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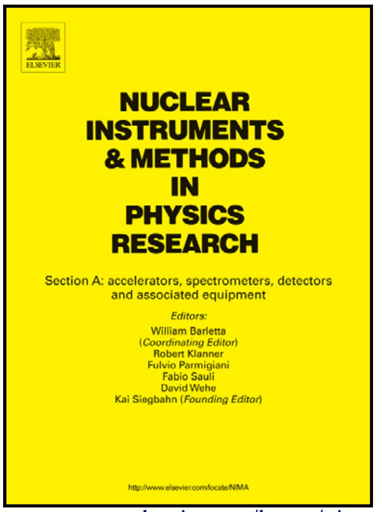

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Neutron Crosstalk between Liquid Scintillators

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Abstract

A method is proposed to quantify the fractions of neutrons scattering between liquid scintillators. Using a spontaneous fission source, this method can be utilized to quickly characterize an array of liquid scintillators in terms of crosstalk. The point model theory due to Feynman is corrected to account for these multiple scatterings. Using spectral information measured by the liquid scintillators, fractions of multiple scattering can be estimated, and mass reconstruction of fissile materials under investigation can be improved. Monte Carlo simulations of mono-energetic neutron sources were performed to estimate neutron crosstalk. A Californium source in an array of liquid scintillators was modeled to illustrate the improvement of the mass reconstruction.

Keywords: liquid scintillators, crosstalk, multiple scattering, neutron multiplicity, neutron correlation, fissile materials

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1. Introduction

The purpose of this work is to quantify the fractions of fast neutrons scattering between adjacent liquid scintillators, a phenomenon known as neutron crosstalk. We propose a new method to quantify them. While this paper will focus on theoretical development to model neutron crosstalk, and show simulation results, the strength of this new method lies in that it can be used to determine neutron crosstalk experimentally using fissile materials as neutron sources. This will enable experimentalists to quickly characterize their array of liquid scintillators in terms of multiple scattering fractions/neutron crosstalk, the same way as instruments are calibrated in energy, and detectors are synchronized in time, prior to taking data. The authors are currently working on a second paper, where an array of liquid scintillators is thus characterized experimentally. Preliminary results are available in Ref. [1].

It is well known [2, 3, 4, 5] that masses of nuclear materials undergoing fissions can be determined using ^{3}He tubes counting thermal neutrons. For general neutron multiplicity counting (NMC) applications, the theory usually assumes that neutrons can only be counted once. This assumption is correct for ^{3}He tubes, where neutrons are captured when counted. However, for liquid scintillators, a neutron can scatter and deposit enough energy in multiple liquid scintillators to record multiple counts. The measured count rate and the two- and three-neutron correlations will thus be adversely increased. NMC applications are very sensitive to two-, three- and higher order correlations. With fast neutrons registering multiple correlated counts, the standard Feynman

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