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

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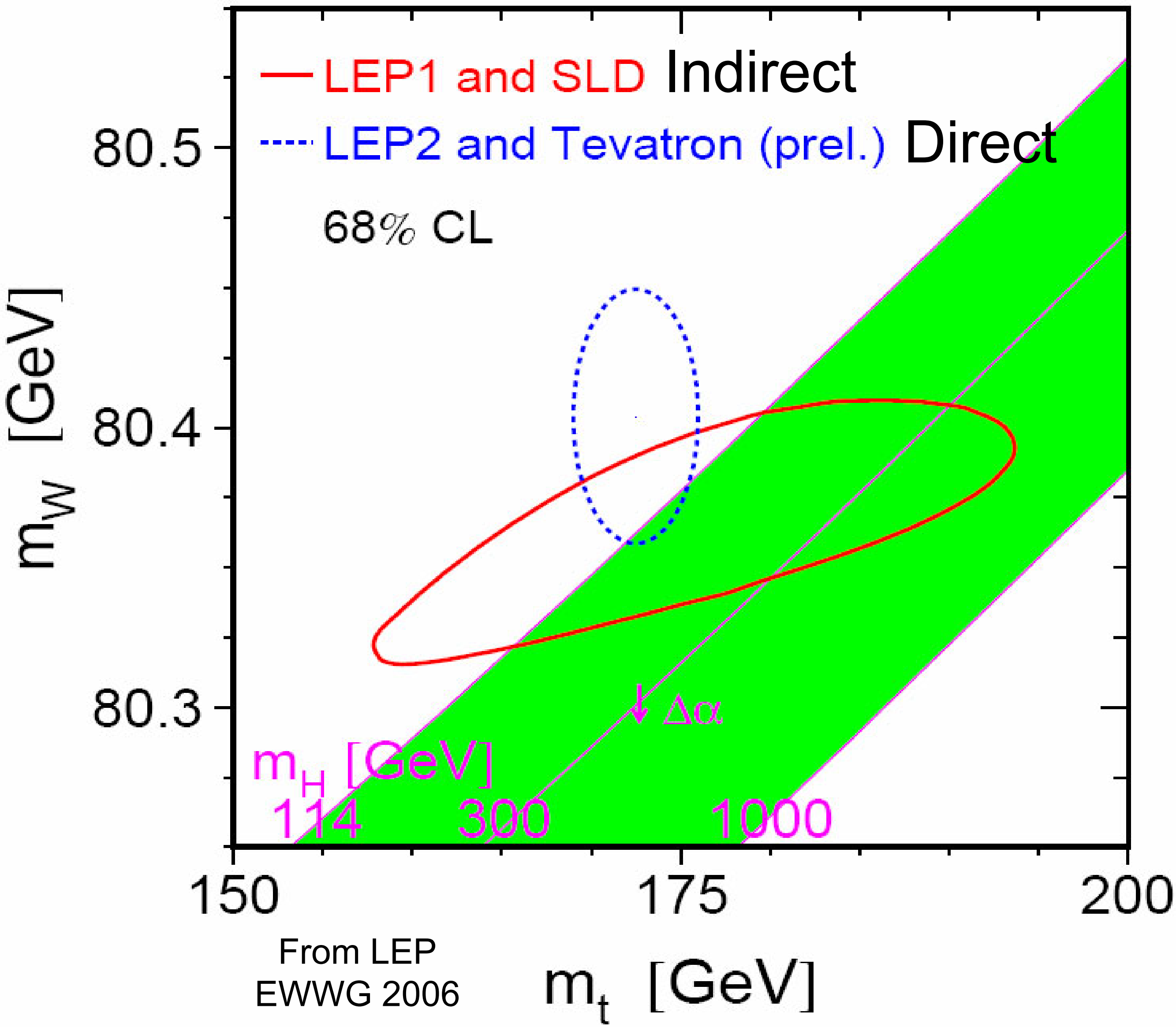
Outline

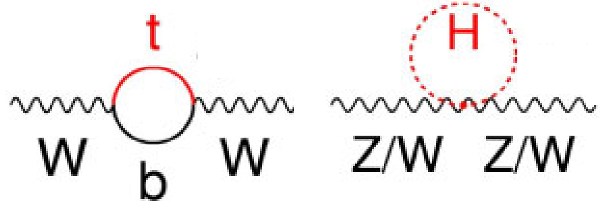
- Measuring W mass
- PDF Uncertainties
- Constraints from W Charge Asymmetry Measurement

Motivation



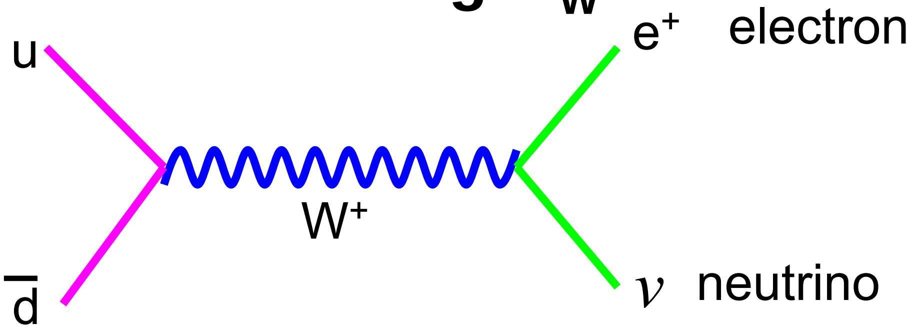
From LEP EWWG 2006

- 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.

Measuring M_W



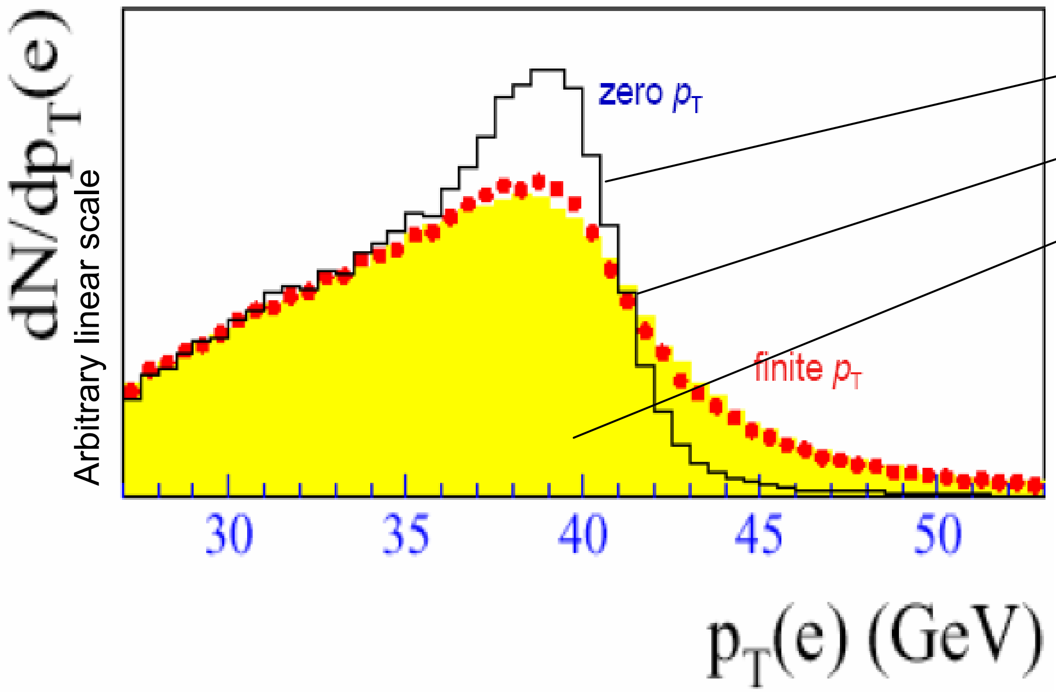
- Can't measure invariant mass directly.
- Several distributions are sensitive to M_W: $\mathbf{M_T}$, $\mathbf{p_T(e)}$**, or** $\mathbf{p_T(\nu)}$**.**

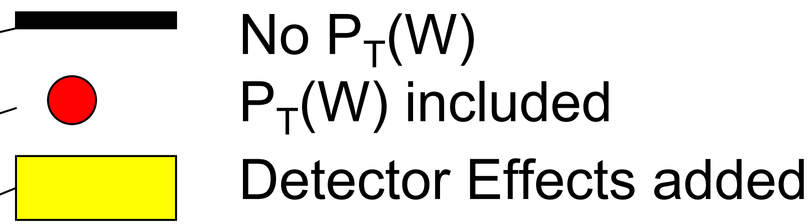
$$\cdot\ M_T = \sqrt{2E_T(e)E_T(\nu)(1-\cos(\phi_{e,\nu}))}$$

- 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.

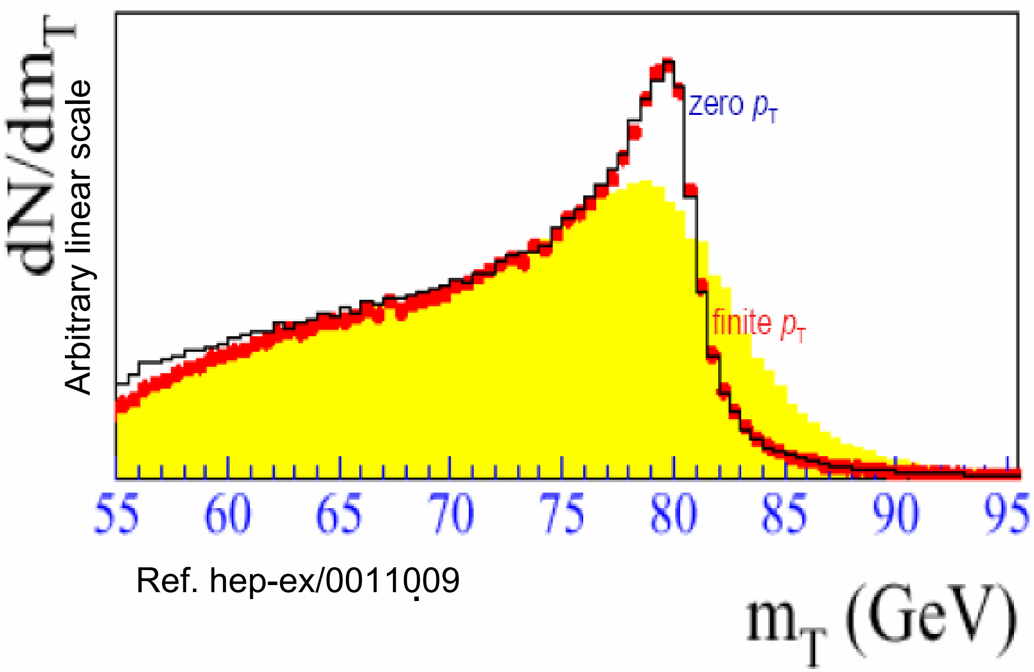
- MC templates are calculated from theoretical models and folded with detector effects determined from Z→ee events in data.

Distributions





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

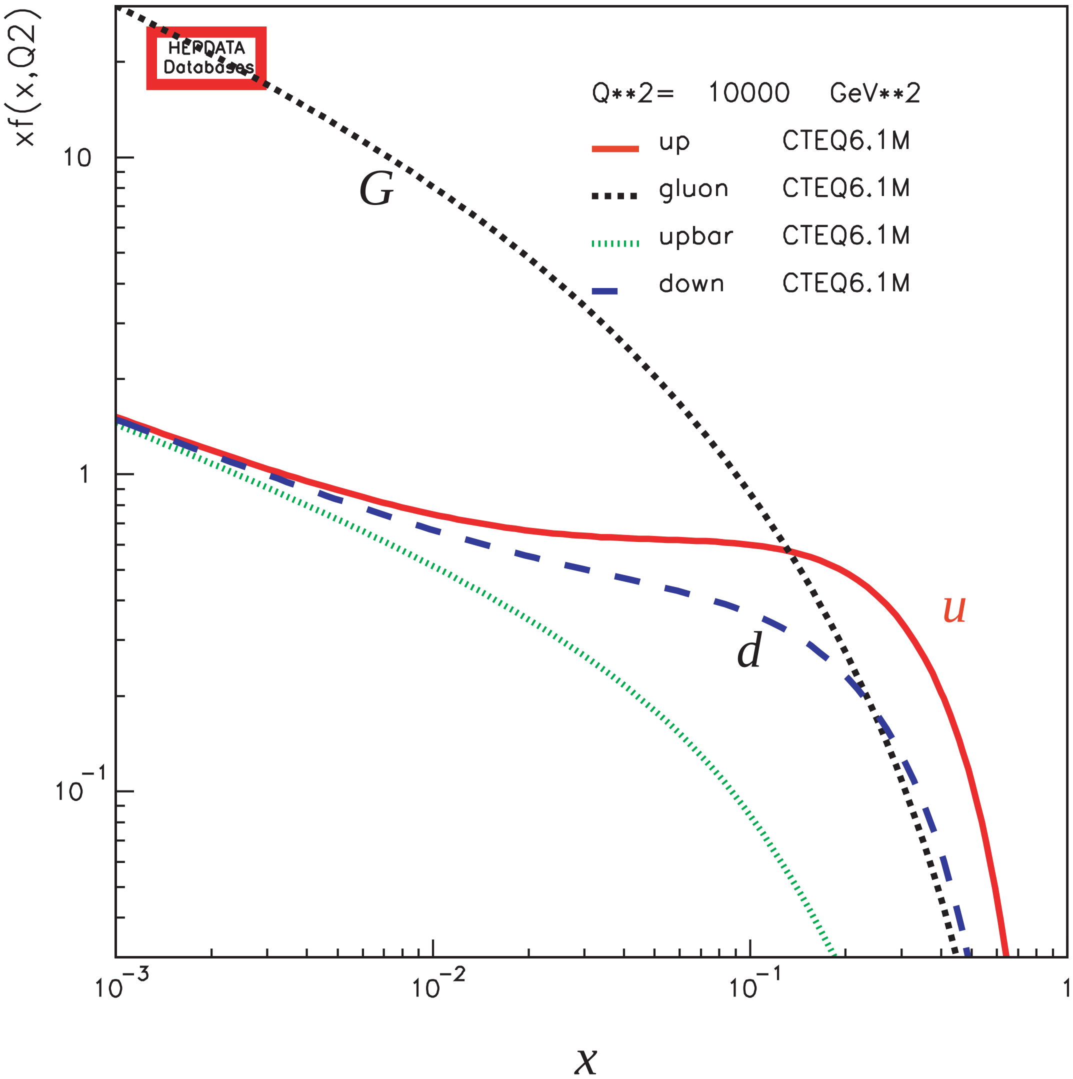


Ref. hep-ex/0011009

- 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 experiment 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.



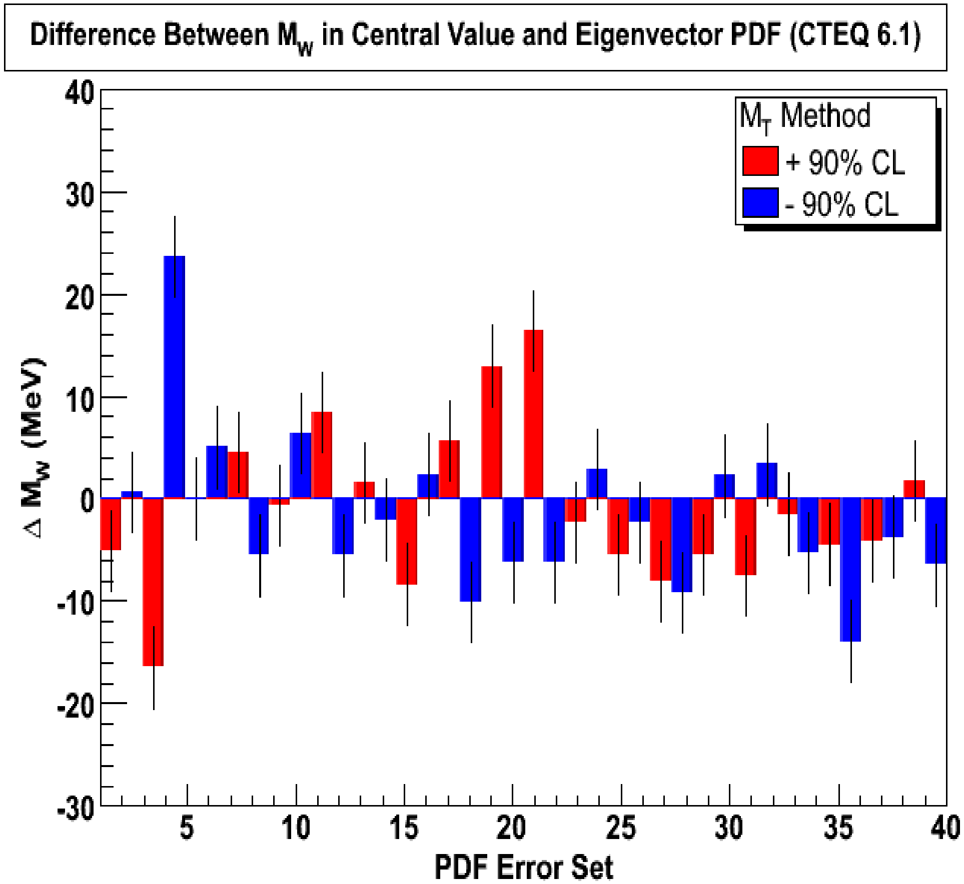
Parton Distribution Function (PDF) Uncertainty

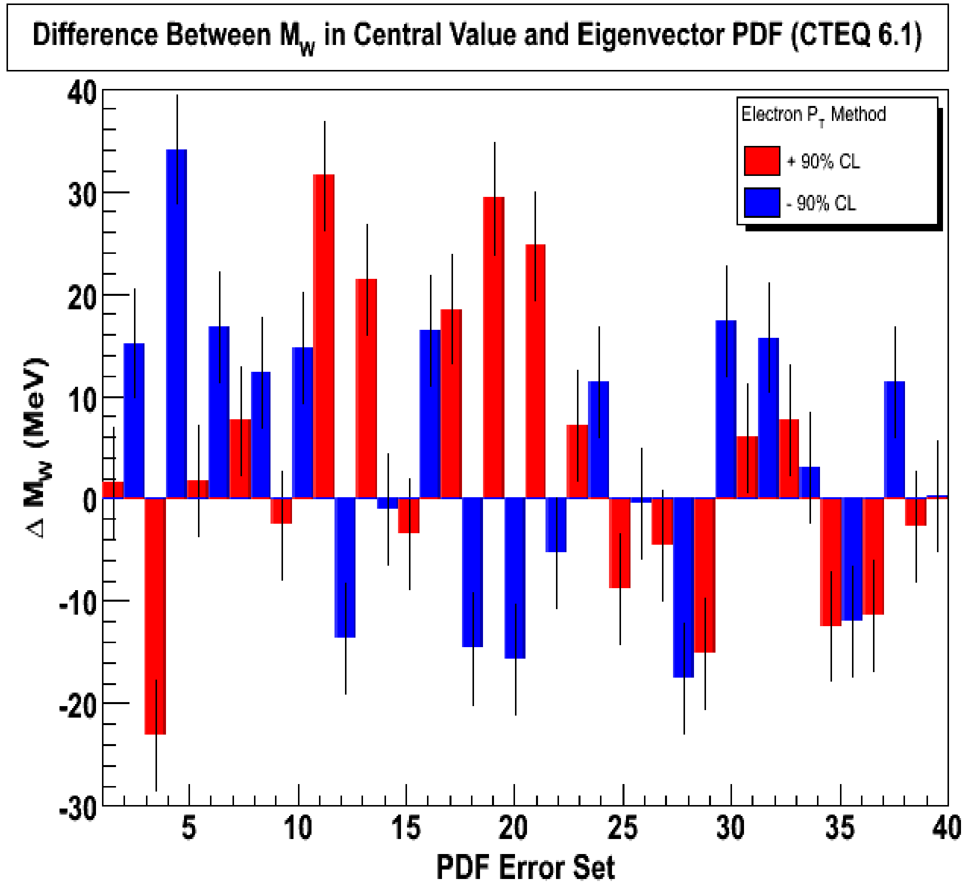
- To estimate the uncertainty from our knowledge of PDFs :
  - Generate distributions with each PDF using the **Resbos** (hep-ph/9704258) event generator and D0 Detector Simulation (10 million events for each PDF).
  - Fit mass with each set of distributions.
  - Compare the mass determined with the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

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

Conversion to1σ

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:

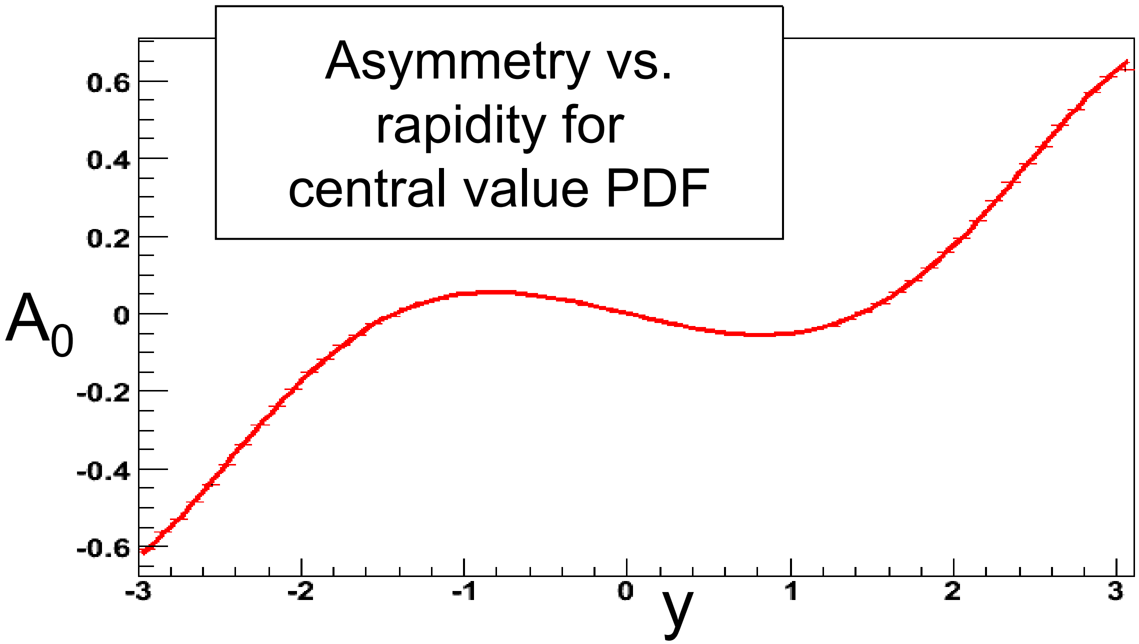
$$A(y_e) = \frac{N_{e^+}(y) - N_{e^-}(y)}{N_{e^+}(y) + N_{e^-}(y)}$$

- To determine the sensitivity to each eigenvector calculate:

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

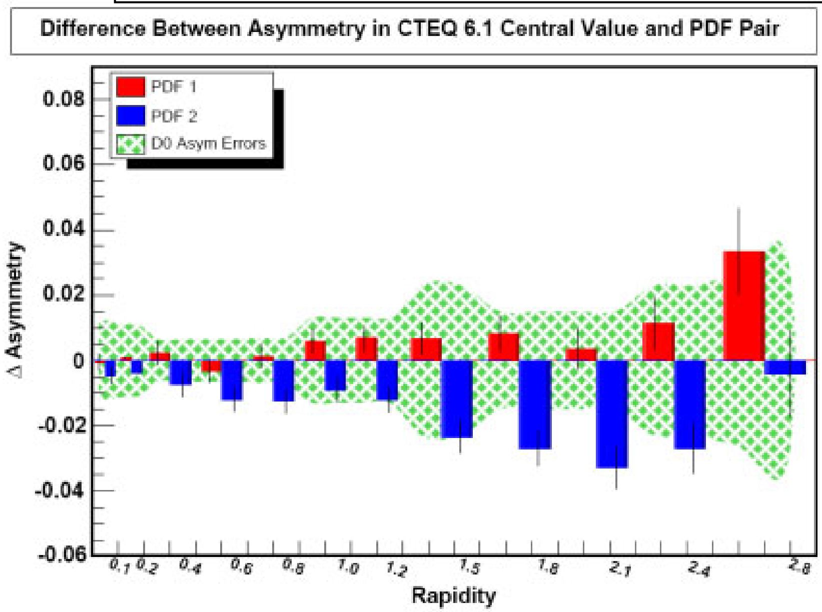
- where A_i is the asymmetry found for the *i*th PDF set. Then plot the ± pair together for each eigenvector.

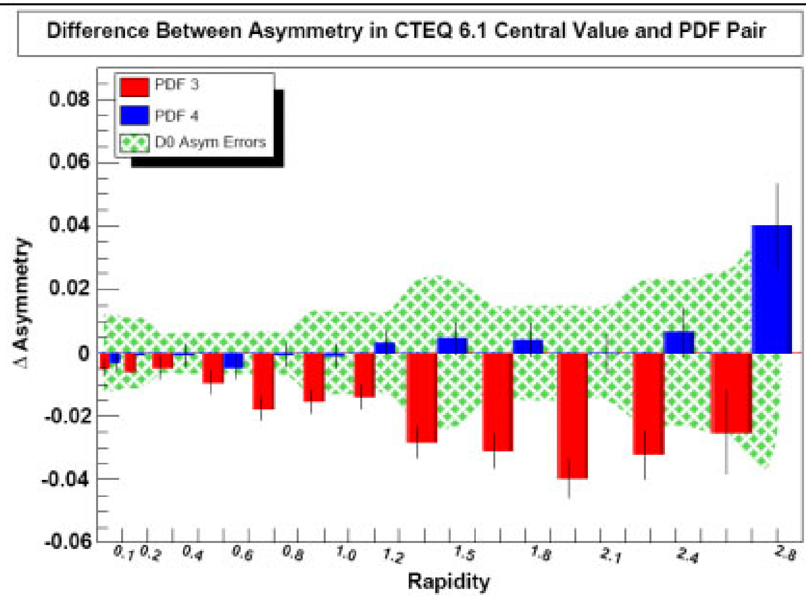
Cuts:
$|y|<2.8$
$P_T(e) > 25$ GeV
$P_T(\nu) > 25$ GeV

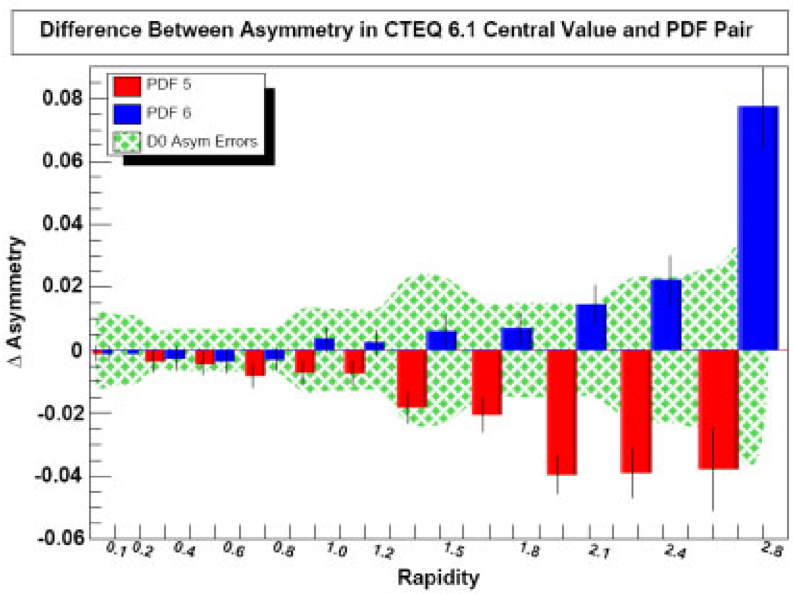


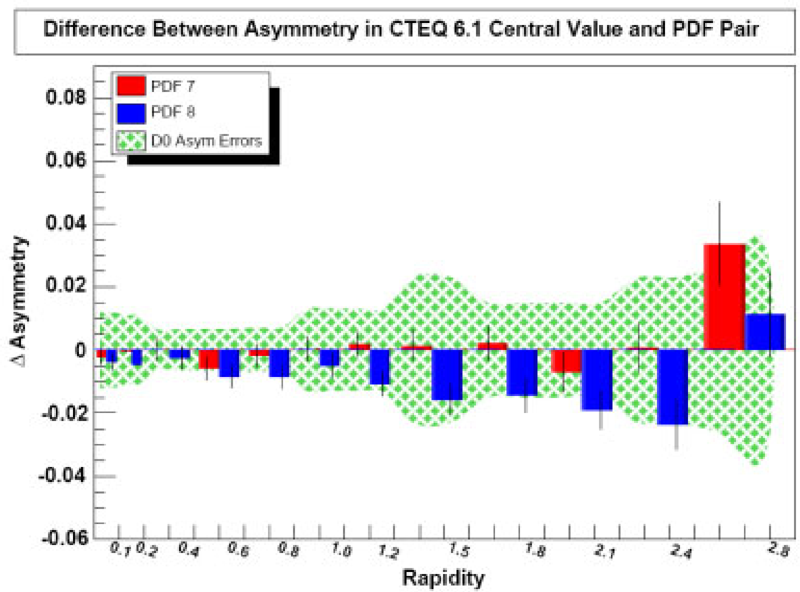
Asymmetry per PDF

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 ~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^{nd} 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.