

# Week 8 Review

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# ZDC Clustering: Brief Re-cap

- We have continued working on clustering to reconstruct the neutron and 2 gamma from ZDC hit data
- G is working on applying density based algorithms for separating clusters
- Alessio has paused work on ML methods due to the time it would take to get usable results
- Instead, focusing on peak finding to isolate cluster centers for cluster reconstruction
- Goals are to reconstruct clusters and understand which clusters we can reconstruct

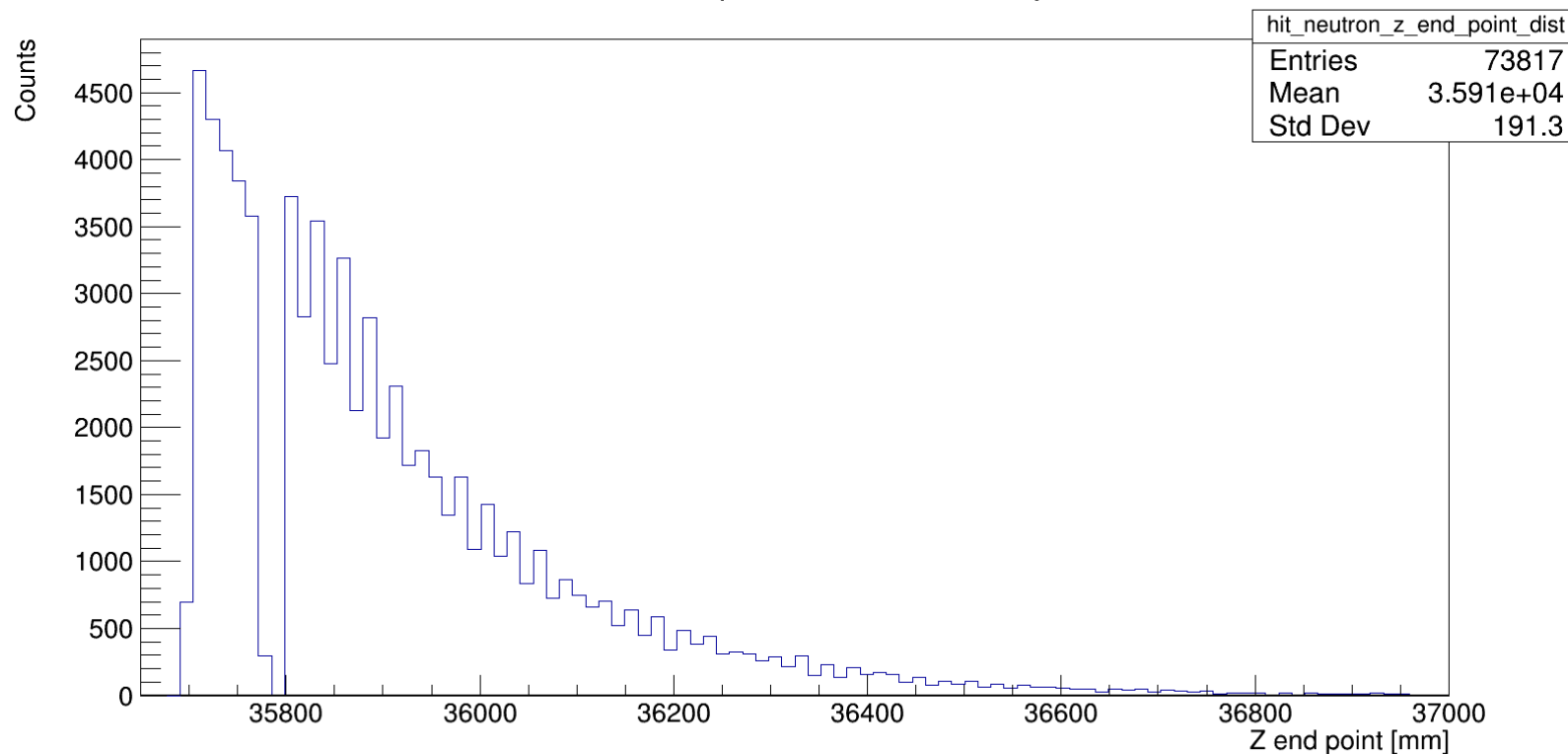
# ZDC Clustering: Determining which events can be clustered

- Previously, we have discussed the distance between neutron and gamma as the factor of how well clustering can be performed
- Recently, we have found that a more important factor is the position where the neutron starts showering in the ZDC
- Using the MC endpoint, we can get an approximate idea of where the shower starts
- This is only for events which have passed previous checks for all particles landing in ZDC

# ZDC Clustering: Neutron MC end-point position

- Data is unpolarized lambda particle gun, 25mrad with no angle
- Data is rotated to 25mrad frame

Distribution of the 25mrad z end point of neutron for all particles land in ZDC

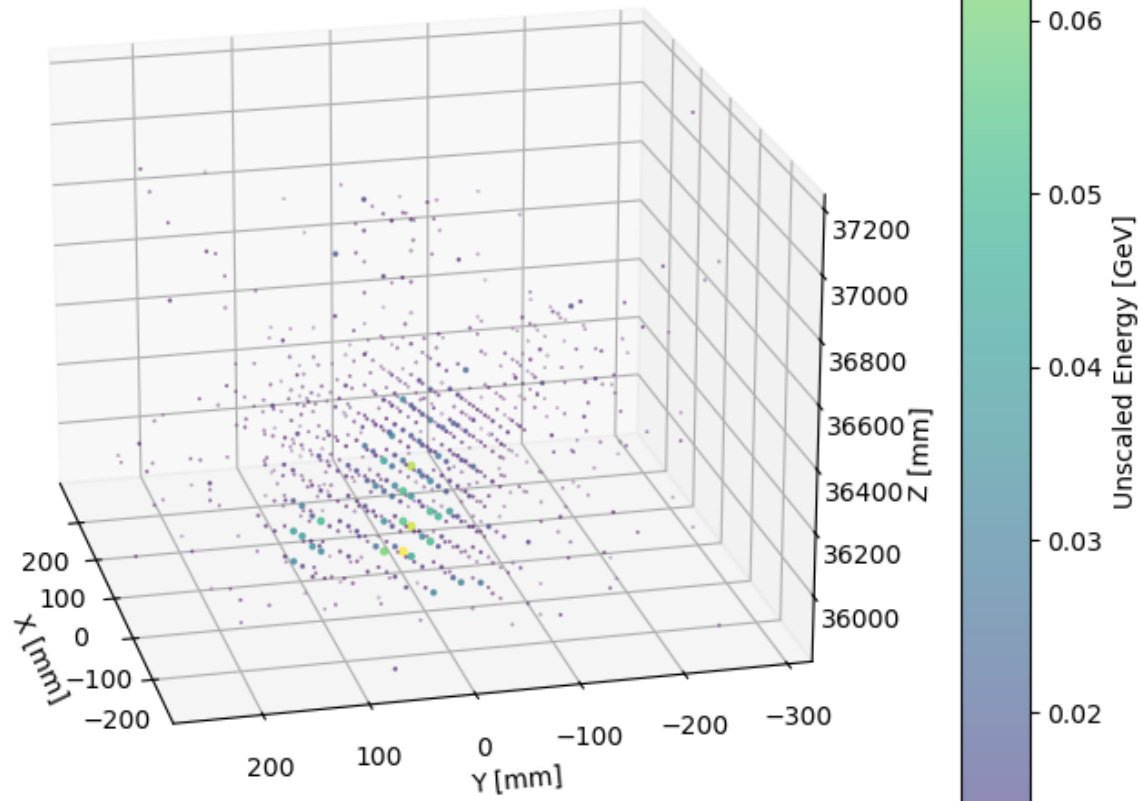


# ZDC Clustering: Neutron early shower vs late shower

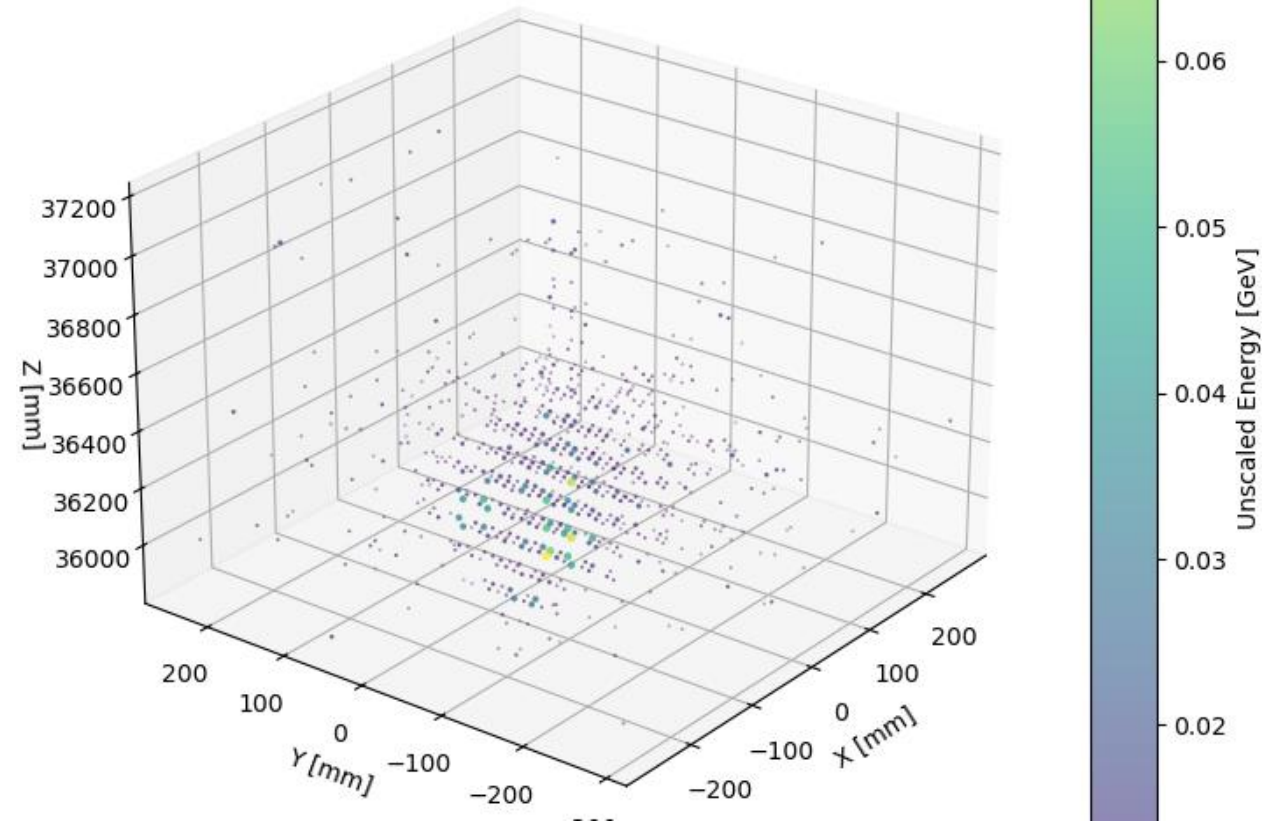
- Next, I will present how the HCal hits for an early neutron shower and a late neutron shower look
- The critical point is: early neutron showers leave significant hits and energy in the same HCal layers critical to gamma reconstruction
- The hits from the neutron hide the gamma hits making complete reconstruction difficult
- Some early shower events can be reconstructed, but this is heavily dependent on neutron shower shape and location of gammas

# ZDC Clustering: Neutron early shower

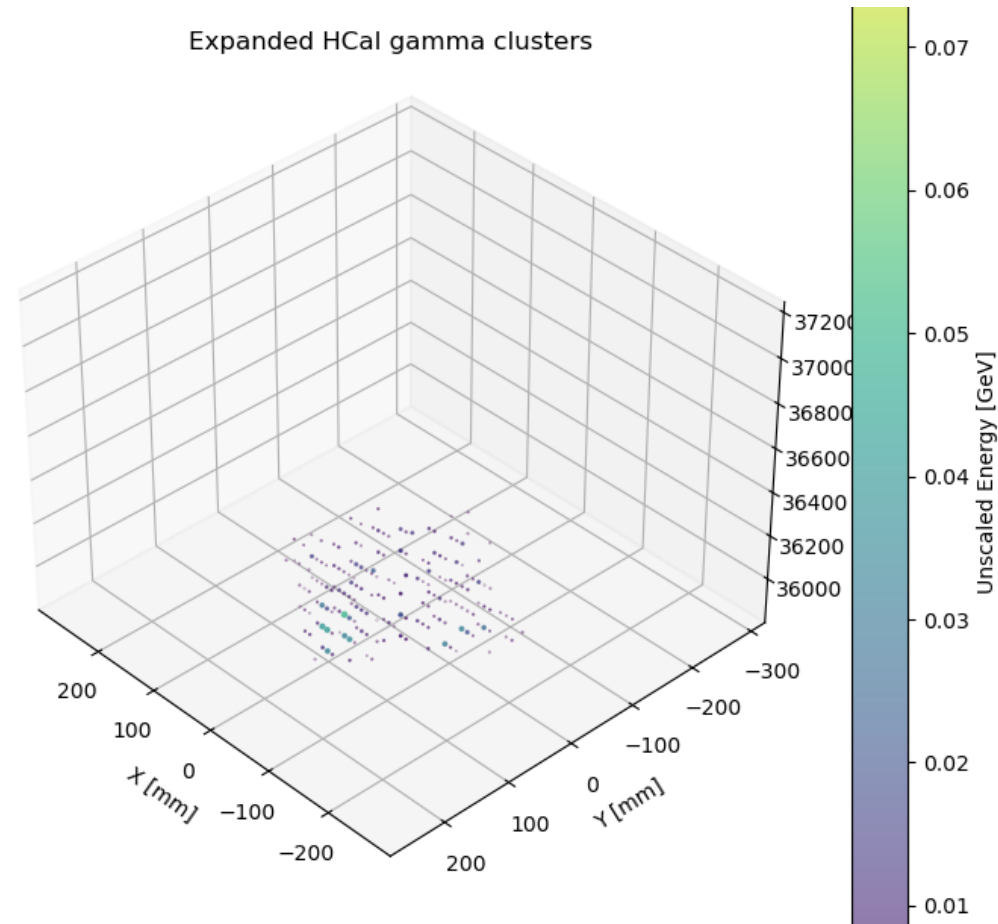
HCal data 25 mrad rotated, energy cut



HCal data 25 mrad rotated, energy cut

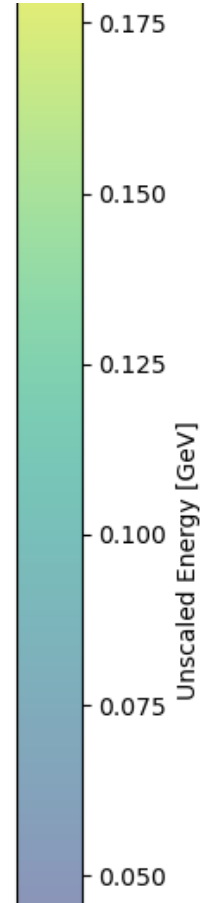
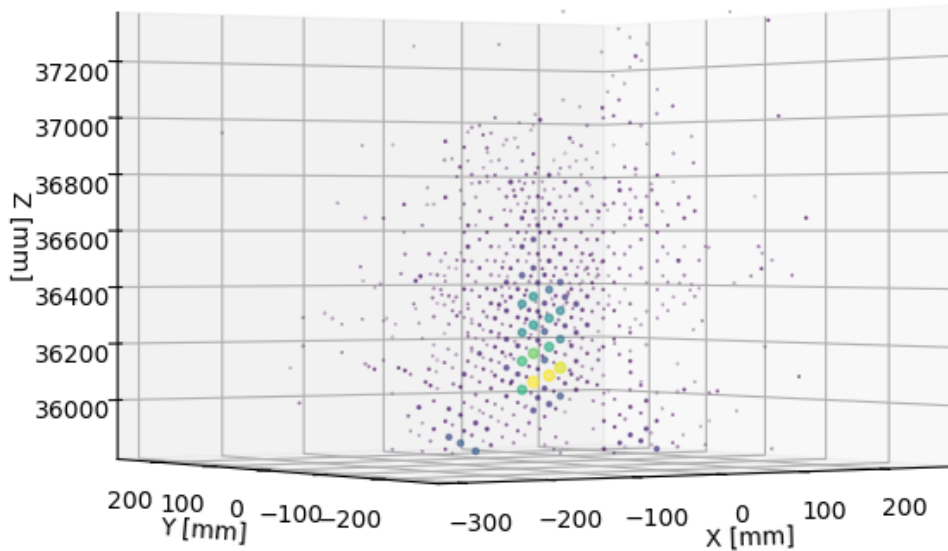


# ZDC Clustering: Neutron early shower extracted gamma clusters

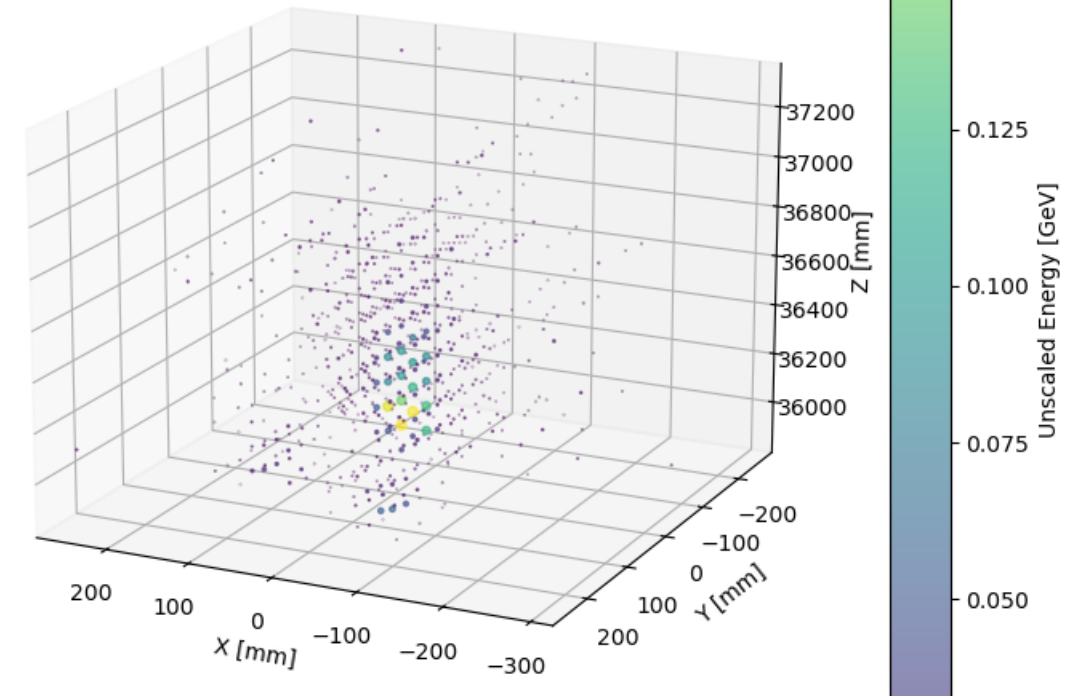


# ZDC Clustering: Neutron late shower

HCal data 25 mrad rotated, energy cut

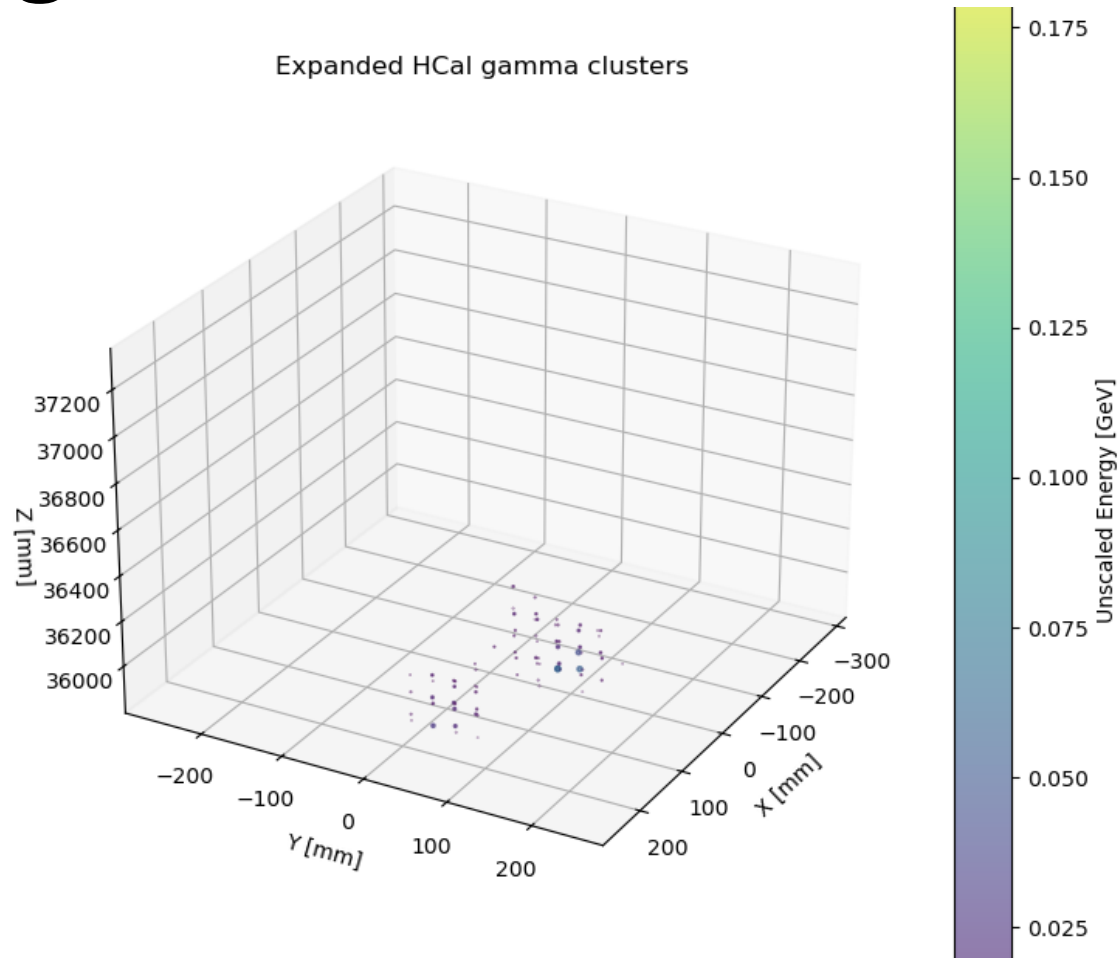


HCal data 25 mrad rotated, energy cut





# ZDC Clustering: Neutron late shower extracted gamma clusters



# ZDC Clustering: Cutting Events

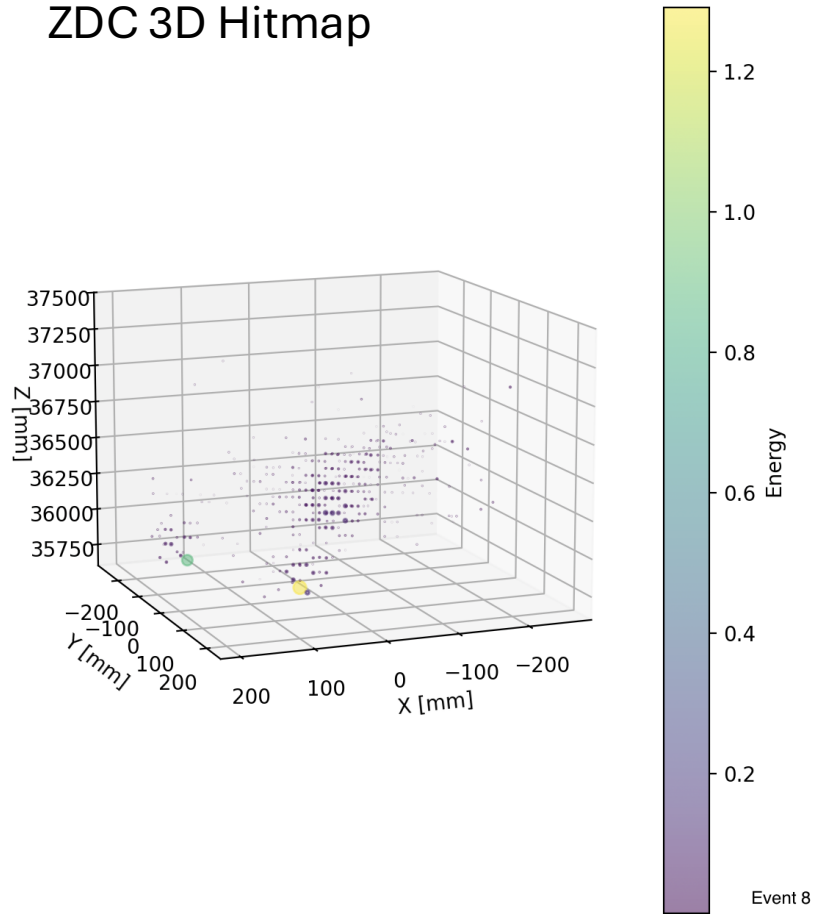
- The current process for determining events which can be clustered is:
  - Cut based on the MC neutron endposition, cut any neutron which end in the ECal
  - Apply peak finding in ECal and HCal, cut any event which does not have 2 good gamma candidates
- Further work needed to determine which early shower events can be clustered
  - Currently experimenting with calculating the energy density between clusters to quantify background
- Once reconstruction can be done, study the energy/momentum resolution of the gamma/pion as a function of the neutron shower background

# ZDC Clustering: DBSCAN Clustering

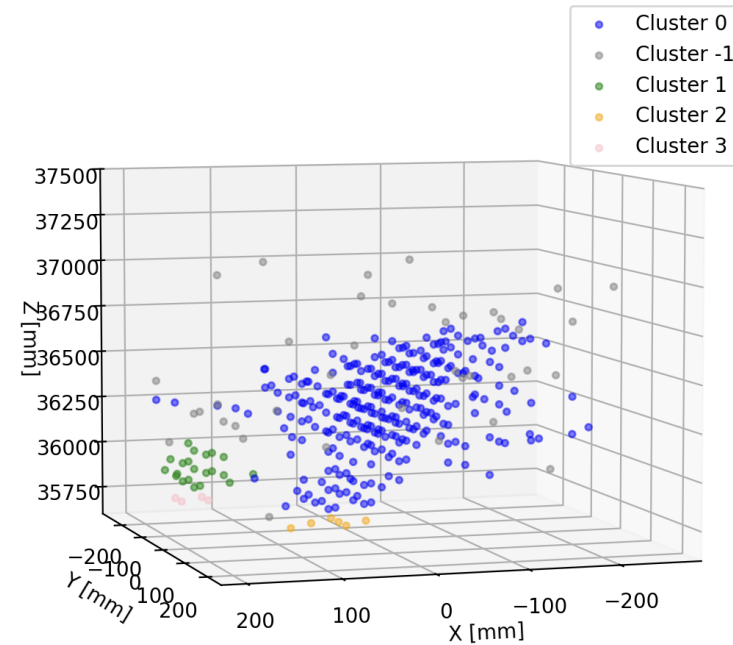
- Current state:
  - Clustering is done for the full ZDC (ECal and HCal)
  - Algorithm works in two steps. Step 1 performs clustering based on an energy threshold for determining core points. Step 2 is more aggressive and performs clustering based on the change in energy density as we move away from the core of the neutron cluster
  - Performance is better than before though it is still having trouble isolating photon and neutron clusters when they are connected by a few hits and the photon energy is like that of the hits at the edges of the neutron cluster

# ZDC Clustering: DBSCAN Clustering

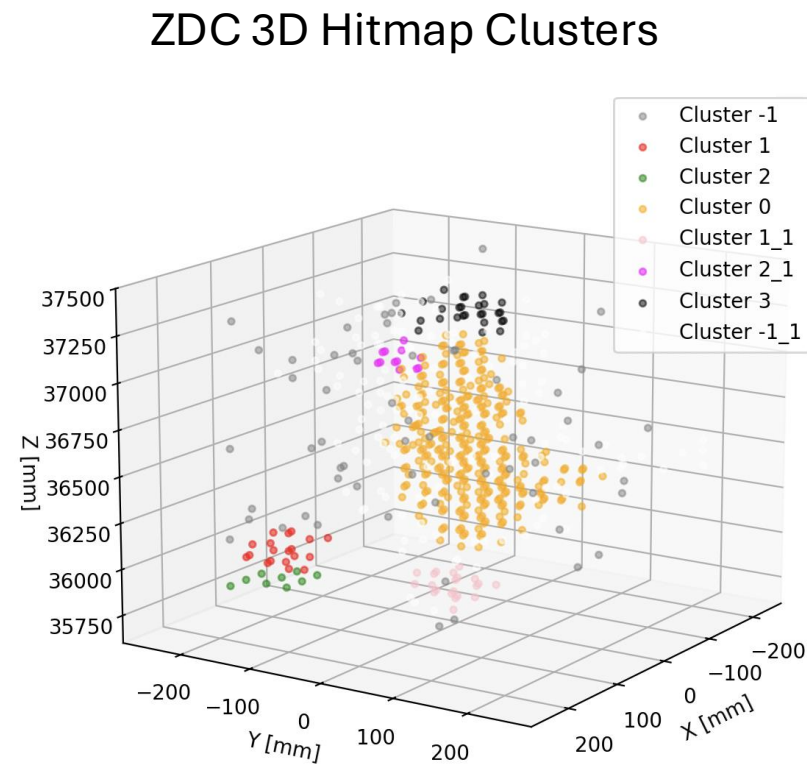
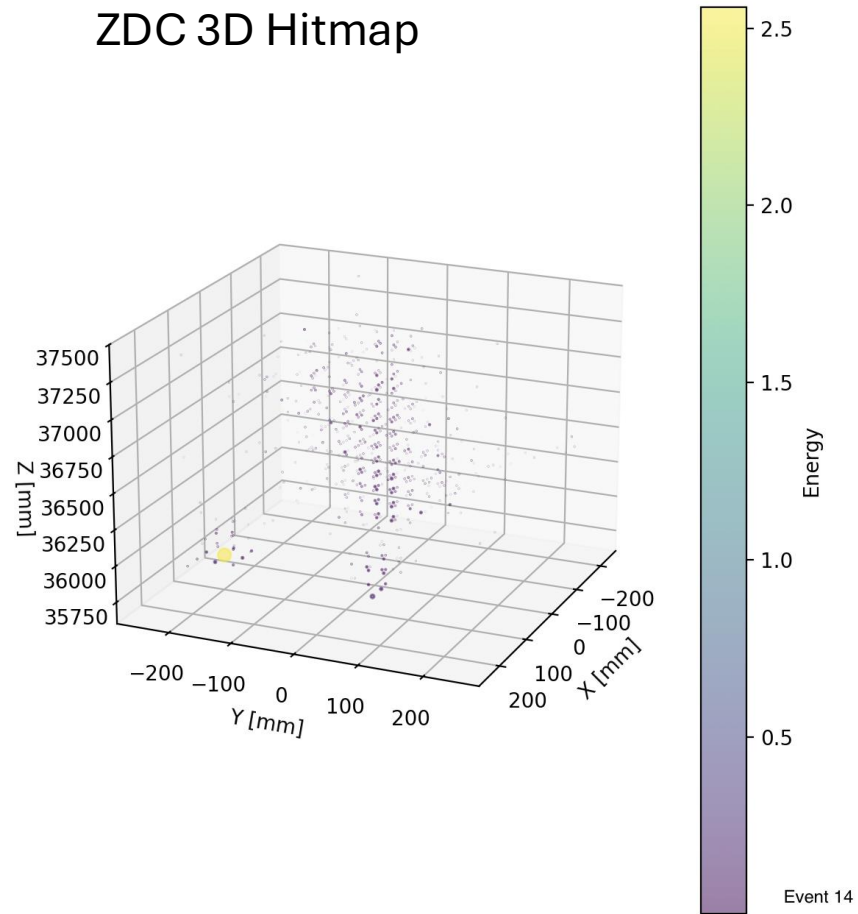
ZDC 3D Hitmap



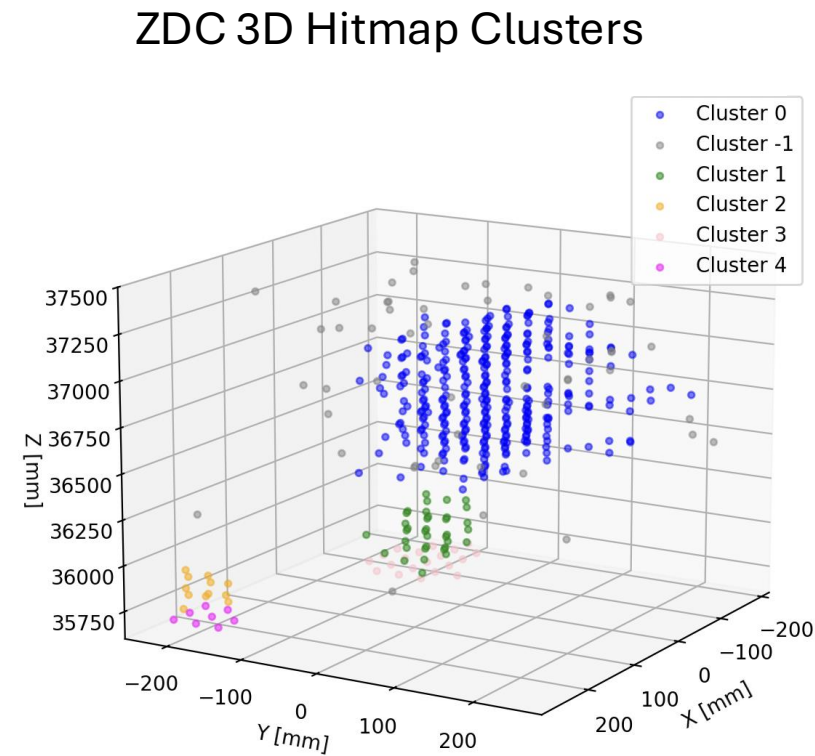
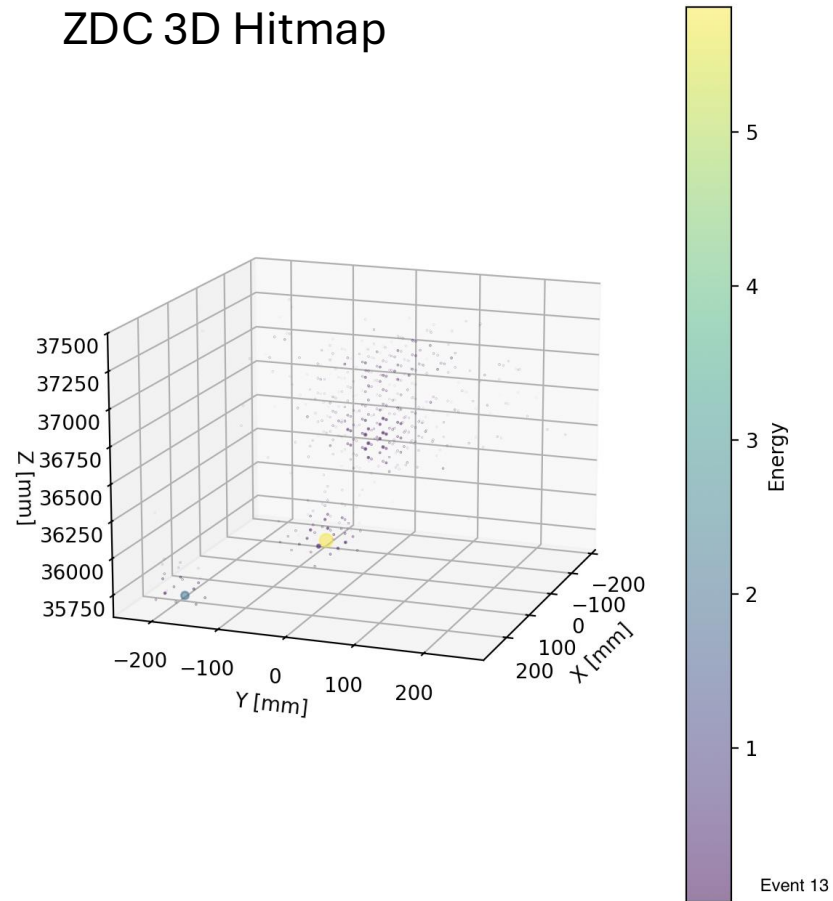
ZDC 3D Hitmap Clusters



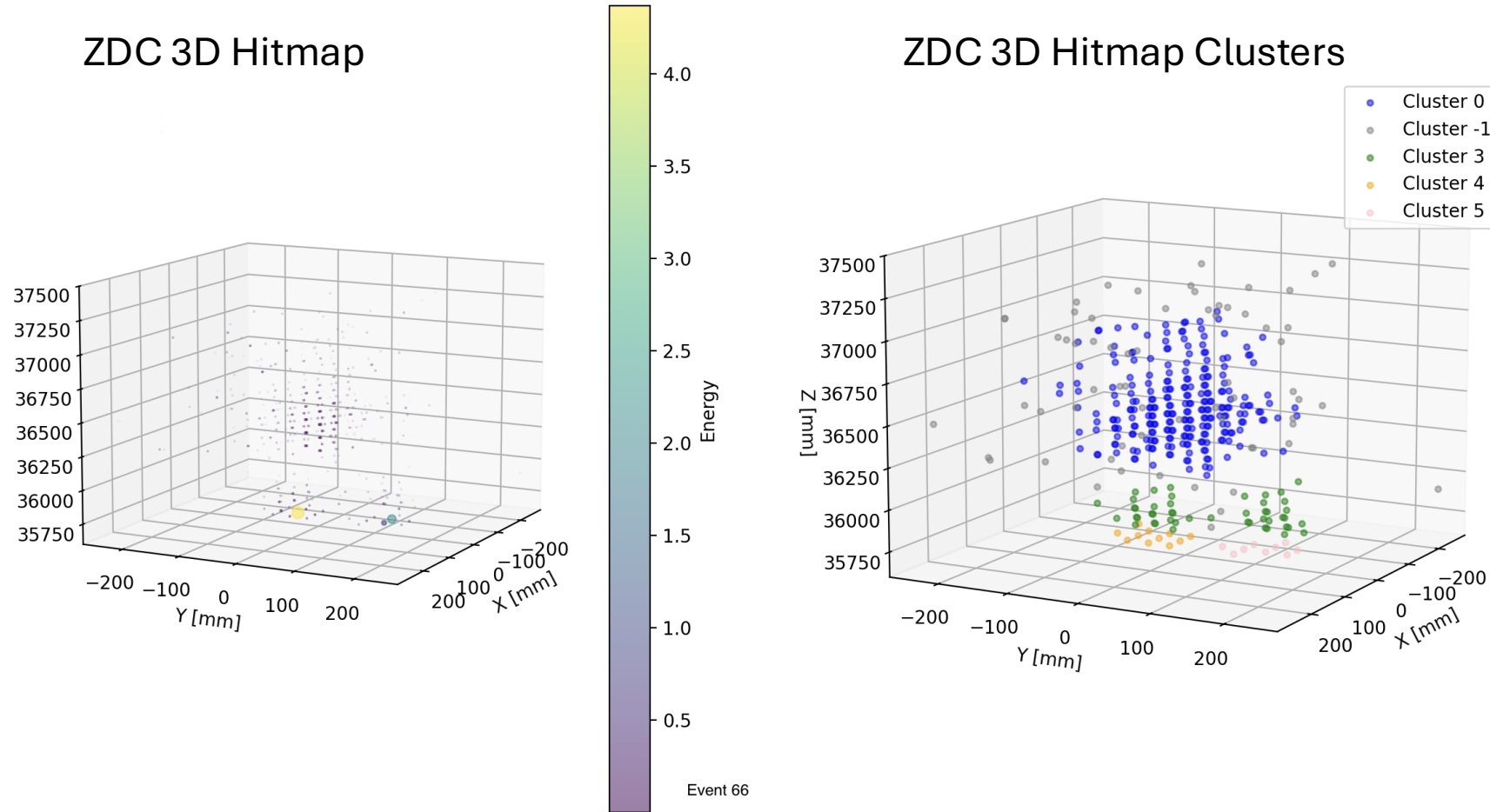
# ZDC Clustering: DBSCAN Clustering



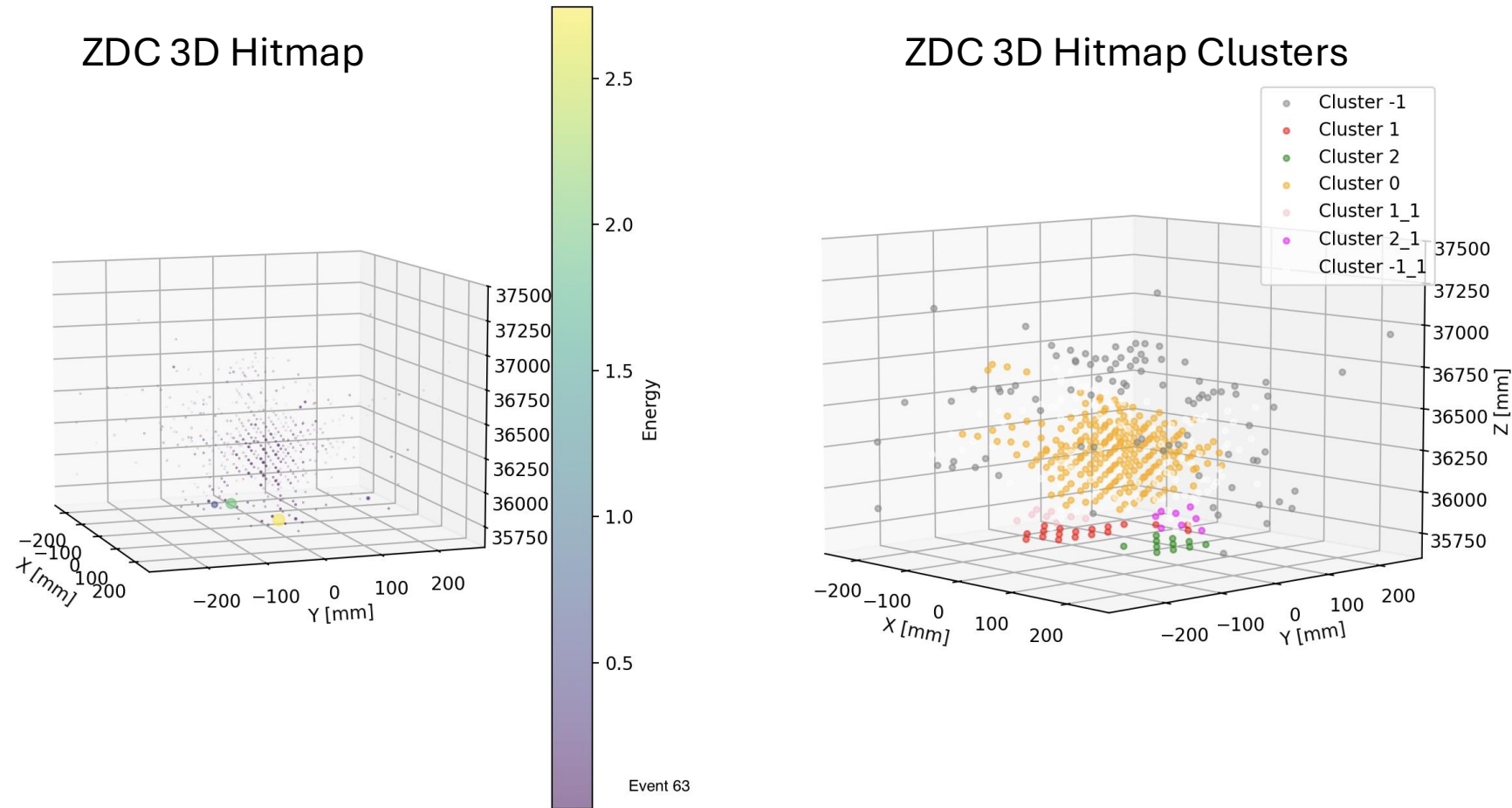
# ZDC Clustering: DBSCAN Clustering



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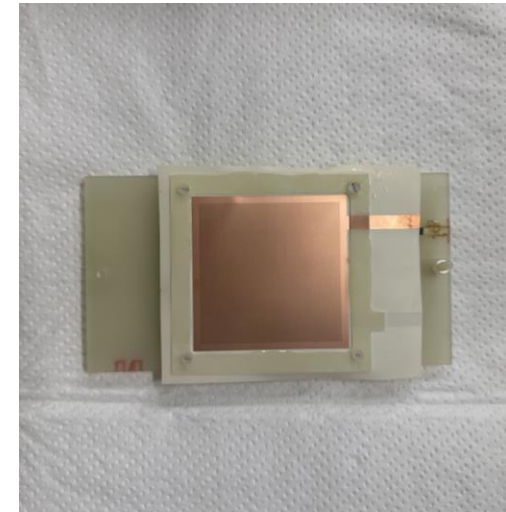
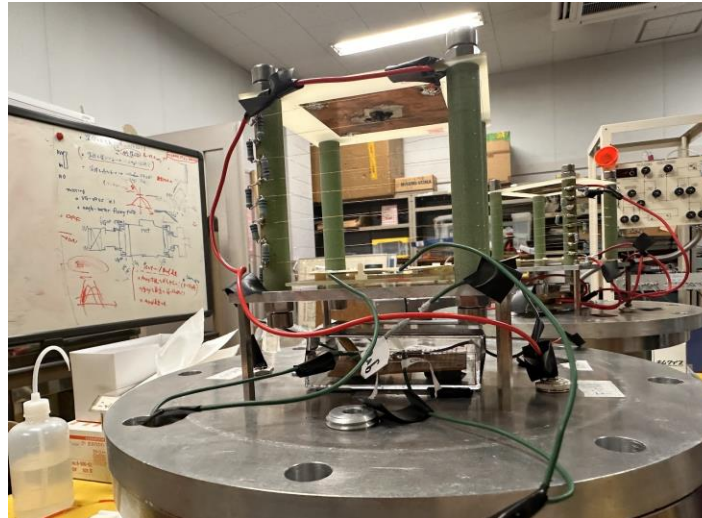
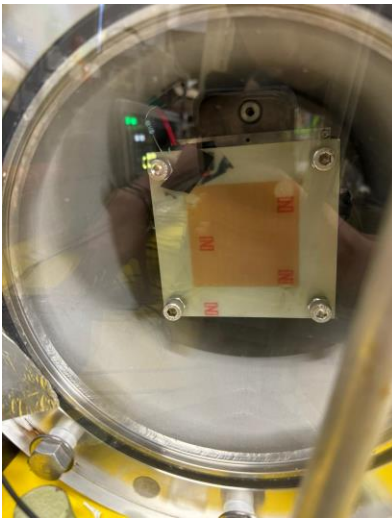
- Next Steps:
  - Add an additional clustering step where the ECal clusters are used as seeds to isolate HCal clusters from one another when they are touching, and the energy is too low
  - This step will forcefully split any remaining clusters based on the location of ECal hits and depth in the HCal

# ZDC Clustering: $\pi^0$ Reconstruction

- Currently using the weighted average of the hit position in ECal and HCal layers for the photon clusters to try and reconstruct the vertex
- This should work well for the neutron since it has large showers in the HCal but may not for the photon since the showers are not as robust. The HCal has 64 layers so the smaller a shower is the more difficult it is to estimate the average hit position well since there are not that many hits in each layer
- How should we use the HCal photon hit data for the  $\pi^0$  reconstruction?

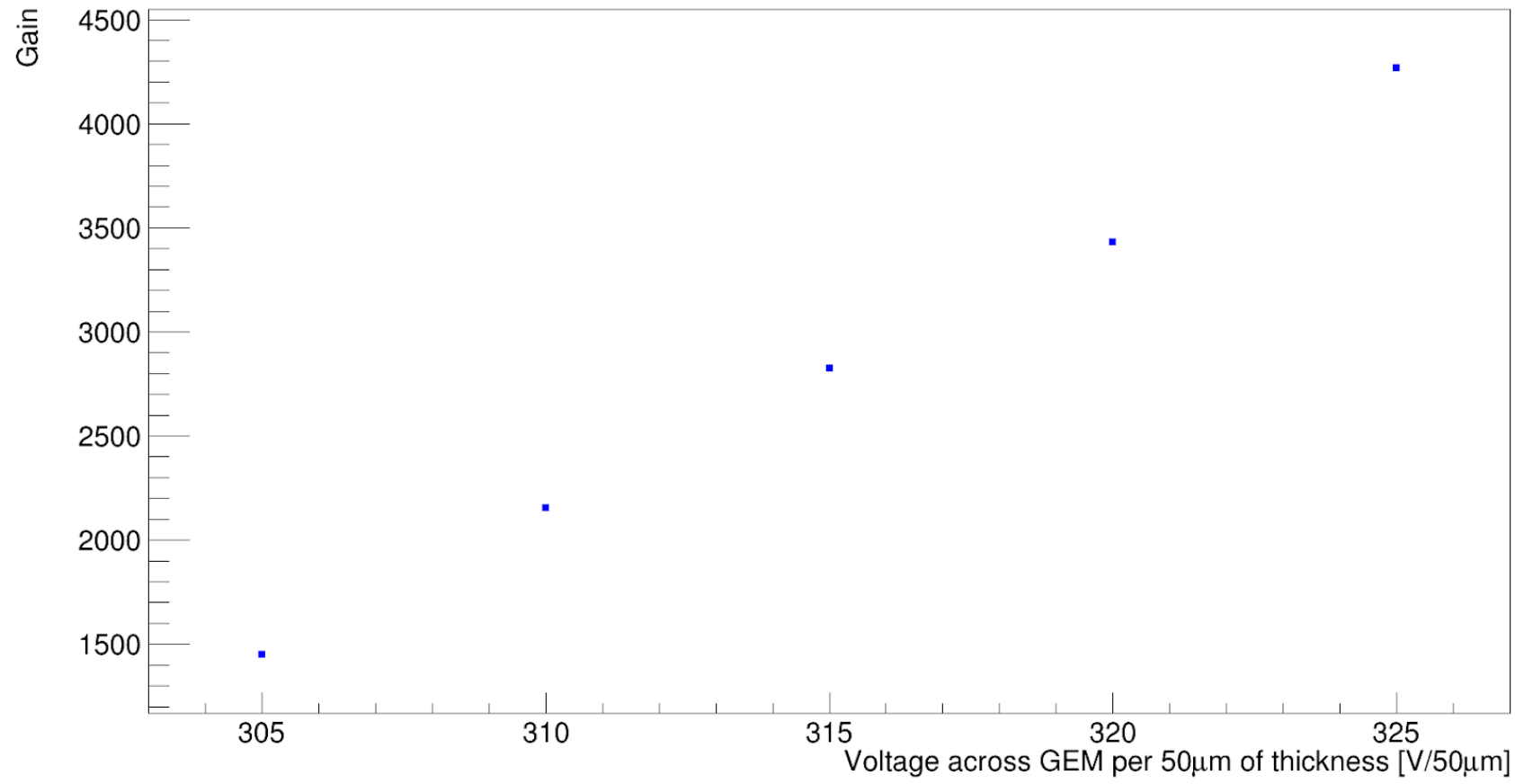
# TPC Build

- After additional troubleshooting we were finally able to get the TPC working. It is currently collecting cosmic data
- Calculated the gain for the GEM and used the MCA to see the spectra for the Iron-55 source

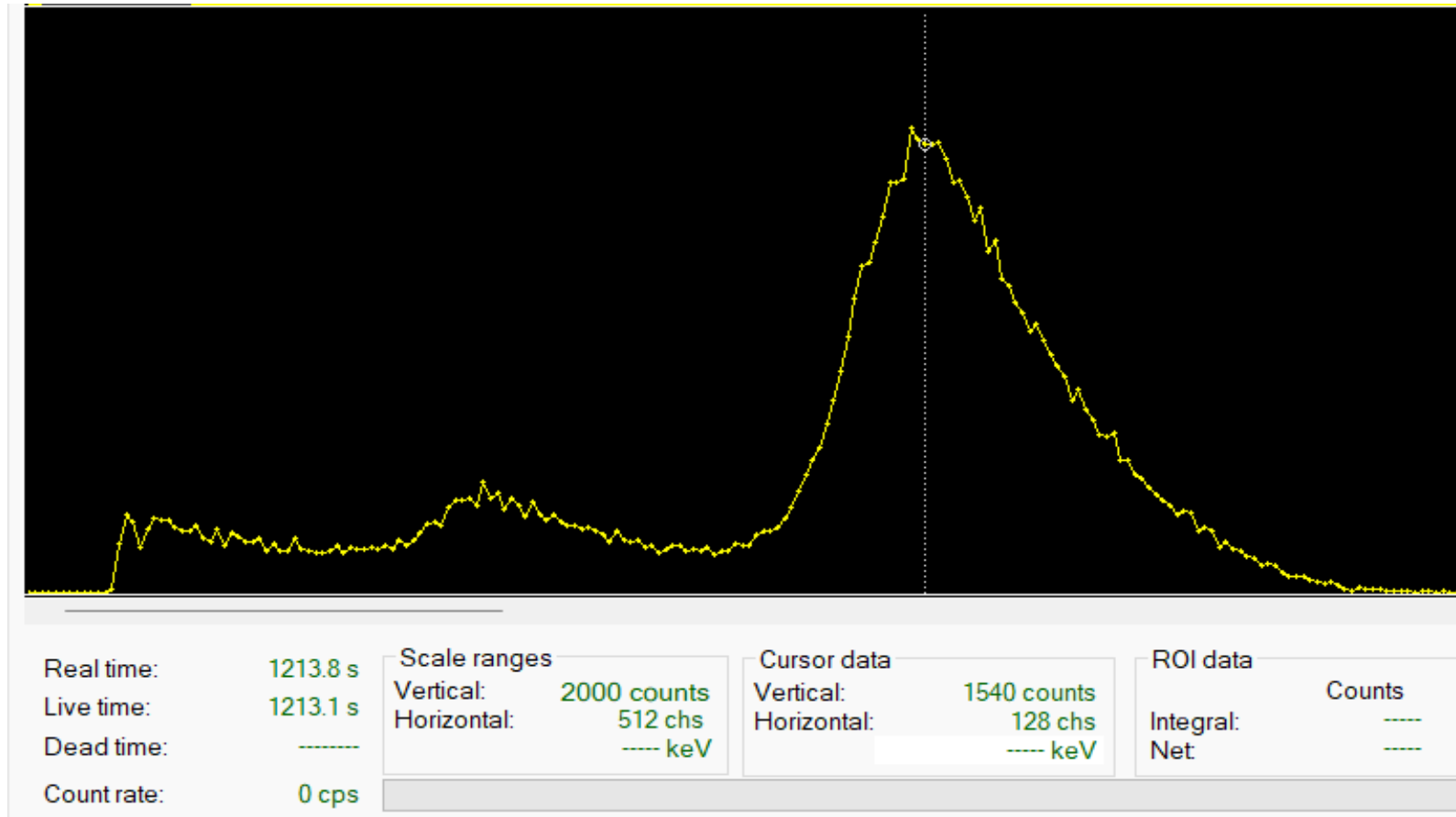


# TPC Build

GEM Gain vs. GEM voltage per 50 $\mu$ m of thickness



# TPC Build



Iron-55 Spectrum  
GEM Voltage: 1300V  
Field voltage: 1000V