W/Z Physics at DØ

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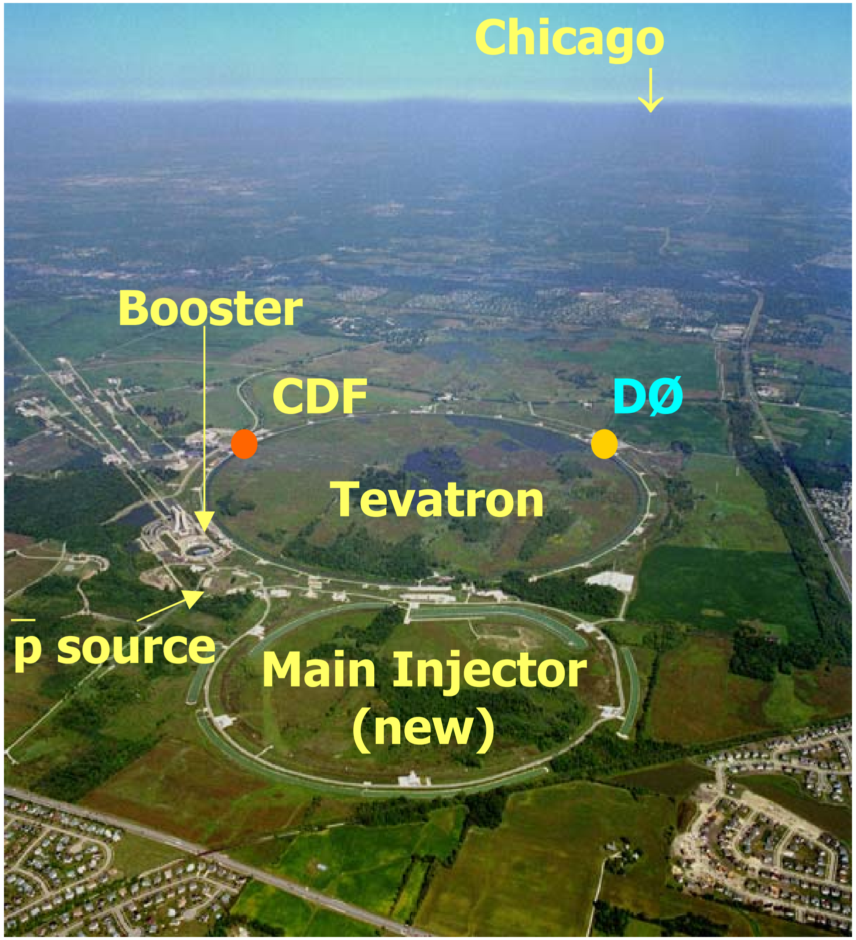
Plan of the talk:

- Overview of Tevatron and DØ Detector
- Introduction to W/Z Physics
- Results
- Summary and outlook

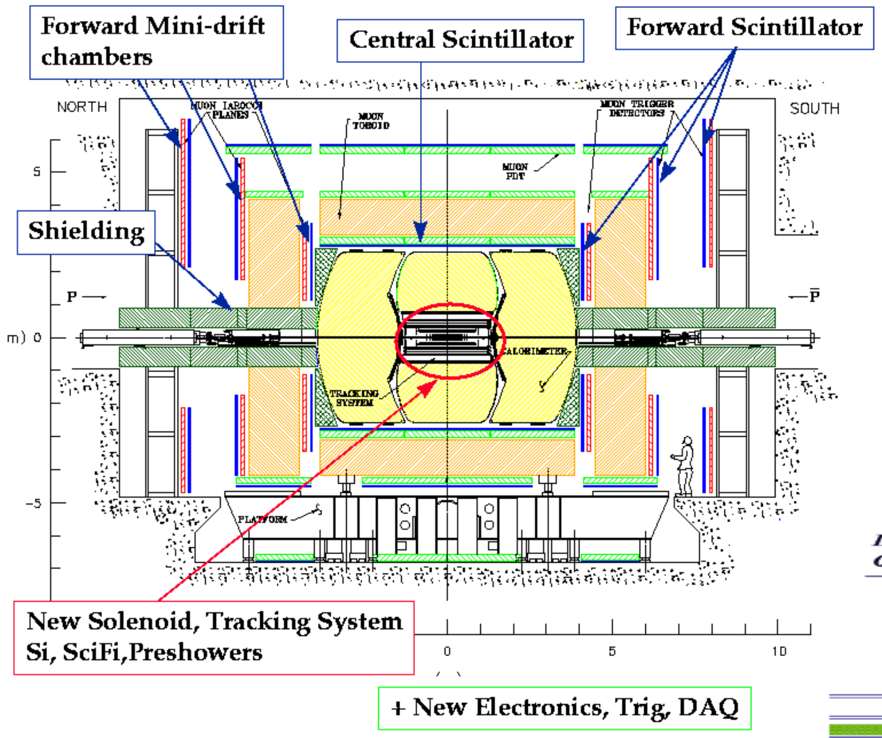
The RunII Tevatron



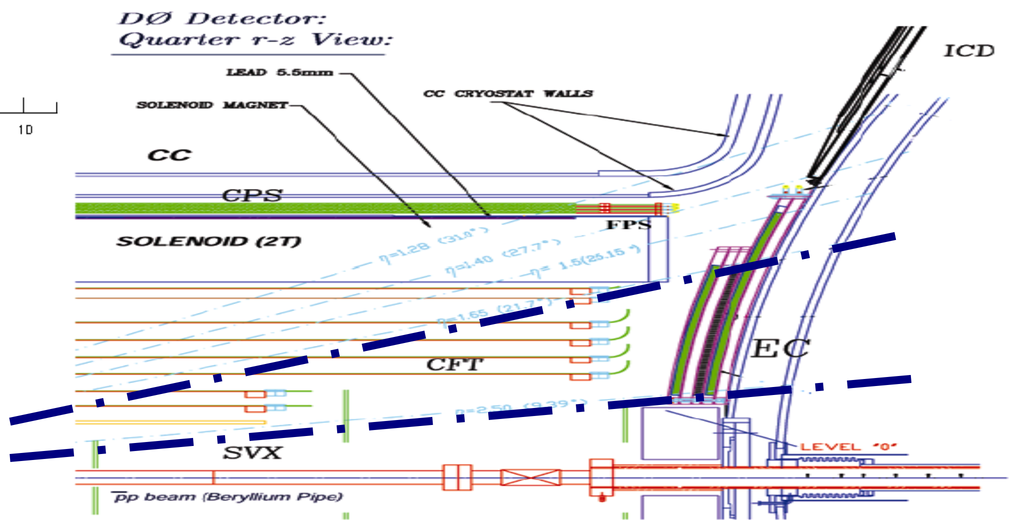
Increased center of mass energy
1.8 Tev → 1.96 TeV

Increased luminosity

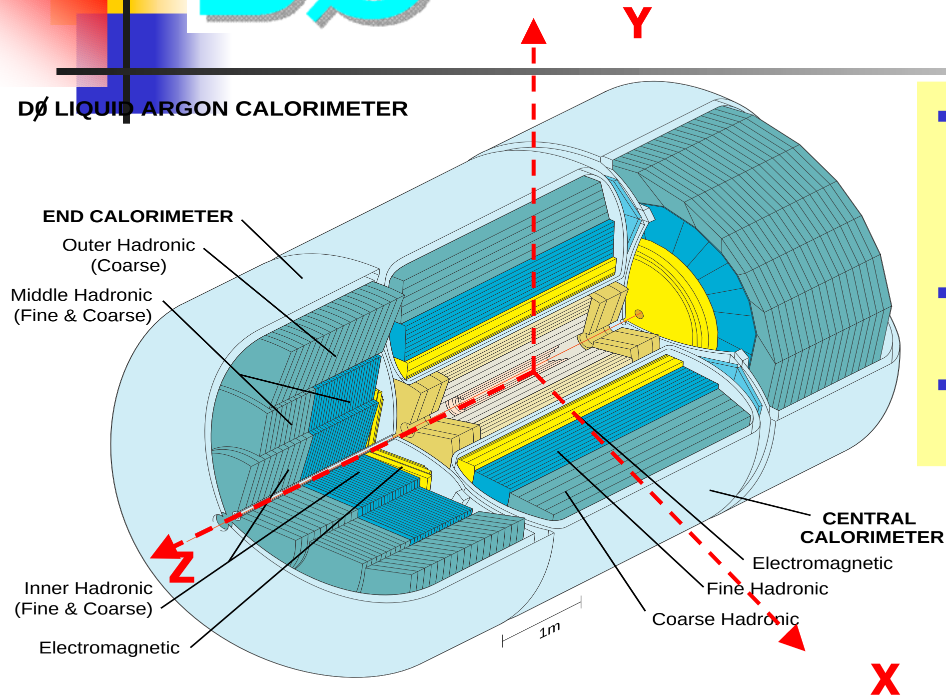
Overview of DØ Detector



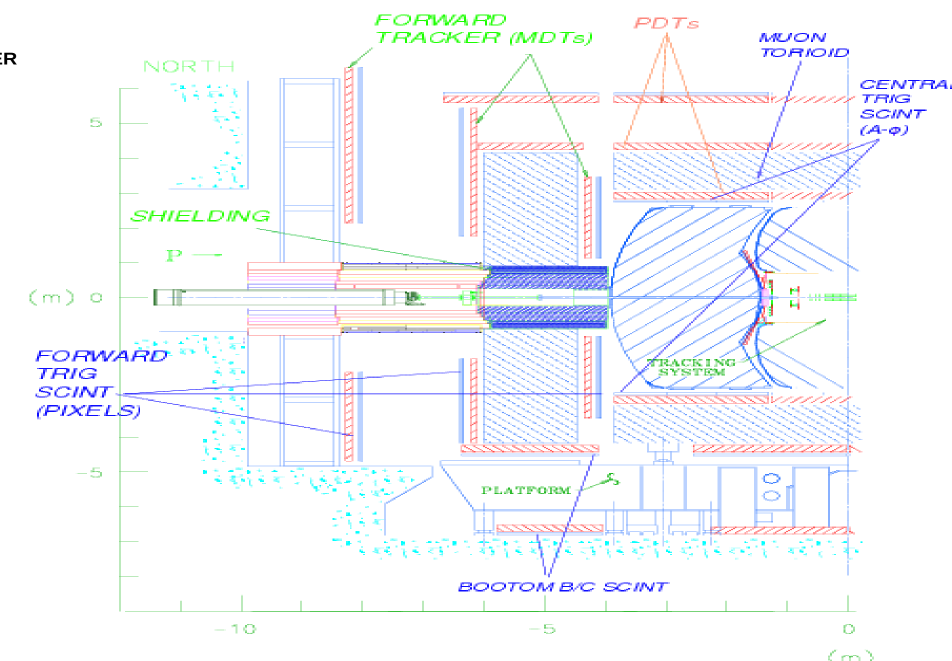
- 2 Tesla solenoid magnetic field for central tracking system to facilitate charge and momentum measurement.
- Silicon and fiber tracker detector.
- Add scintillator detector in muon system for faster trigger
- Pre-shower detectors.
- Pipelined 3 Level trigger



Overview of the DØ Detector

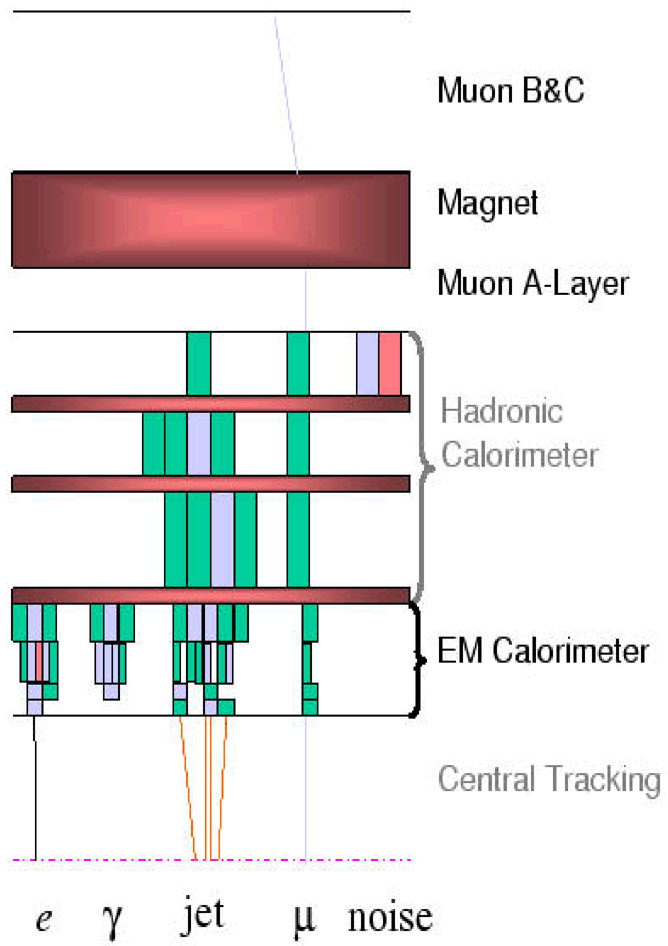


- Liquid argon sampling
  - Stable, uniform response, rad. hard, fine spatial seg.
  - LAr purity important (impurity <0.5 ppm)
- Uranium absorber (Cu or Steel for coarse hadronic)
  - Compensating $e/\pi \sim 1$, dense $\Rightarrow$ compact
- Uniform, hermetic with full coverage
  - $|\eta| < 4.2$ ($\theta \approx 2°$), $\lambda_{int} > 7.2$ (total)



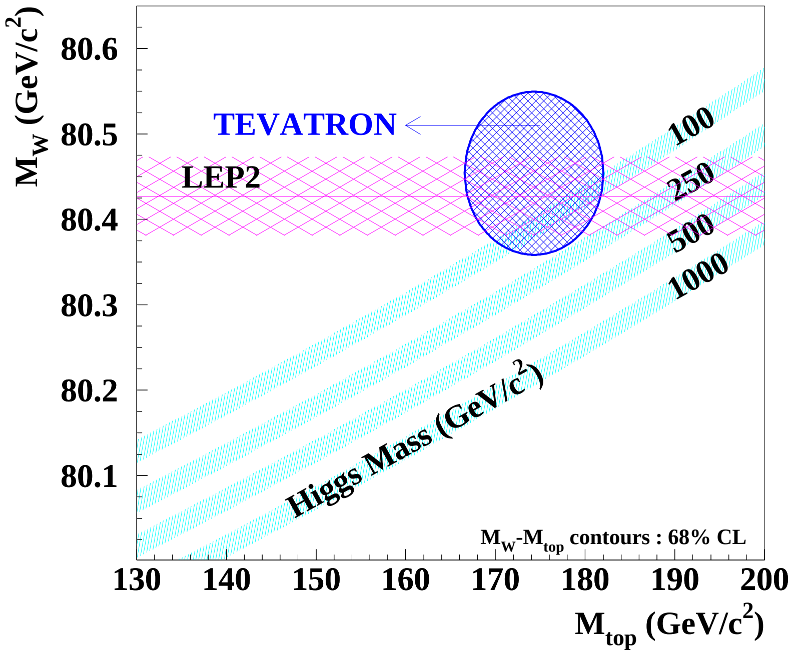
- Three layers of Scintillator detectors and Drift Tubes divided into two regions central and forward.
- One layer inside toroid magnet and two layer outside.
- Muon η coverage to ±2
- Shielding reduces backgrounds by factor of 50-100 .

Particle identification



Importance of W/Z Physics

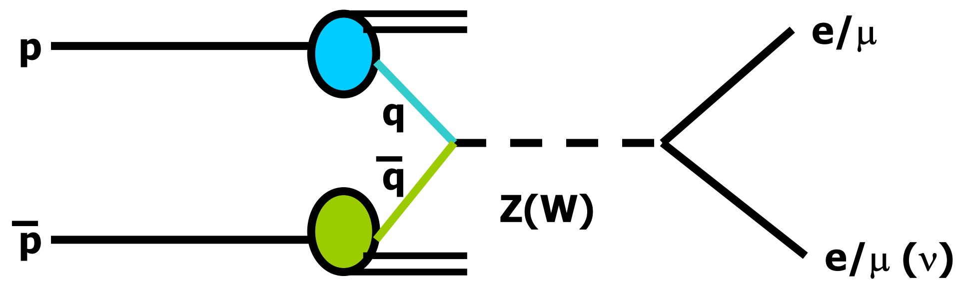
- Test of standard model couplings
- Help predicting and test higher order QCD corrections
- Constrains PDFs
- Helps in understanding detector performance, trigger studies, tuning up algorithms
- Used to understand background processes of other physics processes like top and Higgs.
- Can used as independent measurement of integrated luminosity
- Precision measurement of W mass in conjunction to top mass can be used to predict bounds on Higgs mass



Mechanism of W/Z production

W/Z production is dominated by $q\bar{q}$

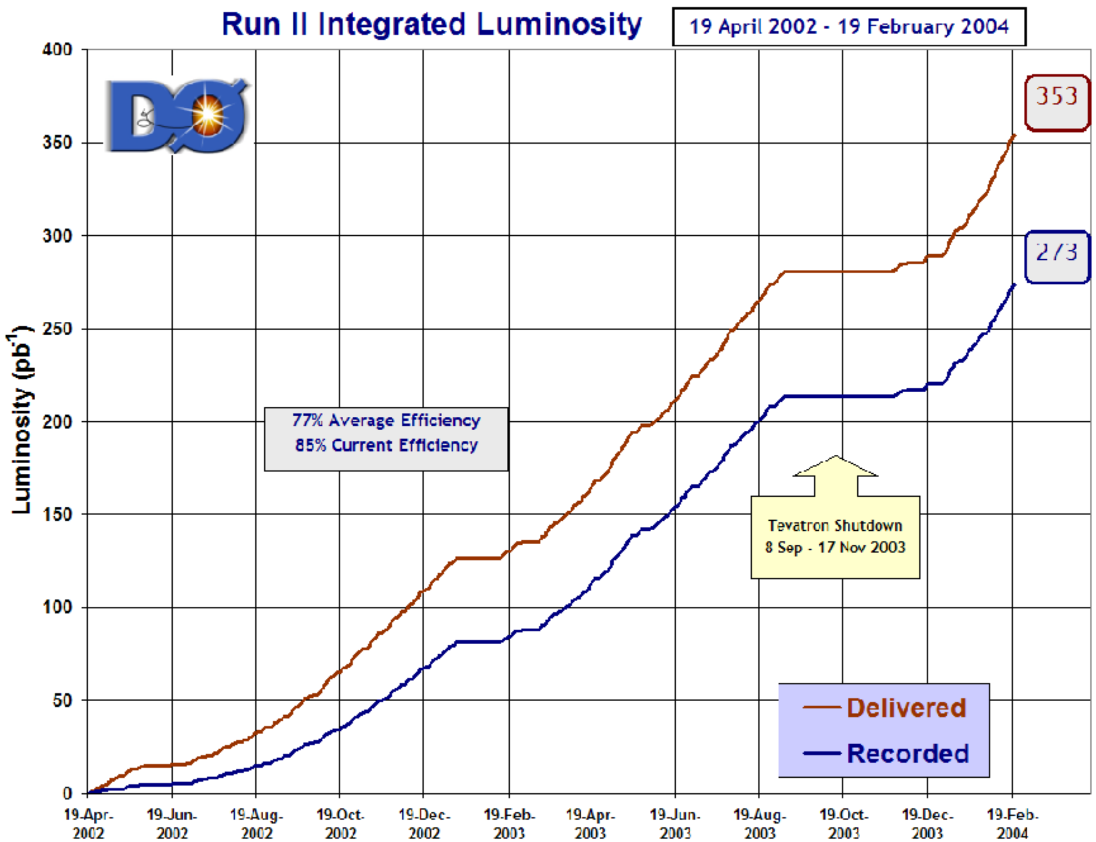
In RunII millions of Ws and 100ks of Zs will be produced



At DØ use leptonic decay modes

- **Avoids high QCD background**
- **~11% Br per leptonic mode for W**
- **~3% Br per leptonic mode for Z**
- **Clean distinctive signature**
- **High PT leptons**
  - **For W : 1 high p_T lepton and high missing E_T**
  - **For Z : 2 high p_T leptons**

Dataset



Only a portion of the dataset collected so far has been used for the analysis reported here.

Measurement of σ.B

$$\sigma \cdot B = \frac{N_{obs} - N_{bkg}}{A\varepsilon \int \mathcal{L} dt}$$

N_{obs} is the number of events observed

N_{bkg} is the estimated number of background events

A is the acceptance, derived from Monte Carlo

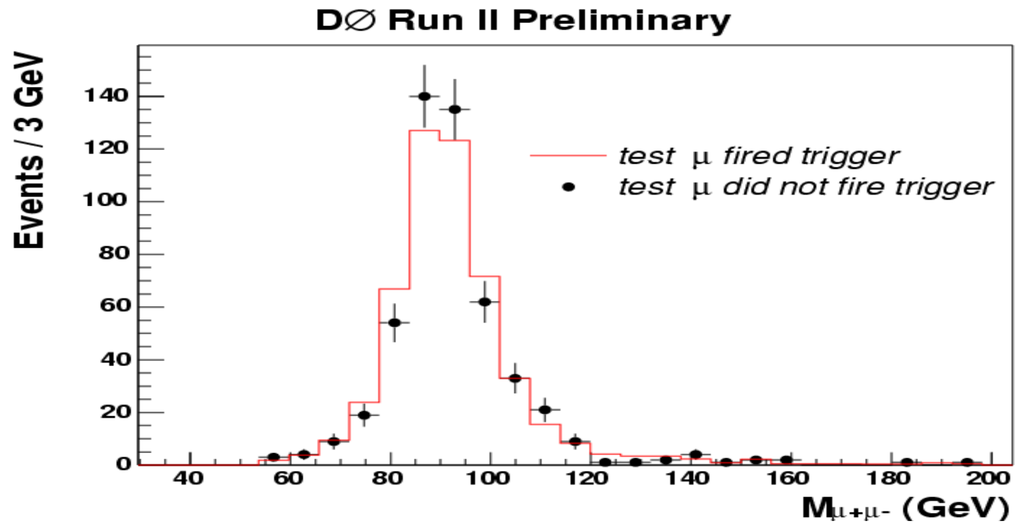
ε is the efficiency, computed mostly from data

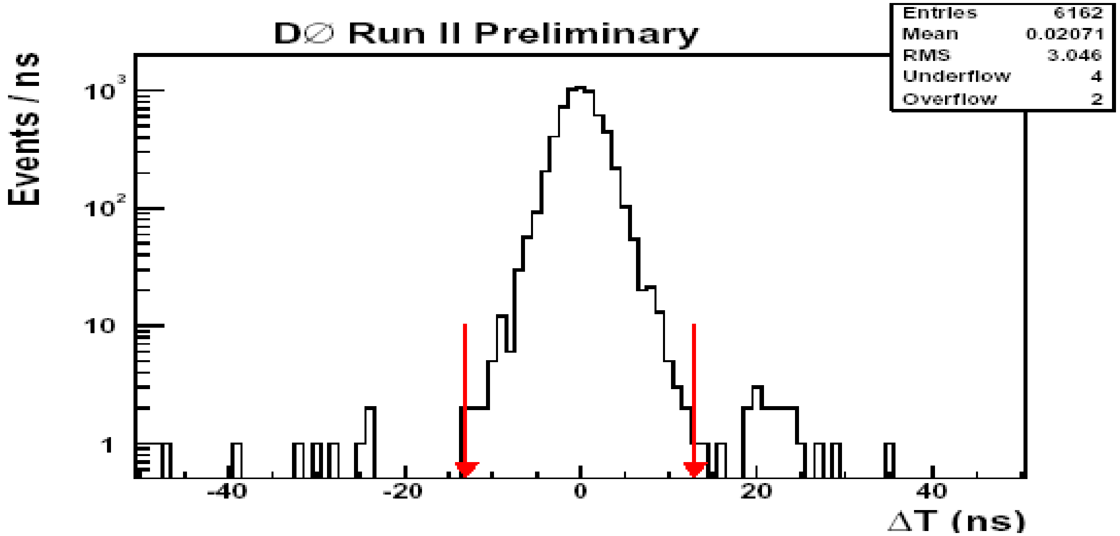
$\int \mathcal{L}\, dt$ is the total integrated luminosity

Z → $\mu^+ \mu^-$

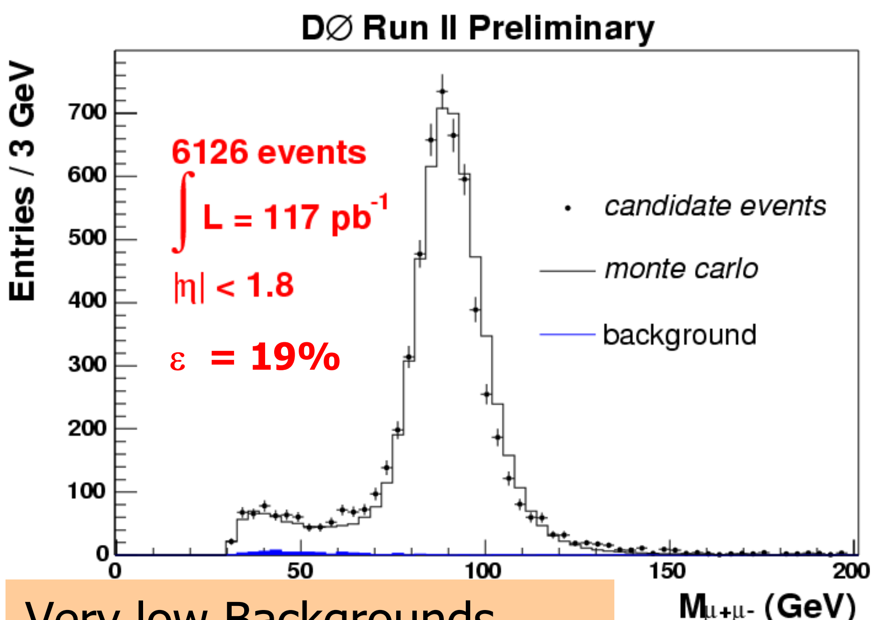
Selection criteria:

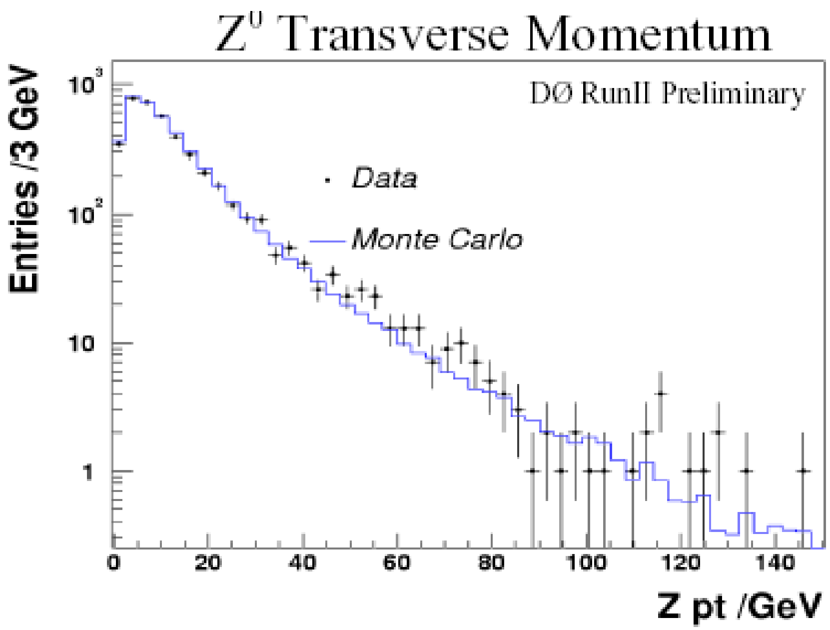
- **Two central tracks:**
  - **loose μ-id**
  - **pT > 15 GeV**
  - **opposite charge**
- **|η| <1.8**
- **M $_{\mu\mu}$ > 30 GeV**
- **Cosmic veto**
- **≥ 1 isolated**





$Z \rightarrow \mu^+ \mu^-$





Very low Backgrounds

QCD (0.6 ± 0.3)%

$Z \rightarrow \tau\, \tau$ (0.5 ± 0.1)%

$$\sigma_Z \bullet Br(Z \rightarrow \mu^+\mu^-) = 261.8 \pm 5.0 \pm 8.9 \pm 26.2 \text{ pb}$$

stat. syst. lumi.

$Z \rightarrow e^+e^-$

Selection Criteria:

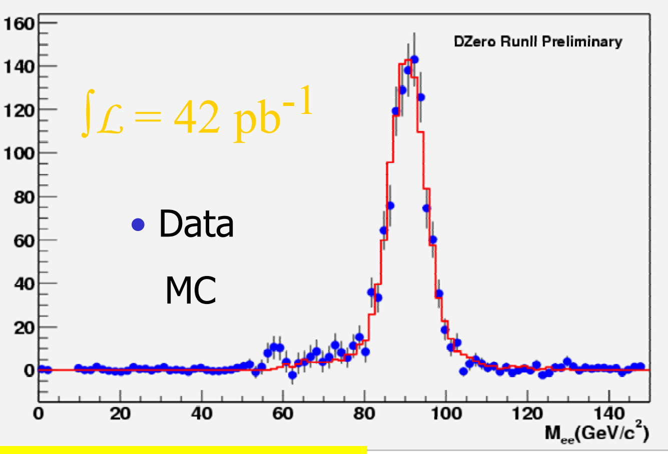
- **Two Isolated electrons**
  - **E_T > 25 GeV & |η| < 1.1**
  - **Electrons also must satisfy shower shape, Emfr cuts.**
- **70< M_{ee} <110**

Electron ID efficiency:

-Trigger 98+/-2 %

-EMF, isolation ~100 %

-Shower shape 86+/-1



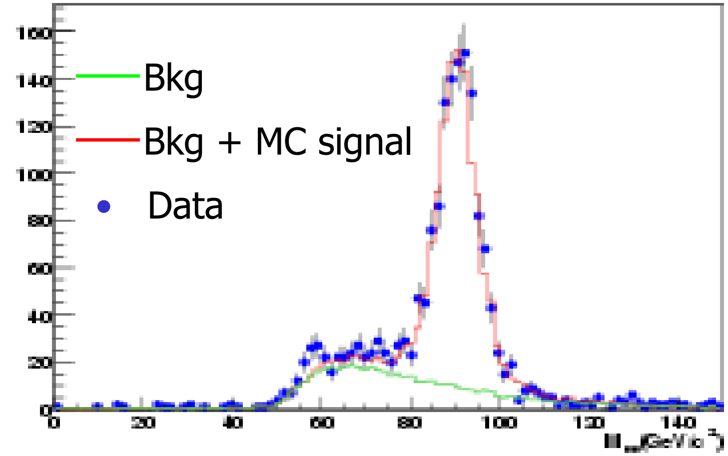
Number of Z events after background subtraction 1139 ±42

Drell-Yan Contribution

- **Small effect (1.7%) in the mass window of 70 < m_{ee} < 110 GeV**

QCD Background

- **Determined to be (2.3 ±1.0)% from data by fitting signal and bkg distributions.**



DØ: $\sigma_Z \bullet Br(Z \rightarrow e+e-)$ = 275 ± 9 (Stat) ± 9 (syst) ± 28 (lumi) pb

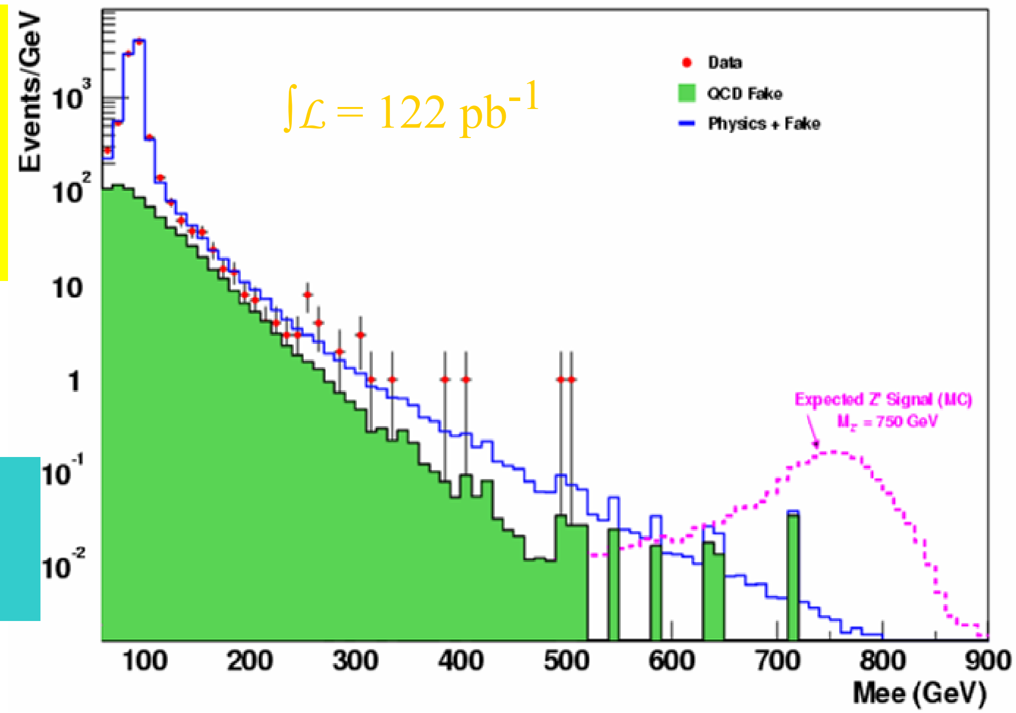
Z′ search in Z′ → ee Channel

Many extensions of SM predicts the Existence Z′

Look for bumps in the high mass region of the invariant mass distribution.

Two isolated electrons with same criteria as Z → ee except with extended η coverage for one electron and track match requirement for one CC electron

$\varepsilon_{trk} = 73 \pm 2$ %



Assuming SM coupling

Z′ < 719 GeV excluded at 95% C.L.

RunI limit was 670 GeV at DØ

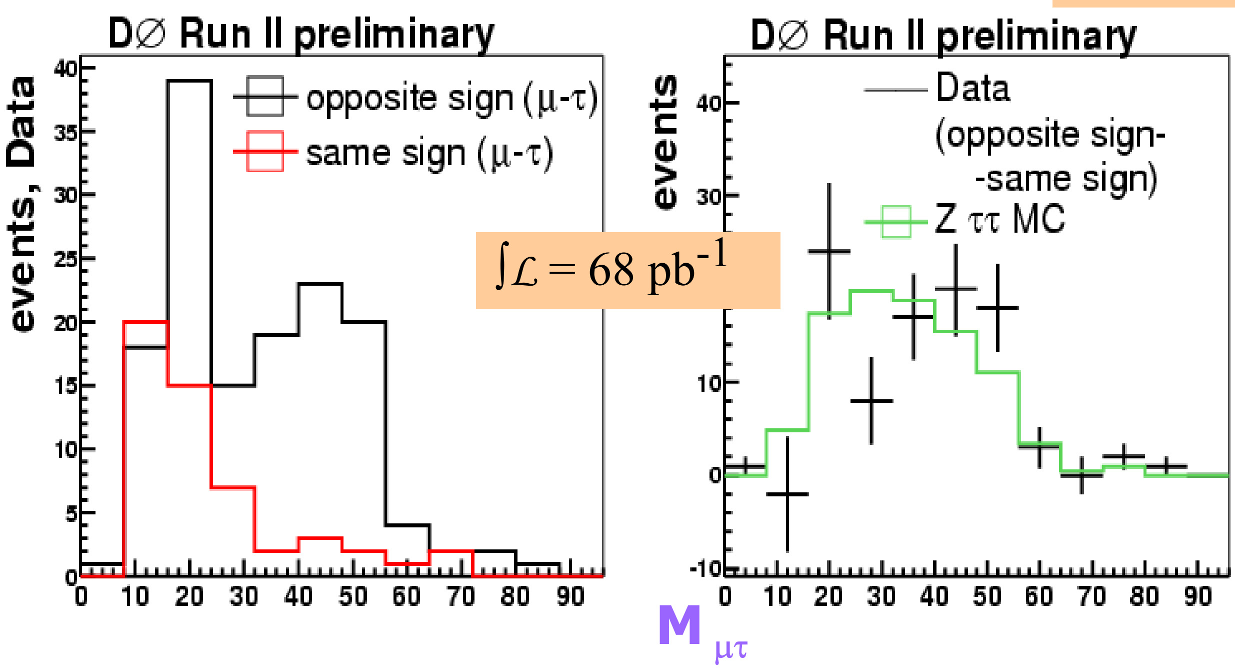
$Z \rightarrow \tau^+\tau^-$

$Z \rightarrow \tau\ (\rightarrow \mu\nu\nu)\ \tau\ (\rightarrow \pi^{\pm}\nu + n\pi^0)$

Event signature is isolated high p_T muon opposite to narrow hadronic jet

Background

- **QCD μ from $b\bar{b}$ or π/K decay**
- **W $\rightarrow \mu\nu$ or $\tau\nu$ + jet**
- **Z $\rightarrow \mu\mu$**



$\int \mathcal{L} = 68\ pb^{-1}$

Handfull of events consistent with SM expectation

$W \rightarrow e\ \nu$

Selection Criteria

- **One Isolated electrons**
  - **E_T > 25 GeV & $|\eta|$ < 1.1**
  - **Electrons also must satisfy shower shape, Emfr cuts.**
  - **Should have track matching**
- E_T^{miss} > 25 GeV

Backgrounds:

- **Dominant source QCD dijet events**

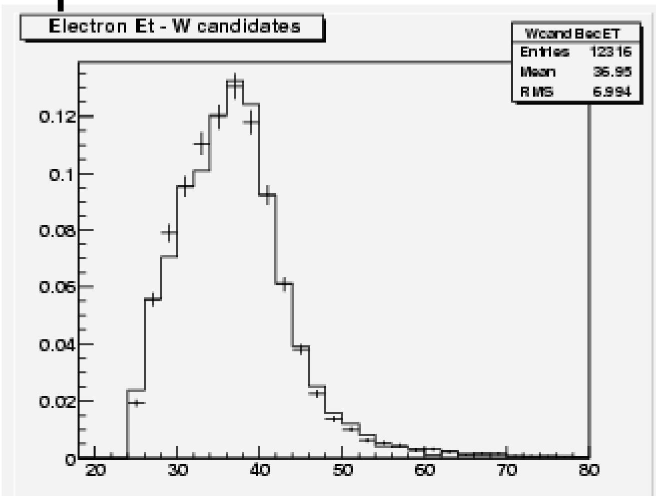
  Estimated from data
- **$W \rightarrow \tau\nu \rightarrow e\nu\nu\nu$**

  $Z \rightarrow e\ e$

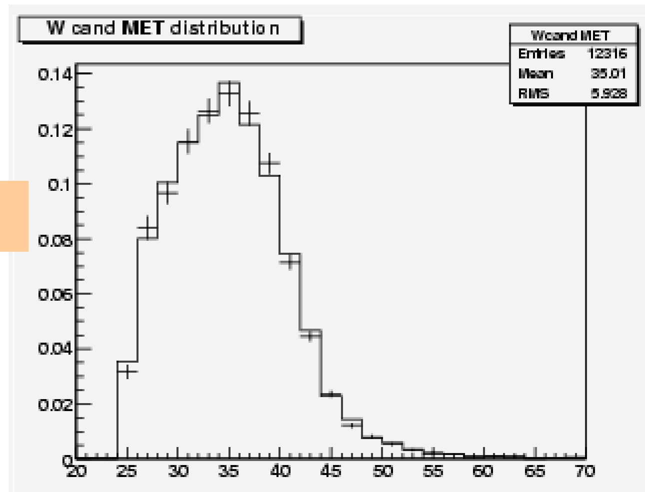
  Both these two backgrounds are estimated from MC

W→e ν

E_T Distribution of Electrons

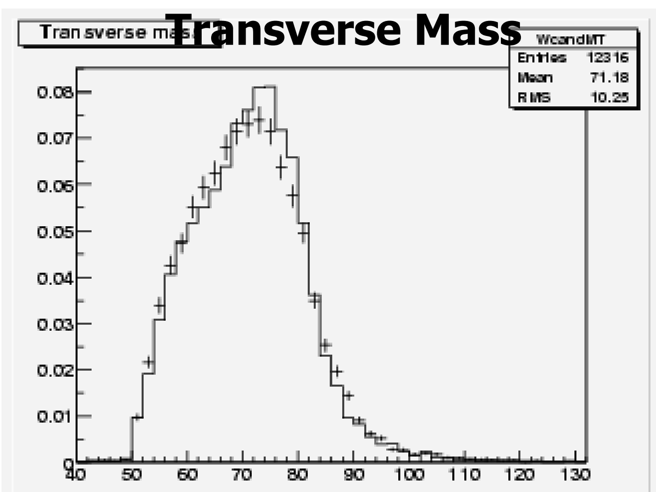


Missing E_T Distribution of Electrons



$\int \mathcal{L} = 42\ pb^{-1}$

Transverse Mass



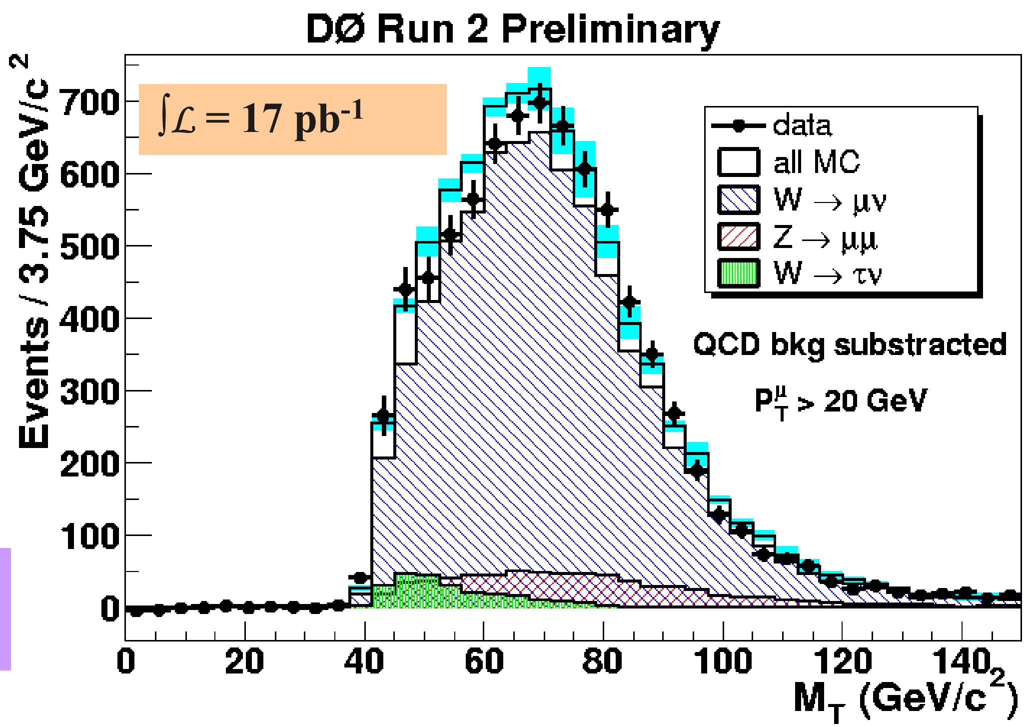
Number of Candidate events after background subtraction 27370 ± 898

$\sigma_W \bullet Br(w \to e\ \nu)$ = **2844 ±21 (stat) ±128 (syst) ± 284 (lumi)**

W→μν

Selection Criteria

- $p_T(\mu) > 20$ GeV
- $E_T^{miss} > 20$ GeV



Number of Candidate events after background subtraction 8302

$\sigma_W \bullet Br(W \rightarrow \mu\nu)$ = **3226 ± 128 (stat) ± 100 (syst) ± 322 (lumi)**

Determination of R

$$R = \frac{\sigma_W \cdot Br(W \to l\nu)}{\sigma_Z \cdot Br(Z \to l^+ l^-)}$$

- **Luminosity error cancels out**
- **Common systematic uncertainty like PDF uncertainty cancels out**

DØ RunII Preliminary:

- $R_e = 10.34 \pm 0.59$
- $R_\mu = 12.32 \pm 0.73$

Summary and Outlook

- Preliminary result from W/Z cross sections available and are consistent with SM
- Performance of detectors, triggers, details of simulations are being better understood.
- Limit on Z′ mass already exceeded Run I Limit
- More data is being collected
- More precise results with ~ 200 pb^{-1} luminosity will be available soon.