Review of

Measurement of the Lepton Charge Asymmetry in Inclusive W Production in pp Collisions at $\sqrt{s}$ = 7TeV

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Group E

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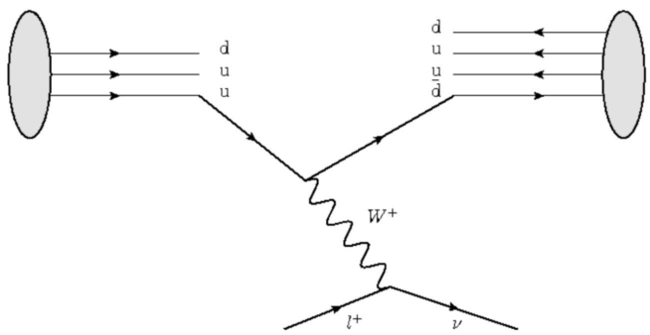
Outline

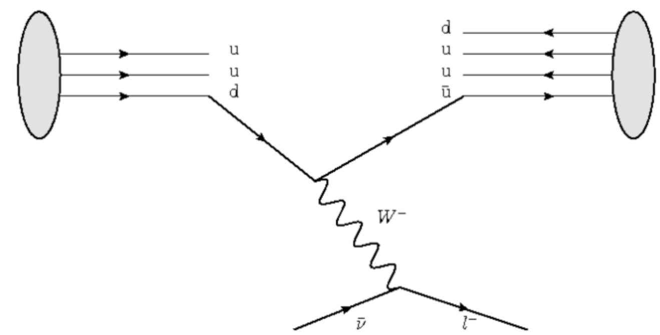
- Motivation
- CMS Detector
    - Object reconstruction
- Analysis Method
    - W → eν Signal Extraction
    - W → μν Signal Extraction
- Results

Motivation

Due to the presence of 2 u valence quarks, there's an overall excess of W^+ over W^- bosons.



$$d\bar{u} \rightarrow W^+$$

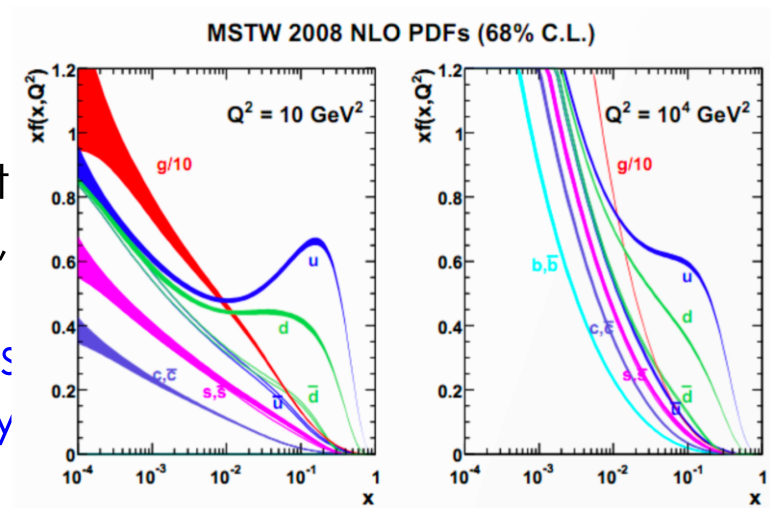


$$u\bar{d} \rightarrow W^-$$

Charge asymmetry → insight ... sea
... nsities,

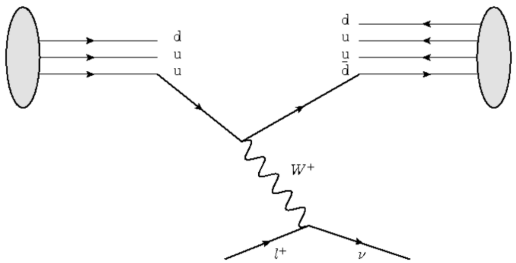
$$x_d x_{\bar{u}} \sqrt{s} \approx m_W$$

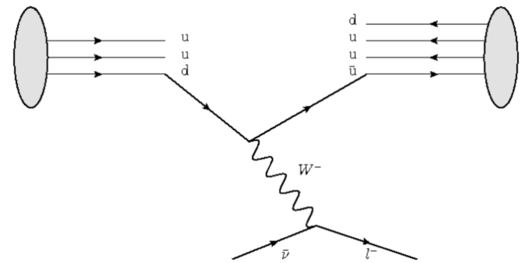
This measurement serves as ... ark
distributions providing a way ... DFs.



Motivation

Due to the presence of 2 u valence quarks, there's an overall excess of W^+ over W^- bosons.





This measurement serves as a constraint on the u and d quark distributions providing a way to improve the knowledge of PDFs.

The experimental accessible quantity is the **lepton** charge asymmetry, that retains sensitivity to the underlying W boson asymmetry.

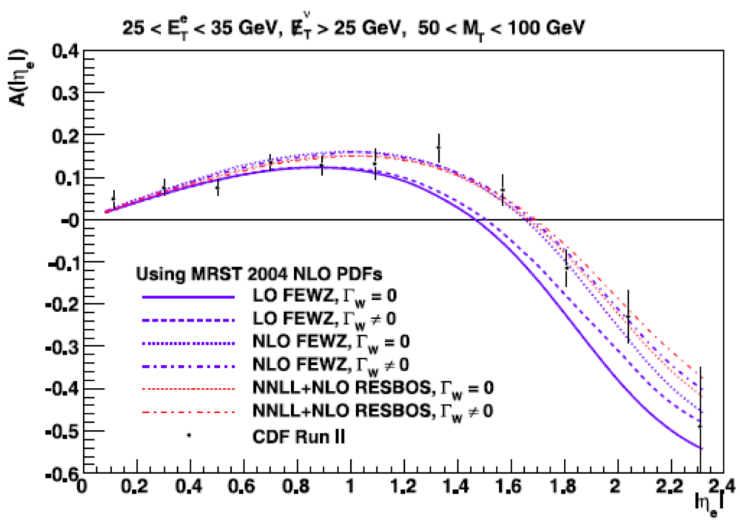
$$\mathcal{A}(\eta) = \frac{d\sigma/d\eta(W^+ \rightarrow \ell^+\nu) - d\sigma/d\eta(W^- \rightarrow \ell^-\bar{\nu})}{d\sigma/d\eta(W^+ \rightarrow \ell^+\nu) + d\sigma/d\eta(W^- \rightarrow \ell^-\bar{\nu})}$$

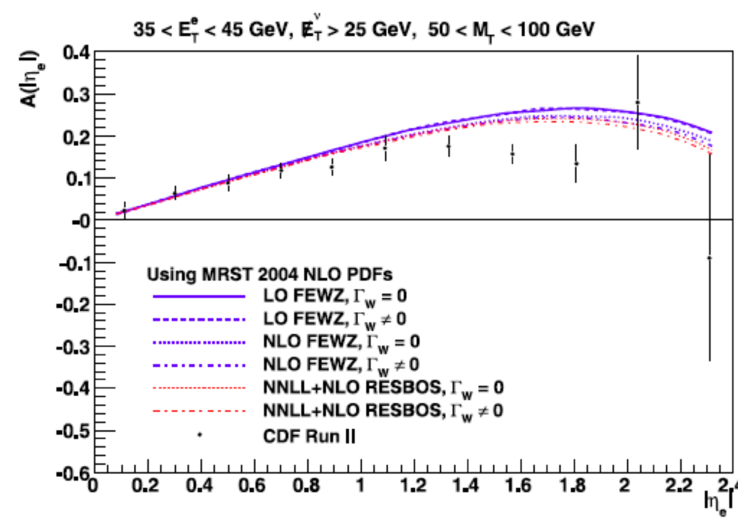
$$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$

Motivation

Differences with respect to Tevatron (p-pbar collisions)

- Small sensitivity to sea quarks contribution is strongly suppressed in p-pbar collisions compared to pp collisions.
- The asymmetry with respect to W rapidity, in pp collisions is symmetric, whereas in p-pbar collisions is anti-symmetric.

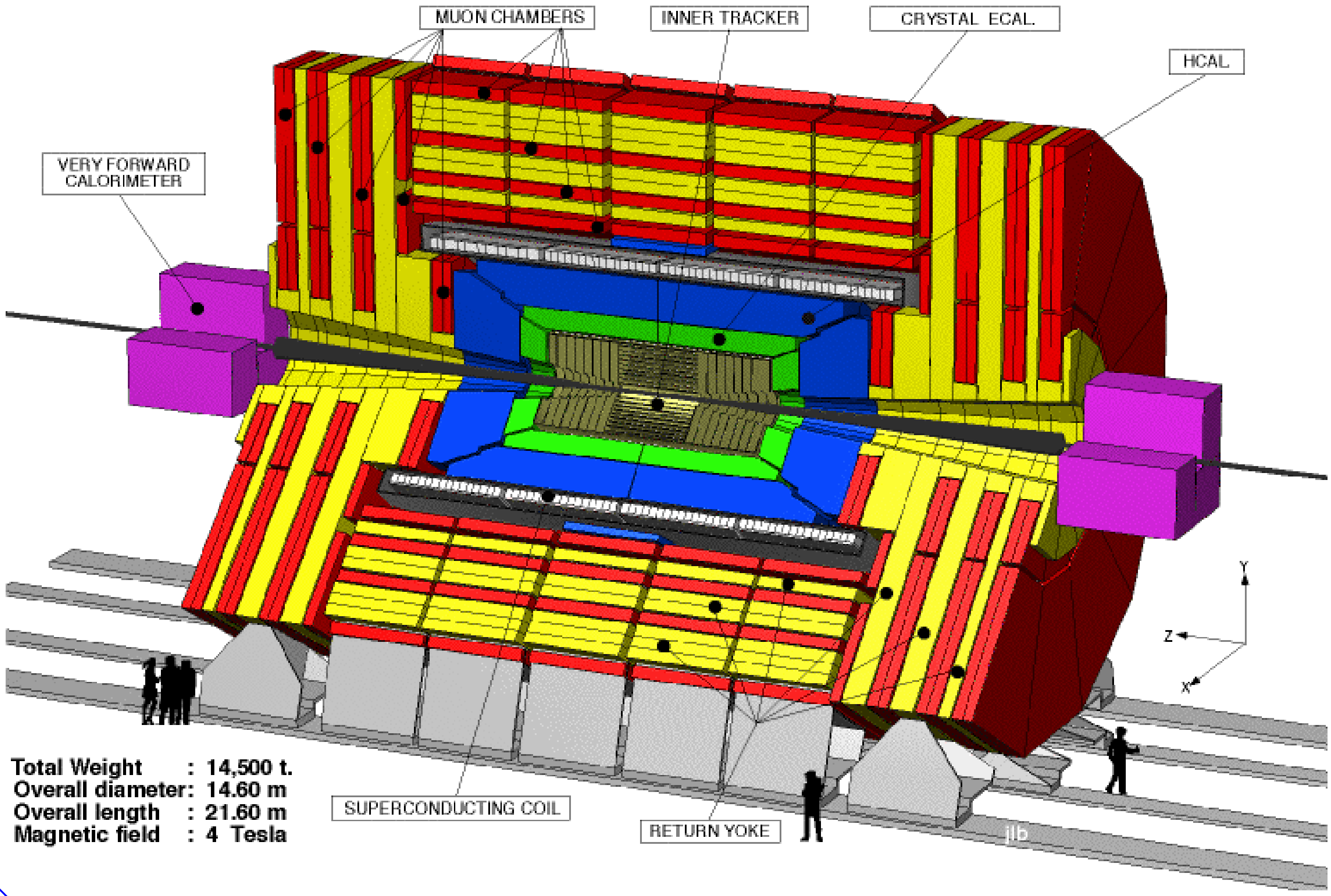




Since this quantity depends on the PDFs there is a strong momentum dependence.

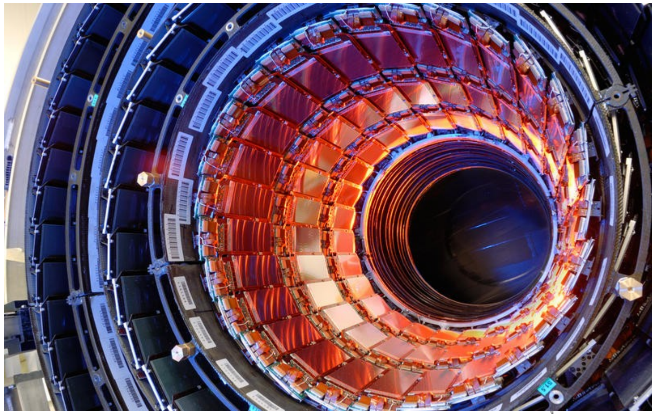
CDF Collaboration. "Direct Measurement of the W Production Charge Asymmetry in p-pbar Collisions at $\sqrt{s}$ = 1.96 TeV".

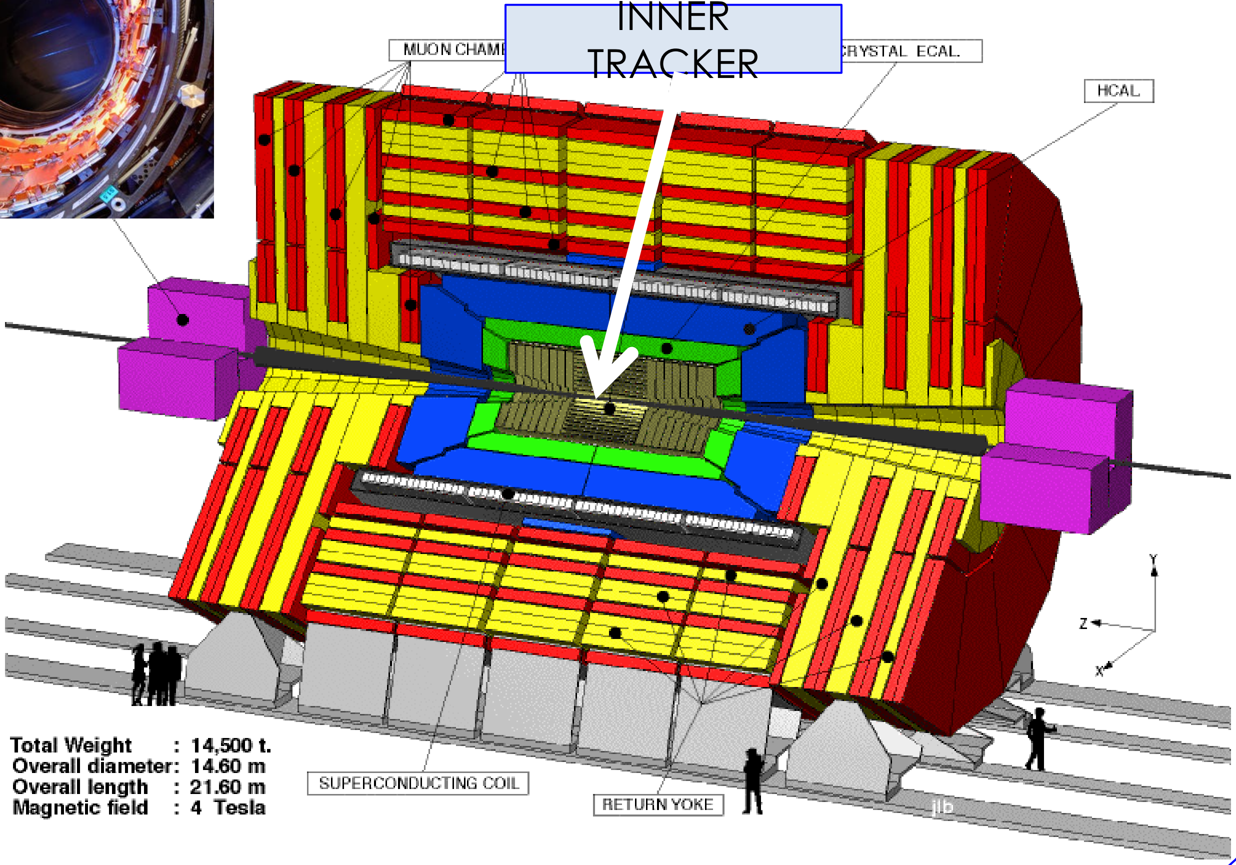
CMS detector



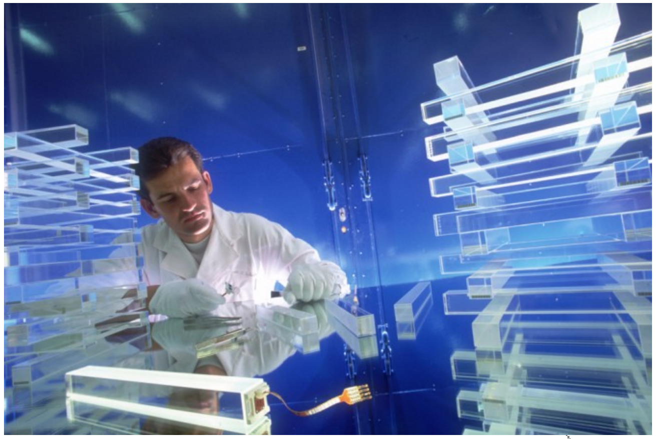
Total Weight : 14,500 t.
Overall diameter: 14.60 m
Overall length : 21.60 m
Magnetic field : 4 Tesla

Inner Detector

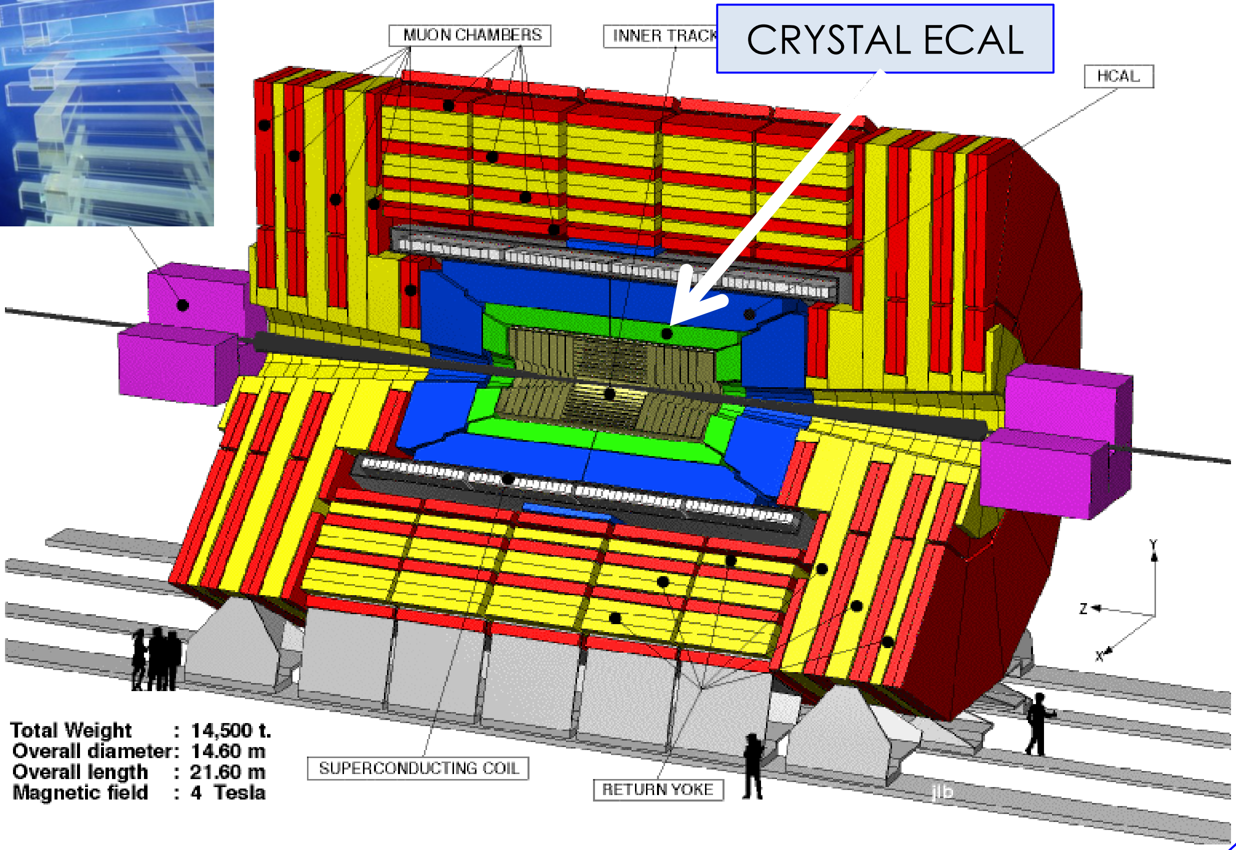




Electro-Magnetic Calorimeter

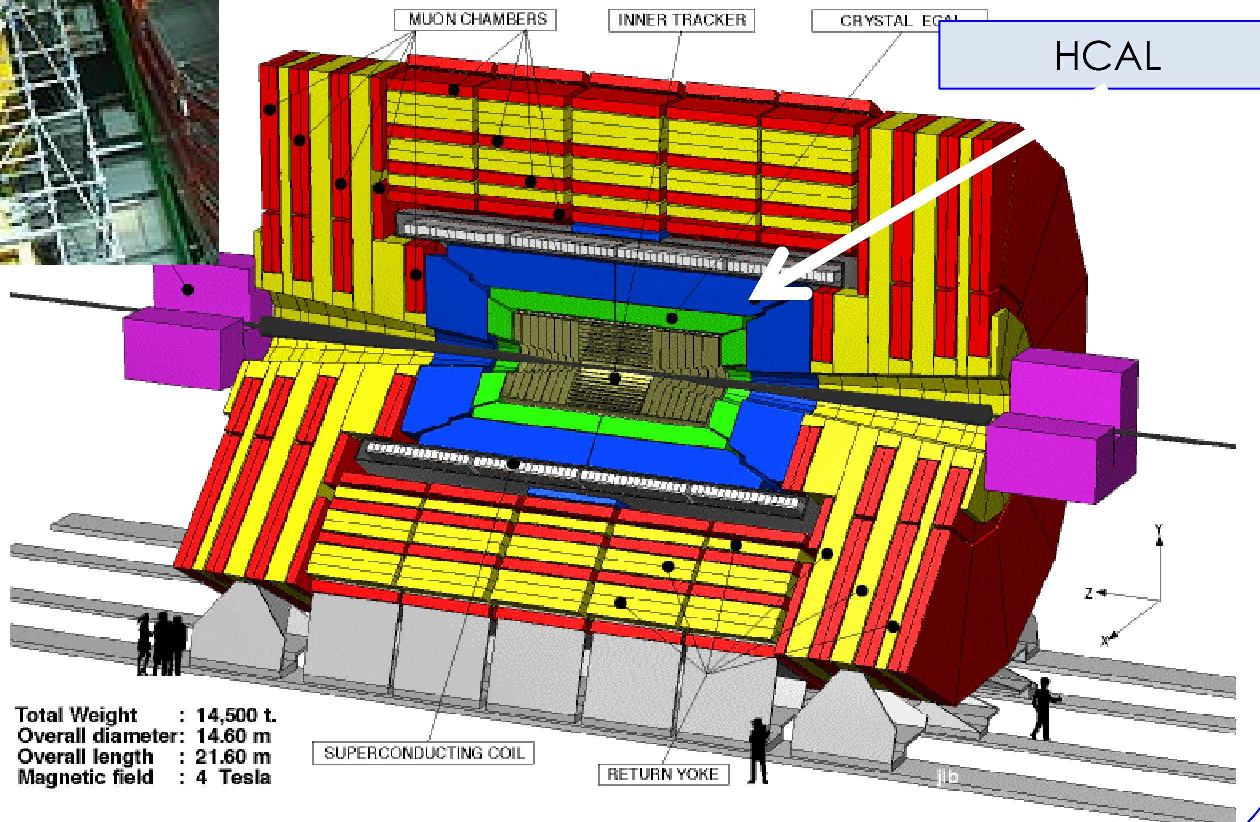


The electron energy resolution is 3%, or better in the ranges of this analysis

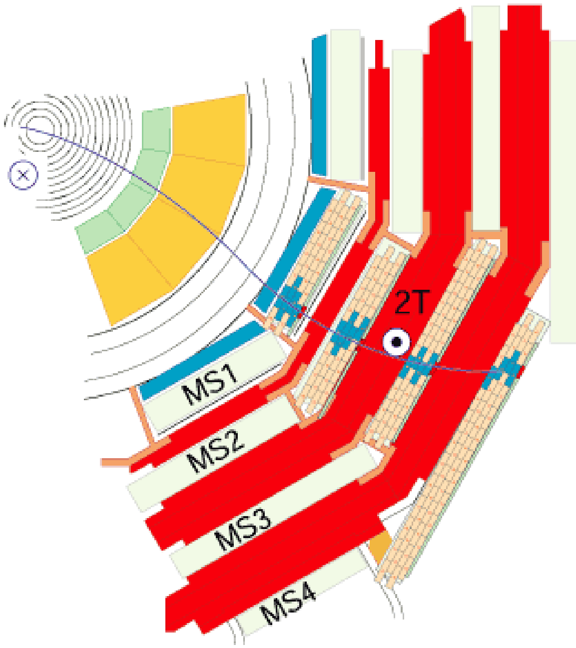


Hadronic Calorimeter

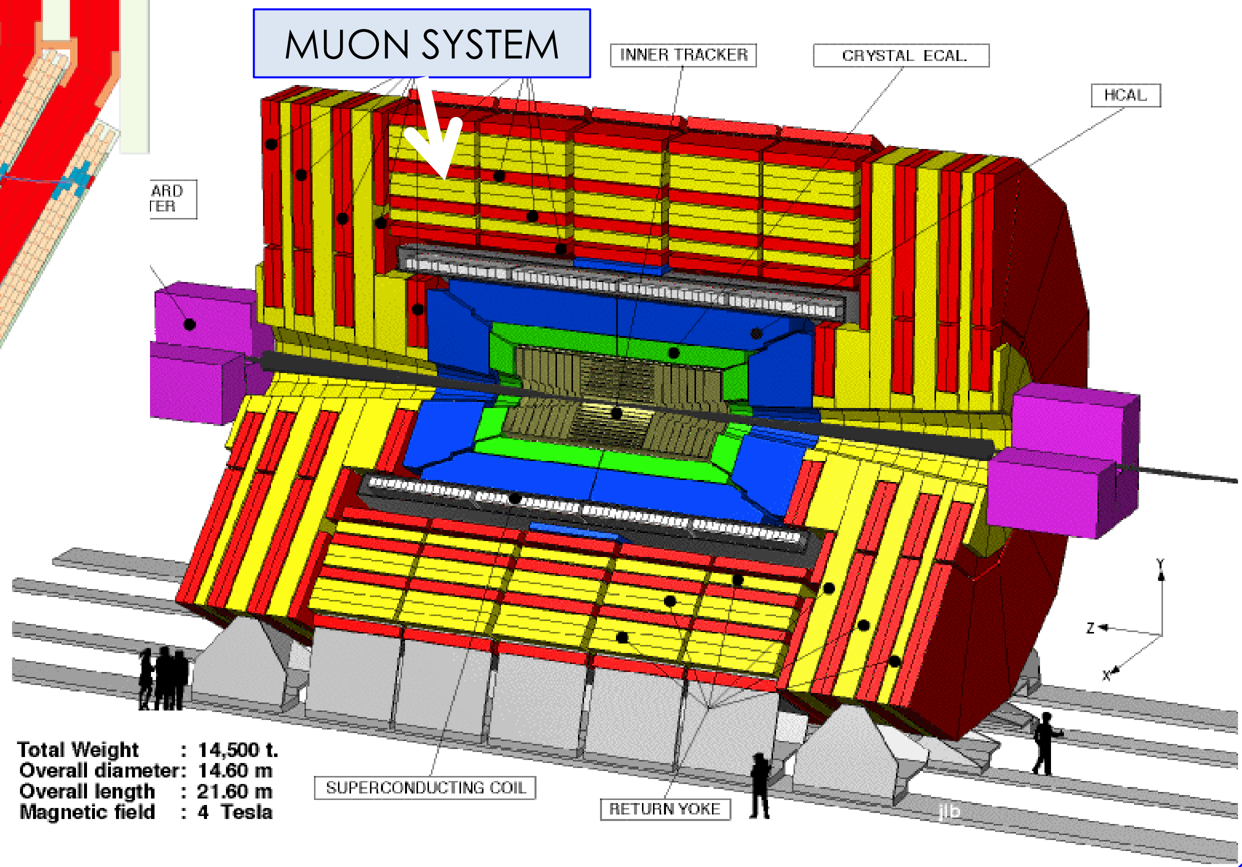
The Missing transverse energy is reconstructed using a particle flow technique.



Muon System



Matching the muons with the tracks measured in the tracker, results in a p_T resolution of ~2% in the relevant p_T range.



Analysis Method

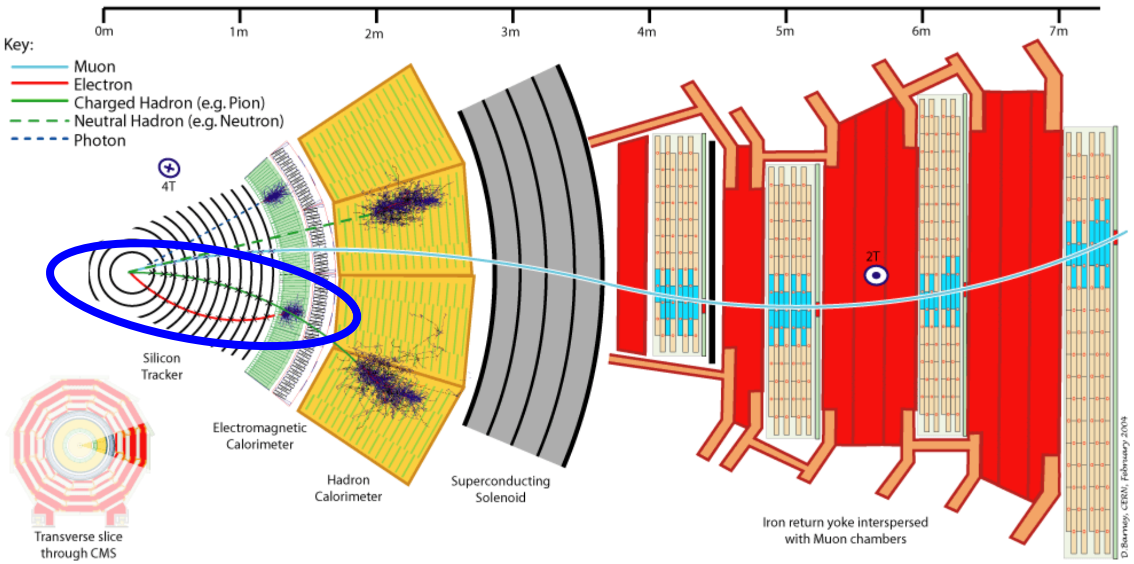
$W \rightarrow l\nu$ characterized by:

- High p_T lepton
- Missing energy from the neutrino
- Triggers:
  Single electron/muon with p_T threshold of 15 GeV/c,
in the $|\eta|<2.1$ region.

- Background
  - QCD
  - Top quark pair
  - Drell-Yan
  - EWK ($W \rightarrow \tau\nu$)

Note: $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$

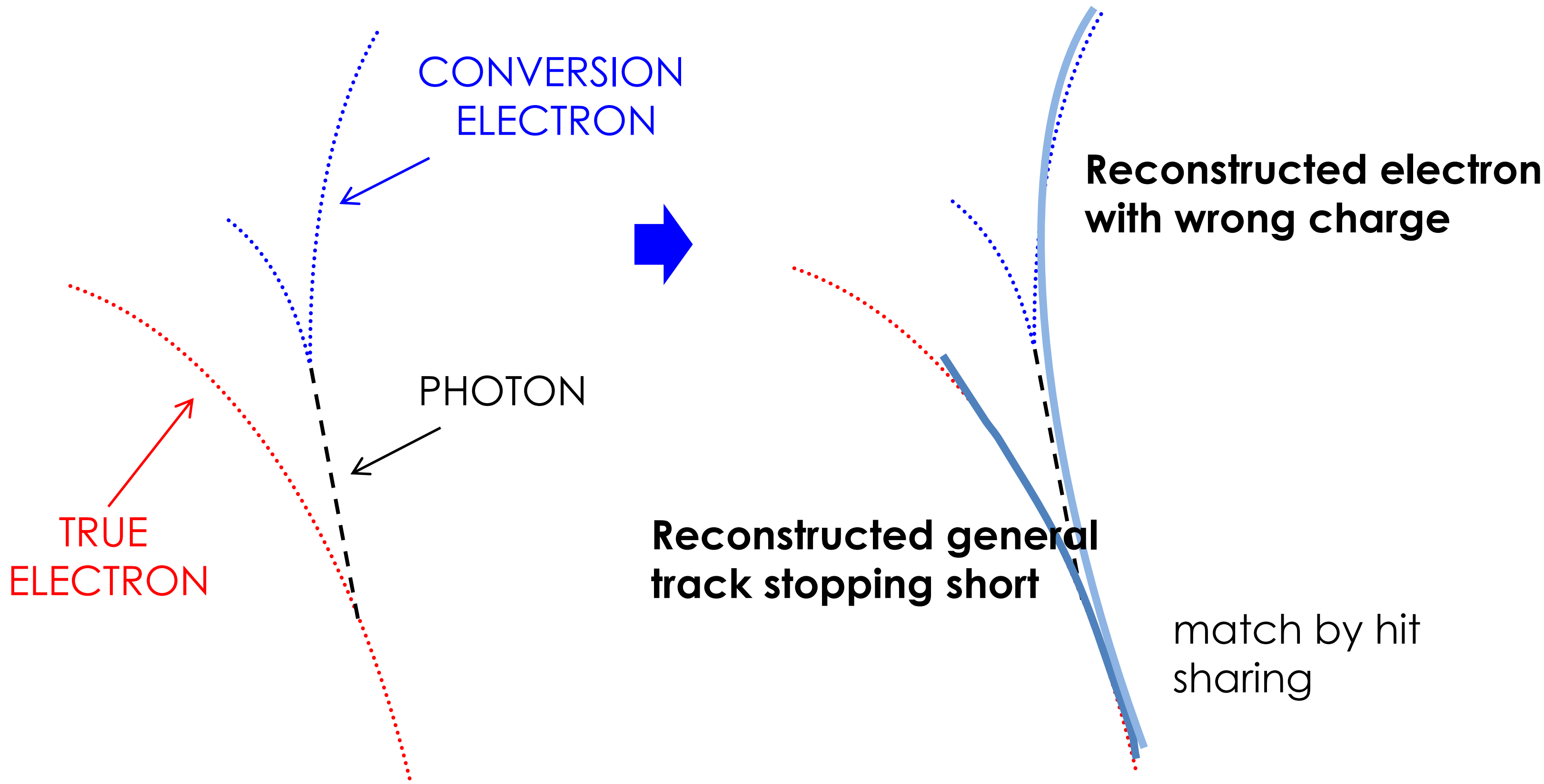
W → eν :: Electron identification



- Electron Trigger
- Kinematic Selection
  - $p_T > 25$ GeV
  - $|\eta| < 2.5$
  - Exclude Crack Region $|\eta|$ [1.44, 1.57]
- Isolation ($\Delta R < 0.3$) calculated in three sub-detectors
- Conversion rejection
- Background suppression

W → eν :: Charge Misidentification

The true charge asymmetry is diluted due to charge misidentification



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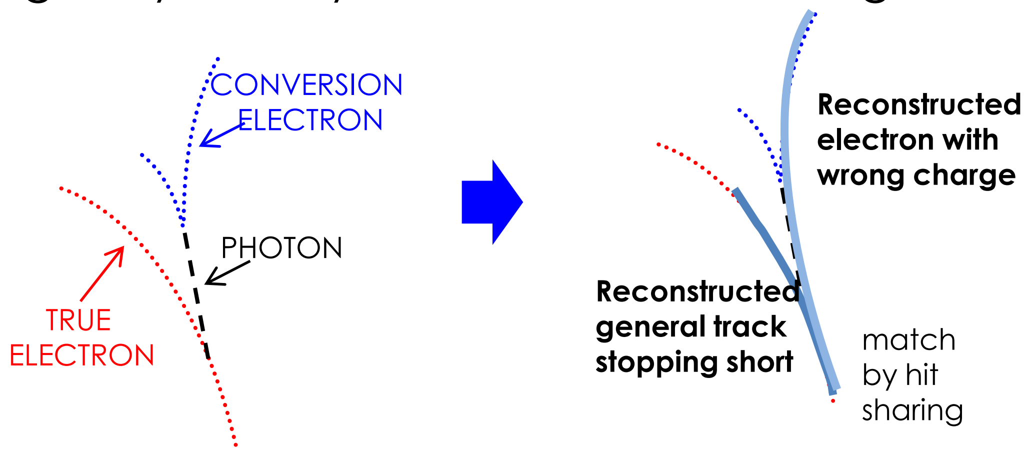
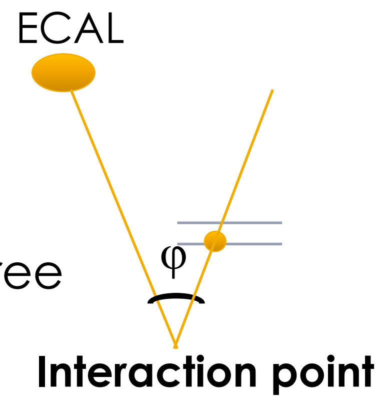


- General track (Kalman filter)
- Gaussian Sum Filter (GSF)
- Azimuthal angle φ

→ We require that all three charge measurements agree

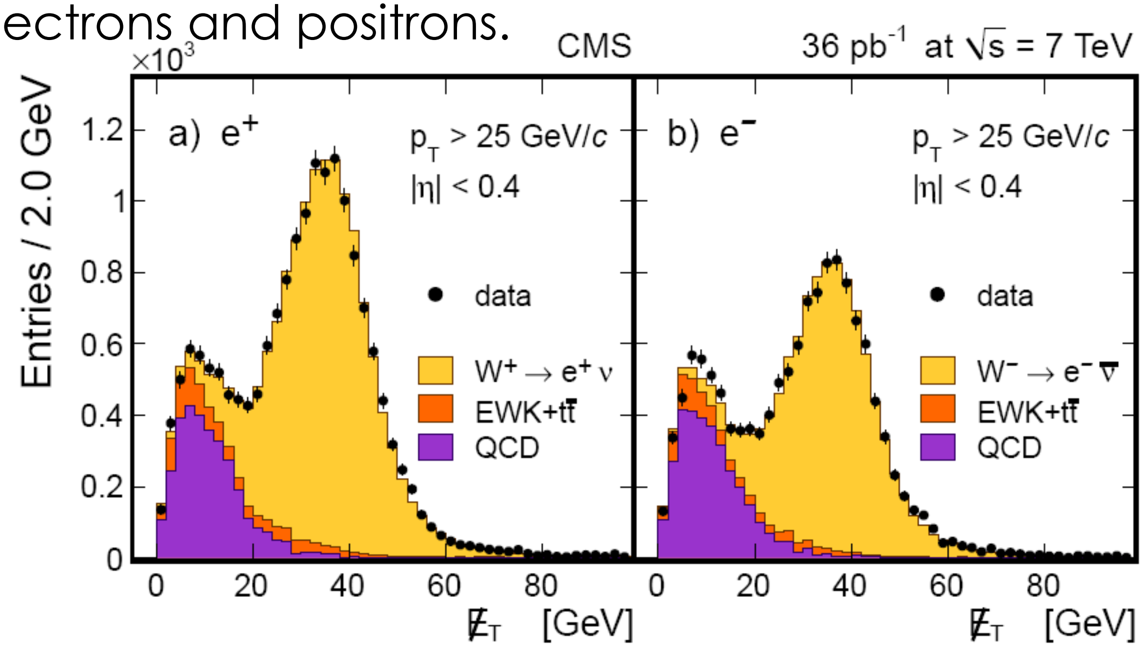


W → eν Signal Extraction

- Background analysis → MET distribution.

- QCD background shape determined from control sample from data, rest of backgrounds from MC.

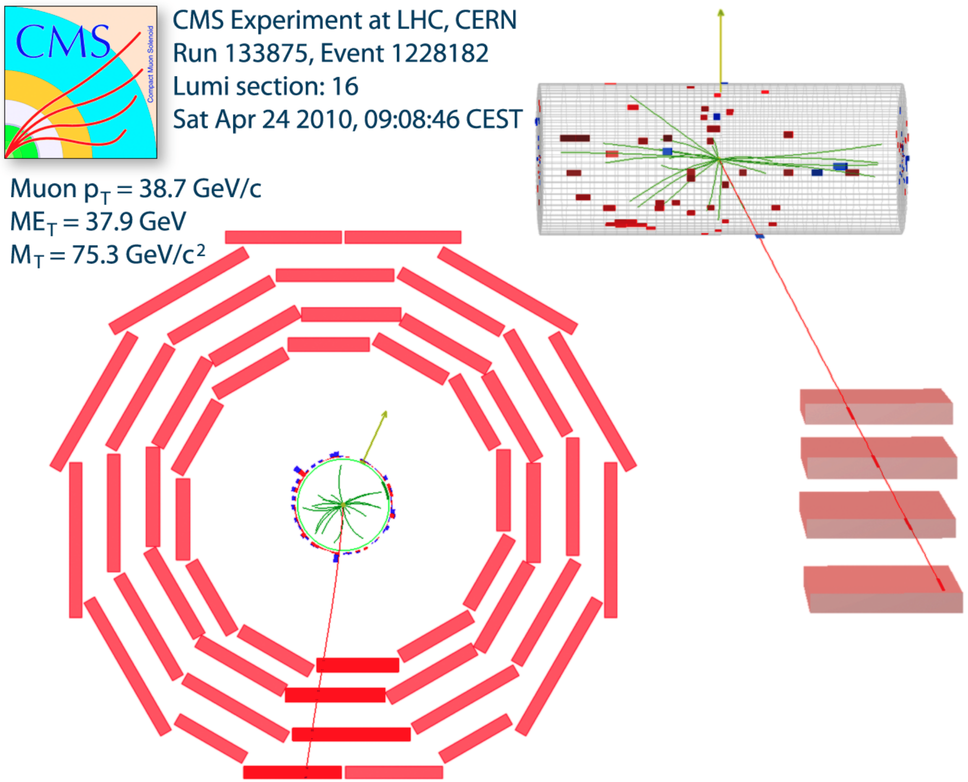
- A fit is performed over the MET distribution to estimate the W signal yield for electrons and positrons.



The picture shows the result of the fits to the data for the first pseudo-rapidity bin.

W → $\mu\nu$ :: Muon identification

- A global track fit (charge from ID track)
- Muon Trigger
- Kinematic Selection
  - $p_T > 25$ GeV
  - $|\eta| < 2.1$
- Background suppression
  - Cosmic Ray Muons
  - Drell – Yan, t-tbar



W → μν Signal Extraction

The signal estimation is done by fitting the distribution of an isolation variable

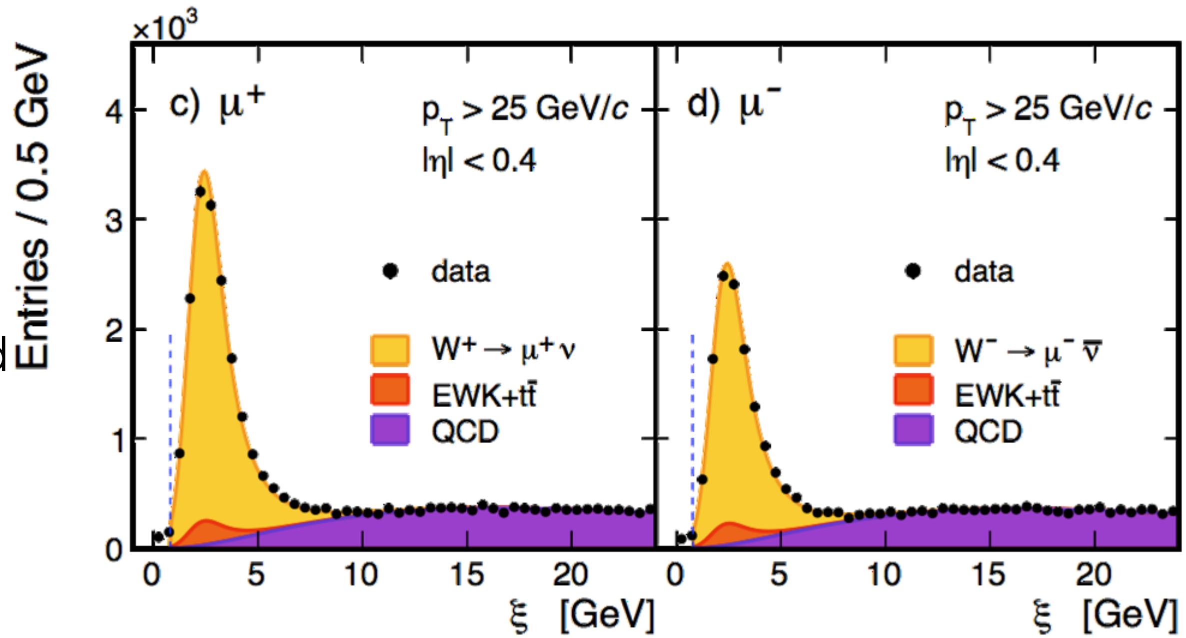
$$\xi = \sum E_T = \left[\sum p_T^{TRK} + \sum E_T^{ECAL} + \sum E_T^{HCAL}\right]_{\Delta R<0.3}$$

Muon energy is excluded.

The shape of the distribution is parameterized as a Landau distribution convoluted with a Gaussian resolution function. The tail modified to be exponential.

QCD background is parameterized by the empirical function:

$$\xi^{\alpha} \cdot e^{\beta\sqrt{\xi}}$$



The picture shows the result of the fits to the data for the first pseudo-rapidity bin.

Systematics

- The efficiency ratio between l^+ and l^-
- Energy momentum scale (~1%)
- Signal and background estimation
  - Electron channel
    - Modeling of MET shape
    - Uncertainties in the background MC cross section
    - QCD background shape modeling
    - Charge misidentification
  - Muon channel
    - Signal and background parameterization
    - Uncertainties in the Drell-Yan and t-tbar background estimation
    - Ratio between signal $W \rightarrow \mu\nu$ and background $W \rightarrow \tau\nu$.
    - Charge misidentification

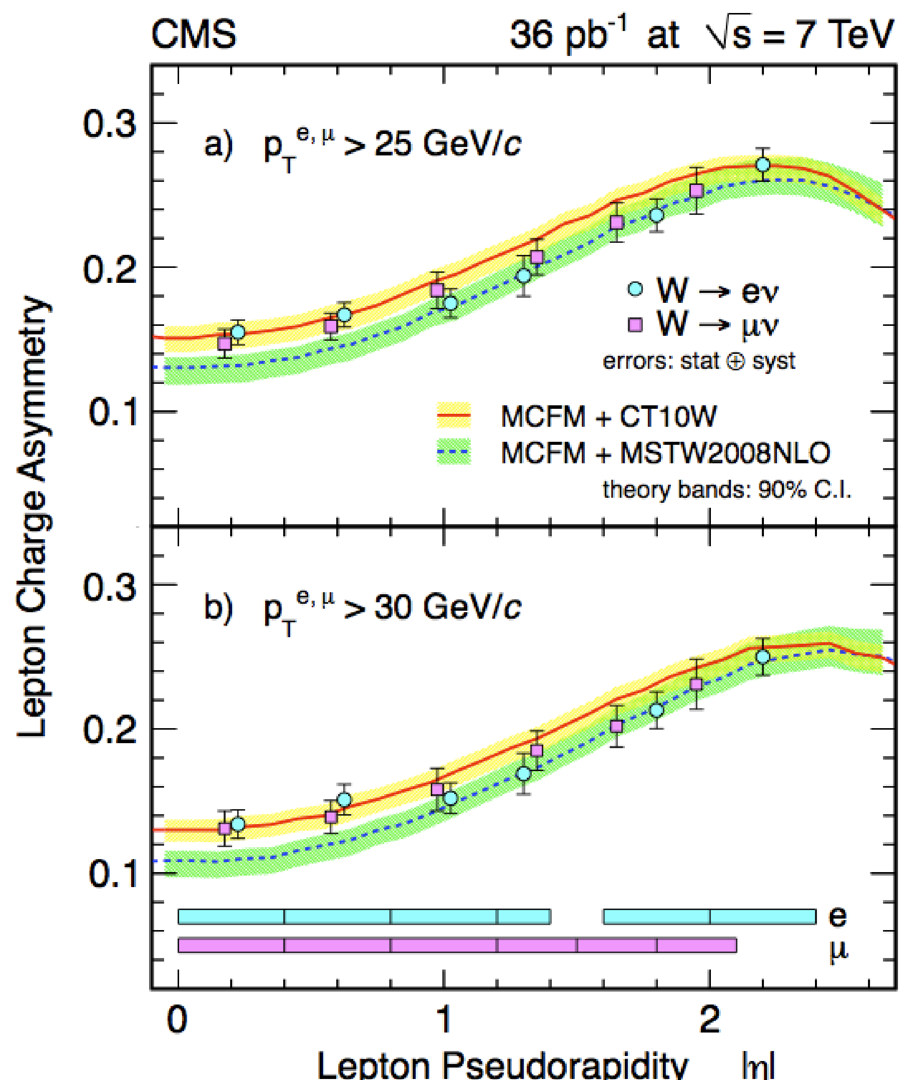
Results

- Measurement performed for p_T>25 GeV/c and p_T>30GeV/c

- The electron and the muon measurements are in agreement with each other

- data suggests a flatter pseudorapidity dependence of the asymmetry than the PDF models studied

- **The input of the data presented in this paper is expected to contribute to a better determination of PDF sets, and help to reduce PDF uncertainties.**



Comparison of the measured lepton charge asymmetry to different PDF models. The errors bars include both statistical and systematic uncertainties.

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M. Aguilar, L. Alvarez-Gaume, F. Barrio, M. T. Dova, J. Ellis, N. Ellis, C. Grojean, H. Haller, R. C. Shellard, M. Spiropulu, A. Zepeda, G. A. Alves, M. A. Ferreira Dias, M. Gandelman, C. Göbel, V. de Souza, A. Sznajder, J. Takahashi,

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THANK YOU

References

- CMS Collaboration. "Measurement of the Lepton Charge Asymmetry in Inclusive W Production in pp Collisions at √s = 7 TeV".
- CMS Collaboration. "Measurement of Inclusive W and Z Cross Sections in pp Collisions at √s = 7 TeV"
- CMS Collaboration. "The CMS experiment at the CERN LHC".
- CDF Collaboration. "Direct Measurement of the W Production Charge Asymmetry in p-pbar Collisions at √s = 1.96 TeV".
- ATLAS Collaboration. "Measurement of the Muon Charge Asymmetry from the W Bosons Produced in pp Collisons at √s = 7 TeV with the ATLAS detector".
- CMS Collaboration. "CMS MET Performance in Events Containing Electroweak Bosons from pp Collisions at √s = 7 TeV"
- A. D. Martin, W. J. Stirling, R. S. Thorne et al. "Parton distributions for the LHC".

Backup

Systematic

$p_T^\ell > 25\,\mathrm{GeV}/c$

$\|\eta\|$ bin	Electron Channel [0.0, 0.4]	[0.4, 0.8]	[0.8, 1.2]	[1.2, 1.4]	[1.6, 2.0]	[2.0, 2.4]	Muon Channel [0.0, 0.4]	[0.4, 0.8]	[0.8, 1.2]	[1.2, 1.5]	[1.5, 1.8]	[1.8, 2.1]
Charge Misident.	0.02	0.03	0.03	0.08	0.09	0.10	0	0	0	0	0	0
Eff. Ratio	0.70	0.70	0.70	0.70	0.70	0.70	0.59	0.39	0.92	0.72	0.81	1.17
e/μ Scale	0.11	0.09	0.19	0.47	0.40	0.45	0.50	0.48	0.50	0.48	0.50	0.42
Sig. & Bkg. Estim.	0.16	0.19	0.26	0.33	0.25	0.25	0.23	0.29	0.34	0.40	0.53	0.58
Total	0.73	0.73	0.77	0.90	0.85	0.87	0.80	0.68	1.10	0.95	1.08	1.37

$p_T^\ell > 30\,\mathrm{GeV}/c$

$\|\eta\|$ bin	Electron Channel [0.0, 0.4]	[0.4, 0.8]	[0.8, 1.2]	[1.2, 1.4]	[1.6, 2.0]	[2.0, 2.4]	Muon Channel [0.0, 0.4]	[0.4, 0.8]	[0.8, 1.2]	[1.2, 1.5]	[1.5, 1.8]	[1.8, 2.1]
Charge Misident.	0.02	0.02	0.03	0.07	0.08	0.10	0	0	0	0	0	0
Eff. Ratio	0.70	0.70	0.70	0.70	0.70	0.70	0.59	0.39	0.93	0.72	0.82	1.18
e/μ Scale	0.07	0.17	0.26	0.46	0.53	0.55	0.80	0.78	0.83	0.81	0.73	0.77
Sig. & Bkg. Estim.	0.16	0.19	0.26	0.33	0.25	0.25	0.20	0.20	0.27	0.35	0.51	0.56
Total	0.72	0.75	0.79	0.91	0.92	0.93	1.01	0.90	1.27	1.14	1.21	1.52

Charge Asymmetry per eta bin

	$p_T^\ell > 25\,\mathrm{GeV}/c$				$p_T^\ell > 30\,\mathrm{GeV}/c$			
$\lvert\eta^e\rvert$	$\mathcal{A}(e)$ ($\pm$stat $\pm$ sys)	$\mathcal{A}^R$	$\mathcal{A}^M$	$\Delta(+/-)$	$\mathcal{A}(e)$ ($\pm$stat $\pm$ sys)	$\mathcal{A}^R$	$\mathcal{A}^M$	$\Delta(+/-)$
[0.0, 0.4]	$15.5 \pm 0.6 \pm 0.7$	15.7	15.3	$+0.8/-1.0$	$13.4 \pm 0.7 \pm 0.7$	13.4	13.1	$+0.7/-0.9$
[0.4, 0.8]	$16.7 \pm 0.6 \pm 0.7$	16.9	16.7	$+0.9/-1.0$	$15.1 \pm 0.7 \pm 0.8$	14.6	14.5	$+0.8/-0.8$
[0.8, 1.2]	$17.5 \pm 0.7 \pm 0.8$	19.3	19.2	$+0.8/-1.1$	$15.2 \pm 0.7 \pm 0.8$	16.9	16.8	$+0.8/-1.0$
[1.2, 1.4]	$19.4 \pm 1.0 \pm 0.9$	21.6	21.7	$+0.8/-1.1$	$16.9 \pm 1.1 \pm 0.9$	19.1	18.9	$+0.8/-1.0$
[1.6, 2.0]	$23.6 \pm 0.8 \pm 0.9$	25.6	25.4	$+0.8/-1.1$	$21.3 \pm 0.9 \pm 0.9$	23.4	23.7	$+0.8/-1.1$
[2.0, 2.4]	$27.1 \pm 0.8 \pm 0.9$	27.1	26.9	$+0.8/-1.1$	$25.0 \pm 0.9 \pm 0.9$	25.7	25.4	$+0.8/-1.1$
$\lvert\eta^\mu\rvert$	$\mathcal{A}(\mu)$($\pm$stat $\pm$ sys)	$\mathcal{A}^R$	$\mathcal{A}^M$	$\Delta(+/-)$	$\mathcal{A}(\mu)$($\pm$stat $\pm$ sys)	$\mathcal{A}^R$	$\mathcal{A}^M$	$\Delta(+/-)$
[0.0, 0.4]	$14.7 \pm 0.6 \pm 0.8$	15.7	15.3	$+0.8/-1.0$	$13.1 \pm 0.7 \pm 1.0$	13.4	13.1	$+0.7/-0.9$
[0.4, 0.8]	$15.9 \pm 0.6 \pm 0.7$	16.9	16.7	$+0.9/-1.0$	$13.9 \pm 0.7 \pm 0.9$	14.6	14.5	$+0.8/-0.8$
[0.8, 1.2]	$18.4 \pm 0.6 \pm 1.1$	19.3	19.2	$+0.8/-1.1$	$15.8 \pm 0.7 \pm 1.3$	16.9	16.8	$+0.8/-1.0$
[1.2, 1.5]	$20.7 \pm 0.7 \pm 1.0$	22.0	22.0	$+0.8/-1.1$	$18.5 \pm 0.8 \pm 1.1$	19.6	19.4	$+0.8/-1.0$
[1.5, 1.8]	$23.1 \pm 0.8 \pm 1.1$	24.6	24.5	$+0.8/-1.1$	$20.2 \pm 0.8 \pm 1.2$	22.2	21.9	$+0.8/-1.1$
[1.8, 2.1]	$25.3 \pm 0.8 \pm 1.4$	26.5	26.3	$+0.8/-1.0$	$23.1 \pm 0.9 \pm 1.5$	24.5	24.1	$+0.8/-1.1$

Missing Transverse Energy Reconstruction

CMS uses three algorithms to reconstruct MET:

- based on calorimeter energies and calorimeter tower geometry
- calculated by replacing the calorimeter tower energies matched to charged hadrons with their corresponding charged-track momenta.
- **calculated using a complete particle-flow technique.**

Particle-flow (PF) method

This technique aims to reconstruct a complete, unique list of particles in each event using an optimal combination of information across all CMS sub-detector systems. Particles which are reconstructed and identified include muons, electrons (with associated bremsstrahlung photons), photons (unconverted and converted), and charged and neutral hadrons. The PF-MET is then simply the negative vector sum of all such reconstructed particles in the event.

Monte Carlo Simulations

- Signal
  - POWHEG with CT10 PDF model
- Background
  - QCD multijet → PYTHIA with CTEQ6L PDF
  - Top quark pair → PYTHIA + MC@NLO
  - Drell-Yan → PYTHIA
  - EWK ($W \rightarrow \tau\nu$) PYTHIA
  - QCD γ+jets PYTHIA