Run12 and Run13 W Ratio Cross Section Update

Matthew Posik[1] and Maxence Vandenbroucke[2]

[1]Temple University
Philadelphia, PA 19122
[2]CEA Saclay / IRFU

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Outline

End Goal of Analysis

- Use $W^{\pm}$ cross section ratio (R_W) to study unpolarized anti-quark sea.
- R_W is sensitive to $\bar{d}/\bar{u}$.

$$R_W = \frac{\sigma_{W^+}}{\sigma_{W^-}} = \frac{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}{\bar{u}(x_1)d(x_2) + d(x1)\bar{u}(x_2)} \quad (1)$$

- Independently compute the $W^{\pm}$ cross section ratios for:
  - Run12 (Maxence Vandenbroucke)
  - Run13 (Matt Posik)
- Combine Run12 and Run13 results and release for preliminary and publication.

W± Cross Section Ratio

Definition

- W± Cross Section Ratio (RW):

$$RW = \left(\frac{N^{+}_{obs} - N^{+}_{bkg}}{N^{-}_{obs} - N^{-}_{bkg}}\right)\left(\frac{\epsilon^{-}_{\eta}}{\epsilon^{+}_{\eta}}\right) \quad (2)$$

- $N^{\pm}_{obs}$ are the observed $W^{\pm}$ events
- $N^{\pm}_{bkg}$ are the background $W^{\pm}$ events
- $\epsilon^{\pm}_{\eta}$ is the $W^{\pm}$ efficiency as a function of η

$$\delta RW = \sqrt{\sum_{i}\left(\frac{\partial RW}{\partial i}\delta i\right)^{2}} \quad (3)$$

- δi is the statistical uncertainty on quantity i
- Where $i = N^{\pm}_{obs}, N^{\pm}_{bkg}$, and $\epsilon^{\pm}_{\eta}$

$N^{\pm}_{obs}$ Run-12

Stats:

- 685 runs
- 2,934 W's used in RW calculation
- Integrated luminosity $L = 77pb^{-1}$.
- W candidate selection done using Justin's code

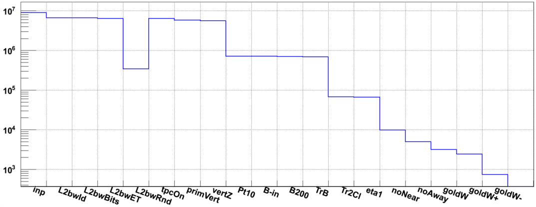

Figure : Run12: Data selection.

Binning:

- η was split into 8 bins
- $[-1.1, -0.8]$, $[-0.8, -0.5]$, $[-0.5, -0.25]$, $[-0.25, 0.0]$
- $[0.0, 0.25]$, $[0.25, 0.5]$, $[0.5, 0.8]$, $[0.8, 1.1]$

$N^{\pm}_{obs}$
Run-13 (Period 1)

Stats:

- **All** Run 13 data shown is from period one (slightly more than 1/2 total run 13 stats)
- A total of 938 runs were analyzed.
- A total of 4,584 W events used in RW calculation ($25GeV \leq E_T \leq 50GeV$).
- Integrated luminosity $L = 126pb^{-1}$.

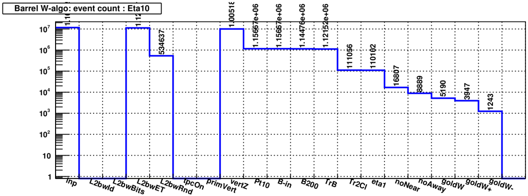

Figure : Run13: Data selection.

Binning:

- η was split into 8 bins
- $[-1.1, -0.8]$, $[-0.8, -0.5]$, $[-0.5, -0.25]$, $[-0.25, 0.0]$
- $[0.0, 0.25]$, $[0.25, 0.5]$, $[0.5, 0.8]$, $[0.8, 1.1]$

$N_{bkg}^{\pm}$

- Run-9 background code is used
- Code is modified to compute 8 η bins rather than 4
- Backgrounds calculated from embedded MC

Background Contributions:

- Data driven QCD
- Second EEMC
- $W^{\pm} \to \tau^{\pm}\nu$
- $Z \to e^{+}e^{-}$

Run-12:

- W^{+} events $\sim$ 110k
- W^{-} events $\sim$ 35k
- Z events $\sim$ 25k

Run-13:

- W^{+} events $\sim$ 125k
- W^{-} events $\sim$ 40k
- Z events $\sim$ 30k

W^+ Background Contributions

Run-12

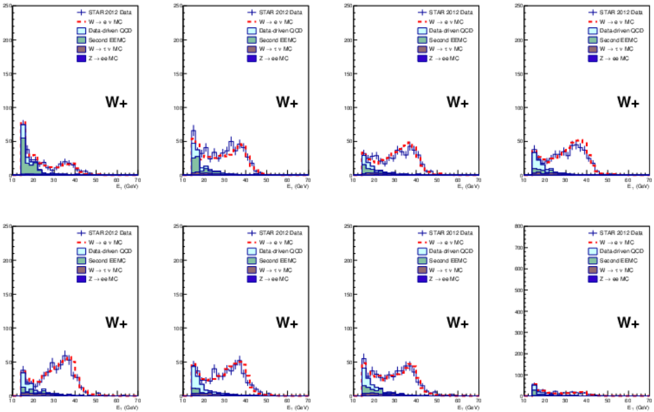

Figure : Run-12 W$^+$ background contributions. Upper left:eta-bin 1, upper right: eta-bin 4, lower left: eta-bin 5, lower right: eta-bin 8.

W^+ Background Contributions

Run-13

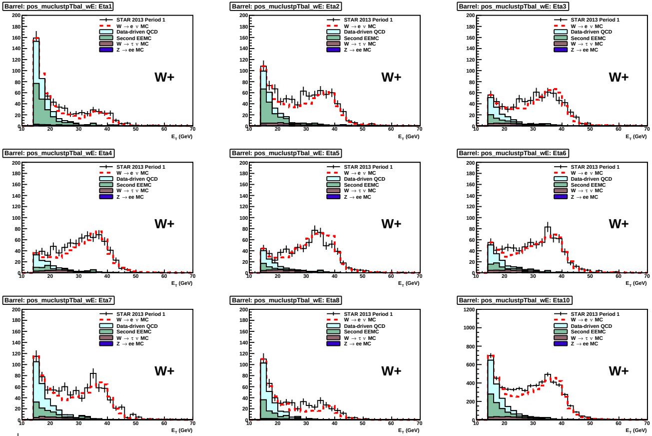

Figure : Run-13 W$^+$ background contributions. Upper left: eta-bin 1, upper right: eta-bin3, mid left: eta-bin 4, mid right: eta-bin 6, lower left: eta-bin 7, lower right: eta-bins 1-8.

W^- Background Contributions

Run-12

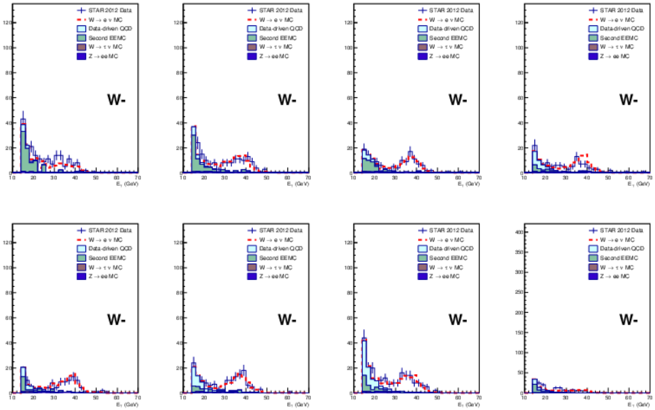

Figure : Run-12 W$^-$ background contributions. Upper left:eta-bin 1, upper right: eta-bin 4, lower left: eta-bin 5, lower right: eta-bin 8.

W^- Background Contributions

Run-13

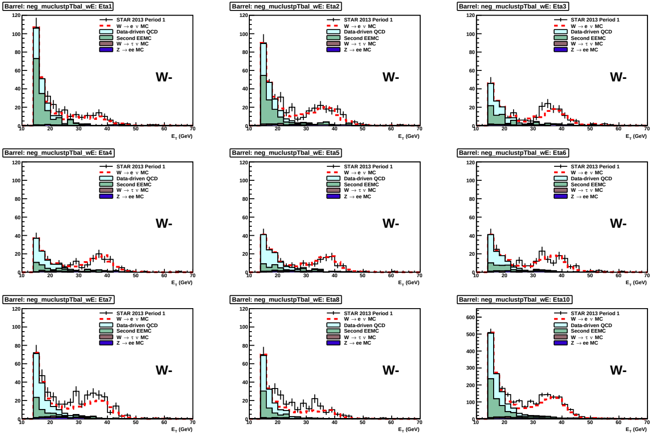

Figure : Run-13 W$^-$ background contributions. Upper left: eta-bin 1, upper right: eta-bin3, mid left: eta-bin 4, mid right: eta-bin 6, lower left: eta-bin 7, lower right: eta-bins 1-8.

$W^{\pm}$ Efficiencies

Definition

- An efficiency is defined as

$$\epsilon = \frac{\text{Events that pass a condition}}{\text{Thrown MC events}} \quad (4)$$

- Four efficiencies were computed for $W \rightarrow e + \nu$:
  - Trigger efficiency (numerator: l2bitET = true)
  - Z vertex reconstruction efficiency (numerator: rank > 0 and $|vertex| < 100$ cm)
  - Tracking efficiency (numerator: tracks with $pt > 10$ GeV)
  - Efficiency of W finding algorithm (numerator: track match to cluster and cluster.ET/near.TotET > 0.88 and ptBalance > 14 GeV and awayTotET < 30 GeV)
- Total efficiency:

$$\epsilon = \epsilon^{trig} \cdot \epsilon^{vert} \cdot \epsilon^{trk} \cdot \epsilon^{algo} \quad (5)$$

- Uncertainty is defined as

$$\delta\epsilon = \frac{1}{\sqrt{N_0^i}} \quad (6)$$

- Where N_0^i = MC events thrown for the i^{th} bin

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Two Efficiency Methods

- Two independent methods are used to compute the efficiencies.
- Differences between initial MC η values (true-η) and reconstructed MC η values (measured-η) lead to bin migration.
- Maxence's code accounted for this by looping on the reconstructed η 8 times and selecting only MC leptons within a particular bin.
- Matt's code reads in the entire η distribution and divides into particular η ranges.
- The difference between the two methods can be used to get a handle on the size of the bin migrations.
- Maxence's and Matt's methods are consistent when cutting out events from bin edges: discrepancies are only a result of bin migration.

Bin Migration Size (1)

Use Run-12 data and compute W efficiencies using Matt's and Maxence's code:

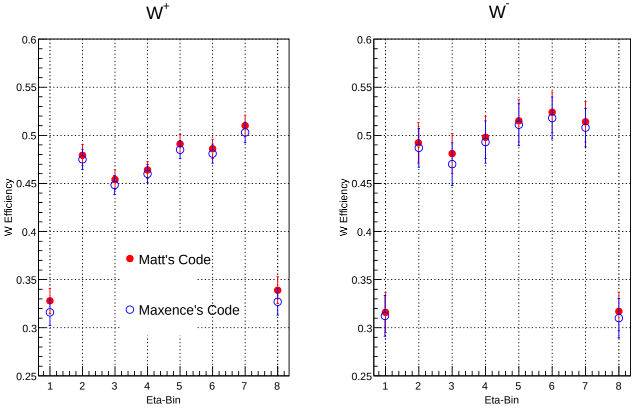

Figure : Comparison of Matt's and Maxence's W efficiency code.

Bin Migration Size (2)

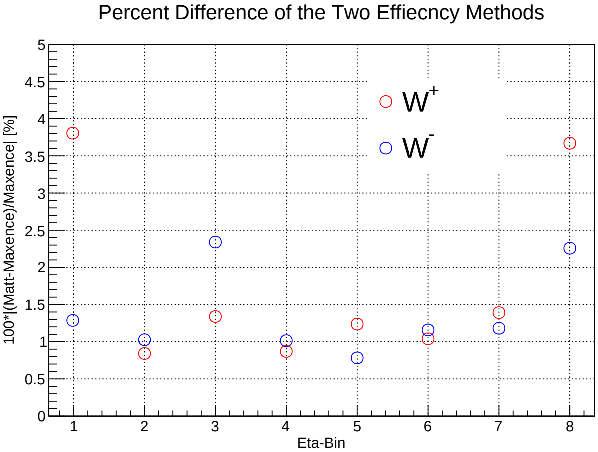

Figure : Percent difference between Matt's and Maxence's W efficiency code.

$W^{\pm}$ Efficiencies: $\epsilon^{\pm}$

Run-12 and 13

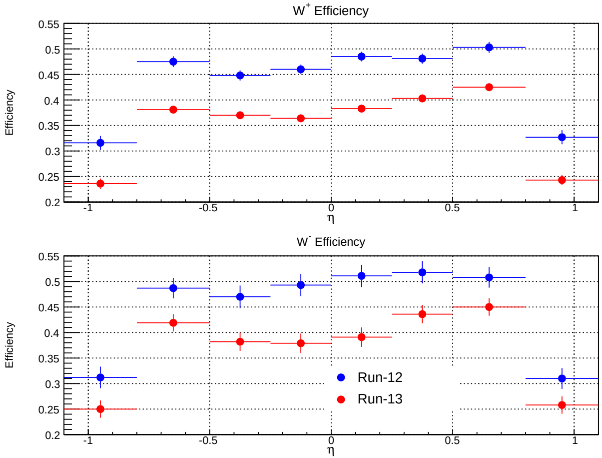

Figure : Run-12 and Run-13 $\epsilon_{\eta}^{\pm}$.

Run-12 and 13 Luminosity Dependence

Higher luminosity leads to lower W efficiency!

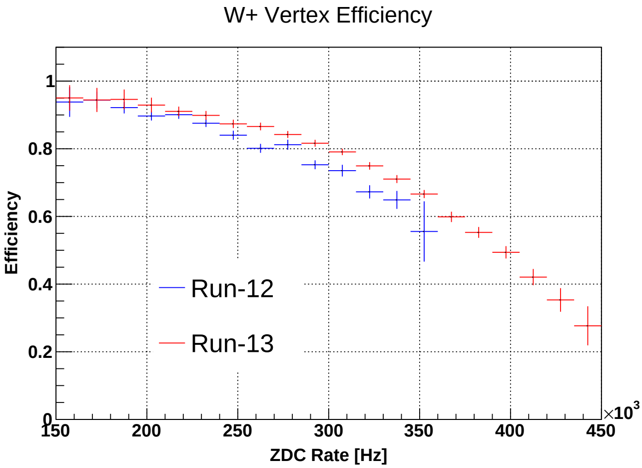

Figure : Run 12 and Run 13 W^+ vertex reconstruction efficiency as a function of zdc rate.

W$^{\pm}$ Cross Section Ratio: RW

Run-12 and 13

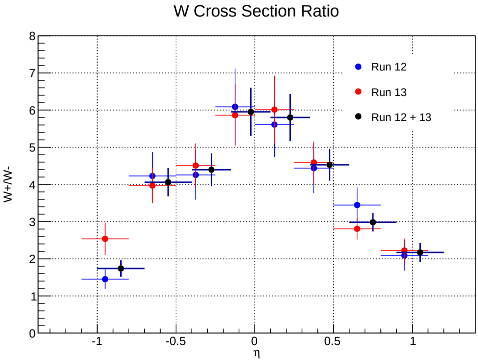

Figure : Run-12 and Run-13 W^+/W^- ratios.

- Run-12 and Run-13 data are combined using statistically weighted sum, and are offset in η for clarity.

Eta Bins 1 and 7

			Run12	Run13			
Eta Bin	Nobs+	Nbkg+	Nobs-	Nbkg-	Eff+	Eff-	RW
1	131	15.57	86	7.49	0.32	0.31	1.45
1	225	29.72	99	17.45	0.24	0.25	2.54
7	327	21.65	101	11.50	0.50	0.51	3.45
7	515	36.78	204	23.62	0.43	0.45	2.81

Figure : Run-12 and Run-13 η-bins 1 and 7.

W$^{\pm}$ Cross Section Ratio: RW

Run-12 + 13 Compared to Run-9

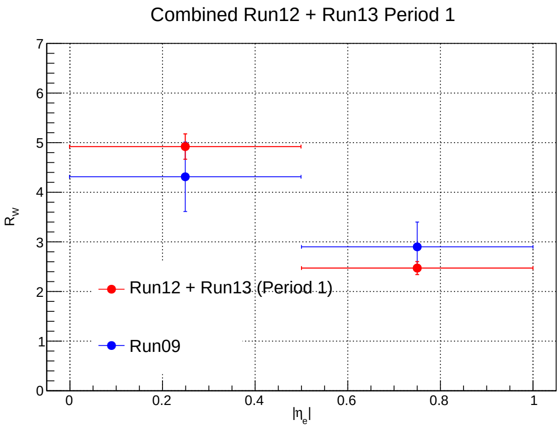

Figure : Run-09 and Run-12+13 W^{+}/W^{-} ratios.

Summary

Summary

- $W^{\pm}$ cross section ratios computed for Run-12 and 13 (period 1).
- Consistent results between Runs-9,12, and 13.
- Bin migrations during efficiency study are small.

Investigate

- Implement more accurate efficiency uncertainty (Run-12 and 13).
- Further characterize bin migration (real η vs measured η,W+,W-,RW).
- Investigate Run-13 η bins 1 and 7, they show a larger discrepancy from Run-12.
- Estimate systematic uncertainties.
- Apply theory calculations to cross section ratio plots.
- Include Run-13 period 2 data into results.