NIST Virtual Gamma Spectrometry System: A Comparison of Counting Efficiencies from Measurements and Monte Carlo Simulations

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Abstract

Anthropometric and anthropomorphic phantoms have been used extensively for characterizing in-vivo measurement systems that determines internally deposited radionuclides. The accuracy in activity determination relies critically on system design, calibration routine, and reproducbility in material composition, geometry configuration, and physical dimensions of the phantoms respect to the actual objects to be measured. It is required by the ANSI N13.30 standard to assure the measurement results to be consistent with the national physical standards with stated analytical bias and uncertainties. Therefore, a series of realistic application-dependent phantoms need to be developed and standardized based on reliable and confirmable measurement and simulation results, in order to establish measurement traceability for in-vivo radiobioassay.

In response to the needs of national phantom standards for in-vivo measurements, a virtual gamma spectrometry system has been assembled at the Radioactivity Group of the National Institute of Standards and Technology (NIST). The system consists of a three-dimensional with three hundred and sixty-degree rotational translation range, a high-purity germanium coaxial detector (HPGe), and a PC-based Monte Carlo N-Particle Code System (MCNP4B2). The system was initially calibrated with NIST ^{60}Co and ^{137}Cs point- and ampoule- sources, respectively, at the precisely defined source-to-detector arrangements. The Monte Carlo simulations were performed to match the experimental conditions. The system counting efficiencies from measurements and MCNP simulations were compared for the photo peaks of 661.7 keV, 1173.2 keV, and 1332.5 keV. With the validated detector and system parameters, the system models developed for MCNP simulations were further tested using the selected pieces of **Bottle Mannequin Absorber** (BOMAB) phantom filled with a known amount of ^{60}Co and ^{137}Cs activities.

This paper describes the results of comparison between the measured and simulated counting efficiencies under various counting geometries. The dependency of system counting efficiency on source position, detector dead layer thickness, and peak area integration were also investigated. The results from this preliminary study validated the entire system parameters and provided a foundation for future MCNP simulations and activity determinations of more complex phantom-detector geometries.