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Cosmic ray muon scattering imaging system based on scintillation detector

Cosmic ray muon imaging, as a non-invasive imaging modality, utilizes naturally occurring cosmic ray muons as penetrating probes to reconstruct the distribution of matter. A critical challenge in designing position-sensitive muon detectors lies in optimizing the trade-off among three key parameters: detection area, spatial resolution, and manufacturing cost. Owing to their proven feasibility and operational robustness, scintillator-based detectors remain the preferred choice for muon imaging systems, despite their inherent limitation in achieving sub-centimeter spatial resolution.

The primary objective of our project is to develop a large-area, high-position-resolution, and cost-effective cosmic ray muon scattering imaging system based on plastic scintillator detectors. The system achieves an effective detection area of 53 cm × 53 cm, with submillimeter position resolution (<1 mm) under optimized 1.1 cm center-to-center spacing between scintillator strips. Following system assembly, clear imaging results were successfully obtained for 2 cm × 2 cm square lead and tungsten blocks, demonstrating the system's capability for high-Z material identification.

Finally, to further reduce detector fabrication costs, an investigation was conducted using organic liquid scintillators as the sensitive medium for muon detection, replacing conventional plastic scintillators. Initial tests of the liquid scintillator prototype demonstrated promising position resolution performance (σ < 1.5 mm).

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