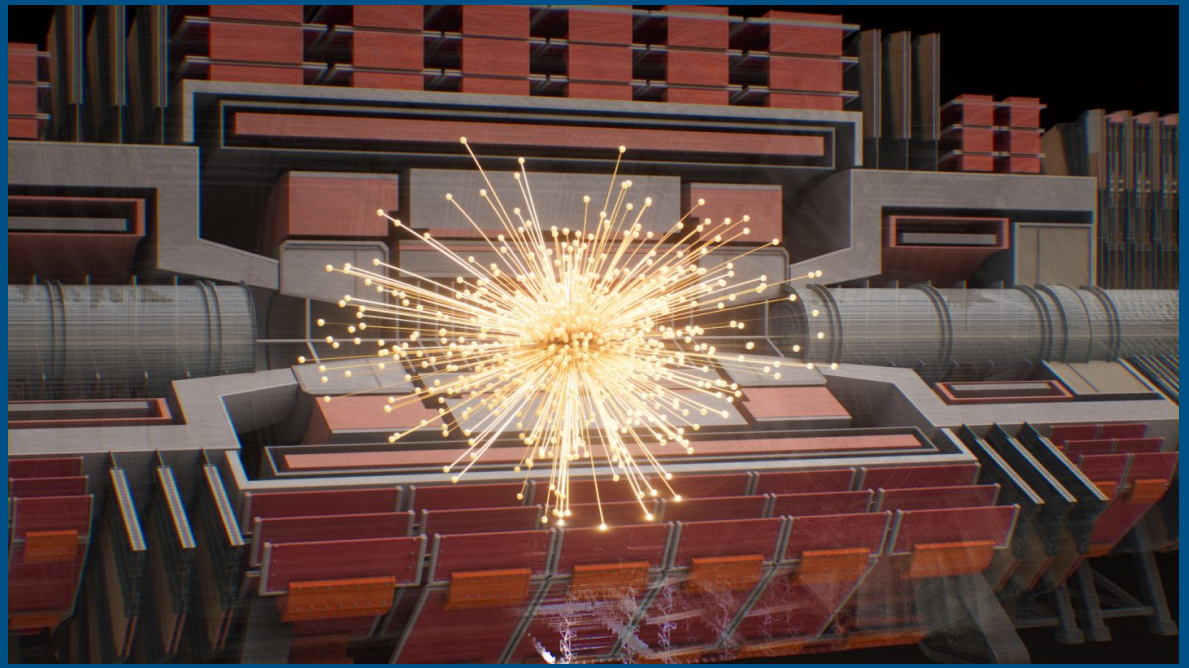
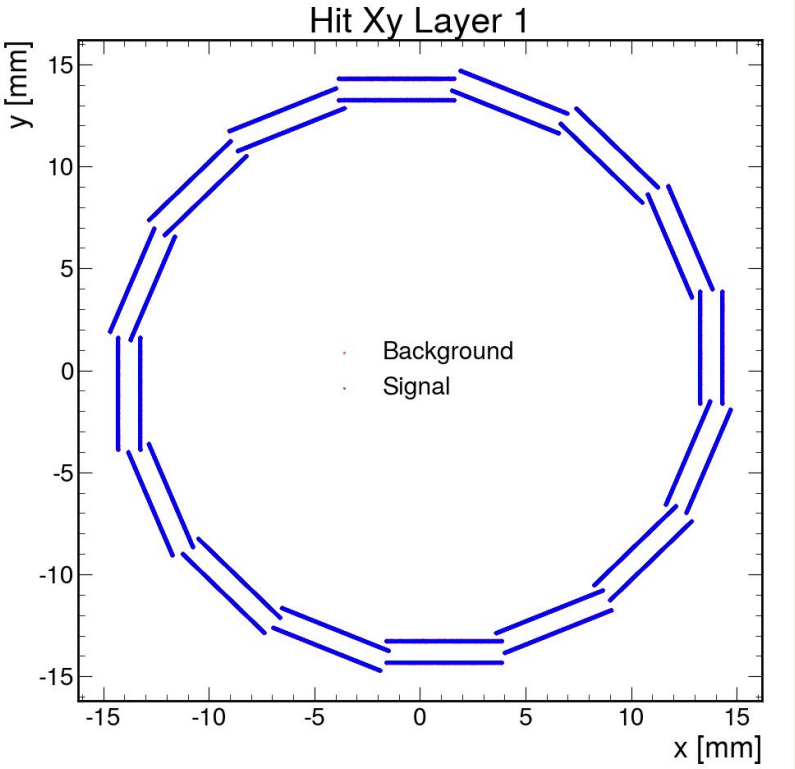
FCCee Geometric Clustering Characterization



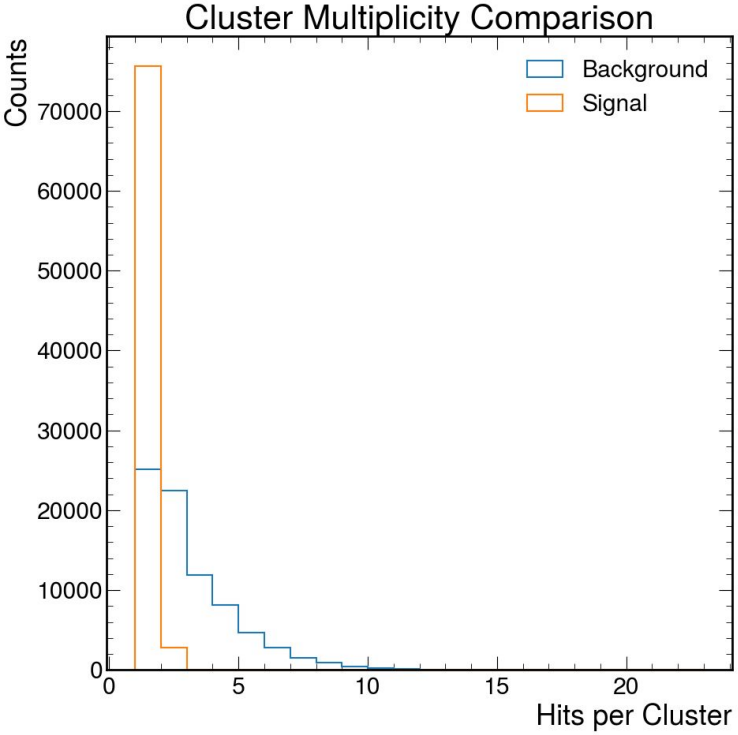
Emmett Forrestel | 07.2025

Layer 1 X vs. Y



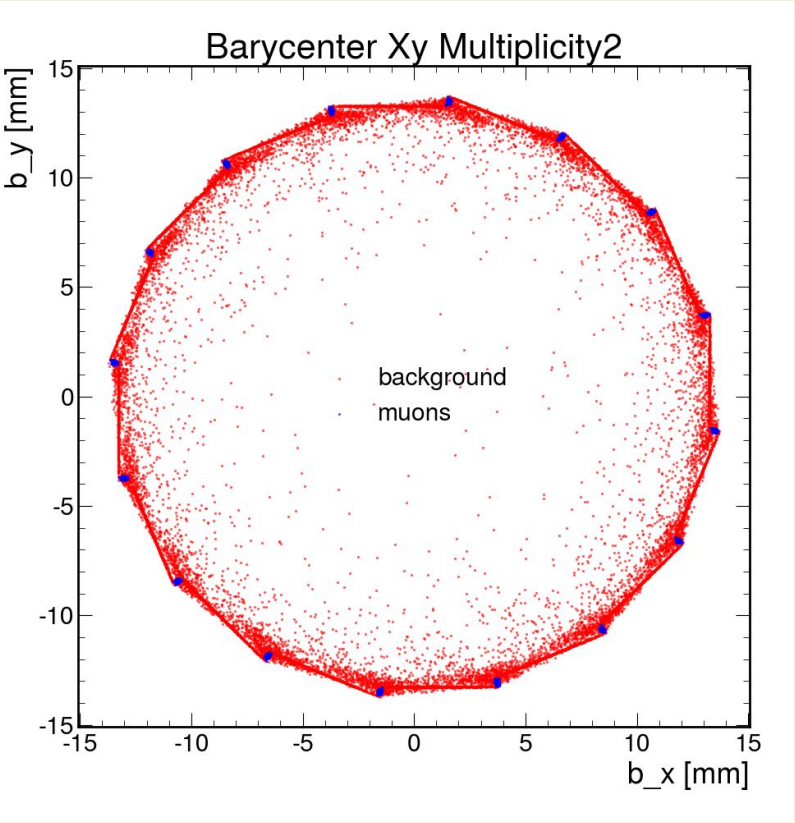
- This plot shows all hits from background and signal on CLD layer 1.
- We see two readout layers. The outer I refer to as, layer 1B, the inner as layer 1A.

Cluster Multiplicity Layer 1A



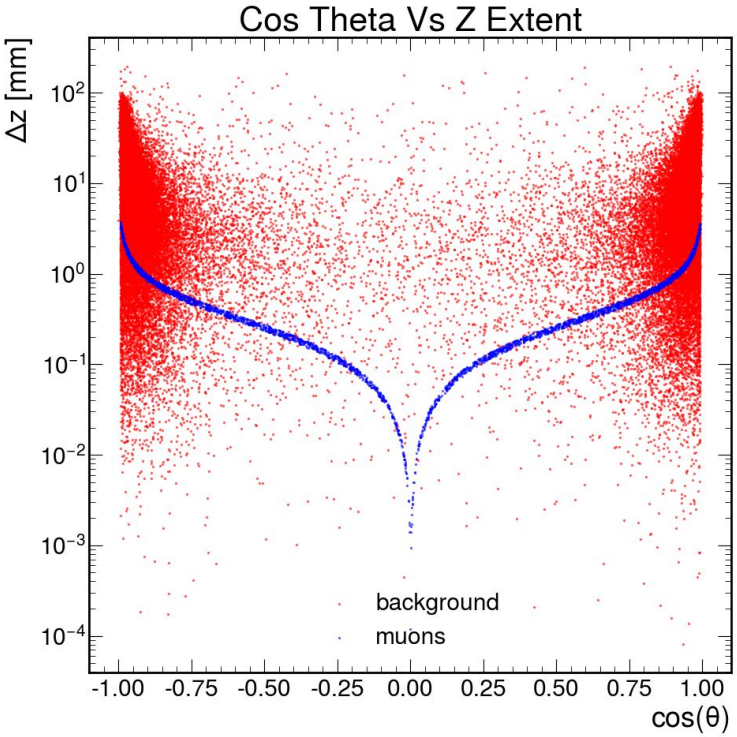
- This plot displays all the hits shown on the true innermost layer, 1A.
- Just a small number of muon clusters still have two hits.
- This results from a muon passing through overlap sections.

Barycenter, Mult 2



- All muon clusters with a multiplicity of two lie at these 16 overlap regions.
- For background, however, they are quite distributed.
- A barycenter is valid as long as it lies on a line segment connecting any two points on the actual silicon.

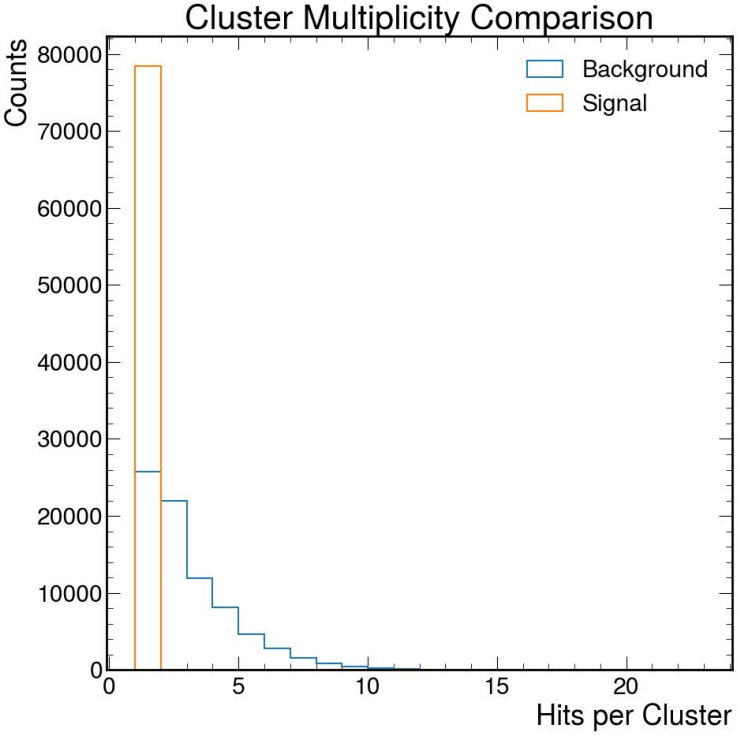
ΔZ vs. Cos(Θ)



- This $\ln(\Delta z) = K*\ln|\cot(\Theta)|$, where represents the differences in radius between the two overlapping modules.
- Muons leave this clean pattern as they originate from the interaction points, where background need not.

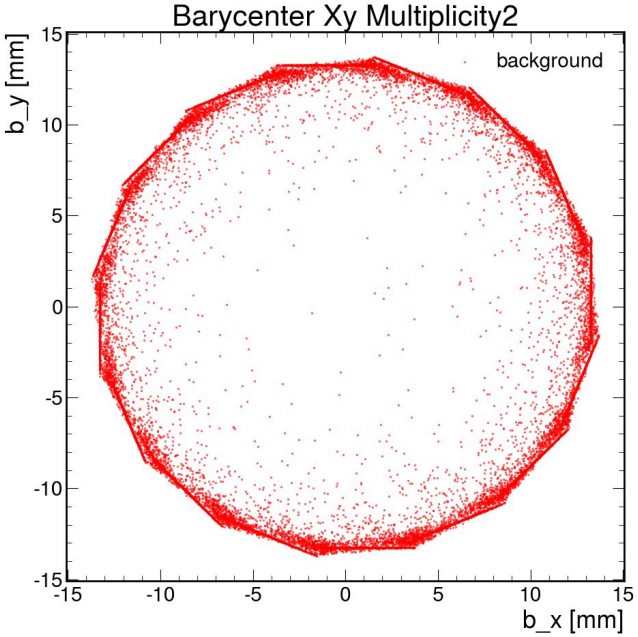
Merging Module Overlaps

Muon Cluster Multiplicity

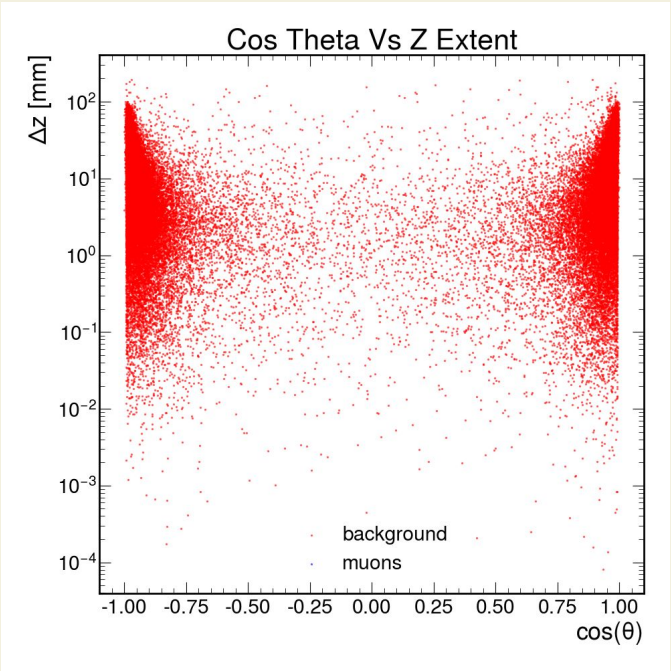


- Applied an algorithm to merge any two hits on overlapping sections, keeping the innermost hit and averaging energy deposited.
- After application, all muon clusters only contain one hit.
- Many background clusters still contain multiple hits.

Barycenter, ΔZ vs. Cos(Θ)

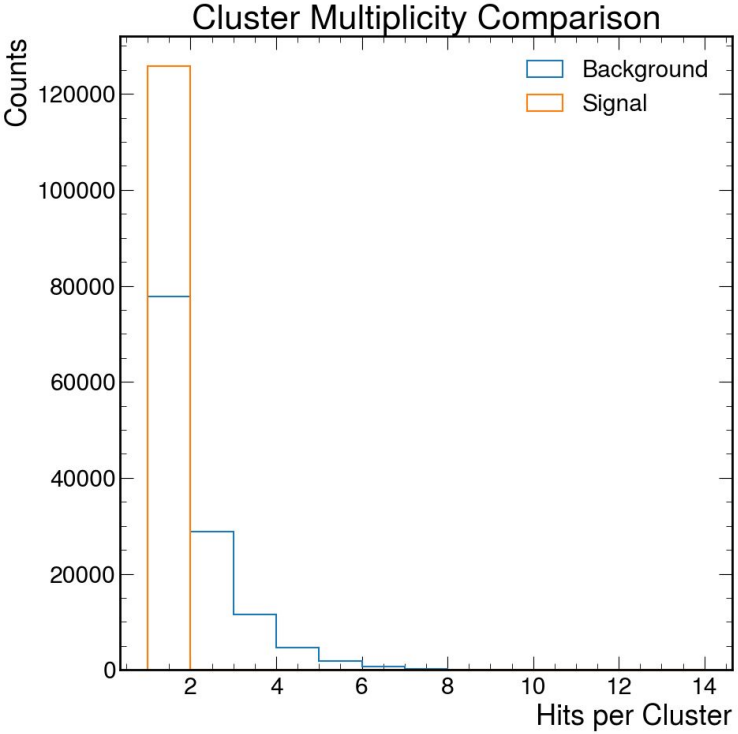


- No muon clusters with a multiplicity of two remain, as overlaps are merged.
- Consequently, this ΔZ vs. Cos(Θ) relationship no longer remains.



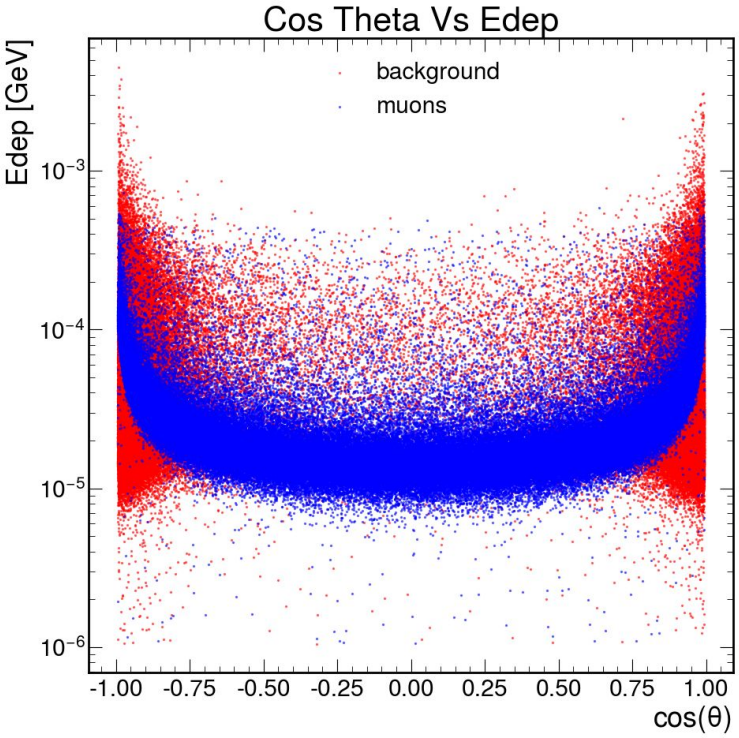
Conservative Module Level Separation

Muon Cluster Multiplicity



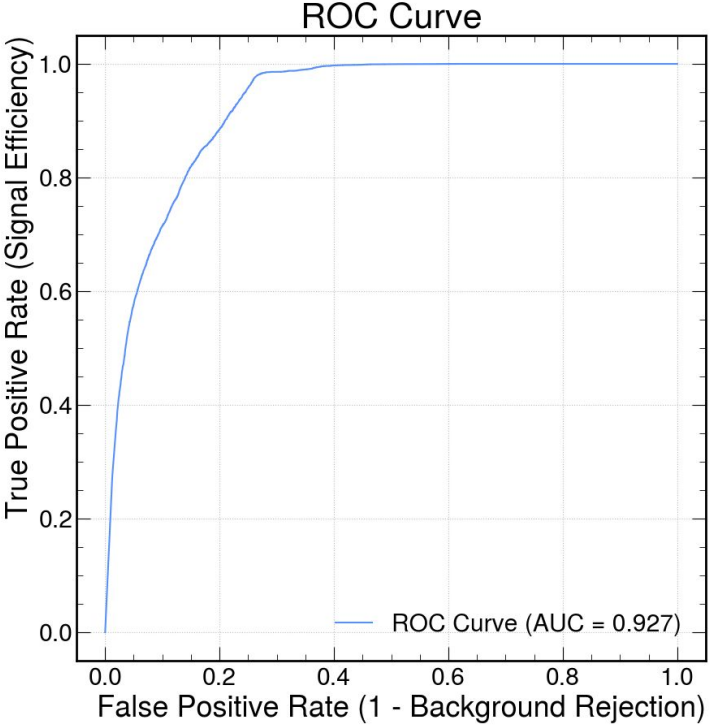
- Analyzing each module independently reflects the reality of CLD design.
- Considering each module individually does not affect muon clusters but cuts background cluster multiplicity, as many background clusters span several modules.

Edep vs. Cos(Θ)



- This plot displays energy deposited vs. Cos(Θ) of each clusters barycenter.
- This metric still show prominent differences between signal and background, likely as this background doesn't necessarily originate at the IP.
- One of the only remaining metrics with strong differences.

Preliminary Separation Testing



- Used a random forest classifier with a cutting threshold of 0.25, to prioritize retaining signal.
- Signal retention: 99.91%
- Background rejection: 54.08%
- Precision (signal): 69%
- ROC area under curve: 0.9265
- Only losing 24 signal clusters, for cutting more than half of background.

Next Steps

- Analyze radius of curvature vs. MC particle energy to verify curling in phi.
- Test more optimistic classifiers, considering possibility of cross talk between modules in layer 1A and 1B.
- Test Z->qq and background classification.