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Towards a SiPM-based Ring Imaging Cherenkov detector at CBM: Design, noise, and radiation hardness challenges.

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We present the design, implementation, and characterization of an 8×8 SiPM (AFBR-S4N66P024M) array adapted to the readout electronics of the CBM Ring Imaging Cherenkov detector. The front-end of the array consists of a preamplification stage with low power consumption ($12 \mu\text{W}/\text{channel}$), high linearity, and low cost. In addition, we evaluated the performance of the SiPMs after neutron irradiation and electrical annealing. The SiPMs were irradiated with different dose from $3 \times 10^8 \text{ n}_{eq}/\text{cm}^2$ to $1 \times 10^{11} \text{ n}_{eq}/\text{cm}^2$. We analyze the dark current, dark count rate, crosstalk, afterpulses, and photon resolution.

Summary (500 words)

The Compressed Baryonic Matter (CBM) experiment, at the Facility for Antiproton and Ion Research (FAIR), will study the phase diagram of strongly interacting matter at high densities and moderate temperatures. CBM is composed of several subdetector systems, including a Ring Imaging Cherenkov (RICH) detector for dielectron measurements. The RICH detector will have two photon cameras comprised of H12700 Multi-Anode Photomultipliers (MAPMTs), two spherical glass mirrors as focusing elements, and a CO₂ radiator gas. The main drawbacks of MAPMTs are their sensitivity to external magnetic fields, low granularity, moderate photon detection efficiency, modest mechanical robustness, and high operating voltages. Today, RICH detectors are exploring new photon detection technologies to improve timing, spatial, and amplitude resolutions. Silicon photomultipliers (SiPMs) measure light intensities down to the single photon level, picosecond timing precision, photon detection efficiency above 50%, and magnetic field immunity. However, SiPMs have high dark-count rates and low radiation hardness, making their implementation challenging in RICH detectors, particularly when operating in trigger-less readout mode under high-radiation environments. We present the design, implementation, and characterization of an 8×8 SiPM (AFBR-S4N66P024M) array adapted to the readout electronics of the CBM RICH. The front-end of the array consists of a preamplification stage with low power consumption ($12 \mu\text{W}/\text{channel}$), high linearity, and low cost. In addition, we evaluated the performance of the SiPMs after neutron irradiation and electrical annealing. The SiPMs were irradiated with different dose from $3 \times 10^8 \text{ n}_{eq}/\text{cm}^2$ to $1 \times 10^{11} \text{ n}_{eq}/\text{cm}^2$. We analyze the dark current, dark count rate, crosstalk, afterpulses, and photon resolution.

Authors: PAULY, Christian (Wuppertal University); PENA RODRIGUEZ, Jesus (Bergische Universität Wuppertal); KAMPERT, Karl-Heinz (Universität Wuppertal)

Presenter: PENA RODRIGUEZ, Jesus (Bergische Universität Wuppertal)

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