Test beam experiment at ELPH in Tohoku University for sPHENIX INTT

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The sPHENIX[1)] collaboration will start data acquisition from 2023 to study quark-gluon plasma and cold quantum chromodynamics at the Relativistic Heavy Ion Collider (RHIC) in Brookhaven National Laboratory. The intermediate silicon tracker (INTT),[2)] one of the tracking detectors in the sPHENIX detector complex, plays a crucial role in tracking and jet flavor tagging with high precision and low background. Fifty-six INTT ladders with about 370 thousand silicon strips in total form a double-layer barrel to surround the interaction point. The position and timing resolutions of the prototype showed satisfactory performance in the previous experiment at Fermilab in 2019. Although a detection efficiency of 100% is expected owing to its high sensitivity to ionizing radiation, a detection efficiency about 96% was obtained in the experiment.[3)] An internal clock of 9.4 MHz (beam clock, BCO) in the system drove the INTT while the signals synchronized with the beam collision drove at RHIC. The timing mismatch of the BCO and the beam may explain the insufficient detection efficiency. The insufficient detection efficiency in the experiment may be due to the unsynchronized operation of INTT with the test beam.

We performed a test beam experiment in December 2021 to test the hypothesis and perform the following:

- Tests and performance evaluation of the mass-production ladders
- Tests of the long readout extension cable of 1.2 m[4)]
- Analog-digital converter distribution measurements with various beam injection angles with respect to the INTT ladders
- Performance evaluation of the ladders in a multi-track condition similar to that in RHIC by installing a lead plate the upstream of the setup

We measured hits on INTT ladders with a positron beam of 1 GeV at the Research Center for Electron Photon Science (ELPH) in Tohoku University. A dark box containing four INTT ladders, which have 6656 strips in the active area of about 465.5×20.0 mm^2, was set on the beamline, and two plastic scintillators were placed upstream and downstream as external triggers (Fig. 1). Depending on the trigger and veto configurations, the trigger rate was up to 100 Hz. Three of the ladders could take hit data successfully. A readout card acquires hit information from the ladders, and the DAQ stores hit coincidences with the external trigger signal. A fingertip scintillator was installed additionally to restrict the position of the hits in analysis.

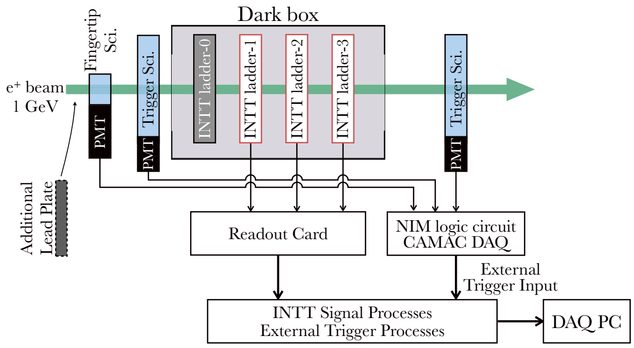

Fig. 1. Schematic diagram of the setup.

Data acquisition for about 50 h, divided into 65 runs, collected about 4×10^7 hits (Fig. 2). A hit map of ladder-1 with a typical setup (Fig. 3) shows the beam profile clearly. Data analysis is currently ongoing, and preliminary results for the detection efficiency are discussed in this report.[5)]

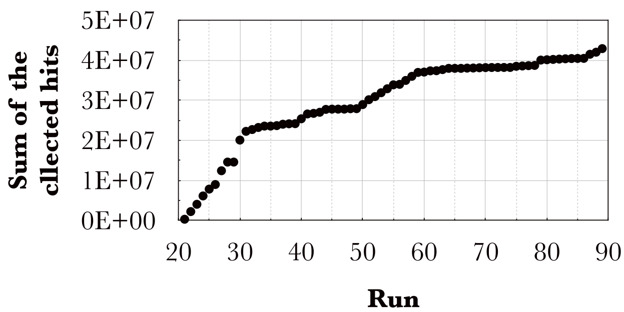

Fig. 2. Sum of the collected hits on the INTT ladders.

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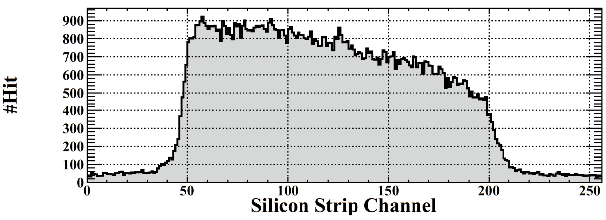

Fig. 3. Hit map of ladder-1.

References

1) A. Adare *et al.*, sPHENIX proposal (2015).
2) I. Nakagawa *et al.*, in this report.
3) A. Suzuki, Master thesis, Nara Women's University (2020).
4) T. Hachiya *et al.*, in this report.
5) M. Morita *et al.*, in this report.