Bias Voltage Dependence of the MIP Peak Position

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My Diploma thesis
Bias voltage dependence of the MIP peak position

Motivation

- The MIP peak appeared around ADC=71 in the 3rd beam test with bias voltage=50V.

- While in Run24 pp collisions, it was 100V.

- Although the beam type and energy differed, both are considered almost MIP.

- The MIP peak positions appeared 30% difference between two measurements.

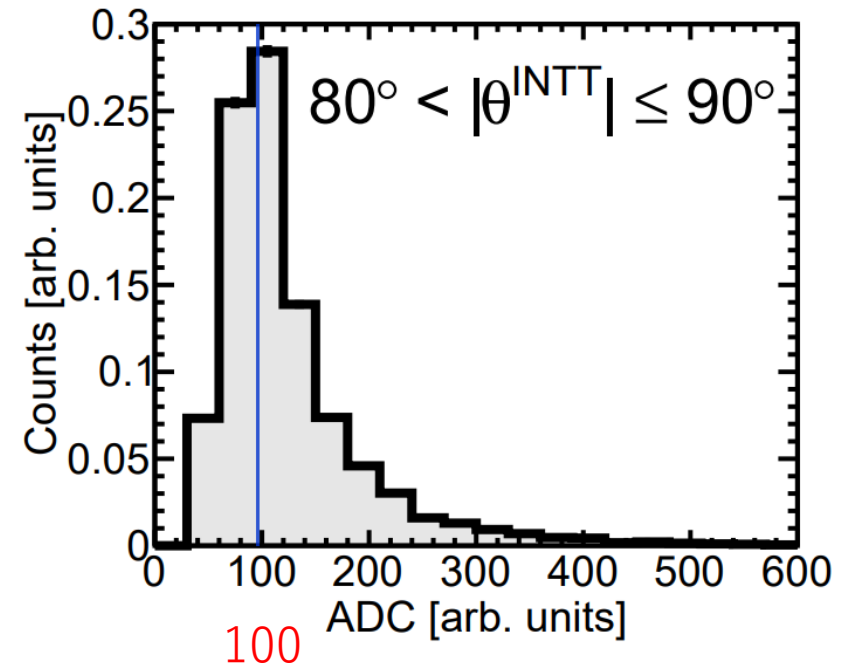- The study is to check the Bias voltage dependence of the MIP peak position.

Testbeam2021, 50 V
Positron beam, 1 GeV

Landau_MPV: 71.13±0.43
χ^2 / ndf: 34.77 / 25

— Total Fit
--- Signal
··· Noise

noise ratio: 0.3%

71
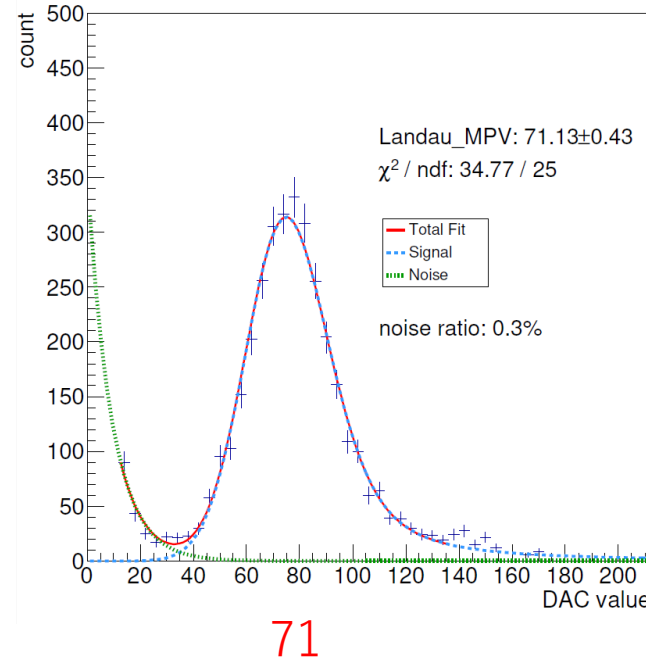
Analysis by Sugiyama(NWU)

(NWU)杉山由佳,202402,RHIC-sPHENIX 実験の初年度の
データを用いた中間飛跡検出器INTTの動作検証より

sPHENIX Preliminary Run-24, 100 V
Proton-Proton collision at 200 GeV

$80° < |\theta^{INTT}| \leq 90°$

100

https://www.sphenix.bnl.gov/sites/default/files
/2024-10/sphenix-perf-9-24-
mip_50889_multi_panel_preliminary.pdf

Run with various bias voltage

- Bias voltage scan was conducted in Run24 Au+Au collision.
- A pair of special runs were taken for bias voltages at 50V, 75V, 100V.

Date/Time	Run#	Run Type	Mag	Bias voltage
2024/10/16 1:11	54679	beam	on	50V
2024/10/16 1:41	54681	beam	on	75V
2024/10/16 2:05	54685	beam	on	100V
2024/10/16 2:19	54686	beam	on	50V
2024/10/16 2:30	54687	beam	on	75V
2024/10/16 2:46	54688	beam	on	100V

ADC	0	1	2	3	4	5	6	7
DAC	35-45	45-60	60-90	90-120	120-150	150-180	180-210	210-

Details of data

ADC	0	1	2	3	4	5	6	7
DAC	35-45	45-60	60-90	90-120	120-150	150-180	180-210	210-

Run#	Run Type	Mag	Link	Duration (min)	Event	MBD-NS	Active Felix List	DAC 0	L1 Delay	n_coll	open time	Modebit	Comments
54688	beam	On		10min			All Felix	35	114	100	60	intt_triggermode	HV scan HV=100V

- The run described slide 3 were processed as follows

(The initial process with Fun4All were handled by Genki)

-Excluding hot channel by the hot channel of Run 50377.

-Clustering was done.

-10k events were analyzed.

-Vertex was reconstructed by using InttXYVertexFinder and InttZVertexFinder in the coresoftware repository.

-**Note** : The run was taken in the local mode so MBD data is not available.

- The cluster ADC histogram was filled from 0 to 900 and was divided into 30 bins.
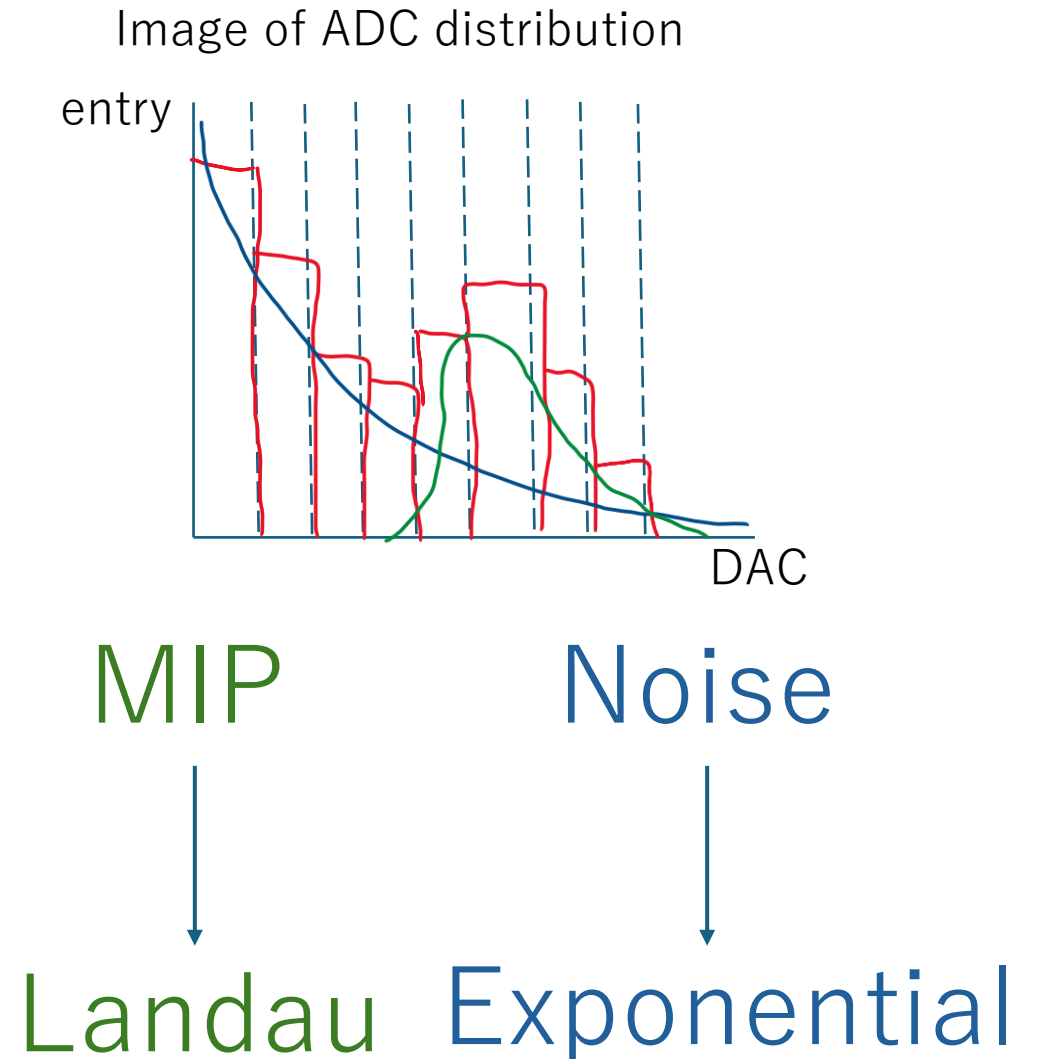

ADC_distribution
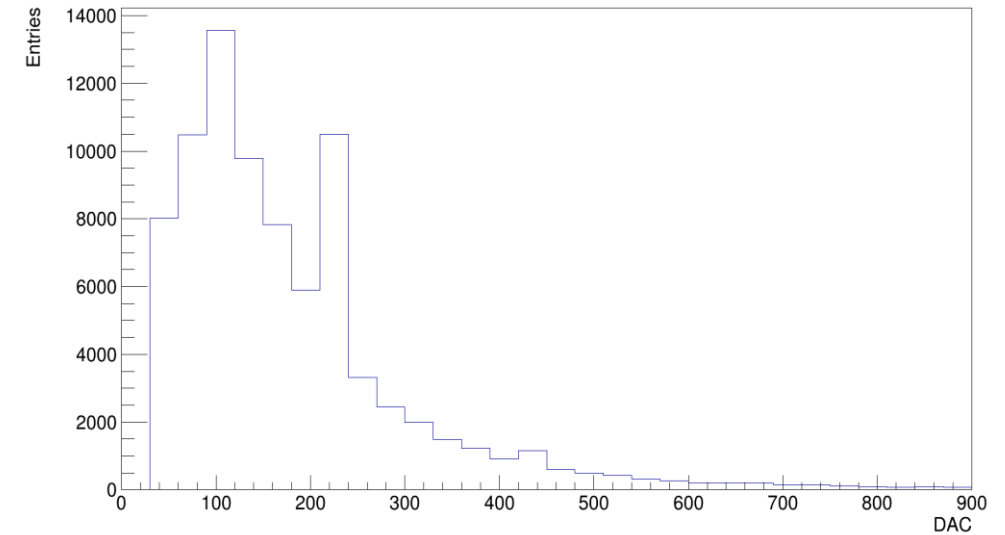
To do
- Modification for peaks at DAC=210(ADC7)
- Compare MIP peaks across different bias voltages

Determination of the MIP position by fitting

- The ADC distribution assumed to have MIP and noise components.
- So I use the following function. A sum of **Landau** distribution and an **exponential** function.

$$f(x) = \underline{A_1} \cdot Landau(x, \underline{MPV}, \underline{sigma}) + \underline{A_2} \cdot e^{-\frac{x}{\underline{tau}}}$$

Note : I decide these parameter by fitting.

Image of ADC distribution

entry

DAC

MIP → Landau

Noise → Exponential

ADC7peak cut

- Due to the FPHX chip's specification, hits with DAC value 210 or more are assigned to 210. So I cut two- thirds of single-hit clusters.

    →See the reference for more details

    ([1] M.Hata, 2024. [2] G.Nukazuka, 2024).

- Process DAC value 420(cut 8/9 double-hit clusters) same as 210.

- Better handling of the ADC overflow bin is under consideration.
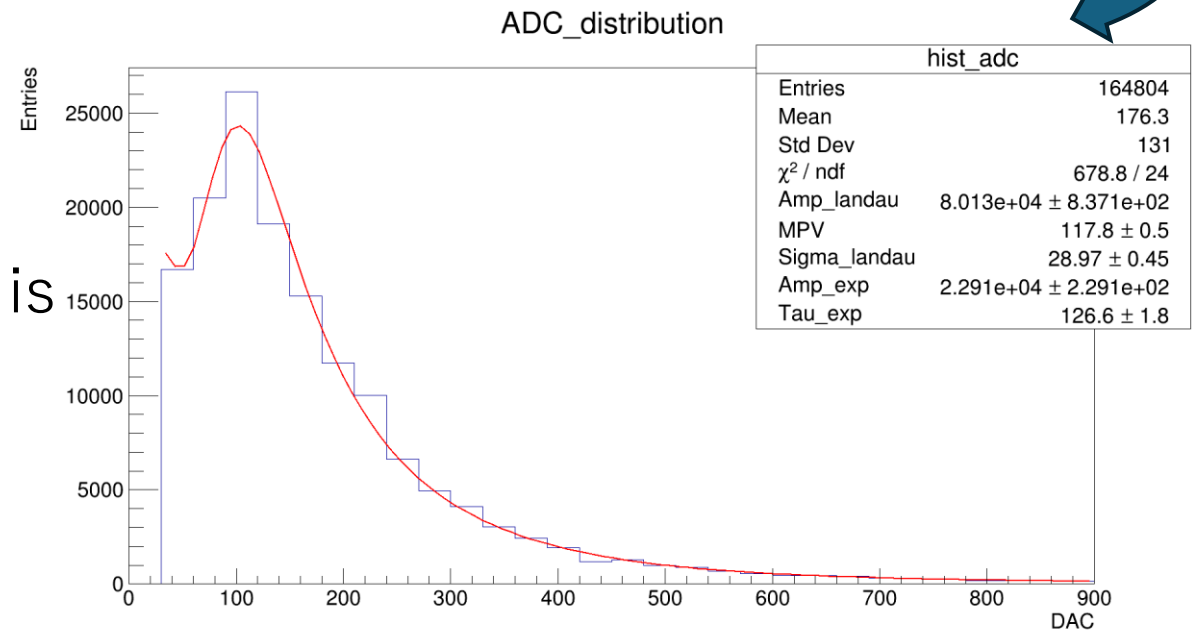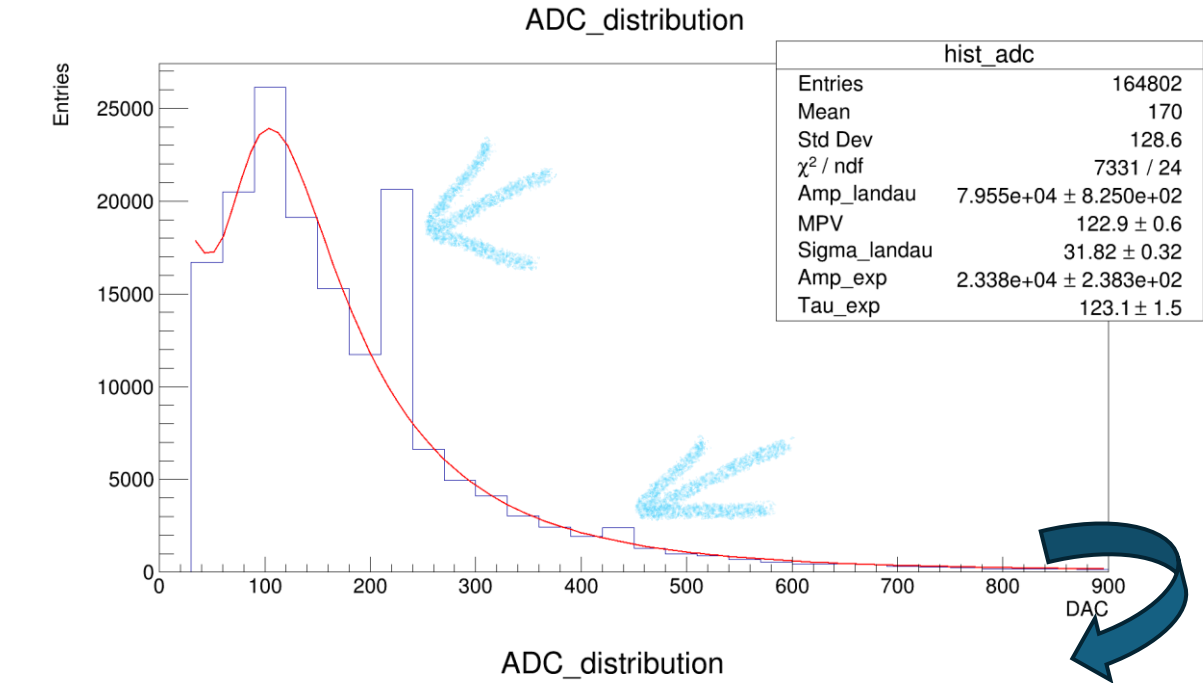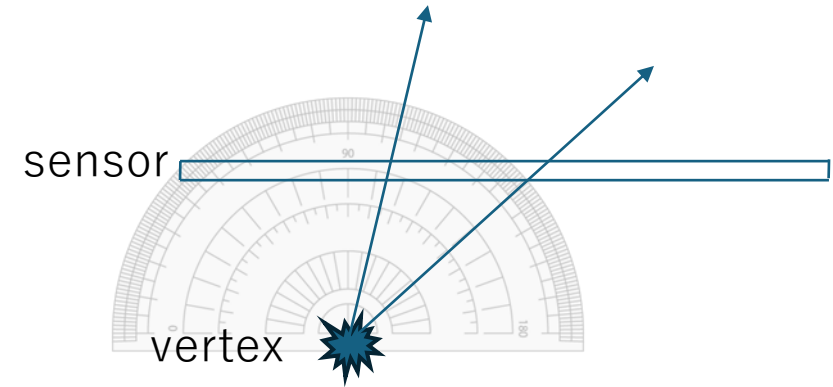
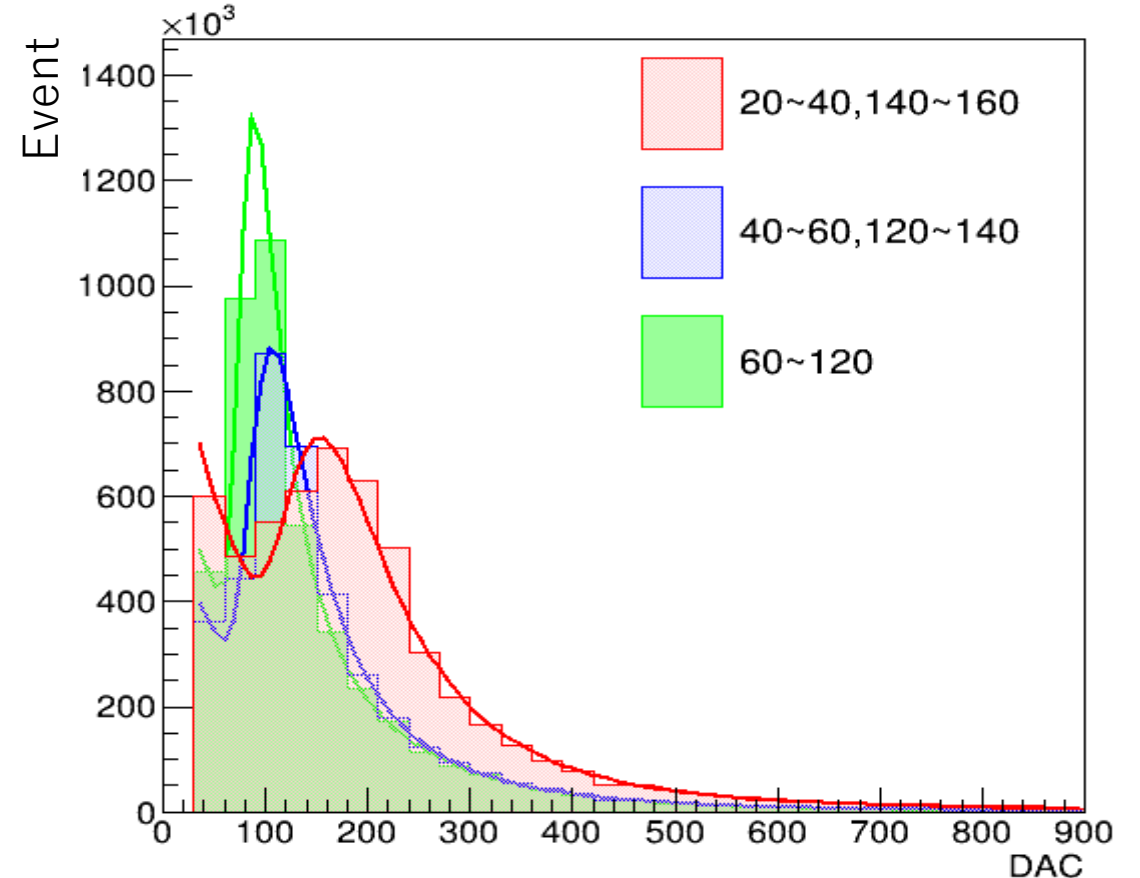# ADC distribution with theta

- Theta is polar angle of cluster in polar coordinate

- The MIP peak position moves to higher as lower theta region is selected.

- In this analysis, angular range is limited to simplify the case.
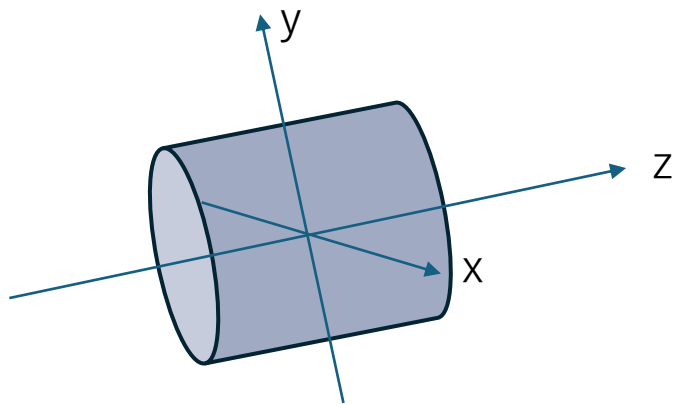
$\vec{z}$:beam direction
$\vec{y}$: vertical direction
$\vec{x} \equiv \vec{y} \times \vec{z}$.
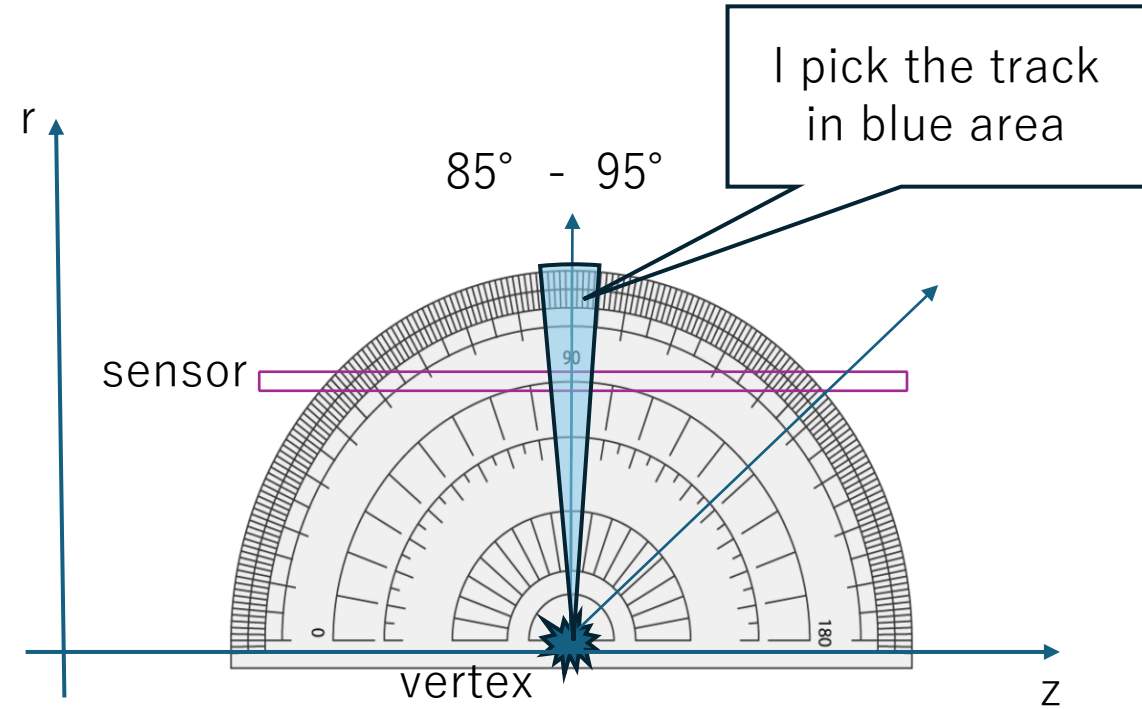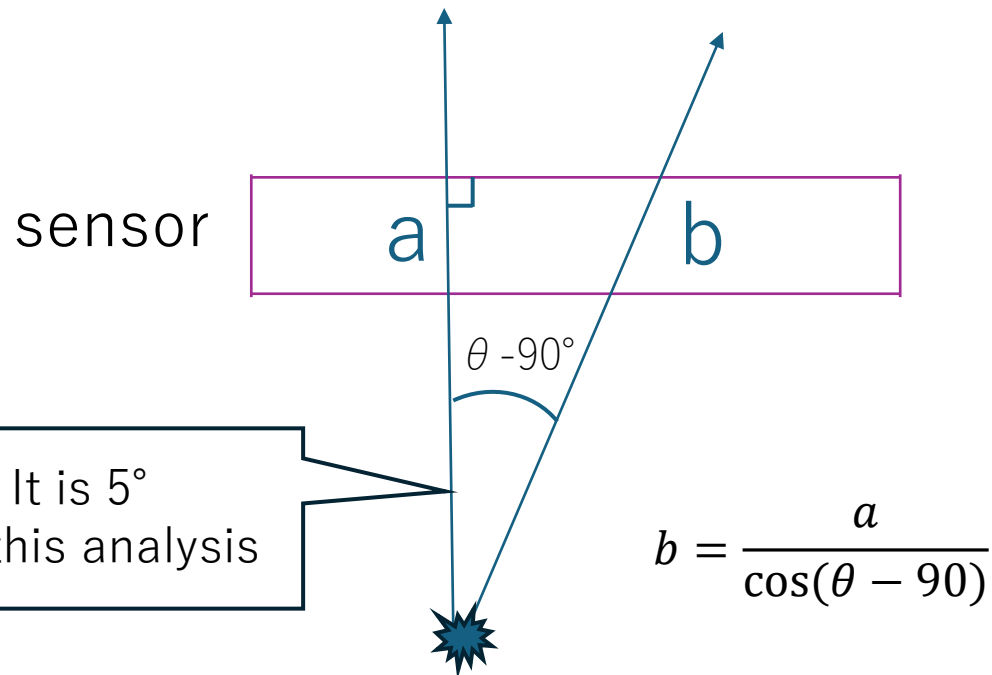θ, ϕ: polar coordinate polar and azimuthal angles

ADC_distribution

Legend:
- 20~40,140~160
- 40~60,120~140
- 60~120

θ range selection

- Examining the cluster made by the track incident in vertical.

- θ region of 90° ±5° was selected for analysis.

- MIP peak position will have fluctuation up to 0.4%

r

85° - 95°

I pick the track in blue area

sensor

90

0

180

vertex

z

sensor

a   b

θ -90°

It is 5°
in this analysis
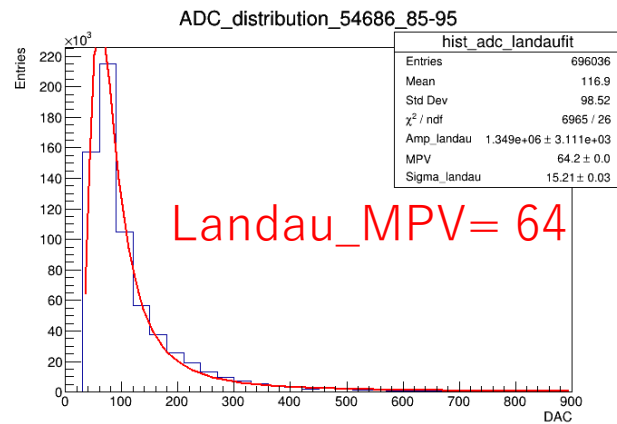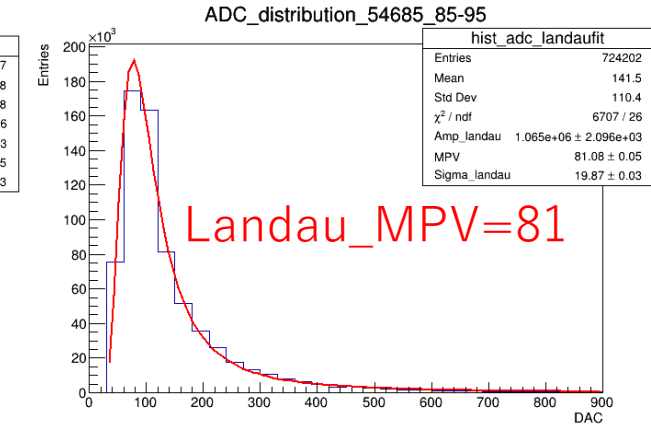
$$b = \frac{a}{\cos(\theta - 90)}$$

MIP peak each bias voltage
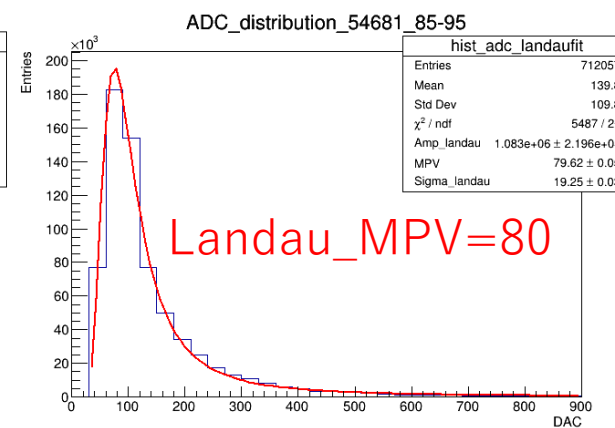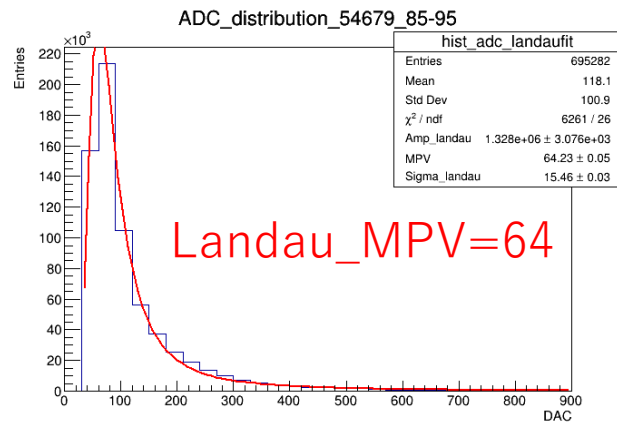
- Fitting with only **landau** for each bias voltage.
- Cluster ADC distribution for each run is shown with their fitting line.
- The red number written in the graph is MPV with no error.

Bias Voltage	50V	75V	100V

- MIP peak position are different by each bias.
- Peak position especially depend on the first bin at 75V and 100V
- Chi square is too big(about 6000).
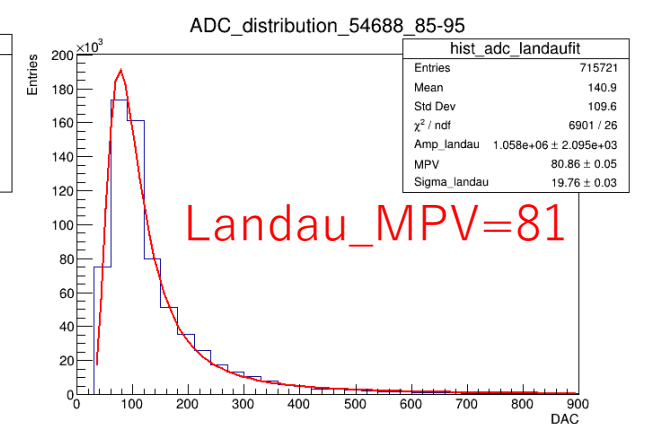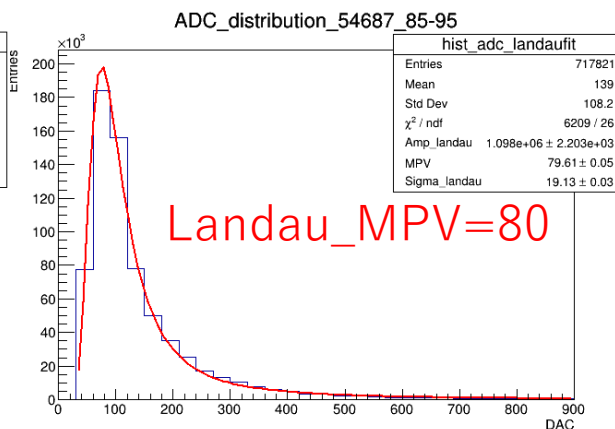
MIP peak each bias voltage
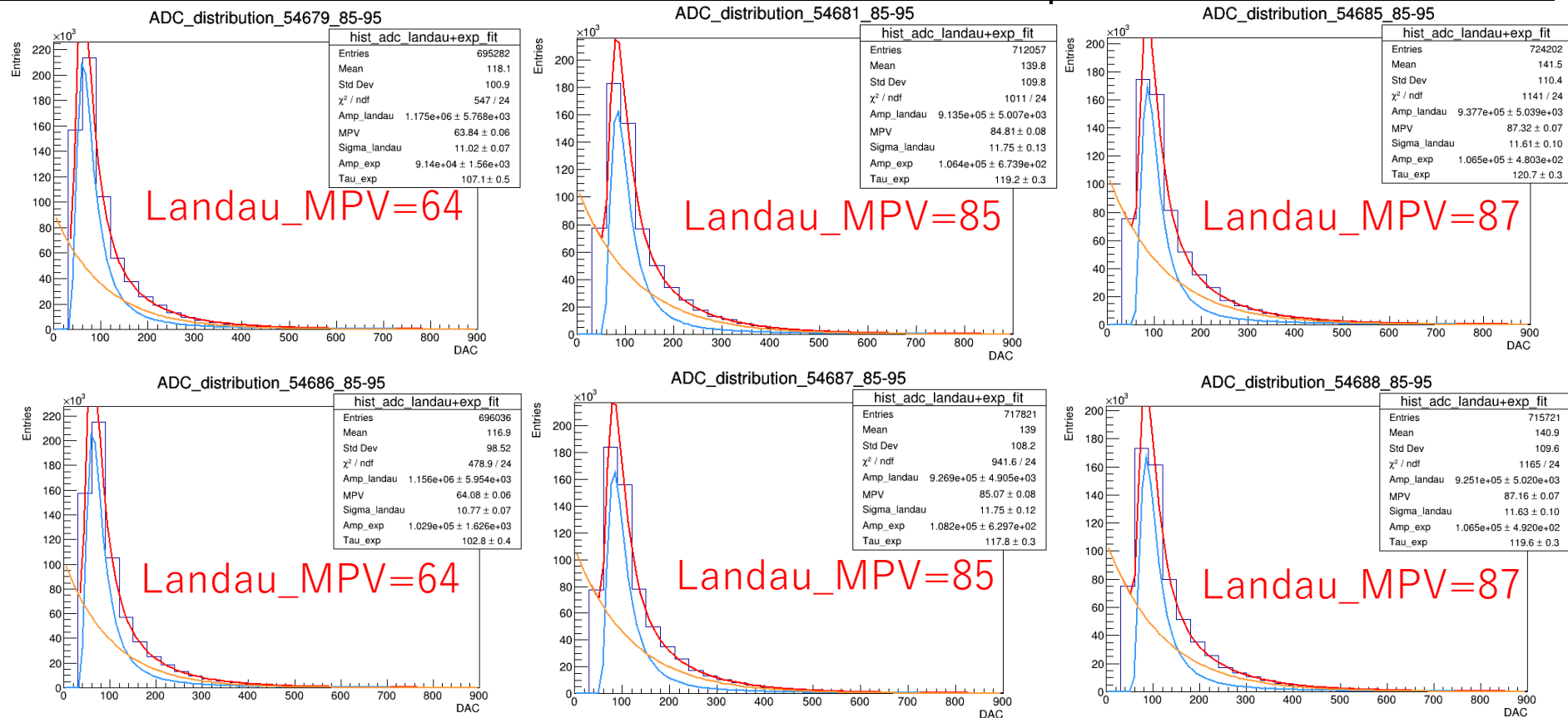
- Fitting with sum of **landau** distribution and an **exponential** function for each bias voltage.
- Cluster ADC distribution for each run is shown with their fitting line.

  (sum of two functions→red, landau→blue, exponential→orange)

Bias Voltage	50V	75V	100V

- MIP peak position are also different by each bias.
- Chi square is smaller than only landau fitting.

conclusion and next

- The fitting result at 50V seems to be consistent with 3rd beam test though, further check will be made as below.

- Better estimate of the noise component using shallower angle data samples.
- Check some fitting functions(convolution of landau and gaussian etc…).
- Improve the process of ADC7 handling.

Back up

ADC_distribution_54685_85-95

hist_adc_landaufit	
Entries	724202
Mean	141.5
Std Dev	110.4
χ^2 / ndf	6707 / 26
Amp_landau	1.065e+06 ± 2.096e+03
MPV	81.08 ± 0.05
Sigma_landau	19.87 ± 0.03

ADC_distribution_54685_85-95

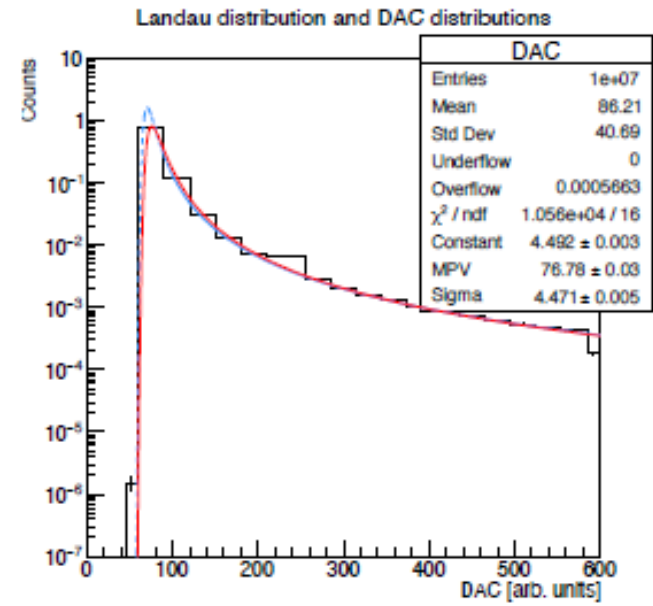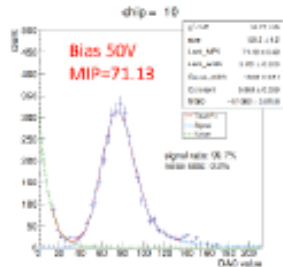| hist_adc_landau+exp_fit	
Entries	724202
Mean	141.5
Std Dev	110.4
χ^2 / ndf	1141 / 24
Amp_landau	9.377e+05 ± 5.039e+03
MPV	87.32 ± 0.07
Sigma_landau	11.61 ± 0.10
Amp_exp	1.065e+05 ± 4.803e+02
Tau_exp	120.7 ± 0.3

Back up

## The modification factor for hits with ADC7

Parameters of landau distribution were taken from
Yuka's study of DAC scan in the test beam experiment:

- MPV: 71.13
- width: 3.251

Note: The peak position is expected to at DAC 90

$$\frac{N(\text{DAC} = 210)}{\sum_{\text{DAC}=210}^{\text{DAC'}} N}$$

Landau distribution and DAC distributions

	DAC	
Entries	1e+07	
Mean	86.21	
Std Dev	40.69	
Underflow	0	
Overflow	0.0005663	
χ² / ndf	1.056e+04 / 16	
Constant	4.492 ± 0.003	
MPV	76.78 ± 0.03	
Sigma	4.471 ± 0.005	

ADC	DAC	Value	Ratio
9	210	0.00651	100%
10	255	0.00276	70.3%
11	285	0.00206	57.5%
12	315	0.00162	50.3%
13	345	0.00127	45.8%
14	375	0.00105	42.6%
15	405	0.000869	40.3%
16	435	0.000726	38.6%
17	465	0.000632	37.2%
18	495	0.00054	36.1%
19	525	0.000472	35.2%
20	555	0.000421	34.4%
21	585	0.000181	34.1%

Bias 50V
MIP=71.13

2021 Beam test

Peak at 71
Peak at 90

Ratio: N210 / ΣN

DAC
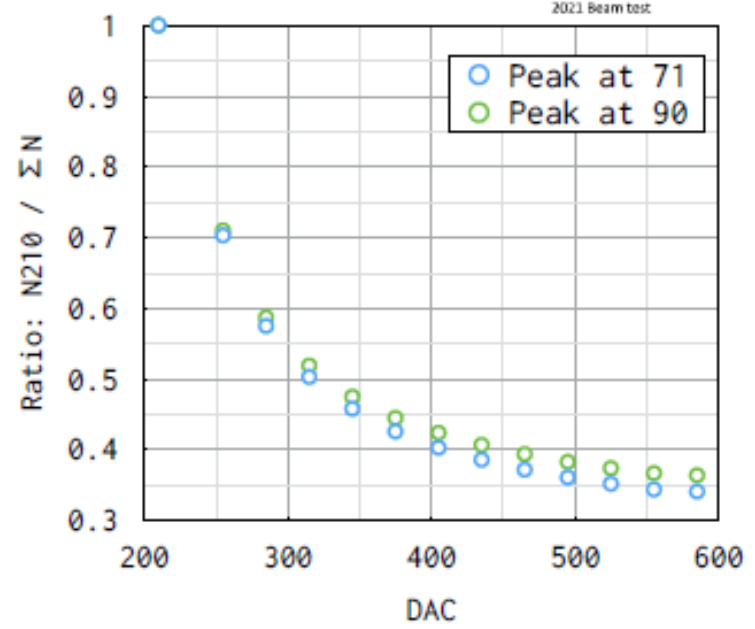
0.35 is reasonable for the modification factor

Back up