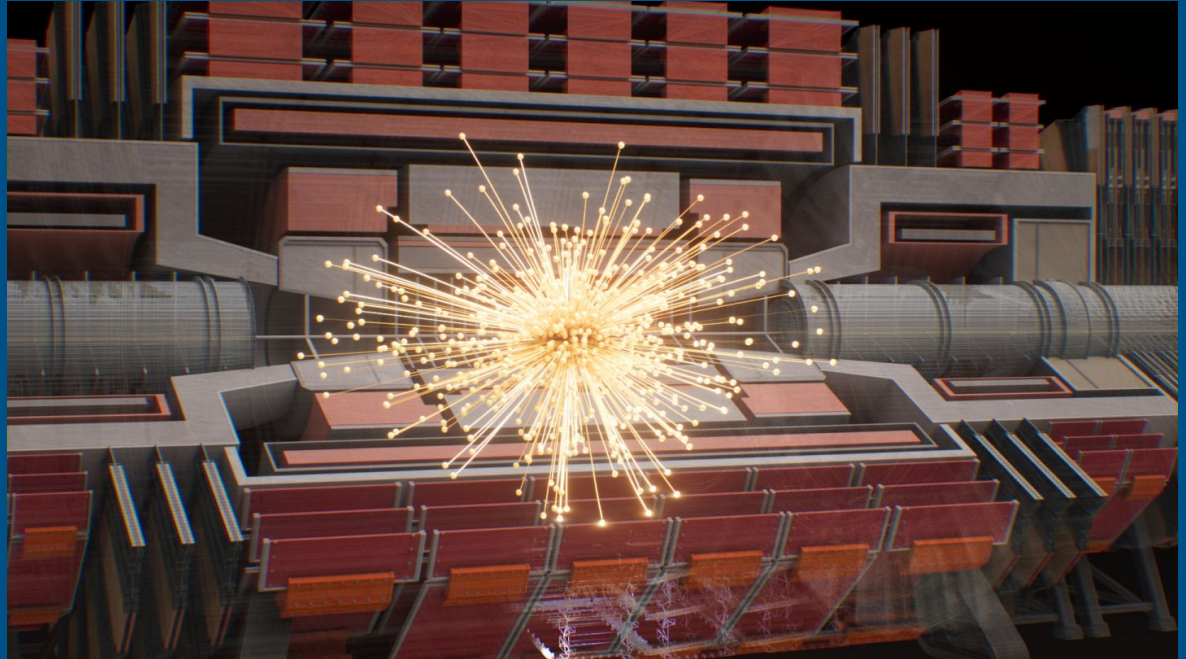


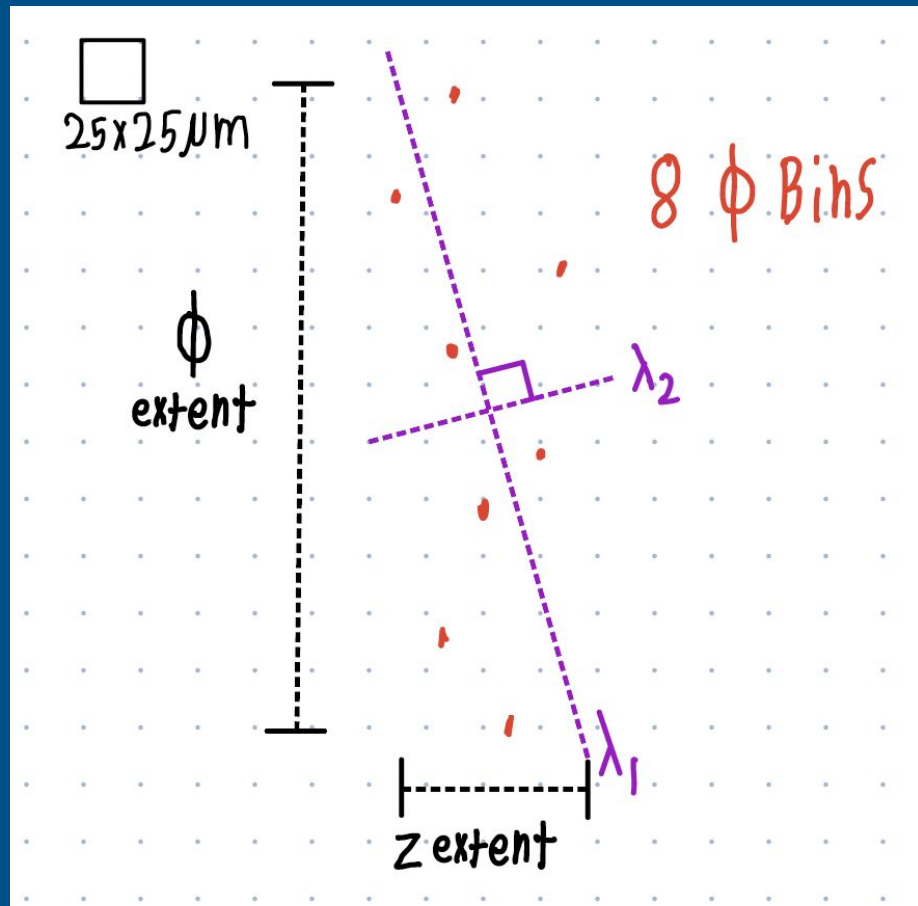
FCCEe Geometric Clustering Characterization

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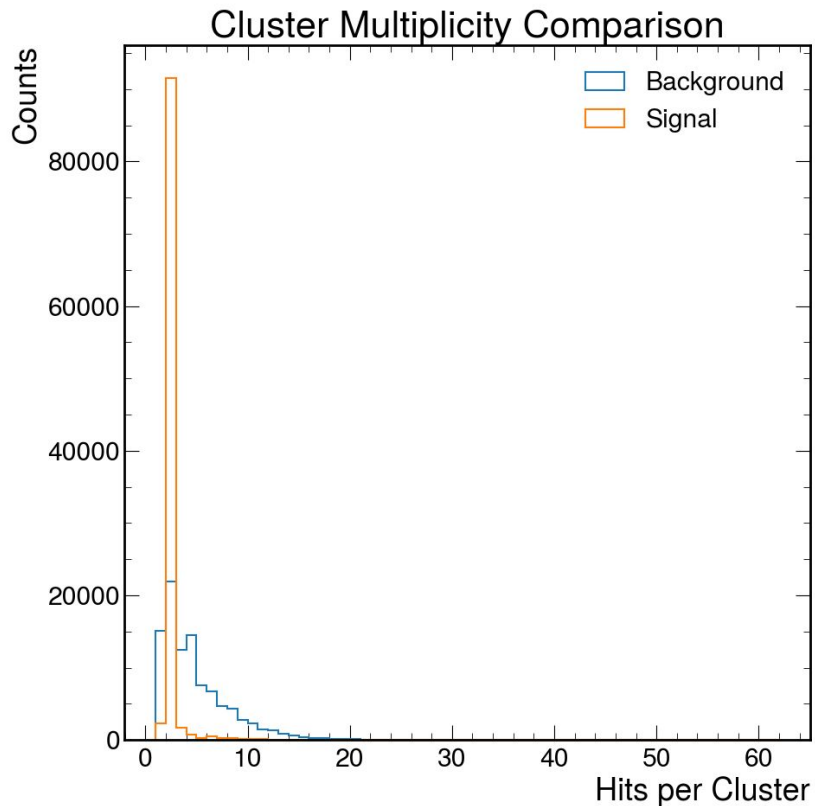


Introduction

- Analyzed hit clusters from a single MC particle in the first layer of the CLD vertex detector using simulation background data.
- Computed a number of geometric descriptors per cluster to study track shapes and detector response: Number of ϕ rows hit, Z extent, PCA elongation (λ_1/λ_2), $\cos(\theta)$, energy deposited, etc.

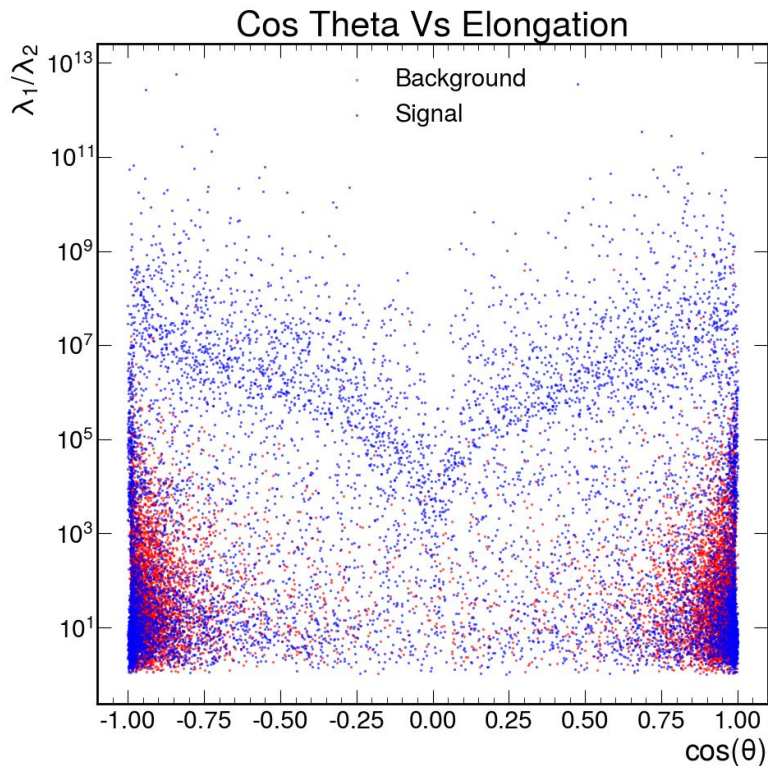


Multiplicity



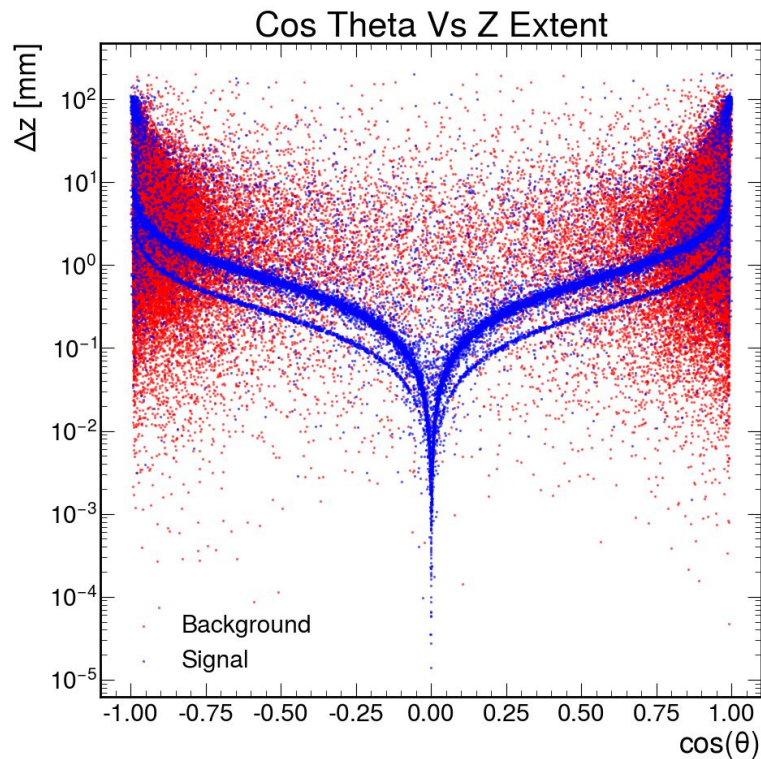
- Vast majority of signal clusters have a multiplicity of two, background clusters are more uniformly distributed.
- This metric of multiplicity informs interesting Z extent vs. $\cos(\Theta)$ patterns.
- If this pattern represents real physics, then it can be used to cut on.

Elongation vs. $\text{Cos}(\Theta)$, Mult > 2



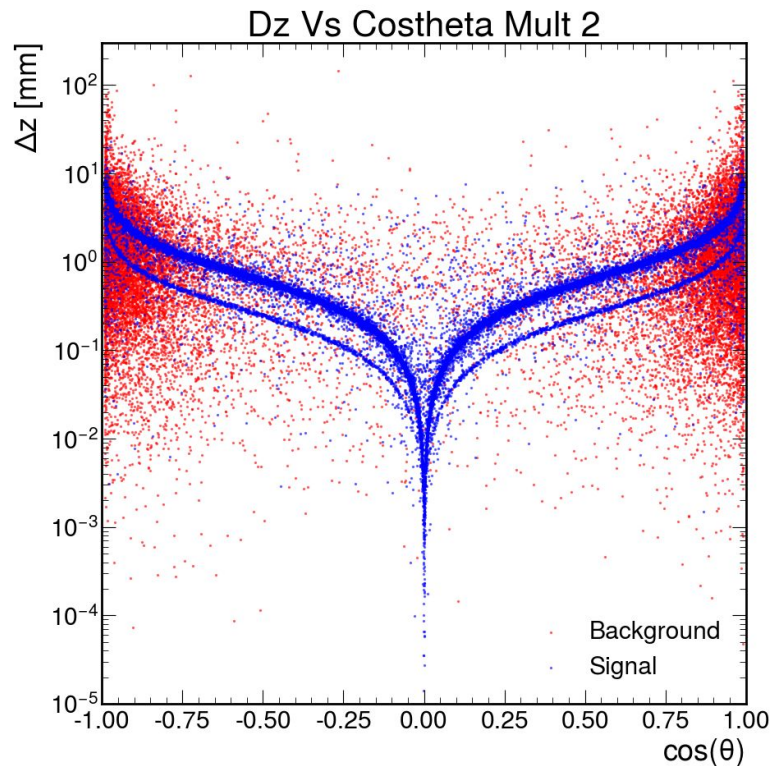
- With clusters of three or more hits, $\log(\text{elongation})$ demonstrates a strong correlation with $\cos(\Theta)$.
- Likely, lower energy clusters remain less linear, even at high theta, whereas higher energy signal clusters track very linearly, especially at high theta.

Z Extent vs. $\cos(\Theta)$, All Mult



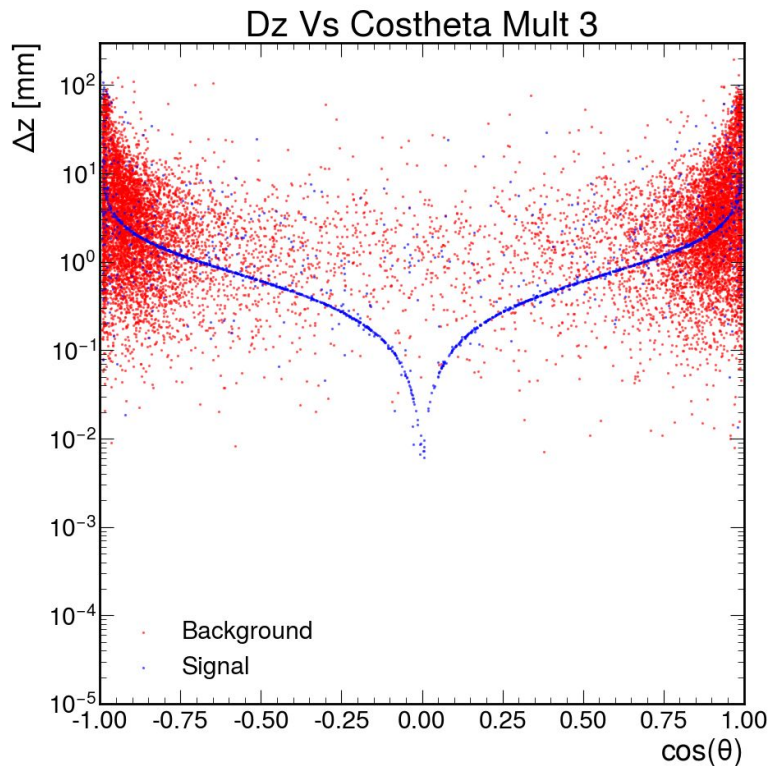
- When plotting $\log(z_extent)$ (Z difference between max and min z in a cluster) against $\cos(\Theta)$, signal clusters follow a very strong relationship.
- These two 'bands' represent two groups of z dispersion that signal clusters tend to fall in to.

Z Extent vs. $\cos(\Theta)$, Mult 2



- This double band pattern is evident in clusters with a multiplicity of two.
- Almost the same pattern of signal appears as that with all multiplicities, except in very high z extent clusters, where $\cos(\Theta) \approx 1$, which are only apparent at higher multiplicities.

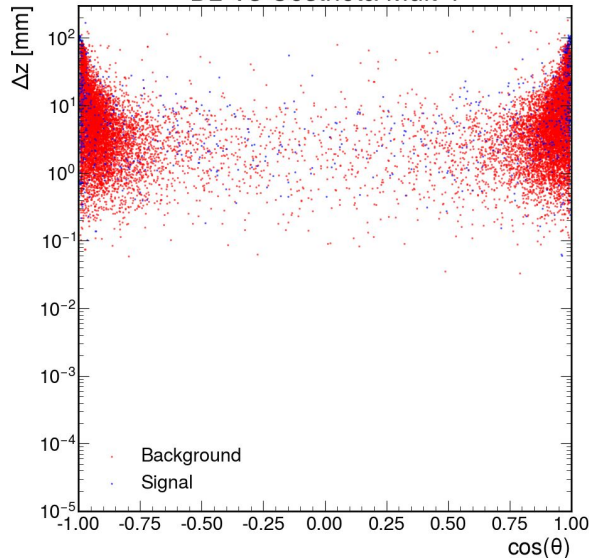
Z Extent vs. $\cos(\Theta)$, Mult 3



- Clusters with a multiplicity of three, only populate the upper of the two bands.
- It could be that there are not enough samples to populate the smaller lower band, but it appears that this double band pattern only appears in clusters of two hits.

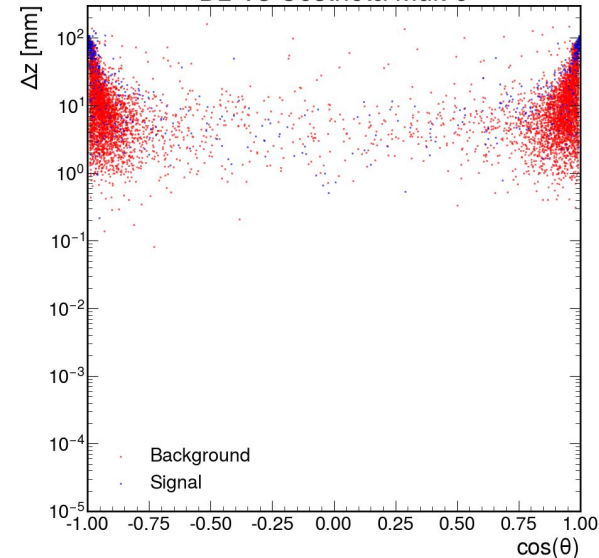
Z Extent vs. $\text{Cos}(\Theta)$, Mult > 3

Dz Vs Costheta Mult 4



- At higher multiplicity, the evident signal pattern disappears.
- Likely due to the fact that virtually all signal clusters have less than 4 hits.
- High multiplicity clusters nearly only appear at high $\text{Cos}(\Theta)$

Dz Vs Costheta Mult 6



Next Steps

- Further explores event displays to understand what patterns are producing this double band pattern (energy deposited in each band, particles ID of particles in each bands, see if both bands are produced within single events).
- Run my analysis on $Z \rightarrow qq$ or vv to explore beam background produced in signal events, if any is present.
- Test cuts on transformation of z extent vs. $\cos(\theta)$ pattern.
- Considering Naives Bayes, Quadratic Discriminant Analysis, SVM.