Charged Pions in MAIA

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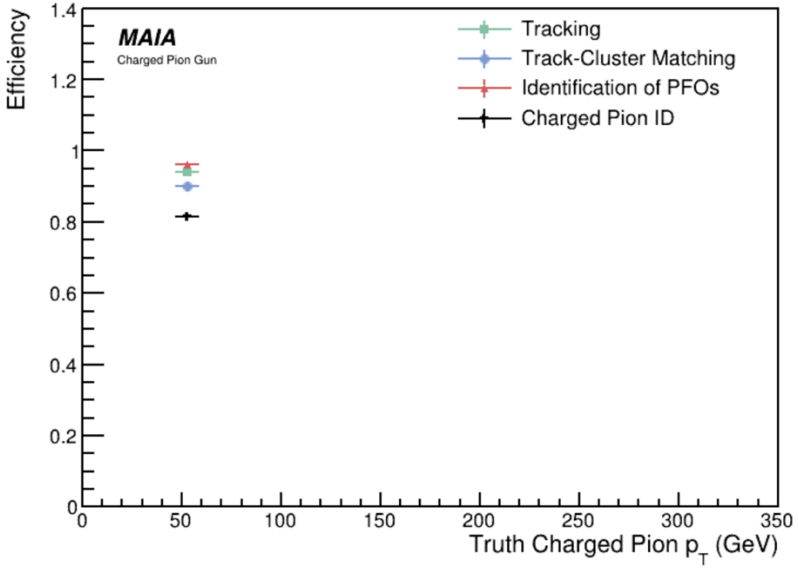
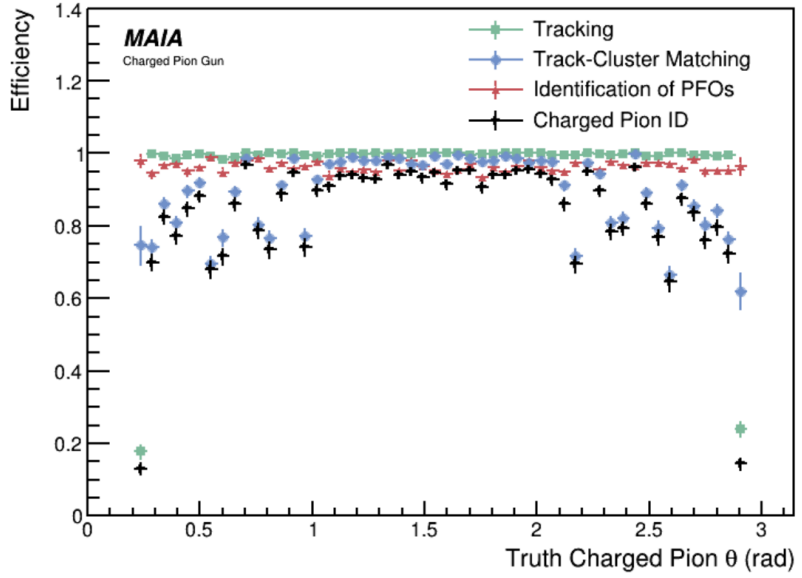
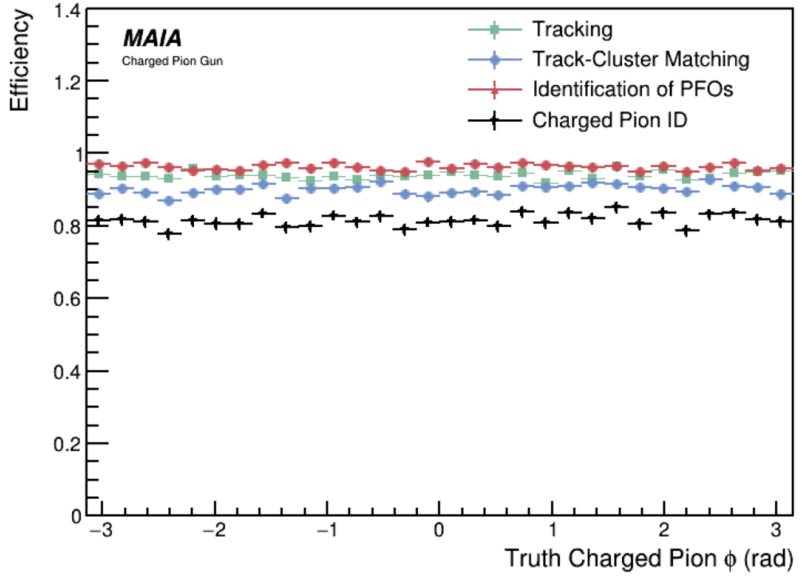
Quick Reminder

- Realized that track-cluster matching is called ~20 times in Pandora config (link to last presentation)
- Forcing all instances of track-cluster matching to have near-infinitely loose cuts yields better charged pion reconstruction efficiency
  - Cluster lower hadronic energy cut → 0 GeV
  - Layers of calorimeter to search for hits to associate to track → 100
  - Maximum track-cluster perpendicular distance → 100 m
  - Maximum track-cluster parallel distance → 100 m
  - Minimum cosine angle between track and cluster → 0

event-level efficiency definitions







Simplify!

- Results from those settings aren't interpretable or realistic
- Work towards simplicity & interpretability:
  - Run only the strictly required elements of PandoraPFA, build on top of it

All Pandora Algorithms

1. Track selection & hit preparation
2. Clustering
   1. Photon clustering
   2. Fast photon identification
   3. Cone clustering
   4. Topological cluster merging
      1. This involves ***9(!)*** edge cases that recluster, targeting various phenomena (some involving tracks)
   5. Re-clustering
   6. Photon identification and recovery
   7. Fragment removal
   8. Formation of particle flow objects

"Most Basic" Pandora

1. Track selection & hit preparation
2. Cone clustering
3. Formation of particle flow objects

Track Selection & Hit Preparation

Link to Pandora paper

- **Track selection**
  - Track reaches ECal
  - Track radius of curvature not 0 mm
  - $\sigma(p)/p > 0.15$
  - Is a parent track
  - Tunable selections dependent on config, see more (details in slide 19 here)
- **Calorimeter hit preparation**
  - Energy cut (in MIP, separate values for ECal and HCal) and calibration
  - Detector geometry associated with hits (pixel size, layer in calorimeter)
  - Removal of isolated hits
    - Cut based on # of other hits within a particular distance
  - Flagging MIP-like hits, used for identifying minimum ionizing tracks in the calorimeter
    - Upper energy threshold
    - Upper limit on # of adjacent pixels in same layer with energy above threshold
  - Hits are then ordered first by calorimeter layer and then by energy
    - Innermost layer to outermost layer

Cone Clustering

Link to Pandora paper

- Clusters seeded with direction of tracks projected to the ECal face
- Loop over each layer:
  - Compare compatibility of each hit in layer to each hit in previous layer
    - Hits are clustered together if they are within specified parallel and perpendicular distance, calculated with respect to the cluster direction axis

$\vec{r}_{ij}$: displacement between hits

$\hat{u}$: directions of clusters

$$d_{\parallel} = \vec{r}_{ij} \cdot \hat{u}$$
$$d_{\perp} = |\vec{r}_{ij} \times \hat{u}|$$

$$d_{\perp} < d_{\parallel} \tan A + b D_{pad}$$

A : cone half-angle

b : # pixels added to cone radius

D_{pad} : pixel size

- A, b determined from config file
- Dpad read from geometry file
- If hit not within distance of any others, it seeds its own cluster
  - New cluster direction is radial distance from interaction point

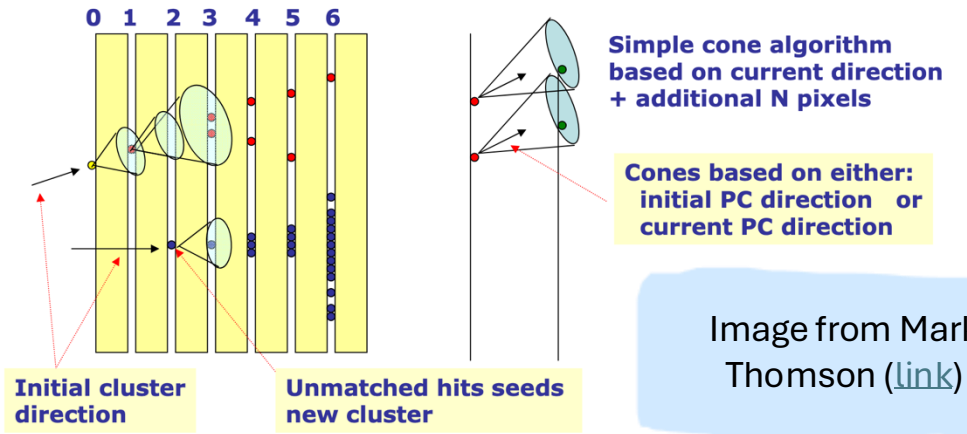


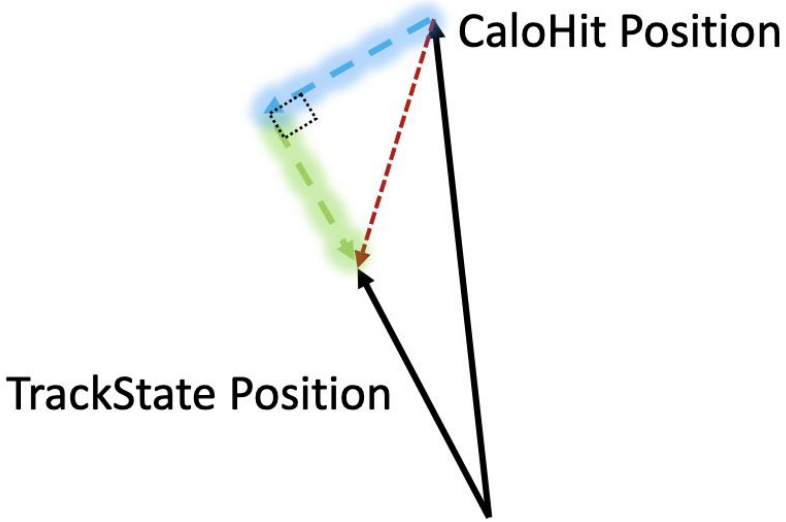
Image from Mark Thomson (link)

PFO Creation

Link to Pandora paper

- Track-cluster matching
  - Tracks are propagated through the first 9 layers of the calorimeter (tunable in config)
  - If a hit is found within a set distance (tunable in the config), an association is made

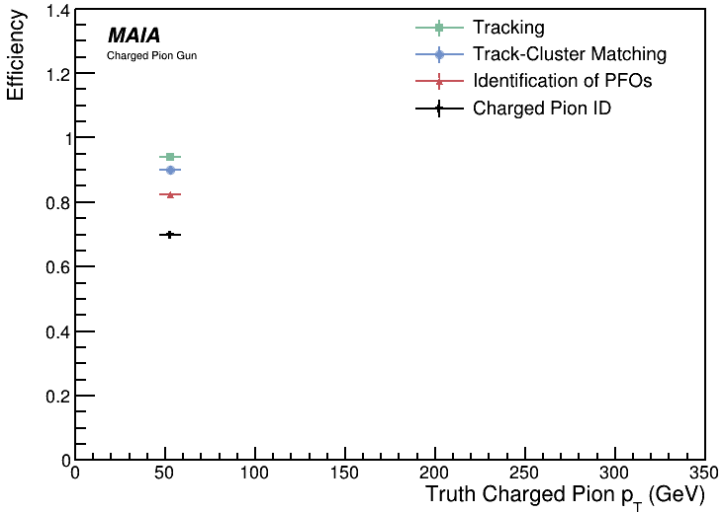
Image from Rose (link)

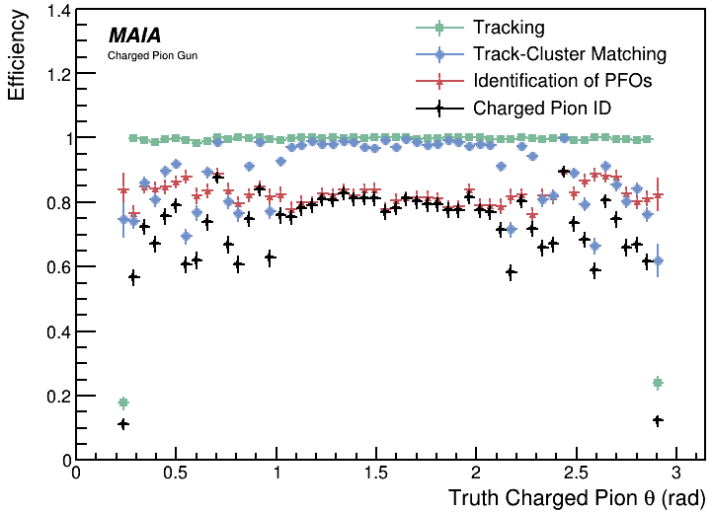


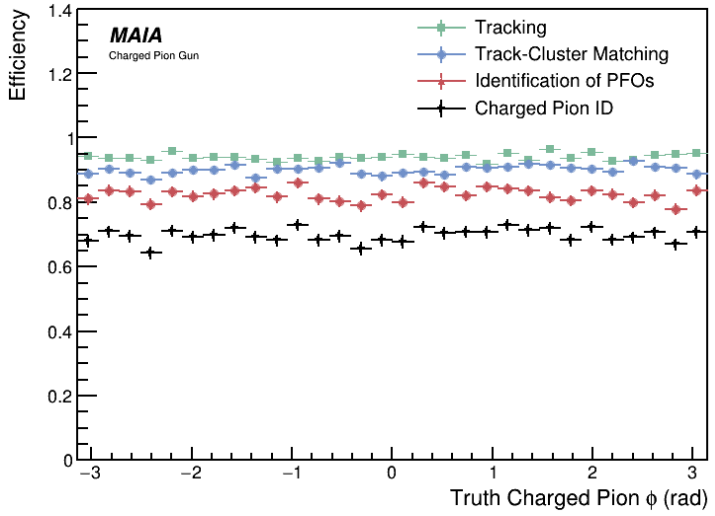
- PFO identification
  - I won't go into detail today

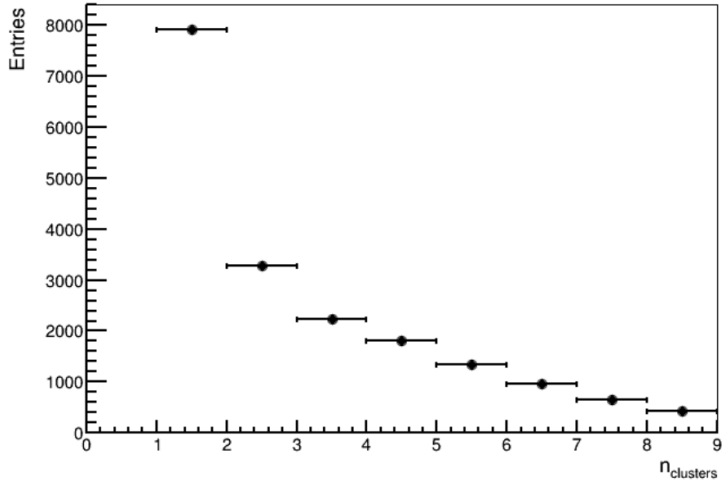
“Most Basic” Pandora

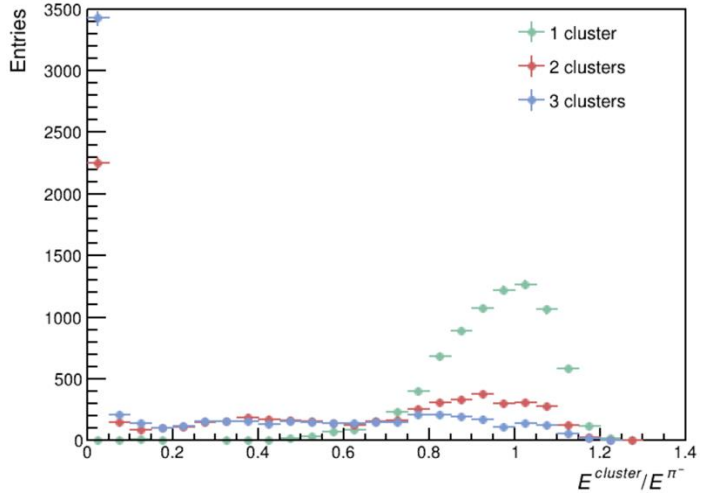
- Run with the same extremely loose track-cluster parameters as previous week (cuts on slide 1):
- Turn off everything but Cone Clustering and PFO Creation







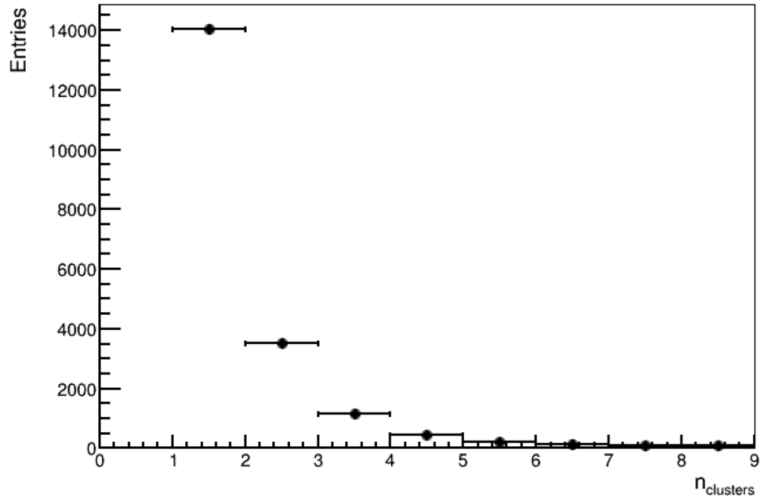


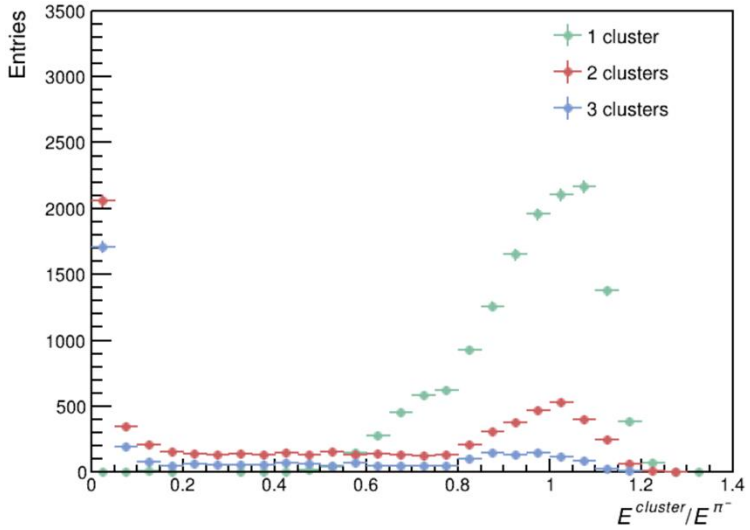


event-level efficiency definitions

Pandora vs. “Most Basic” Pandora

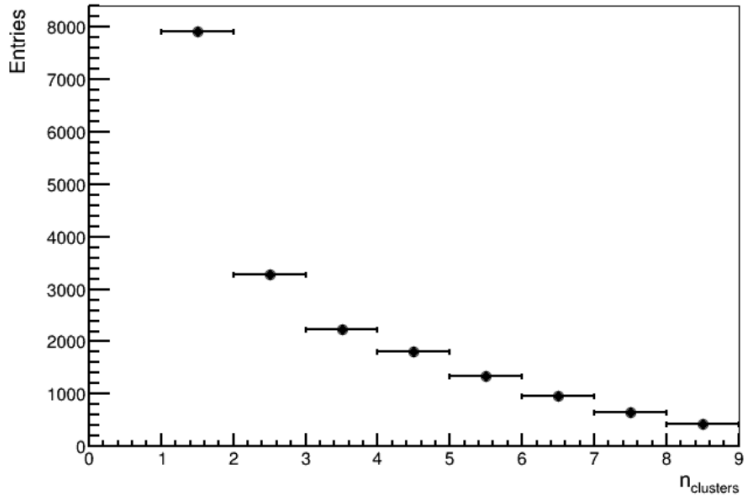
All Pandora Algorithms

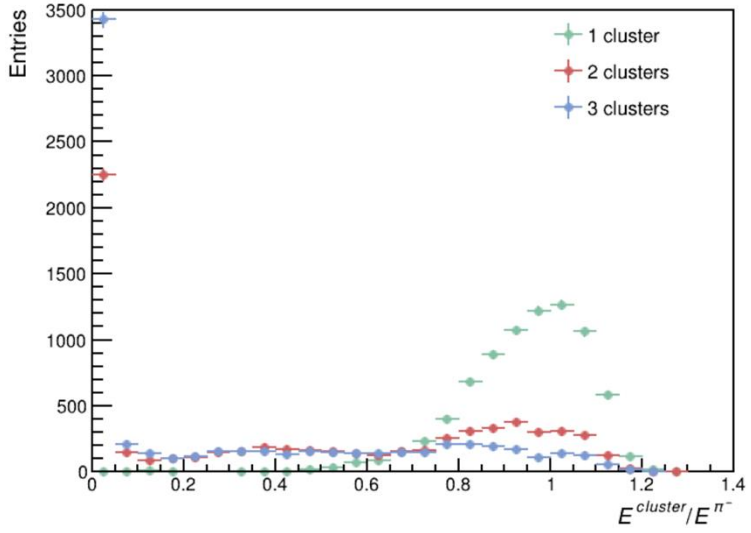




Clusters much more split!

Cone Clustering + PFO





Pandora vs. "Most Basic" Pandora

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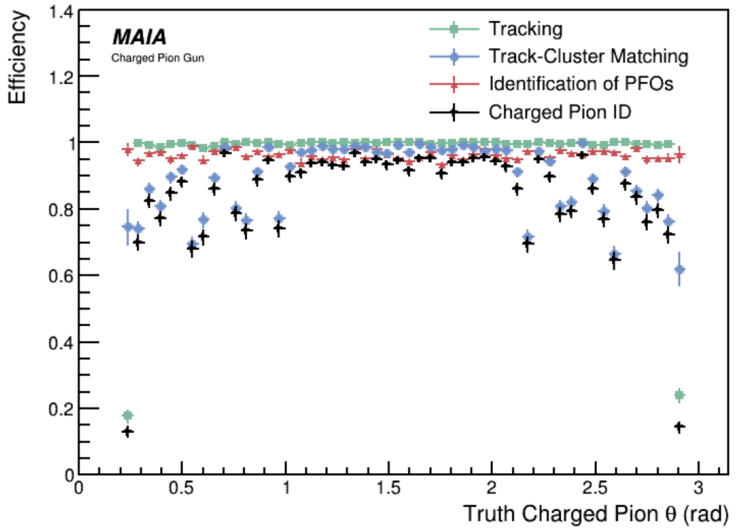
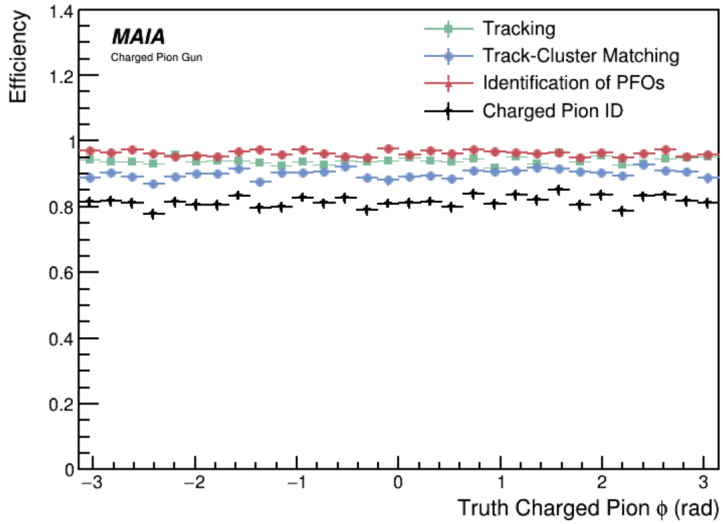
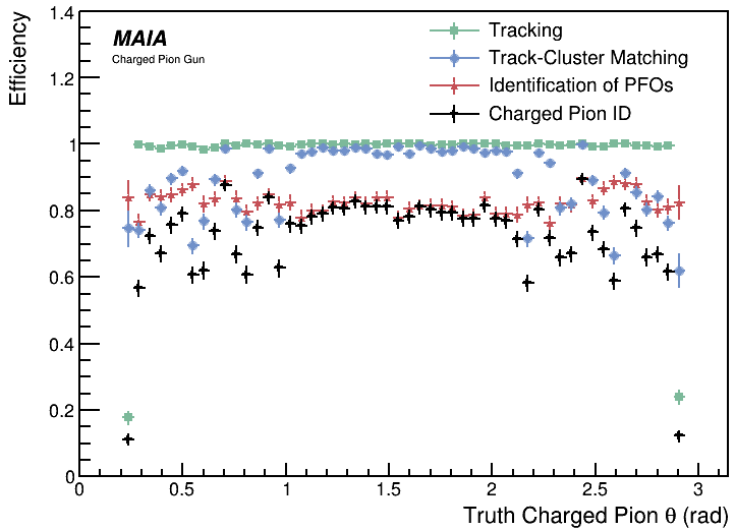


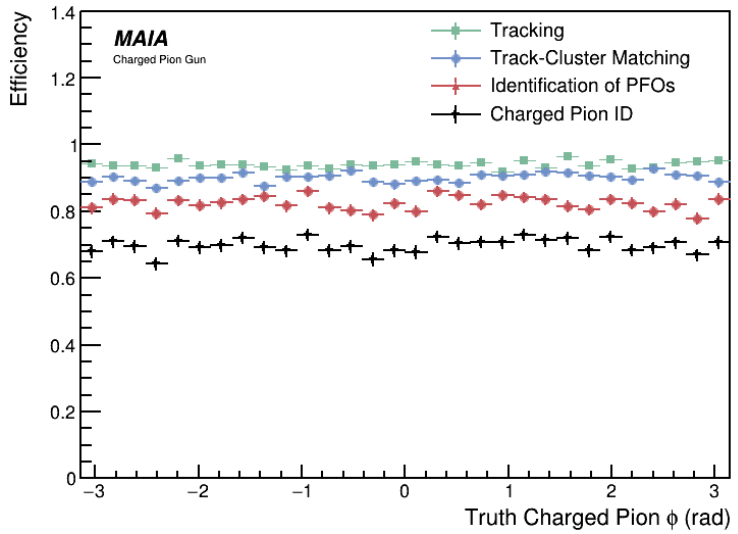


event-level efficiency definitions

PFO ID efficiency drops by ~15%

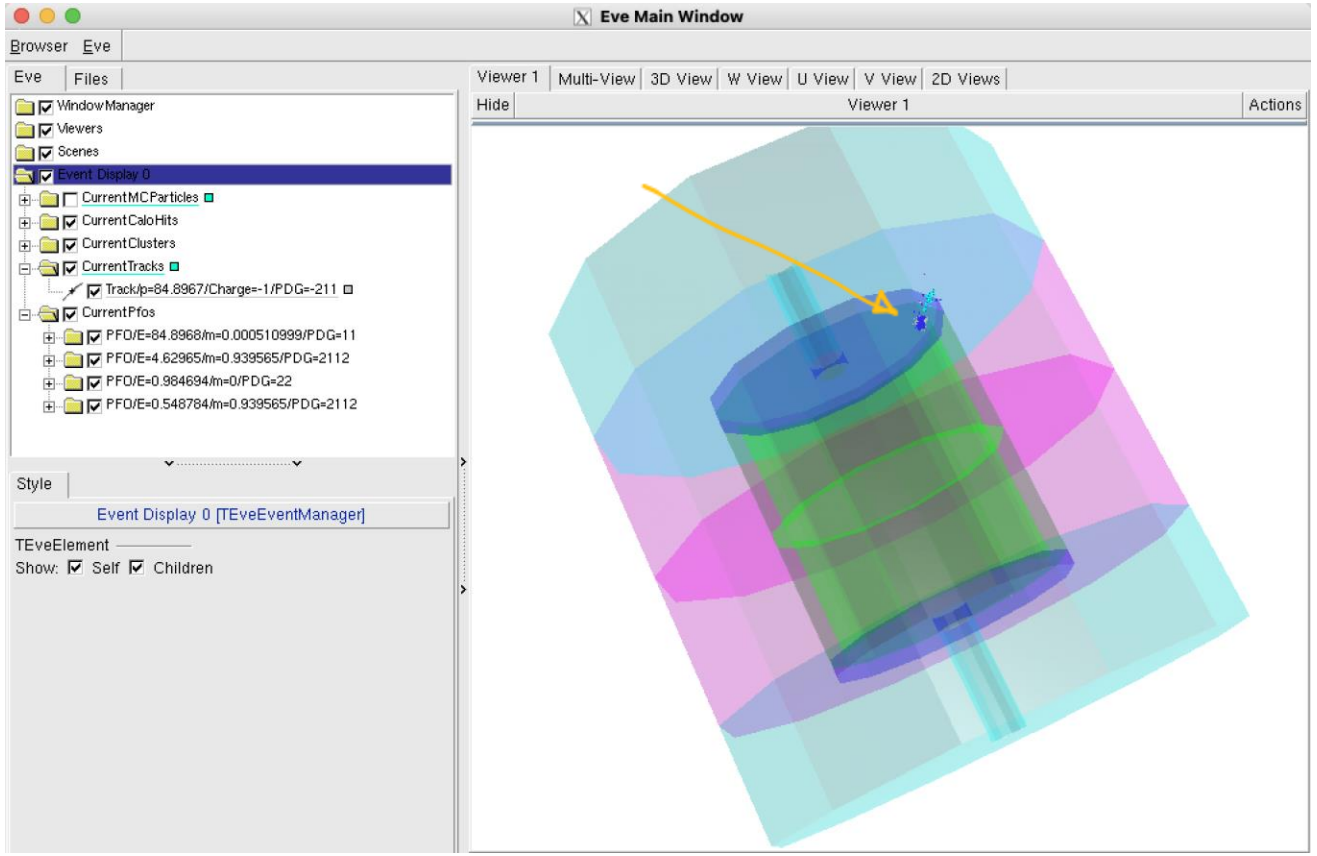
Cone Clustering + PFO





Event Displays

- Need more than the plots that I've been showing
  - Where are the tracks? The clusters?
- With the help of Thomas Madlener and Anna Zaborowksa, I was able to run PandoraMonitoring
- Still playing around with the event display:
  - Don't know how to zoom in
  - Tracks not being visualized?
- For Cone Clustering + PFO Pandora, it shows 4 PFOs:
  - An electron with almost all the energy of the charged pion → misidentified!
  - Two neutrons and a photon → misclustering!
- In principle, we can watch Pandora as it goes through the algorithm



Next

- Debugging the track-cluster inefficiency is still ongoing
  - Tightening those cuts even a little is giving poor efficiencies
  - Currently working on tracks on event display, track-cluster distance plots, and print statements
- Once that is fixed, ideally:
  - Add BIB → should we begin to set this up now? Do we have digitized charged pion gun events w/ BIB?
  - Add topological cluster merging to Pandora → should improve charged pion ID efficiency

Thanks!