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Environmental Compton camera development: imaging radionuclide transport in soils and geomaterials

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Current research in the Nuclear Instrumentation group of the University of Liverpool focuses on the optimisation of the gamma ray Compton camera [1]. Such an imaging system can utilise two energy and position sensitive semiconductor detectors with the Compton scattering formula to gain position and energy information of gamma-ray emitting radioactive sources. This presents a significant improvement in efficiency and dynamic range over coded aperture systems currently used in industry [2]. We present the progress of a project funded by the Natural Environment Research Council, aiming to optimise a Compton camera system for environmental radioactivity measurements. The project will investigate the feasibility of a range of applications, from small scale imaging of radiation transport through soil and uptake in plants, to large scale monitoring of soil erosion and radioisotope retention in tree canopies. This will build upon previous work that developed the proof of concept of a fused radiometric and optical stereoscopic imaging system for use in nuclear decommissioning.

This project employs a Compton camera that consists of two planar HPGe semiconductor detectors of dimensions 60x60x5 mm and 60x60x20 mm. The processes of radiometric image generation will be presented in the context of an experiment that imaged 20 MBq Cs-137 point sources at standoff distances of 0.8–1.5 m. The merits of a new iterative image reconstruction algorithm will be demonstrated that gives significant improvements in image resolution over analytical methods. Experiments will now focus on the ability of the system to image low activity sources and initial measurements will look to develop previous work by Corkhill et al [3] that produced time lapse images of Tc-99m transport using a gamma camera. A liquid Ce-139 source will be dripped through a column of sand and the Compton camera used to monitor flow, with the aim of enabling detailed quantification of radionuclide reactive transport in a wide range of wastewater filtration and environmental scenarios. This will be presented alongside GAMOS [4] simulations that investigate the limits of the system. The potential for fusion with optical stereoscopic images will be discussed alongside prospects for this project beyond the laboratory work.

1. R.B. Todd et al, "A proposed gamma camera."Nature, vol. 251, no. 5471, pp. 132-134, 1974.
2. E. Caroli et al, "Coded aperture imaging in X- and gamma-ray astronomy."Space Science Reviews, vol. 45, no. 3-4, pp. 349-403, 1987.
3. C. L. Corkhill et al, "Real-Time Gamma Imaging of Technetium Transport through Natural and Engineered Porous Materials for Radioactive Waste Disposal." Environ. Sci. Technol. vol. 47, pp. 13857–13864, 2013
4. P. Arce, "GAMOS: A Geant4-based easy and flexible framework for nuclear medicine applications," in Conf. Rec. 2008 IEEE Nuclear Science Symposium, pp.3162,3168, 19-25 Oct. 2008

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