PDF Constraints from DØ Data

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DIS 2007
April 17, 2007

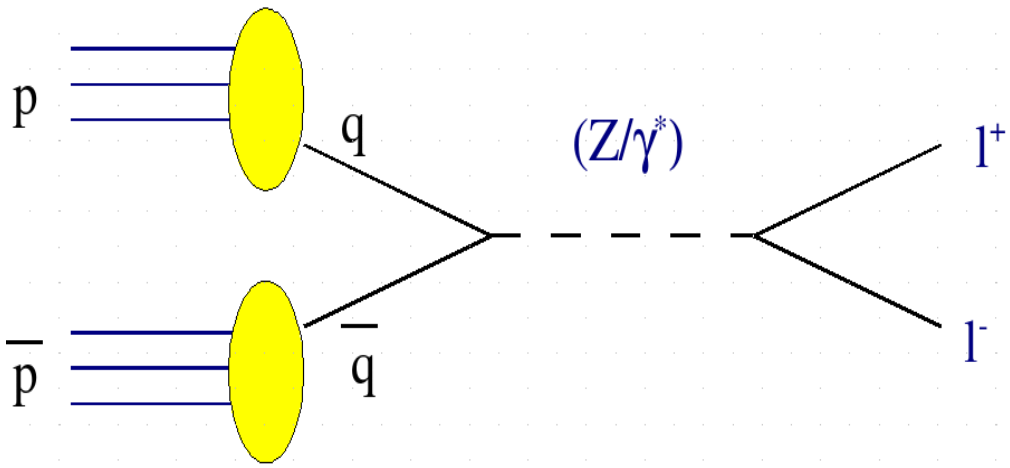
Introduction

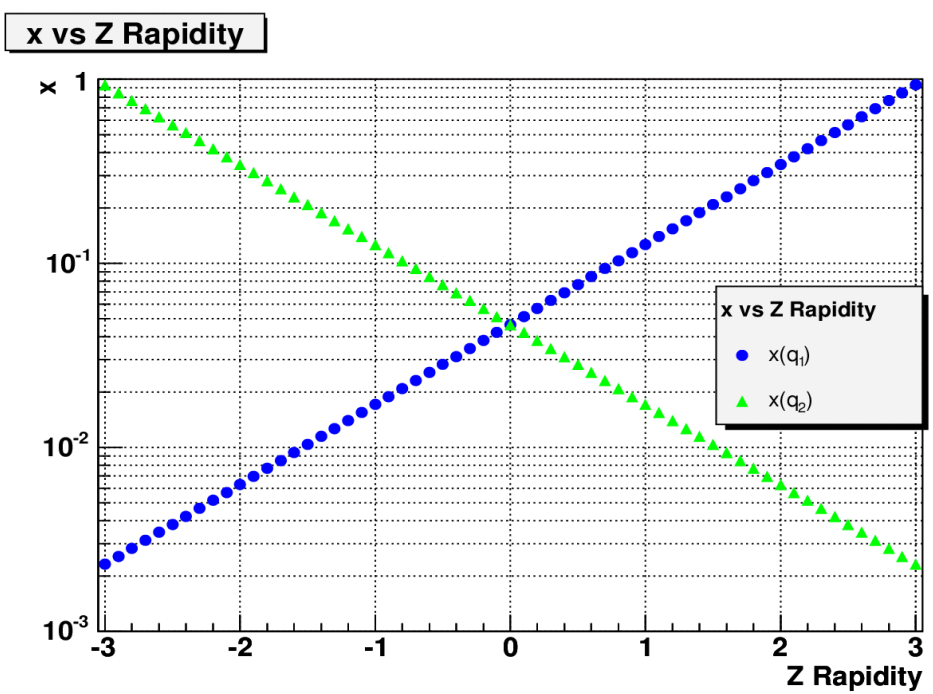
- A good understanding of PDFs is critical to the success of the physics program underway at the Tevatron
- Tevatron experiments are in position to contribute to our understanding of PDFs
  - $p\bar{p}$ provides special opportunities, $\sqrt{s}$ allows access to wide range of (x, Q^2), already have a large data set in hand and accelerator is performing very well, ...
- A number of the measurements we can make that are sensitive to PDFs involve LO processes
- Due to the processes involved, and the excellent coverage of detectors, often deal with clean signals and low backgrounds

Topics

- Z rapidity using electrons
- $W \rightarrow \mu\nu$ charge asymmetry
- γ + jets differential cross section

Z Rapidity





- Main contribution from $q\bar{q}$
- $Q^2 \sim M^2(Z) \sim 10^4\,\mathrm{GeV}^2$
- Momentum fraction x is related to Boson rapidity at LO through

$$x_{1,2} = \frac{M_Z}{\sqrt{s}} e^{\pm y}$$

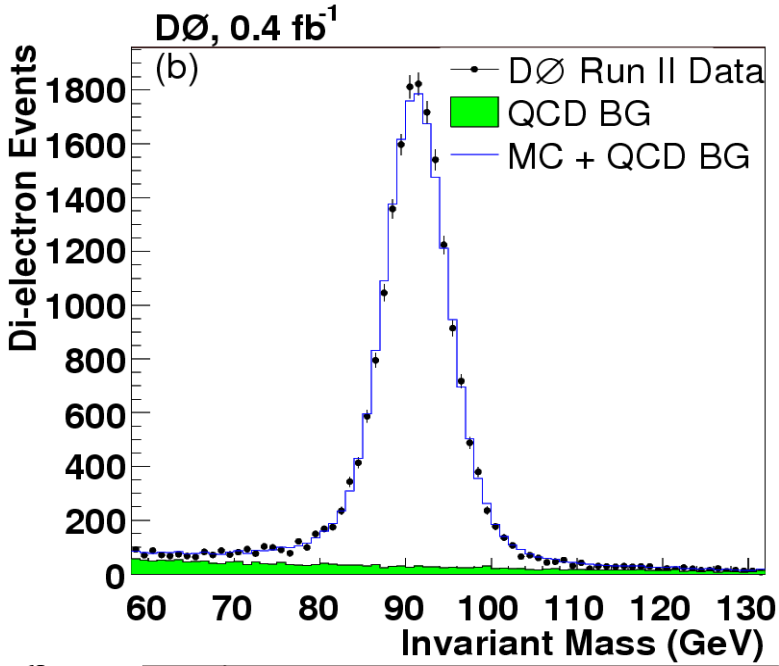
At large boson rapidity, probing low and high x

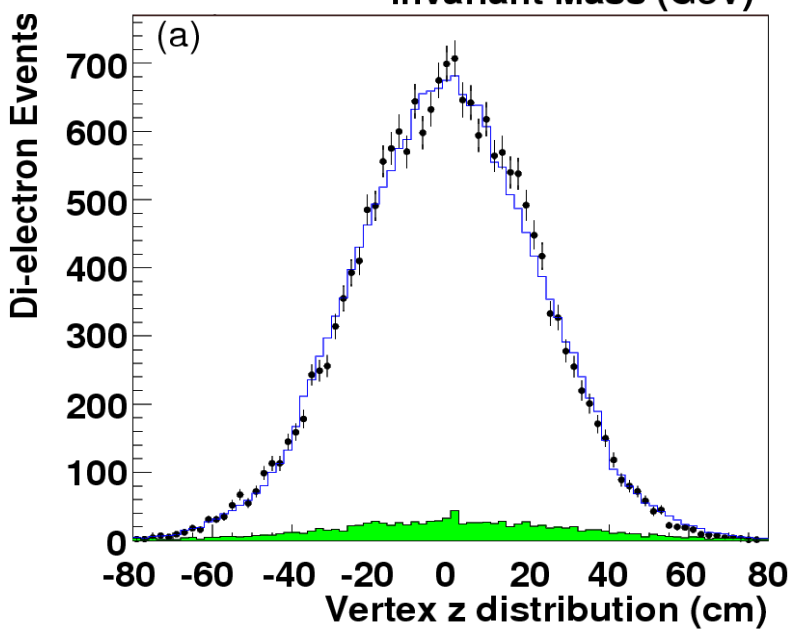
- Measurement overlaps in (x,Q^2) with jet data, but different systs

Z Rapidity

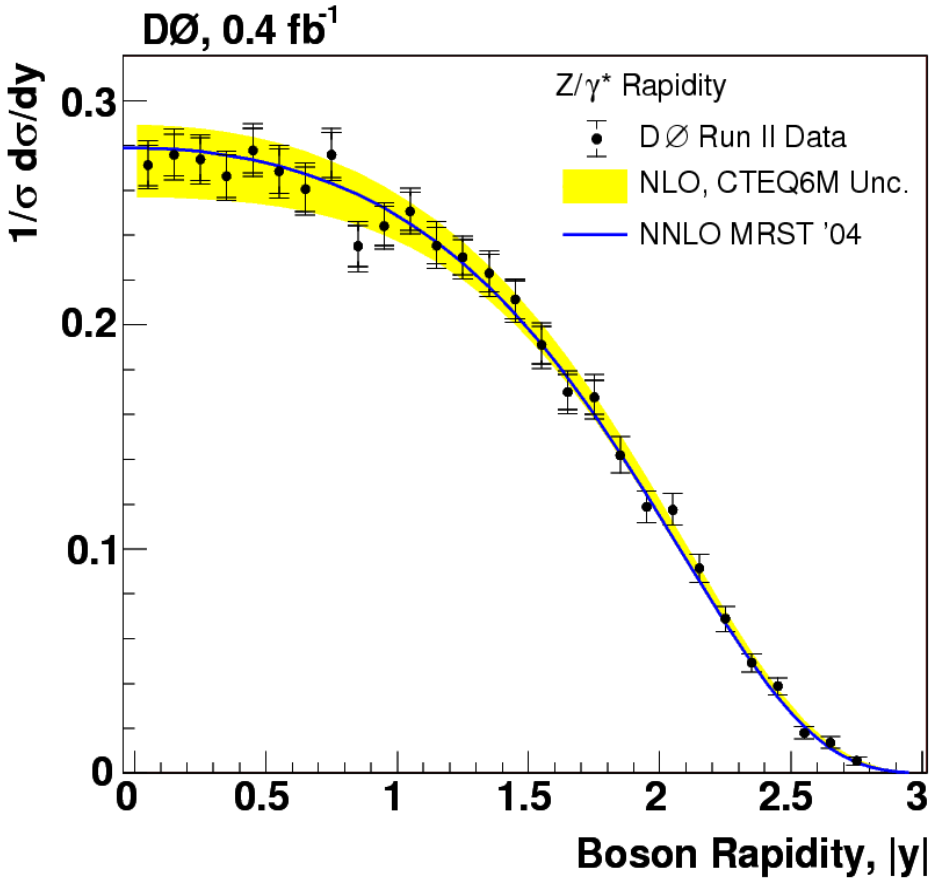
Event Selection:

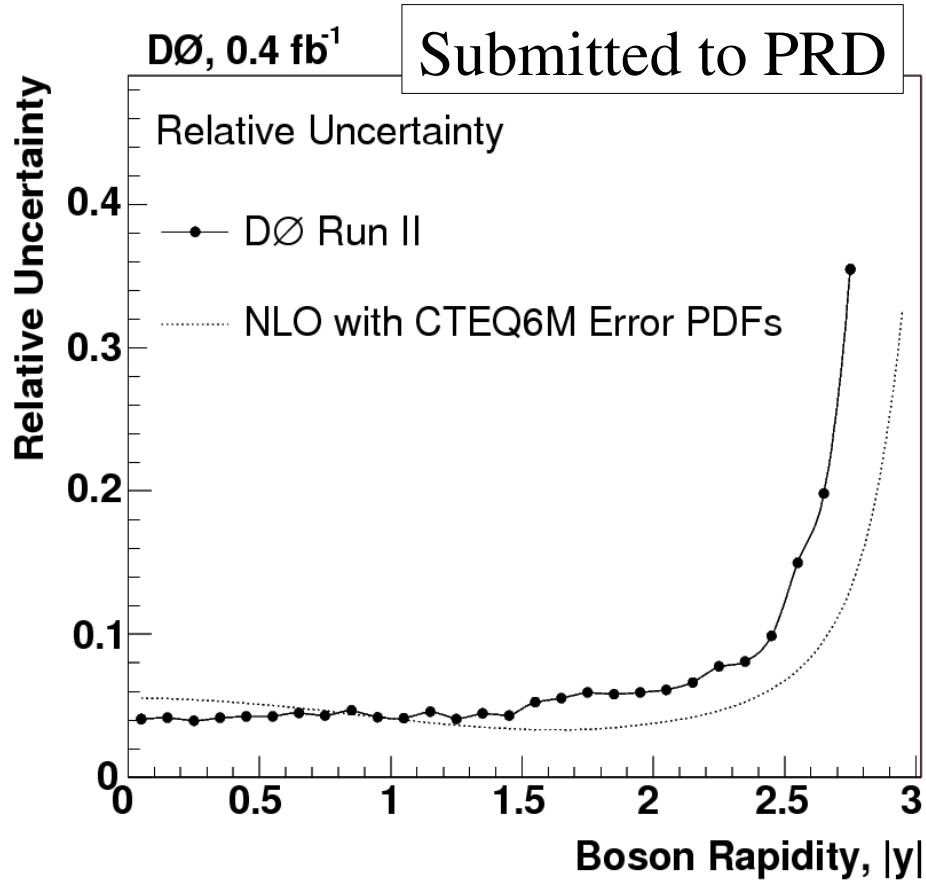
- Require 2 isolated electrons
  - $p_T(e1)>15$ GeV, $p_T(e2)>25$ GeV
  - Pass shower shape cuts
  - At least one electron has track match
- $|\eta_D| < 0.9$ $1.5 < |\eta_D| < 3.2$
- 71 GeV < M(ee) < 111 GeV
- Main backgrounds: multijet or e+jet
- 18k Z events in 0.4 fb^{-1}





Z Rapidity

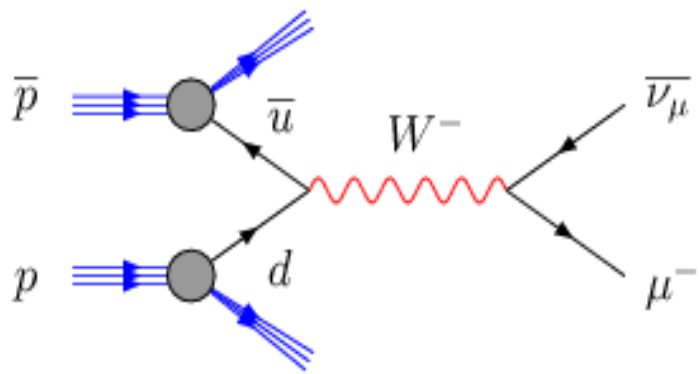




- Main contributions to syst's: eff's, backgrounds. At high y: eff's, PDFs
- Theory and data in good agreement
- Measurement is currently statistics limited

* Curves made with code from Anastasiou, et. al., PRD69, 094008 (2004).

W Charge Asymmetry



$$u + \bar{d} \rightarrow W^+ \rightarrow \mu^+ \nu$$

$$\bar{u} + d \rightarrow W^- \rightarrow \mu^- \bar{\nu}$$

W gets boost in direction of:

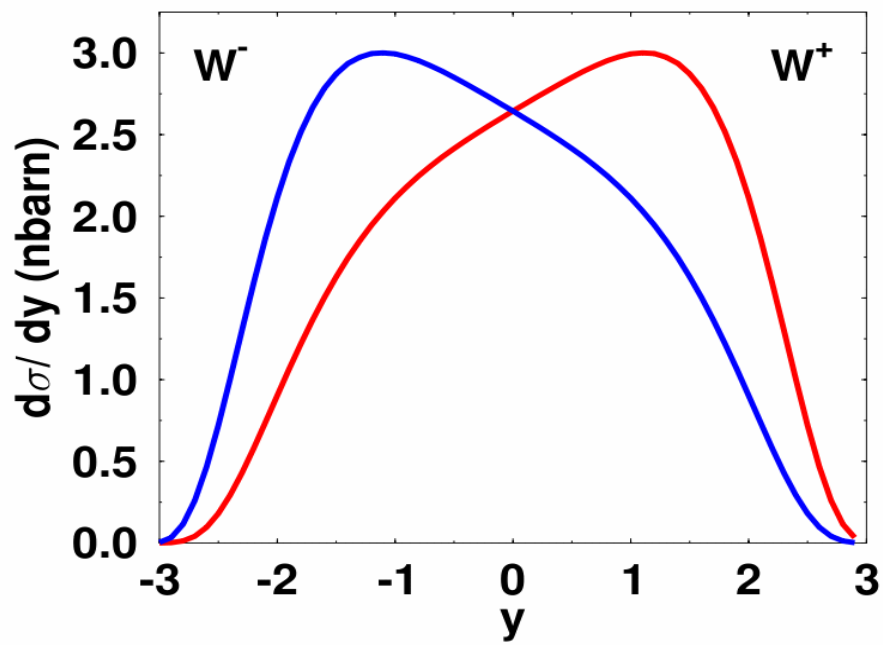
p beam -- W^+

$\bar{p}$ beam -- W^-

- Constrains the u/d ratio
- $Q^2 = M_W^{\ 2}$ $\quad 0.005 < x < 0.3$

Measure asymmetry of decay products:

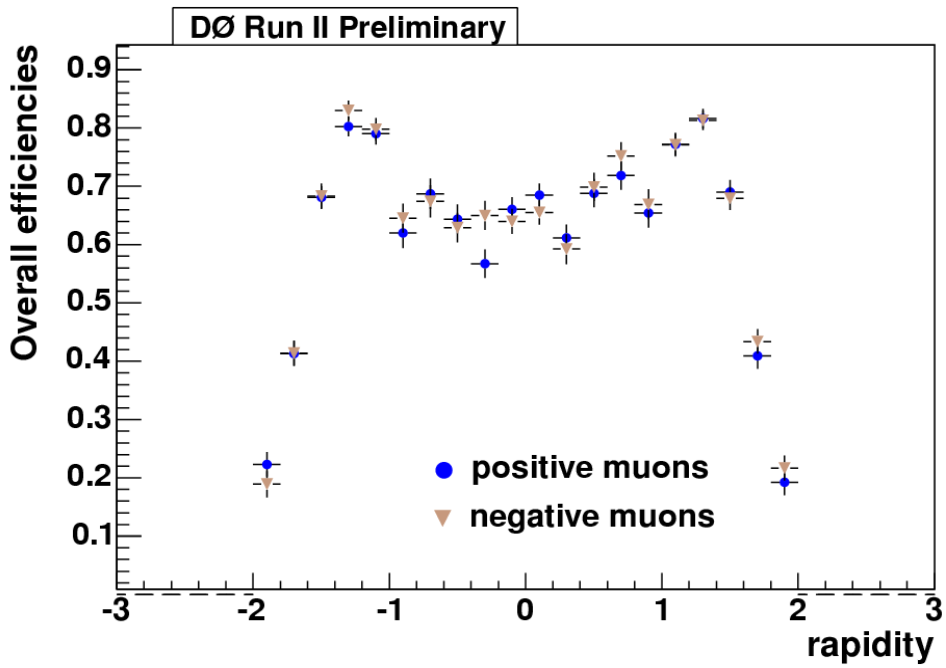
$$A(y_\mu) = \frac{\frac{d\sigma(\mu^+)}{dy} - \frac{d\sigma(\mu^-)}{dy}}{\frac{d\sigma(\mu^+)}{dy} + \frac{d\sigma(\mu^-)}{dy}}$$



where: $$\frac{d\sigma(\mu^\pm)}{dy} = \frac{N_{\mu^\pm}(y)}{LA\epsilon_\pm(y)}$$

W Asymmetry – Analysis details

- Same Acceptance for μ^+, μ^-
  - Cancels in asymmetry
  - Reduces dependence on PDFs
- Low charge misID rate: 1/10k

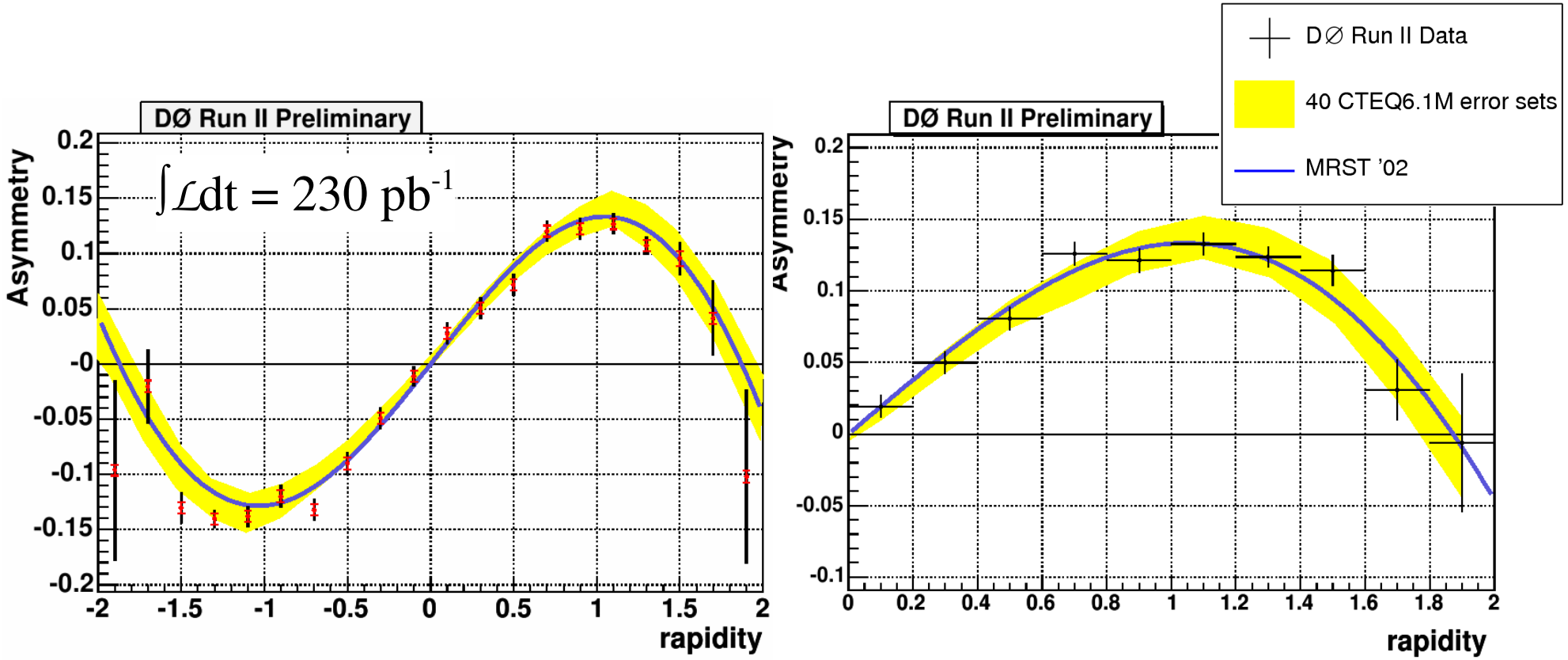


Cuts:

- Isolated muon with $p_T > 20$ GeV

  (lower than typical electron p_T cut)
- $|\eta| < 2$
- $\not{E}_T > 20$ GeV; $M_T(W) > 40$ GeV
- Backgrounds: $Z \rightarrow \mu\mu$,(~4%), $W \rightarrow \tau\nu$, (~2%), Multijet (~3%)

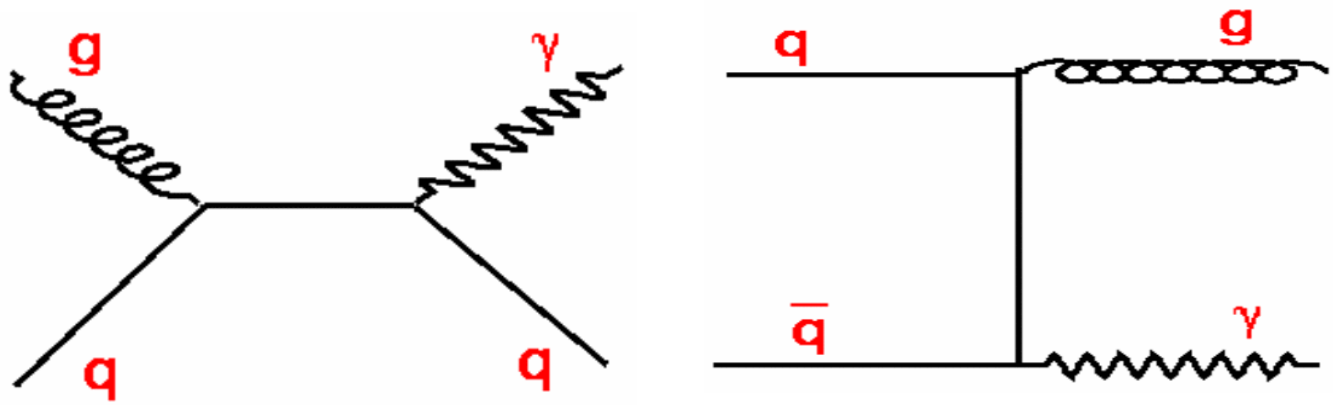
W Charge Asymmetry with muons



- Curves produced with Resbos-A
- Main systematic uncertainty is from efficiencies $\varepsilon_{\pm}$
- Measurement currently statistics limited

γ + Jet + X Differential Cross Section

Main Contributions



- Sensitive to gluon
- Compton diagram dominates for $p_T(\gamma)<150$ GeV

Measurement made in 4 kinematic regions defined by $\eta(\gamma)$ and $\eta(\text{jet})$

Region 1: γ central, jet central; $\eta(\gamma) \times \eta(\text{jet}) > 0$ -- Same Side (SS)

Region 2: γ central, jet central; $\eta(\gamma) \times \eta(\text{jet}) < 0$ -- Opposite Side (OS)

Region 3: γ central, jet forward; $\eta(\gamma) \times \eta(\text{jet}) > 0$ -- Same Side (SS)

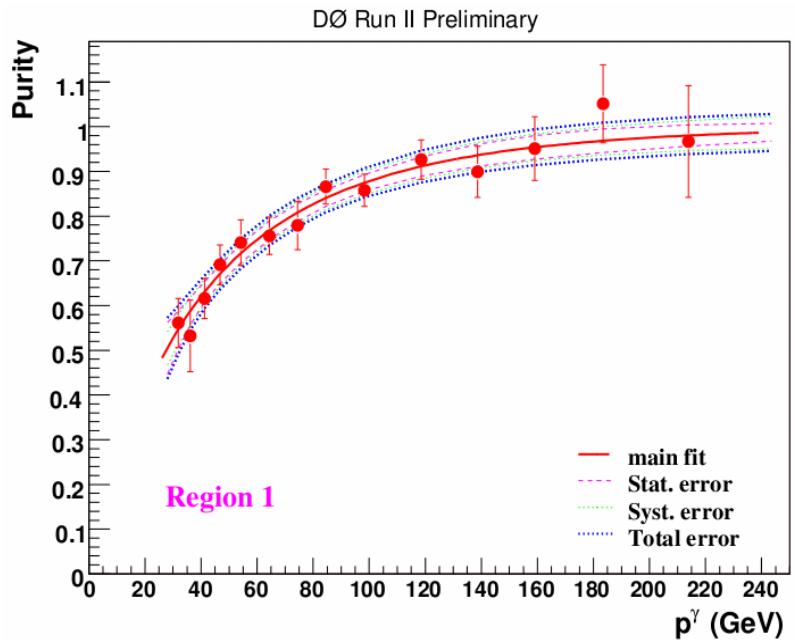
Region 4: γ central, jet forward; $\eta(\gamma) \times \eta(\text{jet}) < 0$ -- Opposite Side (OS)

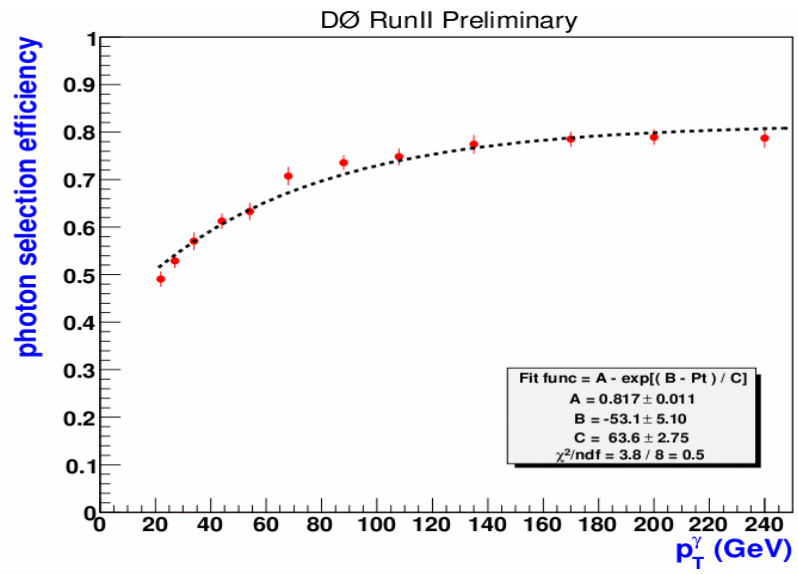
For more details, see O. Atramentov's talk in Hadronic Final States and QCD:1

γ+Jets Analysis

Selection Criteria:

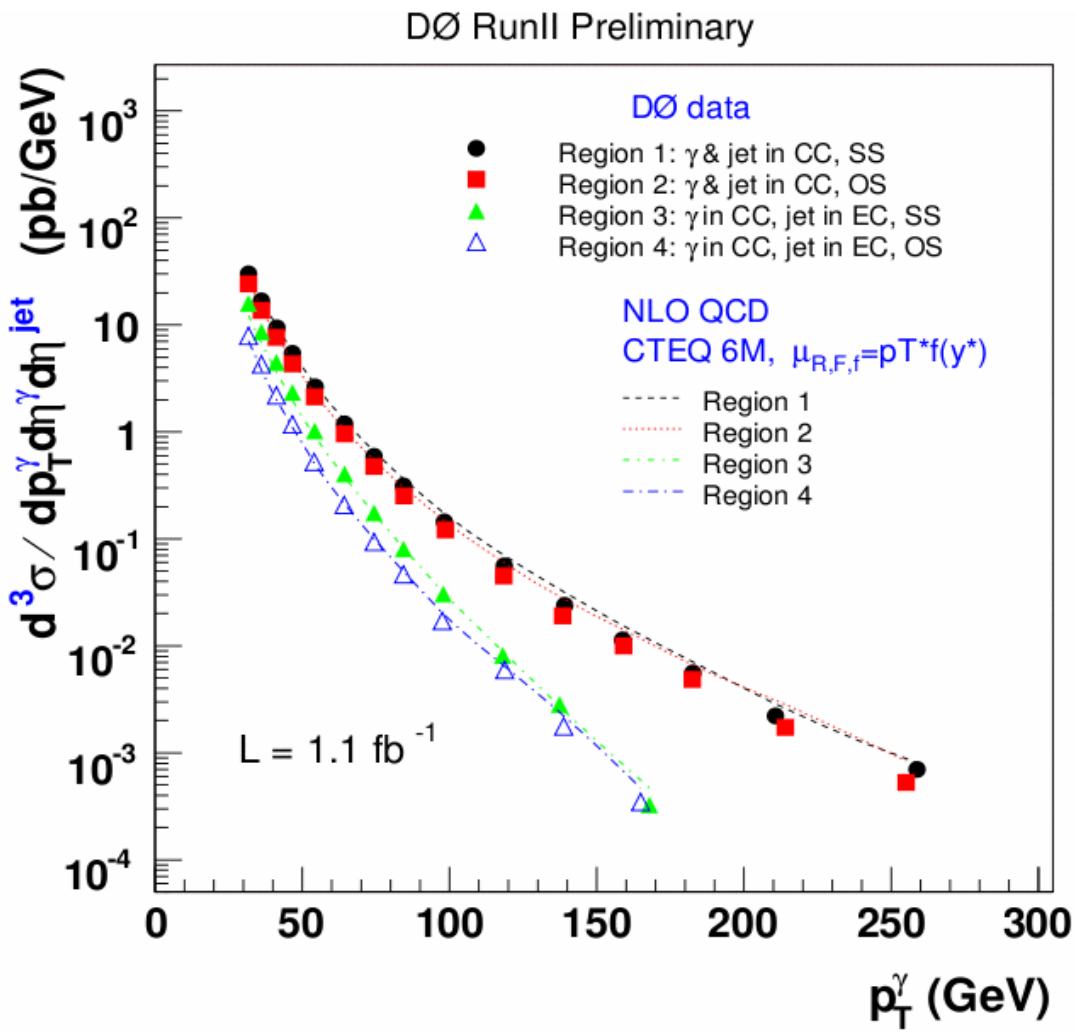
- Isolated γ in central region
  - anti-track match
- Leading jet with p_T>15 GeV in central or forward region
- γ, jet separated in η–φ space dR(γ,jet)>0.7
- Main backgrounds from jet-jet or e-jet events where jet or e fakes γ
  - Use Neural Network for background suppression, to measure γ purity





γ+Jet Differential Cross section

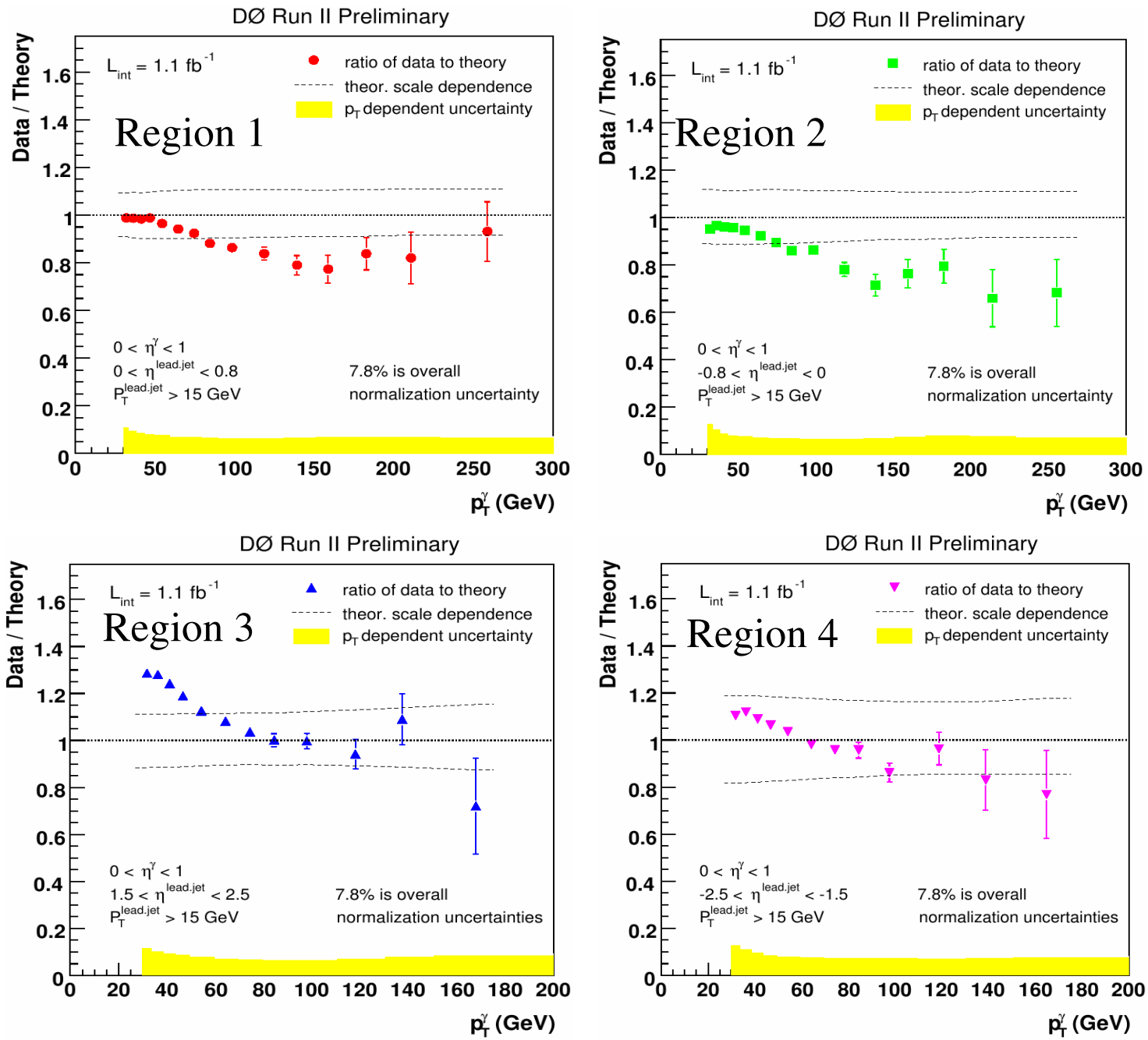
- 2.4M events in 1.1fb^{-1}
- Main systematics due to
  - purity, γ and jet selections (~3-5% each)
  - luminosity (~6%)



NLO QCD curves produced with JetPhox using CTEQ6.1M PDFs

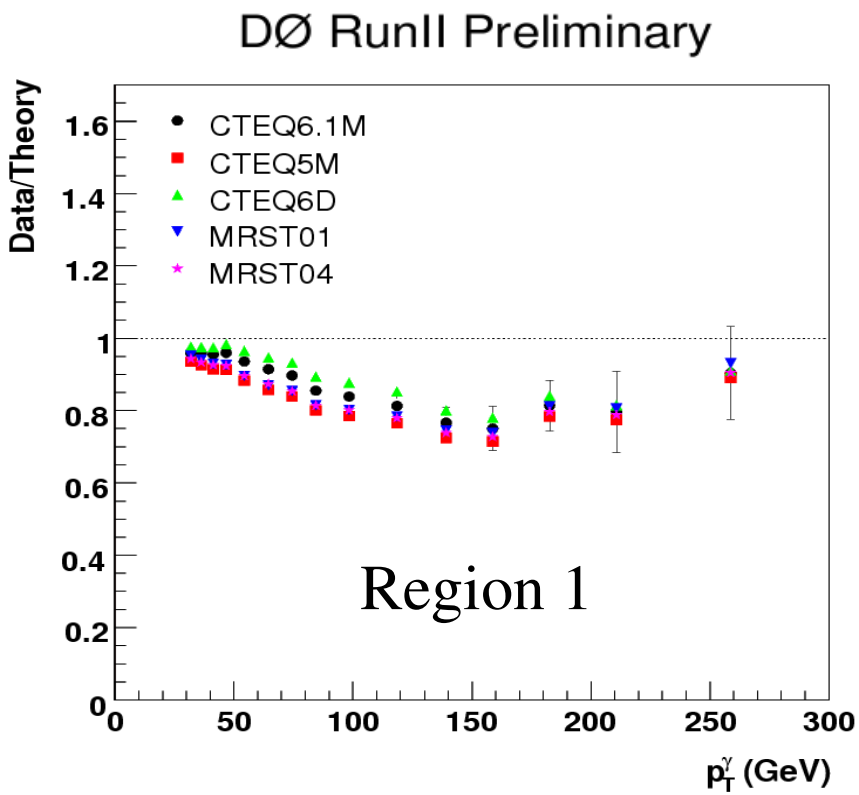
(http://wwwlapp.in2p3.fr/lapth/PHOX_FAMILY/main.html)

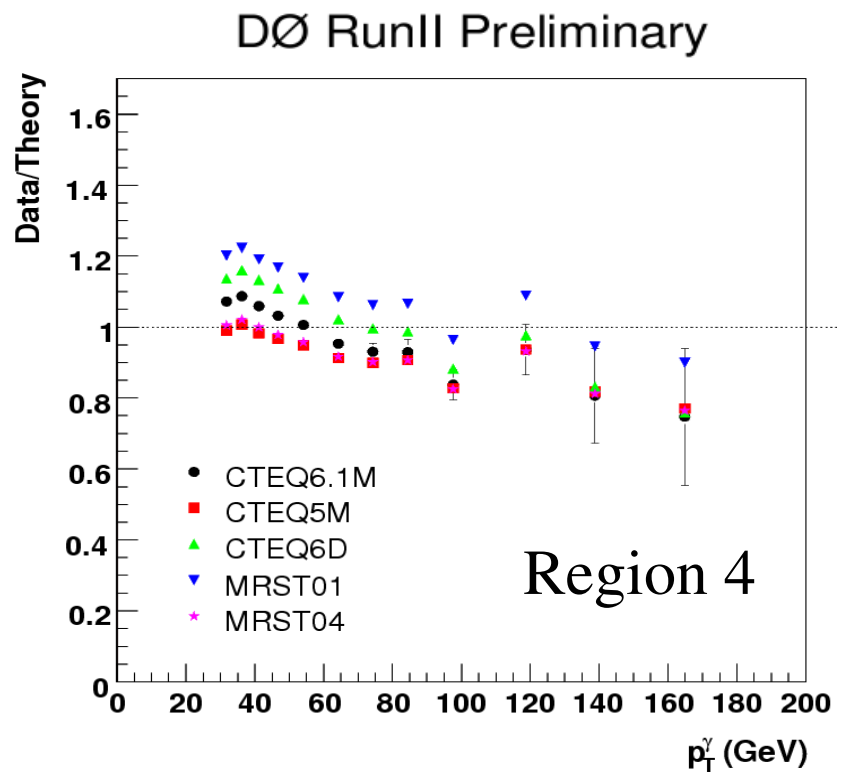
γ+Jet --- Data/Theory



Data/theory disagreement similar to that seen earlier by UA2, CDF, and D0 RunII.

γ+Jet Data/Theory for Different PDFs





- JetPhoX is used for theory curves
- Only experimental errors are shown

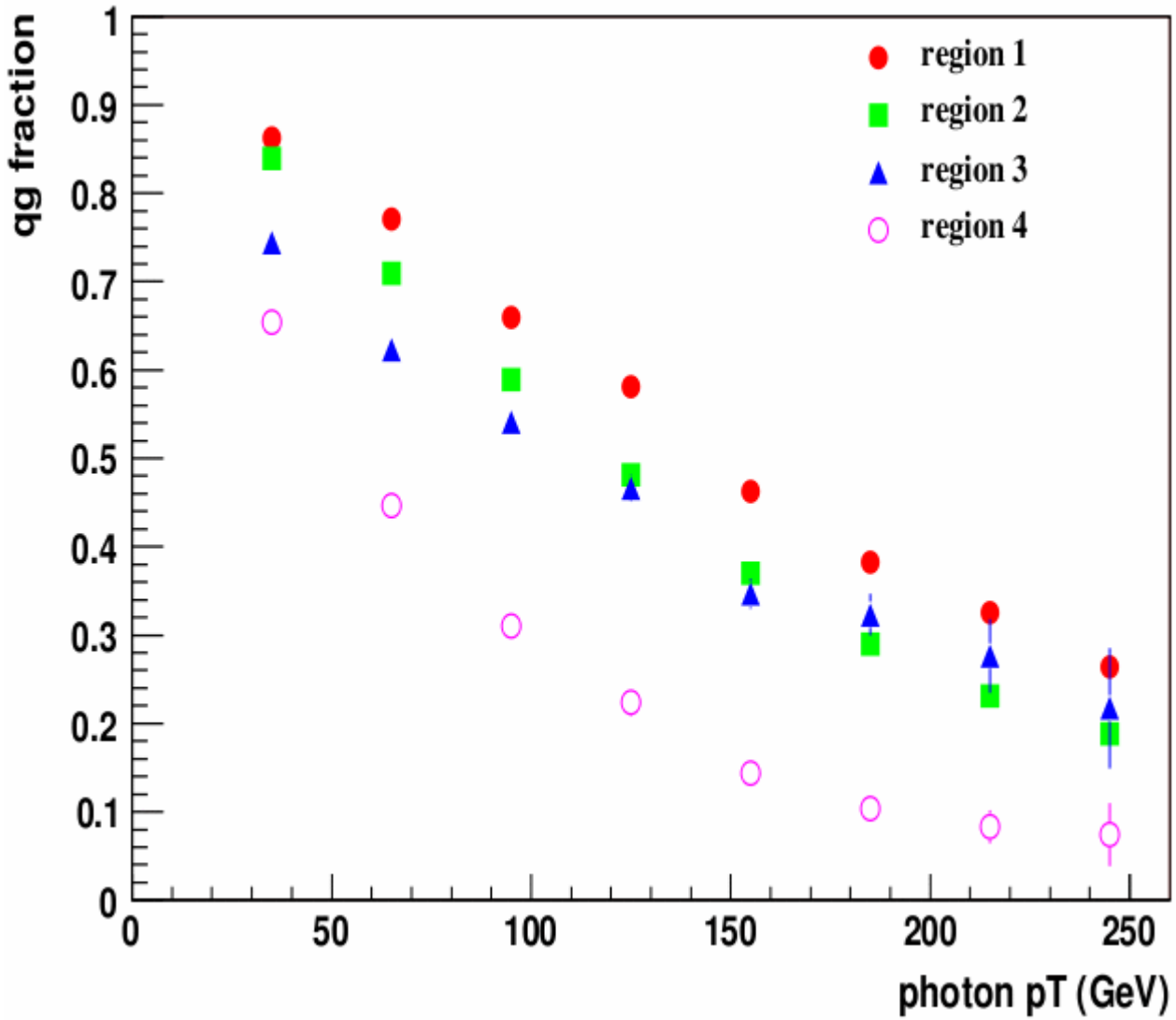
Region 1: γ & Jet central, SS

Region 4: γ central, Jet forward, OS

Summary

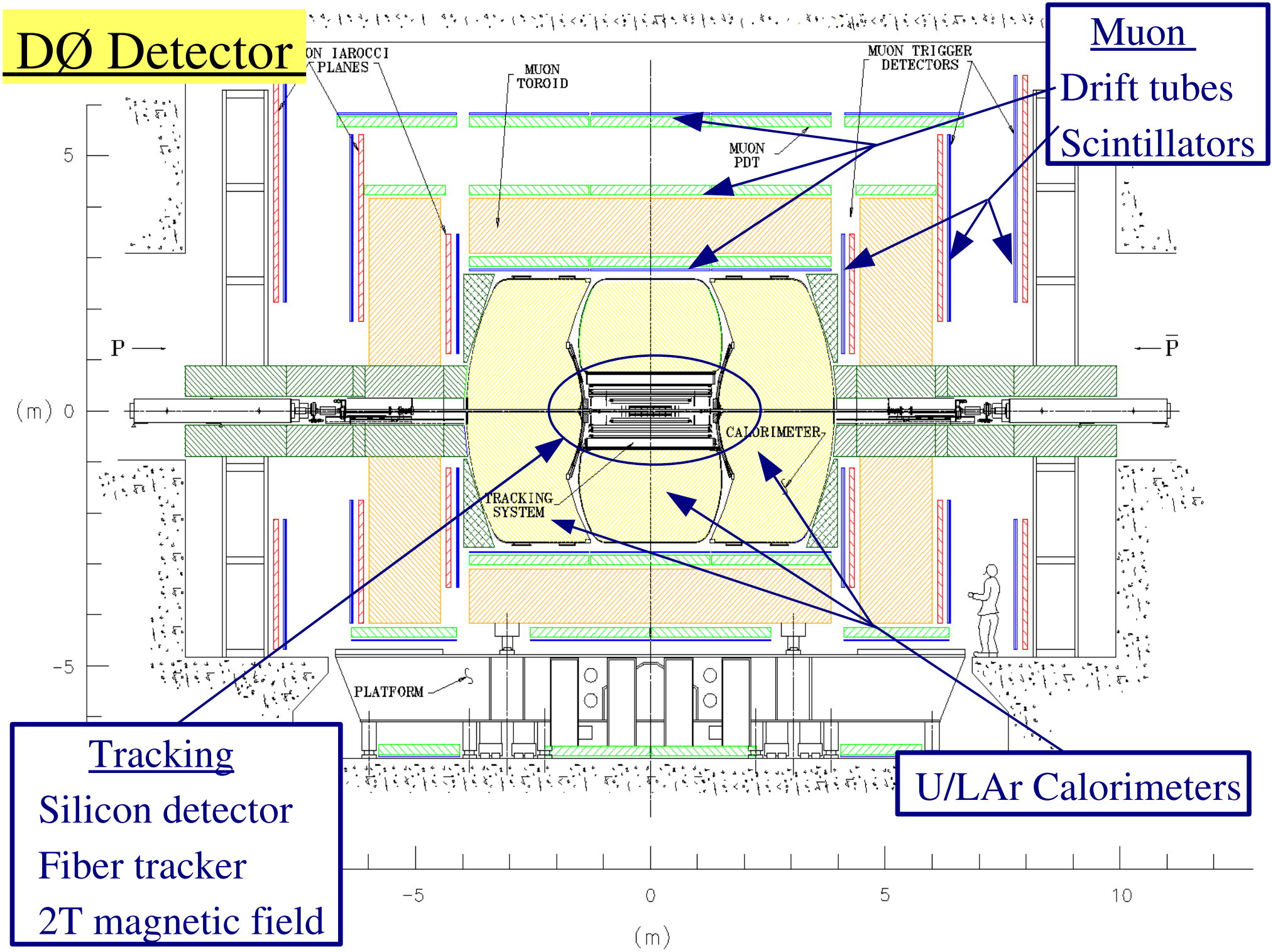
- Even with small statistics, DØ analyses sensitive to PDFs
- As usual, analyses are done using fraction of available data
  - Currently have 2.4 fb^{-1} on tape
  - Tevatron is still running
- In addition, there are a number of analyses in progress that will complement the existing set
    - W+jets/Z+jets
    - σ(W + c-jet)/σ(W+jet), W + b-jet, γ+b-jet
    - W charge asymmetry with electrons

Additional Slides



Fractional contribution of qg->qγ to production of direct γ + leading jet. Done with Pythia

DØ Detector


ON IAROCCI PLANES
MUON TOROID
MUON TRIGGER DETECTORS
MUON PDT
P
P̄
CALORIMETER
TRACKING SYSTEM
PLATFORM
(m) 0
5
-5
-5
0
5
10
(m)
Muon
Drift tubes
Scintillators
Tracking
Silicon detector
Fiber tracker
2T magnetic field
U/LAr Calorimeters