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Investigation of Single Event Latch-up effects in the ALICE SAMPA ASIC

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During RUN 3/RUN 4 at the Large Hadron Collider (LHC), the SAMPA chip will be used for the upgrade of read-out the front end electronics of the ALICE (A Large Ion Collider Experiment) Time Projection Chamber (TPC) and Muon Chambers (MCH). This work will present the irradiation campaigns performed on the V2, V3 and V4 prototypes of the SAMPA chip. The irradiation campaigns have been performed using the Heavy-Ion facility at UCL (Université Catholique de Louvain - Belgique) and the Single-Photon laser facility at IES (Institute of Electronics and Systems - Montpellier).

Summary

After Long Shutdown 2 (LS2) period at LHC, the expected interaction rate of the lead ions for the ALICE experiment will be increased from 8 kHz to 50 kHz. The present readout electronics do not cope with the higher collision rates for the TPC and MCH detectors. Thus, a new custom-made, trigger-less and continuous readout chip SAMPA is currently being developed to replace the current readout electronics in both detectors. With the increased interaction rate expected after LS2, the radiation load on the new SAMPA chip will consequently also increase. The SAMPA chip should withstand a Total Ionizing Dose (TID) of 2.1 kRad and a flux of 3.4 kHz⁄cmˆ2 of High Energy Hadrons (HEH) to operate safely in the worst case locations for both TPC and MCH detectors.

The SAMPA chip is designed in TSMC 130 nm CMOS technology with a nominal supply voltage of 1.25 V. The SAMPA chip includes 32 data processing channels, each containing a charge-sensitive pre-amplifier, a shaper, a 10-bit 20 MHz Analog to Digital Converter (ADC) followed by a Digital Signal Processor (DSP). The data readout takes place, either in continuous or triggered mode, by enabling up to eleven 320 Mbps Scalable Low-Voltage Signaling (SLVS) serial links, allowing a data throughput of up to 3.2 Gbps.

Previously, it was reported that the SAMPA V2 prototypes were susceptible to the high energy proton induced Single Event Latch-up (SEL) events. The measured SEL cross-section for SAMPA V2 was 3.1×10ˆ(-11) cmˆ2/chip. Due to this high SEL cross-section, further irradiation campaigns were planned to find the root of SEL events in SAMPA V2 prototypes, and to verify that the SEL sensitivity for SAMPA V3/V4 prototypes has been reduced or even completely removed.

This work will present the results from the heavy-ion irradiation campaign performed at UCL in May 2017 to find the threshold of SEL events and identify the source of SEL events in SAMPA V2 prototypes. For that purpose, specific collimators were prepared to irradiate specific parts of V2 prototypes during the tests. Design improvements were implemented in the SAMPA V3/V4 prototypes and a new heavy-ion irradiation campaign was performed at UCL in November 2017 to qualify the new SAMPA prototypes against SEL events. Finally, Single Photon laser tests were conducted in January 2018 in order to reproduce and locate the regions of SEL events in the SAMPA V2 prototypes, and confirm that the same regions of the SAMPA V3/V4 prototypes are unsusceptible to SEL events. Both heavy-ion and laser irradiation campaigns confirm that the SAMPA V3/V4 prototypes are well tolerant against SEL events.

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