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The CMS-HF Calorimeter Readiness for Data Taking

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Abstract

The HF Calorimeter in the CMS Detector was commissioned and ready for data taking in 2008. Final commissioning tasks done in 2008 will be summarized. Some results from the splash event when the LHC was turned on will be presented. Anomalous events seen in the HF-PMTs have been understood and proposed methods to resolve this problem are explained. The HF readiness for the data taking in 2009 will be also discussed.

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The CMS-HF Calorimeter Readiness for Data Taking

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Keywords: Calorimetry, LHC, CMS, Forward Calorimetry, Diffractive Physics, Luminosity, Commissioning

1. Introduction

The CMS-HF Calorimeter was designed¹ for the purpose of detecting the forward particles in an eta range of 3 to 5 to optimize the detection of those processes that produce forward jets, especially processes involving heavy Higgs and SUSY particles. It has also an added benefit to improve the determination of the missing transverse energy.

The two cylindrical HF units placed at each end of the detector at the beam height is 1.65 m long and has 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 slices of 20-degree sections. Long (1.65 m) and short fibers (1.43 m) in the calorimeter sample the energy in electromagnetic and hadronic showers, respectively. Light produced in each fiber through Cerenkov radiation goes into its own PMT. Phototubes used in the HF were selected and tested at the University of Iowa PMT test station.²⁻⁵

The HF Calorimeter in the CMS Detector was commissioned and ready for data taking in September 2008 when LHC was supposed to start. Before placing both detectors in the garage position, the RADDAM fibers to

monitor the radiation damage in the HF fibers were placed in 28 positions in each HF. Both detectors had been completely searched for light leaks and closed for the beam and placed in their proper position during the CRUZET (Cosmic RUn at ZERo Tesla) and CRAFT (Cosmic Run At Four Tesla) runs.⁶

While the LHC was getting ready to start last September, the CMS detector was also preparing for the eventual beam. The whole detector was closed up and the solenoid was being turned on for the full field. It was decided that the full field would be 3.8 T instead of 4.0 T as initially planned. During the magnetic field ramp-up, the effect of the magnetic field on the HF detector was extensively studied. Especially, the motion of the detectors due to the central field and the fringe field at various locations of the detector were measured carefully.

The motion of the HF was minimal and without any permanent displacement (Figure 1-left). $HF^{\pm}$ radial motion was less than 1.5 mm and the axial motion was at most about 10 mm. However, the CASTOR detector in front of the HF^{-} started moving and had to be taken out to prevent its damage to the beam pipe. After redesigning its table and the way it is fitted into its position, it is put back in.

Fig. 1. During the magnet ramp-up HF detectors slightly move. Left plot shows the motion of the HF^{+} . Right plot shows the fringe field due to the CMS magnet at the location of the HF ROBoxes.

Measurement of the fringe field at the position of the HF-ROBoxes was made (Figure 1-right) during the field ramp-up and found to be tolerable (slightly above 100 Gauss). Also the stability of the LED signals for moni-

toring the calibration and the raddam signals for monitoring the radiation damage to the fibers were tested at different magnetic field values. These signals were found to be stable, too.

During the first beam circulation in the LHC there were some hits that caused a “splash” of muons in the detector (Figure 2). These so-called “splash” events were produced by the 450 GeV beam particles hitting the collimators upstream of the detector. Unfortunately these were the only data taken during the initial turn-on due to the incident at sector 3-4 and subsequent shutdown of the LHC for repairs.

Fig. 2. Splash events seen in the whole CMS detector during the first low energy beam circulation in the LHC. HF events are seen on each side in the sideview of the detector (left) and in the front of the detector in the perspective view (right).

However, these splash events were very illuminating for further understanding of the HF detectors. In addition to showing the overall status of the detector, they clearly displayed the extent of the problem caused by the anomalous events. The anomalous events were first seen in the 2004 test beam data as abnormally high energy events, much higher than the energy of the test beam particles by orders of magnitudes. These were later understood to be the signals produced by the charged particles causing a Cherenkov radiation in the PMT window directly.⁸

A solution proposed for this problem was to install special crystals between the PMTs and the light guides so that the charged particles hitting the PMTs instead of the calorimeter would produce a very large signal. Hence, such events would be identified this way without any doubt and discarded. To study this proposal, further crystals had been installed before closing up and were there during the splash events and the following

CRAFT runs.

The hits observed in these crystals occurred either in the short fibers (HAD) or the long fibers (EM) and showed up along either axis in a scatter plot of the EM hits versus the HAD hits without showing any correlation between the EM and HAD channels, as expected.⁷ This behavior has been seen in both the CRAFT runs and the beam splash events. Different types of PMTs were further studied during this summer at CERN test beam facility. A four-anode PMT was tested for the future purpose of replacing the existing PMTs in the HF to eliminate the anomalous events and also to improve the signal quality.

After the shutdown, both HF detectors were placed in the garage position again and checked for possible light leaks, mechanical damages, etc. All the newly developed light leaks and other mechanical problems caused by the movement of the detectors in and out of the garage position and into the beam position were fixed. A He detection system has been planned to be installed to monitor the He levels in the HF detectors to prevent possible He poisoning of the PMTs. The work on finalizing the Raddam system and optimizing the laser settings is continuing.

During the long shutdown, various calibration checks and studies continued and the HF was part of the full detector during all the Cosmic Ray runs (CRUZET and CRAFT). At the beginning of Summer 2009, both detectors were placed in their proper positions at the beam height. There were plans to perform some additional source calibration runs during the time that the LHC was getting ready to begin the beam operations.

More simulation studies to understand the detectors and how to use the HF data to determine the luminosity of the beam are also underway, in addition to the continuing analysis of the data collected during the various cosmic and calibration runs with the source and LED. Using the HF detectors in the di-jet studies and forward physics topics are also ongoing. Even though the work on different facets of the detectors continues, the HF detectors are ready for the beam.

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