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Proton-Induced Radiation Effects in MAROC3, a full readout 0.35 µm SiGe ASIC

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The MAROC chip was dedicated to MaPMT readout, and its third generation was backup solution in the front-end electronics of the RICH-LHCb Upgrade. Given the expected radiation environment for RICH, the MAROC3 was tested with 35 MeV proton beam at the Nuclear Physics Institute in Juelich, Germany. Investigated samples had the behavior recorded using a dedicated test bench. An increasing in power consumption followed by a rapid annealing - which proceeds at room temperature –was observed. The threshold for TID effects was found between 50 - 100 krad TID (Si), for a TID rate of about 30-170 rad/s.

Summary

For the third and the fourth LHC runs, the LHCb detector will be upgraded to operate at much higher proton-proton collisions rate than the present. Both RICH subdetectors will have the photodetection system redesigned based on MaPMT sensors and the entire detector will benefit from a flexible software-based trigger system, while the RICH readout will be at 40 MHz LHC bunch collisions rate. Embedded in the sensors elementary cells, the front-end electronics of the RICH photodetection system should have a reliable operation in a harsh environment which is estimated to have up to 200 krad (Si) total ionising dose (TID). Among the ASICs considered in the redesign of photodetection system, it was included the MAROC3 backup chip. Therefore, an irradiation campaign was implemented to establish the radiation hardness of this device. Our group investigated the radiation hardness of MAROC3 using a 35 MeV proton beam from Julich Isochronous Cyclotron (JULIC) facility based at the Nuclear Physics Institute of the Research Centre Julich, Germany. A custom test bench was developed to monitor and record the device parameters even during sample irradiation. Two samples were irradiated up to 200 krad TID (Si) while a third one up to 400 krad (Si), with variable TID rate of about 30-170 rad/s. Increasing of power consumption on both digital and analogue blocks was observed due to the leakage current growth within semiconductor structure. Once the irradiation was stopped, a rapid annealing process decreased the power consumption at room temperature close to the baseline values. No permanent failure was seen in the ASICs functionality. Temporary impairments manifesting as changes in triggers efficiency were mitigated through annealing. The TID rate for the third sample was chosen almost six times larger than the rest, and after 200 krad (Si) the MAROC3 configuration was affected in addition to the TID effects, however the device recovered after one hour annealing at room temperature. The main transient problem was found in one of the digital to analog convertor (DAC0). We estimate no operation problems for this chip in an LHCb-like environment with about 0.008 rad/s TID rate.

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