A new on-line luminometer and beam conditions monitor using single crystal diamond sensors.

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Introduction

The First Beam Condition Monitor (BCM1F) detector is one of the subdetectors of the CMS Beam Radiation Monitoring and luminosity (BRIL) project. It is designed for bunch-to-bunch luminosity and beam background measurements. The BCM1F Detector consists of 4 half-ring PCBs (C-shapes), positioned 1.6 m and 2 m of the interaction point or at a radius of 6.5 cm from the beam pipe, as shown in Fig.1. Each sensor has a 2 pad metalization. The signal of each pad is read out by a 500 MHz flash CAEN ADC. The BCM1F detector was used to reconstruct the beam intensity as a function of time. VME ADC data was collected with the first colliding beams in the LHC. An example of the signal, corresponding to one MIP signal, is shown in Fig.8. Its amplitude is ~70 mV (1 ADC count = 4 fC input signal, a gain of 50 mV/fC, an equivalent noise of less than 10 mV, half maximum of less than 10 ns and a short recovery time for input signal of less than 1 ns). Successful application at LHC

Diamond sensors

The BCM1F detector based on single crystal diamond was siliconized and tested in the LHC. SCD sensors were chosen for the BCM1F detector, as they match the requirements to be used in radiation hard environment close to the interaction point. Only diamonds with leakage current in the pA range up to 1000 V of bias voltage were accepted. An example of the result is shown in the Fig.3. Also signal stability over time was monitored. An example of the result is shown in the Fig.4. The charge collection efficiency (CCE) as a function of the bias voltage is presented in the Fig.4. Electrical characterisation and Charge Collection Efficiency (CCE)

Testbeam at DESY-II, 5 GeV electron beam

The BCM1F detector was provided with crystals from the laboratory. A first prototype of Real-time Histogramming Unit was installed in the LHC. Successful application at LHC

Radiation hard ASIC

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A sketch of a quarter of the BCM1F detector and PLT

BCM1F backend

The BCM1F Detector has proven to be a robust and reliable beam-background monitor, as they match the requirements to be used in radiation hard environment close to the interaction point. Only diamonds with leakage current in the pA range up to 1000 V of bias voltage were accepted. An example of the result is shown in the Fig.3. Also signal stability over time was monitored. An example of the result is shown in the Fig.4. The charge collection efficiency (CCE) as a function of the bias voltage is presented in the Fig.4. Electrical characterisation and Charge Collection Efficiency (CCE)

First results from successful operation of the BCM1F detector in Run II

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Outlook

During Run II the BCM1F Detector based on single crystal diamond sensor has proven to be a robust and reliable beam-background monitor, and online luminosity monitor. The upgraded SCD11 system will be successfully installed in the LHC beam in 2015. Energetic diamonds, from 68 fully characterised, passed the quality criteria. New radiation hard front end ADCs 100 MHz (CMS technology) with 100 kHz rate, were successfully tested. These ADCs are installed in VME and CAEN flash VME ADCs with 2 ns sampling time are used to record data from all VME systems. These data is needed for detector performance monitoring, e.g. amplitude spectra and arrival time. For higher rates a dedicated fast VME ADC system is under development, allowing even for 1 MHz rate. 35 diamond were tested in the laboratory to choose 24 for installation. Before installation in the CMS experiment the crystals were tested in a prototype detector. In order to reconstruct the beam intensity as a function of time, the beam intensity was measured. An example of the result is shown in Fig.8. Its amplitude is ~70 mV (1 ADC count = 4 fC input signal, a gain of 50 mV/fC, an equivalent noise of less than 10 mV, half maximum of less than 10 ns and a short recovery time for input signal of less than 1 ns). Successful application at LHC

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