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A Prototype Scintillating-Fibre Tracker for the Cosmic-Ray Muon Tomography of Legacy Nuclear Waste Containers

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Cosmic-ray muons are naturally-occurring charged particles which are observed at sea level at a rate of 1 per square centimetre per minute. Their high energies (around 3 GeV) allow them to easily penetrate materials. At these energies, they interact with matter primarily through Coulomb scattering from atomic electrons and nuclei. These properties are exploited in muon tomography to image objects inside industrial nuclear waste containers which block or restrictively attenuate more common forms of radiation, such as X-rays or gamma-rays.

To this end, a prototype scintillating-fibre detector system has been developed by the Nuclear Physics group at the University of Glasgow in collaboration with the UK National Nuclear Laboratory (NNL). This system consists of four tracking modules, two above and below the container to be interrogated. Each module consists of two orthogonal planes of scintillating fibres yielding one space point per module. Per plane, 128 _fibres of 2mm pitch, are read out by one Hamamatsu H8500 64-channel MAPMT with two fibres multiplexed onto one pixel. A dedicated mapping scheme has been developed to avoid space point ambiguities while retaining the high spatial resolution provided by the fibres. The configuration allows the reconstruction of the incoming and scattered muon trajectories, thus enabling the container content, with respect to material density (or atomic number Z), to be determined.

The advantage of the chosen design is its ruggedness as the tracking modules do not require a complicated gas system or contain fragile components, thus making it ideal for deployment in an industrial environment. The design and construction of the detector system are presented alongside performance analysis with respect to muon tracking.

A likelihood-based image reconstruction algorithm was developed and tested using a dedicated GEANT4 simulation of the prototype detector system and detailed Monte Carlo modelling of the muonic properties. Images reconstructed from this simulation are presented in comparison with preliminary results from data taken on a test setup. The experimental results verify the simulation, and in both, clear discrimination is observed between the low, medium and high-Z materials imaged.

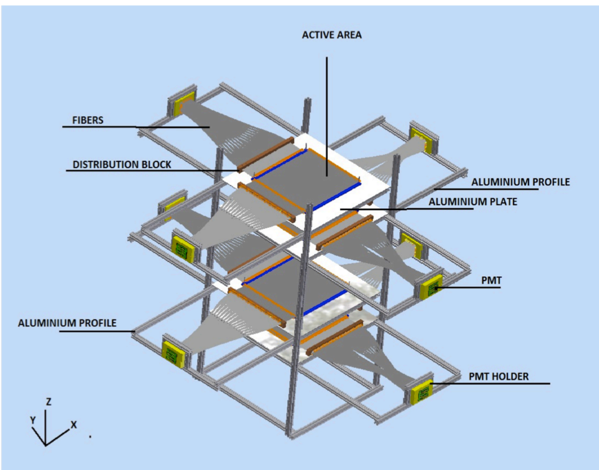

Figure 1: *Schematic View of the Prototype Detector*.