Electroweak Measurements at the Tevatron

Kristian Harder

CCLRC
Rutherford Appleton Laboratory

for the CDF and DØ Collaborations

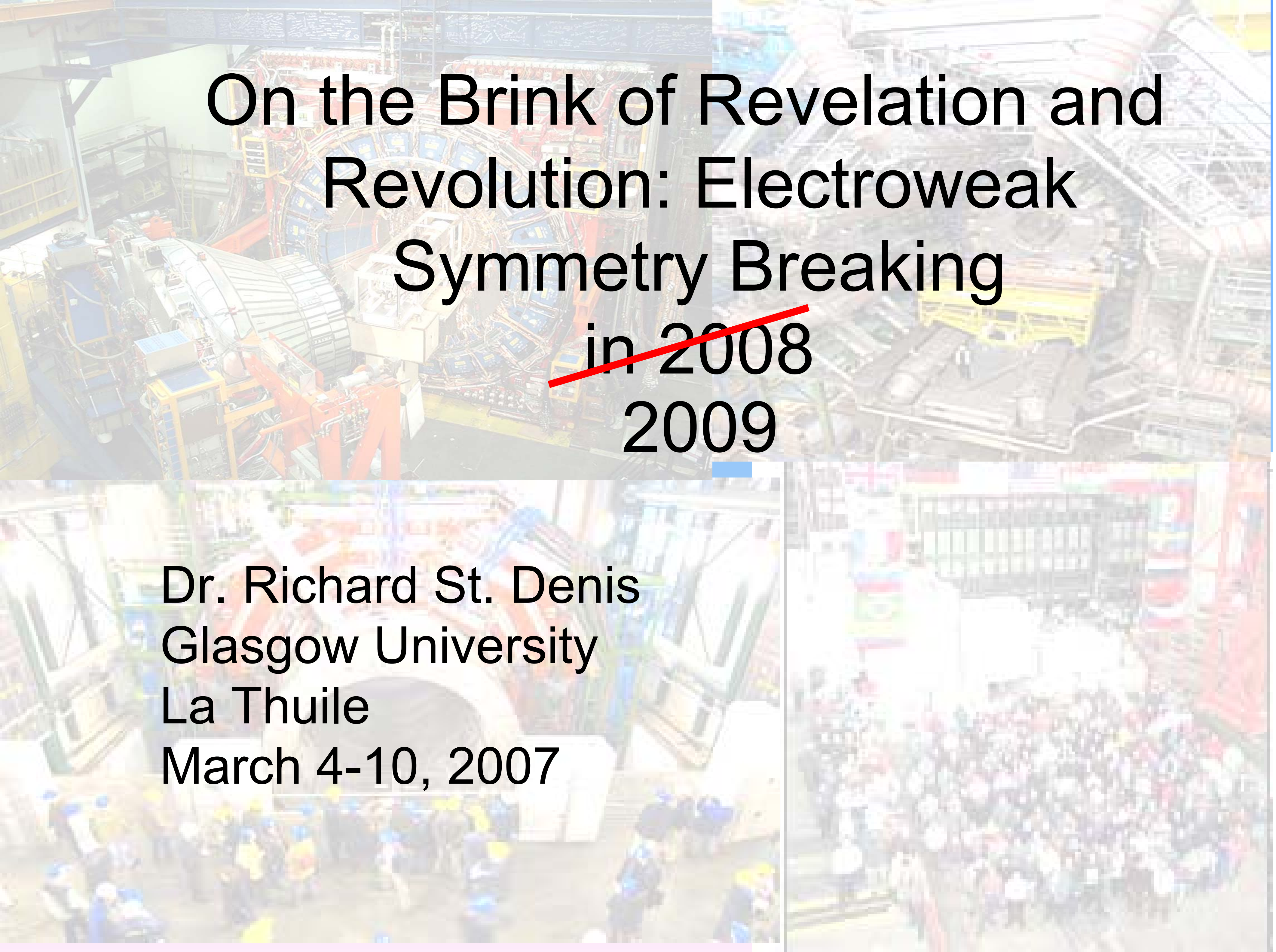
Les Rencontres de Physique de La Vallée d'Aoste, La Thuile, 7 March 2007

Precision Measurement of the *W* Boson Mass with CDF

Chris Hays,
University of Oxford

Les Rencontres de Physique de la Vallee d'Aoste

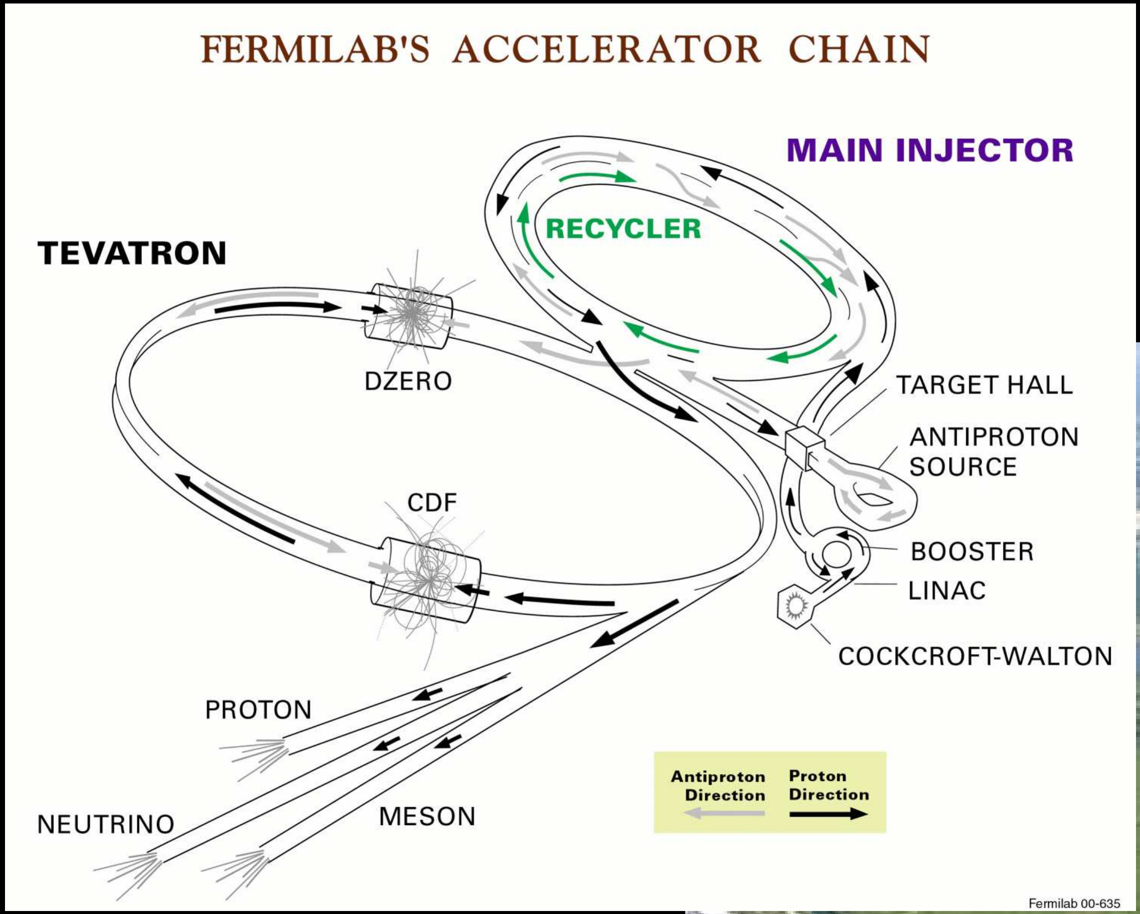
March 7, 2007



On the Brink of Revelation and Revolution: Electroweak Symmetry Breaking ~~in 2008~~ 2009

Dr. Richard St. Denis
Glasgow University
La Thuile
March 4-10, 2007

Where the fb^{-1} are coming from



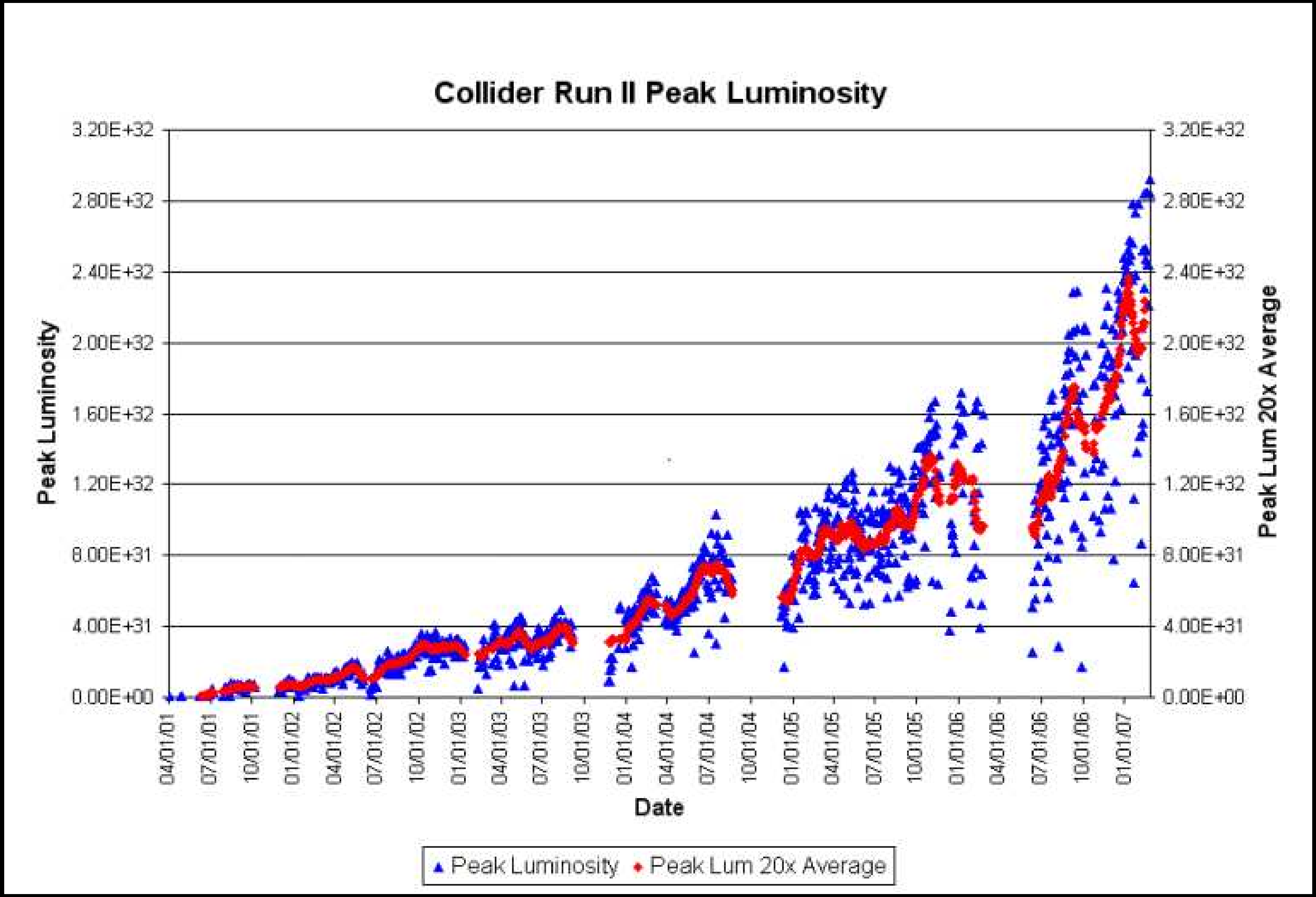
Fermilab 00-635

Fermilab's Tevatron:

2 km diameter $p\bar{p}$ collider

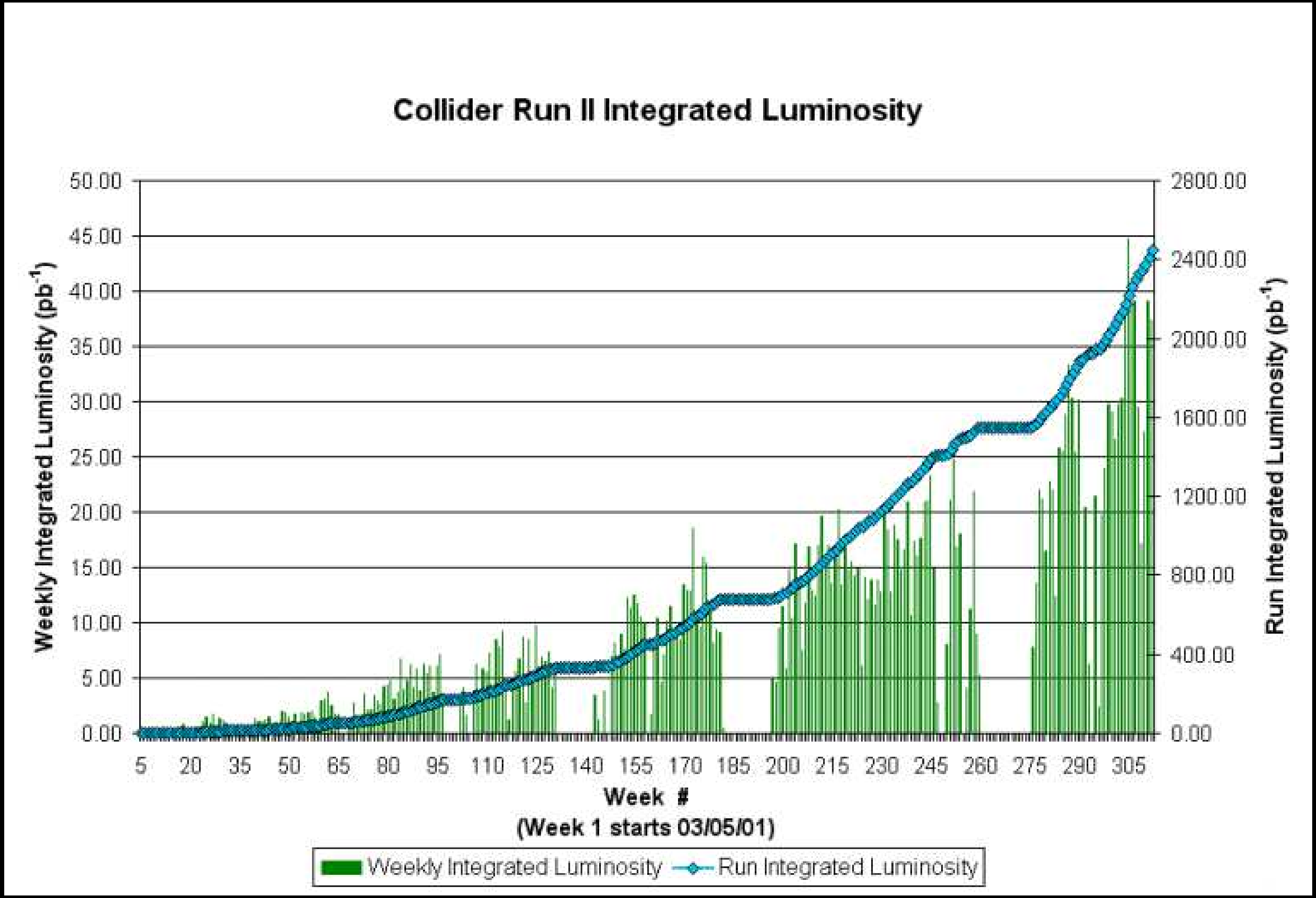
centre of mass energy 1.96 TeV

Tevatron performance: peak lumi



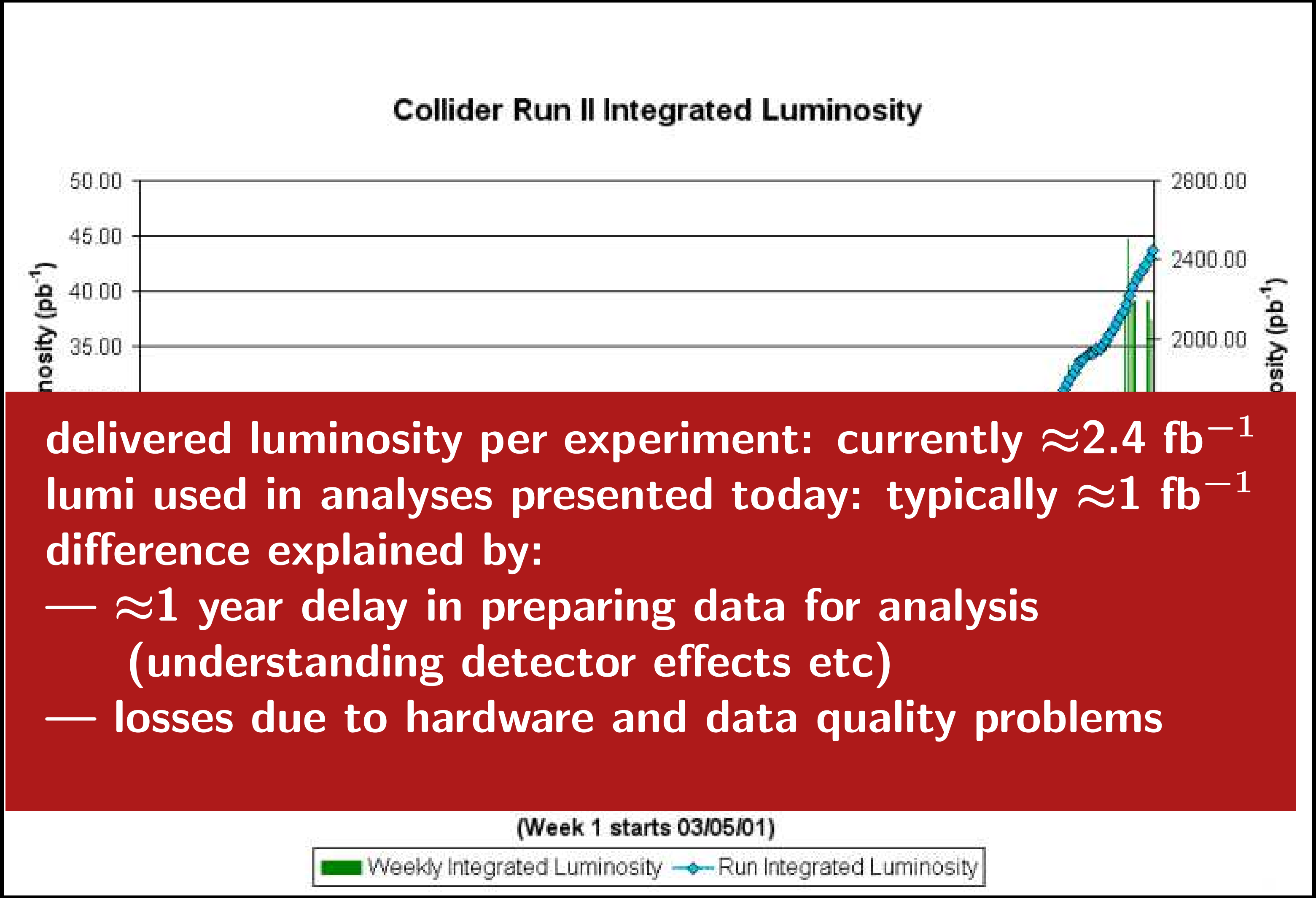
very close to the (revised) design luminosity!

Tevatron performance: integrated lumi



integrated lumi still falling short of 55 pb^{-1} per week expectation.
still problems with antiproton stacking rate!
BUT: delivered lumi per experiment growing quickly

Tevatron performance: integrated lumi



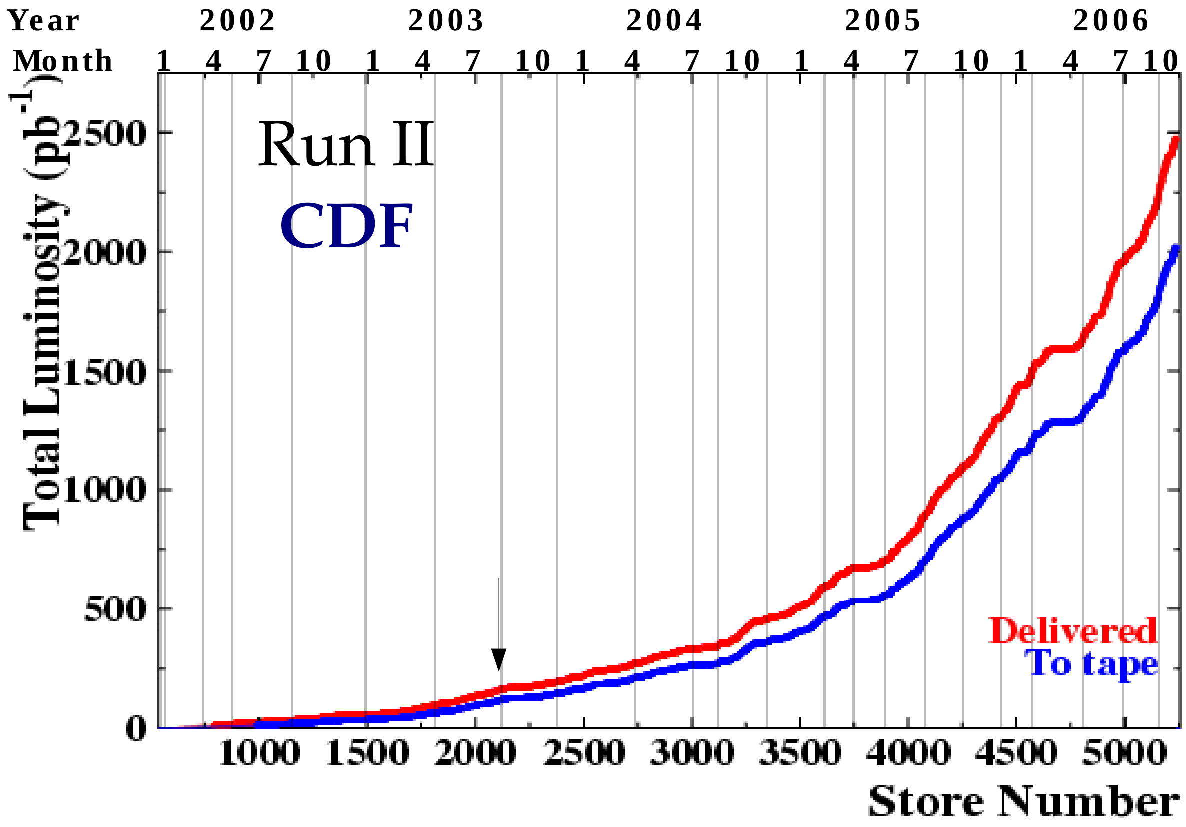
delivered luminosity per experiment: currently $\approx$2.4 fb^{-1}
lumi used in analyses presented today: typically $\approx$1 fb^{-1}
difference explained by:
— $\approx$1 year delay in preparing data for analysis
(understanding detector effects etc)
— losses due to hardware and data quality problems

integrated lumi still falling short of 55 pb^{-1} per week expectation.
still problems with antiproton stacking rate!
BUT: delivered lumi per experiment growing quickly

Tevatron Run II

Each experiment has collected >**2 fb**$^{-1}$ of 1.96 TeV √s p$\bar{p}$ collisions

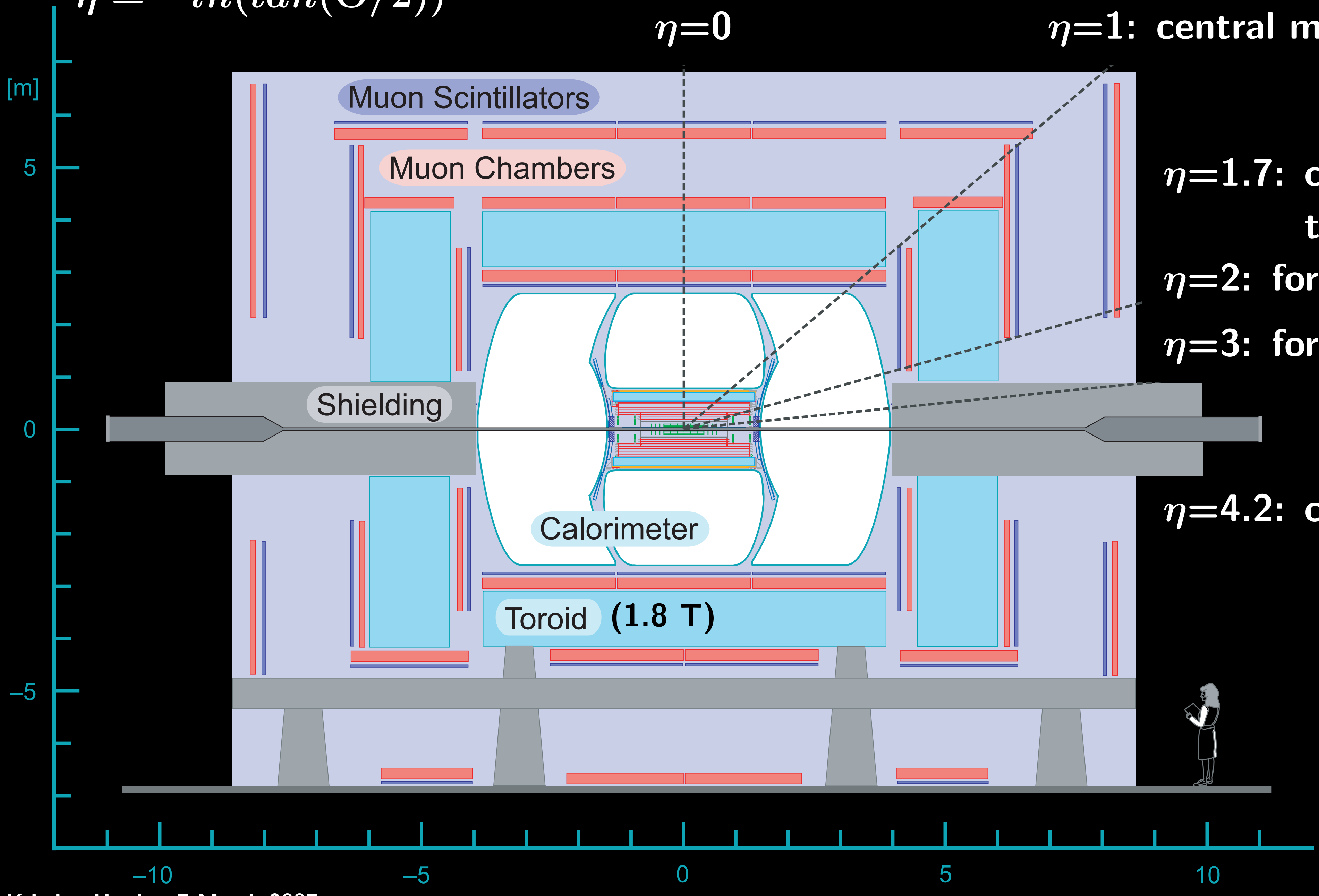
Current Run II: >**15**x Run I data set



First Run II W mass measurement uses 200 pb^{-1} of CDF data

DØ Run II detector

$\eta = -ln(tan(\Theta/2))$



η=0

η=1: central muon

η=1.7: central tracker

η=2: forw muon

η=3: forw trk

η=4.2: calo

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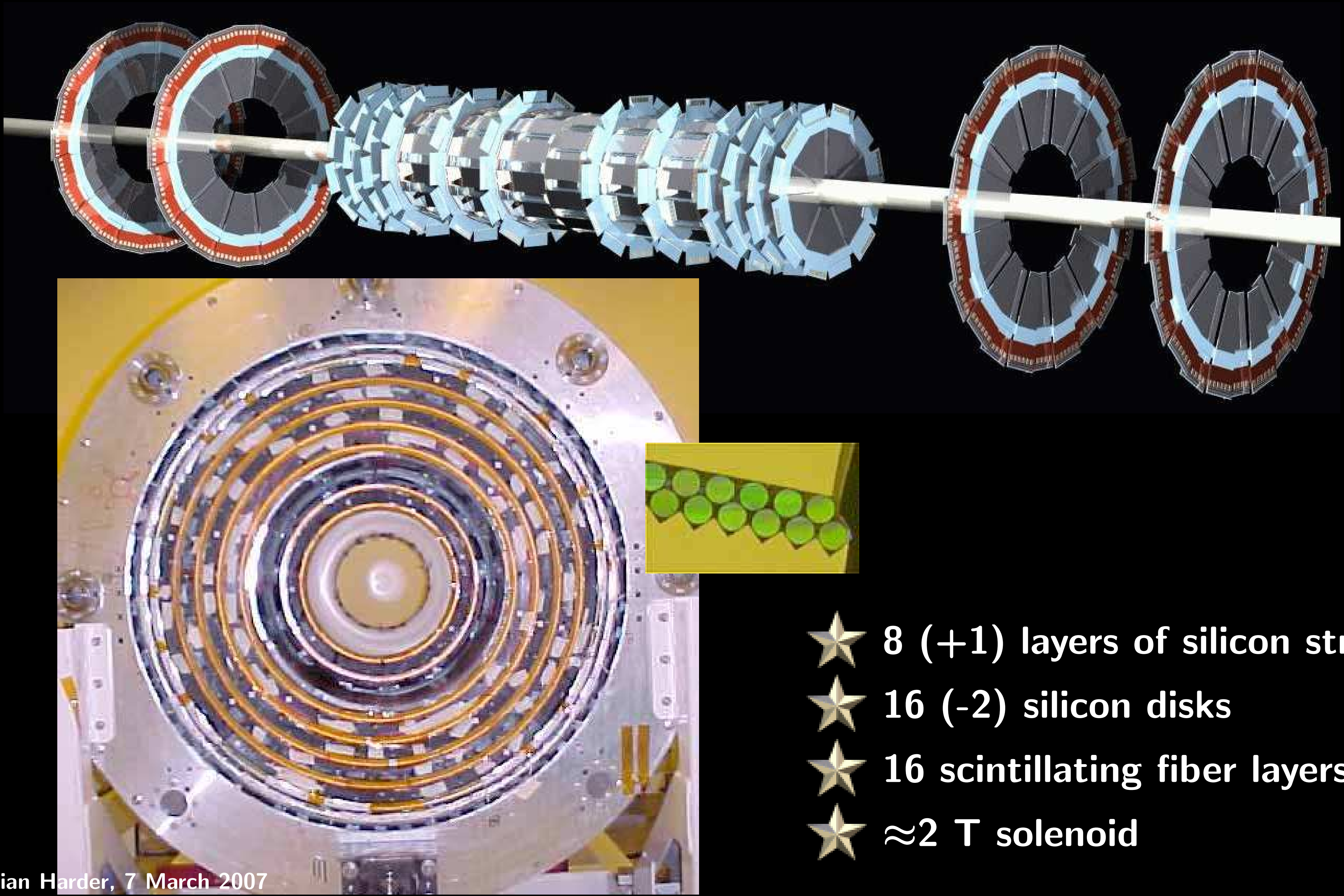
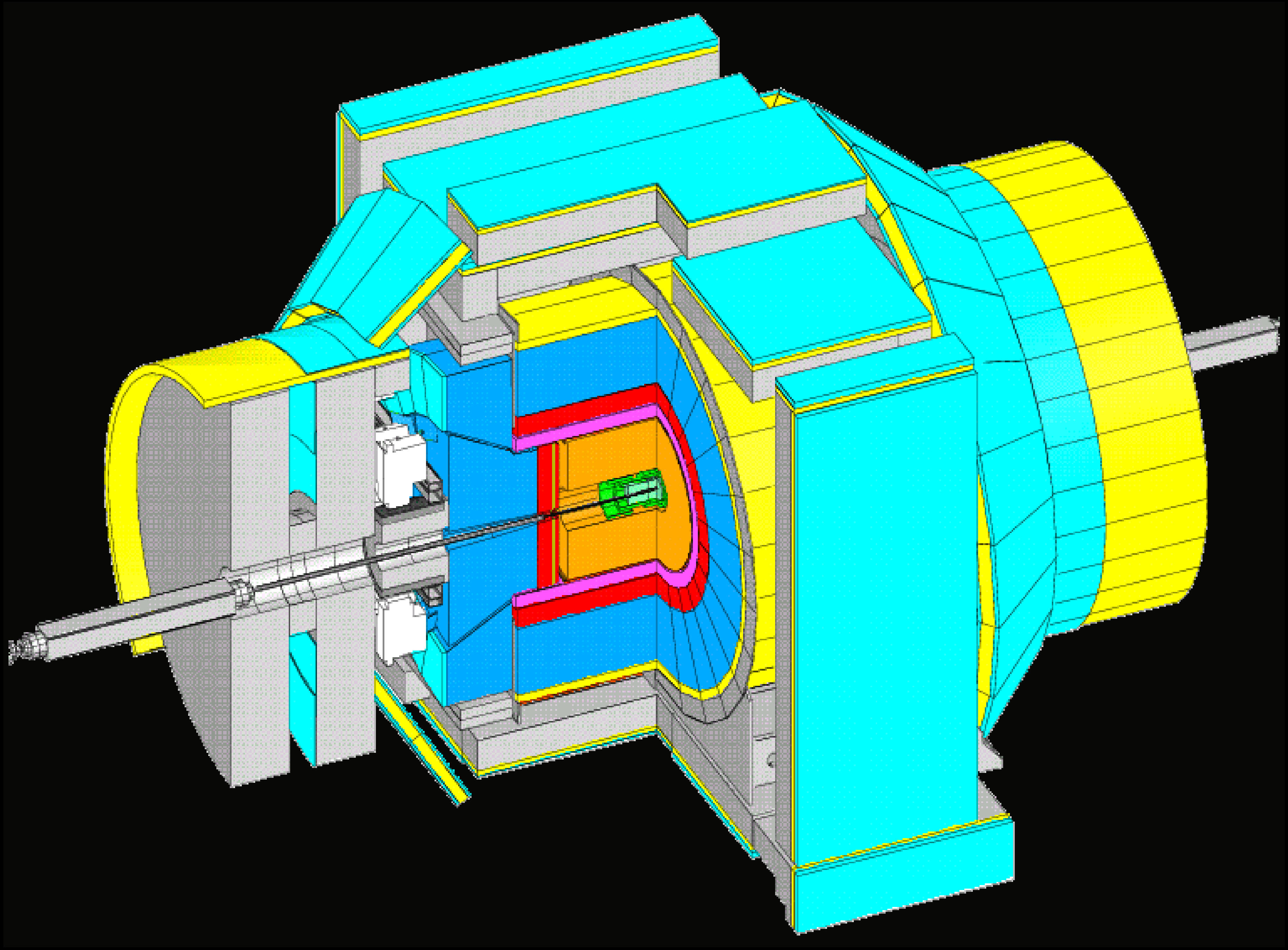
DØ tracking detectors

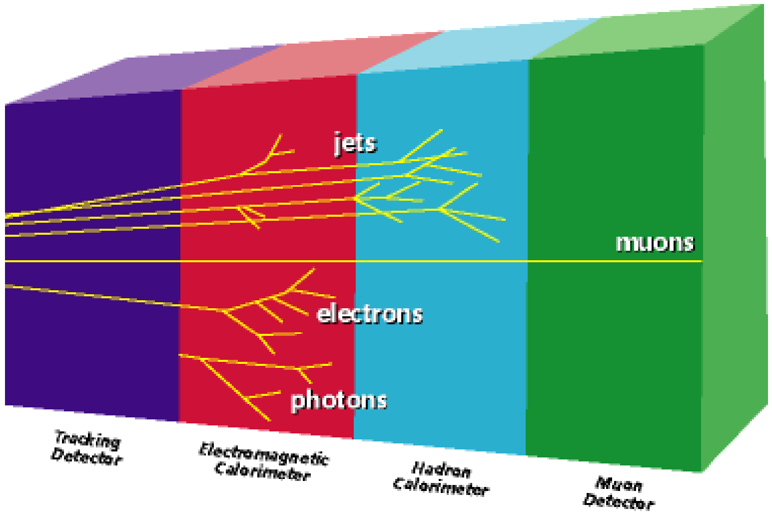


- 8 (+1) layers of silicon strips
- 16 (-2) silicon disks
- 16 scintillating fiber layers
- ≈2 T solenoid

CDF Run II detector



CDF Detector



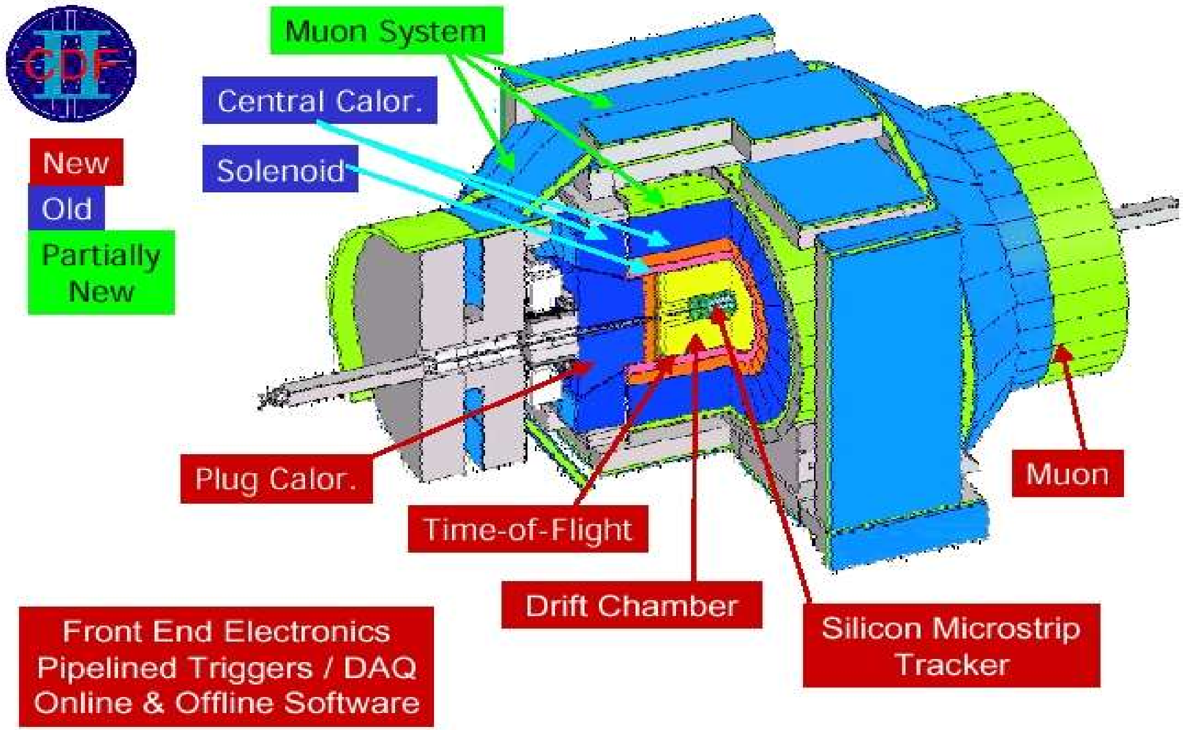
High-precision tracking drift chamber

$\delta p_T/p_T = 0.05\%\, p_T$: 2% for 40 GeV μ

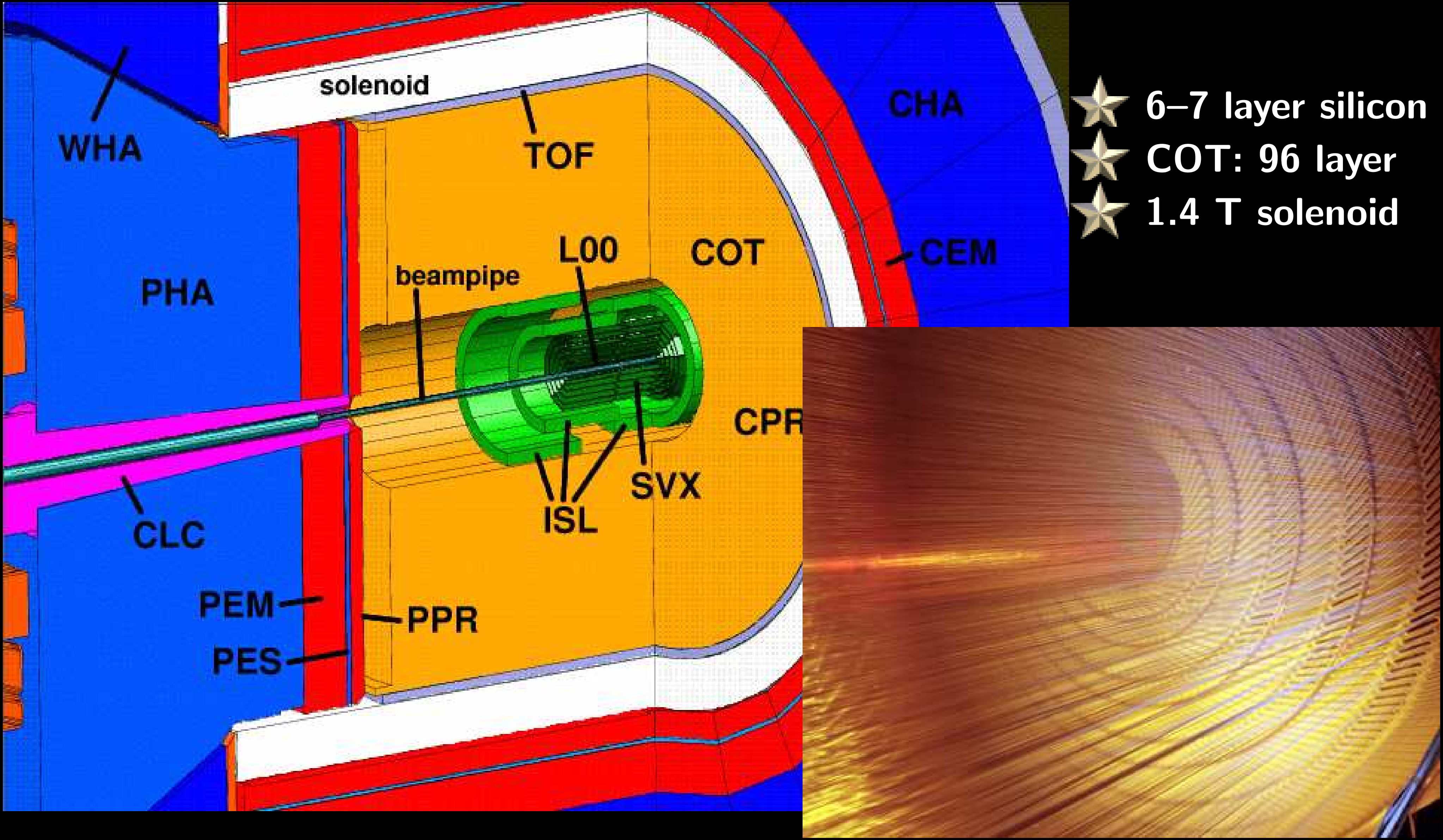
High-precision electromagnetic calorimeter

$\delta E_T/E_T = 13.5\%/\sqrt{E_T} \oplus 1.7\%$:

3% for 40 GeV *e*

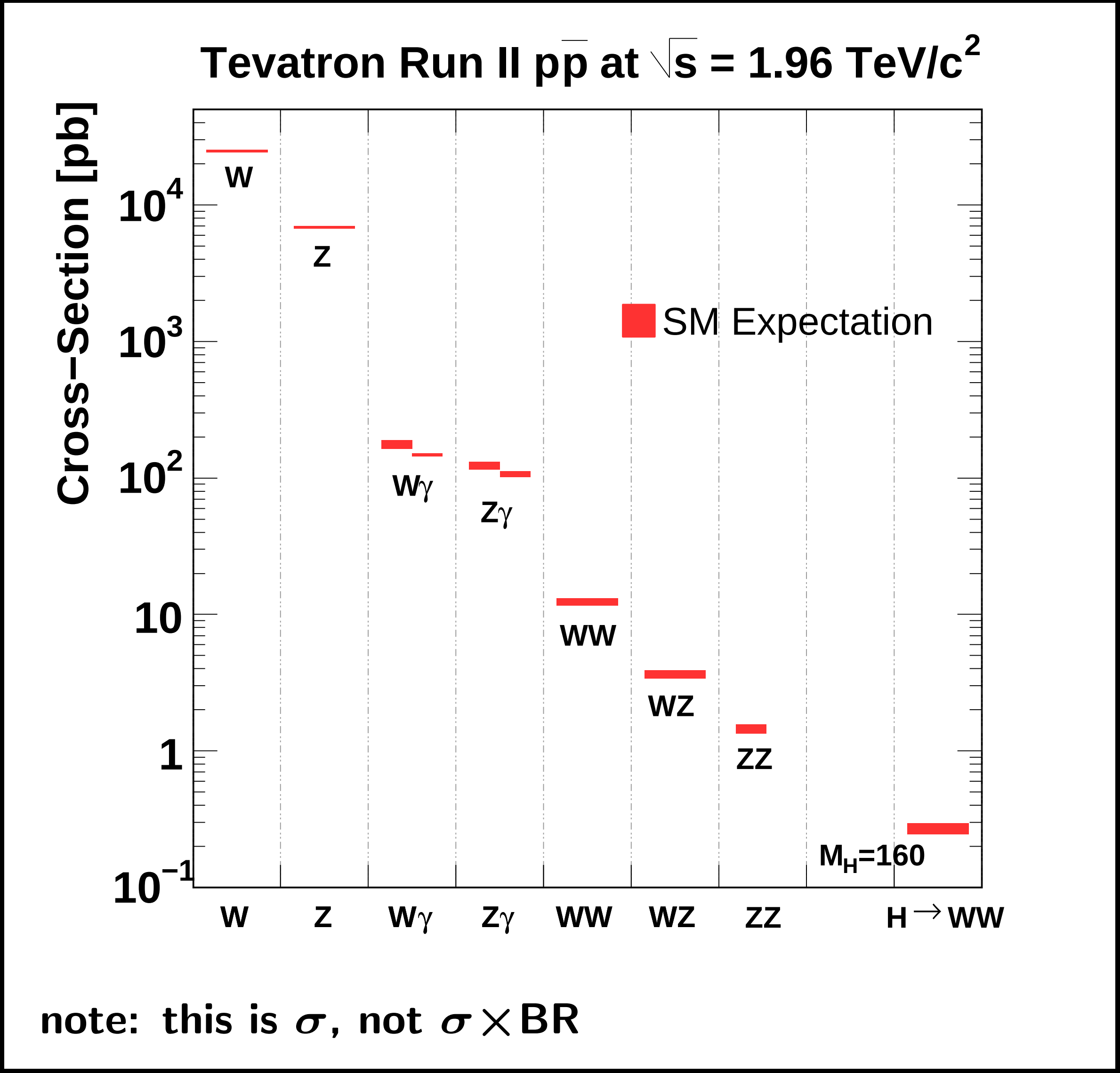


CDF inner detectors



- 6–7 layer silicon
- COT: 96 layer
- 1.4 T solenoid

SM cross-section predictions



note: this is σ, not $\sigma \times$BR

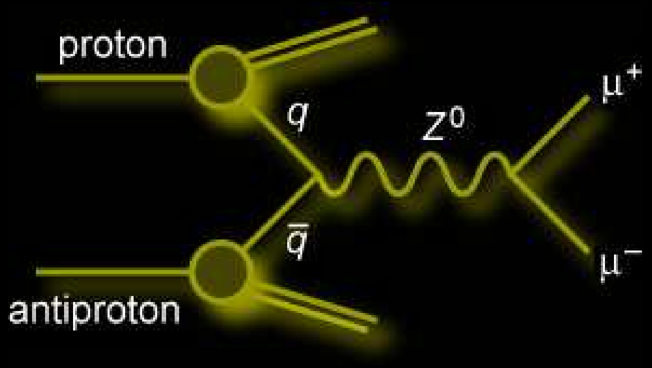
reconstructed events:

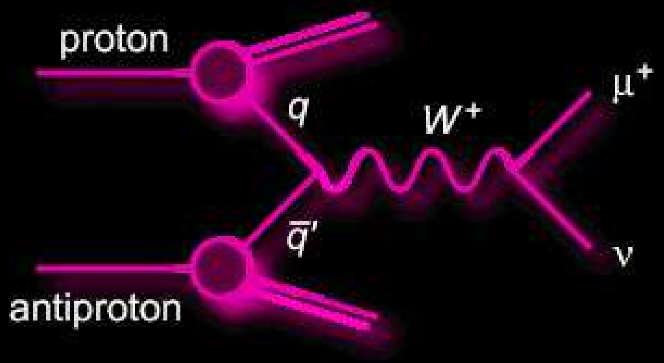
← O(100k) per fb^{-1} per final state

← O(1) per fb^{-1} per final state

Electroweak physics 101

Simplest tree-level diagrams to study at hadron colliders:





Z$\longrightarrow \ell\ell$, W$\longrightarrow \ell\nu$ reconstruction can be studied very well:

- clean signature (high p_t leptons)
- high rate (for single W,Z production)

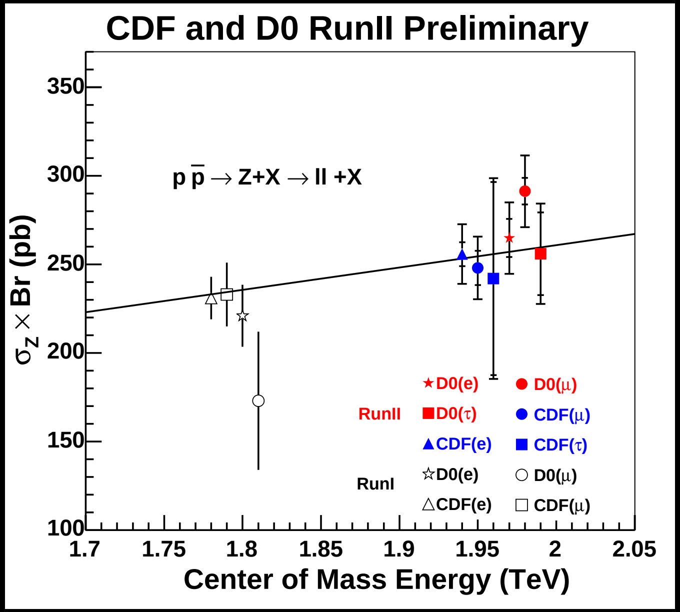
➡ electroweak physics = excellent laboratory for precision studies!

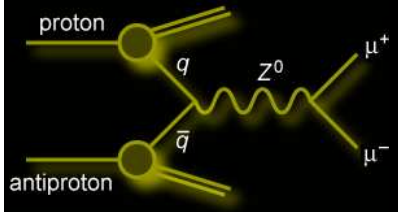
  - testing the SM beyond leading order
  - detecting non-SM contributions
  - constraining PDFs

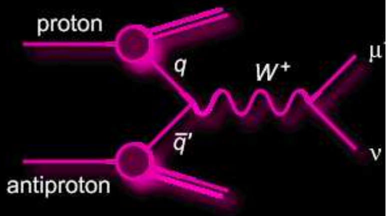
Tevatron Run I/II W/Z cross-sections

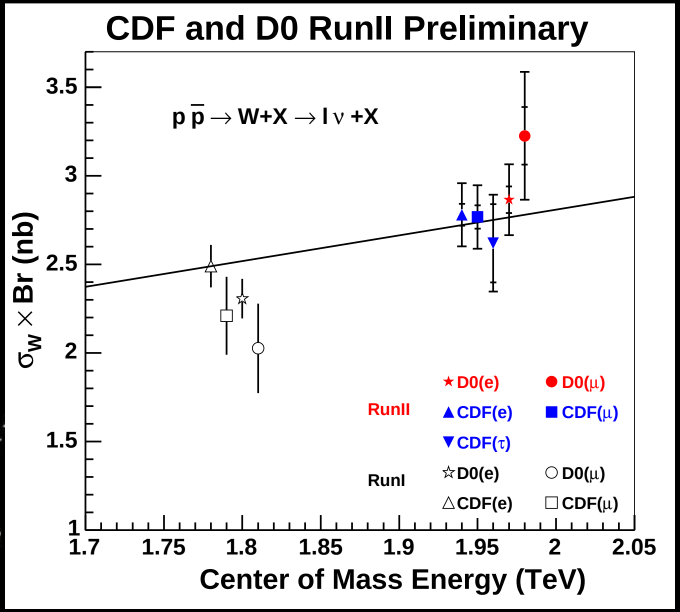
$p\bar{p}$ →Z+X→ $\ell\ell$+X

$p\bar{p}$ →W+X→ $\ell\nu$+X









total W, Z production cross-sections: good agreement with Standard Model

(at current precision!)

BUT: not the most sensitive observable to look at for SM checks!

anyone awake yet?

Electroweak topics of the day

Analyses presented in this talk:

differential Z cross sections (rapidity, transverse momentum)

- better distinction of production mechanisms

diboson production (WW, WZ, ZZ, Wγ, Zγ)

- unknown loop contributions?
- anomalous triple gauge couplings?
- high mass particles decaying to two bosons? (Higgs?)

All these require a lot more integrated luminosity to study than $\sigma_{tot}(p\bar{p} \rightarrow$ W+X) and $\sigma_{tot}(p\bar{p} \rightarrow$ Z+X)

lepton identification

electrons

- E_t above ≈20 GeV
- shower shape criteria
- isolation requirement
- $|\eta|$ coverage CDF $<$1.1 (central), 1.2–2.0 (forward)
  DØ $<$1.1 (central), 1.5–2.5 (forward)

muons

- p_t above ≈20 GeV
- isolation requirement
- $|\eta|$ coverage CDF $<$1.1/1.2 (central)
  DØ $<$1 (central), 1–2 (forward)

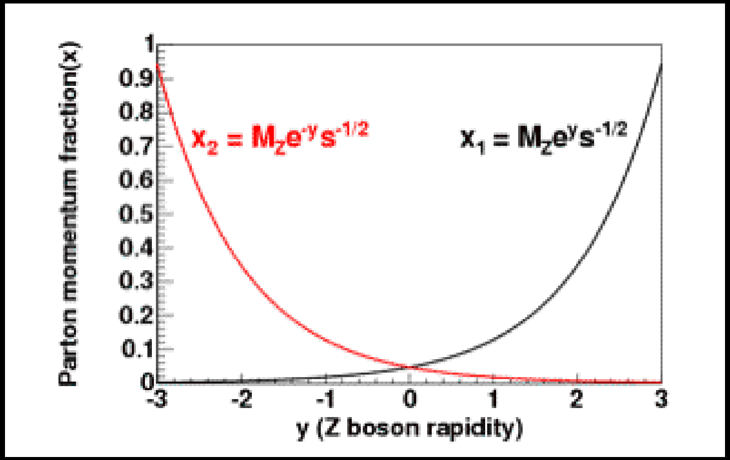
tau not treated separately. $\tau \longrightarrow e$, $\tau \longrightarrow \mu$ included in e,μ channels

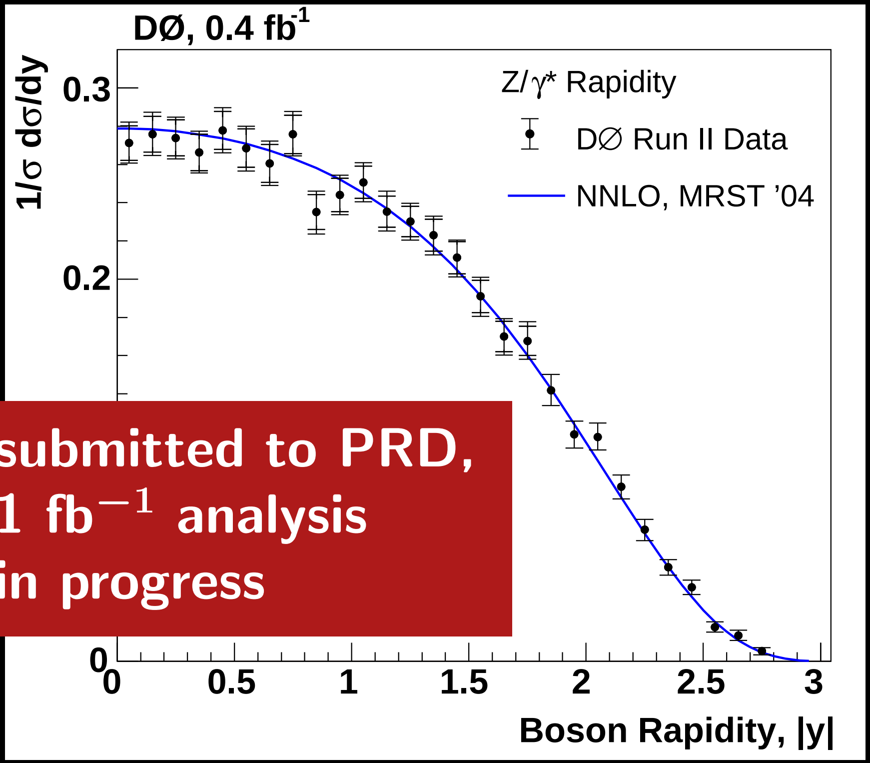
neutrinos

- missing E_t above ≈20 GeV
- CDF: isolation requirement (angular distance)

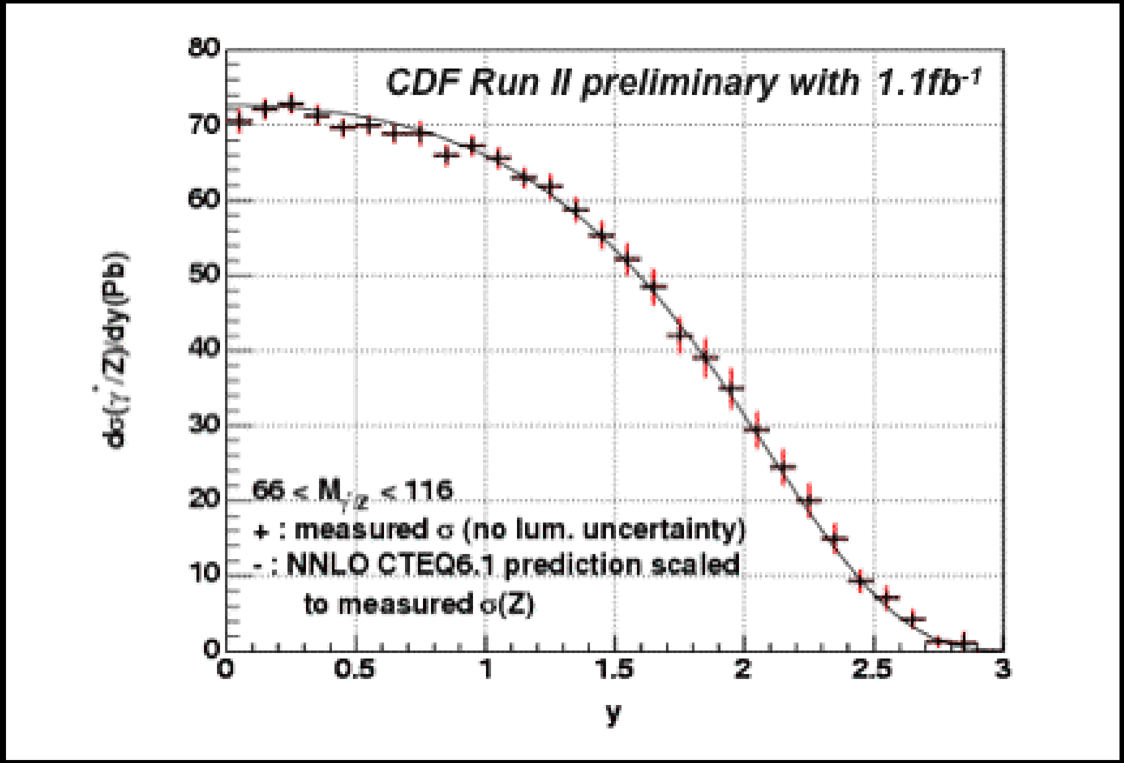
Z rapidity

- forward region probes PDF at low x + large Q^2, and at large x
- use Z→ ee events: best η range — DØ: $|\eta| < 3.2$, CDF: $|\eta| < 2.8$



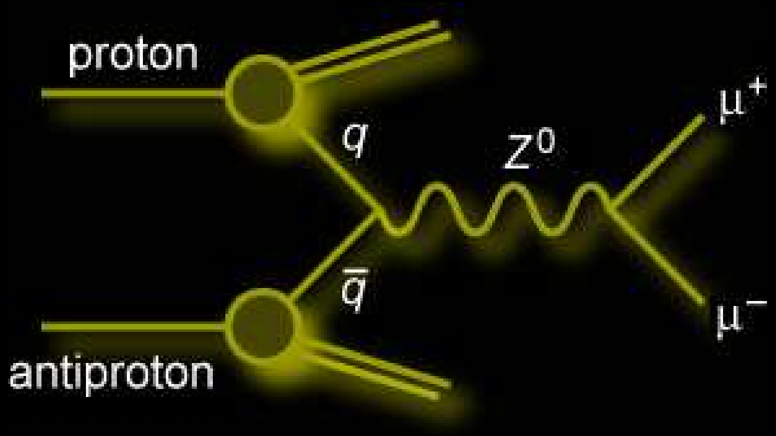


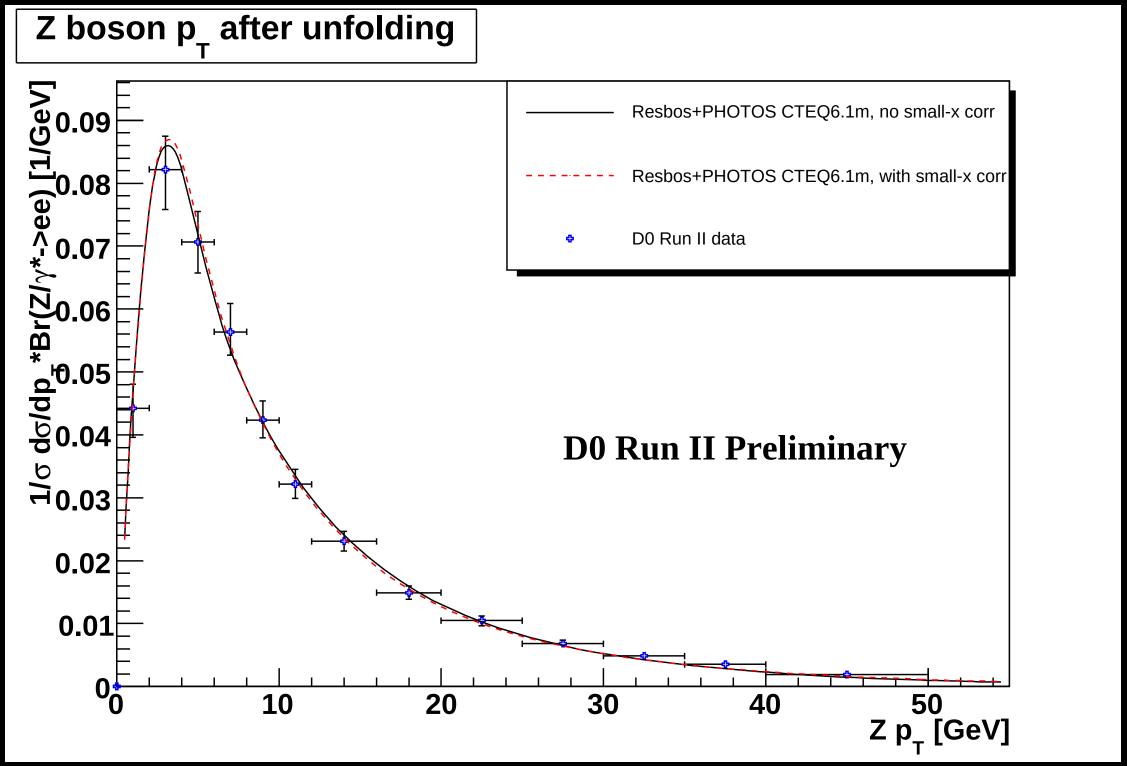
submitted to PRD,
1 fb^{-1} analysis
in progress



Z transverse momentum

- boson p_t can be non-zero for NLO
- p_t shape predicted by resummation
- > 1 model for small x (=large rapidity)
  → forward region very interesting!





tricky analysis:
- sensitive to electron energy scale
- p_t dependence of lepton ID

improving model sensitivity:
- more data
- plot in bins of Z rapidity

→ updated version due soon

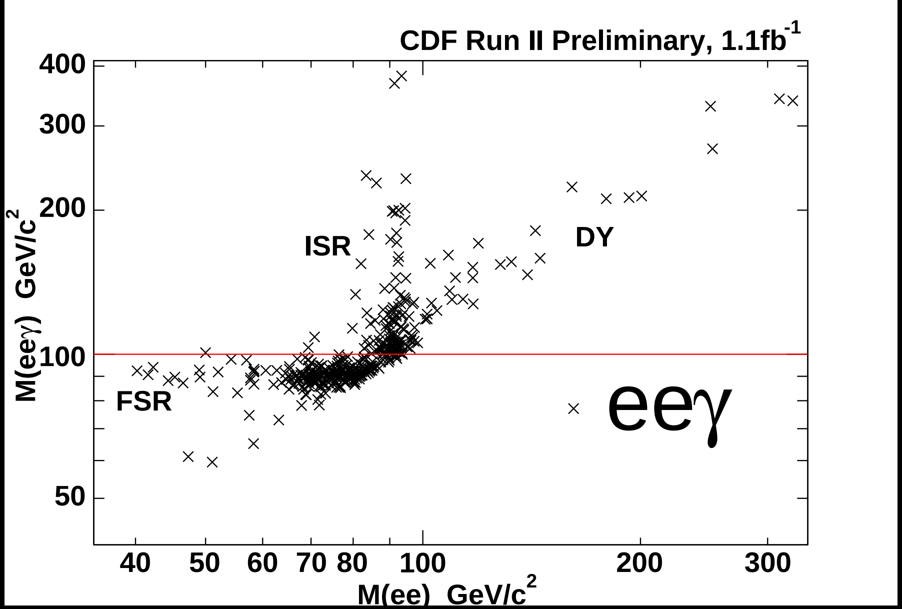
Zγ production

no LO ZZγ and Z$\gamma\gamma$ vertices in SM → Zγ production only as ISR or FSR

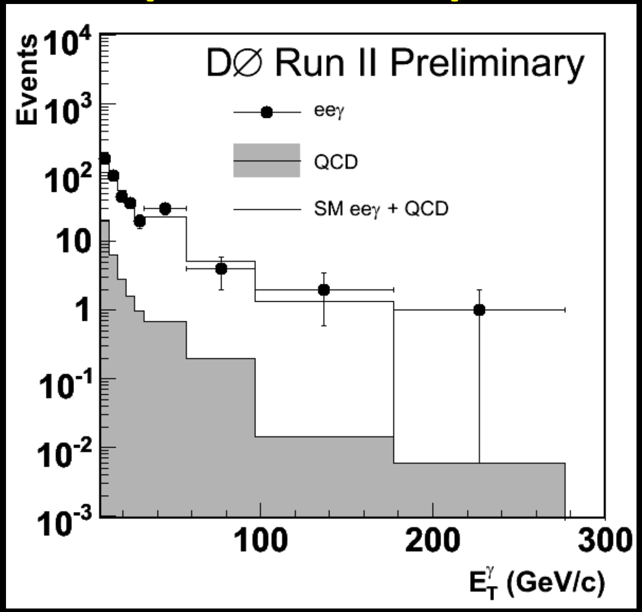
new physics could be found
★ as additional ZZγ or Z$\gamma\gamma$ contribution
★ potentially with high E_t photons

CDF and DØ analyses: Z→ ee selection
photon with $E_t > 7$ GeV (angular separation)

two-body vs three-body mass



photon E_t spectrum



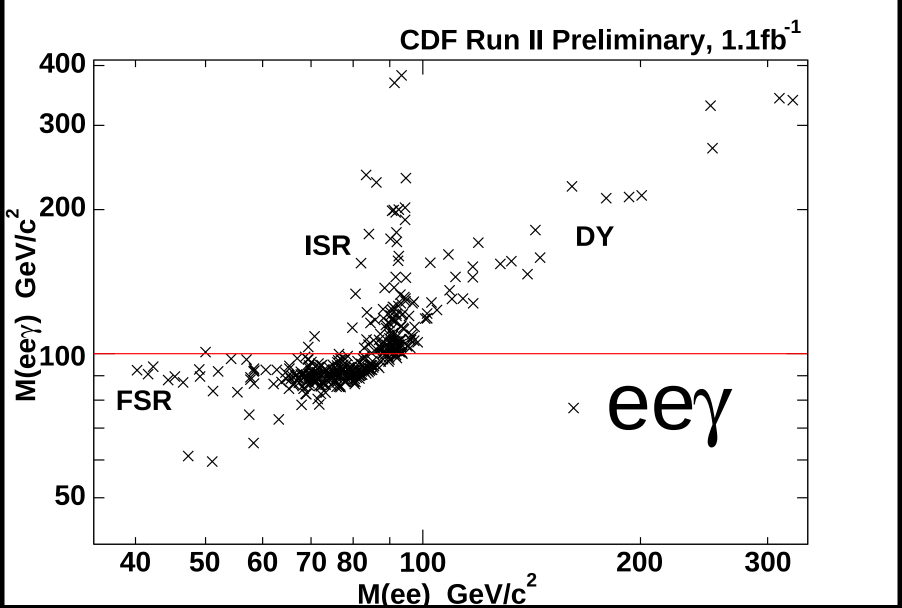
$Z\gamma$ results

	candidates	$Z\gamma$ cross section × BR	SM prediction
DØ	387	4.51±0.37(stat+syst)±0.27(lum) pb	4.2±0.2 pb
CDF	390	4.9±0.3(stat)±0.3(syst)±0.3(lum) pb	4.7±0.4 pb

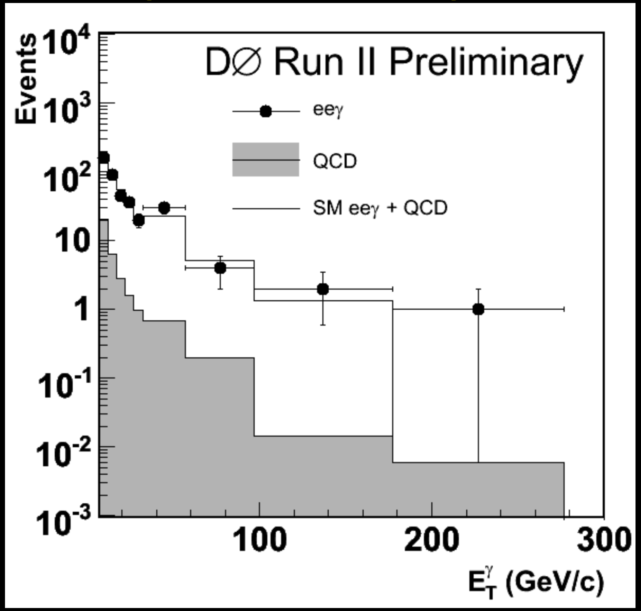
NB: different SM predictions due to different kinematic region

good agreement with Standard Model!

two-body vs three-body mass



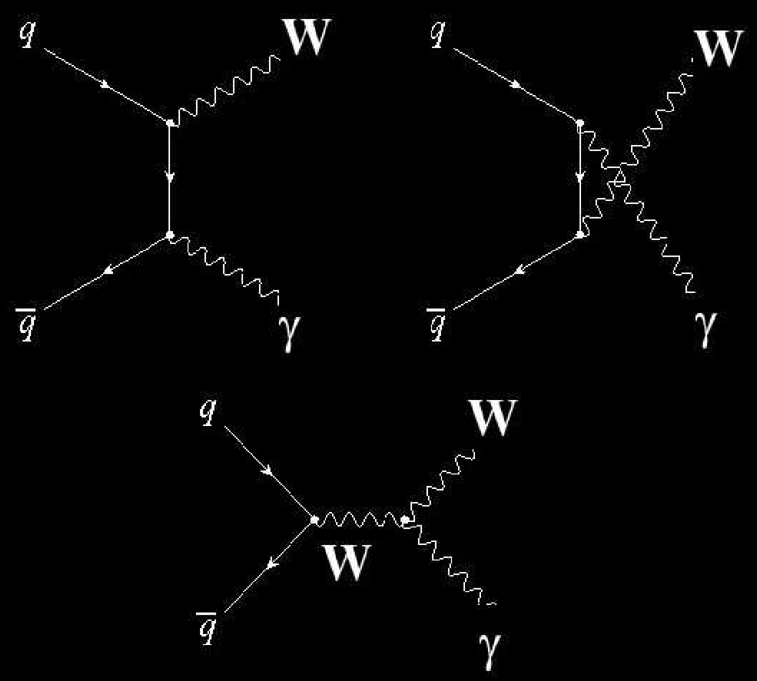
photon E_t spectrum

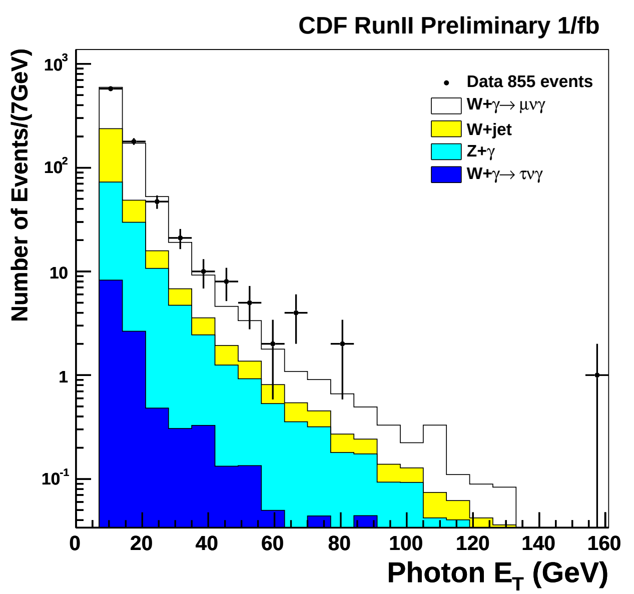


Wγ production

Now *with* LO diagrams:

similar analysis to Zγ,
but W$\to\mu\nu$ (CDF+DØ),
W$\to e\nu$ (DØ)





DØ uses tight FSR veto:
$M_t(W\gamma) > 110$ GeV

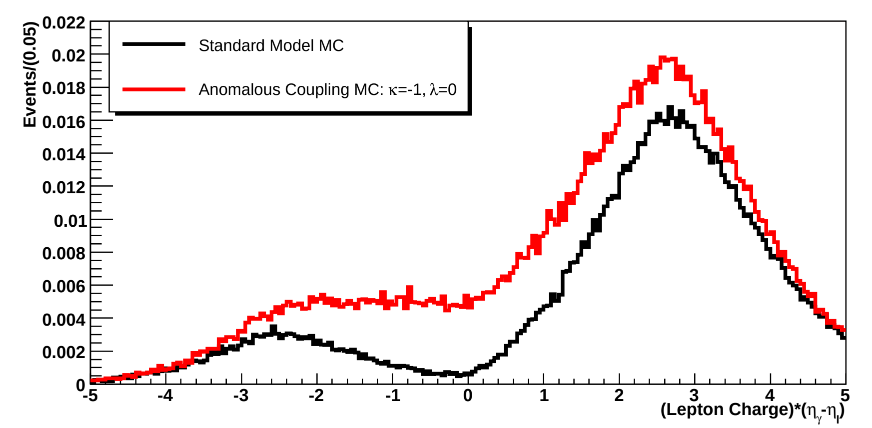
	cands	Zγ cross section × BR	SM prediction
CDF μ	855	19.11±1.04(stat)±2.40(syst)±1.11(lum) pb	19.3±1.4 pb
DØ μ	245	3.21±0.49(stat+syst)±0.20(lum) pb	3.21±0.08 pb
DØ e	389	3.12±0.49(stat+syst)±0.19(lum) pb	3.21±0.08 pb

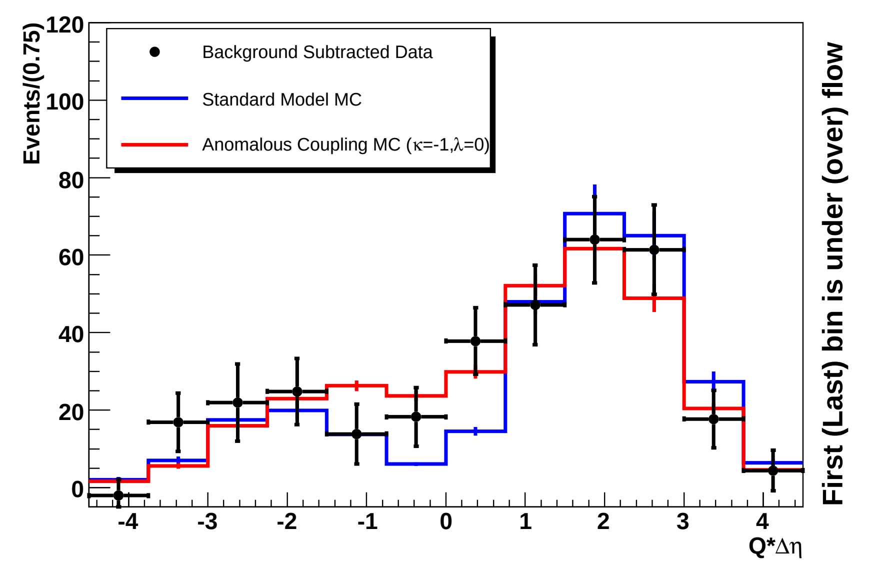
DØ Wγ ++

increased sensitivity to anomalous couplings through
charge-signed rapidity difference:

interference between tree-level diagrams

➡ dip in $Q_\ell \times [y(\gamma) - y(\ell)]$





prediction (SM vs example anom TGC)

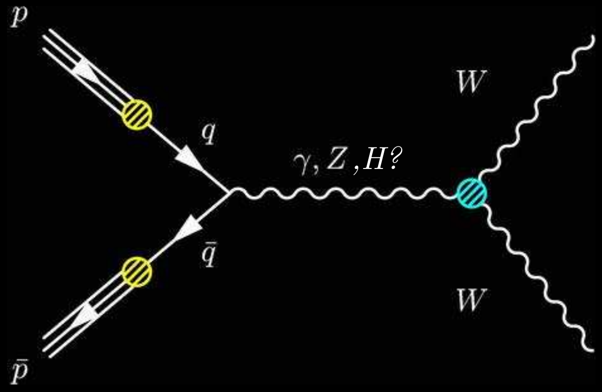
data

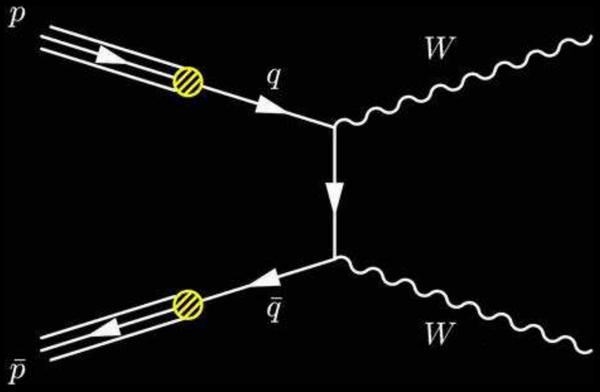
good agreement with Standard Model
...and with many other scenarios...
clearly need more data for this measurement!

WW, WZ, ZZ

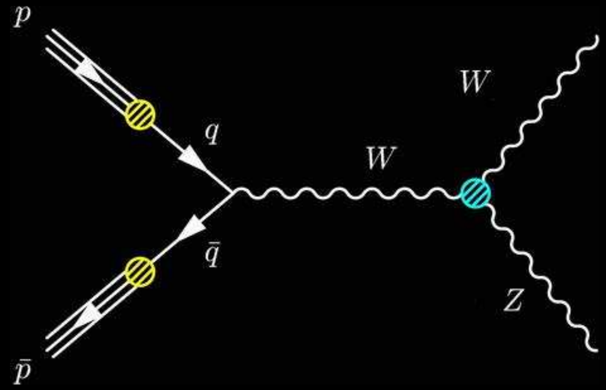
s-channel **t-channel**

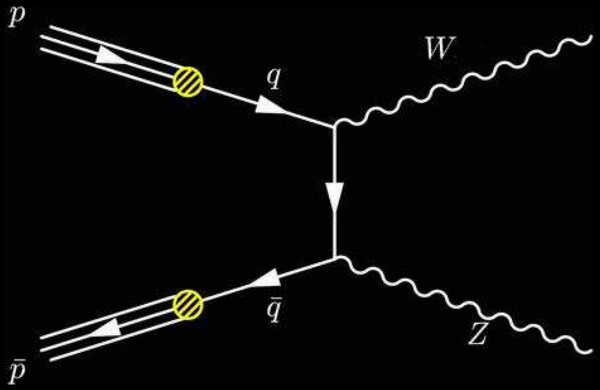
WW
(SM: 12.4±0.8 pb)



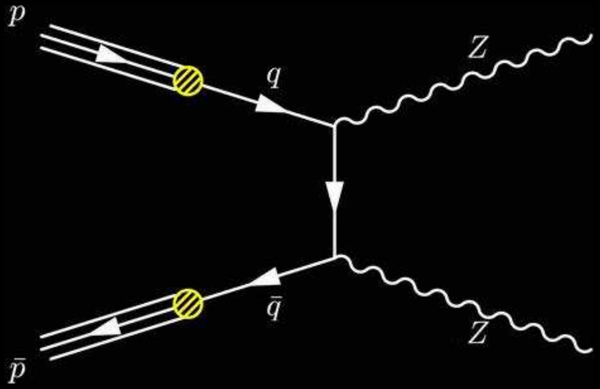


WZ
(SM: 3.7±0.3 pb)





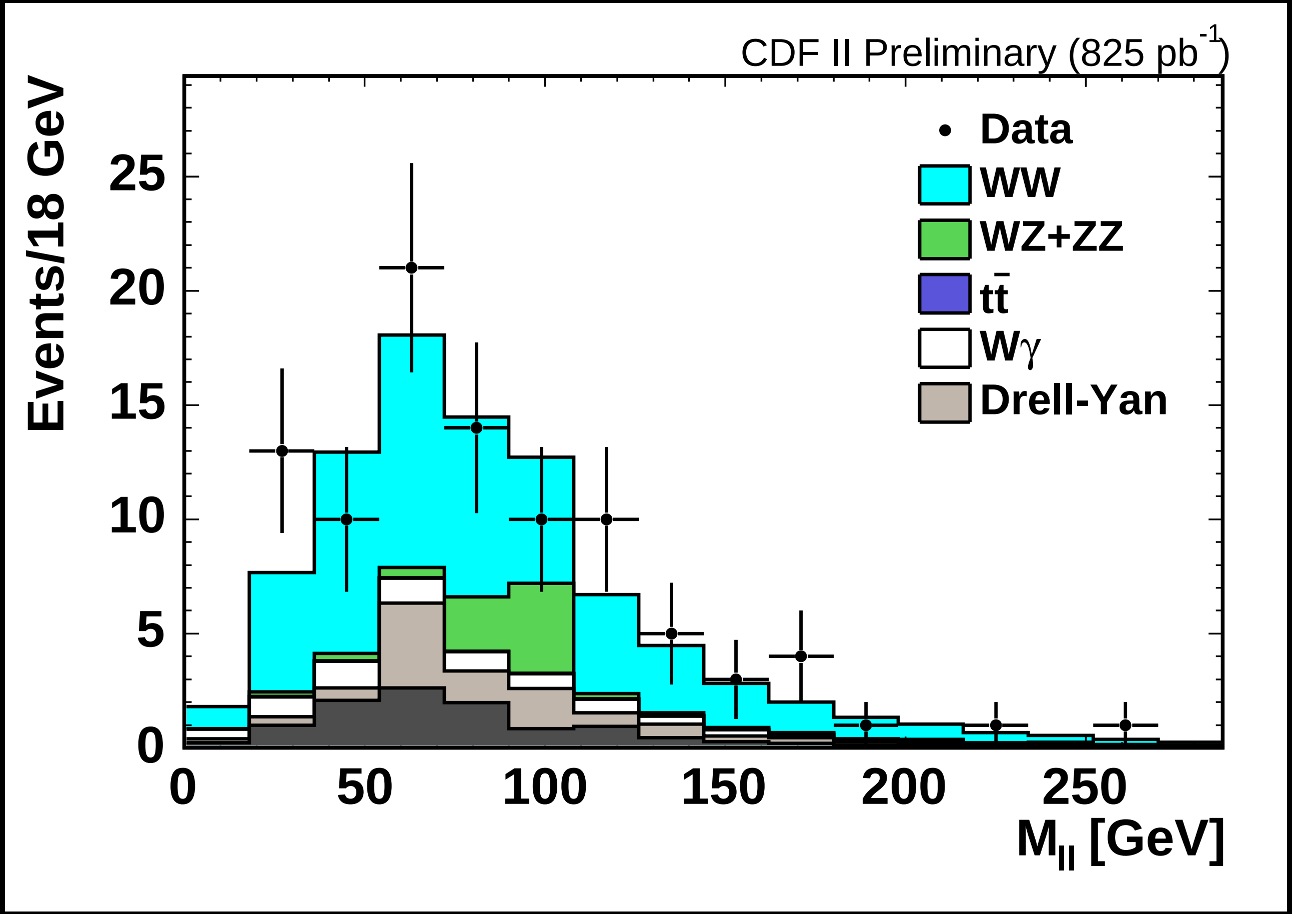
ZZ
(SM: 1.4±0.1 pb)



CDF WW with 0.8 fb^{-1}

WW$\rightarrow \ell\ell\nu\nu$ with $\ell\ell = ee,\ e\mu,\ \mu\mu$

$\approx$ std lepton selection, missing E_t, jet veto, opposite charge, $|\Delta z| < \pm 4$ cm



95 events, cross section 13.6±2.3(stat)±1.6(syst)±1.2(lumi) pb,

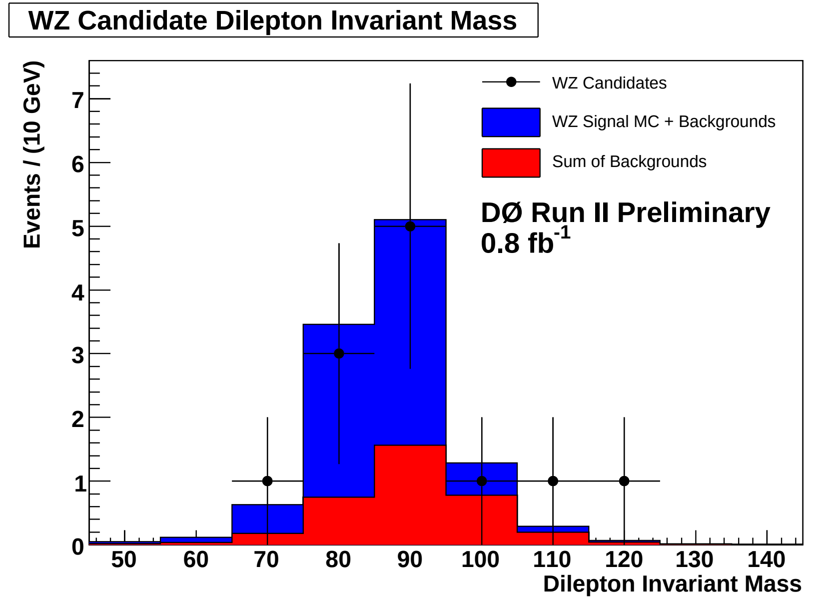
SM prediction 12.4±0.8 pb

WZ observation

WZ$\rightarrow \ell\ell\ell\nu$, with eee, $ee\mu$, $e\mu\mu$, $\mu\mu\mu$ (total BR $\approx$1.5%)
again, standard lepton and missing E_t selection.
require two leptons in Z mass window.

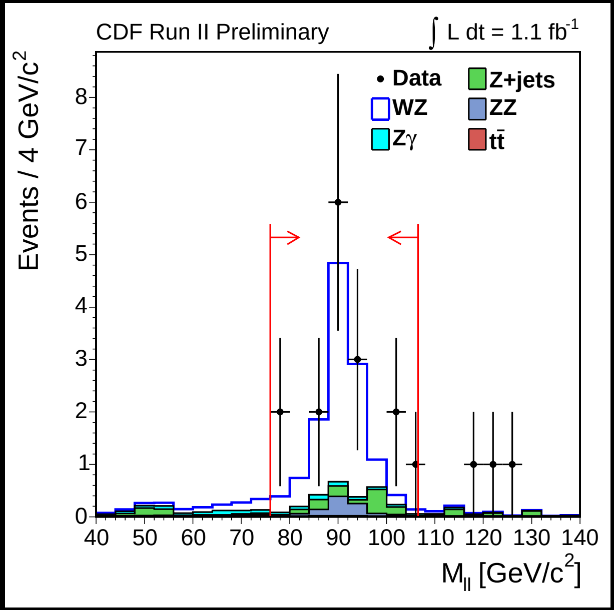
selection results:

	candidates	background	signal significance
DØ:	12	3.61 ± 0.20	3.34σ
CDF:	16	$2.65\pm0.28\pm0.33\pm0.09$	6.0σ



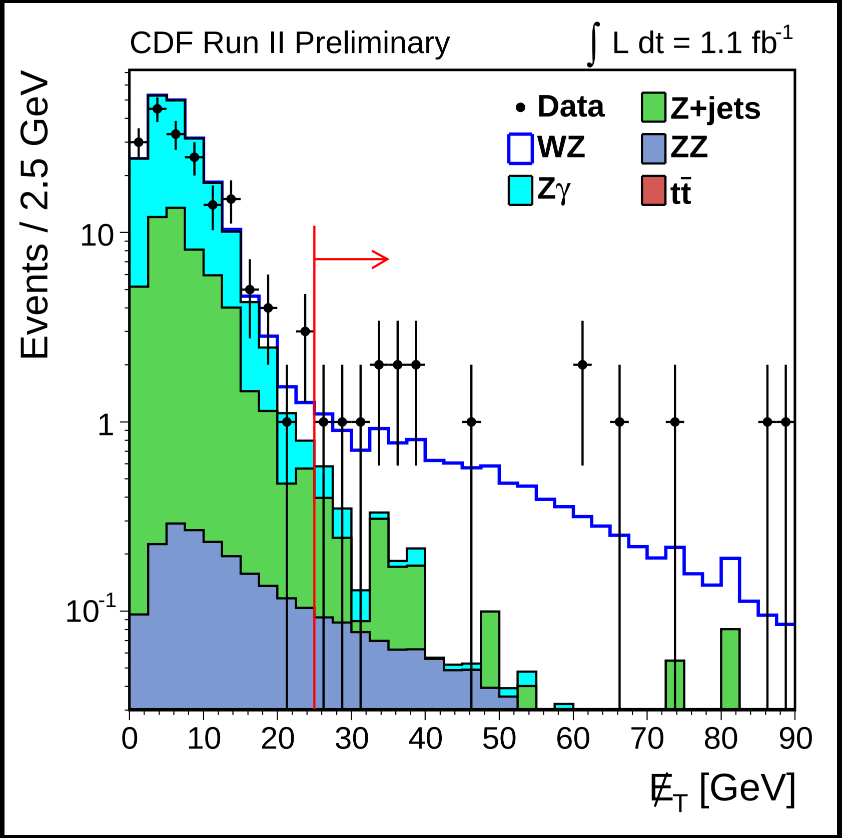
Z mass

background composition similar, just overall worse S/B ratio for DØ



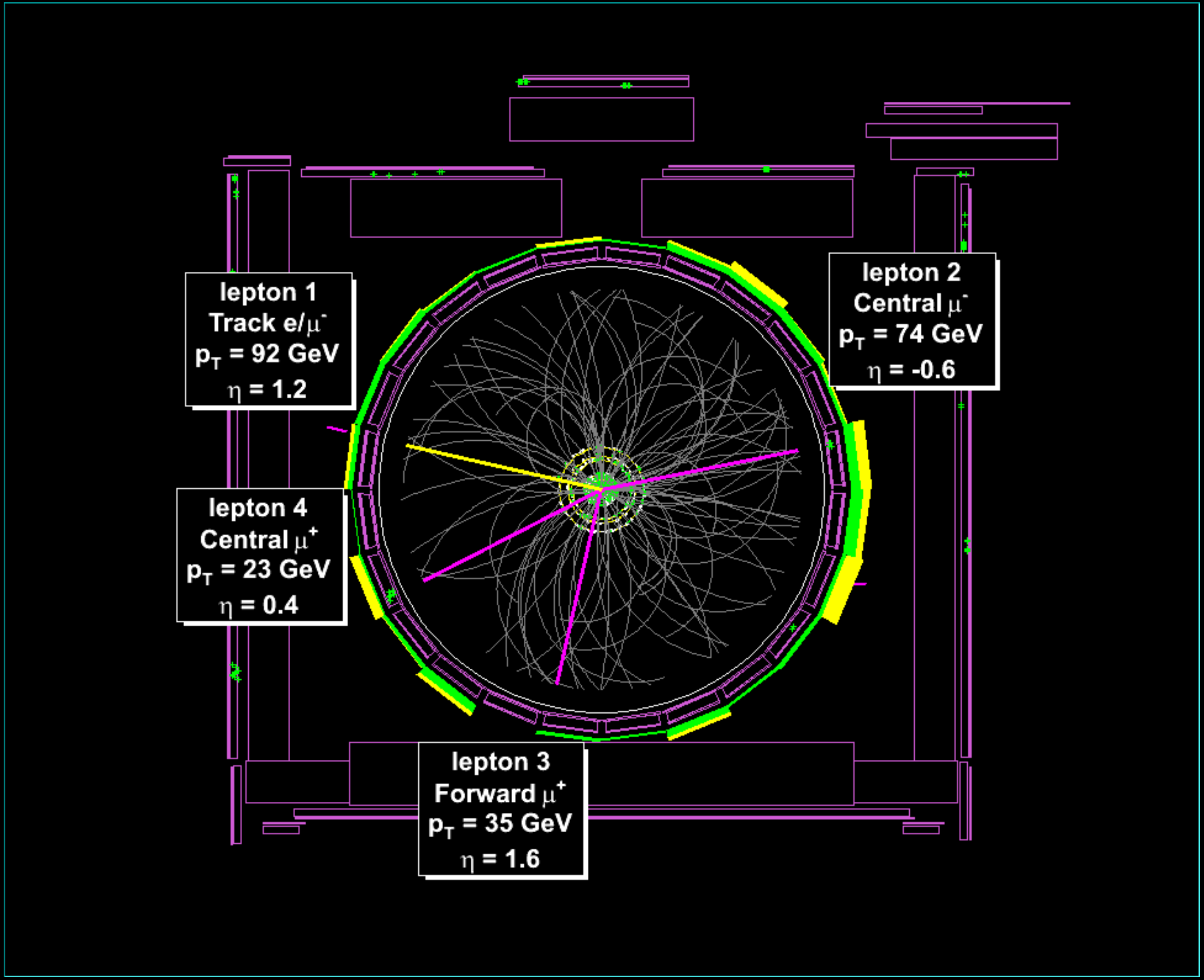
WZ cross section

	measured	predicted
CDF	$5.0^{+1.8}_{-1.4}$(stat)$\pm$0.4(syst) pb	3.7±0.3 pb
DØ	$4.0^{+1.9}_{-1.5}$(stat+syst) pb	3.7±0.3 pb



CDF ZZ search

How about events with 4 leptons? SM predicts ≈2 events in 1 fb^{-1}...



Here is a candidate.

The only one so far.

$\sigma(ZZ) < 3.8$ pb (95% C.L.)

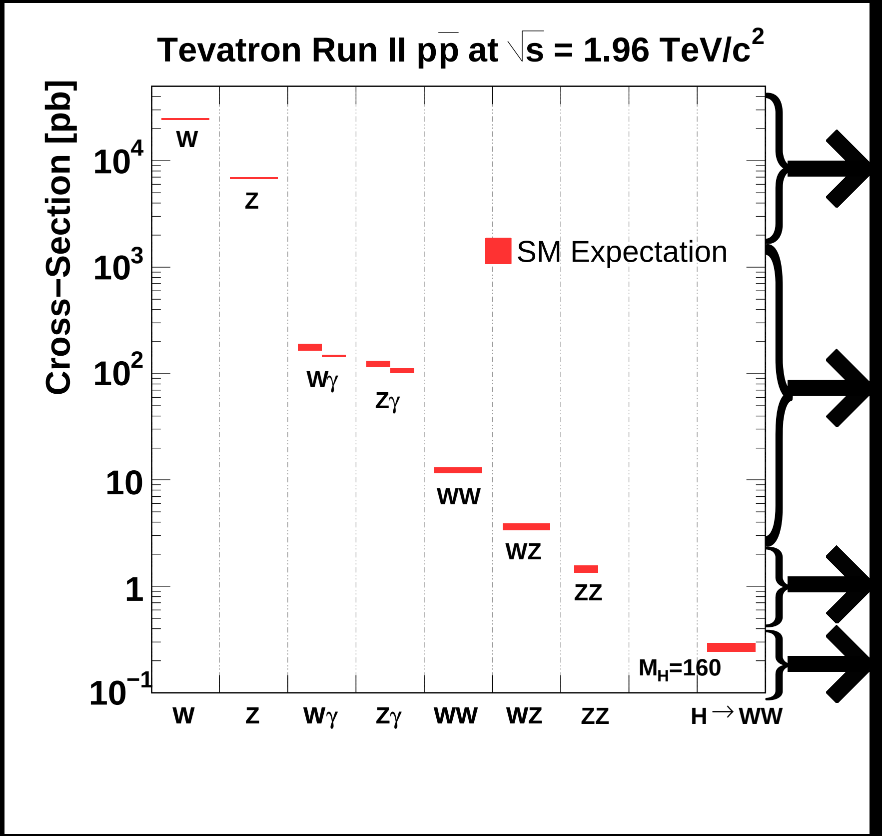
(SM: 1.4±0.1 pb)

With 4–8 fb^{-1}, this could become another first observation.

Summary

- ★ DØ+CDF data samples increase quickly
- ★ understanding of detector response improving as well

➡ bringing electroweak precision physics to the ~~next~~ next-to-next level!



precision physics playground

established signals —
more data should help to improve those!

promising searches

acts of desperation → LHC?

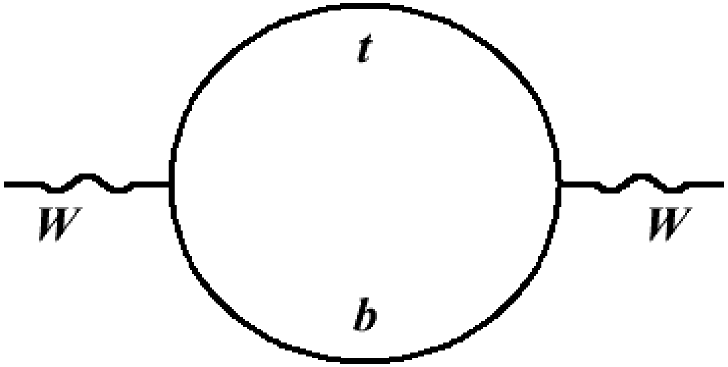
W Boson Mass

Given precise measurements of m_Z and $\alpha_{EM}(m_Z)$, we can predict m_W:

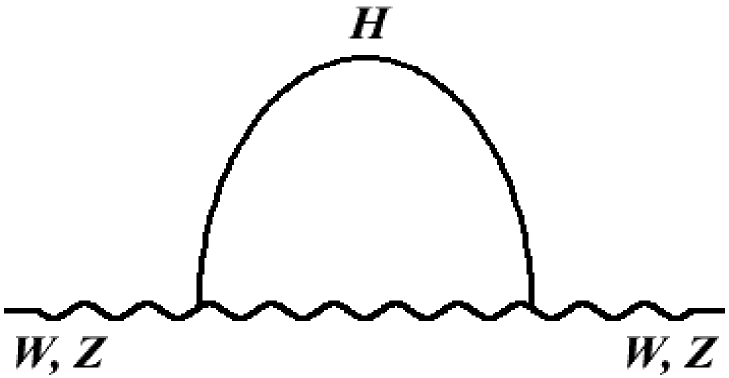
$$\boxed{m_W^2 = \frac{\pi\alpha_{EM}}{\sqrt{2}G_F\,(1 - m_W^2/m_Z^2)(1 - \Delta r)}}$$

("on-shell scheme")

Δr: O(3%) radiative corrections dominated by *tb* and Higgs loops

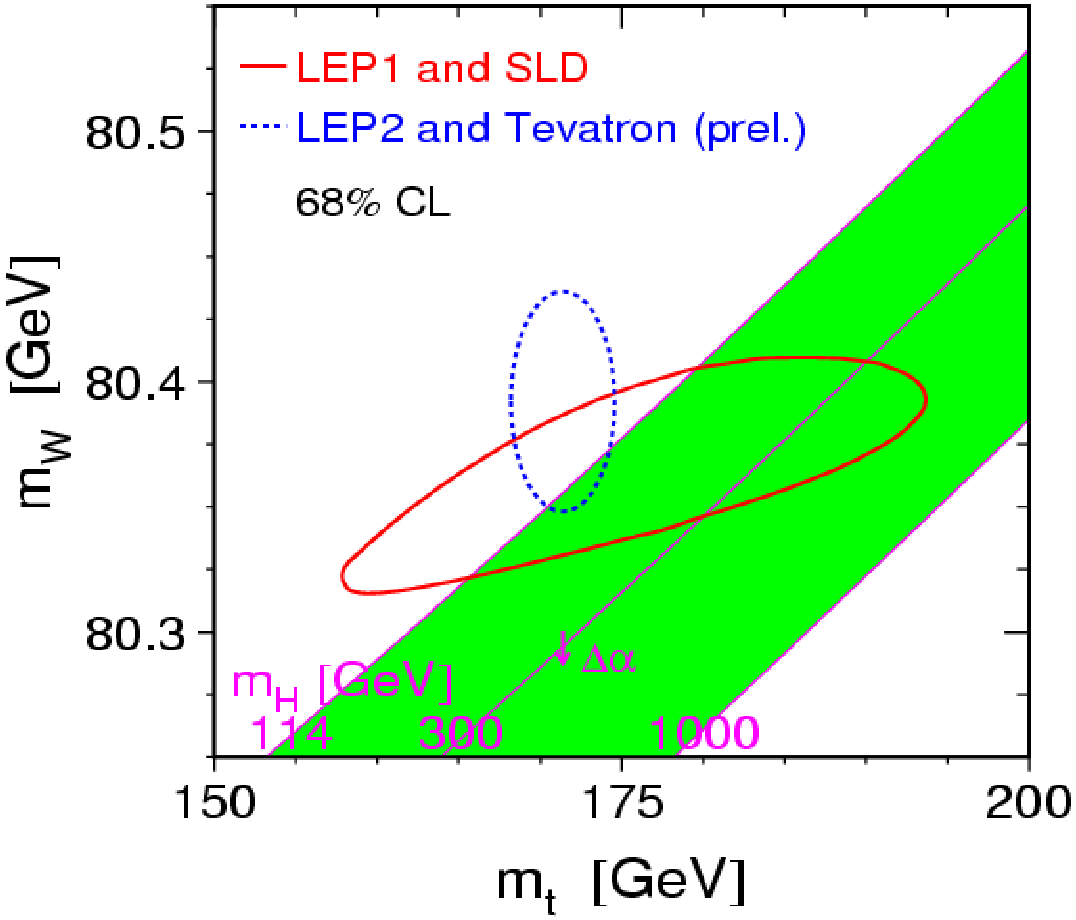


$\Delta m_W \propto m_t^2$



$\Delta m_W \propto ln\,(m_H/m_Z)$

Higgs Mass Prediction



Predicted Higgs mass from global electroweak data:

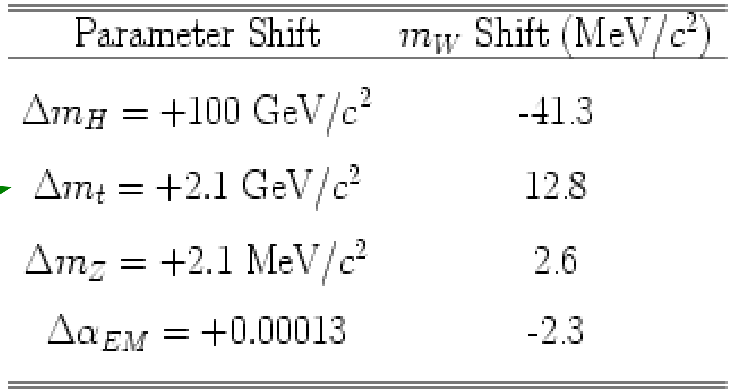
$m_H = 85^{+39}_{-28}$ GeV (< 166 GeV at 95% CL)

Direct search from LEP II: $m_H > 114.4$ GeV at 95% CL

W Mass Prediction and Measurement

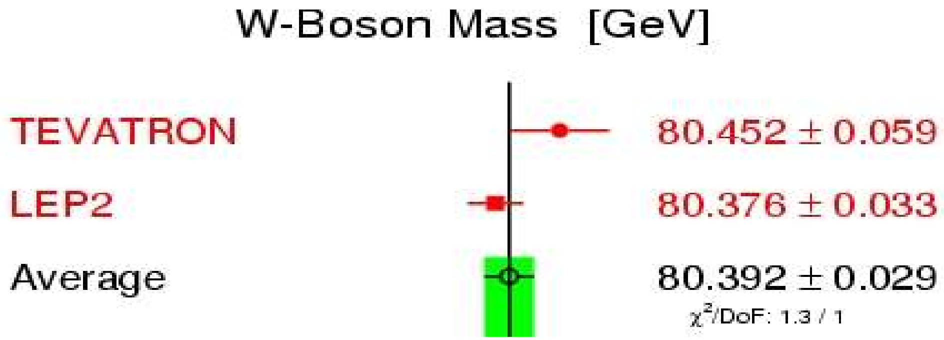
W mass uncertainty from input parameters:

Next talk



Parameter Shift	m_W Shift (MeV/c^2)
$\Delta m_H = +100$ GeV/c^2	-41.3
$\Delta m_t = +2.1$ GeV/c^2	12.8
$\Delta m_Z = +2.1$ MeV/c^2	2.6
$\Delta\alpha_{EM} = +0.00013$	-2.3

Direct W mass measurement



W mass predicted much more precisely (13 MeV) than measured (29 MeV)

Need to reduce δm_W to further constrain m_H and other new physics

Weak Boson Physics

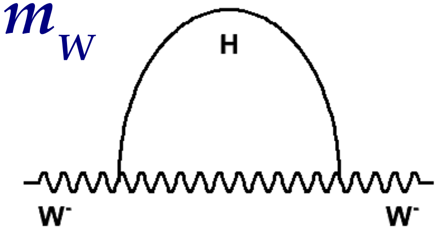
Z boson parameters measured precisely by LEP:

- **17** million measured *Z* candidates: δm_Z = **2.1** MeV, $\delta\Gamma_Z$ = **2.3** MeV

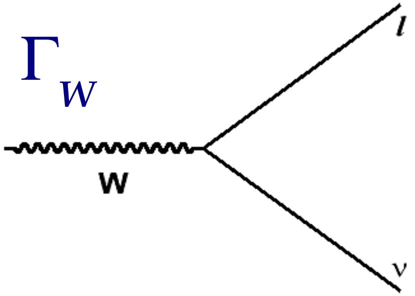
Tevatron goal:

- World's most precise *W* boson measurements
- Expect **15** million measured *W* candidates

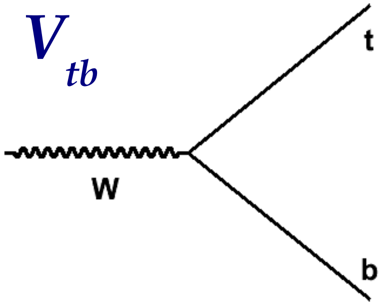
m_W



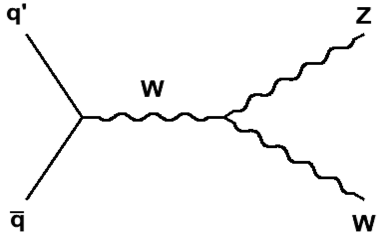
Γ_W



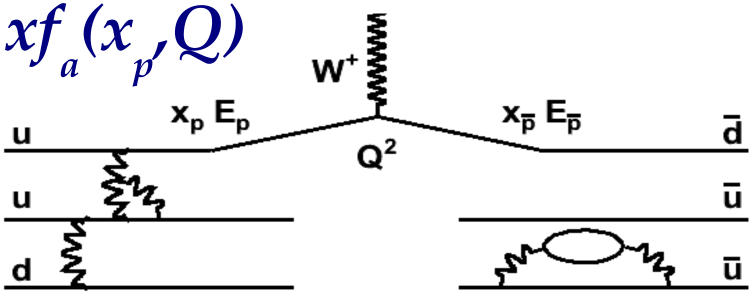
V_{tb}



WWZ coupling

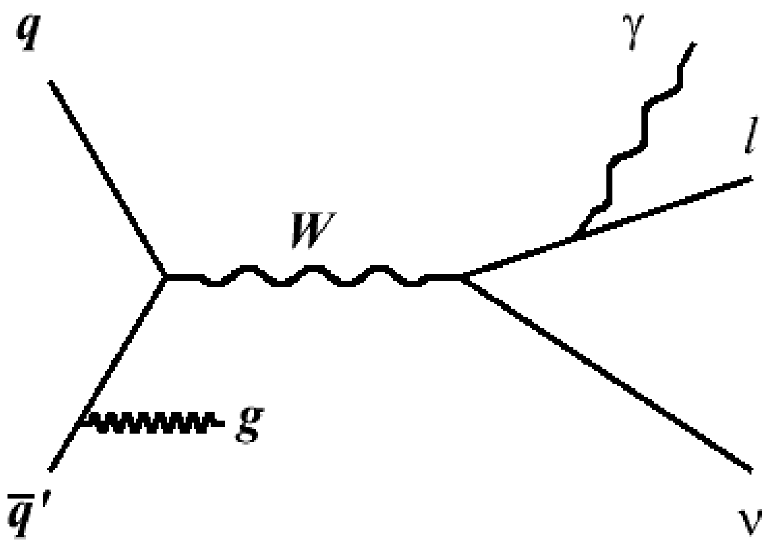


$xf_a(x_p,Q)$



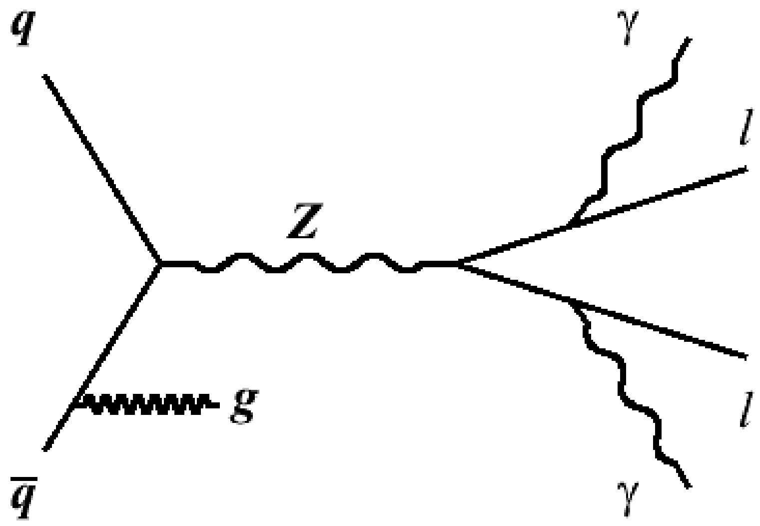
W & Z Boson Production and Decay

Dominant production mechanism: $q\bar{q}^{(\prime)}$ annihilation



$\sigma(W \rightarrow l\nu)$ = 2775 pb

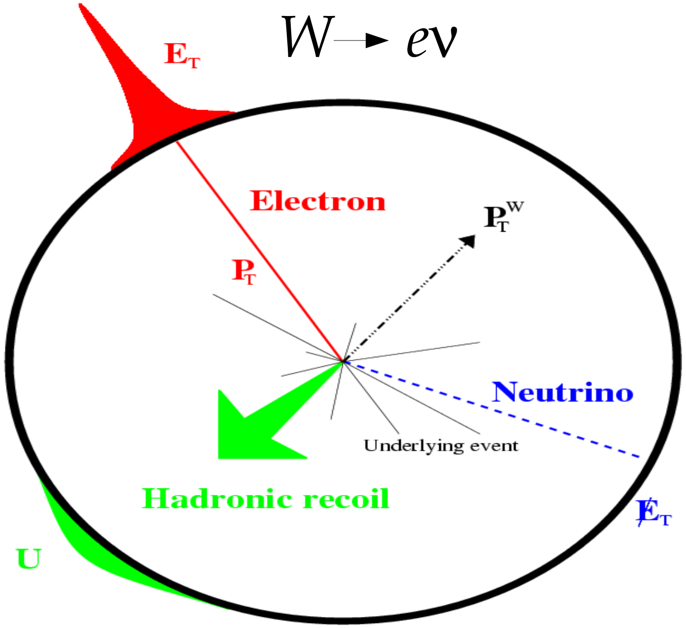
After event selection
(l, ν E_T > 30 GeV):
51,128 $W \rightarrow \mu\nu$ candidates
63,964 $W \rightarrow e\nu$ candidates



$\sigma(Z \rightarrow ll)$ = 254.9 pb

After event selection
(l E_T > 30 GeV):
4,960 $Z \rightarrow \mu\mu$ candidates
2,919 $Z \rightarrow ee$ candidates

Measurement Strategy



Calibrate $l^{\pm}$ track momentum with mass measurements of J/ψ and Υ decays to μ

Calibrate calorimeter energy using track momentum of e from W decays

Cross-check with Z mass measurement, then add Z's as a calibration point

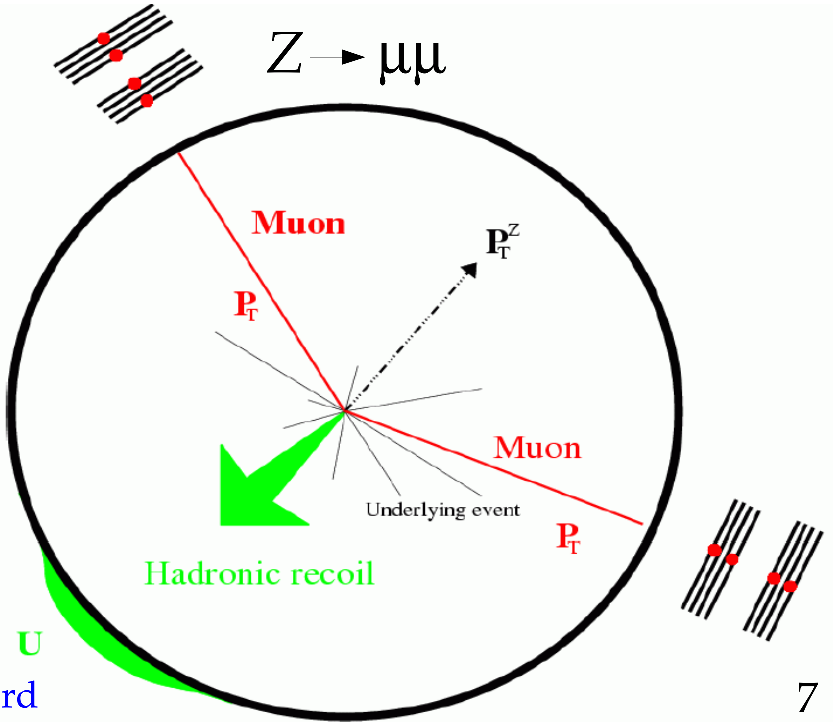
Calibrate recoil measurement with Z decays to e, μ

Cross-check with W recoil distributions

Combine information into transverse mass:

$$m_T = \sqrt{E_T \not{E}_T (1 - \cos\Delta\phi)}$$

Statistically most powerful quantity for m_W fit



Momentum Scale Calibration

Magnetic field along z-axis causes curvature in transverse plane:

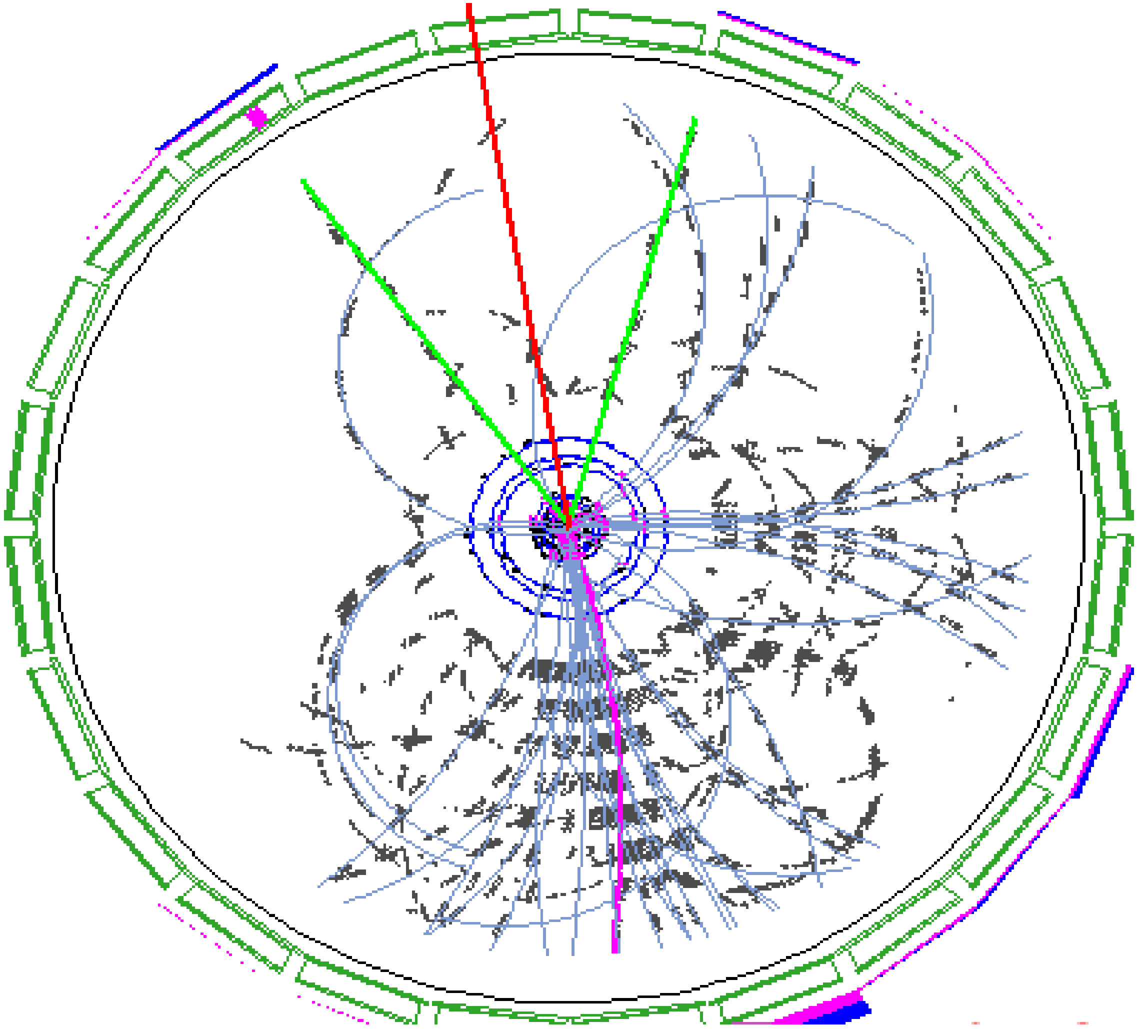
$$mv^2/R = evB,$$
$$p_T = eBR$$

CDF: Insufficient precision on *B* and *R* for *W* mass measurement

In-situ calibration:

(1) Apply relative alignment of drift chamber wires

(2) Determine momentum scales such that *J*/ψ, Υ, and *Z* mass measurements result in the world-average values →



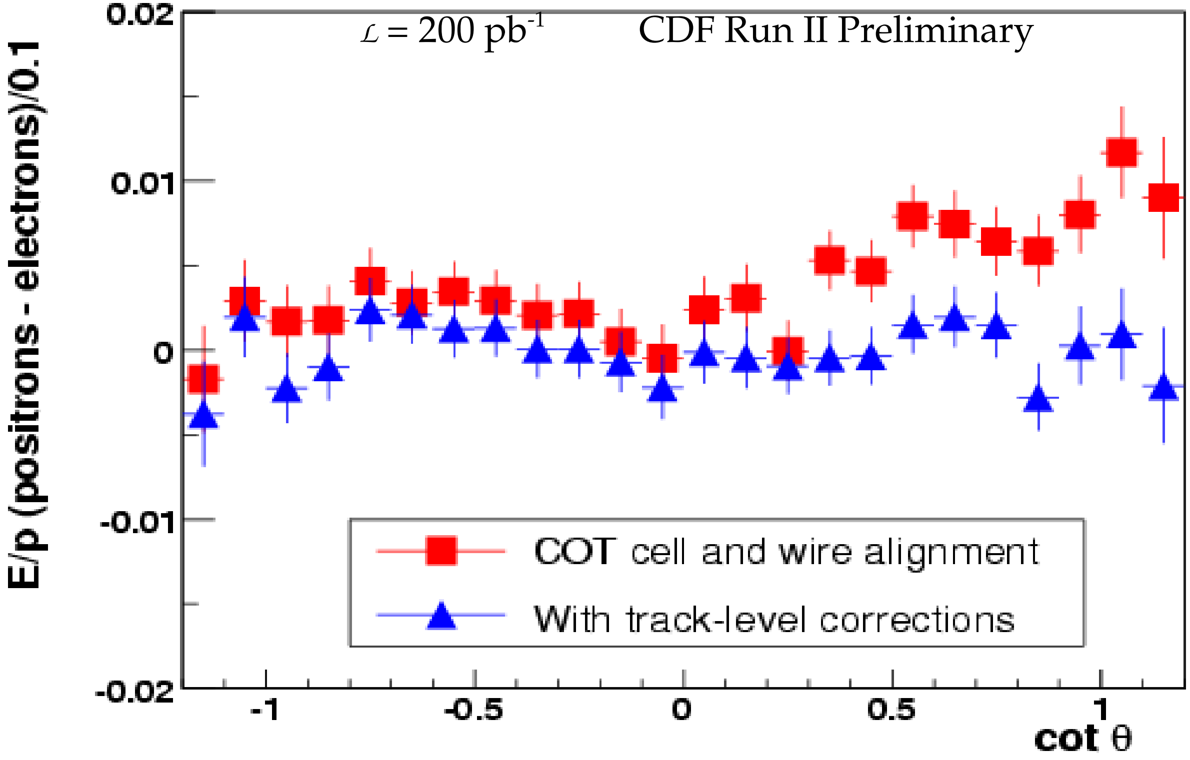
Combine results to obtain scale for m_W measurement

Alignment and Corrections

Align tracker using cosmic-ray data

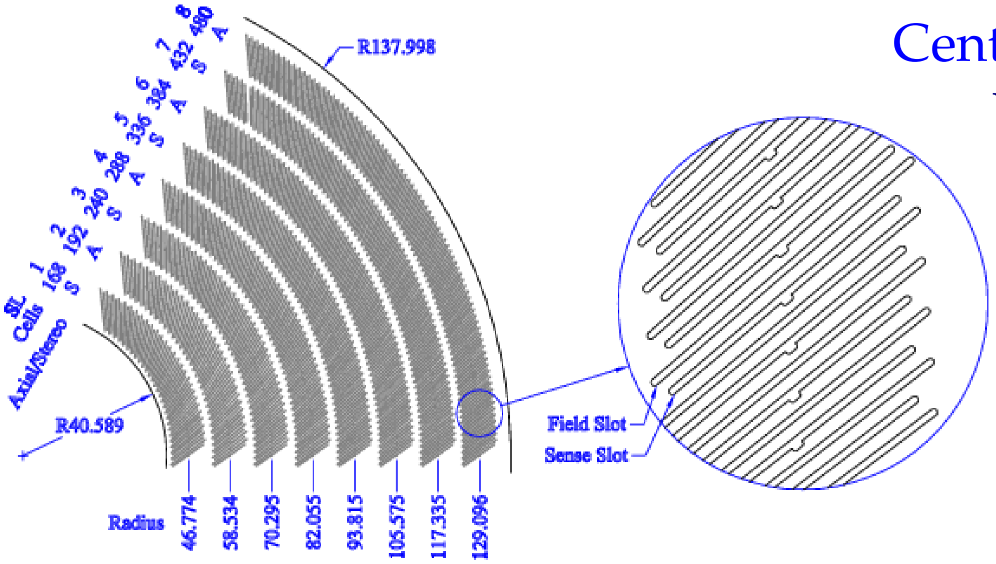
Determine track-level corrections from electron-positron differences

- Use ratio of calorimeter energy to track momentum
- *Curvature biases affect e^+, e^- differently, but calorimeter measurement independent of charge*



Statistical uncertainty of track-level corrections leads to δm_W **= 6 MeV**

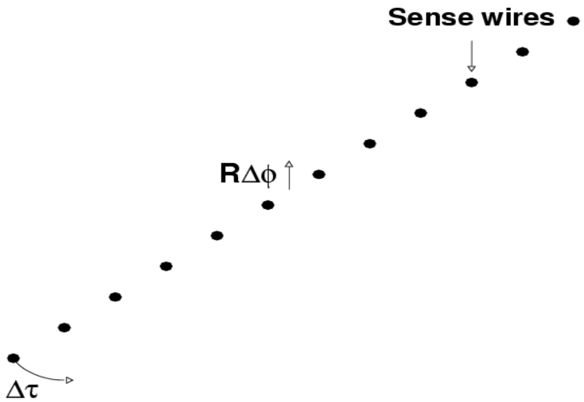
Tracker Alignment

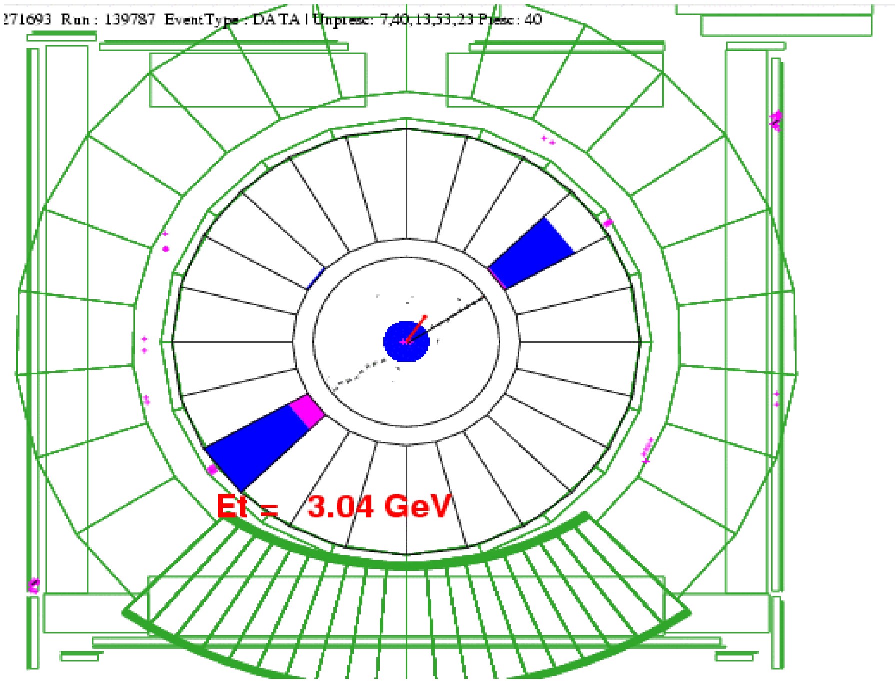


Central Outer Tracker: Open-cell drift chamber

Wires strung under tension between two endplates

Model endplate distortions and constructional variations using a cell-to-cell endplate alignment





Determine individual cell tilts & shifts using cosmic-ray data

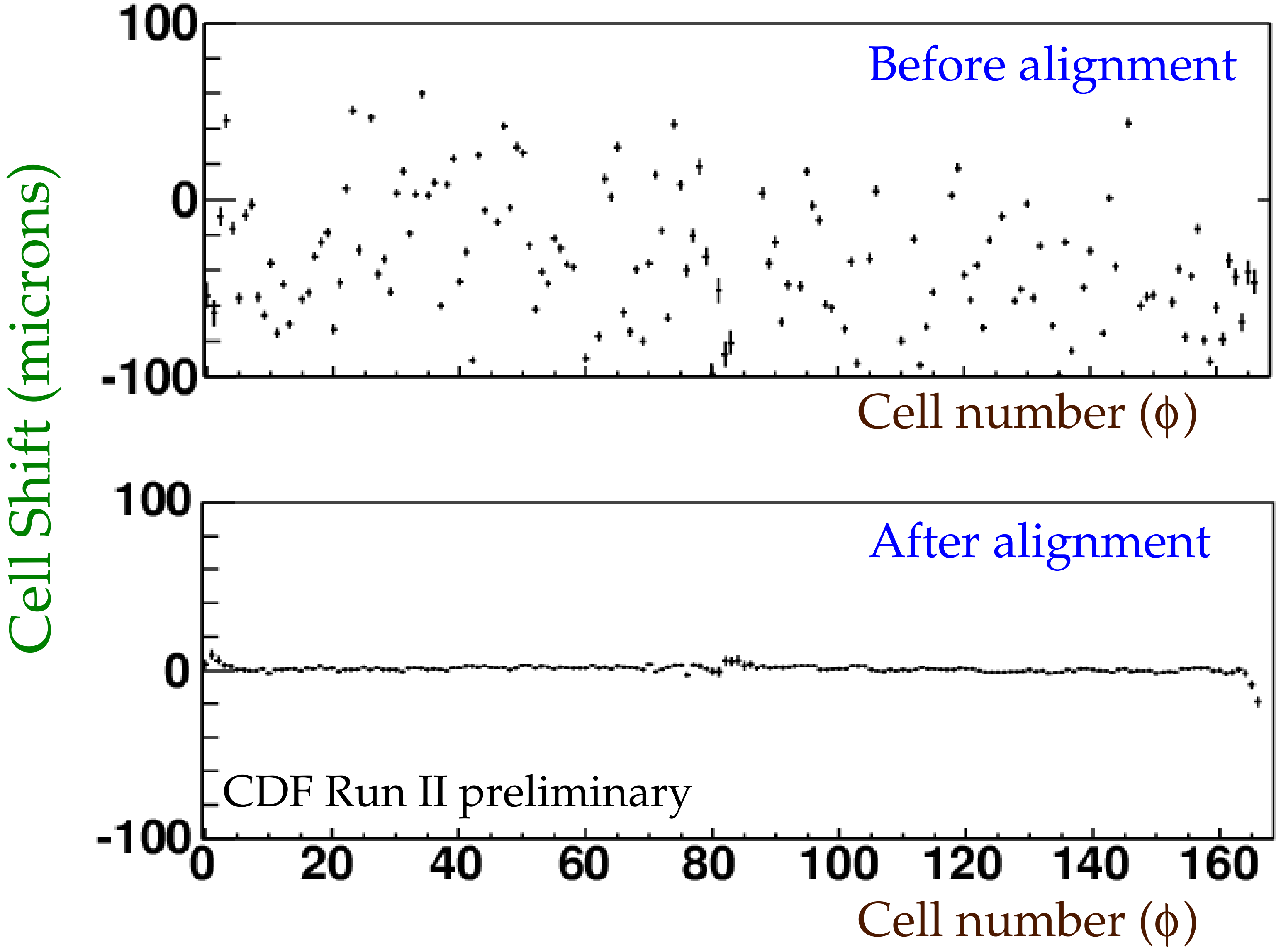
Fit a single 'dicosmic' to track segments on opposite sides of the chamber

Measure cell displacement

(Kotwal, Gerberich, Hays, NIM A 506, 110 (2003))

Alignment Example

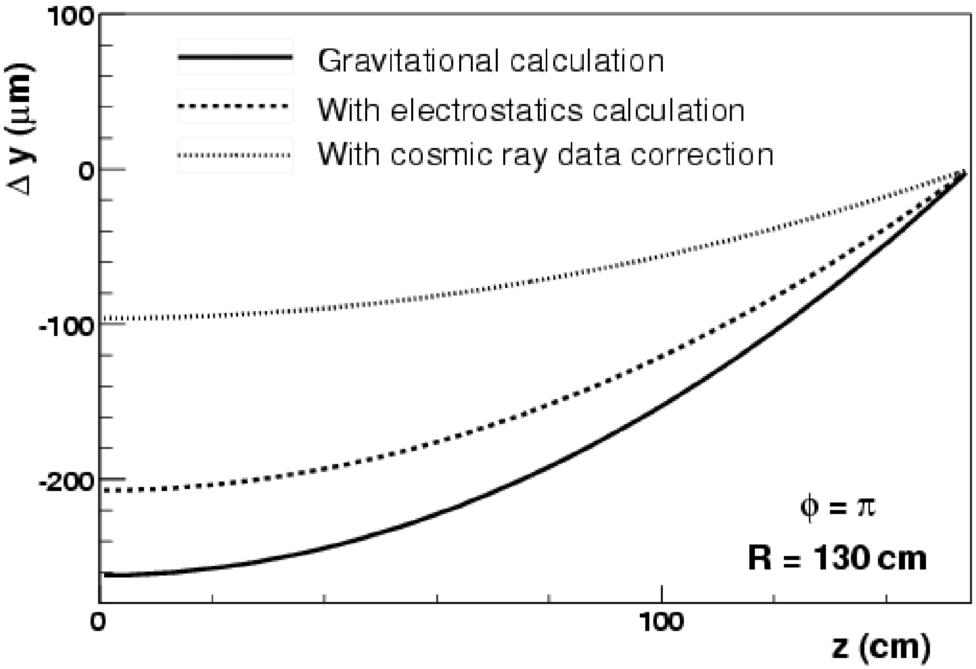
Inner 'Superlayer:'



Wire Alignment

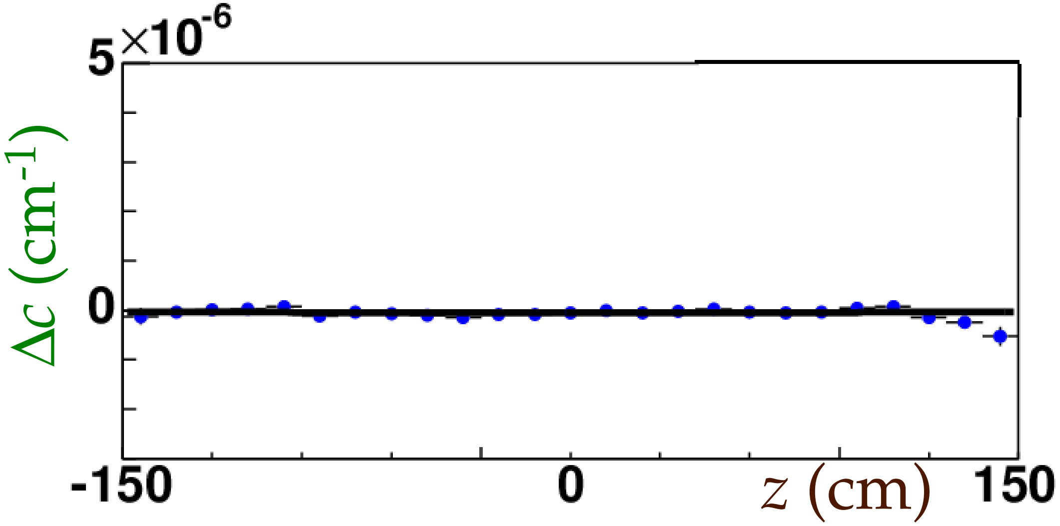
Wire shape along z-axis determined by:

- *Gravitational sag*
- *Electrostatic effects*



Apply additional correction based on cosmic ray study

- *Compare parameters of incoming and outgoing tracks from a cosmic ray muon*



Final correction removes *z*-dependent curvature biases

Mass Measurements

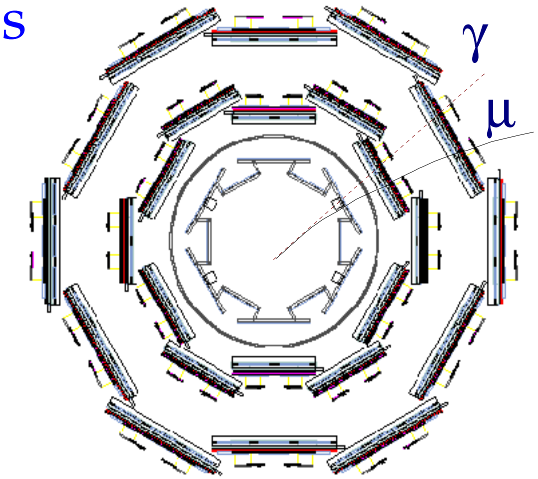
Template mass fits to *J*/ψ, Υ, *Z* resonances in muon decay channels

Fast detector simulation models relevant physical processes

internal bremstrahlung

ionization energy loss

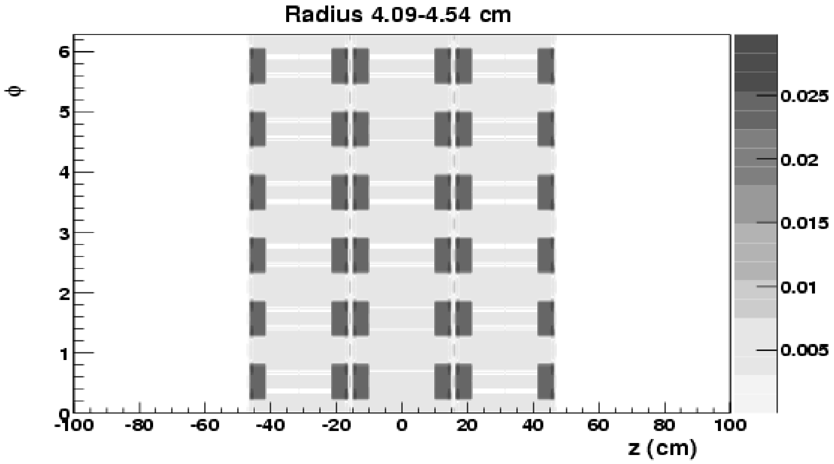
multiple scattering



Simulation includes event reconstruction and selection

Detector material model

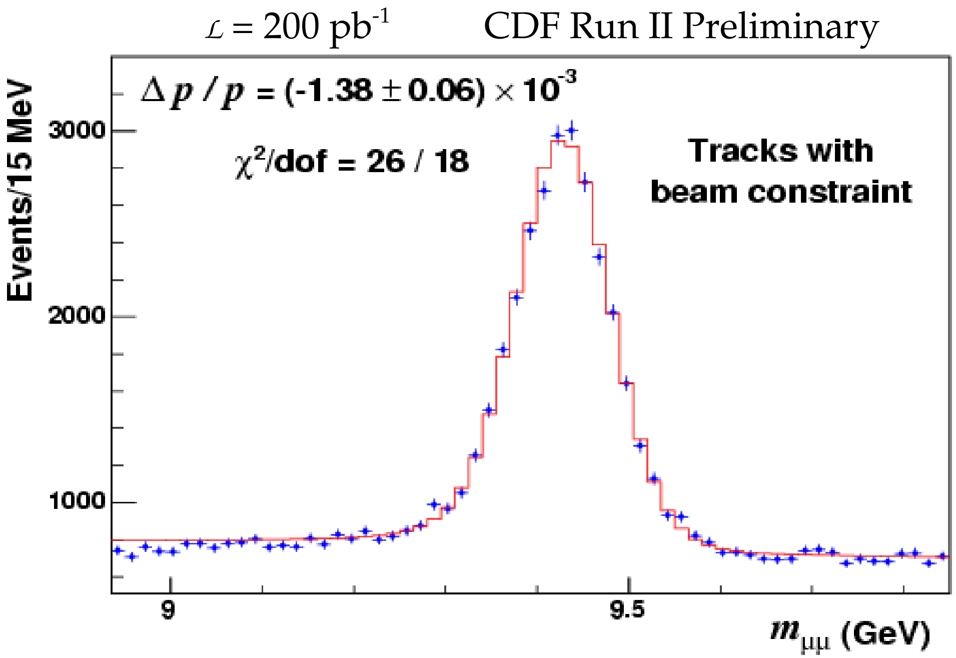
Map energy loss and radiation lengths in each detector layer



One material parameter determined from data:

Overall material scale

Υ Mass Measurement



34,618 Υ → μμ candidates

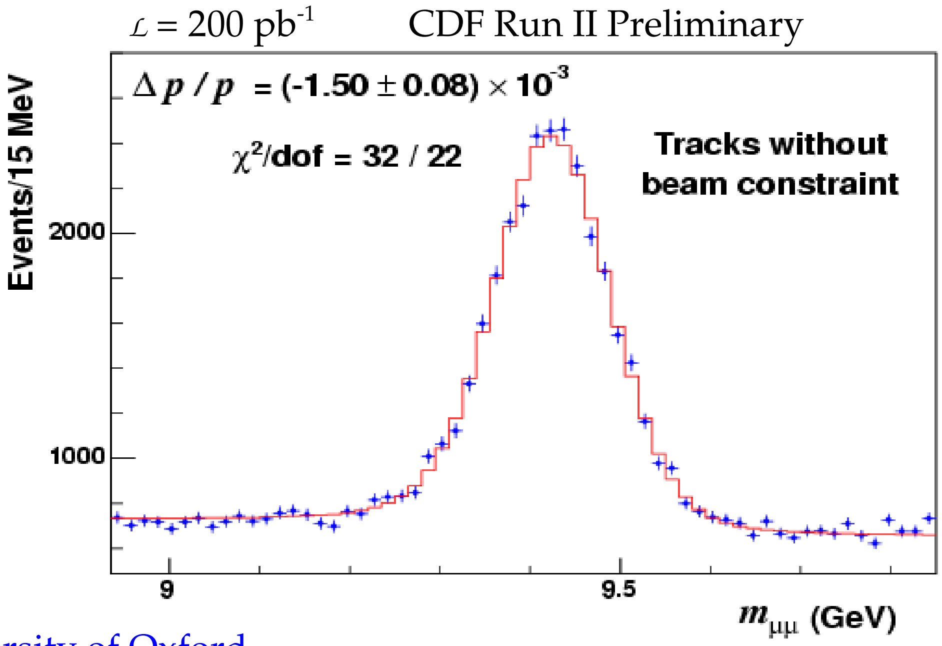
Short lifetime allows a track constraint to the beam line

Improves resolution by a factor of ≈3

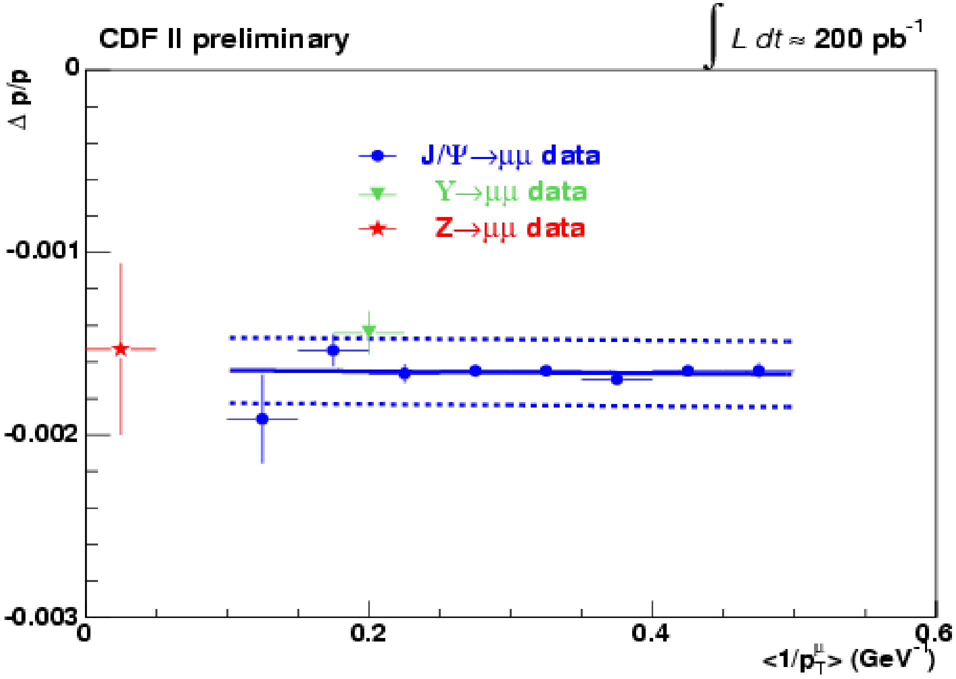
Test beam constraint by measuring mass using unconstrained tracks

Correct by half the difference between fits

Take correction as a systematic uncertainty



Momentum Scale Calibration



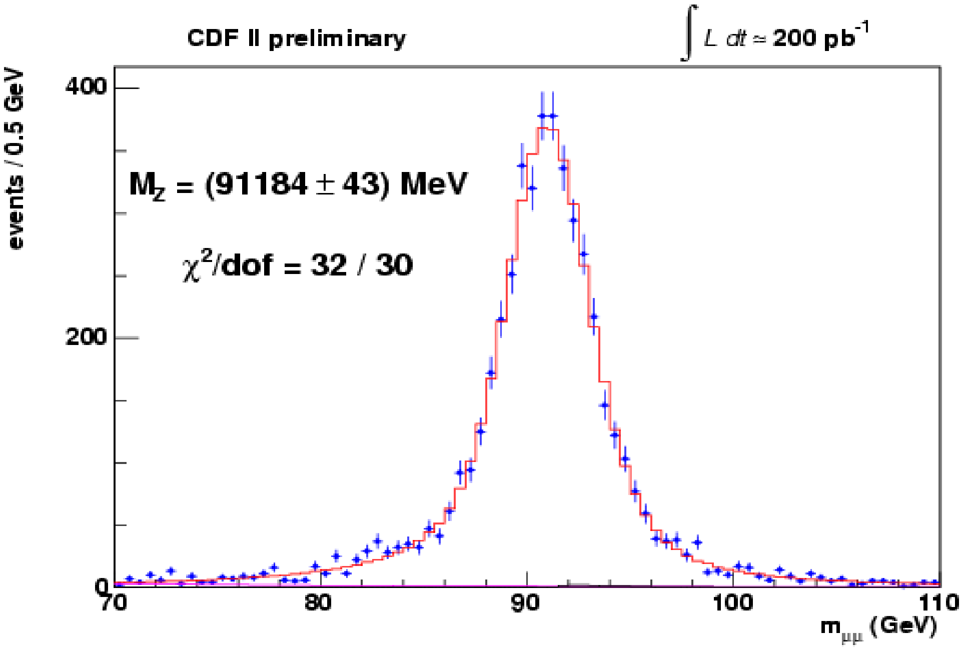
606,701 $J/\psi \rightarrow \mu\mu$ candidates

Fit mass as a function of mean inverse p_T

Slope affected by energy loss modelling

Scale detector material by 0.94 to remove slope

Use calibrated momentum scale to measure Z mass

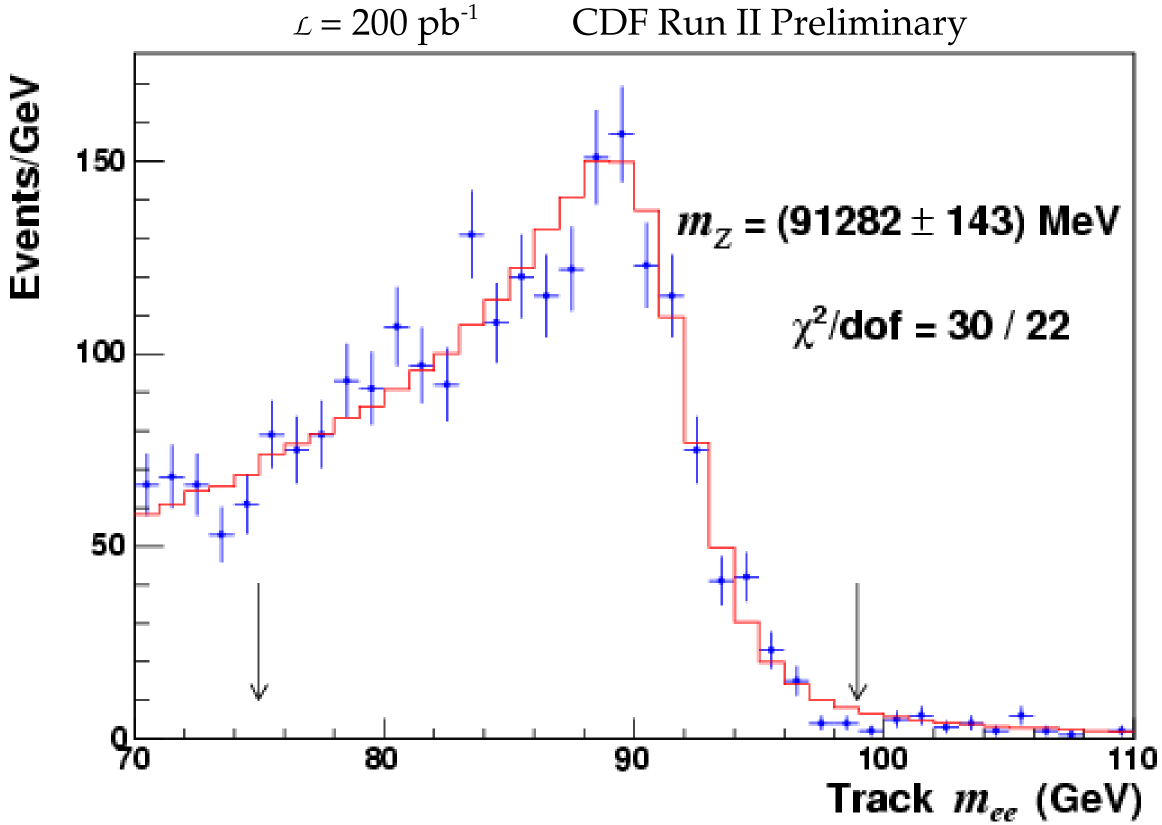


Constrain tracks to originate from the beam line

Improves resolution by a factor of ≈3

Electron Track Model Validation

Fit Z mass reconstructed from electron track momenta



Measured value consistent with world average value (91188 MeV)

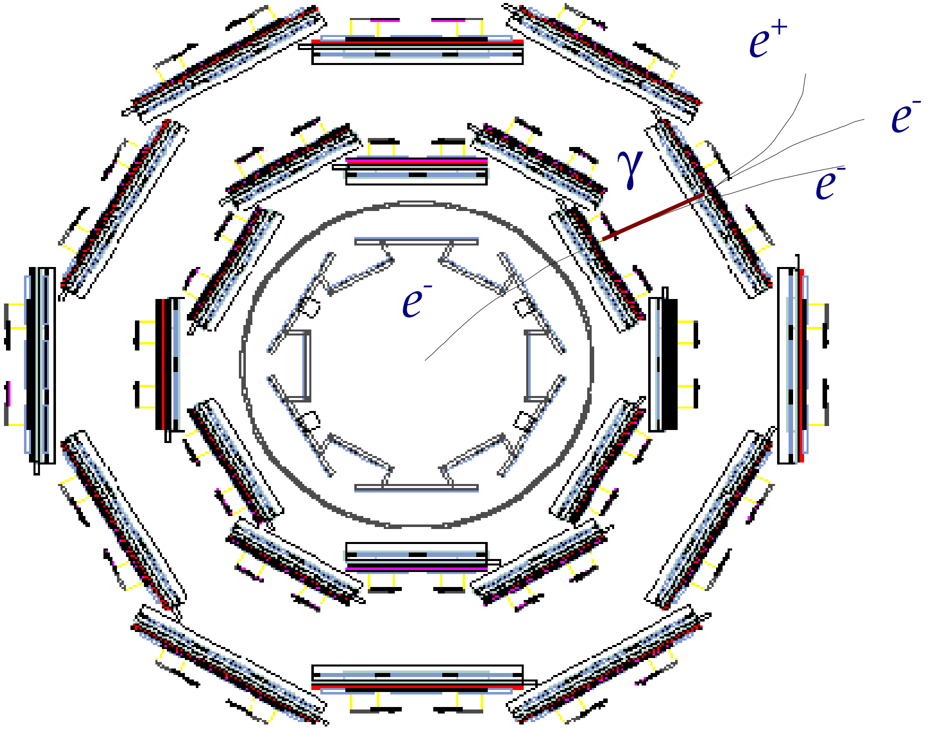
Calorimeter Energy Calibration

Calibrate electron energy using electron track momentum

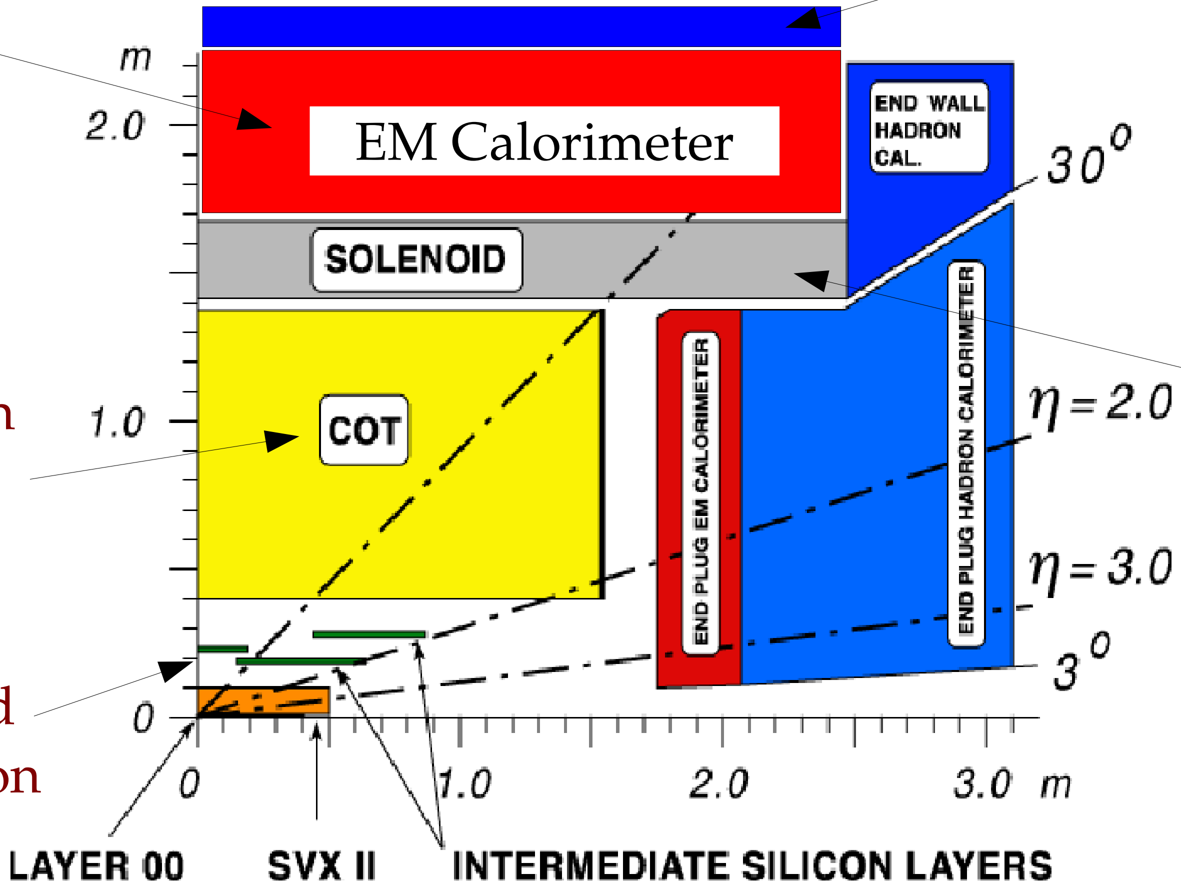
First step: validate model of electrons in tracker

Additional physical effects beyond those associated with muons:

Photon radiation and conversion in tracker



Full Electron Simulation



Response and resolution in EM calorimeter

Energy loss into hadronic calorimeter

Track reconstruction in outer tracker

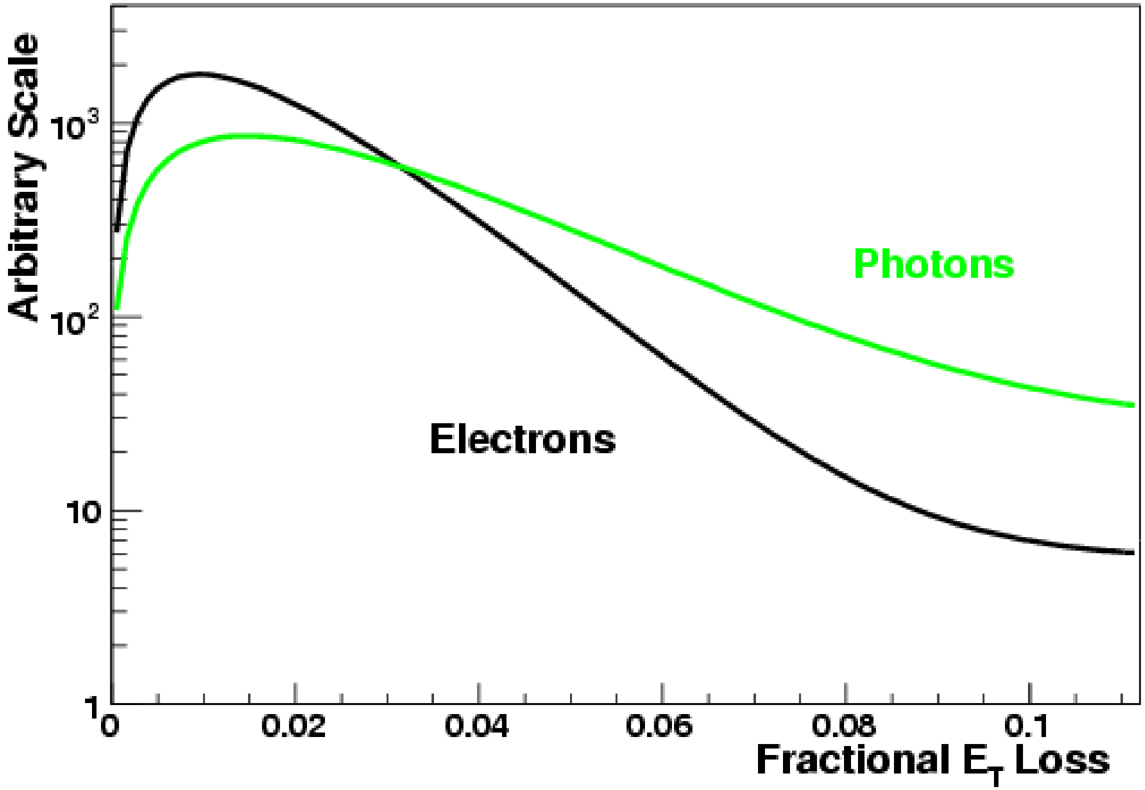
Energy loss in solenoid

Bremstrahlung and conversions in silicon

Energy Loss Model

Use GEANT to parametrize energy loss in solenoid and hadronic calorimeter

Energy loss in hadronic calorimeter:



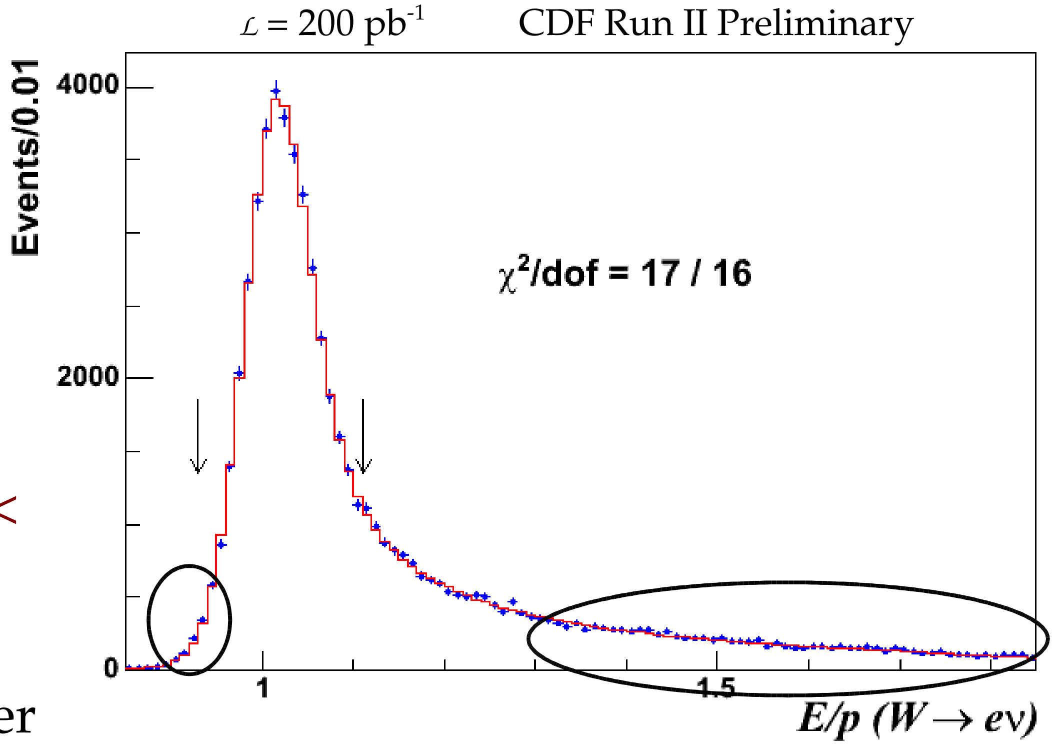
Energy Scale Calibration

Calibrate calorimeter energy with peak of *W* electron *E/p* distribution

One free parameter for X_0 scale (set with high *E/p* region)

Material scale: 1.004 ± 0.009

Calorimeter Energy < Track Momentum:
Energy loss in hadronic calorimeter



Calorimeter Energy > Track Momentum:
Energy loss in tracker

Energy scale uncertainty: 0.034%

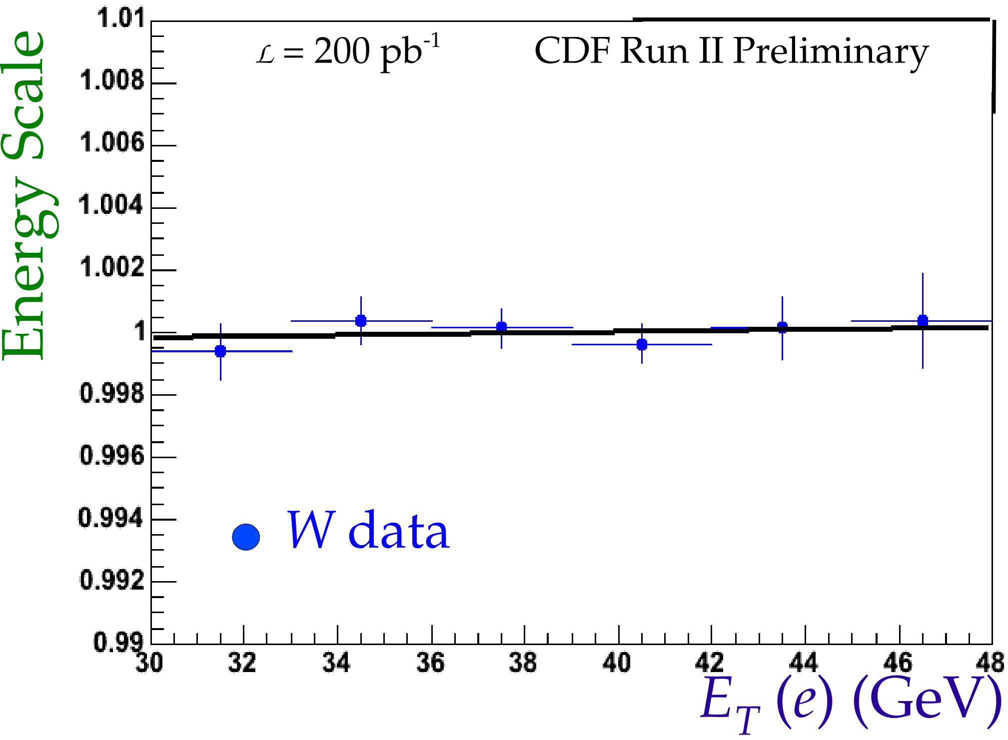
Scale Energy Dependence

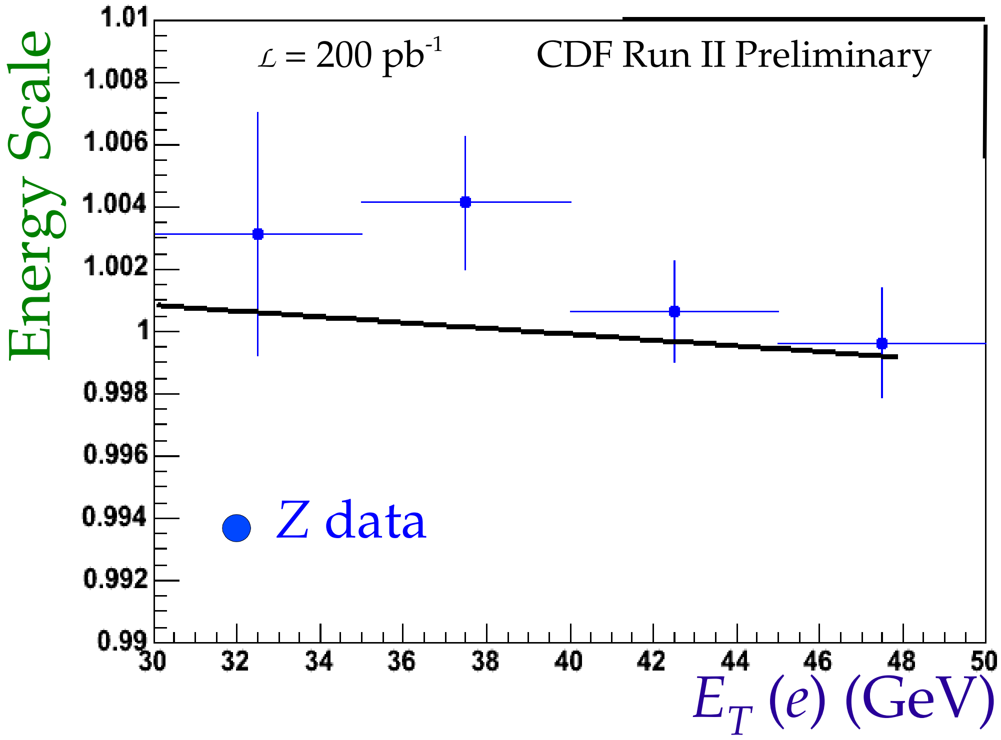
Apply energy-dependent scale to each simulated electron and photon

Determine energy dependence from E/p fits as functions of electron E_T

Scale: $1 + (\mathbf{6 \pm 7}) \times 10^{-5}\,[E_T/\mathrm{GeV} - 39]$ **(δm_W = 23 MeV)**

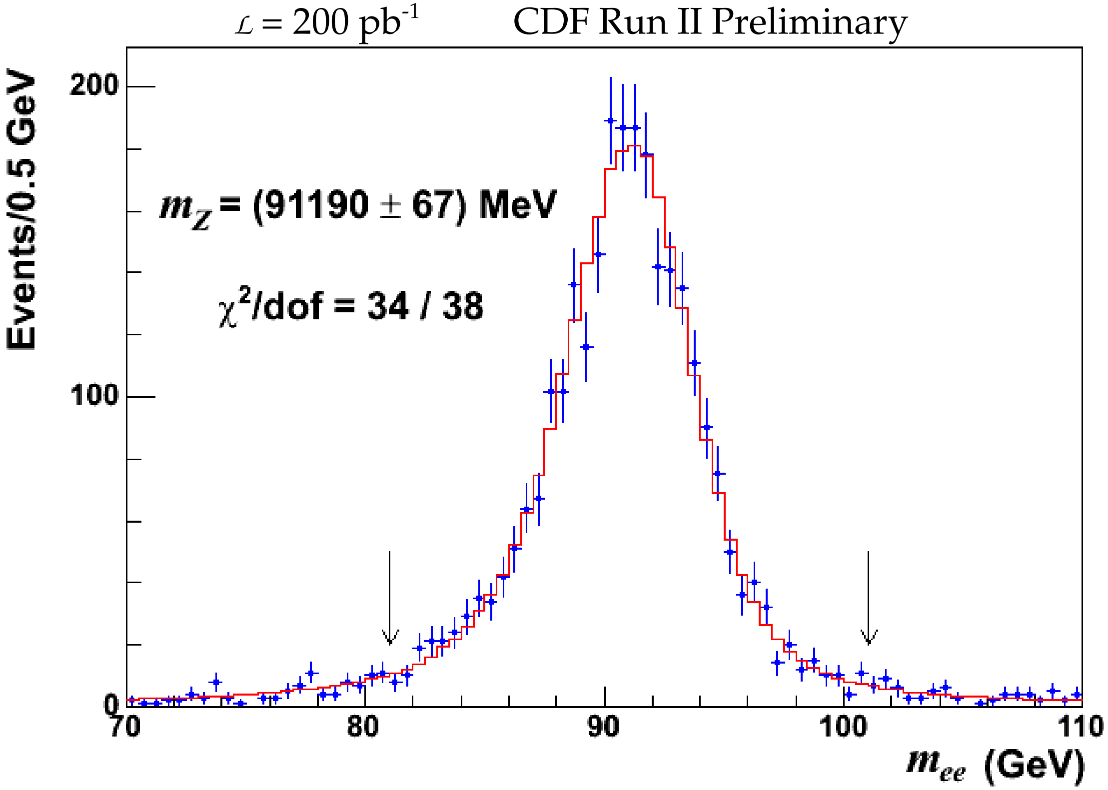
Most energy dependence implicitly accounted for by detector model





Z Mass Measurement

Fit Z mass using scale from E/p calibration



Measured value consistent with world average value (91188 MeV)

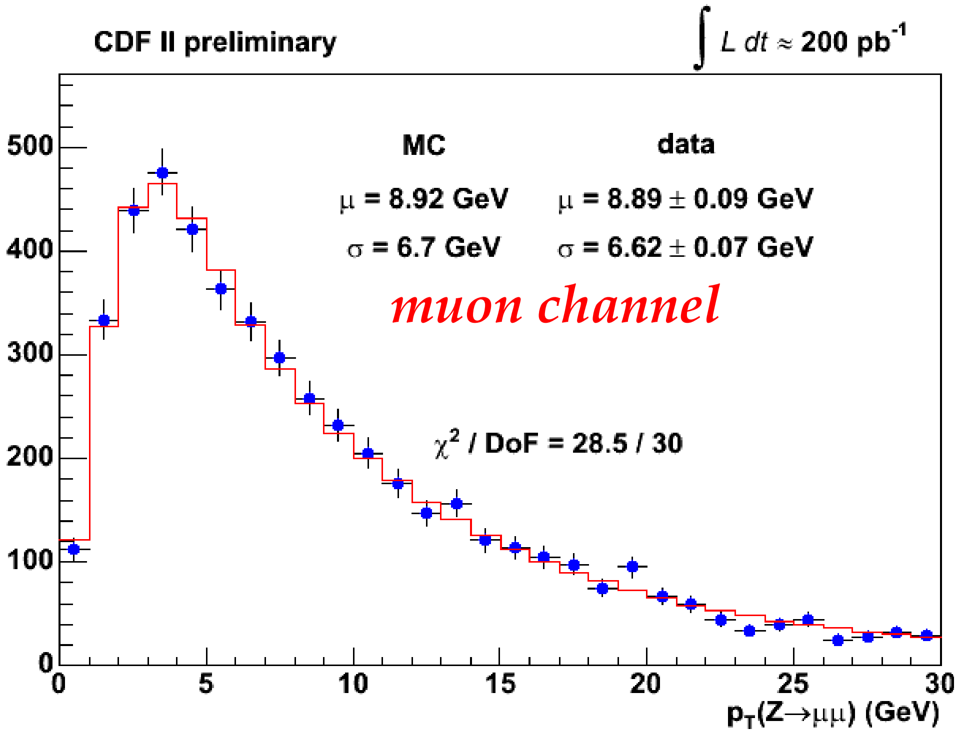
Incorporate mass fit into calibration to reduce scale uncertainty

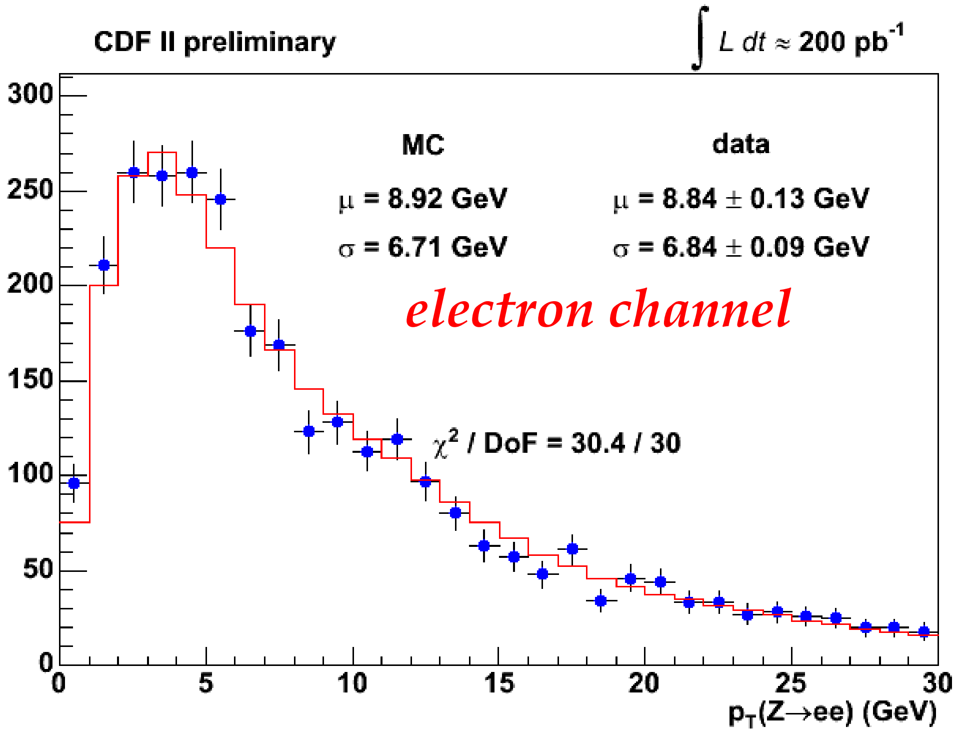
δm_W **= 30 MeV**

Boson p_T Model

Model boson p_T using RESBOS generator with tunable non-perturbative parameters

- "g_2" parameter determines position of peak in p_T distribution
- Measure g_2 with Z boson data (other parameters have negligible effect on W mass)
  - $g_2 = 0.685 \pm 0.048$: δm_W **= 3 MeV**



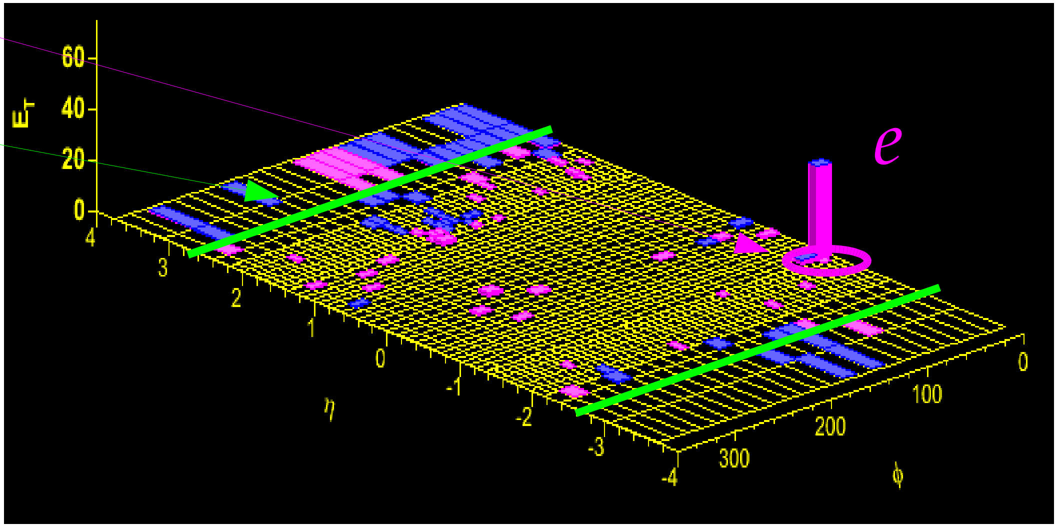


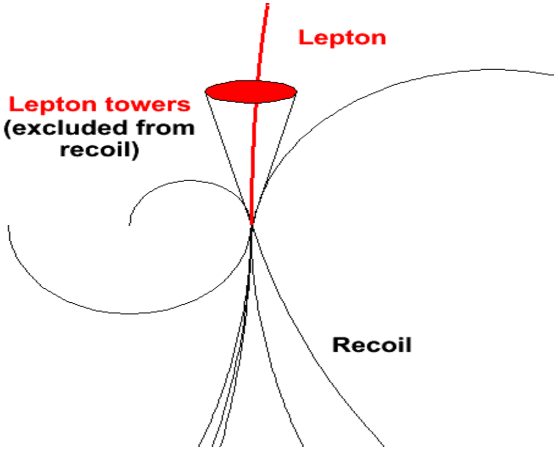
Recoil Measurement

Calculate recoil by summing over calorimeter towers, excluding:

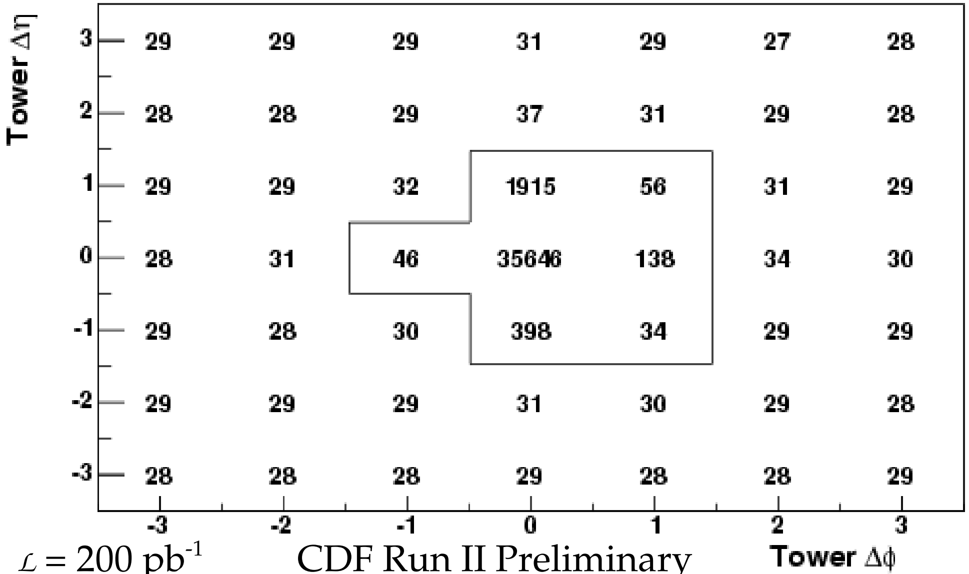
Towers with lepton energy deposits

Towers near the beam line





Electron Electromagnetic E_T (MeV)



Tower Δη \ Tower Δφ	-3	-2	-1	0	1	2	3
3	29	29	29	31	29	27	28
2	28	28	29	37	31	29	28
1	29	29	32	1915	56	31	29
0	28	31	46	35646	138	34	30
-1	29	28	30	398	34	29	29
-2	29	29	29	31	30	29	28
-3	28	28	28	29	28	28	29

$\mathcal{L} = 200\ \mathrm{pb}^{-1}$ CDF Run II Preliminary

Electron: Remove 7 towers (shower)

Muon: Remove 3 towers (MIP)

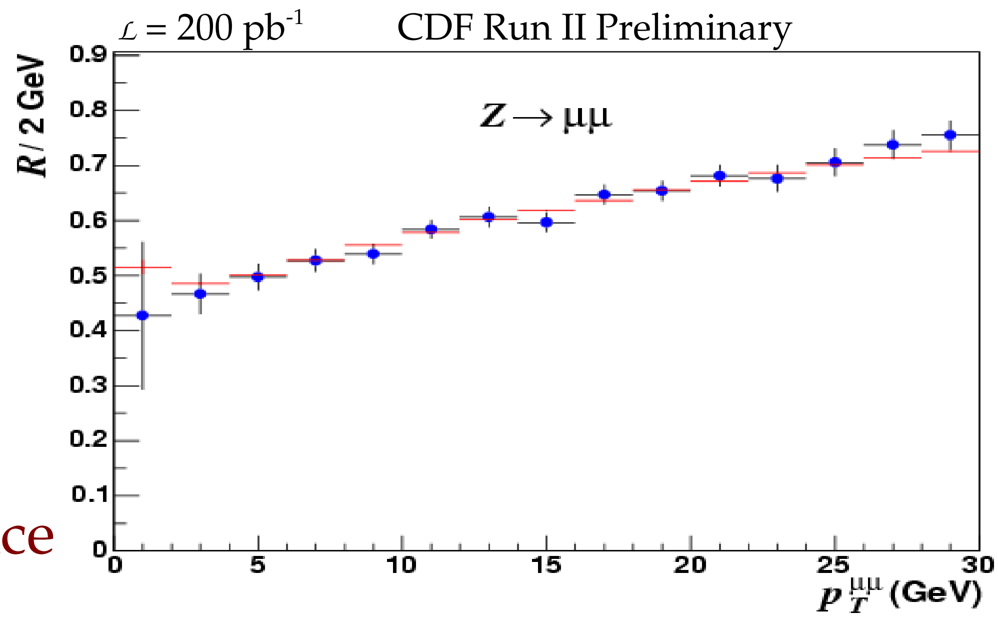
Model tower removal in simulation

δm_W **= 8 (5) MeV for** e **(**μ**)**

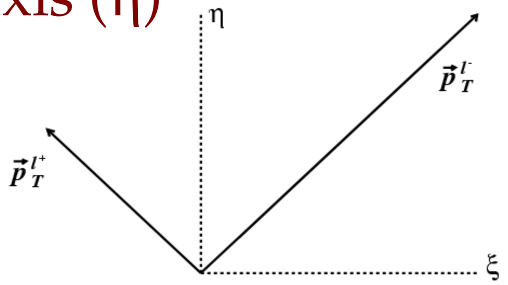
Recoil Model

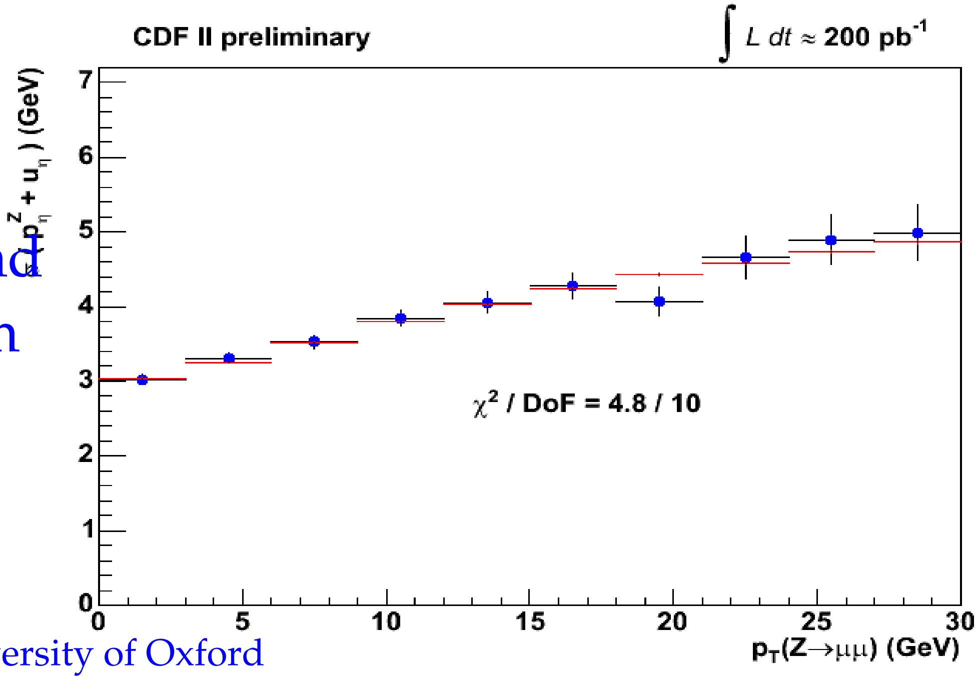
Components:

- *Recoil scale* $(R = u_{meas} / u_{true})$
- *Recoil resolution*
- *Spectator and additional interactions*
  (contribute to resolution)



Calibrate scale with momentum balance along bisector axis (η)





Calibrate models of recoil resolution and spectator interactions using momentum resolution along both axes

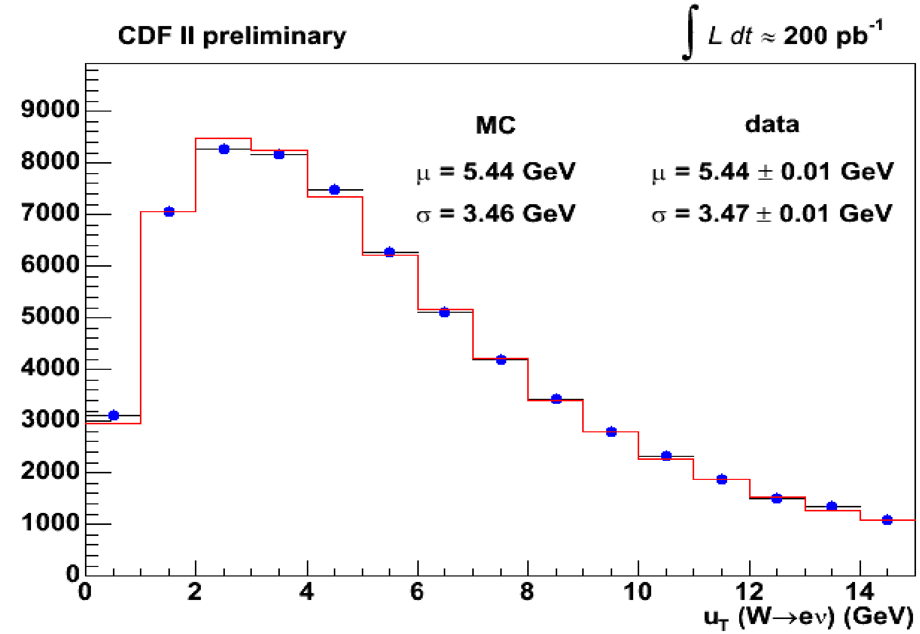
$$\delta m_W = \mathbf{11\ MeV}$$

Recoil Model Checks

Apply model to *W* boson sample, test consistency with data

Recoil distribution

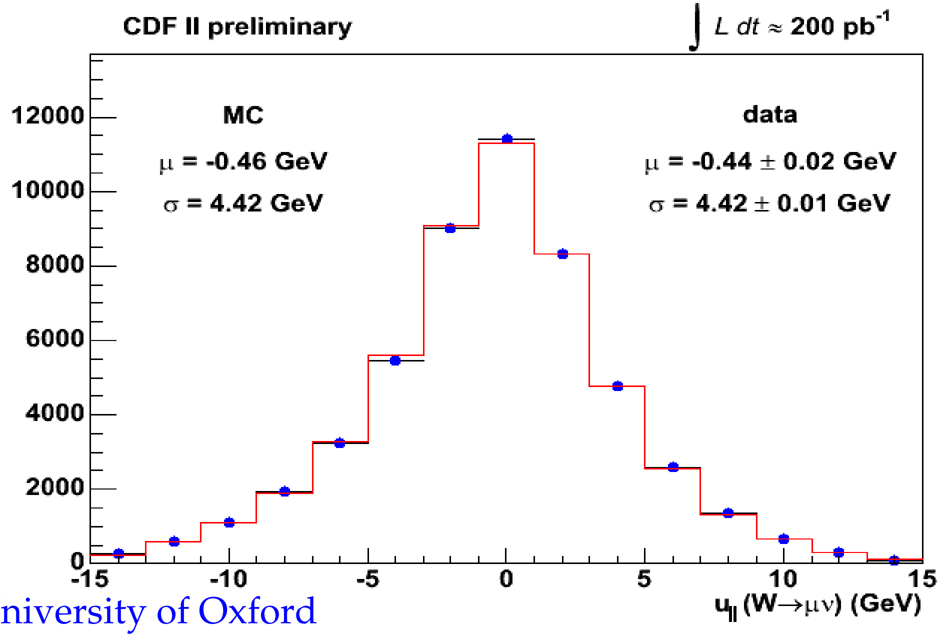
Sensitive to scale, resolution, boson p_T



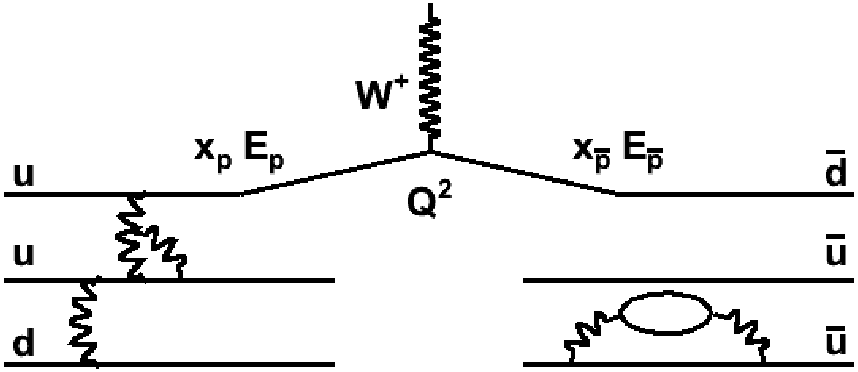
$u_{||}$ distribution

Sensitive to lepton removal, efficiency model, scale, resolution, W decay

Directly affects m_T *fit result*



Production, Decay, Background

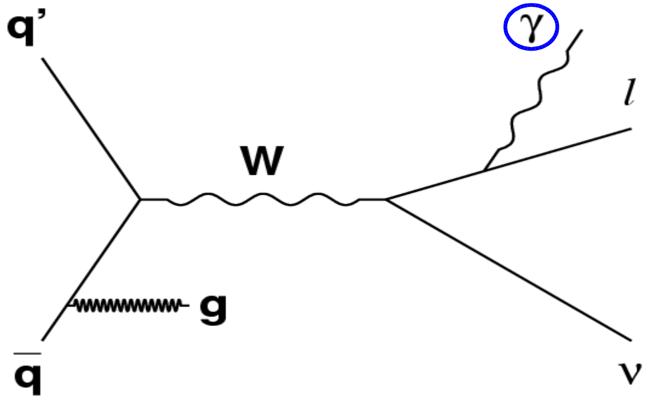


Boson p_z determined by

parton distribution functions

Vary PDFs according to uncertainties

δm_W = 11 MeV



Bremßtrahlung reduces charged lepton p_T

Predict using NLO QED calculation,

apply NNLO correction

δm_W = 11 (12) MeV for *e* (μ)

Background affects fit distributions

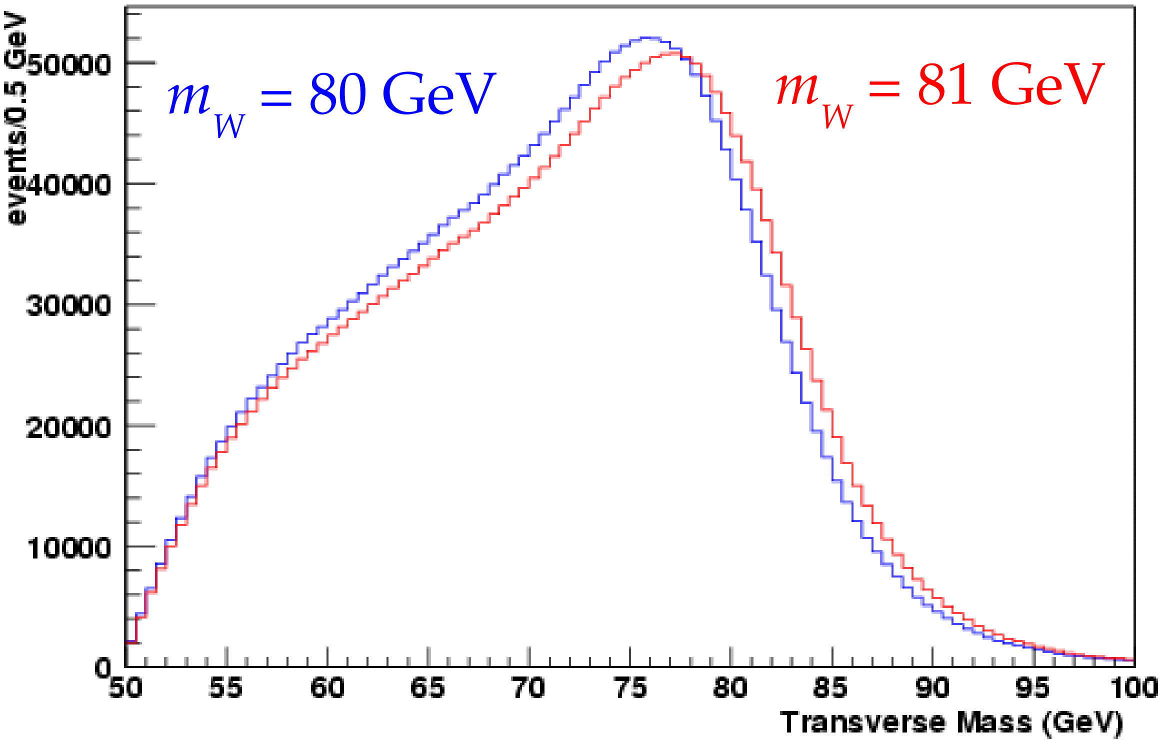
QCD: Measure with data

Electroweak: Predict with MC

δm_W = 8 (9) MeV for *e* (μ)

Background	% (μ)	% (*e*)
Hadronic Jets	0.1 ± 0.1	0.25 ± 0.15
Decays in Flight	0.3 ± 0.2	-
Cosmic Rays	0.05 ± 0.05	-
$Z \longrightarrow ll$	6.6 ± 0.3	0.24 ± 0.04
$W \longrightarrow \tau\nu$	0.89 ± 0.02	0.93 ± 0.03

Transverse Mass Distribution

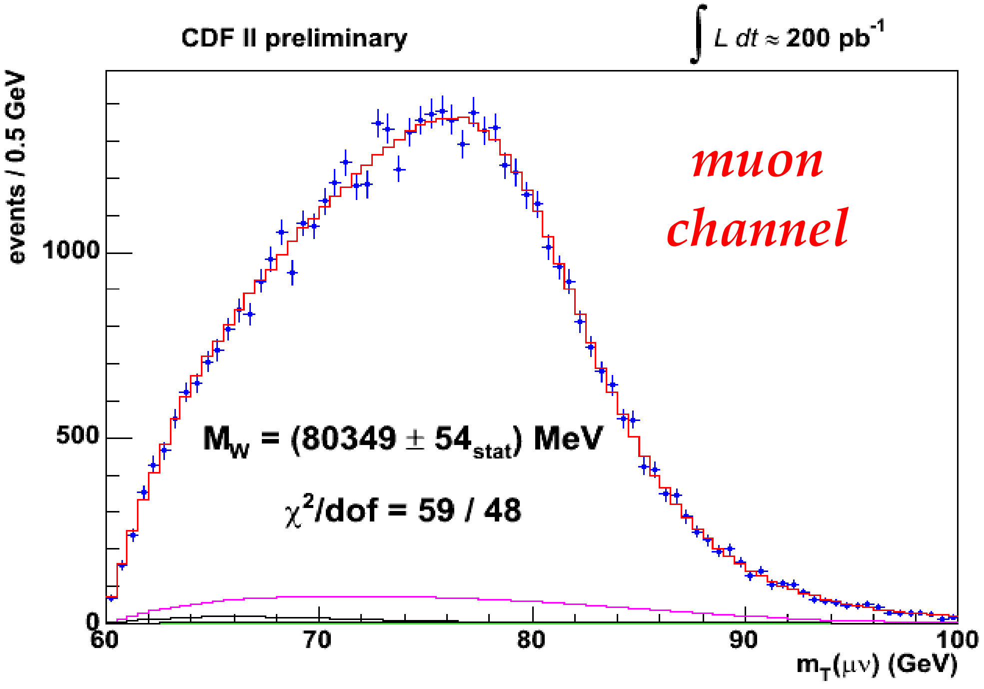


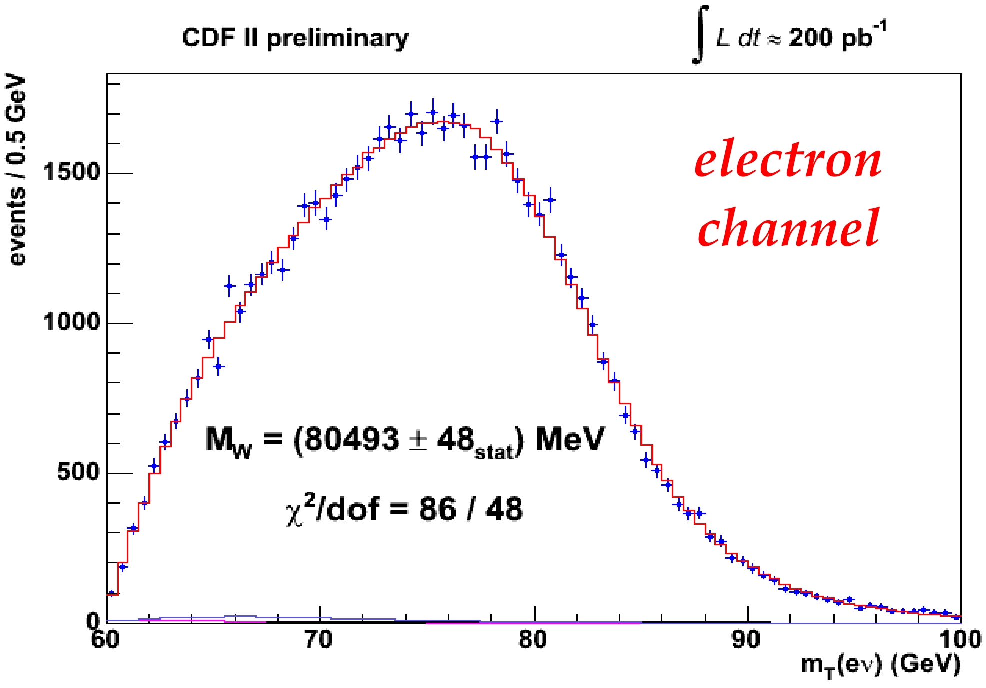
Distribution peaks just below m_W and falls sharply just above m_W

W Mass Fits

Mass fit results blinded with [-100,100] MeV offset throughout analysis
Upon completion, offset removed to determine final result

Transverse mass fits:





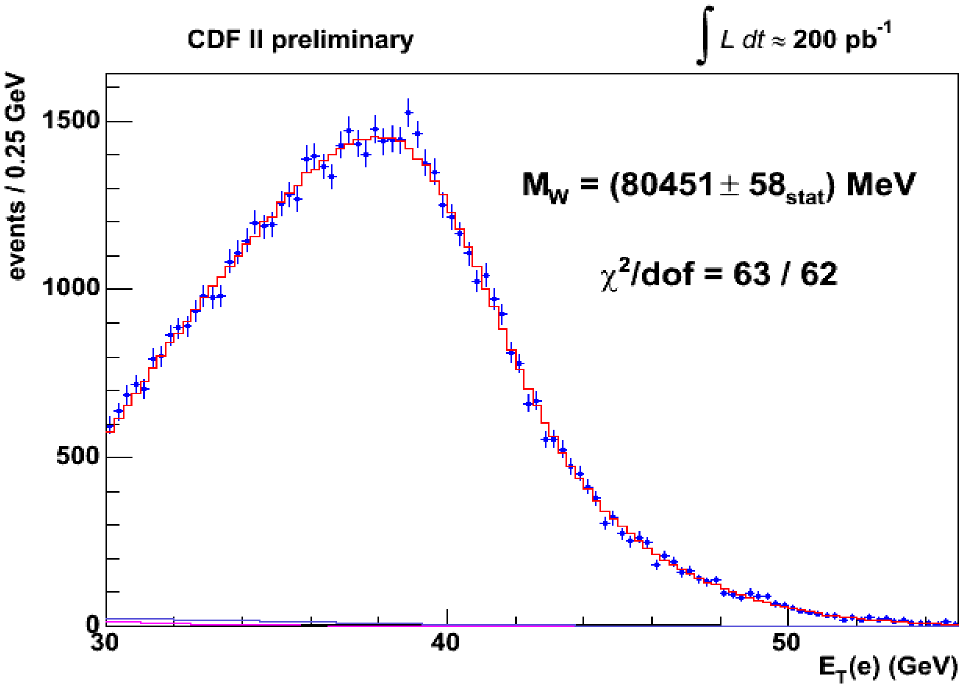
m_W = 80417 ± 48 MeV (stat + sys)

for $e + \mu$ combination ($P(\chi^2) = 7\%$)

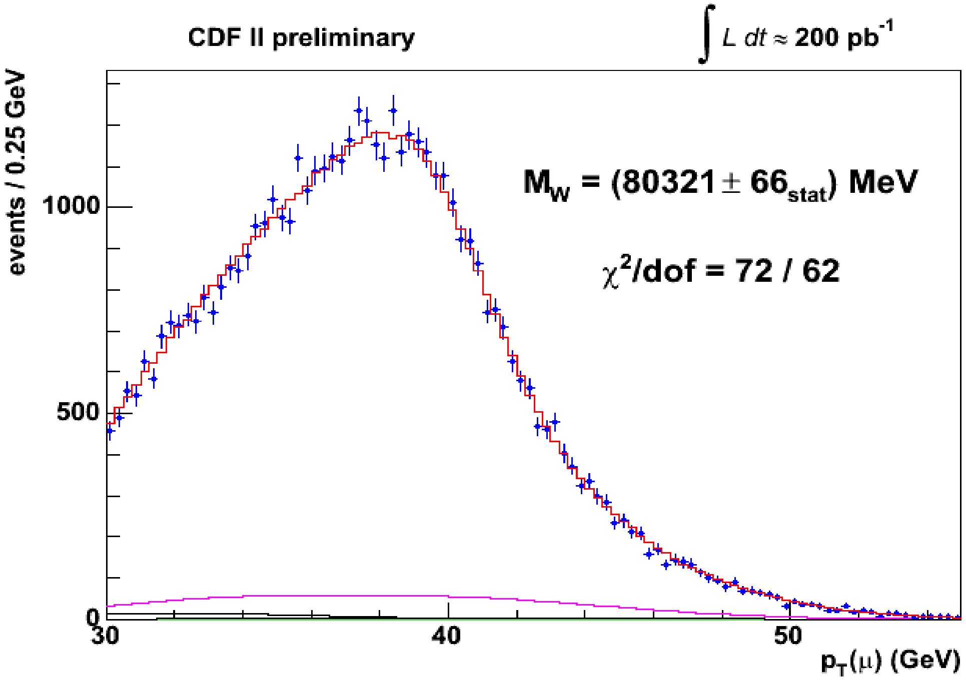
W Mass Fits

Fit E_T, $\not{E}_T$ distributions and combine with m_T to extract most precise result

Electron E_T fit:



Muon p_T fit:



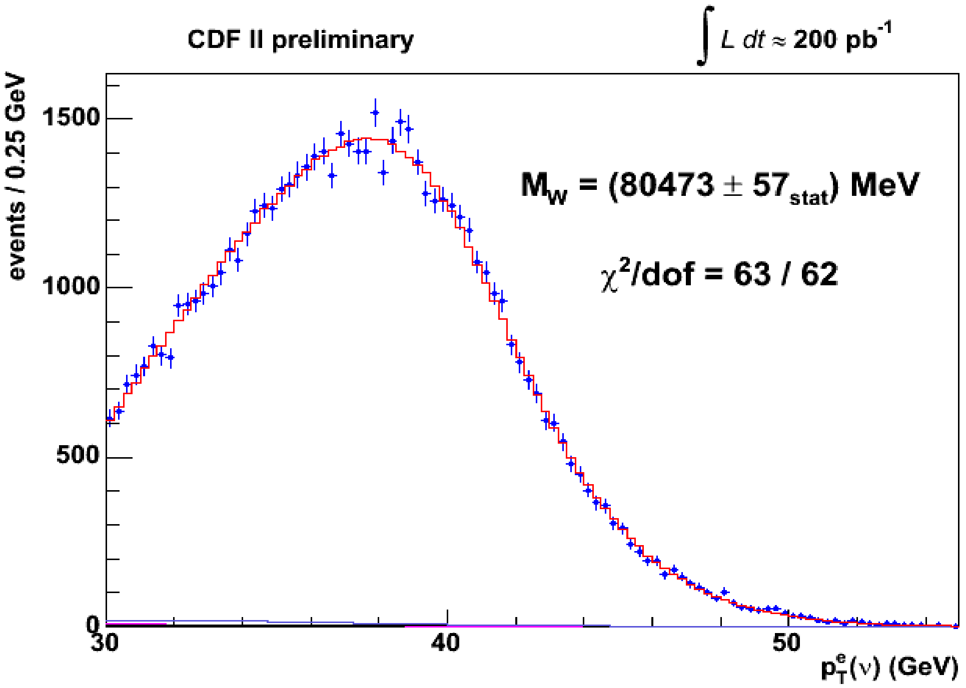
m_W = 80388 ± 59 MeV (stat + sys)

for lepton p_T $e + \mu$ combination ($P(\chi^2) = 18\%$)

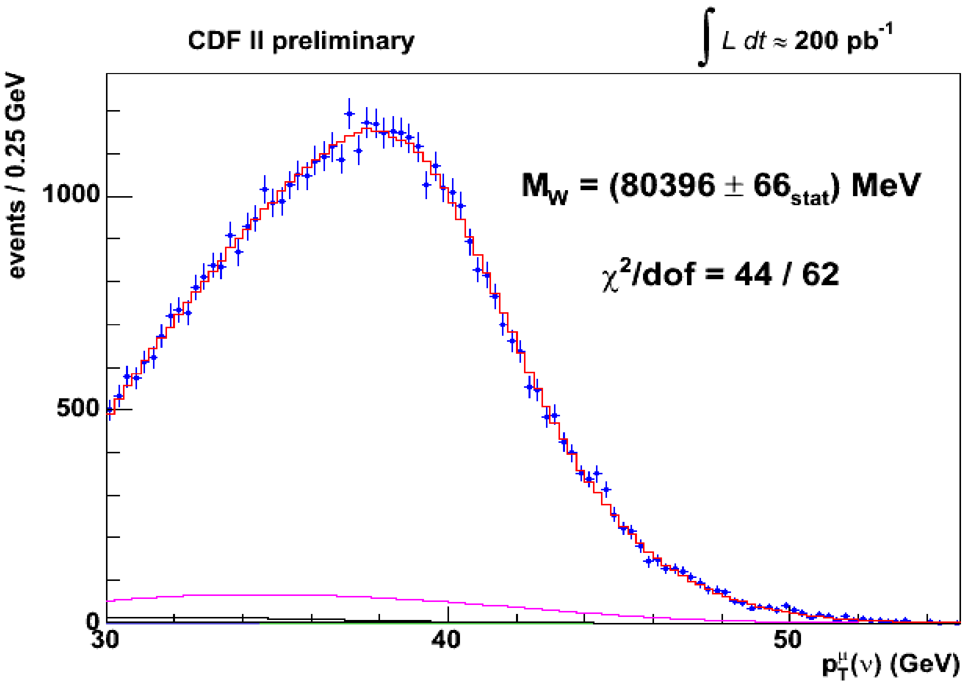
W Mass Fits

m_W = 80434 ± 65 MeV (stat + sys)
for neutrino p_T $e + \mu$ combination ($P(\chi^2)$ = 43%)

Electron $\not{E}_T$ fit:

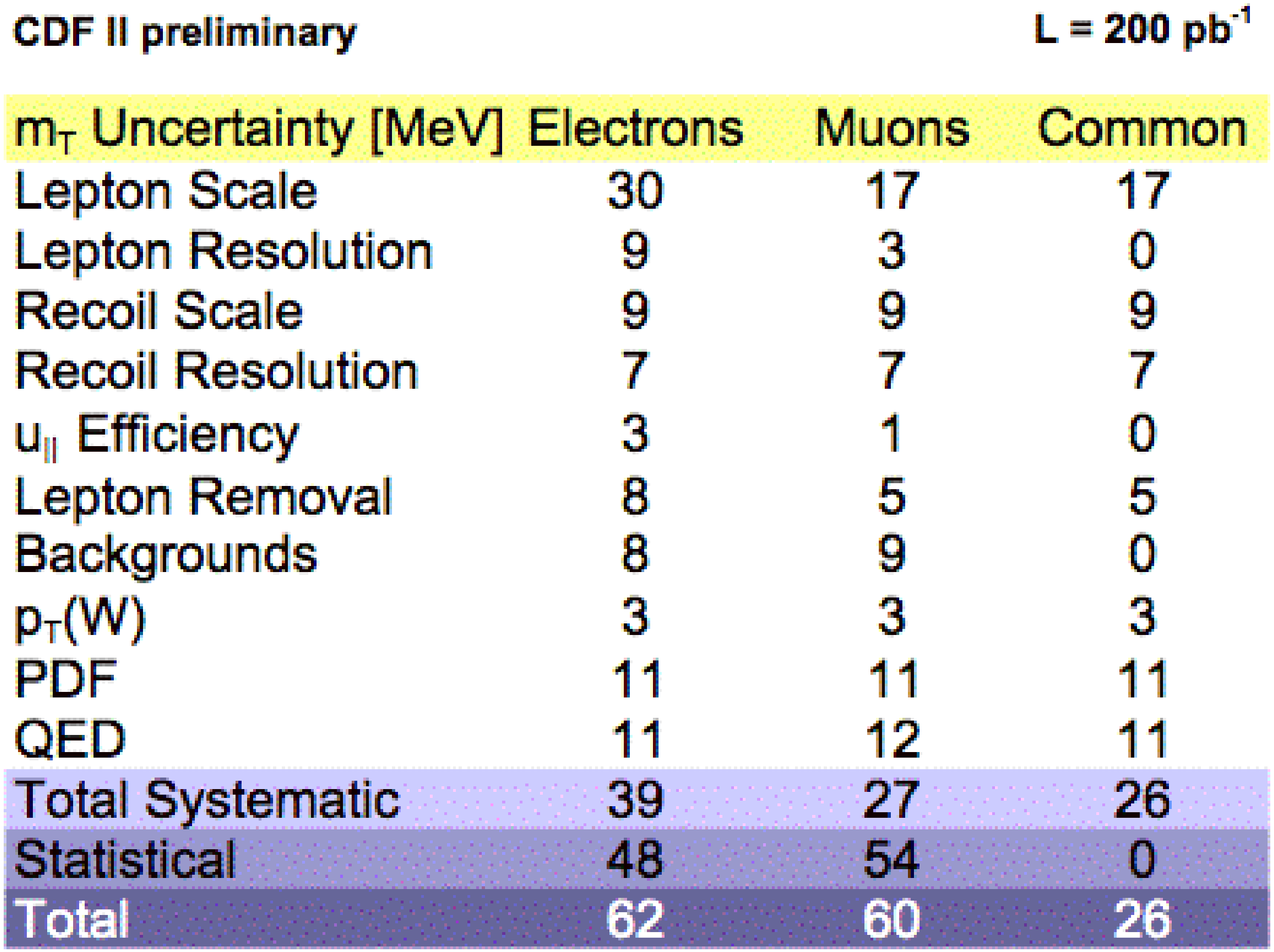


Muon $\not{E}_T$ fit:



m_W = 80413 ± 48 MeV (stat + sys)
for six-fit combination ($P(\chi^2)$ = 44%)

W Mass Uncertainties



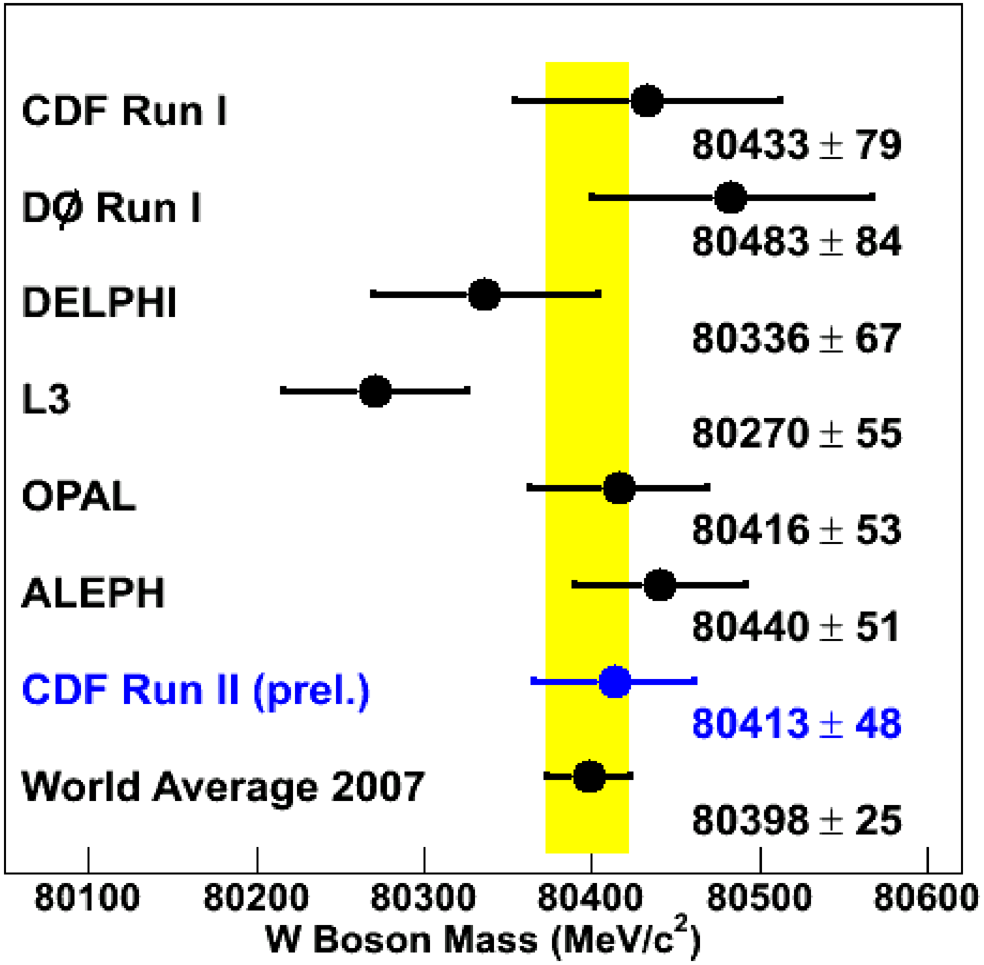
CDF II preliminary **$L = 200\ \mathrm{pb}^{-1}$**

m_T Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	9	9	9
Recoil Resolution	7	7	7
$u_{\parallel}$ Efficiency	3	1	0
Lepton Removal	8	5	5
Backgrounds	8	9	0
$p_T(W)$	3	3	3
PDF	11	11	11
QED	11	12	11
Total Systematic	39	27	26
Statistical	48	54	0
Total	62	60	26

W Mass Result

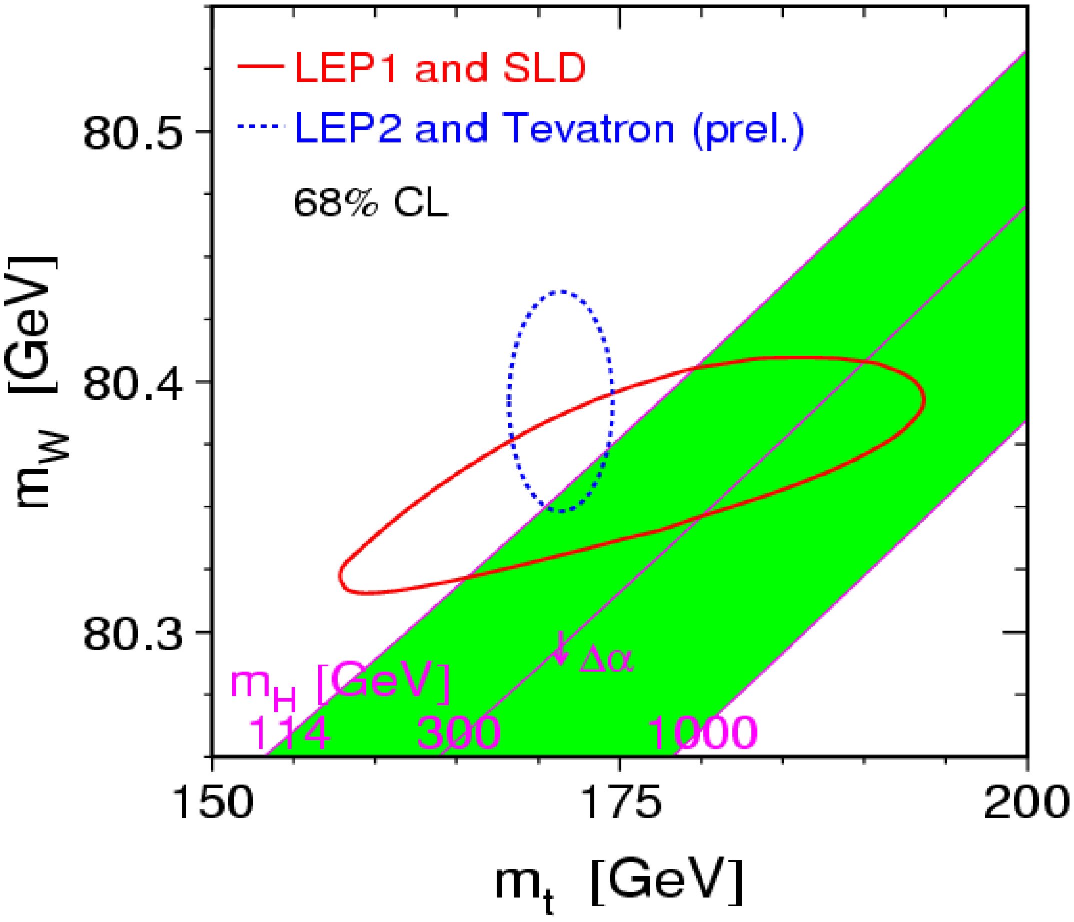
New CDF result is world's most precise single measurement

Central value increases: 80392 to 80398 MeV
World average uncertainty reduced ~15% (29 to 25 MeV)



C. Hays, University of Oxford

Previous Higgs Mass Prediction

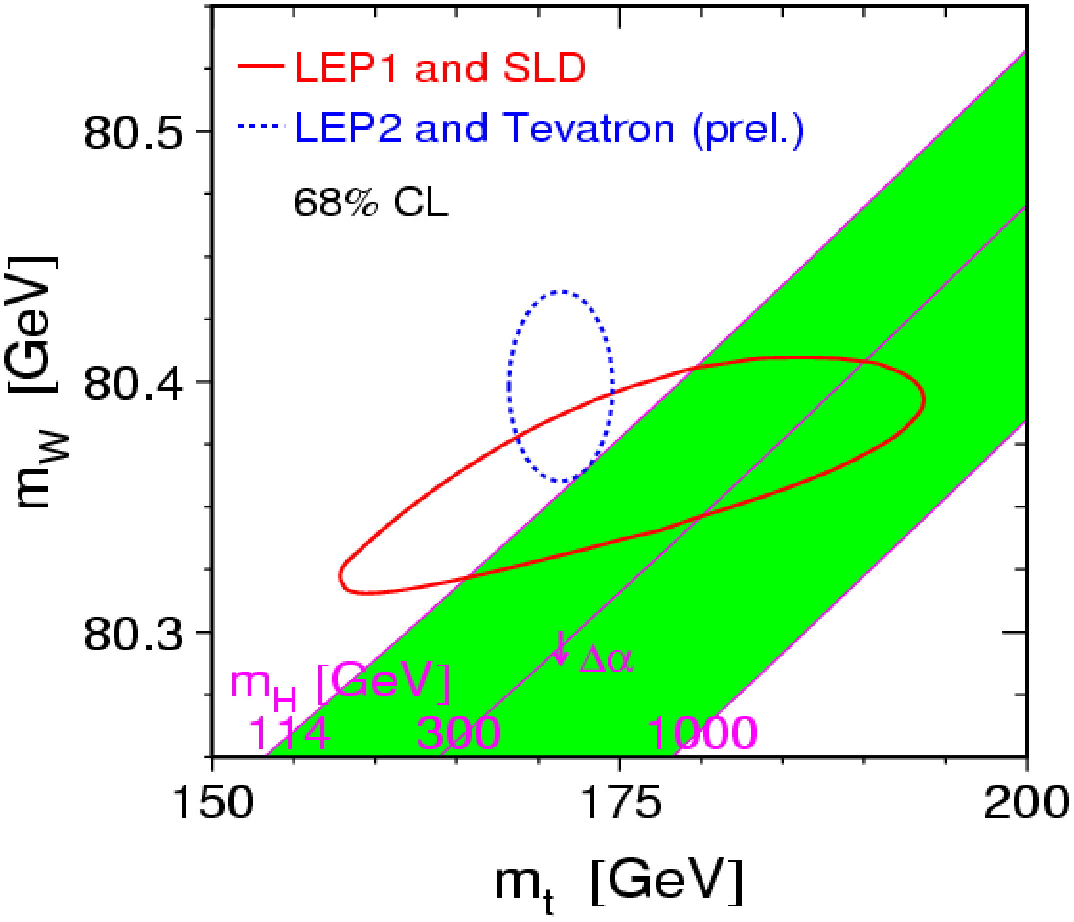


Predicted Higgs mass from global electroweak data:

$m_H = 85^{+39}_{-28}$ GeV (< 166 GeV at 95% CL)

Direct search from LEP II: $m_H > 114.4$ GeV at 95% CL

New Higgs Mass Prediction



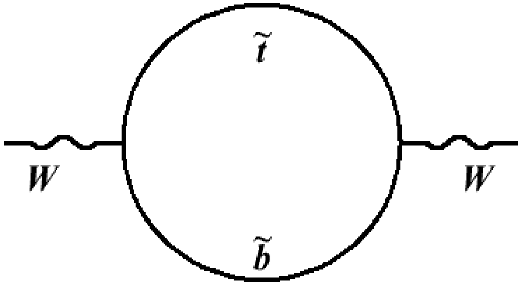
Predicted Higgs mass from global electroweak data:

$m_H = 80^{+36}_{-26}$ GeV (< 153 GeV at 95% CL)

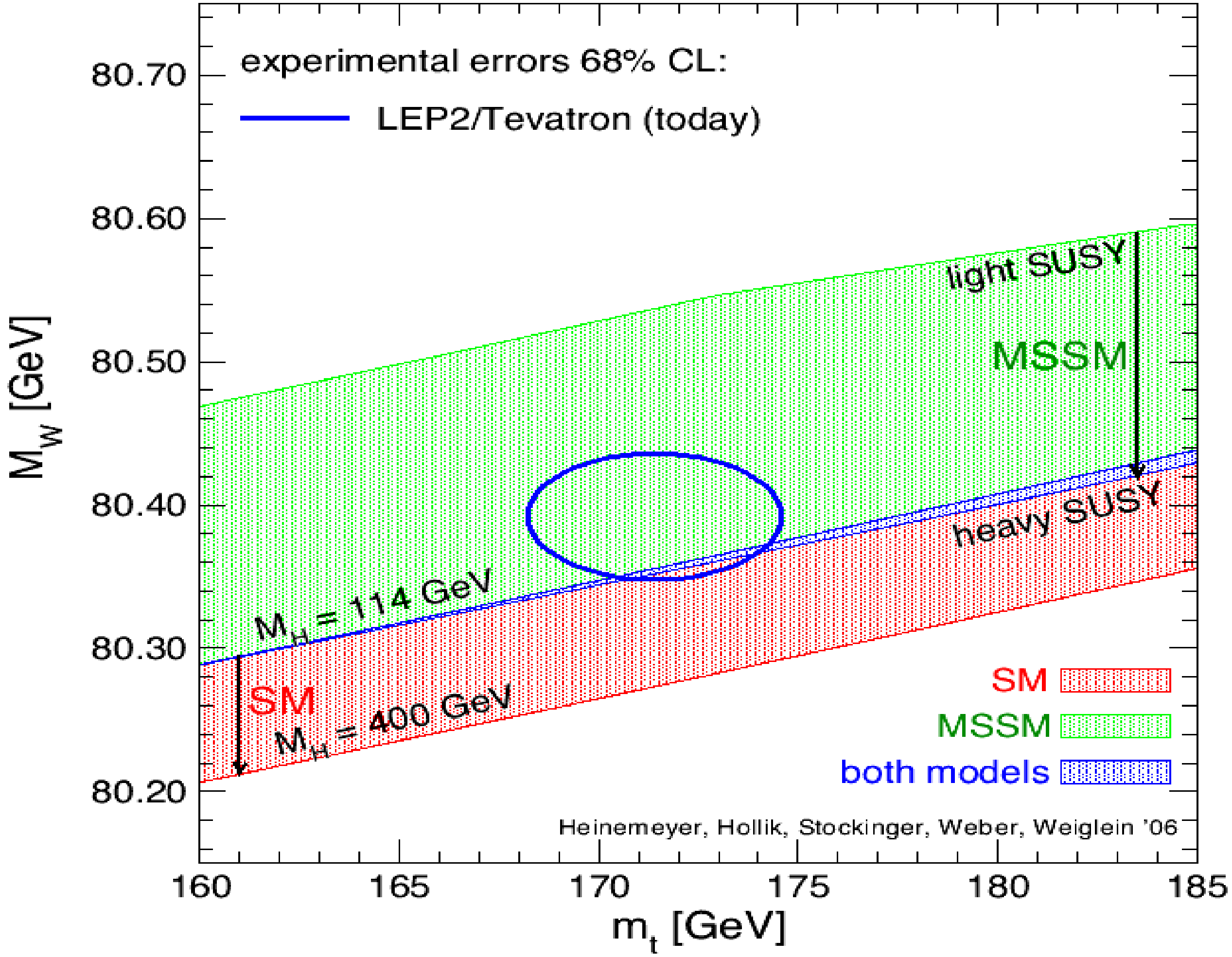
Direct search from LEP II: $m_H > 114.4$ GeV at 95% CL

Effect on New Physics Models

Additional space-time symmetry (Supersymmetry) would affect the *W* mass

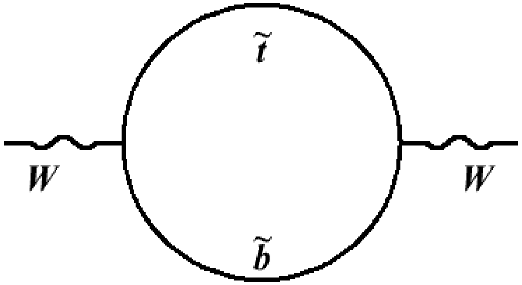


Previous world average:

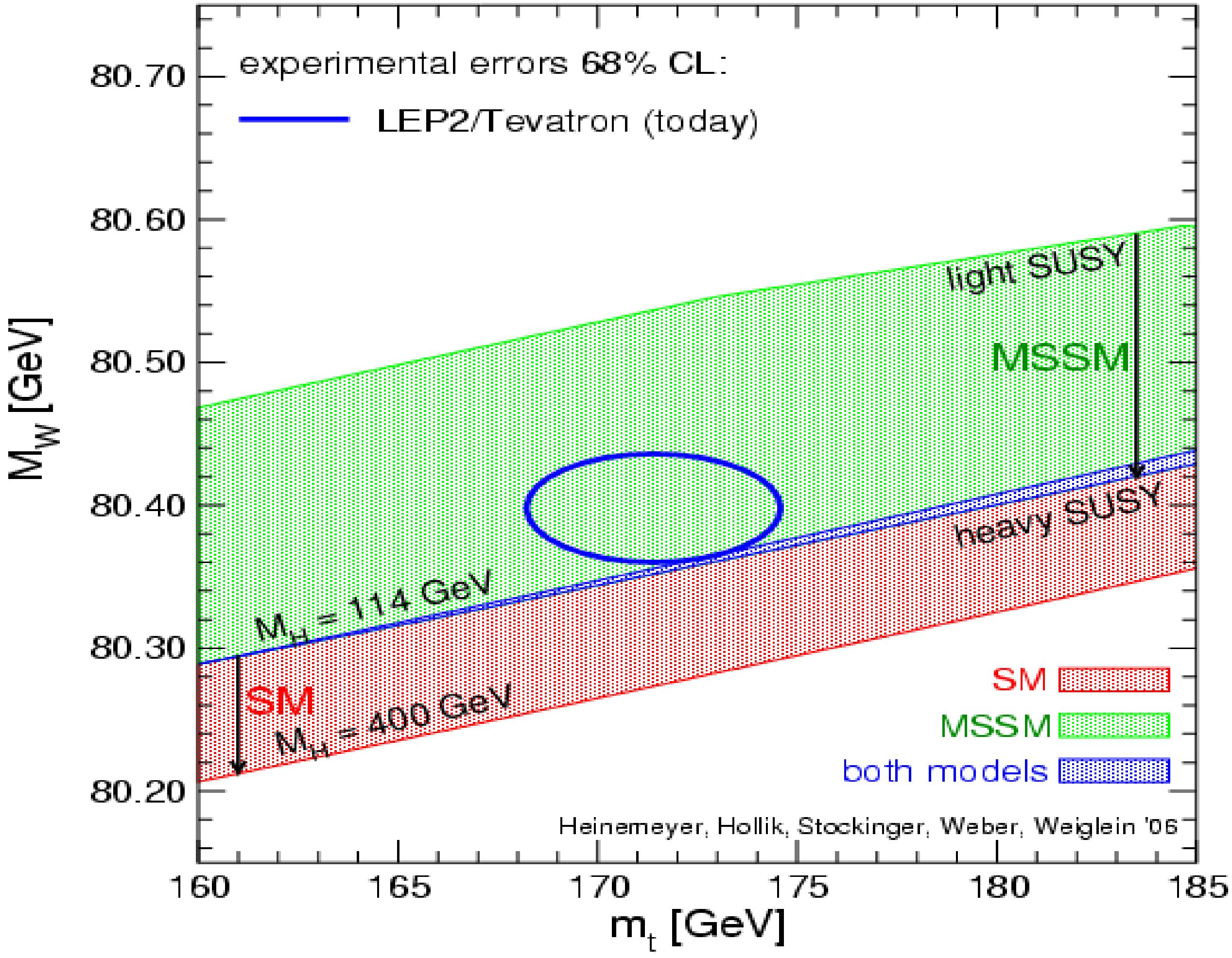


Effect on New Physics Models

Supersymmetry now preferred at 1σ level...



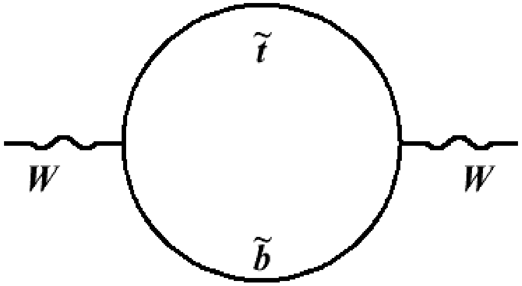
New world average:



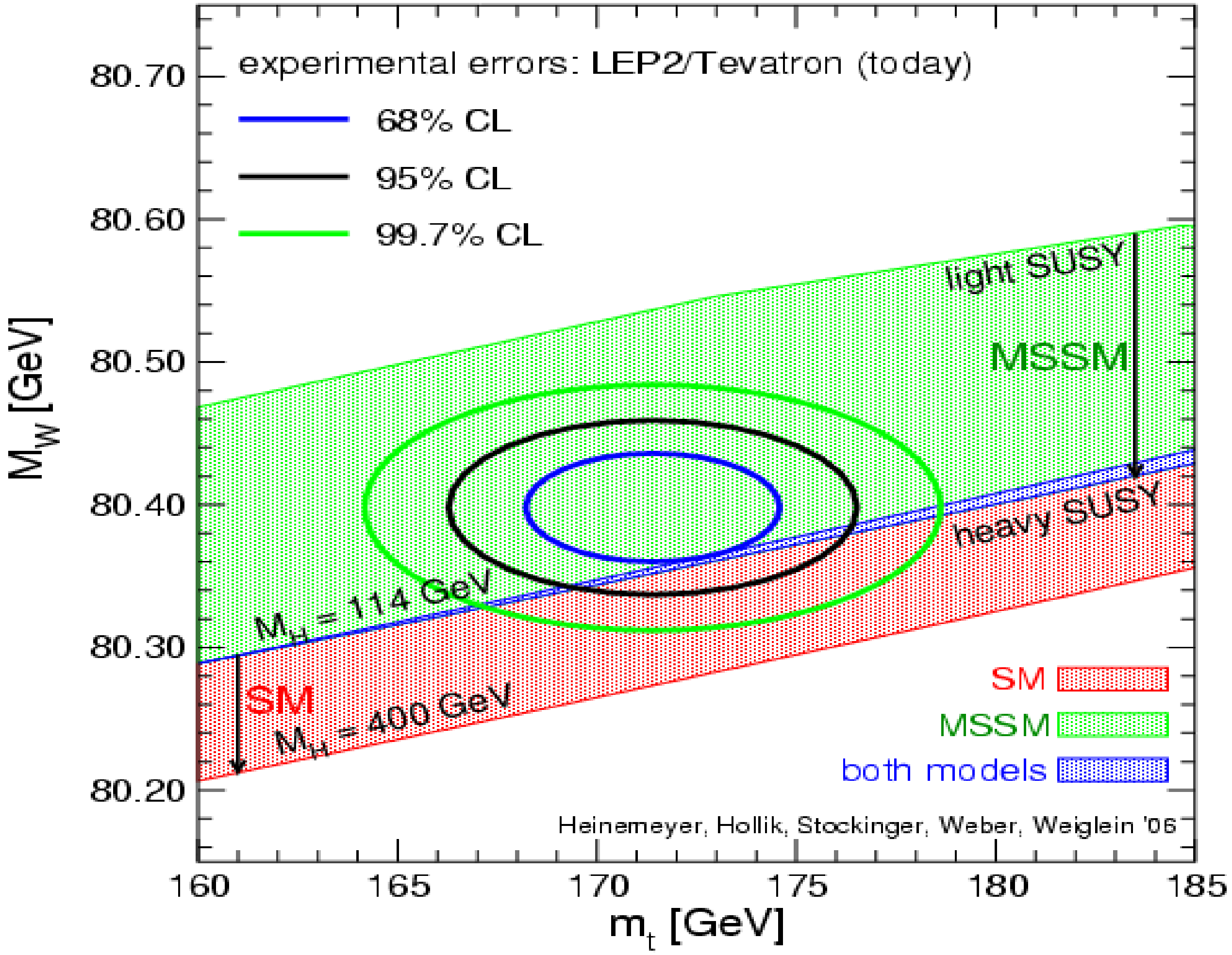
C. Hays, University of Oxford

Effect on New Physics Models

Supersymmetry now preferred at 1σ level…

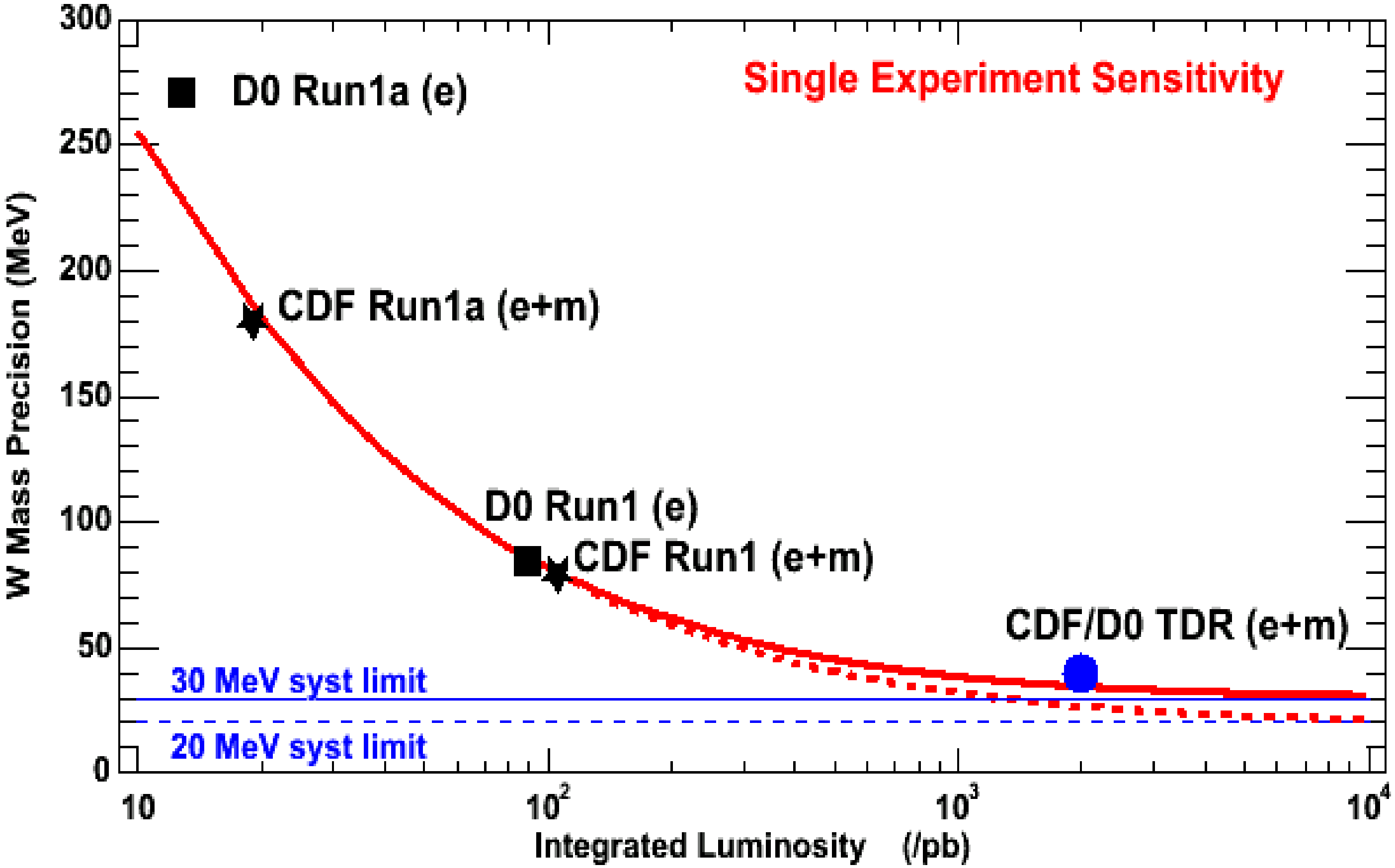


New world average:



Previous *W* Mass Projections

Previously projected Tevatron precision as a function of luminosity:

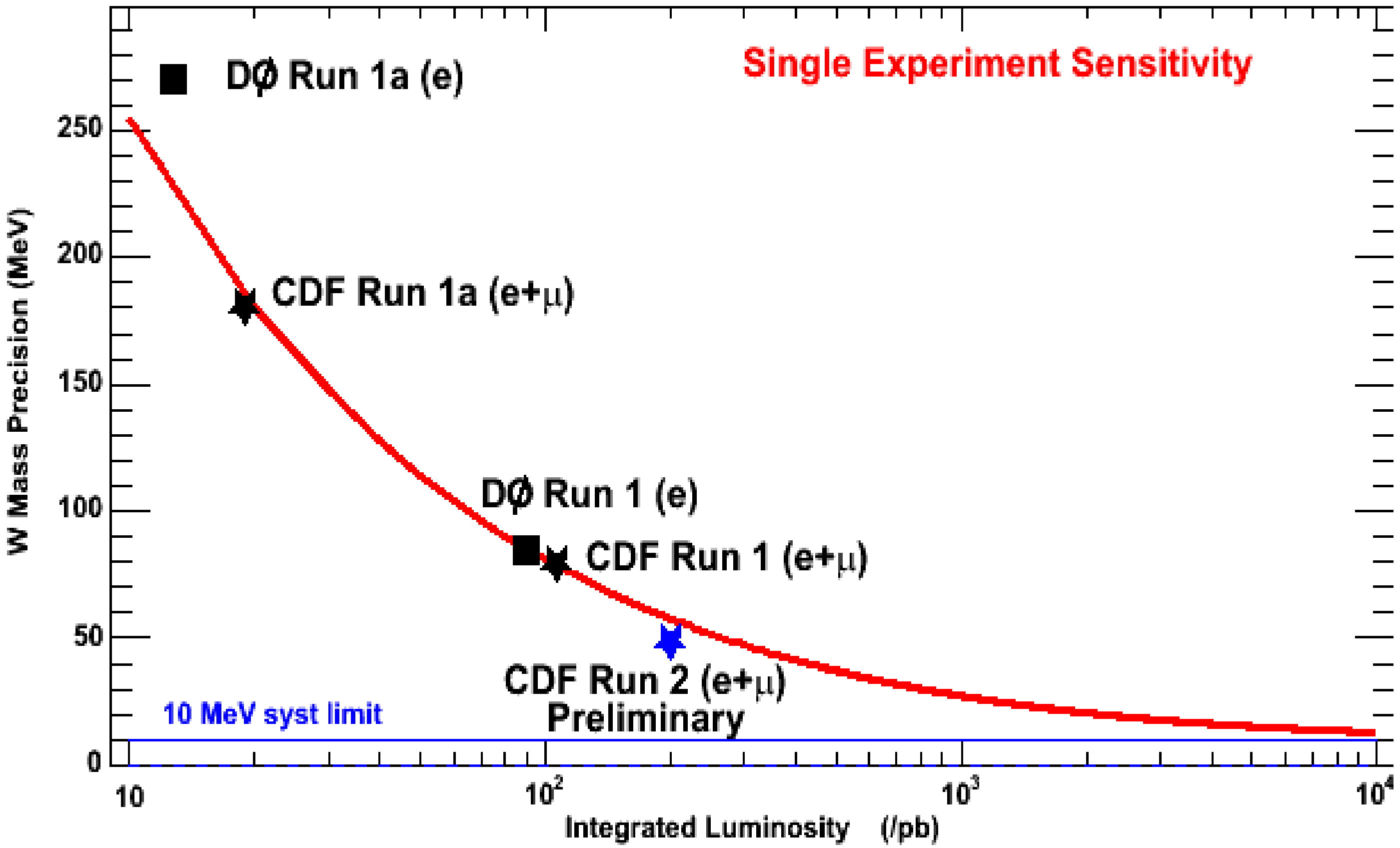


Projection with 2 fb^{-1} of data:

δm_W = 40 MeV per experiment

New *W* Mass Projections

New projected Tevatron precision as a function of luminosity:



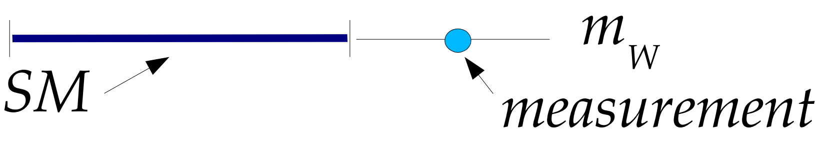
New projection with 1.5 fb^{-1} of data:

$\delta m_W < 25$ MeV with CDF

Filling in the Pieces

Precision electroweak data will continue to guide us to the next physics

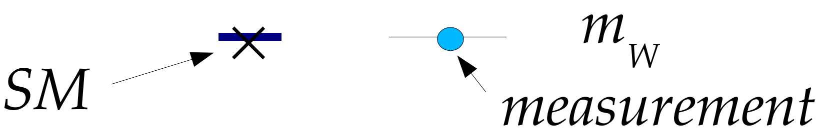
Today: $\delta m_W = 25$ MeV, $m_H < 153$ GeV at 95% CL



SM

m_W *measurement*

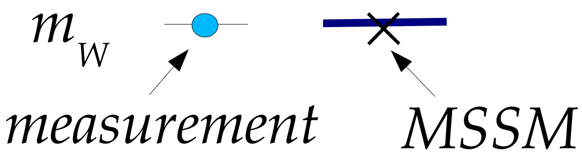
After Higgs: $\delta m_W = 15$ MeV, SUSY predicted at 95% CL?



SM

m_W *measurement*

After SUSY: $\delta m_W = 10$ MeV, more new physics?



m_W *measurement*

MSSM

Summary

W mass excellent probe for new particles coupling to the electroweak sector

CDF has made the single most precise *W* mass measurement

m_W = 80413 ± 34 MeV (stat) ± 34 MeV (sys)

= 80413 ± 48 MeV (stat + sys)

New SM Higgs mass prediction: $m_H = 80^{+36}_{-26}$ *GeV*

Mass has moved further into LEP-excluded region

Expect CDF $\delta m_W < 25$ MeV with 1.5 fb^{-1} already collected

Will squeeze SM in conjunction with Tevatron Higgs results

Electroweak data will probe more new physics after the Higgs

Projections on Virtual

δM_t = 1.2 GeV,
δM_W = 24 MeV, world avg
(LEP2 + δM_W = 30 MeV(Tevatron),
no LEP/TeV correlations)