γ-Sources and the 2-by-2

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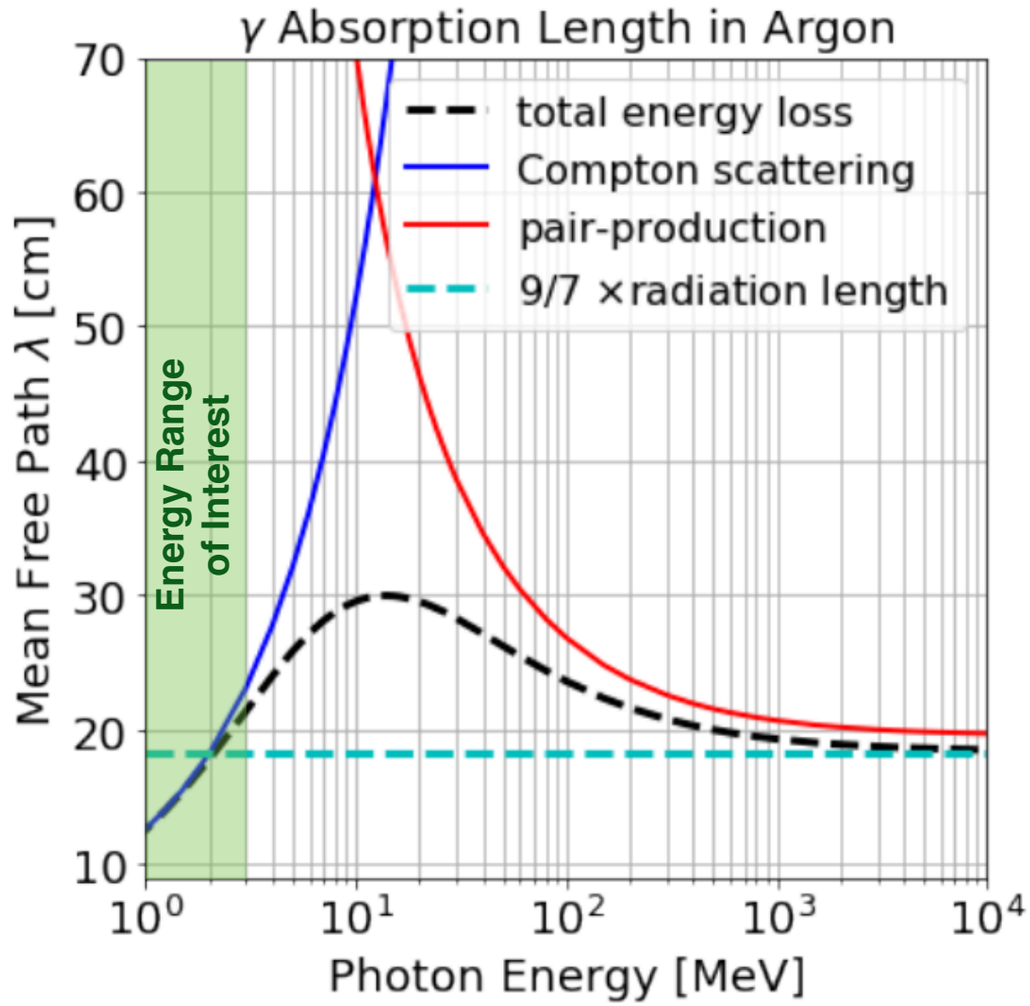
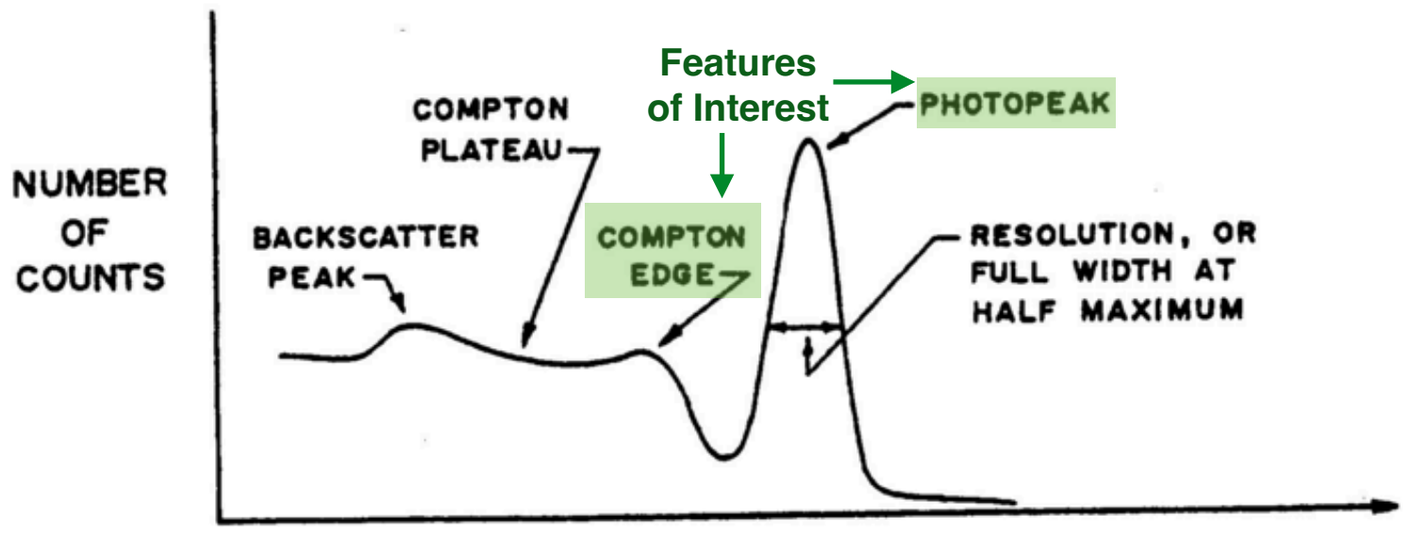
Radioactive Gamma Sources

- Calibrating LArTPCs can be challenging due to a lack of known sources

- Radioactive sources can create monoenergetic MeV-scale photons
  - Predominantly Compton scattering in the LAr

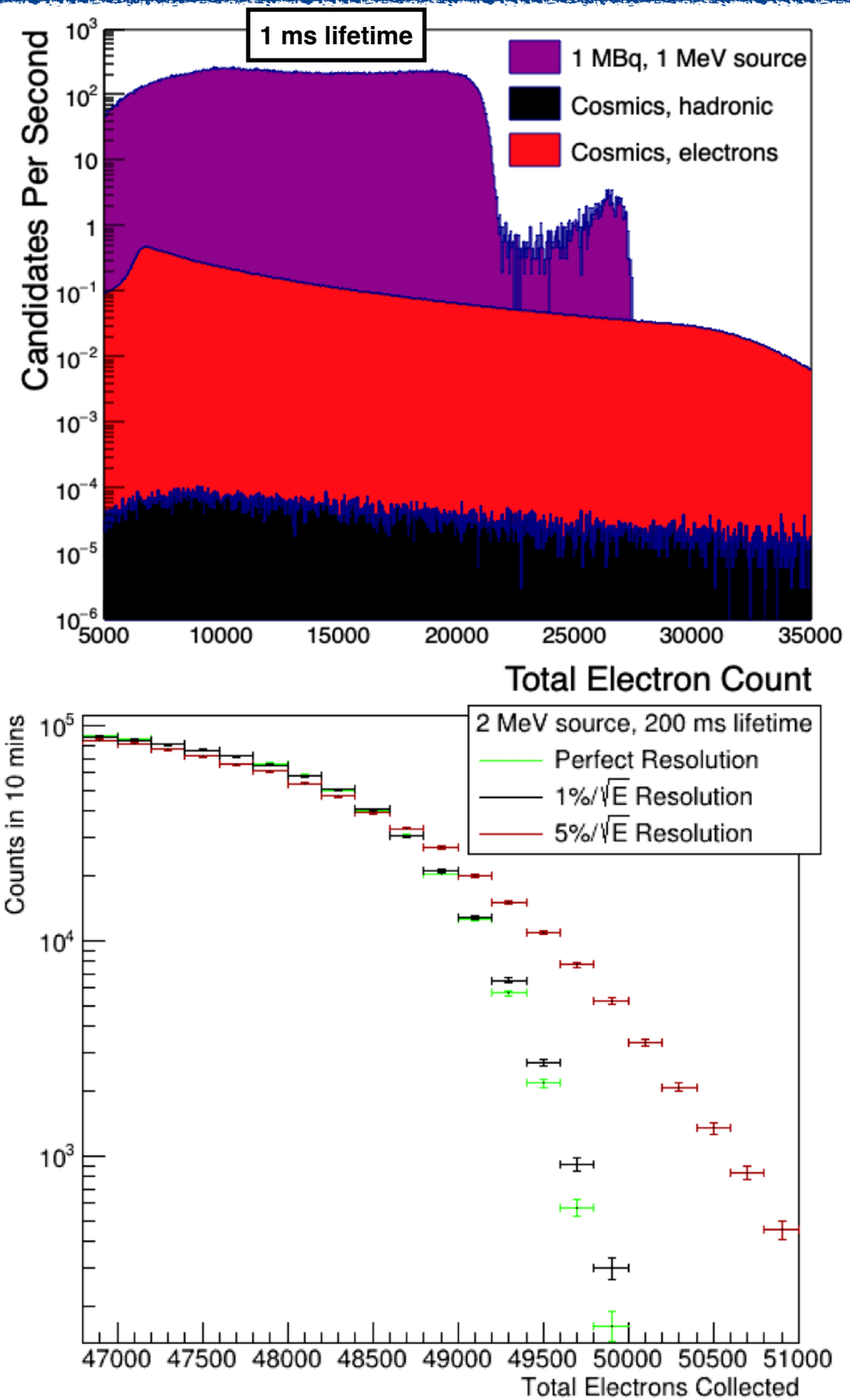
- Compton scatters produce two features that can be used to calibrate the detector
  - Photopeak and Compton edge





Gamma Sources in a LArTPC

- When used in a LArTPC, external backgrounds must be considered
  - Simulated a surface LArTPC with CORSIKA cosmic backgrounds
  - **Cosmic backgrounds will be 1,000 times smaller in MINOS underground area**
- Can use two features to explore the detector's response
  - The width of the **photopeak** is a measure of the energy resolution
  - The cutoff of the **Compton edge** depends on the energy resolution
- 1 MBq source can provide enough data for measurements in ~10 mins

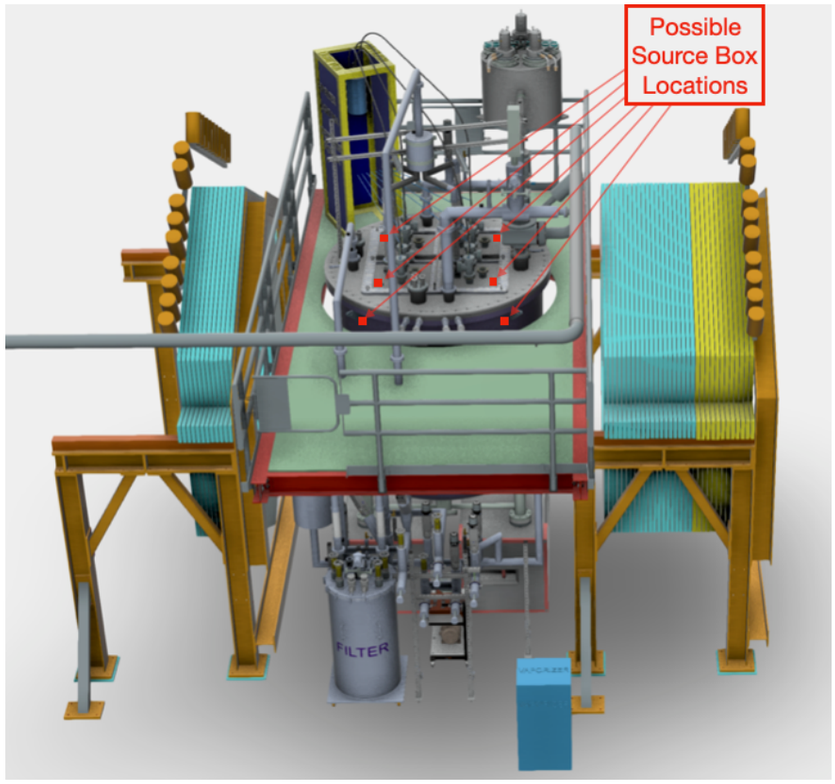


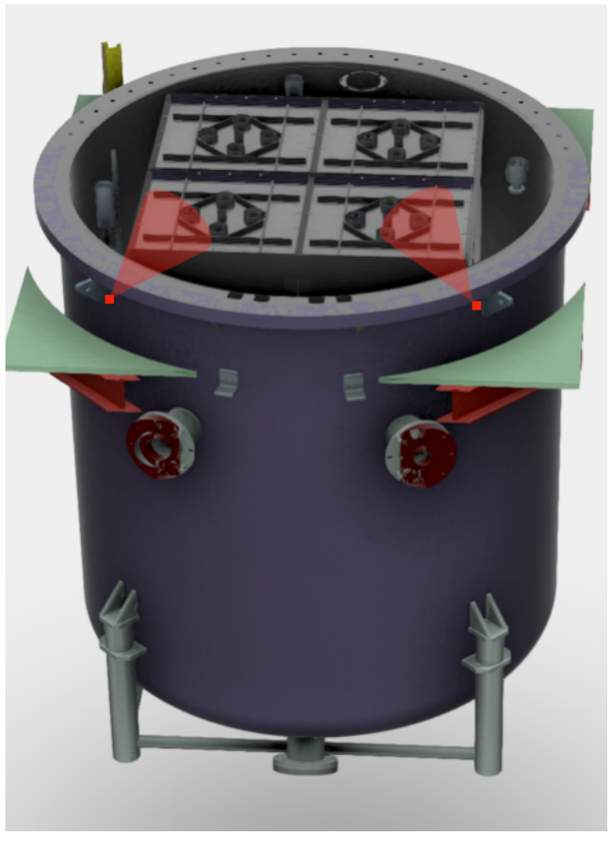
Gamma Sources for Calibrations

- Using two sources allows for scan of photon energies:
  - Y-88 produces 0.898 MeV and 1.836 MeV photons
  - Co-60 produces 1.173 MeV and 1.333 MeV photons
  - G10 typically has Tl-208, which produces a 2.614 MeV photon
- Measurements of the energy resolution allow for:
  - Energy scale and resolution comparisons between data and MC
  - Allow for validation of low energy detector response checks
  - Detector spatial and temporal uniformity checks with known sources
- Enables development of low-energy (“blip”) reconstruction techniques in a data-driven enviornment

Sources for 2-by-2

- **Propose placing sources on the outside of the cryostat**
  - Allows for sources to be added during beam downtimes and can be removed as the beam returns (only need short exposures)
  - 70% of photons will travel through the cryostat
- The sources could be placed in a number of locations to study detector uniformity
  - Alternatively, photons will travel throughout the detector volume and a longer exposure could be used to study uniformity
- These sources would allow for direct data-to-MC comparisons with a known source
  - Enable vetting and constraint of systematic uncertainties

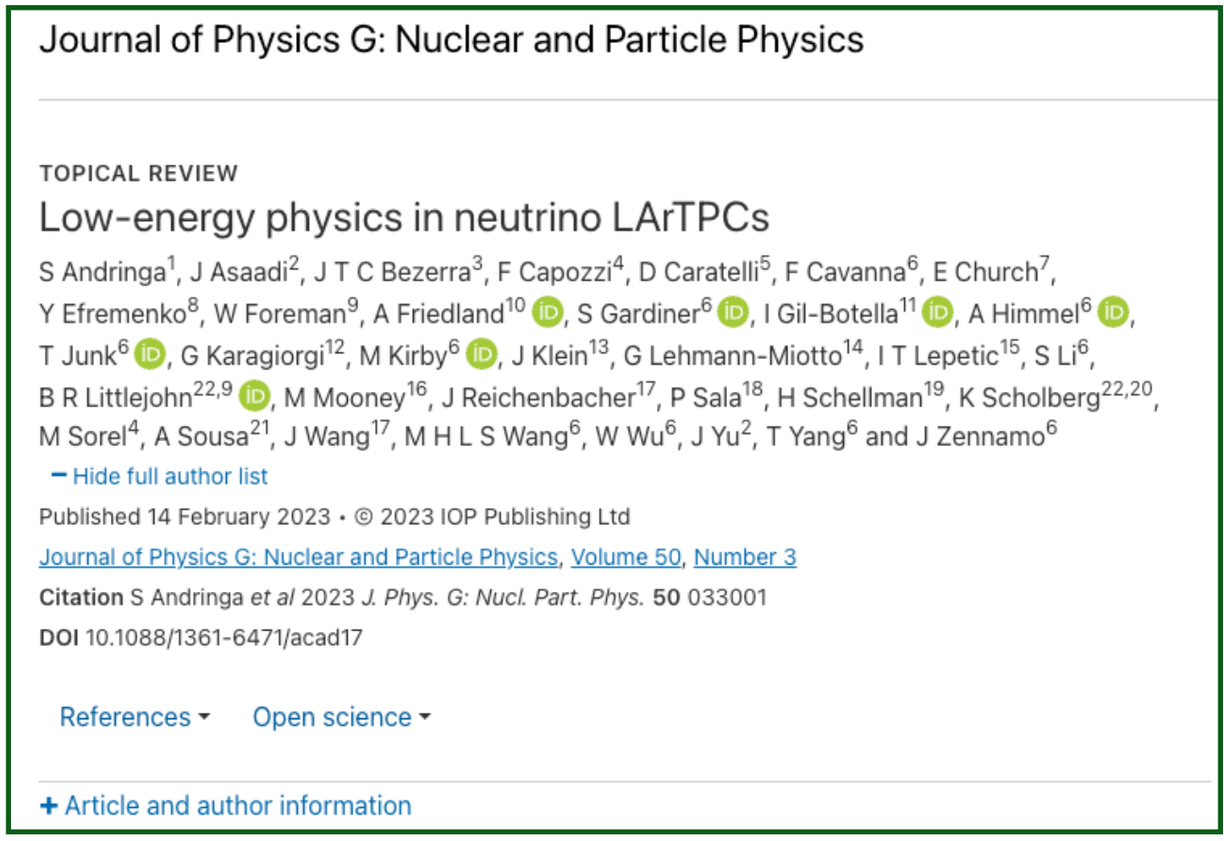




Impact for the Community

- There is a large interest in the community to explore low-energy events

- There are few demonstrations of LArTPC performance at low energies



Journal of Physics G: Nuclear and Particle Physics

TOPICAL REVIEW

Low-energy physics in neutrino LArTPCs

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Published 14 February 2023 • © 2023 IOP Publishing Ltd

Journal of Physics G: Nuclear and Particle Physics, Volume 50, Number 3

Citation S Andringa *et al* 2023 *J. Phys. G: Nucl. Part. Phys.* **50** 033001

DOI 10.1088/1361-6471/acad17

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- Using these sources, the 2-by-2 could produce the first publication of a data-driven MeV-scale energy resolution measurement by a neutrino LArTPC