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Simulating the response of a liquid scintillation detector to neutrons

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Neutrons are one of the most critical contributors to background signals. Understanding the neutron background is crucial as they can easily mimic the Weakly Interacting Massive Particle (WIMP) signals in dark matter search experiments. Organic liquid scintillation detectors are often used to detect fast neutrons. EJ-301 is a popular liquid scintillator used to detect fast neutrons because of its good pulse shape discrimination property. In this work, we unfold the response of an EJ-301 detector to Am-Be neutron spectra using two unfolding methods: Roo-Unfold and the GRAVEL method. Once the response of the detector is modeled, using the unfolding method, it will be possible to obtain the information of the fast neutron background at different rare event background sites.

A $2'' \times 2''$ cylindrical liquid scintillation detector (EJ-301) has been modeled using the GEANT4 framework. Various properties of the detector like the light output of the scintillator, quantum efficiency of the photocathode, material composition have been defined using values from literature and detector manuals. A photon to electrical signal conversion (Photo-multiplier tube) and digitization method has also been implemented in GEANT4 from which we obtain the response of the detector in terms of integrated electronic charge. Simulated gamma spectra from the detector for different gamma sources like (^{60}Co, ^{22}Na, etc.) show excellent agreement with the experimental gamma measurements providing confidence in the modeling. In the first stage, energy spectra of monoenergetic neutrons are simulated at fixed neutron energy intervals to construct the response matrix. In the second stage, neutrons having energy distribution following the ISO Am-Be continuous neutron energy spectrum are made incident on the detector and the energy spectrum is simulated. The spectrum obtained after the second stage is unfolded using the response matrix generated in the first stage to obtain the actual input ISO Am-Be spectrum. We see that both the methods are able to predict the actual ISO spectrum very well.

What is your experiment?

R&D of neutron detector for Darkmatter Search Experiment

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