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The CMS-HF Forward Calorimeter Commissioning

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Abstract

The CMS HF Calorimeter was the first detector to be lowered into the cavern at UX5. It was placed in the garage position during the lowering of the rest of the big CMS pieces. The commissioning of the hardware parts is continuing, especially integrating the HF and completing the monitoring systems, such as, online laser, LED and radioactive source monitoring. Also a special monitor system for the radiation damage of the quartz fibers is being implemented. Calibration measurements of the calorimeter had already started even before the lowering. Progress in the calibration work and current plans for the HF calorimeter during the low luminosity run are summarized.

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1 Introduction:

CMS forward hadron calorimeter (HF) was designed [1, 2, 3] to detect the forward particles with eta values from 3 to 5 for optimizing the identification of those processes that produce forward jets, especially processes involving Higgs and SUSY particles. The Calorimeter also improves the determination of the missing transverse energy.

The two cylindrical HF units for each end of the detector are 1.65 m long and have an active radius of 1.4 m. The HF is a sampling calorimeter with plastic clad quartz fibers embedded into iron absorber. Each unit is composed of 18 20-degree slices. Each slice has 24 towers. There are long (1.65 m) and short fibers (1.43 m) in each tower to sample the energy in hadronic and electromagnetic showers, respectively. Light produced in each fiber through Cerenkov radiation goes into its own photomultiplier tube (PMT). Phototubes used in the HF were selected and tested at the University of Iowa PMT test station [4, 5, 6].

Commissioning of the HF involves completing the hardware installation and lowering the detector into the underground cavity and also the calibration of the detector.

2 Calibration:

Before lowering the CMS detector into the cavern, there was much work done above ground, especially in calibration. In 2004, during test beam studies, several slices of the HF were tested with electron, pion, and muon beams at energies varying from 30 GeV to 300 GeV. There were also tests with a ^{60}Co wire-source [7, 8, 9]. During these tests, data were taken while the wire-source was being inserted into the detector. Charge collection as a function of the position of the source inside the absorber provides information for the energy calibration of the detector. There is a clear difference in the number of counts between the wire-source positions inside the detector and at park position. These tests were carried out to understand the performance of the various hardware parts, absorber, PMTs, fibers, read-out boxes, etc. During 2006, LED and wire-source data were taken to understand the calibration constants of the calorimeter. With the experience gained in the 2004 Test Beam study, the analysis of the 2006 LED and wire sourcing data improved the calibration constants. These measurements were done in the Building 186 and then the HF was moved to SX5 prior to the lowering into the cavern [10]. Radiation damage tests also continued [11, 12]. The online radiation damage monitoring system was tested and finalized for the installation into the HF detector. The lifetime of the PMTs were addressed earlier and the measurements done at the UI PMT test station showed that their photocathodes could provide more than 3000 C of charge with less than 50% degradation in the gain at 1100V [6].

Charge collected in the single photoelectron (SPE) peak provides one of the constants. This calibration constant is obtained using a single photoelectron spectrum of the phototubes accumulated with a source or an LED [7, 8, 9]. This is directly related to the PMT gains. Among the tests done at the University of Iowa PMT test station there were measurements of the relative gains at 1100 V for all the PMTs [6]. PMT gains as a function of HV for over 200 PMTs were also measured. Using these gain values and the 2004 test beam data, it is shown that the relative gains measured at the University of Iowa PMT test station and the gains obtained from the SPE data are highly correlated [7]. These relative gain values were used to group the PMTs to be installed in different tower positions (the lower the gains are, the closer to the beam they are). It also confirms the reliability of using the SPE peaks in monitoring the gains with the LED system. In the earlier versions of the CMS Software package the calibration constant related to the integrated charge per photo electron is taken as 5.92 and 4.35 fC/p.e. for the long and short fibers, respectively. On the other hand, measured values for the nominal PMT HV of 1100 V is about 16.75 and 11.06 fC/p.e. for the long and short fibers, respectively [13].

The energy calibration in terms of the amount of charge collected per unit energy of a particle is done with the help of the wire sourcing and the measured value is about 0.21 and 0.34 GeV/fC for the long and short fibers, respectively [13]. Of course, some of these measurements were done at higher HVs than the nominal value of 1100 V. All the results were extrapolated to the nominal HV value. These studies helped us understand the operation of the QIE elements, pedestals, and the noise in the system. Specific values for these quantities were determined from the data. Consistency of the calibration constants means that the three calibration constants: charge per photo electron, energy per unit charge and photo electrons produced per GeV energy, should result in unity when they are multiplied all together. (The first two are determined from the data. The third could be estimated from the standalone shower library. A better estimate would be to use the unity condition mentioned.) A value of 0.25 p.e. per GeV means the constants are consistent within 10% [12, 13].

3 Lowering into the cavern:

The CMS HF Calorimeter was the first detector to be lowered into the cavern at UX5 in Fall 2006 (Figure 1) [14]. The HF detector was lowered into the cavern without any problem and placed in the garage position during the lowering of the rest of the big CMS pieces. Various cables, patch panels, and other electrical and mechanical pieces were either installed or in the process of being installed. In general, the commissioning of the hardware parts is continuing. Especially, integrating the HF and completing the monitoring systems, such as, online laser, LED, and radioactive source monitoring. Also a special online monitoring system for the radiation damage (raddam) of the quartz fibers is being implemented.

Both HF units are the first detectors ready for the overall data taking test (Global Run). During the Global Run and also other data acquisition test runs, the HF system has been tested for overall debugging of the data acquisition and also to determine the pedestals of all the channels. LED runs were also used to make sure that there are no missing channels.

Figure 1: HF+ was lowered into the cavern UX5 in November 2006.

4 Conclusion:

There will be no data taking runs during 2007 due to problems in the LHC. For the same reason, the schedule for the next year is also uncertain. The HF calorimeter is considered to be a candidate for luminosity measurements, in addition to some possible ideas about diffractive physics.

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