Tevatron Electroweak Results
W - Z cross sections

~~Pierre Pétroff~~ Drew Alton

~~*LAL Orsay France*~~ U. of Michigan

for the CDF and DØ Collaborations

ICHEP04

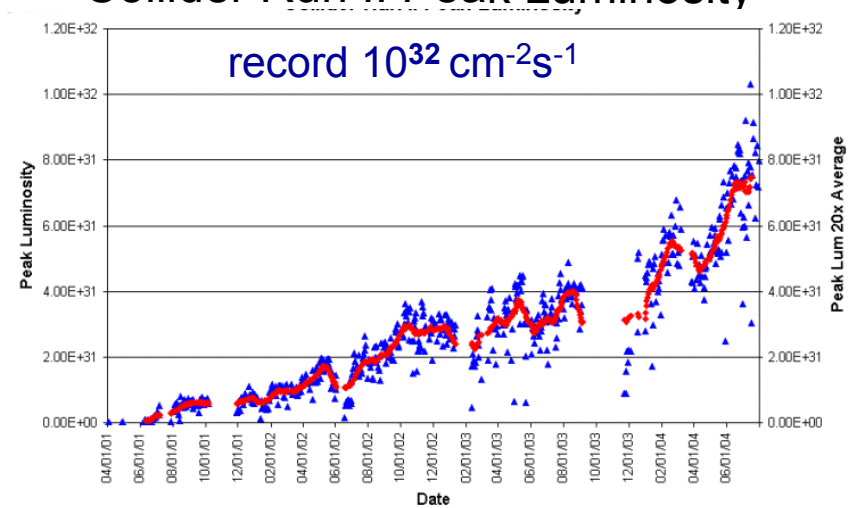
Beijing

16-21 August 2004

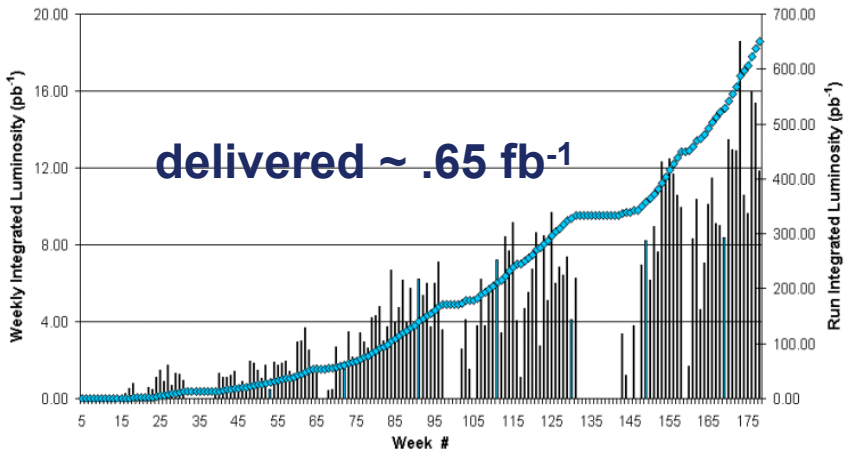
TeVatron for Run II

New 120 GeV Main Injector
36x36 bunches (396 ns)
CM increased form 1.8 TeV to 1.98 TeV

Collider Run II Peak Luminosity



Collider Run II Integrated Luminosity

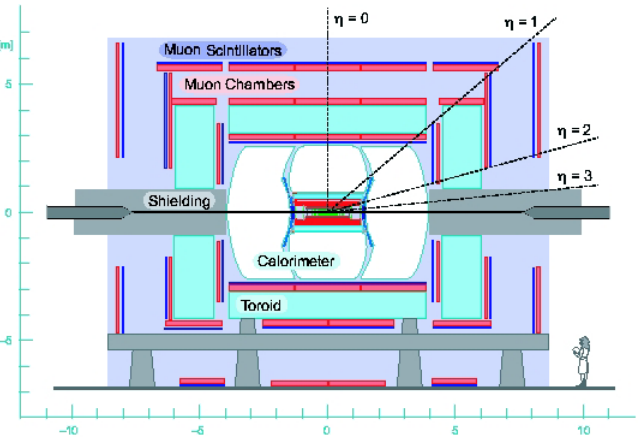


lumi design: 8 fb^{-1} by 2008

week 1 = 3/5/01

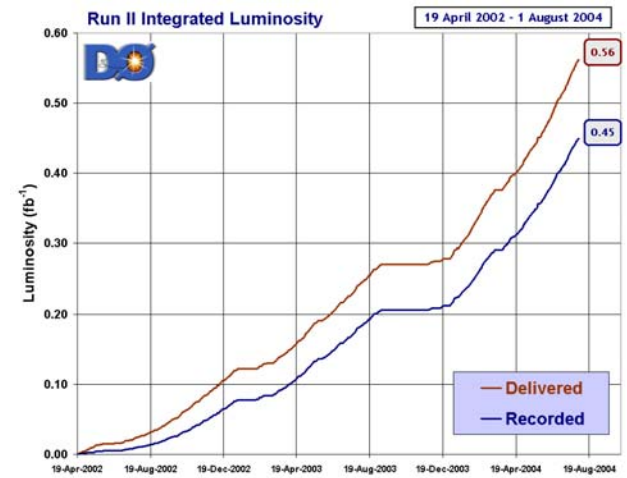
Detectors

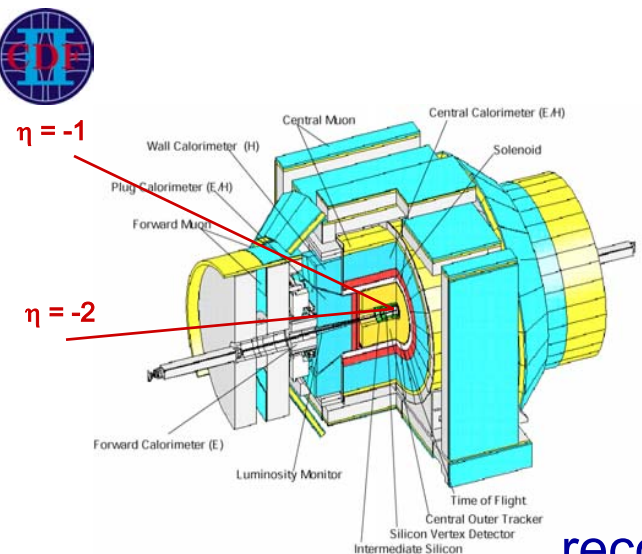
DØ analysis here used: 42-200 pb^{-1}



DZero Run II upgrades

- 2T solenoid
  - inner tracking
- Preshower
  - extended μ coverage
  - and shielding
- Trigger, DAQ

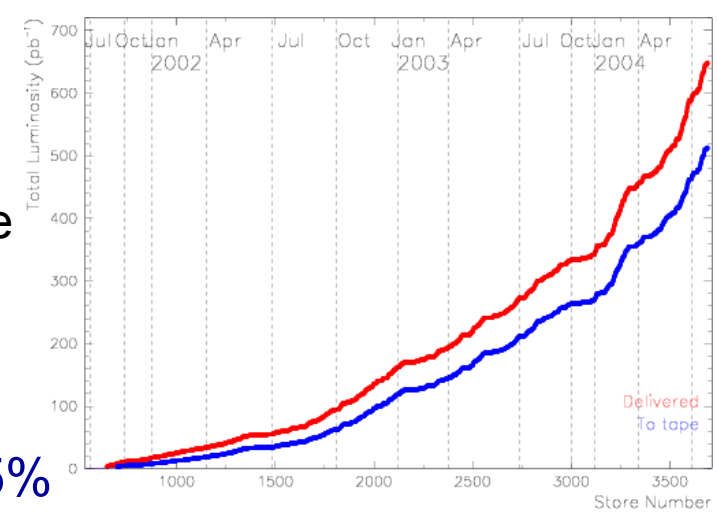




CDF analysis her used: 72-200 pb^{-1}

CDF Run II upgrades

- Inner tracking
- Forward calorimeter
- extended μ coverage
- Trigger, DAQ



recorded .500 - .450 fb^{-1}

data taking efficiency ~ 85%

W/Z Measurements at TeVatron

Precise EW measurements → one of the main physics goal at TeVatron

Cross sections

- Decays to e,μ,τ → lepton universality
- Ratio of W/Z cross sections * BR → indirect W width
- W width → CKM matrix elements like $|V_{cs}|$

This talk

W/Z Drell Yan

- Forward-backward asymmetry → $\sin^2(\theta_w)$, quark couplings
- W charge asymmetry → PDF
- Look for new resonances

Diboson production - WW/WZ/Wγ(γ)/Zγ (γ)

- Probe EW gauge structure (triple and quartic gauge couplings)
- New physics

Measure of Wm_T and lepton P_T → m_W and W width (direct measurement)

W/Z/Diboson production are important backgrounds for top, Higgs and SUSY production

W/Z Production and Event Topology

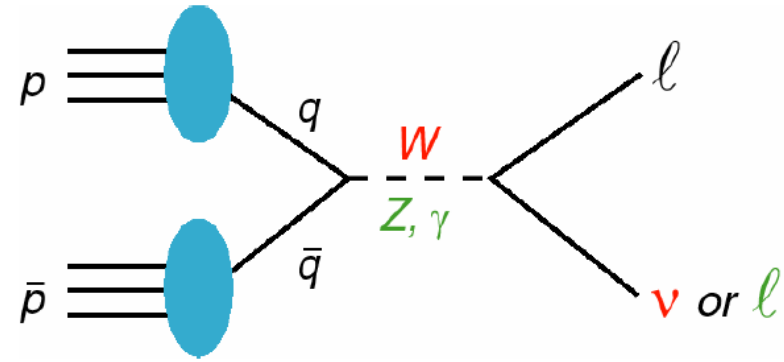
Use clean leptonic decays

Cross sections high/well known

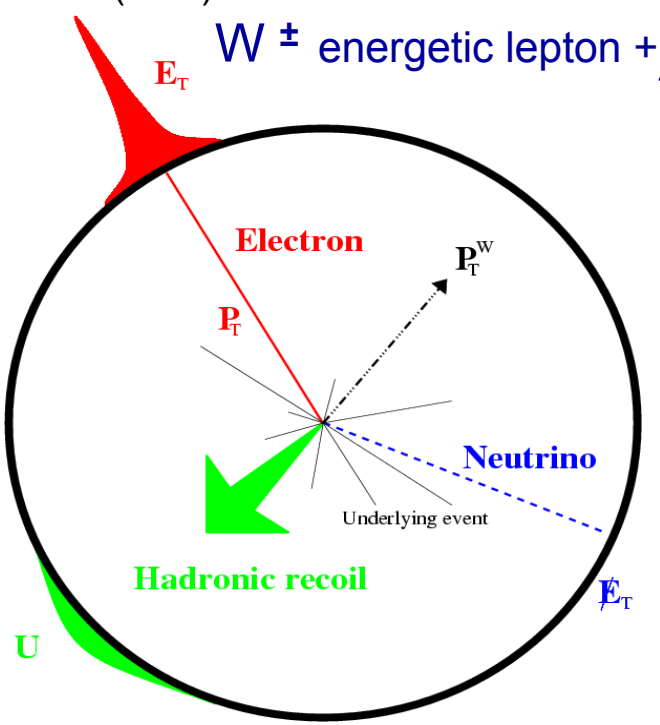
$\sigma \times$ br $\approx$ 0.2-2.3

Systematics limited:

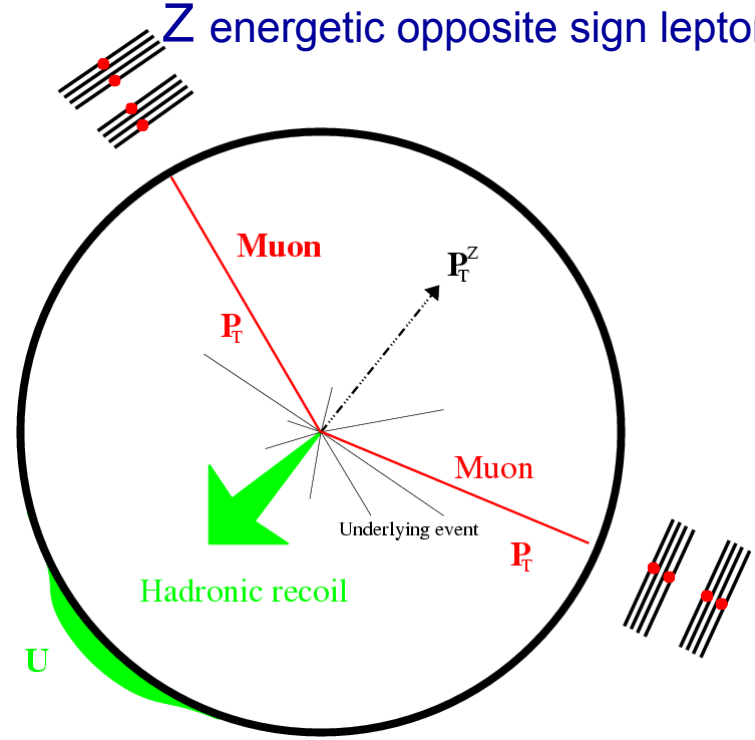
- luminosity ~ 6%
- PDF (CTEQ6 error sets) → ~1-2%
- Letpon ID (~1-2%)
- Others (<1%)



W ± energetic lepton + $\not{E}_T$



Z energetic opposite sign leptons



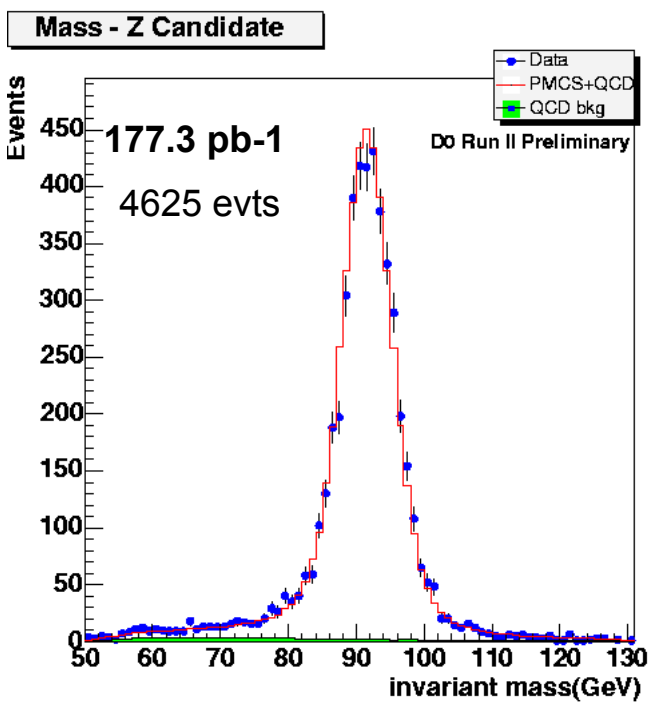
σ x BR(Z → ee)

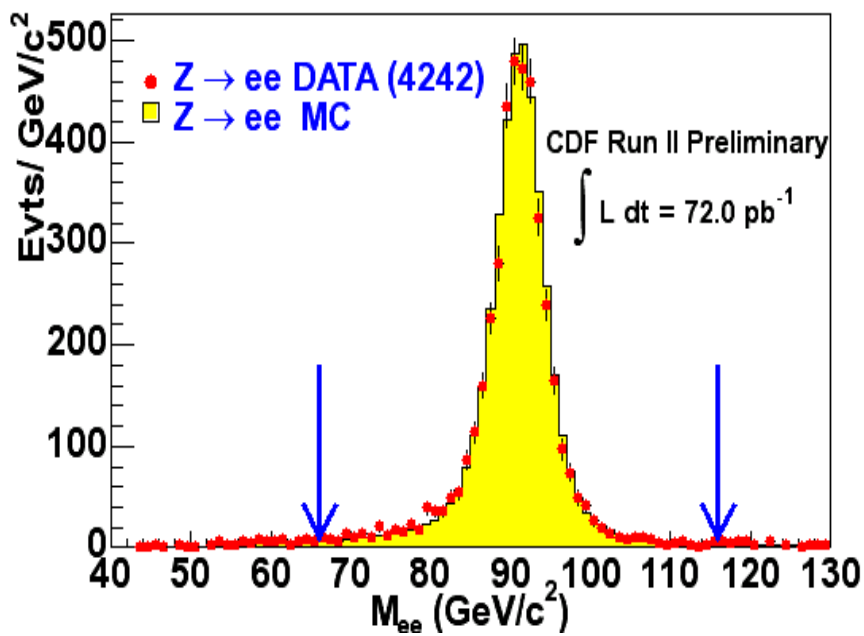
Two electrons, E_T > 25 GeV

- DØ : $|\eta|$ < 1.1 central only
- CDF: $|\eta|$ <2.8 central + plug calo

Small backgrounds from QCD, Z → $\tau\tau$

DY correction for pure Z contribution





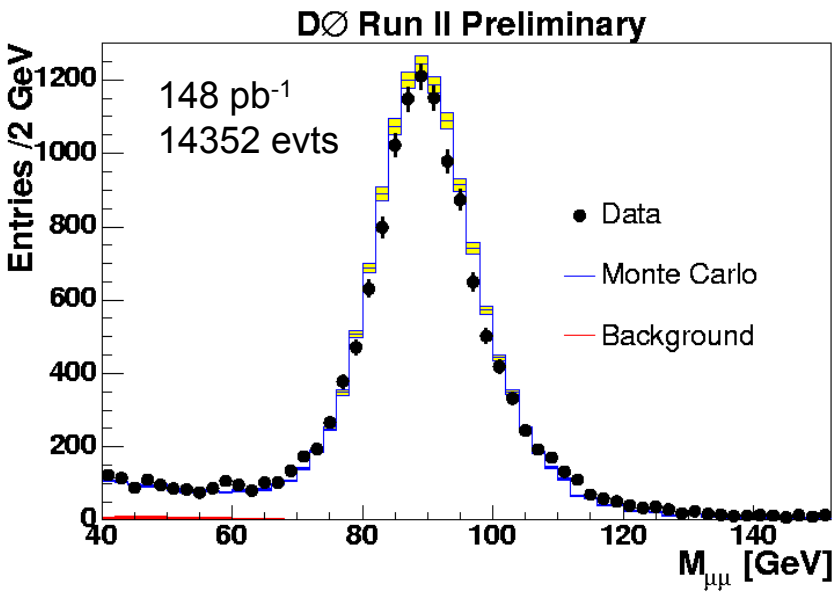
CDF: = 255.8 ±3.9 $_{stat}$ ±5.5 $_{syst}$ ±15.4 $_{lum}$ (pb)

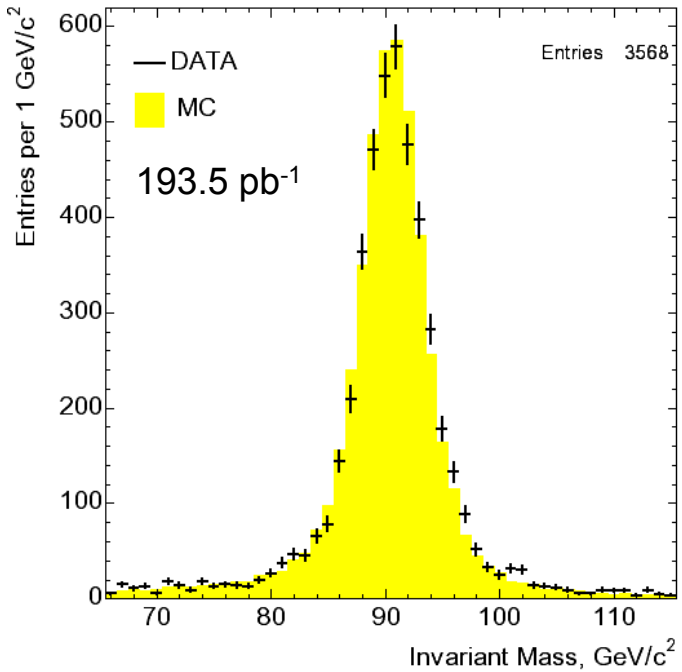
DØ : = 264.9 ±3.9 $_{stat}$ ±9.8 $_{syst}$ ±17.2 $_{lum}$ (pb)

σ x BR(Z → μμ)

Two opposite charged muons, p_T > 15-20 GeV

- CDF: |η| < 1.0, DØ | η |< 1.8
- very small background : QCD(b-jets), Z→ ττ





CDF: = 253.1 ±4.2 $_{stat}$ ±7.3 $_{syst}$ ±15.2 $_{lum}$ (pb)

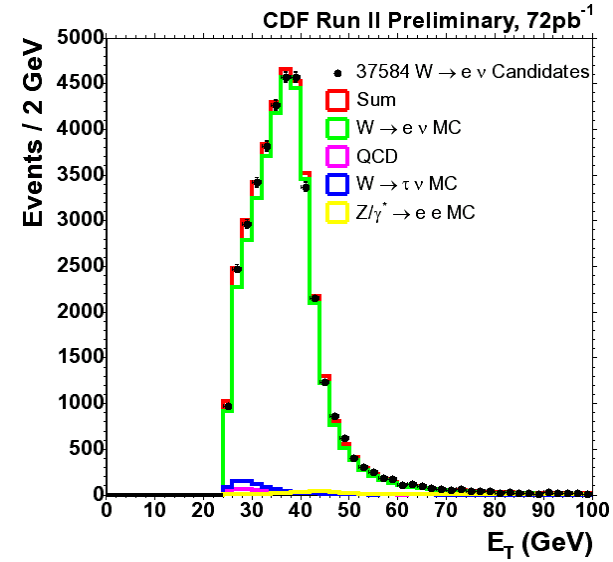
DØ : = 291.3 ±3.0 $_{stat}$ ±6.9 $_{syst}$ ±18.9 $_{lum}$ (pb)

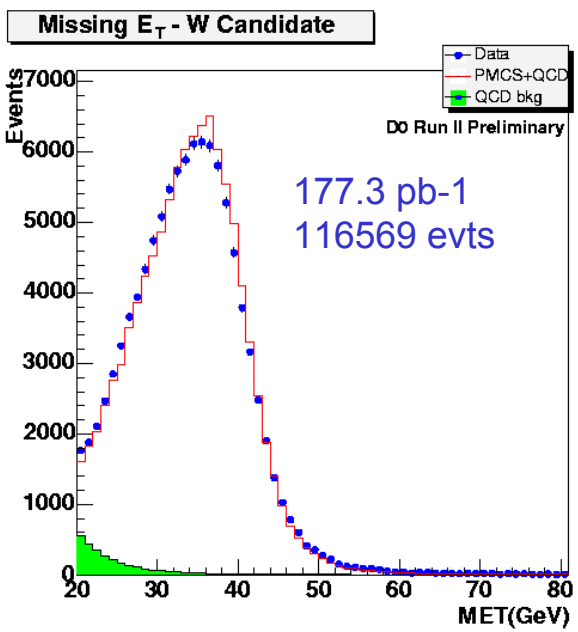
σ x BR(W → eν)

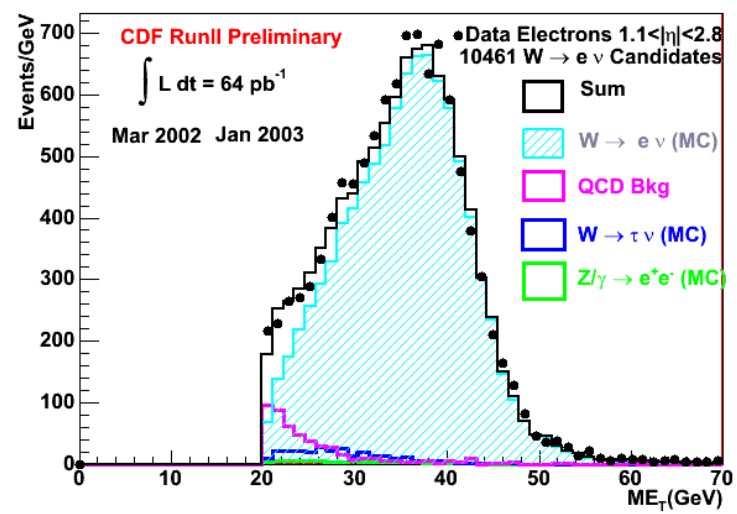
One electron, p_T > 25 GeV and $\not{E}_T$ > 25 GeV

- DØ : |η| < 1.1
- CDF: |η| < 2.8 central & plug (cut at 20 GeV)

Backgrounds: QCD, W→τν, Z→ee







CDF: = 2780 ±14 $_{stat}$ ± 60 $_{syst}$ ±167 $_{lum}$ (pb) central

= 2874 ±34 $_{stat}$ ±167 $_{sys}$ ±172 $_{lum}$ (pb) plug

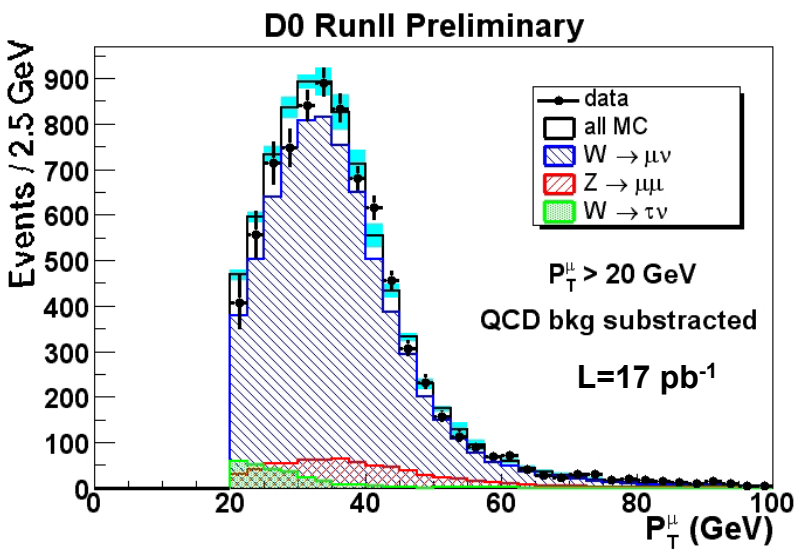
DØ : = 2865 ±8 $_{stat}$ ±75$_{sys}$ ±186 lum (pb)

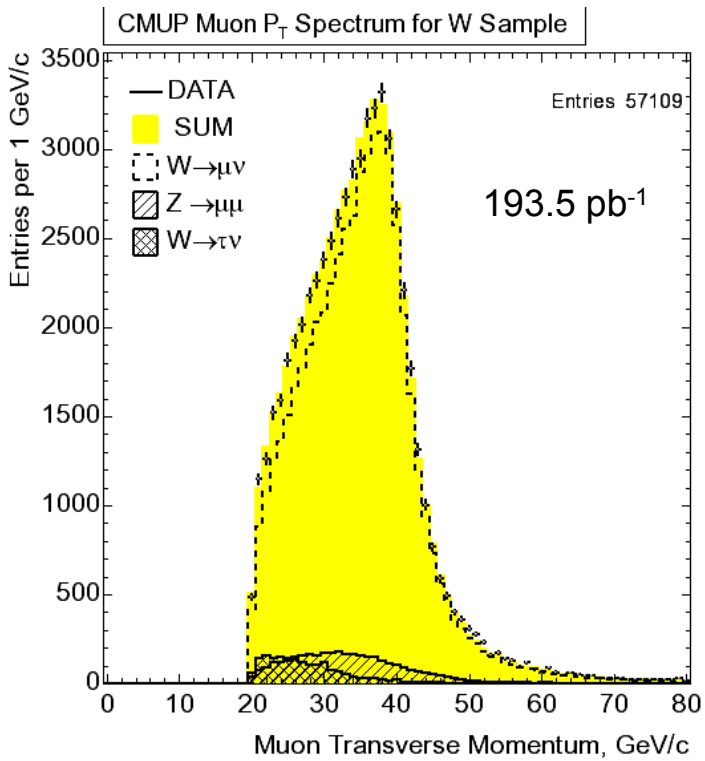
σ x BR(W → μν)

One muon, p_T > 20 GeV, missing E_T > 20 GeV

- DØ : |η| < 1.6
- CDF: |η| < 1.0

Backgrounds: Z→μμ, W→ τν, jets(b)





CDF: = 2786 ± 12 $_{stat}$ ± 60 $_{sys}$ ±166 $_{lum}$ (pb)

DØ : = 3226 ±128 $_{stat}$ ±100 $_{sys}$ ±323 $_{lum}$ (pb)

CDF/DZero Summary

Channel	# events	Purity (%)	Luminosity Used (pb^{-1})	ε * A (%)	η coverage
W→eν CDF	48.0K	94.0	72	23.1	2.8
DZero	117K	97.0	177.3	22.5	central
W→μν CDF	57K	90.5	193.5	9.6	central
DZero	8.3K	88.0	17	13.2	1.6
Z→ee CDF	4.2K	98.5	72	22.7	2.8
DZero	4.6K	98.0	177.3	10	central
Z→μμ CDF	3.6K	99.6	193.5	7.3	central
DZero	6.1K	98.9	148	30.0	1.8

$$\sigma \cdot Br = \frac{N - N_{bkg}}{\varepsilon \cdot A \cdot \int L\,dt}$$

Similar efficiencies and purities

- CDF: Includes forward electrons
- DØ : Includes forward muons
- Improved stat + combined results in the near future

Preliminary Ratio and Indirect W Width measurement

Tree level NNLO QCD calc (Van Neerven)

$$R \equiv \frac{\sigma_W \times BR(\ell\nu)}{\sigma_Z \times BR(\ell\ell)} = \frac{\sigma_W}{\sigma_Z}\frac{\Gamma(Z)}{\Gamma(Z\to ll)}\frac{\Gamma(W\to l\upsilon)}{\Gamma(W)}$$

SM EWK Calculation

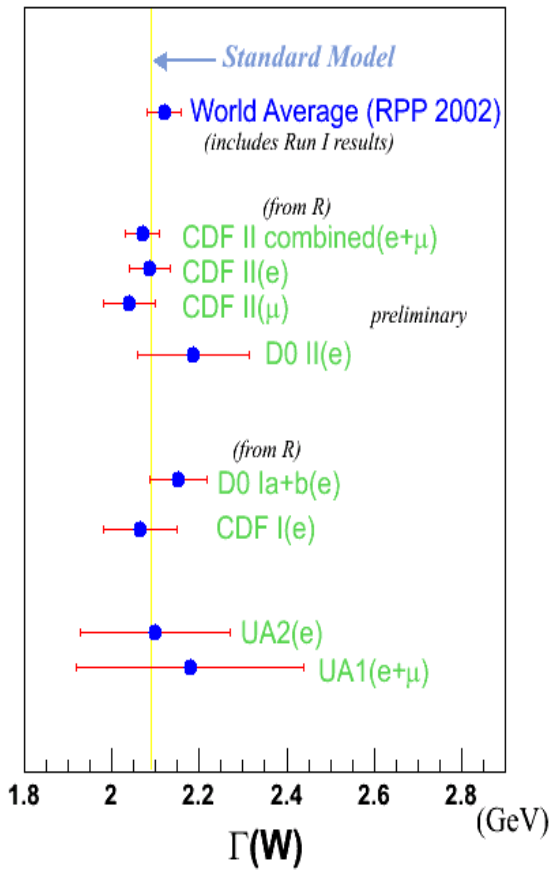
PDG(LEP)

CDF: R(e+μ) = 10.92 ±0.15 $_{stat}$ ± 0.14 $_{syst}$ (with 72 pb^{-1})
DØ : R(e) = 10.82 ± 0.16 $_{stat}$ ± 0.28 $_{syst}$

CDF:
NNLO, PDG → σ(pp →W)/ σ(pp → Z) = 3.368 ±0.024
LEP → Γ(Z→ ll)/Γ(Z) = (3.366 ±0.002)%
→ W width: Γ_W=2078.8 ±41.4 Me
World average = 2118 ±42 Mev

$$\Gamma_W = 3\Gamma_W^0 + 3\left(1+\frac{\alpha_s}{\pi}+1.409(\frac{\alpha_s}{\pi})^2 - 12.77(\frac{\alpha_s}{\pi})^3\right)\sum_{[\text{no top}]}|V_{qq'}|^2\,\Gamma_W^0$$

→V_{cs} = 0.967 ±0.030



Z production in $\tau\tau$

→ look for one hadronic decay and for other leptonic

CDF electron back to back with "seed" track(s) matched to a narrow cluster

DØ muon back to back to:

type 1: one track+calo cluster no EM cluster "π" like

type 2: one track+calo cluster+EM cluster "ρ" like

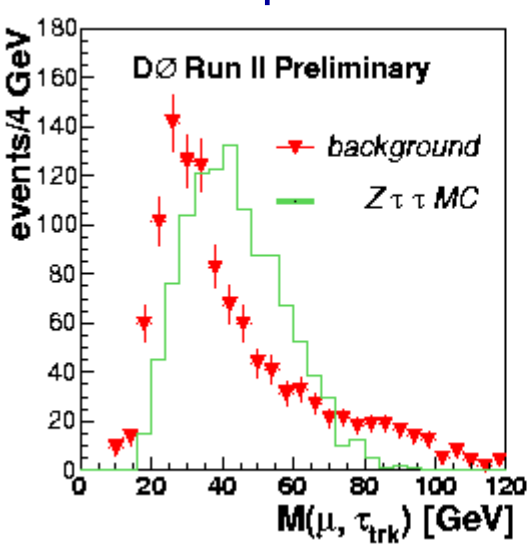
type 3: 2 or 3 tracks ~ $M\tau$ and calo cluster

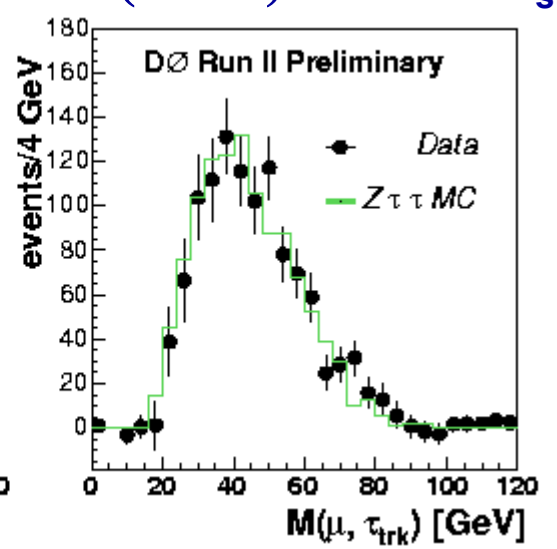
→ 3 separate NN's

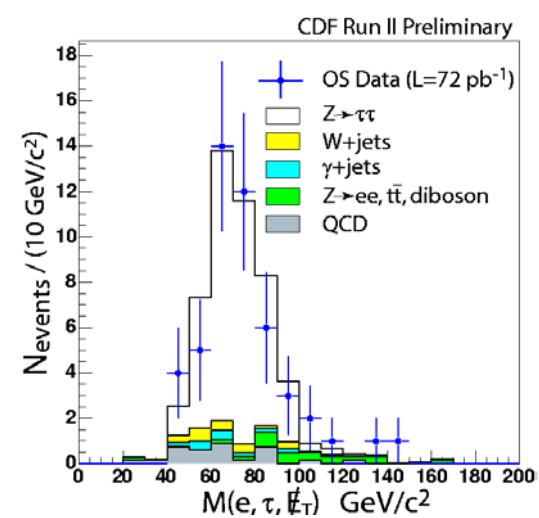
Proof of principle that $\tau\tau$ resonances are seen at TeVatron

72 pb^{-1} **CDF $\sigma(Z\rightarrow\tau\tau) = 242 \pm 48_{sta} \pm 26_{sys} \pm 15_{lumi}$ pb**

207 pb^{-1} **DØ $\sigma(Z\rightarrow\tau\tau) = 256 \pm 16_{sta} \pm 17_{sys} \pm 16_{lumi}$ pb**





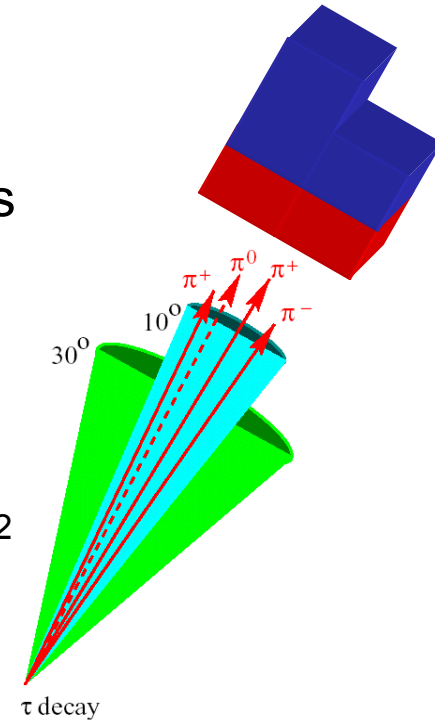


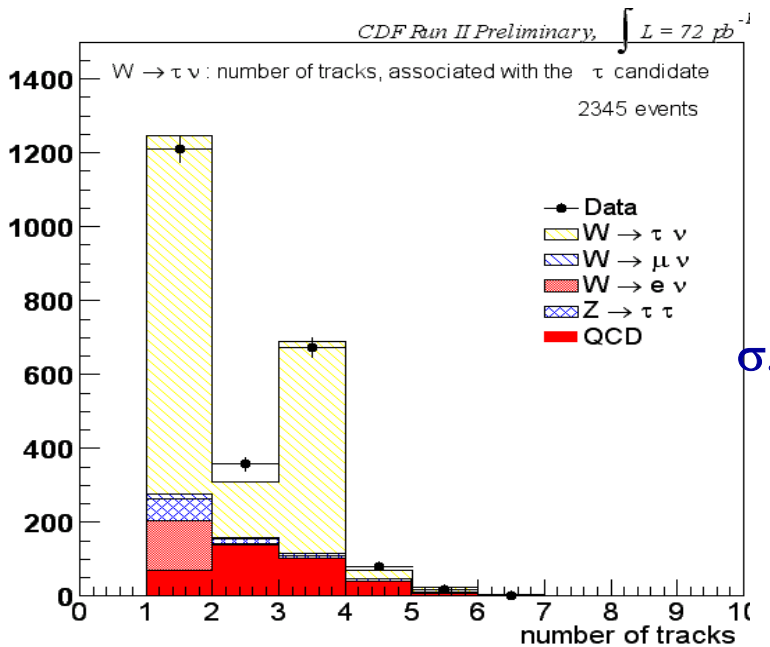
Physics with τ

τ reconstruction is challenging ! → new physics !

$W \rightarrow \tau\nu$ CDF Preliminary 72 pb^{-1} 2345 evts purity 74%

- Use hadronic decays for ID (1 or 3 charged tracks + π^0's
- jets + $W \rightarrow \mu\nu$ + $W \rightarrow e\nu$ + $Z \rightarrow \tau\tau$
- Look for tracks in 10^0 cone pointing toward a narrow calorimeter cluster + 30^0 isolation for tracks
- π^0 reconstructed (in Shower Max)
- require combined mass of tracks and π^0's < 1.8 GeV/c^2





σ.Br ($W \rightarrow \tau\nu$) = 2.62 $\pm 0.07_{stat}$ $\pm 0.21_{sys}$ $\pm 0.16_{lum}$ nb

Lepton universality

e-μ universality tested with $R\mu/Re = g^2\mu/g^2e$ by CDF

$g\mu/ge = 0.998 \pm 0.004_{sta} \pm 0.011_{sys}$

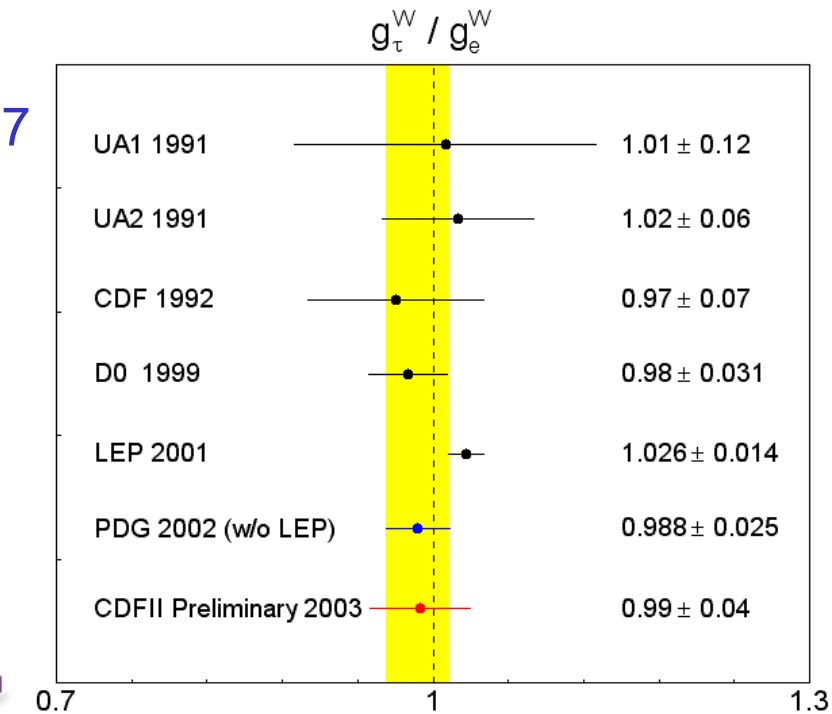
R combined e and μ

σ x Br ($W \rightarrow l\nu$) = $2775 \pm 10_{sta} \pm 53_{sys} \pm 167_{lum}$ pb

σ x Br ($Z/\gamma^* \rightarrow l^+l^-$) = $254.9 \pm 3.3_{sta} \pm 4.6_{sys} \pm 15.2_{lum}$ pb

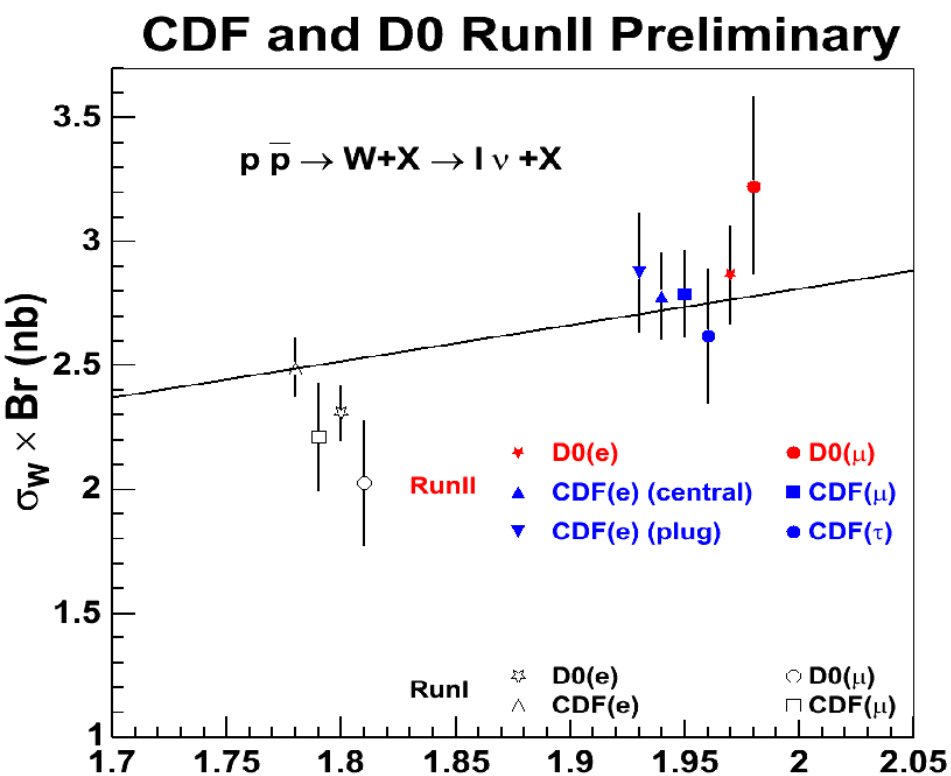
$Br(W \rightarrow \tau\nu)/Br(W \rightarrow e\nu) = 0.99 \pm 0.04 \pm 0.07$

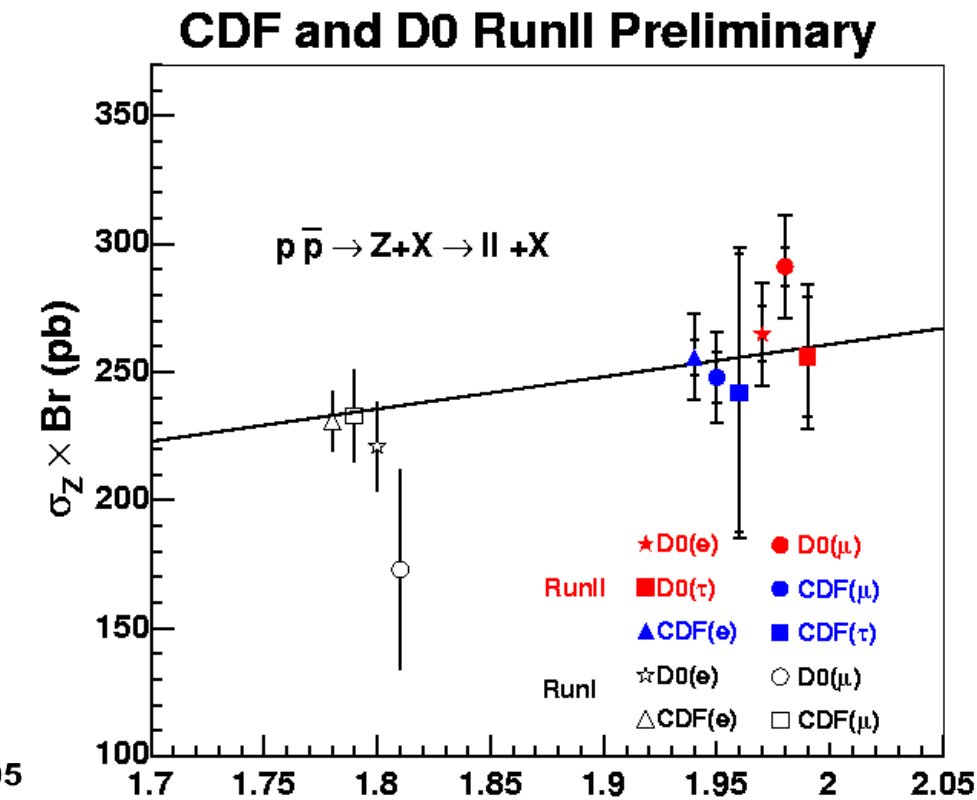
$\rightarrow$ **$g\tau/ge = 0.99 \pm 0.02_{sta} \pm 0.04_{sys}$**



W/Z Cross Sections Summary

Current preliminary results consistent with SM





Theoretical calculation NNLO from Hamberg, van Neerven and Matsuura

Conclusion

* The TeVatron, CDF and DØ are running well
* Cross sections (W/Z) x Br (e/μ/τ)
* Ratio → W width
* Proof physics with τ
* All results consistent with SM
* More statistics very soon (already on tape !)
* Publications on the way ..(CDF PRL submitted 72 pb-1)
* Help
  - understanding the detectors and the background
  - Use as a relative luminosity measurement with ~ 2% error in the future
* PDFs one the main contribution to the systematic errors (after lumi)
* Very soon precision measurement sensitive to new physics ?
* Combine CDF and DØ results ! (Tevatron Electroweak working group)
  – Standardized error reporting
  – Account for error correlation