Preliminary results of INTT beam test 2021 at ELPH†

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The Intermediate silicon Tracker, INTT, is one among the sub-detectors of sPHENIX tracking system.[1] A beam test experiment was performed with INTT ladders at the end of 2021 at ELPH, Japan. In the experiment, a telescope of 4 INTT ladders was installed, and 3 ladders were operated. The positron beam with the energy of 1 GeV was delivered. One of the goals of this experiment was to demonstrate the detection efficiency of INTT ladder. As the radiation length of INTT ladder was 1.08% X_0, the track was assumed to be a straight line.

This study focused on the column with the highest events.[2] The clustering was performed on 3 ladders, the adjacent fired channels in a column were grouped to form a hit cluster. The cluster position y in vertical direction was determined by $y = \Sigma_i E_i \cdot y_i / \Sigma_i E_i$, where E is the energy deposit. The track reconstruction was performed by the upstream ladder, L0, and downstream ladder, L2, and the detection efficiency of the middle ladder, L1, was measured. In the reconstruction process, no cluster in the adjacent columns of all ladders was required, and the number of clusters was required to be one on the same column for L0 and L2. The tracks passing the criteria were considered as track candidates. The residual r is defined as $r \equiv (y + C_y) - y_{pred}$, where y_{pred} is the y position at L1 predicted by the track candidate, and C_y is an offset term indicating the misalignment. An alignment correction of $-C_y$ was applied in the study.

Several cuts were applied to maximize the authenticity of the results. For L0 and L2, the single-hit cluster was rejected to minimize the false track candidates based on accidental noise hits. The track candidates within five channels from the edges were rejected to suppress the misalignment effect (edge effect). In addition, the track candidates with large deviation in the angle (±0.01 radian) from the beam axis were excluded (Slope cut). The track candidates that passed all criteria were considered as good tracks. Subsequently, the clusters in L1 were checked. Three categories were considered:

(1) The closest cluster is close to y_{pred} (N_{good}),
(2) The closest cluster is far from y_{pred} (N_{far}),
(3) No cluster was found (N_{no_hit}).

The residual distribution of the first two categories is shown in Fig. 1. The first category requires $|r| < 0.234$ mm (Residual cut).

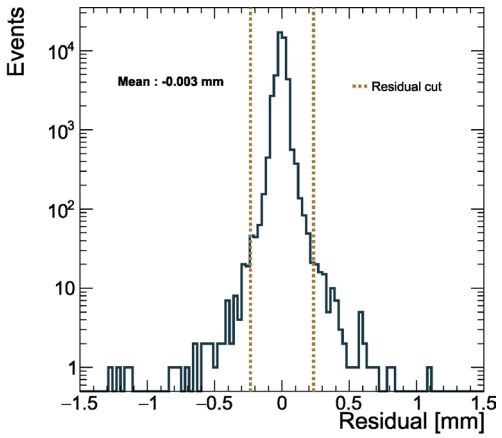

Fig. 1. Residual distribution in L1.

The equation of detection efficiency of L1 is defined as $\frac{N_{\rm good}}{N_{\rm no\_hit}+N_{\rm good}+N_{\rm far}} \times 100\%$. The systematic uncertainties associated with the detection efficiency originate from the determinations of the three cut values, the **slope cut**, **edge effect**, and **residual cut**. Scanning cut values provides the variation of each source, and the variation average estimates the uncertainties. The numerical values are summarized in Table 1.

Table 1. Sources of the systematic uncertainties affecting the detection efficiency calculation.

Sources	Scan range	Uncertainty (%)
Residual cut	0.164–0.304 mm	0.063
Slope cut	0.0088–0.0112 radian	3e-3
Edge effect	0–10 channels	4e-4
Total		0.063

Considering the systematic uncertainty, the detection efficiency of ladder L1 was 99.33 ± 0.04 (stat) ±0.06 (syst)%. The performance of INTT ladder is excellent enough for the sPHENIX experiment.

References

1) Conceptual Design Report of sPHENIX (2018).
2) G. Nukazuka *et al.*, ELPH Annu. Rep. (2022).

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