Direct measurement of the *W* boson production charge asymmetry at CDF

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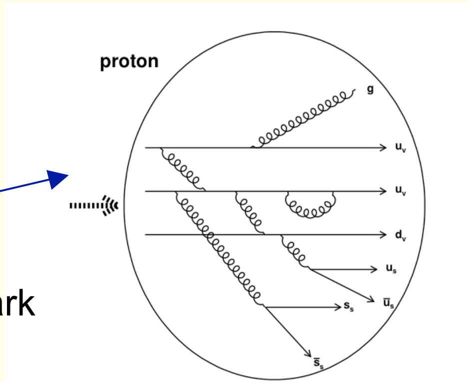
Outline

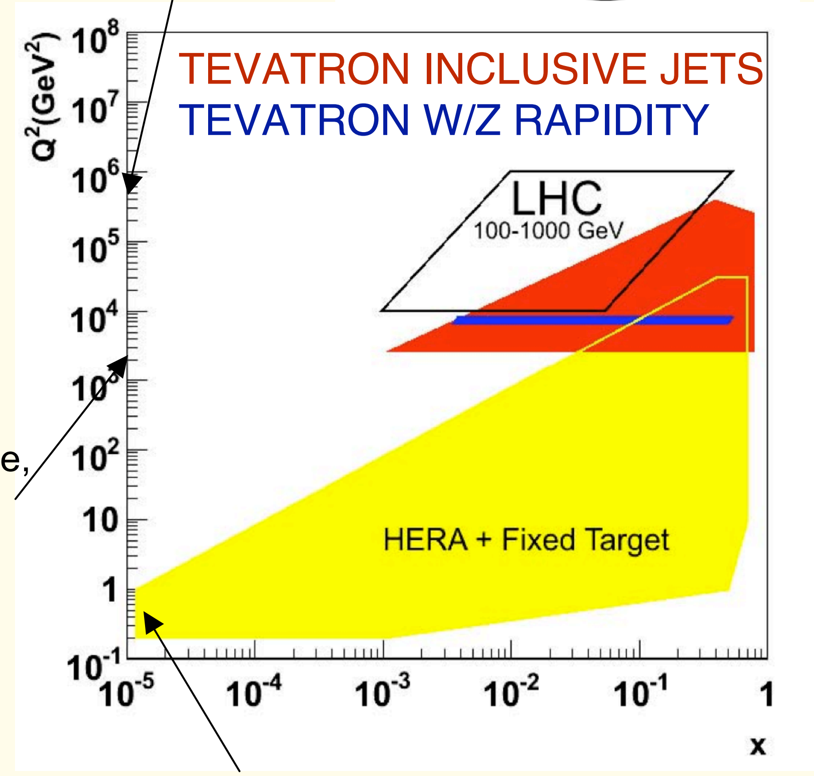
- Introduction
- New Analysis Technique
- Signal, Background and Corrections
- Uncertainties
- Results
- Comparison to latest results from DØ and status of PDF fits

Physics Motivation (I)

- Parton distribution functions (PDFs) describe *quark* and *gluon* content of the proton.
- PDFs are essential input to perturbative calculations of signal and background processes at hadron colliders.
- Tevatron data provide 10% of the data-points in the PDF fits
- Complement HERA and fixed-target data providing constraints at high-Q^2
- PDF fitting groups: CTEQ and MRST (now MSTW)



Gluon and sea quark PDFs dominate

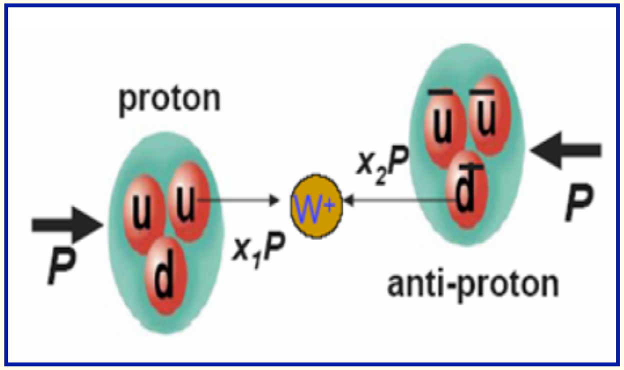


Proton composite, valence quarks dominate

Proton interacts as a single particle

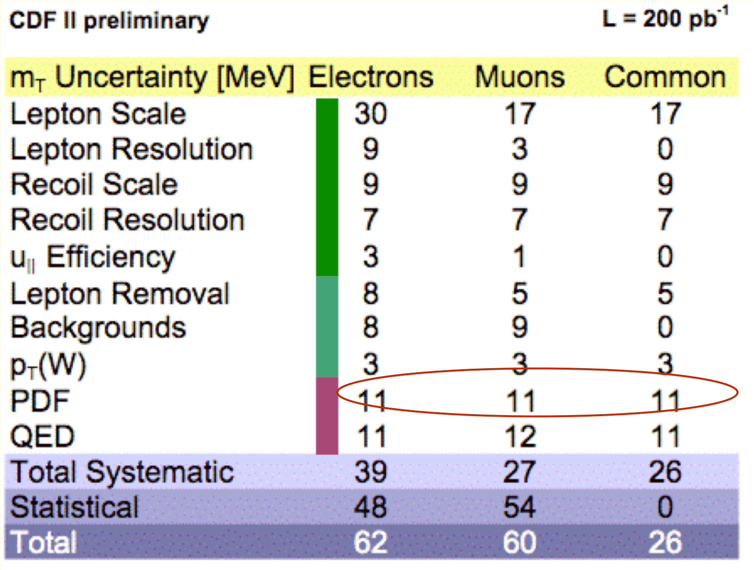
Physics Motivation (II)

- A measurement of the **W charge asymmetry** at the Tevatron provides information on d(x)/u(x) of the proton
  - truly clean measurement



- **Example:** Improvement in PDF uncertainties will reduce total error on W mass

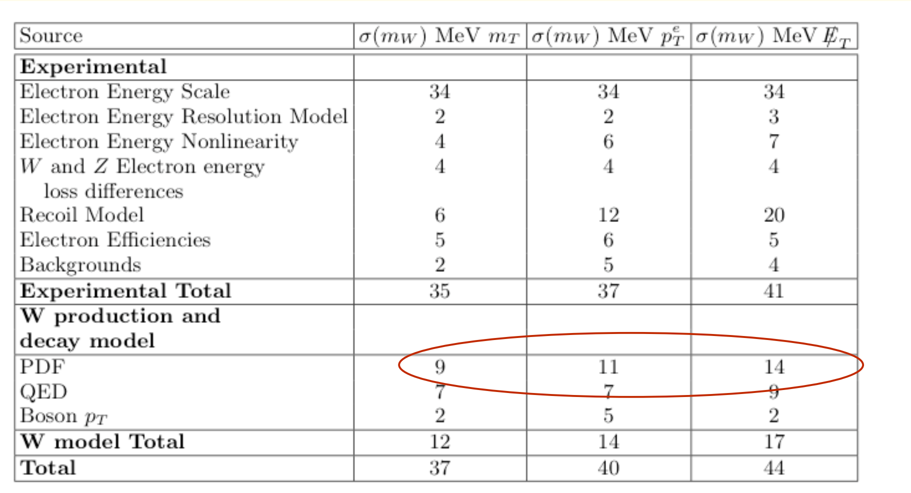
CDF 200pb^{-1}



CDF II preliminary L = 200 pb^{-1}

m_T Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	9	9	9
Recoil Resolution	7	7	7
$u_{\|\|}$ Efficiency	3	1	0
Lepton Removal	8	5	5
Backgrounds	8	9	0
p_T(W)	3	3	3
PDF	11	11	11
QED	11	12	11
Total Systematic	39	27	26
Statistical	48	54	0
Total	62	60	26

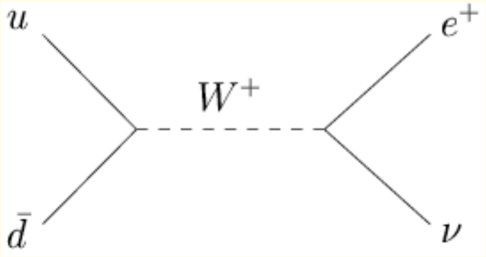
DØ 1 fb^{-1}

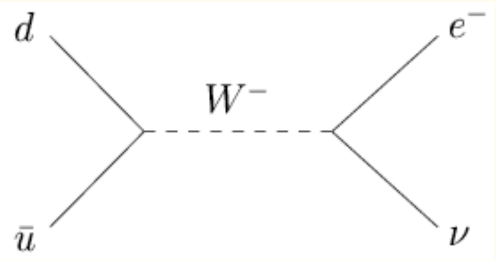


Source	$\sigma(m_W)$ MeV m_T	$\sigma(m_W)$ MeV p_T^e	$\sigma(m_W)$ MeV $\not{E}_T$
Experimental			
Electron Energy Scale	34	34	34
Electron Energy Resolution Model	2	2	3
Electron Energy Nonlinearity	4	6	7
W and Z Electron energy loss differences	4	4	4
Recoil Model	6	12	20
Electron Efficiencies	5	6	5
Backgrounds	2	5	4
Experimental Total	35	37	41
W production and decay model			
PDF	9	11	14
QED	7	7	9
Boson p_T	2	5	2
W model Total	12	14	17
Total	37	40	44

W Charge Asymmetry at the Tevatron

At the Tevatron, $W^{\pm}$ are produced primarily by:

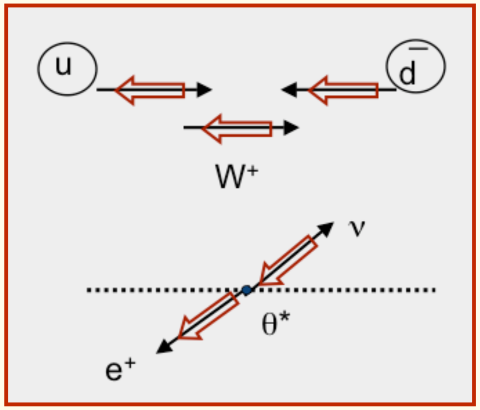


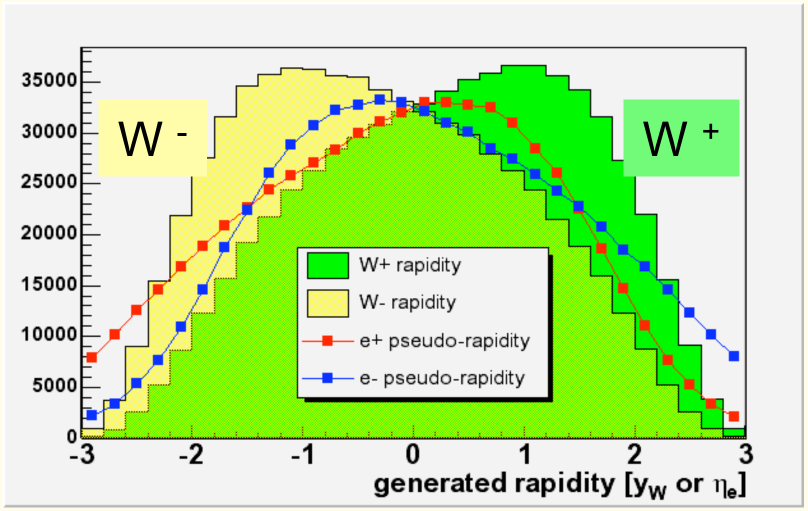


u quark carries higher fraction of proton momentum!

W+ boosted in proton direction and

W- boosted in anti proton direction.



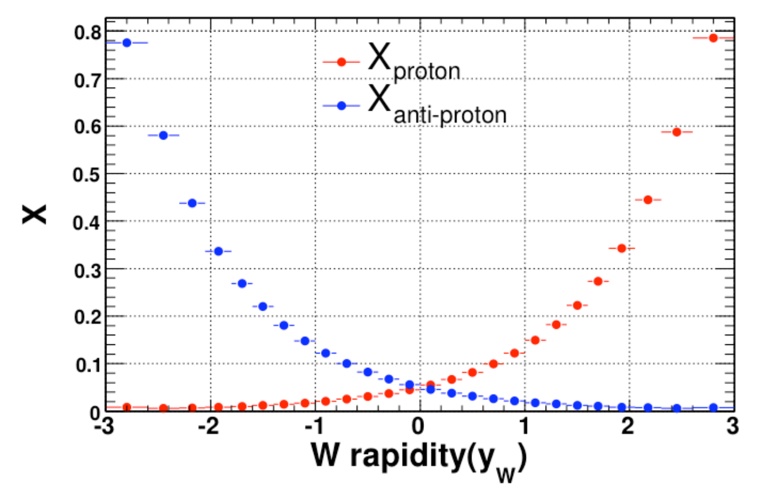


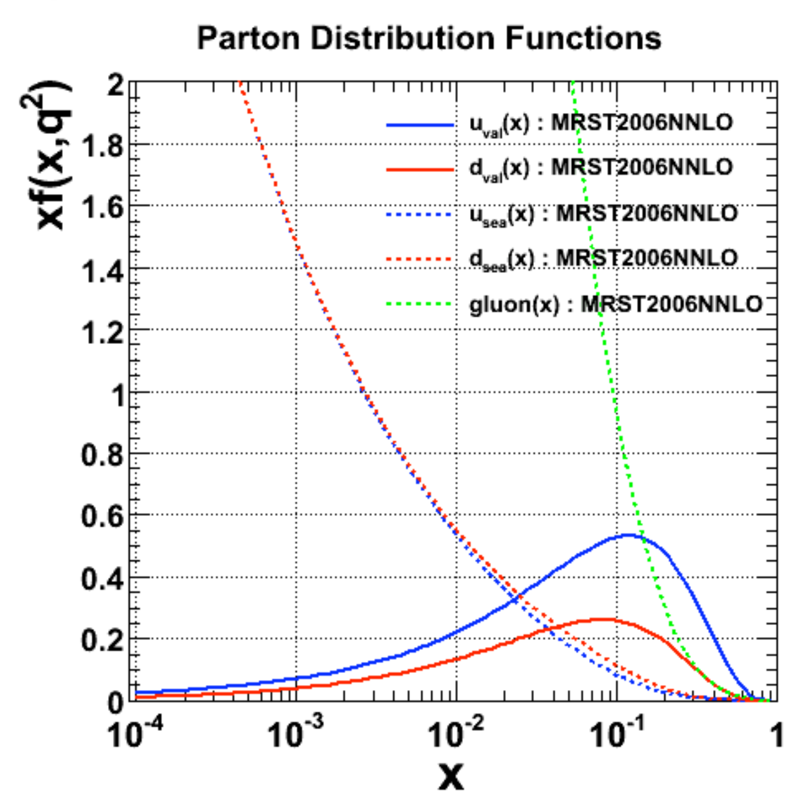
←anti-proton direction   proton direction→

W Charge Asymmetry at the Tevatron

W's produced mainly from valence quarks.

W production requires at least one high x parton in the collision.





[http://durpdg.dur.ac.uk/hepdata/pdf3.html]

$$y_W = \frac{1}{2}\ln\left(\frac{E-P_z}{E+P_z}\right)$$

$$x_{1,2} = x_0 e^{\pm y_W}$$

$$x_0 = M_W/\sqrt{s}$$

$$\boxed{A(y_W) = \frac{d\sigma_+/dy_W - d\sigma_-/dy_W}{d\sigma_+/dy_W + d\sigma_-/dy_W} \approx \frac{u(x1)d(x2) - d(x1)u(x2)}{u(x1)d(x2) + d(x1)u(x2)}}$$

sensitive to d(x)/u(x) ratio

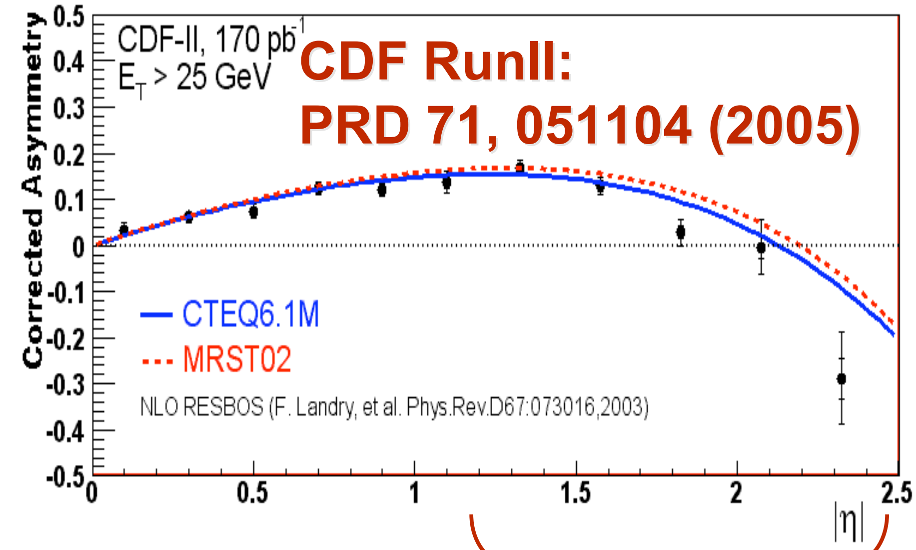
Measurement of the W charge asymmetry constrains PDF's of the proton.

Lepton Charge Asymmetry

Traditionally we measure lepton charge asymmetry

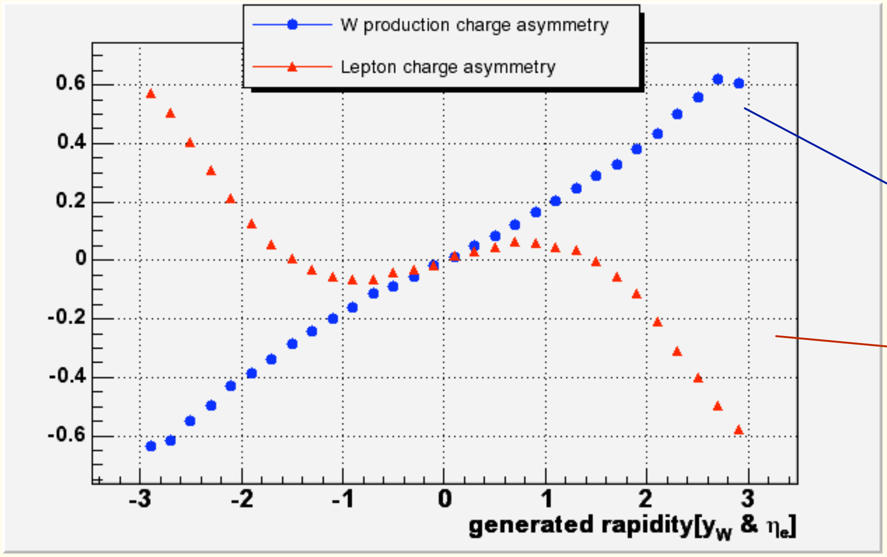
- leptonic W decay involves ν
  → P_z^{ν} is unmeasured
- lepton charge asymmetry is a convolution of both the *W* charge asymmetry and V-A *W* decay structure
- Results in “turn over” at high |η|
- W^+'s produced boosted in proton direction and polarized in the antiproton direction

W charge asymmetry does not have this effect, so we probe high y_W



CDF RunII: PRD 71, 051104 (2005)

Least constrained at high η!

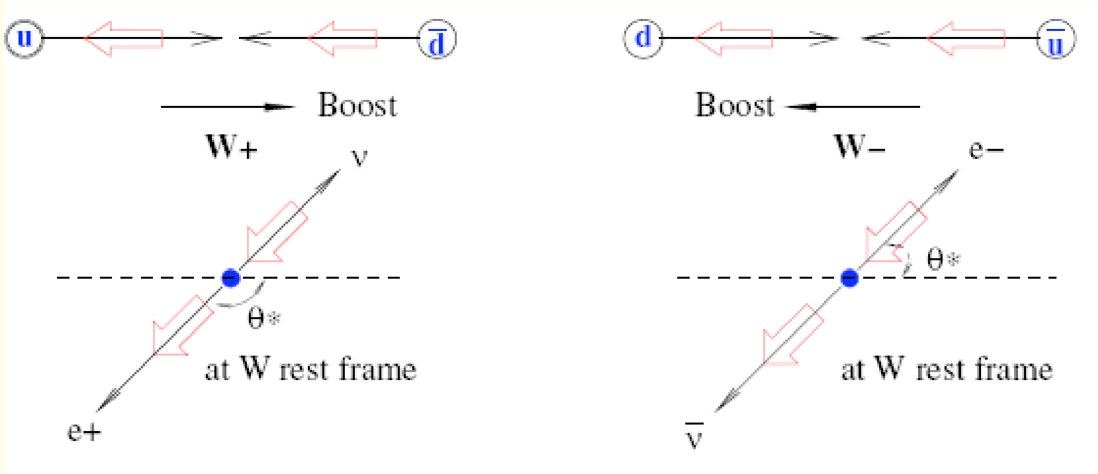


$$\boxed{A(y_W) = \frac{d\sigma_+/dy_W - d\sigma_-/dy_W}{d\sigma_+/dy_W + d\sigma_-/dy_W}}$$

$$\boxed{A_l(\eta) = \frac{d\sigma(l^+)/d\eta - d\sigma(l^-)/d\eta}{d\sigma(l^+)/d\eta + d\sigma(l^-)/d\eta}}$$

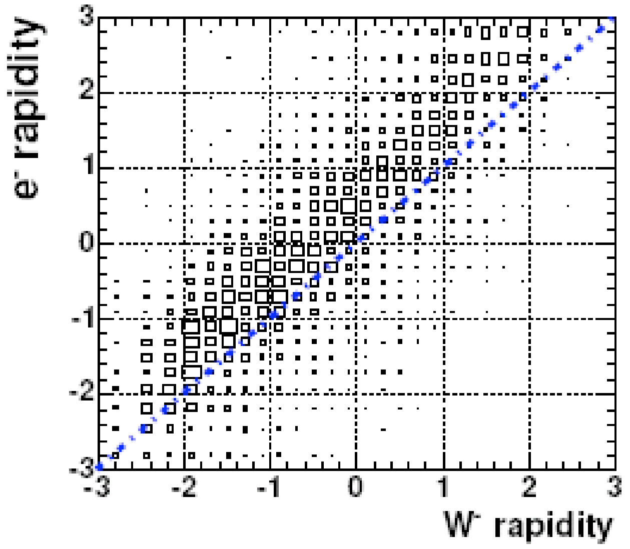
More on the lepton asymmetry later…

Lepton and W rapidity



$$\frac{d\Gamma(W\rightarrow e^{\pm}\nu)}{d\theta^{*}} \propto \left(1\mp\cos\theta^{*}\right)^{2}$$

Lepton prefers to decay against boost



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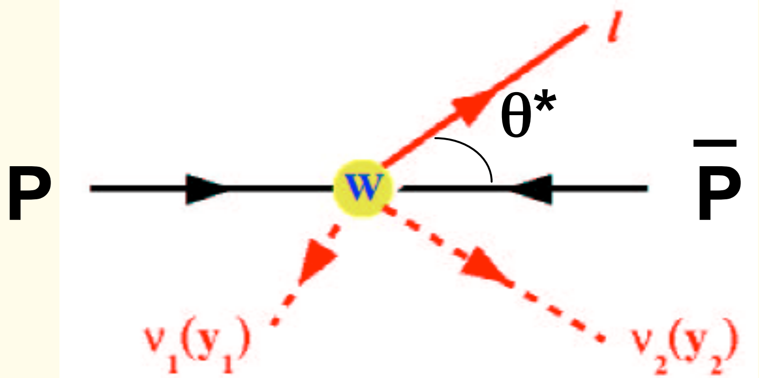
Analysis Technique (I): New Approach



Q: How to reconstruct y_W?

- Measure ***W*** ± rapidity ➡ $$y_W = \frac{1}{2}\ln\left(\frac{E - P_z}{E + P_z}\right)$$ $$\overrightarrow{P_z^W} = \overrightarrow{P_z^l} + \overrightarrow{P_z^\nu}$$

  can't measure !!!

- Use ***W*** mass constraint

  solve eqn. $$M_W^2 = (E_l + E_\nu)^2 - (\vec{P_l} + \vec{P_\nu})^2$$ answer : $\boxed{P_{z1}^\nu,\ P_{z2}^\nu}$

- Develop the weight factor

  Probability of angular distribution

$$w_{1,2}^{\pm} = \frac{P_\pm(\cos\theta_{1,2}^*, y_{1,2}, p_T{}^W)\sigma_\pm(y_{1,2})}{P_\pm(\cos\theta_1^*, y_1, p_T{}^W)\sigma_\pm(y_1) + P_\pm(\cos\theta_2^*, y_2, p_T{}^W)\sigma_\pm(y_2)}$$

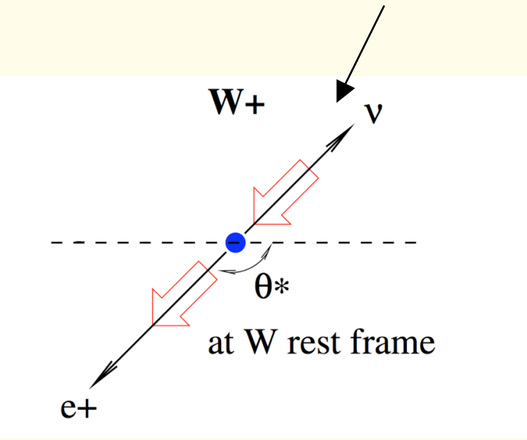
➡ **Differential *W* cross section**

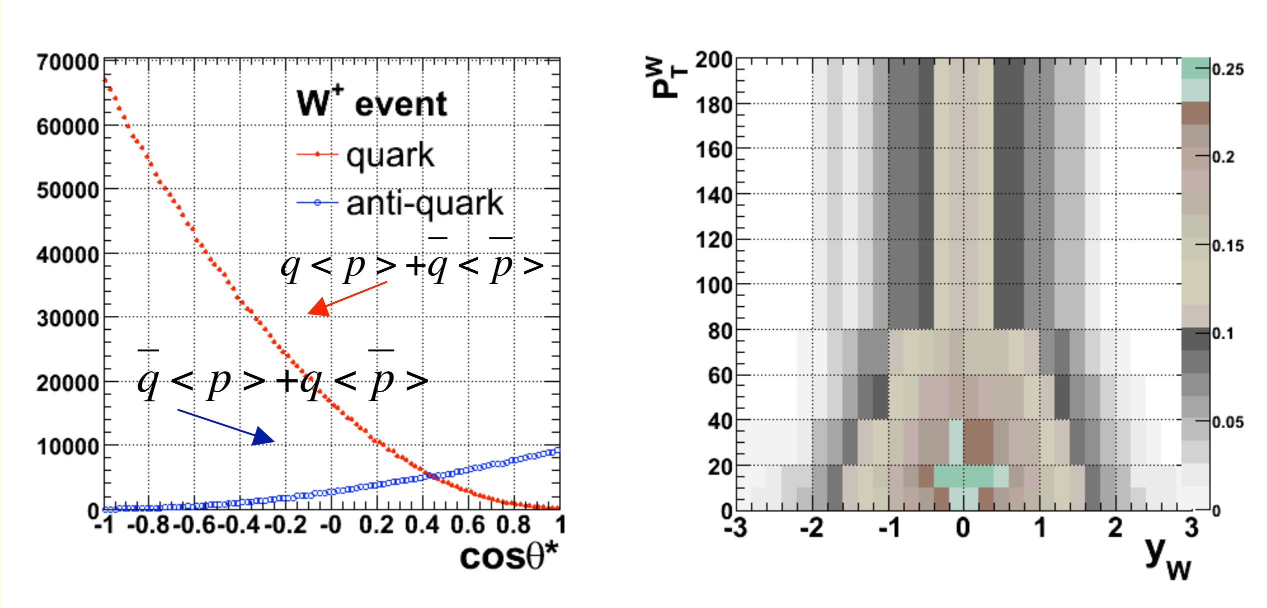
- Iterate the method to remove input bias
  - *shown it does not depend on assumed charge asymmetry*

Analysis Technique (II): W production from the sea

The W production probability from angular distribution

[cosθ* : in Collins-Soper frame (W rest frame)]





$$P_\pm(\cos\theta^*, y_W, p_T^W) = \underset{q<p>+\bar{q}<\bar{p}>}{\boxed{(1\mp\cos\theta^*)^2}} + Q(y_W, p_T^W)\underset{\bar{q}<p>+q<\bar{p}>}{\boxed{(1\pm\cos\theta^*)^2}}$$

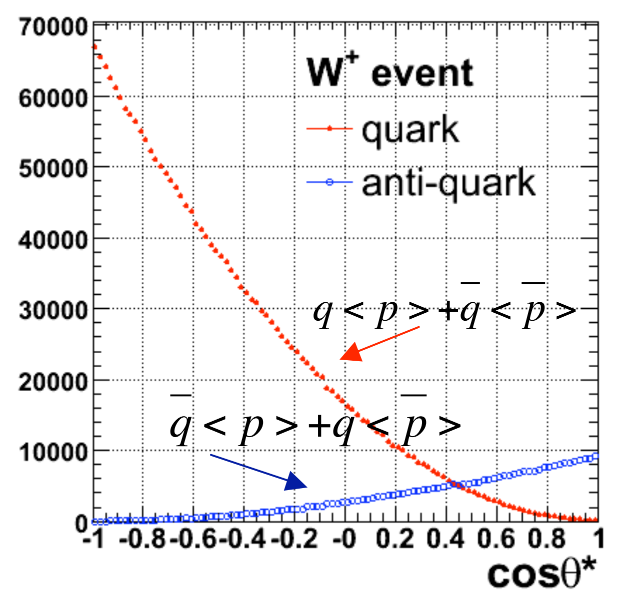
Sign of V-A angular bias flips when $W^\pm$ is produced from anti-quarks

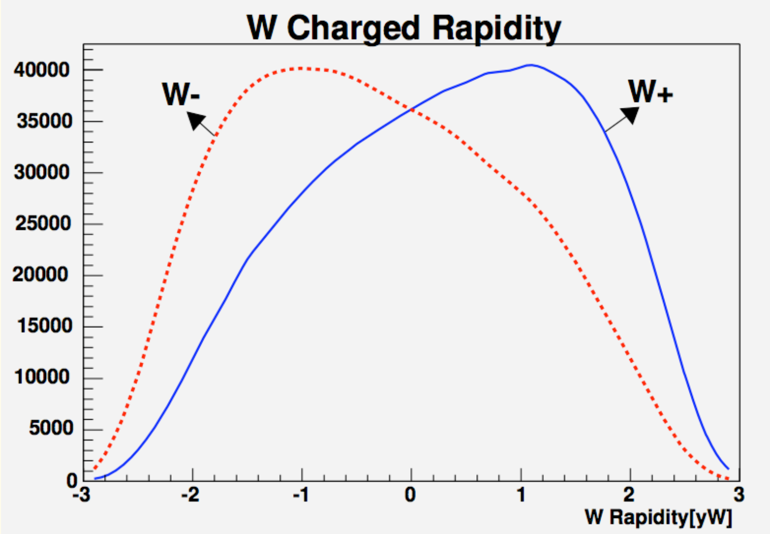
→ take this fraction as an input

ratio of two angular distributions at each rapidity

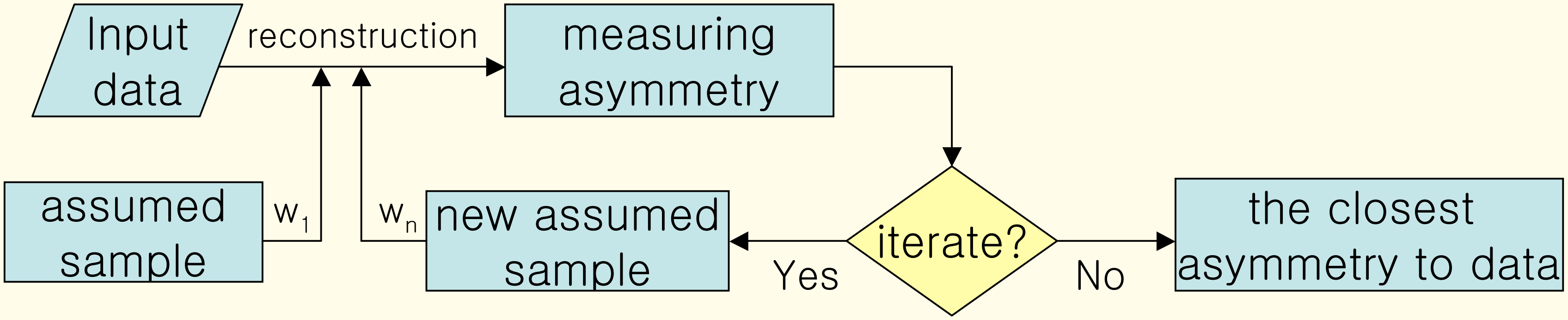
What is input?
What is measured?

- Inputs from theory:
  - $\frac{\bar{u}+\bar{d}}{u+d}$ and $\frac{d\sigma(p\bar{p}\to W^{+}X)}{dy_W}+\frac{d\sigma(p\bar{p}\to W^{-}X)}{dy_W}$





What is input?
What is measured?



Input data

reconstruction

measuring asymmetry

assumed sample

w_1

w_n

new assumed sample

iterate?

Yes

No

the closest asymmetry to data

- Output from iteration:

$$A\left(y_W\right)=\frac{\dfrac{d\sigma(p\bar{p}\to W^+X)}{dy_W}-\dfrac{d\sigma(p\bar{p}\to W^-X)}{dy_W}}{\dfrac{d\sigma(p\bar{p}\to W^+X)}{dy_W}+\dfrac{d\sigma(p\bar{p}\to W^-X)}{dy_W}}$$

Method documented in:

Thesis student

A. Bodek, Y. Chung, E. Halkiadakis, B. Han, K. McFarland, Phys. Rev. D 79, 031101(R) (2009).

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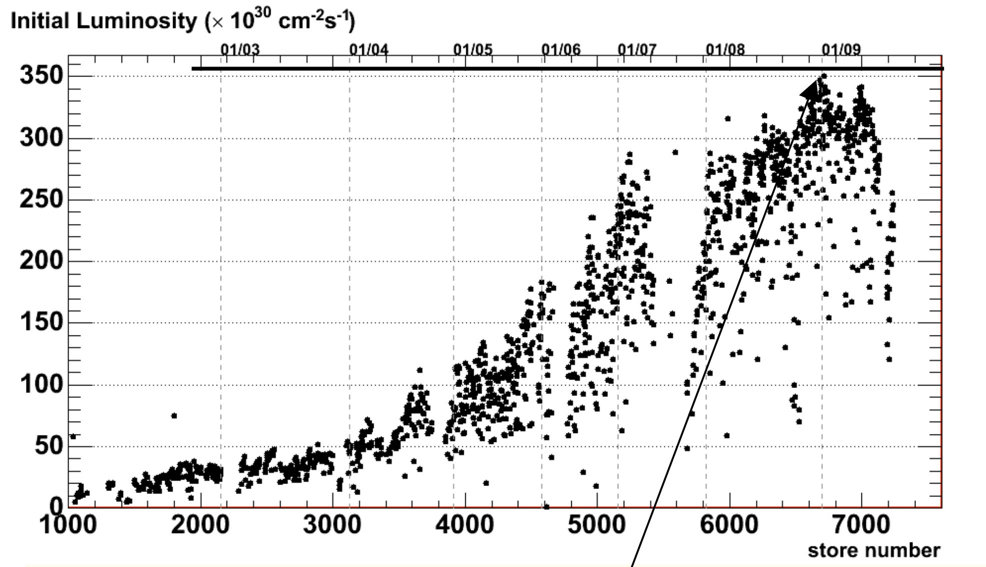
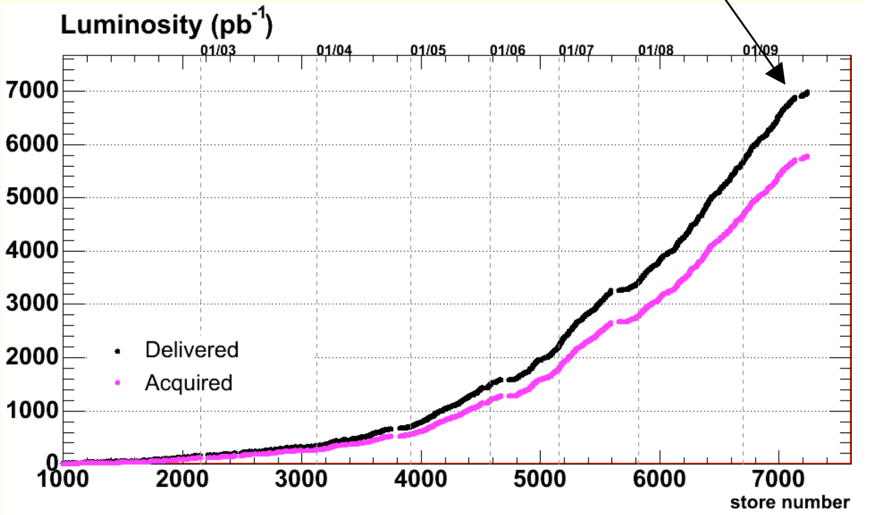
Tevatron & CDF Performance

Integrated $\mathcal{L}$

Total delivered: ~7 fb^{-1} /expt

Total recorded: >5.5 fb^{-1} /expt





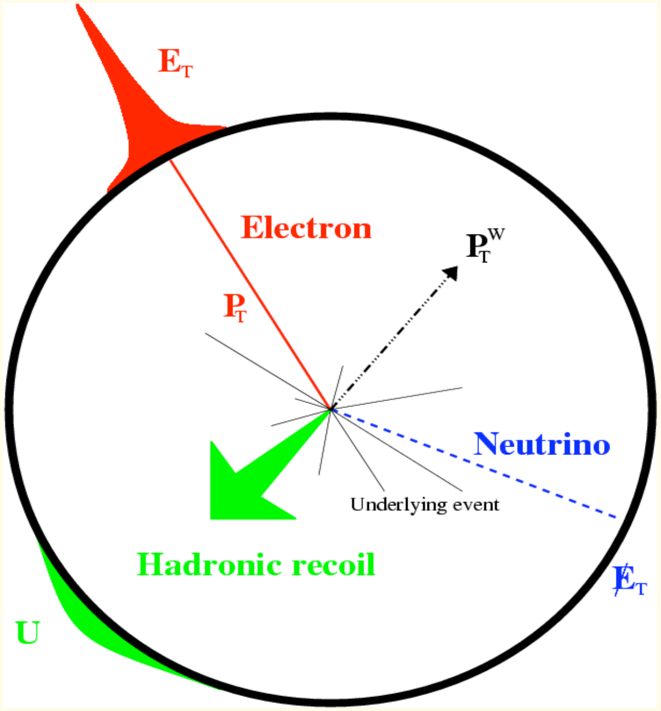
Record peak $\mathcal{L}$ ~3.7x10^{32} $cm^{-2}s^{-1}$

This analysis: 1fb^{-1}

W →eν event selection

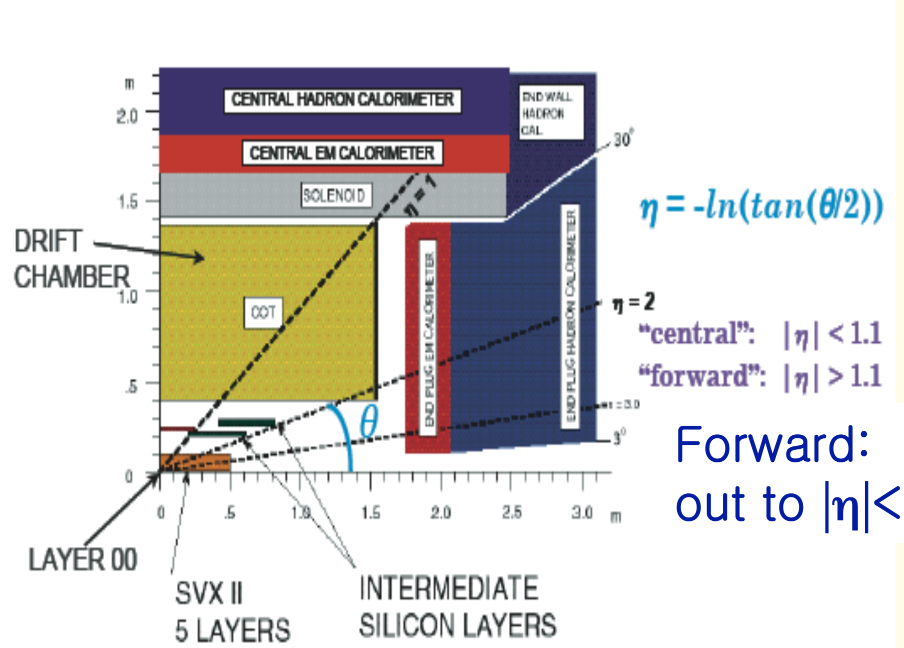
- Electron selection
  - Isolated EM calorimeter energy
  - Transverse Energy

    $E_T > 25$ (20) GeV in central (forward) detector



- Neutrino selection
  - Determined from missing transverse energy

    missing $E_T > 25$ GeV



$\eta = -ln(tan(\theta/2))$

"central": $|\eta| < 1.1$

"forward": $|\eta| > 1.1$

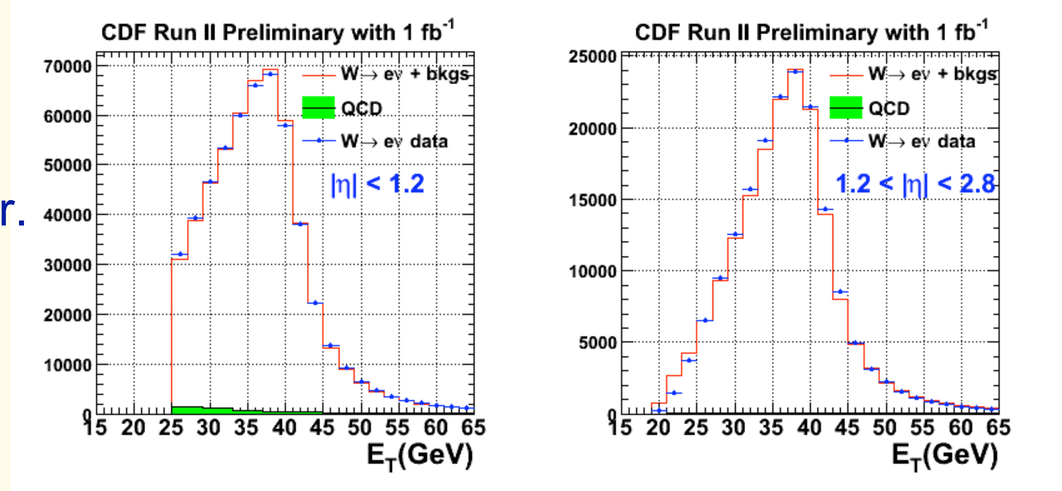
Forward: out to $|\eta|<2.8$

~538K events in central and ~177K in forward

Electrons and Missing Energy

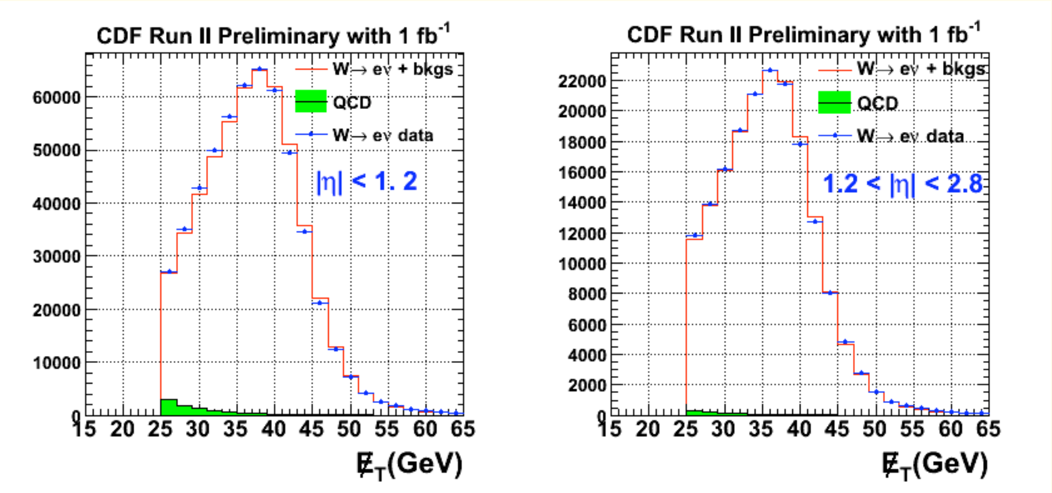
Electrons :

- Have charged particle track.
- Leave almost all of their energy in the electromagnetic calorimeter.
- Ask for no other nearby tracks
  - We do not want leptons from (heavy flavor) jets.



Missing E_T :

- Measure “Missing Transverse Energy” with transverse energy balance.
- EM and hadronic components measured in calorimeters
- Corrected for jets



Scale and resolution tuned on Z →ee data.

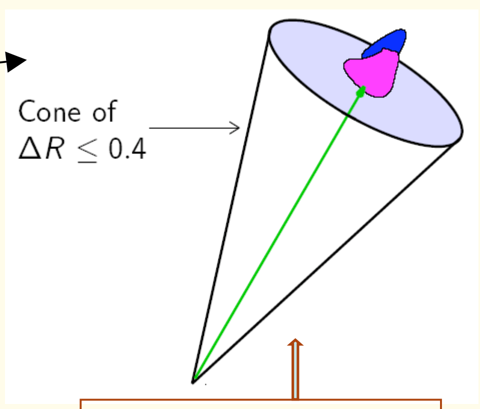
W recoil energy also tuned on data.

Backgrounds (I)

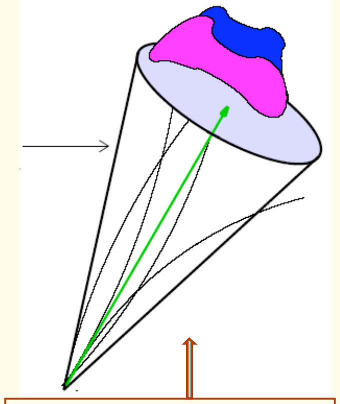
- Measure jet backgrounds directly in data
  - use extra energy “isolation” around electron to separate, and fit shape to background fraction
- Illustrative fit (one of many) below
  - use jet sample to predict measured “y_W” and charge from this sample
  - uncertainty is ~0.15% of total sample

Technique :

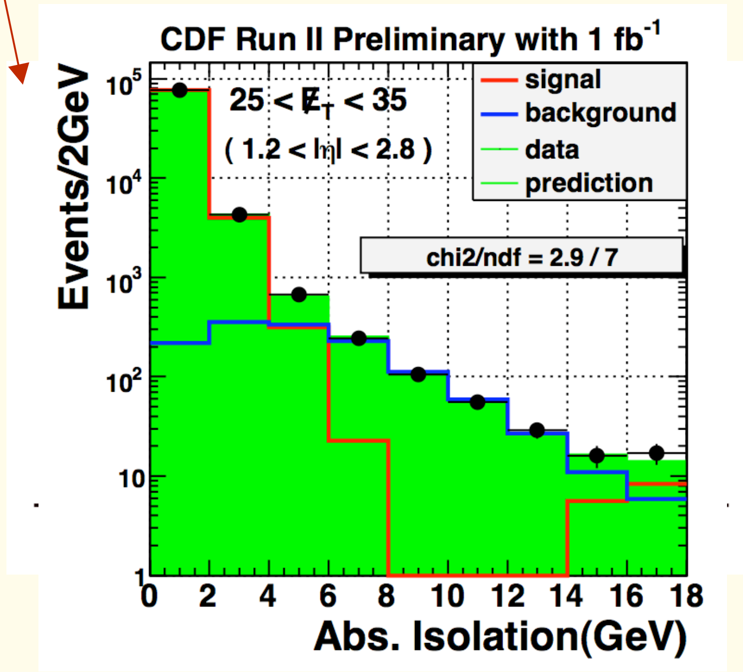
use extra energy “isolation” around electron to separate, and fit shape to background fraction

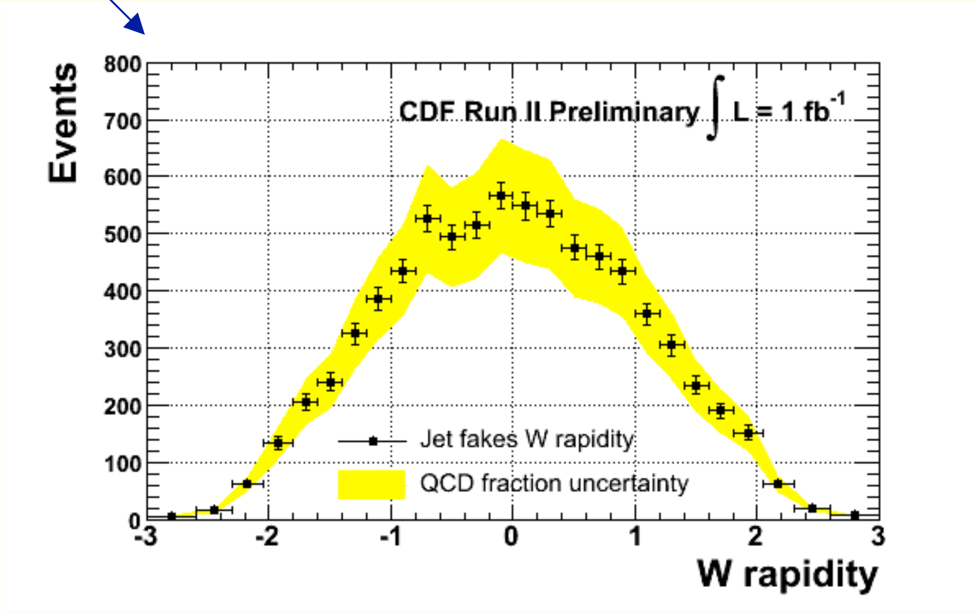


Real electrons from Boson decay are isolated.



Fake or real electrons in jets are non-isolated.





Backgrounds (II)

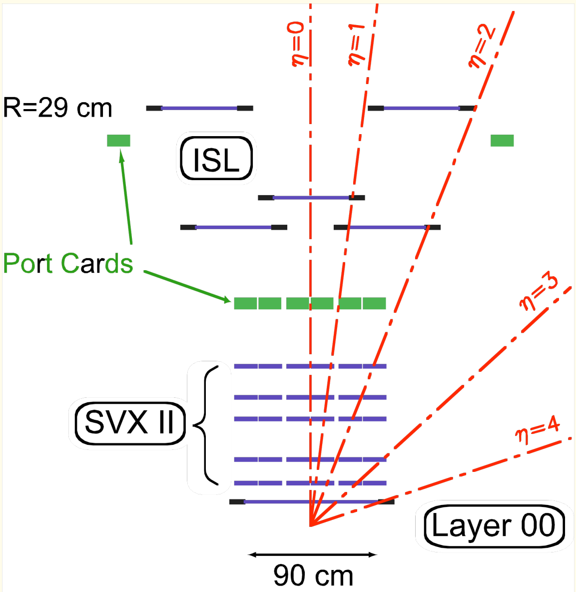
A number of additional minor backgrounds from MC simulation:

- **$Z \to e^+e^-$, $Z \to \tau^+\tau^-$**
- Standard model top pair production→ very small cross-section (< 10 pb)
  - Negligible
- Dibosons: WW and WZ diboson production → very small cross-sections (≤10 pb)
  - Negligible
- $W \to \tau\upsilon \to e\upsilon\upsilon$: Not background - included in acceptance (signal!)

Backgrounds	**central**	**plug**
$Z \to e^+e^-$	0.59 ± 0.02 %	0.54 ± 0.03 %
$Z \to \tau^+\tau^-$	0.09 ± 0.00 %	0.10 ± 0.01 %
QCD	1.21 ± 0.14 %	0.67 ± 0.12 %
(Signal) $W \to \tau^+\upsilon$	2.30 ± 0.04 %	2.04 ± 0.05 %

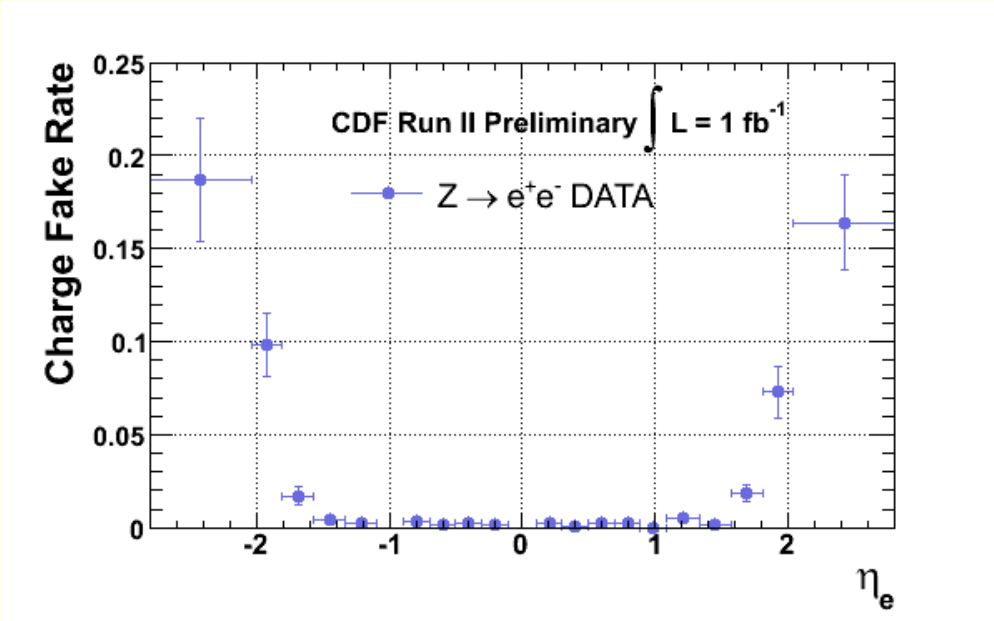
Electron Charge Identification

- Charge identification is crucial for this measurement.
- Forward tracking has fewer points at shorter lever arm
- Measure charge fake rate using $Z \rightarrow e^+e^-$ data sample (background subtracted)



$$f_{mis} = \frac{N_{same\ sign}}{N_{opposite\ sign} + N_{same\ sign}}$$

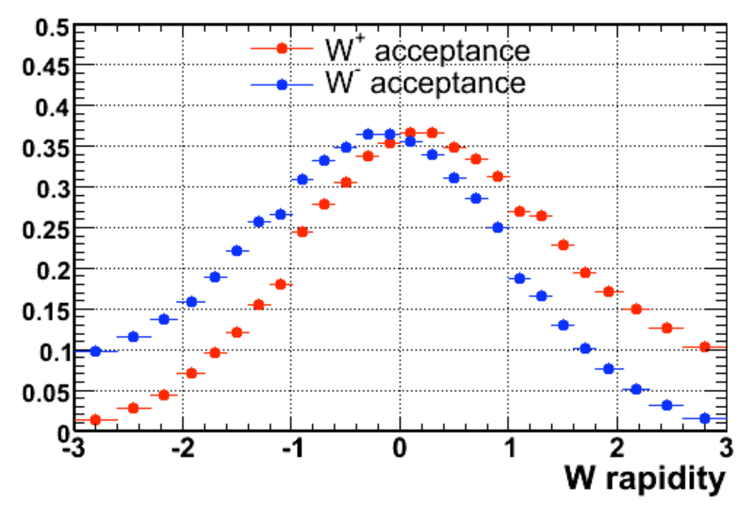
- And then determine the charge fake rate as a function of the reconstructed charge and the weight factors.



Acceptance

- Correction for the detector acceptance

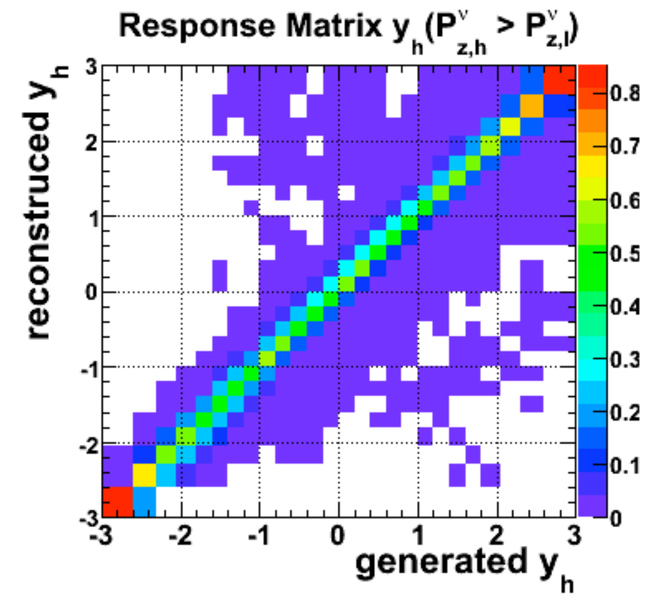
$$a^{\pm}(y_W) = \frac{\sum w^{\pm}(y_W)}{d\sigma^{\pm} / dy_W^{gen}}$$



- Trigger and electron ID efficiencies are also addressed to correct detector acceptance.

- Response Matrix : detector smearing

$$\begin{aligned} R_{ij}^{\pm} &= \frac{P(\text{ observed in bin } i \text{ and true value in bin } j \text{ })}{P(\text{ true value in bin } j \text{ })} \\ &= P(\text{ observed in bin } i \mid \text{true value in bin } j \text{ }) \end{aligned}$$



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Uncertainties

Statistical:

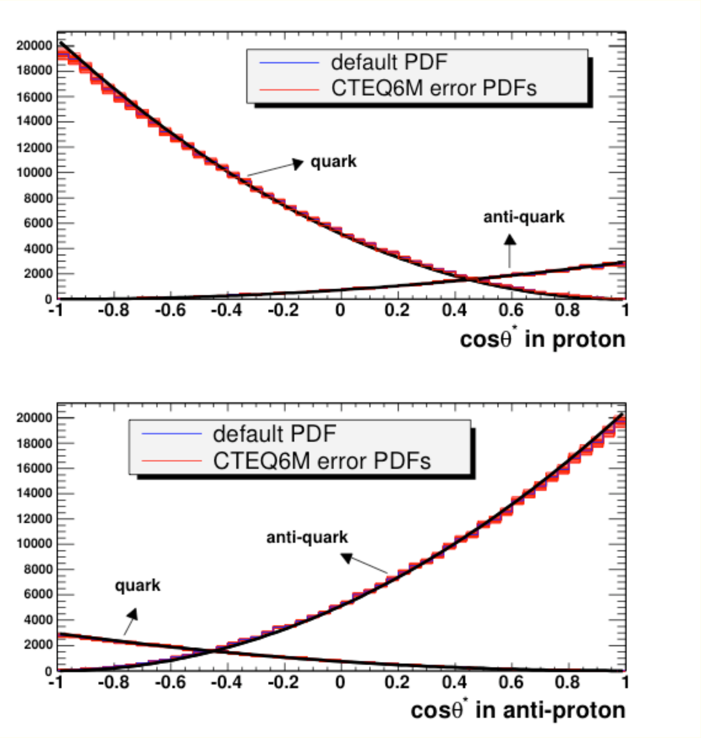
- Unfolding could correlate the statistical errors in nearby bins
- The statistical correlation coefficient between bins is found to be < 0.05.

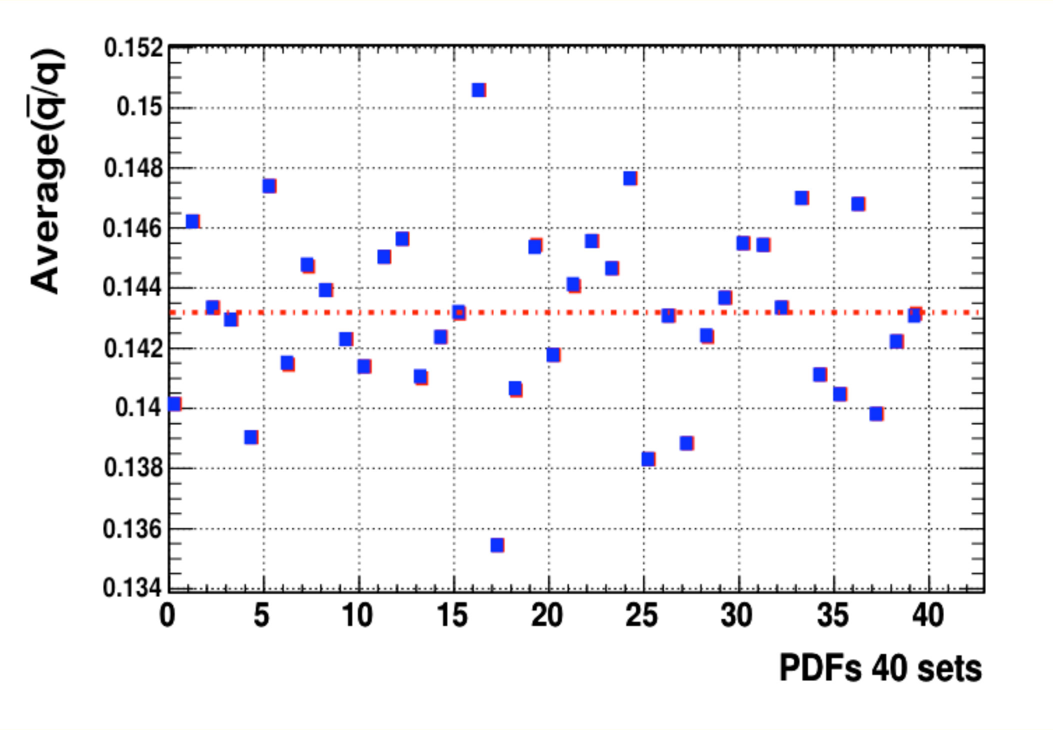
Systematic:

- Detector response
  - energy scale and smearing for electron and recoil
  - efficiency to find electron and pass missing E_T cut
- Reconstruction & Backgrounds
  - Uncertainties on charge fake rate and background estimates
- Inputs
  - PDF uncertainties (CTEQ6 PDF error sets) for total W production and quark/anti-quark fractions

Evaluation of Systematics

- Derive result with shifted parameters
- Example: effect of PDF's on Q factor (sea/valence quark ratio)

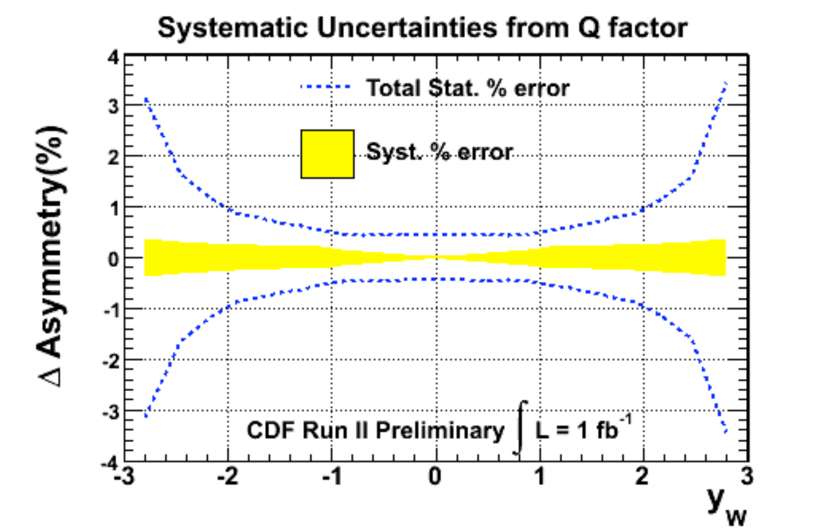


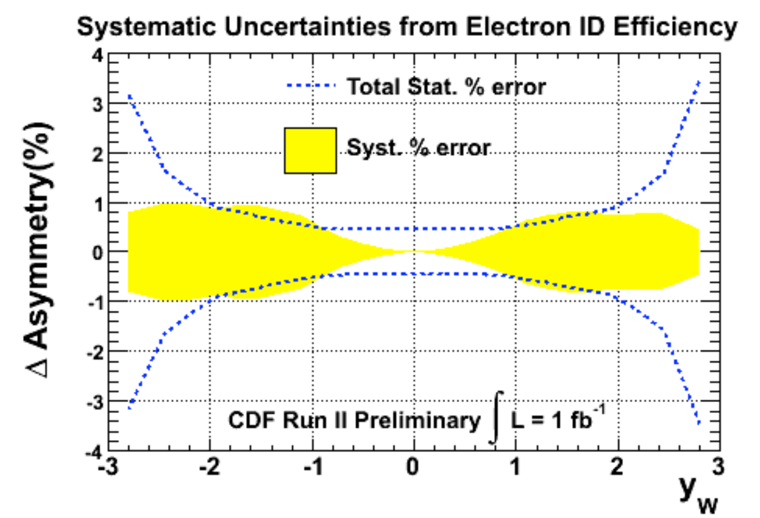


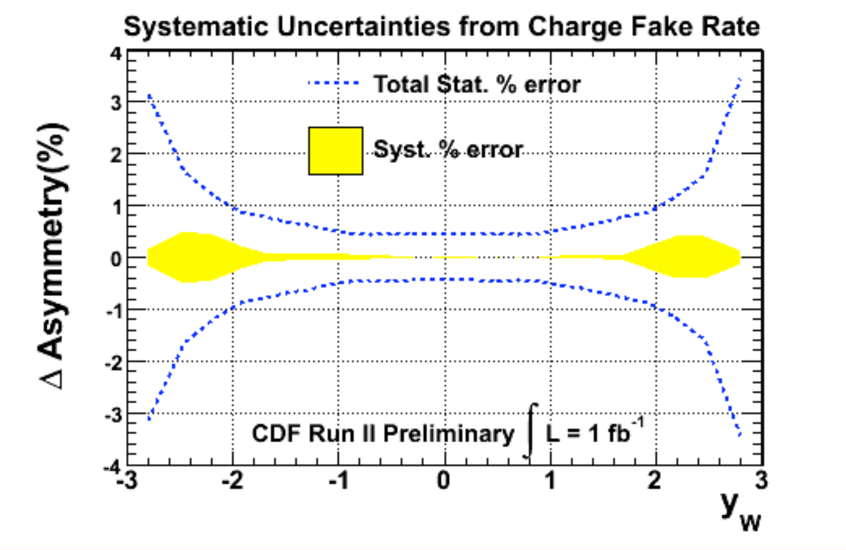
The effect of the 40 error PDFs
from CTEQ on the cosθ∗ distributions
in the proton (top) and anti-proton (bottom).

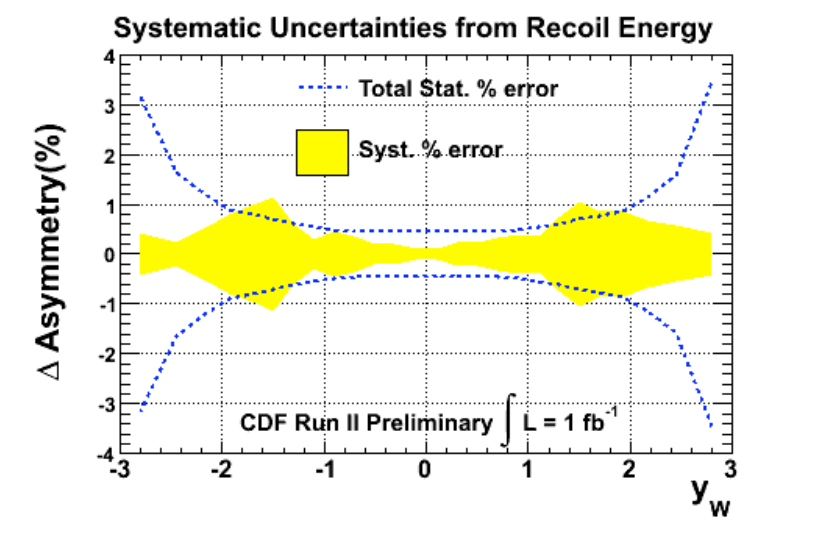
The average ratio of anti-quark to
quark for each of the 40 error PDF sets.

Systematic Uncertainties

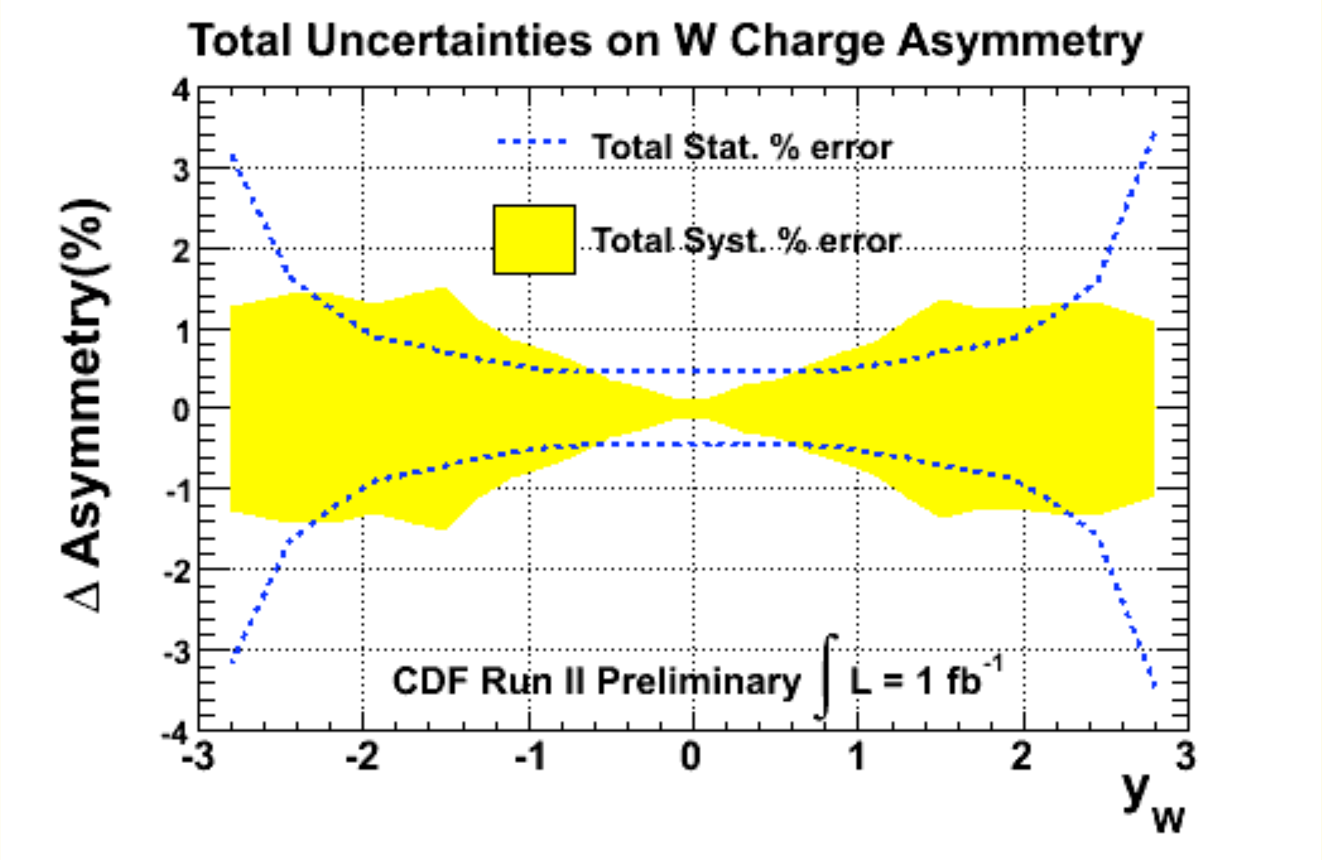

Systematic Uncertainties from Q factor


Systematic Uncertainties from Electron ID Efficiency


Systematic Uncertainties from Charge Fake Rate


Systematic Uncertainties from Recoil Energy

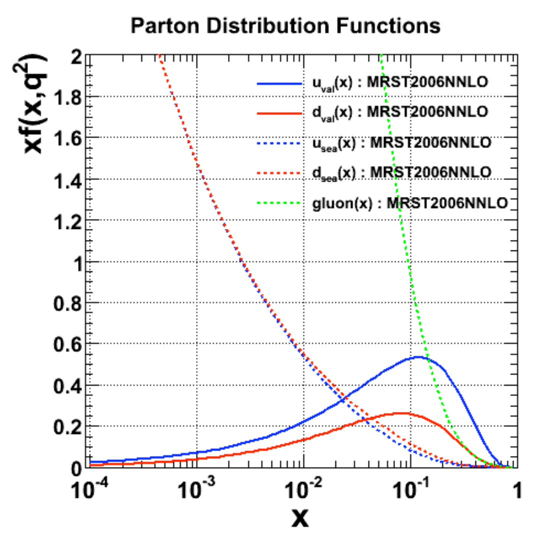
Systematic Uncertainties

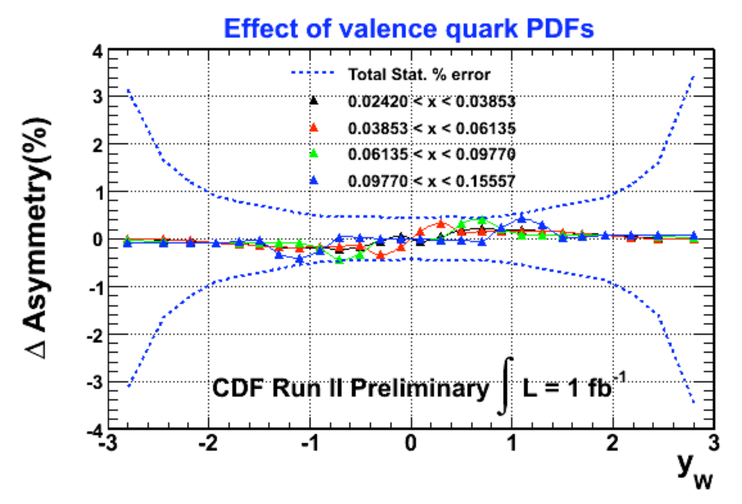


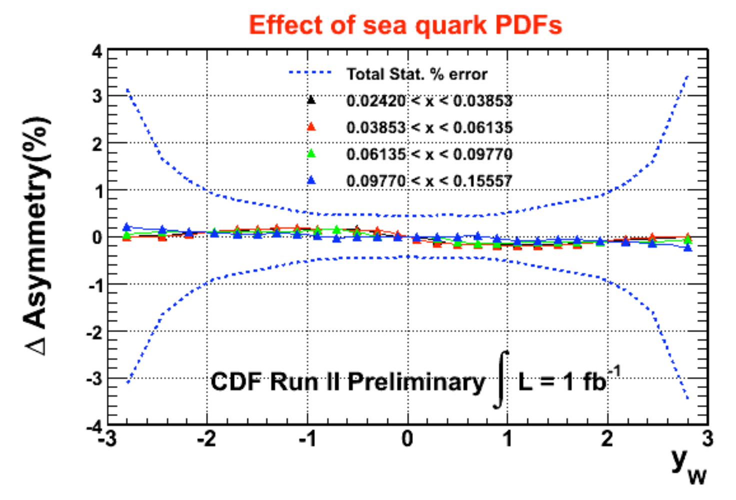
Systematics <1.5 % for $|y_W| > 2.0$

Effect of Input PDFs

- Studied effect of how W charge asymmetry measurement depends on *input* valence quark, sea quark and gluon PDFs
- Below we show the x range for which we find the largest differences in the measured W charge asymmetry
- Note that the effects of even these large changes in the quark and gluon distributions is small (< 0.003) compared with the statistical uncertainty (> 0.004).







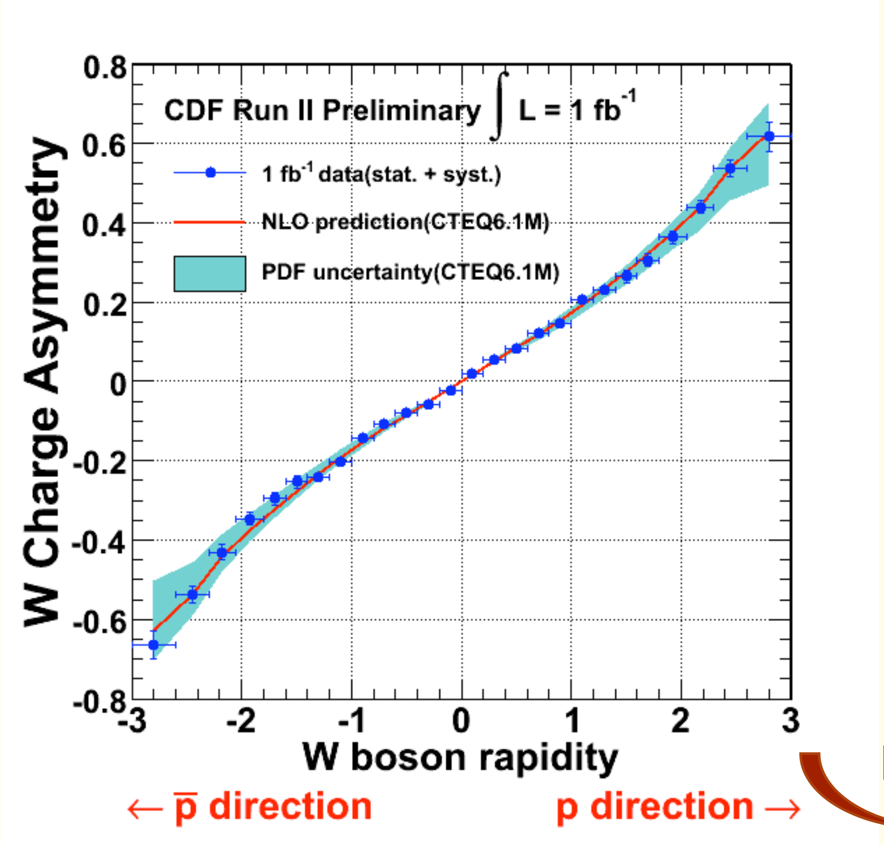
effect of increasing valence u+d by +5%

effect of increasing sea u+d by +5%

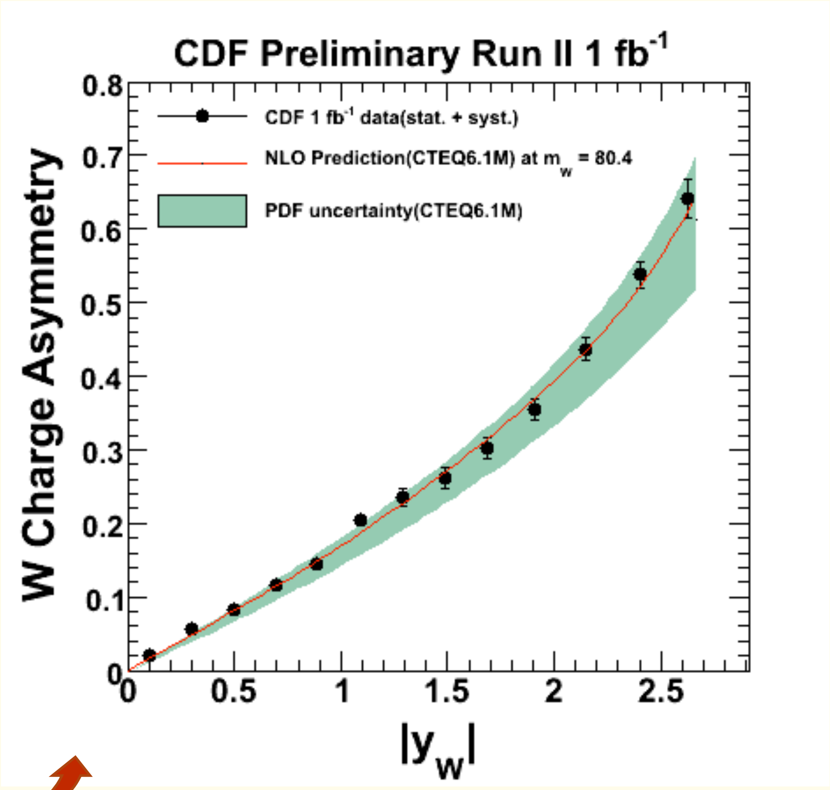
Outline

- Introduction
- New Analysis Technique
- Signal, Background and Corrections
- Uncertainties
- **Results**
- Comparison to latest results from DØ and status of PDF fits

CDF Result ($1 fb^{-1}$)



Fold



Precision *much* better than error band!

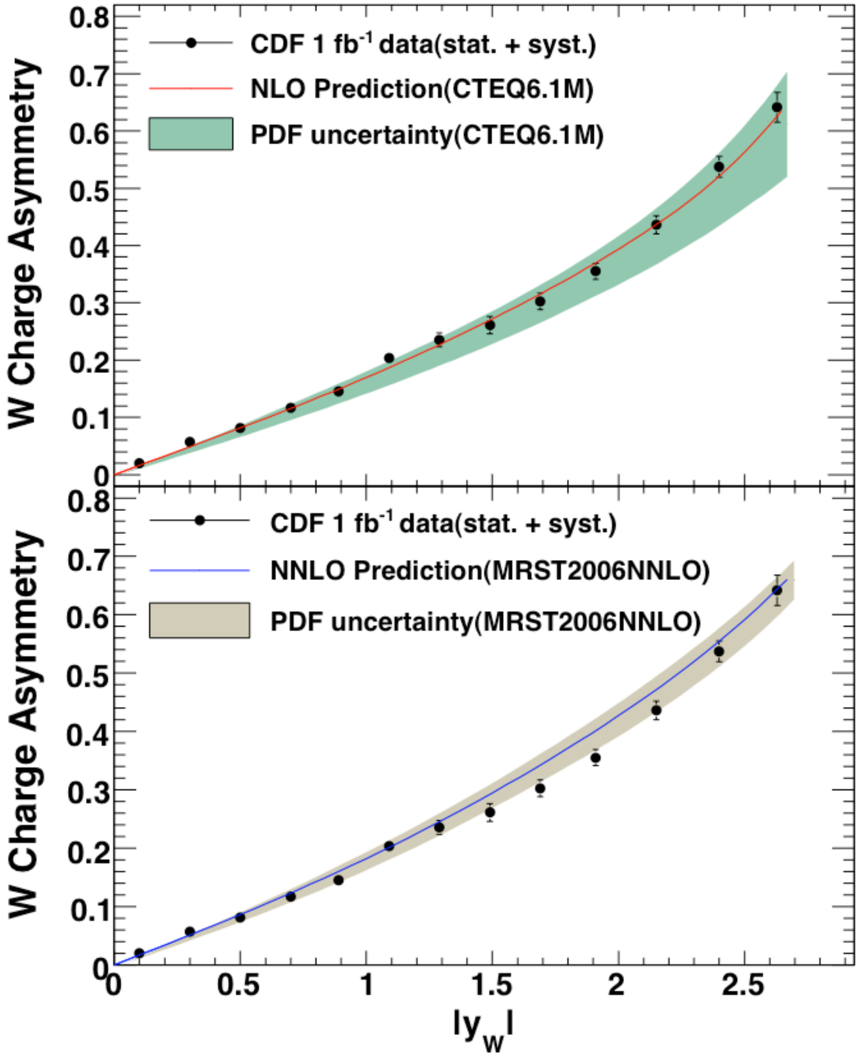
- Positive and negative y_W agree, so fold
- The combination of the asymmetry accounts for all correlation for both positive and negative bins in y_W.
- Compare to NLO Prediction
  - NLO error PDFs (CTEQ)

CDF Result ($1fb^{-1}$)

Phys. Rev. Lett. 102, 181801 (2009).
Recently published in PRL!

Compare to CTEQ6M (NLO) and MRST2006 (NNLO) PDFs and their uncertainties

Precision _much_ better than error band!



CTEQ6 NLO:P. M. Nadolsky et al., Phys. Rev. D 78, 013004 (2008).

CTEQ6 error PDFs: D. Stump et al., J. High Energy Phys. 10 (2003) 046.

NNLO Prediction: C. Anastasiou et al., Phys. Rev. D69 , 094008 (2004).

MRST 2006 PDFs: A. D. Martin et al., hep-ph/0706.0459, Eur. Phys. J., C28 , 455 (2003).

Outline

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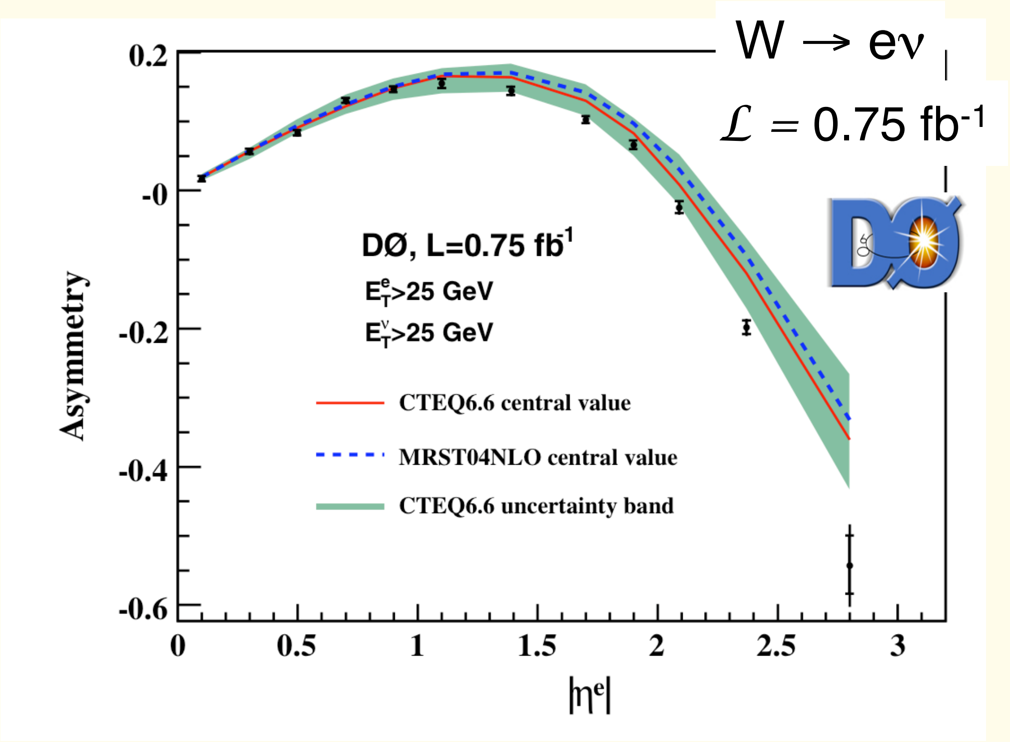
Latest Electron Charge Asymmetry from DØ

$$A_l(\eta) = \frac{d\sigma(l^+)/d\eta - d\sigma(l^-)/d\eta}{d\sigma(l^+)/d\eta + d\sigma(l^-)/d\eta}$$



PRL 101, 211801 (2008)

The measured charge asymmetry tends to be lower than the theoretical predictions for high $|\eta_e|$.

CTEQ6 NLO:P. M. Nadolsky et al., Phys. Rev. D 78, 013004 (2008).

CTEQ6 error PDFs: D. Stump et al., J. High Energy Phys. 10 (2003) 046.

MRST04NLO: A. D. Martin, R. G. Roberts, W. J. Stirling, and R. S. Thorne, Phys. Lett. B 604, 61 (2004).

Latest Electron Charge Asymmetry from DØ

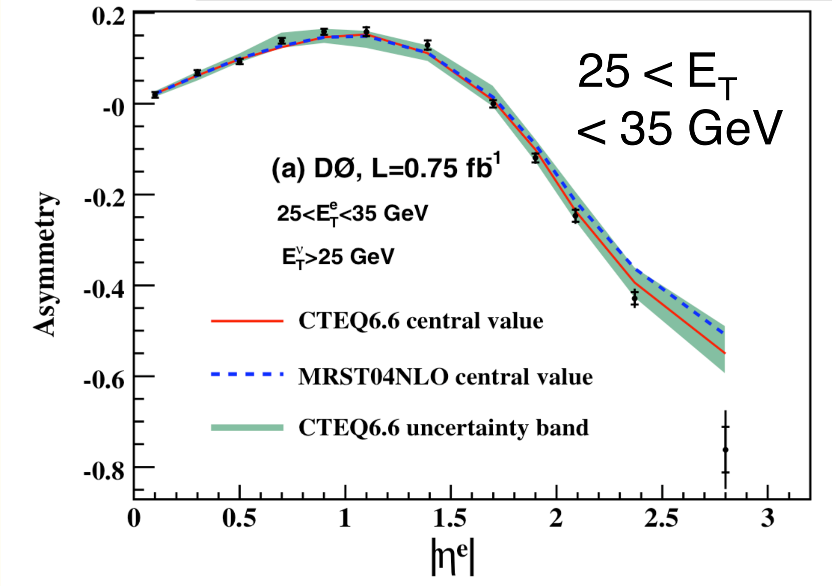
- Also measure the asymmetry in two bins of electron E_T
  - $25 < E_T < 35$ GeV and $E_T > 35$ GeV
- For a given η_e, the two E_T regions probe different ranges of y_W
  - For higher E_T, electron direction closer to W direction
  - Anti-quark term enhanced at low E_T
  - Can provide some distinction between sea & valence
  - Improve sensitivity to the PDFs

$$\cos\theta^* = \sqrt{1 - 4E_T^2/M_W^2}$$

Angle between lepton and proton in W rest frame

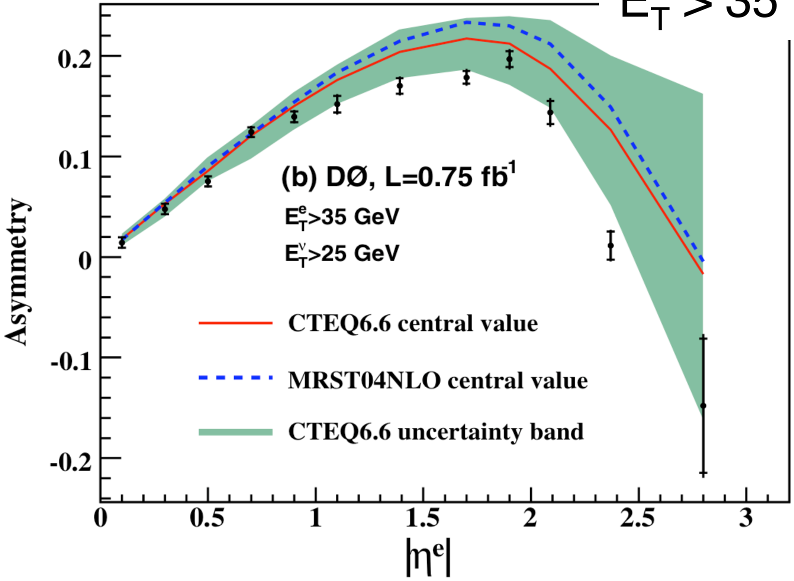
$$y_l = y_W \pm \frac{1}{2}\ln\left(\frac{1+\cos\theta^*}{1-\cos\theta^*}\right)$$

$$d\sigma(l^+)/d\eta_l - d\sigma(l^-)/d\eta_l \approx u(x_1)d(x_2)(1-\cos\theta^*)^2 + \underline{\bar{d}(x_1)\bar{u}(x_2)}(1+\cos\theta^*)^2 - d(x_1)u(x_2)(1+\cos\theta^*)^2$$



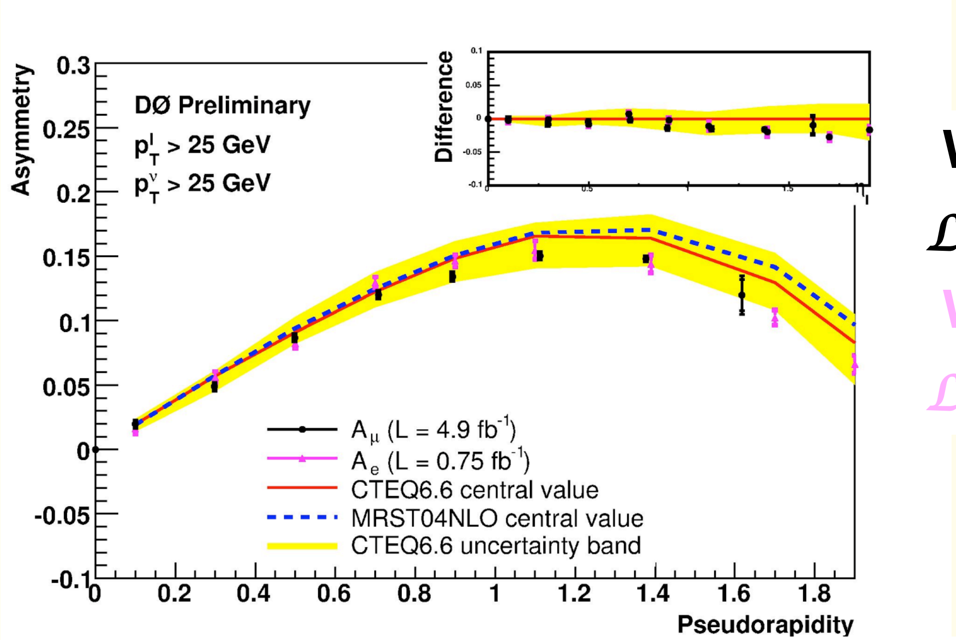
25 < E_T < 35 GeV

E_T > 35 GeV



Latest muon charge asymmetry from DØ

DØ electron and muon charge asymmetries are consistent

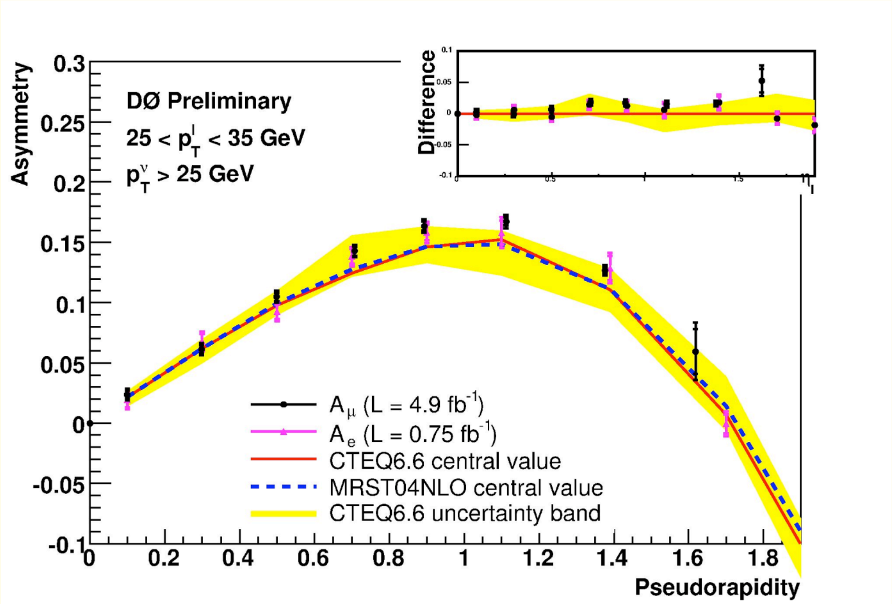


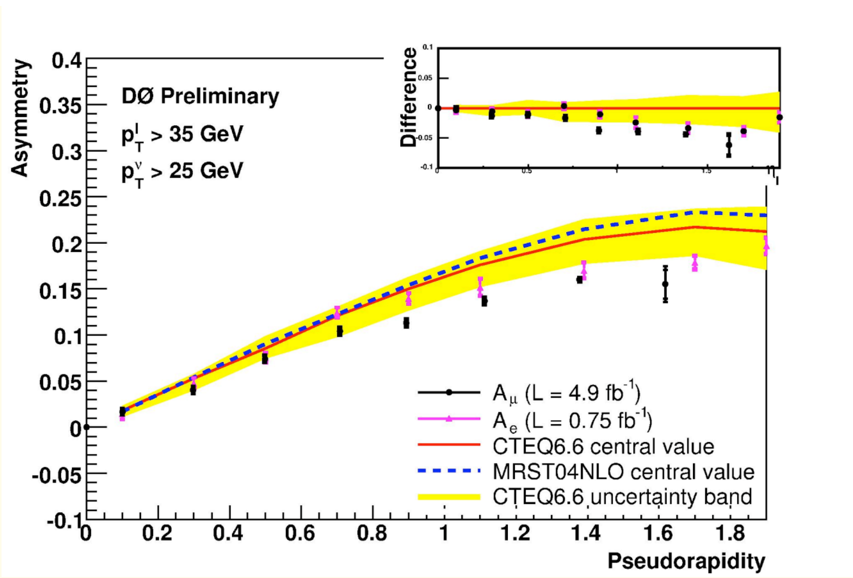
$W \to \mu\nu$

$\mathcal{L}$ = 4.9 fb^{-1}

$W \to e\nu$

$\mathcal{L}$ = 0.75 fb^{-1}



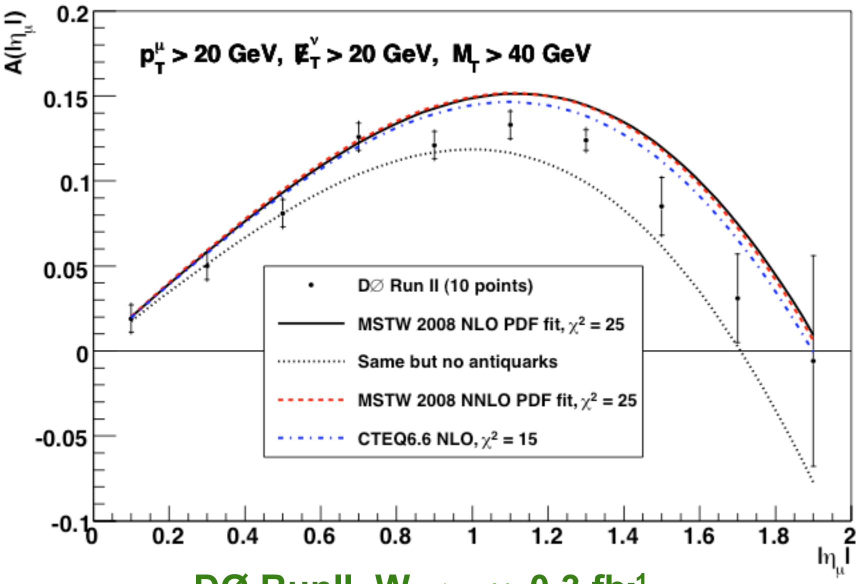


Latest fits from MSTW

- Latest fits from MSTW *do not* use the latest Tevatron results just shown. They use:
  - DØ Run II, W → $\mu\nu$, 0.3 fb^{-1}
  - CDF Run II, W → $e\nu$, 0.17fb^{-1}
- Show anti-quark discriminating power at low E_T

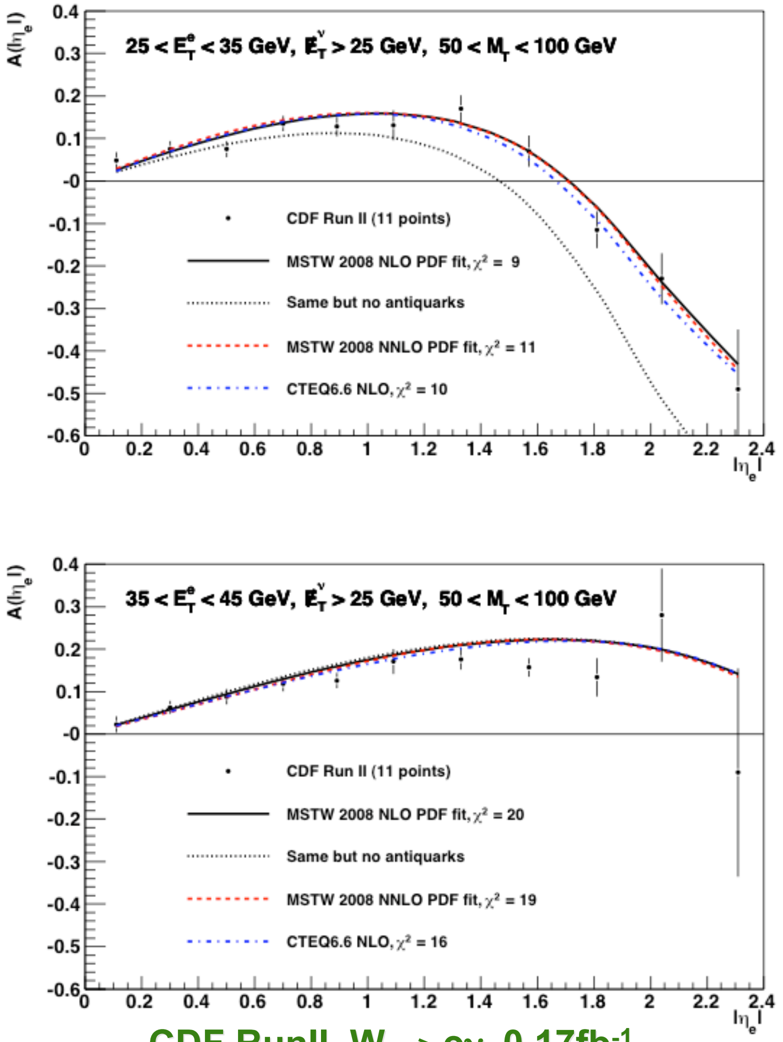
A.D. Martin, W.J. Stirling, R.S. Thorne, G. Watt: arXiv:0901.0002v1 [hep-ph]

DØ data on lepton charge asymmetry from W→μν decays



DØ RunII, W → $\mu\nu$, 0.3 fb^{-1}
PRD 77, 011106 (2008)

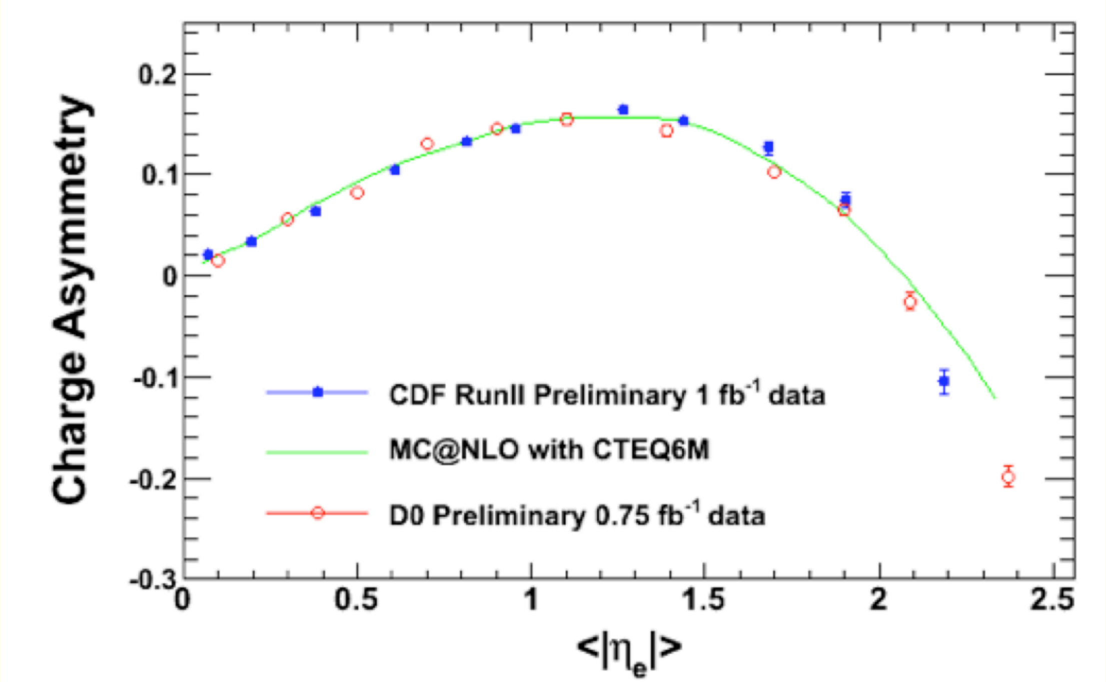
CDF data on lepton charge asymmetry from W→eν decays



CDF RunII, W → $e\nu$, 0.17fb^{-1}
PRD 71, 051104 (2005)

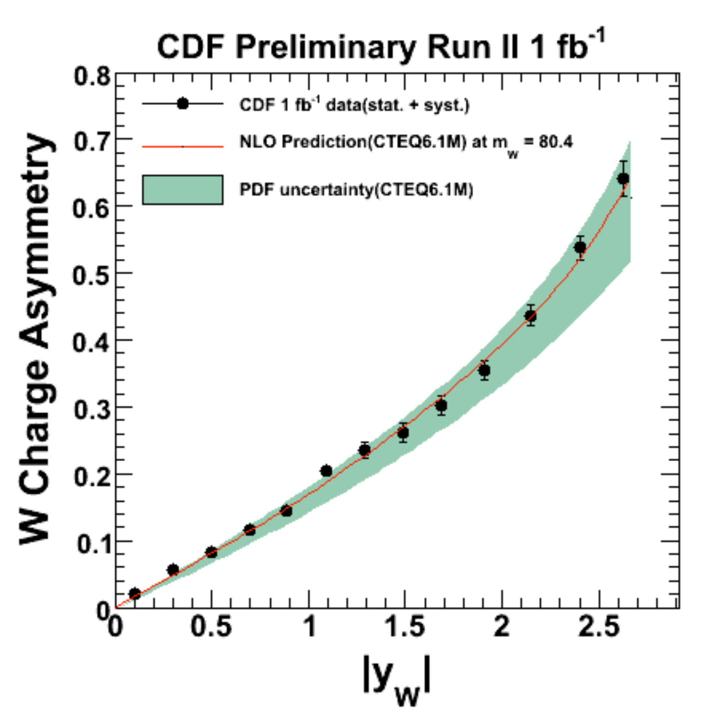
Comparison of latest CDF & DØ measurements

- Both latest CDF/DØ data should be providing improved d/u constraints but life is never that simple...



- Note:
  - CDF provides stat. only η_l data above for $1fb^{-1}$
  - Distributions not broken down in E_T bins
- For $0.8 < \eta_l < 2.0$: DØ data below CDF
- Investigation ongoing … **we are having a joint CDF + DØ workshop to get to the bottom of this soon.**

Conclusions



- First direct measurement of *W* charge asymmetry
  - despite additional complication of multiple solutions, it works!
  - appears that it will have impact on *d/u* of proton
- Compare to CTEQ6M (NLO) and MRST2006 (NNLO) PDFs and their uncertainties
- **Both experiments working with PDF fitting groups to incorporate results and understand differences**

Measurement: Phys. Rev. Lett. 102, 181801 (2009).

Thesis of B. Han: FERMILAB-THESIS-2008-15

Method: Phys. Rev. D 79, 031101(R) (2009).

Backup

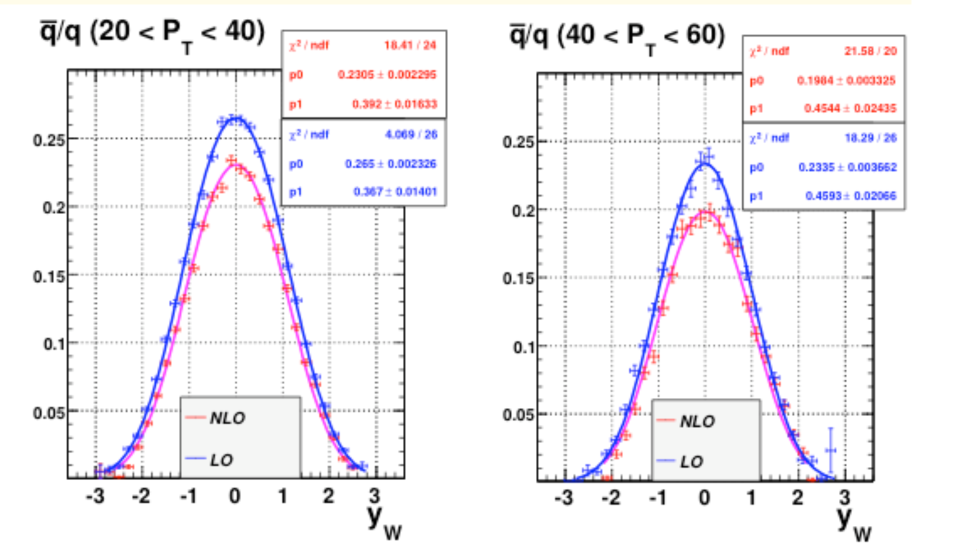
V-A Decay Distribution

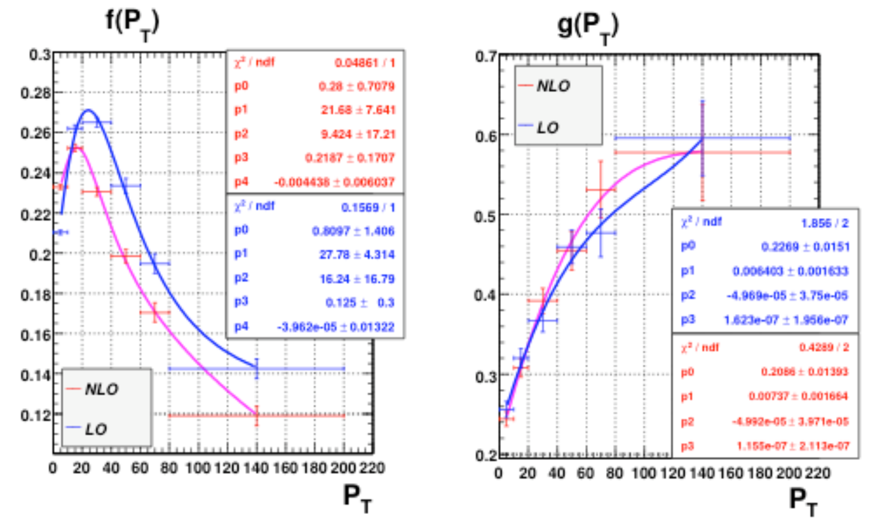
$$P_{\pm}(cos\theta^*, y_W, p_T^W) = (1 \mp cos\theta^*)^2 + Q(y_W, p_T^W)(1 \pm cos\theta^*)^2,$$

$$Q(y_W, p_T^W) = f(p_T^W)e^{-[g(p_T^W)*{y_W}^2+0.05*|{y_W}^3|]},$$

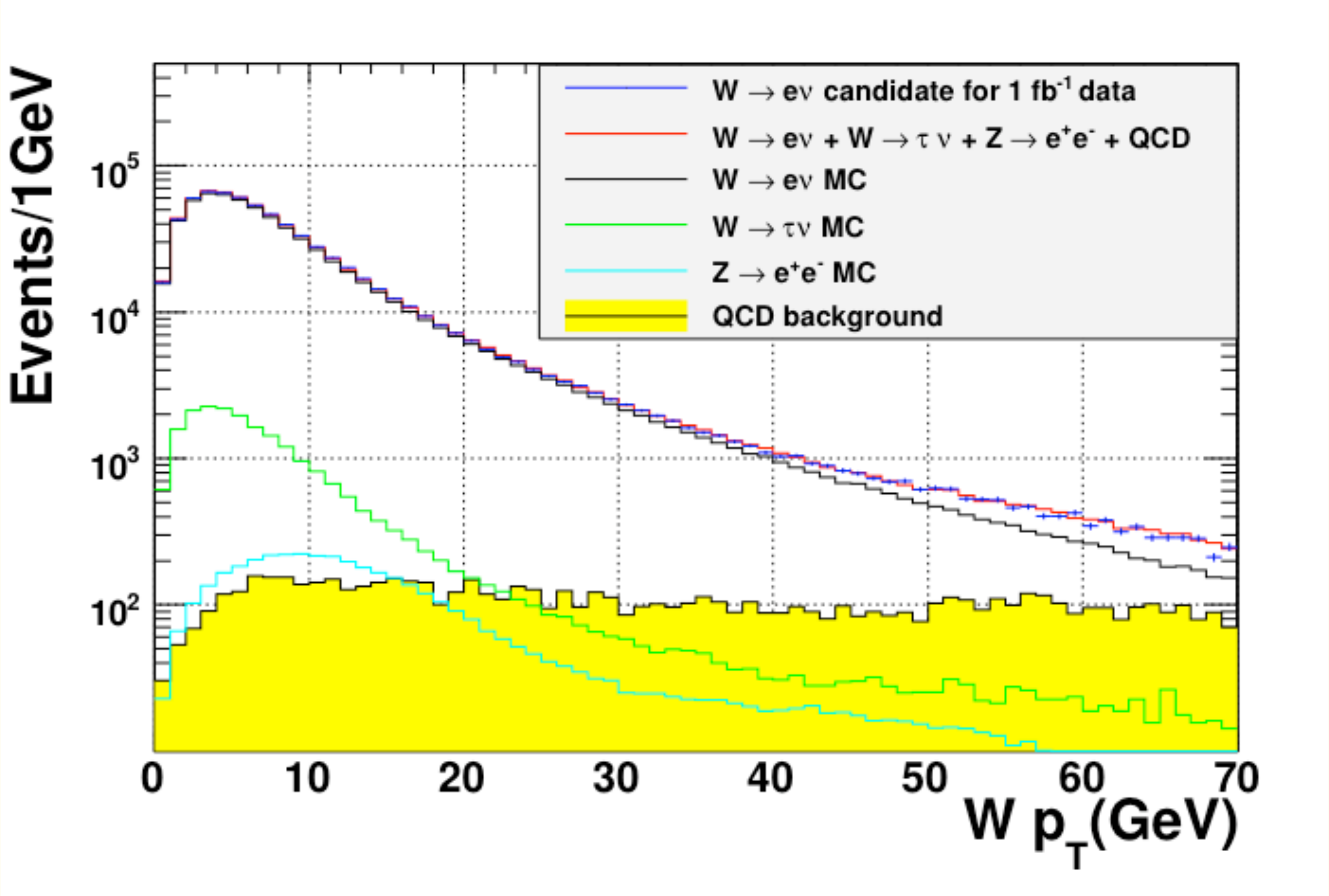
vhere the functions $f(p_T^W)$ and $g(p_T^W)$ are

$$\begin{aligned} f(p_T^W) &= 0.2811\mathcal{L}(p_T^W, \mu = 21.7\text{GeV}, \sigma = 9.458\text{GeV}) \\ &\quad +0.2185e^{(-0.04433\text{GeV}^{-1}p_T^W)}, \\ g(p_T^W) &= 0.2085 + 0.0074\text{GeV}^{-1}p_T^W \\ &\quad -5.051 \times 10^{-5}\text{GeV}^{-2}{p_T^W}^2 \\ &\quad +1.180 \times 10^{-7}\text{GeV}^{-3}{p_T^W}^3. \end{aligned}$$

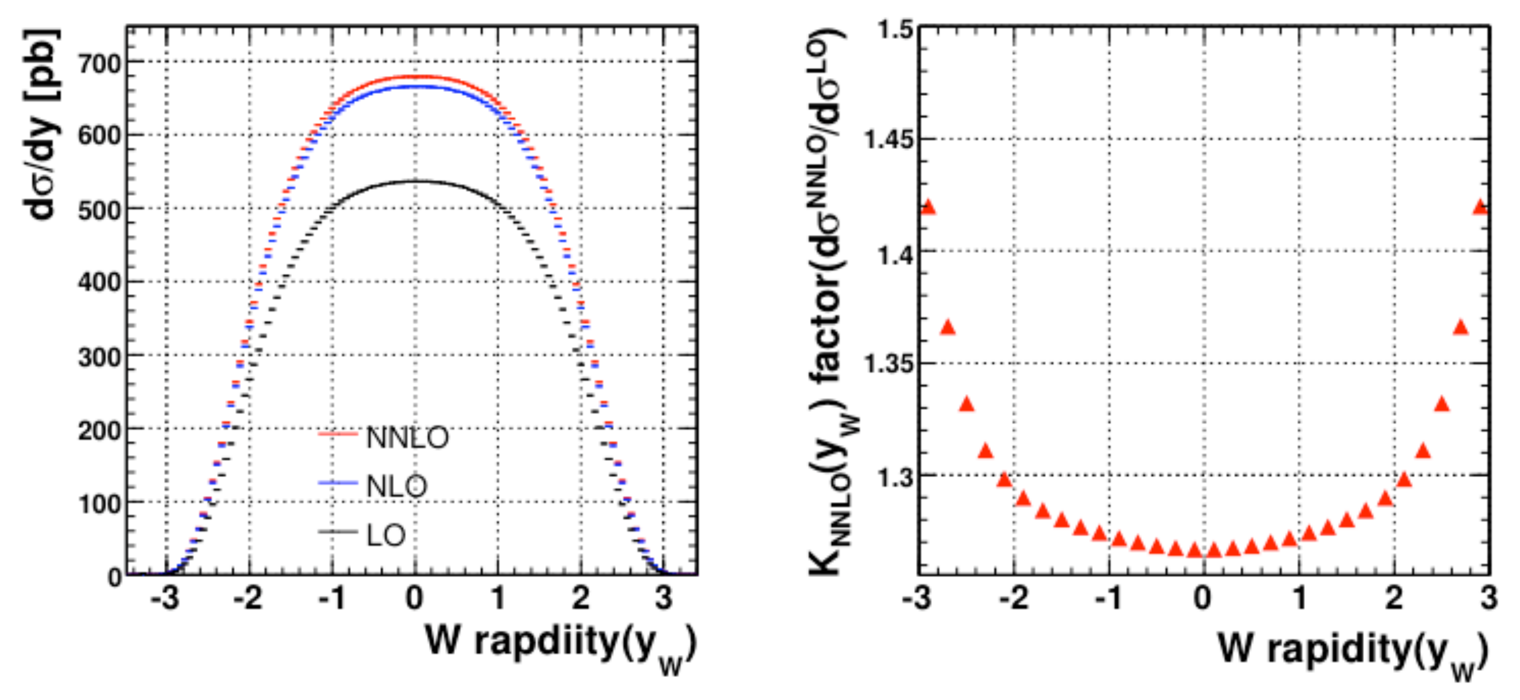




P_T W


Events/1GeV
10^5
10^4
10^3
10^2
0
10
20
30
40
50
60
70
W p_T(GeV)
W $\rightarrow$ eν candidate for 1 fb^{-1} data
W $\rightarrow$ eν + W $\rightarrow$ τ ν + Z $\rightarrow$ e^+e^- + QCD
W $\rightarrow$ eν MC
W $\rightarrow$ $\tau\nu$ MC
Z $\rightarrow$ e^+e^- MC
QCD background

K factor


dσ/dy [pb]
700
600
500
400
300
200
100
0
NNLO
NLO
LO
-3
-2
-1
0
1
2
3
W rapdiity(y_W)
K_NNLO(y_W) factor(dσ^NNLO/dσ^LO)
1.5
1.45
1.4
1.35
1.3
-3
-2
-1
0
1
2
3
W rapidity(y_W)

Tables

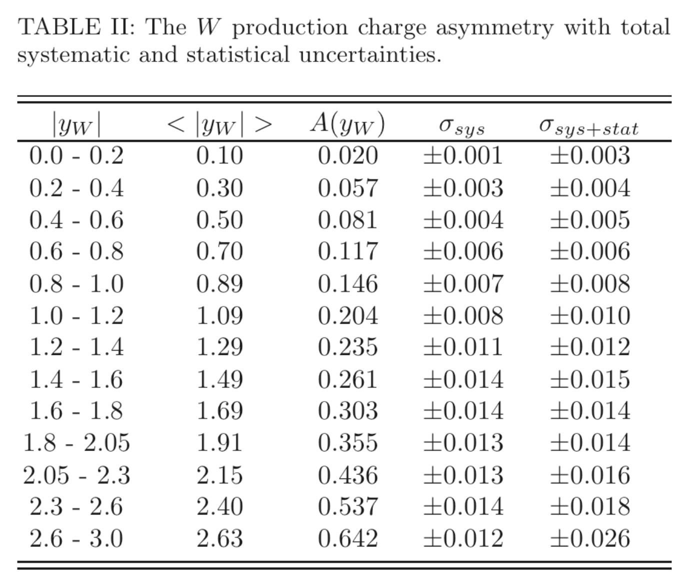


TABLE II: The W production charge asymmetry with total systematic and statistical uncertainties.

$\lvert y_W \rvert$	$< \lvert y_W \rvert >$	$A(y_W)$	σ_{sys}	$\sigma_{sys+stat}$
0.0 - 0.2	0.10	0.020	±0.001	±0.003
0.2 - 0.4	0.30	0.057	±0.003	±0.004
0.4 - 0.6	0.50	0.081	±0.004	±0.005
0.6 - 0.8	0.70	0.117	±0.006	±0.006
0.8 - 1.0	0.89	0.146	±0.007	±0.008
1.0 - 1.2	1.09	0.204	±0.008	±0.010
1.2 - 1.4	1.29	0.235	±0.011	±0.012
1.4 - 1.6	1.49	0.261	±0.014	±0.015
1.6 - 1.8	1.69	0.303	±0.014	±0.014
1.8 - 2.05	1.91	0.355	±0.013	±0.014
2.05 - 2.3	2.15	0.436	±0.013	±0.016
2.3 - 2.6	2.40	0.537	±0.014	±0.018
2.6 - 3.0	2.63	0.642	±0.012	±0.026

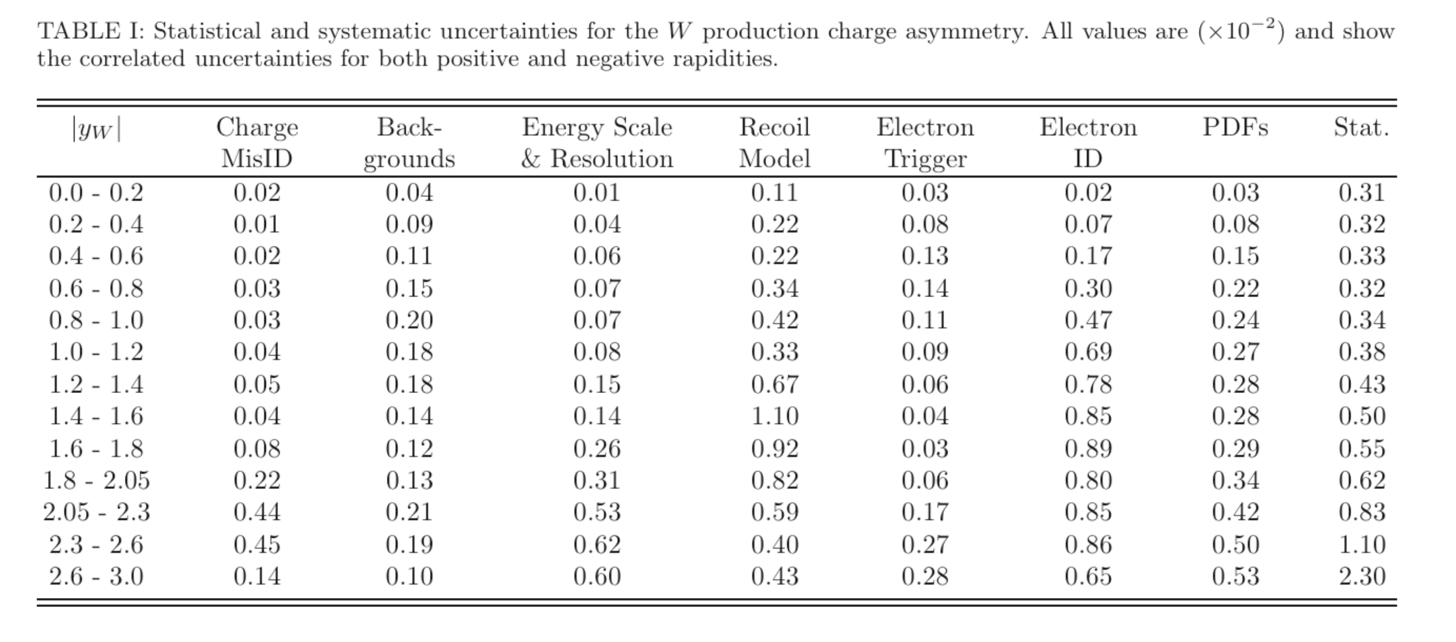
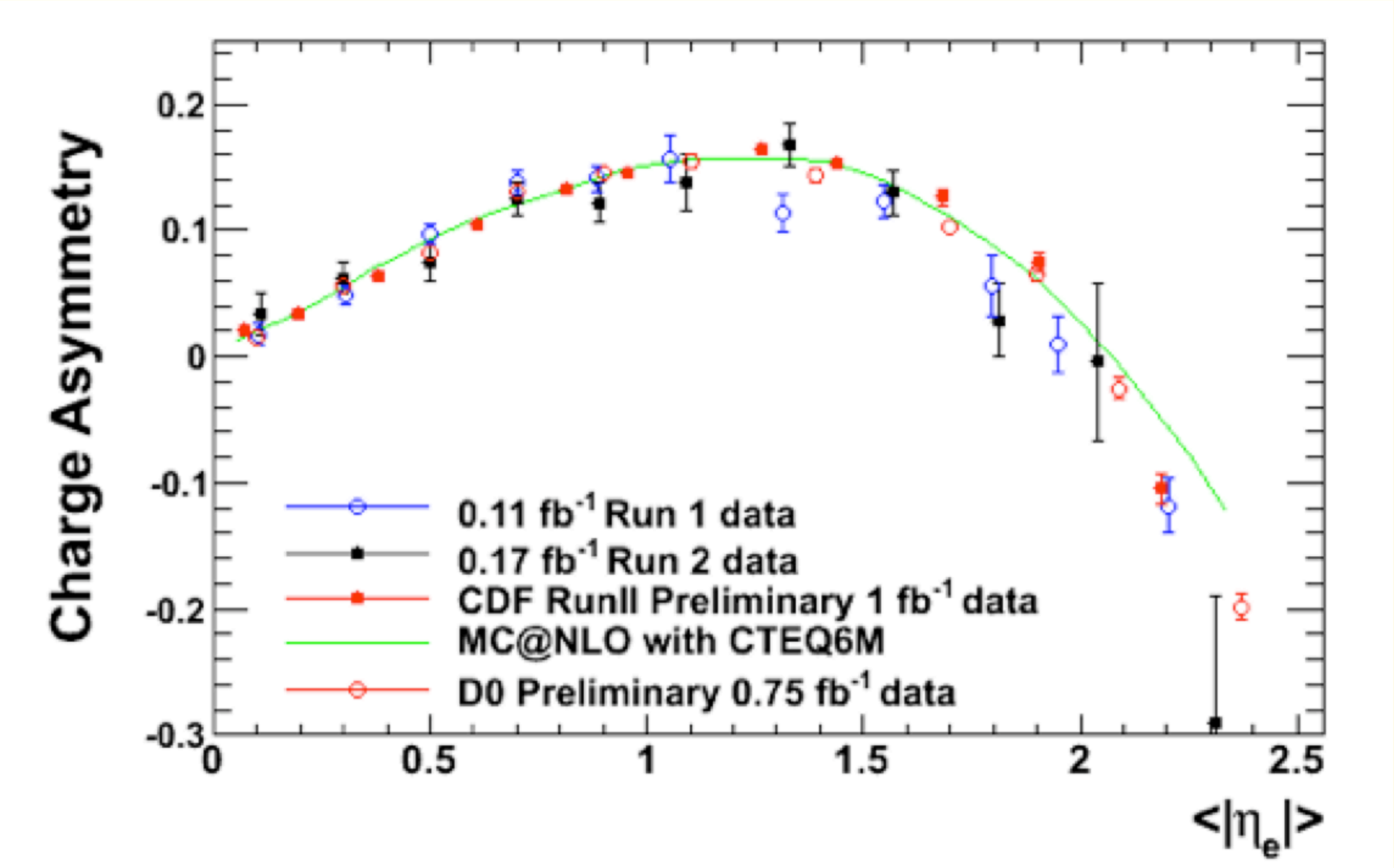


TABLE I: Statistical and systematic uncertainties for the W production charge asymmetry. All values are $(\times 10^{-2})$ and show the correlated uncertainties for both positive and negative rapidities.

$\lvert y_W \rvert$	Charge MisID	Back-grounds	Energy Scale & Resolution	Recoil Model	Electron Trigger	Electron ID	PDFs	Stat.
0.0 - 0.2	0.02	0.04	0.01	0.11	0.03	0.02	0.03	0.31
0.2 - 0.4	0.01	0.09	0.04	0.22	0.08	0.07	0.08	0.32
0.4 - 0.6	0.02	0.11	0.06	0.22	0.13	0.17	0.15	0.33
0.6 - 0.8	0.03	0.15	0.07	0.34	0.14	0.30	0.22	0.32
0.8 - 1.0	0.03	0.20	0.07	0.42	0.11	0.47	0.24	0.34
1.0 - 1.2	0.04	0.18	0.08	0.33	0.09	0.69	0.27	0.38
1.2 - 1.4	0.05	0.18	0.15	0.67	0.06	0.78	0.28	0.43
1.4 - 1.6	0.04	0.14	0.14	1.10	0.04	0.85	0.28	0.50
1.6 - 1.8	0.08	0.12	0.26	0.92	0.03	0.89	0.29	0.55
1.8 - 2.05	0.22	0.13	0.31	0.82	0.06	0.80	0.34	0.62
2.05 - 2.3	0.44	0.21	0.53	0.59	0.17	0.85	0.42	0.83
2.3 - 2.6	0.45	0.19	0.62	0.40	0.27	0.86	0.50	1.10
2.6 - 3.0	0.14	0.10	0.60	0.43	0.28	0.65	0.53	2.30

Lepton charge asymmetry comparison



Comparison of latest CDF & DØ measurements

- DØ lepton asymmetry implies a lower W Asymmetry and a larger difference from MRST2006NLO than implied by the CDF data
- Plot from R. Thorne:
  - NLO fit without DØ fits CDF OK

  or
  - NLO fit to weighted DØ is below CDF

  (for one specific W Asymmetry for DØ that will fit the DØ data)
- From this comparison, CDF/DØ inconsistency appears significant
- Investigation ongoing:
  - backgrounds, cut consistency, E_T/MET scale, smearing, charge mis-id, etc.