COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

$W \rightarrow e\nu$ charge asymmetry

David Khatidze
for the D0 collaboration

Introduction

- W^+ and W^- are mainly produced by $\bar{u}d$ and $u\bar{d}$ valence quarks in $p\bar{p}$ collisions.

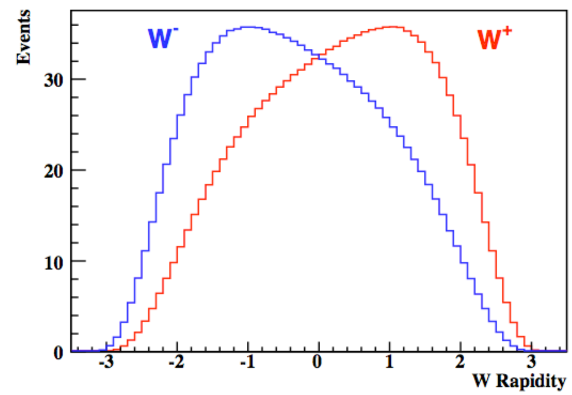
- On average the u qaurks in the proton carry more momentum than the d quarks, which causes asymmetry in the W^+ and W^- rapidity distributions.

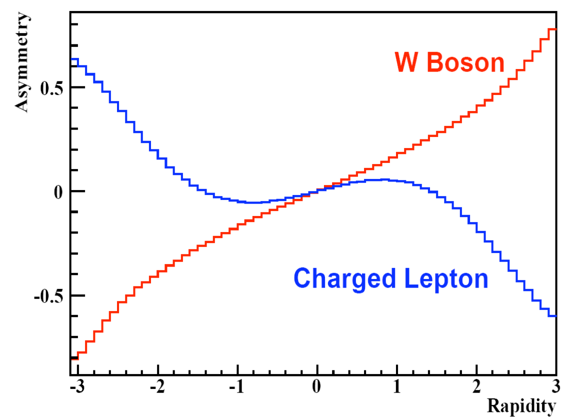
- Use Ws to probe proton structure.

- $W \rightarrow e\nu \Rightarrow A(y)$ difficult to measure

- W asymmetry → Electron asymmetry

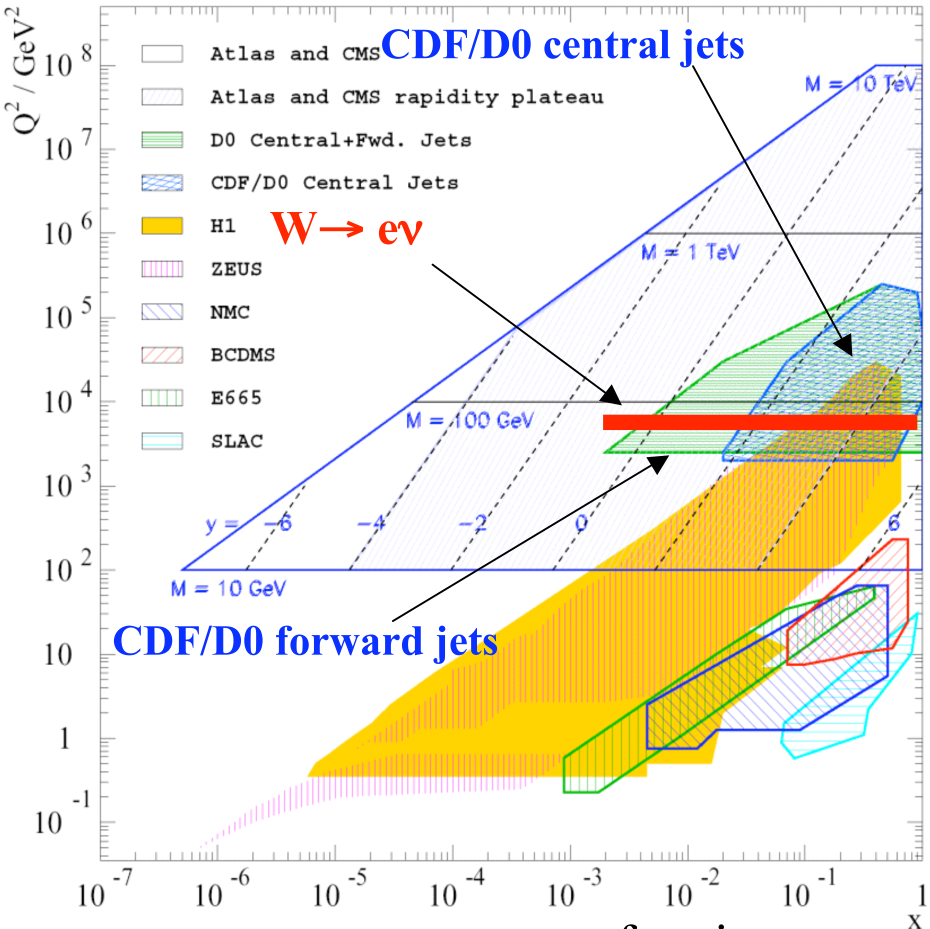
- Electron asymmetry: $A(y)\otimes(V\text{-}A)$





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

Q^2, x reach



x = parton momentum fraction

Q^2 = square of momentum transfer

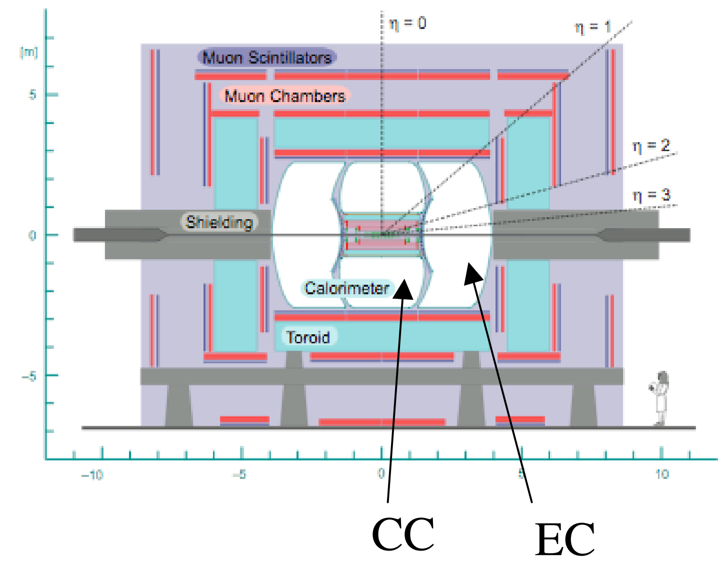
- Traditionally PDFs are measured in deep inelastic scattering.
- In W asymmetry measurement:

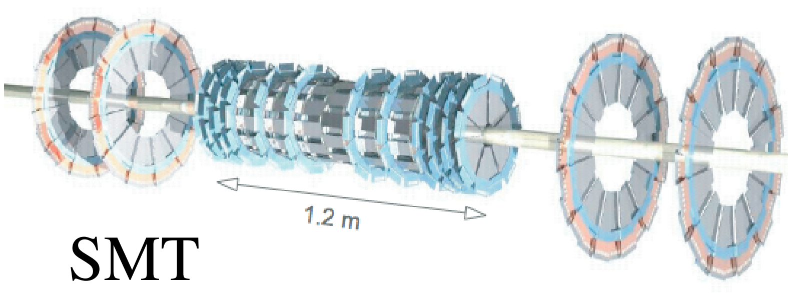
$$Q^2 \approx M_W^2, \quad x = \frac{M_W}{\sqrt{s}} e^{\pm y_W}$$

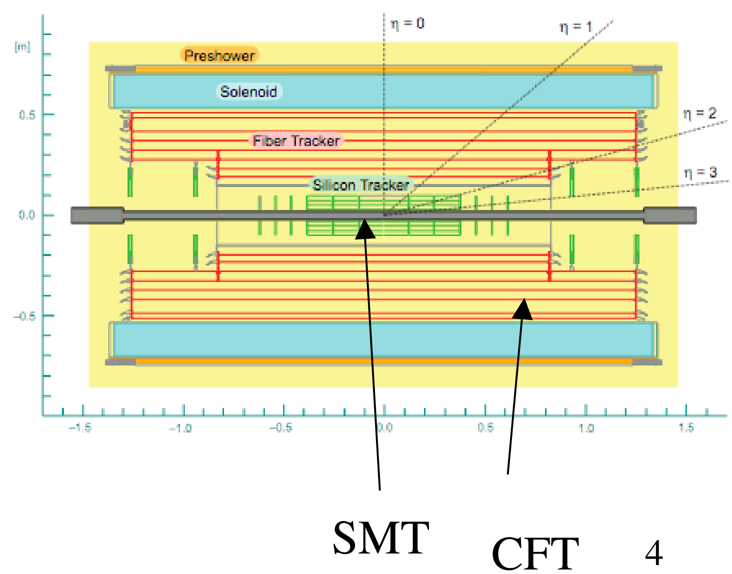
- This measurement:
  - $|y_W| < 3.2 \Rightarrow 0.002<x<1.0$
- Previous measurements:
  - $|y_W| < 2.5 \Rightarrow 0.003<x<0.5$
- Complimentary to central/forward jet measurements at D0 and CDF

D0 detector

- Calorimeter:
  - Central Calorimeter(CC)(|y| < 1.1)
  - Endcap Calorimeter(EC)(|y| < 4.0)
- Tracking System:
  - Silicon Microstrip Tracker(SMT)(|y| < 3.0)
  - Central Fiber Tracker(CFT)(|y| < 2.5)
  - Superconducting 2T Solenoid







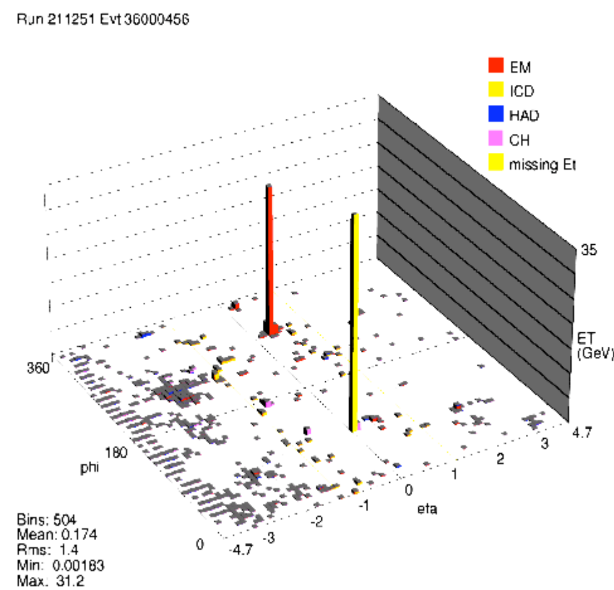
Data Selection

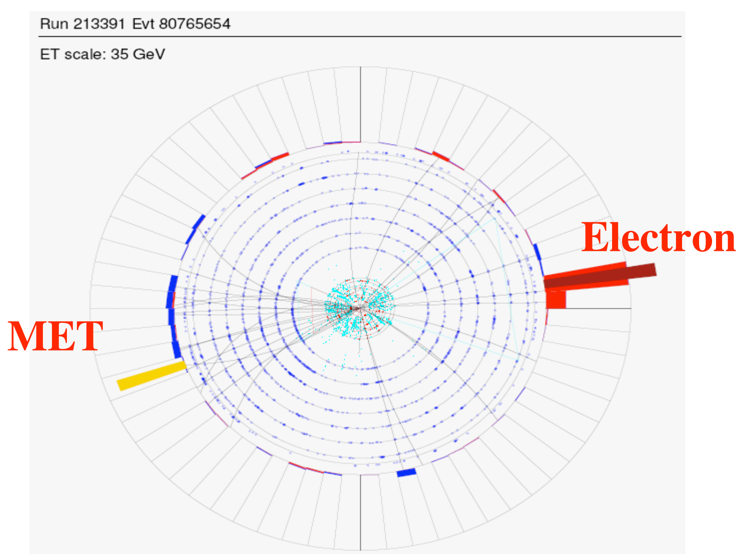
Kinematic cuts:
- Electron $E_T > 25$ GeV
- Missing transverse energy > 25 GeV

EMID cuts:
- Isolated EM cluster in the calorimeter
- Large EM fraction
- Shower shape requirement
- Tight track matching

Triggers:
- Set of single electron triggers based on calorimeter information only

- 750pb^{-1} used





Matrix Method

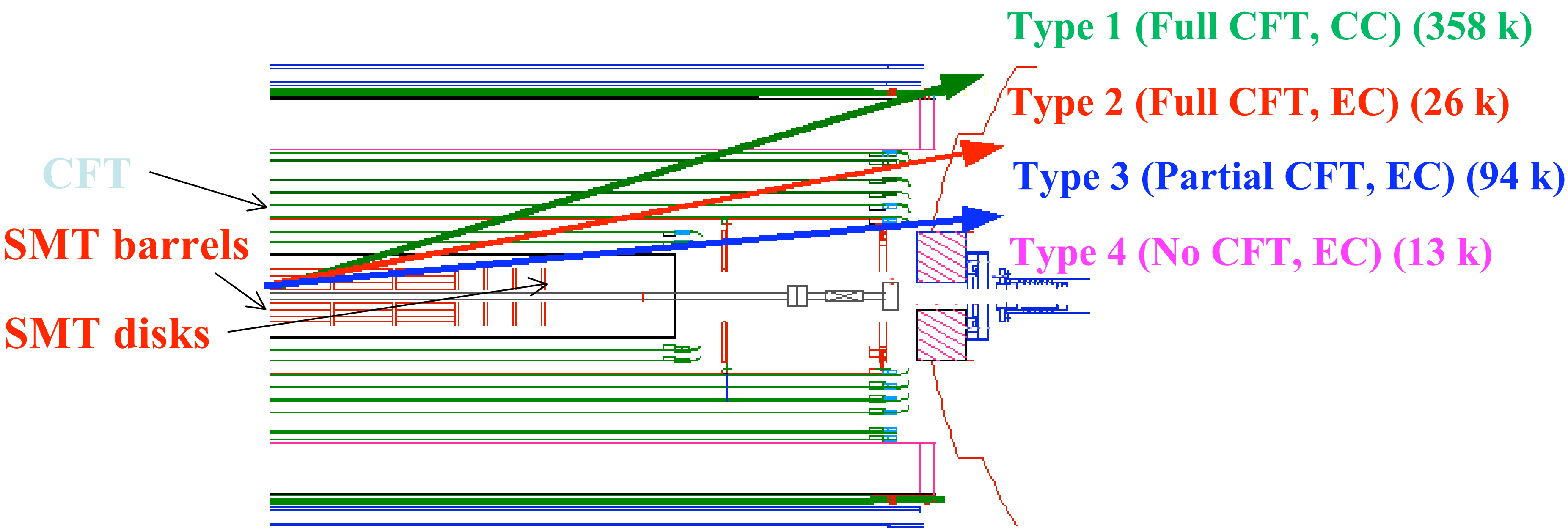
- $N_L = N_T^+ + N_T^- + N_{nt} = N_e^+ + N_e^- + N_{QCD}$
- $N_T^+ = \varepsilon\,(1-g)N_e^+ + \varepsilon\, gN_e^- + f^*N_{QCD}/2$
- $N_T^- = \varepsilon(1-g)N_e^- + \varepsilon\, gN_e^+ + f^*N_{QCD}/2$
- N_L, N_T, N_{nt} are number of events that pass loose, tight and loose but not tight shower shape cuts, respectively.

- ε here is signal efficiency. That is probability for loose electron to pass tight cuts.
- f, EM-like jet id probability, is a probability for fake loose electron pass tight cuts.
- g is charge misidentification rate. Probability for electron charge to be misidentified.

$$A = \frac{N_{e+} - N_{e-}}{N_{e+} + N_{e-}} = \frac{\varepsilon - f}{\varepsilon(1-2g)} \cdot \frac{N_{T+} - N_{T-}}{(1-f)\cdot(N_{T+} + N_{T-}) - f \cdot N_{nt}}$$

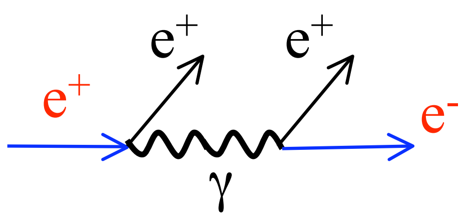
Electron Types

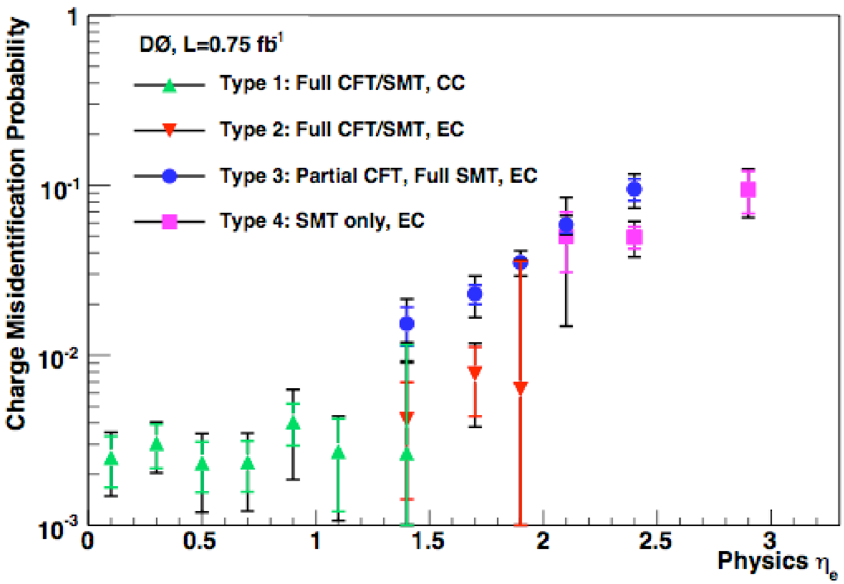
- Important to determine electron charge correctly
- High rapidity bins suffer from low statistics and higher charge mis-identification rate
- Splitting data into 4 electron types depending on the position of EM cluster, incident angle and the primary vertex
- Different track quality cuts applied for different electron types



Charge mis-identification

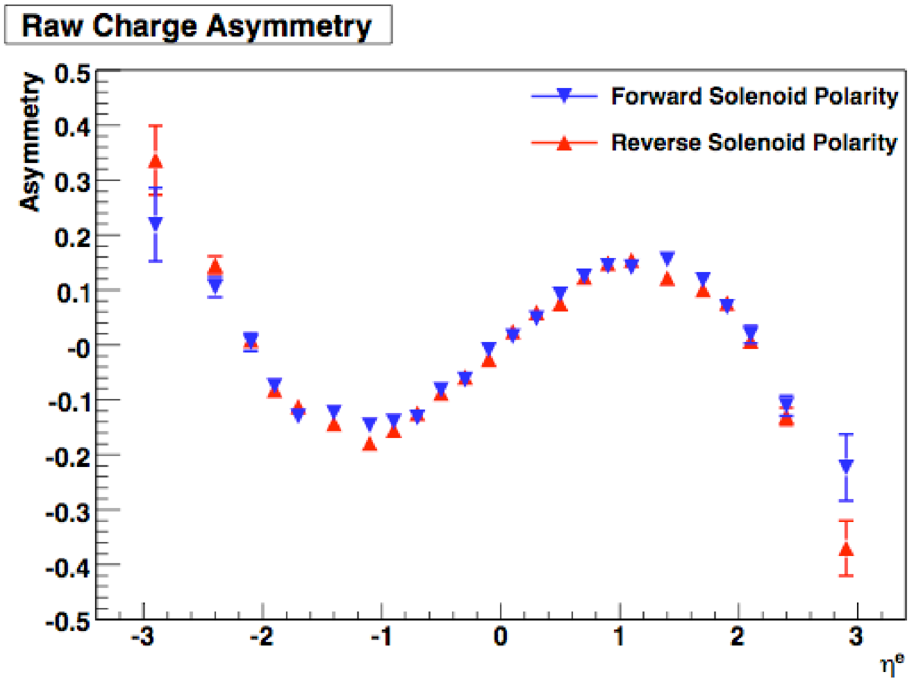
- **Misidentified charges dilute the asymmetry**
- Rate measured using $Z \rightarrow e^+e^-$ events: First make tight selection requirements on one electron, and then check the charge of the other electron.
- ~ 0.3% for $|\eta| < 1$, ~ 9% for $2.8 < |\eta| < 3.2$
- Caused mainly by electron bremsstrahlung





Possible charge bias

- Detector bias: flip the magnetic field direction frequently.
  - No difference observed on A(y) for different polarities
  - 46% forward polarity, 54% backward polarity

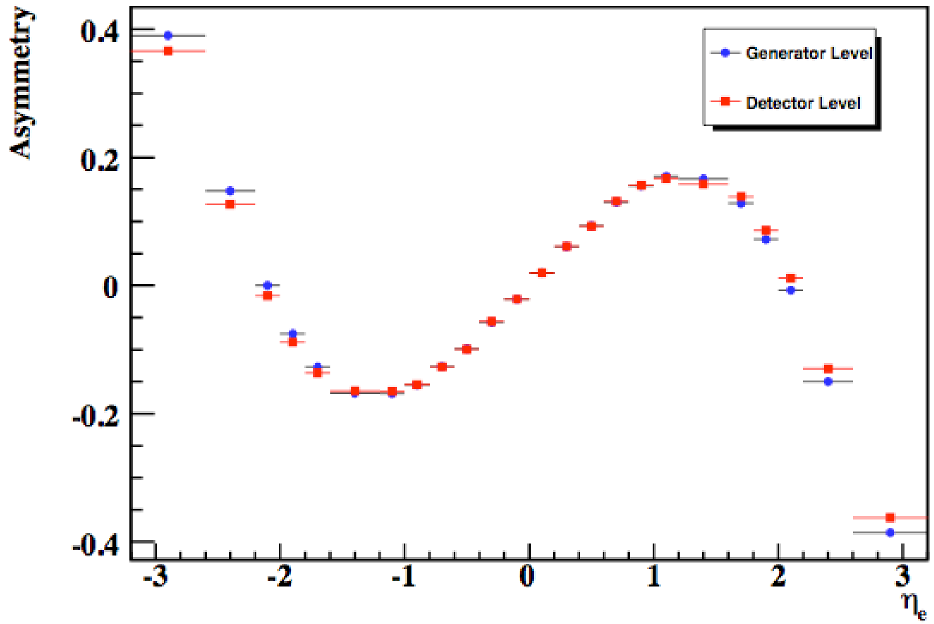


- Efficiencies: check electron and positron efficiencies separately.
  - Their ratio consistent with 1

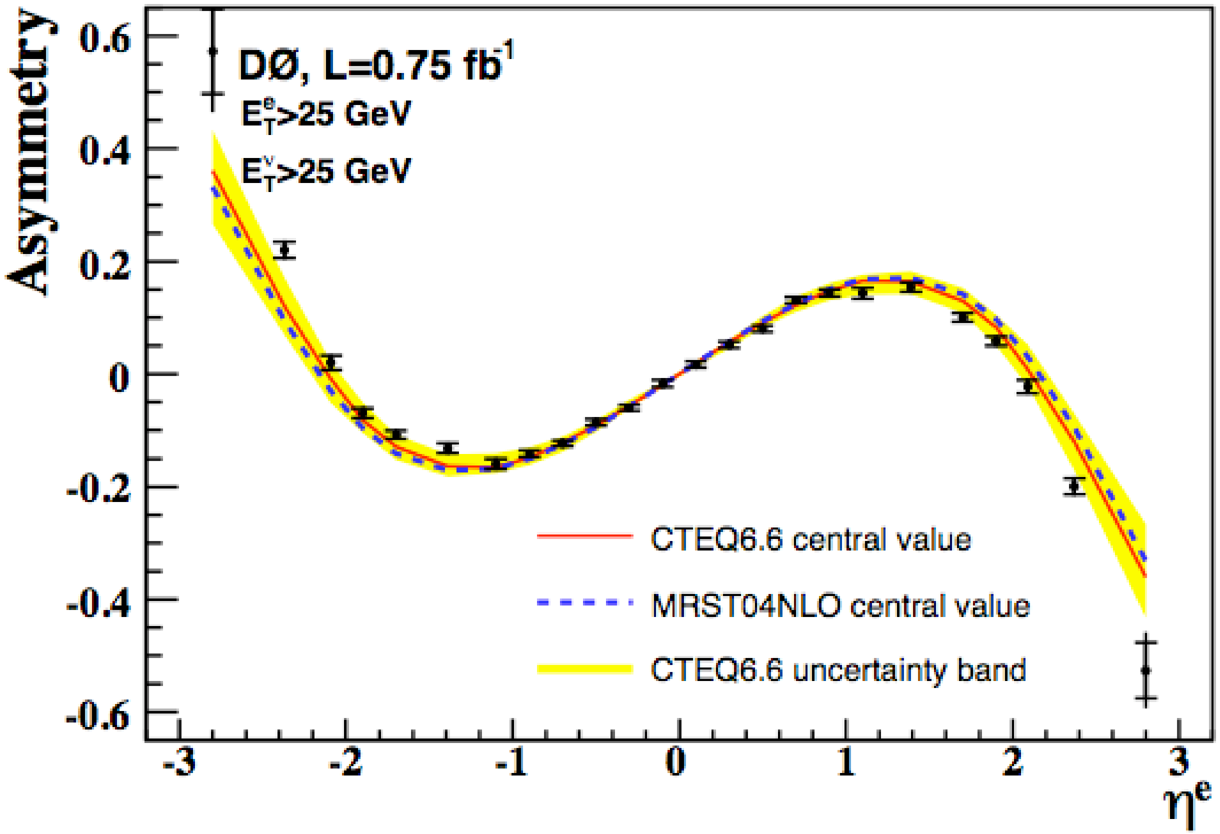
Corrections for smearing

- Observed asymmetry is slightly shifted from true asymmetry by smearing across cut boundaries E_T and MET.

- **Results are corrected for the smearing**
  - GEANT/PYTHIA MC tuned to agree with data
  - Effects from detector estimated by comparing generator level asymmetry and detector level asymmetry on MC.



Asymmetry for E_T>25GeV

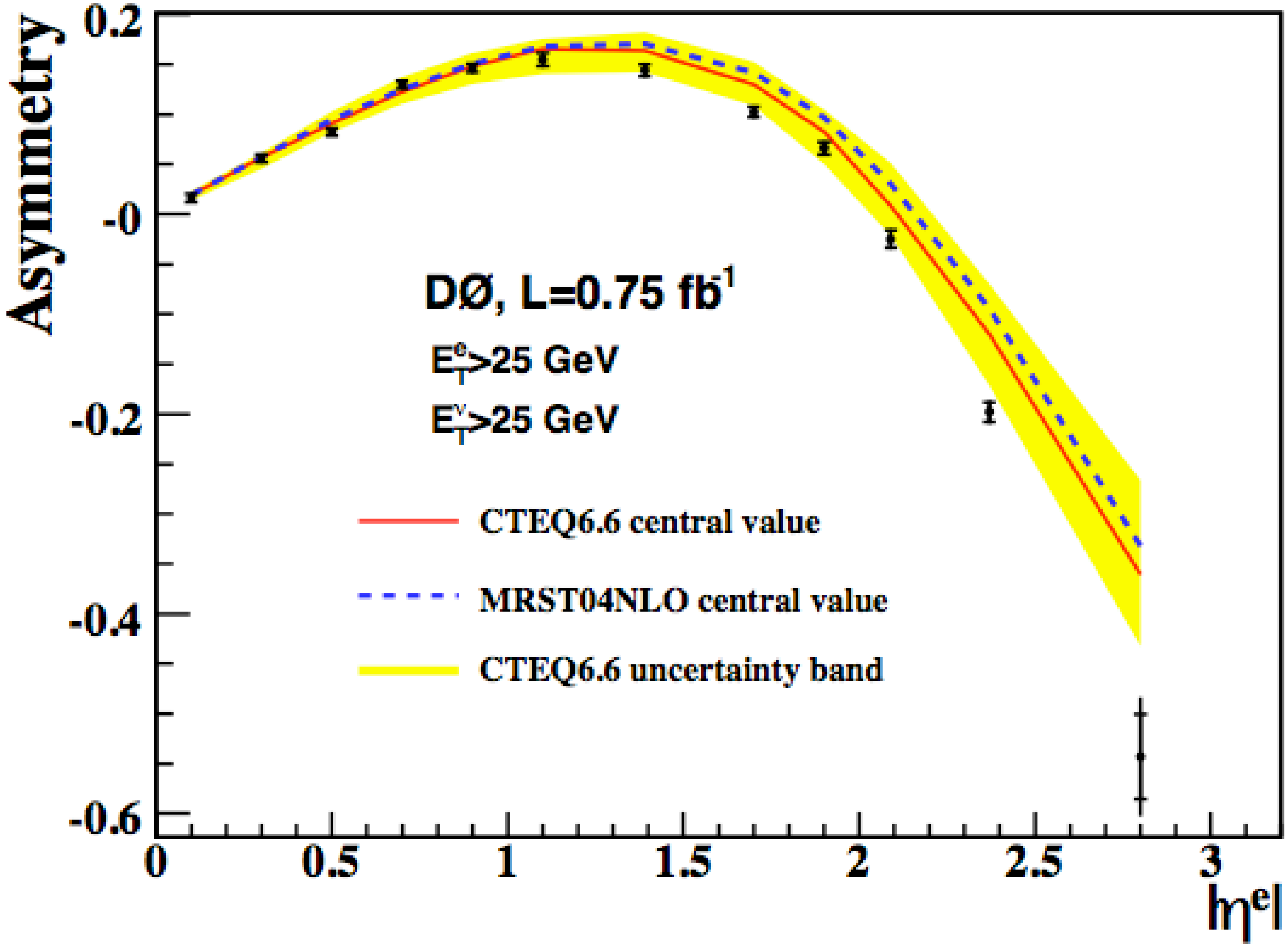


- From CP invariance: A(y)=-A(-y)
- Fold data to increase statistics.

- ResBos+PHOTOS
- CTEQ6.6 NLO PDFs
  - P.M. Nadolsky et al., Phys. Rev. D78 013004(2008)
- MRST2004
  - A.D. Martin, R.G Roberts, W.J. Stirling, and R.S. Thorne Phys. Lett. B604, 61(2004)
- PDF uncertainties:

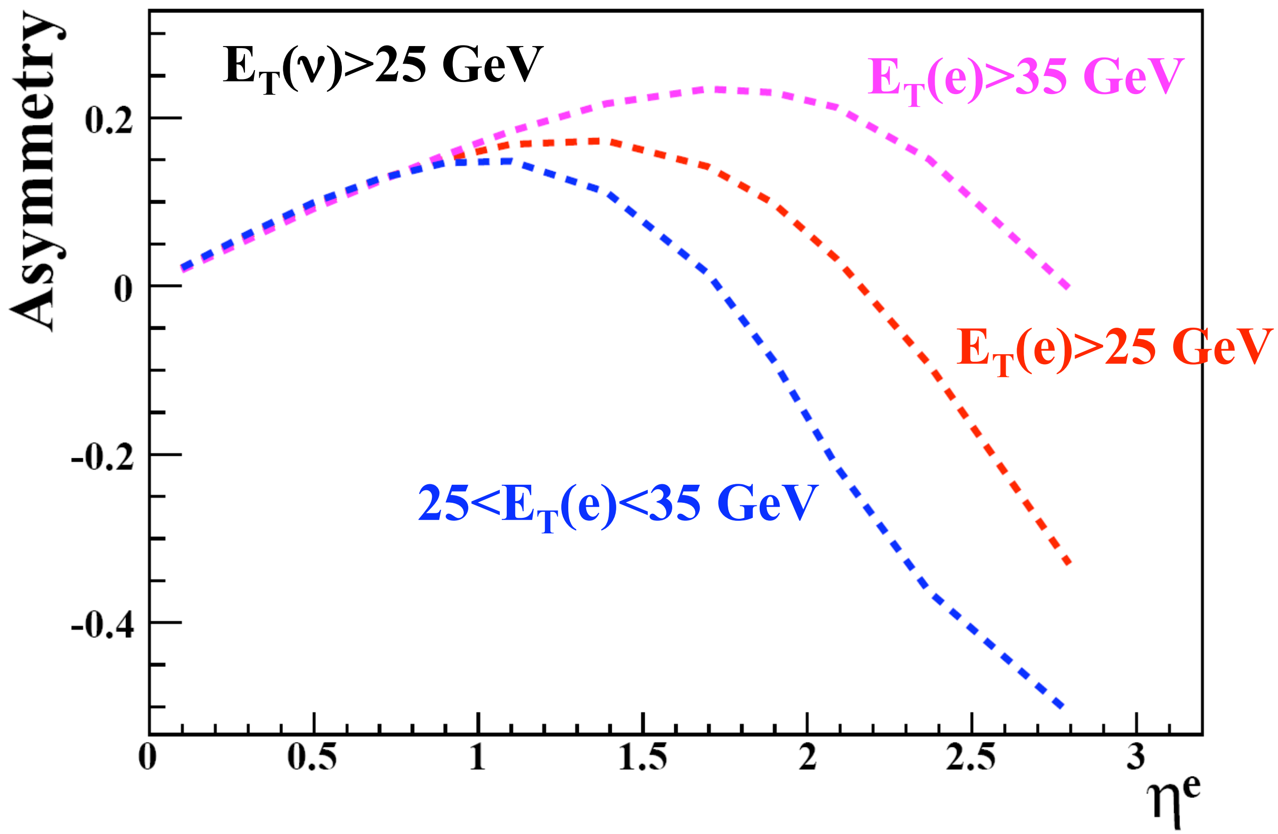
$$\Delta A^{\pm} = \sqrt{\sum_{i=1}^{n} [A(a_i^{\pm}) - A_0]^2}$$

Folded asymmetry E_T>25



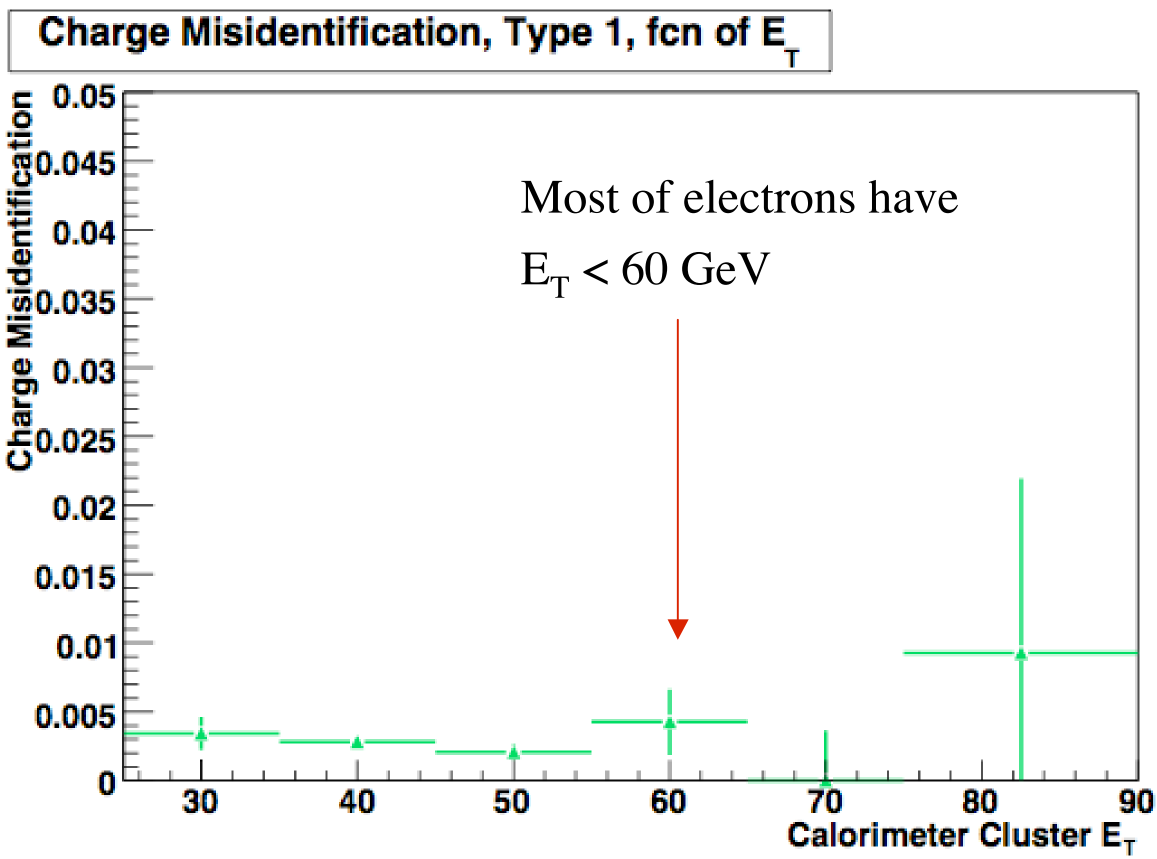
Electron E_T bins

- For a given η(e), different E_T regions probe different ranges of y_W.
- Allows finer probe of the x dependence.

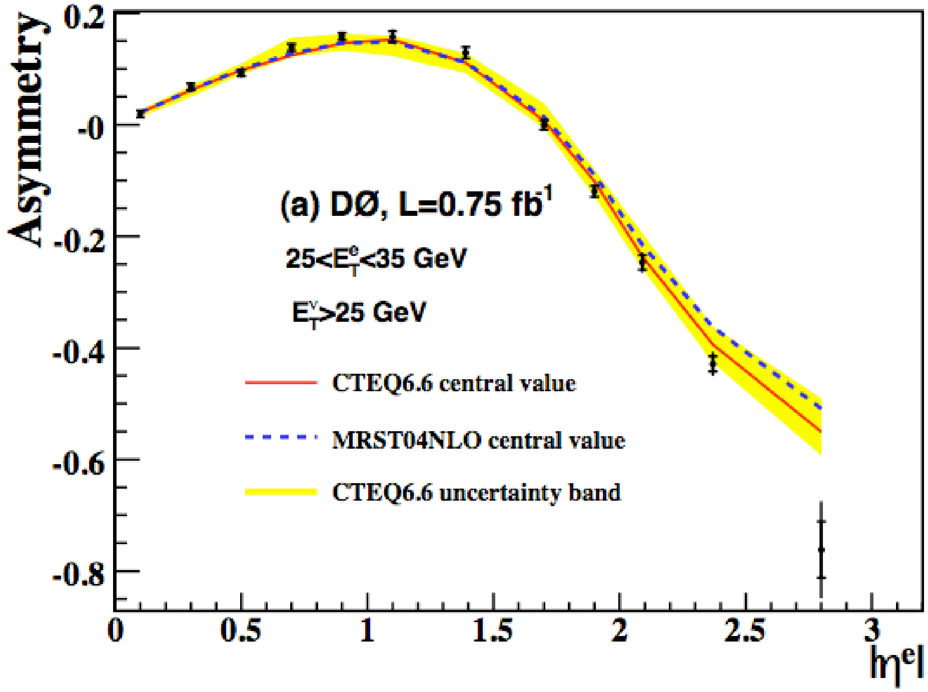


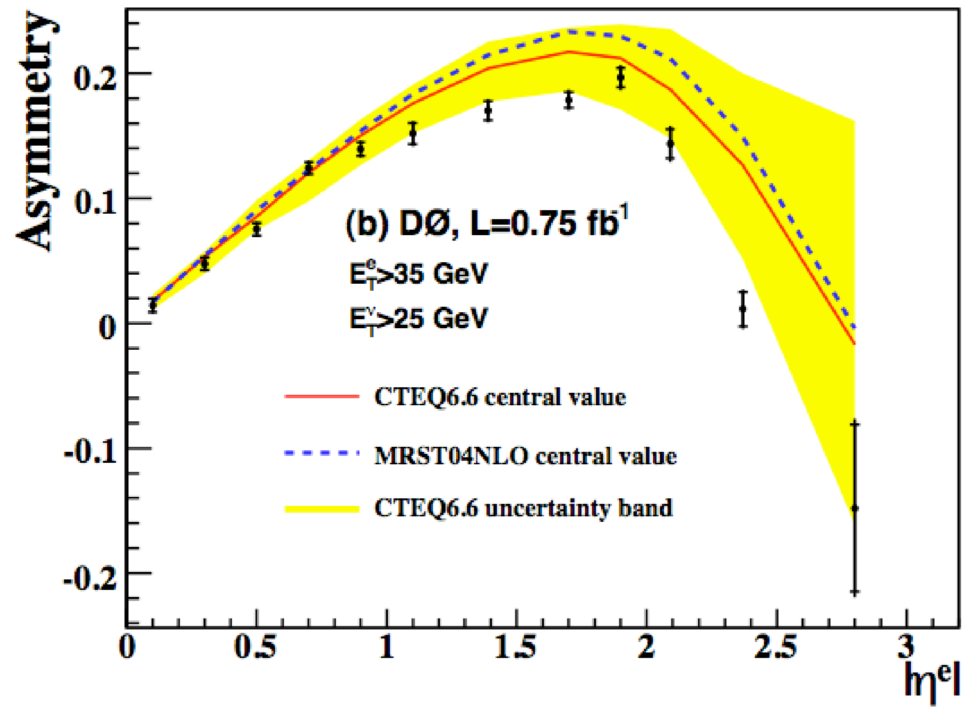
E_T bins

- Each step of the analyses was done separately for E_T bins.
- No significant E_T dependence for charge misid.

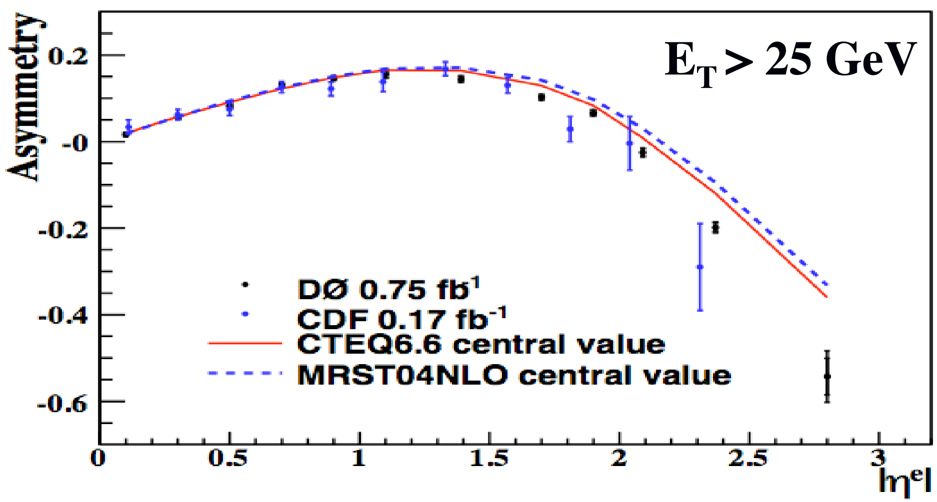


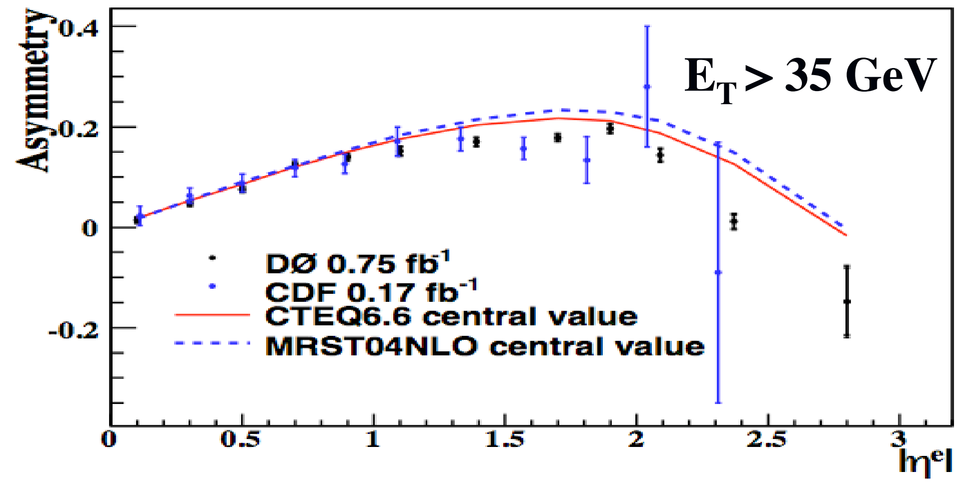
Folded asymmetries for $25<E_T<35$ and $E_T>35$

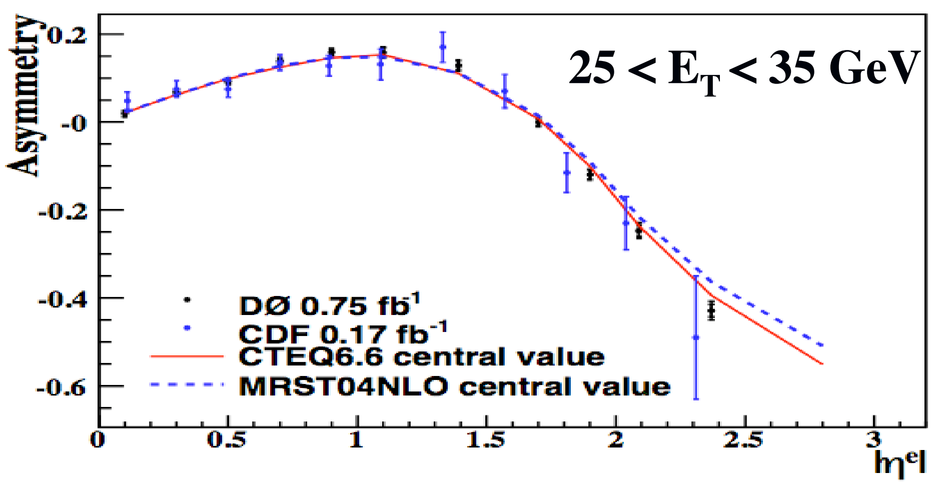




Comparison to CDF





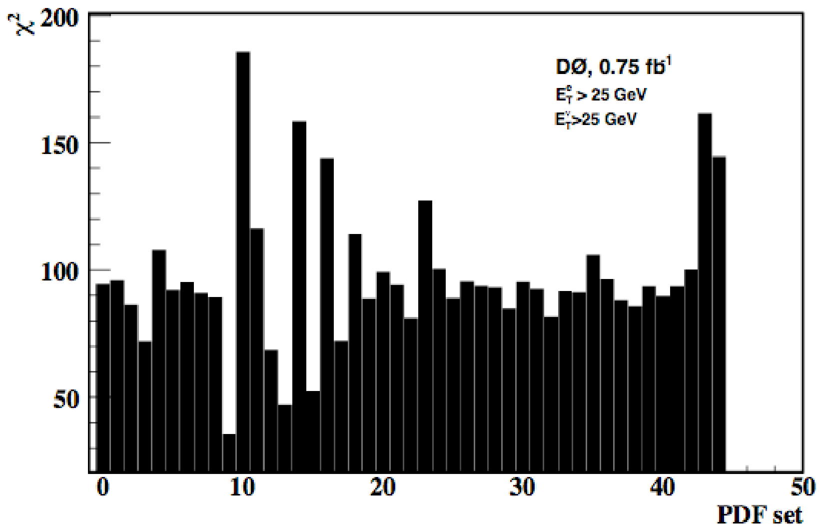


- CDF and DØ agree within their uncertainties.
- Both CDF and DØ indicate a larger asymmetry than predicted in the high |η| region.

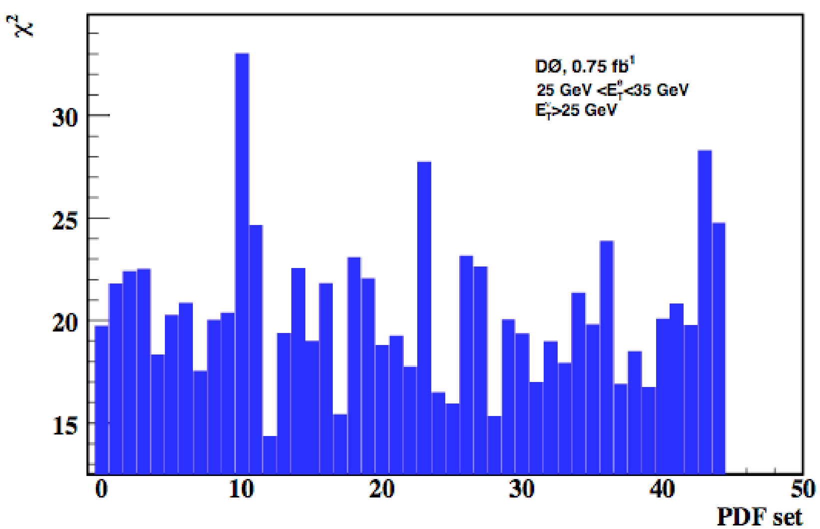
CDF: D. Acosta et al., Phys. Rev. D71, 051104 (R)(2005)

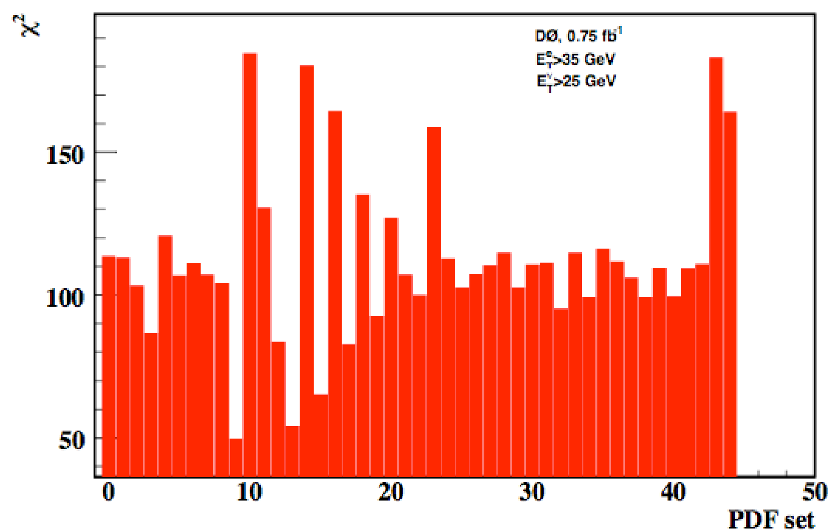
DØ : arXiv:0807.3367 submitted to PRL

Chi^2 vs each PDF set



12 bins in each plot





Conclusions

- We measured $W \rightarrow e\nu$ charge asymmetry using ~750pb^{-1} data.
- Extended electron η coverage to 3.2.
- The measured asymmetry uncertainties are smaller than CTEQ6.6 PDF uncertainties for most bins.
- Inclusion of our results will further constrain future fits and improve predictions.

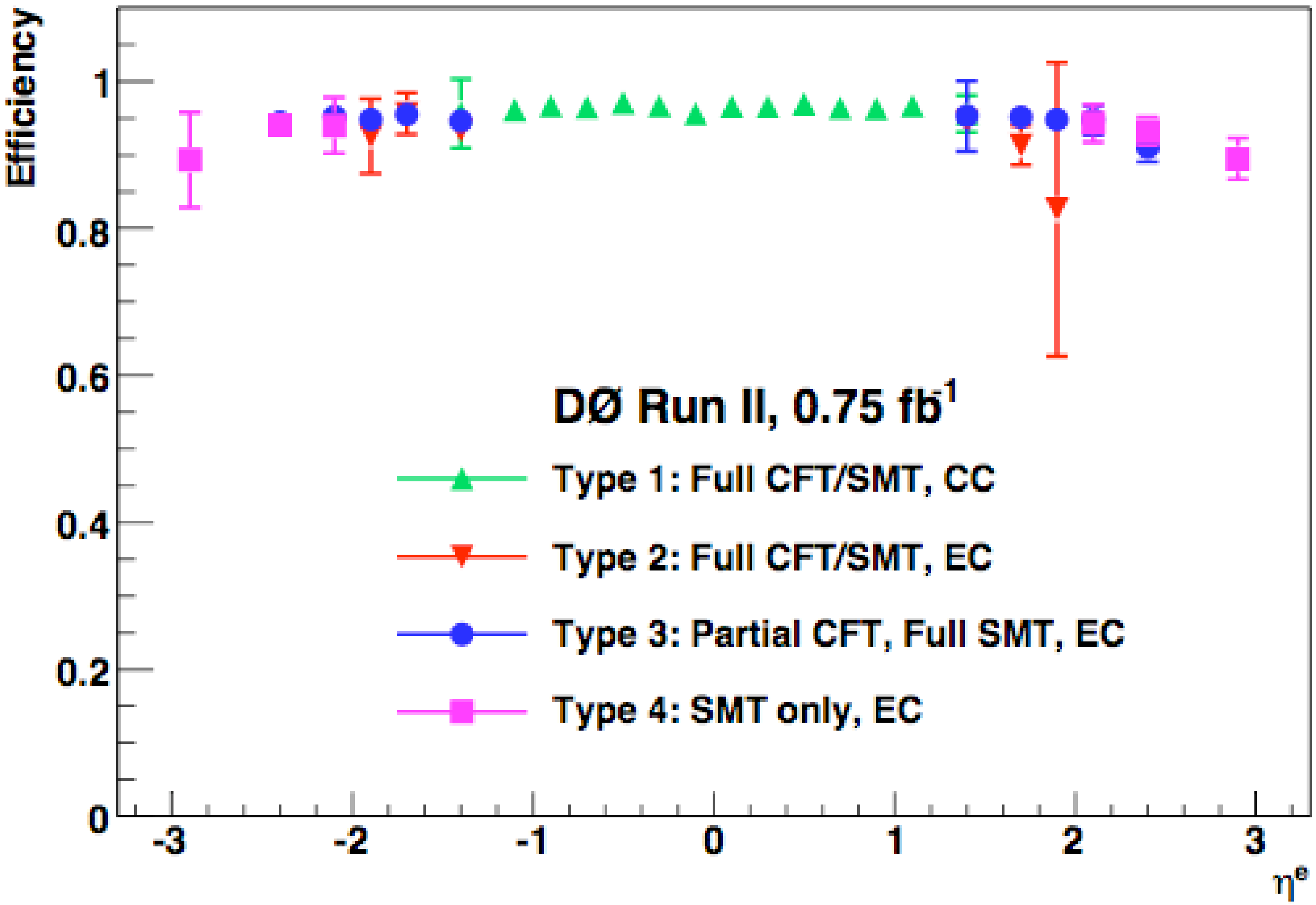
Backups

Final table

η^e region	$\langle\lvert\eta^e\rvert\rangle$	$A(\lvert\eta^e\rvert)$					
		$E_T > 25$ GeV		$25 < E_T < 35$ GeV		$E_T > 35$ GeV	
		Data	CTEQ6.6	Data	CTEQ6.6	Data	CTEQ6.6
$0.0 - 0.2$	0.10	$1.6 \pm 0.4 \pm 0.3$	$1.9^{+0.4}_{-0.5}$	$1.9 \pm 0.6 \pm 0.5$	$2.1^{+0.5}_{-0.8}$	$1.4 \pm 0.5 \pm 0.4$	$1.8^{+0.5}_{-0.7}$
$0.2 - 0.4$	0.30	$5.6 \pm 0.4 \pm 0.3$	$5.7^{+0.4}_{-1.2}$	$6.8 \pm 0.6 \pm 0.5$	$6.2^{+0.8}_{-1.3}$	$4.8 \pm 0.5 \pm 0.4$	$5.3^{+0.5}_{-1.3}$
$0.4 - 0.6$	0.50	$8.2 \pm 0.4 \pm 0.3$	$9.1^{+1.2}_{-0.9}$	$9.3 \pm 0.6 \pm 0.5$	$9.8^{+1.2}_{-0.8}$	$7.5 \pm 0.5 \pm 0.4$	$8.5^{+1.3}_{-1.1}$
$0.6 - 0.8$	0.70	$13.0 \pm 0.4 \pm 0.3$	$12.2^{+1.5}_{-1.2}$	$13.8 \pm 0.6 \pm 0.5$	$12.4^{+3.1}_{-0.3}$	$12.4 \pm 0.5 \pm 0.4$	$12.1^{+1.0}_{-2.3}$
$0.8 - 1.0$	0.90	$14.6 \pm 0.4 \pm 0.3$	$14.8^{+1.3}_{-1.8}$	$15.8 \pm 0.7 \pm 0.6$	$14.6^{+1.7}_{-1.3}$	$13.9 \pm 0.5 \pm 0.4$	$15.0^{+1.3}_{-2.4}$
$1.0 - 1.2$	1.10	$15.5 \pm 0.6 \pm 0.5$	$16.6^{+1.0}_{-2.5}$	$15.8 \pm 1.0 \pm 0.8$	$15.2^{+0.7}_{-3.0}$	$15.2 \pm 0.8 \pm 0.6$	$17.6^{+1.5}_{-2.4}$
$1.2 - 1.6$	1.39	$14.4 \pm 0.6 \pm 0.5$	$16.4^{+1.8}_{-2.2}$	$12.9 \pm 1.0 \pm 0.8$	$11.1^{+1.8}_{-1.8}$	$17.0 \pm 0.8 \pm 0.6$	$20.4^{+2.2}_{-2.6}$
$1.6 - 1.8$	1.70	$10.2 \pm 0.5 \pm 0.4$	$13.0^{+2.3}_{-2.2}$	$-0.1 \pm 0.8 \pm 0.6$	$0.7^{+3.2}_{-1.3}$	$17.9 \pm 0.6 \pm 0.6$	$21.7^{+2.0}_{-3.1}$
$1.8 - 2.0$	1.90	$6.6 \pm 0.6 \pm 0.5$	$8.3^{+2.2}_{-3.3}$	$-12.0 \pm 1.0 \pm 0.8$	$-10.1^{+2.2}_{-2.7}$	$19.7 \pm 0.8 \pm 0.7$	$21.2^{+2.7}_{-4.1}$
$2.0 - 2.2$	2.09	$-2.5 \pm 0.9 \pm 0.6$	$0.9^{+4.3}_{-3.0}$	$-24.7 \pm 1.3 \pm 1.2$	$-23.6^{+4.1}_{-2.2}$	$14.4 \pm 1.2 \pm 0.9$	$18.7^{+4.8}_{-3.9}$
$2.2 - 2.6$	2.37	$-19.8 \pm 1.0 \pm 0.7$	$-12.0^{+5.1}_{-5.1}$	$-42.9 \pm 1.4 \pm 1.6$	$-39.4^{+3.2}_{-3.3}$	$1.1 \pm 1.4 \pm 0.7$	$12.6^{+7.4}_{-7.5}$
$2.6 - 3.2$	2.80	$-54.3 \pm 4.2 \pm 4.2$	$-36.1^{+9.4}_{-7.2}$	$-76.2 \pm 5.0 \pm 7.1$	$-55.1^{+6.0}_{-4.3}$	$-14.8 \pm 6.7 \pm 2.6$	$-1.7^{+17.9}_{-14.4}$

TABLE I: Folded charge asymmetry for data and CTEQ6.6 predictions tabulated in percent. For data, the first uncertainty is statistical and the second is systematic. For CTEQ6.6 predictions, the first one is for ΔA^+ and the second one is for ΔA^-.

Efficiencies



Em-like jet id probability