

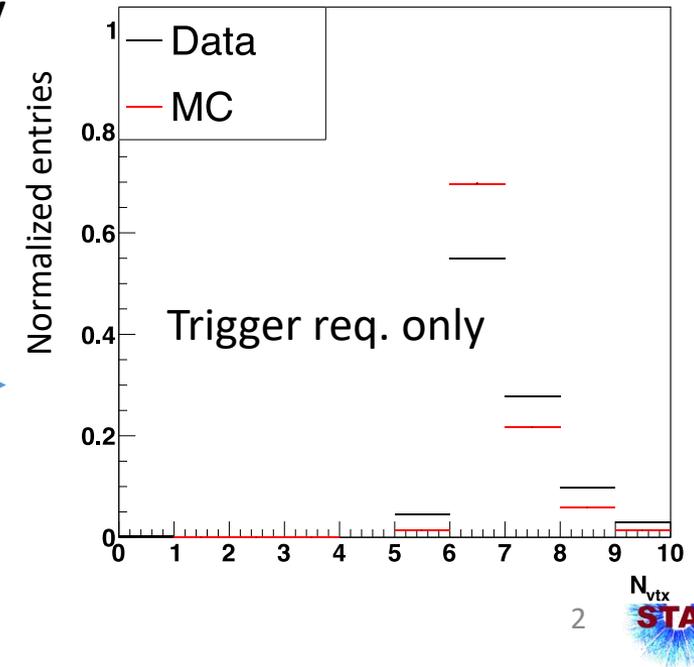
W^+ / W^- cross-section ratio with STAR Run 2017

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Temple Univ.



Recap

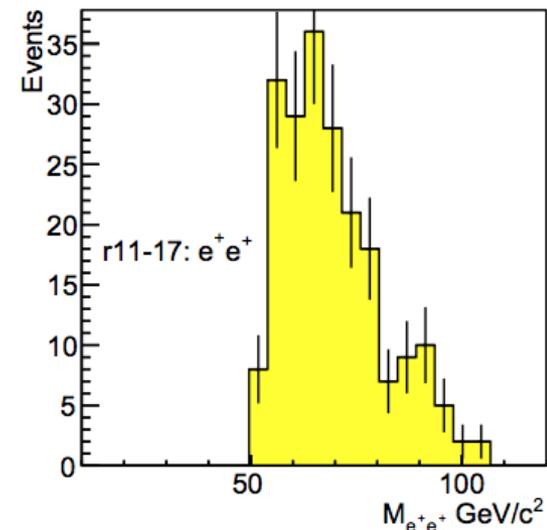
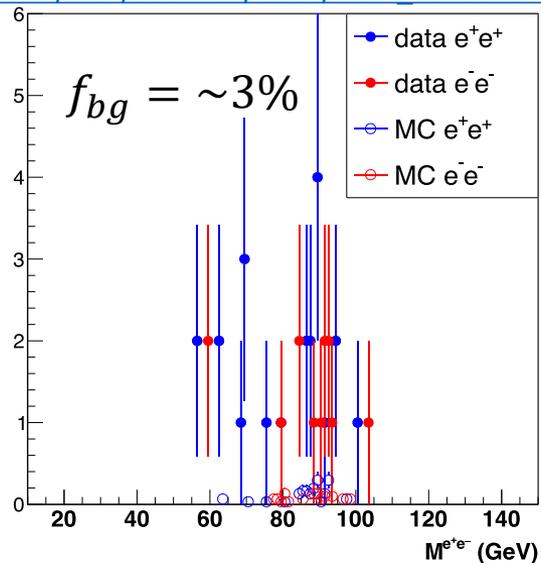
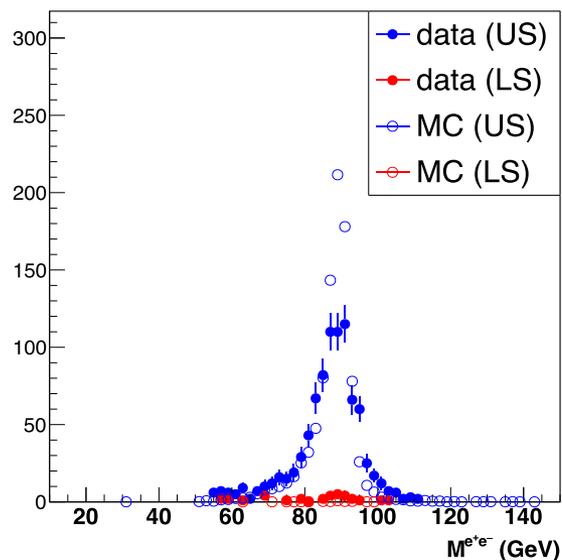
- Z cross section extracted using Run 13 cuts
 - Agreed with Run 13 results $\sim 1\sigma$
 - Also agreed with FEWZ NLO $\sim 1\sigma \rightarrow$ No issues with Z?
 - Failed to describe LS BGR seen in Run 17 pub
 - Tight charge requirement ($q \times E_T/p_T$) may not be justified
 - $\sigma_Z \sim 3.2 \pm 0.3 \text{ pb}$ (this study) vs. $\sim 4.5 \text{ pb}$ (pub)
- Mis-estimated signed- $p_{T,bal}$ efficiency
 - How do jets look in MC?
- Overview
 - Run 17 data with Run 17 cuts
 - Non-selection with N_{vtx} \rightarrow
($N_{vtx} \geq 3$ for data, ≥ 1 for MC)
 - Investigations of MC jets with Z



Z Signal with Run 17 cuts

- Strategy detailed in Apr 9, 2025 presentation

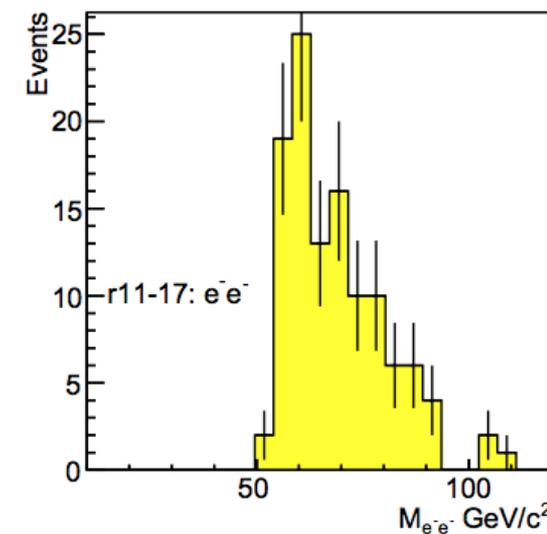
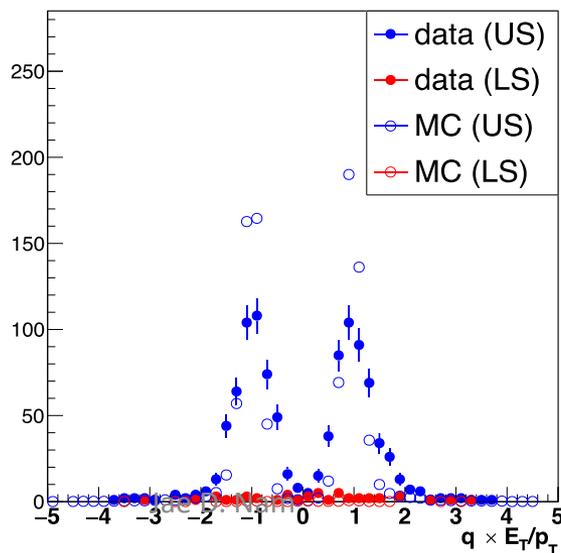
- https://drupal.star.bnl.gov/STAR/system/files/userfiles/6368/Nam_20250409.pdf



- Unable to describe LS BGR

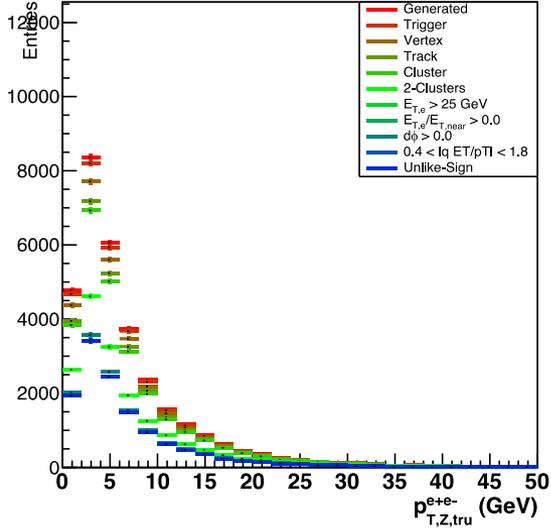
- Run 17 (no 11-13) pub reproduced soon (Xiaoxuan)

- $0.4 < |q \times E_T/p_T| < 1.8$ cuts rejects 20% of data but only 5% in MC

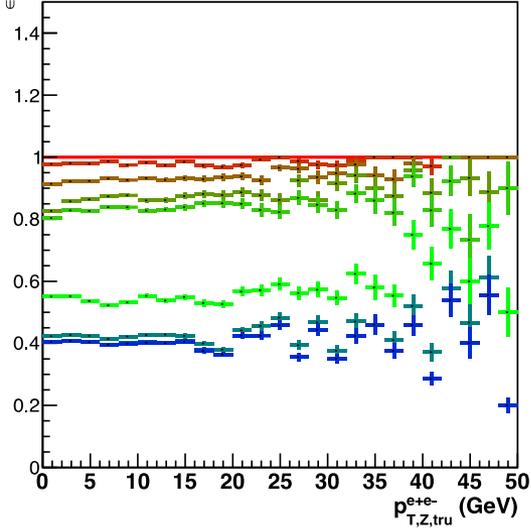


Efficiency Calculation

Yield (this study)

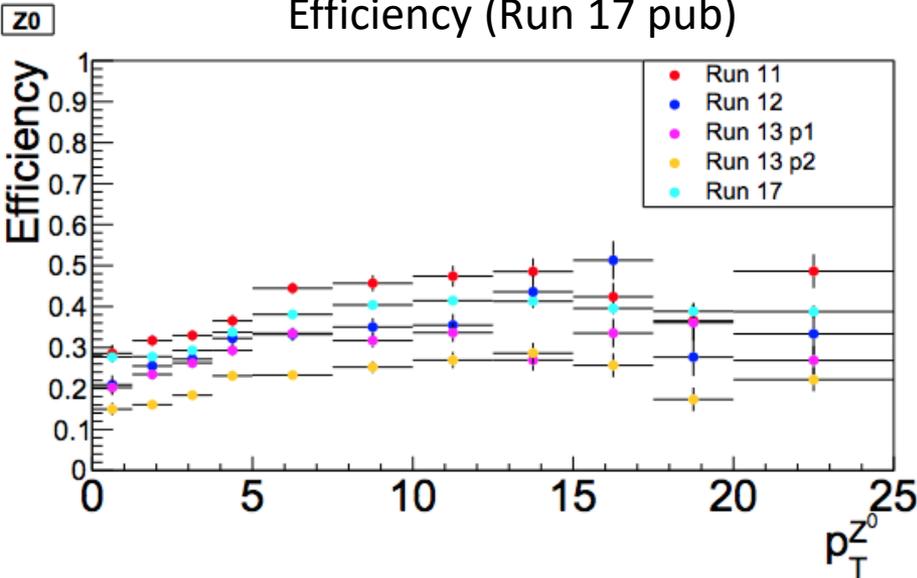


Efficiency (this study)



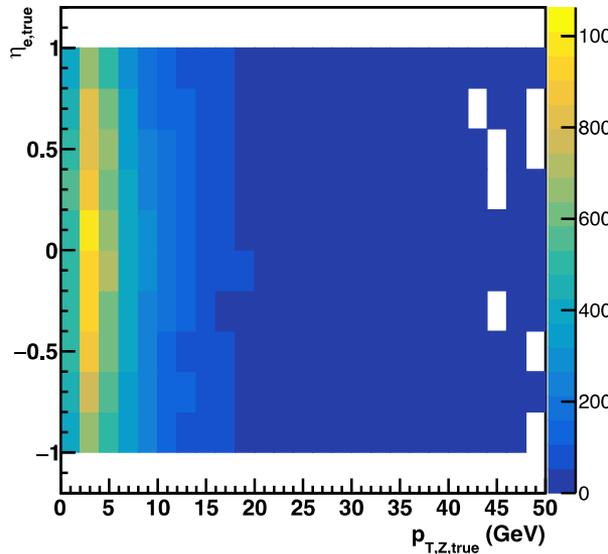
- No p_T dependence after removing ETnear cut
- (Potential) sources of mismatch in efficiency identified and will be investigated
- What about electron acceptance effect?

Efficiency (Run 17 pub)

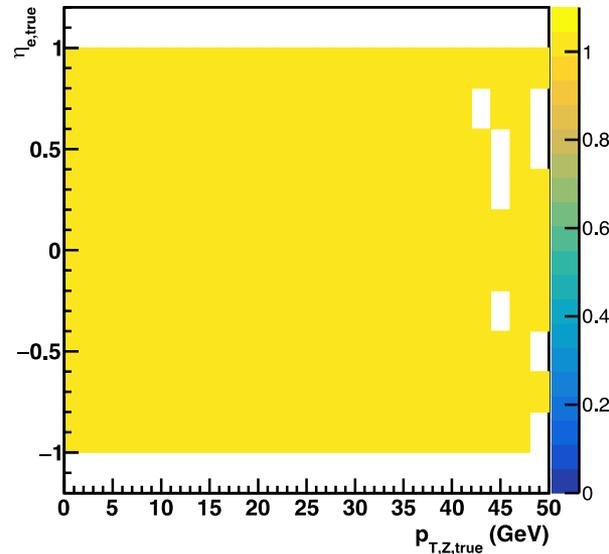


Efficiency Calculation

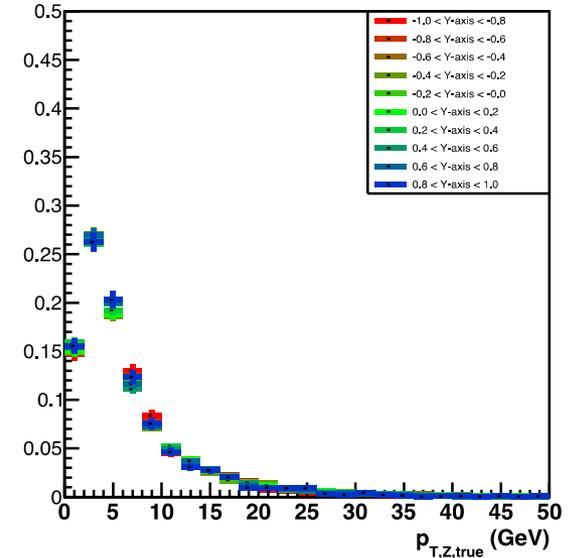
Yield (Generated)



Efficiency (Generated)



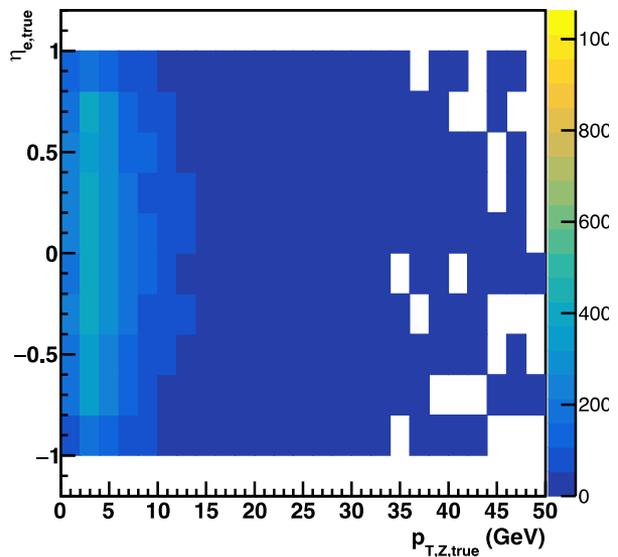
Normalized Yield Along Y-Axis



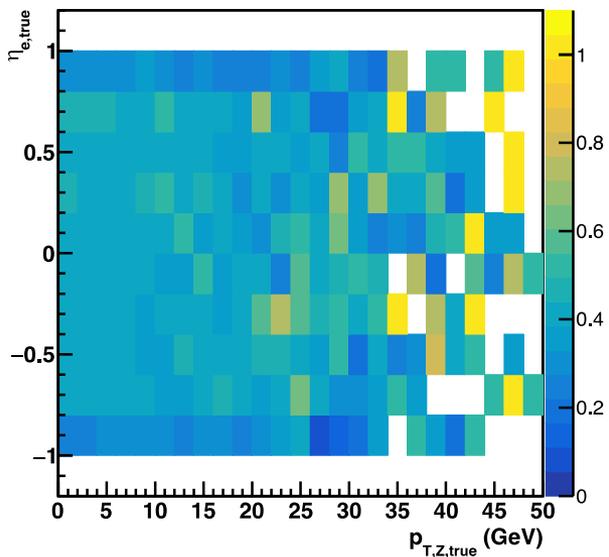
- η_{e^+} vs $p_{T,Z}$ distributions and efficiency at **Generator level**
 - No strong charge dependence identified
 - No strong η_e dependence in $p_{T,Z}$ distribution

Efficiency Calculation

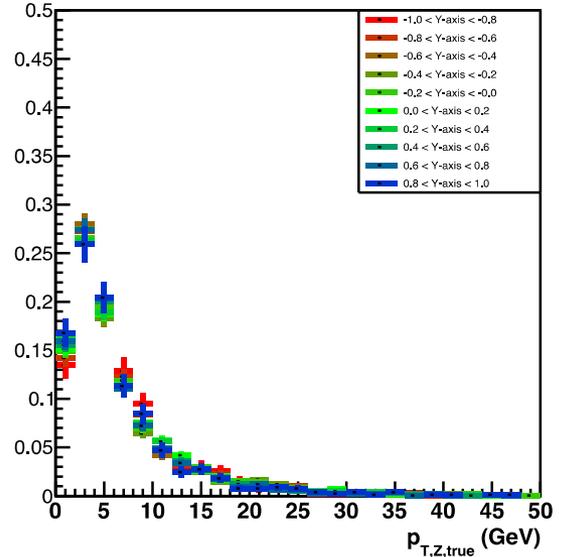
Yield (Unlike-Sign)



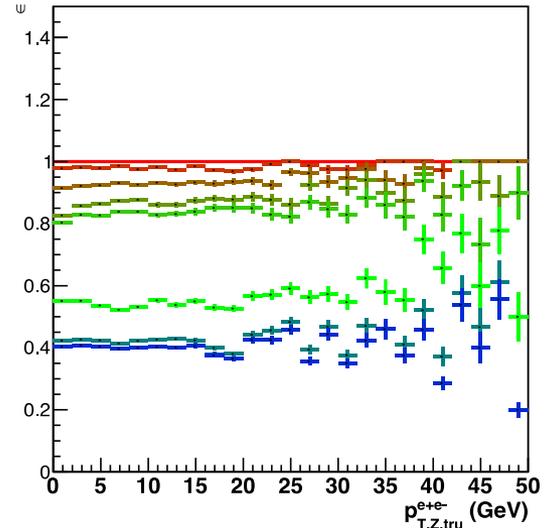
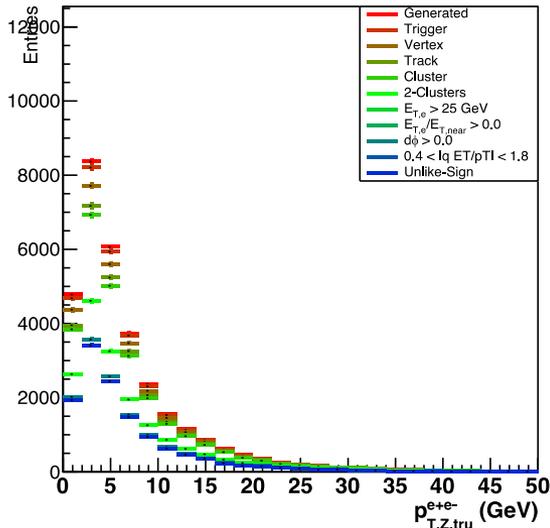
Efficiency (Unlike-Sign)



Normalized Yield Along Y-Axis

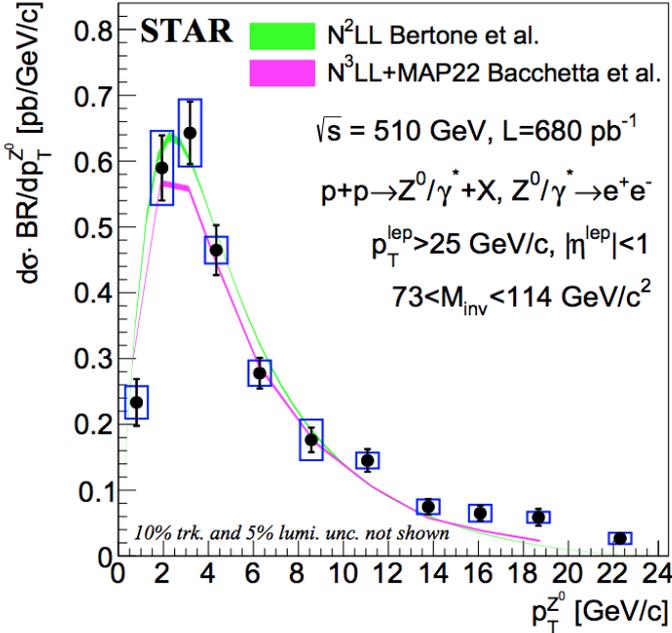
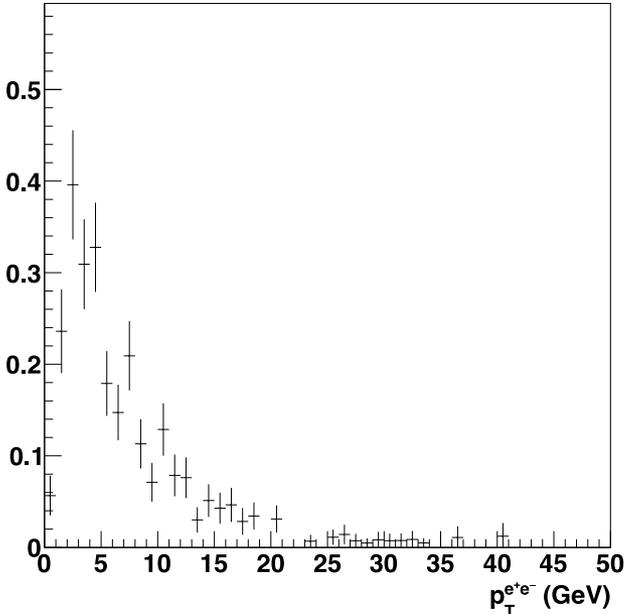


- η_e dependence **does exist**, however no strong low- $p_{T,Z}$ favoring in this η region
- The resulting efficiency does not bias against low- $p_{T,Z}$

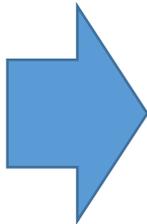


Cross section

Integrated cross section = 2.69738 ± 0.142343 pb



- The resulting cross section $\sim 2.7 \pm 3\%$ (LS) + 15% (charge) pb
- In the publication, ~ 4.5 pb
- Sources currently being investigated
 - Efficiency calculation
 - LS background
 - STAR Library

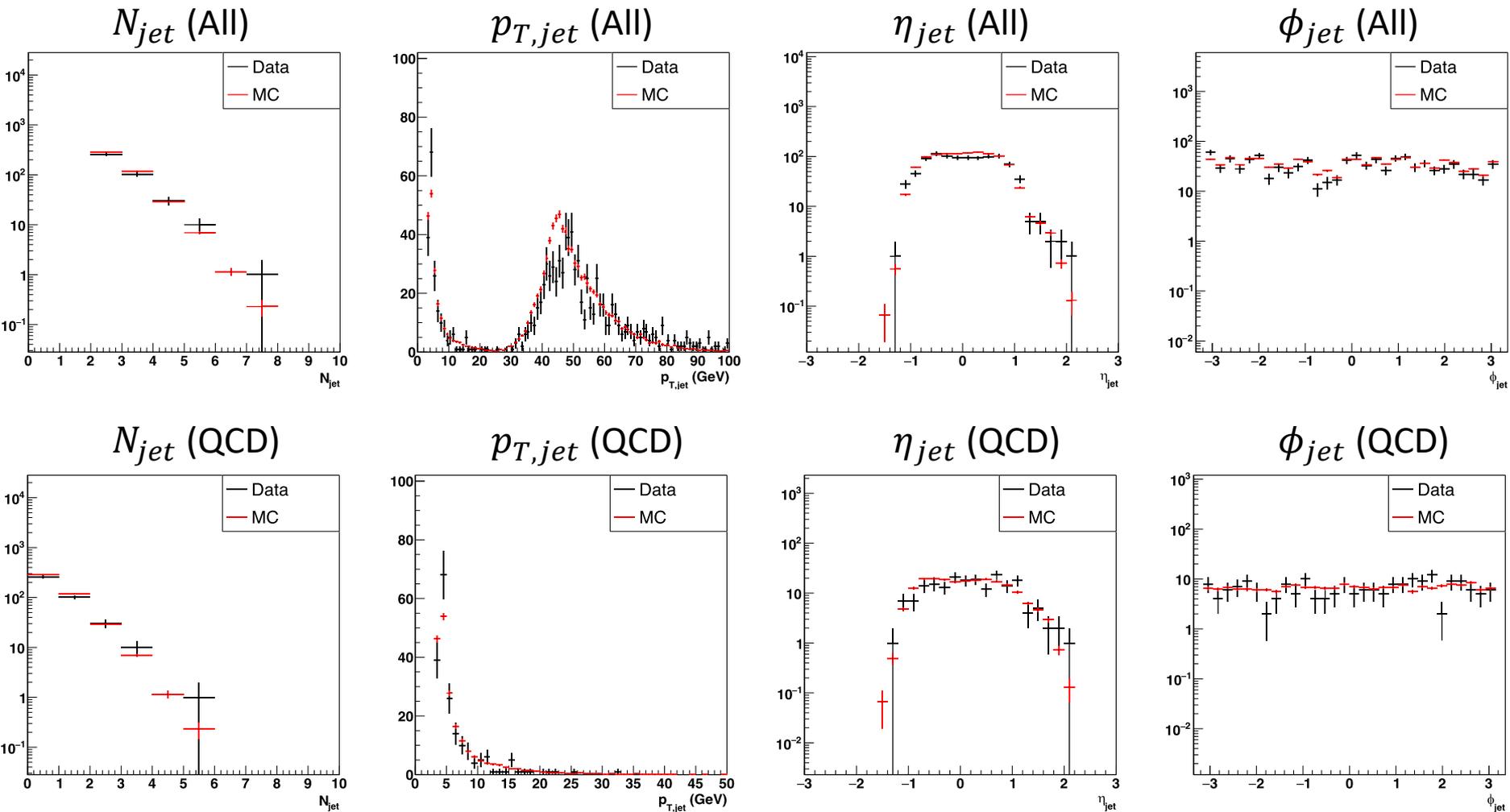


- Active investigation with Z experts (Xiaoxuan, Salvatore)
- Step-by-step comparisons planned
- Will revisit once progress is made

Jet description by Pythia

- Mis-estimation of signed- $p_{T, bal}$ cut efficiency found to be $\sim 20\%$, indicating mismatches in underlying jet distributions
→ Is this really the case?
- While it is difficult to obtain clean W signal without signed- $p_{T, bal}$ requirement, it is possible with Z
- Strategy
 - Jets reconstructed with Z events
 - StJetFinder, anti-kT, E-scheme, $R = 0.6$, min- $p_T = 3.5$ GeV
 - Events with all Z selection + M_Z window (Run 17 pub)
 - Classify jet list as follows
 - "All" jets: all jets reconstructed with detector responses
 - No input object list manipulation at runtime
 - Include 2 electron-driven jets
 - "QCD" jets: all jets with $\Delta R(e, jet) > 0.6$ (both e^+ and e^-)
 - For electron jet rejection
 - Challenging statistics with more sophisticated requirements
 - Additional requirements may also introduce bias difficult to understand

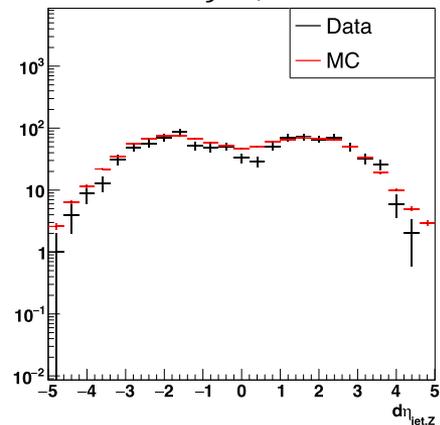
Jet comparisons



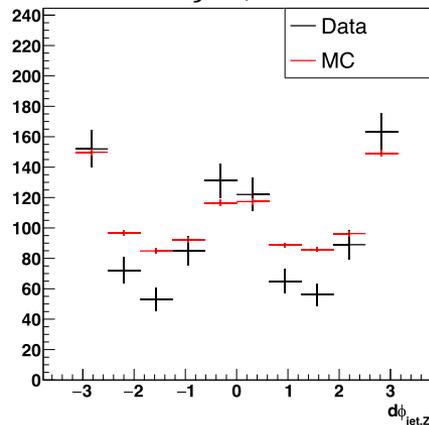
- No significant mismatch between data and MC

Jet comparisons

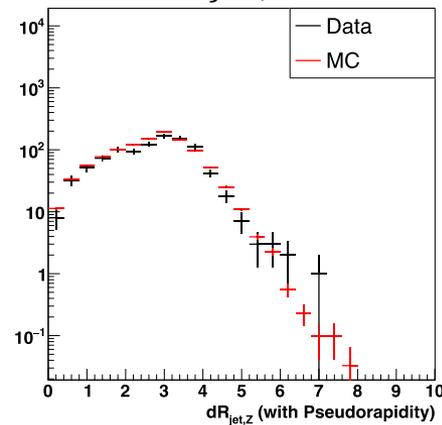
$d\eta_{jet,Z}$ (All)



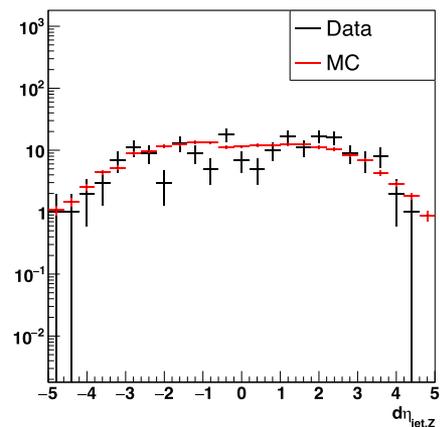
$d\phi_{jet,Z}$ (All)



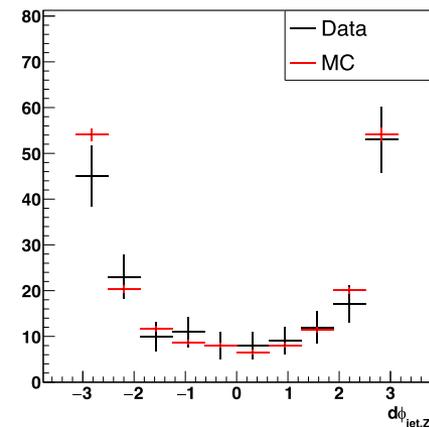
$dR_{jet,Z}$ (All)



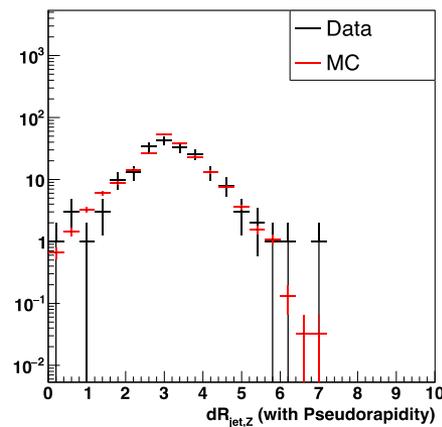
$d\eta_{jet,Z}$ (QCD)



$d\phi_{jet,Z}$ (QCD)



$dR_{jet,Z}$ (QCD)

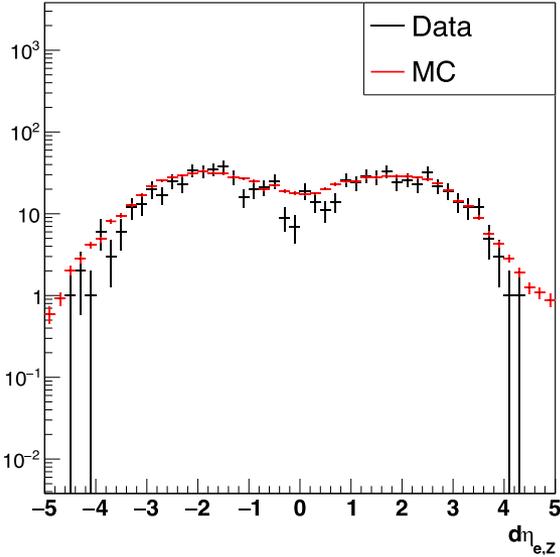


- No significant mismatch with “QCD” jets
- Less jet- Z correlation in $d\phi$ with “all” jet, while this is not seen with “QCD” jets
- Perhaps, the issue is not with $Z + jet$, but with $Z \rightarrow e^+e^-$?

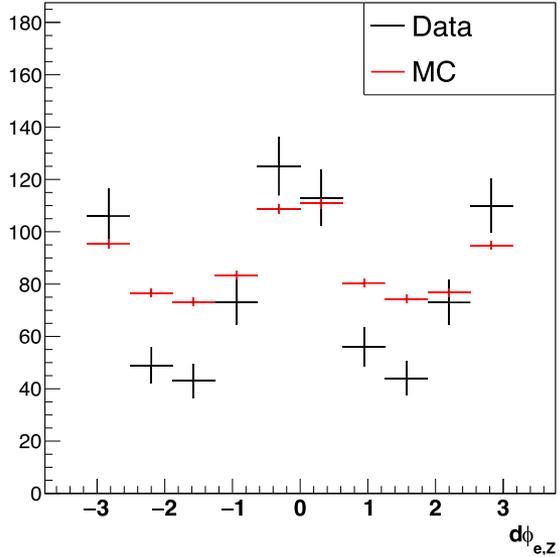
e - Z comparisons

Electron tracks, not jets

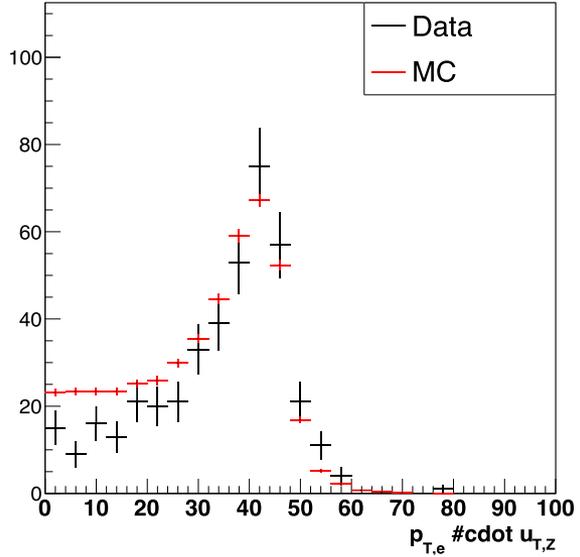
$d\eta_{e,Z}$



$d\phi_{e,Z}$

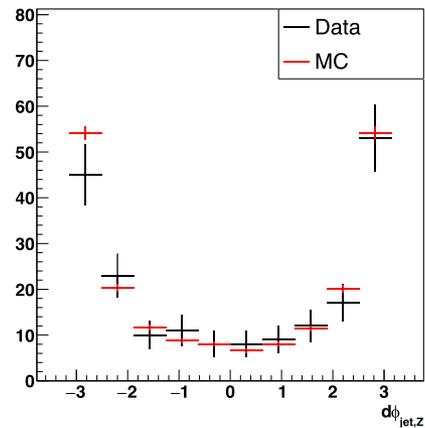


$\vec{p}_{T,e} \cdot \hat{p}_{T,Z}$

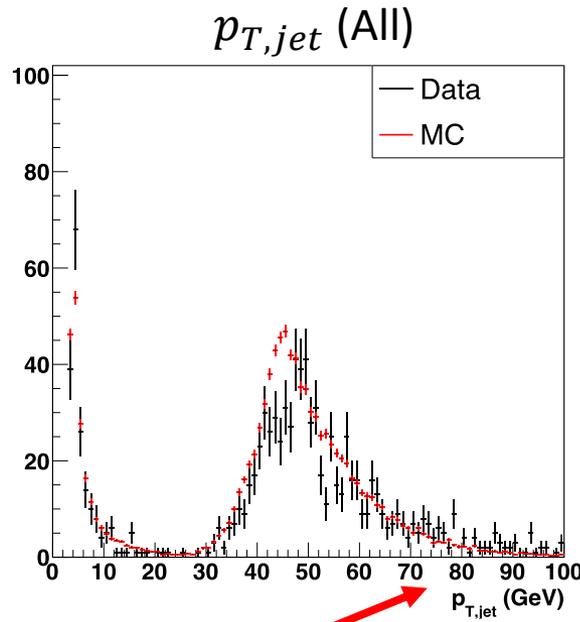


- No significant charge dependence $\rightarrow e^{\pm}$ combined
- Much stronger azimuthal e - Z correlation in data
- Higher sensitivity to back-to-back $Z + jet$ kinematics
- Potential source of signed- $p_{T,bal}$ mismatch

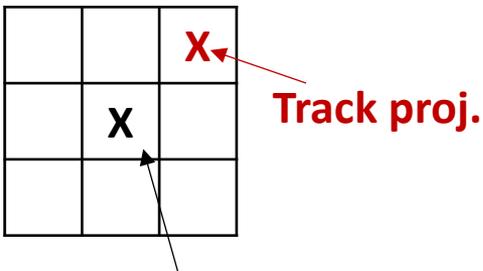
$d\phi_{jet,Z}$ (QCD)



Understanding Jet p_T distribution



e-jets with $p_T \sim 100 \text{ GeV}$?



High tower

- (Real) QCD jets overlapping with electron with $p_T \sim 100 \text{ GeV}$ should be included in mock-W study (as was done before)
- In StJetMaker, input tower energy is corrected for p_{trk}

$$E_{tow,input} = \max(E_{tow} - p_{trk,proj}, 0)$$

From Spin PWG Presentation (Mar 26, 2025)

- New kinematic quantities are obtained as
 - $E_{T,away,+} \rightarrow E_{T,away,+} + (\hat{p}_{T,+} \cdot \hat{p}_{T,-} \cdot E_{T,-}^{2 \times 2}) + (\hat{p}_{T,+} \cdot p_{T,-})$
 - $\text{signed-}p_{T,bal,+} \rightarrow \text{signed-}p_{T,bal,+} + (\hat{p}_{T,+} \cdot \hat{p}_{T,-} \cdot E_{T,-}^{2 \times 2})$
- **Signed- $p_{T,bal}$** is reconstructed with **jets** (min- $p_T = 3.5 \text{ GeV}$)
 \rightarrow lingering soft jets may increase $spTbal$ slightly ($< 3.5 \text{ GeV}$ for some events)

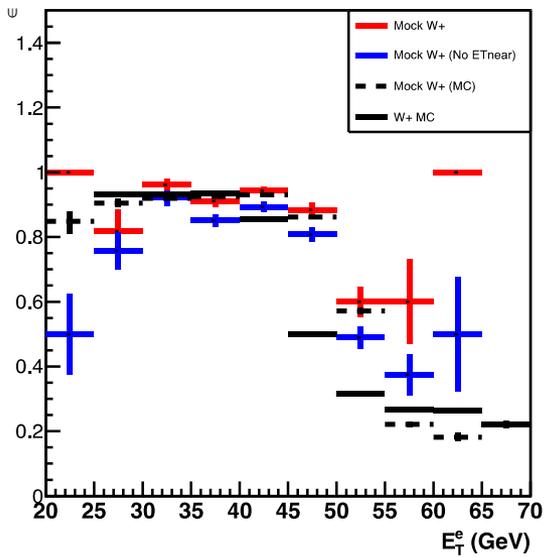
- Events with high p_T electron jets due to tower-track mapping issue may underestimate signed- $p_{T,bal}$ (overestimate c_{mis})
- Two approaches to address these issues
 - \rightarrow Jet reconstruction with input list manipulation at runtime
 - \rightarrow mock-W (data) vs. mock-W (MC), instead of mock-W (data) vs. W (MC)

\rightarrow No charge dependence must be presumed

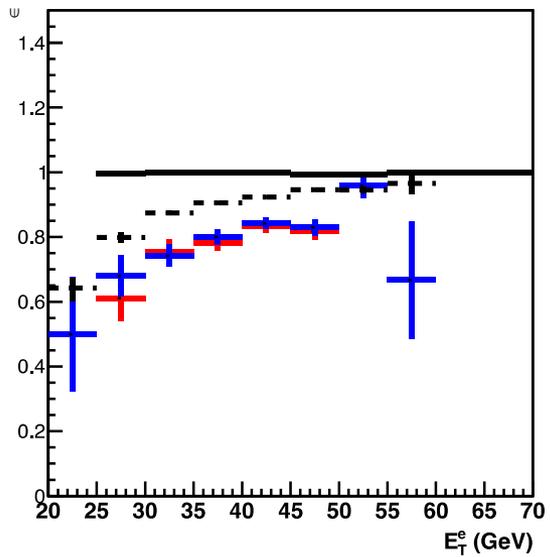


Mock-W study (e^+ and e^- combined)

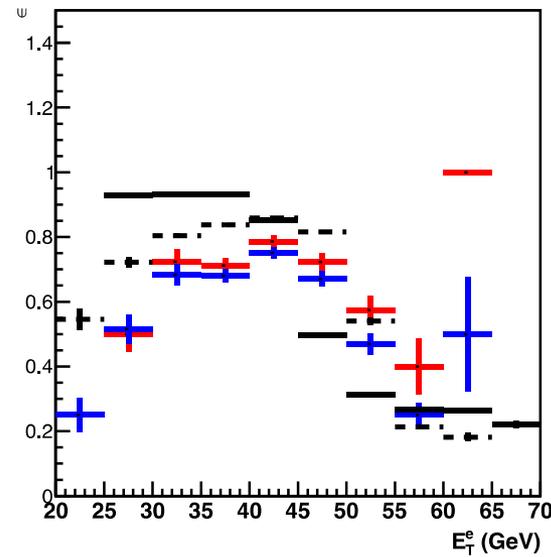
$E_{T,away}$ efficiency



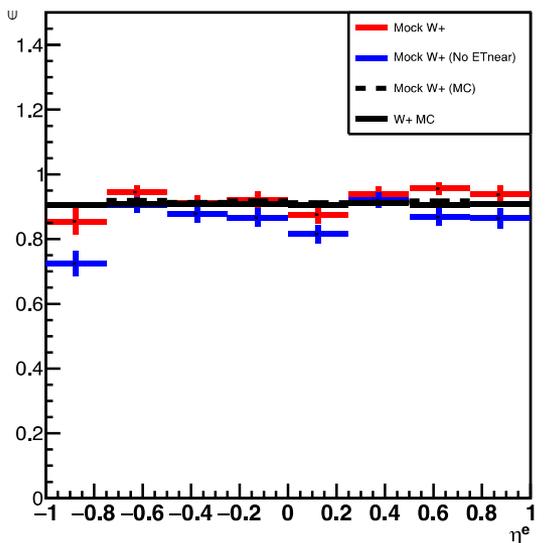
signed- $p_{T,bal}$ efficiency



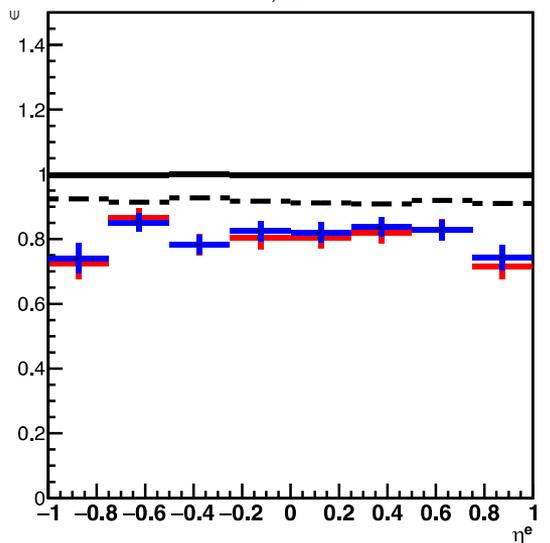
Combined ($E_{T,away} \times$ signed- $p_{T,bal}$) efficiency



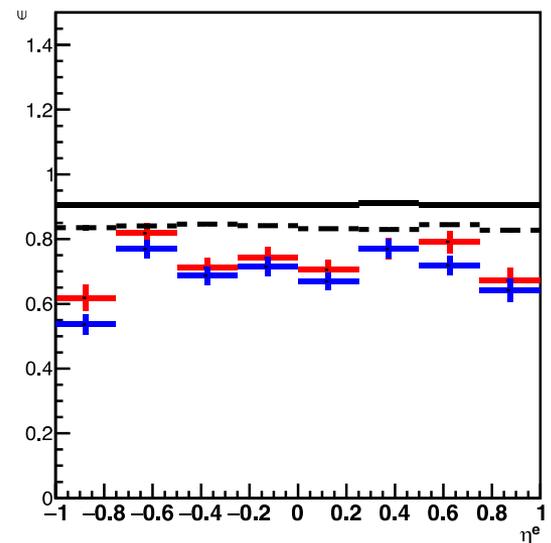
$E_{T,away}$ efficiency



signed- $p_{T,bal}$ efficiency



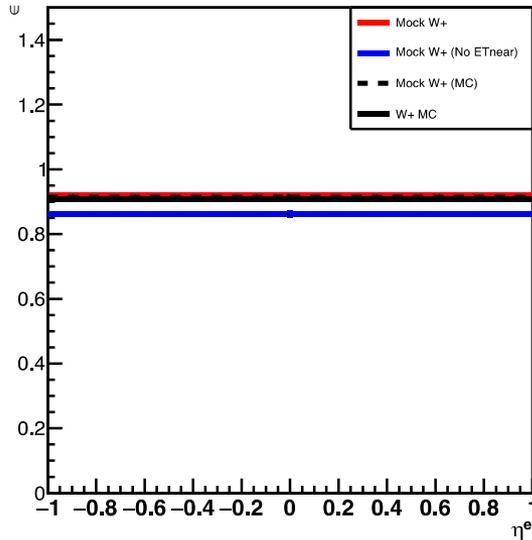
Combined ($E_{T,away} \times$ signed- $p_{T,bal}$) efficiency



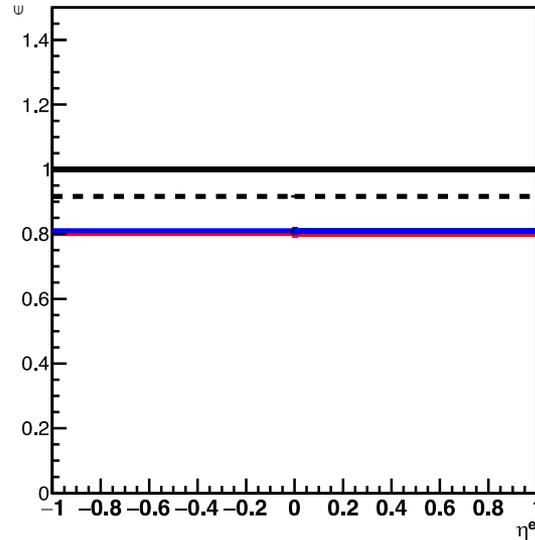
Final result

- Assuming **No η_e** or **charge dependence**

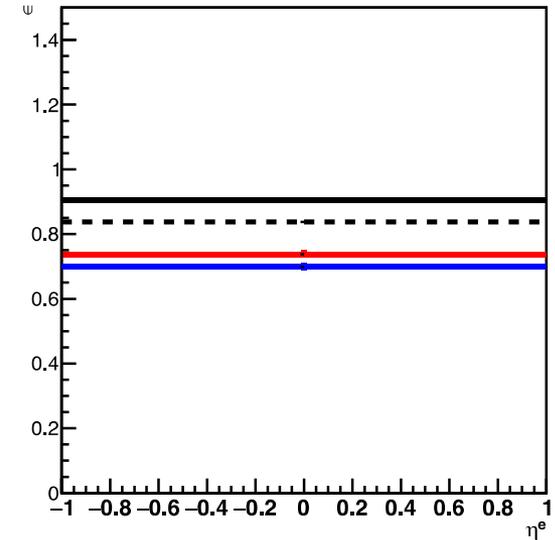
$E_{T,away}$ efficiency



signed- $p_{T,bal}$ efficiency



Combined ($E_{T,away} \times \text{signed-}p_{T,bal}$) efficiency

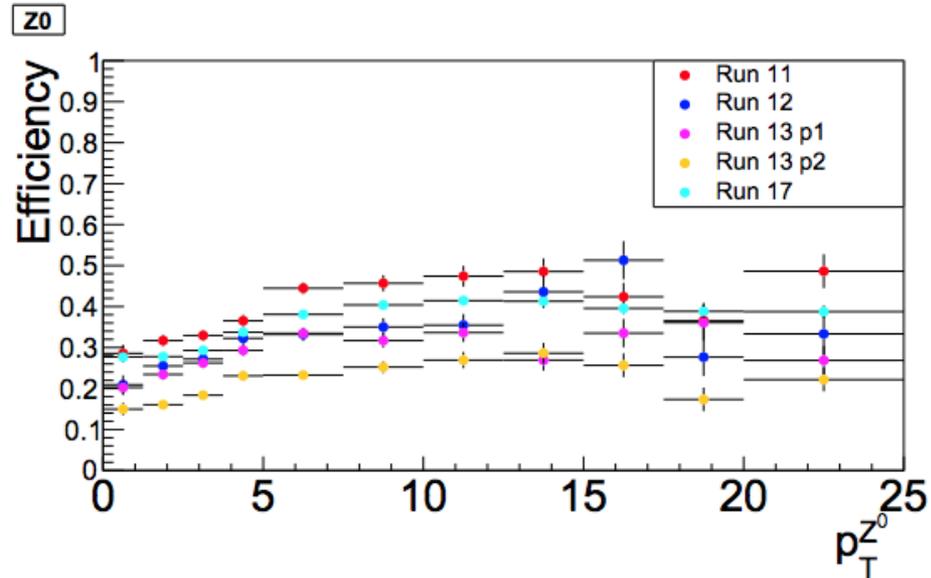
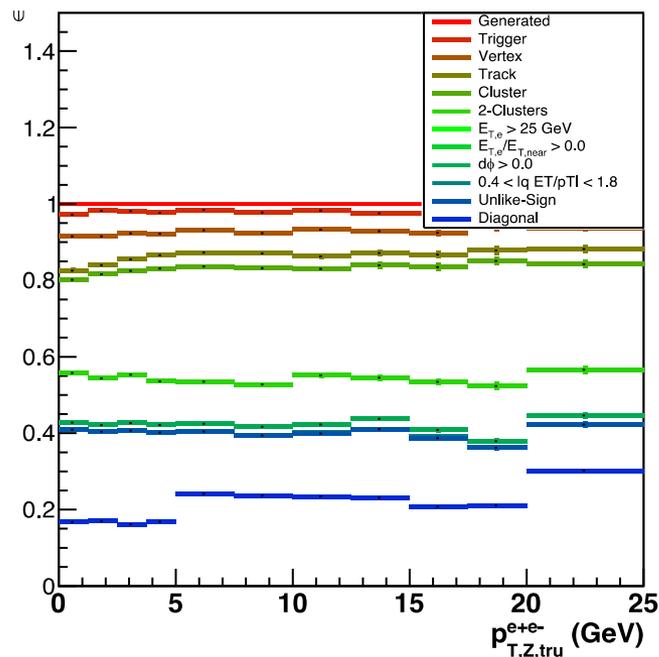
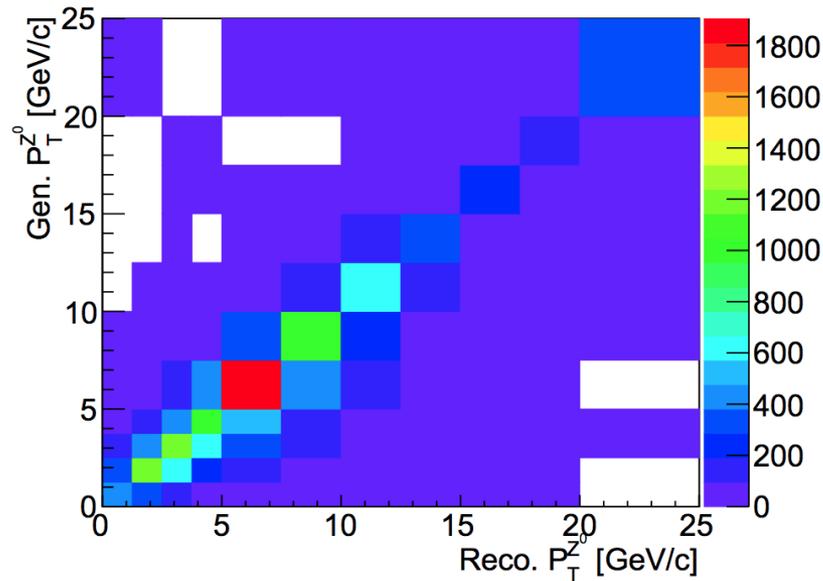
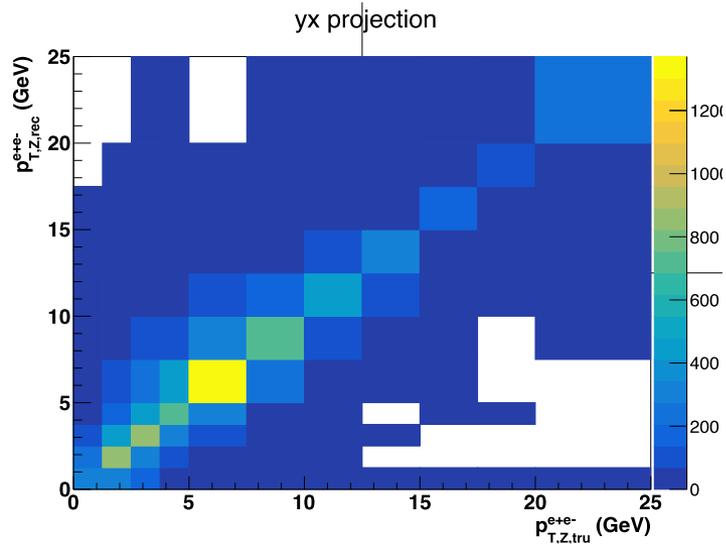


- $C_{mis} = \epsilon_{MC} / \epsilon_{mock,data}$
 - = Nominal \pm [Nominal – Alternative (No ETnear cut)]
 - = 1.23 ± 0.07 , mock-W (data) vs W (MC)
 - = **1.14 ± 0.06** , mock-W (data) vs mock-W (MC)
- Resulting in $\sim 14\%$ increase in the final cross section

Summary

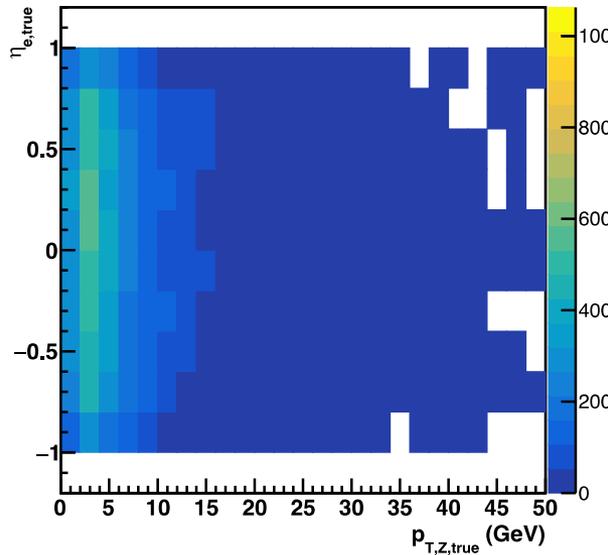
- Internal cross check Z cross section
 - WIP, actively communicating with Z experts
 - Potential sources of mismatch identified
 - (W.r.t the W analysis) FEWZ NLO no-jet effect with Z found to be insignificant ($\sim 1\sigma$)
 $3.2 \pm 0.3(stat)pb$ (This study) vs. $\sim 4.5pb$ (17 Pub) vs. $3.6pb$ (FEWZ NLO) vs. $2.7pb$ (FEWZ NLO 0J)
- Mis-estimation of signed- $p_{T,bal}$ efficiency
 - No significant mismatch in $Z + jets$ between data/MC
 - Mismatch in $e-Z$ correlation found
 - (Assuming this mismatch persists in $W \rightarrow e\nu$)
Now c_{mis} extracted from mock-W data vs mock-W MC
 - $\sim 14\%$ correction to cross section (without estimating η and charge dependence)
- Paper preview request
 - Draft nearly completed
 - Awaiting ResBos2 predictions (FEWZ for paper preview)



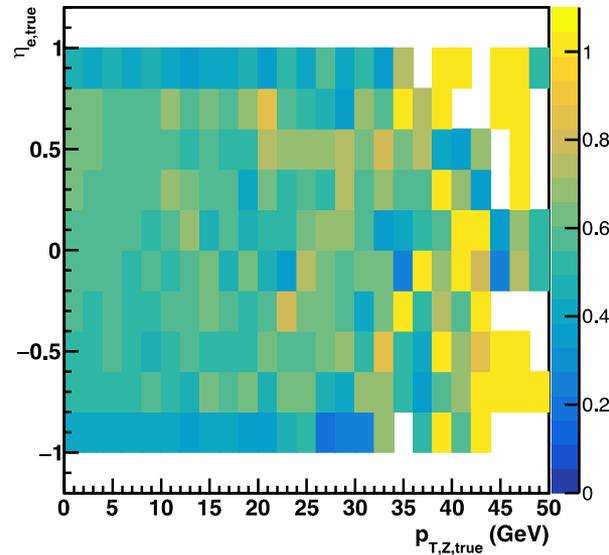


Efficiency Calculation

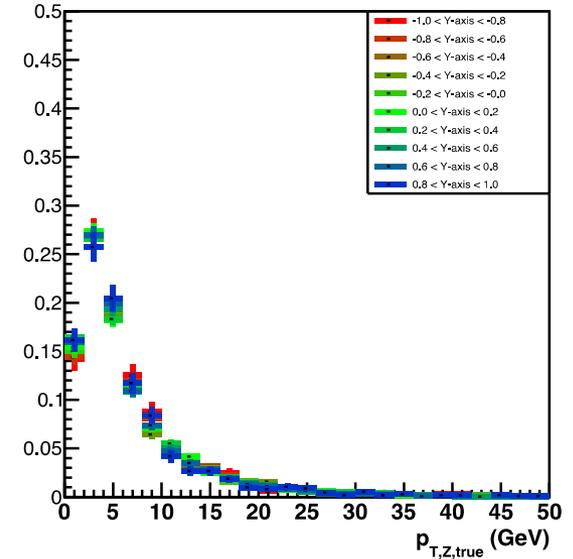
Yield (2-Clusters)



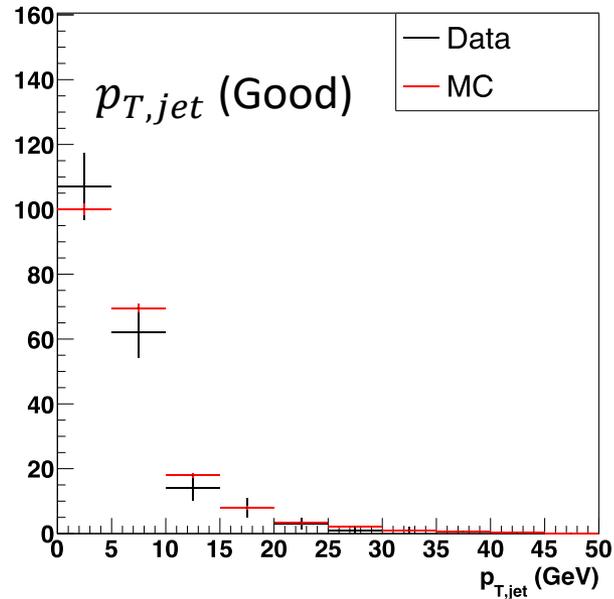
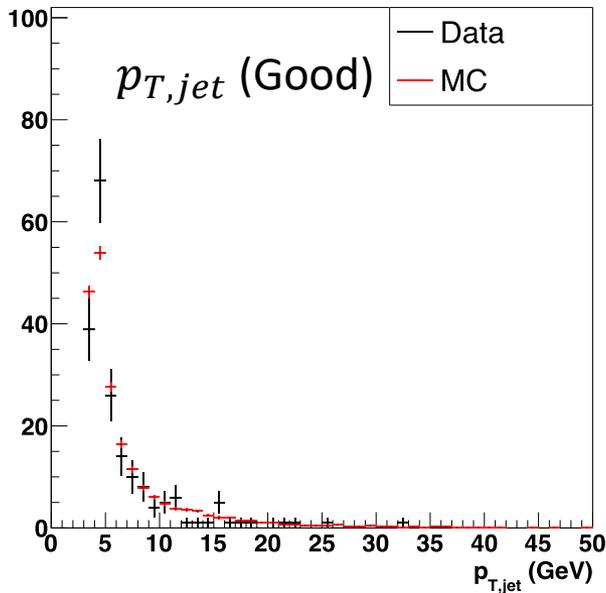
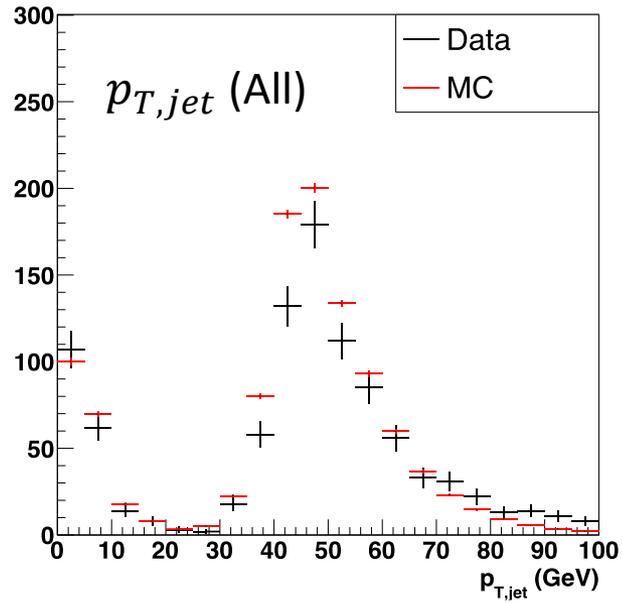
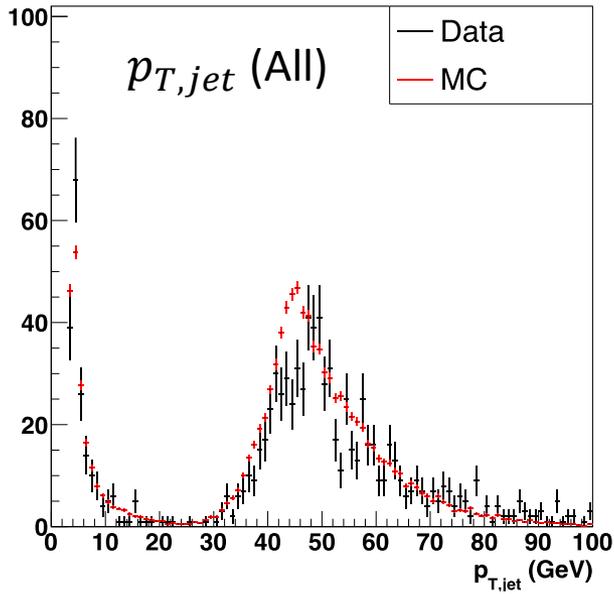
Efficiency (2-Clusters)

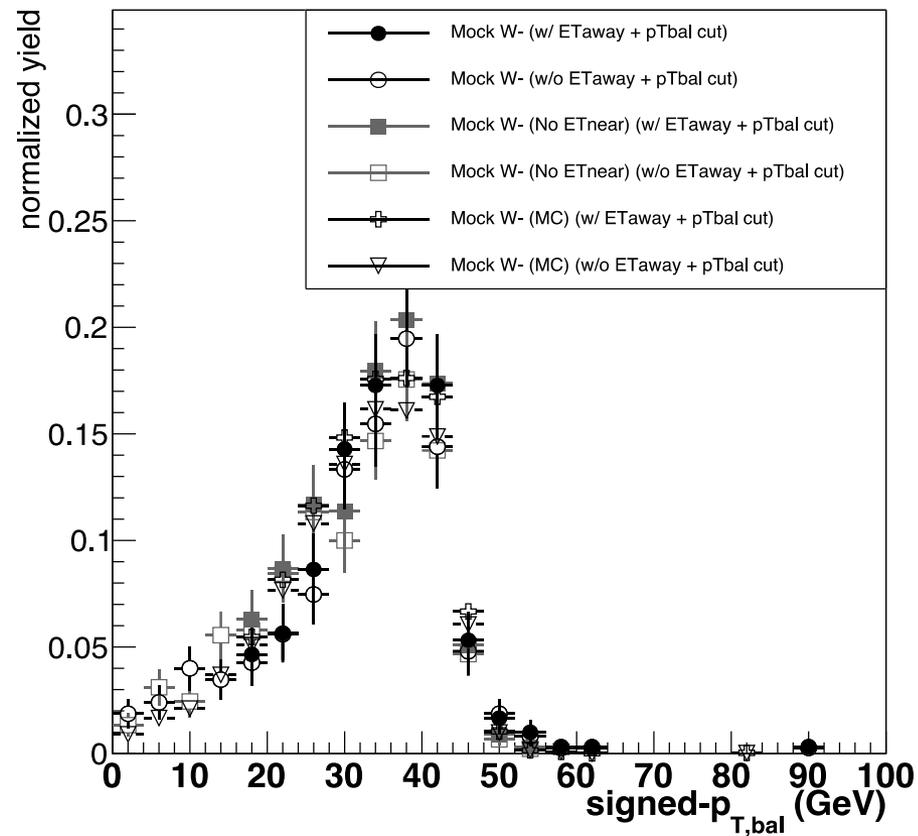
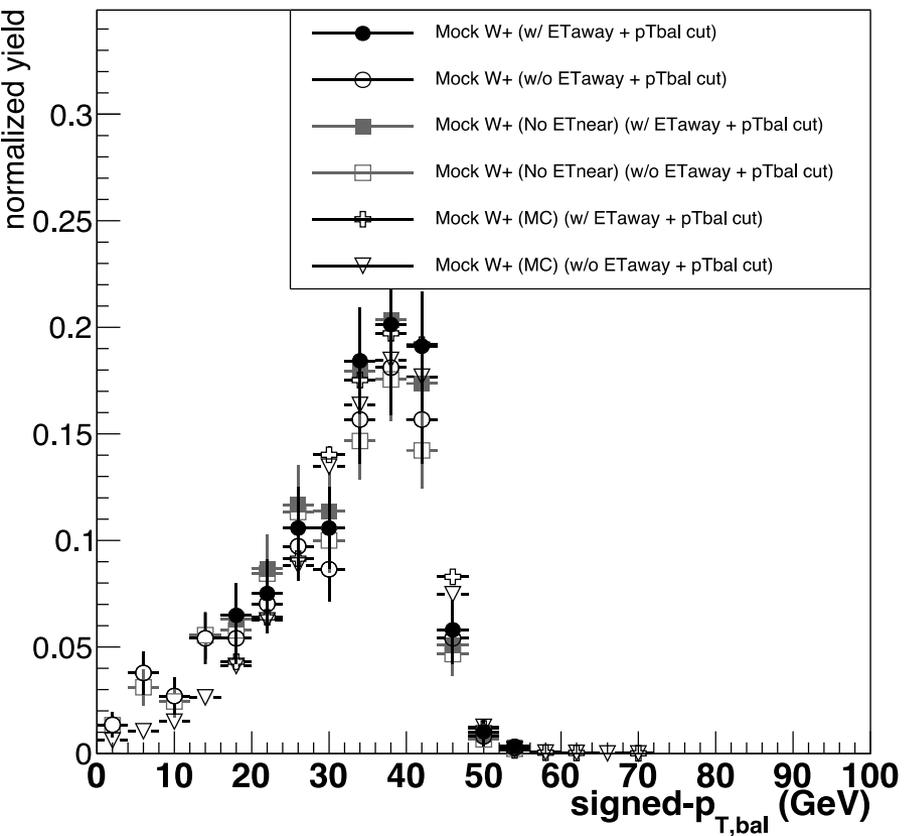


Normalized Yield Along Y-Axis



- (Visible) η_e dependent efficiency observed after requiring two “good” clusters ($E_{T,e} > 16$ GeV, $E_{T,e}/E_T^{4 \times 4} \sim 1$, etc.)
- No strong low- $p_{T,Z}$ bias in all η_e region

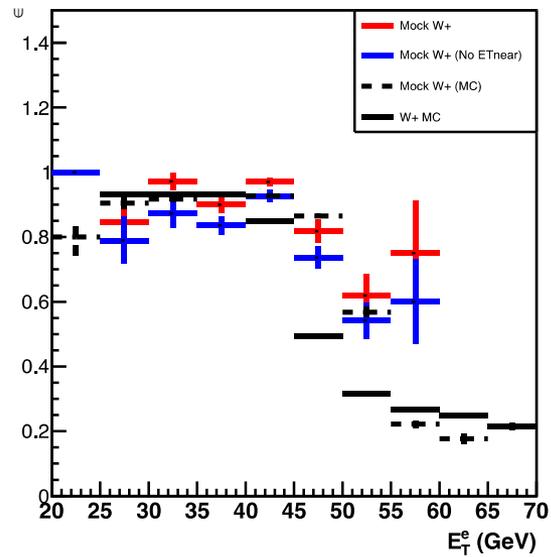




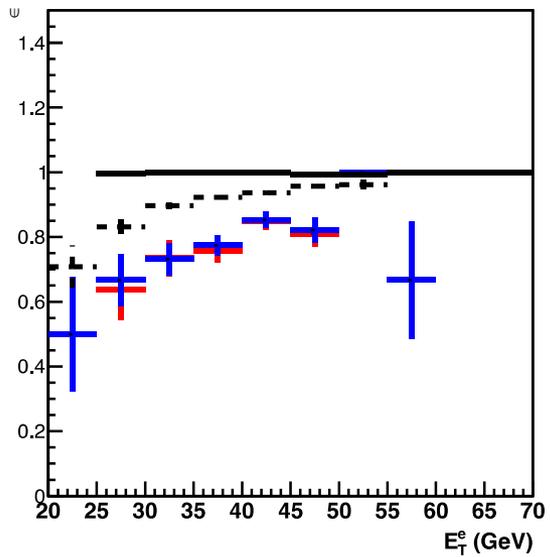
- Comparisons between black open circle (mock-W data) and open triangle (mock-W MC) in $\text{signed-}p_{T,bal} < 16 \text{ GeV}$

Revisiting Mock-W study (W+)

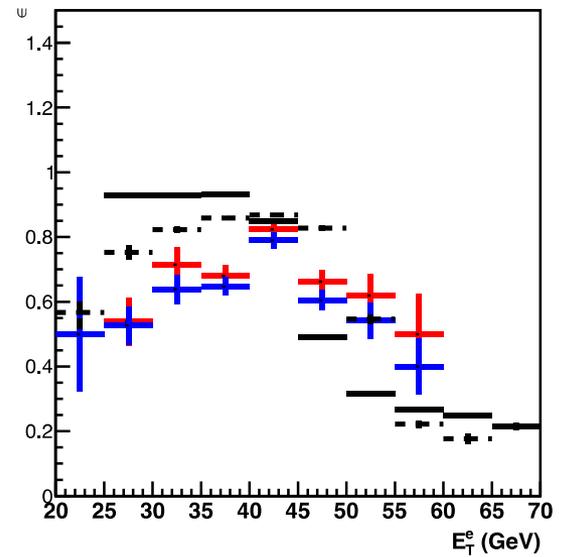
$E_{T,away}$ efficiency



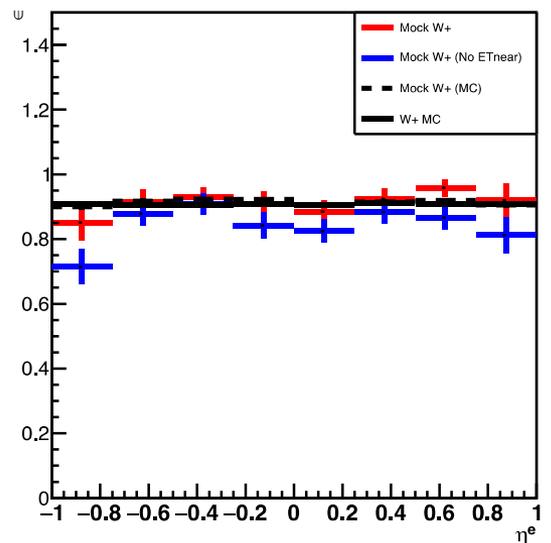
signed- $p_{T,bal}$ efficiency



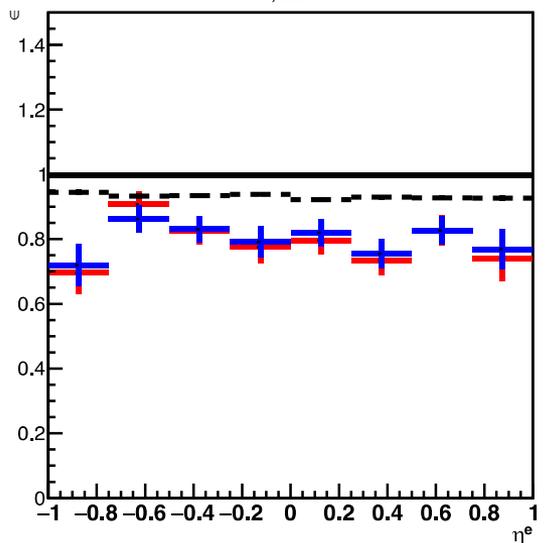
Combined ($E_{T,away} \times \text{signed-}p_{T,bal}$) efficiency



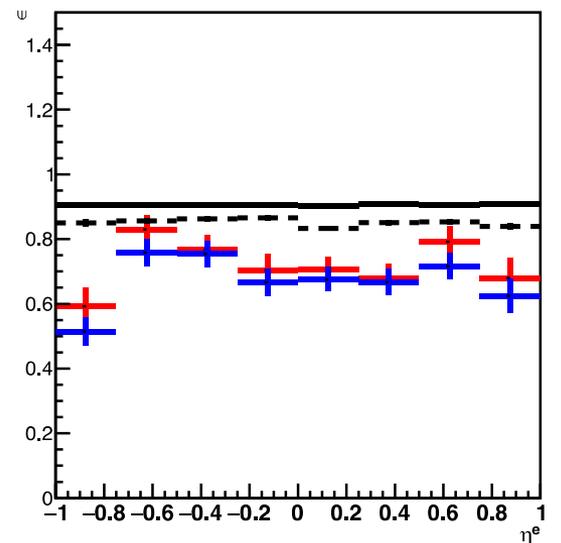
$E_{T,away}$ efficiency



signed- $p_{T,bal}$ efficiency

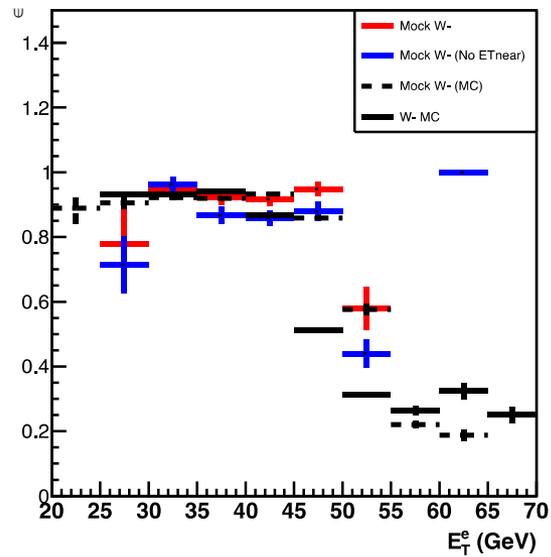


Combined ($E_{T,away} \times \text{signed-}p_{T,bal}$) efficiency

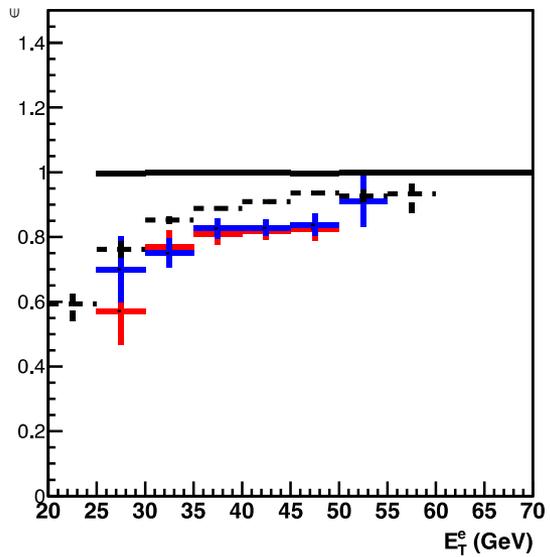


Revisiting Mock-W study (W-)

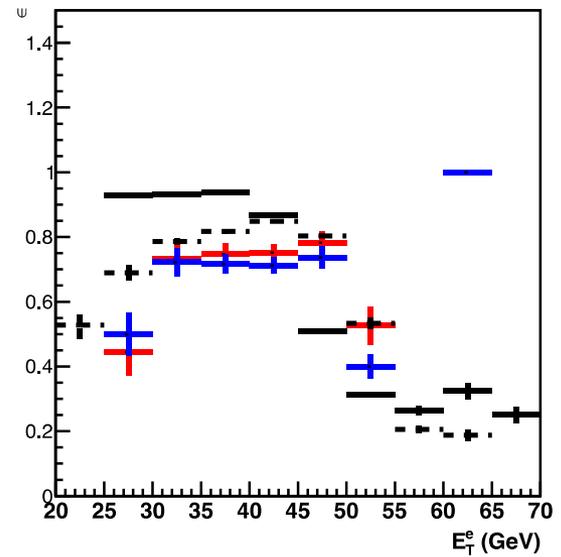
$E_{T,away}$ efficiency



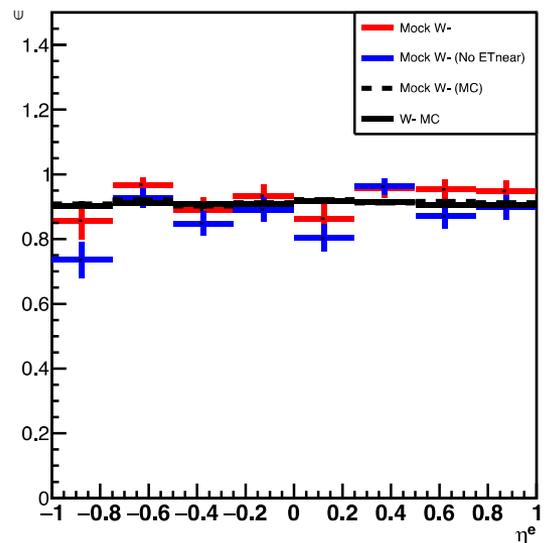
signed- $p_{T,bal}$ efficiency



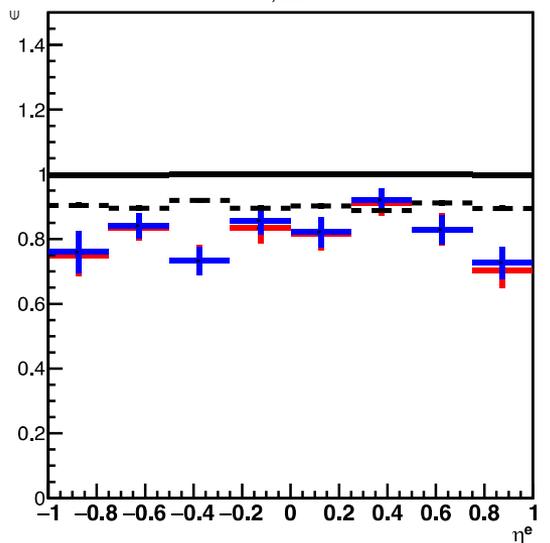
Combined ($E_{T,away} \times$ signed- $p_{T,bal}$) efficiency



$E_{T,away}$ efficiency



signed- $p_{T,bal}$ efficiency



Combined ($E_{T,away} \times$ signed- $p_{T,bal}$) efficiency

