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SiPM and CMOS SPAD characterization at liquid nitrogen temperatures

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A number of high energy physics and cosmology experiments use or plan to use single-photon avalanche diodes (SPADs) or SPAD based silicon photomultipliers in harsh conditions, such as cryogenic temperatures and/or high radiation environments. In this contribution, studies of the operation of SPADs, front-end electronics, and micro-lens arrays at temperatures down to liquid nitrogen will be presented. SPADs designed by EPFL AQUA Lab in 180 nm, 110 nm and 55 nm CMOS technology were tested at different temperatures between room temperature and liquid nitrogen. The characterization included direct IV curve measurement and waveform analysis, in the dark, at low-light illumination, and in time-correlated single-photon regimes by way of picosecond lasers and monochromators. The most important quantities extracted were the single-photon time resolution (SPTR), dark count rate (DCR), and photon detection probability (PDP) at different temperatures. The SPADs and micro-lens structures, produced in technologies that could be applied to these SPADs, were also neutron irradiated with fluences up to 10^{14} neutron equivalent/cm^2 and re-characterized after irradiation. The results of this study will be used to inform the photodetector design considerations in the planned Upgrade II of the LHCb ring imaging Cherenkov counter (RICH).

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