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Assessment of Photodetection Performance of Analog and Digital SiPMs Exposed to Cold Neutrons

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Small Angle Neutron Scattering (SANS) technique uses cold or thermal neutrons for investigation of soft and condensed matter. Significant developments in microelectronics enabled the use of scintillation-based pixelated neutron detectors that exploit Silicon Photomultipliers (SiPM) for detecting visible light generated within a scintillator, in our case a 1 mm thick Ce-doped 6Li-glass [1]. We investigated the dark signal [1], the breakdown voltage, and the photon detection efficiency (PDE) performances [2] of three SiPM technologies: two analog ones and one based on digital counting of avalanche events. The temperature dependence of the dark signal performance, and the breakdown voltages of SiPMs were additionally investigated. The following photodetector arrays have been characterized: SensL Series-C 12×12 array C-30035-144P, Hamamatsu 8 × 8 MPPC array S12642-0808PB-50, and digital Philips DPC3200-44-22 module. We irradiated the photodetector arrays with cold neutrons (lambda = 5 Å) at the KWS-1 instrument [3] of the Heinz Maier Leibnitz Zentrum (MLZ) in Garching, Germany, up to a dose of 6E12 n/cm². During the irradiation campaigns, the SiPM detectors were at all times fully operational, and the measurements were performed partially in-situ.
In this work, we discuss the measurement methods, and instrumentation developed for these tasks. Special emphasis is put on a custom measurement system implemented in a joint effort by the company aSpect Systems GmbH and the Central Institute for Electronic Systems (ZEA-2) of the Forschungszentrum Jülich for temperature and position sensitive measurement of wavelength dependent PDE in the range between 300 nm and 1100 nm. Finally, the results of the characterization of the SiPM arrays carried out before, during, and after cold neutron irradiation are presented.

References

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