Measuring the W Mass at DØ

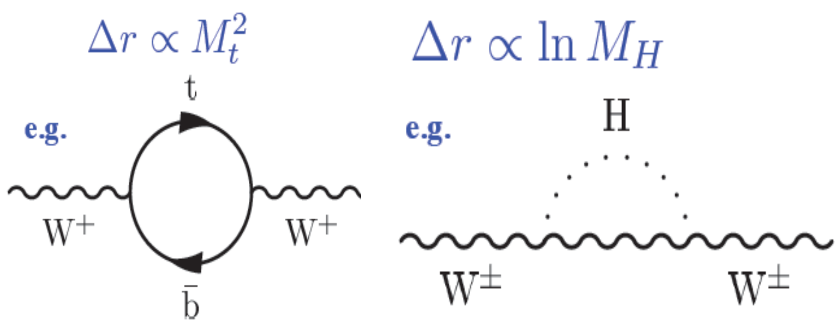
Mandy Rominsky on behalf of the DØ Collaboration

Why is precisely measuring the W mass important?

- In the Standard Model, the M_W can be calculated from other EW parameters:

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

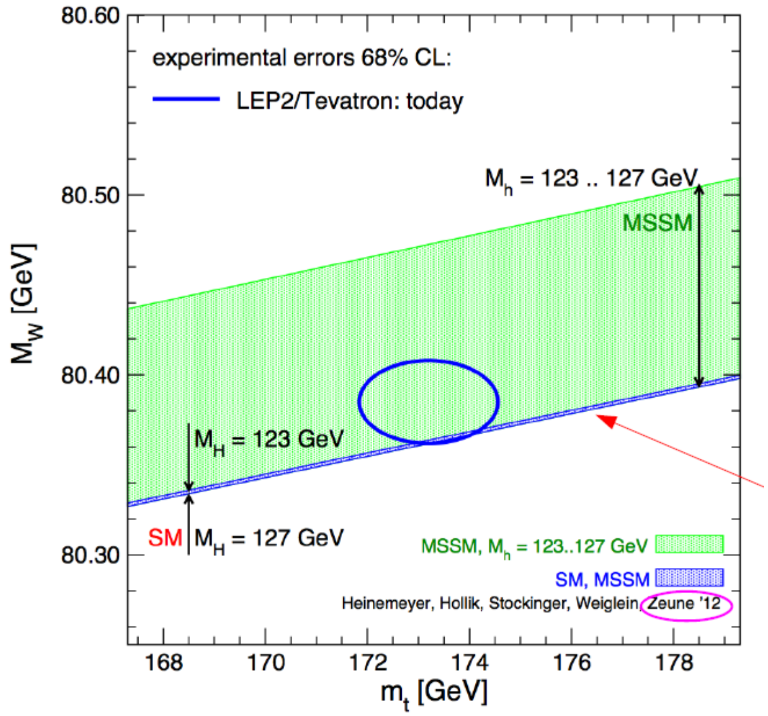
- And through radiative corrections (Δr) is related to M_{top} and M_H



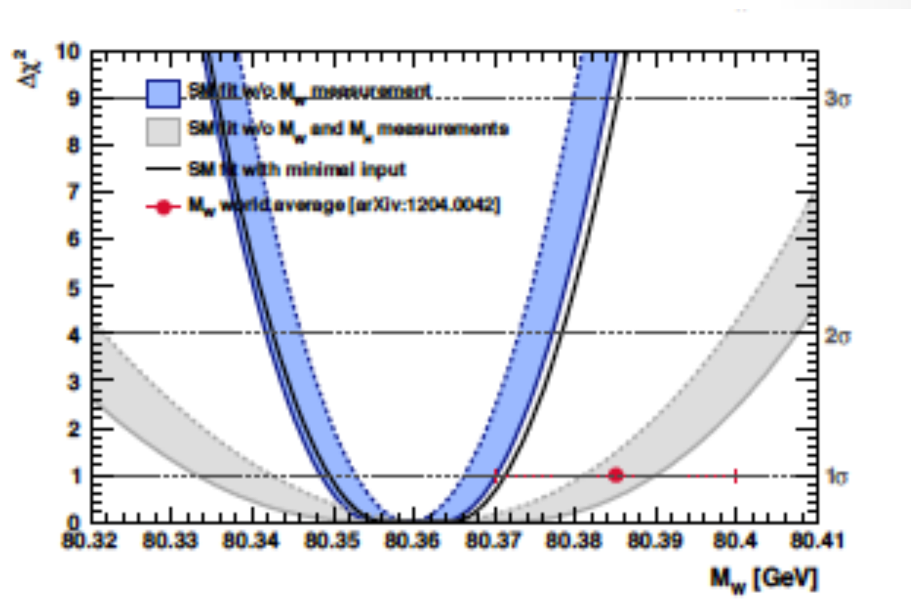
- Unknown particles in these loops will change the form of Δr

Precisely measuring M_W limits couplings to new particles

Why is precisely measuring the W mass important?



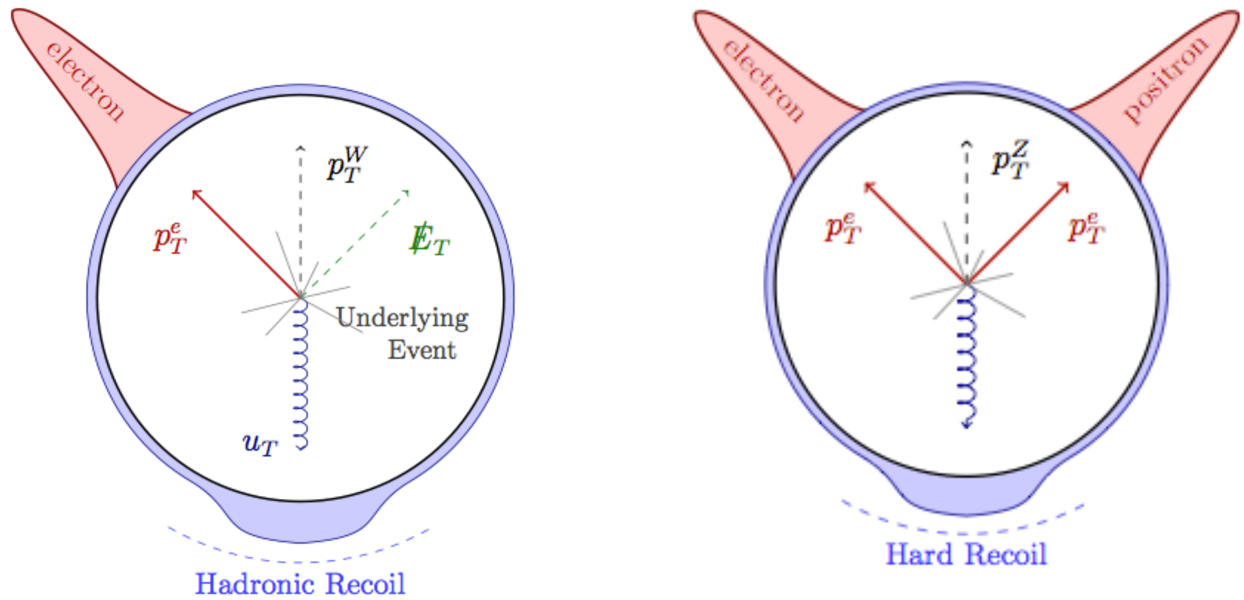
- Prior to July 2012: Use M_W to constrain M_H
- Now can also use M_H to constrain M_W



Any deviation would be new physics

- Limited by the precision in ΔM_W
  - Direct measurement: 15 MeV
  - Indirect measurement: 11 MeV

What are we measuring?

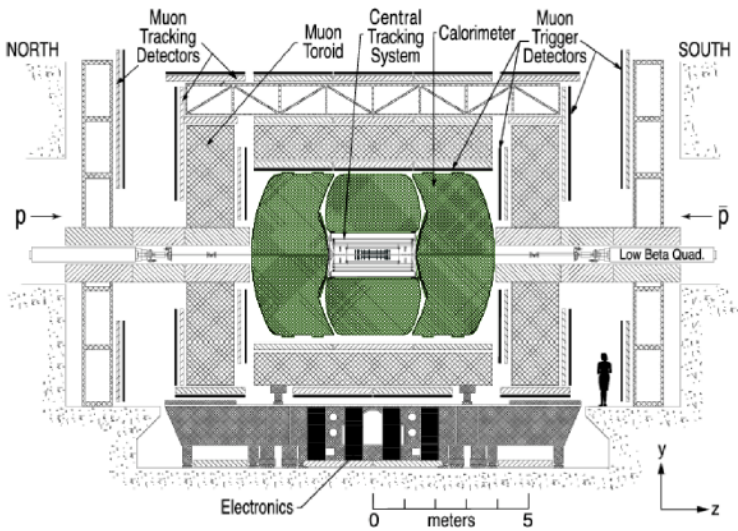


- M_W is measured using the kinematic distributions in W -> eν events:
  - Transverse mass
  - Lepton momentum
  - Missing transverse energy

$$M_T^W = \sqrt{2 P_T^e \not{E}_T (1 - \cos \Delta\phi)}$$

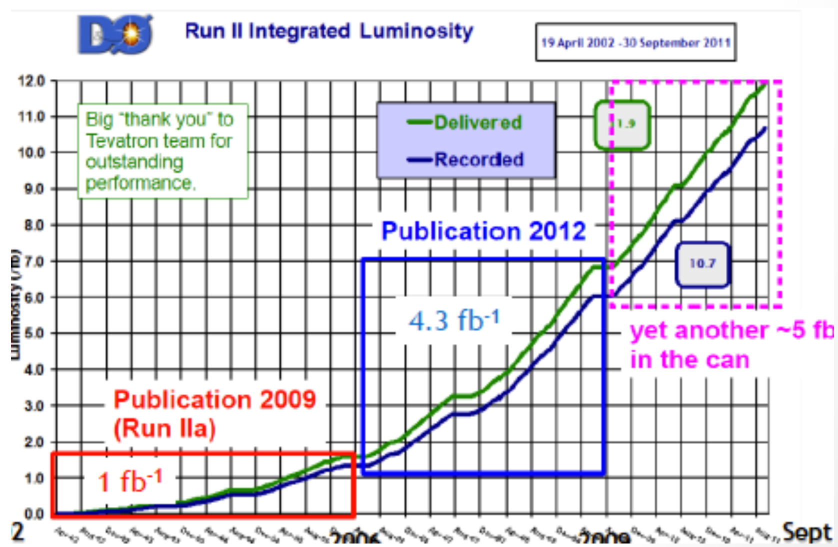
- Z->ee events are used for detector calibration

And where are we measuring it?

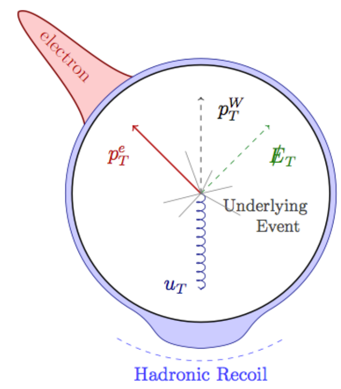


- Use the D0 calorimeter
  - Central electron energy resolution is 4.2% averaged over electron E and η spectra in W->eν events
- Use central electrons: $|\eta_{det}| < 1.05$

- Results presented here are based on 5.3 fb^{-1} of data
- Another 5 fb^{-1} are on tape and being analyzed



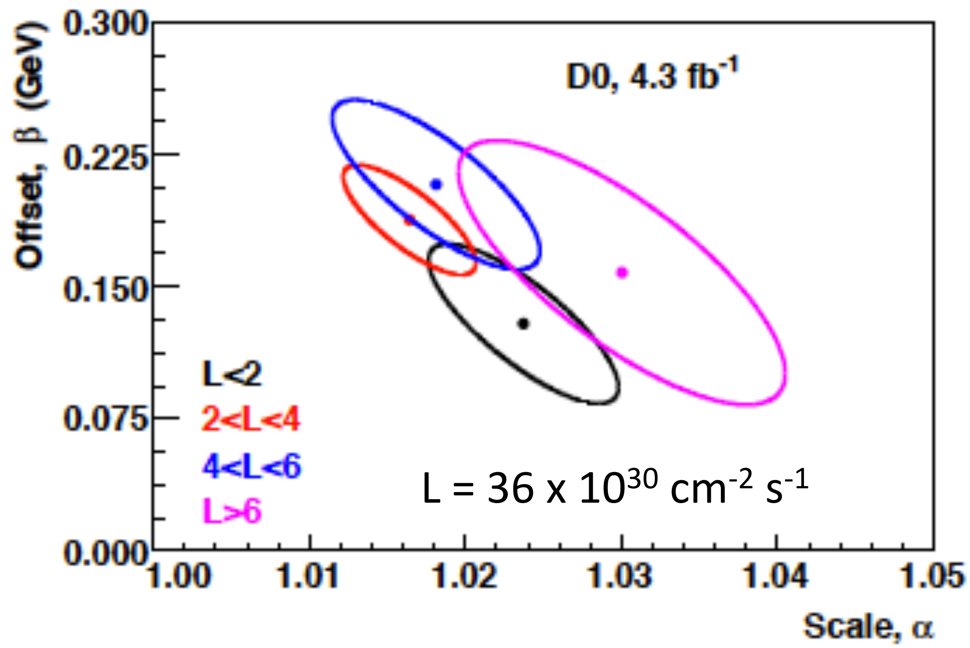
Analysis Strategy



- Measure distributions of 3 variables: M_T^W, MeT, p_T^e
- Compare data to parameterized detector model templates with different mass hypotheses
- Templates made with:
  - Generator level done with ResBos (W/Z production and decay) , Photos (FSR)
  - Parameterized detector model built using Z->ee data samples
- Blinded Analysis
  - Central value hidden by an unknown offset.
- Use binned likelihood fits to extract mass from templates fit to data
- Combine results across observables
- Full MC closure test was performed to study the method

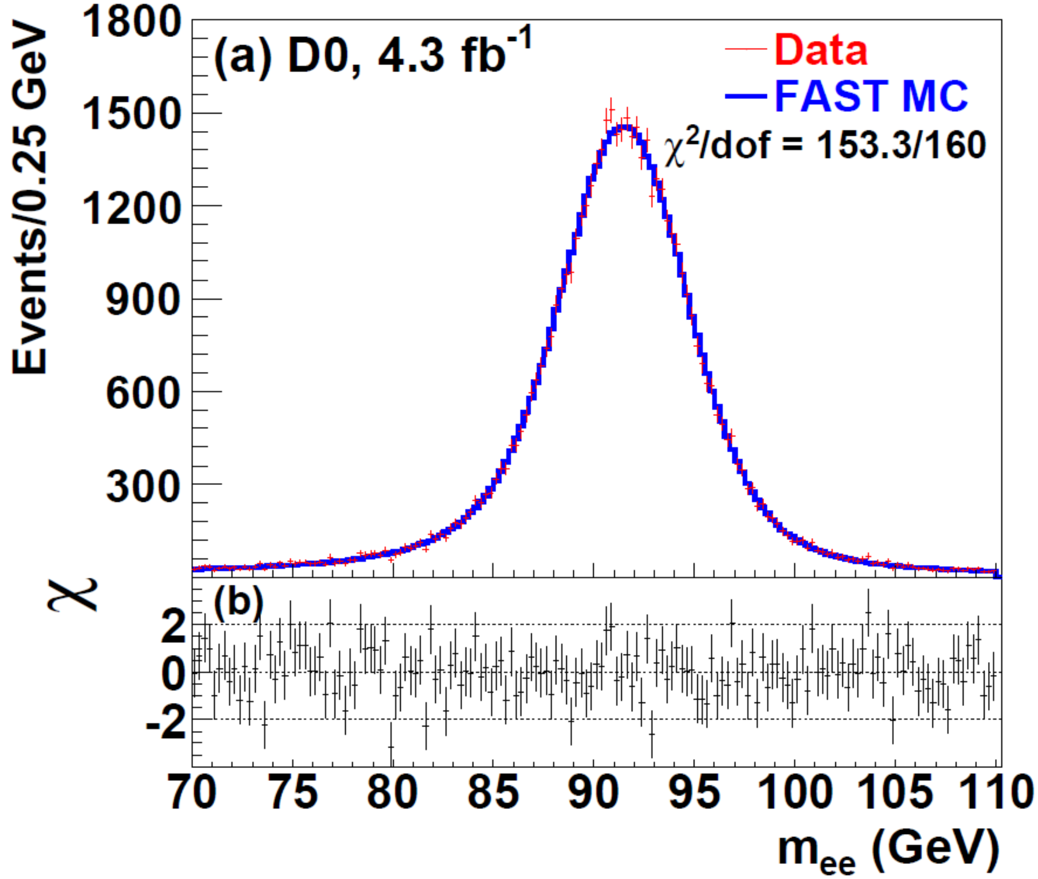
Electron Energy Response

- Calibrate the calorimeter for electron response
  - Use Z->ee data events
  - Use the Z peak to fit the parameters (precisely measured by LEP)
- First correct for nonlinear effects like underlying events and dead material
- Then assume a linear response $R_{EM}(E) = \alpha(E - \bar{E}) + \beta + \bar{E}$
  - Use 4 luminosity bins



Electron Energy Response

- Closure test using Z->ee data



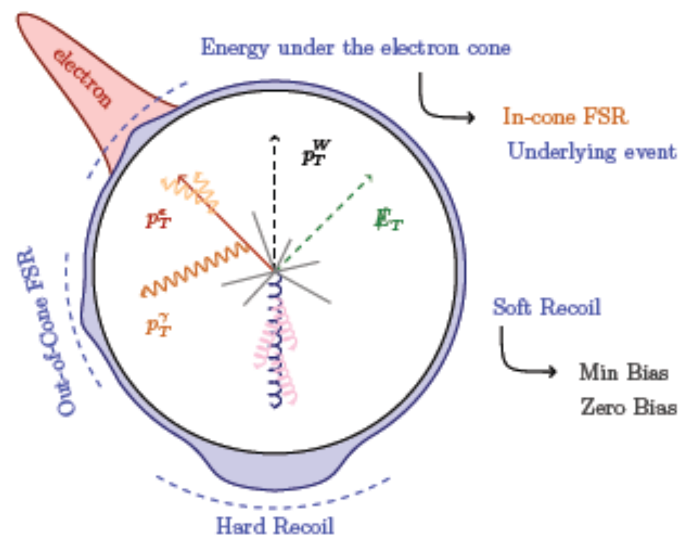
M_Z = 91.193 ± 0.017 (stat) GeV

World Average M_z = 91.188 ± 0.002 GeV

Hadronic Recoil Response

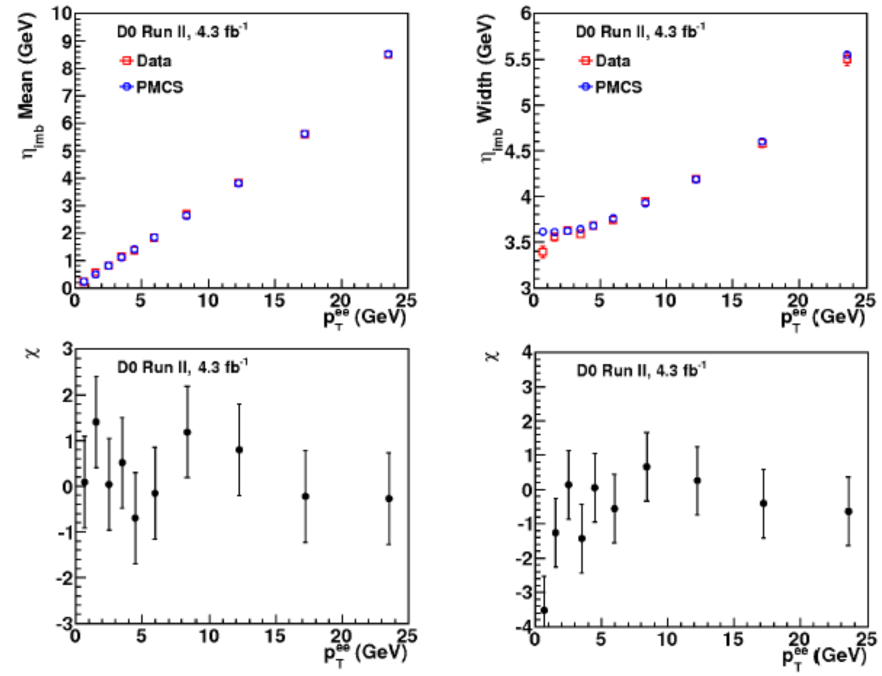
$$\vec{u}_T = \vec{u}_T^{HARD} + \vec{u}_T^{SOFT} + \vec{u}_T^{ELEC} + \vec{u}_T^{FSR}$$

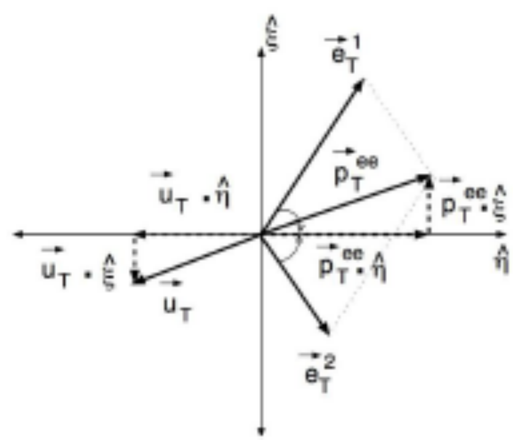
- u_T^{Hard} : Recoil against *W/Z*
- u_T^{Soft} : Recoil from pileup and spectator partons
- $u_T^{electron}$: Hadronic energy in cone or electron shower leakage out of cone
- u_T^{FSR} : Final state radiation photons



Hadronic Recoil Response

- The u_T^{Hard} component is derived from Z-> νν events
- u_T^{Soft} comes from zero bias and min bias data look up tables
- u_T^{Elec} and u_T^{FSR} are determined from dedicated simulations
- Final response and resolution taken from fits to momentum imbalance $\vec{p}_T(ee)+\vec{u}_T$



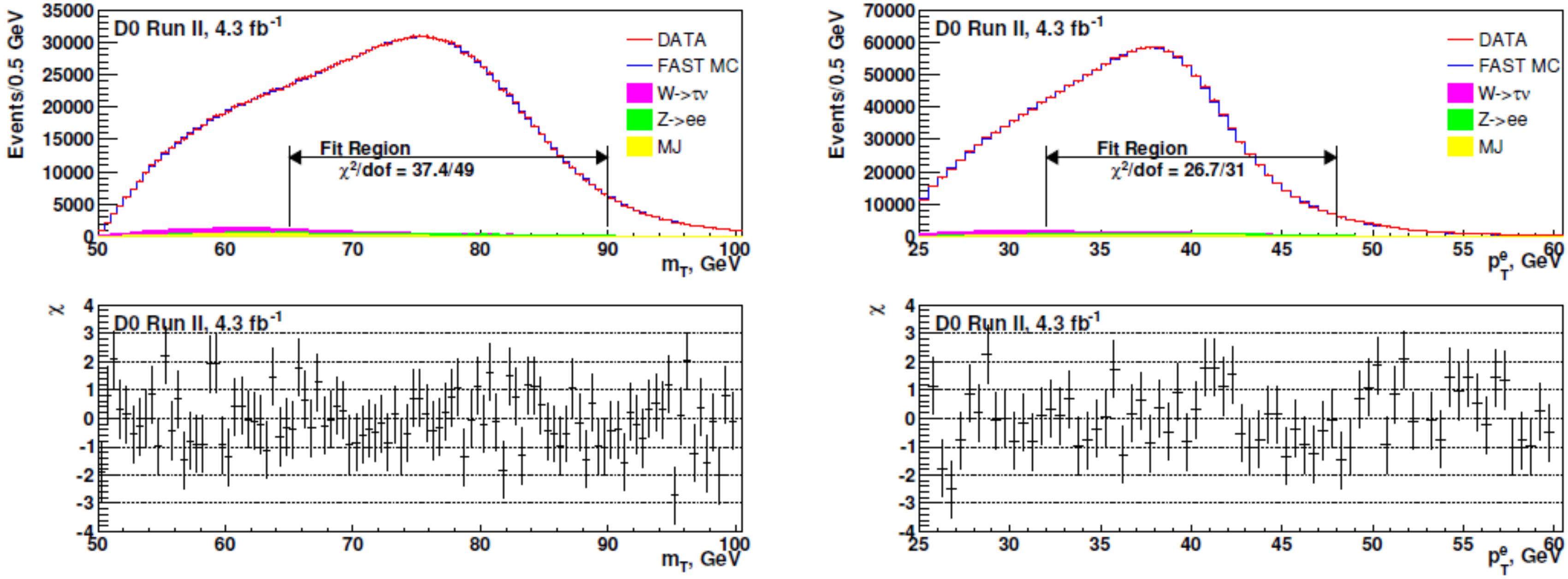


Systematic Uncertainties

- Experimental systematic uncertainties are driven by the statistics of the Z sample
- Electron Energy scale and PDF are the largest uncertainties

Source	$\sigma(m_W)$ MeV m_T	$\sigma(m_W)$ MeV $p_T(e)$	$\sigma(m_W)$ MeV $\not{E}_T$
Experimental			
Electron Energy Scale	16	17	16
Electron Energy Resolution	2	2	3
Electron Energy Nonlinearity	4	6	7
W and Z Electron energy loss differences	4	4	4
Recoil Model	5	6	14
Electron Efficiencies	1	3	5
Backgrounds	2	2	2
Experimental Total	18	20	24
W production and decay model			
PDF	11	11	14
QED	7	7	9
Boson p_T	2	5	2
W model Total	13	14	17
Total	22	24	29

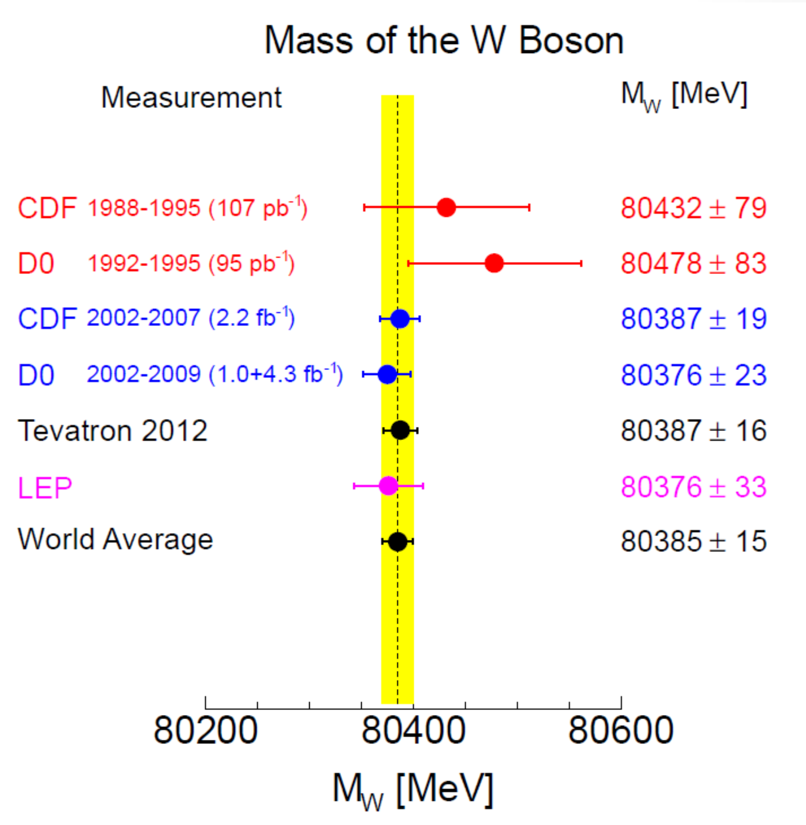
Results



Method $(4.3\,fb^{-1})$	M_W (MeV)
$m_T(e,\nu)$	80371 ± 13(stat)
$p_T(e)$	80343 ± 14(stat)
$\not{E}_T(e,\nu)$	80355 ± 15(stat)
Combination $m_T \oplus p_T$ $(4.3\,fb^{-1})$	80367 ± 26(syst + stat)
Combination $(5.3\,fb^{-1})$	**80375 ± 23**(syst + stat)

Conclusions

- D0 measured the W mass to ΔM_W = 23 MeV
  - Same as previous world average
- Current world average is ΔM_W = 15 MeV
  - Includes latest CDF result
- By including the full data set and end calorimeter electrons, we should reach ΔM_W = 15 MeV with D0 alone



Backups

Event Selection

Event selection
- Single EM trigger
- Vertex |z| < 60 cm

Electron Selection
- $p_T > 25$ GeV
- HMatrix7 < 12, emf > 0.9, iso < 0.15
- $|\eta_{det}| < 1.05$ (calorimeter fiducial region)
- In the calorimeter φ fiducial region, as determined by track
- Spatial track match, track $p_T > 10$ GeV and at least 1 SMT hit

Z->ee Selection
- At least 2 good electrons
- Hadronic recoil transverse moment $u_T < 15$ GeV
- Invariant mass:
  $70 < m_{ee} < 110$GeV

W->eν Selection
- At least one good electron
- Hadronic recoil transverse moment $u_T < 15$ GeV
- Invariant mass:
  $50 < m_T < 200$ GeV
- MeT > 25 GeV

Forward electron Requirements: Hmatrix8 < 20 , $1.5 < |\eta_{det}| < 2.5$