Analysis of Neutron and Gamma-Ray Cross-Correlation Functions for Determining Plutonium Oxide Masses

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ABSTRACT

ORNL is currently developing methods that can easily and efficiently determine the mass of nuclear and possibly harmful material without risking the lives of human beings. This method consists of using neutrons in order to interrogate the material and placing liquid scintillation detectors around it to detect gamma rays and neutrons that are emitted due to induced and spontaneous nuclear fission. The program currently used is the MCNP – PoliMi code (MCNP stands for 'Monte Carlo N-Particle'), an extremely powerful computer program aimed at simulating real physical events. After the experiment is set up with the neutron source above the sample of plutonium-oxide of known mass and the liquid scintillation detectors are placed around the sample in a known configuration, a certain amount of neutrons exit the source and collide with the sample, causing multiple fissions. These fissions emit both gamma rays and neutrons, which can collide with of the sample, hit the detectors, or leave the geometry. When the particles hit the detectors, the type of particle, either neutron or gamma ray, is stored to a file, which is later analyzed. The data is placed on an *x y* coordinate system with time in nanoseconds on the x-axis and occurrence on the y-axis. The graphs created from the analyzed data display *n* detections, where *n* represents both neutron and gamma rays alike. These graphs also display multiple curves, including combinations n-n, n-p, p-n, p-p, and total (with n representing neutrons and p representing gamma rays). The unique feature of each isotope is the height/width of the side peaks of the total cross-correlation function, and this information can be used for sample identification. Several results have been obtained using MCNP – PoliMi, including different detector distances and sample masses along with the introduction of lead plates in front of the detectors for the purpose of preventing as many cross-talk events as possible (cross-talk events result from the interference of different detectors and can lead to strewn results). The results showed that sample masses can be determined by appropriate data analysis. This project is just a small piece of a much larger project, involving multiple people from the past and many more in the future, in an attempt to help homeland security and stop terrorism.