Advancement of airborne radiation measurement technology: (2) Simulations of unmanned helicopter and $LaBr_3$(Ce) detector used for estimating radiocesium distribution in soil

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Here we report PHITS Monte Carlo simulations of a $LaBr_3$(Ce) gamma spectroscopy system used in unmanned helicopter radiation surveys in Fukushima Prefecture. The simulated spectra were verified against measurements taken under controlled laboratory conditions. Simulations were used to characterize the peak-to-Compton method for estimating the vertical distribution of radiocesium in soil from airborne surveys.

Keywords: $LaBr_3$(Ce), gamma spectroscopy, unmanned helicopter, airborne survey, PHITS, peak-to-Compton method, simulation

1. Introduction

Unmanned helicopter radiation surveys play an important role in characterizing the radioactive fallout distribution in Fukushima Prefecture [1,2]. Unmanned helicopters are permitted to fly at lower altitudes above the ground than crewed aircraft in Japan, so therefore can yield measurements with better spatial resolution of the fallout. Recently Ochi et al. (2017) [3] demonstrated the use of an unmanned helicopter for assessing the vertical distribution of radiocesium in Fukushima soils. The method was based on the ratio of direct-to-scattered gamma rays detected by the onboard $LaBr_3$(Ce) gamma spectroscopy system (the so-called 'peak-to-Compton' method). The goal of this study was to simulate this unmanned helicopter system and understand how the peak-to-Compton count ratio varies for different radiocesium depth distributions and helicopter flight altitudes.

2. Method

The $LaBr_3$(Ce) detector system was modelled with PHITS [4]. The peak-broadening parameters in the simulations were calibrated using measurements of the detector energy resolution taken from spectra of ^{152}Eu and ^{137}Cs sources. Simulated spectra were verified against various spectra measured in the laboratory. The modelling of scattering was checked by comparing peak-to-Compton count ratios from the simulations to the test measurements. The amount of scattering was varied by using a water tank to shield a ^{137}Cs test source from the detector. The peak-to-Compton method was investigated by simulating a semi-infinite soil-air system. The radiocesium depth distribution in soil and height of the helicopter above the ground were varied in the analysis.

3. Results

The simulation results clarify the dependency of the peak-to-Compton count ratio on the helicopter height and the depth distribution of radiocesium in soil. Both exponential and uniform distributions of radiocesium within soil were considered in the analysis.

References

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