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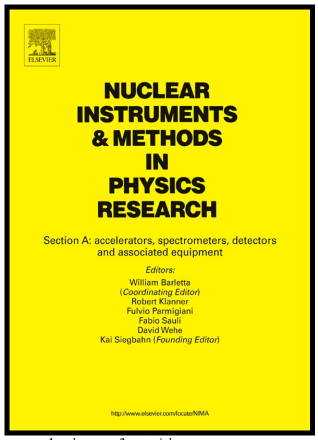

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Triple Pulse Shape Discrimination and Capture-Gated Spectroscopy in a Composite Heterogeneous Scintillator

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Abstract

We demonstrate an all-solid-state design for a composite heterogeneous scintillation detector sensitive to interactions with high-energy photons (gammas), fast neutrons, and thermal neutrons. The scintillator exhibits triple pulse shape discrimination, effectively separating electron recoils, fast neutron recoils, and neutron captures. This is accomplished by combining the properties of two distinct scintillators, whereby a 51-mm diameter, 51-mm tall cylinder of pulse shape discriminating plastic is wrapped by a 320-µm thick sheet of ^{6}LiF:ZnS(Ag), optically coupling the scintillators to each other and to the photomultiplier tube. In this way, the sensitivity to neutron captures is achieved without the need to load the plastic scintillator with a capture agent. We demonstrate a figure of merit of up to 1.2 for fast neutrons/gammas and 5.7 for thermal neutrons/gammas. Intrinsic capture efficiency is found to be 0.46±0.05% and is in good agreement with simulation, while gamma rejection was 10^{-6} with respect to the capture region and 10^{-4} with respect to the recoil region using a 300 keVee threshold. Finally, we show an improvement in capture-gated neutron spectroscopy by rejecting accidental gamma coincidences using pulse shape discrimination in the plastic scintillator.

Keywords: composite scintillator, pulse shape discrimination, capture-gating

1. Introduction

Detection of both fast and thermal neutrons is of great interest for applications in homeland security, nonproliferation, and basic research. Nuclear recoils resulting from neutron elastic scattering on protons represent one commonly used mechanism for fast neutron detection. Another type of neutron detection technique is more effective for thermal neutrons and is based on neutron capture reactions, such as ^{6}Li(n,t)^{4}He or ^{10}B(n,α)^{7}Li. Fast neutrons are also commonly detected through a combination of thermalization and neutron capture. Homogeneously-doped scintillators containing ^{6}Li and ^{10}B can be used to detect fast and thermal neutrons via a combination of those mechanisms, and their performance and pulse shape discrimination (PSD) capabilities have been

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