Development of SiPM-Based Scintillator Tile Detectors for a Multi-Layer Fast Neutron Tracker

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We present the development and characterization of thin tile scintillator detectors with silicon photomultiplier (SiPM) readout for use in a multi-layer fast-neutron tracker. The tracker is based on interleaved Timepix and plastic scintillator layers [1]. Fast-neutrons recoil protons in the plastic scintillators, which may then travel to and stop in the neighboring Timepix. Using the measured recoil energy and direction of multiple recoiling protons, it is possible to reconstruct the energy and direction of the impinging neutron.

In this configuration, the scintillator detector's role is to measure the energy lost by the proton in the scintillator and trigger the Timepix acquisition. Requirements for good energy resolution and fast time response motivated the use of SiPMs for the detection of the scintillation light.

The SiPM is a solid-state photo-detector, consisting of a matrix of self quenched Geiger-mode avalanche diodes connected in parallel on a common substrate. SiPMs were found to be well suited for optical readout of scintillator tiles in the multi-layer design, due to their compact size and large internal gain. The initial tile detector prototypes employed dual 3x3 mm area SiPMs, light-guide coupled to a 15x15x2 mm plastic scintillator. A proton beam at the ANSTO Heavy Ion Microprobe was used to calibrate the detectors for 3, 4, and 5 MeV proton energies and to assess energy resolution, linearity and spatial uniformity [2].

We describe our subsequent efforts to improve the detector by increasing the scintillation light detected by the SiPM. An alternative readout geometry was tested, using a larger SiPM array to cover the entire top face of the tile. Variants using different types of plastic scintillator are compared. We also present benchmark results obtained using a deuterium-tritium (DT) fast-neutron source.

This work has been carried out in the framework of the CERN Medipix Collaboration.

[1] J. Jakubek, J. Uher, P. Soukup, *Fast neutron tracker based on 3D position sensitive semiconductor voxel detector*, NSS/MIC (2010).
[2] R. Preston, J. Jakubek, D. Prokopovich and J. Uher, *JINST* **7**, PO2007 (2012).