First steps to Res-CCπ^0

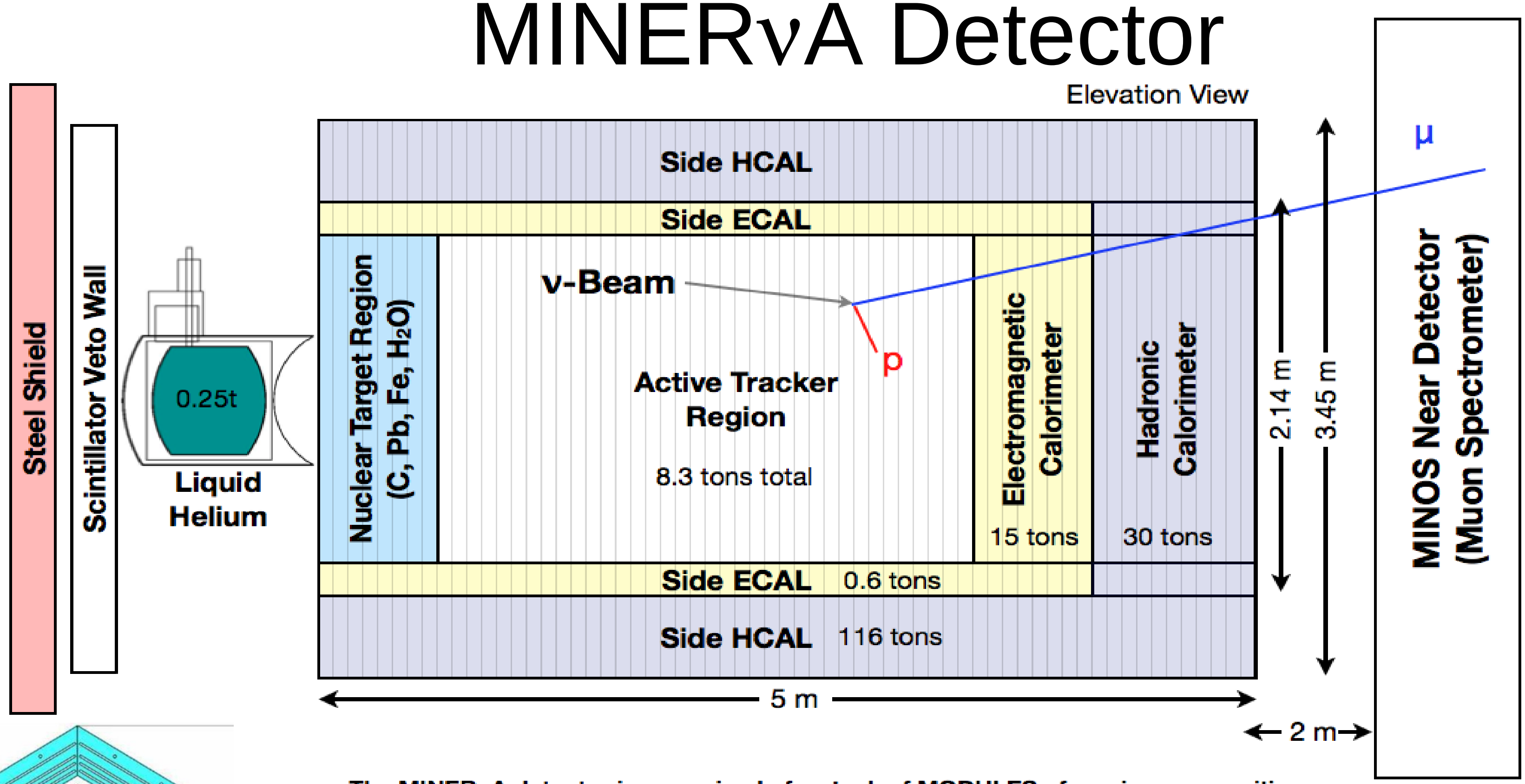
José Palomino

Brazilian Center for Physics Research - CBPF

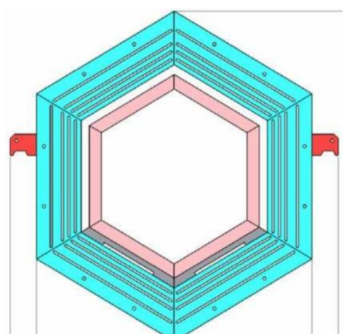
Overview

- MINERνA.
- Motivation.
- EM Showers.
- Shower characterizations:
  - Shower filter.
  - π^0 mass like discriminator.
  - Shower direction.
- Blobs* to contain Photons.

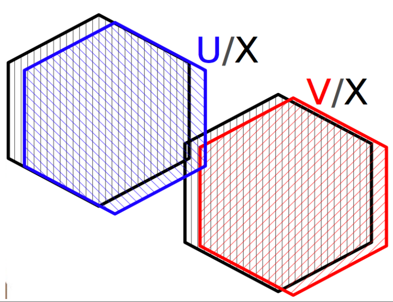
MINERνA Detector

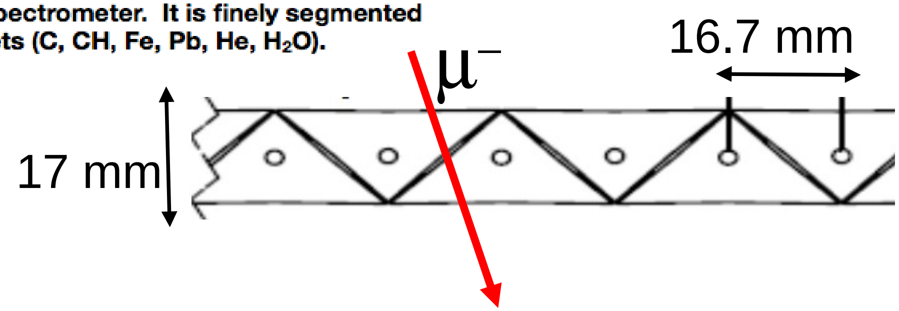


The MINERνA detector is comprised of a stack of MODULES of varying composition, with the MINOS Near Detector acting as a muon spectrometer. It is finely segmented (~32 k channels) with multiple nuclear targets (C, CH, Fe, Pb, He, H_2O).

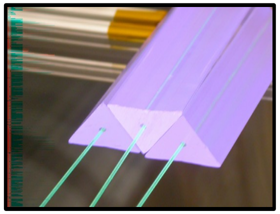


127 scintillator strips per plane.





Tracker module = 2 planes
ECAL module = 2 planes + 2 (2 mm thick) sheet of lead
HCAL module = 1 plane + 1 (1 inch thick) sheet of steel



Triangular strip to allow charge sharing

Motivation

- One of the largest limitations on neutrino experiments comes from the not complete information about neutrino cross sections in the GeV energy range.
- High statistics and the final states characterization will improve these measurements(detector granularity and good reconstruction).
- Importance to oscillation searches($\nu_\mu \rightarrow \nu_e$): they also have to recognize muon and electron(E.M. shower) and one of the main backgrounds to the ν_e signal comes from ν_μ interactions producing π^0's. The π^0's cross section estimation is very important.

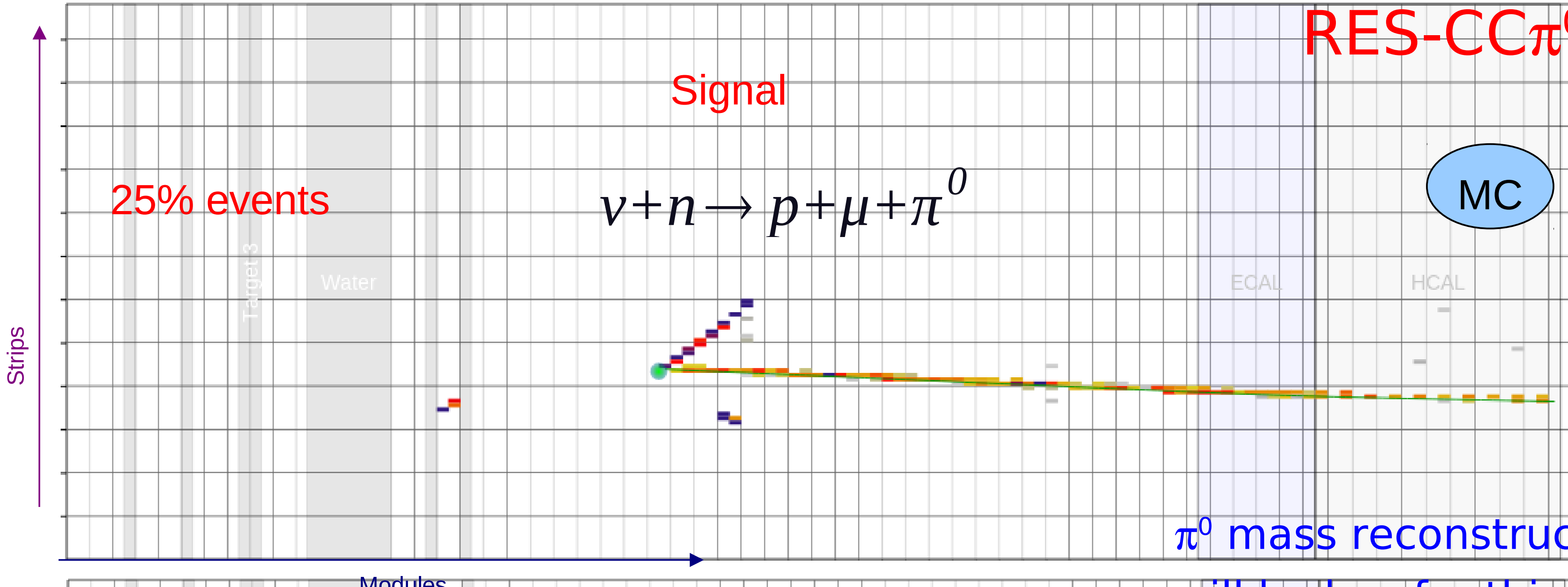
Motivation

RES-CCπ^0

Signal

25% events

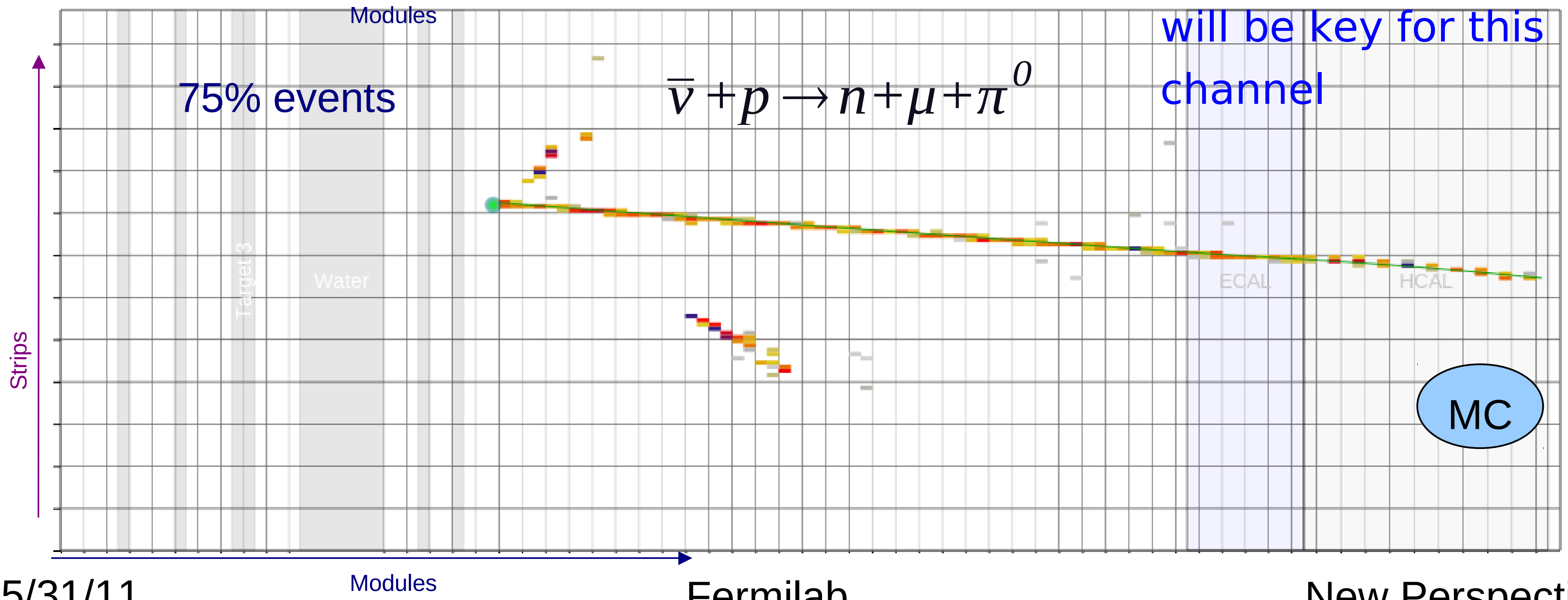
$$\nu + n \rightarrow p + \mu + \pi^0$$



π^0 mass reconstruction will be key for this channel

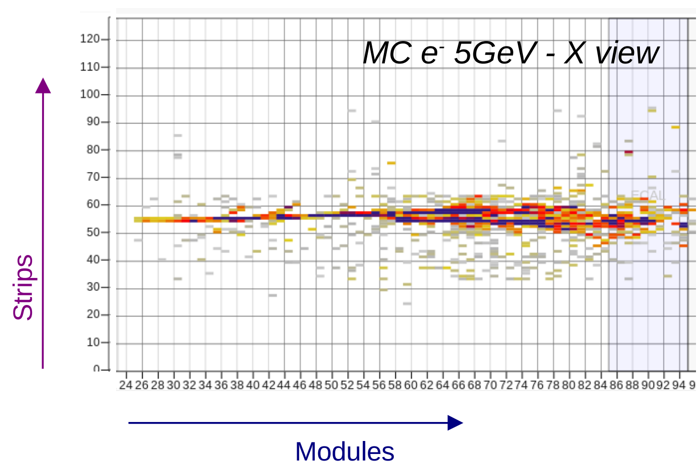
75% events

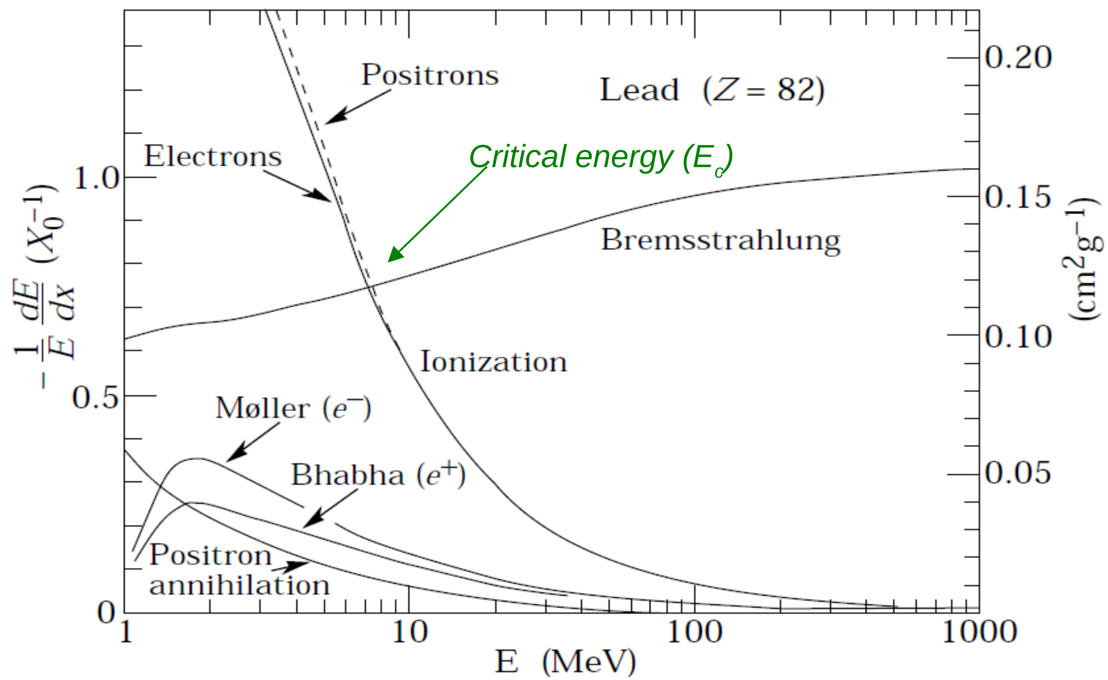
$$\bar{\nu} + p \rightarrow n + \mu + \pi^0$$



EM showers

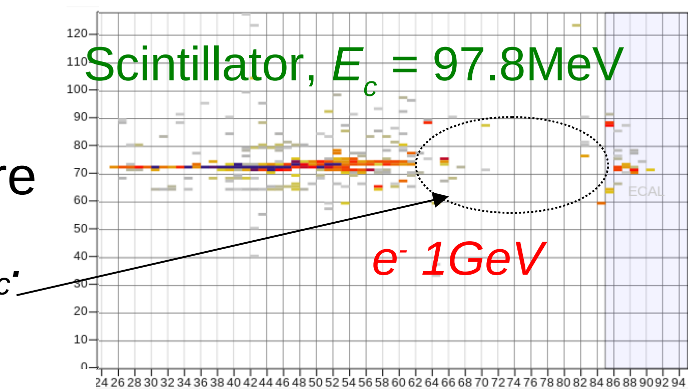
- Particle multiplication driven by bremsstrahlung(e^- and e^+) and pair production(γ).
- Ionization process is the most basic mechanism to deposit energy.

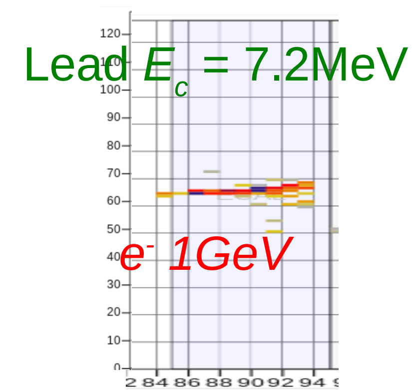




$$E_c = \frac{610\ \mathrm{MeV}}{Z + 1.24}$$

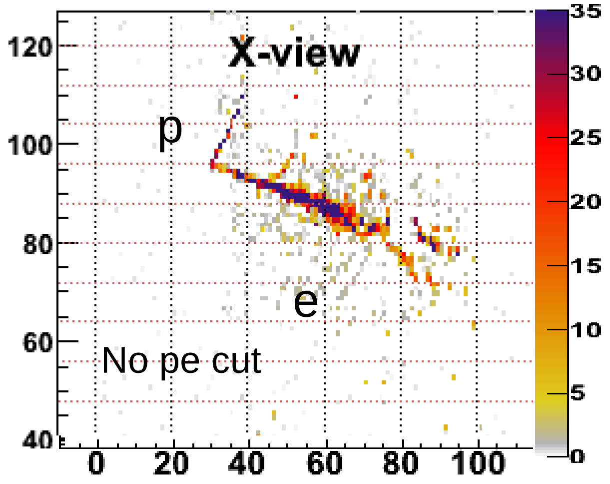
- Particle multiplication is dominant when E_c(Z high) is lower than shower energy.
- There can be gaps when there are non energetic showers and high E_c.

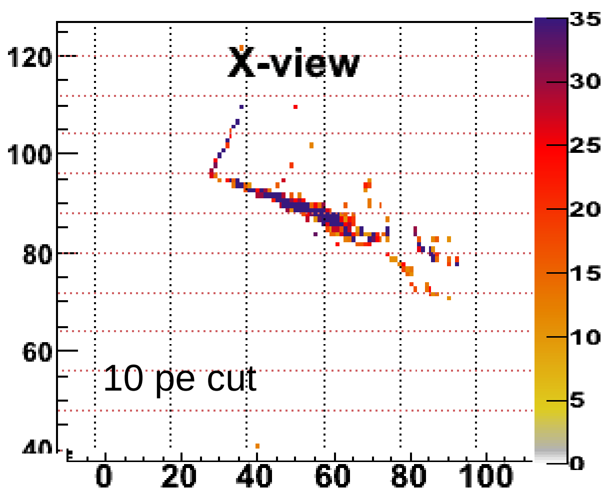


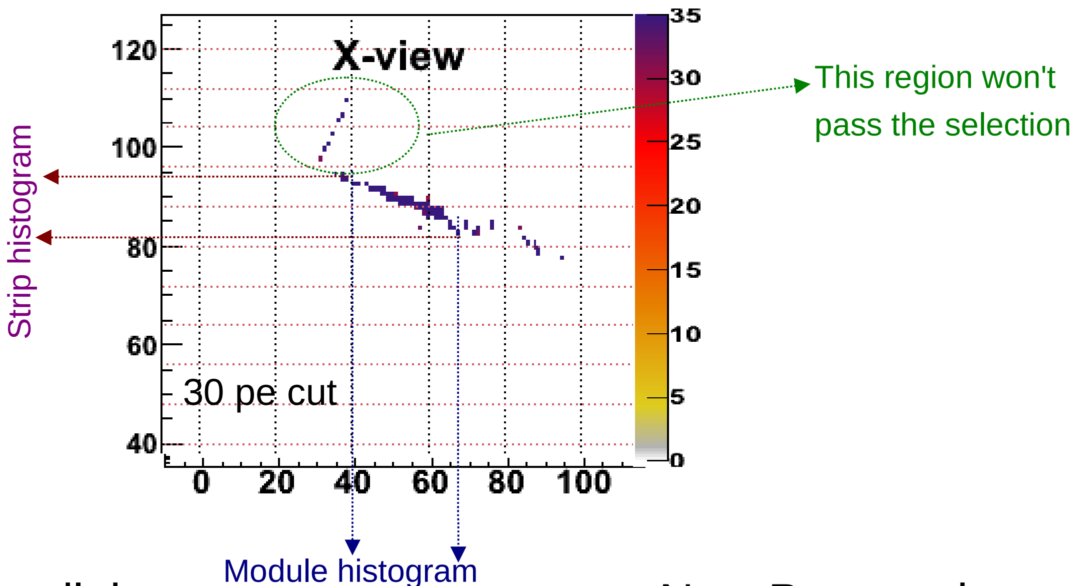


Shower Filter

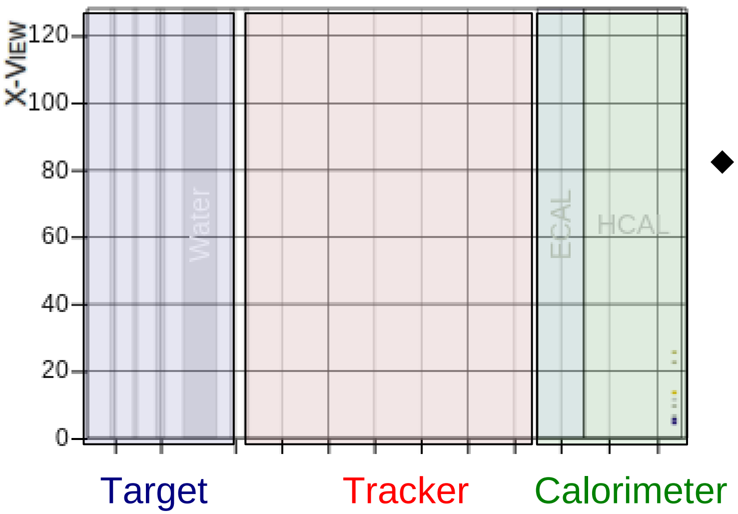
- I started using an event sample selected by “hand scan” with notorious electromagnetic showers topology (no tracks).
- Then apply an appropriate energy cut to isolate the main core of the shower.
- Project the shower core into “Module and Strip histograms”, those histograms have to pass RMS threshold and minimum number of entries.



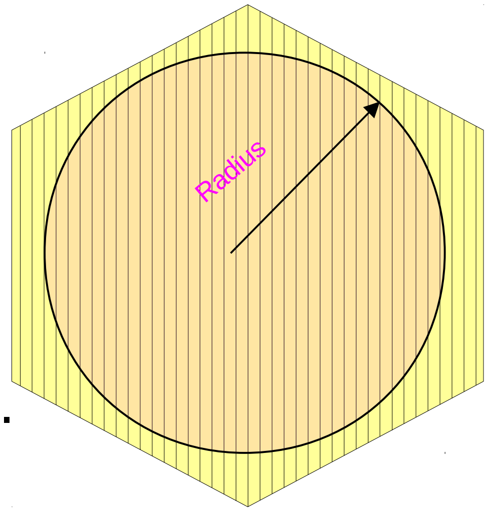




Shower Filter



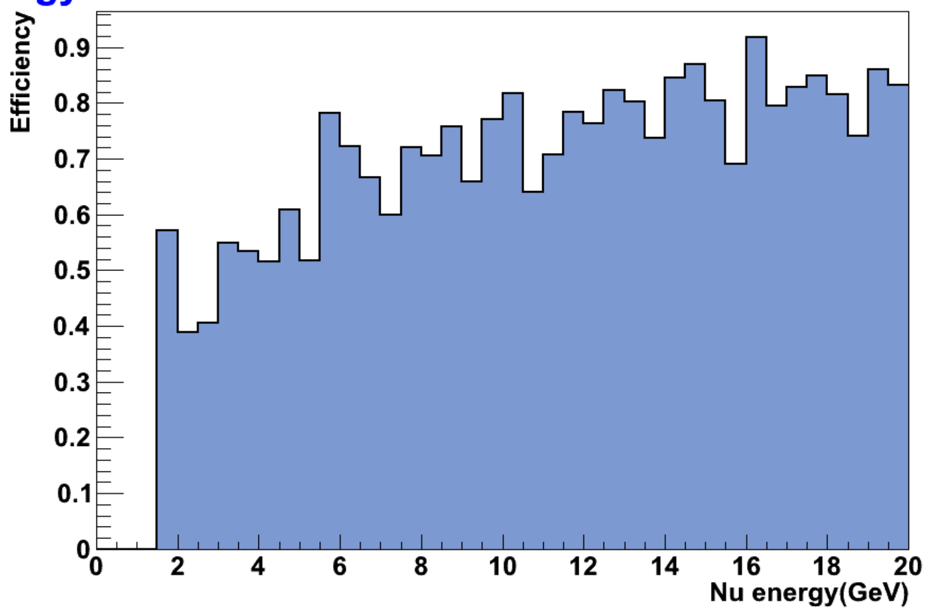
- I took a sample to efficiency study:
  - MC Low Energy mode (ν_u and ν_e) ~ 100K events.
- Additional cuts:
  - Incoming neutrino energy 1 – 20GeV.
  - Vertex Z position inside the Tracker Region.
  - Transversal vertex position has to be inside circular region (Radius = 800mm).



- Potential Candidates *(e^-'s, γ's, π^0's)*.
- Main Candidates *(e^-'s > 1 GeV, γ's > 1GeV and π^0's > 1.5GeV)*.
- Efficiency = #Main Candidates (pass filter) / #Main Candidates.
- Purity = *#Potential Candidates(pass filter) / #Candidates(pass filter).*

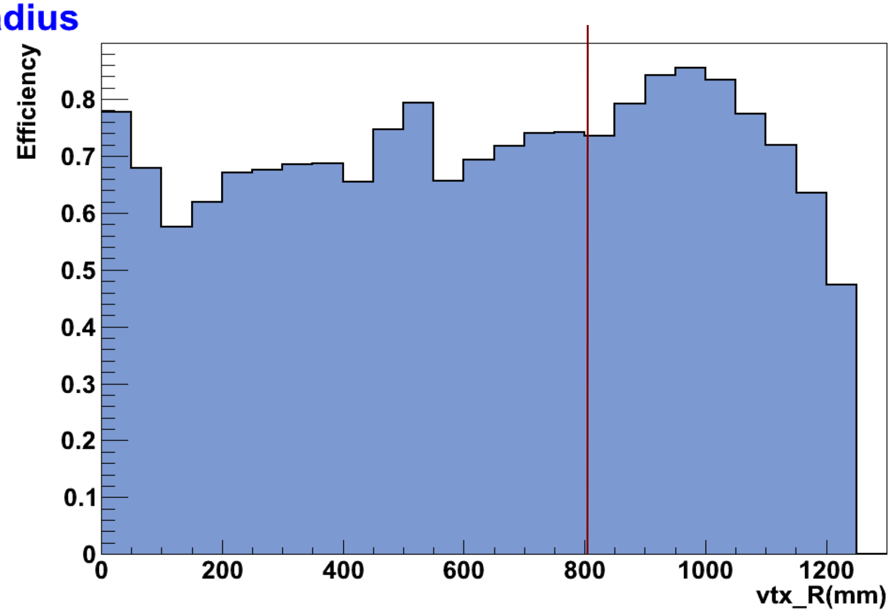
Shower Filter - Efficiency

Energy

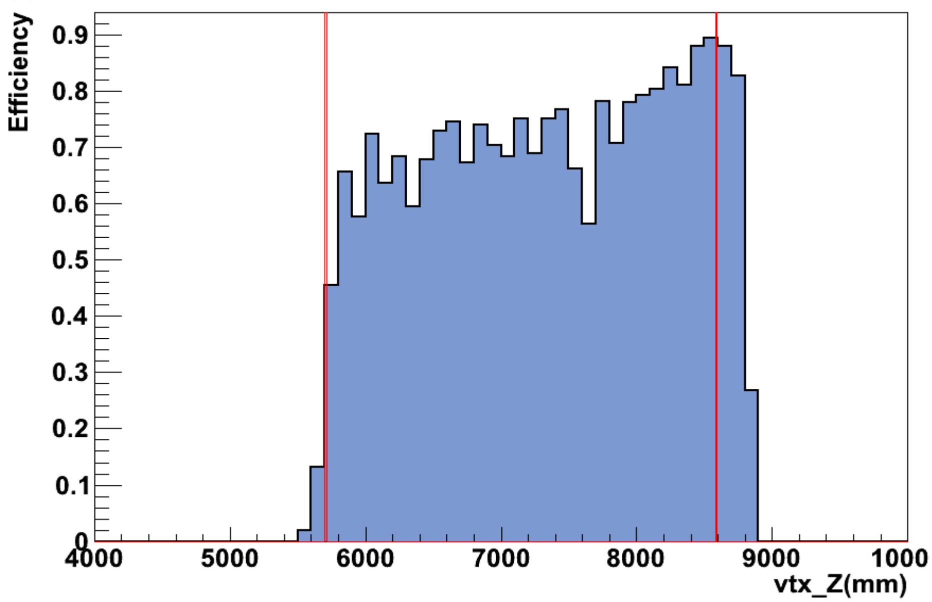


Purity is ~88%, where most of the "fake events" are coming from DIS channel

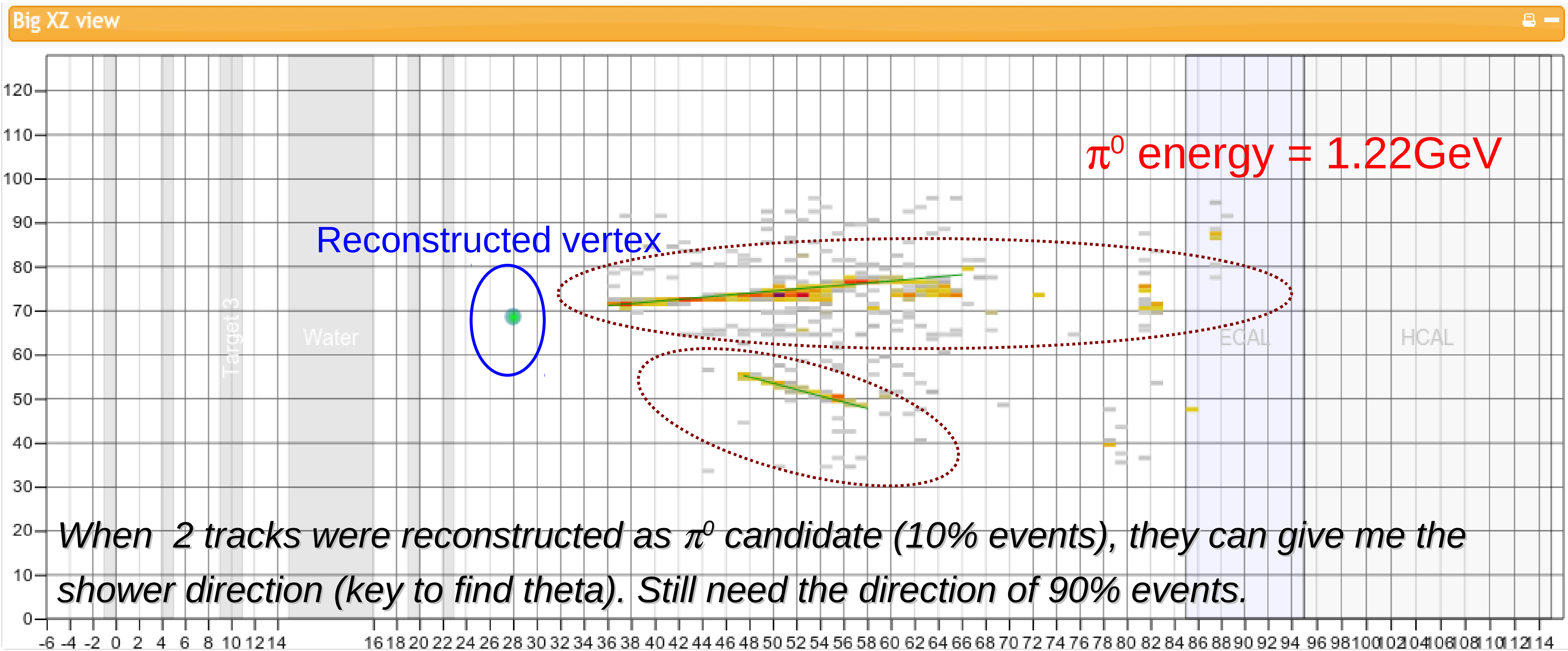
Radius



Vertex Z



About π^0 Mass



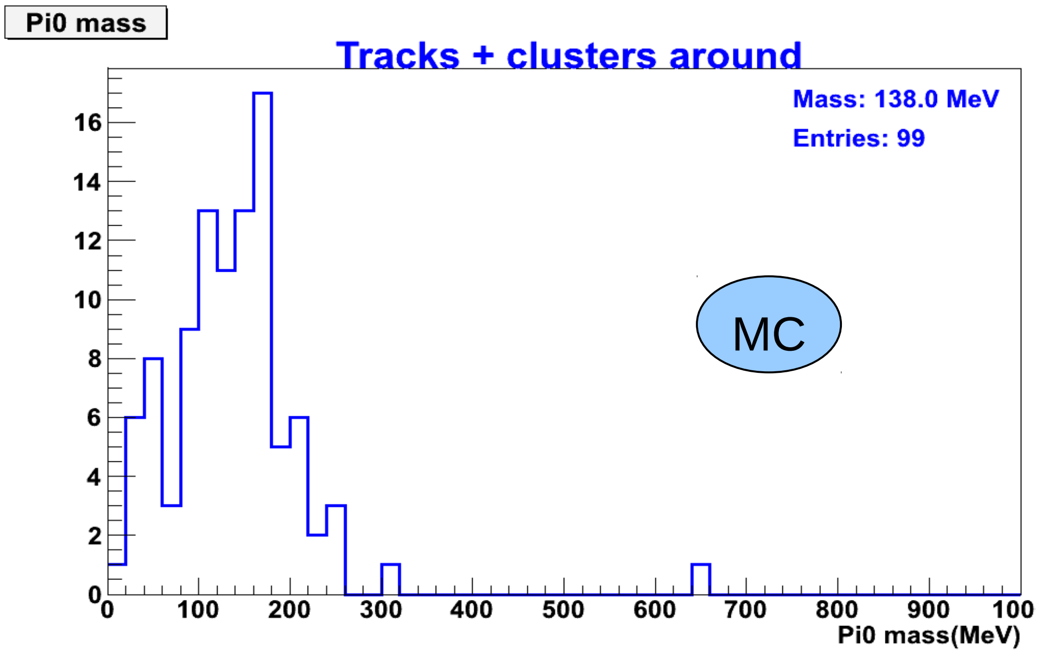
$$M_{\pi^0} = \sqrt{2 \cdot E_{\gamma_1} \cdot E_{\gamma_2} \cdot (1 - cos(\theta_{\gamma_1,\gamma_2}))}$$

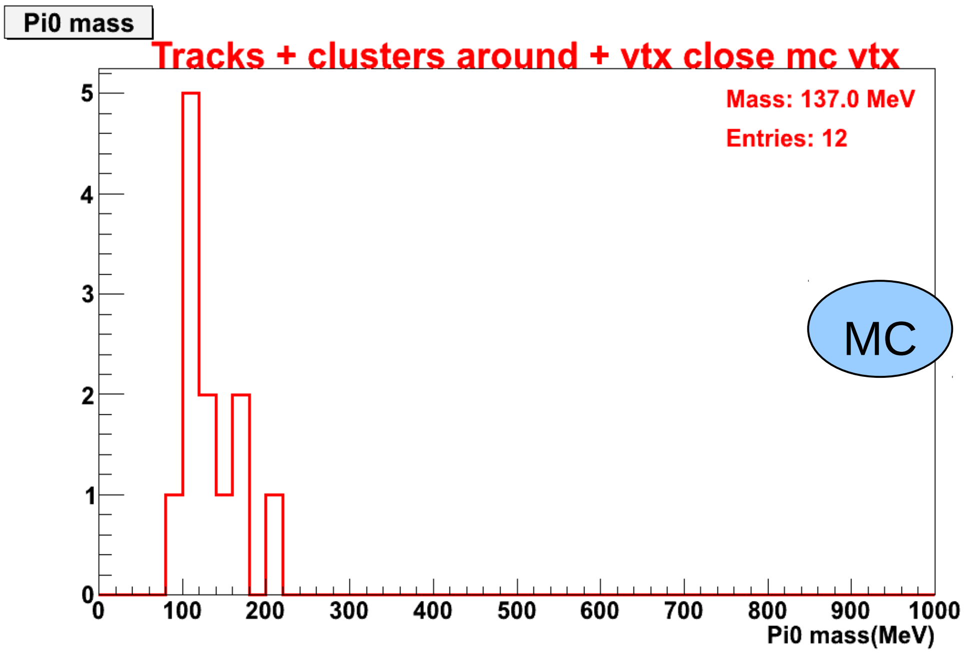
π^0 mass reconstruction:

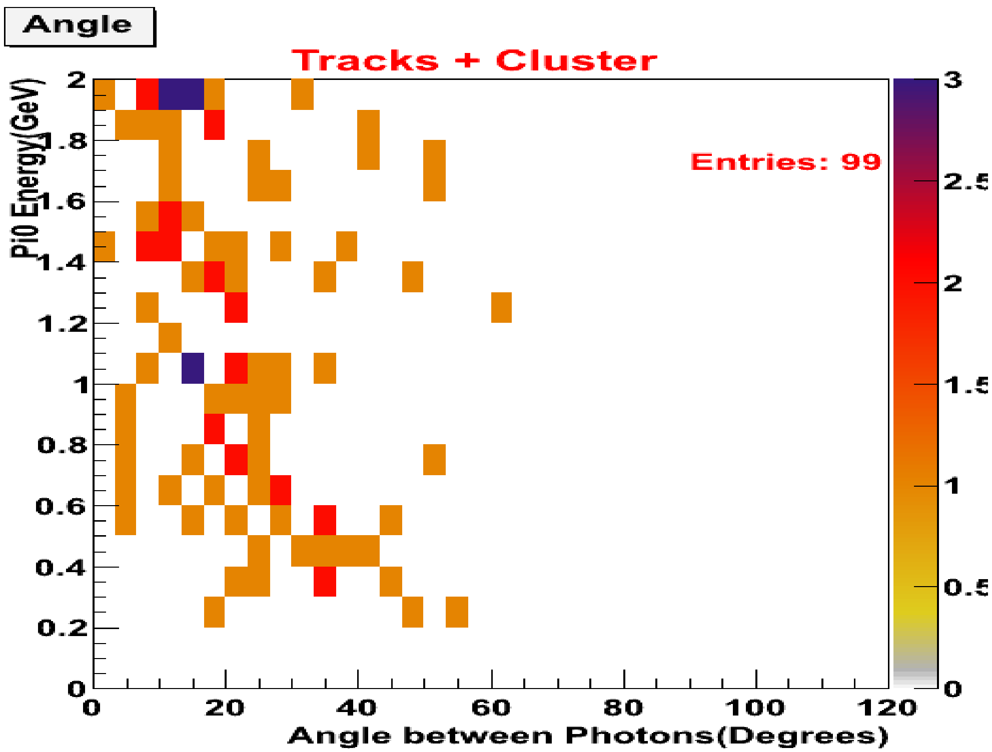
1) Using visible energy from tracks adding cluster around them.

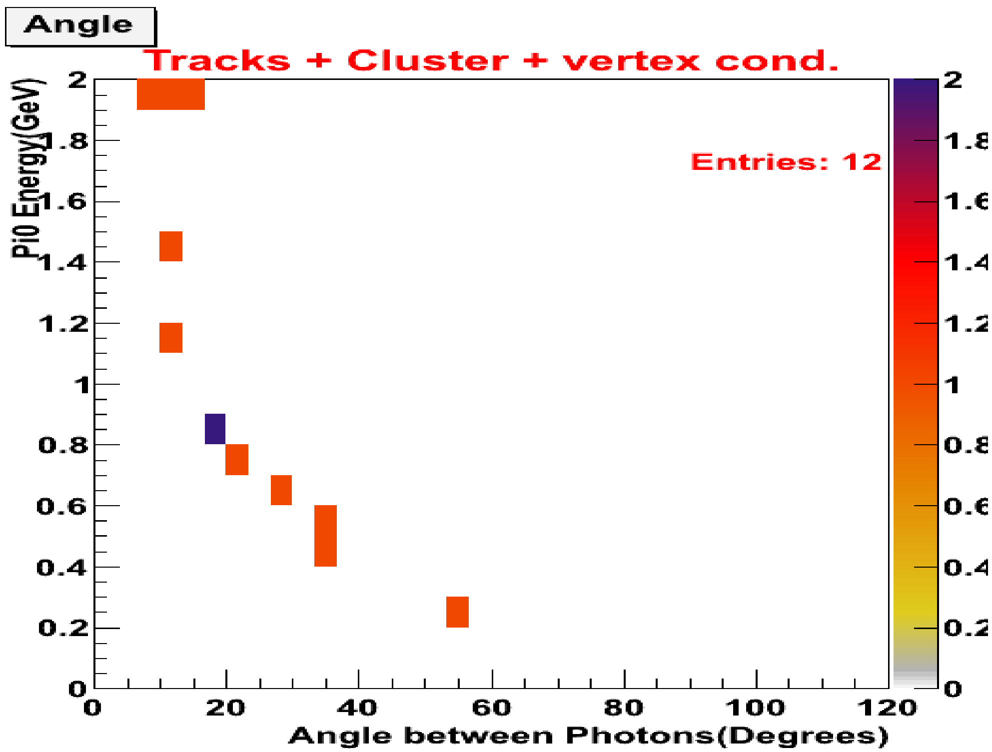
2) Reconstructed vertex close to true vertex(1module 5 strips)

About Pi0 Mass



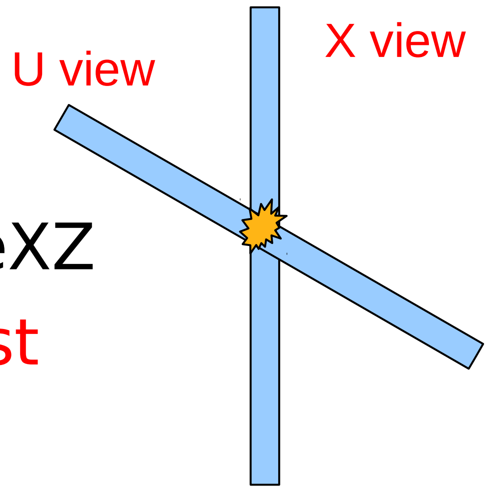






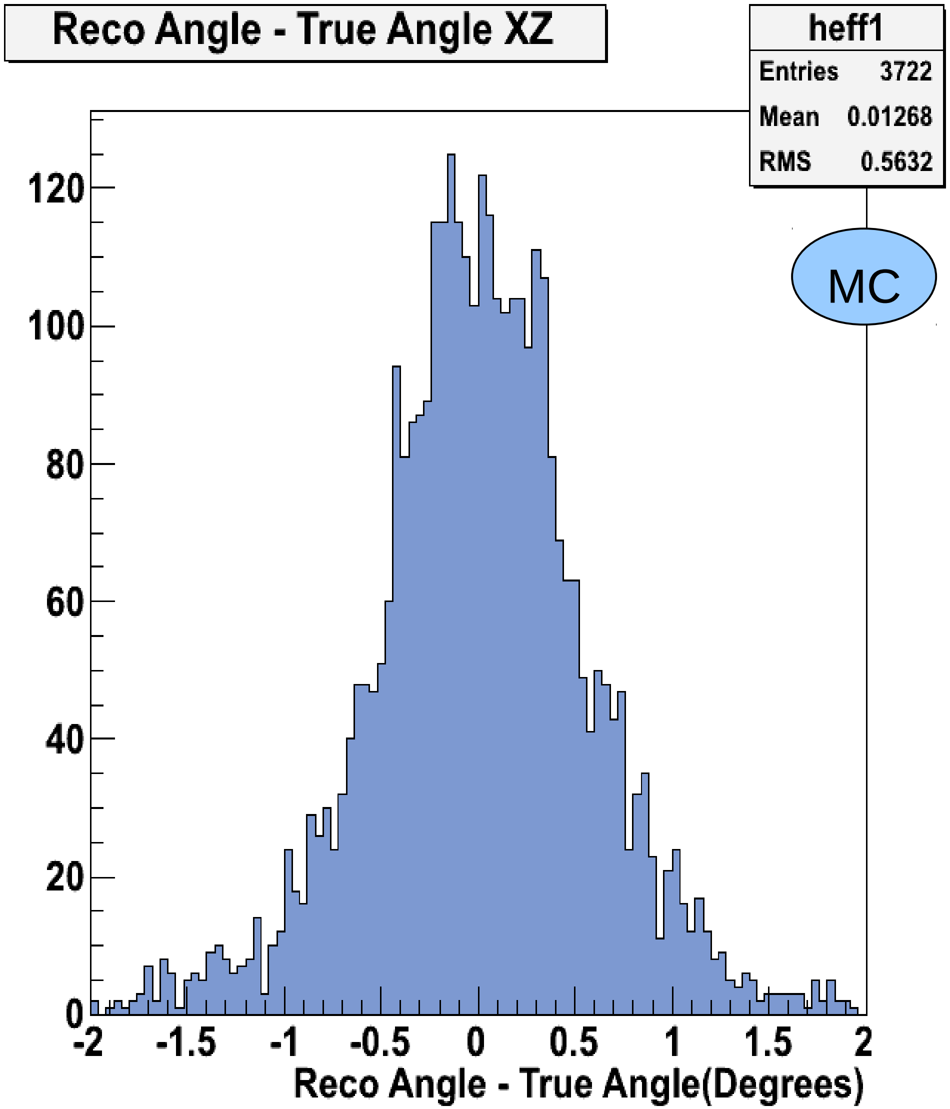
Shower Direction

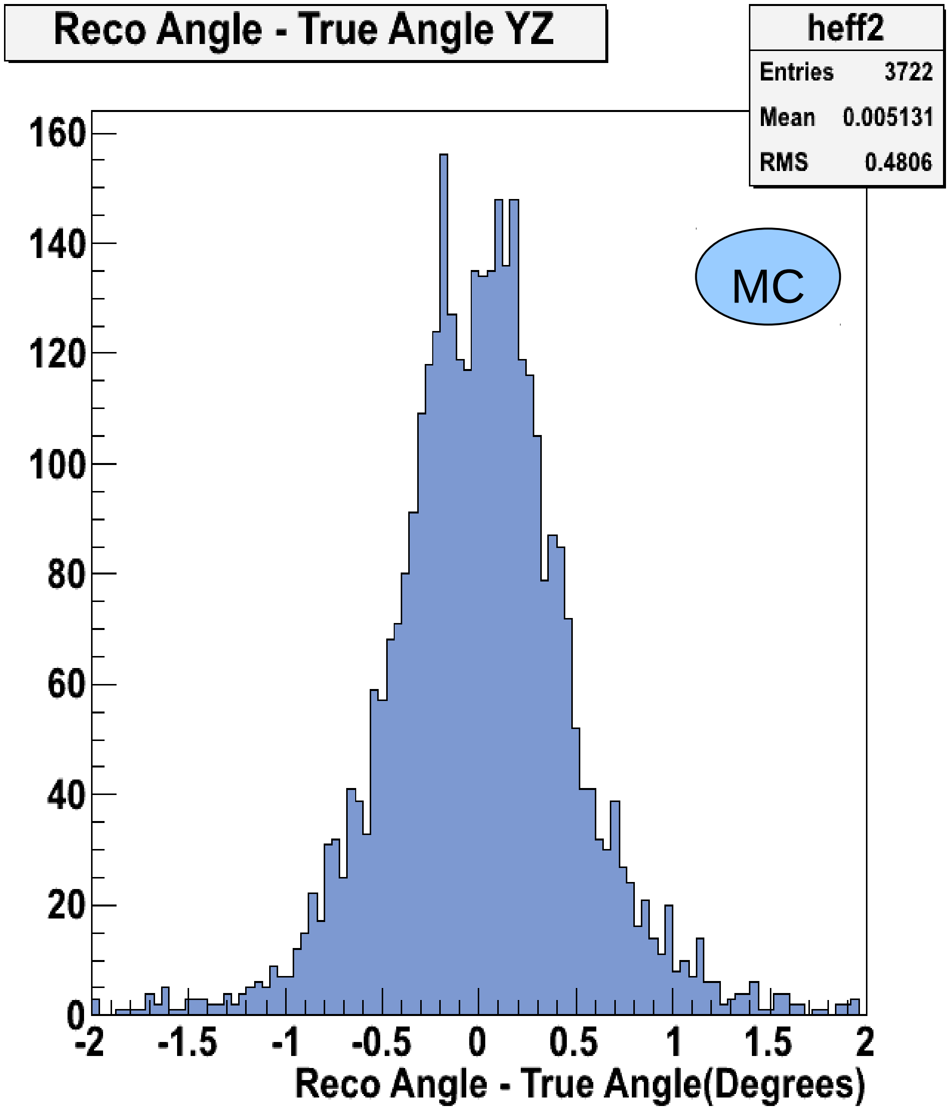
- The idea is estimate the angle between the shower direction and the beam direction per XZ and YZ views.
- Using shower core and the energy weighted position per view, I can assume an intersection “point” per module. Every modules has views.



- Finally, I have a X-Y-Z coord. per module. With those points I can calculate the slopeXZ slopeYZ using Simple linear regression(first approx).
- I will use a simulation with a single electron going to MINERvA detector to test this algorithm.

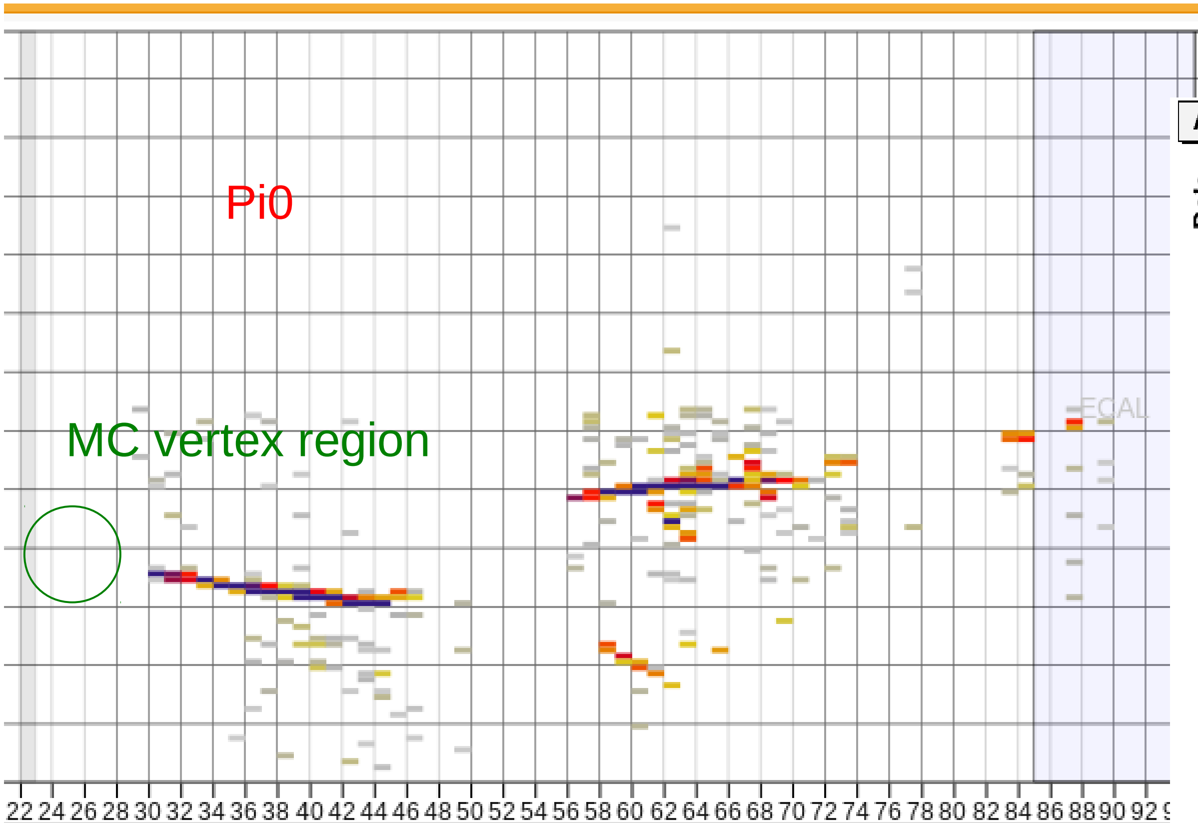
Shower Direction



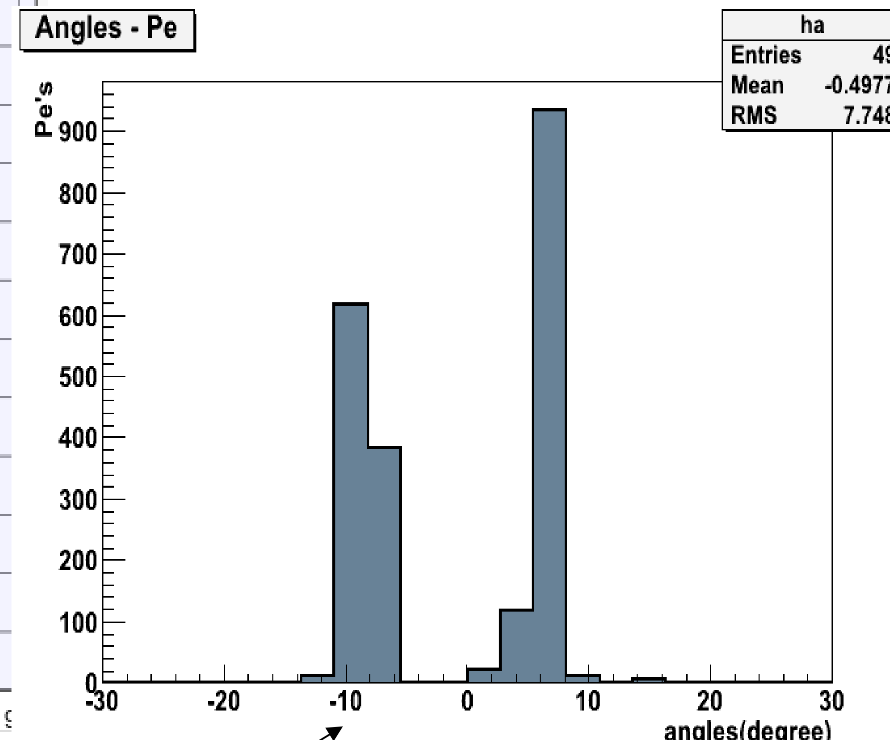


Simple MC electron sample (5 GeV)

Blob* to contain photons

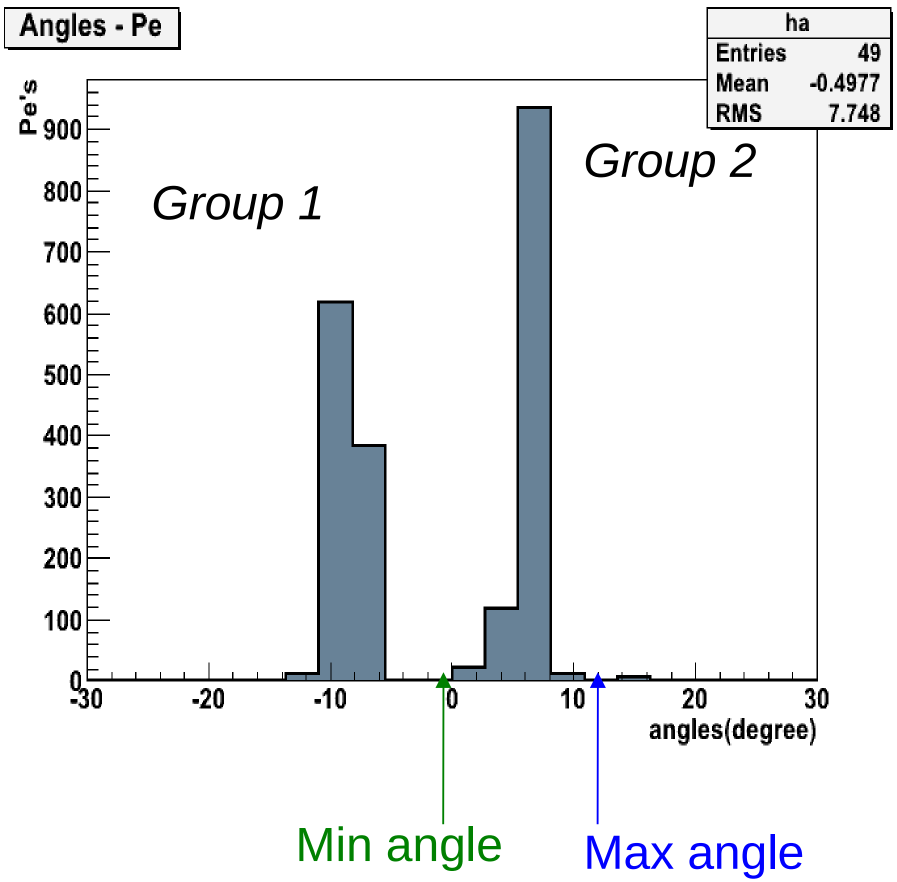


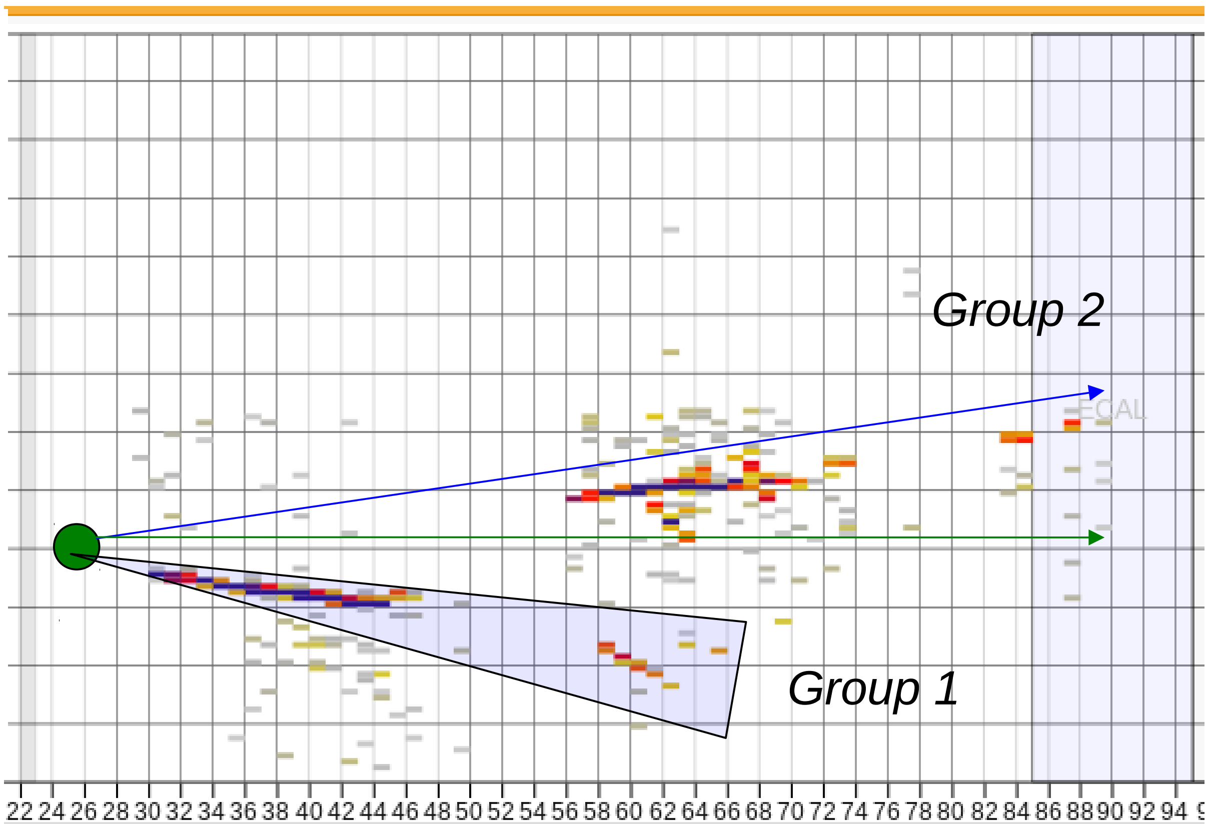
*Blob: spatially continuous regions of hits



Using vertex like relative point, I fill out a 1D histogram, where every entry is the angle between every hit and the vertex, weighted by its charge. Similar to Hough Transformation with r = 0.

Blob to contain Photons

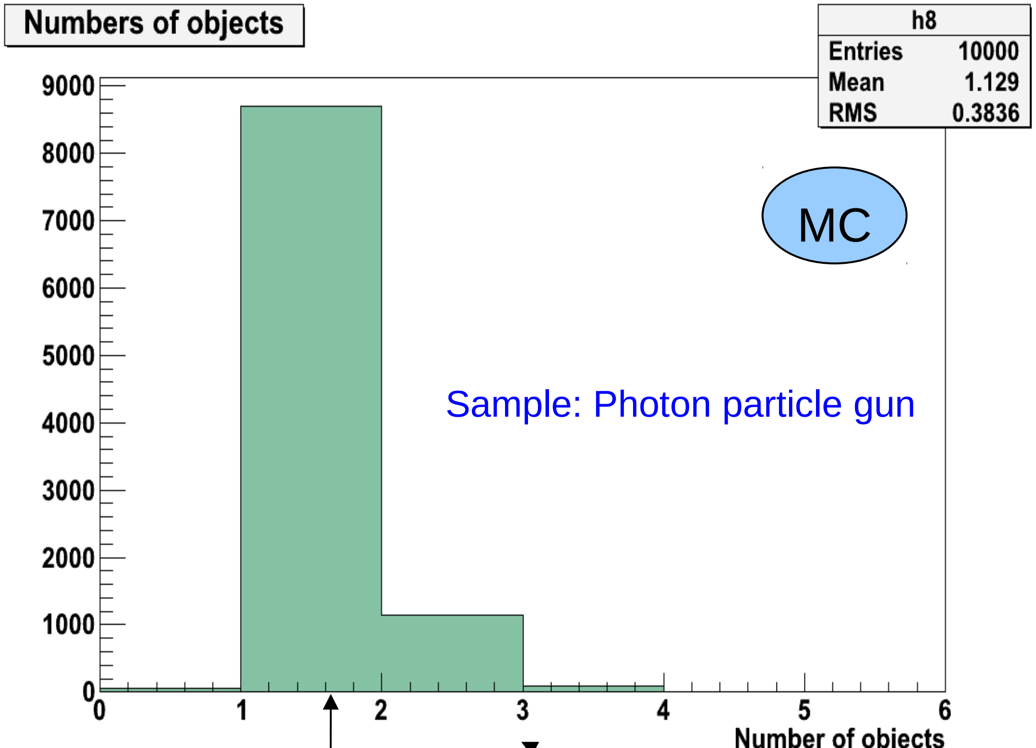




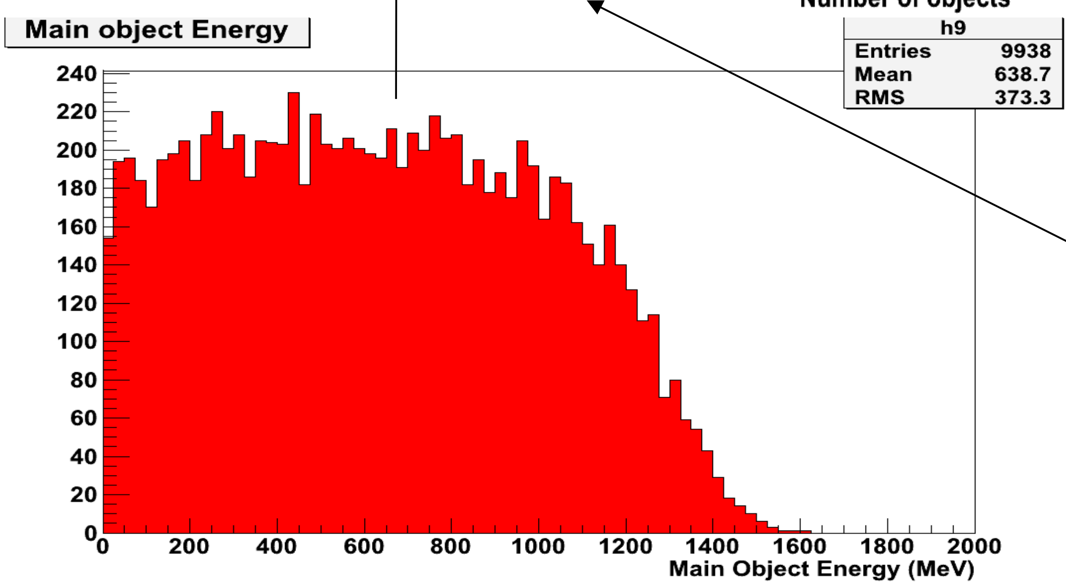
Then every group (particle) inside the histogram will have a minimum angle and maximum angle(Peak finder is not implement yet in overlap case)

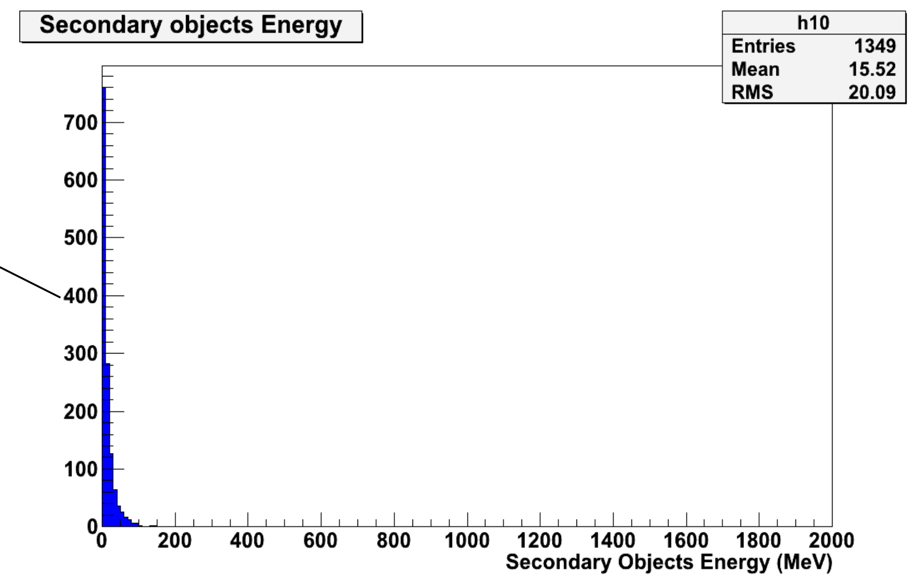
Loop over hits to find those inside the "Cone Area", this method can also catch the shower hits beyond gaps.

Number of blobs per event

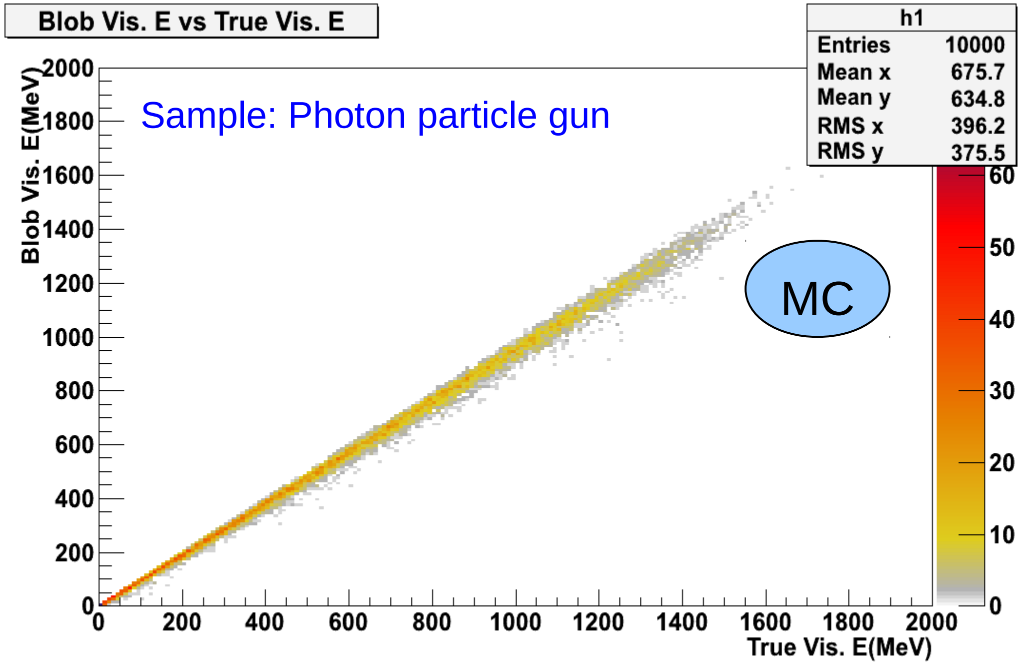


The number of blobs for this sample has to have an average 1. In some events this number is more than 1 because not every particle follow shower direction. But this contribution is not significant like the main object.



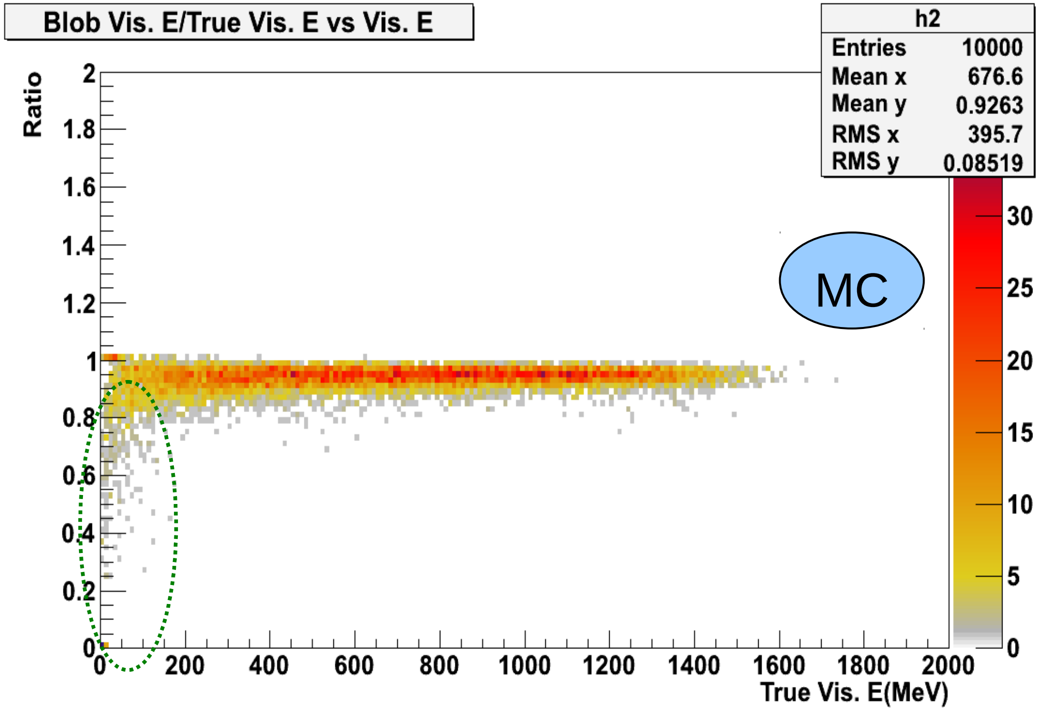


Blob containing visible energy



The main blob in average is containing 93% of the True visible energy

This blob shows fluctuations when visible energy is low (less than 200MeV).

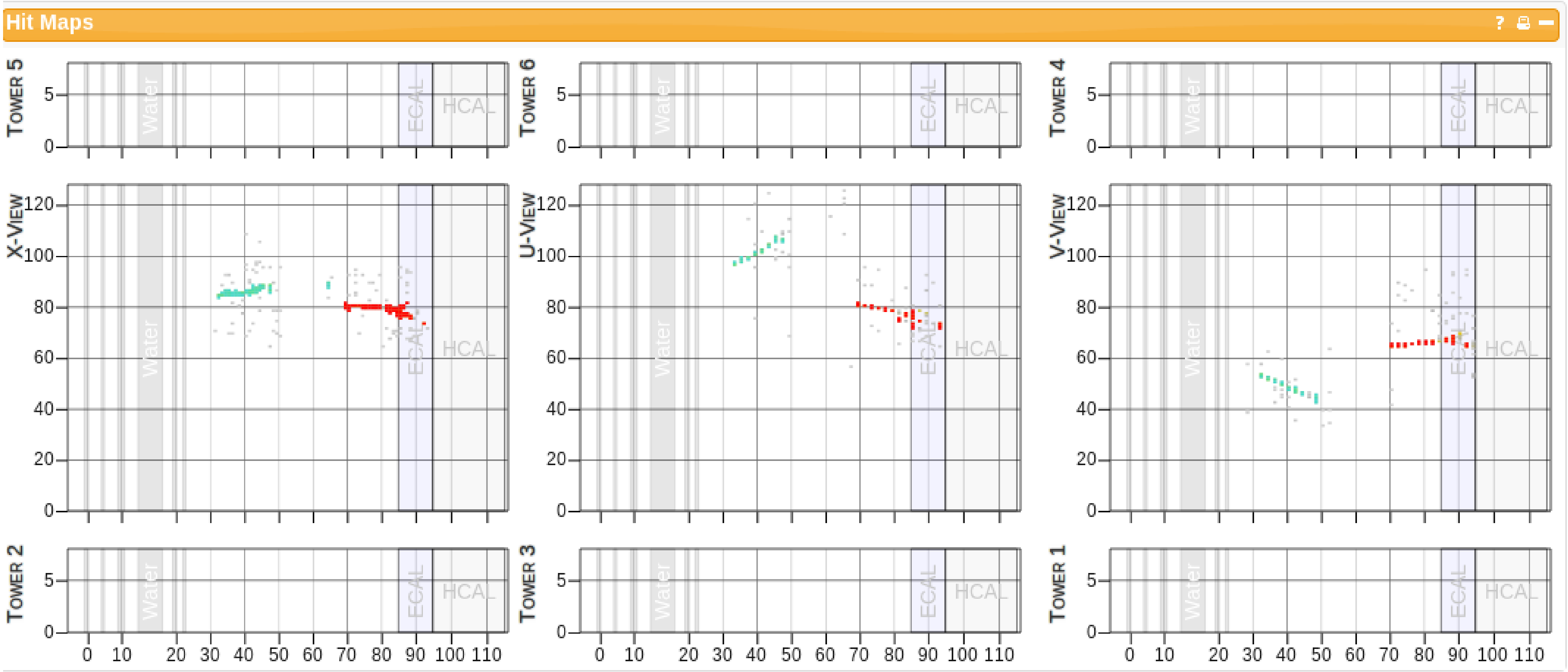


Conclusions

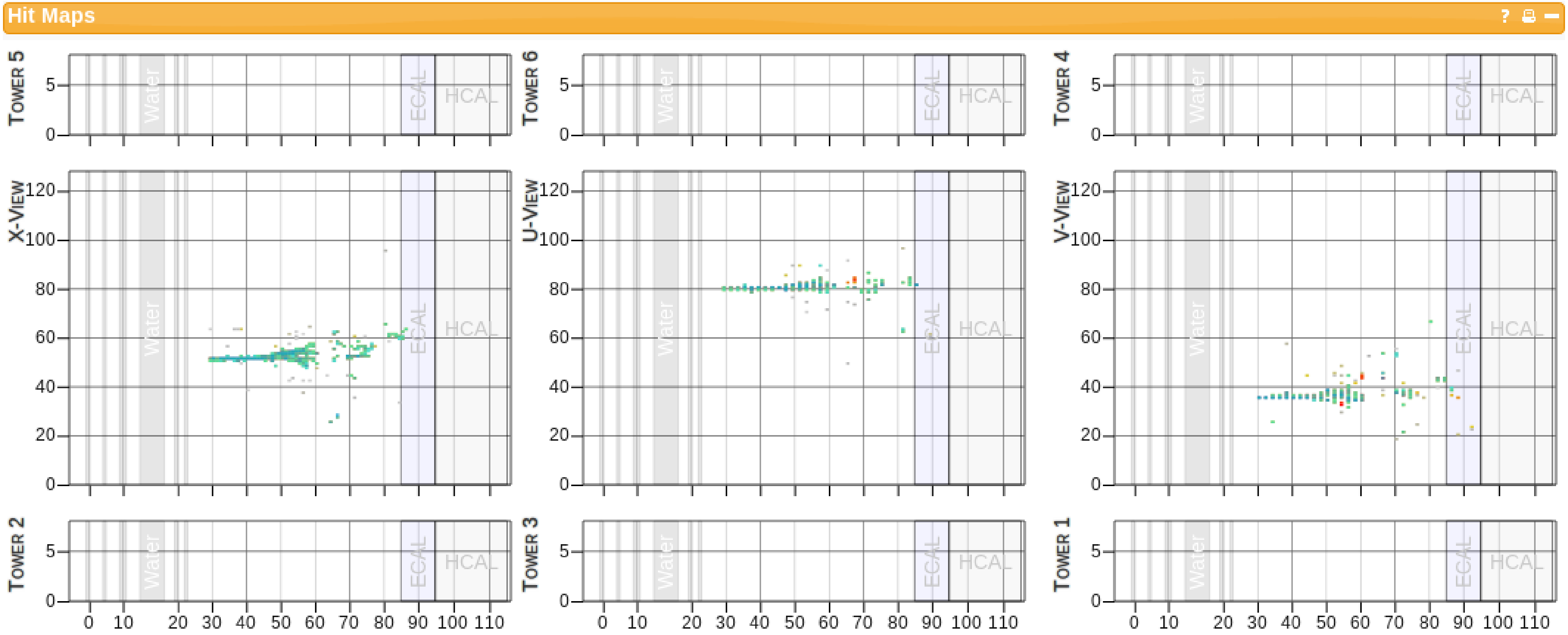
- I will use vertex position given by Muon track to scan the γs coming from π^0.
- π^0 mass will be a nice tool to isolate my sample.
- Improve this blob algorithm, merging 3 MINERνA views with non trivial topology, apparently is working not too bad.
- More studies, more coffee and finish PhD degree....

Backup slides

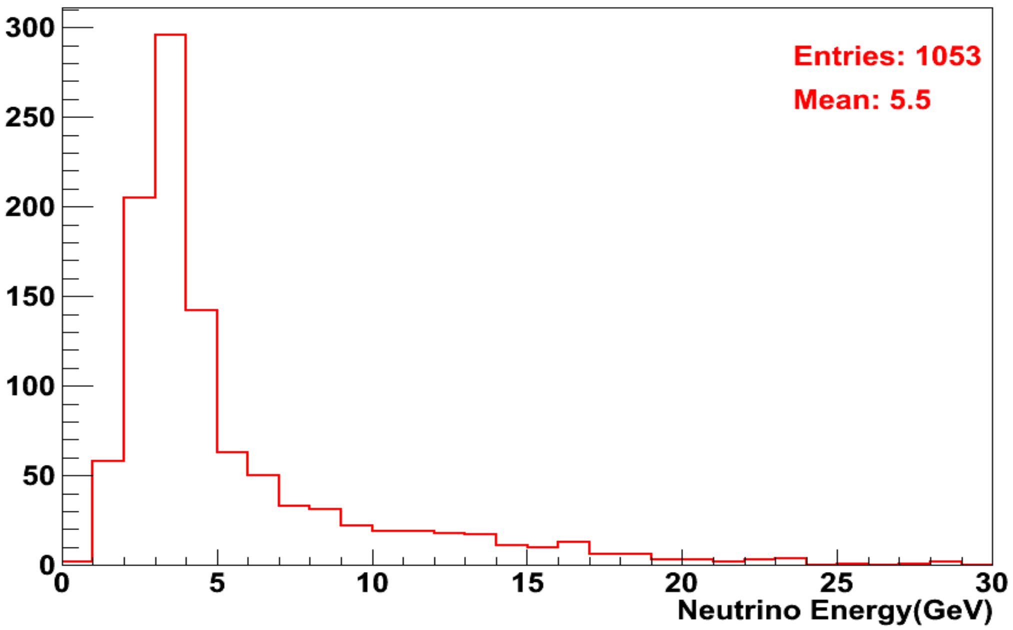
Example: Pi0


Hit Maps
Tower 5
Tower 6
Tower 4
X-View
U-View
V-View
Tower 2
Tower 3
Tower 1
Water
ECAL
HCAL
0 10 20 30 40 50 60 70 80 90 100 110

Example: Photon



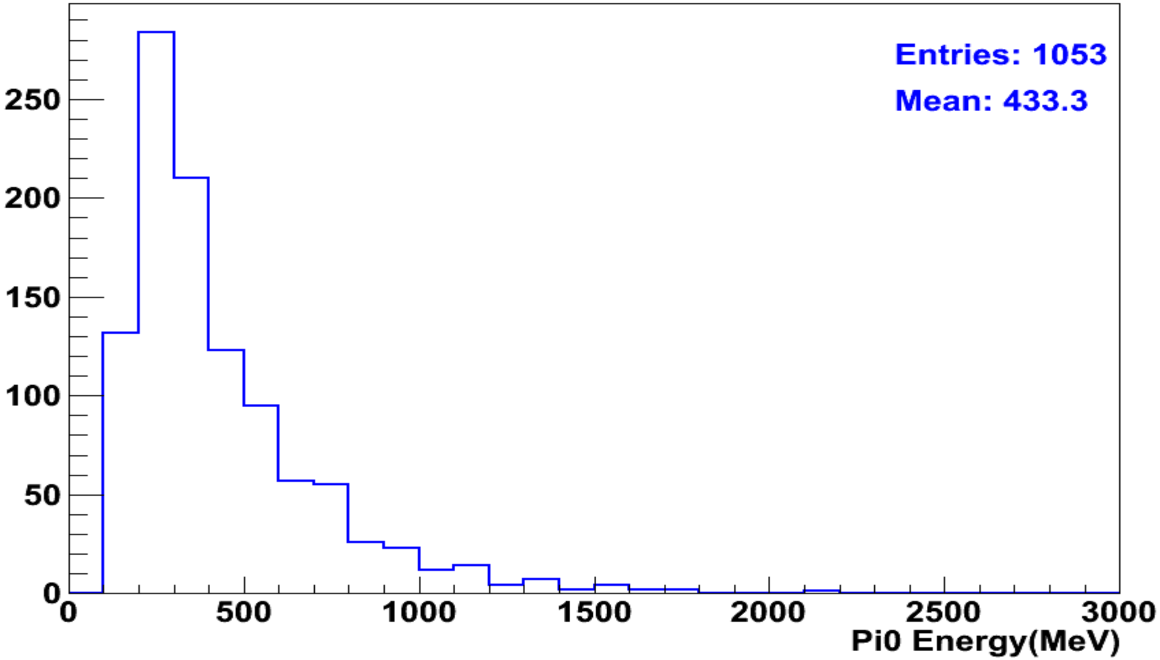
About Pi0 Energy



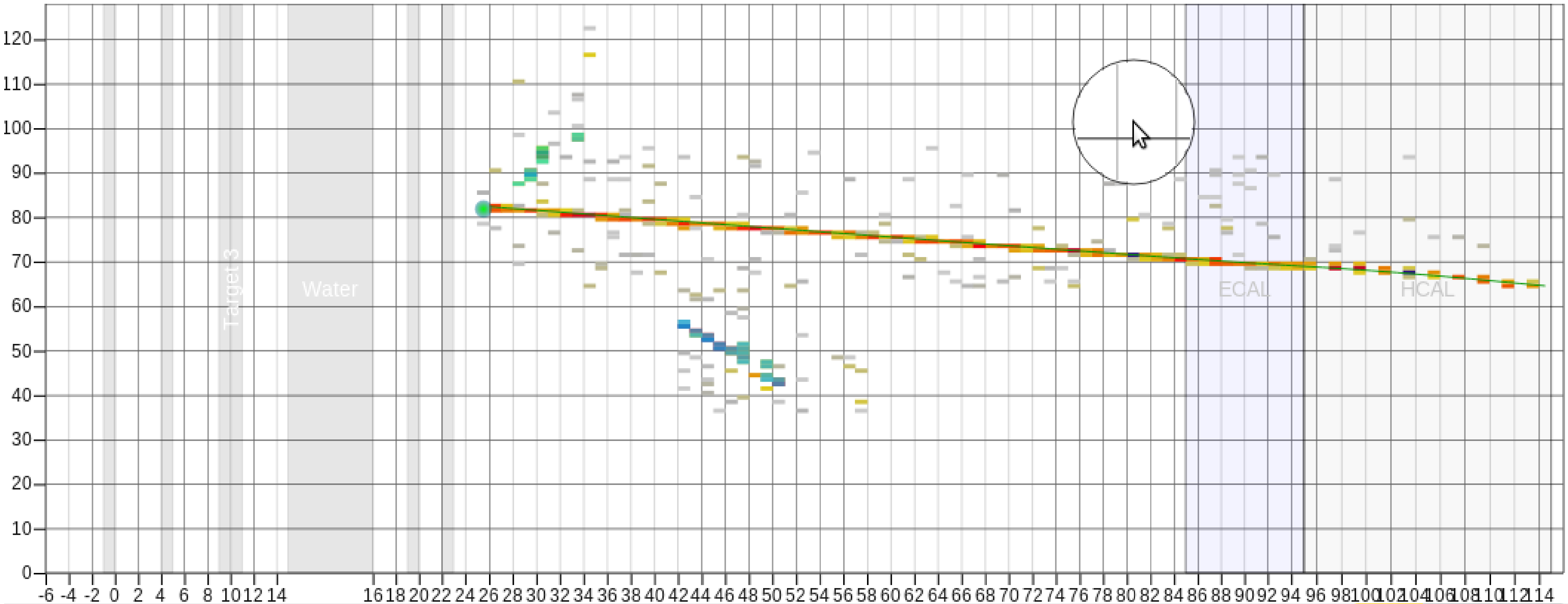
I select on mc data:

- RES channel,
- Charge current
- One Pi0 in the final state.

Pi0 energy distribution has a median value below 1GeV. (Problems with shower gaps).



Goals - Ideas



CC-ResPi0 with Minos match

Shower Purity