W/Z PRODUCTION AT THE FERMILAB TEVATRON

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for the
D0 and CDF Collaborations

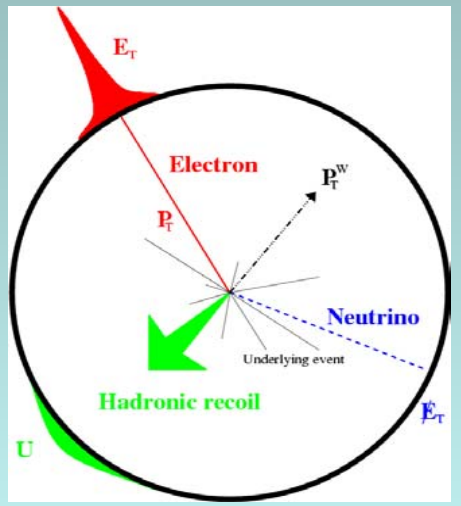
- Introduction
- Run 2: Detector & accelerator upgrades
- $\sigma \times B$ for W & Z
- W width
- Conclusions

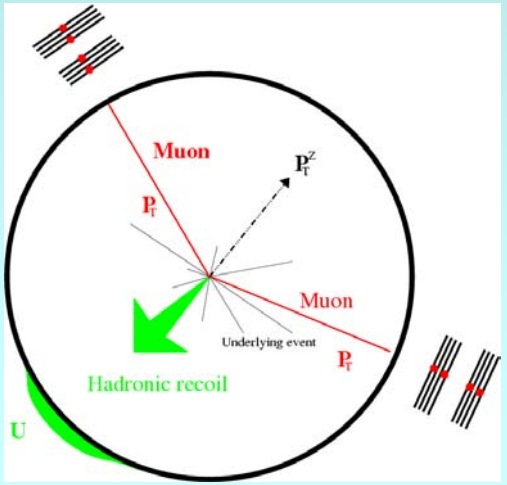
Importance of W/Z Production

- Tests of theory
  - Standard Model couplings
  - Higher order QCD corrections
  - Constrain proton parton distribution functions (PDF)
- Understanding detector performance
- Ultimately use W as luminosity monitor

Production of W's and Z's

- Production dominated by $q\bar{q}$ annihilation
  - Run2 will have 10^6 W's, 10^5 Z's
- Use leptonic decays of W and Z
  - Avoids large $p\bar{p} \rightarrow jj$ contribution
  - BR ~11% per mode for $W \rightarrow \ell\nu$
  - BR ~3% per mode for $Z \rightarrow \ell\bar{\ell}$
  - Clean, low background, event signatures
    - High p_T isolated leptons
    - W: 1 high p_T lepton + missing E_T (from ν)
    - Z: 2 high p_T leptons

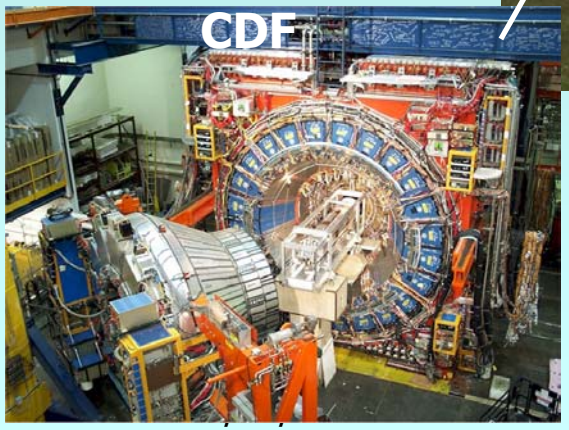




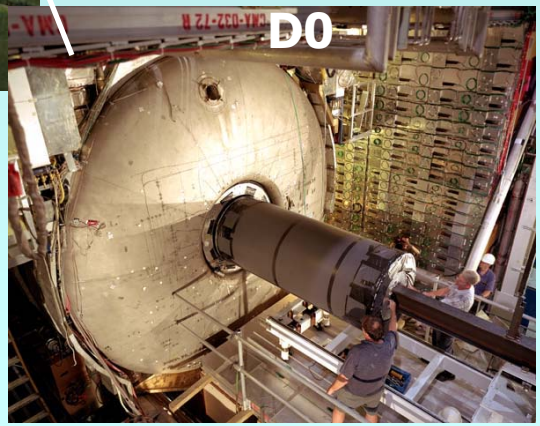
D0 and CDF Upgrades at Fermilab TeVatron – Run 2

- CDF: Drift chamber, silicon, plug calorimeter, daq, electronics

- D0: Silicon, fiber tracker, solenoid, muon, daq, electronics



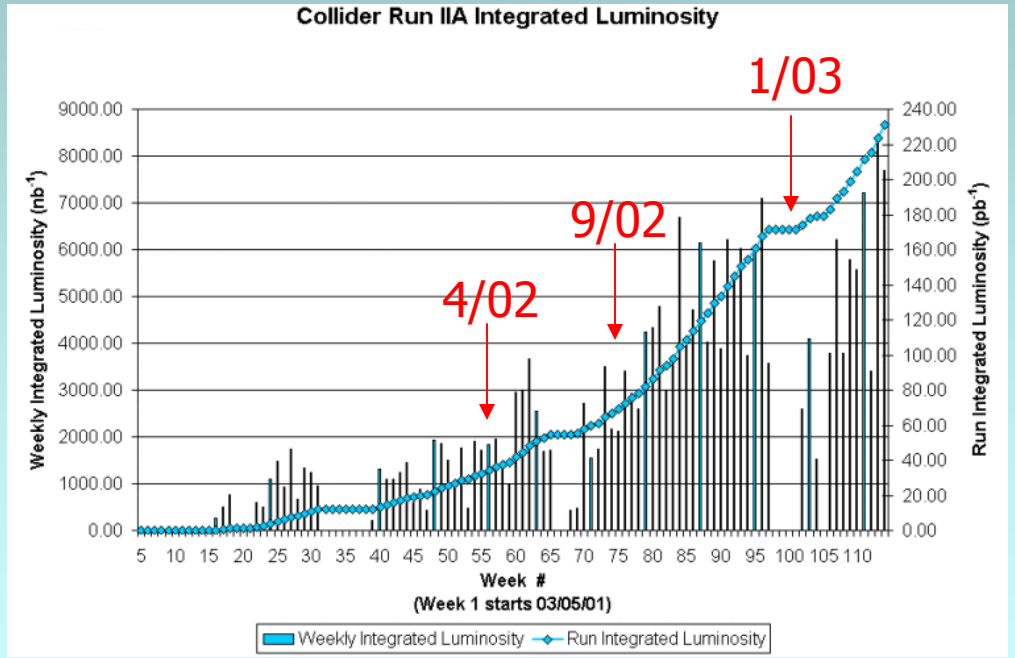
- Fermilab: 1.96TeV, Main Injector



Data Samples

- Tevatron performance improving
  - Peak lum ~40 x 10^{30}
- Data samples presented here
  - CDF: 4/02-1/03 (~72pb^{-1})
  - D0: 9/02-1/03 (~17-42pb^{-1})
- Detector data collection efficiency improving (now 85-90%)

Delivered Luminosity



W and Z Cross Sections

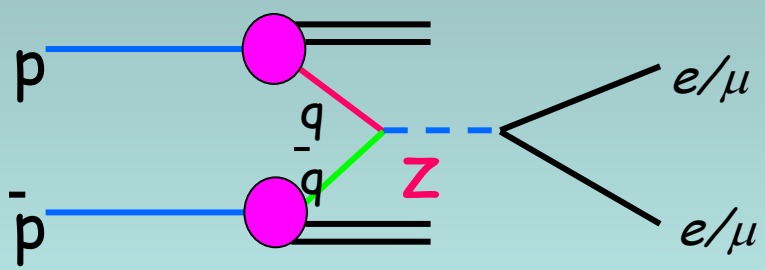
- The cross sections x branching ratio

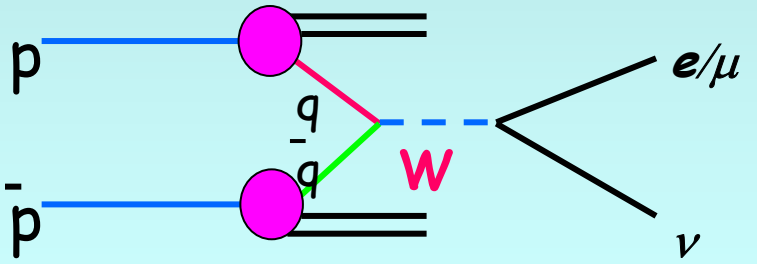
$$\sigma \cdot BR = \frac{N_{observed} - N_{background}}{A\varepsilon \int Ldt}$$

- Where
  - A = acceptance (from Monte Carlo)
  - ε = net efficiency (from data if possible)
- Uncertainties: luminosity, pdf's, detector simulation, efficiency – nitty gritty details left out of this presentation
- … so we just count

W and Z Cross Sections

- Start with Z production
  - Muon channel (D0, CDF)
  - Electron channel (D0, CDF)
- … then W production
  - Muon channel (D0, CDF)
  - Electron channel (D0, CDF)
  - Tau channel (CDF)

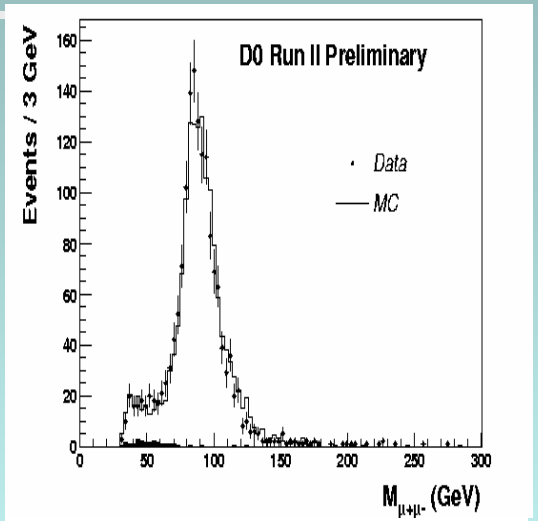




Z Production
Muon Channel

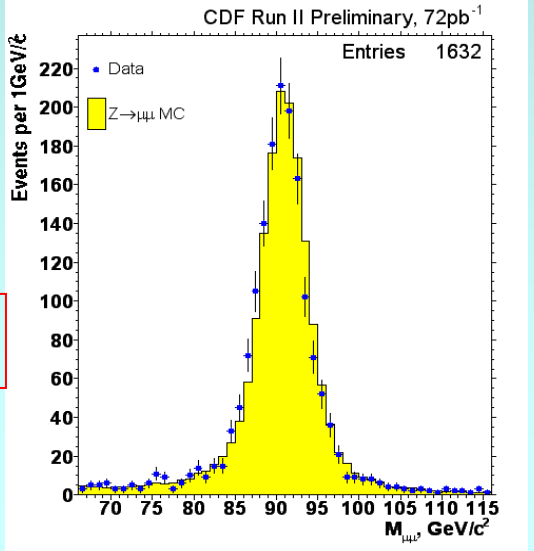
- D0: 32pb^{-1}, 1585 evt, background ~1.5%, A×ε =.16, DY+interference = .88

$$\sigma(p\bar{p} \to Z) \times B(Z \to \mu\mu) = (264 \pm 7_{Nz} \pm 17_{syst} \pm 26_{lum})\, pb$$



- CDF: 72pb^{-1}, 1632 evt, background ~1%, A×ε =.09

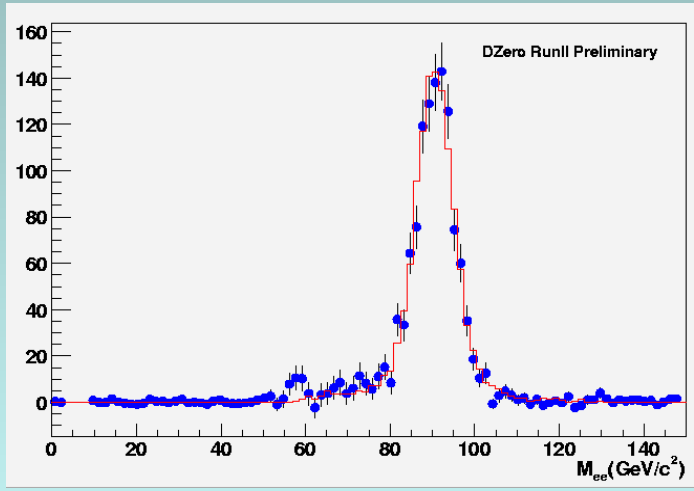
$$\sigma(p\bar{p} \to Z) \times B(Z \to \mu\mu) = (246 \pm 6_{Nz} \pm 12_{syst} \pm 15_{lum})\, pb$$



Z Production Electron Channel

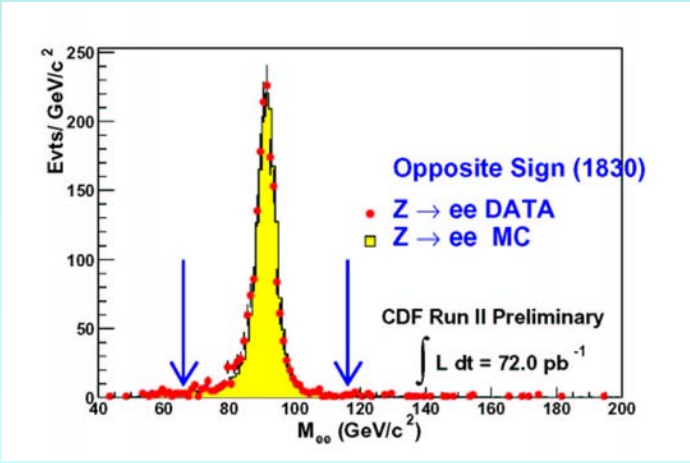
- D0: 42pb^{-1}, 1139 evt, background subtracted, A×ε =.09, DY = 1.7%

$$\sigma(p\bar{p} \to Z) \times B(Z \to ee) = (294 \pm 11_{Nz} \pm 8_{syst} \pm 29_{lum})\, pb$$



- CDF: 72pb^{-1}, 1830 evt, background 10, A×ε =.10

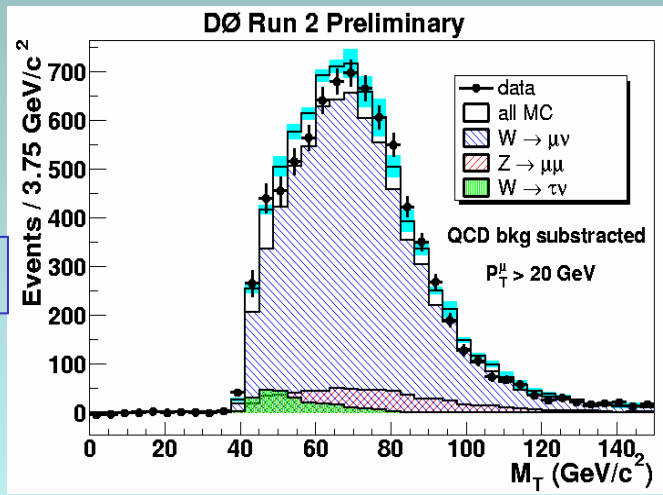
$$\sigma(p\bar{p} \to Z) \times B(Z \to ee) = (267 \pm 6_{Nz} \pm 15_{syst} \pm 16_{lum})\, pb$$



W Production
Muon Channel

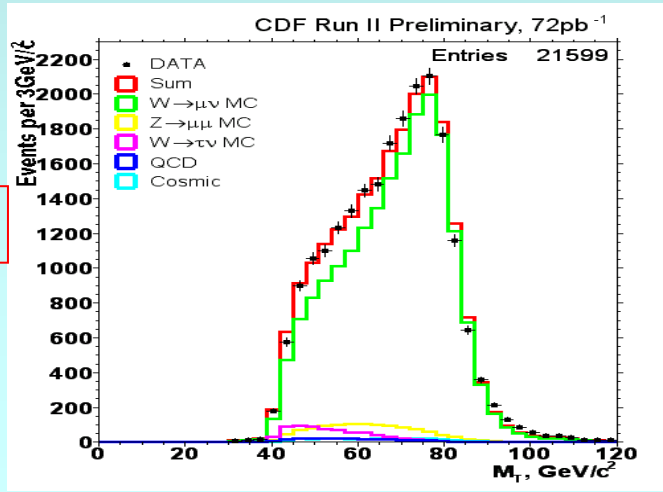
- D0: 17pb^{-1}, 8817 evt, background 1465, A×ε =.13

$$\sigma(p\bar{p} \to W) \times B(W \to \mu\nu) = (3.23 \pm 0.13_{Nw} \pm 0.10_{syst} \pm 0.32_{lum})nb$$



- CDF: 72pb^{-1}, 21599 evt, background 2337, A×ε =.10

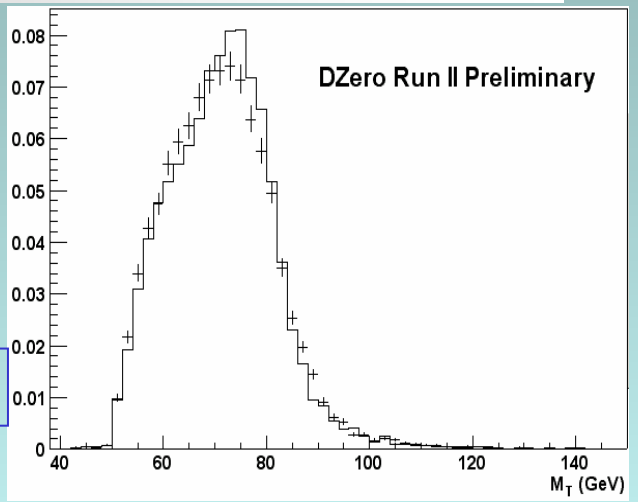
$$\sigma(p\bar{p} \to W) \times B(W \to \mu\nu) = (2.64 \pm 0.02_{Nw} \pm 0.12_{syst} \pm 0.16_{lum})nb$$



W Production Electron Channel

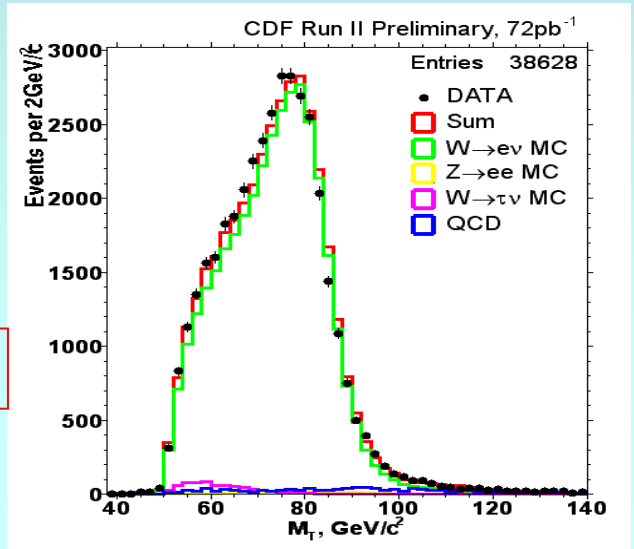
- D0: 42pb^{-1}, 27370 evt, background subtracted, A×ε =.22

$$\sigma(p\bar{p} \to W) \times B(W \to e\nu) = (3.05 \pm 0.10_{Nw} \pm 0.09_{syst} \pm 0.31_{lum})nb$$



- CDF: 72pb^{-1}, 38628 evt, background 2456, A×ε =.19

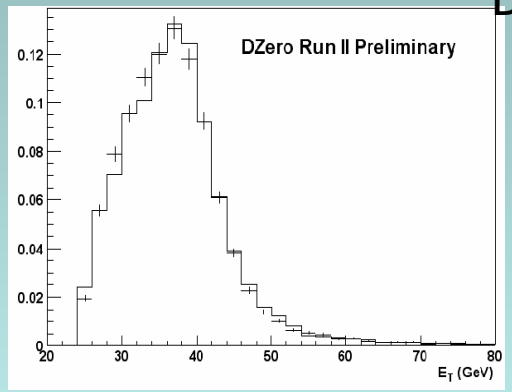
$$\sigma(p\bar{p} \to W) \times B(W \to e\nu) = (2.64 \pm 0.01_{Nw} \pm 0.09_{syst} \pm 0.16)nb$$

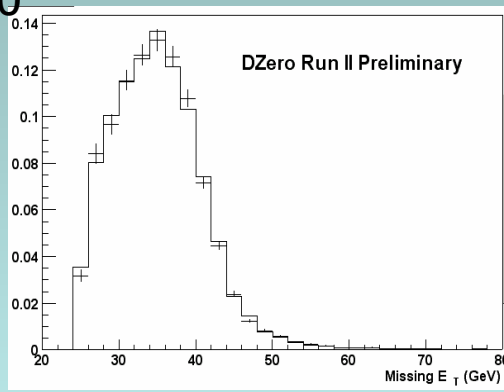


Understanding the Detectors

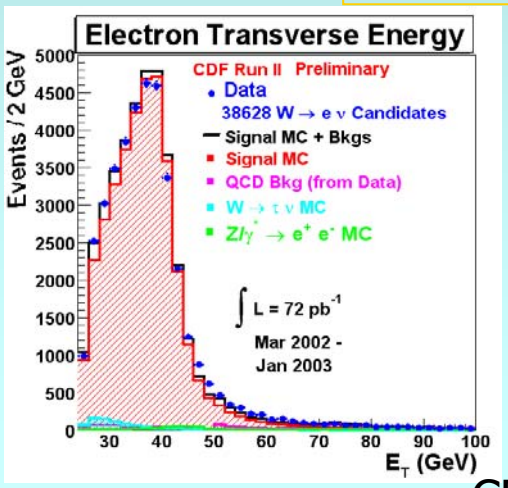
- W and Z data vs Monte Carlo is an indication of how well we understand the detectors, backgrounds,…

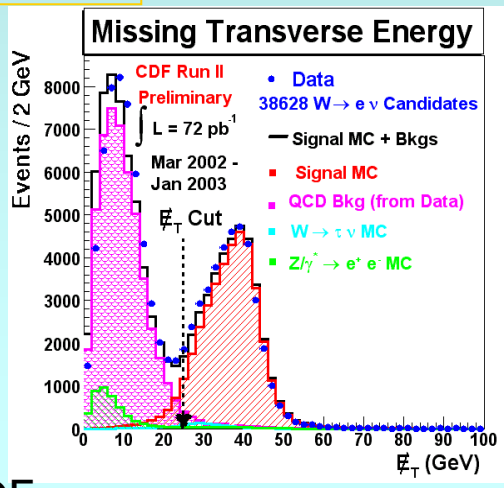
D0





E_T $W \rightarrow e\nu$ Missing E_T

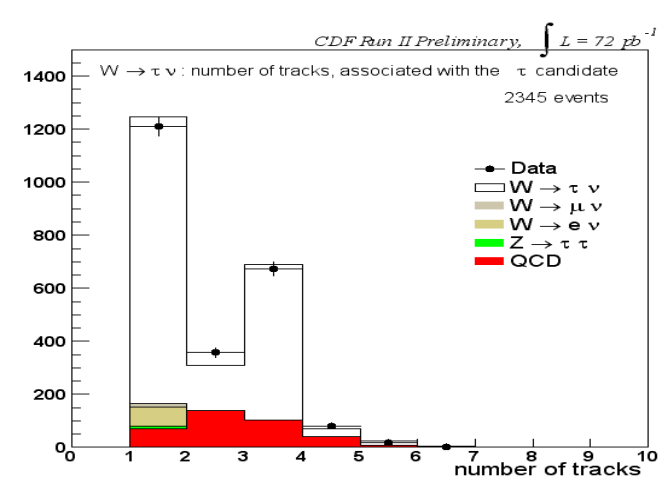




CDF

W Production
Tau channel

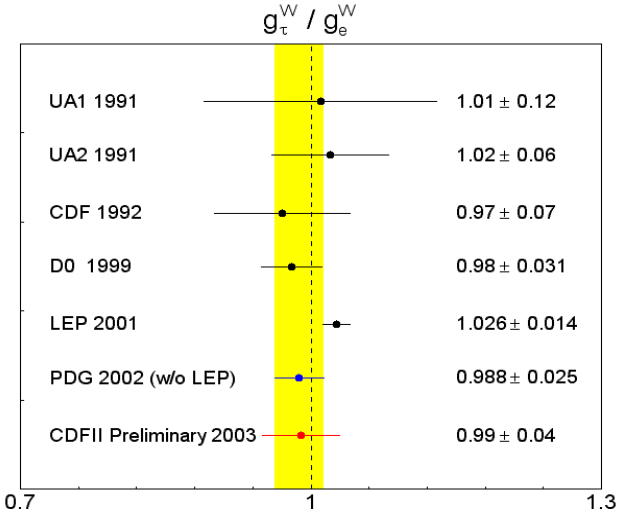
- CDF: 72pb^{-1}, 2345 evts, high p_T monojet + missing E_T; p_T>1 GeV tracks in jet within 10 degrees of τ candidate



$$\sigma(p\bar{p} \to W) \times B(W \to \tau\nu) = (2.62 \pm 0.07_{Nw} \pm 0.21_{syst} \pm 0.16_{lum})nb$$

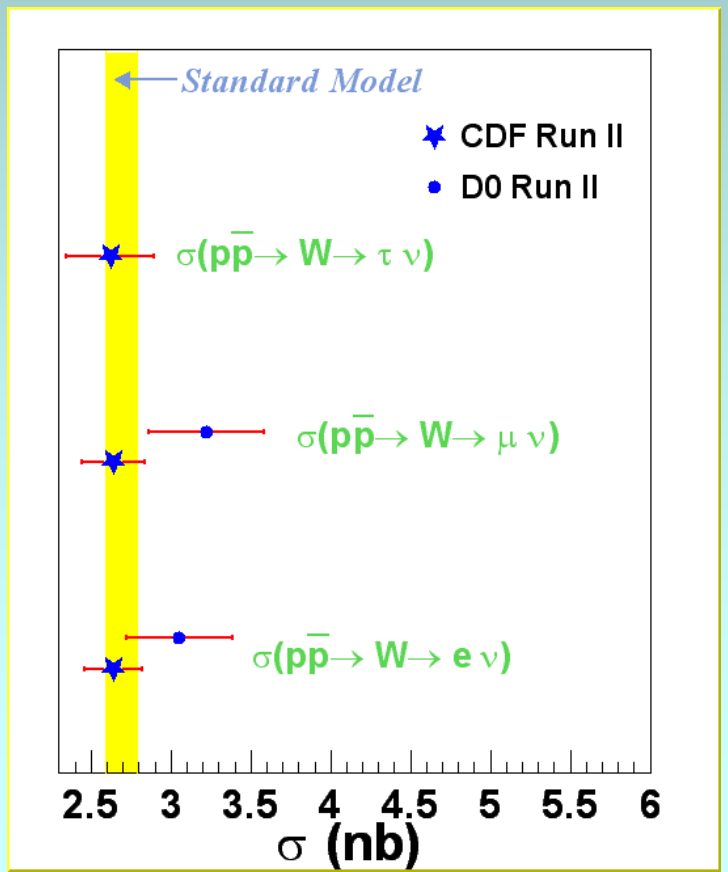
- Test of τ universality

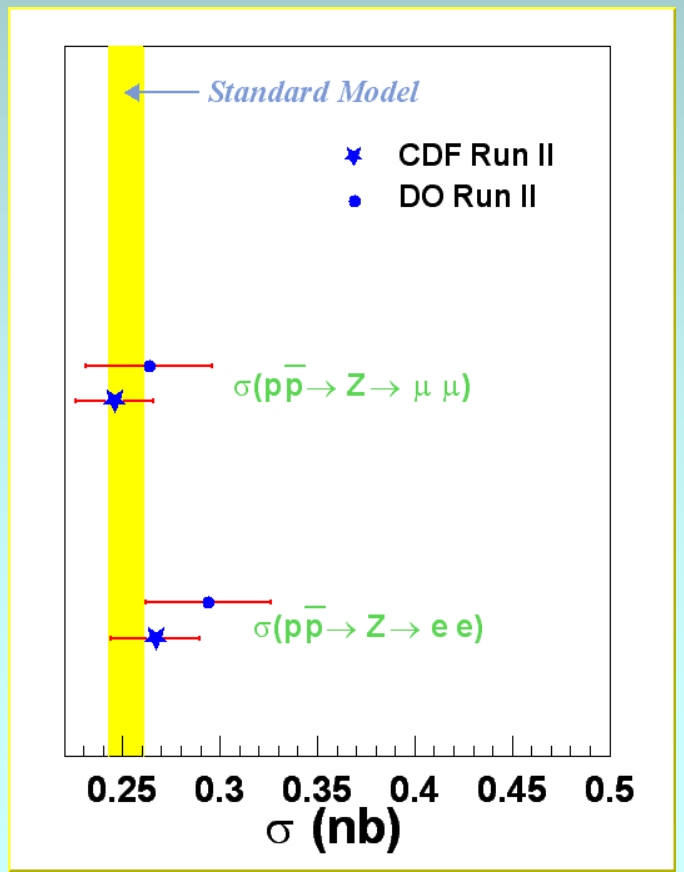
$$\frac{g_\tau}{g_e} = 0.99 \pm 0.02_{stat} \pm 0.04_{syst}$$



W and Z Cross Section Summary I

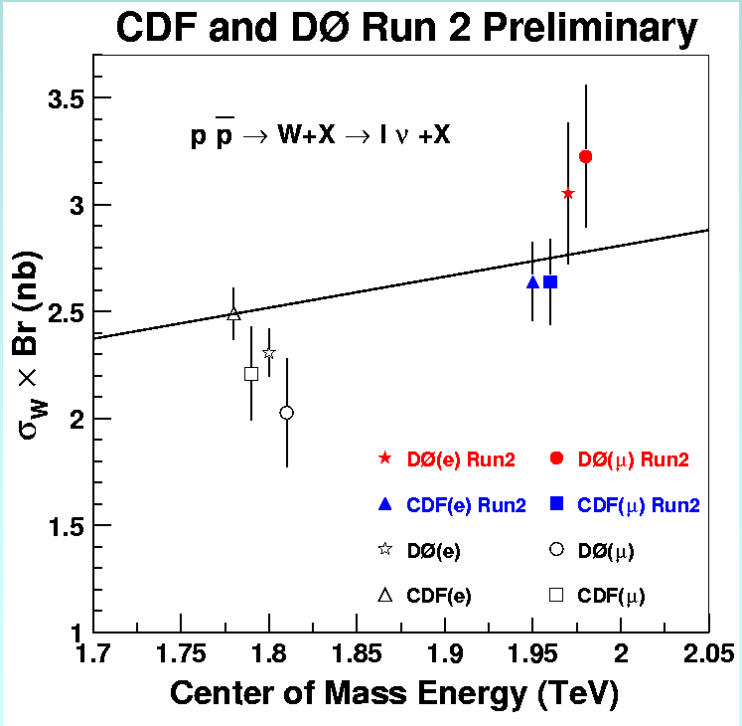
- Run 2 measurements consistent with predictions

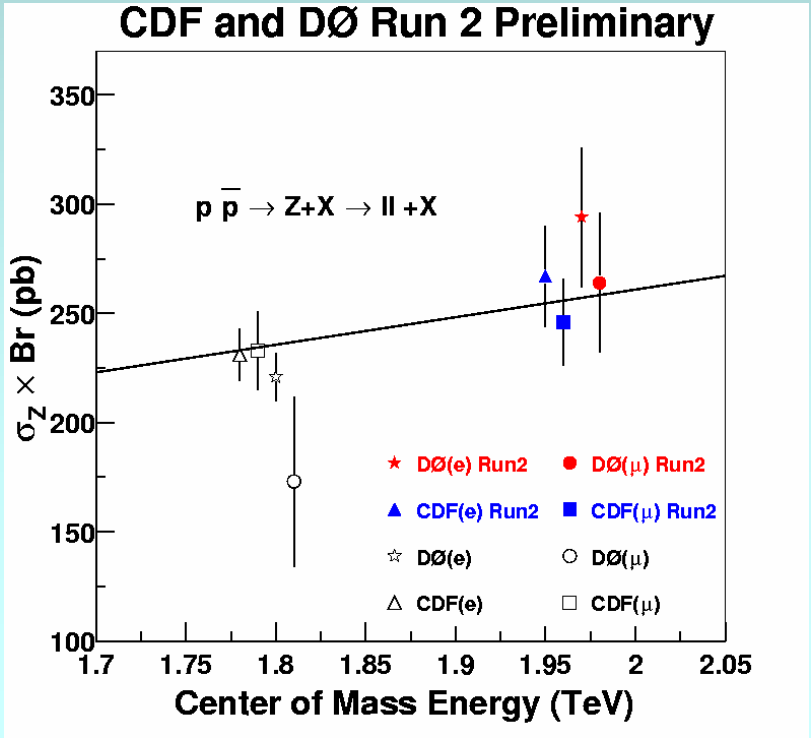




W and Z Cross Section Summary II

- Scaling with cm energy consistent (Run 1 & Run 2)
  - CR Hamberg, WL van Neerven and T Matsuura, Nucl. Phys. B359 (1991) 343 [CTEQ4M pdf]





R and the width of the W

- Use previous $\sigma \times B$ measurements in ratio, extract $\Gamma(W)$

$$\frac{\Gamma^e}{\Gamma(W)} \quad \text{Theory}$$

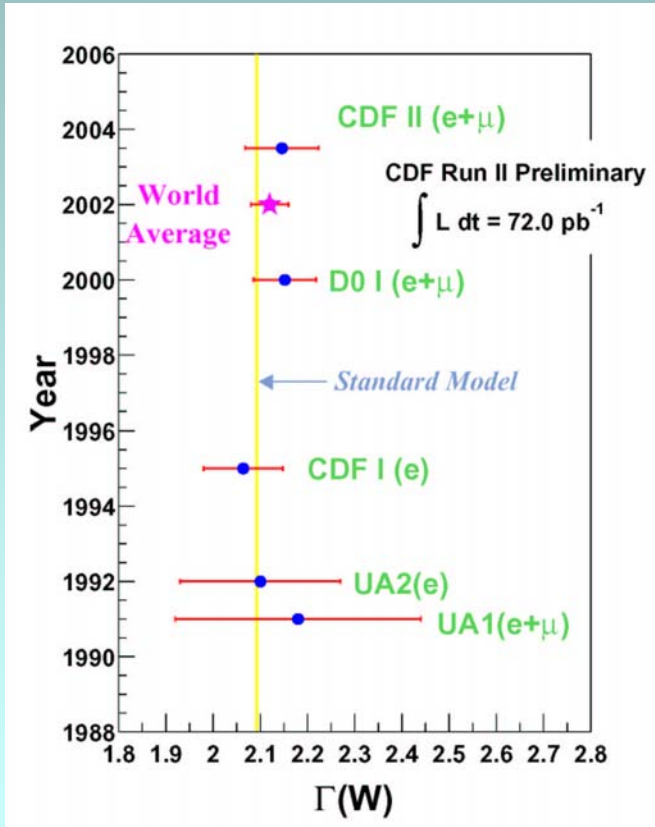
$$R = \frac{\sigma(W) \times B(W \to \ell\nu)}{\sigma(Z) \times B(Z \to \ell\ell)}$$

Theory Expt LEP

- CDF:

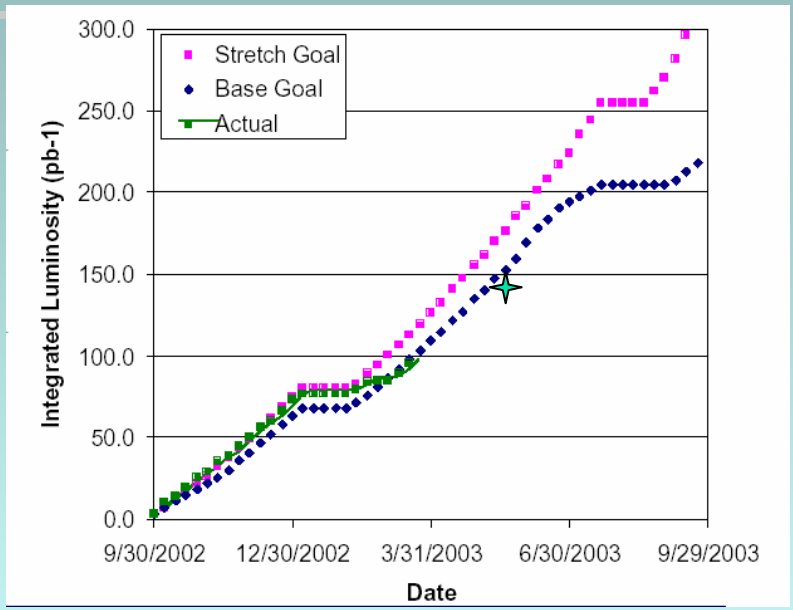
$$R_e = 9.88 \pm 0.24_{stat} \pm 0.47_{syst}$$

$$R_\mu = 10.69 \pm 0.27_{stat} \pm 0.33_{syst}$$



Future Prospects

- Near term: expect at least doubling of analyzed data for summer conferences
- Detector upgrades for FY06 (Si, trigger)
- Long term: reaching 7-11 fb^{-1} in FY08 (Steve Holmes @ P5)



"A reasonable range of goals based on our current experience would be:"

FY02	.08	.08	fb^{-1}
FY03	0.2	0.32	
FY04	0.4	0.6	
FY05	1.0	1.5	
FY06	1.5	2.5	
FY07	1.5	3.0	
FY08	1.8	3.0	
TOTAL	6.5	11.0	fb^{-1}

Note: Taking account of a seven month shutdown in FY06 and typical re-start performance experience could decrease these numbers by ~15%. Running beyond FY08 will increase them by ~25%/year.

Conclusions

- Five new W and Z cross section measurements from the Tevatron (D0/CDF) @ 1.96 TeV
- Consistent with predictions
- Detectors working well
- Significantly more data analyzed by the time of the summer conferences