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Performance degradation of SiPM sensors and recovery via high-temperature annealing

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The performance of silicon photomultipliers (SiPMs) degrades significantly when exposed to high-energy hadrons (neutrons or protons) that induce defects in the silicon lattice. A moderate level of radiation leads to an increase in dark current and dark count rates (DCR) and potentially affects the single-photon detection capability due to pile-up and limitations in the readout electronics. At very high doses, radiation damage can also modify operational parameters (breakdown voltage, gain) and decrease photon detection efficiency (PDE). Nevertheless, several studies show that high-temperature annealing can significantly accelerate the recovery of radiation-induced defects, thereby lowering dark current and DCR.
In this talk we present a summary of the studies and the main results achieved in the context of the R&D for the dual-radiator RICH (dRICH) detector at the future Electron-Ion Collider (EIC), where a large number of SiPMs were tested for usability in single-photon applications in a moderate radiation environment. Proton irradiation was performed up to integrated fluences of 10^{11} 1-MeV n_{eq}/cm^{2} and at different proton energies from 18 to 138 MeV. Neutron and gamma irradiations were performed as well. The sensors have characterised before and after irradiation and underwent various annealing procedures to measure their recovery capability from radiation damage. Particular attention was given to an annealing procedure exploiting the Joule effect, where high temperatures were achieved via self-heating of the sensor. Repeated irradiation and annealing cycles were performed to simulate a realistic experimental scenario and to assess the robustness of the sensors against such procedures.

Secondary track

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