π^0 Analysis update

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Reminder of the Analysis

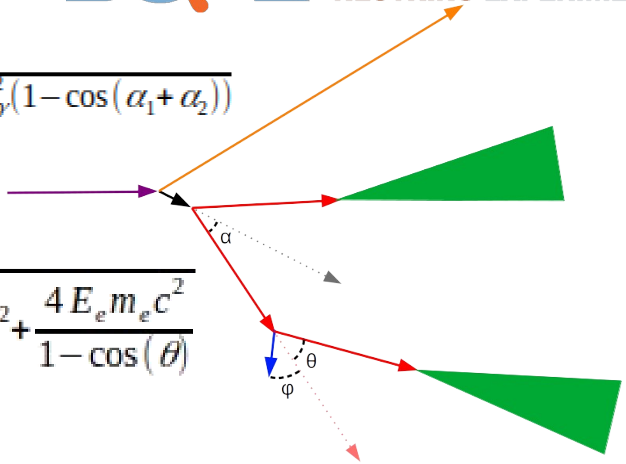
Looking for π^0 decays with a photon that undergoes a Compton scatter before it showers.

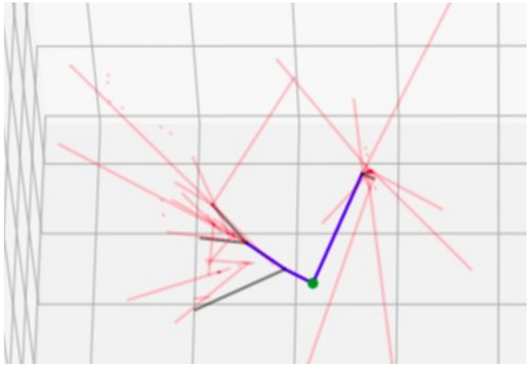
Then find the angle of deflection, θ using the starting points of the muon, electron, and photon shower.

These studies can be a unique way to study MeV scale electrons in Liquid Argon

$$m_{\pi^0} = 2\sqrt{E_\gamma^1 E_\gamma^2 (1-\cos(\alpha_1+\alpha_2))}$$

$$E_\gamma = E_e + \sqrt{Ee^2 + \frac{4E_e m_e c^2}{1-\cos(\theta)}}$$



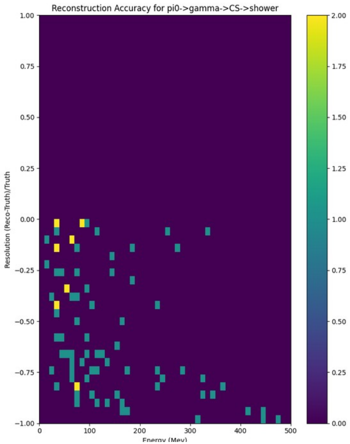


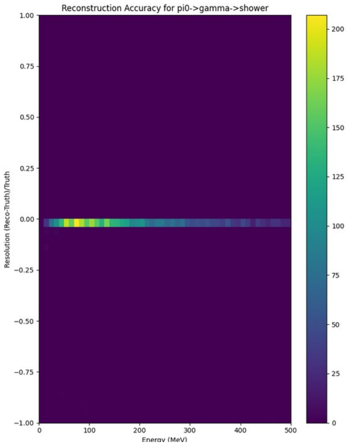
Truth level studies

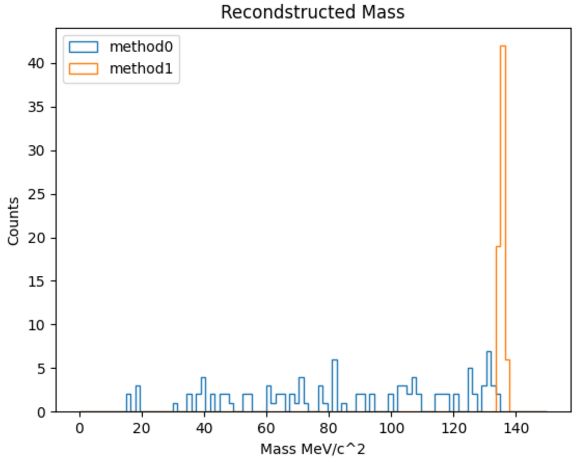
Top figure shows the reconstructed energy resolution (“reco”-true)/true for events with 1 photon undergoing a Compton scatter

Top left shows just energy of photon shower (method 0). Top right shows adding energy of Compton scattered electron (method 1).

Bottom shows invariant mass of photons for method 0 and method 1



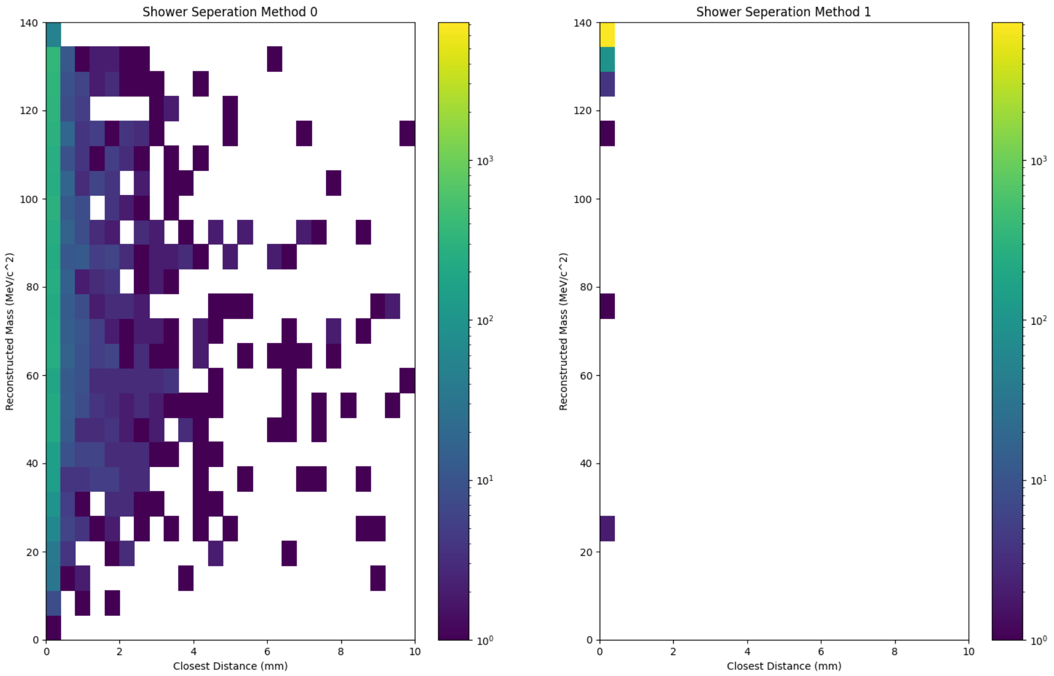




Truth level studies

These plots show the closest distance between the two showers and the reconstructed mass

Failing to deal with these events appropriately skews the mass reconstruction and can hurt reconstruction efficiency

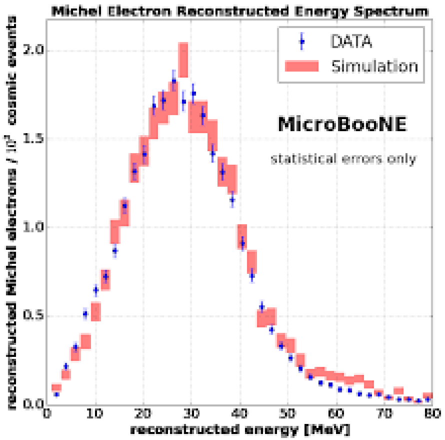


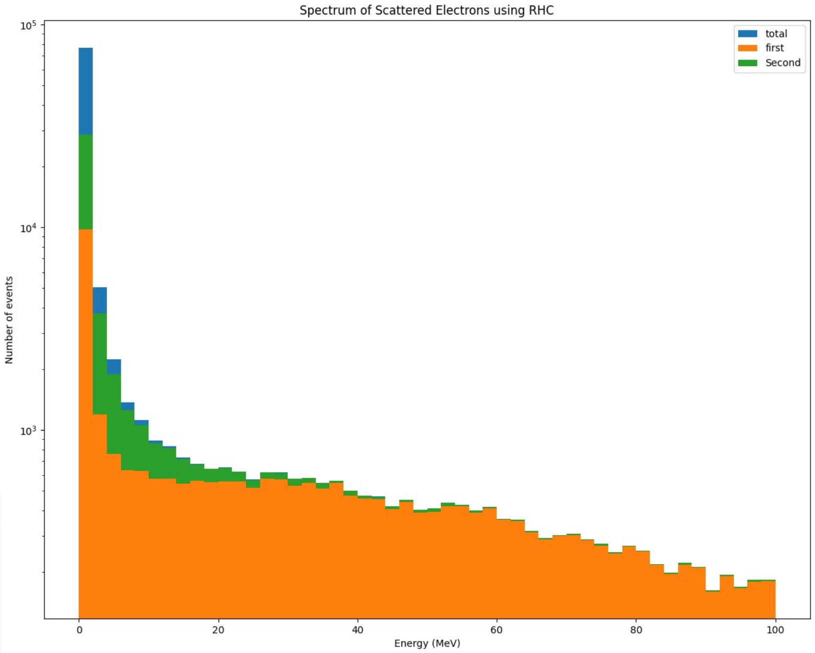
Truth Level Studies

These studies can be a unique way to study MeV scale electrons in Liquid Argon

Has a different spectrum than Michel electrons

This might be useful for supernova studies or low energy physics





Statistics

This decay mechanism with ensuing Compton scatter occurs in approximately 3.0% of π^0 decays. So we would expect ~2100 events/month

- 17.3k π^0 events in MR4 (1E19POT)
- 530 π^0 with CS photon in MR4
- 209 of these events were CC
- MR4 ~3 days of beam

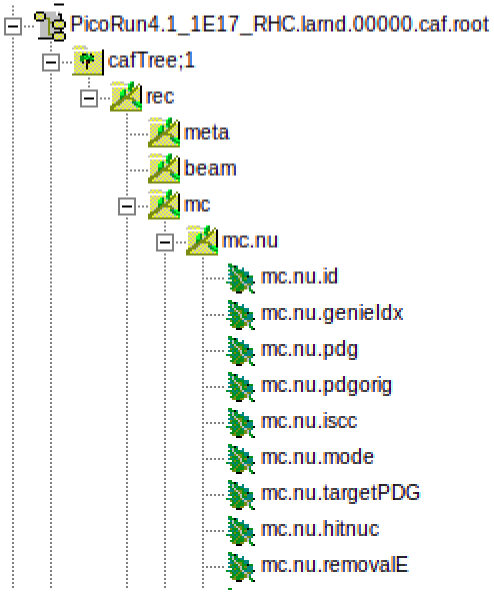
Uncertainties on beam time and selection efficiencies will affect how many events we can reconstruct

Reconstructed objects in CAFs

The previous studies used the Edep-sim information from the Mini Run 4 FLOW files

Used the selection parameters from the MicroBooNE π^0 analysis

The following slides show a π^0 reconstruction (based on ML reco outputs) that allow us to test some of the tools we would need for the Compton scatter analysis



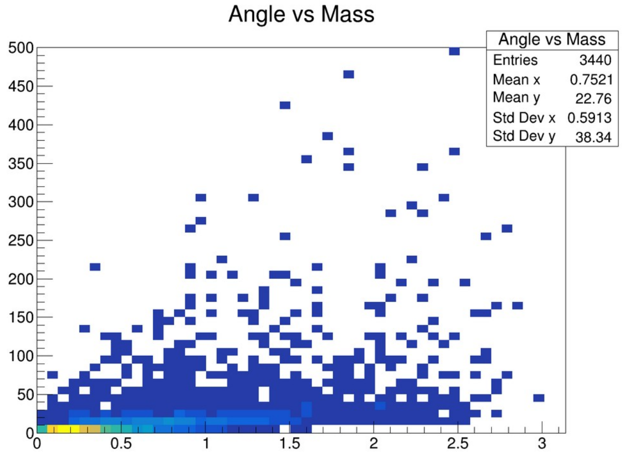
Applying preliminary cuts

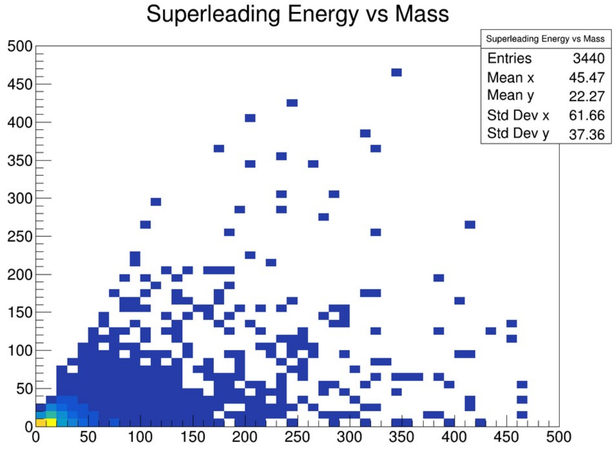
These studies were performed with MiniRun 4 CAFs (no Genie truth information available)

So I used 2D histograms to apply preliminary cuts:

- Closest approach of showers
- Distance between shower and muon start
- Angular separation of showers
- Photon energies

Plots show all combinations of showers





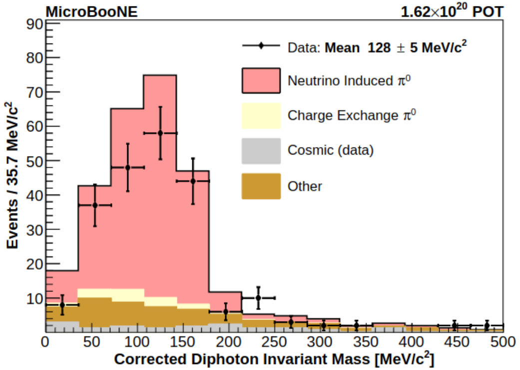
Effects of Preliminary cuts

Left shows invariant shower mass from the MicroBooNE π^0 selection (https://arxiv.org/abs/1811.02700)

Right shows the invariant shower mass of the preliminary π^0 selection

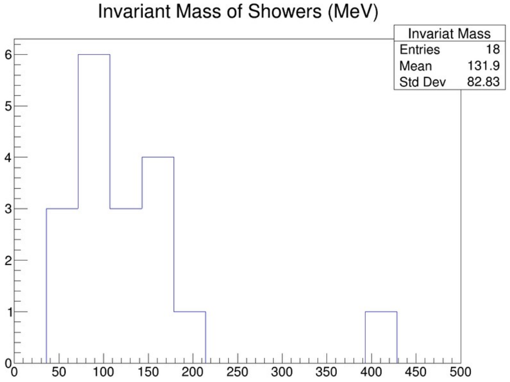
Cuts:

- Shower separation: 4 cm
- Subleading photon energy: 0 MeV
- Leading photon energy: 67.5 MeV
- Minimum angular separation: 0.5 radians
- Maximum angular separation: 1.7 radians
- 1st shower-muon separation: 4 cm
- 2nd shower-muon separation: 4 cm



Cuts:

- Shower separation: 8 cm
- Subleading photon energy: 30 MeV
- Leading photon energy: 67.5 MeV
- Minimum angular separation: 0.5 radians
- Maximum angular separation: 1.7 radians
- 1st shower-muon separation: 10 cm
- 2nd shower-muon separation: 10 cm



PicoRuns

Genie truth information became available in these files

This enabled me to look into selection efficiencies

Selection efficiencies of cuts shown on previous page are low (<1%, for context MicroBooNE had a selection efficiency of ~6%)

Work on selection is ongoing

Also working on implementing selection purity calculations

The larger data sets from MR 5 will help refine selection parameters

Summary

I'm aiming to get a dataset of low energy electrons

I don't see why this can't be generalized to other LArTPCs

Can be used on similar topologies (single photon production)

Byproduct of this study is a π^0 reconstruction and analysis

Pico runs don't have enough data to look for Compton scattered electrons

Beginning to work on selection efficiencies and purities

Still an ongoing process