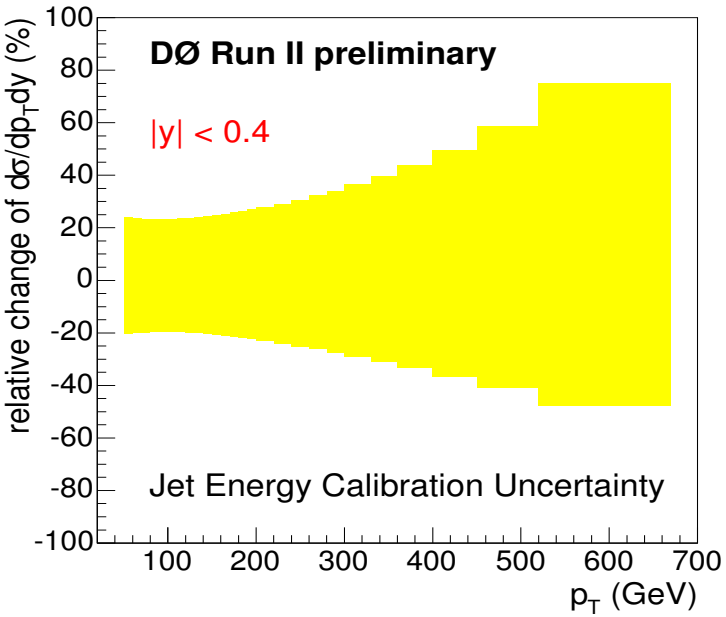
Inclusive Jet Cross-section 2

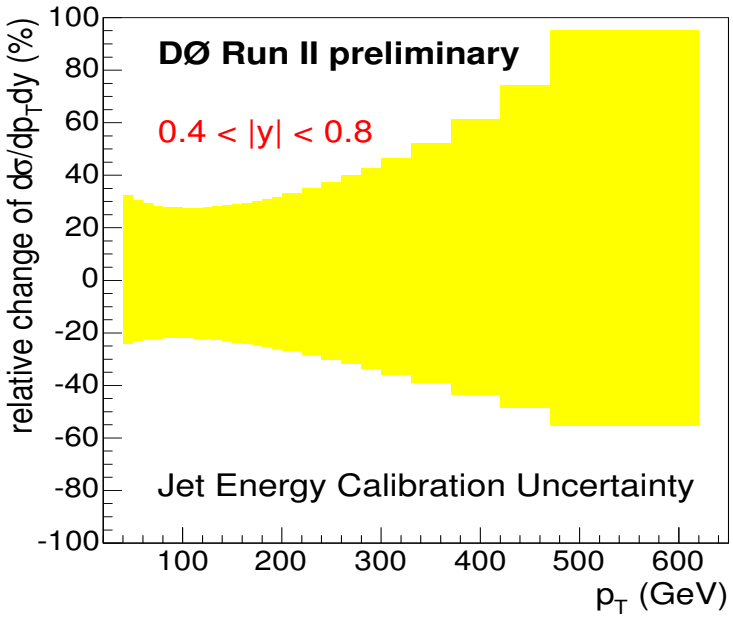


- Two rapidity ranges ($| y |< 0.4$ cross-section is scaled)
- Cross-section in $0.4 <| y |< 0.8$ falls slightly more steeply

Experimental Uncertainties

- Largest uncertainty coming from Jet Energy Calibration
- Reconstruction inefficiencies (trigger, vertex, etc.)





Non-perturbative effect

- Effects of hadronization and underlying event

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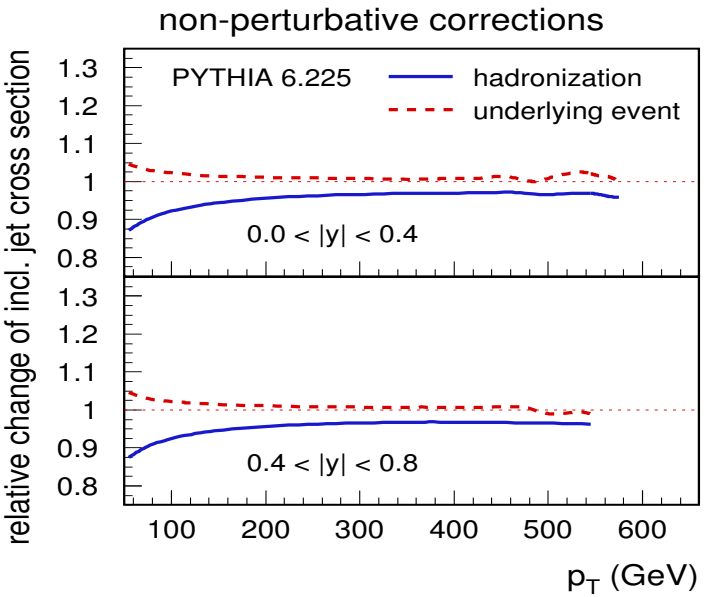
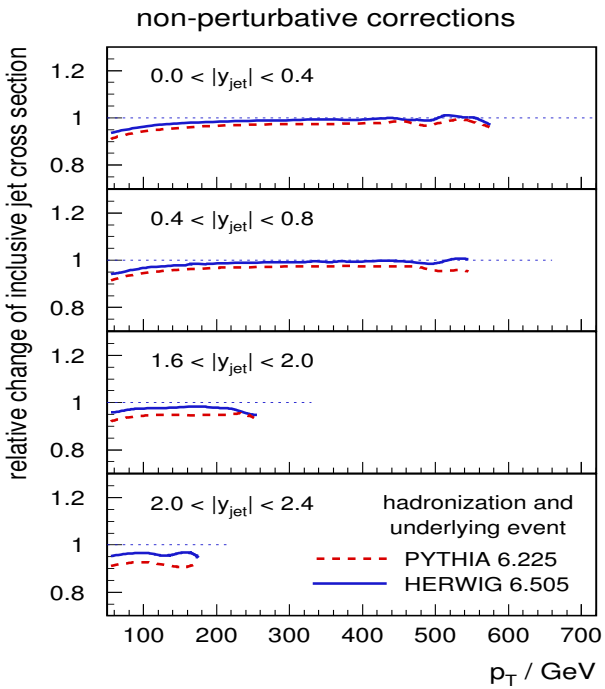
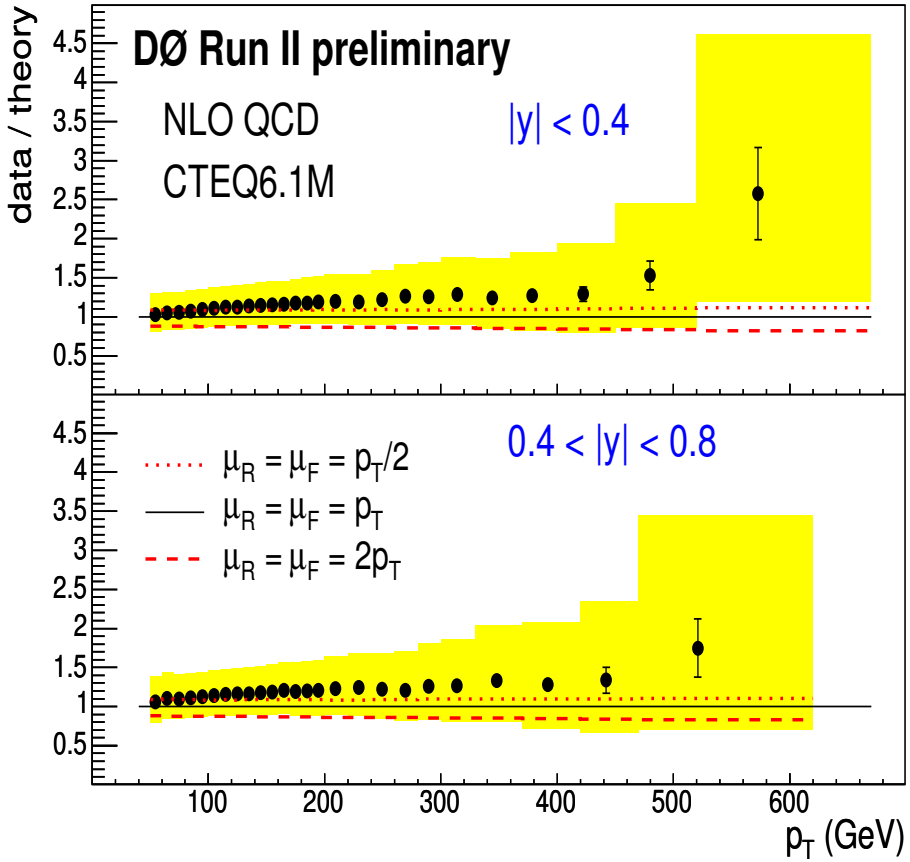
- Effects of hadronization and underlying event
  - were studied in MC
  - consistent results were found in PYTHIA and HERWIG
- Effects of hadronization and underlying event have opposite directions and are both below 5% for $p_T > 150$GeV

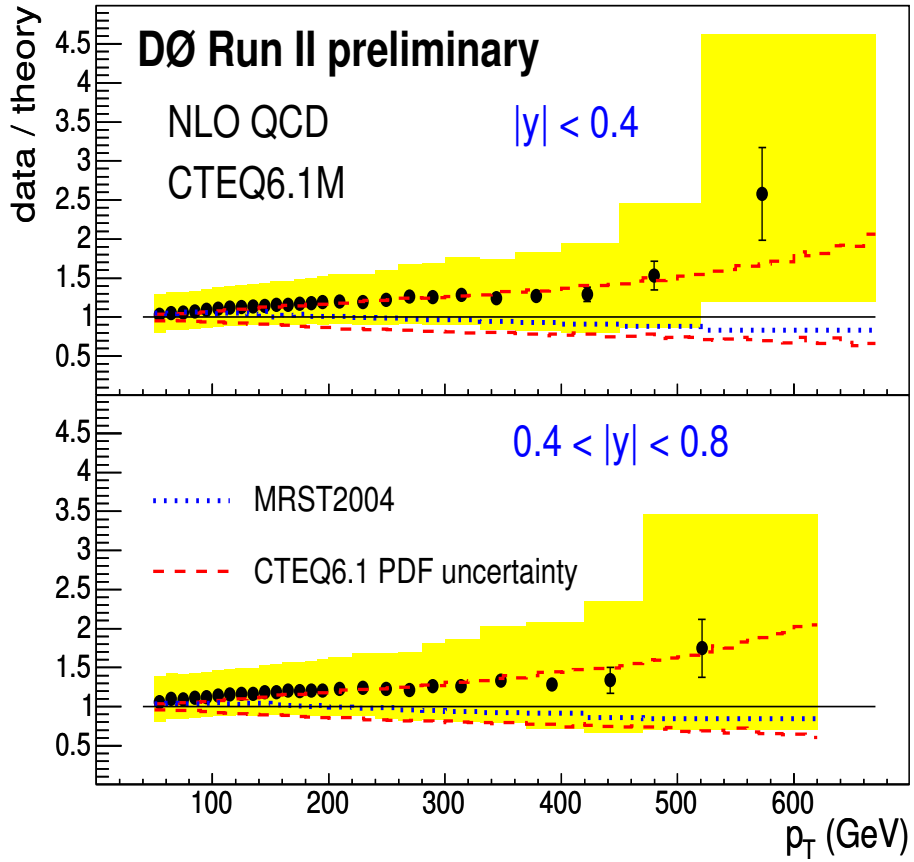




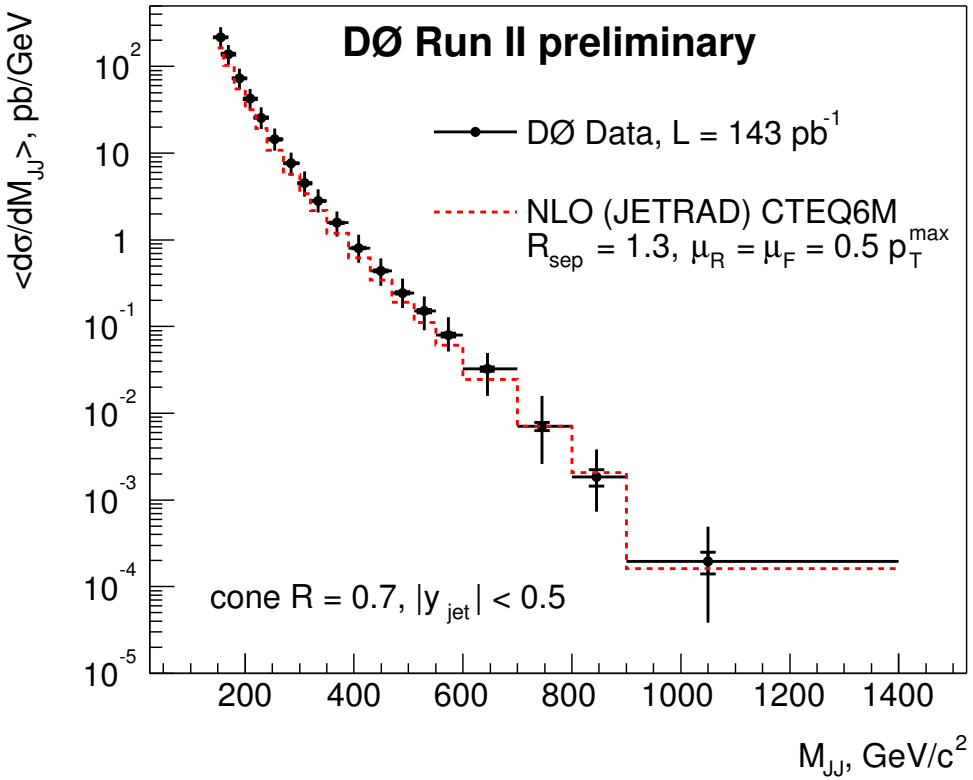
Data-Theory Comparison

- Scale dependence of NLO (dotted and dashed lines) (left)
- Theoretical uncertainty coming from PDFs (right)
- Total experimental uncertainty in yellow

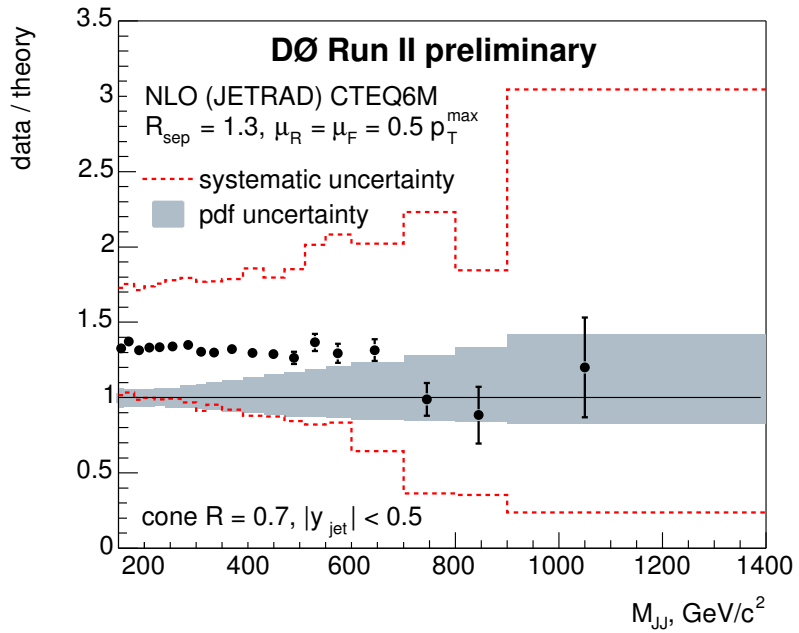




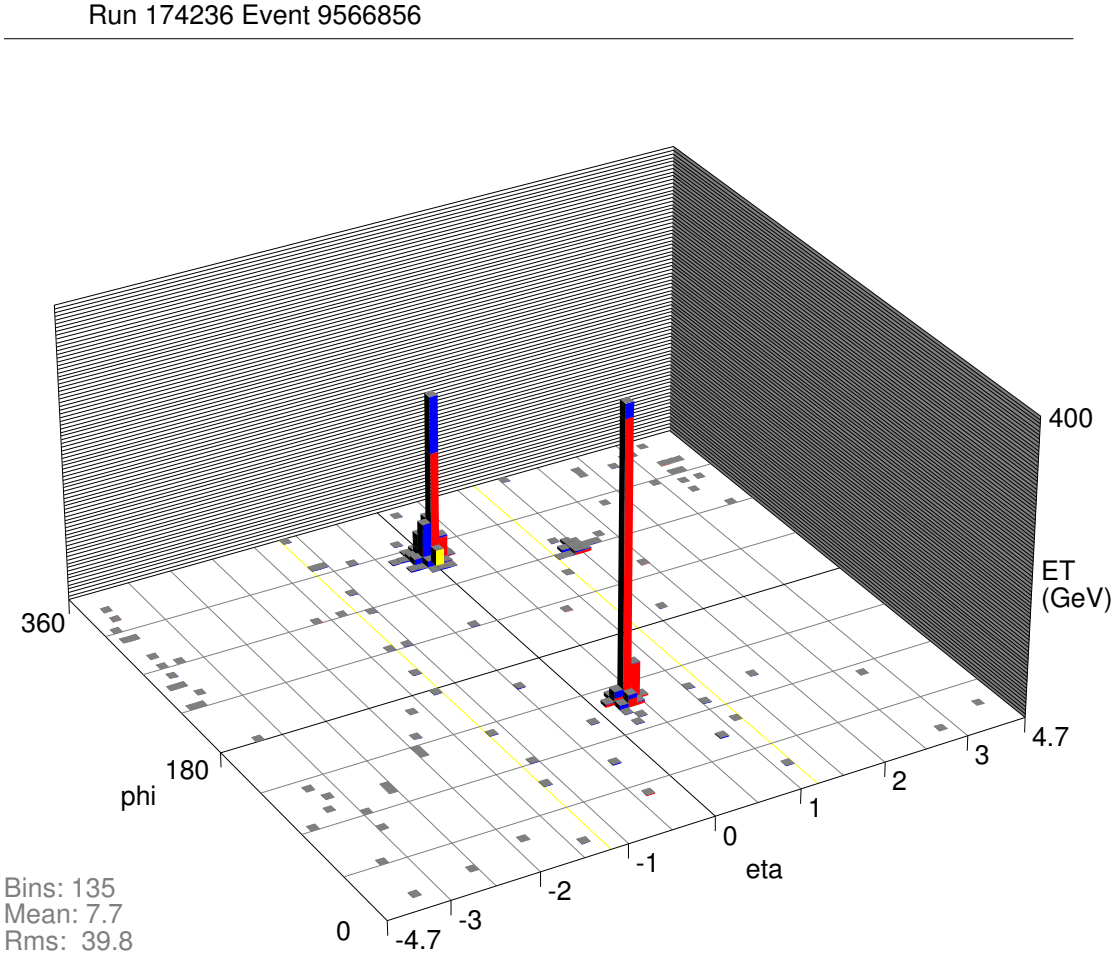
Dijet Cross-section Measurement



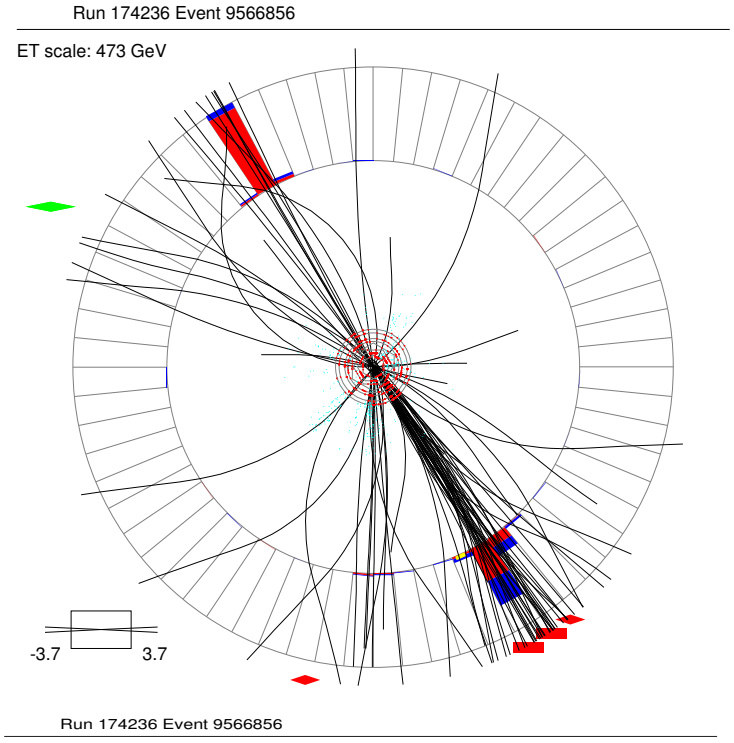
- Dijet cross-section presented as a function of dijet invariant mass
- Smaller statistics $L = 143\text{pb}^{-1}$

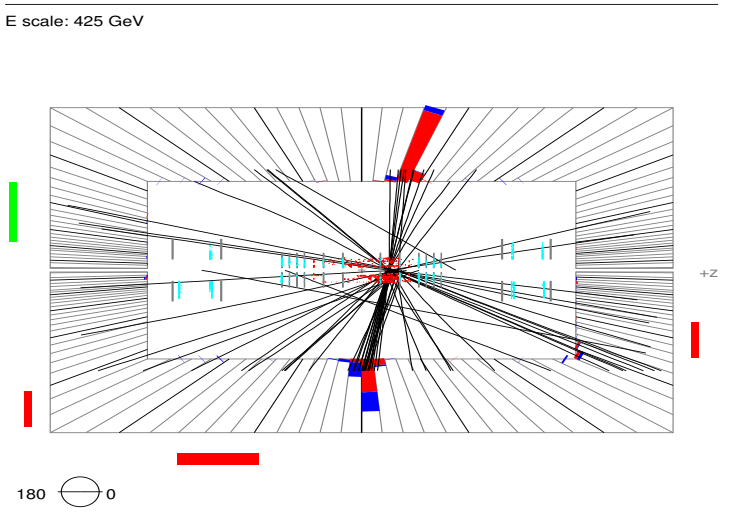


Highest p_T Event



Bins: 135
Mean: 7.7
Rms: 39.8
Min: 0.0204
Max: 398



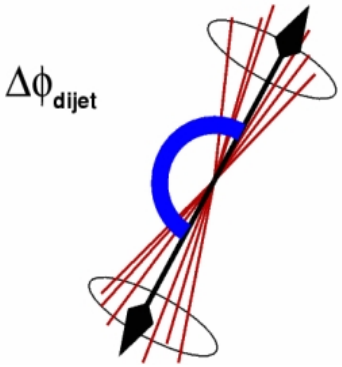


	1st jet	2nd jet
p_T	631 GeV	560 GeV
y_{jet}	0.14	-0.17
ϕ_{jet}	2.10	5.27
$M_{jj} = 1208$GeV		

mE_t: 20.8
phi_t: 295 deg

Dijet Azimuthal Decorrelations

- Dijet production in lowest order pQCD
  - jets have equal p_T and $\Delta\phi_{\text{dijet}} = \pi$



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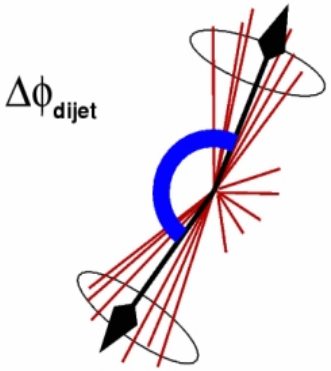

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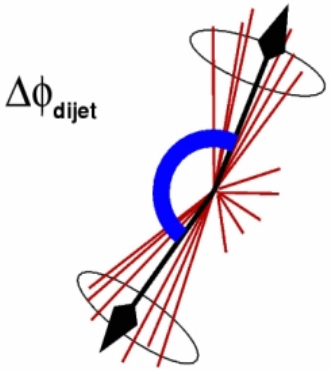

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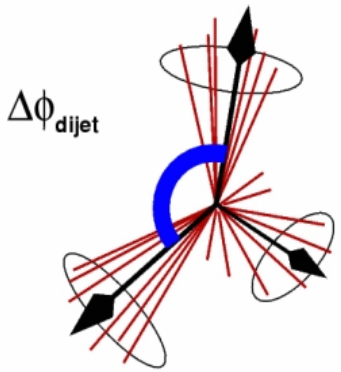

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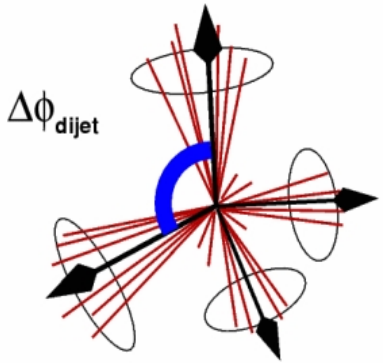

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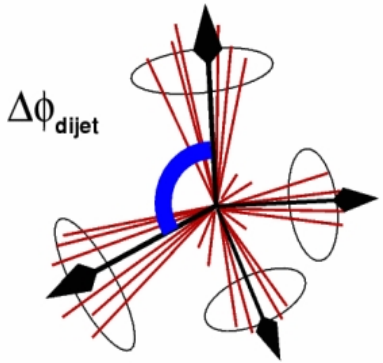

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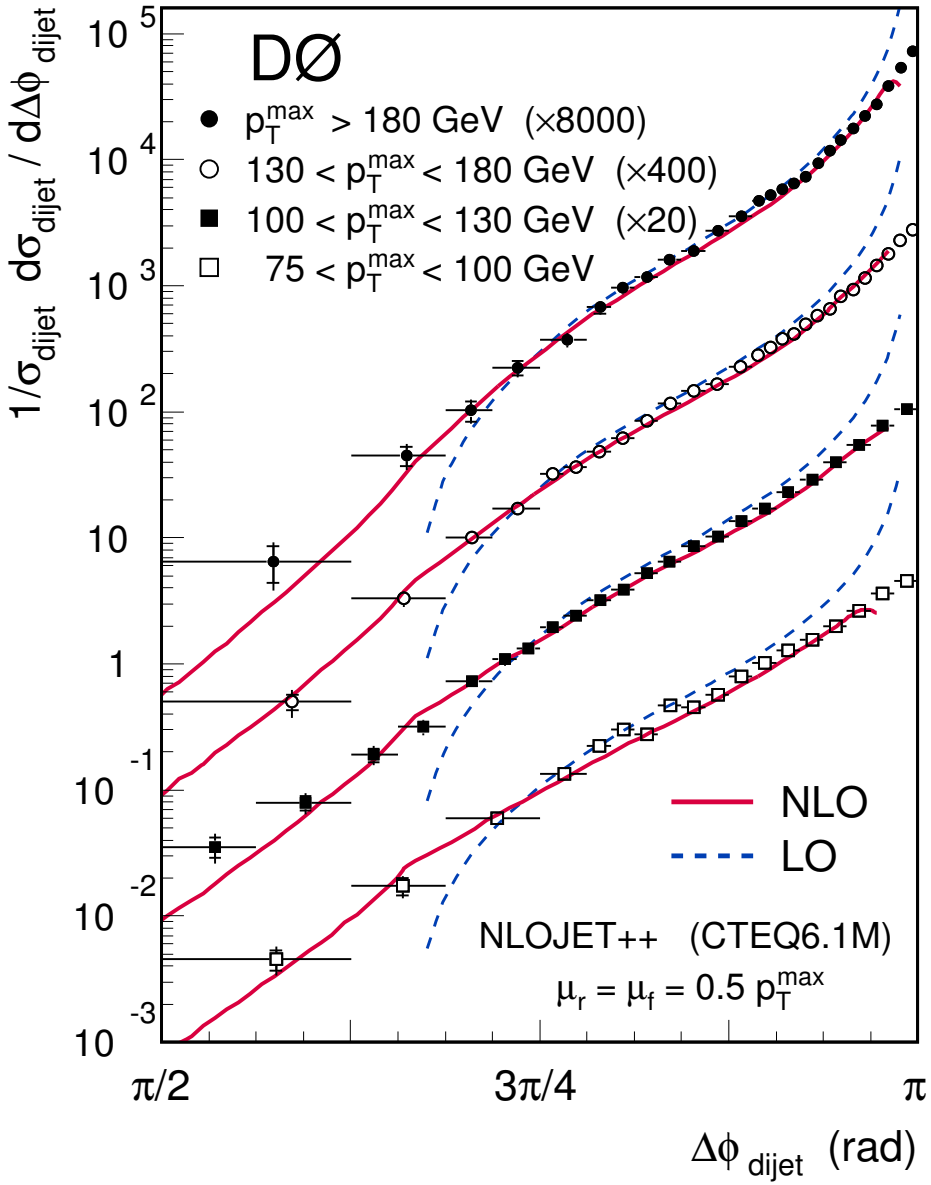
$\Rightarrow$ $\Delta\phi_{\text{dijet}}$ is sensitive to higher order QCD radiation without explicitly measuring third and fourth jets

Azimuthal Decorrelations 2 - The Measurement

The measurement:

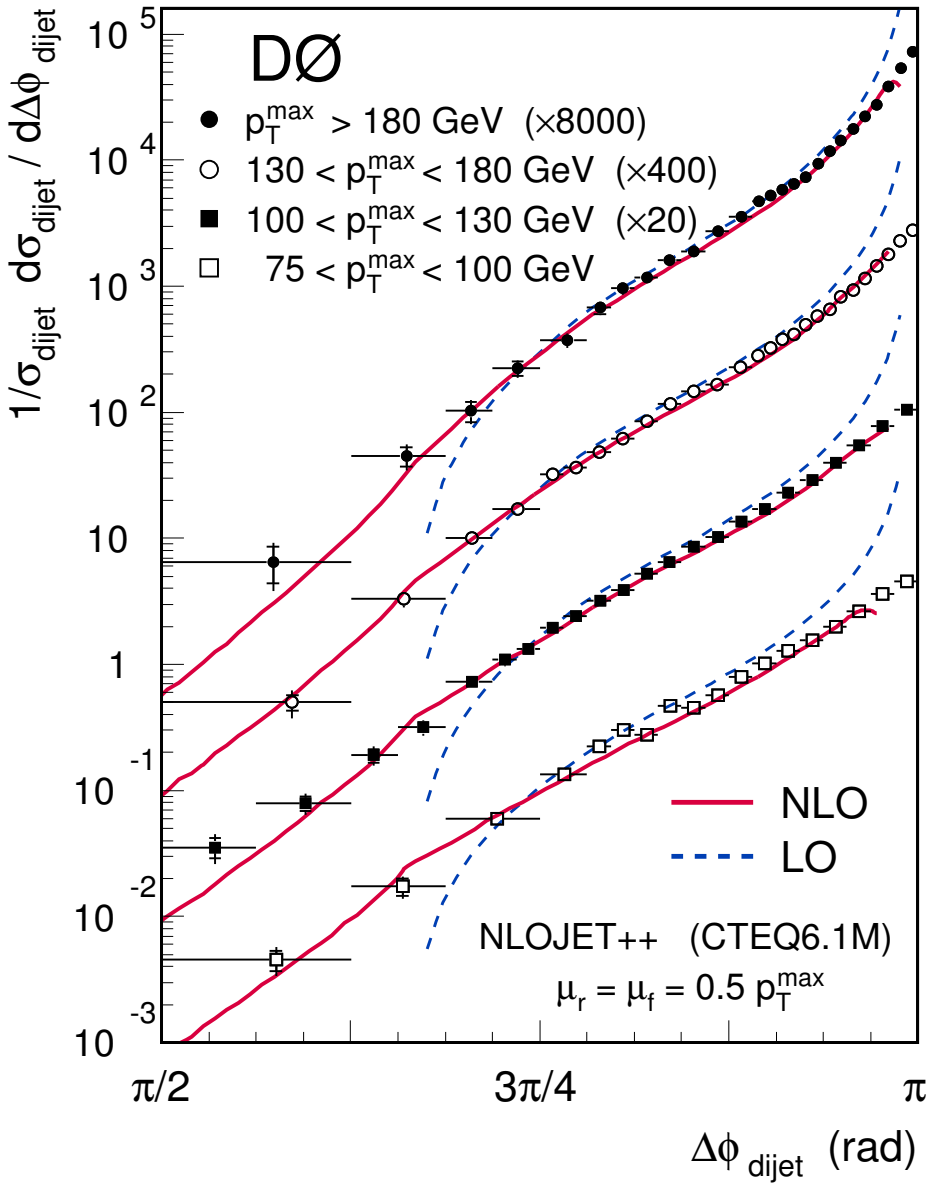
- Observable: $\frac{1}{\sigma_{\text{dijet}}} \cdot \frac{\mathrm{d}\sigma_{\text{dijet}}}{\mathrm{d}\Delta\phi_{\text{dijet}}}$
- Inclusive dijet sample:
  - Selected by jet triggers
  - Four bins in leading jet p_{T}: 75, 100, 130, 180 GeV
  - Second leading jet: $p_{\mathrm{T}} > 40$GeV
  - Both leading and second leading jets central: $|\, y \,| < 0.5$



Accepted by PRL, hep-ex/0409040

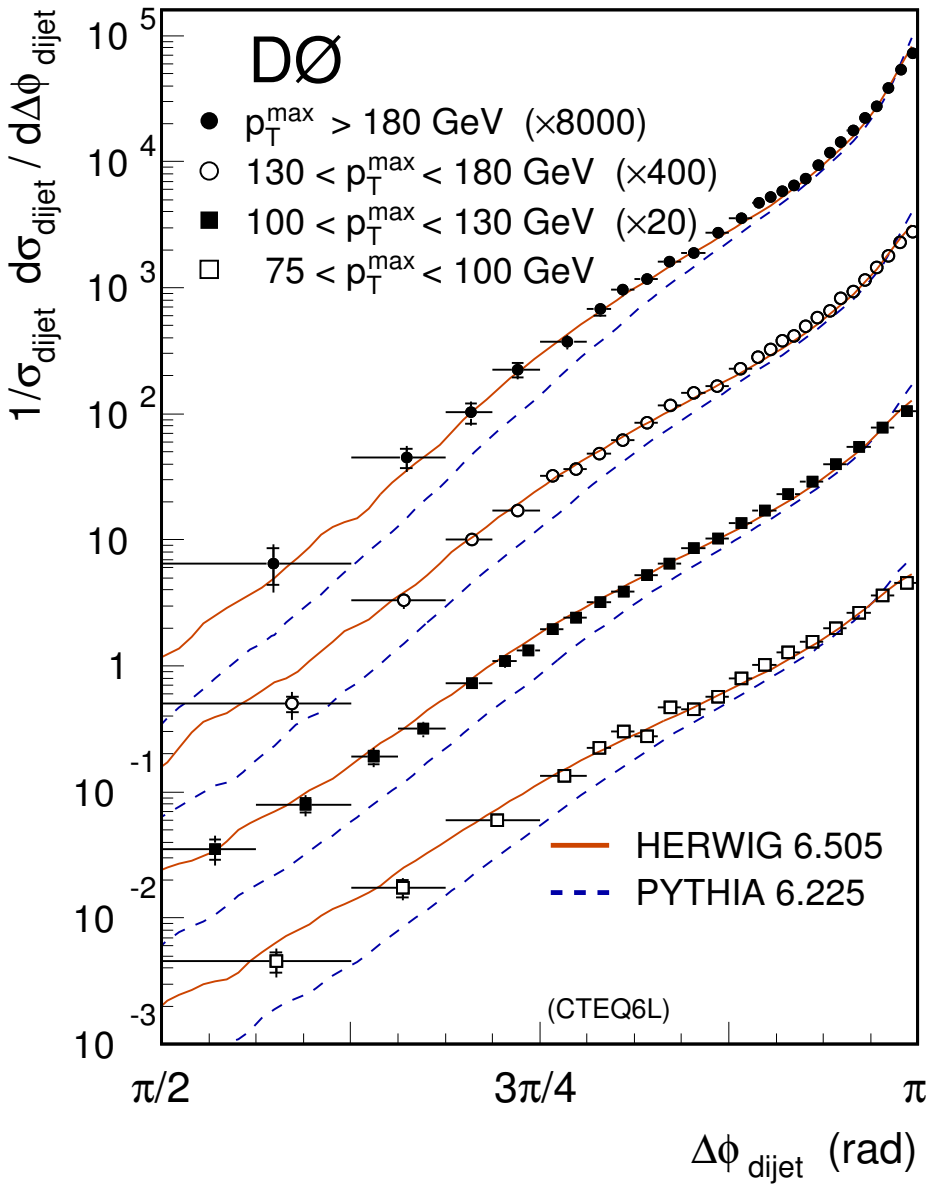
LO and NLO Theory Comparison - NLOJET++

- $\left.\frac{1}{\sigma_{\text{dijet}}}\right|_{\text{(N)LO}} \left.\frac{\mathrm{d}\sigma}{\mathrm{d}\Delta\phi_{\text{dijet}}}\right|_{\text{(N)LO}}$
- CTEQ6.1M
- $\mu_r = \mu_f = 0.5 p_T^{max}$
- LO pQCD (in 3-jet production)
  - Poor agreement
  - Divergent at π
- NLO pQCD (in 3-jet production)
  - Good agreement over large range
  - Divergent at π



Event Generator Comparisons

Herwig v6.505 vs. Pythia v6.225
LO pQCD + parton showering



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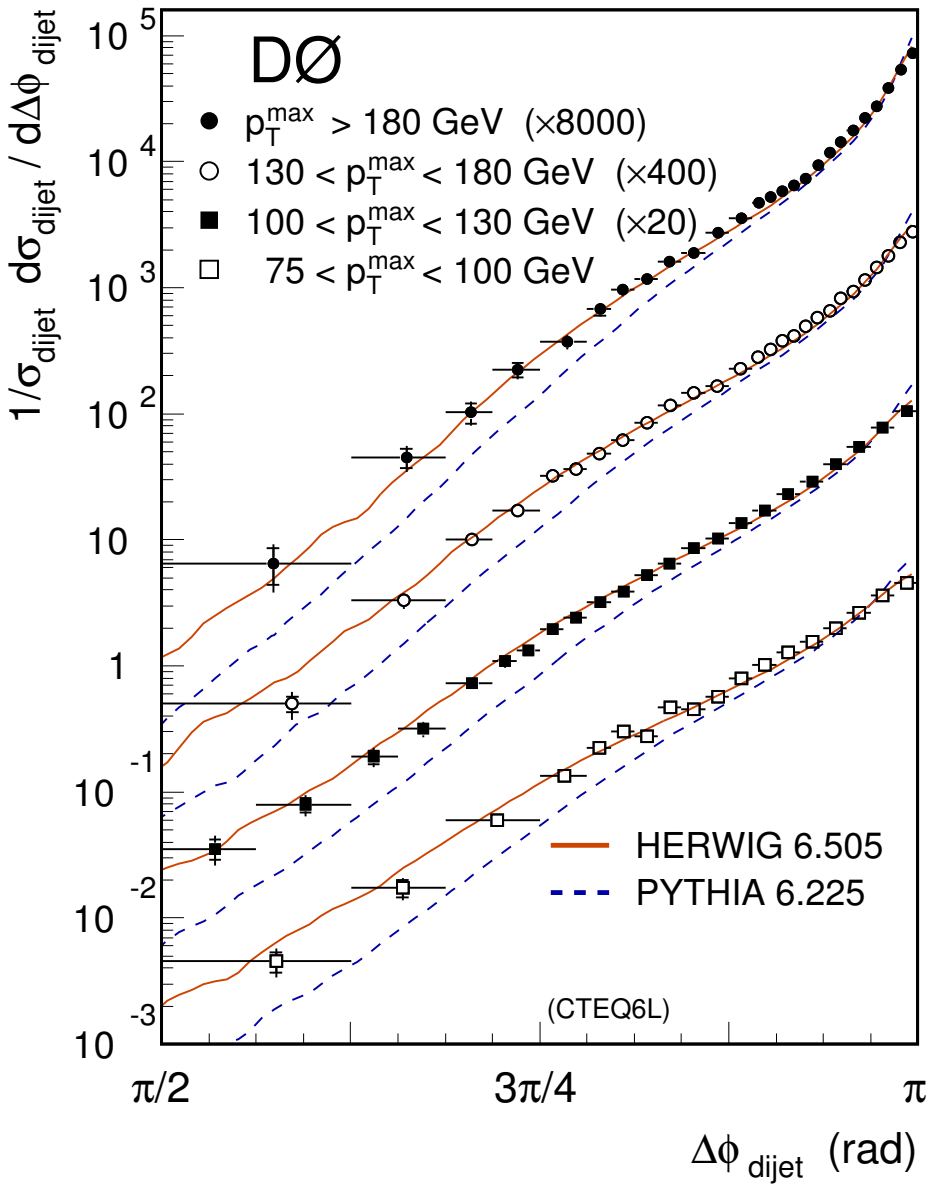

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- Pythia
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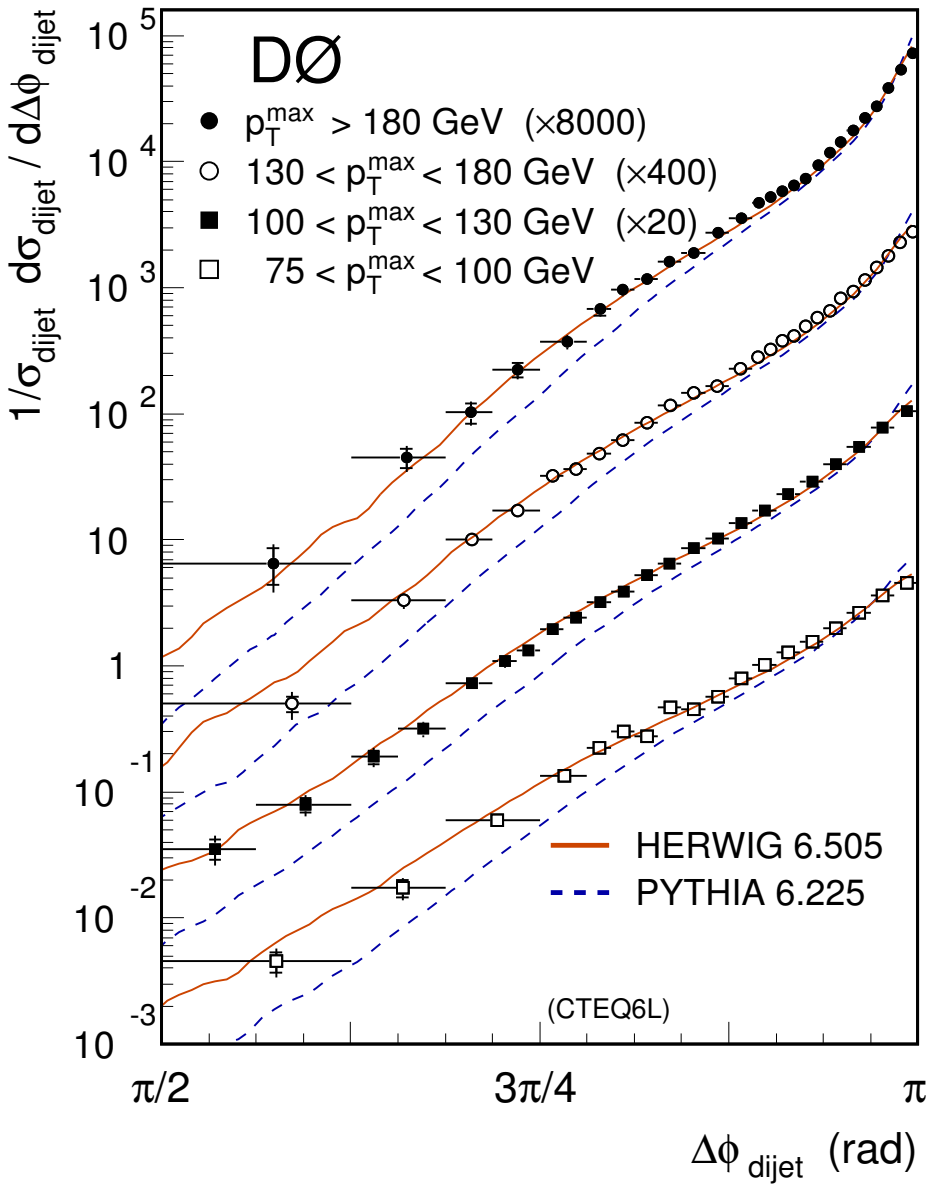
  - But many parameters to adjust



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LO pQCD + parton showering

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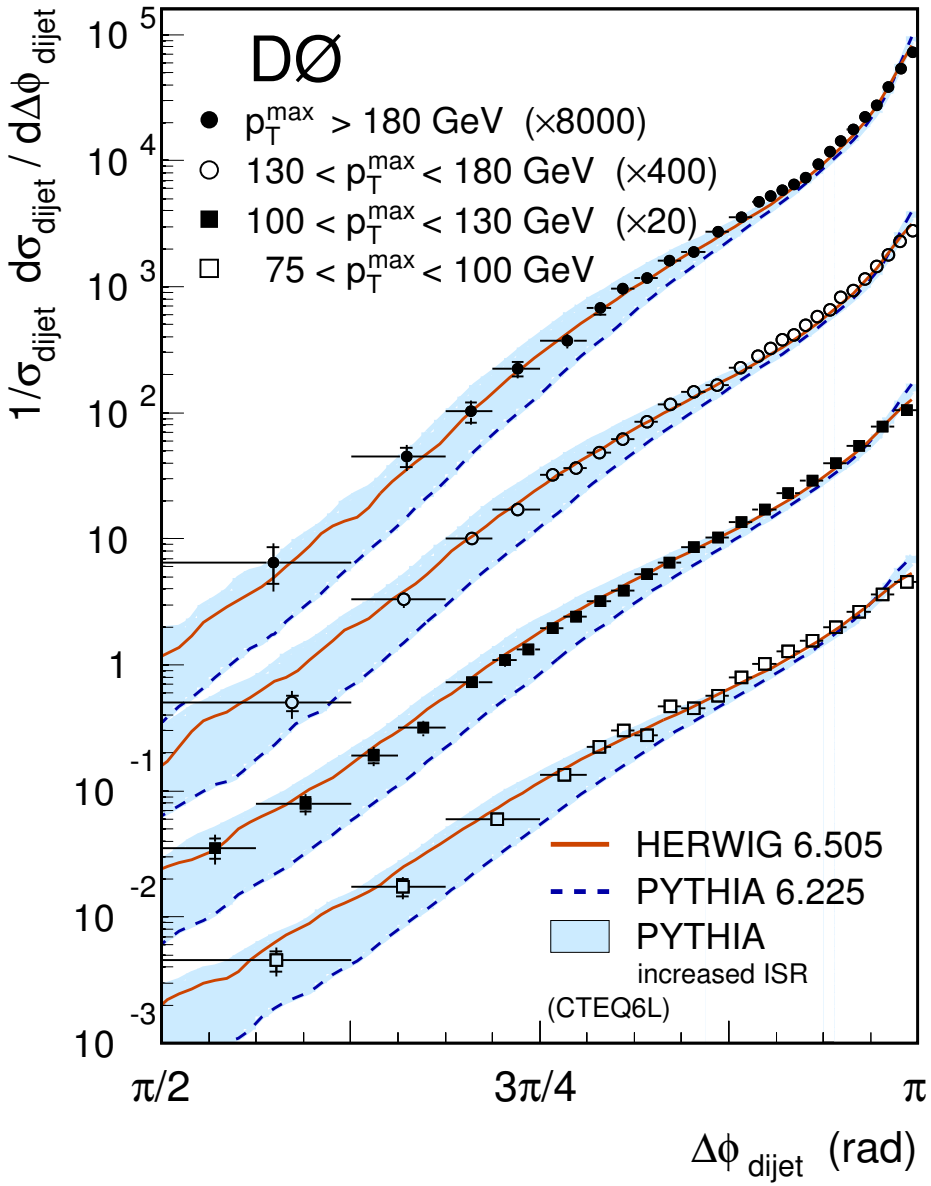
- Pythia
  - Poor agreement
  - But many parameters to adjust
  - Adjusting maximal virtuality of ISR



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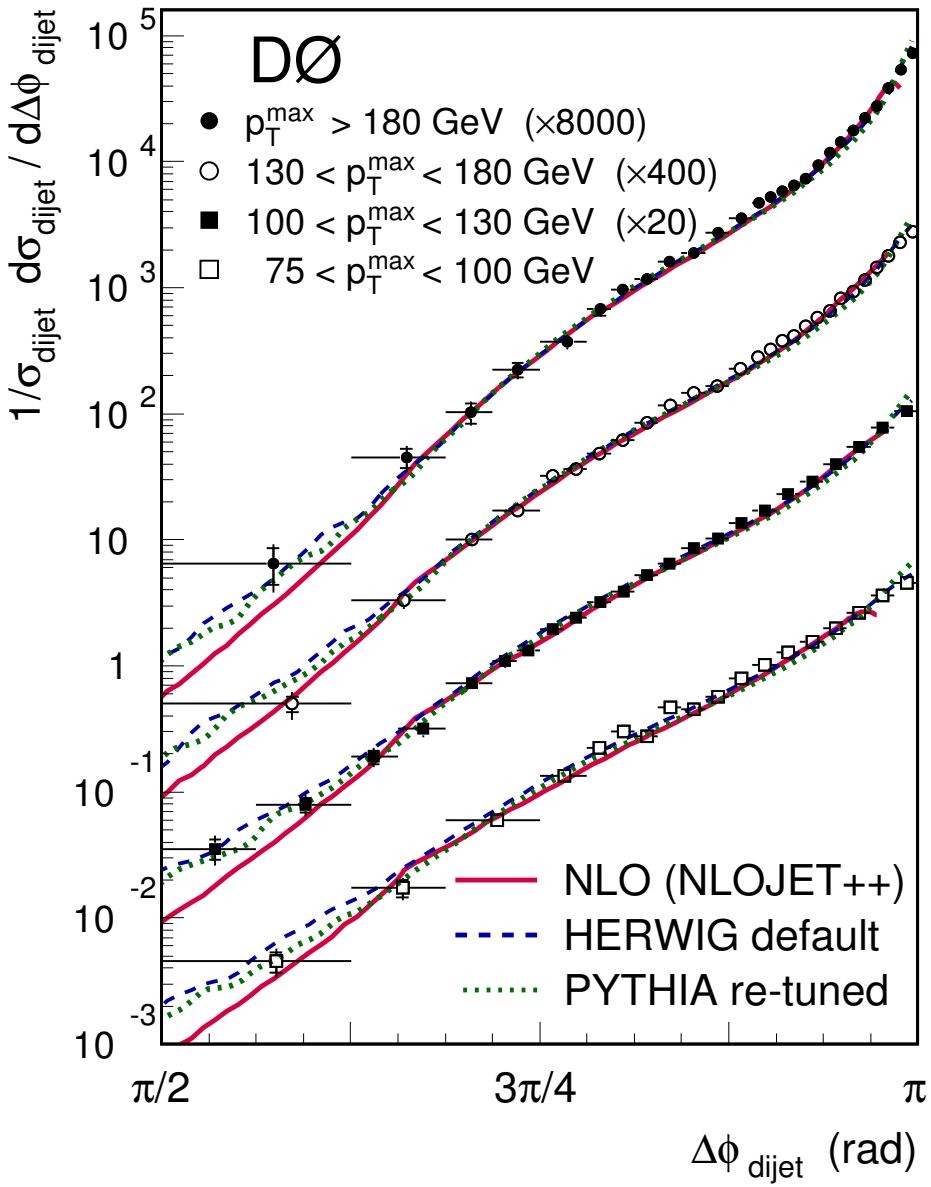
  $\Rightarrow$ Significant improvement



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- NLO pQCD describes the data very well
- Parton shower models tested in Herwig and Pythia
  - Herwig v6.505 with default parameters describes the data
  - Pythia v6.225 does not fit data very well, but tuning its internal parameters improves agreement