

Performance of CMS ECAL Very Front End Electronics

Tuesday, 26 September 2006 15:05 (25 minutes)

We report the results of tests of 12800 Very Front End (VFE) readout cards for the barrel of the CMS electromagnetic calorimeter. A thorough test sequence was applied to each card including power-on test, burn-in and final detailed calibration. The results show excellent uniformity of the VFE cards. For instance the analogue, digital and buffer currents have average values of 1.59, 0.43 and 0.144 A with RMS values of 0.01, 0.01 and 0.008 A, respectively. The relative gains vary about 1%. Only a few per mille of the cards were failing the power-on test. The results prove the very high quality of the VFE cards.

Summary

The CMS electromagnetic calorimeter (ECAL) is divided into the Barrel (EB) and two end-caps (EE) made of 61200 and 14648 crystals, respectively. The EB is split up into 36 super modules with 1700 crystals each. The EE is made of 4 DEEs with 3662 crystals each.

The Very Front End (VFE) card is used to amplify, shape and digitize the signals. It comprises five identical read-out channels, serving five crystals. Each channel has a Multi Gain Pre-Amplifier (MGPA) and a four channel ADC followed by LVDS to CMOS level-converters (LVDS_RX). The MGPA shapes and amplifies the signals with 3 different gains (1, 6 and 12). The 3 analogue output signals of the MGPA are digitized in parallel by the four channel 40 MHz 12-bit ADC (AD41240). Digital logic internal to the ADC selects the highest not saturated gain for output. In addition a Detector Control Unit (DCU) reads the leakage currents of the Avalanche Photo Diodes (APD) and the temperature sensors which are mounted on the crystals. All active components are application specific integrated circuits (ASICs) implemented in 0.25 μm technology.

The production and test of the EB VFE cards is completed. The test sequence included:

1. Automatic Optical Inspection (AOI) done by the manufacturer.
2. Power-On test: It is the first electrical test of the VFE cards. It measures the voltages, the currents and performs a functional test of the card.
3. Burn-in test for 72 hours at 60 °C.
4. Calibration of the characteristics of each individual channel by measuring the gain in ADC counts per pC, the pedestal, the noise, the linearity and other relevant parameters.

The voltage distribution measured in the Power-On test for the analogue, digital and buffer voltages are (2.489, 2.499 and 2.45) V with RMS (0.001, 0.001 and 0.03) V. The relative gains are 5.43 and 10.6 with RMS values of 0.047 and 0.11 compared to the design values of 6 and 12, respectively. This indicates very good uniformity of about 1%.

The MGPA-ADC system was calibrated by injecting 21 different charge pulses distributed over the full dynamic range of 60 pC. Slopes and offsets of the fitted lines are 63.0 ± 0.8 , 341.7 ± 3.8 and 666.7 ± 7.7 ADC count/pC and -6.1 ± 1.0 , 2.4 ± 1.2 and 1.7 ± 1.0 ADC counts for the gains 1, 6 and 12, respectively.

The noise of completed super modules is found to be 0.58, 0.73 and 1.04 ADC counts with RMS values of 0.04, 0.04 and 0.07 ADC counts for gains 1, 6 and 12, respectively. This corresponds to an expected energy resolution of ~ 45 MeV, achieving the design goals.

At the time of writing, 11470 out of 12880 VFE cards had been calibrated, of which 137 did not pass the test criteria and have consequently been rejected.

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Session Classification: Parallel Session A2-Readout, commissioning and integration 2