Performance evaluation of a sensor module for INTT at sPHENIX

A. Suzuki,*[1] Y. Akiba,*[2] D. Cacace,*[3] K. Cheng,*[4] E. Desmond,*[3] T. Hachiya,*[2,*1] S. Hasegawa,*[5] T. Kondo,*[6] C. Kuo,*[4] M. Lenz,*[3] E. Mannel,*[3] C. Miraval,*[3] M. Morita,*[1] I. Nakagawa,*[2] R. Nouicer,*[3] R. Pisani,*[3] M. Shibata,*[1] C. Shih,*[4] T. Todoroki,*[2] X. Wei,*[7] and R. Xiao*[7]

The intermediate silicon strip tracker (INTT) is one of the tracking detectors of sPHENIX.[1)] An INTT sensor module consists of a silicon strip sensor, a readout chip called FPHX and a high-density interconnect (HDI).[2)] The size of the silicon strip sensor is $232.2 \times 22.5 \times 0.32$ mm^3. FPHX is a read-out LSI chip used for PHENIX.[1)] One FPHX reads out 128 channels. 26 FPHXs correspond to 128×26 read-out channels. Each channel is equipped with a shaping amplifier and 3-bit ADC. HDI is a flexible PC board.

We performed a beam test using a 120 GeV proton beam in June, 2019 at Fermilab and analyzed the data to evaluate the performance of the INTT sensor module. Figure 1 shows the setup of three sensor modules and two trigger scintillators. We call the layers from the front of the beam direction L0, L1 and L2. Two scintillators are arranged to sandwich the sensor modules.

We define the efficiency of L0 by Eq. (1) and describe how to calculate the efficiency. (1) Figure 2 shows the hit channel distributions for 26 FPHXs in a layer. The beam spot was observed at chip 6, 7, 19 and 20, respectively. L1 and L2 required a single strip hit at chip 6 and ADC > 3 to reduce noise. An L0 hit can be multi-strip hits among several chips around the beam spot. (2) We calculate the channel difference between L1 and L2 to choose the coincident hit from the track. Figure 3(a) shows the hit correlation between L1 and L2 so that events of channels with a difference $<\pm 5$ are selected for as shown in Fig. 3(b). (3) We calculate the hit expectation of L0 using L1 and L2 hits by using Eq. (2) to search for the most probable hit at L0. (4) We search for a corresponding hit at L0 to choose the one closest to the hit expectation. L0 channels are numbered from 0 to 256 by combining two FPHX chips to cover the whole width of the sensor. Figure 3(c) shows the hit correlation of L0 with the expectation so that events of the closest hit of channels with a difference $<\pm 5$ are selected as shown Fig. 3(d). (5) The events of (2) as the denominator and (4) as the numerator for Eq. (1) are counted. The detection efficiency is evaluated as $96.0 \pm 0.5\%$, which is within the error margins of the value of $96.4 \pm 1.0\%$ obtained in the previous experiment conducted in 2018.

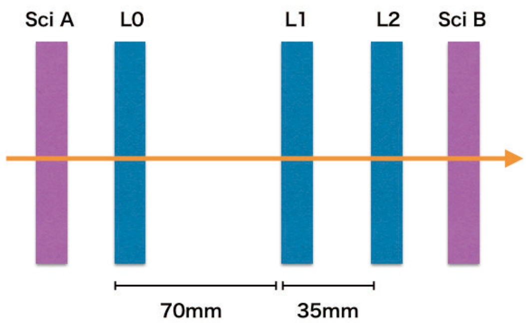

Fig. 1. Setup of ladders and scintillators in the beam test. The orange arrow indicates the beam direction.

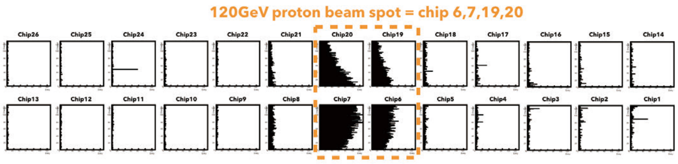

Fig. 2. Hit channel distribution of L0. X-axis: entries, Y-axis: channel number.

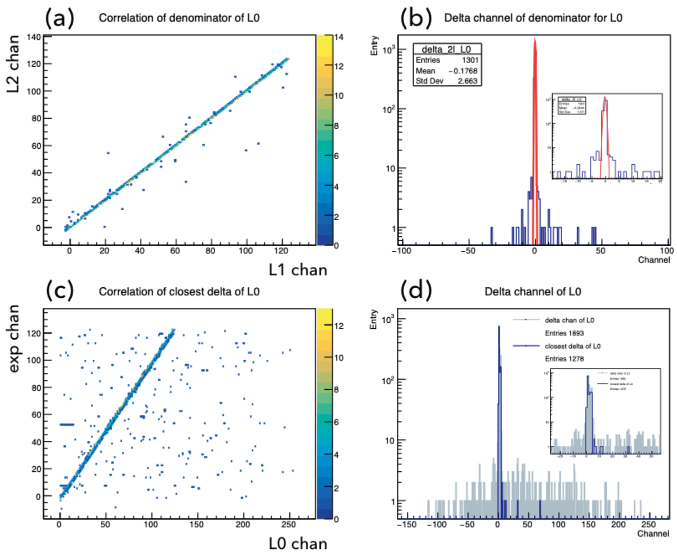

Fig. 3. (a) Hit correlation between L1 and L2. X-axis: L1 channel, Y-axis: L2 channel. (b) Difference (L1 channel - L2 channel). (c) Hit correlation between L0 and expectation. X-axis: L0 channel, Y-axis: expected channel. (d) Difference (L0 channel - expected channel).

$$\text{L0 Efficiency} = \frac{N(\text{L0}_{\text{hit}} \cap \text{L1}_{\text{hit}} \cap \text{L2}_{\text{hit}})}{N(\text{L1}_{\text{hit}} \cap \text{L2}_{\text{hit}})}. \quad (1)$$

$$\text{L0}_{\text{exp}} = \text{L1}_{\text{chan}} \times 3 - \text{L2}_{\text{chan}} \times 2. \quad (2)$$

In summary, we analyzed the beam test data to evaluate the efficiency of the INTT sensor module. The efficiency of L0 is $96.0 \pm 0.6\%$. This result is consistent with the 2018 result.

*1 Nara Women's University
*2 RIKEN Nishina Center
*3 Brookhaven National Laboratory
*4 National Central University
*5 Japan Atomic Energy Agency
*6 Tokyo Metropolitan Industrial Technology Research Institute
*7 Purdue University

References

1) I. Nakagawa *et al.*, in this report.
2) C. Aidata *et al.*, Nucl. Instrum. Methods Phys. Res. A **755**, 44–61 (2014).