V0.8 Photon Samples – High Multiplicity Events

2/6/25

Summary of MAIA Meeting Last Week/Developments This Week

- *Paper:*
  - *got the ok from the IMCC! discussed IMCC endorsement statement, funding acknowledgements, and bib style, but overall ~~ready to post to arXiv this week~~* ***POSTED TO ARXIV!!!!***
  - *https://arxiv.org/abs/2502.00181*
  - *will probably wait on journal submission until we have v0.8 updated plots*

- *European strategy:*
  - *aim to have updated tracking, photon, neutral hadron plots*
  - *Greg and Ethan (Yale) optimistically hope to contribute their tau studies as well*
  - *I have been in contact with Greg about inputs to Pandora clustering algorithms this week*

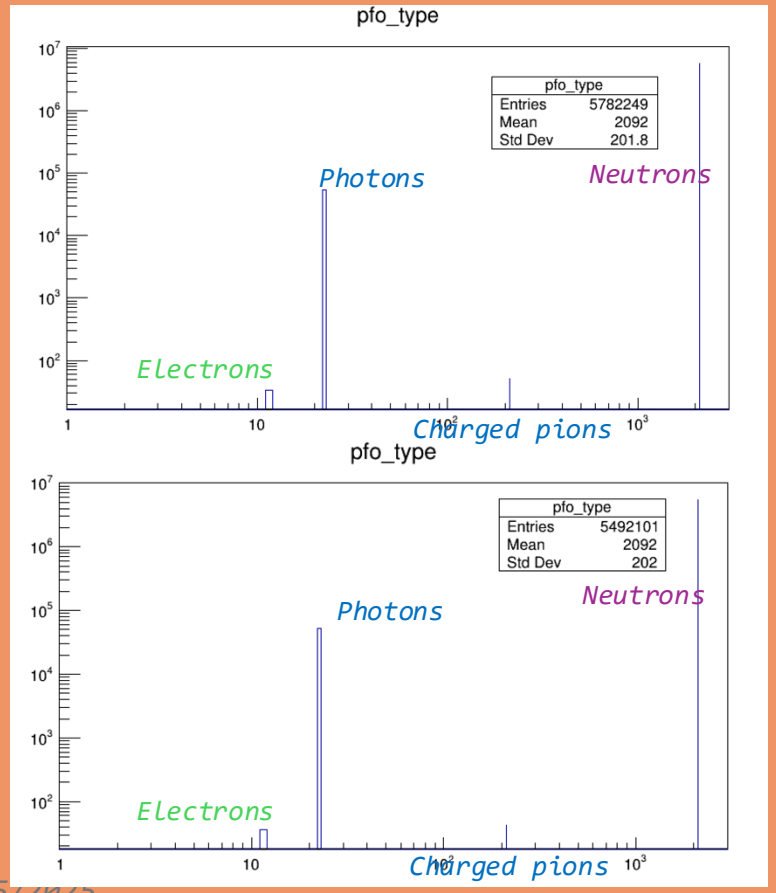
- *v0.8 Photon Samples:*
  - *evidence of some clustering failure in events with high PFO multiplicity*
  - *More in the following slides!*

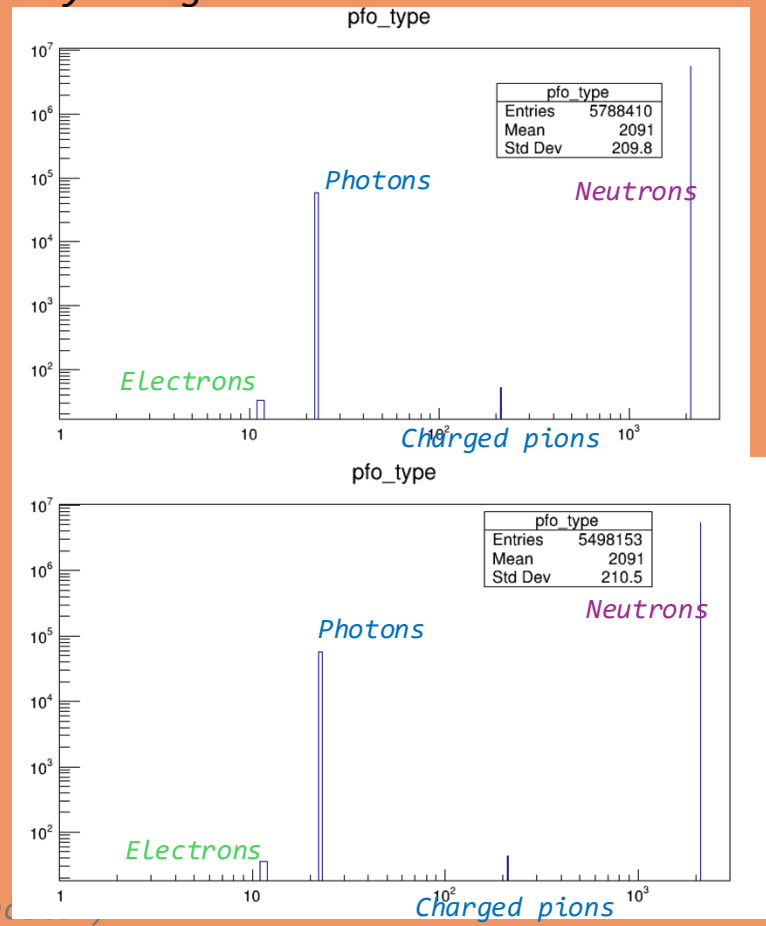
Outline

- *Last week, observed some strange behavior in the new photonGun samples with v0.8 lattice*
- *Events with O(1000) reconstructed photons, unexpected PDG ID's in reco objects*
- *Bimodality in supposedly Gaussian distributions of Delta E / E in each energy bin*
- *This week: investigated these high-multiplicity events more thoroughly, ran into some new issues with statistics and matching*

PFO Type Distro for Events with nPFO>100

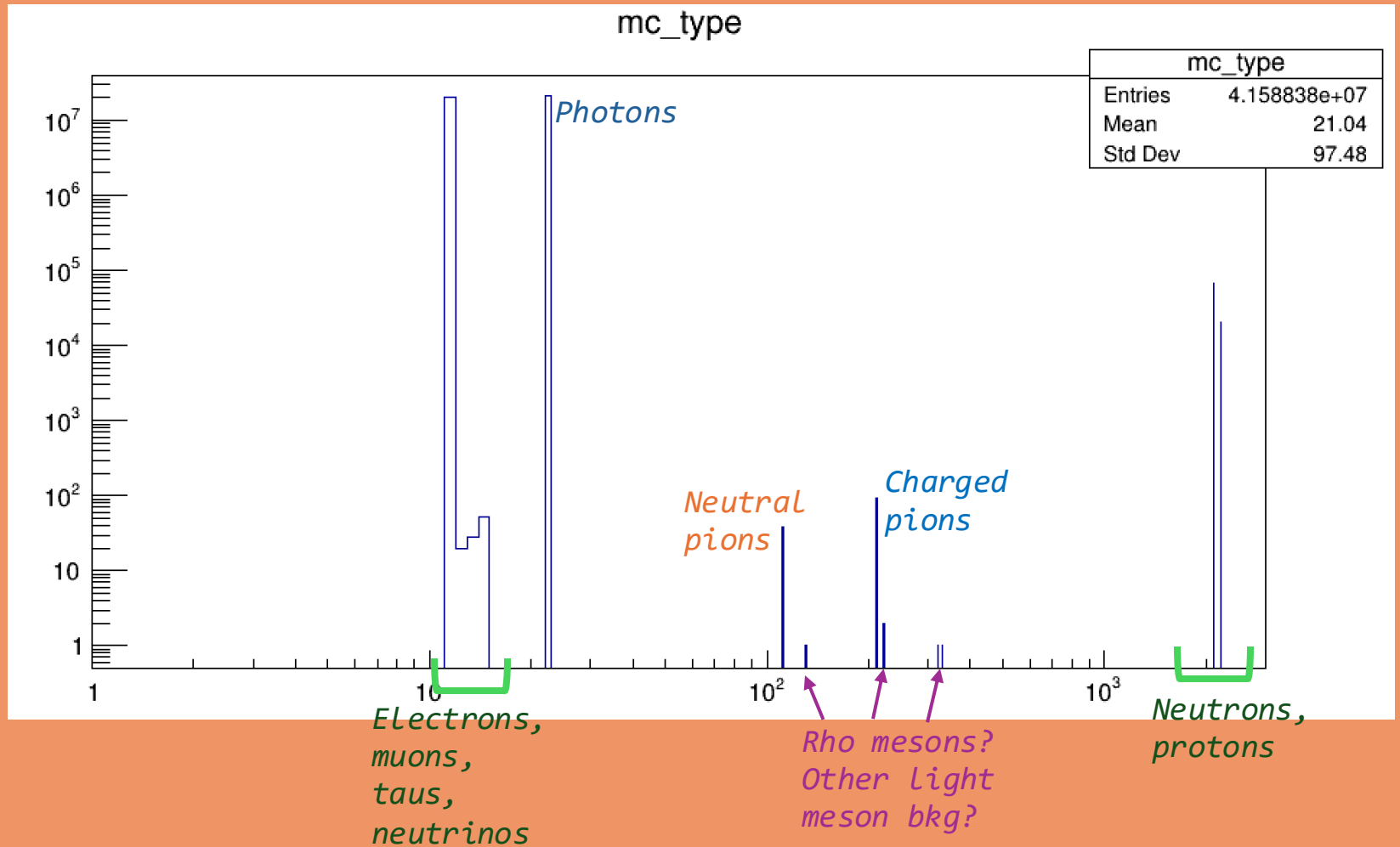
- *High-multiplicity on the left, overall on the right*
  - *No significant difference from overall distribution*
  - *Electron and pion peaks still present but not any larger*





MC PFO Type Distribution

- *Do we have MC electrons that have converted? Are pion PFOs misidentified?*
- *This is 250-1000, 50-250 slice looks similar*
- *So the pion and electron PFOs might* ***not*** *be misID'd*

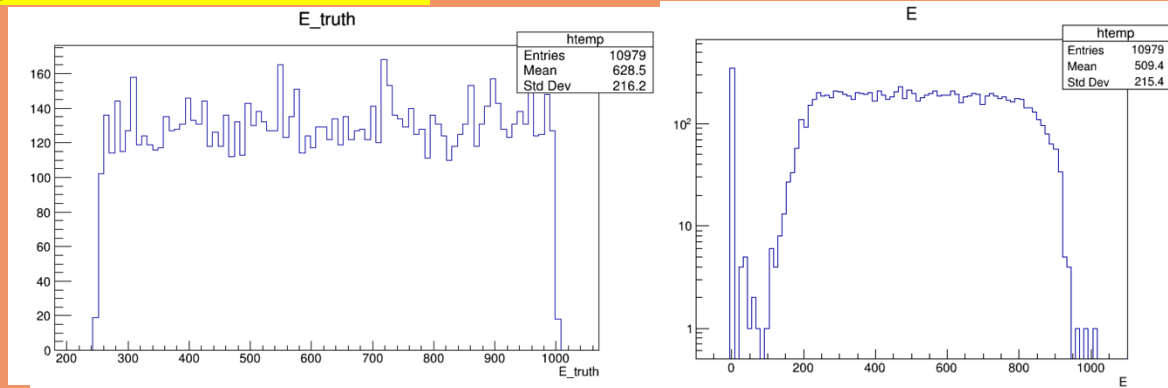


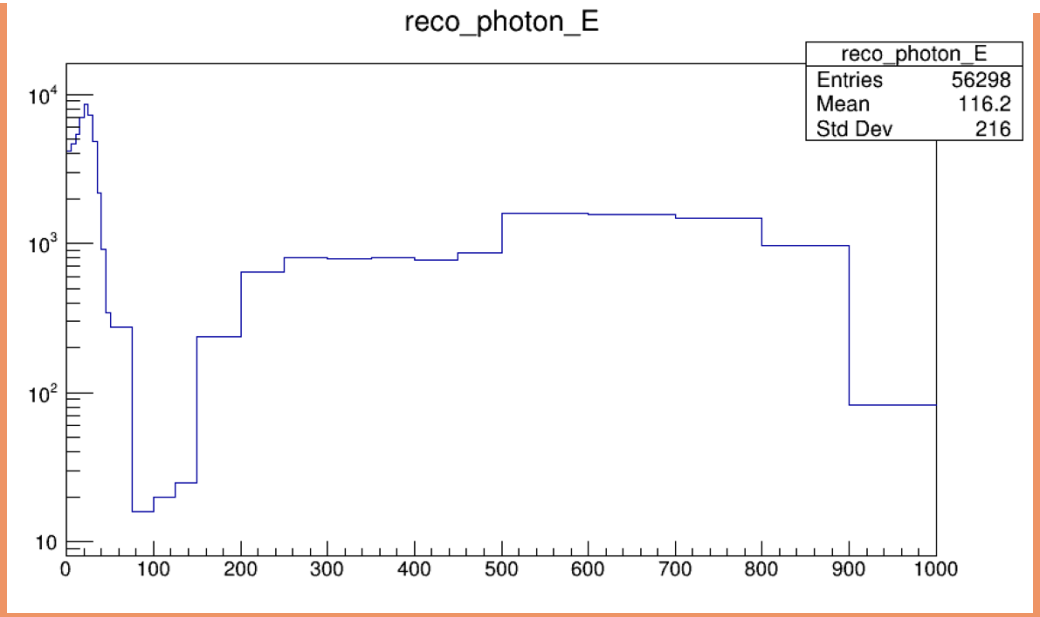
Resolution Study, nPFO per evt <= 5

- *Decided to restrict to events with <=5 PFO, see if bimodality in endcap and barrel regions goes away*
- *It **does**, but the **worse-response peak** is what remains*
- *(See individual Gaussian fits in backup slides)*
- *Additionally, significant loss of statistics – n=5 may be too aggressive of a cut*
- *Instead, tried a loose cut of n<=100 (good enough to cut that peak at O(1000), which is what we are really worried about)*
  - *Varying the cut in between 5 and 100 doesn't change much*

Overall Lack of Matching in High-E Slices

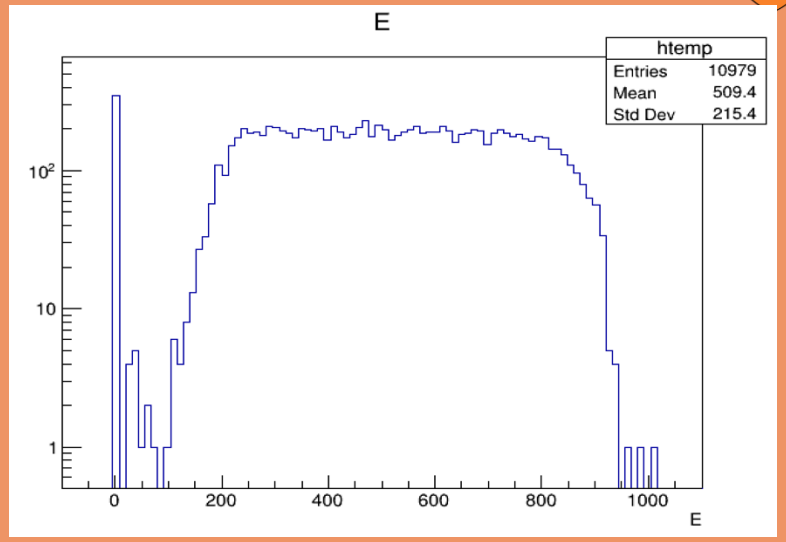
- *Even without a cut on high-multiplicity events, the 250-1000 GeV slice has O(1) matched photon for energies > 850 GeV*
- *Not a gen-level problem*
- *Something is preventing us from matching photons at high energies*
- *Motivated a pre-matching inspection of high-energy PFOs*
  - *Plotting energy of **all** photon-identified PFOs, before any quality cuts*
- *We do see a significant drop in statistics, but there are O(100) reco photons at E>850 GeV*

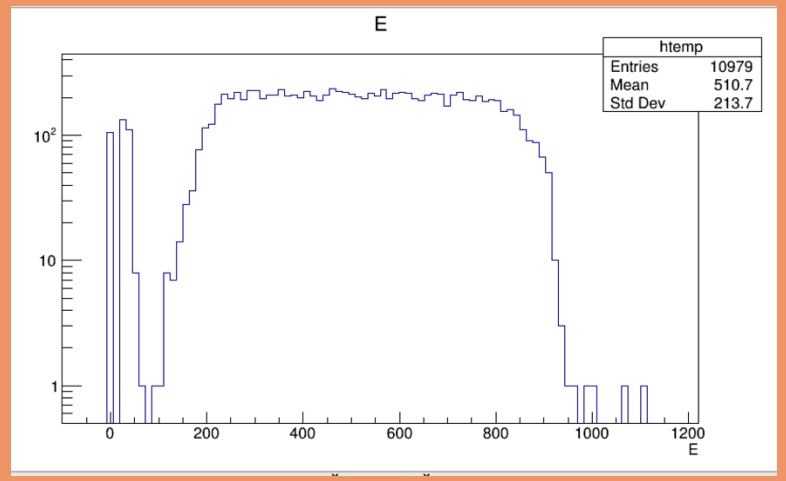




Evaluating Matching Failure

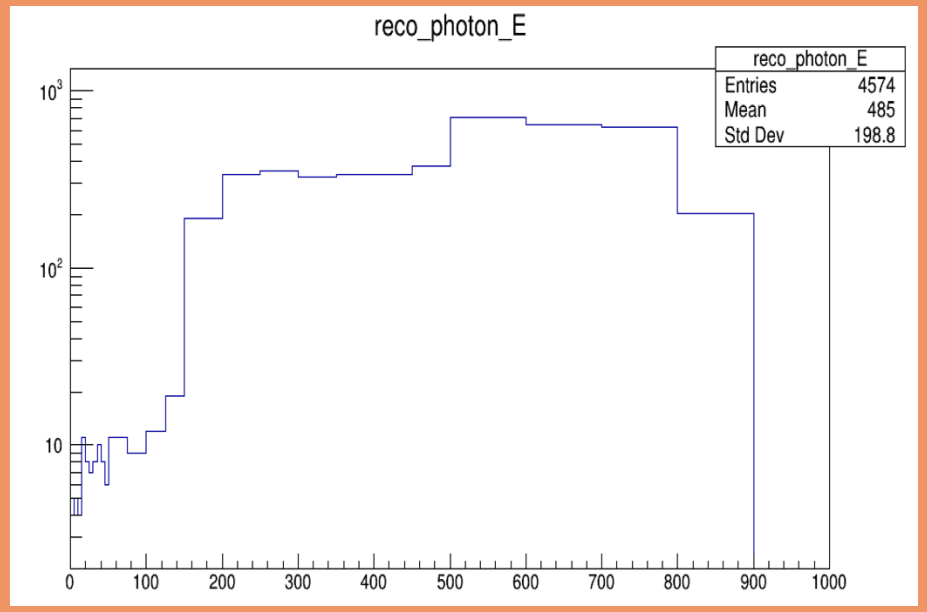
- *Our two matching cuts are dR-based and pT-based. We select the candidate with maximum pT and minimum dR*
- *Clearly max pT is not causing the matching failure at high energies*
- *Tried removing the dR cut; slight improvement in high-energy bins*
  - *Might make sense to remove dR cut since reco in this sample is already restricted to a cone of ~0.4 around photon*
- *But we see concerning spike in 30-50 GeV bin*
- *(no dR cut is the bottom plot)*

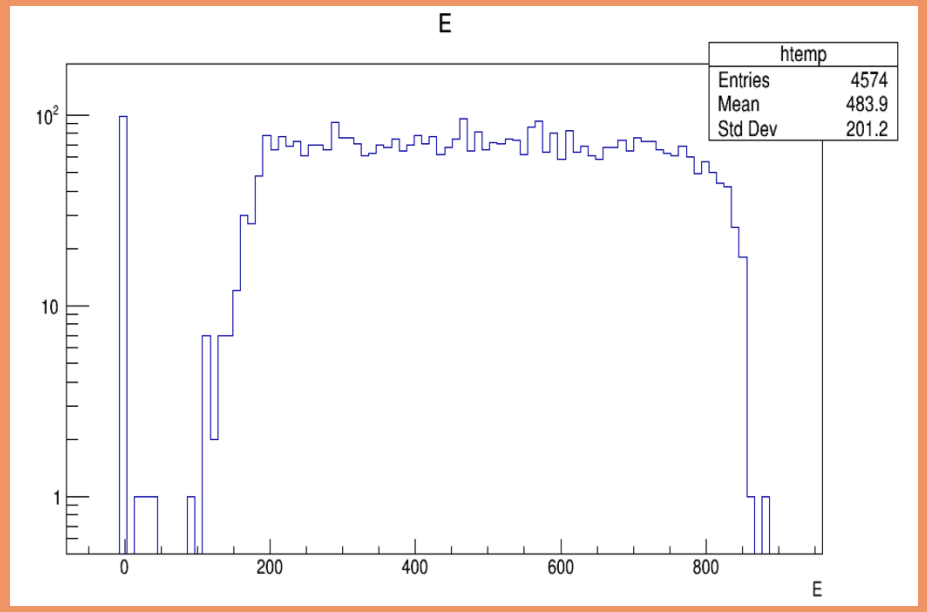




High-energy bins have > 100 PFOs

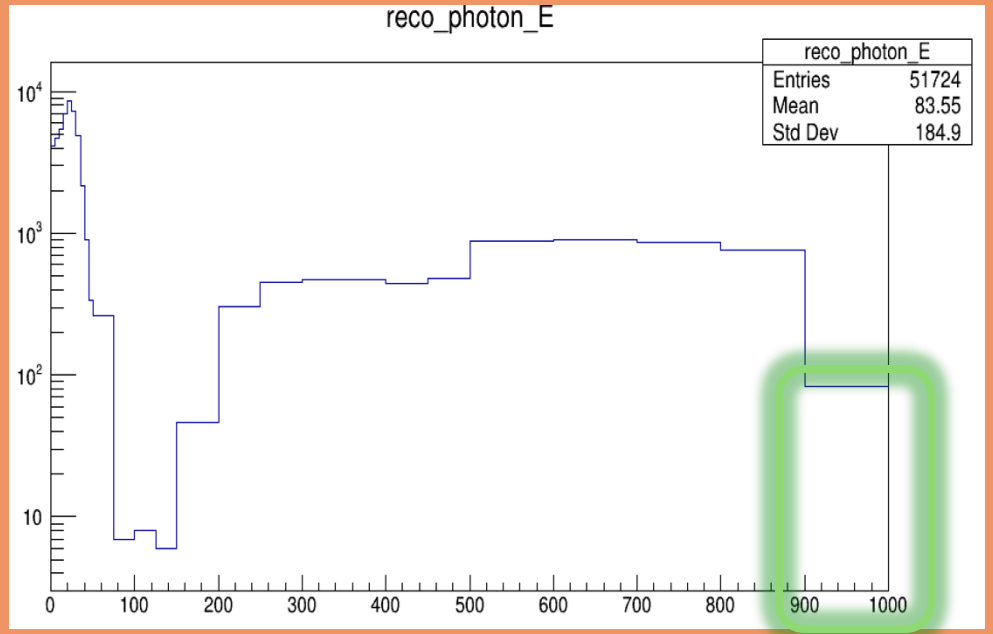
- *Removed dR cut and restricted to events with <= 100 PFOs*
- *Lack of statistics above 900 GeV for reco photons even pre-matching*
- *All reco photon E at left, matched reco photon E at right*

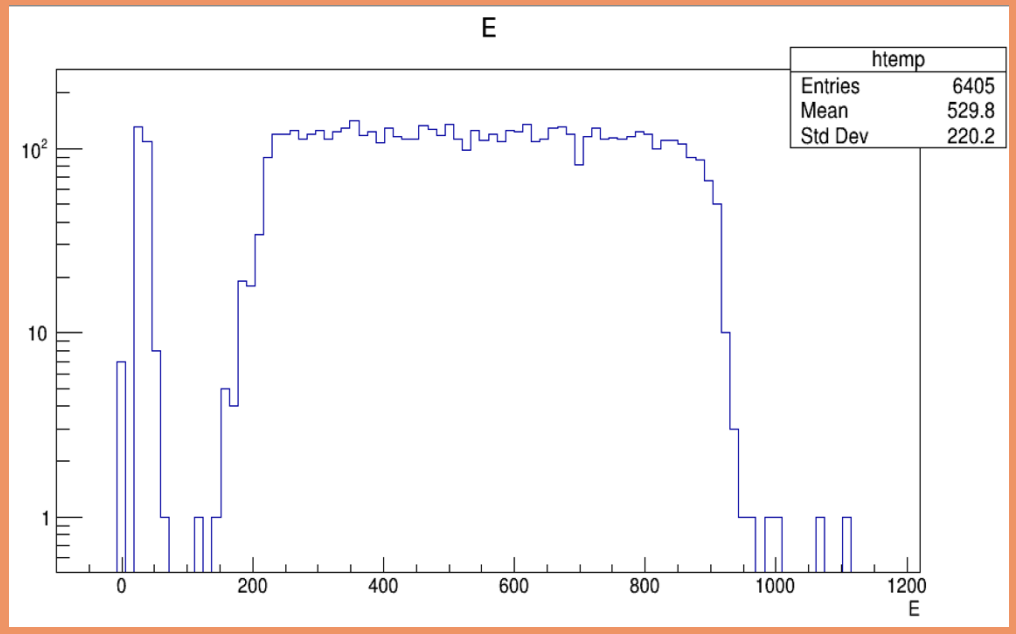




nPFO > 100: reco photon energy

- *The ~100 reconstructed photons with energy in the 900-100 GeV range when we remove the dR cut are **all** high-multiplicity events (nPFO > 100)*
- *Regardless, only O(10) events with E_rec>950 GeV are matched (even in high-multi sample)*

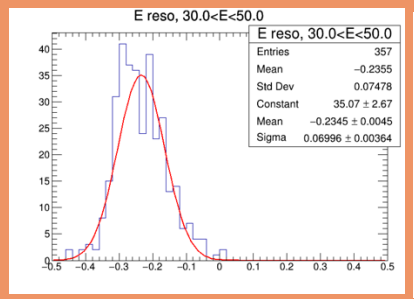


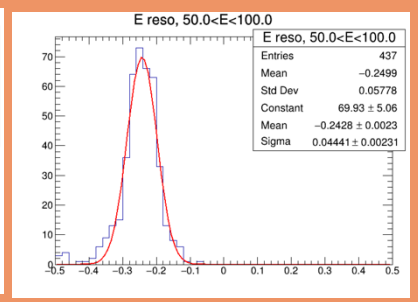


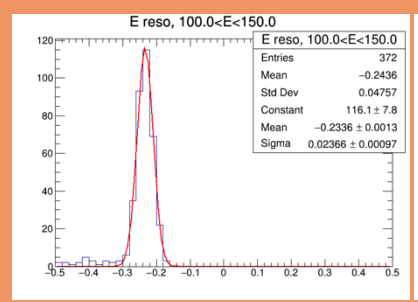
Conclusions

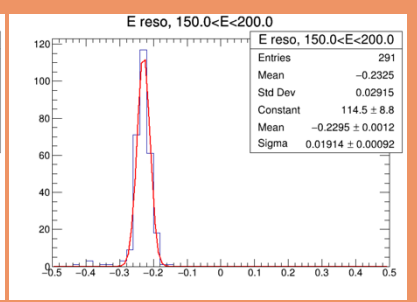
- *There is no single type of PFO contributing to high-multiplicity events*
- *Removing high-multi events eliminates the double peak in individual Gaussians*
  - *The remaining ‘true’ peak has a slightly worse response*
- *Our dR matching requirement kills statistics in the 900-1000 GeV range*
- *When dR cut is removed, all events in this range are high-multiplicity, and even those are not as well-matched as we would like*
- *Overall, three outstanding problems:*
  - *What is actually **causing** the high-multiplicity events? Is this just a catastrophic clustering failure, or is something weirder going on?*
  - *Lack of low-multiplicity statistics in high-energy bins; we may need to rerun highest energy slice*
  - *May need to reevaluate matching strategy; dR cut no longer appropriate*

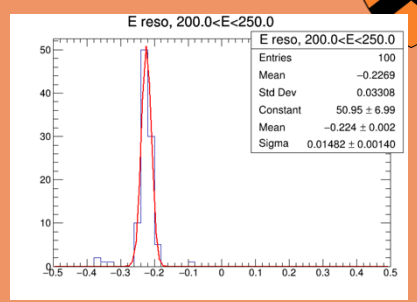
Backup – Endcap Region, nPFO <= 5

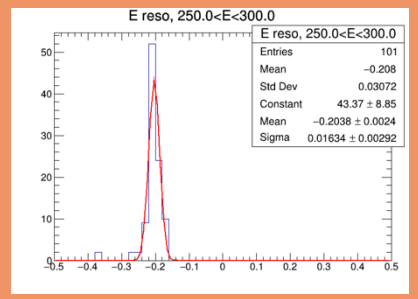


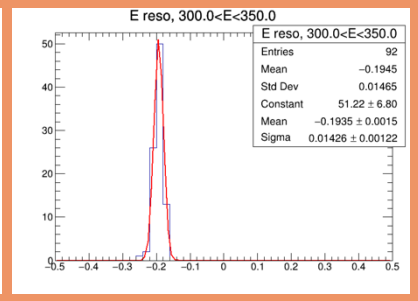


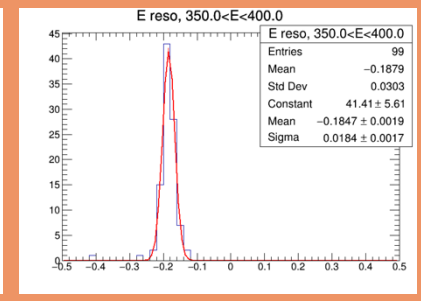


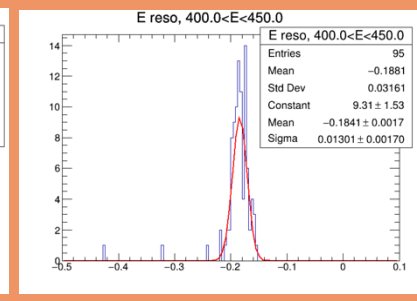


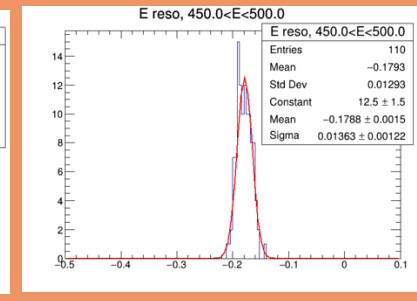


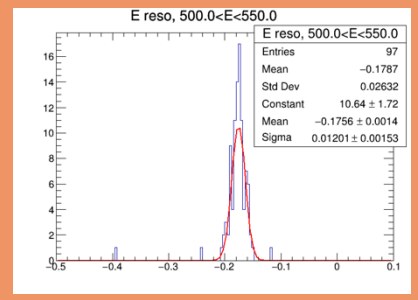


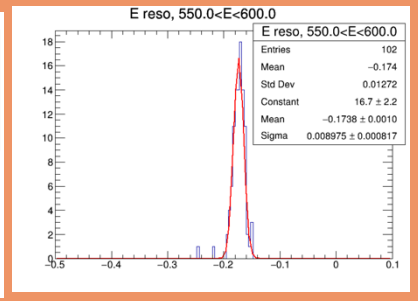


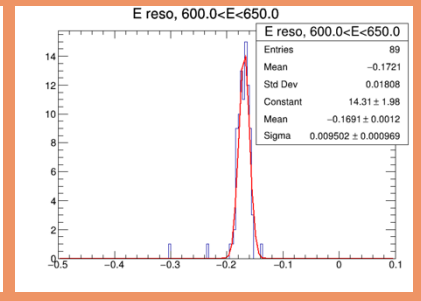


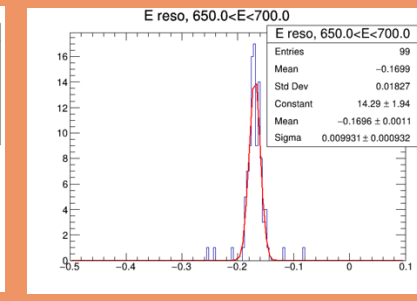


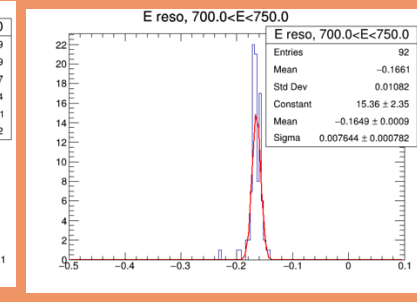


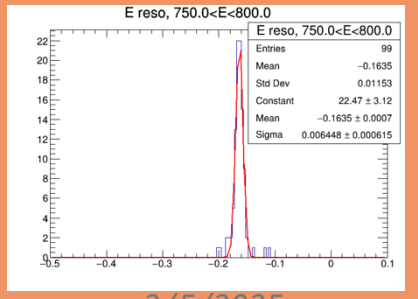


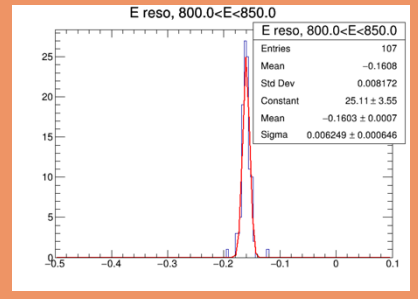




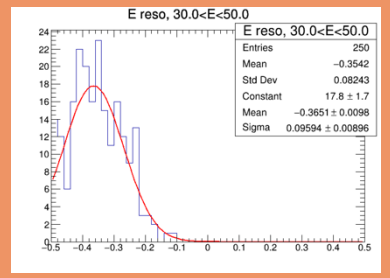


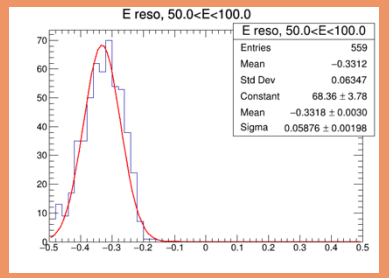


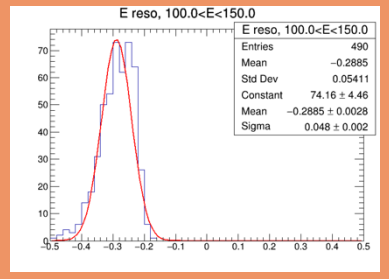


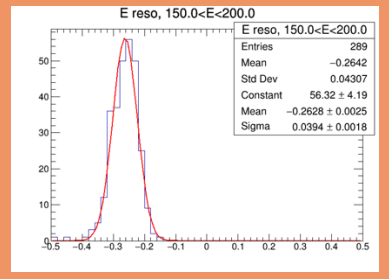


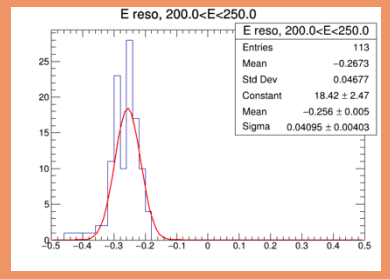
Backup – Barrel Region, nPFO <= 5

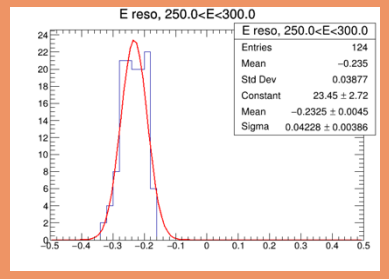


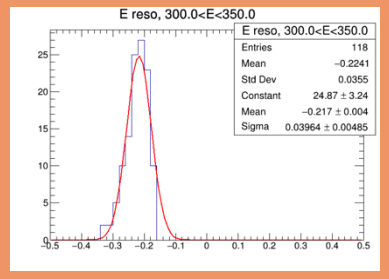


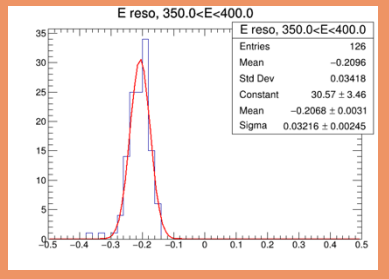


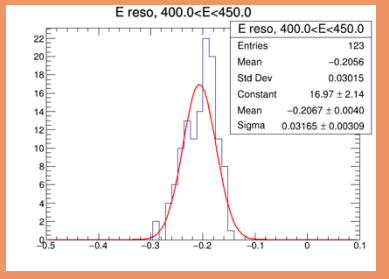


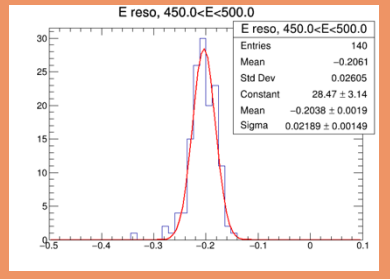


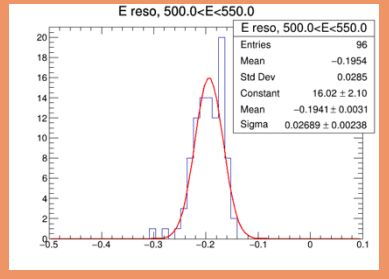


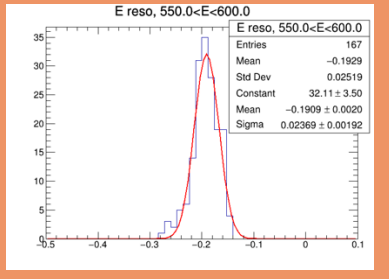


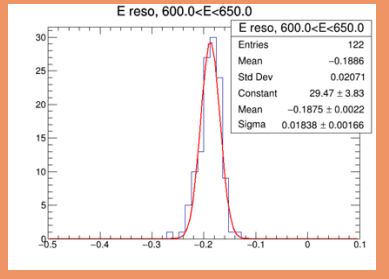


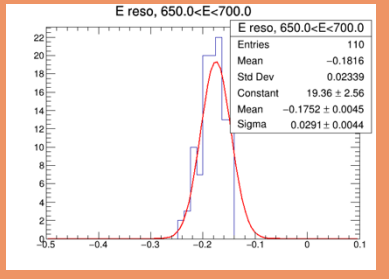


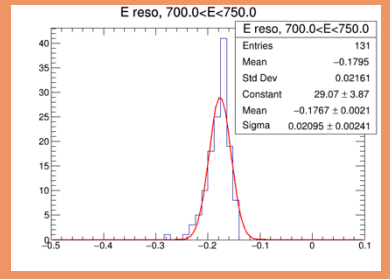


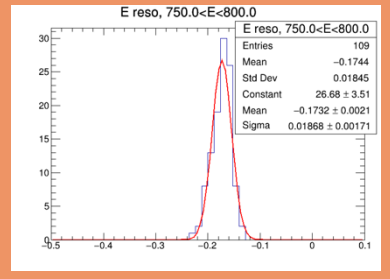


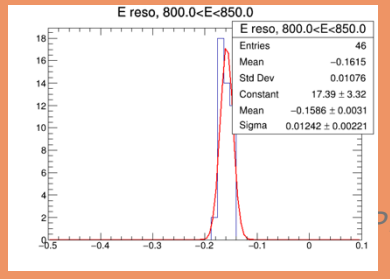












Backup – Transition Region, nPFO <= 5