

MAD-PSD: A reactor antineutrino detector based on ⁶Li-doped pulse shape discriminating plastic

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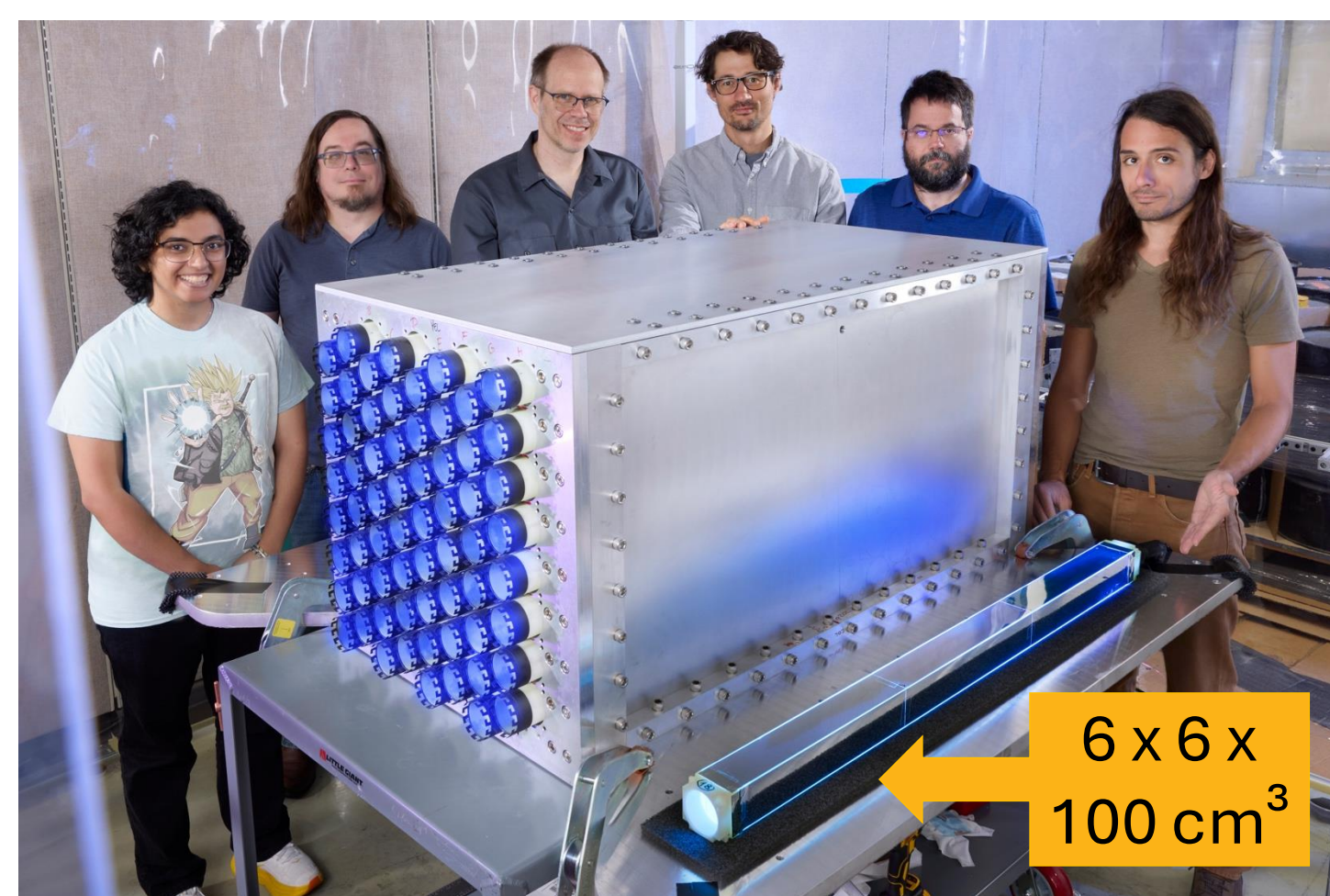
MAD-PSD is one of two reactor antineutrino detection subsystems designed and built by the **Mobile Antineutrino Demonstrator (MAD)** collaboration to perform reactor monitoring measurements with little to no overburden. Constructed with 64 large (6 x 6 x 100 cm³) bar castings of ⁶Li-doped **pulse shape discriminating (PSD)** plastic scintillator, MAD-PSD uses segmentation and particle identification to efficiently reject cosmogenic neutron backgrounds. This poster describes important design features of the detector and present commissioning and calibration measurements in preparation for a reactor deployment.

See the other MAD posters:

Ibukun on MAD-CHANDLER: **381**
 Ohana on ROADSTR measurements: **494**
 Nathaniel on the overall MAD project: **492**



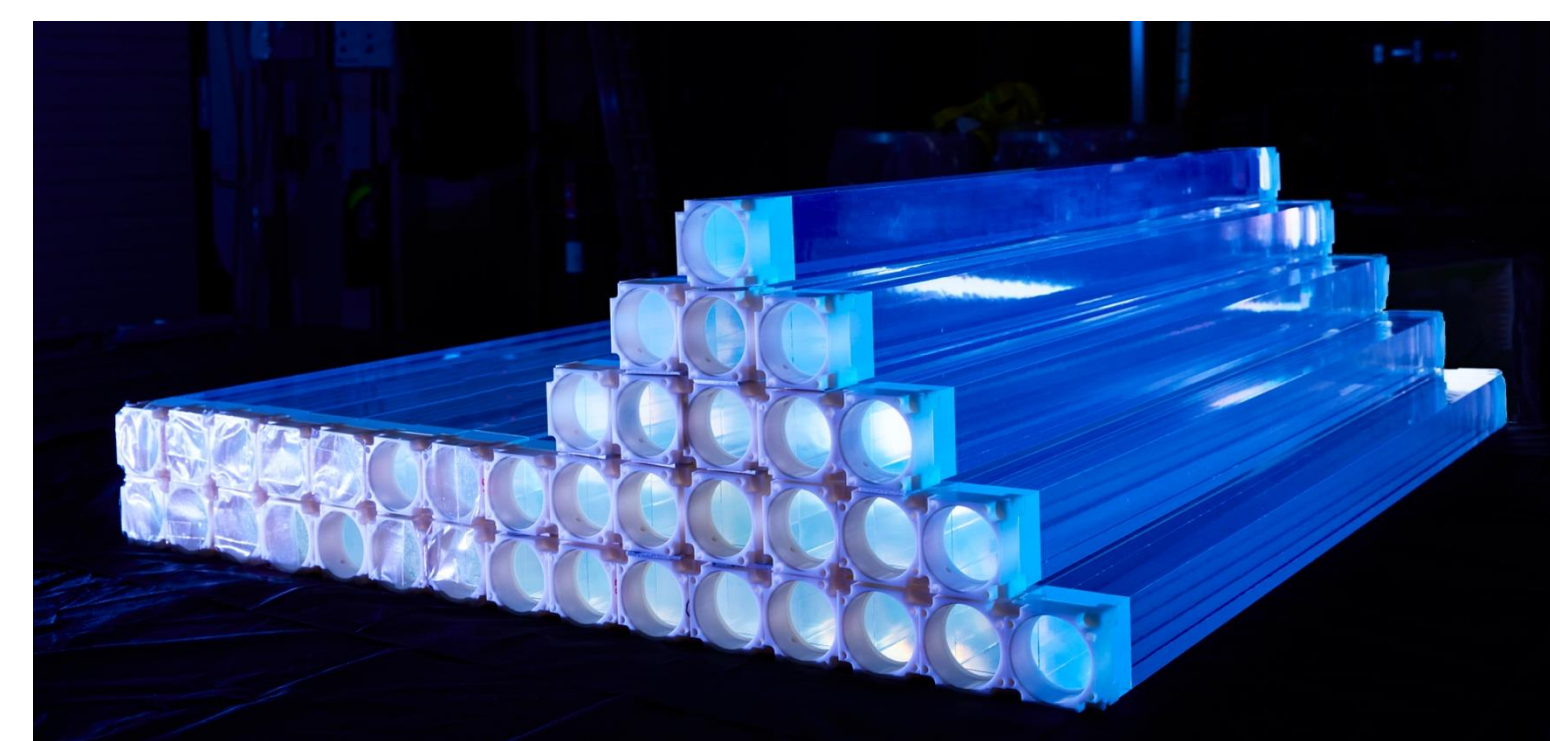
MAD-PSD Detector Overview



Started	September 2025
Layout	8 x 8 layout = 64 bars
Bar size	6 x 6 x 100 cm
Scintillator	⁶ Li-doped PSD plastic
Active mass	248.8 kg (record!)
Channels	128 PMTs (64 per side)

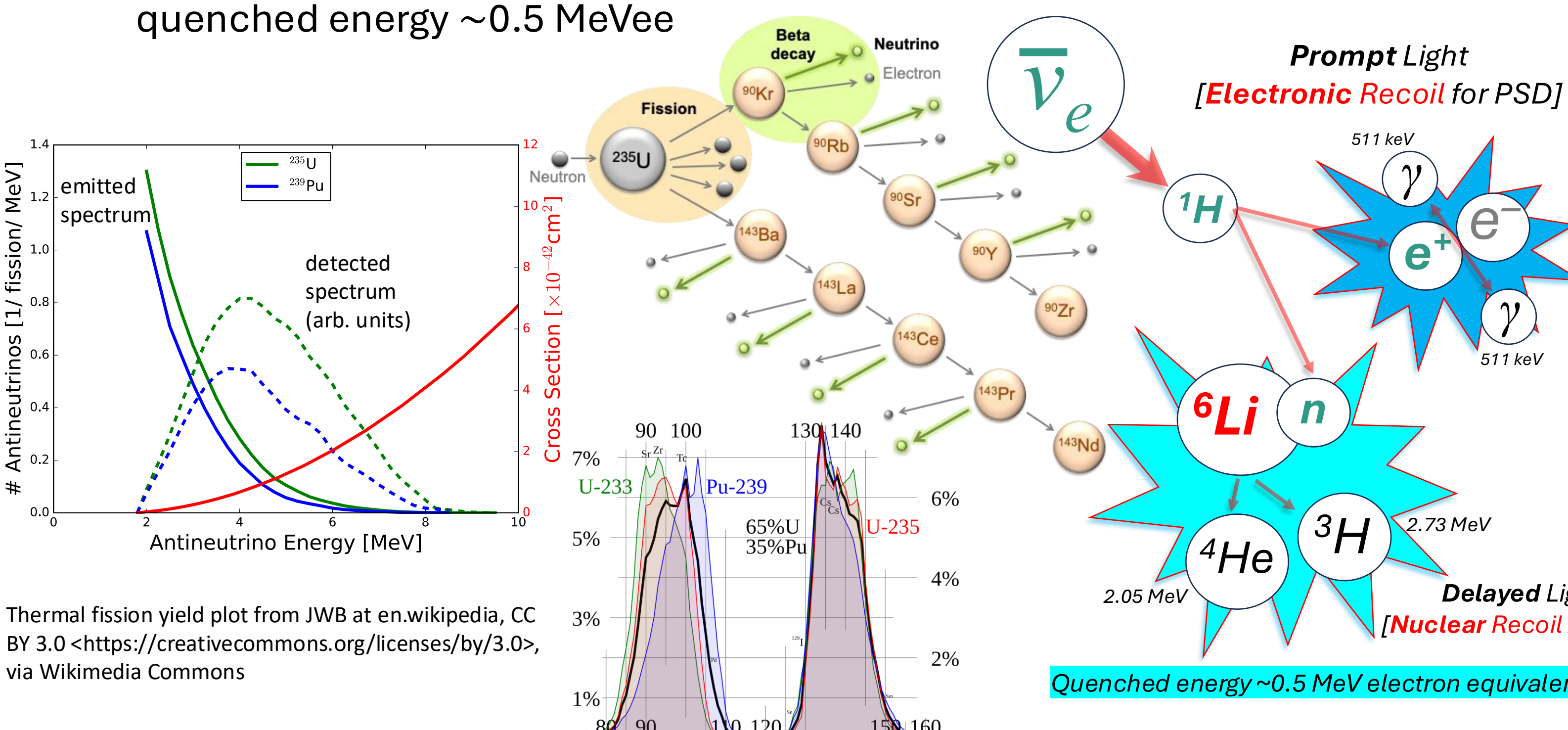
EJ-299-50 PSD ⁶Li-doped Plastic Scintillator Bars

- ⁶Li: 0.1% by weight, providing ~88% of thermal neutron captures on ⁶Li.
- Effective attenuation length ~100 cm with dual-ended 2" PMT readout.
- Air-coupled 3M DF2000MA specular reflector film enables Total Internal Reflection while allowing light collection enhancement.
- Continuous monitoring over one year demonstrates light output and PSD suitable for IBD detection.



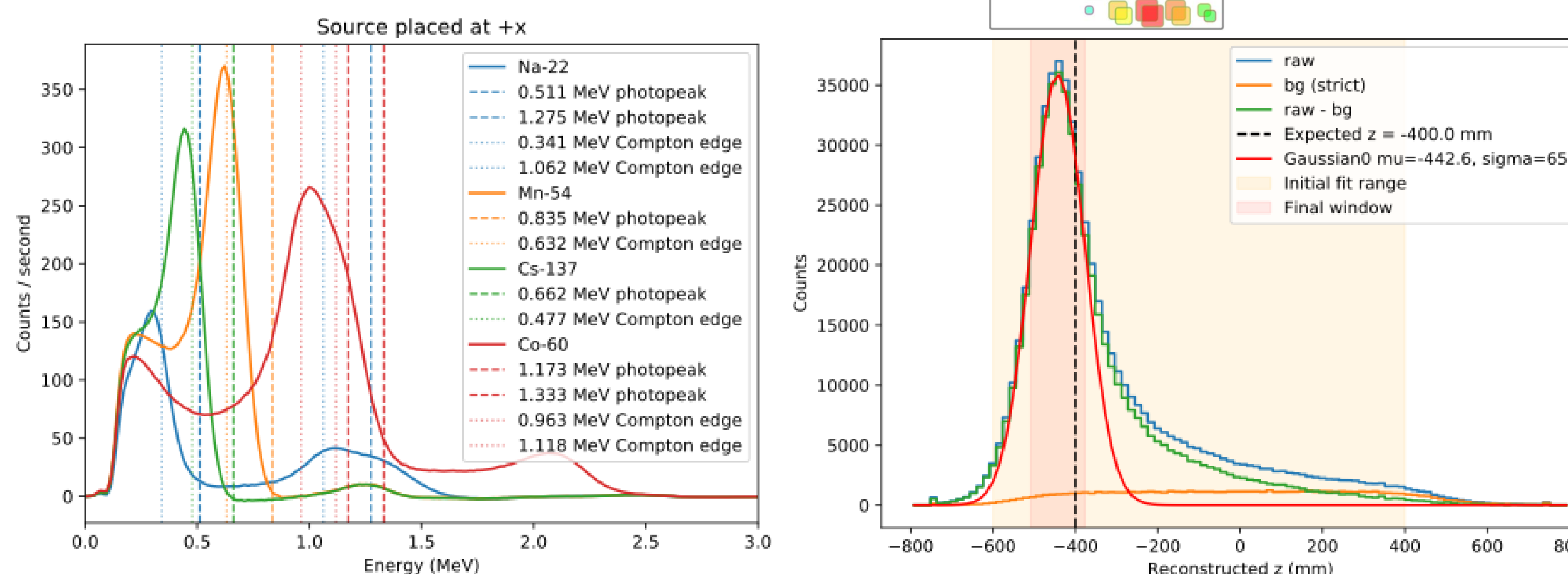
Inverse Beta Decay

- Prompt: e⁺ annihilation (511 keV)
- Delayed: thermal neutron capture ⁶Li(n, α)³H with Q = 4.78 MeV
- Short-range reaction products (triton) provide localized scintillation with quenched energy ~0.5 MeVee

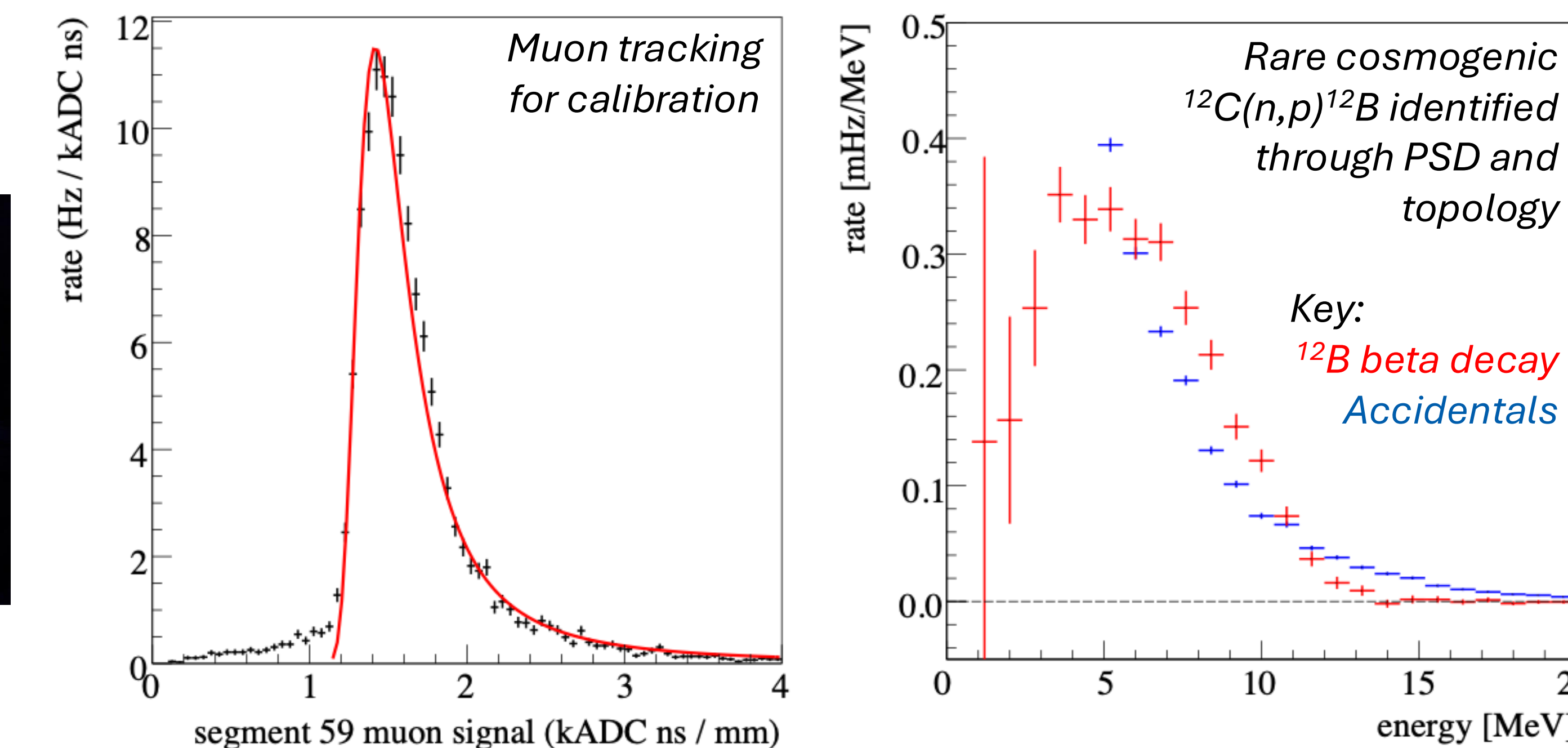


Calibration for energy scaling and position

- Muons + source placement
- Long-term response stability achieved with ⁶Li feature and muon-based calibration

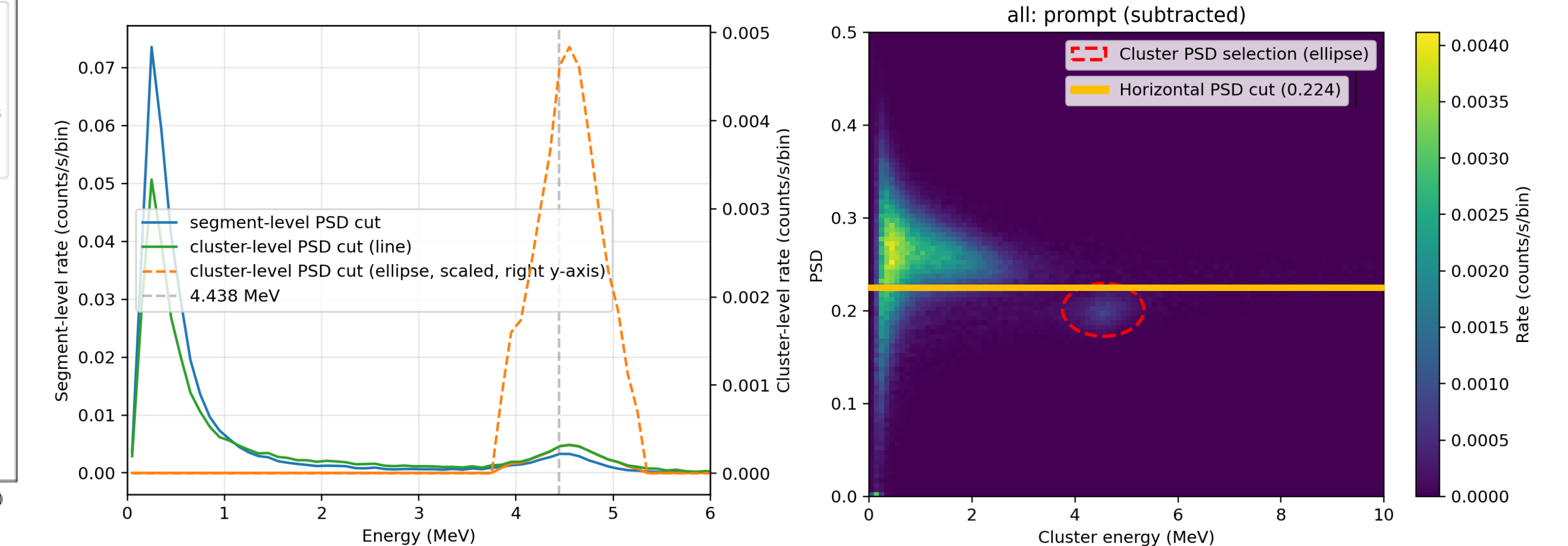


Muon-based attenuation / position calibration

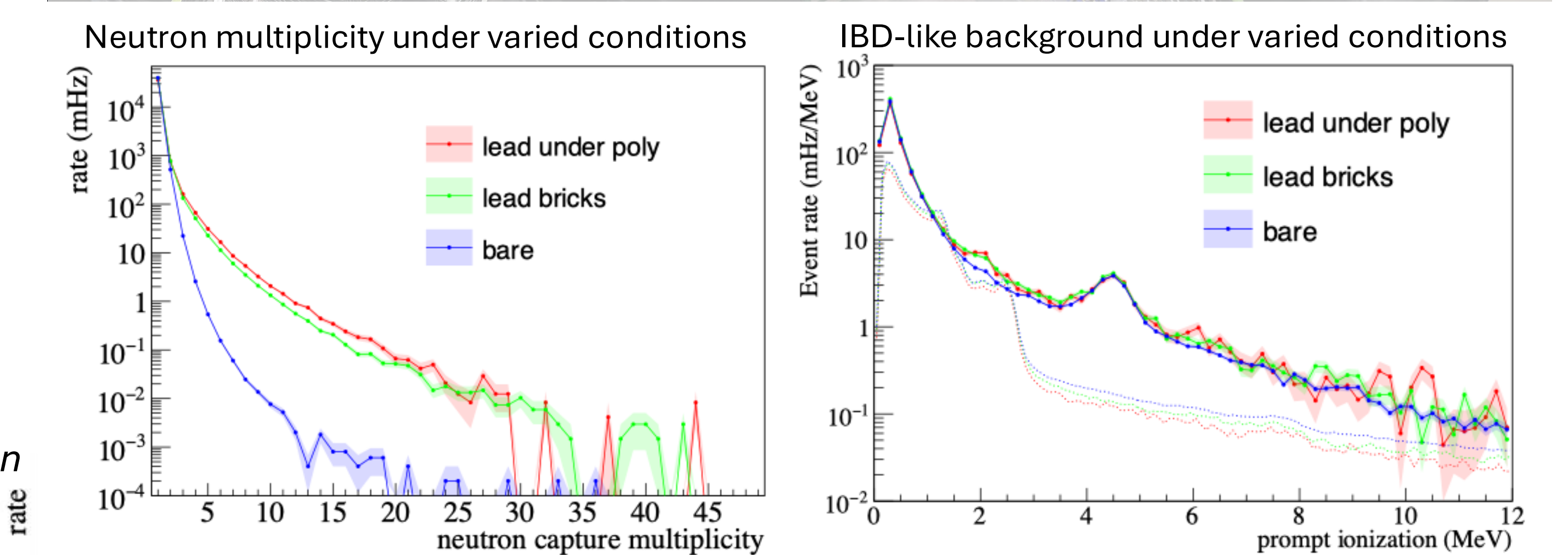
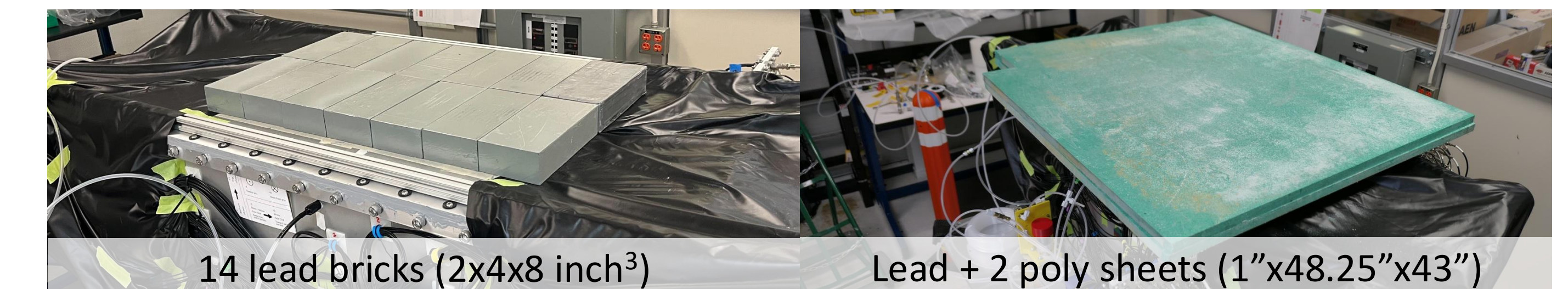


Performance Studies

- PSD performance tested with AmBe source, which emits a 4.4 MeV gamma and a coincidental neutron; can test IBD sensitivity
- Varied shielding data collected to tune background models
- Simulation studies + event topology analysis for both currently underway



Neutron capture rejects* shower backgrounds



Summary and deployment readiness

- Commissioning establishes analysis techniques, energy calibration, and basic reconstruction performance in the lab.
- PSD performance with AmBe tagged-neutron data supports neutron-scatter discrimination relevant to low-overburden backgrounds.
- Next: MAD-PSD at HFIR (ongoing as of June 15th, 2026 – see poster #494) and then ship to Virginia Tech to be united with MAD-CHANDLER (3D cubic scintillator stack – see poster # 381) and measured at North Anna.