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Longevity of CMS ECAL Electronics

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The CMS Electromagnetic Calorimeter (ECAL) has played a vital role in the discovery of the Higgs Boson and other physics requiring the precise detection and measurement of electrons and photons. It is a homogenous lead tungstate scintillating crystal calorimeter with on-detector electronics based mainly on CMOS 0.25um ASICs and rad-hard gigabit optical links. The ECAL provides sums of energy of groups of up to 25 crystals, which are read-out at 40 MHz to be used as part of the level-1 trigger. On-detector circular buffers store the digital signals, with 12-bit precision, for up to 6.4us, sending the data out upon reception of a level-1 trigger. The ECAL will continue to be a critical component of CMS throughout the remainder of LHC operation, as well as during the precision study of, for example, Higgs physics at the High Luminosity LHC (HL-LHC) from about 2023 onwards. We assess the ability of the existing on-detector electronics to meet the demanding requirements of high luminosity running until 2035, including studies of the longevity of the electronics components and their susceptibility to ionizing and non-ionizing radiation. We conclude with an outline of possible upgrades to the electronics, both on-detector and off-detector.

Summary

The CMS electromagnetic calorimeter (ECAL) is used to detect and measure the energy of photons and electrons produced in collisions at the LHC. It has played a vital role in the discovery of the Higgs Boson and other physics requiring the precise detection and measurement of electrons and photons. It is a homogenous lead tungstate (PbW04) scintillating crystal calorimeter with on-detector electronics based mainly on CMOS 0.25um ASICs and rad-hard gigabit optical links. The ECAL provides sums of energy of groups of up to 25 crystals, which are read-out at 40 MHz to be used as part of the level-1 trigger. On-detector circular buffers store the digital signals, with 12-bit precision, for up to 6.4us, sending the data out upon reception of a level-1 trigger. The on detector electronics readout systems is organized in 4 different electronics boards, named “Motherboard”(MB) , “Very Front End”(VFE), “Low Voltage Regulators”(LVRB) and “Front End”(FE). The MBs, installed near the crystals, route signals and power supply of Avalanche Photodiodes (APD) used to detect scintillation light coming from crystals as well as host the other boards (FE, LVRB). There are 4 VFEs and 1 LVRB boards for each MB installed vertically through connectors. The former host the preamplifier used to condition the signal coming from the APD and the analog to digital converter, the latter contains all the regulators used to generate the different low voltages (5, 3.3, 2.5 Volts) needed from the electronics starting from a single 5V generated from a system located in the CMS service cavern. The FE board, installed on top of the VFEs and LVRB through connectors, contains the FENIX ASICs used to buffer the energy values before to be send to the data acquisition sub-system through the optical link . The study of these four boards in order to understand their longevity is relevant because the ECAL will continue to be a critical component of CMS throughout the remainder of LHC operation, as well as during the precision study of, for example, Higgs physics at the High Luminosity LHC (HL-LHC) from about 2023 onwards. We assess the ability of the existing on-detector electronics to meet the demanding requirements of high luminosity running until 2035, including studies of the longevity of the electronics components and their susceptibility to ionizing and non-ionizing radiation. Different study approaches will investigate the electronics reliability starting from statistics on the data we have concerning failure rates during the 2008-2012 running periods. In addition, failure analysis using existing military standards on reliability prediction of electronics equipment, measurements of critical parameters (temperature, humidity, $\cdots$) and accelerated aging test on spare boards and components. Information collected from the previous analysis will be the base to take a decision in the ECAL electronics upgrade

activities forecast for the next years (2014-2021).

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