Characterization of Boron-Loaded Liquid Scintillator

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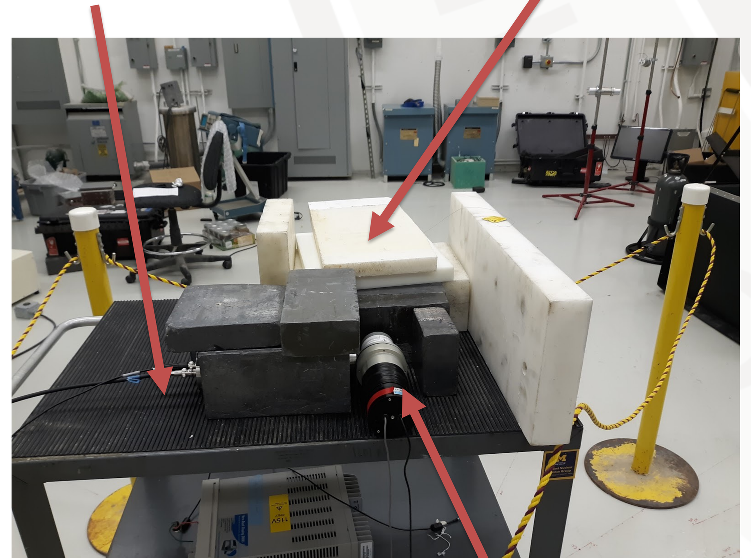
Introduction and Motivation

Lithium-doped organic scintillators have been demonstrated to be capable of combined gamma, thermal neutron, and fast neutron measurements and capture-gated neutron spectroscopy [1,2]. Natural boron-loaded liquid PSD organic scintillator may also provide these capabilities, but the picture is somewhat complicated by the lower Q-value and gamma escape from the ^{10}B neutron capture reaction.

Mission Relevance

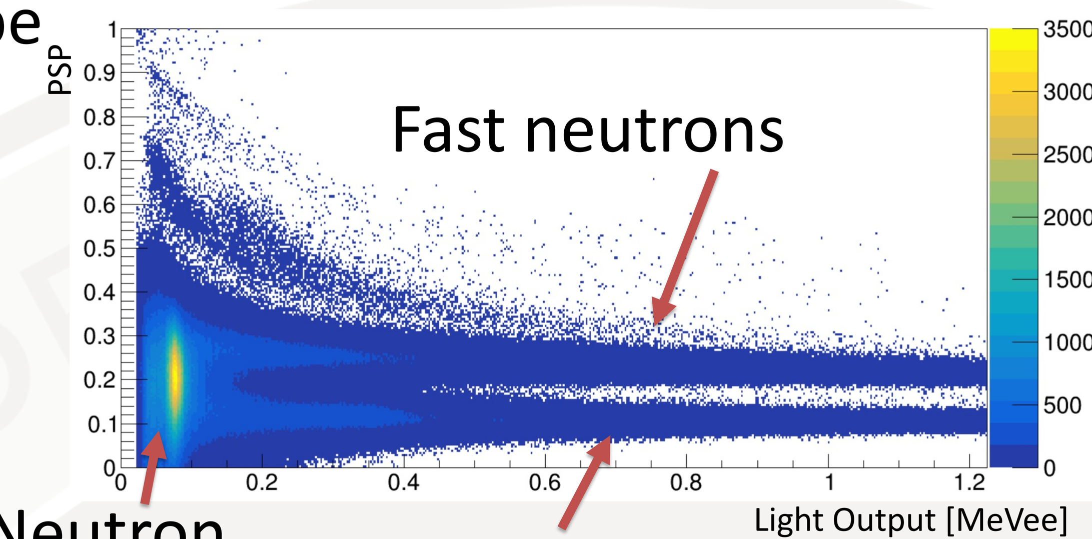
The ability to detect and distinguish among fast neutrons, thermal neutrons, and gammas is important for the detection and monitoring of special nuclear materials. Our detector has the capability to detect all 3 sources of radiation through a single output channel, making its operation convenient.

Technical Approach

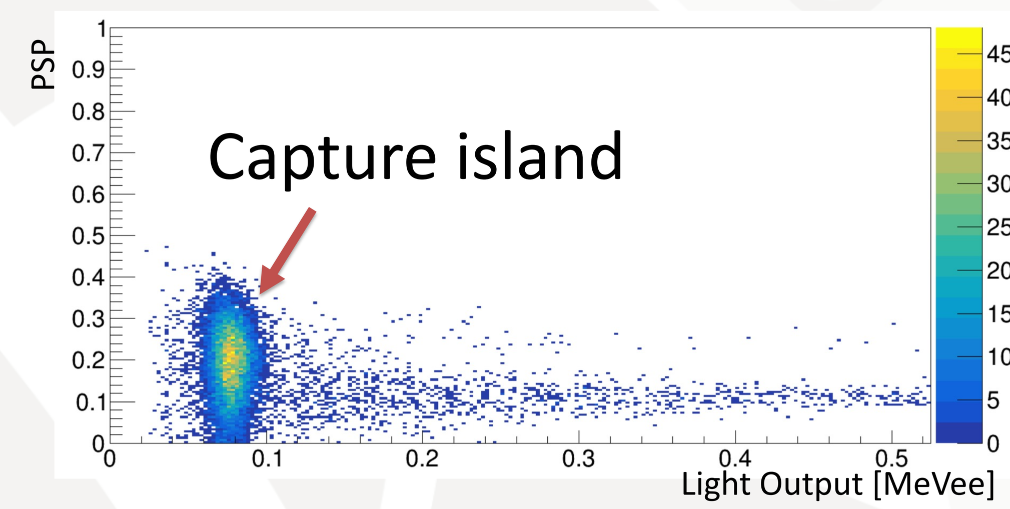


We use a $LaBr_3$ detector to tag gammas from ^{10}B neutron capture in EJ309B.

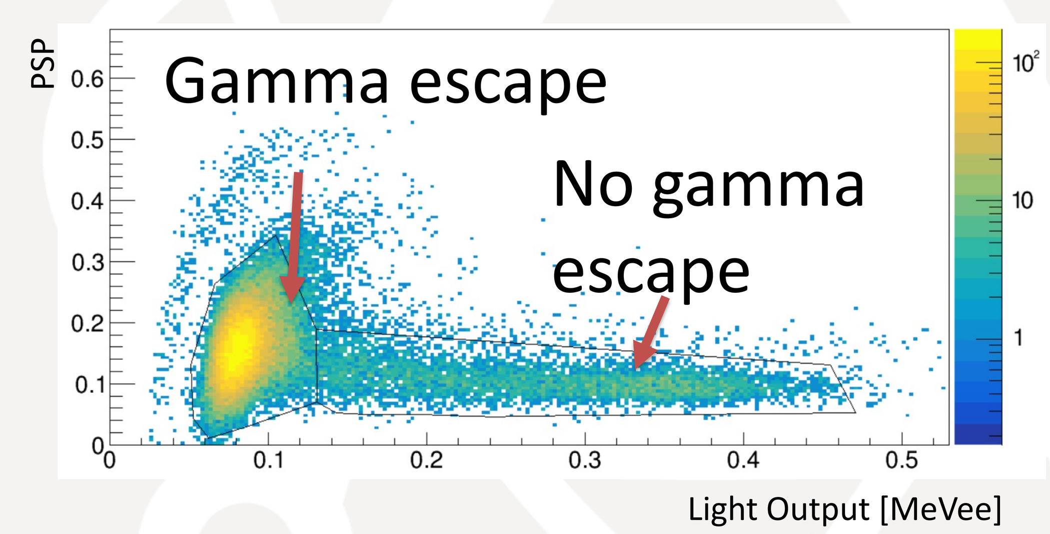
Results



Without coincidence



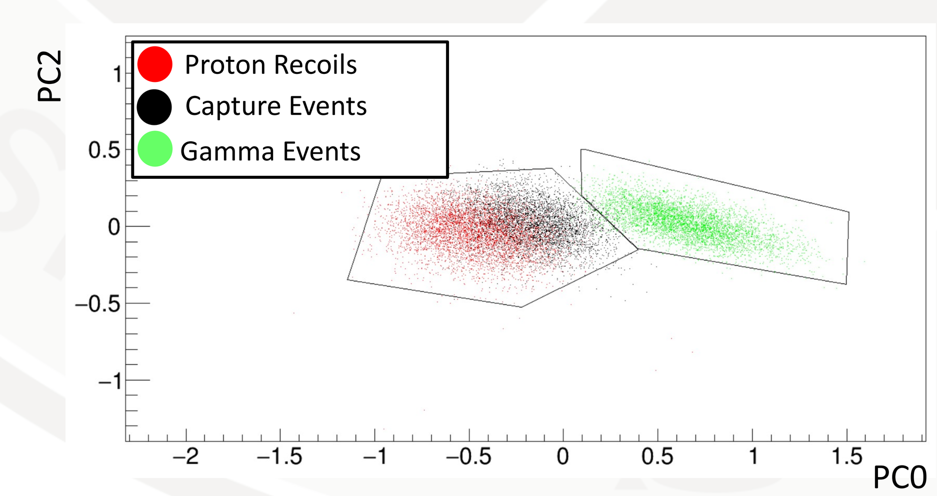
With coincidence



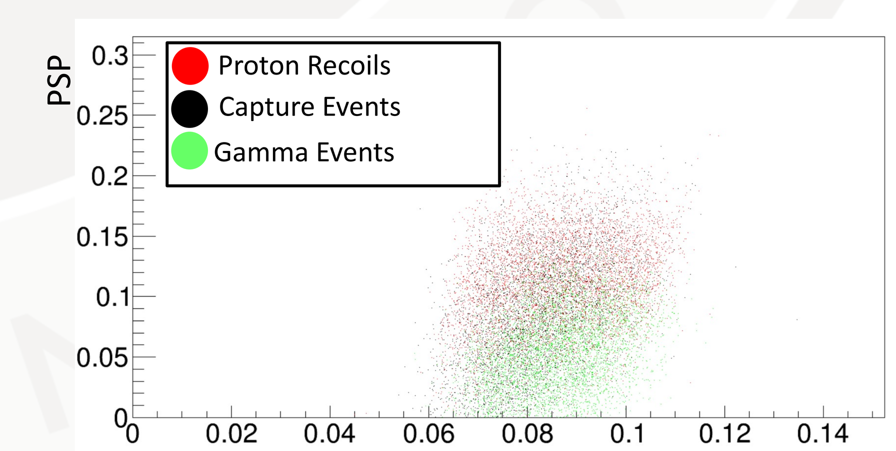
Isolated capture events from thermalization for gamma escape probability measurement

Simulated and measured gamma escape probability

Result Type	Gamma Escape Probability [%]
Measurement	81.2±0.49
Geant 4 Simulation	81.1±0.38



Principal component analysis (PCA) for digitized waveforms



Comparison of PCA waveforms in PSP/LO space

Expected Impact

Optimize discrimination among thermal neutrons, fast neutrons, and gammas in the EJ309B scintillator, improving its performance in mixed radiation field.

MTV Impact

This project has been done in close collaboration with ORNL, facilitating the expansion of national lab connections. This medium may be of interest to both UM and ORNL in applications involving special nuclear material and antineutrino detection.

Conclusion

We have thus far been able to demonstrate capture isolation using coincidence and thermalization and the ability to discriminate between gamma events and thermal neutrons using PCA. Coincidence appears to be necessary to effectively separate neutron captures from proton recoils.

Next Steps

We will continue working on implementing other methods of discrimination to improve PCA, including digital zero crossing time and template fitting.

Citations: [1] M. Mayer, J. Nattress, V. Kukharev, A. Foster, A. Meddeb, C. Trivelpiece, Z. Ounaies, I. Jovanovic, Development and characterization of a neutron detector based on a lithium glass–polymer composite, Nuclear Instruments and Methods in Physics Research A 785 (2015) 117–122. [2] M. Sharma, J. Nattress, K. Wilhelm, I. Jovanovic, Triple Pulse Shape Discrimination and Capture-Gated Spectroscopy in a Composite Heterogeneous Scintillator, Nuclear Instruments and Methods A (2017).

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