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Intermodular Configuration Scrubbing of On-detector FPGAs in the Aerogel RICH at Belle II

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On-detector digital electronics in High-Energy Physics experiments is increasingly being implemented by means of SRAM-based FPGA, due to their capabilities of reconfiguration, real-time processing and multi-gigabit data transfer. Radiation-induced single event upsets in the configuration hinder the correct operation, since they may alter the programmed routing paths and logic functions. In most trigger and data acquisition systems, data from several front-end modules are concentrated into a single board, which then transmits data to back-end electronics for acquisition and triggering. Since the front-end modules are identical, they host identical FPGAs, which are programmed with the same bitstream.

In this work, we present a novel scrubber capable of correcting radiation-induced soft-errors in the configuration of SRAM-based FPGAs by majority voting across different modules. We show an application of this system to the read-out electronics of the Aerogel Ring Imaging CHerenkov (ARICH) subdetector of the Belle2 experiment at the SuperKEKB collider of the KEK laboratory (Tsukuba, Japan). We discuss the architecture of the system and its implementation in a Virtex-5 LX50T FPGA, in the concentrator board, for correcting the configuration of up to six Spartan-6 LX45 FPGAs, on pertaining front-end modules. We compare the performance, resource occupation and reliability of our solution to the ones of the Xilinx soft error mitigation controller. We discuss results from fault-injection and neutron irradiation tests at the TRIGA reactor of the Jožef Stefan Institute (Ljubljana, Slovenia). We also report about single event upsets field results from the operation in Belle2 and we correlate them with beam conditions.

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