INTT progress report

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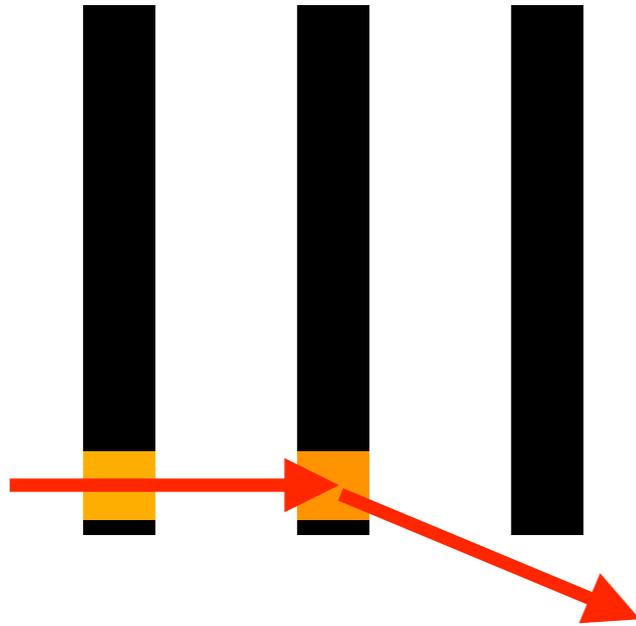
2022/3/25

Assembly status

- Ladder :
  - 28 ladders were assembled → 12 remaining.
- Module :
  - 23 modules were assembled → 2 remaining !!

- Lead time ~ 4/15

- Source test : almost done
  - 6 ladders were tested → have the plan to test 4 more ladders.

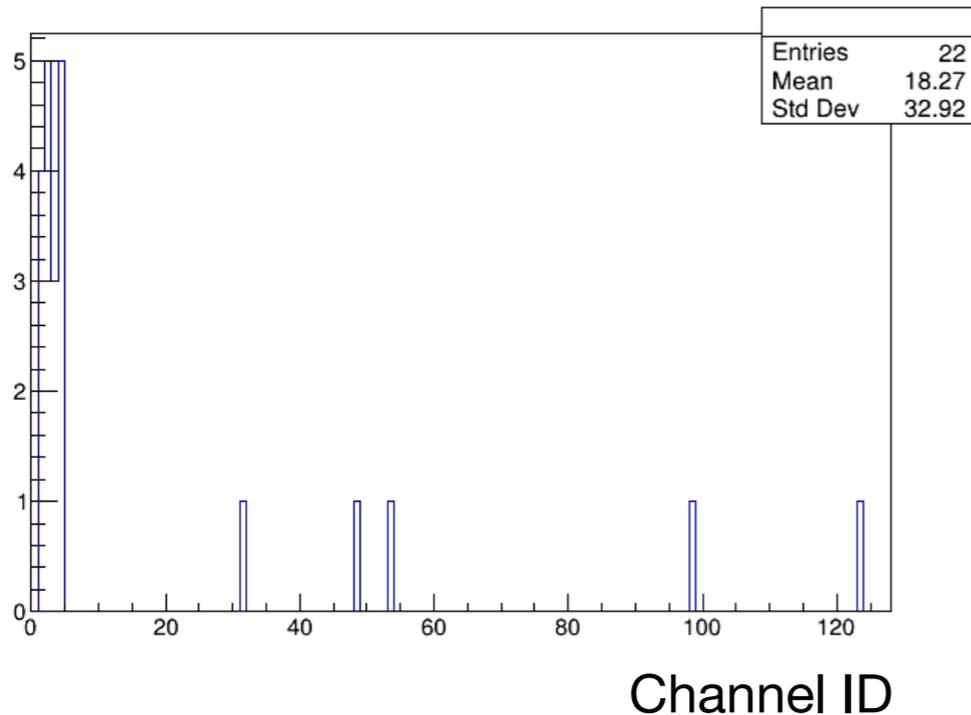# Testbeam - efficiency

The boundary cut was not applied before

The test for new boundary cut,
exclude chan_id <5 && chan_id >250

Use run 89 for the test

A. use all chips before
B. use all chips after
C. use chip10 only before
D. use chip10 only after
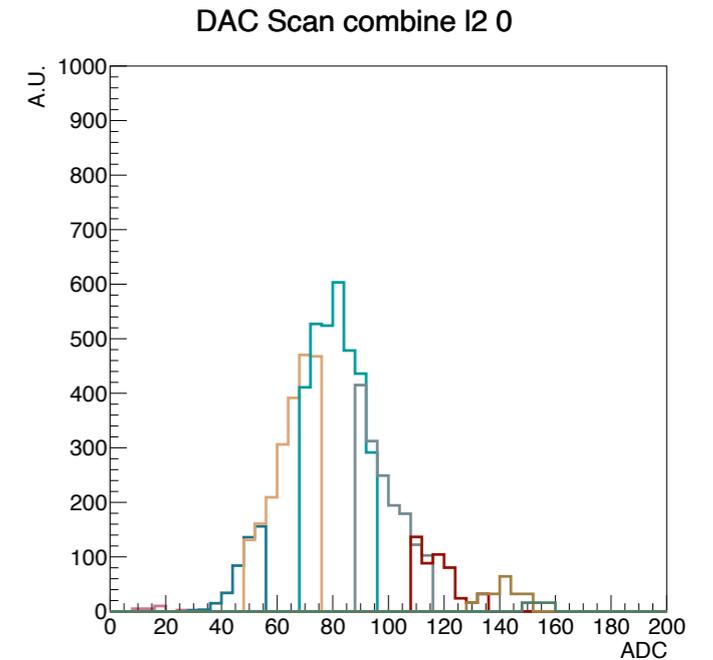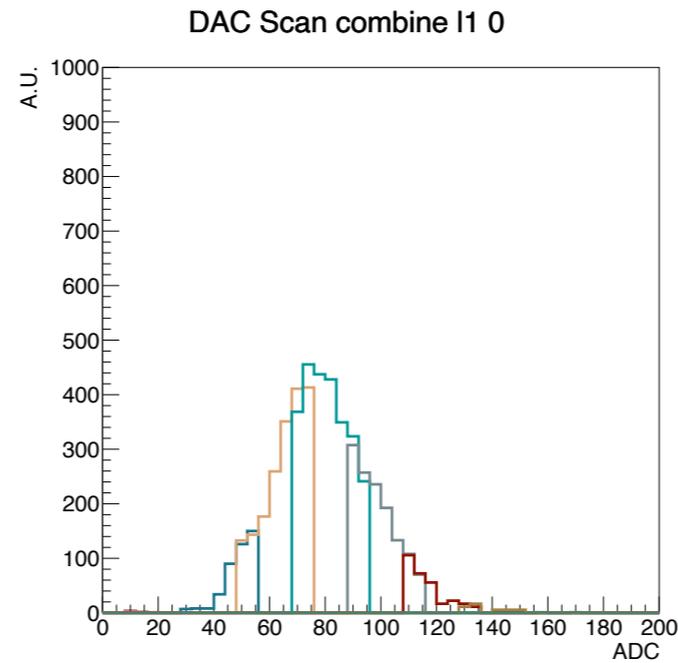
The average position of l0 & l1 of the "110" event

Entries	22
Mean	18.27
Std Dev	32.92

Channel ID

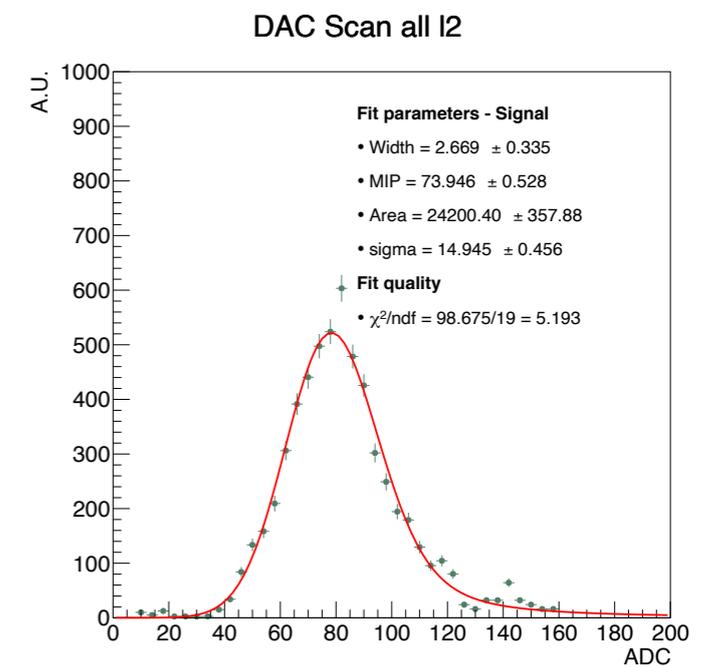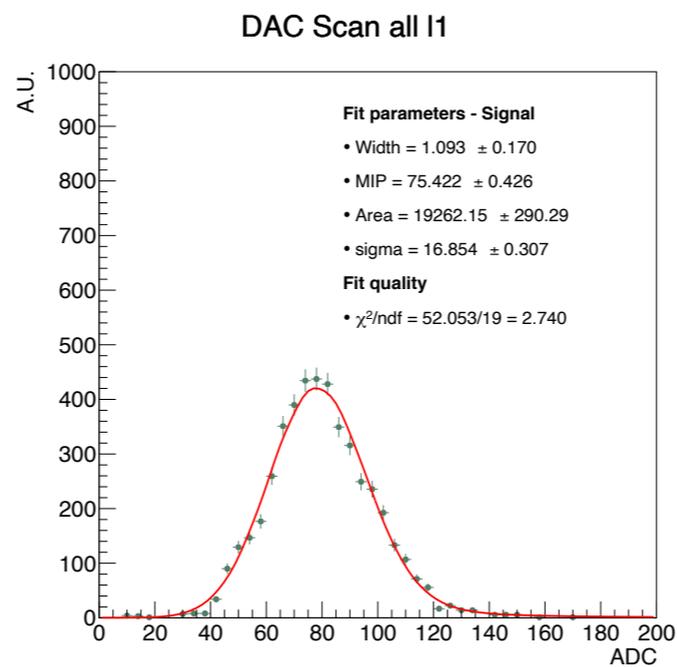| Case	effi. L0 (%)	effi. L1 (%)	effi. L2 (%)
A	$99.25^{+0.17}_{-0.21}$	$99.48^{+0.14}_{-0.18}$	$97.11^{+0.32}_{-0.36}$
B	$99.30^{+0.16}_{-0.21}$	$99.49^{+0.14}_{-0.18}$	$98.42^{+0.24}_{-0.28}$
C	$99.27^{+0.24}_{-0.33}$	$99.84^{+0.11}_{-0.21}$	$96.69^{+0.50}_{-0.58}$
D	$99.24^{+0.25}_{-0.35}$	$99.83^{+0.11}_{-0.22}$	$99.07^{+0.27}_{-0.37}$

Around 1 ~ 2% improvement !

DAC scan

Histogram matching

DAC Scan combine l0 0

DAC Scan combine l1 0

DAC Scan combine l2 0
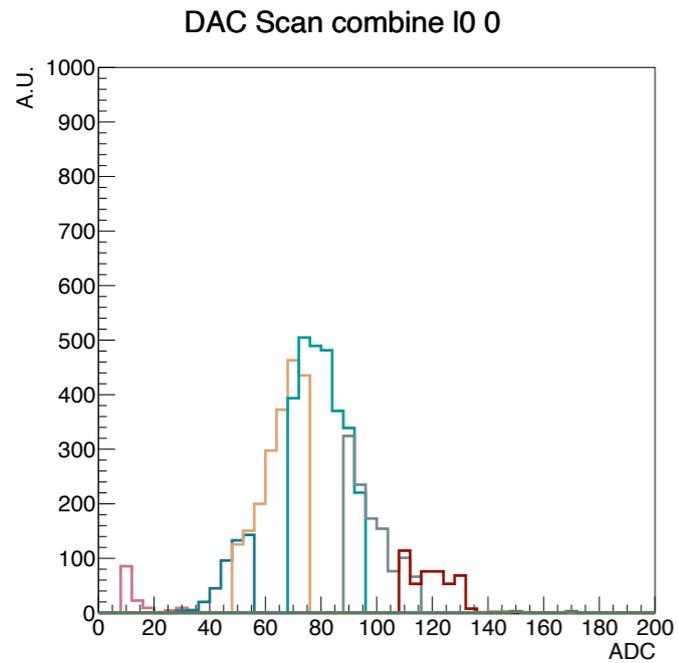
Fitting function : Landau convolute with Gaussian

DAC Scan all l0

Fit parameters - Signal
- Width = 4.400 ± 0.288
- MIP = 71.427 ± 0.406
- Area = 20489.48 ± 385.27
- sigma = 10.331 ± 0.732

Fit quality
- χ^2/ndf = 845.726/16 = 52.858

DAC Scan all l1

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

DAC Scan all l2

Fit parameters - Signal
- Width = 2.669 ± 0.335
- MIP = 73.946 ± 0.528
- Area = 24200.40 ± 357.88
- sigma = 14.945 ± 0.456

Fit quality
- χ^2/ndf = 98.675/19 = 5.193

DAC scan comparison

Based on the materials I found
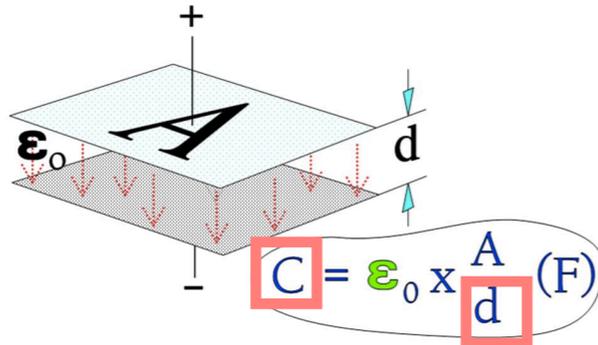
$$C = \varepsilon_0 \times \frac{A}{d} \ (F)$$

$$W = \sqrt{2\epsilon (V + V_{bi})/Ne} = \sqrt{2\rho\mu\epsilon(V + V_{bi})}$$

d

$$C = \sqrt{\frac{\varepsilon_0\varepsilon_r}{2\mu\rho|V|}} \cdot A$$

Based on the theory :
$$C \propto \frac{1}{d} \propto \frac{1}{\sqrt{V}} \propto \frac{1}{signal}$$

C : capacitance
d : the distance of the depletion region
V : supply bias voltage
signal : edep

$$\frac{dE/dx \cdot d}{I_0} = \frac{3.87 \cdot 10^6 \, eV/cm \cdot 0.03 \, cm}{3.62 \, eV} \approx 3.2 \cdot 10^4 \, e^- h^+ - pairs$$
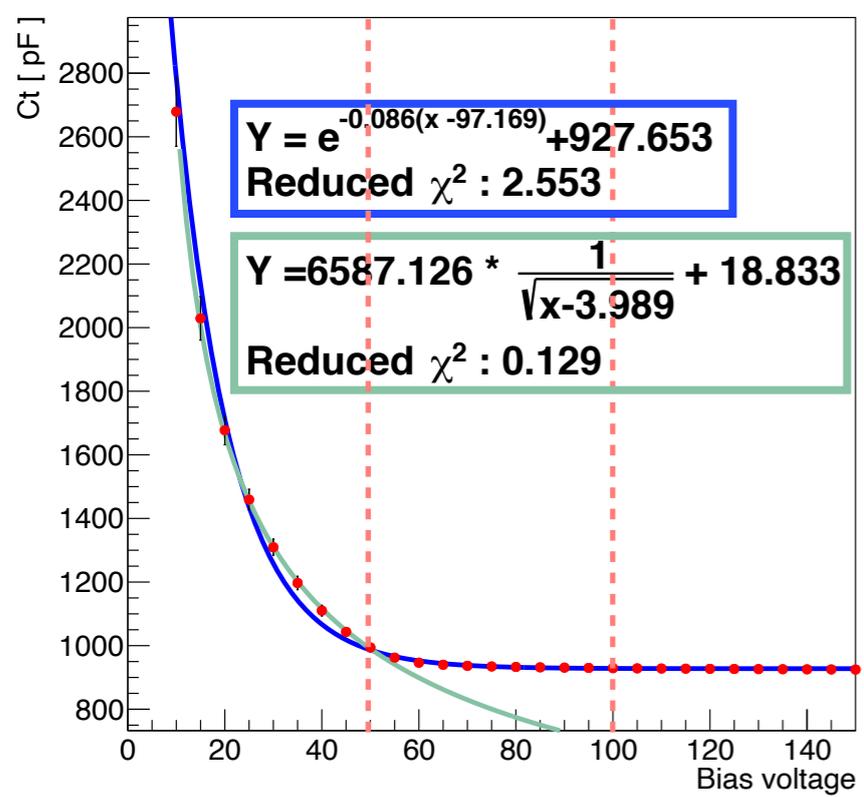
Signal

DAC scan comparison

Based on the theory :

$$C \propto \frac{1}{d} \propto \frac{1}{\sqrt{V}} \propto \frac{1}{signal}$$

C : capacitance
d : the distance of the depletion region
V : supply bias voltage
signal : edep

Verify capacitance vs voltage

INTT Type-A sensor, CV curve

$Y = e^{-0.086(x\ -97.169)}+927.653$
Reduced χ^2 : 2.553

$Y =6587.126 * \dfrac{1}{\sqrt{x-3.989}} + 18.833$
Reduced χ^2 : 0.129

Ct [pF] (y-axis): 800, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2600, 2800
Bias voltage (x-axis): 0, 20, 40, 60, 80, 100, 120, 140

	@24.35 V	@ 50 V	@ 100 V
Type A, Ct [pF]	1465.42	994.149	929.325

$$\frac{1}{\sqrt{50}}\bigg/\frac{1}{\sqrt{24.35}} = \boxed{0.697} \qquad \frac{C@50V}{C@25.34V} = \frac{994.149}{1465.42} = \boxed{0.678} \ \checkmark$$

- -

$$\frac{1}{\sqrt{100}}\bigg/\frac{1}{\sqrt{50}} = \boxed{0.707} \qquad \frac{C@100V}{C@50V} = \frac{929.325}{994.149} = \boxed{0.934} \ \times$$

For the case of INTT, $C \propto \dfrac{1}{\sqrt{V}}$ seems to be suitable to describe the data only for the range 0 V to 50 V
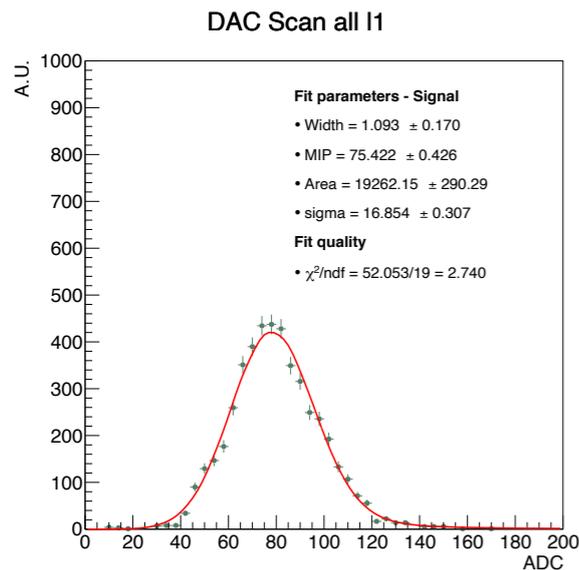
DAC scan comparison

Based on the theory :
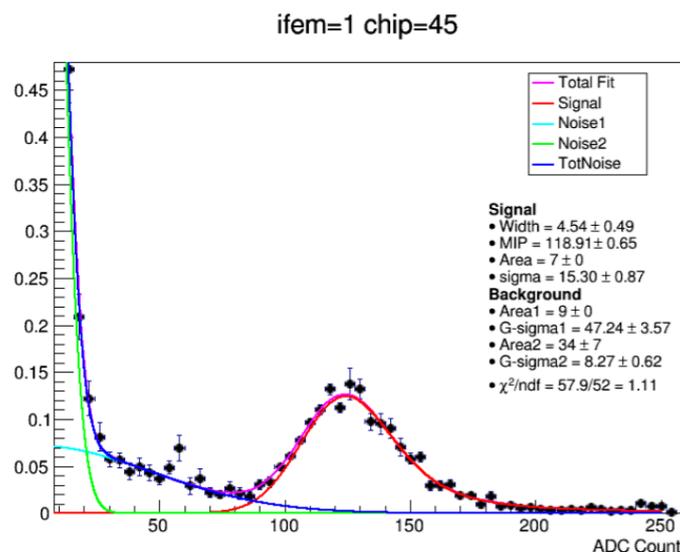$$C \propto \frac{1}{d} \propto \frac{1}{\sqrt{V}} \propto \frac{1}{signal}$$

C : capacitance
d : the distance of the depletion region
V : supply bias voltage
signal : edep

Verify edep vs voltage (V) and capacitance (C)

DAC Scan all l1

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

Compare $\dfrac{1}{\sqrt{V}}$ and $\dfrac{1}{signal}$ →

$$\frac{1}{\sqrt{100}} \Big/ \frac{1}{\sqrt{50}} = 0.707$$

$$\frac{(\frac{1}{edep@100})}{(\frac{1}{edep@50})} = 0.634$$

✔️

ifem=1 chip=45

- Total Fit
- Signal
- Noise1
- Noise2
- TotNoise

Signal
- Width = 4.54 ± 0.49
- MIP = 118.91 ± 0.65
- Area = 7 ± 0
- sigma = 15.30 ± 0.87

Background
- Area1 = 9 ± 0
- G-sigma1 = 47.24 ± 3.57
- Area2 = 34 ± 7
- G-sigma2 = 8.27 ± 0.62
- χ^2/ndf = 57.9/52 = 1.11

Compare "C" and $\dfrac{1}{signal}$ →

$$\frac{C@100V}{C@50V} = \frac{929.325}{994.149} = 0.934$$

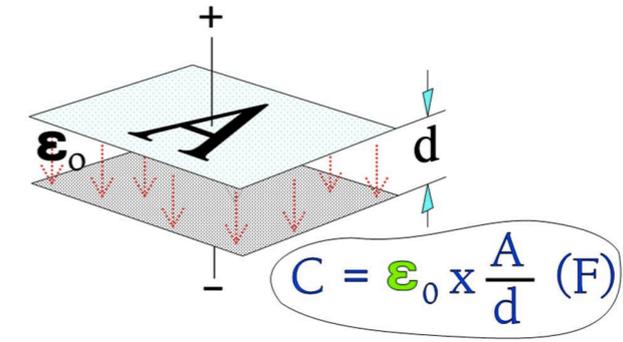$$\frac{(\frac{1}{edep@100})}{(\frac{1}{edep@50})} = 0.634$$

❌

Summary

- We are gonna about to finish the ladder assembly

- By adding the boundary cut, the efficiency of l2 improved by the amount 1 ~ 2 %

- For the case of INTT, $C \propto \dfrac{1}{\sqrt{V}}$ seems to be suitable to describe the data only for the range 0 V to 50 V.

- The bias voltage in the Testbeam2021 seems to be smaller than 50 V.
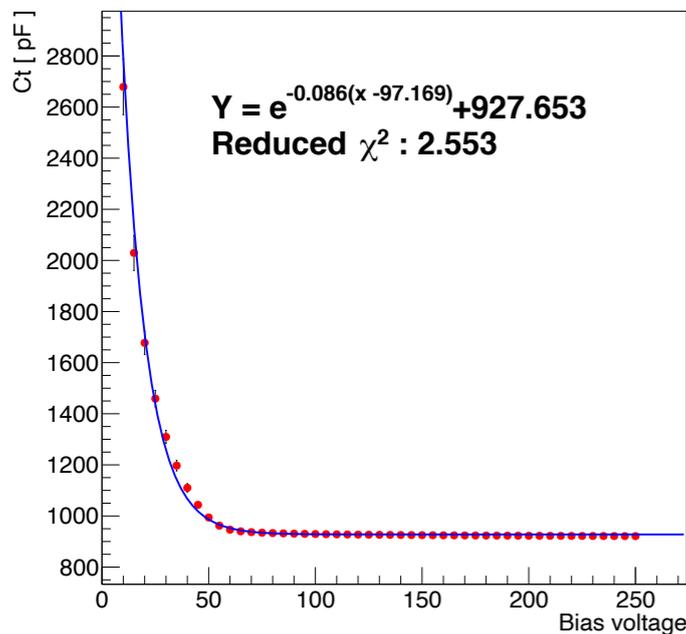
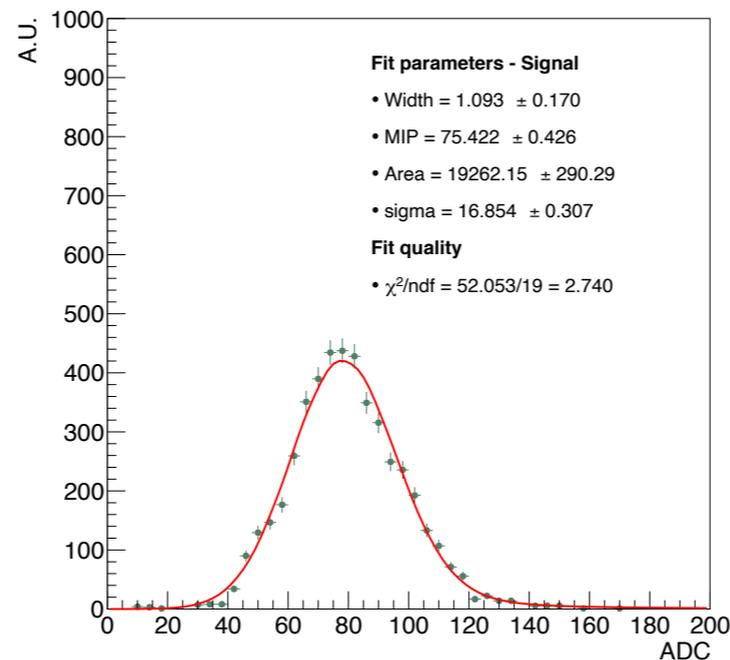# Back up

DAC scan

- Based on 148 sets of sensors

$$C = \varepsilon_0 \times \frac{A}{d} \quad (F)$$

	@24.35 V (from fit)	@ 50 V	@ 100 V	ratio (24.35 V/100 V)	ratio (50 V/100 V)
Type A, Ct [pF]	1465.42	994.149 ± 9.453	929.325 ± 1.613	1.577	1.069 ± 0.0128
Type B, Ct [pF]		774.764 ± 7.547	723.023 ± 1.362		1.071 ± 0.0128
Testbeam, edep		75.422 ± 0.426	118.91 ± 0.65		1.577 ± 0.017

INTT Type-A sensor, CV curve

$$Y = e^{-0.086(x - 97.169)} + 927.653$$
Reduced χ^2 : 2.553

DAC Scan all l1

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ifem=1 chip=45

— Total Fit
— Signal
— Noise1
— Noise2
— TotNoise

Signal
- Width = 4.54 ± 0.49
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Background
- Area1 = 9 ± 0
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- χ^2/ndf = 57.9/52 = 1.11
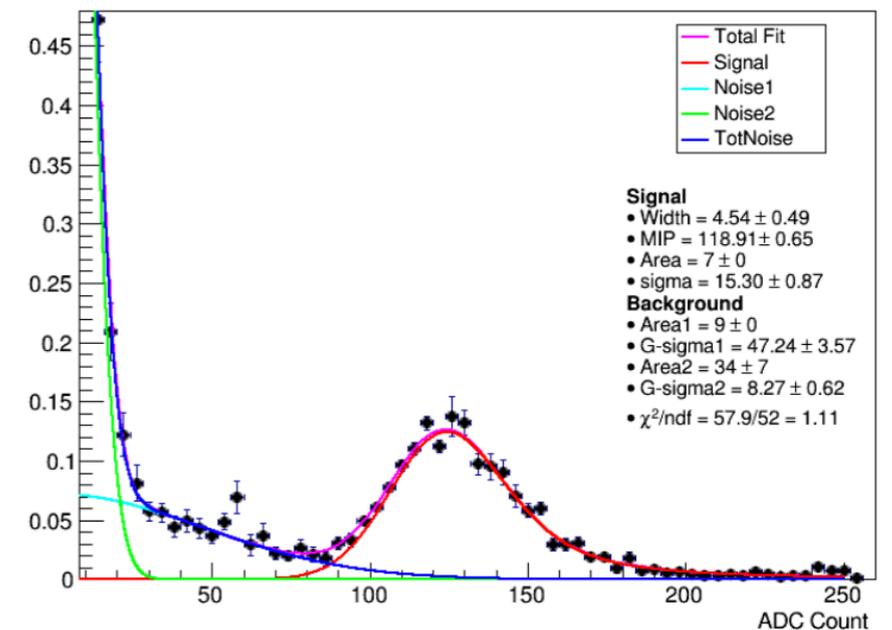
MIP of Testbeam2019 is based on the link

DAC scan

Previous results, 2020/06/19

chip_id=14

chip_id=15

chip_id=16
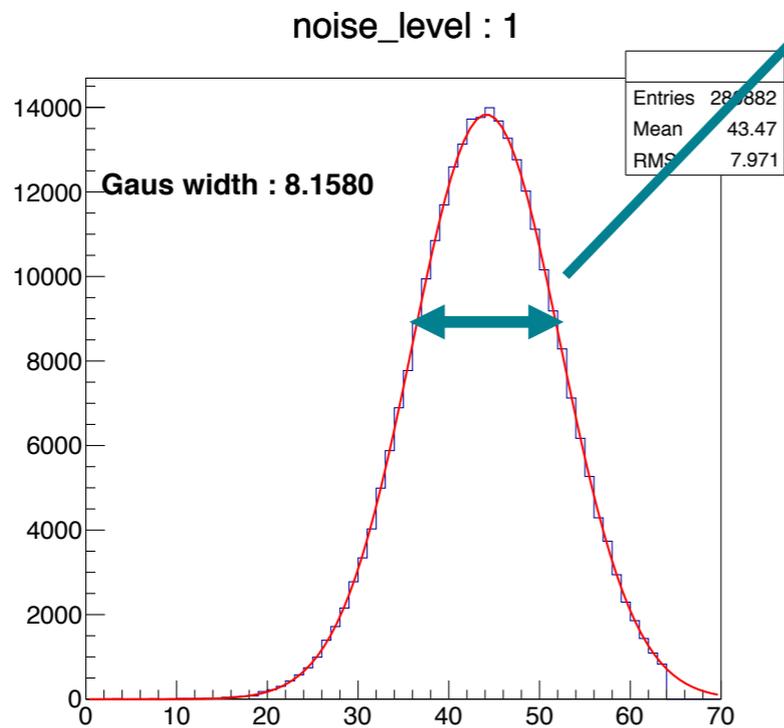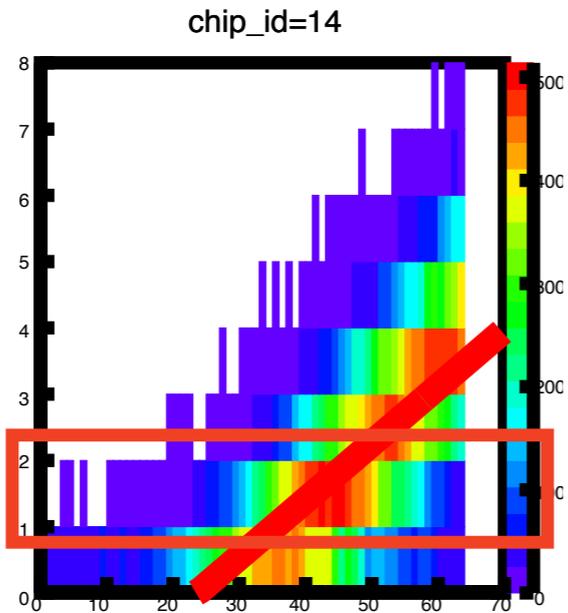
pre-Production-002, gaus_width to V

noise_level : 1

Entries	280882
Mean	43.47
RMS	7.971

Gaus width : 8.1580

No.1148 Chip19

Bottom readout pads

C-V plot from Kai Yu

gaus_width

voltage (V)
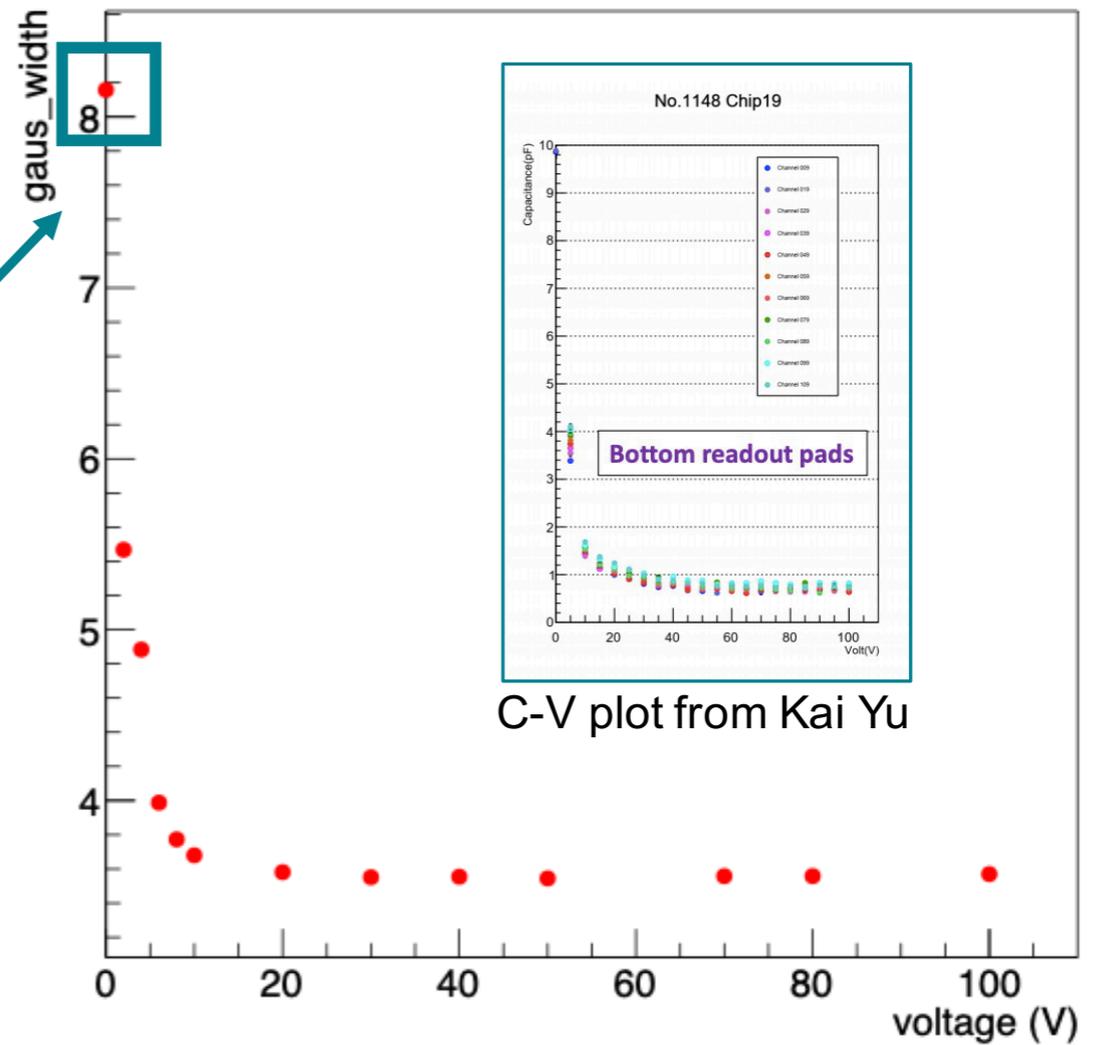
The raw number of the run89


```
run 89
run file : BeamData_20211210-2043_0_filter // note : below : use all chips, NO boundary cut.
layer 3 final counting :
 N_HHH : 2653
 N_LHH : 20
 N_HLH : 14
 N_HHL : 79
 N_LLL : 795
=====3-layers=====efficiency results==========
99.25178    +0.16552    -0.20651
99.47507    +0.13841    -0.18048
97.10835    +0.32092    -0.35737
=====3-layers=====efficiency results==========


run file : BeamData_20211210-2043_0_filter  // note : below : use all chips, add the boundary cut.
layer 3 final counting :
 N_HHH : 2552
 N_LHH : 18
 N_HLH : 13
 N_HHL : 41
 N_LLL : 680
=====3-layers=====efficiency results==========
99.29961    +0.16320    -0.20610
99.49318    +0.13856    -0.18251
98.41882    +0.24454    -0.28482
=====3-layers=====efficiency results==========
```

```
run file : BeamData_20211210-2043_0_filter // note : only chip10 or chip23. with l0 correction -0.2825. NO boundary cut.
layer 3 final counting :
 N_HHH : 1227
 N_LHH : 9
 N_HLH : 2
 N_HHL : 42
 N_LLL : 283
=====3-layers=====efficiency results==========
99.27184    +0.23776    -0.33078
99.83727    +0.10510    -0.21423
96.69031    +0.50257    -0.58190
=====3-layers=====efficiency results==========


run file : BeamData_20211210-2043_0_filter // note : only chip10 or chip23. with l0 correction -0.2825. add boundary cut.
layer 3 final counting :
 N_HHH : 1175
 N_LHH : 9
 N_HLH : 2
 N_HHL : 11
 N_LLL : 243
=====3-layers=====efficiency results==========
99.23986    +0.24818    -0.34522
99.83008    +0.10975    -0.22368
99.07251    +0.27472    -0.36997
=====3-layers=====efficiency results==========
```