Contribution ID: **205** Type: **Poster**

Development of a transportable neutron imager for localization of radioactive sources

Wednesday 3 July 2024 14:52 (1 minute)

Locating radioactive hot spots presents a challenge for the nuclear industry and security applications, such as waste management, decommissioning, radiation protection, and the management of nuclear accidents. Detection of fast-neutron emission offers an alternative technique to gamma imaging for verifying the location of radioactive materials. In this study, we present a prototype of gamma-neutron imager utilizing a 12 × 12 plastic scintillator (PS) pixel matrix, with each pixel measuring 3.6 mm × 3.6 mm × 3.6 mm and coupled to a silicon photomultiplier (SiPM). The light response of each pixel is separated by 0.6 mm of PTFE wall. The electronic readout includes the ArrayC-30035-144P SiPM from SensL, Cork, Ireland, connected to the diode-coupled charge division readout from AiT. We utilized a rank 7 MURA coded aperture, comprising two layers: 1 mm of lead and 1 cm thick polyethylene, with a surface area of 11.4 cm × 11.4 cm. This aperture is positioned 5 cm away from the detector and with this setup, the prototype has a field of view (FoV) of 68°. Additionally, all components were assembled within a polyethylene camera housing measuring 17 cm × 14 cm × 9 cm.

We performed Geant4 simulations to determine the optical parameters of the scintillator, explore quenching mechanics, and examine neutron interactions within our scintillator. The simulation framework was validated using experimental results. Additionally, we conducted tests on the prototype using a proton beam at the Cyrcé facility at IPHC, employing a CMOS MAPS sensor to evaluate the beam profile. In this talk, we will discuss the simulation results, comparing them with the experimentals outcomes. Moreover, we will illustrate the spatial resolution capability of the prototype and present our calibration study on its energy response, using both simulation and test results.

Keywords: Neutron imaging, Pixelated plastic scintillator (PS), silicon photomultiplier (SiPM), Geant4, Cyrcé facility

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Session Classification: Poster Session