

# Updated on Electron Energy Reconstruction

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University of Houston

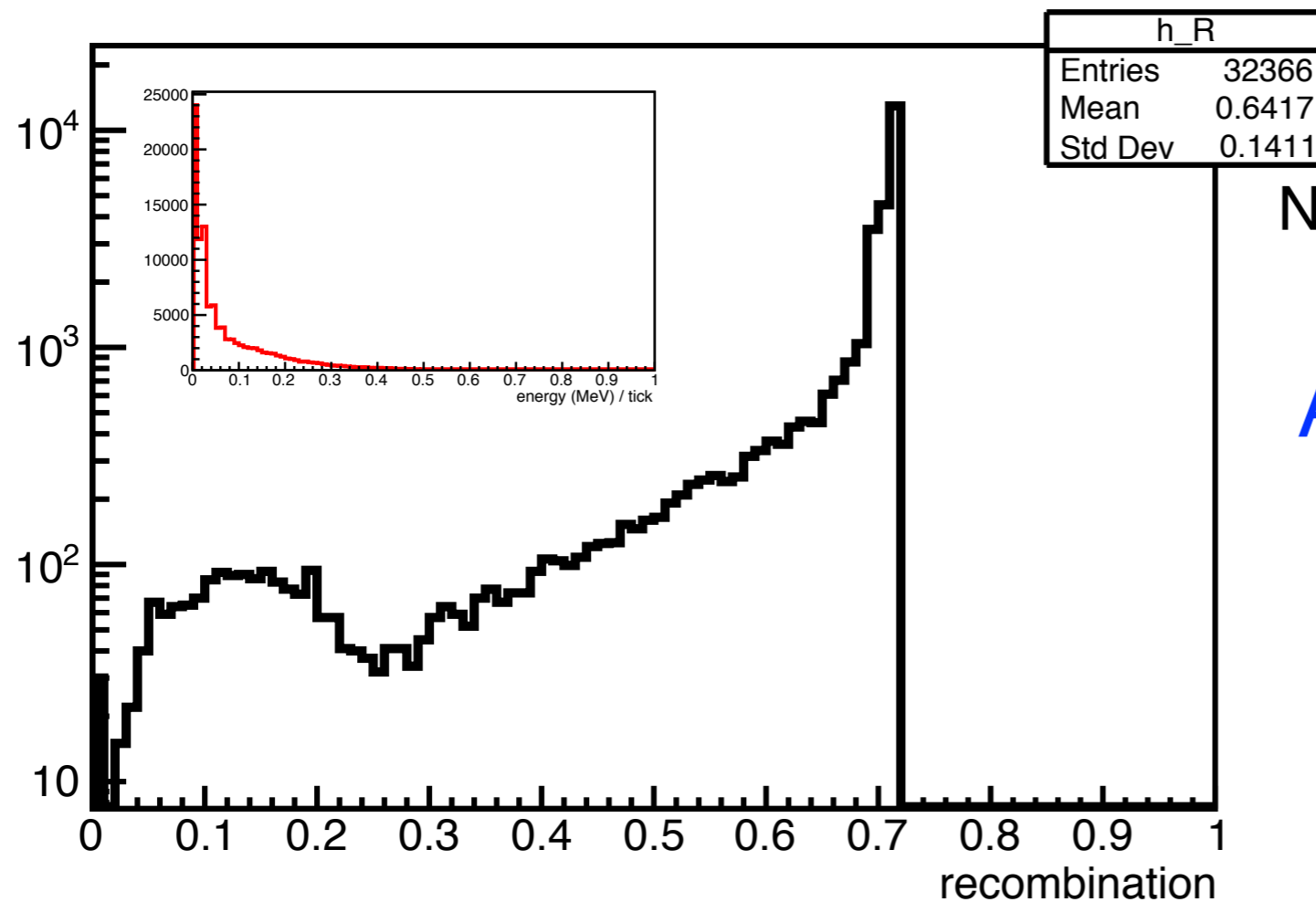
# Recombination Factor

$$R = \frac{1}{\xi} \ln(A + \xi) \quad \xi = B \frac{dE}{dx} E_{field}$$

See, [larsim/LArG4/ISCalculationSeparate.cxx](#)

ModBoxA: 0.930

ModBoxB: 0.212



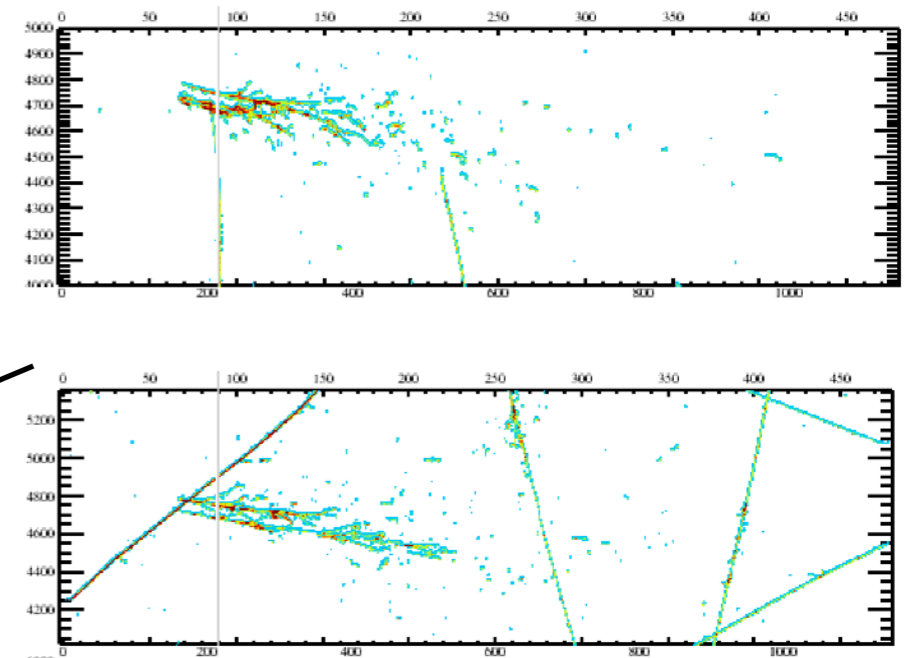
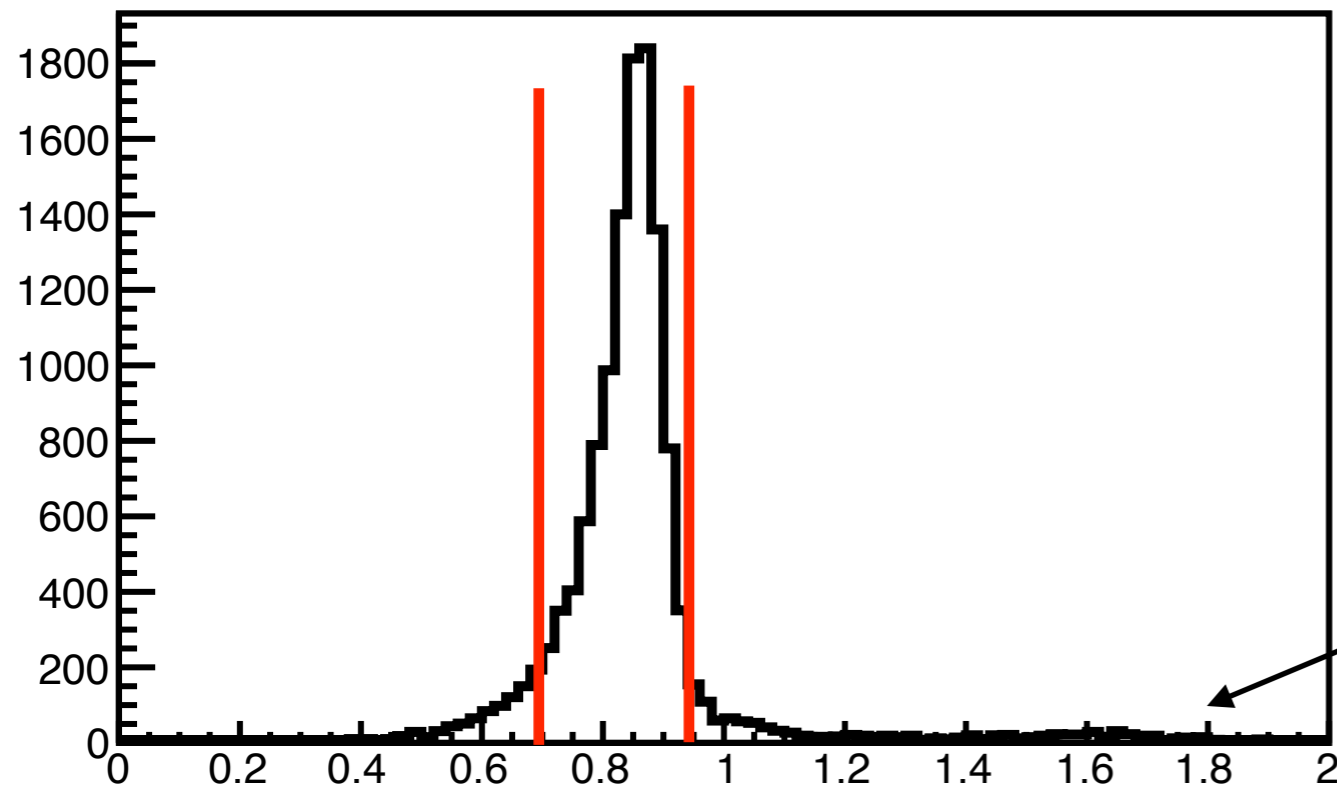
Nucl.Instrum.Meth.A523:275-286,2004

Average value R=0.6417

$$E_{calo} = \sum_{i=1}^{i=N \text{ hits}} \frac{\epsilon_i(X, Y Z) dQ_i W_{ion}}{\text{calorimetry factor} \cdot \text{Recombination factor}}$$

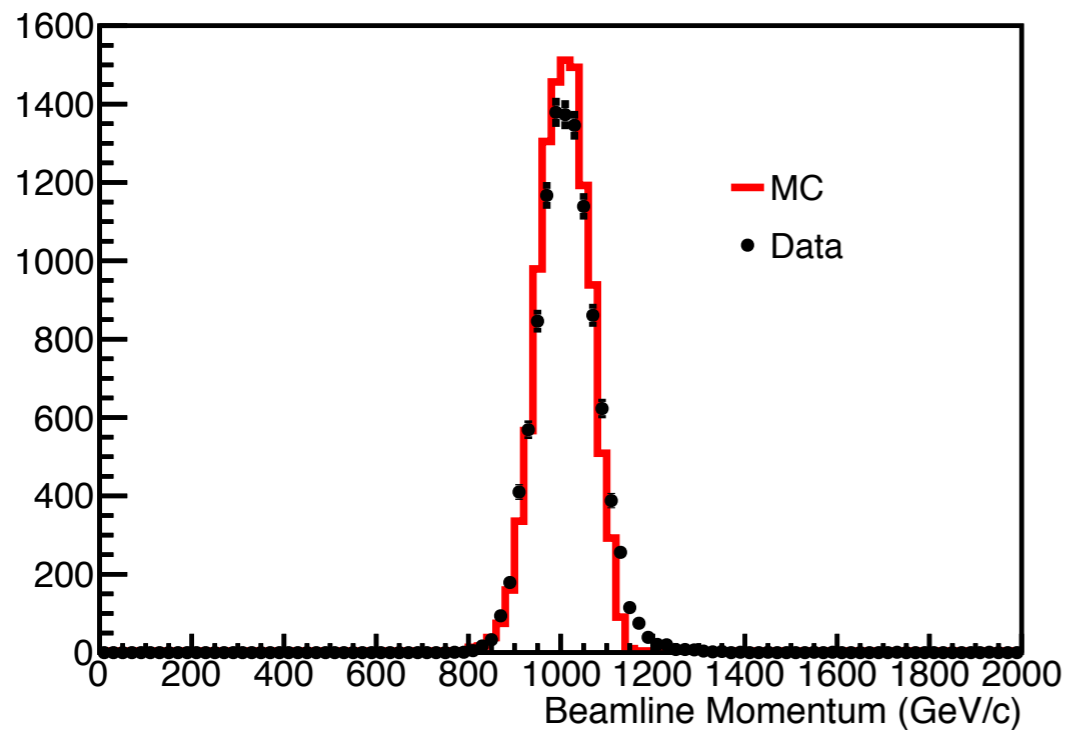
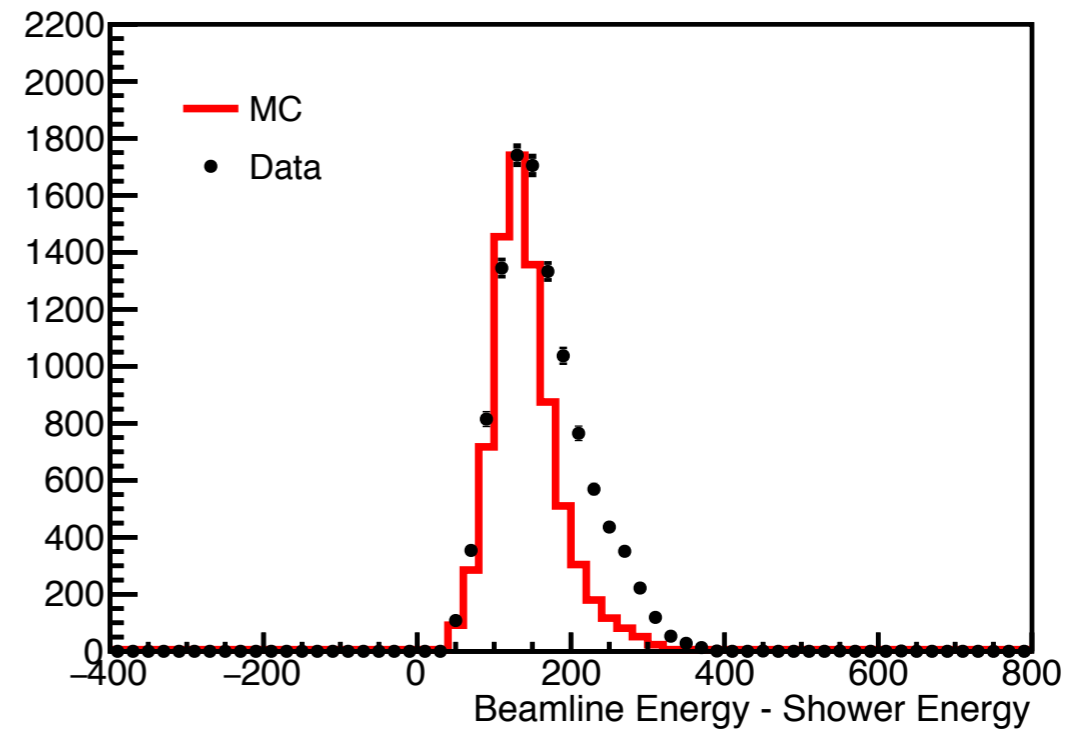
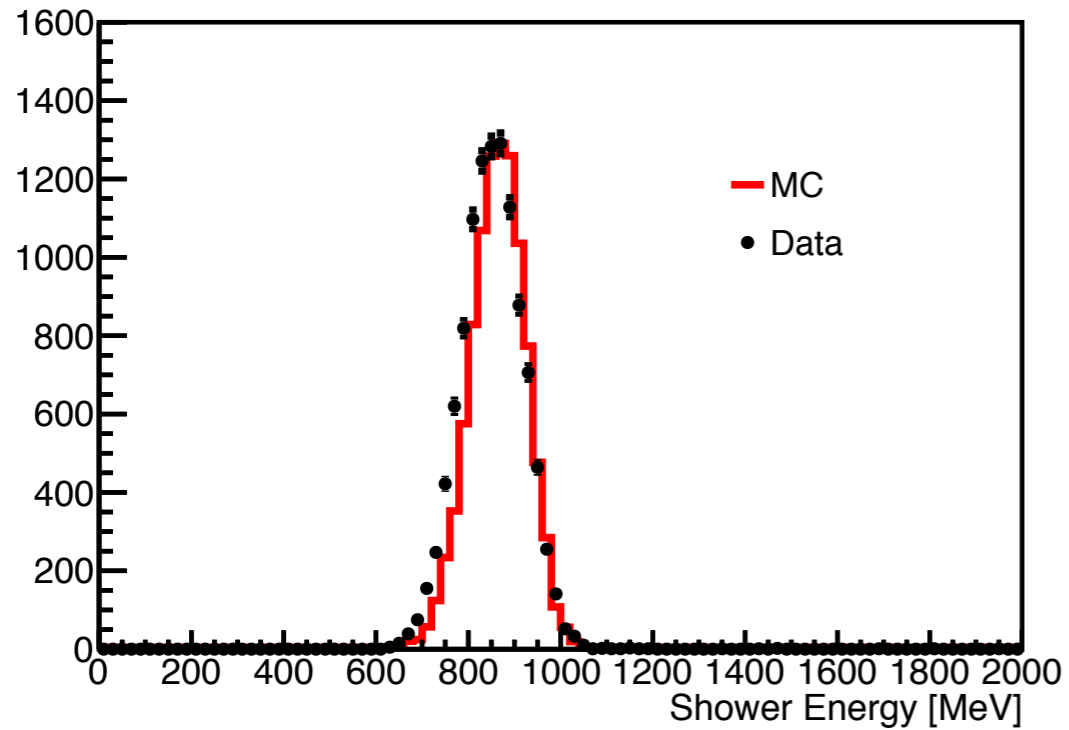
# Energy Reconstruction

- Select events with complete showers
- Look at shower energy/beam line energy



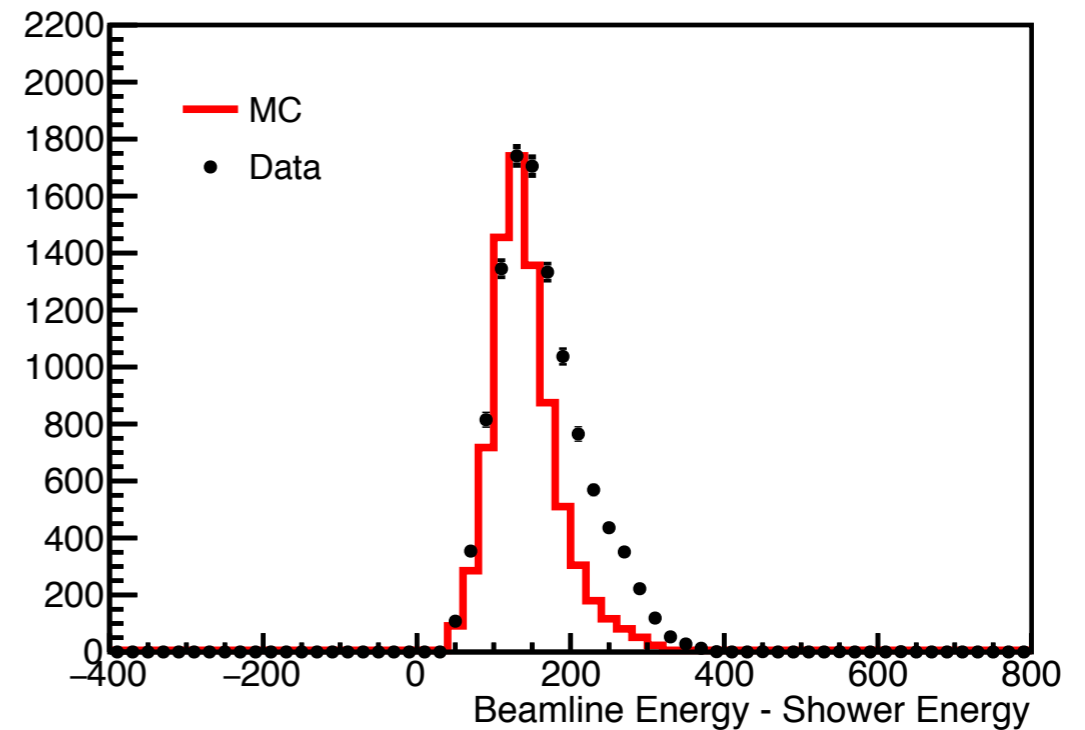
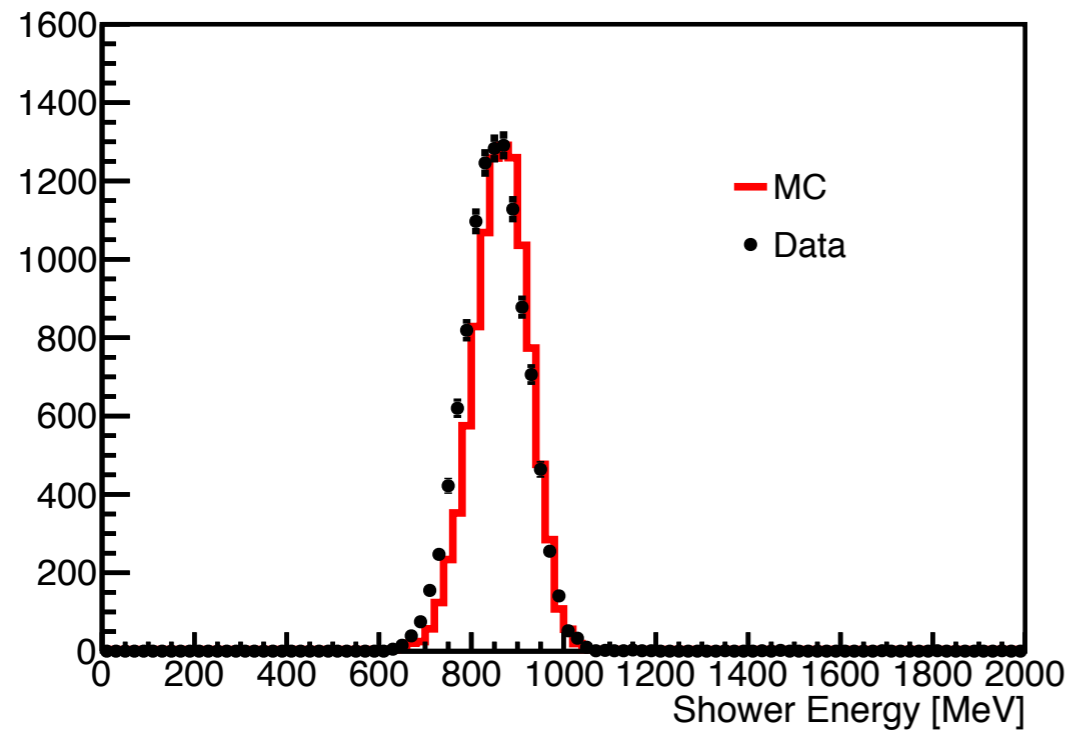
Focus on complete showers

# Energy Reconstruction



There is  $\sim 160$  MeV bias between shower energy reconstruction and beamline energy

# Energy Reconstruction



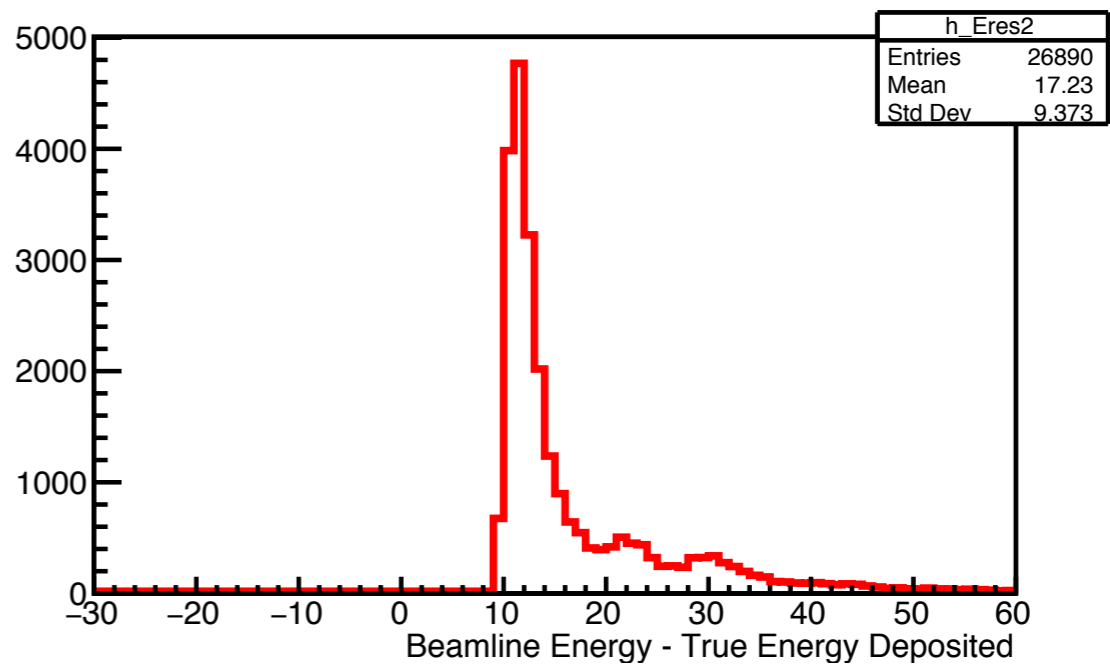
There is  $\sim 160$  MeV bias between shower energy reconstruction and beamline energy

***Residual  $\sim$  Energy loss upstream + Reconstruction Thresholds(recob::Wire & recob::Hit)  
+ Shower Reconstruction (incomplete showers, missing hits)***

# Energy Reconstruction

***Residual ~ Energy loss upstream + Reconstruction Thresholds(recob::Wire & recob::Hit)  
+ Shower Reconstruction (incomplete showers, missing hits)***

***Energy loss upstream = 50 MeV (from MC ~18 MeV true energy deposited - MC energy at creation)***



# Energy Reconstruction

*Residual* ~ *Energy loss upstream* + *Reconstruction Thresholds(recob::Wire & recob::Hit)*  
+ *Shower Reconstruction (incomplete showers, missing hits)*

*Energy loss upstream* = 50 MeV

*Reconstruction Thresholds(recob::Wire & recob::Hit)*

Use a single 1 GeV electron to study recob::wire threshold

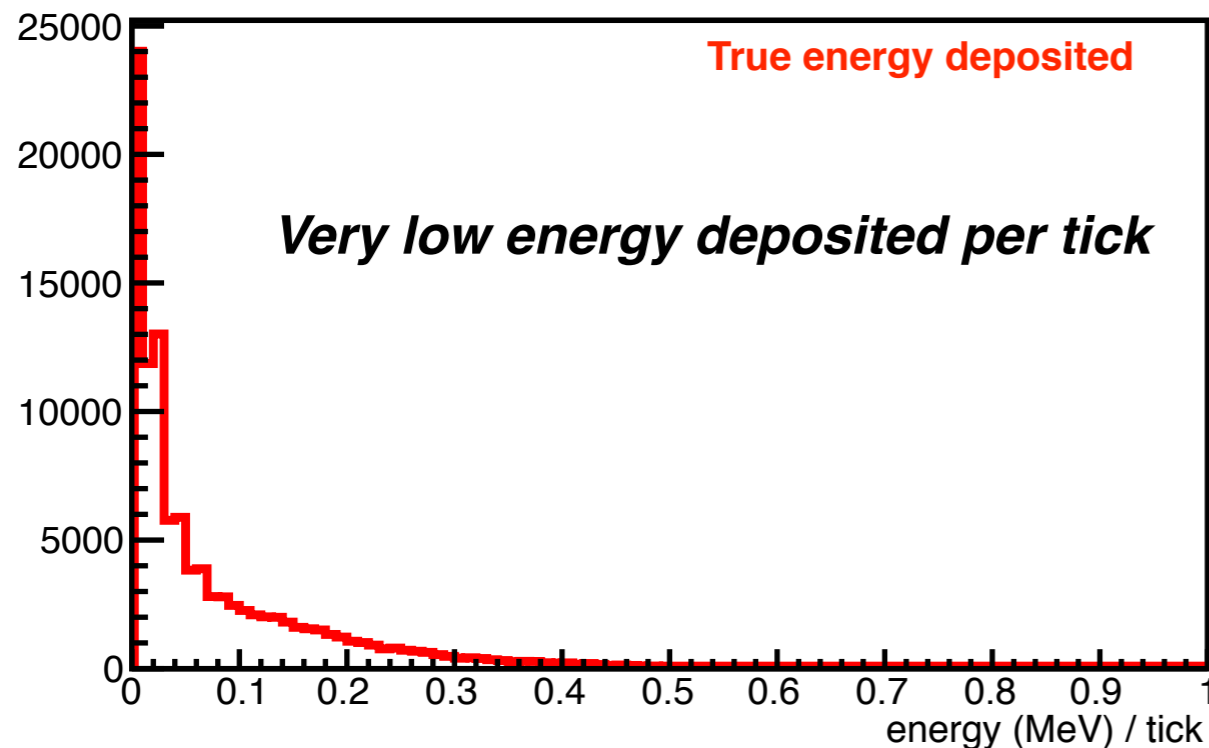
# Energy Reconstruction

***Residual ~ Energy loss upstream + Reconstruction Thresholds(recob::Wire & recob::Hit)  
+ Shower Reconstruction (incomplete showers, missing hits)***

***Reconstruction Thresholds(recob::Wire & recob::Hit)***

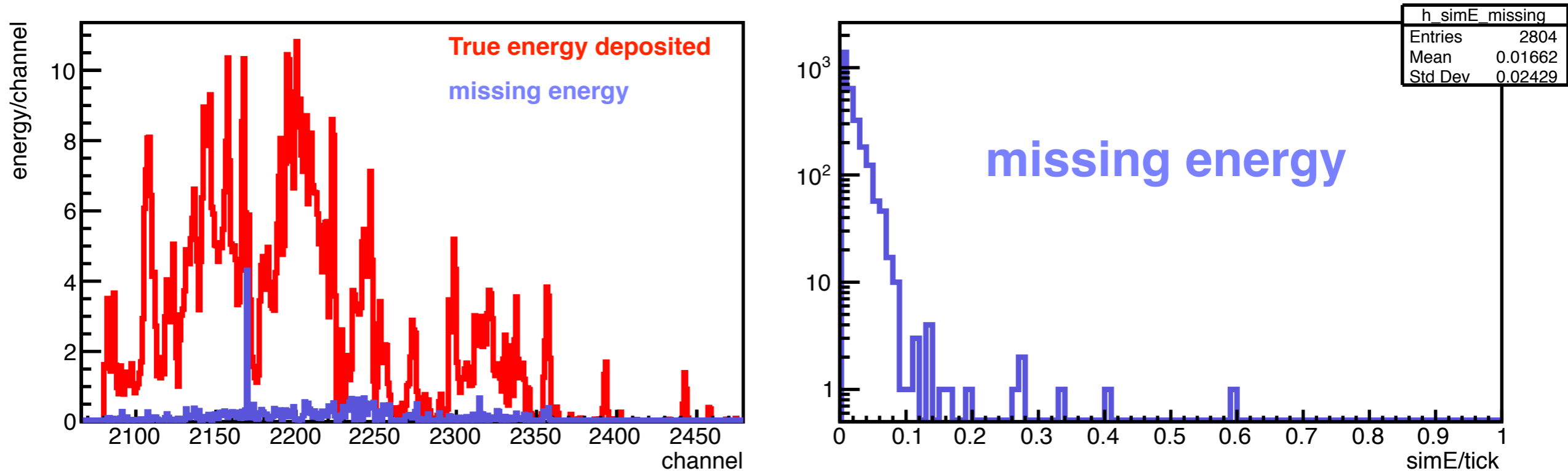
***Use a single 1GeV electron to study recob::wire threshold***

***Look at every single simchannel.TDCIDEMap()***



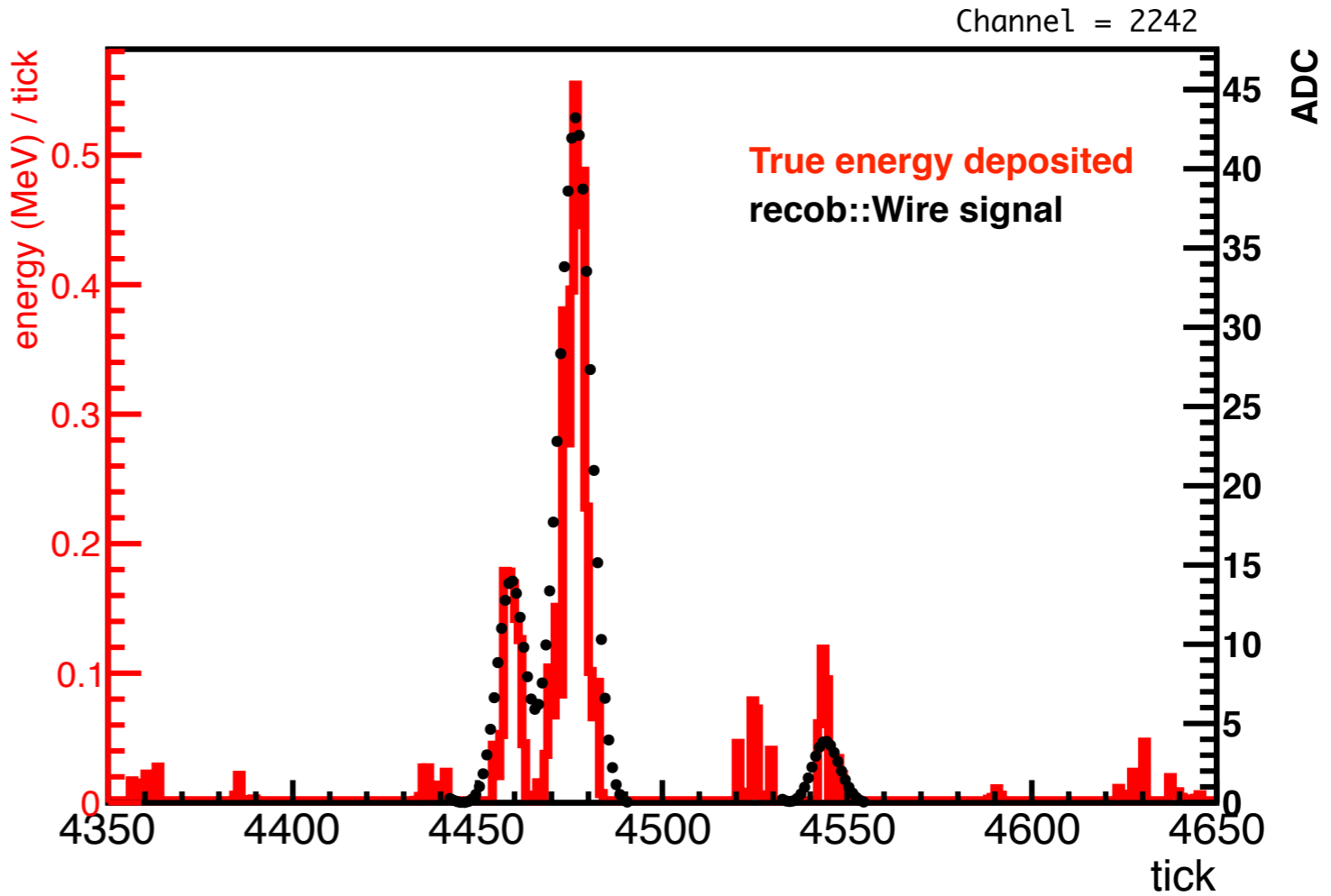
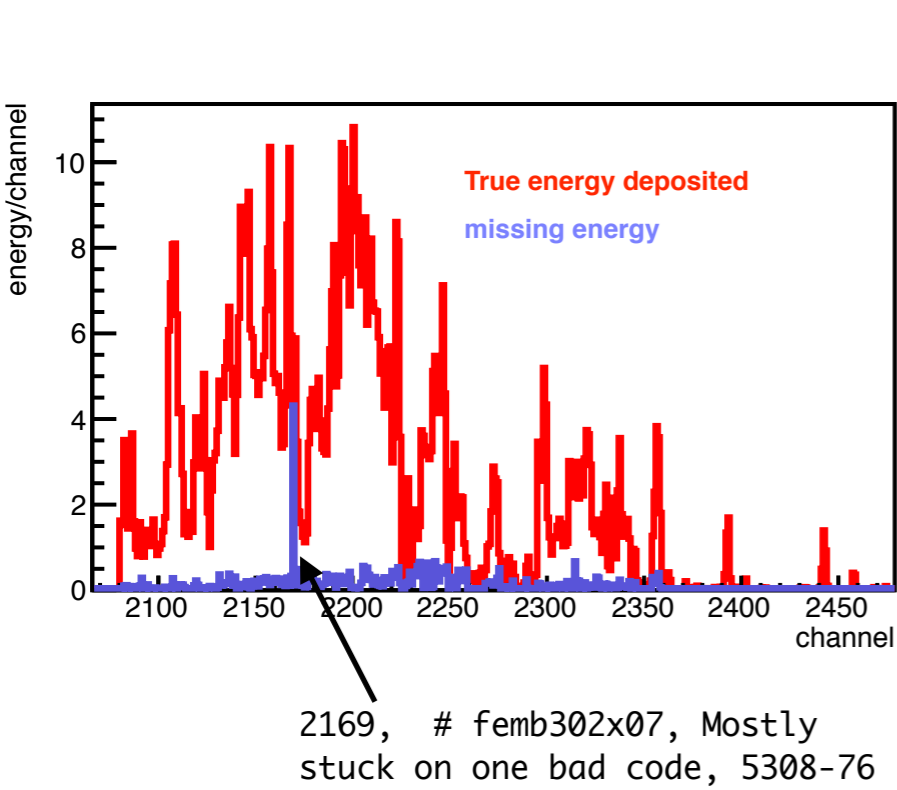


# Energy Reconstruction



- Estimate the missing energy due to recob::Wire threshold
- Look at channels (recob::Wire) that do not have a signal
- The missing energy per channel, as expect, is coming from low energy deposits (less 100 keV)

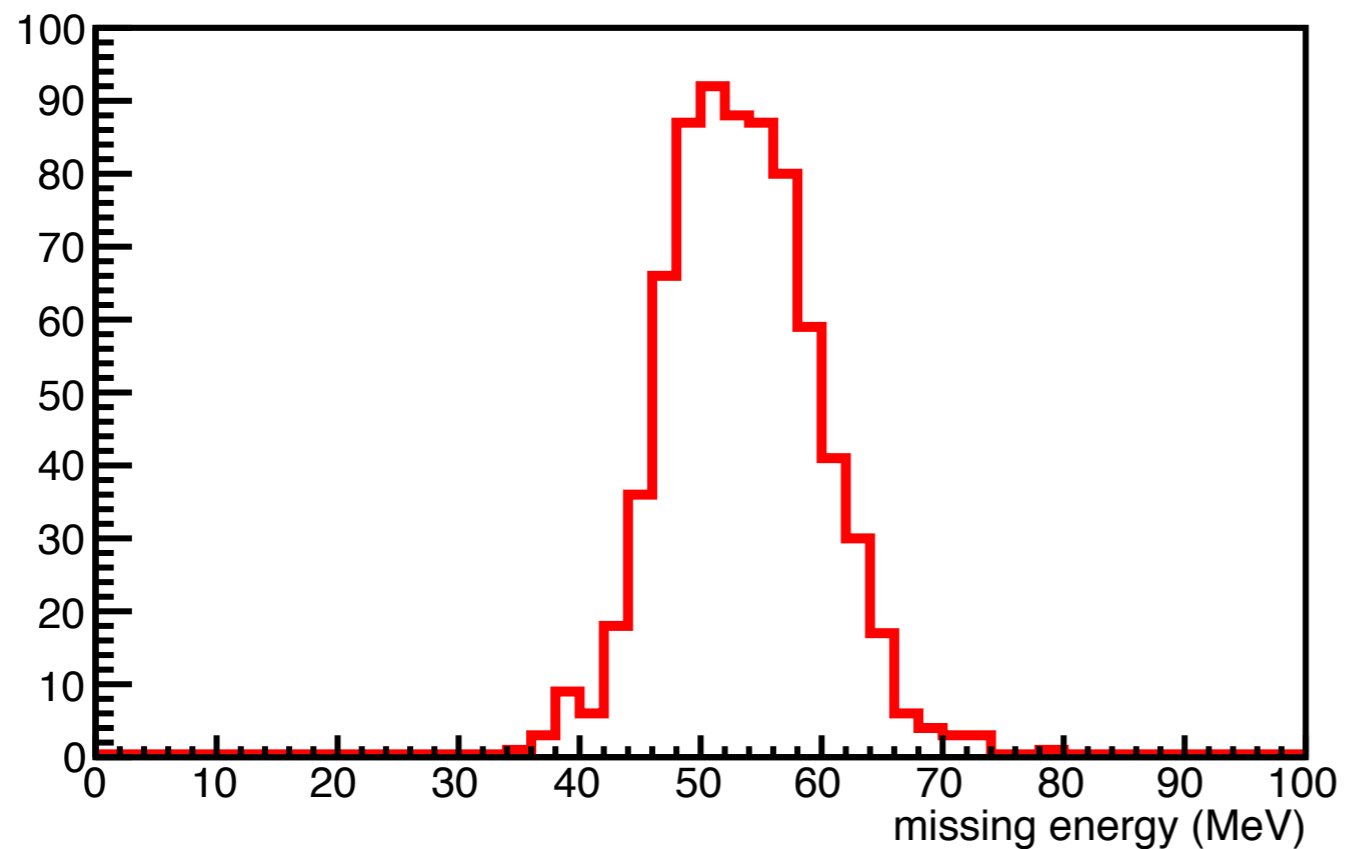
# Energy Reconstruction



- Threshold is **~100 keV/tick**

# Energy Reconstruction

- Given the threshold of **100 keV/tick** we lose  $\sim 50$  MeV where  $\sim 5$  MeV are due to dead/bad channels



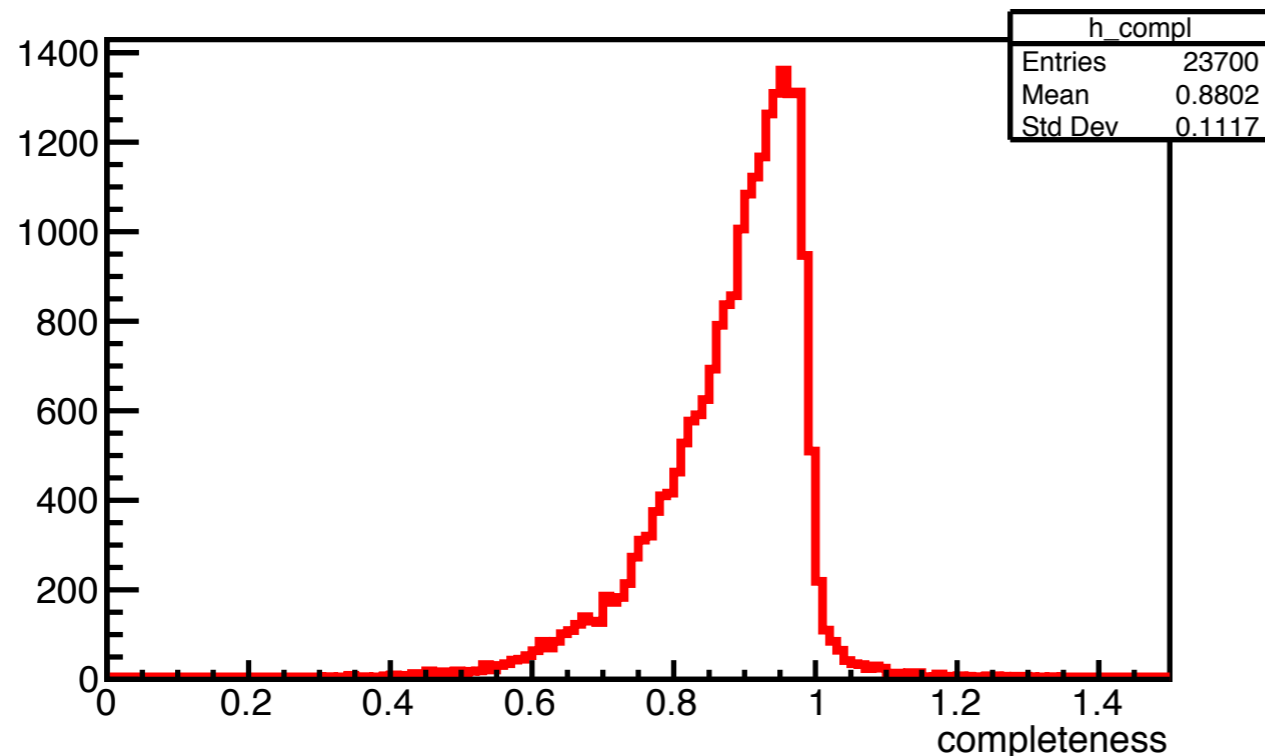
# Energy Reconstruction

**Residual** ~ **Energy loss upstream** + **Reconstruction Thresholds(recob::Wire & recob::Hit)**  
+ **Shower Reconstruction (incomplete showers, missing hits)**

**Energy loss upstream** = ~50 MeV

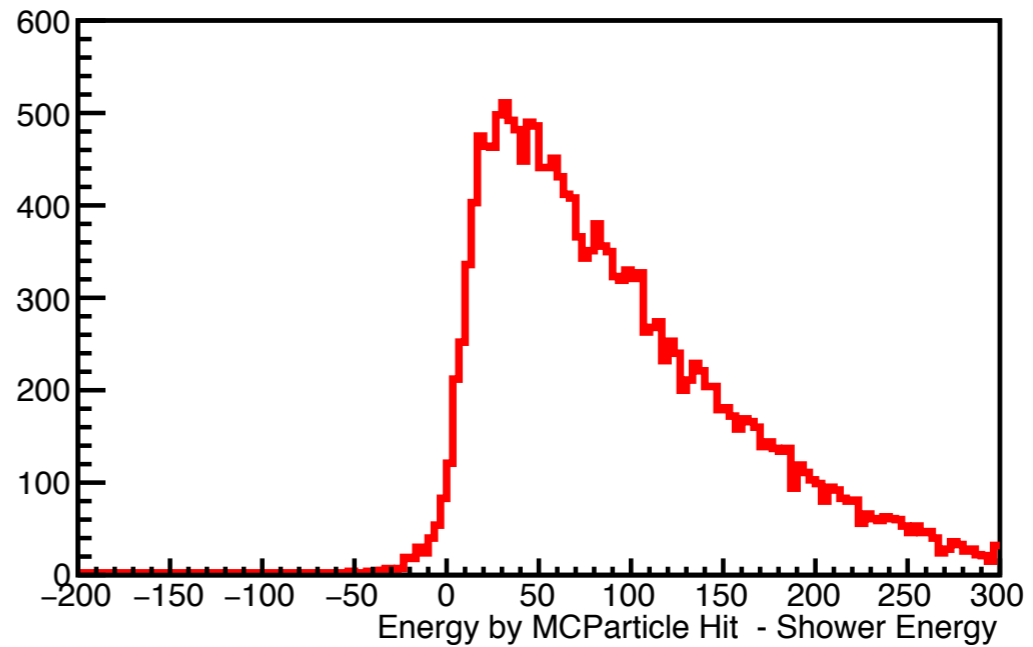
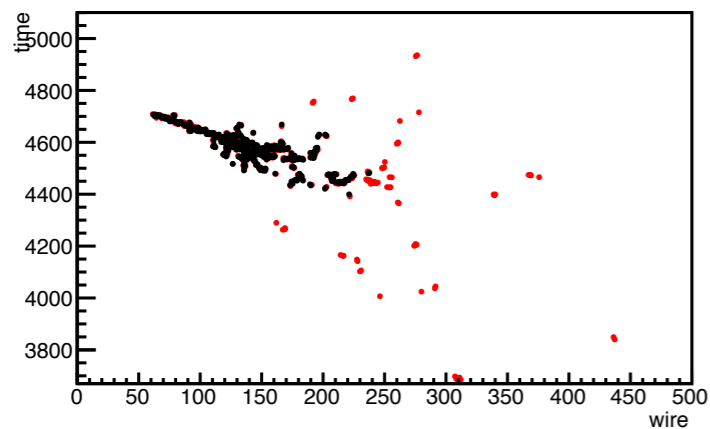
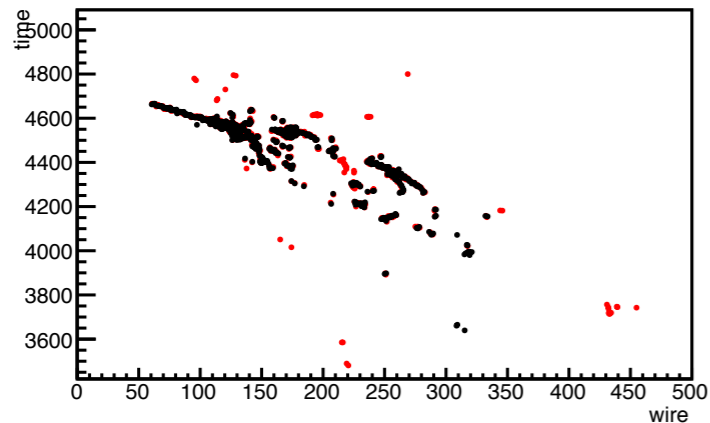
**Reconstruction Thresholds(recob::Wire & recob::Hit & Dead wires)** = ~50 MeV

**Shower Reconstruction (incomplete showers, missing hits)** =



$$compl = \frac{\sum_i reco\ pandora\ hit_i\ charge}{\sum_i MC\ particle\ hit_i\ charge}$$

# Energy Reconstruction



Energy using MCParticle hits = All hits generated by the MCParticle (electron)

Shower energy = using hits associated to the shower

hits from MCParticle  
Pandora shower hits

***Shower Reconstruction (incomplete showers, missing hits) = ~50 MeV***

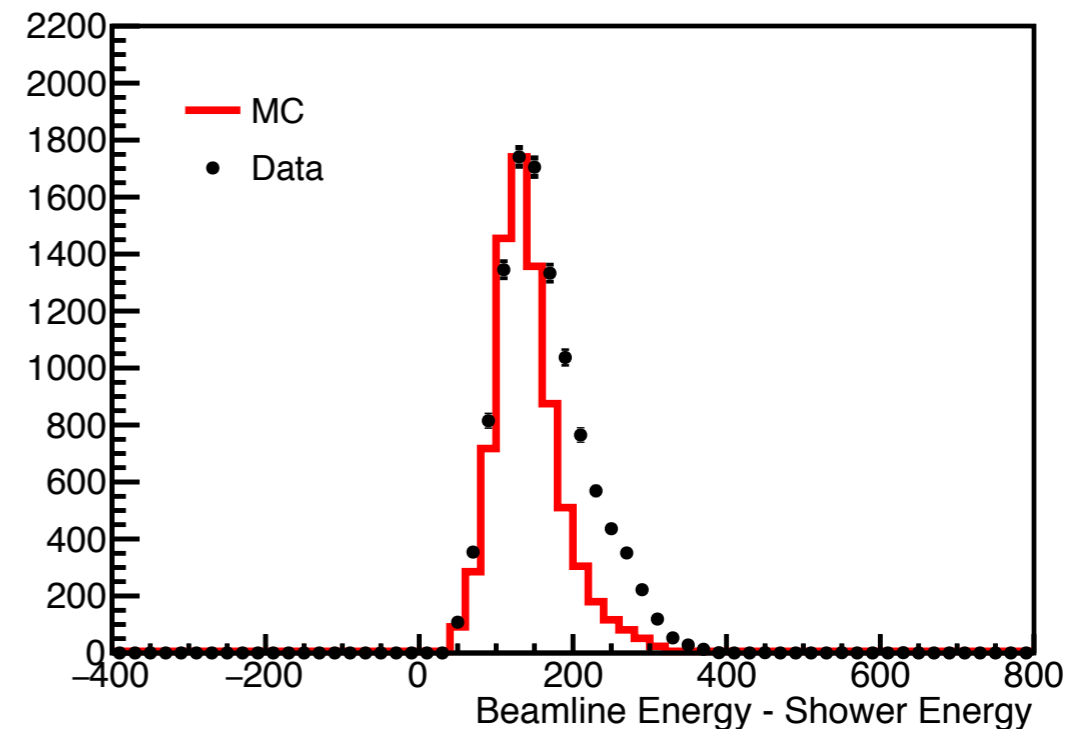
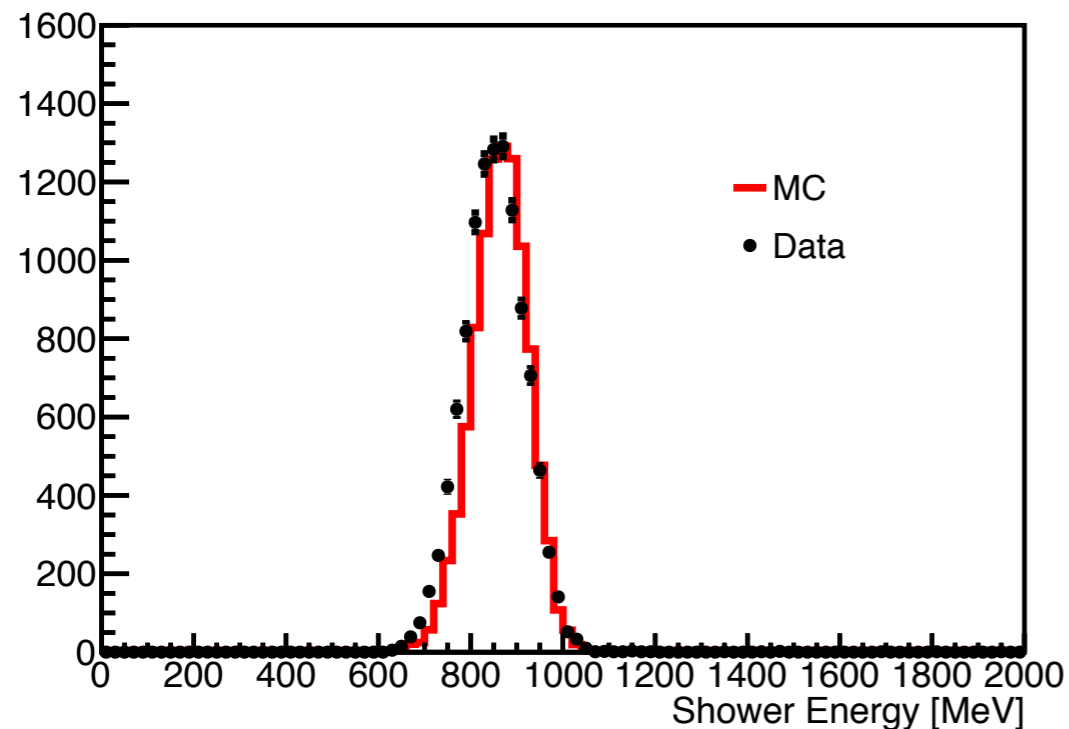
# Energy Reconstruction

**Residual** ~ **Energy loss upstream** + **Reconstruction Thresholds(recob::Wire & recob::Hit)**  
+ **Shower Reconstruction (incomplete showers, missing hits)**

**Energy loss upstream** = ~50 MeV

**Reconstruction Thresholds(recob::Wire & recob::Hit & Dead wires)** = ~50 MeV

**Shower Reconstruction (incomplete showers, missing hits)** = ~50 MeV



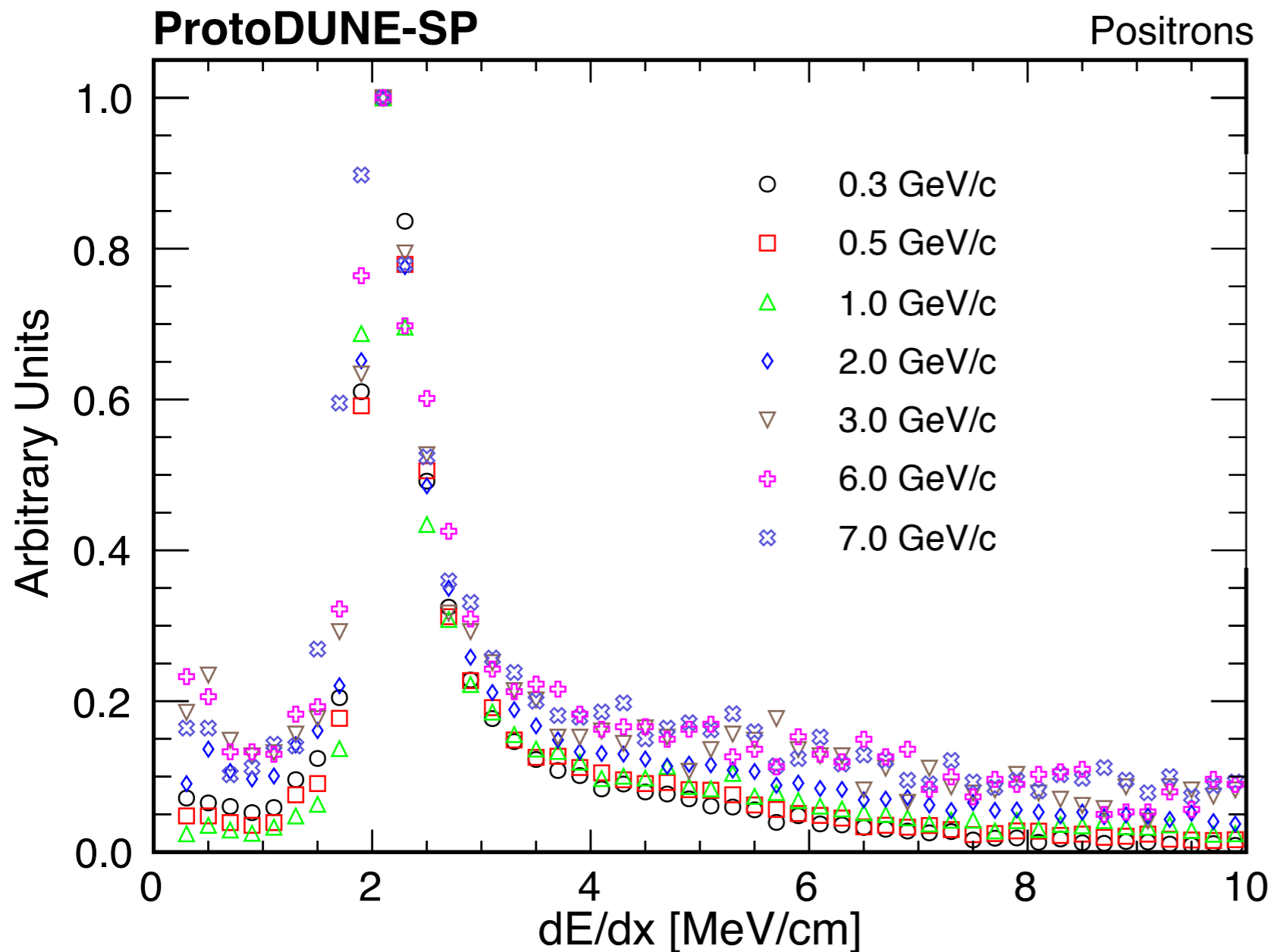
Look at others momenta

(0.3, 0.5, 1.0, 2.0, 3.0, 6.0, 7.0) GeV/c

Runs (5834, 5826, 5809, 5824, 5777, 5770, 5145)

# dE/dx vs Various Momenta

- Calibration procedure à la Ajib (based on cosmic muon dE/dx w/SCE calibration based on one E-field map)
- Look at others momenta



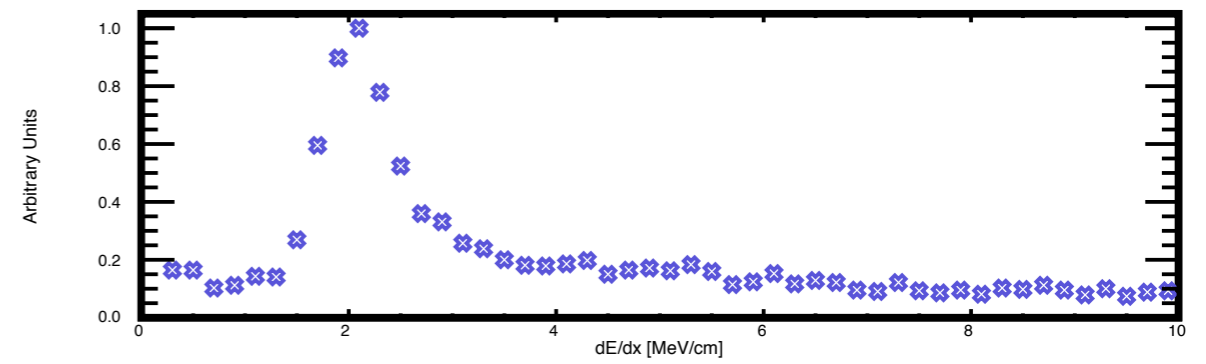
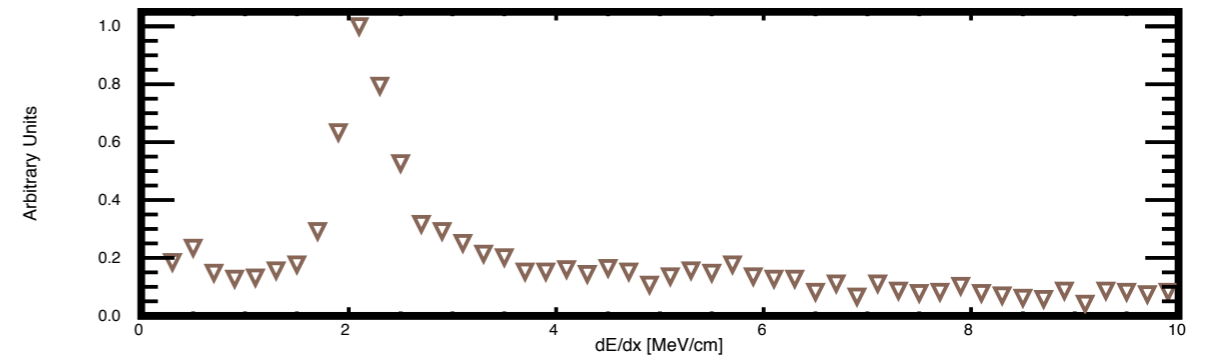
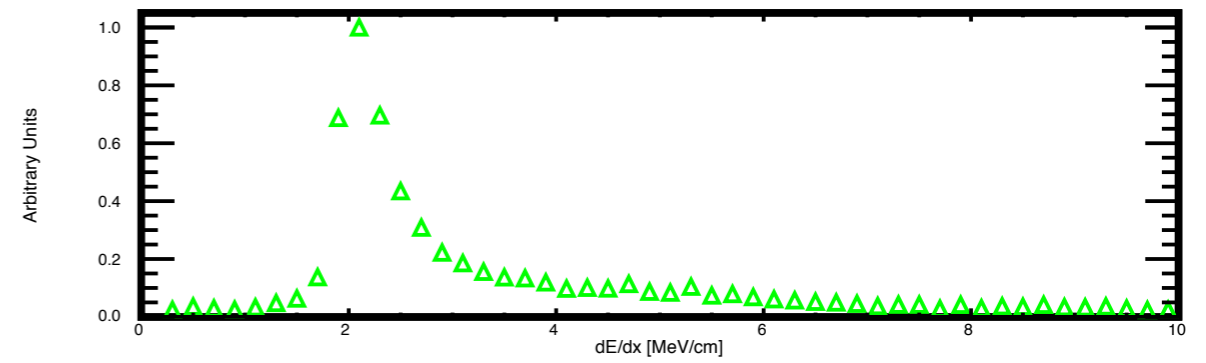
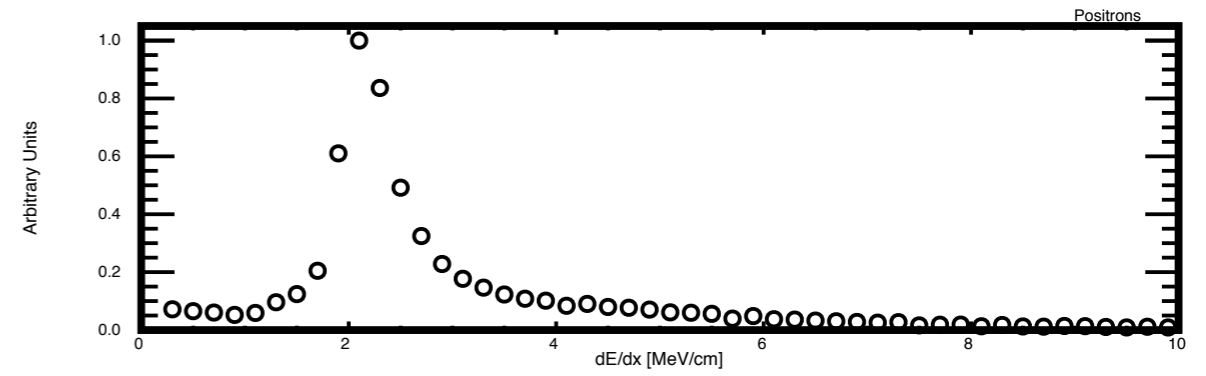
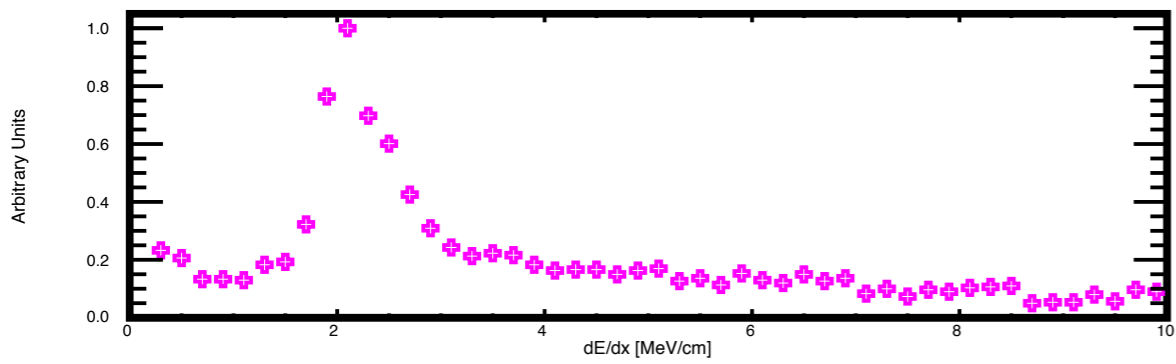
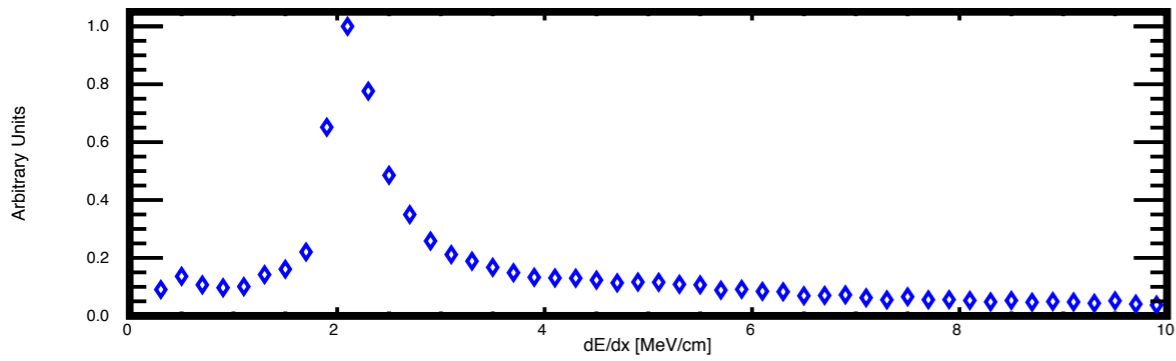
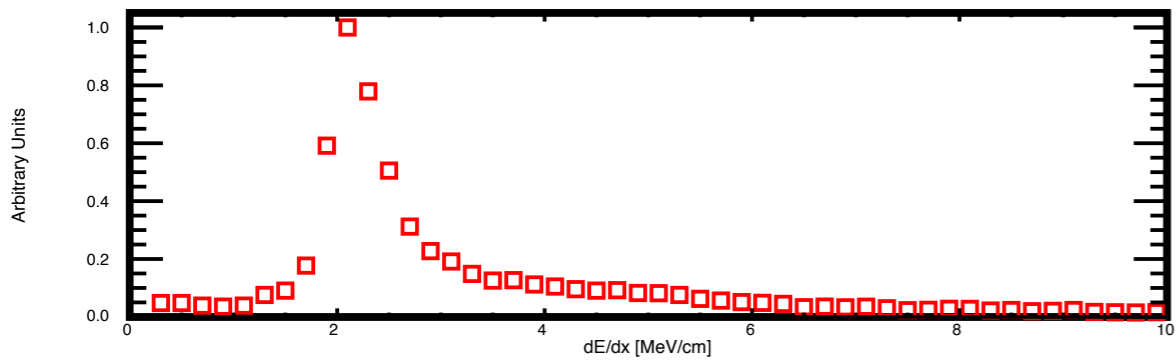
- To cross check my calibration I looked at dE/dx at the beginning of the shower for every run



# dE/dx

ProtoDUNE-SP

- 0.3 GeV/c
- 0.5 GeV/c
- △ 1.0 GeV/c
- ◇ 2.0 GeV/c
- ▽ 3.0 GeV/c
- ⊕ 6.0 GeV/c
- ⊗ 7.0 GeV/c

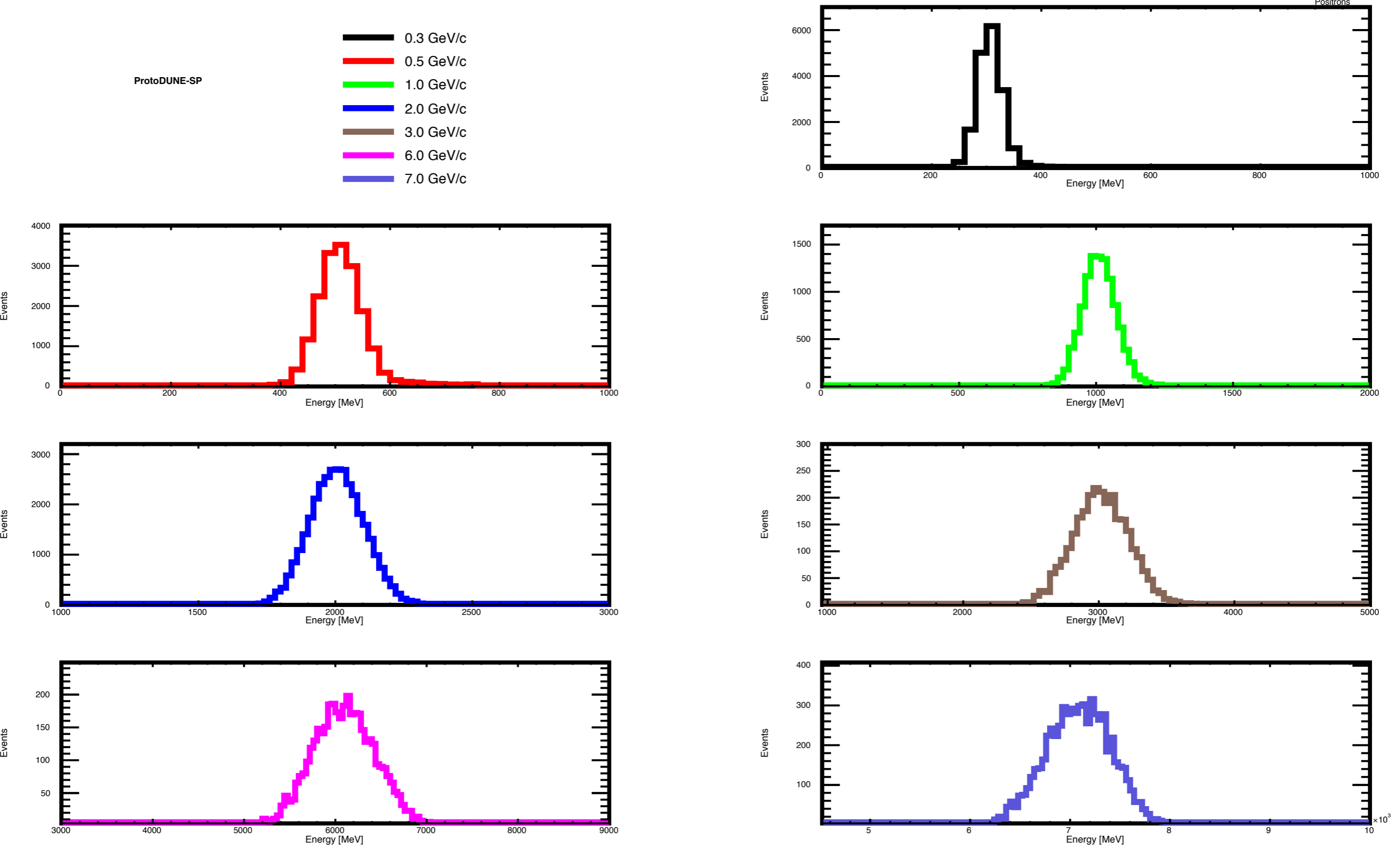


# Momentum Reconstruction (Beamline)

ProtoDUNE-SP

- 0.3 GeV/c
- 0.5 GeV/c
- 1.0 GeV/c
- 2.0 GeV/c
- 3.0 GeV/c
- 6.0 GeV/c
- 7.0 GeV/c

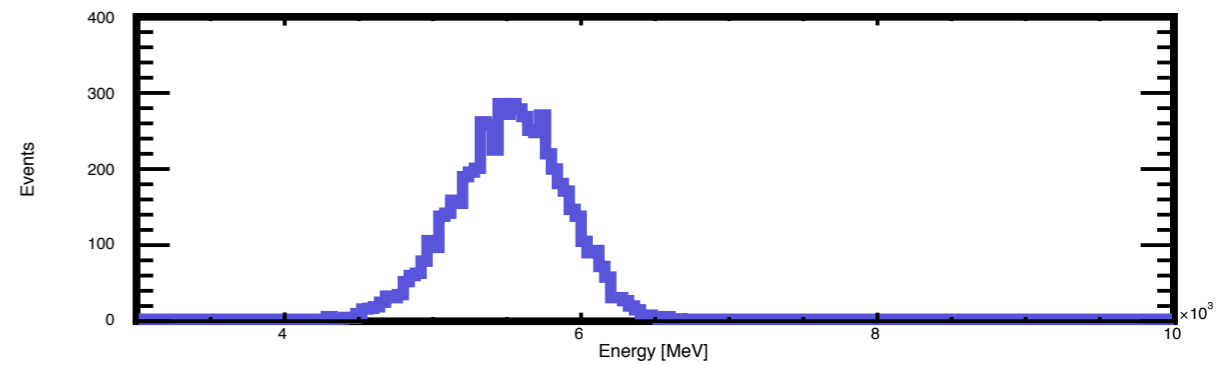
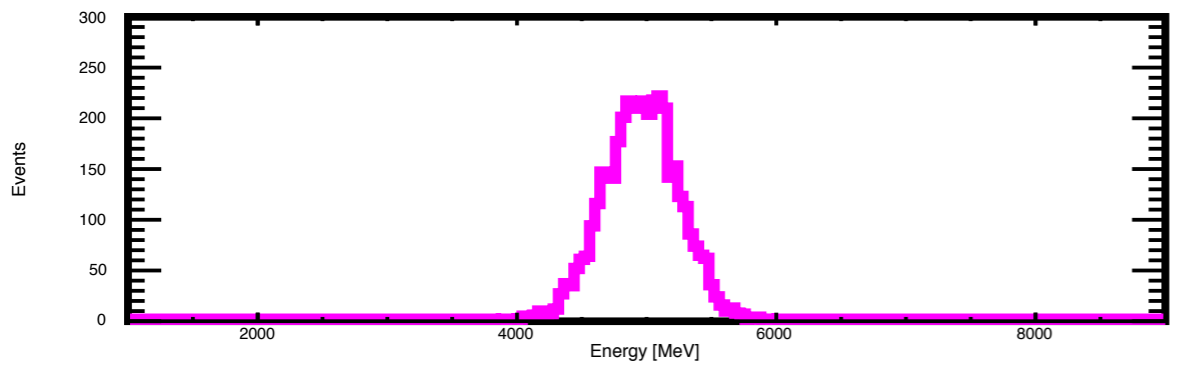
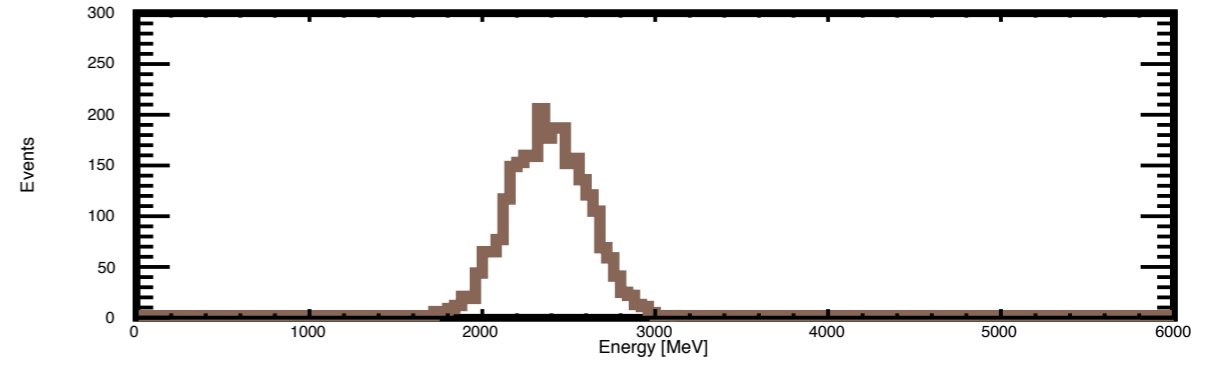
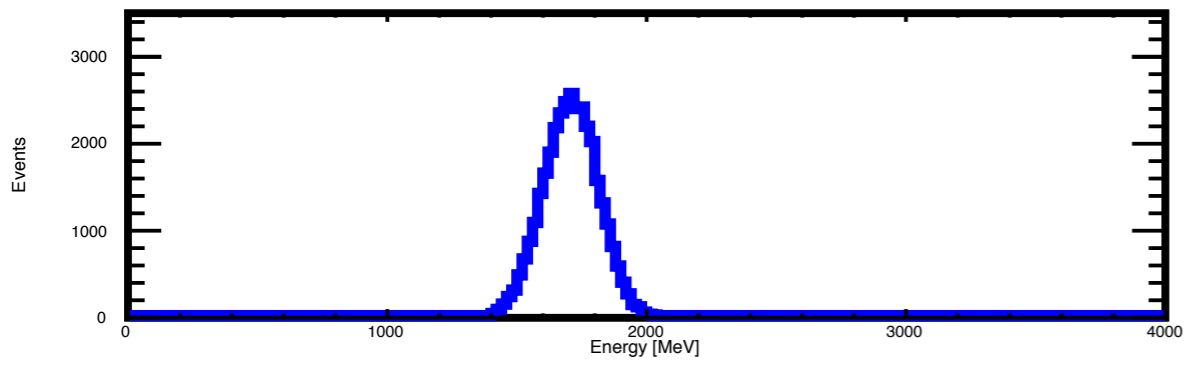
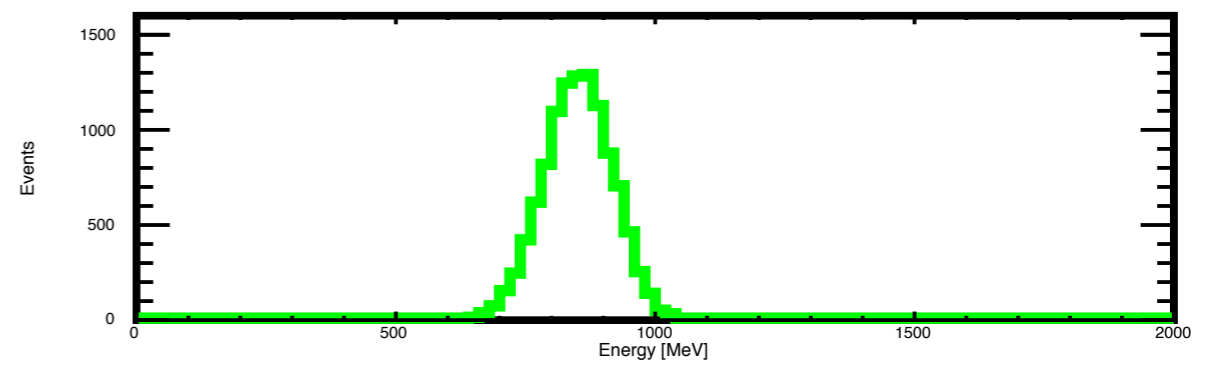
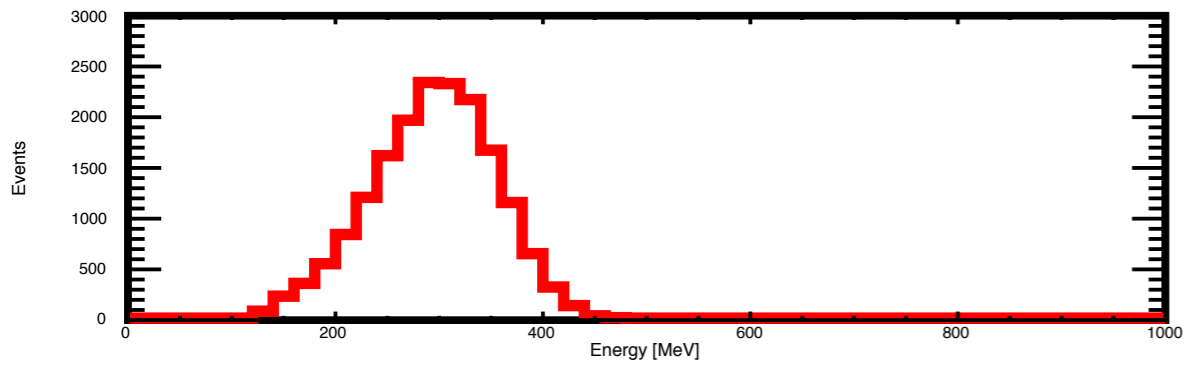
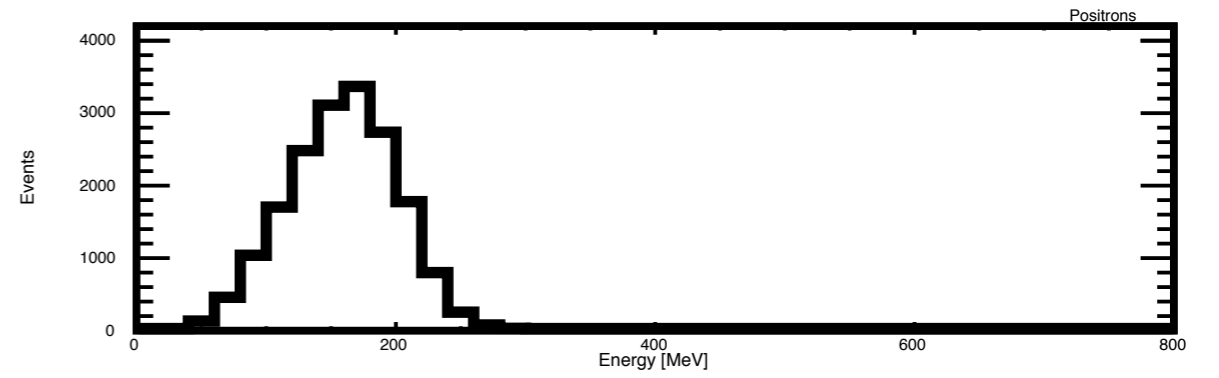
Positrons



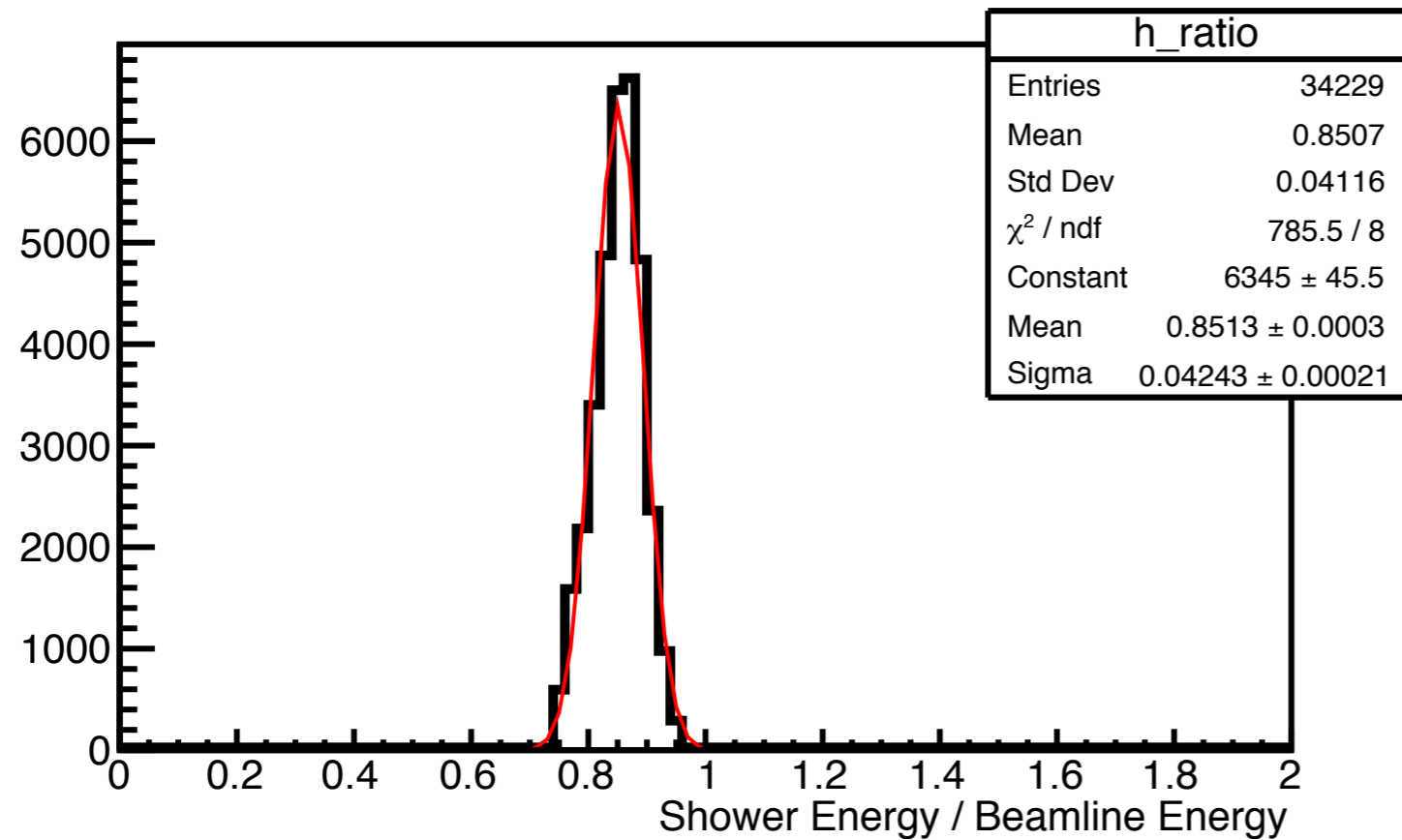
# Energy Reconstruction

ProtoDUNE-SP

- 0.3 GeV/c
- 0.5 GeV/c
- 1.0 GeV/c
- 2.0 GeV/c
- 3.0 GeV/c
- 6.0 GeV/c
- 7.0 GeV/c

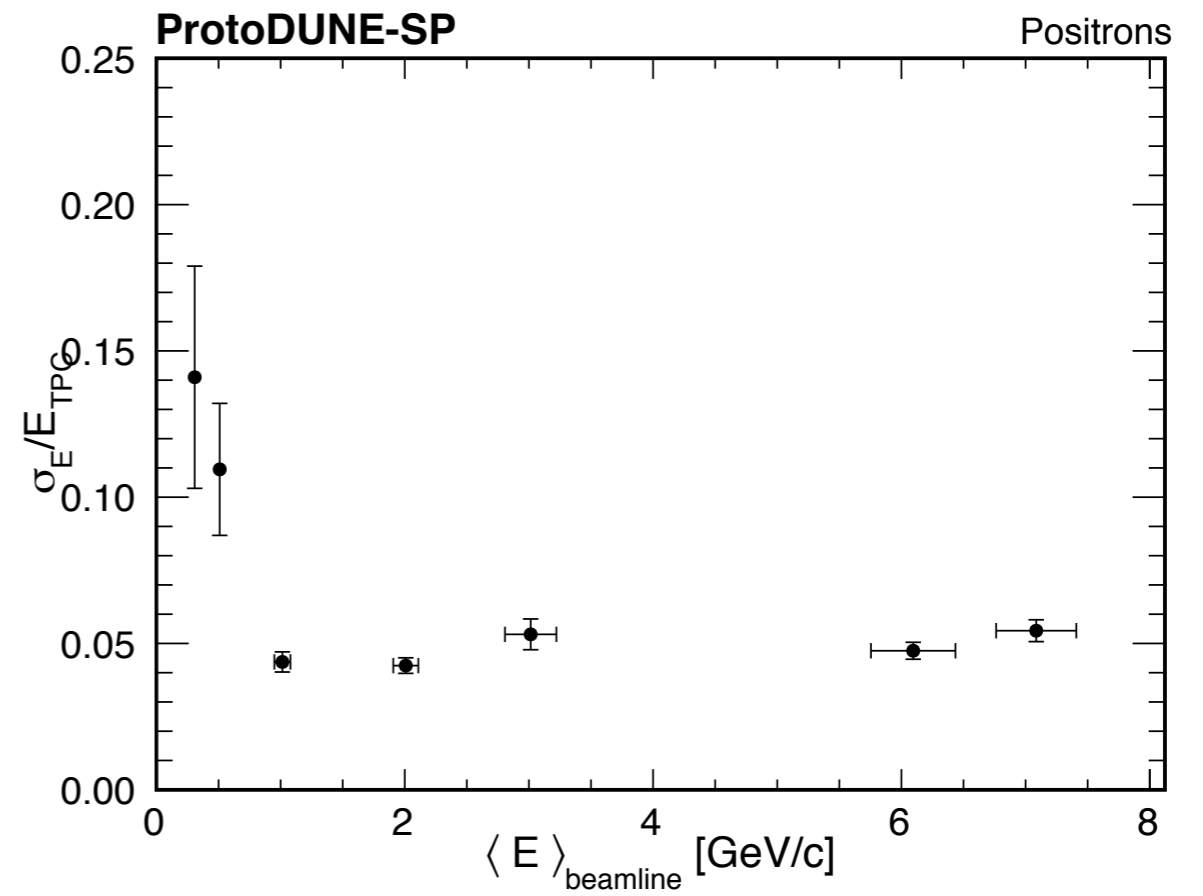
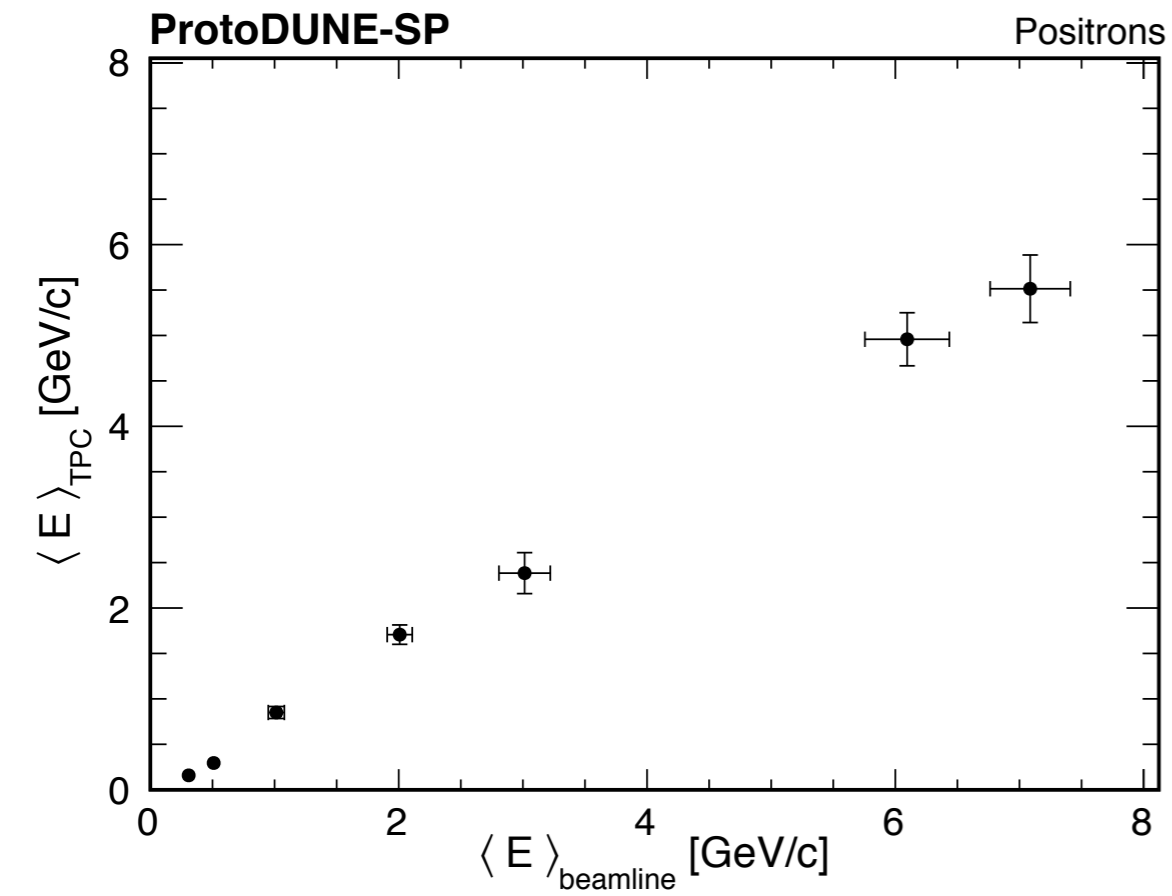


# Energy Resolution



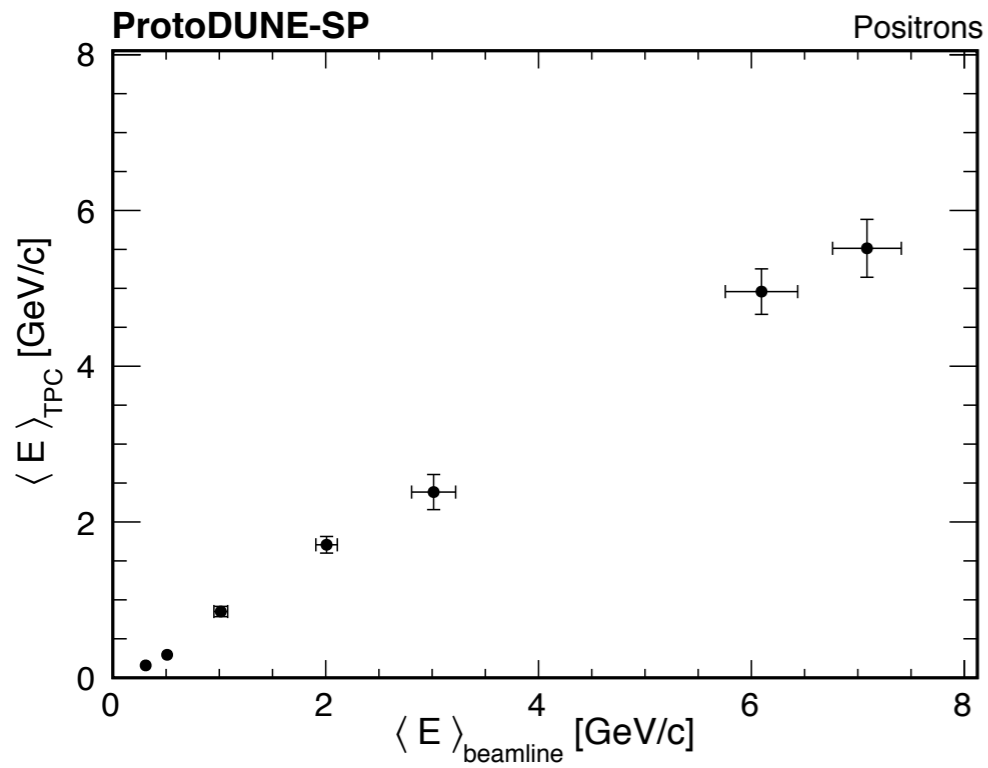
- How do we calculate  $\sigma(E)$ ?
- For now fit the ratio of shower energy / beamline energy

# Energy Resolution

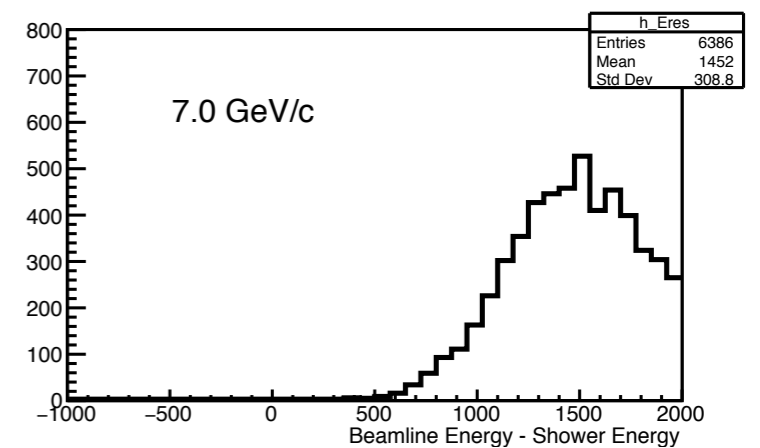
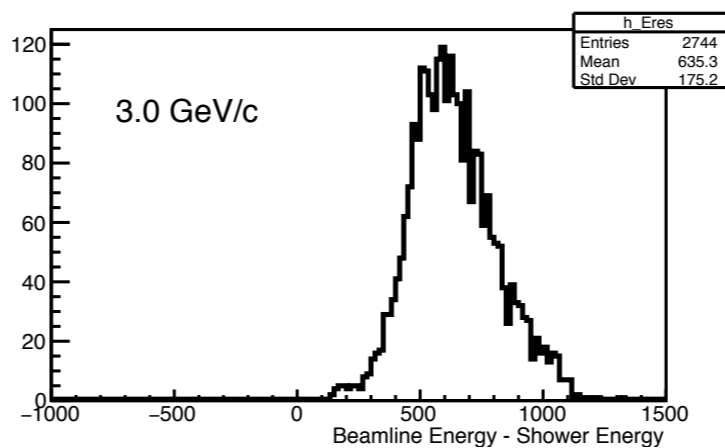
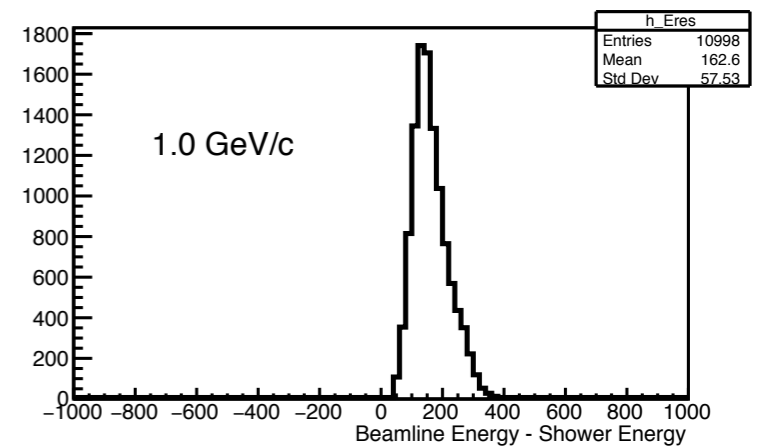
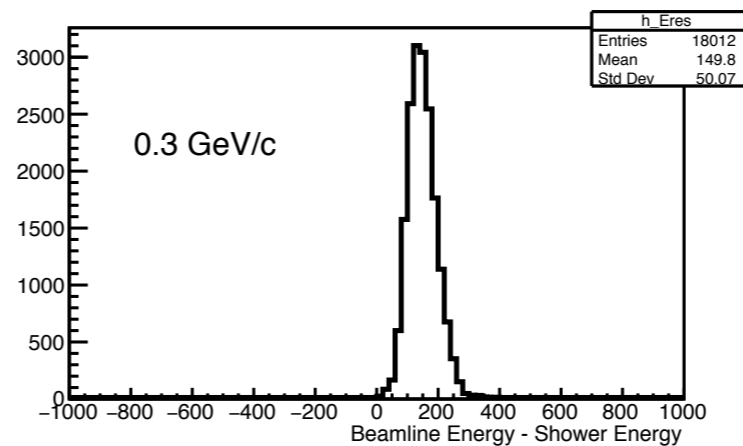


- Only statistics errors

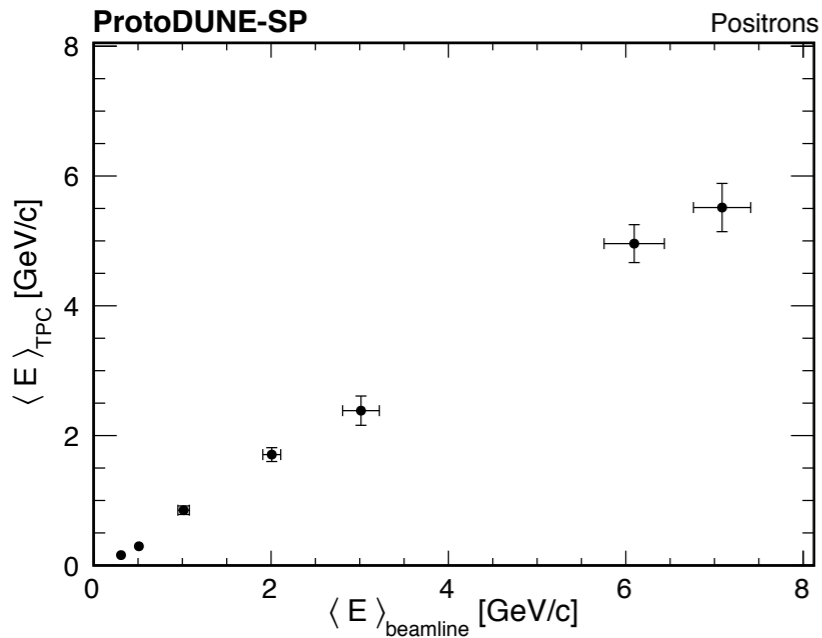
# Electron Analysis



- As momentum increase energy reconstruction is getting slightly worse
- Why?
- Homogenous calorimeter should work better at high energies

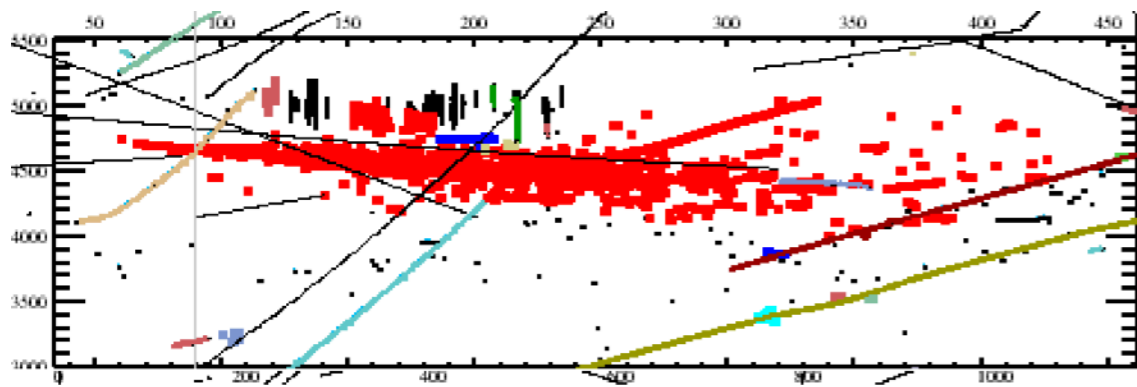


# Electron Analysis

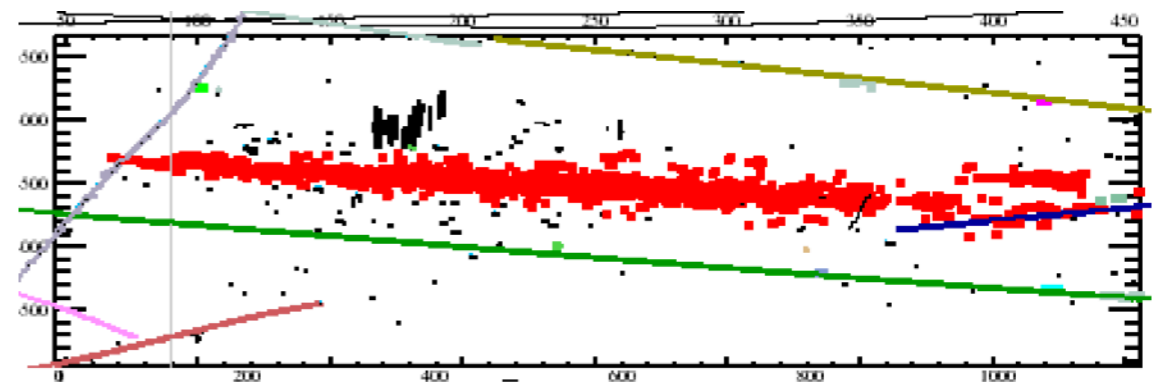


- As momentum increase energy reconstruction is getting slightly worse
- Why?
- Is there an issue with shower reconstruction? No, selection is working properly to include well reconstructed (complete) showers

7GeV/c 5145/247640

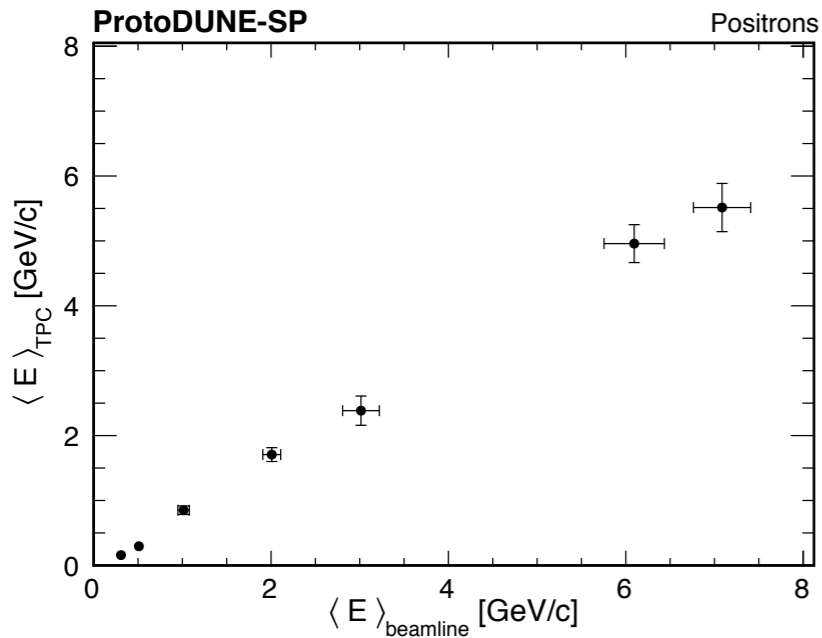


7GeV/c 5145/247645



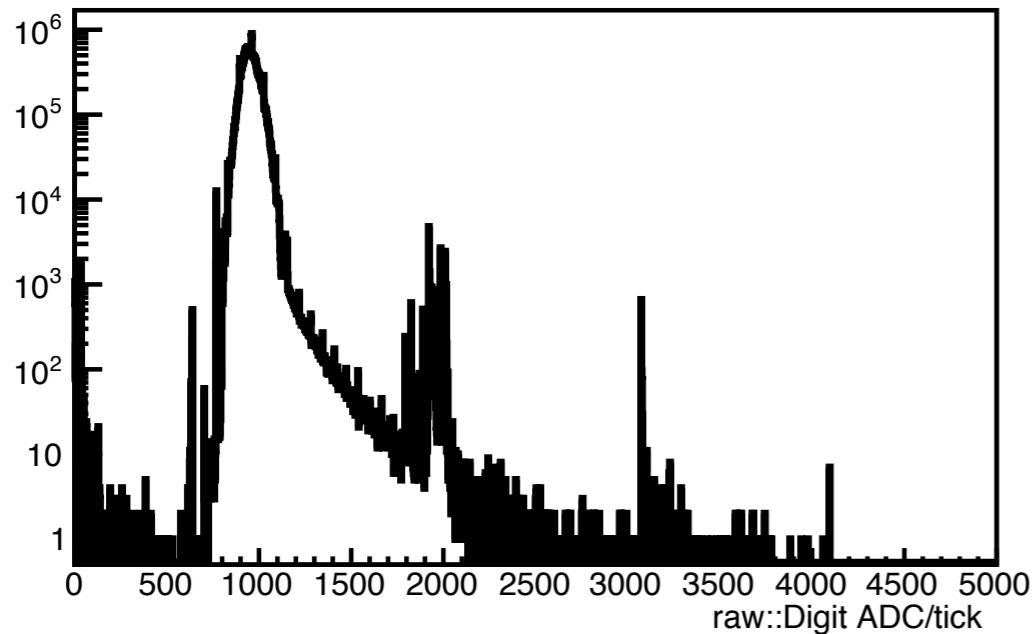
- After a few scan not obvious issue with the patten recognition

# Electron Analysis

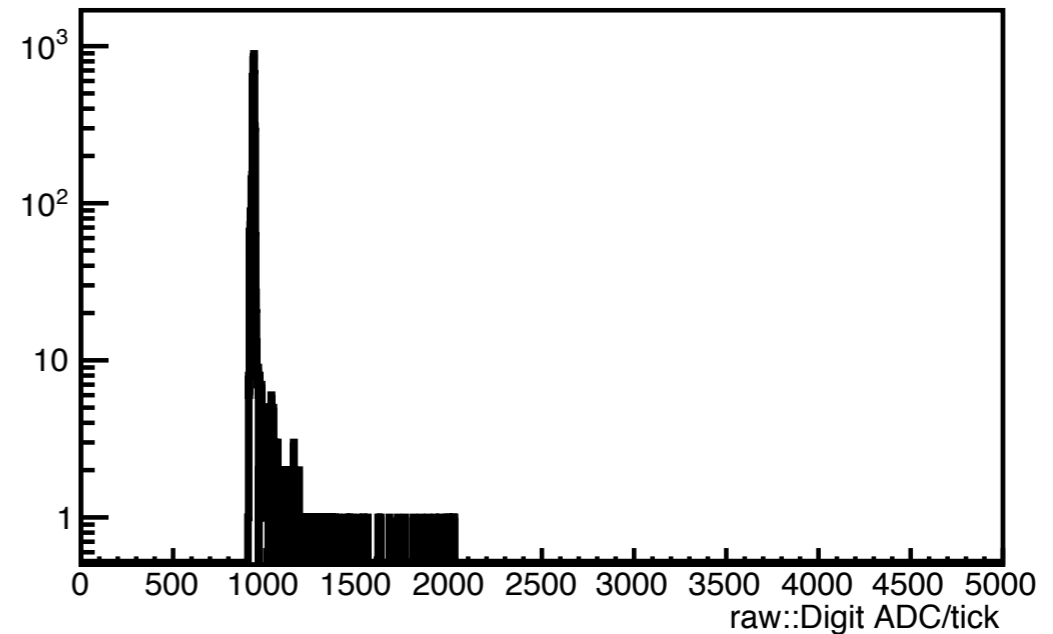


- As momentum increase energy reconstruction is getting slightly worse
- Why?
- Are we seeing saturation due to heavy ionization and/or large pulses?
- Look at raw::Digit ADC (collection plane)

7GeV/c 5145/247640



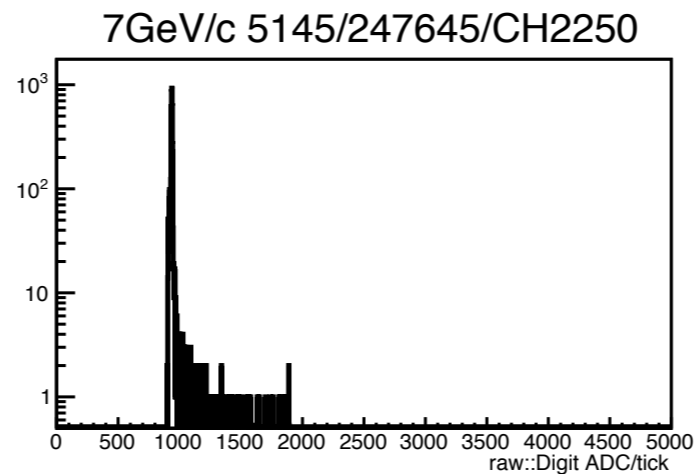
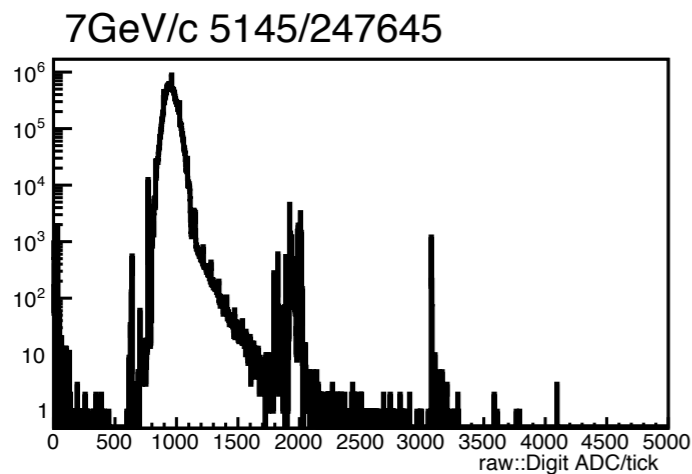
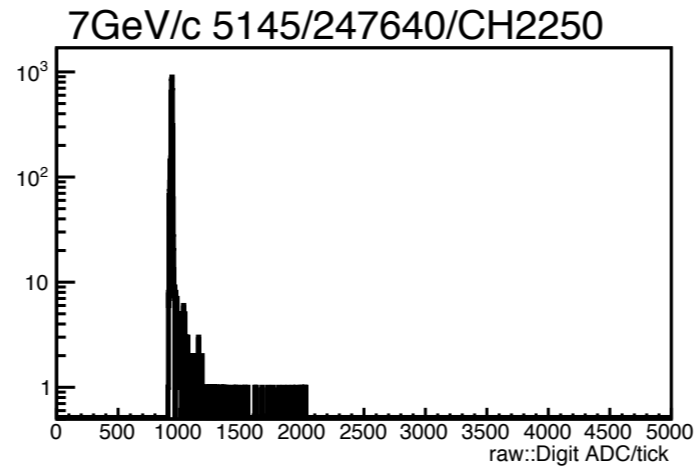
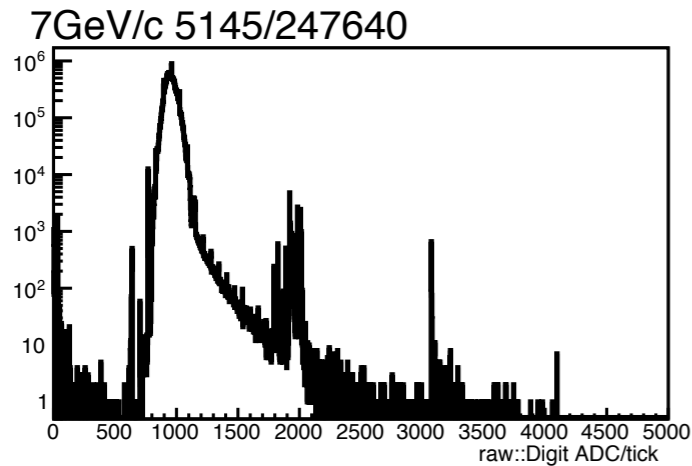
7GeV/c 5145/247640/CH2250





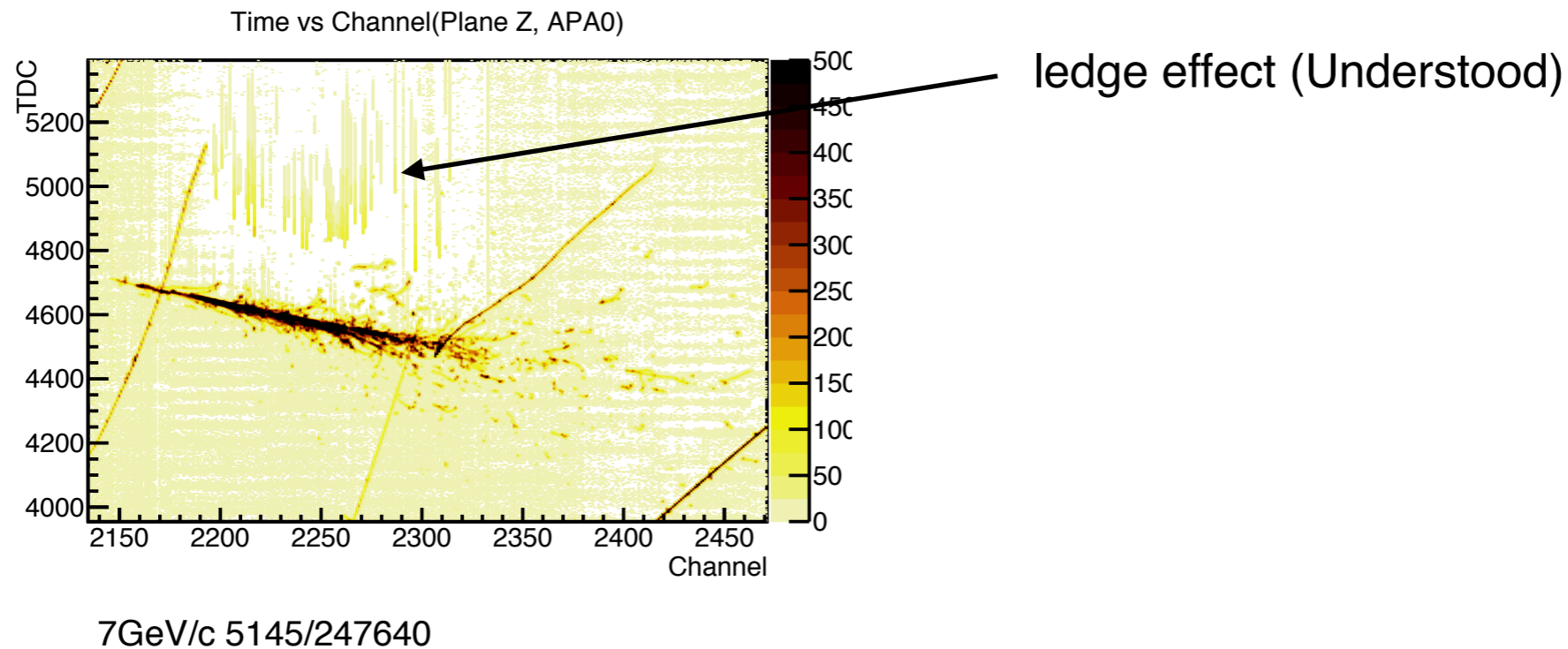
# Electron Analysis

- Look at raw::Digit ADC (collection plane)
- The ADC ASIC has 16 independent 12-bit digitizers (Max ADC is 4095)
- Saturation seems to start at ~1200 ADC/tick?



# Electron Analysis

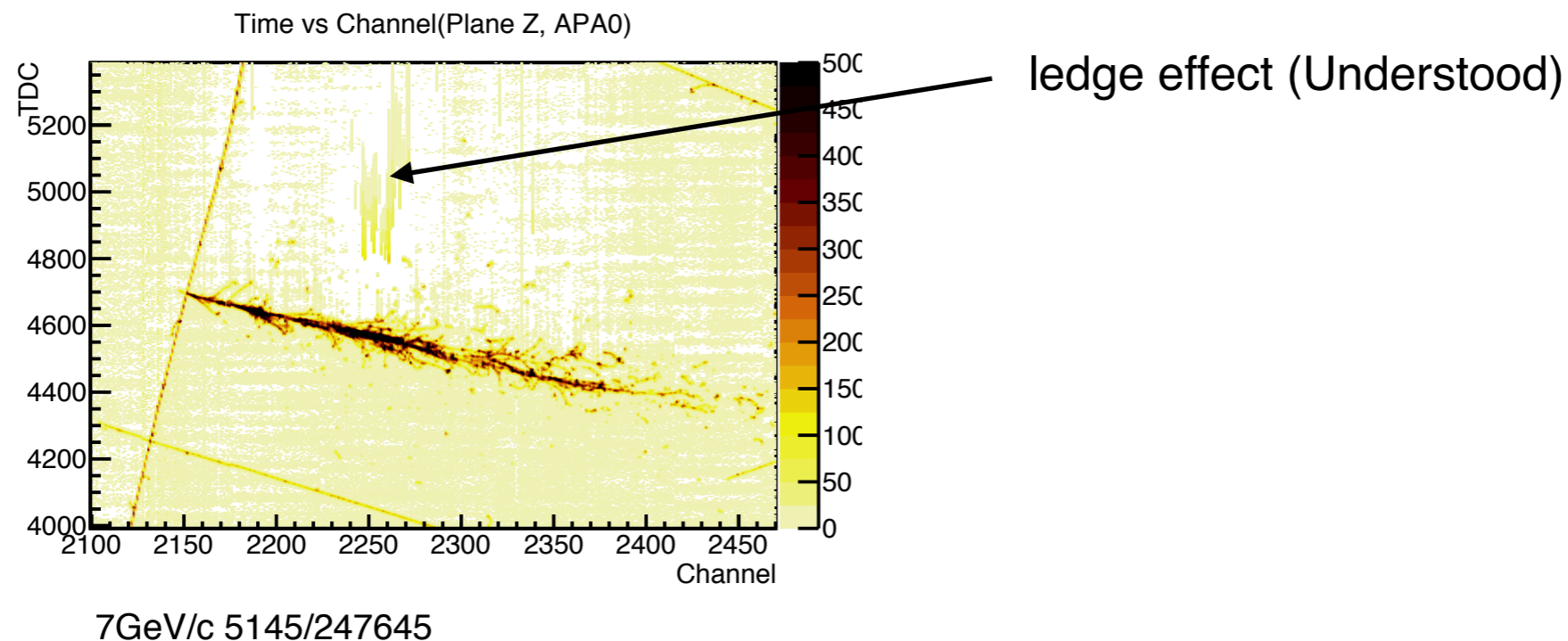
- Are we seeing saturation due to heavy ionization and/or large pulses?
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number of ADC uncompressed without pedestal

# Electron Analysis

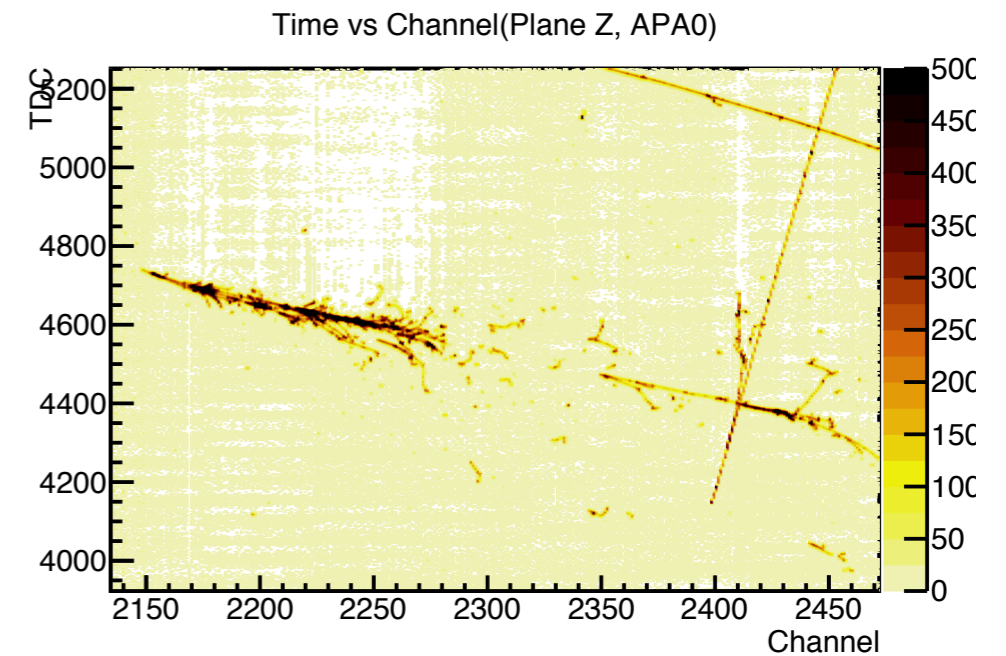
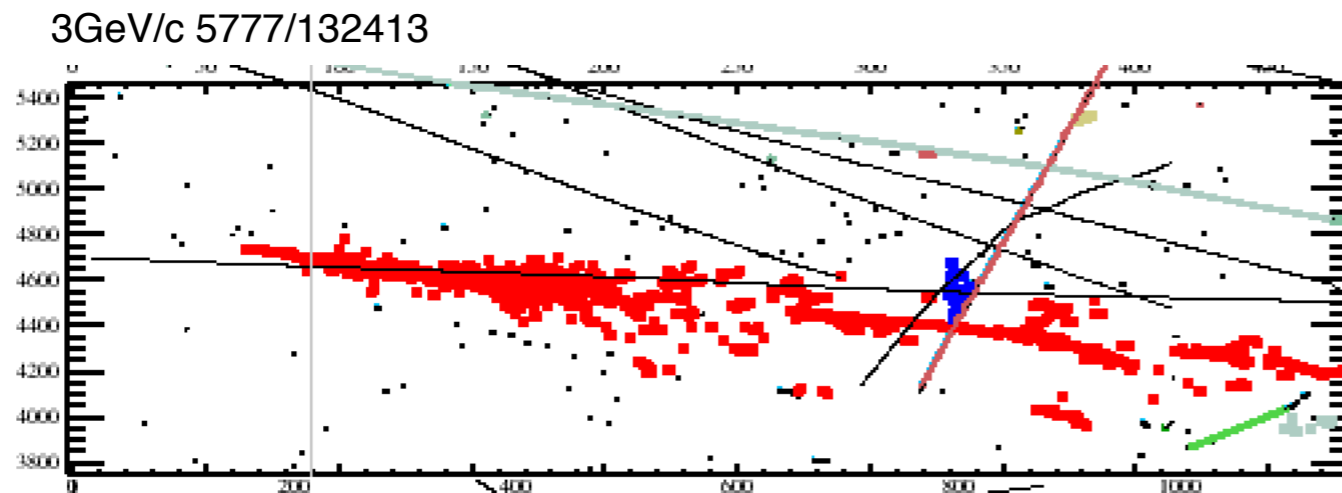
- Are we seeing saturation due to heavy ionization and/or large pulses?
- Look at raw::Digit ADC (collection plane)
- The ADC ASIC has 16 independent 12-bit digitizers (Max ADC is 4095)
- Are we seeing saturation due to heavy ionization and/or large pulses?



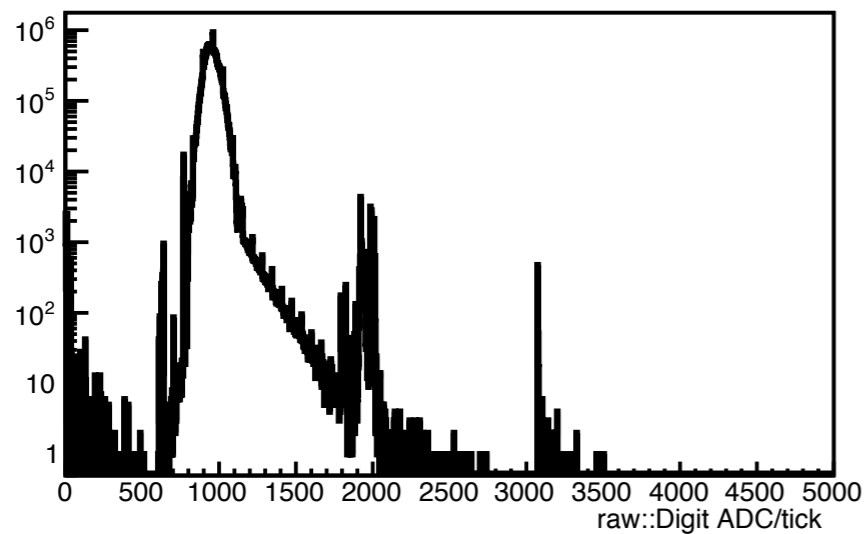
number of ADC uncompressed without pedestal

# Electron Analysis

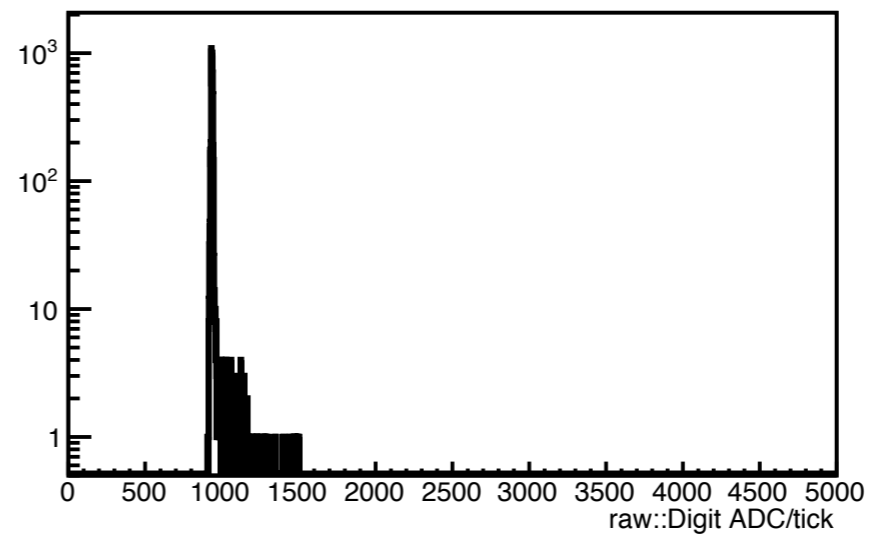
- Do we have ADC saturation due the high energy shower?
- Look at raw::Digit ADC (collection plane)



3GeV/c 5777/132413

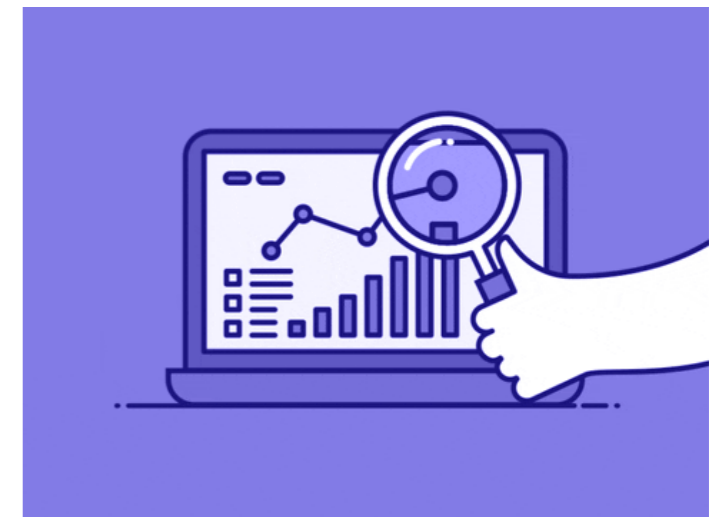


3GeV/c 5777/132413 CH2250

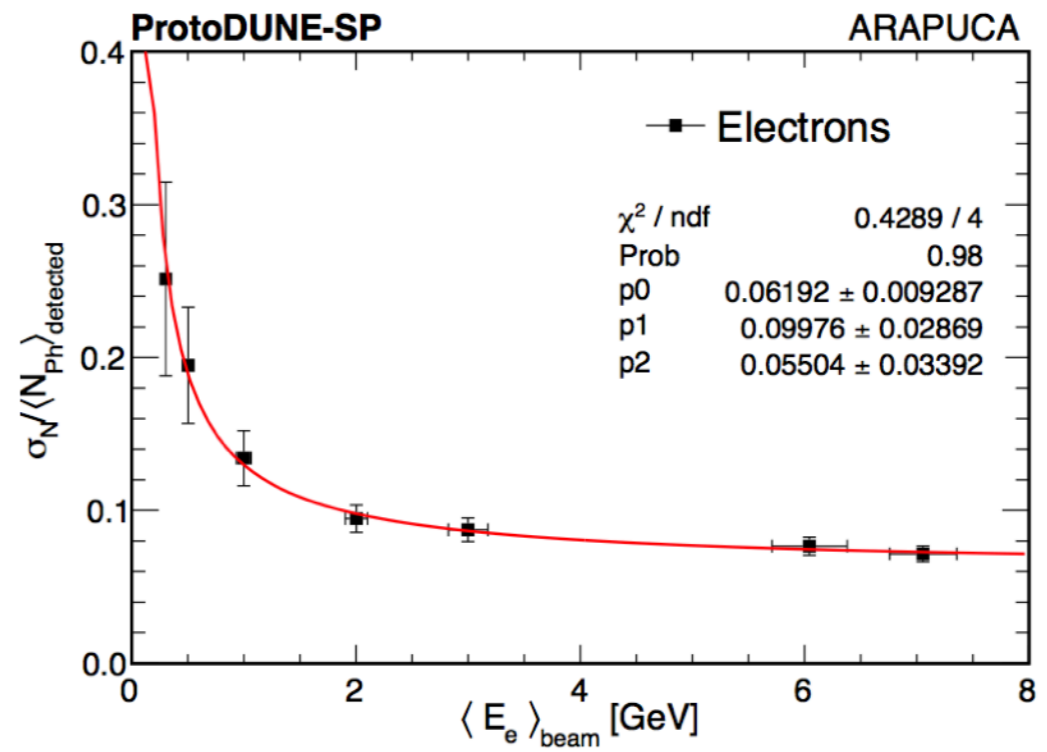
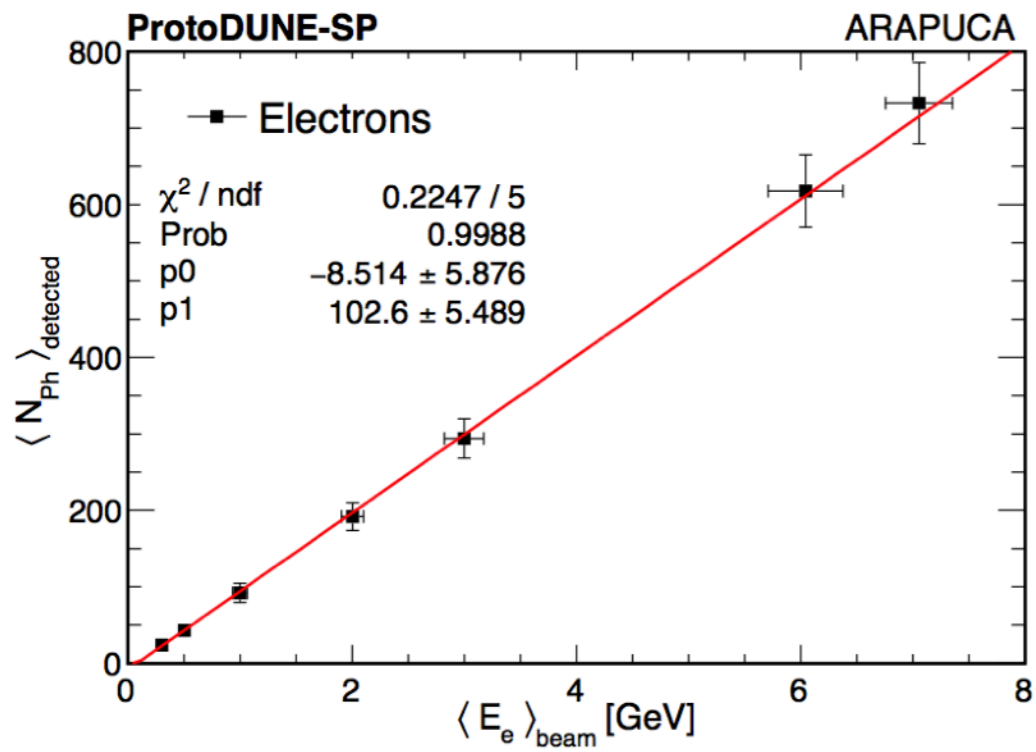
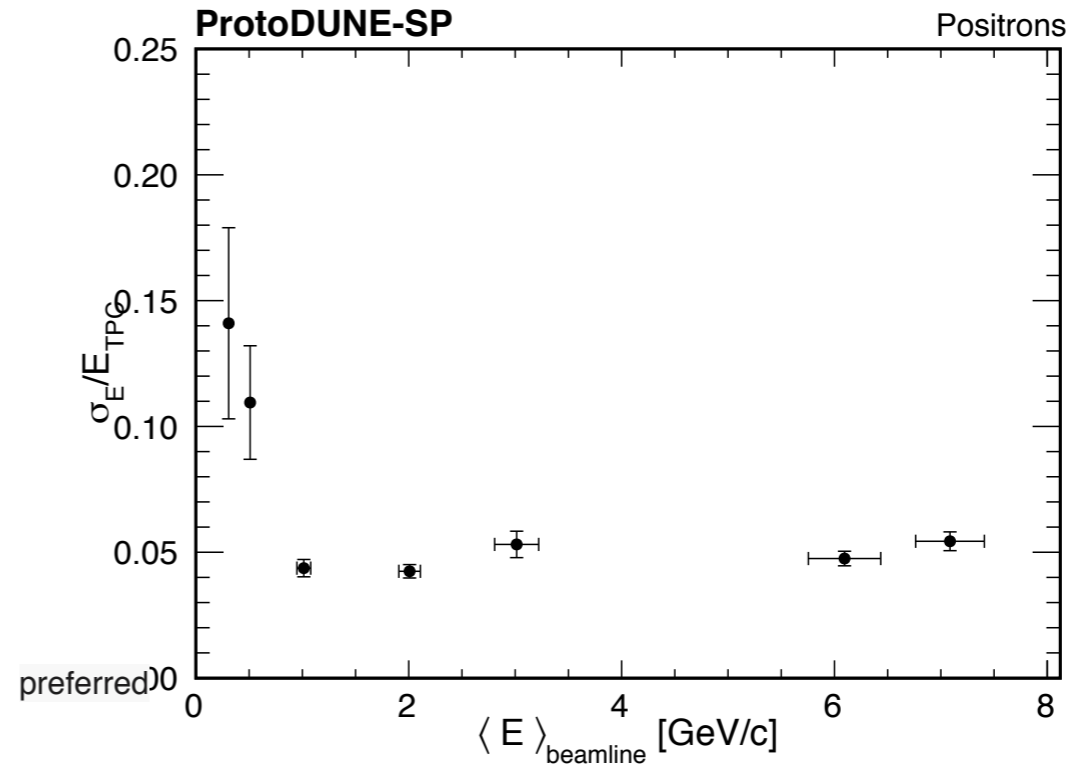
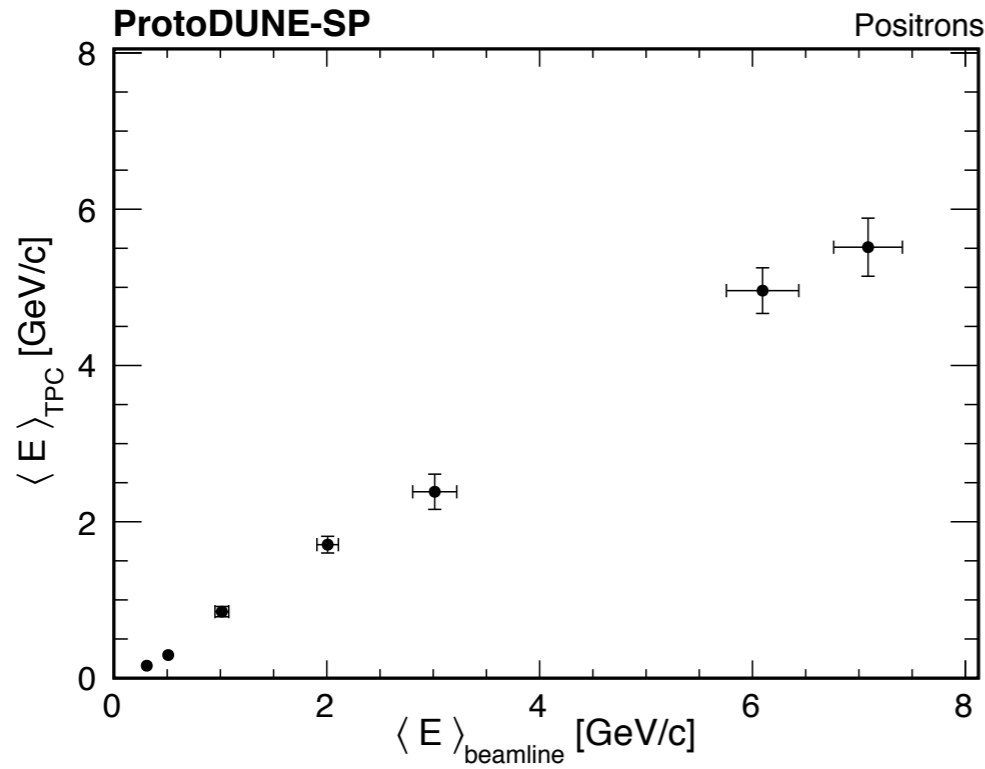


# Summary

- It is a lot of fun looking at the data
- Many things have been understood
- More to understand... and more fun to come
  - ADC saturation has an impact on energy resolution
  - Need to flag this events and probably skip them, how?
  - More MC studies for every momentum

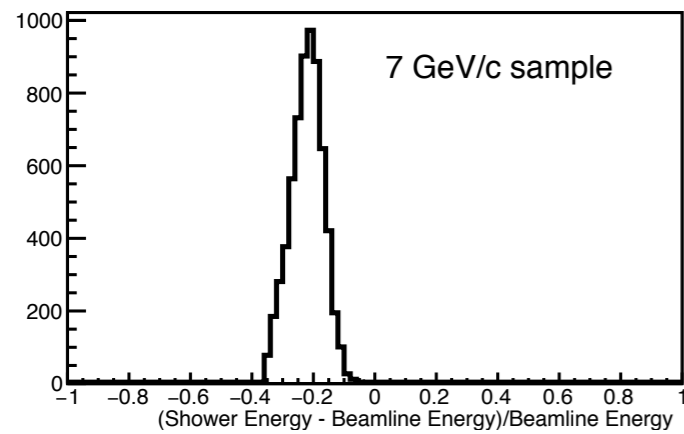
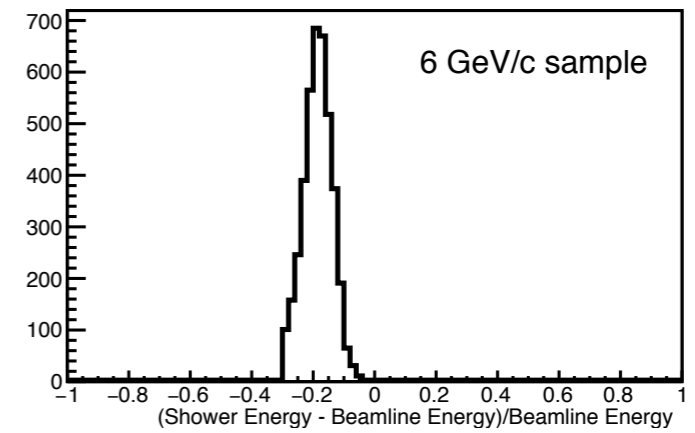
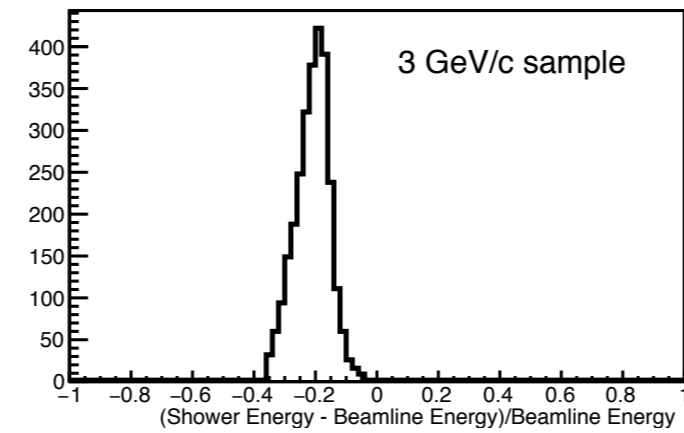
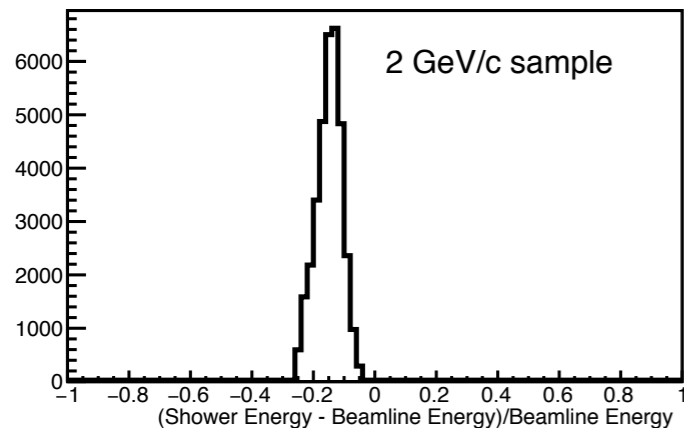
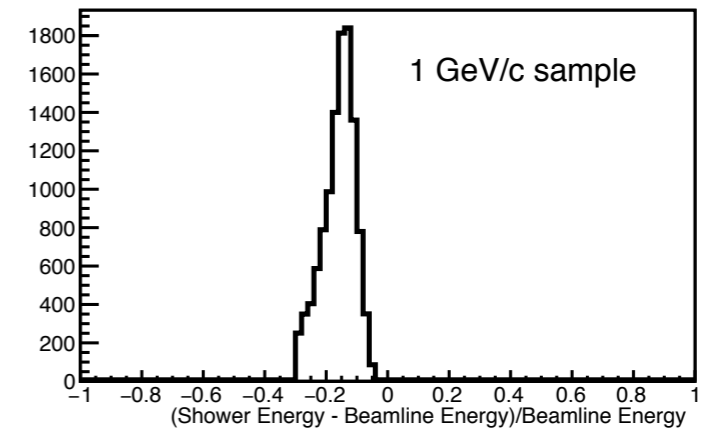
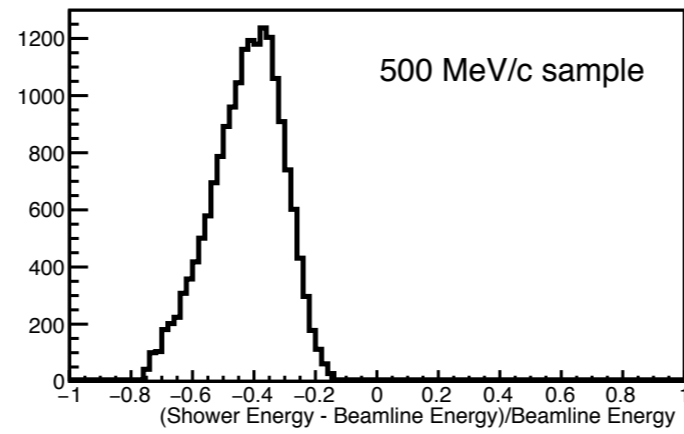
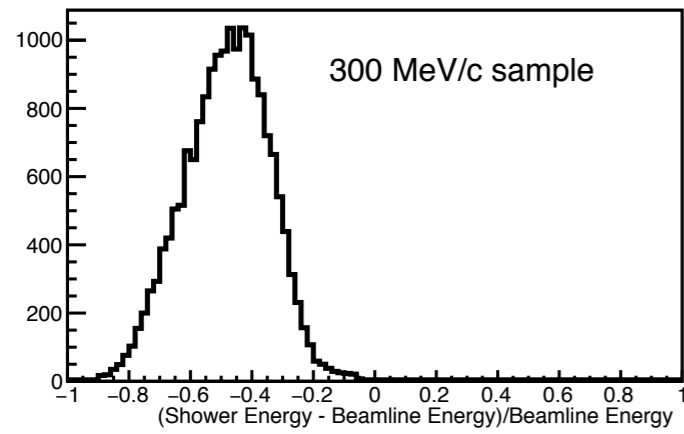


# Summary



The End

# Extras





# Extras

