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Measurements of lepton & W charge asymmetry with the D0 detector

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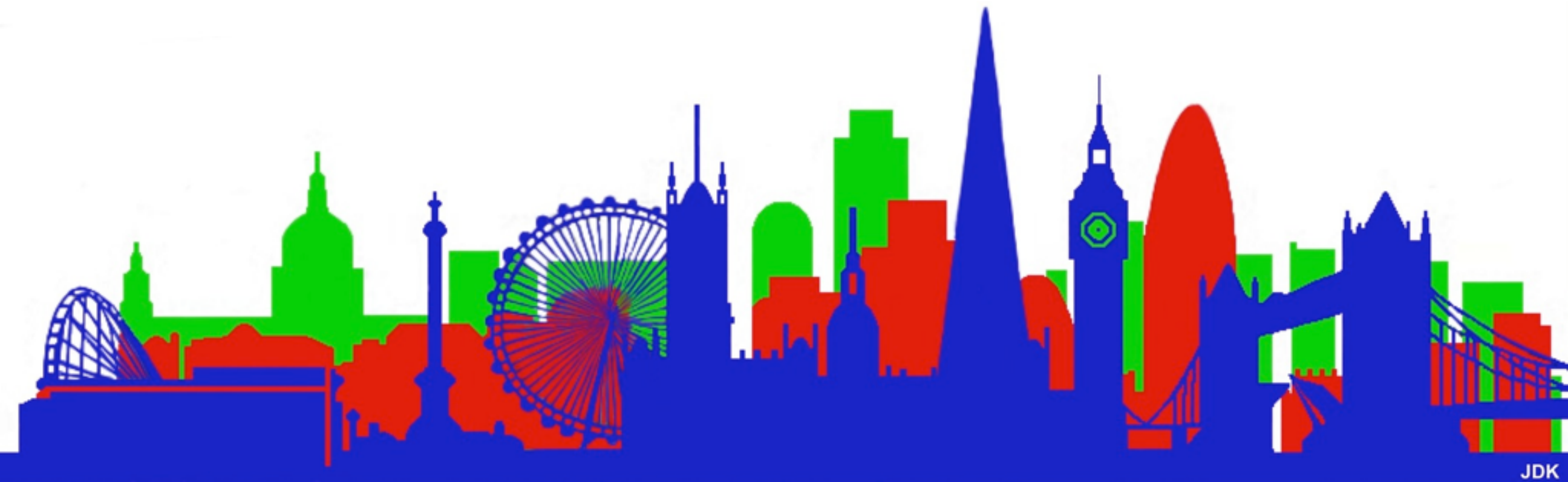
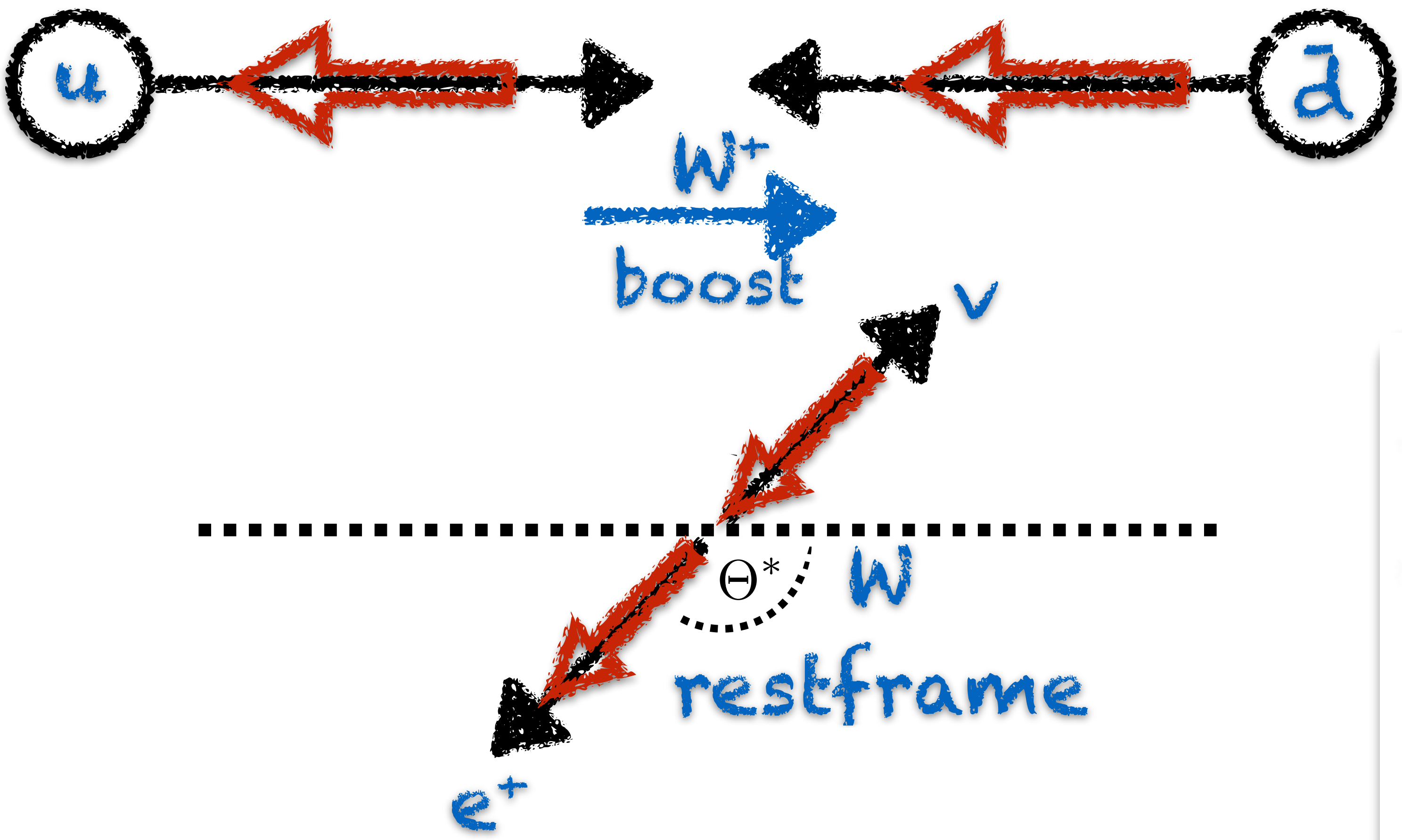
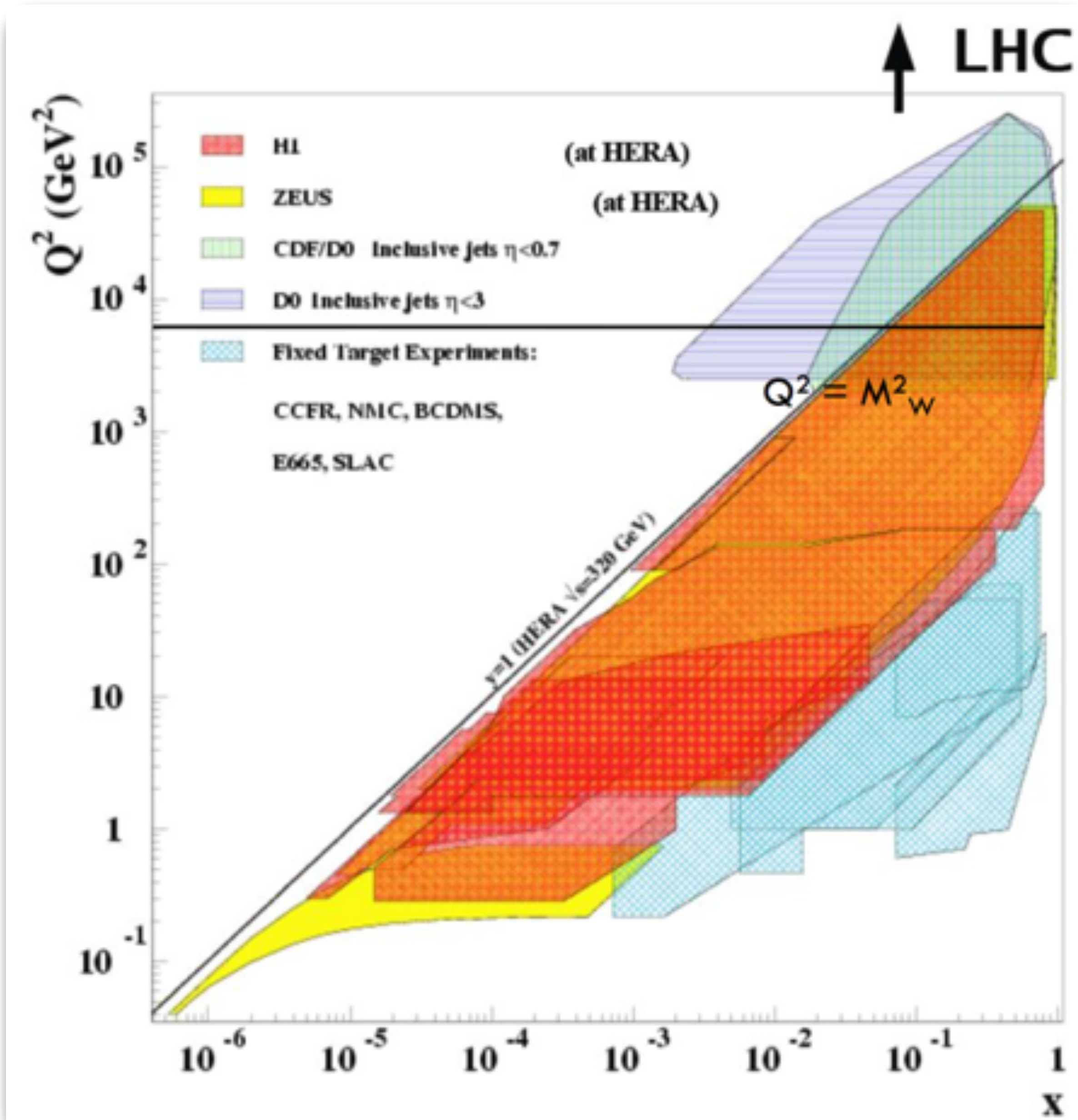


W asymmetry in p-pbar collisions

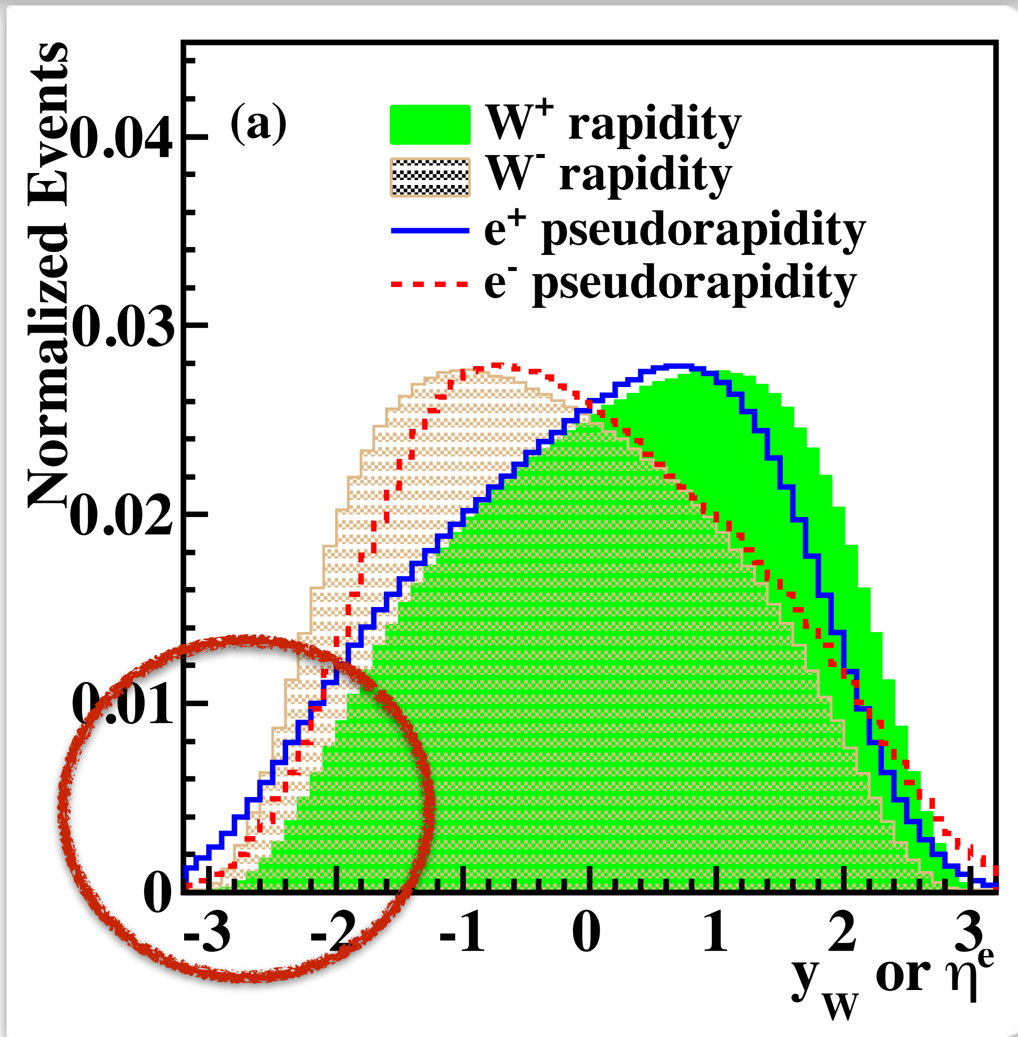


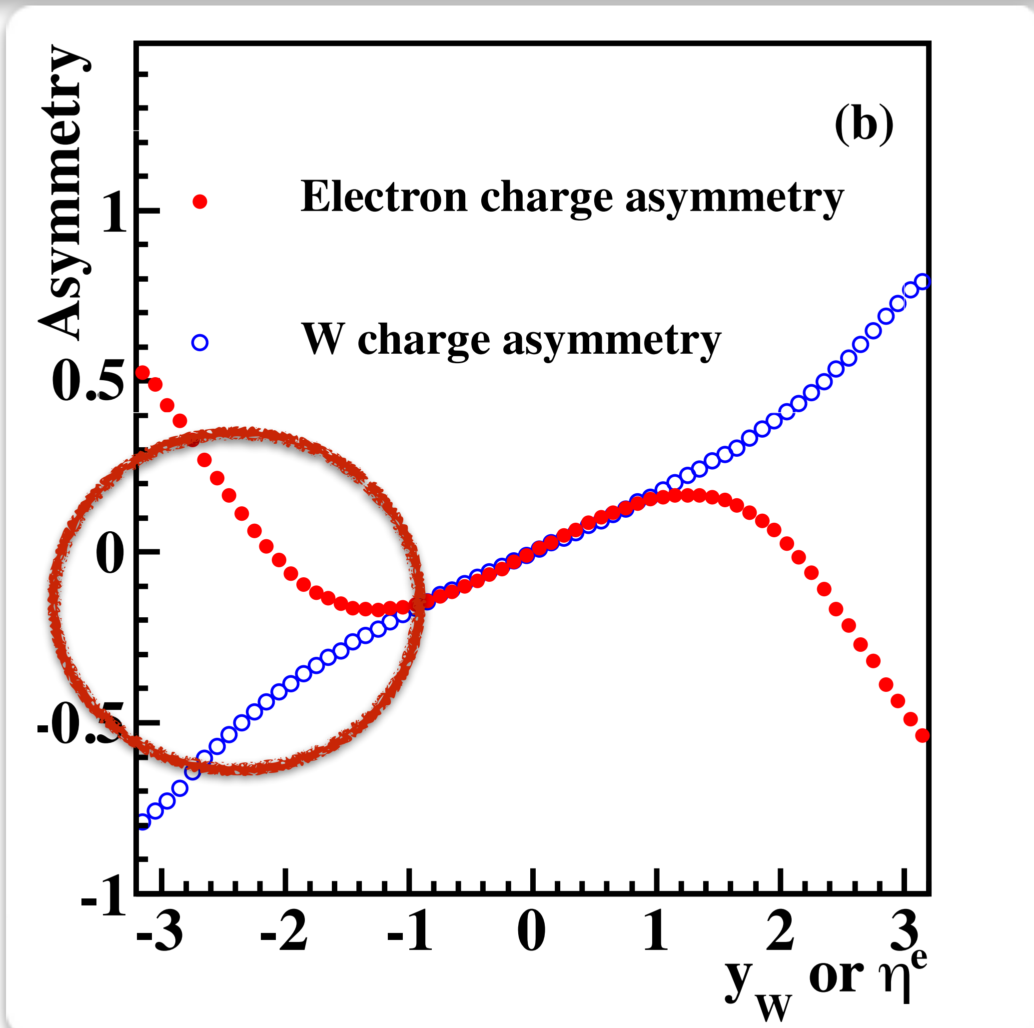
- U-quark more momentum than d quark → W^+ boosted in p direction (corresponding for anti-particles)



- Yields information for valence-quarks for wide range of x and high Q^2
- In corresponding LHC measurement W produced from sea quarks/gluons
  - Atlas:1109.5141
  - CMS:1103.3470, 1312.6283

Two Methods





- Traditional: lepton rapidity

$$A(\eta^e) = \frac{N^{e^+}(\eta^e) - N^{e^-}(\eta^e)}{N^{e^+}(\eta^e) + N^{e^-}(\eta^e)}$$

- W boson asymmetry and V-A structure convoluted

- New: W rapidity

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

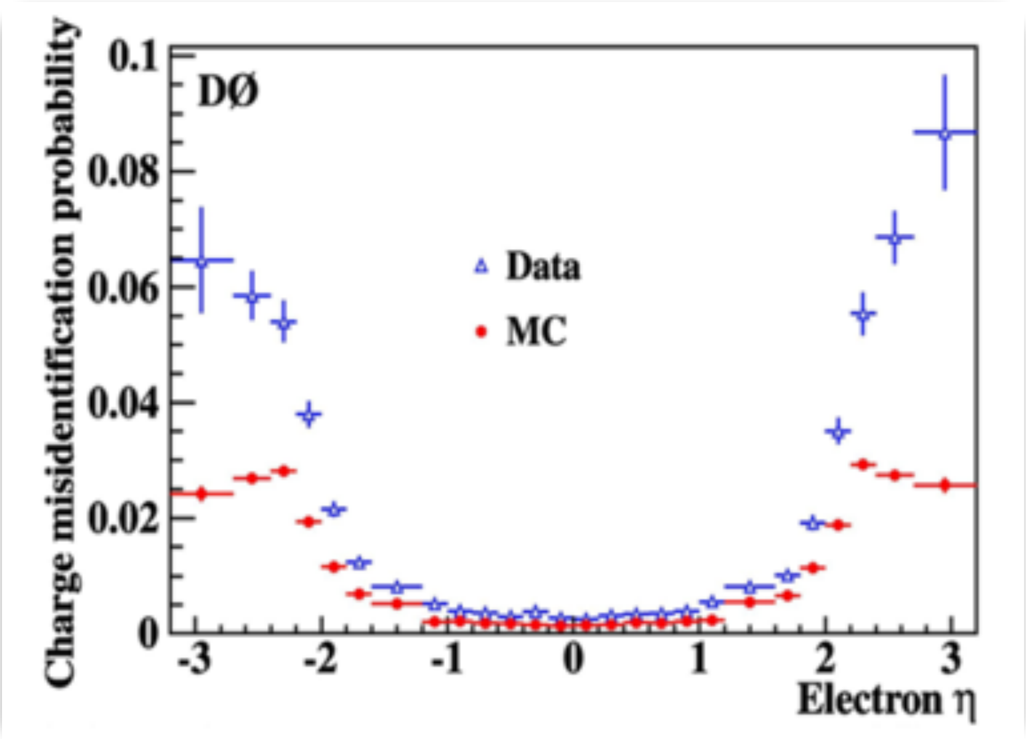
- Requires some creativity due to missing p_z^ν

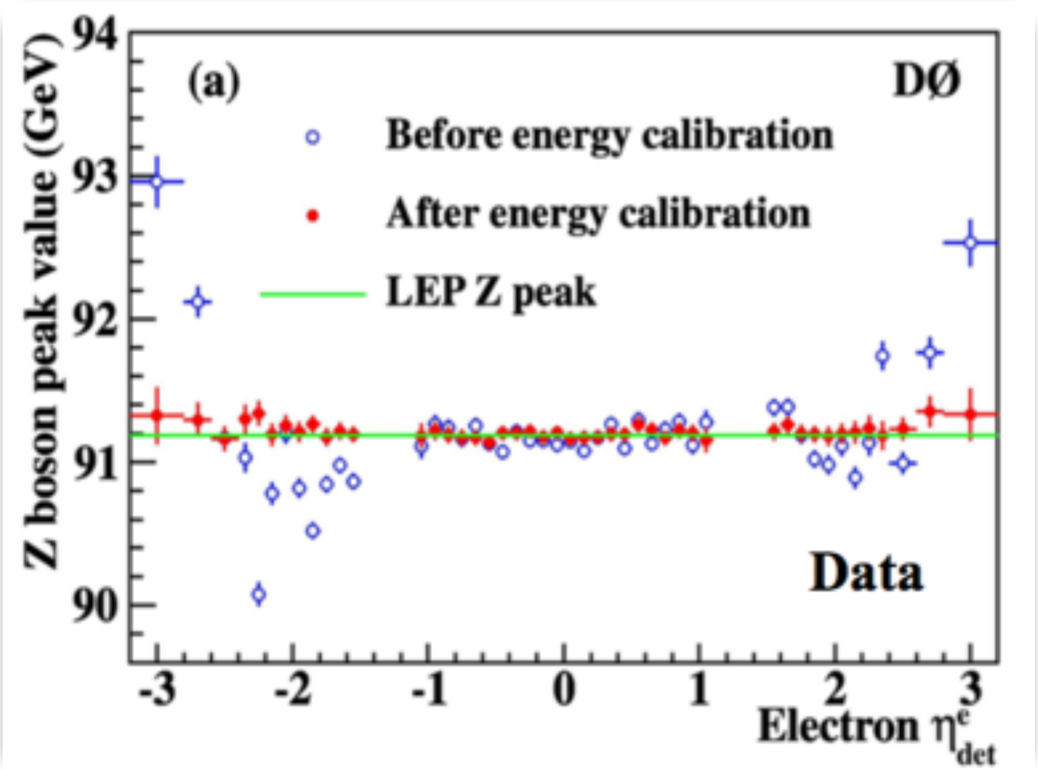
General Selection

- Using full Run II dataset: $9.7 fb^{-1}$
- Require exactly one electron
  - One triggered, good electron in calorimeter
  - $\eta(e) < |1.1|$ or $|1.5| < \eta_e < |3.2|$
  - $25 < p_T(e) < 100$ GeV,
  - $E^T_{miss} > 25$ GeV
  - $50 < m(W) < 130$ GeV
- Additional selections include restrictions on the z vertex range, recoil and total calorimeter activity etc
- Backgrounds include QCD, $W \rightarrow \tau\nu$, $Z \rightarrow ee$, $Z \rightarrow \tau\tau$,
  - Largest background is QCD (4%),no charge asymmetry
- Efficiency corrections: charge mis-ID, electron energy scale, trigger, hadronic response, electron ID efficiency, etc.

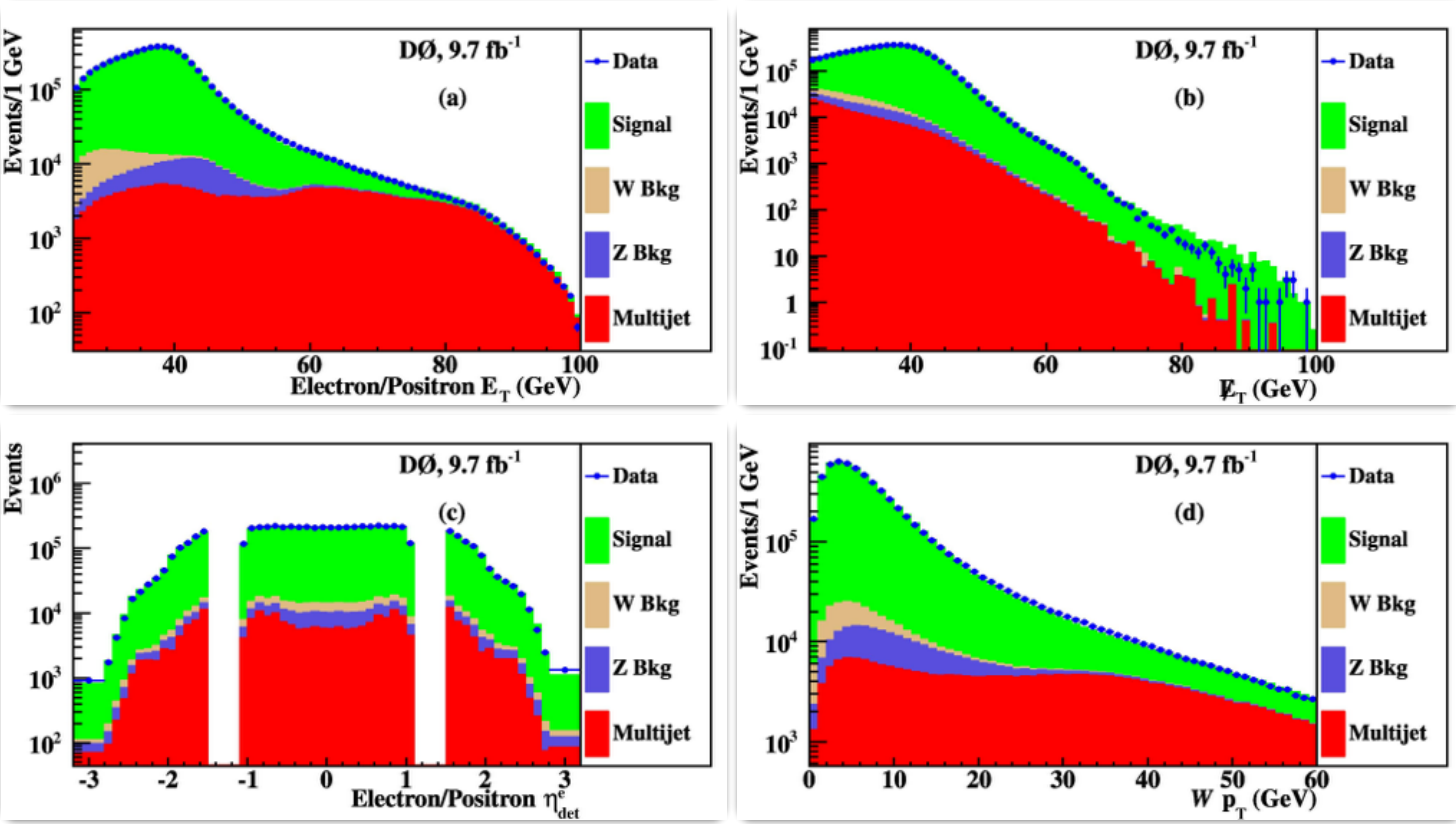
Corrections

- **Charge mis-ID:**
  Tag and probe method with Z→ee
  - Function of η and p_T(e)
  - Similar efficiency in data and MC (central)
  - If necessary correct MC to match data (forward)
- **Electron energy:**
  - Use Z events to perform 'in situ' calibration
  - Compare to LEP value and fit for correction parameters iteratively
  - Lepton η, luminosity and calorimeter scalar E_T dependencies





Example Distributions



Reasonable Agreement

Lepton Asymmetry Details

- If the W+ and W- efficiencies and acceptances are similar, we can approximate

$$A(\eta^e) = \frac{N^{e^+}(\eta^e) - N^{e^-}(\eta^e)}{N^{e^+}(\eta^e) + N^{e^-}(\eta^e)}$$

- Perform unfolding to remove detector effects and compare with generator level
  - considering electron selection efficiencies, luminosity, and event acceptance
- 5 bins, for electron p_T and/or E_T^{miss} thresholds of 25 and 35 GeV (symmetric and asymmetric bins)

Uncertainties

- Variety of systematics considered: 1-20% for increasing η
  modeling, selection efficiencies, corrections, unfolding

η^e	Gen	EMID	$K_{\text{eff}}^{q,p}$	Energy	Recoil	Model	Bkgs	Q_{mis}	Unfolding	Total
0.0 – 0.2	0.06	0.02	0.20	0.03	0.04	0.28	0.26	0.54	0.82	1.08
0.2 – 0.4	0.06	0.18	0.10	0.18	0.26	0.75	0.54	0.56	0.81	1.40
0.4 – 0.6	0.12	0.24	0.27	0.25	0.35	1.05	0.87	0.59	0.80	1.79
0.6 – 0.8	0.07	0.34	0.04	0.34	0.49	1.32	1.81	0.60	0.80	2.55
0.8 – 1.0	0.12	0.36	0.12	0.36	0.53	1.72	2.37	0.76	0.85	3.23
1.0 – 1.2	0.09	0.37	0.47	0.37	0.55	2.42	2.71	1.20	1.17	4.10
1.2 – 1.6	0.03	0.42	0.64	0.39	0.58	4.10	3.94	1.67	1.04	6.11
1.6 – 1.8	0.11	0.28	0.18	0.22	0.34	4.26	1.37	1.53	0.95	4.85
1.8 – 2.0	0.34	0.36	1.07	0.05	0.10	4.21	1.43	2.46	1.13	5.34
2.0 – 2.2	0.37	0.36	1.38	0.04	0.07	3.33	1.75	4.37	1.47	6.14
2.2 – 2.4	0.19	0.30	2.78	0.02	0.05	3.40	1.54	7.15	1.93	8.76
2.4 – 2.7	0.21	0.43	5.54	0.29	0.48	4.24	2.16	8.65	2.36	11.6
2.7 – 3.2	0.05	0.87	9.00	0.81	1.30	3.48	3.99	18.9	5.48	22.3

- Example: symmetric selection E_T^{miss}>25 GeV, E_T>25 GeV

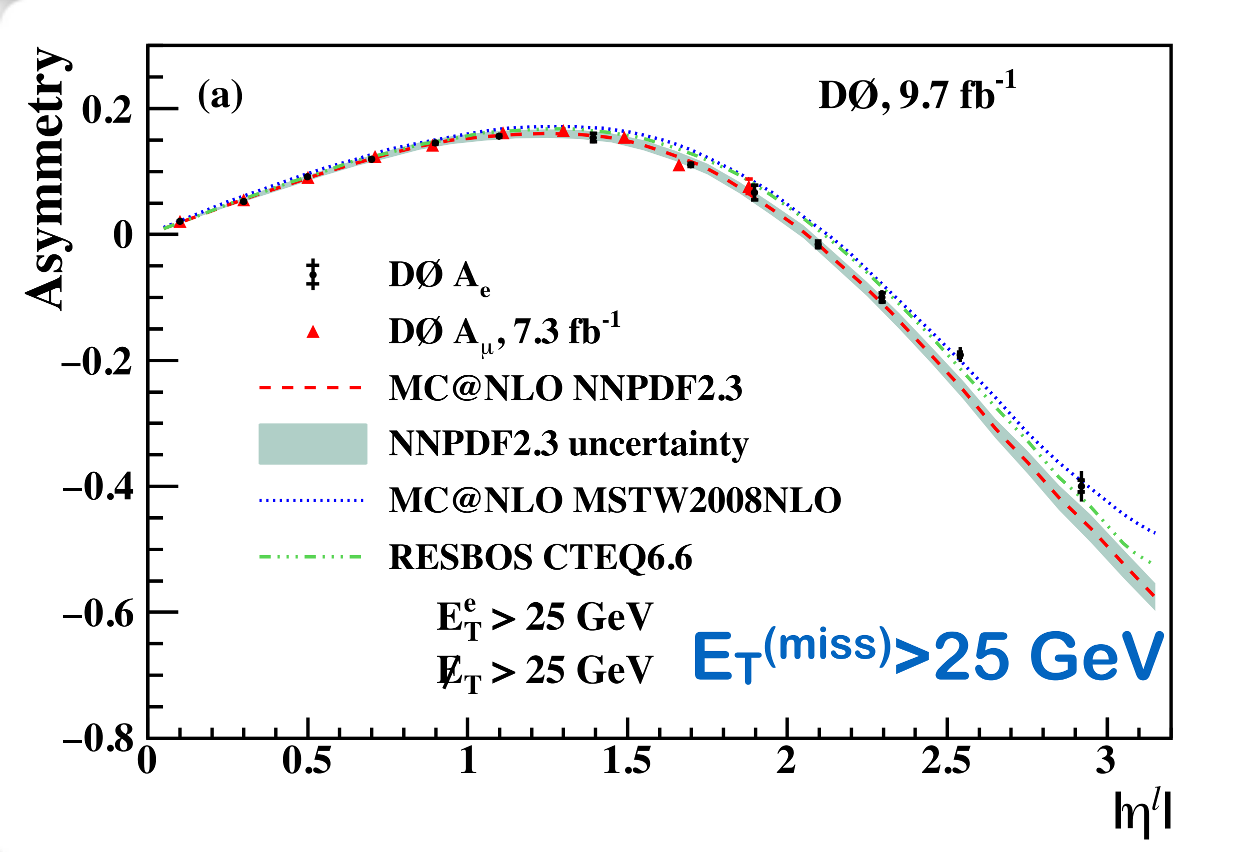
Results

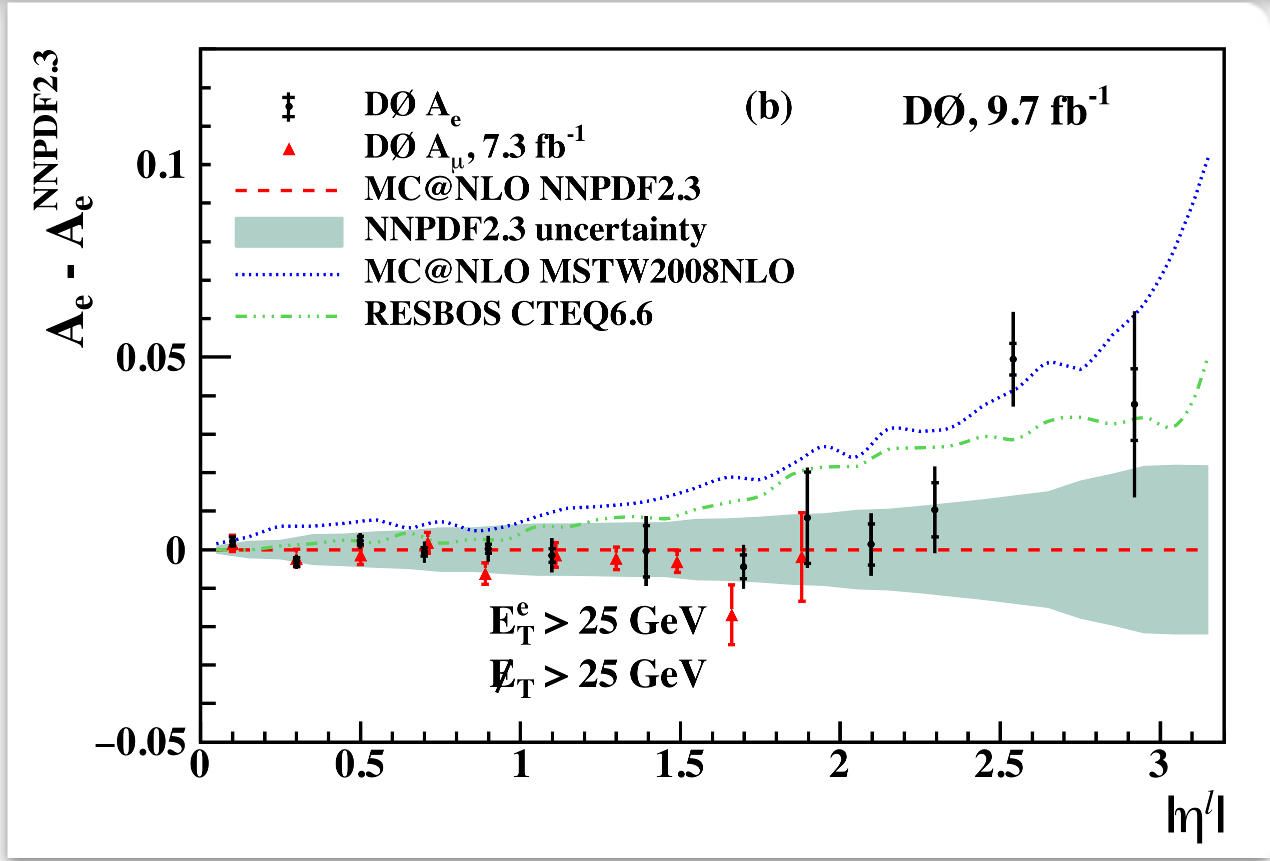
- Results shown in detailed tables for each η-bin and selection

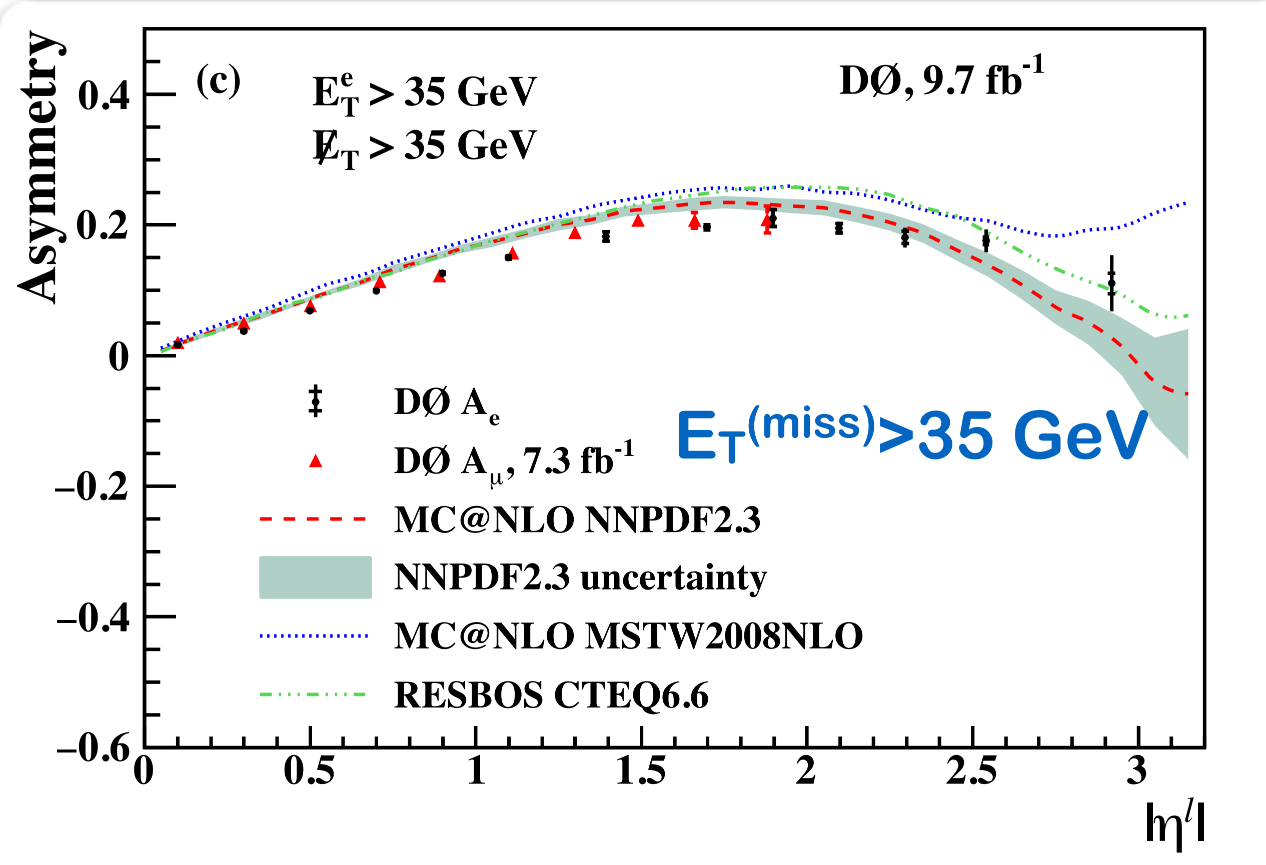
$\langle\|\eta^e\|\rangle$	$25 < E_T^e < 35$ GeV, $\not{E}_T > 25$ GeV		$25 < E_T^e < 35$ GeV, $25 < \not{E}_T < 35$ GeV	
	Data	Prediction	Data	Prediction
0.10	$2.32 \pm 0.16 \pm 0.24$	2.47 ± 0.21	$2.30 \pm 0.19 \pm 0.27$	2.07 ± 0.24
0.30	$6.36 \pm 0.15 \pm 0.24$	7.18 ± 0.38	$6.93 \pm 0.18 \pm 0.28$	6.04 ± 0.51
0.50	$10.53 \pm 0.15 \pm 0.27$	11.26 ± 0.60	$11.31 \pm 0.17 \pm 0.31$	9.00 ± 0.78
0.70	$12.60 \pm 0.14 \pm 0.28$	14.73 ± 0.73	$12.97 \pm 0.17 \pm 0.31$	11.55 ± 0.98
0.90	$14.58 \pm 0.16 \pm 0.30$	17.10 ± 0.80	$14.92 \pm 0.18 \pm 0.32$	12.44 ± 1.02
1.10	$14.11 \pm 0.23 \pm 0.39$	17.36 ± 0.87	$13.85 \pm 0.27 \pm 0.44$	10.98 ± 1.14
1.39	$9.95 \pm 0.74 \pm 0.38$	13.74 ± 0.87	$6.63 \pm 0.88 \pm 0.45$	3.78 ± 1.17
1.70	$-1.40 \pm 0.44 \pm 0.34$	3.24 ± 0.94	$-7.99 \pm 0.51 \pm 0.40$	-12.19 ± 1.24
1.90	$-12.70 \pm 1.72 \pm 0.54$	-8.31 ± 0.98	$-21.85 \pm 1.70 \pm 0.65$	-27.66 ± 1.23
2.10	$-28.36 \pm 0.76 \pm 0.78$	-21.63 ± 1.09	$-40.05 \pm 0.85 \pm 0.95$	-42.94 ± 1.28
2.30	$-41.27 \pm 0.93 \pm 1.04$	-33.54 ± 1.15	$-52.93 \pm 1.00 \pm 1.17$	-53.65 ± 1.27
2.54	$-50.86 \pm 0.48 \pm 1.26$	-44.33 ± 1.32	$-59.43 \pm 0.49 \pm 1.51$	-61.49 ± 1.38
2.92	$-60.00 \pm 1.04 \pm 2.75$	-55.99 ± 2.05	$-64.68 \pm 1.07 \pm 2.94$	-69.79 ± 2.13

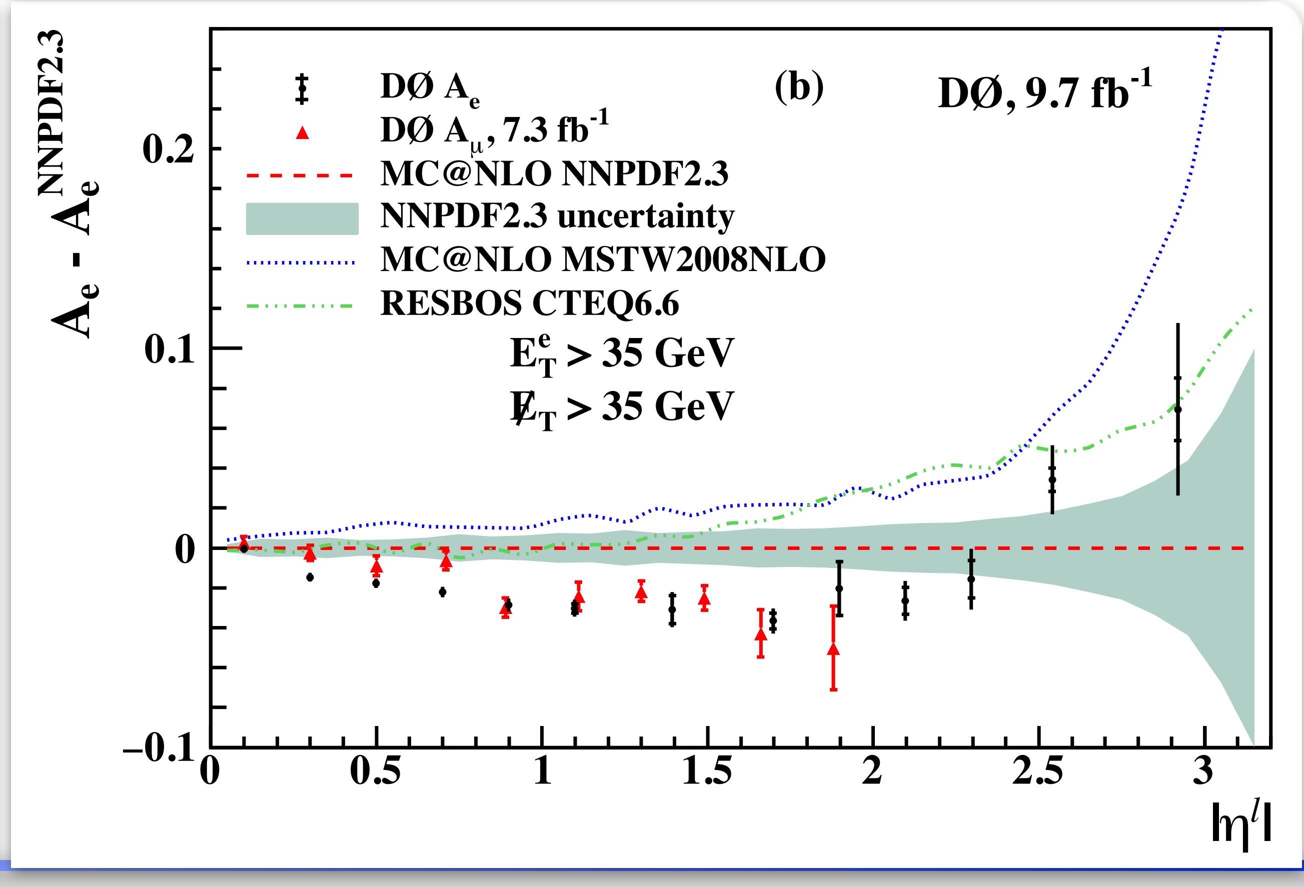
- **Predictions from MC@NLO + NNPDF2.3**

Results Symmetric Selections

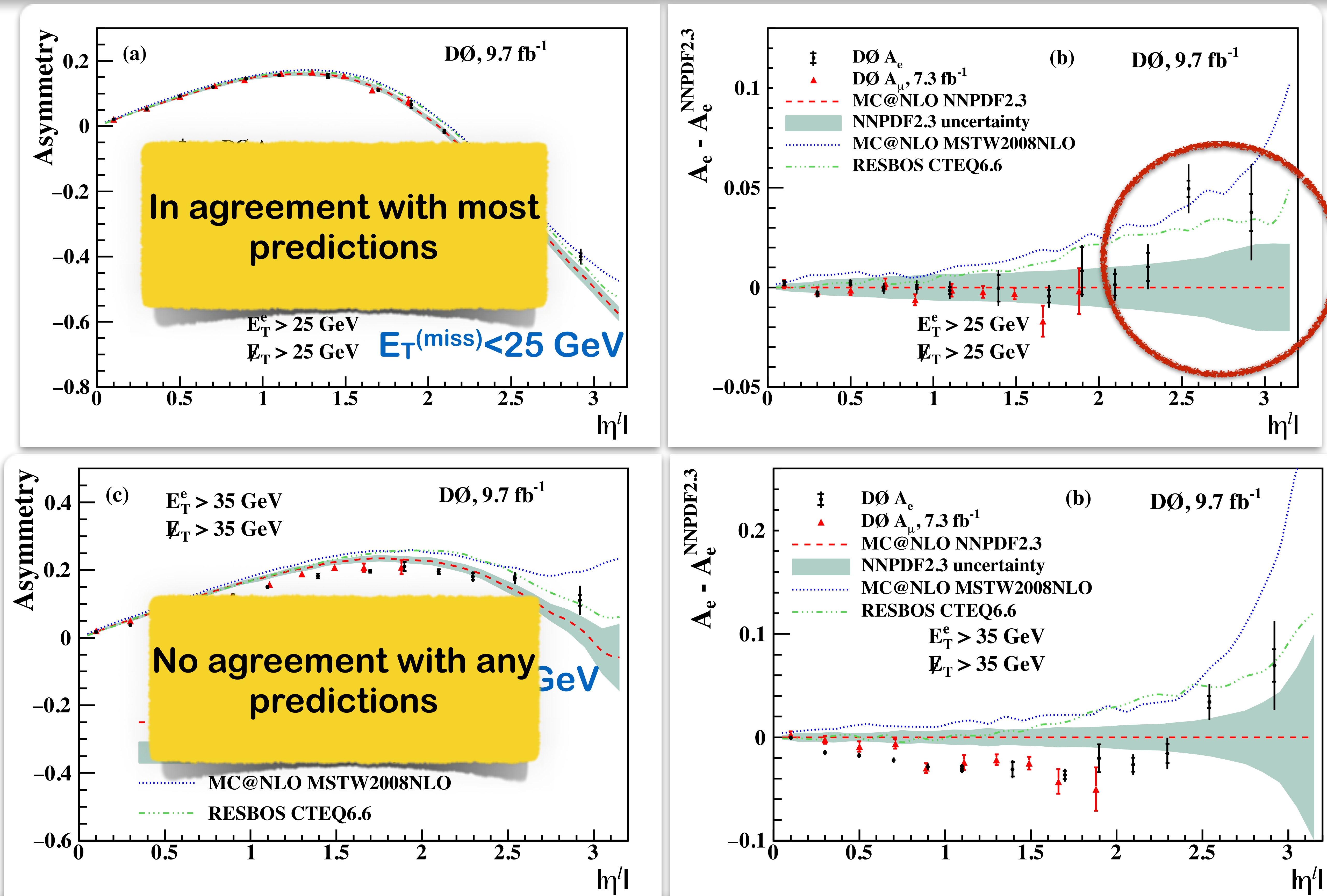








Results Symmetric Selections

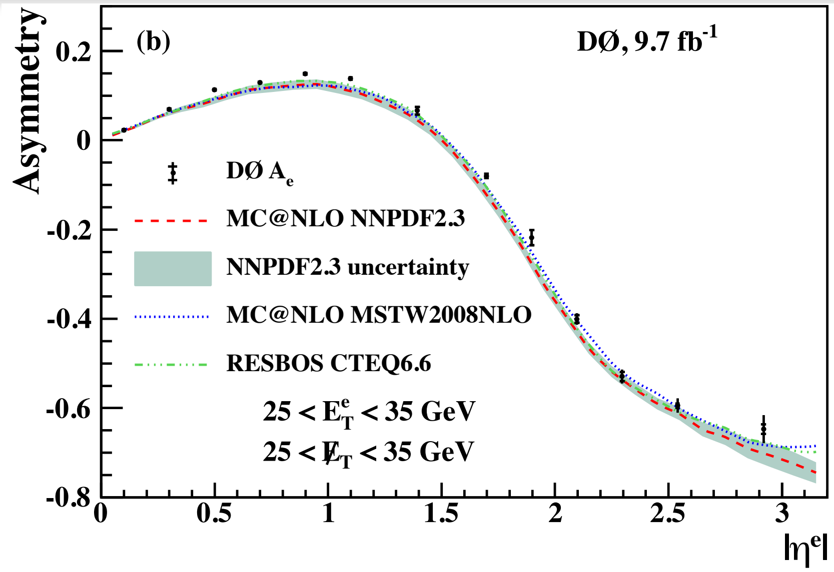


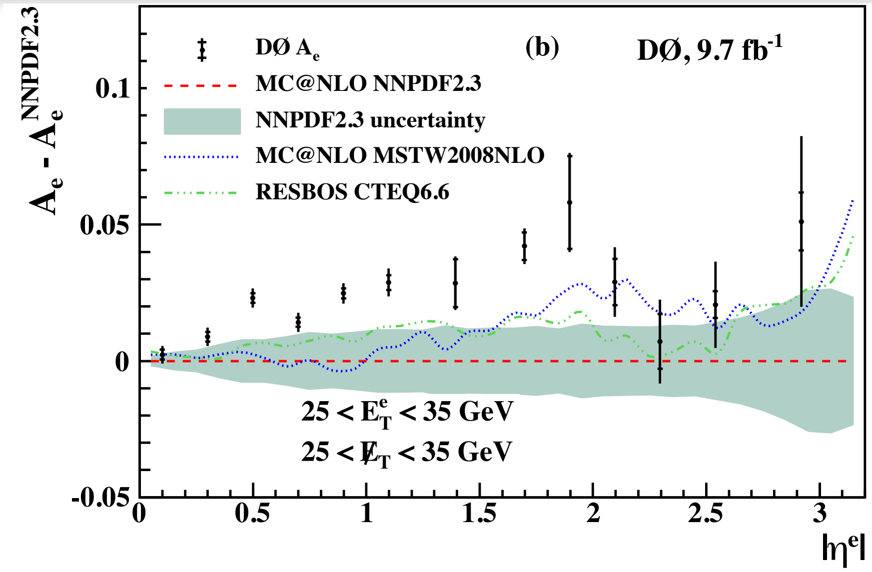
In agreement with most predictions

No agreement with any predictions

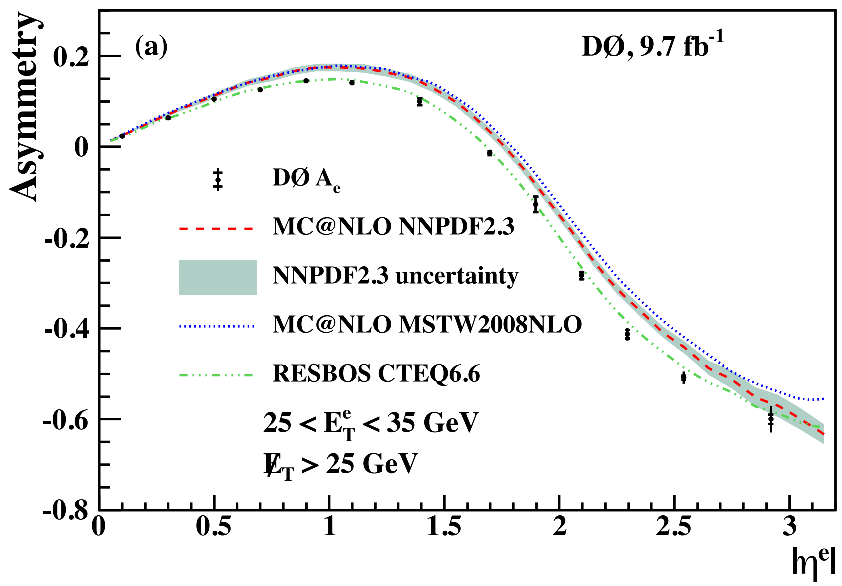
Results Asymmetric Selections

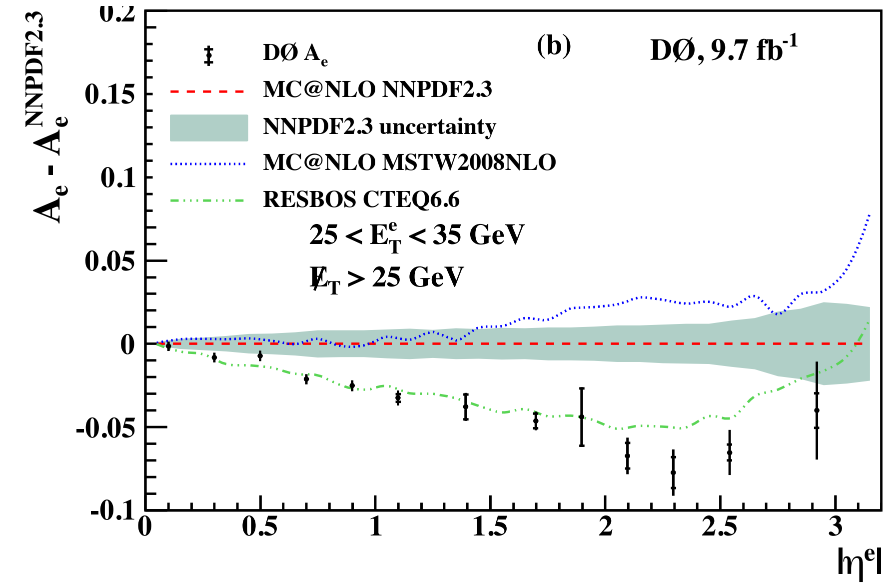
25< $E_T^{(miss)}$<35



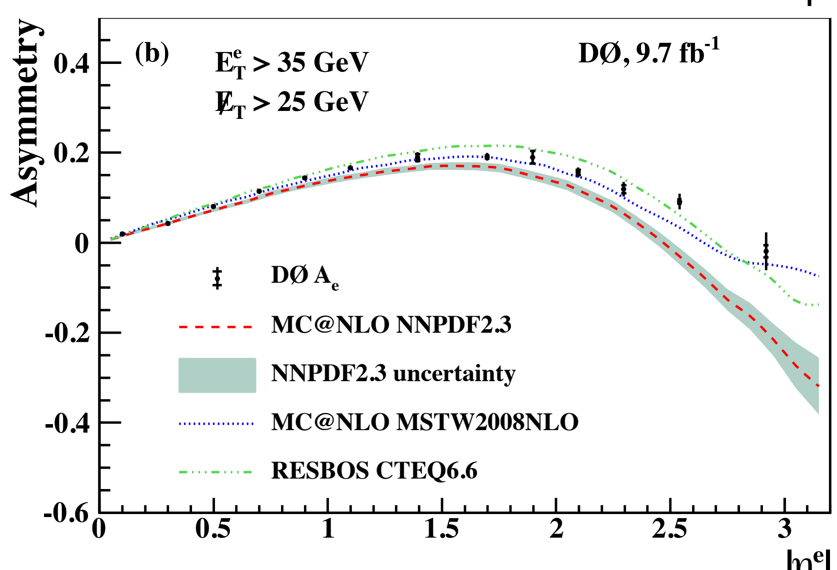


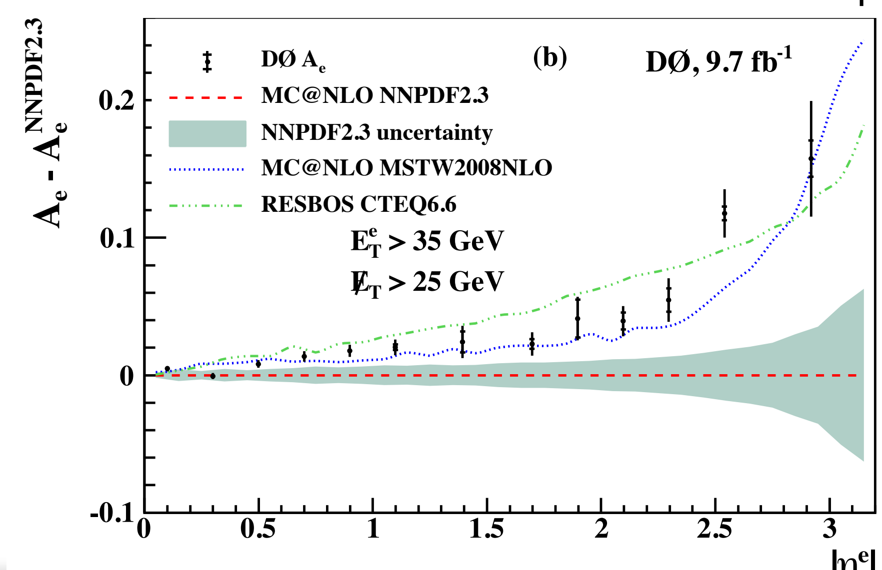
25< E_T<35
E_T^{miss}>25





E_T>35
E_T^{miss}>25





Results Asymmetric Selections

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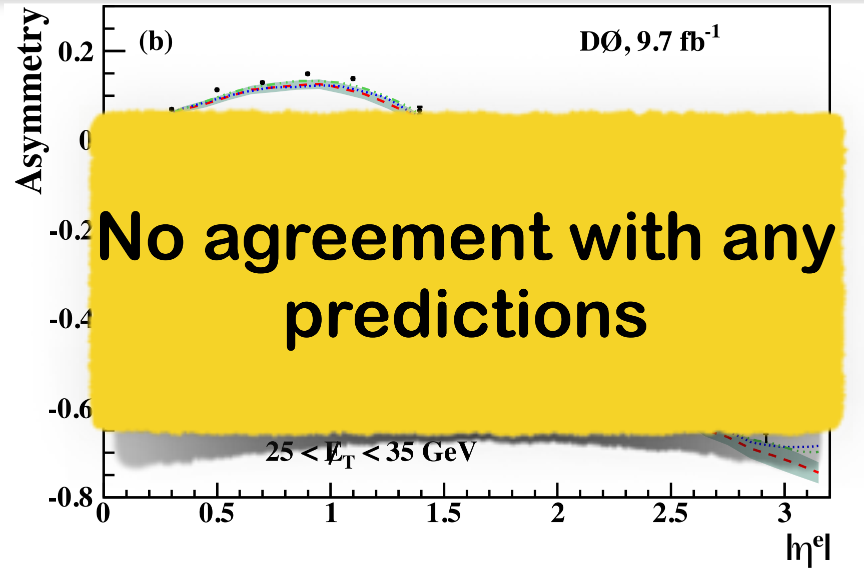
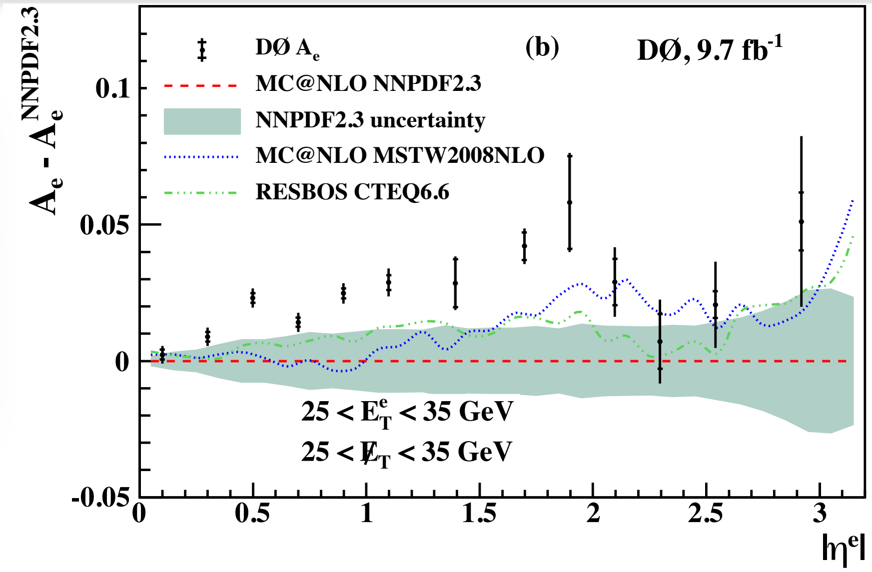
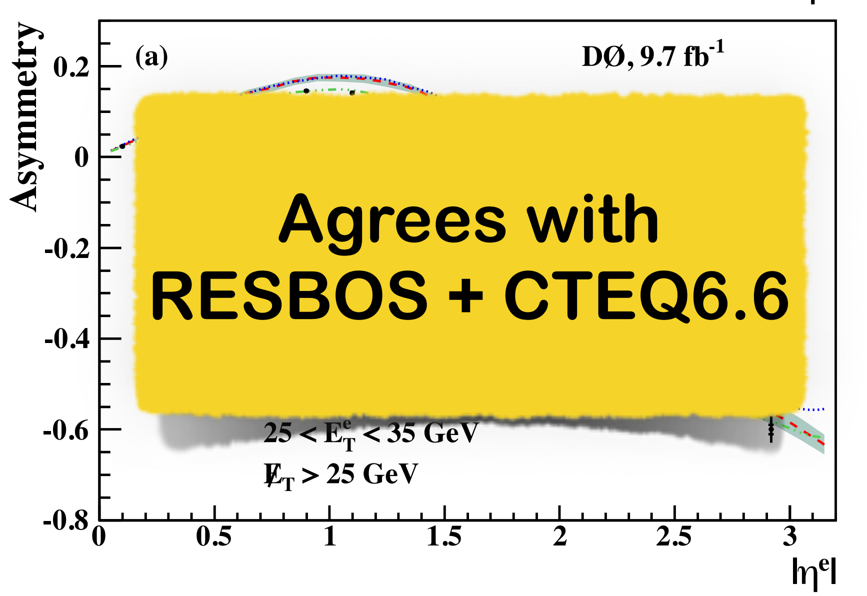


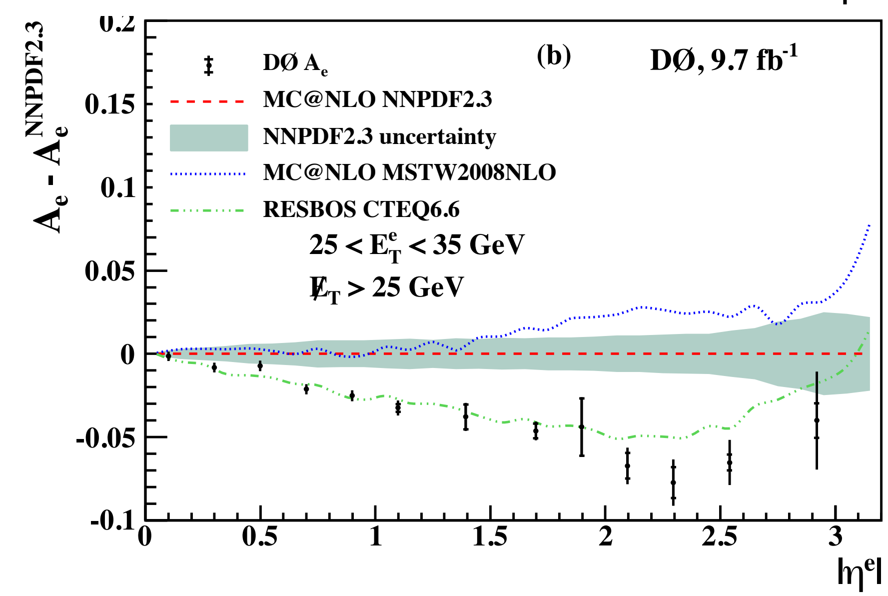
No agreement with any predictions



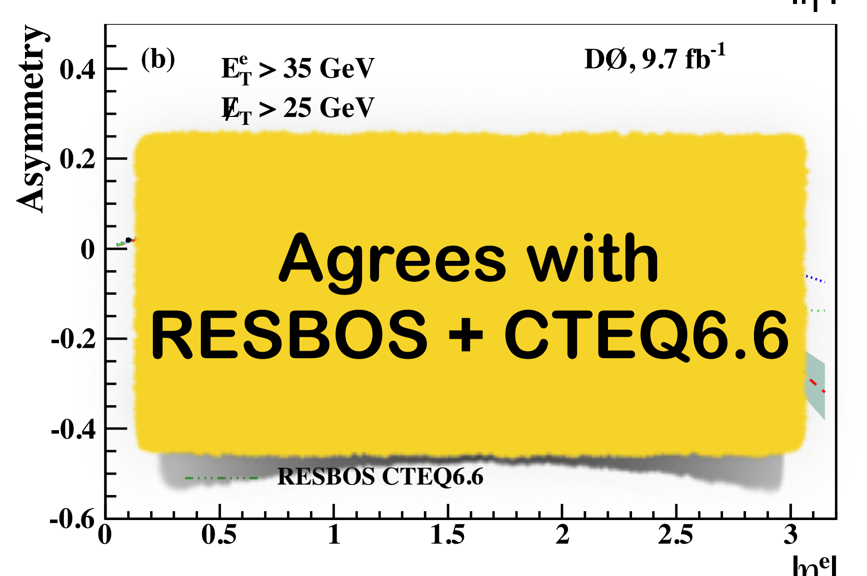
25< E_T<35
E_T^{miss}>25



Agrees with RESBOS + CTEQ6.6



E_T>35
E_T^{miss}>25



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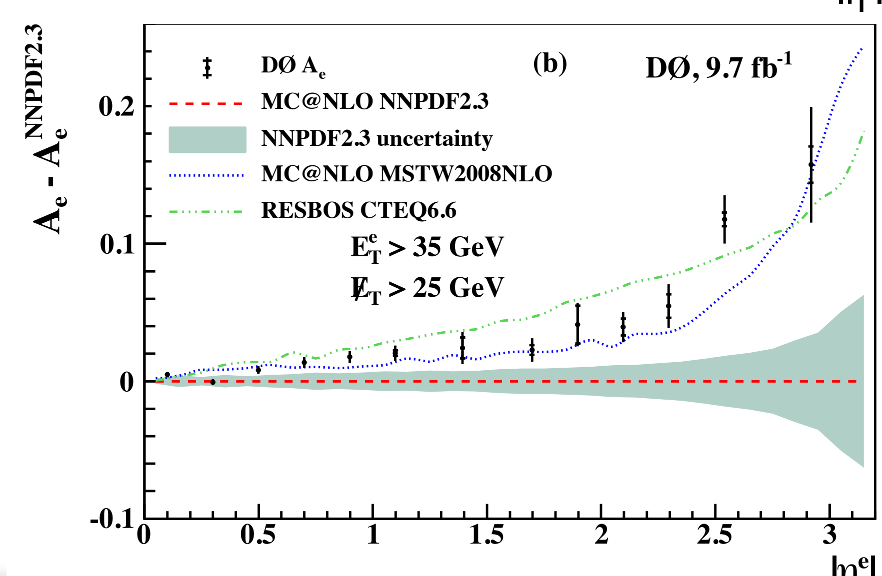
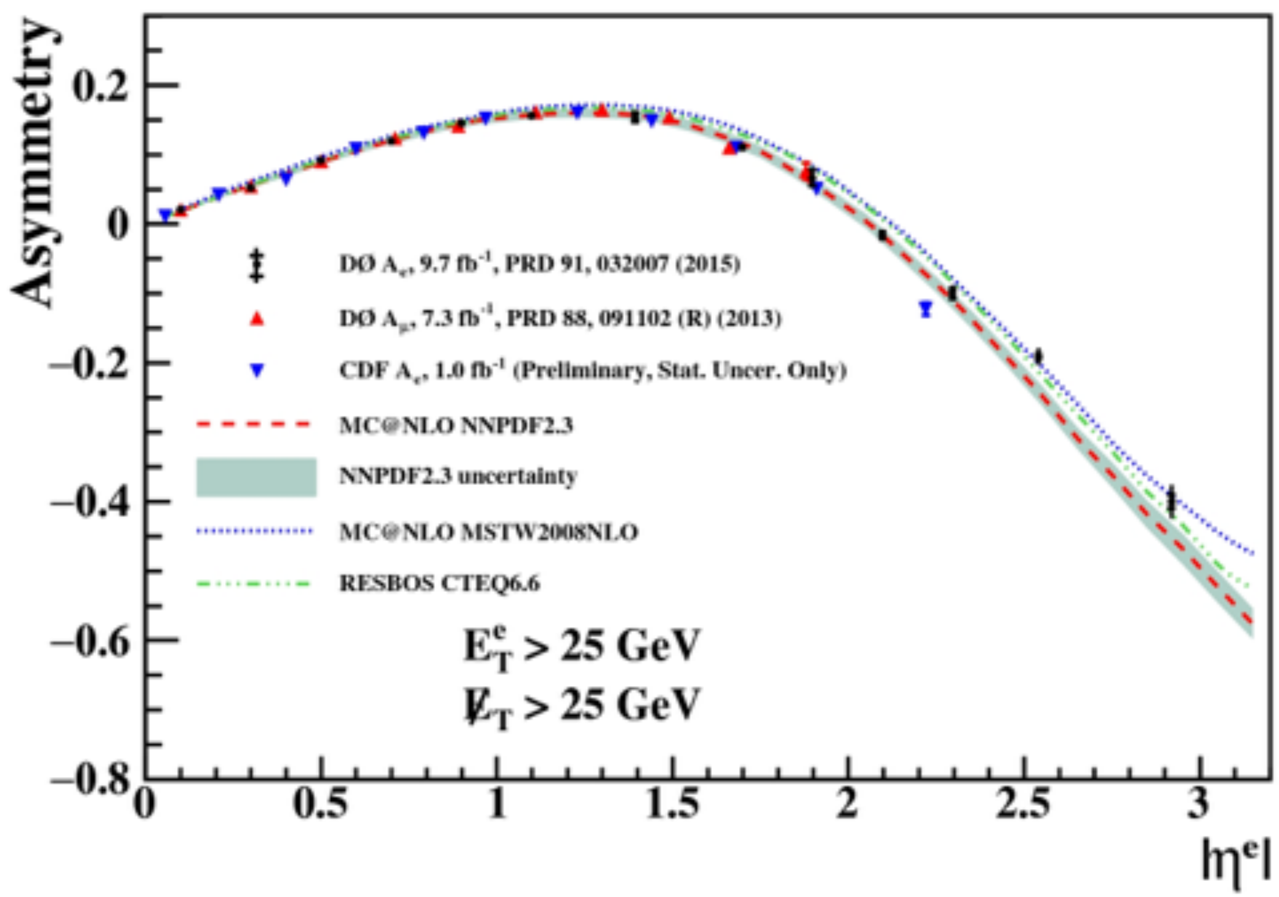
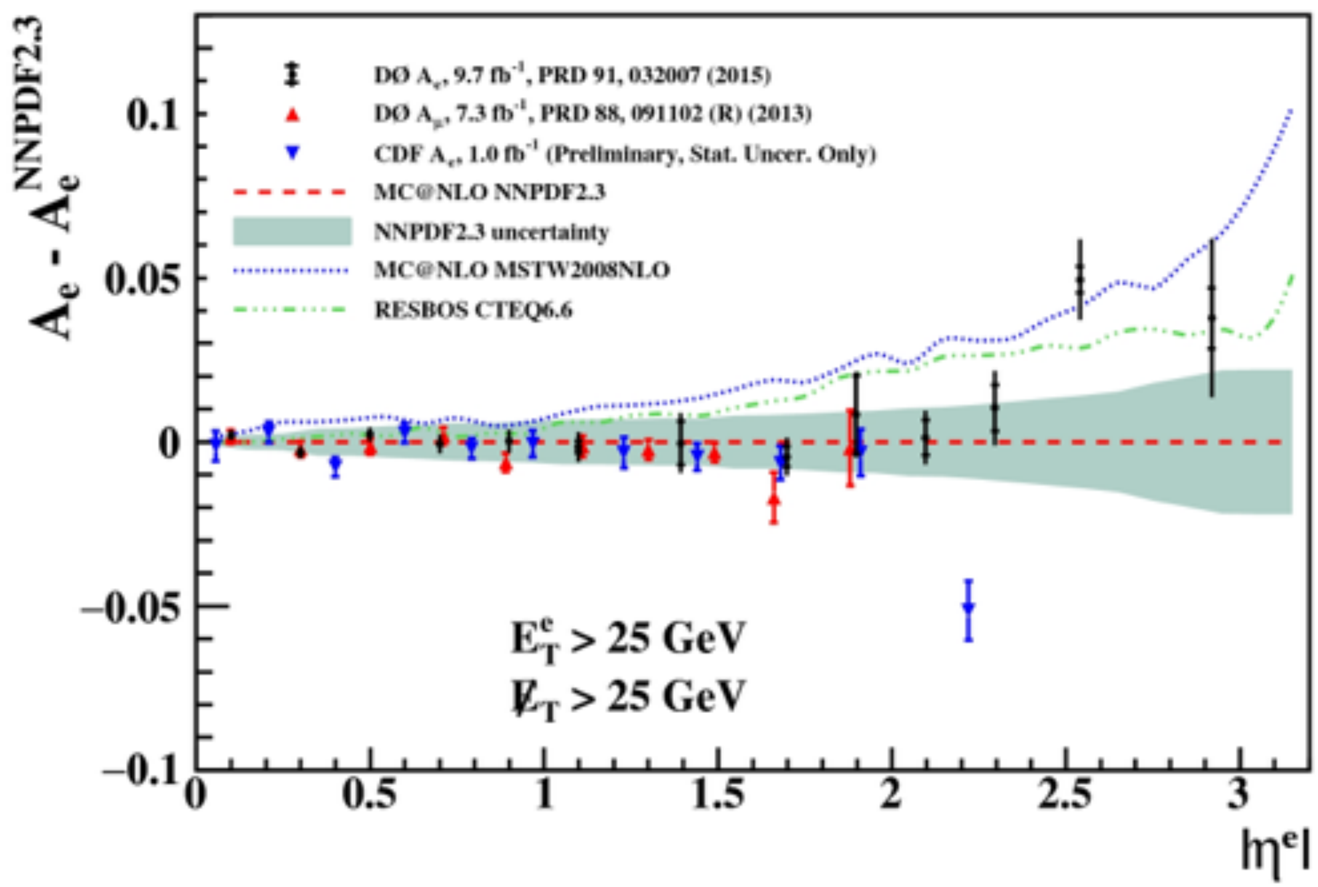


Comparison with CDF





- CDF, D0 agrees well

W Asymmetry Overview

- Asymmetry is difference in W differential cross-sections (in rapidity) over total.
- Unknown neutrino z value is an issue

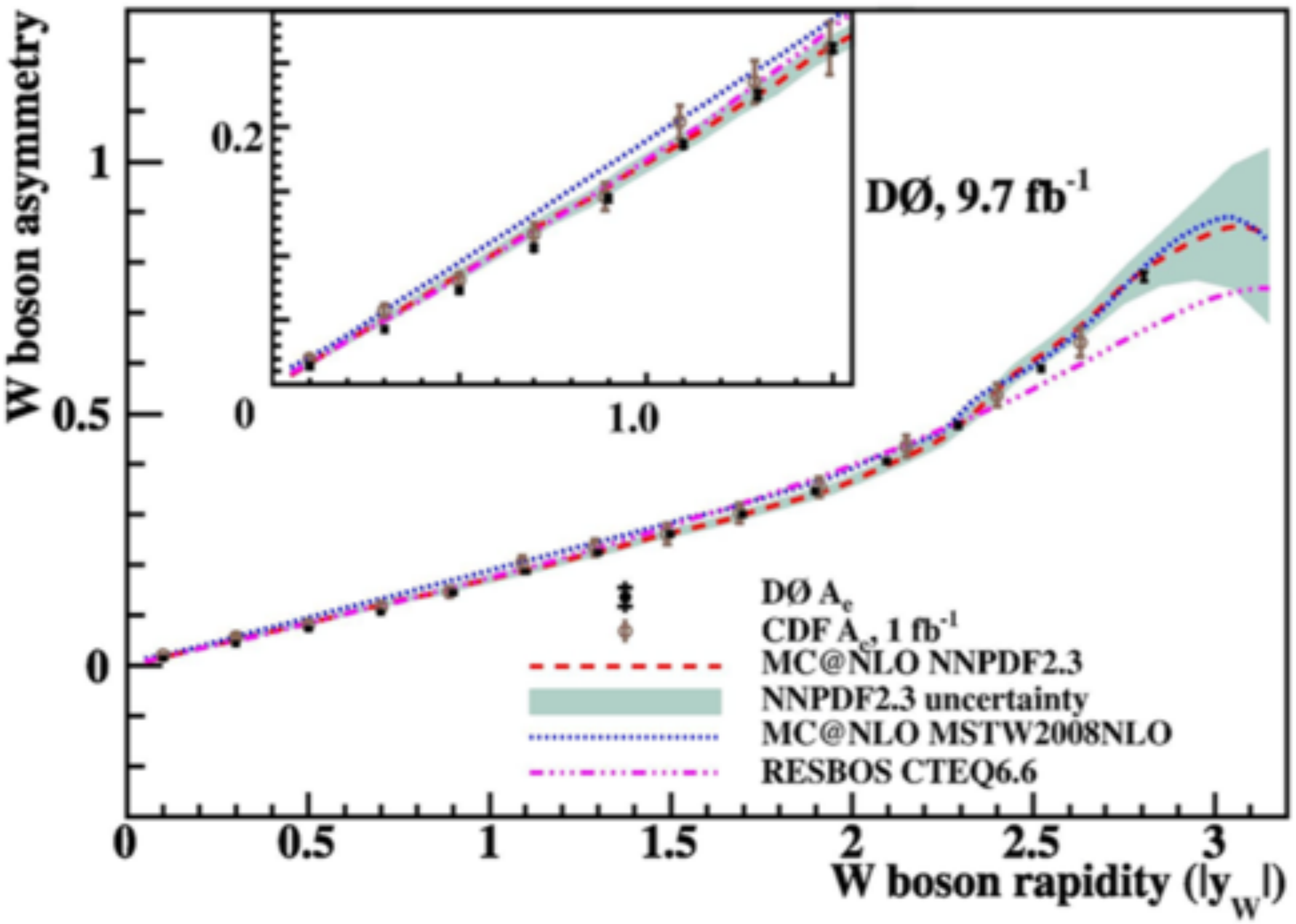
$$y_W = \frac{1}{2} \ln \frac{E + p_z}{E - p_z}$$

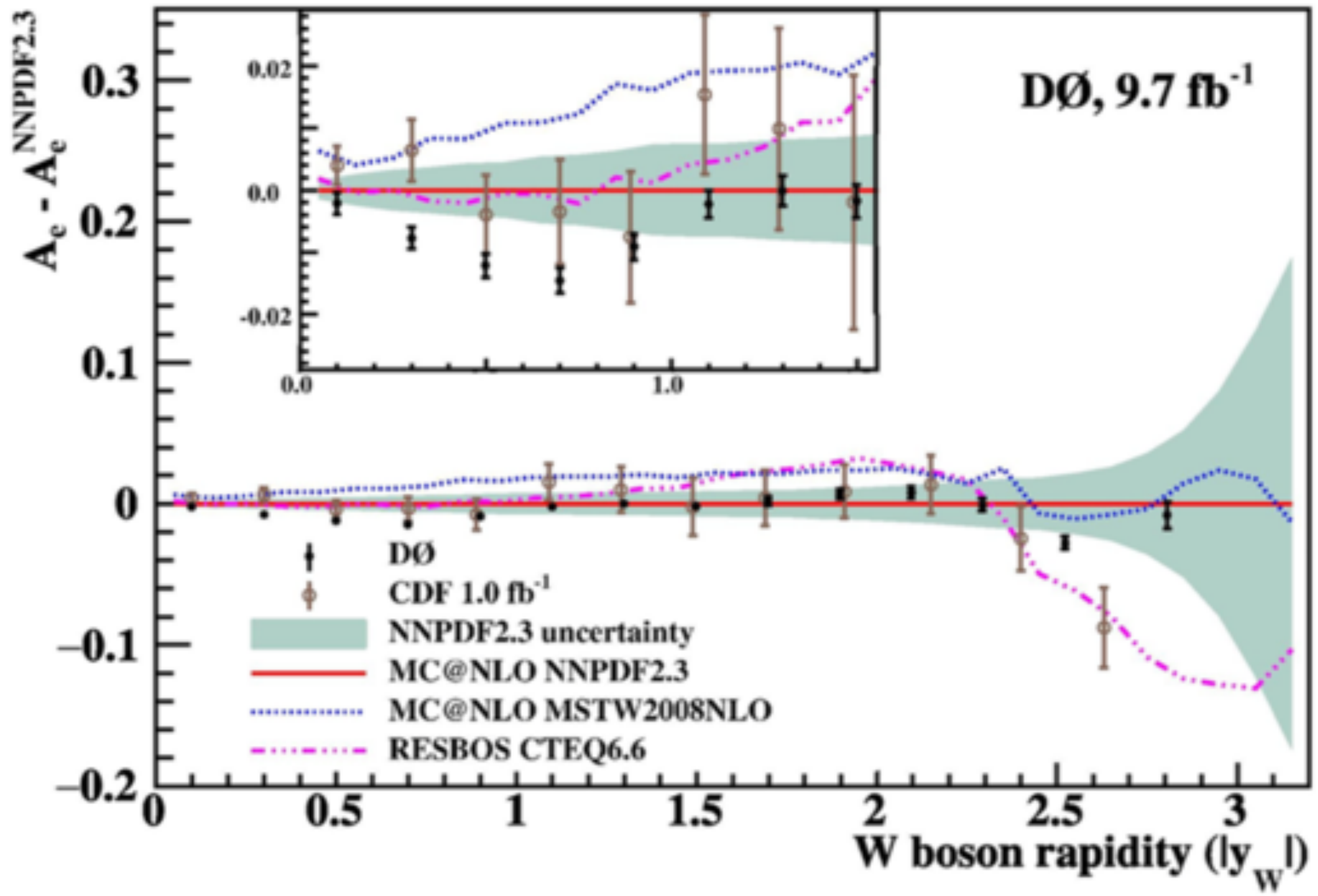
- Well known m(W), use to determine z momentum within some two-fold ambiguity:

$$M_W^2 = (E_e + E_\nu)^2 - (\vec{P}_e + \vec{P}_\nu)^2$$

  - In case of complex $p_z(\nu)$ assume E_T^{miss} is mis-reconstructed and scale accordingly
- Ambiguity resolved by assigning weights to the event, for each solution, related to cosθ*, W rapidity and $p_T(W)$

W Asym Results





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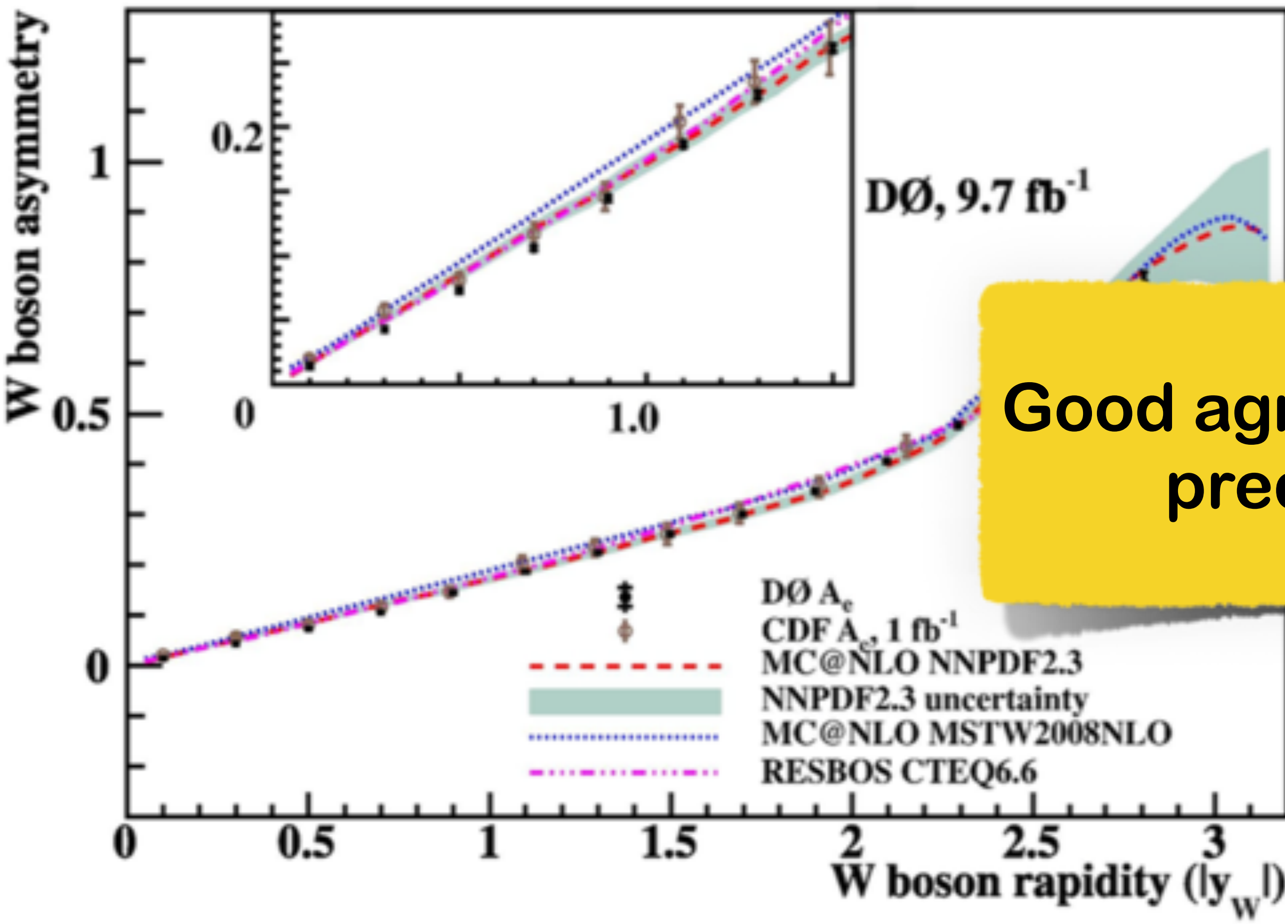

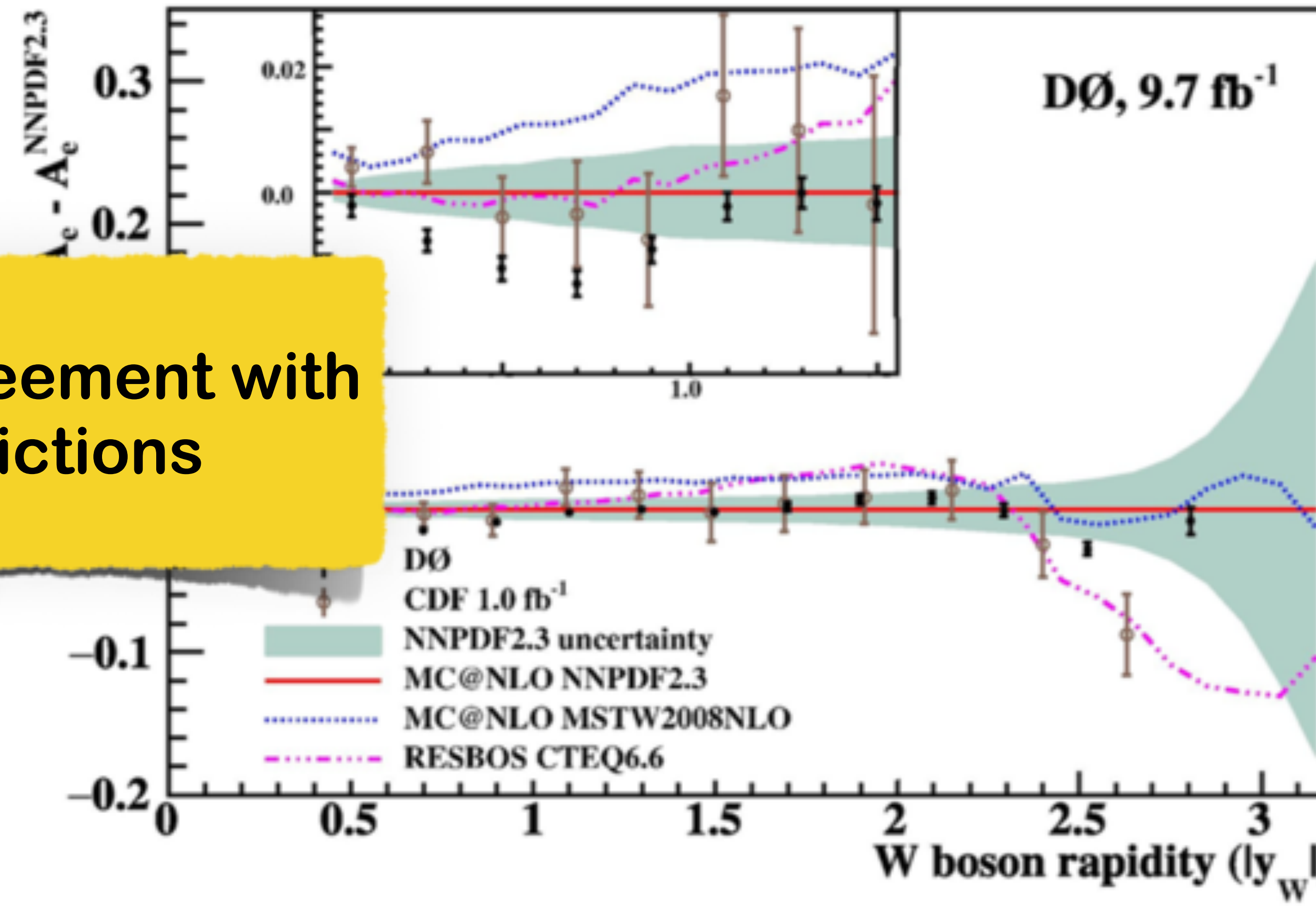

Good agreement with predictions

Summary

- New W charge asymmetry measurements using the full Run II dataset in W→eν decays
- Two separate methods to measure charge asymmetry:
  - Difference charged electron number (arXiv:1412.2862)
  - Reconstructing the W using neutrino weighting (arXiv:1312.2895)
- Probe different phase space than LHC
- Measurements agree with previous Tevatron results
- Most precise measurements to date, and should be for useful for PDF fits
- From recent CT14 paper (1506.07443): "....these new A_ch data sets are perhaps the most challenging and valuable among all that were added in CT14"