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CMS Forward Pixels Geometry Simulation

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Abstract

The Large Hadron Collider (LHC) is being built at the European Center for Nuclear Research (CERN) to produce collisions between protons and protons at an unprecedented energy of 14 TeV. Compact Muon Solenoid (CMS) is one the five detectors that will be placed on the 17-mile long ring of the LHC, to record data for physics analysis from these collisions. The Forward Pixel Detector of CMS is an integral part of the Tracking system, which would play a key role in addressing the full physics potential of the collected data. This note describes the development of geometry simulation for the Forward Pixel Detector

Keywords: CMS Pixel Detector; Geometry Simulation

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1 Introduction

The CMS detector will have a robust tracking with precise vertex reconstruction within a strong magnetic field of 4 Tesla. This will be the key element to address the full range of physics accessible at energy of 14 TeV. At the heart of the tracking lies the pixel detector. The main task of this detector is vertex finding and flavor tagging. An efficient tagging of particles like b-quark, c-quark and tau, requires tracking as close as possible to the interaction vertex. The high spatial particle track density close to innermost tracking makes it necessary to be composed of pixel devices. These would provide a fine granularity in three-dimensional space information for vertexing. The discovery of Higgs Boson and Supersymmetric particles [1] relies on b-tagging. The study of B-physics, CP-violation and Top Quark physics require Pixel Detector. The Pixel Detector will have an active surface area close to one square meter, instrumented with approximately 60 million channels. It consists of two components - barrels and disks. The disks comprise the Forward Pixel detector, which is being built at the Silicon Detector Facility at Fermilab in Batavia, Illinois, USA.

2 Forward Pixel Detector

The design of the Forward Pixel detector is a complex one. It is comprised of 4 circular disks, two on each side of the barrels. The inner and the outer radius of each disk is 6 cm and 15 cm, respectively. The pseudorapidity (η) coverage of these disks is from 1.5 to 2.25. Each of the four disks includes 24 wedge shaped blades arranged in a turbine like geometry [2]. Each blade is rotated 20° around their radial symmetry axis to increase charge sharing among pixels. This would provide a hit resolution of the order of $10\text{ }\mu\text{m}$ [3].

Each blade has a set of 45 readout chips (ROC). These are arranged in 7 different arrays of five different types (1x2, 1x5, 2x5, 2x4, 2x3) on its two sides. An array of ROCs is bump bonded to a single silicon sensor of thickness $300\text{ }\mu\text{m}$. There are 4160 pixels in a ROC, each of size $100\mu\text{m} \times 150\mu\text{m}$. Each pixel on ROC is electrically connected to a corresponding pixel on the sensor via a bump bond. This bump bonded module is glued on top of a flex circuit called VHDI (Very High Density Interconnect) that is laminated to a silicon substrate. The VHDI is wire-bonded to the ROCs. This forms a multi-layer structure, called a plaquette. As a result we have 7 different plaquettes of five different types. These 7 plaquettes are glued in groups of 3 or 4 on flex circuits called HDI (High Density Interconnect). The HDI is wire-bonded to VHDI. Each of the two HDIs is glued onto a wedge shaped beryllium plate of thickness 0.5 mm and forms a panel. These two panels are mounted on either side of a V-shaped cooling support channel resulting in a blade. The HDI interfaces electrically to the rest of the detector.

3 Geometry Simulation

The goal of the current work is to develop the geometry simulation for the Forward Pixel disks. The previous geometry description had been machine translated from the GEANT-3 simulation program. However, this was not user friendly, very difficult to modify and non-readable by the users. Therefore, we developed a new package, which uses the detector description database (DDD) interface for the XML (eXtensive Markup Language) to GEANT simulation. The DDD description of the Forward Pixel detector is based on the precise measurements of different components. Most of the geometry files are written in XML and the usage of symmetry is maximized. The current geometry that has been developed is user-friendly and extendable. This flexibility allows to plug-in the geometry code of those components for which the design is not yet final. Sensitive volumes have been defined in the local reference frame of a plaquette. This is necessary for digitization and GEANT4 reconstruction software for tracking. Each subsystem in the package is standalone, so that changes can be made individually and tested independently. Figure 1 shows the simulation of hits generated in 1x5 plaquettes of three forward pixel disks. The original design consists of 2 disks, with a possible upgrade to a third disk later. The latest version of the code is always stored in the CMS software repository.

Figure 1: Simulated hits in global coordinates of 1x5 plaquettes in the three disks. The measurements in X and Y are in millimeters. The smallest circle represents the disk that is farthest down the beam line from the interaction point. Only two disks will be installed initially, with a possible upgrade to a third disk later on.

3 Conclusions

The geometry package developed for the Forward Pixel disks is fully tested. It is robust and being used for further simulation and reconstruction analysis.

References

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