Electroweak Results from DØ

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For the DØ Collaboration

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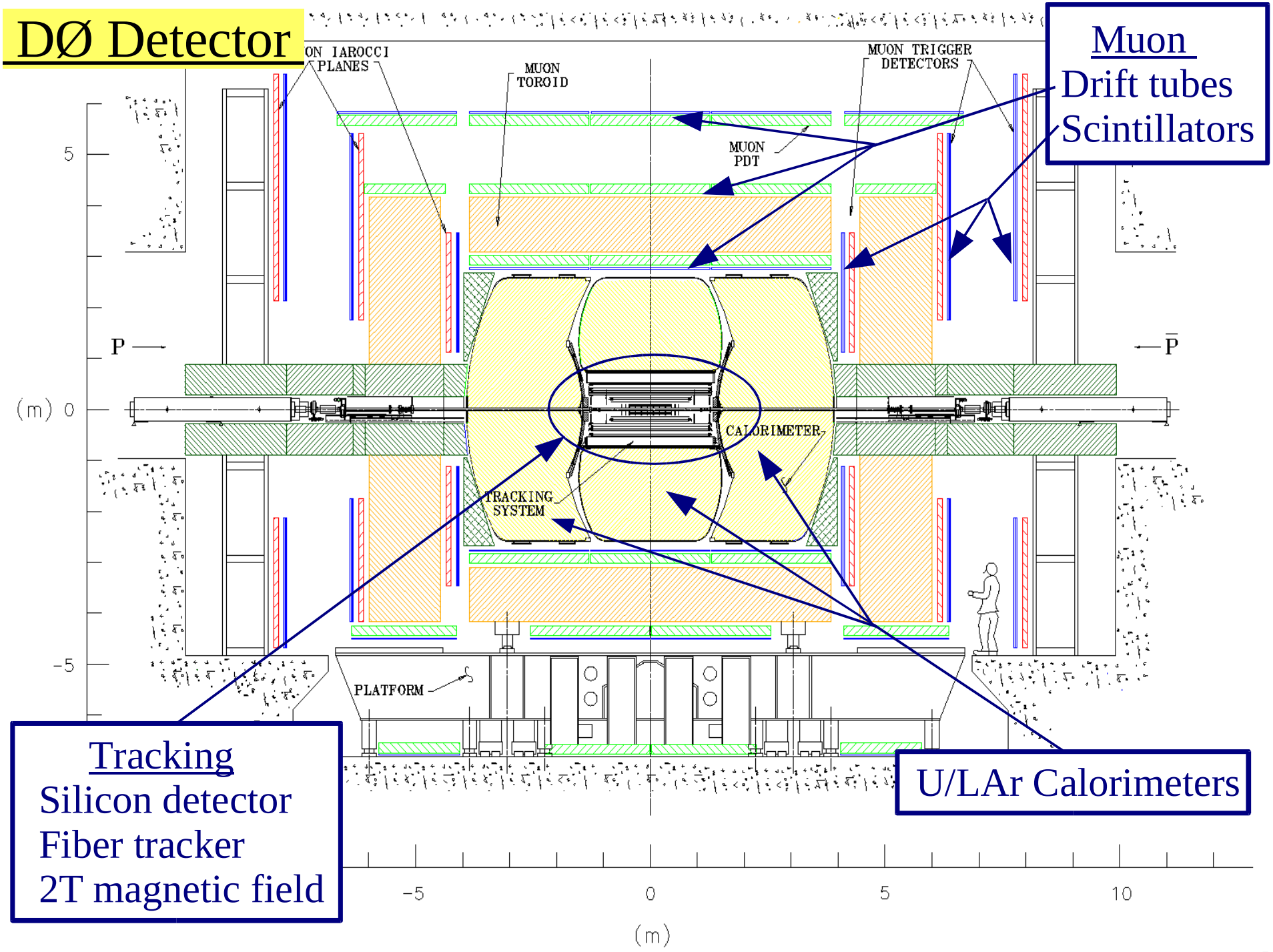
DØ Detector



Muon
Drift tubes
Scintillators

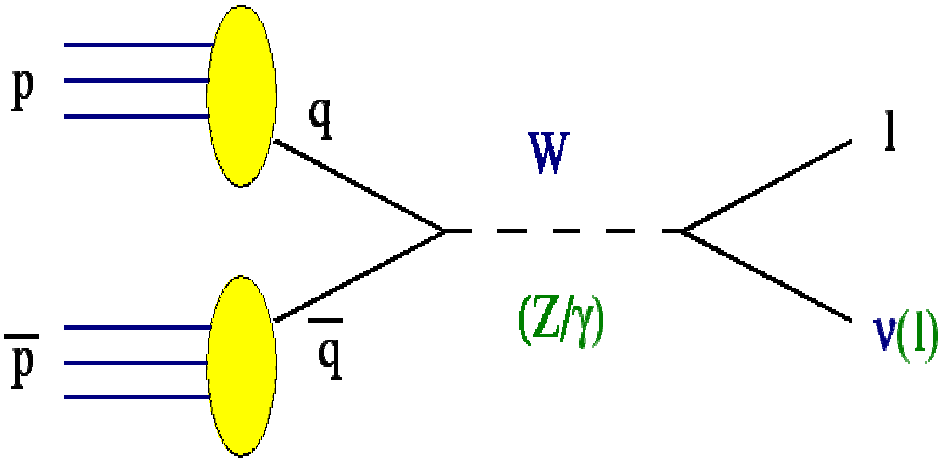
Tracking
Silicon detector
Fiber tracker
2T magnetic field

U/LAr Calorimeters

W/Z Production Cross Sections

- Study/improve performance of detector and software
  - Optimize triggers
  - Calibrate energy and momentum scales
  - Improve particle ID and reconstruction algorithms
  - Tune detector simulation
- W/Z event count can be used to determine integrated luminosity
- Test theory:
  - Test SM couplings
  - Test higher order QCD corrections
  - Constrain PDFs
- Benefits related topics:
  - Measure backgrounds to Top, Higgs (W+jets)
  - Needed for M_W, Γ_W precision measurements
    - Constrain fit for M_H

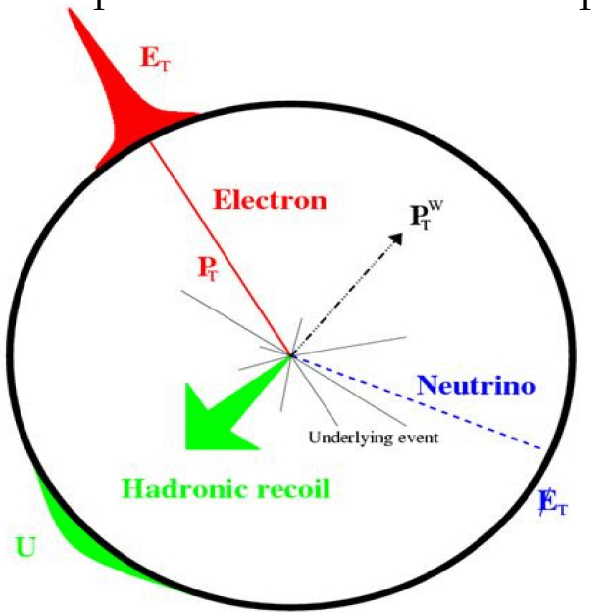
W/Z Production

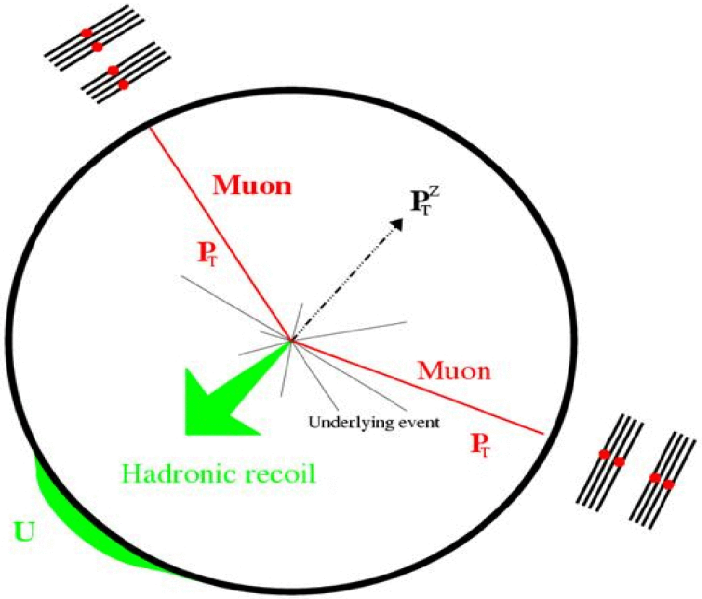


- Production dominated by $q\bar{q}$
- Large data samples
  - $W^{\pm}$ @ 1Hz at 2×10^{32} $cm^{-1}s^{-1}$
- Low backgrounds

$W^{\pm}\rightarrow l^{\pm}\nu$ (l=e, μ)

high P_T, isolated lepton, $\not{E}_T$





$Z^0\rightarrow l^+l^-$ (l=e, μ)

2 high P_T, oppositely charged, isolated leptons

Cross Section x Branching Ratio

$$\sigma * Br = \frac{N_{evts} - N_{bg}}{\varepsilon_{total} * A * \int \mathcal{L} dt}$$

- N_{evts}: Number of events observed
- N_{bg}: Number of background events
- ε_{total}: Total efficiency
  - Determined from data (when possible)
- A: Acceptance
  - Estimated from MC
- $\int \mathcal{L} dt$: Luminosity

$Z^0 \rightarrow e^+e^-$

Trigger:

- Level 1: 1 Calorimeter object >10GeV
- Level 3: $e^{\pm}$ candidate > 20 GeV, shower shape cut

Event Selection

- 2 isolated electrons with:
  - $E_T > 25$ GeV
  - $|\eta| < 1.1$
  - Large EM fraction, shower shape requirement
- 70 GeV < M_{ee} < 110 GeV

Efficiencies:

- Obtained from same data sample
- Method:
  - Tight cuts on one $e^{\pm}$
  - Loose cuts on other $e^{\pm}$
    - Apply cut under study to loose $e^{\pm}$, test if it passes
  - Low background
  - Unbiased sample
- $\varepsilon_{total} * A \sim 10\%$

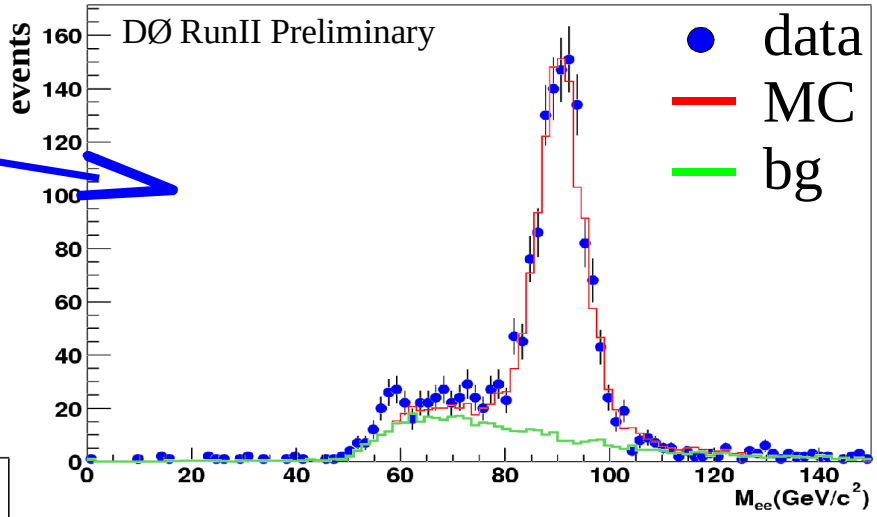
Efficiencies per electron:

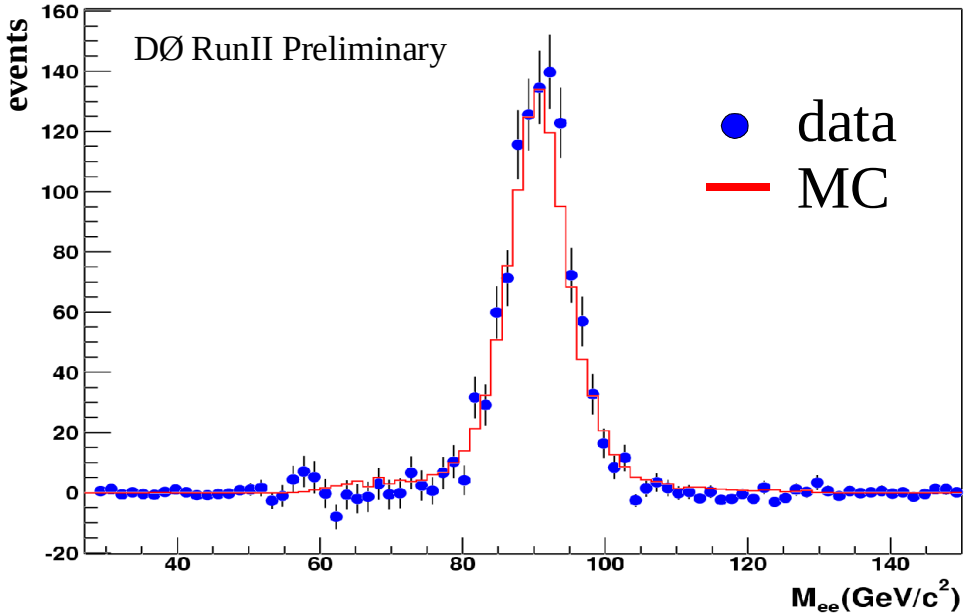
Trigger:	98 ± 2%
Shower shape:	86 ± 1%
EM fraction, isolation:	~100%

$Z^0 \rightarrow e^+e^-$ Mass Distribution

QCD background

- dijet events
- Shape from fit to data
- Size estimated from MC





Drell-Yan interference corr.: ~2%

$70\ \text{GeV} < M_{ee} < 110\ \text{GeV}$

1139 events

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

$\sigma(Z) \times Br(Z \rightarrow e^+e^-) = 275 \pm 9\ (\text{stat}) \pm 9\ (\text{sys}) \pm 28\ (\text{lumi})\ \text{pb}$

Di-EM Spectrum at High Masses

⇒ Look for deviation from SM in e^+e^- pairs at highest energies

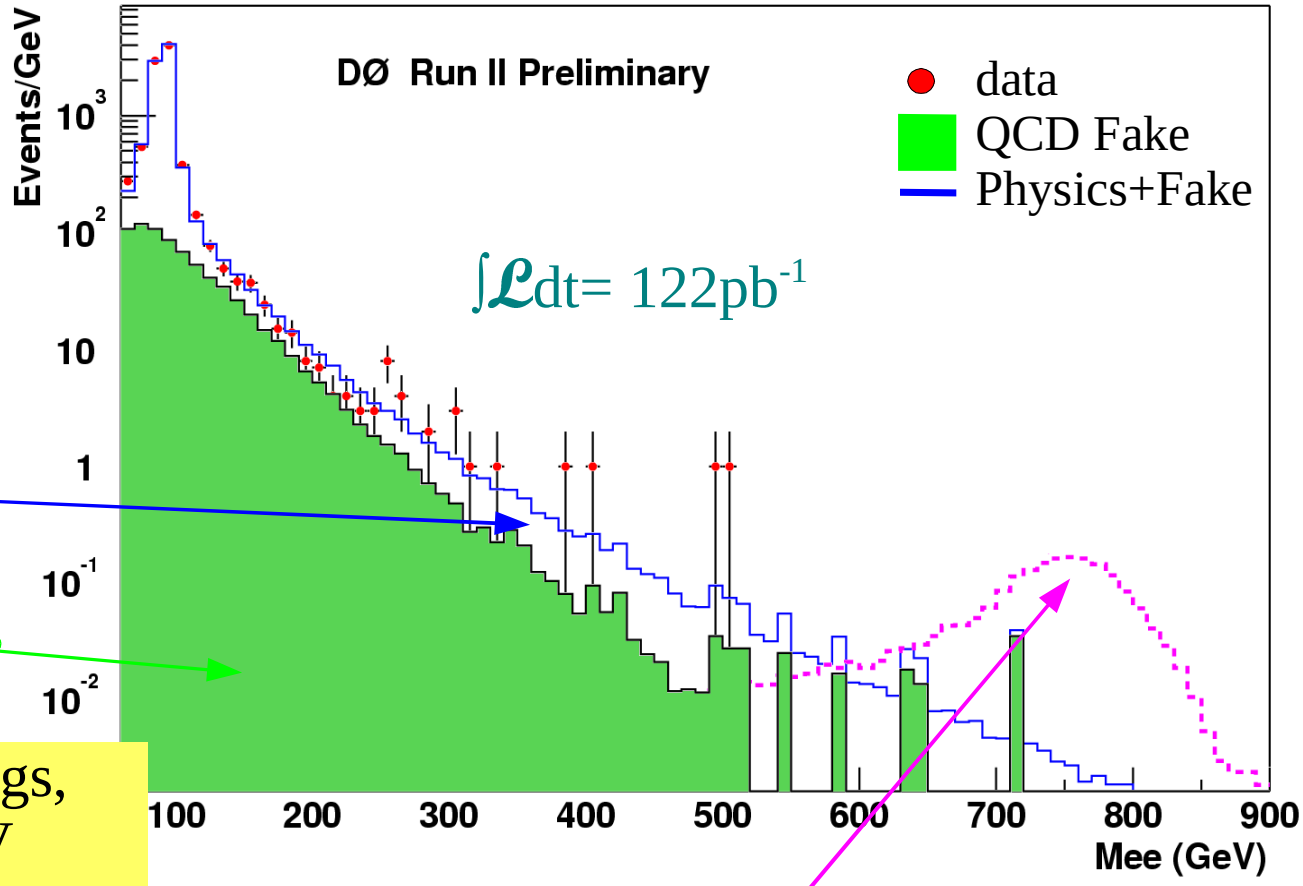
Event selection:

Same as $Z^0 \rightarrow e^+e^-$ plus:

- η coverage includes forward region
- Track match to ≥ 1 $e^{\pm}$

e^+e^- from Z/γ*, WW, Wγ, $t\bar{t}$,etc.

Jets mis-ID'd as $e^{\pm}$



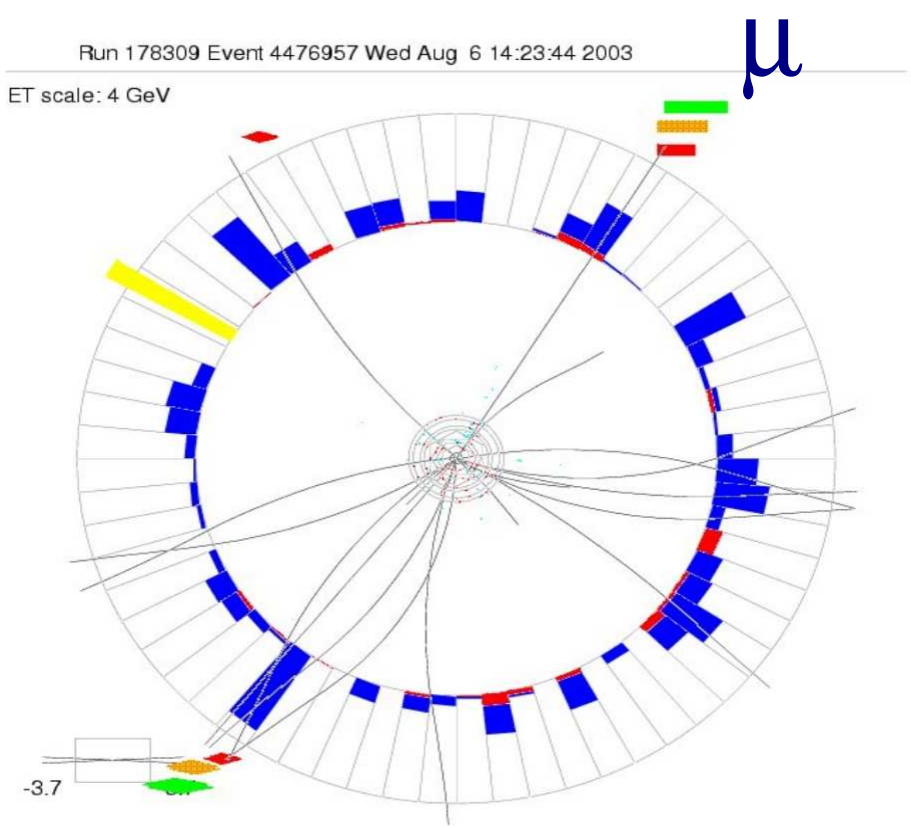
Assuming SM couplings, Z' mass < 719 GeV excluded at the 95% C.L.

⇒ Surpasses Run I limit

$Z^0 \rightarrow \mu^+\mu^-$

Event selection:

- Di-muon trigger
- ≥1 isolated μ
- $|\eta(\mu)|<1.8$
- Cosmic veto
  - Timing cut on scintillator
- $M_{\mu\mu} > 30$ GeV
- Match to 2 central tracks:
  - Opposite charge
  - $P_t > 15$ GeV



μ

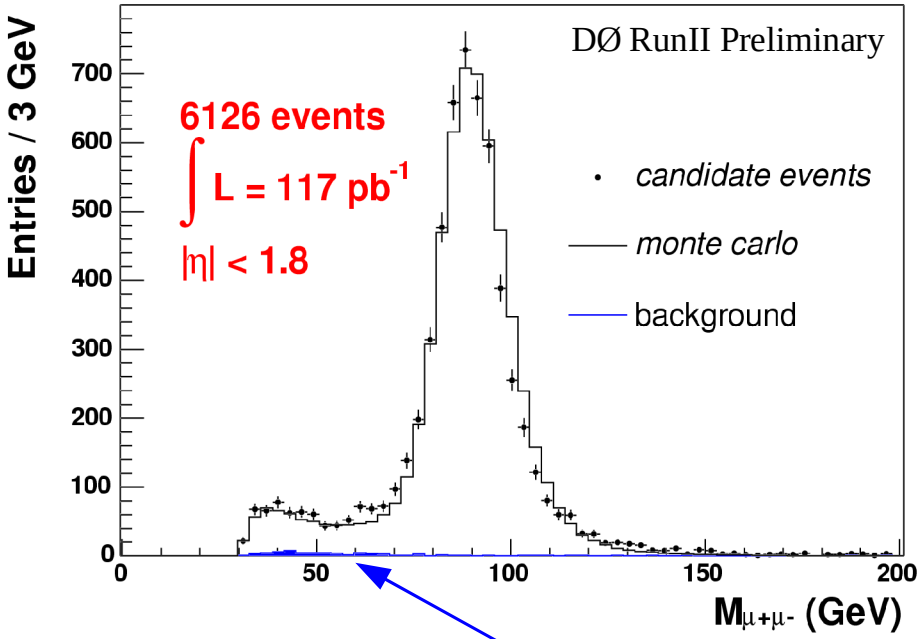
μ

$\varepsilon_{total} * A$: ~19%

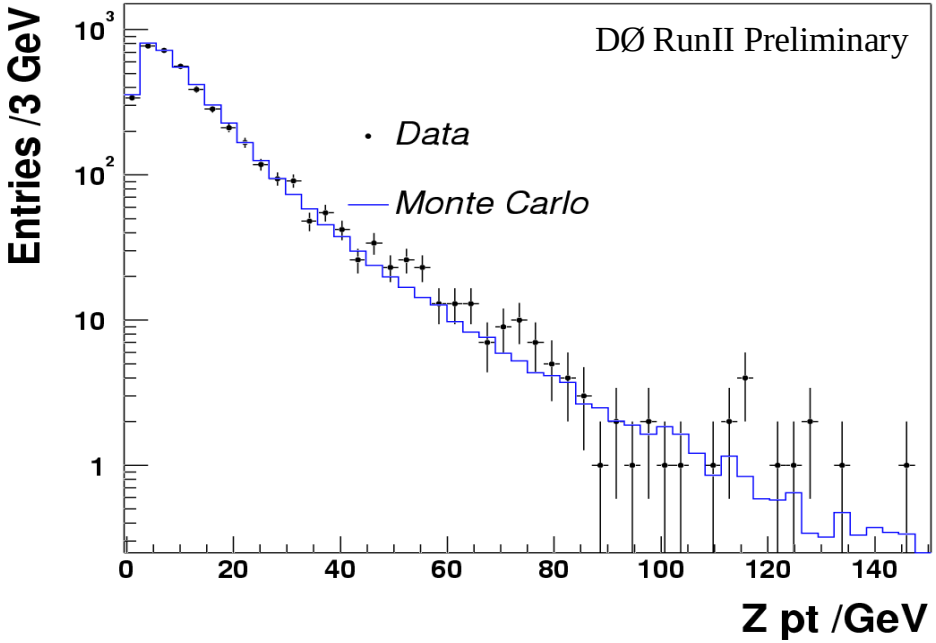
$Z^0 \rightarrow \mu^+\mu^-$ Mass Spectrum

Backgrounds: $b\bar{b}$, cosmic rays: 0.6% $Z \rightarrow \tau\tau$: 0.5%

Z^0 Invariant Mass



Z^0 Transverse Momentum



small backgrounds

$\sigma(Z) \times Br(Z \rightarrow \mu\mu) = 262 \pm 5$ (stat) ± 9 (syst) ± 26 (lumi) pb

$Z^0 \rightarrow \tau_\mu \tau_{had}$

Looking at 1-pronged decays:

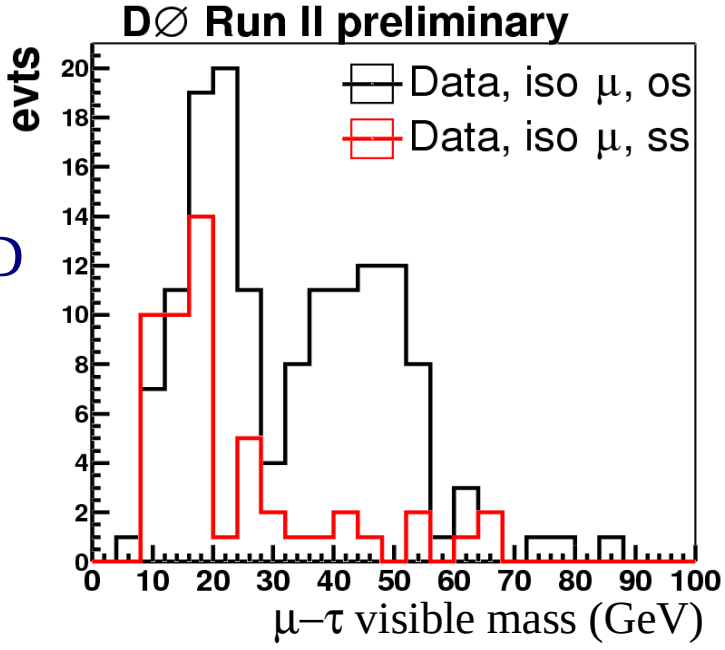
$Z^0 \rightarrow \tau\ \tau$

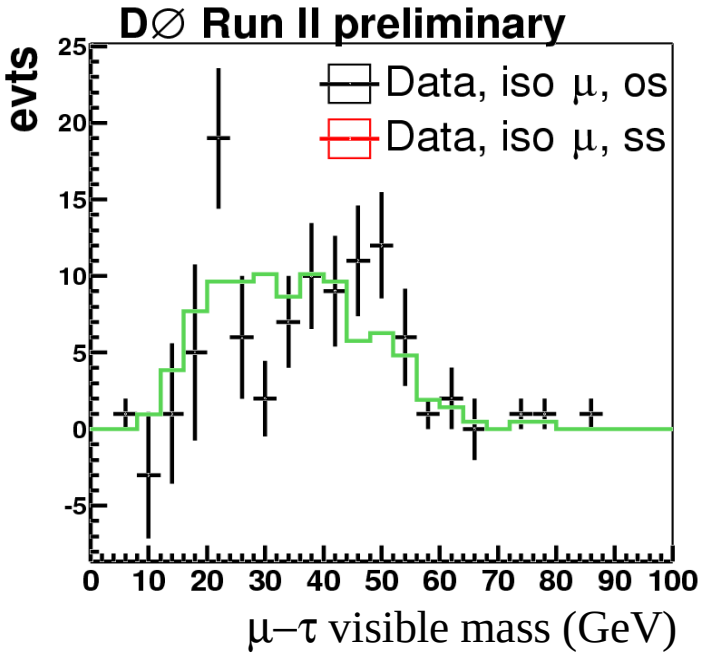
- $\tau \rightarrow \mu\nu\nu$
- $\tau \rightarrow \pi^{\pm}\nu + n\pi^0$

Main backgrounds:

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

- Understand τ ID
- Important for searches





$\int \mathcal{L} dt = 68 pb^{-1}$ Small number of events $\rightarrow$ Consistent with SM

$W \rightarrow e\nu$

Event selection:

- Trigger on single $e^{\pm}$
- Isolated electron with:
  - $E_T > 25$ GeV
  - $|\eta| < 1.1$
  - Central track match
- Missing $E_T > 25$ GeV

Efficiencies:

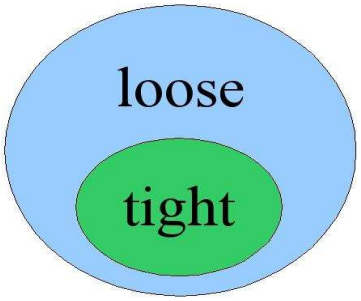
- Use from $Z^0 \rightarrow e^+e^-$ analysis
- $\varepsilon_{total} * A \sim 23\%$

Backgrounds:

- QCD dijet events
  - Main source
  - Estimated from data
- Additional sources:
  - $W \rightarrow \tau\nu \rightarrow e\nu\nu\nu$
  - $Z^0 \rightarrow e^+\not{e}$:
  - Small contribution ~1%
  - Estimated from MC

W→eν Backgrounds

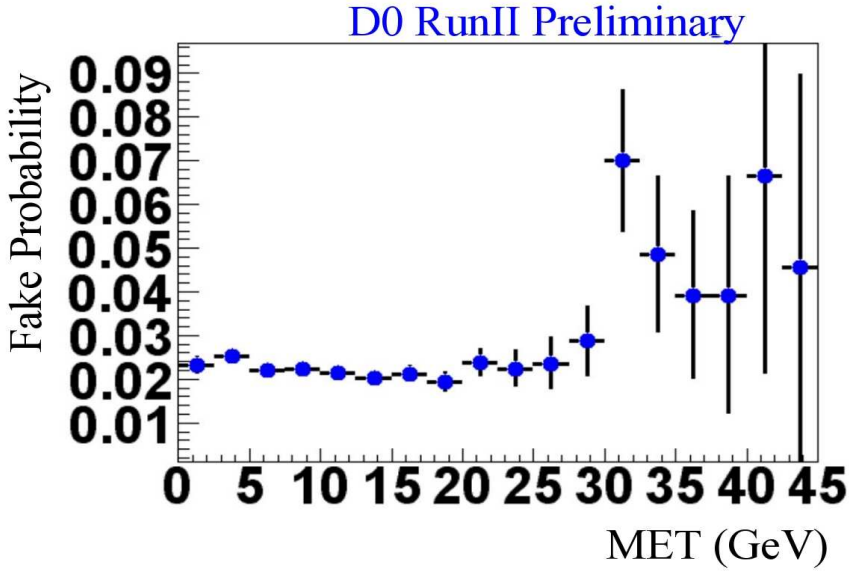
QCD Background subtraction



tight = loose + track match

$$N_{loose} = N_W + N_b$$
$$N_{tight} = N_w \varepsilon_{trk} + N_b \varepsilon_f$$

} Solve for N_W

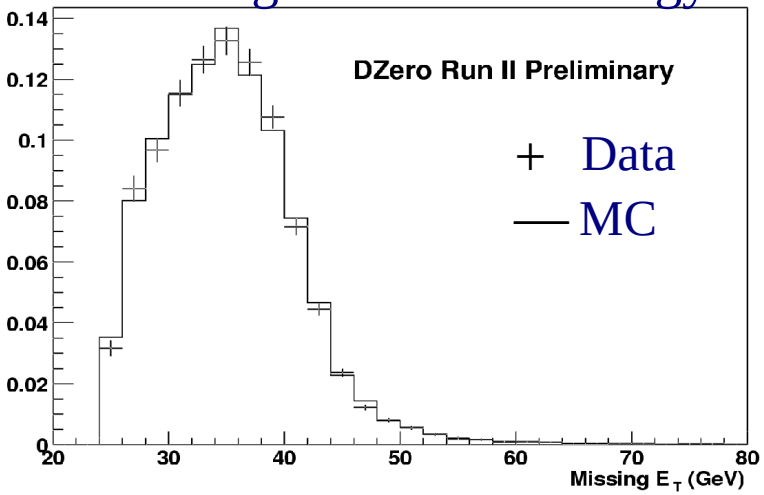


$\varepsilon_f = 2.3\%$ rate for jet to fake track matched $e^{\pm}$

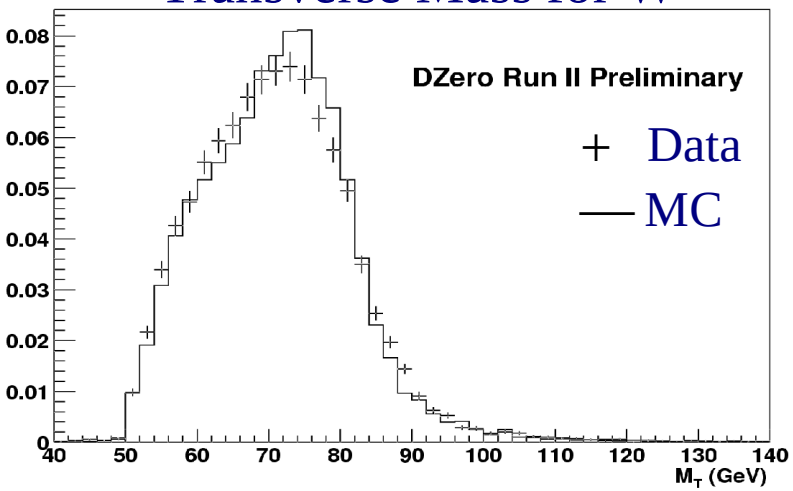
$\varepsilon_{trk} = 73\%$ track matching efficiency

W→eν Cross Section*Br

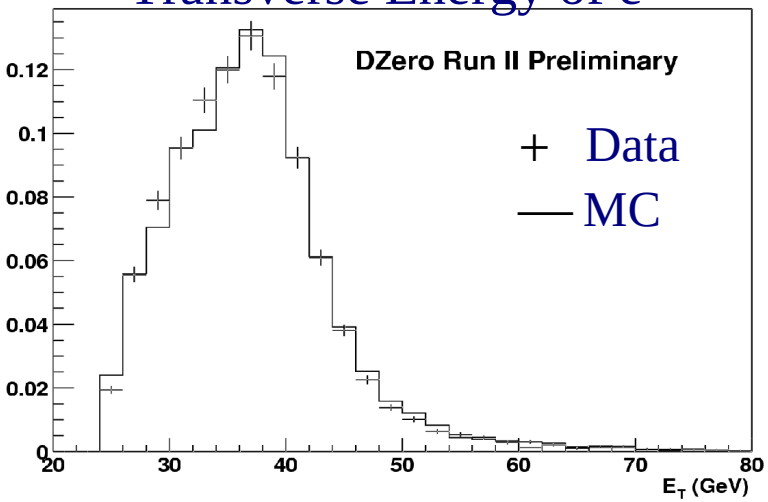
Missing Transverse Energy



Transverse Mass for W



Transverse Energy of $e^{\pm}$



Data after background subtraction

27,370 events

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

$\sigma(W) \times Br(W \to e\nu) = 2844 \pm 21\ (stat) \pm 128\ (syst) \pm 284\ (lumi)\ pb$

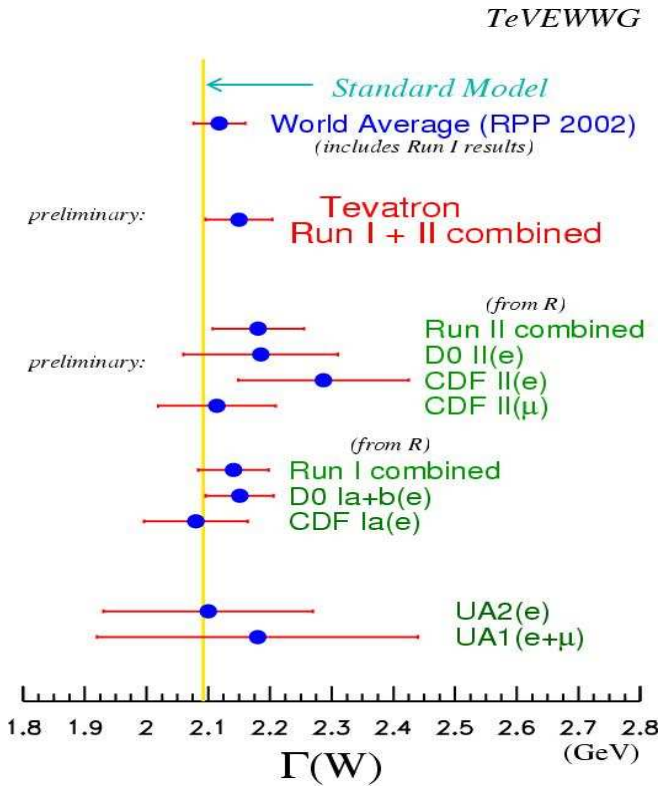
Indirect W Width

- Derived from W and Z σ*Br measurements
- Many uncertainties due to systematics and luminosity cancel

$$R \equiv \frac{\sigma_W \times Br(W \to l\nu)}{\sigma_Z \times Br(Z \to ll)} = \frac{\sigma_W}{\sigma_Z} \frac{\Gamma_Z}{\Gamma_{Z \to ll}} \frac{\Gamma_{W \to l\nu}}{\Gamma_W}$$

from LEP

from theory



DØ Run II Preliminary

$R_e = 10.34 \pm 0.59$

TeVEWWG RunII Preliminary*

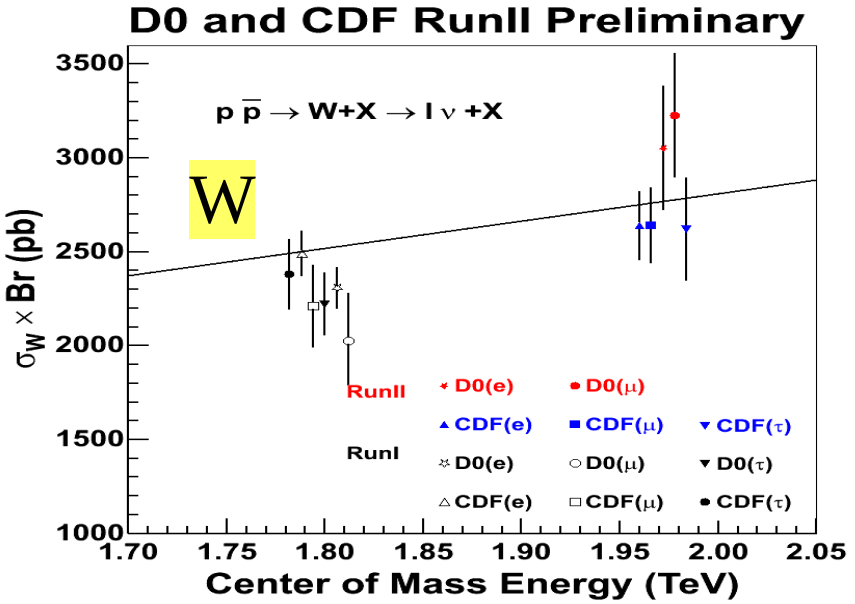
$R_{e,\mu} = 10.36 \pm 0.31$

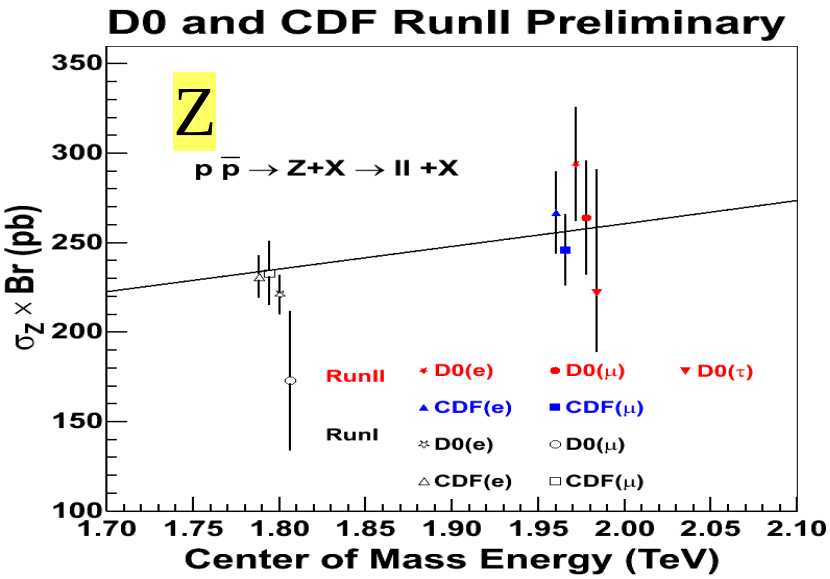
$\Gamma_W = 2.181 \pm 0.074$ GeV

*TeVEWWG uses DØ(e) and CDF(e,μ)

Summary

- Preliminary results of W and Z production cross sections are consistent with SM
  - Provide benchmark measurements for understanding detector
- Limit on Z' has surpassed that of RunI
- Current measurements are being updated to include:
  - larger data sets -- ~200pb^{-1}
  - Extended η coverage
  - Improvements in reconstruction





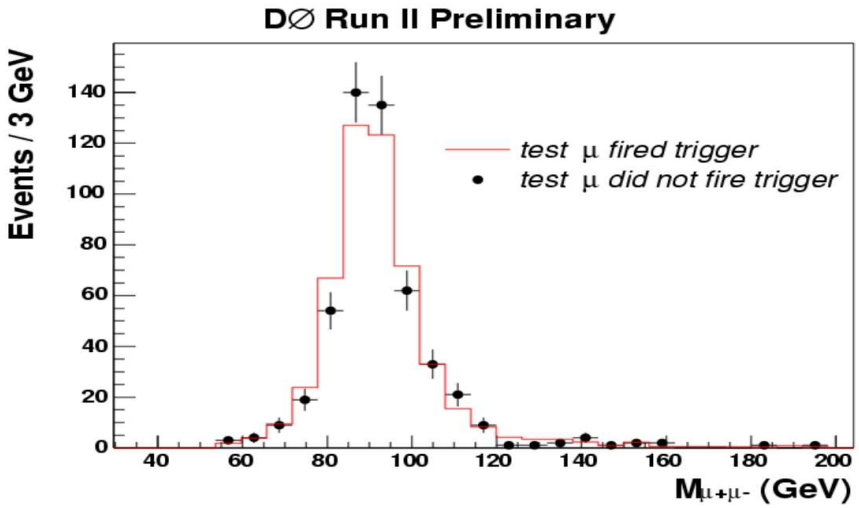
*Curves are NNLO calculation from Hamberg, Van Neerven, and Matsuura, Nucl. Phys. B359 (1991) 343. [CTEQ4M pdf]

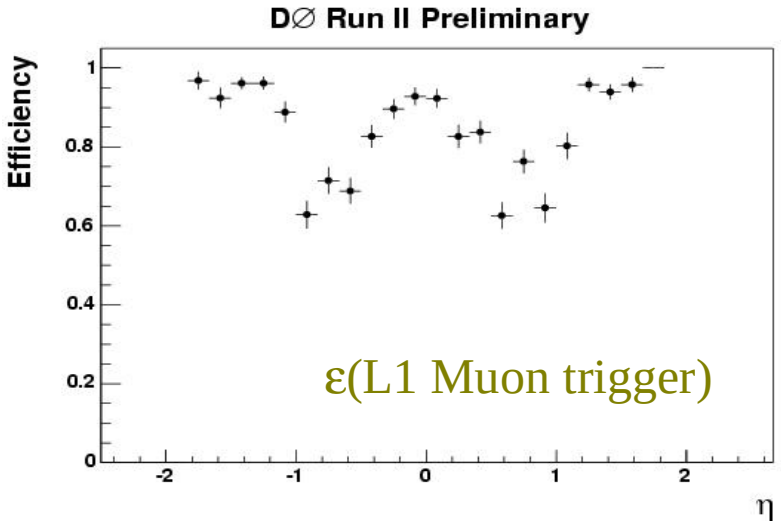
Extras

$Z^0 \rightarrow \mu^+\mu^-$ Efficiencies

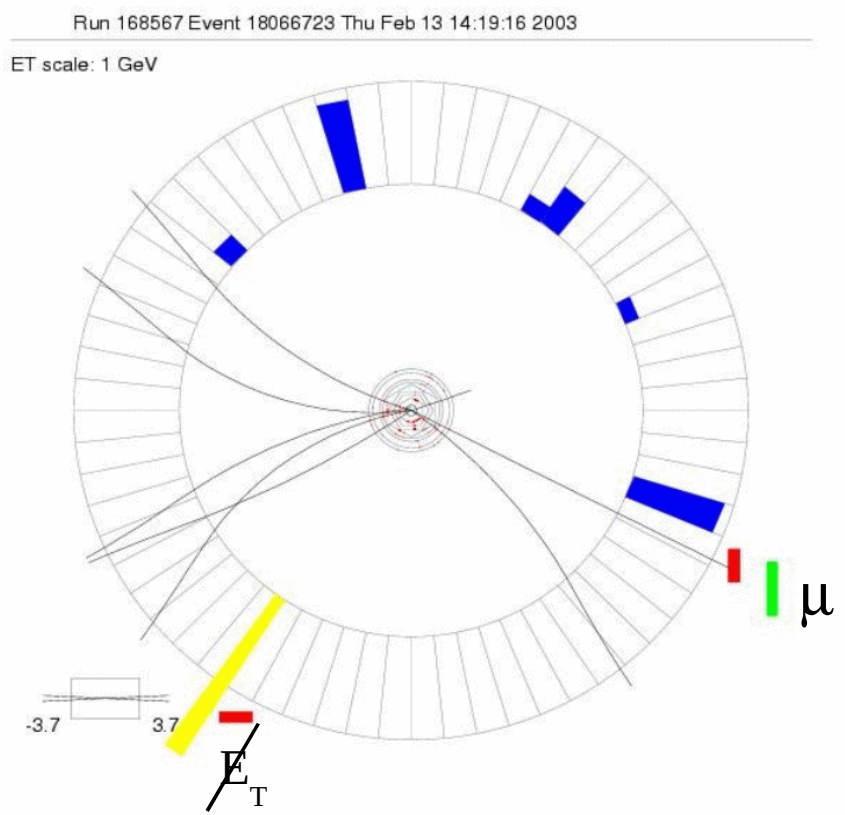
Efficiencies:

- One μ is "control" with tight cuts
- Second μ is probe with loose cuts
- Apply cut under study to μ_{probe}





$W \rightarrow \mu\nu$



Trigger:

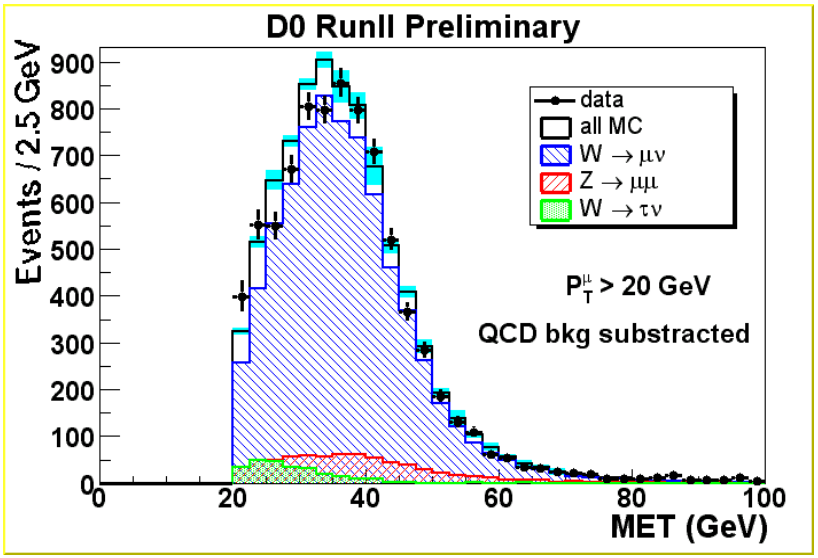
- Level 1: Scintillator based single μ
- Level 2: One μ with p_T>5 GeV
- Level 3: One track with p_T>10 GeV

Event Selection:

- Isolated μ with:
  - central track match
  - p_T > 20 GeV
  - $|\eta| < 1.6$
- $\not{E}_T$ > 20 GeV
- Cosmic veto
- No second μ ($Z \rightarrow \mu\mu$ veto)

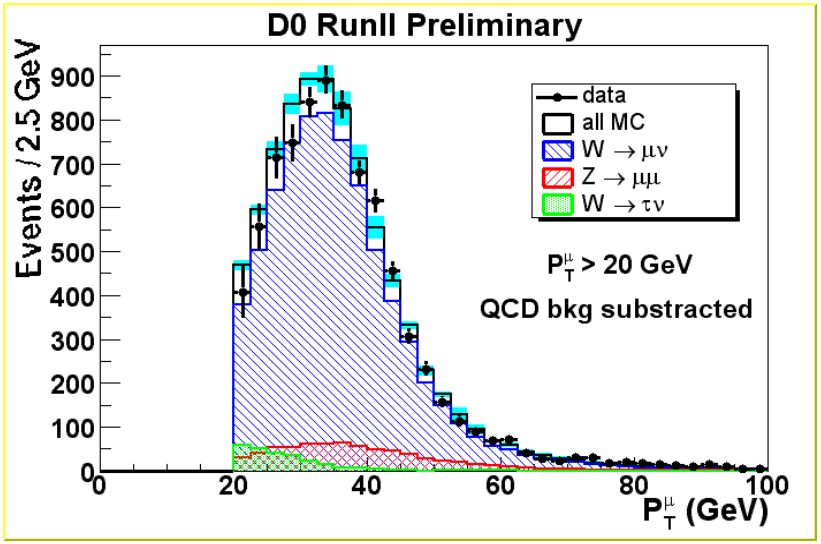
$\varepsilon_{total} * A \sim 13\%$

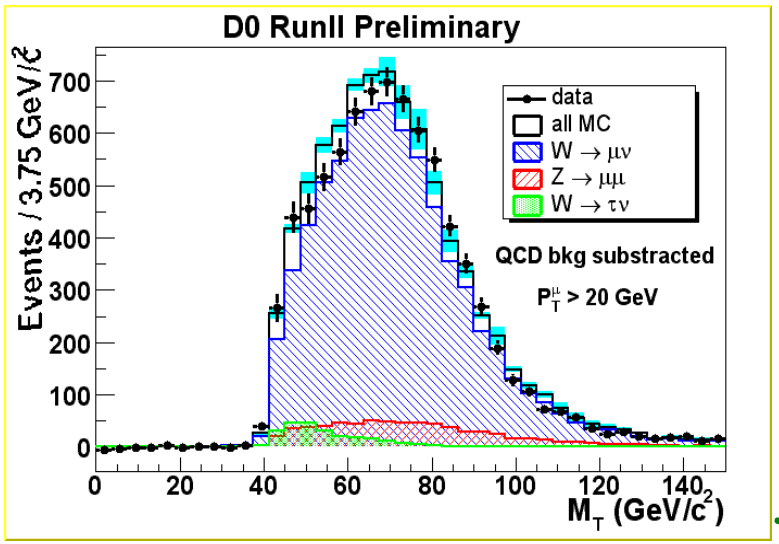
W→μν Cross Section*Br



Backgrounds:

- QCD background estimated from data
  - $b\bar{b}$, b→μν ~5.8%
- Z →μμ: ~9%
- W→τν→μνν: 3.6%





$\int \mathcal{L} dt = 17 pb^{-1}$

$\sigma(W) \times Br(W \to \mu\nu) = 3226 \pm 128 \text{ (stat)} \pm 100 \text{ (syst)} \pm 323 \text{ (lumi) pb}$