Measurement of the $pp \to W \to \ell\nu$ Charge Asymmetry at $\sqrt{s} = 7$ TeV

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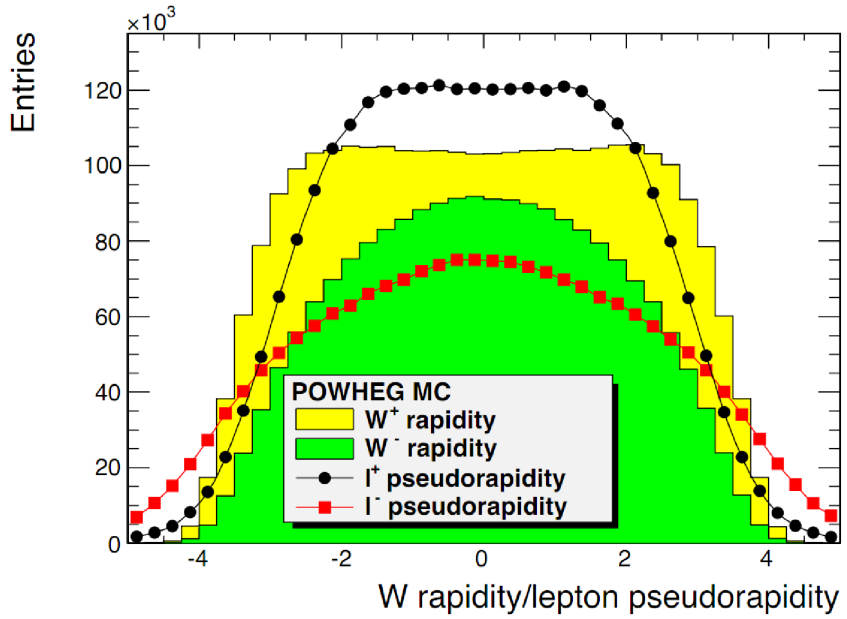
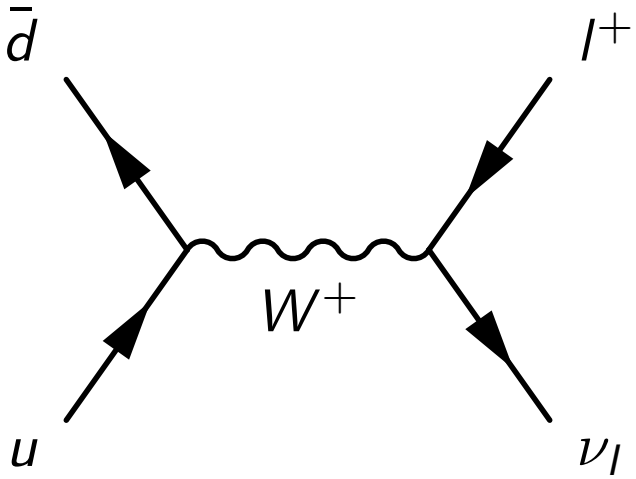
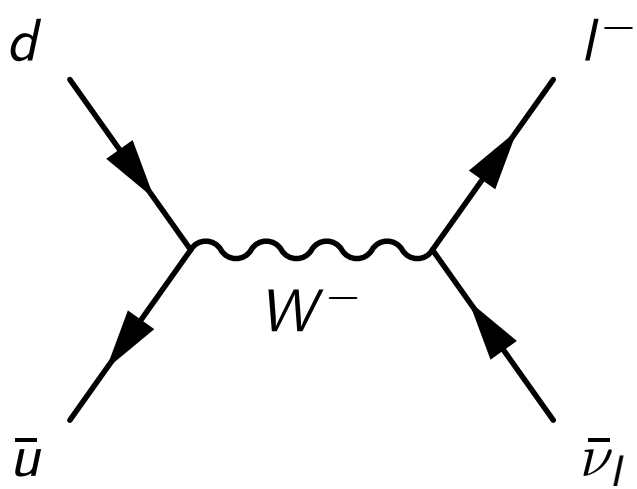
Rencontres de Moriond EW 2011

Motivation/Introduction

- W production at the LHC is sensitive to the proton structure
- More W^+ than W^- (prevalence of u vs d quarks)
- We are entering the regime where our measurements can constrain the PDF's





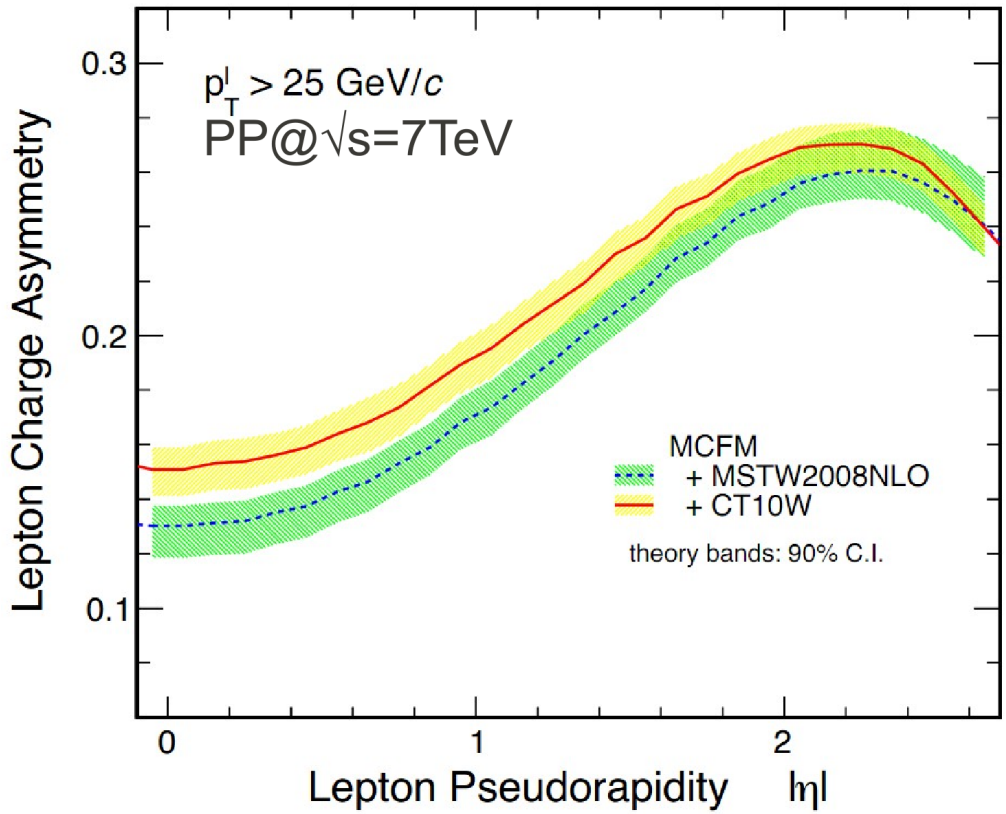


Motivation/Introduction

- Experimentally accessible observable is the charge asymmetry as a function of lepton pseudorapidity

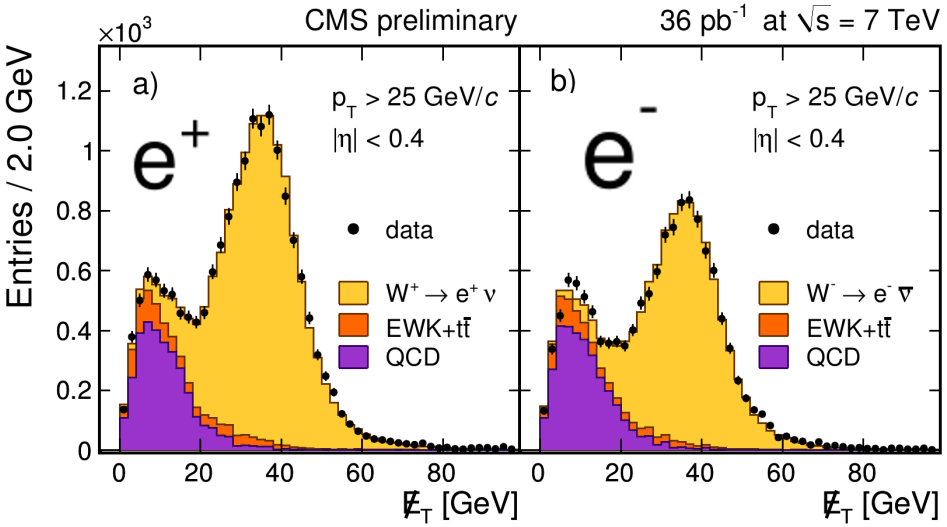
$$\mathcal{A}(\eta) = \frac{\frac{d\sigma}{d\eta_\ell}(W^+ \to \ell^+ \nu_\ell) - \frac{d\sigma}{d\eta_\ell}(W^- \to \ell^- \bar{\nu}_\ell)}{\frac{d\sigma}{d\eta_\ell}(W^+ \to \ell^+ \nu_\ell) + \frac{d\sigma}{d\eta_\ell}(W^- \to \ell^- \bar{\nu}_\ell)}$$

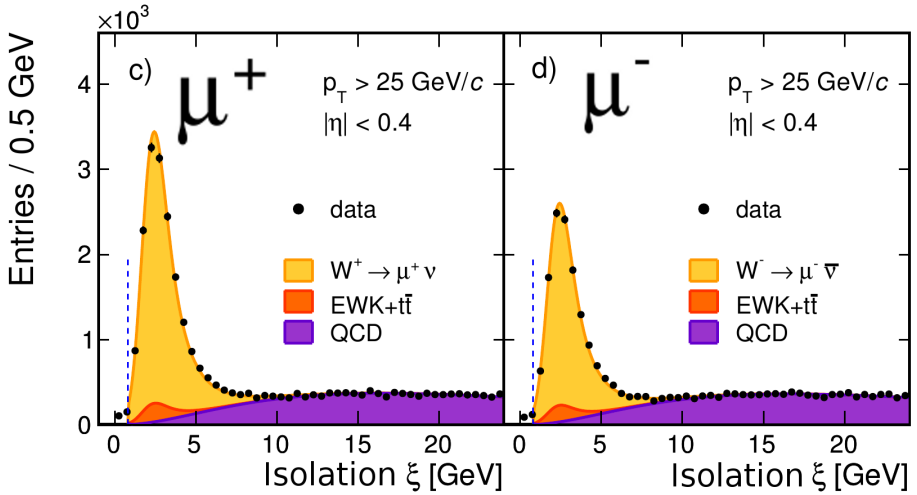
- Measured in both electron and muon channel
- Select single isolated lepton with $p_T > 25/30$ GeV and ID cuts
- Extract signal charge asymmetry over remaining QCD and EWK background in bins of $|\eta|$



Signal Extraction

- Electron signal extraction with template **fit to Particle Flow** $\not\!\!E_T$
- Signal shape from MC, with $\not\!\!E_T$ response/resolution modeled from hadronic recoil in $Z \to ee$
- QCD shape from data control region (inverting electron ID cuts)
- EWK background shapes from MC, normalized to signal yield





- Muon signal extraction with **fit to modified isolation variable**
- Signal shape constrained from $Z \to \mu\mu$
- Empirical parameterization for QCD constrained with MC and data control region
- EWK background estimated with MC (normalized to $Z \to \mu\mu$ data)

Systematic Uncertainties

- Most systematics are determined with **data-driven methods**, mainly with $Z \to \ell\ell$ control samples
- Systematics **largely complementary** between electron and muon channel

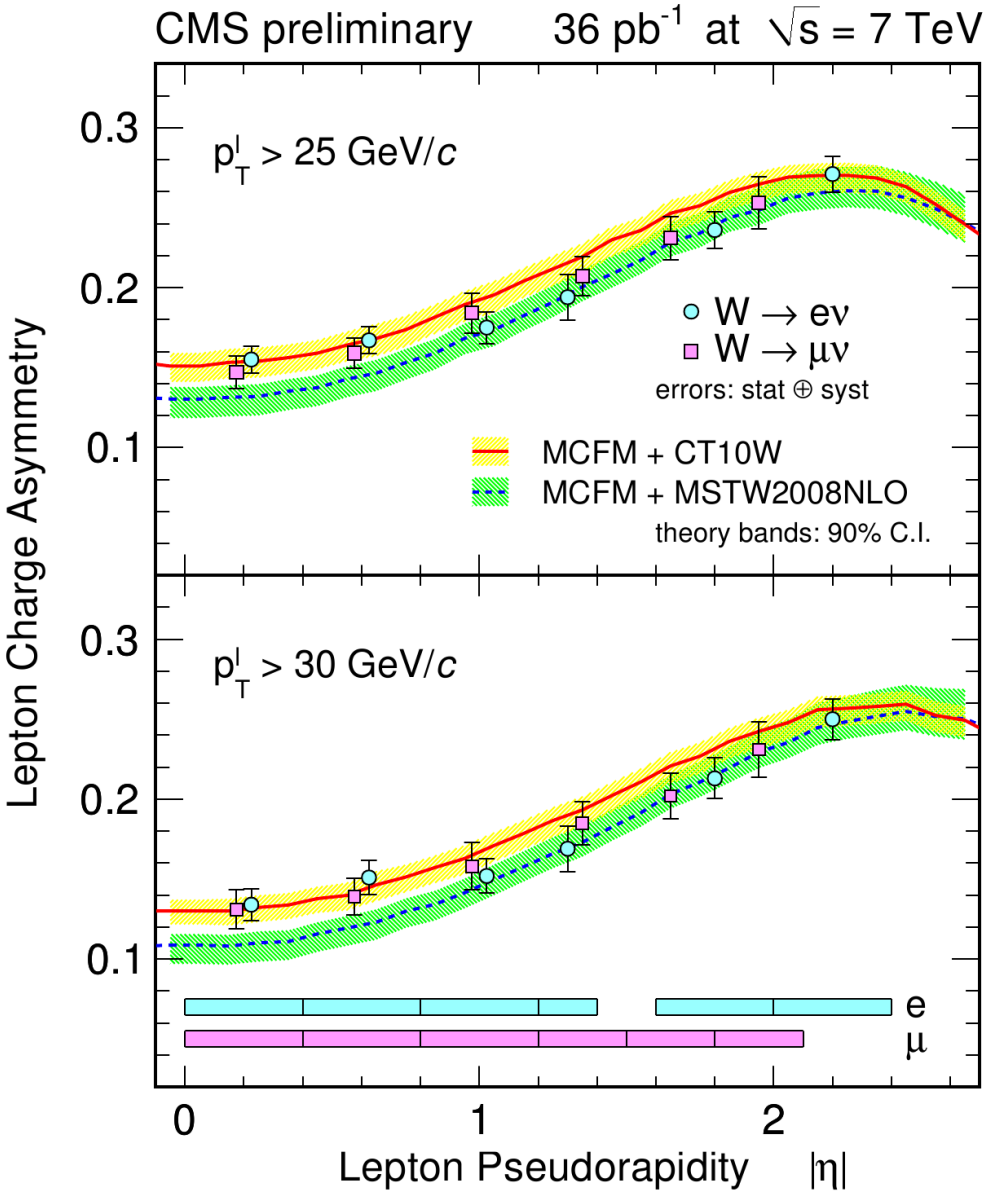
Electrons	**Muons**
Efficiency Ratio ϵ_+/ϵ_- (Electron ID/Reconstruction)	Efficiency Ratio ϵ_+/ϵ_- (Muon ID/Reconstruction)
Energy Scale (Ecal Calibration)	Momentum Scale (Tracker Alignment)
Signal Extraction (Hadronic Recoil, QCD Shape)	Signal Extraction (Drell-Yan Normalization)
Charge Mis-Identification ($< 0.5\%$ across η range)	-

Systematic Uncertainties

- Most systematics are determined with **data-driven methods**, mainly with $Z \to \ell\ell$ control samples
- Systematics **largely complementary** between electron and muon channel

Electrons	**Muons**
Efficiency Ratio ϵ_+/ϵ_- (0.0070-0.0070)	Efficiency Ratio ϵ_+/ϵ_- (0.0039-0.0117)
Energy Scale (0.0011-0.0047)	Momentum Scale (0.0042-0.0050)
Signal Extraction (0.0016-0.0033)	Signal Extraction (0.0023-0.0058)
Charge Mis-Identification (0.0002-0.0010)	-

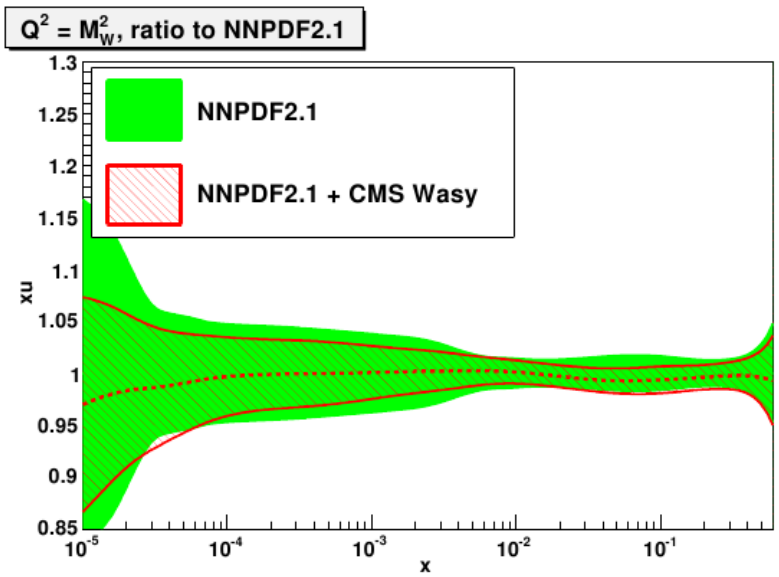
Results



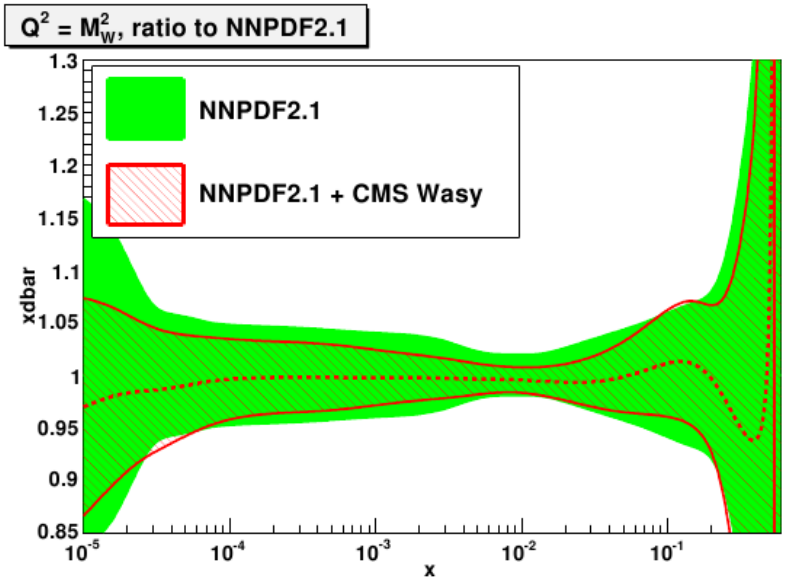
- Good agreement between electron and muon results
- Results quoted within two well defined regions of phase space: $p_{T\ell} > 25/30$ GeV, no cut on $p_{T\nu}$
- Provides first constraints on PDF's from LHC
- More details in CMS-PAS-EWK-10-006

Backup: PDF Constraints

- Preliminary addition of CMS asymmetry data in NNPDF2.1 shows reduced uncertainties on sea quarks



(a) $xu(x, M_W^2)$

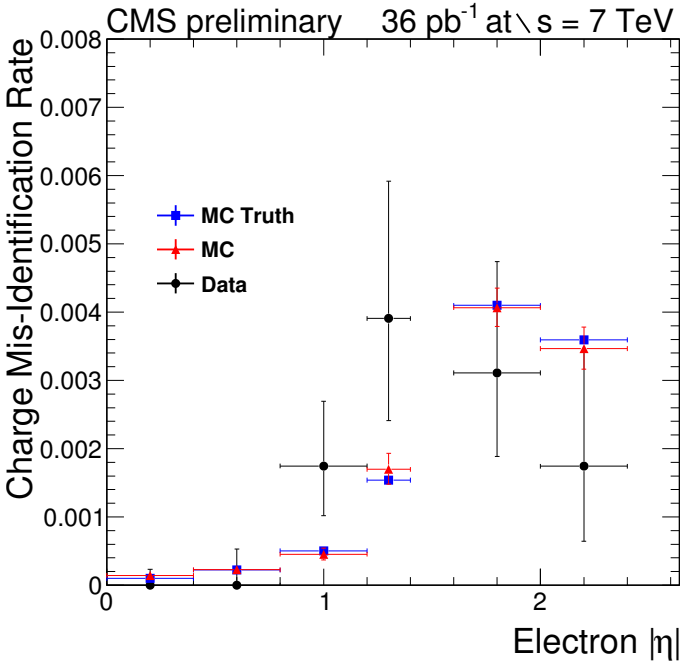


(b) $x\bar{d}(x, M_W^2)$

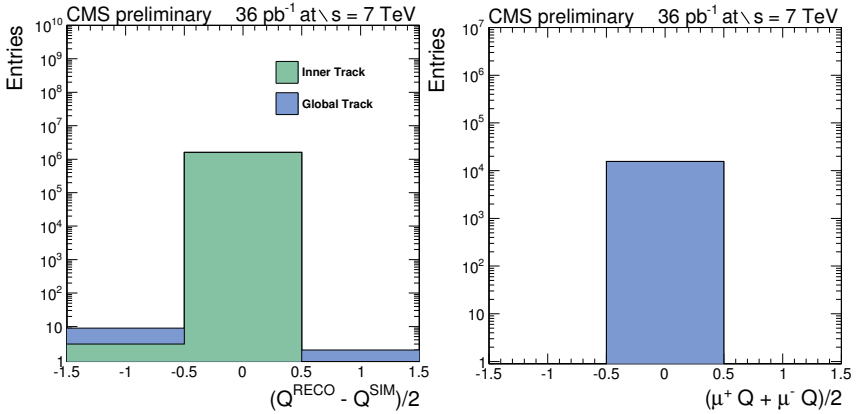
Figure: NNPDF Collaboration, PDF4LHC Meeting, Mar. 7, 2011

Backup: Charge Identification

- Electron charge-ID challenging due to Bremsstrahlung and conversions
- Require agreement of three charge assignment methods: $q_{ckf} = q_{gsf} = q_{\Delta\phi}$
- Charge mis-ID reduced to $< 0.5\%$ across η (measured from $Z \to ee$)

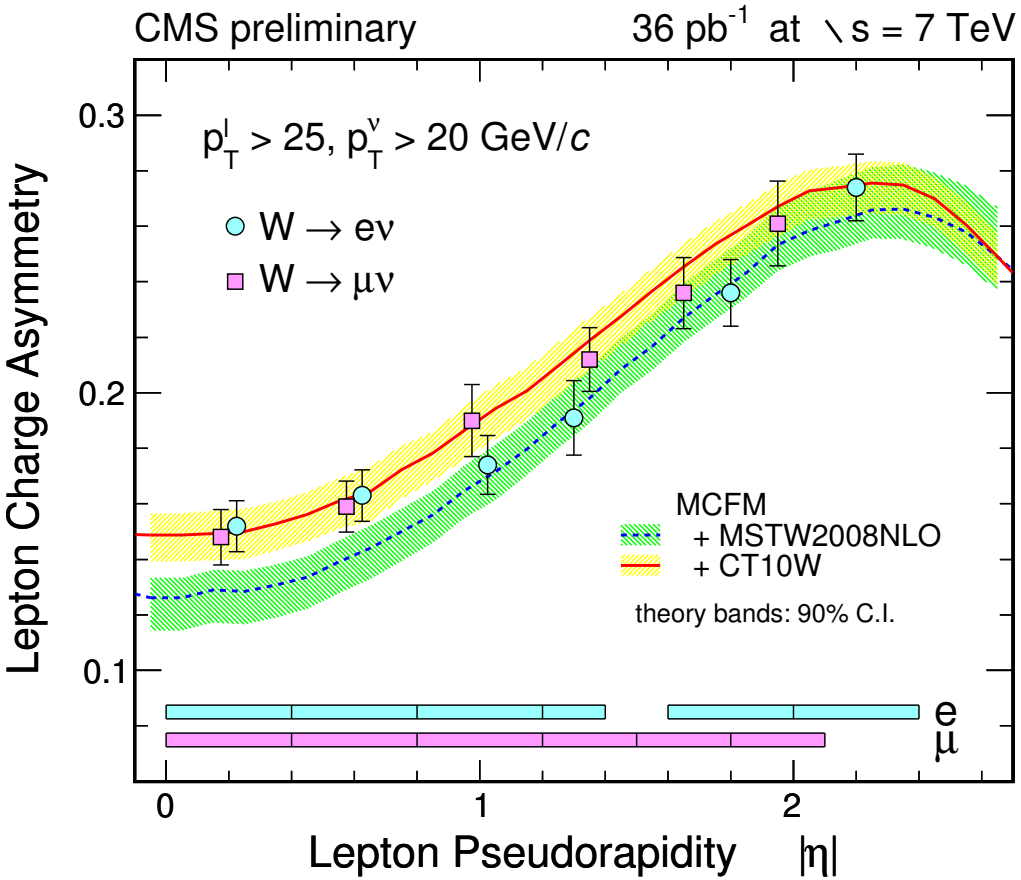


- Muon curvature in Silicon Tracker unambiguous in this momentum range
- Charge mis-ID $< 10^{-5}$ in MC, upper limit of 10^{-4} from cosmic data (track splitting method)



- Electron results corrected in each bin, uncertainty propagated as (small) systematic
- Muon charge mis-ID negligible for this analysis

Backup: Asymmetry with $p_{T\nu}$ cut



- Lepton charge asymmetry shown in phase space: $p_{T\ell} > 25$ GeV, $p_{T\nu} > 20$ GeV
- Background substantially reduced
- Additional systematic uncertainty on $\not\!\!E_T$ cut (constrained again from hadronic recoil in $Z \to \ell\ell$)