The preliminary results of INTT Testbeam 2021 at ELPH

Cheng-Wei Shih[1] for the sPHENIX INTT collaboration

[1]Department of Physics & Center for High Energy & High Field Physics, National Central University, ..., Taiwan

The sPHENIX is an upgrade project of the former PHENIX experiment at Relativistic Heavy-Ion Collider (RHIC). The sPHENIX aims to study the quark-gluon plasma by measuring jets, jet correlations and Upsilons (Υs) precisely, and cold QCD physics. The tracking system of sPHENIX consists of the MVTX, the TPC and the INTermediate silicon Tracker (INTT). The INTT bridges the tracks of the MVTX and the TPC, aims to improve the momentum resolution for charged particles with the high transverse momentum, and aids the pattern recognition and event synchronization. As a tracker, the detection efficiency of the INTT is required be close to 100% to save all track candidate hits. A testbeam experiment was performed at the end of 2021, at ELPH, Japan. It provides us an opportunity to understand the performance of the INTT more completely. The preliminary testbeam results are presented in this poster.

INTT facts

- 2 layers of barrel silicon strip tracker
- Consists of 56 silicon ladders
- Location : between the MVTX and TPC
  - The bridge of tracks
- Detection efficiency : ~ 100%
  - Main goal of this testbeam experiment
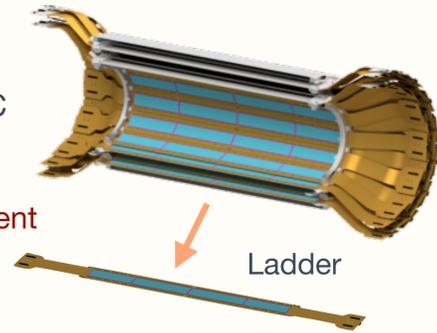
Ladder

Element	Value	Unit
Strip width	78	μm
Strip length	20 or 16	mm
Material budget	1.08%	X/X_0
# of channel	128	per chip
# of chip	52	per ladder

Type A sensor : 8 x 2 = 16 cells
Type B sensor : 5 x 2 = 10 cells

A B

Testbeam configuration

- Positron beam with energy of 1 GeV was delivered
- Upgraded testbench DAQ system was employed
- 4 ladders were installed in the testbeam box
  - First ladder was not operated
- External trigger : 2 scintillators coincidence

INTT Box

1 GeV e+

Trig. sci. | First Ladder | Ladder - 0 | Ladder - 1 | Ladder - 2 | Trig. sci.

INTT Box

1 GeV e+
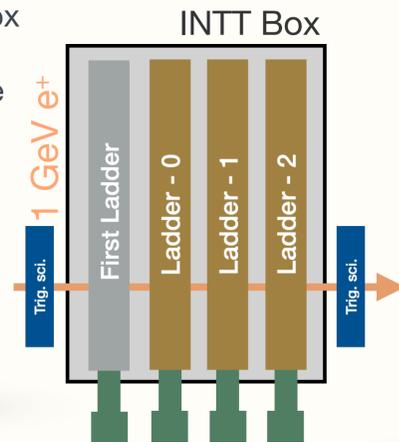
Tracking algorithm

Strategies :

1. The track trajectory is expected to be a straight line due to low material budget of INTT ladder and zero magnetic field environment.
2. For each event, the best track is selected and studied.
3. One of 4 event-profile candidates (111, 110, 101, 011) are assigned to each event based on track condition.
   → 1 (good): this layer has qualified hit.
   → 0 (bad) : this layer has no qualified hit or no hit.

Categorization

Count the number of the layers whose selected chip has at least one hit

- If count = 3 → algorithm-1 is applied
- If count = 2 → algorithm-2 is applied
- If count = 1 or 0 → skip

Hit

Count = 3   Count = 2

L0 L1 L2   L0 L1 L2
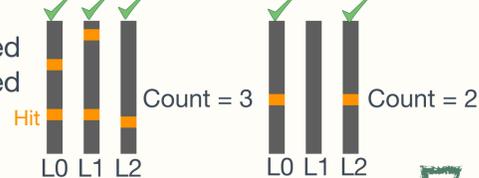
Algorithm-1

1. Fit all combinations and pick up the one with minimum χ^2 / NDF
2. Check the residual (R^l) of each layer
3. If < tolerance → event-profile 111
4. If > tolerance → algorithm-2 is applied

L0 L1 L2

Fitting line

R^l

Hit
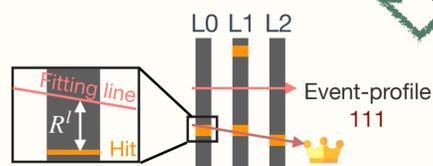
Event-profile
111

Algorithm-2

1. Ignore the layer with no/outlier hit
2. Check the position difference of the rest 2 layers, and assign the event profile
3. If < tolerance → 110, 101, 011
4. If > tolerance → 000

Outlier hit   No hit

Event-profile
101

Event-profile
✗ 000

L0 L1 L2   L0 L1 L2

Ladder energy deposit

- INTT readout : FPHX chip, 3-bit ADC
- DAC Scan was performed to study the full energy deposit distribution with a good resolution
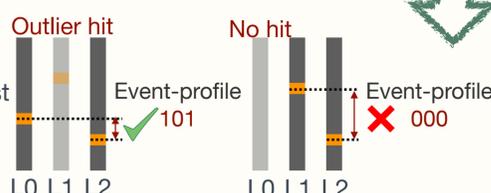
Fit function : Land & Gaus convolution

MIP (ch) :
75.42 ± 0.43 ADC

DAC Scan combine l1 0   DAC Scan all l1

ADC 15   ADC 15

Fit parameters - Signal
- Width = 1.093 ± 0.170
- MIP = 75.422 ± 0.426
- Area = 19262.15 ± 290.29
- sigma = 16.854 ± 0.307
Fit quality
- χ^2/ndf = 52.053/19 = 2.740

Ladder threshold value : ADC 15 → the evidence to expect > 99% efficiency
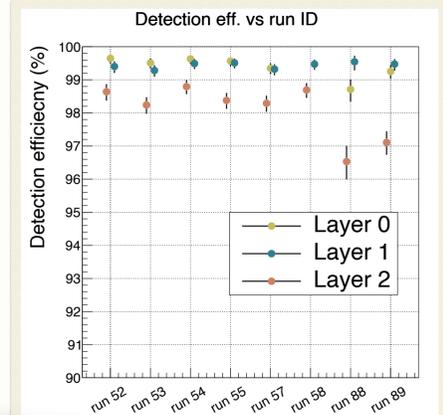
Detection efficiency

- The detection efficiency is based on the counting of the event-profile, defined by the function :

$$\text{Efficiency of layer-0} = \frac{\# \ of \ 111 \ event}{\# \ of \ 111 \ event \ + \ \# \ of \ 011 \ event}$$

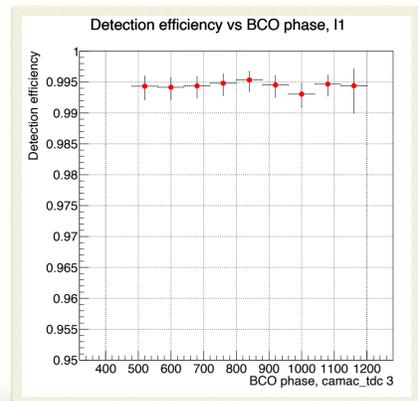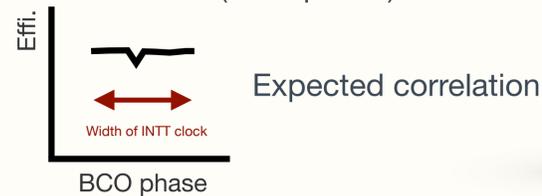| Run ID	effi. L0 (%)	effi. L1 (%)	effi. L2 (%)
52	$99.65^{+0.11}_{-0.15}$	$99.40^{+0.14}_{-0.18}$	$98.64^{+0.22}_{-0.25}$
53	$99.51^{+0.12}_{-0.15}$	$99.28^{+0.14}_{-0.17}$	$98.24^{+0.22}_{-0.25}$
54	$99.63^{+0.10}_{-0.13}$	$99.49^{+0.12}_{-0.15}$	$98.79^{+0.18}_{-0.21}$
55	$99.57^{+0.11}_{-0.14}$	$99.51^{+0.12}_{-0.15}$	$98.38^{+0.21}_{-0.24}$
57	$99.35^{+0.13}_{-0.17}$	$99.32^{+0.14}_{-0.17}$	$98.29^{+0.22}_{-0.25}$
58	$94.46^{+0.38}_{-0.41}$	$99.47^{+0.12}_{-0.16}$	$98.69^{+0.19}_{-0.22}$
88	$98.71^{+0.28}_{-0.35}$	$99.54^{+0.17}_{-0.24}$	$96.53^{+0.46}_{-0.52}$
89	$99.25^{+0.17}_{-0.21}$	$99.48^{+0.14}_{-0.18}$	$97.11^{+0.32}_{-0.36}$

Detection eff. vs run ID

Layer 0
Layer 1
Layer 2

The efficiency can be up to 99.6 % !

Detection effi. v.s. BCO phase

RHIC beam
INTT clock
ELPH Beam

Hits Hits Hits sync!

Hits Hits non-sync!

- TDC module : event process time measurement (BCO phase)

Effi.

Expected correlation

Width of INTT clock

BCO phase

- Another approach : run 58
- # of 011 event : ~ 200
- 011 event may indicates the lack of event process time.

Width of INTT clock

Expected correlation

BCO phase

Detection efficiency vs BCO phase, l1

The BCO phase distribution of 011 event of run 58

106 ns
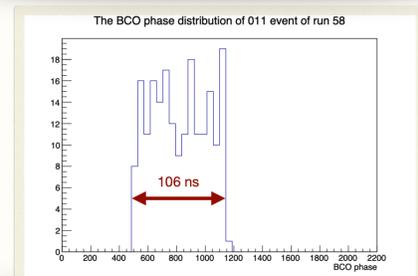
The BCO phase distribution of 011 event seem to be no tendency

Conclusion

- A testbeam experiment with INTT ladders was performed at ELPH.
- The DAC scan was performed, it provides us the evidence to expect > 99% efficiency.
- The detection efficiency can be up to 99.6%, excellent performance !
- The correlation of the BCO phase and efficiency hasn't been confirmed.