Measurement of the Forward-Backward Charge Asymmetry from W -> e ν Production in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV
hep-ex/0501023

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On the behalf of CDF Collaboration

more information:
http://fcdfwww.fnal.gov/physics/ewk/2004/w_charge_asym/w_charge_asymmetry.html

PDFs significant for many measurements at the Tevatron

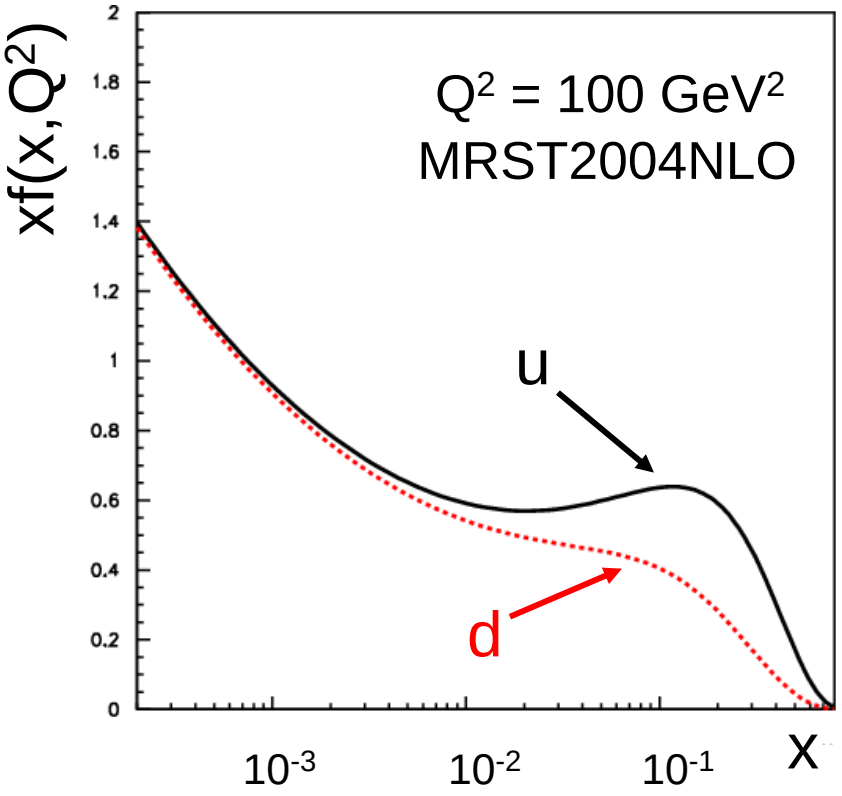
How can we gain insights into parton momentum distribution functions (PDFs) of the proton at the Tevatron???

Measure W Charge Asymmetry

$$A = \frac{d\sigma(W^+)/dy_W - d\sigma(W^-)/dy_W}{d\sigma(W^+)/dy_W + d\sigma(W^-)/dy_W}$$

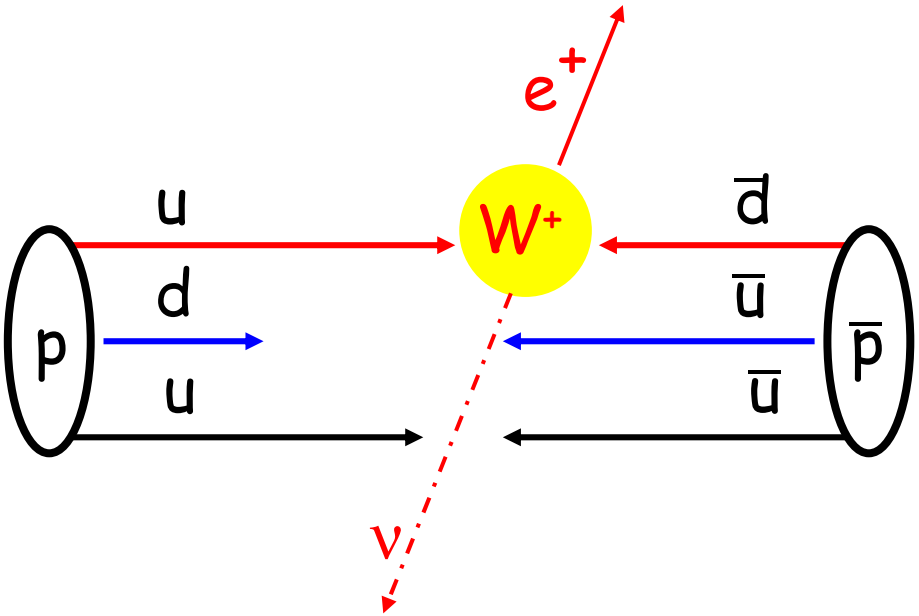
PDFs not well known at high x (high η)
↑Don't already know the answer, need to measure.
Can improve many of our upcoming measurements.

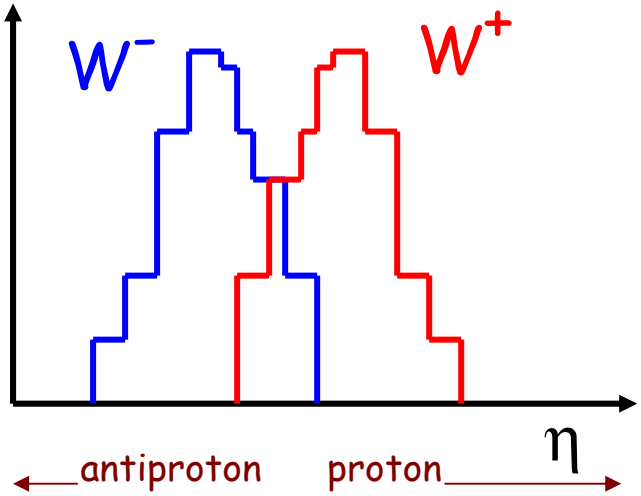
Reason for W Charge Asymmetry?



u quarks carry more momentum than d quarks

Reason for W Charge Asymmetry?





W+ and W- boosted in forward and backward direction;
Information about u(x)/d(x) convoluted in W Asymmetry

Measure Charge Asymmetry of Lepton Channel

Asymmetry in W production complicated by unknown ν p_z

use lepton asymmetry:

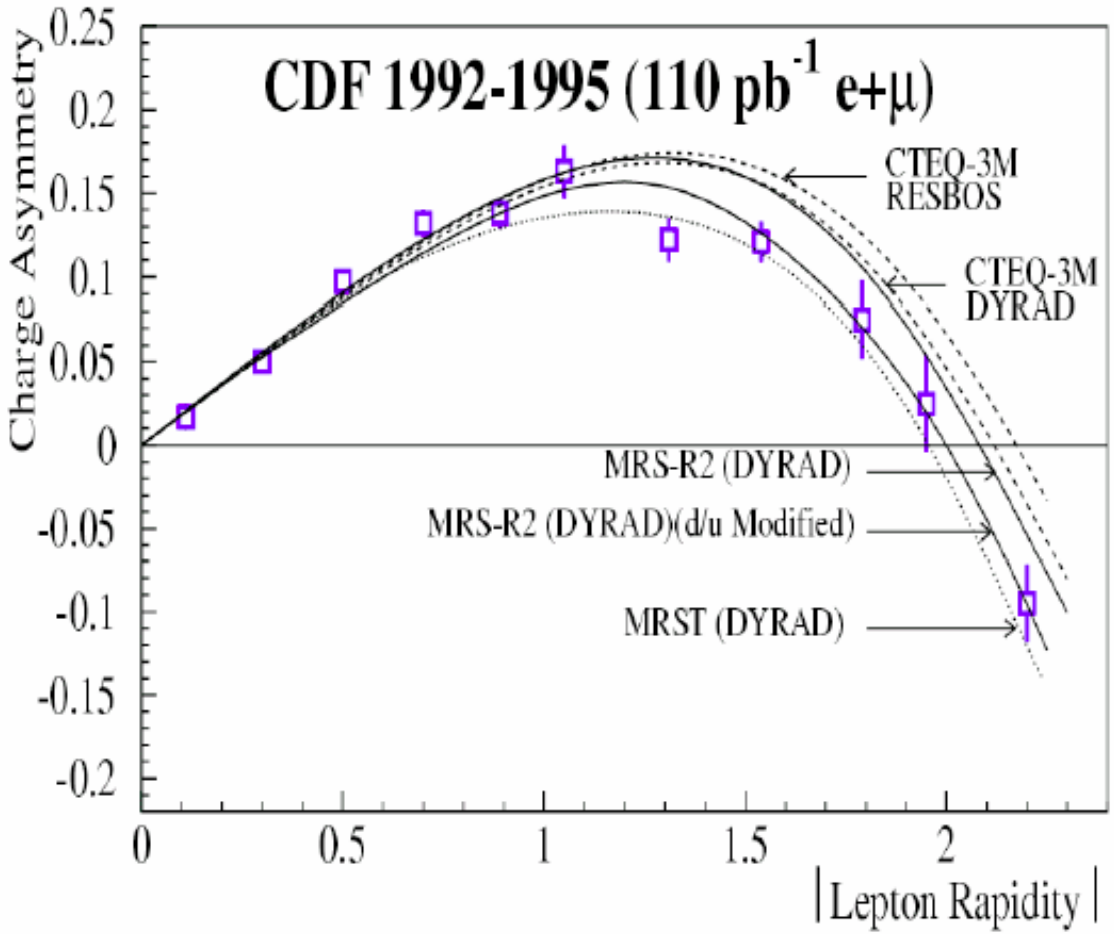
$$A_l(\eta) = \frac{d\sigma(e^+)/d\eta - d\sigma(e^-)/d\eta}{d\sigma(e^+)/d\eta + d\sigma(e^-)/d\eta} \simeq \frac{\mathrm{d}(x)}{\mathrm{u}(x)}$$

which convolves W production with V-A decay.

sensitive to PDF's !

uncertainty on PDF's significant error in several measurements at CDF !

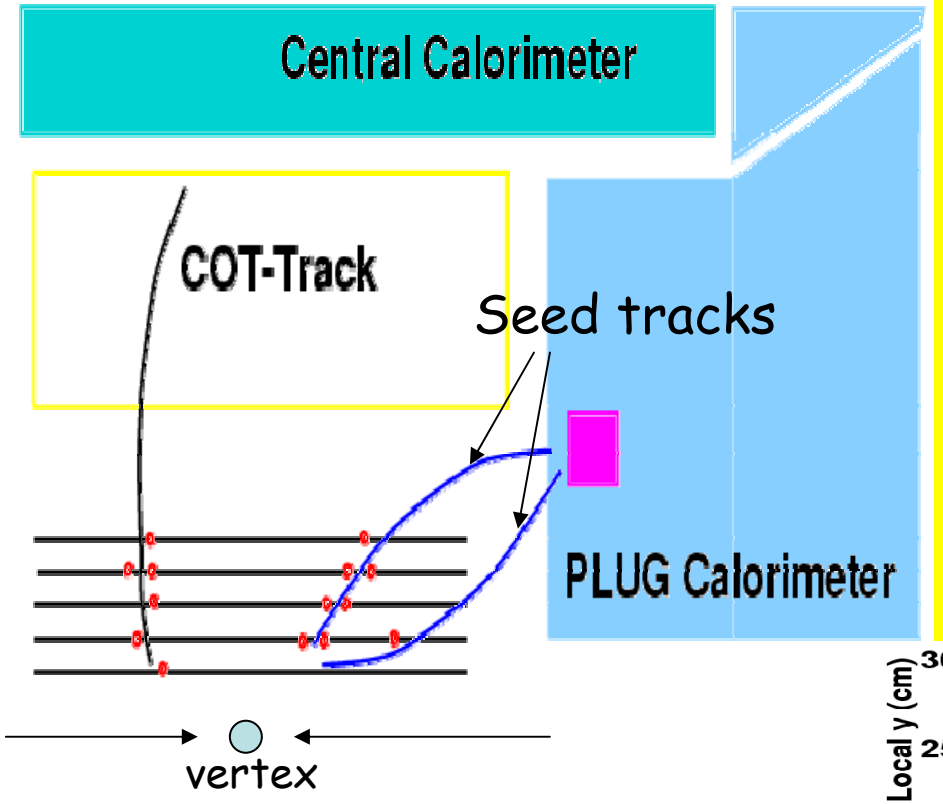
CDF Run1 Result



Measurement at large η has high impact on PDF fits

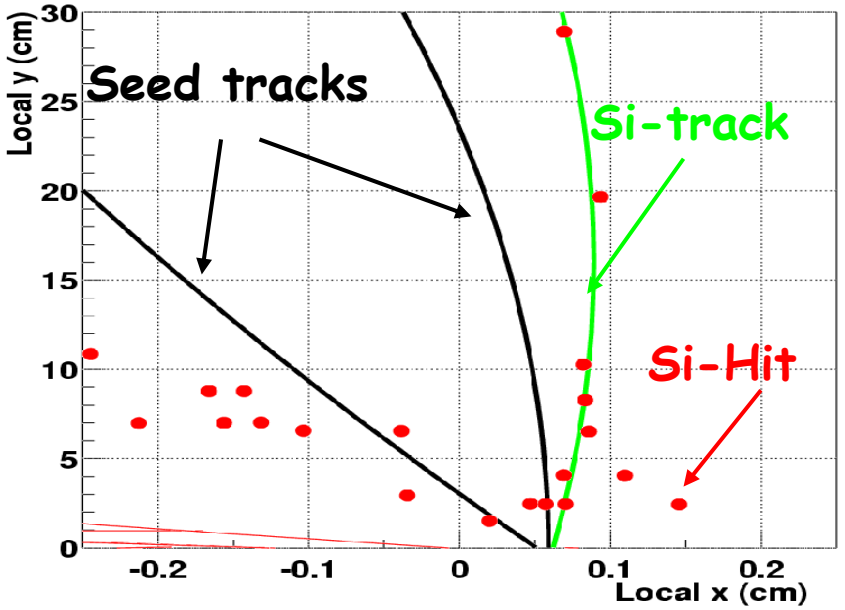
Forward Tracking and Charge ID is the key!!

Calorimeter Seeded OI Si-Tracking (PHX)



1) Reconstruction of Seed Track with
   - Calorimeter cluster position
   - Event vertex
   - Calorimeter cluster E_T
2) Reconstruction of Si-Tracks
   - Using same algorithm as the COT OI Si-Tracking to attach Si hits.

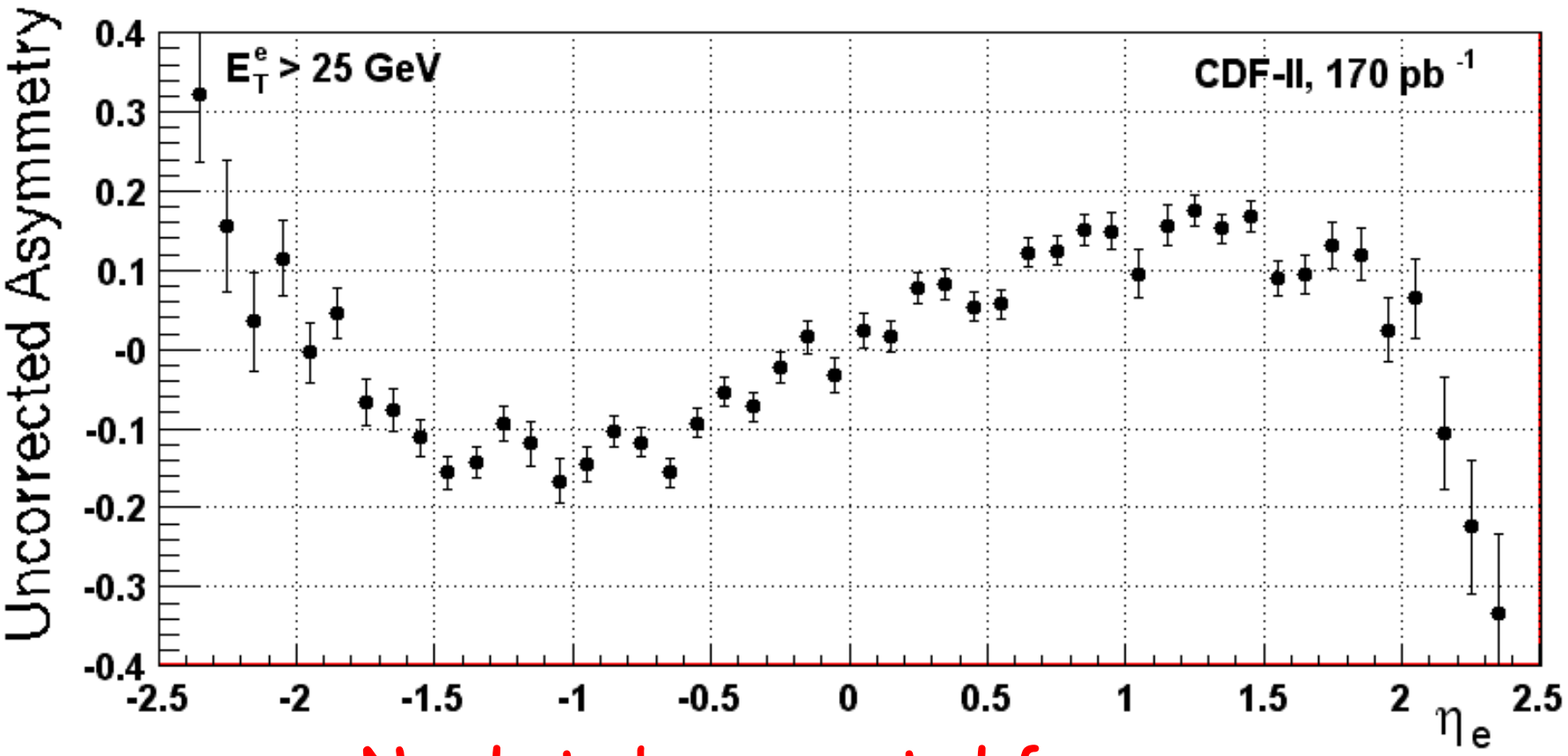
Forward Tracking outside COT



W Event Selection

- Baseline electron selection
- PHX track optimized for good charge identification:
  - #hits $\geq$ 4
  - $\chi^2 < 8$
  - $\Delta\chi^2 > 0.5$
  - Pull Ratio $\equiv \frac{\chi^2_{seed}/dof \text{ for track with lesser } \chi^2_{total}/dof}{\chi^2_{seed}/dof \text{ for track with greater } \chi^2_{total}/dof} < 0.4$
- $E_T > 25$ GeV
- Missing $E_T > 25$ GeV
- $50 < M_T < 100$ GeV/c^2
- No other EMO with $E_T > 25$ GeV to suppress QCD and DY

Raw, uncorrected Charge Asymmetry



Needs to be corrected for

- background contributions and
- charge misidentification.

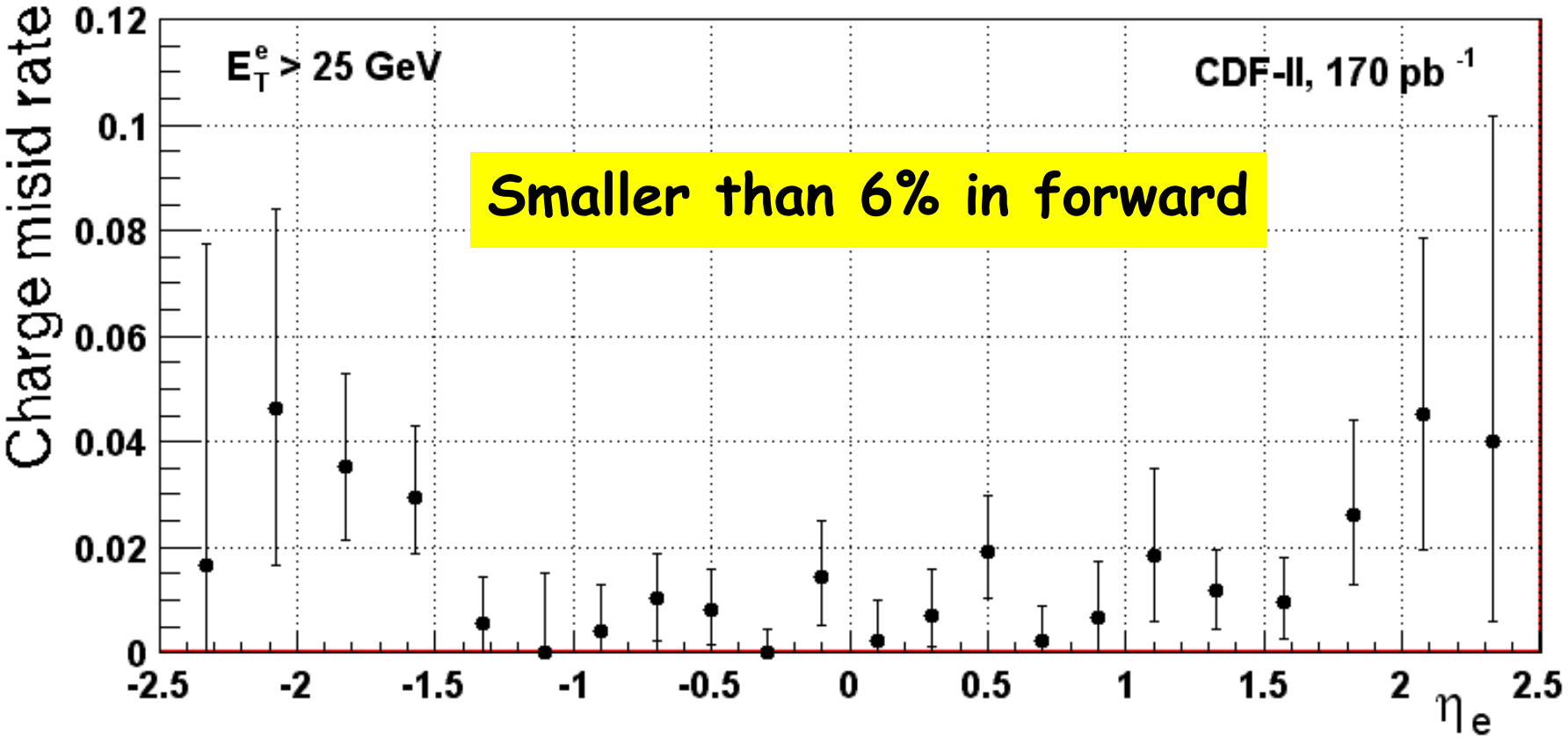
Charge Identification

Incorrectly identified charge dilutes asymmetry.
We can correct for it, if we know f=#wrong/total.

MC does not include residual misalignments.
Must measure it in data as function of η.

Measure f with $Z \rightarrow e^+e^-$.
Use central ($|\eta| < 1.5$) leg to tag charge of other leg.

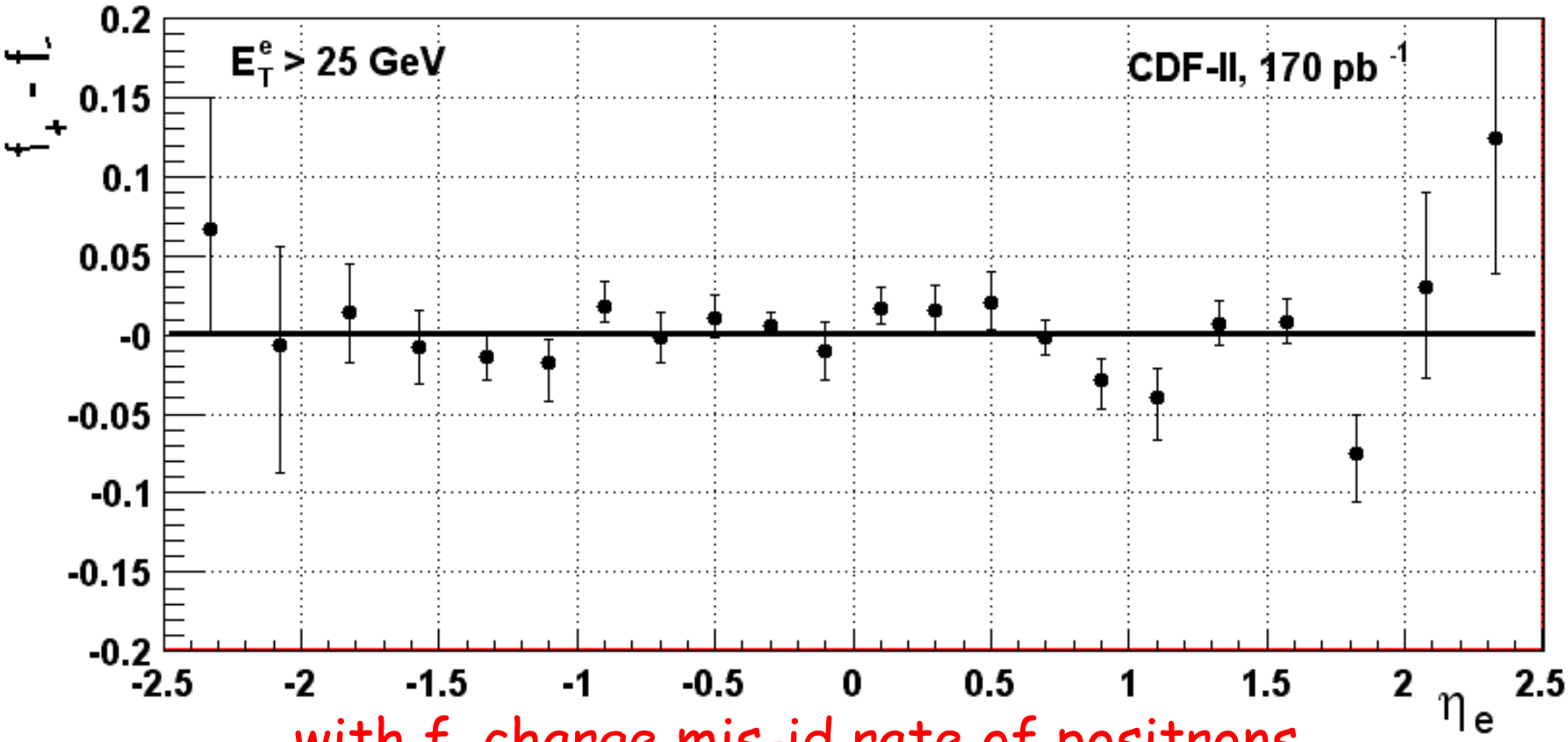
PHX Charge Misidentification Rate



Error calculated with Bayesian prescription

Correction of Raw Asymmetry for Charge MisID

A charge dependence of charge id would directly bias measurement, hence: $A = (A_{raw} + f_+ - f_-) / (1 - f_+ - f_-)$



with f_+ charge mis-id rate of positrons,
f_- charge mis-id rate of electrons

Background Corrections

We correct the asymmetry in each η bin for backgrounds from

- $W \rightarrow \tau\, \nu \rightarrow e\nu\nu\nu$

  Asymmetric, measured from MC, 4%

- $Z \rightarrow e^+ e^-$

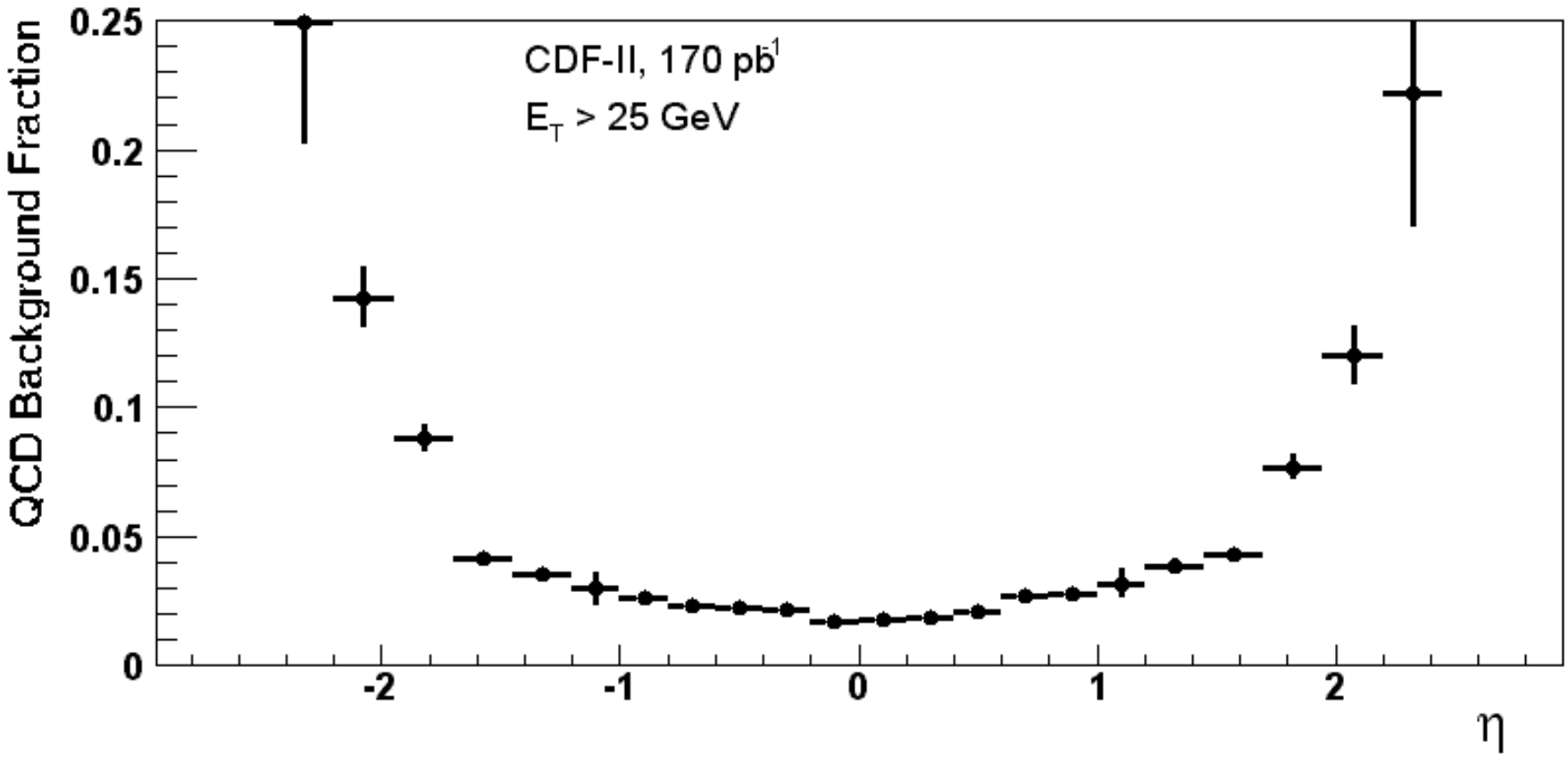
  Asymmetric, measured from MC, 1%

- QCD

  Symmetric, measured from data using Isolation vs MEt.

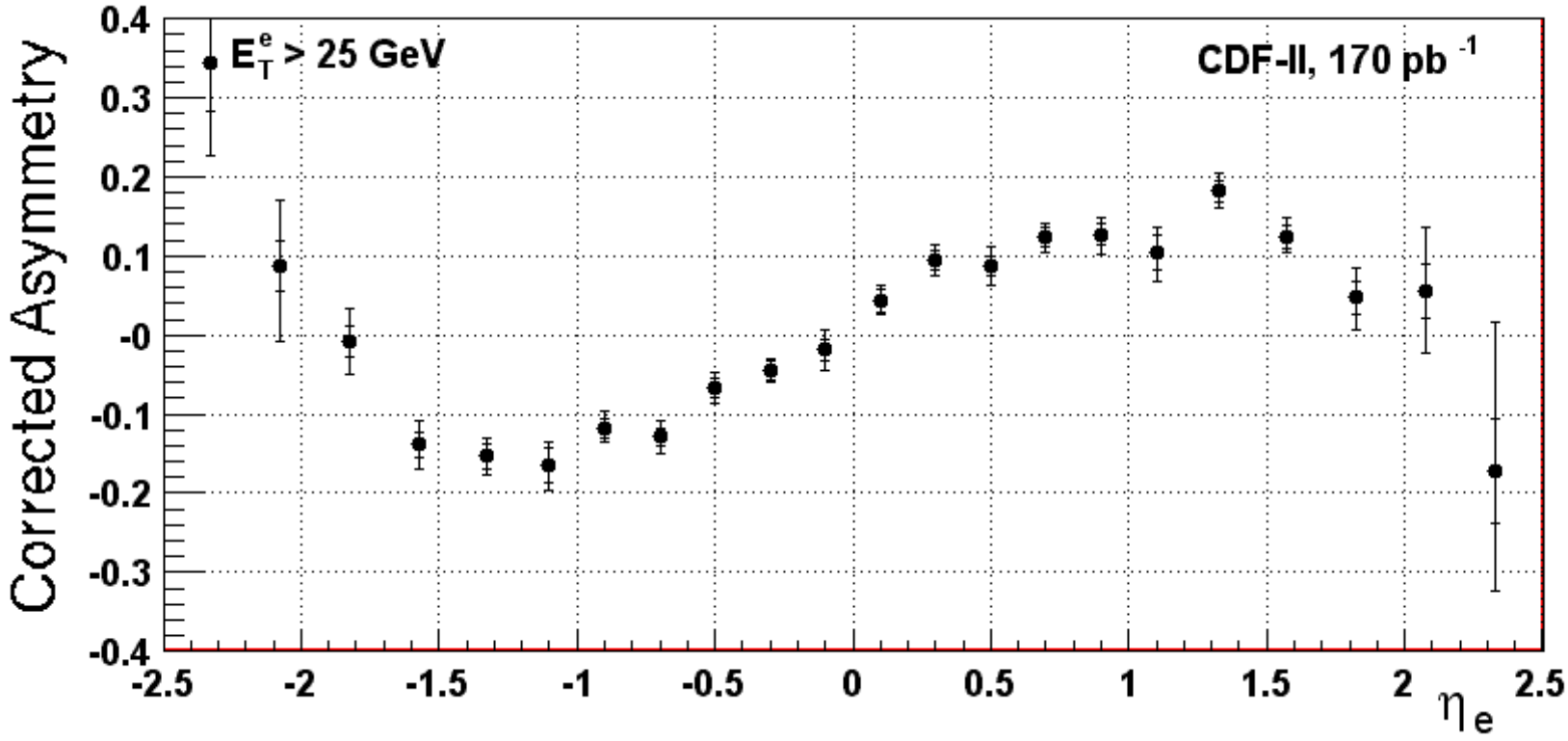
QCD Background (BKG)

upper limit



We use (0.5 ± 0.25)*BKG. Becomes significant for η >1.8

Corrected Asymmetry with stat + total uncertainties



No evidence of CP asymmetry, level of agreement χ^2/dof=9.5/11.
We are using method by R. Barlow, PHYSTAT2003, SLAC, Stanford, California, September 8-11, 2003, for incorporating the asymmetric uncertainties in the error propagation using likelihood distributions.

NEW : E_T Dependence of Asymmetry

For higher E_T electrons, η is closer to y_W.

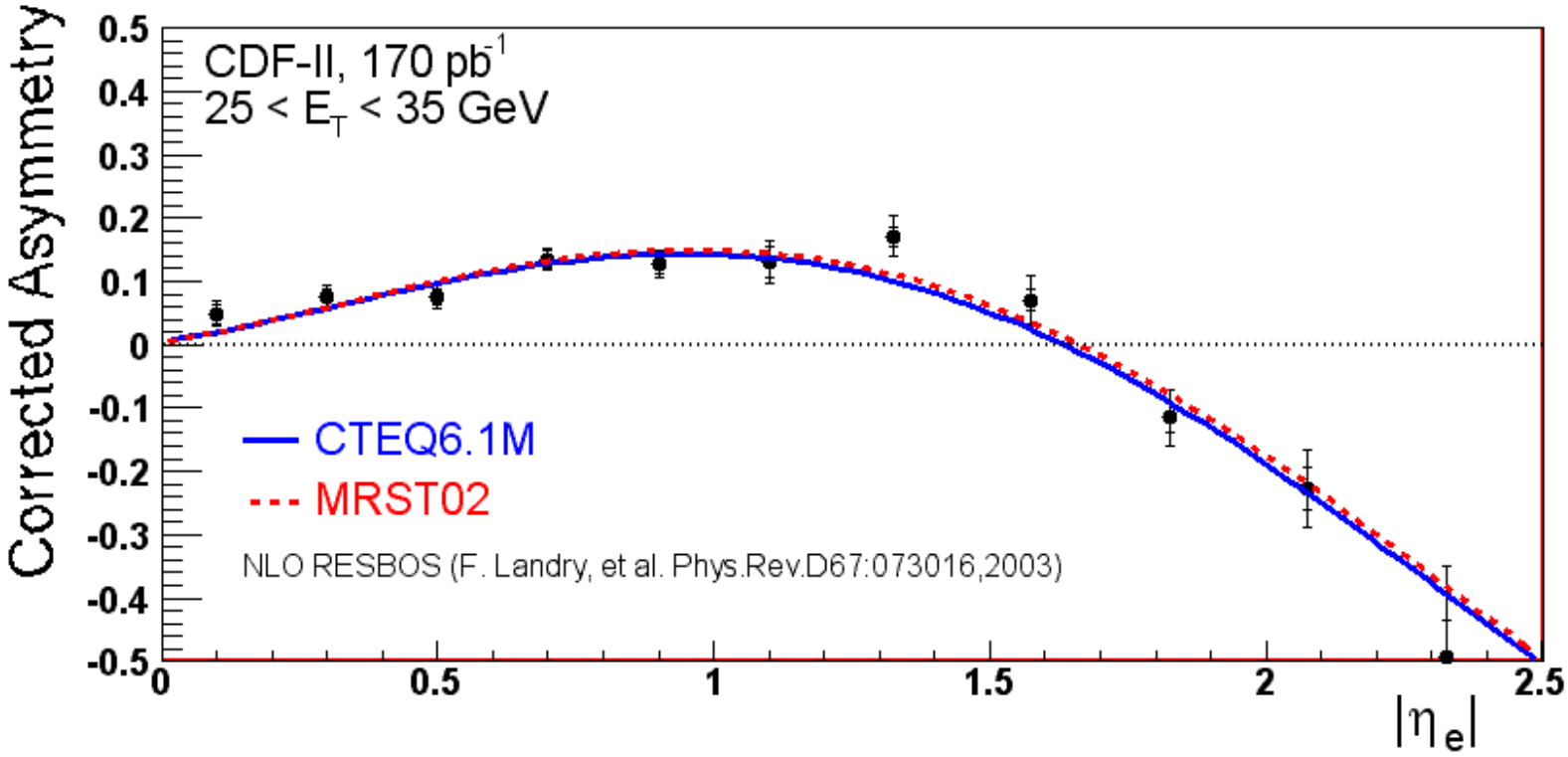
More information can be gained by measuring A in bins of electron E_T.

Current statistics allow use of two E_T bins.

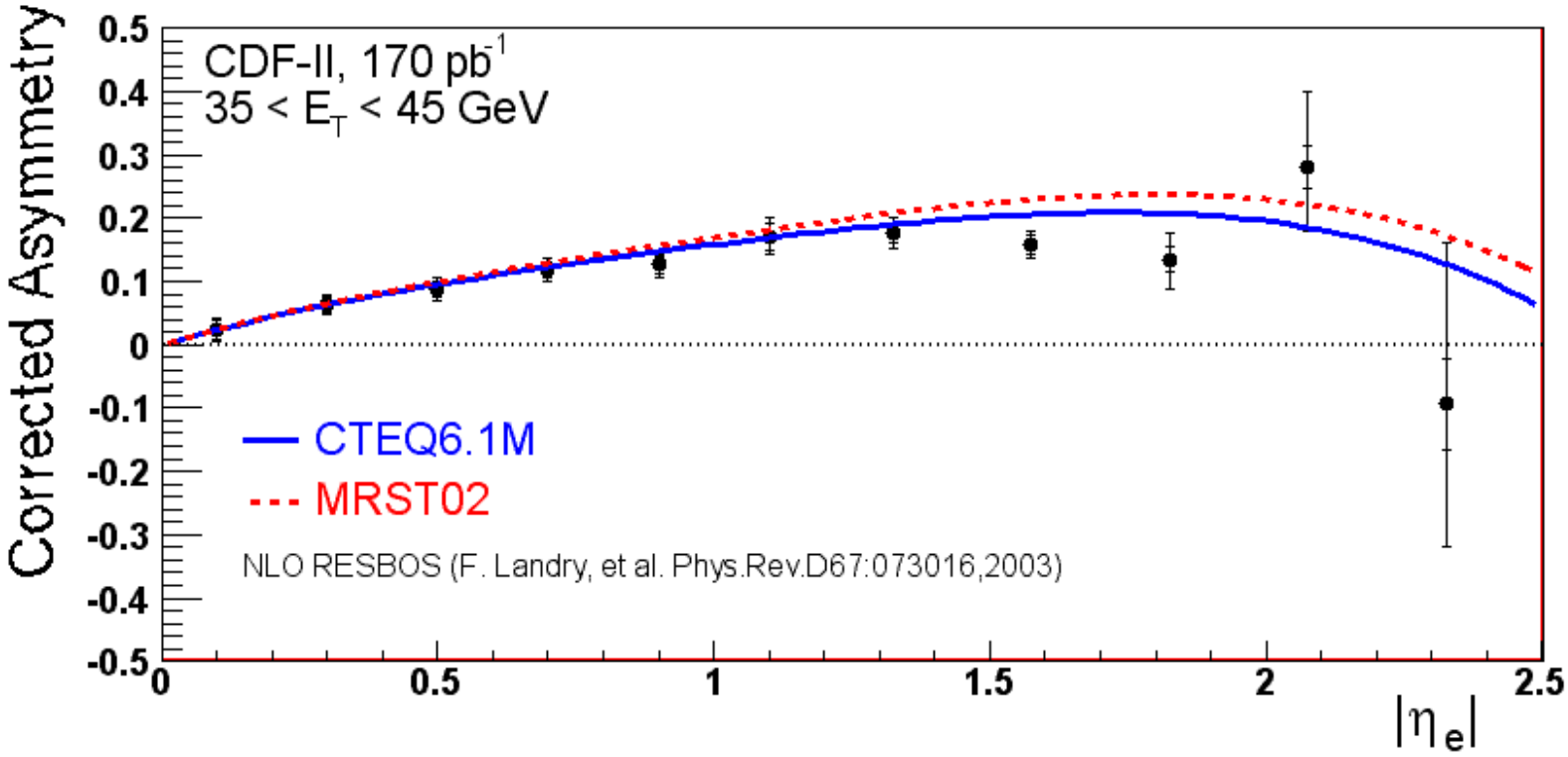
$$25\ GeV < E_T < 35\ GeV$$
$$35\ GeV < E_T < 45\ GeV$$

Results for 25 GeV < E_T < 35 GeV

Corrections for charge mis-id and backgrounds are measured and applied for each E_T bin.



Results for 35 GeV < E_T < 45 GeV



χ^2 probabilities are 11% for CTEQ and 0.6% for MRST

Inclusion of our results will further constrain fits and improve predictions.

Outlook & Conclusion

- Results will be included into new PDF fits.
- CDF is beginning to explore a new method which fully reconstructs the W direction, see talk of Boyoung Han at APS 2005.

- CDF Run2 W Charge Asymmetry measurement provides new PDF constraints, particularly when separated by E_T range.
- Measured Asymmetry for the first time in different E_T bins.

Backup Slides

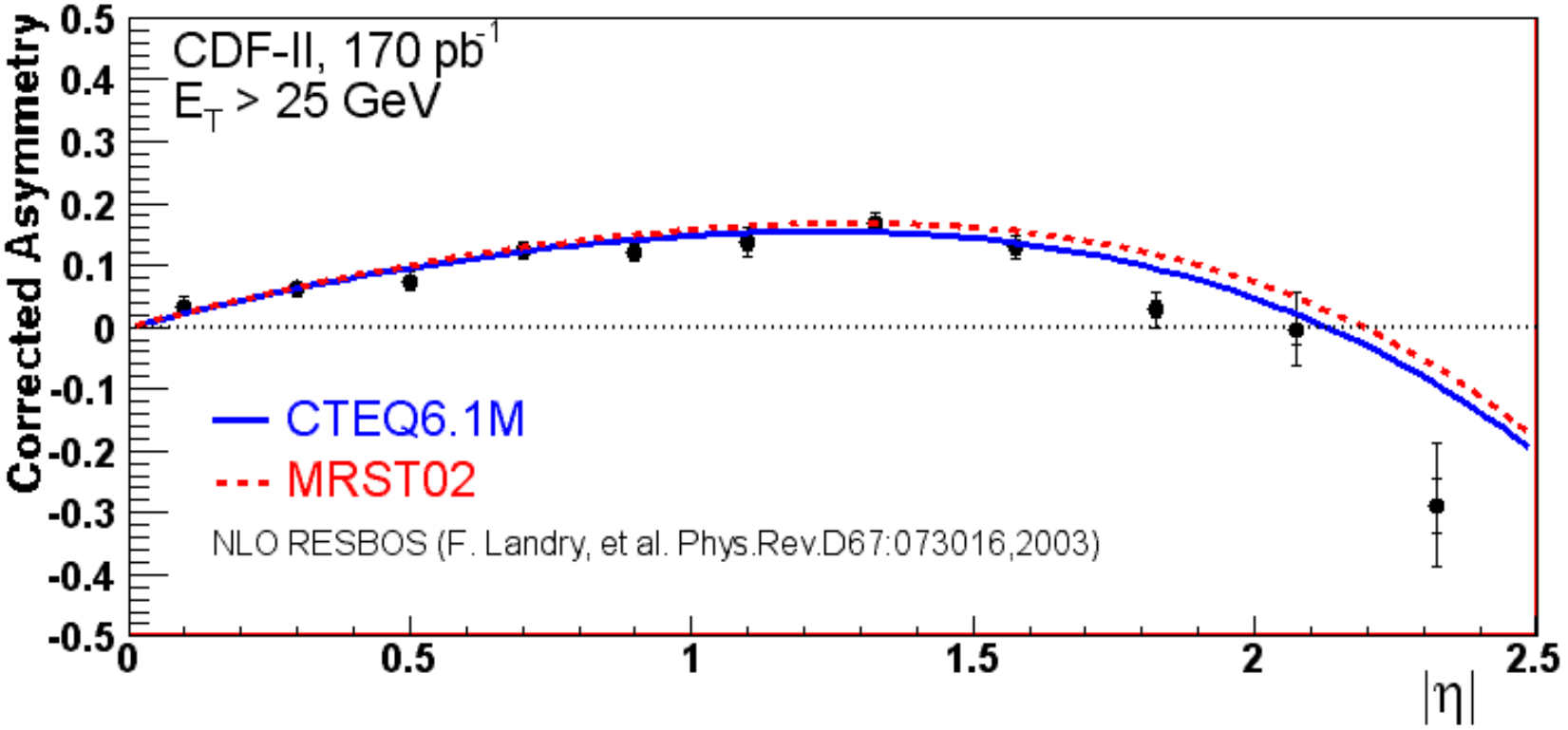
Systematic

- Statistical uncertainty on charge mis-id rate dominates
- Uncertainty from QCD jet background is small and other backgrounds are negligible
- Using COT tracks, when available, results in no significant difference
- Checked that variation of detector alignments within their uncertainty has no significant effect on asymmetry
- No difference between asymmetry in the EAST and WEST
- Studied possible biases introduced by detector effects in the MC and found no significant effects.

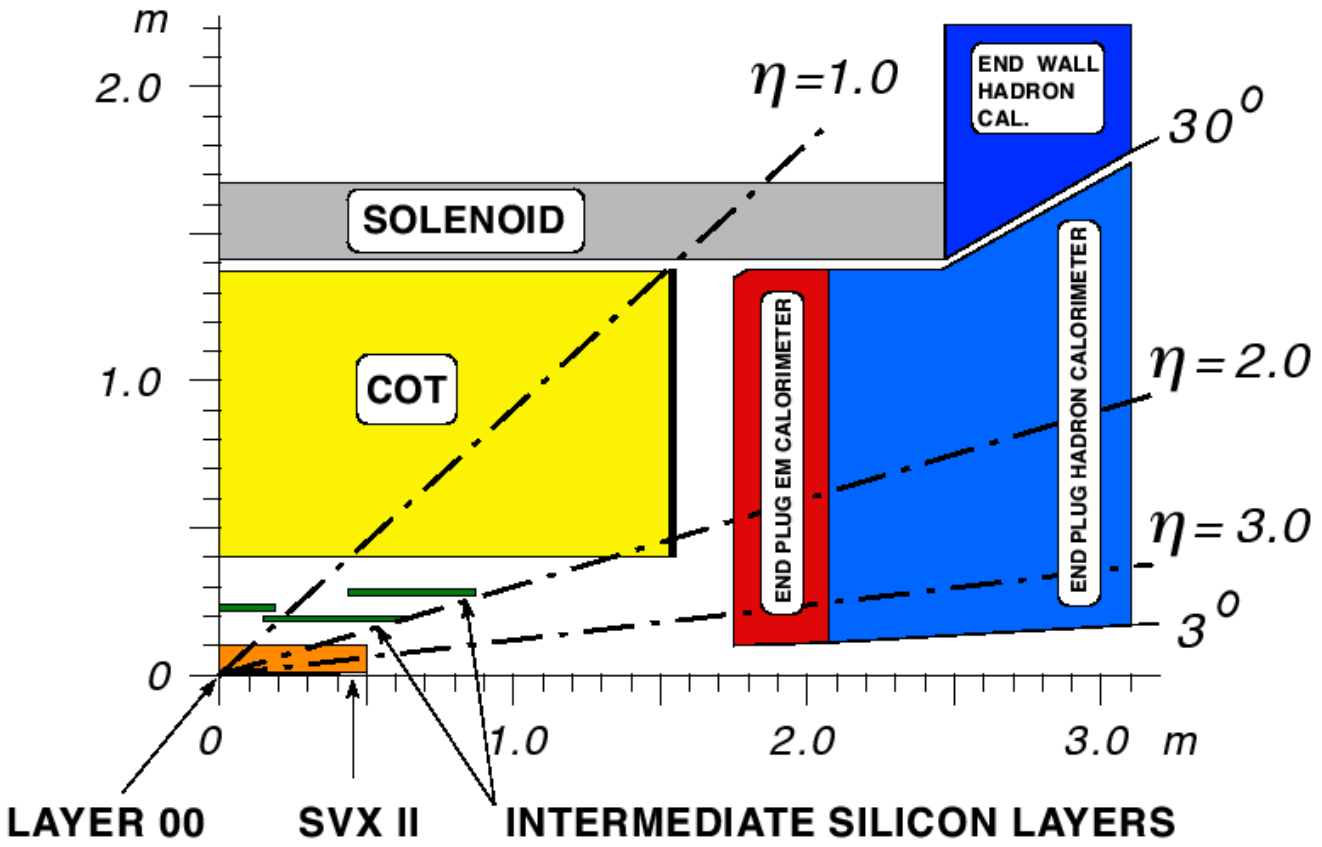
Results: W Charge Asymmetry w. total error

$\lvert\eta_e\rvert$	$A(\lvert\eta_e\rvert)$		
	$E_T > 25$	$25 < E_T < 35$	$35 < E_T < 45$
0.11	$3.4\ ^{+1.6}_{-1.5}$	4.8 ± 2.0	2.3 ± 1.9
0.30	6.2 ± 1.2	7.5 ± 1.9	6.3 ± 1.5
0.50	7.5 ± 1.5	7.5 ± 1.9	8.8 ± 1.8
0.70	12.6 ± 1.3	13.5 ± 1.8	11.8 ± 1.7
0.89	$12.2\ ^{+1.6}_{-1.4}$	12.8 ± 2.3	$12.6\ ^{+1.7}_{-1.9}$
1.09	13.8 ± 2.3	13.1 ± 3.5	17.1 ± 2.9
1.33	16.8 ± 1.6	$17.0\ ^{+3.4}_{-3.0}$	17.6 ± 2.4
1.57	13.0 ± 1.8	$7.0\ ^{+3.8}_{-3.6}$	15.7 ± 2.2
1.81	2.9 ± 2.9	$-11.5\ ^{+4.2}_{-4.5}$	$13.4\ ^{+4.4}_{-4.6}$
2.04	$-0.4\ ^{+6.2}_{-5.7}$	-23 ± 6	$28\ ^{+12}_{-10}$
2.31	-29 ± 10	-49 ± 14	$-9\ ^{+26}_{-23}$

Corrected W Charge Asymmetry Et>25 GeV

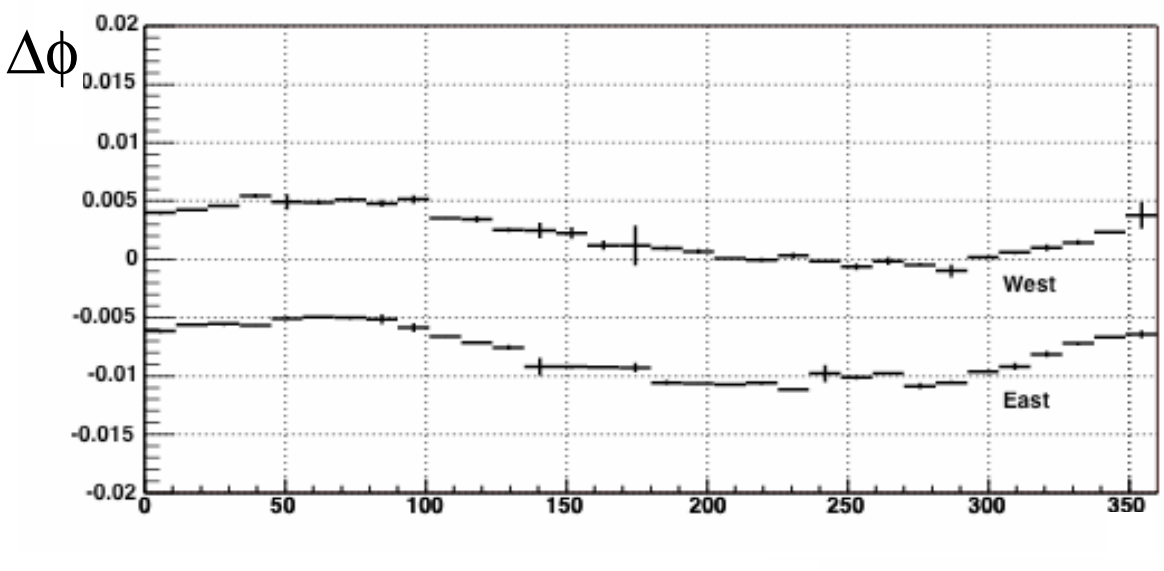


CDF Run 2 Detector



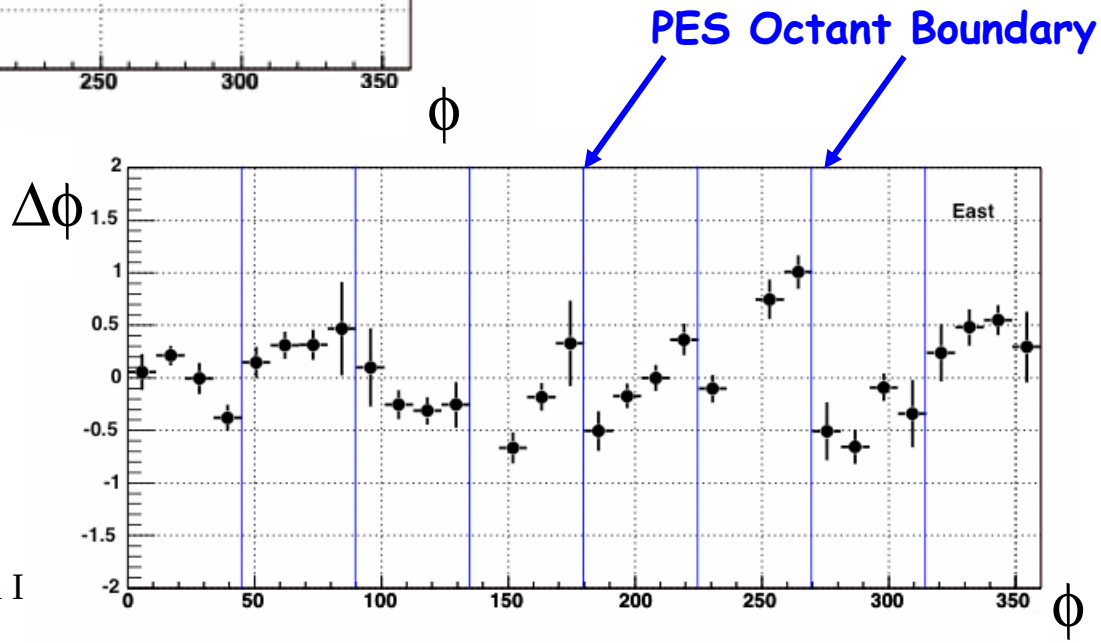
Plug/PES Alignment

Align PLUG calorimeter with COT tracks:
allow offsets in x,y,z and a rotation in phi



global misalignments
2<φ<8mrad;x,y ~3mm

internal misalignments
φ~1mrad, r~1mm



Background Determination Method