Electroweak Results from the Tevatron

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On behalf of the CDF and DØ Collaborations

XX Rencontres de Physique de La Vallée d'Aoste
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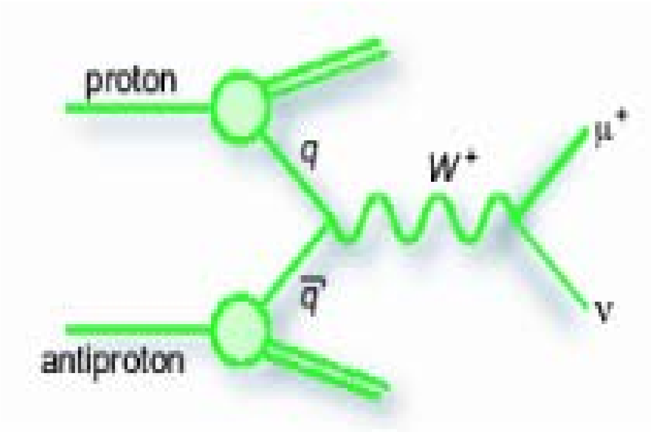
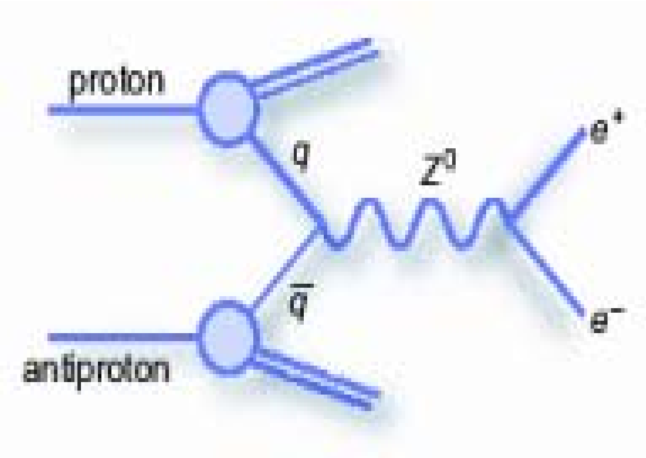
Outline

- W and Z production
  - Cross-sections
  - R : W/Z ratio measurement

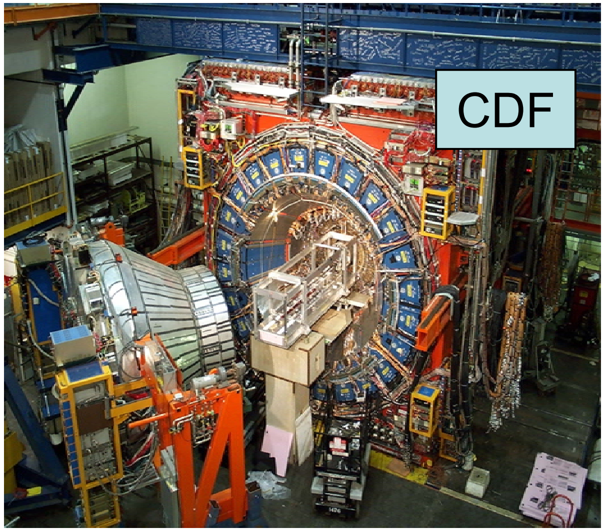




- Z Rapidity
- W Charge asymmetry
- Di-boson production

Tevatron, CDF and DØ

Delivered luminosity ~ 1.4fb^{-1}



proton anti-proton collider
1.96 TeV, 396 ns bunch spacing
Expected integrated lumi: 8fb^{-1} by 2008

Production Cross Section

Precise measurements allow tests of Standard Model predictions

NNLO @ 1.96 TeV theory predictions with few % precision

Can be used as a “standard candle” to measure or cross-check luminosity

Ratio of cross-sections give indirect measurement of W width

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

SM: 226.4±0.3MeV

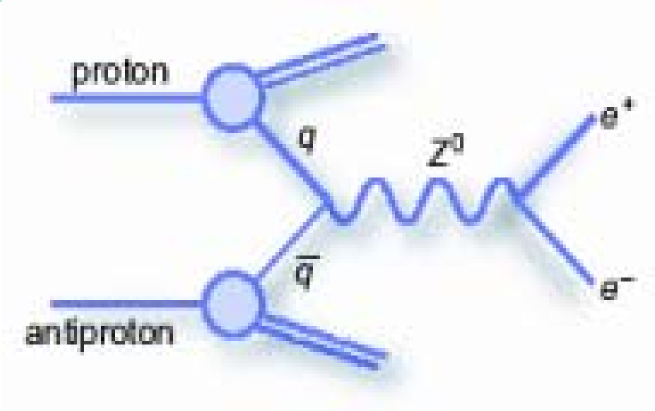
SM: 3.361±0.024

LEP

Measurements generally limited by systematic uncertainties:
- Luminosity ~ 6%
- Parton Density Functions (PDF) ~ 1.5%
- Lepton ID Efficiencies ~ 1%

W and Z Boson Production

Look at the leptonic decays of W and Z



Select Z bosons with:

single electron/muon triggers

require two reconstructed leptons

cut on lepton transverse momentum ~ 20 GeV

Hadronic decays difficult to pick out from the background

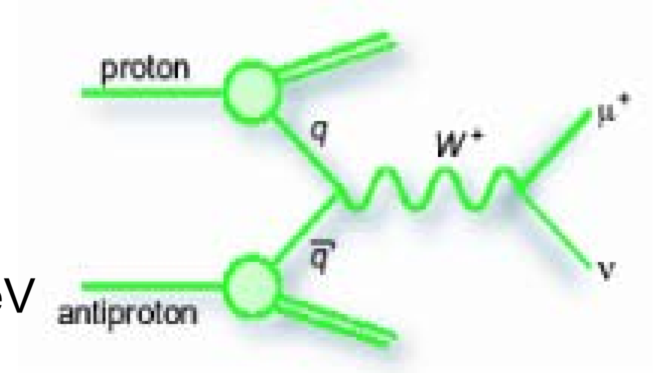
Select W bosons with:

single electron/muon triggers

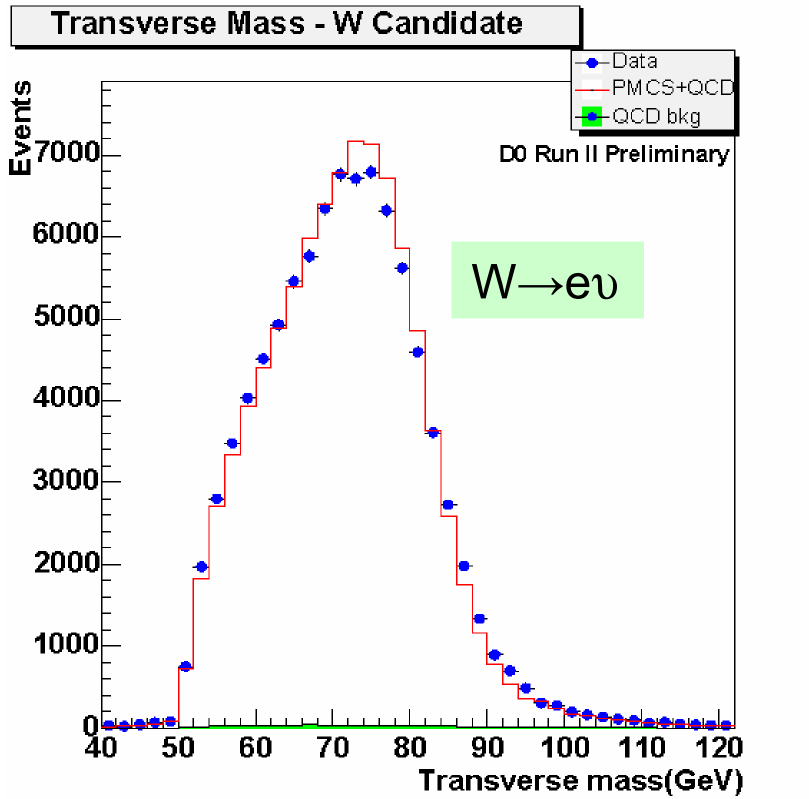
lepton identification cuts

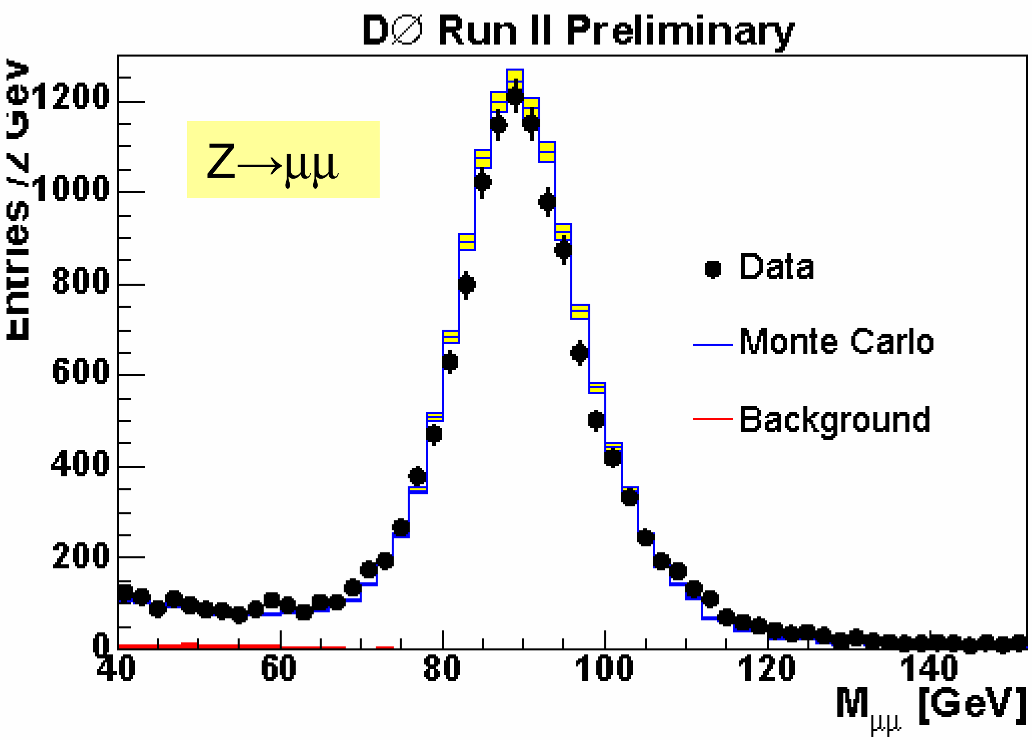
cut on lepton transverse momentum ~20GeV

cut on missing transverse momentum ~20 GeV



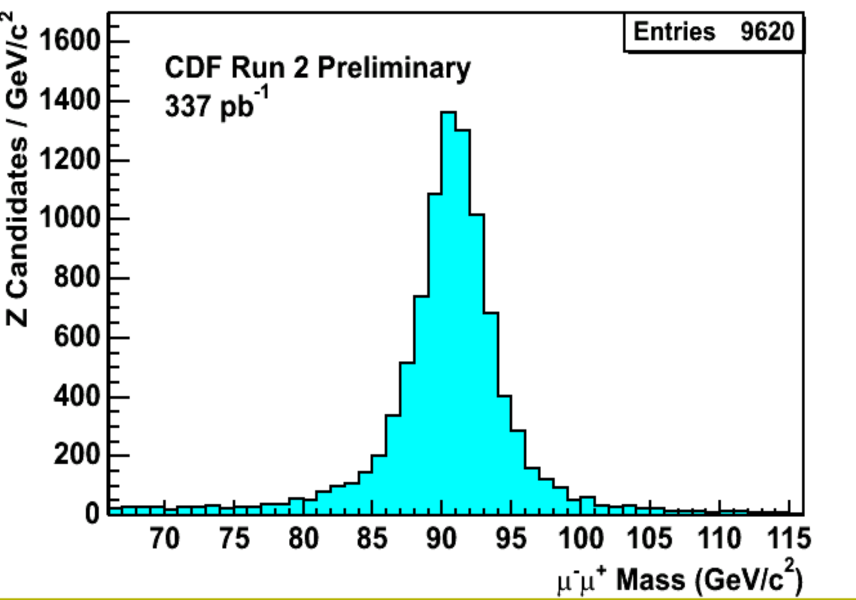
W and Z Production at DØ



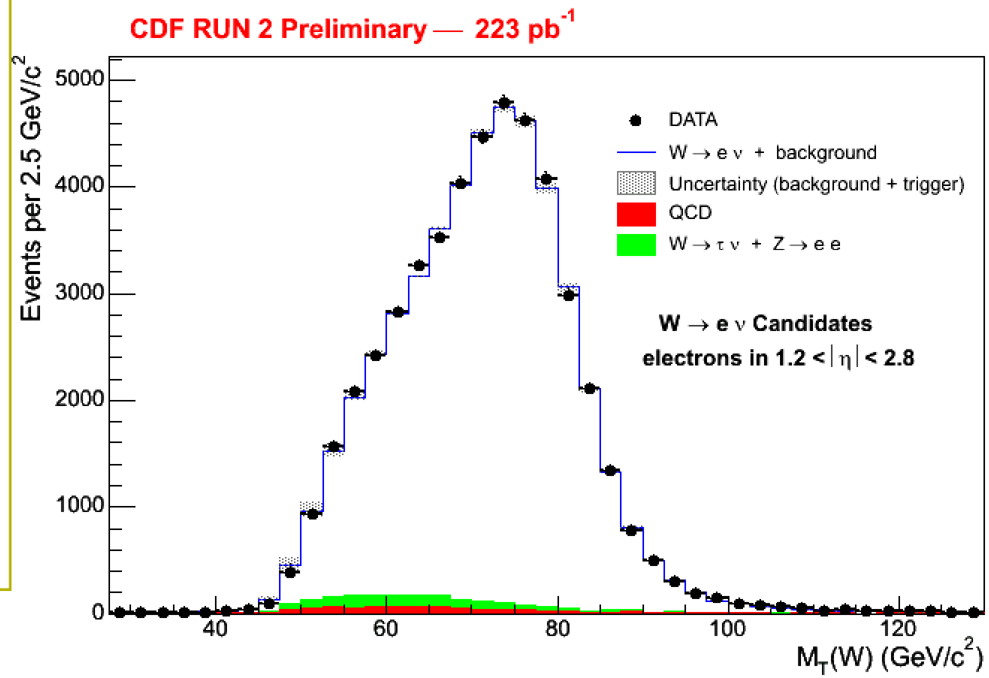


$\int L = 148 pb^{-1}$	$\sigma_Z \times Br(Z \to \mu\mu) = 291 \pm 3.0_{(stat)} \pm 6.9_{(sys)} \pm 18.9_{(lum)}$ pb
$\int L = 177 pb^{-1}$	$\sigma_Z \times Br(Z \to ee) = 264.9 \pm 3.9_{(stat)} \pm 8.5_{(sys)} \pm 5.1_{(pdf)} \pm 17.2_{(lum)}$ pb
$\int L = 177 pb^{-1}$	$\sigma_W \times Br(W \to e\upsilon) = 2865.2 \pm 8.3_{(stat)} \pm 62.8_{(sys)} \pm 40.4_{(pdf)} \pm 186.2_{(lum)}$ pb
$\int L = 96 pb^{-1}$	$\sigma_W \times Br(W \to \mu\upsilon) = 2989 \pm 15_{(stat)} \pm 81_{(sys)} \pm 194_{(lum)}$ pb

W and Z Production at CDF



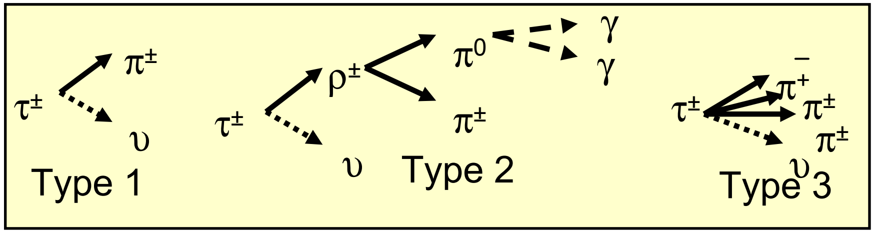
Mass window: $66 \le M_Z \le 116$ GeV



$\int L = 223 pb^{-1}$	$\sigma_W(\text{e-plug}) = 2815 \pm 13_{(stat)}\ {}^{+94}_{-89(sys)} \pm 169_{(lum)}$ pb
$\int L = 337 pb^{-1}$	$\sigma_Z \times Br(\gamma^*/Z \to \mu\mu) = 261.2 \pm 2.7_{(stat)}\ {}^{+5.8}_{-6.9(sys)} \pm 15.1_{(lum)}$ pb
$\int L = 72 pb^{-1}$	$\sigma_Z(e+\mu) = 254.9 \pm 3.3_{(stat)} \pm 4.6_{(sys)} \pm 15.2_{(lum)}$ pb
	$\sigma_W(e+\mu) = 2775 \pm 10_{(stat)} \pm 53_{(sys)} \pm 167_{(lum)}$ pb

PRL 94 091803 (2005)

W and Z decays to Taus



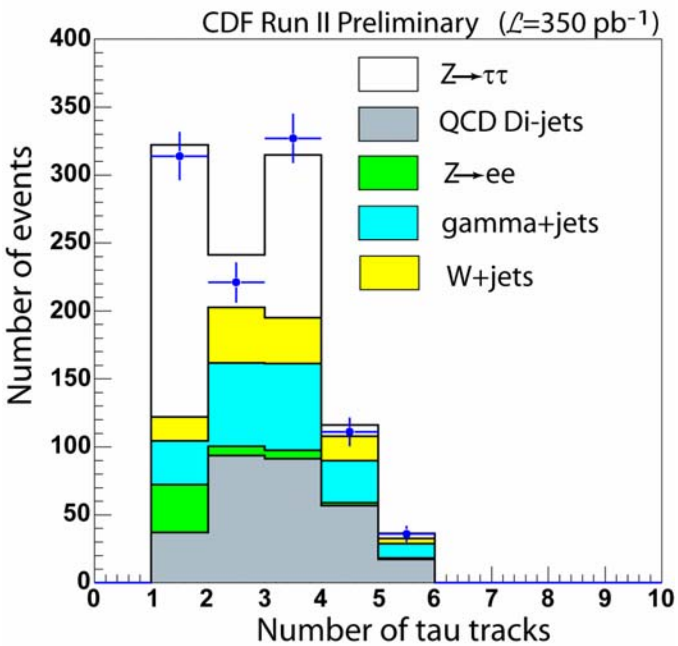
DØ looks for $Z\rightarrow\tau_\mu\tau_h$

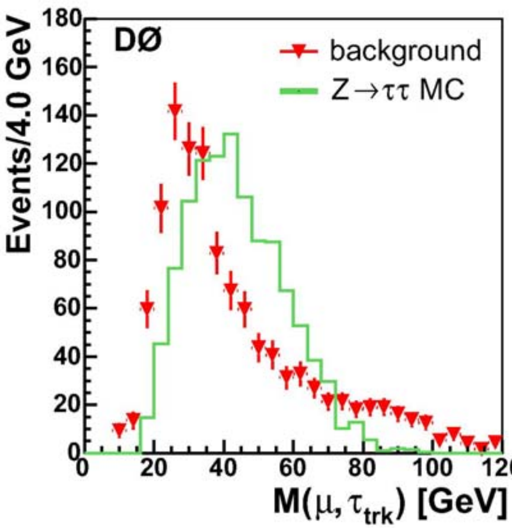
Identify τ types with NN

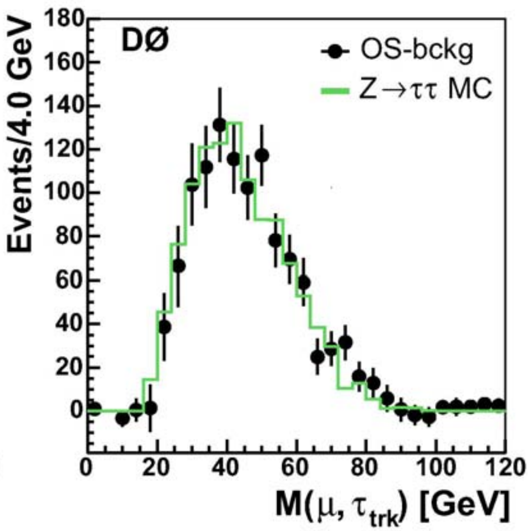
$\int L = 226 pb^{-1}$

$\sigma_Z \times Br(Z\rightarrow\tau\tau) = 237 \pm 15_{(stat)} \pm 18_{(sys)} \pm 15_{(lum)}$ pb

PRD 71,072004(2005)







$\int L = 350 pb^{-1}$

$\sigma_Z \times Br(\gamma^*/Z\rightarrow\tau\tau) = 265 \pm 20_{(stat)}\ 21_{(sys)} \pm 15_{(lum)}$ pb

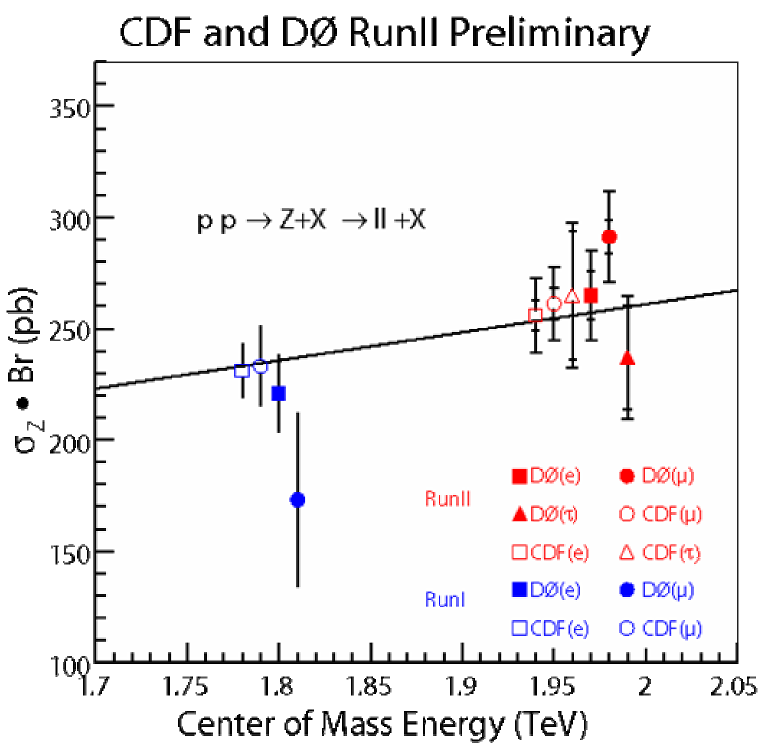
CDF looks for $Z\rightarrow\tau_e\tau_h$

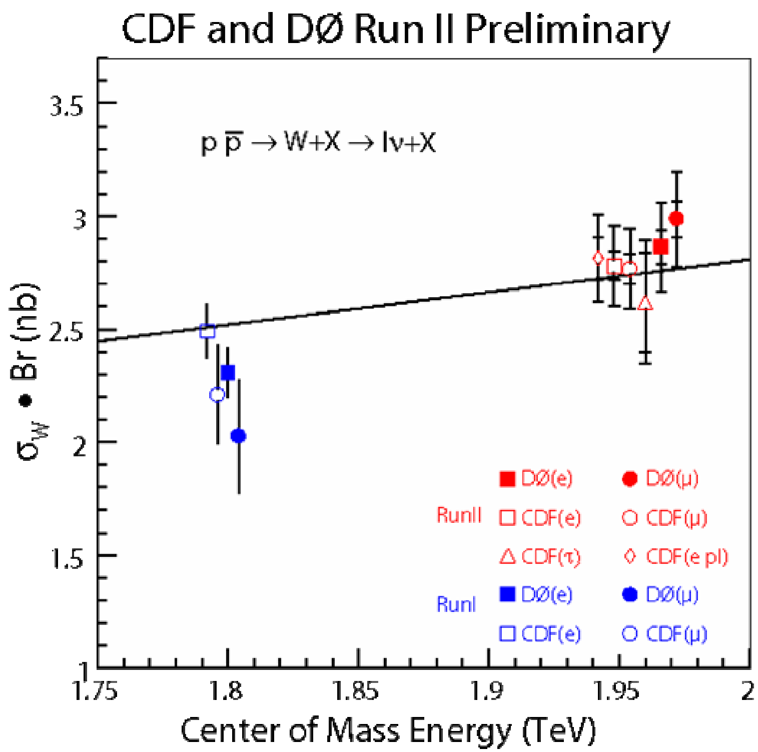
$\int L = 72 pb^{-1}$

$\sigma_W \times Br(W\rightarrow\tau\upsilon) = 2620 \pm 70_{(stat)} \pm 210_{(sys)} \pm 160_{(lum)}$ pb

Cross sections Summary

Benchmark analyses for all high p_t lepton analyses





Systematics limited measurements ~2-3% level (excl luminosity)

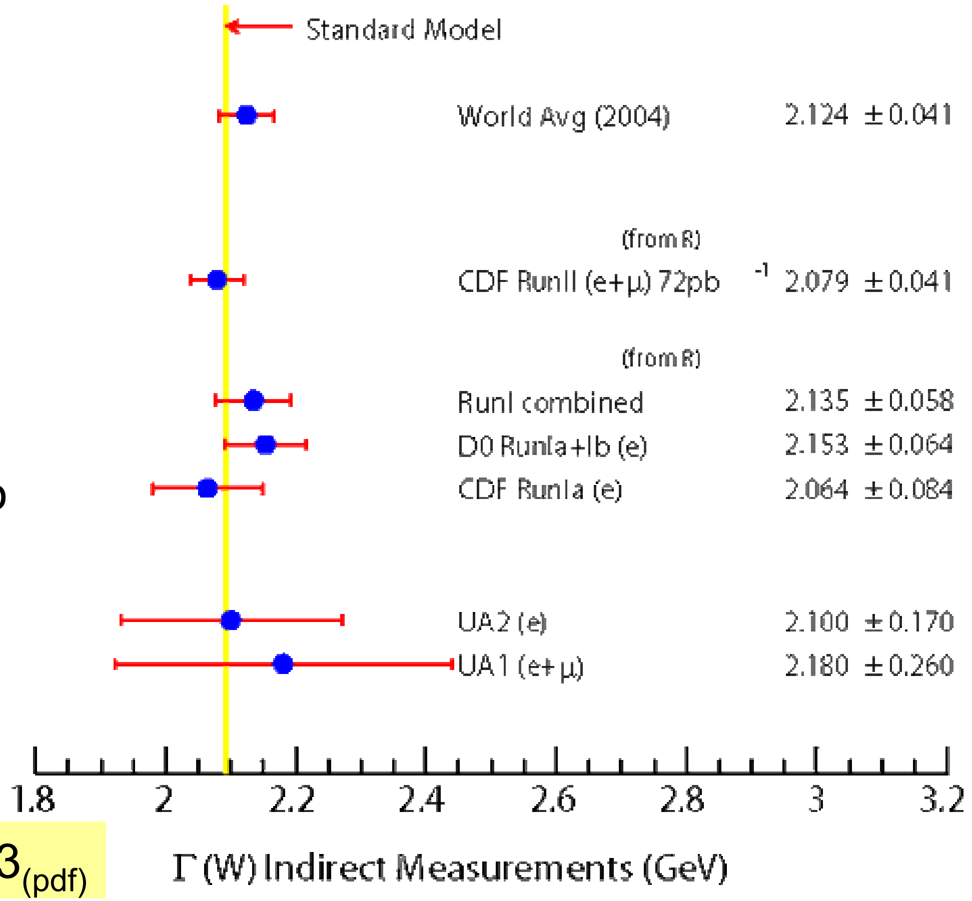
Dominant contributions from acceptance (e.g. PDF uncertainties) and lepton efficiencies

Cross-section Ratios

Ratio of cross-sections provides an indirect measurement of the W width

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

Luminosity essentially cancels in ratio
Efficiencies and acceptance also cancel to a degree → reduced errors



DØ preliminary:

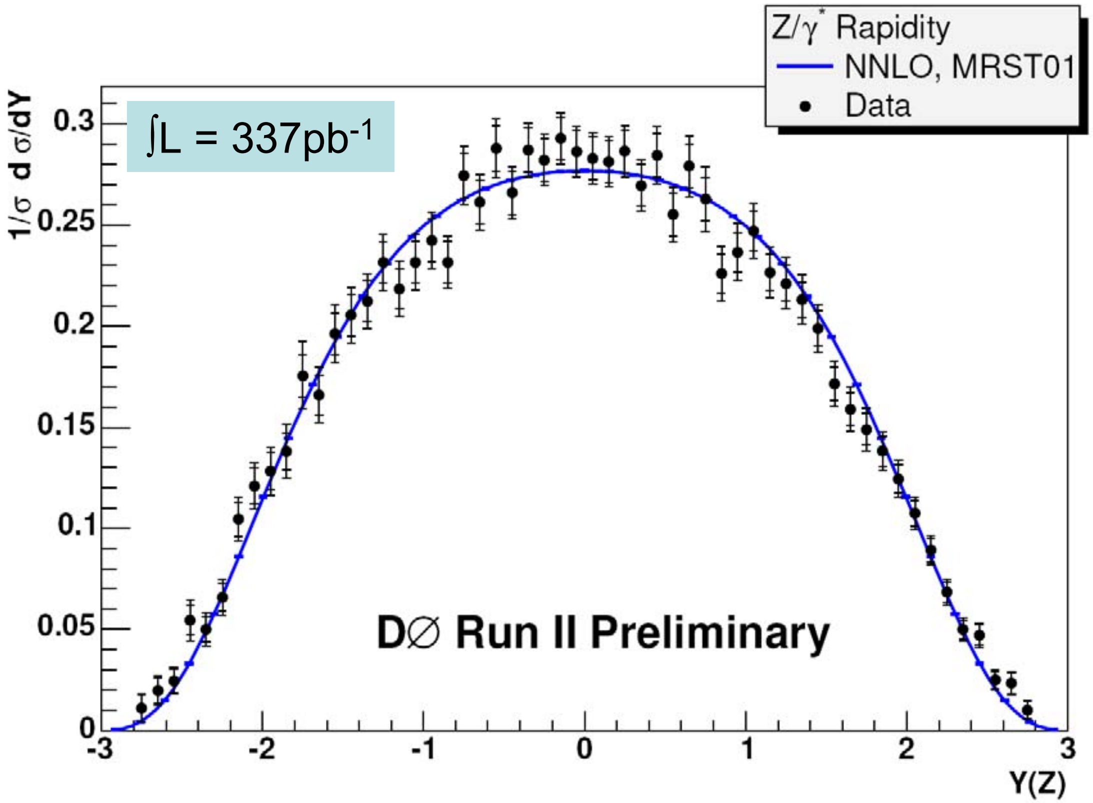
$R(e) = 10.82 \pm 0.16_{(stat)} \pm 0.25_{(syst)} \pm 0.13_{(pdf)}$

CDF PRL 94 091803 (2005)

$R(e+\mu) = 10.92 \pm 0.15_{(stat)} \pm 0.14_{(syst)}$

$\Gamma_W = 2.079 \pm 0.041$ GeV

Z Rapidity



C. Anastasiou, L. Dixon, K. Melnikov and F. Petriello

At large Y probes low (~0.001) and high (~1) x and high Q^2 (~M_Z^2)

$$x_{1(2)} = \frac{M_Z}{\sqrt{s}} e^{+(-)y_Z}$$

Systematics different from those in jet data

For central rapidities

PDFs ~ 1.5%

Lepton ID ~ 1%

For forward rapidities

PDFs ~ 10%

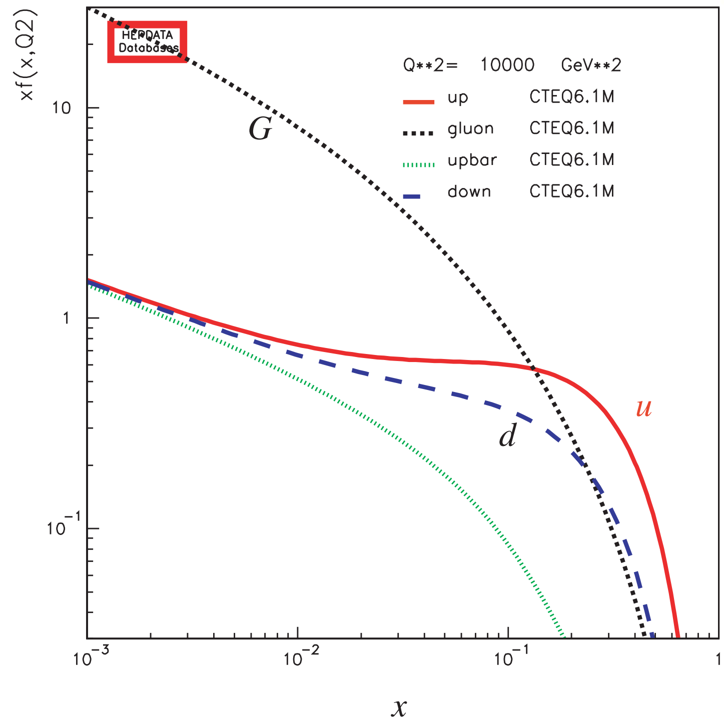
Lepton ID ~ 20%

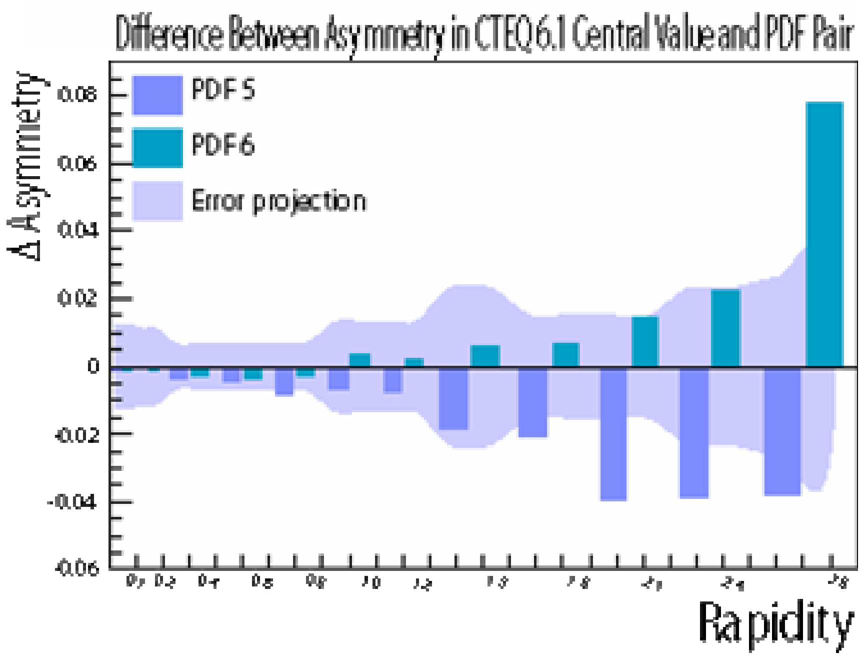
Excellent use of wide coverage of detector

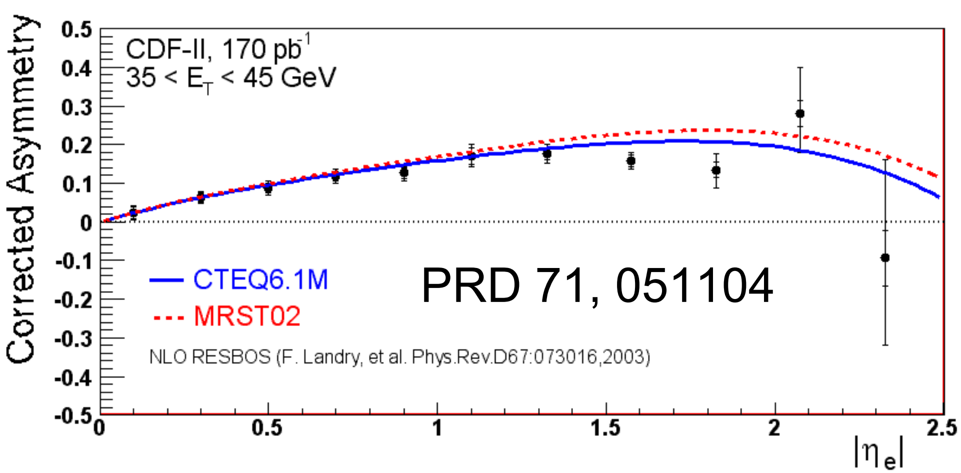
W Charge Asymmetry

W Charge Asymmetry gives important input on up and down quark PDFs

$$A(y) = \frac{d\sigma^+/dy - d\sigma^-/dy}{d\sigma^+/dy + d\sigma^-/dy}$$







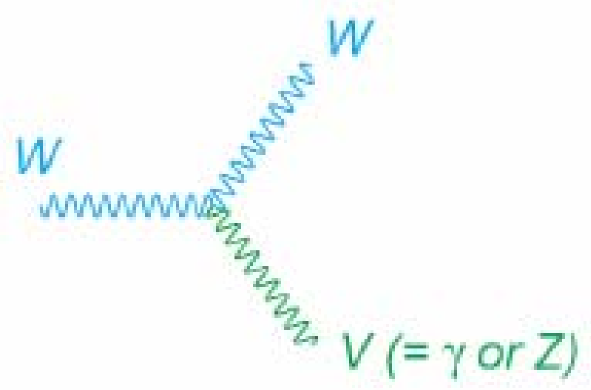
Di-Bosons: Wγ, WW, WZ, Zγ

Standard model makes specific predictions

Measure:

cross-sections

anomalous coupling



Observation of events above SM expectation would be indication of new physics

Backgrounds to other measurements

top pair production

Higgs and new phenomena searches

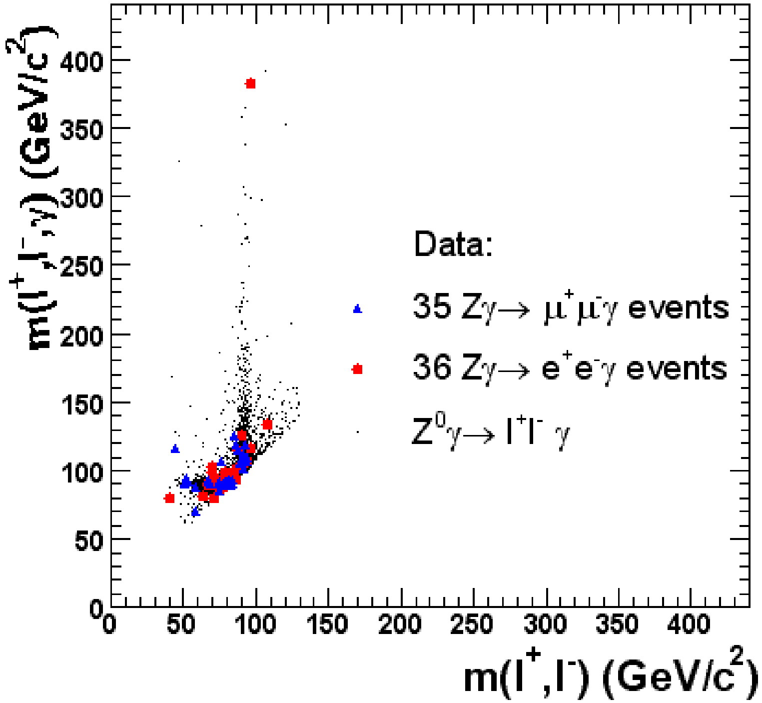
Di-Bosons at CDF: $W\gamma$, $Z\gamma$

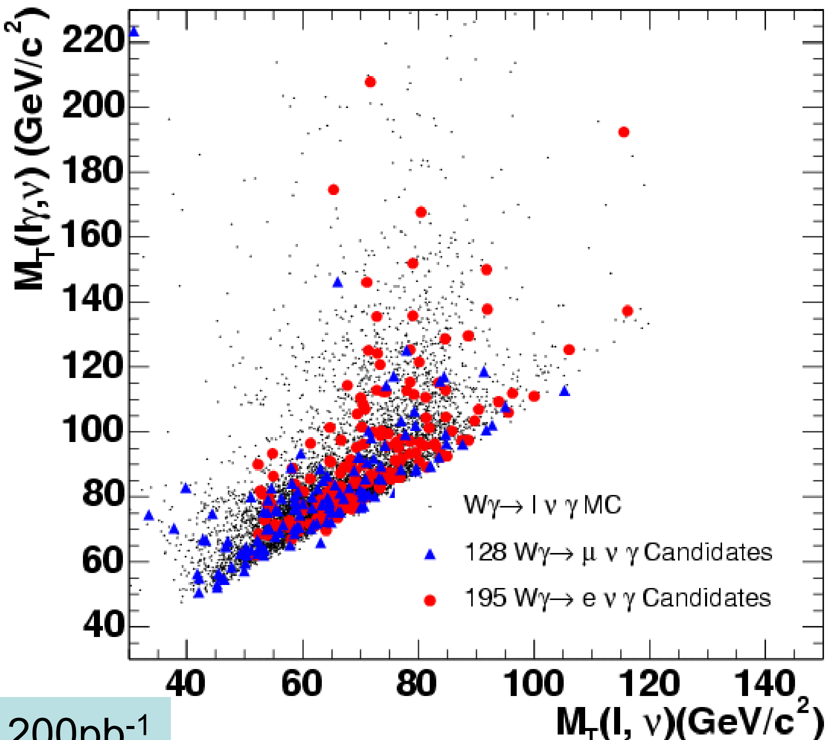
PRL 94, 041803

$E_T(\gamma) > 7$ GeV, $\Delta R_{l\gamma} > 0.7$, $M_{ll} > 40$ GeV

$\sigma(Z\gamma) = 4.6 \pm 0.6$ pb

SM Prediction: $\sigma(Z\gamma) = 4.5 \pm 0.3$ pb





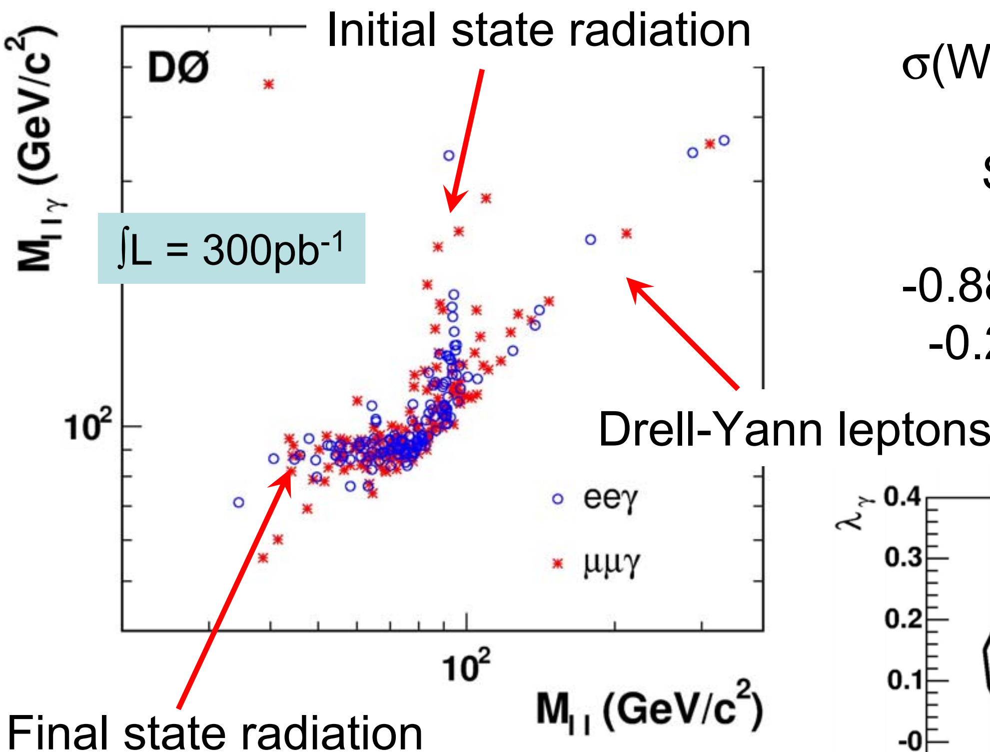
$\int L = 200 pb^{-1}$

$E_T(\gamma) > 7$ GeV, $\Delta R_{l\gamma} > 0.7$

$\sigma(W\gamma) = 18.1 \pm 3.1$ pb

SM Prediction: $\sigma(W\gamma) = 19.3 \pm 1.4$ pb

Di-Bosons at DØ : Wγ, Zγ



$\sigma(ll\gamma) = 4.2 \pm 0.5$ pb
SM Prediction: 3.9 ±0.2 pb

$E_T(\gamma) > 8$ GeV, $\Delta R_{l\gamma} > 0.7$, $M_{ll} > 40$ GeV

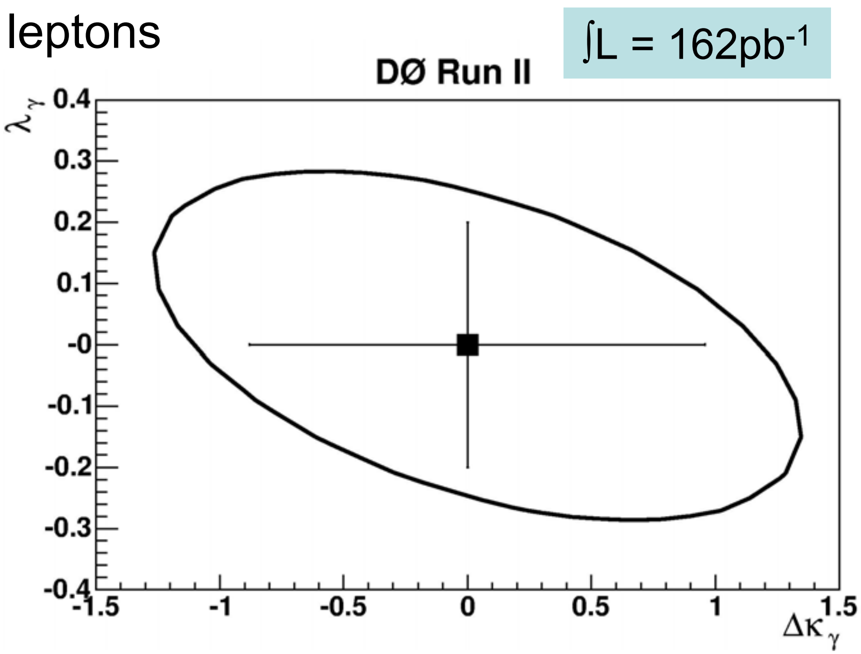
PRL 95, 051802 (2005)

$\sigma(W\gamma) = 14.8 \pm 1.6_{(stat)} \pm 1.0_{(sys)} \pm 1.0_{(lum)}$

SM Prediction: 16.0 ±0.4 pb

$-0.88 < \Delta\kappa < 0.96$
$-0.2 < \Delta\lambda < 0.2$

1D limits at 95% CL



PRD 71, 091108 (2005)

Di-Bosons at CDF: WW, WZ, ZZ

$\sigma(WW \rightarrow l\upsilon l\upsilon) = 14.6\ ^{+5.8}_{-5.1(stat)}\ ^{+1.8-3.0(sys)} \pm 0.6_{(lum)}$ 17 events observed

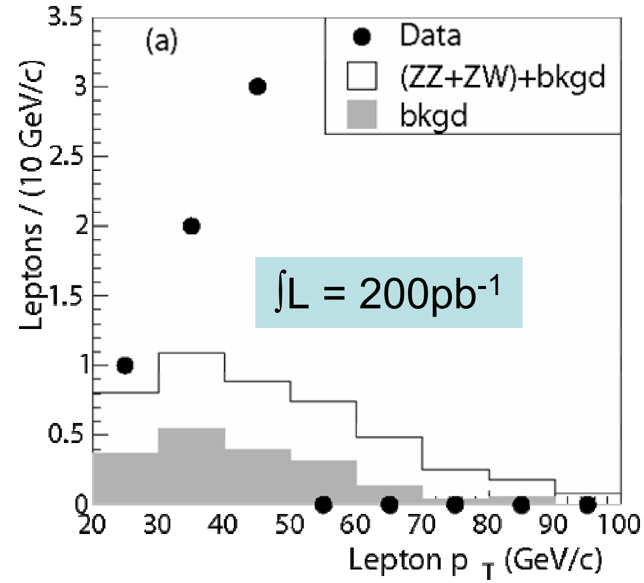
NLO prediction: 12.4 ± 0.8 pb

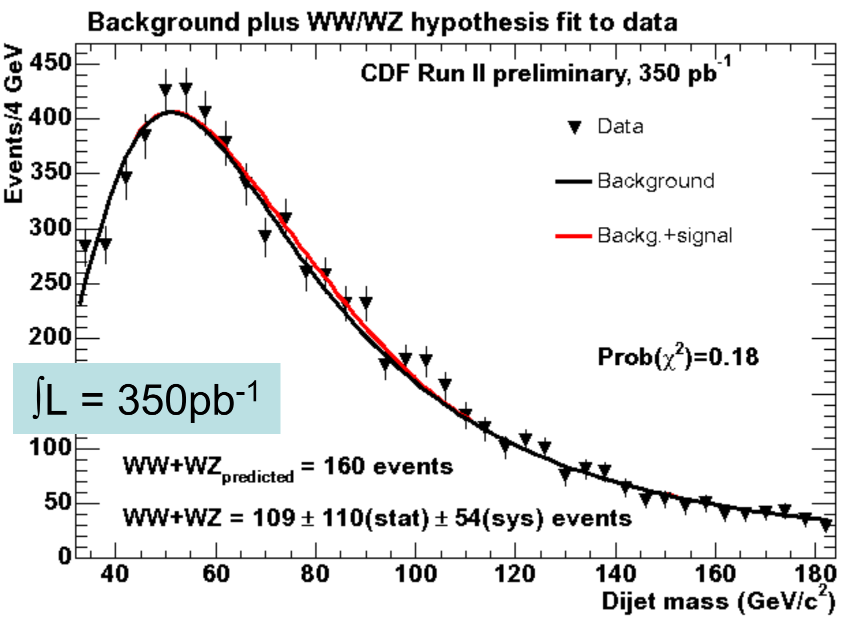
$\sigma(WW+WZ \rightarrow e/\mu+jj) < 36pb$ @ 95% CL ($350pb^{-1}$)

$-0.52 < \Delta\kappa < 0.65$

1D limits @ 95% CL ($200pb^{-1}$)

$-0.37 < \Delta\lambda < 0.39$





Final states with 2, 3 and 4 charged leptons

3 candidates observed

expected bkg 1.02 ± 0.24

$\sigma(WZ+ZZ) < 15.2pb$ @ 95% CL

SM Prediction: 5.0 ± 0.4 pb

PRD 71, 091105

Di-bosons at DØ : WW, WZ

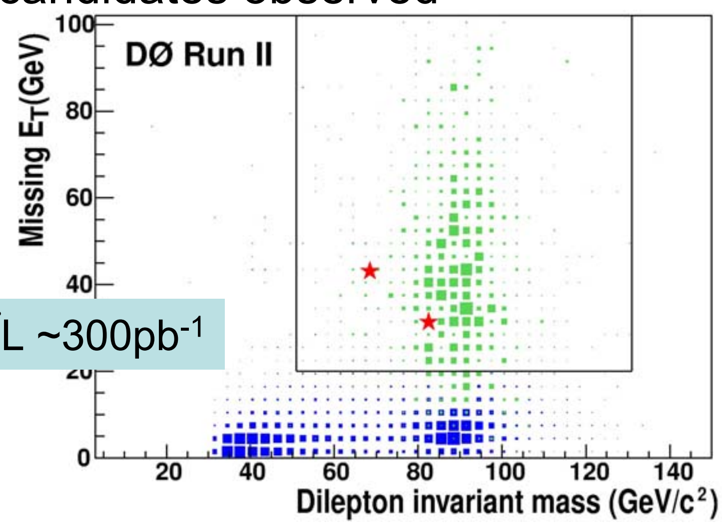
PRL 95, 141802 (2005)

$\sigma(WZ) = 4.5^{+3.8}_{-2.6}$ pb

$\sigma(WZ) < 13.3$ pb @ 95% CL

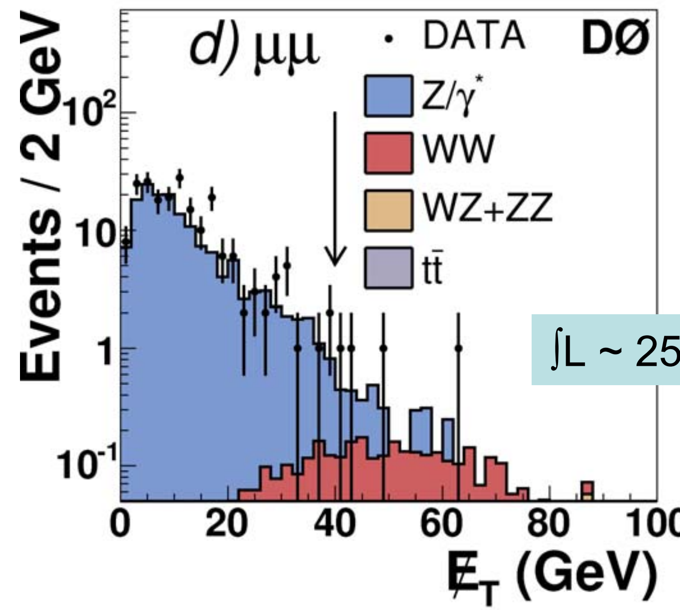
$-2.0 < \Delta\kappa_Z < 2.4$; $\Lambda = 1$TeV
$-0.48 < \Delta\lambda_Z < 0.48$; $\Lambda = 1.5$TeV
$-0.49 < g_1^Z < 0.66$

3 candidates observed



$\int L \sim 300 pb^{-1}$

Di-muon channel



$\int L \sim 250 pb^{-1}$

25 candidates observed with est. bkg

$8.1 \pm 0.6_{(stat)} \pm 0.6_{(sys)} \pm 0.5_{(lum)}$

$WW \to l\upsilon l\upsilon$ observed with 5.2σ significance

$\sigma(WW) = 13.8^{+4.3}_{-3.8}{}_{(stat)}{}^{+1.2}_{-0.9}{}_{(sys)} \pm 0.9_{(lum)}$

NLO Prediction: 12.0 - 13.5 pb @ 1.96TeV

PRL 94, 151801(2005)

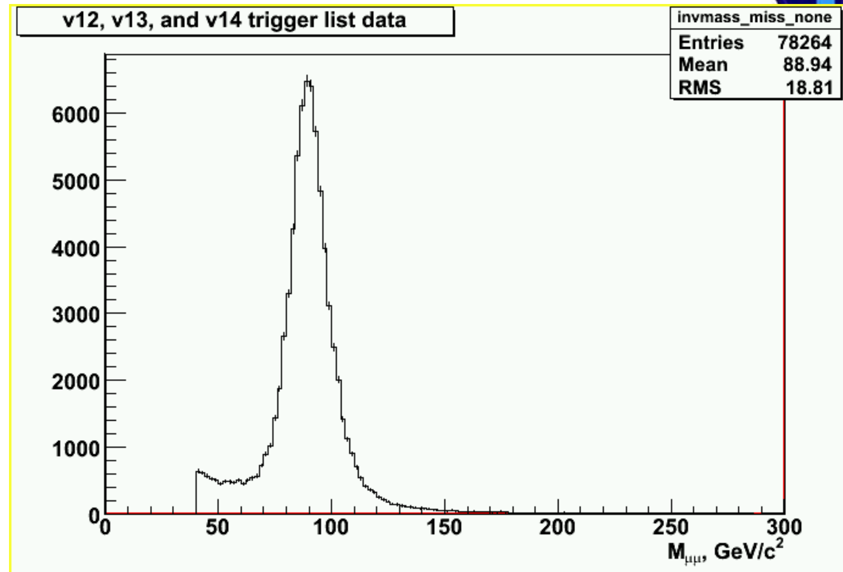
Prospects with 1fb-1

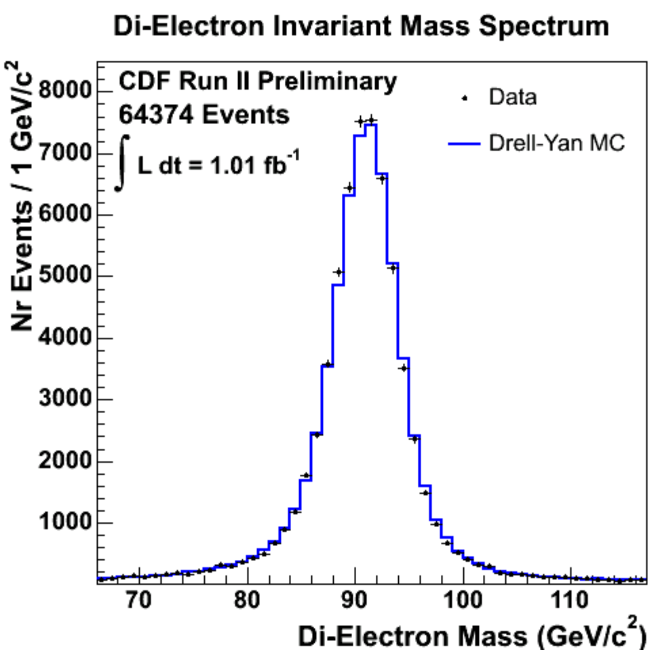
Results shown so far use less than

50% of the data set

No surprises so far!

>1 fb^{-1} is on tape and waiting to be analyzed!





Expect improvements in:

- W/Z ratio measurement
- Z rapidity
- W Charge asymmetry
- Di-bosons
  - observation of WW+WZ
  - improve cross-section and anom. coupl. limits

Publications so far…

$Z \rightarrow \tau\tau$ cross-section	PRD 71, 072004
$W \rightarrow l\upsilon$, $Z \rightarrow ll$ cross-sections	PRL 94, 091803
$W \rightarrow e\upsilon$ charge asymmetry	PRD 71, 051104
$Z \rightarrow ee$ forward backward asymmetry	PRD 71, 052002
$W\gamma$,$Z\gamma$ cross-sections + anom coupl.	PRL 94, 041803,
	PRD 71, 091108
	PRL 95, 051802
WW cross-section	PRL 94, 151801,
	PRL 94, 211801
WZ cross-section + anom. coupl.	PRL 95, 141802
WZ+ZZ search	PRD 71, 091105