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Measuring the photon detection efficiency of VUV-sensitive digital SPAD arrays at TRIUMF

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The high-efficiency detection of vacuum ultraviolet (VUV) photons is essential to the operation of particle physics detectors employing LXe as a scintillator. Silicon photomultipliers (SiPMs) have been selected as the photon detector of choice for current LXe experiments such as MEG II, as well as future detectors such as nEXO and PIONEER, due to their high radiopurity, fast timing performance, and compact form factor. SiPMs will also be employed in LAr experiments such as DUNE and Darkside-20K. Recent R&D efforts to enable these experiments have produced SiPMs which detect LXe scintillation light at 175nm. However, currently available VUV-SiPMs employ an 'analog' structure, in which the outputs of all SPAD pixels are connected together as one channel. This talk will present the first measurements of the detection of VUV light using a digital SPAD array, in which individual SPAD pixels are controlled and read out individually. Developing SiPMs which operate using a digital architecture will facilitate future detectors, which are likely to employ tens of thousands of SiPMs, by simplifying DAQ for large numbers of channels, reducing power consumption, and allowing for on-chip signal processing and filtering. The devices tested are SPADs on a 2-D digital array platform, developed by the University of Sherbrooke as a testbed for technologies to be implemented on a fully 3-D integrated platform. Broadband photon detection efficiency (PDE) measurements have been performed using facilities at TRIUMF for wavelengths from 150-830nm. Devices have been tested with a bare silicon surface, with an SiO2 passivation layer, and with MBE surface treatments. Results indicate that, at 175 and 150nm respectively, PDE of ~17% and ~15% can be achieved using a bare silicon surface, with MBE treatment increasing efficiency to ~19% and ~24%. This performance is comparable to commercially available analog VUV-SiPMs. We will also describe the existing VUV characterization capabilities at TRIUMF and the new facilities currently under development, which will incorporate an ultrafast pulsed laser operating at VUV wavelengths.

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