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ATLAS Diamond Beam Monitor

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The Diamond Beam Monitor (DBM) is a pCVD diamond pixel tracker for detecting high-energy charged particles. It is planned to be installed in the ATLAS experiment at CERN for the luminosity measurements. In this talk, the overview of the DBM system and the operation of the diamond pixel sensors are described.

Summary

Accelerator luminosity is a measure of the number of particles that pass through a given area each second multiplied by the opacity of the detector. It is one of the most important parameters for the physics analysis of the particle collisions. It is measured by special detector systems inside the particle detectors. In ATLAS experiment at the Large Hadron Collider (CERN), this system is called the Beam Conditions Monitor (BCM), a pCVD pad diamond detector.

The Large Hadron Collider at CERN has been running with the energy of 8 TeV and it is planned to increase to 14 TeV in 2015, after the next long shutdown. Current instantaneous luminosity is at a few 10^33 cm-2s-1 and is planned to increase by a factor of 10 in the next five years. The average number of particle collisions per bunch crossing (every 25 ns) will increase from the current 20 to over 200. This might cause saturation of the current luminosity detectors. Hence, a new detector called the Diamond Beam Monitor (DBM) has been designed to account for the augmented number of collisions taking place at the ATLAS experiment. Diamond material was chosen because its properties after an irradiation don't change significantly, as opposed to silicon.

The DBM is a charged-particle detector. Its purpose is to monitor the bunch-by-bunch luminosity and bunch-by-bunch position of the beam spot. 8 telescopes, each housing 3 consecutive pixel modules, are placed approximately 1 m from the collision point in the high-eta region of approximately 3.5. Every time a particle traverses a sensor plane, a hit is recorded in the corresponding pixel. The telescope-like positioning of the pixel sensors allows to track the particle paths while traversing the sensor planes. The DBM will calculate the luminosity by counting the number of particle tracks. It will be able to to distinguish whether a particle came from the collision point or from some other place inside the detector (beam halo), and choose only the relevant hits/tracks for the luminosity calculation.

The FE-I4 ASIC front-end chip is used for the front-end electronics. Its integrated circuit contains readout circuitry for 26,880 hybrid pixels arranged in 80 columns on 250 um pitch by 336 rows on 50 um pitch. It operates at 40 MHz with a 25 ns acquisition window and is hence able to correlate hits/tracks with their corresponding bunch count.

CVD diamond has been chosen as the sensor material due to its high radiation hardness, negligible noise and fast signal response. Only polycrystalline diamonds are commercially available in the required sizes (21 mm x 18 mm, 500 um thickness).

After extensive processing, the diamonds are bump-bonded to the front-end chip. The modules are then wire-bonded to the PCB and installed in the telescope mechanics.

In this talk, the overall system and the preliminary detector test results will be presented. Then, the QA procedure and the installation status will be given.

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