Measurement of $d\sigma(Z/\gamma^* \rightarrow e^+e^-)/dy$ at DØ

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For DØ Collaboration

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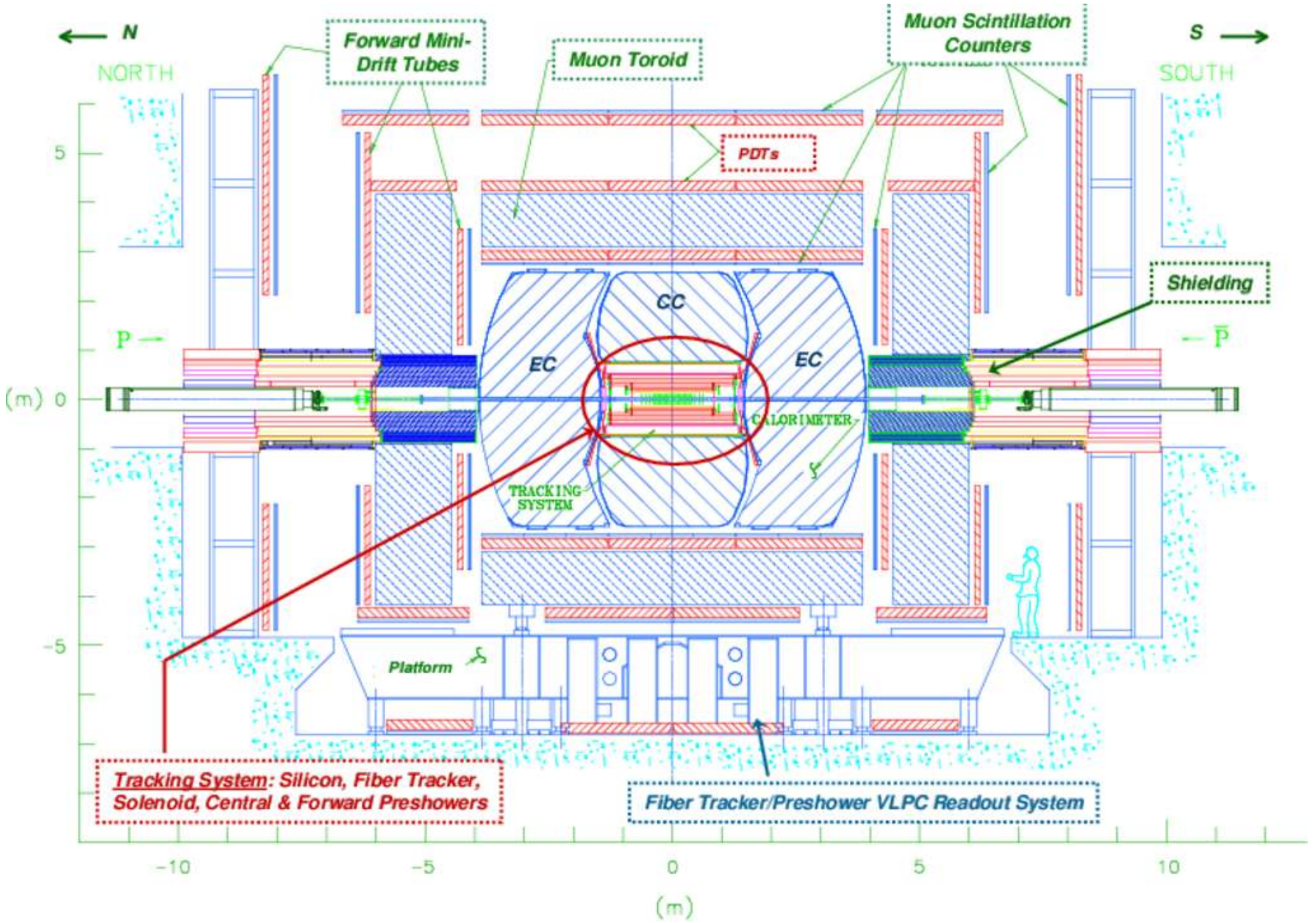
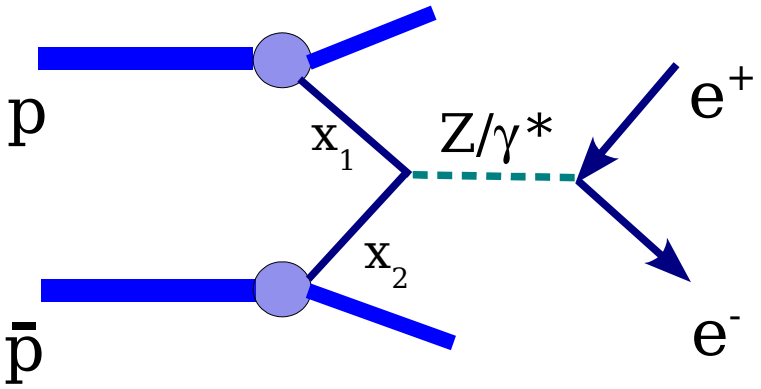
Outline

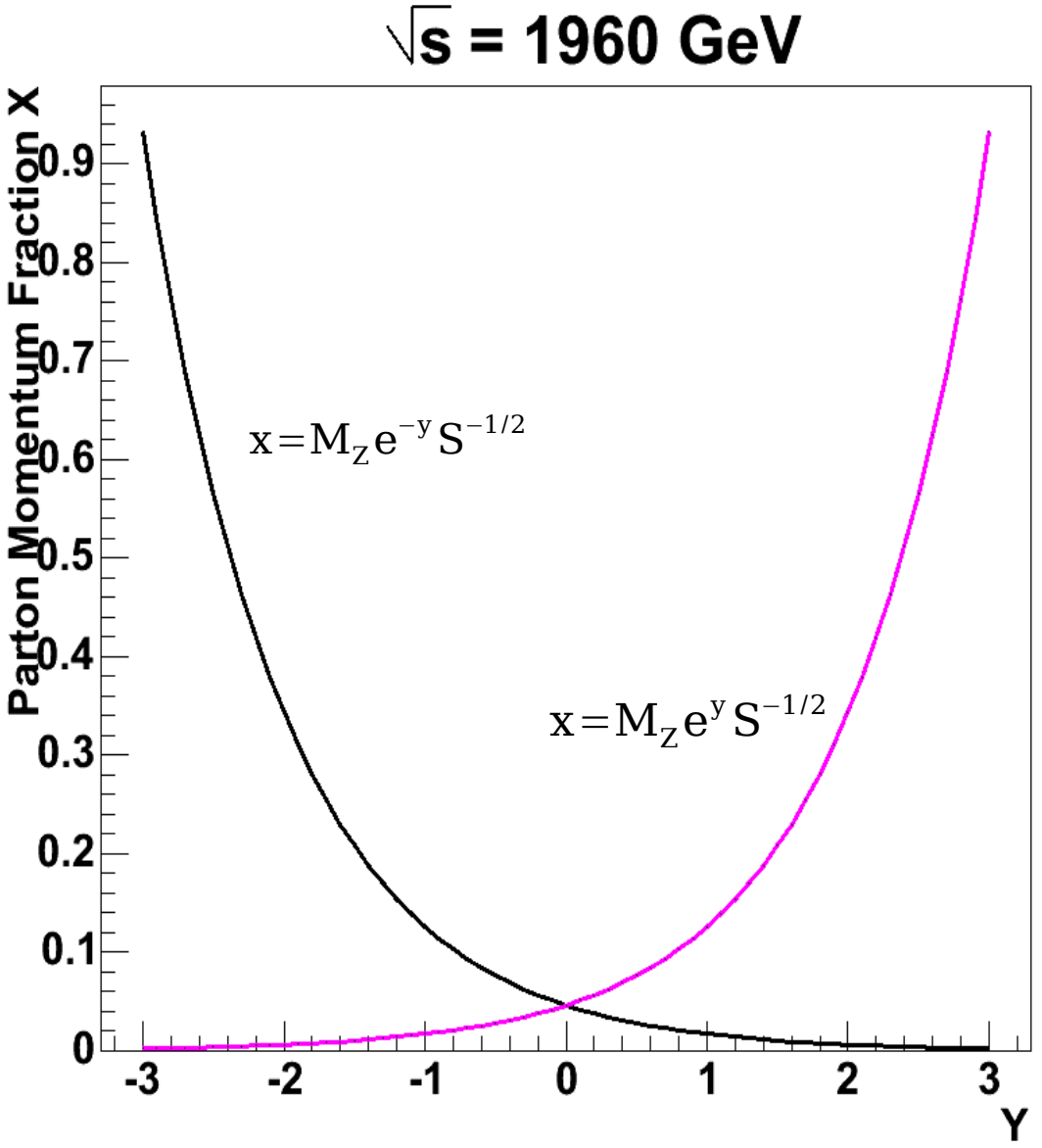
- Motivation
- Single electron efficiencies
- Boson efficiency × Acceptance
- Systematics
- Results and Conclusion

DØ Detector


N
NORTH
Forward Mini-Drift Tubes
Muon Toroid
Muon Scintillation Counters
S
SOUTH
PDTs
Shielding
CC
EC
EC
P
$\bar{P}$
CALORIMETER
TRACKING SYSTEM
Platform
Tracking System: Silicon, Fiber Tracker, Solenoid, Central & Forward Preshowers
Fiber Tracker/Preshower VLPC Readout System
5
0
-5
(m)
-10
-5
0
5
10
(m)

Z/γ* Production at Tevatron

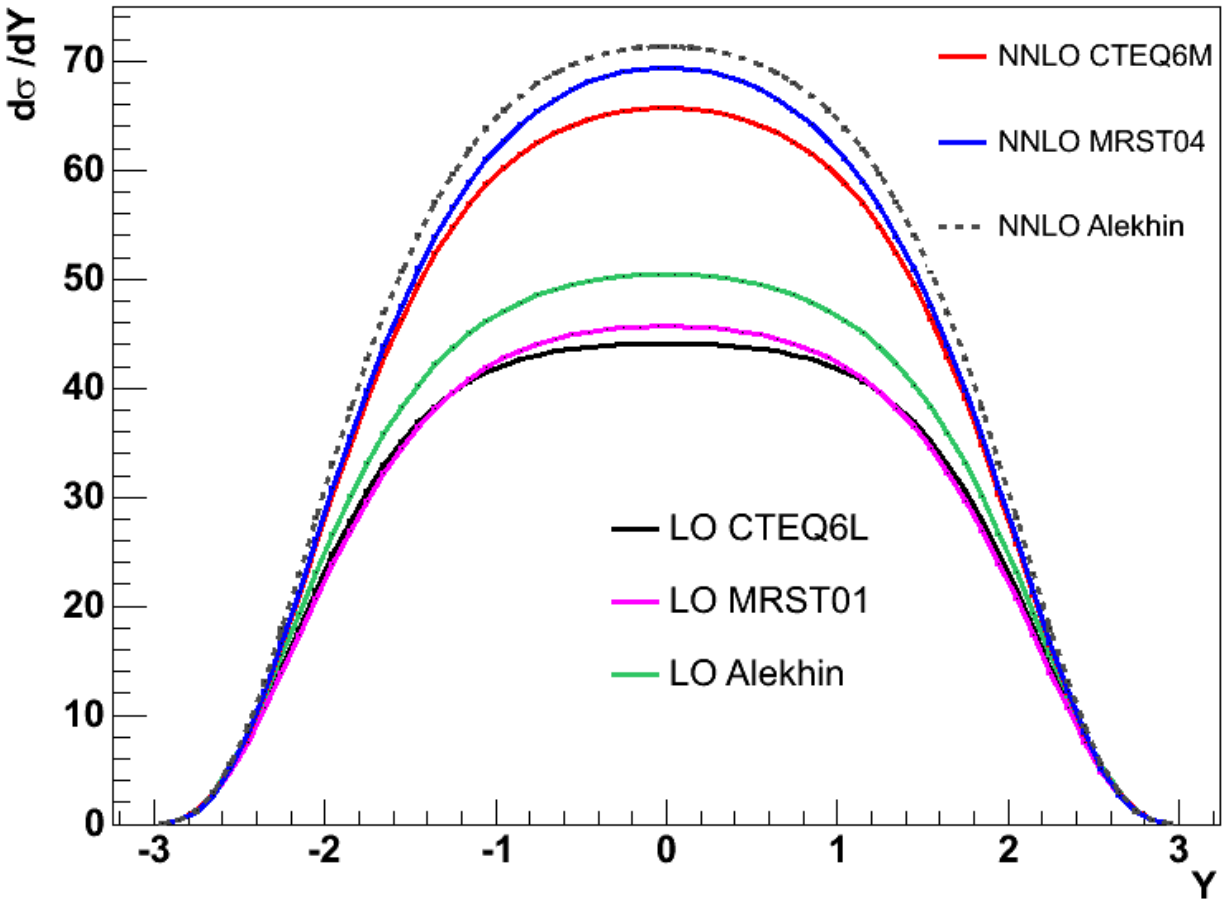




- Measure at high Q^2, large and small x
  - At 1.96 TeV, Y_{max}~3.0, x~10^{-3}
  - $Q^2 \sim M^2_Z$
  - Cover some area not covered by jets
  - Smaller systematics than jets
  - Reach larger $x_F = x_1 - x_2$ than fixed target experiment

NNLO Theoretical Calculation

- Help us better understand parton distribution functions
- Provide a method to test NNLO theoretical calculation
- Test PDF at high Q^2 ($\sim 91^2$) and higher X_F



** Calculation based on Anastasiou, Phys Rev D 69 094008(2004)*

Measurement Strategies

Differential cross section:

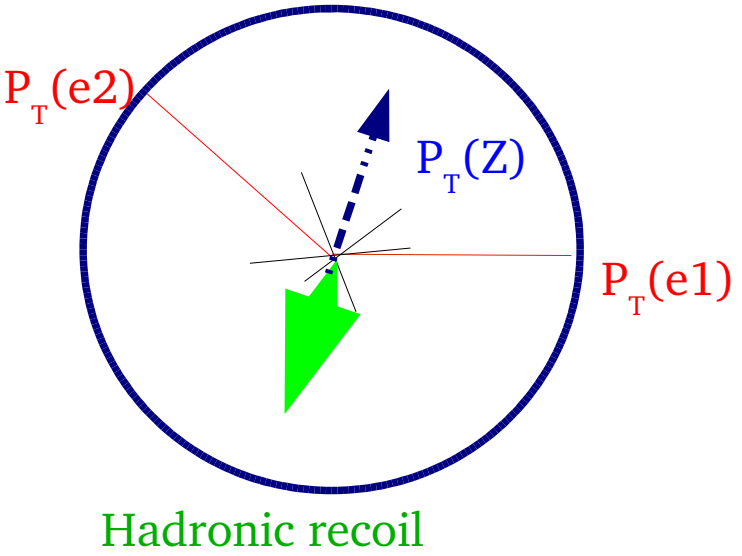
$$\frac{d\sigma(Z/\gamma^* \to e^+ e^-)}{dy} = \frac{N_i - B_i}{\Delta_i (\varepsilon A)_i \mathscr{L}}$$

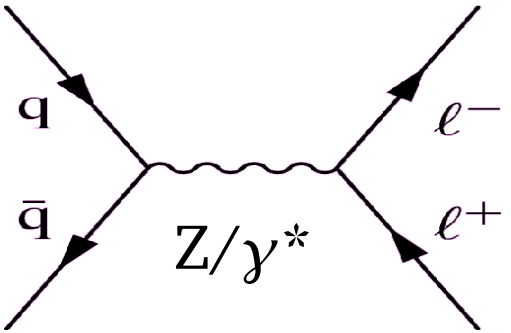
A: boson acceptance
ε : boson efficiency
$\mathscr{L}$: Integrated luminosity
N: Z/γ^* events
B: Background
i : boson rapidity bin

Strategies:

- Look for di-electron events
- Determine number of Z and Drell-Yan events from electrons
- Estimate background
- Determine Z and Drell-Yan selection efficiency from single electron cut efficiencies
- Determine acceptance using Monte Carlo simulation

$Z/\gamma^* \rightarrow e^-e^+$ Events Selection



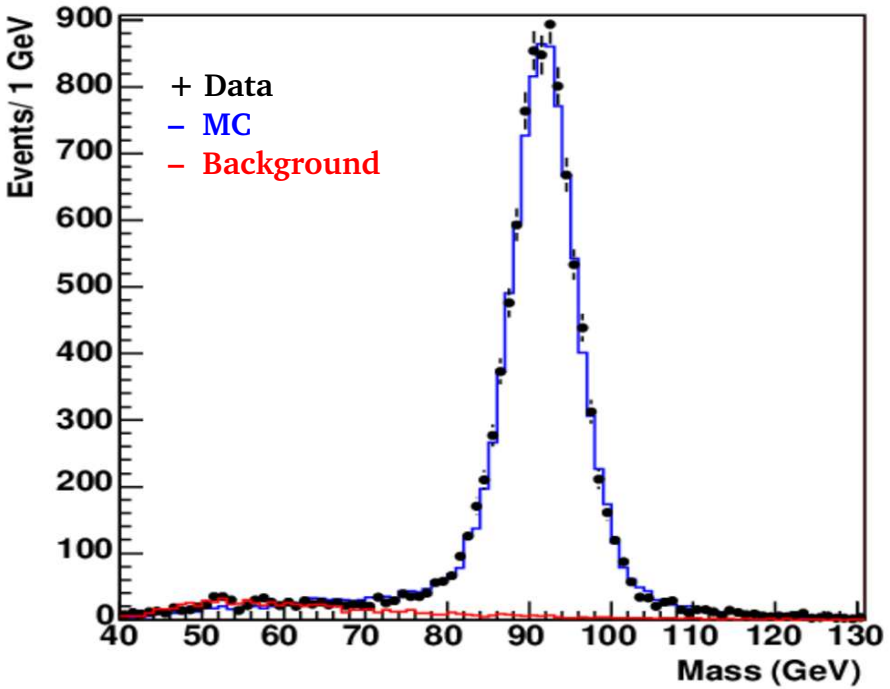


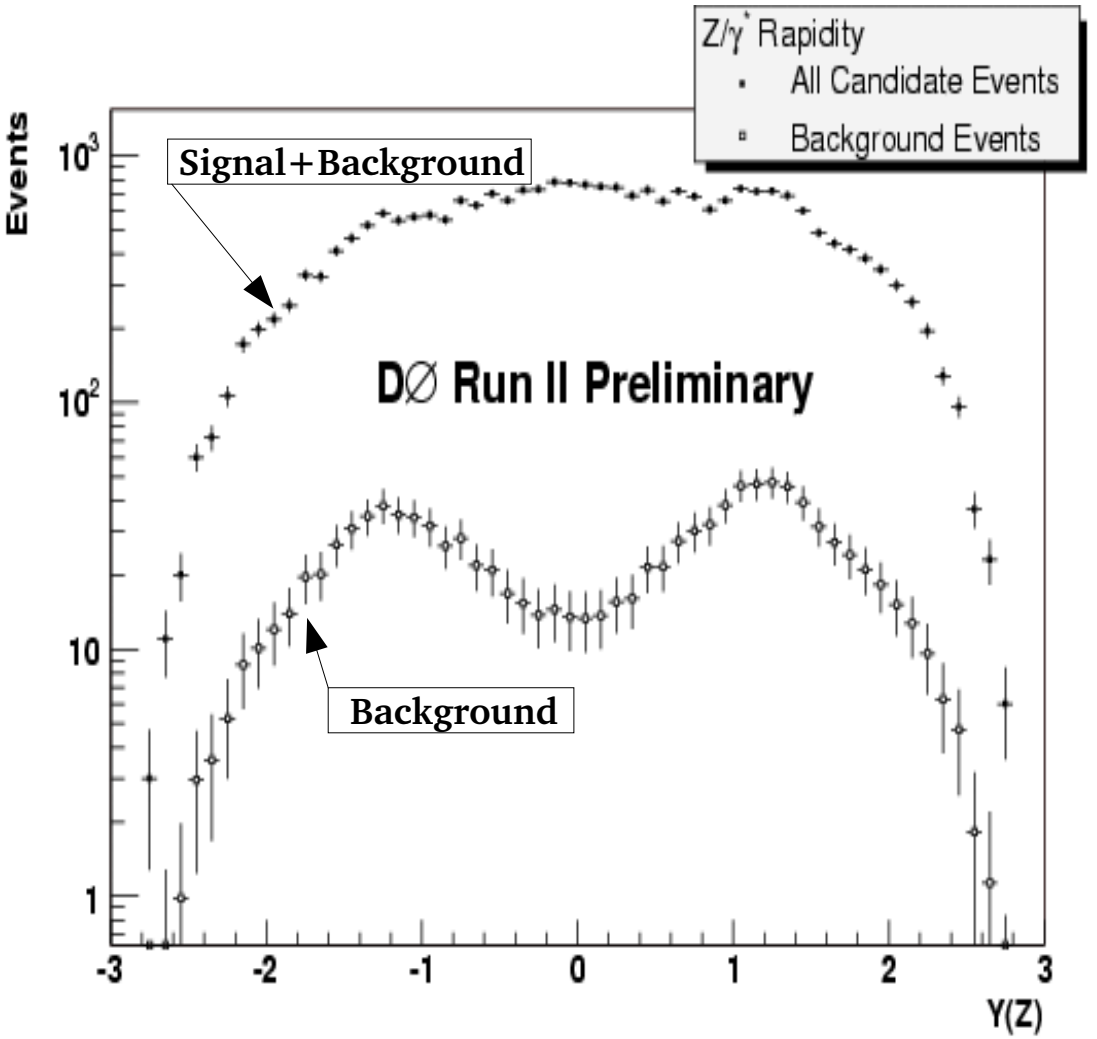
- Total integrated luminosity: 337pb^{-1}
- look for events with two good high P_T electrons:
  - $P^{e1}_T > 15$ GeV, $P^{e2}_T > 25$ GeV
  - With two track matching in central and at least one track matching in forward
  - Z/γ^* invariant mass window $71 < M_{ee} < 111$ GeV
- Bin events in boson rapidity bins:

$$Y_{Z/\gamma^*} = \frac{1}{2} \ln \frac{E + P_Z}{E - P_Z}$$

Background Distribution

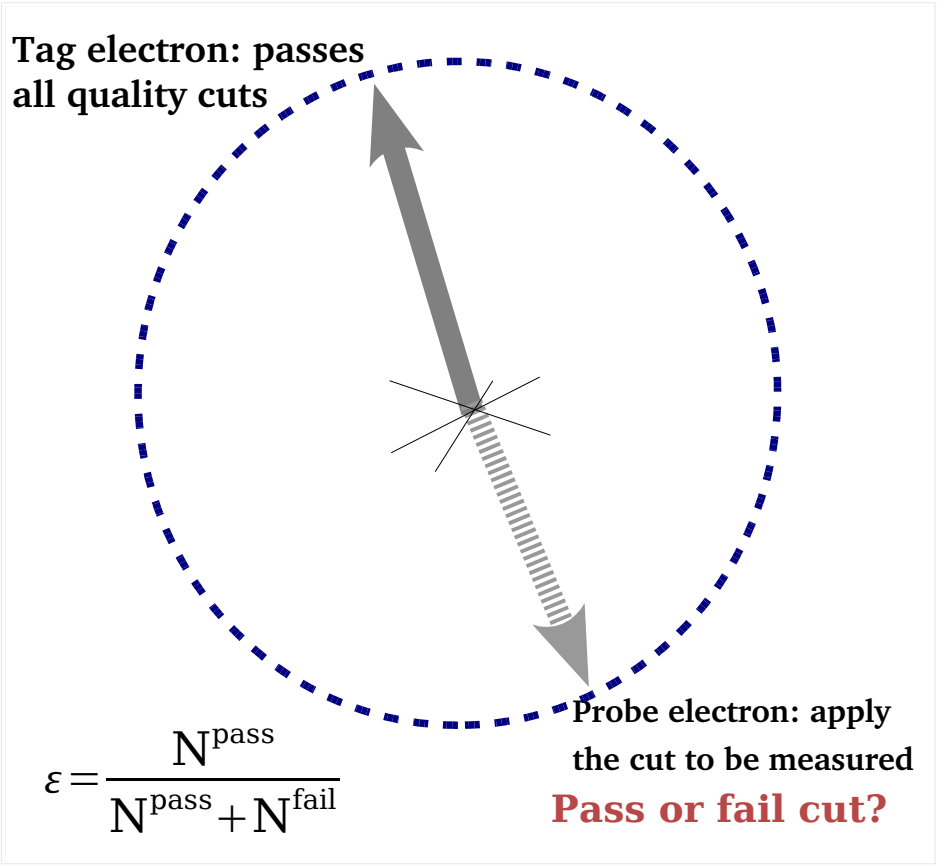
- Main background sources:
  - Di-jets, jet fakes electron
  - W+jets, jet fakes electron
- Determine background ratio within mass window from fitting





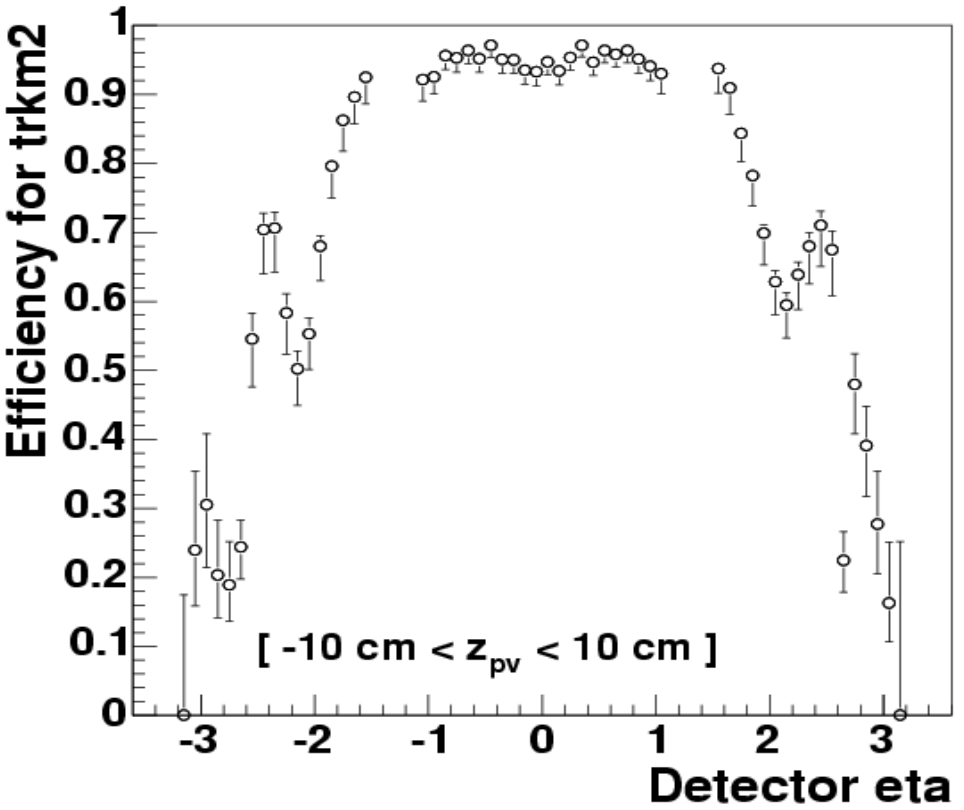
Single Electron Cut Efficiencies

Use $Z \rightarrow e^+e^-$ events:



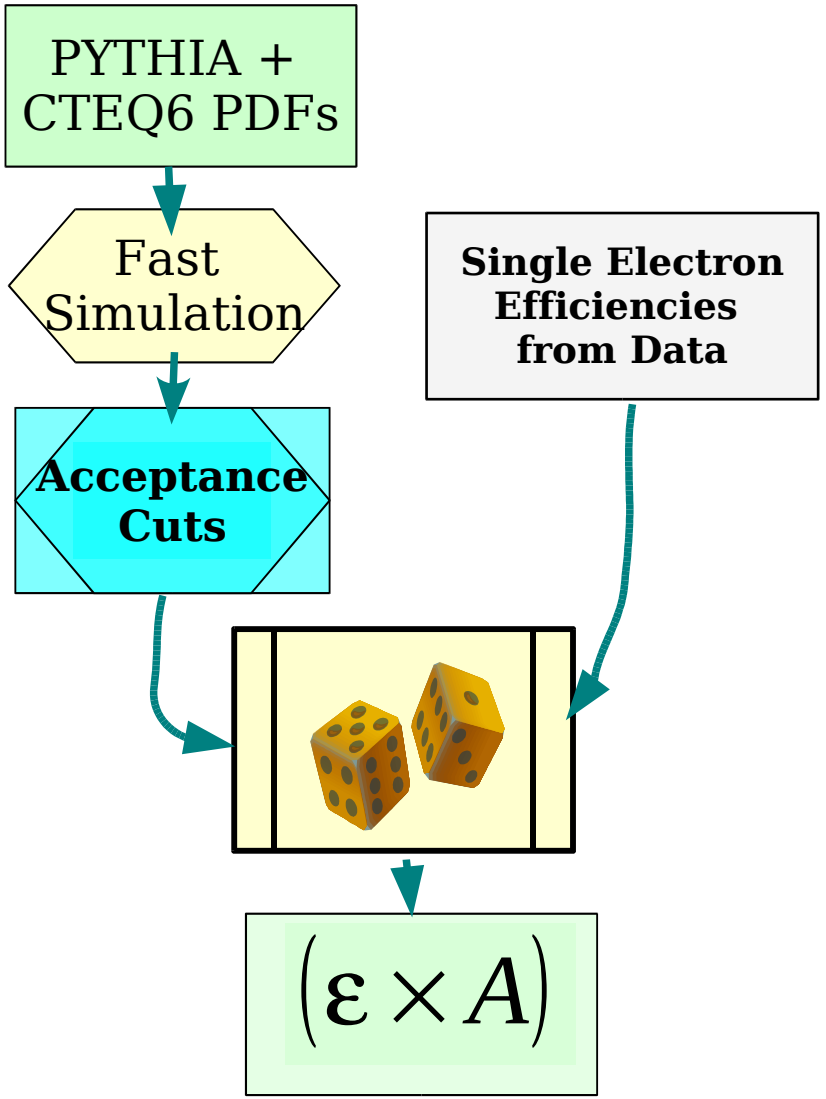
$$\varepsilon = \frac{N^{pass}}{N^{pass} + N^{fail}}$$

Track matching Efficiency



- Single electron selection efficiencies
  - Electron ID efficiency (electron shower shape, ID, etc)
  - Trigger efficiency
  - Track matching efficiency

Z/γ^* Efficiencies×Acceptance Strategies



Use single electron efficiencies to determine Boson efficiency:

- Generate $Z/\gamma^* \rightarrow e^+e^-$ events using Pythia and CTEQ6M PDFs
- Smear electron energy and angular distribution with fast detector simulation code
- Determining smeared electron to PASS or FAIL single electron efficiencies by a flat random number generator
- Count how many Z/γ^* events passed

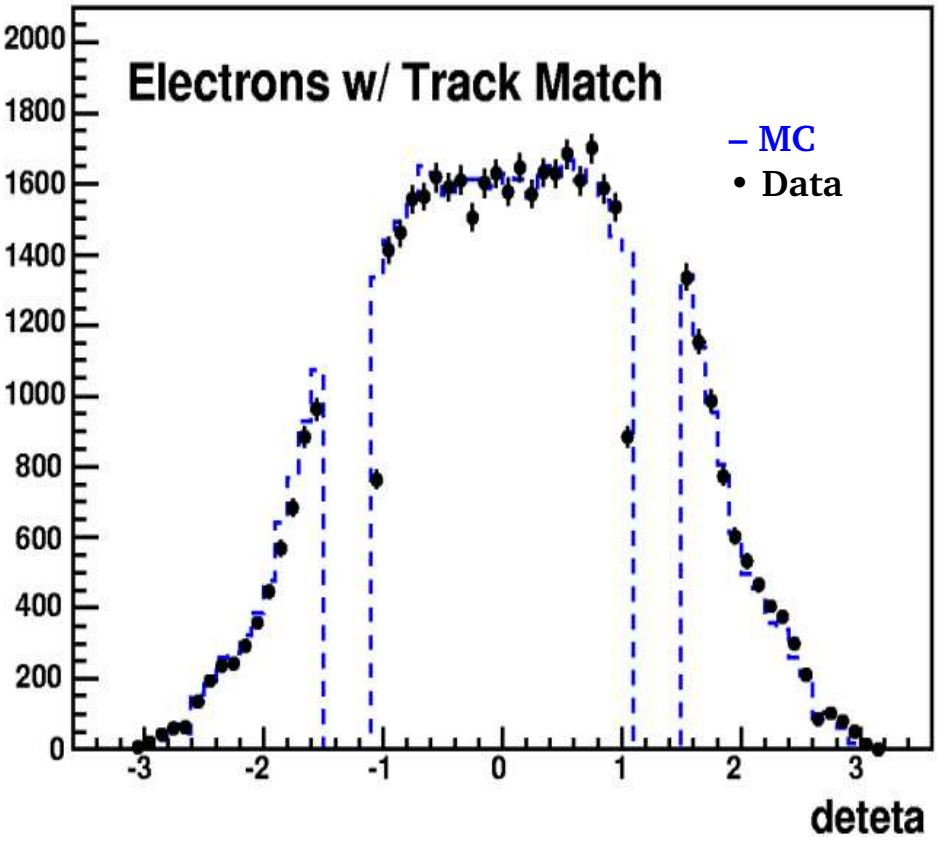
Total 10M events generated:

$$\varepsilon A = \frac{\text{Number of } Z/\gamma^* \text{ passed}}{\text{Number of } Z/\gamma^* \text{ generated}}$$

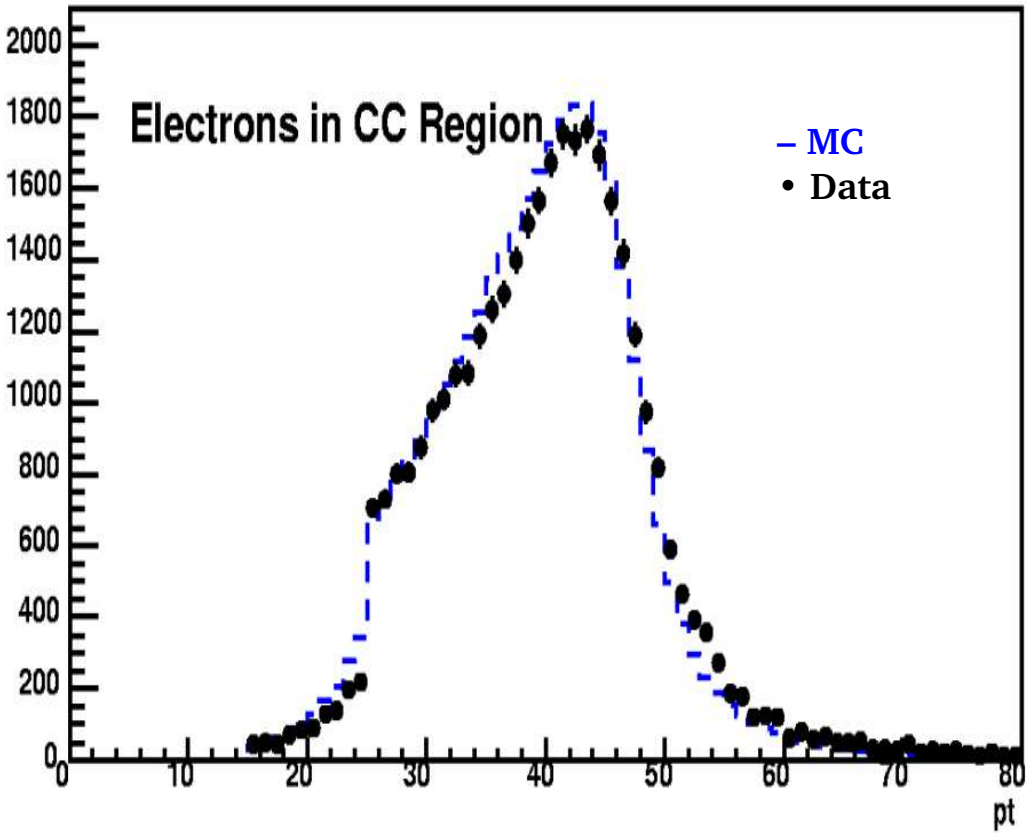
Central-Central : 10.640 ± 0.035
Central-forward : 11.315 ± 0.036
forward-forward: 2.191 ± 0.017

Data and Monte Carlo Comparison

- Verify the boson efficiency × acceptance is correct by comparing output distribution from Monte Carlo with data



electron detector η distribution



electron Pt distribution

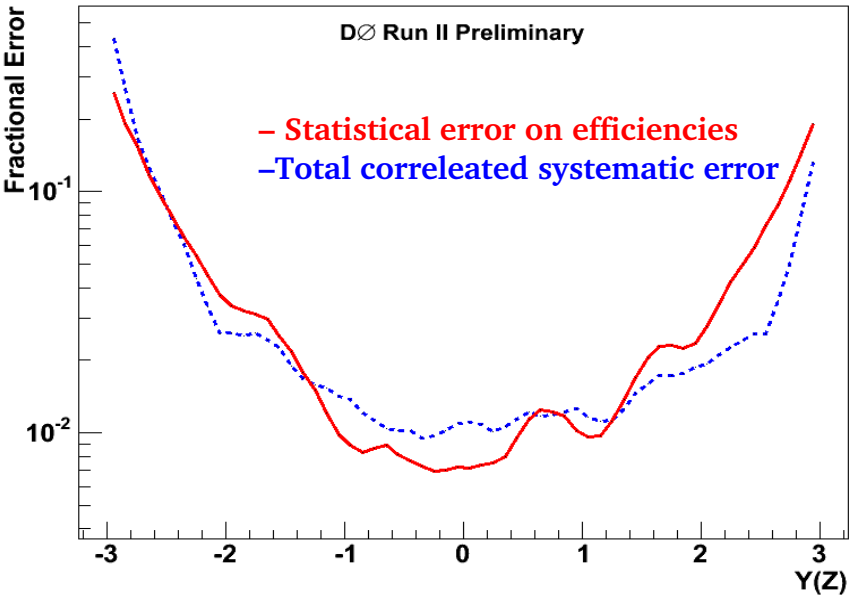
Sources of Systematic Uncertainties

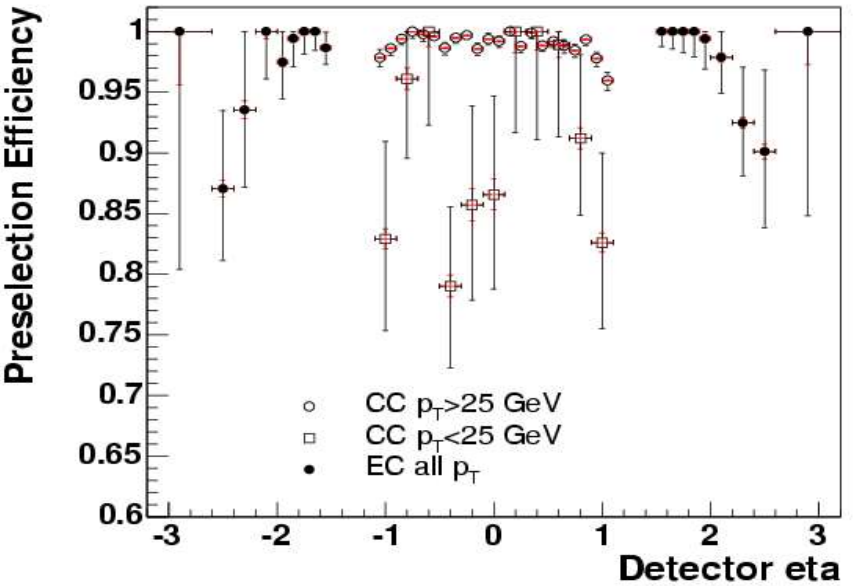
Five major sources:

- Single Electron efficiencies measurement
  - from single electron efficiencies measurement
  - from background subtract method
- EM Energy Scale
  - from calorimeter EM energy scale calibration
- PDFs
  - from choice of different PDF sets
- Z boson P_T and vertex uncertainty
  - difference between Monte Carlo and the data

Estimate Systematics: from Efficiencies

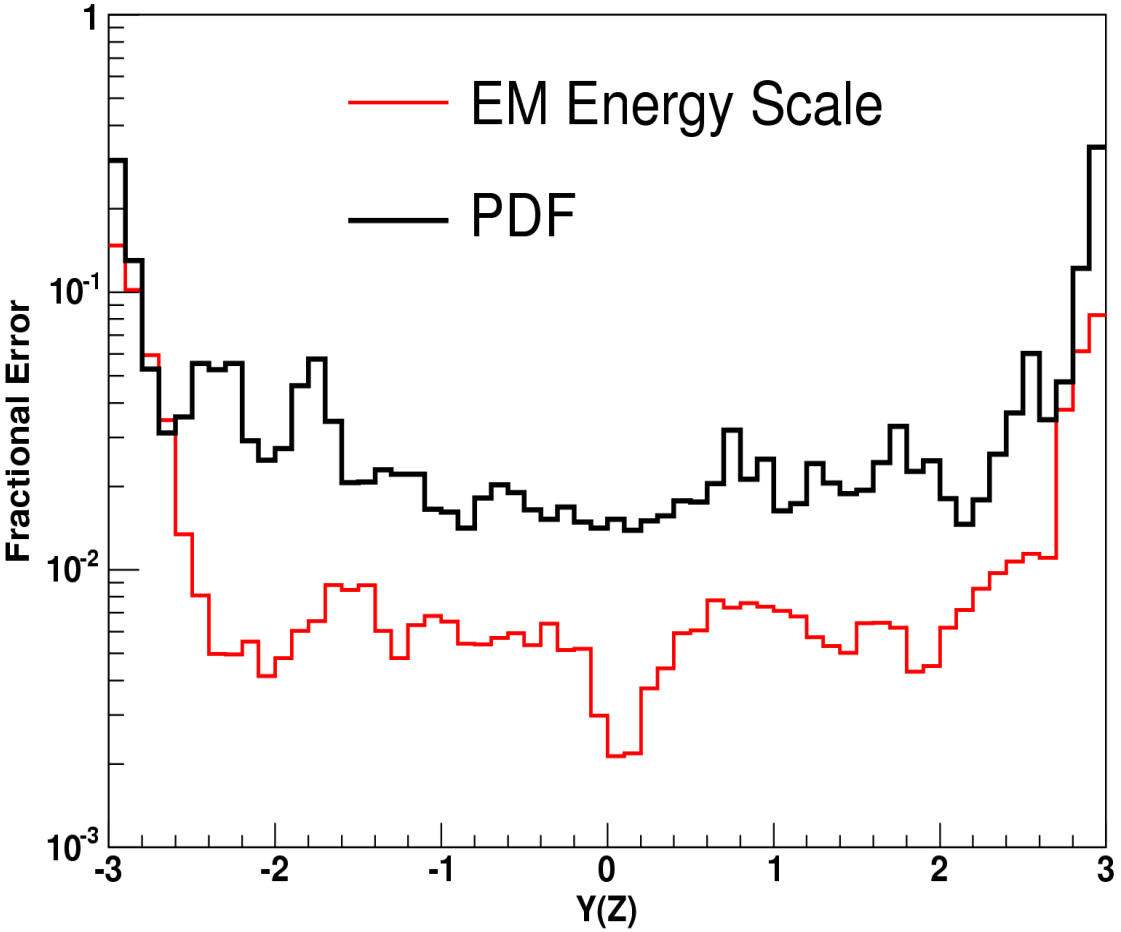
- From single electron efficiencies measurement: (statistical and correlated):
  - repeat boson $\varepsilon \times A$ calculation with single electron efficiencies varied randomly within their ststistical error distributions
  - use binomial random number distribution



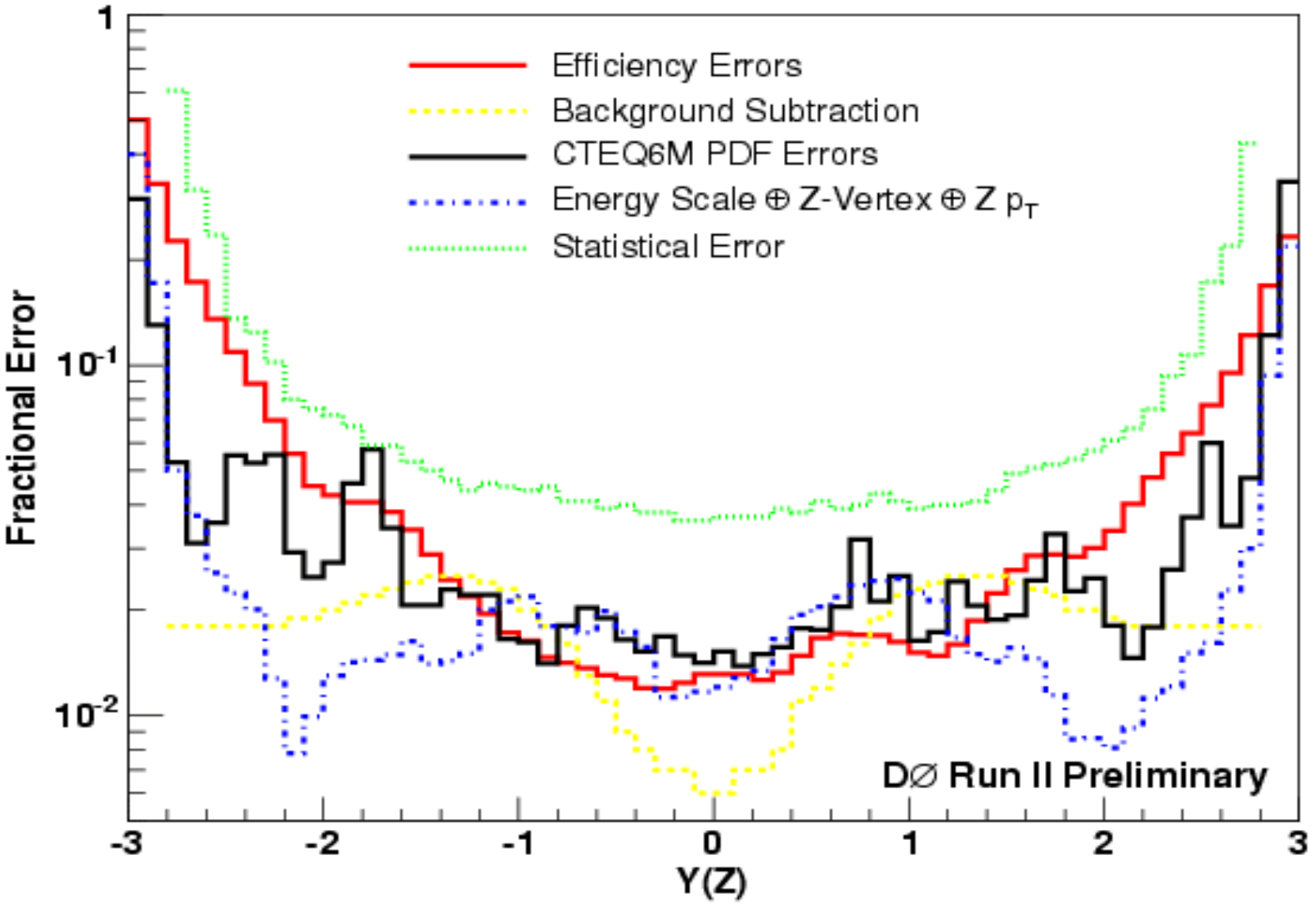


Estimate Systematics: from PDFs

- We use CTEQ6M PDF to determine acceptance
  - CTEQ6M is determined by 20 parameters,
  - Shift each paramater by $\pm 1\sigma$, total 40 PDFs
  - Use 40 PDFs in Monte Carlo generator, total 6M events generated
  - Use difference on $\varepsilon \times A$ as systematics

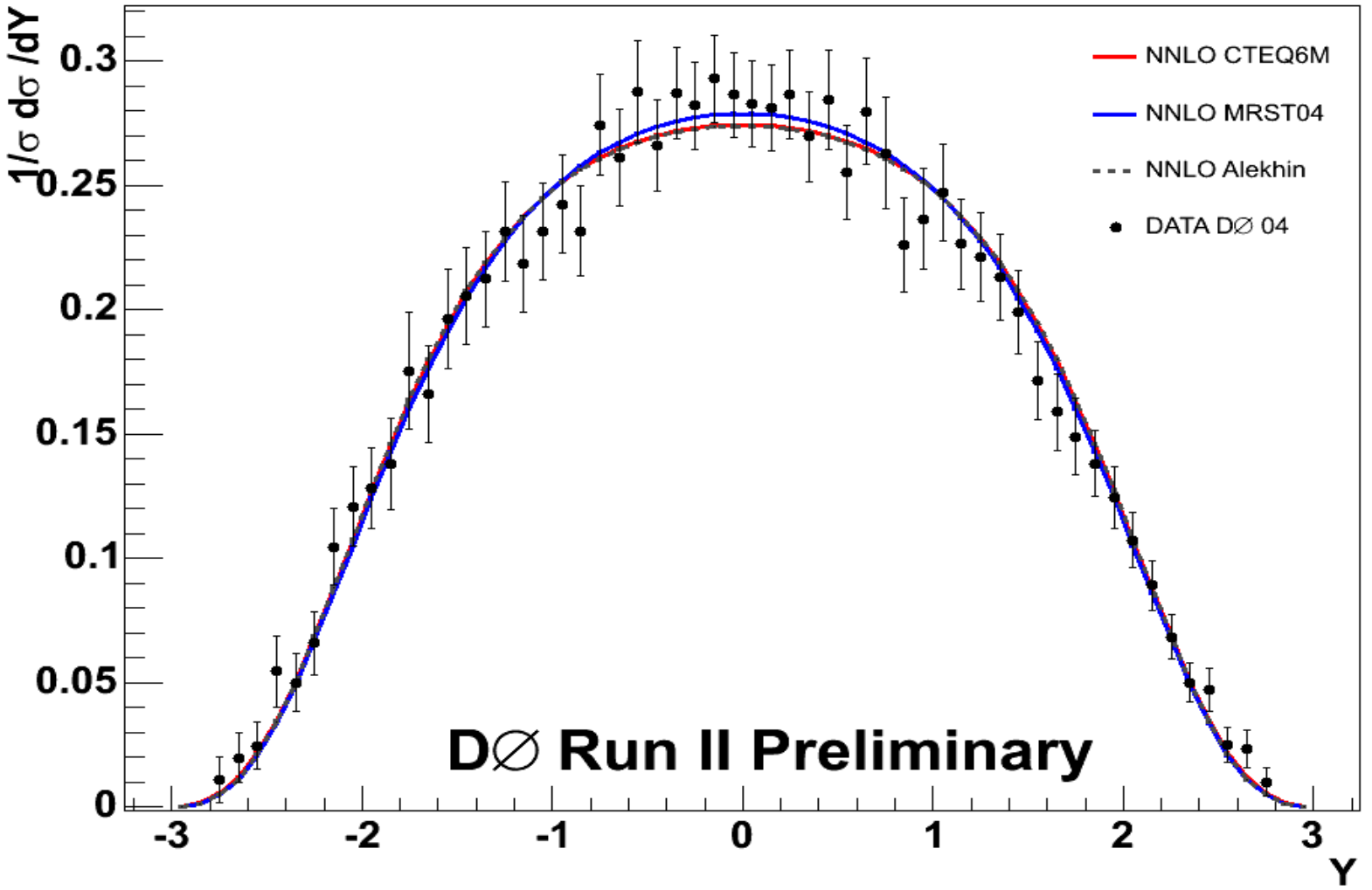


Total Systematics



- PDFs: ~1.5% (|Y| ~0) ~10% (|Y|>2)
- Efficiencies ~1.2% (|Y| ~0) ~20% (|Y|>2)

Differential Cross Section



* NNLO calculation based on Anastasiou Phys ReV D 69, 094008(2004) with latest PDF sets

Conclusion

Z/γ* rapidity distribution measurement at DØ

- Provide rapidity distribution over entire kinematic region at center of mass energy of 1.96 TeV
  - Test with differential cross section from NNLO with latest MRST, CTEQ and Alekhin PDF sets
  - Data agrees with NNLO calculation