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Modeling of Radiative Processes in Organic Scintillators

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ABSTRACT

This thesis presents the development of a Monte Carlo calibration of a whole body counter (WBC), consisting of four large plastic (organic) scintillators, used for determine the body burden of gamma-emitting radionuclides. A scintillator emits optical photons after energy has been deposited by an ionizing particle in the scintillator material. The optical photons are converted into an electric signal by two photomultiplier tubes (PMT) mounted on each plastic scintillator and the final output from the WBC is an energy spectrum. The Monte Carlo model should accurately predict a measured energy spectrum, which requires a detailed model of the radiative processes in the scintillators. In Paper I the geometrical Monte Carlo model of the WBC is verified by comparing the simulated total efficiency (using MCNPX) with the measured total efficiency. Paper I shows that optical physics needed to be included in the Monte Carlo model. Paper II shows that the Monte Carlo code GATE, which can transport ionizing particles and optical photons, can be used to model the plastic scintillators. Paper II also presents a method to model the PMT response in MATLAB. Paper III presents a thorough study of the optical transport in GATE and identifies the key parameters for describing the optical physics processes at a scintillator surface. The Monte Carlo model is verified in Paper IV by comparing simulated results with measured result. Paper IV also presents the final step in the Monte Carlo calibration process by implementing the ICRP human computational phantoms into the Monte Carlo model of the WBC.

Keywords: Monte Carlo, optical photon transport simulations, gamma spectrometry, whole body counting, voxel/computational phantoms.

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