PiOs in the far detector

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DUNE FD Sim/Reco

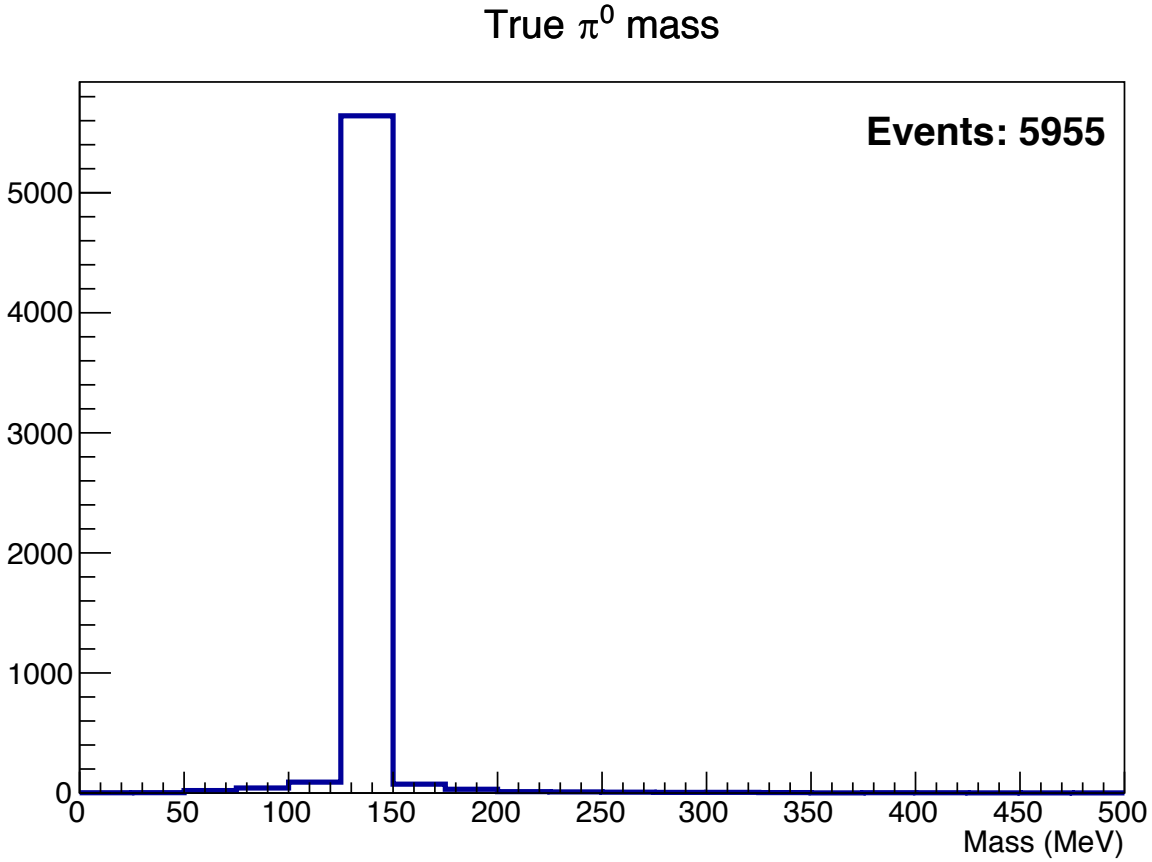
4/27/20

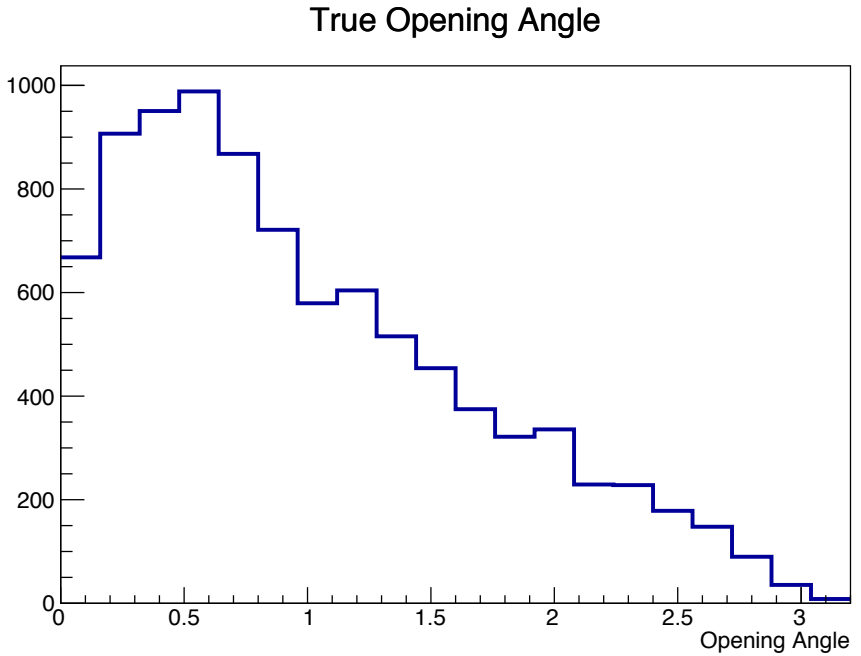
Statistics

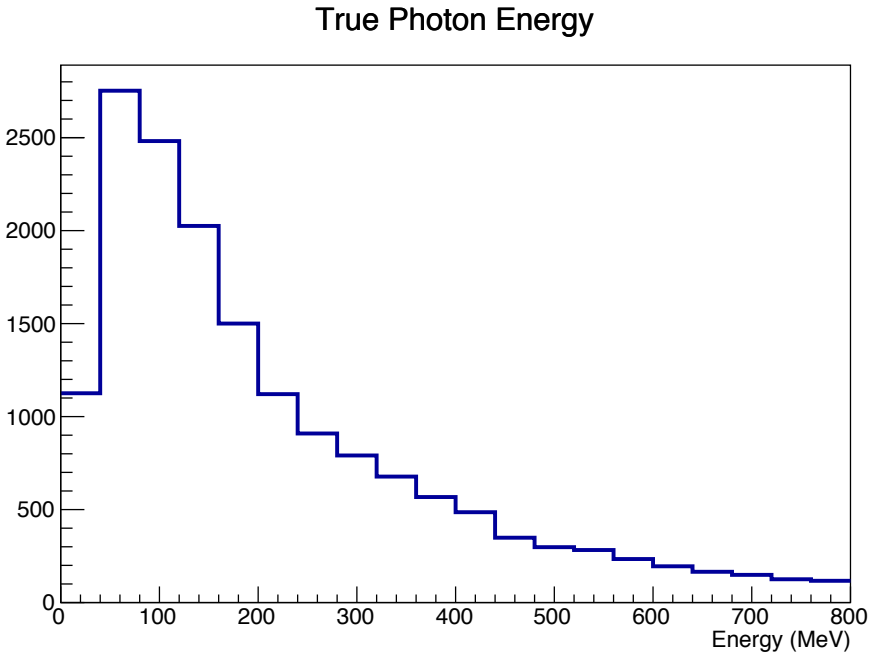
- MCC11 samples: prodgenie_nu_dune10kt_1x2x6_mcc11_lbl_reco
  - Used first 200 files of 9914 total
- Using emshower and gaushit for shower and hit module
- Breakdown of events
  - 48% no pi0
  - 20% 1 pi0
  - 9% 2 pi0
  - 22% 3+ pi0
- Plots scaled to 1.1e21 POT (1 year) -> 5,955 true pi0
  - 717 single pi0 events, but only 230 matched with backtracker

True pi0 mass

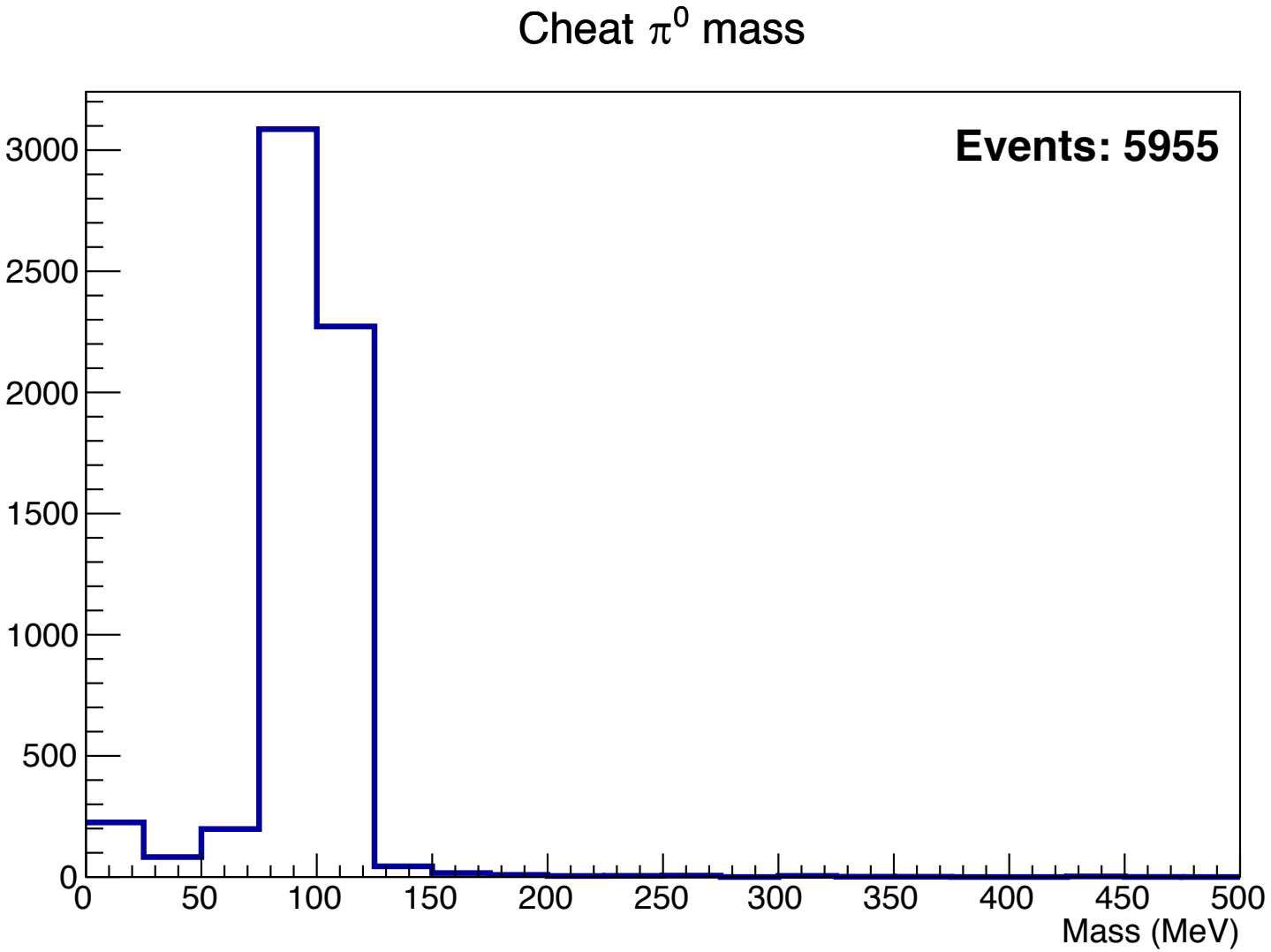
- Use start & end points of true photons to get the opening angle θ
- Use the equation $m_{\pi^0}^2 = 2\,E_1 E_2 (1 - \cos\theta)$







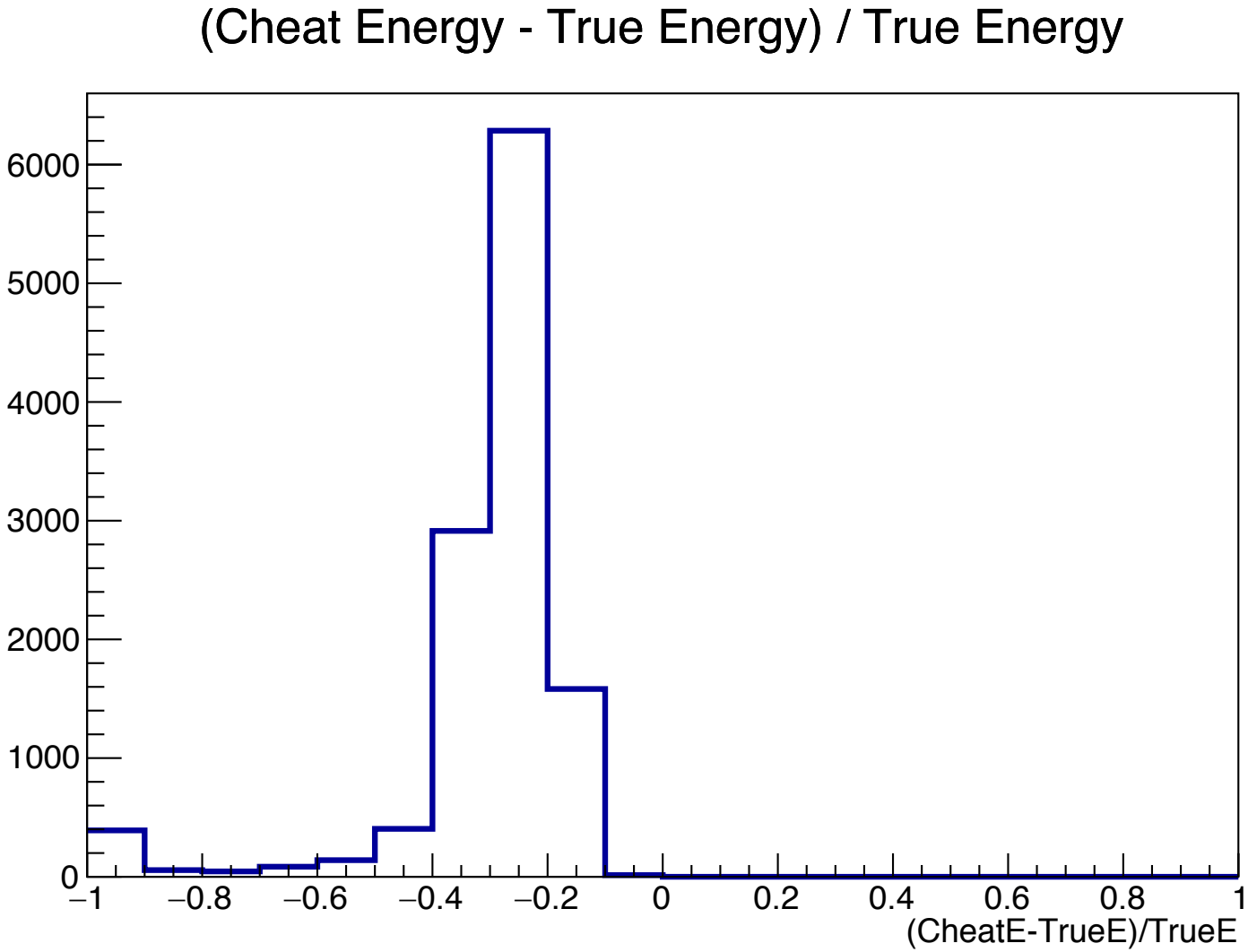
Cheated pi0 mass



- Using backtracker to get the hits associated with each true photon
- Sum ide.energy from hits to get the energy of the photon
- Still using the true opening angle
- Using gaushit

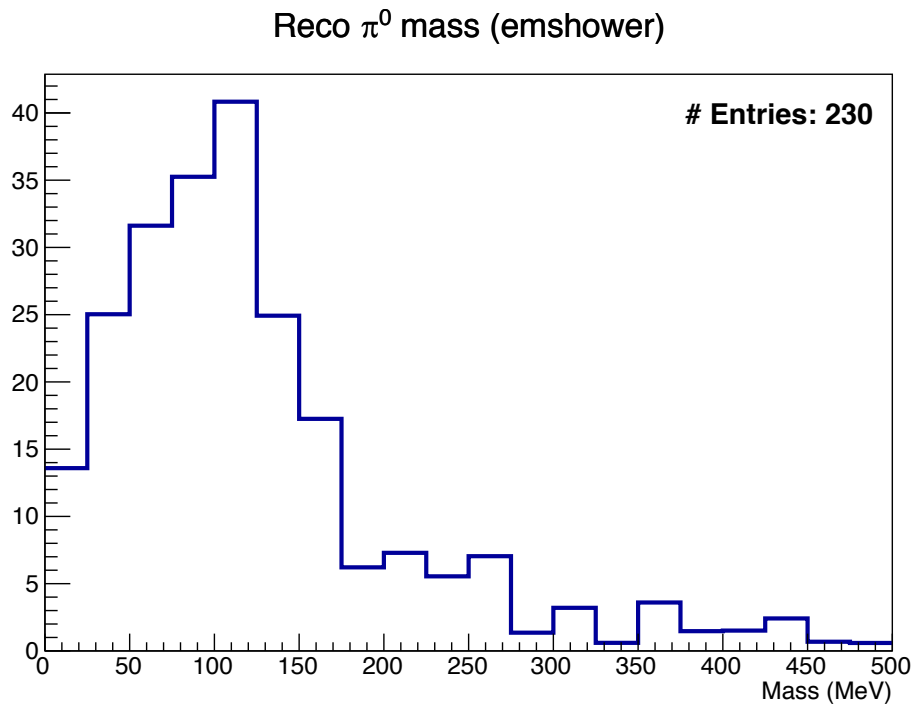
Photon Energy

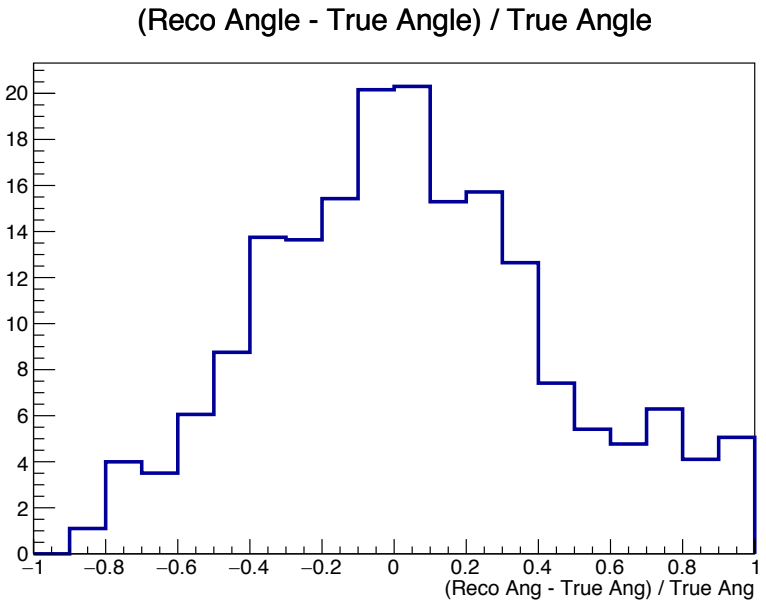
- About 20%-30% difference in energy
- Peak around 100 MeV in cheat mass plot
  - 26% difference from 135 MeV

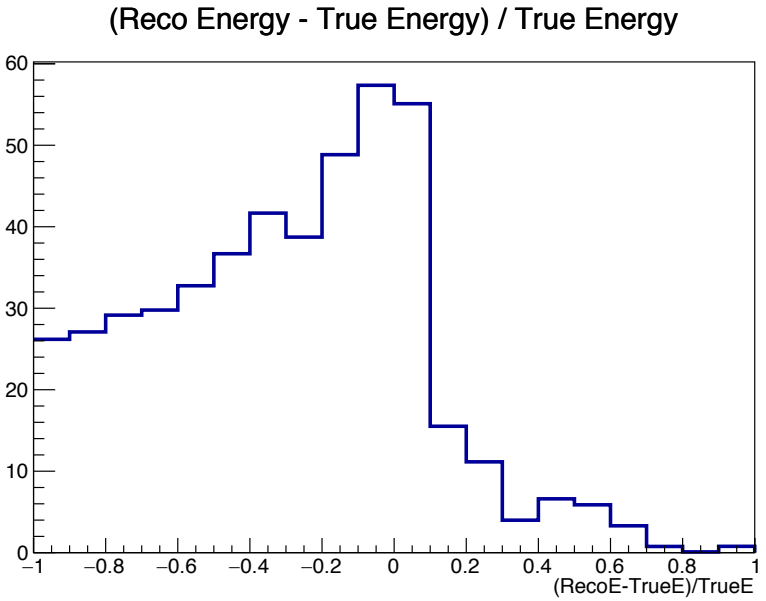


Reco pi0 mass

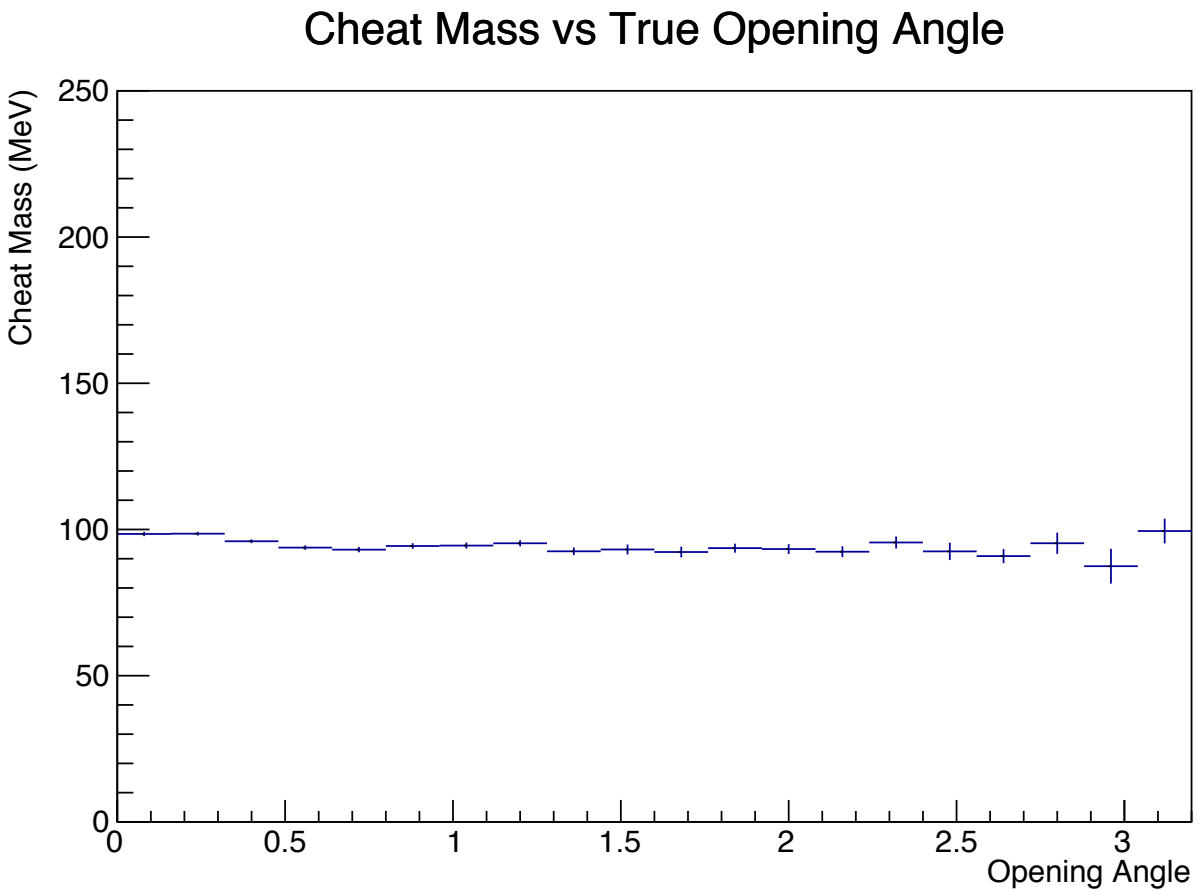
- Events with exactly one true pi0 2 showers matched to pi0 daughter photons (717 true)
- 21 events have both showers matched to same photon
- Matching done using ProtoDUNETruthUtils::GetMCParticleListFromShowerHits()
- Sums ide.energy for each TrackID and chooses one with greatest fraction of total sum of ide.energy

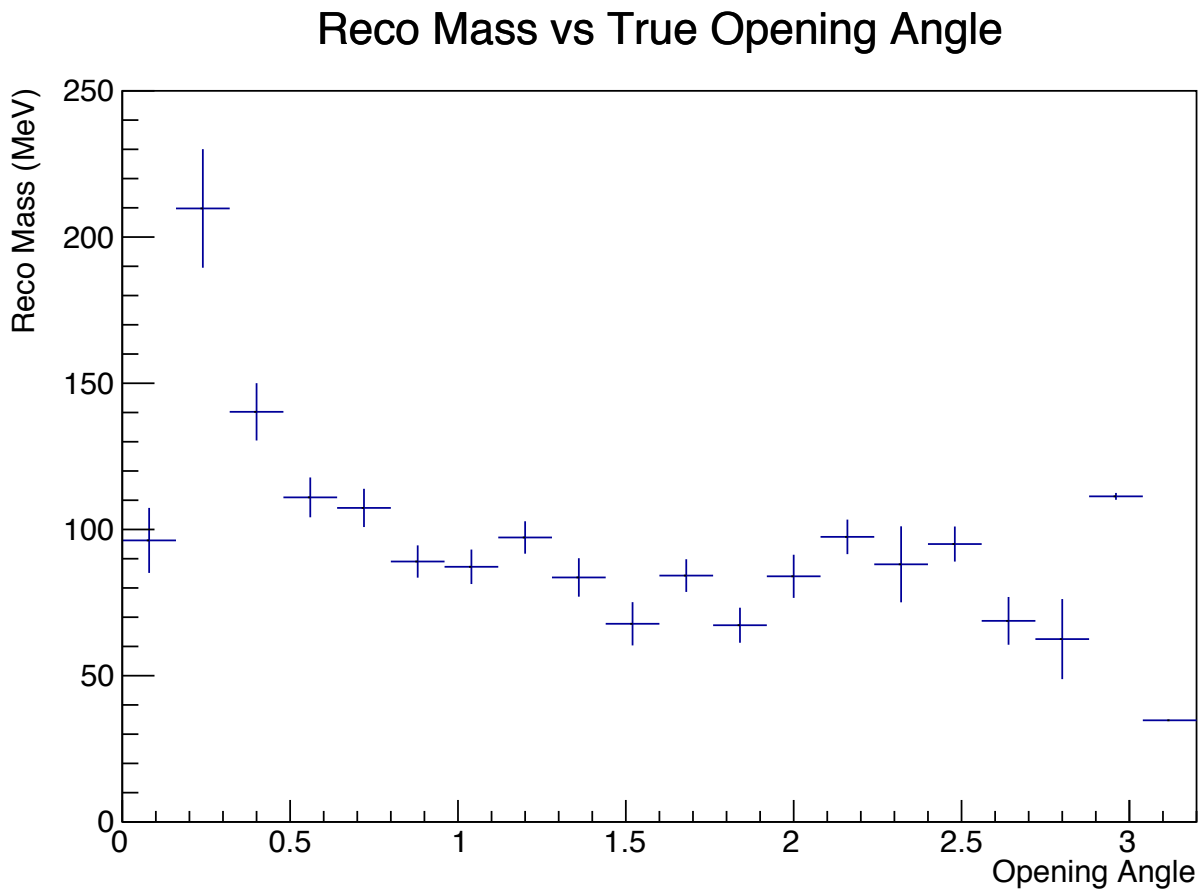




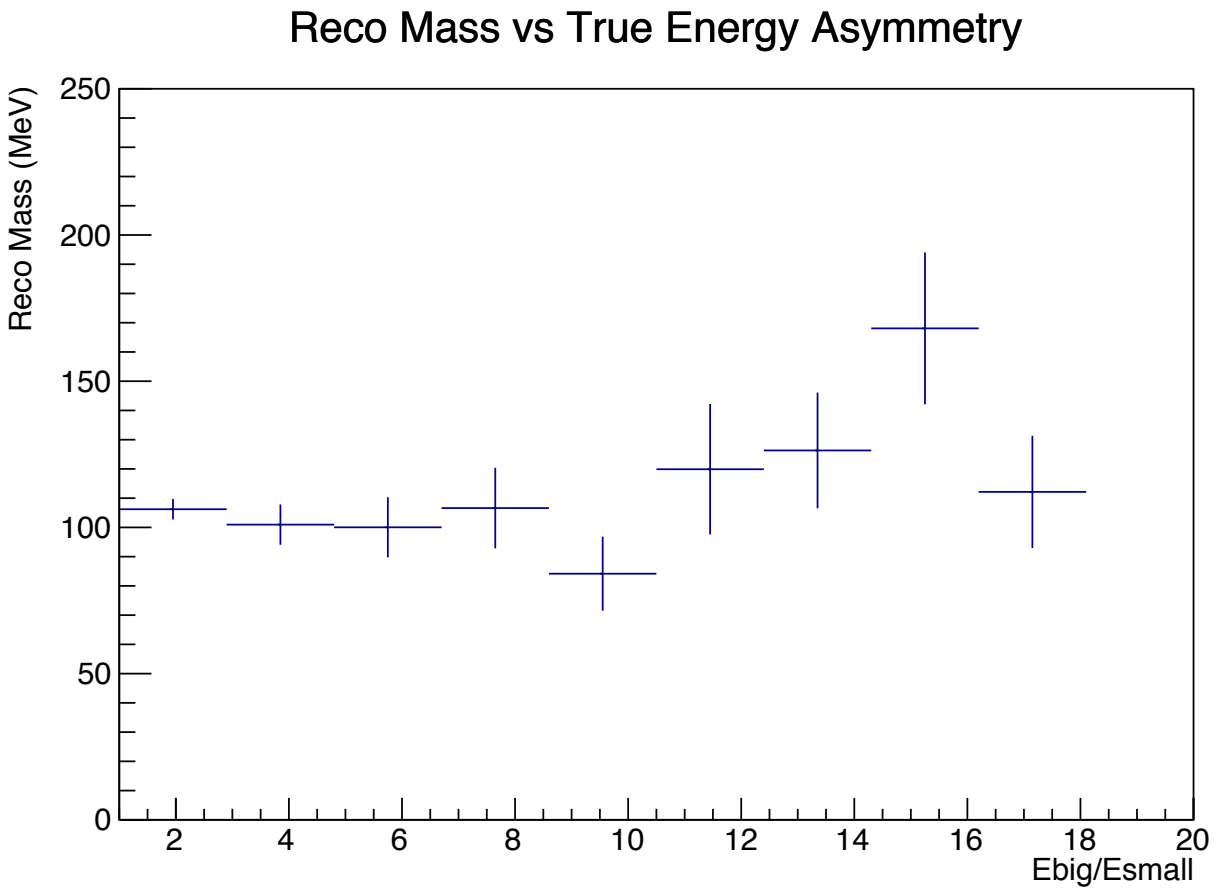


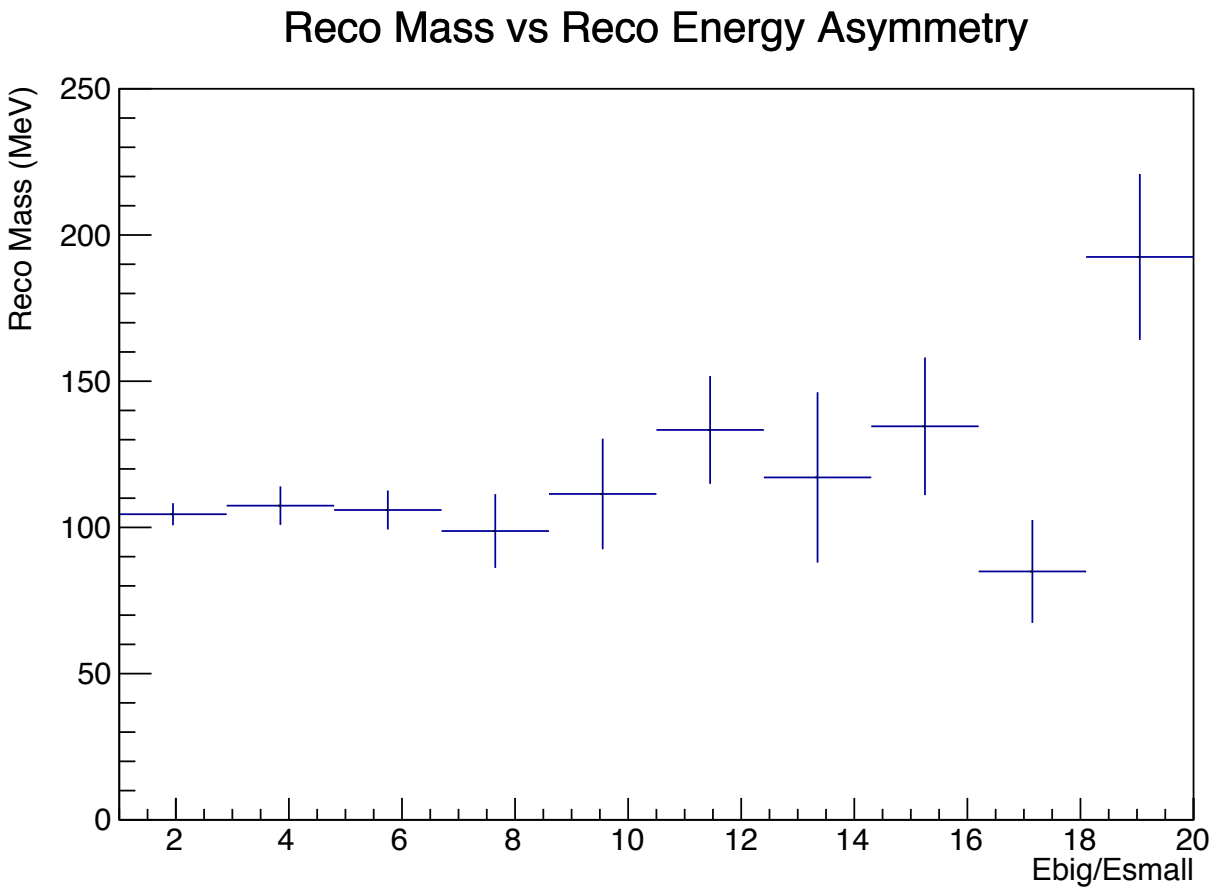
Reco Mass vs Angle





Reco Mass vs Energy





Asymmetry = Max(E1,E2)/Min(E1,E2)

Event Displays

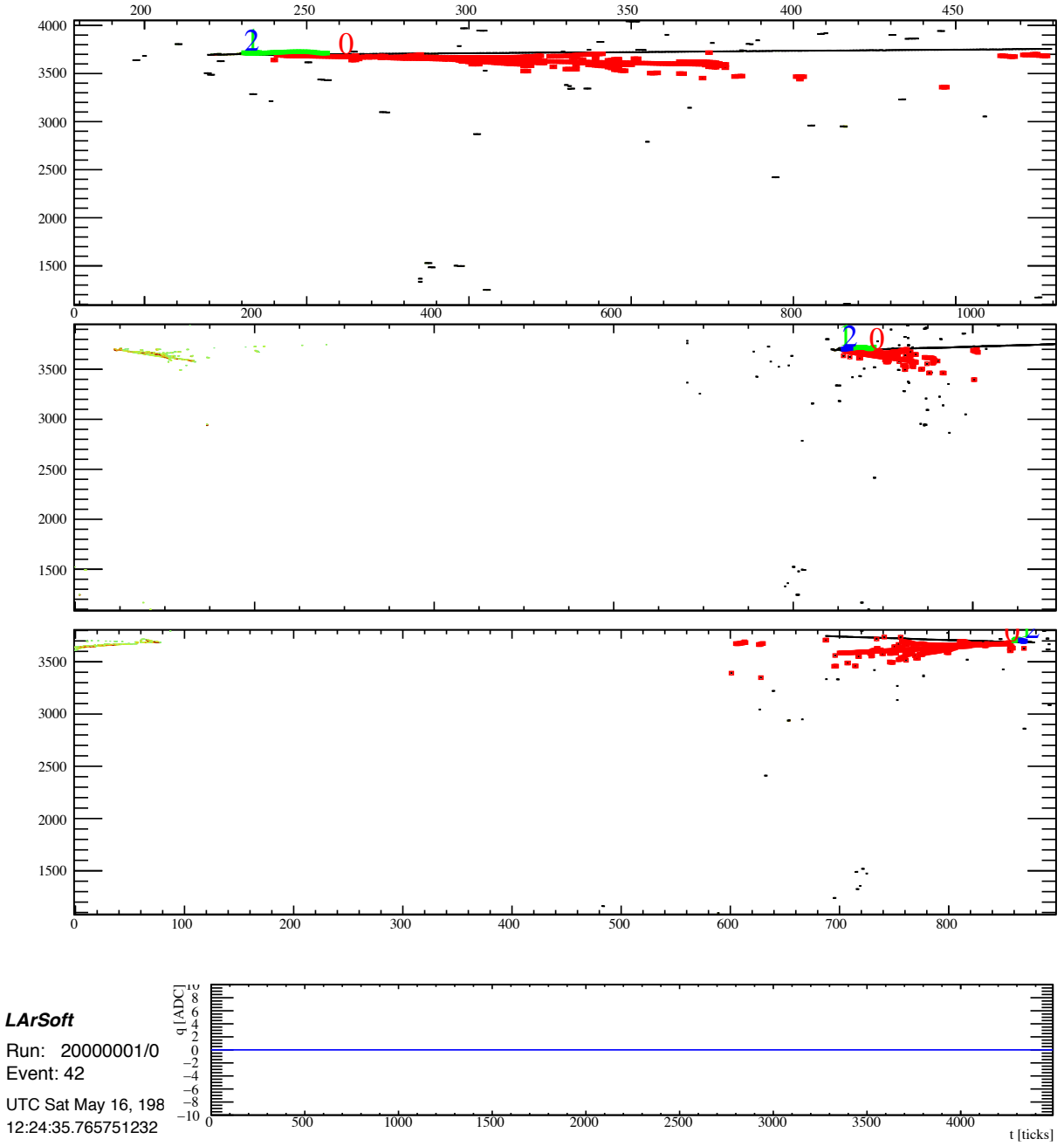
Large True Energy asymmetry

Reco Mass: 381 MeV

True Opening Angle: 32°
Reco Opening Angle: 129°

E1 (true): 738 MeV
E1 (reco): 894 MeV

E2 (true): 81 MeV
E2 (reco): 25 MeV



Event Displays

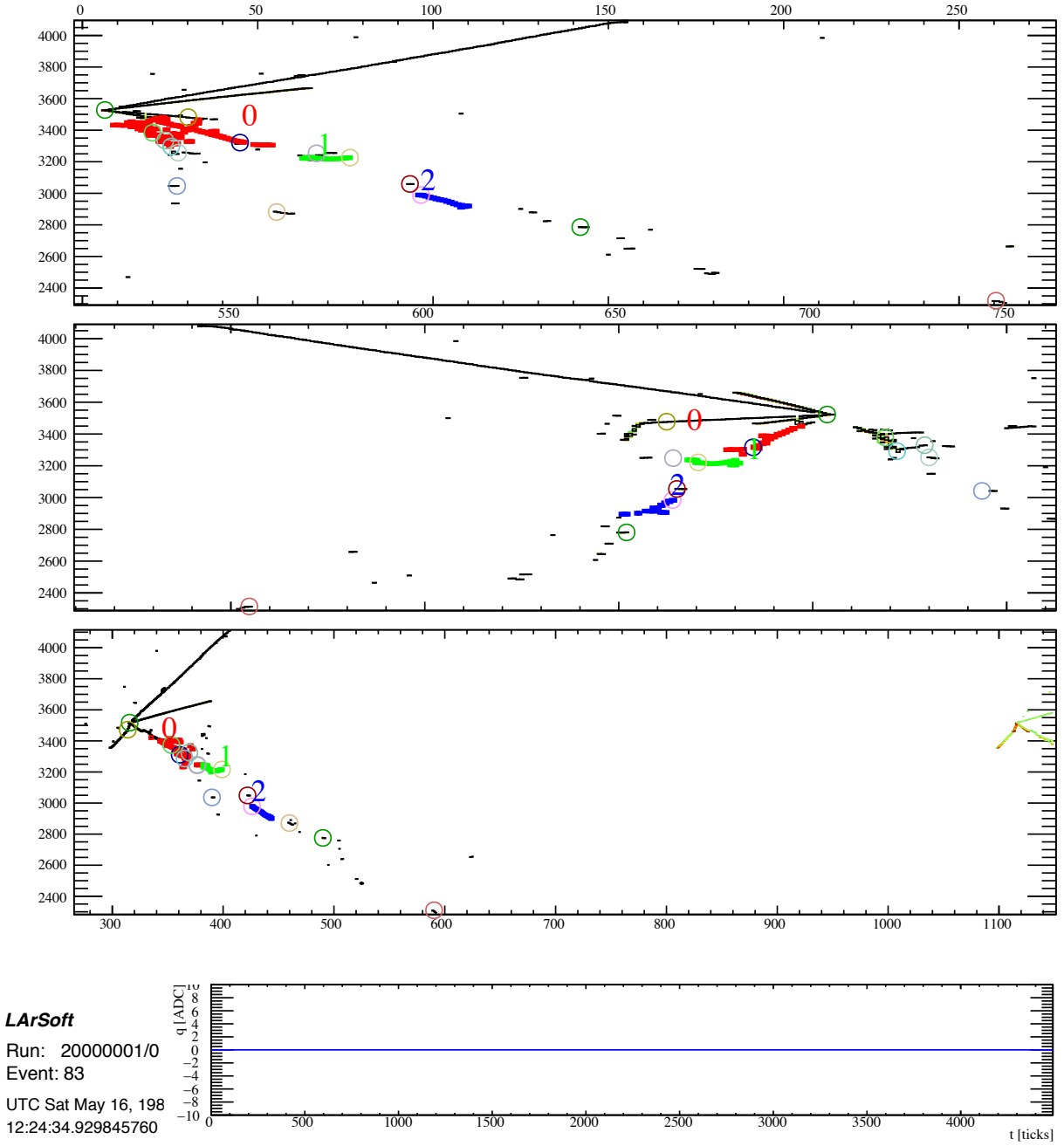
Large reco energy asymmetry, but not true asymmetry.
Reco missed second shower?

Reco Mass: 199 MeV

True Opening Angle: 34°
Reco Opening Angle: 171°

E1 (true): 267 MeV
E1 (reco): 395 MeV

E2 (true): 205 MeV
E2 (reco): 25 MeV



Event Displays

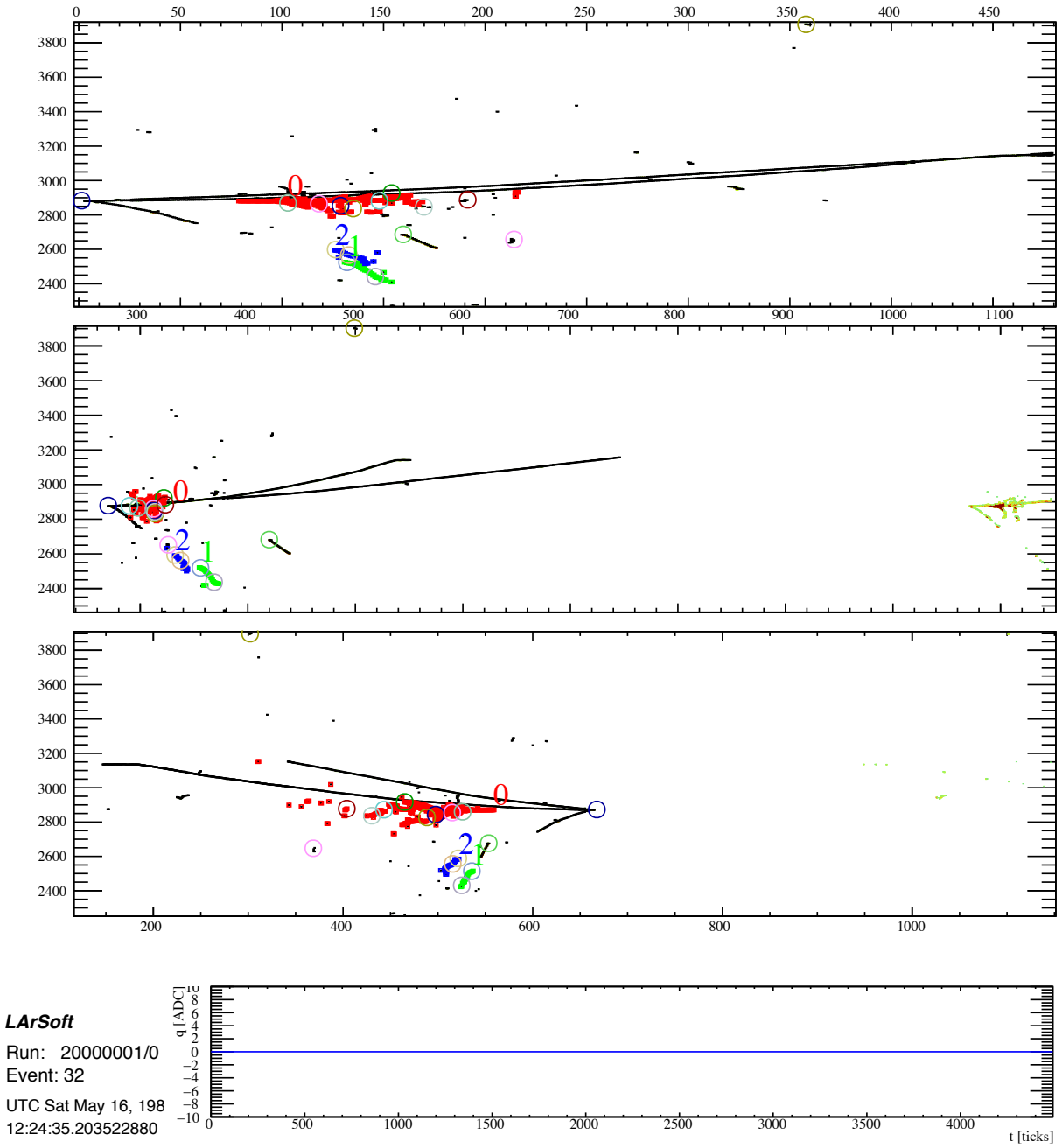
Small angle & large asymmetry

Reco Mass: 275 MeV

True Opening Angle: 19°
Reco Opening Angle: 113°

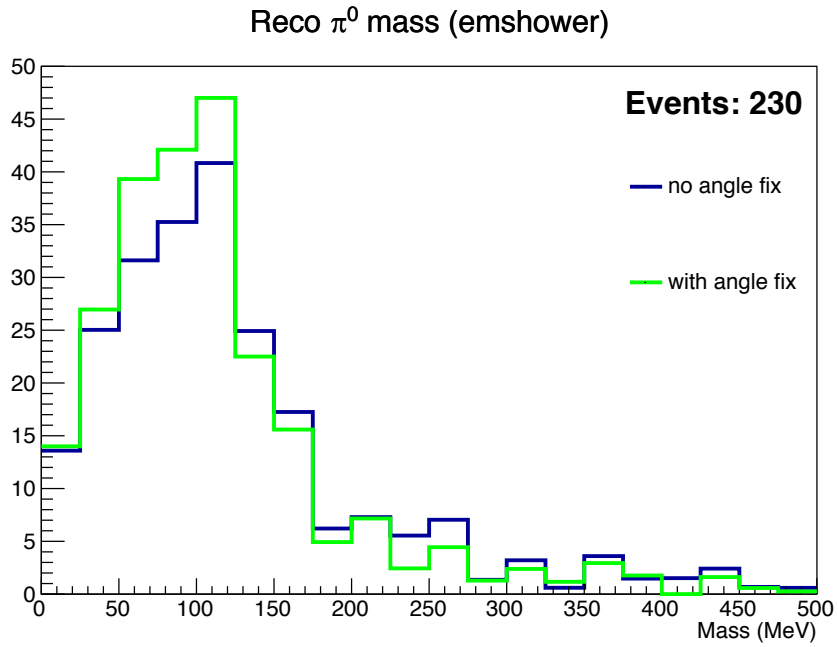
E1 (true): 857 MeV
E1 (reco): 657 MeV

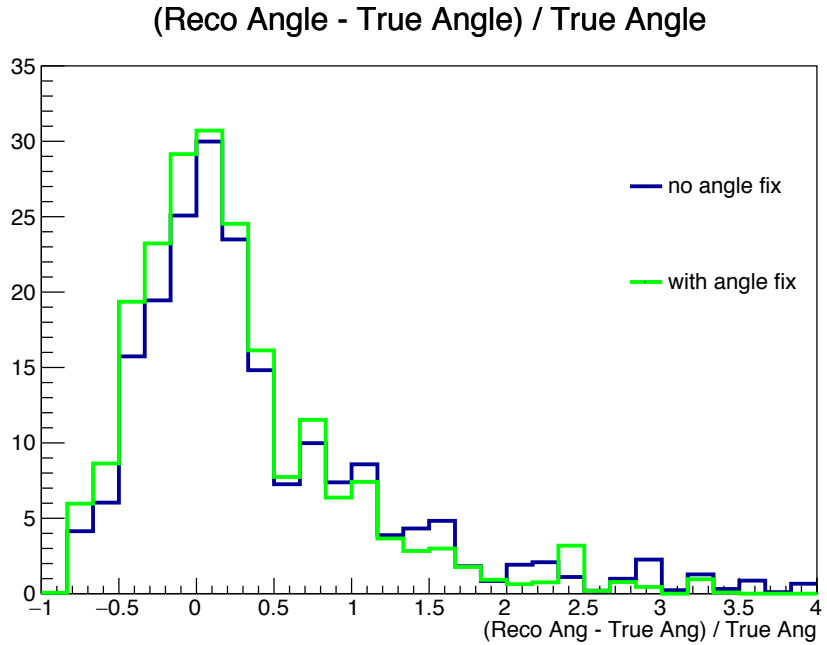
E2 (true): 181 MeV
E2 (reco): 41 MeV



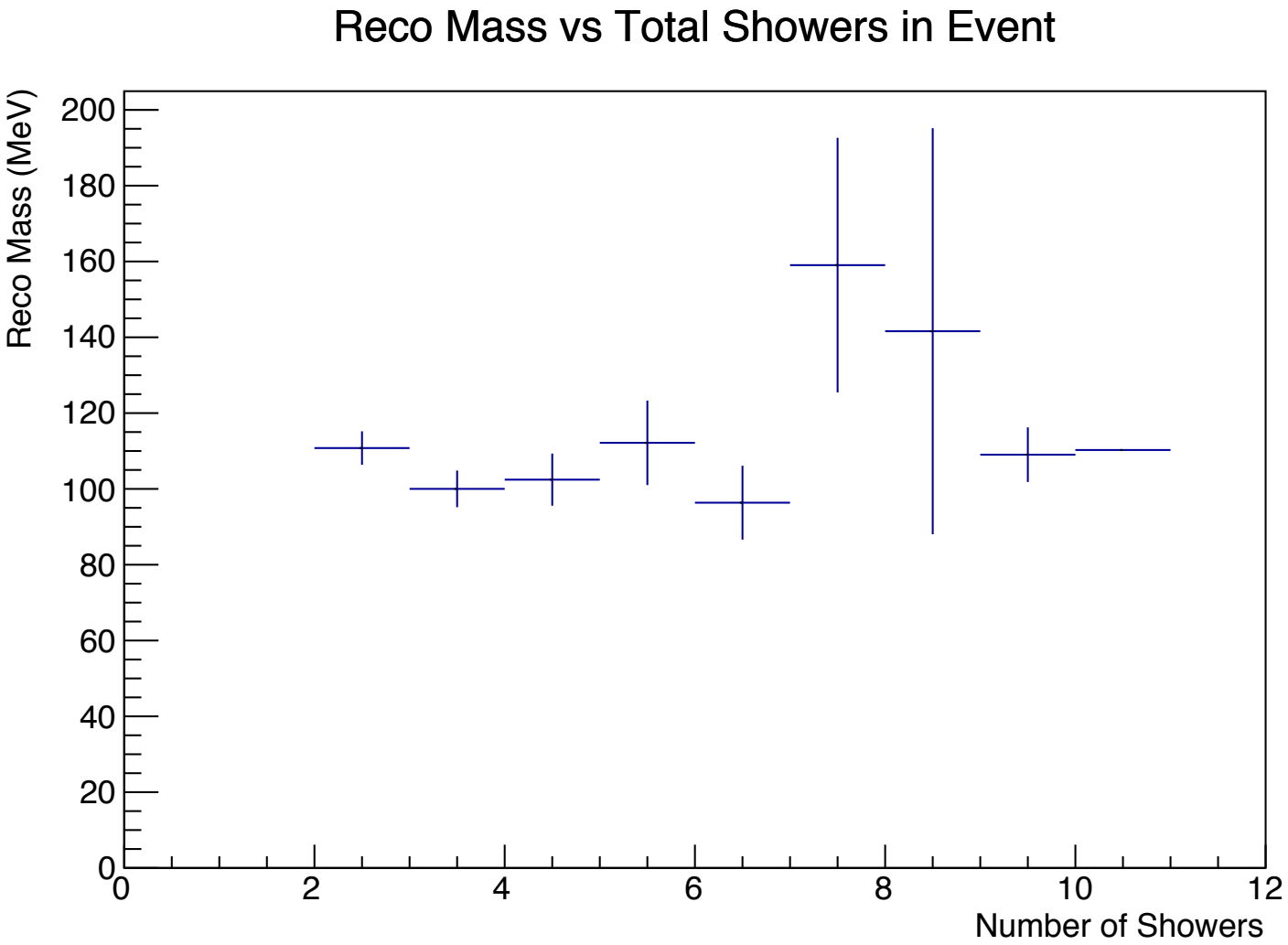
Large Reco Angles

- Possible that some showers have wrong direction
- Then $\theta_{reco} \approx 180° - \theta_{true}$ and $1 - \cos\theta$ is too big
- To test this:
  - If m and θ_{reco} are both large use $180° - \theta_{reco}$
- 40 events affected
- **Note**: This would not give correct angle in previous event displays





Total number of showers

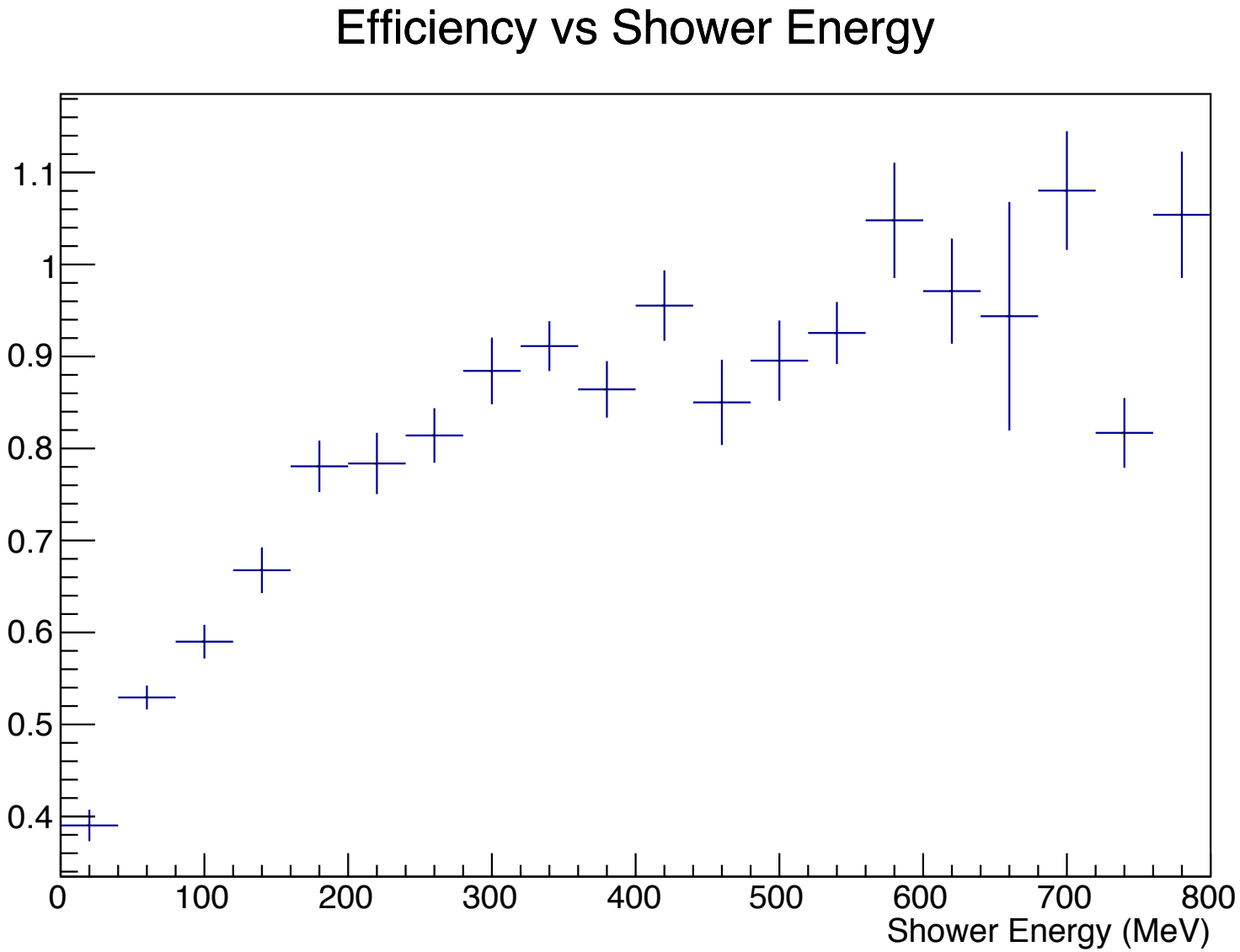


Note: For the reco mass we specifically select only the two showers matched with the two true pi0 photons.

Efficiency

$$Eff = \frac{\#\ Shower\ Hits}{\#\ Photon\ Hits}$$

- Eff > 1 implies too many hits for that shower
- First two event displays show examples of this



Summary

Out of 717 true events with 1pi0

- Only 230 reco with backtracker cut (i.e. exactly two showers matched to a pi0 photon)
- 24 have angle difference >90˚ from true
- 182 have at least one shower with energy difference >30% from true
- 77 have at least one shower with efficiency <0.7
- 43 have at least one shower with efficiency >1
- 40 events affected by angle fix (m > 135 MeV and ang > 90˚)
- 21 events have both showers matched to same photon