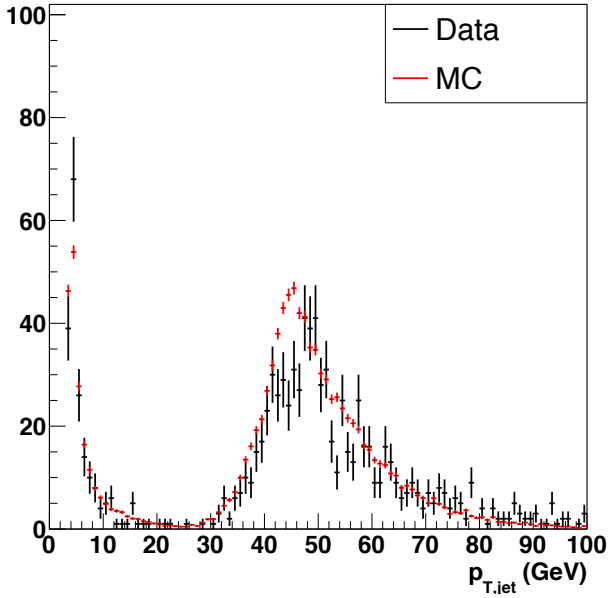
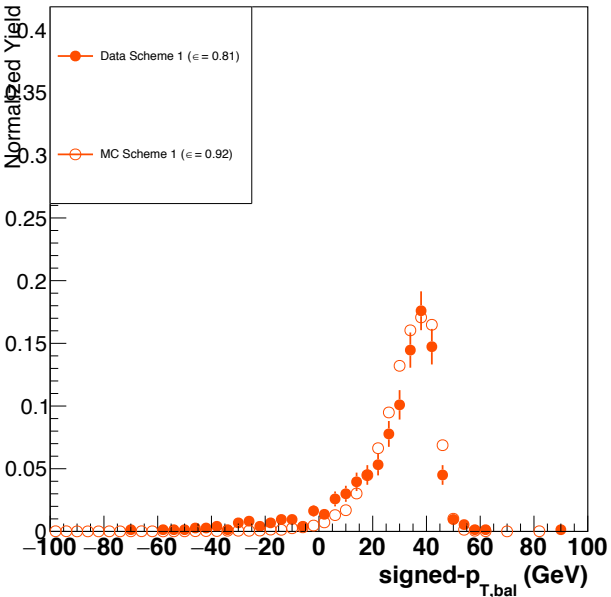
W^+/W^- cross-section ratio with STAR Run 2017

Jae D. Nam

Temple Univ.

Recap





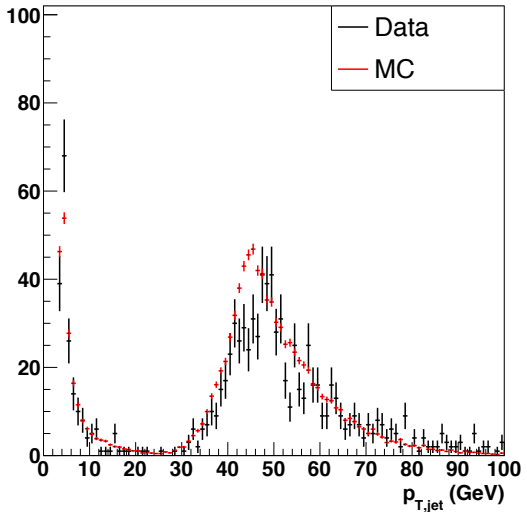
- New kinematic quantities are obtained as
  - $E_{T,away,+} \rightarrow E_{T,away,+} + (\hat{p}_{T,+} \cdot \hat{p}_{T,-} \cdot E_{T,-}^{2\times2}) + (\hat{p}_{T,+} \cdot p_{T,-})$
  - signed-$p_{T,bal,+}$ → signed-$p_{T,bal,+} + (\hat{p}_{T,+} \cdot \hat{p}_{T,-} \cdot E_{T,-}^{2\times2})$
- **Signed-pTbalance** is reconstructed with **jets** (min-pT = 3.5 GeV)
  → lingering soft jets may increase spTbal slightly
  ($< 3.5\ GeV$ for some events)

- In the Mock-W study with Z, high-p_T jets driven by p_T smearing of electrons resulted in low signed $p_{T,bal}$ tail

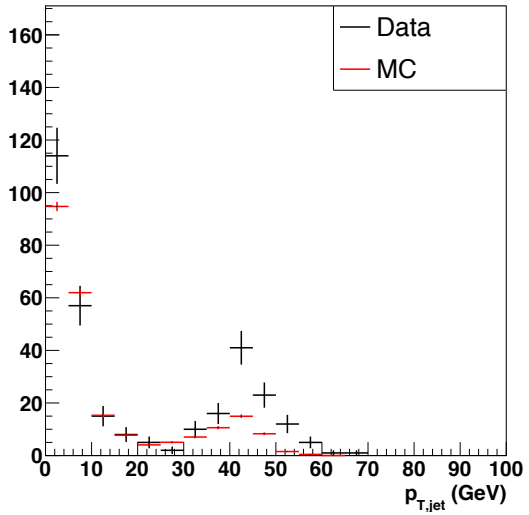
- This resulted in a large mismatch between data and MC under the spTbal cut (signed-$p_{T,bal} < 16\ GeV$), overestimating difference in the spTbal efficiency

Jets in Mock-W sample

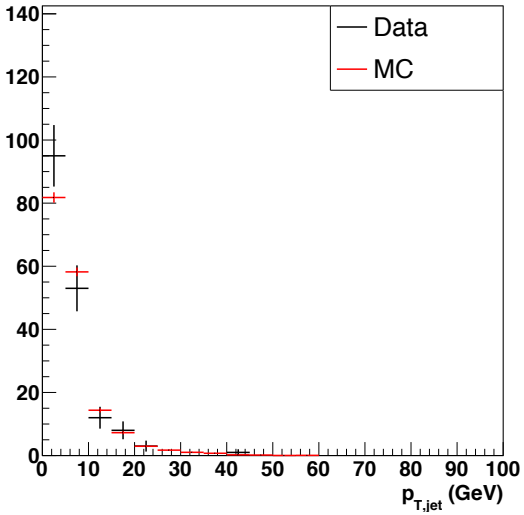
All jet pT, Run 17 sel



QCD jet pT, Run 17 sel



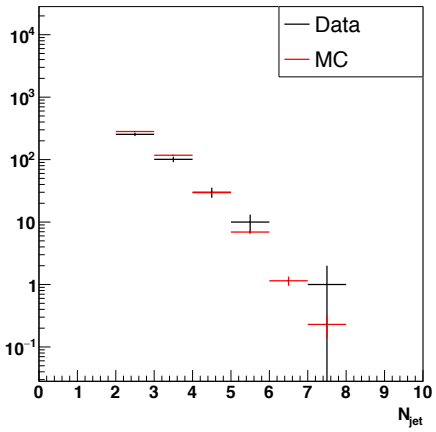
QCD jet pT, Run 13 sel



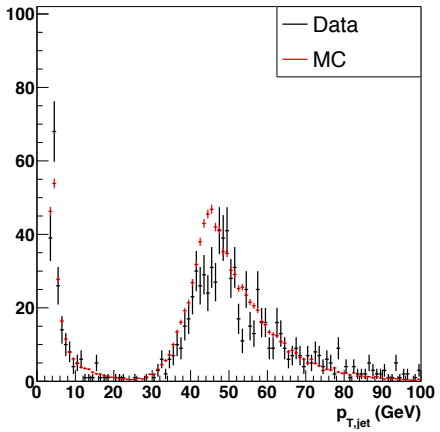
- All/**QCD** jets
  - StJetFinder, Anti-kT, R = 0.6, min-pT = 3.5 GeV
  - $p_{in} = p_{TPC}$, $E_{in} = E_{EMC,SM} - p_{TPC}$ + mip correction
  - **Remove tracks with $p_T > 25\ GeV$ and the surrounding towers**
  - $\Delta R_{e,jet} > 0.7$
  - Run 17 event selection → **Run 13** (electron isolation)
- High pT ($\sim 40\ GeV$) removed after applying electron isolation

Jet comparisons

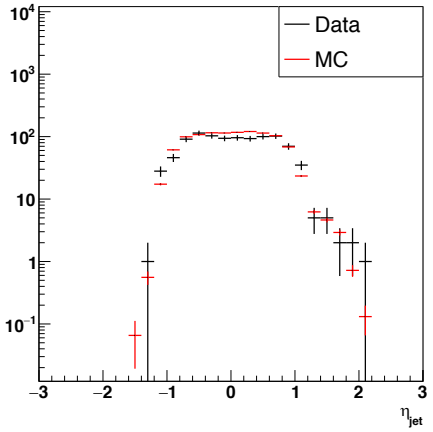
N_{jet} (All)



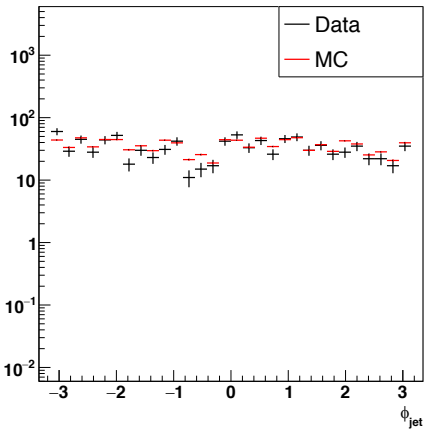
$p_{T,jet}$ (All)



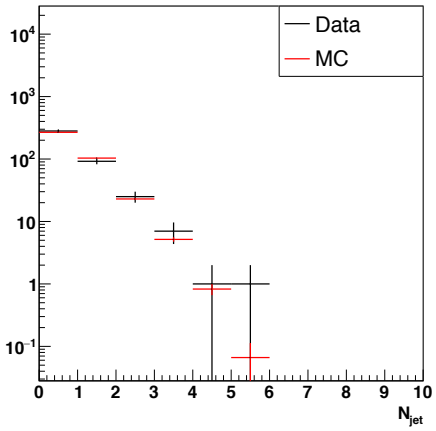
η_{jet} (All)



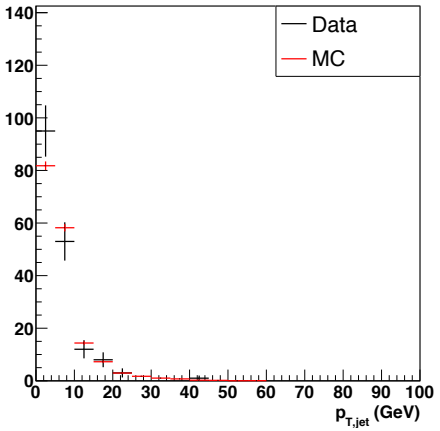
ϕ_{jet} (All)



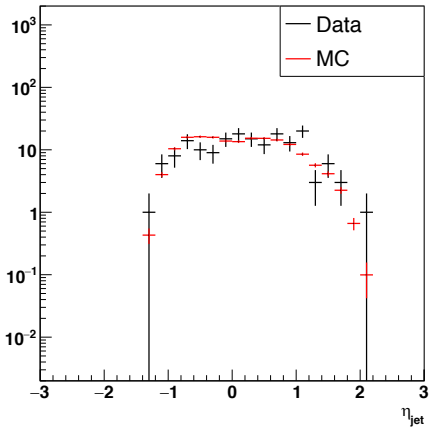
N_{jet} (QCD)



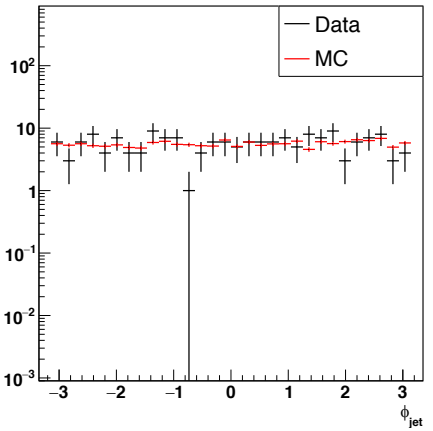
$p_{T,jet}$ (QCD)



η_{jet} (QCD)



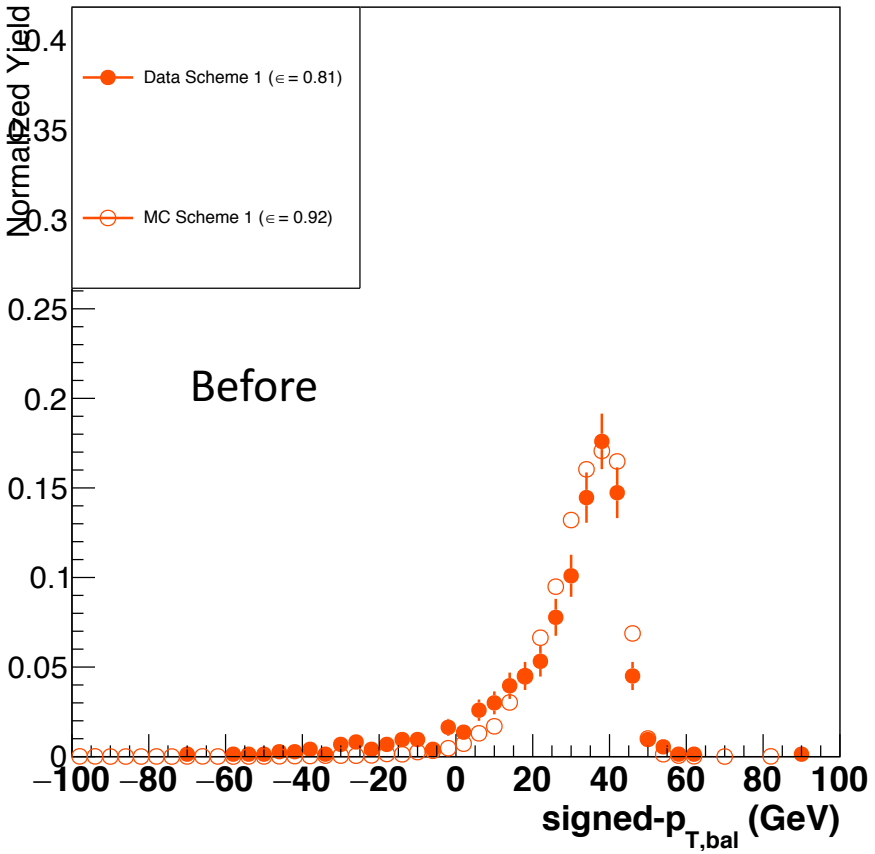
ϕ_{jet} (QCD)



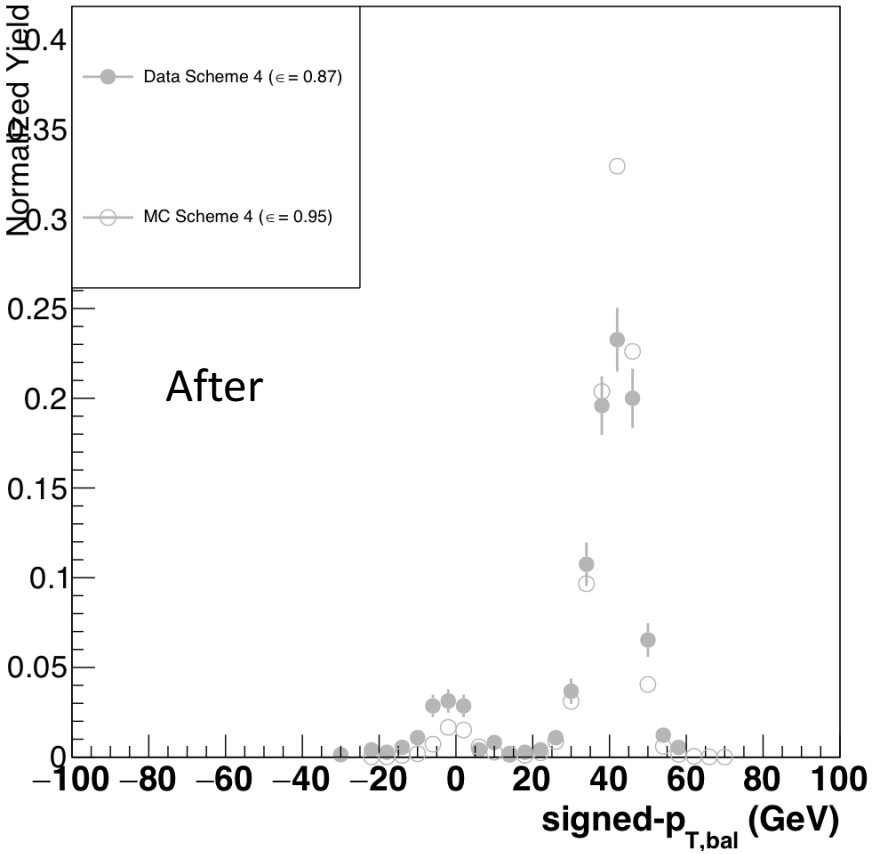
- Good description of jet by MC

spTbal cut efficiency

$p_{T,bal,e+} = E_{T,e+} + \sum p_{T,jet}$(All) $- E_{T,e-}$

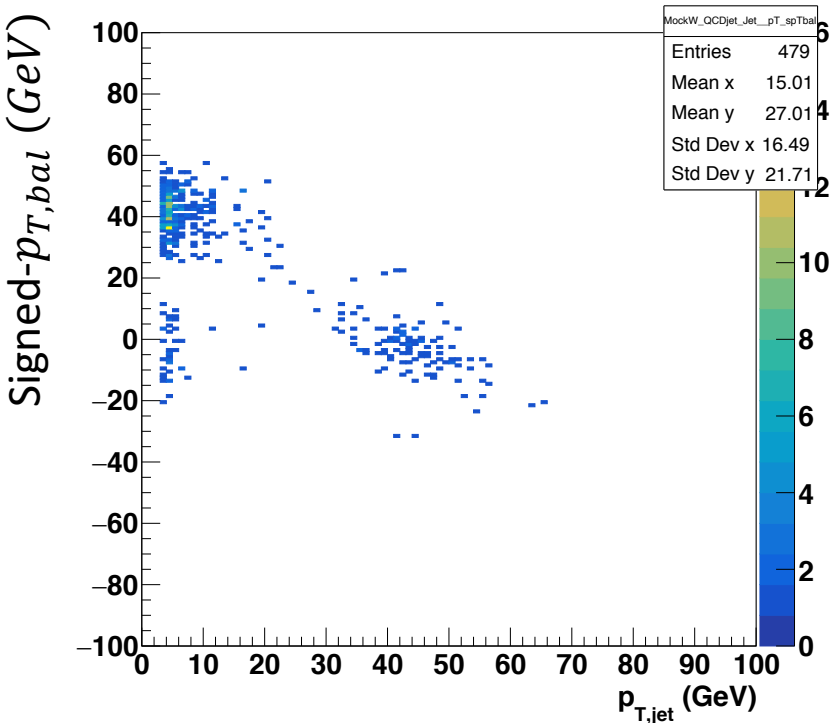


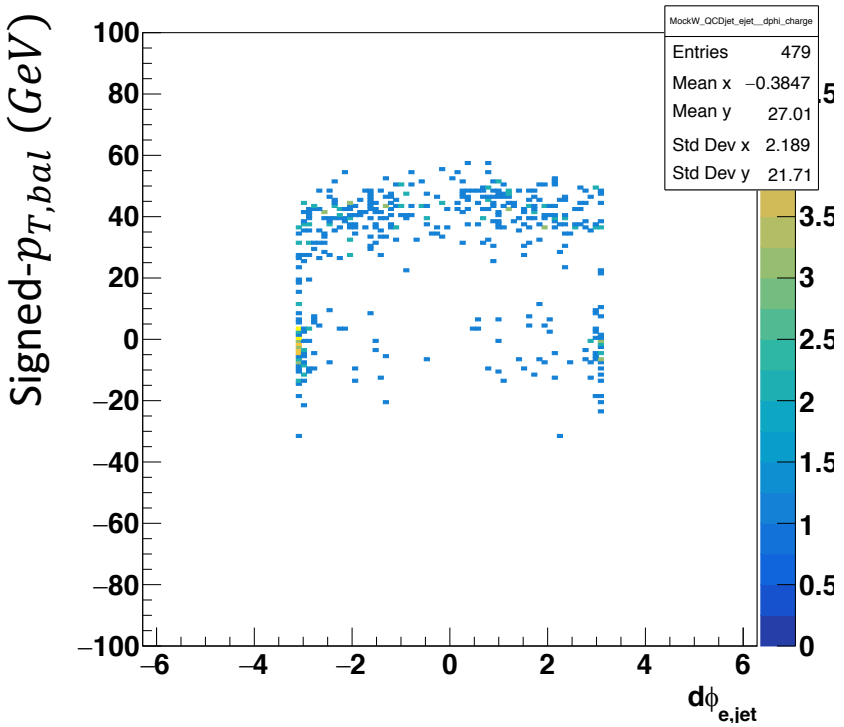
$p_{T,bal,e+} = E_{T,e+} + \sum p_{T,jet}$(QCD)



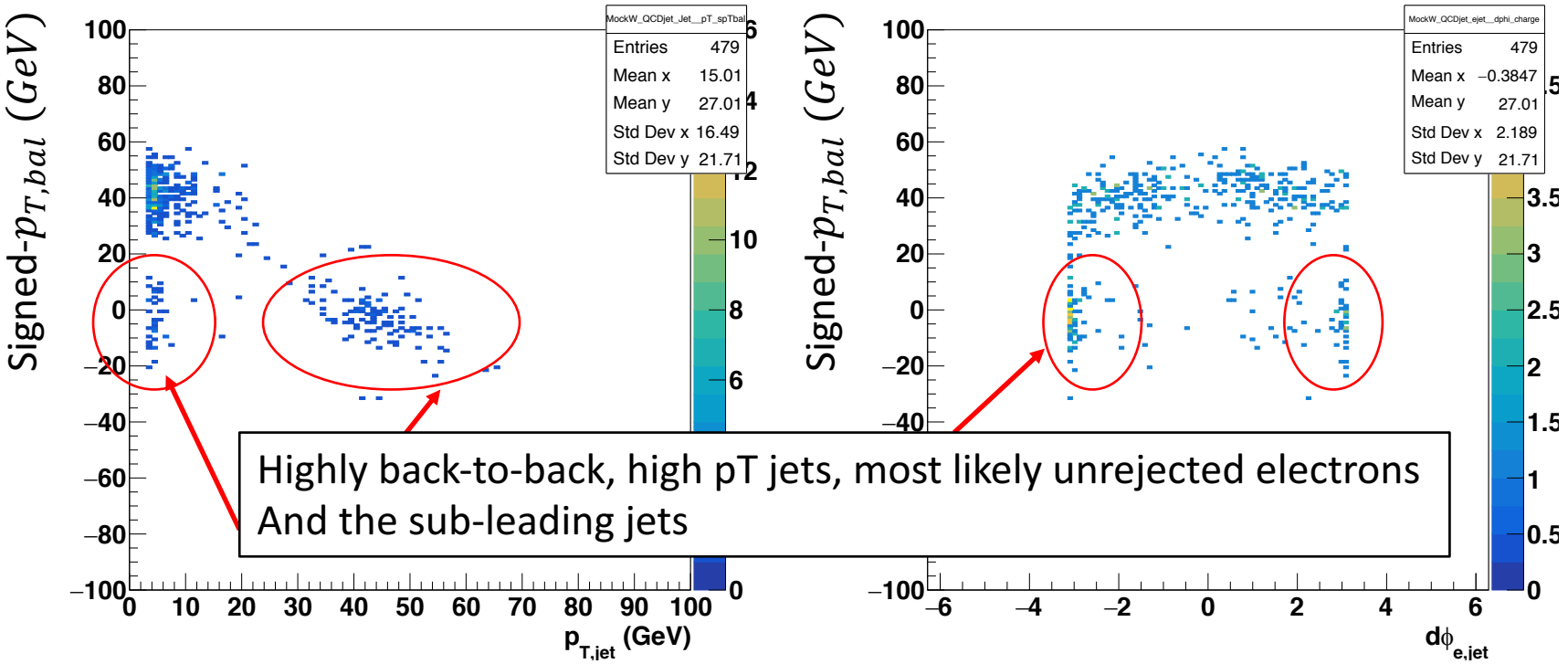
- Low spTbal tail with the new scheme needs to be understood
- Other than this no significant signal below signed-$p_{T,bal} < 16\ GeV$

Low signed-$p_{T,bal}$ tail





Low signed-$p_{T,bal}$ tail



- Low pT tail seems to be mostly consisted of jets driven by unrejected electrons and the subleading jets
- No ”real” signal below signed-$p_{T,bal} < 16\ GeV$

→ **No mis-estimation** of signed-$p_{T,bal}$ selection from mock W study

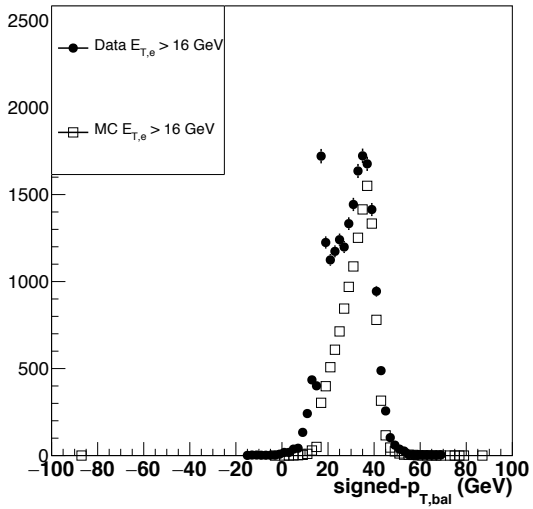
Conclusion from Mock-W study

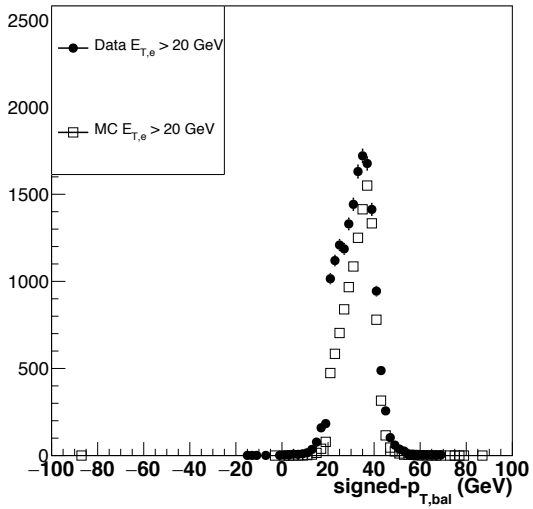
- Mock-W sample from Z data with the opposite electron blinded
  - New jet definition rejecting (some) contribution from the opposite electron
  - No “real” signal (or mismatch with MC) below the spTbal cut $< 16\ GeV$

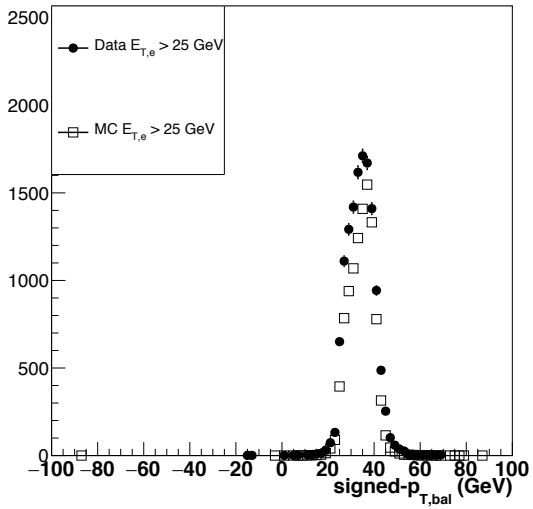
- Reproducing the result with W data
  - spTbal and ETaway distributions
  - Underlying jets
  - Potential mismatch between data & MC

Reproducing Mock-W results with W

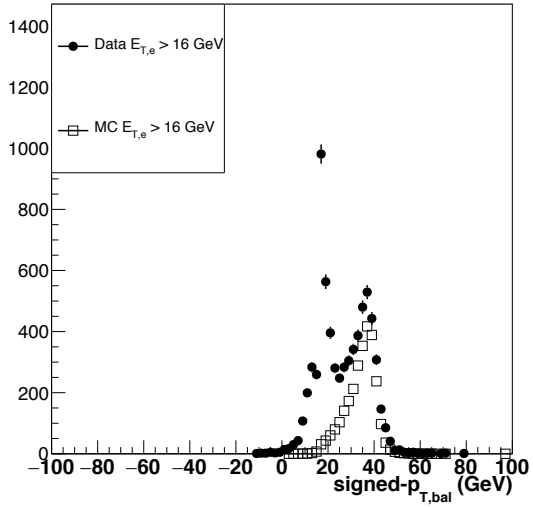
With ETaway selection (W+)

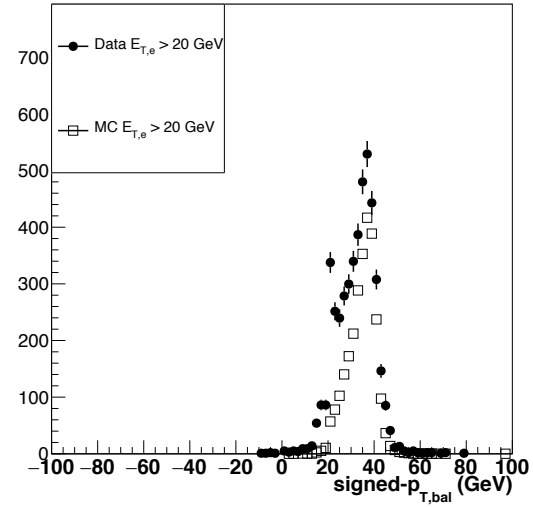


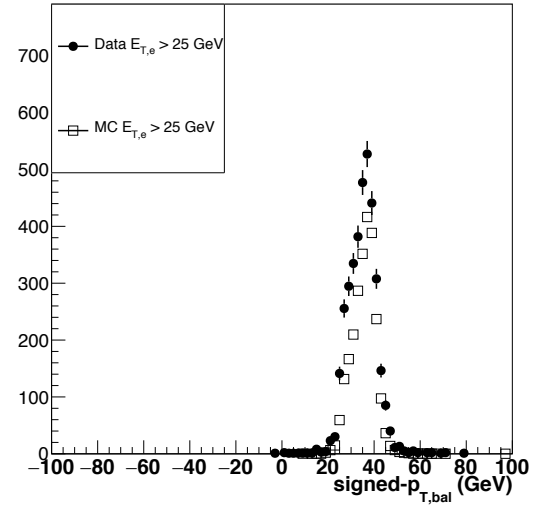




With ETaway selection (W-)

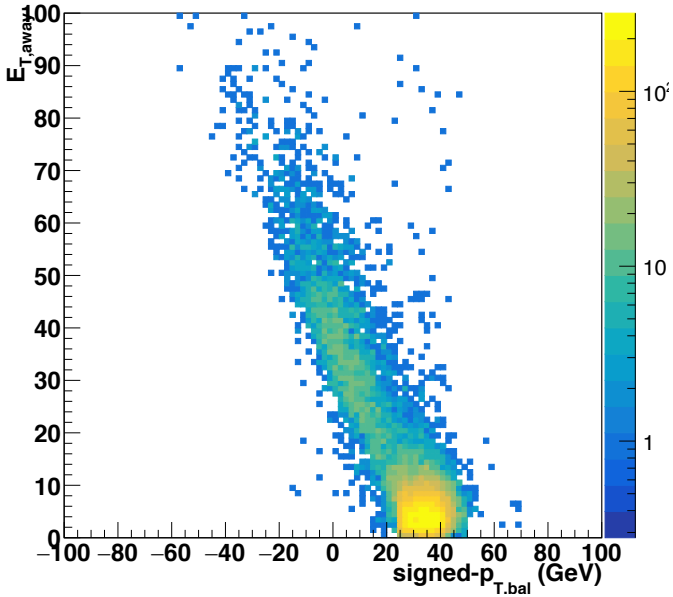




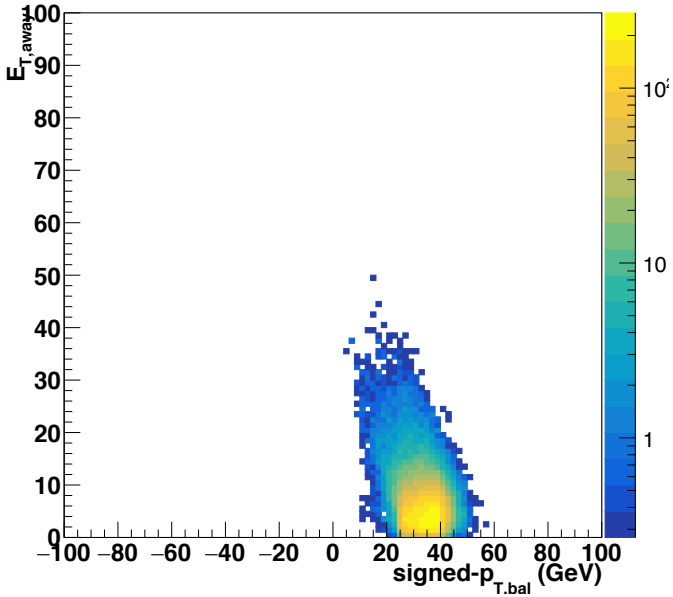


Without ETaway cut

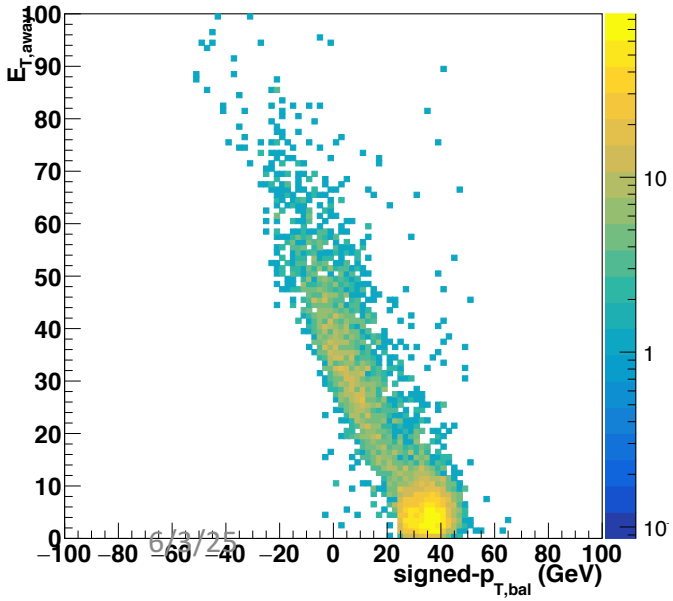
No ETaway cut (W+, data)



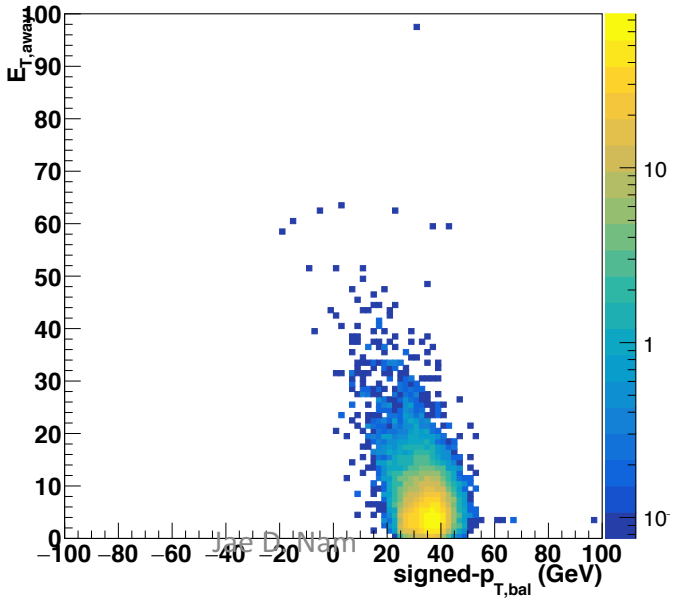
No ETaway cut (W+, MC)



No ETaway cut (W-, data)

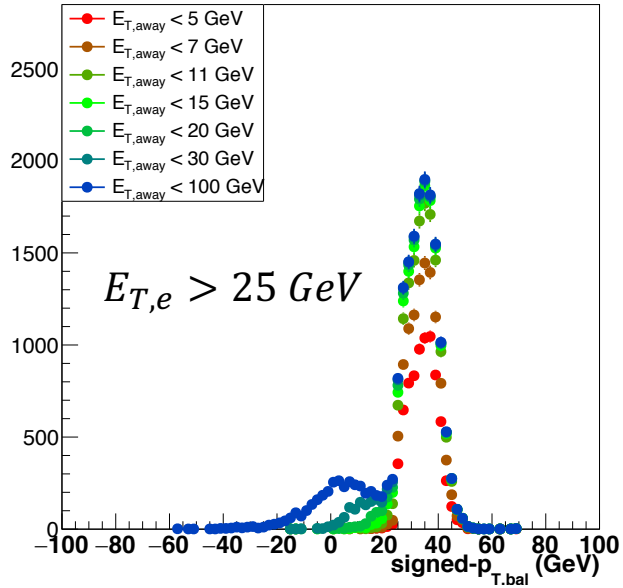


No ETaway cut (W-, MC)

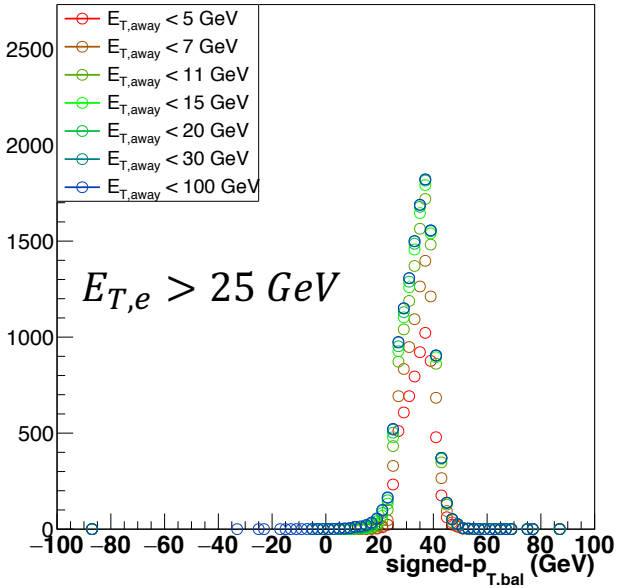


- $E_{T,e} > 25\ GeV$
- No ETaway cut (nominal cut: $E_{T,away} < 11\ GeV$)
- Presence of high ETaway & low signed pTbal in data

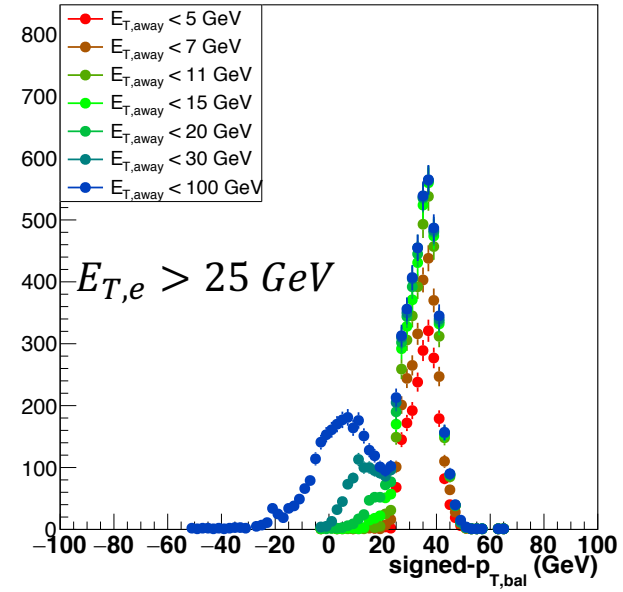
No ETaway cut (W+, data)



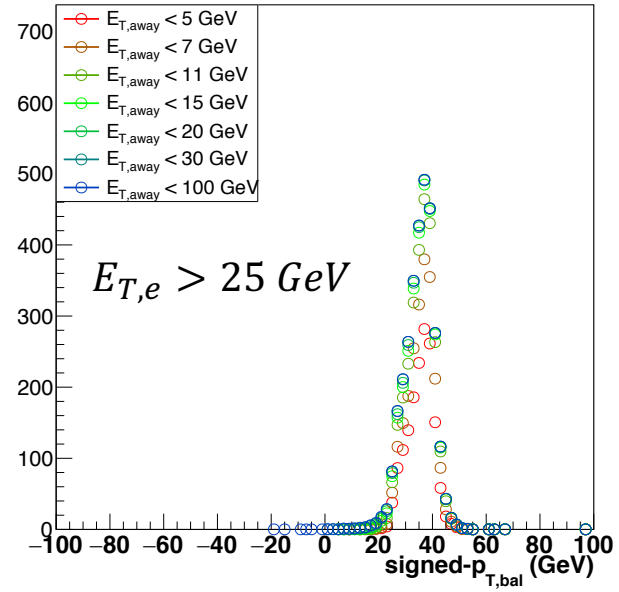
No ETaway cut (W+, MC)



No ETaway cut (W-, data)

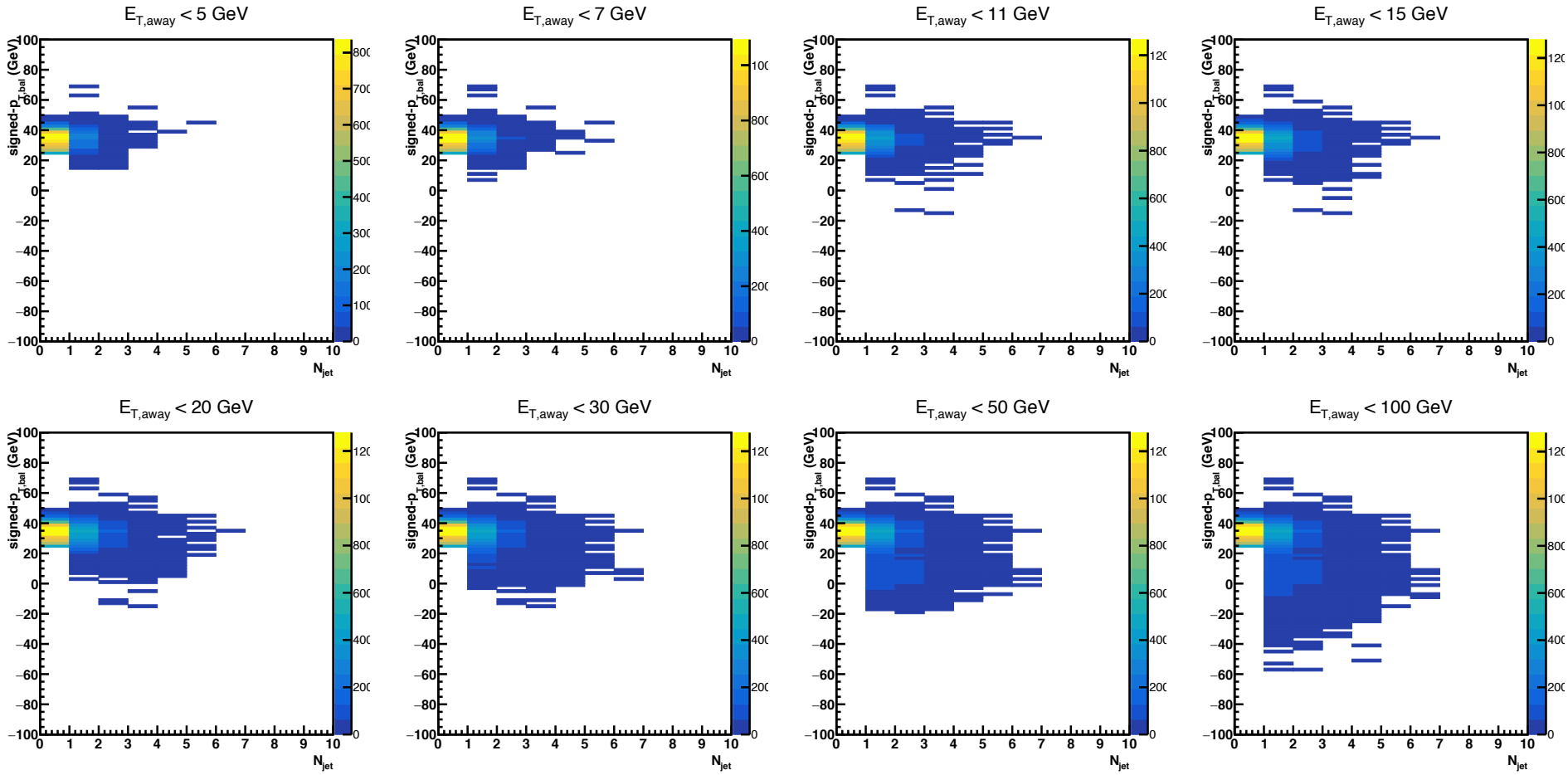


No ETaway cut (W-, MC)



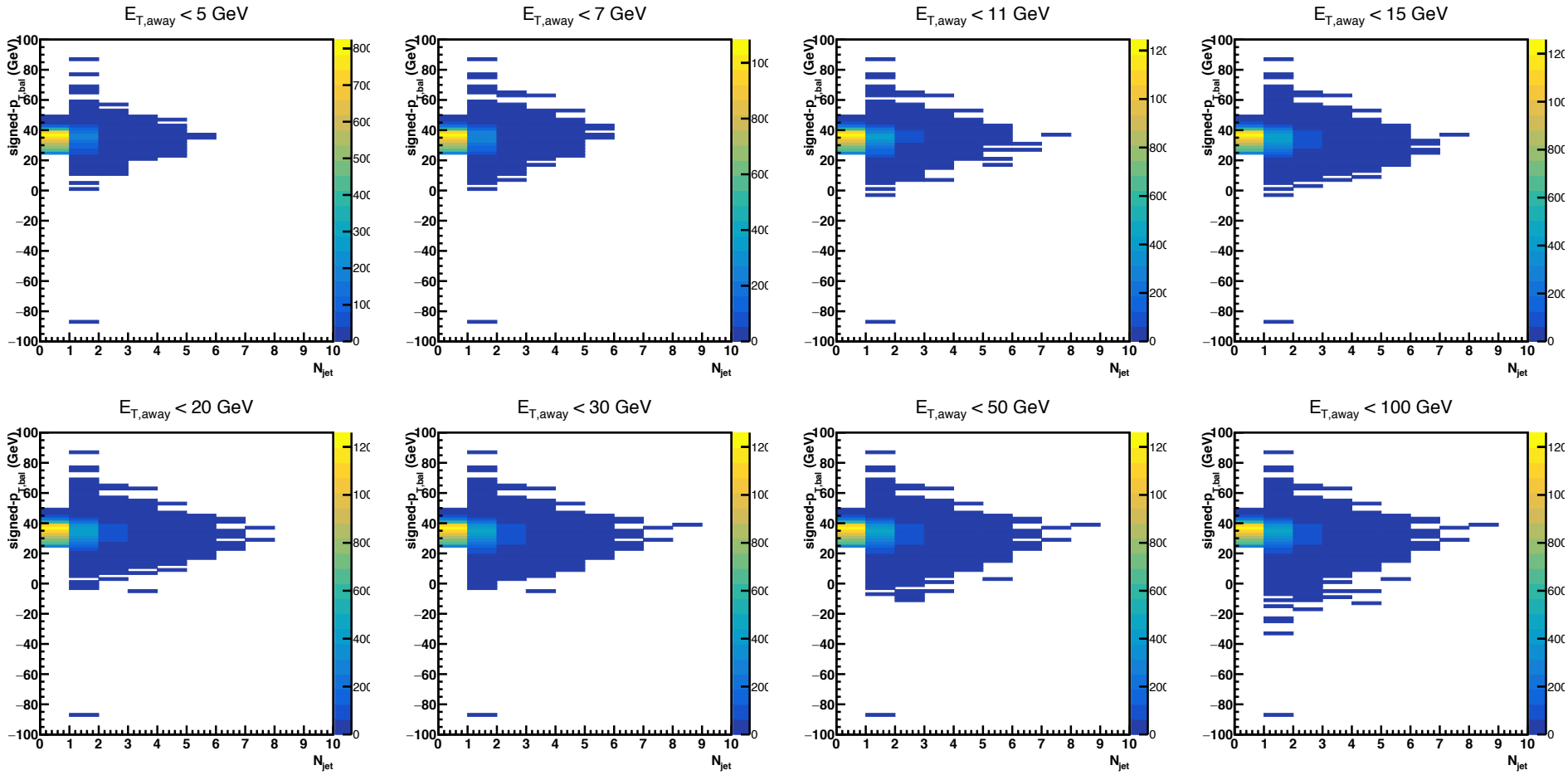
- Without ETaway cut (ETaway < 100 GeV), data show low-spTbal tail, similar to mock-W
- Probably is actual Z + dijet QCD

Jet distributions (N_{jet}, Data, W+)

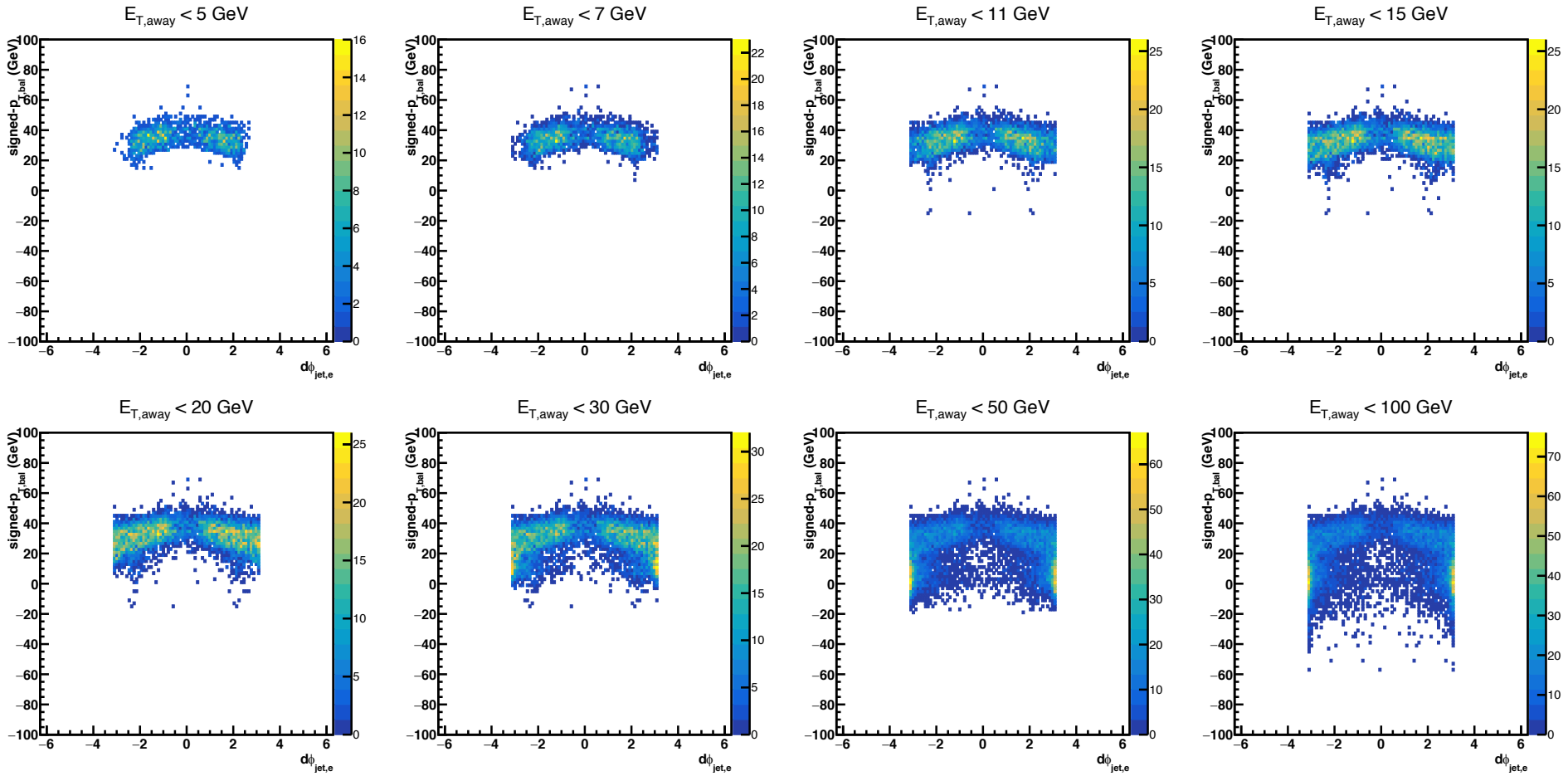


- Second peak appearing at signed-$p_{T,bal}$~0 with relaxed ETaway cut

Jet distributions (N_{jet}, MC, W+)

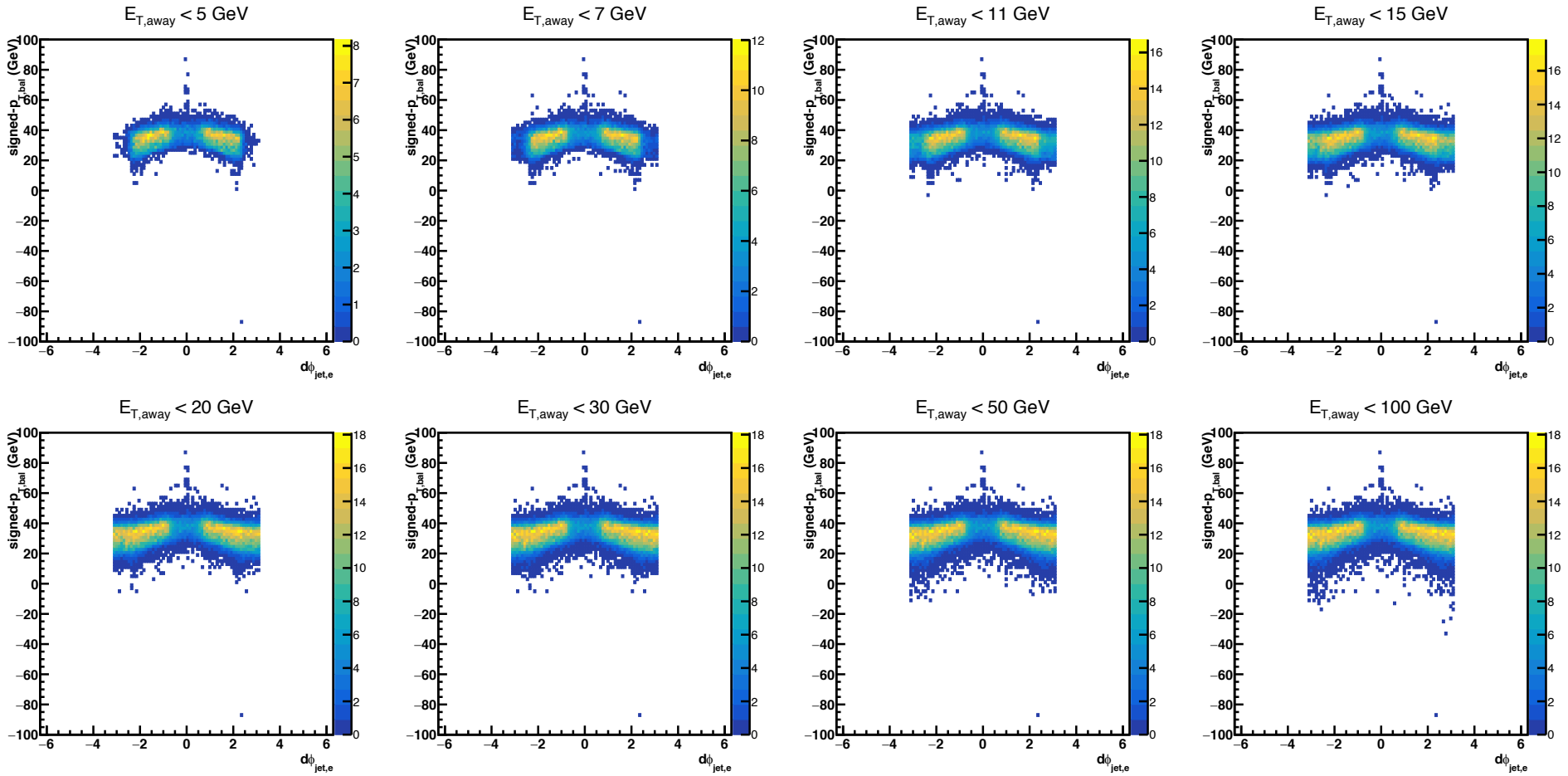


Jet distributions ($\Delta\phi_{e,jet}$, Data, W+)

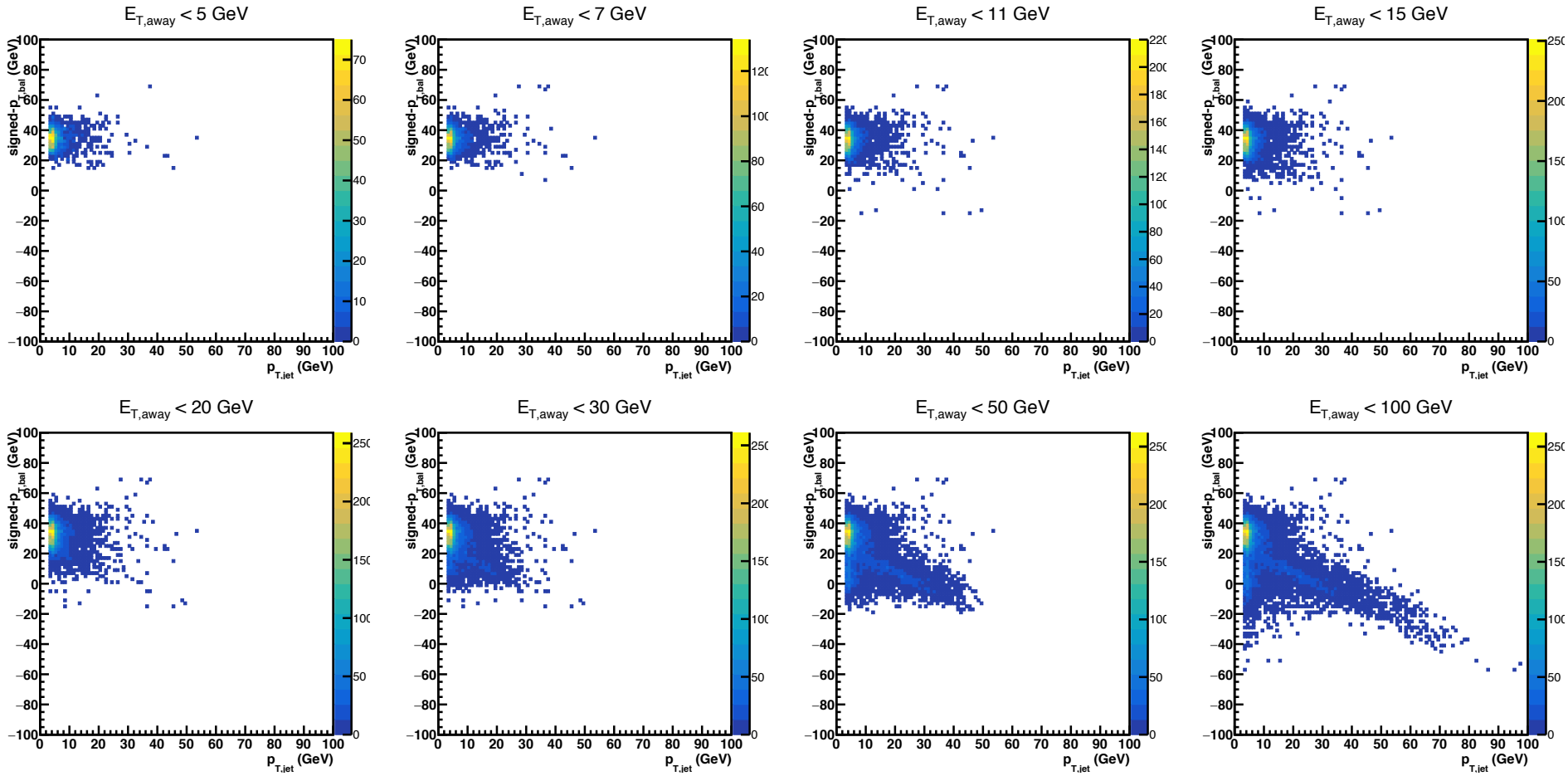


- Second peak appearing at signed-$p_{T,bal}$~0 with relaxed ETaway cut
- Highly back-to-back

Jet distributions ($\Delta\phi_{e,jet}$, MC, W+)

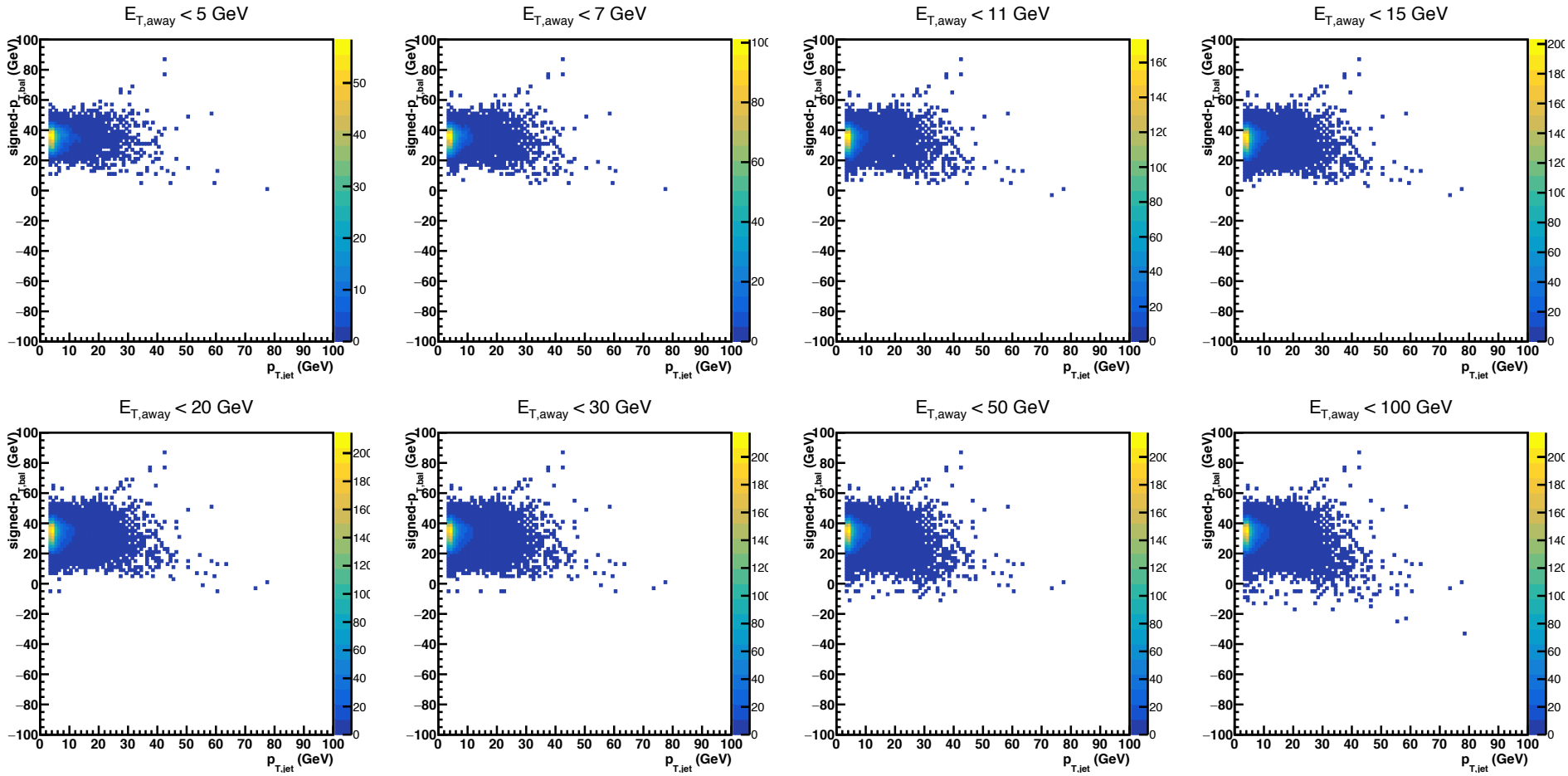


Jet distributions ($p_{T,jet}$, Data, W+)



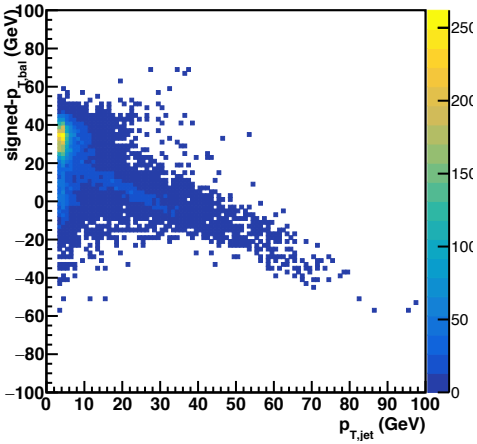
- Second peak appearing at signed-$p_{T,bal}$~0 with relaxed ETaway cut
- Highly back-to-back, one leading jet (Z or dijet) and subleading jet

Jet distributions ($p_{T,jet}$, MC, W+)

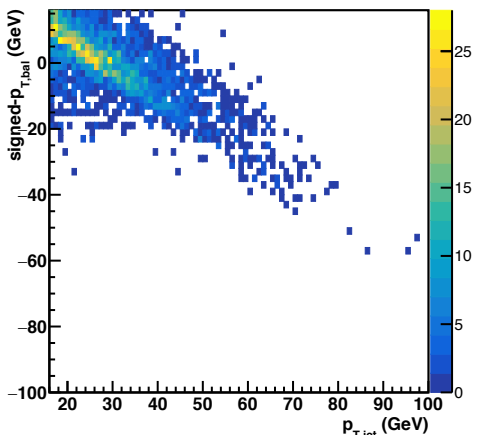


Signed-$p_{T,bal}$ and Jet p_T (W+)

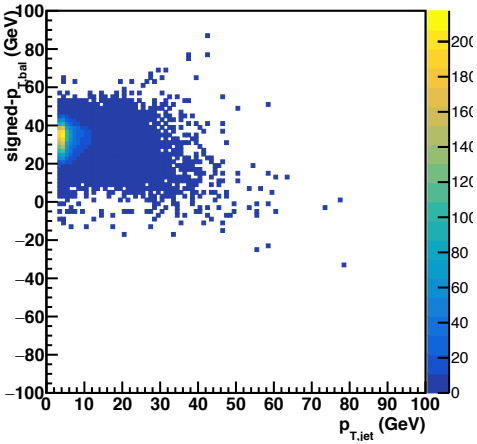
Data W+



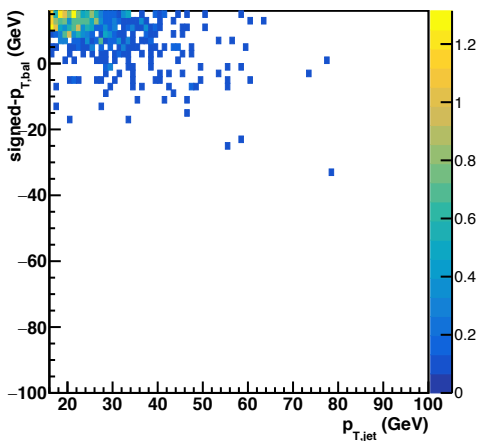
Data W+ (Zoomed in)

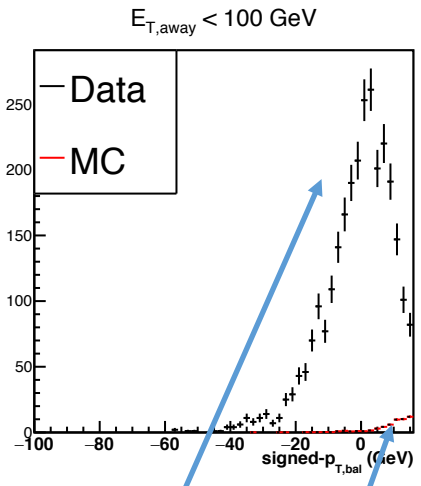


MC W+



MC W+ (Zoomed in)



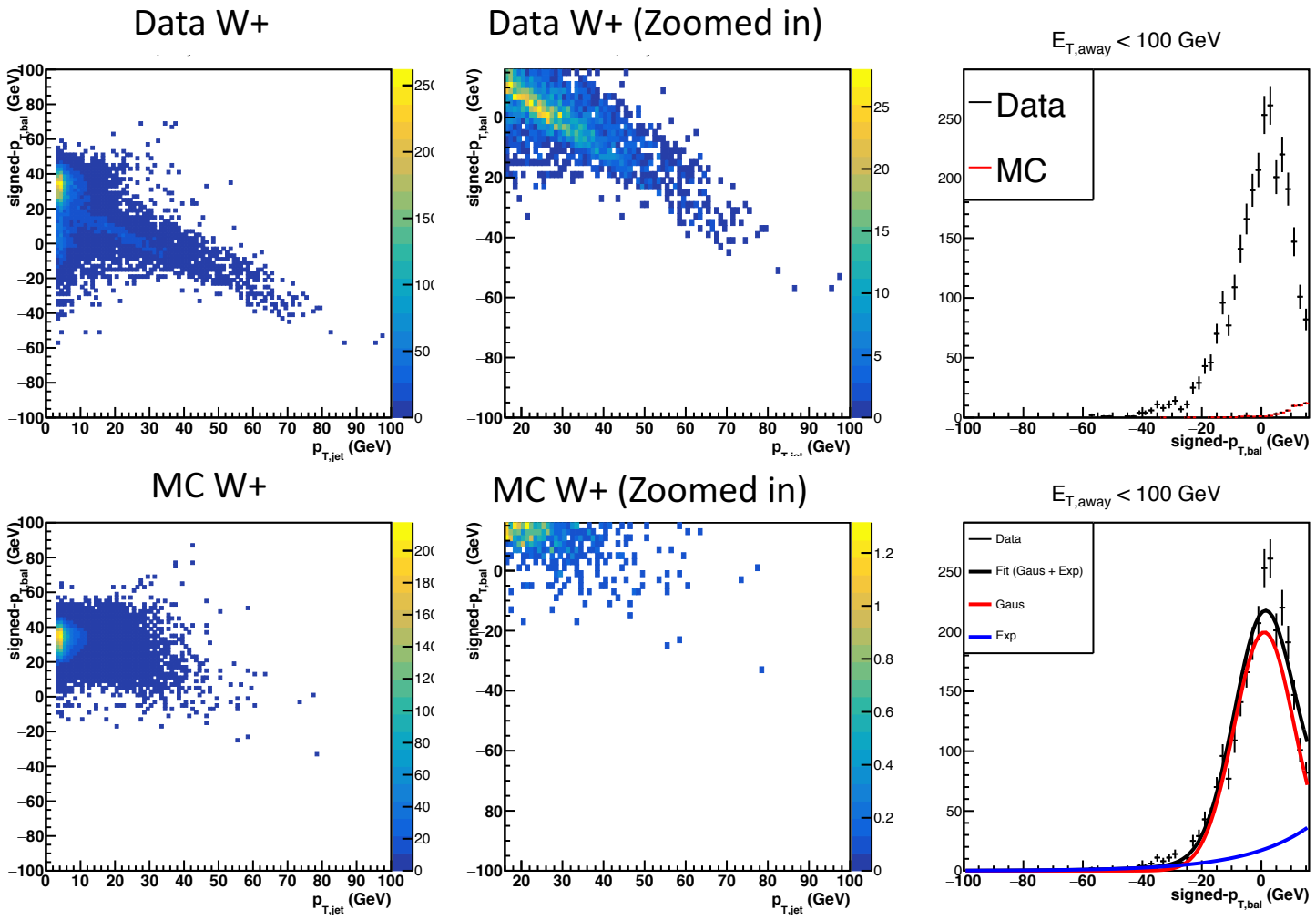


Asymmetric low-spTbal tail of W

Symmetric contribution dominated by Z, QCD-dijet

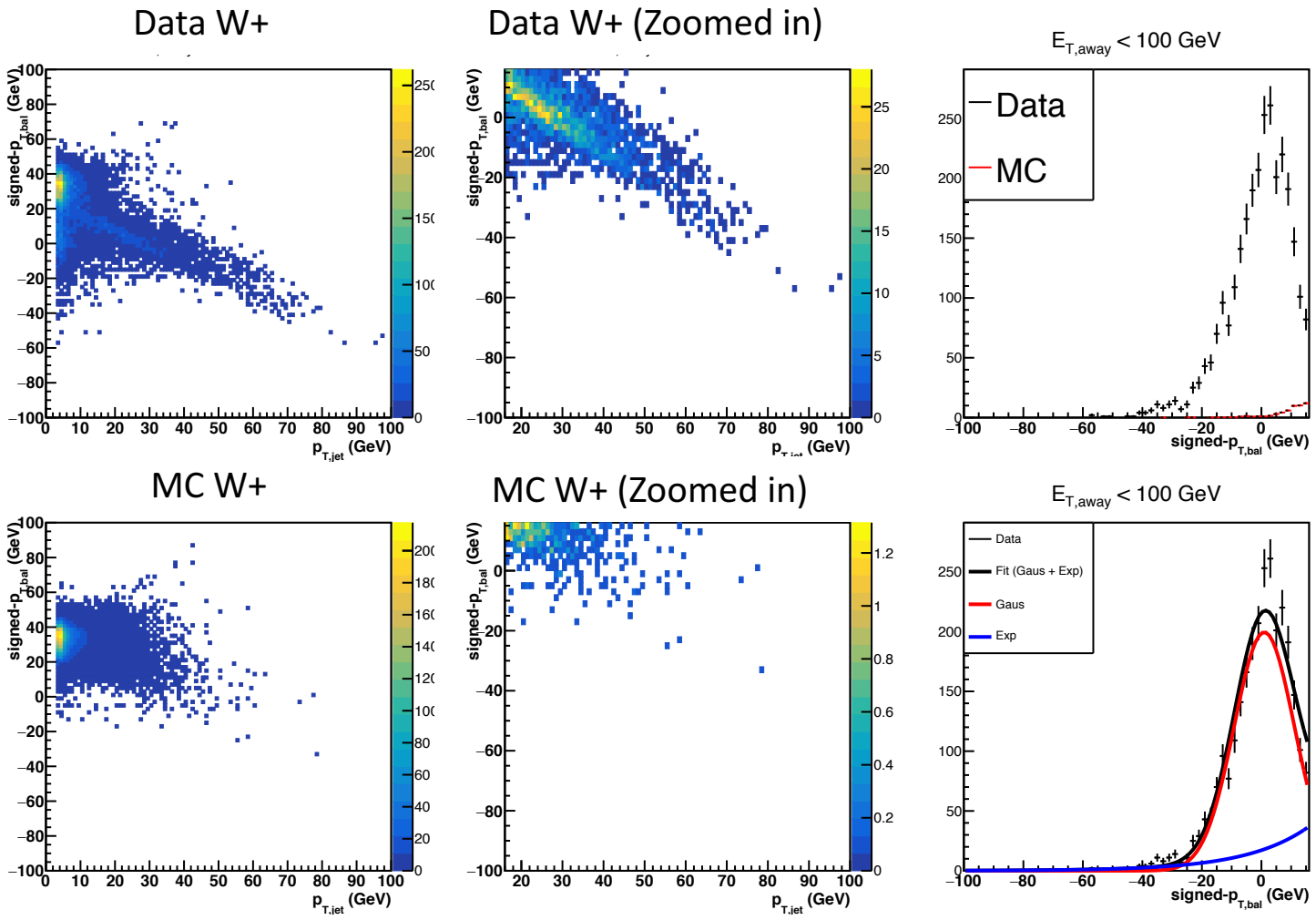
- Looking at signed-$p_{T,bal} < 16\ GeV, p_{T,jet} > 16\ GeV$

Signed-$p_{T,bal}$ and Jet p_T (W+)



- Symmetric (QCD/Z) and asymmetric (possible $W \rightarrow e$ or $W \rightarrow \tau$) fits
- No justification behind choice of fit function (Gaus, Exp)

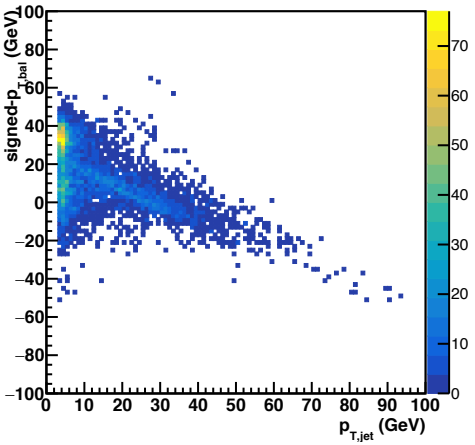
Signed-$p_{T,bal}$ and Jet p_T (W+)



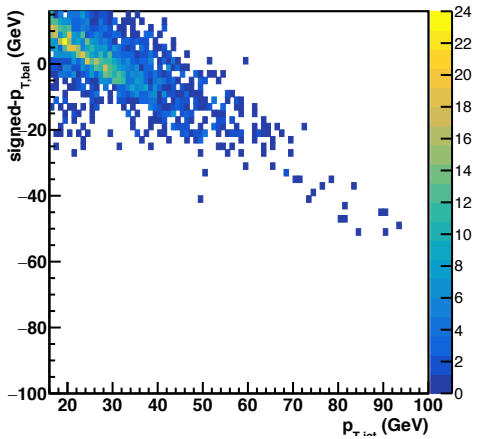
- Asymmetric contribution can be as large as ~5% of signal

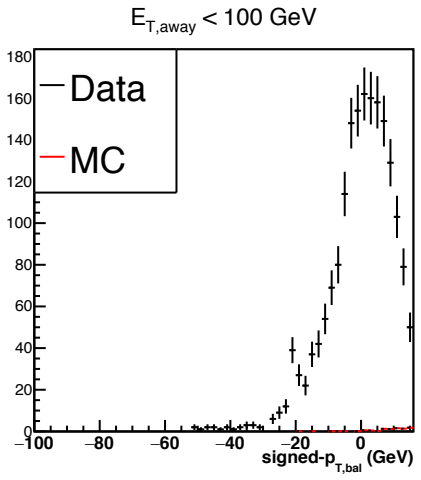
Signed-$p_{T,bal}$ and Jet p_T (W-)

Data W-

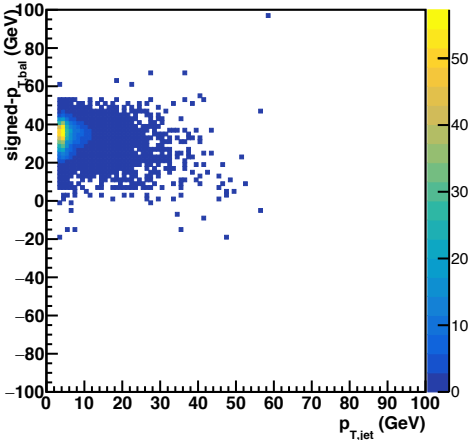


Data W- (Zoomed in)

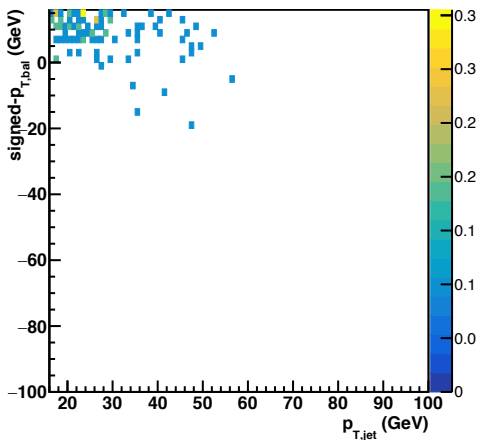


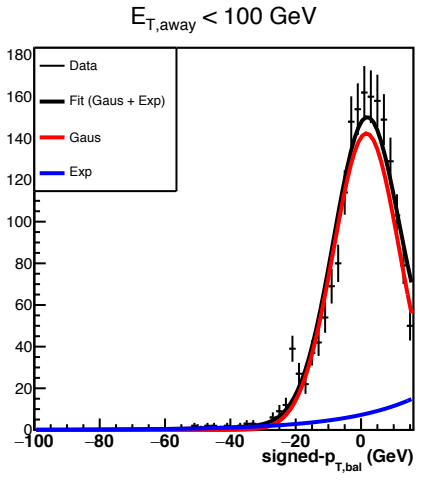


MC W-



MC W- (Zoomed in)





- Similar observation with W-
  (Asymmetric contribution can be as large as ~5% of signal)

Summary

- Mock W study with new QCD jet definition suggests **no significant** mis-estimation of signed-$p_{T,bal}$ cut
- Similar study was repeated with W data and found that the mis-estimation effect can **only be as large as** $\sim 5\%$

→ No significant contribution from signed-$p_{T,bal}$ and $E_{T,away}$

- The following lines will be added In the text,
  - Emission of soft and hard gluons simulated with LO+PS models, such as Pythia, is subject to uncertainties originating from the underlying assumptions behind parton showering algorithms, and cannot be trusted entirely.
  - The resulting misdescription of soft and hard QCD radiation may appear as an incorrect estimation of the reconstruction efficiency in equation (X).
  - The inefficiency of selection criteria based on the activity within a large area of the detector, such as $\boldsymbol{E_T^{\Delta R<0.7}}$ and $\boldsymbol{E_T^{\Delta\phi\sim\pi}}$, and the description of reconstructed jets, such as **signed-$\boldsymbol{p_{T,bal}}$**, have been re-evaluated using reconstructed W and Z samples from data without these requirements.
  - The impact of the misestimation of the reconstruction efficiency to the overall cross section was found to be less than 5% and taken as a **systematic uncertainty**.