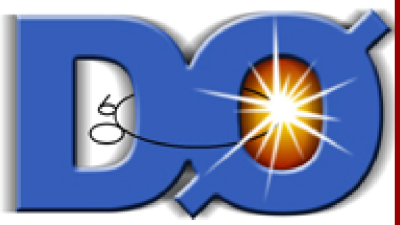
Camille Bélanger-Champagne
for the DØ Collaboration



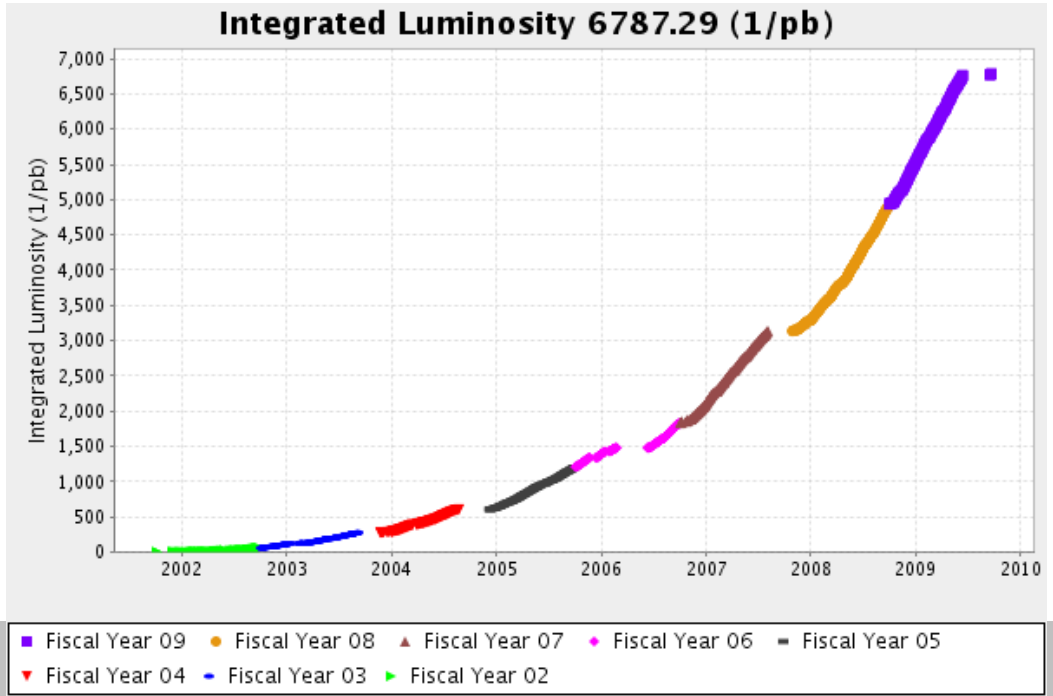
UPPSALA
UNIVERSITET

Results on jet physics and diffraction from DØ

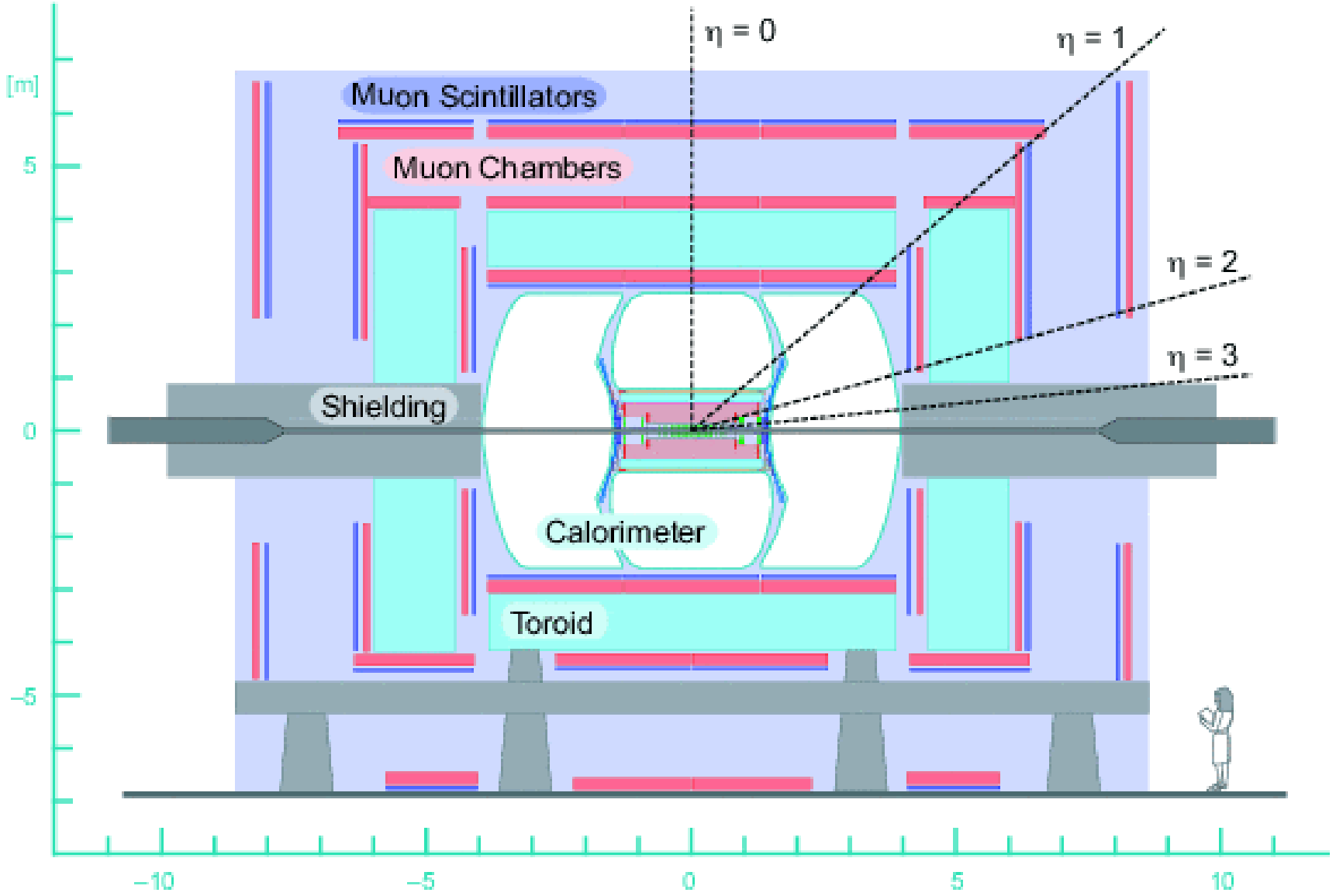
Low x Workshop
Kavala, June 26th 2010

The Tevatron accelerator

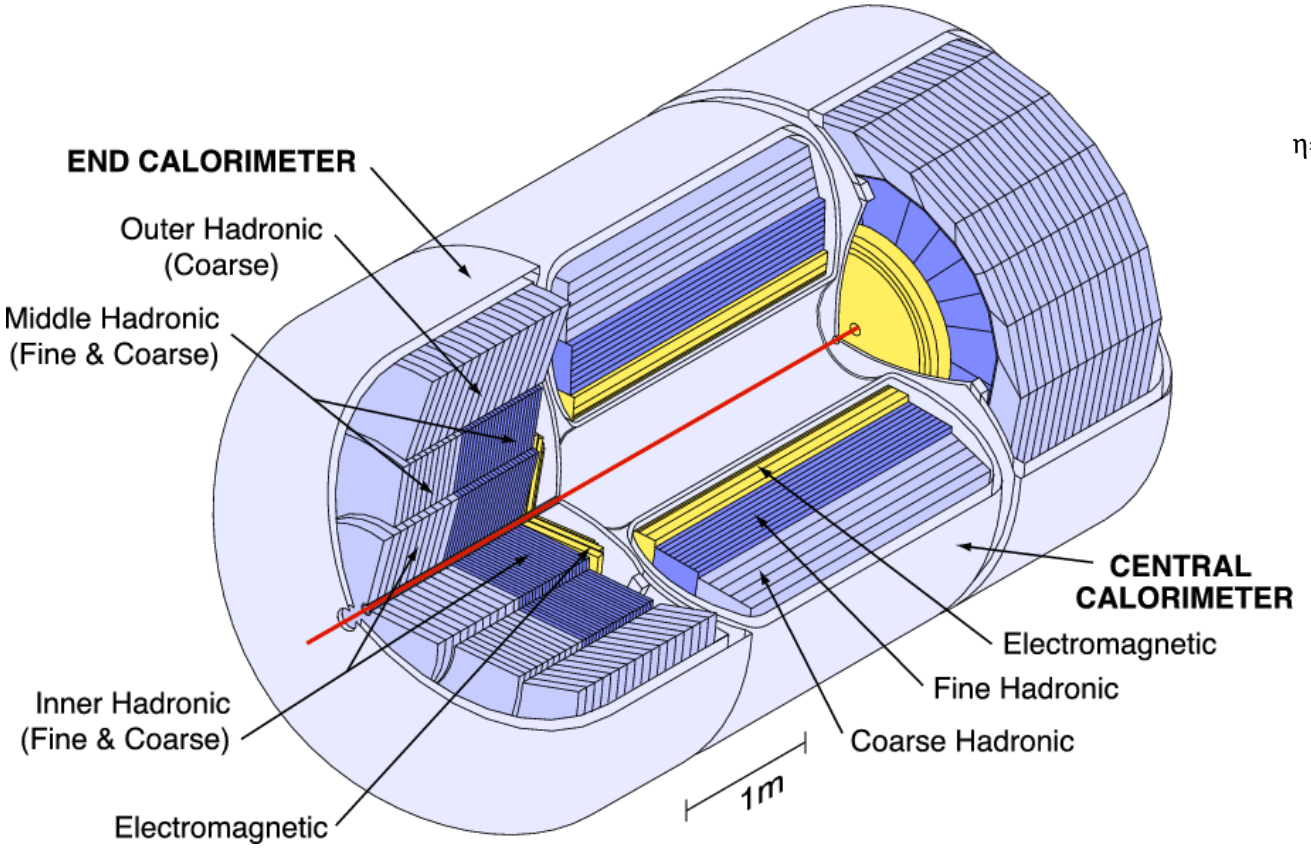
- In Batavia, Illinois, outside Chicago
- ppbar collisions
- $\sqrt{s}$=1.96 TeV
- 2 general purpose detectors: CDF and DØ
- RunII lumi goal: 12fb^{-1} by end 2011

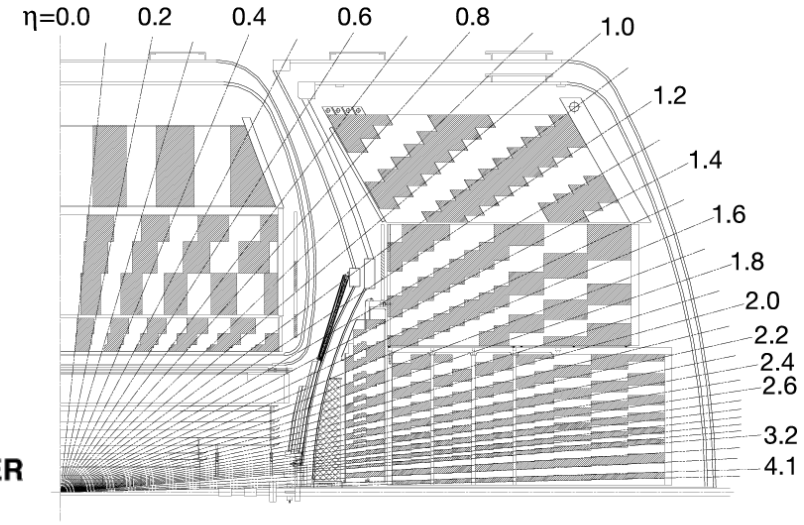


The DØ detector



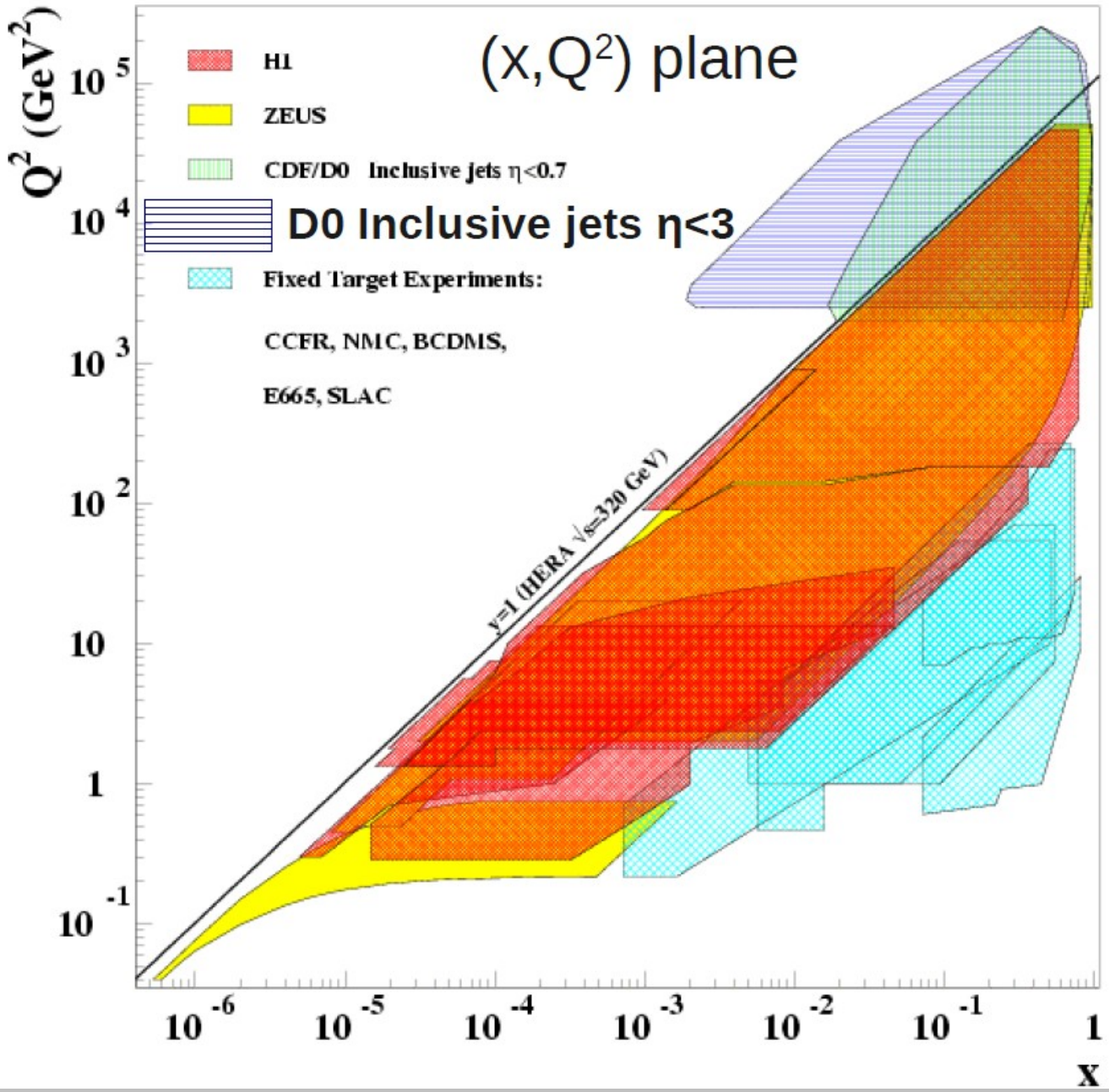
The DØ calorimeter



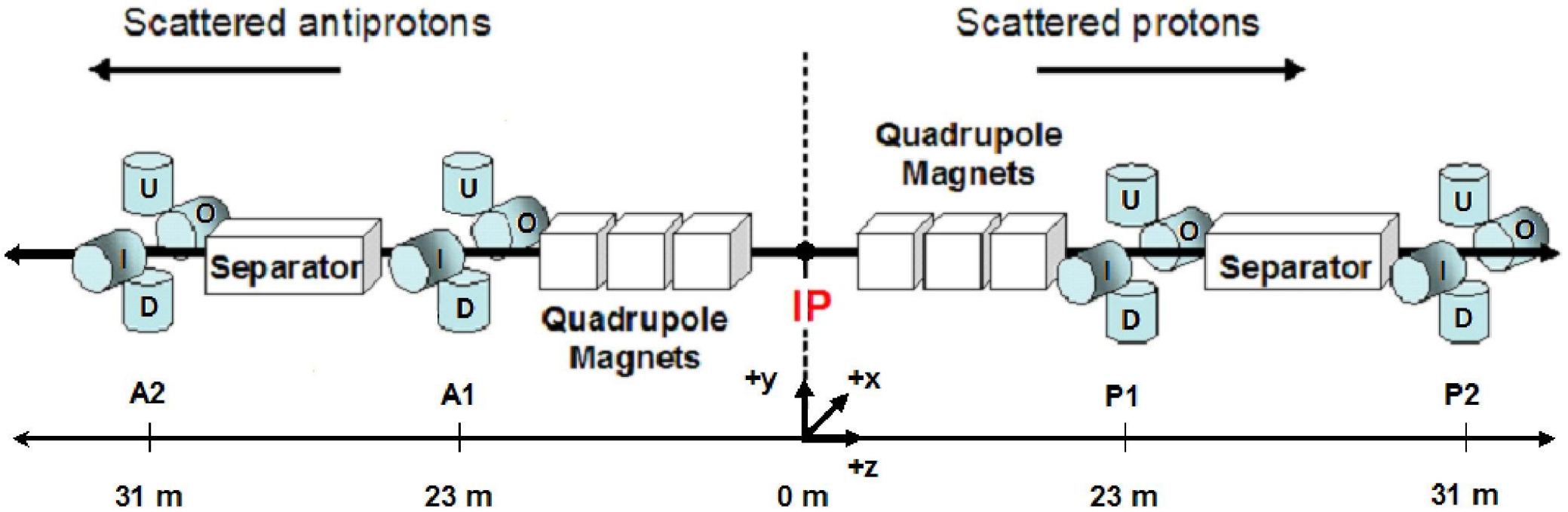


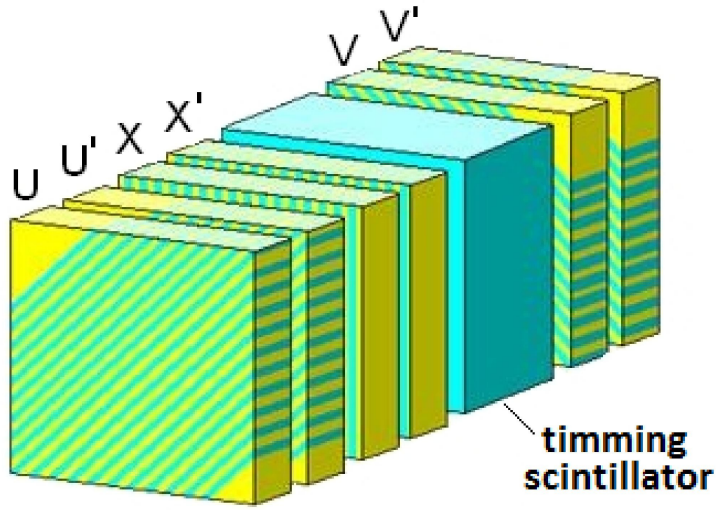
DØ Physics Reach

- Very broad kinematic reach
- Unique coverage but also overlap with other experiments and at other accelerators



The Forward Proton Detector (FPD)



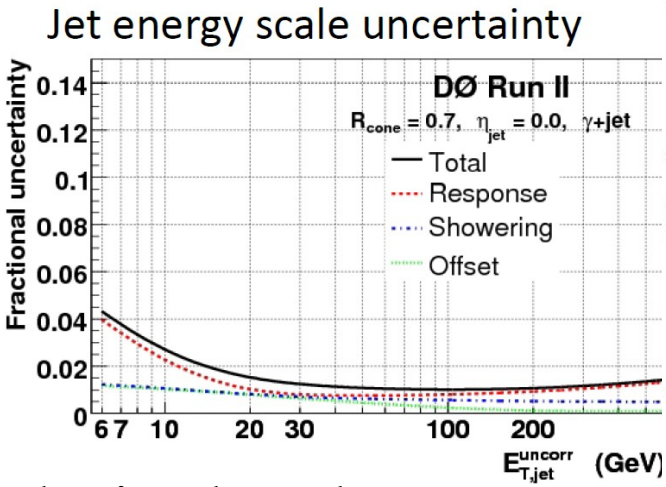


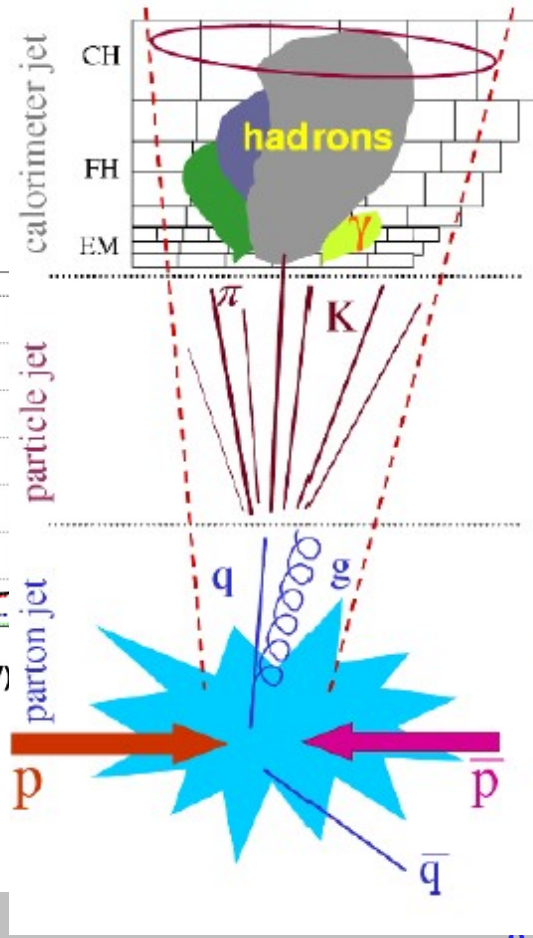
Some technical details

- In all measurements presented, unless otherwise specified
  - The rapidity y is defines as $y=0.5\ln[(1+\beta\cos\theta)/(1-\beta\cos\theta)]$ with $\beta=|\mathbf{p}|/E$
  - The pseudorapidity is defined as $\eta=-\ln(\tan(\theta/2))$
  - Midpoint iterative cone algorithm jets with cone radius $R=\sqrt{((\Delta y)^2+(\Delta\varphi)^2)}=0.7$
  - Single jet triggers
- Leading systematics:
  - Luminosity, 6.1%
  - Jet energy scale 3-45%
  - Jet p_T resolution 1-10%

Theory & Jet Energy Scale

- QCD theoretical predictions
  - NLOJET++ & FASTNLO calculations
  - Correct for hadronization and underlying event effects
- Experimental side
  - Correct for experimental and detector effects
  - Jet energy scale:
    - Energy offset
    - Detector response
    - Out of cone energy
    - Resolution





- Result: comparison at particle-jet level

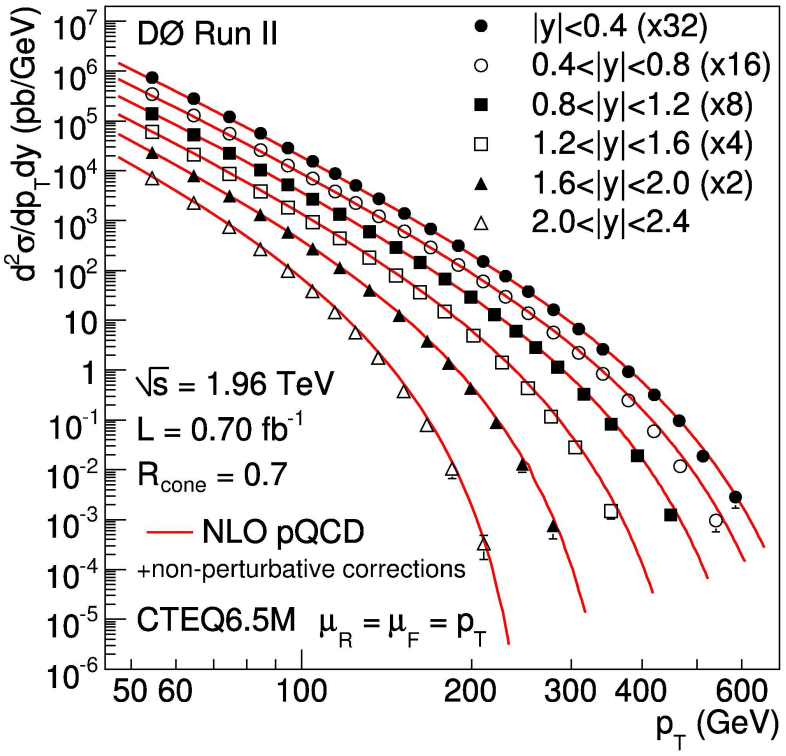
Inclusive jet cross-section

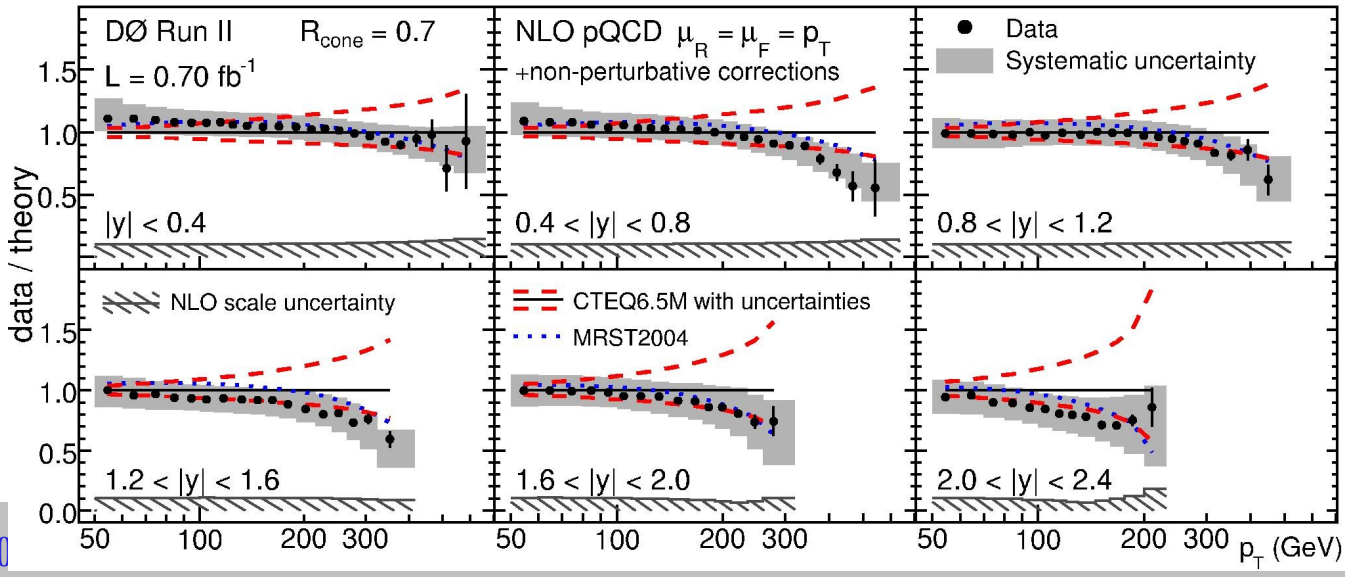
Phys. Rev. Lett. 101, 062001 (2008), arXiv.org:0802.2400

Detailed version to be submitted to Phys. Rev. D

Measurement details

- Luminosity ~ 0.7fb^{-1}
- Differential cross-section relative to leading p_T in 6 rapidity regions
- At least 1 jet with p_T>50 GeV
- Theory uncertainty: 10% per bin





α_s in inclusive jet cross-section

Phys. Rev. D 80, 111107 (2009), arXiv.org:0911.2710

Method for α_s measurement

- 110 data points from measurement of $d^2\sigma_j/dp_T dy$
- Depends on α_s: $\sigma_{\mathrm{pert}}(\alpha_s) = \left(\sum_n \alpha_s^n c_n \right) \otimes f_1(\alpha_s) \otimes f_2(\alpha_s)$

Method for α_s measurement

- 110 data points from measurement of $d^2\sigma_j/dp_T dy$
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n=2,3,4 since theory calculations to NLO plus 4th-order terms from threshold corrections

Perturbative coefficient

Method for α_s measurement

- 110 data points from measurement of $d^2\sigma_j/dp_T dy$
- Depends on α_s: $\sigma_{\mathrm{pert}}(\alpha_s) = \left(\sum_n \alpha_s^n c_n\right) \otimes f_1(\alpha_s) \otimes f_2(\alpha_s)$

Convolution over momentum fraction of hadrons

PDFs of the initial state hadrons

Method for α_s measurement

- 110 data points from measurement of $d^2\sigma_j/dp_T dy$
- Depends on α_s: $\sigma_{\text{pert}}(\alpha_s) = \left(\sum_n \alpha_s^n c_n \right) \otimes f_1(\alpha_s) \otimes f_2(\alpha_s)$
- Must apply correction for non-perturbative effects of hadronization and underlying event physics

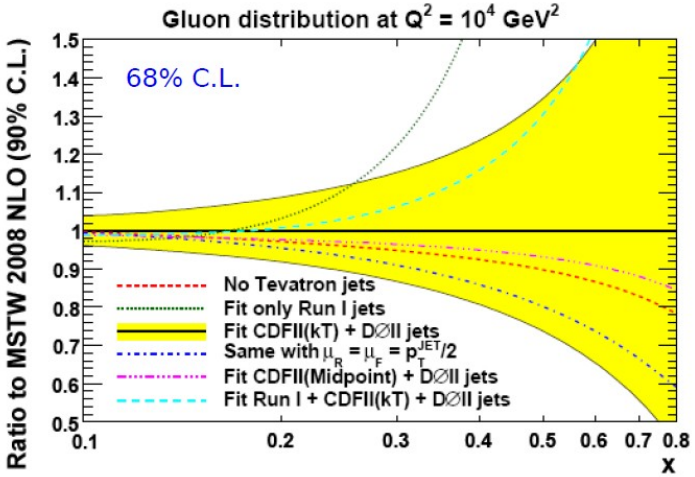
$$\sigma_{\text{theory}}(\alpha_s(M_Z)) = \sigma_{\text{pert}}(\alpha_s(M_Z)) \cdot c_{\text{non-pert}}$$

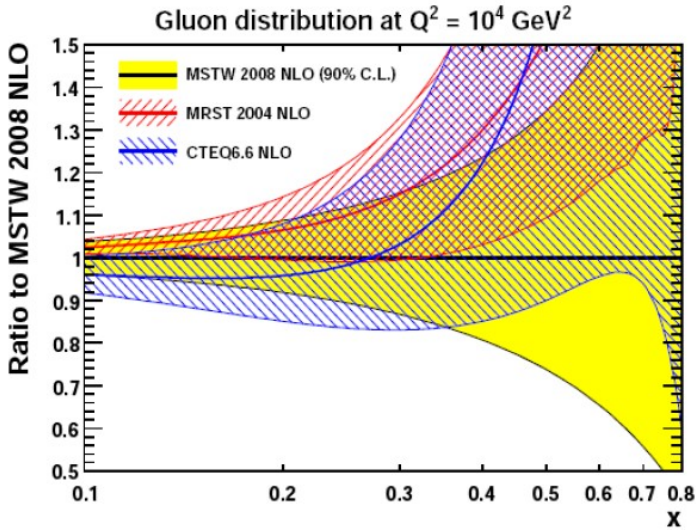
- 2 and 3-loop approximation RGE (Renormalization Group Equation) used

$$\alpha_s(M_Z) = \frac{\alpha_s(\mu_R)}{1 - \alpha_s(\mu_R)(b_0 + b_1\alpha_s(\mu_R)) \ln(\mu_R/M_Z)}$$

Comparison with MSTW2008 PDFs

- Reduce dataset to 22 useable cross-section points

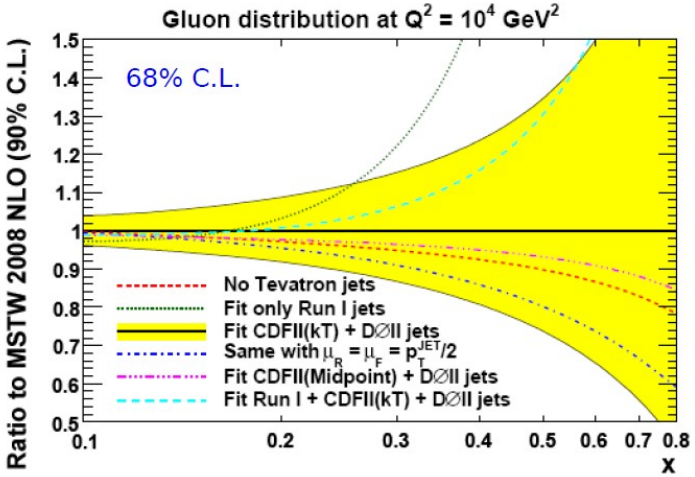




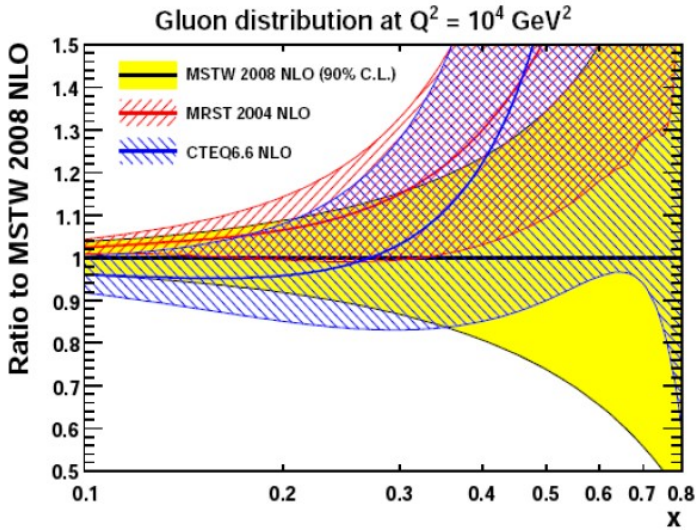
Tevatron RunII inputs dominate high-x gluon PDF determination →throw out those points

Comparison with MSTW2008 PDFs

- Reduce dataset to 22 useable cross-section points



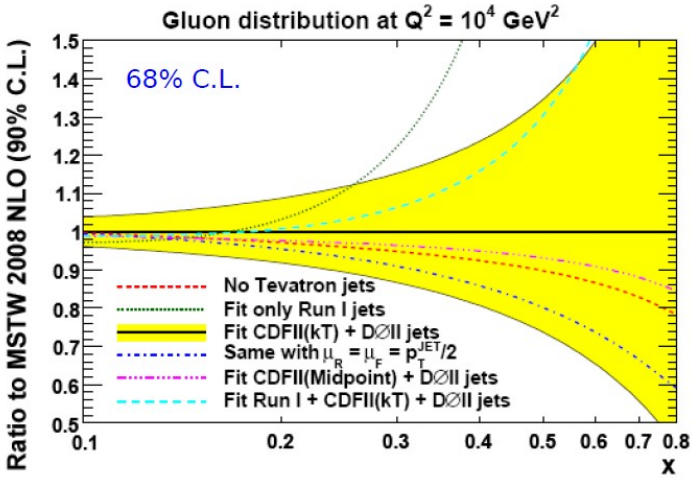
Tevatron RunII inputs dominate high-x gluon PDF determination →throw out those points

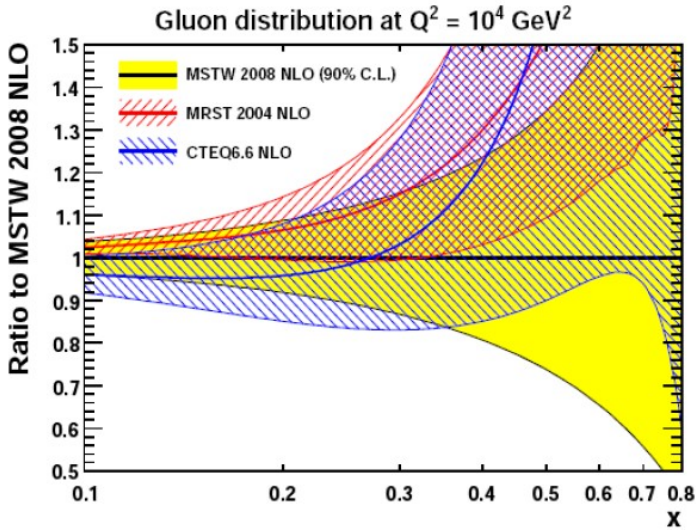


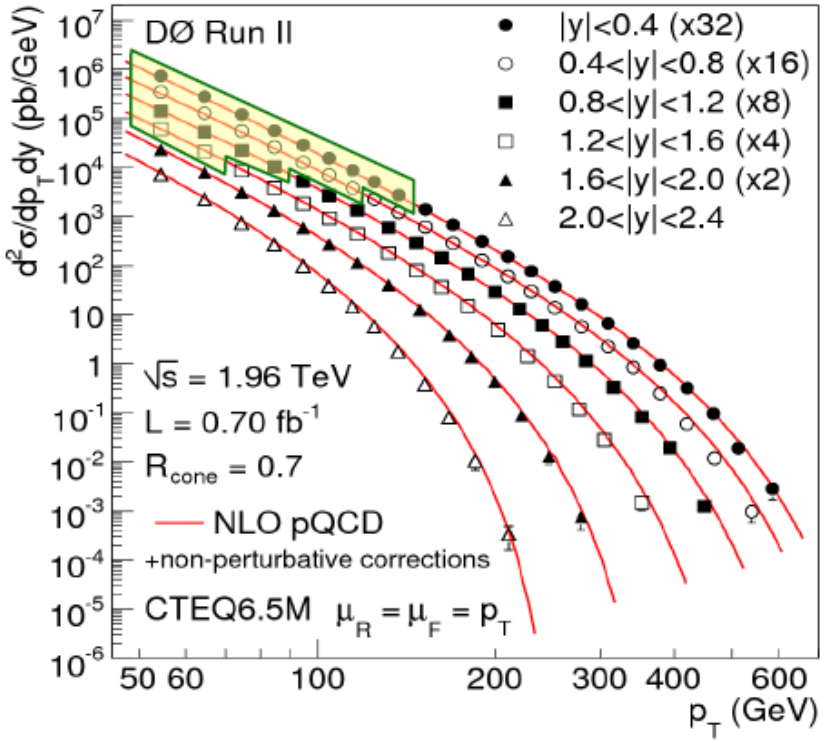
CTEQ6.6 does not use RunII precision data yet agrees with MSTW for x<0.3

Comparison with MSTW2008 PDFs

- Reduce dataset to 22 useable cross-section points

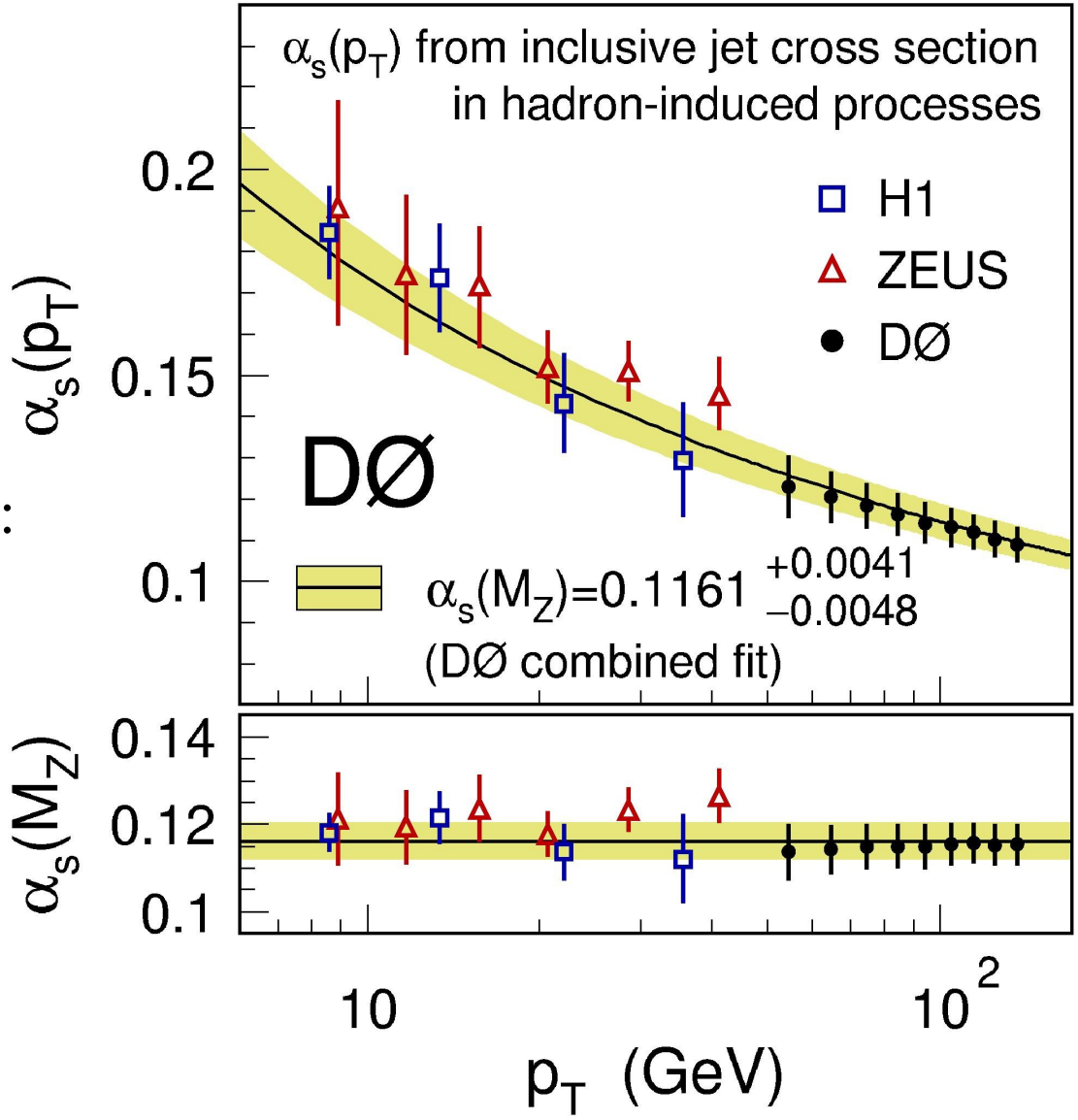






α_s measurement

- Combined fit value:
  $\alpha_s(M_Z)=0.1161^{+0.0041}_{-0.0048}$
- χ^2/NDF=17.2/21
- Value consistent with
  - Combined HERA result:
    0.1189 ±0.0032
  - World average:
    0.1184 ± 0.0007
- Consistent RGE behavior

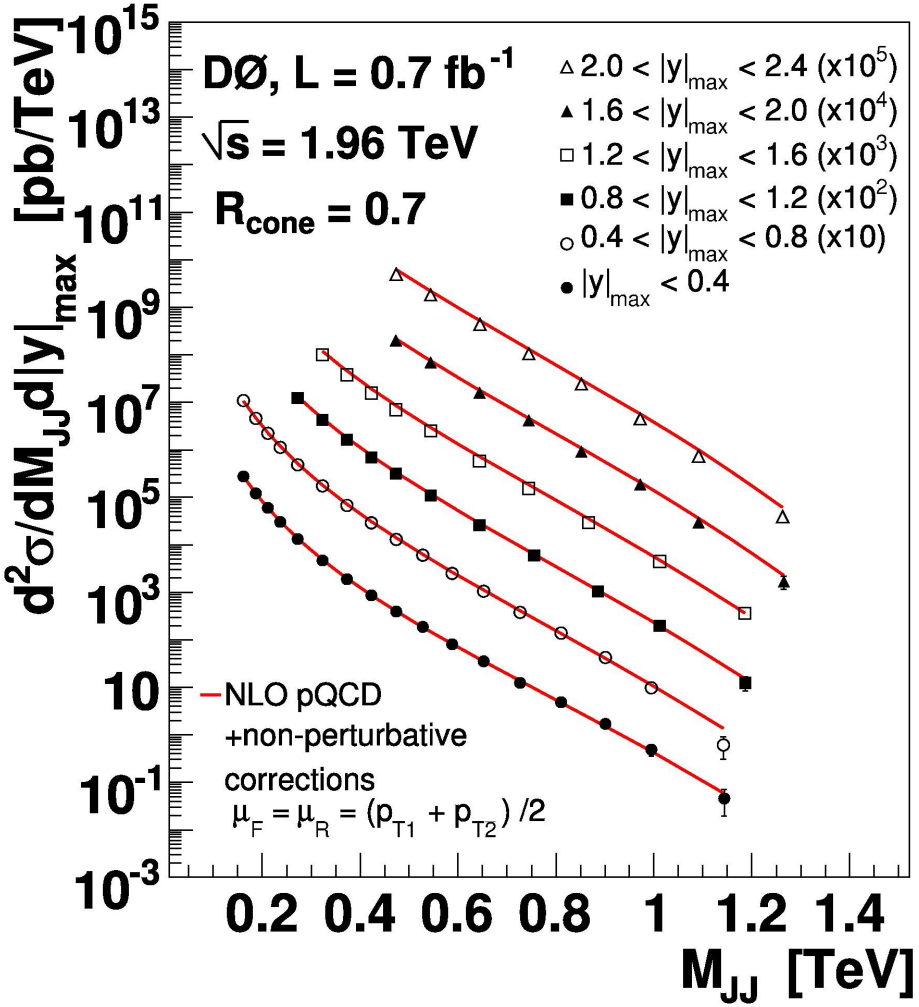


Dijet invariant mass cross-section

Submitted to PRB, arXiv.org: 1002.4594 [hep-ex]

Dijet cross-section

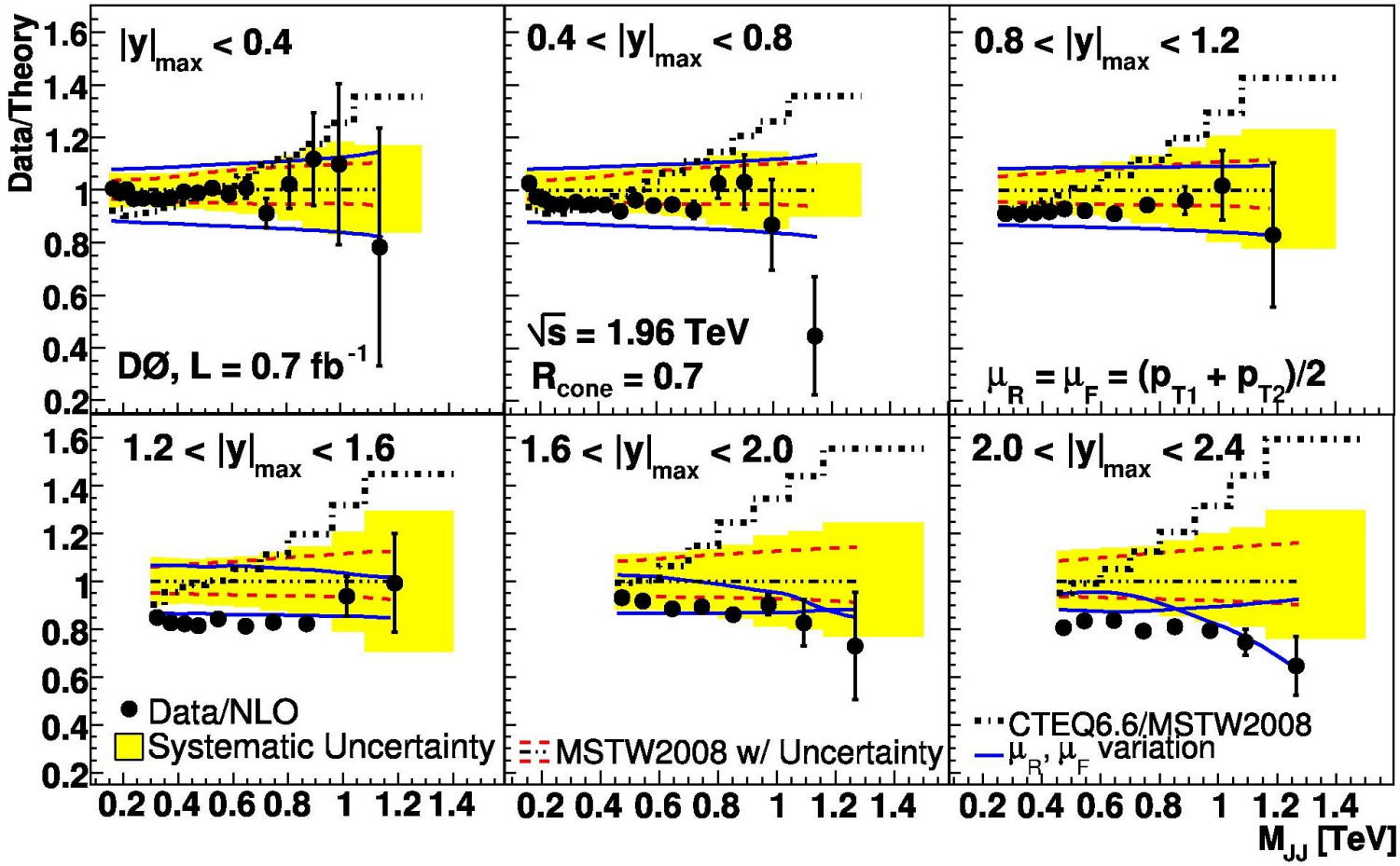
- 2 jets with p_T>40 GeV
- $|y|_{max}$, the absolute rapidity of the jet with the largest y of the 2 leading p_T jets
- M_{jj}, dijet invariant mass
- M_{jj} bins: twice the mass resolution, efficiency and purity above 50%



Statistical errors only

Comparison to NLO prediction

- Uncertainty comparable to PDF, μ_R and μ_F uncertainties
- MSTW2008NLO PDFs are favored by measurement
  - Include DØ inclusive jet cross-section measurement in inputs

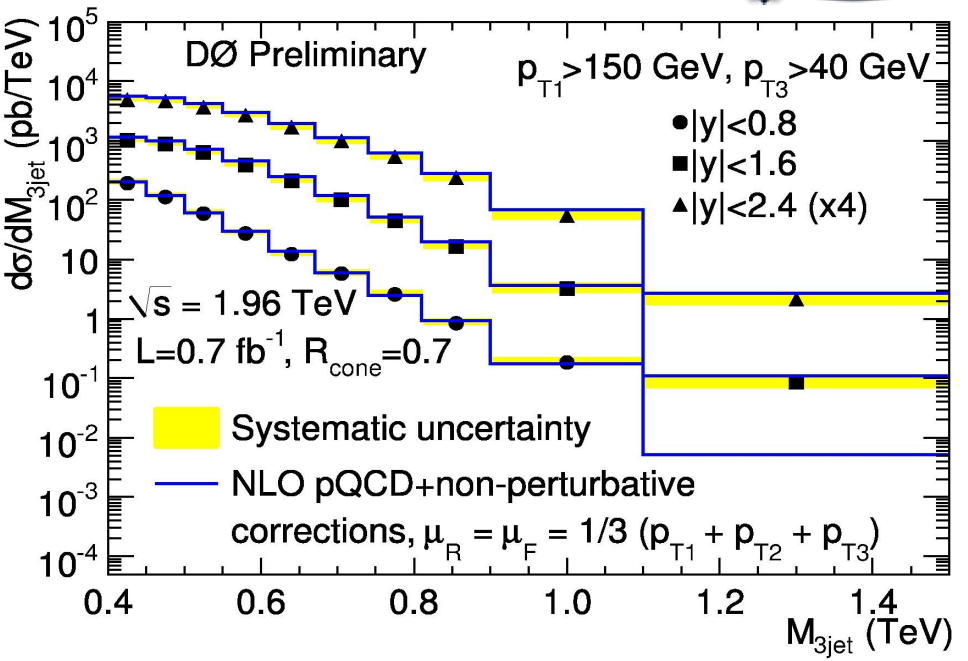


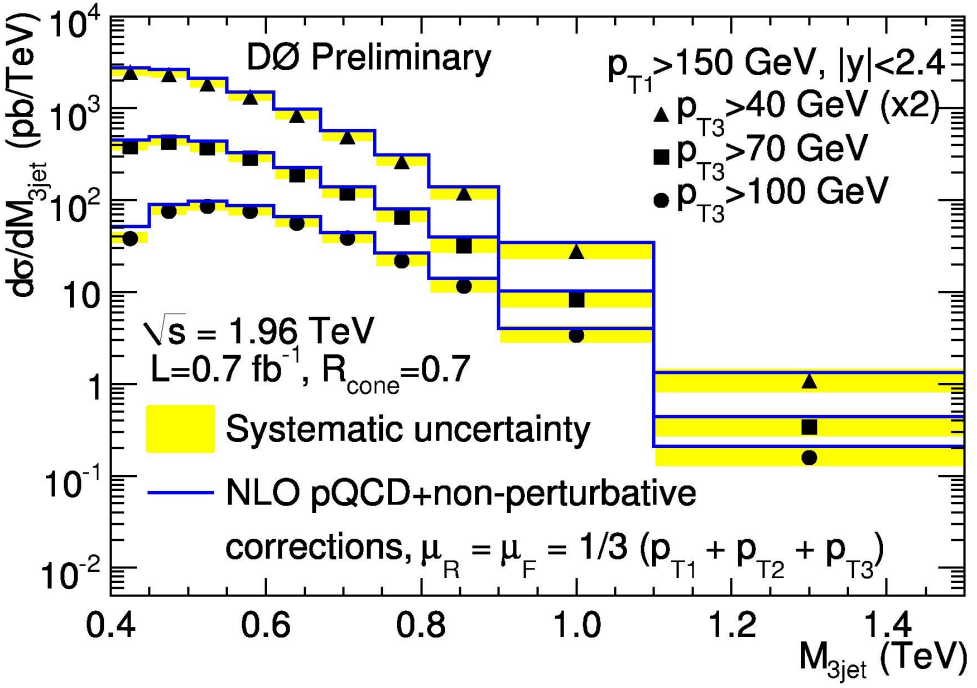
Three-jet mass cross-section

http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/QCD/Q16/

Cross-section results

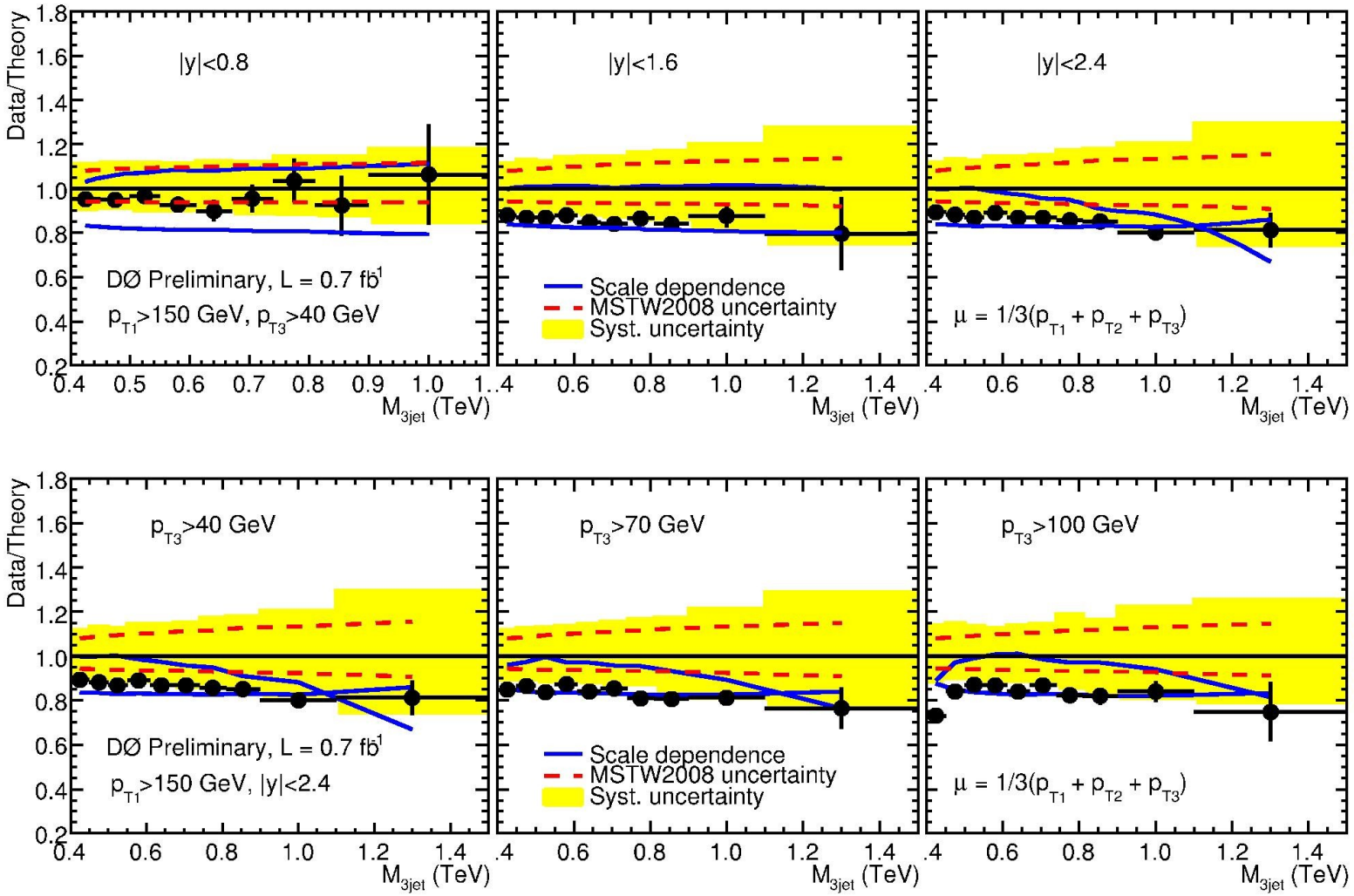
- 3-jet invariant mass M_{3j}
- 3 good jets
  - Leading p_T>150 GeV
  - 3 p_T thresholds and 3 |y| regions
    - p_T>40, 70, 100 GeV
    - |y|<0.8, 1.6, 2.4





Comparison to NLO prediction

- NLO prediction with MSTW2008NLO PDFs



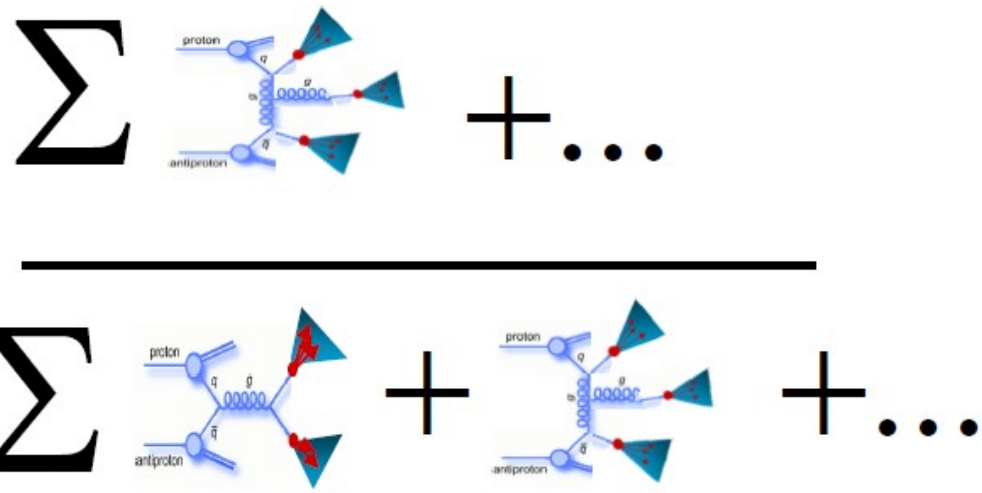
Ratio of multijet cross-sections

http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/QCD/Q16/

Construction and event selection

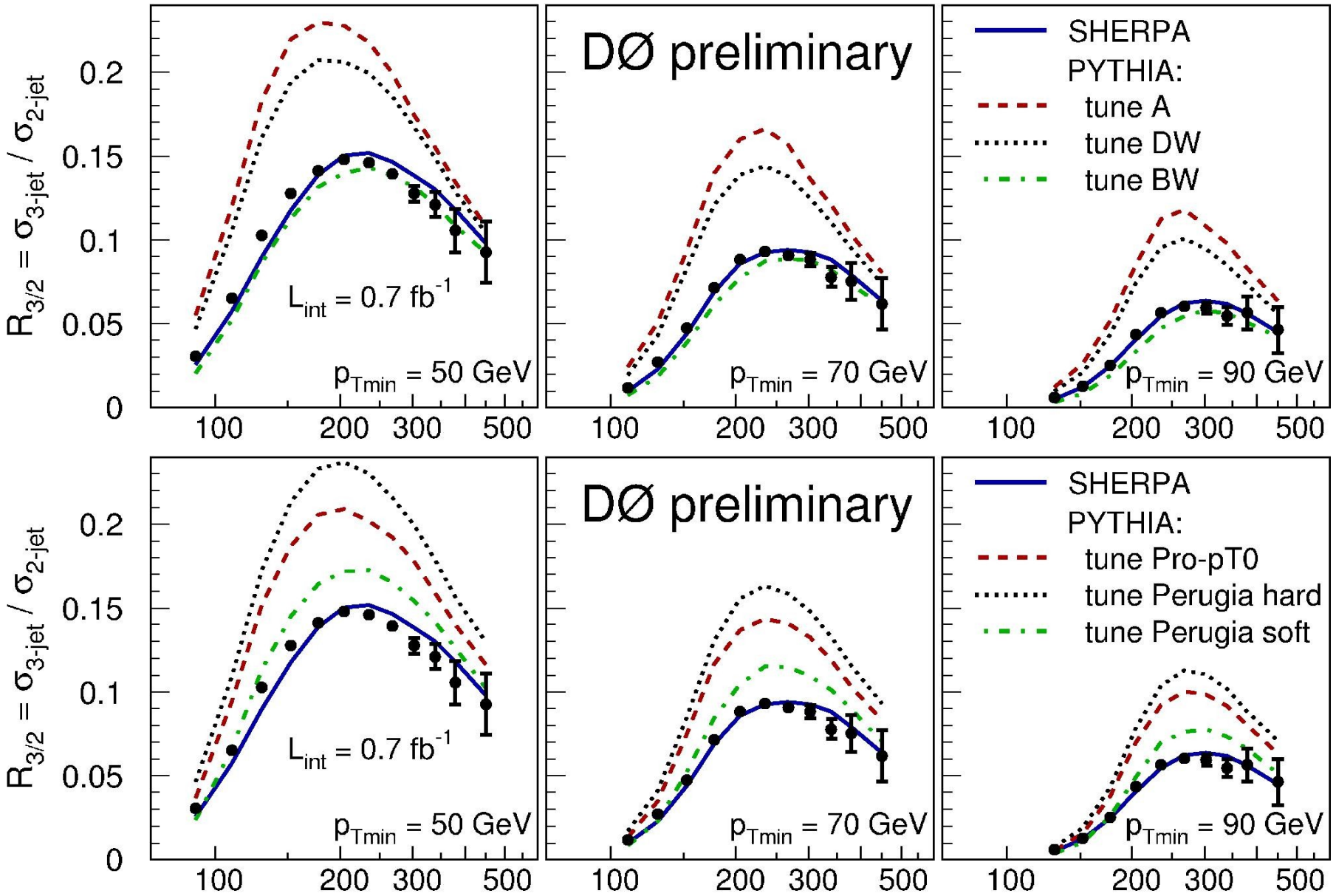
- Inclusive event samples for *n* jets (*n*=2,3) with $p_T > p_{Tmin}$
  - p_{Tmin}=50, 70, 90 GeV
- $R_{3/2}(p_{Tmax})$ $= P(3^{rd}\ \text{jet} | \ 2\ \text{jets})$

  $= \sigma_{3j}/\sigma_{2j}$



- Region: $(p_{Tmin}+30\ \text{GeV}) < p_{Tmax} < 500\ \text{GeV}$
- Cross-section corrections give systematic uncertainty: 2-6% only!

Ratio results – Comparison to MC



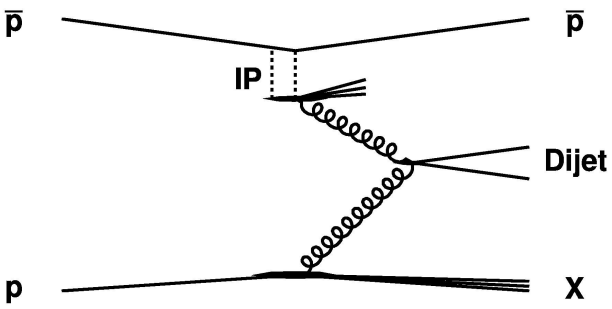
High mass exclusive dijet production

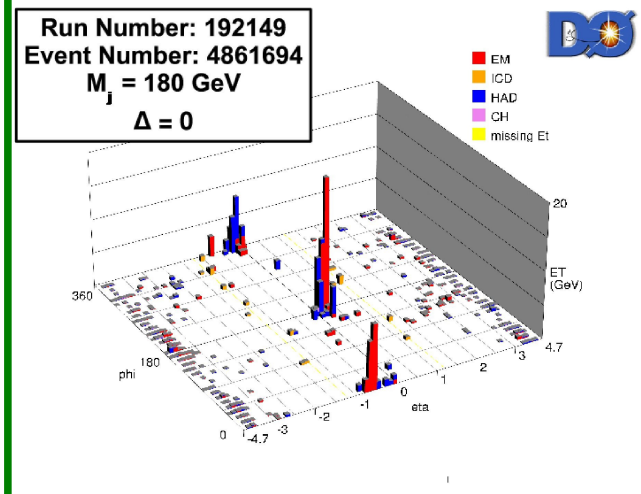
http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/QCD/Q17/

Motivation

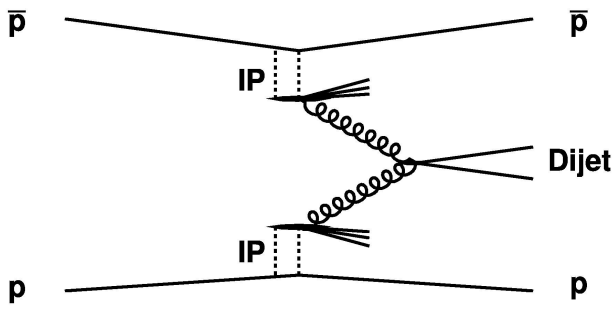
- Events identified by gap devoid of activity in forward region
  - Exchange of colorless object (Pomeron)
- Proposed as Higgs search channel at LHC at very large masses

Single diffraction(SD)

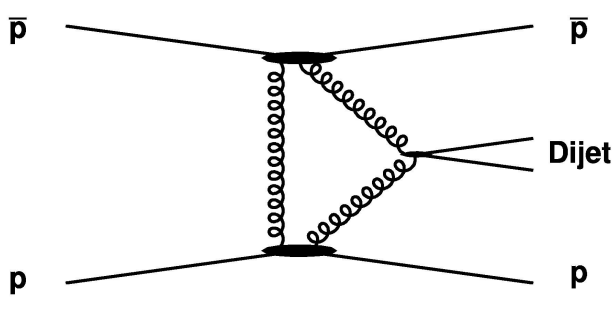


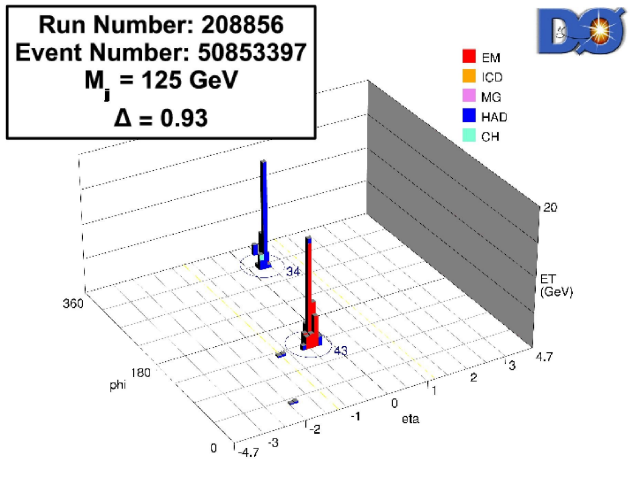


Inclusive double Pomeron(IDP)



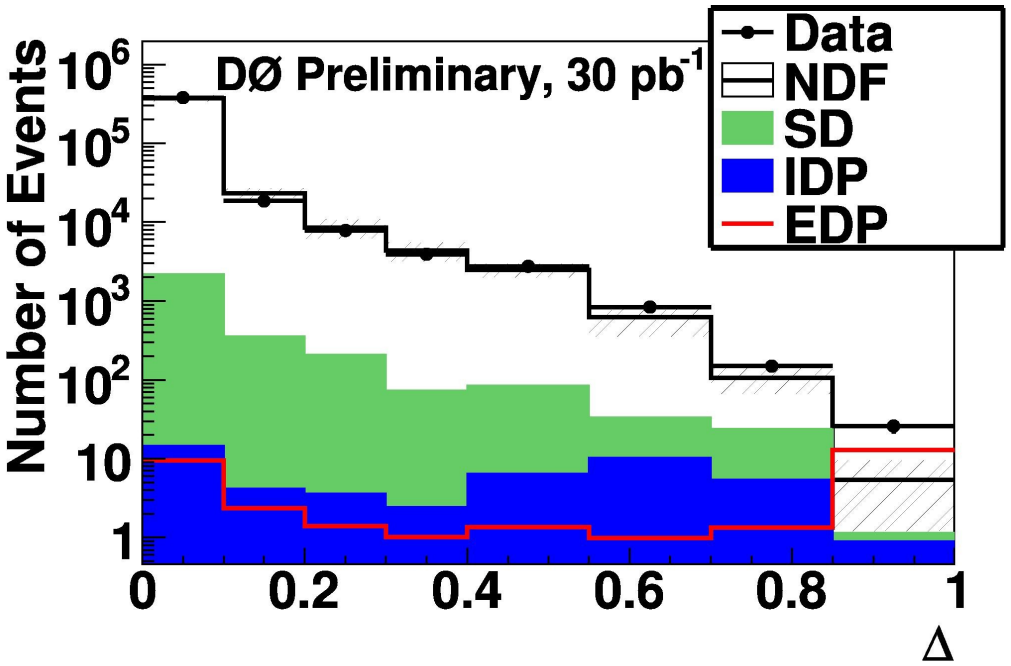
Exclusive diffractive(EDP)



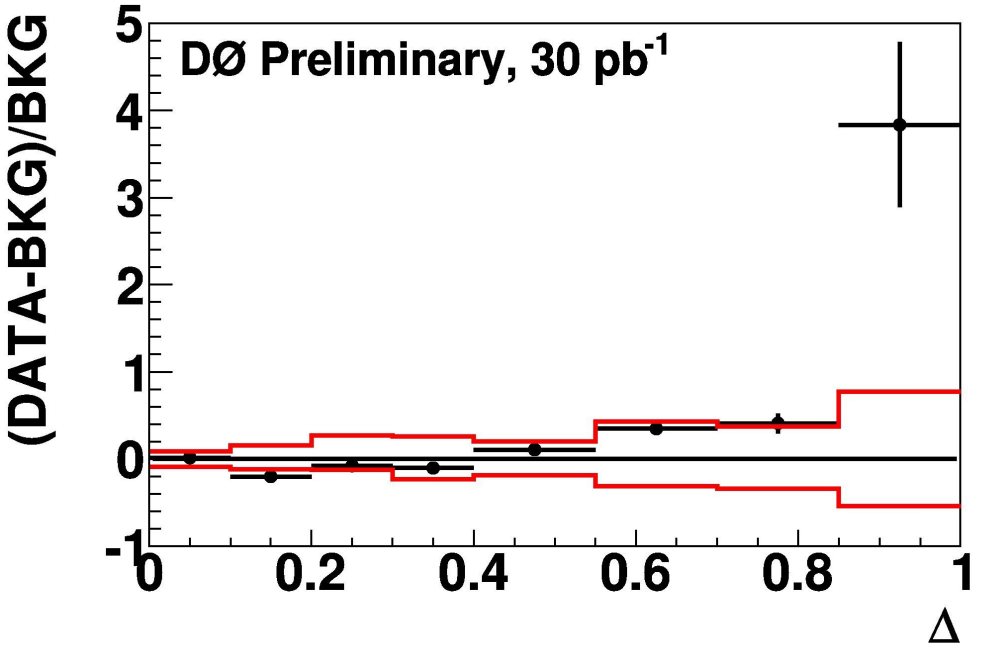


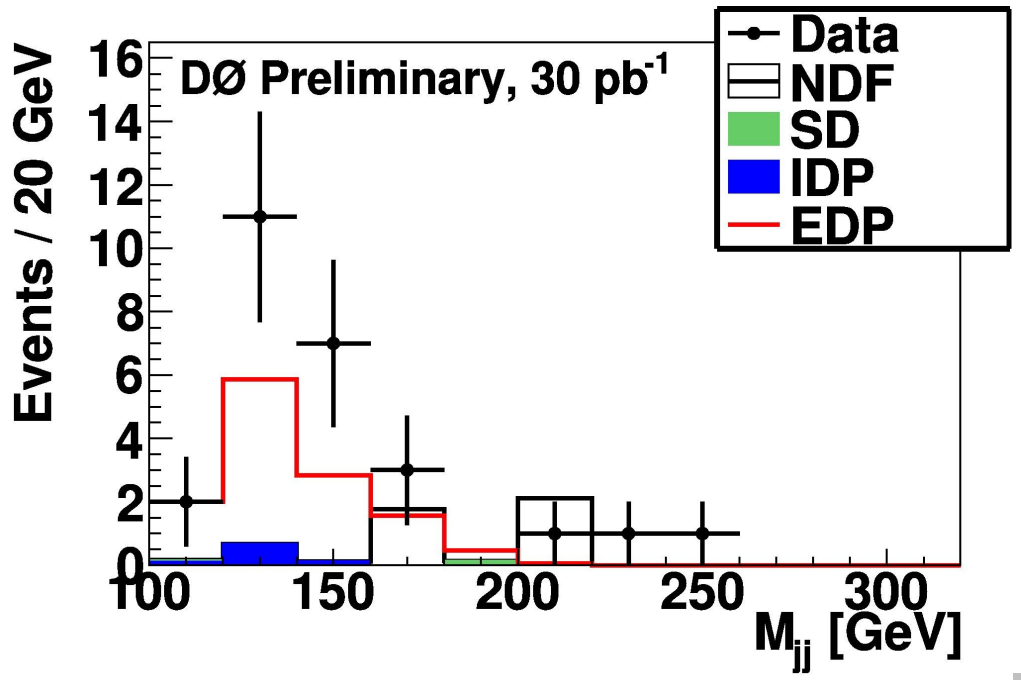
Selection

- 2 back-to-back central jets (|y|<0.8 and $\Delta\varphi > 3.1$rad)
  - p_{T1}>60GeV and p_{T2}>40 GeV, Dijet invariant mass >100 GeV
- Low instantaneous luminosity: avoid multiple interactions
- Discriminant: $\Delta = \frac{1}{2}\exp(-\sum_{2.0<|\eta|\leq 3.0} E_T/\mathrm{GeV}) + \frac{1}{2}\exp(-\sum_{3.0<|\eta|<4.2} E_T/\mathrm{GeV})$



Result





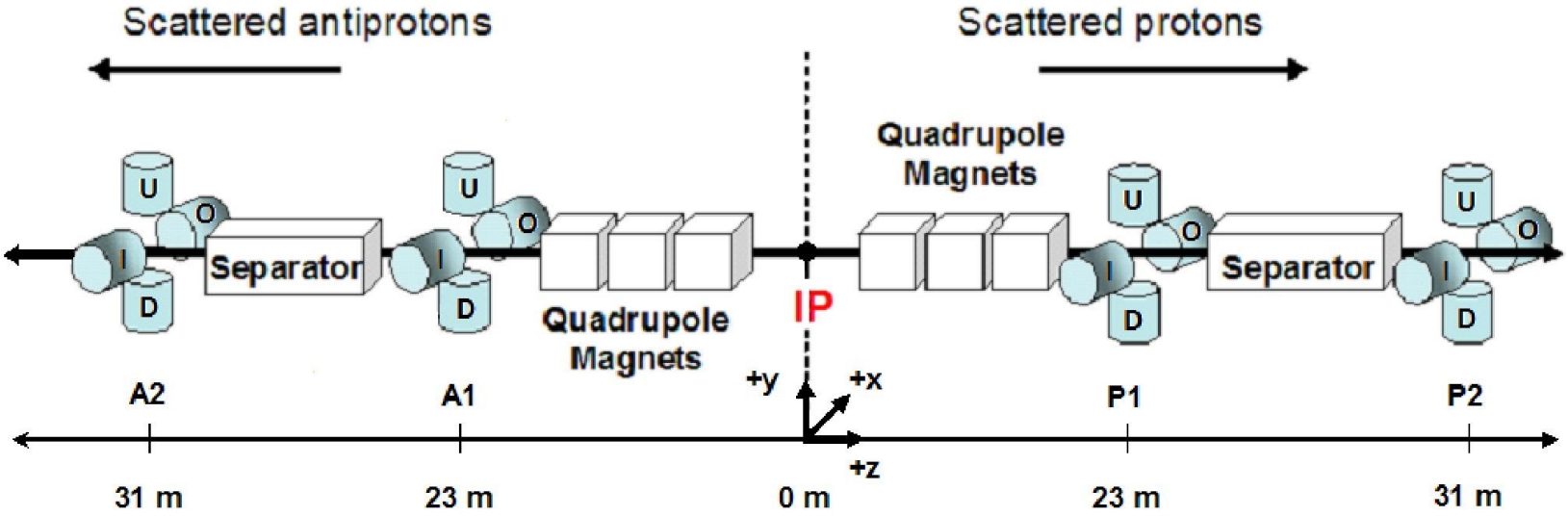
- 26 candidate events, to bkg prediction of $5.4^{+4.2}_{-2.9}$ in excess bin $\Delta>0.85$
- Excess significance: 4.1σ

dσ/d|t| in elastic ppbar scattering

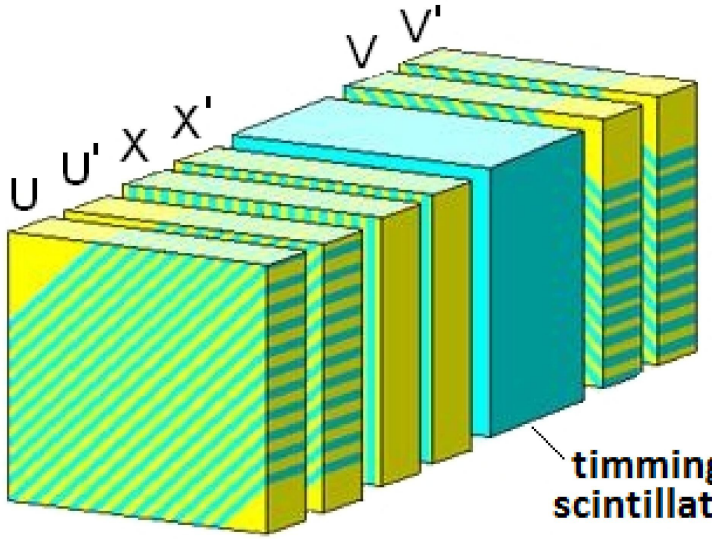
http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/QCD/Q20/

Elastic collision data

- Special Tevatron running: L~30 nb^{-1}, β^*=1.6 m, single bunch
- Forward Proton Detector (FPD)

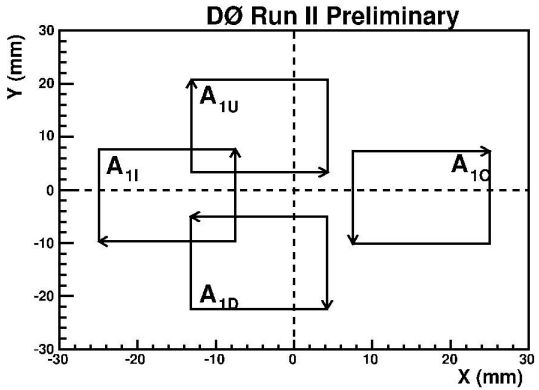


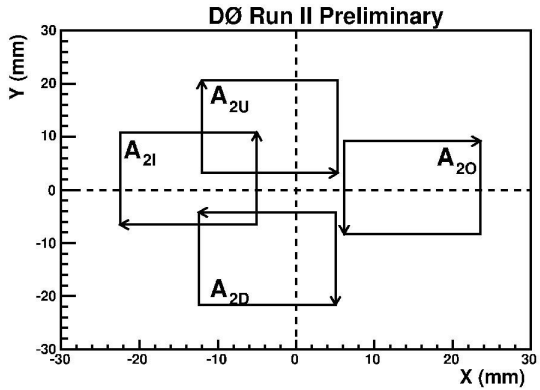
- 8 quadrupole spectrometers
- Trigger by coincidence of diagonal pairs of detectors (elastic combination)

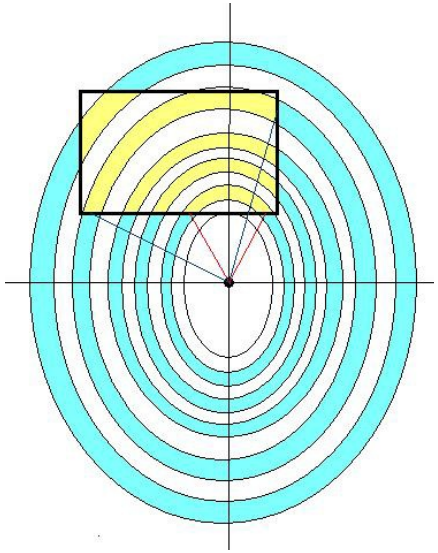


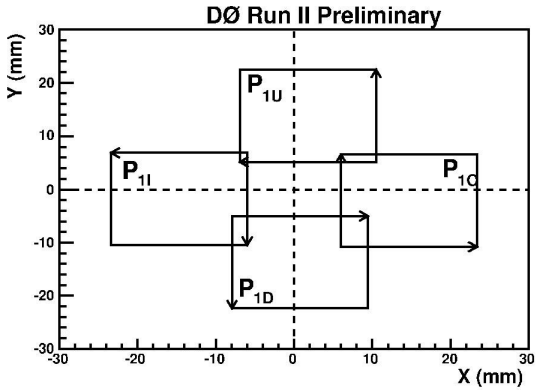
FPD commissioning

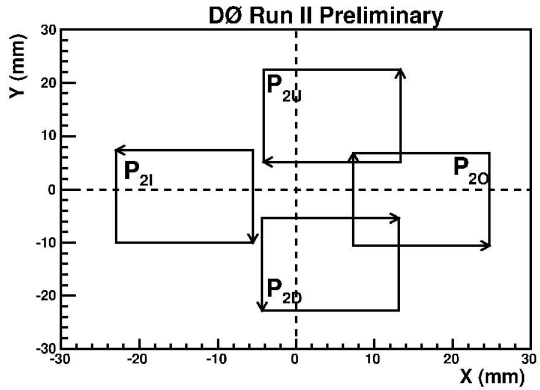
- Alignment, a major challenge

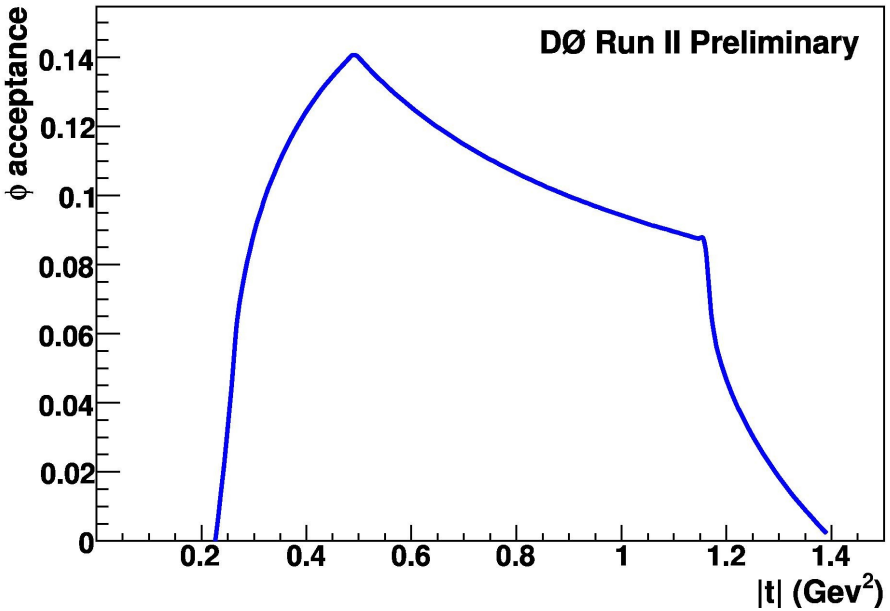






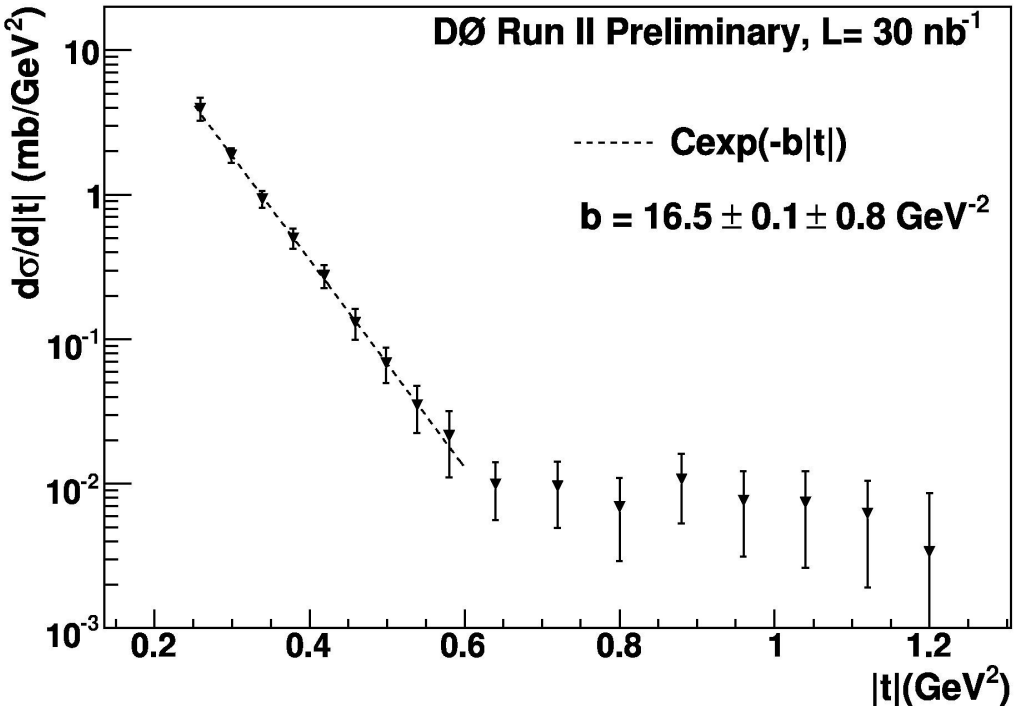






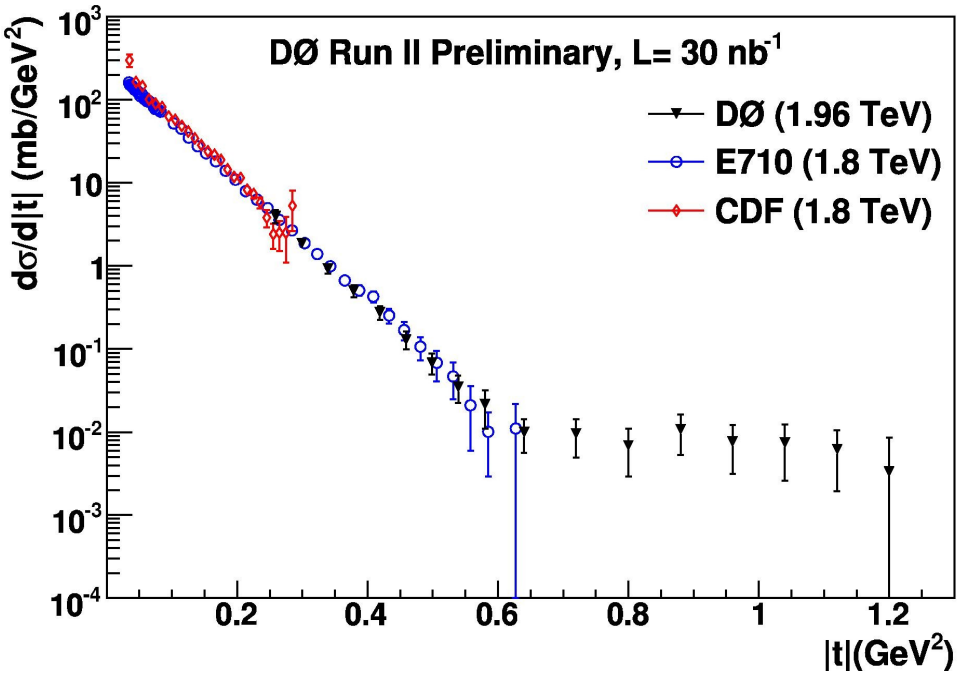
Elastic cross-section

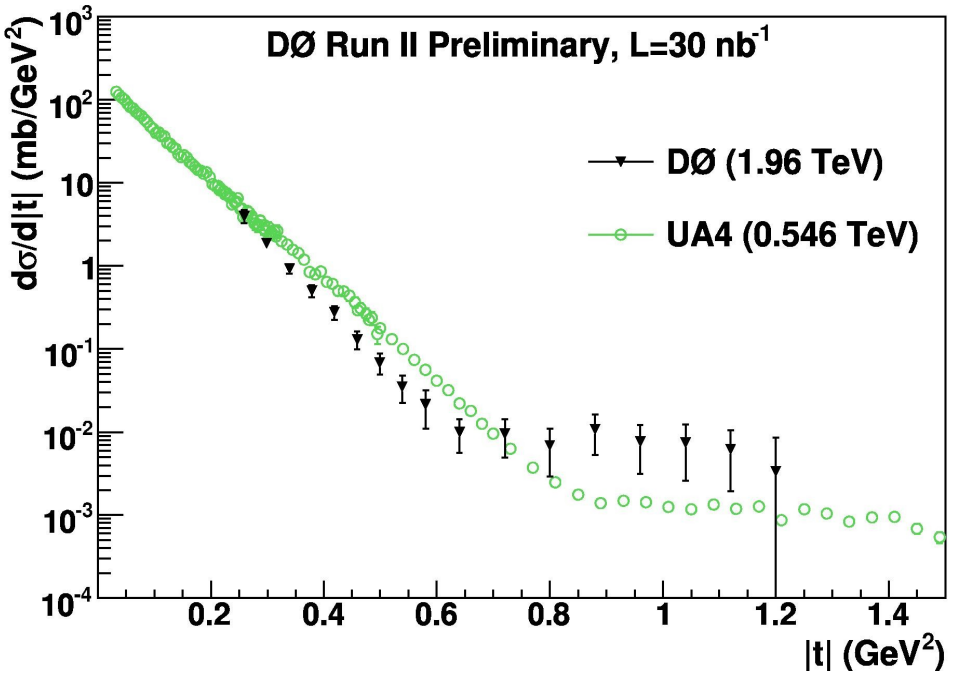
- $d\sigma/d|t|$ where $|t|$ 4-momentum transfer squared
  - $0.25 < |t| < 0.6$ GeV^2 and $0.6 < |t| 1.2$GeV^2
- Fit to form $d\sigma/d|t| = C \exp(-b|t|)$ in range $0.25 < |t| < 0.6$ GeV^2
  - $b = 16.54 \pm 0.10(\text{stat}) \pm 0.80(\text{syst})$ GeV^{-2}
- 14.3% luminosity uncertainty not included in plots
- Other important systematics: detector positions and efficiencies, beam divergence, analysis function



Elastic cross-section

- Comparison to other experiments
  - Slope parameters consistent with similar √s
  - Position of first diffraction minimum moves to lower values of |t| with increased collision energy





Summary

- Hard work to obtain the world's best JES (1-2%) is paying off!
  - Precise measurements of QCD quantities such as jet cross-sections
  - First 3-jet measurements
- Commisionning of the FPD is complete
  - First measurement $d\sigma/d|t|$ shown here
  - More measurements coming
- Proton structure and mechanisms of hadron-hadron interactions
- New constrains on gluon PDF uncertainties
- Unprecedented reach: high η measurements, searches in high-mass-high-p_T region, ...