Study of Michel electron signals in ProtoDUNE-SP photon detectors

T. Yang

ProtoDUNE DPS Sim/Reco meeting

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Introduction

- I gave a talk at the January collaboration meeting on reconstructing PD signals in ProtoDUNE-SP.
- I would like to understand the expected PEs produced by the Michel electrons from beam muon/pion decay.
  - Average photons produced by Michel electrons.
  - Expected PEs using photon library.

Expected photons from Michel

- $Q = N_e = N_i R$
- $L = N_\gamma = N_{ex} + N_i(1 - R)$
- $Q + L = N_{ex} + N_i = \frac{\Delta E}{W_{ph}}$
- $\alpha = \frac{N_{ex}}{N_i} = 0.21$
- $\Delta E = 36.7\ MeV$
- $R = 0.625$ (recombination factor)
- $W_{ph} = 19.5$
- $L = 9.1 \times 10^5$

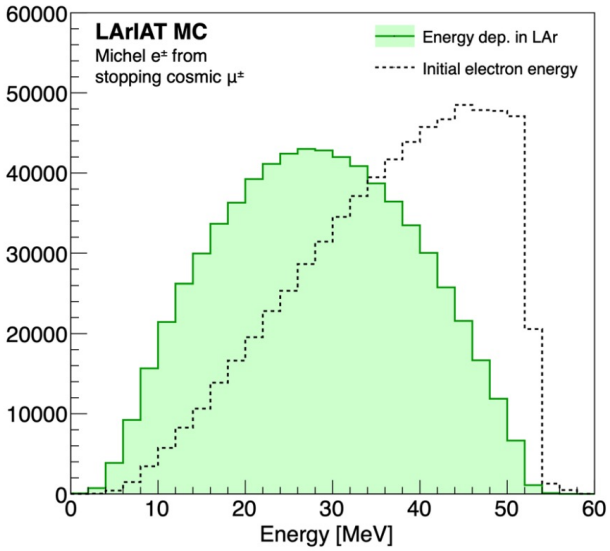

FIG. 9. Simulated distribution of the initial Michel electron energy ($\langle E \rangle = 36.7$ MeV) compared to the visible energy deposited in the LArIAT active volume ($\langle E_{\text{dep}} \rangle = 28.2$ MeV).

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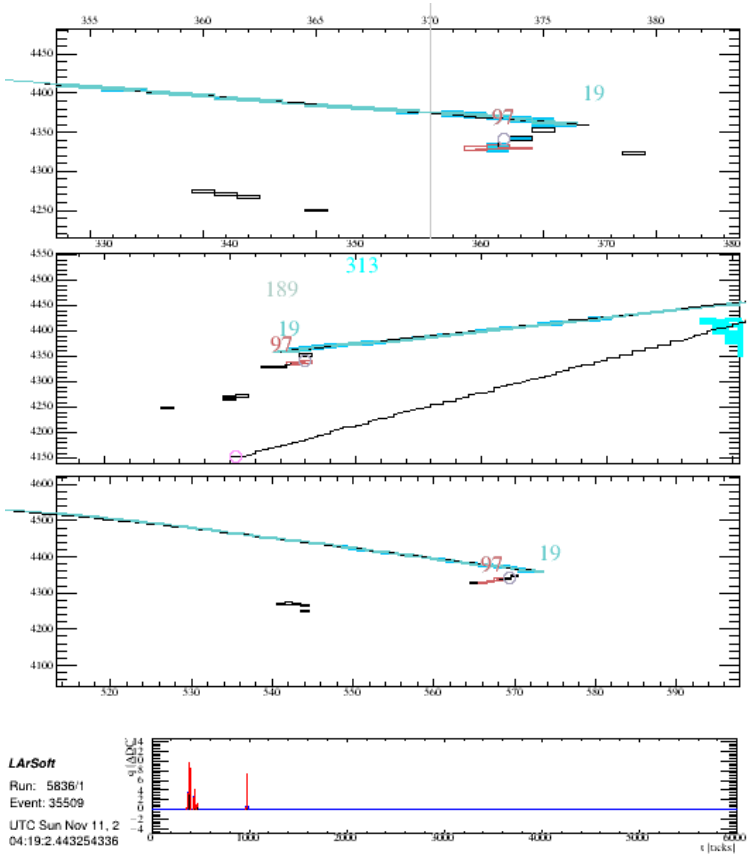
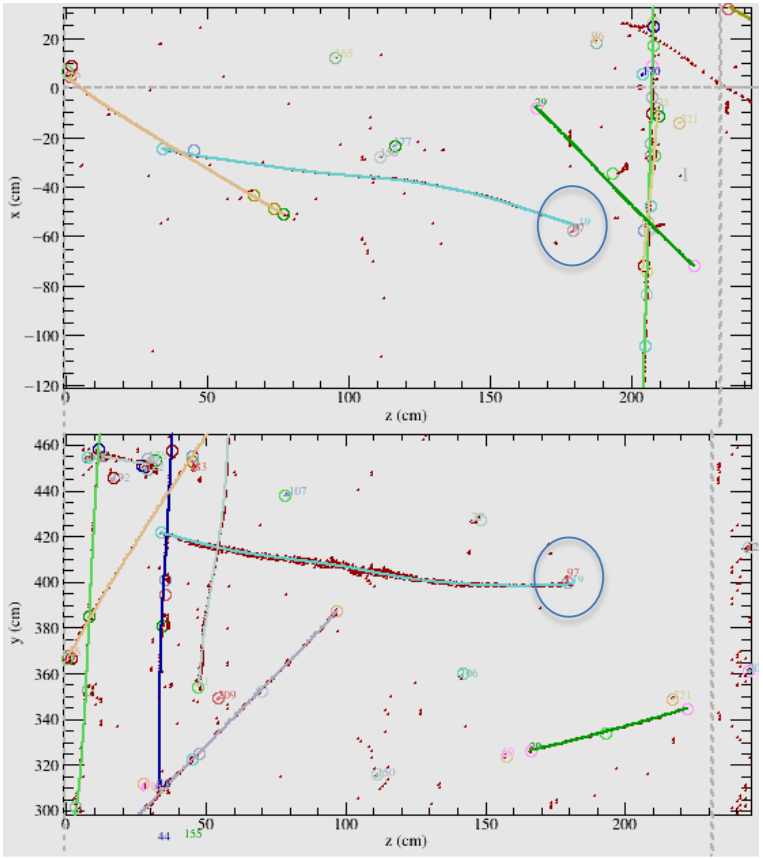
A 0.5 GeV/c stopping pion/muon

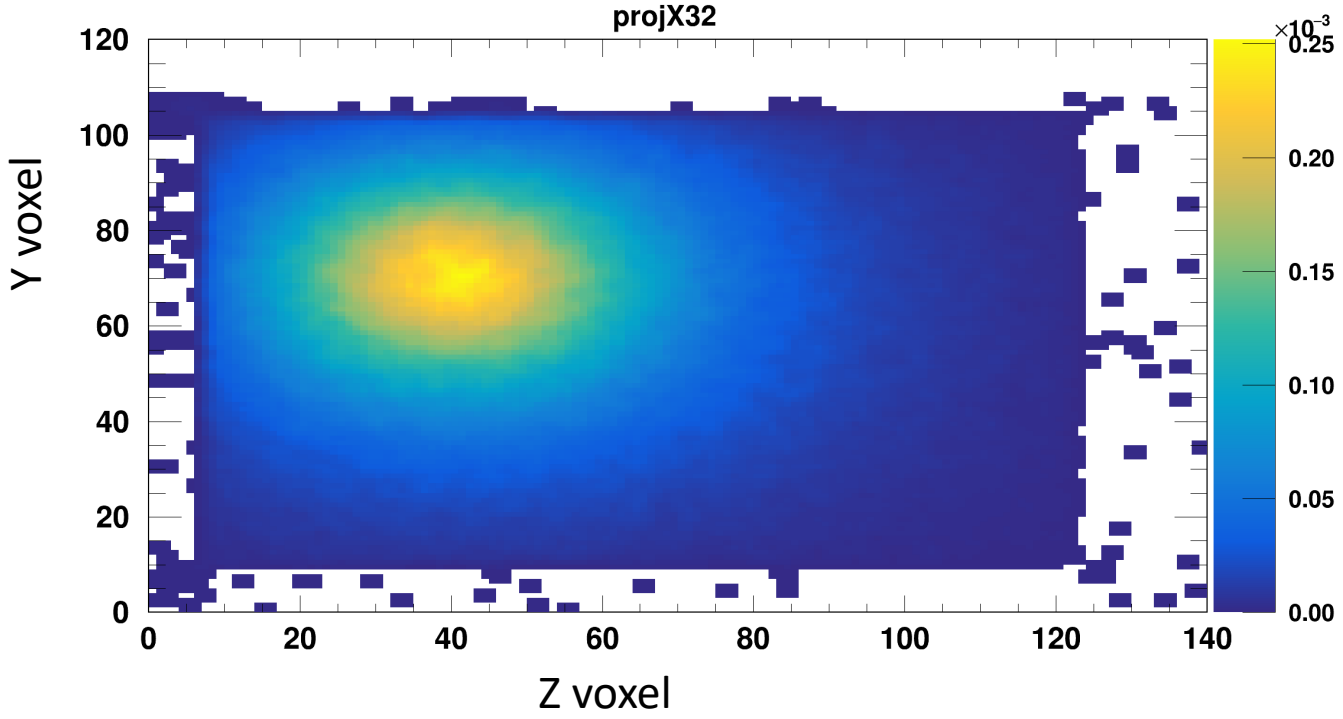




- The Michel electron was produced at (-55, 400, 180) cm.

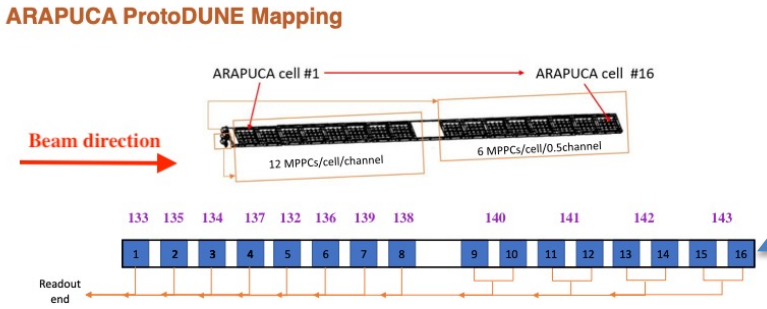
Photon library

- Photon library gives the probability for a photon at a location in the TPC to reach a particular photon detector.
  - Also called visibility
  - lib_Protodunev7_merged_avg.root

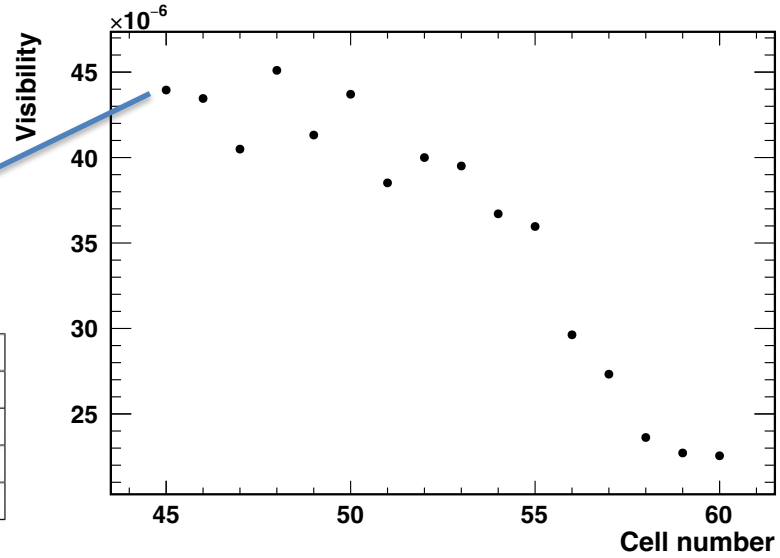


Visibility for one Arapuca cell at fixed x

Visibility for one Michel electron

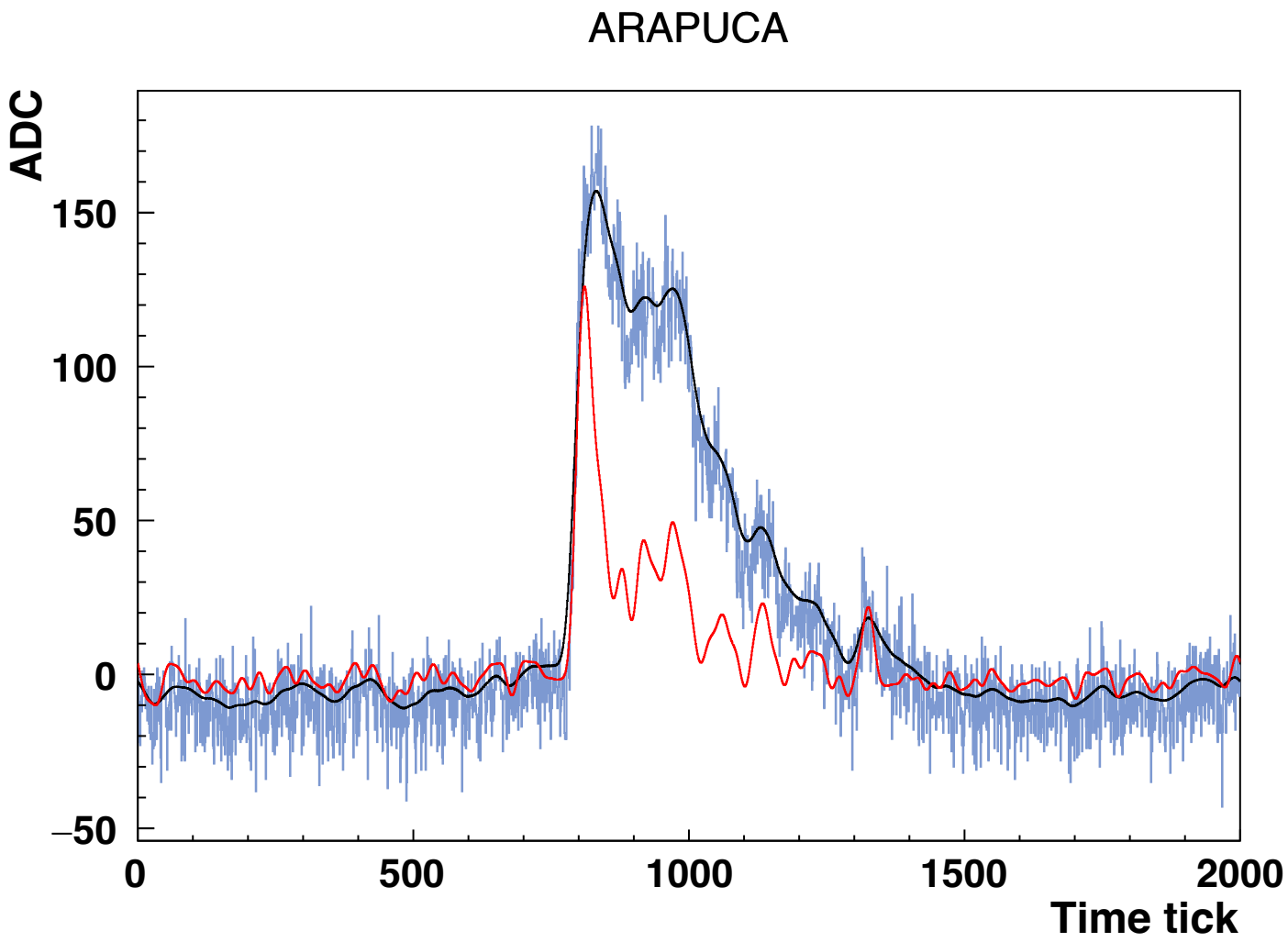


Nº of PDS elements examined	*Detector Type*	*Efficiency*
8	ARAPUCA cell	$\tilde{\epsilon}_A = (2.00 \pm 0.25)$ %
4	ARAPUCA cell (double area)	$\tilde{\epsilon}_{A2} = (1.06 \pm 0.09)$ %
10	Double-shift module	$\tilde{\epsilon}_{DS} = (0.21 \pm 0.03)$ %
9	Dip-coated module	$\tilde{\epsilon}_{DC} = (0.08 \pm 0.02)$ %

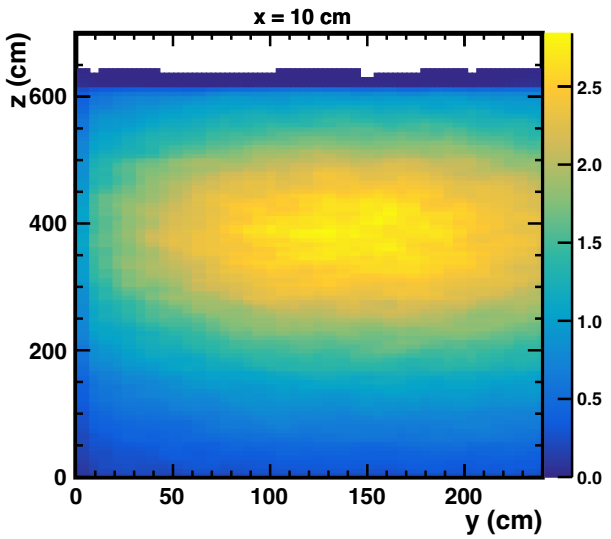


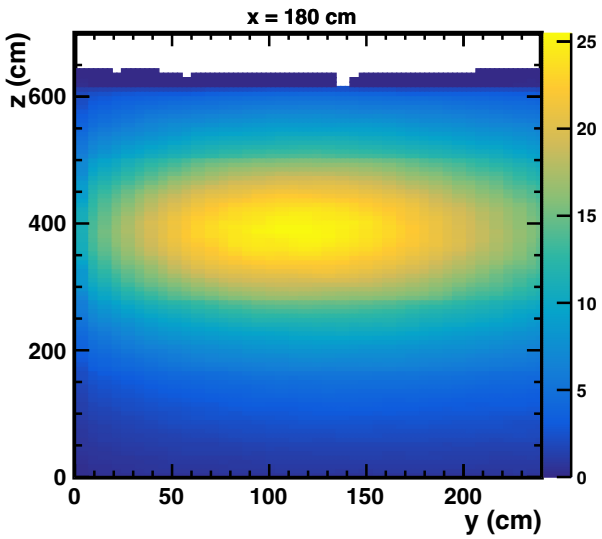
- Transmission coefficient (~68%).
- ARAPUCA efficiency: 2% or 1.06%.
- Total expected PEs for 9.1e5 photons produced at (-55, 400, 180): 5.2.

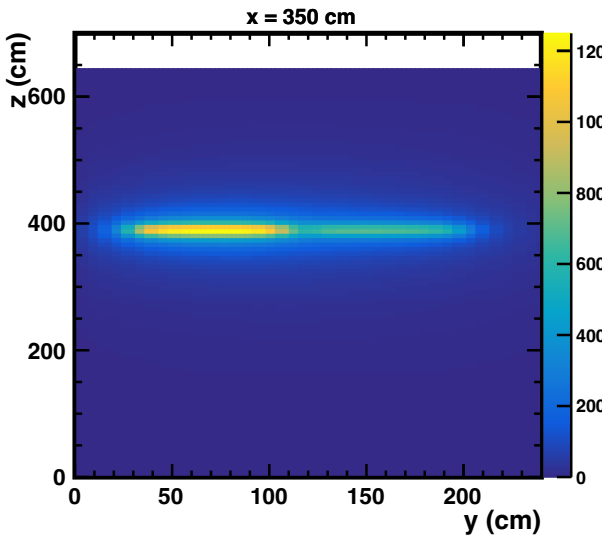
Sum all ARAPUCA waveforms



Expected PEs for different locations







X = 0: cathode

X = 360: anode

Conclusions

- Michel electrons from beam muon decays are expected to only produce a few PEs in the ARAPUCA photon detectors.
- Cosmic muon decays close to the anode can produce sizable photon detector signals.
  - Erin looked at this before. See her talk.
- I would like to thank Laura Paulucci for helping me understand the photon library.