Cluster MCParticle Truth Matching

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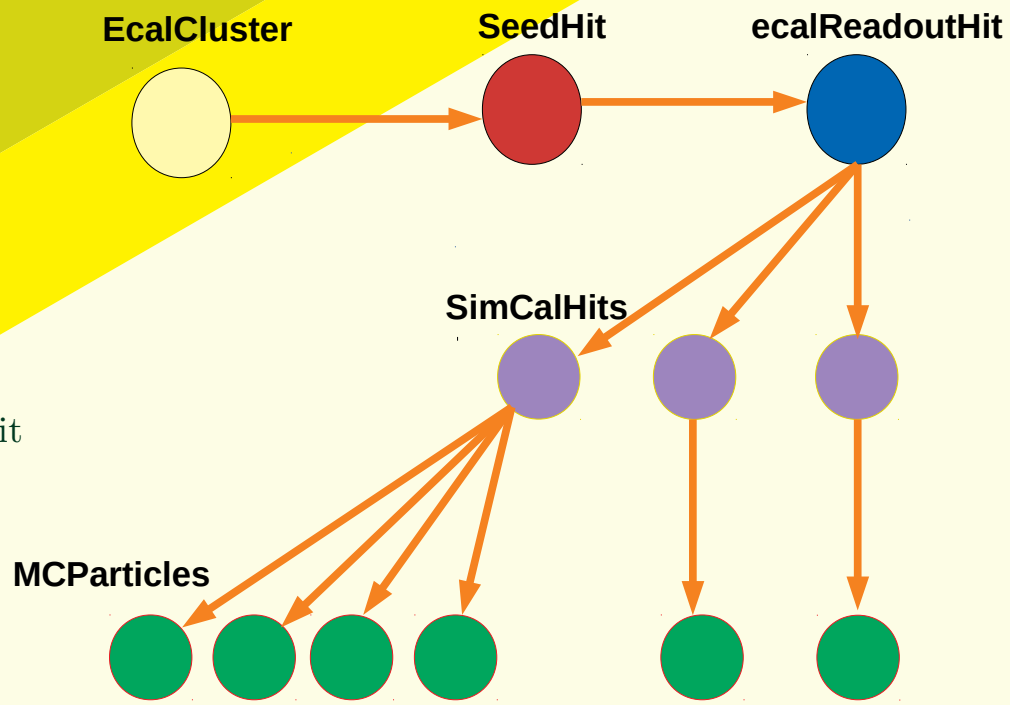
Intro

- Need reliable Cluster truth matching to finish evaluating performance of new KF+GBL compatible TrackClusterMatcher algorithm
- Find cases where a MCParticle is matched to multiple Clusters
  - Often these clusters are in completely opposite quadrants on the Ecal
  - How is it possible to truth match two clusters in opposite sides of Ecal to same MCParticle?
- May be issue with truth matching method
- May be issue with truth information in simulation...

Cluster Truth Matching

- Given EcalCluster, find “SeedHit”
- SeedHit is associated with Ecal Readout Hit
- EcalReadoutHit is associated with multiple Simulated Calorimeter Hits
- Each SimCalHit contributes some fraction of the EcalReadoutHit Energy
- Select SimCalHit with largest Energy contribution
- SimCalHits can have multiple MCParticles associated
- Select MCParticle that contributes most energy to SimCalHit
- Truth match MCParticle to Ecal Cluster



Checking Truth Match Energy

- After matching Clusters to MCParticles, 2d plot energy
- **Top horizontal line** shows FEE's
  - Entries left of x=~2.3 represent edge hits
- **Central diagonal line** shows reasonable Cluster MCParticle matches
  - MCParticles with energy < ~400 MeV should be outside Ecal acceptance
- **Bottom horizontal line** represents **bad matches** between Cluster and MCParticle
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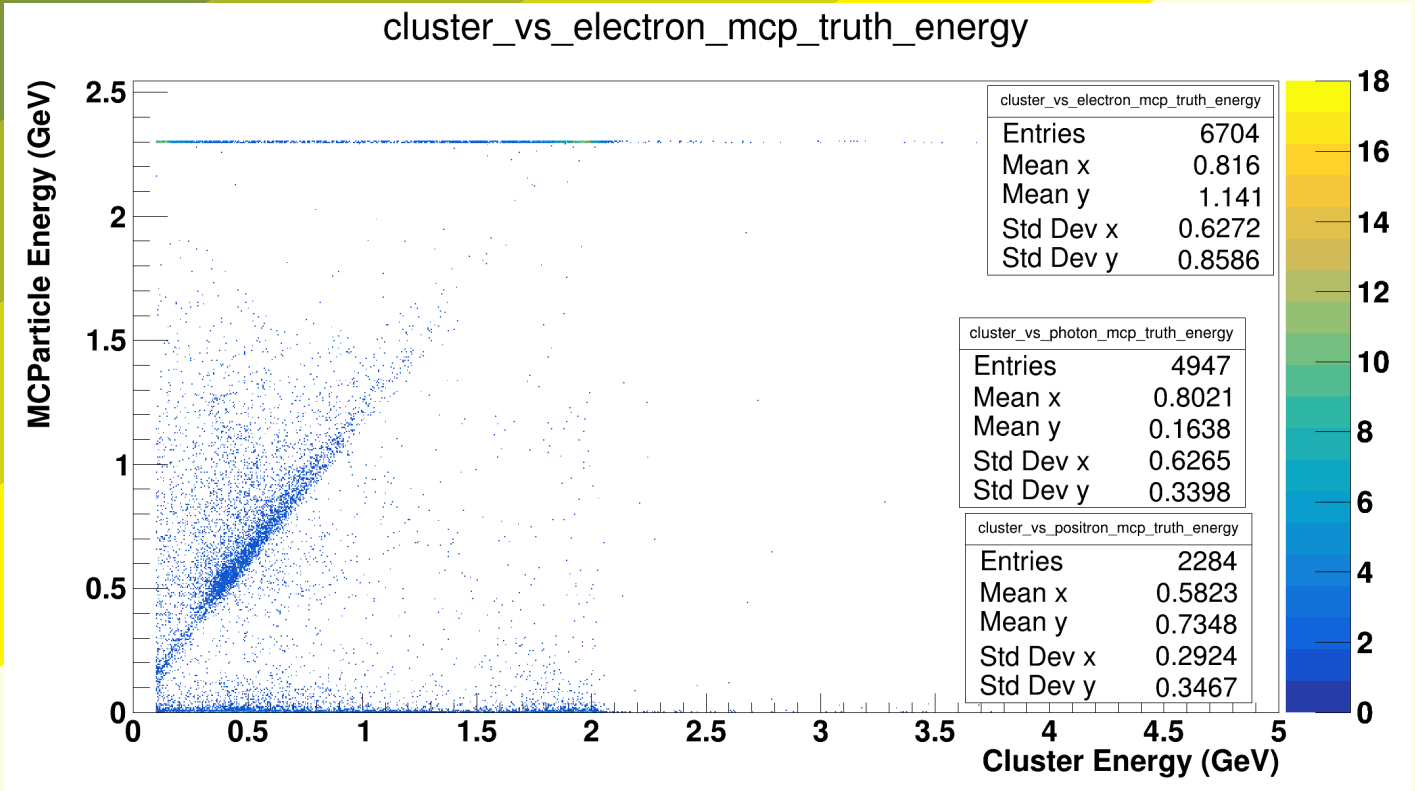
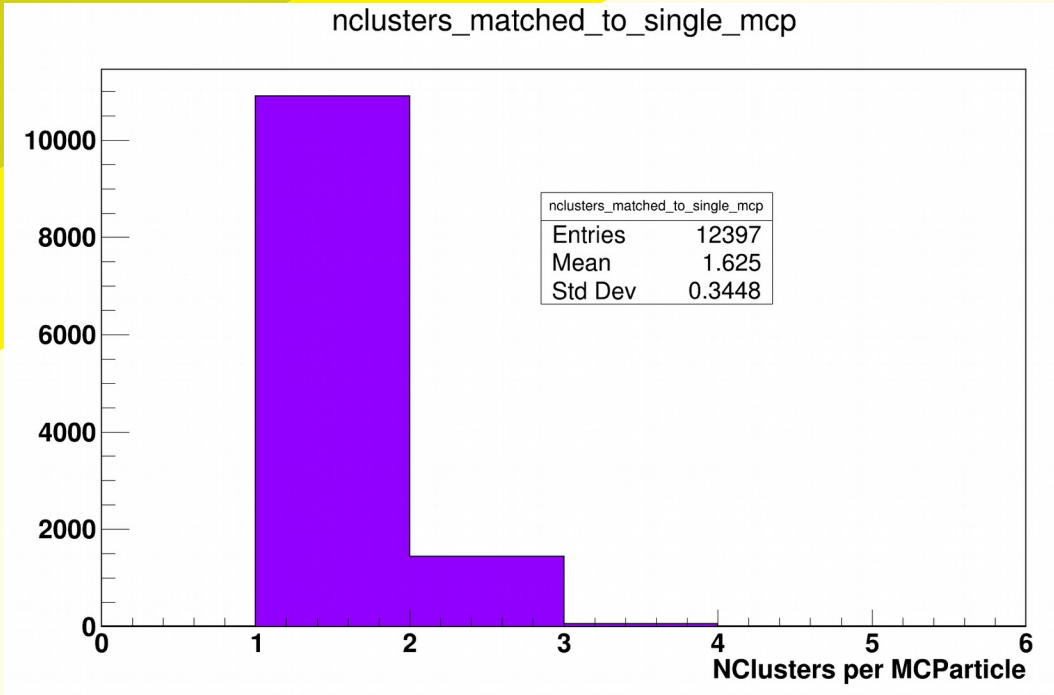


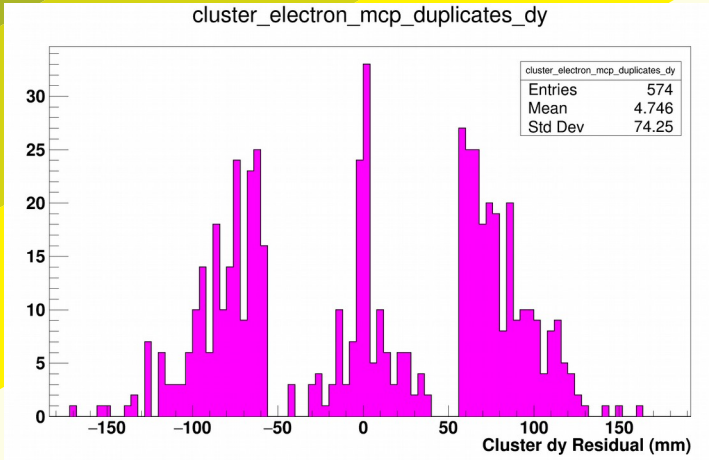
MCParticle Duplicate Clusters

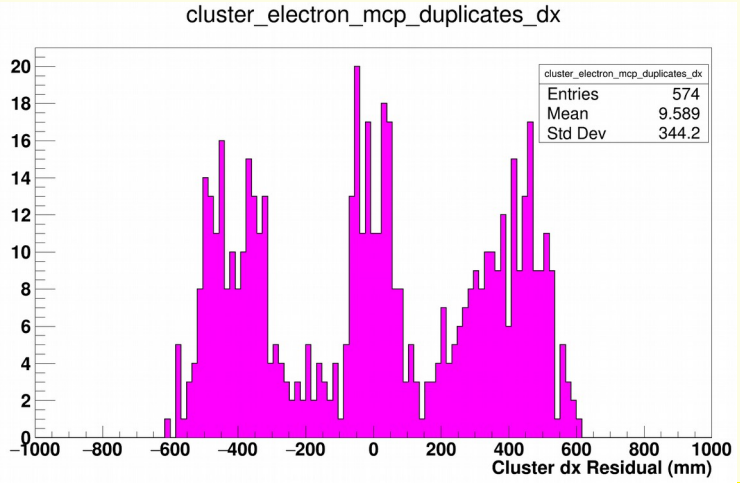
- We find many cases (~12%) where single MCParticle is truth matched to multiple Clusters
  - Should this ever be possible?
- **Maybe** we can understand duplicate matches <u>if the Clusters are very close together in position</u>…
  - If they are close, should the Clusters be “clustered” themselves?
- Lets see how close together these duplicate Clusters are



MCParticle Duplicate Clusters

- Given a MCParticle that gets truth matched to two different Clusters
- Check how far apart those two Clusters are
- We find cases of two Clusters that are supposedly products of the same MCParticle, on completely opposite halves of the Ecal…
- Top plot shows (Cluster1_y – Cluster2_y)
- Bottom plot shows (Cluster1_x – Cluster2_x)
- How can a single MCParticle make clusters in opposite halves of the Ecal?
  - Obvious mistake in truth matching





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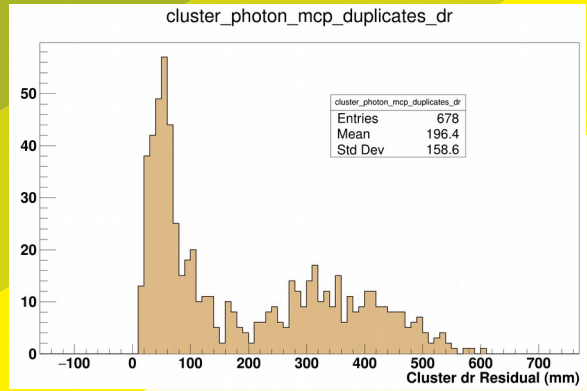
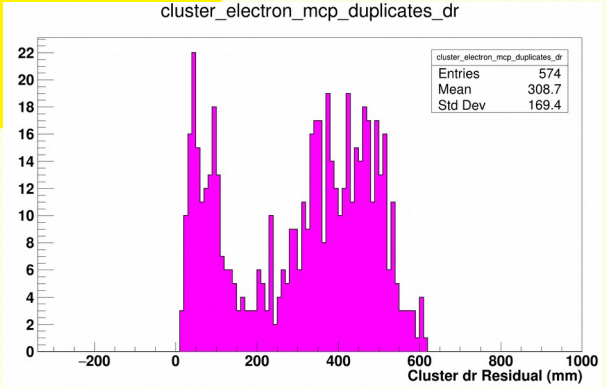
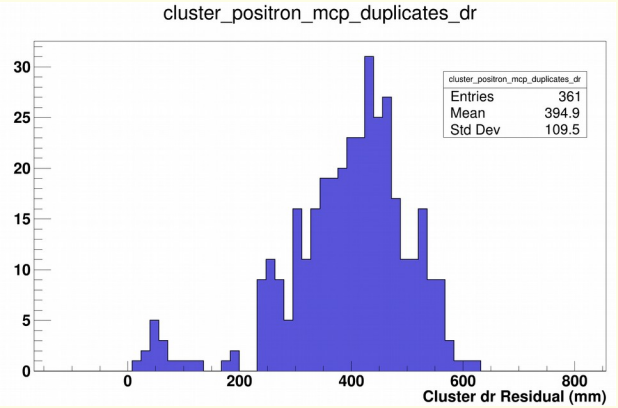
MCParticle Duplicate Clusters

- Plots show position residuals in the xyplane between two Clusters that share a MCParticle
- Broken down into photons, electrons, positrons
- Seems like this issue isn't based on particle type...

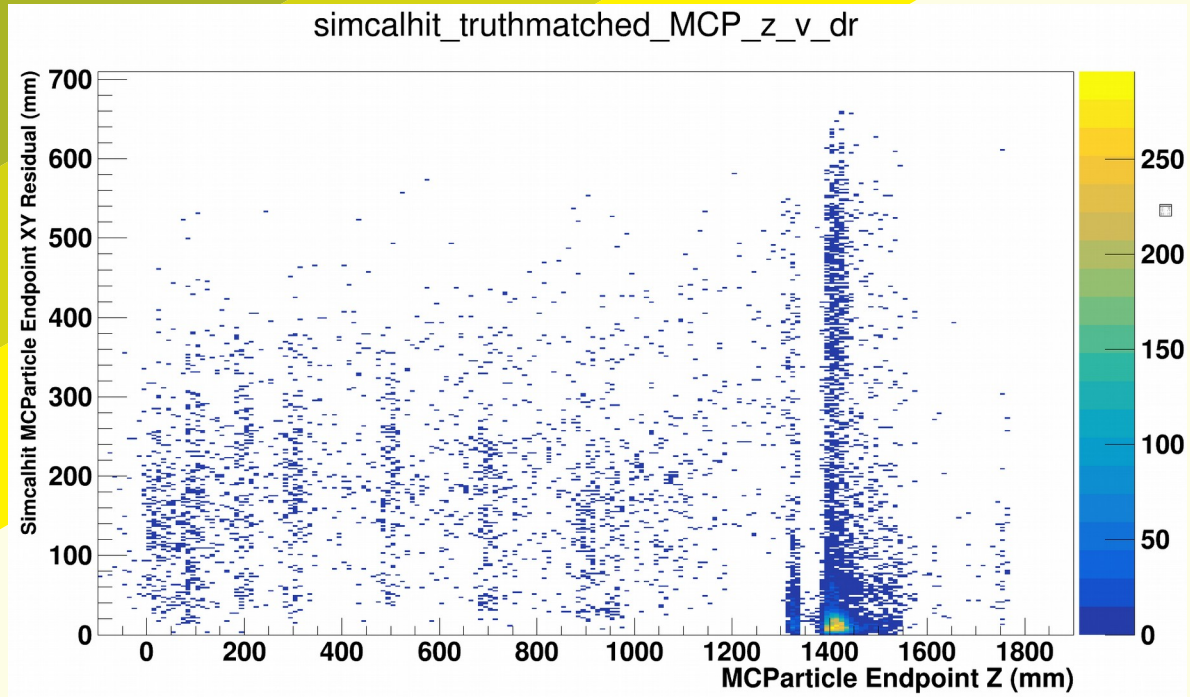






MCParticle Duplicate Clusters

- Check the XY plane position residual between a Cluster's Simcalhit and the largest energy contributing MCParticle in that Simcalhit
- Plotted along MCParticle Endpoint Z, since it varies, where Simcalhit is always at Ecal face ~1330mm
- If MCParticle endpoint is in a tracking layer, why is it associated with a Simcalhit?
- We see cases where Simcalhit positions are very far (> 100 mm) from the largest contributing MCParticle on that hit….

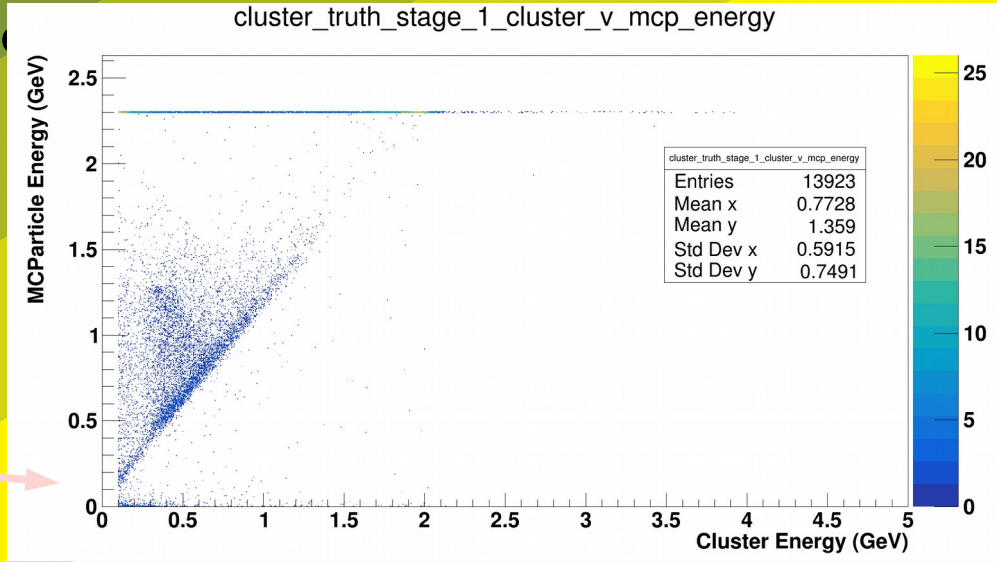


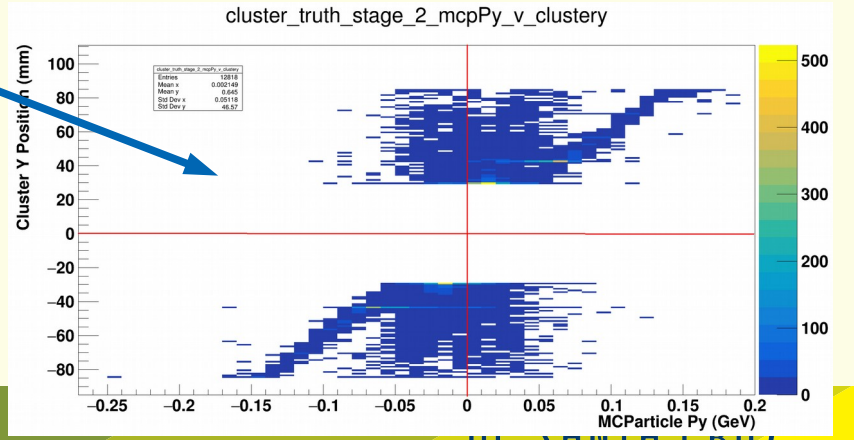
MCParticle Truth Matching Update

- Recalled from previous example of Cluster truth matching where Cluster with ~1 GeV of energy is matched to MCParticle with ~10 MeV
- Potential issue (or misunderstanding on my part) with how the MCP simcalhit energy contributions are assigned in simulation…
  - Appears that the contributed energy is assigned to the wrong particle
  - Or there are some particle tree complications
- Solution is to match to largest energy MCParticle in simcalhit *instead of* largest "contributed" energy

MCParticle Truth Matching Updat

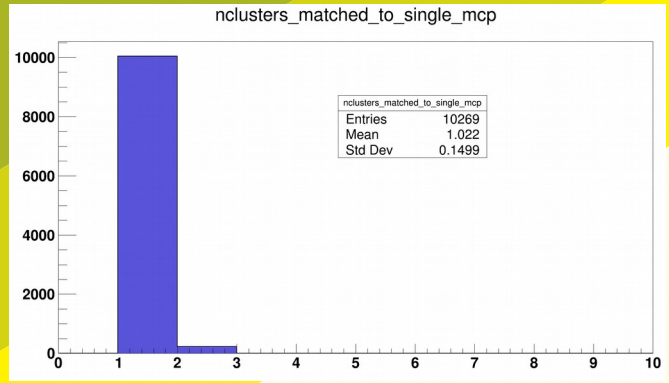
- Solution is to match to largest energy MCParticle energy in simcalhit *instead of* largest "contributed" energy…
- Bad matches that formed the bottom horizontal line in previous plot significantly reduced
- Apply some additional cuts and cleaning….
- Require Cluster MCParticles origin at target
- Impose Py and cluster y position sign matching
  - MCPs with negative Py at target should hit bottom of Ecal, and vice versa

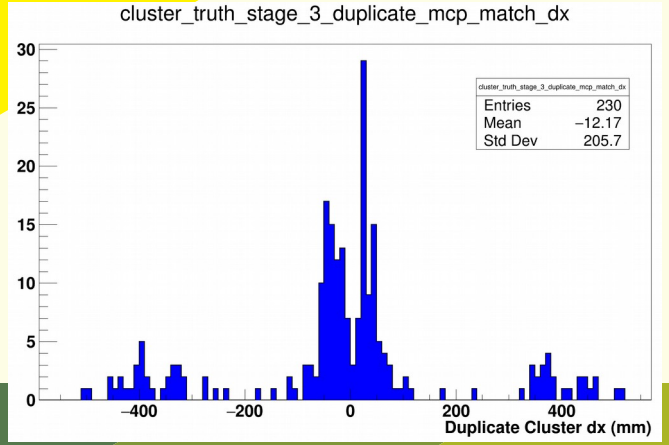


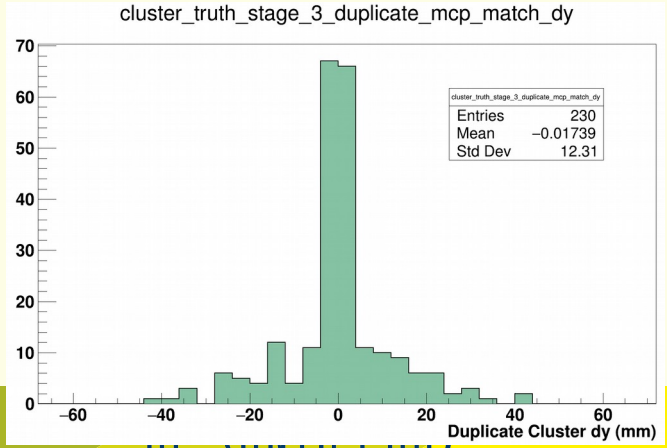


MCParticle Truth Matching Update

- We find number of MCParticles matched to multiple Clusters reduced from ~12% to ~2%
- After those sanity cuts, check for duplicates and adjudicate each case if possible
- Compare MCParticle Endpoint position with each Cluster position
- If Cluster and MCParticle are in different quadrants, match can't (or shouldn't) be correct
- If duplicates remain...cut them all out

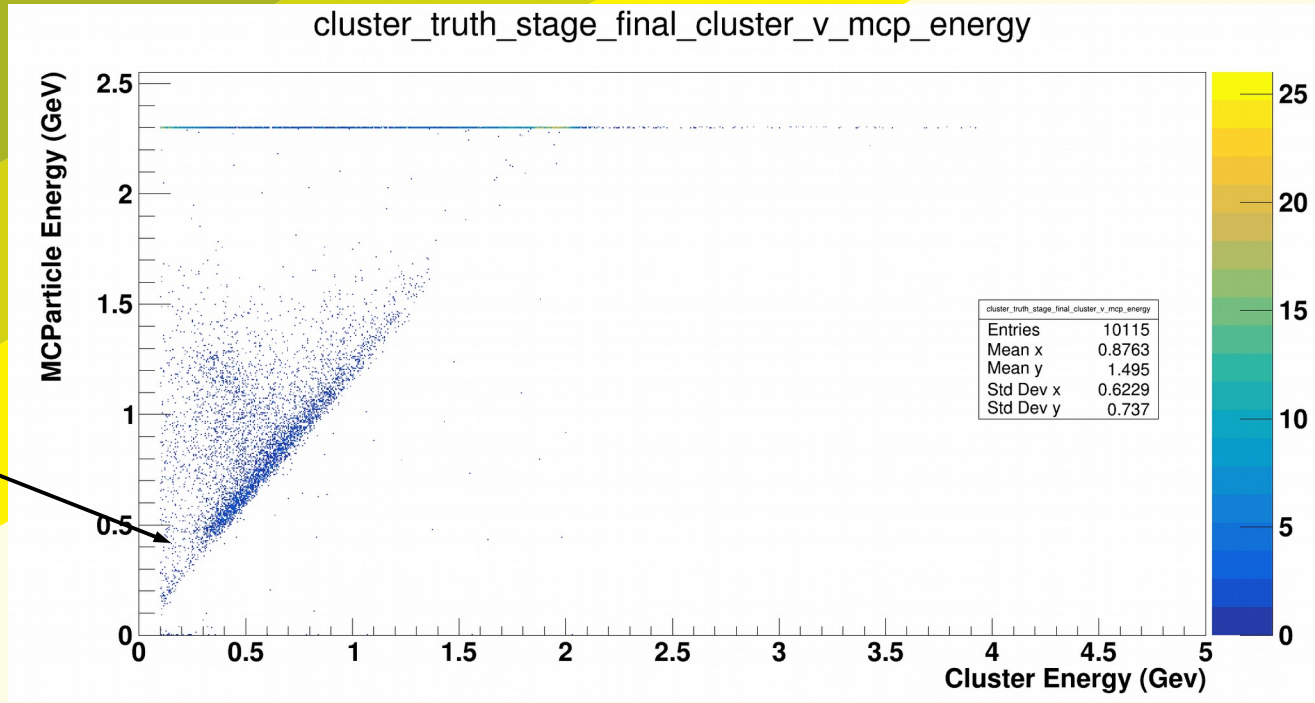






MCParticle Truth Matching Update

- In the end we see that the Cluster MCParticle truth matched pairs look much improved using this new method of matching
- Just a few stragglers remain, where the matching doesnt appear to be correct
  - MCPs with P $<$ 400 MeV shouldn't reach the Ecal Face



Summary

- With the initial Cluster truth matching, we found sizeable instances of MCParticles being matched to multiple Clusters, even Clusters in different Ecal quandrants
- There may be some issue with the way Simcalhit MCP energy contributions are assigned in simulation
- Updating the truth matching to match a Cluster to the MCP with the largest energy has cleaned up most of the “bad” matches we had previously
- There remain a tiny fraction of weird cases
  - In principle, should these cases be impossible?
- The Cluster truth matching appears to be good enough to move forward