π^0 reconstruction in DUNE Far Detector

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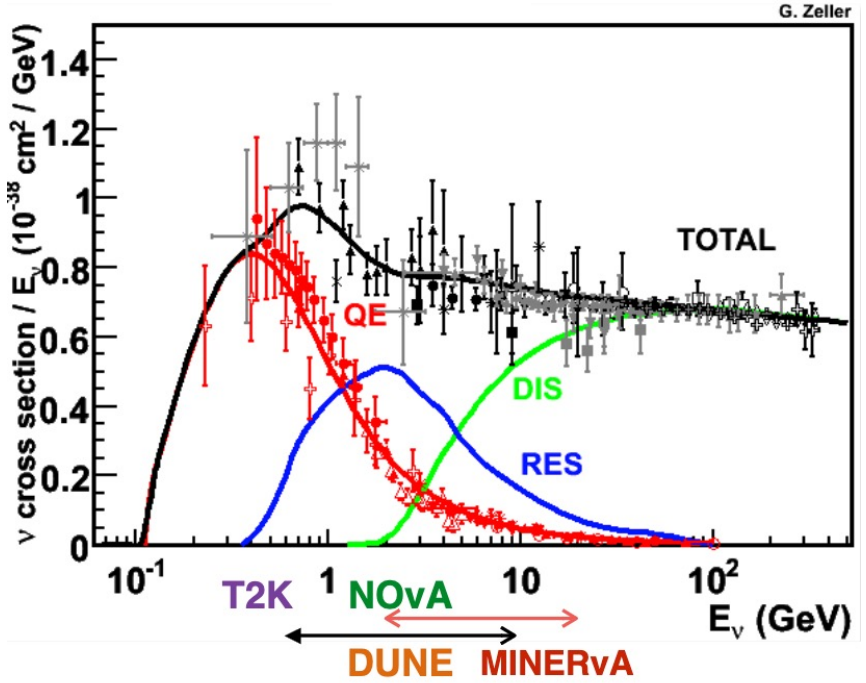
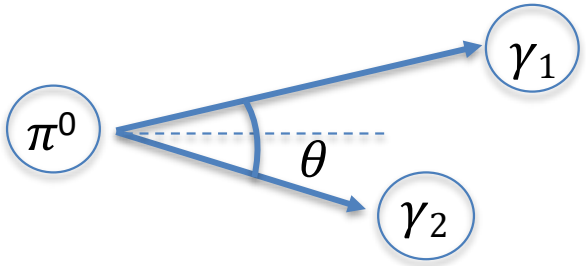
π^0's in DUNE

- π^0 are produced in neutrino interaction via resonant pion production and decays promptly to two photons
- Important to reconstruct in DUNE
  - Background in ν_e appearance (from ν_μ NC interaction)
  - Calibration method for EM shower energy

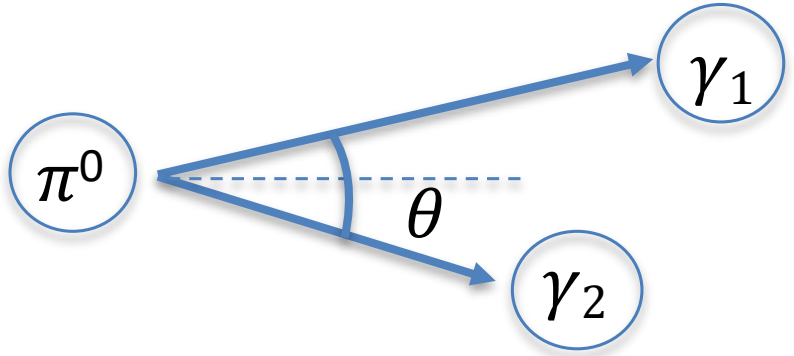


J.A. Formaggio, G. Zeller, Reviews of Modern Physics, 84 (2012)



π^0 reconstruction in DUNE

- π^0 are generally difficult to reconstruct
  - Showers have a small opening angle in lab frame (maximum around 0.5 rad (28°))
  - Most γ_2 are produced at very low energy
- This presentation: first look at FD $\pi^{0's}$ using small sample from the new production
  - Preliminary plots

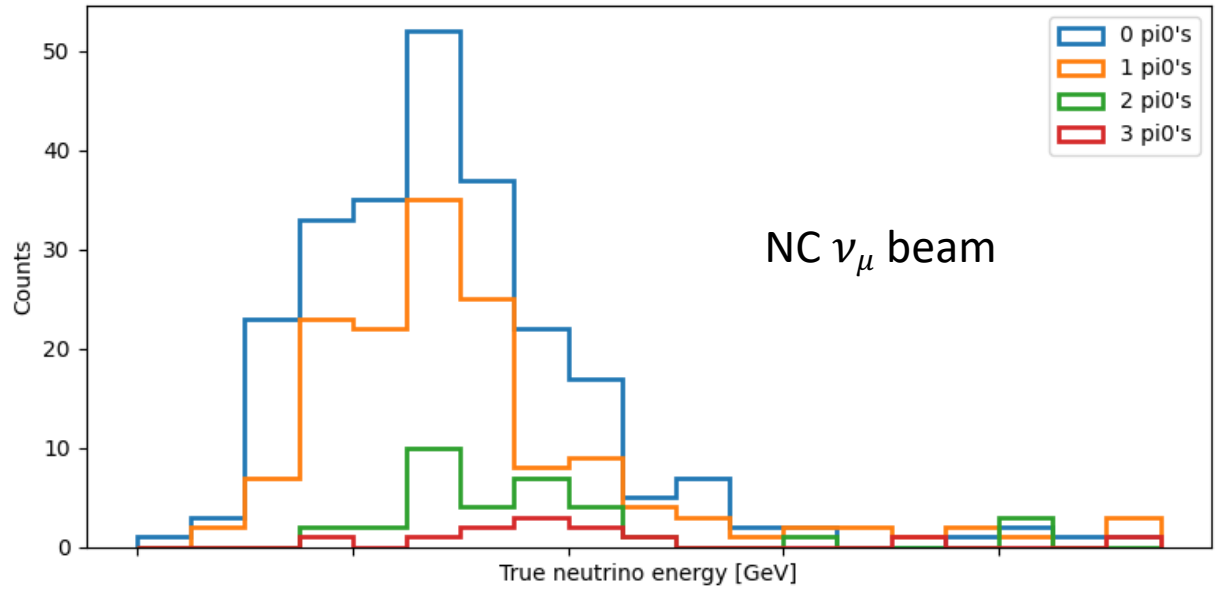


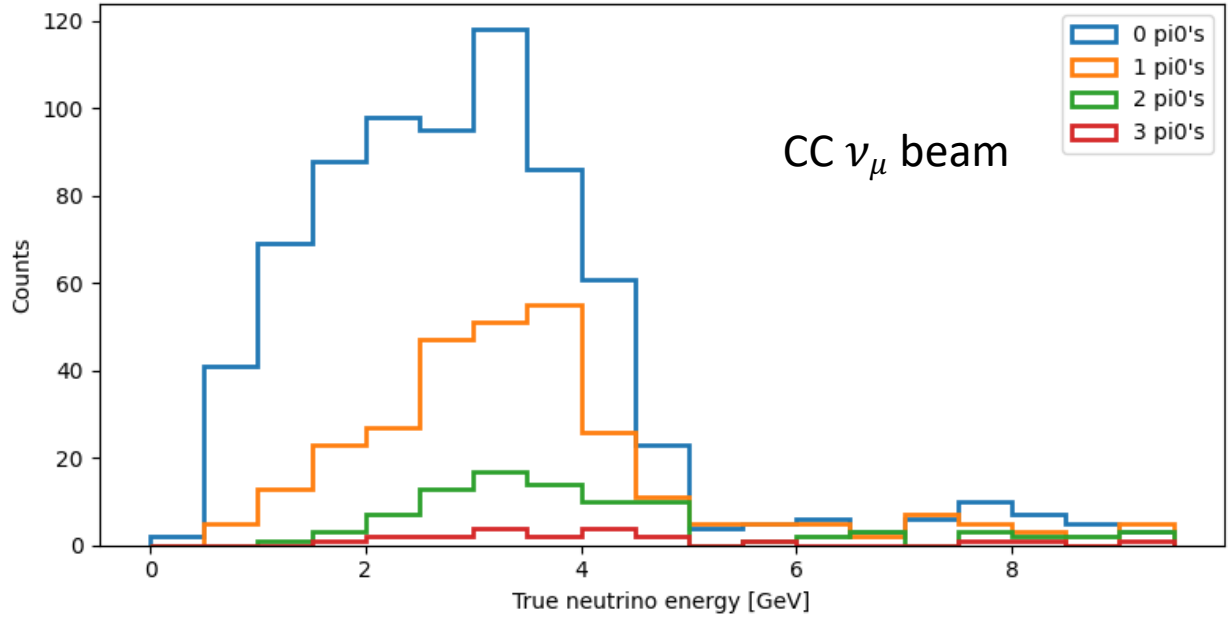
E γ_1 > E γ_2

π^0 produced in FD interactions

ν_μ beam interactions

- 1900 Events : 523 NC interactions and 1377 CC interactions
- If a π^0 has 0 daughters associated in the reconstructed primary daughters, it is not counted here





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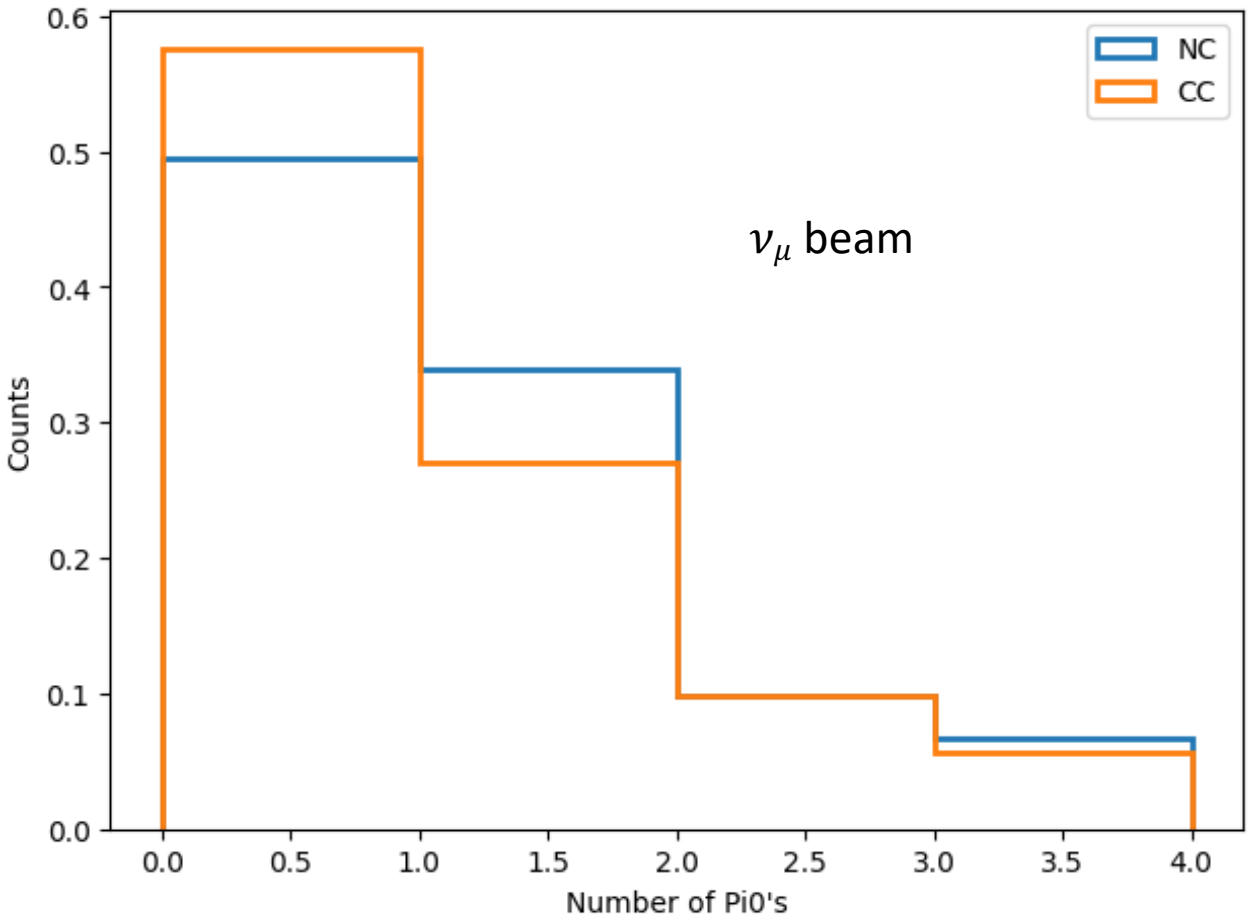
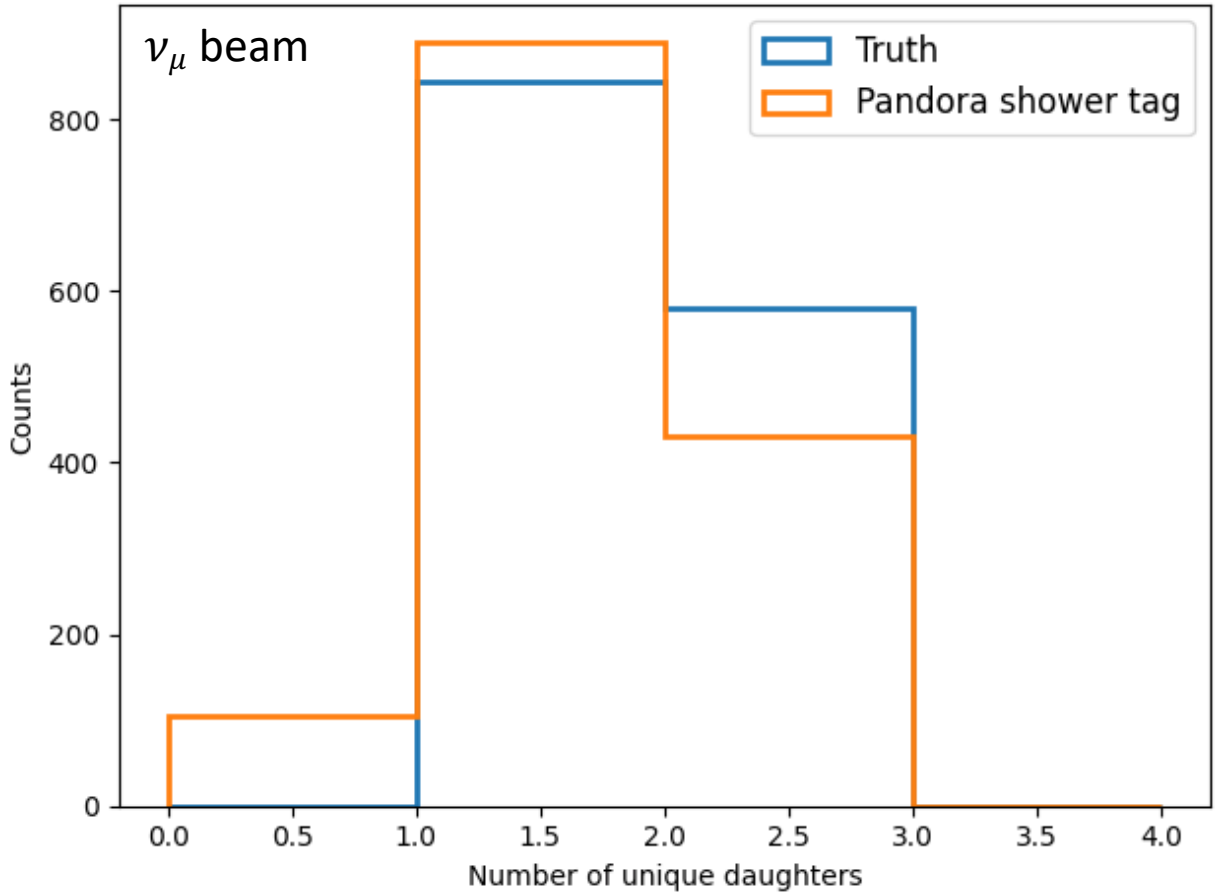


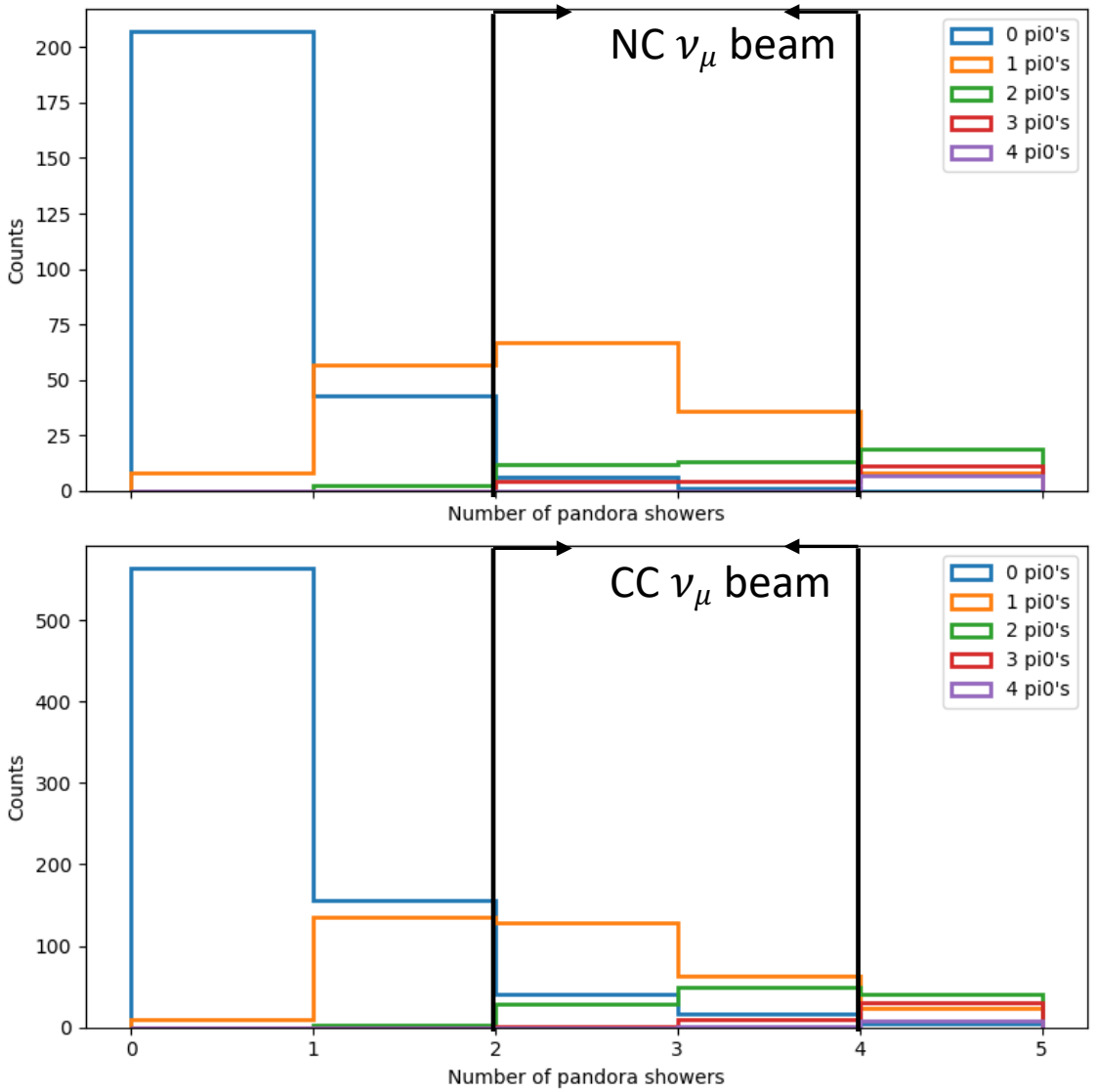
ν_μ beam interactions

- 1900 Events : 523 NC interactions and 1377 CC interactions
- If a π^0 has 0 daughters associated in the reconstructed primary daughters, it is not counted here
- About ~2/3 of the π^0 only have one unique shower in reconstructed daughters with Pandora shower tag



π^0 reconstruction analysis

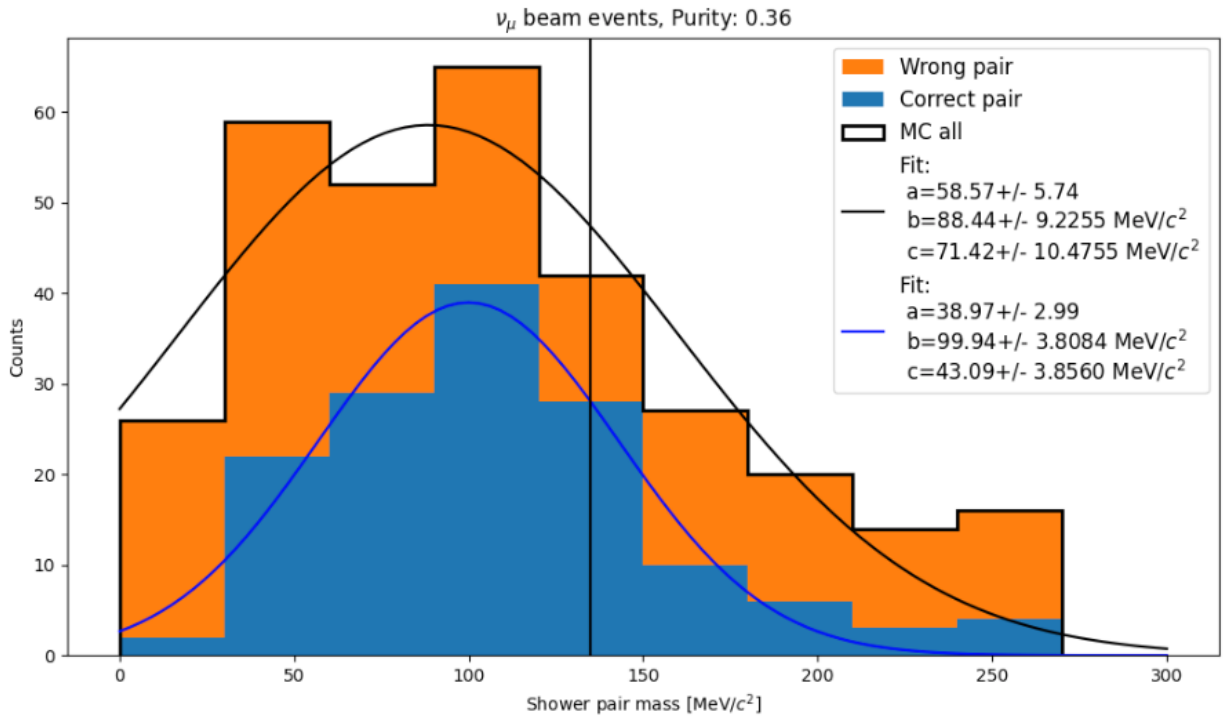
1. Identify EM showers in event primary daughters using Pandora shower tag
   - 1< Number of Pandora showers < 4
2. Select two most energetic showers and reconstruct shower pair
3. Apply selection cuts to improve purity
   1. Opening angle
   2. Shower energy
   3. Shower pair starting distance
4. Shower energy correction



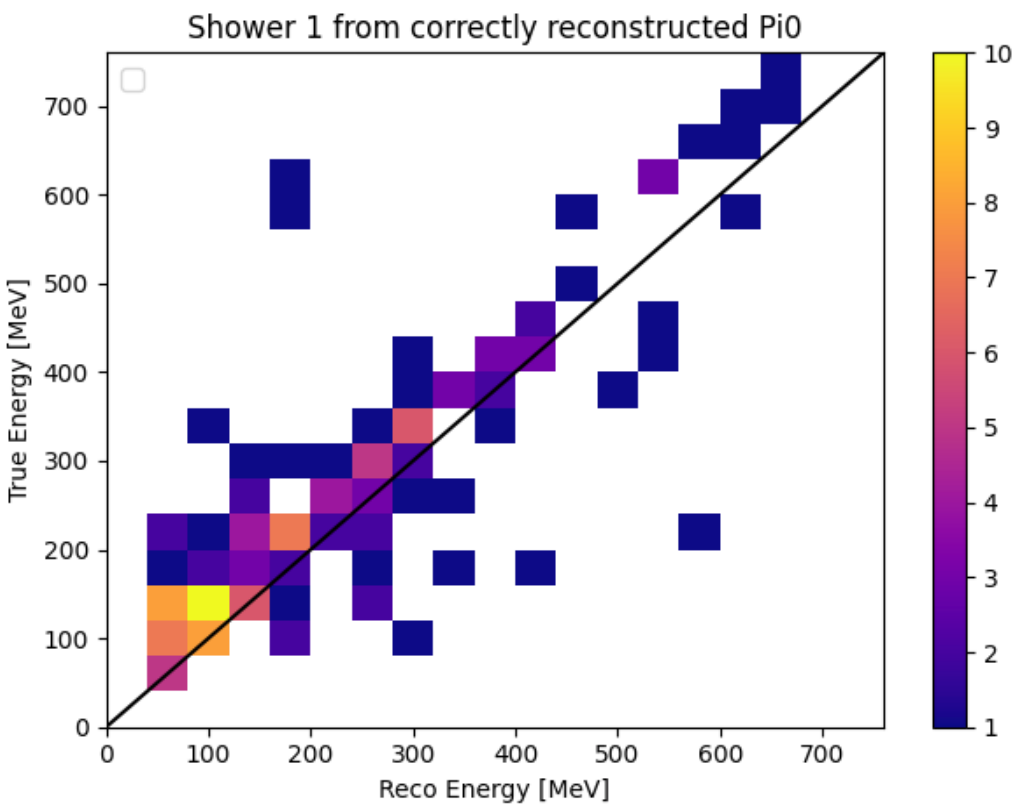
π^0 sample selection (ν_μ beam)

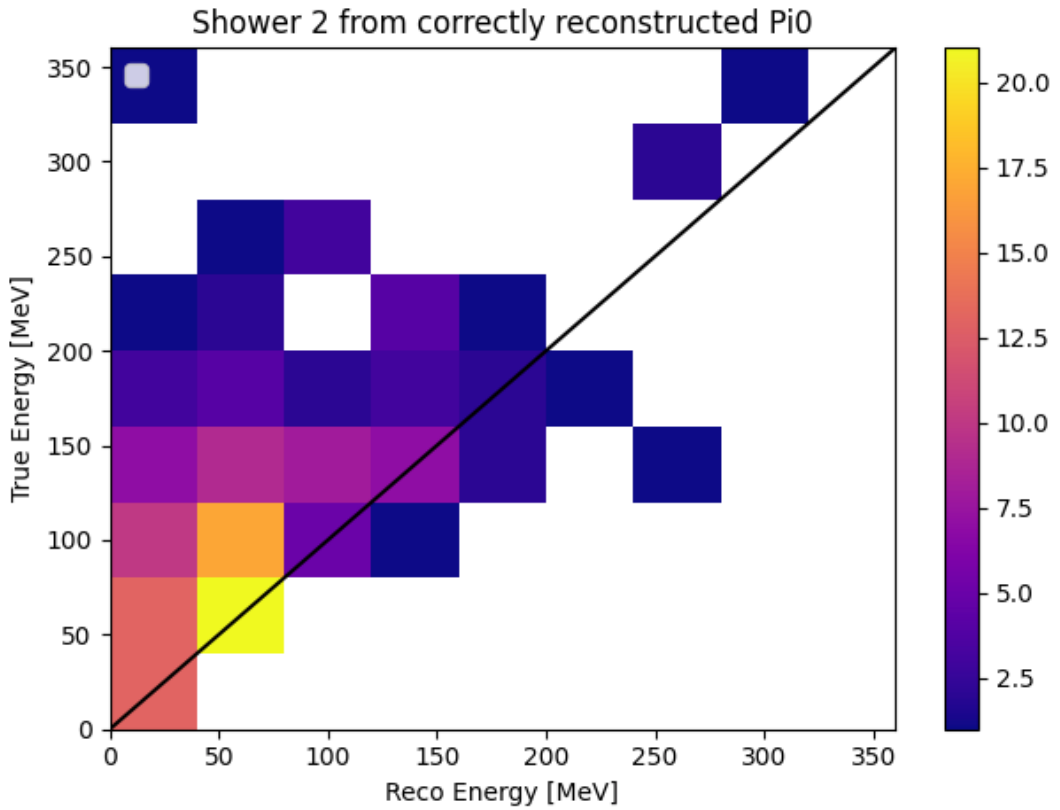
- Events: 1900 (NC : 523 , CC: 1377)
- Total π^0 seen: 1424
- Single π^0 events: 543

Selection	Purity	Efficiency
Most energetic shower pair	0.36	1 (153 π^0's)



π^0 showers energy reconstruction





π^0 sample selection (ν_μ beam)

- Events: 1900 (NC : 523 , CC: 1377)
- Total π^0 seen: 1424
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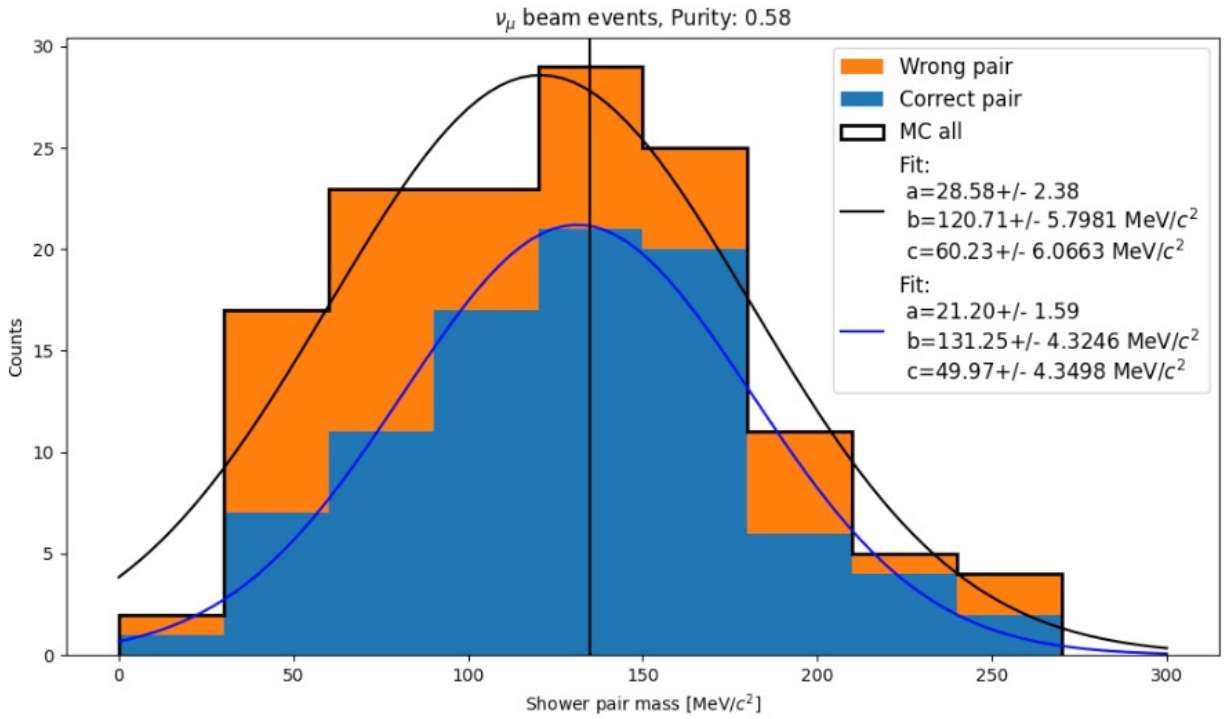
Selection	Purity	Efficiency
Most energetic shower pair	0.36	1 (153 π^0's)
0.4 < Opening angle < 1.6 rad Shower 1 energy > 40 MeV Shower 2 energy < 160 MeV 10 < Shower pair distance <110 cm	0.58	0.61



- Energy correction factor of 1/0.725 (chosen by eye)
- TBD: Calculating correction factor for showers

π^0 reconstruction in ProtoDUNE-I

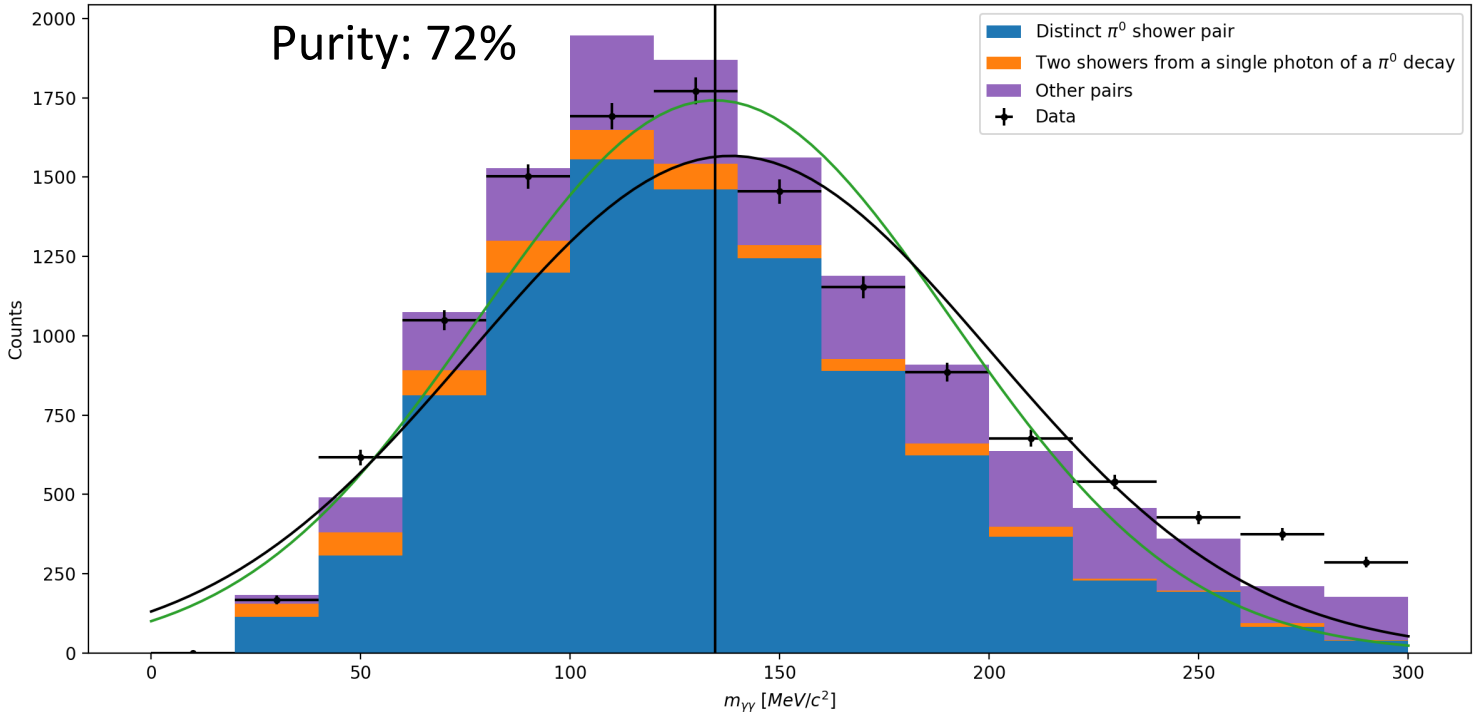
π^0 reconstruction in ProtoDUNE (2 GeV beam)

•MC gaussian fit (green line):

- Amplitude: 504.02 +/- 11.16 cts
- Centre: 134.50 +/- 1.01 MeV/c²
- Width: 56.27 +/- 0.90 MeV/c²

•Data gaussian fit (black line):

- Amplitude: 1567.26 +/- 19.06 cts
- Centre: 138.2 +/- 0.62 MeV/c²
- Width: 62.03 +/- 0.58 MeV/c²



Energy correction of 1/0.821 for all showers (=1/0.67 for a π^0)

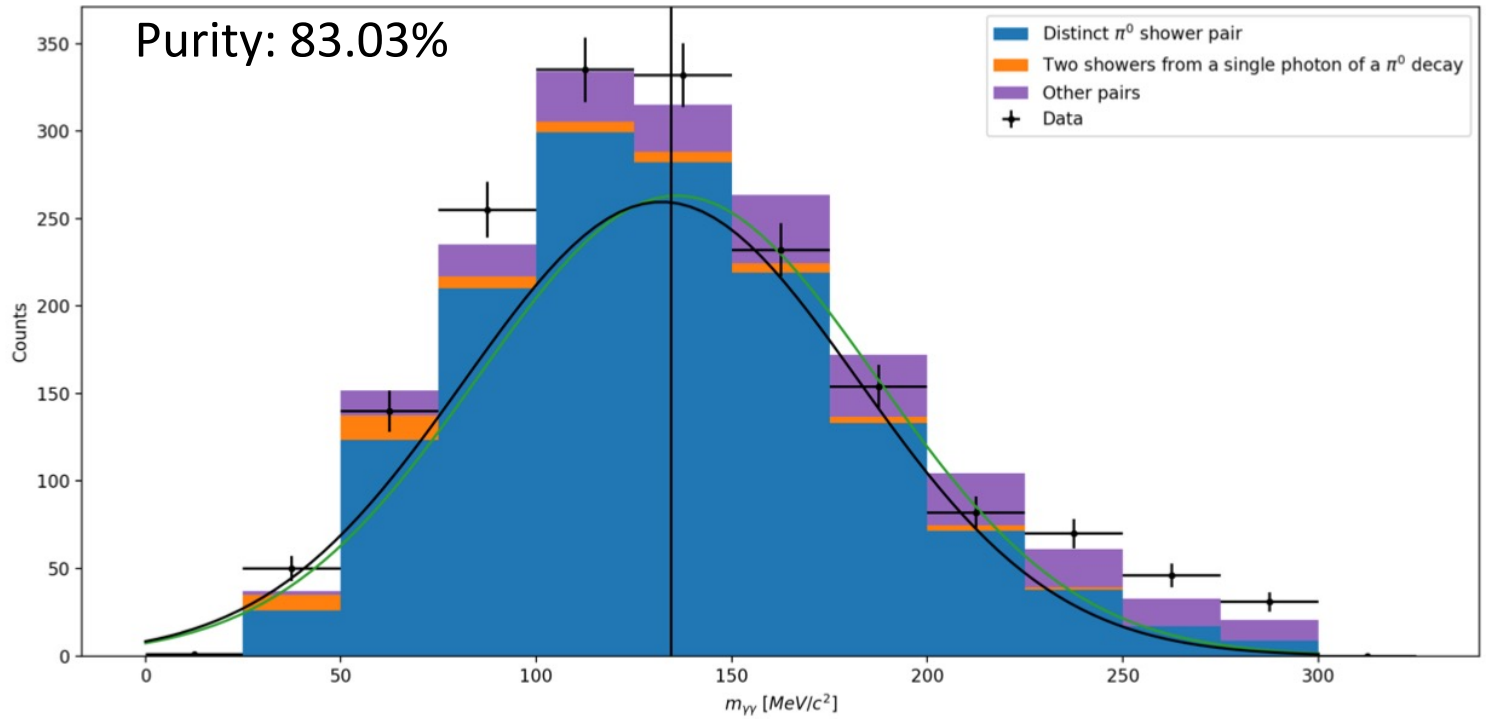
π^0 reconstruction in ProtoDUNE (1 GeV beam)

•MC gaussian fit (green line):

- Amplitude: 383 +/- 9.93 cts
- Centre: 136.03 +/- 1.08 MeV/c^2
- Width: 50.89 +/- 0.87 MeV/c^2

•Data gaussian fit (black line):

- Amplitude: 259.51 +/- 8.36 cts
- Centre: 132.02 +/- 1.316 MeV/c^2
- Width: 50.38 +/- 1.116 MeV/c^2



Energy correction of 1/0.821 for all showers (=1/0.67 for a π^0)

Future steps

- Proper π^0 selection cuts for Far Detector sample
- Look into γ/e^- discrimination performance
- Improving event reconstruction in Pandora