Calibration of the CMS Pixel Detector at the Large Hadron Collider

Tamas Almos VAMI[1]

[1] Wigner Research Centre for Physics, Budapest
vami.tamas@wigner.mta.hu

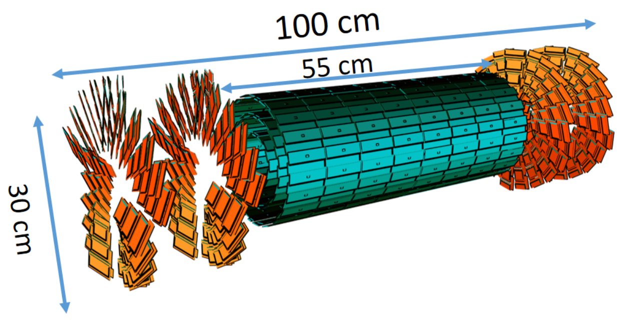

Fig. 1. Schematic picture of the CMS Pixel Detector.

The Compact Muon Solenoid (CMS) detector is one of two general-purpose detectors that reconstruct the products of high energy particle interactions at the Large Hadron Collider (LHC) at CERN. [1] The silicon pixel detector (Figure 1) is the innermost component of the CMS tracking system. It determines the trajectories of charged particles originating from the interaction region in three points with high resolution enabling precise momentum and impact parameter measurements in the tracker. [2]

The pixel detector is exposed to intense ionizing radiation generated by particle collisions in the Large Hadron Collider. This irradiation could result in temporary or permanent malfunctions of the sensors and could decrease the efficiency of the detector.

The bad component database contains the list of permanently or temporarily bad modules. It enables the trajectory building algorithm to skip a tracking layer on which a hit is expected to be missing due to a faulty module.

Bad modules are determined by measuring their occupancy. A map is created, in which the faulty sensors are identified as those with significantly lower occupancy compared to the average of the modules surrounding them. Figure 2 shows the map of the sensors where the white areas correspond to the bad modules.

Temporary faults in modules are caused by ionising radiation that can flip the memory state of the read-out chip. This effect is called Single Event Upset (SEU). The SEUs are fixed by reprogramming the read-out chips. We have developed procedures in order to correct for these effects.

Hit efficiency is defined as the detected fraction of all expected clusters in a fiducial region. After excluding components which are listed in the bad component database the efficiency was measured to be above 99.5%.

The resolution of the cluster position measurement determines the accuracy of the track reconstruction. The resolution is measured from the hit residuals obtained in the track fitting.

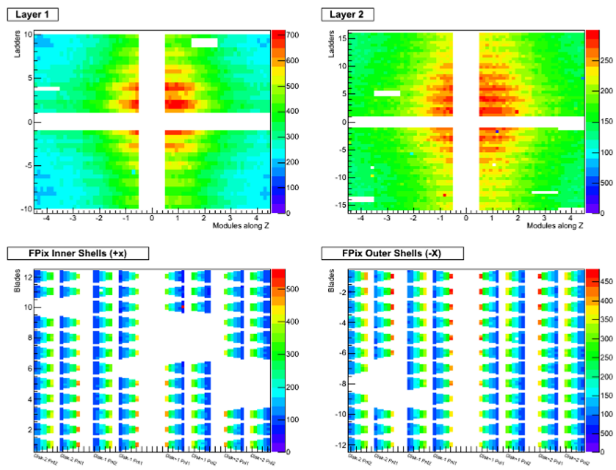

Fig. 2. Occupancy map of the sensors in 2012. Layer 1 and Layer 2 in BPIX (upper plots) and the two disks in FPIX (lower plots). Color code shows the occupancy of the sensors. The coordinates x,y,z refer to the local coordinate system of the CMS [1].

The charge carriers, induced by the traversing particles inside the silicon bulk, are deflected by the Lorentz force due to the 3.8 T magnetic field of the CMS magnet. This drift is characterised by the angle of deflection, which is known as the Lorentz angle. Detailed information can be found in Ref. [3].

In the lecture I will present the resolution, cluster size and the efficiency of the detector in Run 1. I will also give a detailed description of the offline calibration procedures, and I will speak about the Gain Calibration and Lorentz Angle measurement as well. We will also discuss the role of the Bad Component Database and SEUs.

[1] CMS Collaboration, "The CMS experiment at the CERN LHC." doi:10.1088/1748-0221/3/08/S08004.
[2] CMS Collaboration, "CMS Physics: Technical Design Report Vol. 1: Detector Performance and Software", CERN-LHCC-2006-001
[3] B. Henrich, R. Kaufmann, "Lorentz-angle in irradiated silicon.", Nucl. Instrum. Meth. A477 (2002) 304307. doi:10.1016/S0168-9002(01)01865-4.