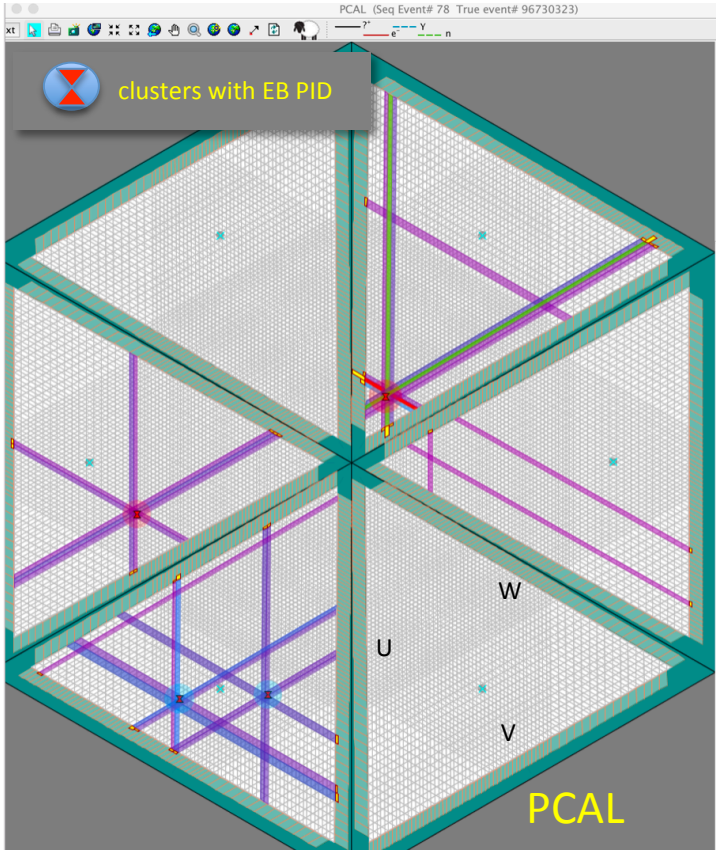
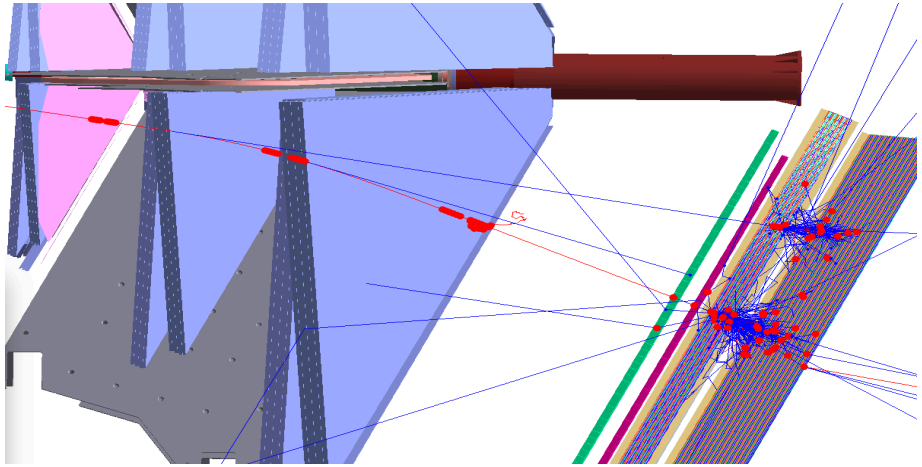
ECAL Neutral Reconstruction Issues

Cole Smith

outline

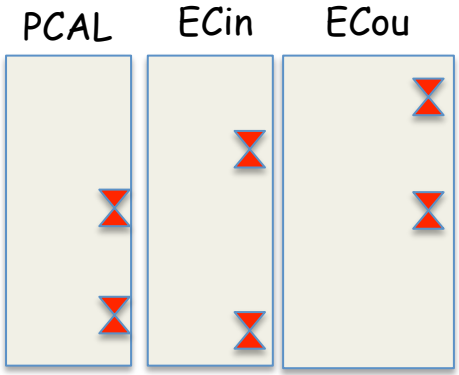
- reconstruction/event builder
- neutral cluster multiplicity
- merged and orphan clusters
- outlook



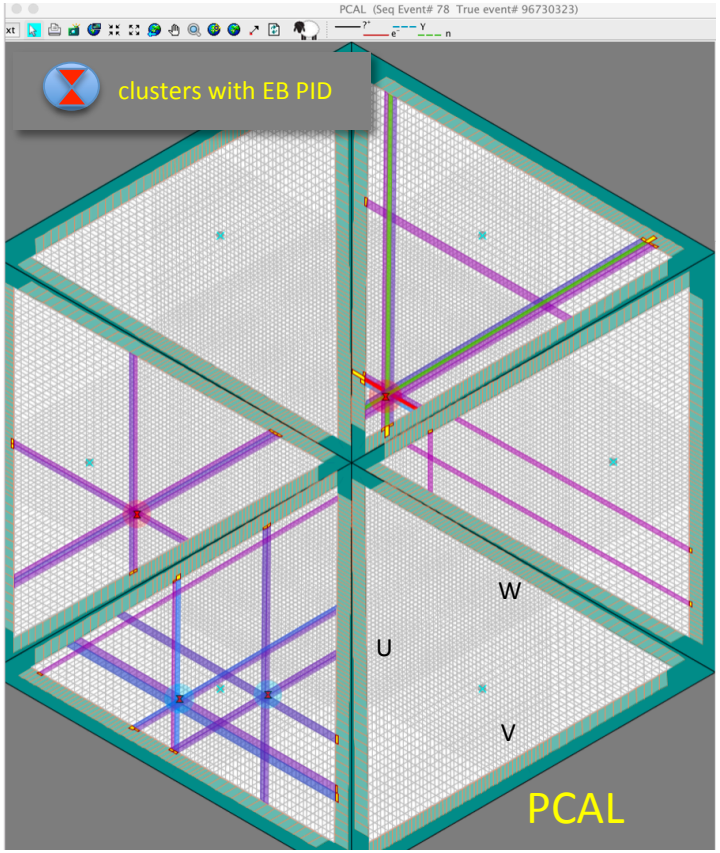


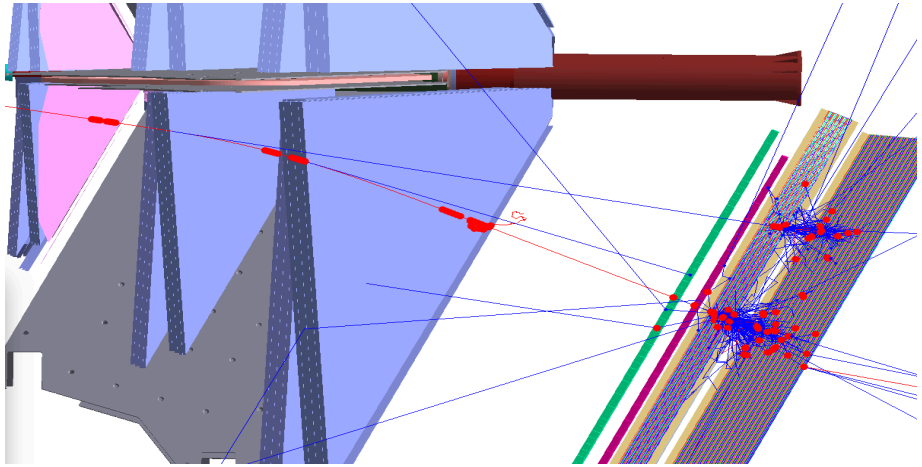
Event Builder

- Build list of DC tracks
- Build list of ECAL clusters



- ECAL: hodoscope design, 3-fold stereo readout to reduce ambiguities
- Contiguous strips define peaks for each U, V, W view
- Intersections of U,V,W peaks define clusters
- Three layers: PCAL, ECIN, ECOU

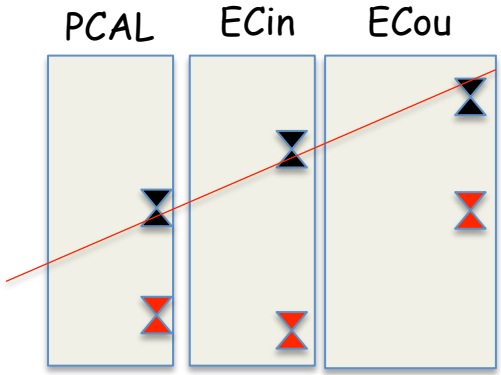


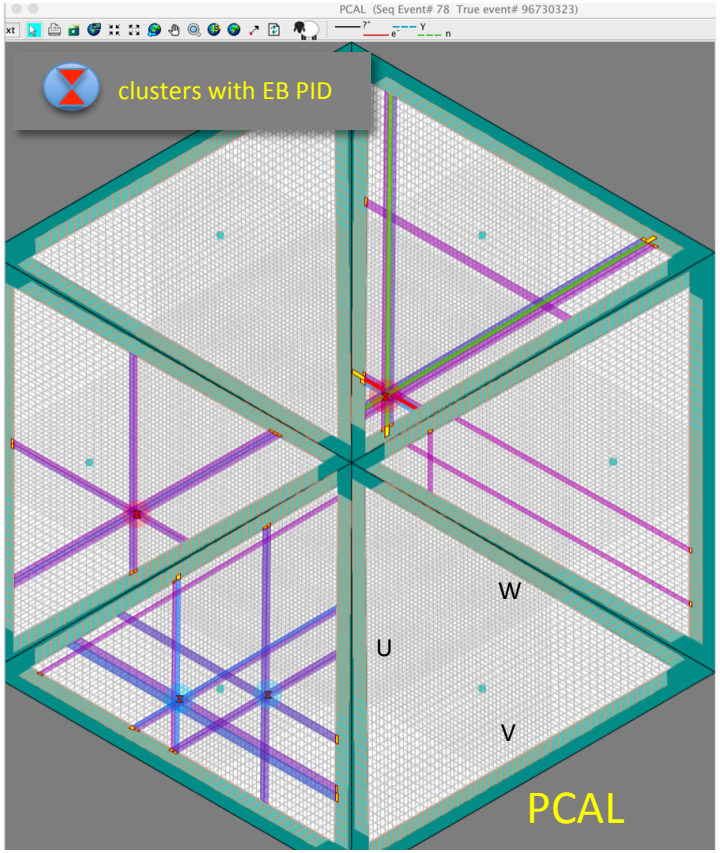


- ECAL: hodoscope design, 3-fold stereo readout to reduce ambiguities
- Contiguous strips define peaks for each U, V, W view
- Intersections of U,V,W peaks define clusters

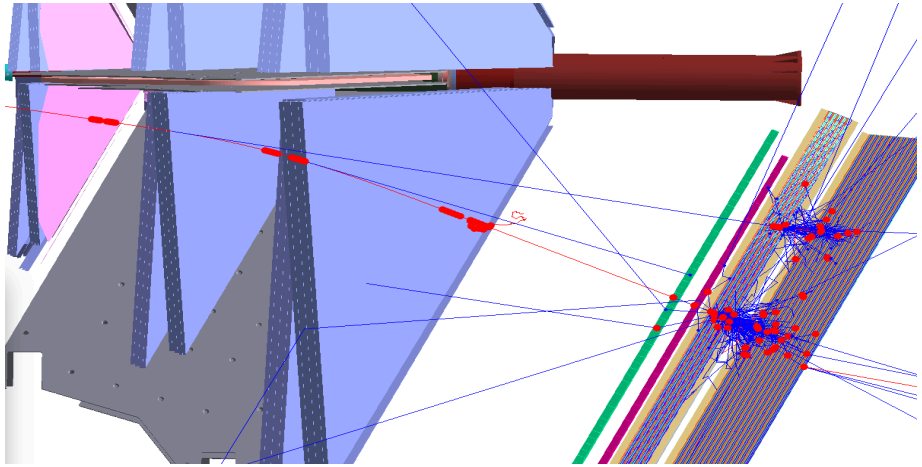
Event Builder

- Build list of DC tracks
- Build list of ECAL clusters
- Match tracks to ECAL clusters
- Particle created w/ FTOF PID



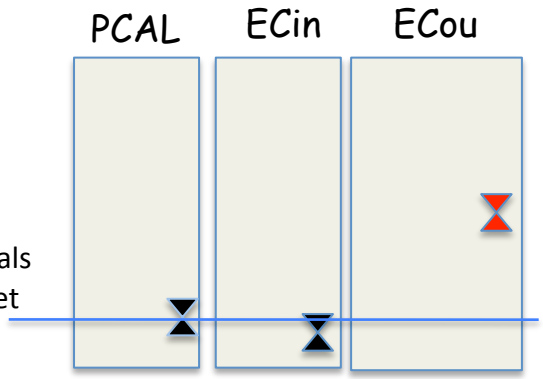


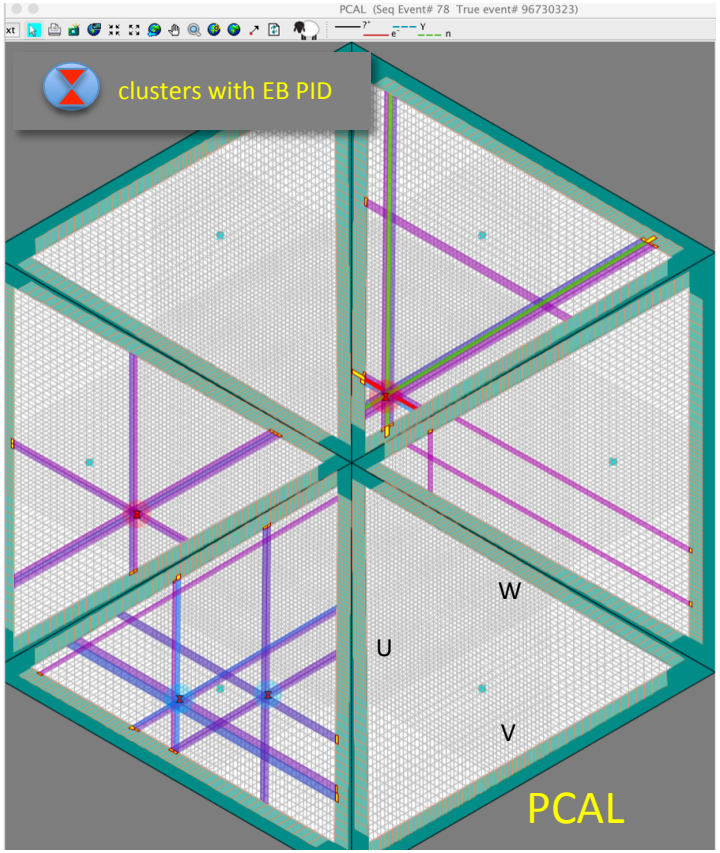
- ECAL: hodoscope design, 3-fold stereo readout to reduce ambiguities
- Contiguous strips define peaks for each U, V, W view
- Intersections of U,V,W peaks define clusters



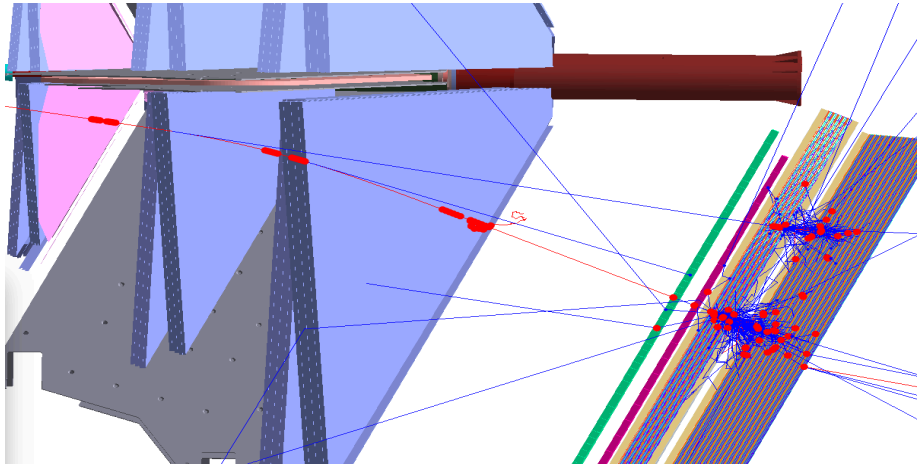
Event Builder

- Build list of DC tracks
- Build list of ECAL clusters
- Match tracks to ECAL clusters
- Particle created w/ FTOF PID
- Remaining clusters assumed neutrals
- Matched to straight line from target
- Particle created w/ ECAL PID (n,γ)



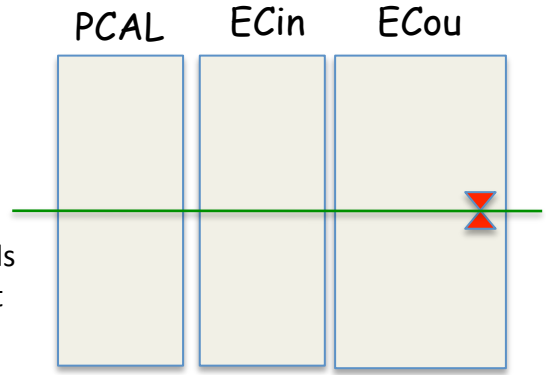


- ECAL: hodoscope design, 3-fold stereo readout to reduce ambiguities
- Contiguous strips define peaks for each U, V, W view
- Intersections of U,V,W peaks define clusters



Event Builder

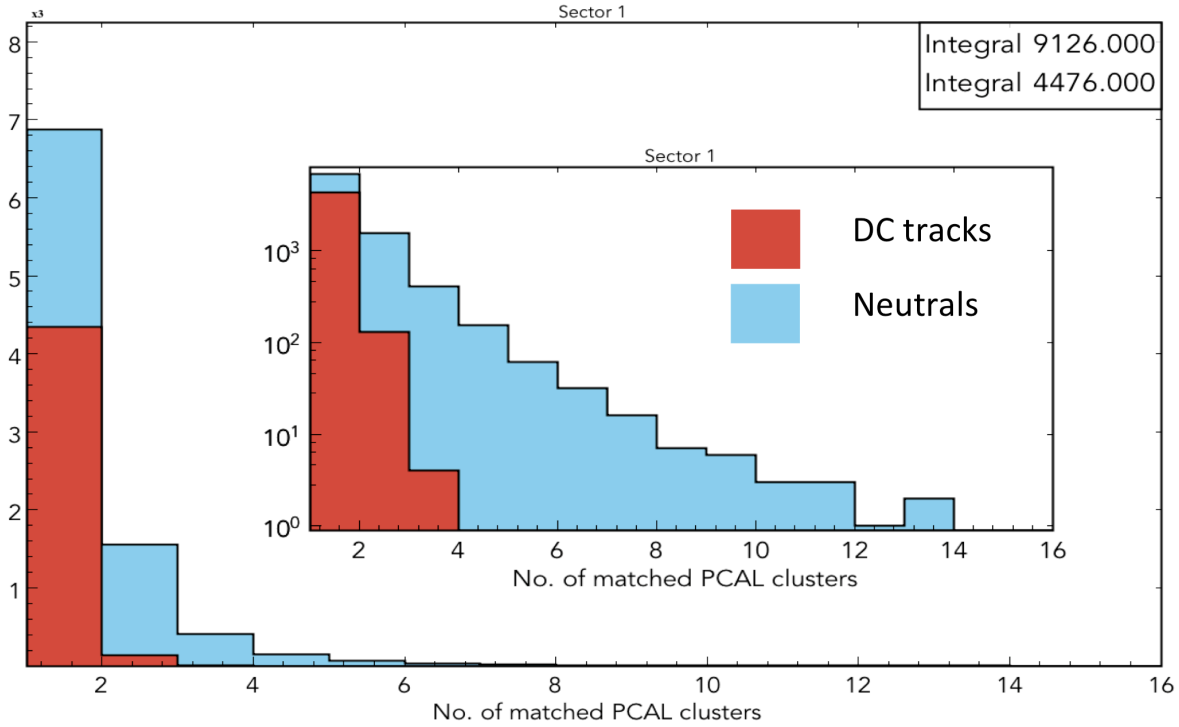
- Build list of DC tracks
- Build list of ECAL clusters
- Match tracks to ECAL clusters
- Particle created w/ FTOF PID
- Remaining clusters assumed neutrals
- Matched to straight line from target
- Particle created w/ ECAL PID (n,γ)
- All clusters are used



Neutral cluster multiplicity − possible sources

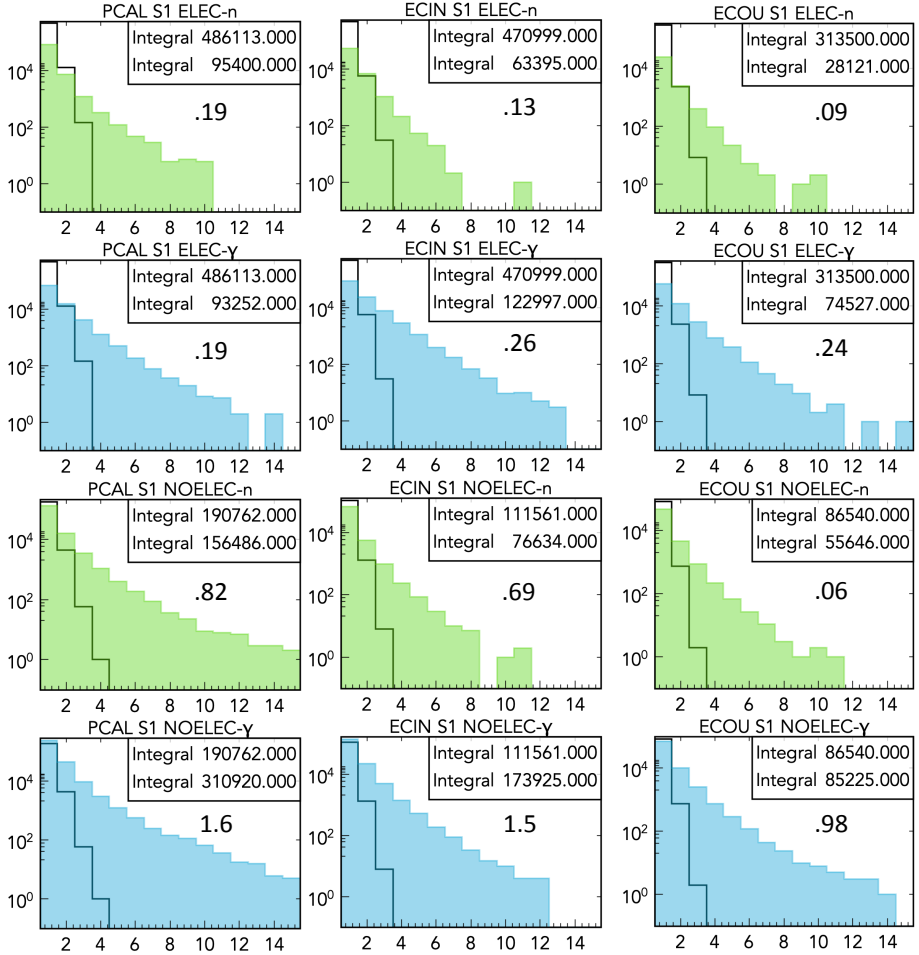
‘Orphan’ clusters

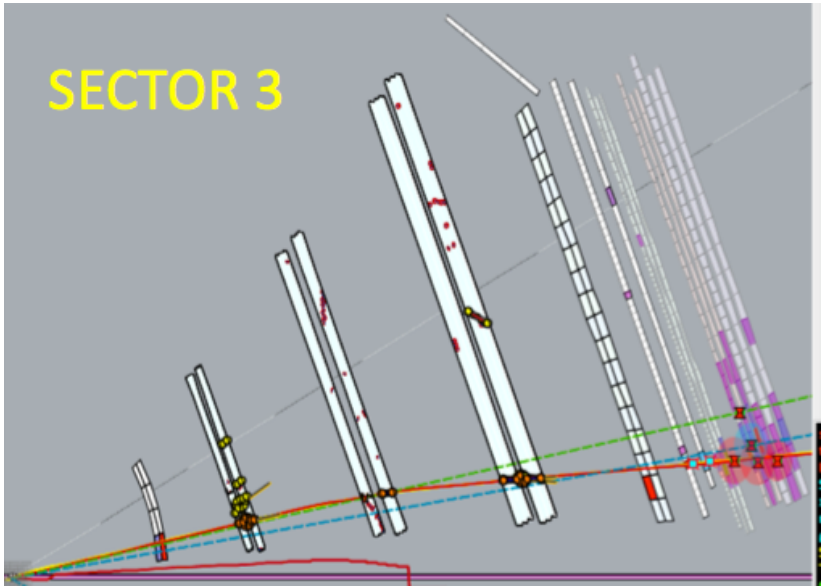
- Extra clusters associated with charged hadron tracks: nuclear interactions, large angle scattering.
- Extra clusters associated with EM e-, γ shower fluctuations (especially ECIN, ECOU).
- Tagged by EB as photons or neutrons. Potential contribution to neutral combinatorial bkg.



Charged (line) and neutral (color) cluster multiplicity for n and γ

RGB-F19
run 11159

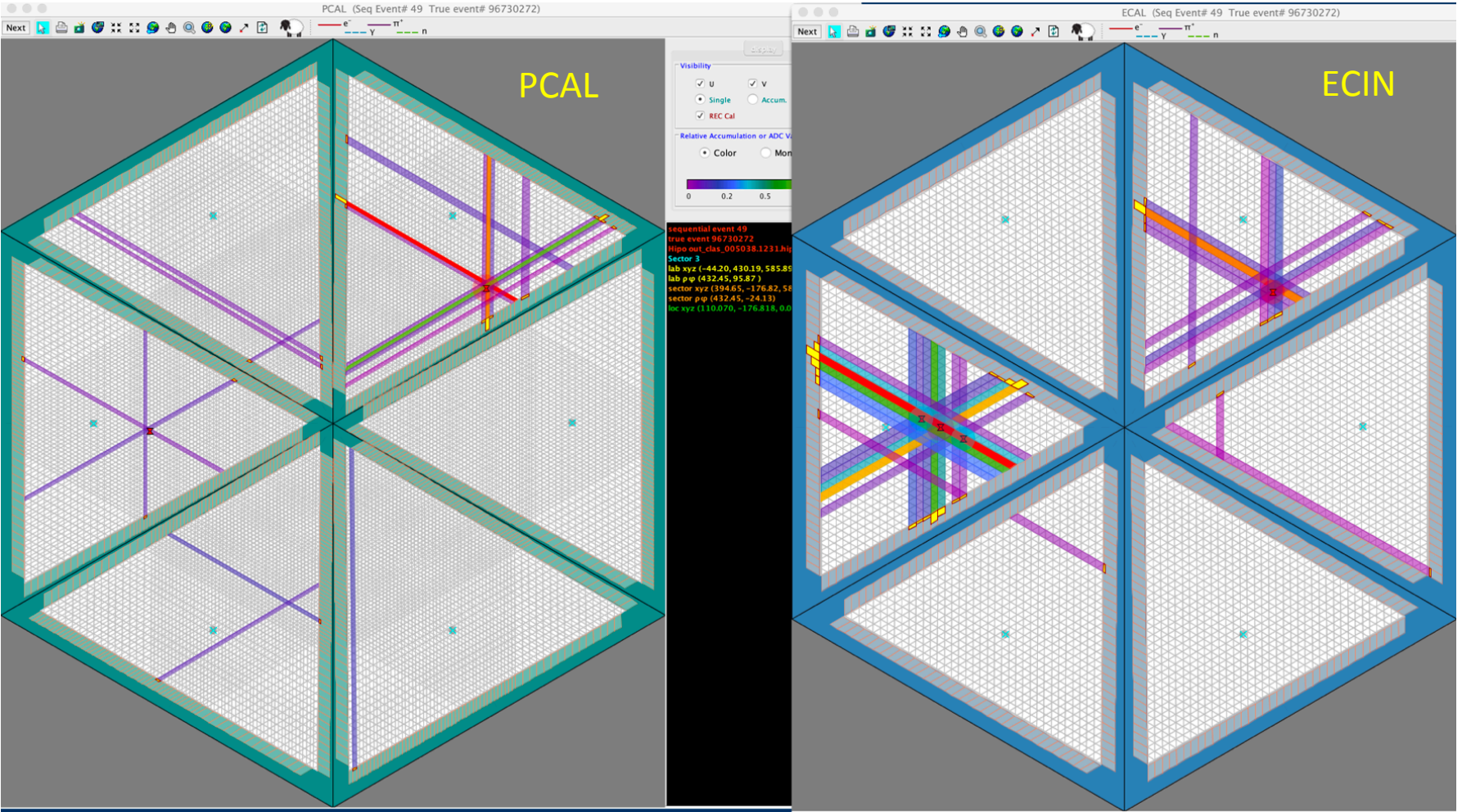




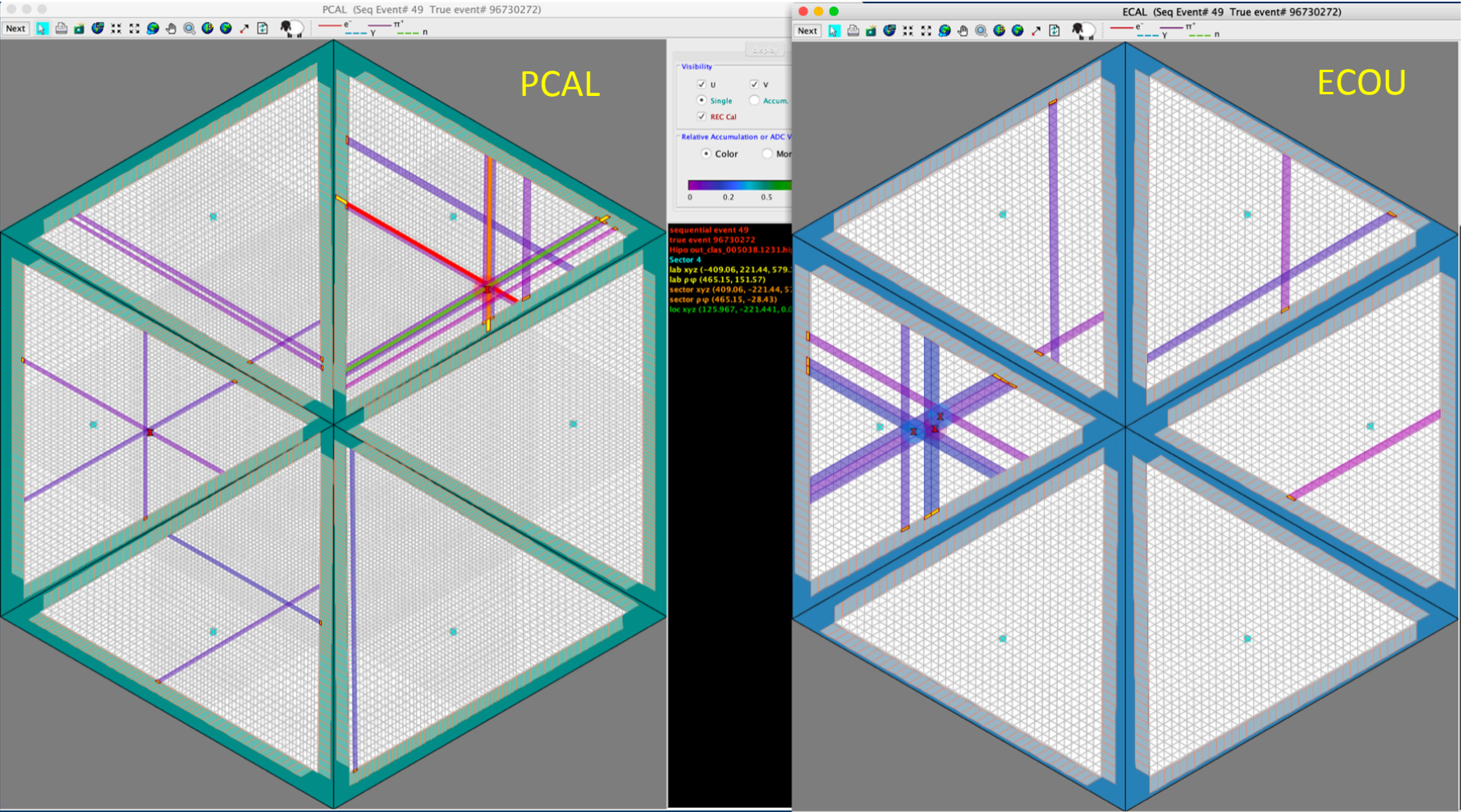
ELEC-γ cases may be artifact of shower leakage fluctuations of EC near fiducial edges.

'Neutron' PID may be radiated photon as suggested by the alignment with e- track.

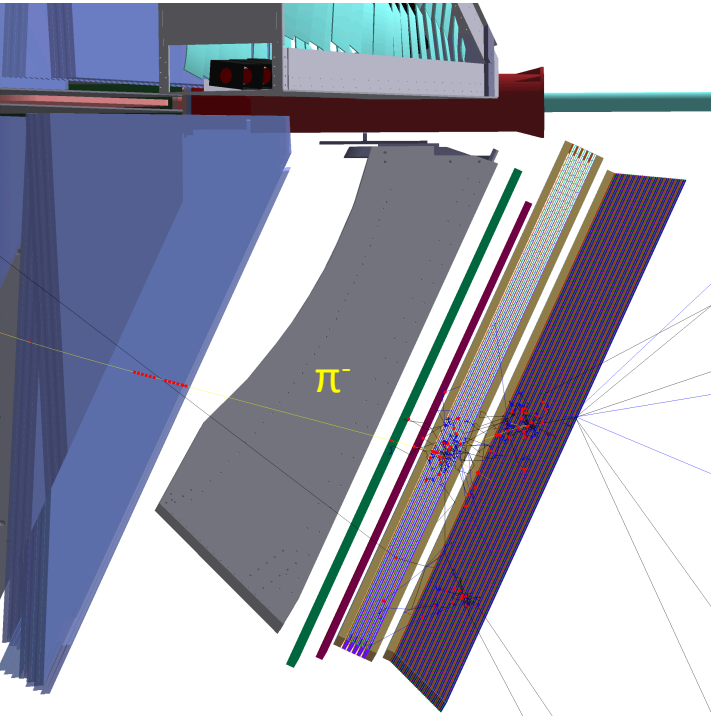
Example of multiple clusters in ECIN in proximity with PID=211 cluster: EB associates 4 clusters with γ in Sector 1

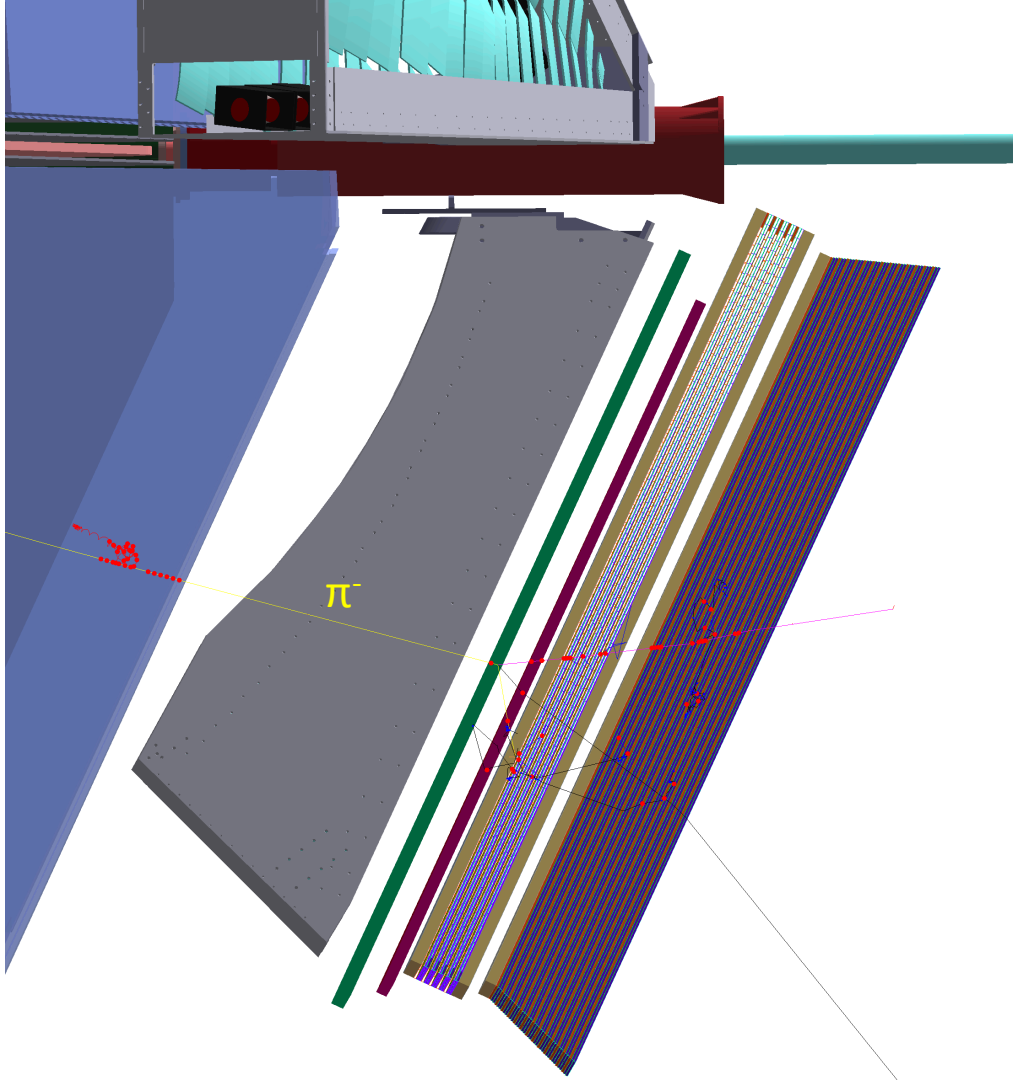


Example of multiple clusters in ECIN in proximity with PID=211 cluster: EB associates 4 clusters with γ in Sector 1

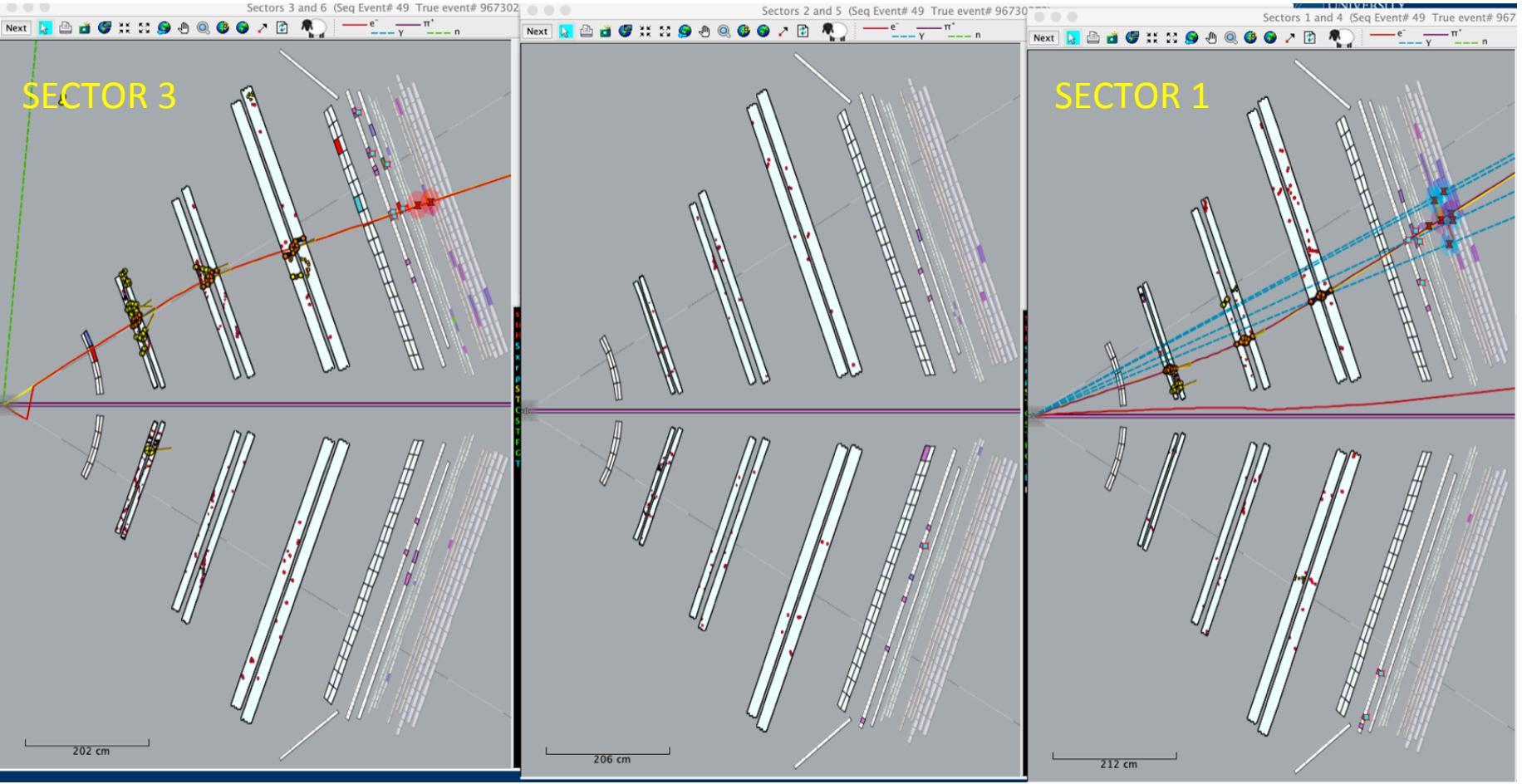


Pion reactions in PCAL (below) and FTOF1B (right) which result in off-trajectory clusters assigned by EB as neutrals

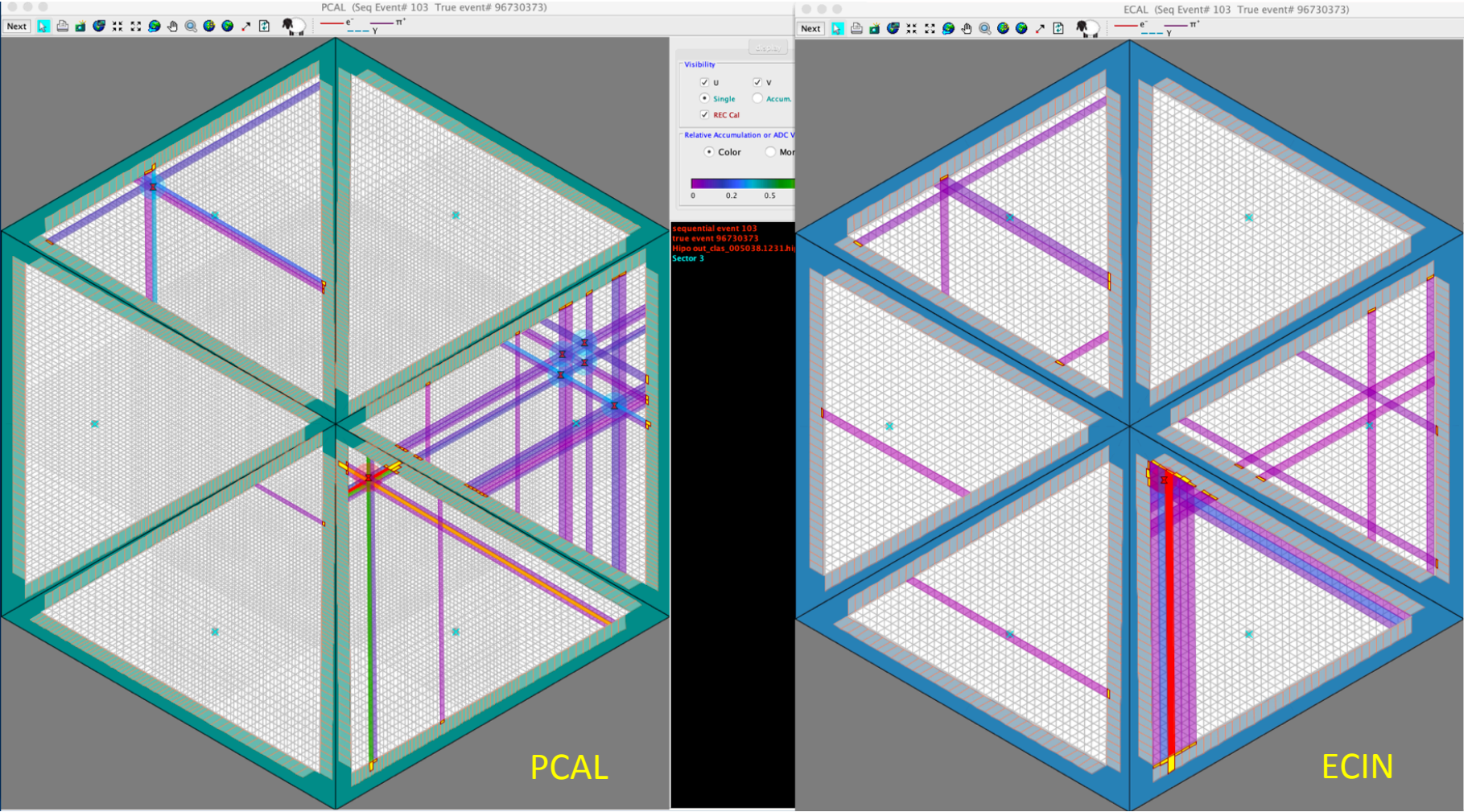




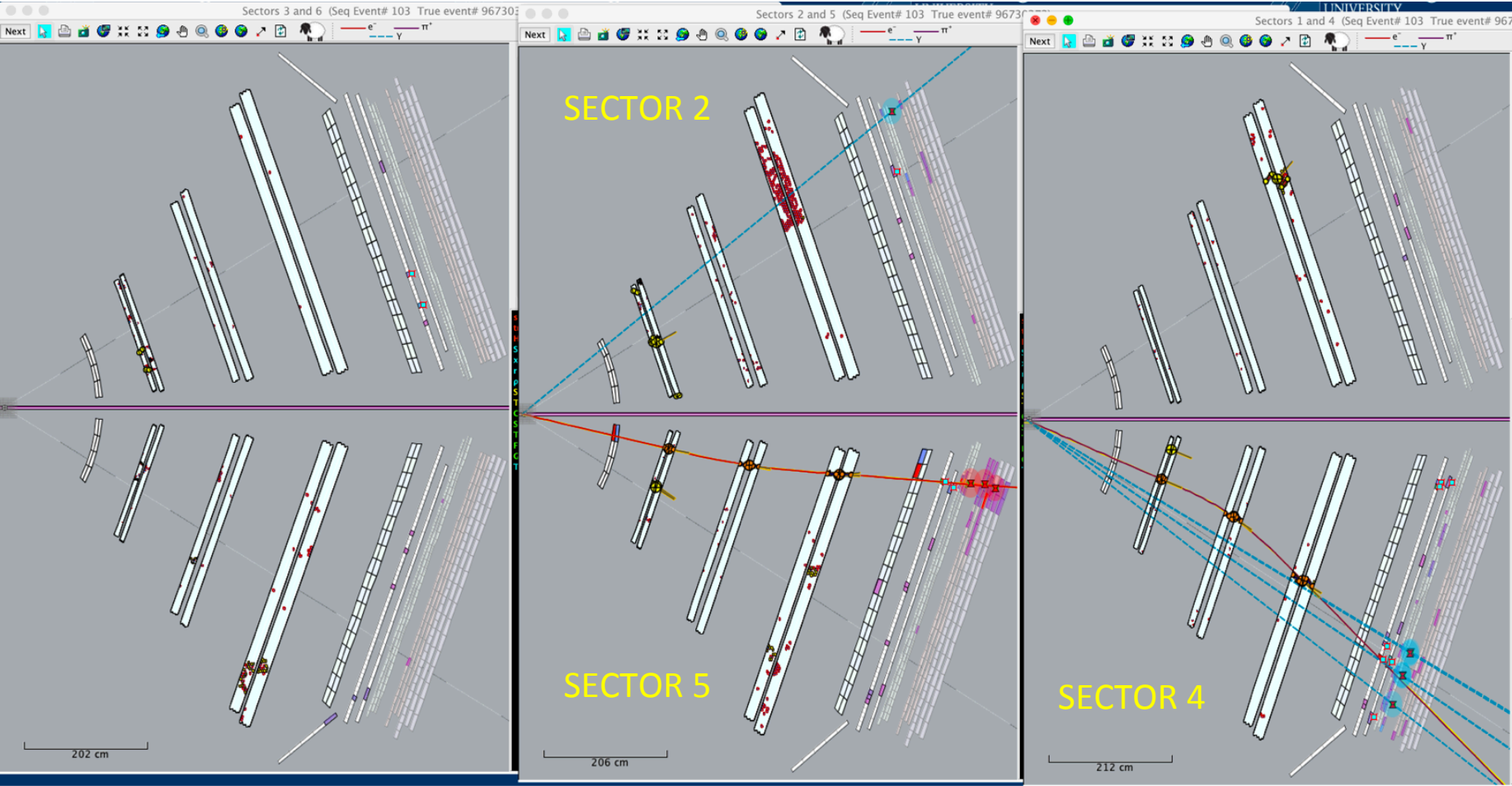
Example of multiple clusters in ECIN in proximity with PID=211 cluster: EB associates 4 clusters with γ in Sector 1



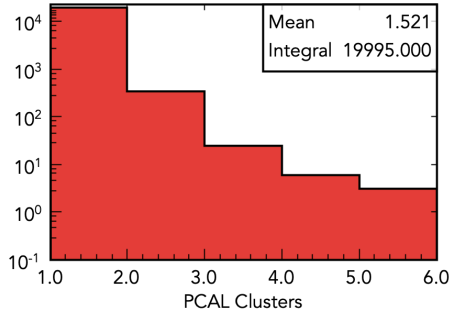
Example of multiple clusters in PCAL in proximity with PID=211 cluster: EB associates 5 clusters with γ in Sector 4

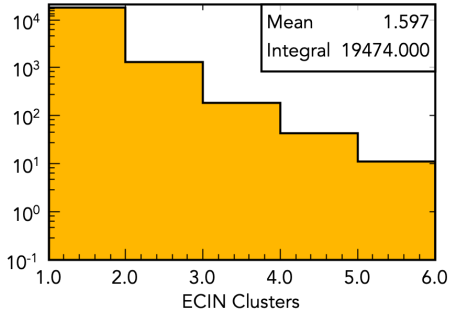


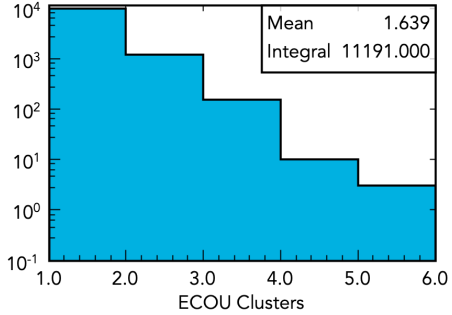
Example of multiple clusters in PCAL in proximity with PID=211 cluster: EB associates 5 clusters with γ in Sector 4



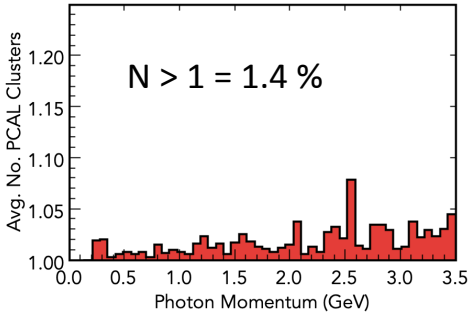
Orphan clusters: multiple reconstructed clusters from single GEMC photons

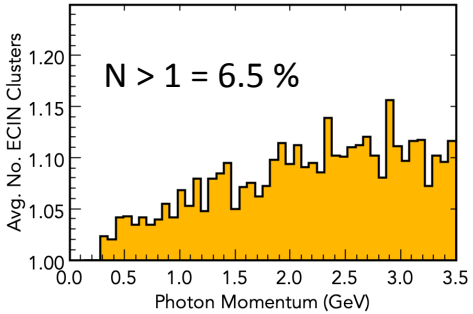


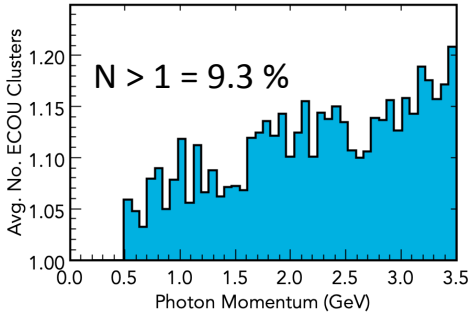




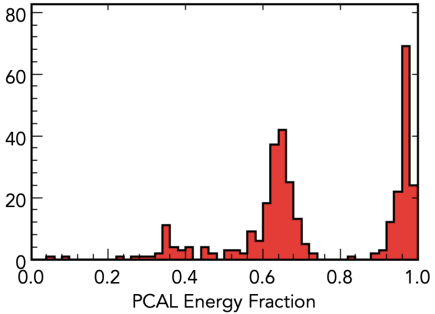
Cluster multiplicity

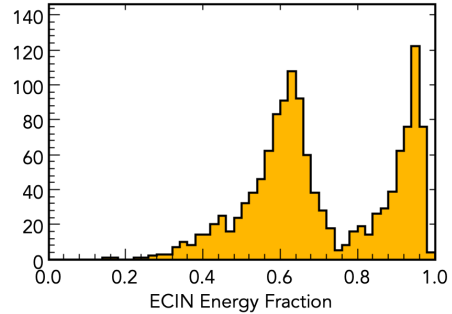


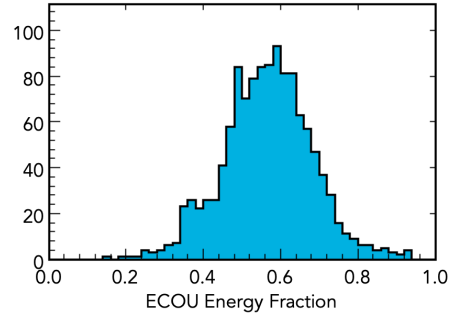




Increases with photon energy and depth

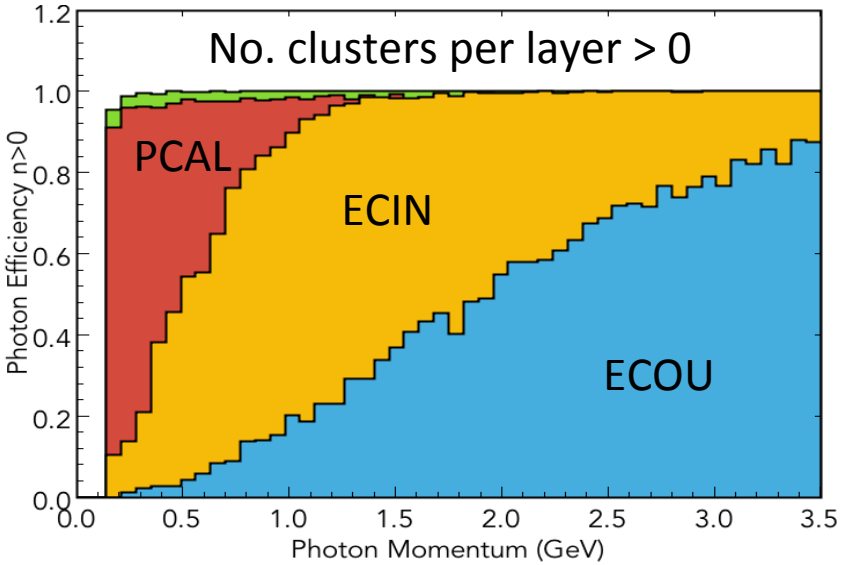


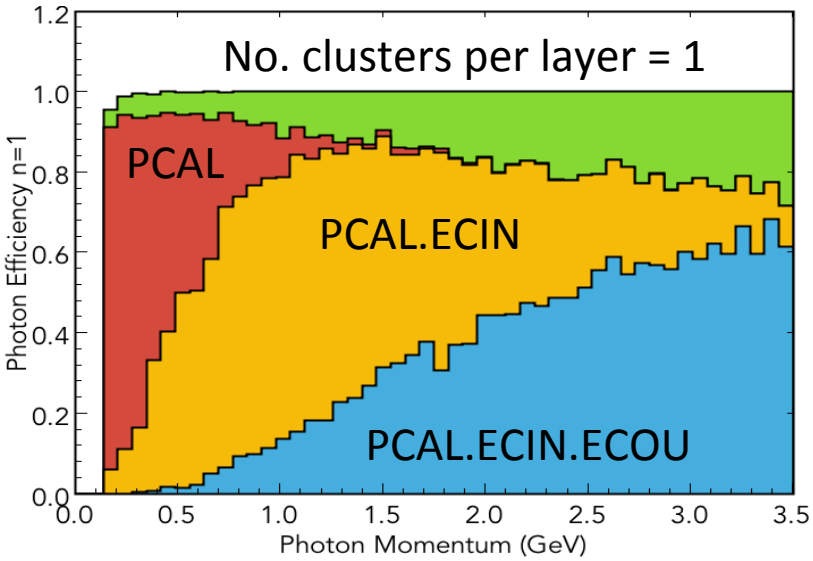




Energy fraction for N > 1 events

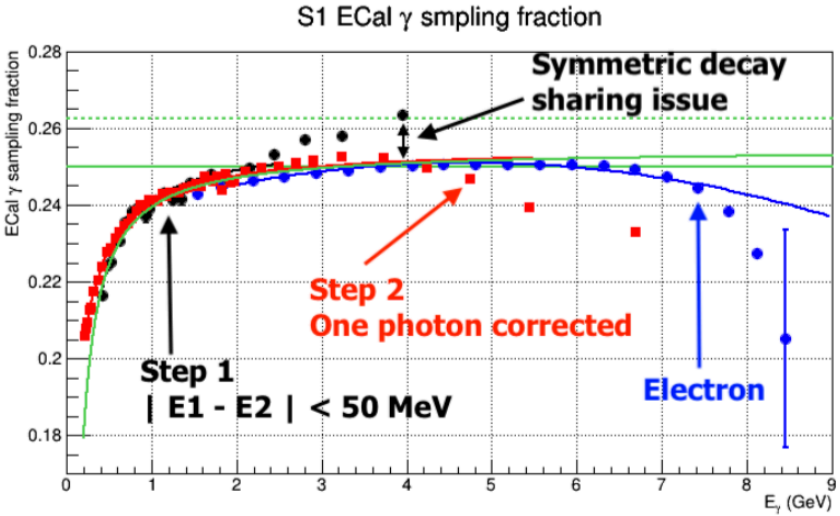
Orphan clusters: loss of efficiency





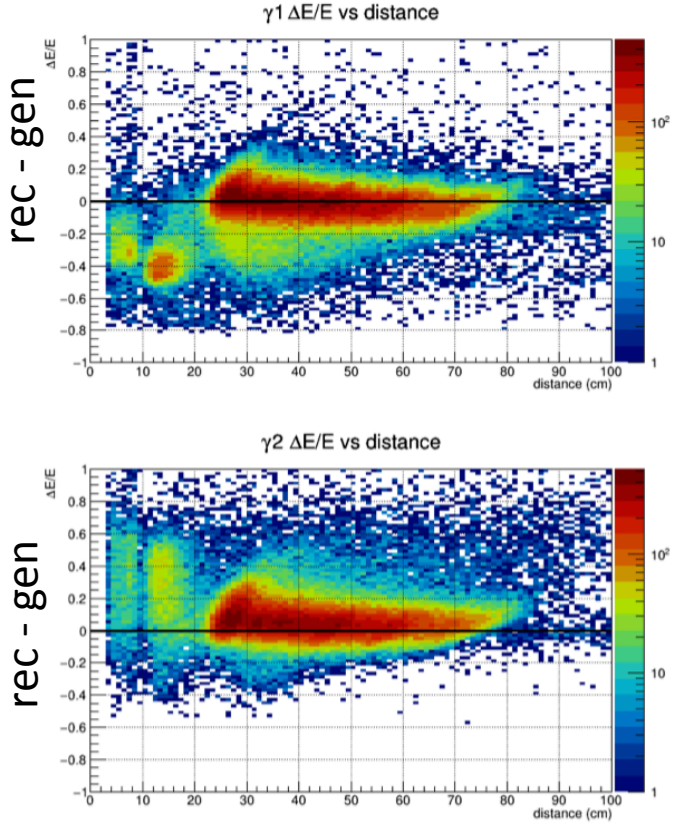
Photon selection based on multiplicity will always introduce inefficiency
Always a trade-off between purity of reconstruction and efficiency

Merged Clusters and DVCS (F-X Girod analysis)



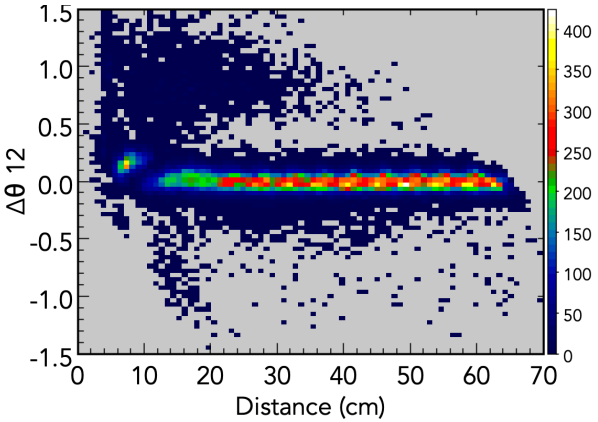
Verified that steps 1-2 discrepancy related to energy

Kinematic fitting of symmetric π^0 decays to extract photon sampling fraction shows departure from expected energy dependence. Direction of discrepancy points to reconstructed photons with too much energy.

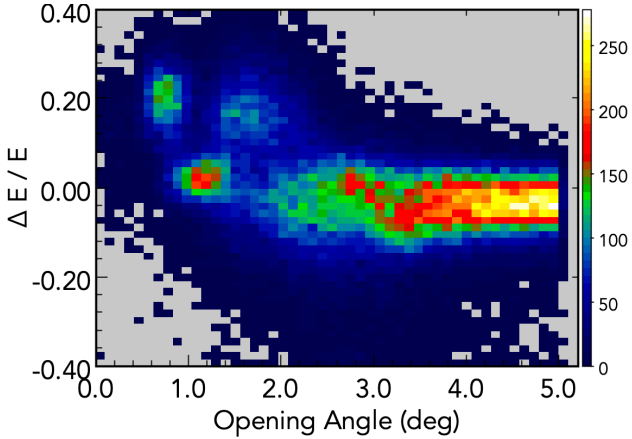


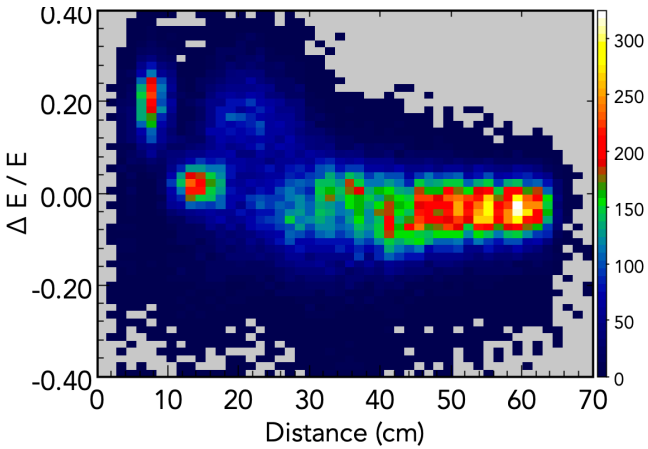
GEMC photons shows excess energy in γ2 at small γ1-γ2 separation distances.

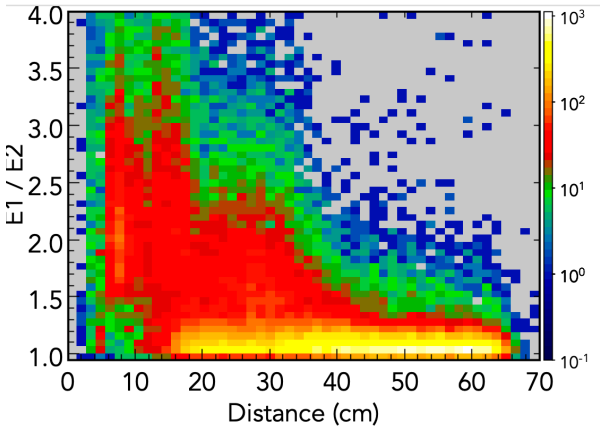
GEMC: Pair of 4 GeV photons thrown over opening angle range of 5 degrees



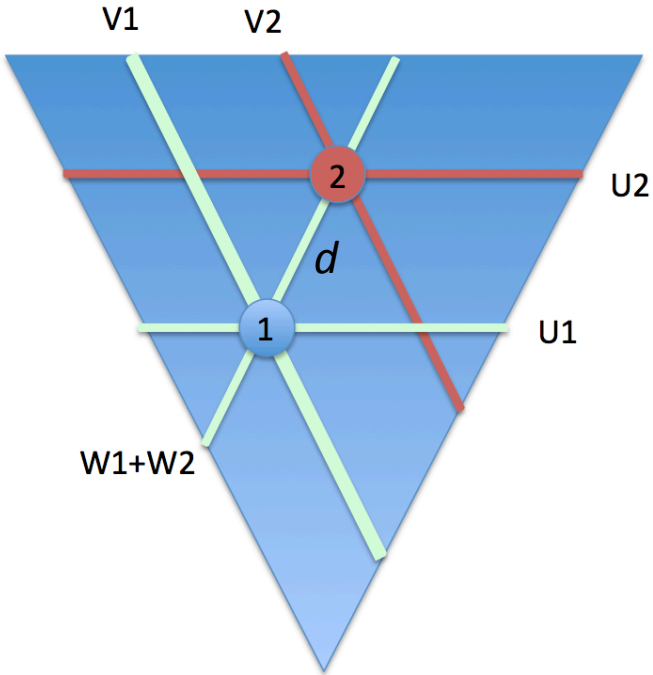
- Opening angle accuracy robust down to 12 cm
- E1/E2 shows onset of energy tail around 40 cm
- ΔE/E peak fades into discreet blobs at 25 cm (2^{o} opening angle)

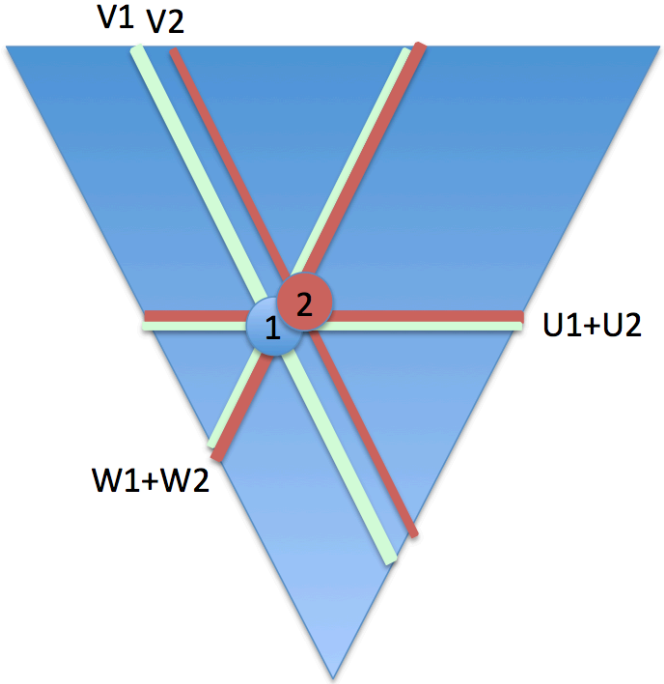






Merged Clusters: Energy Sharing/Peak Splitting

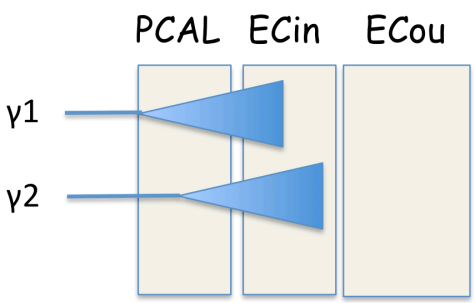


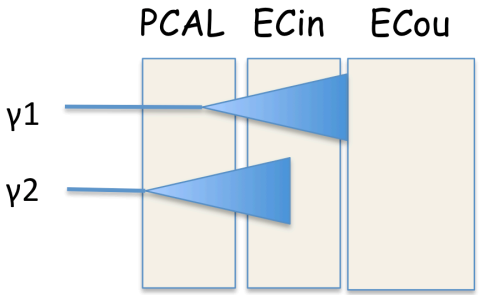


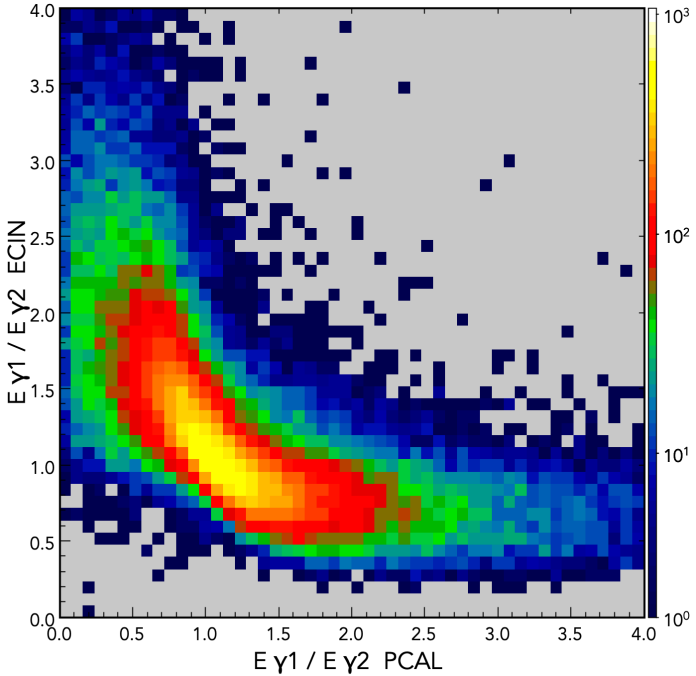
- For large ***d*** two clusters can share the same peak.
- In the case above only energy W1+W2 can be measured.
- ECEngine pattern recognition estimates W1,W2 using ratios U1/U2 and V1/V2.

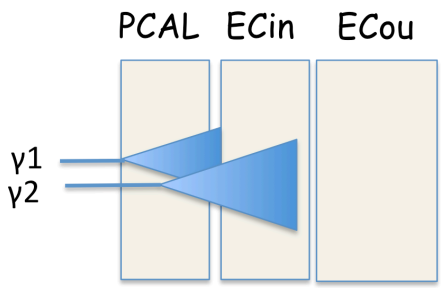
- For decreasing ***d*** two shared peaks are possible
- Energy sharing is less robust in this scenario
- Below some critical value of ***d*** two clusters merge completely.

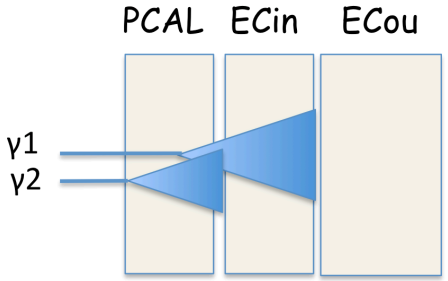
Merged Clusters in ECIN











Would expect clusters to merge in ECIN (10 cm) prior to PCAL (4.5 cm)
Not yet clear whether problem is complete or partial cluster merger
Complete cluster merger in ECIN would use PCAL energy ratios to estimate unmerged energies

Outlook

- Merged cluster investigation in progress with more MC studies planned.
- Post-processing correction may be possible. EB incorporation for pass2 (Priority 2)

- Pizero reconstruction efficiency important for DVCS background.
- Studies of impact of ‘orphan’ clusters on symmetric and asymmetric decays.

- Understand combinatorial backgrounds for tagged neutron efficiency studies.

Supplementary Slides

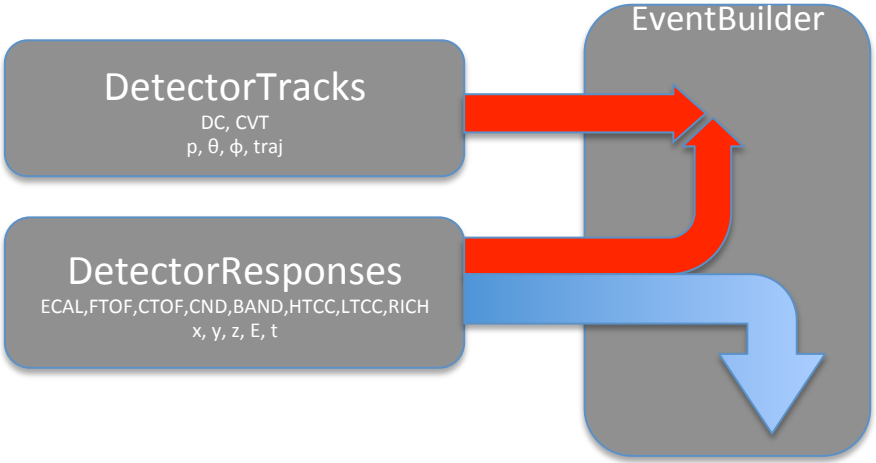
Event Builder

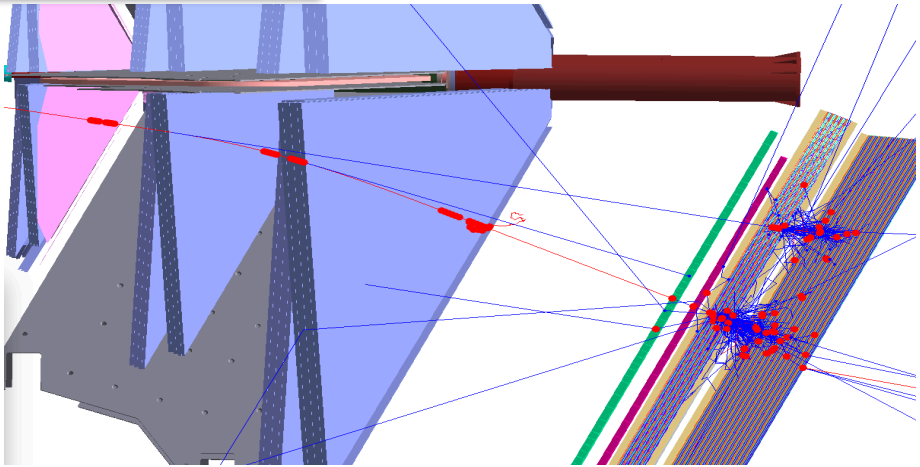
https://clasweb.jlab.org/wiki/index.php/CLAS12_EventBuilder

Charged Particles

For each reconstructed track, from either the central (CVT) or forward (DC) tracking systems, one corresponding charged particle is created.

- For each track, association with the responses of non-tracking detectors is then performed.
  - This association is currently based only on loose geometric matching with fixed windows, where those cut windows are store in CCDB.
  - This geometric matching is performed based on the distance of closest approach between the detector response and the track.





Neutral Particles

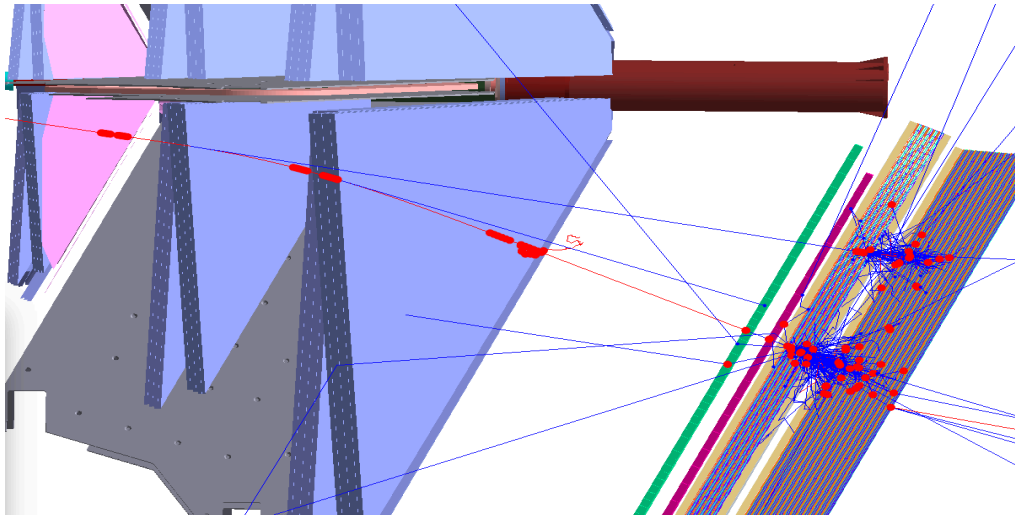
After charged particles are assimilated, calorimeter responses (EC/PCAL/CND) that remain unassociated to any existing particle are then assimilated into neutral particles.

Forward

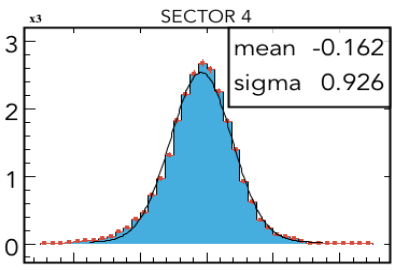
For forward detectors, the algorithm is as follows:

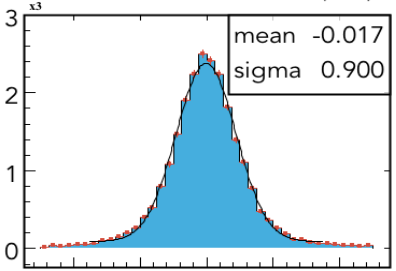
1. PCAL clusters unassociated with any DC track are assigned as new neutrals particles.
   - EC Inner and Outer clusters are then geometrically associated to those PCAL seeds assuming a straight line trajectory form CLAS12 origin.
2. Remaining unassociated EC Inner clusters are assigned as new neutral particles.
   - EC Outer are then geometrically associated to those EC Inner seeds, again assuming a straight line trajectory form CLAS12 origin.
3. Remaining unassociated EC Outer clusters are assigned as new neutral particles.

ECAL/DC X,Y Alignment Precision and Resolution

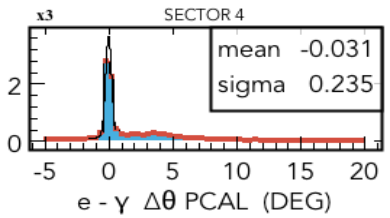


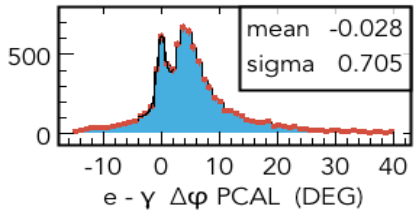
e-

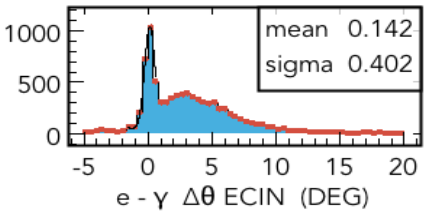




γ







- PCAL, EC transverse alignment adjusted to minimize DC track residuals.
- Alignment checked for neutral reconstruction using radiated photons.
- EB uses track-cluster matching distance of 15 cm.

Z Tracking Planes in PCAL

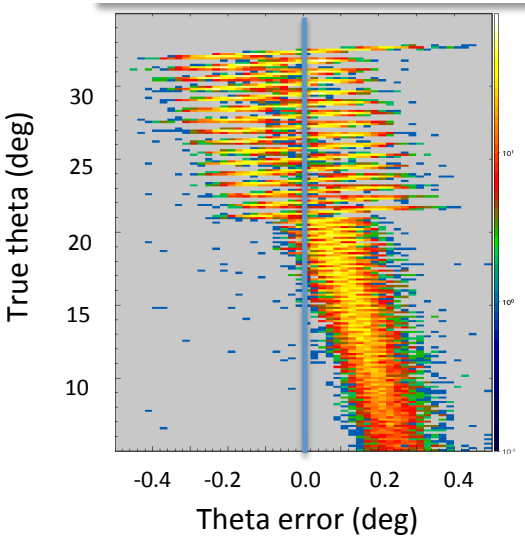
PCAL and EC reconstruction measures only transverse (x,y) cluster position.

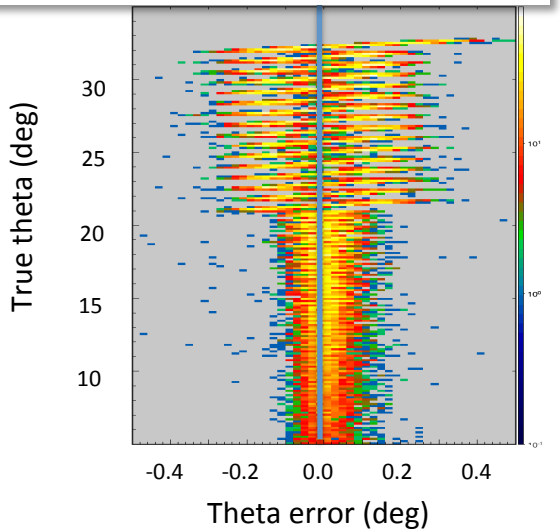
Cluster z position referenced to user-defined z tracking plane.

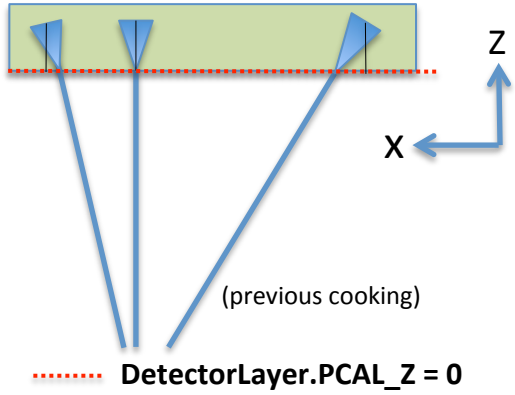
PCAL z tracking plane must approximately coincide with depth of shower maximum to avoid parallax errors in theta for off-normal straight tracks (photons,neutrons).

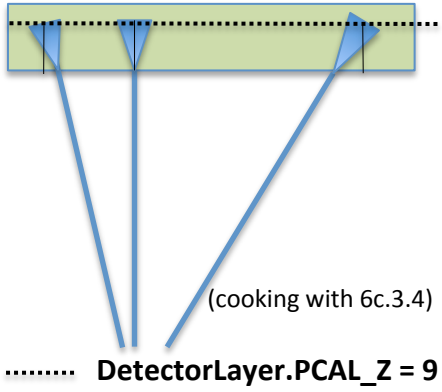
For EC the scintillator projective geometry compensates for parallax.

GEMC: 2.0 GeV photons Theta: 5-35^0 Phi: +/- 5^0

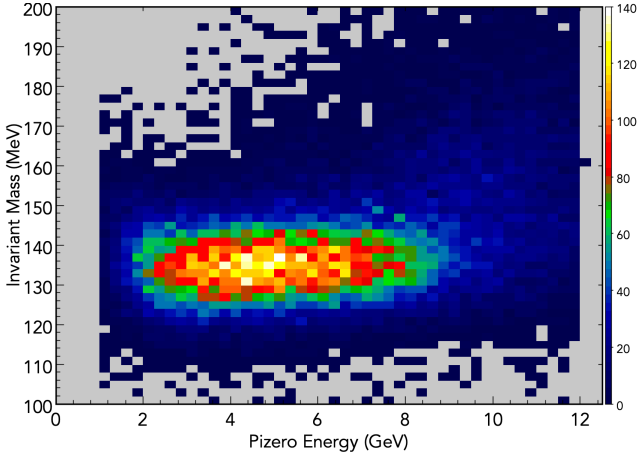


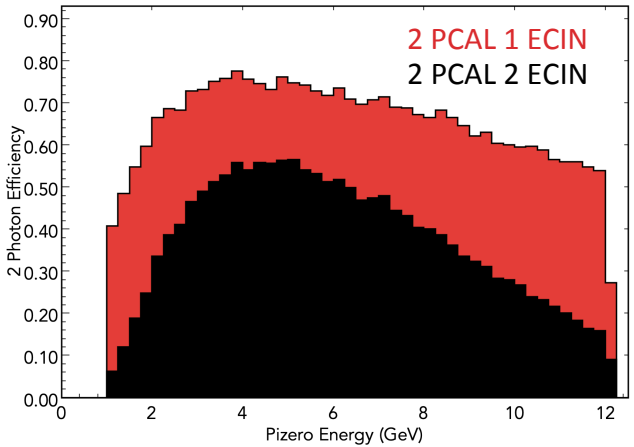






Orphan clusters: GEMC pizeros 1-12 GeV





Loss of asymmetric decays at high energy