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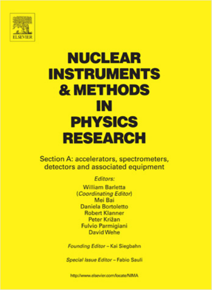
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Numerical Integration of Detector Response Functions via Monte Carlo Simulations

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Abstract

Calculations of detector response functions are complicated because they include the intricacies of signal creation from the detector itself as well as a complex interplay between the detector, the particle-emitting target, and the entire experimental environment. As such, these functions are typically only accessible through time-consuming Monte Carlo simulations. Furthermore, the output of thousands of Monte Carlo simulations can be necessary in order to extract a physics result from a single experiment. Here we describe a method to obtain a full description of the detector response function using Monte Carlo simulations. We also show that a response function calculated in this way can be used to create Monte Carlo simulation output spectra a factor of ~1000× faster than running a new Monte Carlo simulation. A detailed discussion of the proper treatment of uncertainties when using this and other similar methods is provided as well. This method is demonstrated and tested using simulated data from the Chi-Nu experiment, which measures prompt fission neutron spectra at the Los Alamos Neutron Science Center.

Keywords: Detector Response, MCNP, ^{6}Li-glass Detector, Neutron Detection

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1. Introduction

The signal rate for a detector in an experiment is a function of the number of particles emitted from the source and the response function of the detector. In a typical experiment, a particle (neutron, γ ray, ...) is emitted from a source or target with an initial energy, E, and the experimental task is to detect that particle and record some properties of it, such as energy, direction, etc. In some γ-ray experiments, the particle is emitted from the target and potentially scatters along the way to the detector. If the γ ray reaches the detector, it does so with an energy, E', that *may or may not be equal* to E. That γ ray then transfers an energy, E_t, into the detector which is recorded as a count in a bin of an output spectrum that corresponds to E_t. In the case of a γ-ray cascade, multiple γ rays may be emitted nearly simultaneously and coincidence summing can be an issue. Neutron-detection experiments behave similarly with the difference that measured energy, E_t, of a neutron is commonly determined via a time-of-flight technique. In either type of experiment, it is likely that $E_t \neq E$ or E'. As such, determining the true distribution of initial energies, E, from a number of particles measured to have a potentially different energy, E_t, may be difficult and likely requires knowledge

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