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The dRICH at ePIC: first SiPM based cherenkov detector for frontier QCD studies at the EIC

The dual-radiator RICH (dRICH) detector of the ePIC experiment at the future Electron-Ion Collider (EIC) will employ Silicon Photomultipliers (SiPMs) for Cherenkov light detection. The photodetector system will cover an area of approximately 3 m^2 , using $3 \times 3 \text{ mm}^2$ pixel sensors and exceeding 300,000 readout channels, marking the first use of SiPMs for single-photon detection in a high-energy physics (HEP) experiment. SiPMs are favored for their cost-effectiveness and high performance in magnetic fields ($\sim 1 \text{ T}$ at the dRICH location). The dRICH will cover a broad momentum range, from 1 to 50 GeV/c in the hadronic endcap, providing essential hadron PID for the physics programme. However, due to their limited radiation tolerance, extensive testing is essential to ensure sustained single-photon detection capabilities and to control dark count rates (DCR) throughout the ePIC experiment's operational period.

This work provides an overview of the ePIC-dRICH detector system and details the ongoing R&D efforts for the SiPM-based optical readout subsystem. Particular emphasis is placed on the latest beam test results from a large-area prototype SiPM readout plane, comprising up to 2048 sensors with $3 \times 3 \text{ mm}^2$ pixels. The modular prototype utilizes an innovative photodetection unit (PDU) developed by INFN for the EIC, integrating 256 SiPM sensors, cooling systems, and time-to-digital conversion (TDC) electronics within a compact $\sim 5 \times 5 \times 14 \text{ cm}^3$ package. Multiple PDU modules were successfully tested at CERN-PS in October 2023 and May 2024, using a complete front-end and readout electronics chain based on the ALCOR chip, developed by INFN Torino.

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