Abstract

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Validating Organic Scintillator Rossi-alpha Measurements of Fast Metal Assemblies using Simulations

Reactivity, ρ, and the k-effective multiplication factor, keff, describe the propensity of an assembly of special nuclear material to sustain fission chains, and the quantities are of widespread interest in criticality safety, nuclear nonproliferation, safeguards, and emergency response. However, keff cannot be measured directly. We can infer keff from the prompt neutron decay constant, α, which is measured in Rossi-alpha measurements; a microscopic neutron-noise technique based on nonrandom variations of time differences between neutron detections. Rossi-alpha measurements traditionally use He-3 detectors embedded in a hydrogenous, moderating matrix. However, He-3 based systems are insensitive to α for fast assemblies (that can be near or at delayed-critical), due to slowing-down time of neutrons in the moderating matrix. Therefore, it is of interest to investigate detection systems faster than He-3. Organic scintillators do not require moderating material, and measurements are subsequently three orders of magnitude faster (ns vs. μs). We used an array of trans-stilbene crystal organic scintillation detectors to measure a bare sphere of approximately 4.5 kg of alpha-phase, weapons-grade plutonium and reflected by approximately 7.62 cm of iron, nickel, copper, or tungsten. The five configurations were analyzed with the Rossi-alpha technique. We aim to validate organic scintillator Rossi-alpha measurements by comparing measurements to two different, independent simulations and to demonstrate the sensitivity of organic scintillators to α of fast assemblies.