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SiPM-based RICH detector at an upgraded Compressed Baryonic Matter experiment

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In recent years, Ring Imaging Cherenkov (RICH) detectors have explored new photon detection technologies to improve timing, spatial, and amplitude resolutions. Silicon photomultipliers (SiPMs) fulfill the requirements for future experiments in high-energy physics, such as single-photon resolution, picosecond timing precision, and high photon detection efficiency. However, they suffer from high dark-count rates and low radiation hardness. The Compressed Baryonic Matter (CBM) experiment aims to study the phase diagram of strongly interacting matter at high densities and moderate temperatures. We performed a feasibility study of upgrading the photon cameras of the CBM's RICH from Multi-Anode Photomultipliers to SiPMs. CBM RICH will run without an external trigger in a high-radiation environment with a dose of up to 1×10^{11}\,n$_{eq}$/cm^2 when assuming a running scenario with 2 months per year of Au+Au collisions at 35\,AGeV. The combination of SiPM weaknesses and the CBM operations conditions make the implementation of SiPMs in the CBM RICH challenging. In this work, we present the design and characterization of a prototype of SiPM array adapted to the readout electronics of the CBM RICH. We evaluated the performance of the three SiPMs: Broadcom AFBR-S4N66P024M, Hamamatsu S14160-6050HS, and OnSemi MICROFC-60035. We analyze the dark current, dark count rate, crosstalk, afterpulses, and photon resolution, after neutron irradiation (from 3×10^{8}\,n$_{eq}$/cm^2 to 1×10^{11}\,n$_{eq}$/cm^2) and electrical annealing (up to 250\,$^\circ$C during 30\,min). In addition, we implemented a novel triggering system based on signal thresholding within a narrow coincidence window ($\sim$ns). This approach minimizes the impact of dark counts caused by thermal emission or radiation damage.

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