Muon Scattering Tomography: Utilizing Silicon Photomultiplier Arrays to Trilaterate Muon Multiple Coulomb Scattering Events

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Muon scattering tomography is a passive imaging technique able to interpolate the elemental structure of high-Z materials. Given that development of the technique is in a stage of relative novelty, very few renditions are commercially used. The current apparatuses operated at research institutions and companies are extremely cost-inefficient primarily because of the use of drift chambers. In this experiment, the objective is to increase the cost-effectiveness of muon scattering tomography devices by localizing ionization events within prismatic scintillators for optimal rendering of muon multiple-Coulomb scattering incidences. This design implements silicon photomultiplier arrays and a timing circuit to trilaterate muon trajectory when sensing the differential light output from modules of a polyvinyltoluene-based organic scintillator. Means of increasing the photon detection efficiency of the muon detection modules are examined and simulated. Sample-and-hold circuitry with automatic threshold-triggering are developed using discrete components as a cost-effective method of extenuating the analog signal modulation for minimal information loss during digital conversion. The calibration of the device's performance is segmented into three stages: analog signal analysis, digital trilateration, and muon detection. A Monte Carlo simulation is developed to determine the cost effectiveness and time-efficiency of a scaled-up rendition of the device model. When scaled up, our device is a more cost effective design capable of being used in applications including carbon sequestration, cargo inspection, and nuclear waste monitoring.

Awards Won:

Third Award of $1,000