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The SIPM-based optical readout of the ePIC-dRICH detector at the EIC

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The ePIC experiment at the Electron-Ion Collider (EIC) includes a dual-radiator RICH (dRICH) detector for PID in the forward region. This is to provide hadron particle identification capability to the experiment for the in-depth investigation of the nucleon structure planned at the EIC, enabling in particular the study of Semi-Inclusive DIS (SIDIS) events. SIDIS events probe the confined motion of quarks and gluons inside the colliding hadron, which are encoded in the transverse momentum dependent parton distribution functions (TMD PDFs,).

The dRICH will be equipped with 3x3 mm^2 silicon photomultipliers (SiPM) for Cherenkov light detection over a surface of $\approx$ 3 m^2 ($\approx$ 300k readout channels). This will be the first HEP application of SiPMs for a RICH detector. Despite the advantages (mainly cost and immunity from magnetic field), the SiPMs are not radiation hard and show a rapid increase of the dark count rate (DCR) due to the radiation load. The EIC environment will be moderately hostile: at the dRICH location a fluence of ~ $2 \cdot 10^7$ 1-MeV n_{eq} / cm^2 is expected every fb^{-1} of integrated luminosity delivered by the accelerator, with the total NIEL dose therefore not exceeding 10^{11} 1-MeV n_{eq}/cm^2.

A robust R&D program was started since some years to demonstrate it will be possible to preserve single-photon counting capabilities in such environment and maintain the DCR below ~ 100 kHz/mm^2, with an emphasis on the recovery of the radiation damage via high-temperature annealing cycles. SiPM irradiation campaigns have been performed with protons and neutrons using SiPM from different manufacturers and with different characteristics (in particular the SPAD size). The annealing cycles were performed using different techniques, via heating in oven and electrically induced thermal annealing flowing high current in the sensors (Joule annealing). A comprehensive set of results comparing sensor performance following repeated annealing cycles will be presented, together with the solutions being identified finalising the detector design.

Further DCR control and background reduction can be achieved with operation at low temperature and precise timing selection, thanks to the SiPM intrinsic resolution and the use of a new front-end ASIC (ALCOR), with appropriate time resolution. Beam test results obtained at CERN PS with a large area (1280 3x3 mm^2 SiPM sensors) prototype will be also reported, where advanced compact prototypes of the dRICH integrated (sensors, front-end electronics, cooling) Photo Detector Unit have been successfully tested.

session

A. Facilities and Detectors

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