



# AHCAL Optimization

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- Background and Simulation Setup
- Reconstruction Process
- CellSize Optimization
  - Pion and KLong separation
  - Simple PFA method
- Read out layer Optimization
- Conclusion

# Background and Simulation Setup



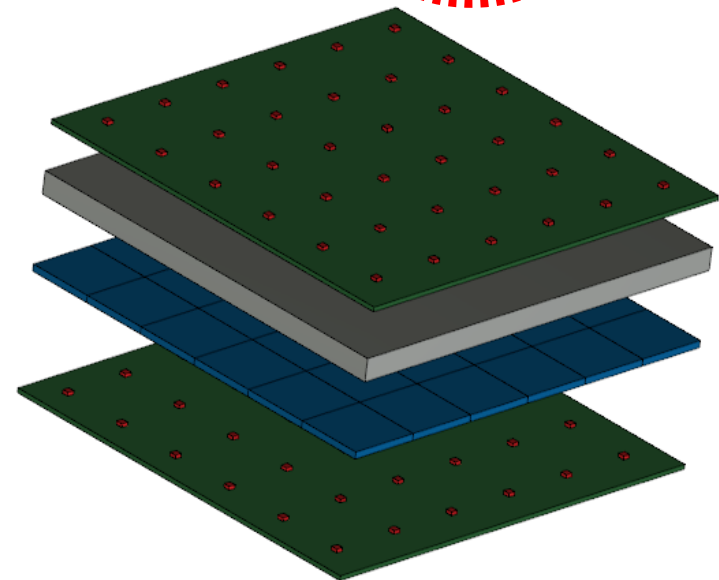
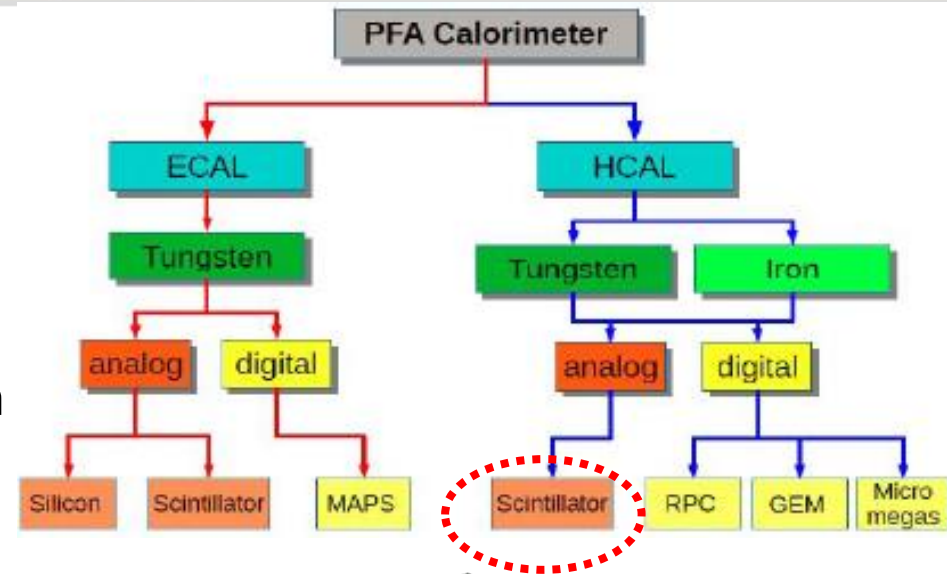
- Simulation Setup

- ECAL

- 30 layers
    - Absorber: 2.8mm tungsten
    - Si:  $10 \times 10 \times 0.5 \text{mm}^3$
    - PCB: 2mm

- AHCAL

- 40 layers
    - Absorber: 20mm Fe
    - Scintillator:  $10 \times 10 \times 3 \text{mm}^3$
    - PCB: 2mm



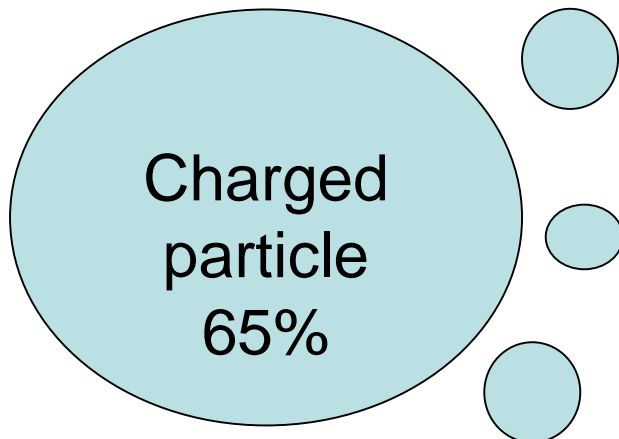
# Background and Simulation Setup



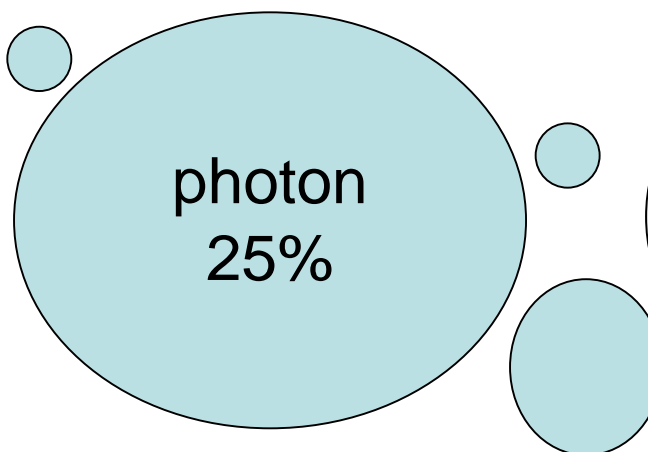
- PFA
  - The resolution of tracker, ECAL and HCAL is quite different
  - The optimal detector to detect different components of a jet
  - Cellsize is the key parameter for PFA calorimeter



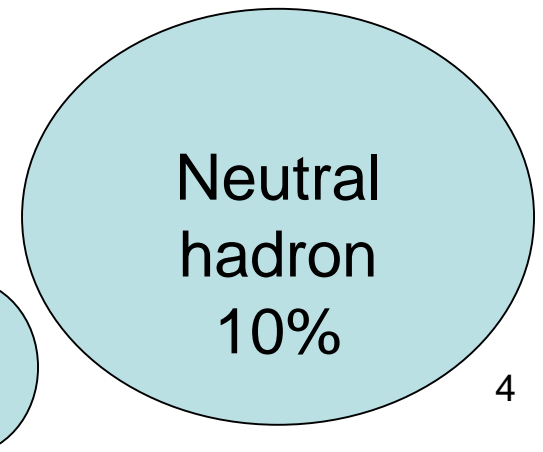
Tracker



ECAL



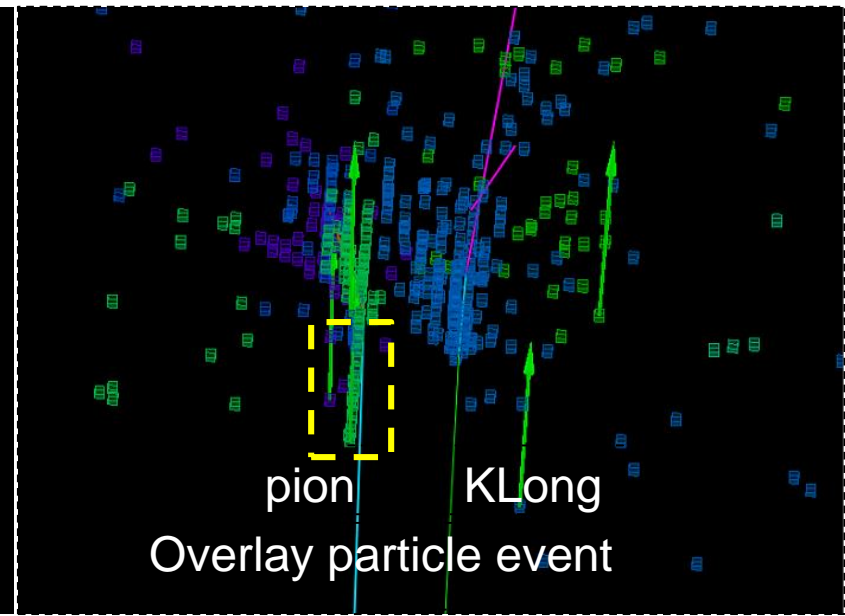
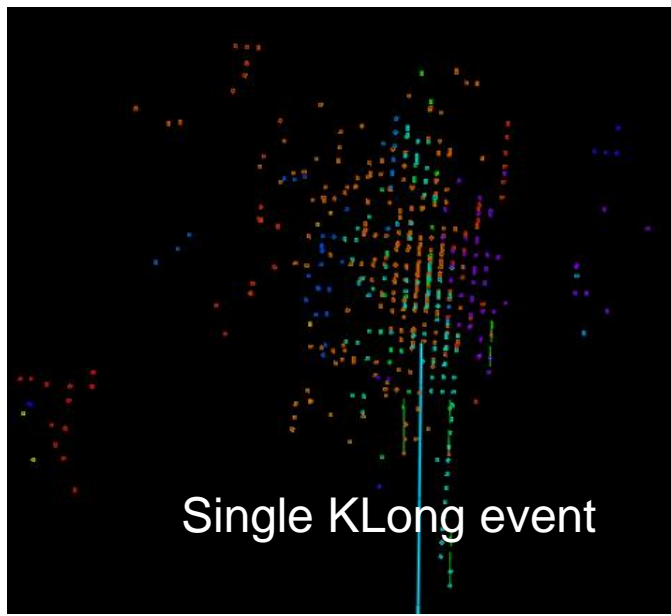
HCAL



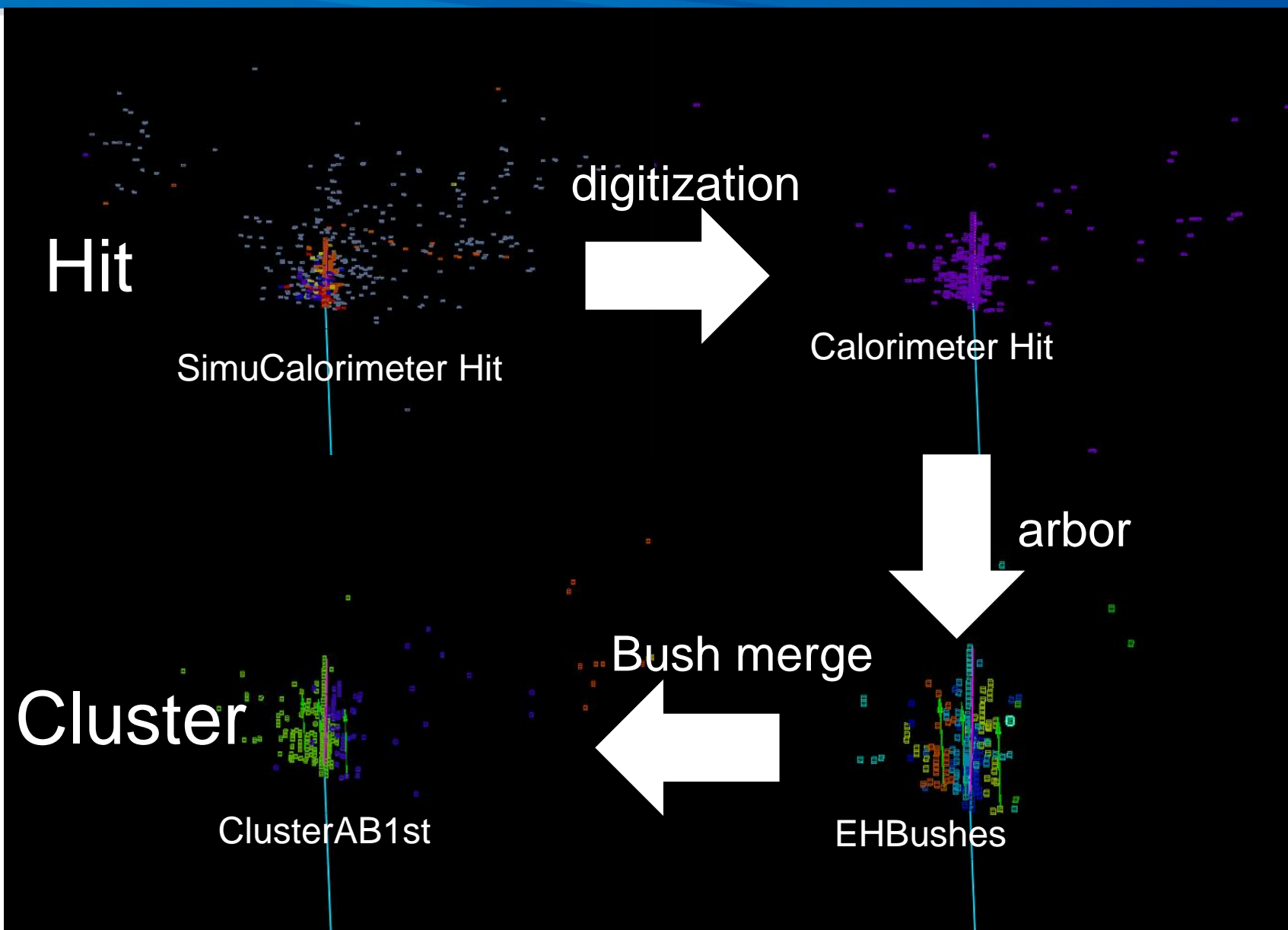
# Background and Simulation Setup



- Incident particle
  - 10 GeV pion-
  - 10 GeV KLong: abundant in H-gg event
- Feature of KLong
  - KLong usually doesn't deposit significant energy in ECAL so that it doesn't have a 'stick' in the front
  - KLong is wider than pion



# Reconstruction Process

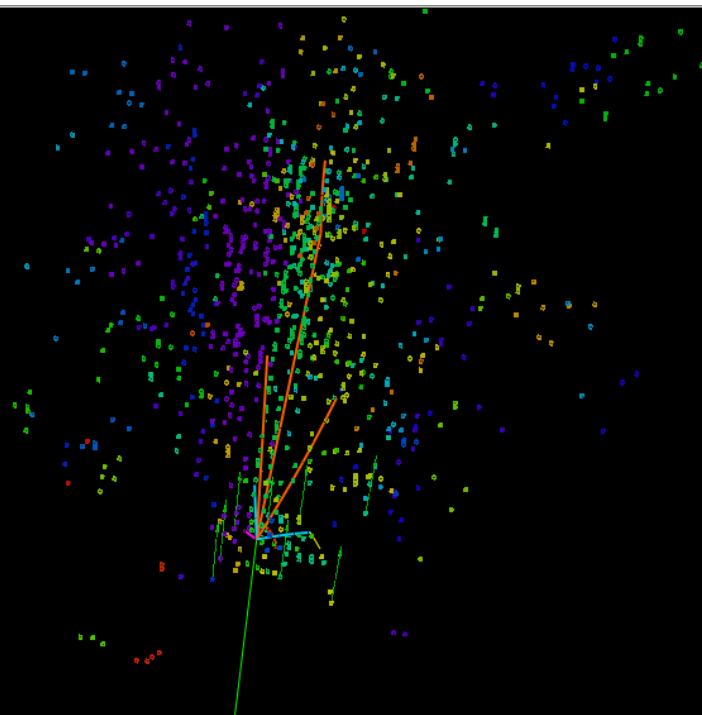


- The physical structure of a shower is exactly like a **tree**
- So we reconstruct **bushes** first

MC particle

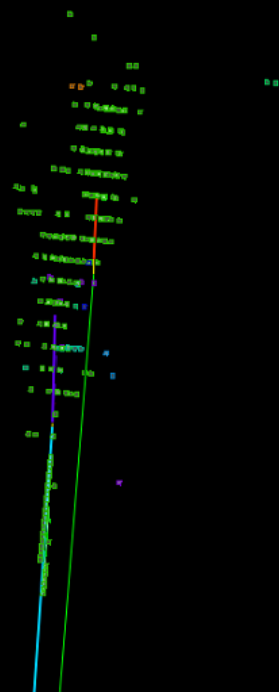


EHBushes

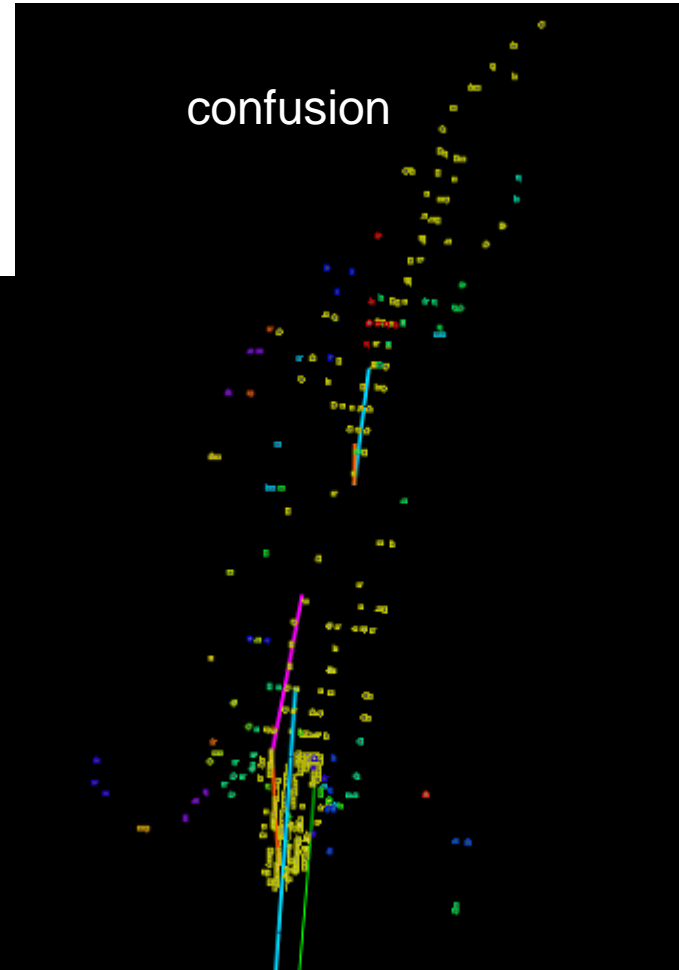


- Fail events
  - Head and tail
  - confusion

Head and tail

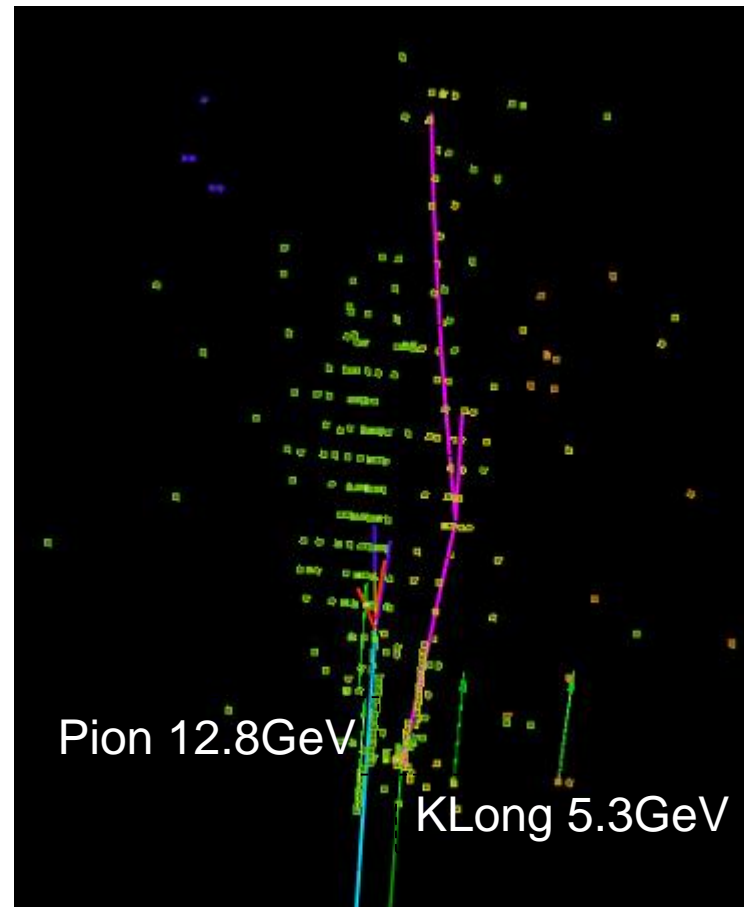
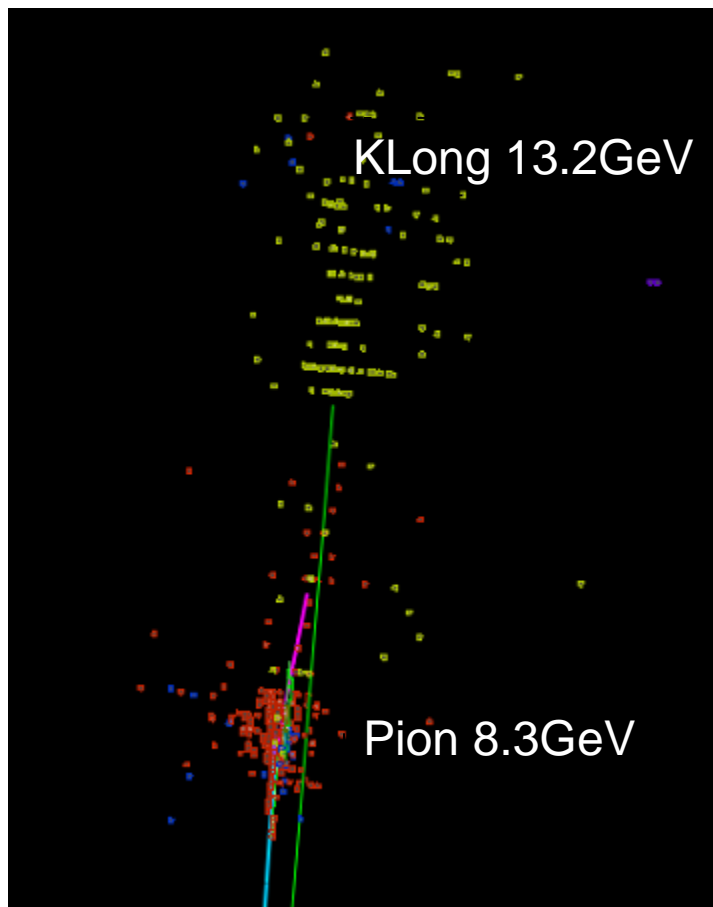


confusion





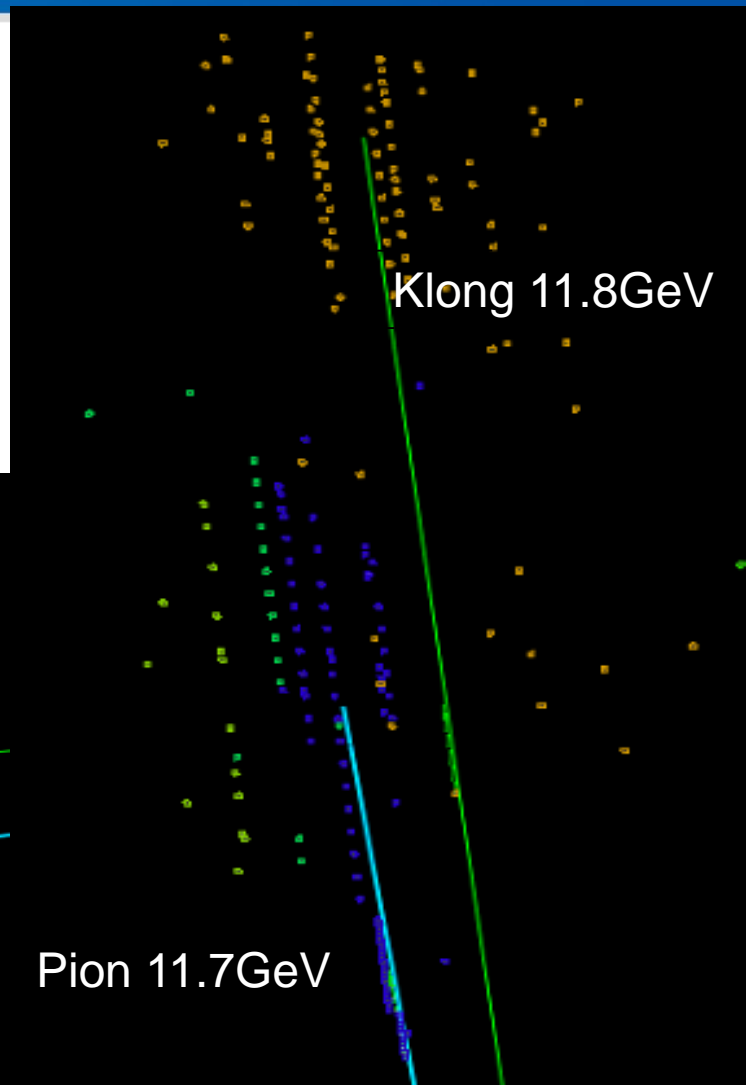
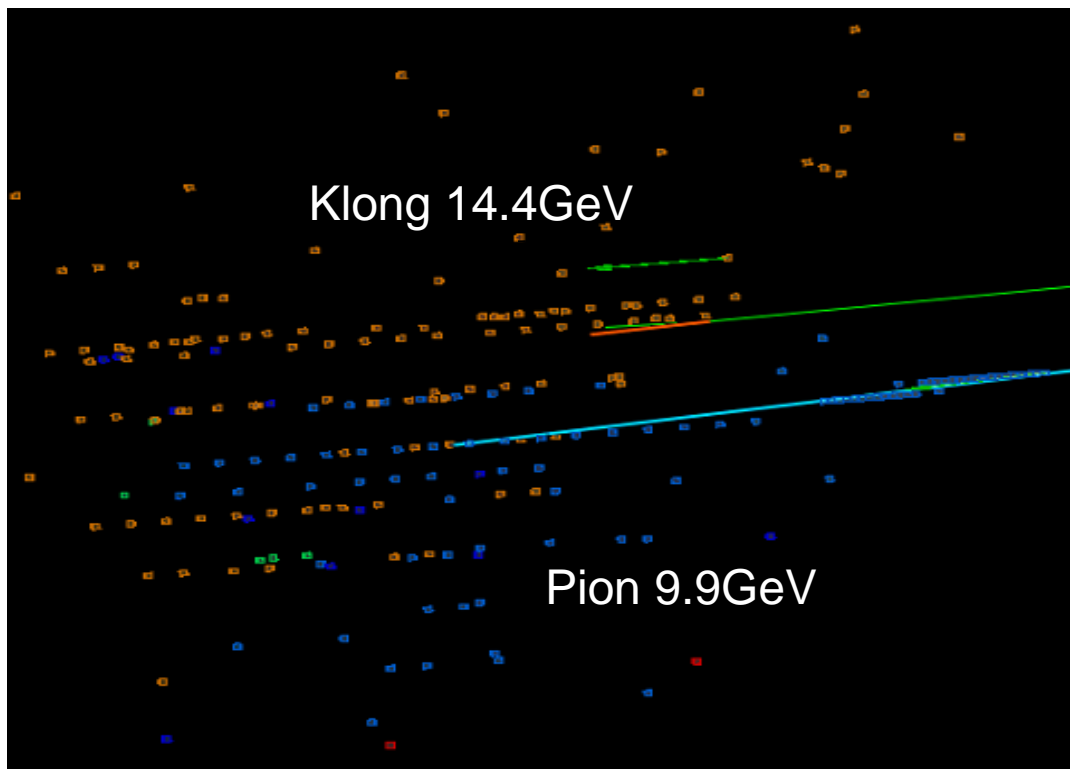
- Successful event
  - Pion KLong distance 30mm



# Reconstruction Process



- 70mm cellsize
  - Incident position
    - pion:75mm
    - Klong:0mm



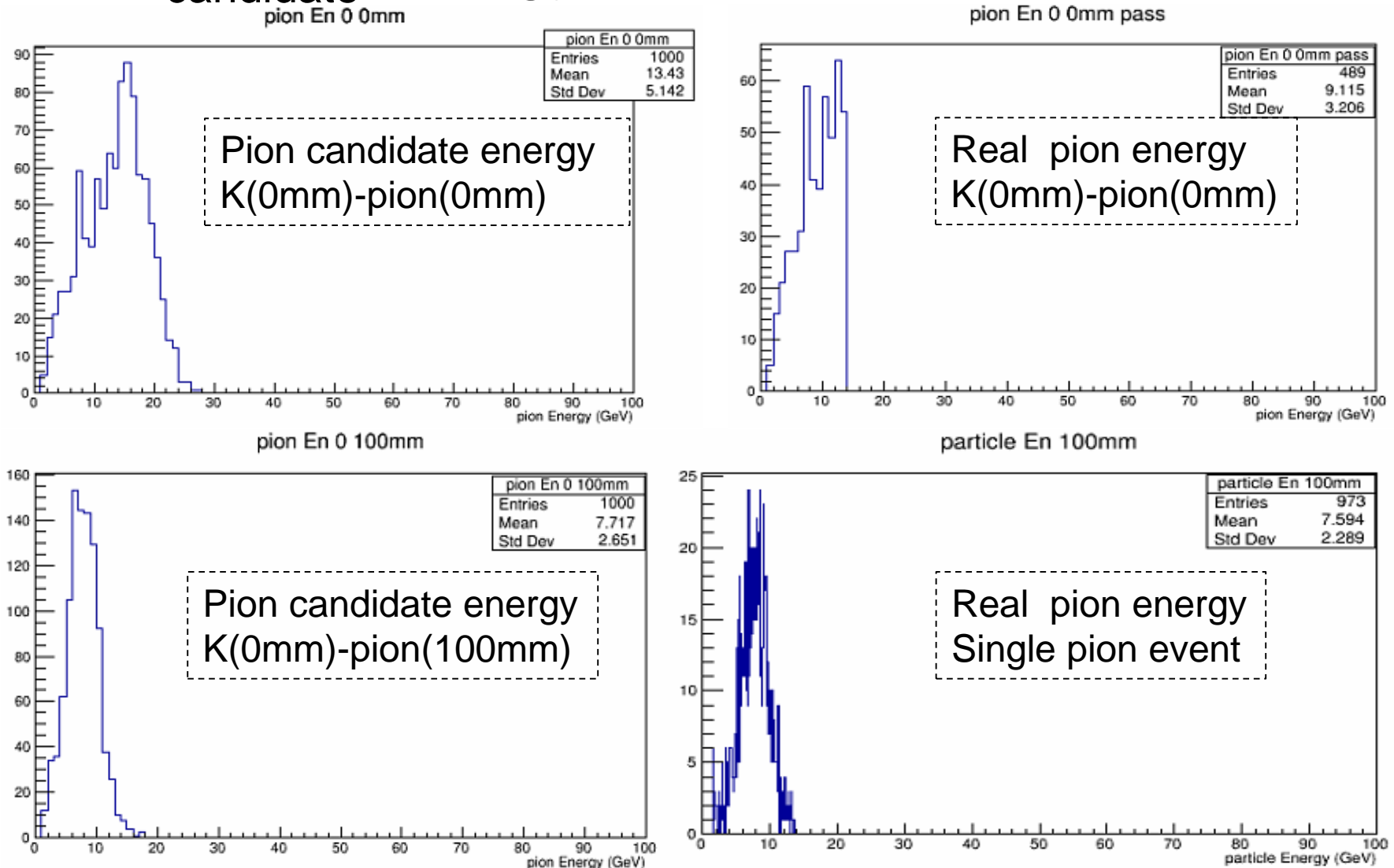


- Real situation
  - Charged particle: track can provide energy and direction
  - Uncharged particle: even don't know the number of them
- Strategy for pion, K in MC
  - Assume that the incident direction is the track in Simplified geometry
  - Pion, K candidate selection
    - **Pion<sub>candidate</sub>**: cluster closest to pion track and energy  $> \text{mean} - 3\sigma$
    - **K<sub>candidate</sub>**: cluster doesn't match pion track with largest cluster energy
    - KLong fragment : cluster away from pion track
  - Efficiency for pion, K
    - **Real pion**:  $|\text{energy}_{\text{pion}_{\text{candidate}}} - \text{mean}_{\text{pion}}| < 3\sigma$  && close to track (COG dis  $< 80\text{mm}$  && Angle  $< 30\text{degree}$ )
    - **Real KLong**:  $|\text{energy}_{\text{K}_{\text{candidate}}} - \text{mean}_{\text{K}}| < 3\sigma$  && close to track
    - All : a Event with a real pion and a real KLong

# Pion and KLong separation

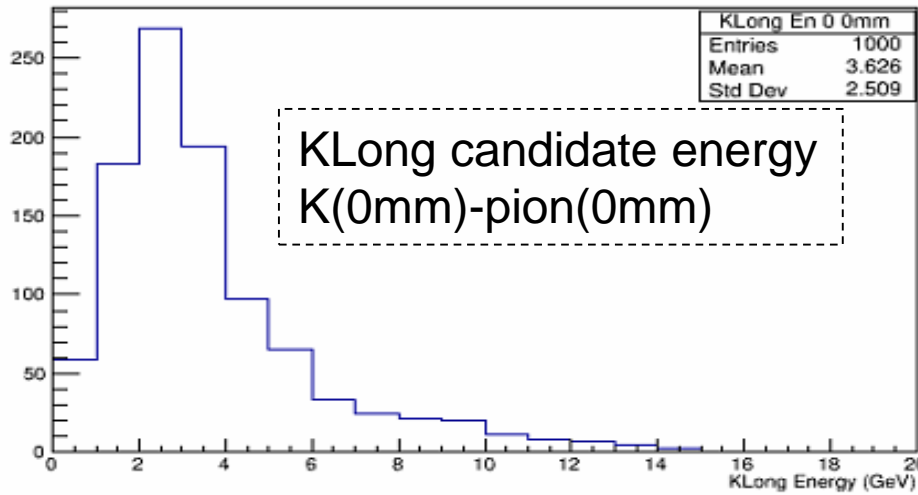


- Pion<sub>candidate</sub> energy distribution

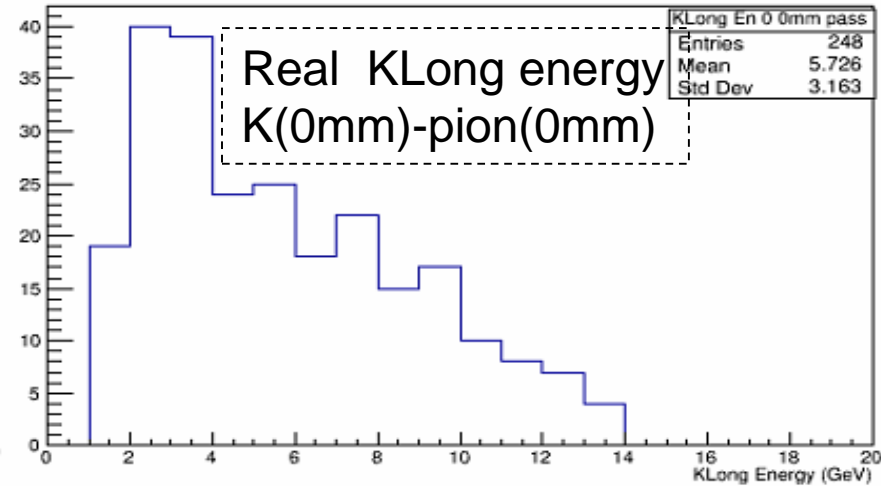


- KLong<sub>candidate</sub> energy distribution

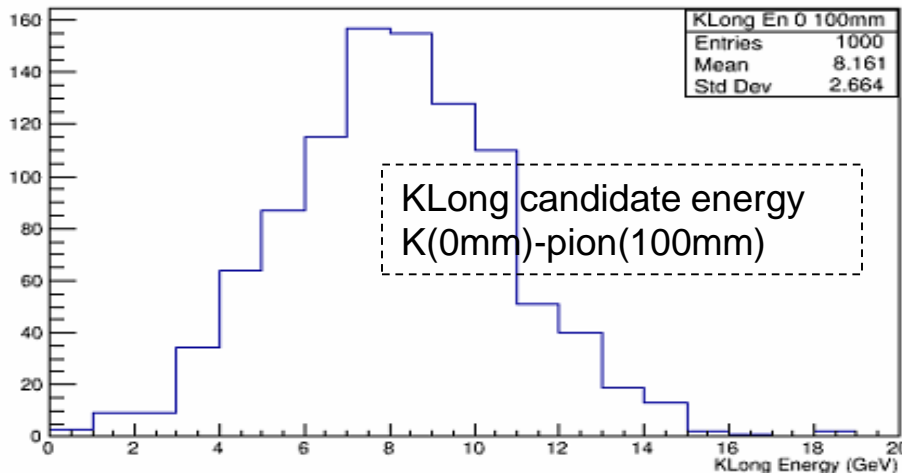
KLong En 0 0mm



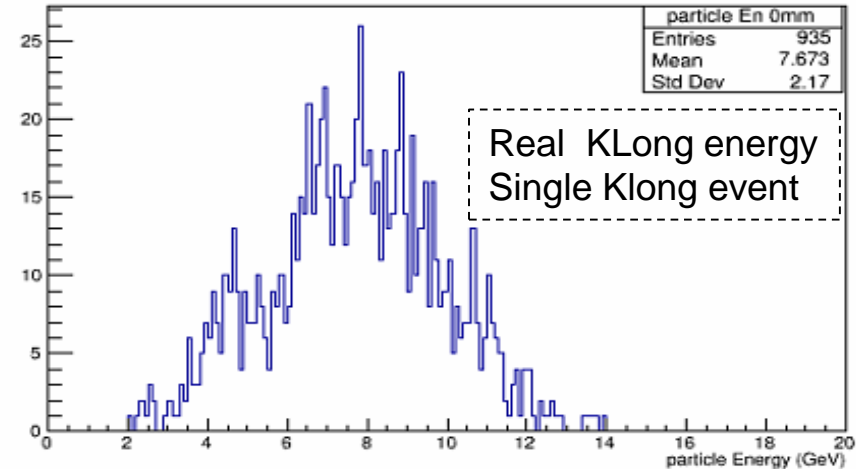
KLong En 0 0mm pass



KLong En 0 100mm



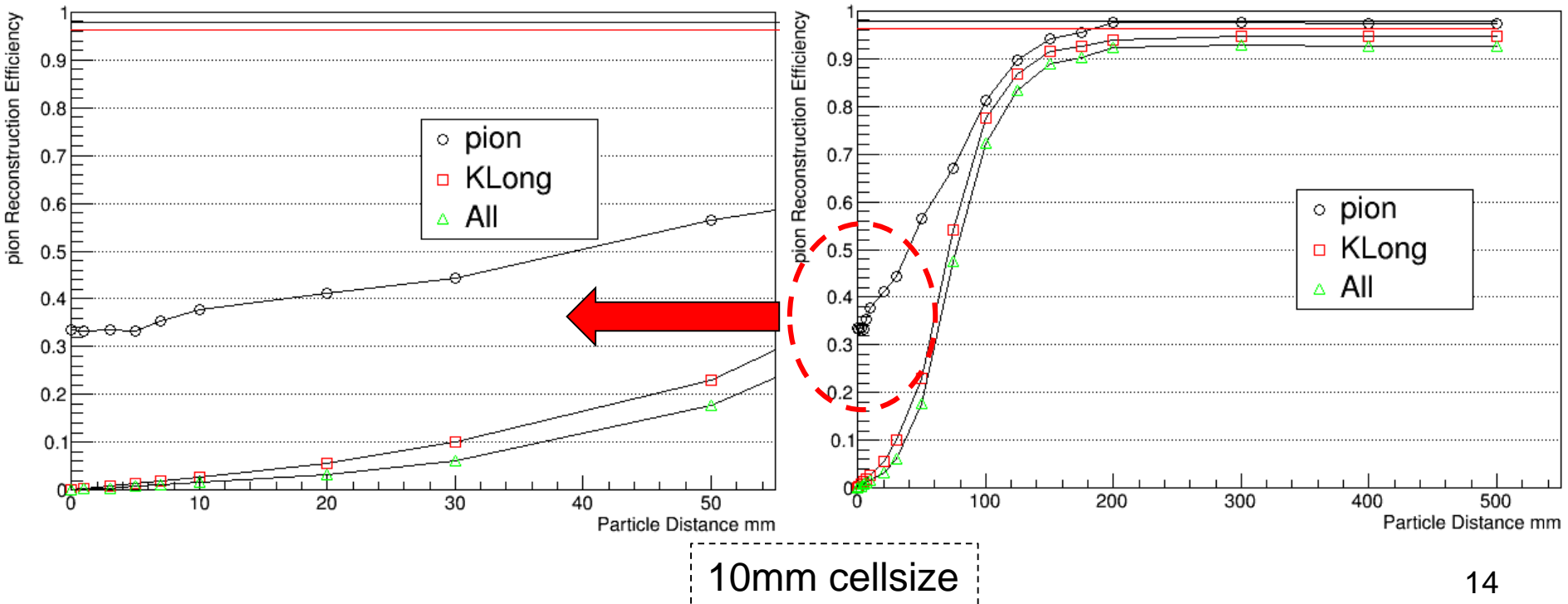
particle En 0mm



# Pion and KLong separation

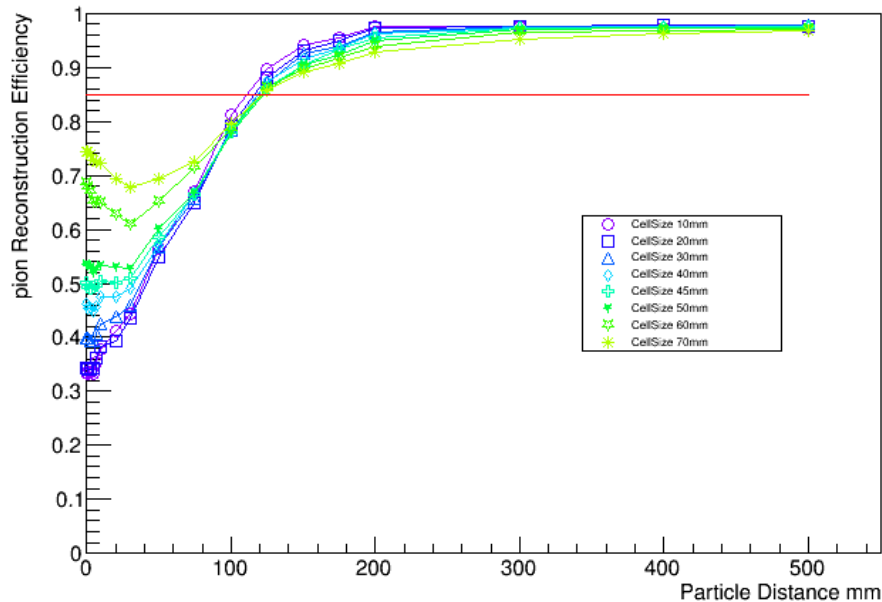


- Straight Line is efficiency of single particle event
- Marker is efficiency of di particle event
- particle distance is the distance of 2 particle on ECAL surface



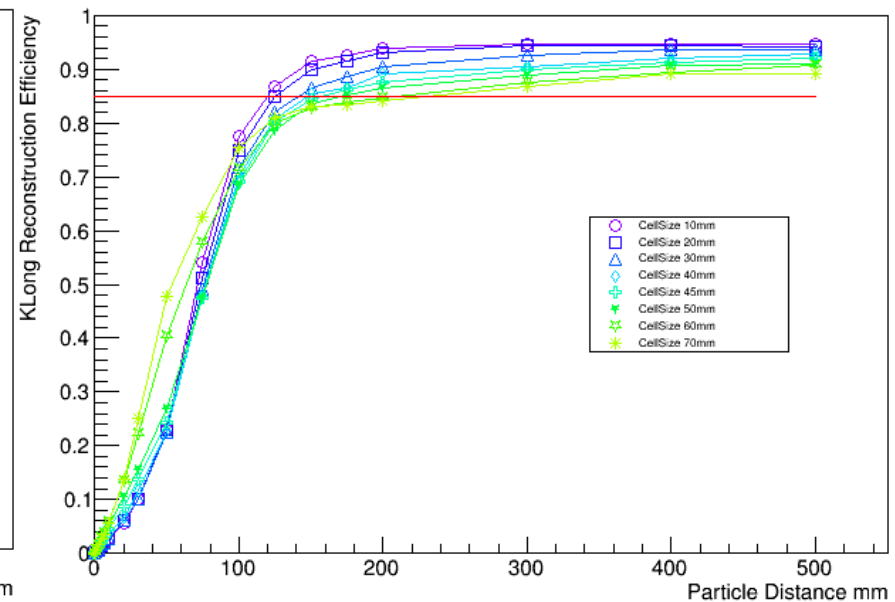
- Different cellsize
  - Keep the energy mean of single particle similar
  - Energy sigma stays unchanged as 10mm cellsize situation

separation efficiency pion 10



Pion reconstruction efficiency

separation efficiency KLong 10



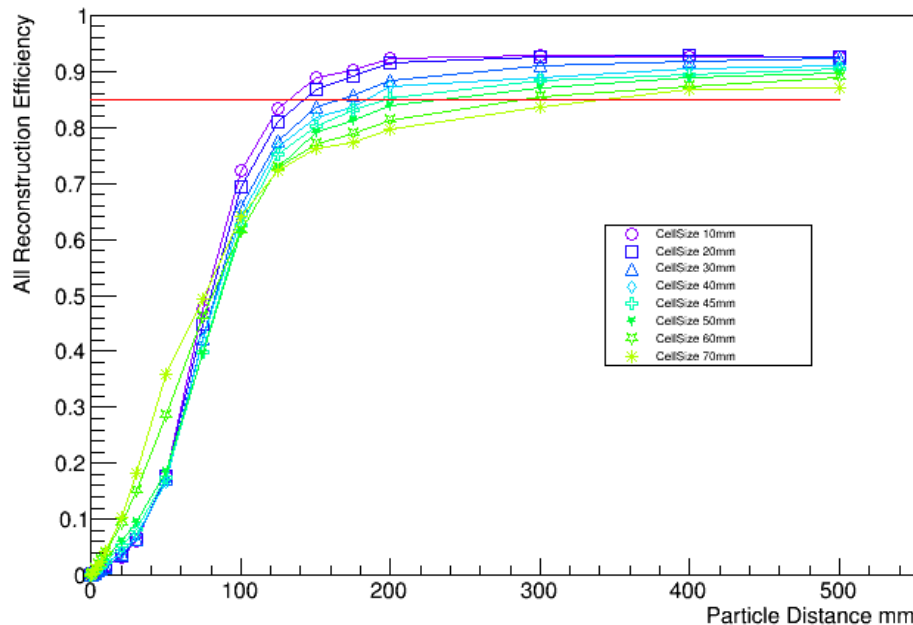
KLong reconstruction efficiency



- Critical Distance

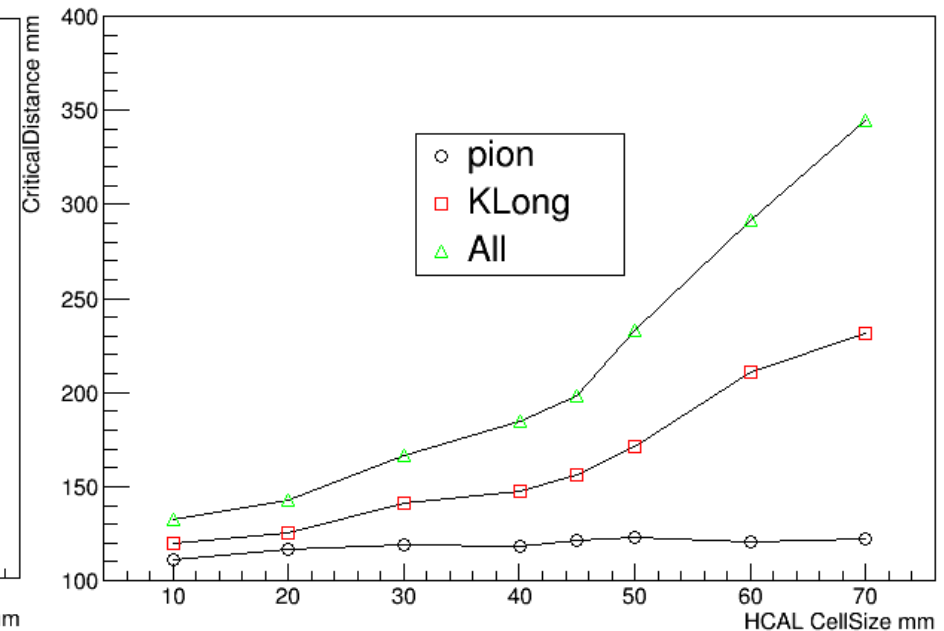
- The distance which has 85% efficiency is define as critical distance

separation efficiency All 10



Pion and K reconstruction efficiency

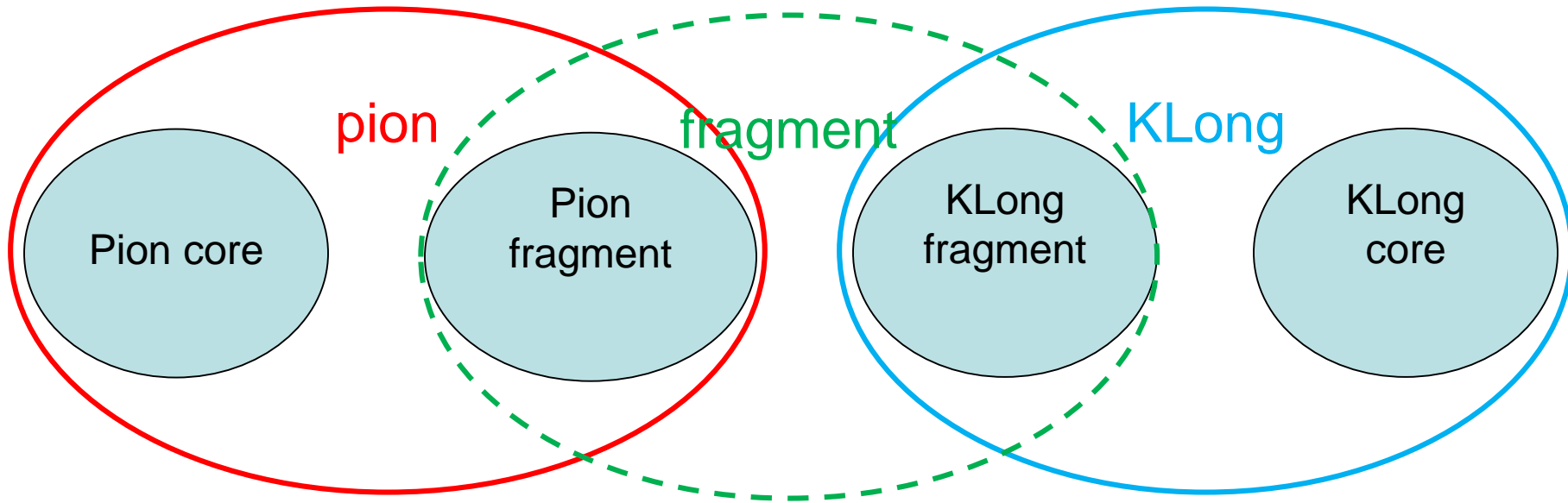
CriticalDistance pion



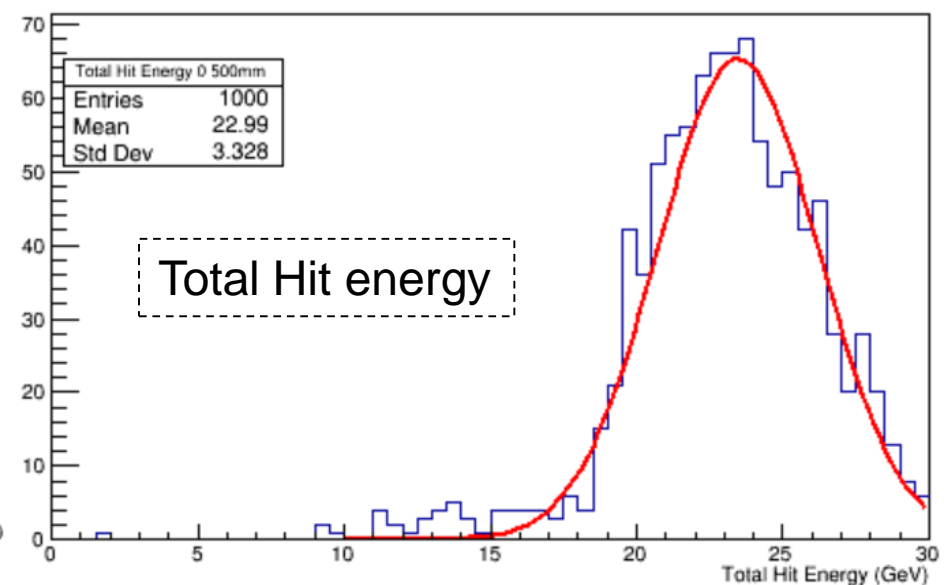
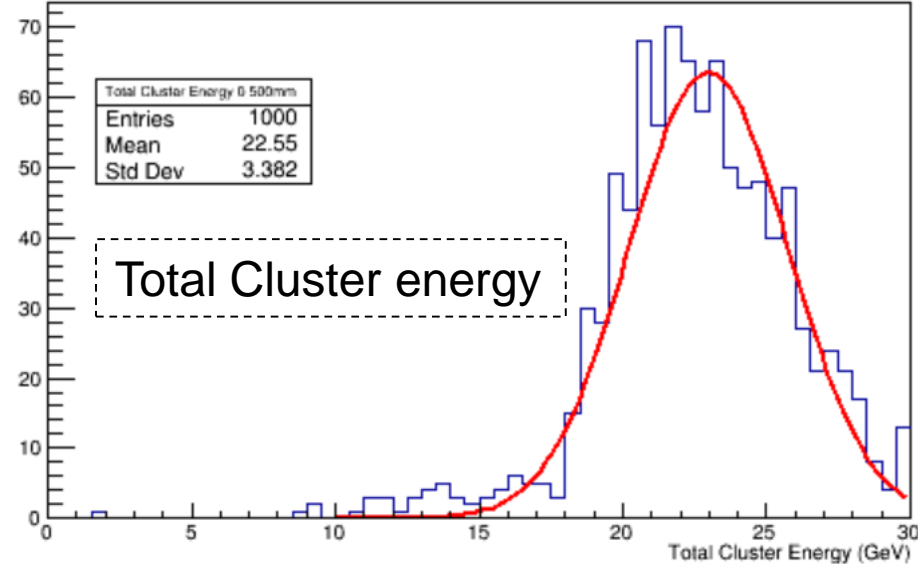
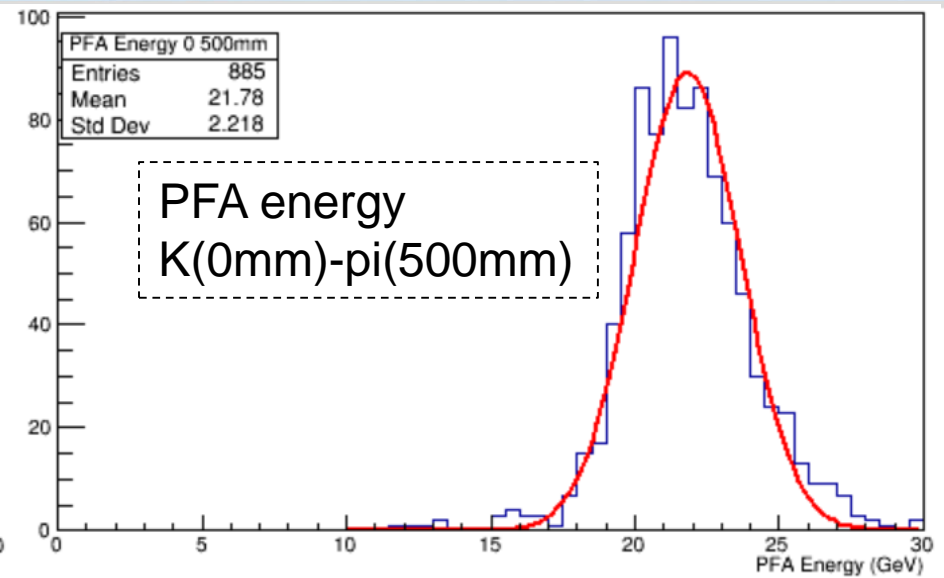
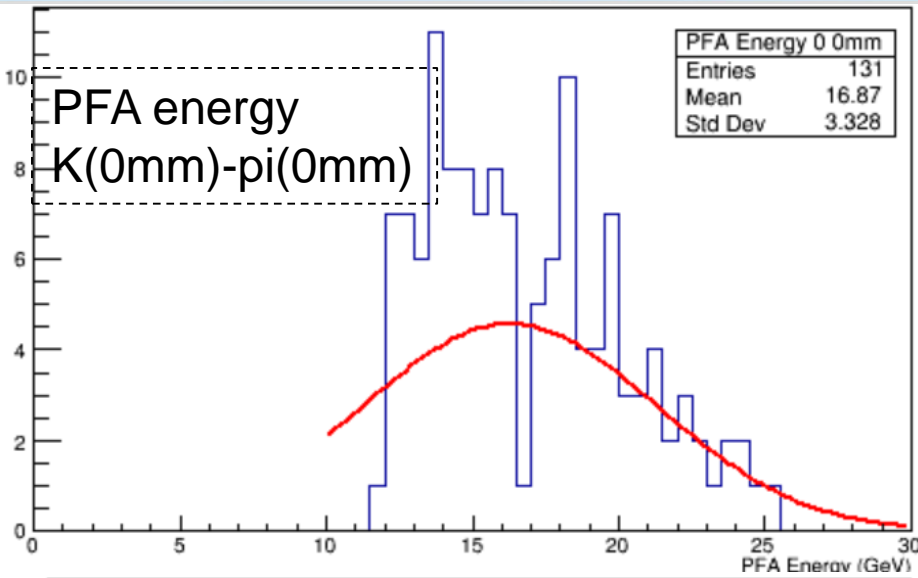
Critical distance – HCAL cellsize



- Simple PFA method
  - PFA:E = pion track + KLong calorimeter
  - Real situation:E = pion track + part of pion fragment + KLong



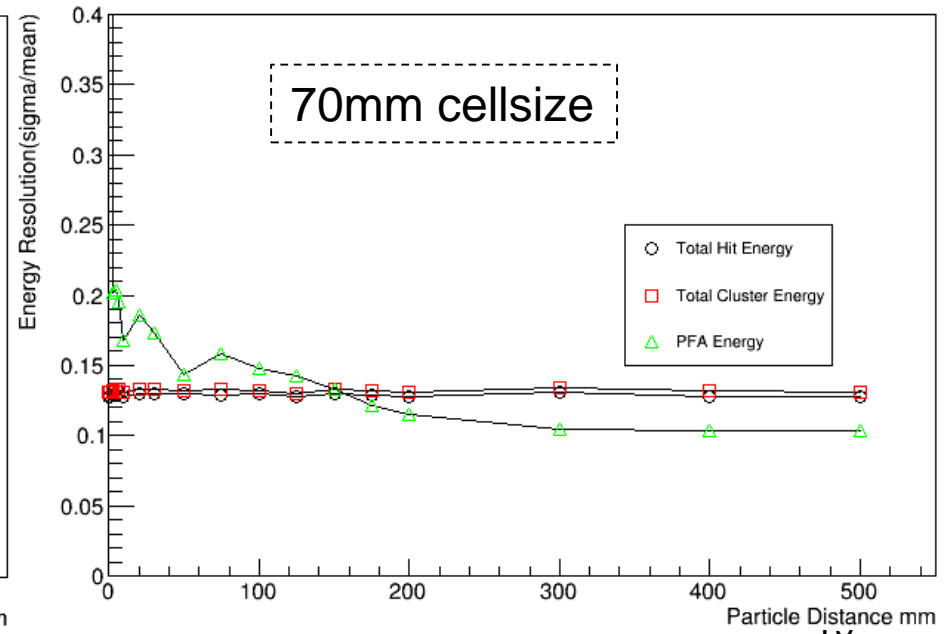
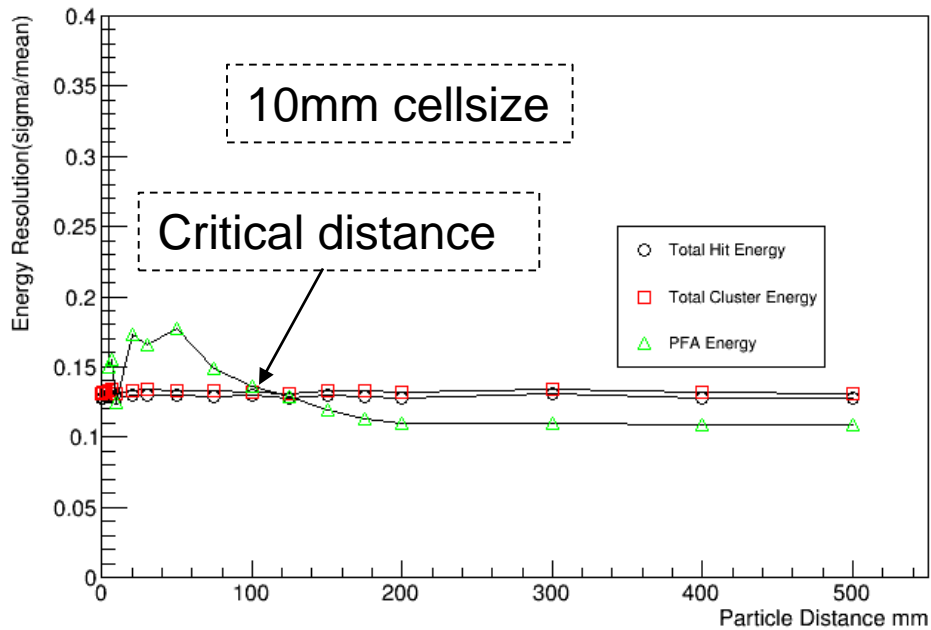
# Simple PFA method



# Simple PFA method



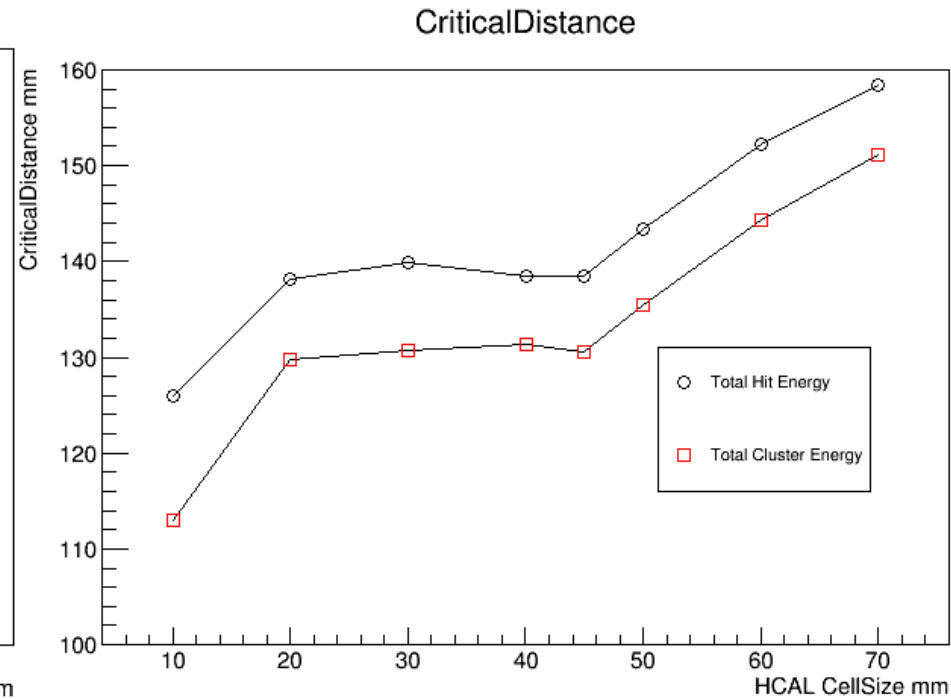
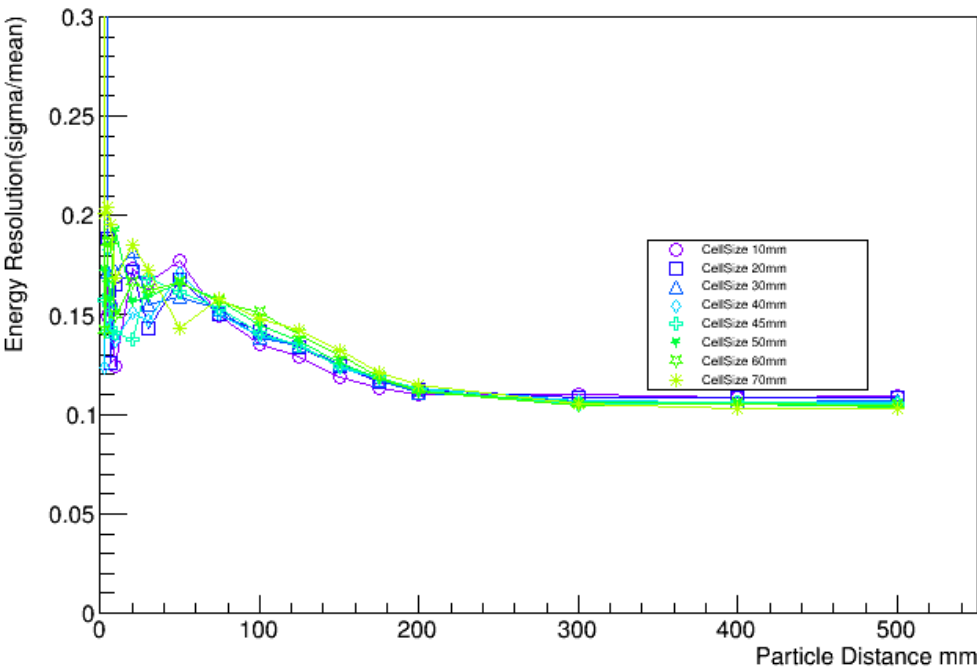
- Energy resolution
  - Total Hit energy resolution
  - Total cluster energy resolution
  - Simple PFA resolution



# Simple PFA method

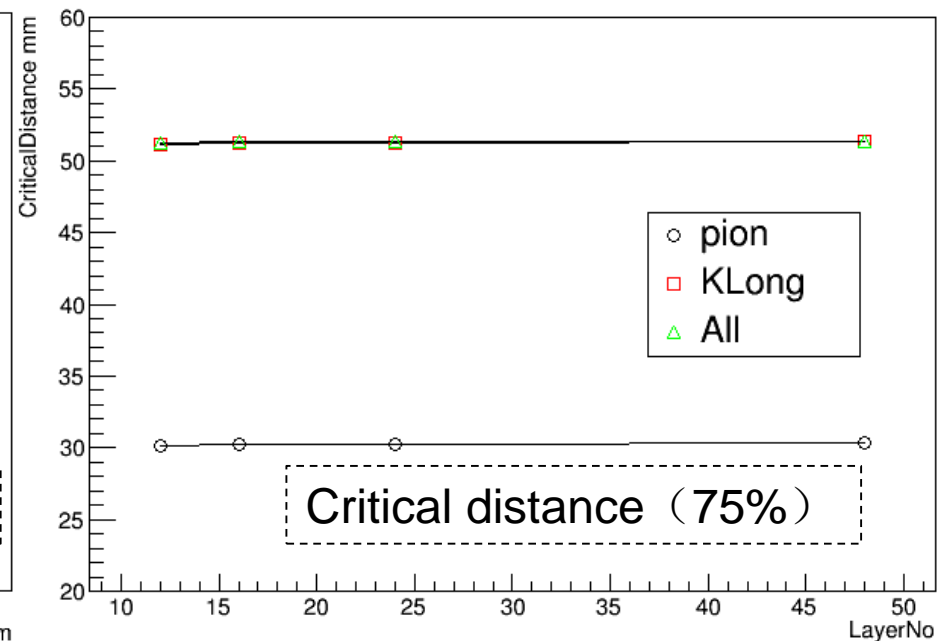
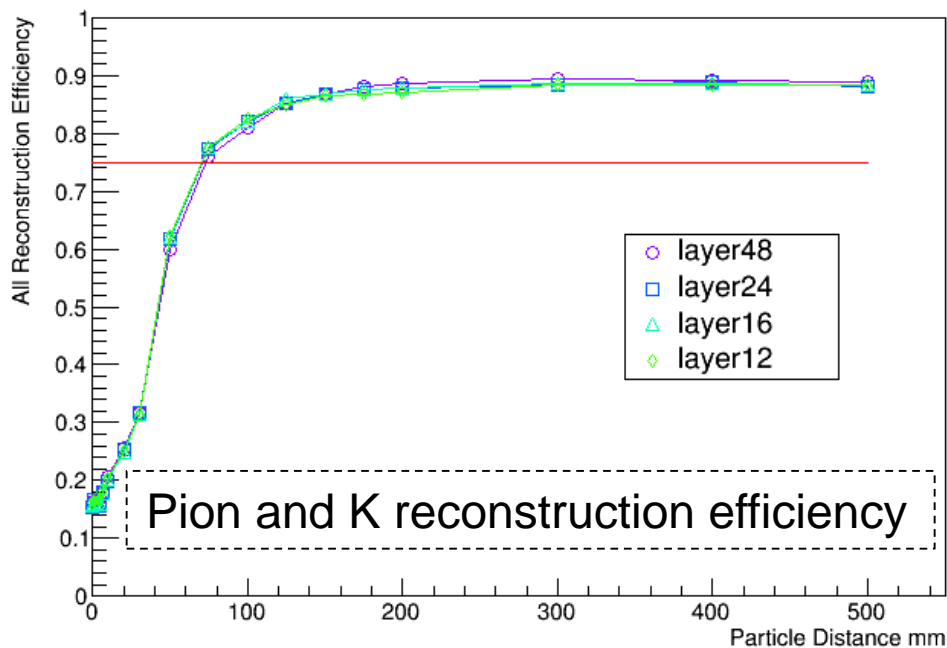


- 50mm is obviously worse than others
- 30mm is a safe choice

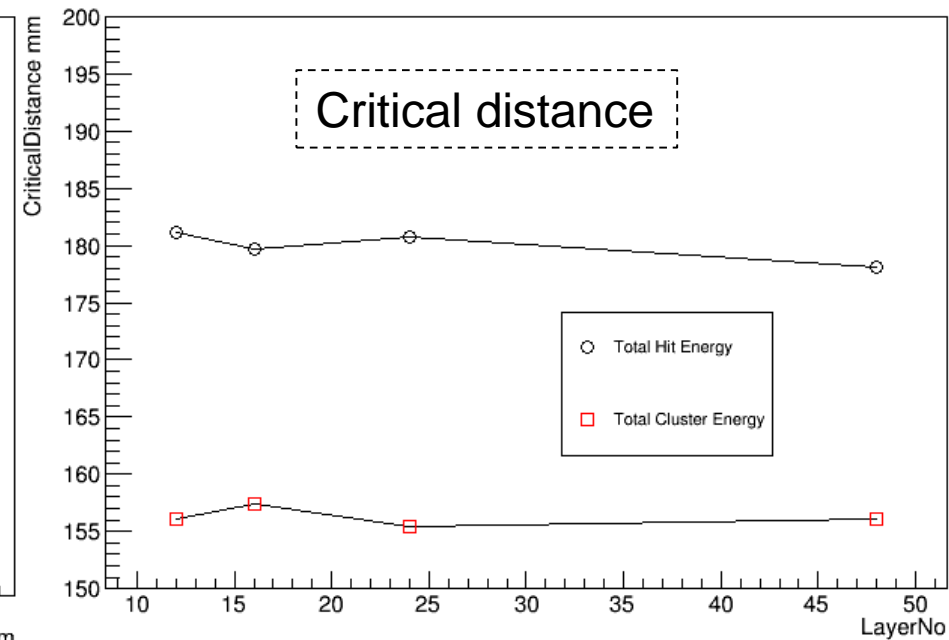
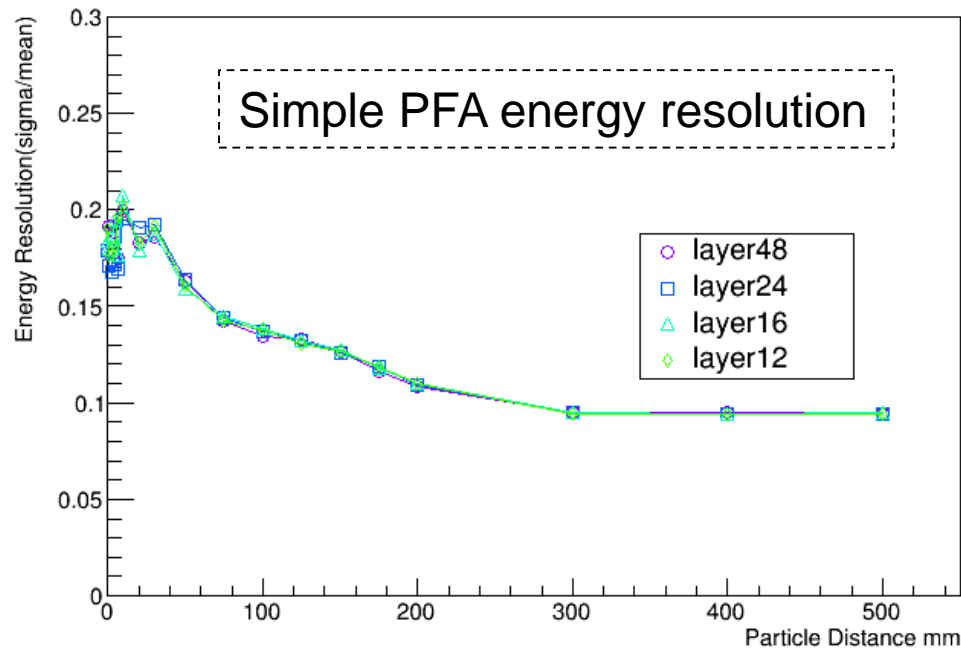


- Setup

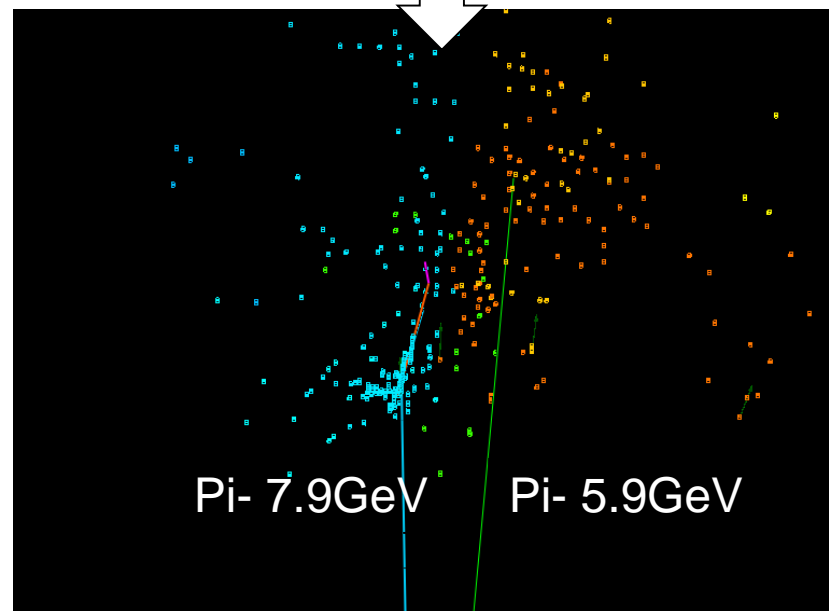
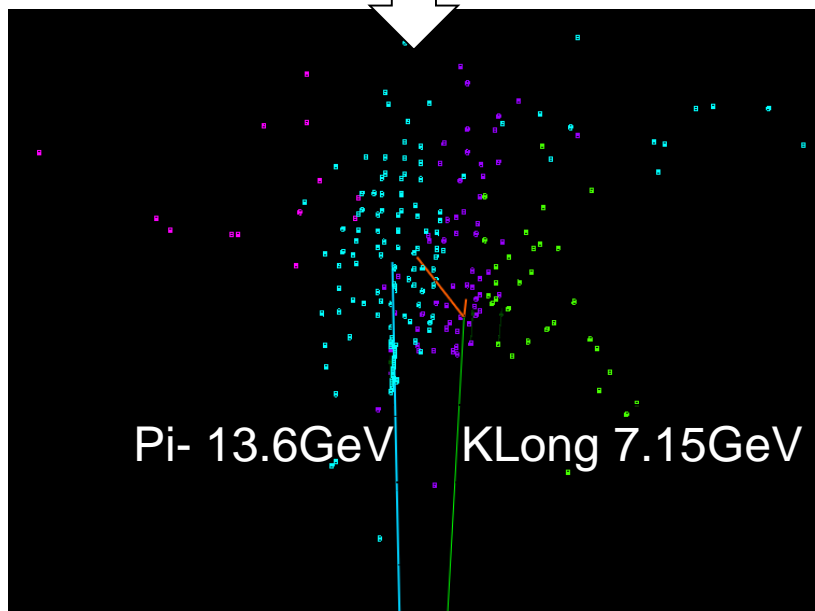
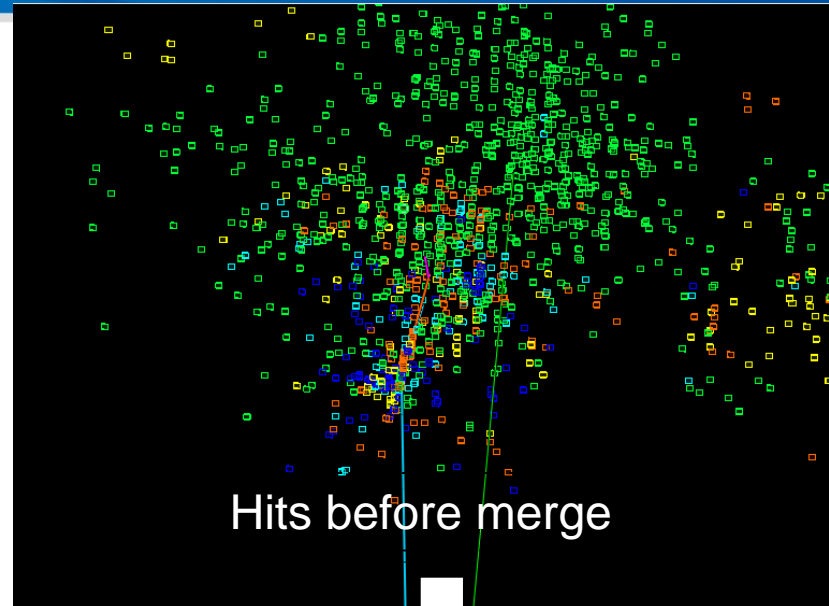
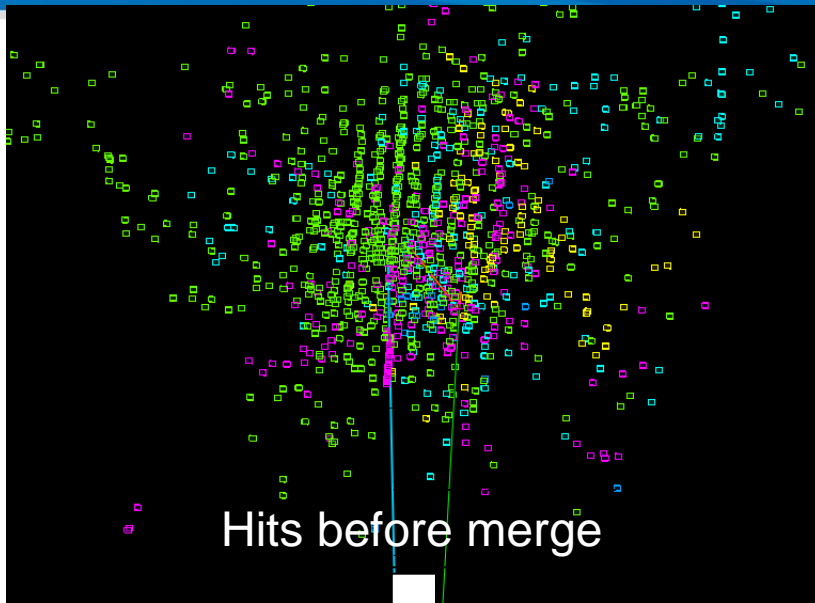
- Optimization of read out layer is done with 30mm cellsize
- The optimization is done by combining the read out of adjoint layers
- Layer ranges from 48 to 24,16,12
- Hit position after combining is set to the 1<sup>st</sup> layer of combined layers



- Results
  - No significant influence is observed till 12 layer



# Read out layer optimization





- CellSize
  - Performance for different AHCAL cellsize has been studied
  - 30mm is a safe choice
- Readout layer number
  - Performance stays unchanged till 12 layer
  - Double layer combined readout won't affect PFA



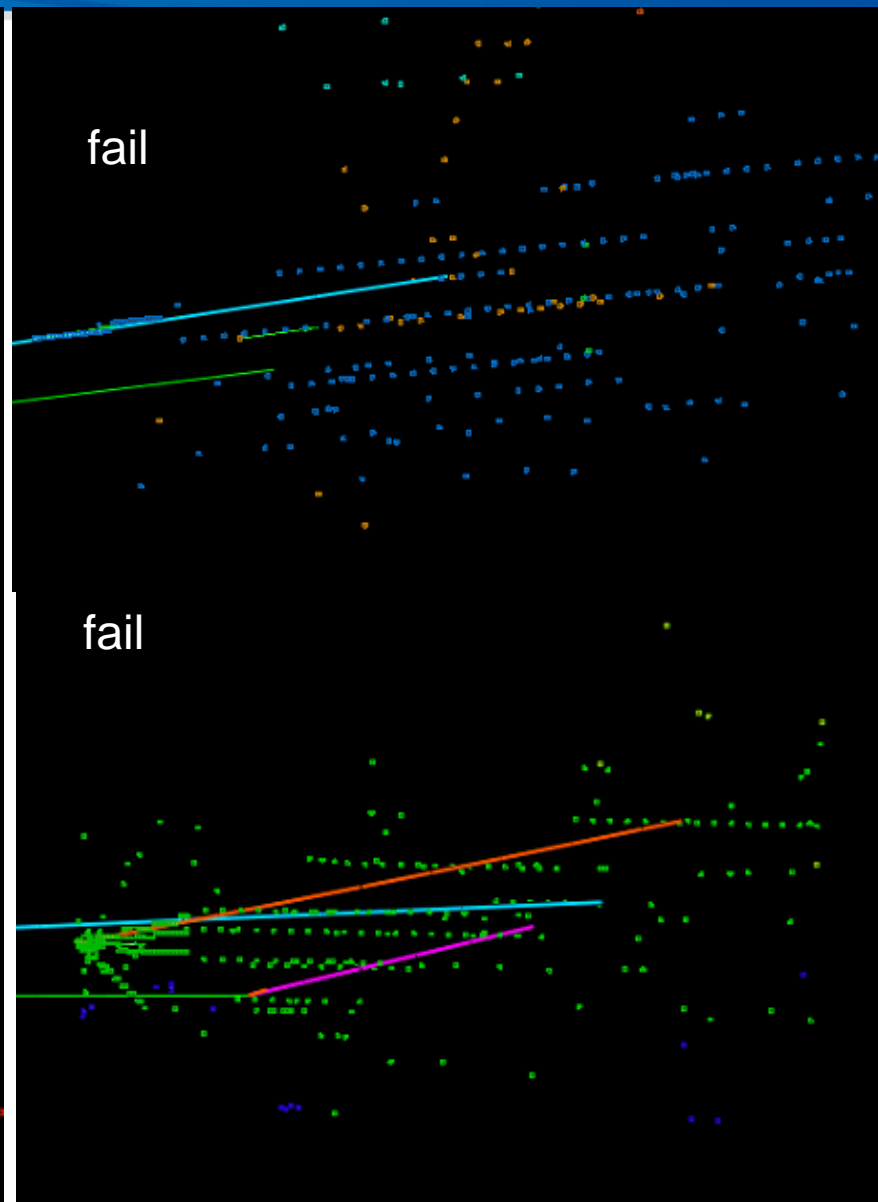
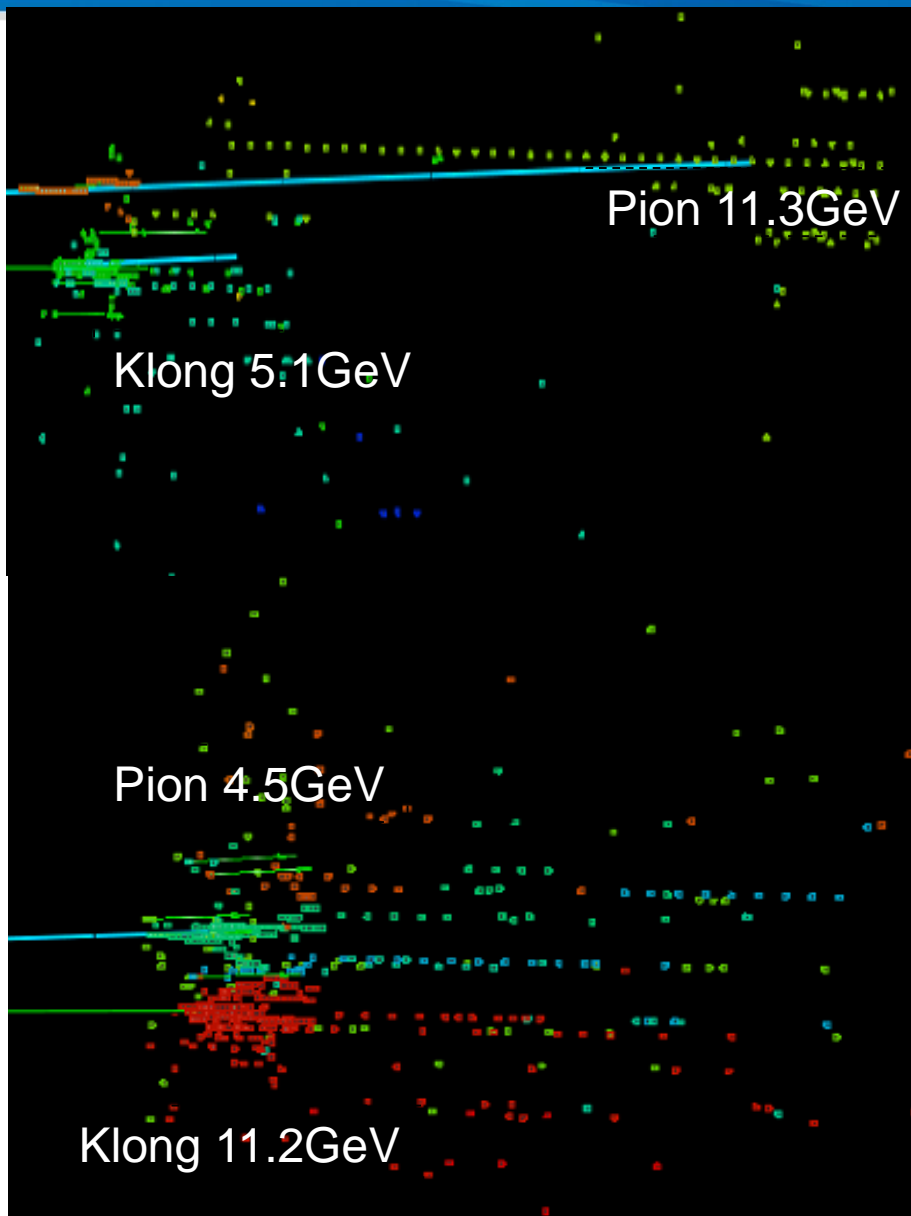


# backup

# Pion and KLong separation



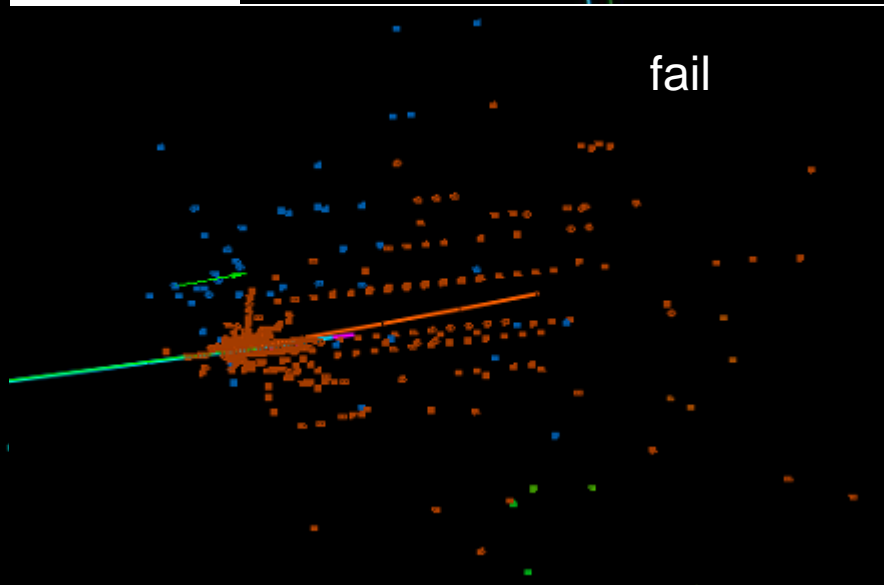
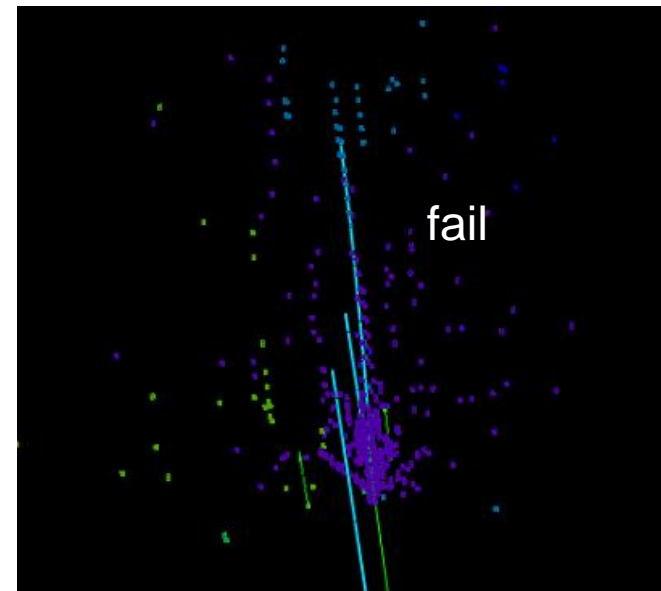
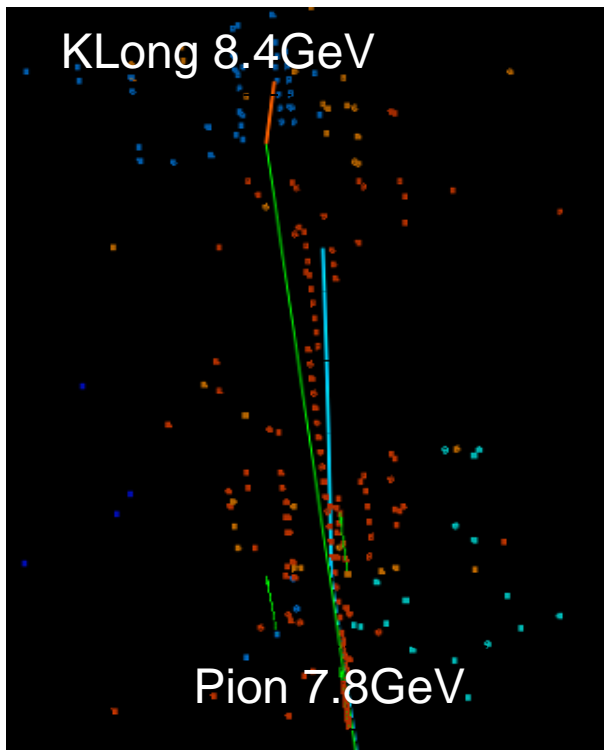
中国科学技术大学  
University of Science and Technology of China



# Pion and KLong separation



- 70mm cellsize
  - Incident position
    - pion:0mm
    - Klong:0mm





- Digitization
  - Combine small cell into the size we want
- arbor
  - 6 parameter in total
  - EE connection(xy direction and z direction)
  - EH connection
  - HH connection(xy direction and z direction)
  - EE Seed connection



- Bush merge

- Merge small cluster into core and fragment
- Cluster Seed: hit closest to origin point in cluster
- Cluster COG: center of energy gravity
- Cluster direction: vector connecting COG and Seed
- Joint: close hits from different cluster
- Cluster depth: distance from cluster Seed to ECAL surface
- Connection of EE, EH, HH clusters has different cut on cluster Seed difference, COG difference, number of joints, transSeed difference
- Only deeper cluster can be merge into shallower cluster

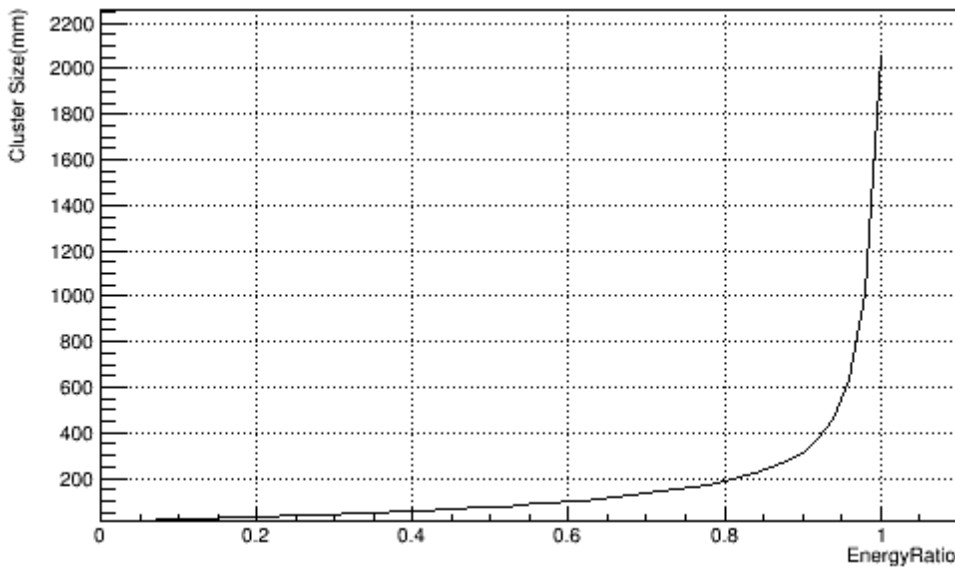
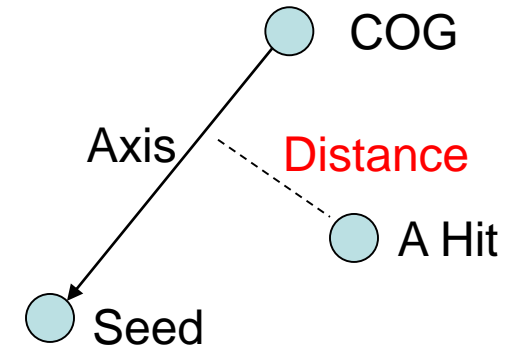
# Reconstruction Process



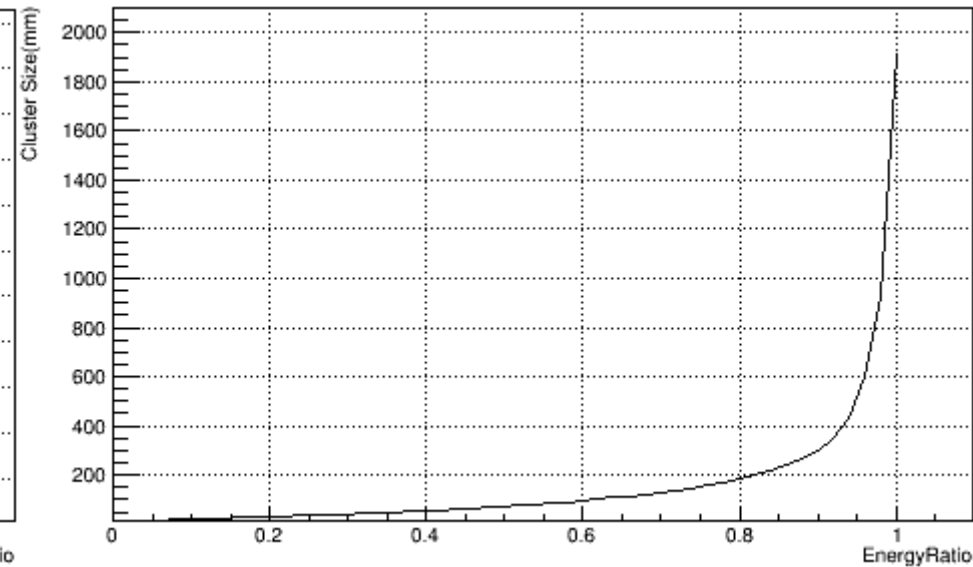
- Cluster Size

- Use **all hits** in a single events

- *Cluster Size* :  $\frac{\sum_{distance < cluster\ size} E_{hit}}{total\ energy} = \text{energy ratio}$



Pion Cluster Size(mm)



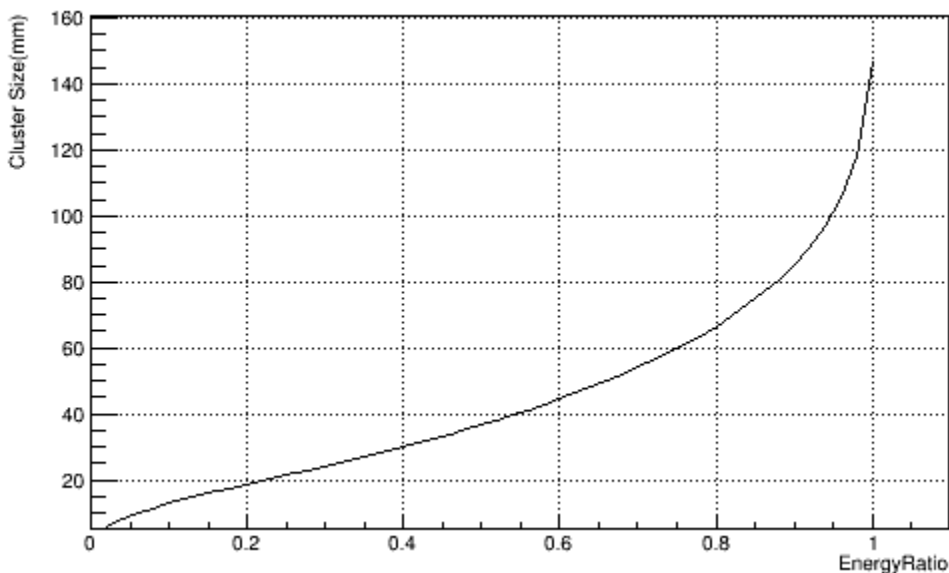
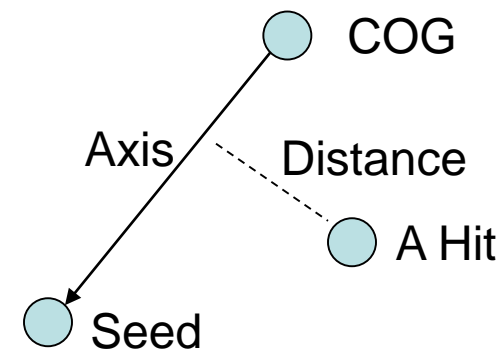
KLong Cluster Size(mm)

# Reconstruction Process

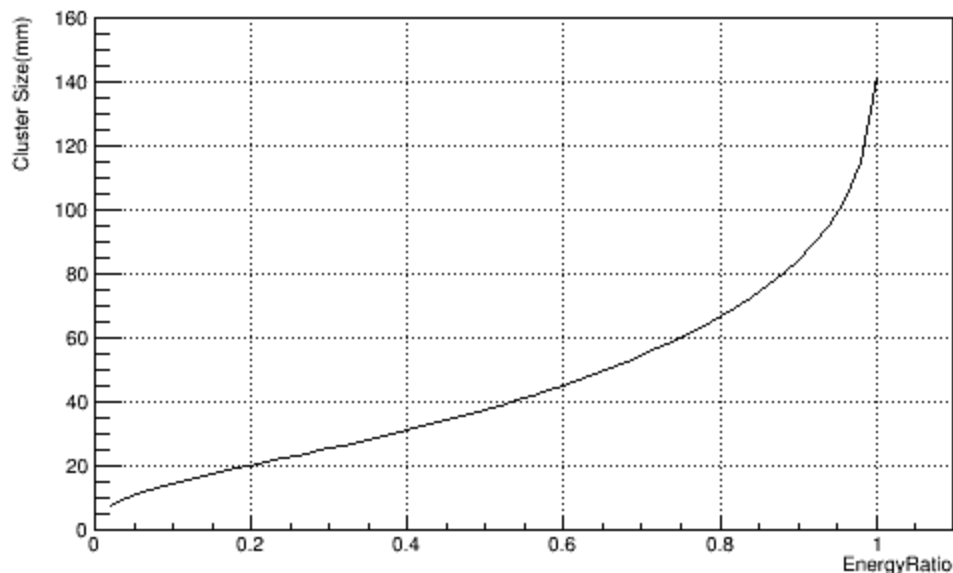


- Cluster Size with **energy weight**
  - Use **all hits** in a single events

$$\text{Cluster Size} = \frac{\sum_{hit} \text{Distance}_{hit-axis} \times E_{hit}}{\sum_{hit} E_{hit}}$$



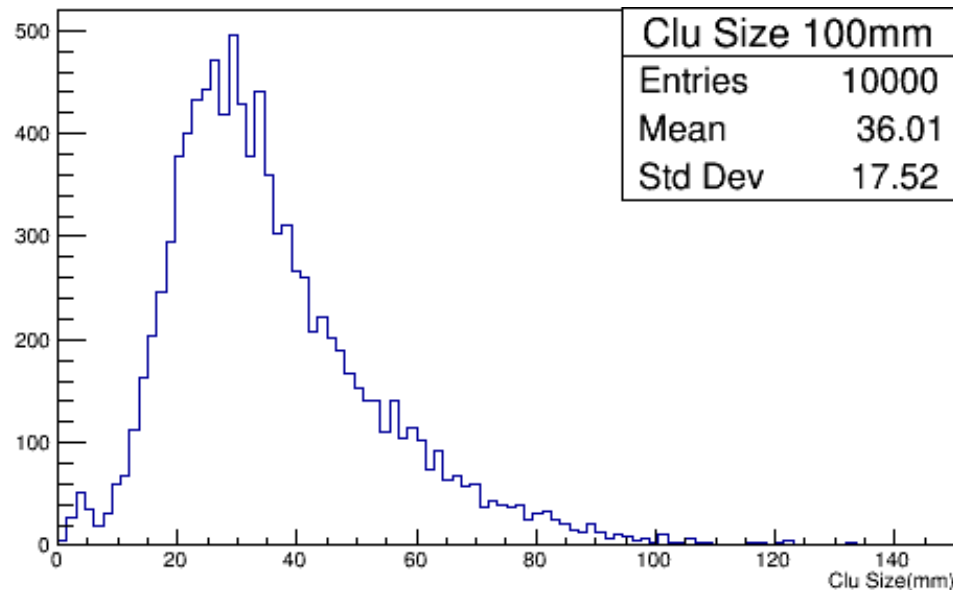
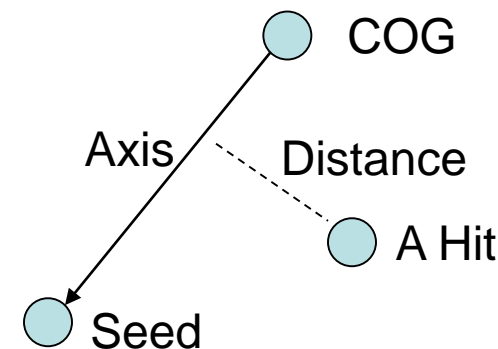
Pion Cluster Size(mm)



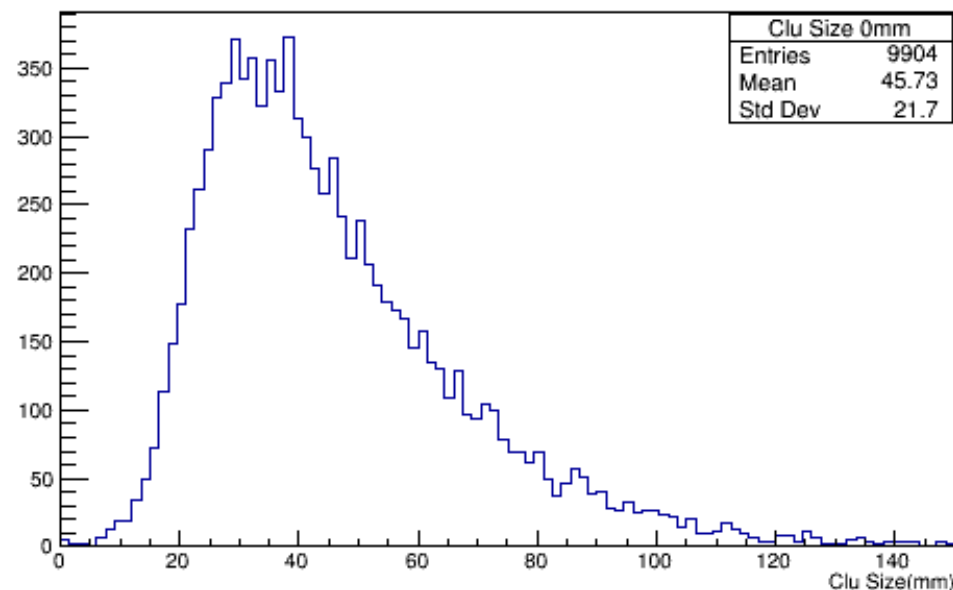
KLong Cluster Size(mm)

- Cluster **Core** Size with energy weight
  - Use hits in **Core** (contains 60% of the particle energy)

$$\text{Cluster Size} = \frac{\sum_{hit} \text{Distance}_{hit-axis} \times E_{hit}}{\sum_{hit} E_{hit}}$$



Pion Core Size(mm)



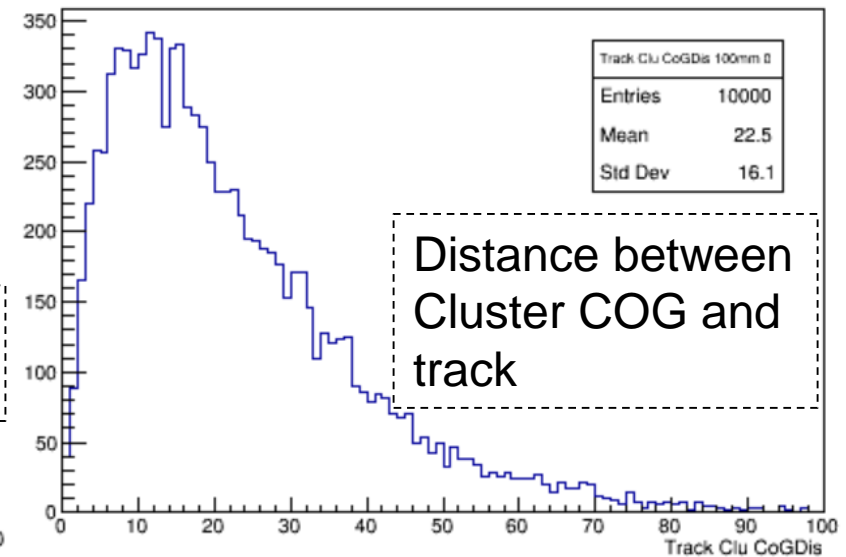
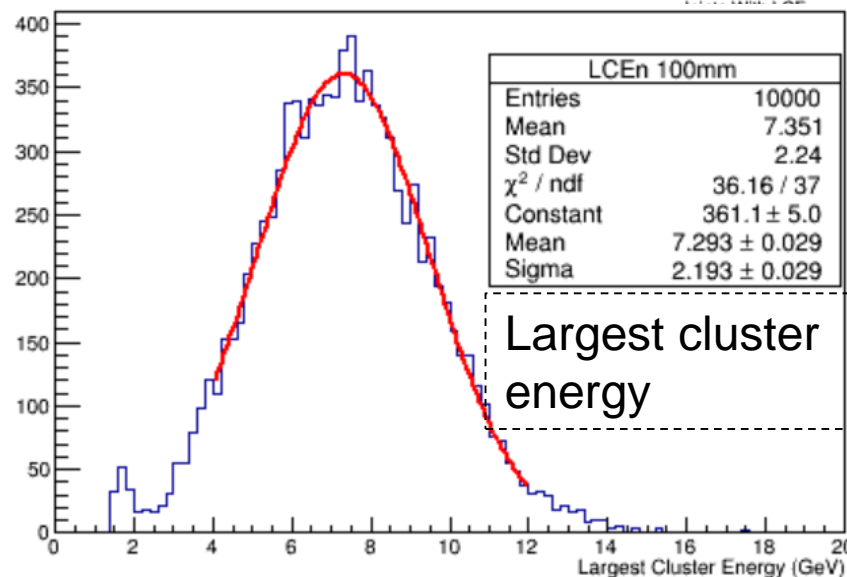
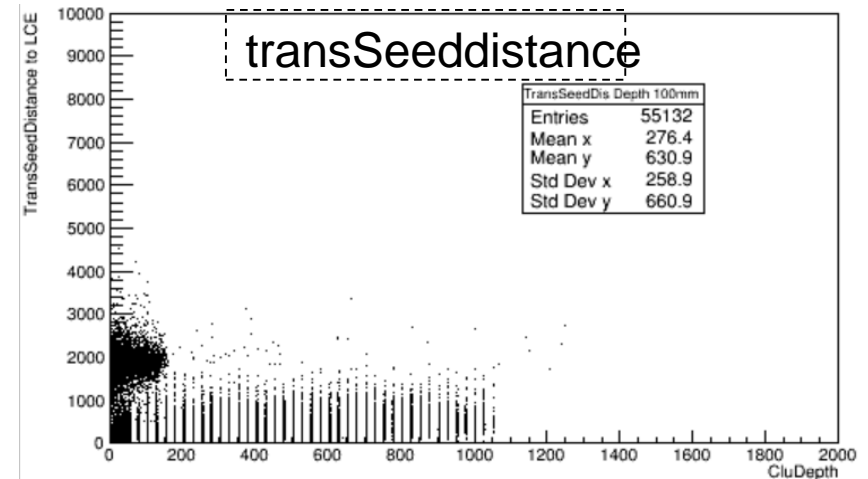
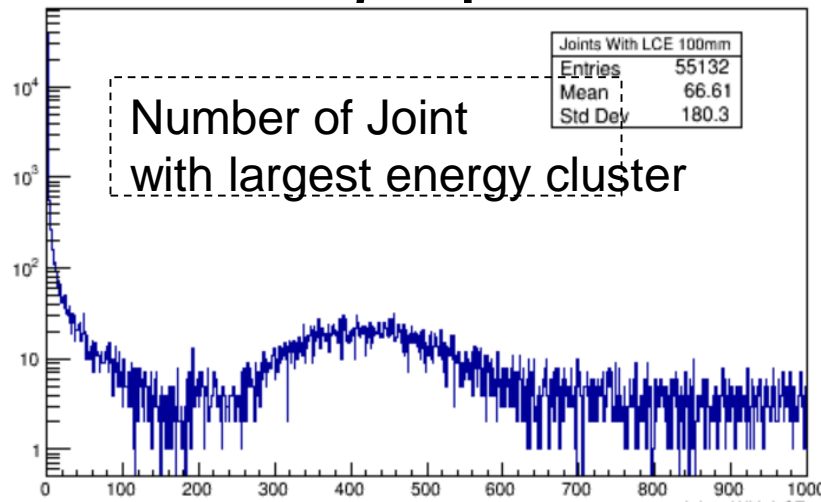
KLong Core Size(mm)



# Marlin arbor and Cluster building



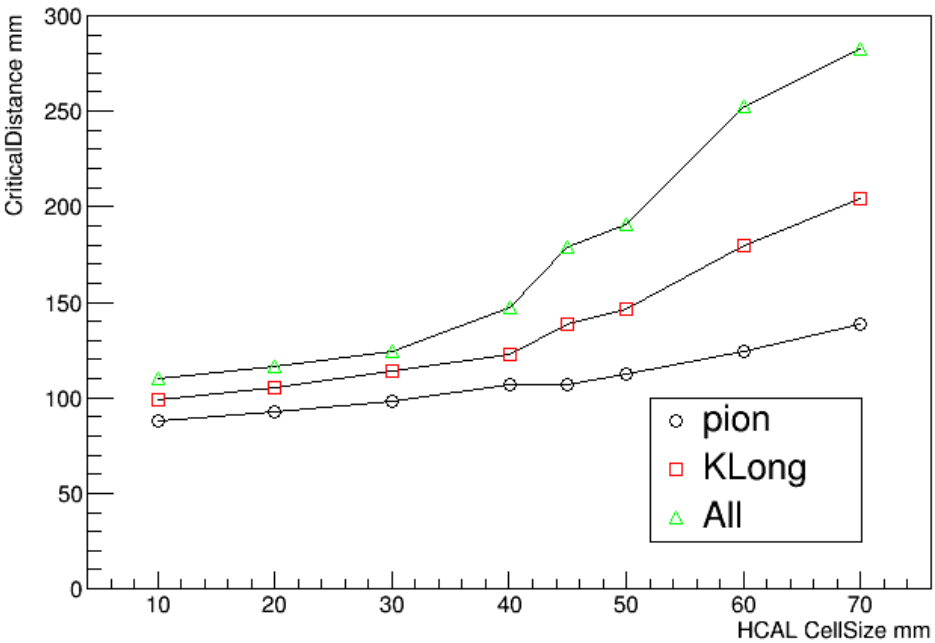
- For single pion event in 10mm cellsize



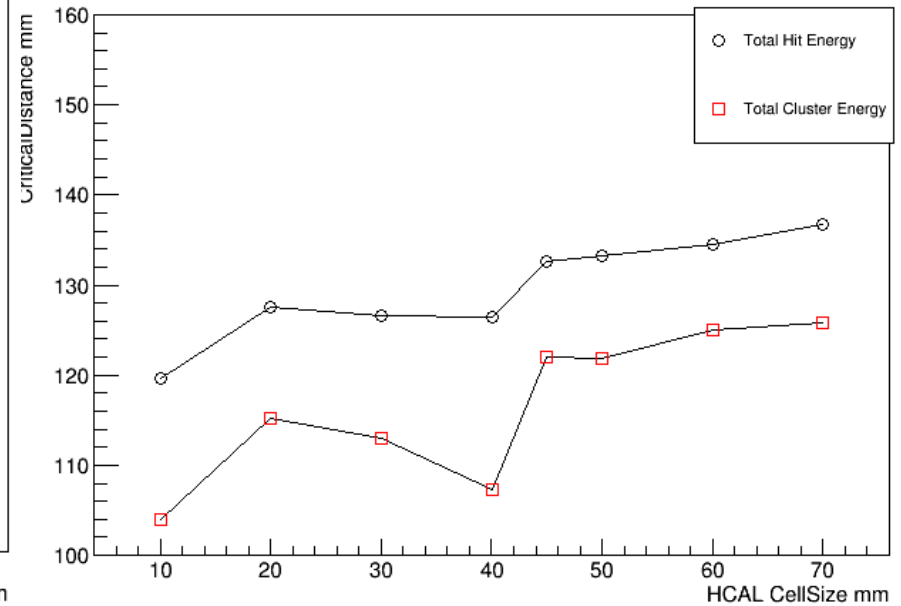
# 74% energy ratio



CriticalDistance pion



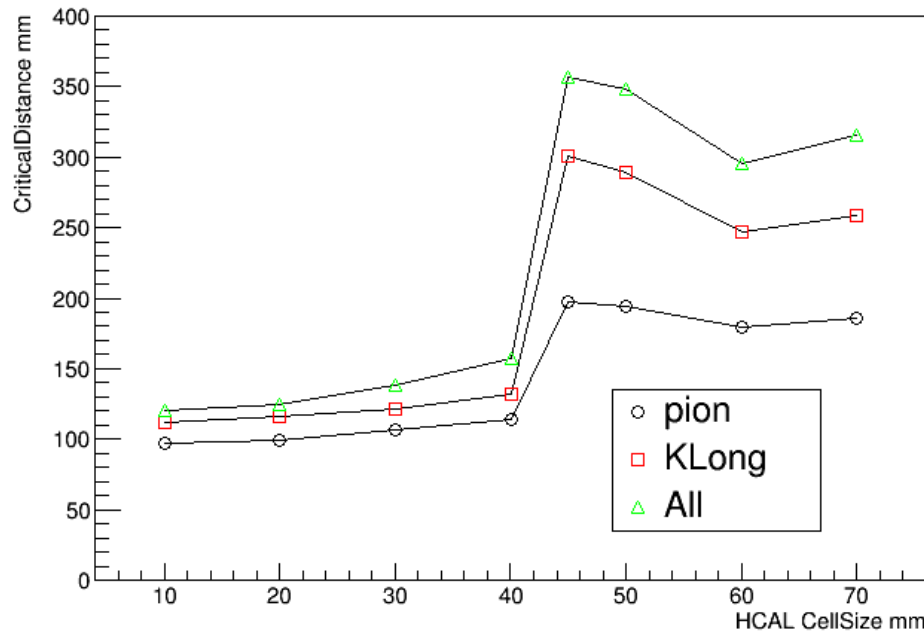
CriticalDistance



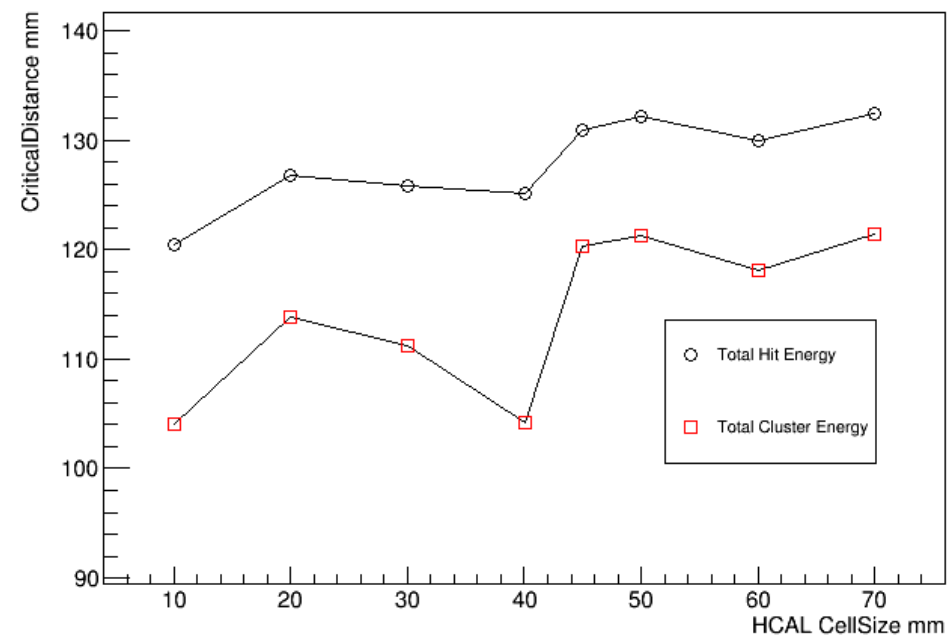
# 74% energy ratio



CriticalDistance pion



CriticalDistance



- Klong:81%
- Pion:75%