IL NUOVO CIMENTO Vol. 33 C, N. 6 Novembre-Dicembre 2010
DOI 10.1393/ncc/i2011-10779-y

Colloquia: IFAE 2010

Performance of the ALICE Silicon Pixel Detector

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(ricevuto l' 8 Ottobre 2010; pubblicato online l'8 Febbraio 2011)

Summary. — The performance of the ALICE Silicon Pixel Detector has been studied during the commissioning phase with cosmic tracks in 2008 and with the first proton-proton collisions in 2009 delivered by LHC since the early phase of its commissioning

PACS 29.40.Gx – Tracking and position-sensitive detectors.

1. – The ALICE experiment and the Silicon Pixel Detector

ALICE (A Large Ion Collider Experiment) is the general-purpose heavy-ion detector at the CERN LHC. Its Inner Tracking System (ITS) consists of six layer barrel of silicon detectors located at radii between 4 and 43 cm from the beam axis and covering the pseudo-rapidity range $|\eta| < 0.9$ for all vertices located within the length of the interaction diamond. It contributes to the tracking of particles with momentum below 200 MeV/c, improves the momentum resolution for particles reconstructed by the large Time Projection Chamber (TPC), the main tracking system in ALICE, and reconstructs particles traversing dead region of the TPC. The two innermost layers of the ITS are made of hybrid Silicon Pixel Detectors (SPD). The SPD is also called vertex detector because it plays a fundamental role in reconstructing the primary vertex and identifying the secondary vertices from the decays of heavy flavor and strange particle. The SPD consists of 9.8 M of pixel cells arranged in 1200 read-out chips, each one containing 8192 pixel cells. Each chip provides a fast trigger signal if at least one hit is detected. The trigger signals from 1200 chips are then combined in a programmable logic unit which provides a level-0 trigger signal contribution for the ALICE data acquisition system [1].

2. – Cosmic data (2008)

2˙1. *Method to evaluate the efficiency of the innermost SPD layer with cosmic tracks.* – The 2008 Cosmic Data acquisition has been taken using the SPD trigger: this trigger selects event having at least a cluster in the top outer half barrel in AND with a cluster in the bottom outer one. To evaluate the inner layer efficiency, we defined a probing track using 3 points: 2 points in the outer layer and the 3rd one in the inner layer. Then a compatible cluster is searched for in the inner layer on the hemisphere opposite to that of the 3rd point. So, if the 4th point is found, a success is added to the efficiency of the chip containing this cluster; if not, a failure is assigned to the chip intersected by the probing track. The efficiency calculated by this method is equal to $99.4 \pm 0.2\%$, meanwhile in Monte Carlo the efficiency is calculated to be $99.91 \pm 0.02\%$. This small difference between Data and Monte Carlo may be due to the geometry misalignment which in real data is greater than the one presently estimated in simulations.

3. – First proton-proton collisions (2009)

The first proton-proton collisions in ALICE occurred on 23rd November 2009. At that date, the Silicon Pixel Detector was set with 100 Half-Staves switched on and the remaining 20 were off (17%), due to not good thermal conditions. In 2010 few more half-staves have been reconfigured and recovered.

3˙1. *Strategy for searching of dead pixels, chip by chip*. – The number of hits cumulated over the available statistics was considered to evaluate the real amount of the dead pixels in SPD. The dead pixels can be less than the never fired ones because of not enough statistics. The method to evaluate the dead pixel number is based on two hypotheses: the track occupancy within the chip is uniform and the detection efficiency is either 0 or 1 (dead or alive). The average number of tracks per alive pixel in a chip is $N_{ave} = \frac{N_{hits}}{N_{pixel} - N_{dead}}$ where $N_{pixel} = 8192$ and N_{hits} is the total number of hits. The probability to have no hit in a pixel is estimated based on Poissonian probability: $P_{poisson}(0 \mid N_{ave})$. So the expected number N_{off} of pixels without any hit can be calculated as the sum between the pixels with no signal because lack of statistics and dead pixels: $N_{off} = N_{pixel} \cdot P_{poisson}(0 \mid N_{ave}) + N_{dead} \cdot (1 - P_{poisson}(0 \mid N_{ave}))$. This equation can be solved numerically to give the unknown N_{dead} in each chip. A procedure to localize which pixels should be considered as alive among those without hit was developed knowing from construction the dead pixels which are mainly located either in the corner of the chip or along columns. We call $N_{over\text{-}dead} = N_{off} - N_{dead}$ the number of alive pixels with no hit and the method developed assigns the dead pixels among those that are never fired in the pixel hit-map. We call N_A the isolated never-fired pixels which are surrounded only by alive pixels; N_B those which have only one adjacent never-fired pixel. If $N_{off} - N_{dead} < N_A$: we choose $N_{over\text{-}dead}$ alive pixels randomly from N_A. If $N_{off} - N_{dead} > N_A$: all the N_A are considered as alive and some of the N_B are randomly considered as alive. After this procedure we have estimated the fraction of isolated dead pixels being $\sim 1\%$, and the total amount of pixels recovered is $N_{over\text{-}dead} = 0.24\%$.

3˙2. *SPD: data and Monte Carlo*. – A good agreement is found in the cluster yield per chip between data and MC, but for Sector 9 because of a problematic configuration of its half-staves, due to cooling problem. This causes a lower efficiency in this sector with respect to the MC estimation. The fit of the ratio between data and MC (excluding sector 9) is equal to 1, for both inner and outer layers. Hence we can conclude that the SPD performance in real data is in good agreement with the MC simulation.

REFERENCES

[1] Aamodt K. *et al.*, *JINST*, **3** (2008) S08002.