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Cosmic-Ray Muon Tomography - Non-Destructive Assay of Illicit Nuclear Material within Shielded Containers

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Tomographic imaging techniques using the Coulomb scattering of cosmic-ray muons are increasingly being exploited for the non-destructive assay of shielded containers in a wide range of applications. One such application is the characterisation of legacy nuclear waste materials stored within industrial containers. The design, assembly and performance of a prototype muon tomography system developed for this purpose are detailed in this work. This muon tracker comprises four detection modules, each containing orthogonal layers of 2 mm-pitch plastic scintillating fibres. Identification of the two struck fibres per module allows the reconstruction of a space point, and subsequently, the incoming and Coulomb-scattered muon trajectories. These allow the container content, with respect to the atomic number Z of the scattering material, to be determined through reconstruction of the scattering location and magnitude. On each detection layer, the light emitted by the fibre is detected by a single MAPMT with two fibres coupled to each pixel via dedicated pairing schemes developed to ensure the identification of the struck fibre. The PMT signals are read out to standard charge-to-digital converters and interpreted via custom data acquisition and analysis software.
The design and assembly of the detector system are detailed and presented alongside results from performance studies with data collected after construction. Images reconstructed from a test configuration of materials have been obtained using software based on the Maximum Likelihood Expectation Maximisation algorithm. The results highlight the high spatial resolution provided by the detector system. Clear discrimination between the low, medium and high-Z materials assayed is also observed.

Country or International Organization

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