# The preliminary results of INTT Testbeam 2021 at ELPH

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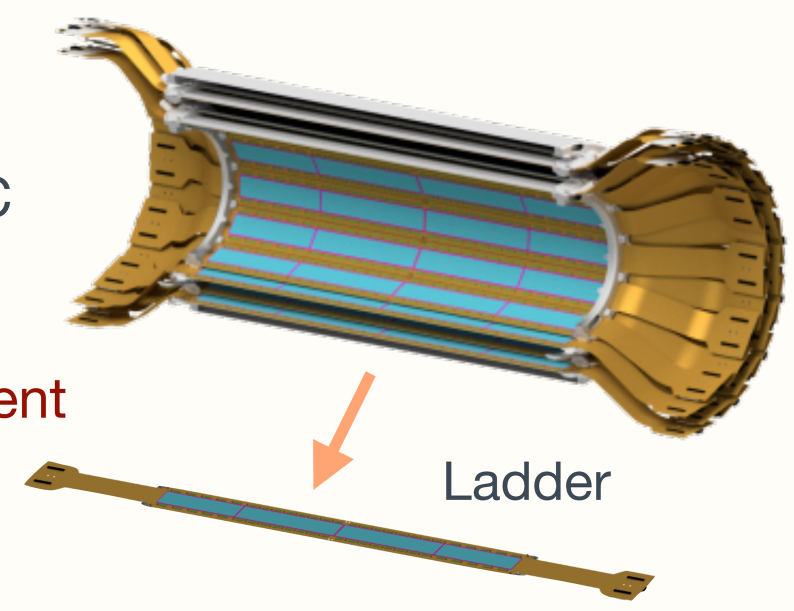
The sPHENIX is an upgrade project of the former PHENIX experiment at Relativistic Heavy-Ion Collider (RHIC). The sPHENIX aims to study the quark-gluon plasma by measuring jets, jet correlations and Upsilons (Υs) precisely, and cold QCD physics. The tracking system of sPHENIX consists of the MVTX, the 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 should be close to 100%. By doing so, all of the track-candidate hits can be kept. 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.

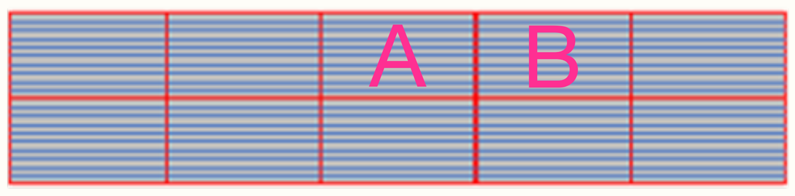
## INTT facts

- 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



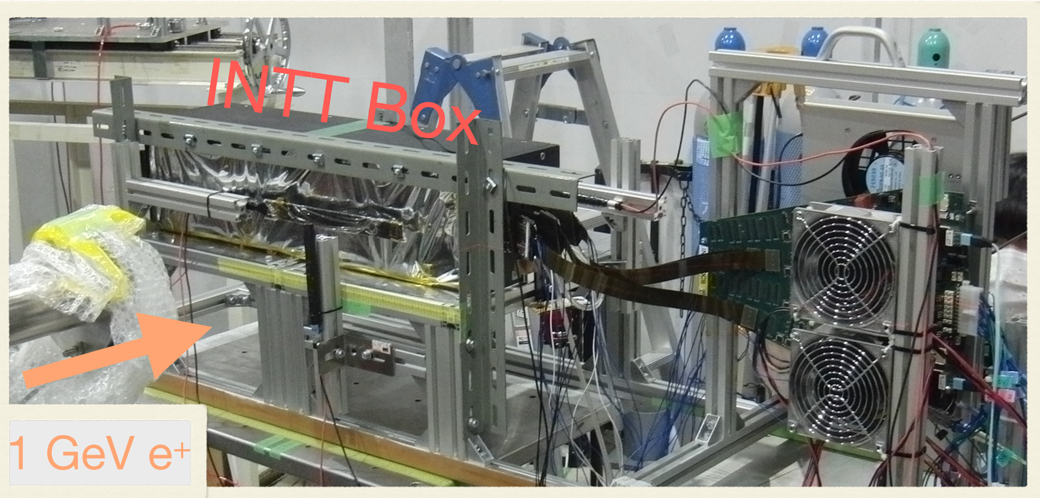

| Element | Value | Unit |
|---|---|---|
| Strip width | 78 | μm |
| Strip length | 20 or 16 | mm |
| Material budget | 1.08% | $X/X_0$ |
| # of channel | 128 | per chip |
| # of chip | 52 | per ladder |

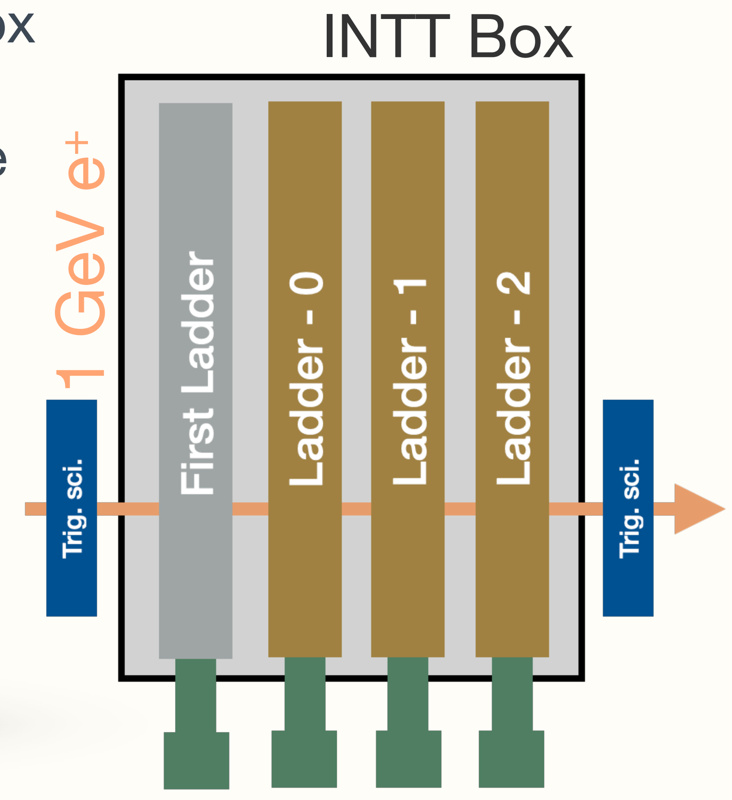
Type A sensor : 8 x 2 = 16 cells
Type B sensor : 5 x 2 = 10 cells




## 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




## Tracking algorithm

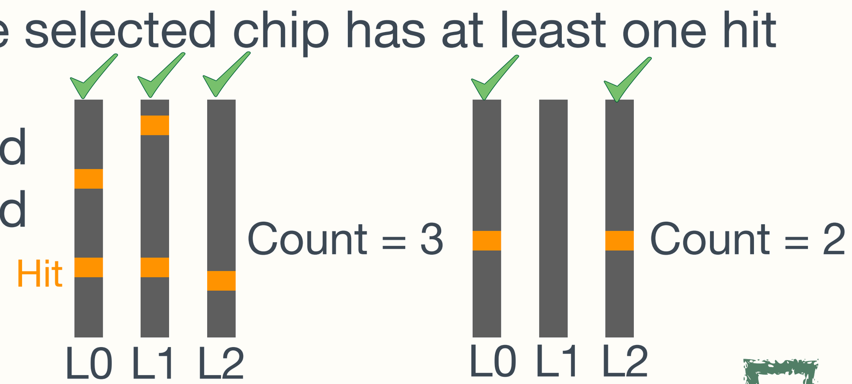
Strategies :

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

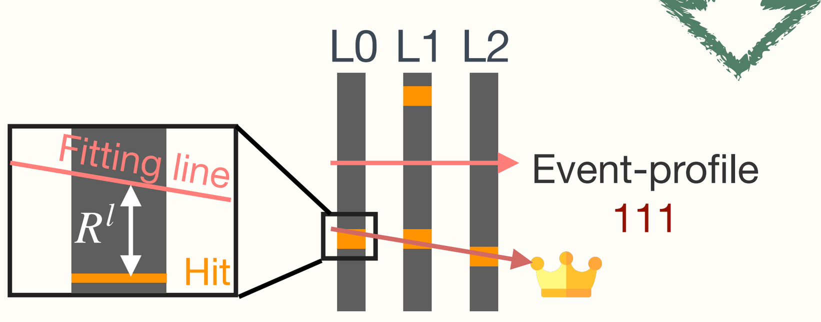
Count the number of the layers whose selected chip has at least one hit

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



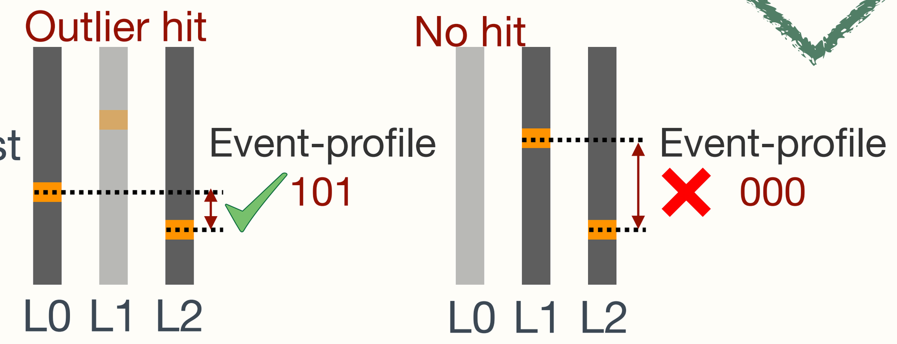

### Algorithm-1

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




### 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

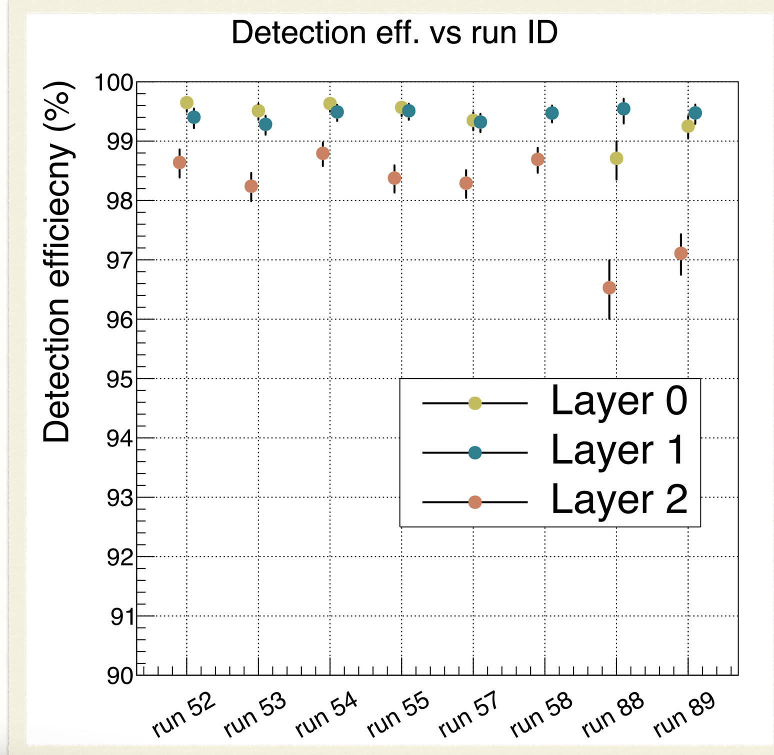



## Detection efficiency

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

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

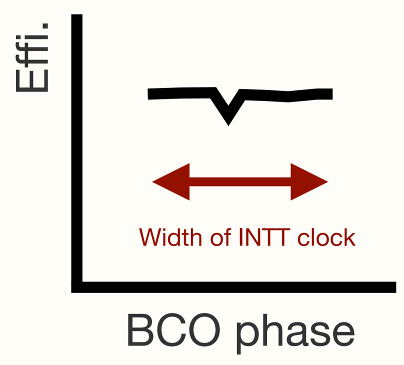
| Run ID | effi. L0 (%) | effi. L1 (%) | effi. L2 (%) |
|---|---|---|---|
| 52 | $99.65^{+0.11}_{-0.15}$ | $99.40^{+0.14}_{-0.18}$ | $98.64^{+0.22}_{-0.25}$ |
| 53 | $99.51^{+0.12}_{-0.15}$ | $99.28^{+0.14}_{-0.17}$ | $98.24^{+0.22}_{-0.25}$ |
| 54 | $99.63^{+0.10}_{-0.13}$ | $99.49^{+0.12}_{-0.15}$ | $98.79^{+0.18}_{-0.21}$ |
| 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 | $99.25^{+0.17}_{-0.21}$ | $99.48^{+0.14}_{-0.18}$ | $97.11^{+0.32}_{-0.36}$ |



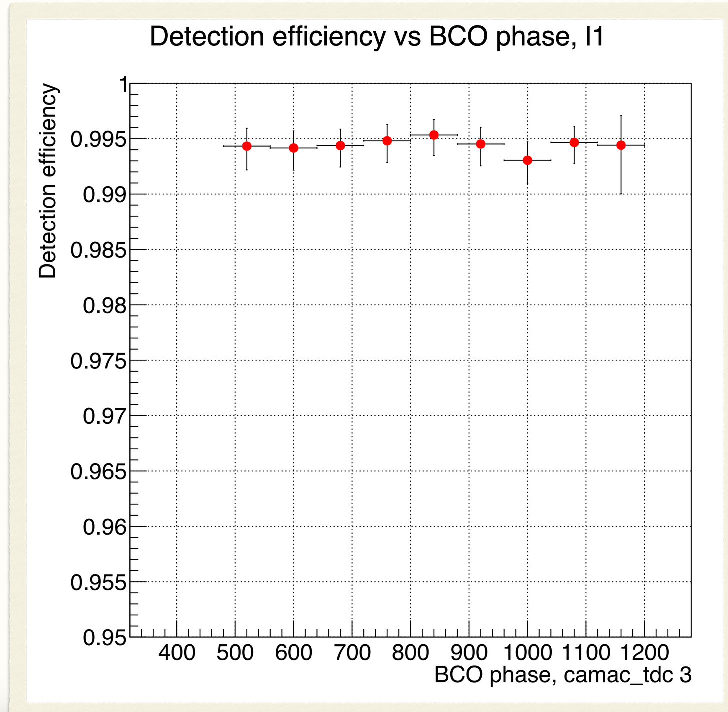

The efficiency can be up to 99.6 % !

## Detection effi. v.s. BCO phase

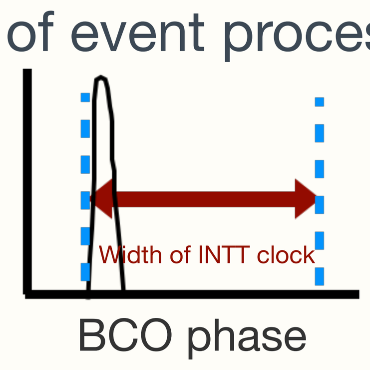
- INTT clock and ELPH beam clock are independent. Some events may not have enough time to process all hits
- In TestBeam2021, a TDC module was introduced for the event process time measurement (BCO phase)



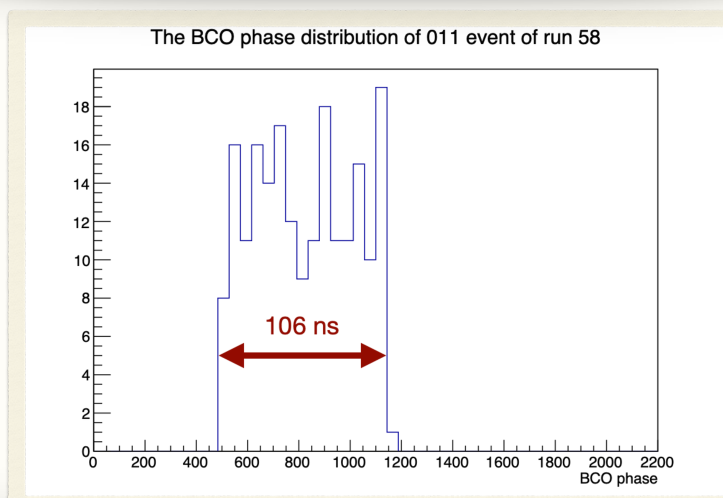

Expected correlation




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




Expected correlation



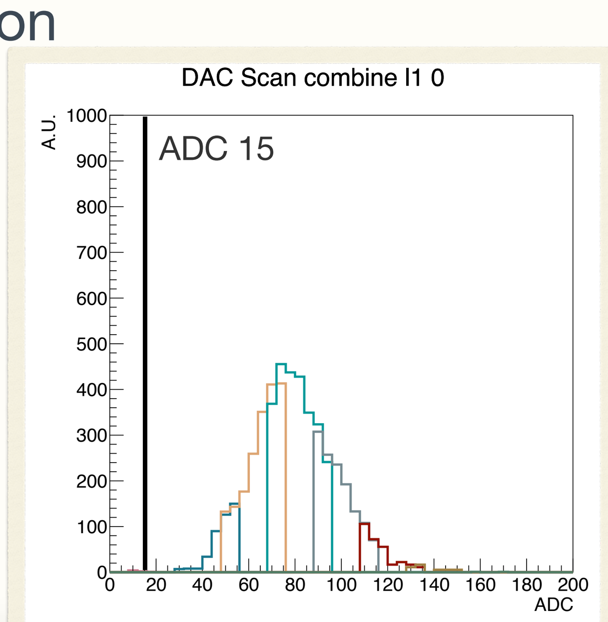

The BCO phase distribution of 011 event seem to be no tendency

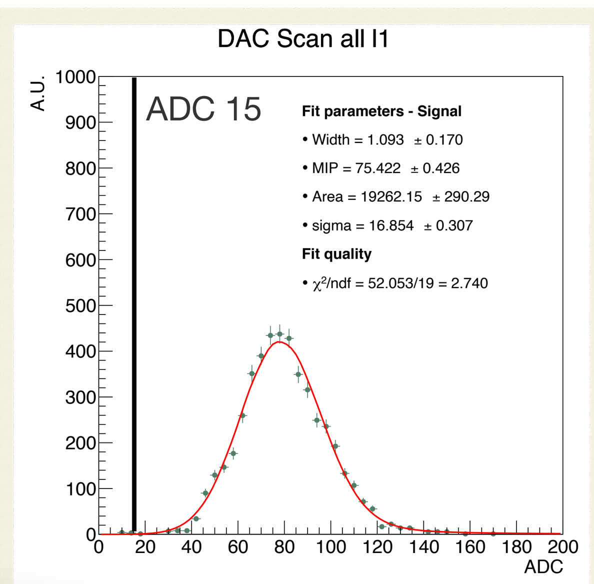
## Ladder energy deposit

- Optimize the threshold value for noise rejection
- INTT readout : FPHX chip, 3-bit ADC
- DAC Scan was performed to study the full energy deposit distribution with a good resolution

MIP (ch) :
75.42 ± 0.43 ADC

ADC 15 seems to have good S/N ratio




Fit function : Land & Gaus convolution

## Conclusion

- A testbeam experiment with INTT ladders was performed at ELPH.
- The detection efficiency can be up to 99.6%, excellent performance !
- The correlation of the BCO phase and efficiency hasn't been confirmed.
- The DAC scan was performed. A threshold value 15 seems to have good S/N ratio.