W Boson Mass and Width Measurements at D0

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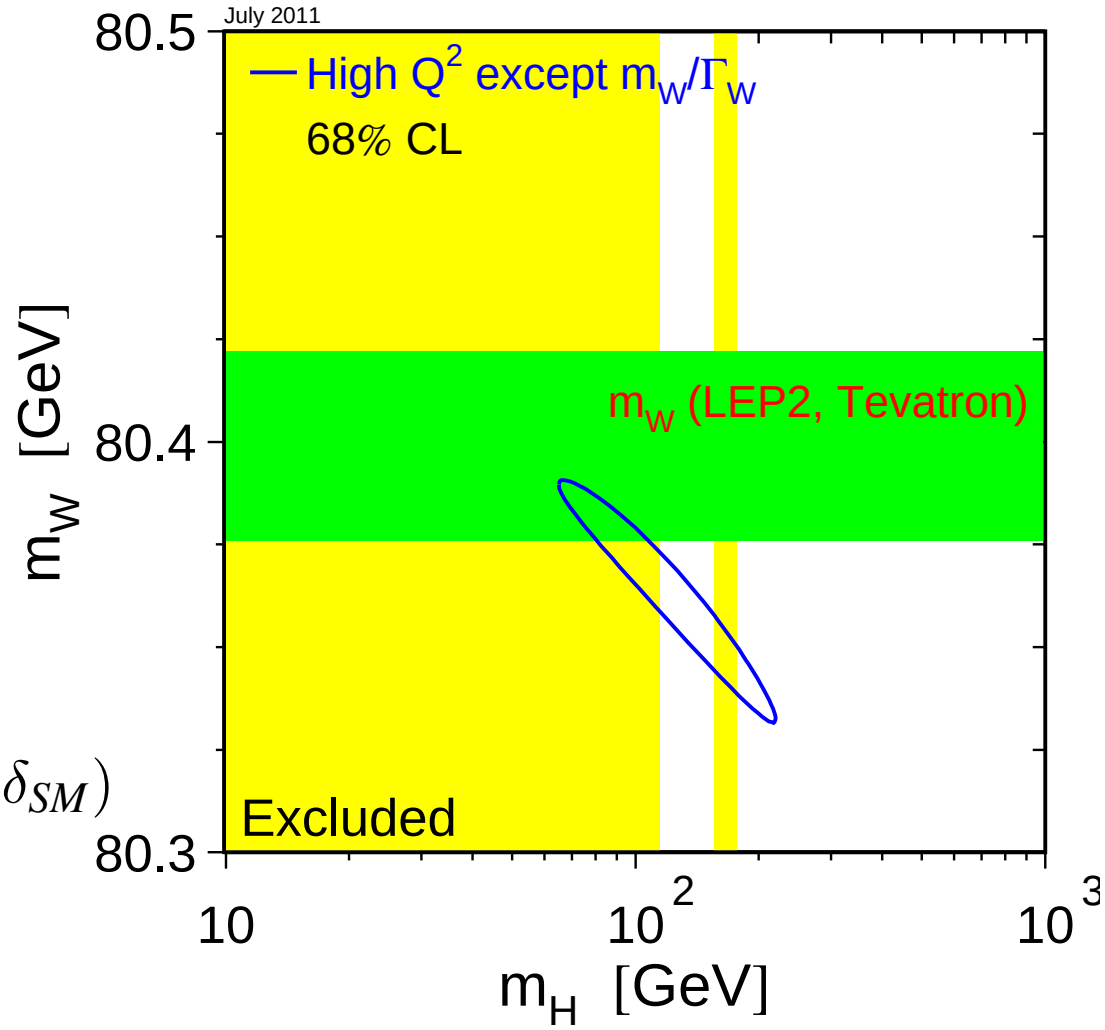
Introduction

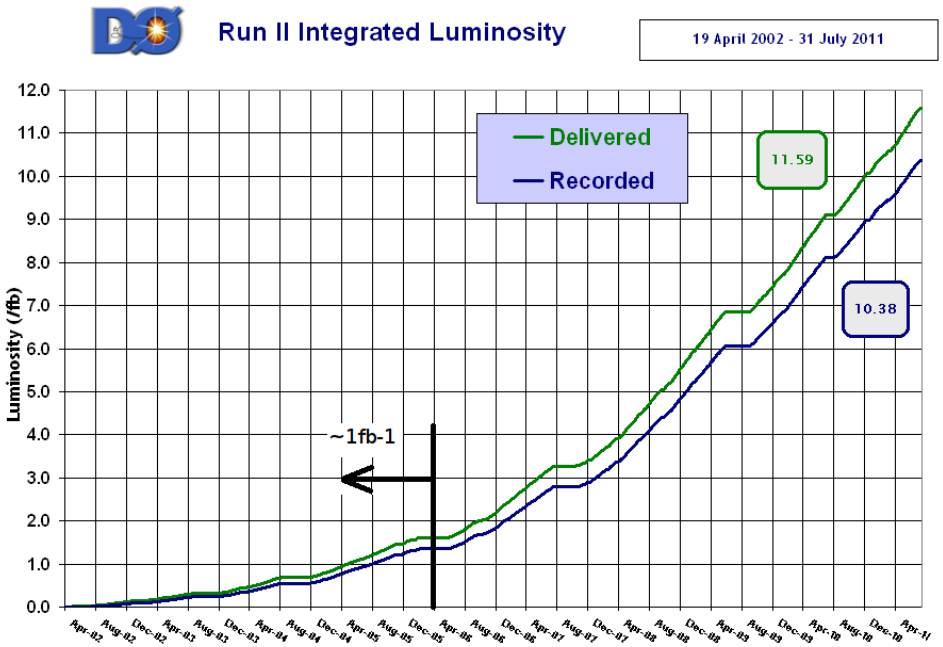
- Precision Measurements:
  - M_W
  - Γ_W
- $W \to e\nu$ decay channel
  - DØ Calorimeter
- M_W: limits M_H
- Γ_W: also important

$$\Gamma(W \to l\nu) = \frac{G_F}{\sqrt{2}} \frac{M_W^3}{6\pi} (1 + \delta_{SM})$$



The Tevatron

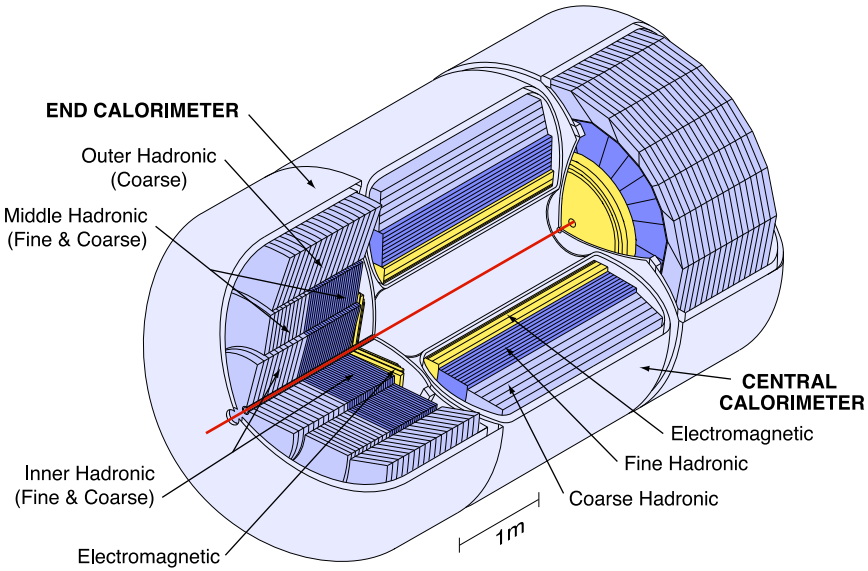
- $p\bar{p}$ collider
- $E_{CM} = 1.96$ TeV
- Recorded ≈ 10 fb^{-1}



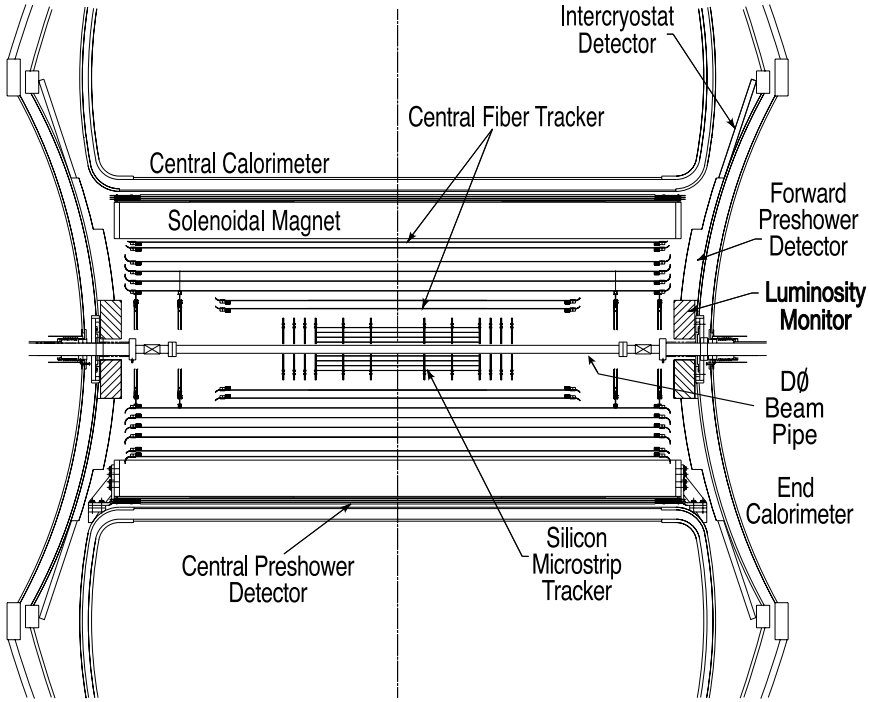
The DØ Detector

- lAr Calorimeter

Central (CC) $|\eta| < 1.1$
End-Cap (EC) $1.5 < |\eta| \lesssim 4$
ICD $1.1 < |\eta| < 1.4$

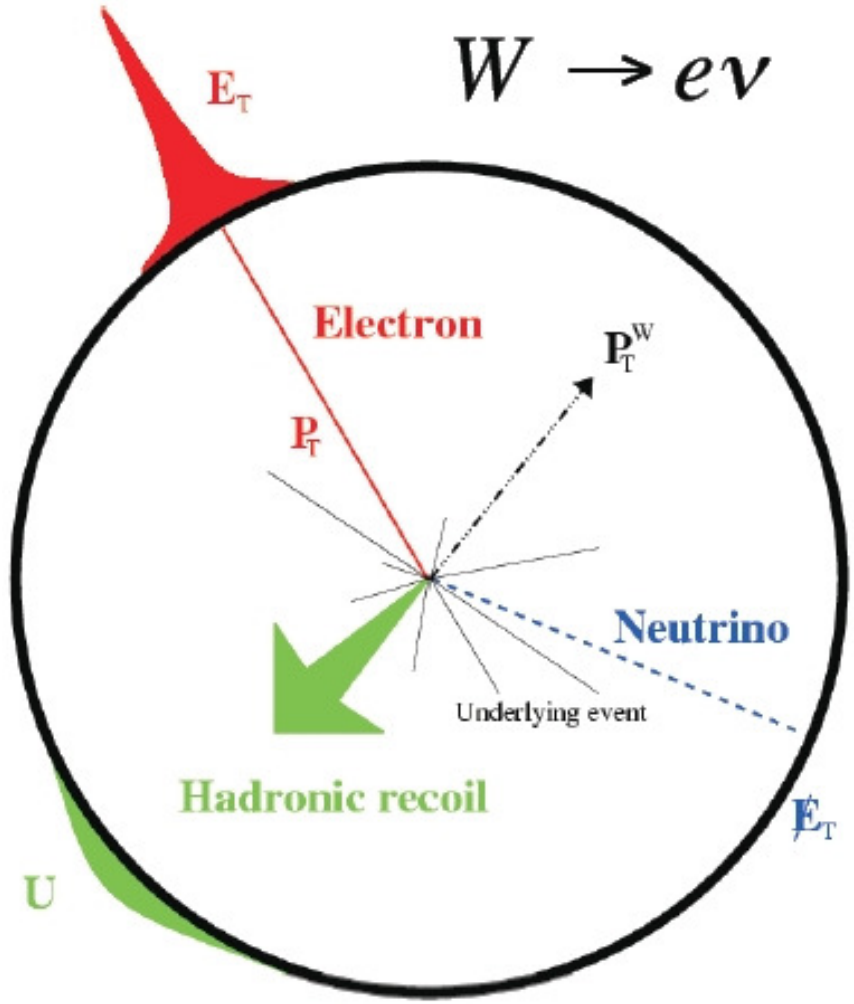


- Tracking Detector:
  - 2 T B-Field
  - Scintillating (CFT)
  - Silicon (SMT)



Event Selection: $W \to e\nu$

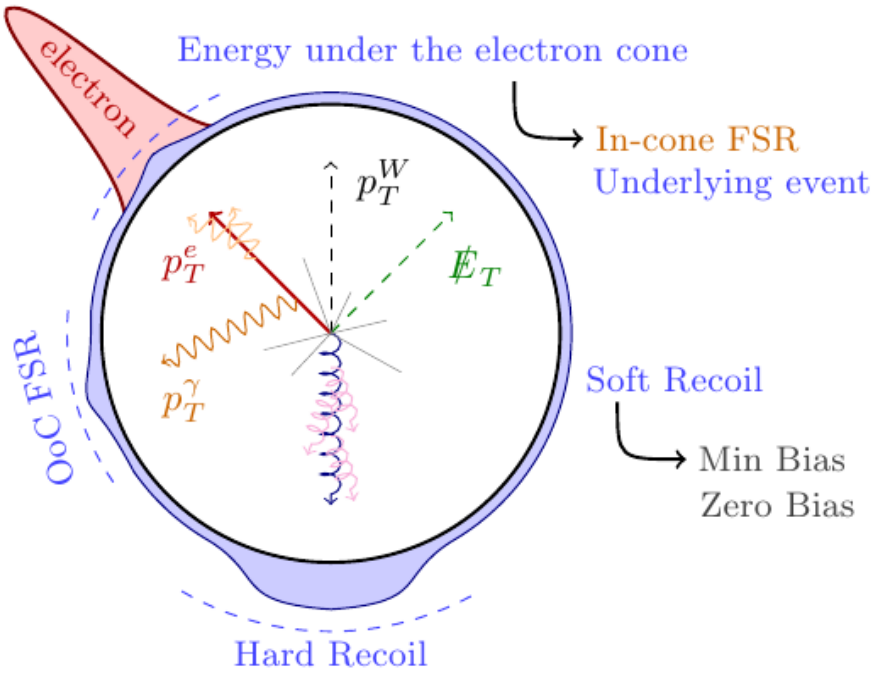
- $W \to e\nu$
  - $p_T^e > 25$ GeV
  - $|\eta| < 1.05$
  - Matched track
  - $\not\!\!E_T > 25$ GeV
  - $u_T < 15$ GeV
  - $50 < m_T < 200$ GeV
    - $m_T = \sqrt{2p_T^e p_T^\nu (1 - \cos\Delta\phi)}$
  - 499830 $W \to e\nu$ candidates
- $Z \to ee$ (Calibration)
  - 2 Electrons, $p_T^e > 25$ GeV
  - $70 < m_{ee} < 110$ GeV
  - 18725 $Z \to ee$ candidates



Backgrounds

- $Z \rightarrow ee$
  - Electron falls into ICD region
  - Estimate using events passing $W \rightarrow e\nu$ selection with track pointing towards ICD
  - $0.91 \pm 0.01\%$
- Multi-Jet
  - Jet fakes electron
  - Estimate using sample without track match
  - $1.49 \pm 0.03\%$
- $W \rightarrow \tau\nu \rightarrow e\nu\nu\nu$
  - Irreducible background
  - Estimated using PYTHIA monte carlo
  - $1.60 \pm 0.02\%$

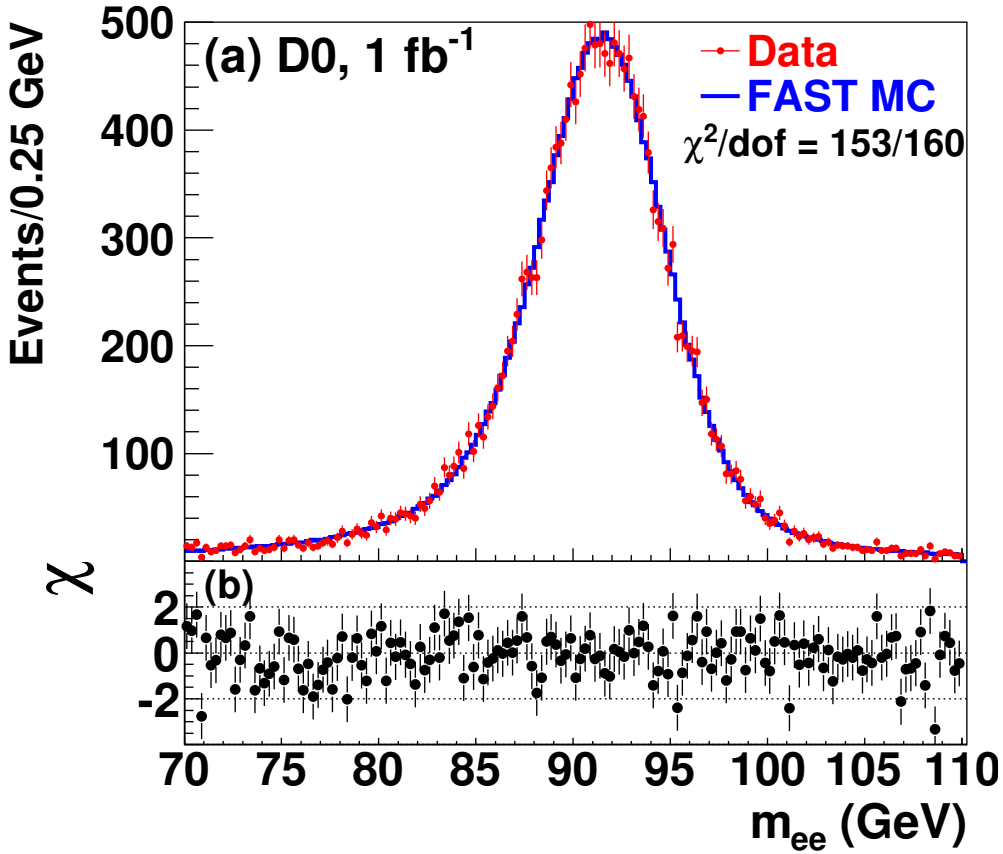
Monte Carlo Simulation



- RESBOS
  - NLO generator with resummation at low boson p_T
- PHOTOS
  - Simulation of photon emmission
- Fast parametric Monte Carlo simulation.
  - Electron Model
  - Recoil Model

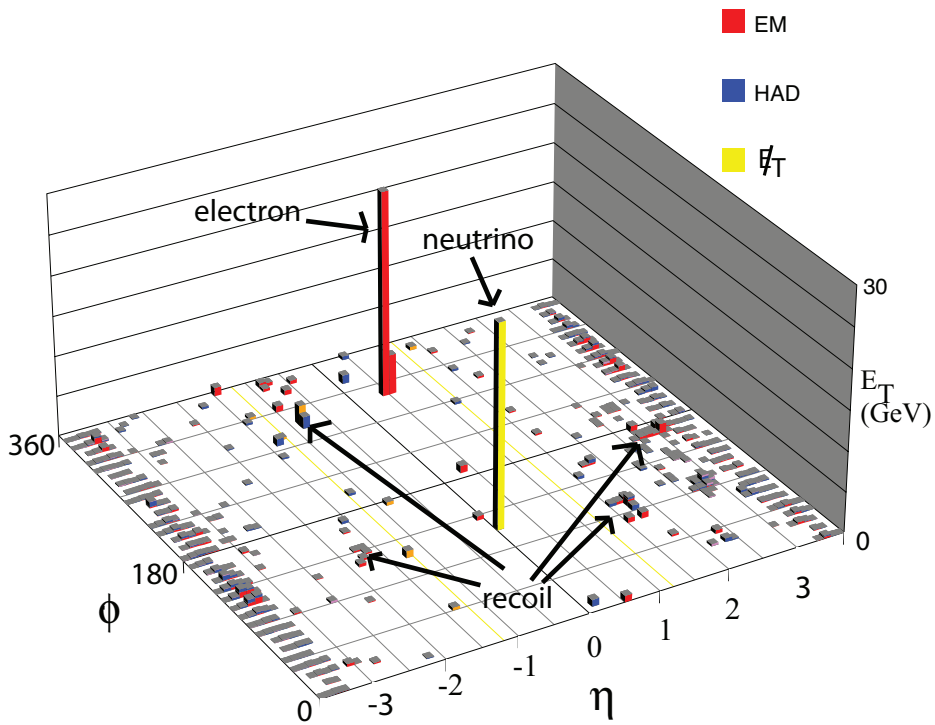
Electron Energy Response Calibration

- m_Z and Γ_Z from LEP
- Effectively measure m_W/m_Z
- $E^{measured} = \alpha E^{true} + \beta$
- $-\log \mathcal{L}$ fit for α, β in Data

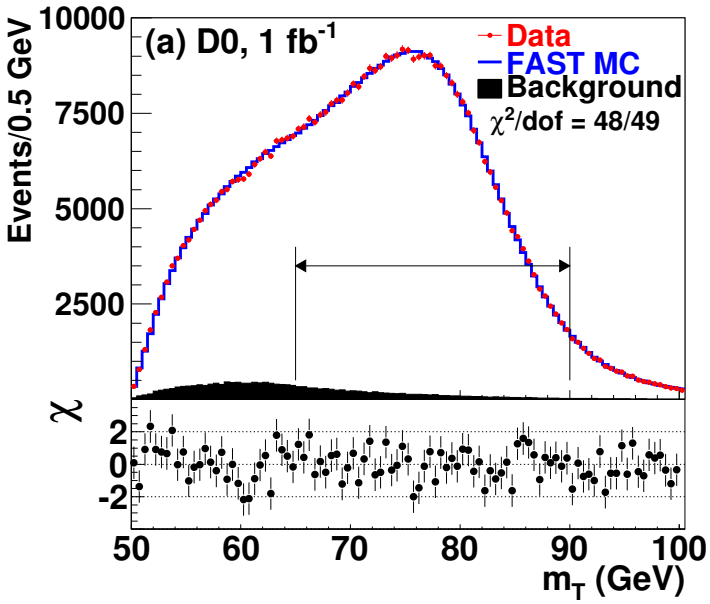


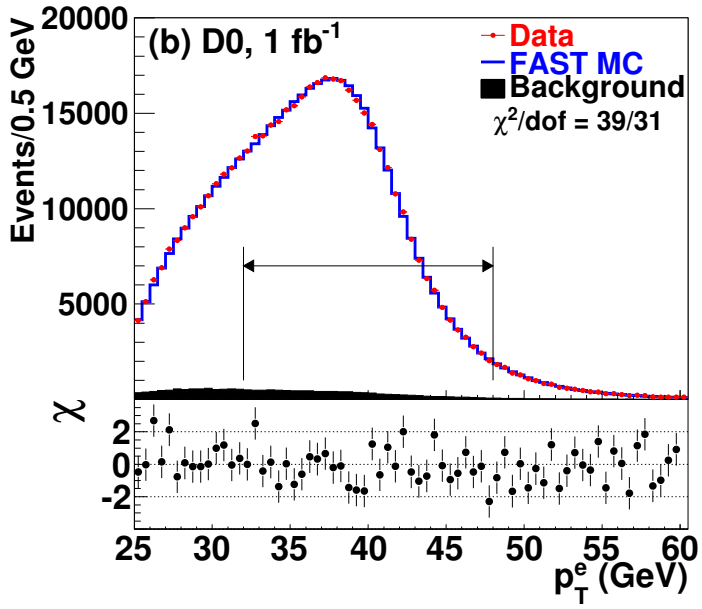
Hadronic Recoil Model

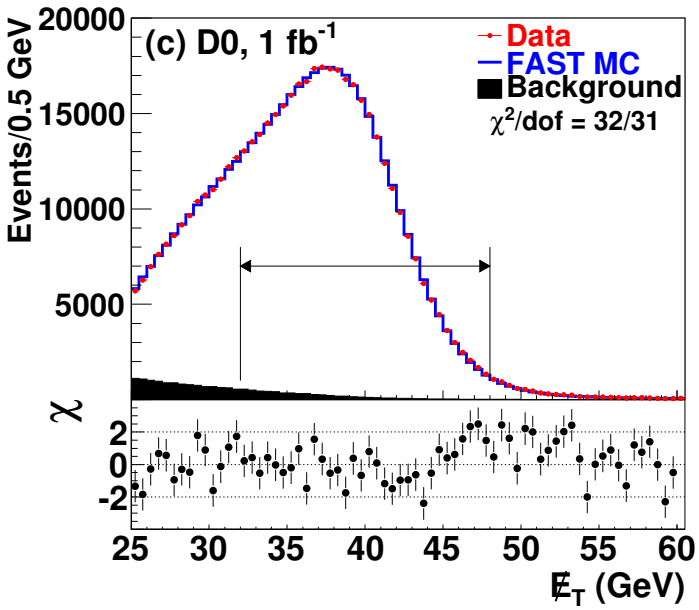
- Parametrized model
  - Hard component:
    - $Z \rightarrow \nu\nu$ Monte Carlo Sample
  - Soft component:
    - zero bias
    - minimum bias
  - Tune using $Z \rightarrow ee$ sample
- Library Model
  - Recoil from $Z \rightarrow ee$ Data
  - Cross check

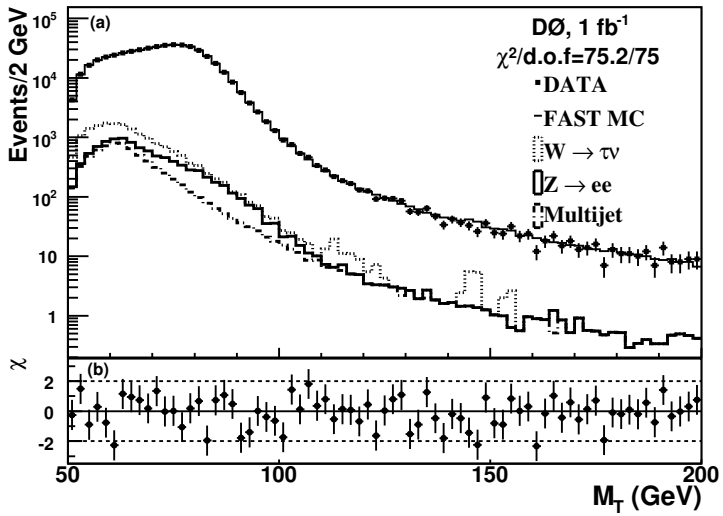


Mass Measurement









Mass Systematics

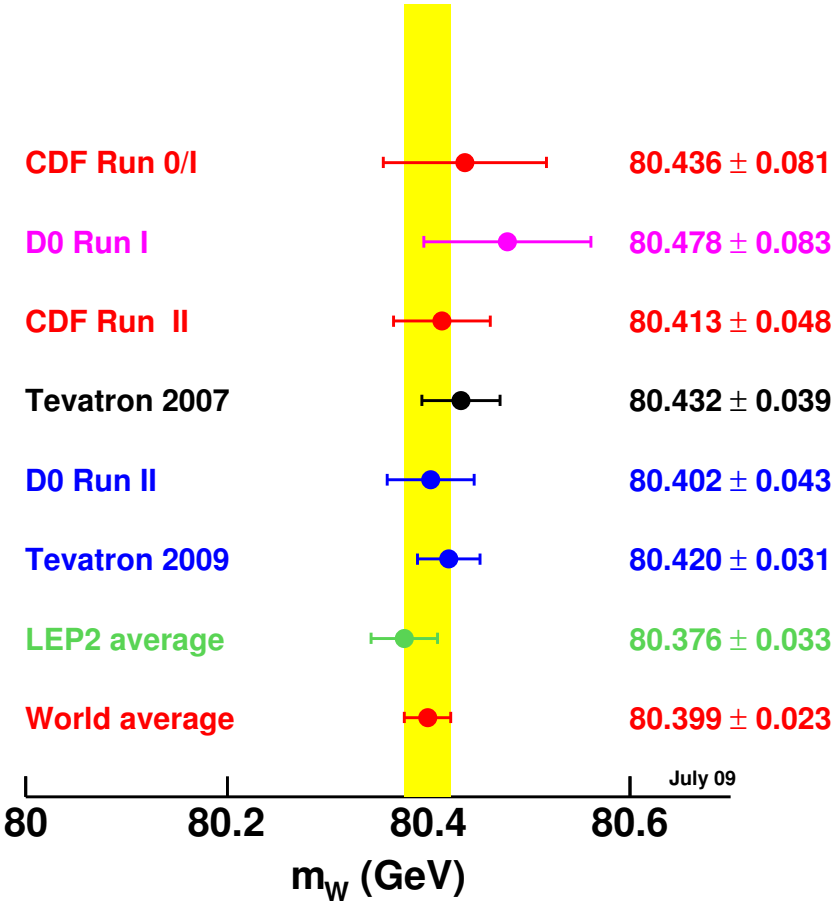
Systematic uncertainties of the M_W measurement	ΔM_W (MeV)		
Source	m_T	p_T^e	$\not\!\!E_T$
Electron energy calibration	34	34	34
Electron resolution model	2	2	3
Electron shower modeling	4	6	7
Electron energy loss model	4	4	4
Hadronic recoil model	6	12	20
Electron efficiencies	5	6	5
Backgrounds	2	5	4
Experimental Subtotal	35	37	41
PDF	10	11	11
QED	7	7	9
Boson p_T	2	5	2
Production Subtotal	12	14	14
Total	37	40	43

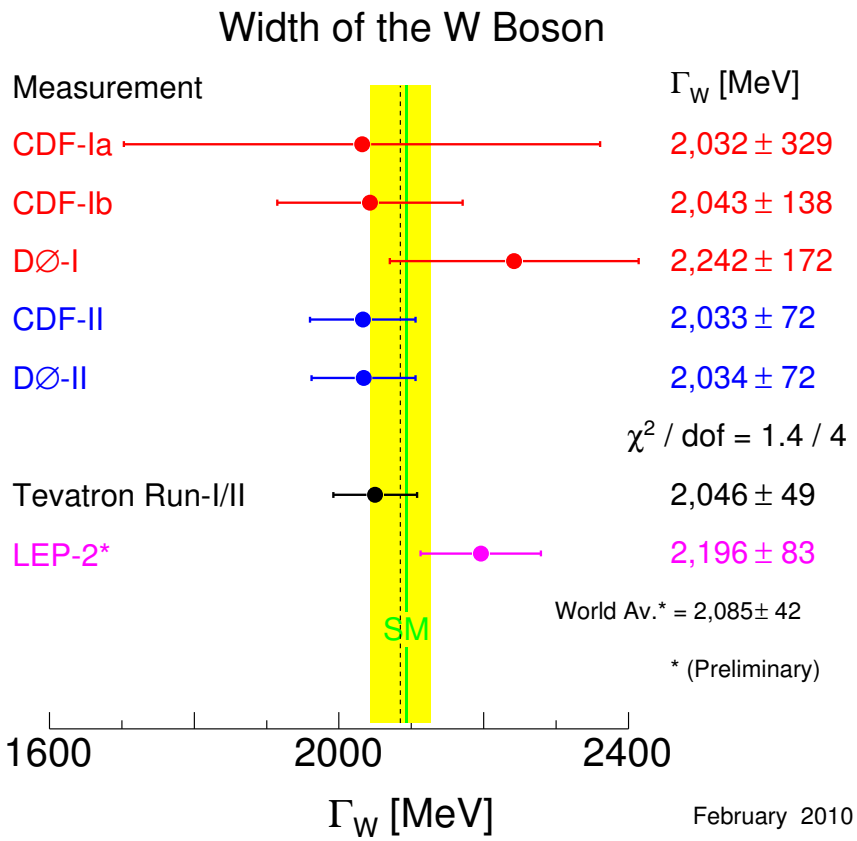
Width Systematics

Table: Systematic uncertainties on the measurement of Γ_W.

Source	$\Delta\Gamma_W$ (MeV)
Electron energy scale	33
Electron resolution model	10
Recoil model	41
Electron efficiencies	19
Backgrounds	6
PDF	20
Electroweak radiative corrections	7
Boson p_T	1
M_W	5
Total Systematic	61

Results


CDF Run 0/I
80.436 ± 0.081
D0 Run I
80.478 ± 0.083
CDF Run II
80.413 ± 0.048
Tevatron 2007
80.432 ± 0.039
D0 Run II
80.402 ± 0.043
Tevatron 2009
80.420 ± 0.031
LEP2 average
80.376 ± 0.033
World average
80.399 ± 0.023
July 09
80
80.2
80.4
80.6
m_W (GeV)


Width of the W Boson
Measurement
Γ_W [MeV]
CDF-Ia
2,032 ± 329
CDF-Ib
2,043 ± 138
DØ-I
2,242 ± 172
CDF-II
2,033 ± 72
DØ-II
2,034 ± 72
χ² / dof = 1.4 / 4
Tevatron Run-I/II
2,046 ± 49
LEP-2*
2,196 ± 83
World Av.* = 2,085± 42
SM
* (Preliminary)
1600
2000
2400
Γ_W [MeV]
February 2010

Conclusion

- DØ m_W measurement most precise single experiment result
- Collected $\times 10$ more data
- Substantial improvement in precision expected:
  - Scale Uncertainty:
    $10\ \text{fb}^{-1} \Rightarrow \Delta m_W \approx 15\ \text{MeV}$
  - Total Systematic:
    $10\ \text{fb}^{-1} \Rightarrow \Delta m_W \approx 25\ \text{MeV}$