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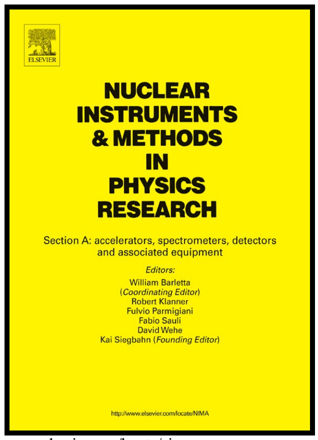

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PII: S0168-9002(16)31048-8
DOI: http://dx.doi.org/10.1016/j.nima.2016.10.023
Reference: NIMA59382

To appear in: *Nuclear Inst. and Methods in Physics Research, A*

Received date: 13 July 2016
Revised date: 11 October 2016
Accepted date: 12 October 2016

Cite this article as: M.M. Bourne, S.D. Clarke, M. Paff, A. DiFulvio, M Norsworthy and S.A. Pozzi, Digital Pile-up Rejection for Plutonium Experiment with Solution-Grown Stilbene, *Nuclear Inst. and Methods in Physics Research A,* http://dx.doi.org/10.1016/j.nima.2016.10.023

Digital Pile-up Rejection for Plutonium Experiments with Solution-Grown Stilbene

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Abstract

A solution-grown stilbene detector was used in several experiments with plutonium samples including plutonium oxide, mixed oxide, and plutonium metal samples. Neutrons from different reactions and plutonium isotopes are accompanied by numerous gamma rays especially by the 59-keV gamma ray of ^{241}Am. Identifying neutrons correctly is important for nuclear nonproliferation applications and makes neutron/gamma discrimination and pile-up rejection necessary. Each experimental dataset is presented with and without pile-up filtering using a previously developed algorithm. The experiments were simulated using MCNPX-PoliMi, a Monte Carlo code designed to accurately model scintillation detector response. Collision output from MCNPX-PoliMi was processed using the specialized MPPost post-processing code to convert neutron energy depositions event-by-event into light pulses. The model was compared to experimental data after pulse-shape discrimination identified waveforms as gamma ray or neutron interactions. We show that the use of the digital pile-up rejection algorithm allows for accurate neutron counting with stilbene to within 2% even when not using lead shielding.

Keywords: stilbene scintillator, plutonium experiments, MCNP, MCNPX-PoliMi

1. Introduction

The ability to accurately measure and identify neutrons from plutonium samples is necessary for nuclear nonproliferation applications. As a dual gamma ray-neutron detector, stilbene has demonstrated excellent pulse-shape discrimination (PSD) when measuring ^{252}Cf, allowing for good neutron efficiency while retaining accurate classification of particles as gamma rays or neutrons [1-3]. It is desired to use stilbene to measure plutonium samples. However, the gamma-ray intensity of plutonium samples is often over 100 times higher than the neutron intensity (for comparison, ^{252}Cf emits 2-10 gamma rays per neutron) and the extra gamma-ray interference poses problems for neutron counting with stilbene.

As the gamma-ray count rate increases in plutonium samples, the near-simultaneous detection of two or more gamma rays in the same scintillator (gamma-ray pulse pile-up) is likely to be misclassified as a neutron by charge integration PSD in stilbene. ^{3}He is the standard tool for detecting neutrons from actinide samples due to its gamma ray-insensitivity, but also has a high cost and requires moderation of incident neutrons. Lead can efficiently shield stilbene from low-energy gamma rays, but shielding reduces portability of stilbene in field applications. Through the use of a digital pile-up rejection algorithm, it was demonstrated that solution-grown stilbene was capable of achieving a gamma-ray misclassification rate to the order of 10^{-6} while maintaining neutron intrinsic efficiency of approximately 15% when measuring ^{252}Cf neutrons without lead shielding [4]. The goal of this work is to determine the need for the pile-up rejection algorithm when measuring several plutonium samples with stilbene scintillators. A variety of plutonium samples were measured with stilbene scintillators, each with varying source composition, source