Search Simulation Analysis Update

Tyler Hague

The Data

- Bethe-Heitler events
  - Both off of nucleus and an electron
- 100,000,000 events
  - Corresponds to 159 seconds of beam time
  - This is calculated using:
    - Integrated cross section (4pi) of sample – 1.83 x 10^11 pb
    - Luminosity at 100nA – 3.45 x 10^-6 (pb * s)^-1

Steps to Analysis

- I have broken the analysis into two distinct portions
  - “Preprocessing”
    - Takes care of things that happen before the “data” gets to the analyzers
  - “Real analysis”
    - Steps that are equivalent to what would happen when analyzing real data

Preprocessing

- Cut out beam hole in center
  - 2x2 block beam hole
- Check trigger
  - Is greater than 70% of the beam energy deposited?
- Merge hits
  - Hits closer than sqrt(2) * block size cannot be distinguished by HyCal, so merge these
  - Average their positions, weighted by energy
  - Sum their energies
  - For first pass (i.e. ignoring GEMs), if one is charged call the hit charged
- Cut 2 inner layers of hycal
  - +/- 3 blocks (6cm) from (0,0)

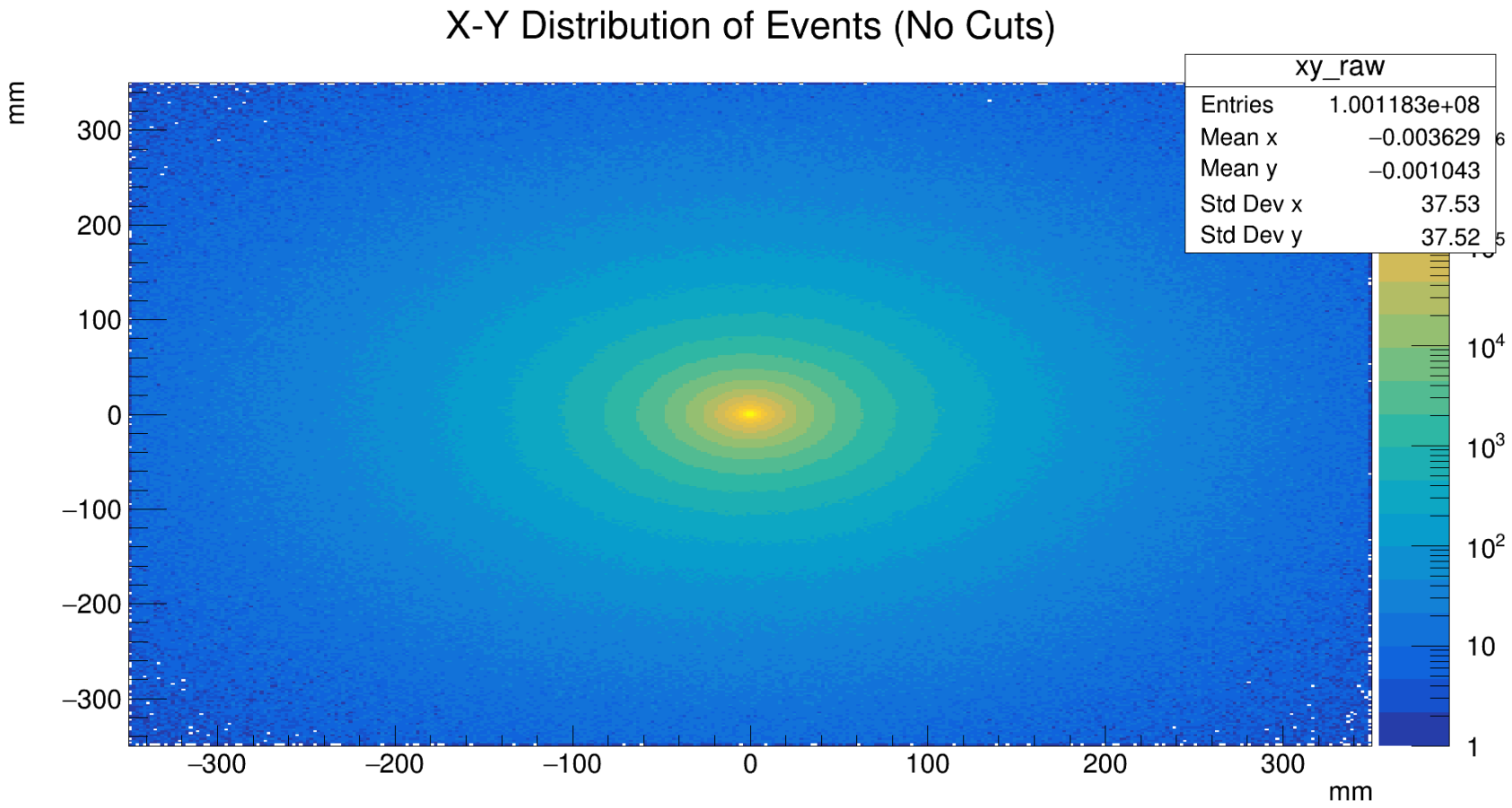
“Analysis”

- Remove hits with less than 2% of beam energy and greater than 85% of beam energy
  - Removes accidentals and Mott scattering
- Remove uncharged hits
- Require exactly 3 hits left
- Energy conservation
  - +/- 150 MeV of beam energy
- Coplanarity
  - +/- 5 degrees delta phi between e` and X candidates

Preprocessing Plots

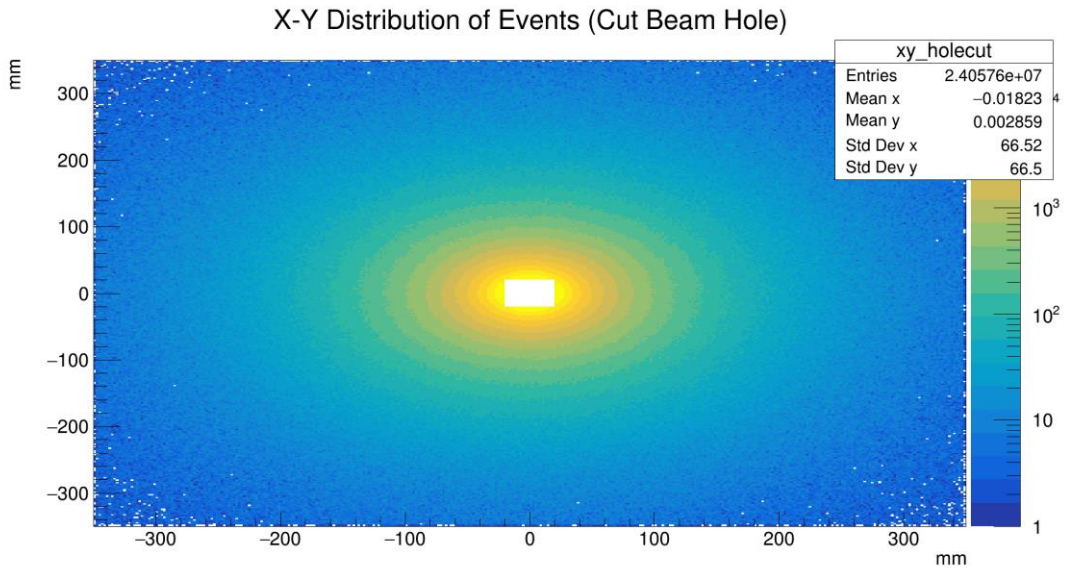
Raw Position Distribution (no cuts)

Nucleus and Electron BH both included (typo prevented their separation in this plot)

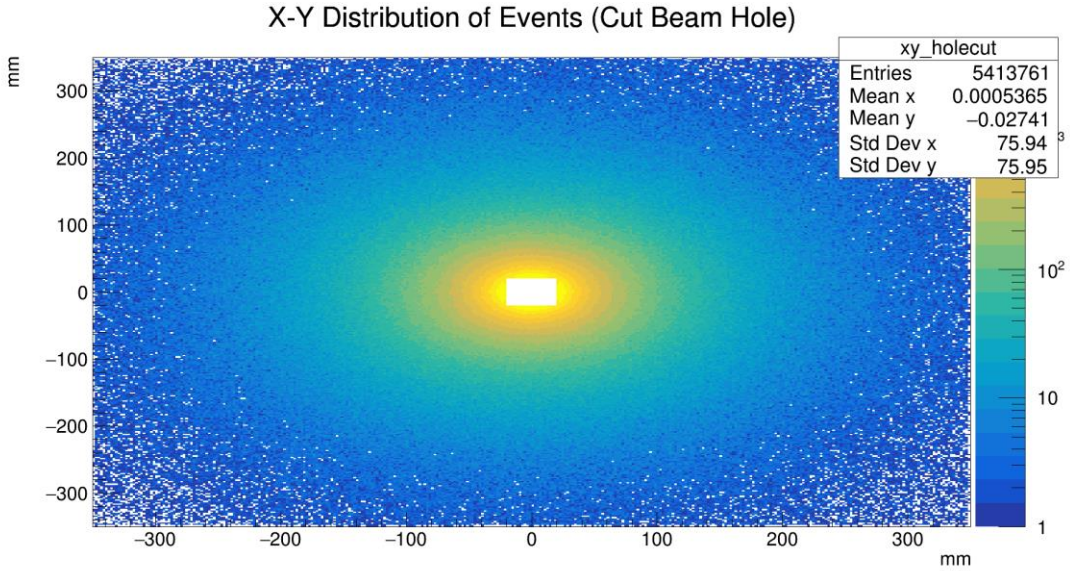


Position Distribution (Beam hole cut)

Nucleus

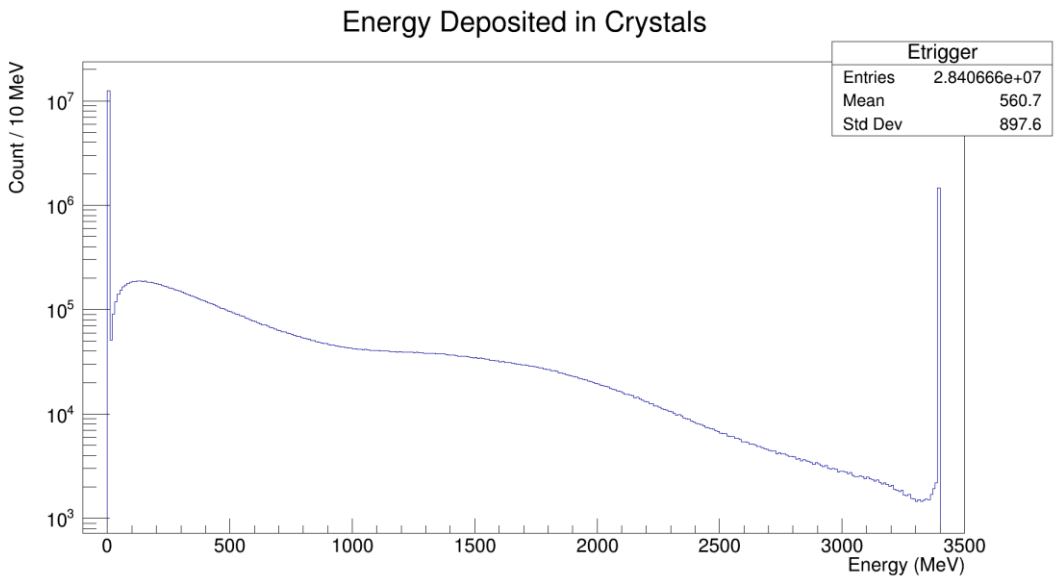


Electron

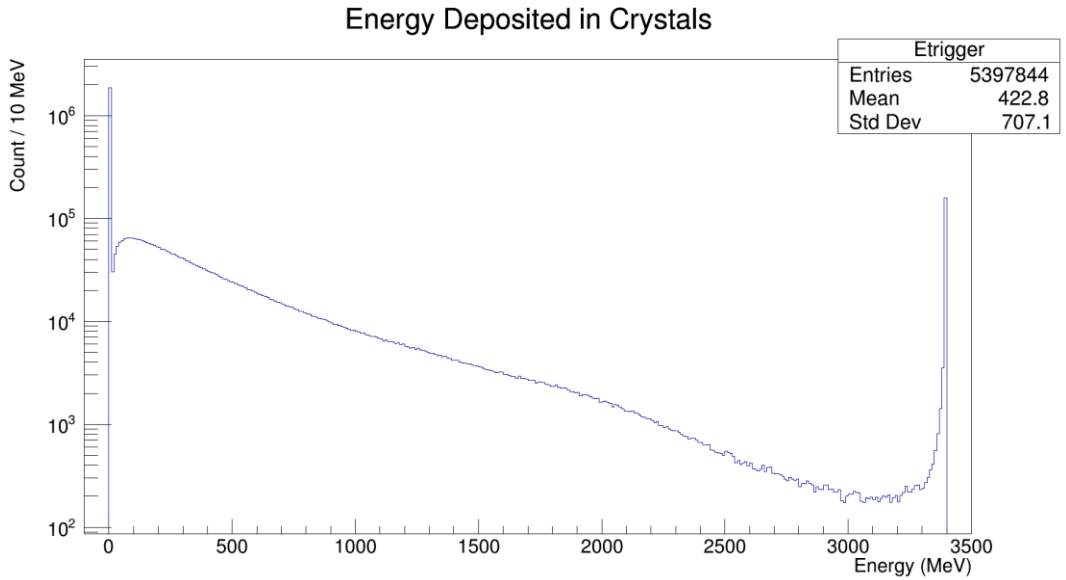


Energy Deposited in HyCal

Nucleus



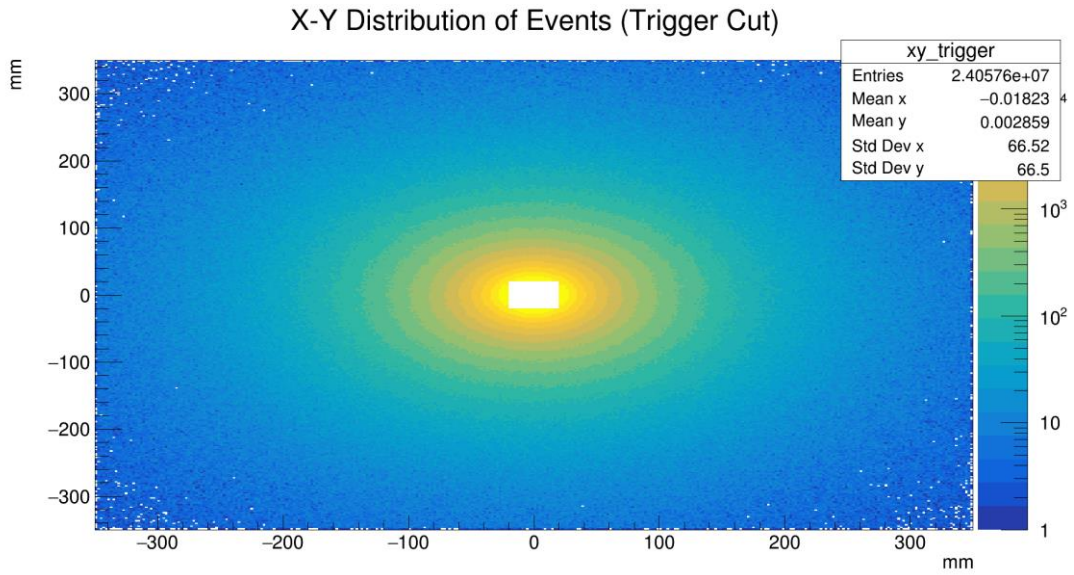
Electron



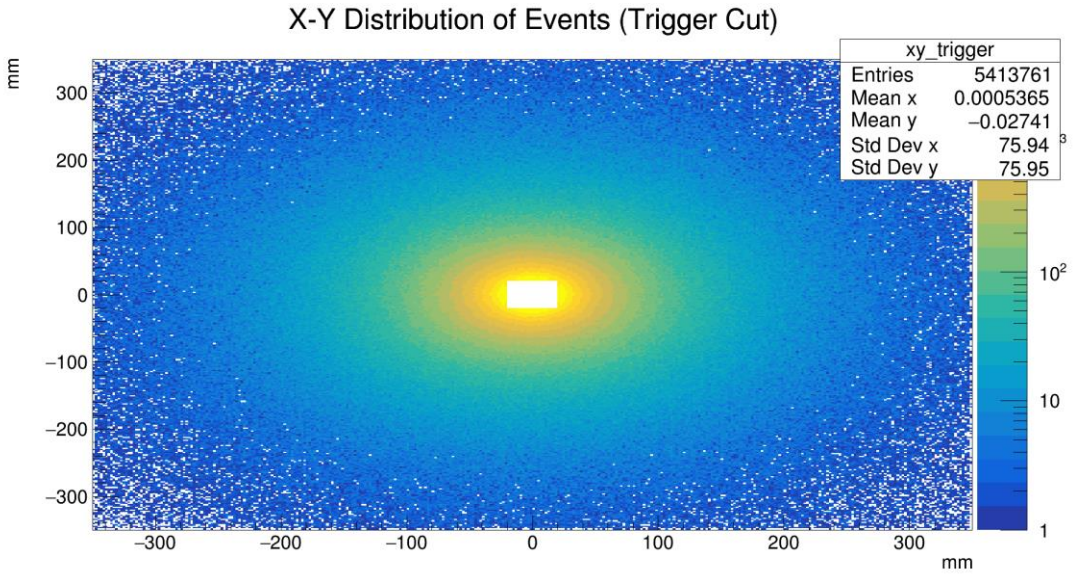
This data sample has a 3400 MeV beam energy. This is then cut at deposited energy greater than 2380 MeV (3400*0.7) to simulate the trigger, as defined in the proposal.

Position Distribution after Trigger Energy Cut

Nucleus

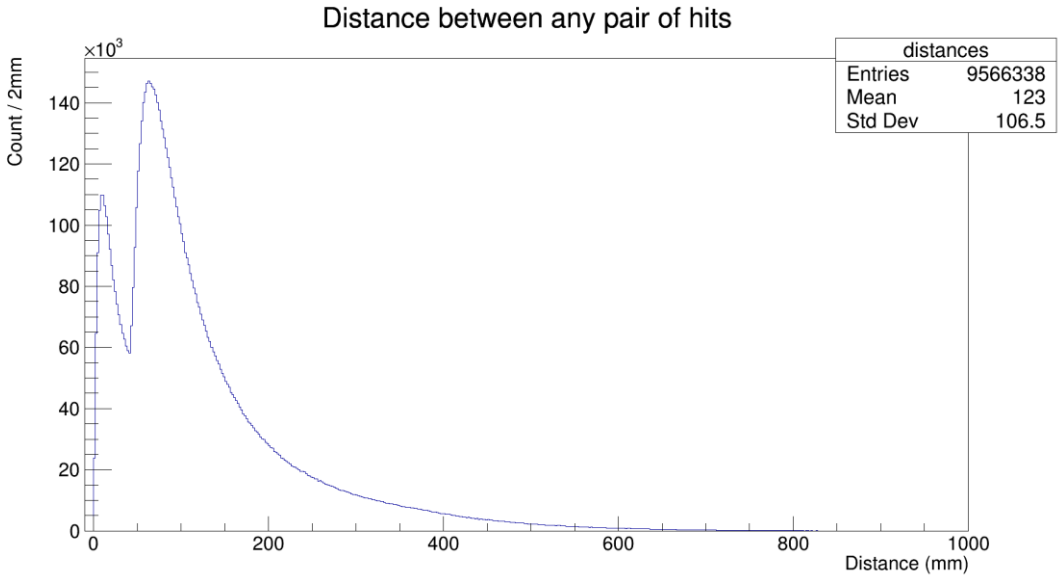


Electron

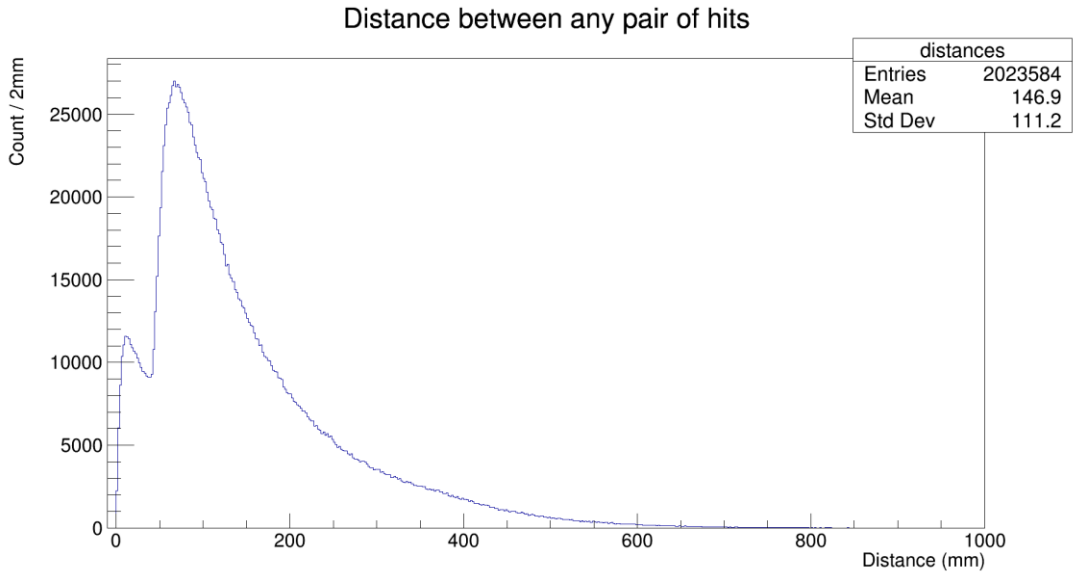


Distance between any pair of showers

Nucleus



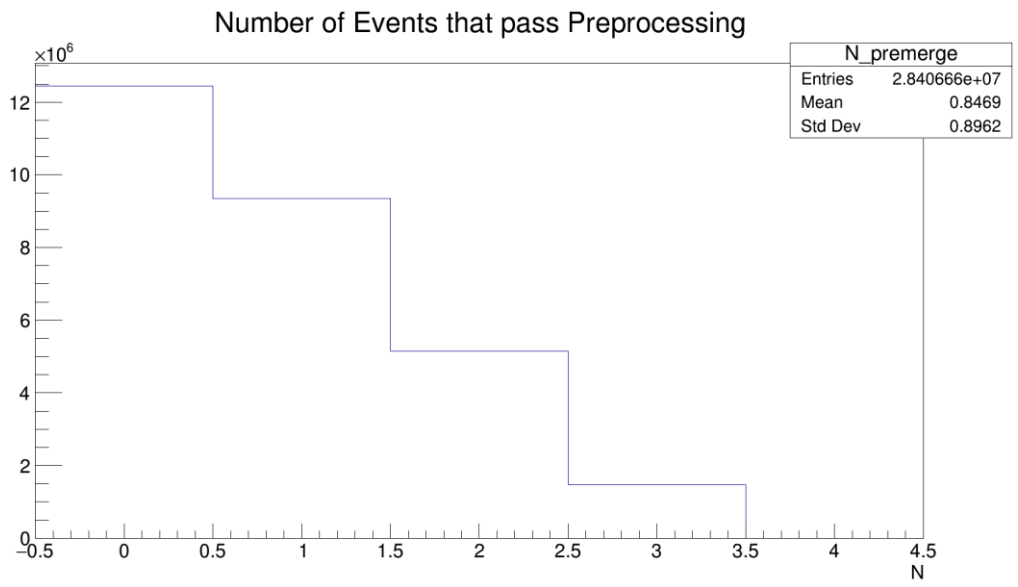
Electron



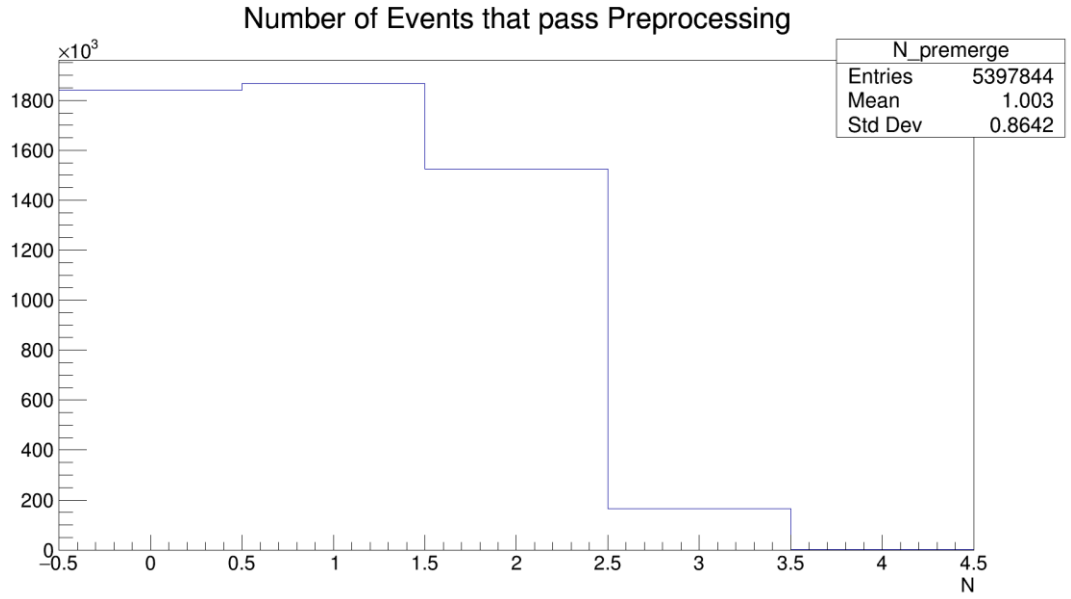
HyCal can only distinguish hits that are greater than sqrt(2)*crystal size (~30 mm) apart. Any hits closer than that are merged by summing their energies and averaging their positions (weighted by energy).

Number of showers per event before merge

Nucleus

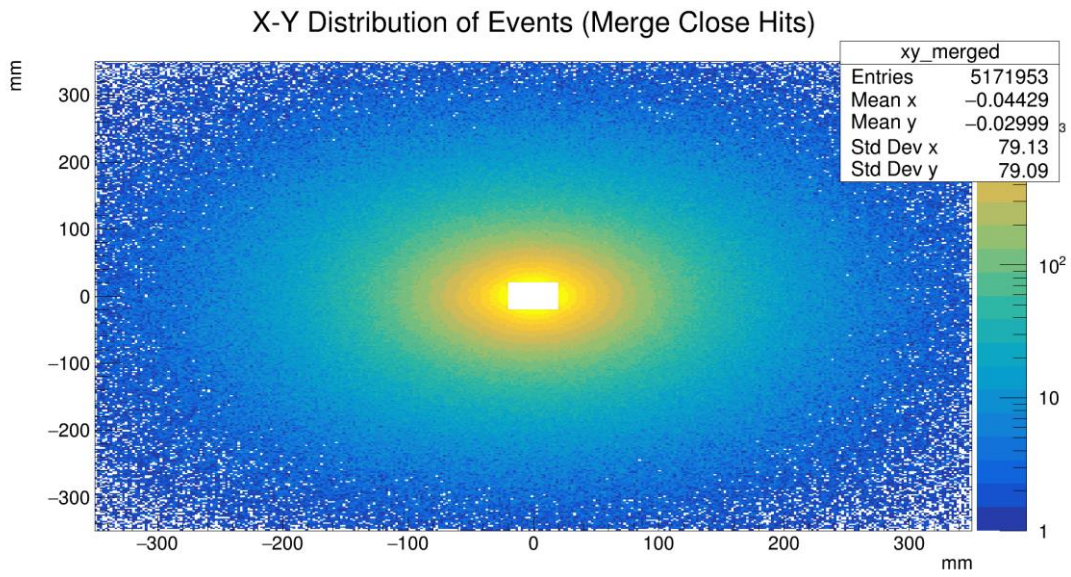


Electron

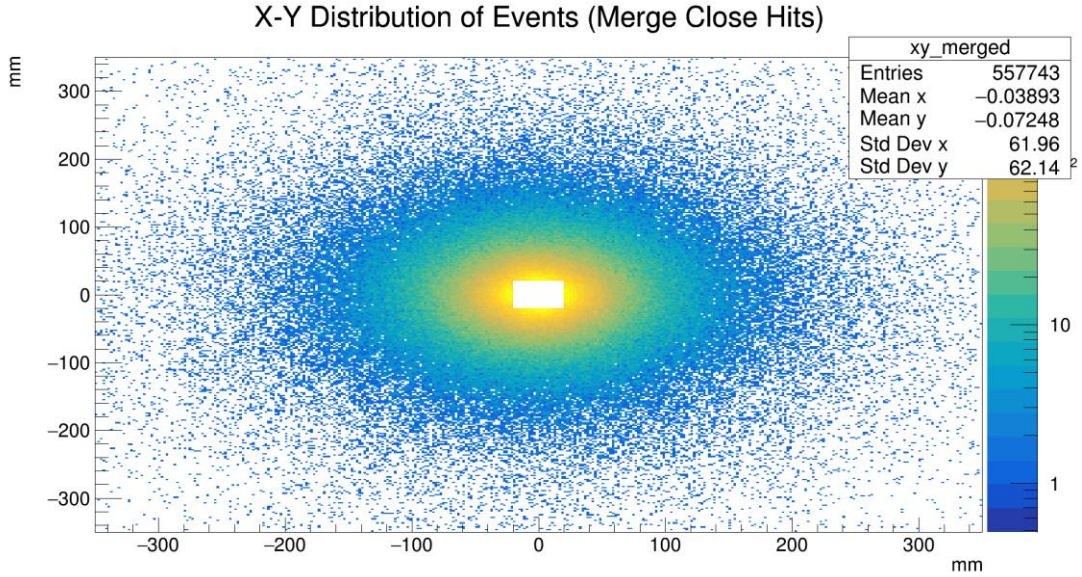


Position Distribution after merging hits

Nucleus

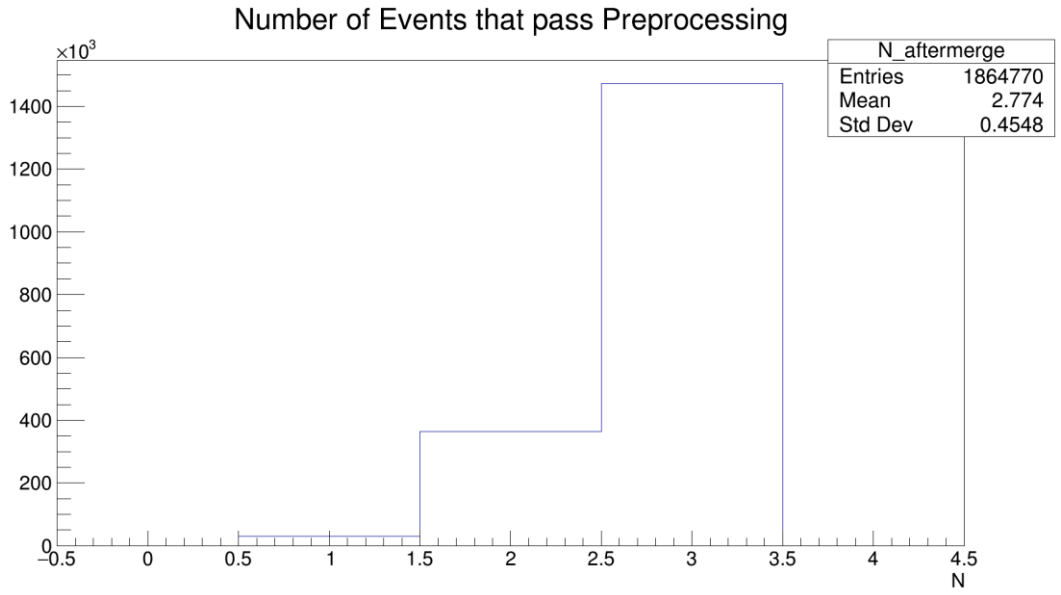


Electron

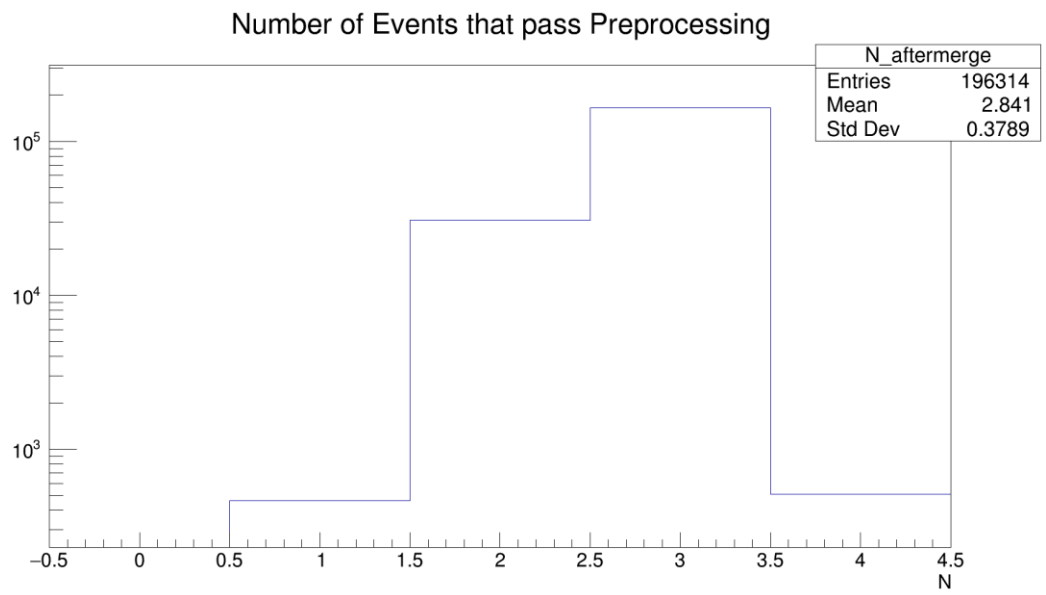


Number of showers per event after merge

Nucleus



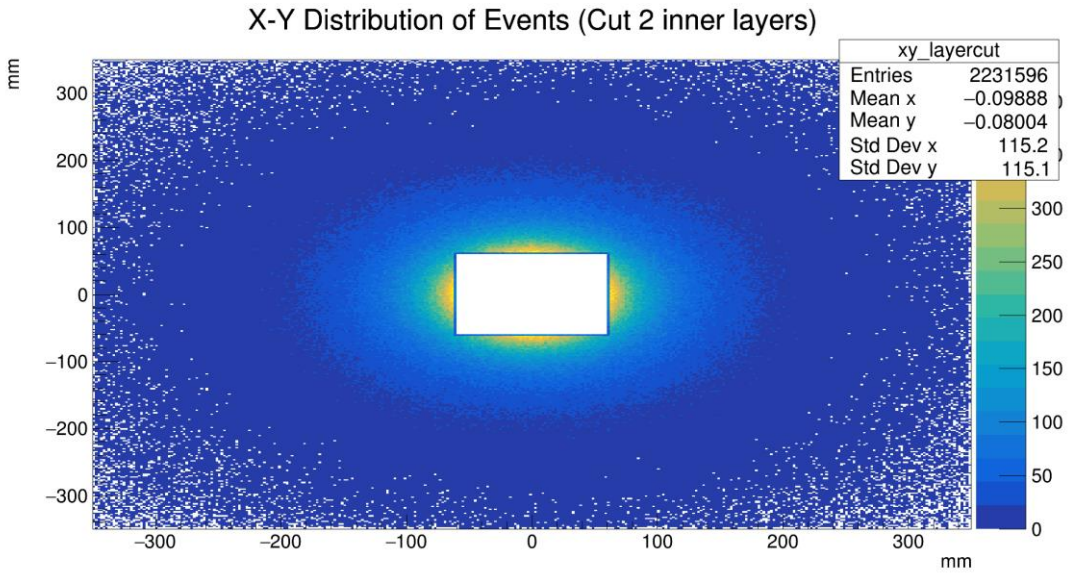
Electron



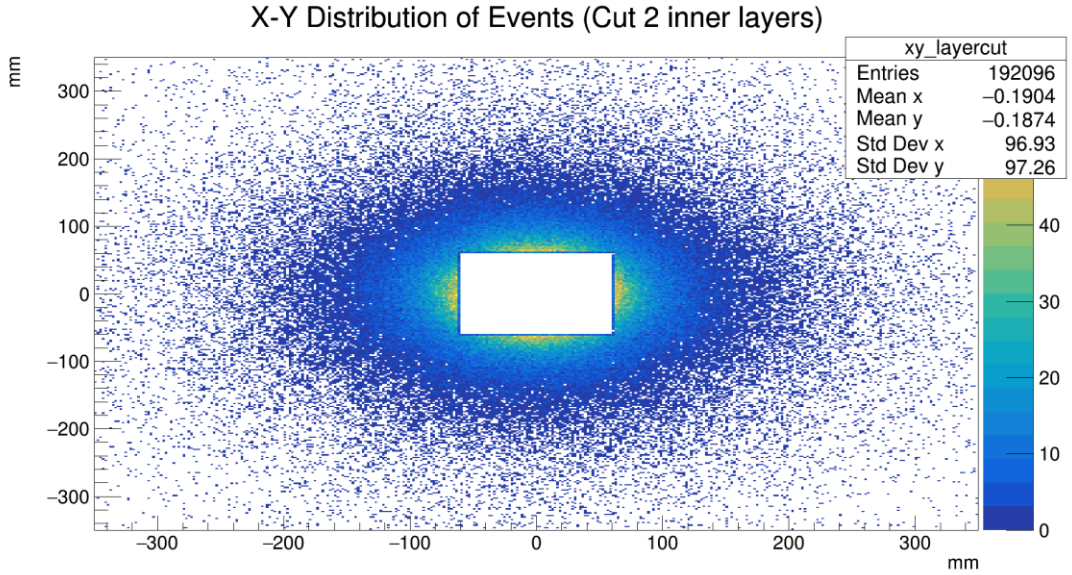
Note that y scale is log on electron plot to show that there are events with 4 leptons

Position Distribution after cutting two layers

Nucleus



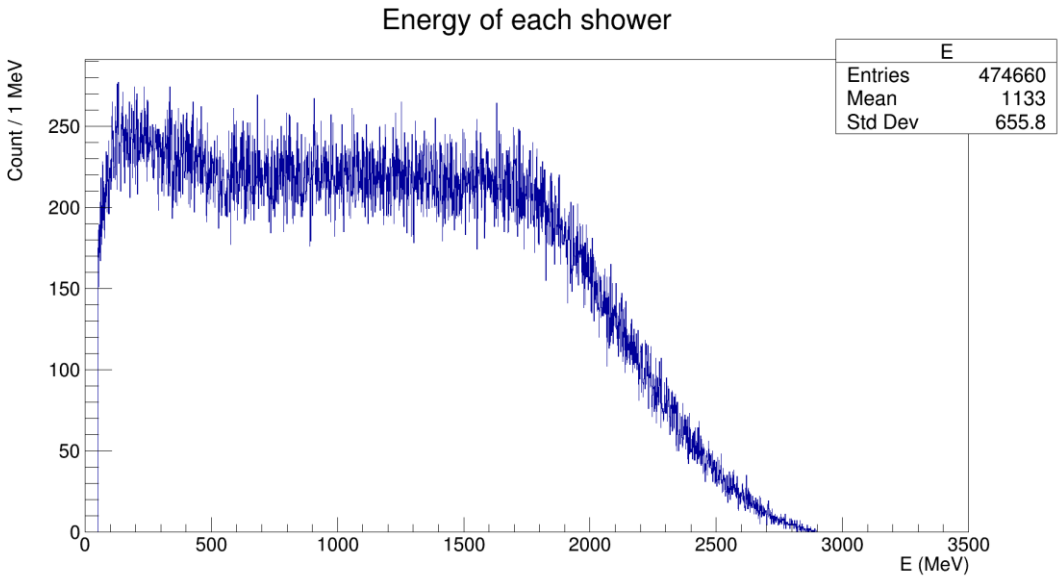
Electron



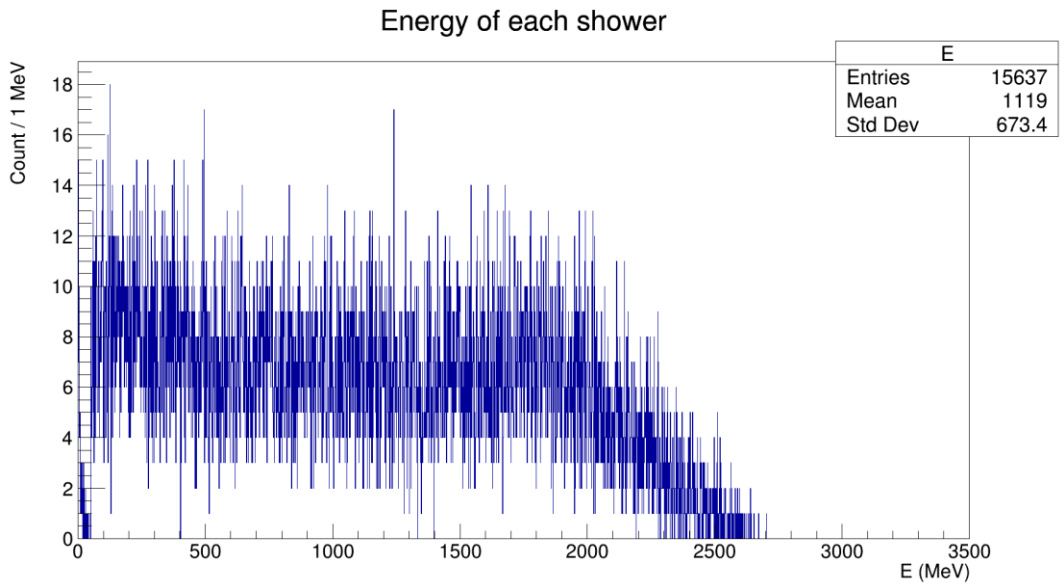
Analysis Plots

Energy of showers before shower selection

Nucleus



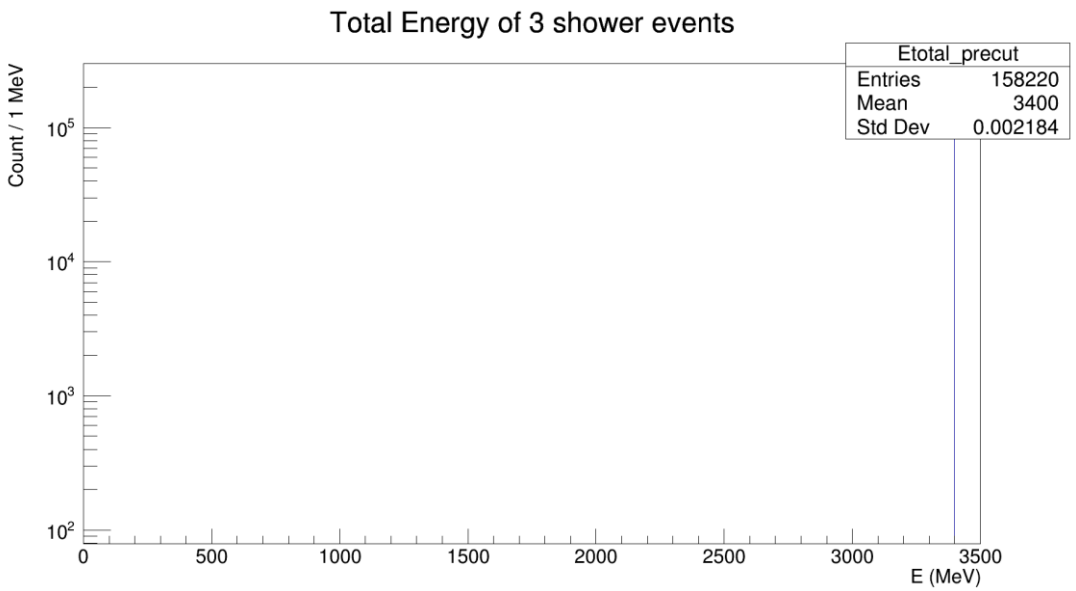
Electron



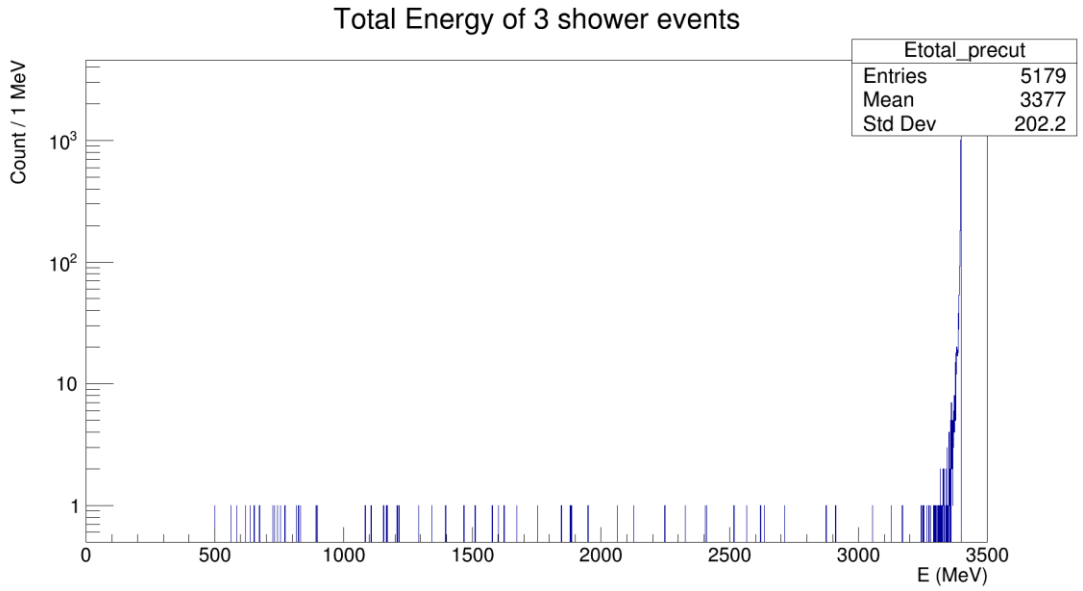
Shower selection is 3 charged hits with energy between 2-85% of the beam energy. Events are rejected if there are more or less than 3 hits that meet these criteria.

Total energy of selected showers

Nucleus



Electron

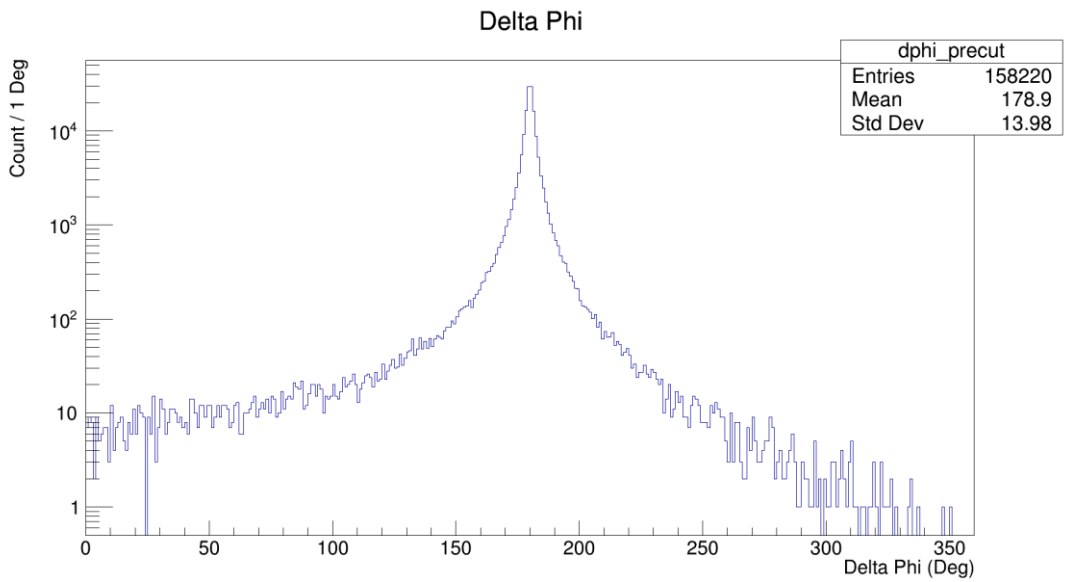


Energies have not been smeared, so a spike at exactly the beam energy is expected.

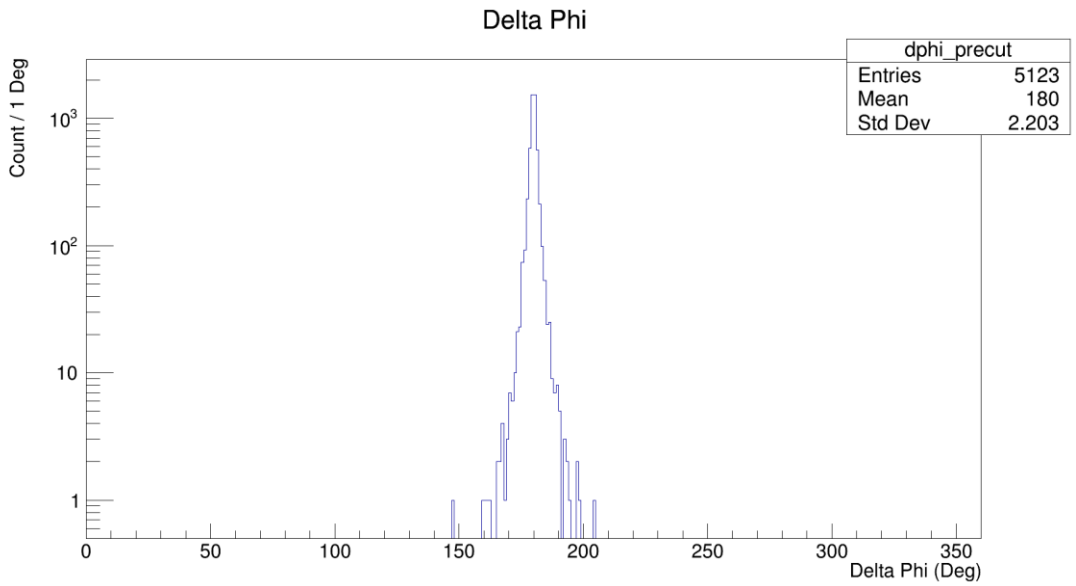
Energy conservation is applied as +/- 150 MeV of the beam energy (3400 MeV)

Delta Phi between any pair of showers and the corresponding e`

Nucleus



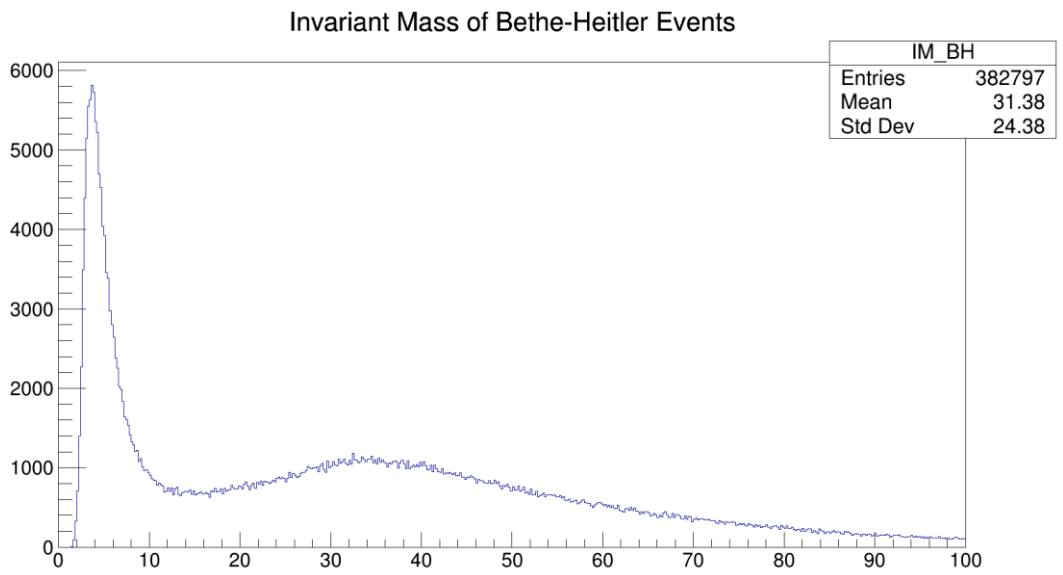
Electron



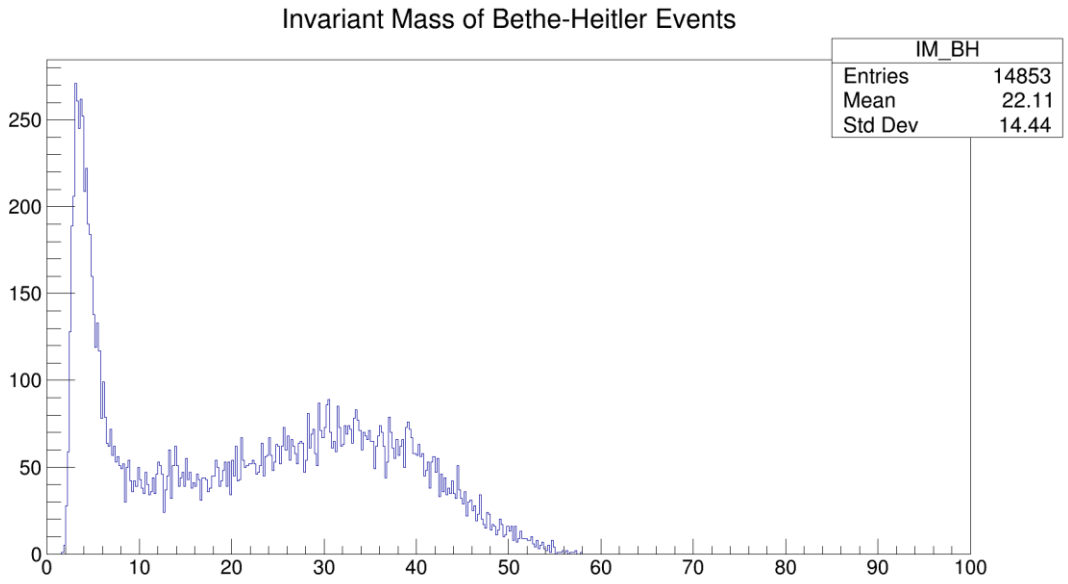
180 degrees is coplanar. Cut on +/- 5 degrees of coplanar.

Invariant Mass of all combinations that pass cuts/selections

Nucleus



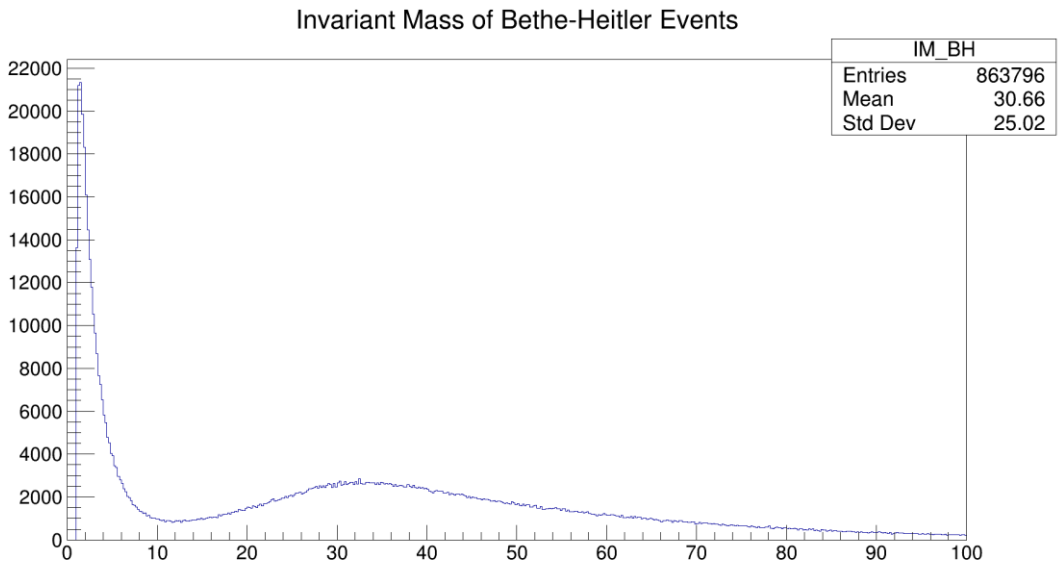
Electron



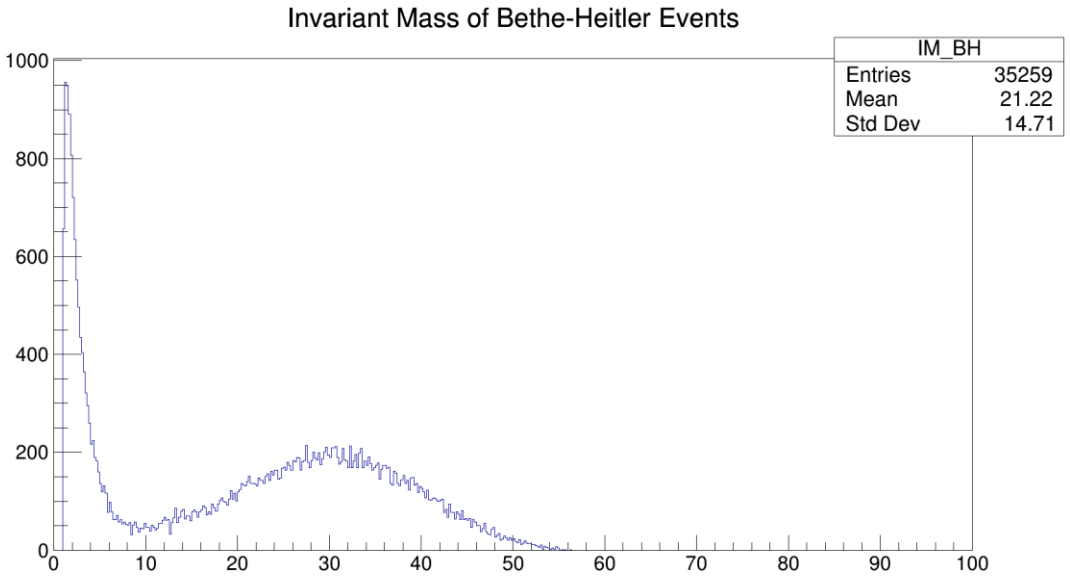
Bethe-Heitler off of the electron constitutes ~3.7% of the BH sample

Out of curiosity, I did all of the same steps but omitted the merging close hits step
The invariant mass is:

Nucleus



Electron



I was curious if the electron BH yield would be lower without merging due to the possibility of 4 leptons being merged to 3. This plots suggests that my guess was mistaken. Both mechanisms increased by approximately the same amount.