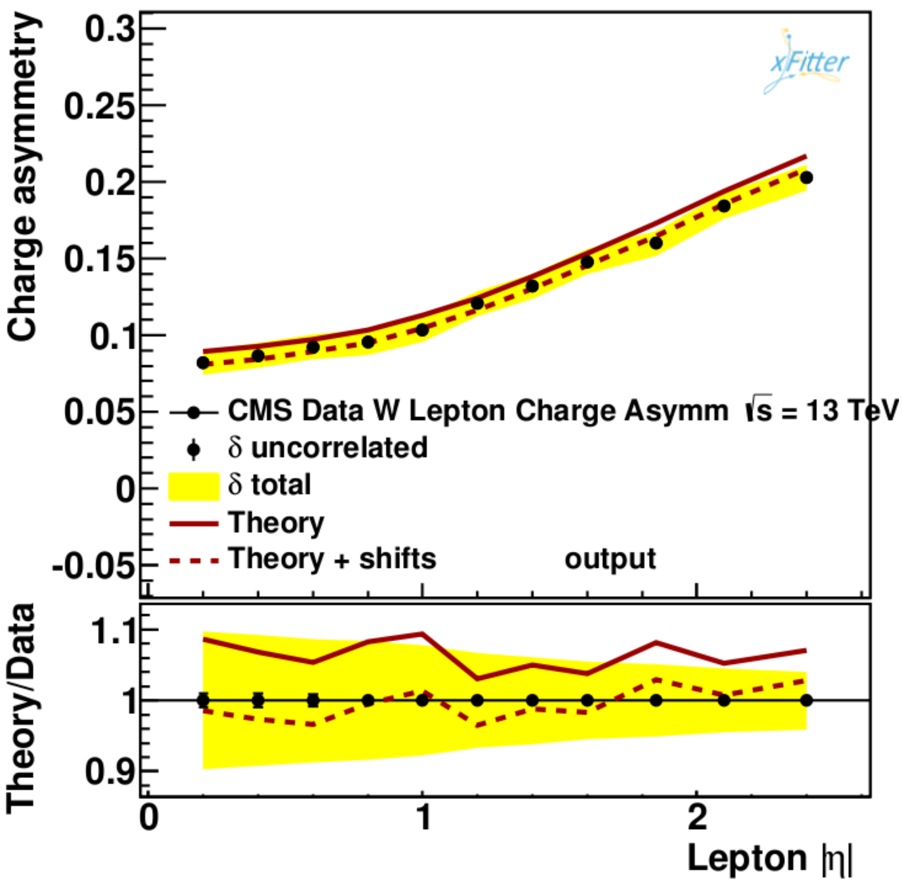
Very first look at systematic uncertainties

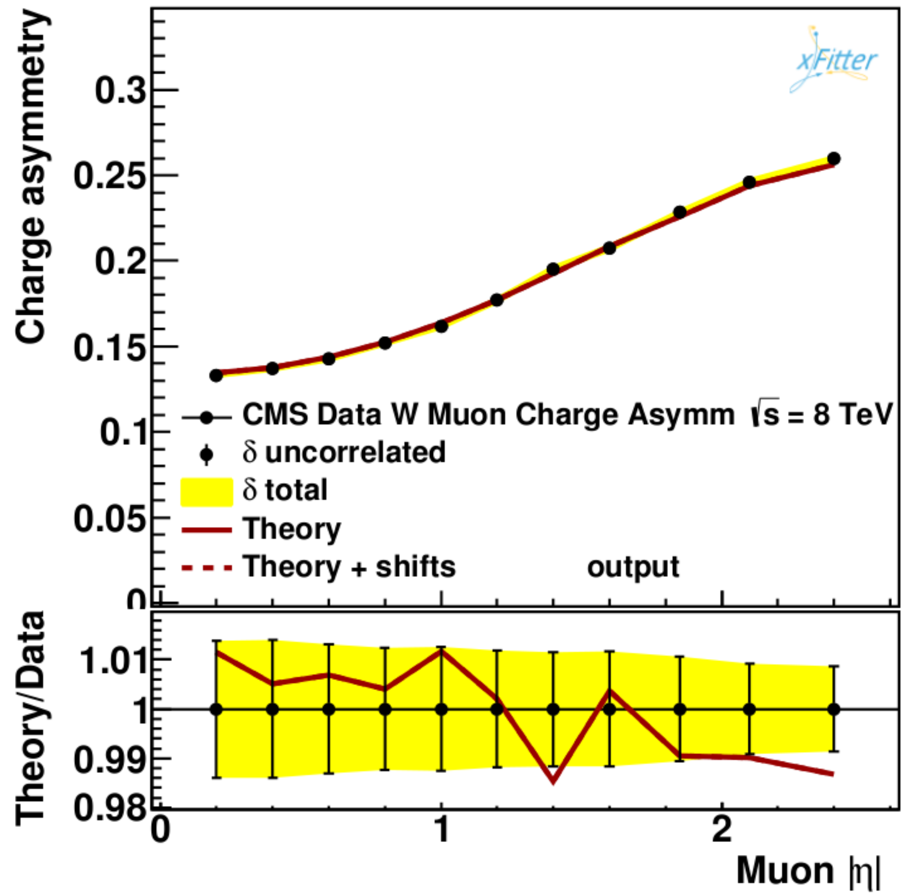
K. Wichmann

Data

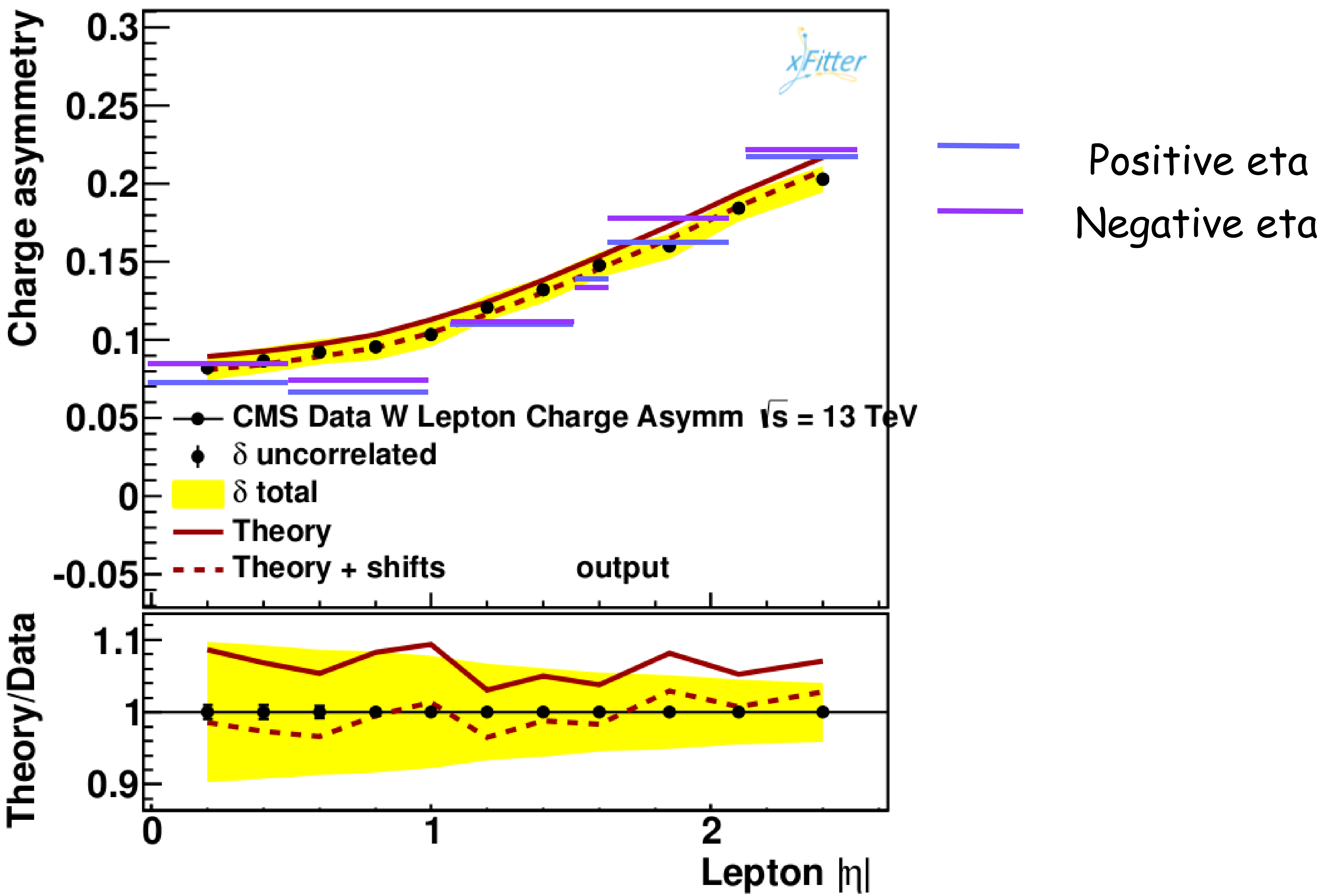
- Data from MIT W group → specifically from Stephanie Brandt
- I got yields (cross sections) for W+ and W- with uncertainties
  - very preliminary data
- Compared to Vlad's first "asymmetry" calculation
  - Only efficiencies, no acceptance yet
  - Acceptance may cancel if not eta-dependent

Asymmetry @ 13 and 8 TeV





Asymmetry @ 13 TeV - old and new



Systematic uncertainties

- **Experimental**, from the inclusive paper draft, from leading ones
  - Integrated lumi → does not apply for asymmetries
  - Measurement of lepton reconstruction and identification efficiency
    - Dominated by signal and background shape modeling when fitting dilepton invariant mass spectrum
    - Statistical uncertainties in efficiency measurements are propagated as systematic uncertainty in x-section measurement
  - Uncertainties affecting shape of E_t^{miss}
    - E_t^{miss} scale and resolution
    - Modeling lepton momentum scale and resolution
- **Theoretical**
  - Resummation and initial state QCD radiation
  - for ratios correlation of theoretical uncertainties taken into account

Source	W^+	W^-
Lepton charge, reco. & id. [%]	0.9	0.9
Bkg. subtraction / modeling [%]	0.3	0.6
E_T^{miss} scale and resolution [%]	0.3	0.4
Muon scale and resolution [%]	0.1	0.3
Pileup modelling [%]	0.3	0.4
Total experimental [%]	1.1	1.2
Theoretical Uncertainty [%]	2.0	1.7
Lumi [%]	2.7	2.7
Total [%]	3.5	3.4

Theoretical uncertainties

- This uncertainties come from acceptance calculations
  - A = 0.44 for W^+
  - A = 0.46 for W^-

There is no single event generator that incorporates both electroweak and QCD effects. Therefore the acceptance estimated using our baseline Monte Carlo simulation (aMC@NLO []) is lacking the influence of different effects, which can be investigated using various simulation tools to derive systematic uncertainties. These uncertainties can arise from higher-order corrections or model assumptions (for example, FSR or PDF descriptions).

Process	NNLO+ISR [%]	>NNLO [%]	FSR [%]	EWK [%]	PDF [%]	Total [%]
$W^+ \to \mu^+\nu$	1.7	0.4	0.6	0.2	0.7	2.0
$W^- \to \mu^-\bar{\nu}$	1.1	0.8	0.3	0.6	0.6	1.7
$W \to \mu\nu$	1.1	0.3	0.5	0.2	0.6	1.3
W^+/W^-	1.8	1.0	0.3	0.8	0.6	2.3
$Z \to \mu\mu$	0.9	0.6	0.6	0.6	0.7	1.5
$W+/Z$	1.3	0.9	1.1	0.7	0.5	2.1
$W-/Z$	0.6	1.1	0.6	1.2	0.4	1.9
W/Z	0.5	0.9	0.8	0.8	0.4	1.6

Table 20: Systematic uncertainties on the acceptance in the muon channel.

K. Wichmann

PDFs uncertainty

Process	NNPDF3.0	MMHT2014	CT14	HERAPDF15	ABM12LHC
$W^+ \to \mu^+\nu$	0.444	0.442	0.443	0.438	0.443
$W^- \to \mu^-\bar{\nu}$	0.459	0.458	0.459	0.462	0.468
W	0.450	0.449	0.451	0.448	0.453
W^+/W^-	0.969	0.965	0.964	0.949	0.946
$Z \to \mu\mu$	0.363	0.362	0.362	0.361	0.366
$W+/Z$	1.225	1.220	1.220	1.217	1.208
$W-/Z$	1.265	1.264	1.267	1.282	1.277
W/Z	1.242	1.239	1.240	1.245	1.237

Table 16: Acceptances in the muon channel for the nominal values of each PDF set using NNPDF3.0, MMHT2014, CT14, HERAPDF15 and ABM12LHC..

- Nominal PDF: NNPDF3.0
- PDF uncertainties calculated with separate samples for each PDF set
  - Need to get these samples!
  - Why only NNPDF3.0 included?

Process	NNPDF3.0 [%]	MMHT2014 [%]	CT14 [%]
$W^+ \to \mu^+\nu$	0.7	0.6	0.8
$W^- \to \mu^-\bar{\nu}$	0.6	0.7	0.9
$W \to \mu\nu$	0.6	0.6	0.8
W^+/W^-	0.6	0.4	0.6
$Z \to \mu\mu$	0.7	0.9	1.1
$W+/Z$	0.5	0.5	0.5
$W-/Z$	0.4	0.4	0.5
W/Z	0.4	0.4	0.4

QCD Resummation and NNLO Corrections

- Nominal generator: **aMC@NLO generator**, interfaced to PYTHIA for parton shower evolution to model soft, non-perturbative QCD effects
  - aMC@NLO is only accurate to leading logarithmic (LL) order for the soft QCD effects
  - RESBOS's resummation procedure gives a next to-next-to-leading-log (NNLL) description
- hard matrix elements in aMC@NLO calculated with MADGRAPH, accurate up to NLO in perturbative QCD
  - RESBOS allows the use of a K-factor grid to get an effective NNLO description $\rightarrow$ RESBOS used to look at both the NNLL and NNLO QCD effects.

Process	aMC@NLO	POWHEG	RESBOS	DYRES
$W^+ \rightarrow \mu^+ \nu$	0.449	0.453	0.459	0.457
$W^- \rightarrow \mu^- \bar{\nu}$	0.469	0.464	0.468	0.469
$W \rightarrow \mu \nu$	0.458	0.457	0.463	0.462
W^+/W^-	0.958	0.975	0.980	0.975
$Z \rightarrow \mu\mu$	0.379	0.377	0.373	0.381
$W+/Z$	1.186	1.200	1.229	1.200
$W-/Z$	1.238	1.231	1.254	1.232
W/Z	1.208	1.213	1.240	1.214

- Systematic uncertainty $\rightarrow$ envelope between aMC@NLO, POWHEG, DYRES
- Why no RESBOS?
- We need all samples!

Higher-Order QCD Corrections

- No calculations available higher than NNLO
- Influence of factoriation and remormalisation scales investigated instead
- FEWZ used to calculate acceptance for different values of μ

$$\mu_R = \mu_F = \mu$$

$$\mu = M_W, 2M_W, M_W/2$$

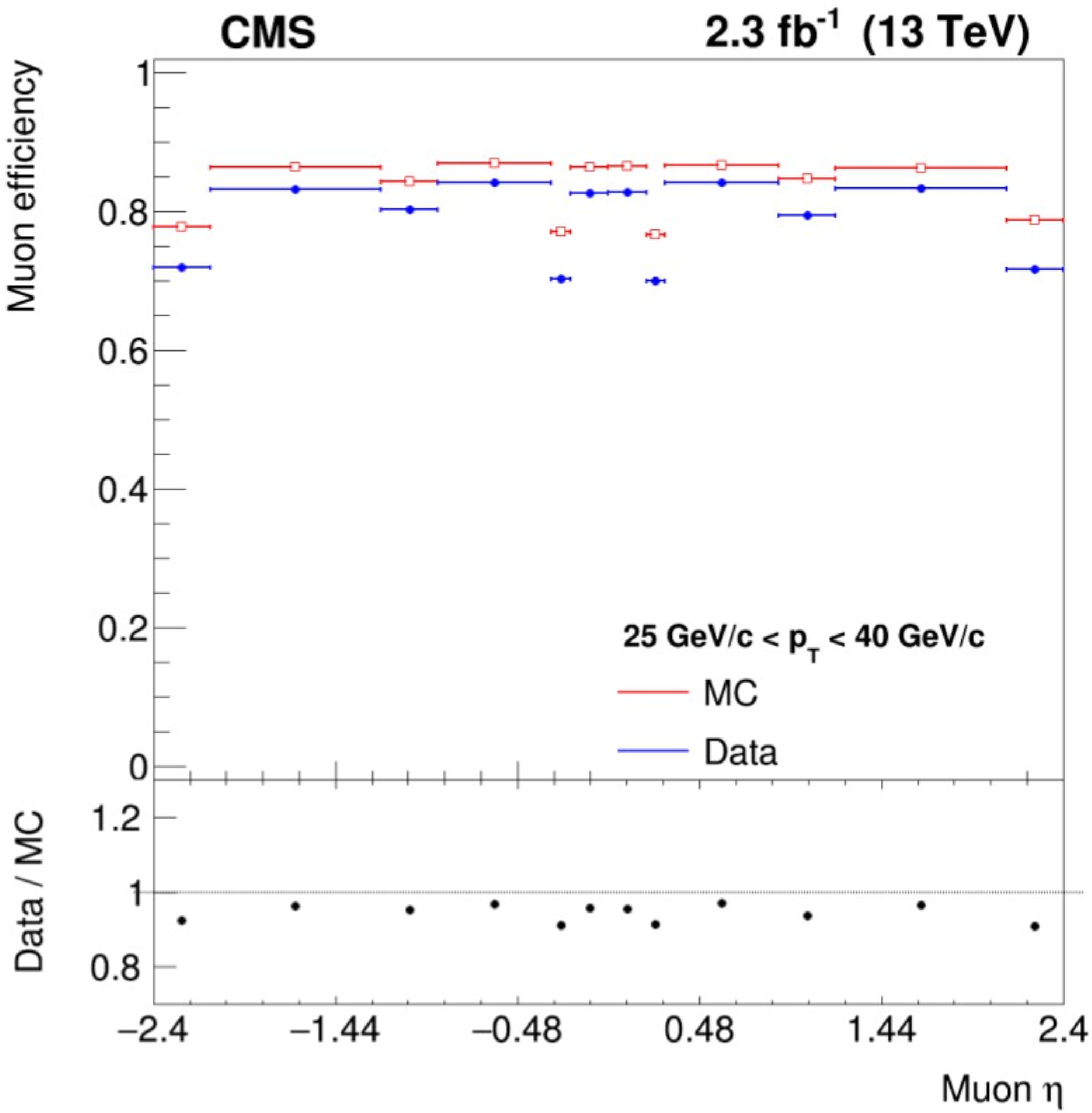
- Final uncertainty

$$\delta_{scale} = \frac{1}{2} max[|Acc_{M_W} - Acc_{2M_W}|, |Acc_{2M_W} - Acc_{M_W/2}|, |Acc_{M_W/2} - Acc_{M_W}|]$$

Elektroweak corrections

- Two souces
  - Missing NLO EW effects
  - Uncertainty of FSR modeling
  - ISR found not significant and was ignored
- Missing NLO EW effects – virtual corrections and radiation from W
  - Quantified using **HORACE** with all corrections switched on to HORACE with only FSR on
- FSR modelling
  - HORACE with FSR only compared to PYTHIA (baseline)
    - For fully reconstructed and selected events – some photon radiation can be recovered by GSF tracking and superclustering procedure

Total muon efficiency



K. Wichmann

09.01.18, Internal Meeting