The Muon Charge Asymmetry Measurement in Inclusive pp→W production at $\sqrt{s}=8$ TeV

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Outline

Introduction

Analysis Details

Results and Implication

Reference:

7 TeV paper:(Published)
Phys. Rev. D 90, 032004 – Published 13 August 2014

8 TeV Analysis: aiming for paper
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSMP14022
Introduction

- In pp collisions, primary mechanism of W production:
  \[ \bar{u}d \rightarrow W^+ \]
  \[ \bar{d}u \rightarrow W^- \]

- \( N(u_V) > N(d_V) \)
  \[ \Rightarrow \text{Total } N(W^+) > N(W^-) \]

- Measurement of W charge asymmetry in bins of rapidity of boson can provide new insight into u/d ratio and sea quark densities in ranges of Bjorken parameter \( x \) probed by pp collisions at \( \sqrt{s} = 8 \text{ TeV} \).

\[ x_{1,2} = \frac{m_W}{\sqrt{s}} \cdot e^{\pm y} \]

\[ A(\eta) = \frac{\frac{d\sigma}{d\eta}(pp \rightarrow W^+) - \frac{d\sigma}{d\eta}(pp \rightarrow W^-)}{\frac{d\sigma}{d\eta}(pp \rightarrow W^+) + \frac{d\sigma}{d\eta}(pp \rightarrow W^-)} \]
**Muon Selection**

- $W \rightarrow \mu \nu$ candidate events are characterized by a high $p_T$ muon and MET due to the neutrino.

- Trigger: single isolated muon trigger, $p_T > 24$ GeV, $|\eta| < 2.4$

- Muon identified by hits in silicon tracker and muon detector, global track fitting chi-squared, $|dxy|$, isolation...

- Sort muons by $p_T$ and the leading one is taken as the $W(\mu \nu)$ candidate. Require the leading muon $p_T > 25$ GeV, $|\eta| < 2.4$ and to trigger the event.

- Reject events with another muon with $p_T > 15$ GeV.
Overview of the analysis

• After the selection of events, Asymmetry is measured in bins of muon pseudorapidity

\[[0,0.2],[0.2,0.4],[0.4,0.6],[0.6,0.8],[0.8,1.0],[1.0,1.2],[1.2,1.4],[1.4,1.6],[1.6,1.85],[1.85,2.1],[2.1,2.4]\]

• In each \(|\eta|\) bin, MET templates from MC samples are fitted to the MET distribution in data for Signal & Background extraction.

• Met fits are performed simultaneously for W+ and W- candidate events.
Backgrounds

- A total of 61 million $W^+ \rightarrow \mu^+ \nu$ and 45 million $W^- \rightarrow \mu^- \nu$ candidate events are selected.

Two dominant processes contributing to the total backgrounds:

1. Multijet (QCD) events with high $p_T$ muons. (~10%)

2. Electro-weak and ttbar events (~8%)

The contribution from single-top and diboson events are negligible.
Raw Charge Asymmetry and Asymmetry

- Raw asymmetry is calculated from the number of W+ and W- signal events, which are obtained from the fits.

\[
A_{\text{raw}} = \frac{N^{W+} - N^{W-}}{N^{W+} + N^{W-}}
\]  
(Eq. 1)

- Correct for efficiency difference between \(\mu^+\)/\(\mu^-\).

\[
A_{\text{true}} = A_{\text{raw}} - \frac{1 - (A_{\text{raw}})^2}{2} \left(\frac{\varepsilon^+}{\varepsilon^-} - 1\right)
\]  
(Eq. 2)

Efficiency correction improves the agreement between + and – eta sides.
Systematic Uncertainties

- Consider sources that affect
  - MET Shapes
  - Yield
  - Background Normalization
  - Araw $\rightarrow$ Atrue correction

- For several systematic sources we smear their corresponding parameters 400 time (redo every step in the analysis)

- At the end we take the RMS of result asymmetry distribution in each $|\eta|$ bin as systematic source
Systematic Uncertainties

Table 2: Systematic uncertainties in $A$ for each $|\eta|$ bin. The statistical uncertainty in each $|\eta|$ bin is also shown for comparison. A detailed description of each systematic uncertainty is given in the text. The values are expressed as percentages (as are the measured asymmetries).

| $|\eta|$ bin | 0.0–0.2 | 0.2–0.4 | 0.4–0.6 | 0.6–0.8 | 0.8–1.0 | 1.0–1.2 | 1.2–1.4 | 1.4–1.6 | 1.6–1.85 | 1.85–2.1 | 2.1–2.4 |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Stat. Unc. | 0.062   | 0.063   | 0.061   | 0.061   | 0.063   | 0.065   | 0.068   | 0.069   | 0.065   | 0.062   | 0.072   |
| Efficiency | 0.058   | 0.071   | 0.057   | 0.058   | 0.082   | 0.091   | 0.092   | 0.085   | 0.085   | 0.082   | 0.134   |
| Muon scale | 0.028   | 0.028   | 0.027   | 0.027   | 0.030   | 0.030   | 0.029   | 0.034   | 0.034   | 0.032   | 0.028   |
| QCD +/-   | 0.151   | 0.150   | 0.152   | 0.152   | 0.155   | 0.165   | 0.176   | 0.172   | 0.138   | 0.102   |         |
| QCD shape | 0.022   | 0.032   | 0.031   | 0.029   | 0.039   | 0.043   | 0.054   | 0.060   | 0.071   | 0.055   | 0.040   |
| EW+tt bkg. | 0.027   | 0.027   | 0.027   | 0.028   | 0.027   | 0.028   | 0.029   | 0.031   | 0.035   | 0.042   | 0.052   |
| $E_T$ shape | 0.033   | 0.042   | 0.039   | 0.043   | 0.055   | 0.059   | 0.060   | 0.084   | 0.086   | 0.085   | 0.067   |
| FSR       | 0.081   | 0.105   | 0.086   | 0.093   | 0.082   | 0.100   | 0.100   | 0.093   | 0.100   | 0.089   | 0.067   |
| PDF       | 0.025   | 0.024   | 0.022   | 0.021   | 0.018   | 0.022   | 0.032   | 0.037   | 0.049   | 0.059   | 0.081   |
| Total Sys. Unc. | 0.191 | 0.208 | 0.195 | 0.200 | 0.207 | 0.223 | 0.234 | 0.247 | 0.253 | 0.224 | 0.221 |
| Total Unc.  | 0.201 | 0.217 | 0.205 | 0.209 | 0.217 | 0.232 | 0.244 | 0.256 | 0.261 | 0.233 | 0.233 |

Dominant systematics are QCD, FSR and Efficiency.
Results

- Measured asymmetry compared to predictions from different PDF sets

CMS work in progress

- The experimental uncertainties are smaller than the current PDF uncertainties in the present QCD calculations.
Implication of Charge asymmetry

- **HERA + W Asymmetry (7 TeV) vs HERA + W Asymmetry (8 TeV)**

![Valence quark PDFs](image)

- **CMS NLO 13 parameter fit**
  - $Q^2 = m_W^2$

- **CMS Preliminary NLO 13 parameter fit**
  - $Q^2 = m_W^2$

**7 TeV**

**8 TeV**

An update work with NNLO is in progress

Similar change of PDF shape. More improved constraints using 8 TeV measurement.
Summary

- W boson muon charge asymmetry measurement at 8 TeV has been performed, it is available to public:
  
  https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSMP14022

- Improves the description of PDF.

- Aiming for paper.

Work in progress

- QCD analysis at NNLO order is being performed.
- Decided to expand the paper with differential cross section.
- Redo QCD analysis with differential cross section results.
Thank You!
Met Fits
Introduction and Motivation: latest Results

CDF result 1 fb⁻¹
Phys. Rev. Lett. 102, 181801 (2009)

D0 result 9.7 fb⁻¹

Conclusion:
the total uncertainties are smaller than the uncertainties coming from PDFs.

Update the CMS muon measurement with Full 2011 CMS data!
Introduction and Motivation: 7TeV CMS Measurement

- Most Precise measurement of W lepton C. Asymmetry.
- The experimental uncertainties are smaller than the current PDF uncertainties in the present QCD calculations.
- Changes the PDF shape, improves constraints on the valence distributions.

CHARACTERIZATION OF 900 FOUR-ANODE PHOTOMULTIPLIER TUBES FOR USE IN 2013 HADRONIC FORWARD CALORIMETER UPGRADE

EMRAH TIRAS

M.S. Thesis Defense Presentation

May 14, 2012

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Results

- HERA + W Asymmetry (7 TeV) vs HERA + W Asymmetry (8 TeV)

Valence quark PDFs

CMS NLO 13 parameter fit

CMS Preliminary NLO 13 parameter fit

7 TeV

8 TeV

Ratio of relative errors

Q^2 = 1.9 GeV^2

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Similar change of PDF shape. More improved constraints using 8 TeV measurement.