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#08-2 On the use of pixelated plastic scintillator and silicon photomultipliers array for coded aperture gamma-neutron imaging

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In the nuclear field, the development of instruments for measuring radioactivity and more particularly imaging systems for locating radioactive material is an important issue. This need for localization can be found in many areas of the nuclear industry (decommissioning, waste management and radiation protection) as well as for Homeland Security applications (non-proliferation of nuclear material), for the management of nuclear accidents or for nuclear research (Generation IV and fusion reactors). Gamma imaging is currently the most mature technique and several systems as iPIX, Polaris-H, ASTROCAM 7000HS, RadCam and NuVision are commercially available, meanwhile for neutrons, there are to date no equivalent industrialized systems. Several prototypes were developed over the last years and have demonstrated the feasibility of implementing localization methods applied to neutron imaging.

Nevertheless, significant improvements in either sensitivity or portability still need to be performed to achieve performances that meet the needs of the nuclear industry, which are even more critical when Homeland Security is involved. CEA List presented in 2018 a highly compact (19×14×15 cm 3 , 2.2 kg) fast-neutron/gamma imager based on a modified uniformly redundant array coded aperture and a Timepix detector enhanced with a paraffin layer. In 2019, several studies were carried out to improve and characterize this prototype, but although the compactness requirement was reached, the sensitivity criterion was clearly limited, especially for Homeland Security applications. This limitation was due to the neutron detection approach based on the use of a neutron converter layer. To overcome it while keeping a small footprint, we have investigated the use of plastic scintillators capable of neutron/gamma discrimination coupled with silicon photomultipliers in their matrix form.

As part of these investigations, we present our research on the use of pixelated plastic scintillators and silicon photomultipliers applied to coded aperture gamma-neutron imaging. Specifically, we verified the ability of a multiplexing readout to discriminate and localize neutron interactions. In its intended final configuration, the neutron imager design consists of a coded aperture aligned with a matrix of 12×12 PS each coupled to a silicon photomultipliers. The coded aperture is a rank 7 MURA, composed of tungsten and cadmium, and placed 5 cm away from the detector, with a total thickness of 1.2 cm and a surface area of 100.4 mm×100.4 mm. The pixelated plastic scintillators is composed of polystyrene and standard fluorophores loaded with 6 Li carboxylate [2], which allows the triple discrimination of thermal neutrons, fast neutrons and photons. The dimensions of the pixelated plastic scintillators were chosen to match those of the ArrayC-30035-144P silicon photomultipliers from SensL.

First, this neutron imager design was modeled and its response was simulated using the MCNP6 Monte Carlo code. The encoding capability, field of view, and spatial resolution of the neutron imager was therefore evaluated. Then the expected gain of this concept over the one with Timepix are presented and compared with first promising experimental results. Finally, we detailed the experimental set-up implemented to demonstrate the feasibility of coupling pixelated plastic scintillator to silicon photomultipliers and showed the results obtained.

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