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Title: Cross-Correlation Breakdown of BC-420 Plastic Scintillators

Abstract

Special nuclear materials (SNM) undergo fission, resulting in multiplets of neutrons and photons. Neutrons can induce subsequent fissions, possibly sustaining a chain reaction in assemblies of SNM. The propensity of an assembly to sustain fission chains and the ability to detect these events are of widespread interest in nuclear nonproliferation, safeguards, criticality safety, and emergency response. Cross-correlation (CC) analysis is a tool typically implemented for understanding fission particle energy and time-correlated behaviors. Emitted neutrons and photons are correlated in time and have well-known and characteristic distributions over many fission events. This work will focus on analyzing the CC breakdown of Li-6-glass-faced BC-420 plastic scintillation detectors through simulation. Specifically, these benchmarks are simulated with MCNPX-PoliMi using various cases including, two 180° separated BC-420 detectors with Cf-252 point source, and a criticality safety benchmark of four BC-420 detectors with 2 uranyl (93.1 wt% U-235) nitrate filled WINCO tanks with separate simulations for full and empty tanks. The simulated collisions in the detectors are processed using MPPost, a detector response post-processing software, to obtain the cross-correlations and pulse heights for each scenario. This simulation work has shown that: 1) photon-photon cross-correlations are much more prevalent, especially in a multiplying assembly, 2) the frequency of neutron-neutron correlations are of significantly lower magnitude than all other correlations regardless of assembly, and 3) photons from inelastic fast neutron scatters in the detector consistently contribute to the frequency at larger time differences in photon-photon cross-correlations, but are minimized in multiplying assemblies.