Paper 4E-20: Calibrating the ProSPECTus System to Enable Rapid and Accurate Point-Source Activity Quantifications

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In response to major radionuclide releases to the environment at Fukushima, Japan, technologies for radiation monitoring that promise significant advantages for nuclear security applications are being developed and tested. At Fukushima, remediation of agricultural land is underway and the scientific focus is now on understanding the dynamics of caesium-137 (^{137}Cs) in the extensive forest ecosystem, an agenda which demands accurate, highly spatially- and temporally-resolved quantification of activity such that rates and pathways of ^{137}Cs processing in plants and soils can be elucidated.

A limitation of Compton-geometry gamma cameras is the difficulty in quantifying source activities. Efficiency is dependent on source position within the camera's field-of-view (FoV), causing difficulty in deducing activity from the measured imaging event rate. This paper presents new work to characterise the response of the ProSPECTus system and hence derive a calibration function enabling accurate estimation of source activity. The potential benefits to security applications of rapid screening for precise activity and source distribution at small scale (sub-cm resolution in sub-metre phase space) are substantial.

The spatial dependence of the ProSPECTus device response was investigated by simulating 1800 ^{137}Cs point sources evenly distributed within a 90 × 170 × 90 mm phase space using GAMOS. A correction factor, *k*, was defined as the quantity by which the number of imaging events registered for each point had to be multiplied to give the known number of gamma rays emitted. Interpolation of *k* values yielded a spatially-dependent correction function *f(x,y,z)*. To validate this, a ^{137}Cs point source was placed at 20 locations within the FoV of ProSPECTus and the event rate measured. A discrepancy coefficient, *g*, was then applied to *f(x,y,z)* by comparing the known activity to that found if *f(x,y,z)* was assumed to be correct.

The validated function was then used to estimate source activity from an earlier pilot experiment in which ProSPECTus monitored the transport of dissolved 137Cs through a soil column [5]. The estimates from the whole phase space calibration method described above (1.535 ± 0.245 MBq) and an independent point calibration (1.486 ± 0.282 MBq) are close to the known activity of 1.797 MBq. The estimated values are very similar, suggesting the difference from the known activity is due to factors pertaining to the column experiment such as attenuation in the soil and the somewhat dispersed source. The dominant sources of error are the uncertainty in column position and spatial resolution of the detector. This result represents a solid foundation upon which to develop the method. The calibration is specific to gamma ray energy, phase space geometry and detector assembly, but the method is generally applicable.