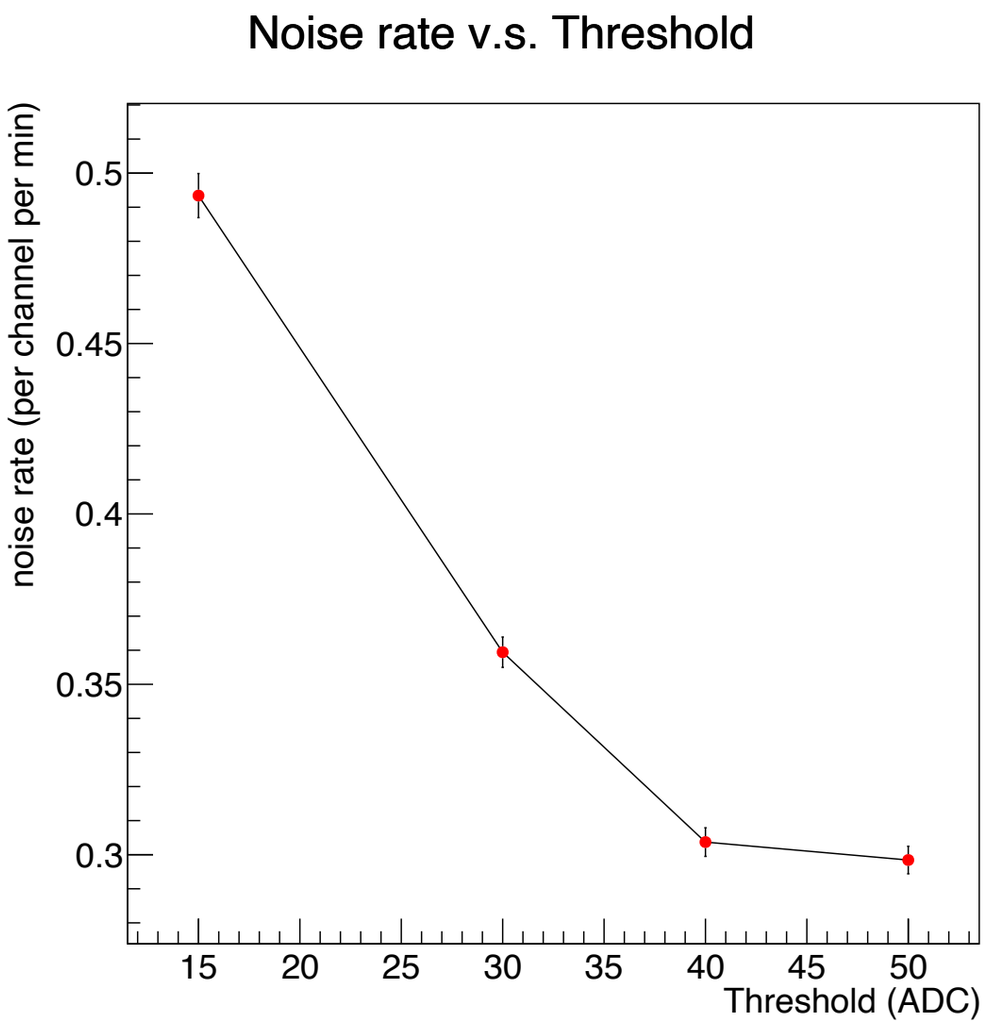
INTT progress report

Cheng-Wei Shih
National Central University

2022/3/4

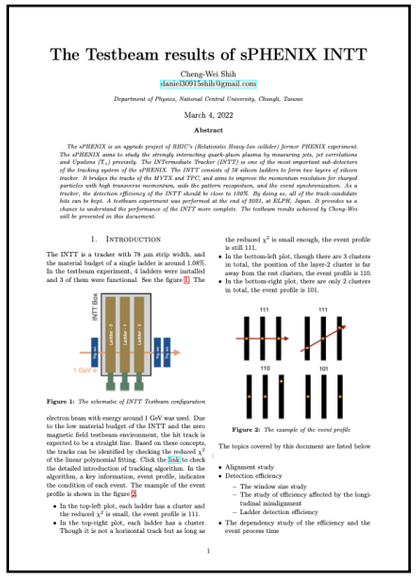
Noise rate v.s. Threshold

Threshold (ADC)	rate (per channel per min)	
15	0.493	±0.0065
30	0.359	±0.0045
40	0.304	±0.0042
50	0.298	±0.004



INTT Testbeam2021 latest results from Cheng-Wei
(preliminary, not official, 2021/03/04)

The document link



The Testbeam results of sPHENIX INTT

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Abstract

The sPHENIX is an upgrade project of RHIC's (Relativistic Heavy-Ion collider) former PHENIX experiment. The sPHENIX aims to study the strongly interacting quark-gluon plasma by measuring jets, jet correlations and Upsilons (Υ_s) precisely. The INTermediate Tracker (INTT) is one of the most important sub-detectors of the tracking system of the sPHENIX. The INTT consists of 56 silicon ladders to form two layers of silicon tracker. It bridges the tracks of the MVTX and TPC, and aims to improve the momentum resolution for charged particles with high transverse momentum, aids the pattern recognition, and the 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 a chance to understand the performance of the INTT more complete. The testbeam results achieved by Cheng-Wei will be presented in this document.

1. Introduction

The INTT is a tracker with 78 μm strip width, and the material budget of a single ladder is around 1.08%. In the testbeam experiment, 4 ladders were installed and 3 of them were functional. See the figure 1. The electron beam with energy around 1 GeV was used. Due to the low material budget of the INTT and the zero magnetic field testbeam environment, the hit track is expected to be a straight line. Based on these concepts, the tracks can be identified by checking the reduced χ^2 of the linear polynomial fitting. Click the link to check the detailed introduction of tracking algorithm. In the algorithm, a key information, event profile, indicates the condition of each event. The example of the event profile is shown in the figure 2.

- In the top-left plot, each ladder has a cluster and the reduced χ^2 is small, the event profile is 111.
- In the top-right plot, each ladder has a cluster. Though it is not a horizontal track but as long as the reduced χ^2 is small enough, the event profile is still 111.
- In the bottom-left plot, though there are 3 clusters in total, the position of the layer-2 cluster is far away from the rest clusters, the event profile is 110.
- In the bottom-right plot, there are only 2 clusters in total, the event profile is 101.

Figure 1: *The schematic of INTT Testbeam configuration*

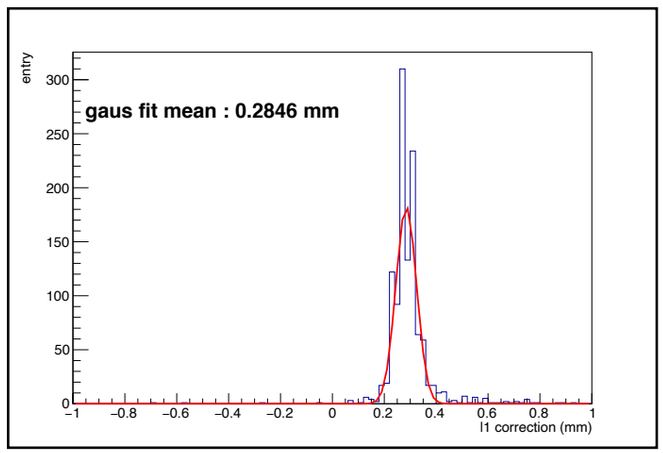
Figure 2: *The example of the event profile*

The topics covered by this document are listed below

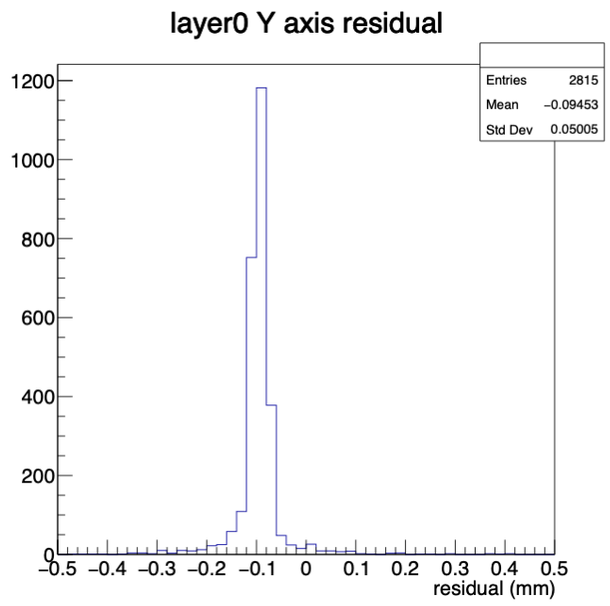
- Alignment study
- Detection efficiency
  - The window size study
  - The study of efficiency affected by the longitudinal misalignment
  - Ladder detection efficiency
- The dependency study of the efficiency and the event process time

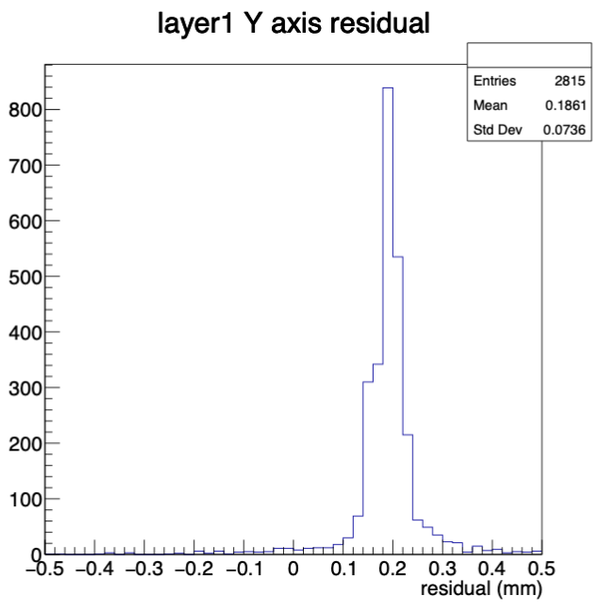
Residual distribution & alignment

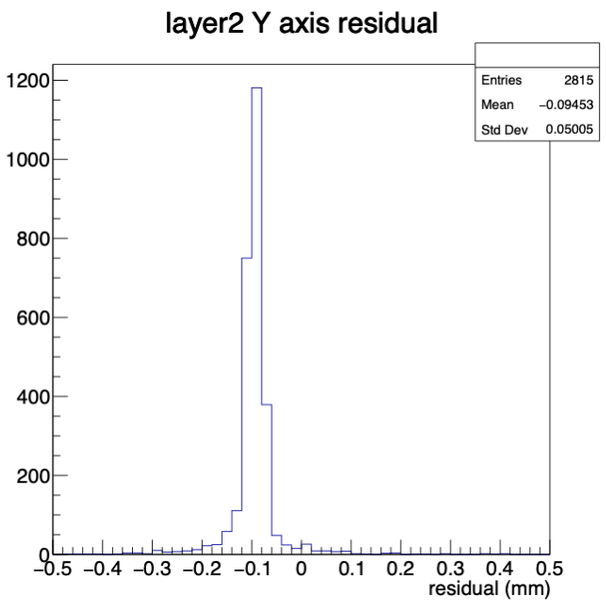
L1 correction



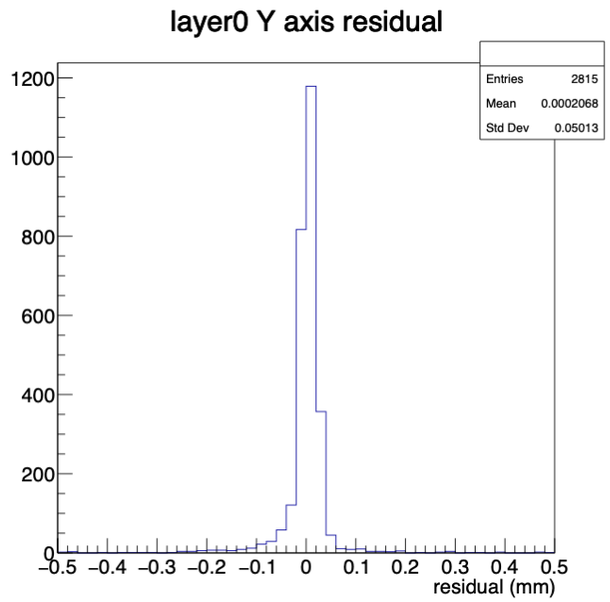
Before alignment correction

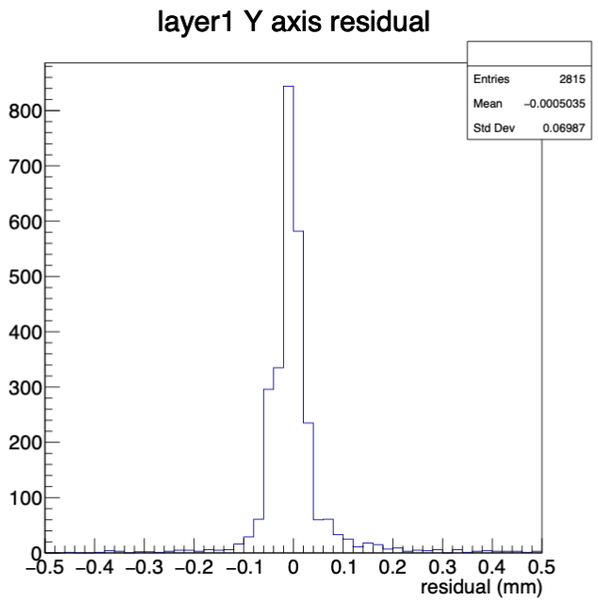


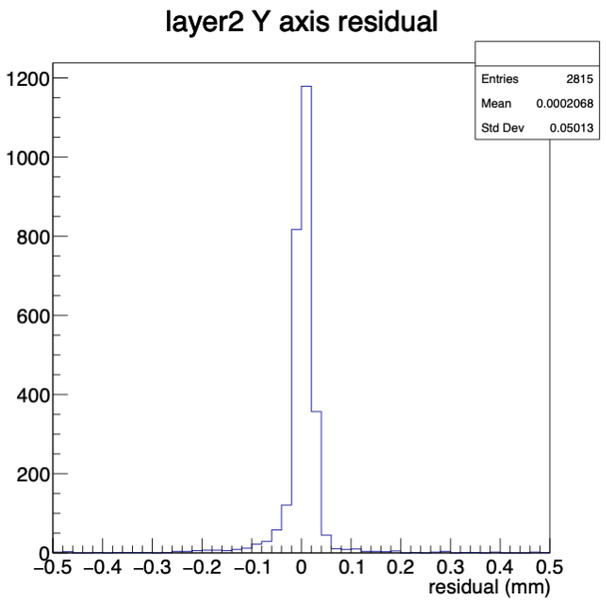




After alignment correction

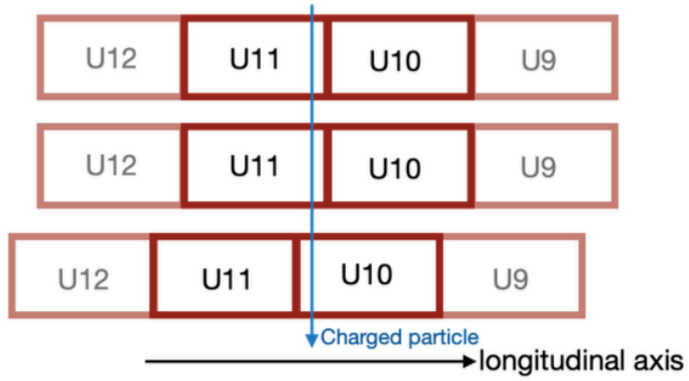






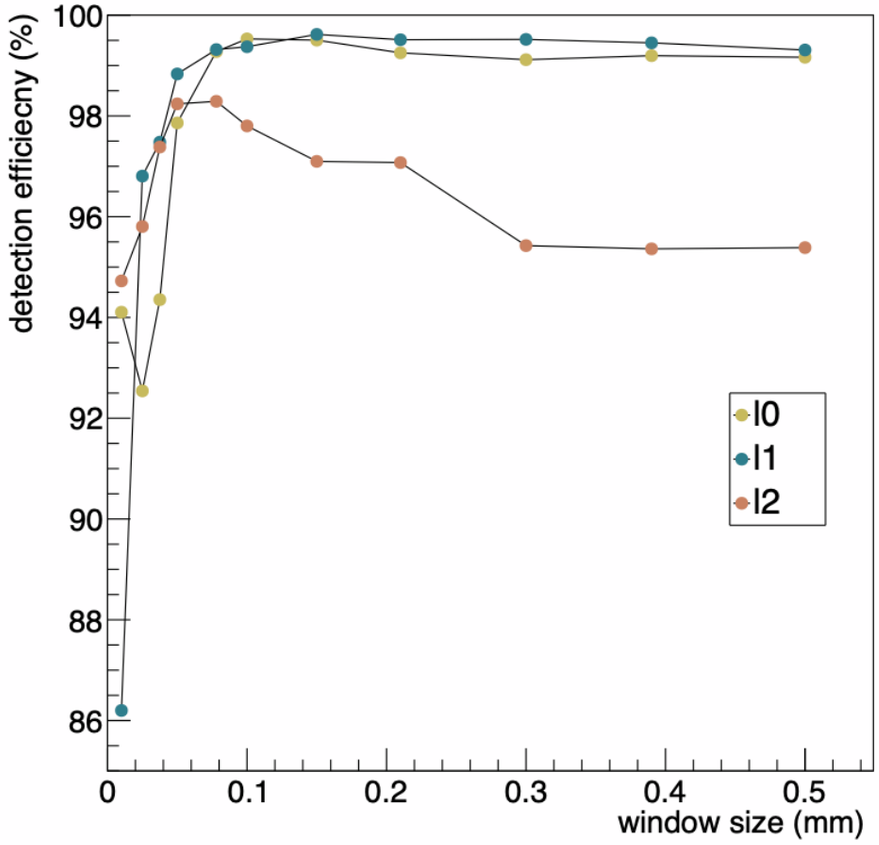
Window cut & LOE

- Silicon strip detector
- Poor resolution in the longitudinal axis
- Alignment can not be performed



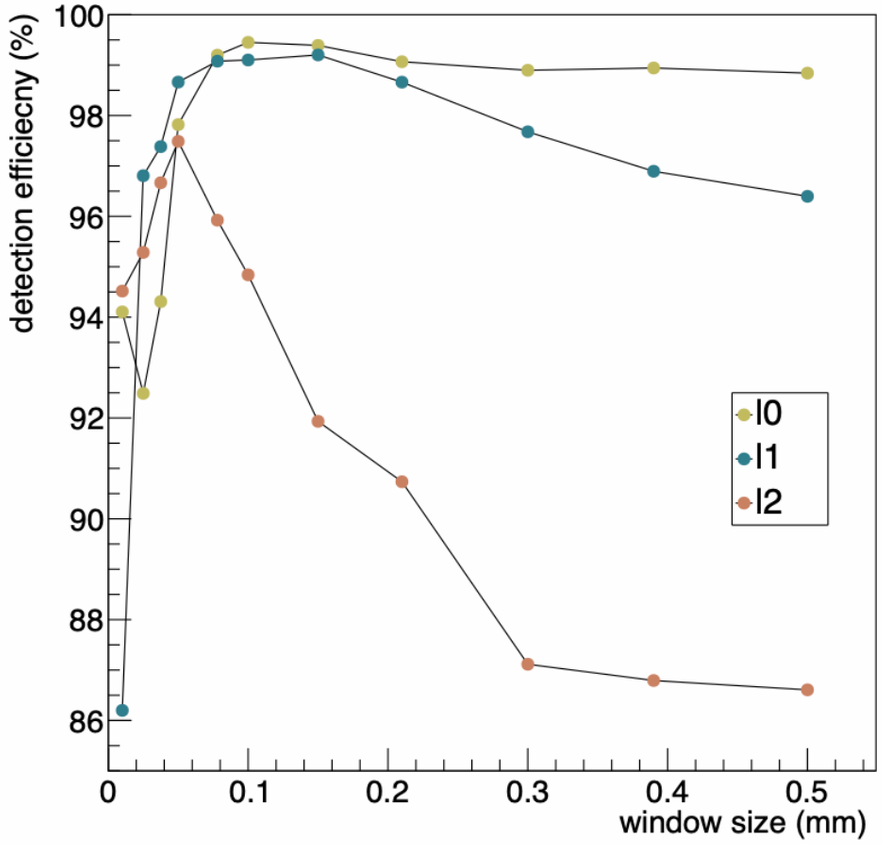
With LoE_removal

detection eff. vs window size



Without LoE_removal

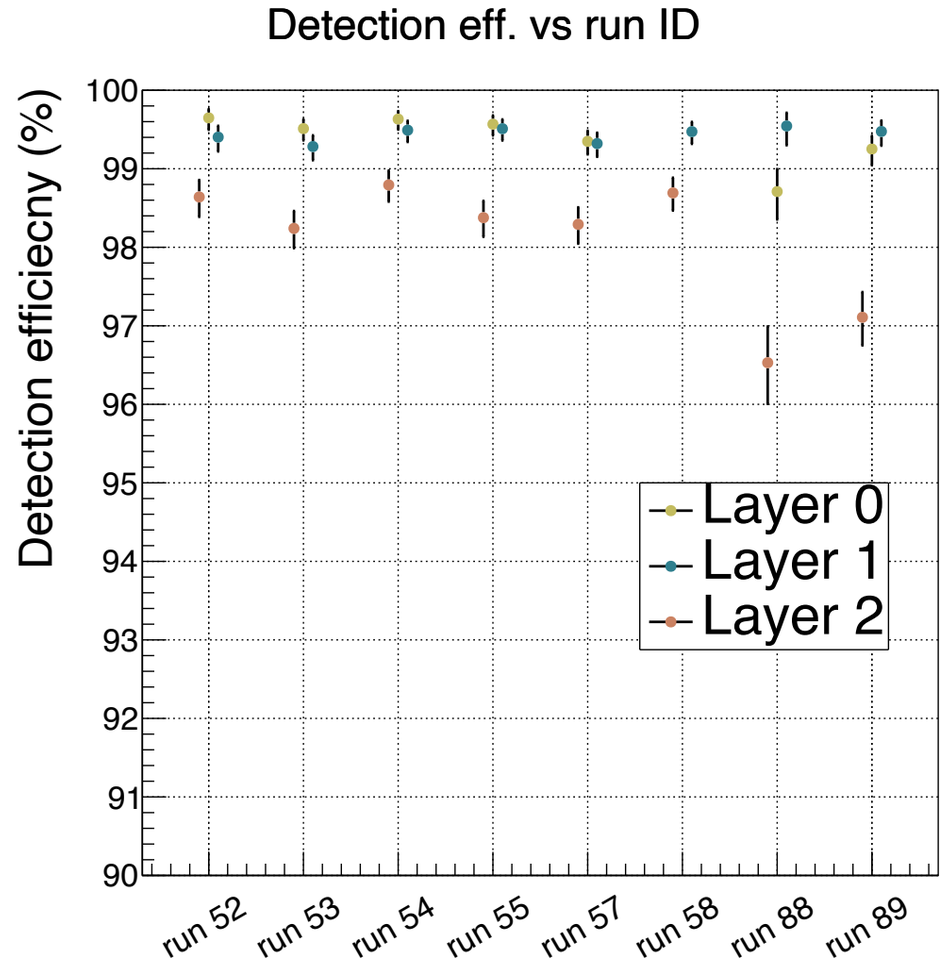
detection eff. vs window size



Efficiency vs run ID (production runs)

Only the first BCO group of each INTT trigger event is considered.

Run ID	effi. l0 (%)	effi. l1 (%)	effi. l2 (%)
52	$99.647^{+0.109}_{-0.149}$	$99.402^{+0.143}_{-0.182}$	$98.640^{+0.215}_{-0.252}$
53	$99.511^{+0.117}_{-0.149}$	$99.282^{+0.142}_{-0.173}$	$98.240^{+0.221}_{-0.250}$
54	$99.632^{+0.100}_{-0.132}$	$99.491^{+0.118}_{-0.149}$	$98.793^{+0.182}_{-0.211}$
55	$99.567^{+0.110}_{-0.142}$	$99.510^{+0.117}_{-0.149}$	$98.376^{+0.213}_{-0.242}$
57	$99.349^{+0.134}_{-0.165}$	$99.320^{+0.137}_{-0.168}$	$98.291^{+0.216}_{-0.245}$
58	$94.464^{+0.382}_{-0.408}$	$99.472^{+0.122}_{-0.155}$	$98.692^{+0.193}_{-0.223}$
88	$98.709^{+0.284}_{-0.354}$	$99.544^{+0.167}_{-0.244}$	$96.529^{+0.460}_{-0.523}$
89	$99.251^{+0.165}_{-0.206}$	$99.475^{+0.138}_{-0.180}$	$97.108^{+0.320}_{-0.357}$



The preliminary shows that the efficiency can be up to 99.6 %

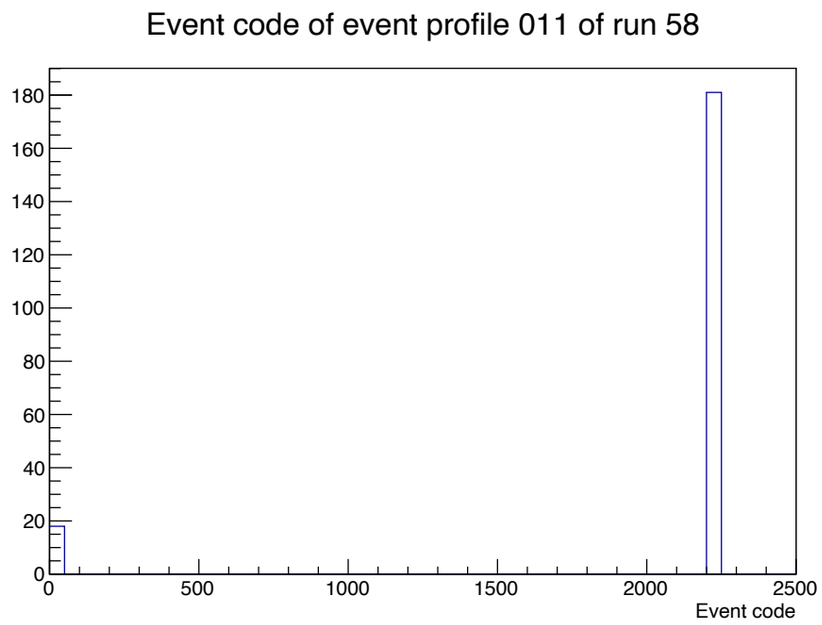
Run 58 layer-0 confirmation

Only the first BCO group of each INTT trigger event is considered.

58	$94.464^{+0.382}_{-0.408}$	$99.472^{+0.122}_{-0.155}$	$98.692^{+0.193}_{-0.223}$

Event code	Description
< 100	has 3 quantified hits in same chip
~ 2200	has 2 quantified hits in same chip
~ 33000	LoE events

Table 2: *The description of event code*



Run 58 : Only 2 layers have useful hits for most of the 011 events

Efficiency vs BCO phase

- INTT clock and Beam clock are not synchronized
- Some events may not have enough time to process the hits
- BCO phase = the amount of event process time

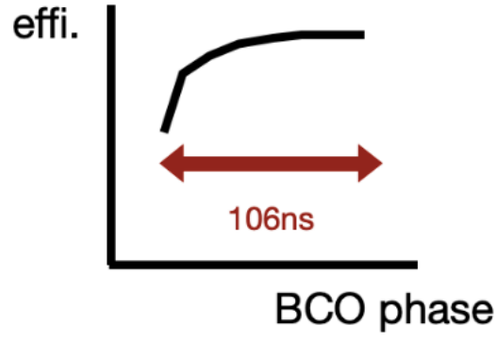
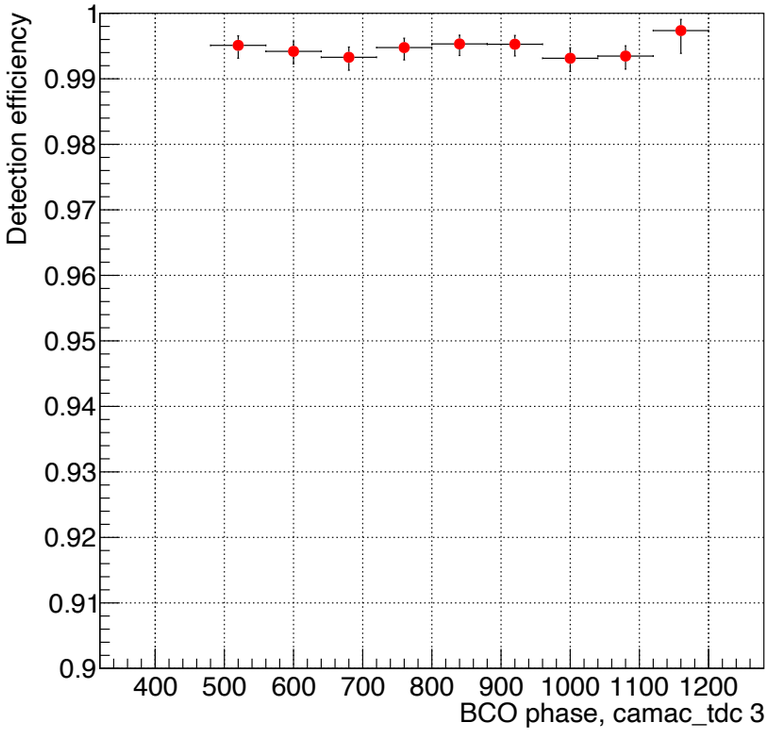
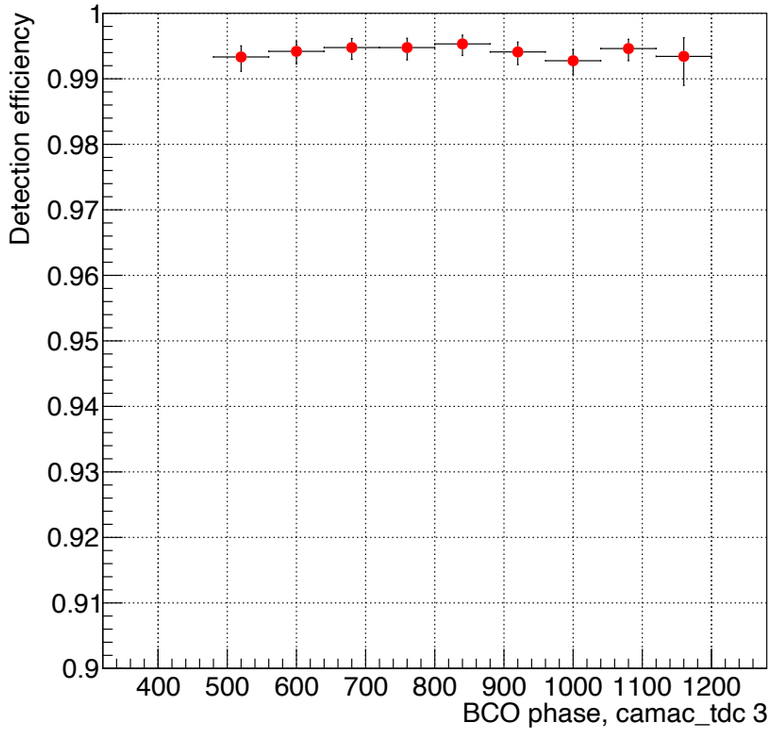


Figure 13: *The hypothesis of the relation between efficiency and event process time*

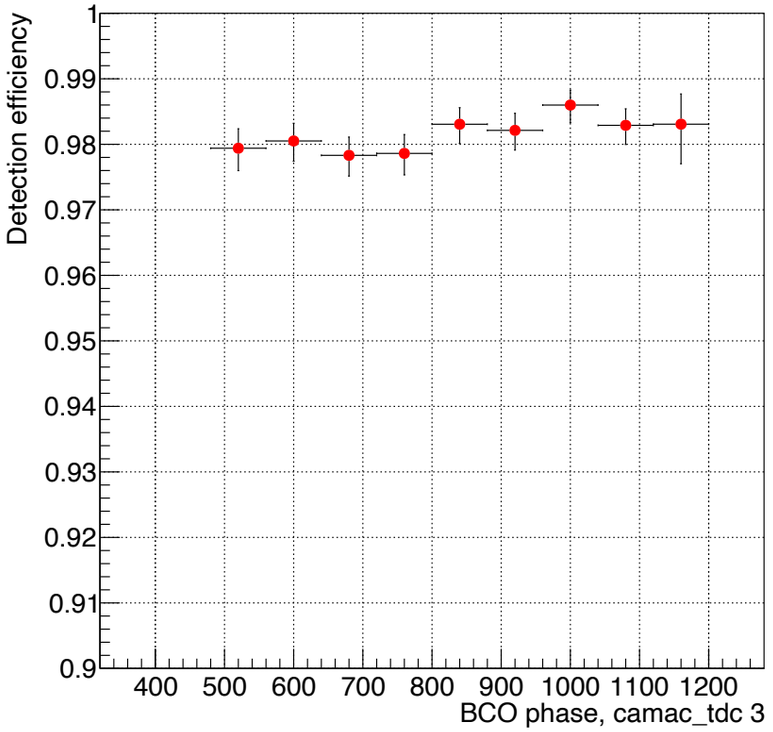
Detection efficiency vs BCO phase, l0



Detection efficiency vs BCO phase, l1



Detection efficiency vs BCO phase, l2



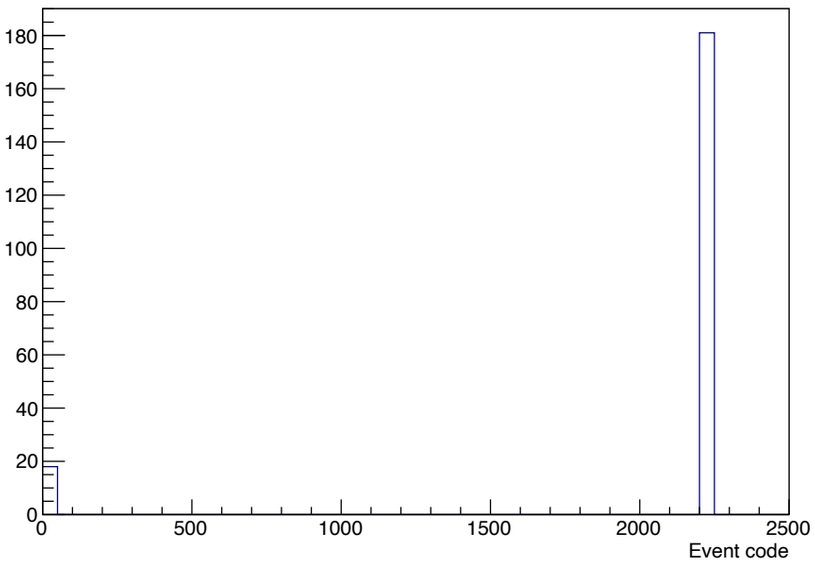
The efficiency seems to be independent to the BCO phase

Efficiency vs BCO phase

- Another approach, run 58 :
  - 011 event → may not have enough process time

58	$94.464^{+0.382}_{-0.408}$	$99.472^{+0.122}_{-0.155}$	$98.692^{+0.193}_{-0.223}$

Event code of event profile 011 of run 58



Run 58 : Only 2 layers have useful hits for most of the 011 events

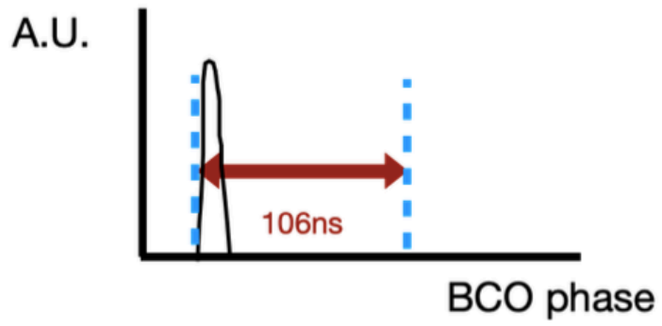
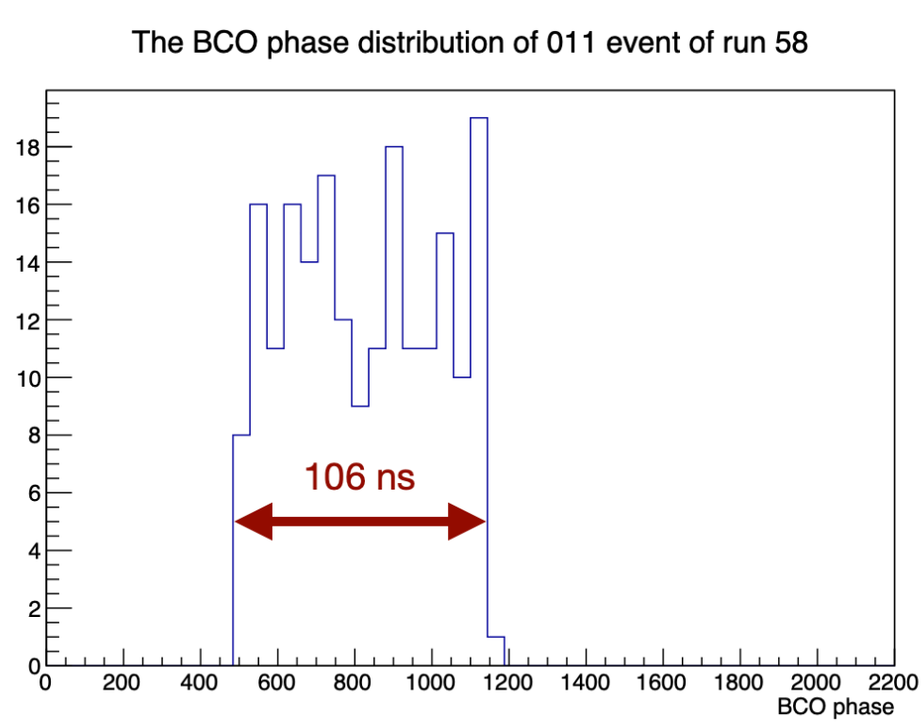
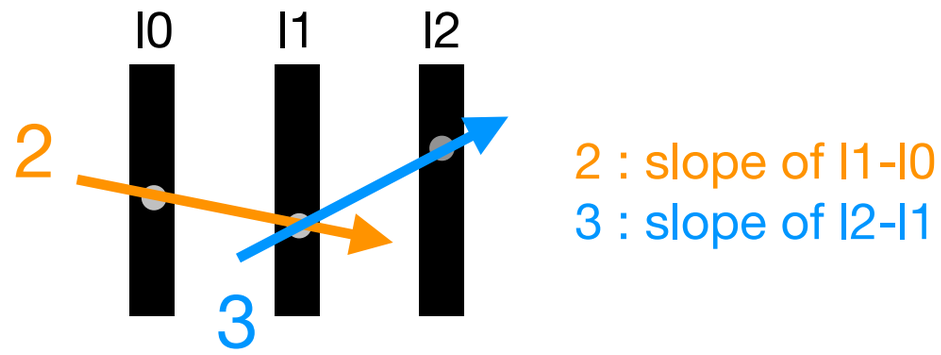


Figure 15: *The expected BCO phase distribution of 011 event of run 58*



Scattering

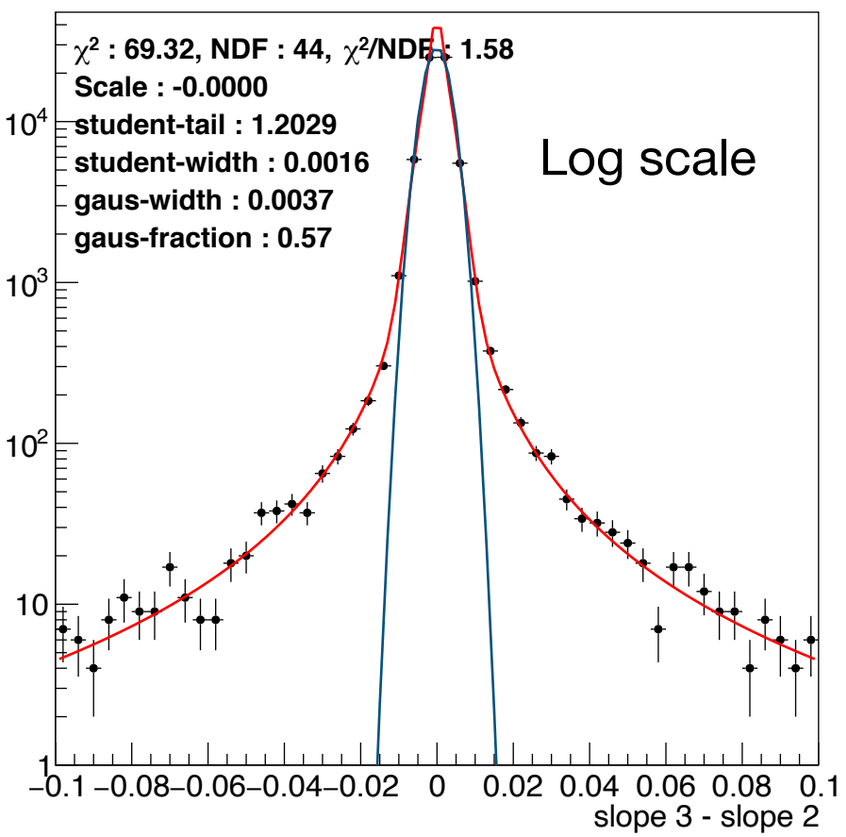
$$f(\theta) = N \cdot \left((1-a) \cdot \frac{1}{\sigma_G \sqrt{2\pi}} e^{-\frac{(\theta-\mu)^2}{2\sigma_G^2}} + a \cdot \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\nu\pi}\sigma\Gamma(\frac{\nu}{2})} (1 + \frac{(\theta-\mu)^2}{\nu\sigma^2})^{-\frac{\nu+1}{2}} \right)$$

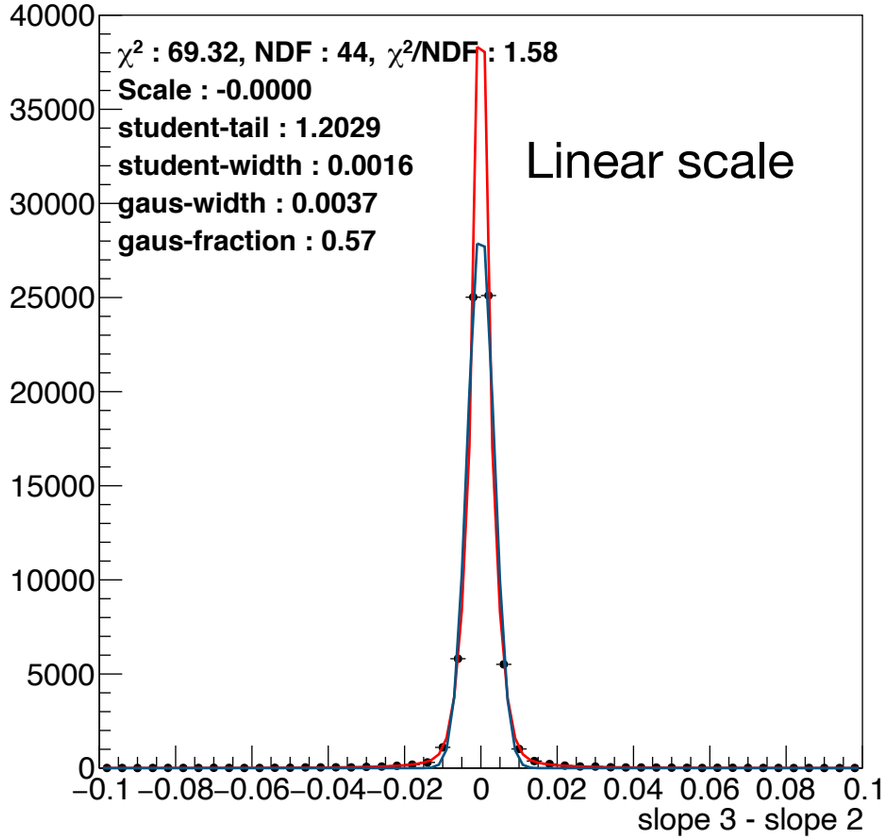


2 : slope of I1-I0
3 : slope of I2-I1

Run 89 is used, Only consider U10 (beam spot)

The scattering happens at the I1





DAC scan

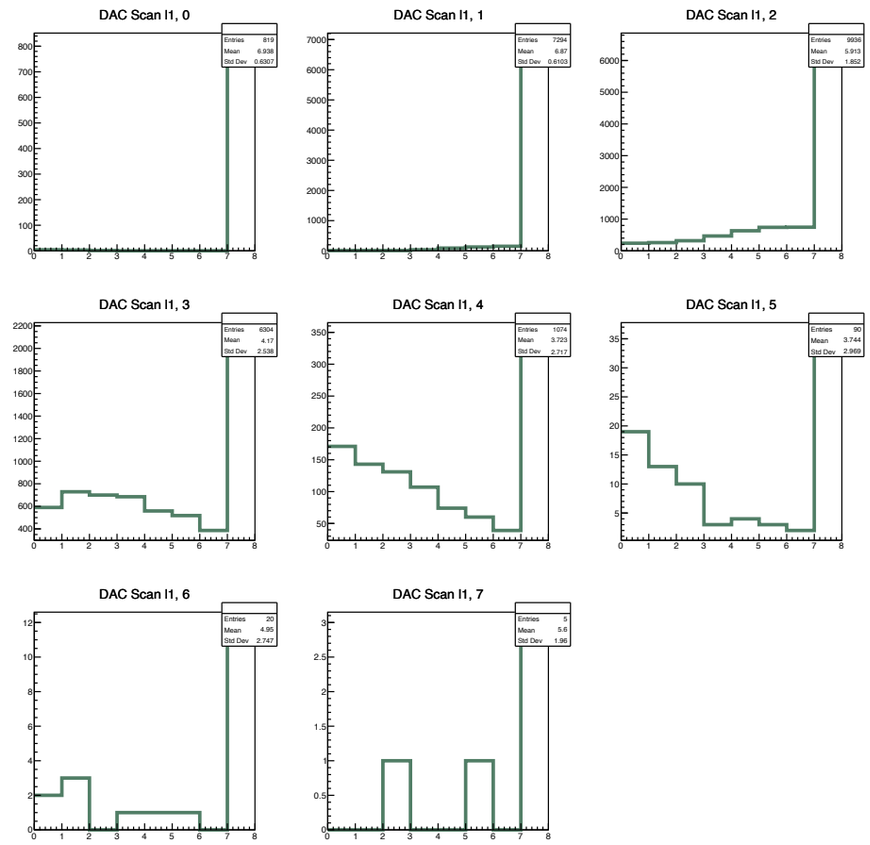
- Algorithm is same as Testbeam2019 :
  - 6th, 7th bins : histogram matching
  - 8th bin : overflow, neglect

- Criteria :
  - Event profile has to be 111
  - single hit for each layer only

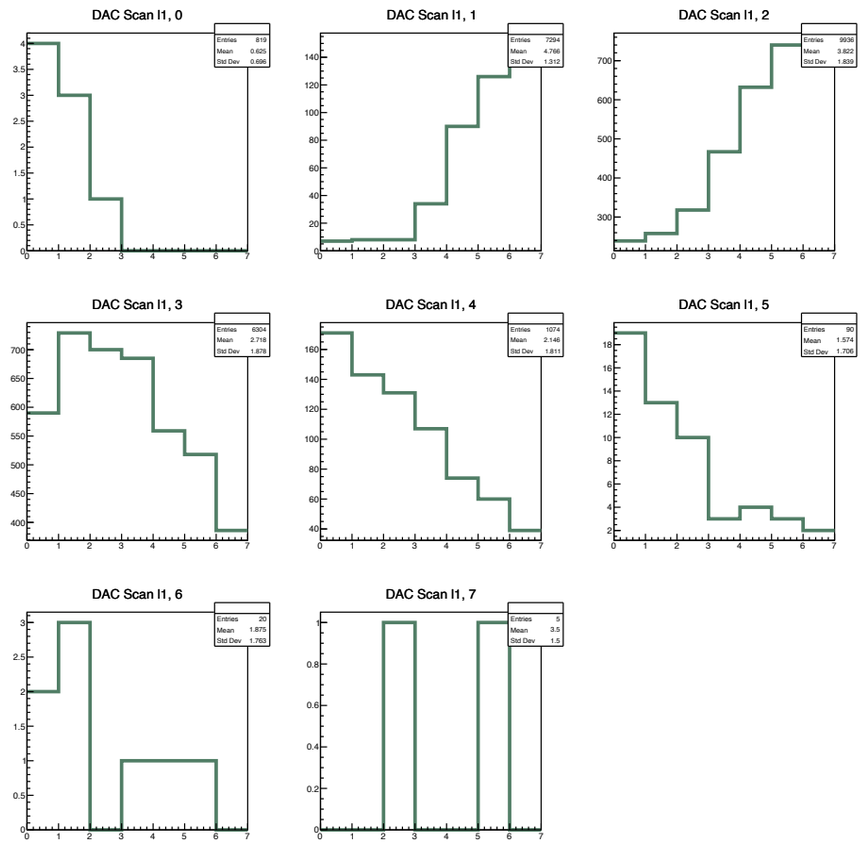
- Event profile has to be 111
- single hit for each layer only
- Clone groups in one INTT trigger event are deleted

run1	run2	run3	run4	run5	run6	run7	run8
8	28	48	68	88	108	128	148
12	32	52	72	92	112	132	152
16	36	56	76	96	116	136	156
20	40	60	80	100	120	140	160
24	44	64	84	104	124	144	164
28	48	68	88	108	128	148	168
32	52	72	92	112	132	152	172
36	56	76	96	116	136	156	176
40	60	80	100	120	140	160	180

With 8th bin, L0



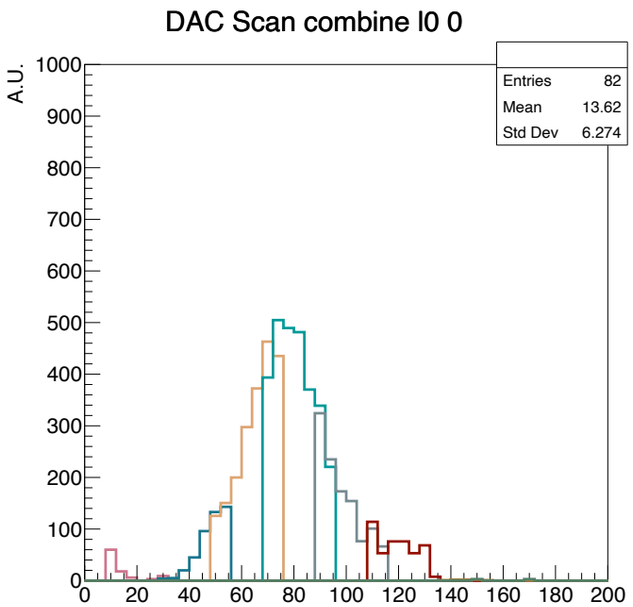
Without 8th bin, L0

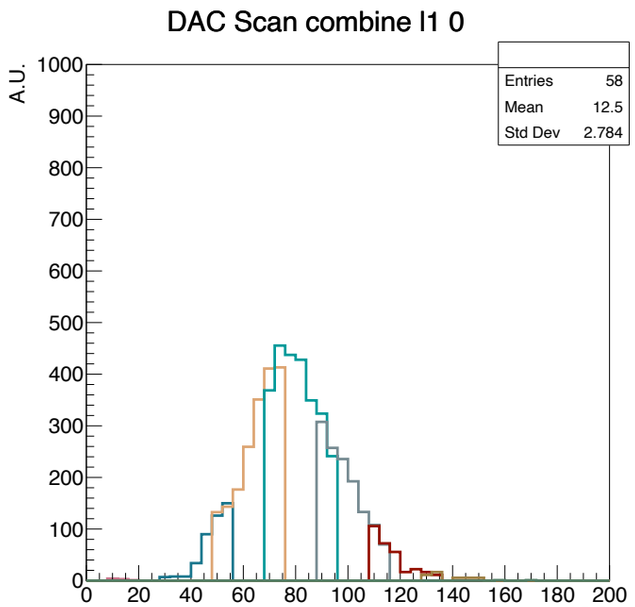


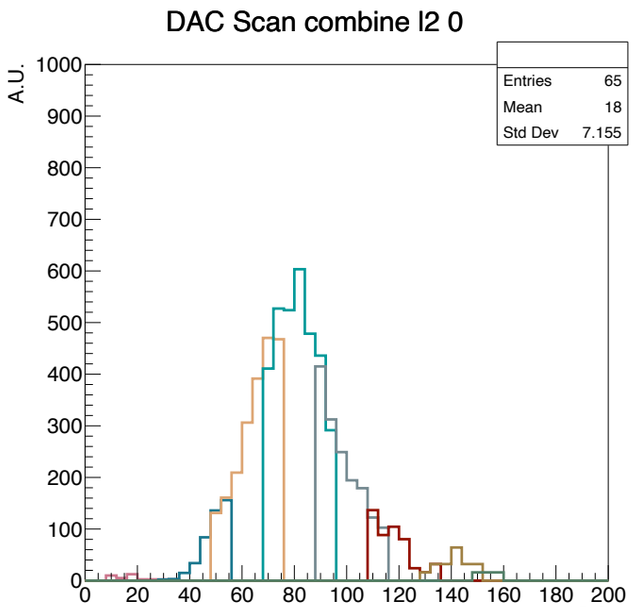
DAC scan

- Event profile has to be 111
- single hit for each layer only
- Clone groups in one INTT trigger event are deleted

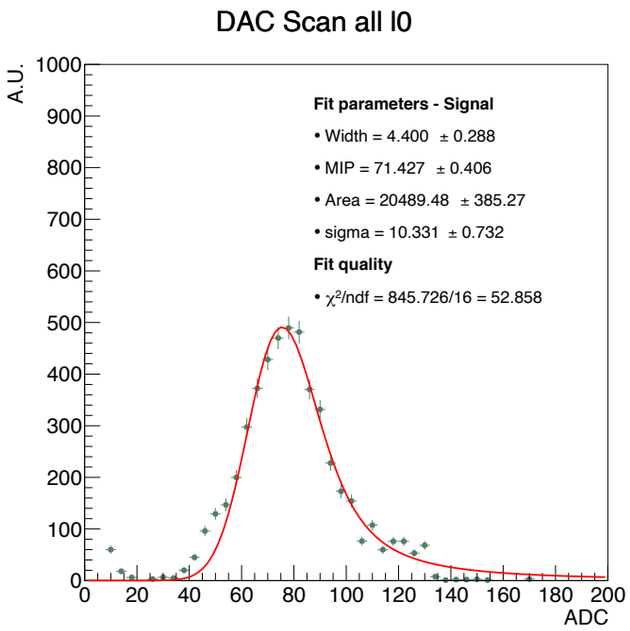
Histogram matching

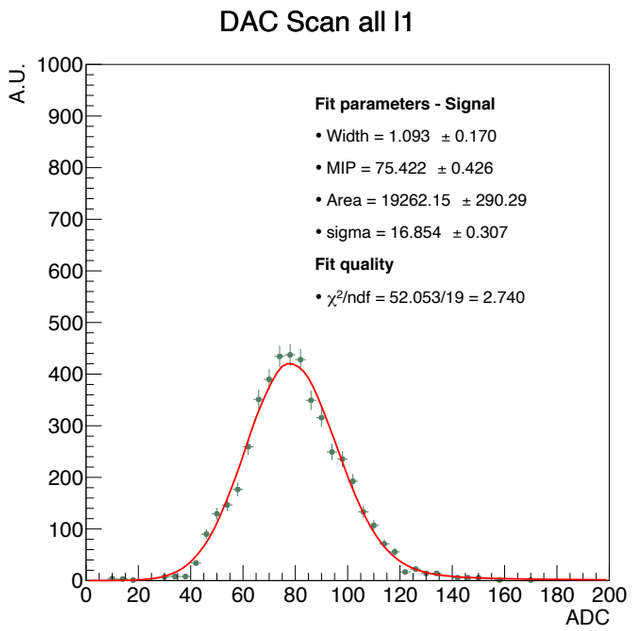


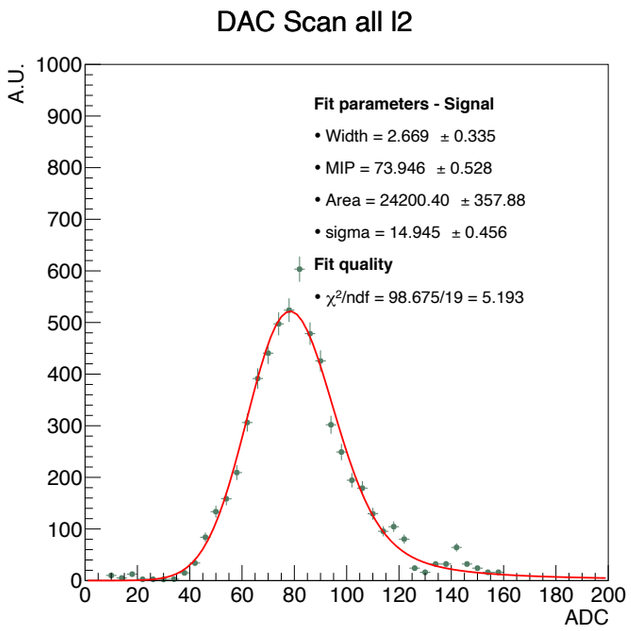




Fitting function : Landau convolute with Gaussian







To do

- Cross check with Genki
- Check the run with BEC

Back up

Production runs study

First BCO group is used

window size : 0.205 mm

energy weighted method : by adc setting, not mV setting

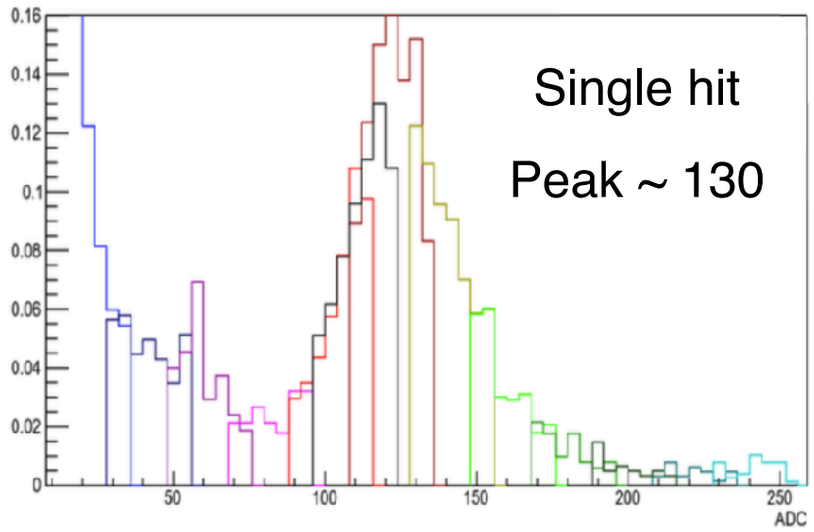
		taking time	note	I0 effi.	I1 effi.	I2 effi.	DSE	align_I	amount
52	BeamData_20211210-0302_0	25 mins	U9	99.648	99.403	98.641	0.08%	I1	0.2840
53	BeamData_20211210-0329_0	25 mins	U9	99.511	99.283	98.240	0.09%	I1	0.2825
54	BeamData_20211210-0427_0	30 mins	U9	99.632	99.492	98.794	0.04%	I1	0.2853
55	BeamData_20211210-0458_0	30 mins	U9	99.568	99.510	98.377	0.20%	I1	0.2840
57	BeamData_20211210-0609_0	31 mins	U10	99.349	99.321	98.292	0.06%	I1	0.2241
58	BeamData_20211210-0642_0	31 mins	U10	94.465	99.473	98.692	0.06%	I1	0.2225
88	BeamData_20211210-2018_0	30 mins	final	98.710	99.545	96.530	0.13%	I1	0.2827
89	BeamData_20211210-2043_0	30 mins	final	99.252	99.475	97.108	0.10%	I1	0.2846

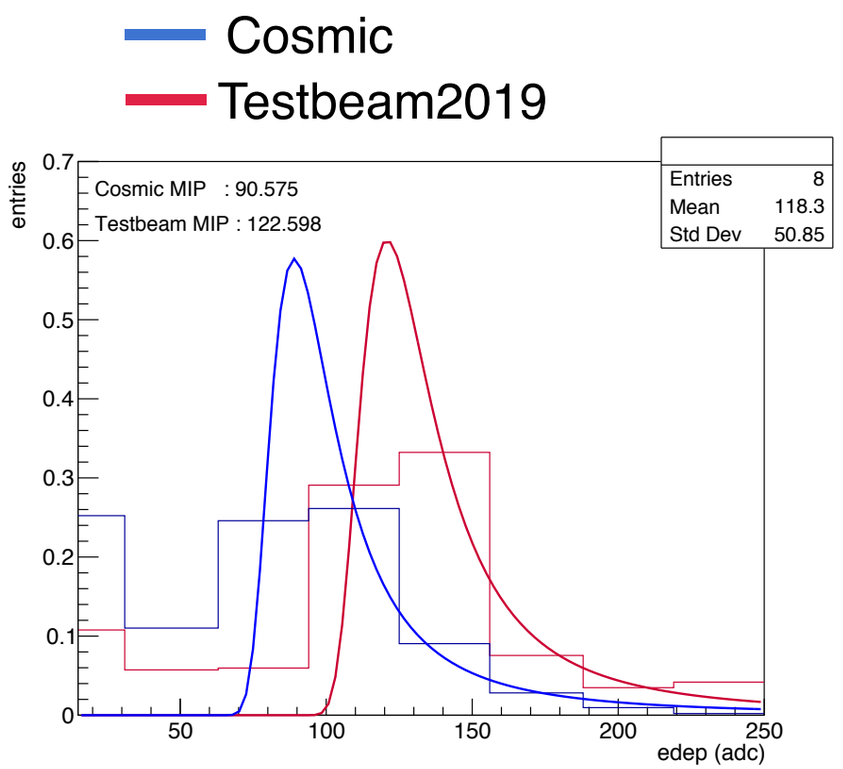
	adc0 L	adc0 R	adc1 L	adc1 R	adc2 L	adc2 R	adc3 L	adc3 R	tdc3 L	tdc3 R
52	-1	50	200	400	250	500			400	1200
53	-1	50	200	400	250	500			400	1200
54	-1	50	200	400	250	500			400	1200
55	-1	50	200	400	250	500			400	1200
57	-1	50	200	400	250	500			400	1200
58	-1	50	200	400	250	500			400	1200
88	75	300	100	350	250	500			400	1200
89	75	300	100	350	250	500			400	1200

		taking time	note	l0 effi.	l1 effi.	l2 effi.	amount
52	BeamData_20211210-0302_0	25 mins	L0	99.64789	0.10937	-0.14987	0.2840
			L1	99.40288	0.14314	-0.18207	
			L2	98.64064	0.21569	-0.25233	
53	BeamData_20211210-0329_0	25 mins	L0	99.51121	0.11721	-0.14914	0.2825
			L1	99.28285	0.14214	-0.17325	
			L2	98.24014	0.22140	-0.25053	
54	BeamData_20211210-0427_0	30 mins	L0	99.63225	0.10057	-0.13255	0.2853
			L1	99.49153	0.11855	-0.14982	
			L2	98.79383	0.18242	-0.21190	
55	BeamData_20211210-0458_0	30 mins	L0	99.56772	0.11023	-0.14249	0.2840
			L1	99.51037	0.11741	-0.14940	
			L2	98.37699	0.21302	-0.24241	
57	BeamData_20211210-0609_0	31 mins	L0	99.34900	0.13447	-0.16533	0.2241
			L1	99.32088	0.13735	-0.16813	
			L2	98.29180	0.21669	-0.24548	
58	BeamData_20211210-0642_0	31 mins	L0	94.46453	0.38255	-0.40819	0.2225
			L1	99.47276	0.12292	-0.15533	
			L2	98.69224	0.19330	-0.22372	
88	BeamData_20211210-2018_0	30 mins	L0	98.70968	0.28498	-0.35489	0.2827
			L1	99.54457	0.16781	-0.24444	
			L2	96.52997	0.46035	-0.52307	
89	BeamData_20211210-2043_0	30 mins	L0	99.25178	0.16552	-0.20651	0.2846
			L1	99.47507	0.13841	-0.18048	
			L2	97.10835	0.32092	-0.35737	

DAC scan - comparison

TestBeam2019

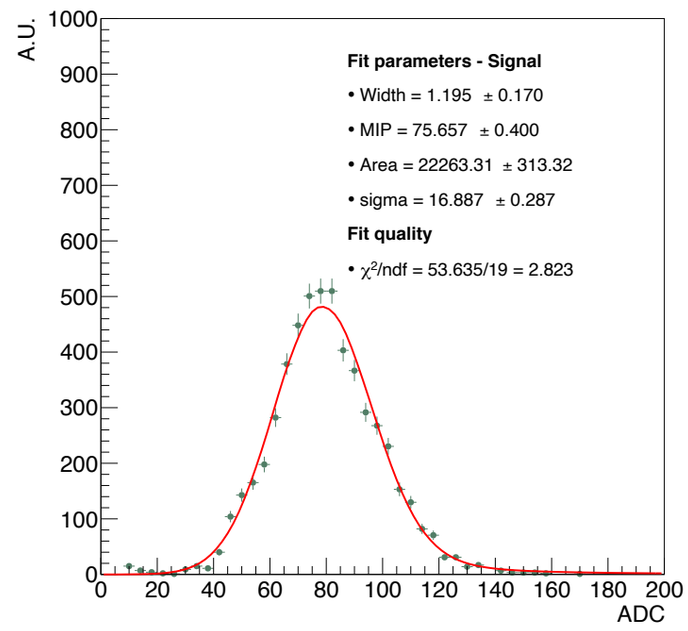




Cosmic MPV : 90.58

Testbeam : 122. 598

DAC Scan all I1



Bias voltage : 50V

MPV : 75.7