Identification of Radioactive Materials by Analysis of Simulations and Measurements of Cross-Correlation Functions

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A fast and robust methodology for identification of radioactive materials is of great interest for applications in the fields of homeland security and nuclear nonproliferation. For fissile materials in particular, several passive and active interrogation techniques are being investigated. These systems rely on the fact that the interrogated material emits correlated neutrons and gamma rays from each induced or spontaneous fission event. A convenient way to look at correlated events in a fissionable material is to study time-dependent detector cross-correlation functions. These functions are unique for a given material and geometry, representing a distinctive signature of the material-geometry configuration. In this work, we focus on the identification of plutonium samples in both metallic and oxide form. The simulation program used in this study is the MCNP-PoliMi code, an improved version of the standard MCNP code. This code allows the user to obtain event-by-event information about the simulated particles. This capability is essential for accurate simulations of cross-correlation events. The number of correlated events as a function of time is obtained from the MCNP-PoliMi output collision file by using special postprocessing algorithms. We investigated several parameters, such as the sample composition and mass, the sample-detector distance, and the shielding between the detector and the sample. We then analyzed the simulated cross-correlation functions to obtain relationships between features from the correlations and sample characteristics. To verify the simulations, measured functions, using a Cf-252 neutron source, fast waveform digitizer, and liquid scintillation detectors, were compared with the simulated ones. In the full paper we will discuss, in detail, the results obtained from the simulations and the measurements. We will also conclude how accurate this interrogation method is in distinguishing the plutonium samples in different chemical forms.