Si-GET Project in HKU

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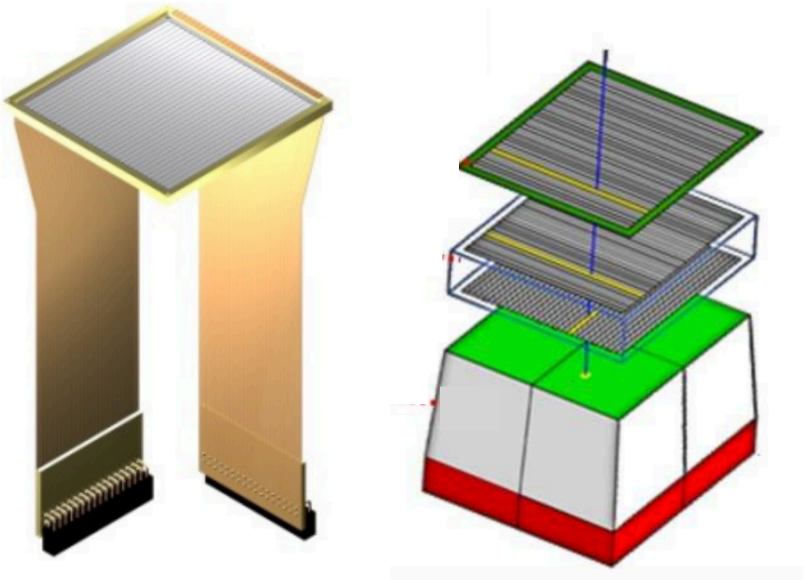
Outlines

- Motivation
- Si-GET Test Bench @HKU
  - TTT4 Summary spectrum
  - Energy Spectrum
  - Coincidence between front, rear strips
  - Coincidence between adjacent strips
  - Map reconstruction
- Commissioning run @HIRFL in Lanzhou
- Summary

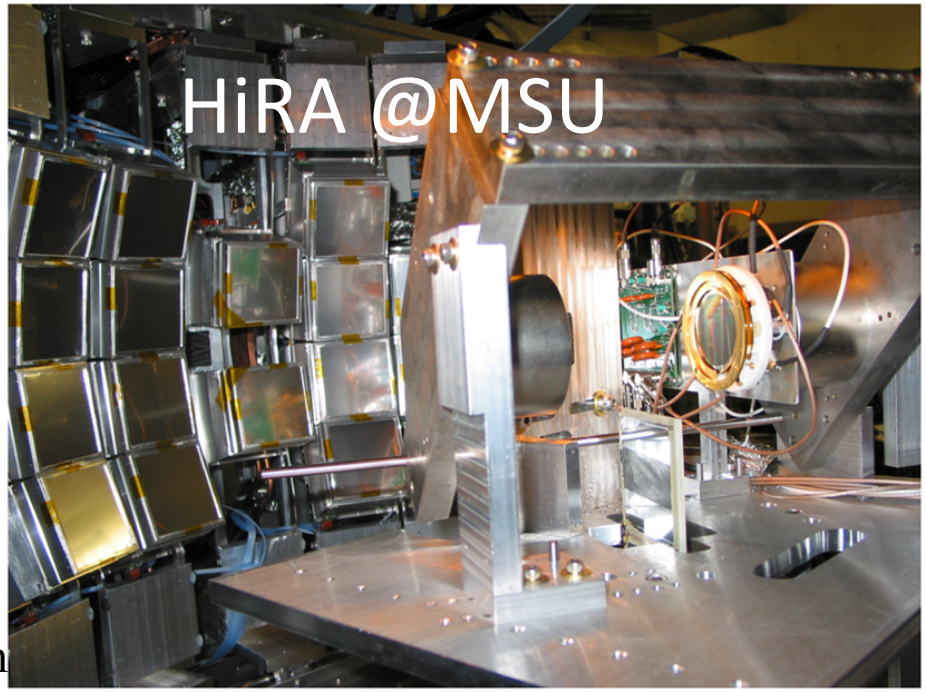
Motivation

HKU Direct Reaction (Transfer & Knock-out) experiments

- Reaction Dynamics ^{34,36}Ar (p,d) at 70 MeV/u @ MSU (2014)
- Nucleon Correlation ^{14}O(^{12}C, X)^{13}O, ^{13}N at 60 MeV/u @ RCNP (2015)
- α clustering ^{10,12,14}Be(p, $p\alpha$) at 150 MeV/u @ RIKEN (2018)



DSSD: BB7 type, 32X32 strip, strip width 2mm



Motivation

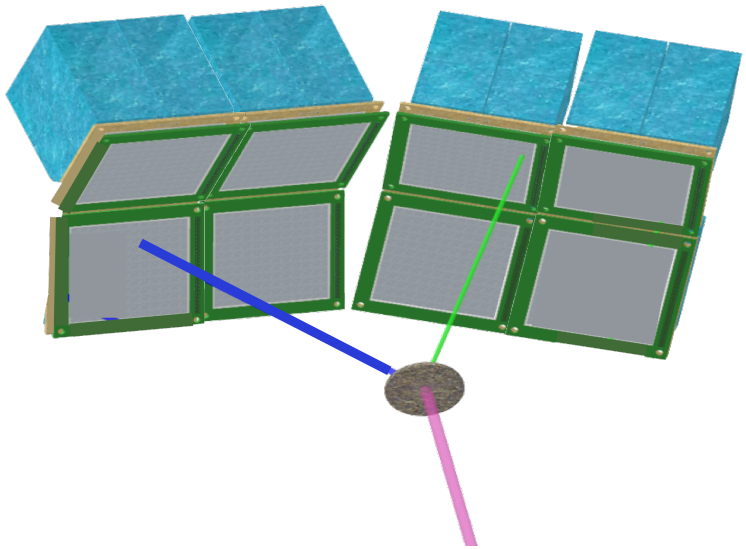
Direct Reaction with RI Beam

- Inverse kinematics
- Low beam intensity

Request for Detector Array

- High Angular resolution
- Large angle coverage

Telescopes X 8 : DSSD+CsI



DSSD Upgrade:

Micron Semiconductor TTT series

- Number of Strips:128X128
- Active Area:100X100mm^2
- Strip Width:760(60)um

Total 2080 channels readout electronics

GET Hardware demand

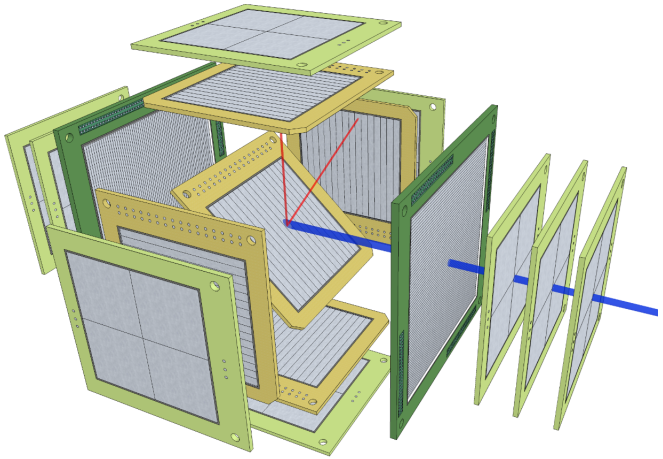
- AsAd Board X 9
- Cobo X3
- Mutant X1
- MCH X 1
- Micro TCA Crate X1

Motivation

HKU decay experiment

βp, $\beta 2p$, $\beta p\alpha$ measurement

- β decay spectroscopy of ^{26}P, ^{22}Al at IMP, Lanzhou (2017)



Center implantation detector

- 1 DSSD (40 μm) with a dip angle of 45˚(30 ˚)

Surrounding detectors

- 6 DSSD with 60, 300,500 μm + QSDs

DSSD Upgrade

1. Better position determination for the implantation
2. Better angular resolution for the decayed particles

DSSD Type	BB7	TTT Series
Channels	260	1828

GET Hardware demand

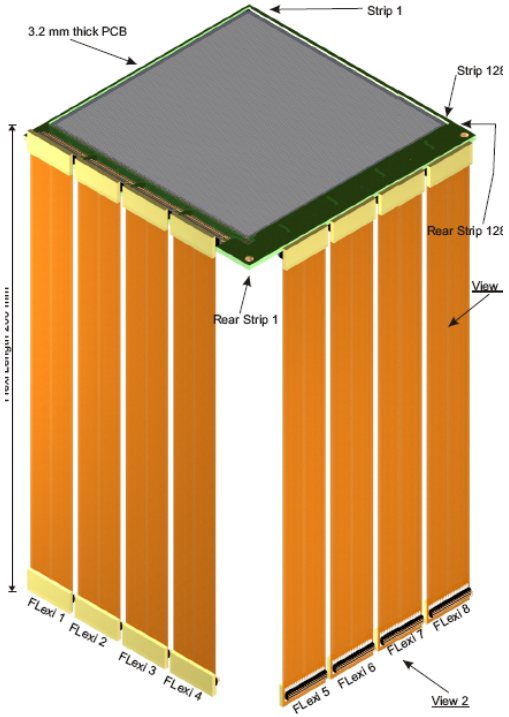
- AsAd Board X 8
- Cobo X2
- Mutant X1
- MCH X 1
- Micro TCA Crate X1

Why do we need GET System for Silicon

Silicon Array Detection System

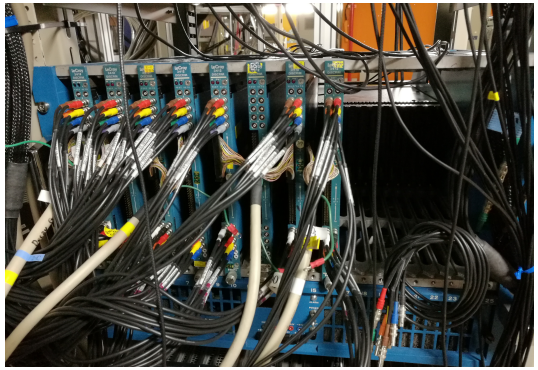
-- Radioactive Nuclei far from stability

- Large angle coverage
- high granularity



Conventional Electronics –TTT4

- 16 ch Preamplifier X16
- 16 ch Amplifier X16
- 16 ch Discriminator X16
- 32 ch ADC X8
- Crates, racks, cables …



128 ch Leading edge discriminator

High granularity DSSD in HKU

Number of Strips: 128X128

Strip Width: 760(60) um

DSSD in Total

- 8 X TTT Series DSSDs
- 2048 channels readout electronic

Why do we need GET System for Silicon

Silicon Array Detection System

-- Radioactive Nuclei far from stability

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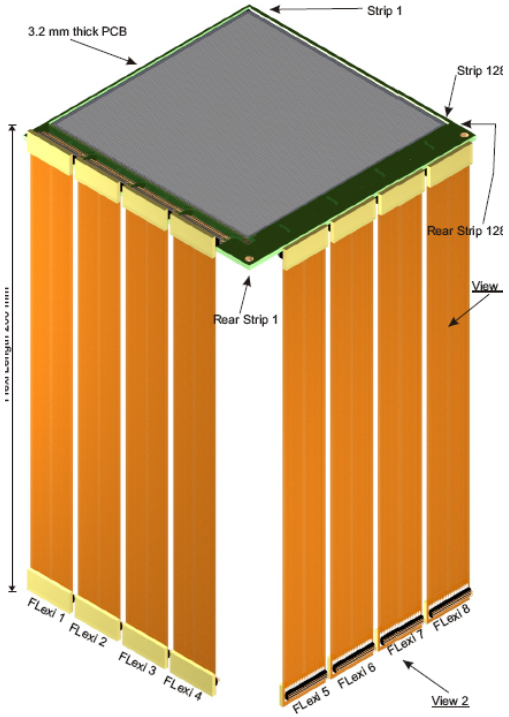
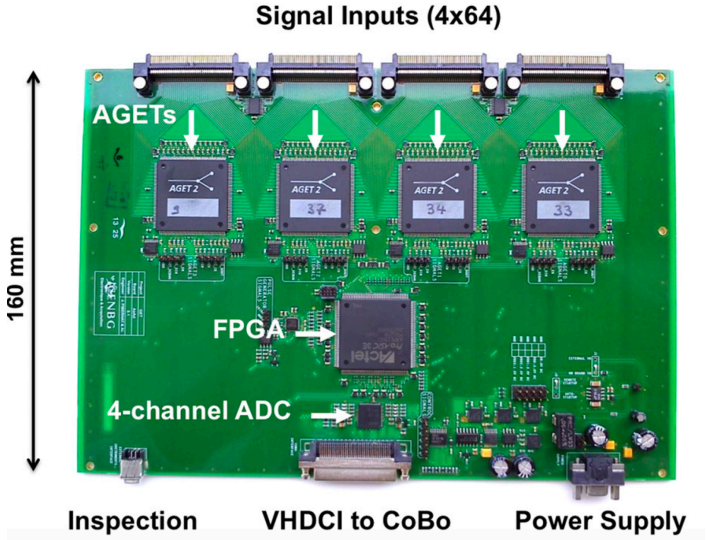


GET System – TTT4



From E.C. Pollacco, et al, NIM Phys. Res. A 887(2018) 81

High granularity DSSD in HKU

Number of Strips: 128X128

Strip Width: 760(60) um

DSSD in Total

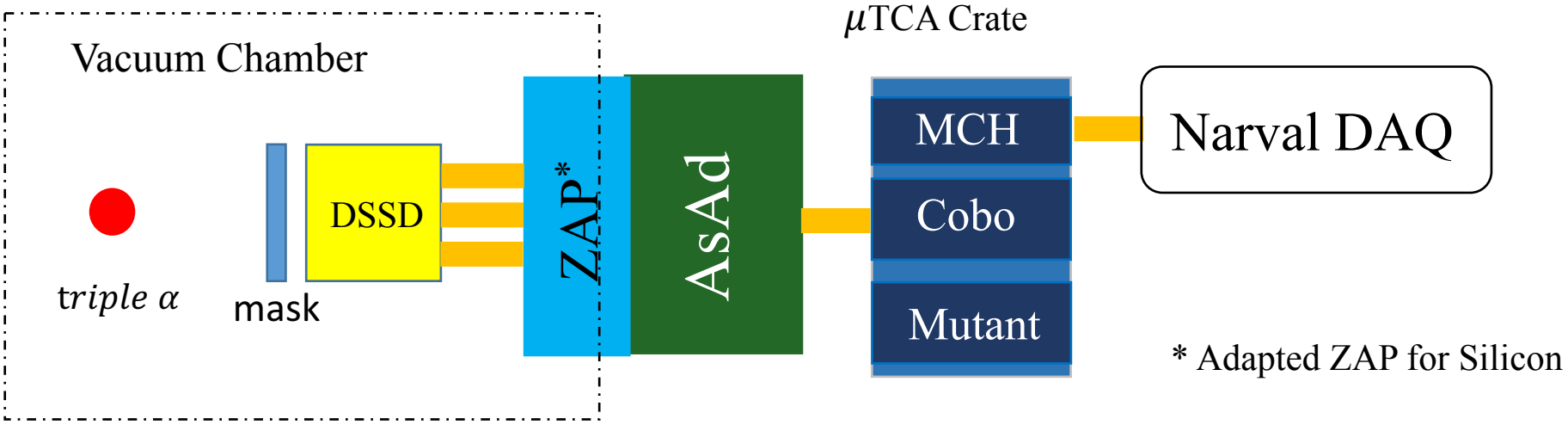
- 8 X TTT Series DSSDs
- 2048 channels readout electronic

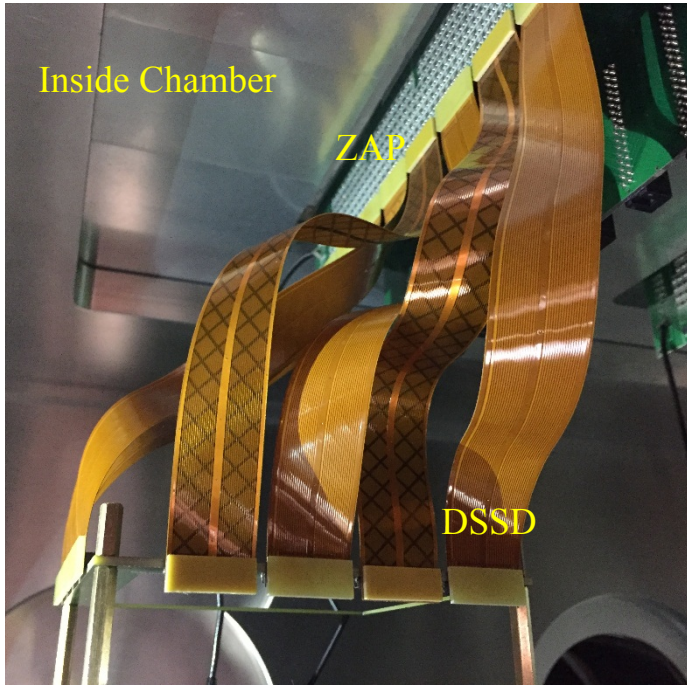
All front end electronics included in AsAd Board

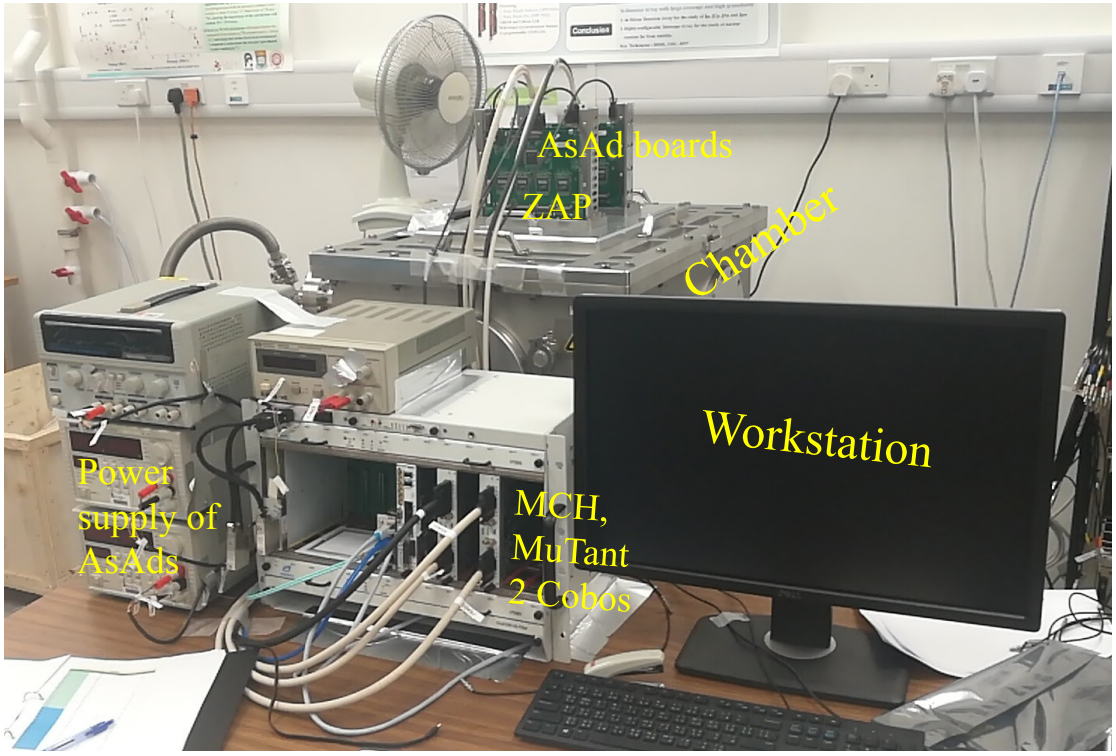
Performance Test of Si+GET @HKU

- Noise level with silicon detectors
- Energy Resolution compared to conventional electronics
- Performance consistency between channels

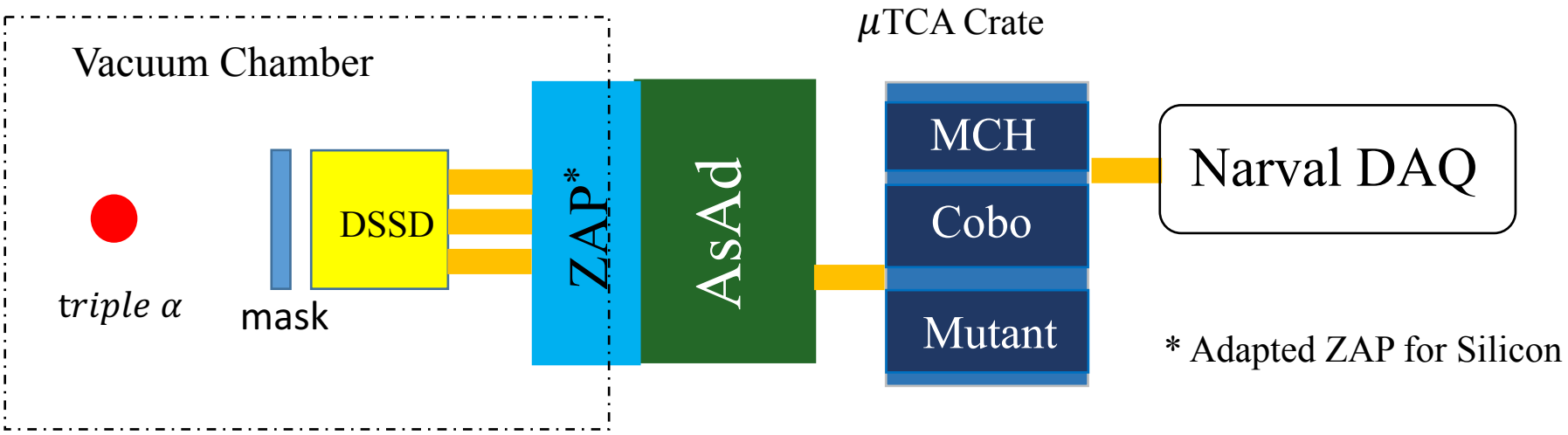
Si-GET Test Bench @HKU







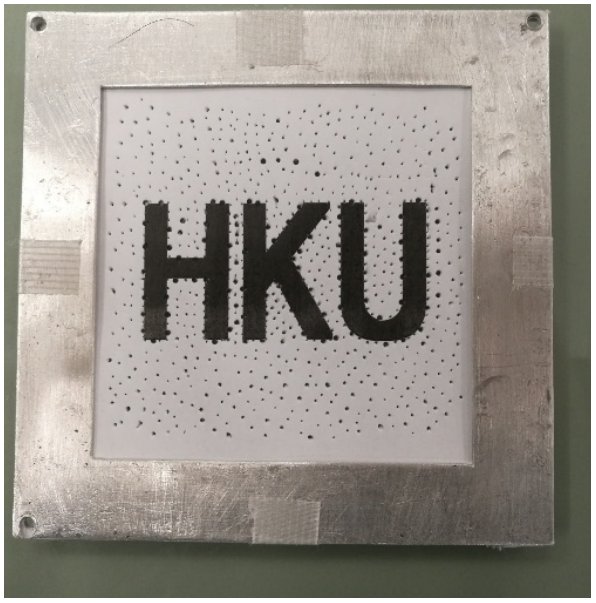
Si-GET Test Bench @HKU

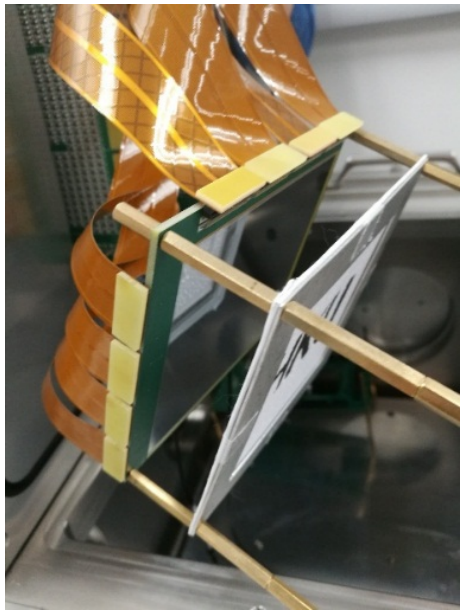


Triple source components

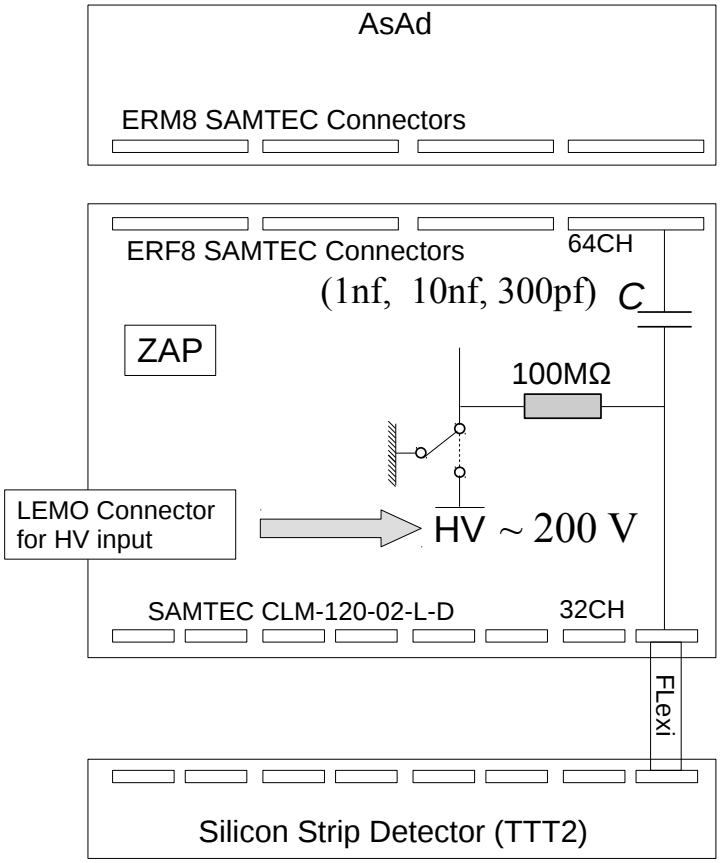
Nuclides	Energy (keV)	Intensities (%)
239 Pu	5105.5(8)	11.94(7)
	5144.3(8)	17.11(14)
	5156.59(14)	70.77(14)
241Am	5442.80(13)	13.1(3)
	5485.56(12)	84.8(5)
244Cm	5762.64(3)	23.10(10)
	5804.77(5)	76.90(10)

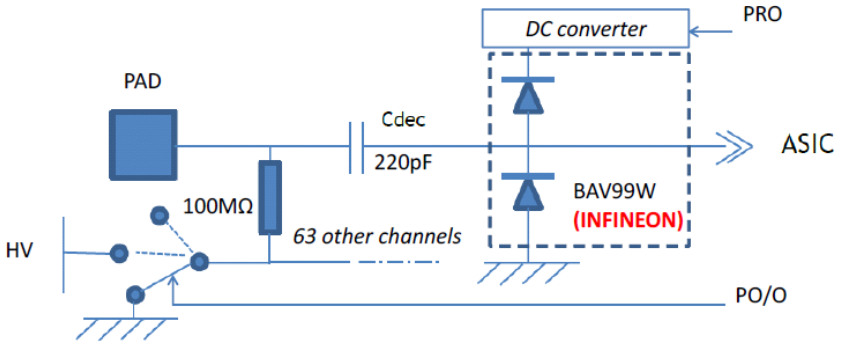
Mask used for checking readout mapping



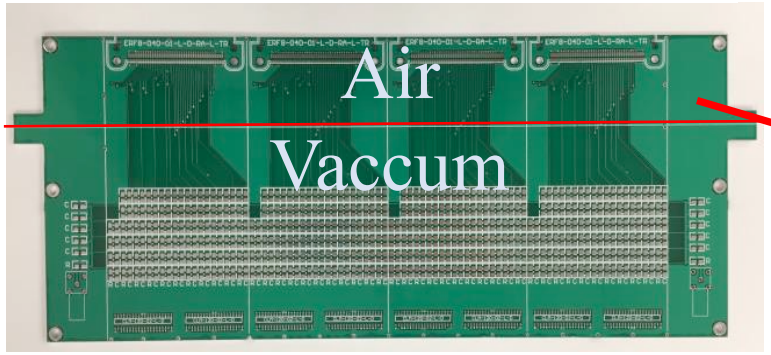


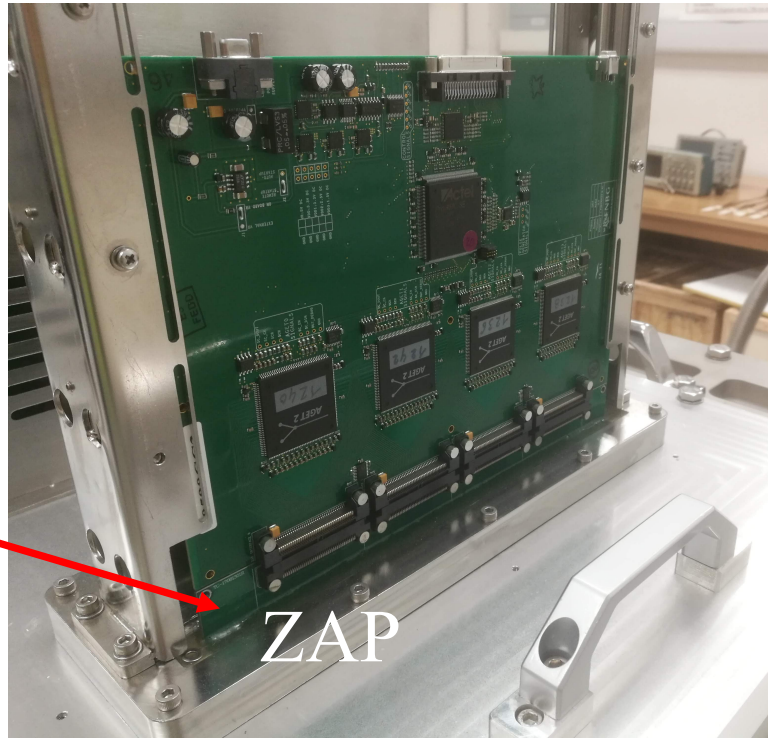
ZAP design





Schematic diagram for ZAP For TPC from ZAP_essential.pdf





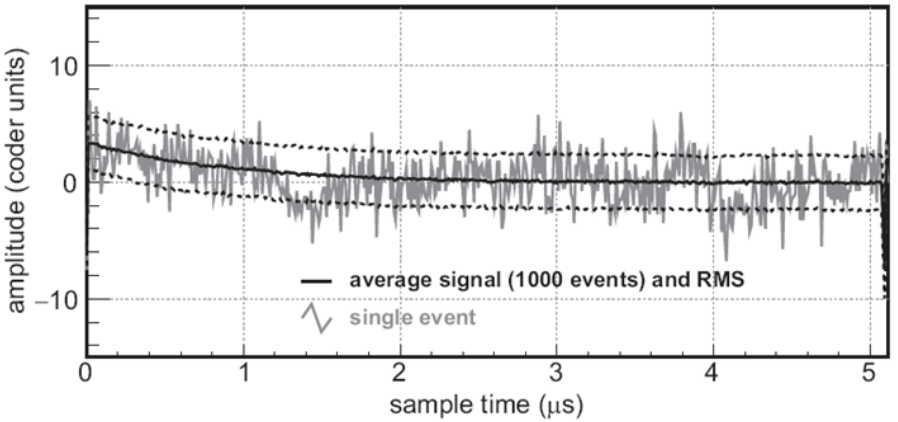
Data Analysis

FPN correction

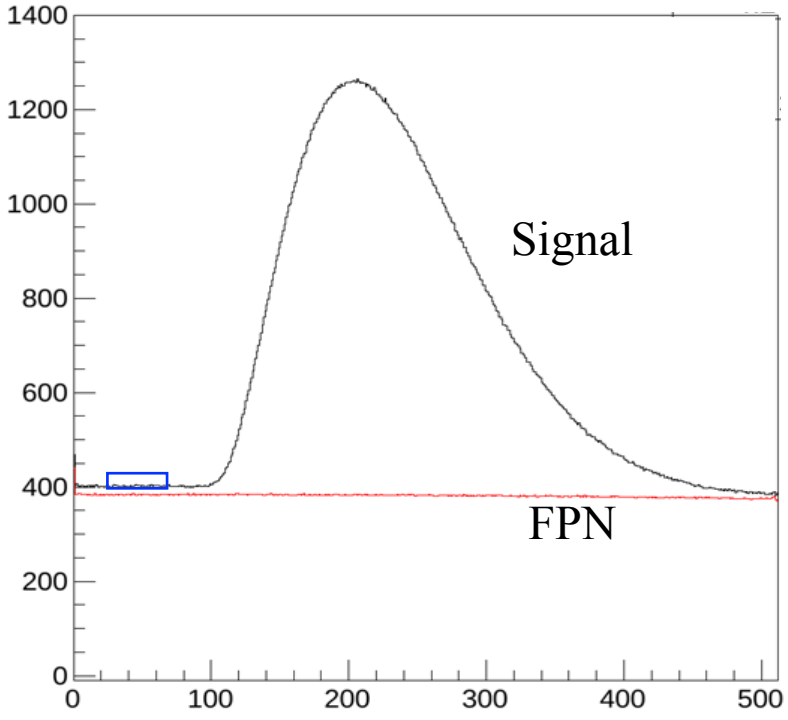
$s_{FPN}[k] = s_{sig}[k] - \mathrm{FPN[k]}$

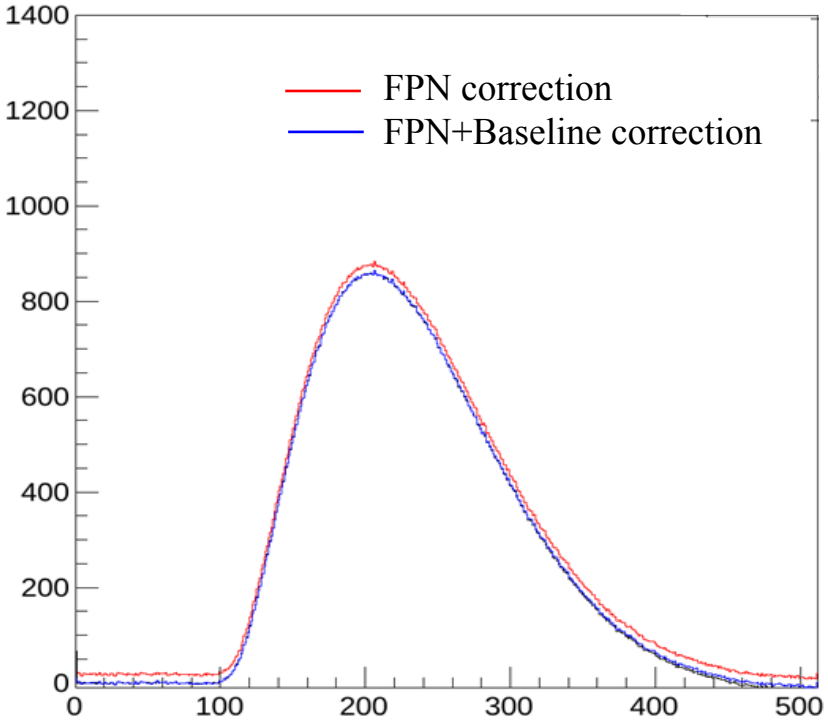
Baseline subtraction

$s_{cor}[k] = s_{FPN}[k] - \mathrm{Average\_Baseline}$

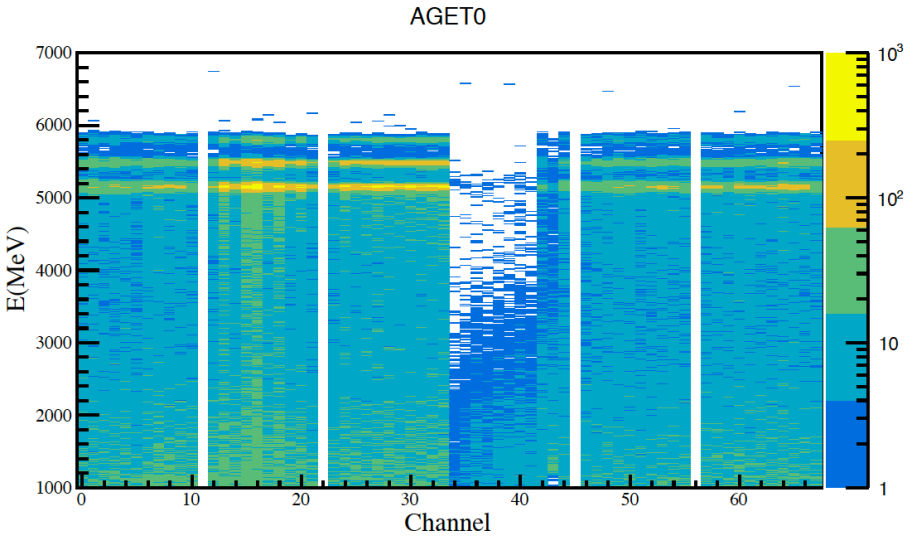


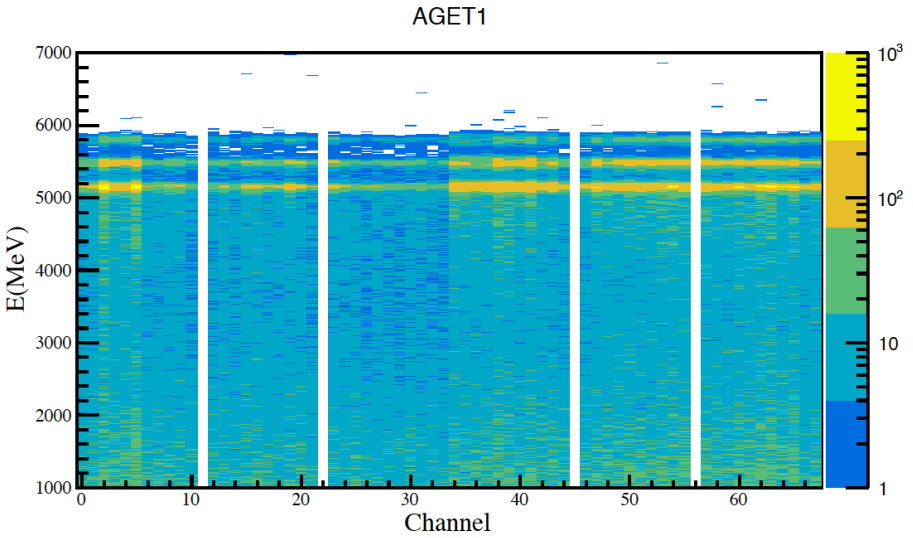
From J. Giovinazzo, et al, NIM Phys. Res. A 840 (2016) 15

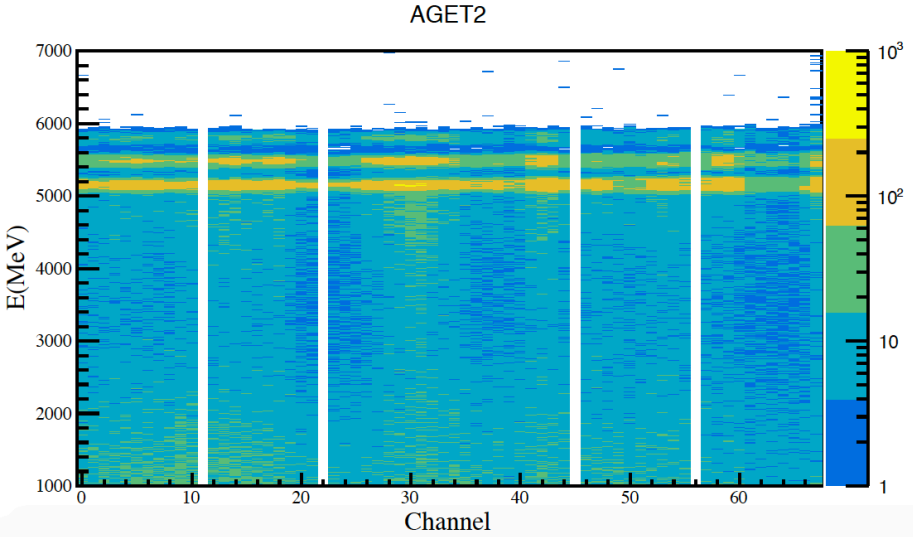


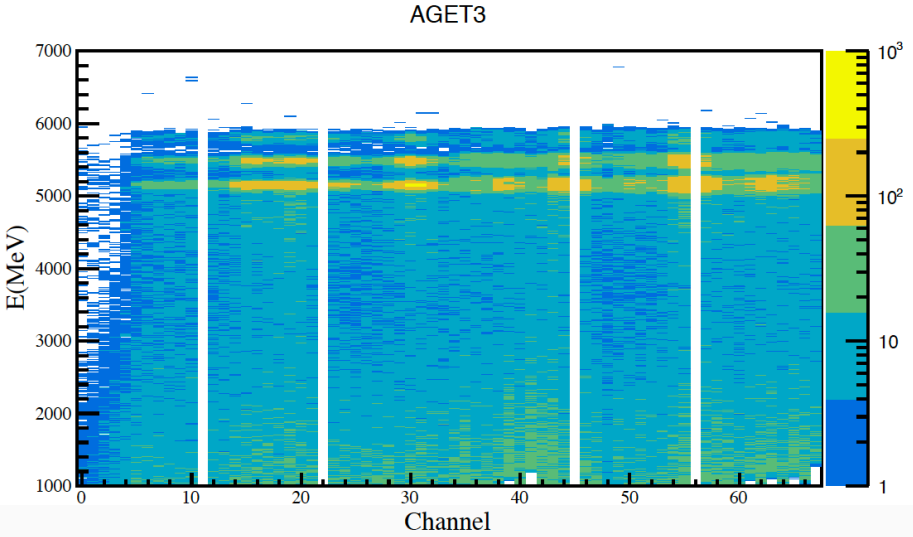


Summary spectrum for TTT4



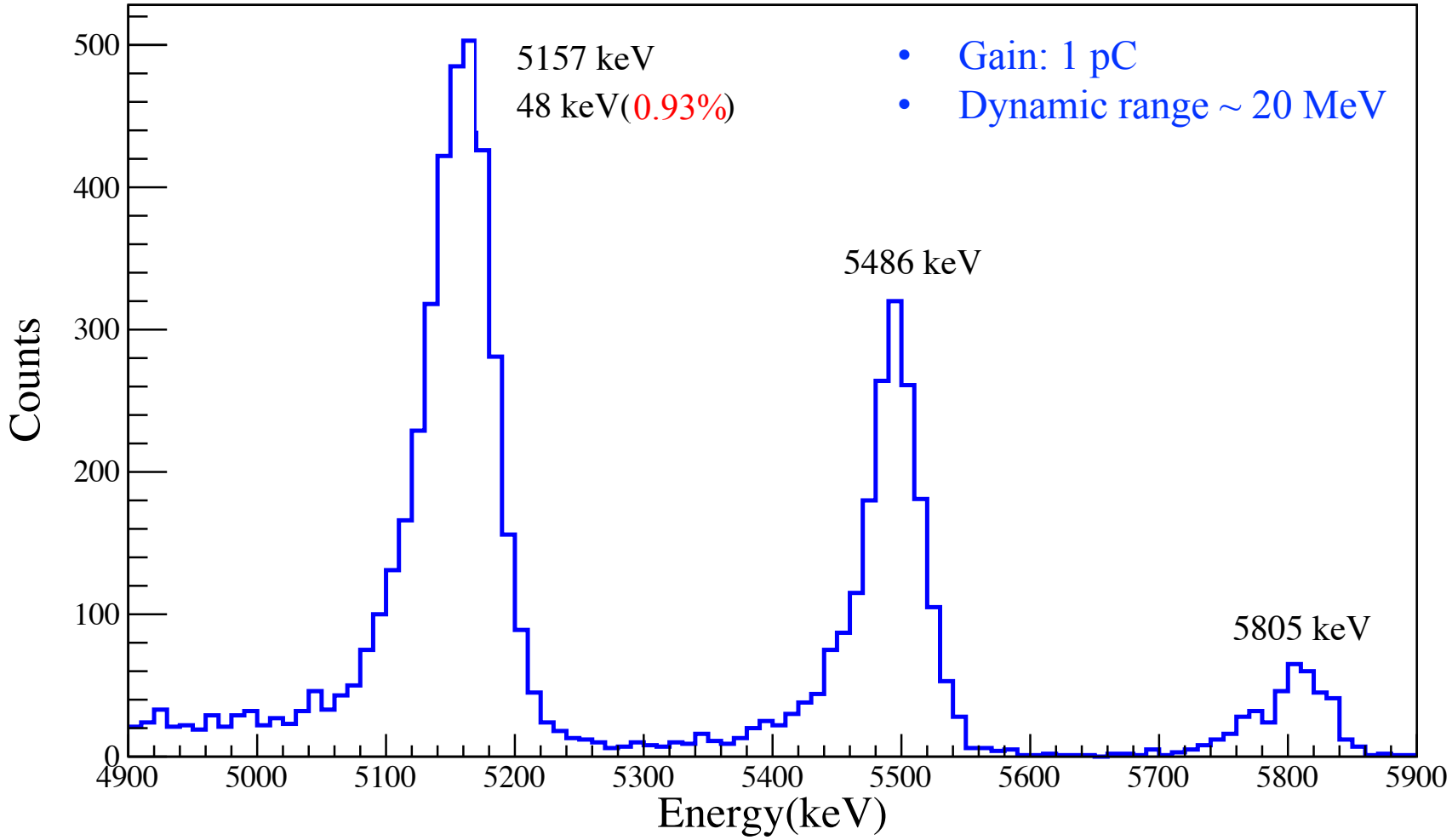




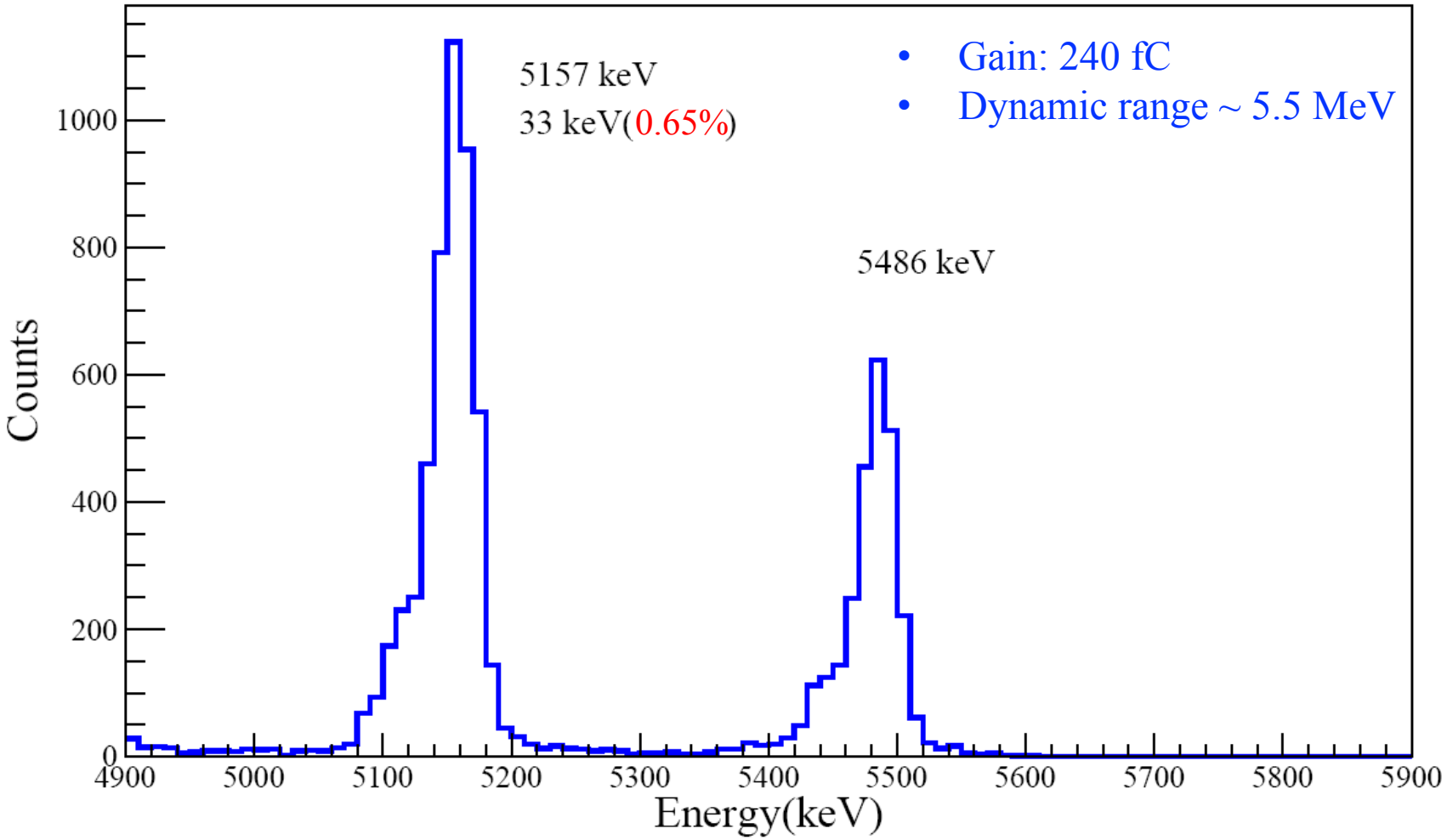


- Channels without full spectrum are strips located at the edge of DSSD and alpha particles are blocked by mapping mask.

Energy Spectrum from one strip



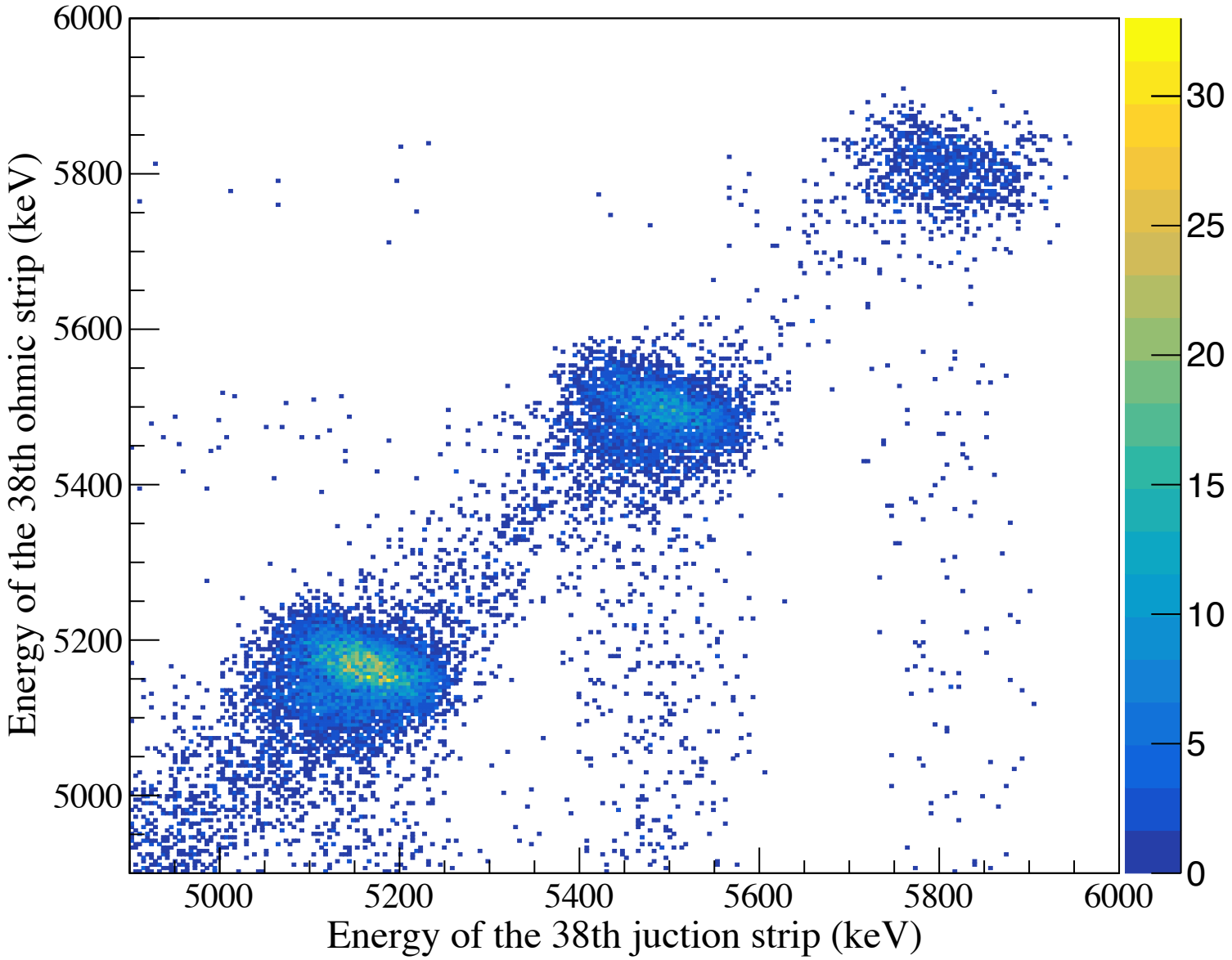
Energy Spectrum from one strip



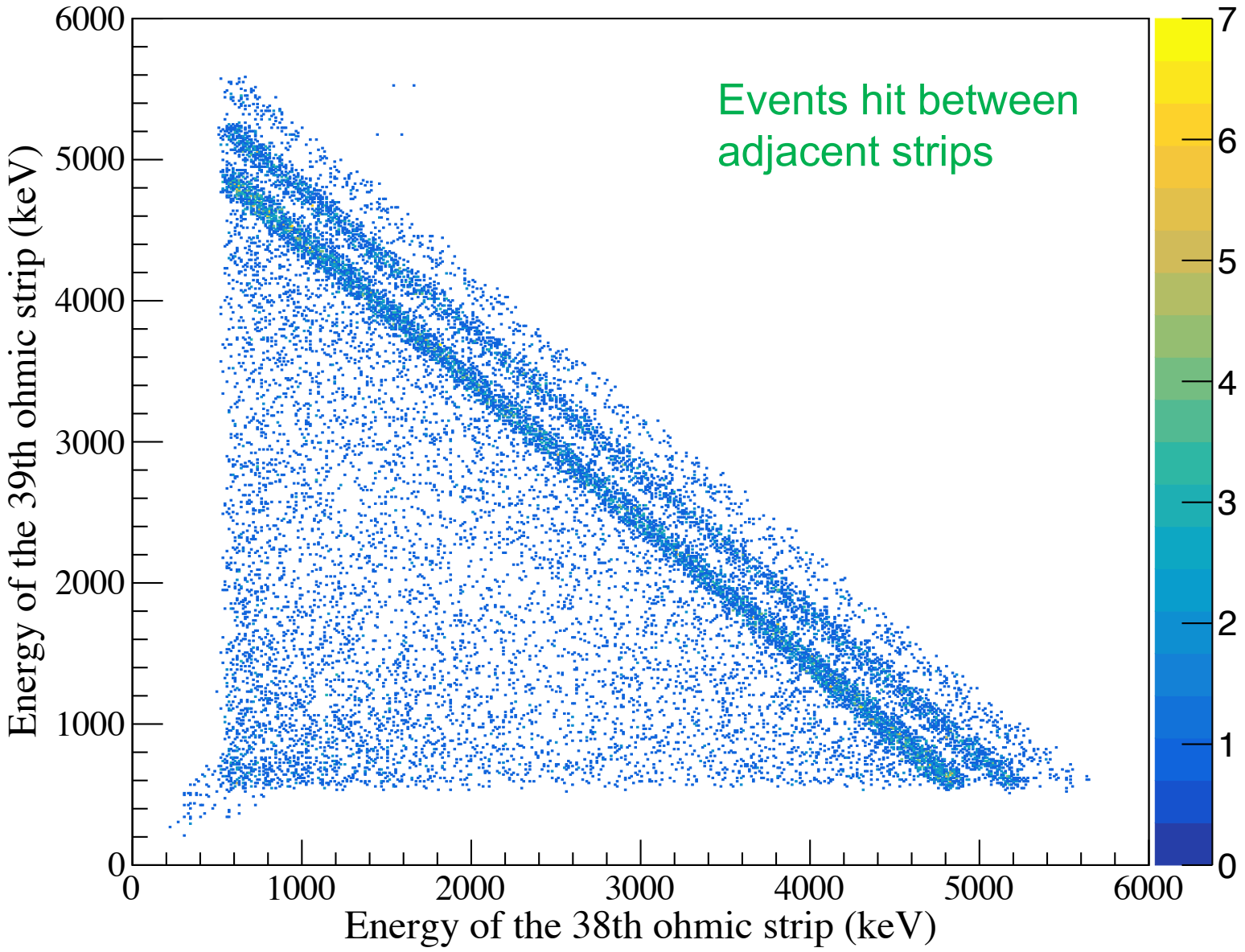
- Gain: 240 fC
- Dynamic range ~ 5.5 MeV

- Signals from third peak are saturated under the condition of gain @240fC

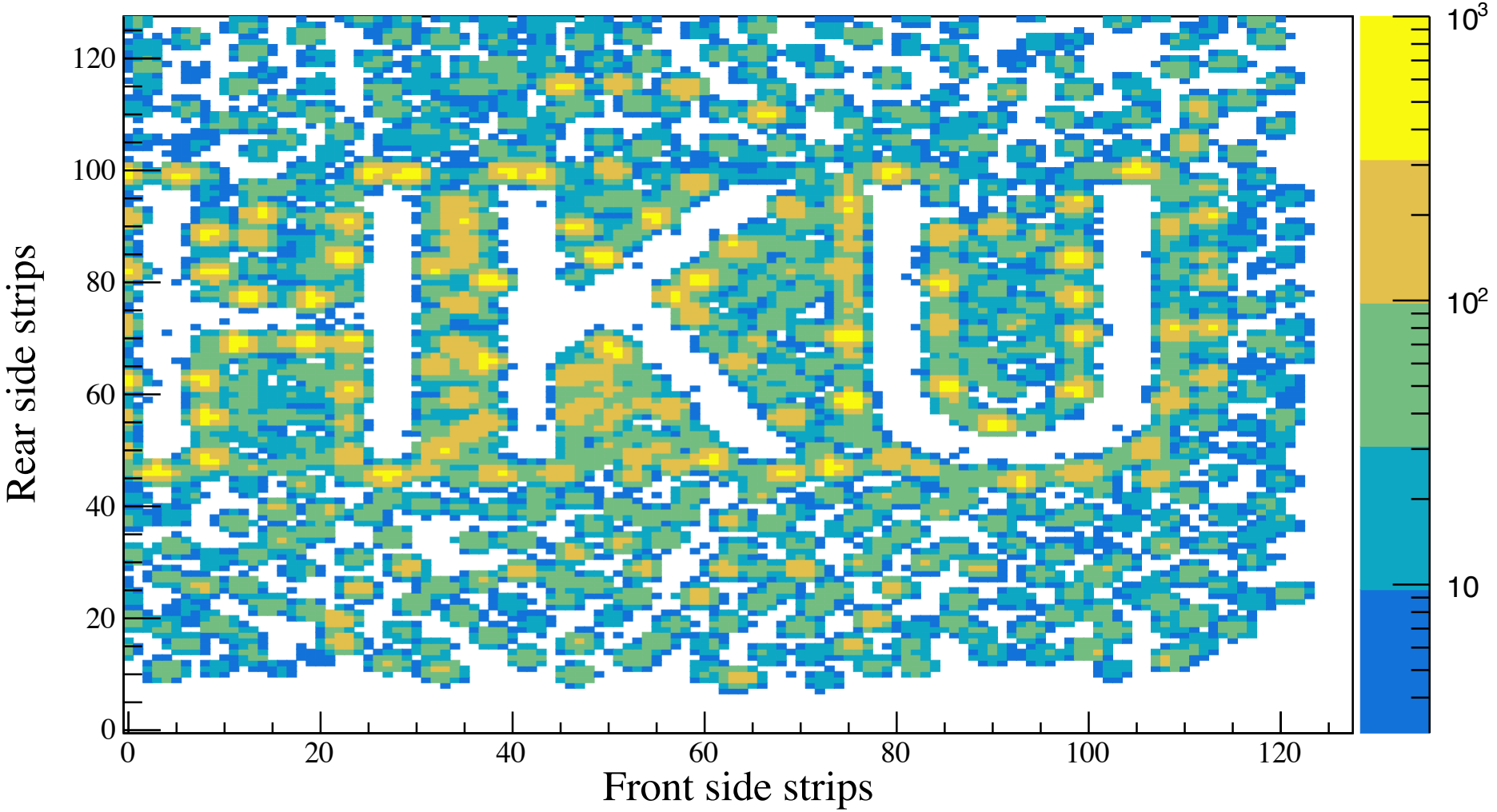
Coincidence between front and rear strips



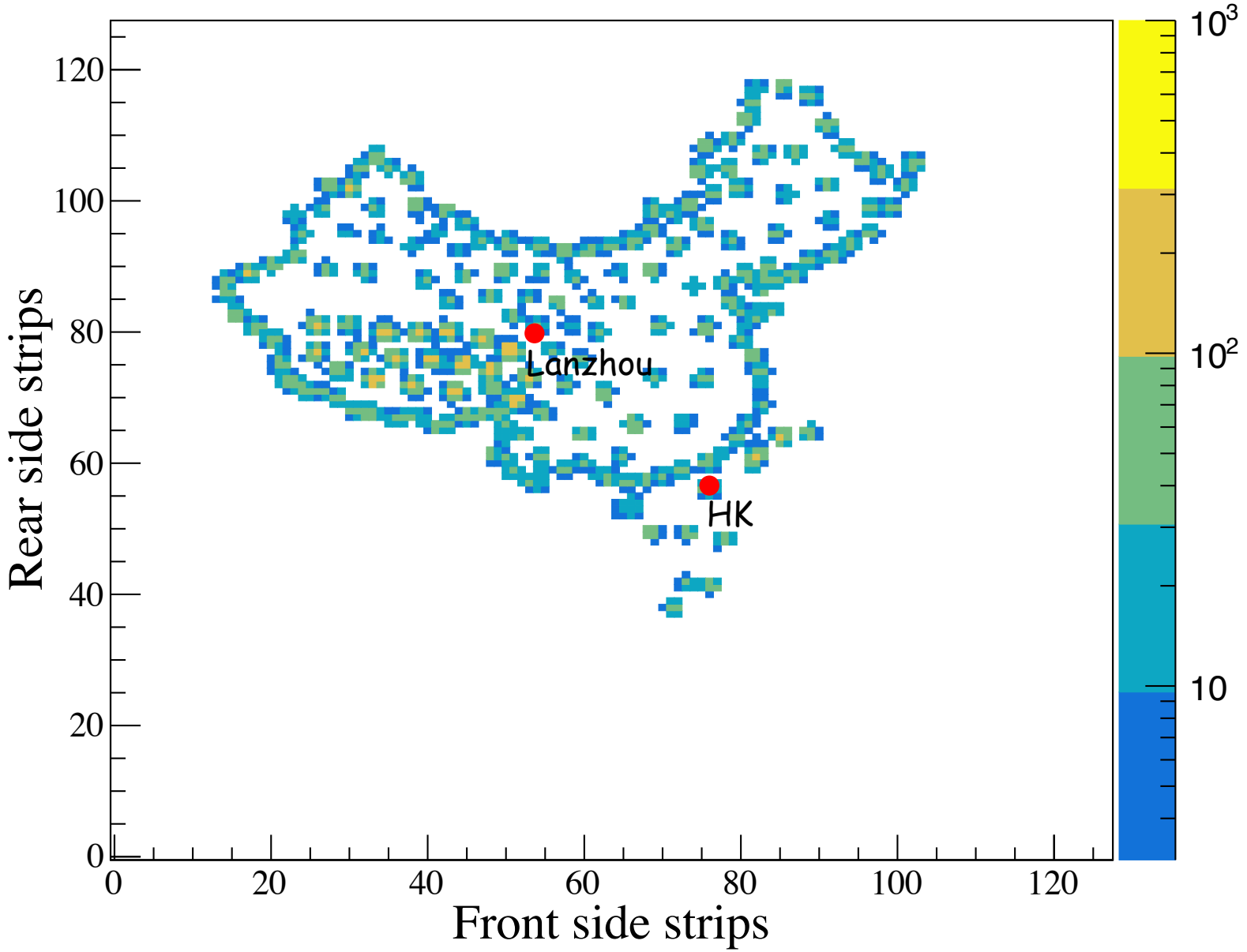
Coincidence between adjacent strips



HKU Map used to check strips mapping



China Map used to check strips mapping



Summary

1) Successfully apply GET system to DSSD readout, using 2 Cobo and multiple AsAd boards with Narval DAQ

2) Energy resolution (FWHM) for Alpha @5.15 MeV
   - Better than 1% at Gain 1pC
   - ~ 0.65% at Gain 240 fC
   - Better than conventional electronics in general

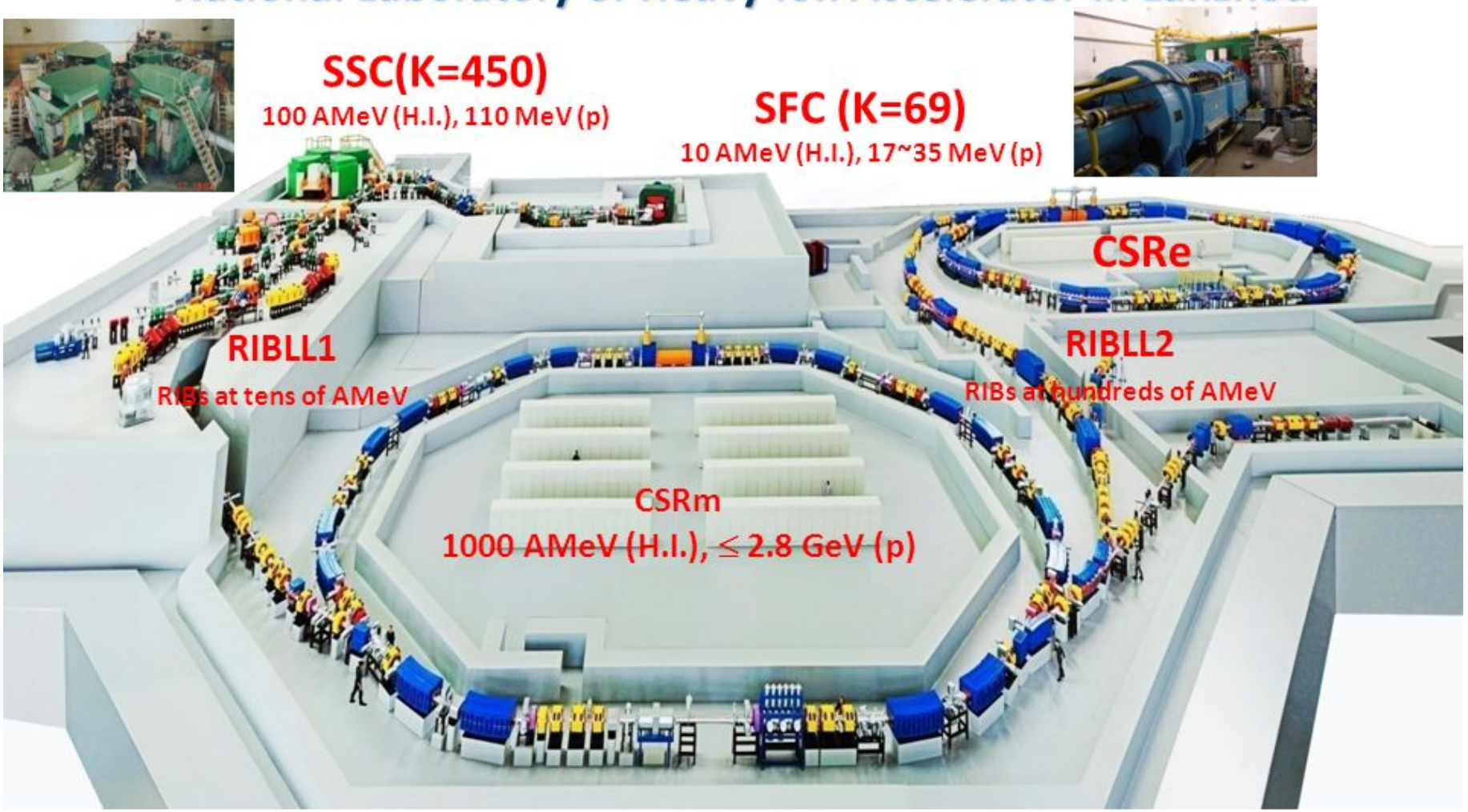
3) Coincidence between strips from front to rear side or adjacent strips is checked

4) Mapping is checked by putting mask in front of DSSD

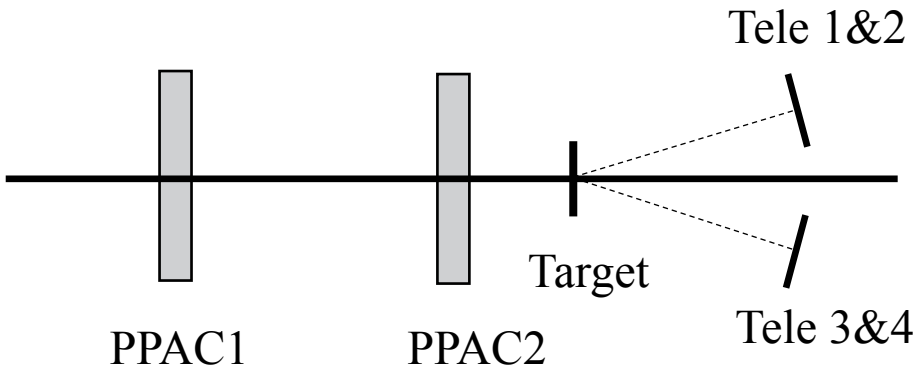
Future Plans

- CsI(Tl) detector test with GET system
- Commissioning run @HIRFL, Lanzhou, China in 2019
- Construction of full setup of Si-CsI Array with GET at HKU (expected in Fall 2019)

Commissioning run @HIRFL in Lanzhou



Commissioning run @HIRFL in Lanzhou



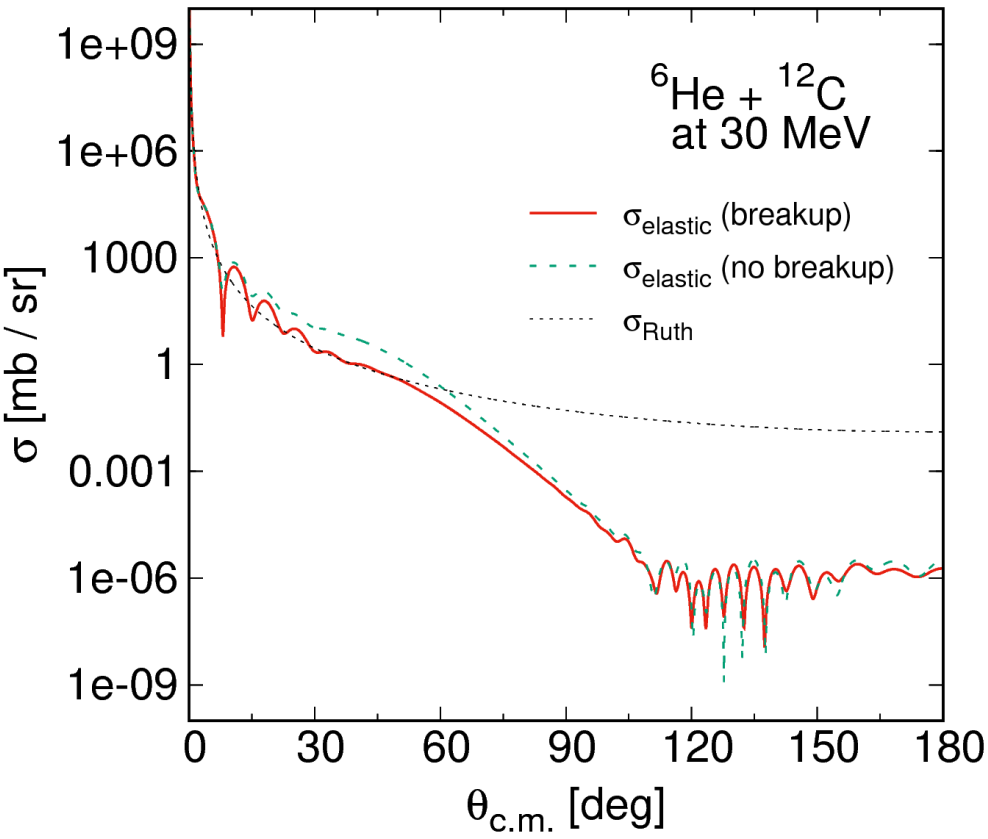
Telescope readout electronics

GET system

^{6}He + ^{12}C scattering @ 30 MeV/u

- Breakup experiment in 2019
- Physics goal is study 4 body effect
- Angular distribution of the elastic cross section will be measured
- Beam time ~ 2days
- Beam intensity 10^{4} pps in Lanzhou

CDCC Calculation from Ogawa-san



Commissioning run @HIRFL in Lanzhou

Si+GET test in experiment

- Stability during experiment
- Noise environment influence compared to lab test
- Energy Resolution compared to conventional electronics
- Trigger condition, limit of counting rate
- DAQ Test, integrated with other DAQ system

Big Thanks

GET Team collaboration for great support and discussions

J.L Pedroza, J. Pibernat and G. Wittwer for visiting HKU lab and great help for the setup of Si+GET test bench

T. Isobe-san for the visit of HKU and great help on the setup of DAQ and many other things.

Thank you for your attention