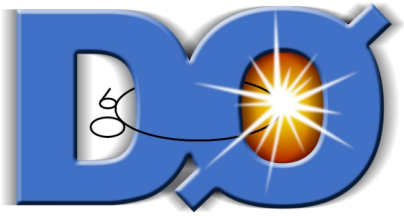
W asymmetry and Z Rapidity Measurements



DIS'05, Madison

April 27, 2005

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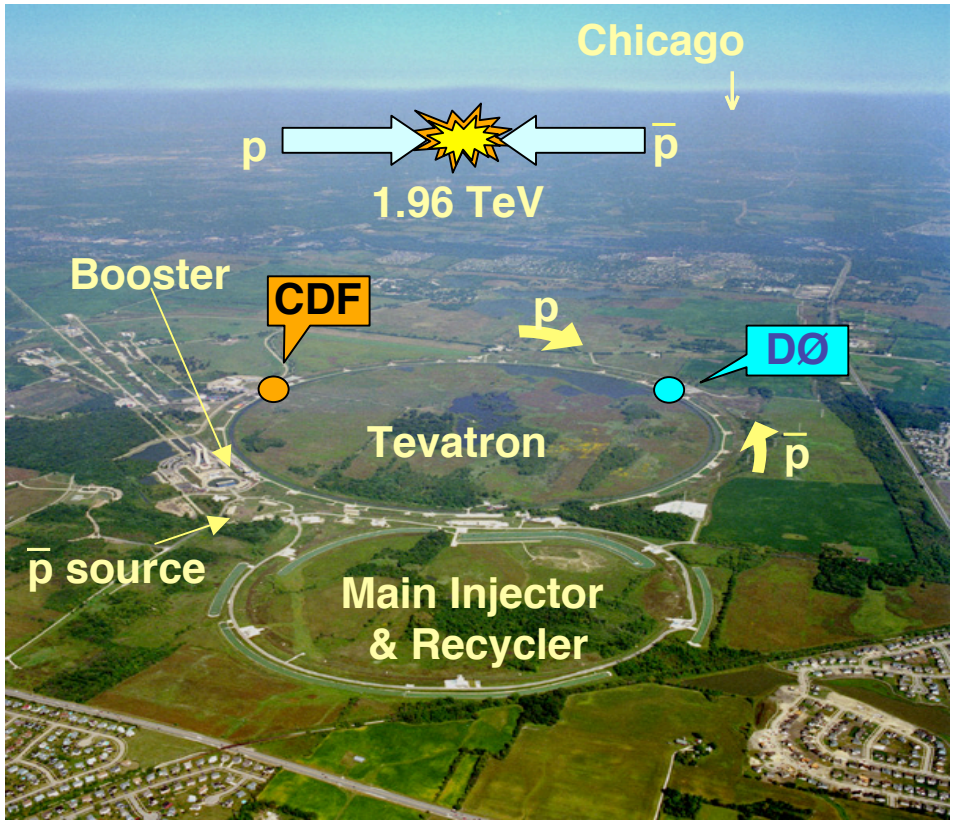
For the D0 and CDF Collaborations

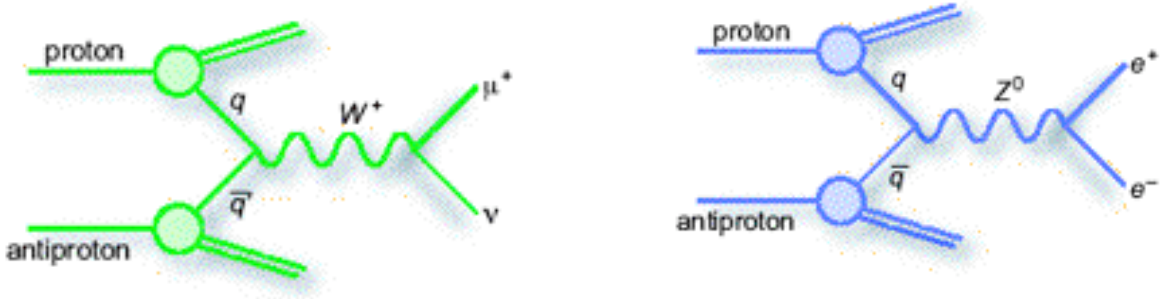
Outline

- Introduction
- D0/CDF detectors
- W Charge Asymmetry
- Z Rapidity Distribution
- Prospect
- Summary



Introduction

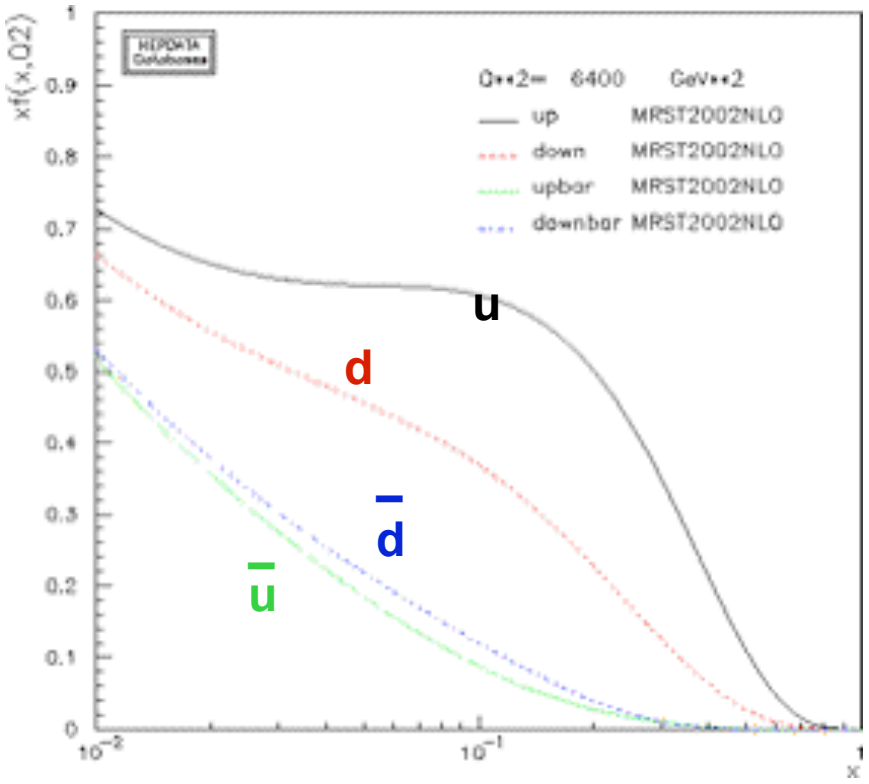
- W and Z productions at Tevatron



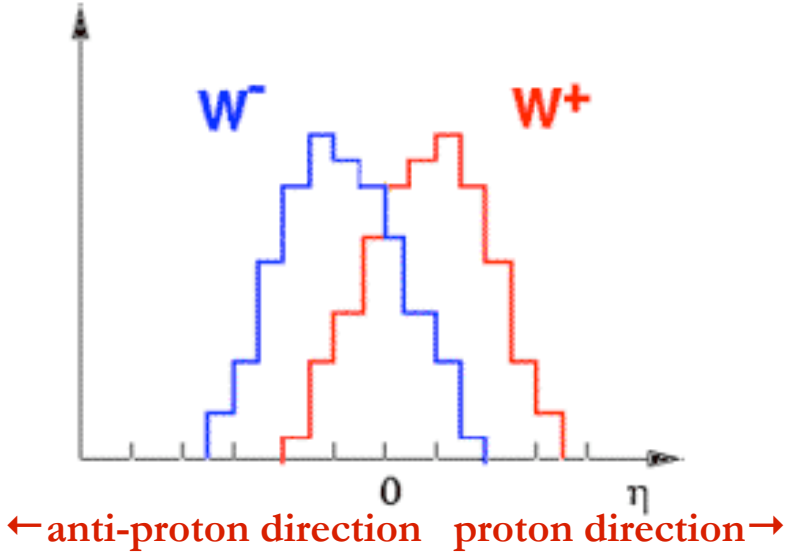
✓ Tevatron precision measurements (W mass, σ and pt distribution of W and Z, and …) are limited by the PDF uncertainties (δM_W = 17 MeV/c^2)

✓ But, Rapidity distribution (ds/dy) and W production asymmetry are inputs to constrain PDFs at high Q^2

W charge asymmetry

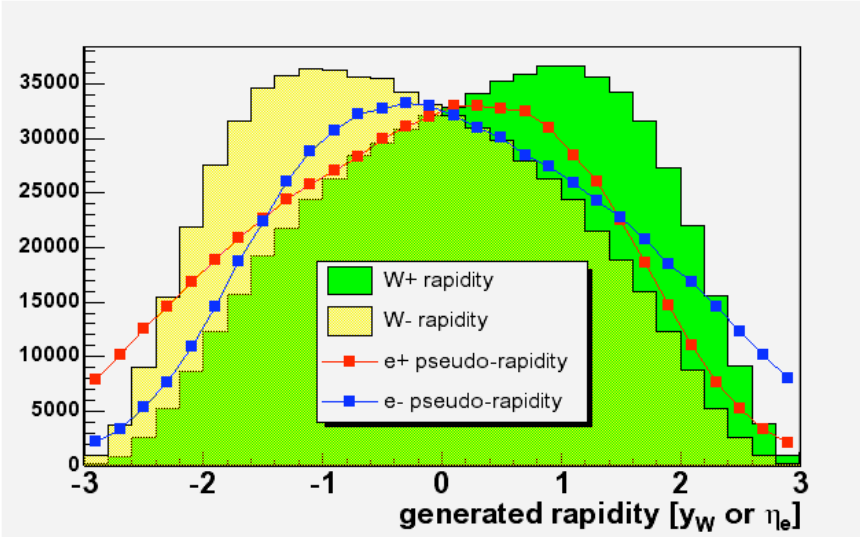


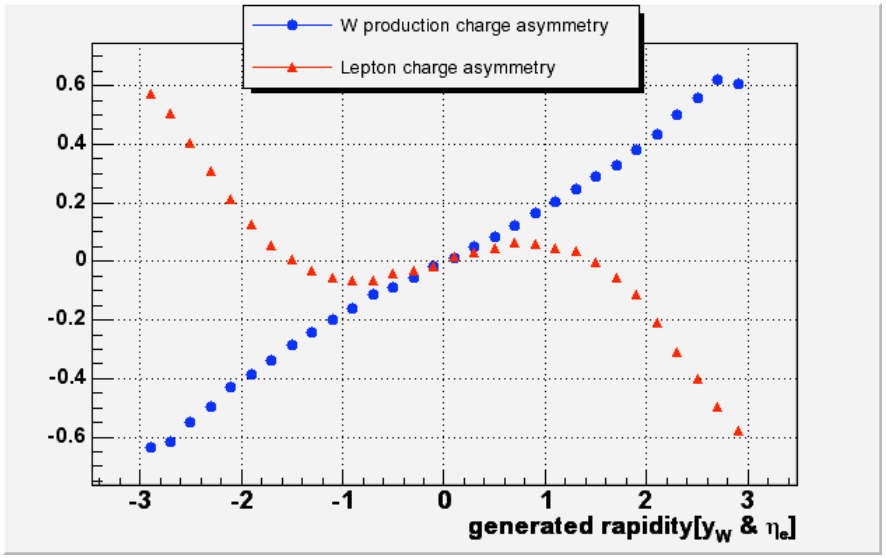
$$A(y_W) = \frac{d\sigma_+/dy_W - d\sigma_-/dy_W}{d\sigma_+/dy_W + d\sigma_-/dy_W} \approx \frac{u(x1)d(x2) - d(x1)u(x2)}{u(x1)d(x2) + d(x1)u(x2)}$$

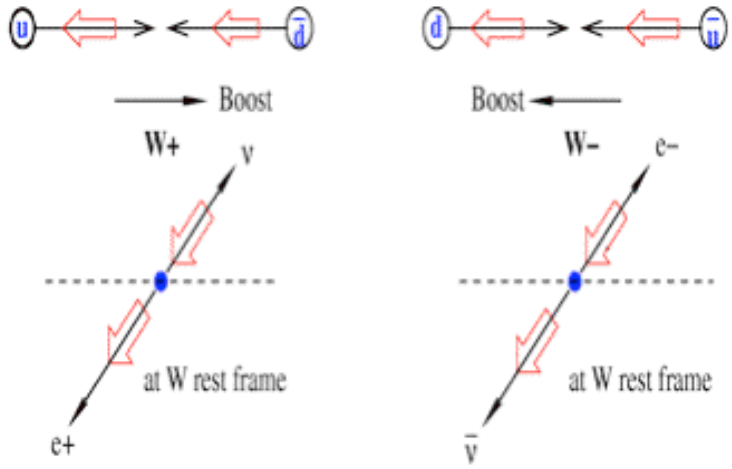


u quarks carry, on average, a higher fraction of proton momentum than **d** quarks

Lepton Charge Asymmetry



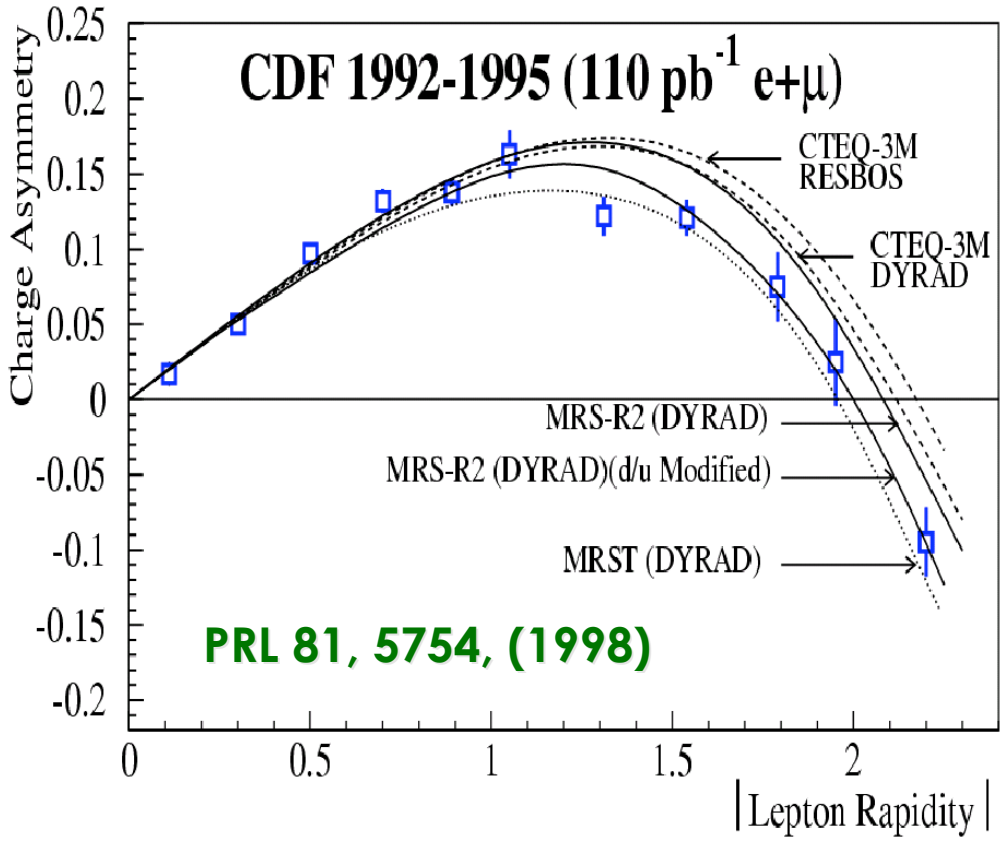




- y_W is not directly determined
- W production asymmetry ⊗ V-A decay
- Sensitivity to the PDFs, u(x)/d(x).

$$A(\eta_l) = \frac{d\sigma_+/d\eta_l - d\sigma_-/d\eta_l}{d\sigma_+/d\eta_l + d\sigma_-/d\eta_l} \sim \frac{d(x)}{u(x)}$$

W asymmetry results (CDF Run I)



CDF Run I Results (e+μ)

$L = 110\ pb^{-1}$

$E_T > 25$ GeV

Missing $E_T > 25$ GeV

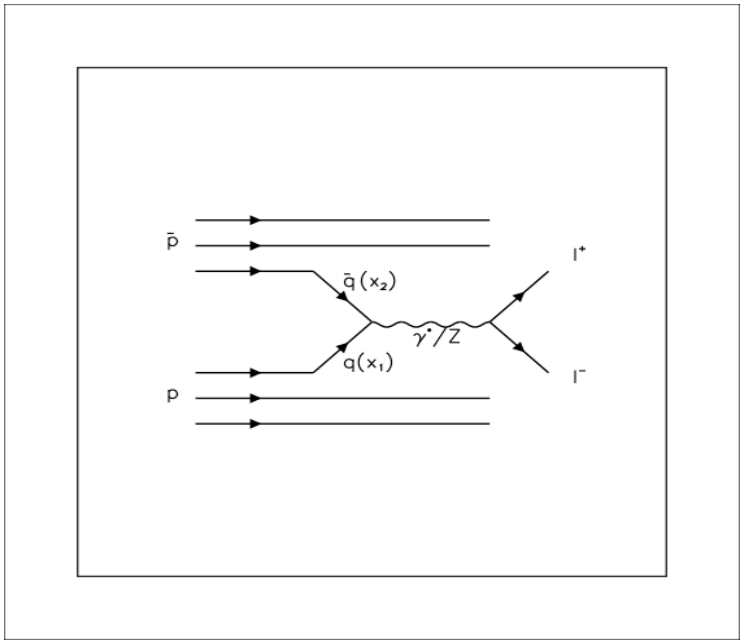
Constraint on the d/u ratio

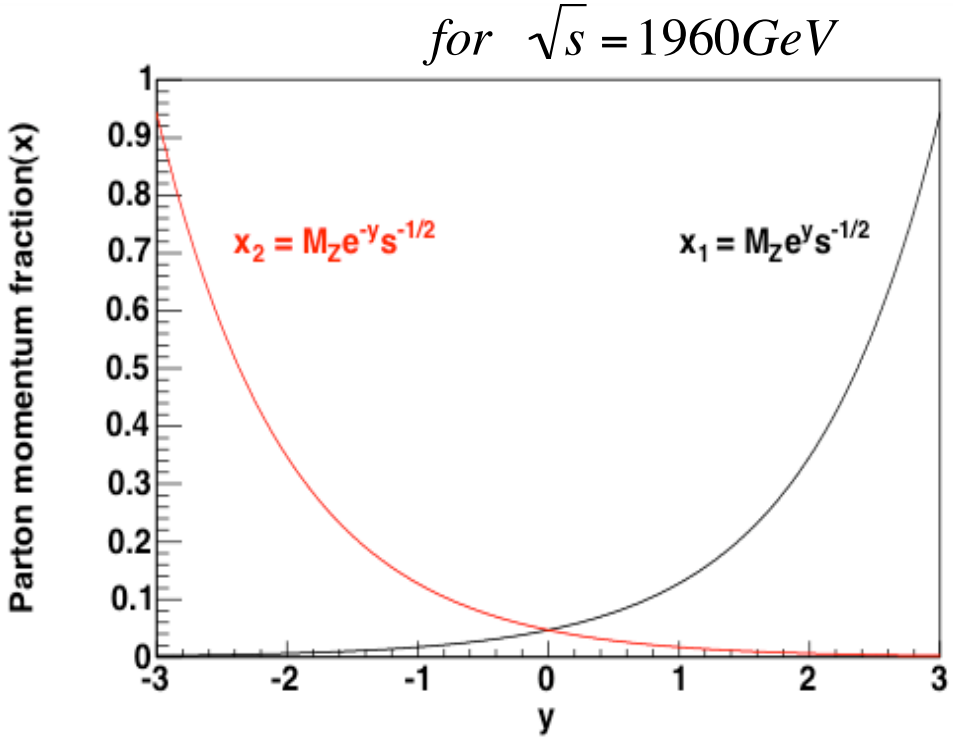
of $0.006 < x < 0.34$ at $Q^2 \approx M_W^2$

δM_W : 50 MeV/c^2 → 20 MeV/c^2

Still, least constrained at high η

Z Rapidity Distribution (dσ/dy)





The momentum fraction of parton from proton is related to y of the Z boson

The search of high y region makes it possible to probe high/low $x_{1,2}$ region

Z Rapidity Result (CDF Run I)

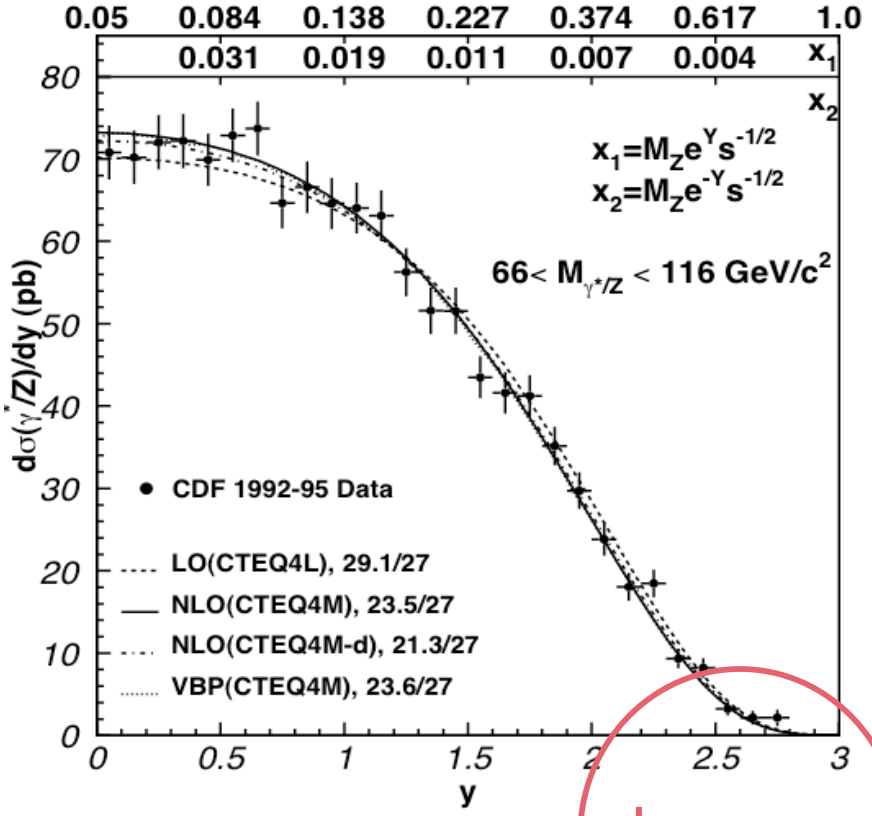
PDF predictions

LO CTEQ4 PDF

NLO CTEQ4 PDF d quark enhanced modified

NLO CTEQ4 PDF

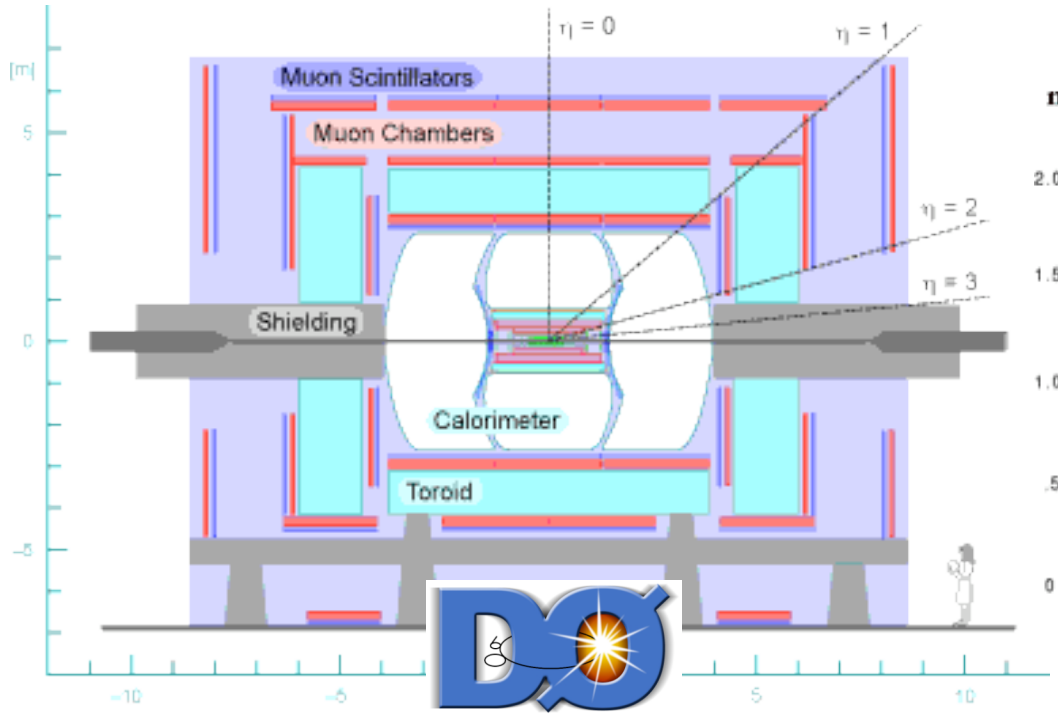
NLO gluon resummed calculation with CTEQ4 PDF

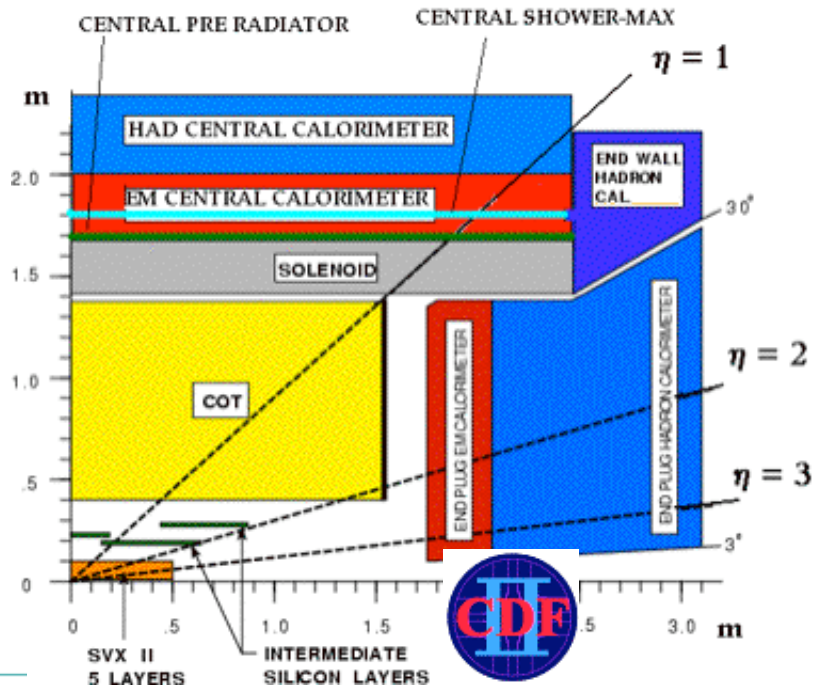


✓ LO PDF doesn't describe the data well

✓ Hard to pick up best PDF for NLO

D0 and CDF Detectors





End Cap cal. covers high η region(~4.0)
dσ/dy can be measured over the nearly the entire kinematic range (y ~3.0)

Plug cal. covers high η region(~ 3.6)
Silicon track covers $|\eta| < 2.8$
⇒ can reach high y region (~2.9)

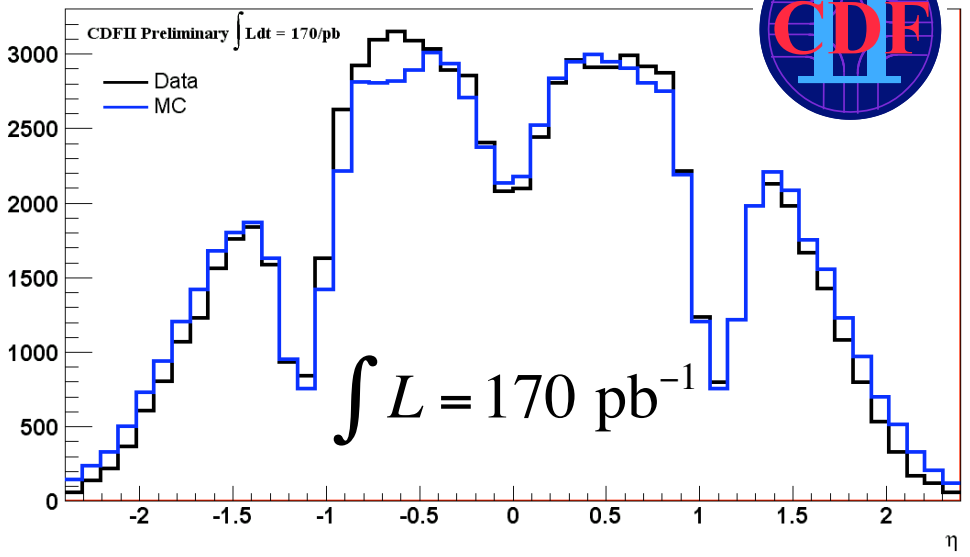
W Asymmetry Measurement

- $W^{\pm} \rightarrow e^{\pm} \nu$ Candidates

  $E_T > 25$ GeV

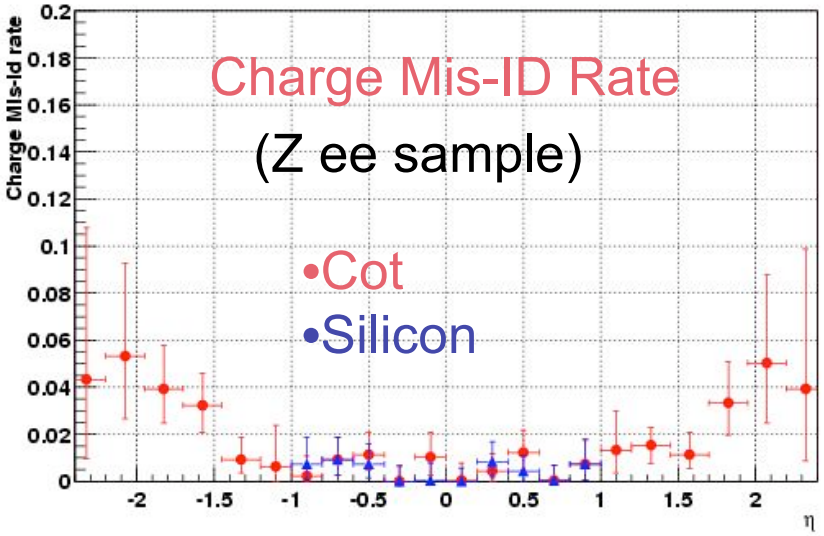
  Missing $E_T > 25$ GeV

  50 GeV $< M_T <$ 100 GeV



Lepton rapidity reaches up to~2.8!

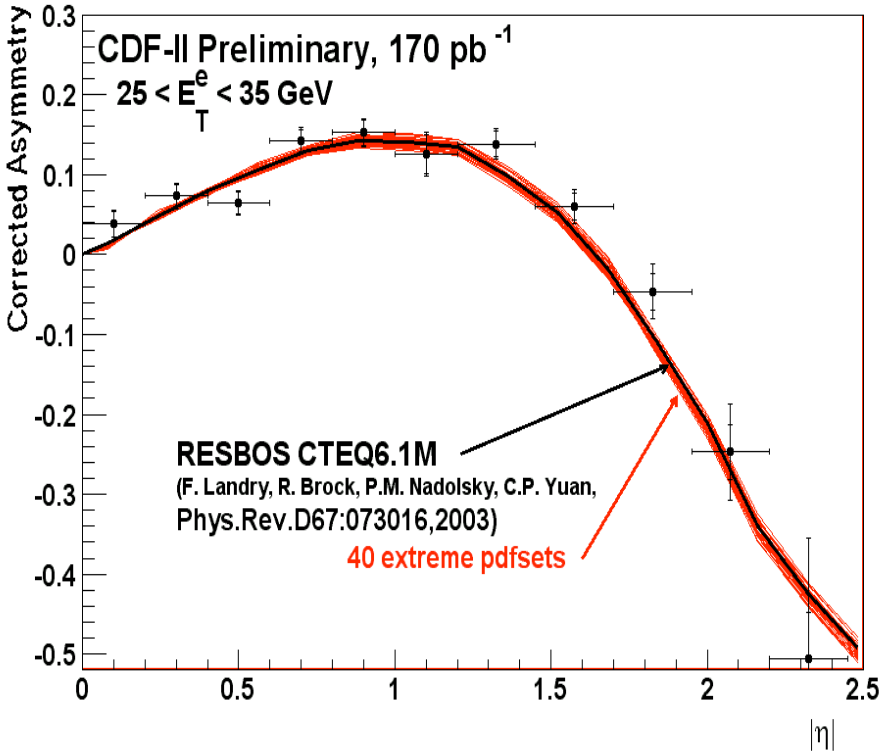
- Charge ID in forward region
  - Use silicon tracker and plug calorimeters.
  - Align forward calorimeters with tracks from central tracker

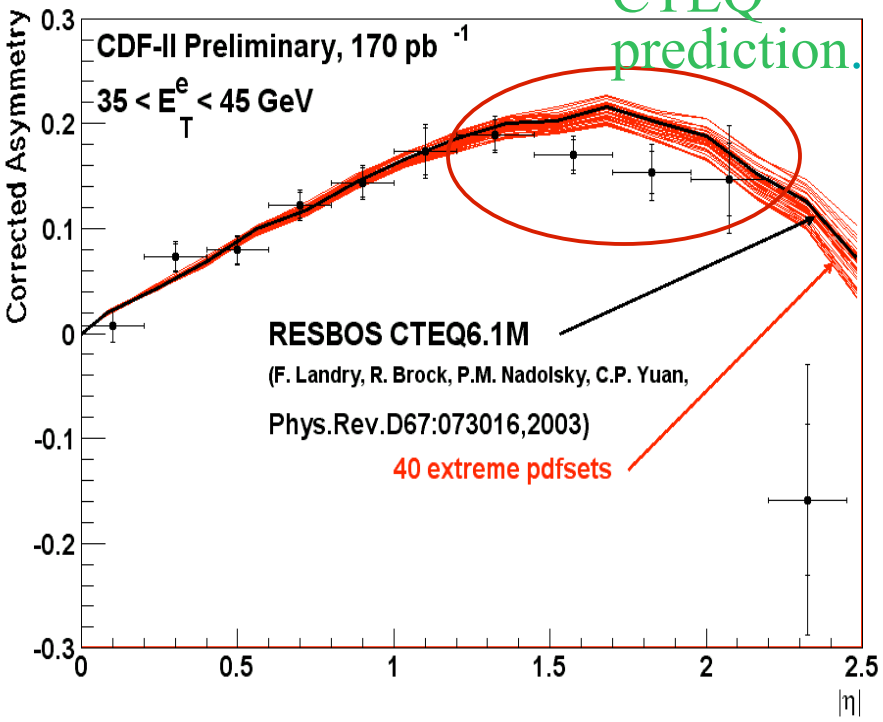


Lepton Charge Asymmetry

Gain sensitivity to W production asymmetry with E_T dependence

Data lower than existing CTEQ prediction.





25 GeV < E_T(e) < 35 GeV

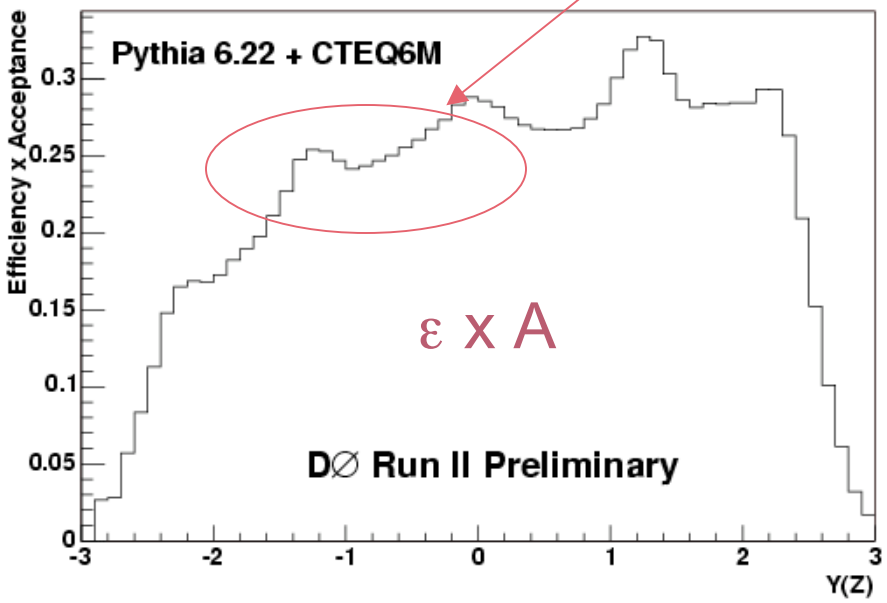
Decay asymmetry enhanced

35 GeV < E_T(e) < 45 GeV

Production asymmetry enhanced

Z dσ/dy measurements

Run-dependent calorimeter acceptance Cuts

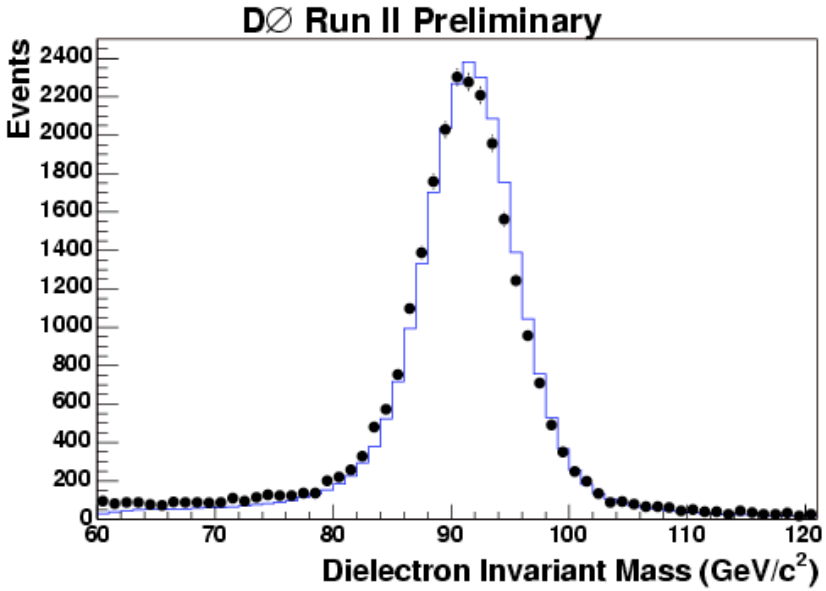


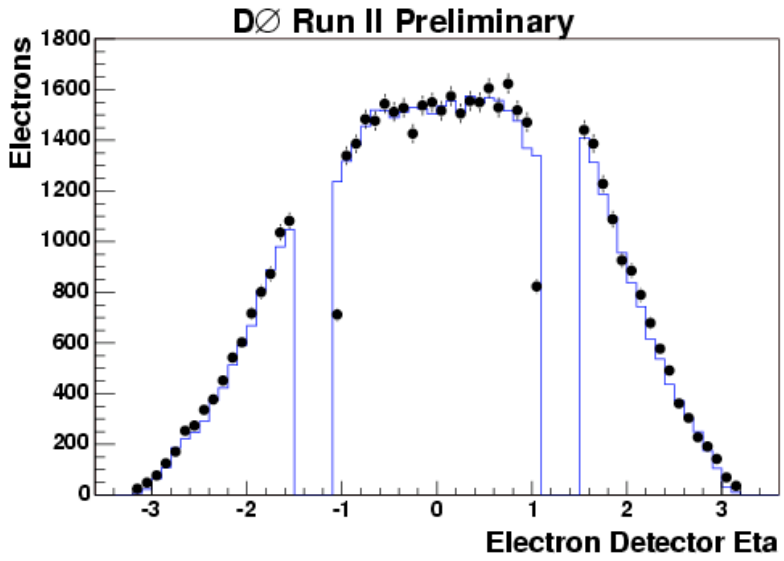
Two Good EM objects
First $p_T(e)>25$ GeV/c
Second $p_T(e)>15$ GeV/c
CC+CE+EE dielectrons
$|\eta| < 1.1$ (central)
$1.5< |\eta| <3.2$ (End Cap)
At least a tight track match
$71 < M(ee)<111$ GeV/c^2

- e x A reaches up to y~3.0
- Central track matching efficiency ~ 95 %
- Efficiency in the End Cap; 92%($|\eta|$ =1.5) ~25%($|\eta|$ =3.0)

Comparison between data and Monte Carlo

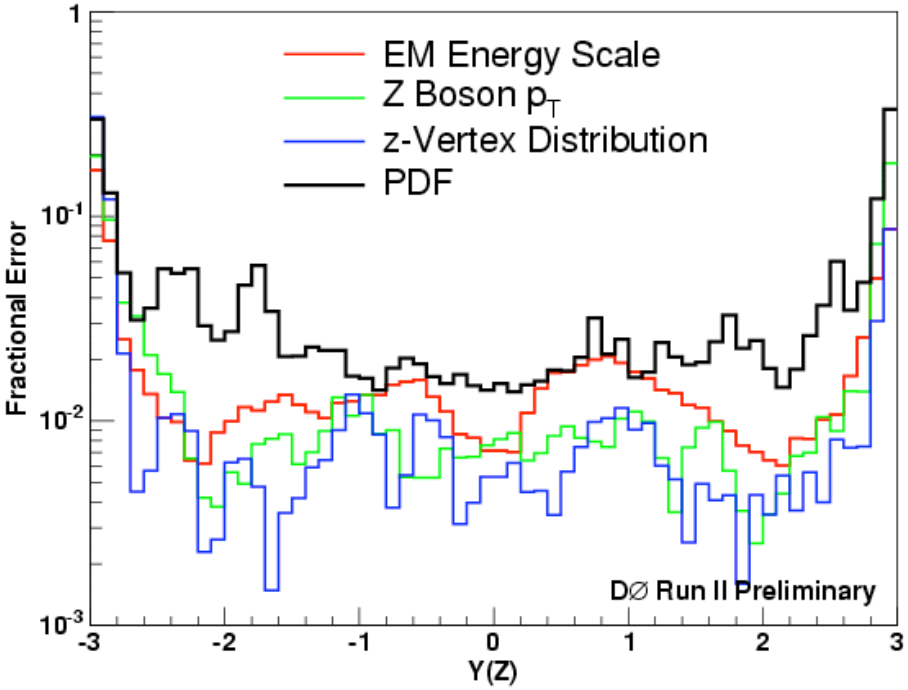
Histogram - Monte Carlo; Points - data

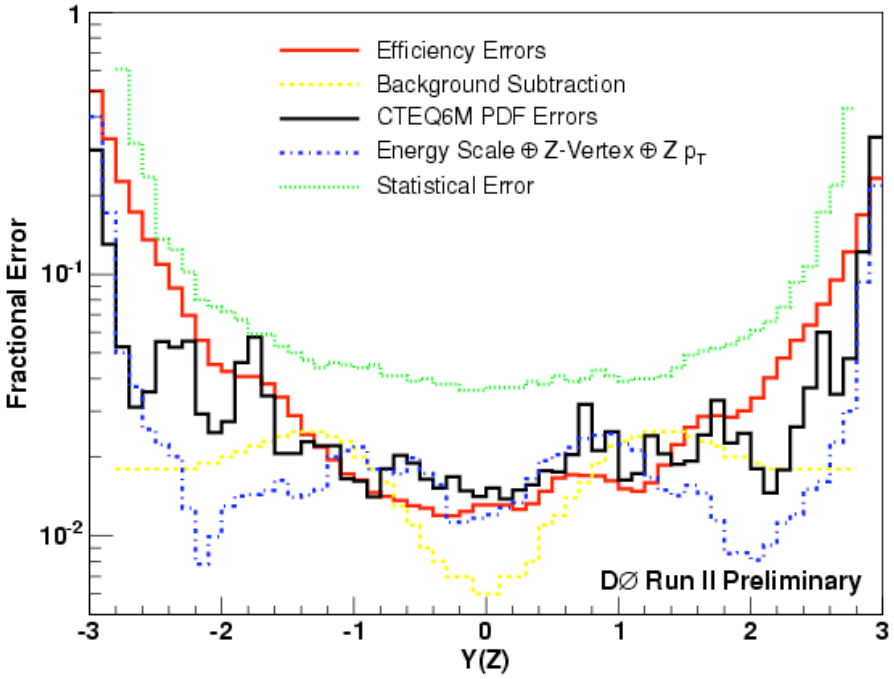




- Cross check to determine acceptance
- No background subtraction is performed
- Overall agreement is good

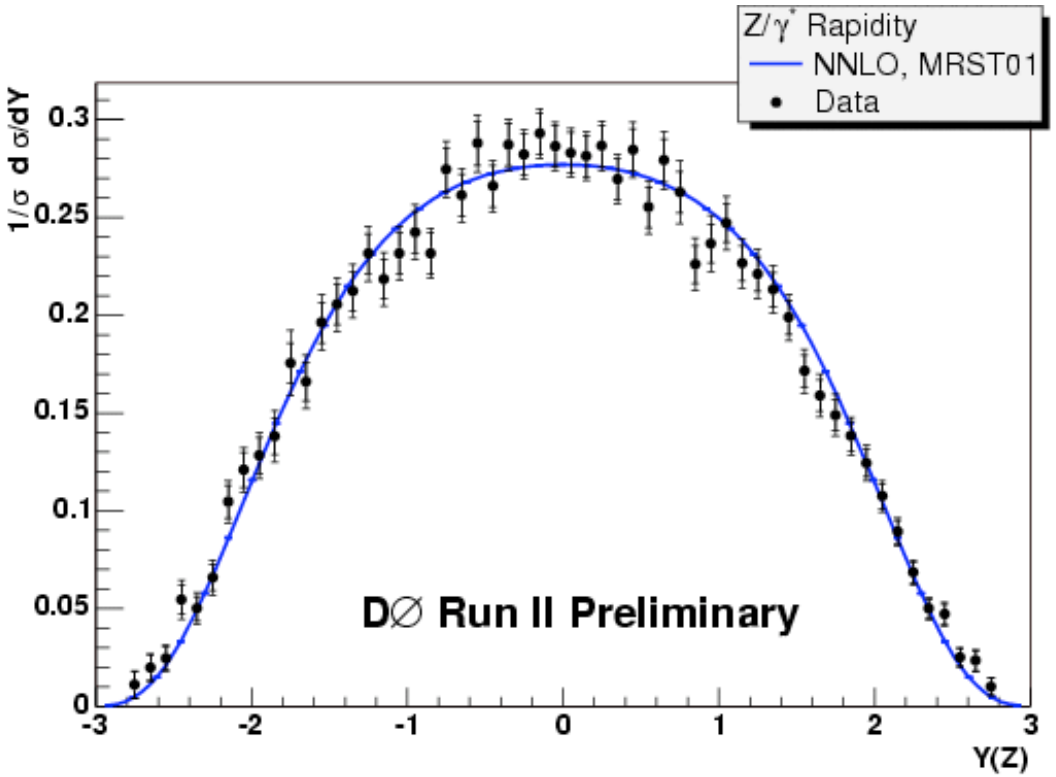
Systematic uncertainties





- PDF error is the single largest source
- Combined electron efficiency dominates the error at large rapidity

Z rapidity distribution (D0)

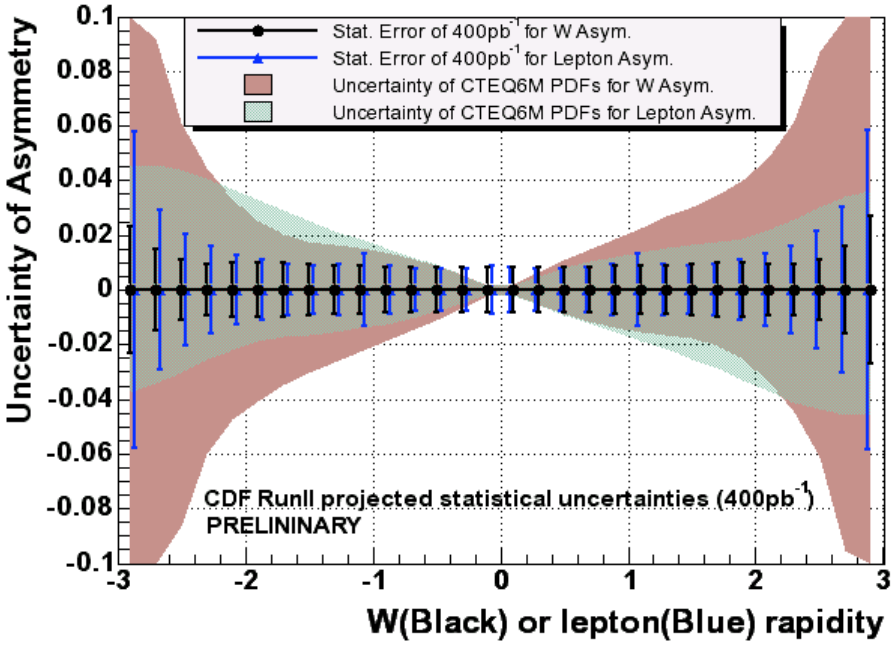


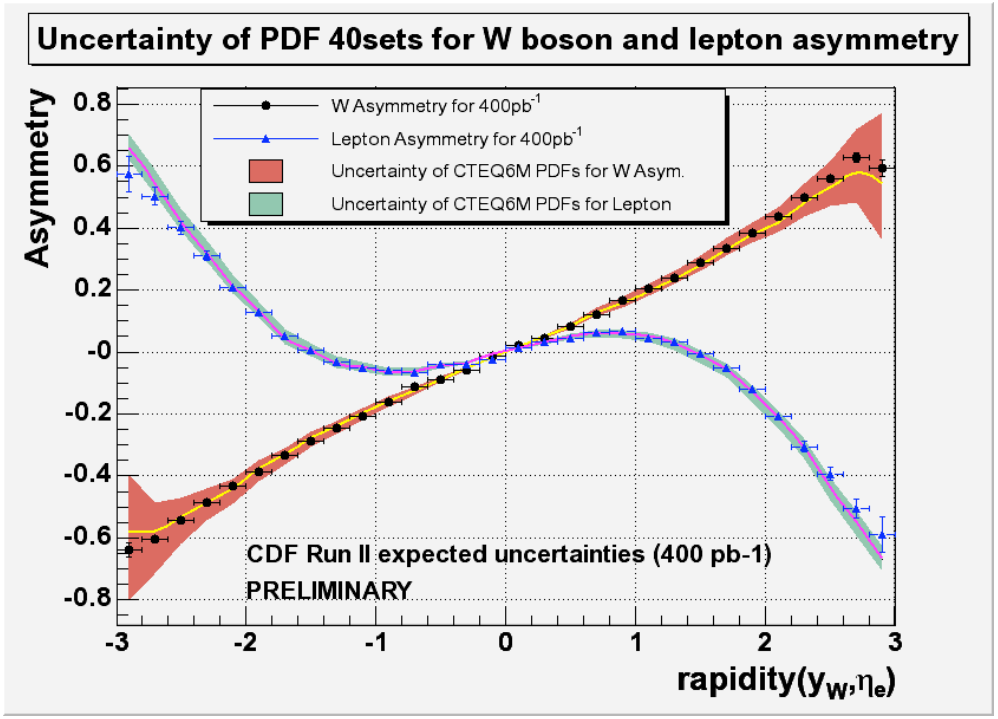
$\int L\,dt = 337\ pb^{-1}$
(08/02 - 06/04)
NNLO with MRST2001

High $Q^2 \sim M_z^2$
Small x region ($x \sim 10^{-3}$)
- compare to HERA
High x region ($x > 0.3$)
- guideline to PDF

- Use of the D0 forward Calorimeters provides data over almost the entire rapidity range accessible at Tevatron
- Data are in generally good agreement with the prediction

The Prospect - New method to A_W





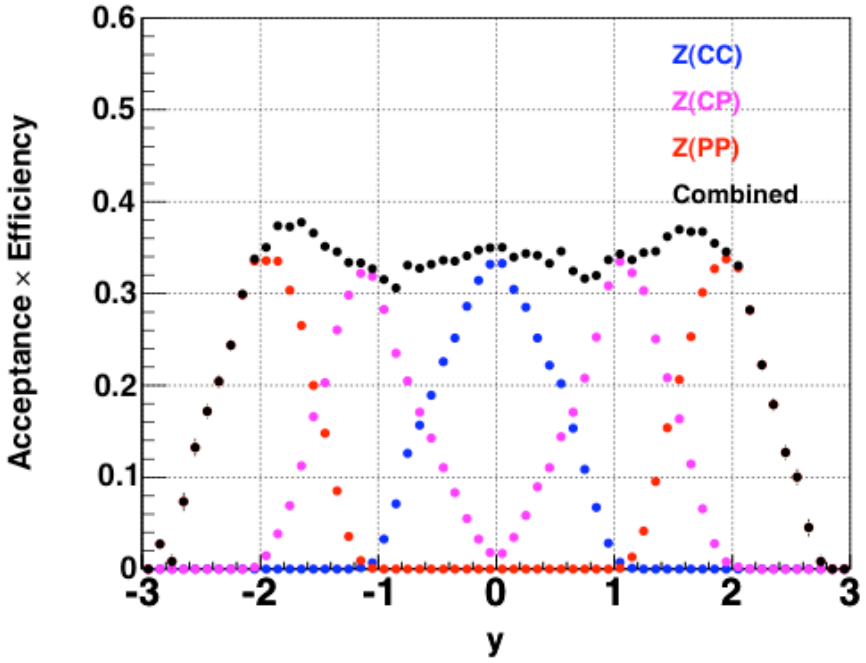
Statistically sensitive to probe PDFs

Systematic checks are under study

Method

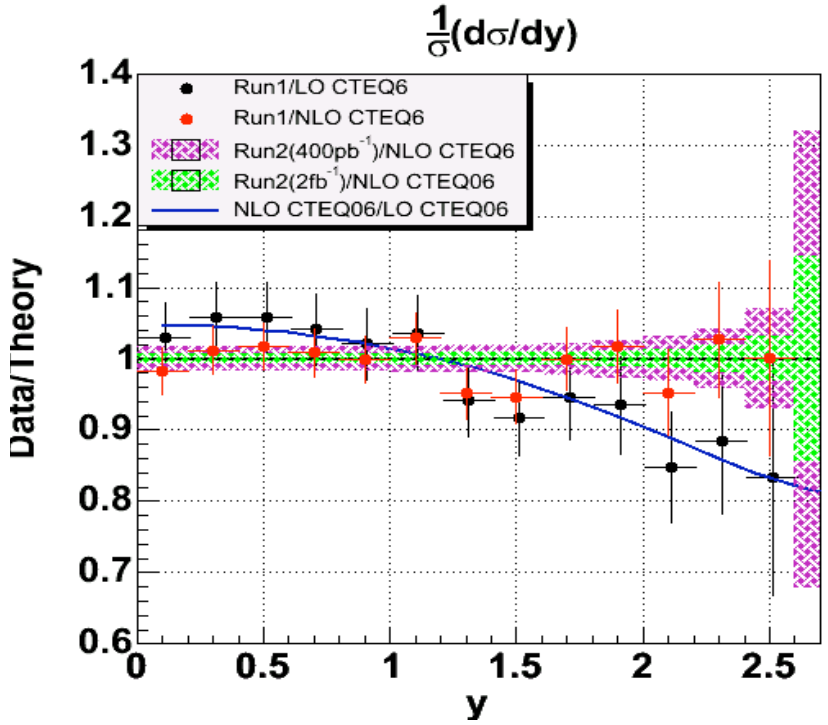
1) Partially reconstruct W rapidity with a given W mass (PDG)
2) Two possible solutions
3) Weighting factor for each solution with angular and rapidity distributions
4) Iteration to find the correct asymmetry

Prospect of Z rapidity at CDF



A × ε is flat up to y ~ 2.0

A × ε reaches up to y ~ 2.9



Scaled Run I results to 1.96 TeV (Run II)

High y => small x (HERA) and
large x (Guideline)

Summary

- CDF has a new measurement of the lepton charge asymmetry in the W decay
  - Data with 170 pb^{-1}
  - Lepton E_T dependence (large E_T) and large η~2.5
  - PDFs uncertainty could be reduced by inclusion of this data in global fits.
- D0 has measured the Z rapidity distribution
  - Data with 337 pb^{-1}
  - Use of forward Calorimeters provides data over y~3
  - Good agreement between data and prediction
- Prospect
  - Expect to collect data ~2fb^{-1} by the end of 2006
  - Expect D0 W asymmetry (e&μ) and CDF Z rapidity results
  - New method to determine W asymmetry
  - Better constrain PDFs by Z rapidity $\otimes$ W asymmetry