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Radiation Testing Techniques and Results For the ATLAS TileCal Upgrade

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We present results from recent radiation tolerance tests that we have performed on prototype boards and components for the front-end electronics intended for the upgrade of the hadronic calorimeter (TileCal) for the ATLAS experiment at the LHC. The tests include Total Ionizing Dose (TID) tolerance, Non-Ionizing Energy Loss (NIEL) tolerance, and Single Event Effects (SEE) tolerance. We describe the test setups used, the methodology, the different boards tested and their radiation tolerance requirements, and test results

Summary

Work is in progress to design and build prototype front-end electronics for the ATLAS hadronic calorimeter detector for the Phase 2 Upgrade of the LHC, a program called the TileCal Demonstrator. The new electronics reside in the TileCal "Drawer,"which contains the photo-multiplier tubes (PMTs) and all front-end electronics for that detector element. The Drawer is divided into four sections called "Mini Drawers."Each Mini Drawer contains 12 PMTs. The PMT signals are amplified and shaped by Front-End Cards, and digitized by ADCs that reside on a Main Board. The digitized data is then collected by the Daughter Board, and sent out to the counting room (USA15) to a readout board called the sROD over high-speed fiber-optic links. The new system makes use of modern parts, and therefore all subcomponents of the system must be re-qualified for radiation tolerance, including the Main Board, the Daughter Board, the front-end boards (FEBs), the high voltage control board (HV_Opto), and the low voltage power supply (LVPS). Two particular parts are of interest: the point-of-load (POL) regulators, which are common among the subcomponents, and the high-speed optical transceiver, which is a commercial part. We performed a special set of radiation tolerance on these subcomponents as well.

We have been developing a radiation tolerance testing program in the United States to test electronics for the LHC upgrade. For Total Ionizing Dose (TID) susceptibility, we use gamma irradiation from the Gamma Irradiation Facility at Brookhaven National Laboratory, which has a 60Co source, with energy of ˜1 MeV. For Non-Ionizing Energy Loss (NIEL) tolerance, we use the Fast Neutron Irradiation Facility at the University of Massachusetts - Lowell, which hosts a research nuclear reactor that produces ˜1 MeV-equivalent neutrons from decay of U235. The sample under test is placed in a water-tight vessel, and lowered into the cooling pond of the reactor using ropes, where it receives the neutron flux from the reactor core. For Single Event Effects (SEE), we use the cyclotron at Massachusetts General Hospital (MGH), which produces a proton beam with energies in the range 20 MeV to 213 MeV. We have also used a test beam at Fermilab that has been designed to produce the approximate composition of particles that are expected in the LHC environment, and the neutron facility at LANSCE, at Los Alamos National Laboratory. We will describe each of these facilities, what the capabilities are for each, and how the tests were configured.

Generally, our approach is to monitor the component under test through the radiation exposure. Each subcomponent generally needed a special interface or data acquisition scheme, customized for the particular performance aspect of interest. We will describe our different test setups, and how we performed the data acquisition and the monitoring of performance through the dose periods. We will also present some of our test results. We will also present some practical aspects and a description of experience in making these types of measurements.

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