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Upgrade of the ALICE TPC FEE online radiation monitoring system

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This paper presents the radiation monitoring system on the Readout Control Unit (RCU) of the the ALICE TPC Front End Electronics. In Run 1, Single Event Upsets (SEUs) in the configuration memory of the SRAM based FPGA were counted, and the results from different run periods with stable beam conditions are presented. For Run 2, a new RCU has been designed where the number of SEUs in dedicated SRAM memories are counted. The paper presents this solution and gives the results from the targeted irradiation campaigns.

Summary

The use of programmable logic devices such as FPGAs is a very attractive solution for High Energy Physics applications. They can typically be reprogrammed in the field giving the often needed flexibility to develop and update already deployed instrumentation. However, a major caveat of SRAM based FPGAs are their susceptibility to radiation. The configuration of the FPGA is stored in SRAM memory and single event upsets in this configuration memory may lead to a malfunction of the FPGA design. In the main tracking detector of ALICE, the Time Projection Chamber, a total of 216 Readout Control Units (RCUs) are used to readout the data from detector with FPGAs directly in the datapath. For Run 1, these FPGAs were SRAM based, and a dedicated reconfiguration solution was implemented to continuously detect and correct any SEUs in the configuration memory of these FPGAs. During the first LHC running period this reconfiguration solution has detected and corrected thousands of single event upsets and a summary of these measurements will be presented.

Following the increase in energy for Run 2, it was decided that a new Readout Control Unit, the RCU2, was needed to avoid a significant loss of efficiency of the Readout Electronics. To increase the radiation tolerance, a Flash based FPGA, the Microsemi SmartFusion2, is used. The flash technology offers an immunity to SEUs. While this is good for the detector operation, it implied that a new type of radiation monitor was desirable. This radiation monitor (RadMon) is based on the idea of the LHC Radmon, featuring 4 8 Mb Cypress SRAM memories and a flash based controller FPGA. The Radmon loops over all addresses for all SRAMs and writes a known pattern. This is then read back and SEUs are counted by comparing against the expected pattern. The patterns written to the SRAMS are inverted between each cycle. There are individual SEU counters per SRAM IC, and these are polled using a custom device driver in the Linux system installed on the embedded microController in the SmartFusion2. By minor modifications to the existing Detector Control System framework, this information is available online in the control room. Due to an increased numbers of bits and a higher SEU cross section for the memories, the new solution will provide an order of magnitude higher sensitivity compared to the FPGA based solution.

The RCU2 have been through several irradiation campaigns and there have been targeted beamtime to test the functionality of the RadMon. The paper will show the results from these irradiation campaigns as well as discussing the main differences between the solution in Run 1 and the RadMon solution to be used in Run 2. These solutions both provide valuable information about the radiation environment in the ALICE TPC.

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