

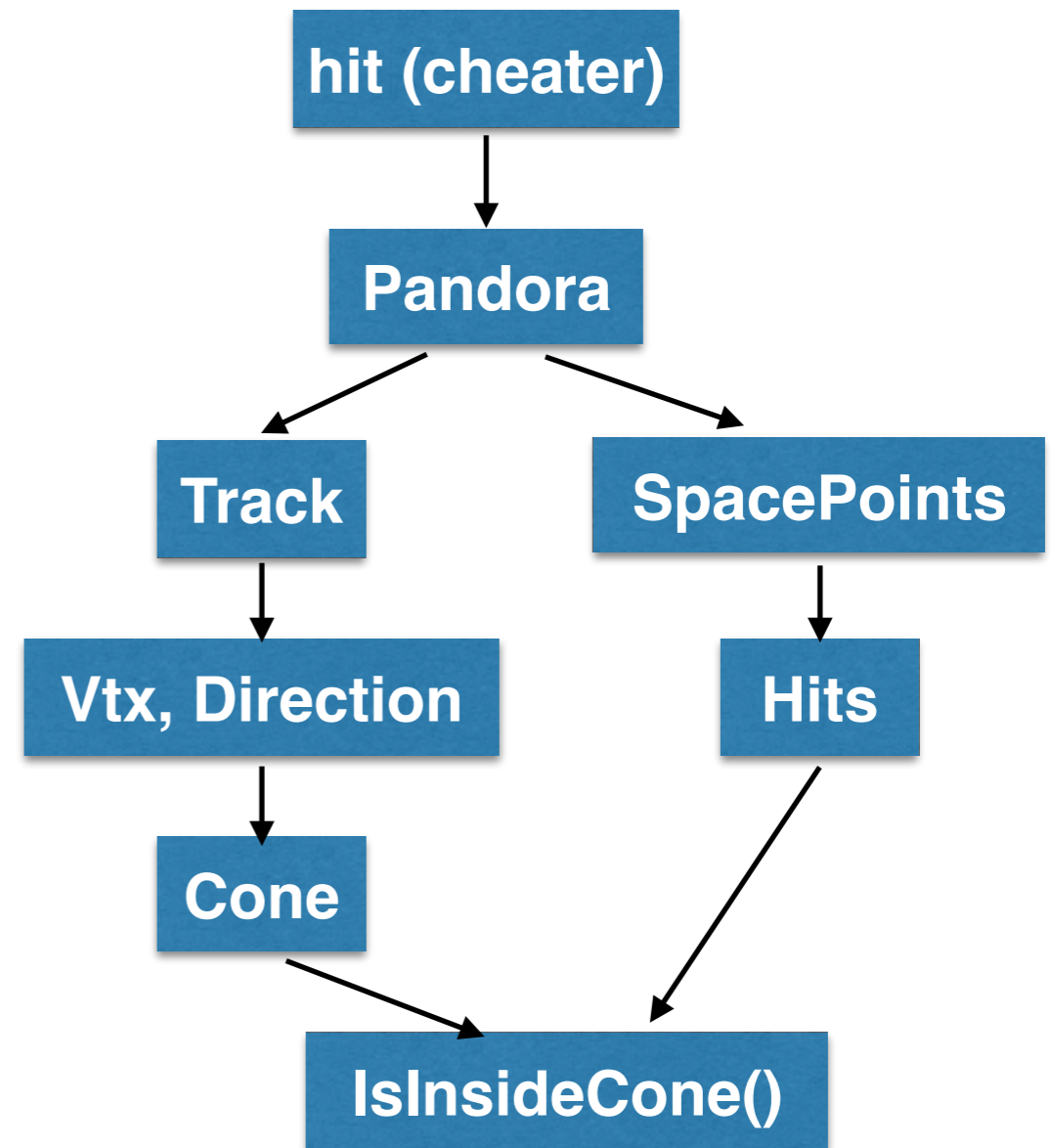
Electromagnetic Shower Reconstruction

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Gamma Reconstruction (Recap)

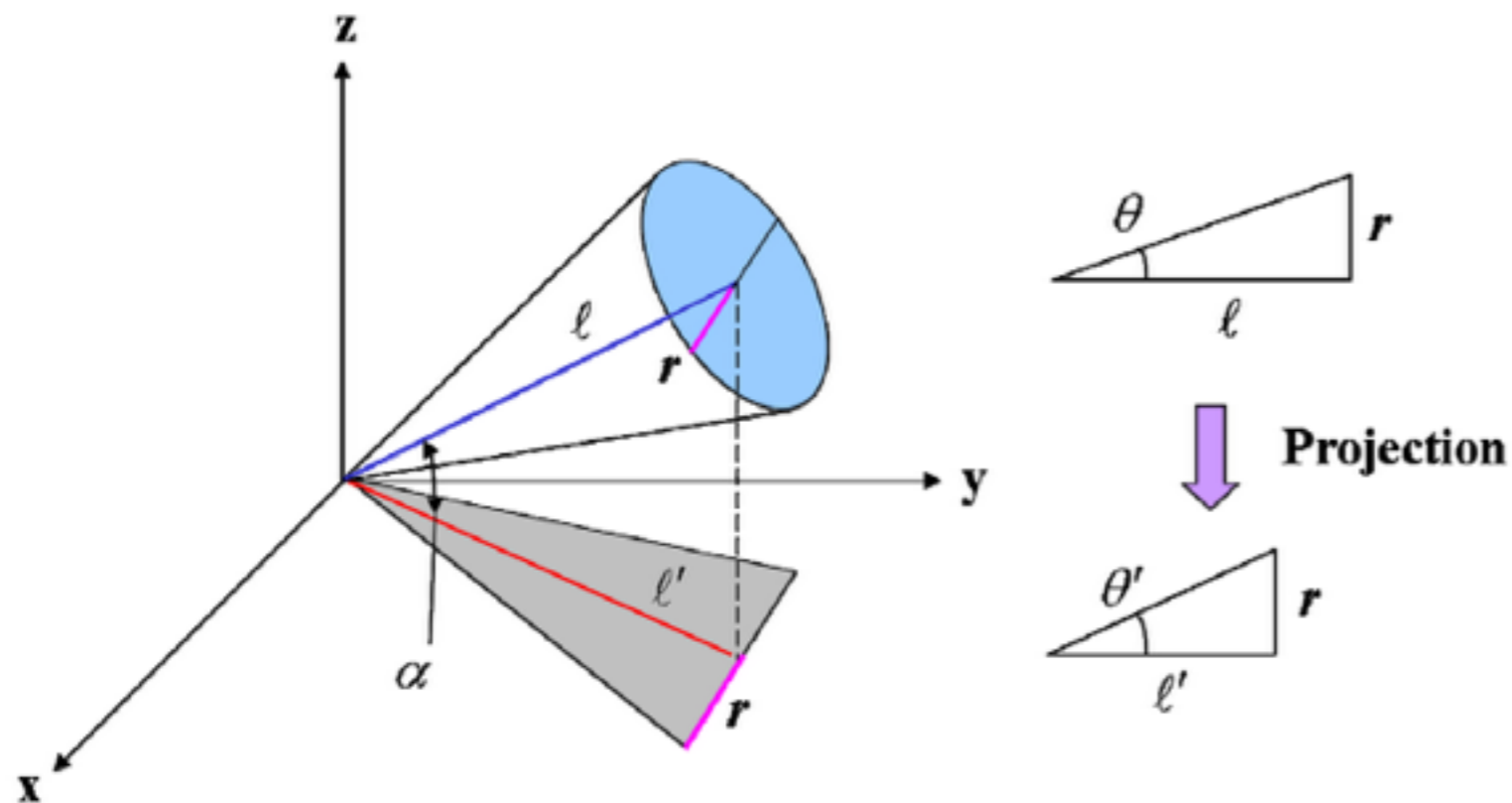
Shower cone algorithm

- ❖ Shower cone algorithm is commonly used for EM shower reconstruction
- ❖ 3D objects inside a 3D cone can be grouped together for energy and direction reconstruction
- ❖ Cone's direction can be reconstructed using track direction
- ❖ Disadvantage: SpacePoints reconstruction will affect the energy reconstruction because a certain number of hits will not be used since there is not SpacePoint associated



Cone3D → Cone2D

- ❖ **Run Pandora**, use reconstructed track from pandora to define 3D cone direction
- ❖ Project 3D cone into UX, VX, YX planes
- ❖ Loop over the hits in each plane and see if the hits are inside 2D cone projection



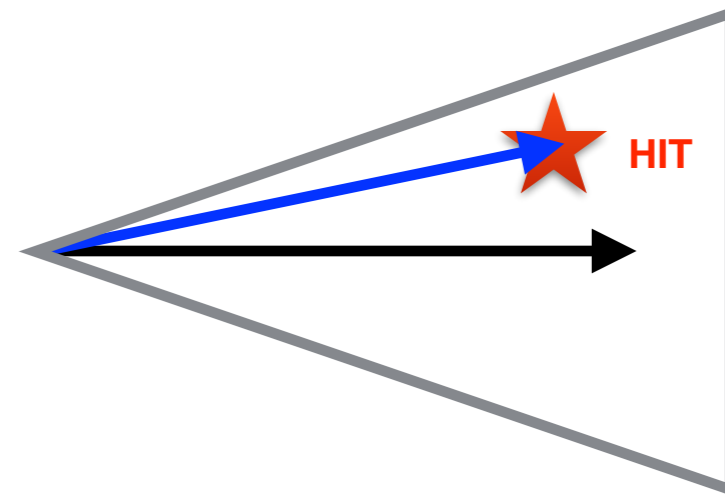
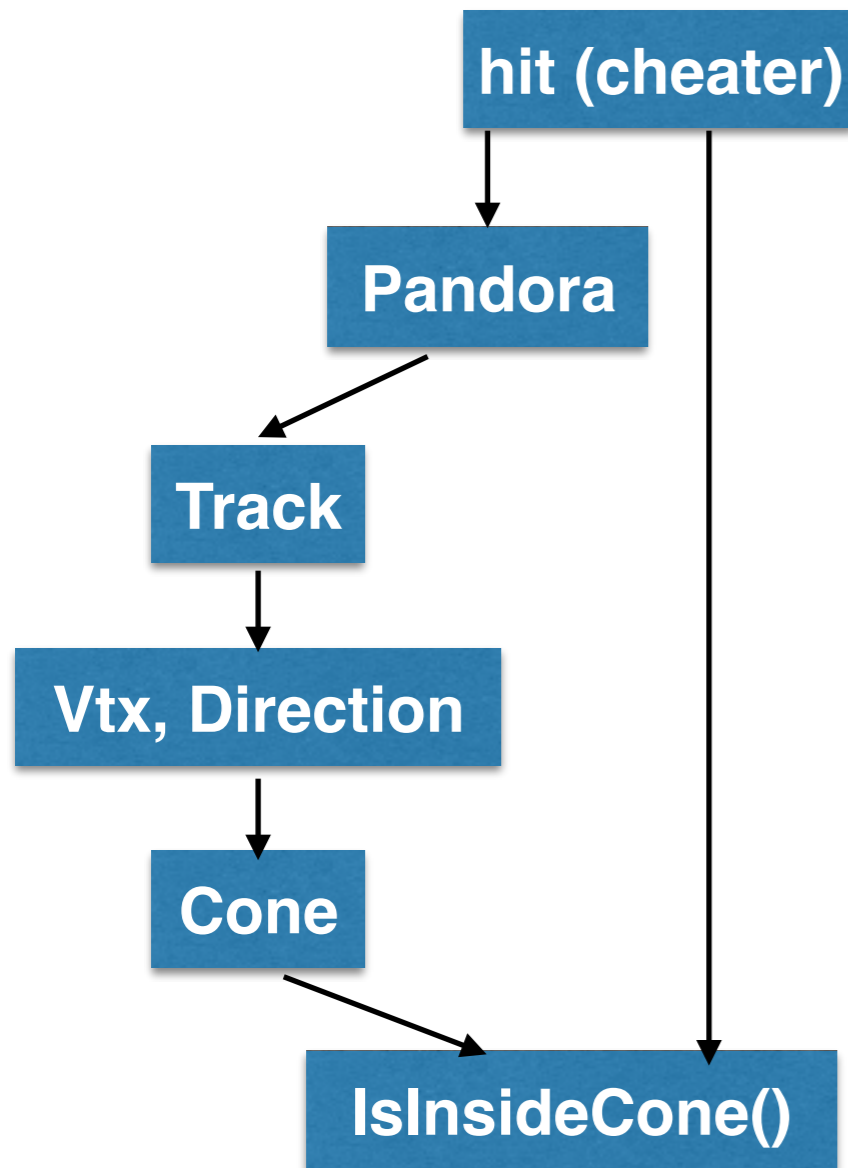
- ❖ Projected cone angle in 2D plane is generally not the same as cone angle 3D

$$\theta' = \arctan\left(\frac{\tan \theta}{\cos \alpha}\right)$$

- ❖ Projected cone angle in 2D for each plane UX, VX, YX

2D Cone; Collection Plane

Shower cone algorithm



```
IsInsideCone(hit){
```

A = track direction (cone axis)

A · B = |**A**| |**B**| cosθ

d = **A**-**B**

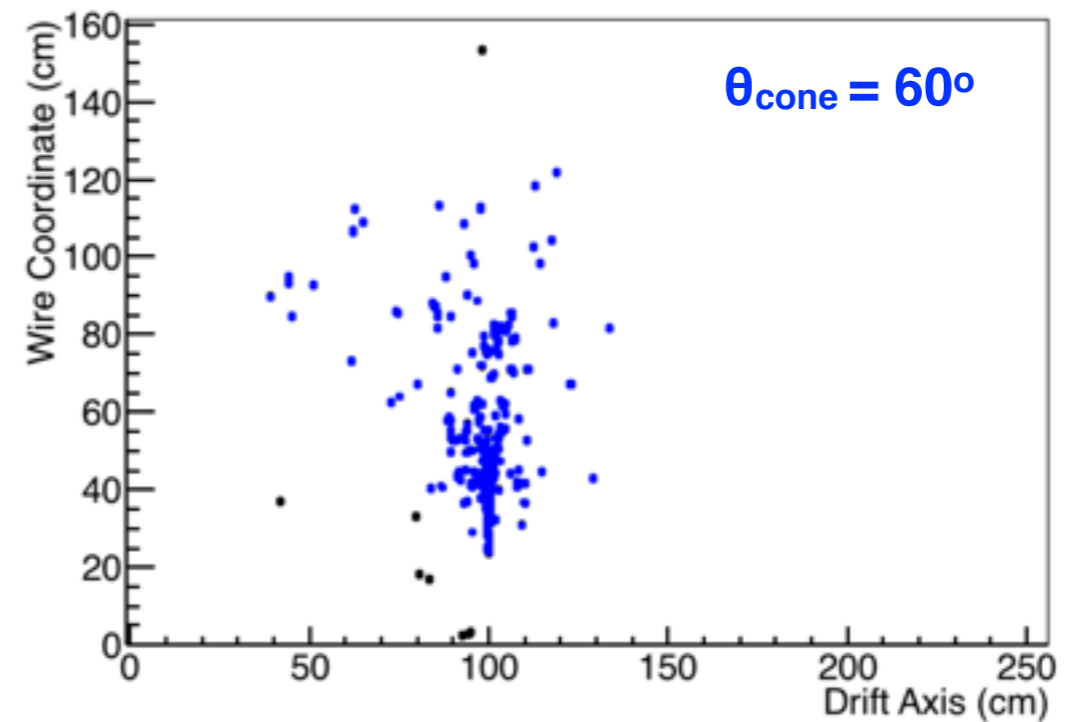
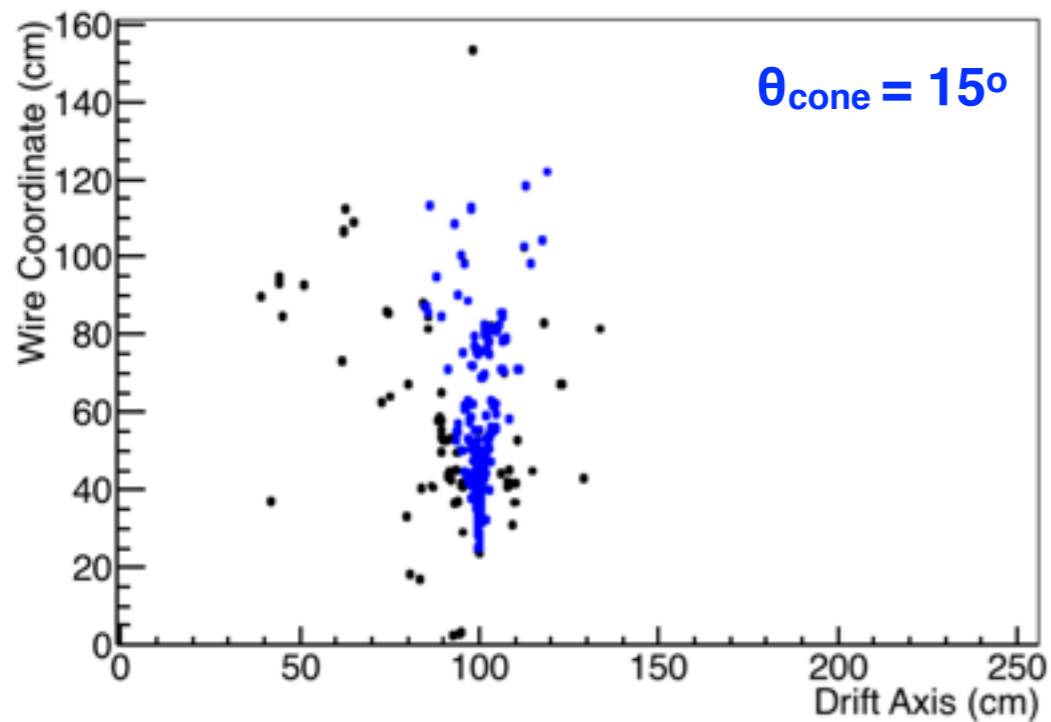
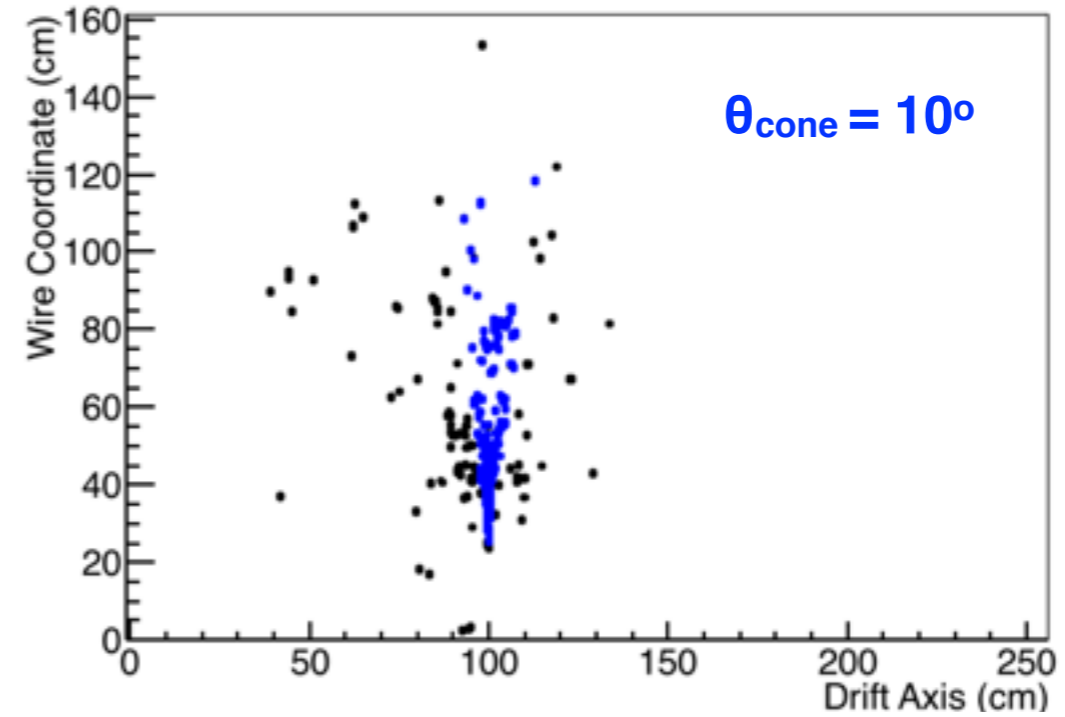
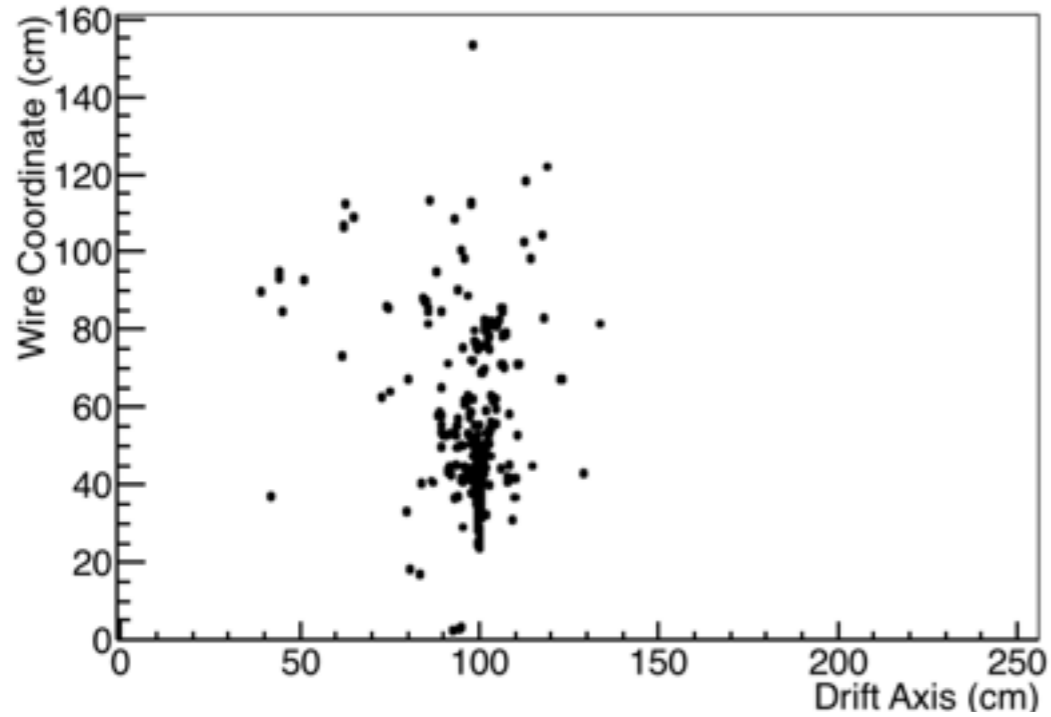
inside = (θ_{hit} ≤ θ_{cone} && |**d**| < coneLength)

return inside

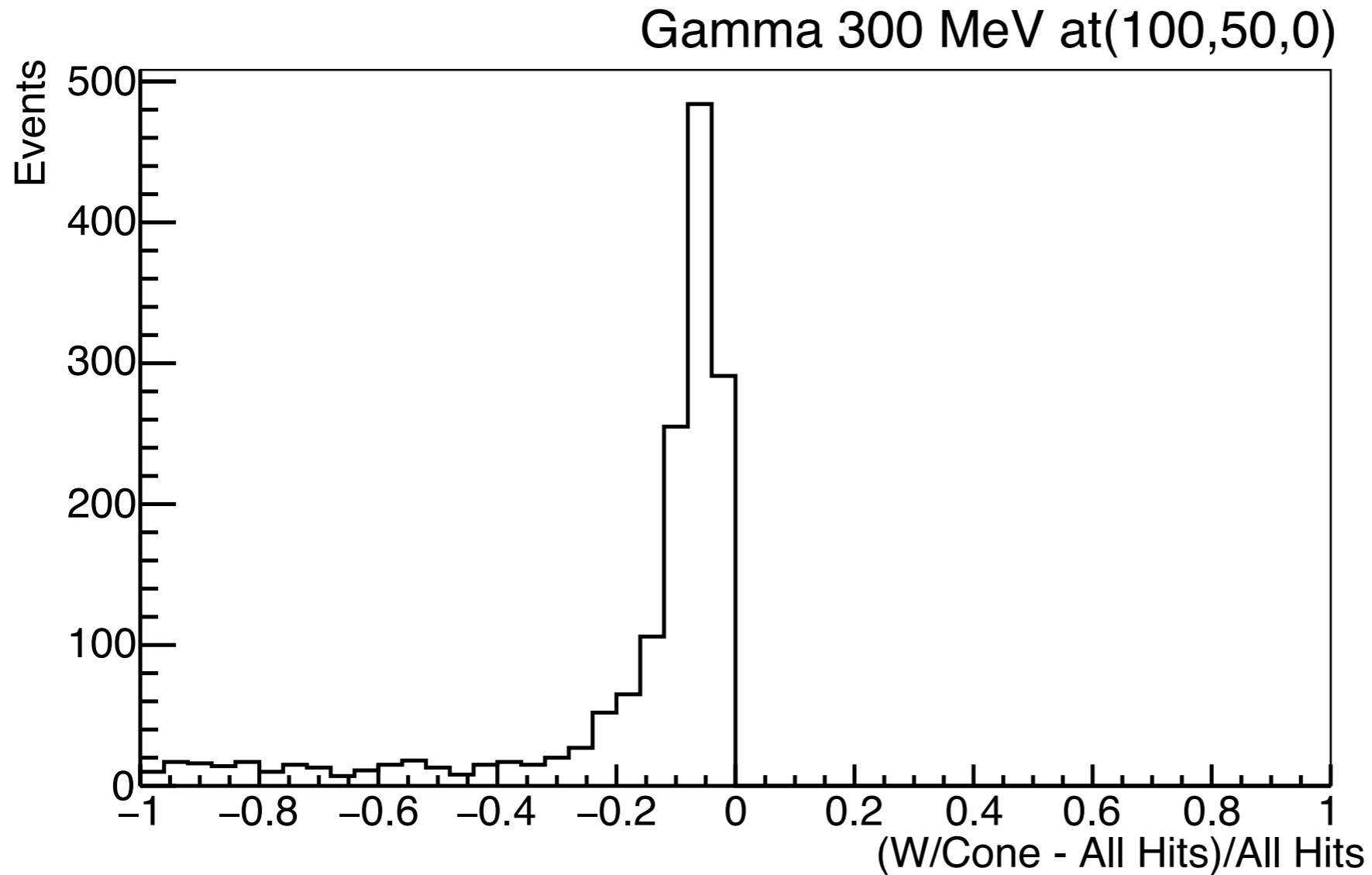
```
}
```

2D Cone; Collection Plane

All Hits

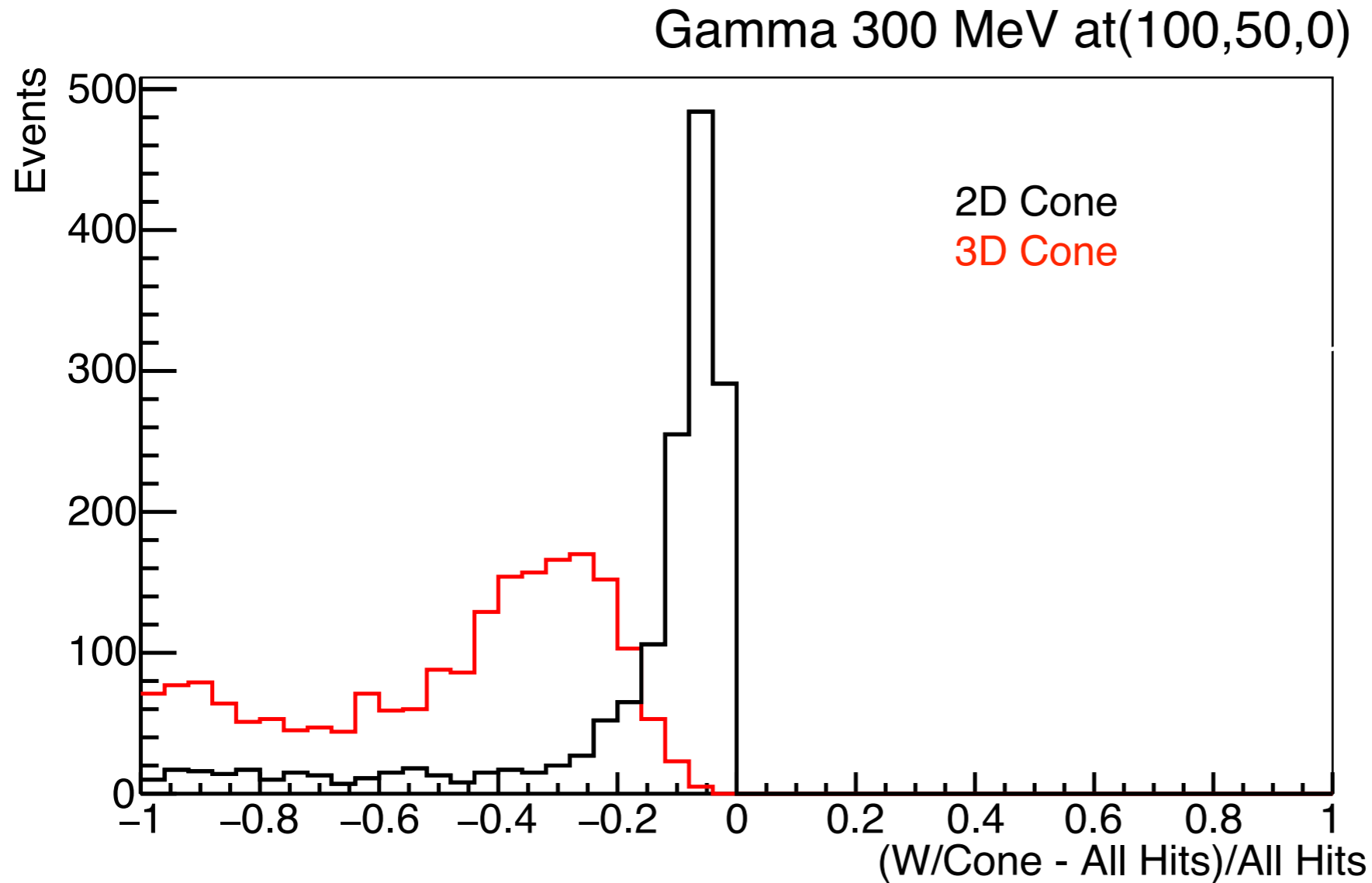


2D Cone; Collection Plane



- * All Hits = Σ hit_charge
- * W/Cone = Σ hit_charge_inside_cone

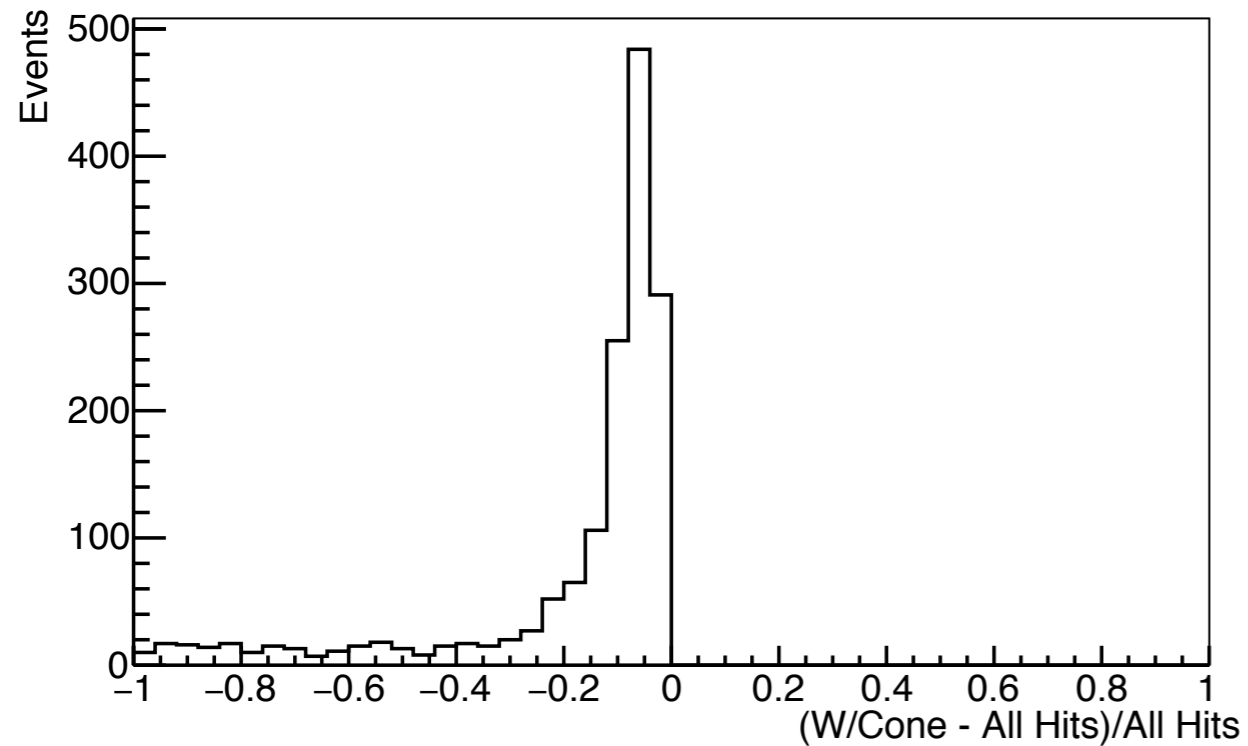
2D Cone vs 3D Cone; Collection Plane



- * All Hits = $\sum \text{hit_charge}$
- * W/Cone = $\sum \text{hit_charge_inside_cone}$

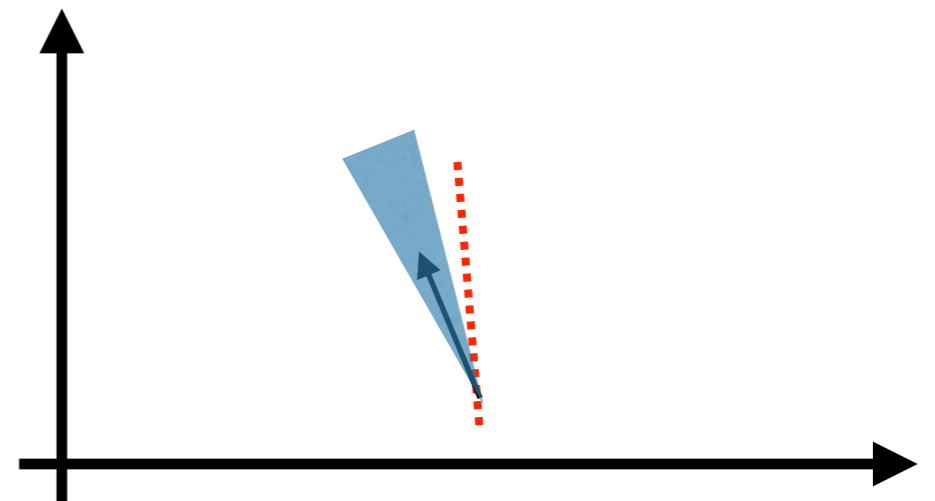
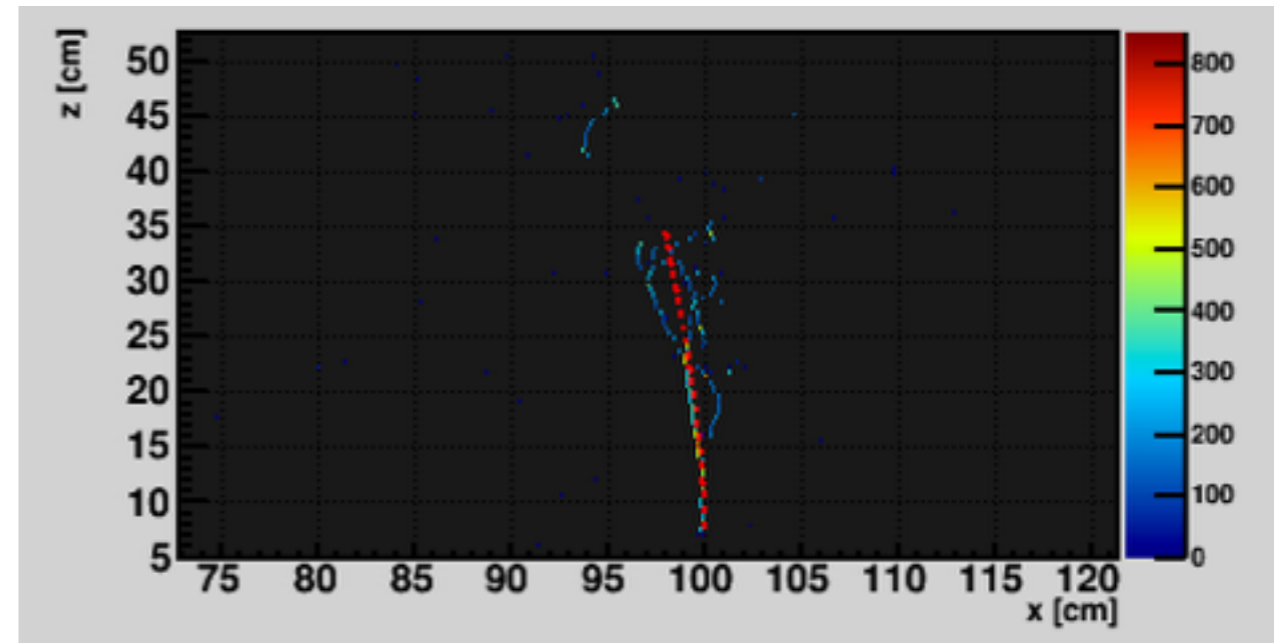
2D Cone; Collection Plane

Gamma 300 MeV at(100,50,0)



- ❖ All Hits = $\sum \text{hit_charge}$
- ❖ W/Cone = $\sum \text{hit_charge_inside_cone}$

Events in the tail



Events in the tail
Cone axis direction = direction at 3rd track node. Due to a “kink” in the direction of the track the cone misses all hits in one view

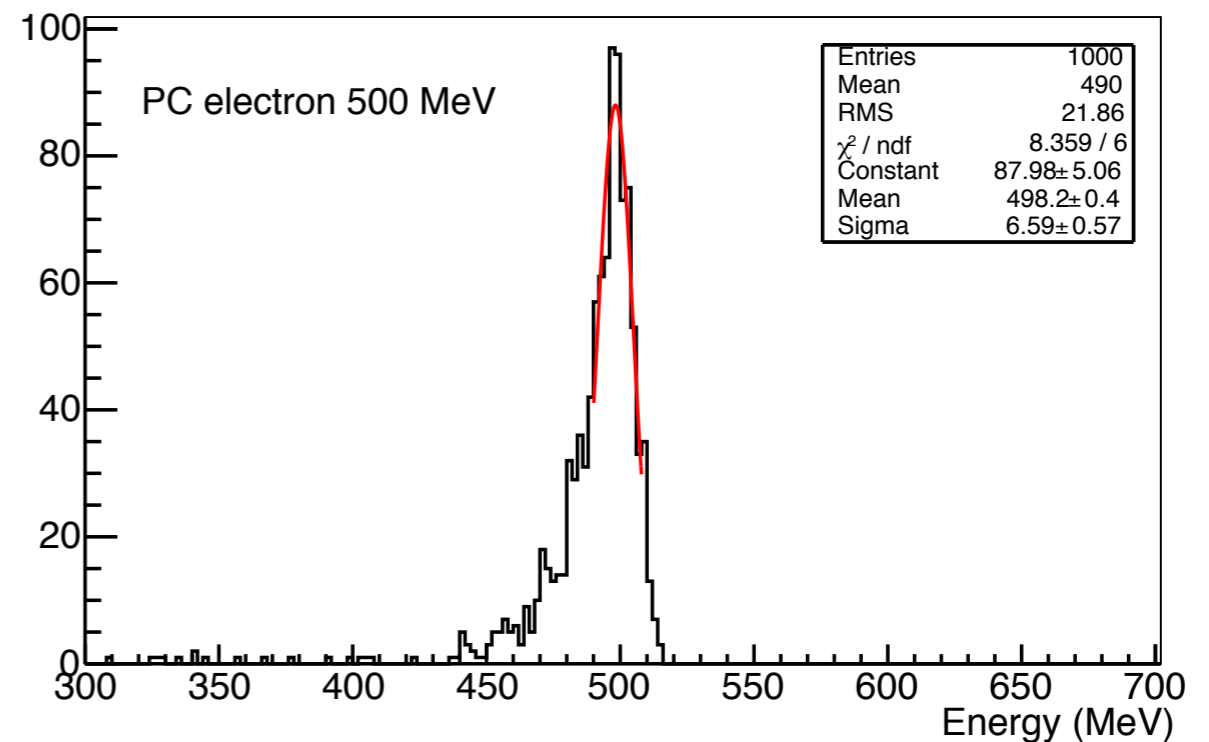
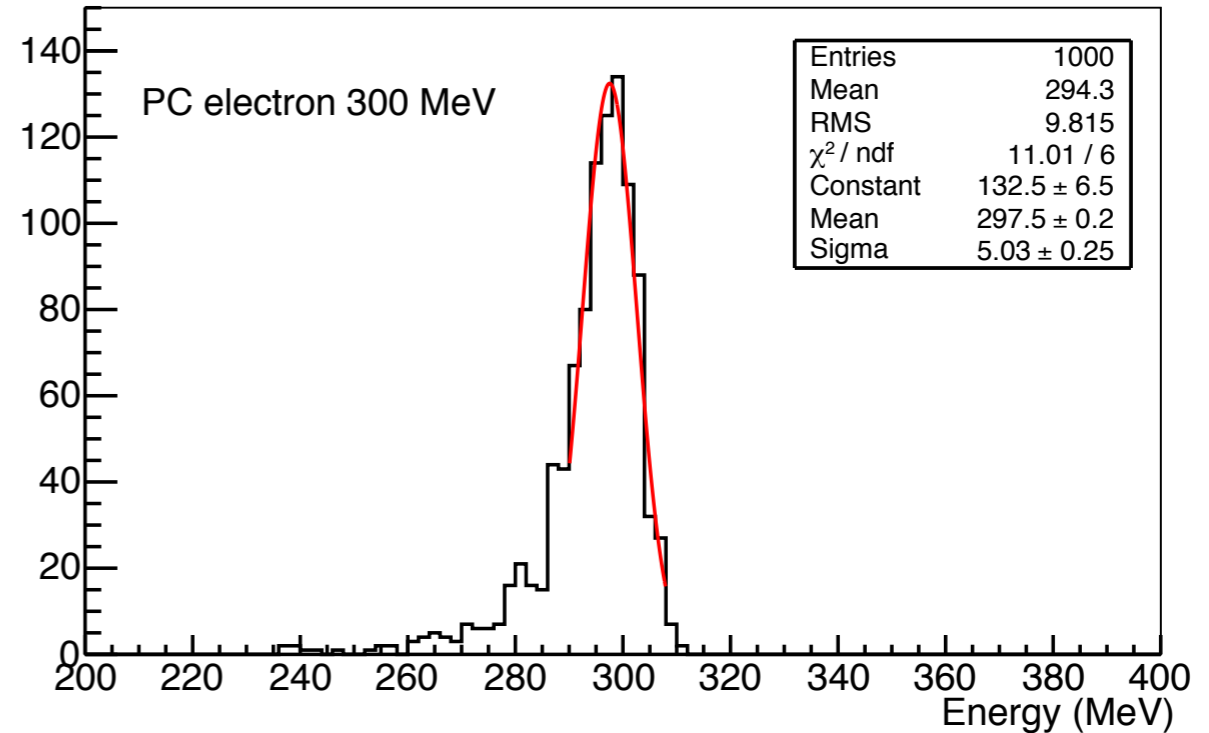
Collection Plane; Energy Calibration

Preliminary

$$E = \alpha \sum Q_i e^{t_i/\tau}$$

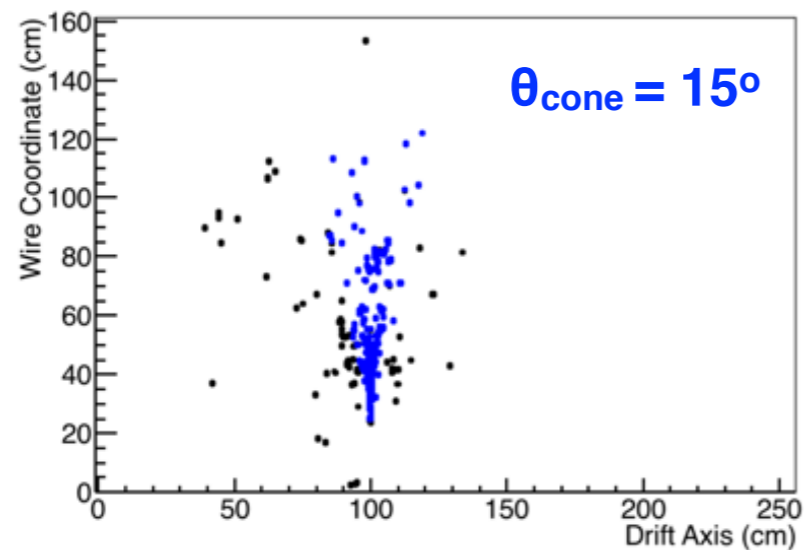
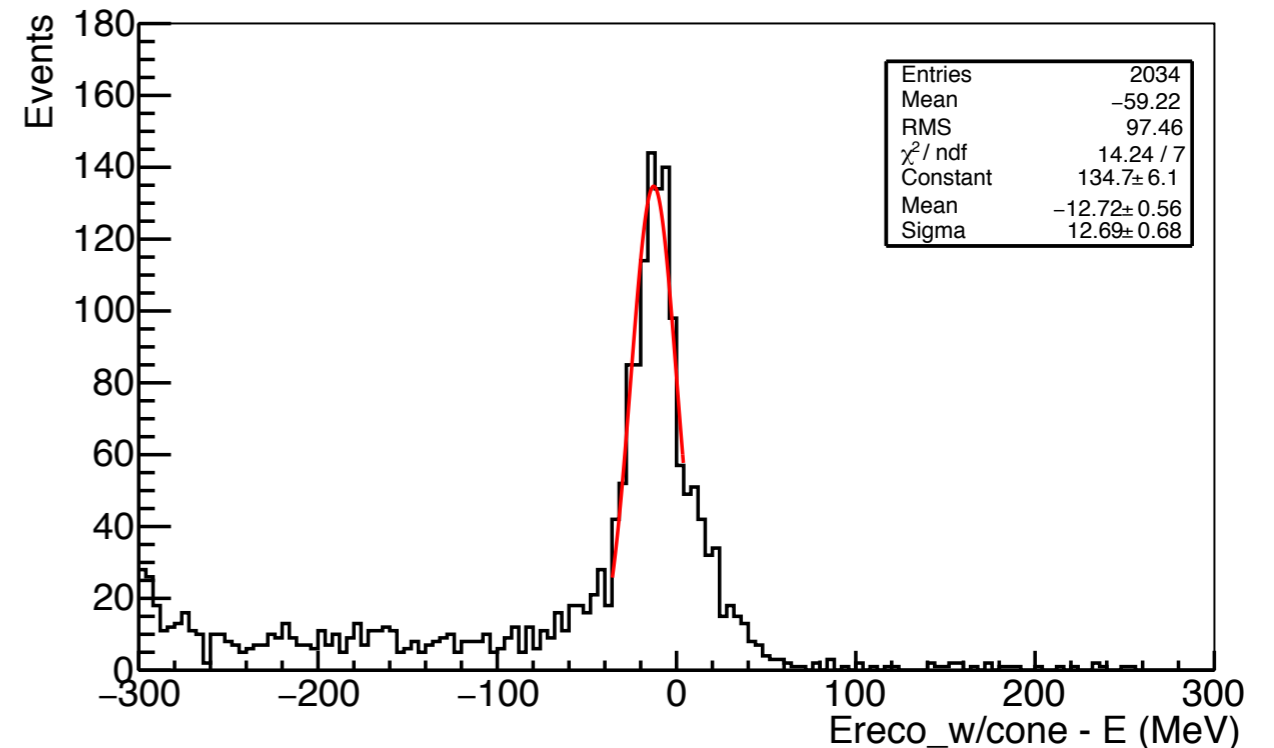
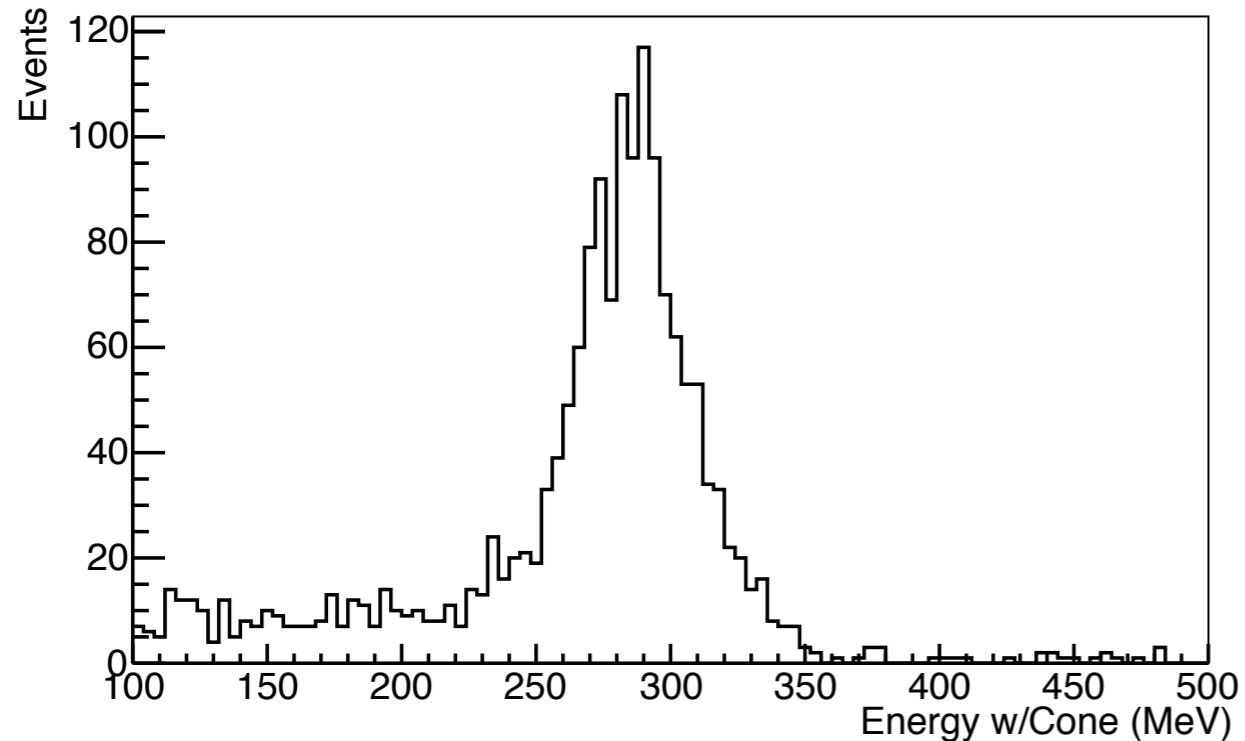
$$\alpha = 5.85e^{-3} \text{ MeV}/\text{ADC}$$

- * Energy resolution $\sim 1\%$
- * No containment requirement
(events in more than 1 TPC)



Energy Reconstruction; Collection Plane

Gamma 300 MeV at(100,50,0)



- ❖ “Out of the box” does not look that bad...
- ❖ Slightly bias in the energy reconstruction

DUNE 35t & π^0 Reconstruction

- ❖ DUNE 35t commissioning will take cosmic ray data
- ❖ π^0 production via hadron interactions
- ❖ To identify π^0

$$M_{\gamma\gamma}^2 = E_{\gamma 1} E_{\gamma 2} (1 - \cos\theta_{\gamma\gamma})$$

- ❖ Use 2D cone

Gamma 1 (pandora track, cone1)

Gamma 2 (pandora track, cone2)

```
Loop (all_hits){
```

```
    if(hit is inside cone1)hits_cone1.push_back(hit)
```

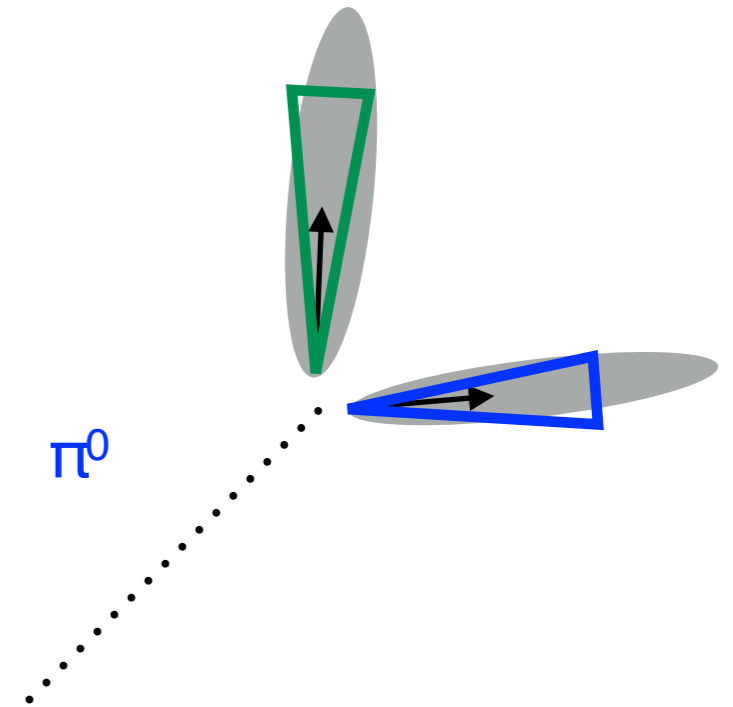
```
    else unUsed_hits.push_back(hit)
```

```
}
```

```
Loop (unUsed_hits){
```

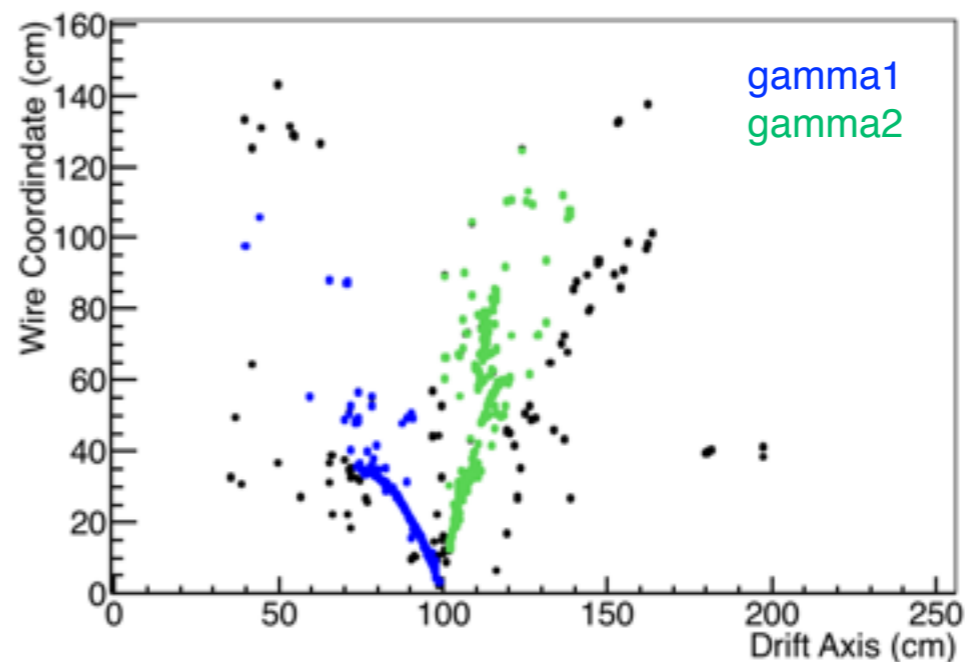
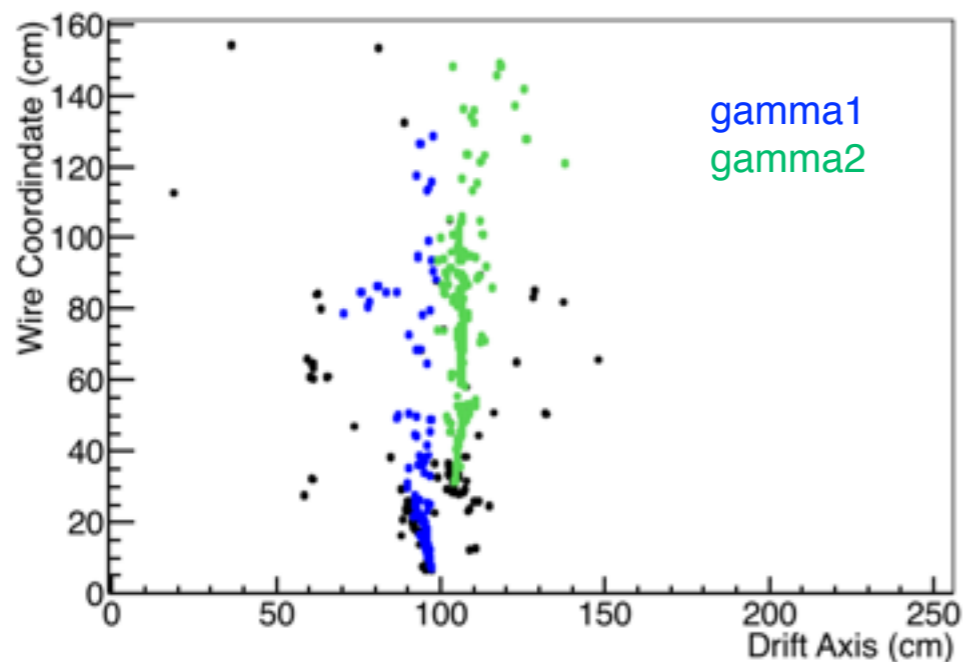
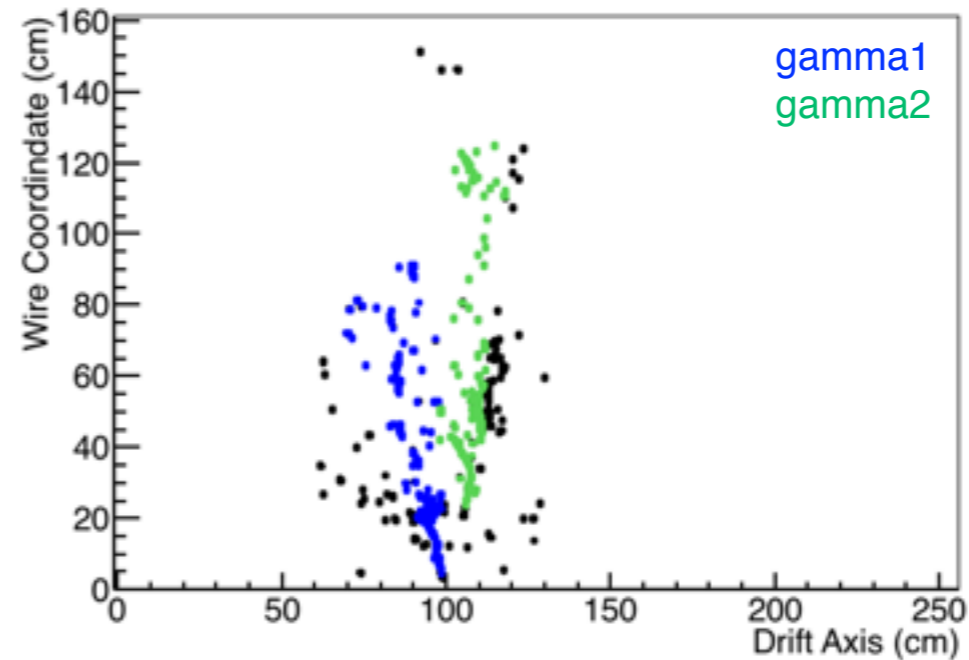
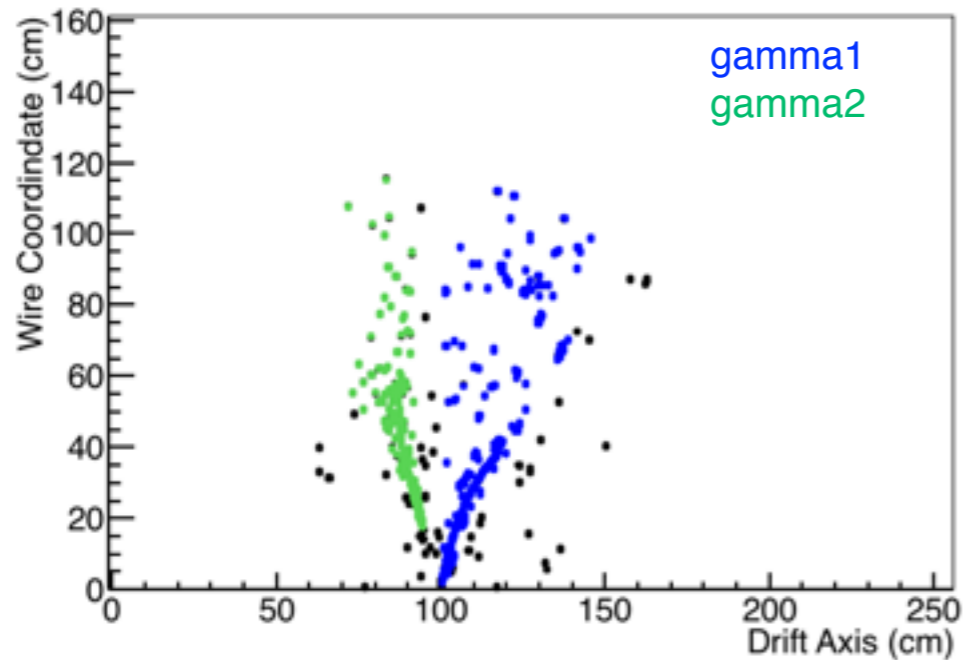
```
    if(hit is inside cone2)hits_cone2.push_back(hit)
```

```
}
```



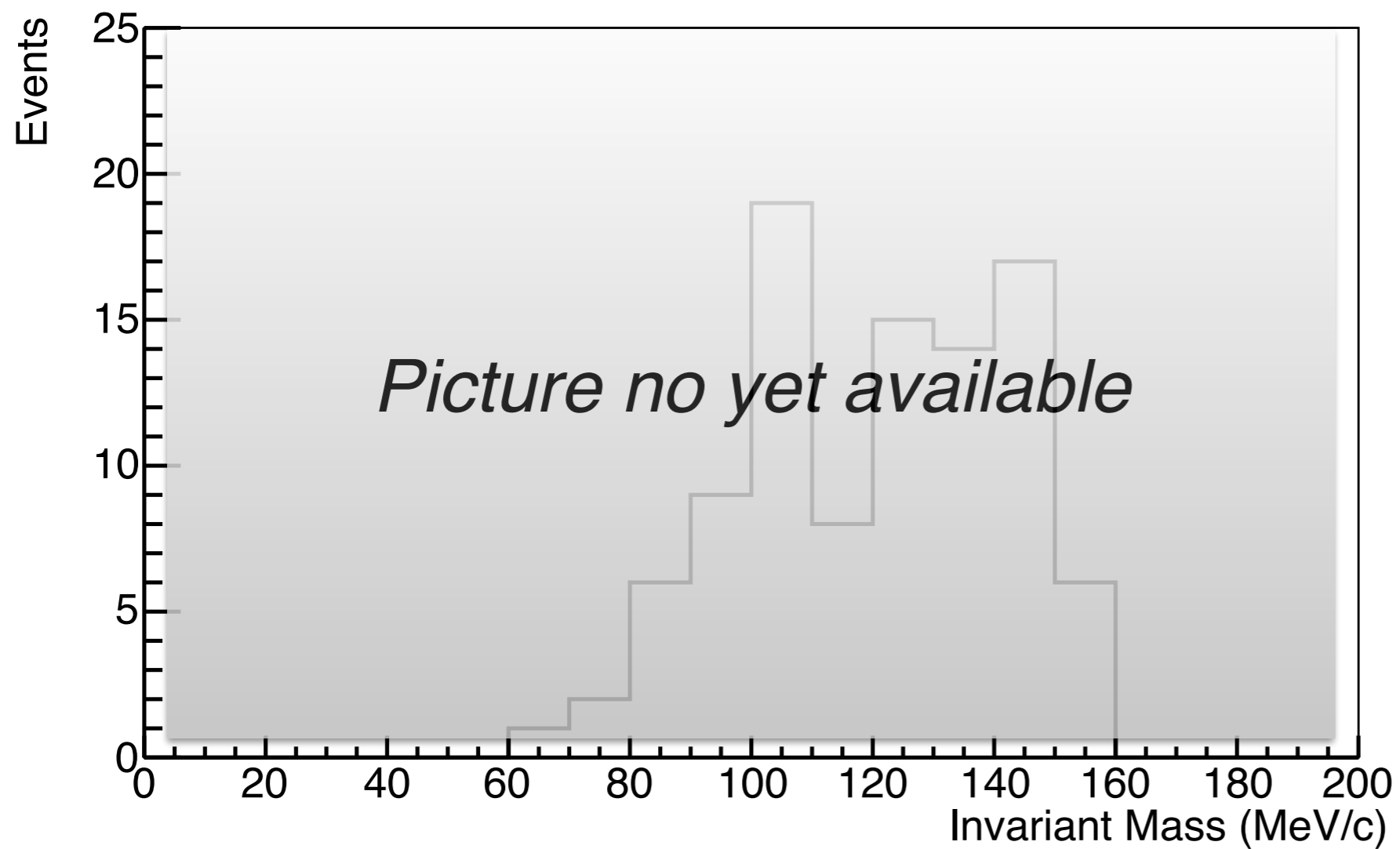
π^0 Reconstruction 2D Cone; Collection Plane

❖ 500 MeV π^0 at (100,50,0)



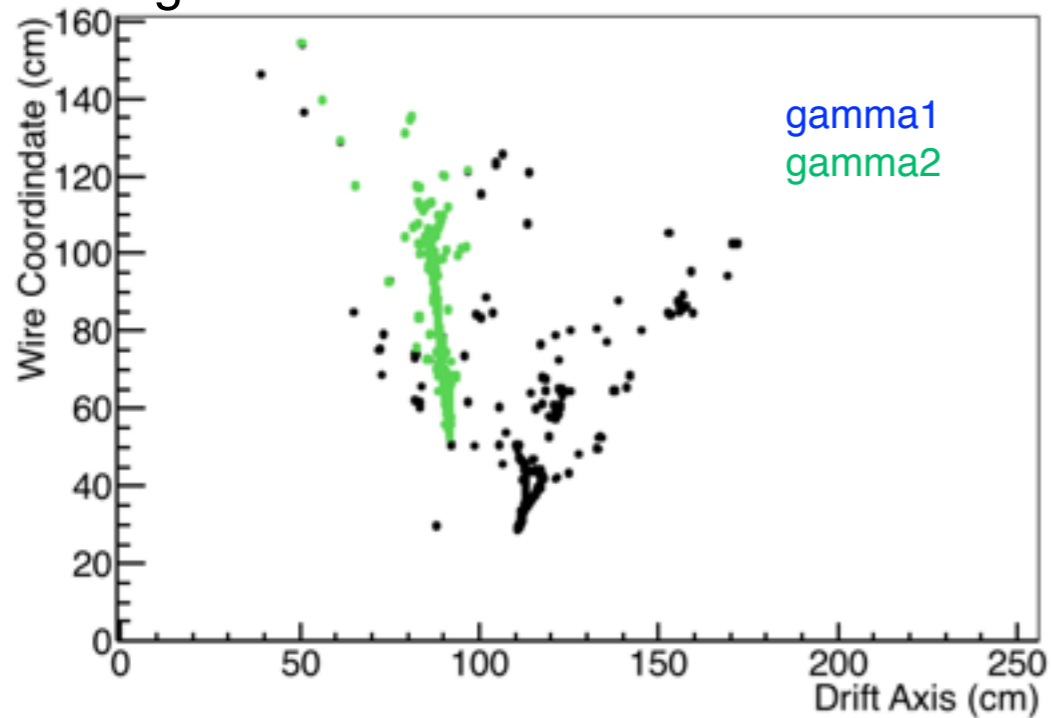
π^0 Reconstruction

$$M_{\gamma\gamma}^2 = E_{\gamma 1} E_{\gamma 2} (1 - \cos\theta_{\gamma\gamma})$$

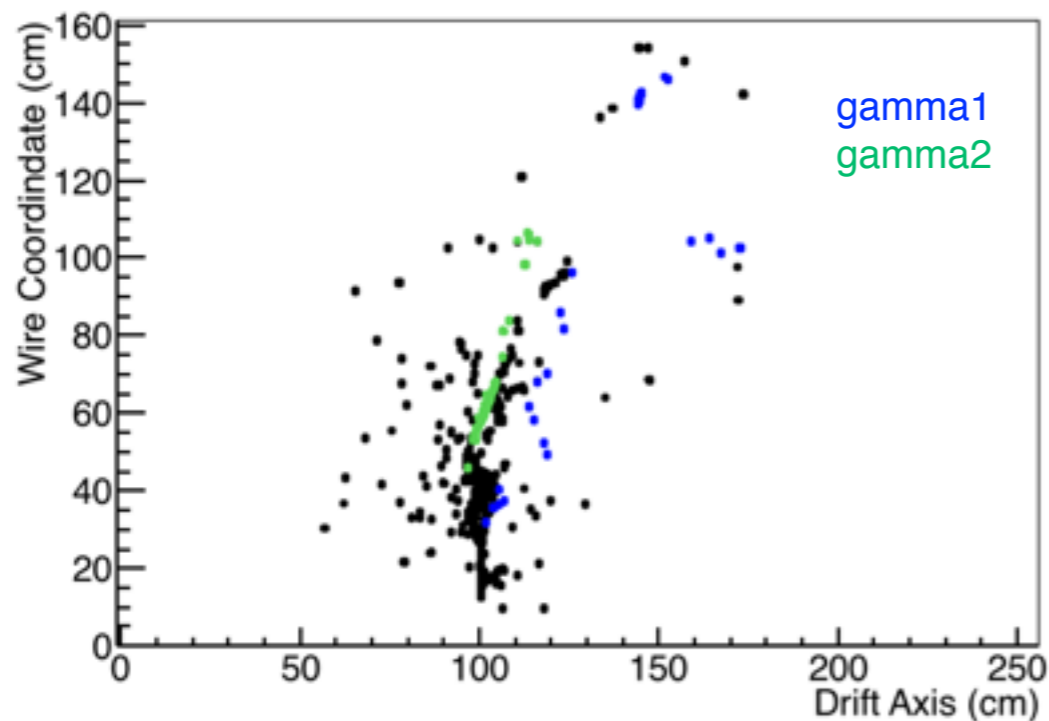
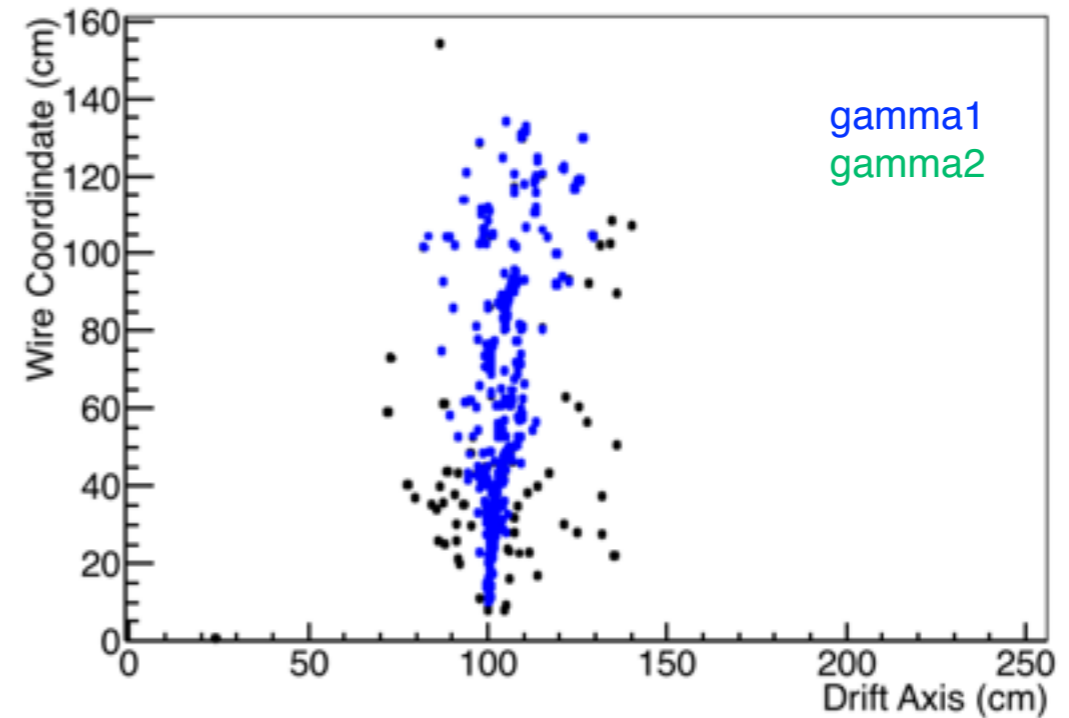


π^0 Reconstruction

- ❖ Only one shower, 1st track missing gamma direction



- ❖ Overlapping gammas, only one track



- ❖ The two tracks that miss the gammas' direction

Comments

- ❖ 2D Cone projection gives a big improvement on shower reconstruction
- ❖ Currently cone algorithm relies a lot on PANDORA track reconstruction
Vertex, track direction \rightarrow Cone, shower direction, open angle, energy
- ❖ Seems reconstruction efficiencies are going to be low
- ❖ To do
 - ❖ Improvements... how?
 - ❖ Suggestions?

Extras

π^0 Topologies

