Report on the analysis of the ion beam test with STM and BBM in 2015

June. 25, 2015

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Outline

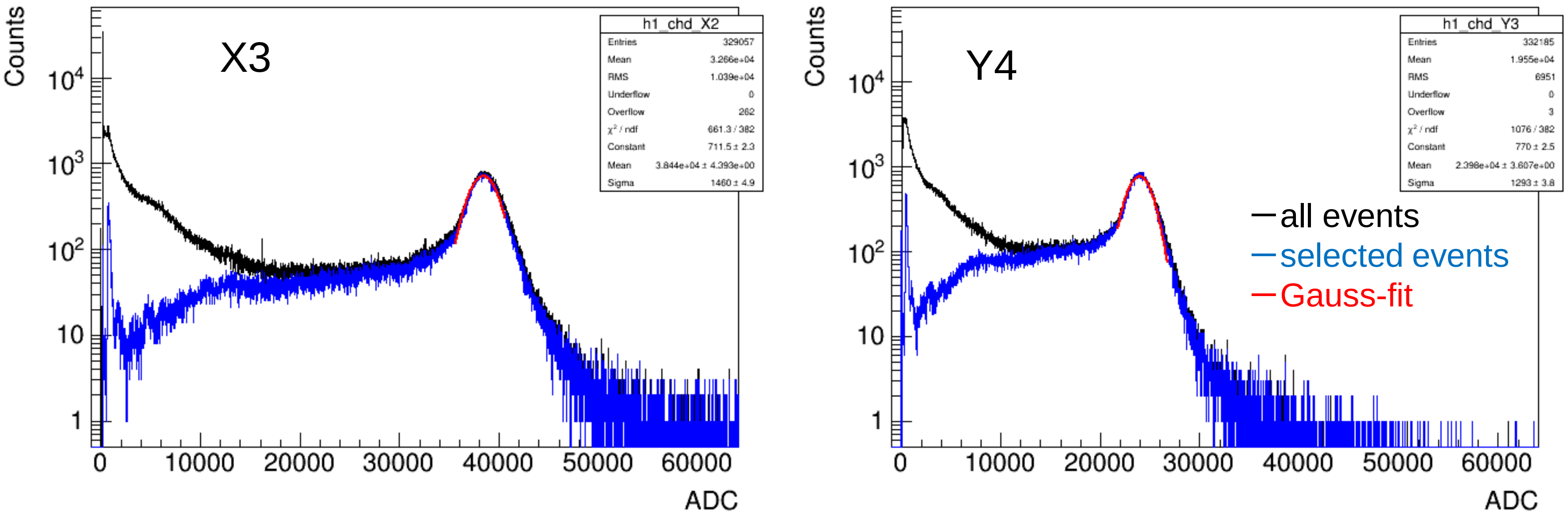
- Charge identification by CHD
  - For 150 AGeV run, Si tracker did not be put
- MIP calibration of TASC
- Energy measurement by TASC
  - 150 AGeV fragment run

Calibration of CHD using Ar beam

<u>Analysis procedure</u>

- select the beam hit channel using reconstructed track by IMC
- Fit the peak region by Gauss function

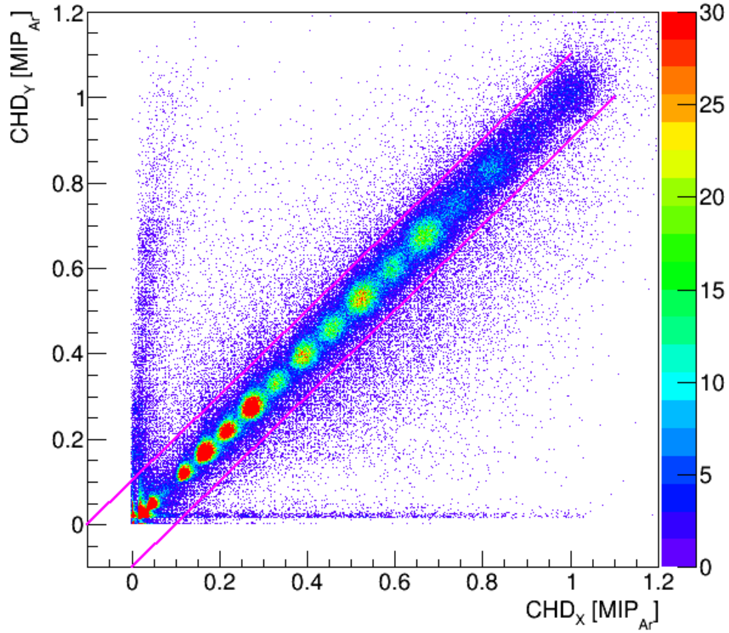
- Beam: Ar 150AGeV
- RunNo: 416 - 513
- HV_CHD: -450V

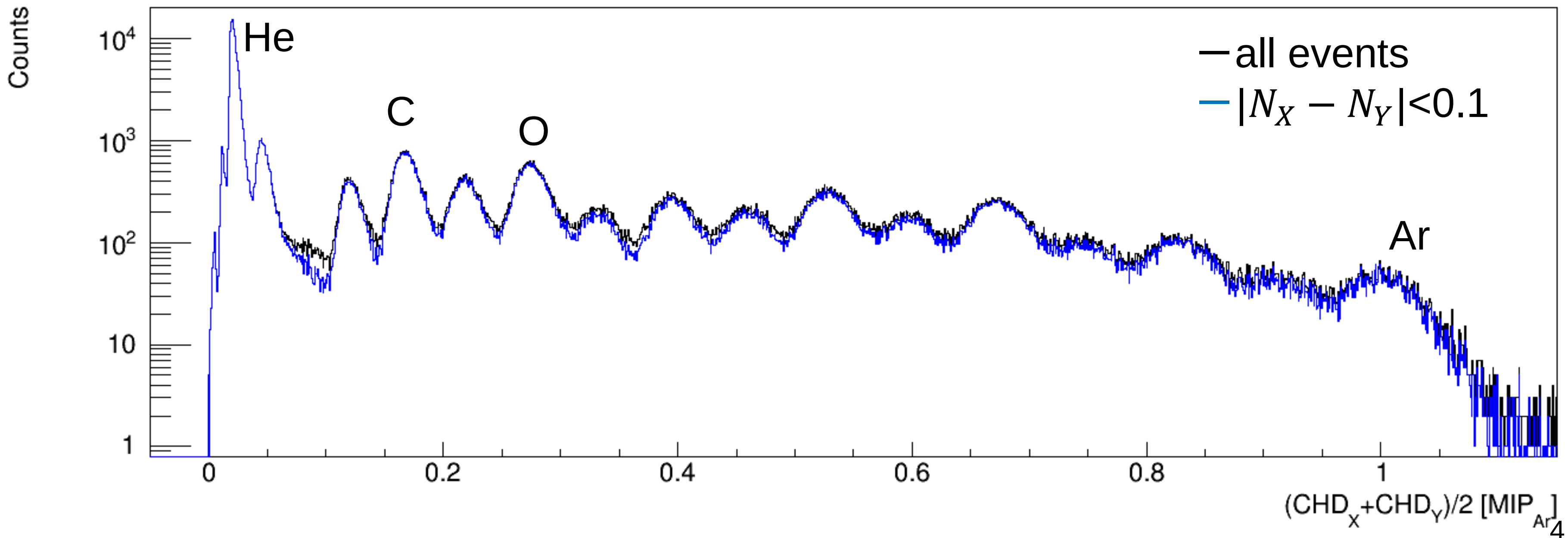


Fragments

<u>Analysis procedure</u>

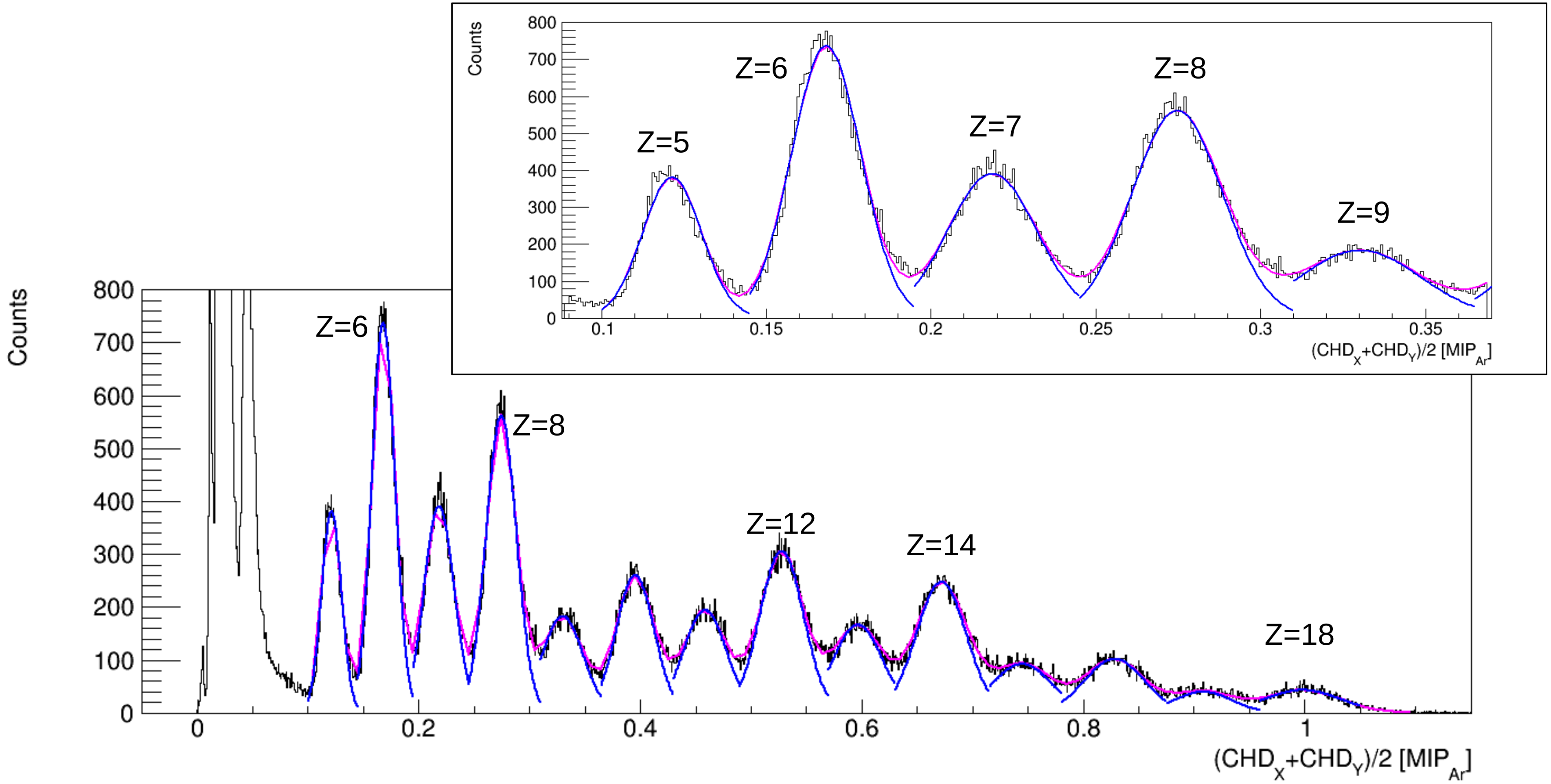
- convert from ADC to the number of particles corresponding to Ar-MIP
- select the hit CHD channel using reconstructed track by IMC, make correlation map between CHD-X and Y
- using the events which has correlation, select events satisfied with $|N_X - N_Y|$<0.1
- make 1D histogram of the average of the number of Ar-MIP





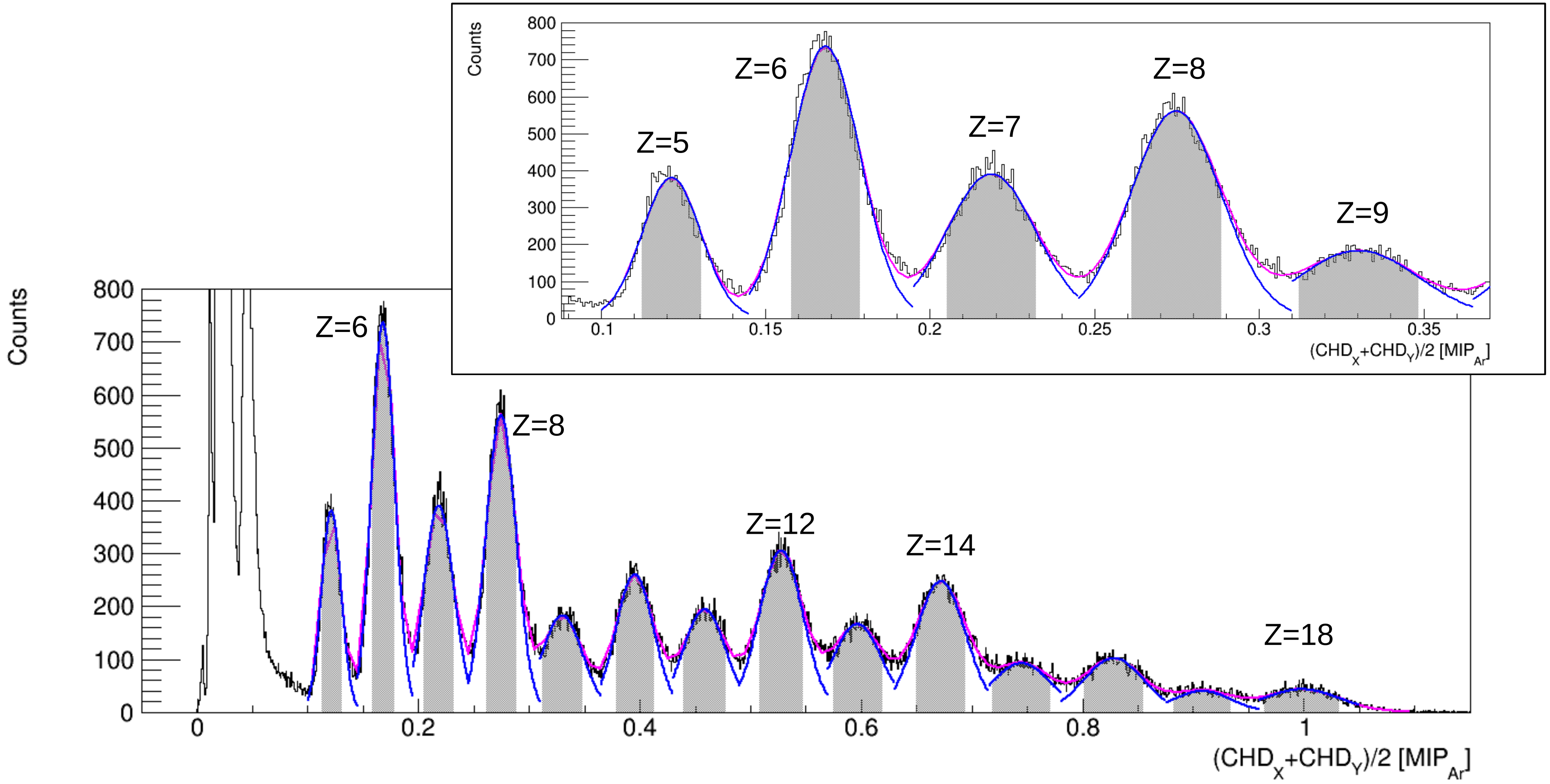
Fitting (Z>5)

- Fit by Gaussian



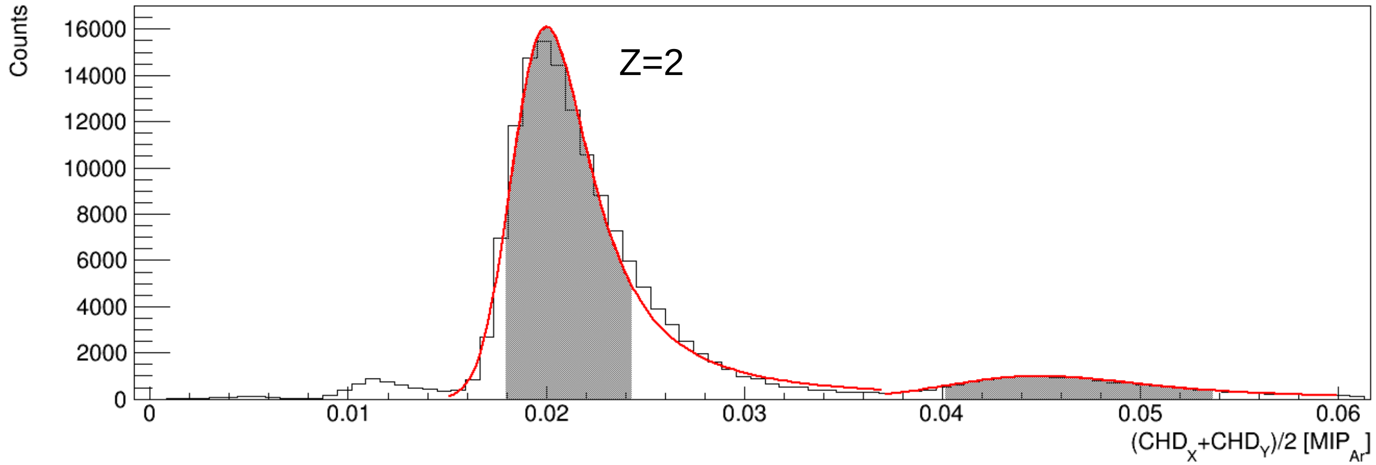
Fitting (Z>5)

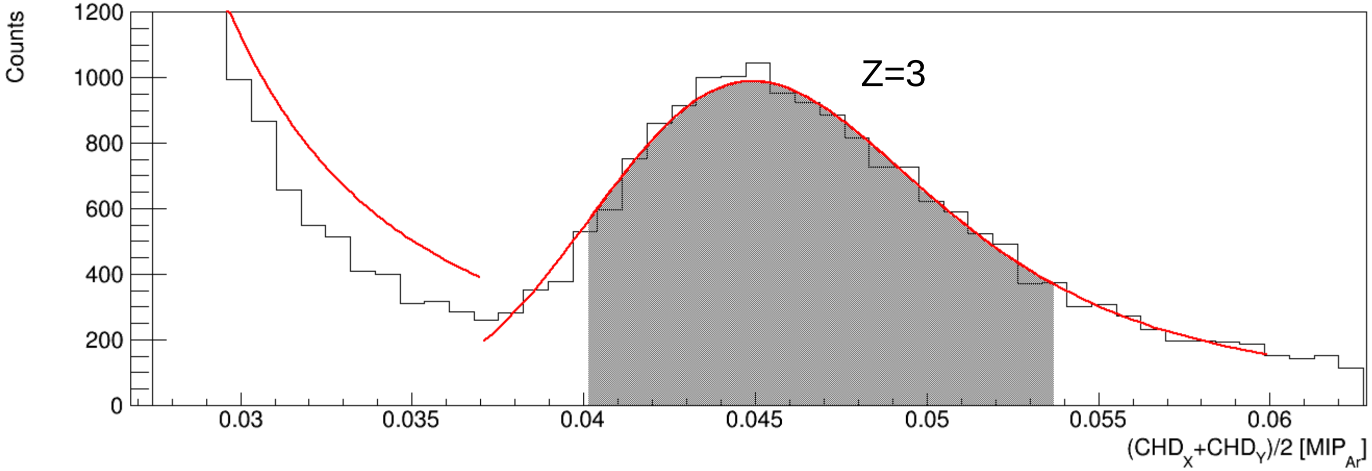
- Fit by Gaussian
- use events between 1σ region for following data analysis



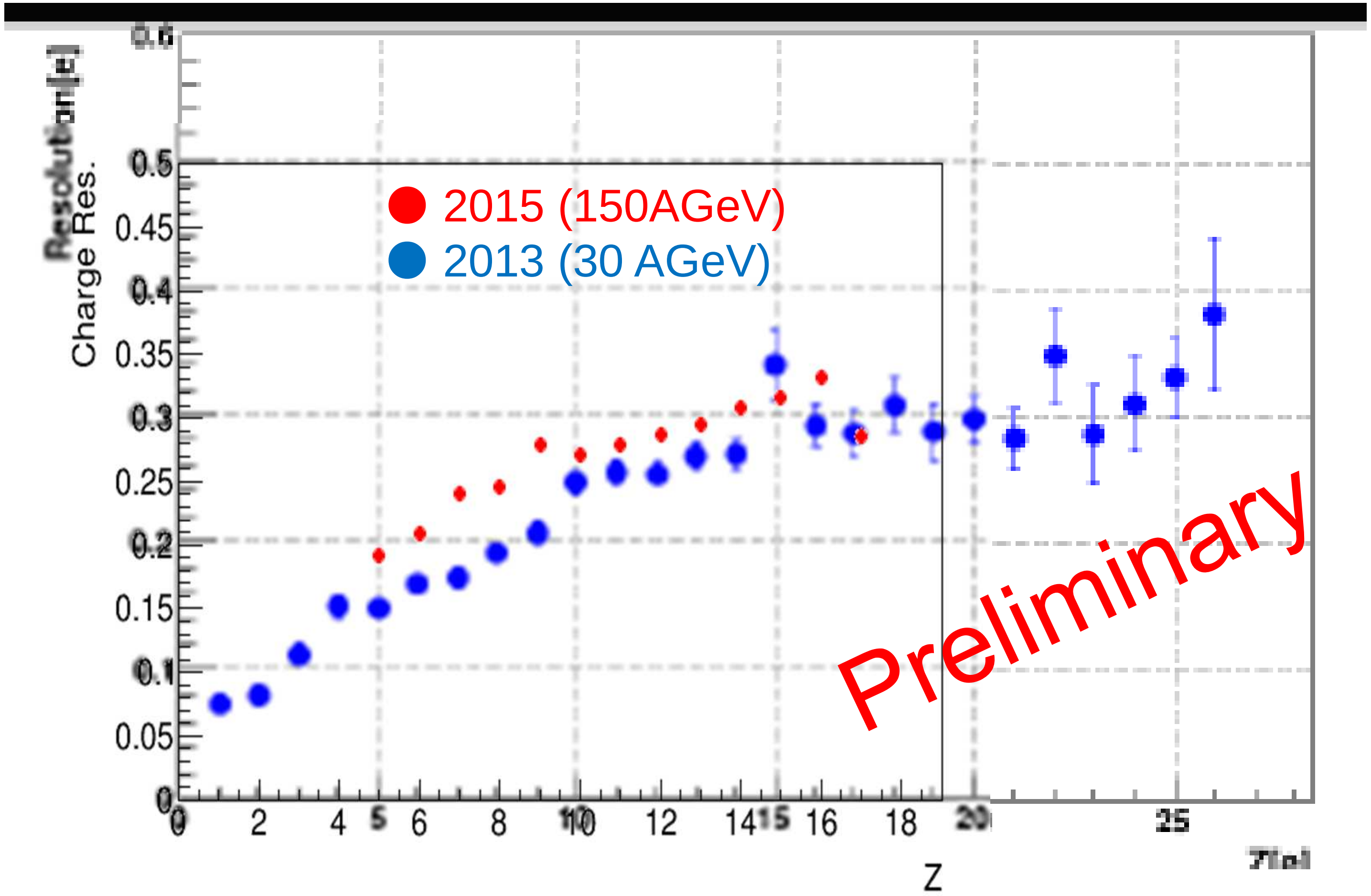
Fitting (Z=2, 3)

- use Landau function convoluted with Gaussian
- select below region for energy measurement analysis
  (MPV-2σ) < N < (MPV+5σ)　　MPV: Landau's MPV
  　　　　　　　　　　　　　σ: Landau's sigma





Charge resolution of CHD



Note: in case of 2013 exp., the information of Si-detector was used
in case of 2015 exp. (150AGeV run), the info is not used.

MIP calibration of TASC

Analysis procedure

- Use He events selected by CHD
- Fit He peak as a tentative MIP without single event selection
- Select single events using Likelihood methods
    - Create template from MC and noise of experimental data
- Fit He single peak

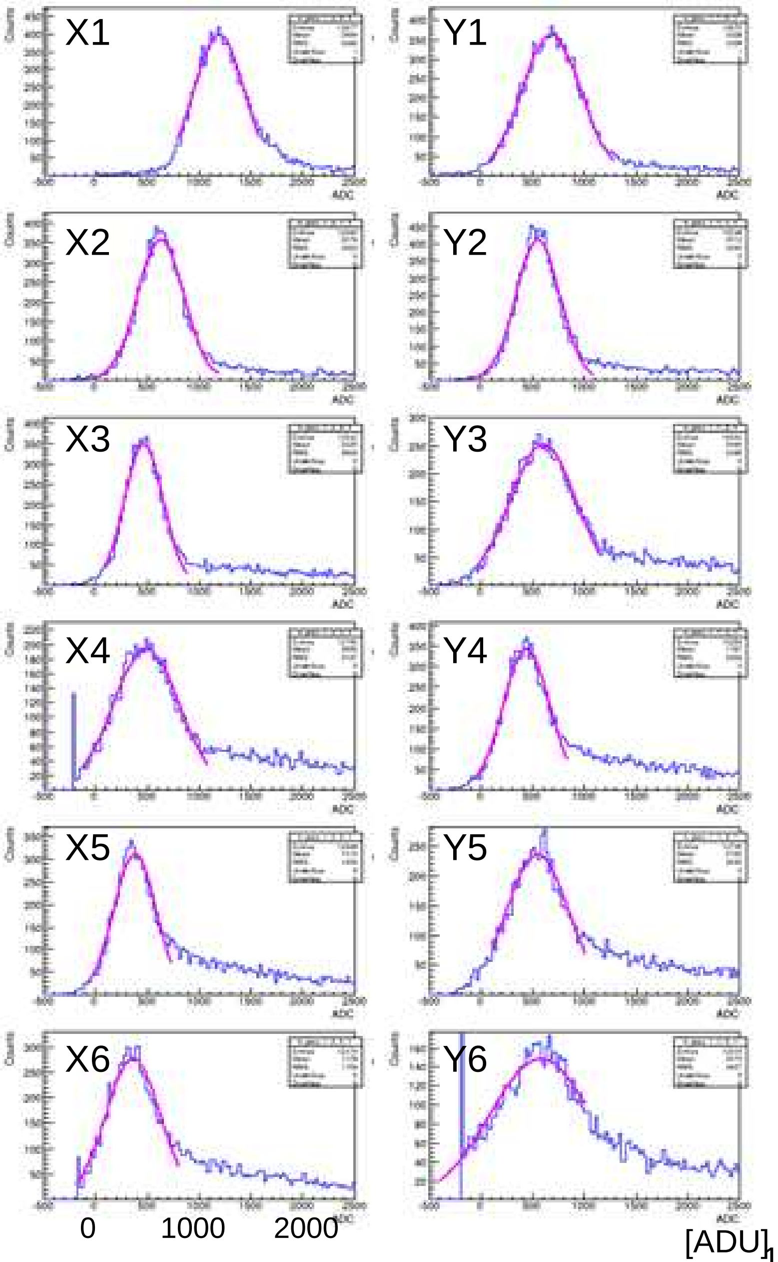
Calibration using He events

<u>Analysis procedure</u>

- Use fragment run (13 AGeV)

  RunNo: 572,574,576,578,580,582

- Select He events by CHD
- Select events the reconstructed track by IMC pass through each PWO log.
- make figures of ADC distribution. (Right figures show the single peak region)
- Fit the peak by gaussian
- The peak value is used as the (tentative) He-MIP for each channel



Single events of He

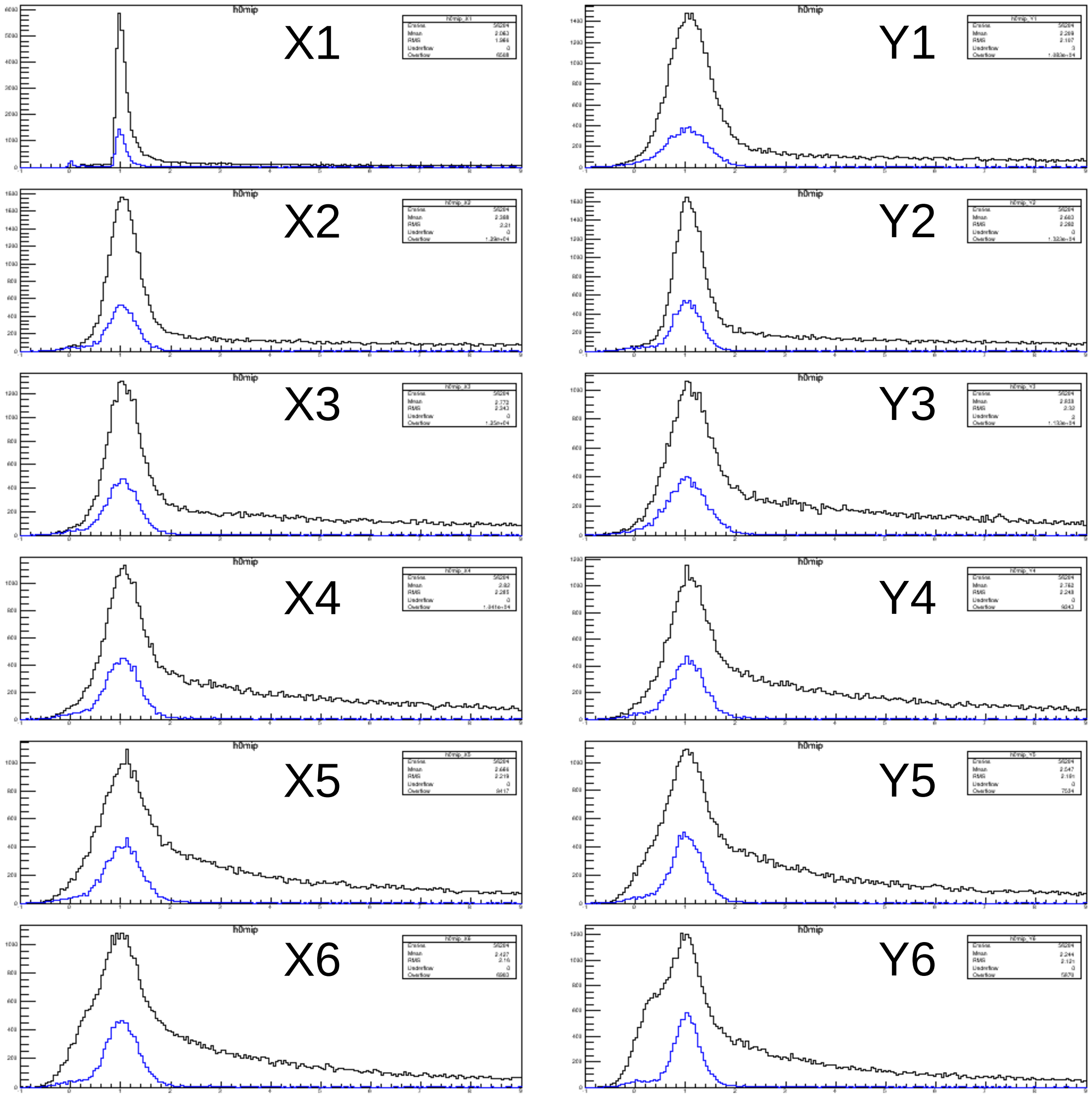
*MC data

- EPICS v9.167
  Comsos v7.645
- DPMJET-III

- He 13 AGeV

Penetrating event ratio is ~14 %
⇒ event selection

— all
— no-interaction (MC-true)



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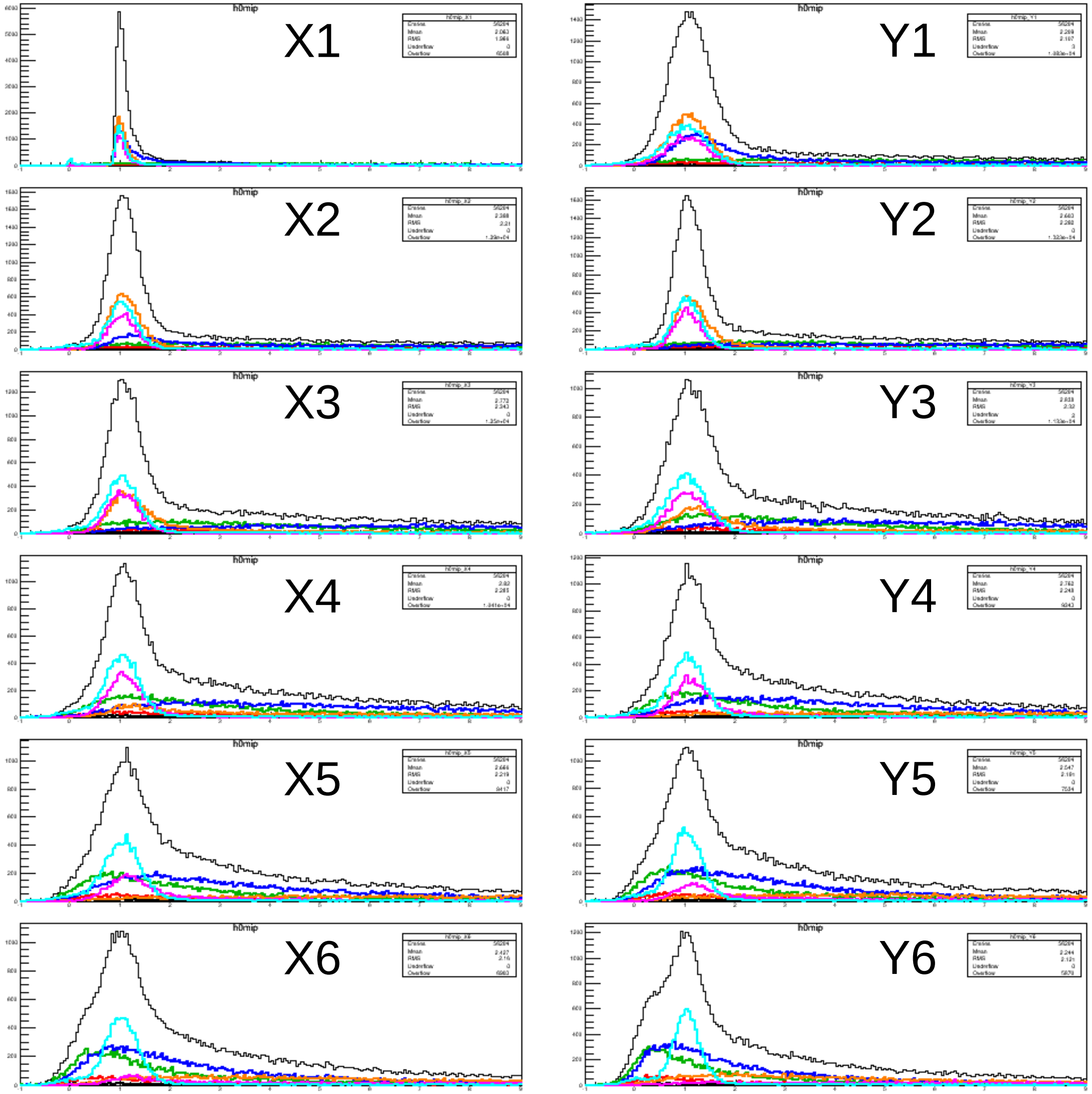


— all
— upstream of det.
— CHD
— IMC
— TASC1-4
— TASC5-8
— TASC9-12
— no-interaction

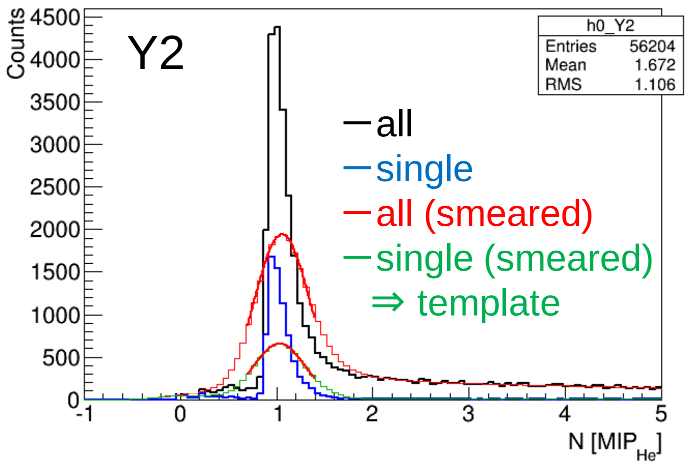
Templates of $\mathrm{MIP}_{\mathrm{He}}$ for Likelihood analysis

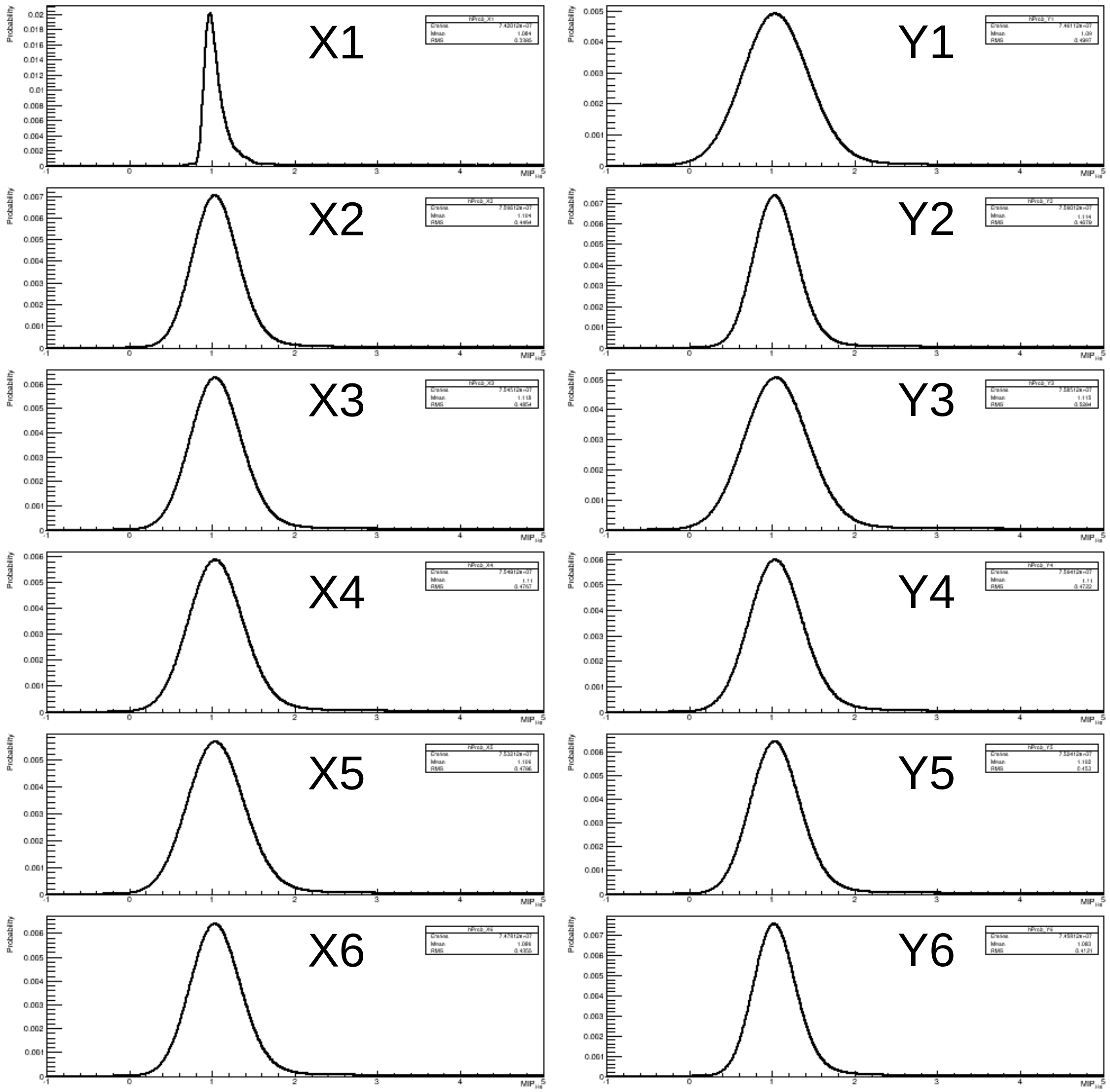
*MC data

using noise of pedestal,
template distribution is made
by reproduce MC
(in ROOT...)

$$N = \mathrm{gRandom} \rightarrow \mathrm{Gaus}\left(\frac{E}{E_{peak}}, \frac{\sigma}{\mu}\right)$$

N: number of particles
E: deposit energy of MC
E_{peak}: He peak energy of MC
σ: pedestal noise of exp. data
μ: peak of He of exp. data

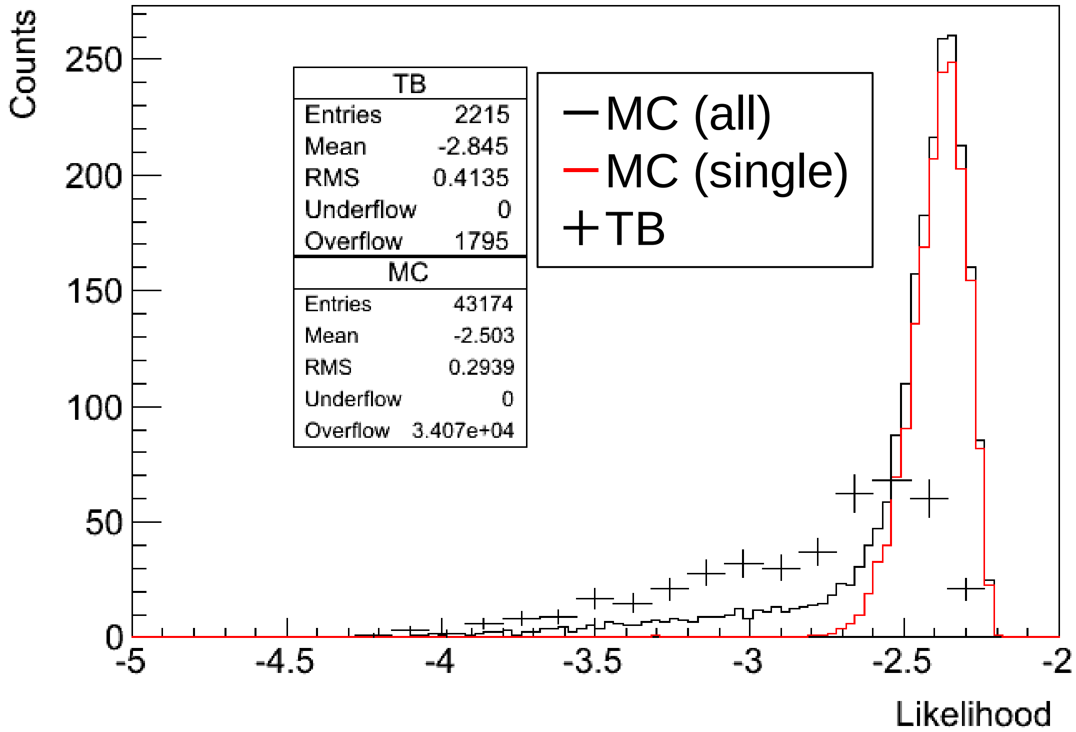




Single event selection by Likelihood

$$L = \sqrt[12]{\sum_{i}^{12} \log_{10}(P_i(s))}$$

if $s < -1$ or $5 < s$, $\quad P_i(s) = 0$,
⇒ such events are expressed as “overflow” in following figure

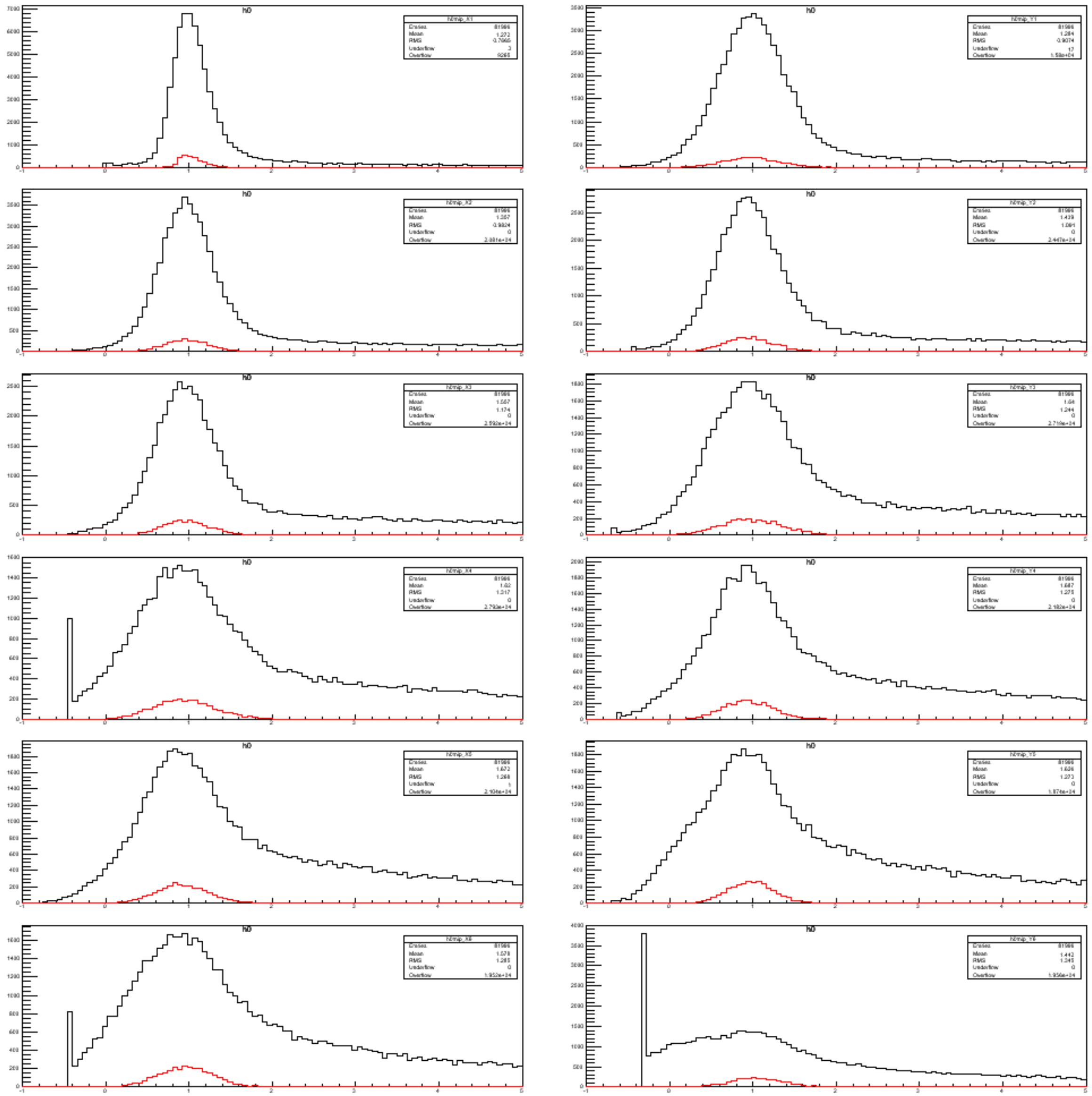


	TB	MC
Entries	2215	43175
Overflow	1795	34070
Ratio	81(±2)%	79%

(*) In MC, beam profile is not considered.

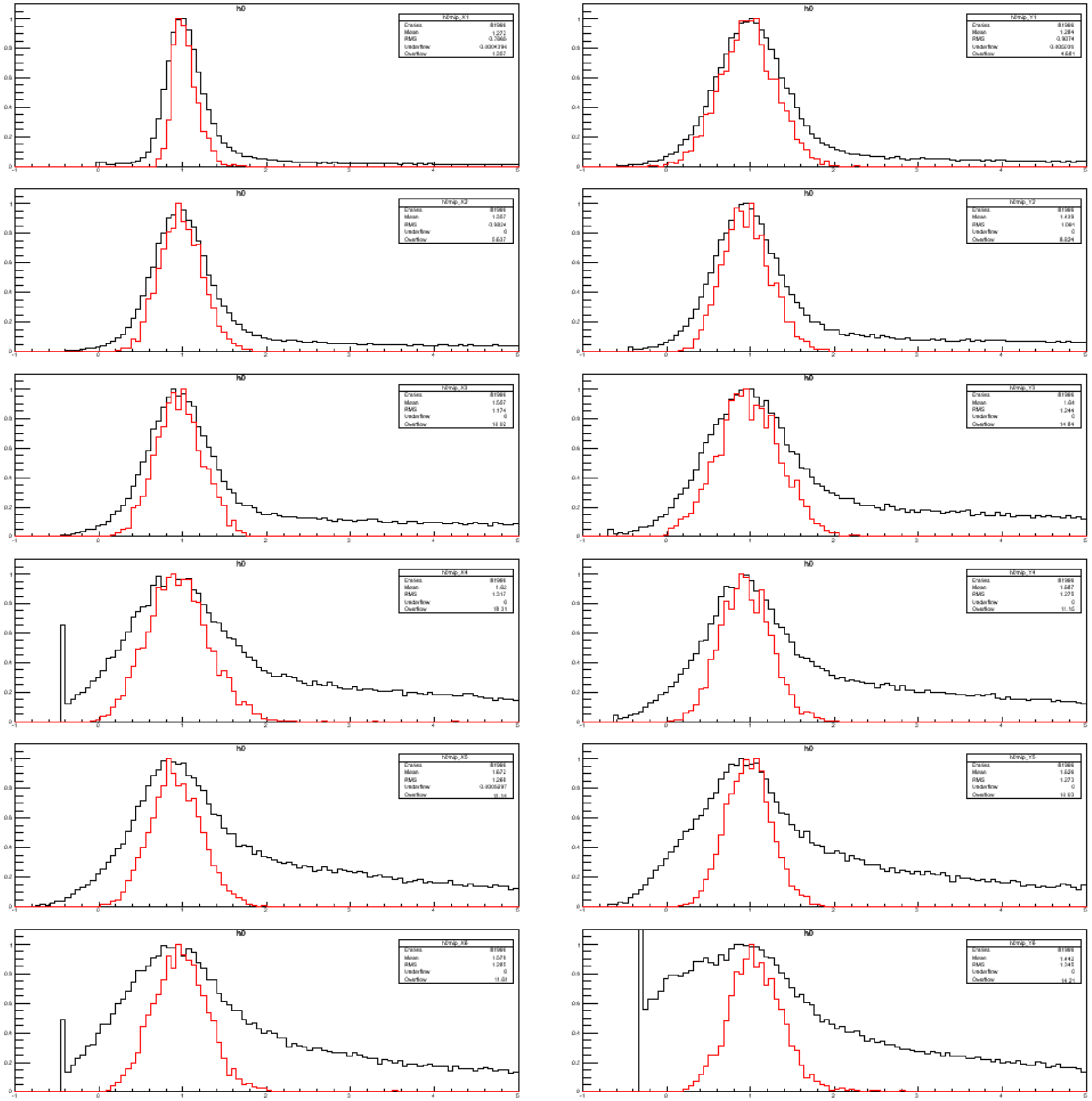
He−MIP

—all events
—selected events



He MIP

— all events
— selected events (scaled)



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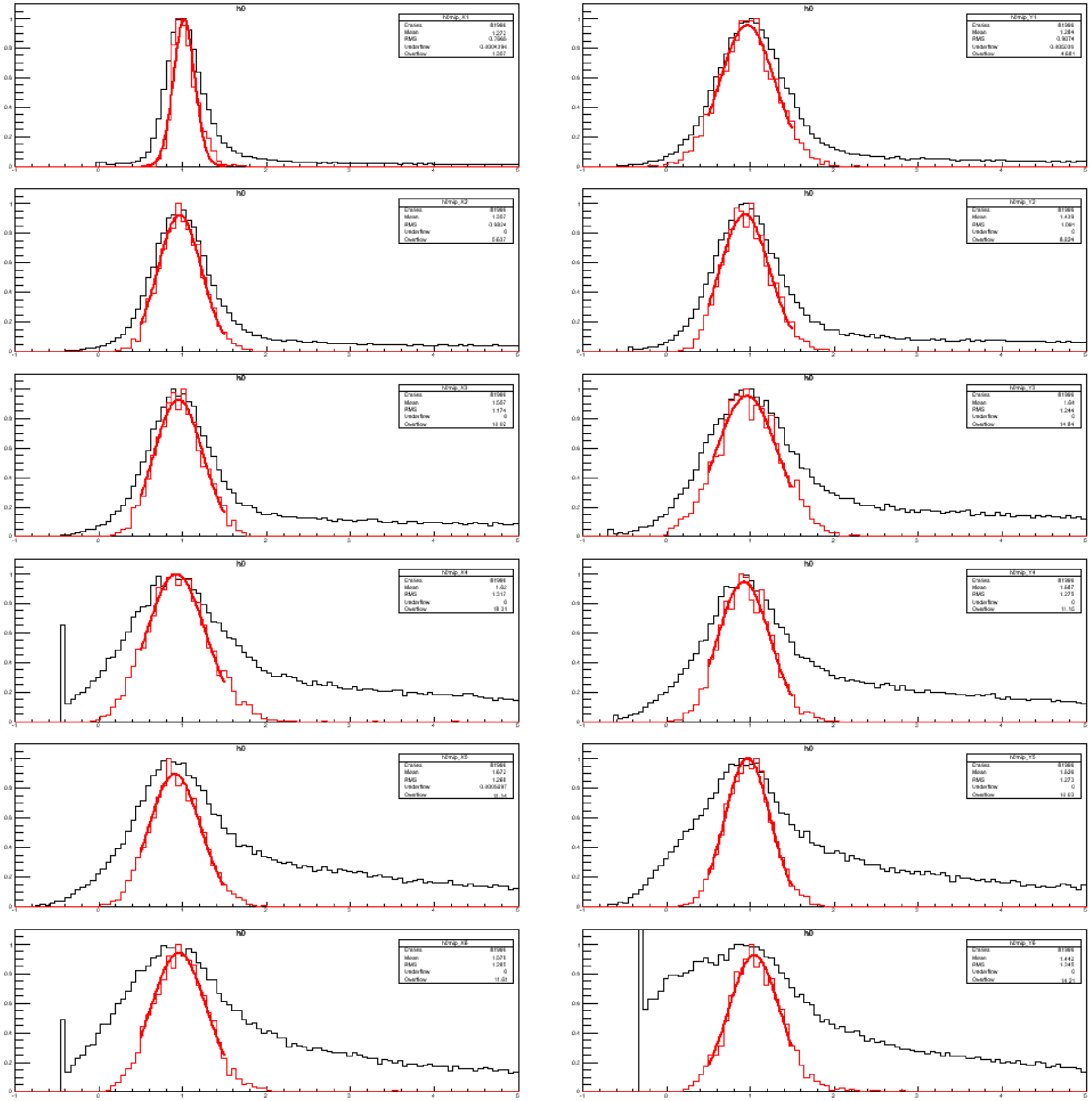
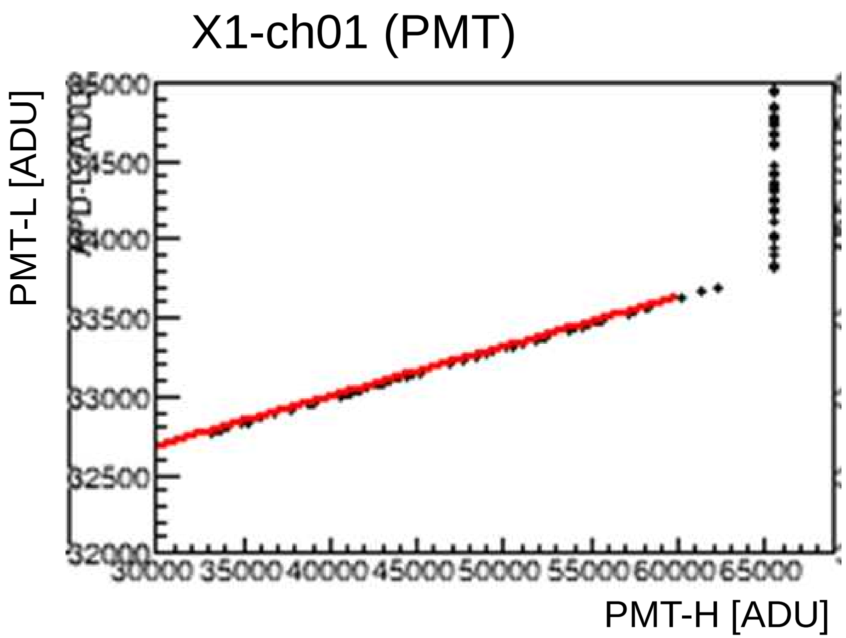
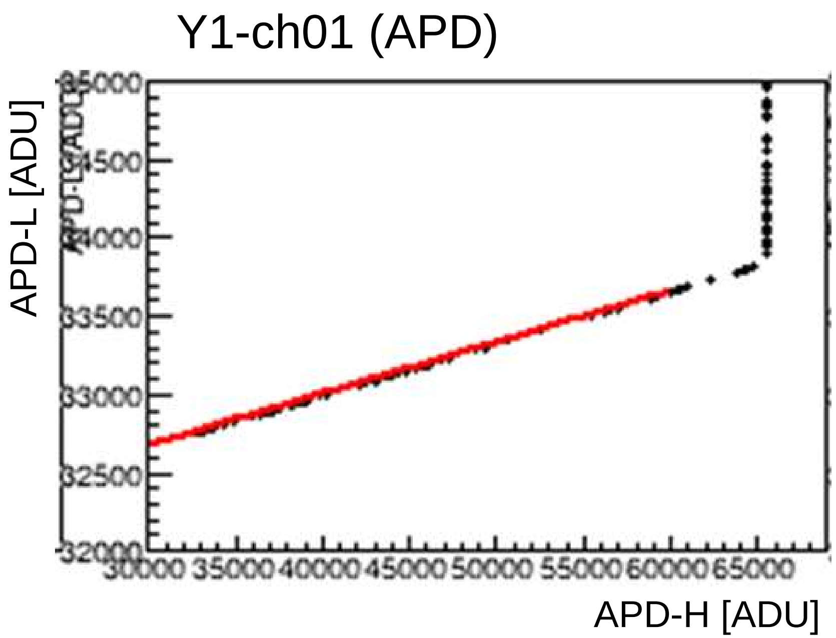


Correlation of PMT, APD High/Low

- Using 150 AGeV run, make the correlation plots of high gain and low gain





Analysis of shower events of fragment beam

<u>Event Selection</u>

- Charge selection by CHD
- High energy shower trigger

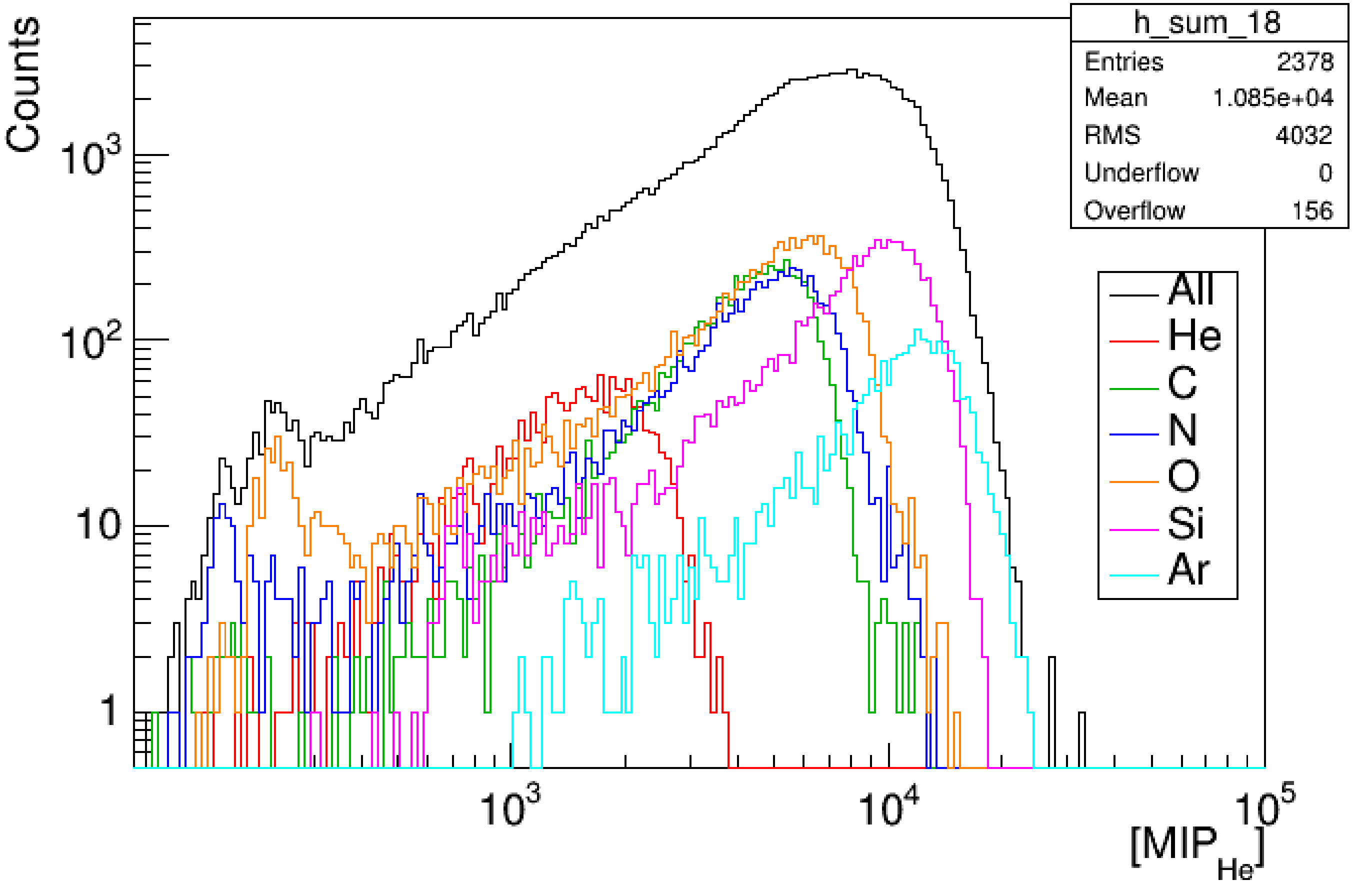
  - $N_{\mathrm{TASC-X1}} > \frac{55}{4}\ \mathrm{MIP_{He}}$
- Position limit
  - Use events that pass through the center of X1 and Y1 PWO log (2cm x 2cm)

Event number after the each selection

run383,385,387,389 Ar-Ion 150AGeV 20,0000event
Beam file:H8A.CALET.005 Position: Bb+

Z	All particle (Tag by CHD)		High energy shower trigger		Position limit	
1	–	–	–	–	–	–
2	14558	100[%]	2089	14.35[%]	1583	10.87[%]
3	7473	100	2477	33.15	1864	24.94
4	–	–	–	–	–	–
5	4912	100	2533	51.57	2048	41.69
6	11166	100	6676	59.79	5752	51.51
7	7801	100	7000	89.73	6101	78.21
8	11465	100	11208	97.76	9868	86.07
9	5551	100	5419	97.62	4602	82.90
10	7231	100	7147	98.84	6263	86.61
11	6226	100	6167	99.05	5419	87.04
12	9647	100	9598	99.49	8495	88.06
13	6290	100	6260	99.52	5492	87.31
14	9102	100	9082	99.78	8018	88.09
15	4487	100	4476	99.75	3919	87.34
16	4722	100	4706	99.66	4129	87.44
17	2056	100	2046	99.51	1805	87.79
18	2758	100	2754	99.85	2378	86.22

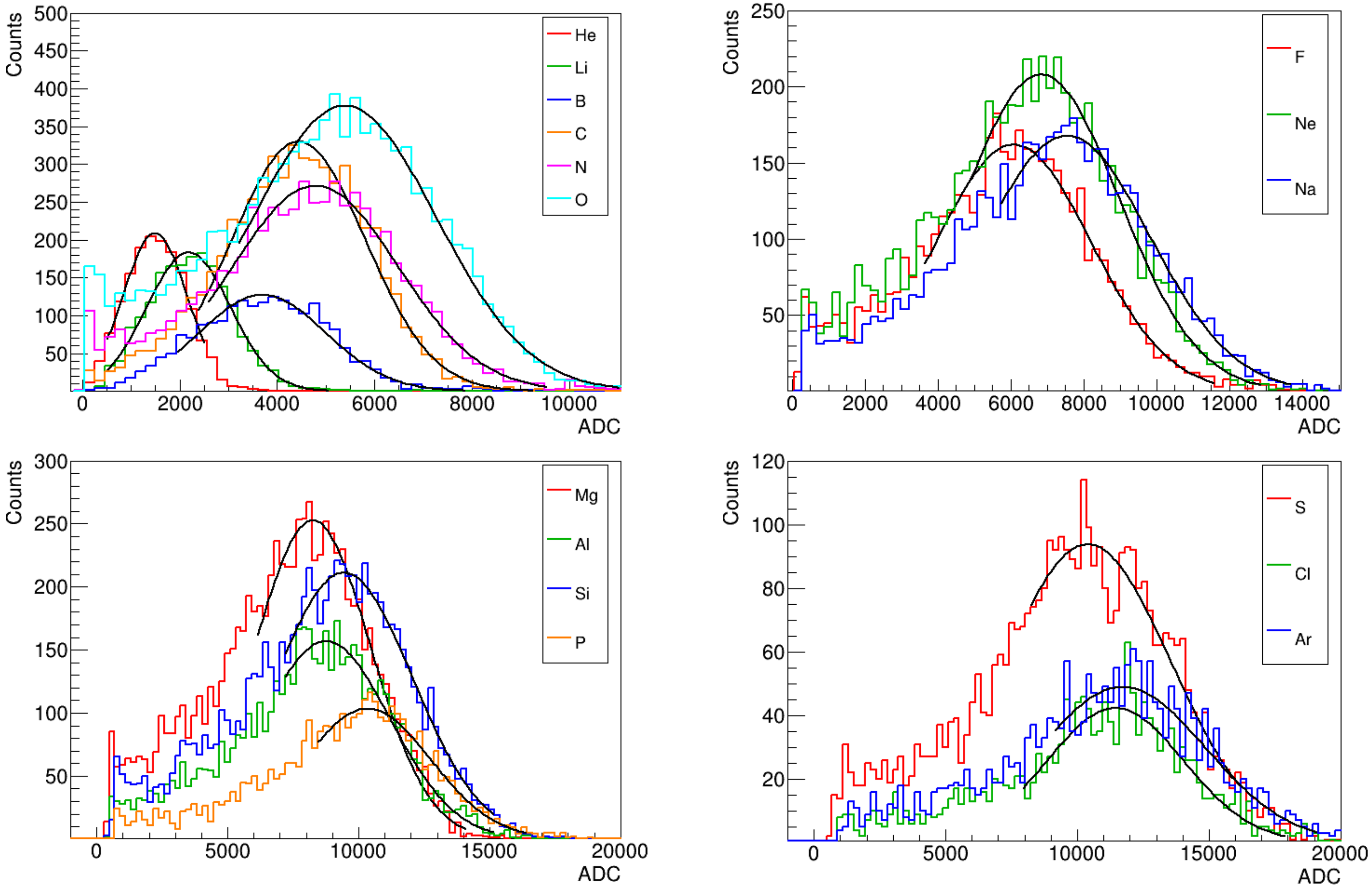
the number of particles of TASC (150 A GeV/c)



Note: the single events of heavy particles (Z>7) are triggered even if HES is applied
because dE/dx ∝ z^2.
the single peak is about $Z^2/Z_{He}^2 \times 12$ [MIP_{He}].
ex.) O: $8^2 / 2^2 \times 12 \sim 192$ MIP_{He}

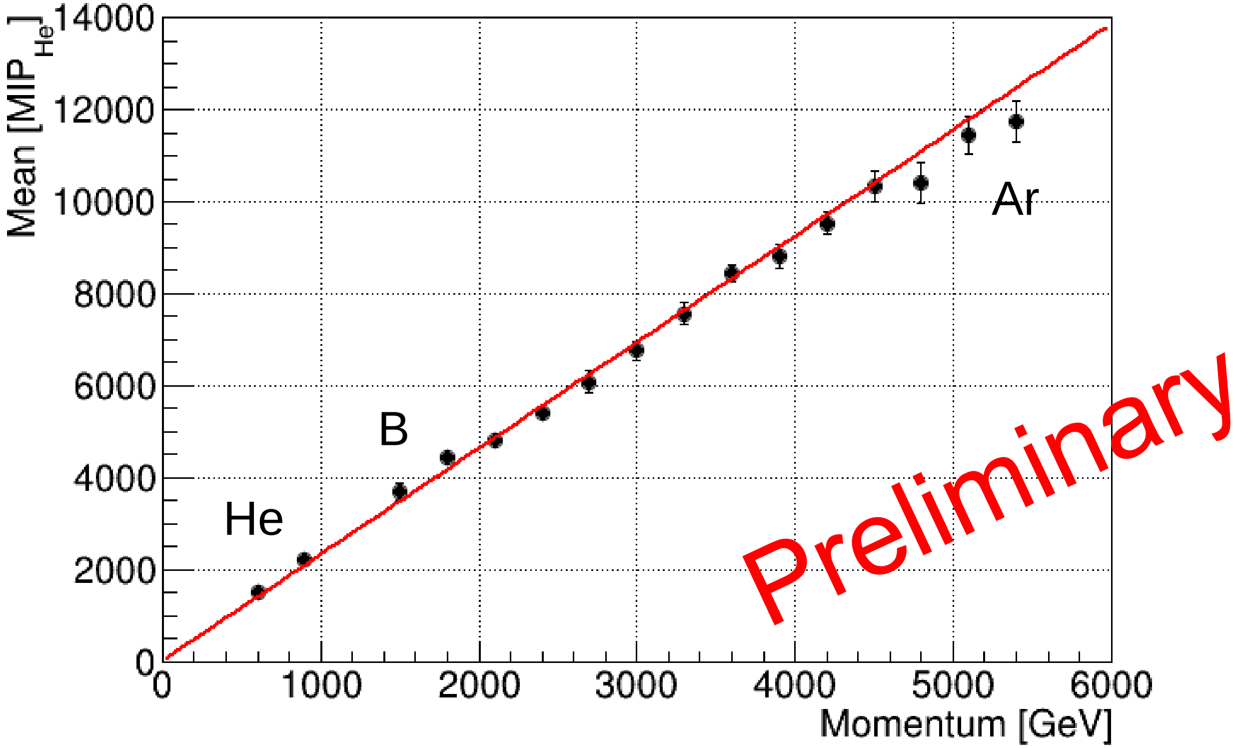
Gauss-fit for shower event region

※x-axis linear



Note: we have not done the shower event selection, in this distribution, the events which penetrate the detector or interact at lower layer are included.

Linearity of the shower energy



Momentum P

$P = 150 \times 2Z$ [GeV]

beam condition: A/Z=2.0

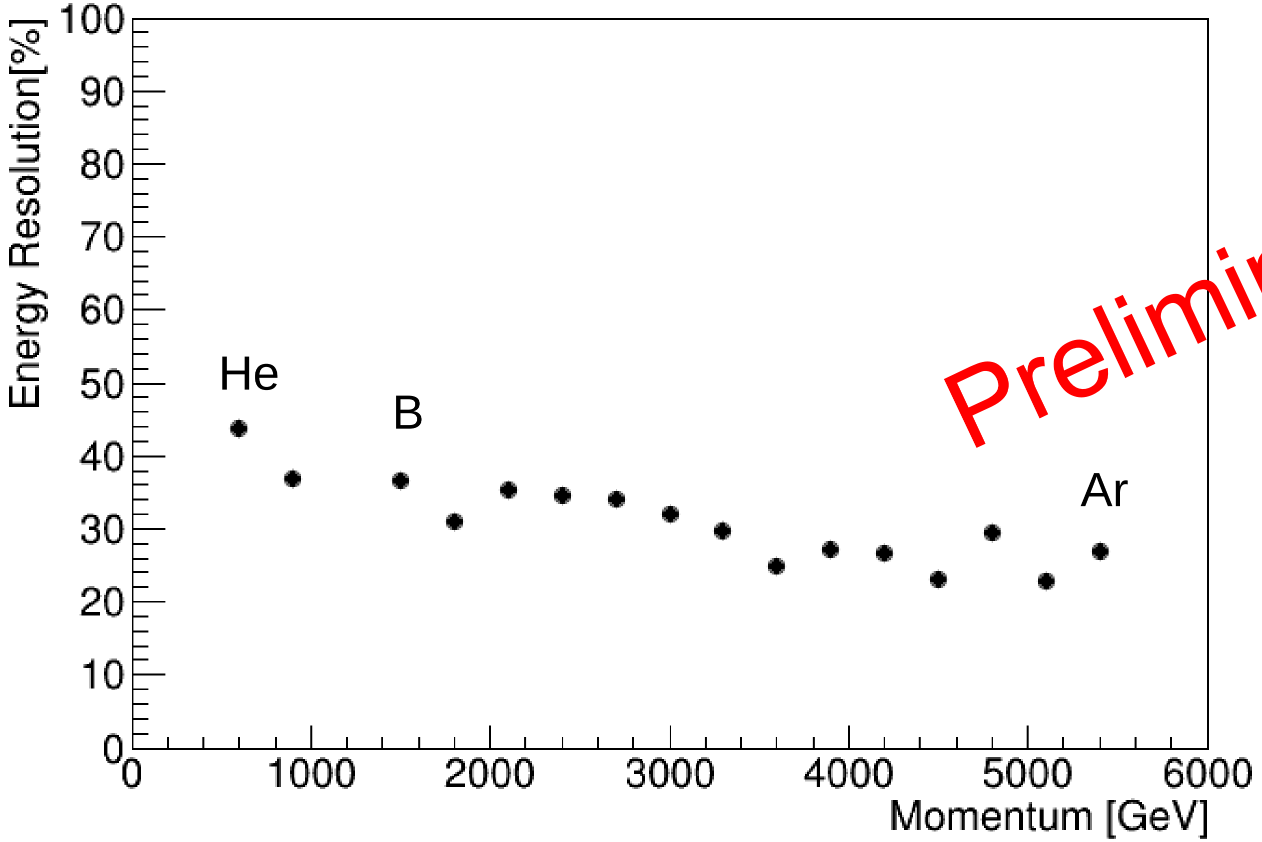
Note: We used APD high/low gain channel, not used PD.

in case of higher charge beam, some events have saturate channels.

Energy resolution

$$R = \frac{\sigma}{\mu}$$

R: Energy resolution
μ: Mean of Gauss-fit:
Σ: Sigma of Gauss-fit



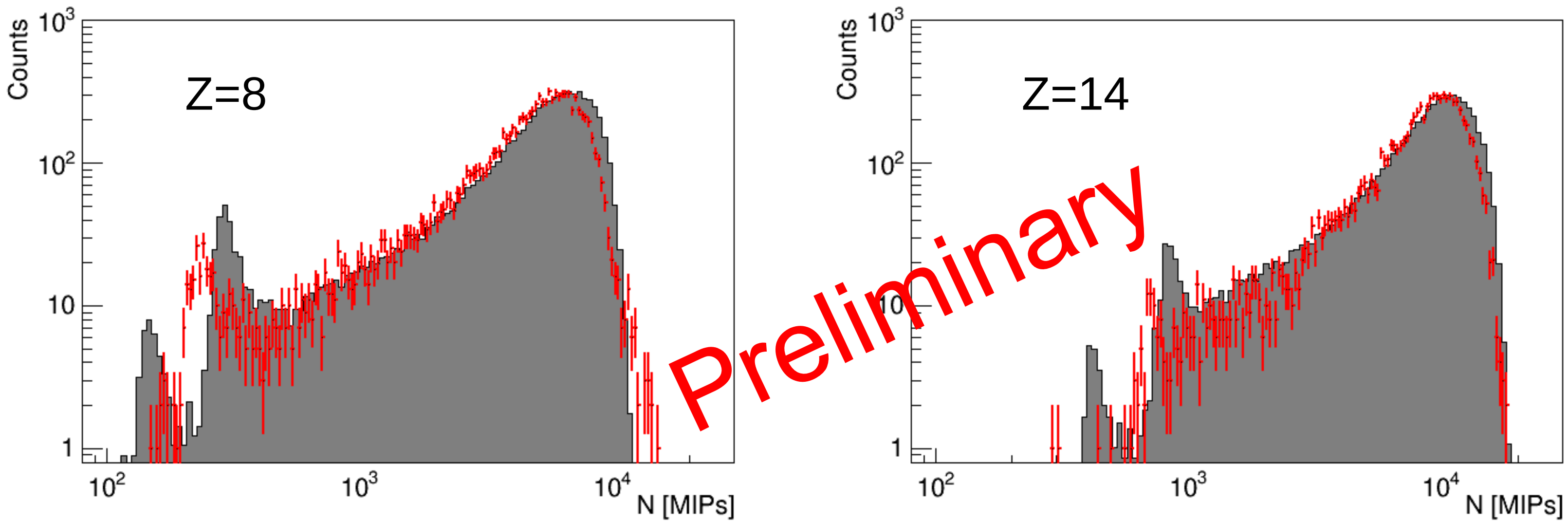
Z	Energy resolution[%]
1	-
2	43.7
3	36.8
4	–
5	36.6
6	30.9
7	35.3
8	34.5
9	34.0
10	32.0
11	29.7
12	24.7
13	27.2
14	26.5
15	22.9
16	29.3
17	22.7
18	26.9

Note: this results do not show the energy resolution of CALET
because the detector configuration is different from flight model..

Comparison with MC

<u>Simulation</u>

- EPICS v9.167 (Cosmos v7.645)
- DPMJET-III
- direction: vertical
- incident position: gauss(σ=0.5cm)



Note: in MC, the beam profile, quenching are not considered.

Future work for CERN2015 exp.

TASC

- Update the methods of single event selection
  - evaluate the shower linearity, resolution
  - compare with MC
- Get quenching parameter for PWO
  - select the MIP events each particles
  - apply the parameters into the MC

IMC/CHD

- Evaluate the charge resolution with track reconstruction
  - accuracy of track reconstruction
  - charge resolution not only CHD, but also CHD and IMC-SciFi
- Optimize the methods to find the interaction point