Week 7 Review

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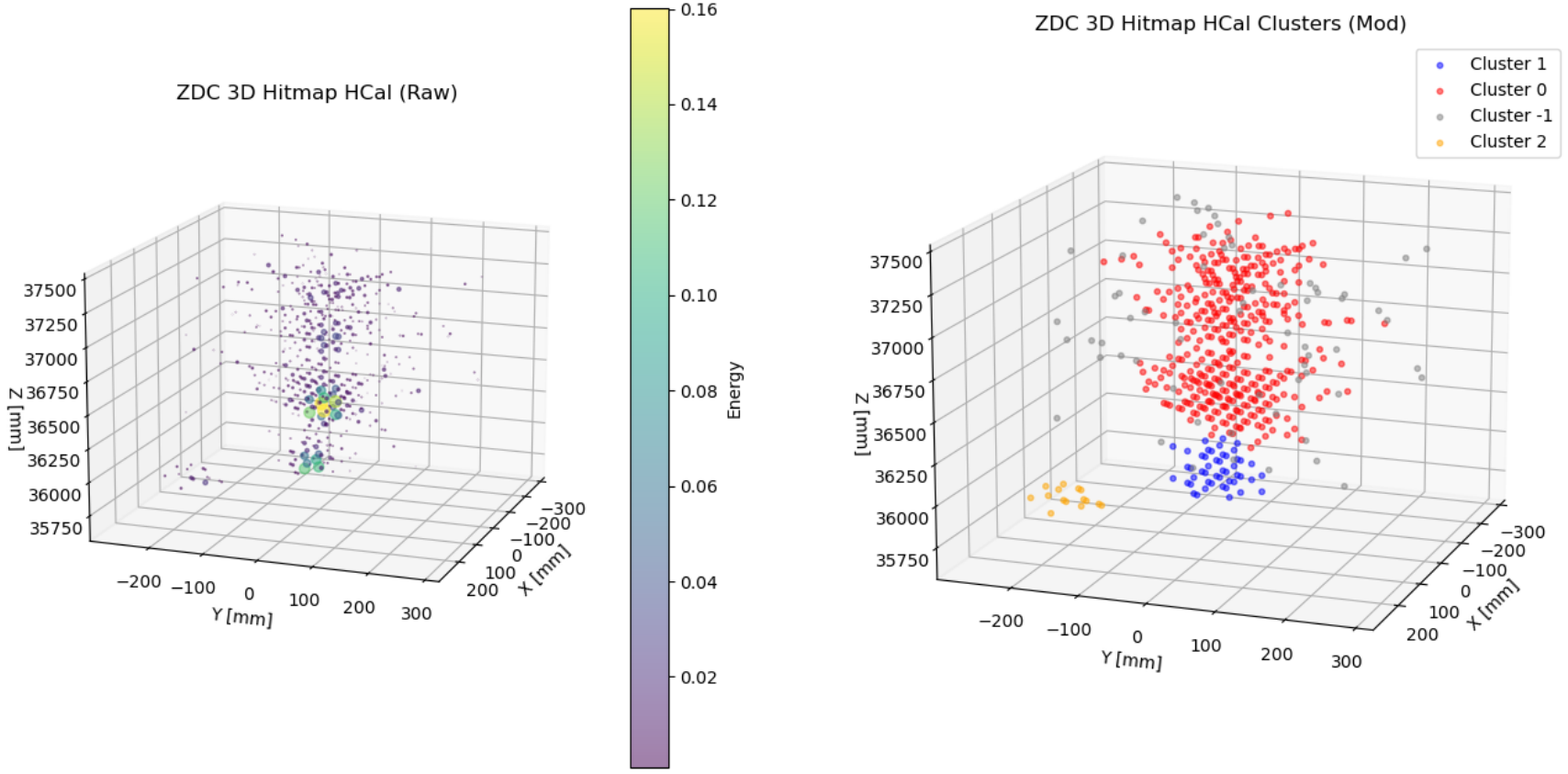
ZDC Simulation: DBSCAN Clustering

- Current State:
  - Clustering is currently done only on hits in the HCal
  - Algorithm is now clustering based on the density of hits and the energy of hits
  - Make a noise cut before clustering (any hits that deposit energy lower than 0.001 GeV in the HCal are ignored)
  - Performance has improved but additional changes will need to be implemented. Modified algorithm struggles to distinguish between photon and neutron clusters when they are close together. This is likely due to the energy of the hits in the photon cluster being close to the energy of edge hits around the core of the neutron cluster.

ZDC Simulation: DBSCAN Clustering



Distance between neutron and closest photon is ~378 mm

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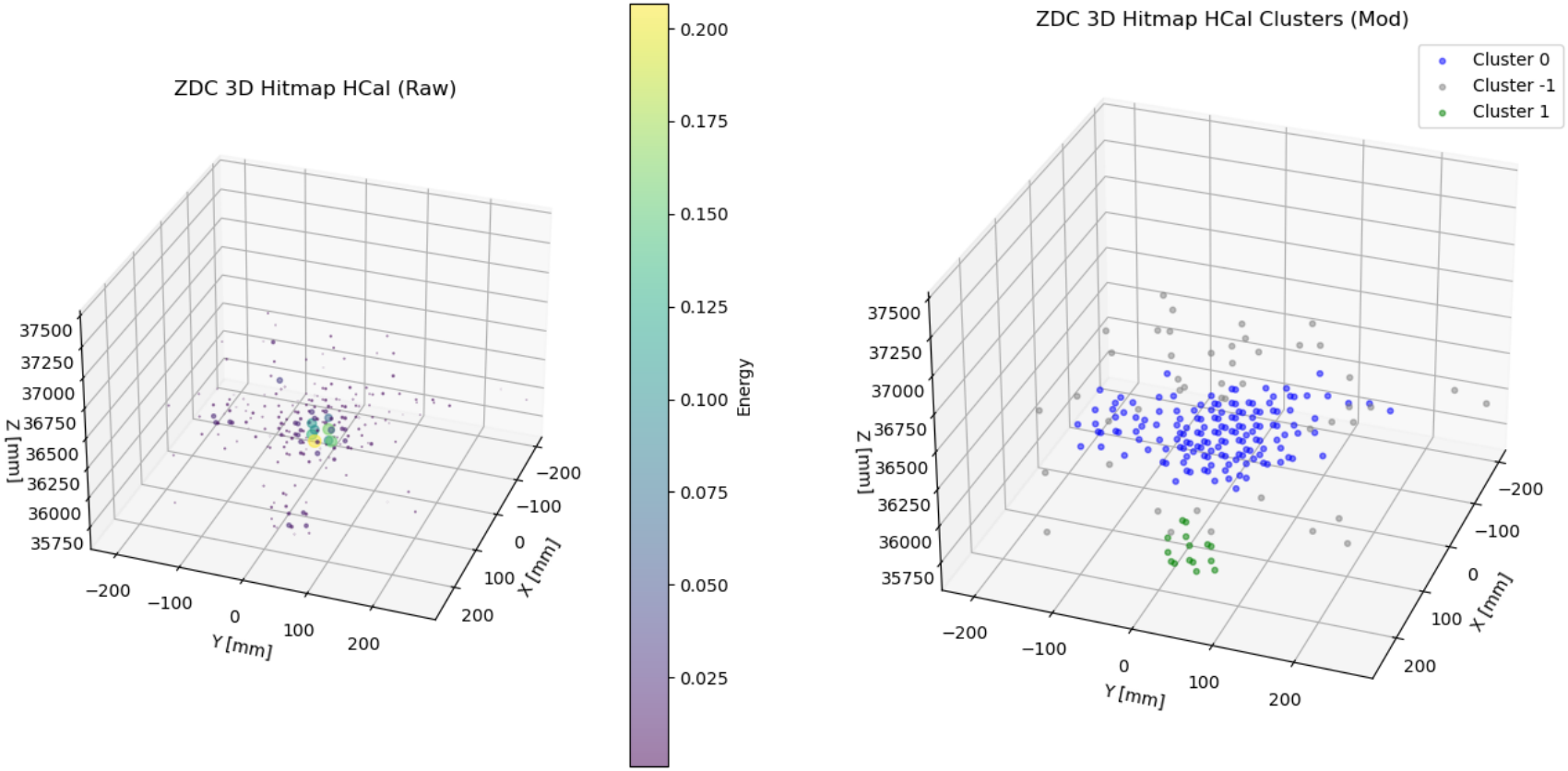
ZDC Simulation: DBSCAN Clustering



Distance between neutron and closest photon is ~165 mm

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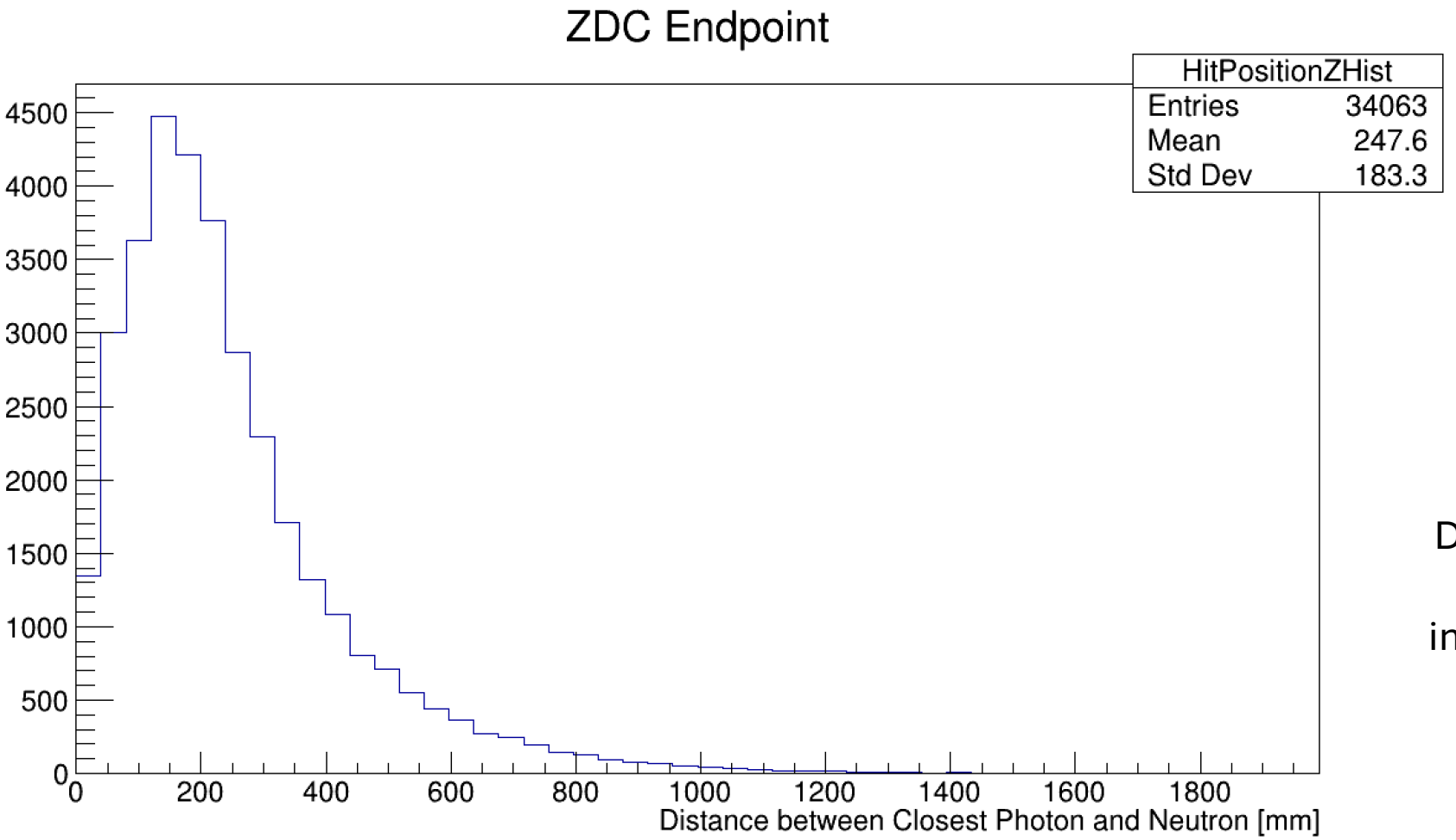
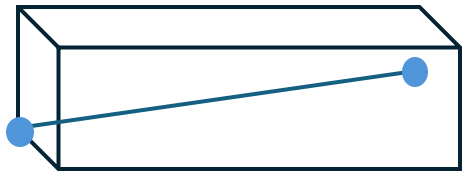
ZDC Simulation: DBSCAN Clustering





Distance between neutron and closest photon
in ZDC for unpolarized Lambda baryons shot directly at ZDC

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ZDC Simulation: DBSCAN Clustering

- Goals for the coming week:
  - Perform clustering in both the ECal and HCal (currently only being done on HCal hits)
  - Continue to modify and tune algorithm so that it can better distinguish between photon and neutron clusters when they are close together
    - Plan is to perform the clustering again on the combined neutron/photon cluster with different parameters to more aggressively isolate them
    - If this is successful implement the two-step clustering: Step 1. Try and identify at least three clusters in ZDC. Step 2. If at least three clusters are not found, try and perform clustering again on the largest cluster from step 1 with modified parameters.

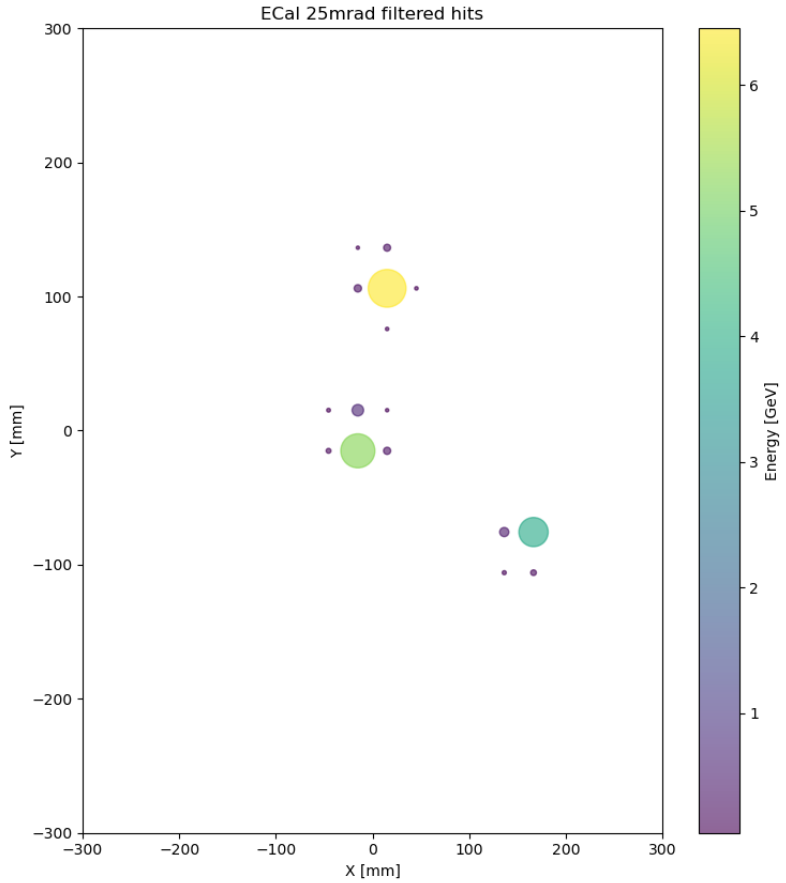
ZDC Clustering: Peak finding and photon and neutron identification

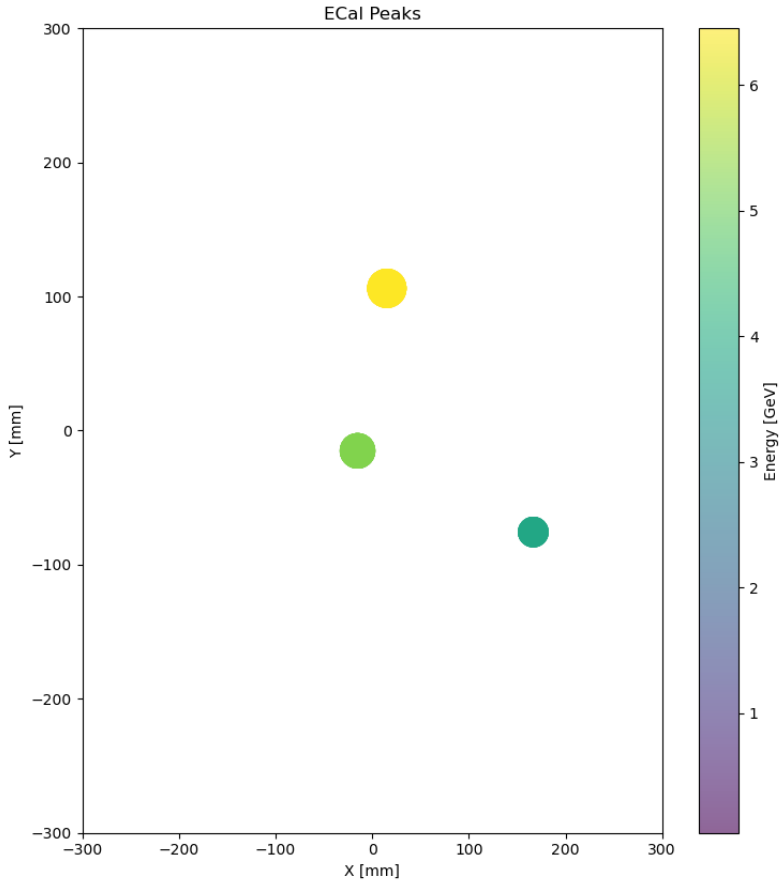
- Based on the remaining timeframe of the project, getting good ML results will take too long
- Started peak finding in both the ECal and the HCal, to compliment G's work with cluster scanning
- Goal is to determine:
  - Peaks in ECal
  - Peaks in HCal
  - Relate each ECal peak to nearby HCal peaks
  - Use energy information to determine which groups are neutrons or photons
  - How close is too close for neutrons and photons to be distinguished
  - Can we perform basic clustering with that information

ZDC Clustering: Peak finding

- Peak finding works by transforming the data into a grid and then finding local maximums
- Nearby HCal peaks are then grouped with the nearest ECal peaks, this lets us distinguish genuine photon peaks from the many neutron peaks
- The event shown unpolarized lambda gun at origin where all three particles hit the ZDC
- Lambda shot directly at ZDC, lambda momentum is 174 GeV
- ECal hit energy cut at .05 GeV, HCal hit energy cut at .001 GeV (no scaling)
- Hits rotated to 25mrad frame for viewing

ZDC Clustering: ECal Peaks





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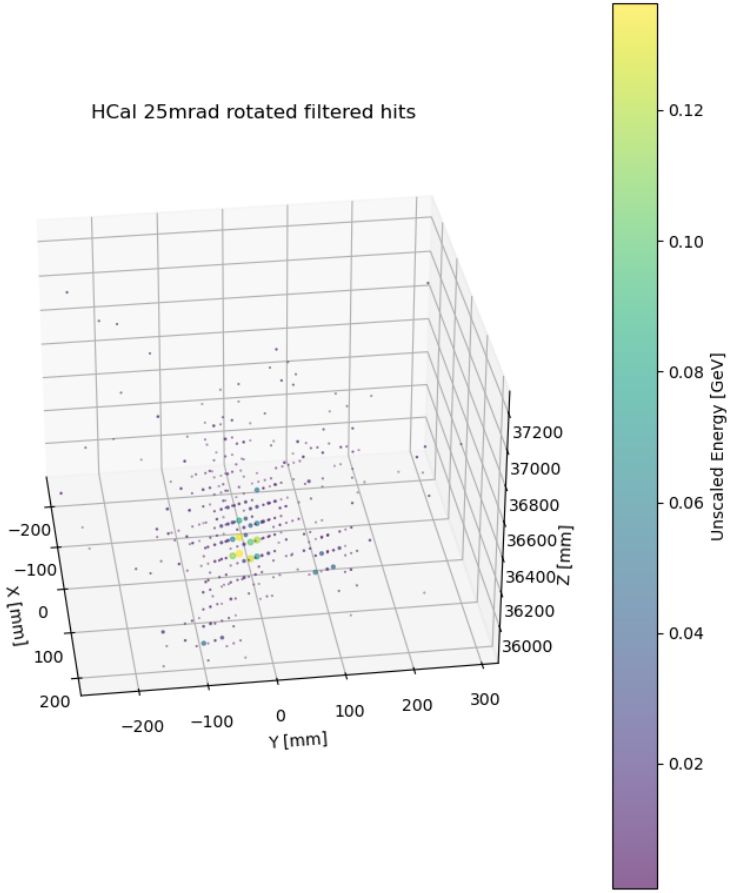
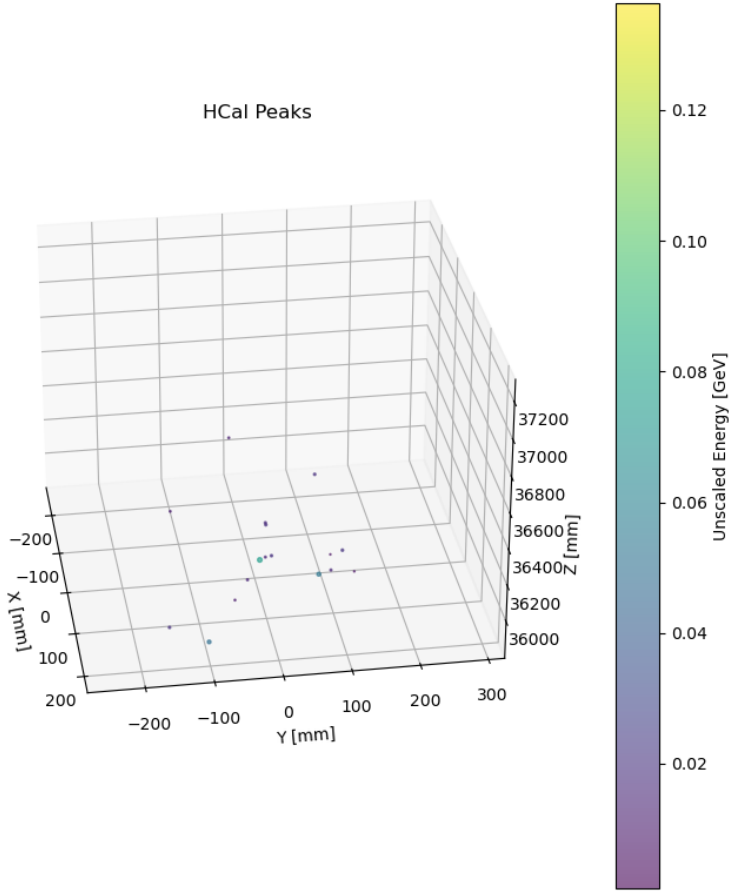
ZDC Clustering: HCal Peaks





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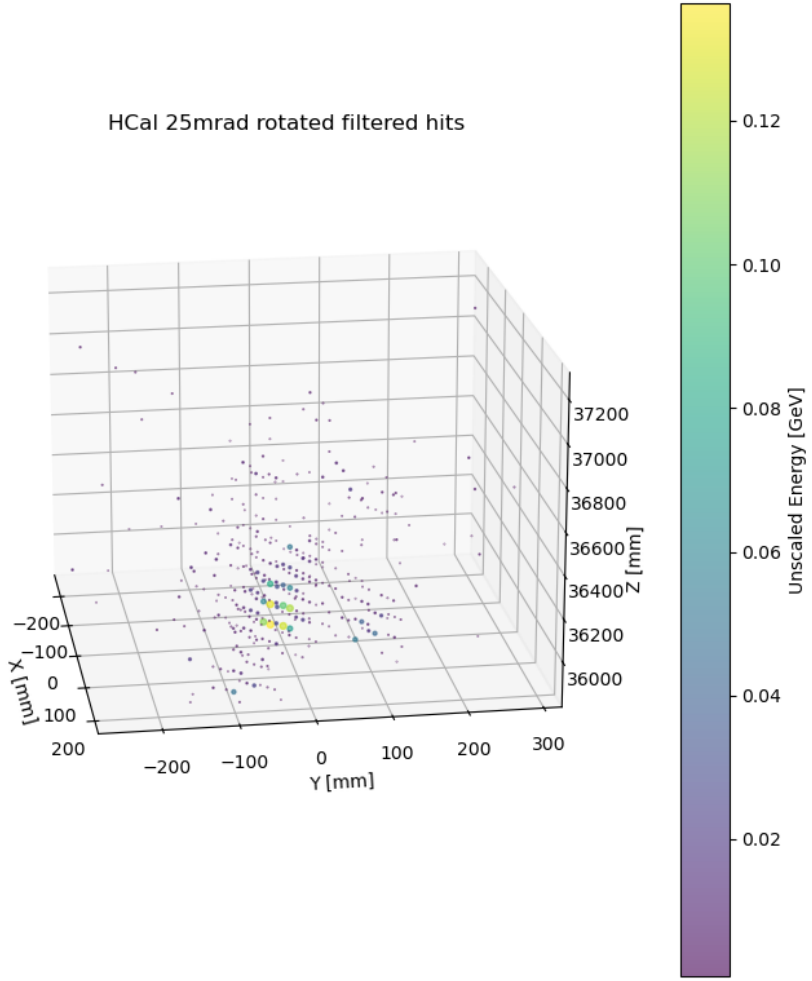
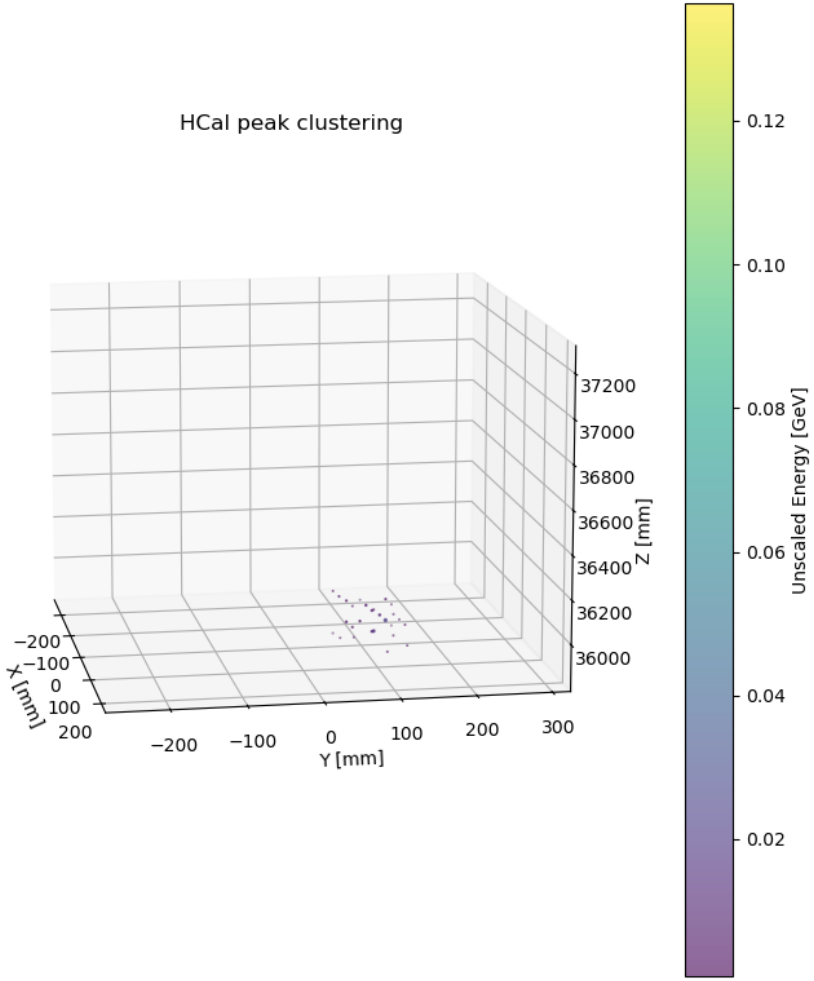
ZDC Clustering: Basic Cluster Finding

- Start with identifying the neutron cluster by its characteristic high energy in the HCal
- Due to having checked the ECal, we can be confident the other groups of photons
- We start at the photon peaks and add neighboring hits in a preset area around the peak until the hits to be added have higher energy than the neighboring points inside the cluster
- The basis is that the further away a hit is from the peak photon energy, the less energy it will have
- Hit energy will only start increasing when the hits are closer to a neighboring neutron peak
- Currently struggles finding high energy points near the main peak due to the energy difference between them and background points
- I would also like to add checks for the global structure of the cluster (I want it to check if the cluster it is making is well contained)

ZDC Clustering: Basic Cluster Finding





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TPC Hardware: Finished testing new TPC set-up

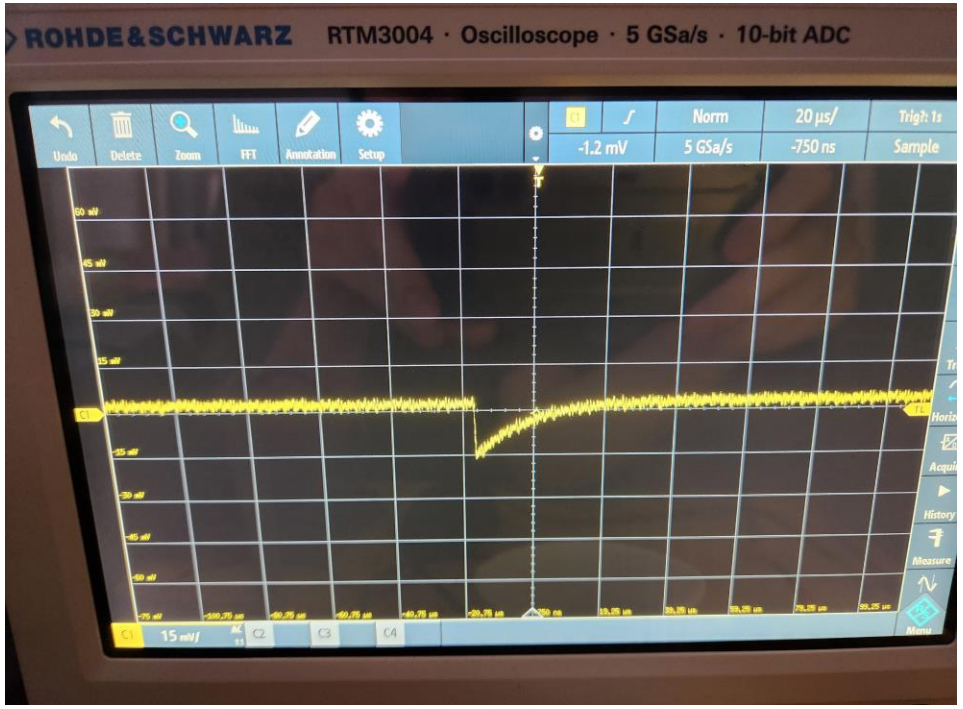
- Changed the top cover of the TPC to allow for the voltage divider circuit to be outside the body of the TPC
  - This introduced slight attenuation with the box, but was mostly solved by isolating the circuit
- Replaced the first GEM with the second GEM, the data seemed to be fine, but we did not get the expected signal with Iron-55 source
- We double checked the GEM, field and signal wires, but couldn't find an obvious cause of the problem
- Decided to prep and test a 3rd GEM to determine if the GEM foil was the cause

TPC Hardware: Testing 3rd GEM part 1

- Placed the GEM foil into the TPC and let it run over night at GEM voltage 1.3 kV, field -1kV and with N2 at 30 ml/minute
- Signal from GEM at that time seemed very noisy with both positive peaks and negative peaks
- The decay time of the signals seemed fine
- The next day, we opened it, placed in iron-55 source, cycled in N2 and then P10 and tested with several GEM voltages
- The GEM signal was extremely noisy due to the rate of negative signals

TPC Hardware: Negative Signal

- Example of a negative signal from GEM
- The negative signals appear around GEM voltage ~1.2kV, regardless of field, their magnitude depends on GEM voltage



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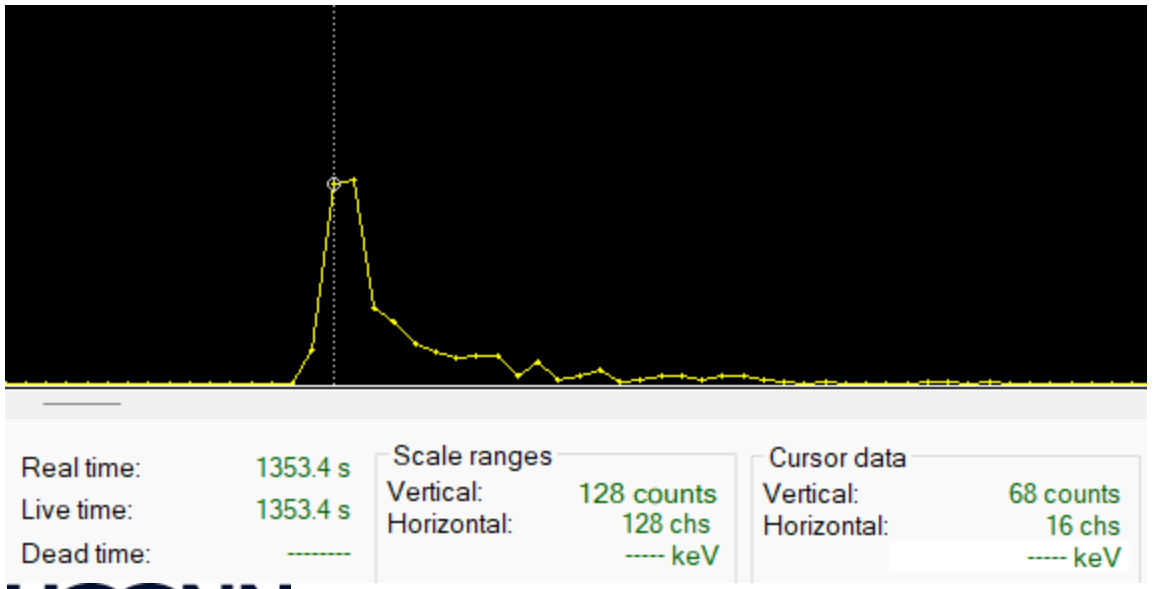
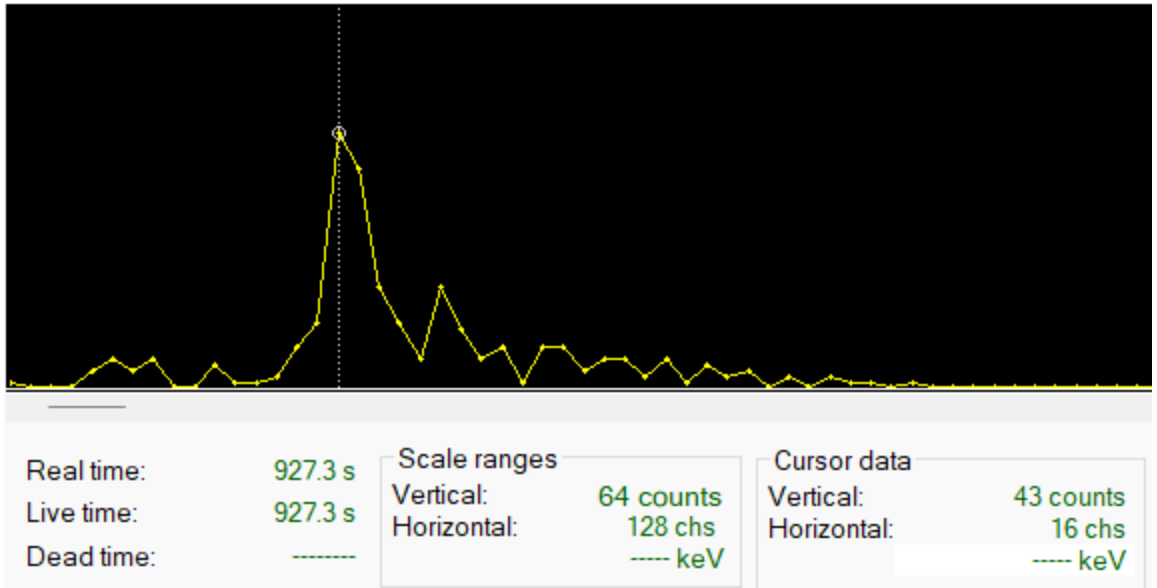
TPC Hardware: Testing 3rd GEM part 2

- GEM behavior was very inconsistent, it seemed to be very sensitive to GEM conditioning
- Raising the voltage very slowly did not seem to improve the rate of negative signals
- Raising the voltage higher (to 1.3kV), letting it run and then lower it down seemed to help
- These two graphs show the same run voltages (GEM 1.2kV, field –1kV), but before and after such conditioning
- Count rate is also significantly lower than what we previously observed with iron-55 source

Before:



After:



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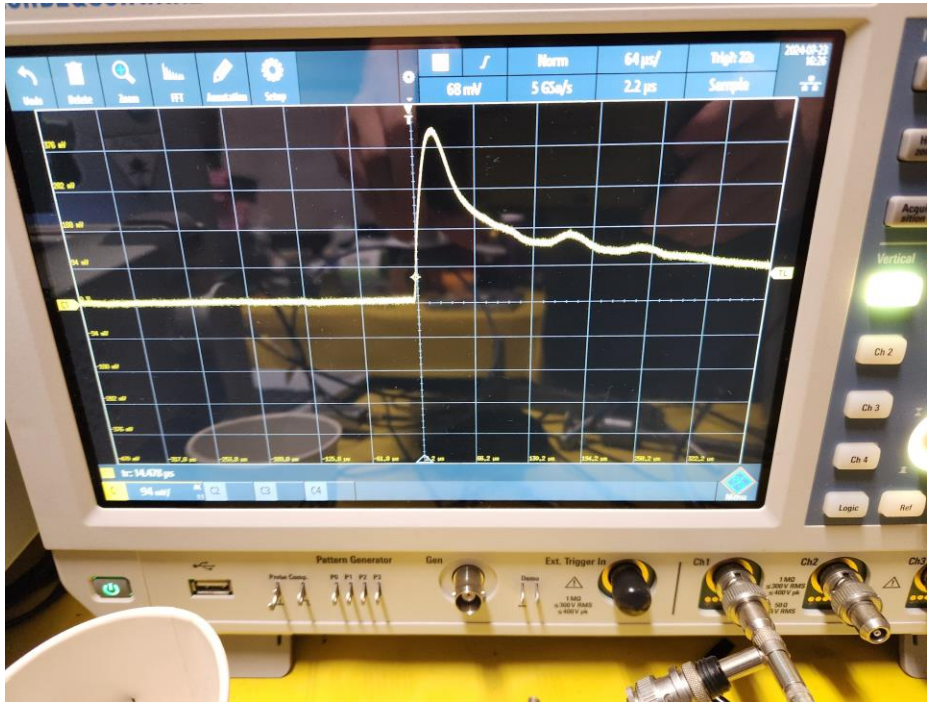
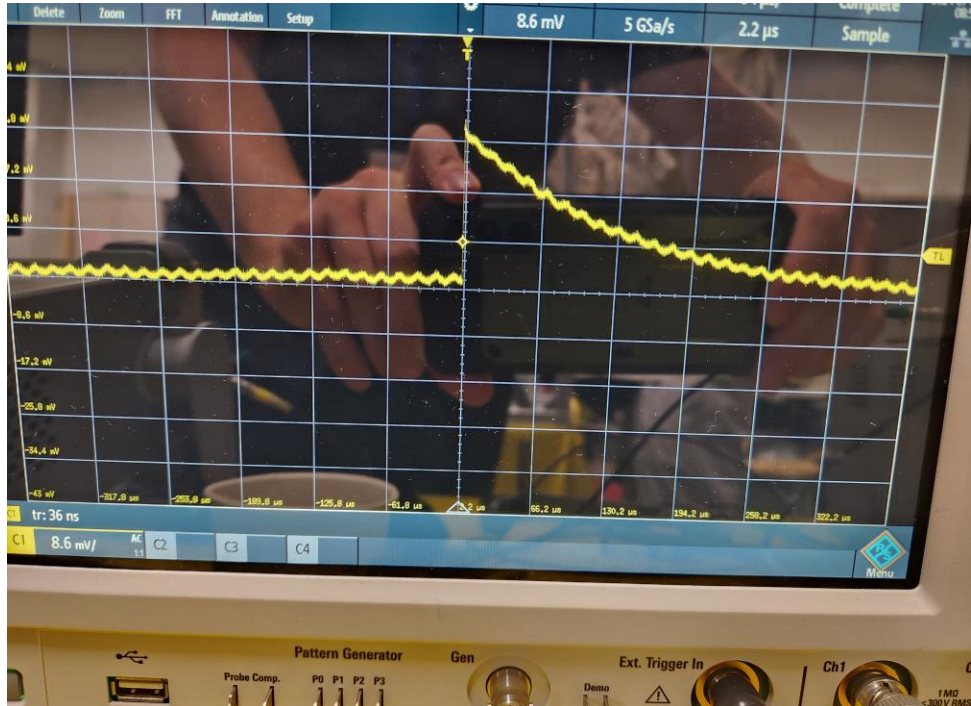
TPC Hardware: Pre-Amplifiers Issue

- While testing the GEM, we noticed some of the pre-amplifiers have much longer decay times than they should
- Decay time should be on the order of 10 microseconds, but we were observing some on the order of a 100 microseconds
- We suspect this is partial to blame for the unusual data distributions of the previous slide
- Left plot is a picture of a data event post voltage conditioning and left is pre-amp response to square wave





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TPC Hardware: Goals for the rest of this week

- We think the TPC's behavior is due to two problems: slow pre-amplifiers and discharge
- We are going to open up the TPC and re-examine GEM bottom, pad and ground to see if there is anything could cause sparking
- Continue to test pre-amplifiers