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# A SiPM-based optical readout system for the EIC dual-radiator RICH

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Silicon photomultipliers (SiPM) are the baseline photodetector technology for the dual-radiator Ring-Imaging Cherenkov (dRICH) detector of the ePIC experiment at the future Electron-Ion Collider (EIC). SiPM optical readout offers a large set of advantages being cheap devices, highly efficient and insensitive to the high magnetic field (~ 1.5 T) at the expected location of the sensors in the experiment. On the other hand, SiPM are not radiation tolerant and despite the integrated radiation level is expected to be moderate (< $10^{11}$ 1-MeV $n_{eq}/cm^2$) it should be tested whether single-photon counting capabilities and the increase in Dark Count Rate (DCR) can be kept under control over the years. Several options are available to maintain the DCR to an acceptable rate (below ~100 kHz/$mm^2$), namely by reducing the SiPM operating temperature and by recovering the radiation damage with high-temperature annealing cycles. Moreover, by utilising high-precision TDC electronics and selecting bunch crossing information, the use of timing information can effectively reduce background due to DCR.

In this talk we present the current status of the research and the results on studies performed on significant samples of commercial and prototype SiPM sensors. The devices have undergone proton irradiation in two campaigns in 2021 and 2022. The first campaign aimed at studying the device performance with increasing NIEL doses up to $10^{11}$ 1-MeV $n_{eq}/cm^2$ delivered at once to different sensor subsets and after long high-temperature annealing cycles to recover the radiation damage. The second campaign aimed at studying the reproducibility of the performance in repeated irradiation-annealing cycles, where the sensors have undergone high-temperature annealing cycles to recover the radiation damage. During the second campaign it was also explored the use of Joule annealing as a potential way to perform high-temperature annealing in-situ. In October 2022 the sensors were mounted inside the dRICH detector prototype and successfully tested with particle beams at the CERN PS accelerator.

The results reported here, obtained in laboratory with SiPM characterisation measurements and in test-beam measurements, are based on the first 32-channel prototypes of the ALCOR chip and on a complete readout system. ALCOR is an ASIC chip that offers both single photon counting and Time-over-Threshold modes with a time resolution of 50 ps and an event rate capability of up to 5 MHz per channel, originally designed for reading out silicon photomultipliers at low temperatures.

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