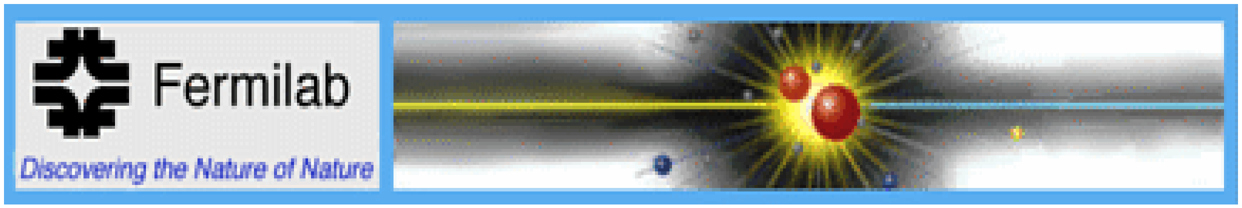
Electroweak Physics Measurements at CDF



Giorgio Chiarelli
Istituto Nazionale di Fisica Nucleare
Sezione di Pisa

This presentation

Electroweak processes look like the bread and butter of high Pt physics at hadron colliders

- ☞ Wrong!

They are the key to understand detectors and physics necessary to go beyond

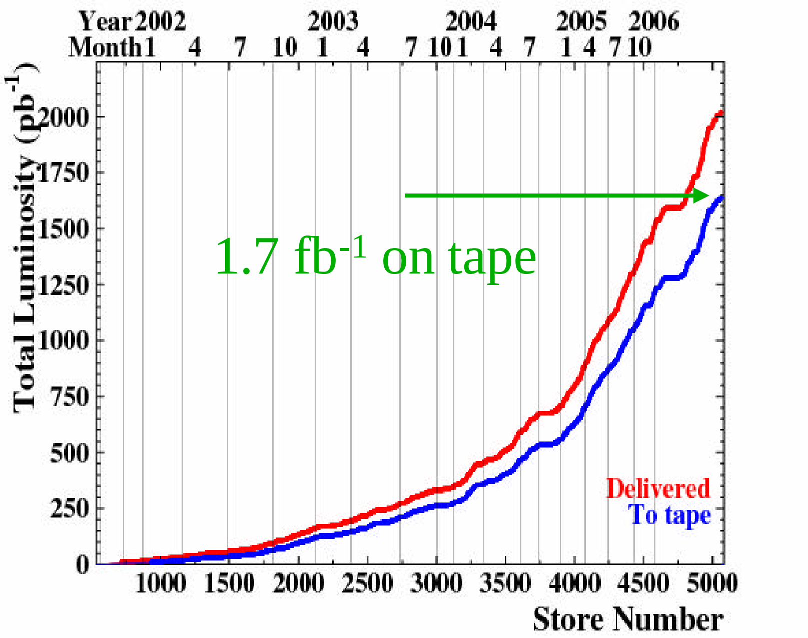
- ☞ In the discovery region

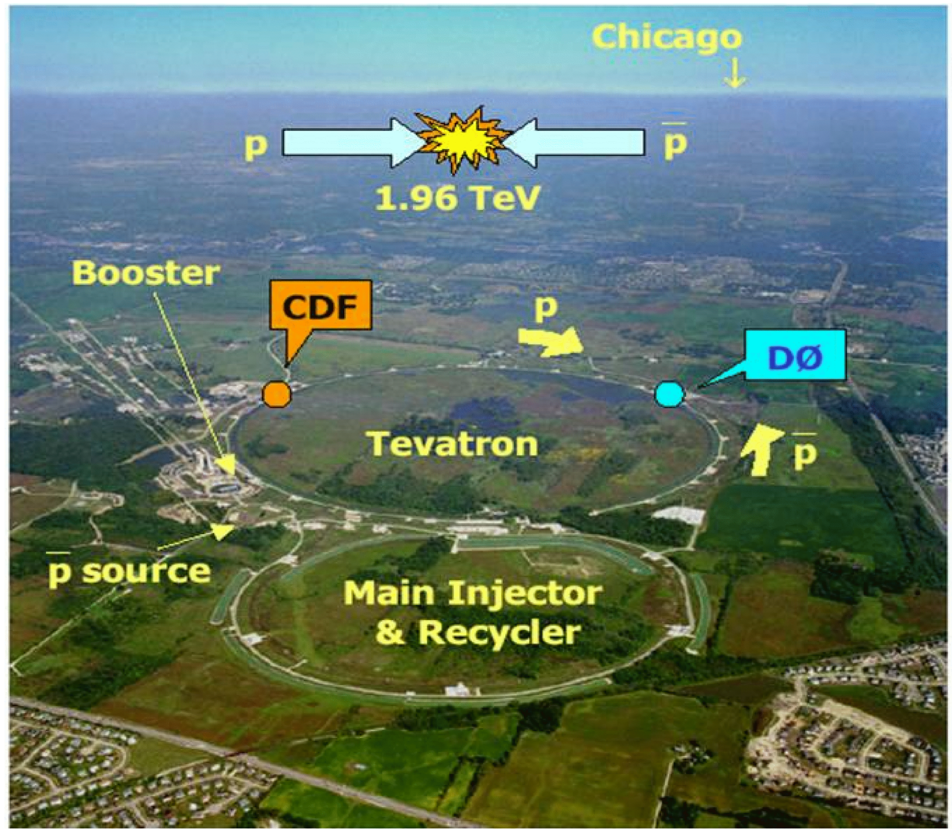
Besides...

- ☞ With large statistics you can perform precision measurements and..
  - ⇨ Look for new physics (LEP legacy)
- ☞ The “clean” theoretical background allows to use them as “standard” against which testing unknow pieces of the puzzle...

Tevatron

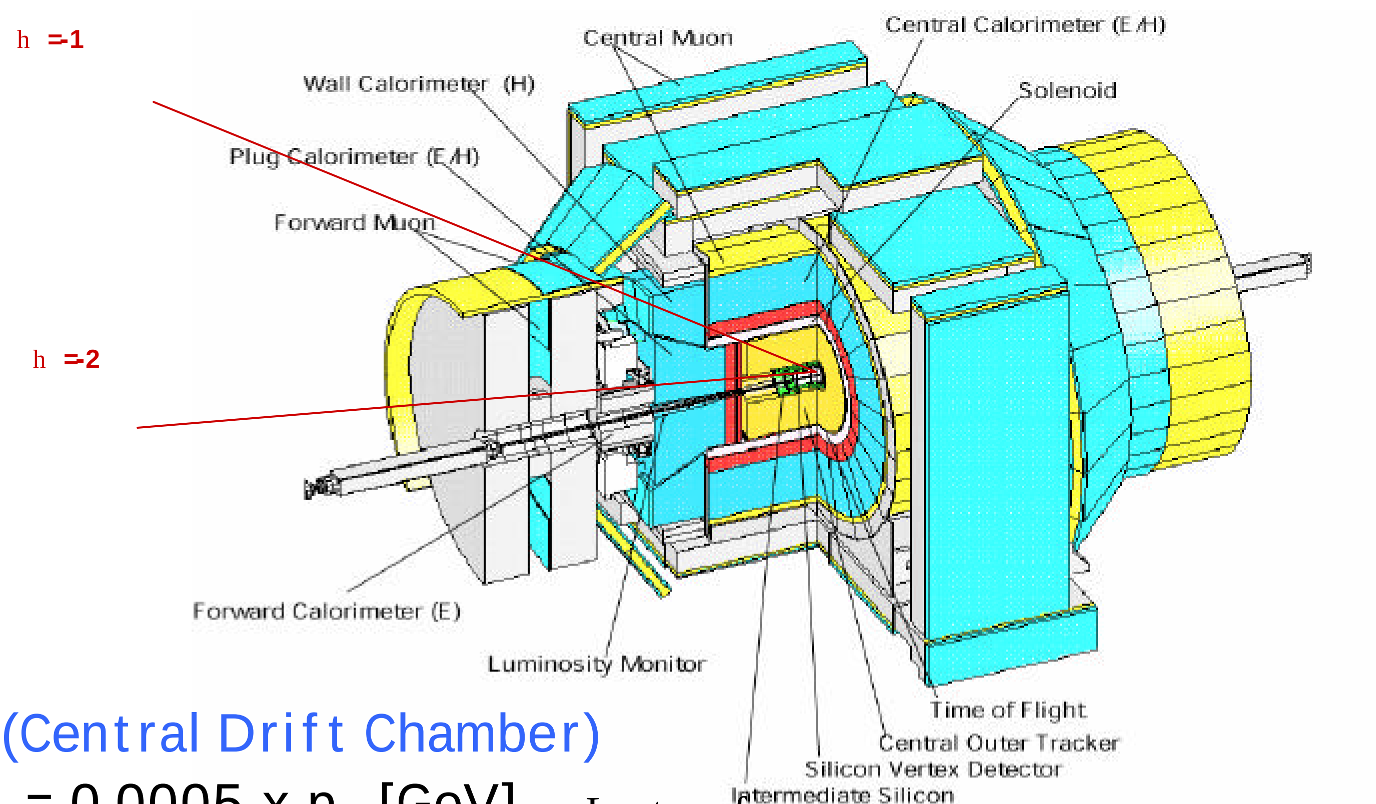
Tevatron is a W & Z factory





Mode	Events/Week/Exp. (before trigger & cuts)
$W \to e\nu$	~50,000
$Z \to ee$	~5,000

CDF Experiment



Tracking (Central Drift Chamber)

☞ $\delta p_T / p_T = 0.0005 \times p_T$ [GeV]

Leptons from W/Z decays

EM Calorimeter

☞ $\delta E_T / E_T \sim 13.5\% / \sqrt{E_T} \oplus 1.5\%$ [GeV, $|\eta| < 1.1$]

Forward region now used

The accelerator

- Fundamental being able to collect data
  - ☞Currently excellent performance
    - ⇨8 different machines running together (included e-cooling)
- The aim is an integrated luminosity plan
  - ☞called “Design”
    - ⇨brings ~8 fb^{-1}/exp. by FY 09
- We also have a “fallback plan”
  - ☞called “baseline”
    - ⇨brings to ~4.5 fb^{-1}/experiment by FY 09

The beams division is working well and the machine is performing!

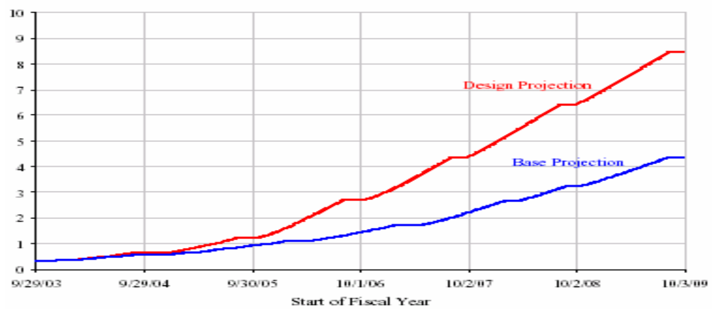
Slide del Aprile 2004

Chiarelli, IFAE 2004

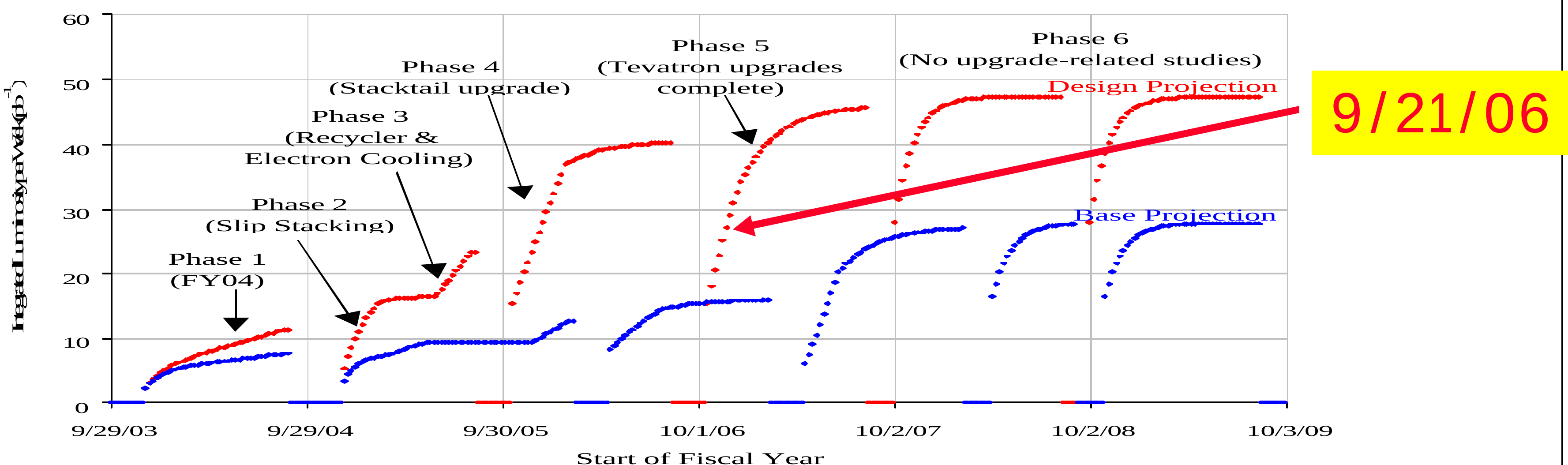
Machine is performing...in the future:

☞CDF &D0, designed for 132 ns

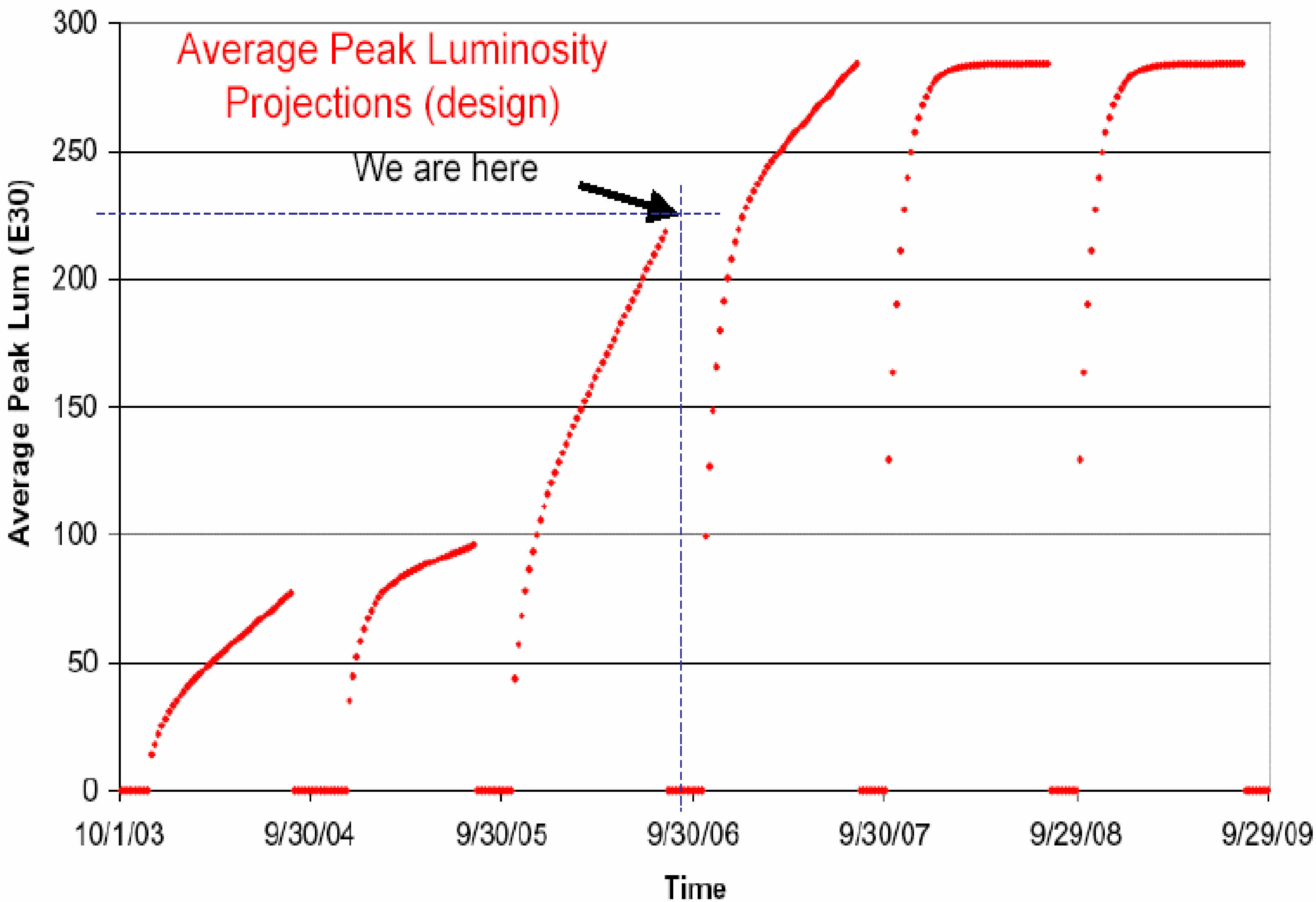
⇨will have to work at 396 and ~2.7×10^{32} $cm^{-2}s^{-1}$



Fiscal Year	Design (fb^{-1})	Base (fb^{-1})
FY03	0.33	0.33
FY04	0.64	0.56
FY05	1.2	0.93
FY06	2.7	1.4
FY07	4.4	2.2
FY08	6.4	3.3
FY09	8.5	4.4

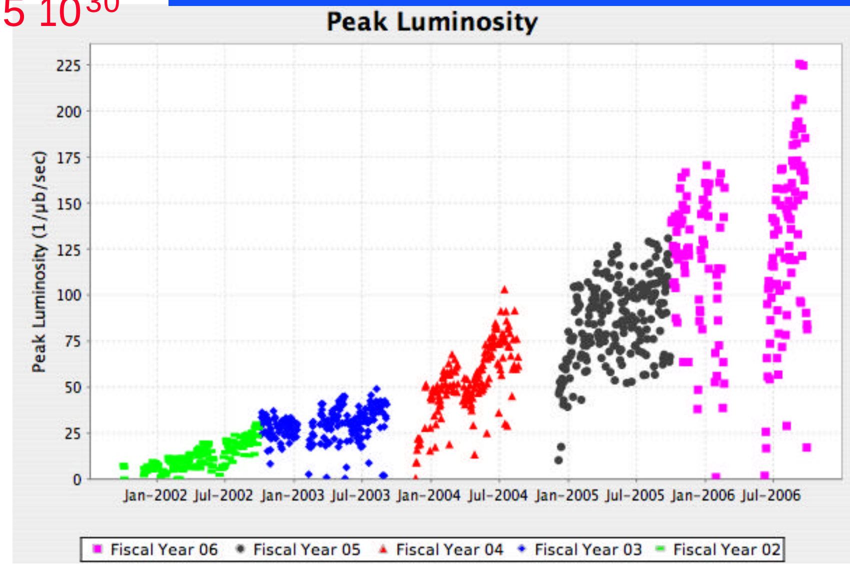


Accelerator Status

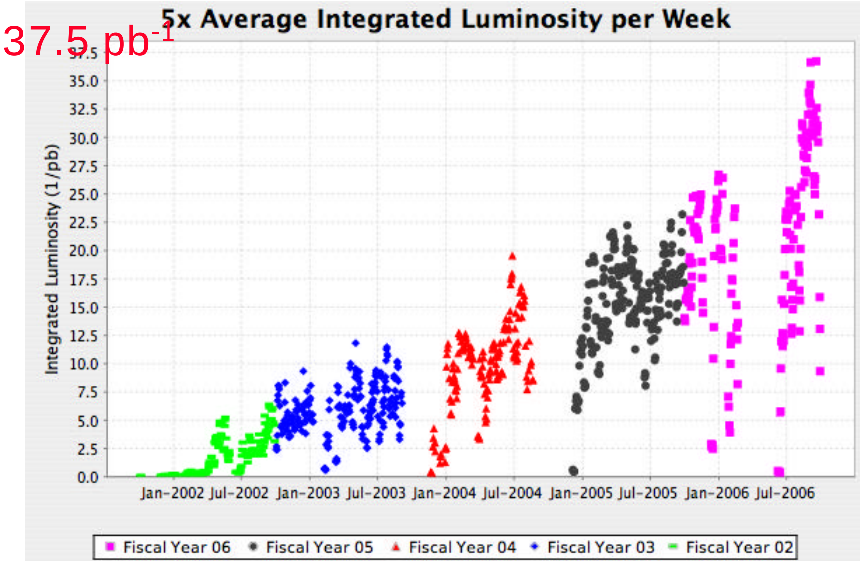


Accelerator performance

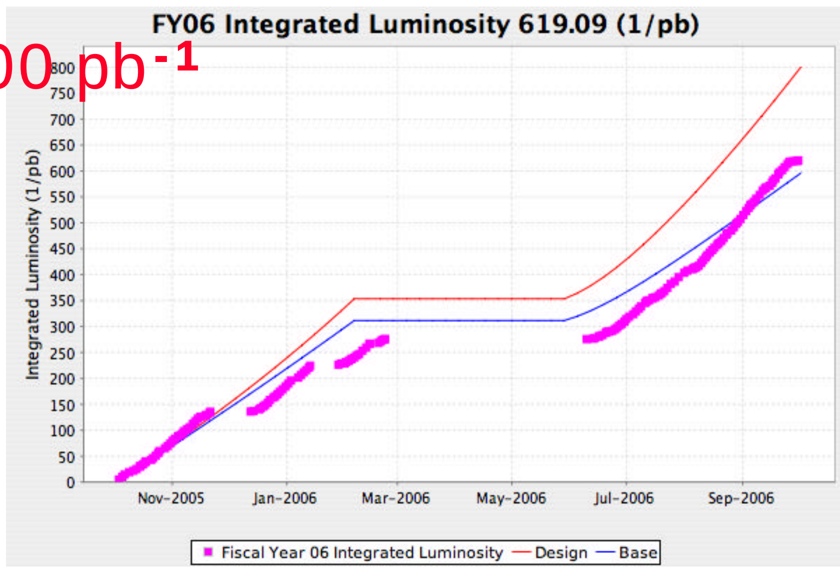
225 10^{30}



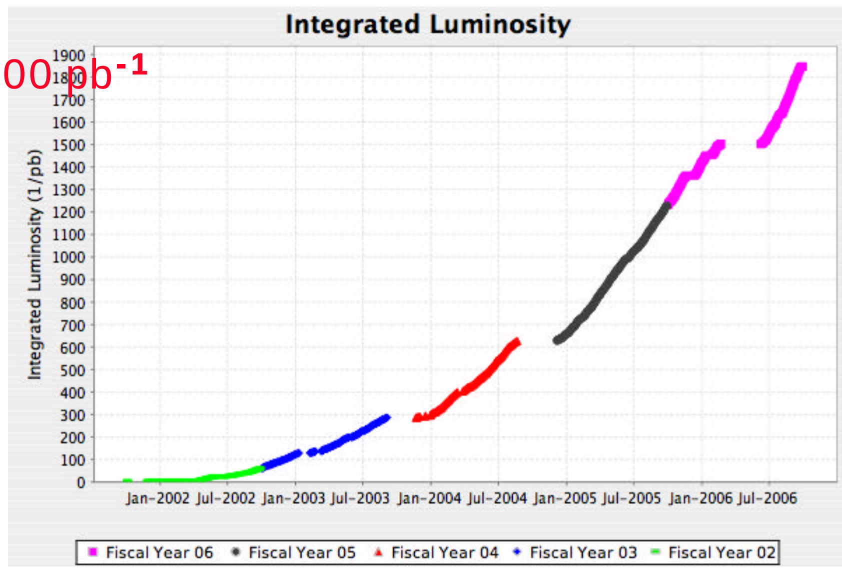
37.5 pb^{-1}



800 pb^{-1}

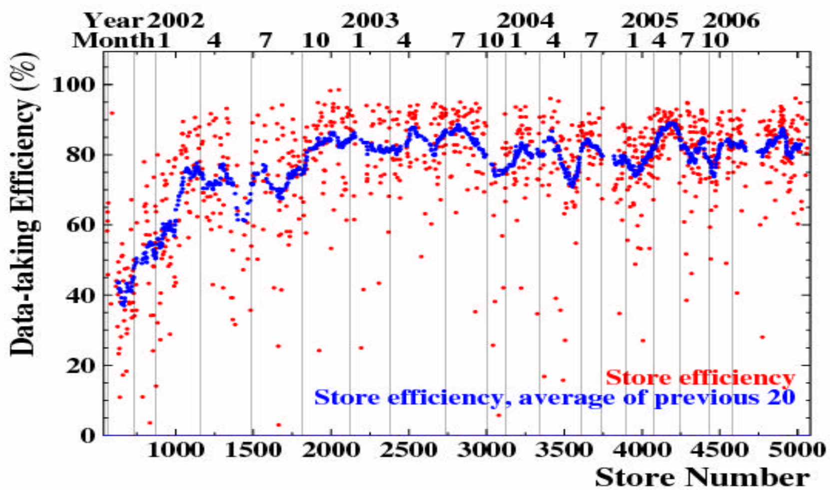


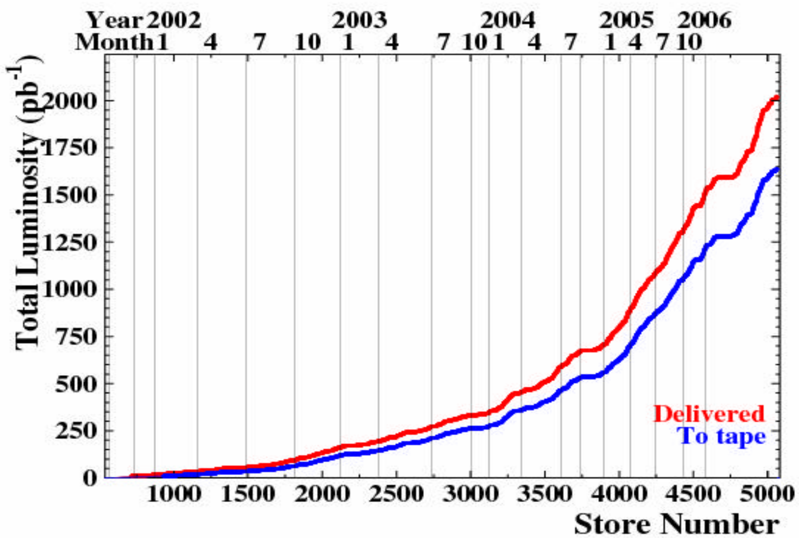
1800 pb^{-1}



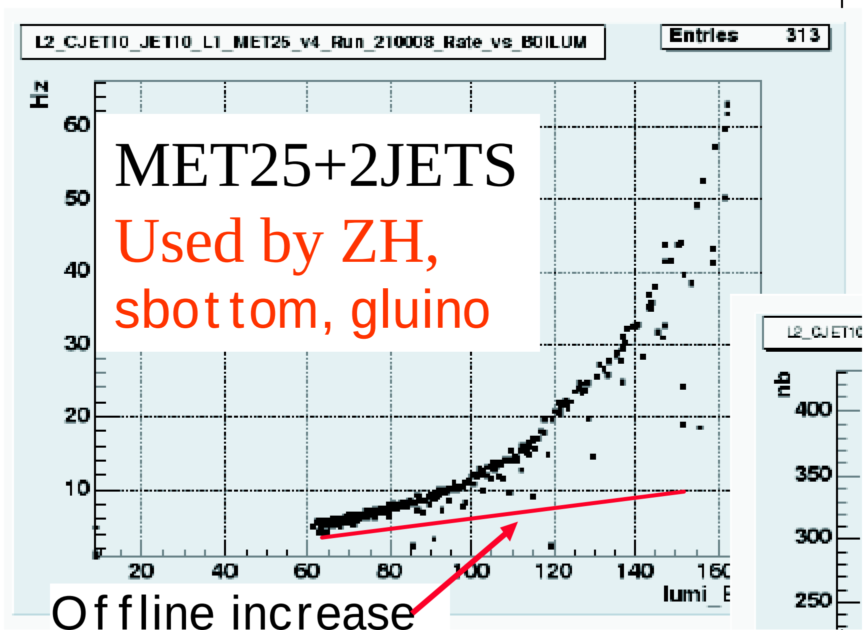
CDF -performance

CDF collects data with good efficiency

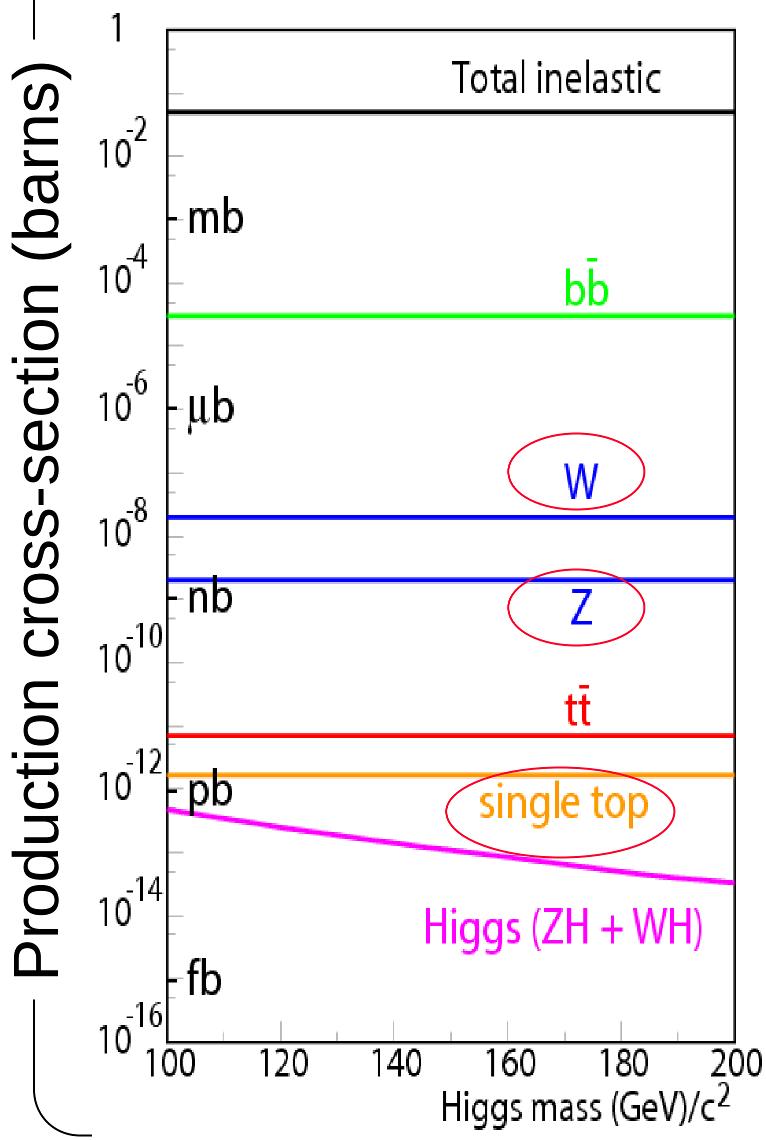




At high instantaneous luminosity we need to act if we want to retain our physics capabilities



The environment



In 1 fb^{-1}

1×10^{11}

6×10^{6}

6×10^{5}

14,000

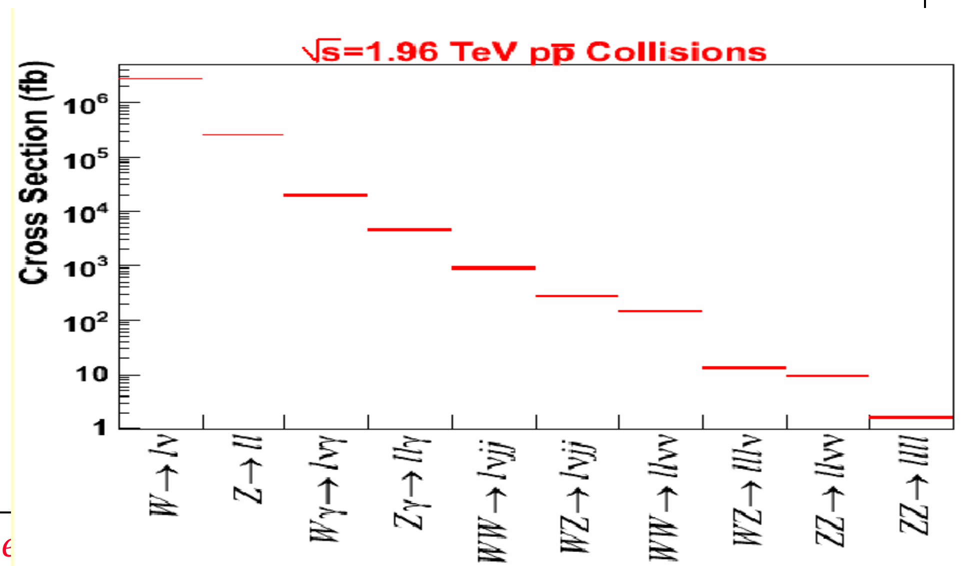
5,000

100 ~

10

We typically run at $L=2\times10^{32} cm^{-2}s^{-1}$..means

- several interactions per crossing
  - ⇨ Tough life
- ...we can go down in the ladder on the left
  - ⇨ Provided that our triggers can select the needle in the haystack



EWK precision tests

Test of the Standard Model

- ⇨ Check for missing pieces (free parameters...)
- ⇨ Anomalies might signal new physics

☞ Test of new tools

- ⇨ Widening of kinematics zones used, new channels
  - → Es: $Z\to\tau\tau$, **W**$\to\tau\nu$

☞ Some channels are sensitive to PDFs

- ⇨ W asymmetry, $d\sigma/dy(Z)$, W mass (!)
- ⇨ $\sigma(W)_{\mathbf{centrale}}/\ \sigma(W)_{\mathbf{forward}}$

☞ Others can be used to understand backgrounds

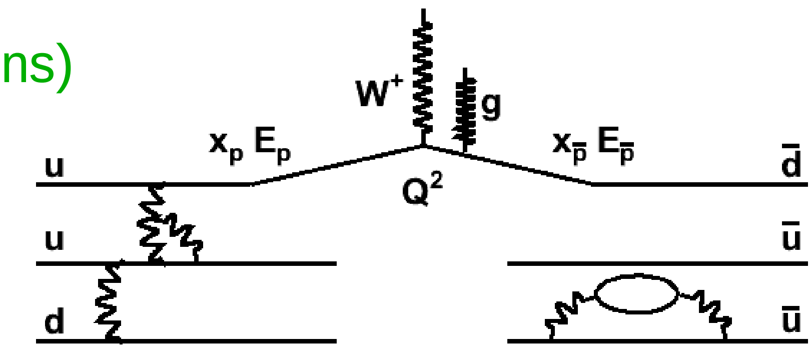
- ⇨ W/Z+jets...
- ⇨ WW, WZ

☞ Separation among topics not always clean

QCD W and Z boson production

Test of QCD

- ☞Can be used to check calculations
  - ⇨NLO since long time
  - ⇨NNLO
    - →(recently with full spin correlations)



$$\sigma = \Sigma_{ab} \int dQ\, \delta(Q - 2E_p\sqrt{x_p x_{\bar p}}) \int dx_p\, f_a(x_p,Q) \int dx_{\bar p}\, f_b(x_{\bar p},Q)\, \hat{\sigma}(Q)$$

Sum over quarks, gluons

Kinematic constraint

Parton distribution functions

Calculable hard scattering cross section

Old W, Z cross section measurements

CDF measured Z, W cross section using 72pb^{-1}

- ☞ σ_W=2775±10(stat)±53(syst)±166(lum) pb
- ☞ σ_Z=254.9±3.3(stat)±4.6(syst)±15.2(lum) pb
  - ⇨ R=10.84±0.15(stat)±0.14(syst)
    - → Can be used to measure Γ (indirectly)
    - → Can be used to measure Vcs

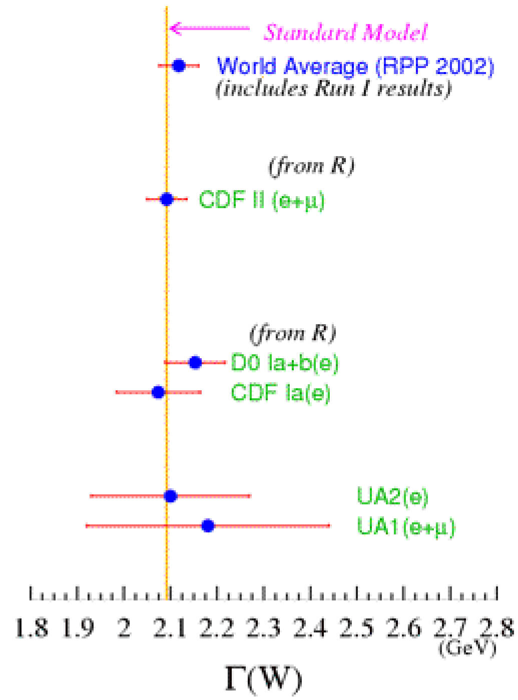
$$R = \frac{s_W \cdot BR(W \to ln)}{s_Z \cdot BR(Z \to l^+l^-)} = \frac{s_W}{s_Z} \cdot \frac{\Gamma_Z}{\Gamma_{Z \to l^+l^-}} \cdot \frac{\Gamma_{W \to ln}}{\Gamma_W}$$

SM : 3.370 ± 0.024

SM : 226.4 ± 0.3 MeV

LEP : BR(*Z* ® *l*+*l*-) = 0.033658 ± 0.000023

$$\Gamma_W = 2.092 \pm 0.042 \ \text{GeV}$$



Vcs

Indirect determination exploiting SM and world-average of the other CKM ME involved:

$$\Gamma_W = 3\Gamma_W^0 \left(1 + K_{QCD}\ (\alpha_S^3) \sum_{|\text{no top}|} \left| V_{qq'} \right|^2 \right)$$

$$\left| V_{cs} \right|_{CDF} = 0.976 \pm 0.030$$

- α_s=0.12, $\Gamma^0{}_W$=226.4 MeV/c²
- Better than LEP (direct) alone (0.97±0.11), worst than LEP+Run I (0.996±0.013)

R can provide precision constraints to SM parameters

- Find new ways...

Indirect Width Uncertainties

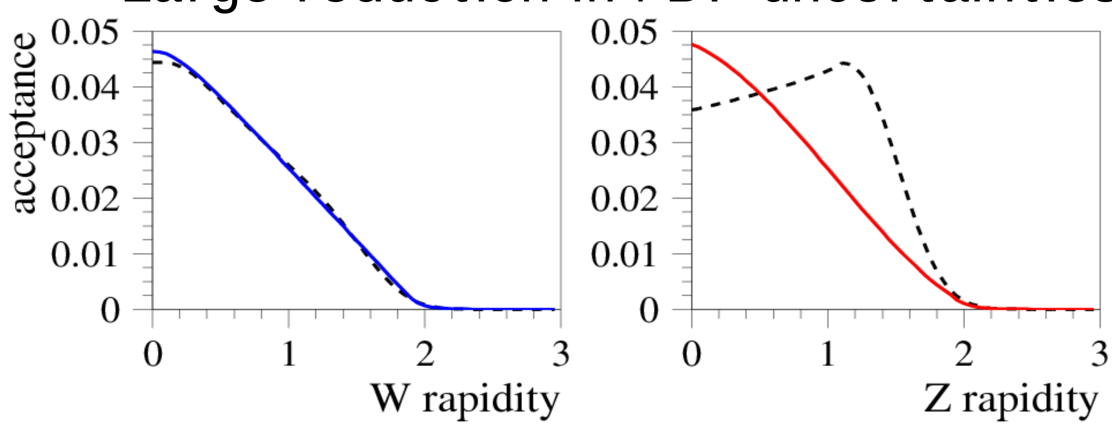
Category	Electron	Muon	Correlation
Stat error	0.1753	0.2705	0.0
Acceptance stat error	0.0294	0.0480	0.0
Boson p_T	0.0019	0.0044	1.0
PDF	0.0704	0.0851	1.0
P_T scale/resolution	0.0012	0.0170	1.0
E_T scale/resolution	0.0185	0.0000	0.0
Material	0.0319	0.0000	0.0
Recoil calibration	0.0267	0.0384	1.0
Uncorrelated efficiency error	0.1203	0.1015	0.0
Track reconstruction efficiency	0.0170	0.0445	1.0
QCD background	0.0435	0.0397	1.0
Uncorrelated EWK background	0.0089	0.0112	0.0
Correlated EWK background	0.0042	0.0290	1.0
Cosmic ray background	0.0000	0.0702	0.0
γ^* correction factor	0.0109	0.0112	1.0

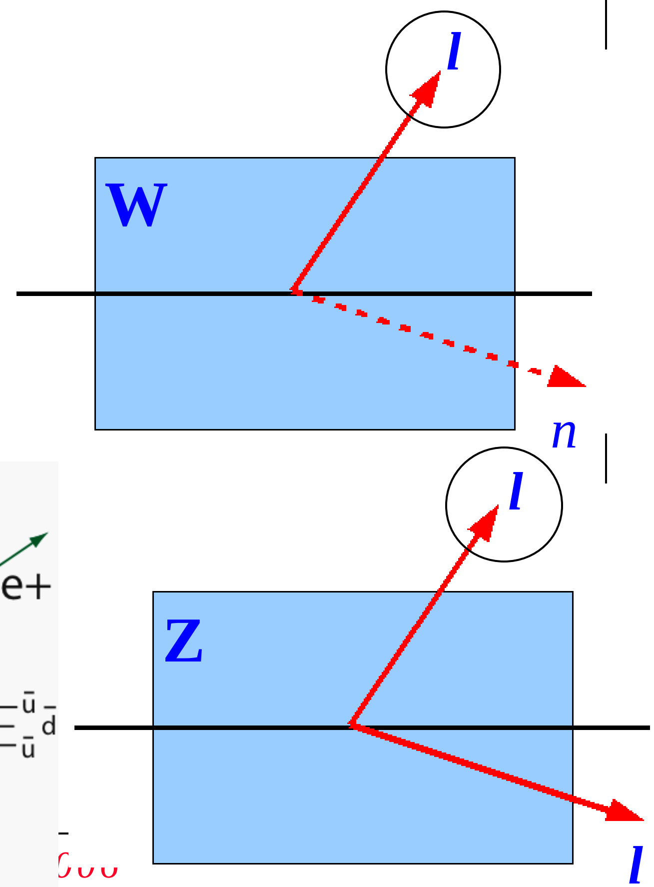
Raw uncertainties on R

Improved Method

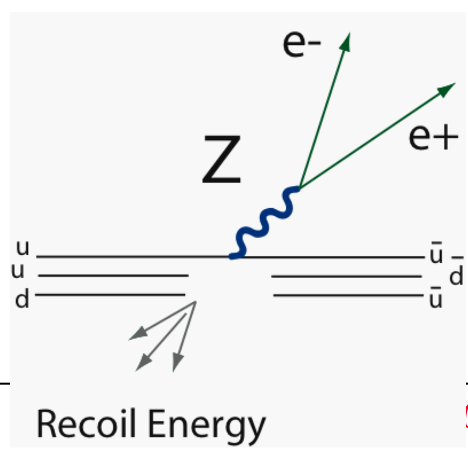
Use a common set of selection criteria for both W and Z events by requiring a single high-quality lepton (fit +/- charges separately)

- ☞ No efficiency or trigger uncertainties
- ☞ Large reduction in PDF uncertainties





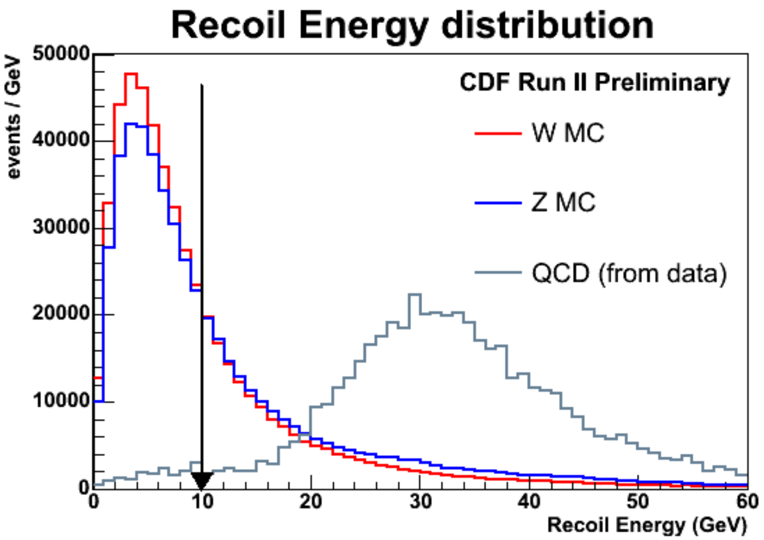
- Exclude 2nd EM object from recoil.
- Include all towers in $\not{E}_T$ calculation.

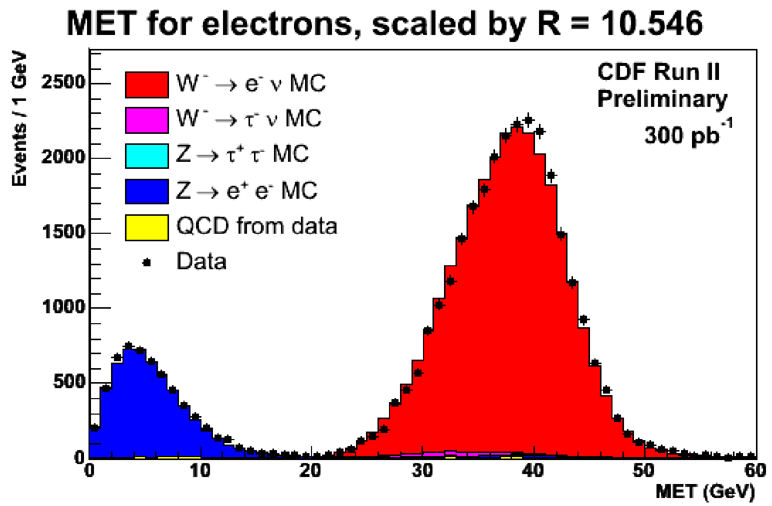


Precision R Measurement

Cut on hadronic recoil |U| < 10 GeV to minimize QCD background

Use maximum likelihood fit to extract W and Z contributions to common candidate sample





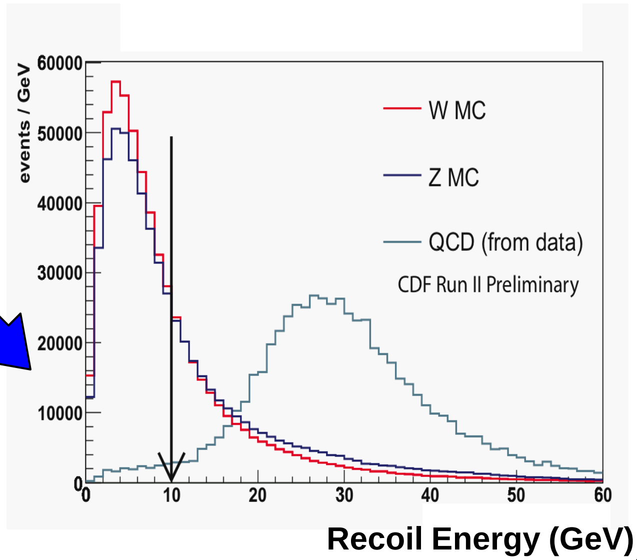
R W/Z: new Method

CDF PRELIMINARY	ΔR/R (%)	
	electron (72 pb-1)	electron (300 pb-1) PRELIMINARY
Statistical	1.7	0.94
PDF	0.65	0.31
Material	0.28	-
Recoil	0.28	0.40
Efficiency	1.10	-
Background	0.37	2.5
Missing-E_T	-	0.5
Total Systematic	1.50	2.6
Stat. + Syst.	2.20	2.76

- **Reduced by x2**
- **Eliminated.**
- **Increased: needs better understanding**

Preliminary systematic study & comparison with earlier analysis.

Recoil distribution for signal & QCD background

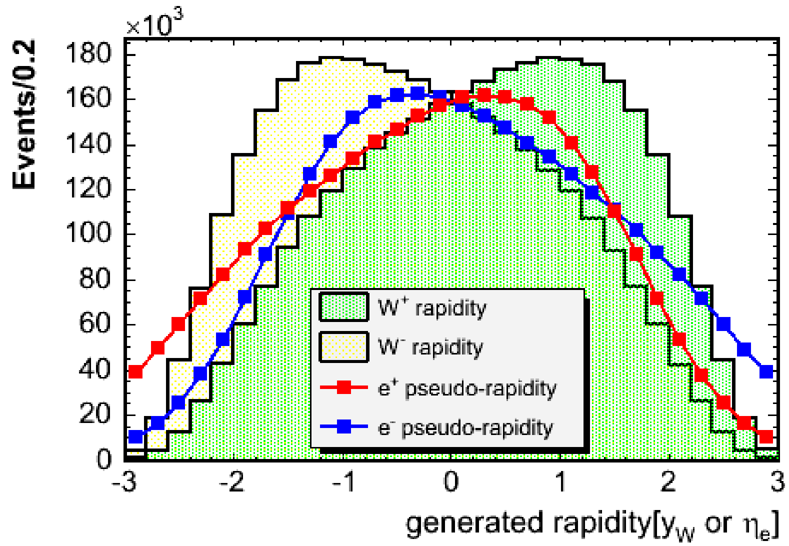


$$R = 10.55 \pm 0.09(\text{stat}) \pm 0.26(\text{syst})$$

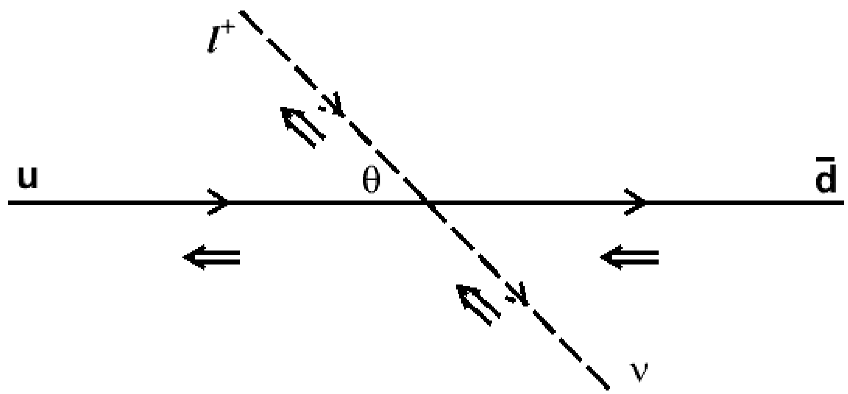
CDF e PRELIMINARY, 374 pb^{-1}

Constr. PDF-W Asymmetry

Asymmetric u,d quark momentum distributions within proton lead to asymmetric W^+,W^- rapidity distributions



☞ V-A decay of W boson reduces the observable asymmetry in the lepton rapidity distributions

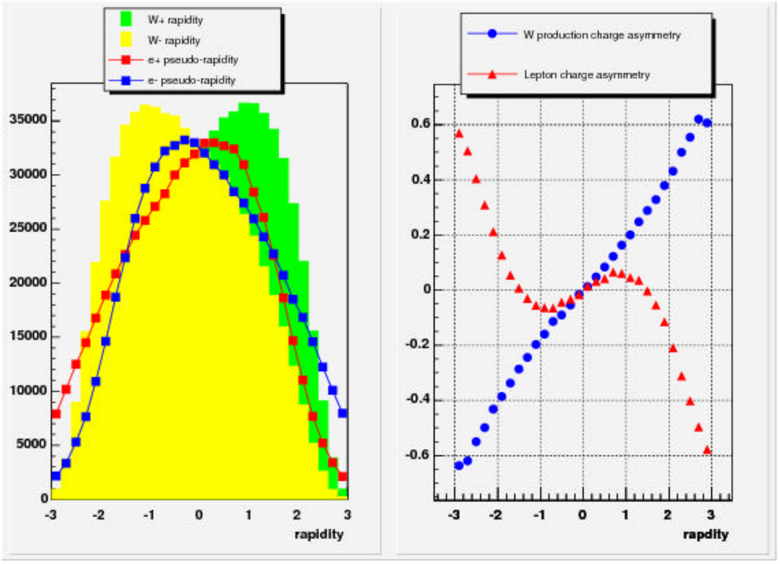


$$d\sigma/d\theta \propto (1 + \cos\theta)^2$$

Charge Asymmetry

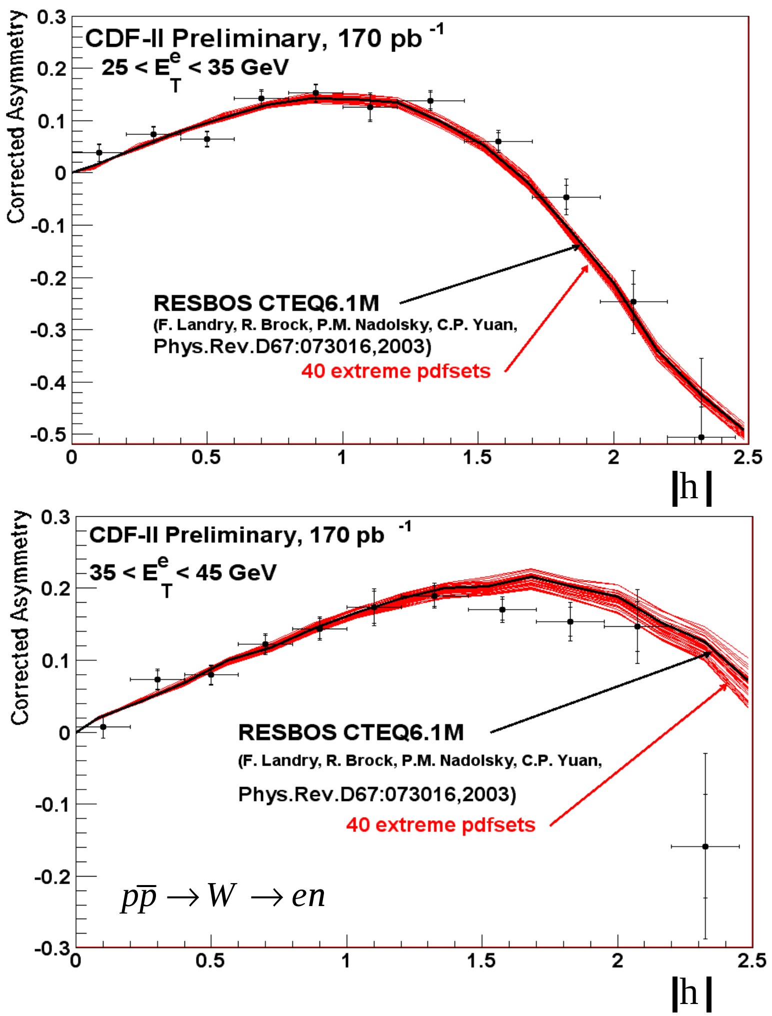
Equivalent definition for
lepton asymmetry

$$A^{\pm}_W(y) = \frac{\sigma_{W+}(y) - \sigma_{W-}(y)}{\sigma_{W+}(y) + \sigma_{W-}(y)}$$



$$A^{\pm}_W(y) = \frac{u(x_p)d(x_{\bar{p}}) - d(x_p)u(x_{\bar{p}})}{u(x_p)d(x_{\bar{p}}) + d(x_p)u(x_{\bar{p}})} \approx F\left[(d/u)_{x_p}, (d/u)_{x_{\bar{p}}}\right]$$

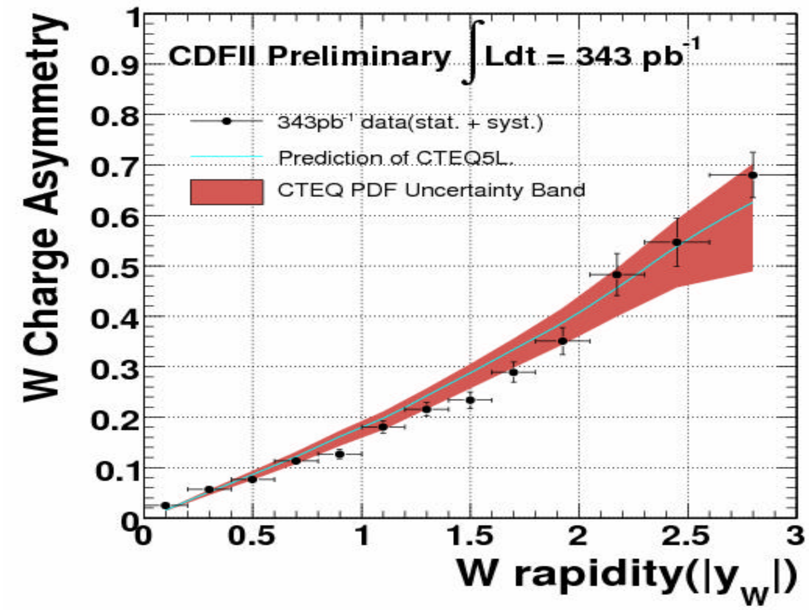
Old and new measurement

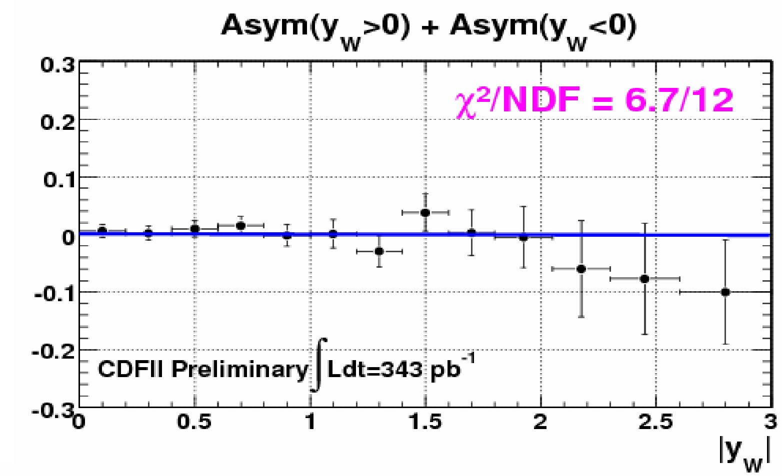


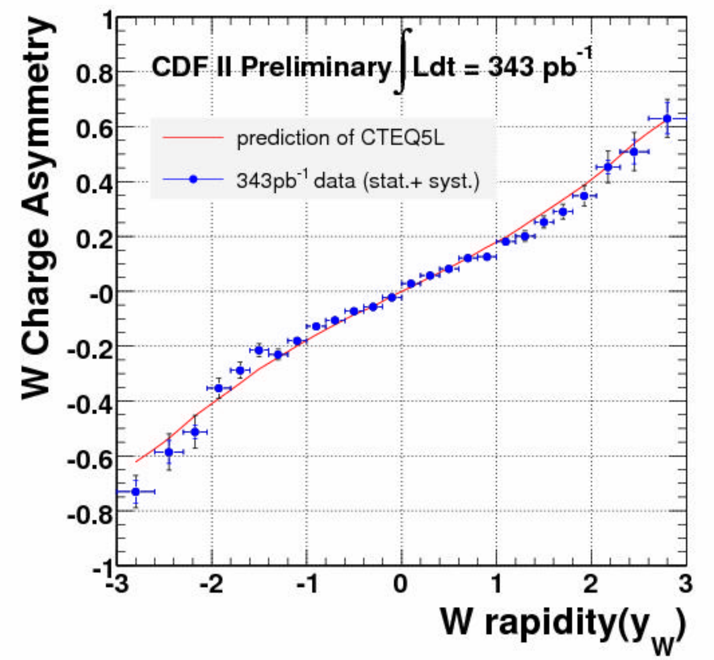
CDF measurement breaks data into separate E_T ranges

- ☞ Electron Channel only

Measuring with 1 fb^{-1}







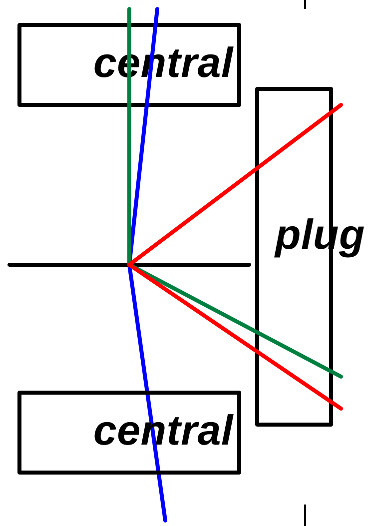
Reconstruct W production asymmetry $A(y_W)$ directly

Two kinematic solutions using M_W constraint

Weight solutions taking into account production & decay

Resolve dependence on y_W iteratively

dσ/dy Z- Selection



Z selection with two central electrons :

- ⇨ Kinematic selection : $E_T \geq 25$ GeV , $|\eta|<1.$
- ⇨ Two electrons with tight and loose ID
- ⇨ Opposite charge electrons required

Z selection with a central and forward electron : Zcp

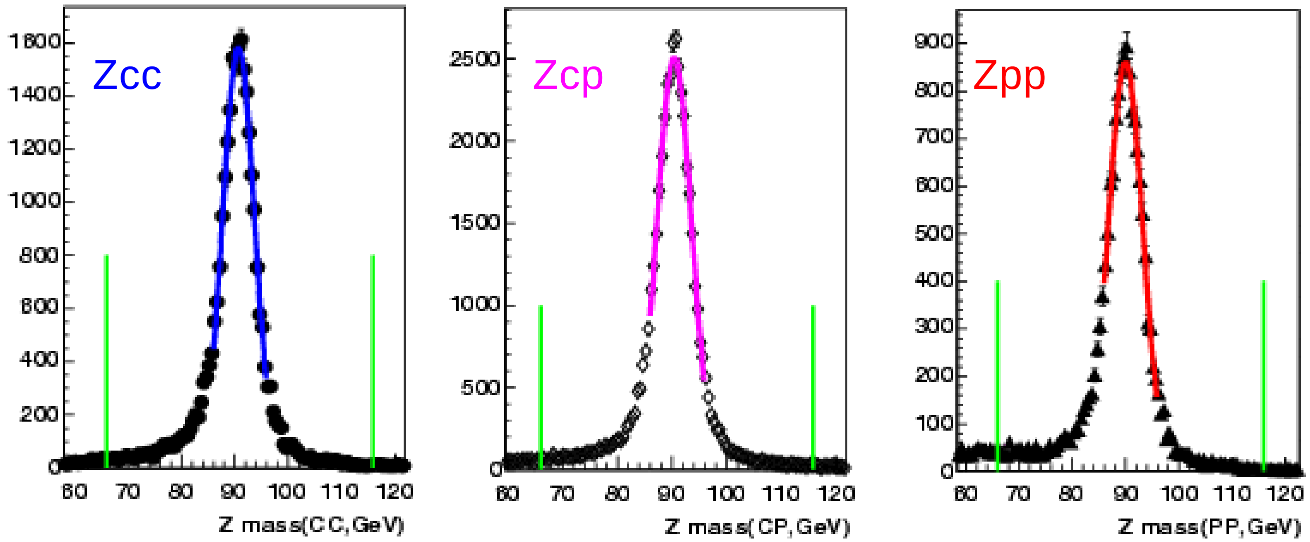
- ⇨ Kinematic selection : $E_T \geq 20$ GeV
  $|\eta|<1.1$ for central, $1.2 < |\eta|<2.8$ for plug
- ⇨ tight central electron and one plug electron

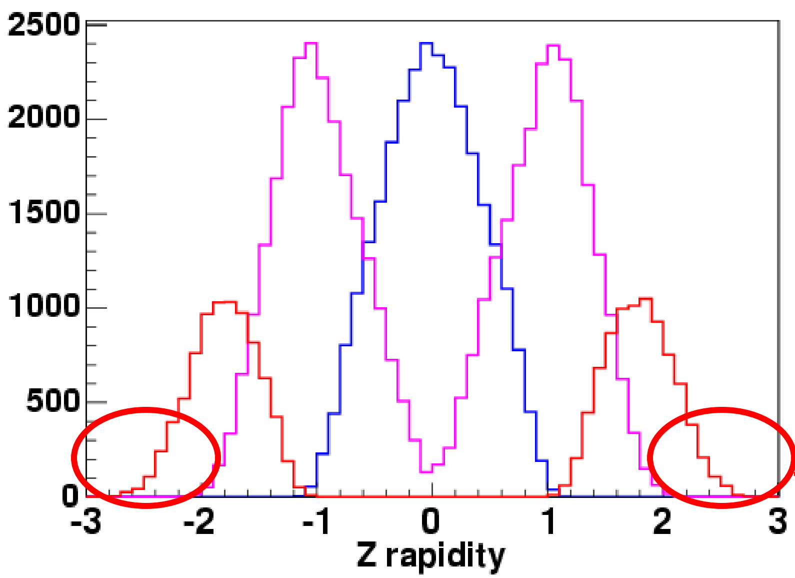
Z selection with two forward electrons : Zpp

- ⇨ Kinematic selection : $E_T \geq 25$ GeV , $1.2 < |\eta| < 2.8$
- ⇨ Two plug electrons
- ⇨ Same side events required
- ⇨ One leg must have a silicon track

Mass and Rapidity

CDF preliminary result





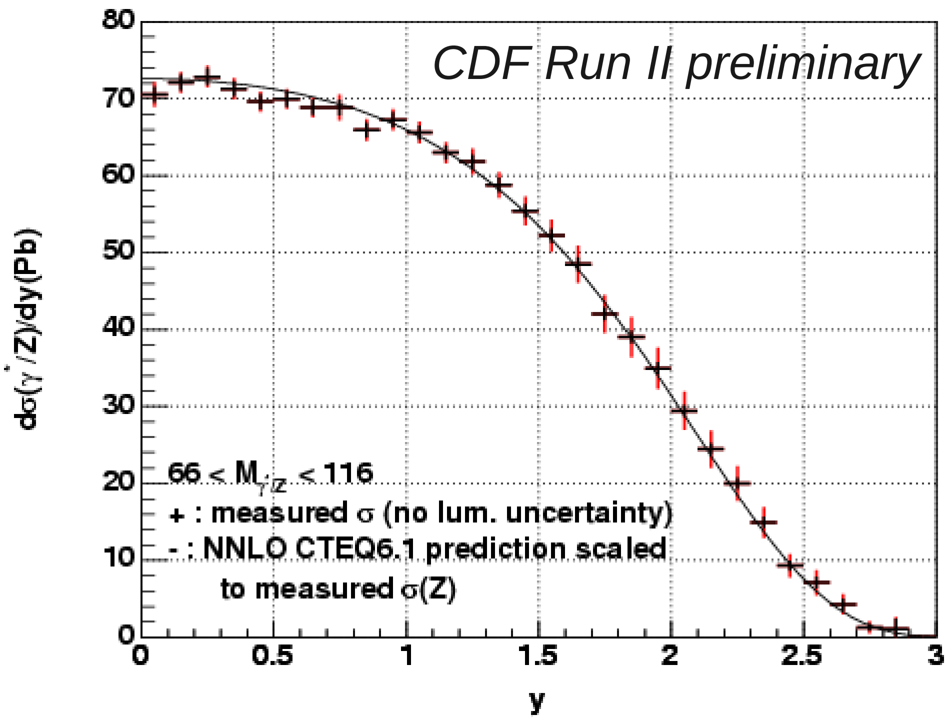
Mass window : 66 < M < 116 GeV

	Z(CC)	Z(CP)	Z(PP)
Events	28097	46676	16589

Probe high y region (~ 2.9)

dσ/dy distribution II

dσ/dy distribution of Z/γ^*

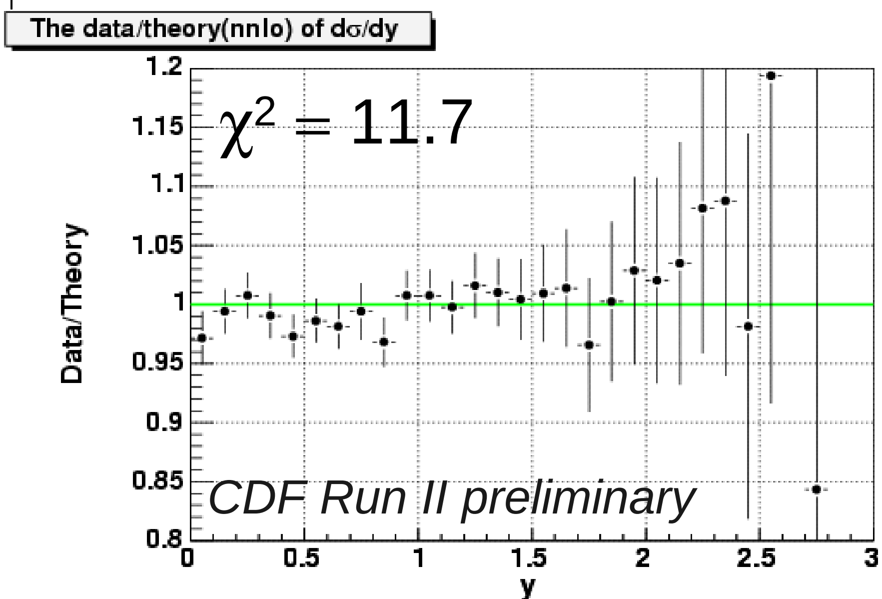


- NNLO calculation with NLL CTEQ6.1 PDF
- σ (Z→ee) : *265.9 ± 1.0(stat.)±1.1(sys.) pb*
- No PDF or luminosity uncertainties included

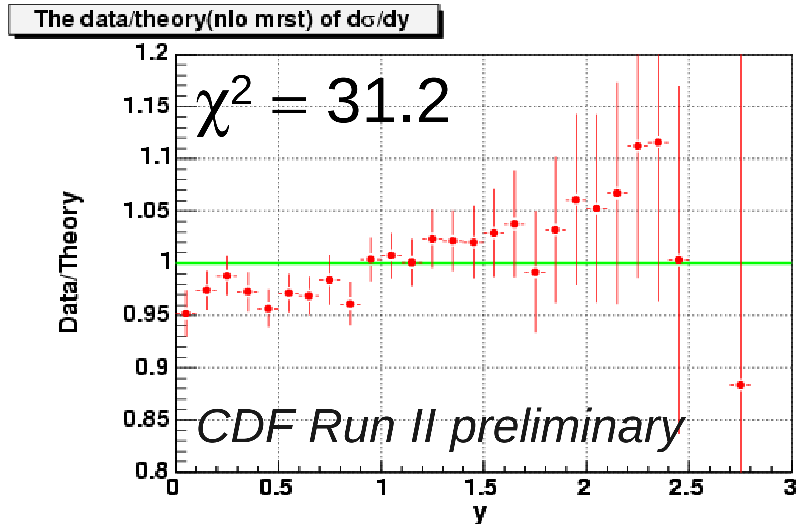
dσ/dy distribution (data/theory)

No PDF or L uncertainties included in data
Theory prediction scaled to measured s (Z)

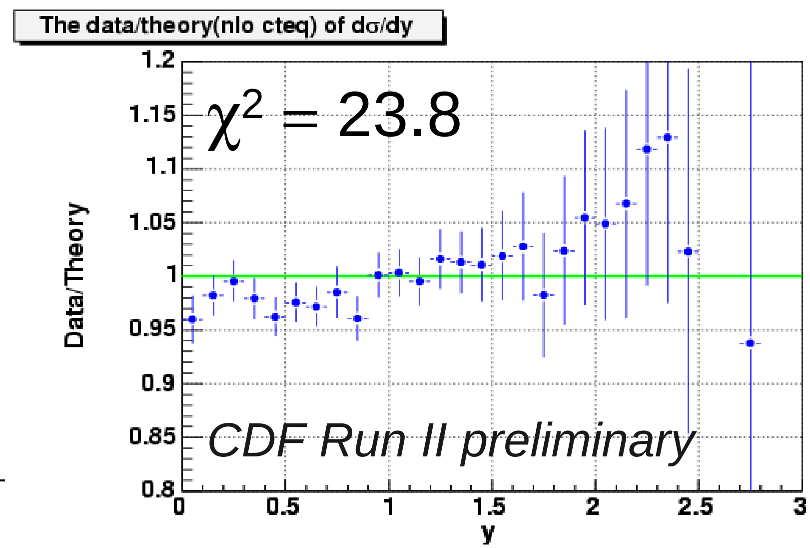
- NNLO calculation with NLL CTEQ6.1 PDF



- NLO calculation with NLL MRST PDF



- NLO calculation with NLL CTEQ PDF



NNLO calculation with NLL CTEQ6.1 PDF describes data best

W in forward region

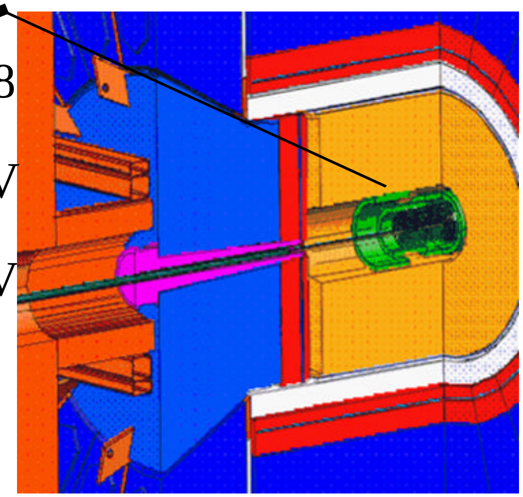
Traditional measurements in CDF involved central leptons (*e*, *m*)

- Thanks to improved tracking and new calorimeter |η|> 1 region is now used for *e* (to a lesser extent for *m*)
- Challenge due to use of silicon seeded tracks and to background

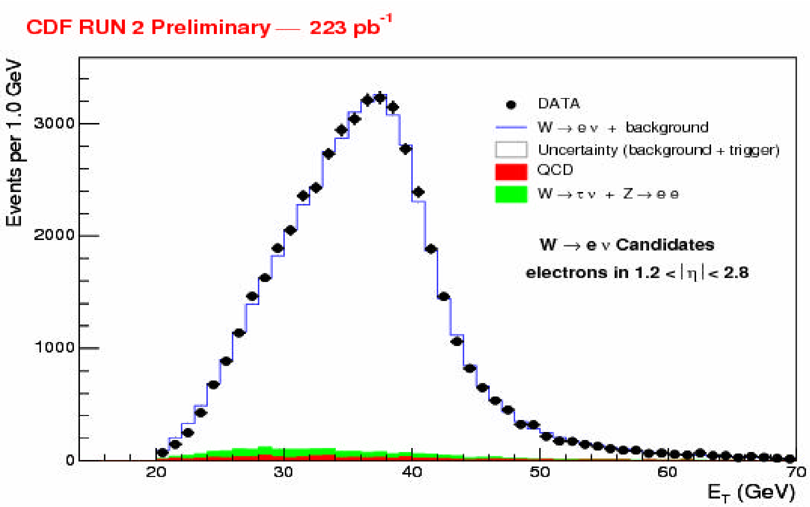
$$1.2 \le h_e \le 2.8$$

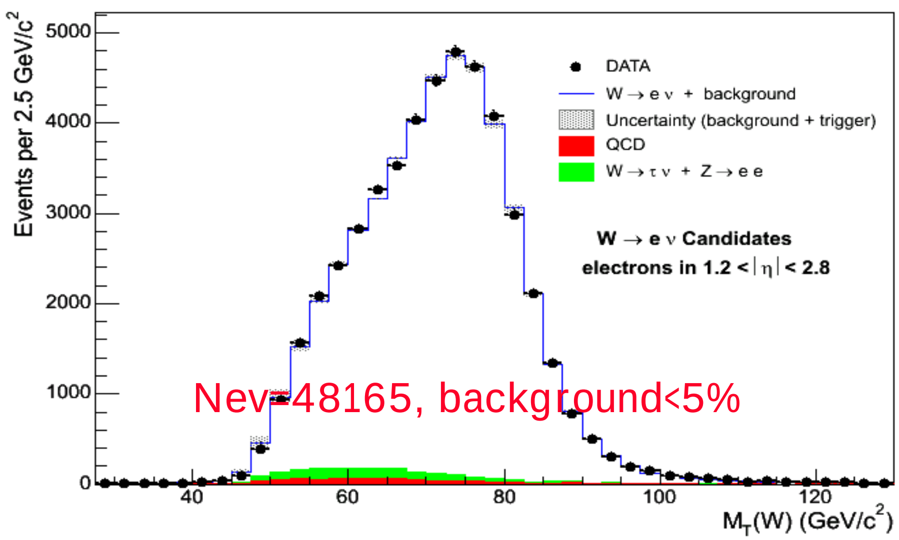
$$E_T^e > 20 \text{ GeV}$$

$$\not{E}_T > 25 \text{ GeV}$$



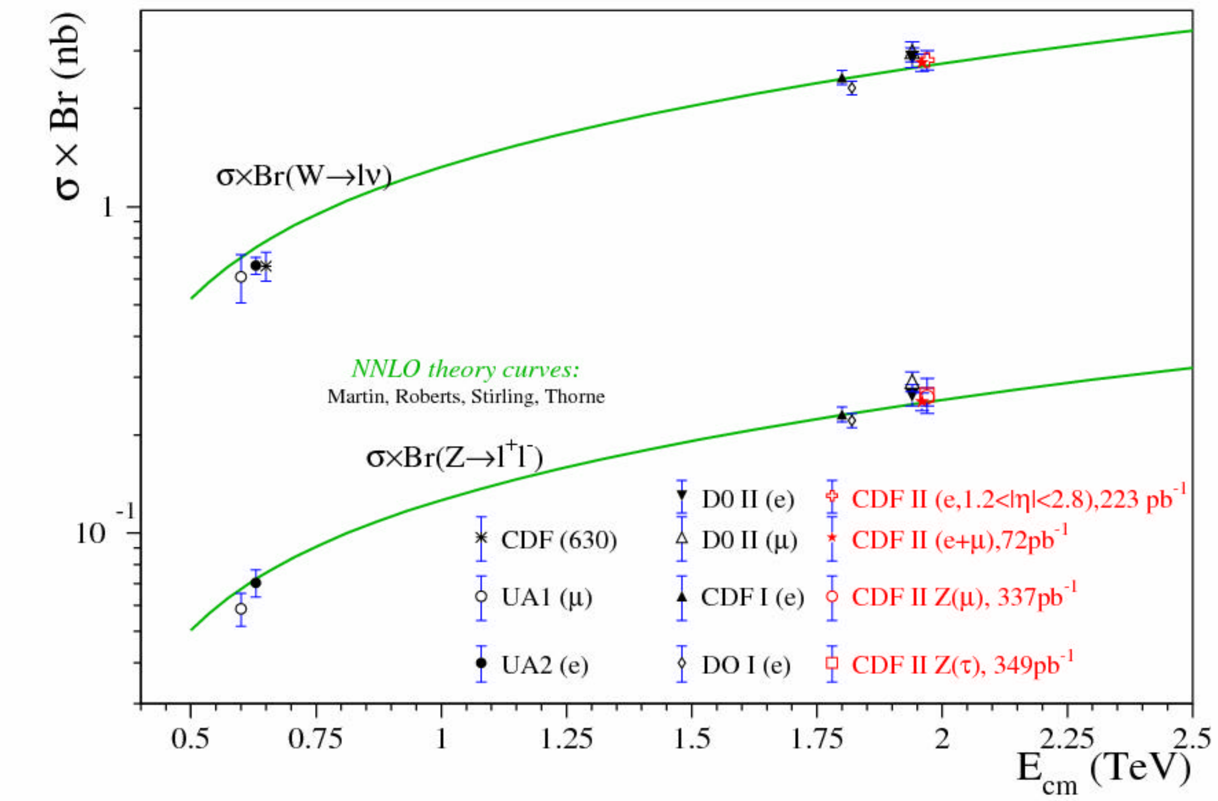
$$s = 2796 \pm 13(stat)^{+95}_{-90}(syst) \pm 162(lum)\, pb$$





25 years of EWK cross sections

In one slide..



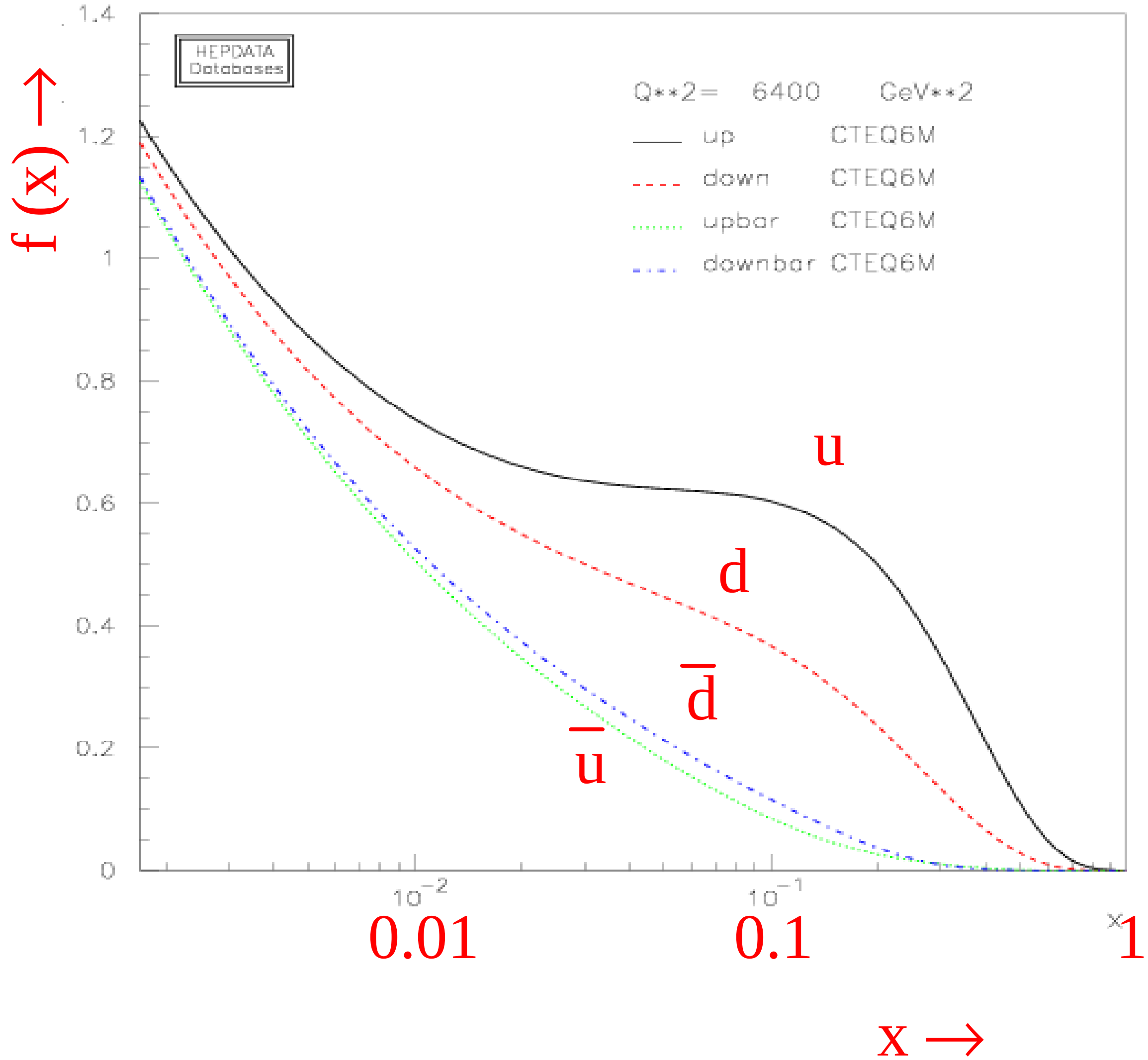
Luminosity unc.=5.8%

4% from extrapolating ppar cross section from 1.8 to 1.96

4.4% from CLC calibration

Parton Distribution Functions

Parton momentum fraction within the proton depends on quark type and is different for valence and sea quarks



PDF Parameterization

$$xf_a(x,Q_0) = A_0\, x^{A1}\, (1-x)^{A2}\, e^{(A3)x}\, (1 + A_4 x)^{A5}$$ (CTEQ)

Separate functions for u,d,g,$\bar{u}$,$\bar{d}$

30 total parameters (10 fixed)

PDF functions are based on fits to experimental data made by two independent groups (CTEQ & MRST)

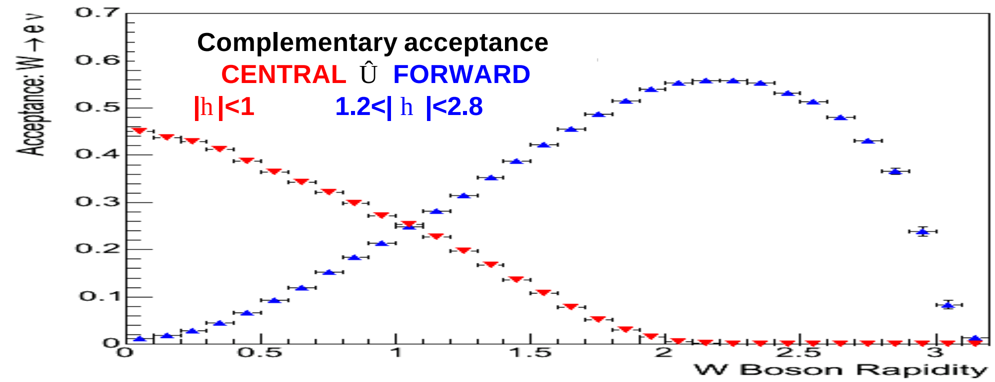
Parameters are determined for Q_0 = 1.3 GeV and the Q dependence is modeled by QCD evolution equations

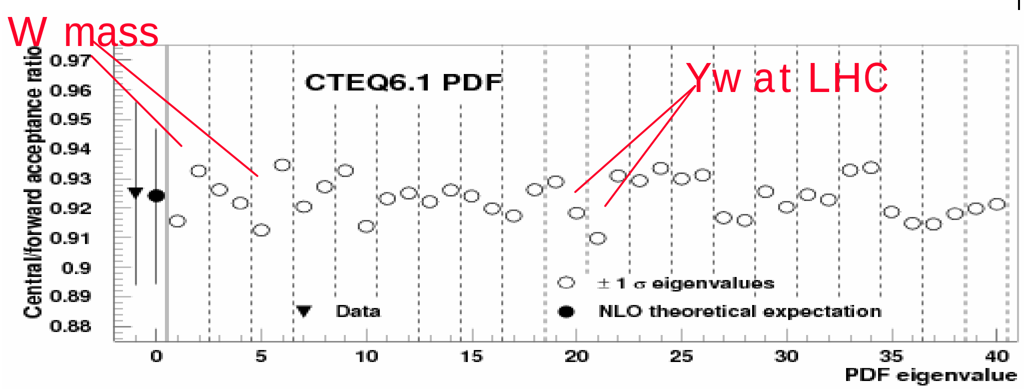
The A_i parameters are correlated and eigenvectors are determined to facilitate uncertainty calculations

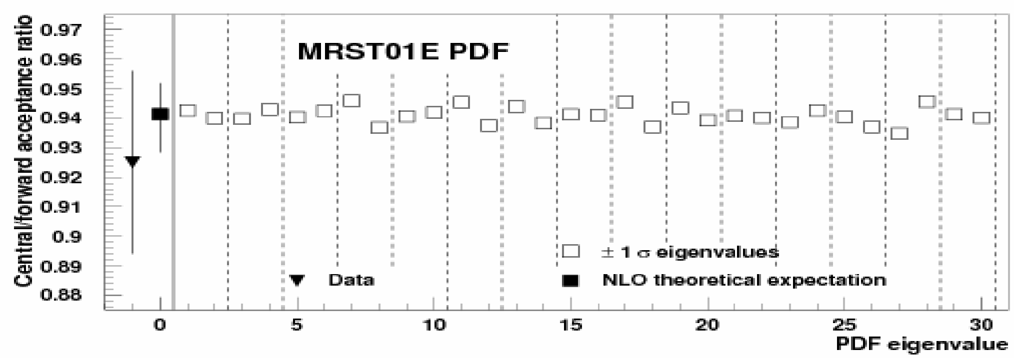
Forward/central can be used

To constrain PDFs:

- Define partial cross section
  - Do not correct for A (PDF, NLO-NNLO effects removed from definition)
  - s_f=718±3±21 pb
  - s_c=664±3±11 pb
- Luminosity uncertainty cancels in the ratio
- R_{exp}=0.925±0.033
- $R_{th}=A^{cent}/A^{forw}$= 0.924±0.037 (CTEQ6.1) 0.941±0.012 (MRST01E)
- R_{tn}(NNLO)= 0.9266±0.0019







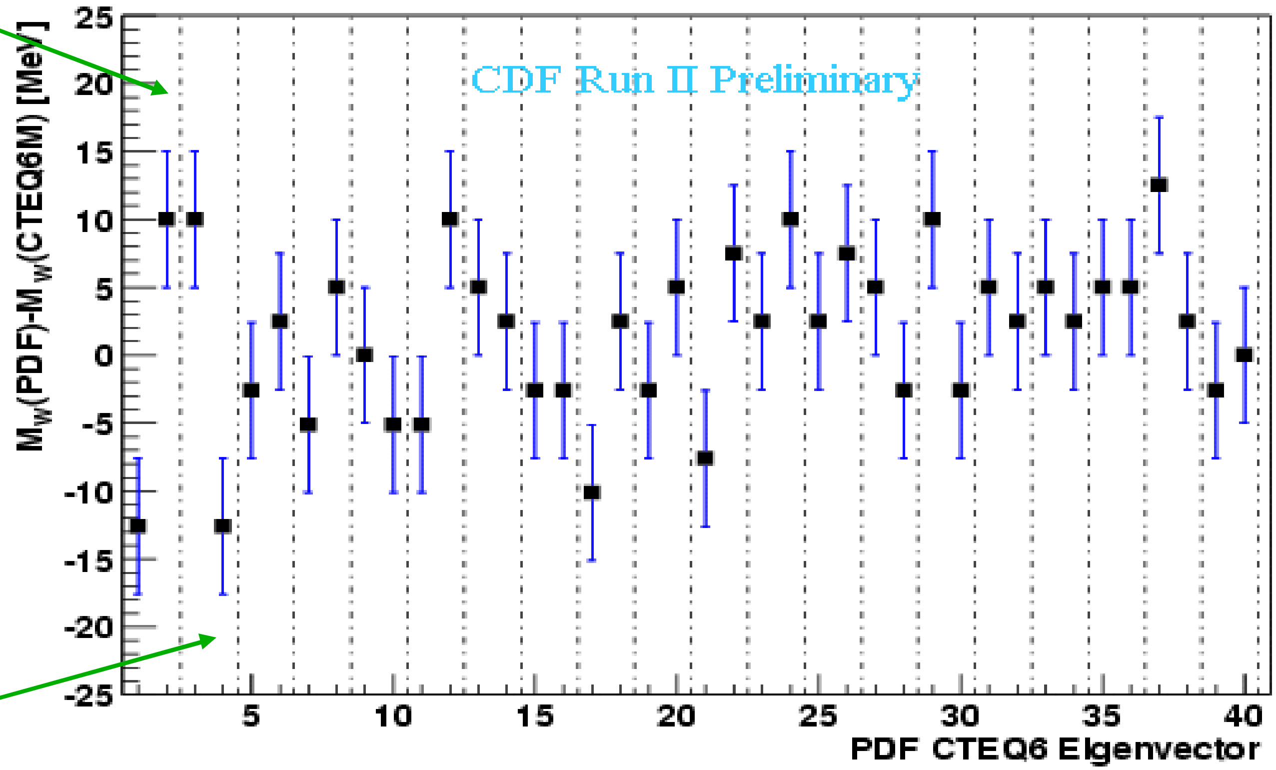
Their impact is not trivial...

W boson mass PDF uncertainty

☞ Improving/constraining will reduce uncertainty

valence up quark

A1: low x

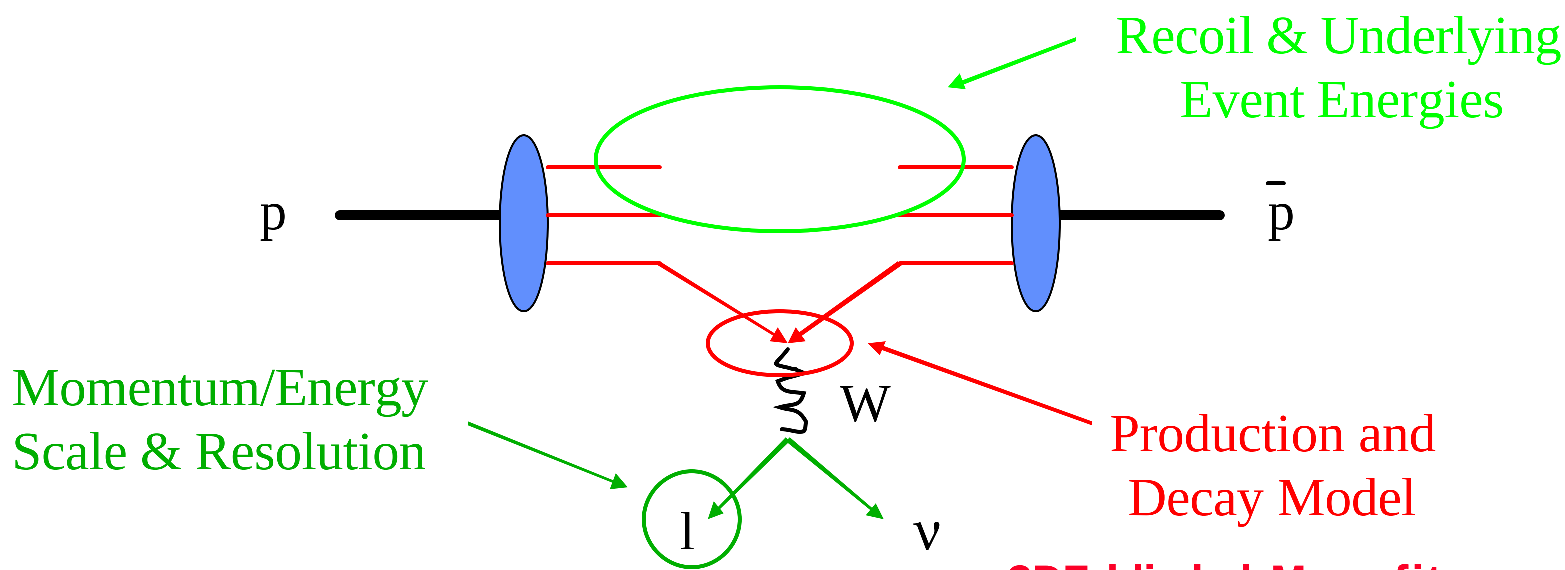


valence down quark,

sea quarks

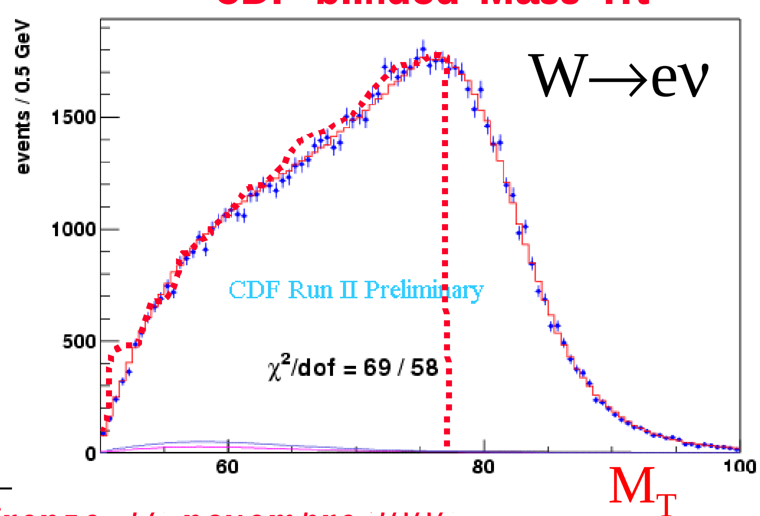
A1: low x

W Mass Measurement



Requires a detailed understanding (~10 MeV) of all aspects of W boson production and detection

CDF blinded Mass fit



W Mass Uncertainties

CDF preliminary syst. uncertainties for 200 pb^{-1}

Currently, estimate a combined 76 MeV uncertainty

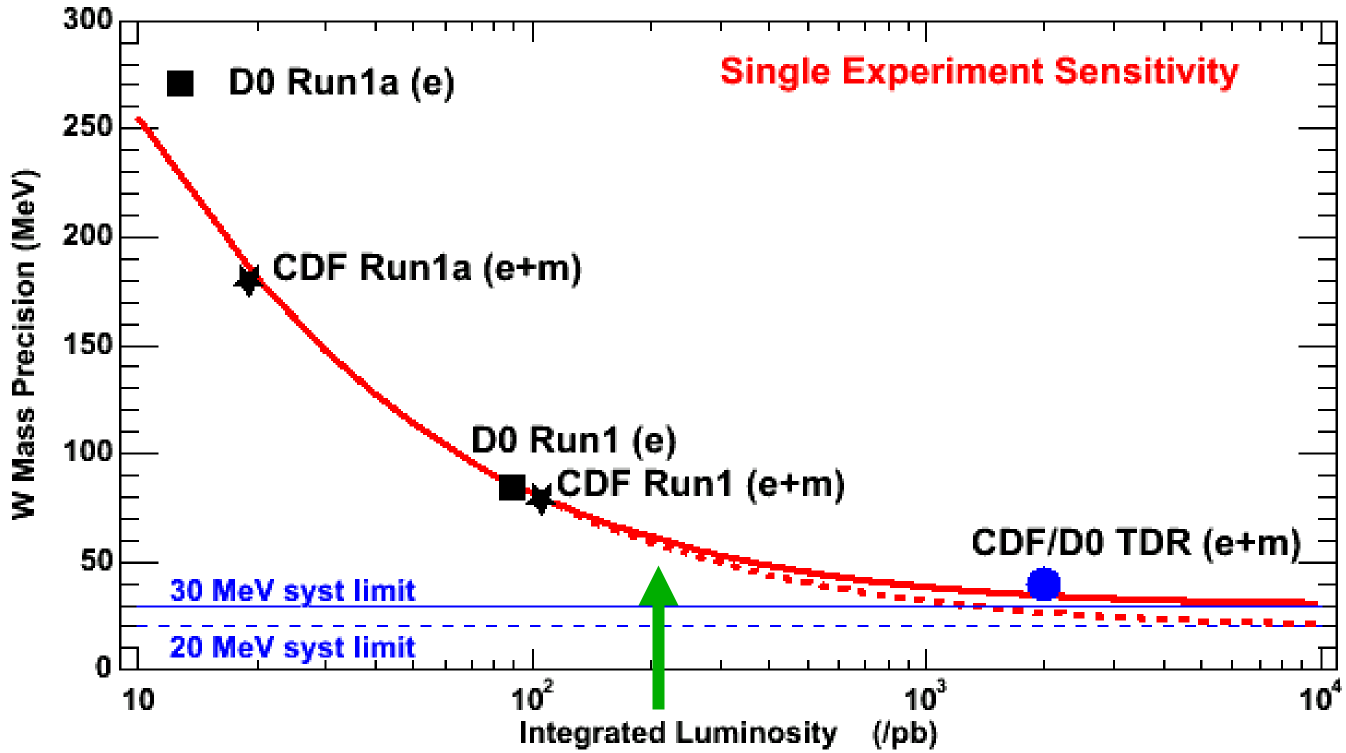
Finalizing analysis and completing exhaustive cross checks

- My prediction:
  - Below 60 MeV

Systematic [MeV]	Electrons	Muons	Common
Lepton Energy Scale and Resolution	70	30	25
Recoil Scale and Resolution	50	50	50
Backgrounds	20	20	
Production and Decay Model	30	30	25
Statistics	45	50	
Total	105	85	60

Improved understanding of the W events will put statistics back into being the most significant contribution to uncertainty

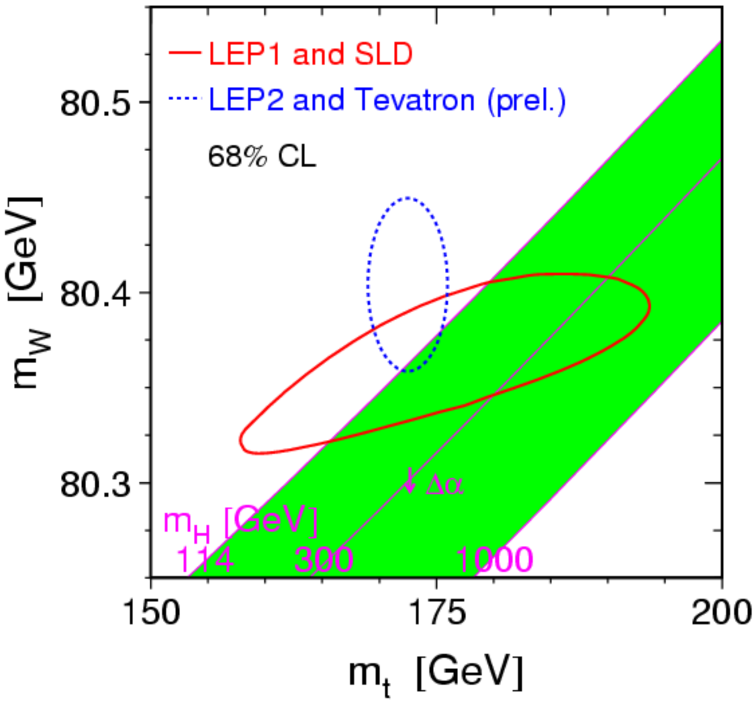
More fb^{-1}...

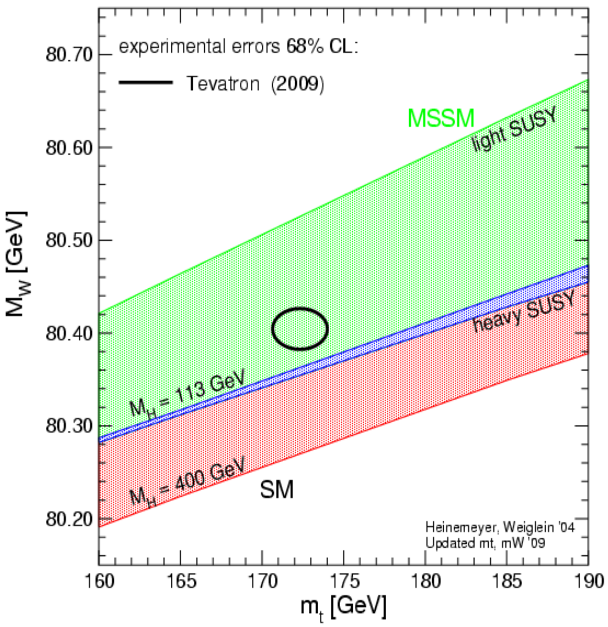


Beyond 1 fb^{-1} overall uncertainty does not improve significantly without better understanding of systematics. However I predict a WA with < 30 MeV soon...

Mw, Mtop, Higgs...

a





CDF, best Mtop:

170.9±1.4(stat)± 1.9(syst) GeV/c^2
[170.9±2.4 GeV/c^2]

TeV combined: 171.4±2.1 GeV/c^2

- CDF aims at controlling individual uncertainties to 10 MeV level to produce overall δM_W=25 MeV.
- D0 expects to achieve δM_W=40 MeV.

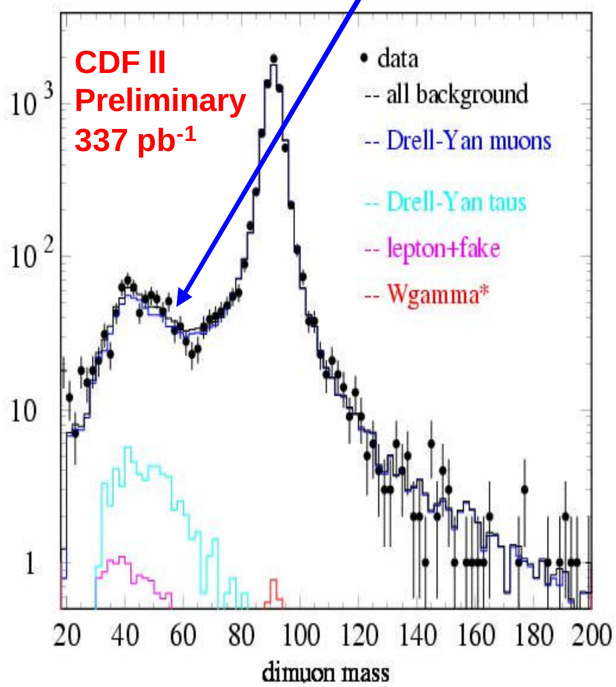
Drell Yan process

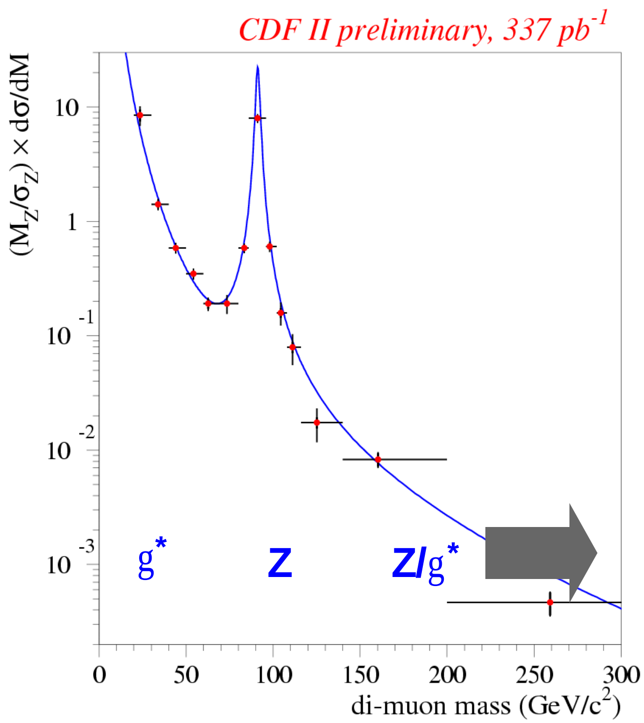
$$p\bar{p} \rightarrow Z/g^{*} \rightarrow l^{+}l^{-} \quad (+X)$$

A standard measurement at hadron colliders :

- control sample for searches (Z', SUSY dilepton channels)
- PDF constraints.

Triggers/cuts distort low mass region





W → τν, Z→ ττ channel

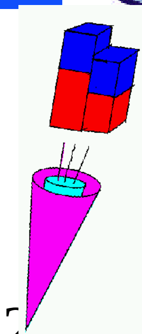
Channel interesting to look for lepton universality etc

- ☞ Experimental challenge
- ☞ Test bed for Higgs (MSSM) searches

W ("easy")

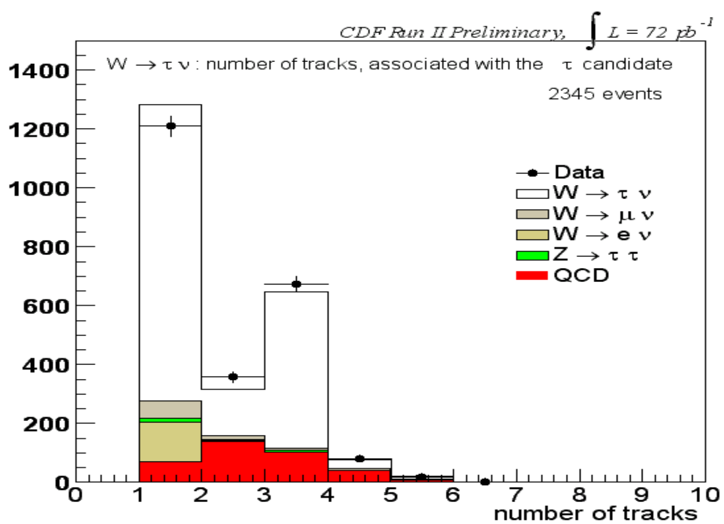
Z (difficult)

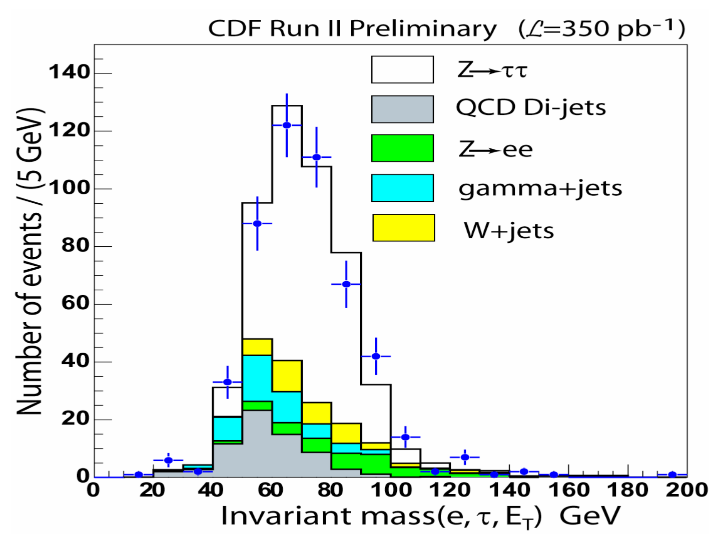
$$Z \to t(e)t(h)$$



$$s_Z \cdot BR(Z \to tt) = 265 \pm 2[illegible]\ (\text{stat})$$
$$\pm 21\ (\text{sys}) \pm 15\ (\text{lum})\ \text{pb}$$

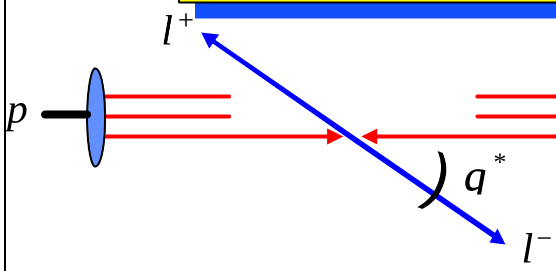
$$s_W \cdot BR(W \to tn) = 2.62 \pm 0.07\ (\text{stat})$$
$$\pm 0.21\ (\text{sys}) \pm 0.16\ (\text{lum})\ \text{nb}$$





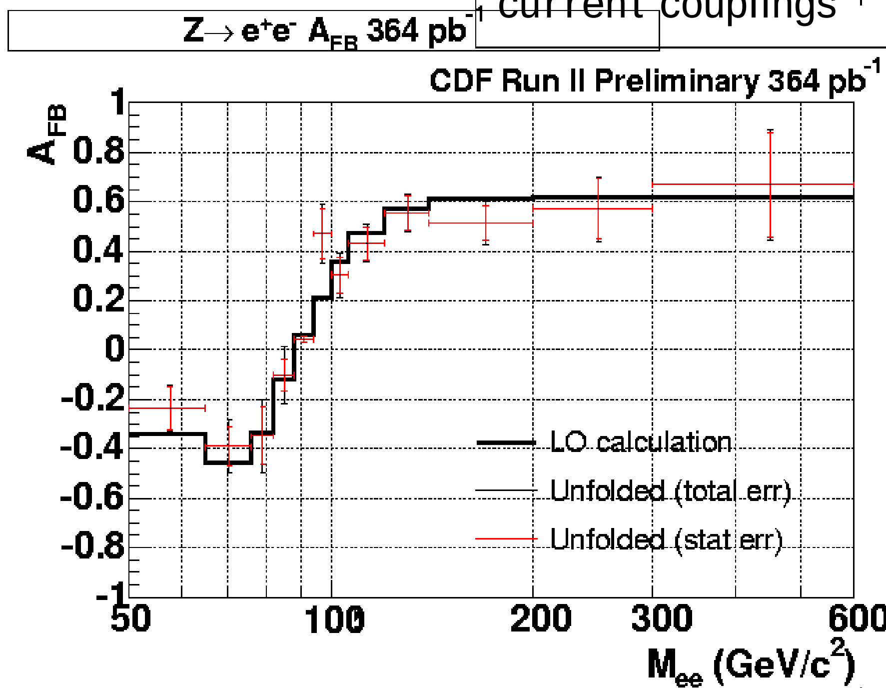
$$\frac{BR(W \to tn)}{BR(W \to en)} = 0.99 \pm 0.04\ (\text{stat}) \pm 0.07\ (\text{sys})$$

A_{FB} Results



$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$

Function of quark & lepton axial and vector neutral current couplings



The relative strengths of the axial and vector couplings of quarks to the Z boson can be extracted from measurement of forward-backward charge asymmetry (A_{FB})

At Tevatron A_{FB} is measured at the Z-pole as well as above and below

Current measurements are statistics limited

The high mass region is of particular interest since this is where new physics can interfere with Standard Model to produce deviations

Diboson production

Production of dibosons in the final state characterize SM processes

- ☞ In some cases a crucial test of the structure
- ☞ Deviations can signal new physics
- ☞ Absence can set boundaries

Production cross section is tiny

- ☞ O(10)-O(1) pb
  - ⇨ In some cases smaller than the ttbar xsec

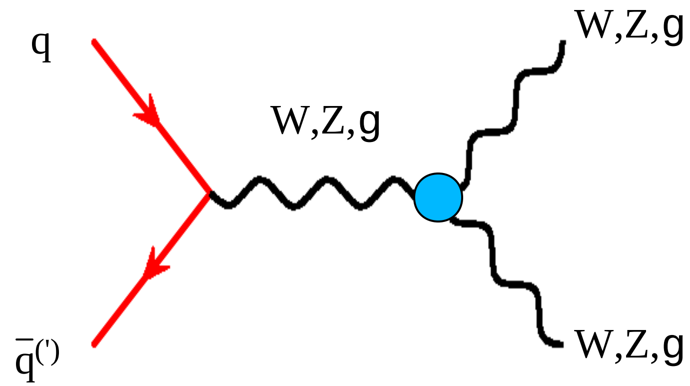
Nevertheless they constitute a background towards the Higgs discovery

- ☞ Wg,Zg,WW,WZ,ZZ
  - ⇨ Wγ,Zγ measured and published (200 pb^{-1}):
    - → Wγ: s(ppbar -> W + ?) = 18.1 ± 3.1 pb
    - → Zγ: s(ppbar -> Z + ?) = 4.6 ± 0.5 ± 0.2 p

Dibosons

Probe non-Abelian nature of $SU(2)_L \otimes U(1)_Y$ via gauge boson self-interactions (triple, quartic)

- Tevatron (ppbar) is sensitive to different combinations of tri-linear gauge couplings than LEP (e^+e^-) and explores higher $\hat{s}$



$$q\bar{q}' \to W^* \to W\gamma \ : WW\gamma \text{ only}$$
$$q\bar{q}' \to W^* \to WZ \ : WWZ \text{ only}$$
$$q\bar{q} \to Z/\gamma^* \to WW \ : WW\gamma\,,\ WWZ$$
$$q\bar{q} \to Z/\gamma^* \to Z\gamma \ : ZZ\gamma\,,\ Z\gamma\gamma$$
$$q\bar{q} \to Z/\gamma^* \to ZZ \ : ZZ\gamma\,,\ ZZZ$$

Absent in SM

Z+γ

Z+g is a complementary channel to W+γ

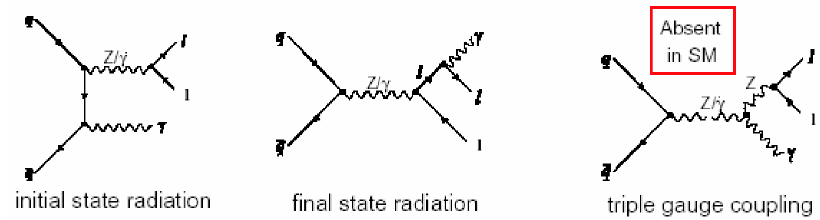
- ☞ Similar SM features but
  - ⇨ There is no radiation amplitude zero

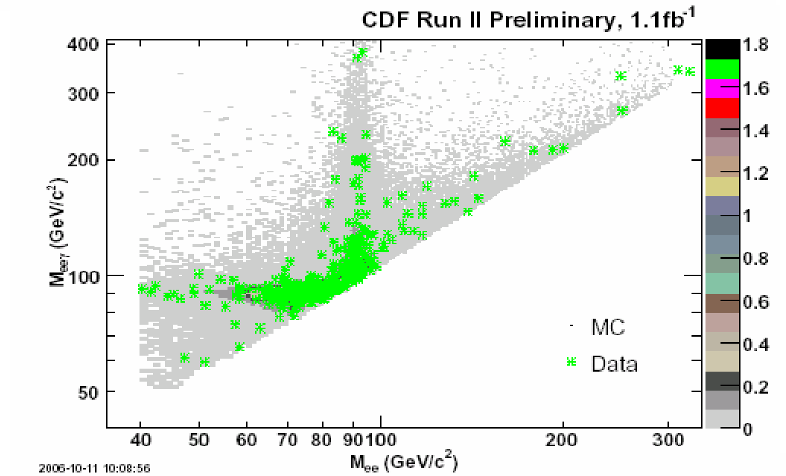
Selection starts with a Z

- ☞ At least one central electron

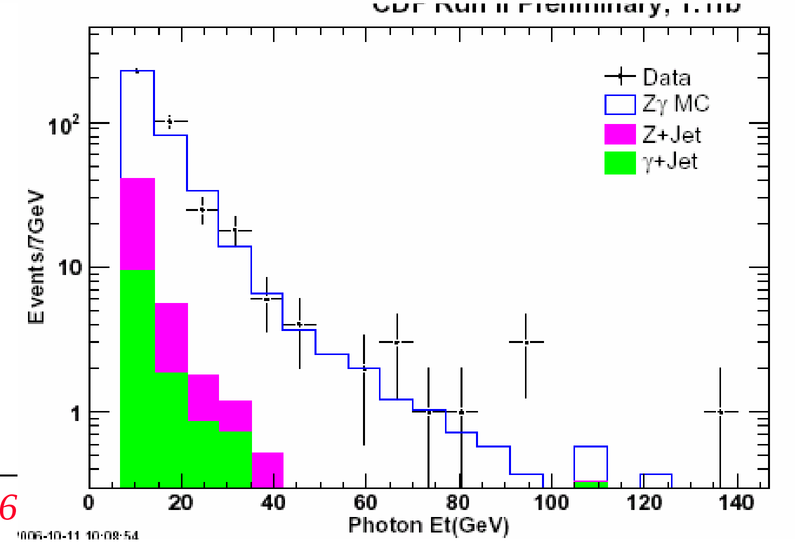
Then require a γ

- ☞ ET>7 GeV, |η|<1.1





$\int \mathcal{L}dt (pb^{-1})$	1074		
$\sigma_{NLO}(pb)$	4.7±0.4		
$Z\gamma$ type	FSR+ISR		
Photon type	Central Photon		
Zee type	CC	CP	CC + CP
$N^{bkg}_{\gamma+Jet}$	1.8 ± 1.2	12.1 ± 5.4	13.9 ± 6.5
N^{bkg}_{Z+Jet}	11.5 ± 4.3	25.6 ± 9.9	37.1 ± 14.3
N^{exp}_{SM}	142.6 ± 7.7	181.2 ± 10.0	323.8 ± 17.3
$N^{exp}_{SM} + N^{bkg}_{QCD}$	155.9 ± 8.9	218.9 ± 15.1	374.8 ± 23.4
N^{obs}	183	207	390
σ^{obs}(pb)			
CC	5.6 ± 0.4 (stat.) ± 0.3 (syst.) ± 0.3 (lum.)		
CP	4.4 ± 0.4 (stat.) ± 0.4 (syst.) ± 0.3 (lum.)		
CC + CP	4.9 ± 0.3 (stat.) ± 0.3 (syst.) ± 0.3 (lum.)		



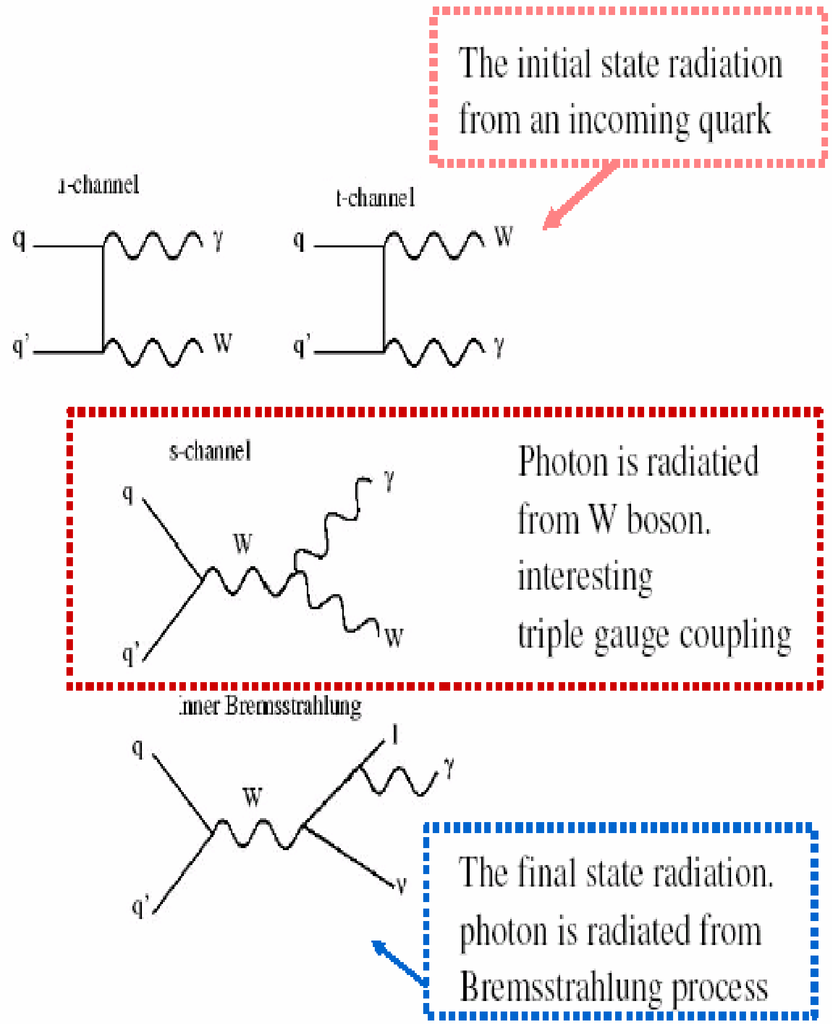
W+γ, 1 fb^{-1}

Recently CDF blessed new results for the W+g analysis with 1 fb^{-1}

- ☞ Old result:

With increase statistics one can look for

- ☞ Deviations from SM
  - ⇨ Kinematics is sensitive to anomalous couplings
  - ⇨ Excess in high pt g
- ☞ Effect of the interference of ISR with s-channel (radiation amplitude zero)



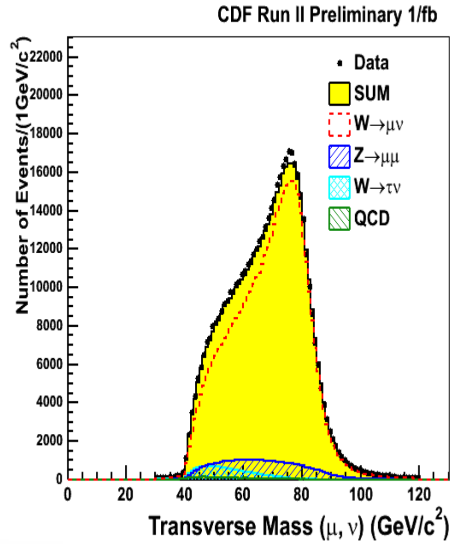
Results W+γ

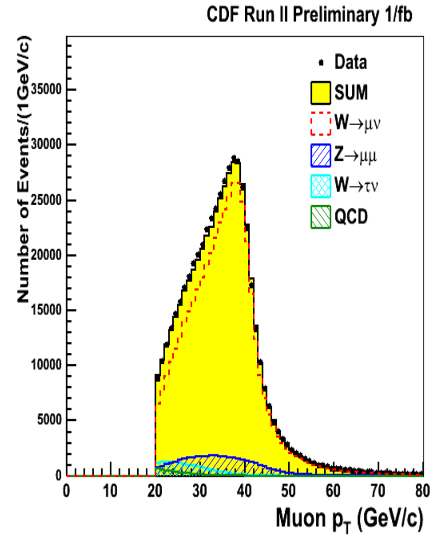
Strategy:
W first, then γ
Select W->μν (20,20)

- Background/yield check

Select g in a given kinematical range

- Et>7 GeV
- |η|<1.1





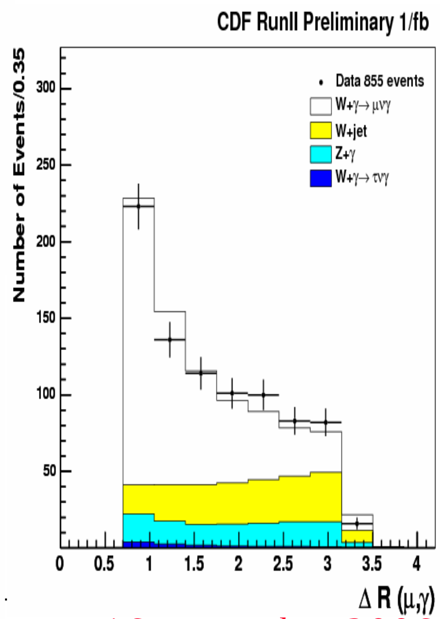
$$\sigma_{W\gamma} = \frac{N_{Data} - N_{QCD} - N_{Z\gamma} - N_{\tau}}{N_{W\gamma}} \times \sigma_{W\gamma NLO}^{E_t>7,\Delta R>0.7}$$

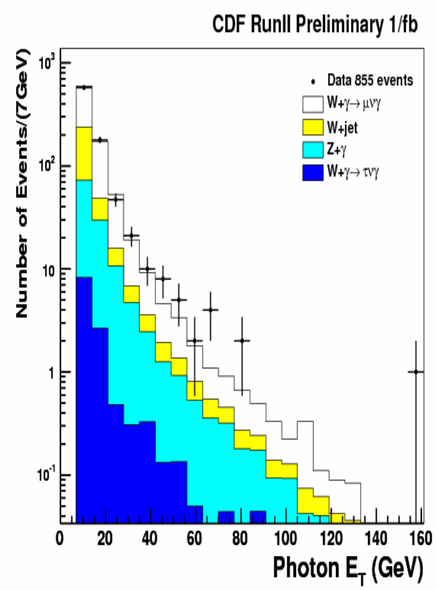
$$N_{W\gamma} = A \cdot \sigma_{W\gamma NLO}^{E_t>7,\Delta R>0.7} \cdot \varepsilon_{all} \cdot \int L dt$$

$$A = \frac{N_{reconst}}{N^{|Z|<60,E_t>7,\Delta R>0.7}}$$

Source	Number of Expected
Data	855
$W\gamma$	542±4.02(stat.)±1.57(sys.)
W+jet	194±0.15(stat.)±66.91(sys.)
$Z\gamma$	112±0.39(stat.)±0.32(sys.)
$W\gamma(\tau)$	12±0.60(stat.)±0.04(sys.)
$\sigma W\gamma$	19.11±1.04(stat.)±2.40(sys.)±1.11(lumi.)

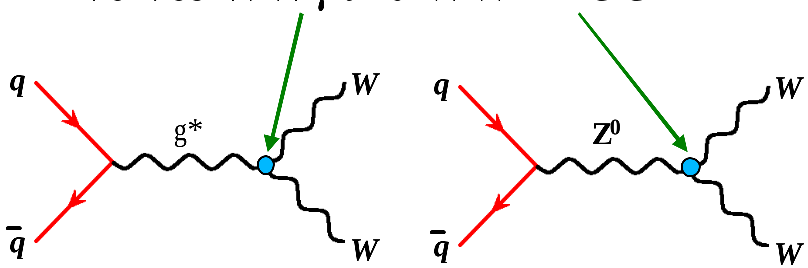
theoretical NLO cross section : 19.3+-1.4 pb

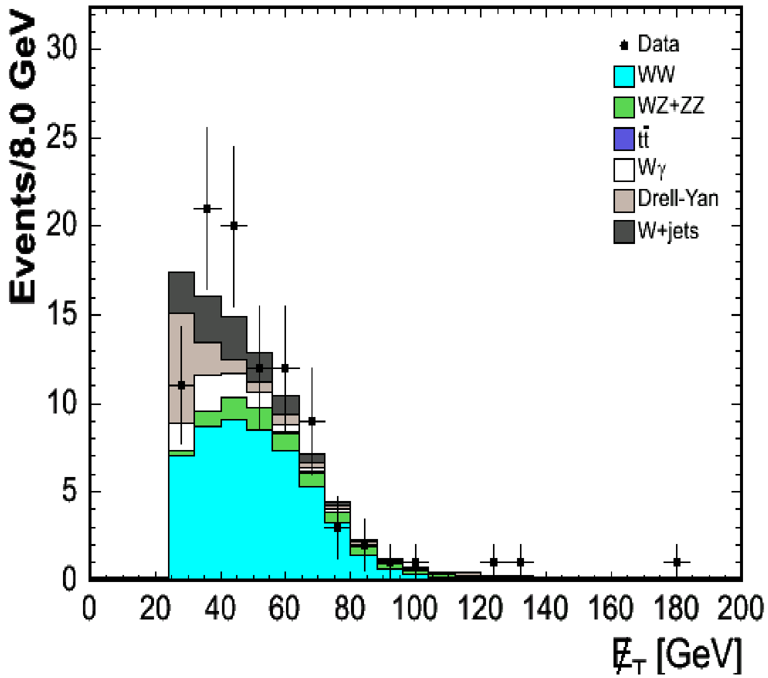




WW Production

Involves WWγ and WWZ TGC





- New CDF cross section measurement (825 pb^{-1})
- Require two opposite sign leptons and large missing E_T
- Expect 38±5 background and 52±4 signal events
- Observe 95 events

$$\sigma(p\bar{p} \rightarrow WW) = 13.6 \pm 2.3(stat) \pm 1.6(syst) \pm 1.2(lum)\ pb$$

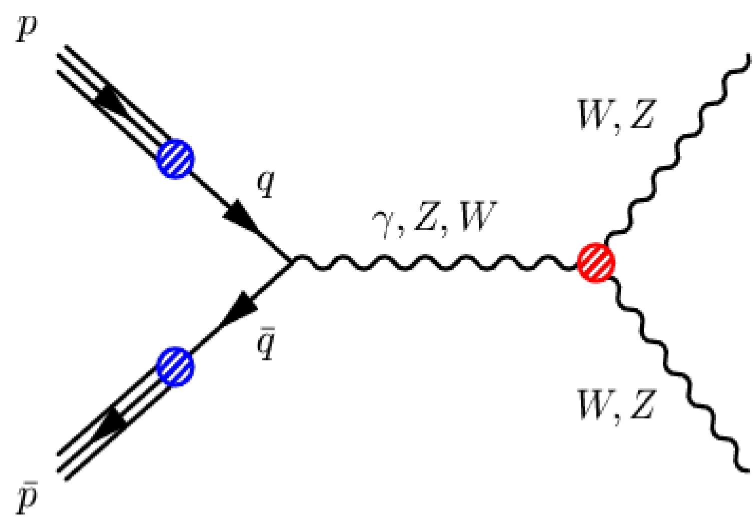
NLO cross section: 12.4 ± 0.8 pb

Campbell,Ellis, Phys.Rev. D60 (1999) 113006

WZ Production

Involves a single tri-linear gauge coupling not accessible at LEP

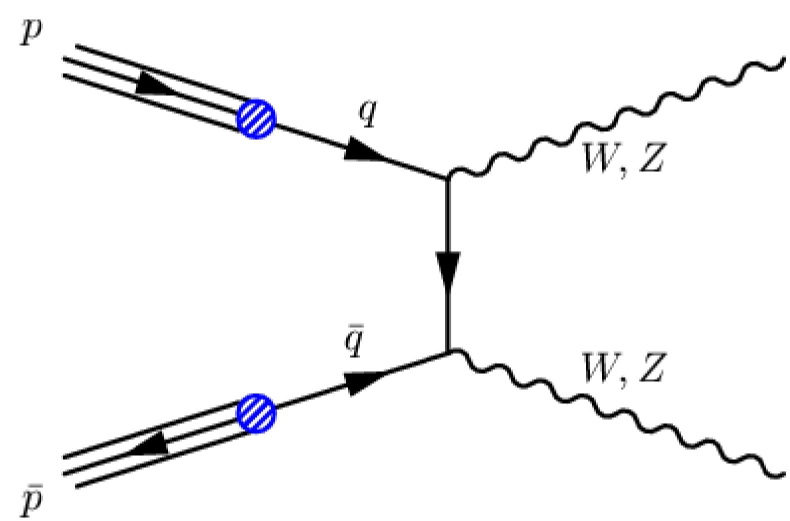
Measure WWZ coupling independent of WWγ



CDF searched using three lepton plus Missing E_T signature (825 pb^{-1}).

Observed 2 events with an expected background of 0.9 ± 0.2 events and signal of 3.7 ± 0.3 events

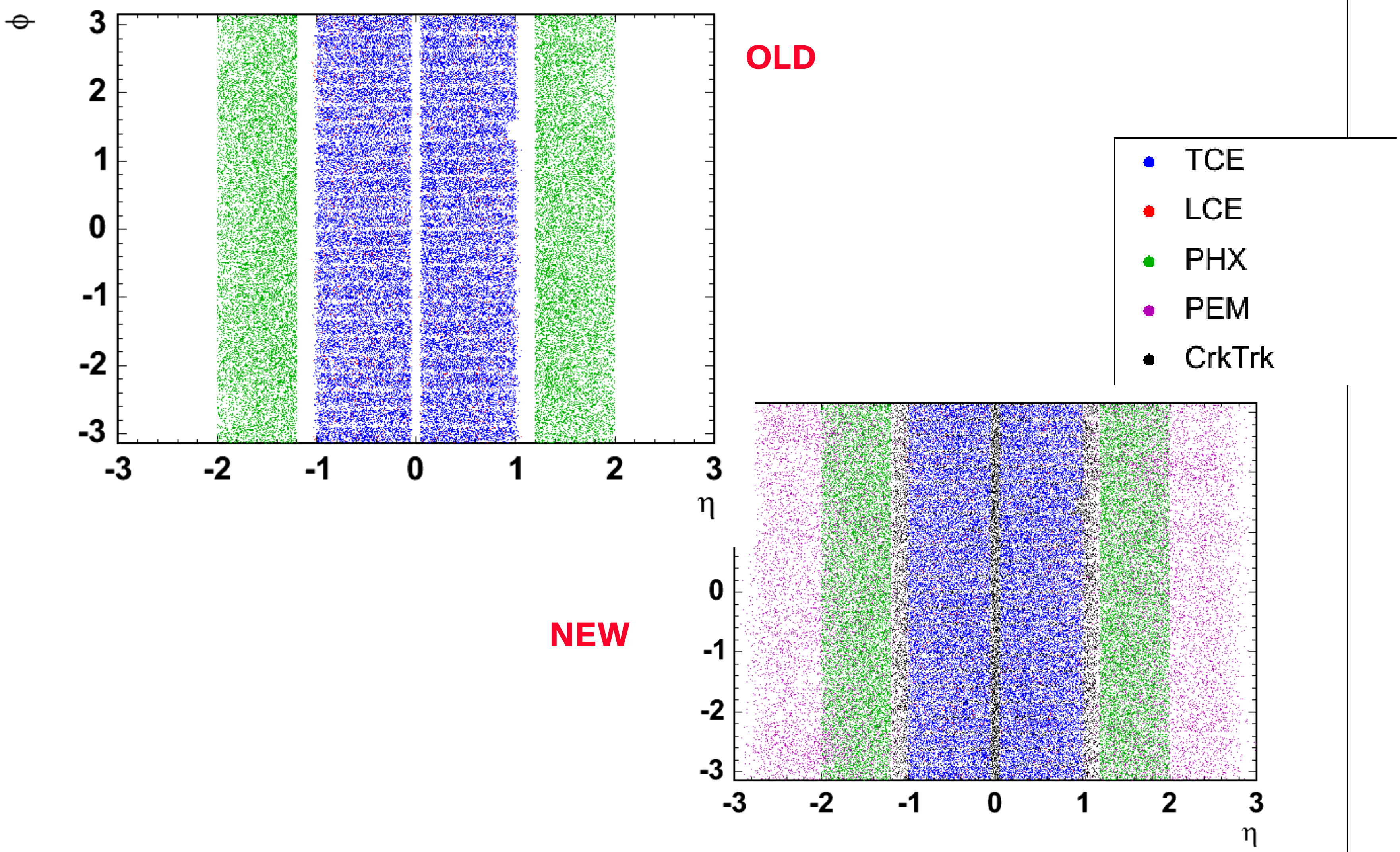
OLD RESULT



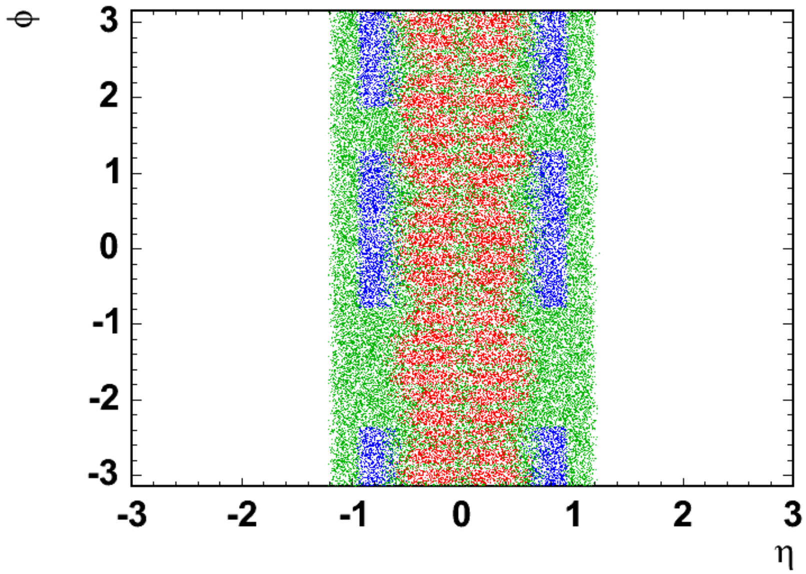
s (WZ) < 6.34 pb (95% C.L.)

Poor acceptance for leptons

Electrons: eta-phi

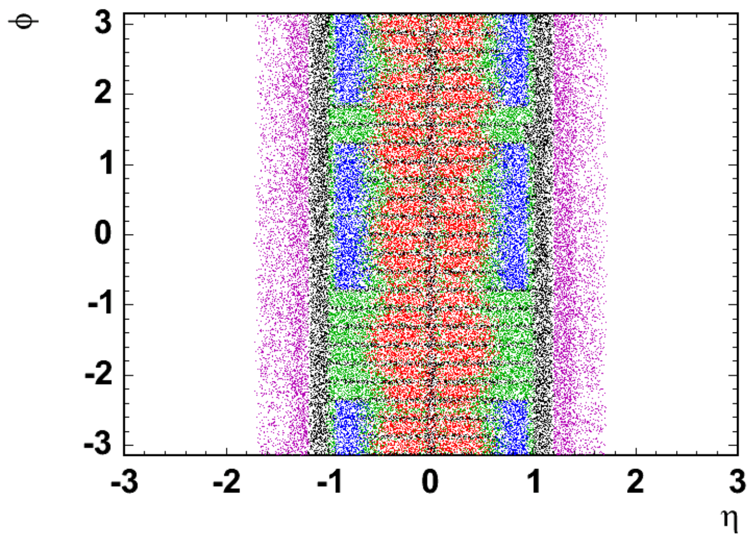


Muons : eta-phi



OLD

NEW



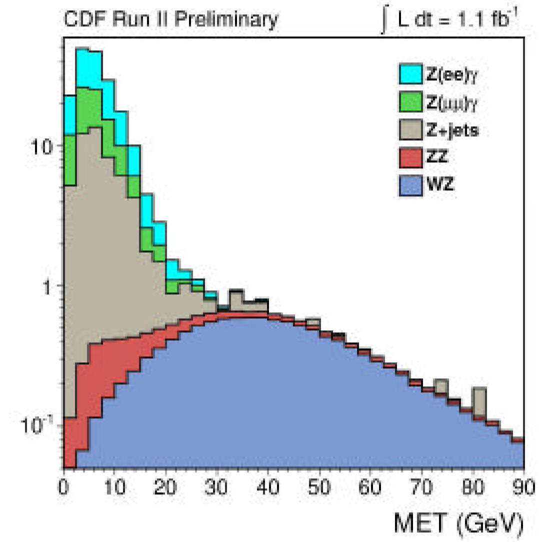
WZ selection

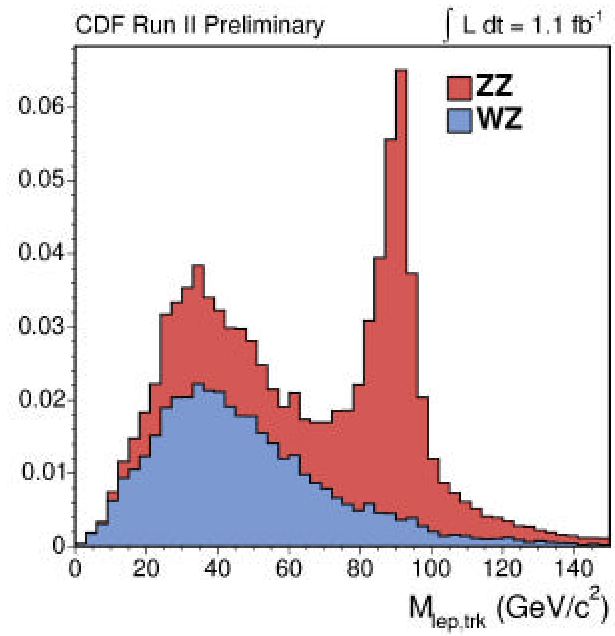
WZ->lllν Selection:

- 3 leptons (e,μ) with Pt > 20,10,10 GeV
- Z mass region:
  - =1 opp-sign, same flavor lepton pair in (76, 106)
  - ZZ Veto: Mlep,trk not in Z mass region (76, 106)
  - ep,trk = invariant mass of non-Z ("W") lepton and an additional track high pT loose (> 8 GeV)
- Δϕ(MET, nearest lepton or jet) > 0.16
- MET > 25 GeV

Backgrounds from Z+jets estimated by applying our P(jet+fake lepton) to dilepton + denominator data

- Other backgrounds estimated using Monte Carlo



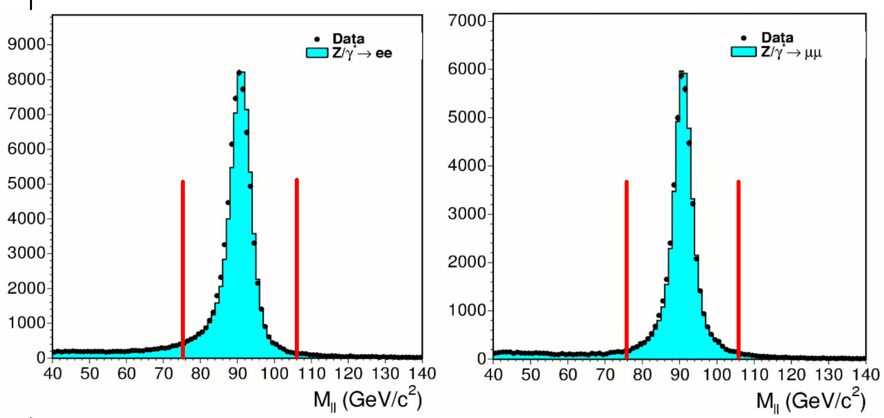


W/Z Control/Signal Region

W? Z^0 → l±l+l- + E_T Signal Region:

- Z region (76 < M_{ll} < 106)
- E_T > 25 GeV

Dilepton (Drell-Yan) Region:



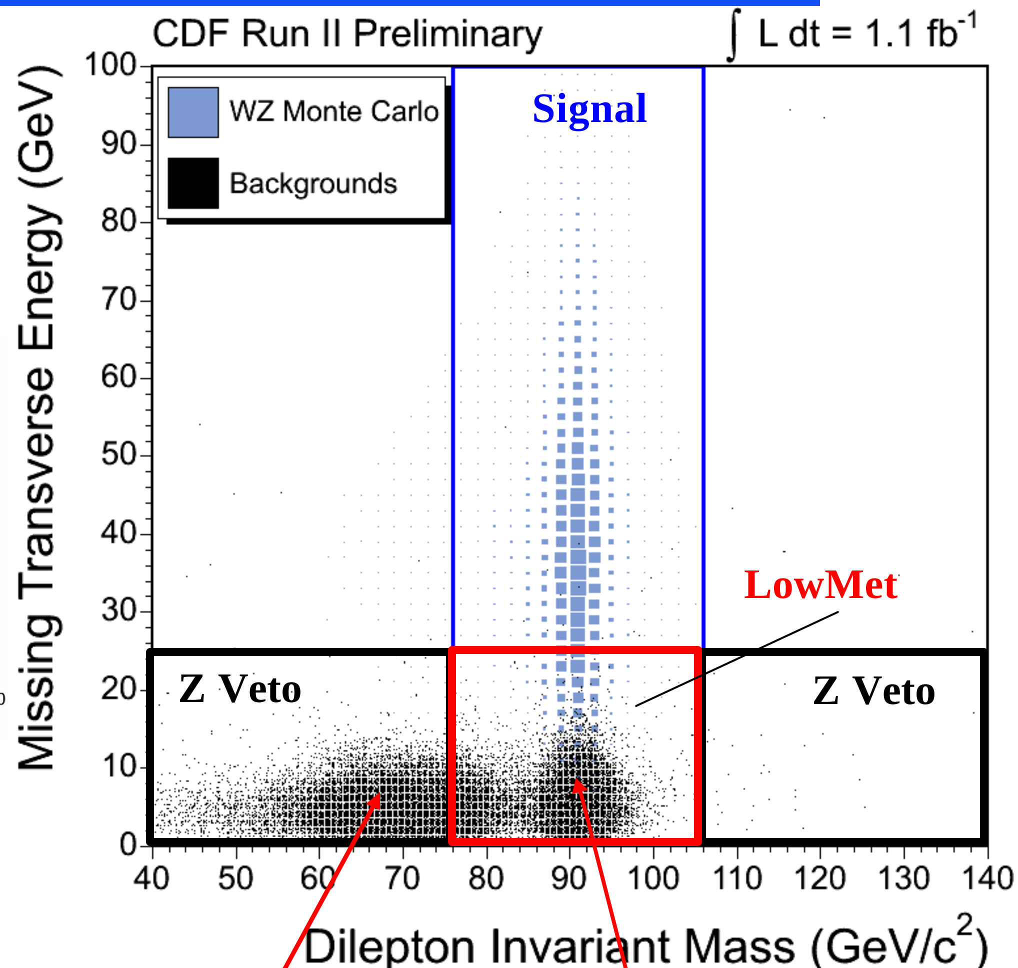
Trilepton Control regions:

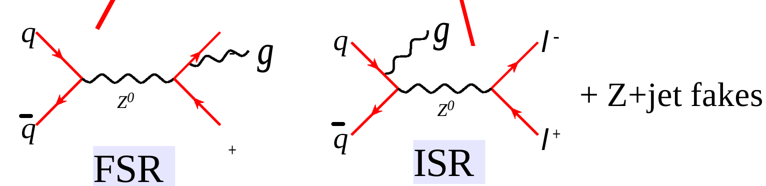
Low MET Region: —— Zγ ISR, Z+jet fakes

- Invert MET cut

Z Veto Region: —— Zγ FSR dominated

- Invert Z mass cut
- Invert MET cut





Results: WZ->lllν

Signal Region (MET>25 GeV)
1-bin counting:

- ☞ Prob(background only) < 1.5 10^{-7} (5.1 σ)

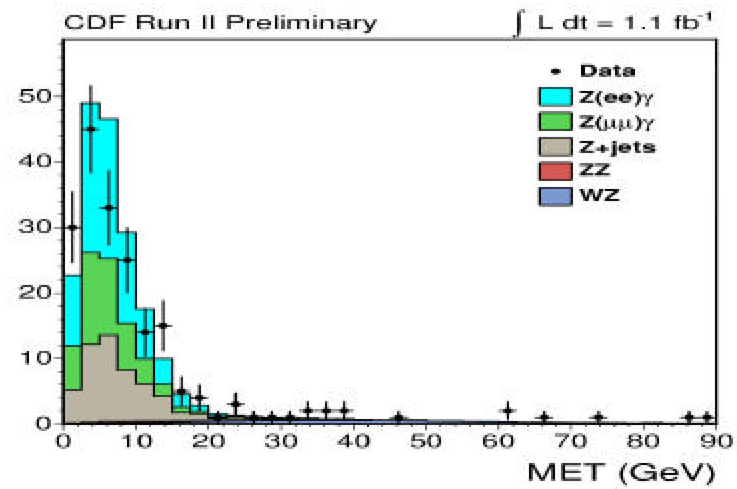
Two bins in MET:

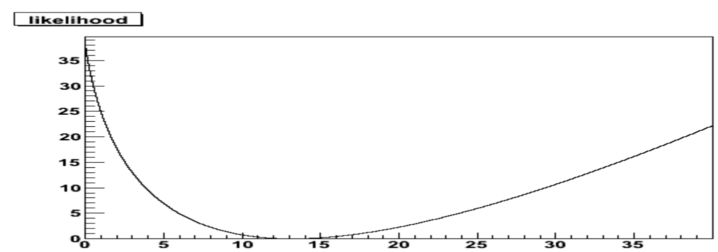
- ☞ Nobs(25 < MET < 45 GeV) = 9
- ☞ Nobs(45 < MET < ? GeV) = 7
  - ⇨ Prob(background only) < 2 10^{-9} (5.9 σ)

First observation of WZ production!

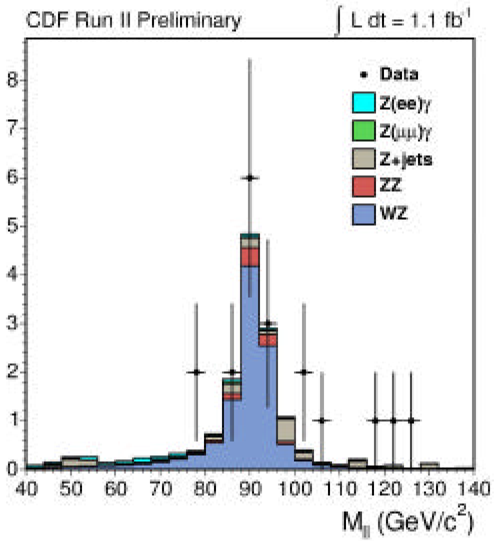
- ☞ We also note that our 2-bin result is ordinary for SM WZ+bkg.
  - ⇨ We find 49% of 10k pseudo-exp's have a joint 2-bin probability smaller than our data

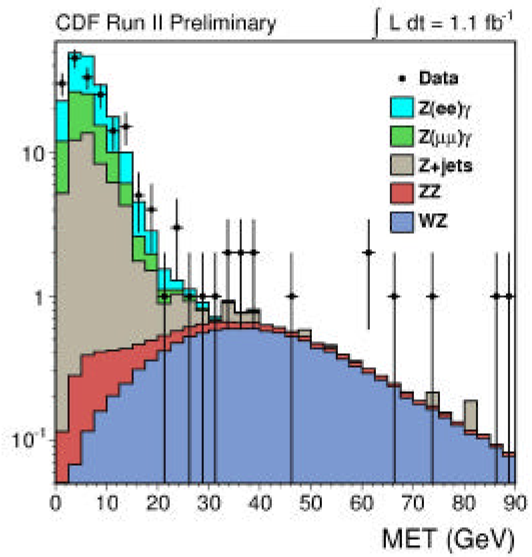
Source	Expectation ± Stat ± Syst ± Lumi
Z+jets	1.22 ± 0.27 ± 0.28 ± -
ZZ	0.89 ± 0.01 ± 0.09 ± 0.05
$Z\gamma$	0.48 ± 0.06 ± 0.15 ± 0.03
$t\bar{t}$	0.12 ± 0.01 ± 0.01 ± 0.01
WZ	9.79 ± 0.03 ± 0.31 ± 0.59
Total Background	2.70 ± 0.28 ± 0.33 ± 0.09
Total Expected	12.50 ± 0.28 ± 0.46 ± 0.68
Observed	**16**

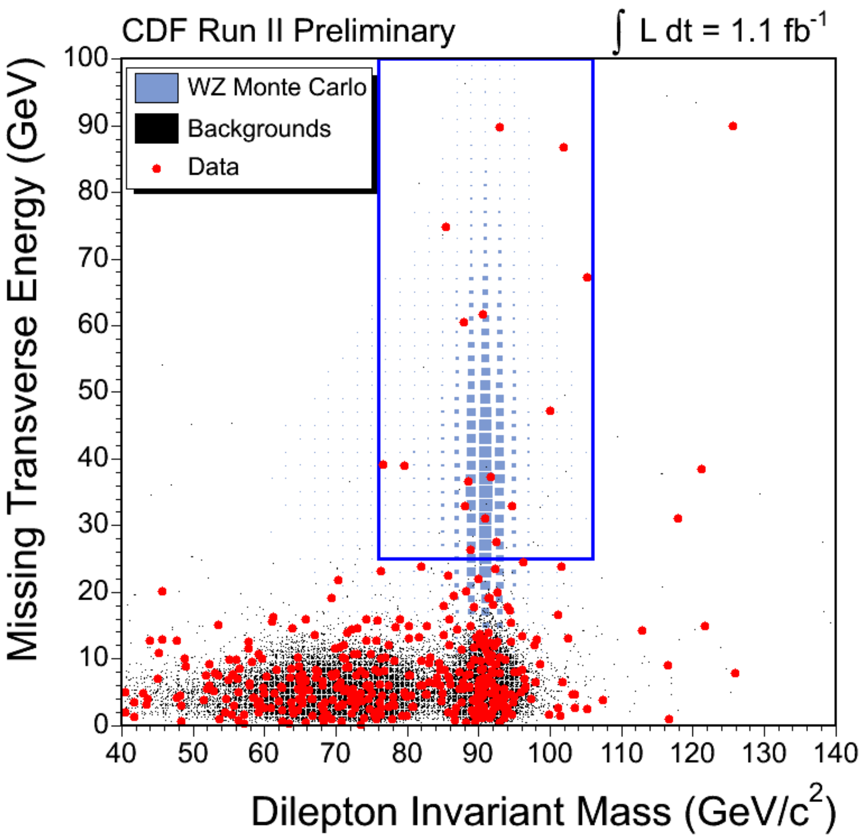




Results: $WZ \rightarrow l l^+ l^- \nu$







$$s = 5.0^{+1.8}_{-1.6}(stat. + syst)\, pb$$

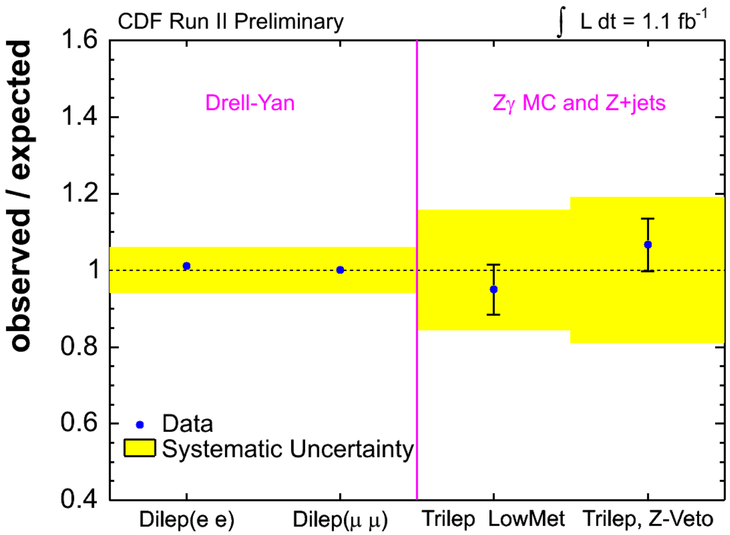
consistent with NLO
σ(WZ) = 3.7±0.3 pb

Check: background

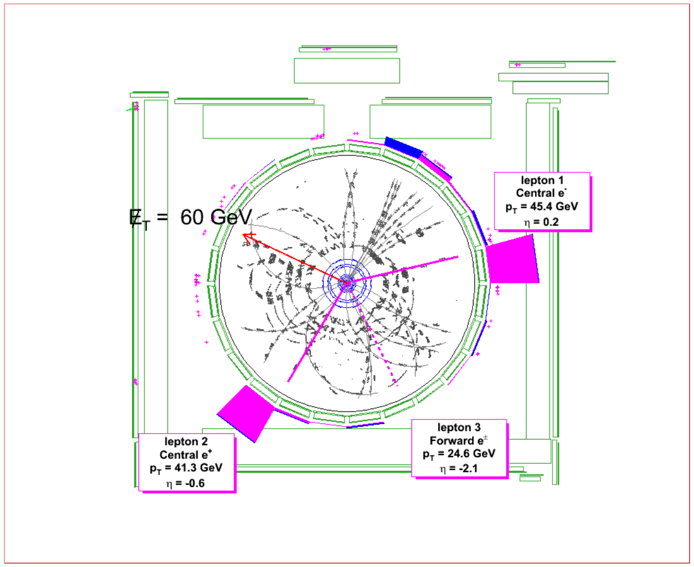
We performed a number of checks to verify our understanding of the back. Contr:

- Low ET region in trilepton sample, Z mass window
  - ⇨ Contribution from Z+γ ISR, Z+jet
- Low Et region in trilepton sample, Z mass veto
  - ⇨ Zγ FSR

Source	Low MET	Z Veto
ZZ	2.2	0.4
Zg	157.5	201.6
Z+jets	63.8	23.3
WZ	2.8	0.3
Total exp.	226.3±35.7	225.9±43.2
Observed	215	241



WZ cand: eee event (PEM)



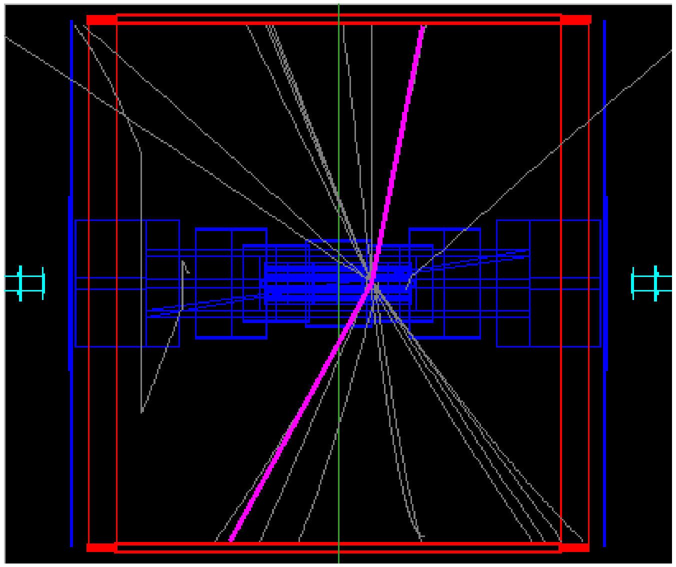
Run=154799 Event=1795709

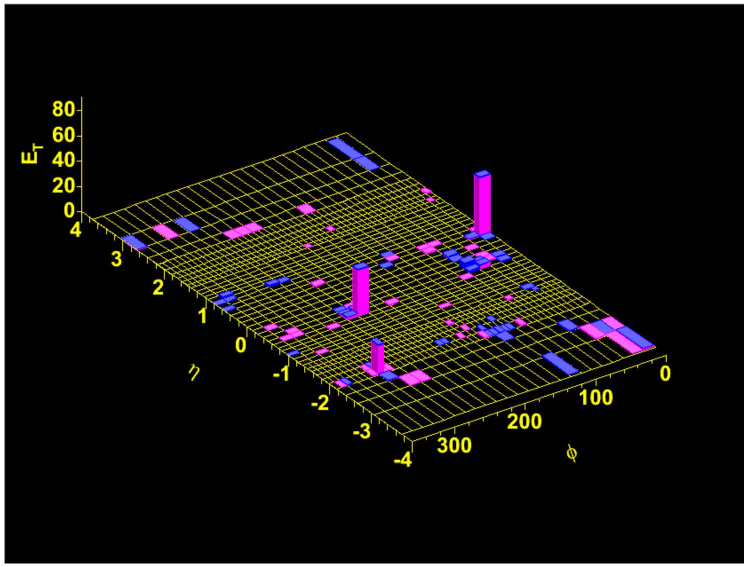
m_{12}=87.91 GeV $|\not{E}_T|$=60.5 GeV

m_{13}=104.37 GeV $\Delta\phi(\not{E}_T, \text{lepton}, \text{jet})$=1.5

m_{23}=59.62 GeV

Type	p_t	η	ϕ
Central e	45.4	0.2	0.2
Central e	41.3	-0.6	-2.1
Forward e	24.6	-2.1	-1.1

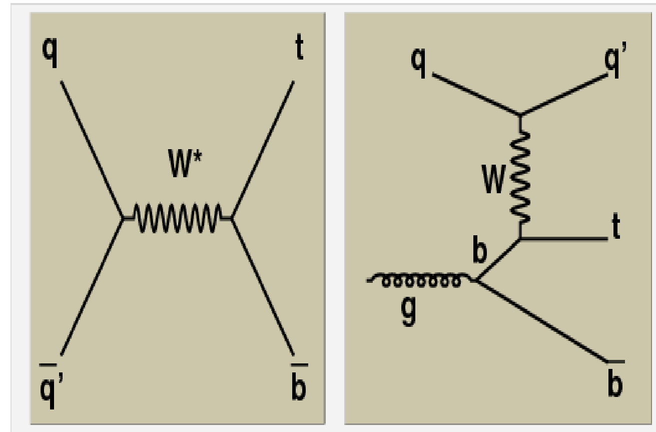


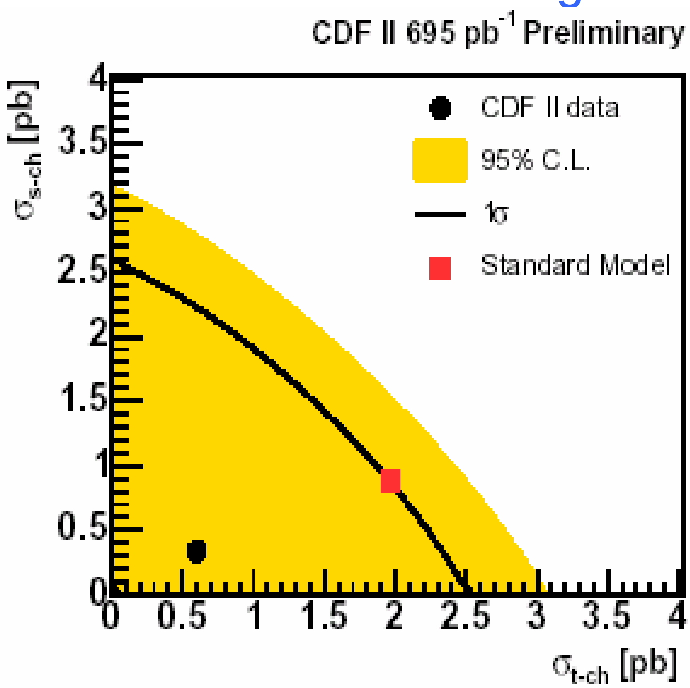


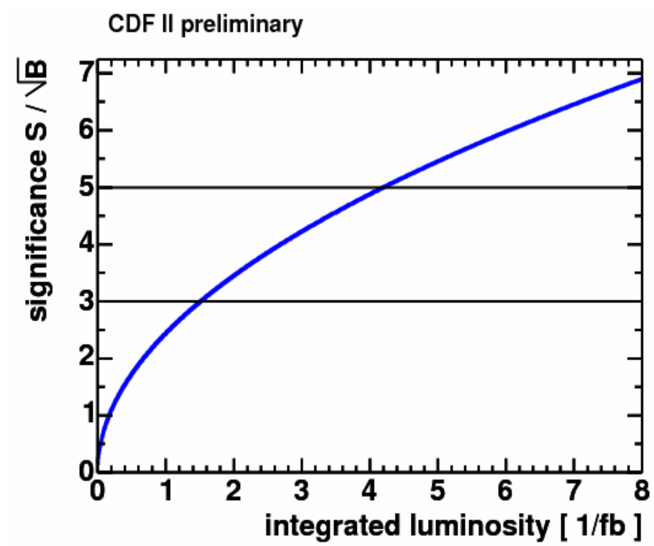
Alcune misure in corso - I I

Single top

- Produzione EWK di top
- s (s+t)<3.4pb@95%CL [0.7 fb^{-1}]
- t channel < 3.1 pb
- s channel < 3.2 pb
  - ⇨ Limiti nell'ipotesi di assenza di single top



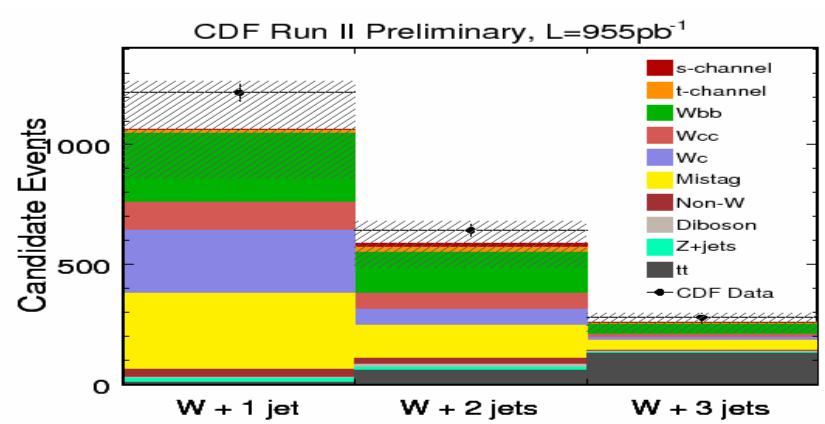


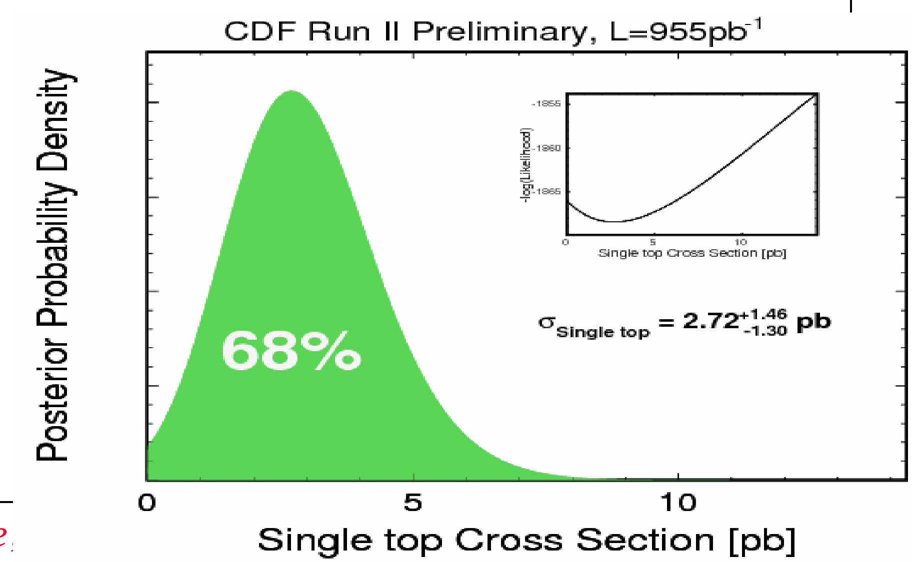


Recent results

CDF recently blessed two analyses on the search for single top (s+t combined), both based on 955 pb-1

- ☞ One uses a multivariate method.
  - ⇨ Negative result (limit <2.7 pb@95% CL)
- ☞ The other sees “evidence” (2.3 s) (consistent with background only at 1%)
  - ⇨ Upfront: given the statistics they are consistent

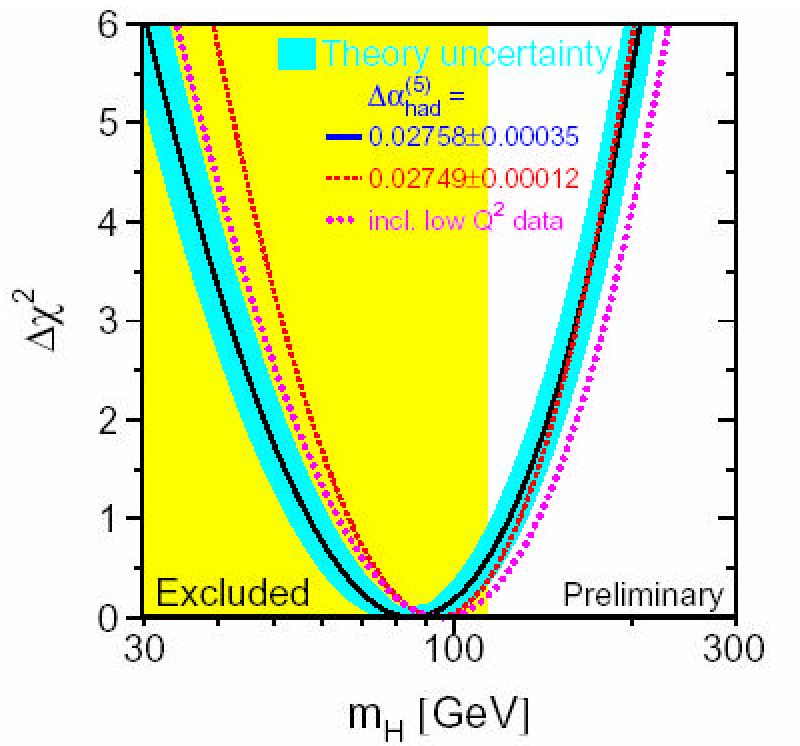




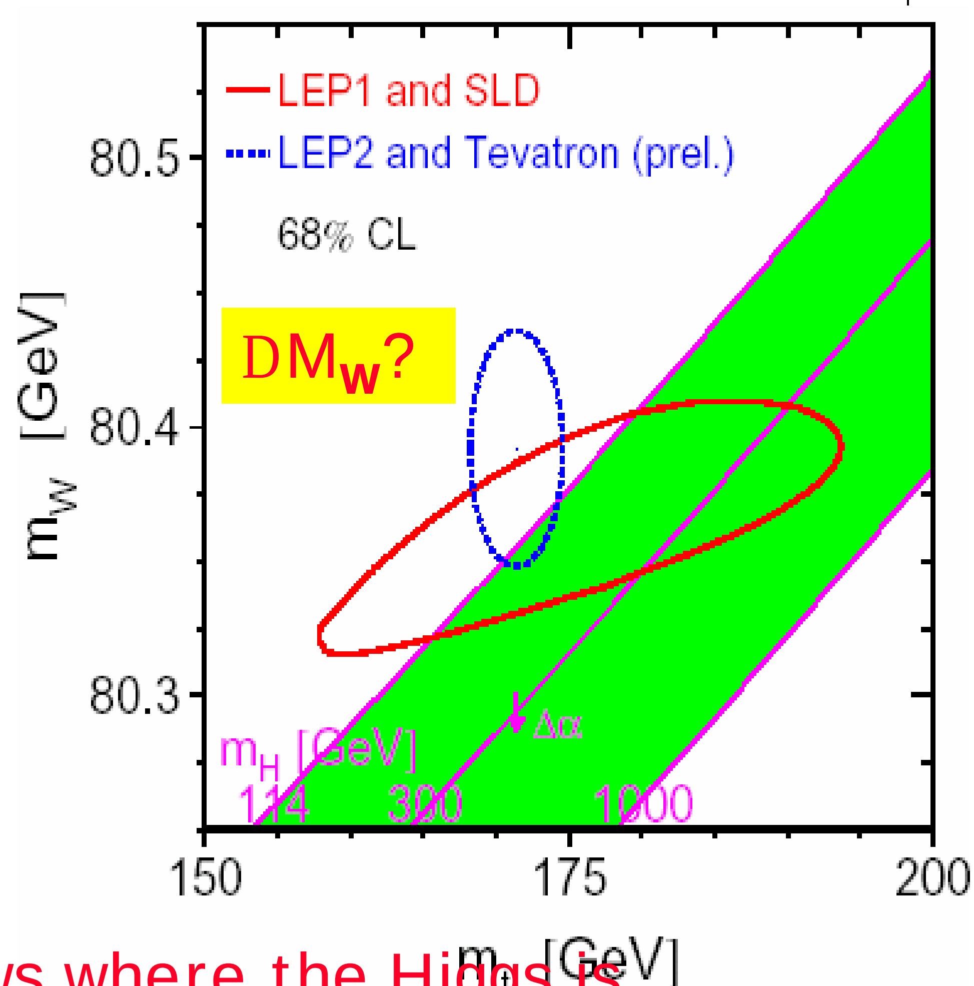
Next...Higgs

This is our contribution..

- $M_H < 199$ GeV/c^2 @95% CL



Of course we can do better



Nobody knows where the Higgs is

Conclusion

CDF is exploiting the good performance of the Tevatron to explore the features of the EWK processes

- ☞Precision tests of the SM
- ☞Probe to better understand QCD processes
- ☞Testing new tools for O(1pb) physics
  - ⇨Higgs?
- ☞Last but not least...
  - ⇨Better define what is “Beyond the Standard Model”..