Latest electroweak results from the Tevatron

Junjie Zhu
State University of New York @ Stony Brook

For the CDF and DØ Collaborations

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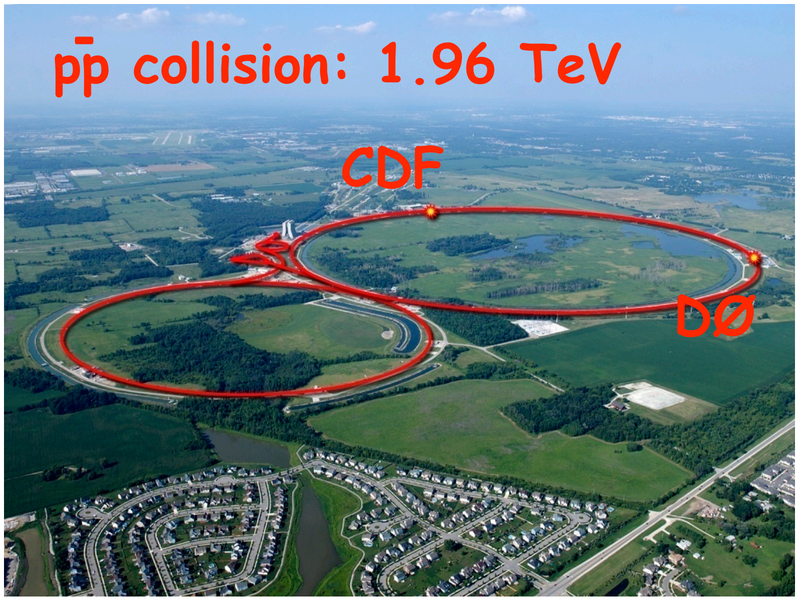
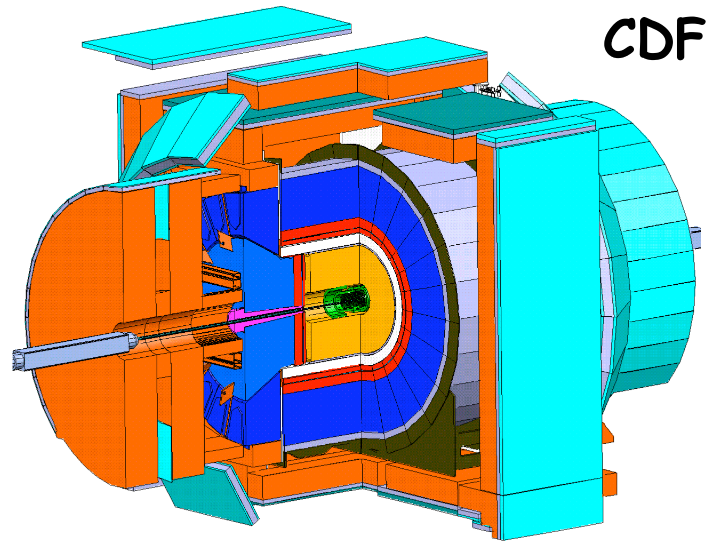
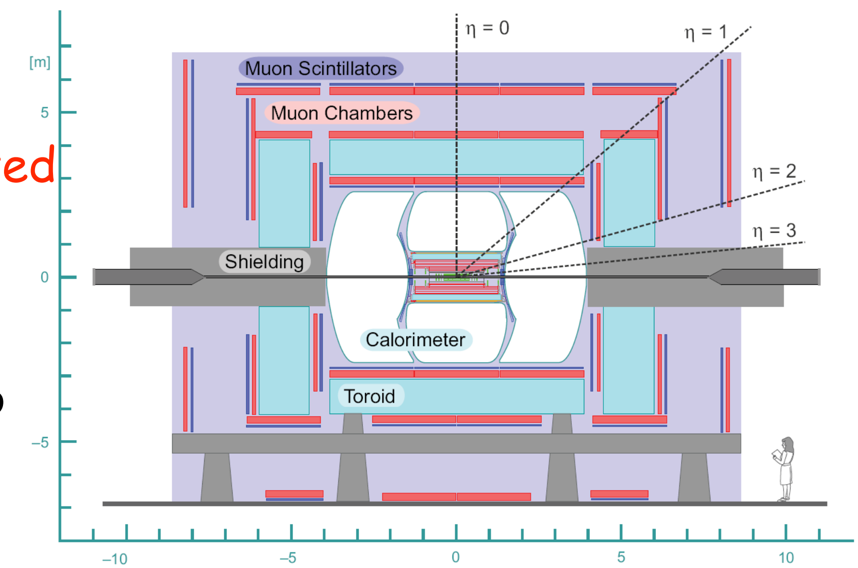
Tevatron and CDF/D0 detectors



CDF



DØ



- Over 7.5 fb^{-1} delivered and ~6.5 fb^{-1} collected by each experiment
- More $W \to l\nu$ and $Z \to ll$ events reconstructed at the Tevatron than at the LEP
  - ~1.7 M $Z \to ll$ ($l=e, \mu, \tau$) events from four LEP experiments
  - ~1 M $Z \to ll$ ($l=e, \mu$) events from DØ (6 fb^{-1})
  - ~5M $W \to e\nu$ events from DØ (6 fb^{-1})

Outline

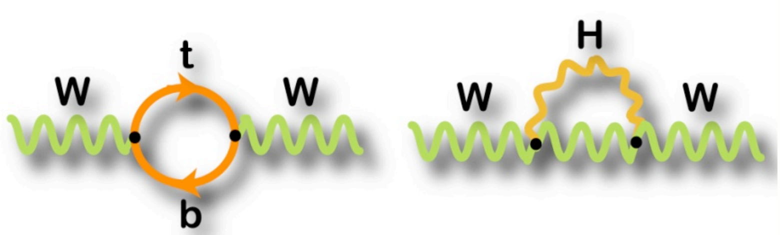
- W and Z boson properties
  - W boson mass and width measurements (DØ)
  - Charge asymmetry measurements (CDF, DØ)
  - Z/γ^* boson A_{FB} and $d\sigma/dy$ measurements (CDF)
- Diboson production
  - $Z\gamma$ production (CDF)
  - $WW \to l\nu l'\nu$ (CDF, DØ)
  - $WV \to l\nu jj$, $VV \to met+jj$ (CDF)
  - ZZ (CDF)

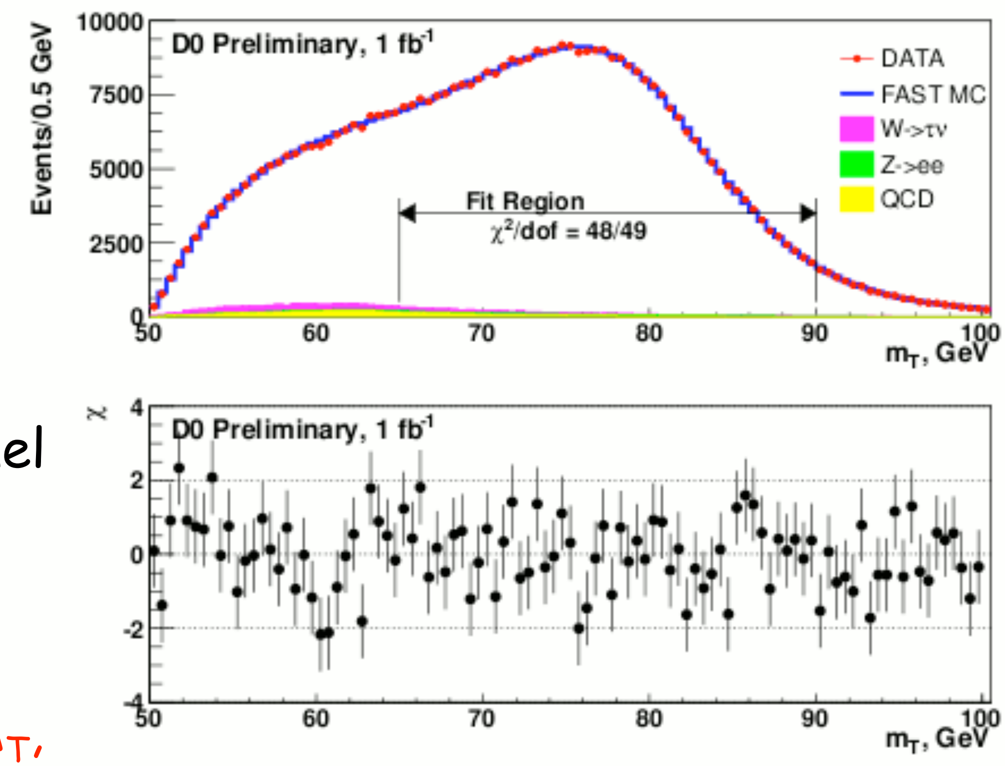
- CDF: http://www-cdf.fnal.gov/physics/physics.html
- DØ: http://www-d0.fnal.gov/Run2Physics/WWW/results.htm

W boson mass

$$M_W^2 = \frac{\pi\alpha}{\sqrt{2}G_F}\frac{1}{\sin^2\theta_W}\frac{1}{(1-\Delta r)}$$

$$M_T^2 = (E_{Te} + E_{T\nu})^2 - |\vec{p}_{Te} + \vec{p}_{T\nu}|^2$$



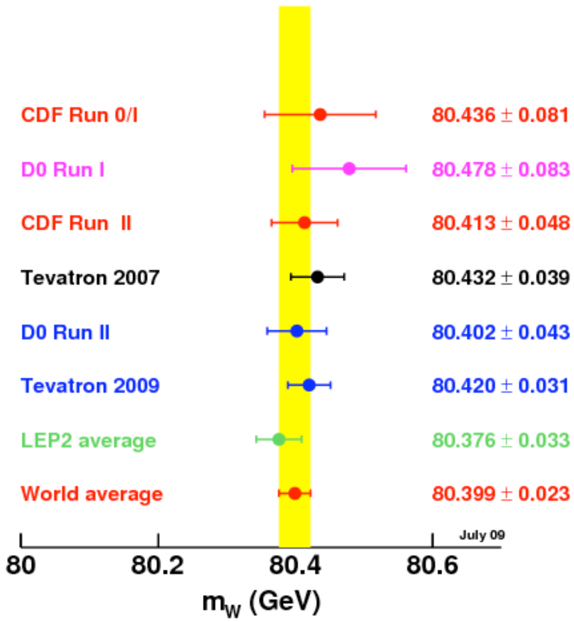


- 1 fb^{-1} of data in electron channel
- Use $Z \rightarrow ee$ events for the calorimeter calibration, effectively measuring M_W/M_Z
- Three observables are used: M_T, $p_T(e)$, $p_T(\nu)$

W boson mass

Source	$\sigma(m_W)$ MeV m_T	p_T^e	$\not{E}_T$
Electron energy calibration	34	34	34
Electron resolution model	2	2	3
Electron energy offset	4	6	7
Electron energy loss model	4	4	4
Recoil model	6	12	20
Electron efficiencies	5	6	5
Backgrounds	2	5	4
Experimental Subtotal	35	37	41
PDF	9	11	14
QED	7	7	9
Boson p_T	2	5	2
Production Subtotal	12	14	17
Total Systematic	37	40	44
Statistical	23	27	23
Total	44	48	50

D0 W mass result: PRL 103, 141801 (2009)
Tevatron combination: arXiv 0908.1374



- Combined result:

  M_W=80.401 ± 0.043 GeV

- Most precise measurement from one single experiment to date
- Tevatron uncertainty is smaller than LEP uncertainty for the first time
- The WA uncertainty (was 25 MeV) is reduced by ~10%

$$M_H = 87^{+35}_{-26}\mathrm{GeV}$$

M_H<157 GeV at 95% C.L. using precision EWK data

Both CDF and D0 experiments are working on new M_W measurements using larger datasets

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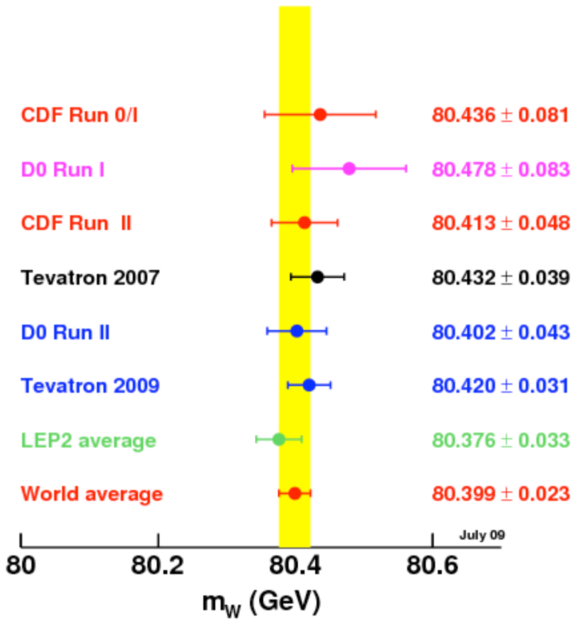


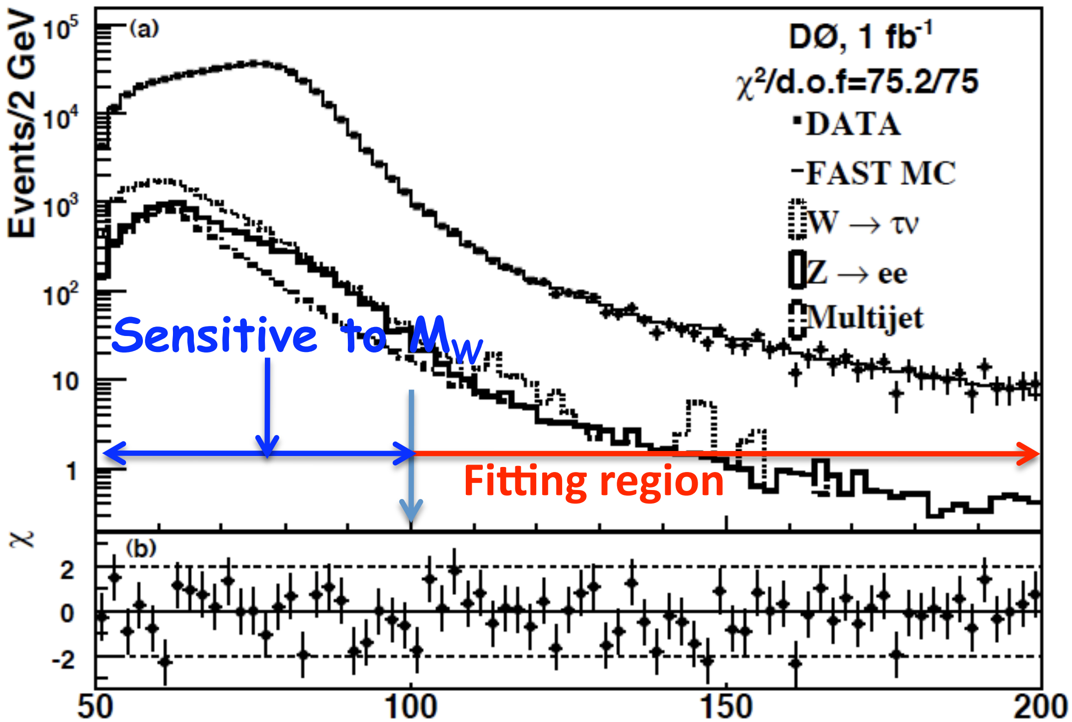
If ΔM_W = 15 MeV (23 MeV now), Δm_{top} = 1 GeV (1.3 GeV now) and M_W=80.400 GeV, M_{top}=172.5 GeV, then

M_H < 117 GeV @ 95% C.L.

(P. Renton, ICHEP 2008)

W boson width

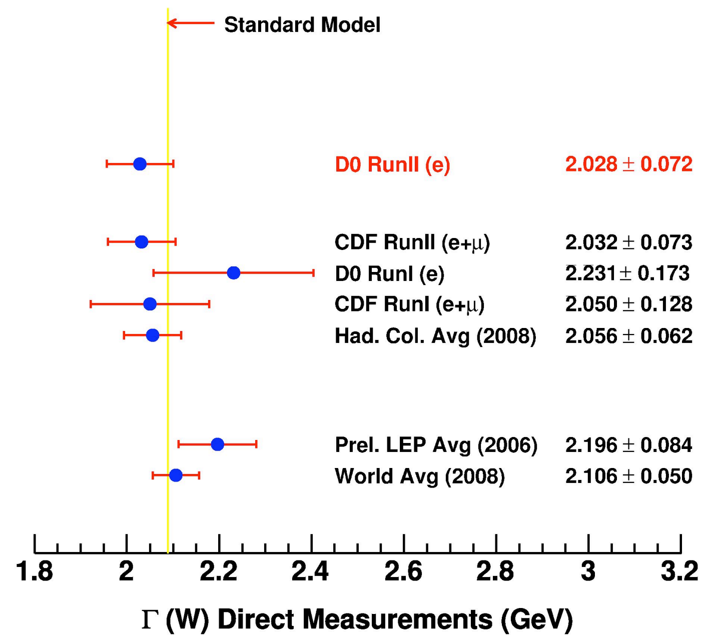
D0 W width result: PRL 103, 231802 (2009)
Recoil library method: NIM 609, 250 (2009)



499,830 events in total
5,272 events in tail region

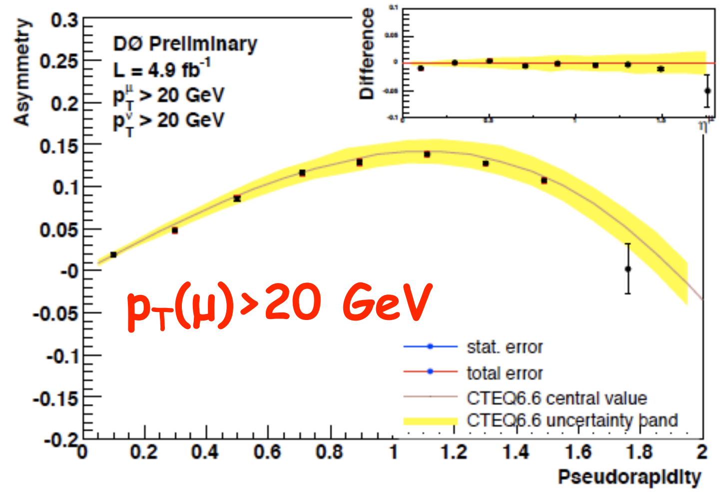
Γ_W= 2.028 ± 0.039 (stat) ± 0.061 (syst) GeV

- Important to understand the recoil system response
- A novel method developed to use the recoil system from Z collider data on the W simulation

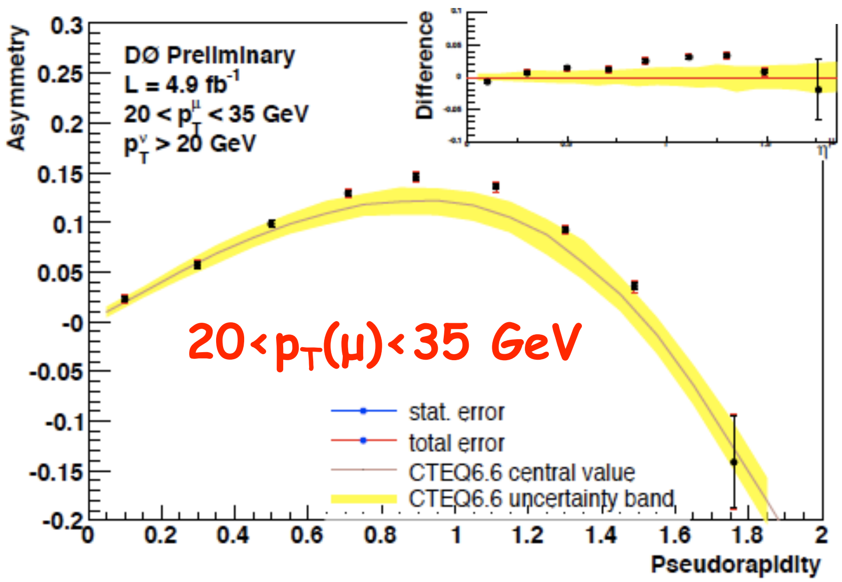


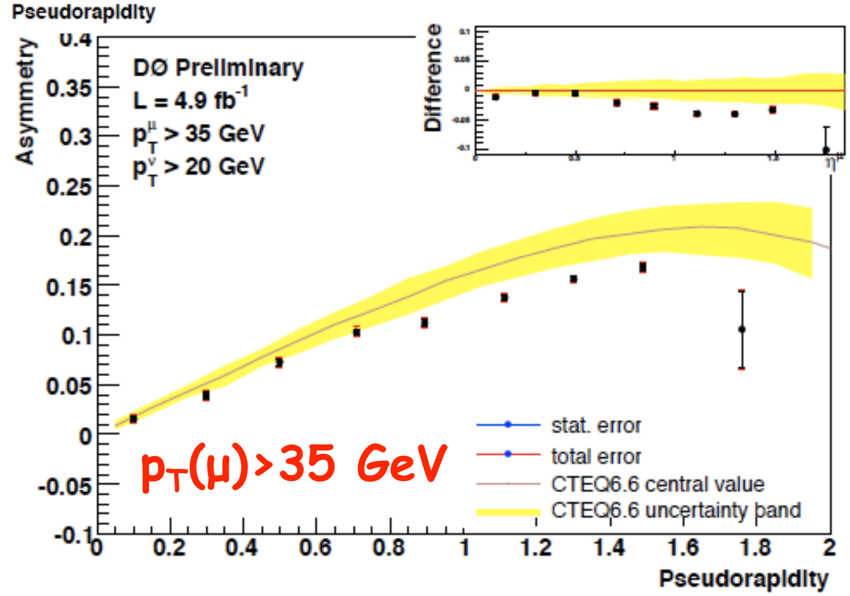
Lepton charge asymmetry

- u quarks carry on average more momentum than d quarks in the proton
- $W^+(W^-)$ tends to move along proton (anti-proton) direction
- Use W (lepton) charge asymmetry's to probe the u/d ratio in the proton

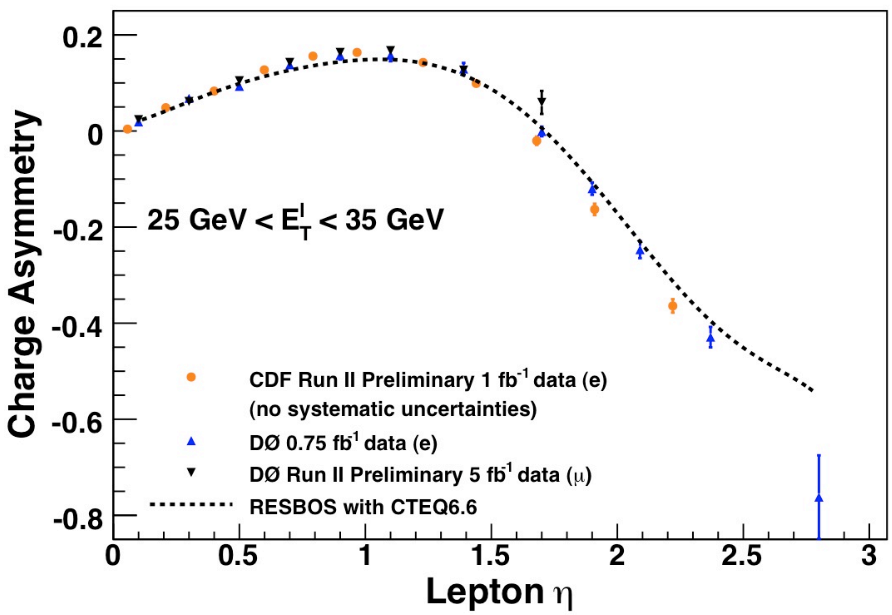


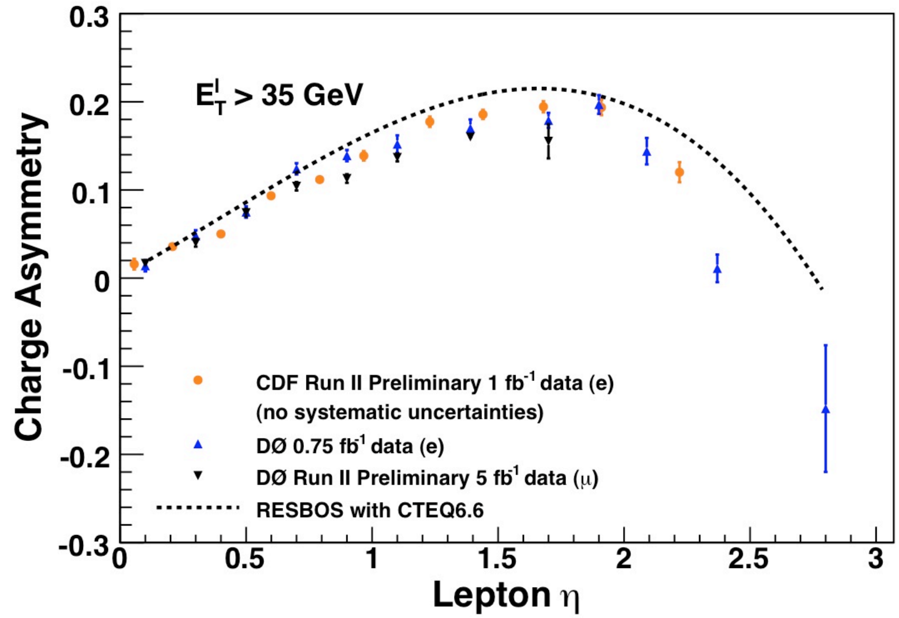
- Experimental uncertainties are much smaller than PDF uncertainties
- Useful constraints for the global PDF fits





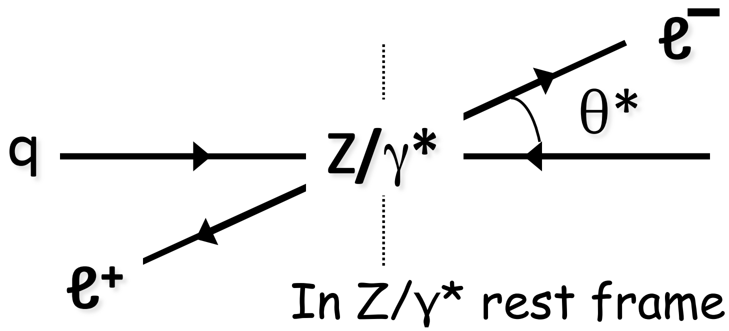
CDF/D0 lepton charge asymmetry



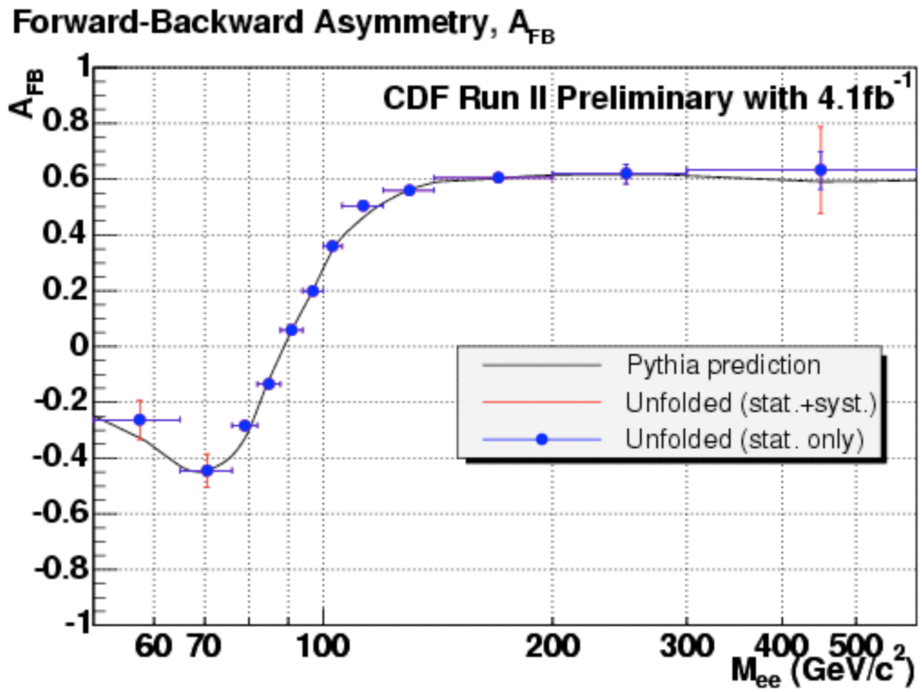


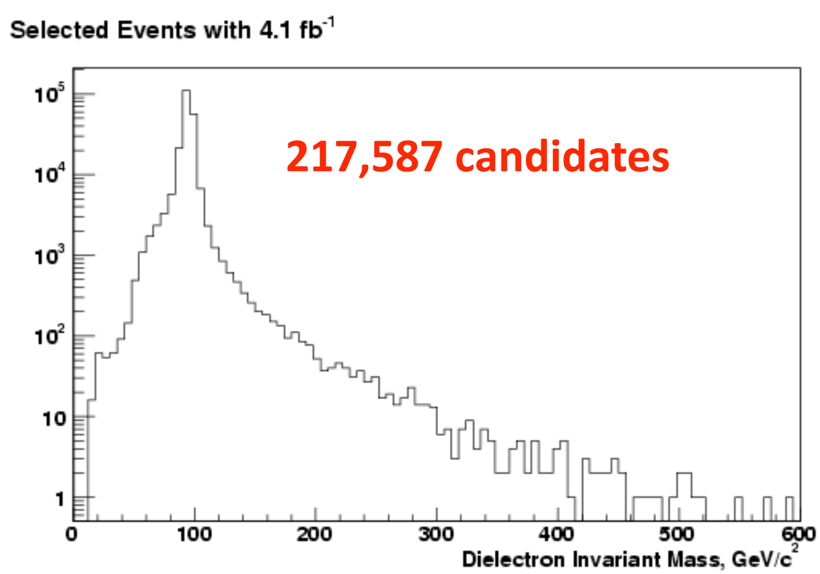
- CDF's W charge asymmetry measurement (PRL 102, 181801 (2009))
- Preliminary electron charge asymmetry results using the same dataset
- CDF electron (1 fb^{-1}), D0 electron (0.75 fb^{-1}) and D0 muon (5 fb^{-1}) charge asymmetry results are consistent with each other

Forward-backward asymmetry



$$A_{FB} = \frac{\sigma(\cos\theta^* > 0) - \sigma(\cos\theta^* < 0)}{\sigma(\cos\theta^* > 0) + \sigma(\cos\theta^* < 0)}$$

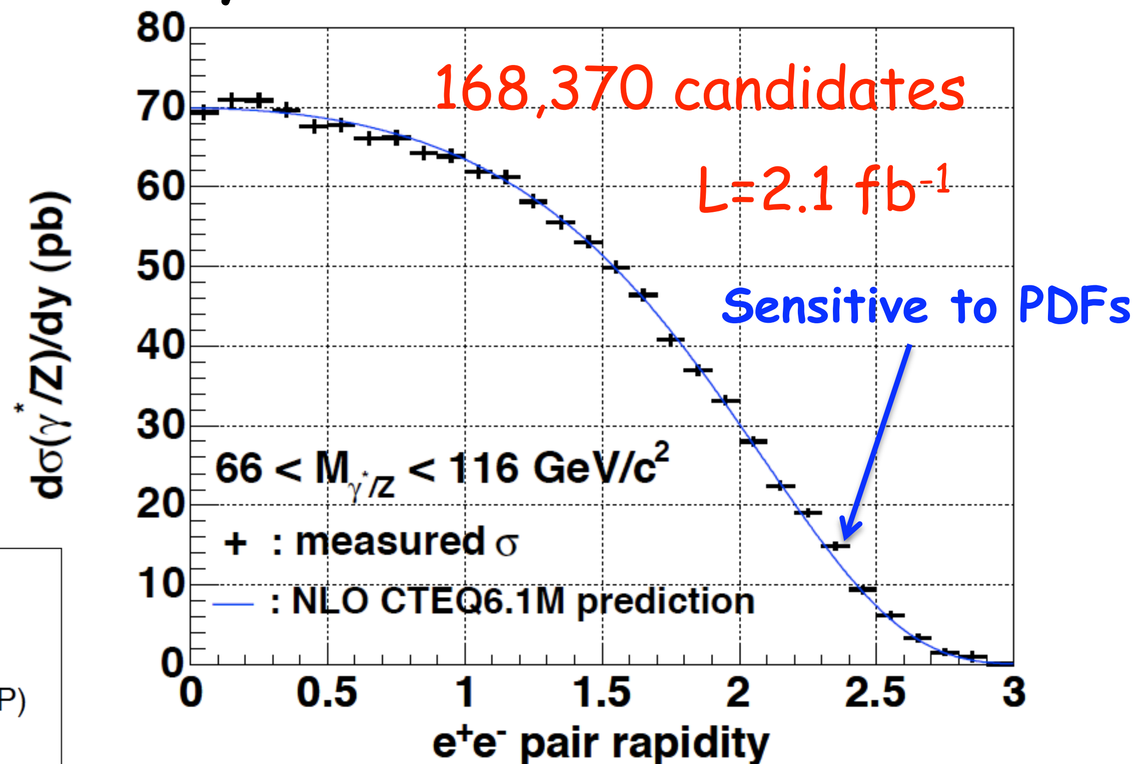


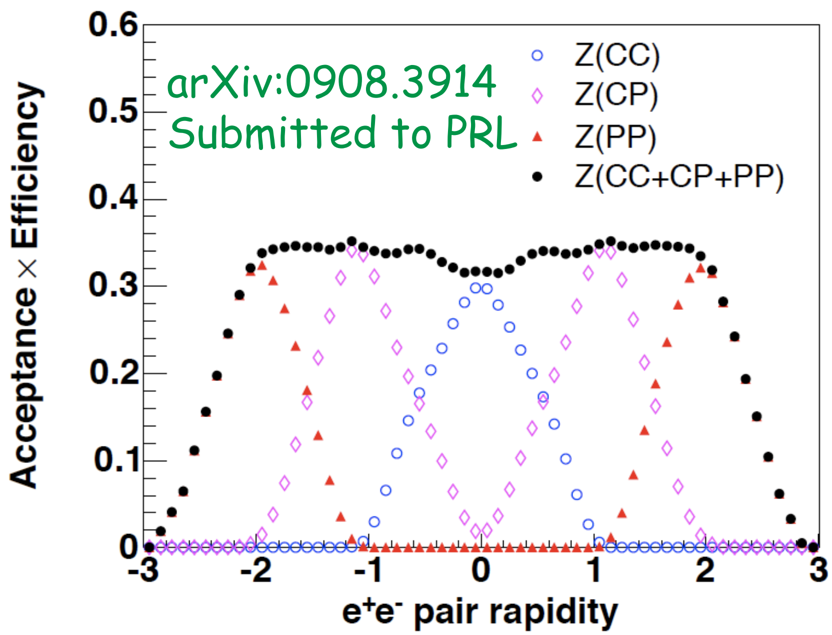


- Sensitive to new physics in high mass
- Sensitive to $\sin^2\Theta_W$ around Z pole: 0.2326 ± 0.0018 (stat) ± 0.0006 (syst) (D0, 1 fb^{-1}, PRL 101, 191801 (2008))
- Sensitive to Z-u and Z-d couplings

Z/γ* boson dσ/dy measurement

$$\frac{d\sigma}{dy} = \frac{N - N_{bkg}}{A \times \epsilon \times \Delta \times L}$$

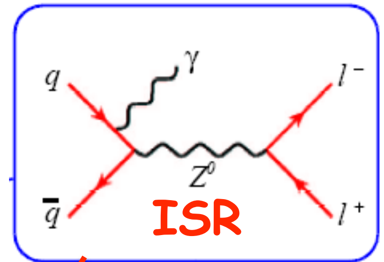


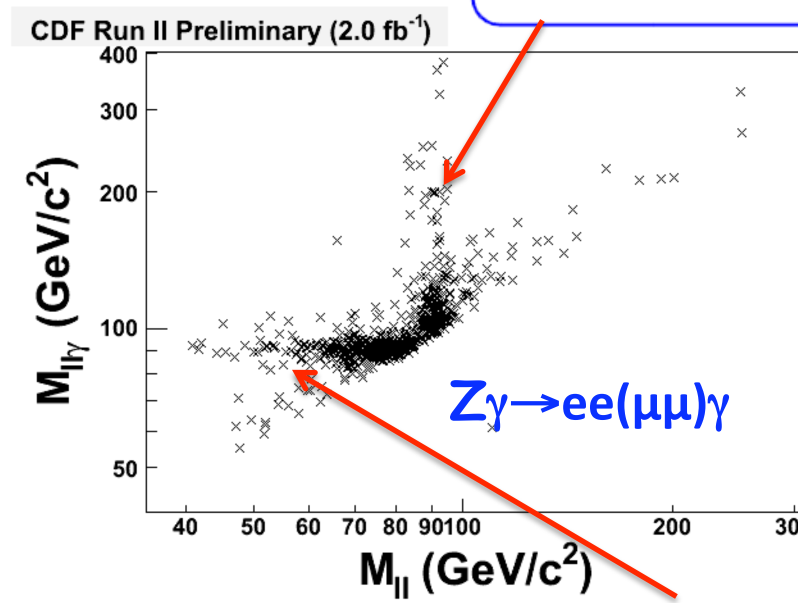


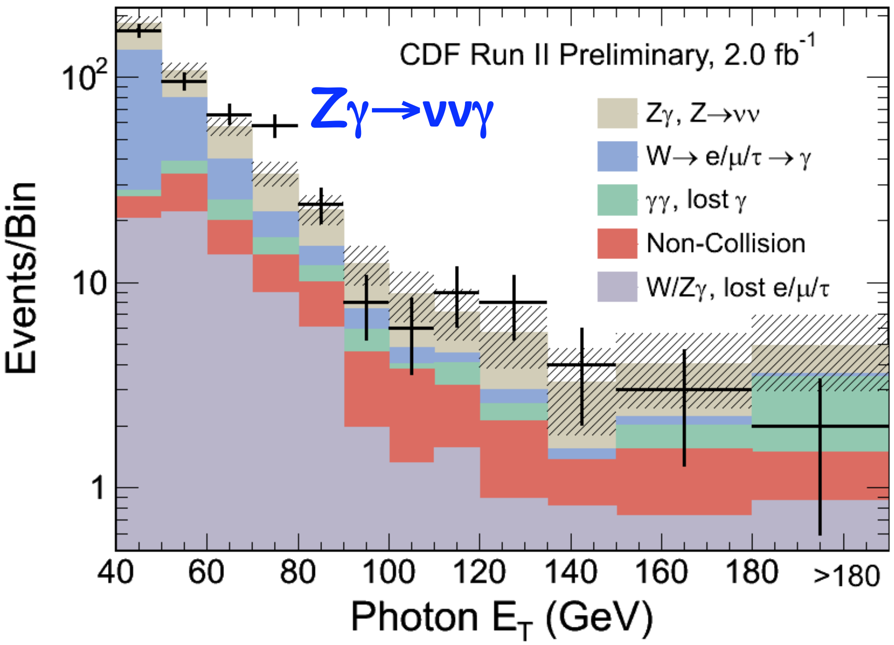
- Measured dσ/dy is larger than (~10%) the theoretical predictions at large rapidities (|y|>2.2)
- Additional tuning of both the NLO and NNLO PDF models may be needed

Zγ production

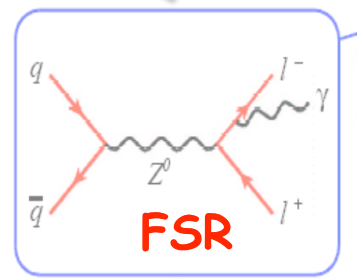
- $E_T(\gamma)>7$ GeV, $\Delta R>0.7$, $M_{ll}>40$ GeV
- σ=4.6±0.2(stat)±0.3(syst)±0.3(lumi) pb agrees with σ_{NLO}=4.5±0.3 pb
- σ=1.2±0.1(stat)±0.2(syst)±0.1(lumi) pb for M(μμγ)>100 GeV (predominantly ISR events)







Limits on the anomalous trilinear gauge couplings using $E_T(\gamma)$:

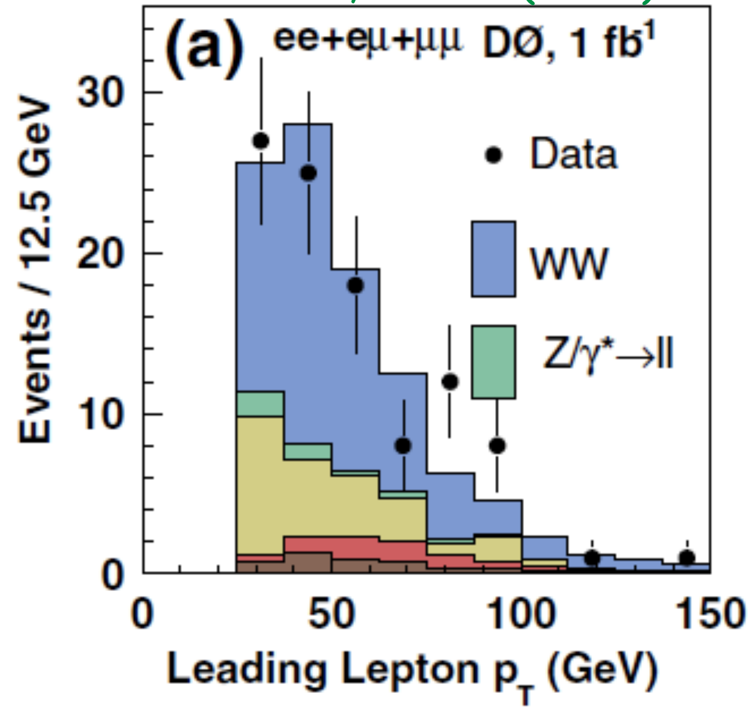


$$|h_3^Z| < 0.050, \quad |h_4^Z| < 0.0034$$
$$|h_3^\gamma| < 0.051, \quad |h_4^\gamma| < 0.0034$$

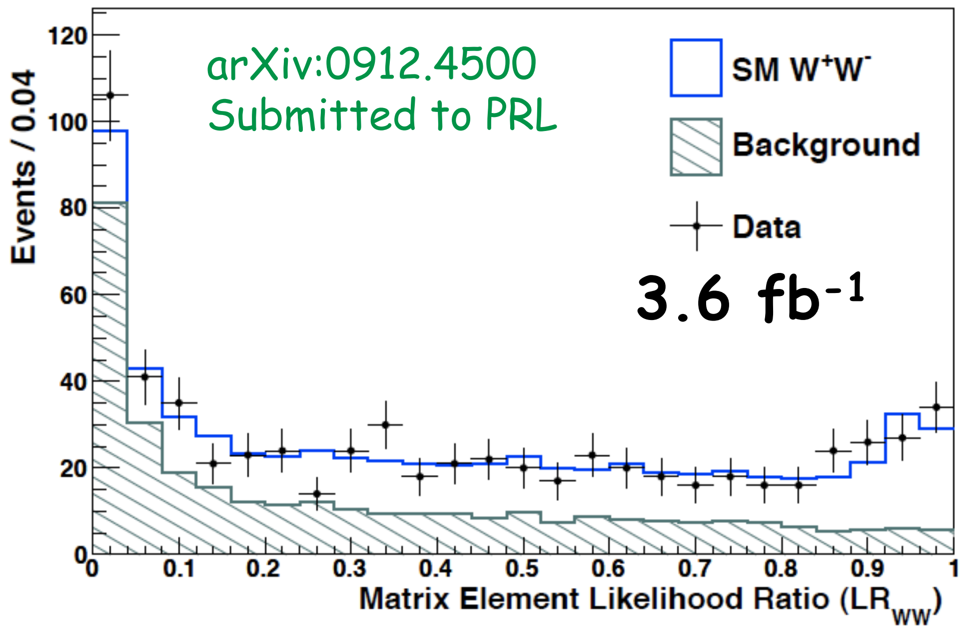
WW→lνl′ν

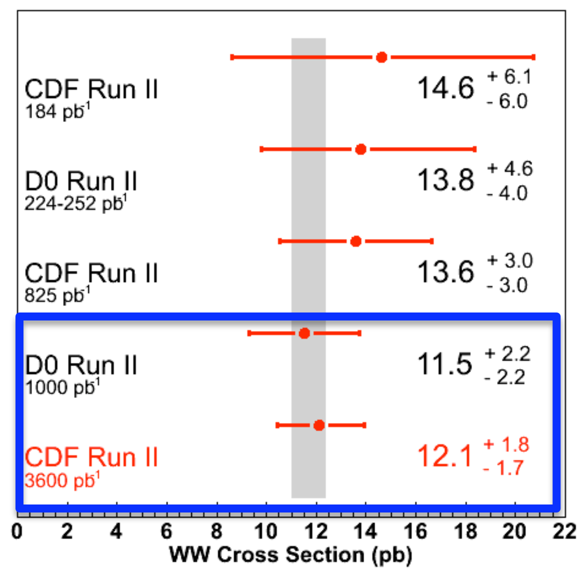
- Important backgrounds for H→WW
- Two high p_T leptons and large MET
- Cut-based analysis (DØ) vs matrix-element likelihood ratio analysis (CDF)

PRL 103, 191801 (2009)



arXiv:0912.4500
Submitted to PRL

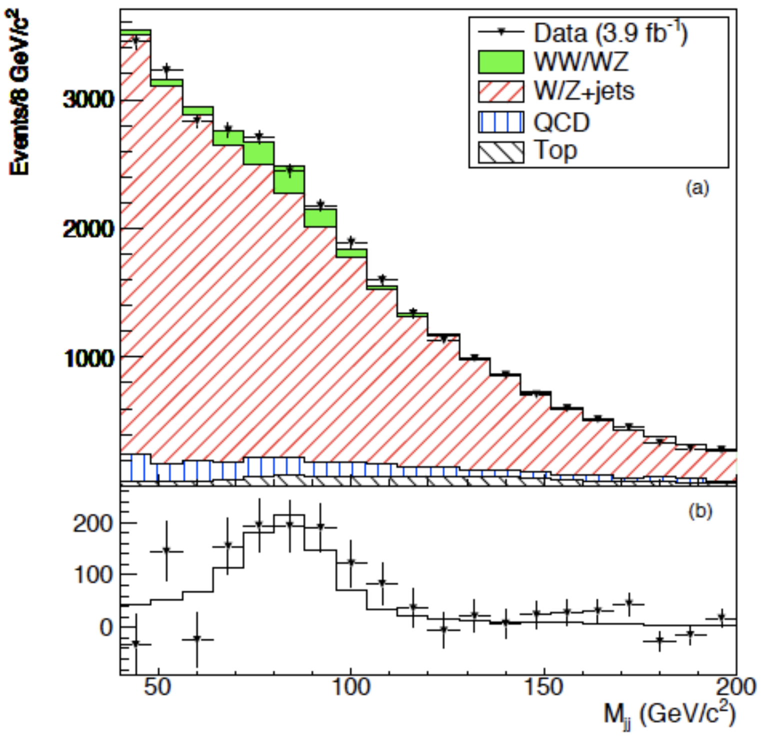


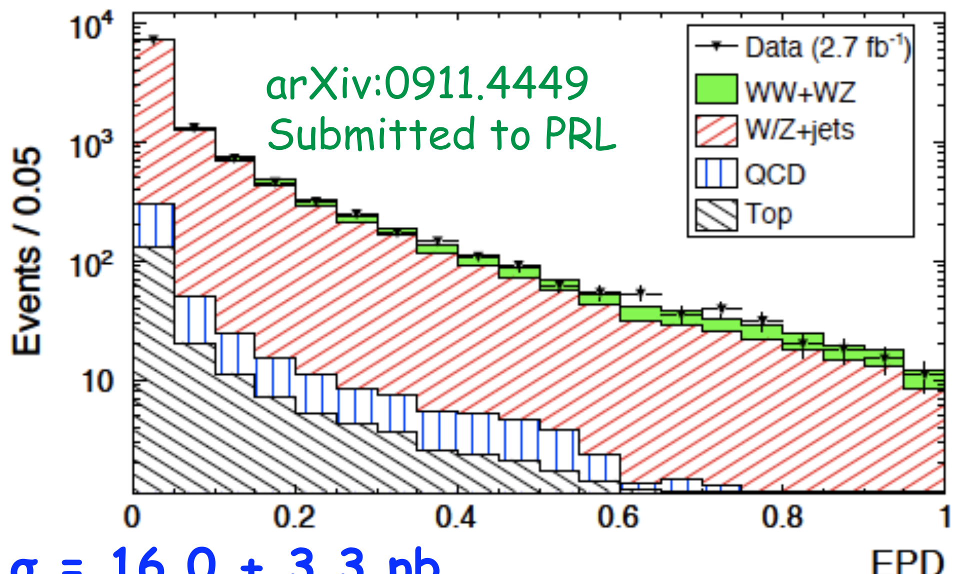


A per-event probability assigned based on a matrix-element-based calculation of the LO cross section for signal and bkgs

WV→lνjj

- Demonstration of search techniques for WH→lνjj
- First evidence reported by D0 in 2009: PRL 102, 161801 (2009)
- Fit M_{jj} spectrum using signal and background M_{jj} templates built from either data or MC simulation
- Use the matrix element method to calculate event probability density (EPD) for both signal and background hypotheses





σ = 16.0 ± 3.3 pb

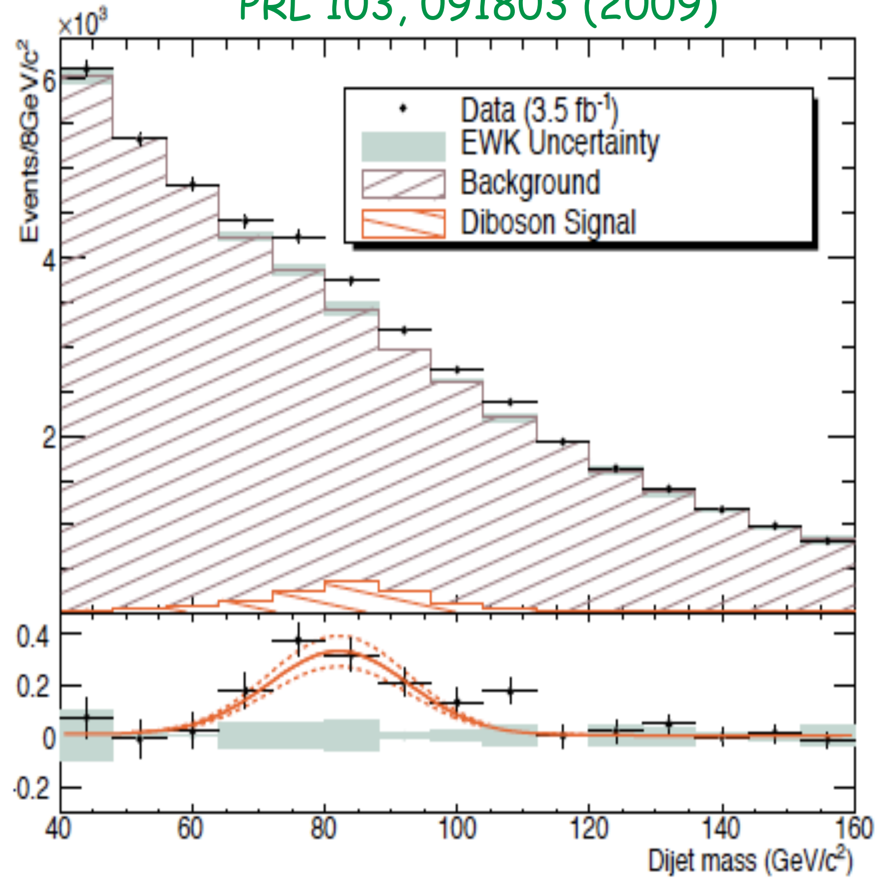
σ(theory) = 16.1 ± 0.9 pb

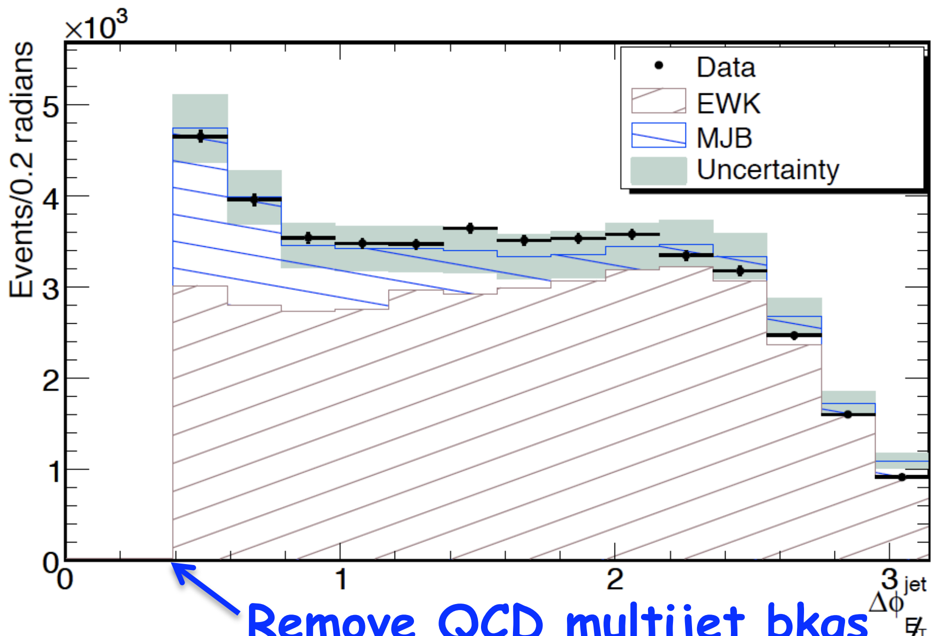
Both collaborations are working on WZ→lνbb

VV→met+jj

- Demonstration of search techniques for VH→l(ν)νjj
- Bkgs: W(Z)+jets, top pair, single top and QCD multijets (lower MET and smaller ΔΦ)
- Unbinned likelihood fit to M_{jj}
- σ = 18±2.8(stat)±2.4 (syst)±1.1 (lumi) pb agrees with σ_{NLO} = 16.8±0.5 pb

PRL 103, 091803 (2009)



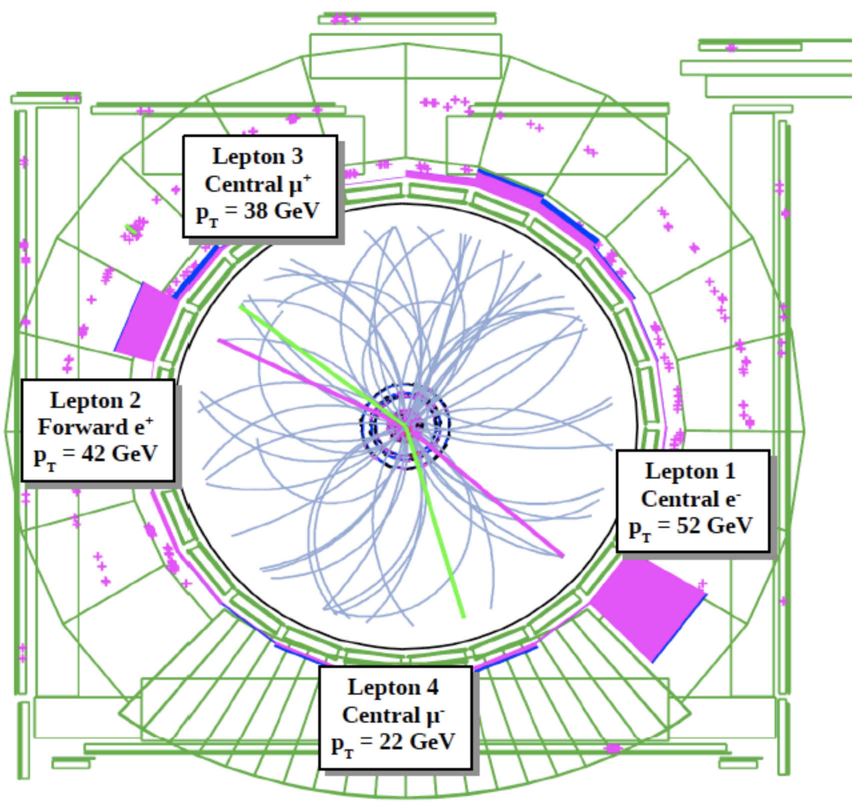


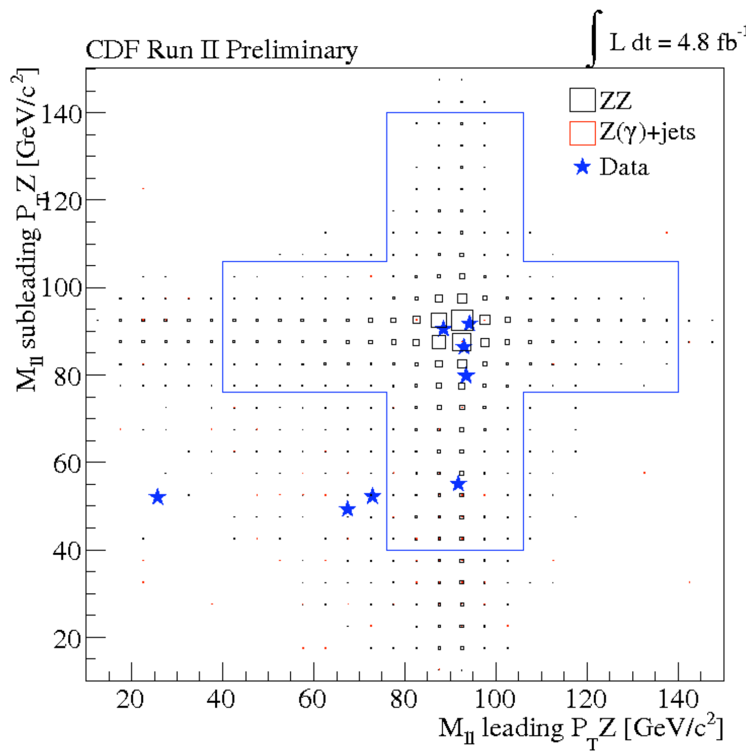
Remove QCD multijet bkgs

First observation of diboson events in a hadronic final state at the Tevatron

ZZ production

- First observation reported by D0 in 2008 (PRL 101, 171803 (2008))
- 5 ZZ→lll'l' candidates observed with 0.04 bkgs expected (5.7σ)
- $\sigma=1.56^{+0.80}_{-0.63}$(stat)±0.25 (syst) pb agrees with σ_{NLO}=1.4±0.1 pb





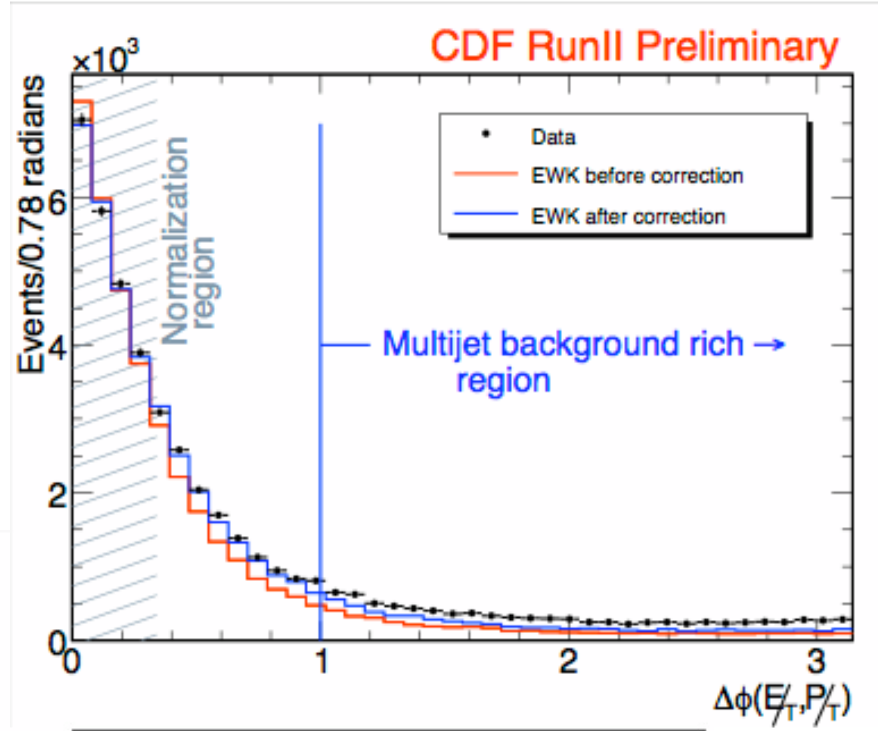
Conclusions

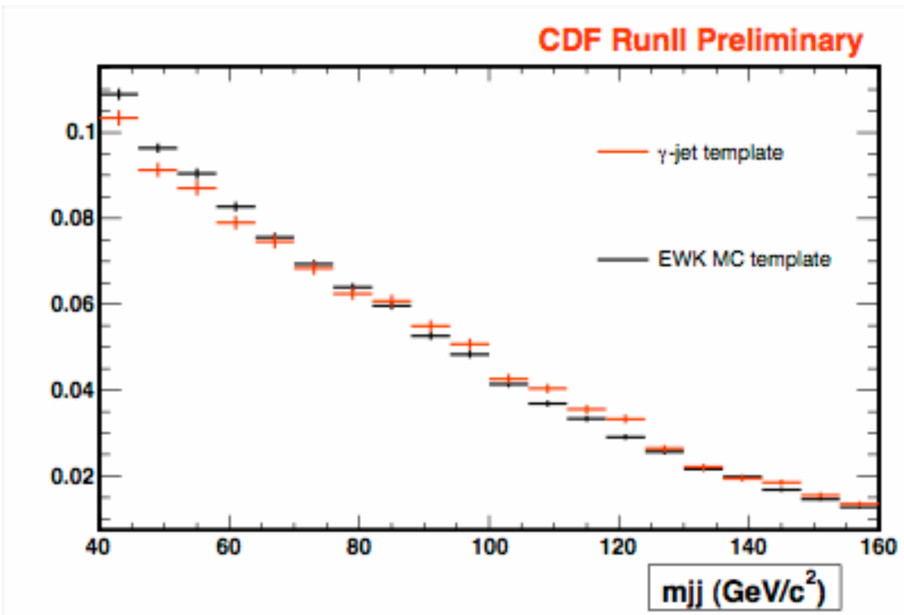
- Electroweak physics program at the Tevatron
  - Precision measurements of W and Z boson properties
  - Useful constraints on PDFs
  - Measurements of diboson production cross sections
  - Limits on the anomalous trilinear gauge couplings
  - Demonstration of techniques for the Higgs boson search
- More data incoming, expect to see more interesting electroweak results from the Tevatron!

Backup

VV→met+jj

- QCD multijets: check angle between MET and trkMET
- MC modelling of EWK bkgs: checked using γ+jet events between data and MC, remaining difference used to determine systematic uncertainties





	Systematic	% uncert.
Extraction	EWK shape	7.7
	Resolution	5.6
	Total extraction	9.5
Acceptance	JES	8.0
	JER	0.7
	$\not\!\!E_T$ resolution model	1.0
	Trigger inefficiency	2.2
	ISR/FSR	2.5
	PDF	2.0
	Total acceptance	9.0
	Luminosity	5.9
	Total	14.4