Construction of PHENIX Silicon Pixel Tracker

H. Torii,[*1] Y. Akiba,[*1] H. Asano,[*1] T. Hachiya,[*1] M. Kurosawa,[*1] T. Moon,[*1] H. Nakagomi,[*1] C. Pankcake,[*2] H. Sako,[*1] S. Sato,[*1] T. Sumita,[*1] A. Taketani,[*1] and the PHENIX VTX group

The PHENIX experiment is upgraded with a central silicon vertex tracker[1] to enhance its physics capabilities in nearly full azimuthal coverage over $|\eta| < 1.2$. The main goal of the upgrade is to track the production vertex of charged particles with the resolution of $50\mu m$. The central vertex tracker consists of four layers, two layers of silicon pixel type and two layers of silicon strip type. The tracker has been constructed in 2009 and has been producing fruitful physics results. During the operation before 2012, the heat cycle during its operation resulted in about 30% of inactive area on the constructed silicon pixel type. In this paper, we will report the status of repairing such the damaged pixel-type tracker and new construction.

The silicon pixel tracker consists of 10 ladders for inner layer and 20 ladders for outer layer. Each ladder is made of mainly three components; a supporting thermo-plate, four hybrid sensor, and a readout bus. The hybrid sensor is made of a silicon sensor plate and four readout chips, with 32×256 readout pixels whose each size is $50 \times 425\mu m$. All the three components are glued each other by epoxy resin with the thickness of $100\mu m \pm 30\mu m$ while the relative distance between two hybrid sensor is kept within $15\mu m$ accuracy, which is smaller than the estimated electron-drift diffusion of $20\mu m$. They are electrically connected by $25\mu m$ alminum bonding-wire. The wires are encapsulated by soft silicon resin in order to prevent any damage from an accidental contact during construction and from vibration caused by the electrical altenative current of 10MHz through the wire and the PHENIX magnetic field. For the damaged ladder, the electrical connection together with the silicon encapsulation are redone after old bonding-wires and old silicon resin are cleaned.

While entire construction procedure, the readout test by the PHENIX readout system[2] using electrical pulse and 0.546MeV beta-ray from Sr^{90} are performed three times; before the encapsulation, before the transportation from Wako to RHIC, and before the installation. The main goal of the test is to ensure the electrical connection between the sensor hybrids and the readout bus and to measure the ratio of the active pixels to all pixels. The threshold during the test is set at about 3,000 e^- while the nominal noise of the hybrid sensor is expected to be $200e^-$. When a minimum ionization particle penetrates the silicon sensor with the thickness of $200\mu m$, 14,000 electrons are estimated to be created and collected by pixel pads. The distribution on the pixel pad surface depends on where the electron and hole pairs are created. If we assume the average distance from pixel pads to such the electrons is $100\mu m$ that is in the middle of pixel sensor thickness, the 14,000 electrons distributes on pixel pads like gaussian distribution with $100\mu m$ sigma from a naive estimate. Because one pixel pad has $50 \times 425\mu m$, two pixel pads is expected to be more than the threshold on average.

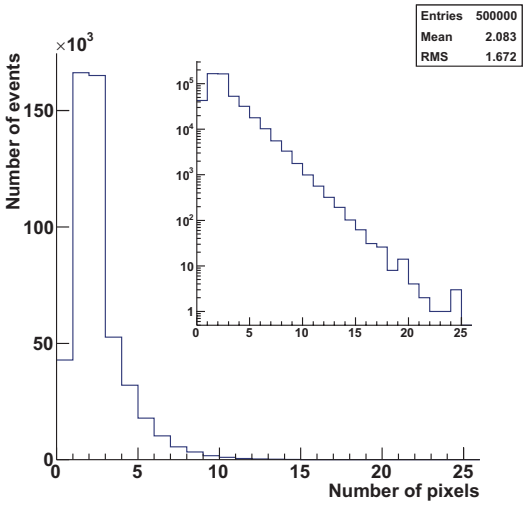

Fig. 1. Number of fired pixels per event in 500k beta-ray events by $Sr-90$ radio active source.

Figure 1 depicts the number of fired pixels per hit. The average of the number of pixels is 2.1, which is consistent with the above estimate. This fact enables us to measure the accurate rate of the active pixel to all pixel by this beta-ray test. Because some beta-ray enters the silicon sensor with angles due to scattering in materials between the radioactive source and the silicon sensor, some gamma-ray produce wider distribution, that is also observed in the figure.

After reparing procedure of 15 ladders, the selected ones were installed[3] with <10% inactive pixels, which is caused by due to faulty bump-bonding between the silicon sensor plates and readout chips. For futher improvement, new construction procedure with improved bump-bonding already started. All hybrids sensor[4] and readout buses are under gluing. At least seven new ladders will be ready for installation before next run of RHIC starting in the beginning of 2015.

References

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*1 RIKEN Nishina Center
*2 Department of Physics, Stony Brook University