Techniques for Improving Calculation Efficiency of Monte Carlo Simulation for Radiation Portal Monitor

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A radiation portal monitor (RPM) system is one of the effective nondestructive testing (NDT) methods for detecting illegal radioactive materials entering through the border. In order to estimate the RPM's performance in various conditions and determine the optimized design, the Monte Carlo simulation technique is considered to be essential; however, the calculation efficiency is frequently needed to be improved when we are dealing with the complex geometry and a wide range of source term (e.g., a few hundred meters in source diameter). In the present study, the applicability of the various techniques to improve calculation efficiency was evaluated. For example, as a simple but highly effective way, the complex geometry of the RPM was surrounded by a simple box, resulting in ~50% of improvement in the calculation efficiency due to the reduced number of calculation for 'safety check' in particle transport, which compares the distance to the next volume boundary and the next interaction position. Additionally, we are evaluating the applicability and effectiveness of the various variance reduction techniques (VRT) in MCNP: weight windows (WWs), exponential transform (EXT), and surface source write and read (SSW/SSR). WWs effectively control particle weights and provide a distribution of particle importance in space, energy, and time. The EXT technique allows particle walks to move in a preferred direction by artificially reducing the macroscopic cross-section. Finally, the SSW records the particle information at the specified surface as a phase space file, and then it can be used for the subsequent simulation as a source term by using the SSR function. These results could substantially improve the calculation efficiency of the Monte Carlo simulation not only for the RPM but for the other radiation detectors in NDT applications.