NE 204: Advanced Concepts in Radiation Detection and Measurement

Experiment 4: Neutron Detection and Pulse-Shape Discrimination in Liquid Scintillation Detectors

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Purpose

Digital signal processing will be used in conjunction with liquid scintillation detectors for the purpose of neutron detection. In addition, pulse-shape discrimination (PSD) techniques will be investigated to distinguish gamma-ray and neutron interactions in the scintillator.

Approach

A liquid scintillator (solvent xylene-based) EJ309 will be used to study neutron detection and ${}^1_0n/\gamma$ discrimination techniques. Digital filters sensitive to the differing decay times of the scintillation pulses resulting from nuclear recoils (induced by neutron scattering) and electrons (via gamma-ray interactions) will be implemented and optimized. Gamma-ray suppression factors will be determined as a function of the energy deposited in the scintillator. A PuBe source is used to provide fast neutrons, while a mCi of ${}^{137}Cs$ serves as a source of gamma-rays. The gamma-ray source will also be used for energy calibration of the electron-induced scintillation signal.

Energy Calibration

Required

- Perform an energy calibration for the electron-induced scintillation channel in the EJ309 detector.
- Discuss the difference in the magnitude of the scintillation signal for neutron-induced interactions vs. electron-induced interactions. Can the energy calibration determined in this step be used for neutron interactions as well? Why or why not?

Pulse Shape Discrimination

Required

- Implement a PSD algorithm to distinguish between neutron and gamma-ray interactions in the EJ309 scintillator. Find a good way to illustrate the ${}^1_0n/\gamma$ separability as a function of deposited energy.

- Experimentally determine the optimum filter parameters to maximize the gamma-ray suppression and neutron acceptance probabilities as a function of deposited energy.

Optional

- Explore techniques for improving the ${}^1_0n/\gamma$ separation factor for low-energy depositions.
- Explore data-driven techniques for ${}^1_0n/\gamma$ separation.