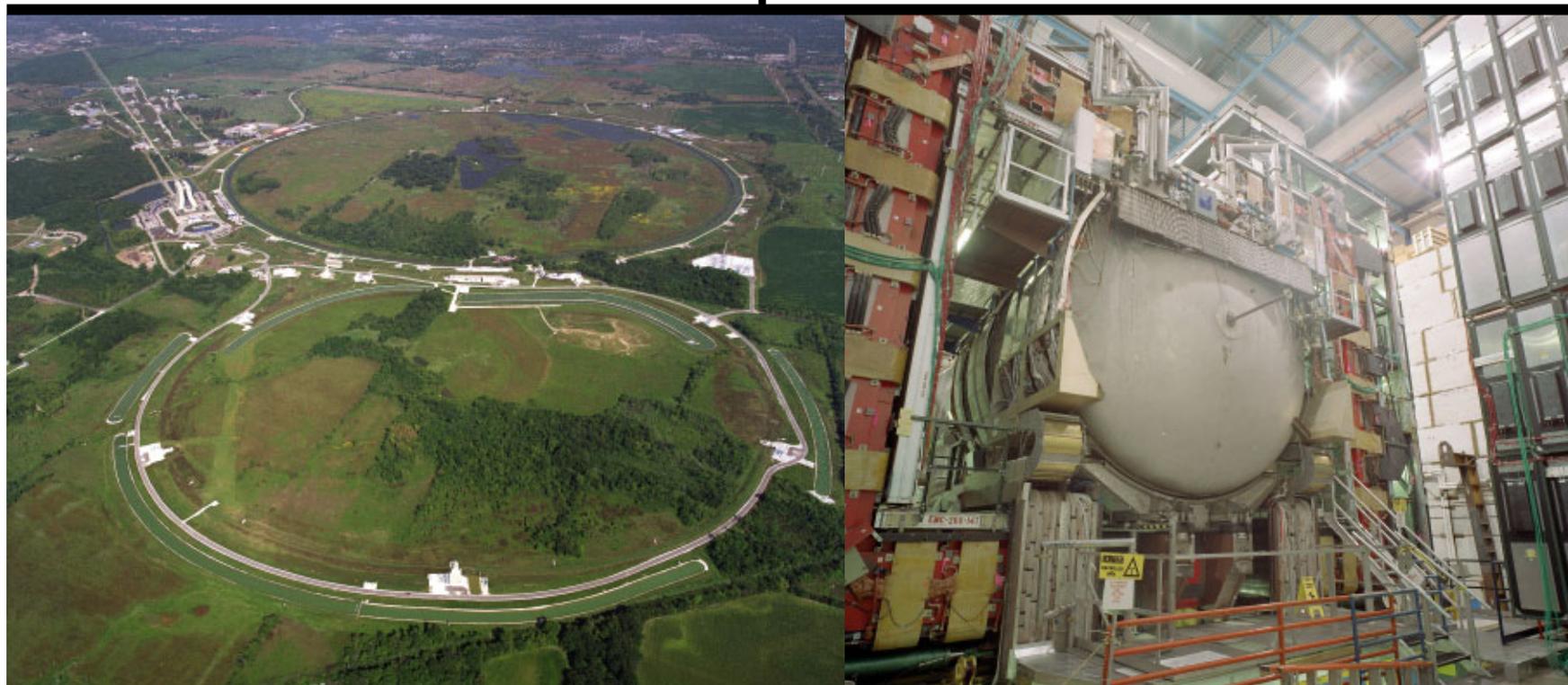


# Uncertainties in the Direct Measurement of the W Boson Mass at D0 Run II

Tim Andeen

Northwestern University  
New Perspectives 2006

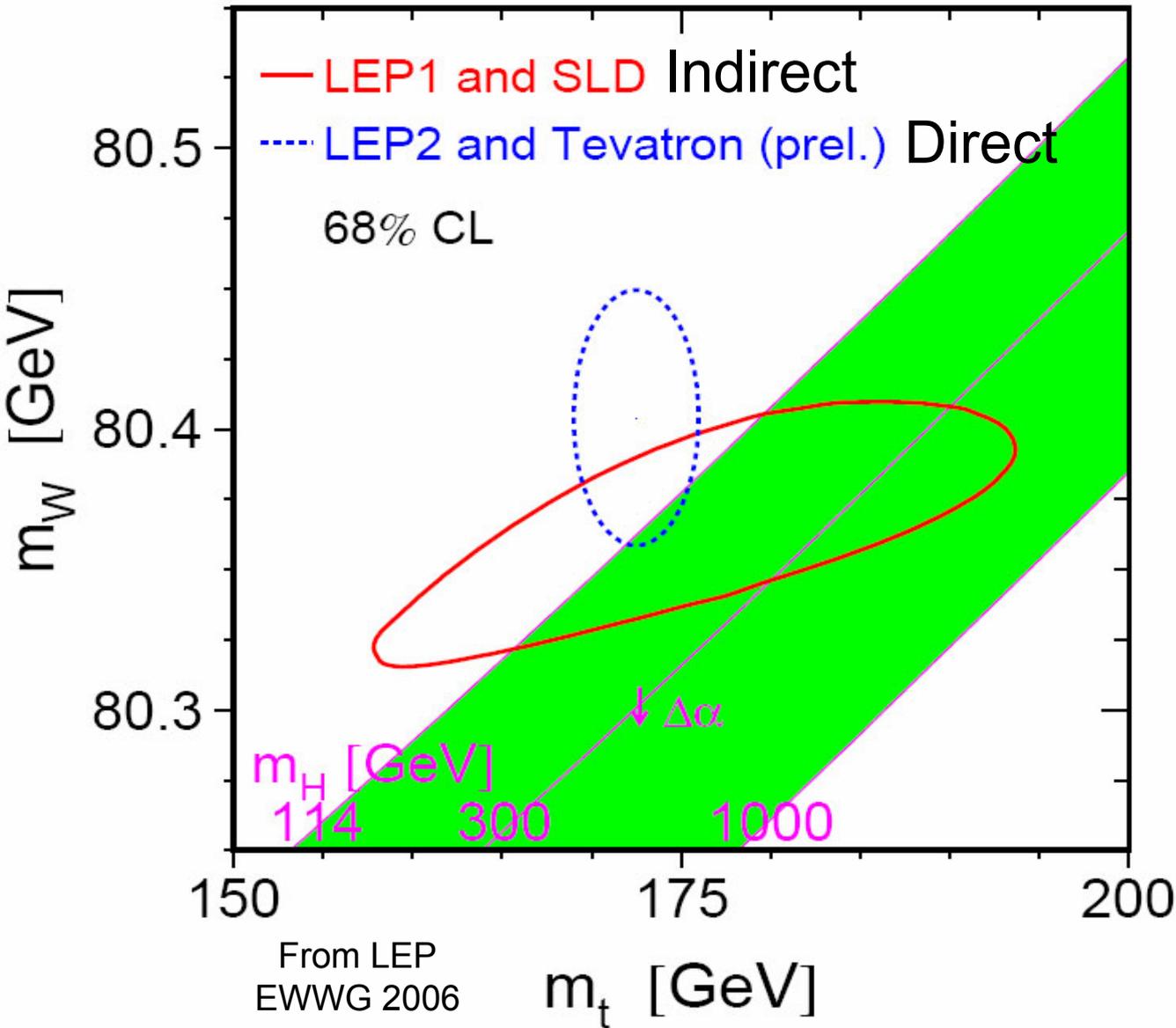




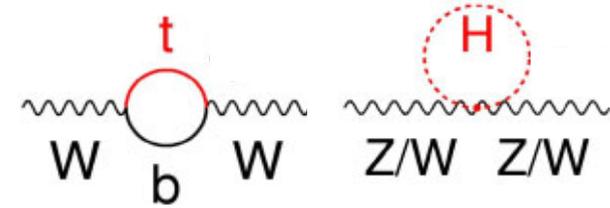
# Outline

- Measuring  $W$  mass
- PDF Uncertainties
- Constraints from  $W$  Charge Asymmetry Measurement



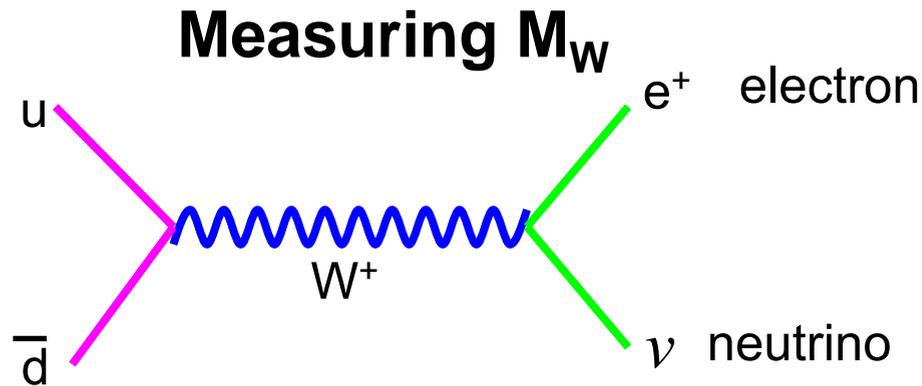


• In the Standard Model the W, top, and Higgs are related by loop corrections.



• Precise measurements of W and top masses constrain the Higgs mass.

• D0 Run II Goal is <40 MeV uncertainty.

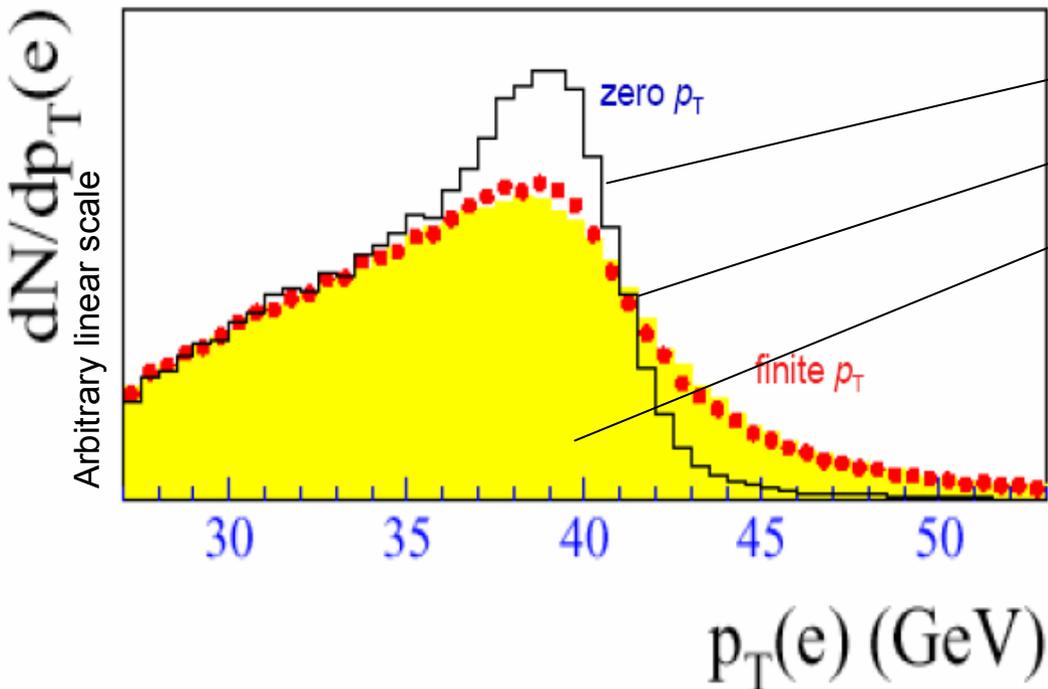


- Can't measure invariant mass directly.
- Several distributions are sensitive to  $M_W$ :  $\mathbf{M}_T$ ,  $\mathbf{p}_T(\mathbf{e})$ , or  $\mathbf{p}_T(\nu)$ .

$$\bullet M_T = \sqrt{2 E_T(e) E_T(\nu) (1 - \cos(\phi_{e,\nu}))}$$

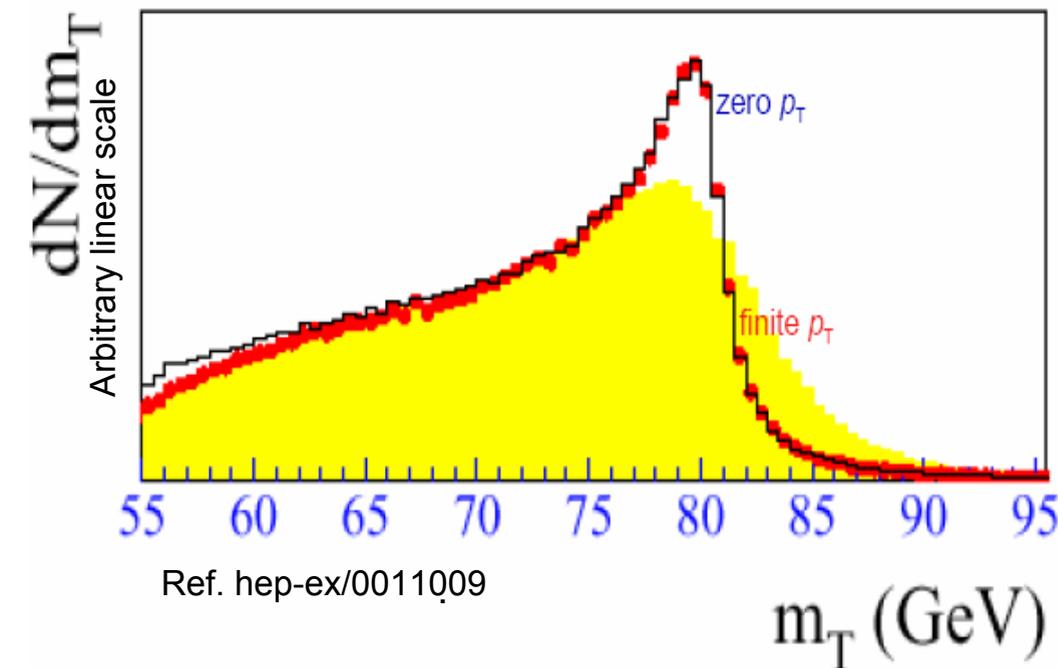
- Compare data with Monte Carlo (MC) templates generated at different values of  $M_W$ , find best match using a log likelihood method, which gives us  $M_W$ .
- MC templates are calculated from theoretical models and folded with detector effects determined from  $Z \rightarrow ee$  events in data.

# Distributions



-  No  $P_T(W)$
-   $P_T(W)$  included
-  Detector Effects added

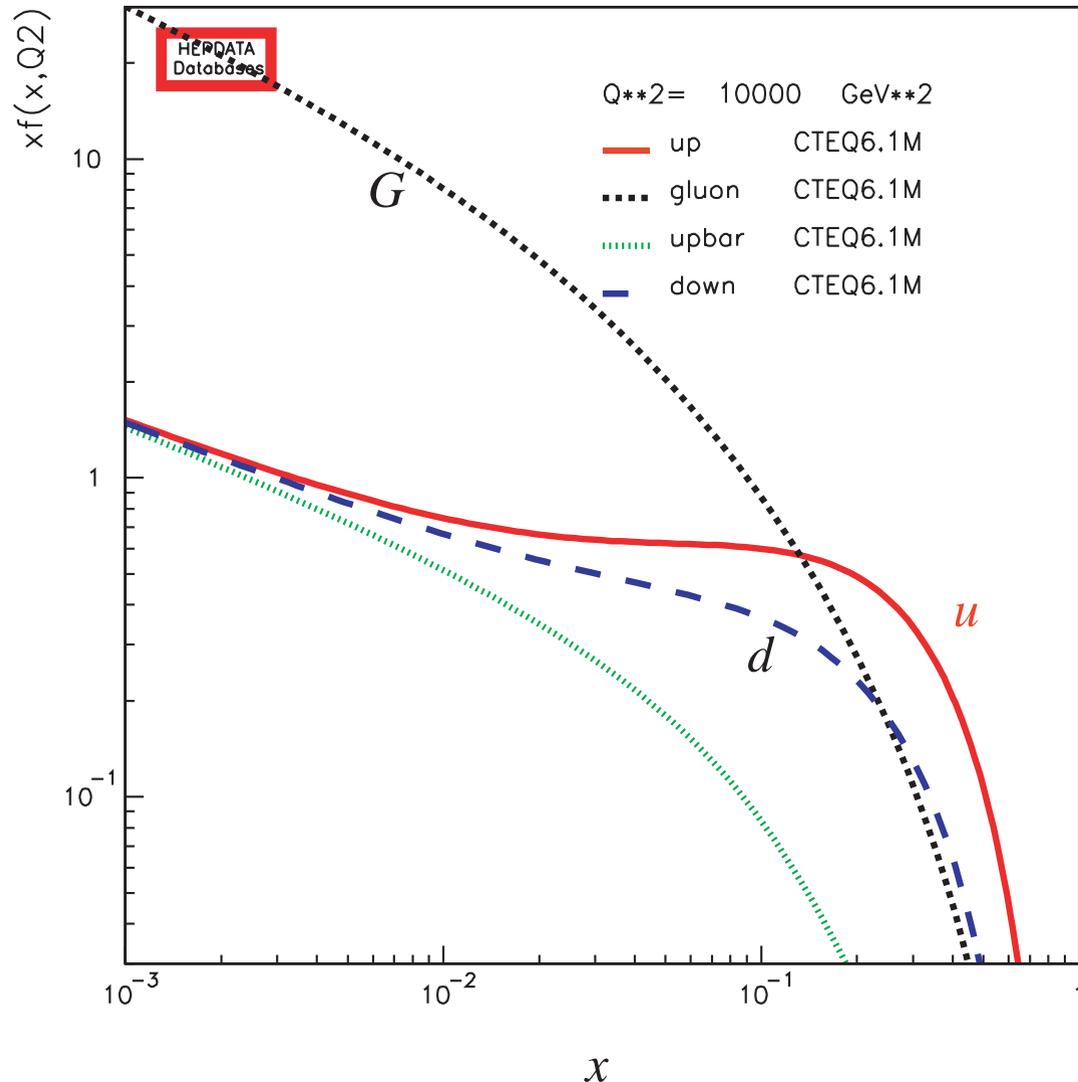
- $p_T(e)$  most affected by  $p_T(W)$ .



- $M_T$  most affected by missing transverse momentum measurement.

# Parton Distribution Function (PDF) Uncertainty

- $W$  production depends on the  $u$  and  $d$  parton distributions.
- The PDF's are the result of fits to other experiments and have intrinsic uncertainties.
- The CTEQ Collaboration provides a set of PDF's, where the 20 parameters used in the global fit are each varied within a reasonable tolerance.



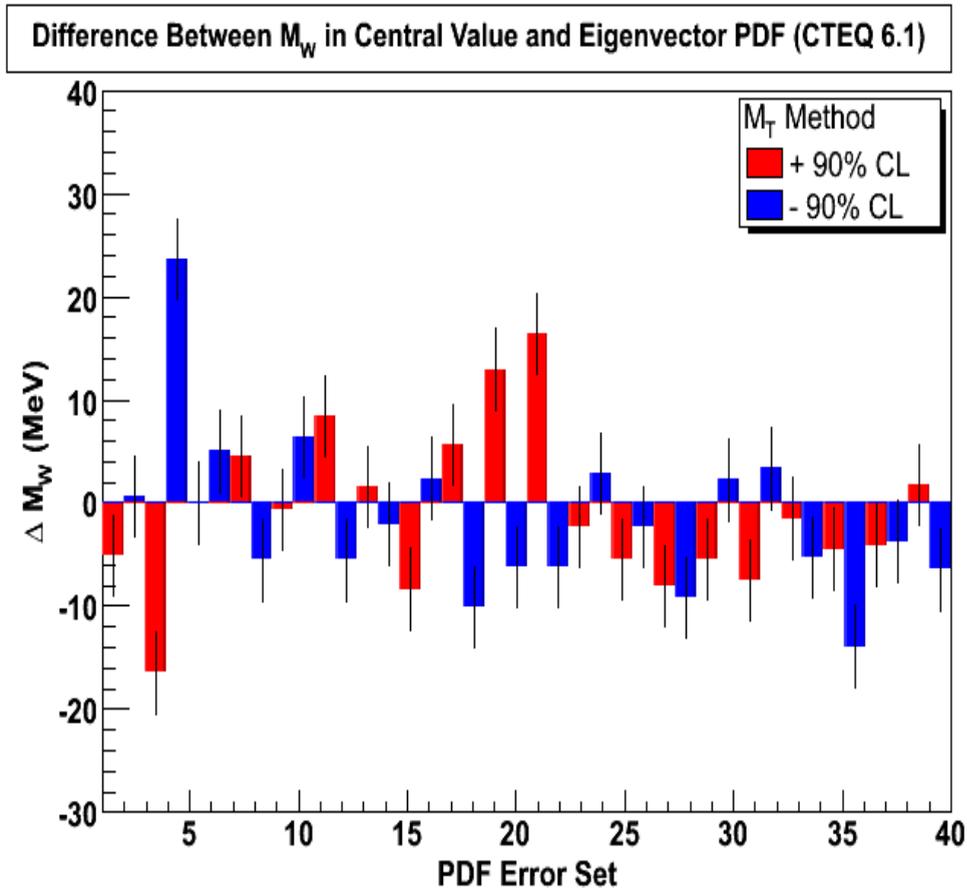
# Parton Distribution Function (PDF) Uncertainty

- To estimate the uncertainty from our knowledge of PDFs :
  - Generate distributions with each PDF using the **Resbos** (hep-ph/9704258) event generator and D0 Detector Simulation (10 million events for each PDF).
  - Fit mass with each set of distributions.
  - Compare the mass determined with the 40 new PDF's to the best fit PDF.
  - Calculate the uncertainty using:

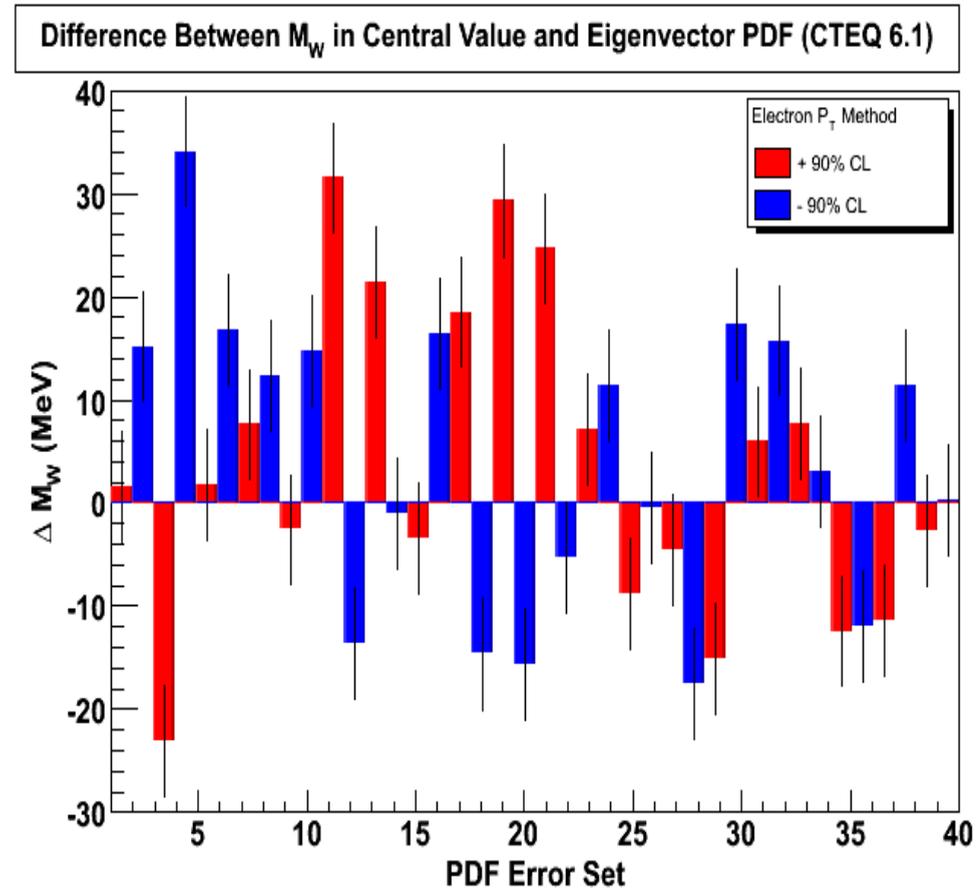
$$\sigma_{PDF} = \frac{1}{1.645} \frac{1}{2} \left( \sum_{i=1}^{20} \left[ \Delta M_W (S_i^+) - \Delta M_W (S_i^-) \right]^2 \right)^{\frac{1}{2}}$$


 Conversion to  $1\sigma$

# PDF Uncertainty Continued



Total Uncertainty:  $\sigma_{PDF}(M_T) = 19.1$  MeV



$\sigma_{PDF}(P_T) = 35.8$  MeV



# W Charge Asymmetry Investigation

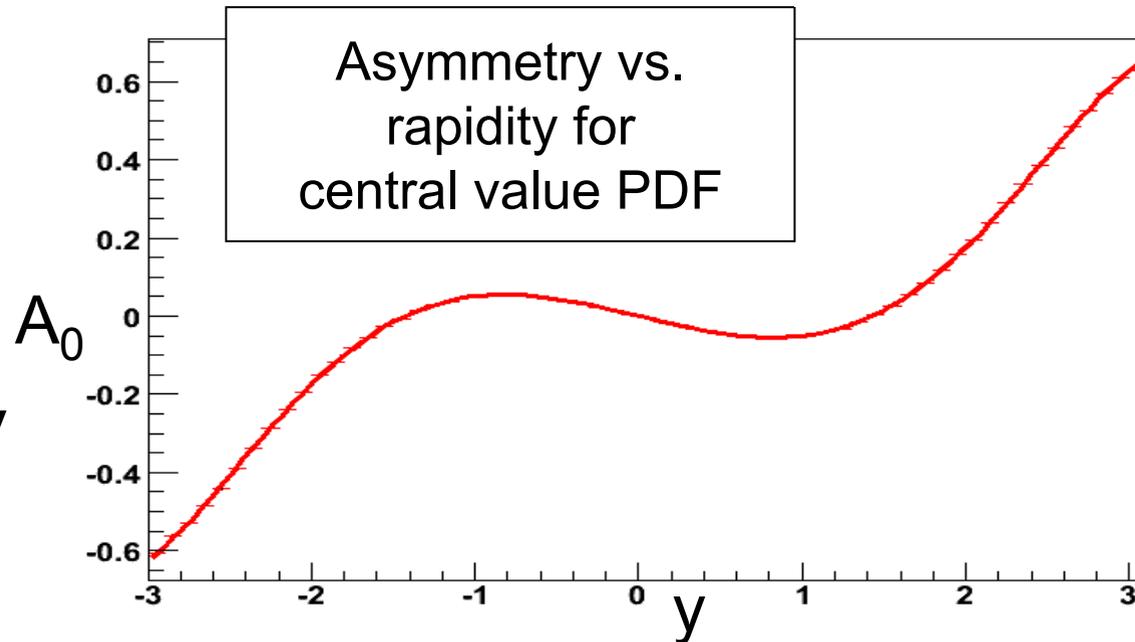
- For each of the 41 PDF sets generate 10M events in Monte Carlo, then calculate the W asymmetry versus rapidity:

$$A(y_e) = \frac{N_{e^+}(y) - N_{e^-}(y)}{N_{e^+}(y) + N_{e^-}(y)}$$

- To determine the sensitivity to each eigenvector calculate:

$$\Delta A(y_e) = A_0(y_e) - A_i(y_e)$$

- where  $A_i$  is the asymmetry found for the  $i$ th PDF set. Then plot the  $\pm$  pair together for each eigenvector.



## Cuts:

$$|y| < 2.8$$

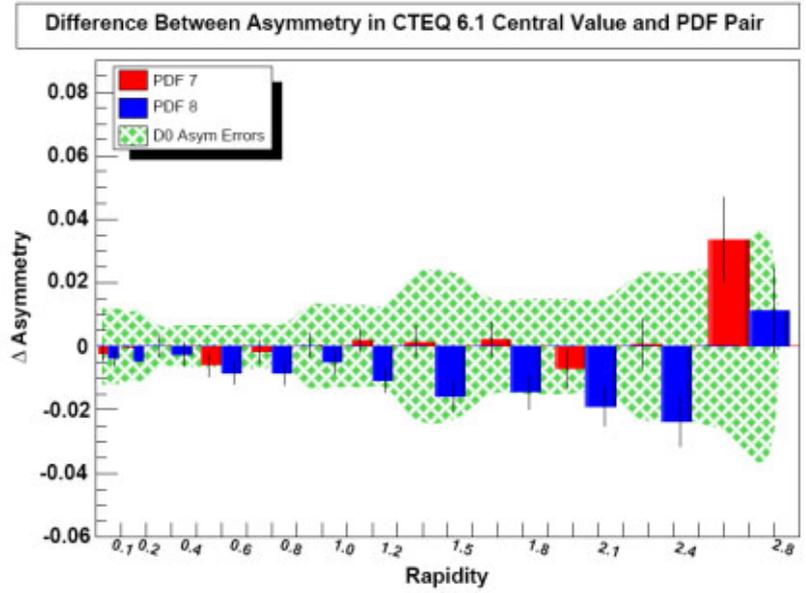
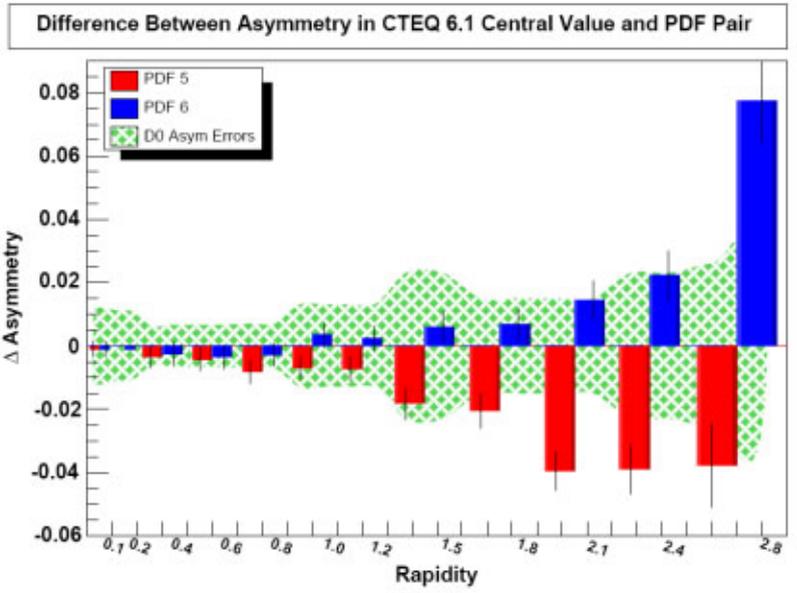
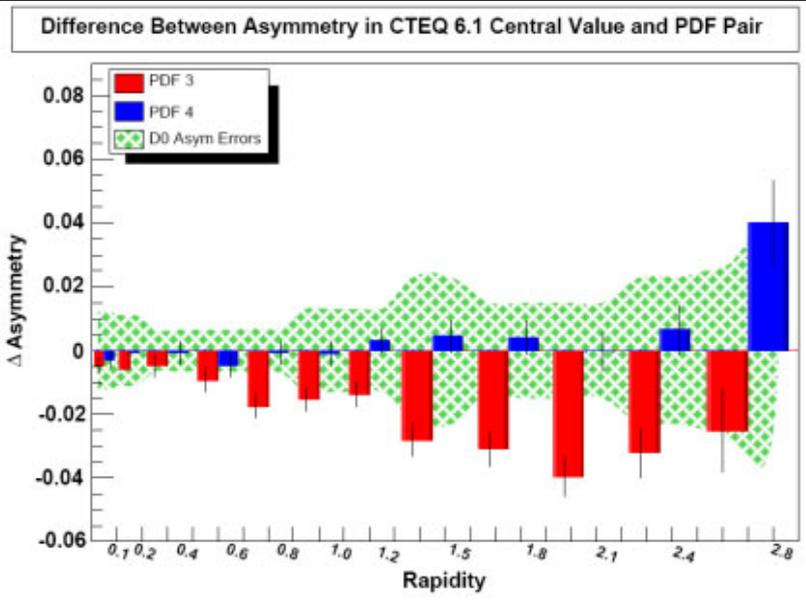
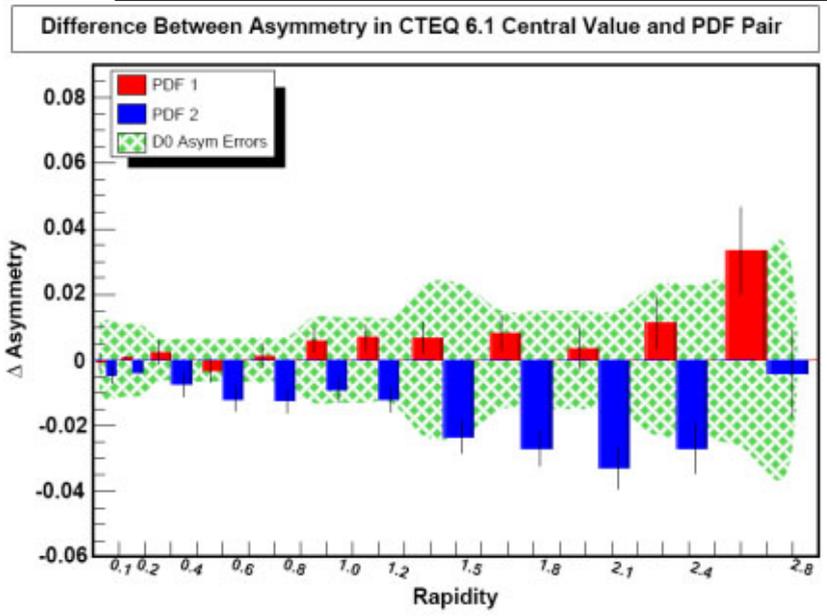
$$P_T(e) > 25 \text{ GeV}$$

$$P_T(\nu) > 25 \text{ GeV}$$

# Asymmetry per PDF



Green shading represents the preliminary uncertainty from the D0 measurement, which is a work in progress.



Some eigenvectors may already be constrained.



# Conclusion

- A precision measurement of  $M_W$  at D0 Run II is important.
- We estimate our uncertainty in  $W$  mass measurement due to the PDF. The results of **19.1 MeV** for the  **$M_T$  method**, **35.8 MeV** for the  **$P_T(e)$** , represent a significant portion of the uncertainty “budget” of  $\sim 40$  MeV.
- With the  $W$  Charge Asymmetry measurement (and other analyses) coming from new Tevatron data, it should be possible to reduce this uncertainty.



# Backup

# General Selection Criteria for Z and W

- **Z:**
  - Two electrons
  - Single electron trigger fired
- **W:**
  - One electron
  - Single electron trigger fired
  - Missing  $E_T > 25$  GeV
  - $p_T(W) < 20$  GeV
  - No 2<sup>nd</sup> electron

## **A Good Electron for the $M_W$ Analysis:**

Defined by the transverse and longitudinal shape of the energy deposited,  $E_T > 25$  GeV,  $|\eta| < 1.05$  (only the central region of the calorimeter is used), a track matched to the calorimeter cluster, and in the fiducial region of the detector.