Commissioning and operation of silicon vertex detector for PHENIX experiment in RHIC Run-14

M. Kurosawa,[*1] Y. Akiba,[*1] H. Asano,[*2] J. Bryshawskyj,[*3] T. Hachiya,[*1] M. Lentz,[*4] B. Miljko,[*5] T. Moon,[*1] H. Nakagomi,[*6] R. Nouicer,[*4] C. Pancake,[*7] P. Stankus,[*5] T. Sumita,[*1] A. Taketani,[*1] M. Wysocki,[*5] and the PHENIX VTX group

The PHENIX experiment aims to elucidate the spin structure of nucleons and the property of the hot and dense matter at the Relativistic Heavy Ion Collider (RHIC). A silicon vertex detector (VTX) was successfully installed in 2010 as a key element in the spin and, hot and dense matter physics. The VTX comprises a four-layer barrel detector built from two inner silicon pixel detectors and two outer silicon strip detectors. As mentioned in our previous report, the silicon pixel detectors were repaired and the active area of VTX was improved from 60% to 90% before Run-14[1]. This report presents the results of the commissioning and the performance of silicon pixel detectors in Run-14.

The silicon sensor module is an assembly of a silicon pixel sensor and four readout chips bump-bonded to the sensor with soldering bumps. Most of the dead area 10% results from the defects of soldering bumps caused by a thermal stress during operation. The pixel response at the boundary between the active and the dead areas is unstable, and those pixels become noisy because they have high resistivity caused by a week electrical connection. The main tasks in the commissioning stage are the determination of the threshold level and mask of noise pixels for all readout chips for minimizing fake hits.

Figure 1 shows the threshold dependence of a hit event rate for a readout chip. The threshold is represented as a DAC value. The higher the DAC value, the lower the number of electrons. The average of the optimized threshold for all readout chips was 180, which correspons to 3,700 electrons. The average was substantially low compared with that for the 14,000 electrons of Minimum Ionizing Particle (MIP).

Pedestal data was taken with a random trigger to detect noise pixels. The location of noise pixels were determined by detecting pixels that have a high hit rate. Since the noise level is dependent on the threshold level, a threshold and noise scan were iterated several times. Figure 1 shows the plot after removing pixels that have high hit rate. Approximately 0.03% of all pixels were masked and the probability of the noise-hit per event was reduced to 10^{-5}.

Figure 2 illustrates a performance plot that shows the correlation of the z vertex between beam-beam counter (BBC) and VTX. The BBC is a Cherenkov counter and determines the z vertex with a precision of 5 mm. The position resolution of VTX is less than 80 μm at over 1 GeV/c[2]. The width of the plot depends on the resolution of the BBC.

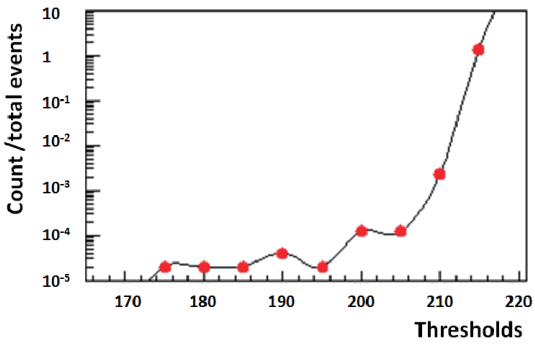

Fig. 1. Relationship between the threshold and the count/total event.

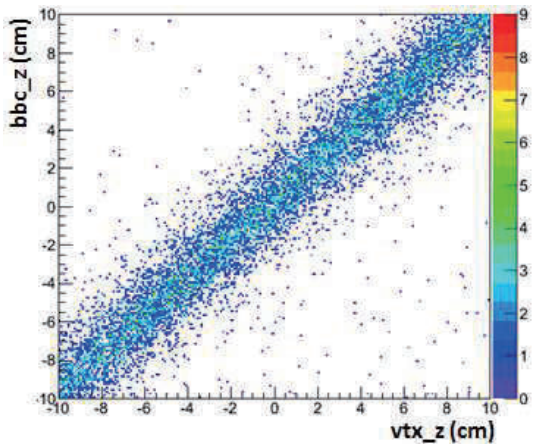

Fig. 2. Scatter plot of the z vertex position for BBC and VTX.

The 200 GeV Au+Au collision run was started in March and it ended in the middle of June. The VTX took about 20 billion events of physics data keeping the active area of 90% without any serious issues during this period.

*1 RIKEN Nishina Center
*2 Department of Physics, Kyoto Univ.
*3 Department of Physics, City Univ. of New York
*4 Brookhaven National Laboratory
*5 Oak Ridge National Laboratory
*6 Department of Physics, Tsukuba Univ.
*7 Department of Physics, Stony Brook University

References

1) M. Kurosawa et al.: RIKEN Accel. Prog. Rep. 47, 228 (2013)
2) T. Moon et al.: In this report.