Sept. 9th ZDC Resolution Study

Alessio I. and Gursimran K.

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Overview

- Last week we discussed looking at the angular data and lambda reconstruction methods
- Today we will show some results for
    - Reconstruction of the photon vectors and pion using ECal + HCal
    - Statistics after cuts of data
    - Clusterability of angular data

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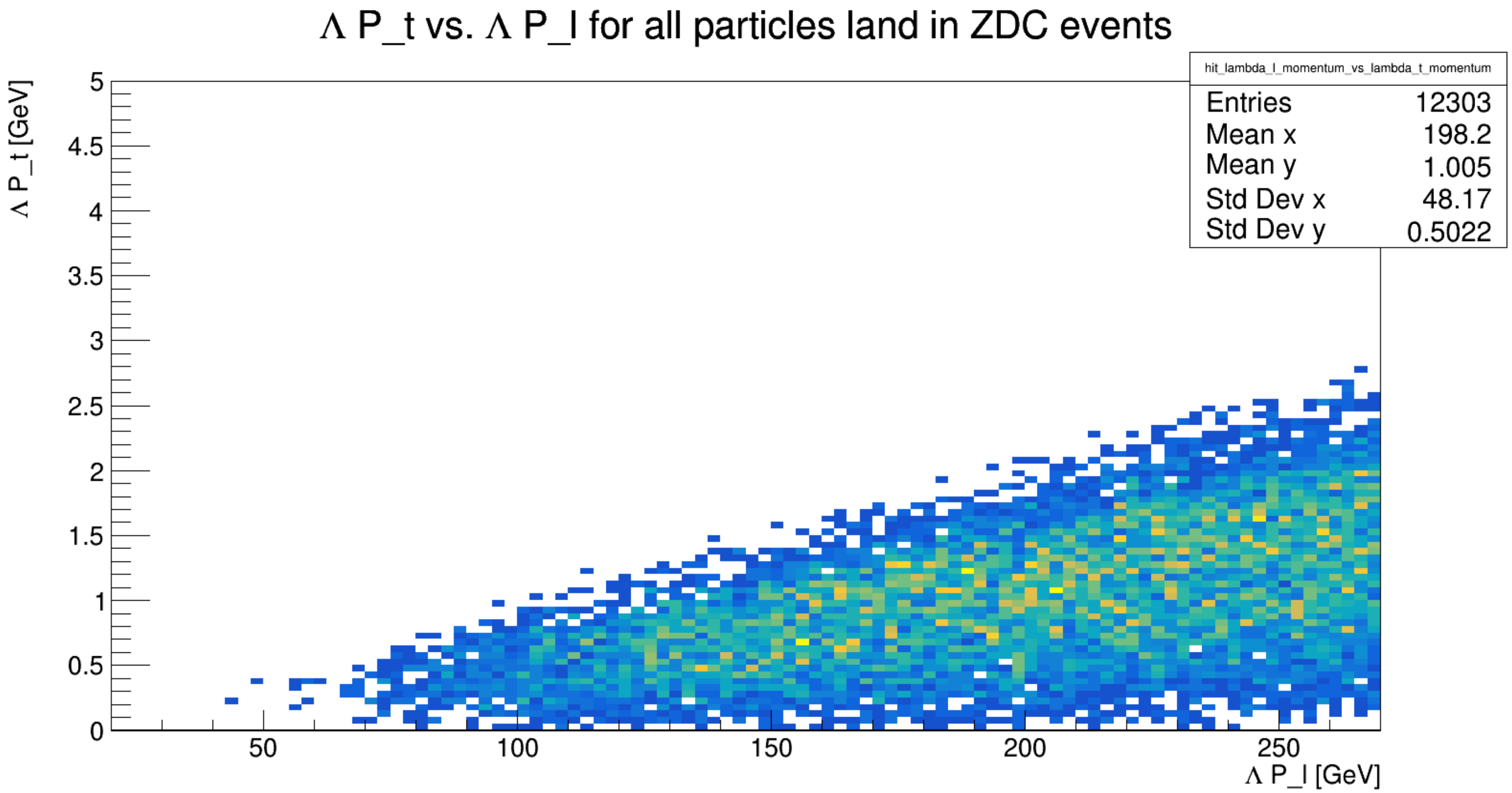
P_t vs P_l

- This is only for events where all three particles land in ZDC



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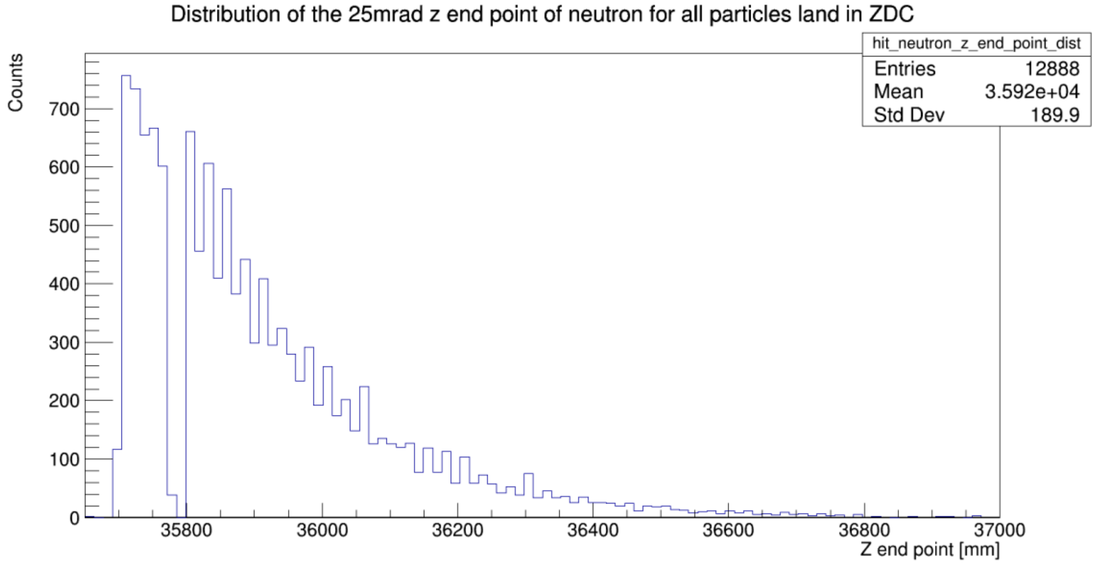
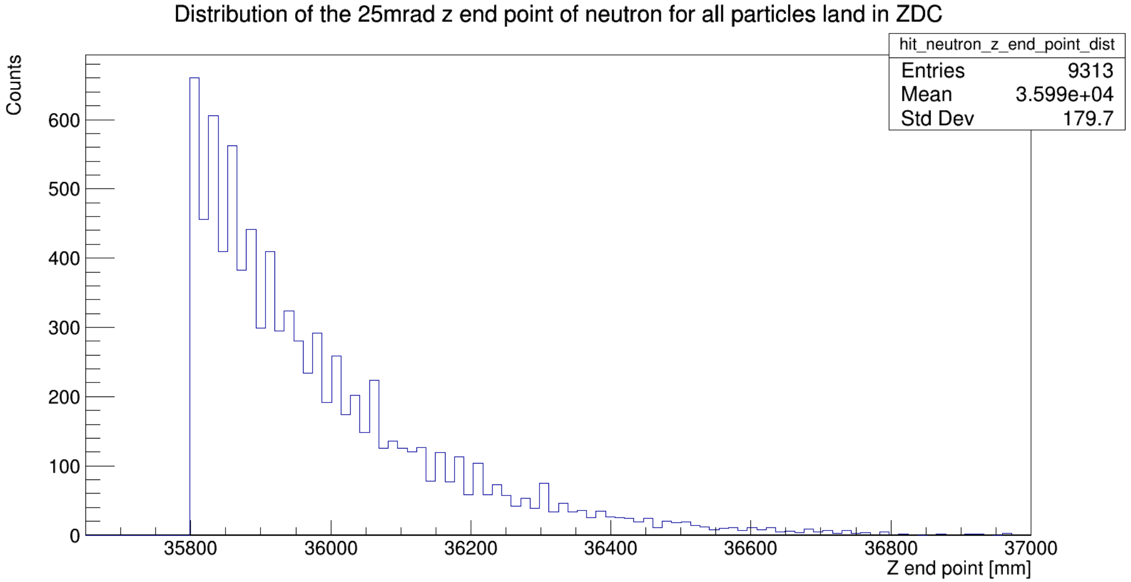
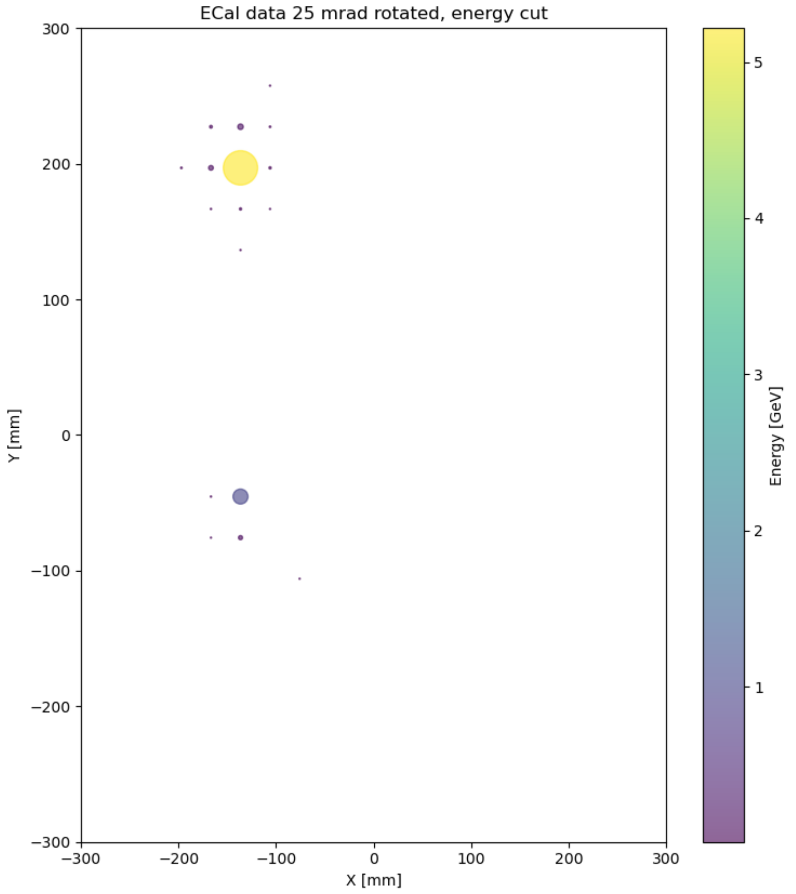
Angular data before and after depth cuts

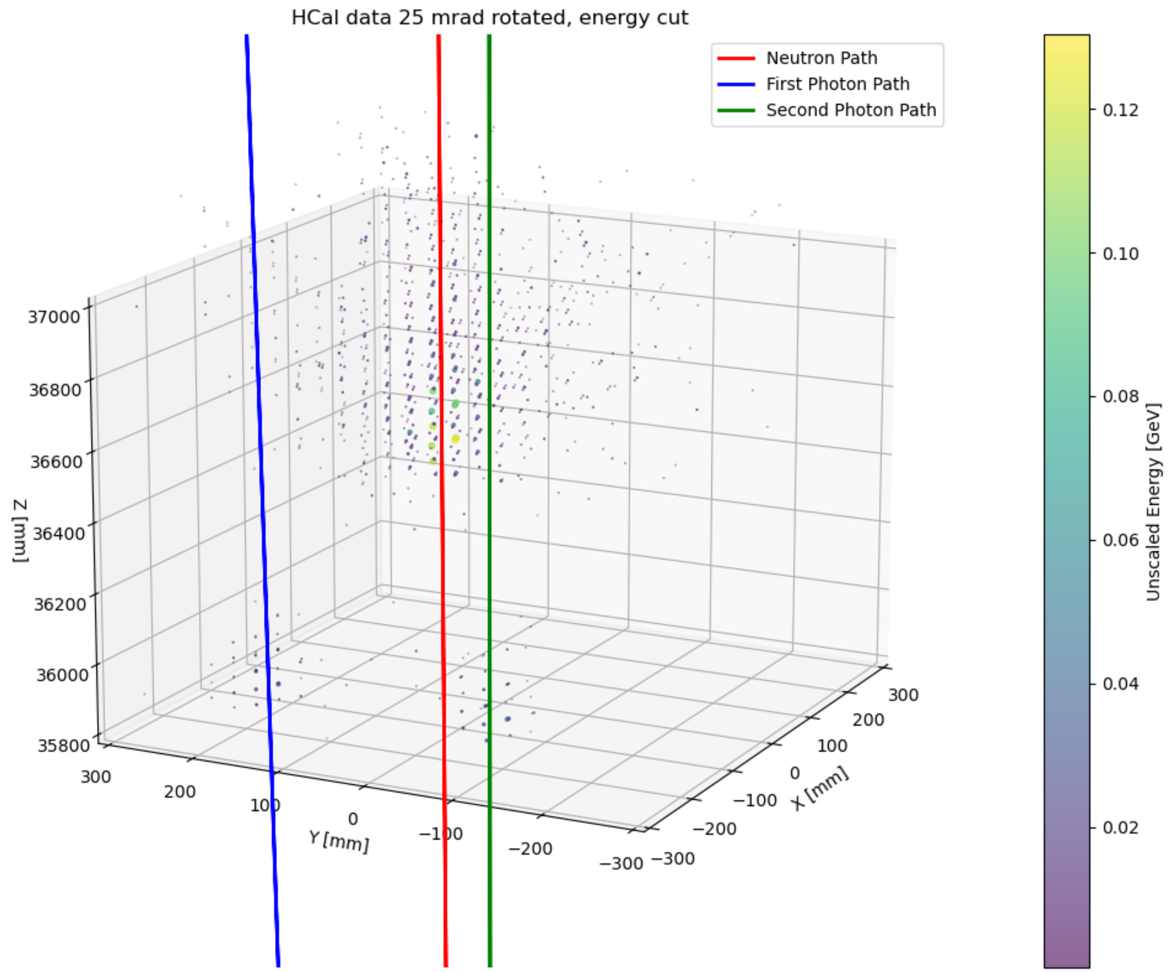
- This is only for events where all three particles land in ZDC
- Reduces 140k events to 12k to 9k
- Non-angle data goes from 200k to 74k to 30k
- Not every deep event can be reconstructed, but most can
- Cut at 35800, but it is better to cut at 36000





Event Display for deep neutron angular events





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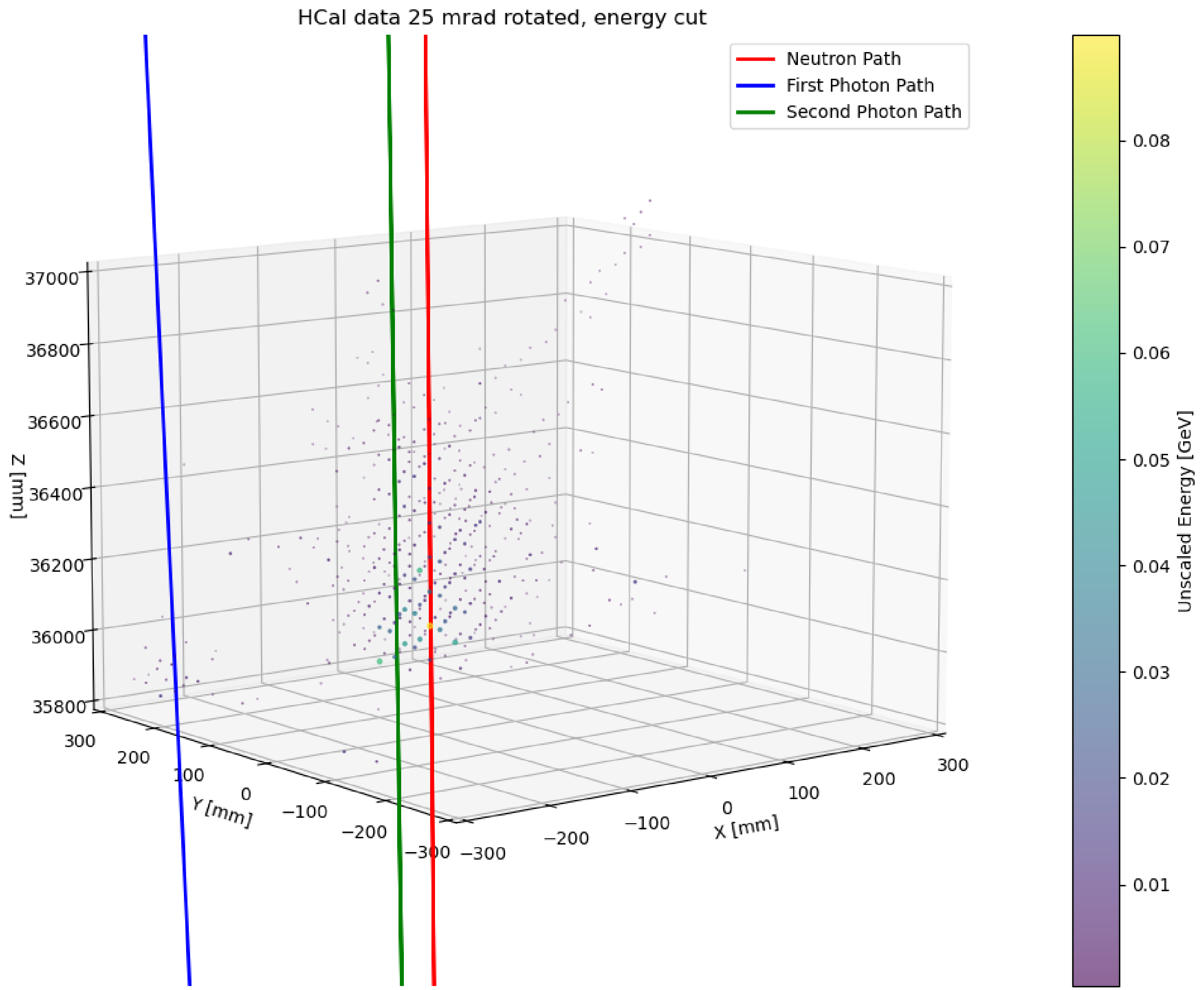
Unusual Events

- The angle events look very similar to the no angle events, very few changes have to be made to cluster angular data
- A few common categories of problems are:
    - Neutron and photon showers touch/over-lap in either ECal or HCal
    - No photon marks/small marks in the ECal (lower limit to photon energy)
    - Neutron shower leaves the ZDC (too close to the edges)
    - Photon overlap
- The most common type of event is one photon close to the neutron, one far away
- The photon shower often extends into the beginning of the neutron shower

The most common problem: overlap

- The most common is the overlap of neutron shower and photon shower
- Sometimes the overlap is so bad, you can't tell a photon is there at all
- Some cases can be clustered, some can't



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Methods to separate these events

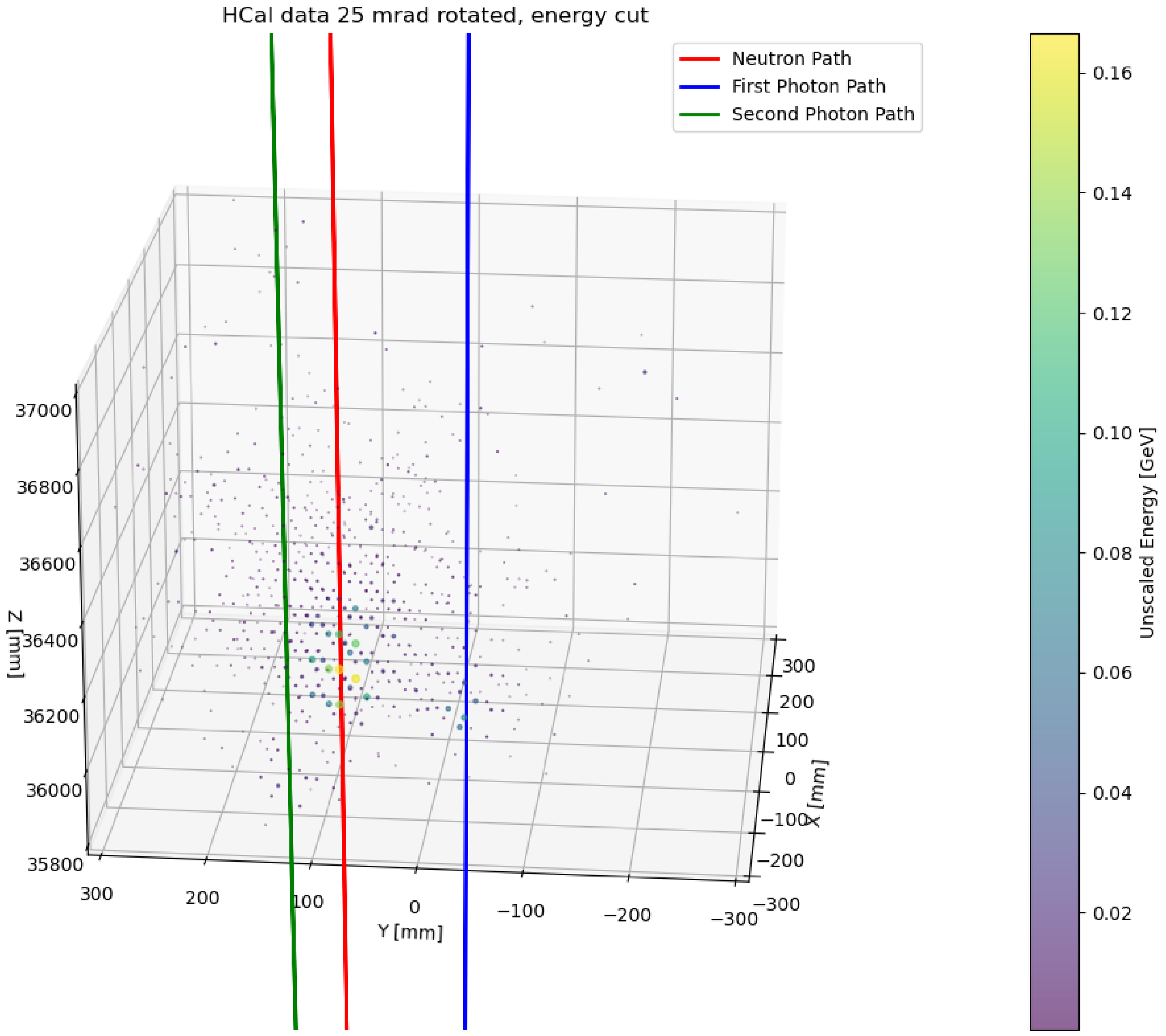
- The easiest and most effective solution is to make the depth cut very deep (>36000 mm), but we quickly run out of statistics
- If we do make restrictive depth cuts, we are left with 3k events in the angular data
- Cutting on the distance between neutron endpoint and gamma endpoint removes some bad events, but does not entirely fix the problem

Peak Finding to Select Events

- Used with the depth finding check
- Search through ECal and HCal data to find all local maximums
- Discard all events without 2 or 3 peaks in the ECal
- Discard all events without atleast 2 or 3 matching peaks in HCal
- Removes the most of the bad overlap events, but there is no guarantee the photon cluster will be distinct enough
- Very sensitive to parameter selection

Slight Overlap

- The noise between the neutron and the photon stumps algorithms
- The only current way to solve it is to make a box around the photon center and only add lower energy hits



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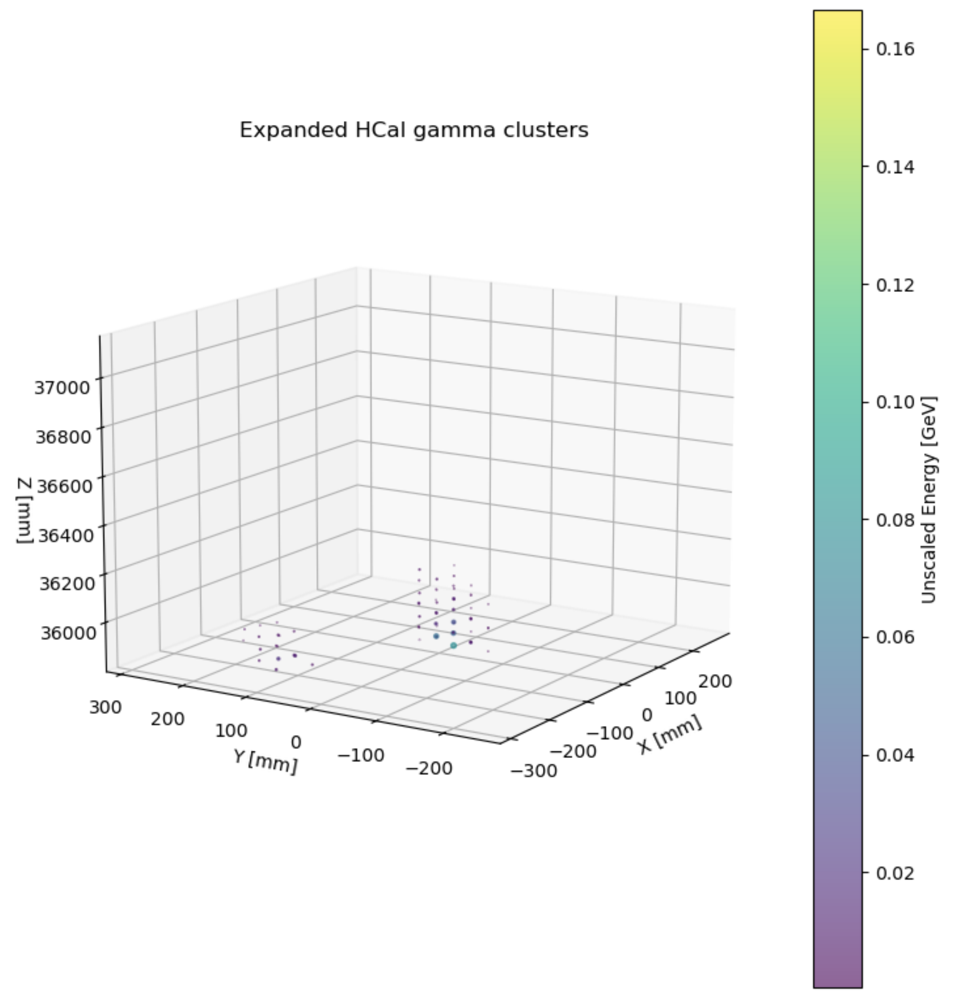
Slight Overlap clustering

- Low tech clustering is done by taking the peak and making a cylinder around it
- Only add hits with similar or lower energy than the core point
- The algorithm cannot distinguish neutron shower from photon shower so it needs to be restrictive



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Pi0 Vertex Reconstruction: Overview

Overview:

- Use average hit position weighted by energy in the ECal and HCal to define position vectors for the photons using two points
- Goal is to find the intersection point of both photon position vectors to determine the decay vertex of the pi0
- Have been able to reconstruct the position vectors and determine the vertex of the pi0 though it is not currently a good estimate of actual pi0 vertex
- Still working modifying the error estimation so that it accounts for energy as well as standard deviation

Pi0 Vertex Reconstruction: Method

- Use average hit position weighted by energy in the ECal and HCal to define position vectors for the photons using two points (1 in ECal and 1 in HCal)
- Determine the points on each vector when the vectors are closest together and use the midpoint of these points as the estimated vertex (The reconstructed vectors are likely skew so will not intersect exactly, this is the closest we can get to finding the pi0 vertex)

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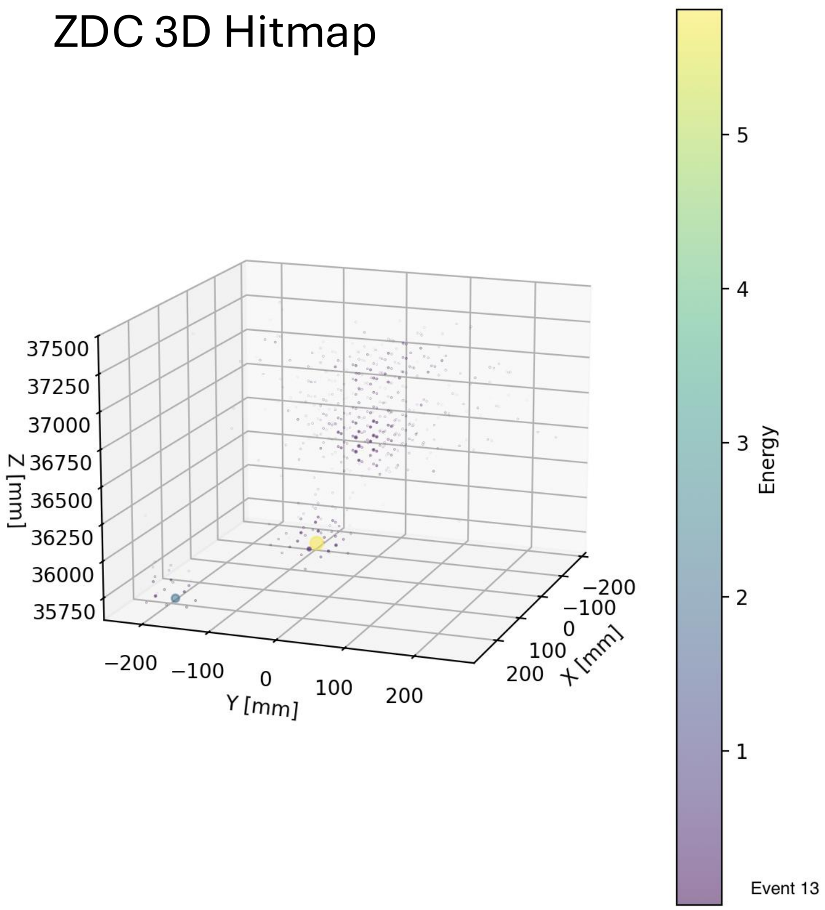
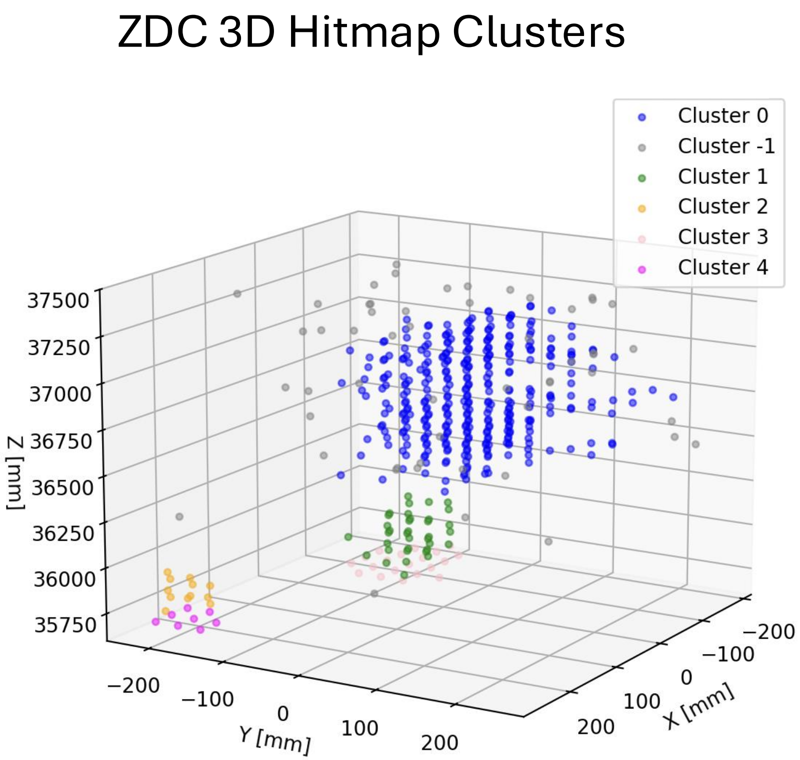
Pi0 Vertex Reconstruction

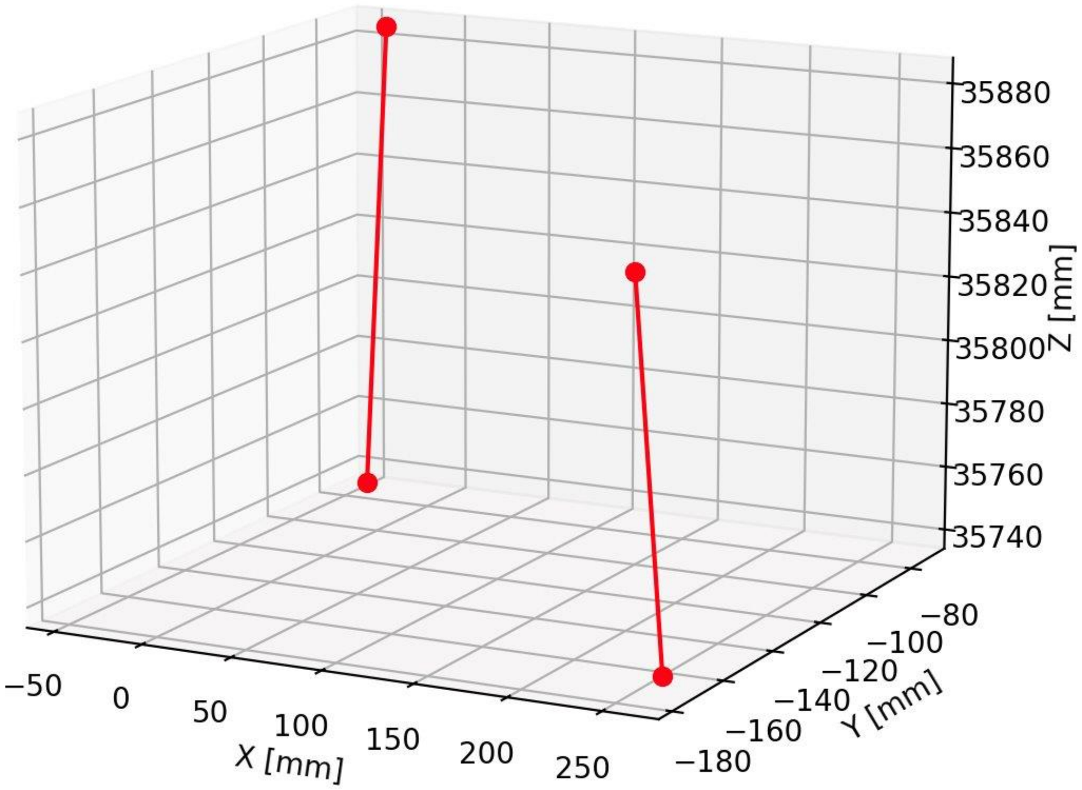




Pi0 Reconstruction

- Estimated Pi0 vertex:
  [120.97403711 , -143.53297353,
  36478.81265729]
- True Pi0 vertex: [-98.68033482131233, -
  2.310313135494700 7e-06,
  3946.391048331116]
- Current HCal hit estimate is not good. It should extend the position vector outwards but is doing the opposite making the estimated vertex beyond the ZDC when it should be in front of it
- The HCal and ECal hit estimates are also too deep in the ZDC

Reconstructed Photon Position Vectors



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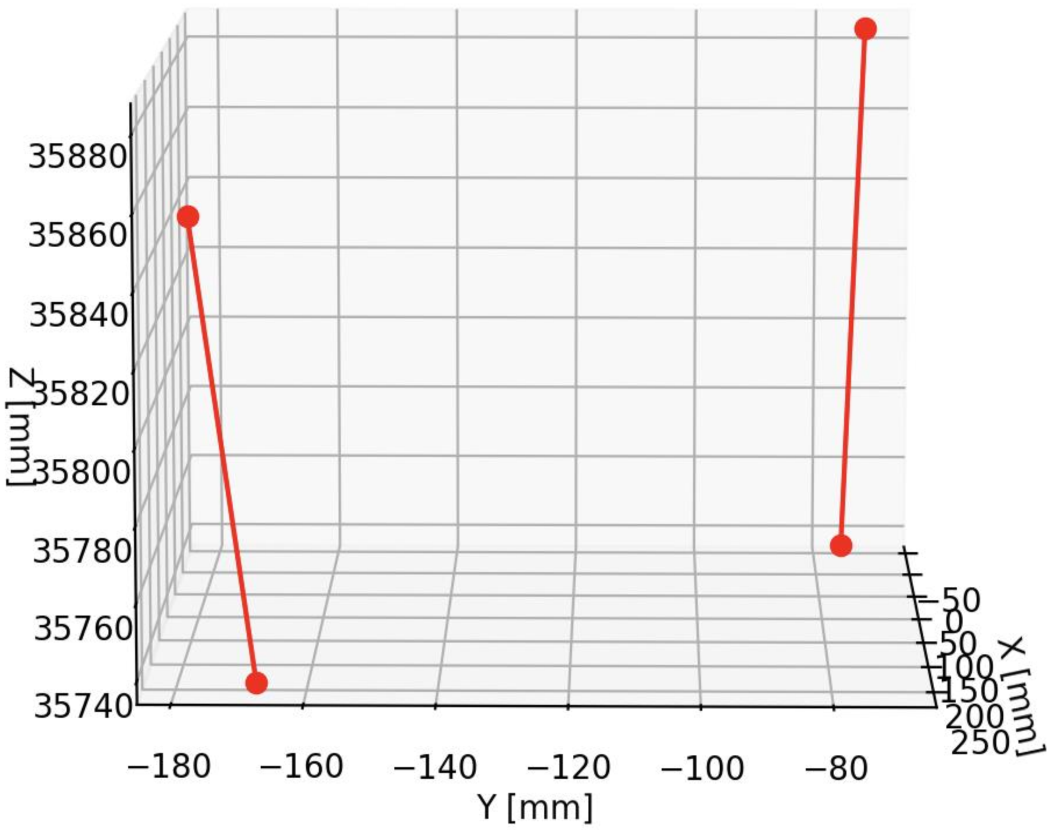
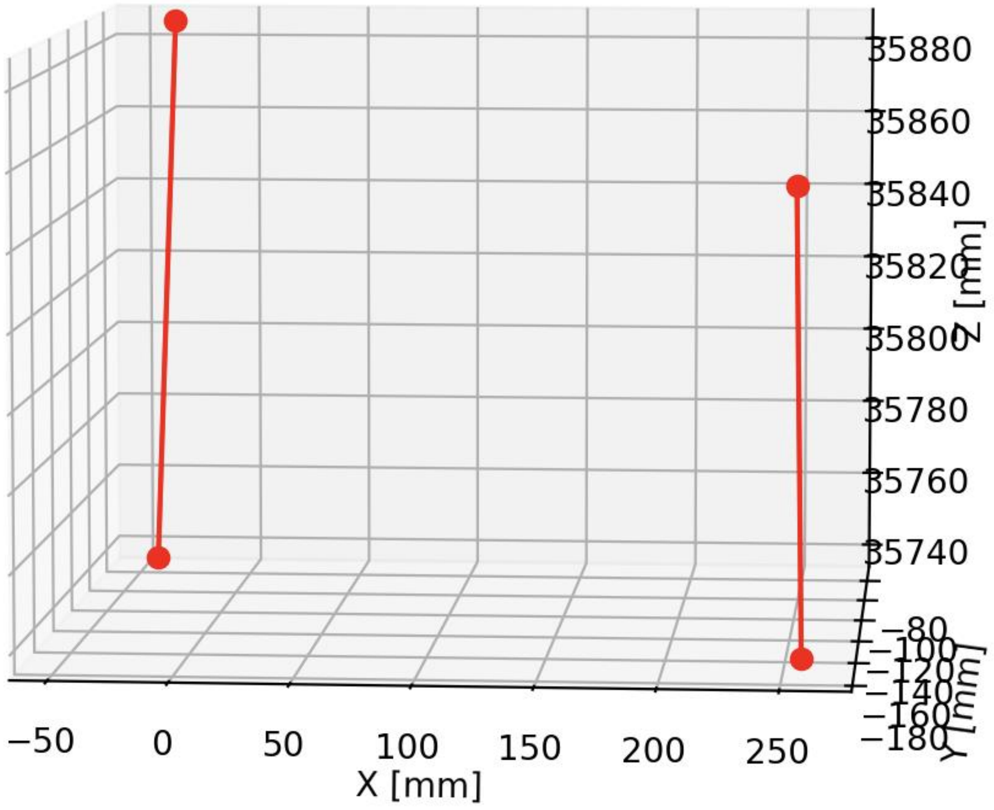
Pi0 Reconstruction





Reconstructed Photon Position Vectors
(different angles)

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Pi0 Reconstruction

- Estimated Pi0 vertex: [120.97403711 , -143.53297353, 36478.81265729]
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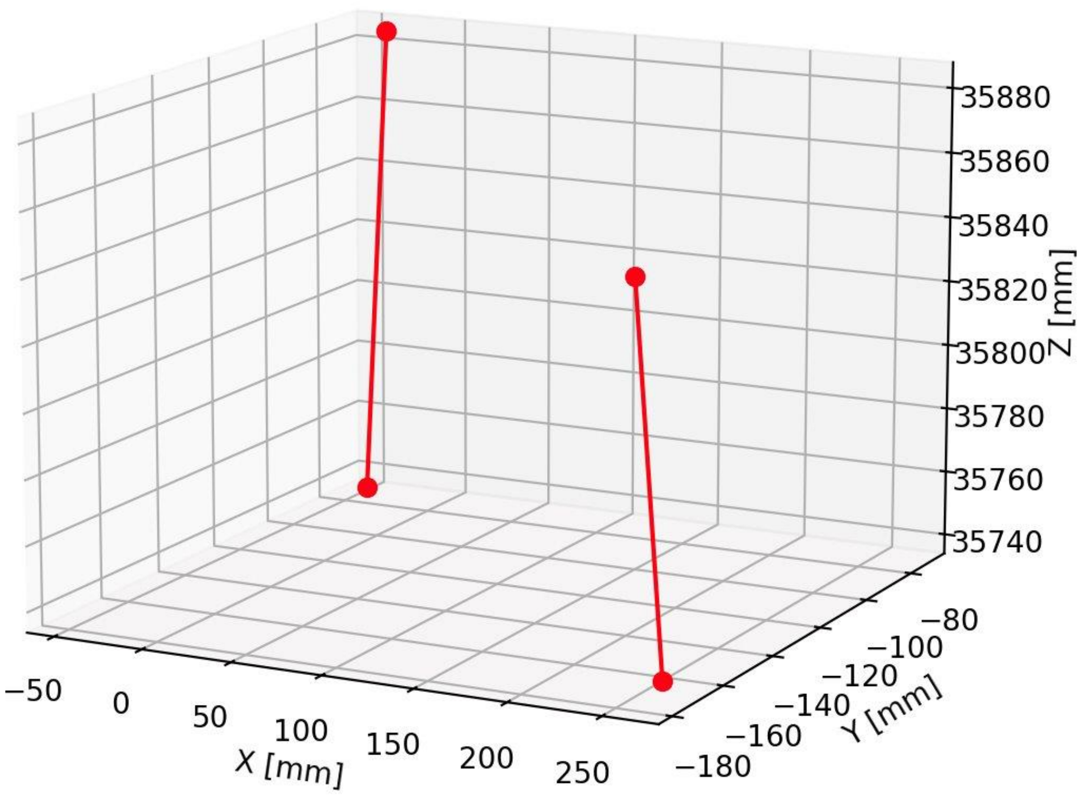
Reconstructed Photon Position Vectors



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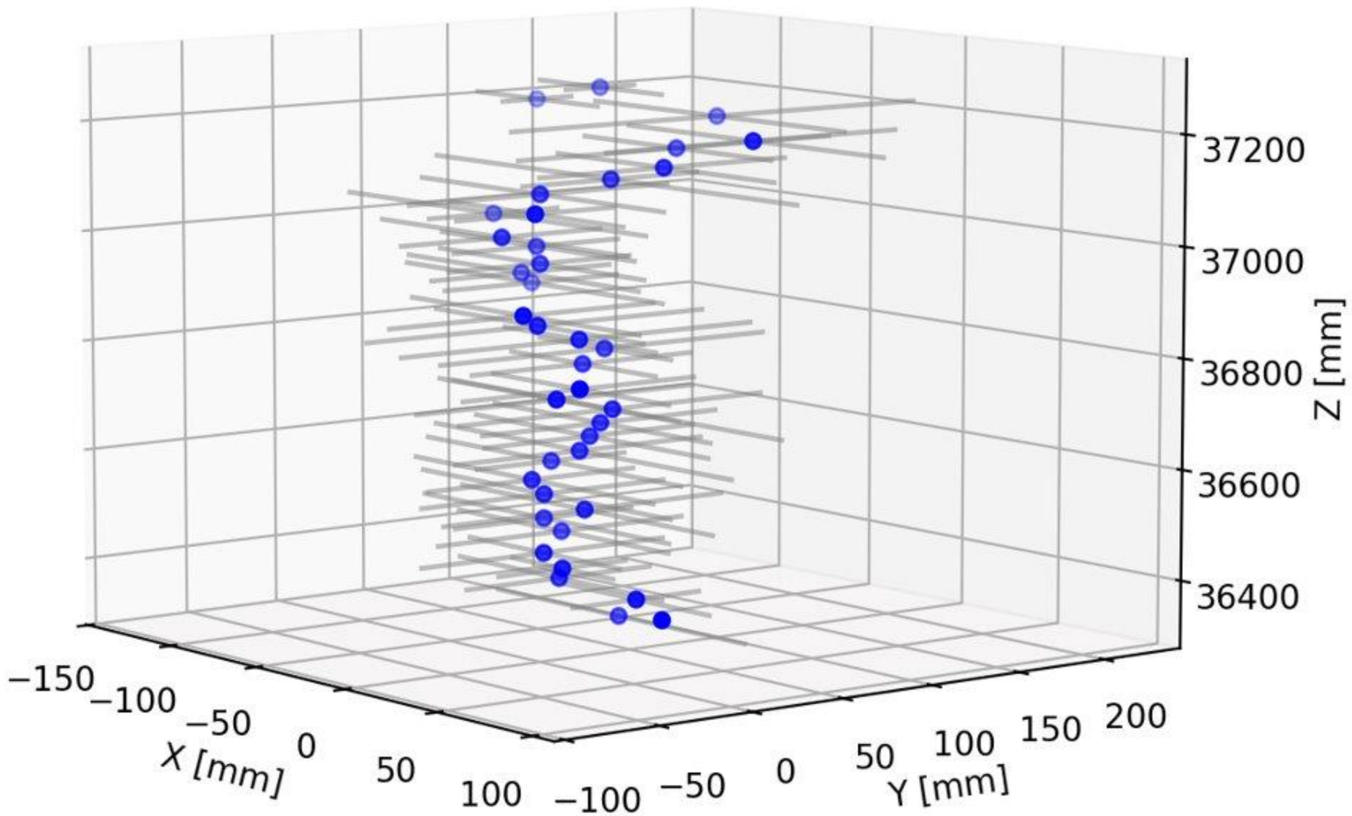
Pi0 Vertex Reconstruction: Next Steps

- Correct average hit position calculation (normalizing energy weights from 0 to 1 might help)
- Use energy weighted stdev to more accurately determine the error for estimated average hits
- Find the average hit position layer by layer in the HCal (similar to the neutron) and use the point with the lowest error along with the ECal hit to reconstruct the position vector
- Try and use relationship between photon distance in the ECal and the opening angle to more accurately estimate HCal hits
- The position vectors need to be coplanar to intersect at an exact point. Should we ensure this before trying to estimate the decay vertex?

Backup

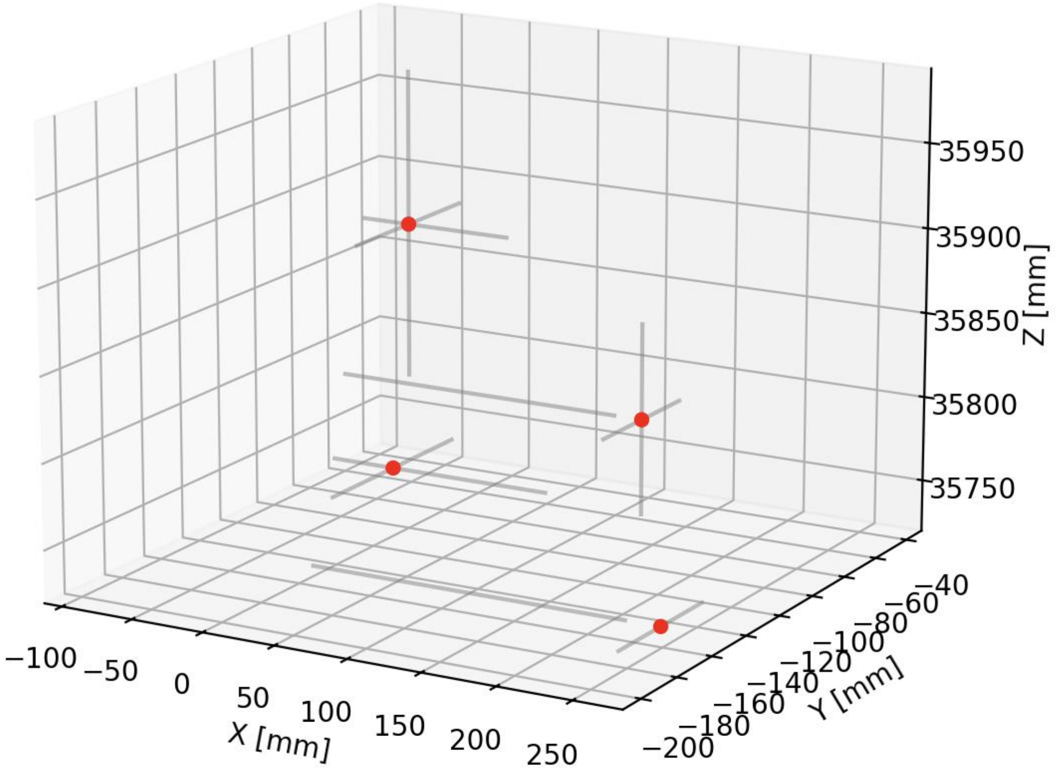
Neutron Reconstruction

Reconstructed Neutron hits with Error (stdev only)



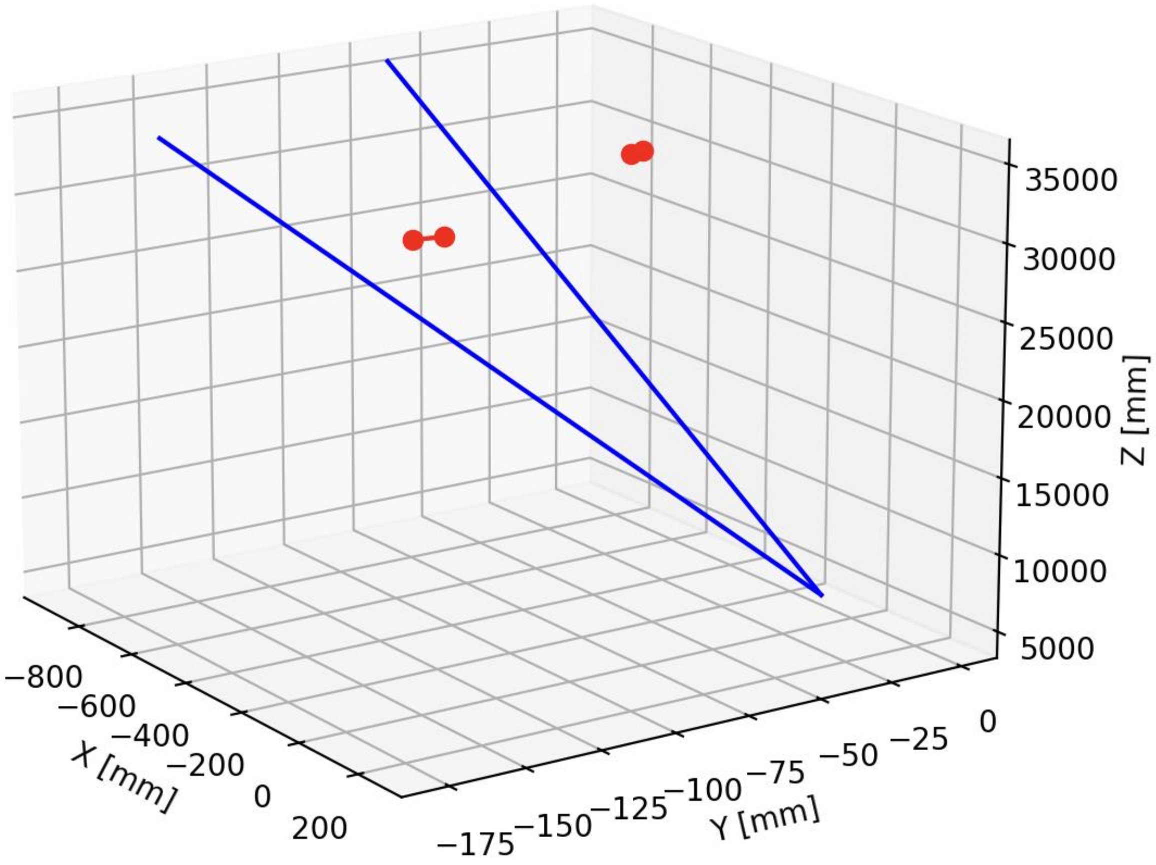
Pi0 Vertex Reconstruction

Reconstructed Photon Hits
with Error (stdev only)



Pi0 Vertex Reconstruction

Reconstructed Photon Vectors (red) and True Photon Vectors (blue)



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