Improving X-Ray Material Separation in Cargo Screening with Fast Scintillators

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Cargo screening, the non-invasive scanning of cargoes with X-rays, is an important industrial use-case for scintillators. Implemented at facilities like ports and border crossings, cargo screening uses transmission x-ray imaging to inspect cargoes to prevent smuggling of drugs, explosives and other contraband. To effectively detect contraband and distinguish it from legitimate cargo, there must be some way to discriminate between different materials. Existing methods for material separation use two X-ray beams at different energies. Material separation can be achieved by looking at differences in transmission at these energies. While effective, this is a relatively slow method, due to the requirement to use two separate beams.

We present work done to improve this process, by using fast scintillators with spectroscopic capabilities to enable material separation with a single X-ray beam. An array of lutetium–yttrium oxyorthosilicate (LYSO) scintillators, coupled to silicon photomultipliers (SiPMs), is used as the detector system. By comparing images taken with this detector system using low and high energy thresholds, material separation could be carried out. Geant4 simulations were used to verify the capabilities of this detector system and the ability to achieve effective material separation. This was confirmed with laboratory tests with γ-ray sources. Finally, a 320 keV X-ray source was used to test the detector system in real-world conditions, against simulated contraband.

Testing with γ-ray sources showed that the detector system could effectively distinguish between materials, showing clear differentiation between metals and organic materials. The simulations, meanwhile, showed that the LYSO system had the capacity to distinguish between multiple materials, including between key forms of contraband, with Z_{eff} being the key differentiator between materials of different densities. These results were confirmed in testing with the 320 keV source. This research shows strong prospects for improving the speed and effectiveness of cargo scanning, by exploiting the capabilities of newly available scintillators.

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