Evaluation of scintillator detection materials for application within environmental radiation monitoring

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The last five years has seen the unabated growth in the number of airborne platforms performing radiation mapping –each using various iterations of low-altitude unmanned aerial vehicle (UAV). Alongside the associated advancements in the base airborne system transporting the radiation detection payload, from the earliest radiological analyses performed using gas-filled Geiger-Muller tube detectors, modern radiation mapping platforms are now based near-exclusively on solid-state scintillator (and to a lesser-extent semiconductor) detectors. With numerous types of these light-emitting crystalline materials now in existence, this combined desk and computational modelling study sought to evaluate the best-available detector material compatible with the requirements for low-altitude autonomous radiation mapping –of naturally-occurring but also anthropogenically-derived radionuclides.

Aside from ground-based radiation surveying undertaken by humans; environmental mapping of radiation distribution (resulting from both anthropogenic activities as well as from naturally-occurring radioactive material) has been performed historically using manned, fixed-wing aircraft. In contrast to the more limited detector volumes carried during on-ground operations (due to size and weight practicalities), the systems carried during these extensive spatial extent aerial surveys are typically not less than 33 litres in detector volume. For the gamma-ray measurements of naturally-occurring radionuclides, the key emission peaks are associated with the daughter products of the U (^{214}Bi) and Th (^{208}Tl) decay chains, alongside a strong contribution from radiogenic potassium (^{40}K). In contrast to the higher-energy (>1.0 MeV) gamma-ray emissions characteristic of the aforementioned naturally-occurring radionuclides, the primary anthropogenically-derived radionuclide released into the environment in extensive quantities during an emergency release event (such as at both Fukushima and Chernobyl) is radiocesium –specifically ^{137}Cs (half-life: 30.17 years), which emits a single gamma-ray photon at 0.662 MeV.

While the currently and widely-used NaI and CsI (both of which are Tl-doped) are the mainstays of radiation monitoring, during this study, LaBr scintillator detectors were determined to possess not only a greater sensitivity to incident gamma-radiation, but also a far superior spectral (energy) resolution over existing detector materials. Combined with their current competitive cost, an array of three such composition cylindrical detectors were determined to provide the best means of detecting and discriminating the various incident gamma-rays incident onto the detector owing to both naturally-occurring or anthropogenically-derived sources.
In this talk, we will present the results of multiple GEANT4 simulations that will inform the potential future development of the next generation of radiation detection materials and their optimal configurations for deployment.