dσ/dy Distribution of Drell-Yan Dielectron Pairs at CDF Run II

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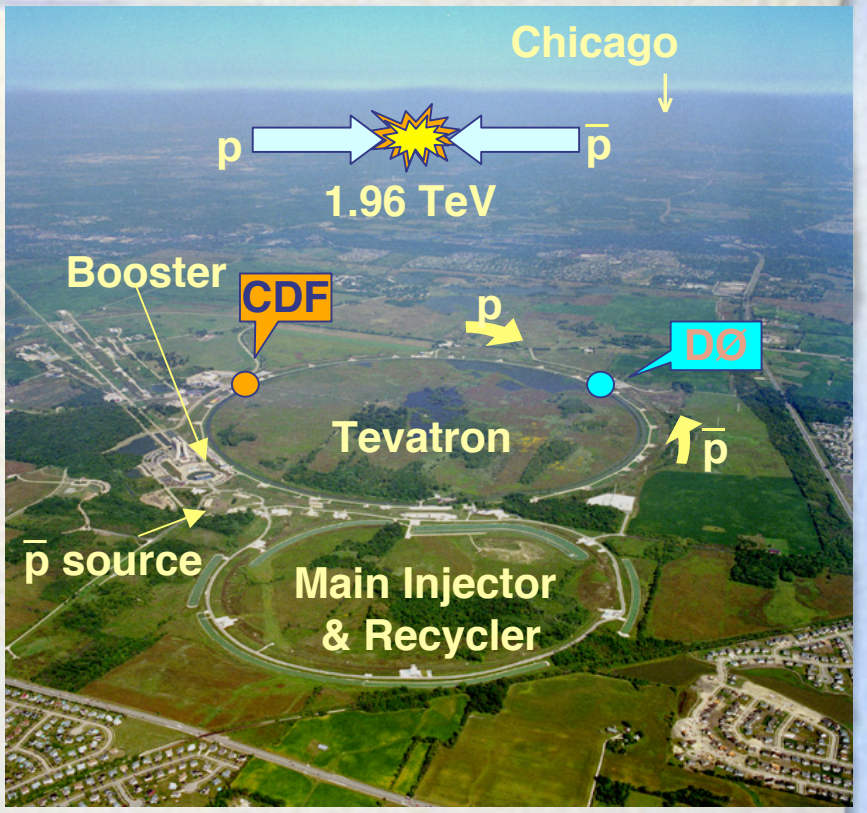
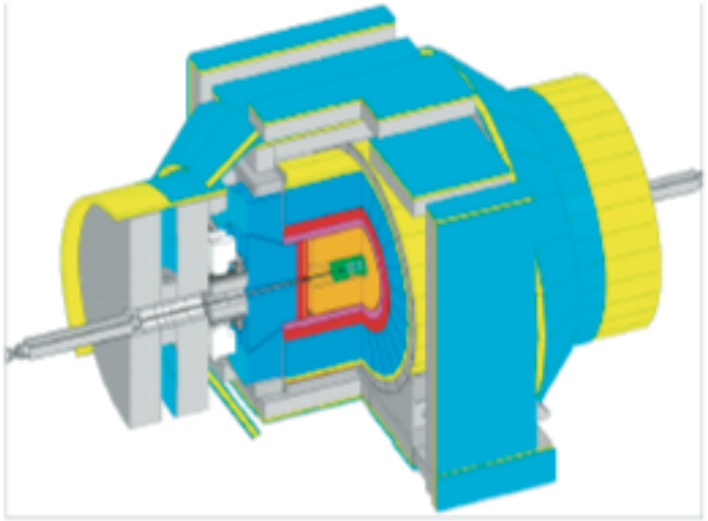
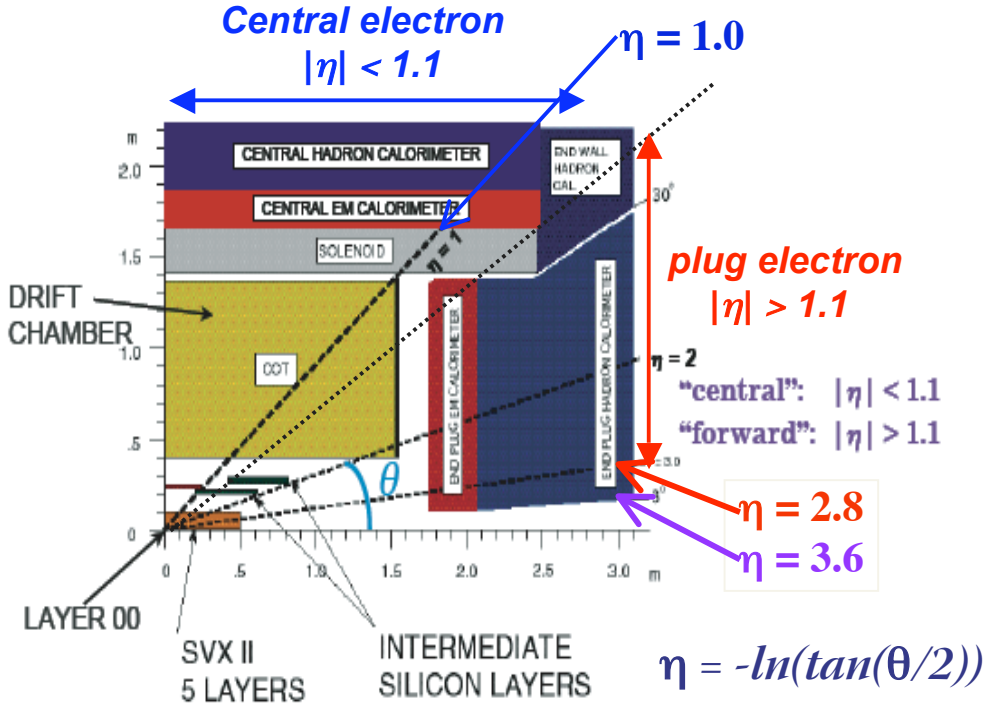


CDF Run II Detector



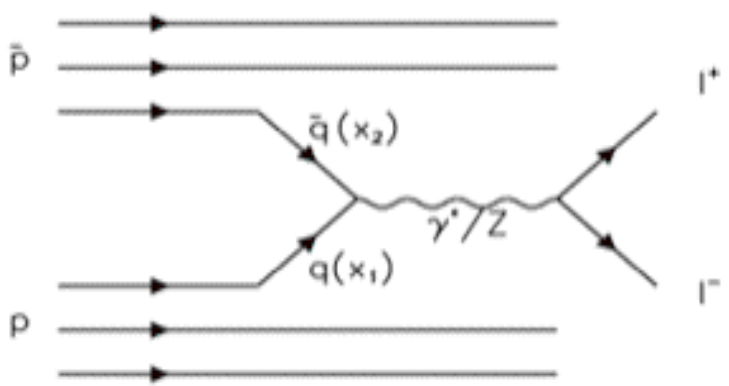
- Silicon Tracking Detectors
- Central Drift Chamber
- Solenoid Coil /TOF
- EM Calorimeter
- Hadronic Calorimeter
- Muon Drift Chambers
- Muon Scintillator Counters

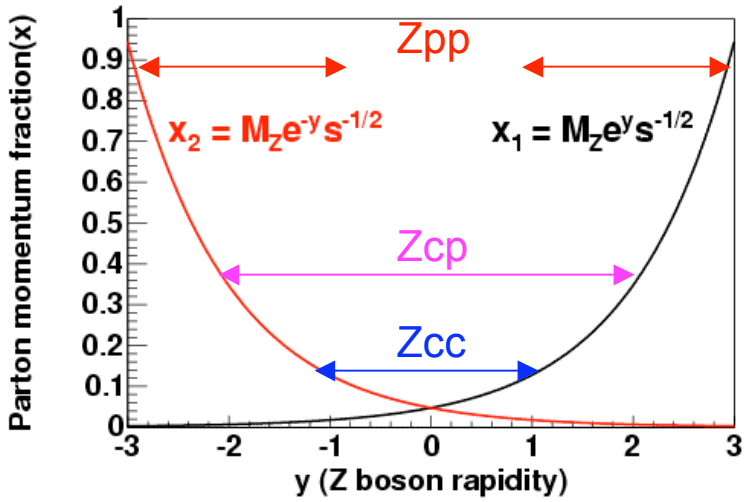


- Plug calorimeter covers high η region(~ 3.6)
- Silicon track covers |η| < 2.8
- Silicon tracking reduces background contamination

Introduction

Feynman Diagram

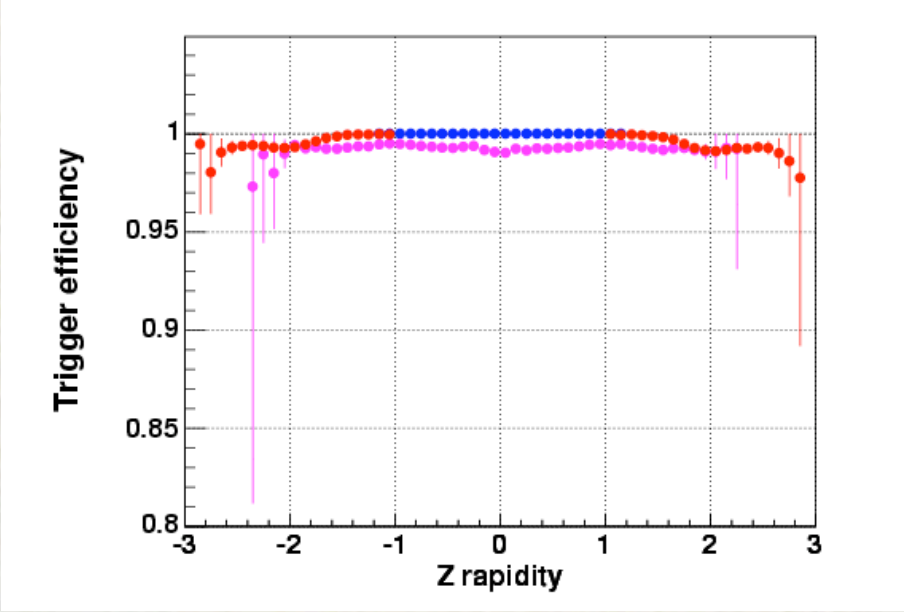




- Parton momentum fractions ($x_{1,2}$) determine rapidity (y) of Z boson
- The measurement of high y region probes high x region
- Z boson decays to two forward electron corresponds to high y
- $d\sigma/dy$ measurement tests PDF predictions

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 %



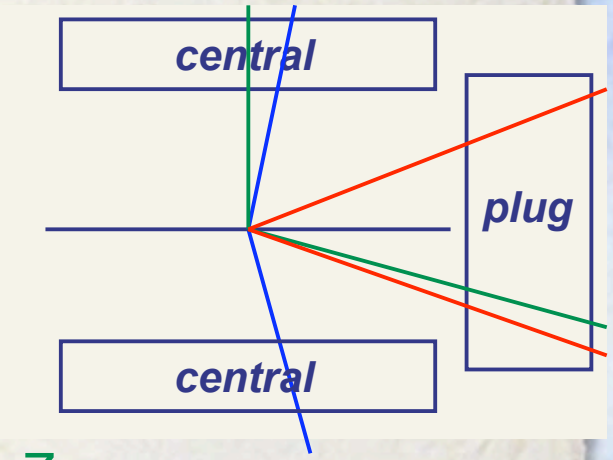
❖ Total trigger efficiency

Zcc : 1.0

Zcp : 0.994±0.001

Zpp : 0.995±0.001

Selection



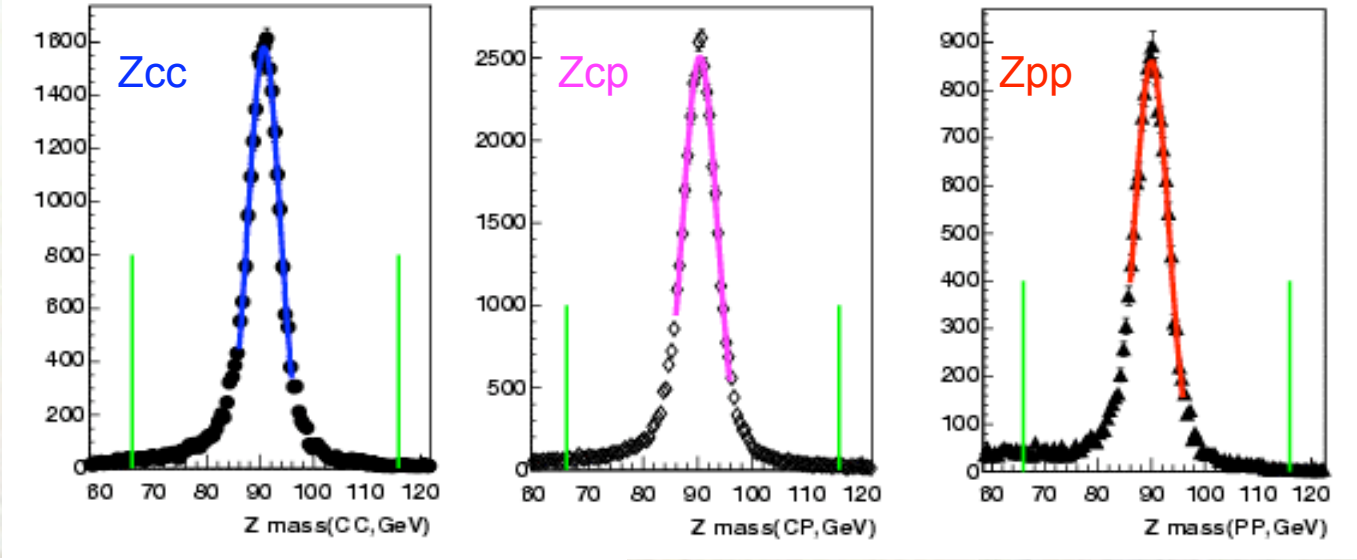
- Z selection with two central electrons : Zcc
  - Kinematic selection : $E_T \geq 25$ GeV , $|\eta|<1.1$
  - Two electrons with tight and loose ID
  - Opposite charge electrons required

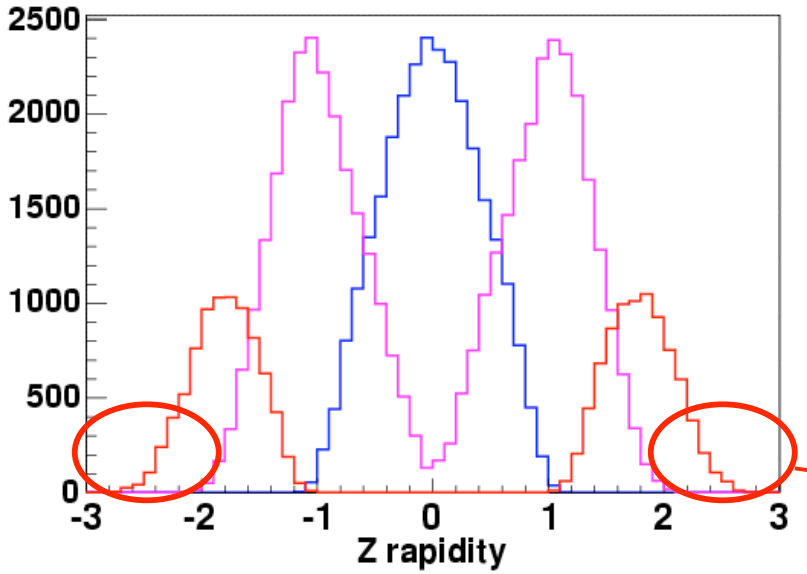
- Z selection with a central and forward electron : Zcp
  - Kinematic selection : $E_T \geq 20$ GeV
    $|\eta|<1.1$ for central, $1.2 < |\eta|<2.8$ for plug
  - One tight central electron and one plug electron

- Z selection with two forward electrons : Zpp
  - Kinematic selection : $E_T \geq 25$ GeV , $1.2 < |\eta| < 2.8$
  - Two plug electrons
  - Same side events required
  - One leg must have a silicon track

Mass and Rapidity

CDF preliminary result





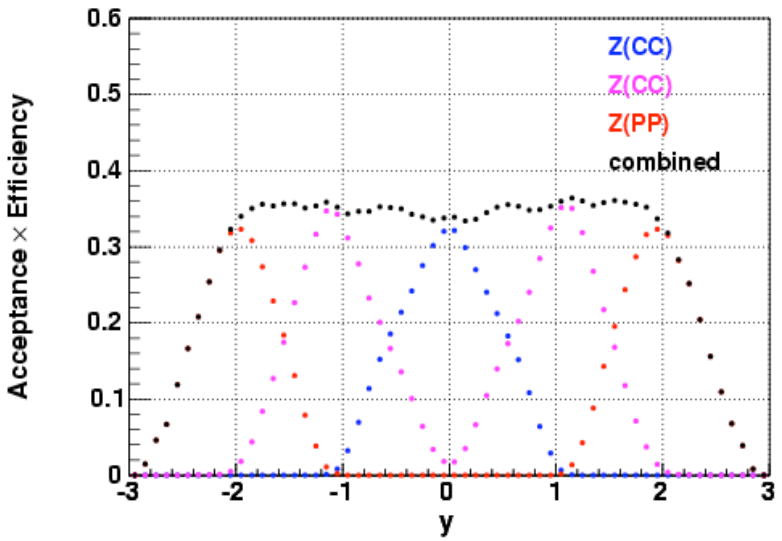
Mass window : 66 < M < 116 GeV

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

Probe high y region (~ 2.9)

Acceptance and Efficiency

- Acceptance × Efficiency in rapidity



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

❖ MC tuned to data
⇒ Energy resolution and scale
⇒ Electron ID efficiency

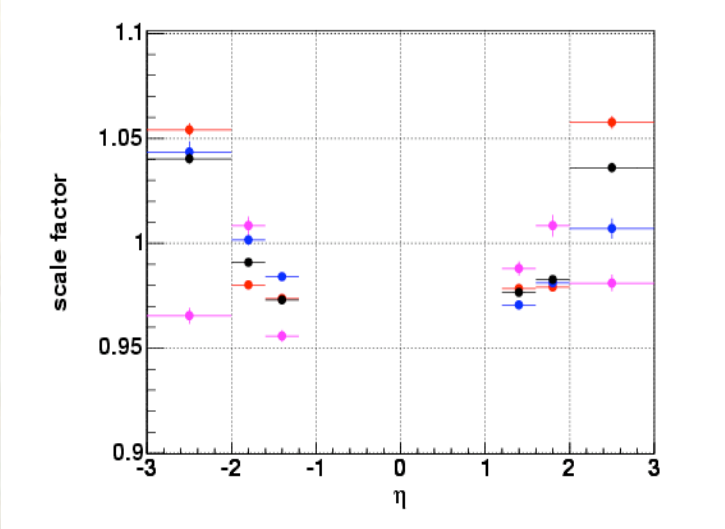
	Zcc	Zcp	Zpp
Acceptance	0.113±0.001	0.239±0.001	0.100±0.001
Efficiency	0.911±0.002	0.702±0.005	0.733±0.010

- A × E is flat up to y ~ 2.0 and non-zero to y ~ 2.9 by adding PP region

Silicon tracking efficiency I

- One Silicon track required in Zpp to reduce the background
- There is a discrepancy between the data and MC silicon track finding efficiencies
  - Data/MC efficiency ratio (scale factor) as a function of Z vertex and η

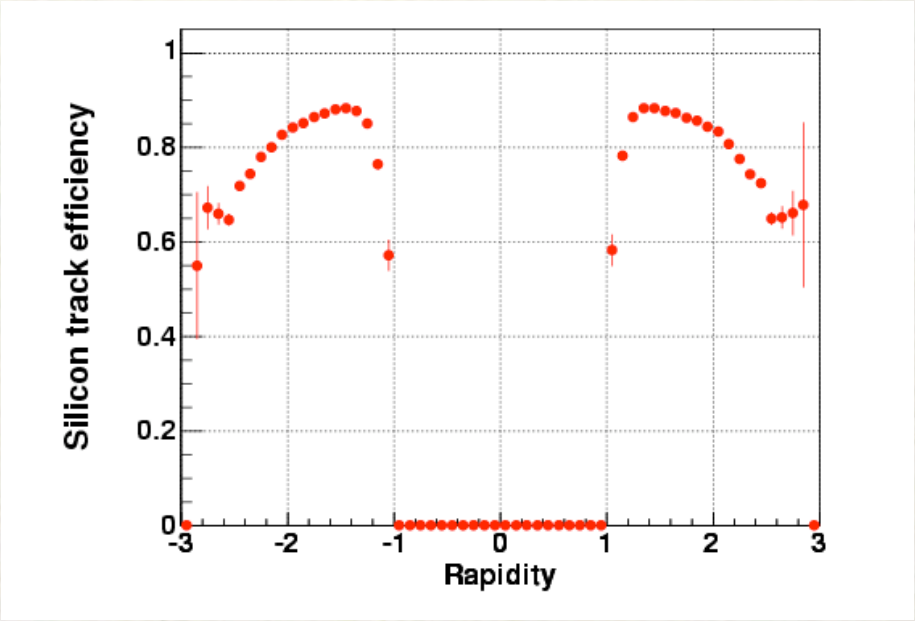
|zvtx|<15
15≤|zvtx|<30
30≤|zvtx|<60
|zvtx|<60



- Scale factors applied to MC on event by event basis

Silicon tracking efficiency II

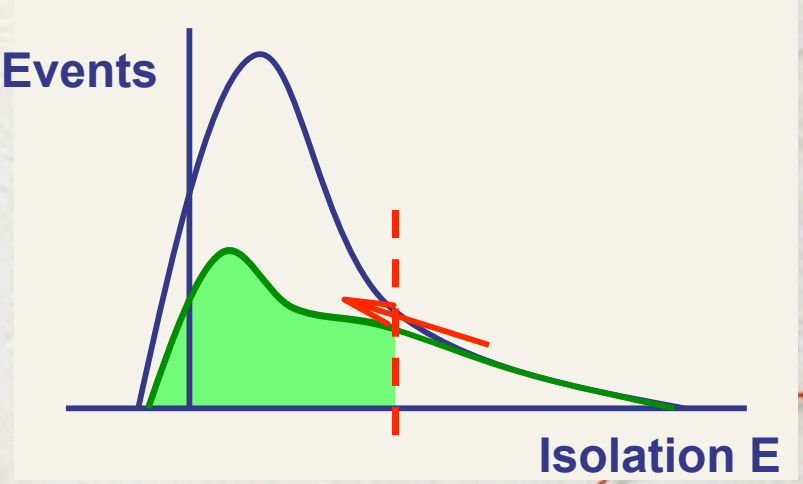
- Measure the effects of the selection efficiency of requiring at least one silicon track as a function of the boson rapidity in Zpp
- Determined from corrected MC
- Total tracking efficiency is 0.845



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

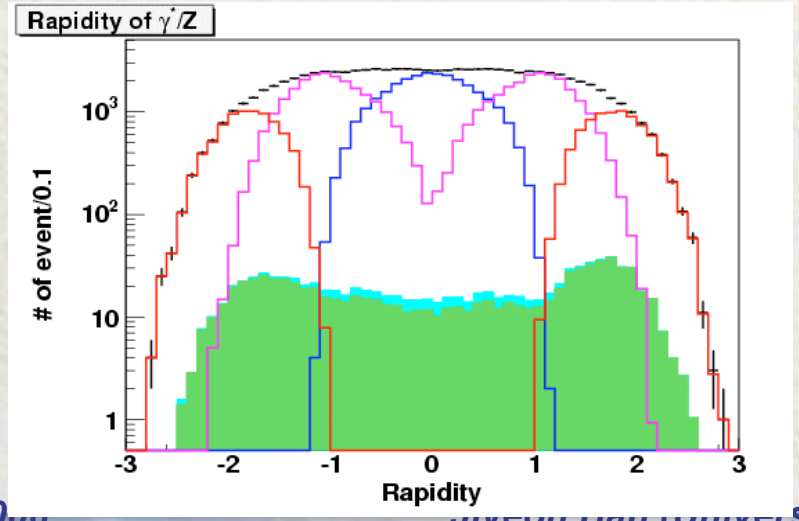
region	QCD background (%)
Zcc	0.38±0.08(stat.)±0.12(sys.)
Zcp	0.65±0.08(stat.)±0.21(sys.)
Zpp	2.62±0.22(stat.)±0.82(sys.)

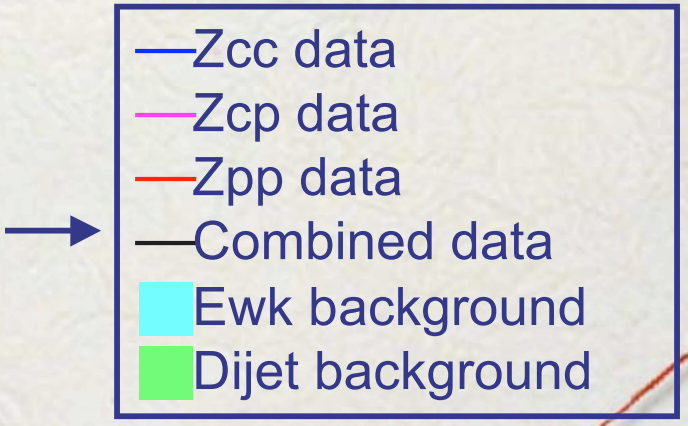


Backgrounds for Z/γ^* : EWK

- EWK background processes
  - Estimated using Pythia MC

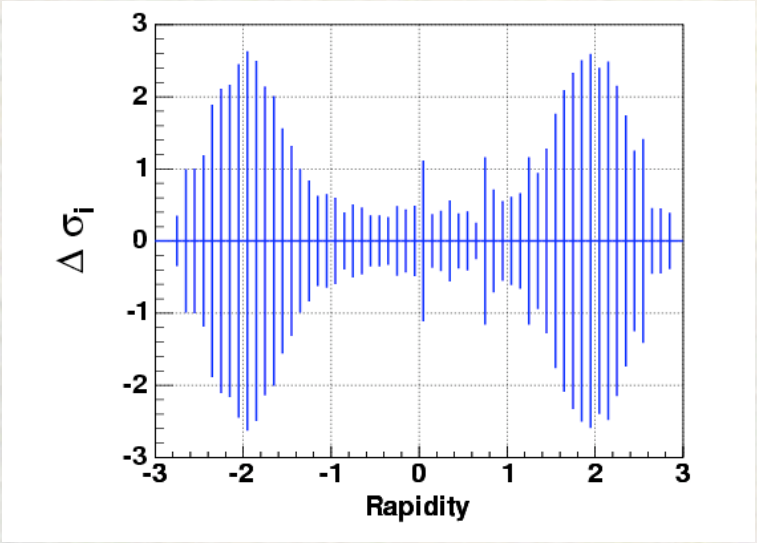
process	Zcc	Zcp	Zpp	Total
WW	10.3±0.7	11.5±0.8	1.7±0.1	23.4±1.1
WZ	18.0±1.2	22.7±1.5	6.3±0.4	46.9±2.0
ttbar inclusive	5.0±0.4	3.4±0.3	0.2±0.1	8.6±0.5
W+jet	2.4±1.1	13.2±2.7	3.9±1.3	19.5±3.2





Systematic study

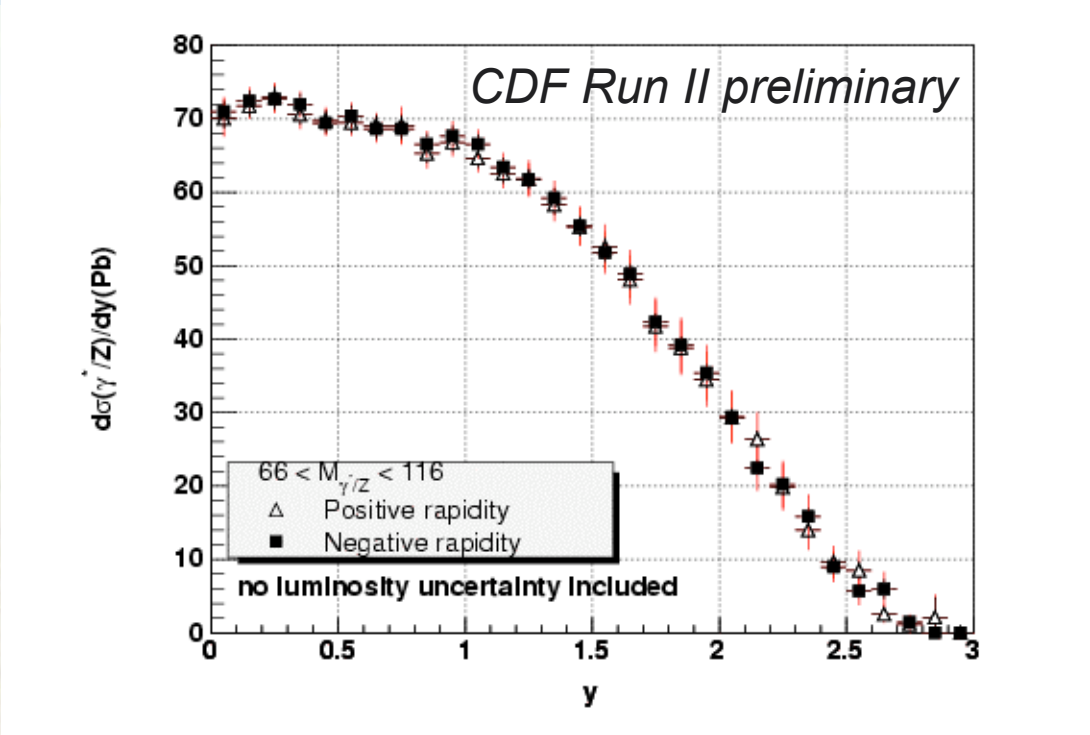
- Systematic uncertainties determined for
  - Detector material modeling
  - Background estimates
  - Electron identification efficiencies
  - Silicon tracking efficiency



- Largest systematic uncertainties associated with measurement of silicon tracking efficiencies

dσ/dy distribution I

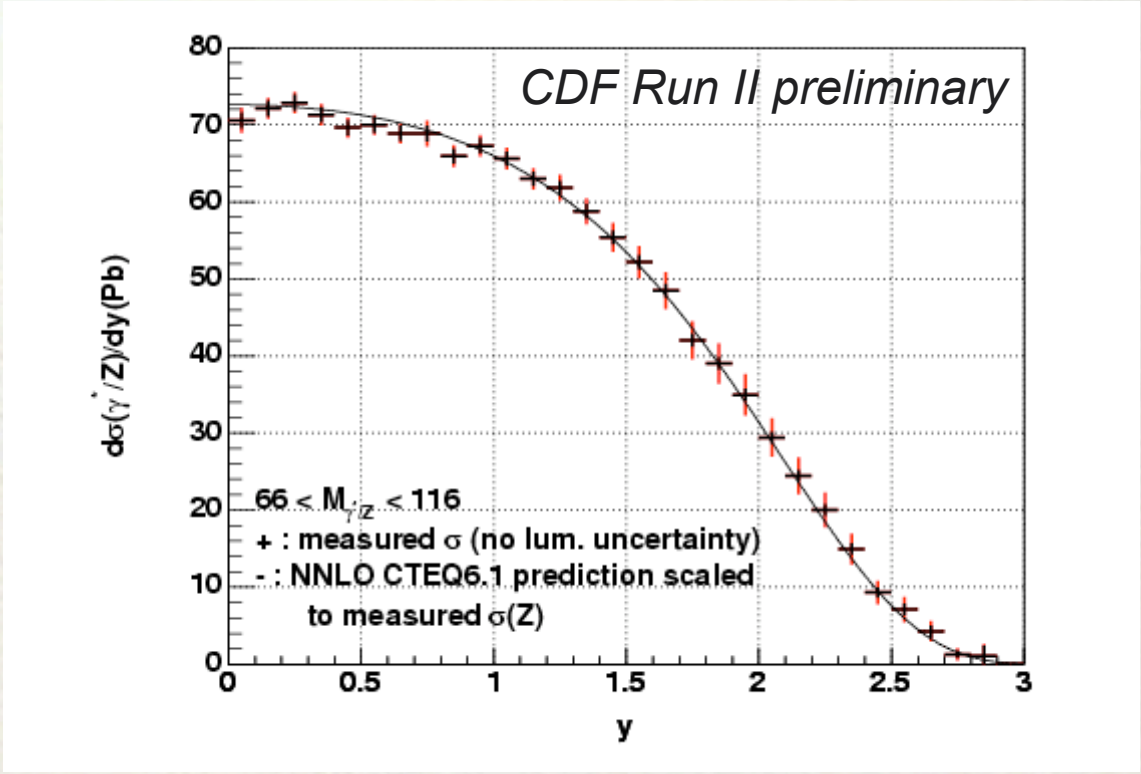
- dσ/dy distribution of Z/γ^* (positive and negative rapidity region)



- σ(y>0) : 265.3±1.5(stat.)±1.5(sys.) pb
  σ(y<0) : 266.6±1.4(stat.)±1.4(sys.) 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^*



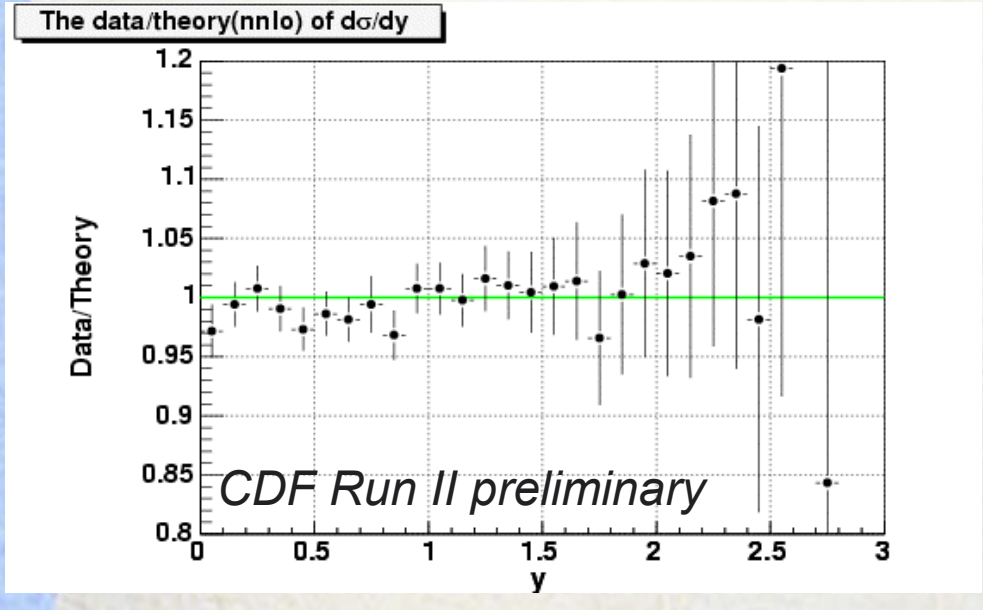
- NNLO calculation with NLO CTEQ6.1 PDF
- σ (Z→ee) : *265.9± 1.0(stat.)±1.1(sys.) pb*
- No PDF or luminosity uncertainties included

dσ/dy distribution (data/theory)

No PDF or $\mathcal{L}$ uncertainties included in data

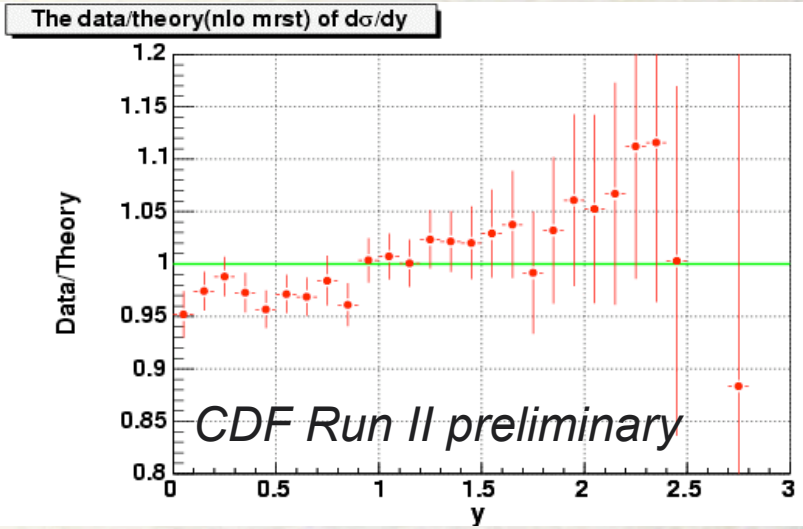
Theory prediction scaled to measured σ (Z)

- NNLO calculation with NLO CTEQ6.1 PDF

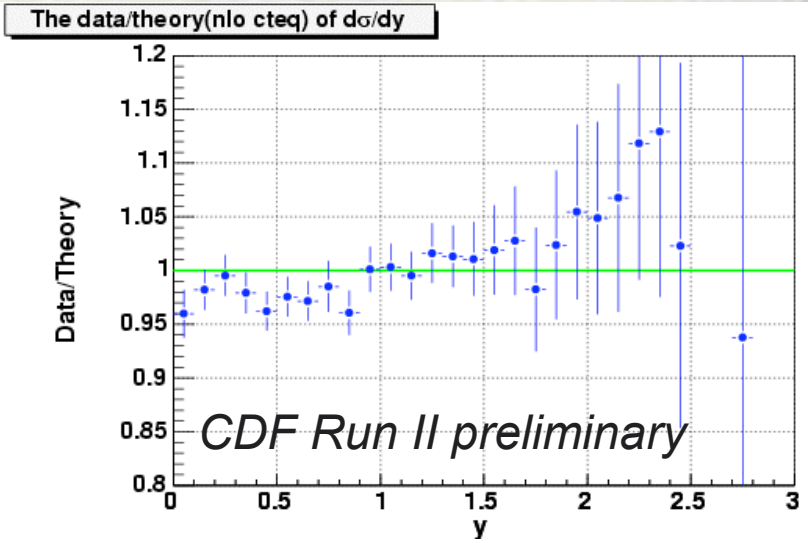


NNLO calculation with NLO CTEQ6.1 PDF describes data best

- NLO calculation with NLO MRST PDF



- NLO calculation with NLO CTEQ PDF



Summary

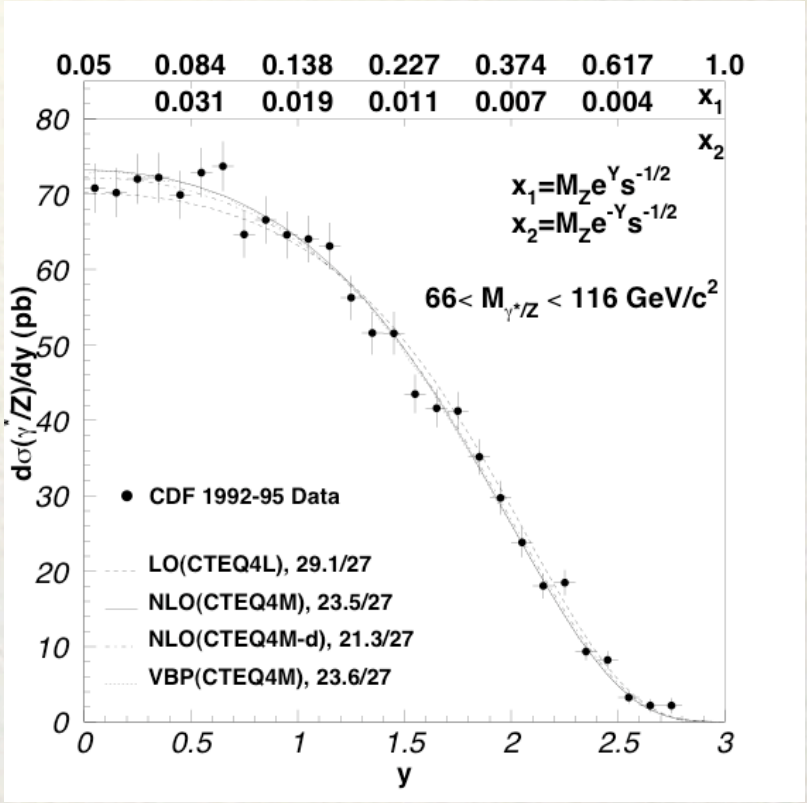
- We measure $d\sigma/dy$ distribution of $Z/\gamma^* \rightarrow e^+e^-$ up to $y \sim 2.9$
- Total cross section = 265.9 ± 1.0(*stat.*) ± 1.1(*sys.*) *pb*
  - *No PDF or luminosity uncertainties included*
- Measured $d\sigma/dy$ shape best matches NNLO calculation with NLO CTEQ6.1 PDF
- need to reduce the systematic uncertainty from silicon tracking

Backup slide

RunI result

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

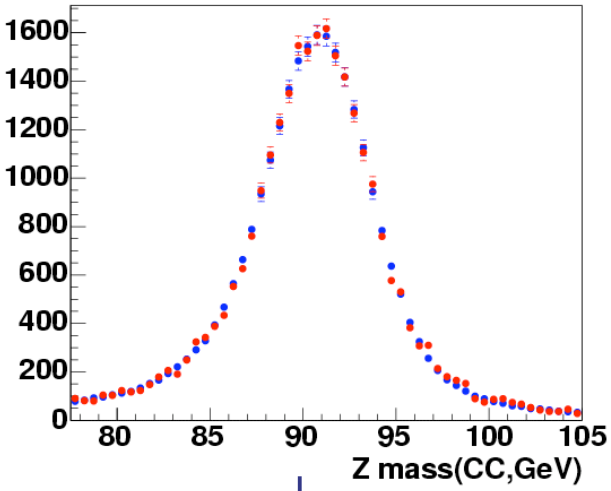
-
- PDF predictios
  - ✓ LO CTEQ4 PDF
  - ✓ NLO CTEQ4 PDF
  - ✓ d quark enhanced modified NLO CTEQ4 PDF
  - ✓ NLO gluon resummated calculation with CTEQ4 PDF

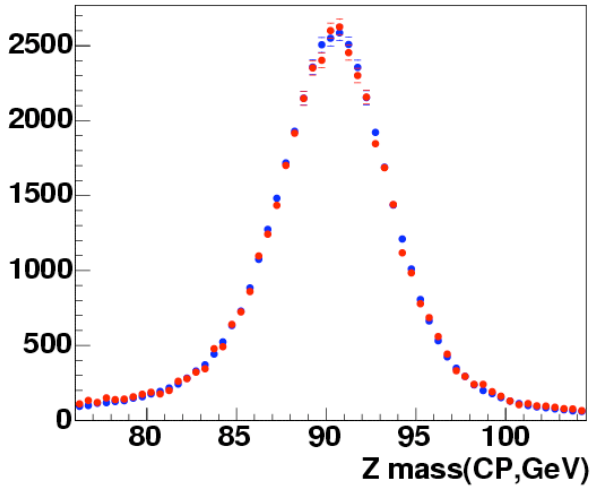


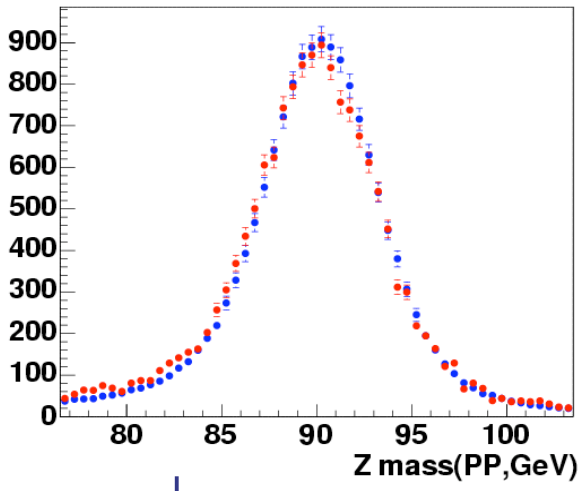
- not enough to make a distinction better PDF

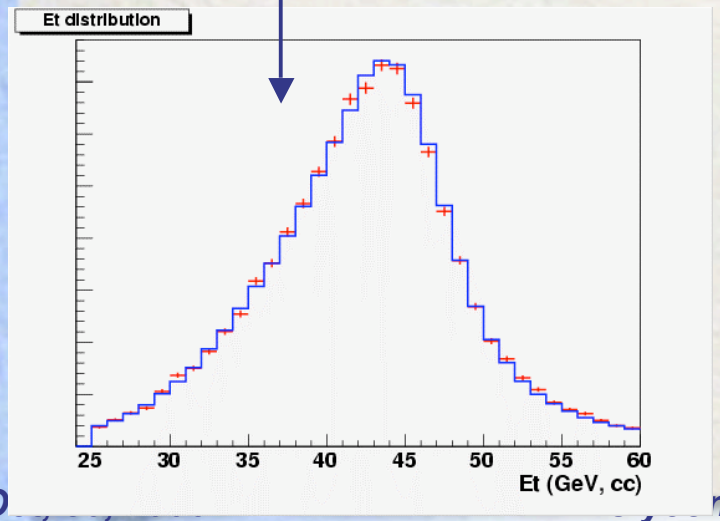
Z mass and Et distribution

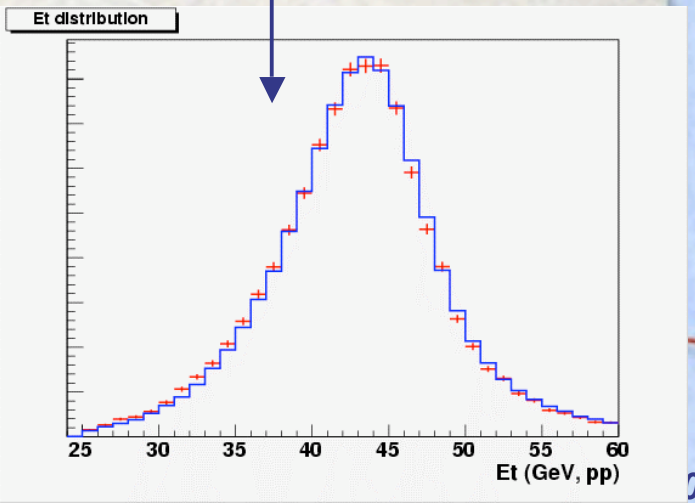
- Z mass and electron Et distribution (data, MC)











Z mass and Et distribution of Zcp

- Z mass and electron Et distribution (data, MC)