PNS Update

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SOUTH DAKOTA MINES

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Overview

- Previous Reconstruction Results
- Alternative Reconstruction Method
- Pulsed Neutron Source Hardware Status

Reminder

- Previously we showed simulated reconstruction using NIST tables for electron stopping power (ESTAR) to estimate dE/dX
  - Use the modified box model equation to calculate dQ/dx
  - Then build a direct relation between **post-recombination charge** and **electron energy**

$$\frac{\mathrm{d}Q}{\mathrm{d}x} = \frac{1}{\beta W_{ion}} \ln\left(\frac{\mathrm{d}E}{\mathrm{d}x} * \beta + \alpha\right)$$

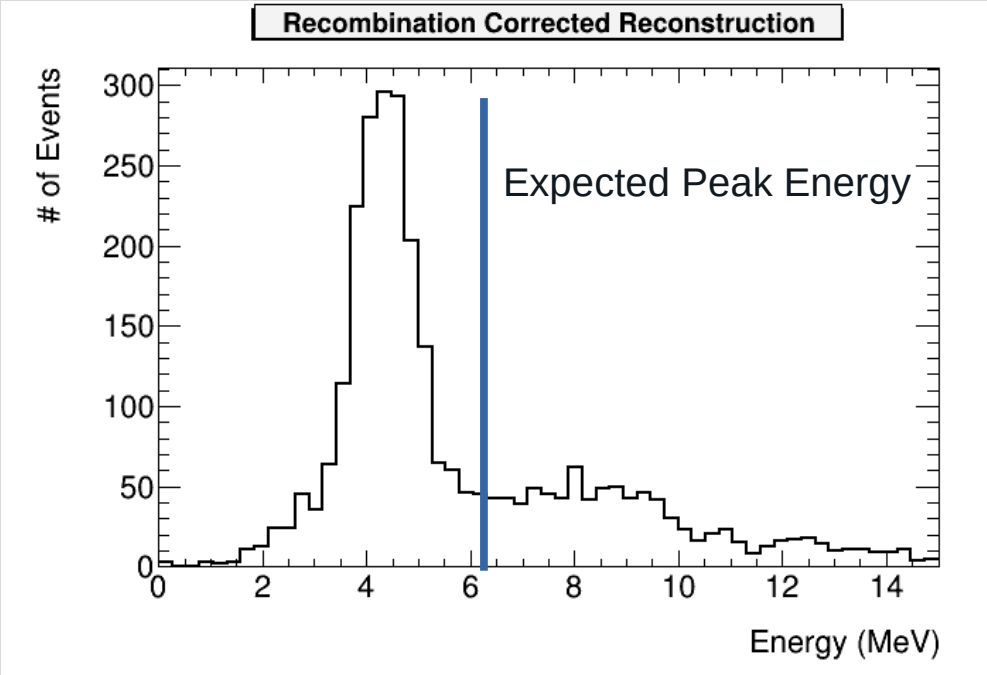
- It is possible to calculate the energy of the electron based on the total ionization charge which survives recombination
- This method was demonstrated in ArgoNeut:

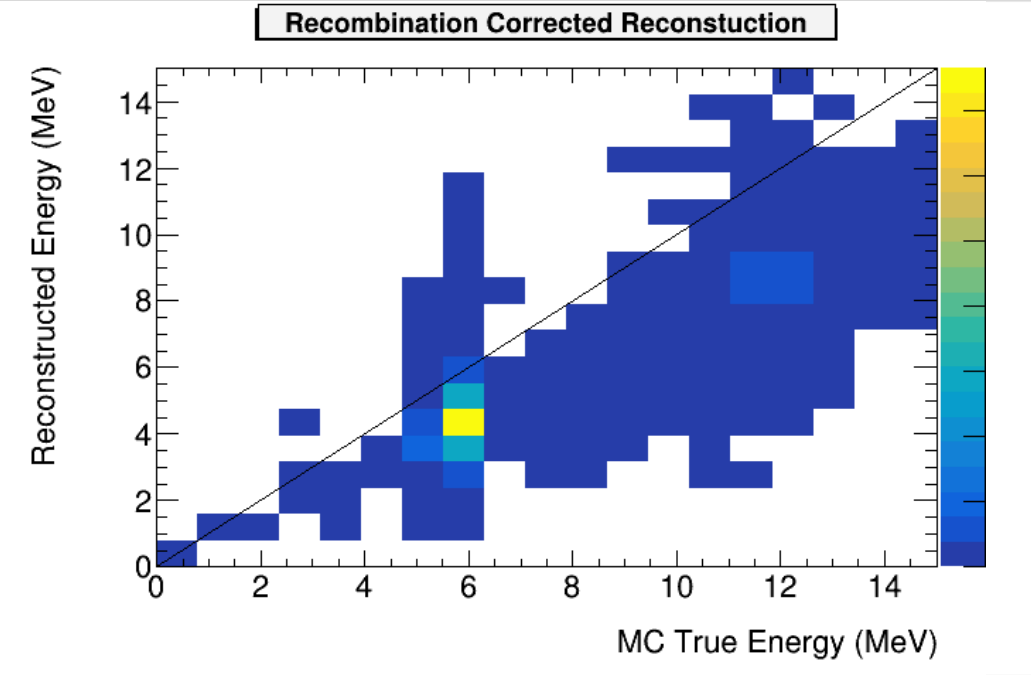
Demonstration of MeV-Scale Physics in Liquid Argon Time Projection Chambers Using ArgoNeuT

Performance

- This method of reconstruction results in an overall lower energy for most neutron capture events
- The shape of the histogram is as expected
- Similar effects reported in recent ProtoDUNE paper analyzing Michel electrons

Paper draft: Identification and reconstruction of low-energy electrons in the ProtoDUNE-SP detector

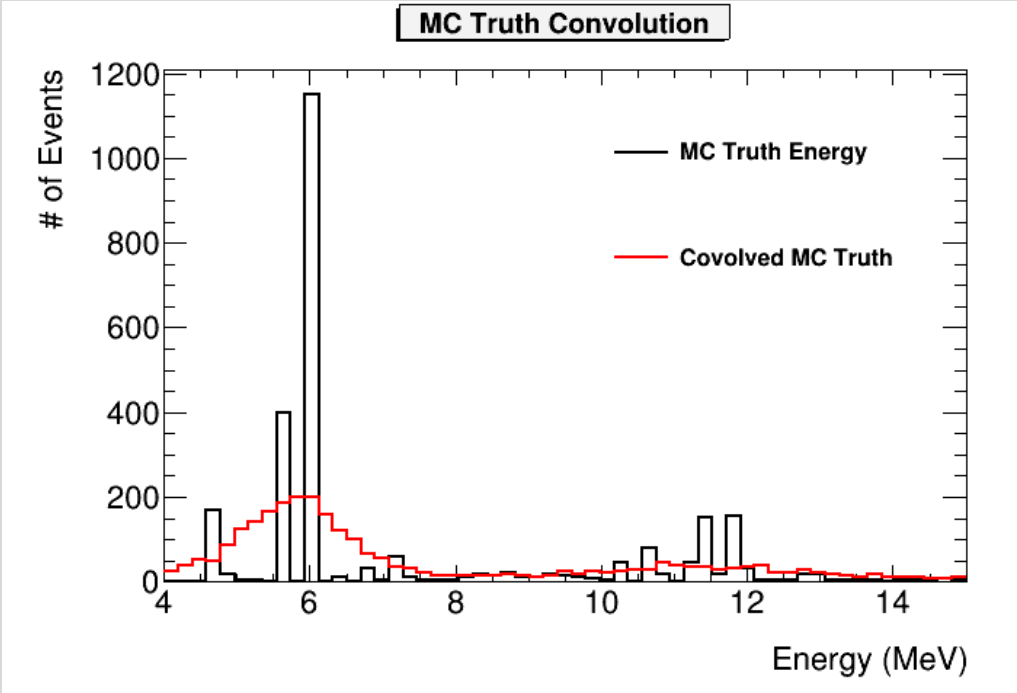




Alternative Method

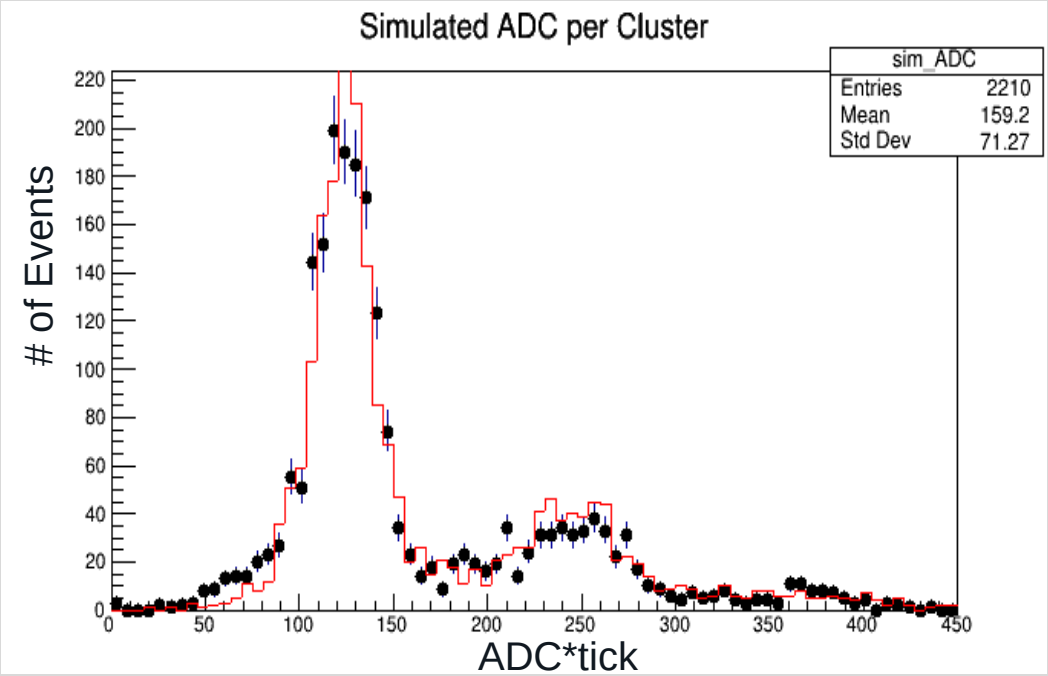
- An alternative method to reconstruction is to fit the data to the theoretical gamma spectrum
  - Here we have used the MC truth data from LArSoft backtracking
- The theoretical spectrum needs to be convolved with a resolution function appropriate for a homogoneous calorimeter

$$\frac{\sigma(E)}{E} = p_0 \oplus \frac{p_1}{\sqrt{E}} \oplus \frac{p_2}{E}$$



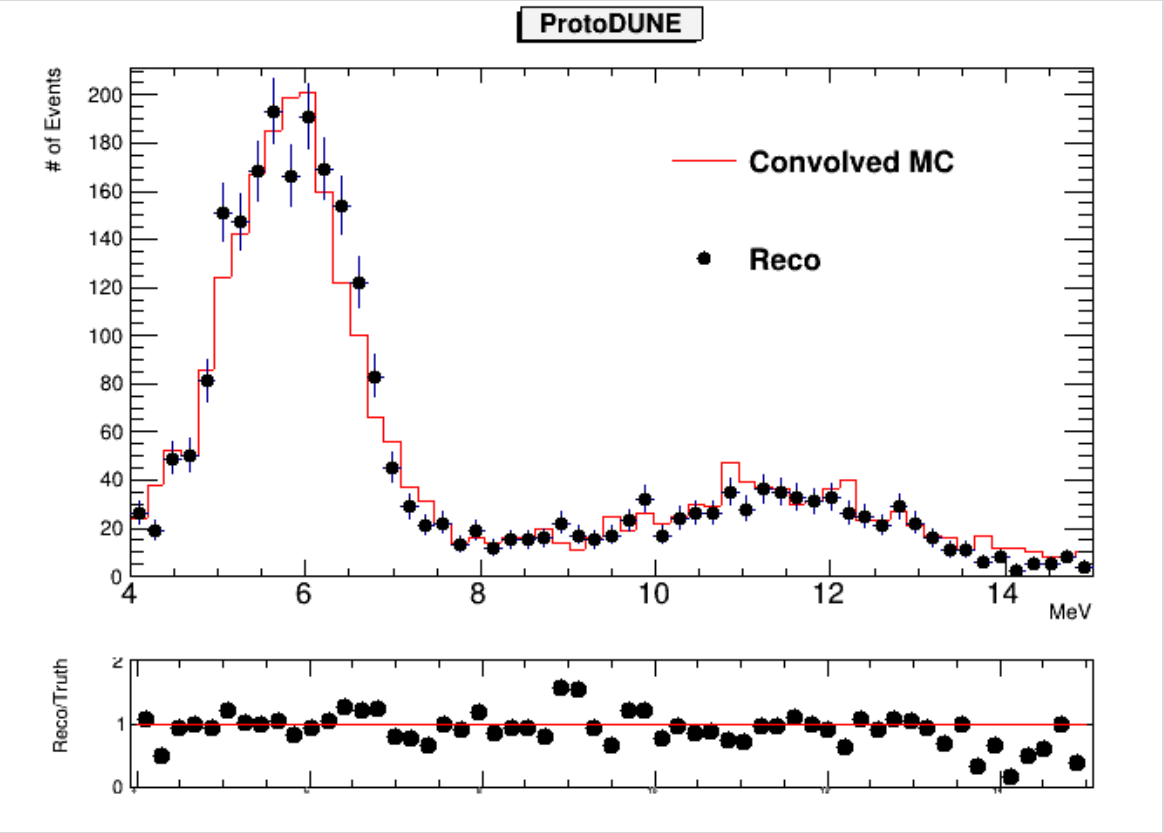
Application

- The convolution is applied to the MC truth, along with a scaling factor, C_{scale} which can convert the data in ADC*tick to energy in MeV
- The 4 parameters are then fit using Minuit to simulated data
- The fitted values are
  - p0 = .09972 +- 2.86e-5
  - p1 = 8.5967e-4 +- 9.86e-6
  - p2 = 0.2000 +- 0.4275
  - C_scale = 21.31 +- 0.65



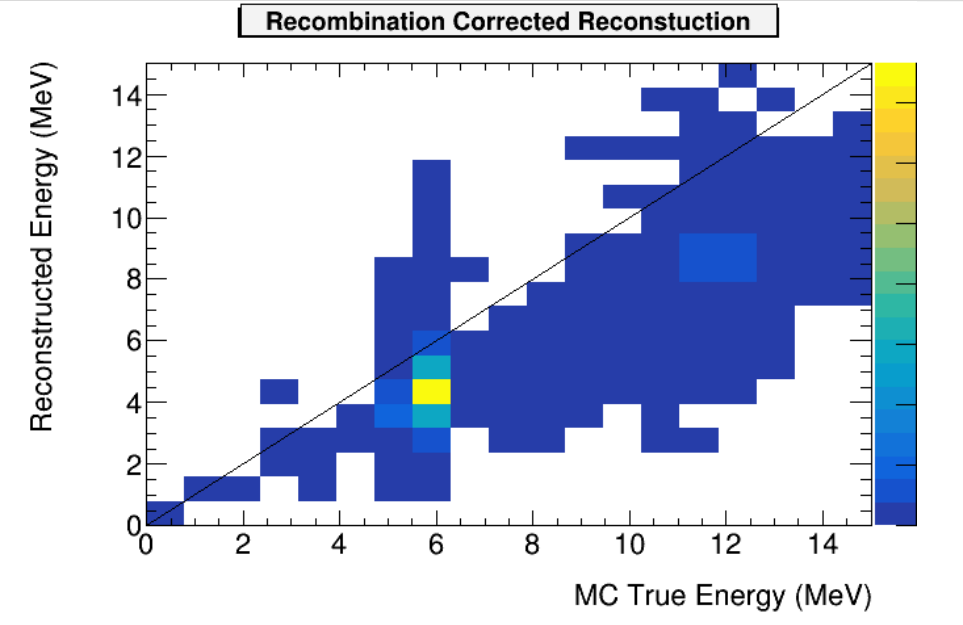
Simulated Reconstruction Result

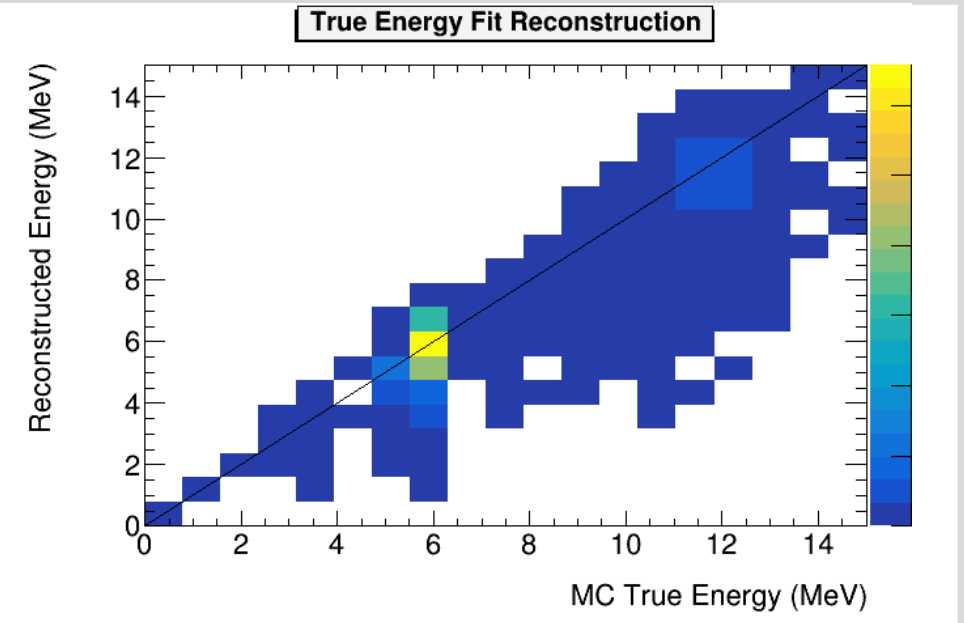
- Then to show the reconstruction ability, we then applied the the fitted scaling factor to the simulated ADC data and compared to the convolved MC (χ^2/ndf = 1.23)



Comparison

- Left: Previous method, using ESTAR data
- Right: Alternative method using true energy fitting





PNS Hardware Status

- The DD Generator is operational, and we have done multiple test runs
  - Familiarizing ourselves with the device
  - Testing operational parameters
- Currently running some Geant4 simulation for optimization of the PNS, will perform tests following the simulation results
  - Lead neutron reflector
  - Gamma shielding

Conclusions & Next Steps

- We can achieve a better reconstruction using the truth fitting method
  - We need to have good knowledge of the clustering to get the theoretical truth value
  - Possibly run DBScan on monte carlo data as a baseline “theoretical” gamma clustering
  - Currently all of the detector effects are folded into one scaling parameter

Next Steps

- Evaluate feasibility of this reconstruction method for real data
  - Can we produce a good theoretical gamma clustering?
- Look into unfolding the recombination effect from the scale factor
- Continue simulation, and run experiments for PNS optimization