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2017 American Nuclear Society Student Conference

Analytic Error Quantification for Generalized Fast-Neutron Multiplicity Counting Equations

Neutron detection systems are widely used for the nonintrusive quantification of fissile material, and multiplicity counting is a time correlation analysis used to analyze such systems. Neutron multiplicity counting traditionally relies on capture-based detectors (e.g. ^{3}He) in which neutrons are moderated to thermal energies. Normally, only the first three neutron multiplicities – singles (*S*), doubles (*D*), and triples(*T*) – are counted. Emitted neutrons can induce further, subsequent fissions, thus we must account for this leakage multiplication (*M*) in our analysis. Recently, there has been more interest in detectors that do not rely on ^{3}He such as scatter-based organic scintillators. Scintillators offer several advantages and do not require moderation, hence serving as fast-neutron multiplicity counters. Fast-neutrons have sufficient energy to deposit energy above the detection threshold more than once; this phenomenon is called cross-talk. Cross-talk is detrimental; counts due to cross-talk cannot be distinguished from a true count and can lead to overestimation of the fissile mass. In this document we will analytically derive a first-order error equation for *M* that works for both thermal and fast neutron systems.