Performance of Detectors Using Diamond Sensors at the LHC and CMS.

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Abstract
Diamond detectors are used as beam loss and luminosity monitors for CMS and LHC. A time resolution in the nanosecond range allows to detect beam losses and luminosity of single bunches. The radiation hardness and negligible temperature dependence allows the usage of diamond sensors in high radiation fields without cooling. Two different diamond detector types are installed at LHC and CMS. One is based on pCVD-diamonds and installed at different locations in the LHC tunnel for beam loss monitoring. Measurements of these detectors are used to perform a bunch-by-bunch beam loss analysis. They allow to distinguish the origin of beam losses. The second type uses scCVD-diamonds and is installed inside CMS for rare decays scan, beam halo and online luminosity monitoring and around the LHC tunnel for beam loss detection. The alignment of the detectors close to the beam is required. The concept of the new detectors will be presented and first results will be shown.

Diamond Detectors Based on scCVD

Diamond sensors based on scCVD-diamonds are installed around the LHC ring. Eight are located inside CMS for beam loss monitoring, four are around the LHC ring for beam loss observation and six are around the LHC tunnel for beam loss observation. scCVD diamond sensors in high radiation fields without cooling. Two different diamond detector types are installed at LHC and CMS.

Vacuum Pressure vs. Luminosity in LHCb

The luminosity in LHCb is kept constant. An increase of vacuum pressure appears during the collision process. The luminosity and vacuum pressure are measured in LHCb as a function of time. Scans during beam loss in LHCb show an increase of rates can be observed due to residual gas interactions during collision in LHCb.

Measurements of the Vacuum Pressure and Luminosity in LHCb

The luminosity in LHCb is defined by:

\[ L = \frac{N \cdot f \cdot \sigma}{\phi} \]

where:
- \( N \) = number of particles in bunches
- \( f \) = orbit frequency
- \( \sigma \) = cross section
- \( \phi \) = luminosity

The beam size is obtained with Van der Meer scans. The Figure shows the measured beam size with Van der Meer scans for the forward calorimeter (HF) and BCM1F. HF and BCM1F show good agreement.

BCM1F Signal Degradation

Degradation of Charge Collection Efficiency

The charge collection efficiency of new scCVD diamonds is 100% with saturation at 100V (0.4V/µm). Degradation of the charge collection efficiency is based on pCVD diamonds and installed at different locations in the LHC tunnel for beam loss monitoring. Measurements of these detectors are used to perform a bunch-by-bunch beam loss analysis. They allow to distinguish the origin of beam losses. The second type uses scCVD-diamonds and is installed around CMS for rare decays scan, beam halo and online luminosity monitoring and around the LHC tunnel for beam loss detection.

BCM1F Upgrade

Upgrade of Diamond Sensors
A new version of the BCM1F will be used and also the layout scheme with an increased number of diamonds. 12 BCM1F diamonds around the beam pipe on each side of the CMS interaction point will be installed.

Upgrade of Front End Electronics
The amplifier will be upgraded to ~75% and no saturation. The charge collection efficiency of new scCVD diamonds is 100% with saturation at 100V (0.4V/µm). Programmable FPGA logic chips are used for luminosity measurements and beam loss counting.

pcCVD Measurements

Beam Loss due to Injection Oscillations

Beam Losses due to injection oscillation are caused by the previous bunch and the deflection of unbunched particles due to the rise time of the injection kicker magnet.