$d\sigma/dy$ Distribution of Drell-Yan Dielectron Pairs at CDF in Run II

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Outline

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- Introduction
- Event selection
- Acceptance and efficiencies
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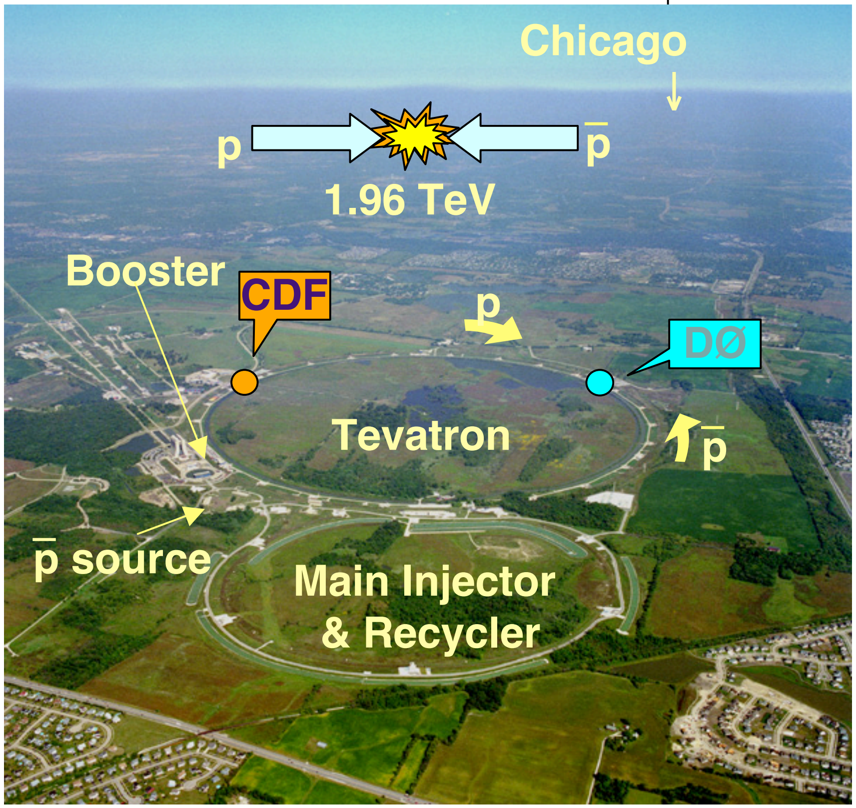
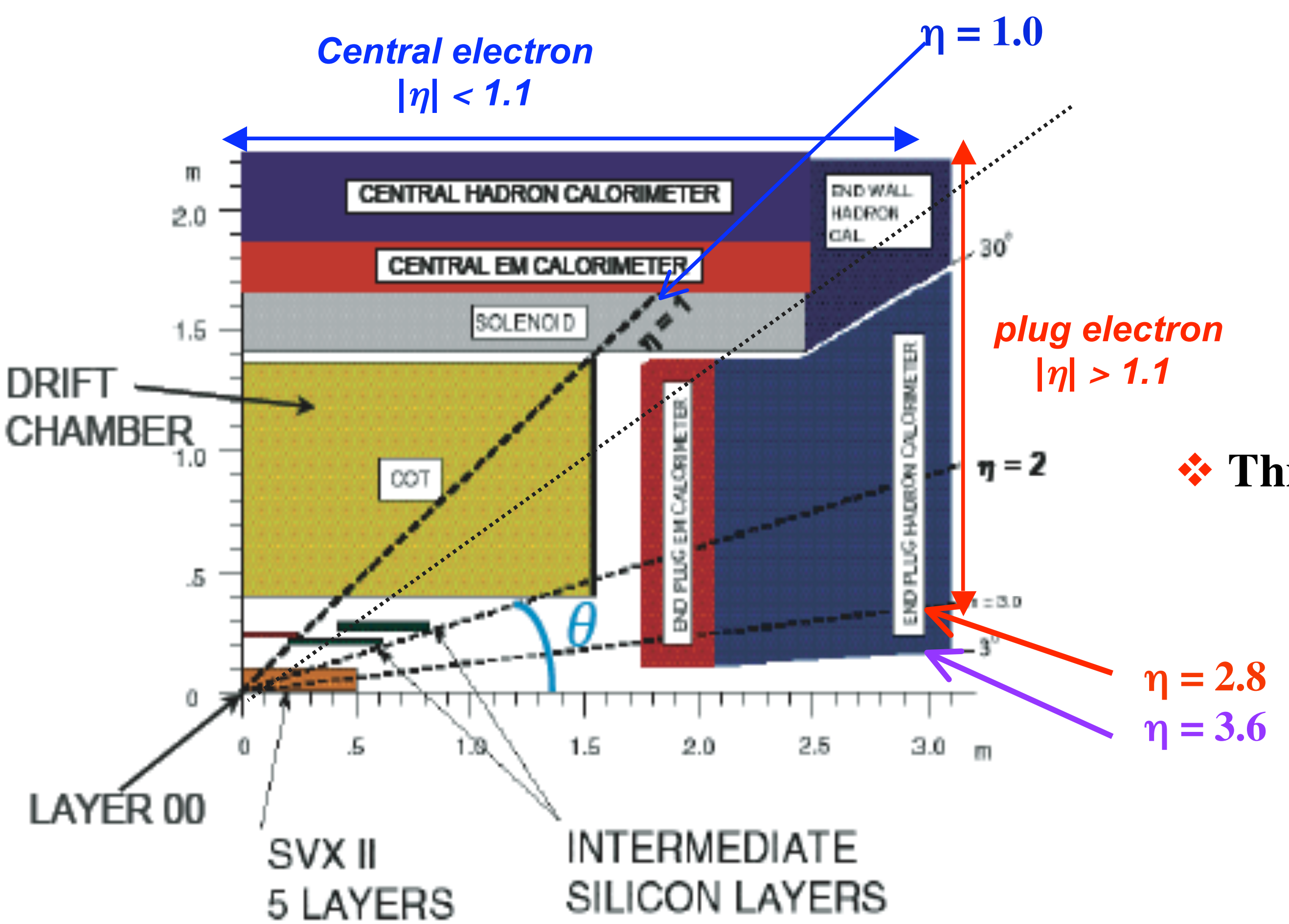
- Summary



CDF Run II Detector

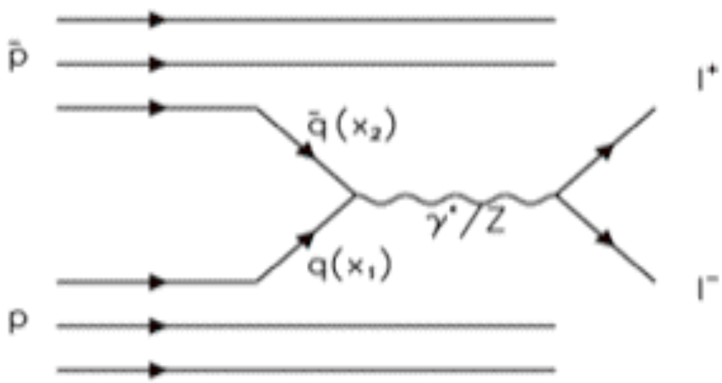


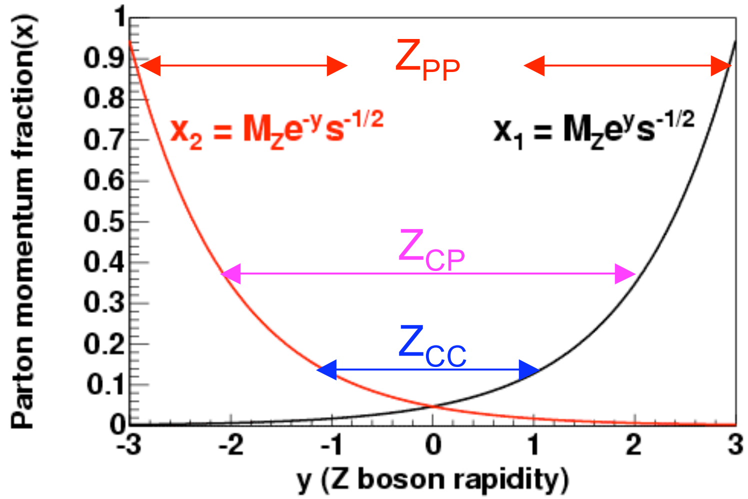
❖ Three dielectron topologies :
central-central (Z_{CC})
central-plug(Z_{CP})
plug-plug(Z_{PP})

❖ Plug calorimeter covers high η region(1.1< |η| < 3.6)
❖ Silicon tracking coverage out to |η| < 2.8
❖ Requiring silicon track matches in forward region reduces background contamination

Introduction

Feynman Diagram

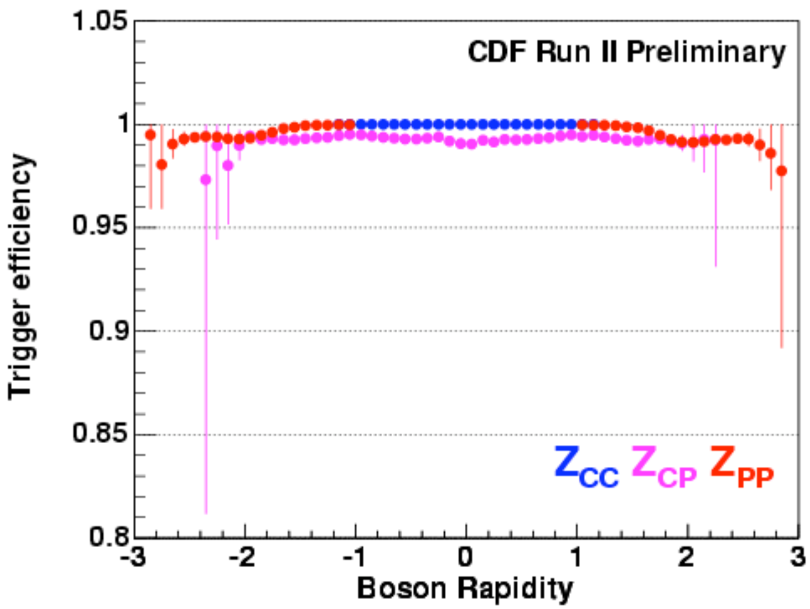




- Parton momentum fractions ($x_{1,2}$) determine Z boson rapidity (y_Z)
- Production measurement in high y_Z region probes high x region of PDFs
- Plug-plug (Z_{PP}) event needed to probe highest x region

Data set

- Data sample : ~1.1 fb^{-1}
  - Inclusive single central electron trigger
  - Two electron trigger (central or forward)
  - Trigger efficiency measured as a function of electron E_T
  - Overall trigger efficiency ~ 100 %



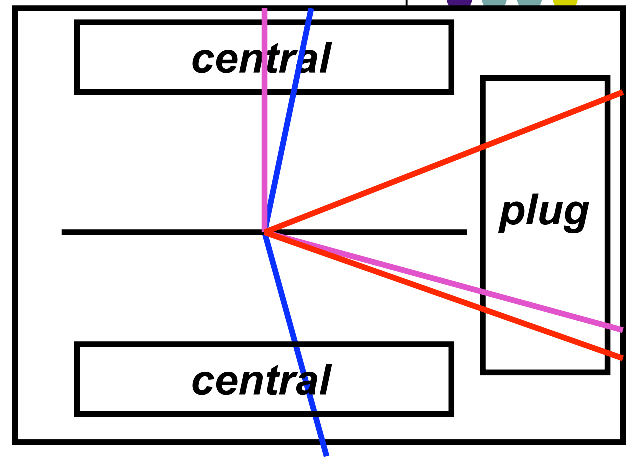
❖ Total trigger efficiency

Zcc : 1.0

Zcp : 0.994±0.001

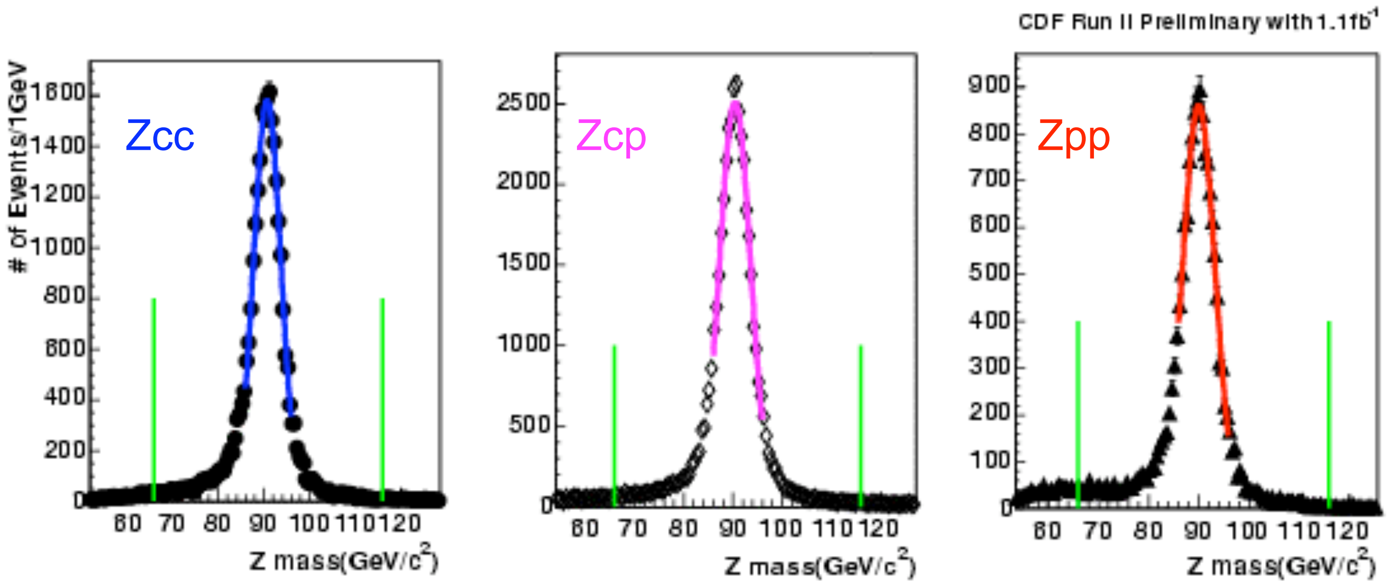
Zpp : 0.995±0.001

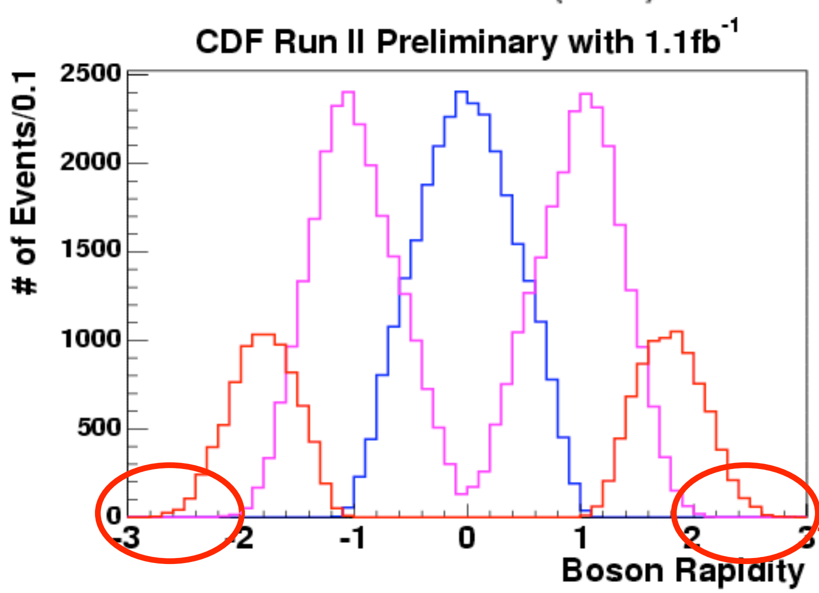
Selection



- Z selection with two central electrons : Zcc
  - Kinematic selection : $E_T \geq 25$ GeV , $|\eta|<1.1$
  - Two good central electrons
  - Oppositely charged electrons
- Z selection with a central and plug electron : Zcp
  - Kinematic selection : $E_T \geq 20$ GeV
    $|\eta|<1.1$ for central, $1.2 < |\eta|<2.8$ for plug
  - One good central electron and plug electron
- Z selection with two plug electrons : Zpp
  - Kinematic selection : $E_T \geq 25$ GeV , $1.2 < |\eta| < 2.8$
  - Two good plug electrons
  - Same side events
  - One electron candidate must have a matched silicon track (~87%)

Mass and Rapidity





Mass window : 66 < M < 116 GeV/c^2

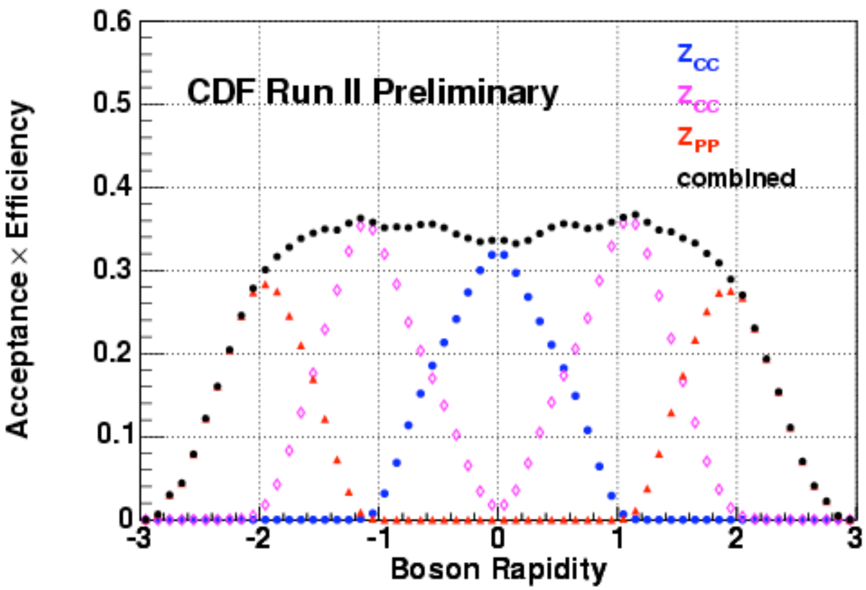
	Z(CC)	Z(CP)	Z(PP)
Events	28097	46676	16589

Total : 91362 events

→Probes high y region (~ 2.9)

Acceptance and Efficiencies

- Measured Acceptance × Efficiencies in Boson rapidity



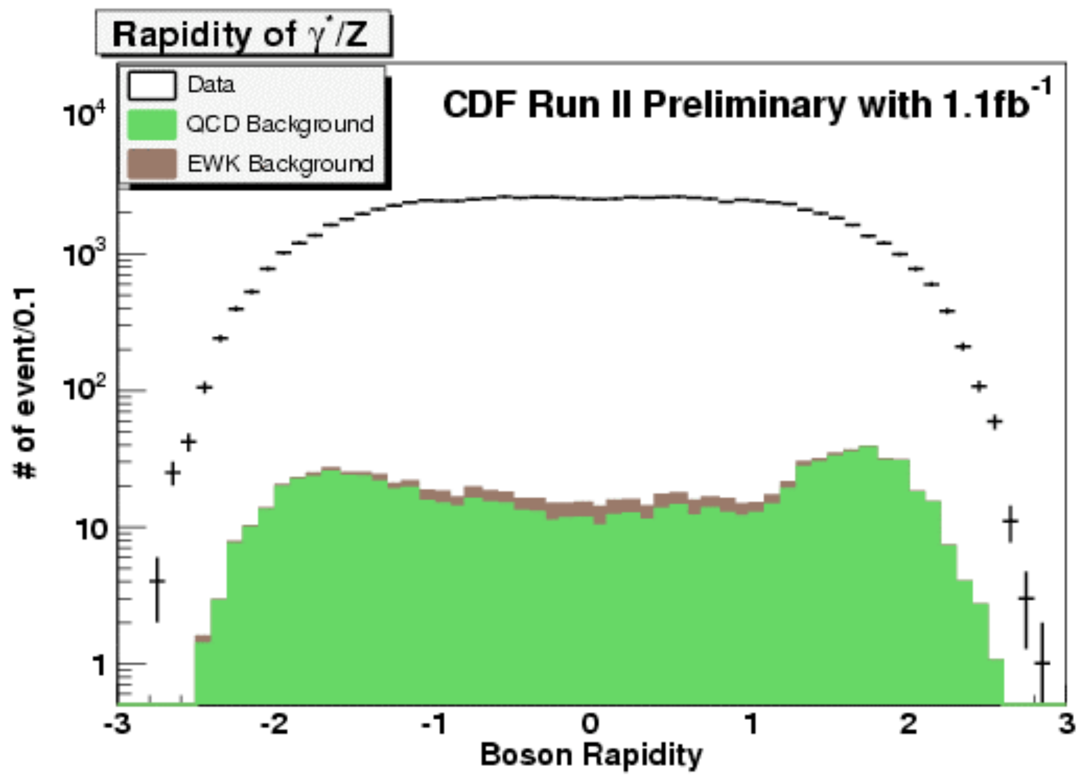
❖ Geometric and kinematic acceptances modeled using Pythia MC and GEANT detector simulation

❖ MC tuned to data
⇒ Energy resolution and scale
⇒ Efficiencies

- Total Acceptance × Efficiencies is 33.5%.
- A × E is flat up to $|y_Z|$ ~ 2.0 and non-zero up to $|y_Z|$ ~ 2.9 by adding Z_{PP} region

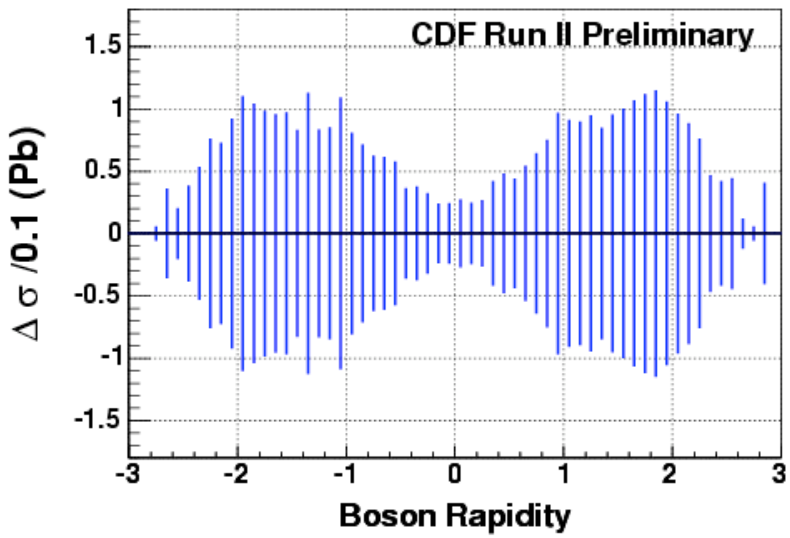
Backgrounds for Z/γ^*

- Background estimation (QCD+EWK)
  - QCD Background is 0.92±0.06%
  - EWK background is 0.11±0.01% (WW,WZ, ttbar inclusive,W+jet)



Systematic study

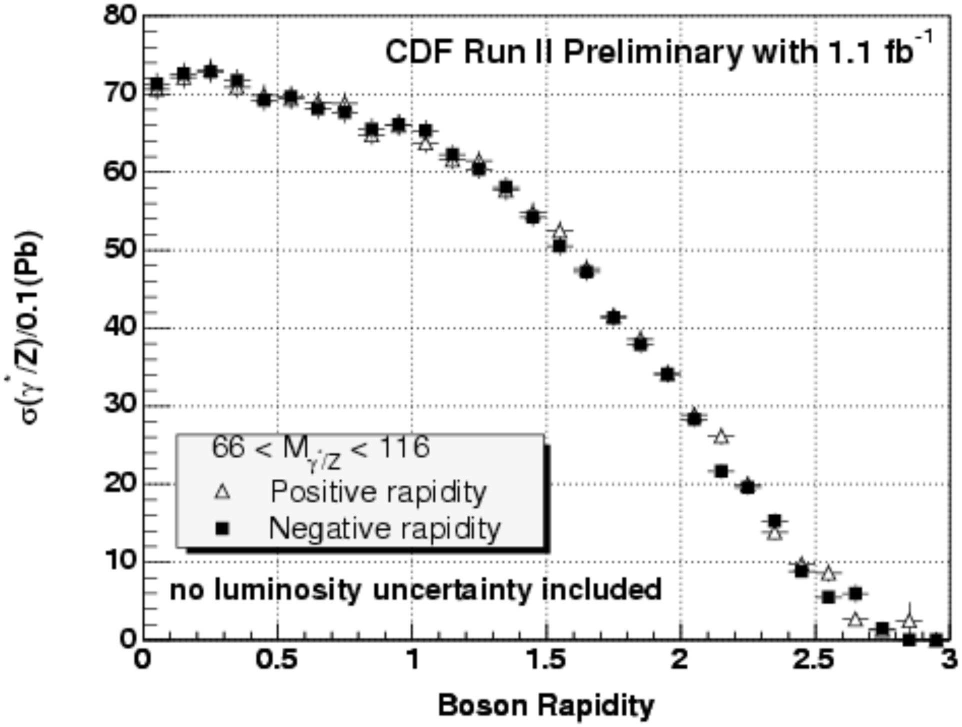
- Systematic uncertainties determined for
  - Detector material modeling
  - Background estimates
  - Electron identification efficiencies
  - Silicon tracking efficiency
  - Acceptance



- Largest systematic uncertainties associated with measurement of electron ID efficiency

dσ/dy distribution I

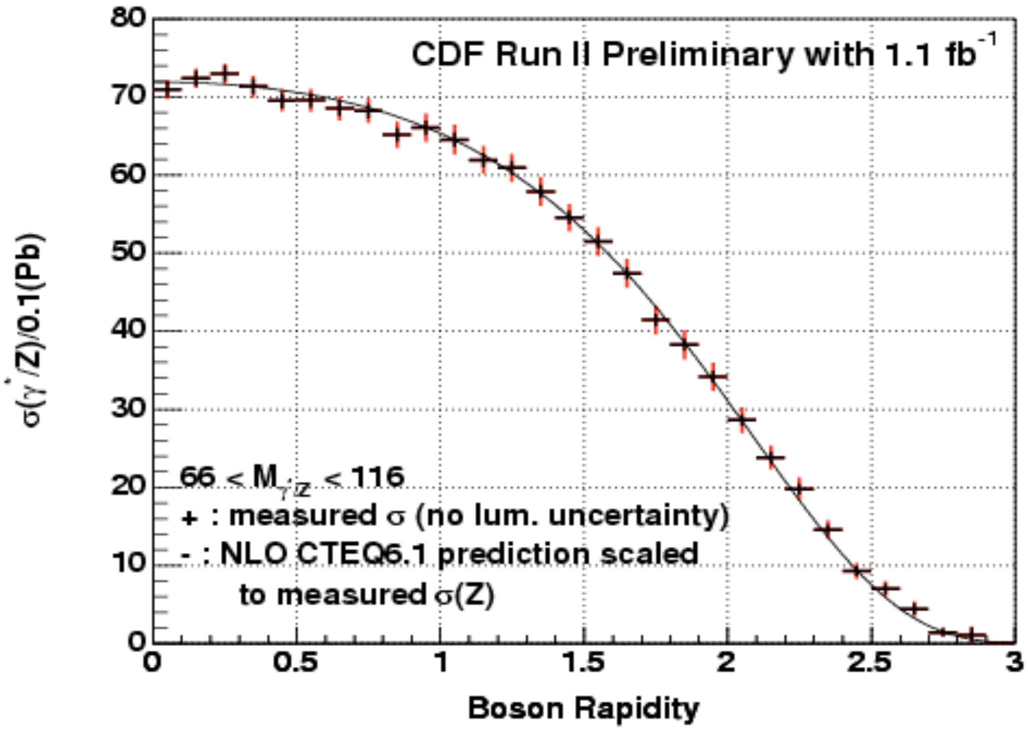
- dσ/dy distribution of Z/γ^* (positive and negative rapidity region)



- σ(y>0) : 264.3±1.4(stat.) pb
  σ(y<0) : 262.5±1.3(stat.) pb
- No PDF or luminosity uncertainties included
- σ of positive and negative rapidity is consistent

dσ/dy distribution II

- dσ/dy distribution of Z/γ^*

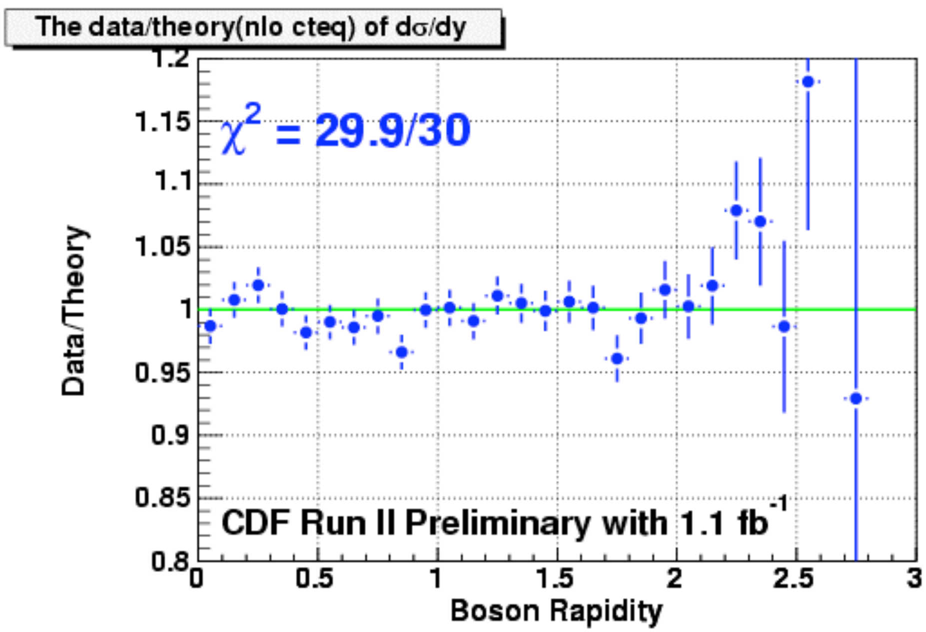


- NLO calculation with NLL CTEQ PDF
- σ (Z→ee) : *263.3± 0.9(stat.)±3.8(sys.) pb*
- No PDF or luminosity uncertainties included

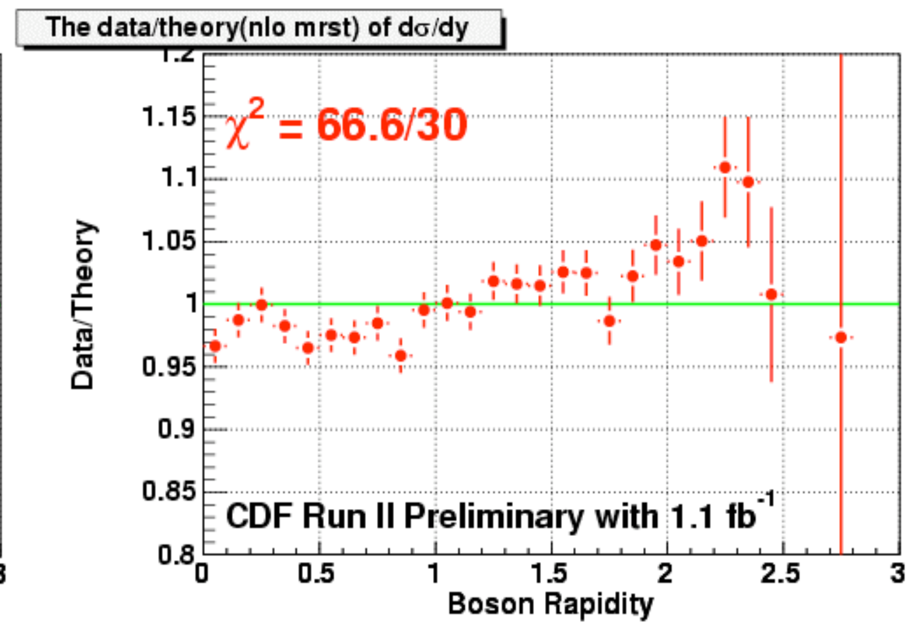
dσ/dy distribution (data/theory)

No PDF or $\mathcal{L}$ uncertainties included in data
Theory prediction scaled to measured σ (Z)
Only statistic uncertainty considered

- NLO calculation with NLL CTEQ PDF



- NLO calculation with NLL MRST PDF

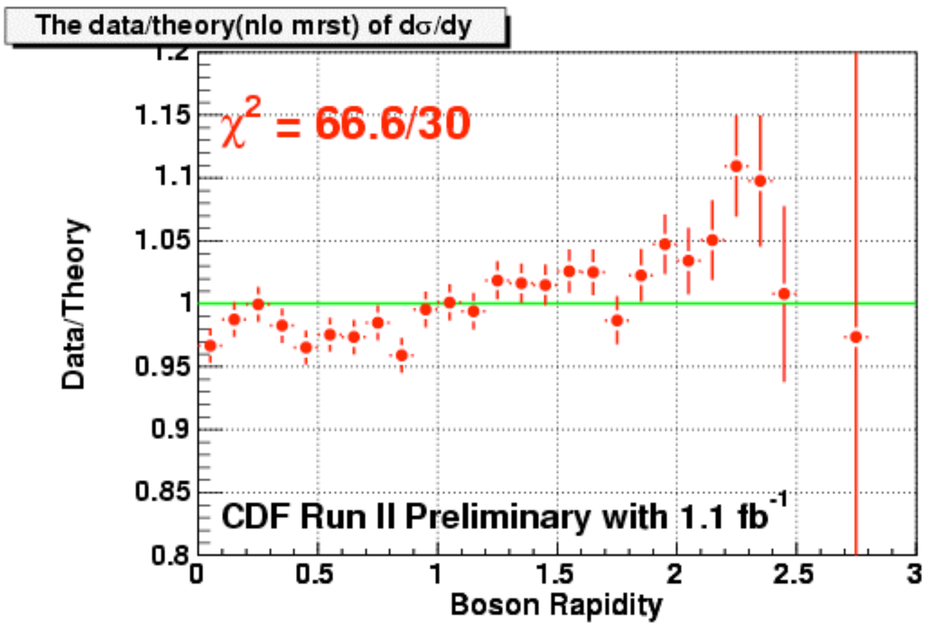


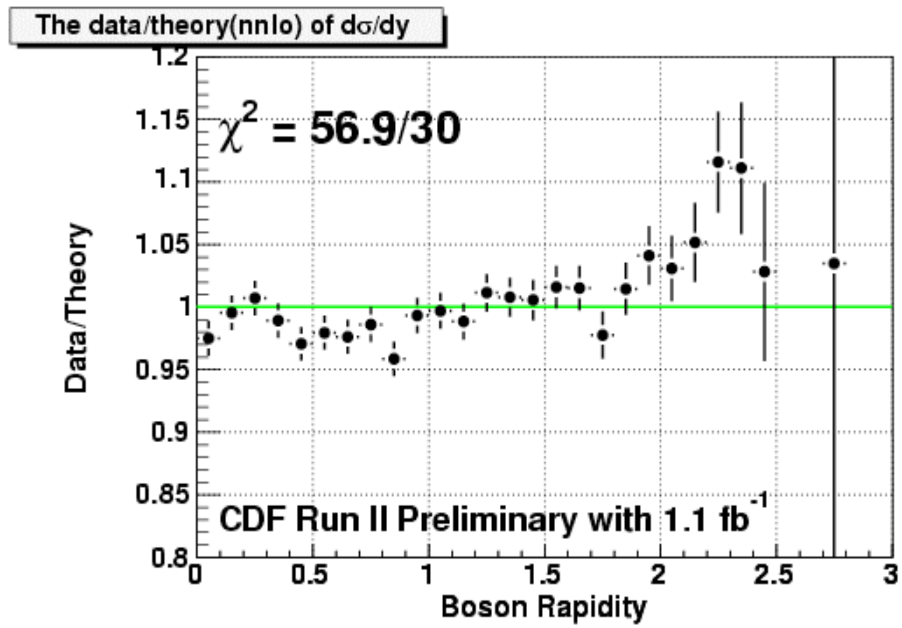
CTEQ PDF describes data better

dσ/dy distribution (data/theory)

No PDF or $\mathcal{L}$ uncertainties included in data
Theory prediction scaled to measured σ (Z)
Only statistic uncertainty considered

- NLO calculation with NLL MRST PDF
- NNLO calculation with NNLL MRST PDF





NNLO calculation is slightly better, but not much different

Reference for NNLO calculation : Phys.Rev.D69:094008

Summary

- We measure $d\sigma/dy$ distribution of $Z/\gamma^* \rightarrow e^+e^-$ up to $|y_Z| \sim 2.9$
- Total cross section = 263.3 ± 0.9(*stat.*) ± 3.8(*sys.*) *pb*
  - *No PDF or luminosity uncertainties included*
- Measured $d\sigma/dy$ shape :
  - Can distinguish between PDFs : CTEQ PDFs has better agreement
  - NNLO vs. NLO : NNLO gives marginally better agreement

Backup slide

RunI result

$$\sigma \times Br(\gamma^* / Z \rightarrow e^+e^-) = 252 \pm 11pb$$

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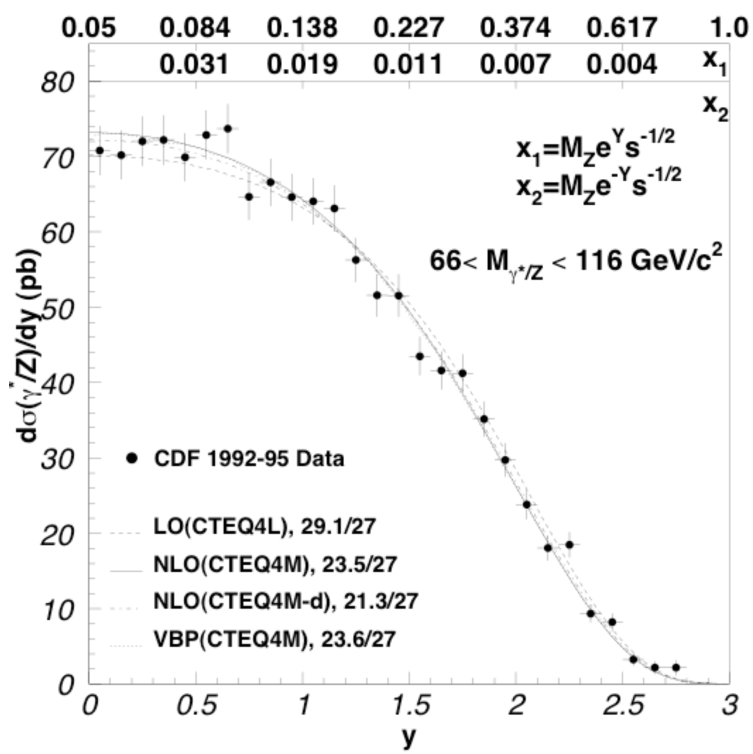
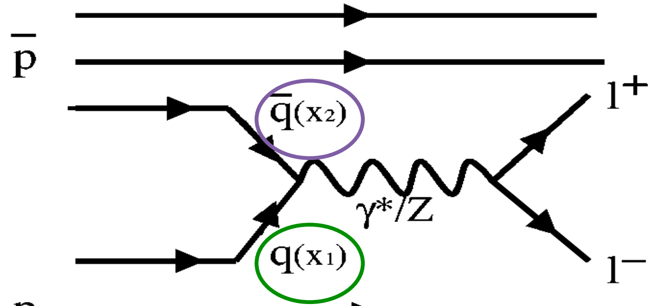
- PDF predictios
  - LO CTEQ4 PDF
  - NLO CTEQ4 PDF
  - d quark enhanced modified NLO CTEQ4 PDF
  - NLO gluon resummated calculation with CTEQ4 PDF



- not enough to make a distinction better PDF

Boson Rapidity

Feynman Diagram of Drell-Yan proccess



- x_1 : **Parton momentum fraction from proton**
- **x_2 : Parton momentum fraction from anti-proton**
- **$x_{1,2}$ determine rapidity of Z boson**
- **What is the rapidity ?**

$$y = \frac{1}{2} ln(\frac{E+P}{E-P})$$

(P: momentum in longitudinal direction)

- What is the relation between $x_{1,2}$ and the rapidity in Z boson?

$P_{\gamma^*/Z} = (x_1E_B + x_2E_B, 0, 0, x_1E_B - x_2E_B)$ → $Y = \frac{1}{2} ln(\frac{x_1}{x_2})$ → $Y = \ln(\frac{\sqrt{s} \times x_1}{M})$

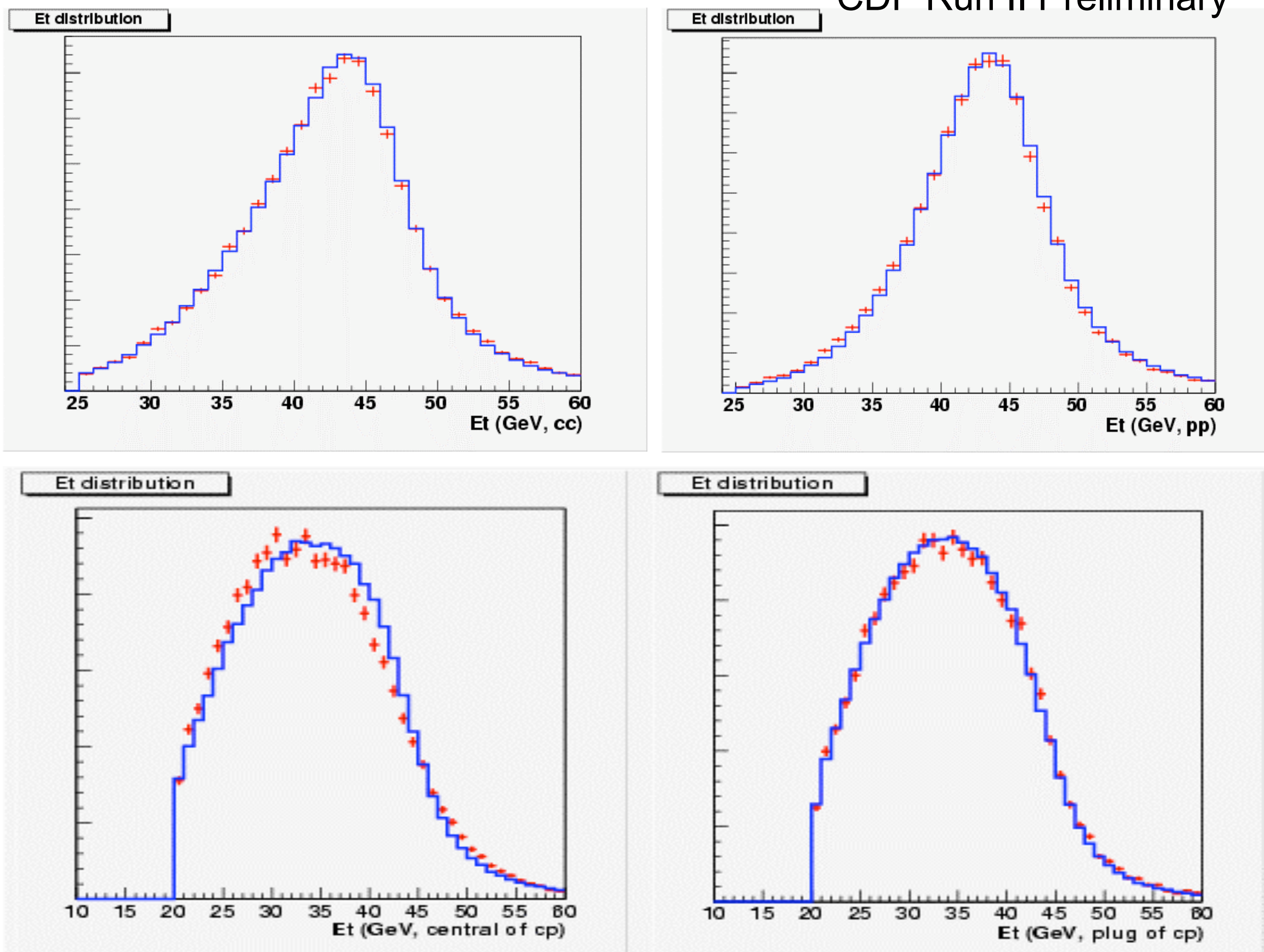
insert $P_{\gamma^*/Z}$ into rapidity definition $x_1x_2 = M^2/s$

E_B : beam energy in the center of mass frame
$s^{1/2}$: total center of mass energy ($= 2E_B$)

Et distribution

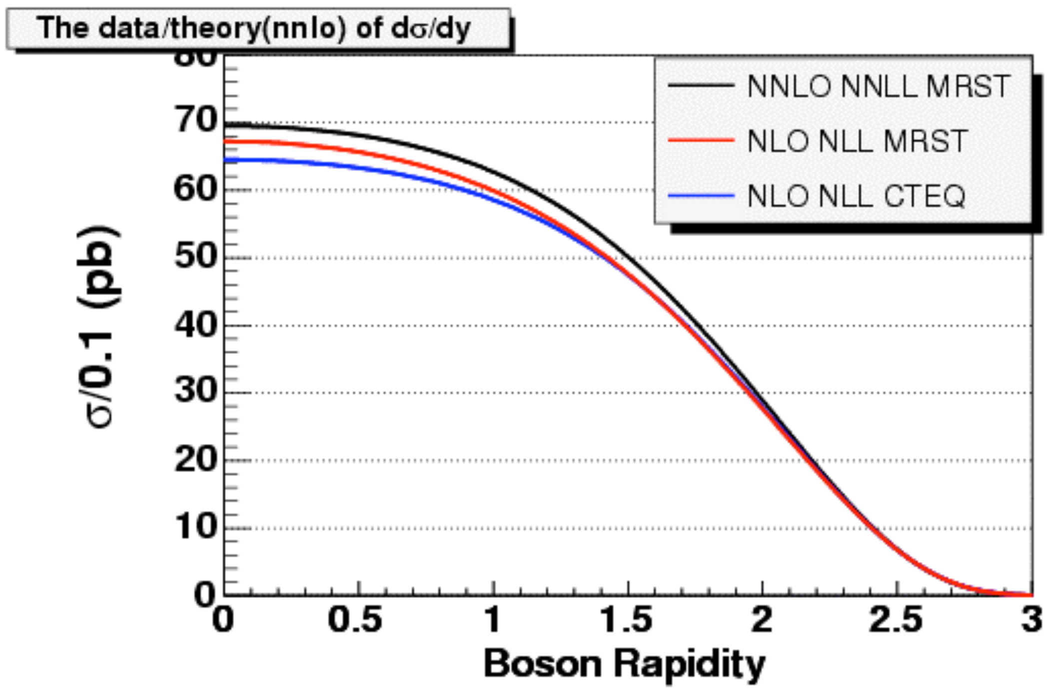
- Et distribution (data, MC)

CDF Run II Preliminary



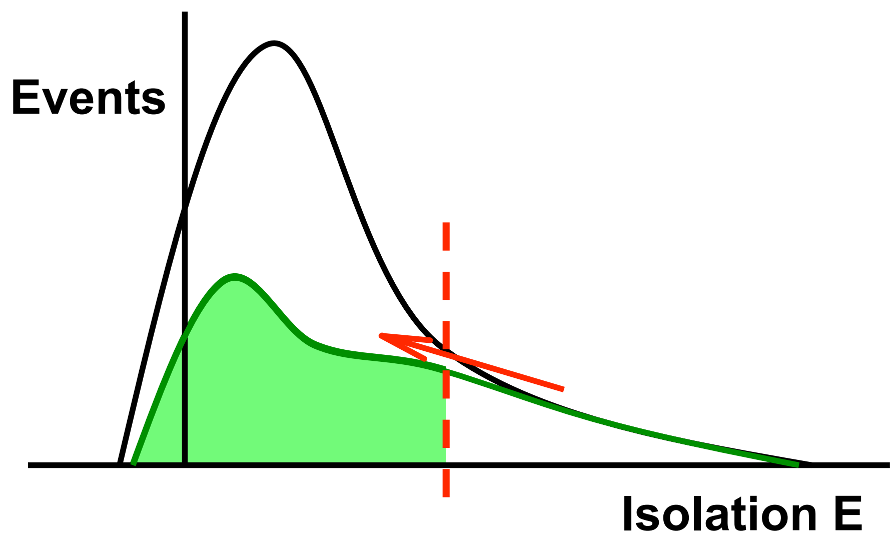
Theory Prediction

- Total cross section
  - NNLO calculation with NNLL MRST PDF : 251.34pb
  - NLO calculation with NLL MRST PDF : 241.01pb
  - NLO calculation with NLL CTEQ PDF : 236.14pb



Backgrounds for Z/γ^* : QCD

- Largest background : QCD dijets
- Magnitude obtained from fit to electron isolation distribution
  - Isolation defined as energy contained in a $\Delta R=0.4$ cone around an electron minus the energy of the electron itself
  - Fit isolation distribution for both signal and background contributions
  - Extrapolate the background from high Isolation tail into the signal region
- Total QCD background = 0.92±0.06%



Systematic Uncertainties

- Systematic uncertainties component

Systematic Component	$\delta\sigma/\sigma$ (%)
Material Effect	0.13
Background Estimation	0.44
Tracking Efficiency	0.15
ID Efficiency	1.30
Acceptance	0.13