Reconstruction Studies for a Scintillator-Tungsten Electromagnetic Calorimeter

Joseph Proulx

University of Colorado at Boulder

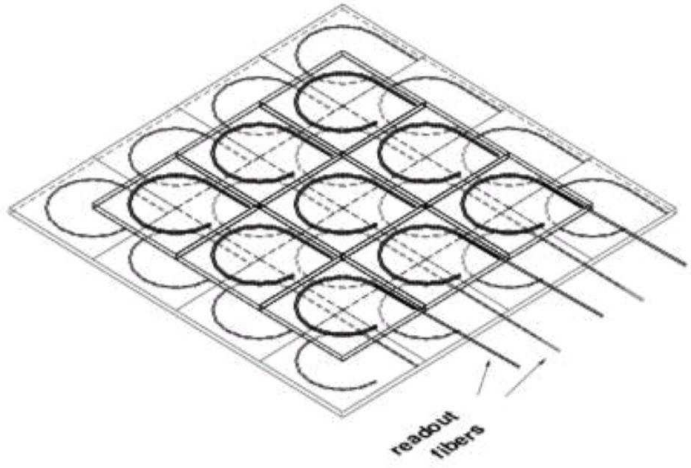
The Colorado Group

Shirley Choi, Keith Drake, Joshua Elliot, Eric Erdos, Chris Geraci, Jack Gill, Jason Gray, Kyle Miller, Sarah Moll, Uriel Nauenberg, Gleb Oleinik, Joseph Proulx, Elliot Smith, Jiaxin Yu, Jinlong Zhang

Outline

- Our design
- Simulating offset tiles
- Clustering performance
- Photon/Merged-π^0 separation
- Cluster direction studies
- Tile saturation studies
- Future work

Our design - basic overview



- 1/2-radiation-length Tungsten plate absorber (1.75mm)
- 2mm-thick scintillator sensitive material
- 5cm square scintillator tiles, offset by 2.5cm in each layer

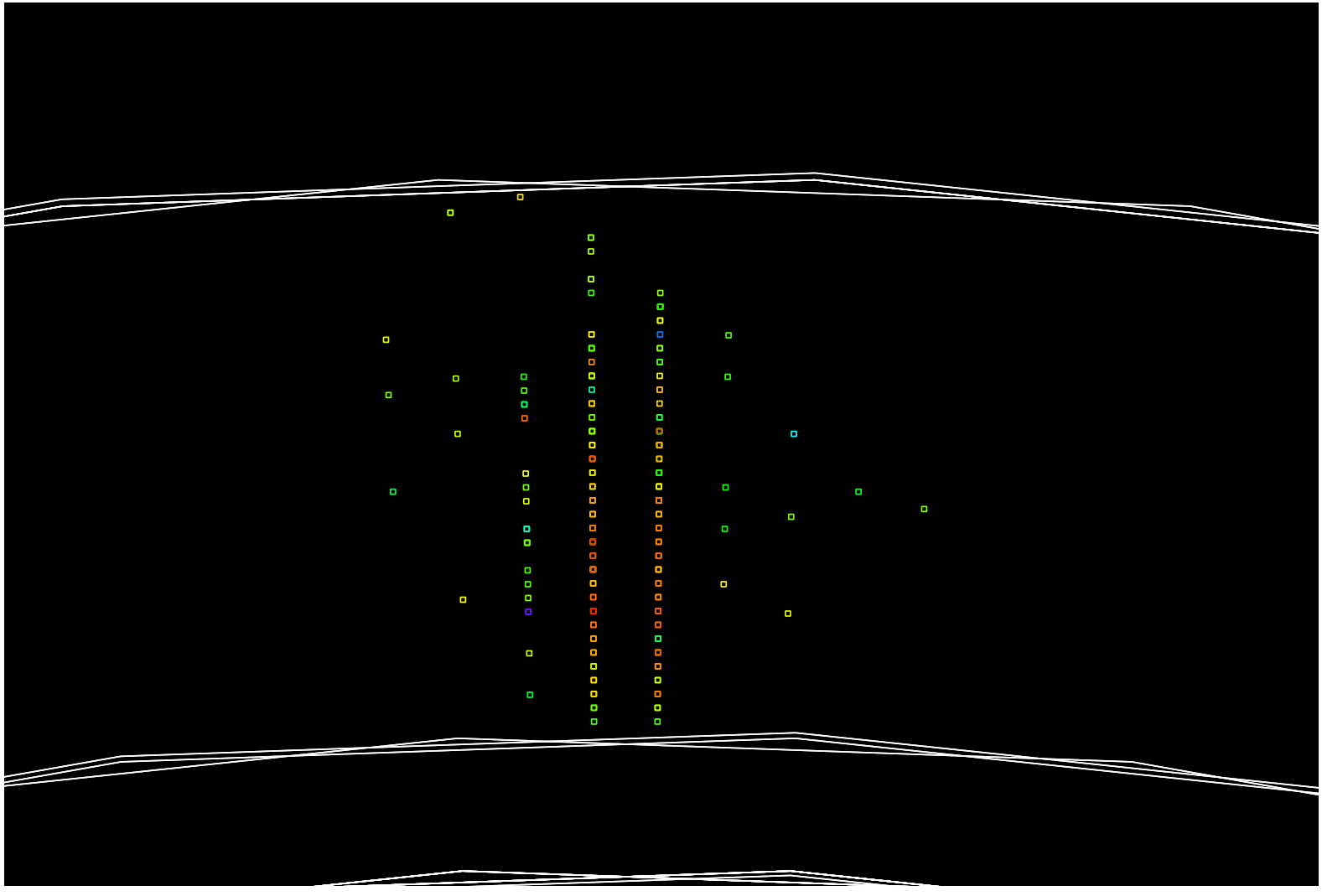
- WLS fiber light guides
- SiPM detectors for easy (or easier) calibration

Simulating offset tiles

- Initial SLIC simulation uses geometry 2.5cm square tiles
- Groups of four tiles are ganged together and their energy averaged
  - New hits are added to create groups of four if necessary
  - Each group of four ganged hits represents one 5cm square tile
- List of averaged, ganged hits is added to the event

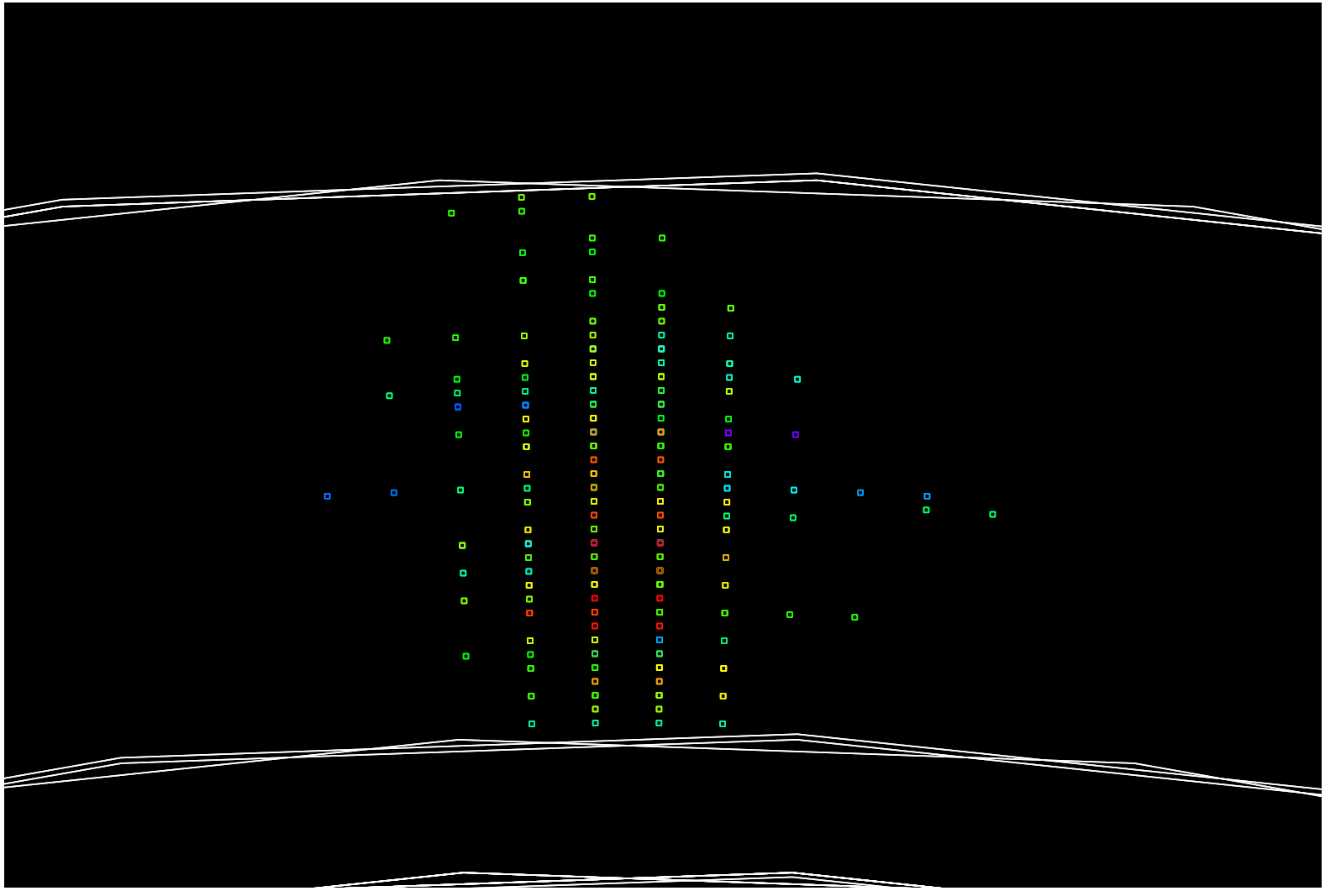
Simulating offset tiles

EcalBarrHits



Simulating offset tiles

EcalBarrHitsGanged

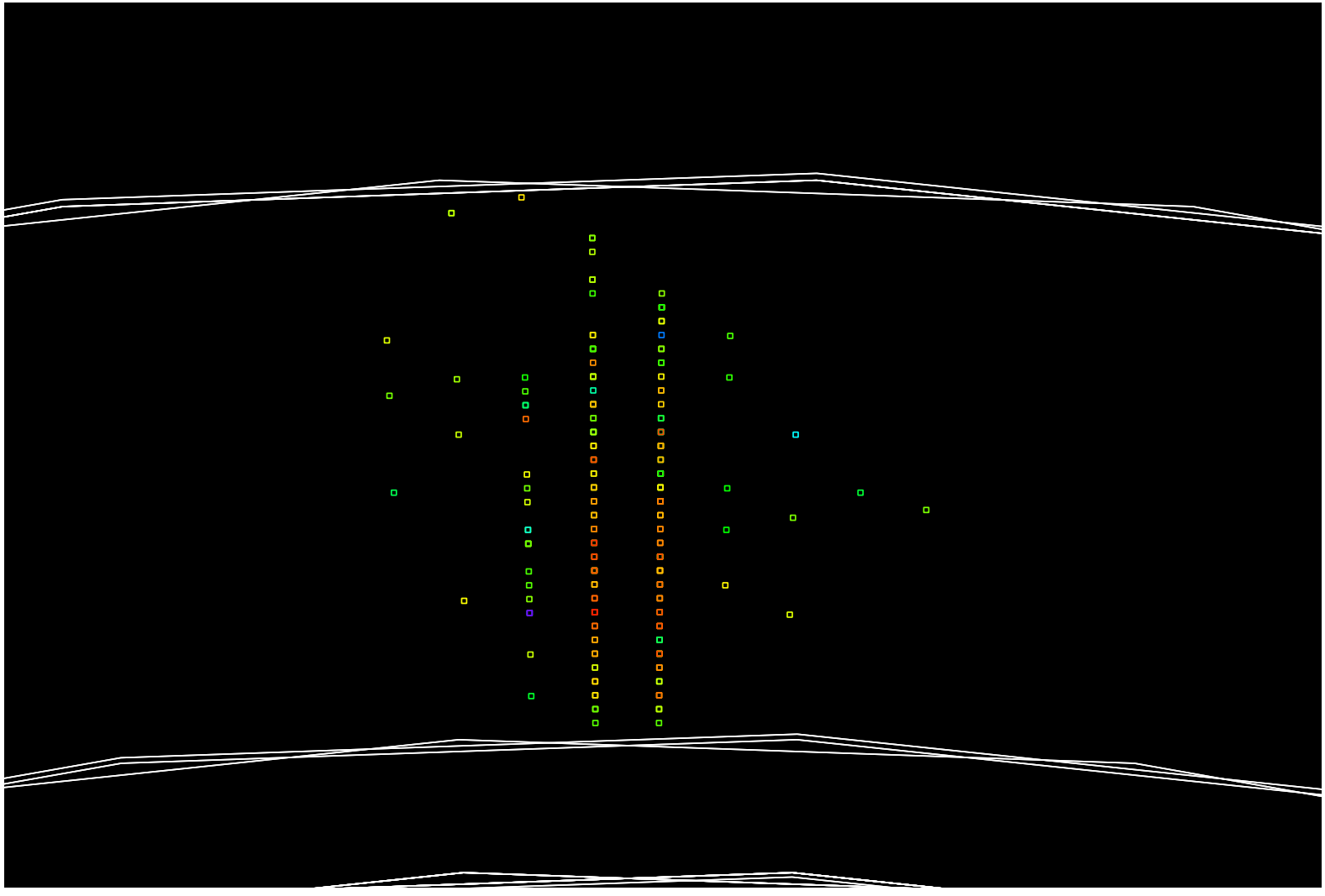


Simulating offset tiles

- Ganged groups are “unganged” by weighting energy in each tile by the energy of the above and below neighbors
- List of UnGanged hits is added to the event
- UnGanged list is used for clustering to avoid problems of offset geometry in clustering algorithms
  - UnGanged MIP traces look almost exaclty as they would in 2.5cm geometry
  - Showers are much better separated in UnGanged list

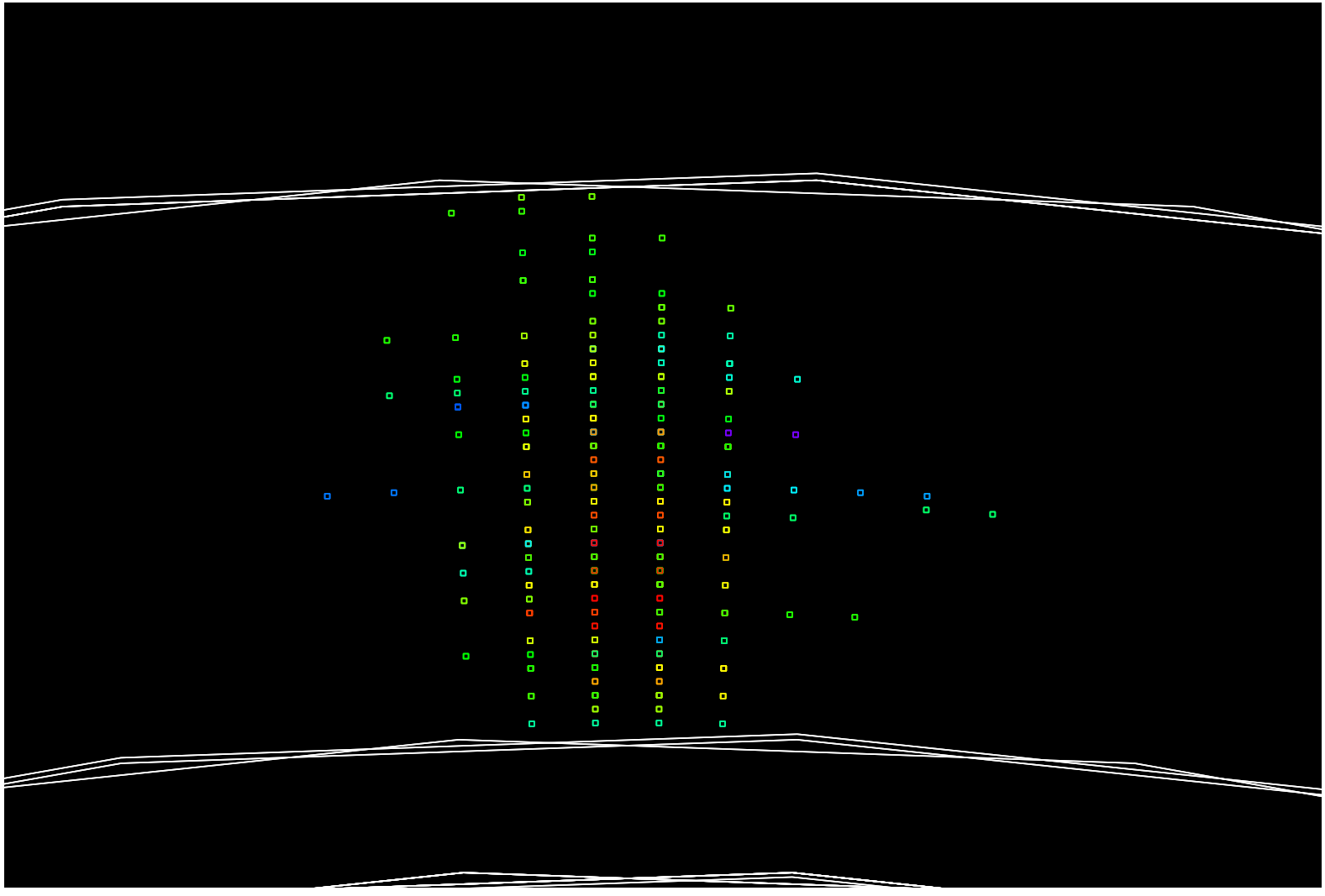
Simulating offset tiles

EcalBarrHits



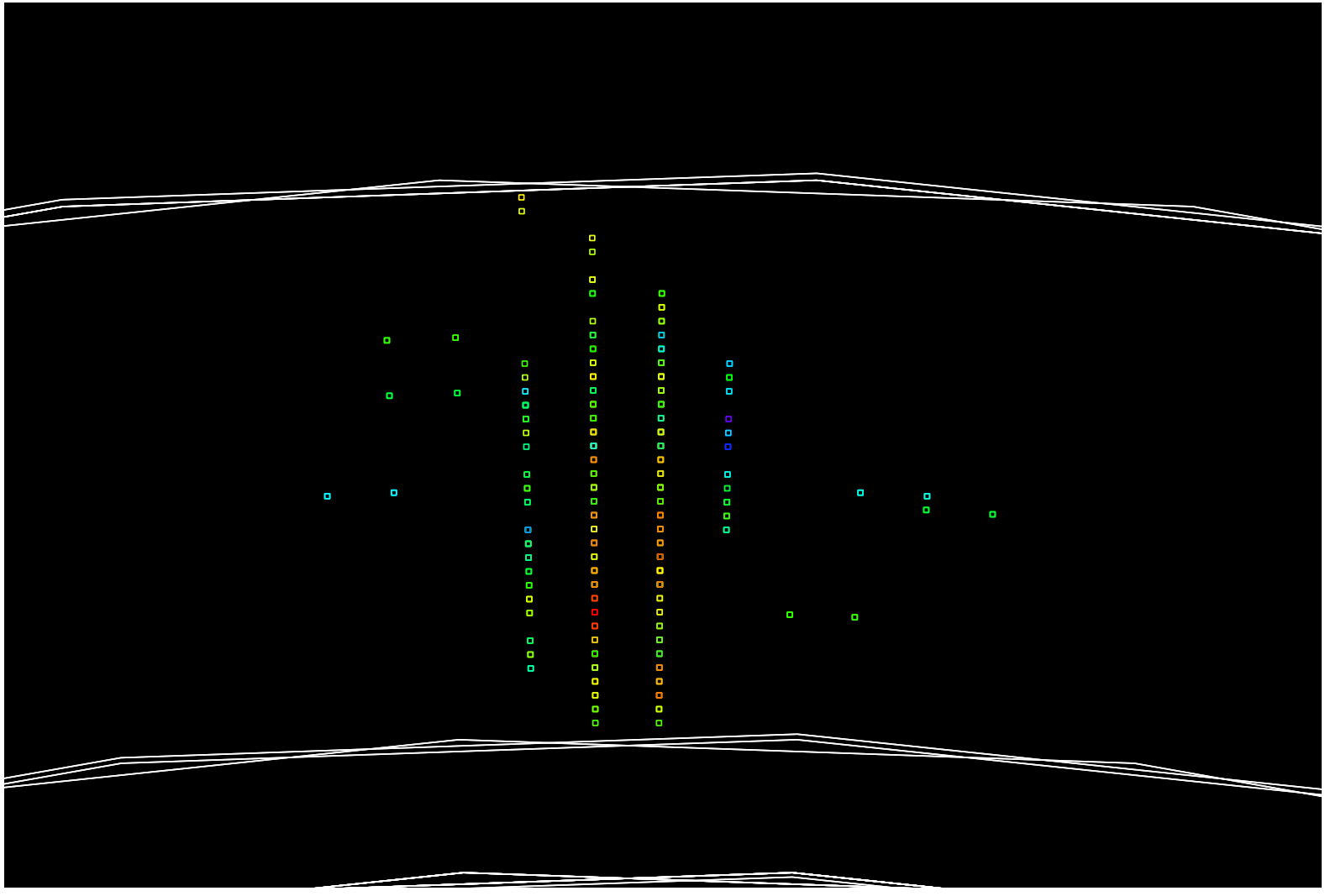
Simulating offset tiles

EcalBarrHitsGanged



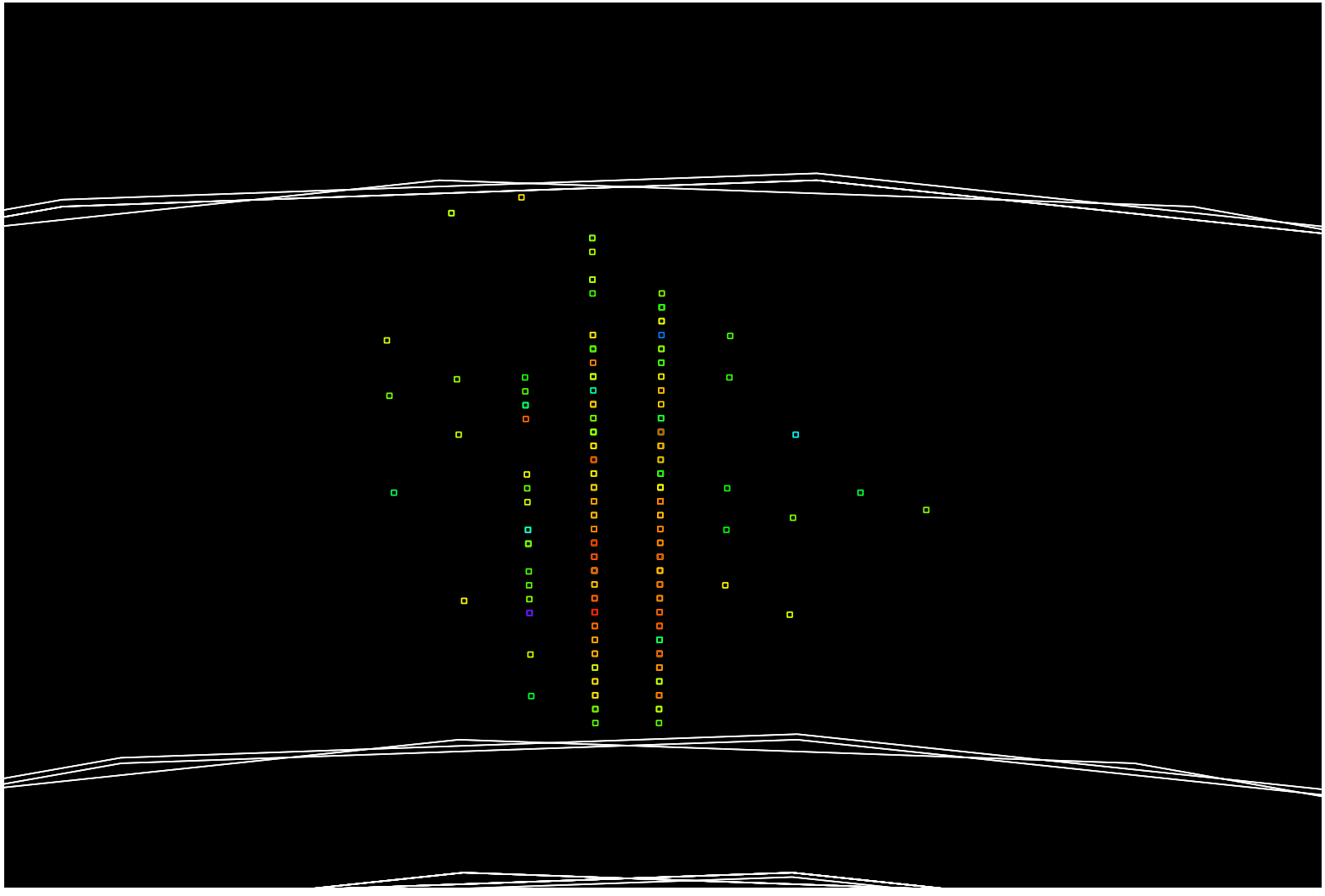
Simulating offset tiles

EcalBarrHitsUnGanged



Simulating offset tiles

EcalBarrHits



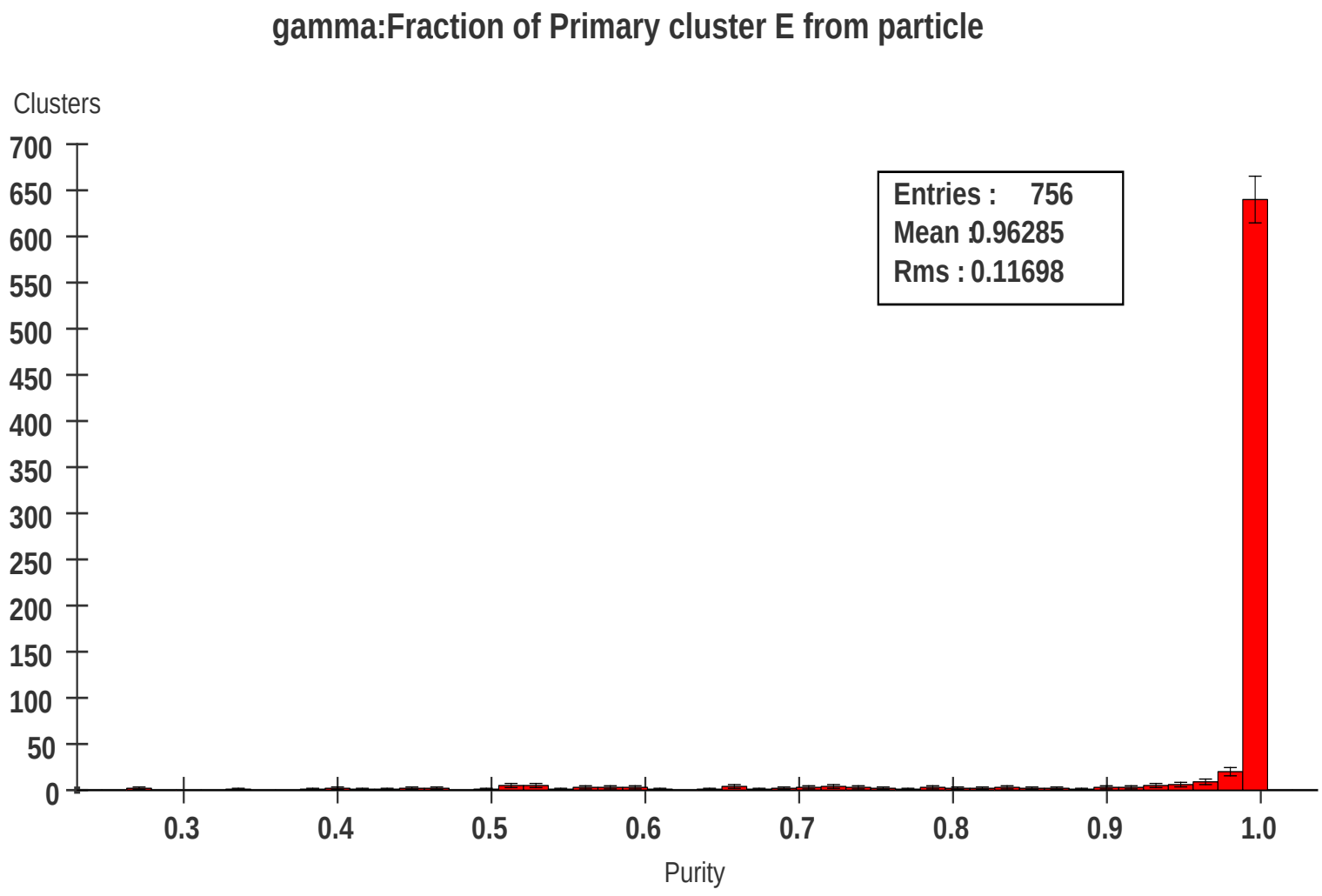
Clustering Performance

We analyzed clustering performance on 500GeV ZZ->jets events

- We remove hits associated with charged tracks from the UnGanged hit list
- Remaining hits are clustered with directed-tree algorithm
- We analyze cluster performance on clusters associated with photons using cluster analysis package in org.lcsim
- Excellent results; rare merged photon clusters cause the only problems

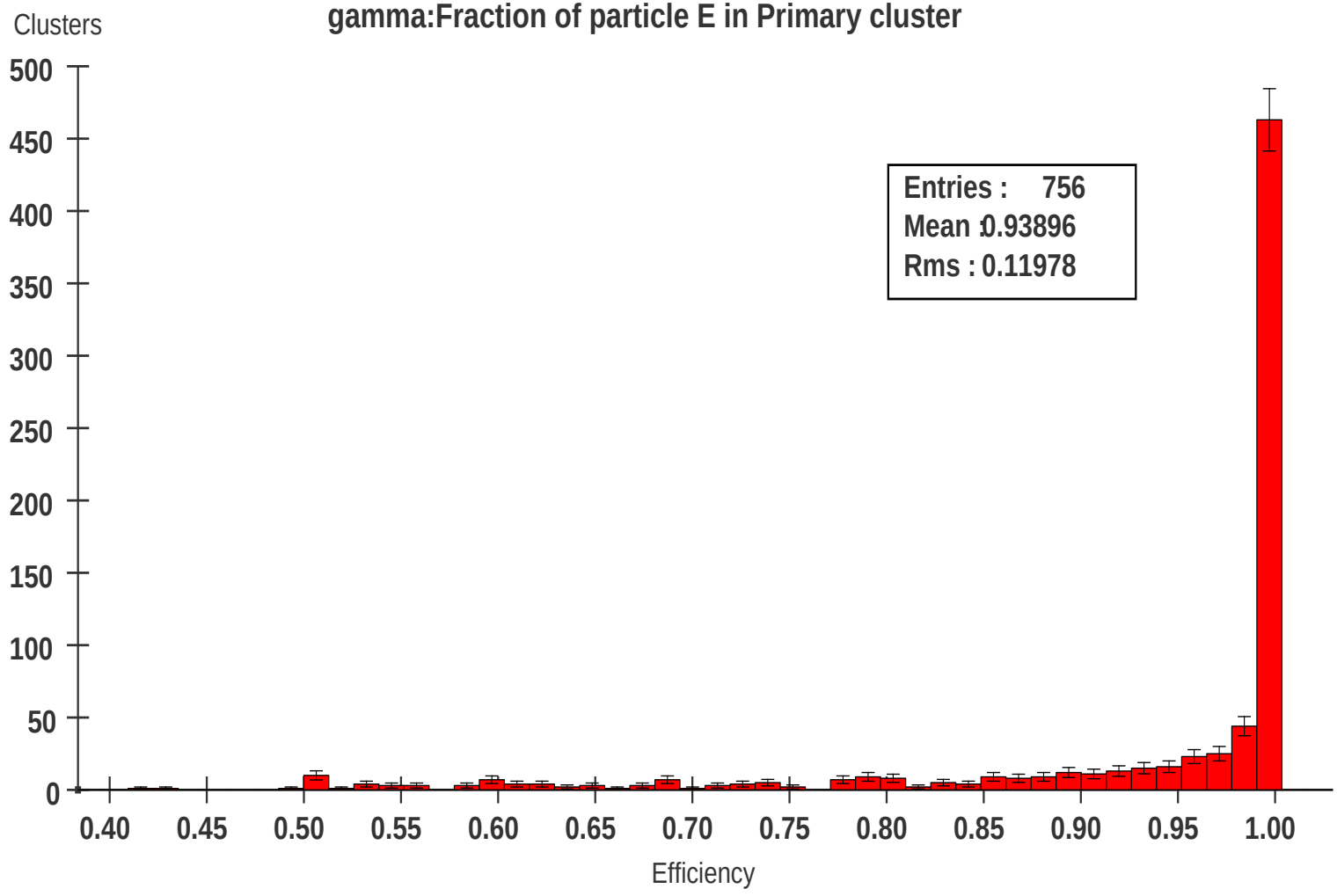
Clustering Performance

Cluster Purity



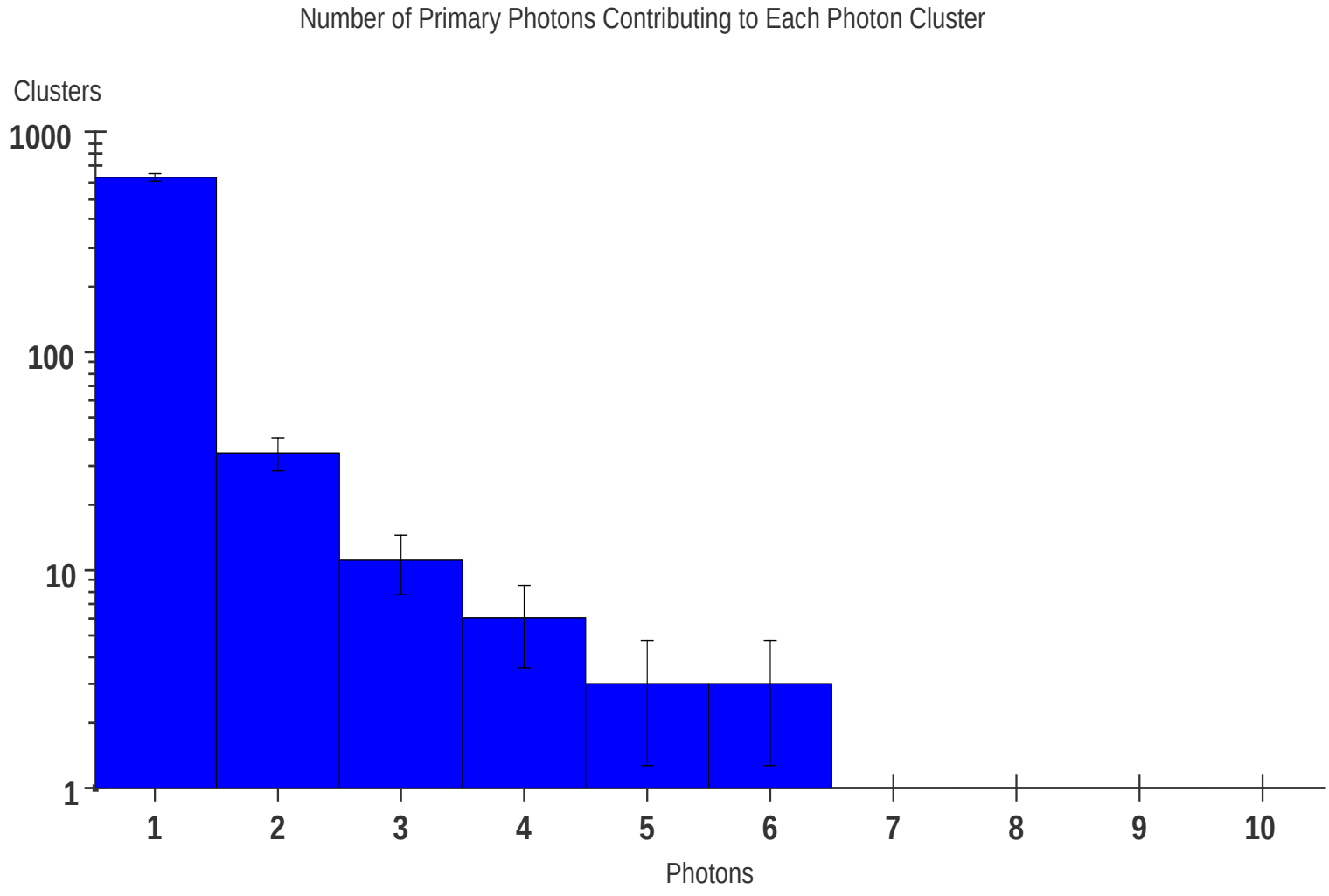
Clustering Performance

Cluster Efficiency



Clustering Performance

Cluster Photon Count



Clustering Performance

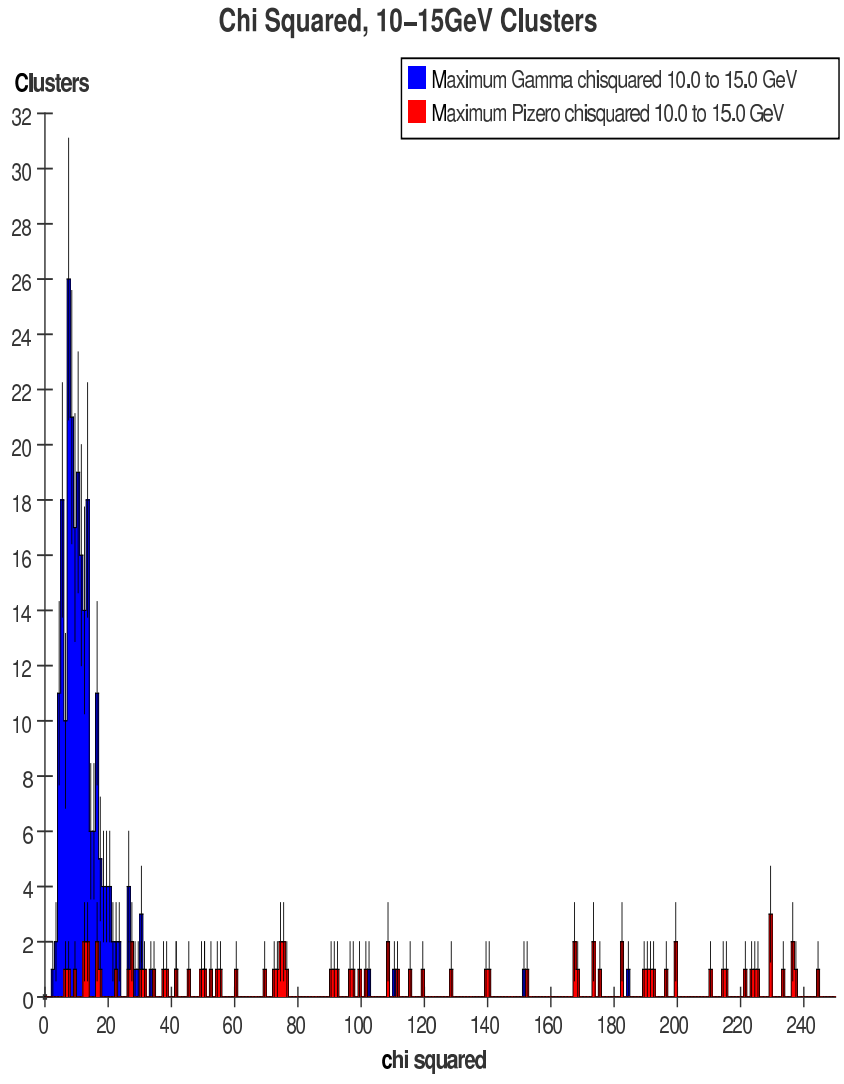
- Results demonstrate that our calorimeter can support particle-flow algorithms in difficult multiple-jet events
- Further analysis on photon clusters may be used to identify merged clusters

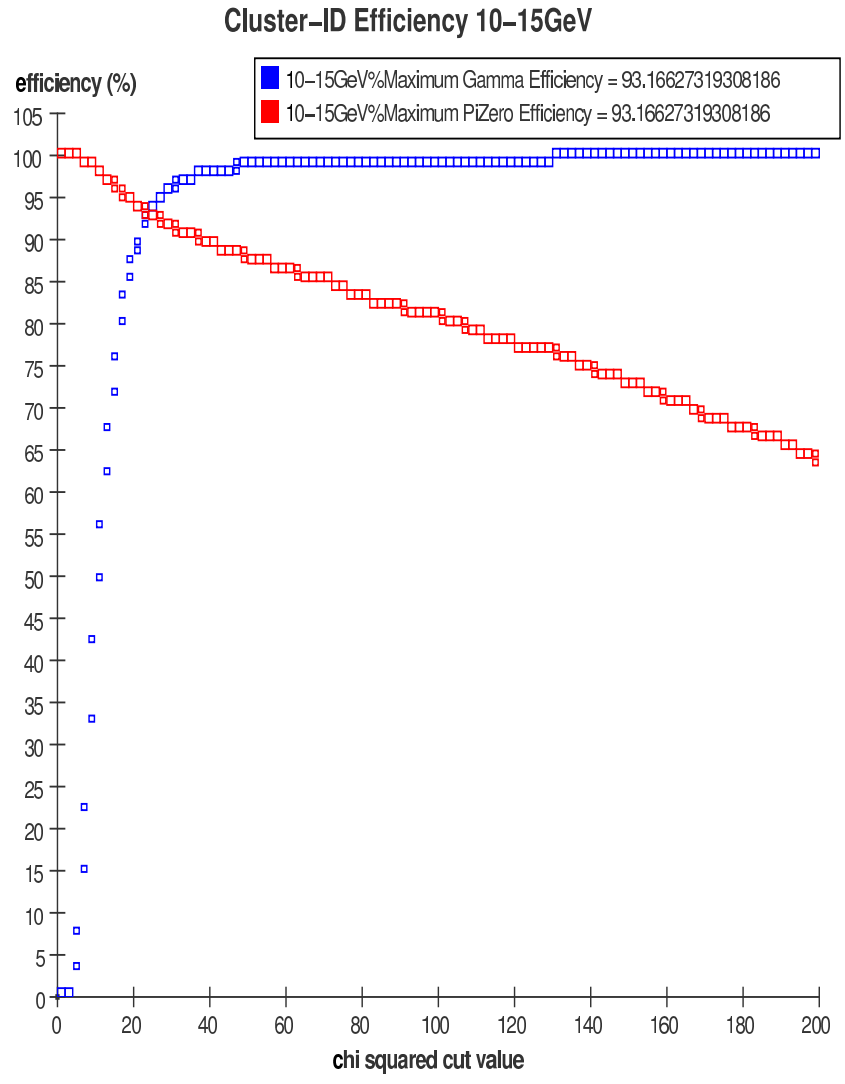
Photon/Merged-π^0 separation

Chi-squared method is used to identify merged clusters

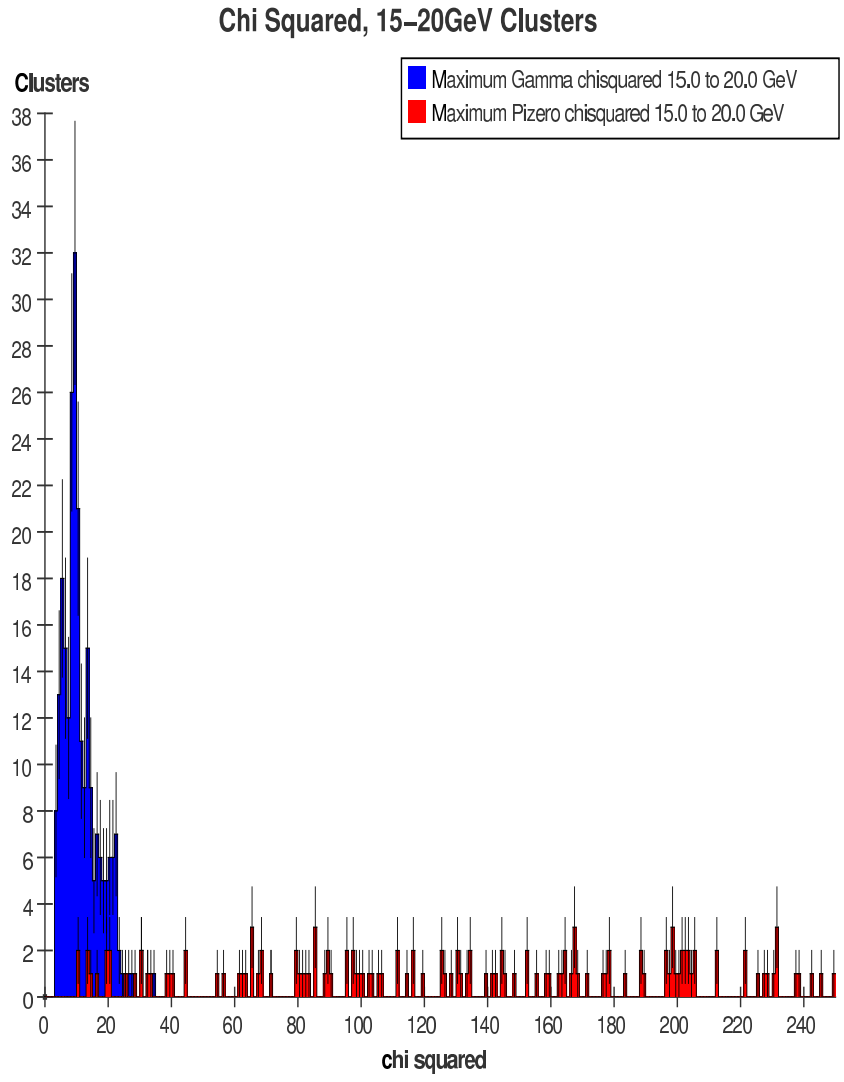
- We use Ganged hits separated into even and odd layers
- Energy in hit towers is summed; maximum tower energy and eight neighbors are used to compute chi-squared
- A different covariance matrix is computed for photons incident on each point in a grid over the tile, as well as for different energies and angles of incidence
- When computing chi-squared, the H-matrix (inverse of the covariance matrix) is interpolated from a look-up table

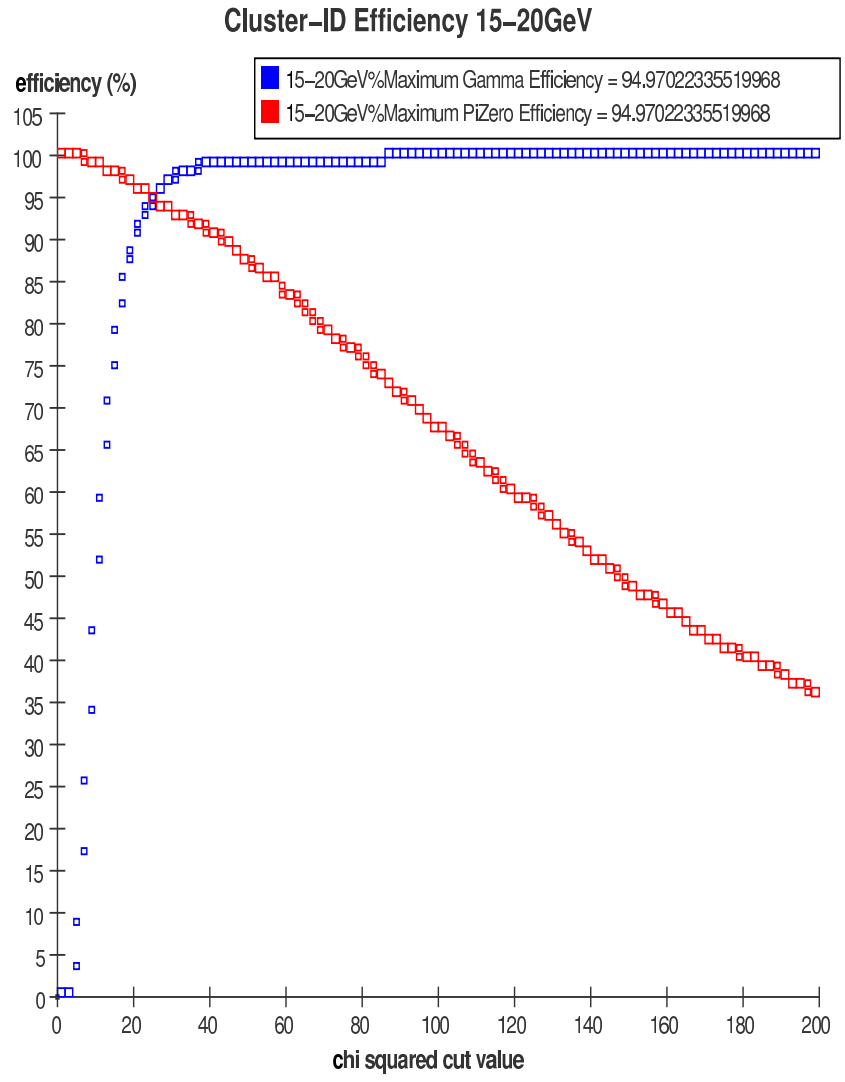
Photon/Merged-π^0 separation: 10-15GeV



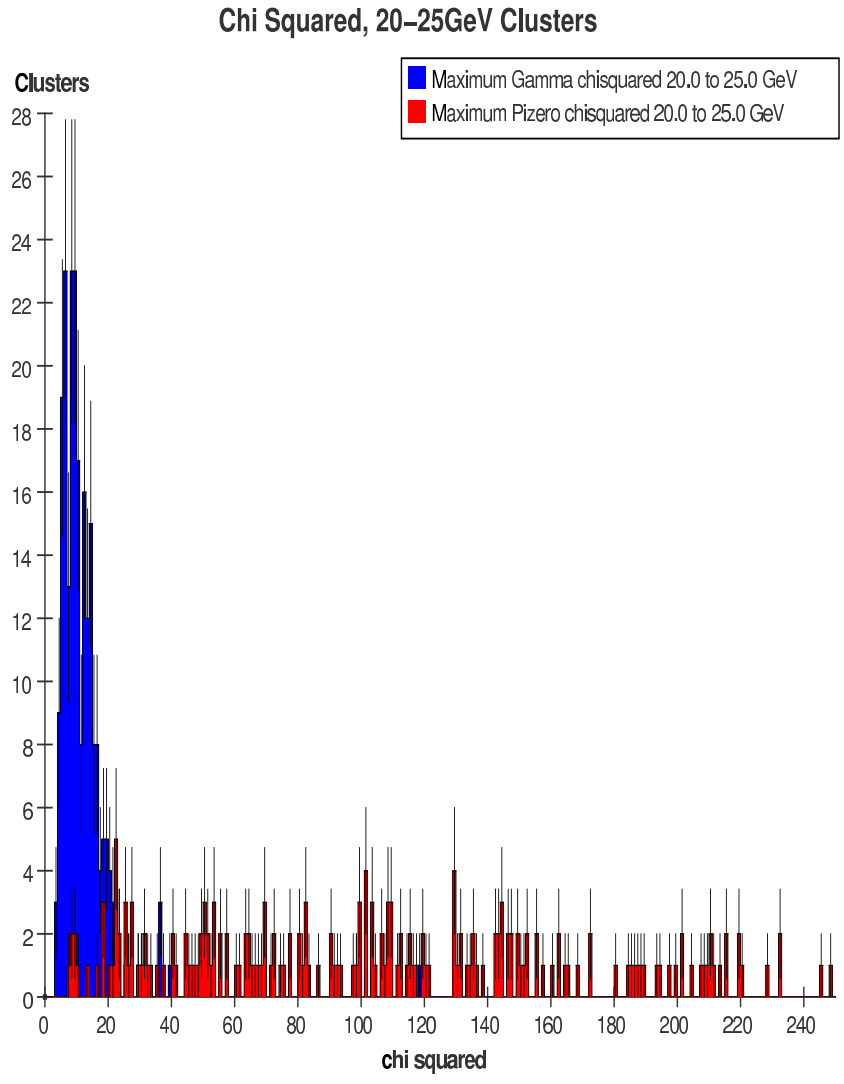


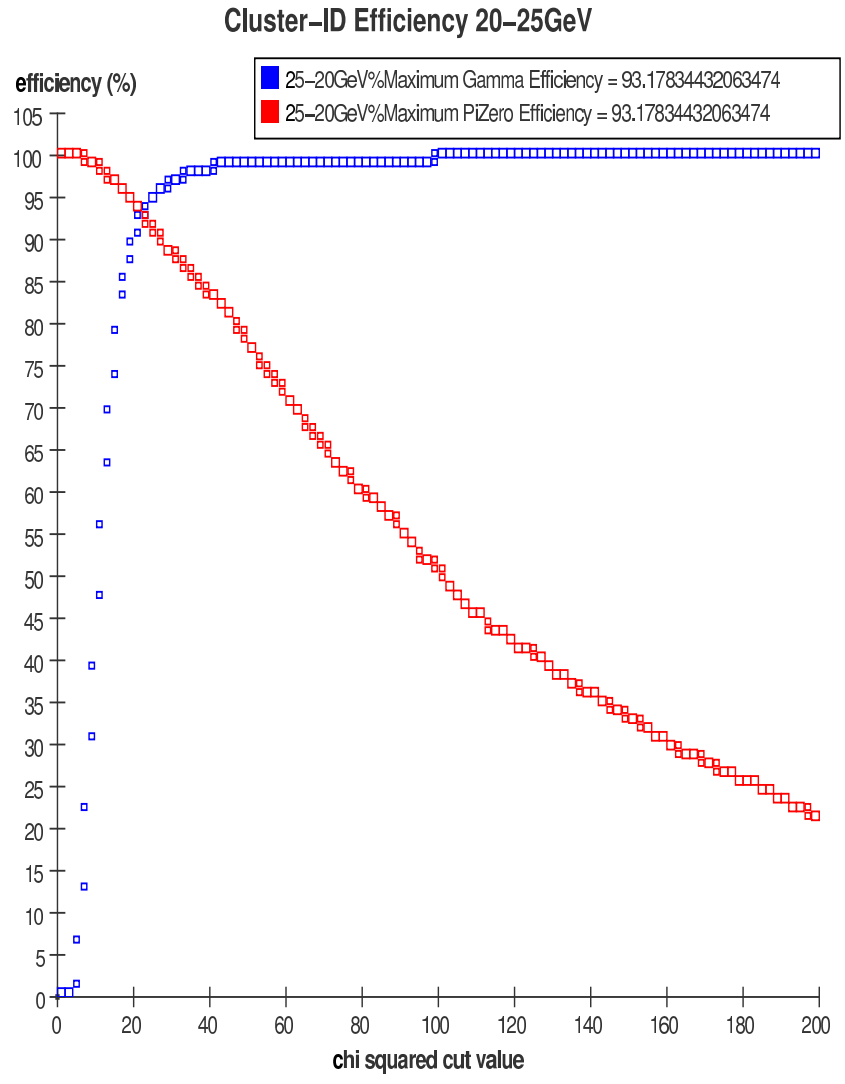
Photon/Merged-π^0 separation: 15-20GeV



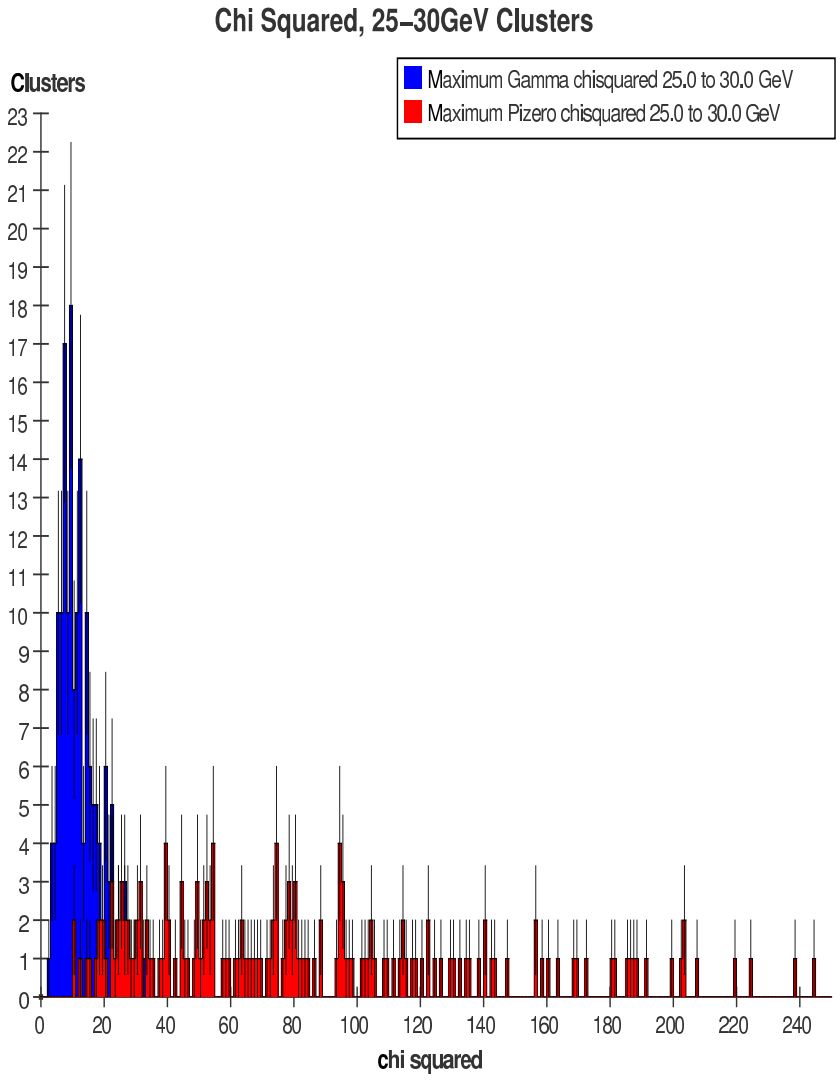


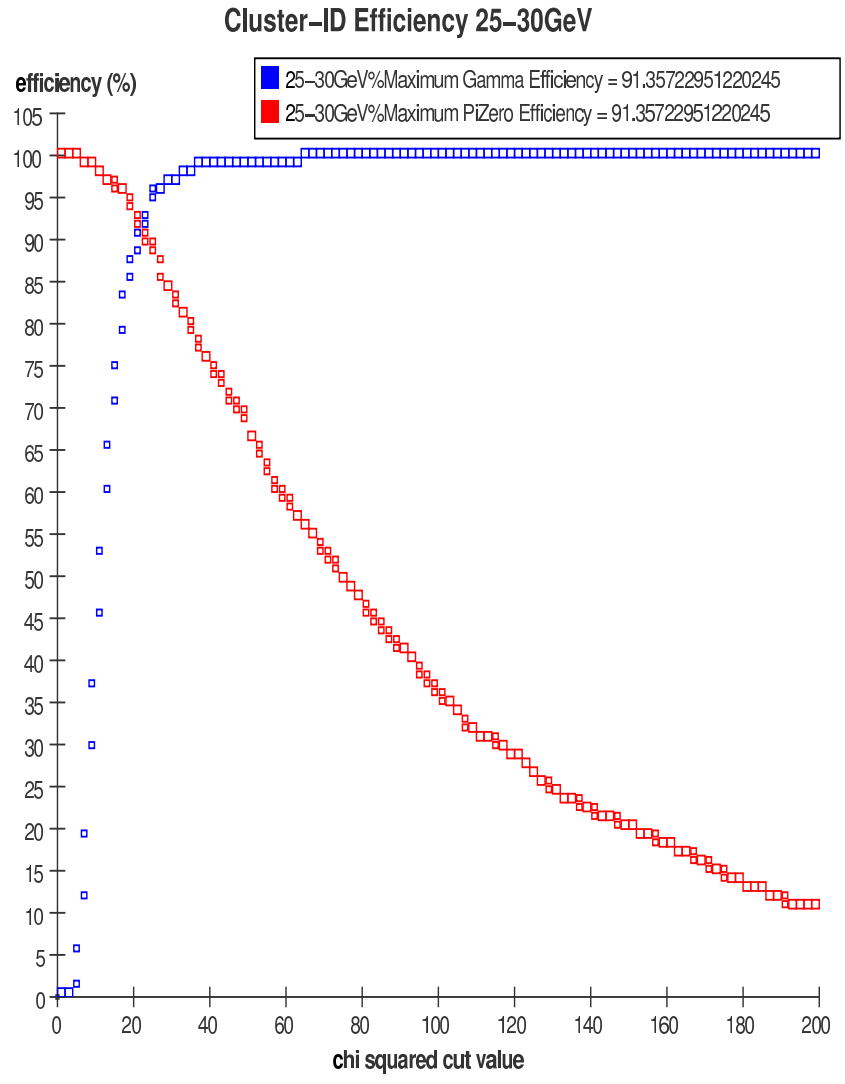
Photon/Merged-π^0 separation: 20-25GeV



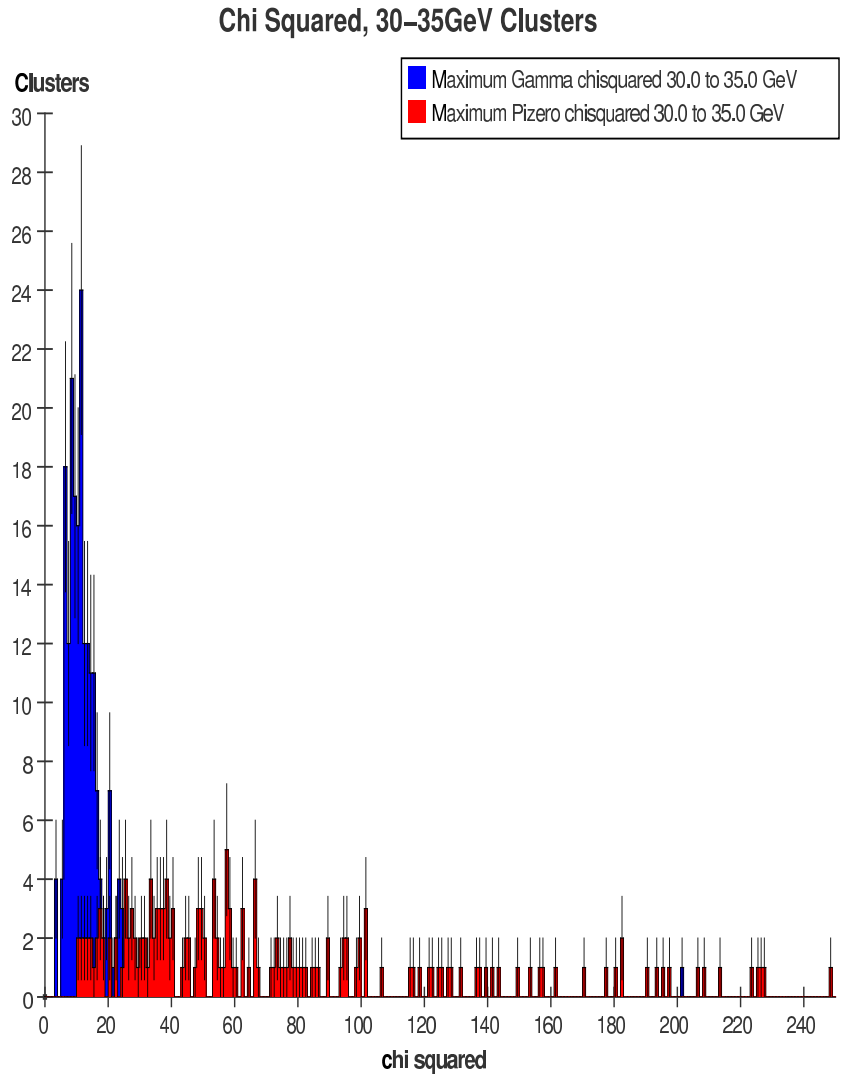


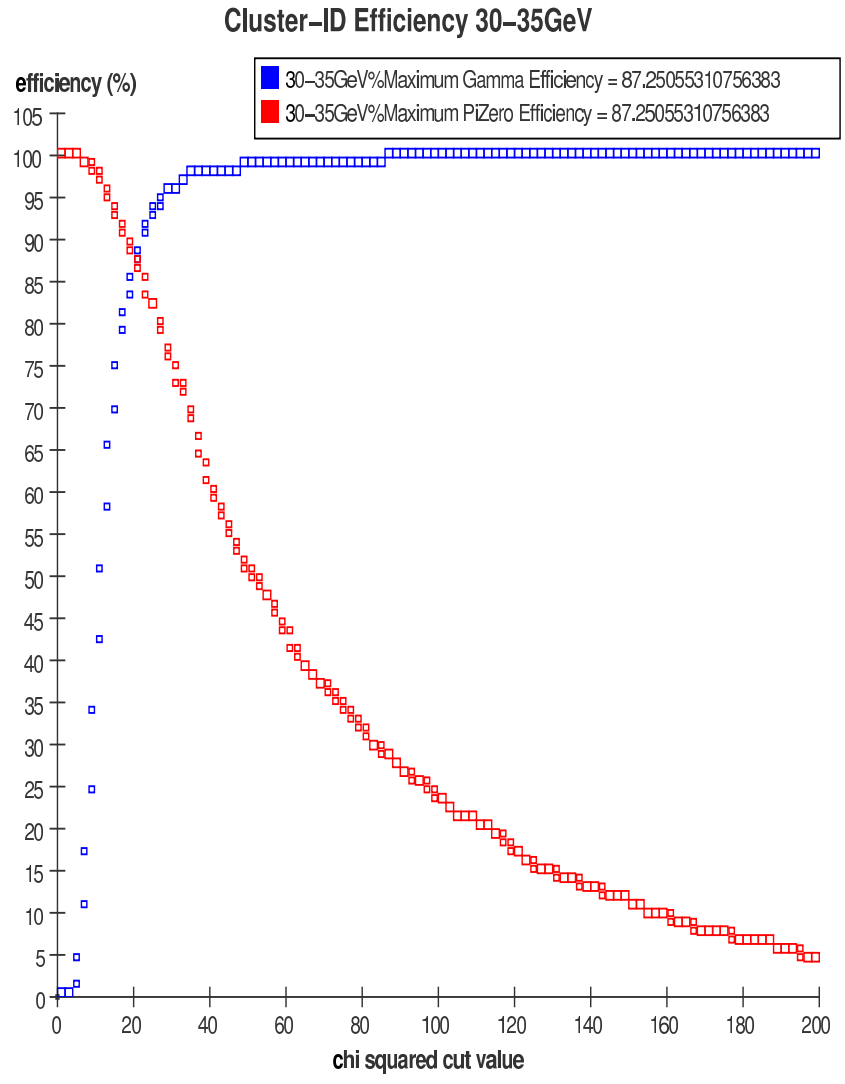
Photon/Merged-π^0 separation: 25-30GeV



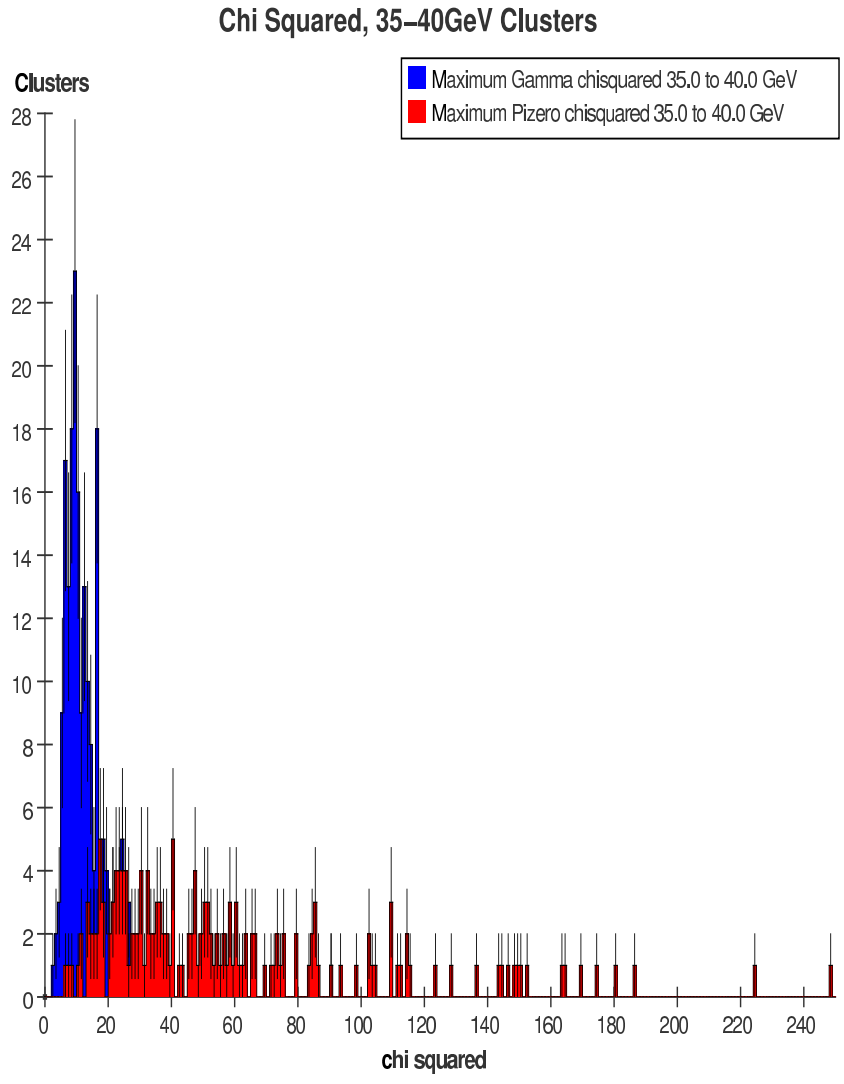


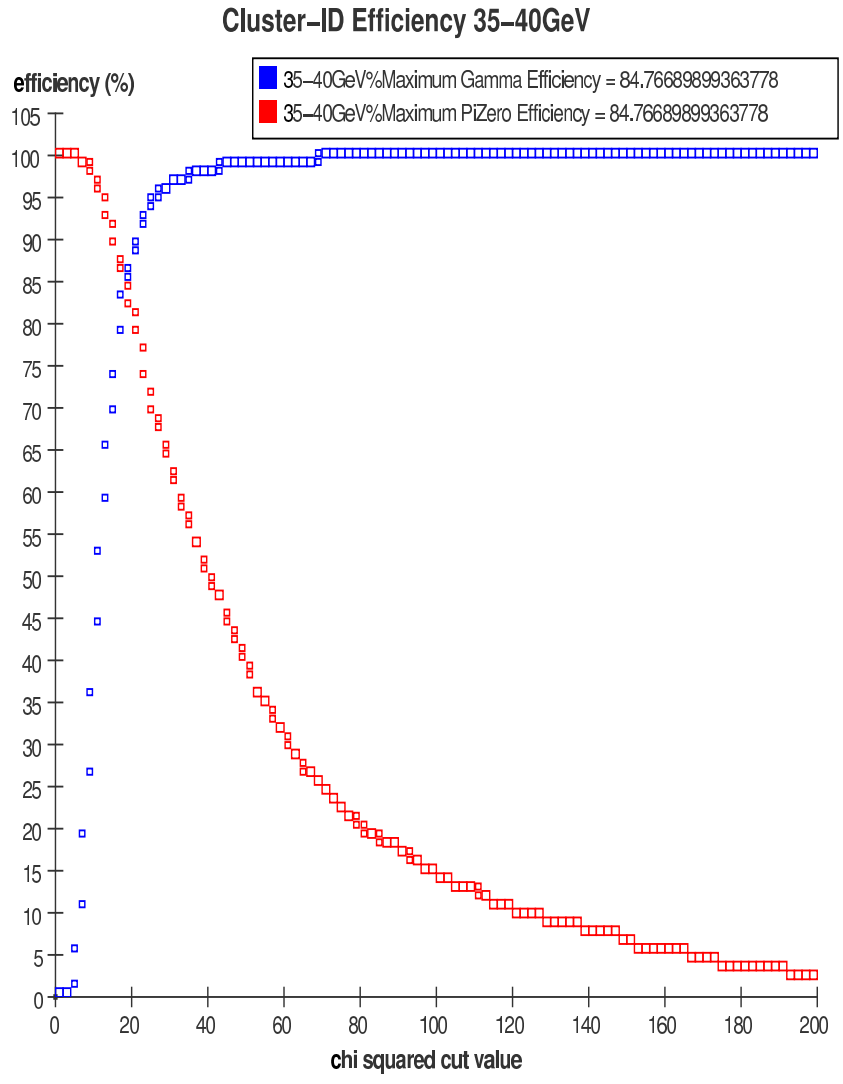
Photon/Merged-π^0 separation: 30-35GeV



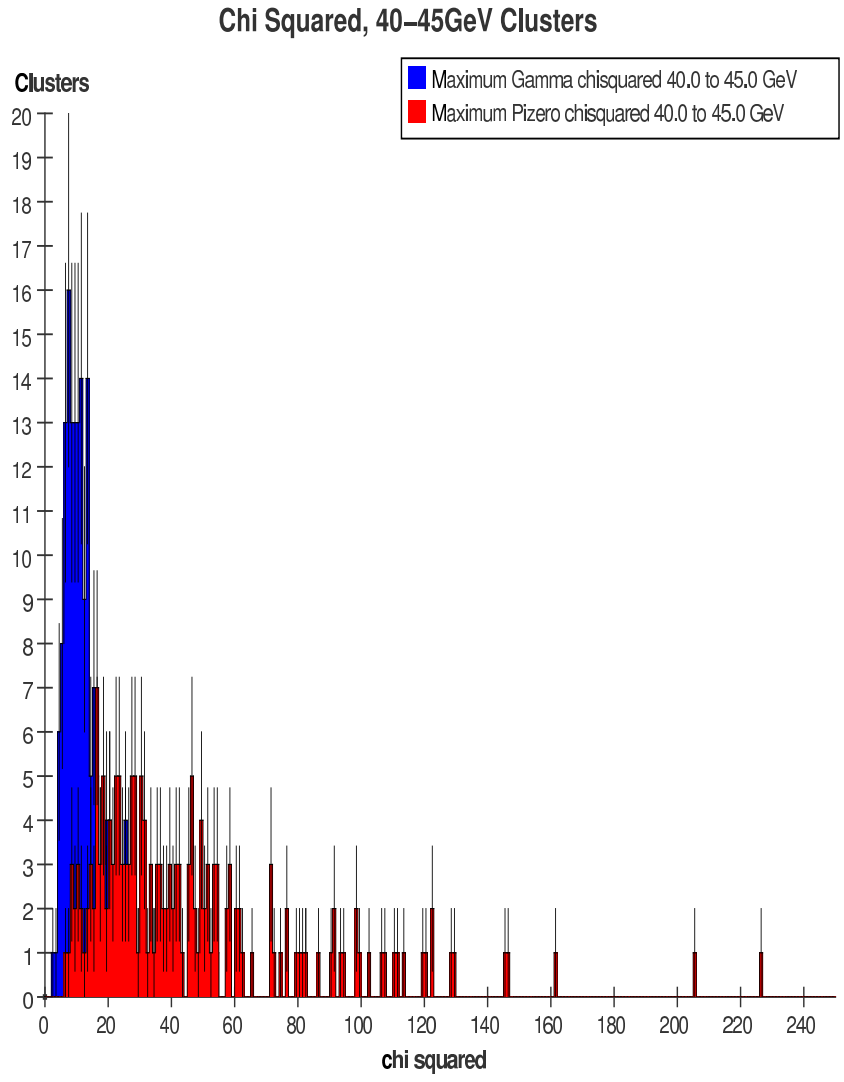


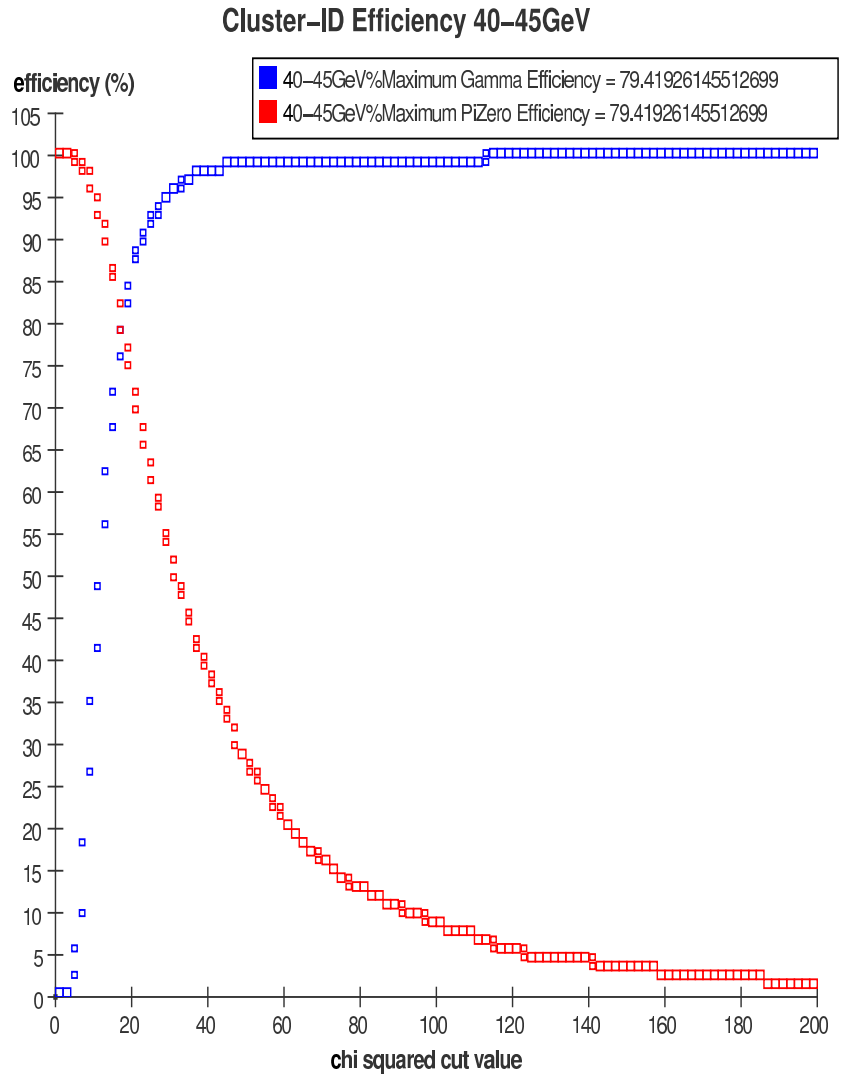
Photon/Merged-π^0 separation: 35-40GeV



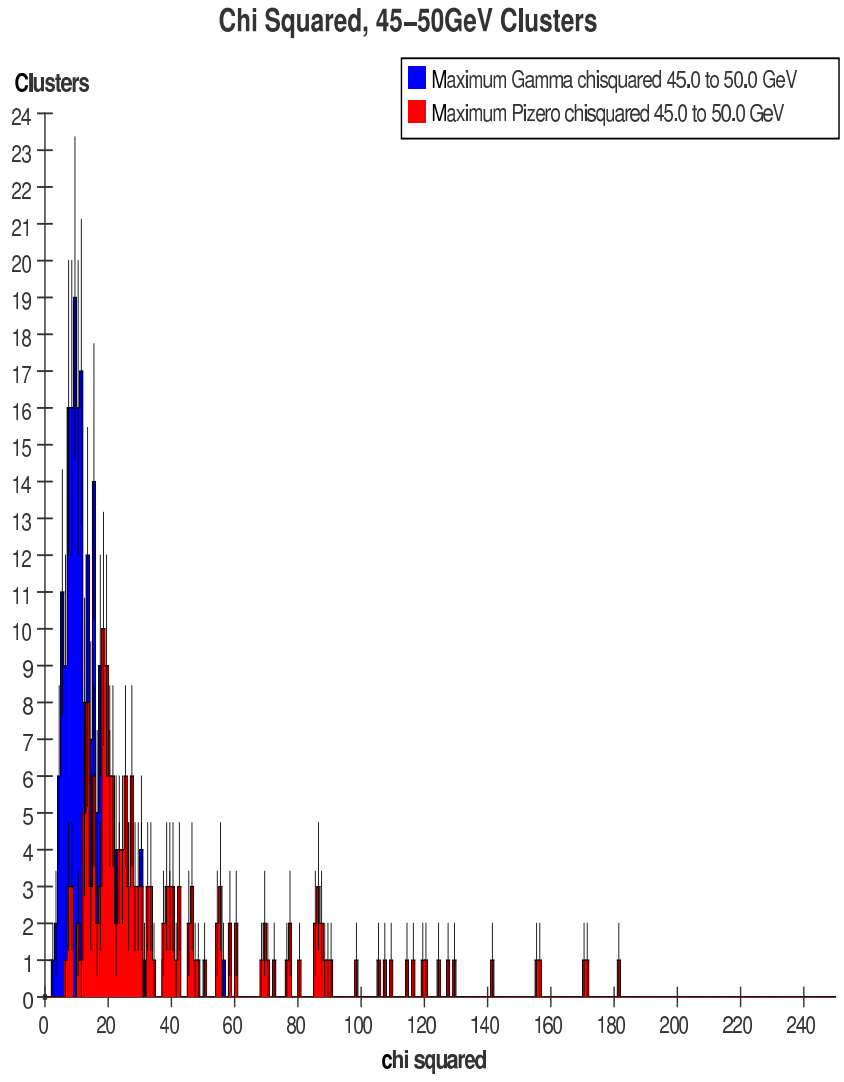


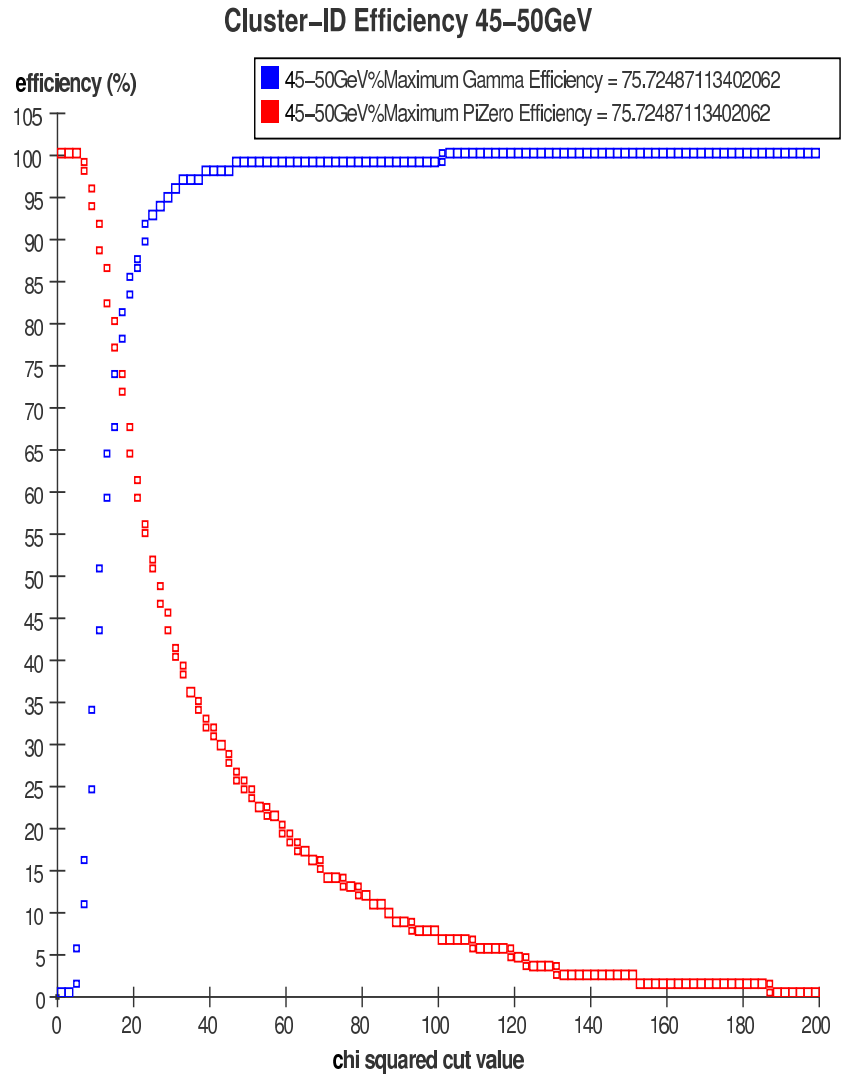
Photon/Merged-π^0 separation: 40-45GeV



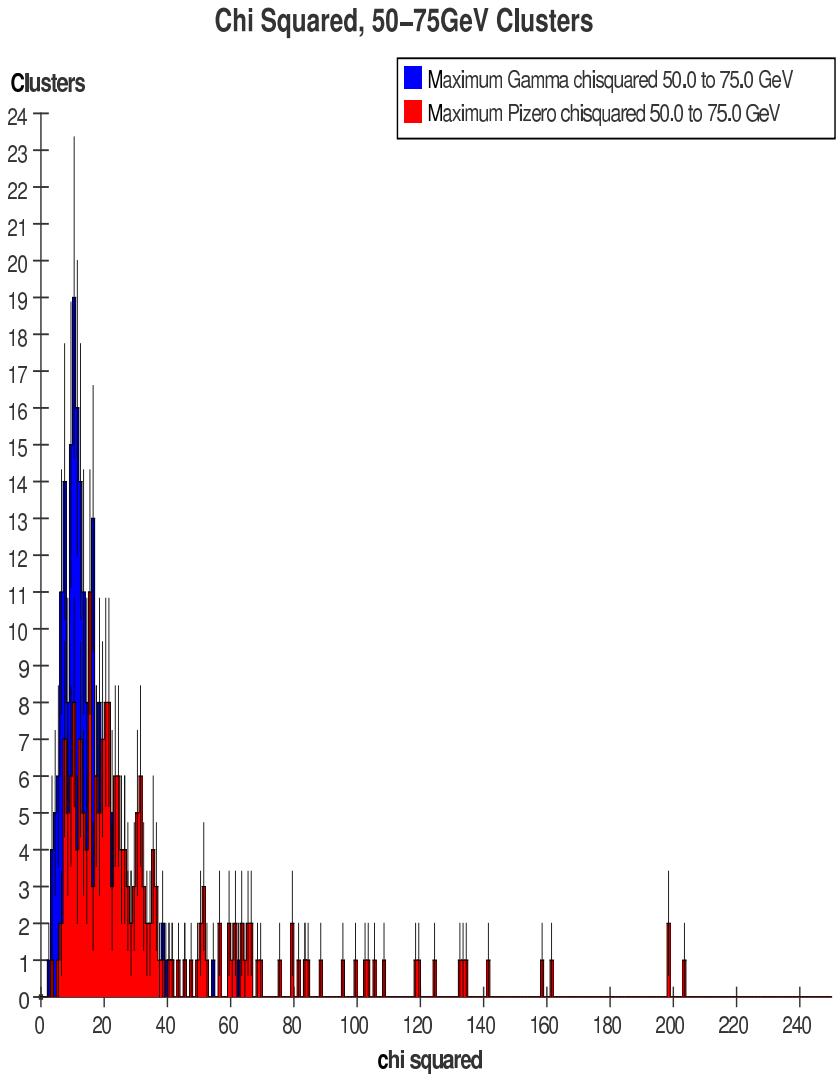


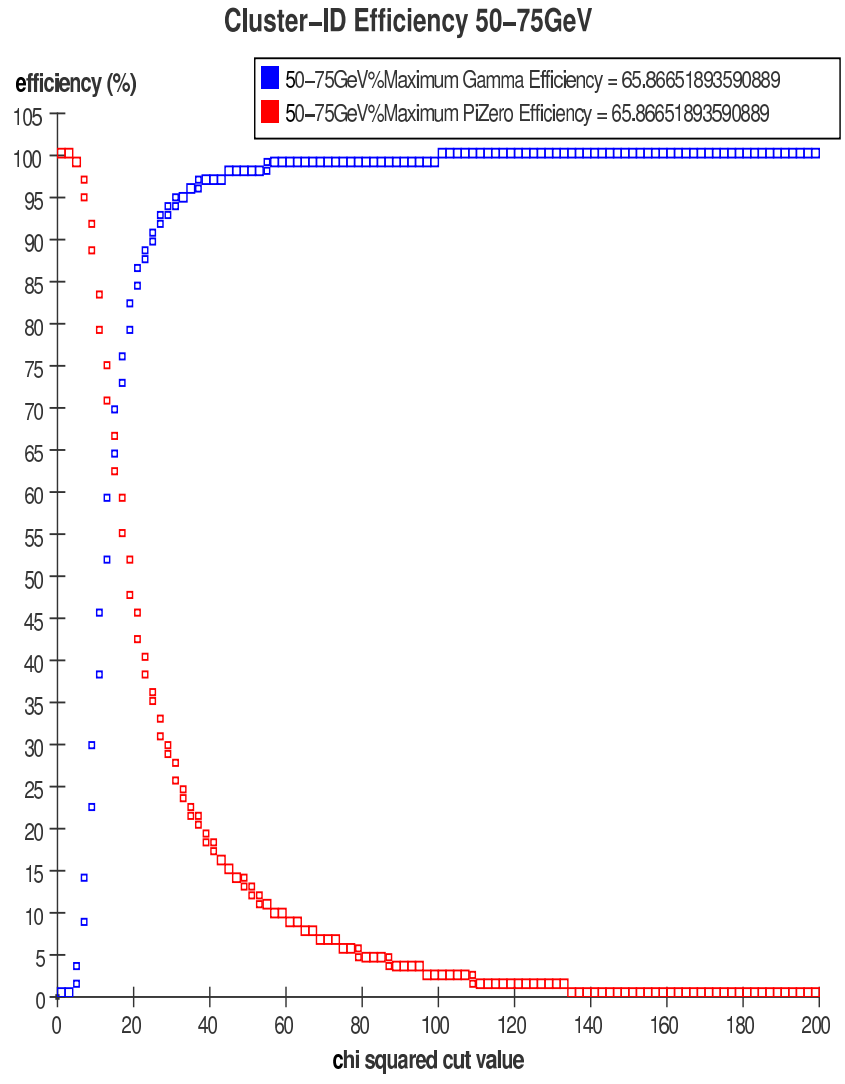
Photon/Merged-π^0 separation: 45-50GeV





Photon/Merged-π^0 separation: 50-75GeV





Photon/Merged-π^0 separation

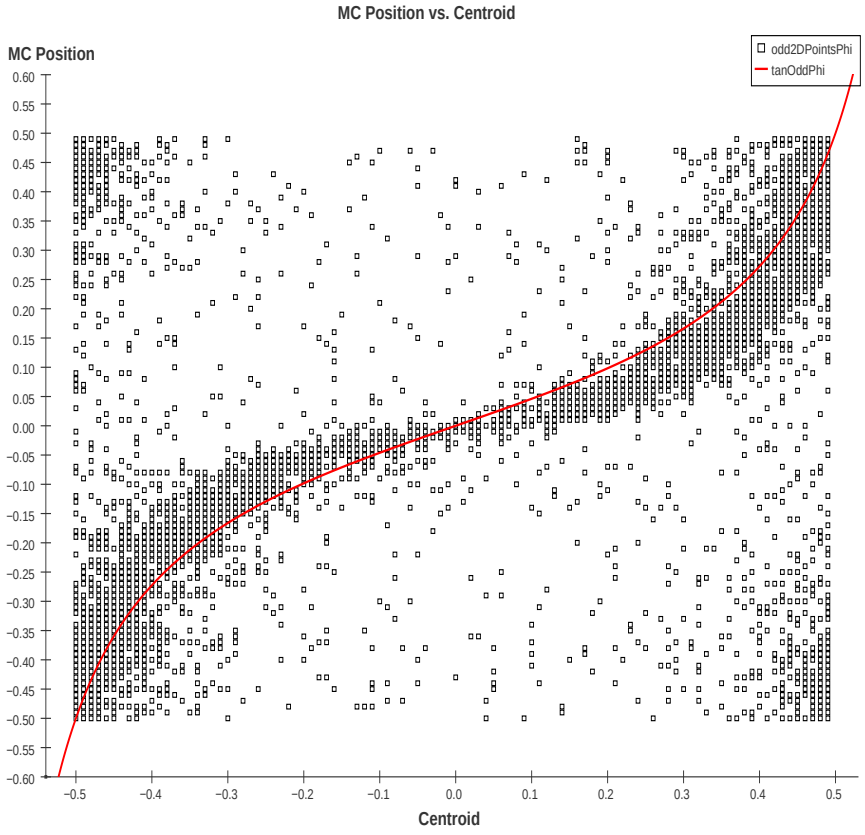
- We achieve good separation of photon and pizero showers to above 50GeV
- Further work to identify better measurement parameters may improve the results
- We plan now to investigate the performance of clusters from the event list.

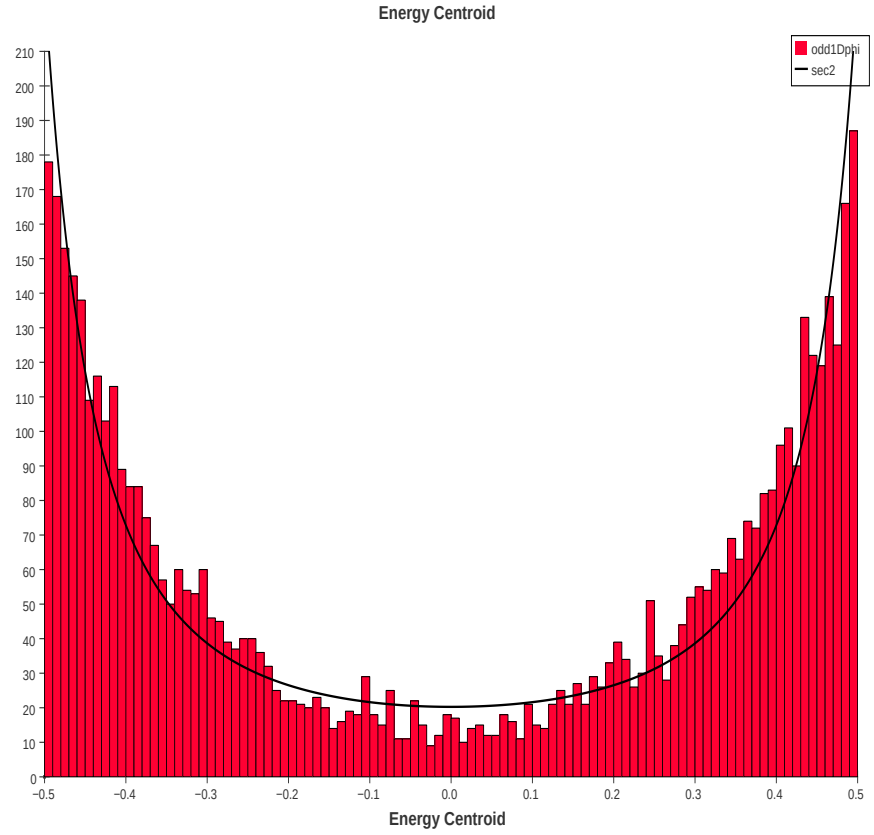
Cluster Direction Studies

- Large tile size causes bias of energy-center of clusters to center of tiles
  - Bad cluster positions
  - Bad cluster directions using cluster principle axis
- Work previously carried out with LCDRoot is now being ported over to org.lcsim.
- Results are to be incorporated into cluster-ID code

Cluster Direction Studies

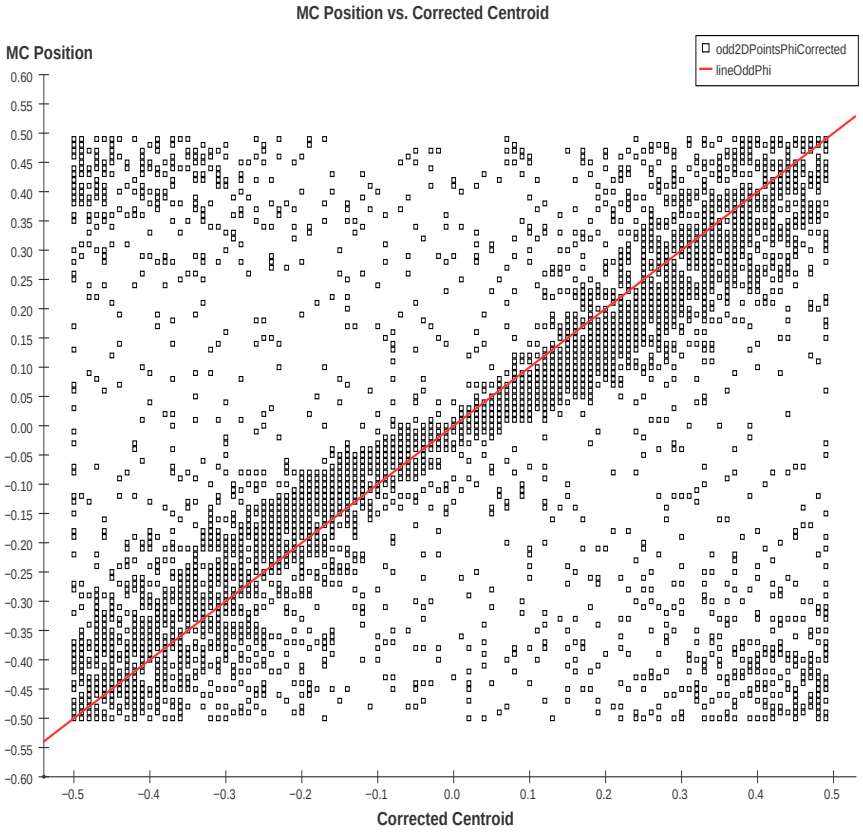
- MC position can be found from the tangent of the energy centroid (as function of distance from tile edge)
- Secant-squared function fit to energy-centroid distribution used to find parameter of tangent function

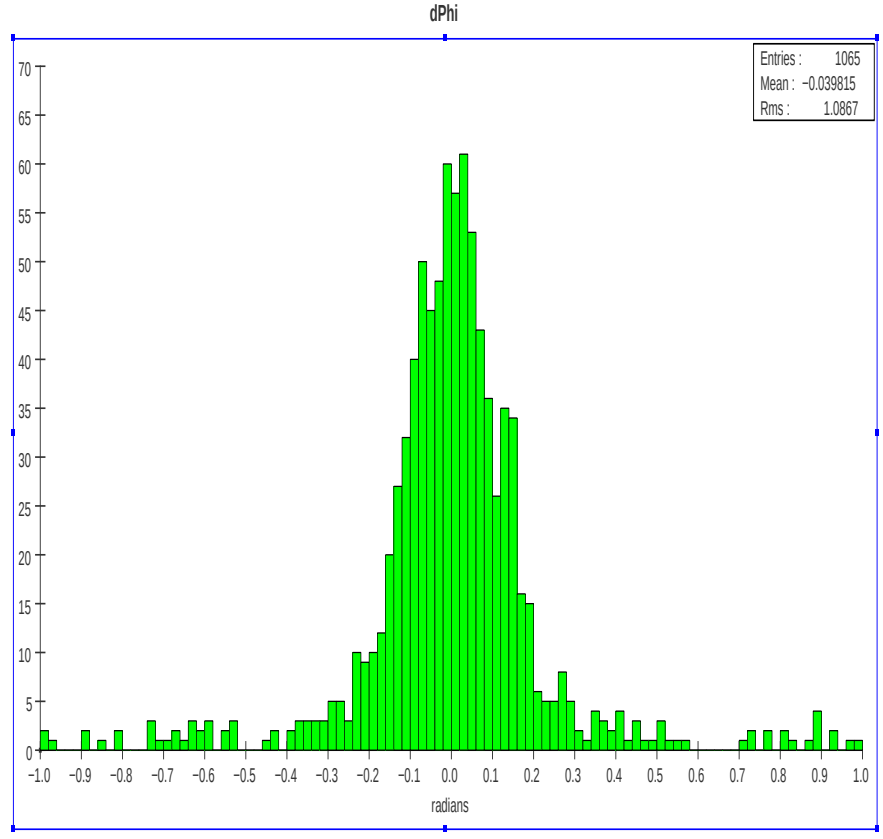




Cluster Direction Studies

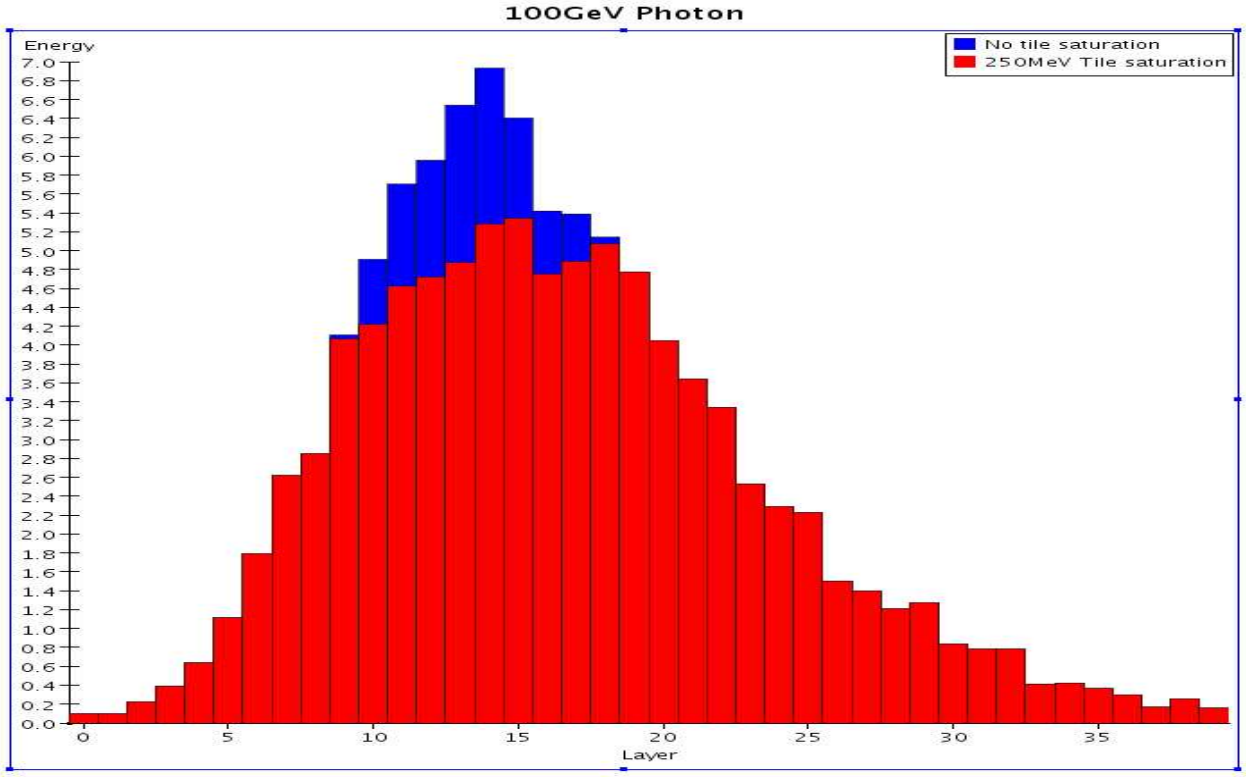
- Using reconstructed position in several slices of a cluster, we can achieve a direction using least-squares fitting
- Much work remains





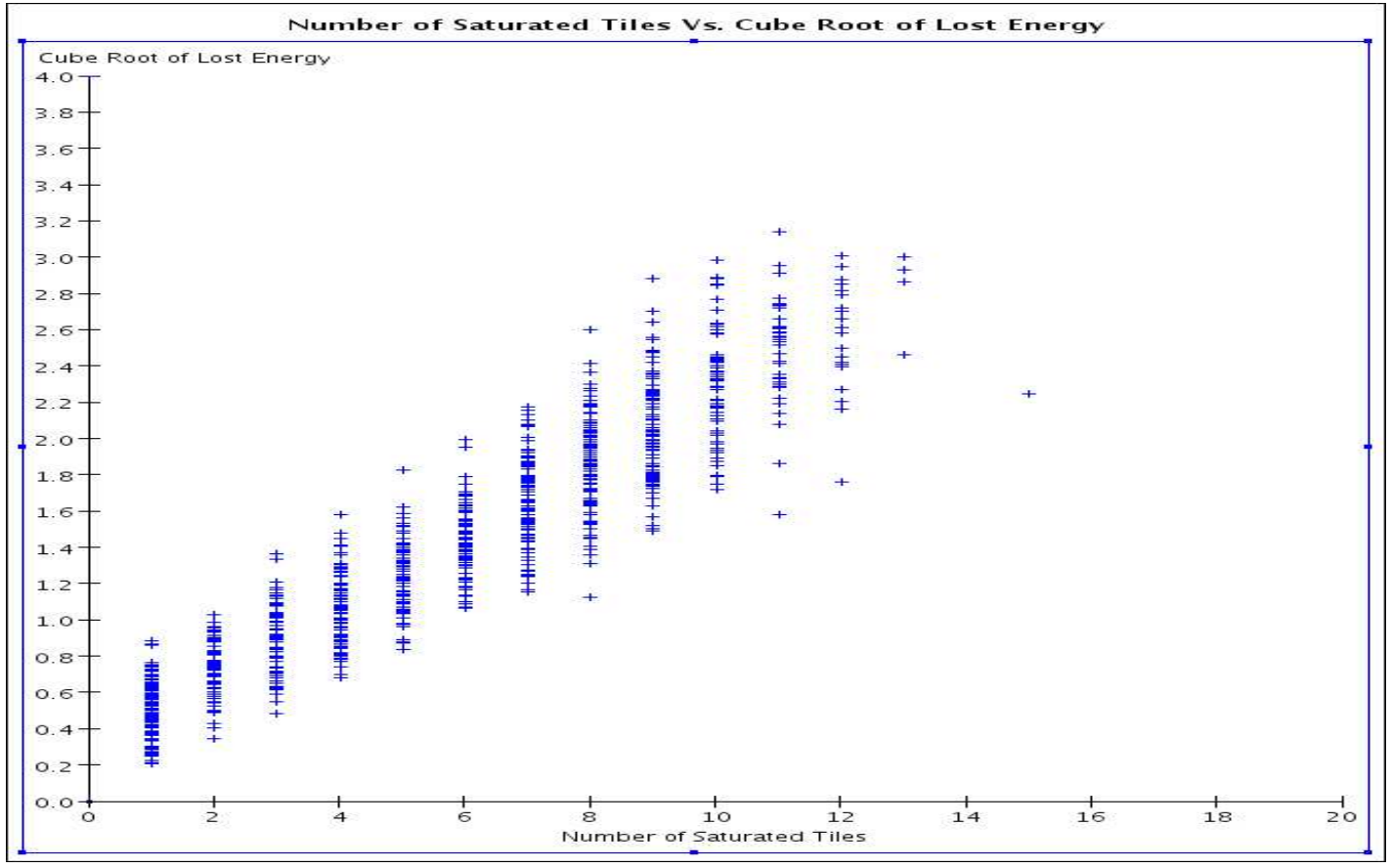
Tile saturation studies

- Limited dynamic range of SiPM's or amplifier may cause tile saturation in high-energy clusters



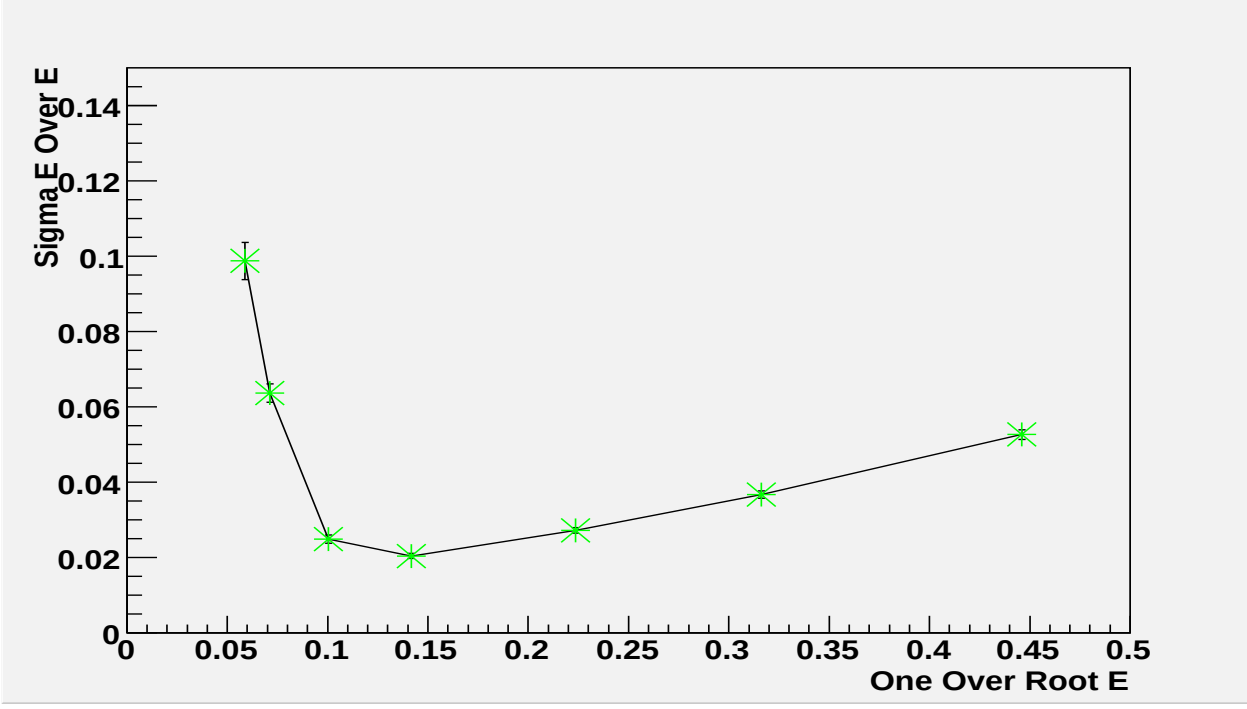
Tile saturation studies

- We have found that number of saturated tiles is proportional to the cube root of the missing energy



Tile saturation studies

- Using a correction based on the number of saturated tiles yields poor energy resolution at very high (>=100GeV) energies
  - Energy scale depends on saturation energy
  - What are the requirements?



Current/Future Work

- Reconstruction of hadrons showering in Ecal
- Continue fine-tuning photon/π^0 studies
- Complete cluster-direction studies
- Further studies of tile saturation effects
- Incorporate full PFA