Sci-Fi detector for DPS

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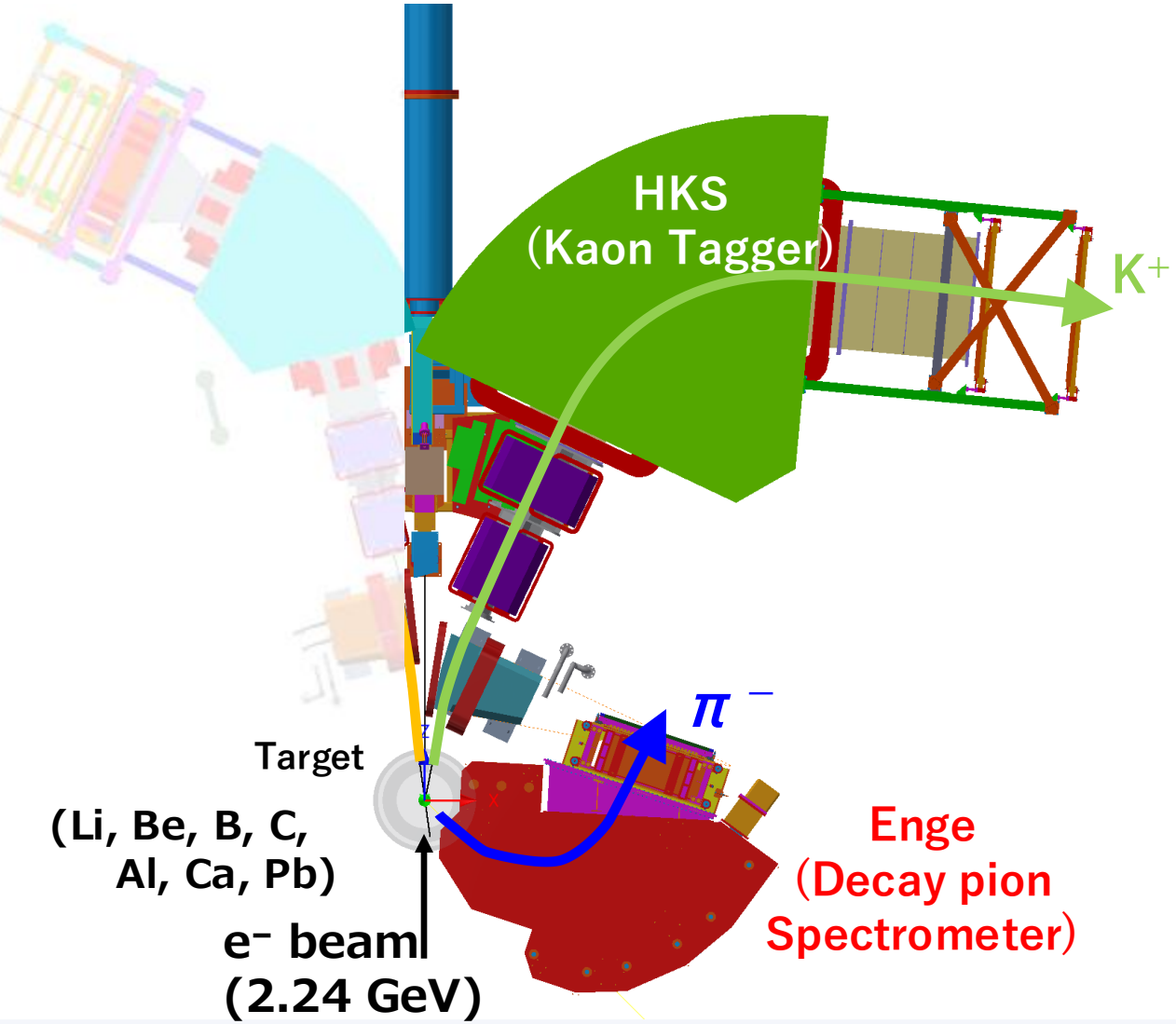
- Role of Sci-Fi detector

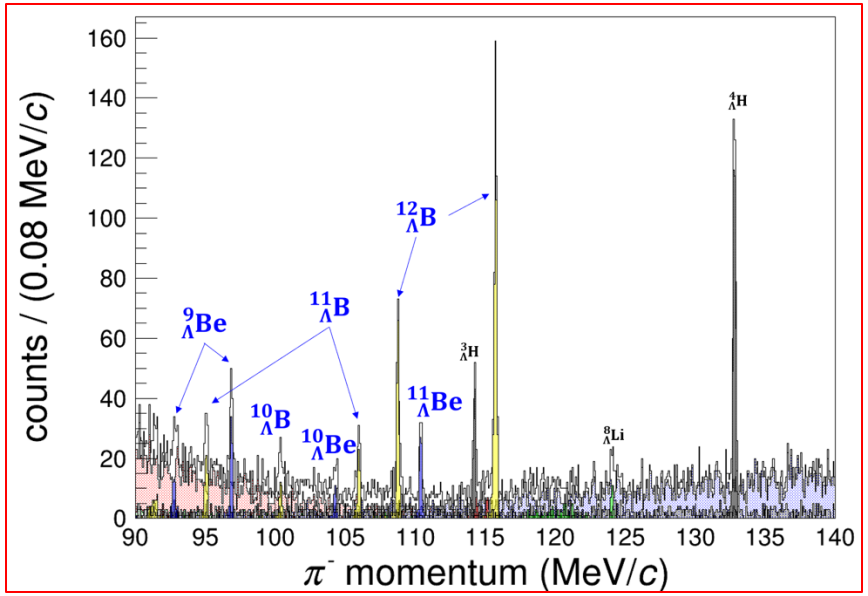
- Design of Sci-Fi detector
  - scintillating fiber
  - photon detector : MPPC
  - readout : NIM-EASIROC

- Fiber test status

- Timeline

ENGE for decay pion spectroscopy





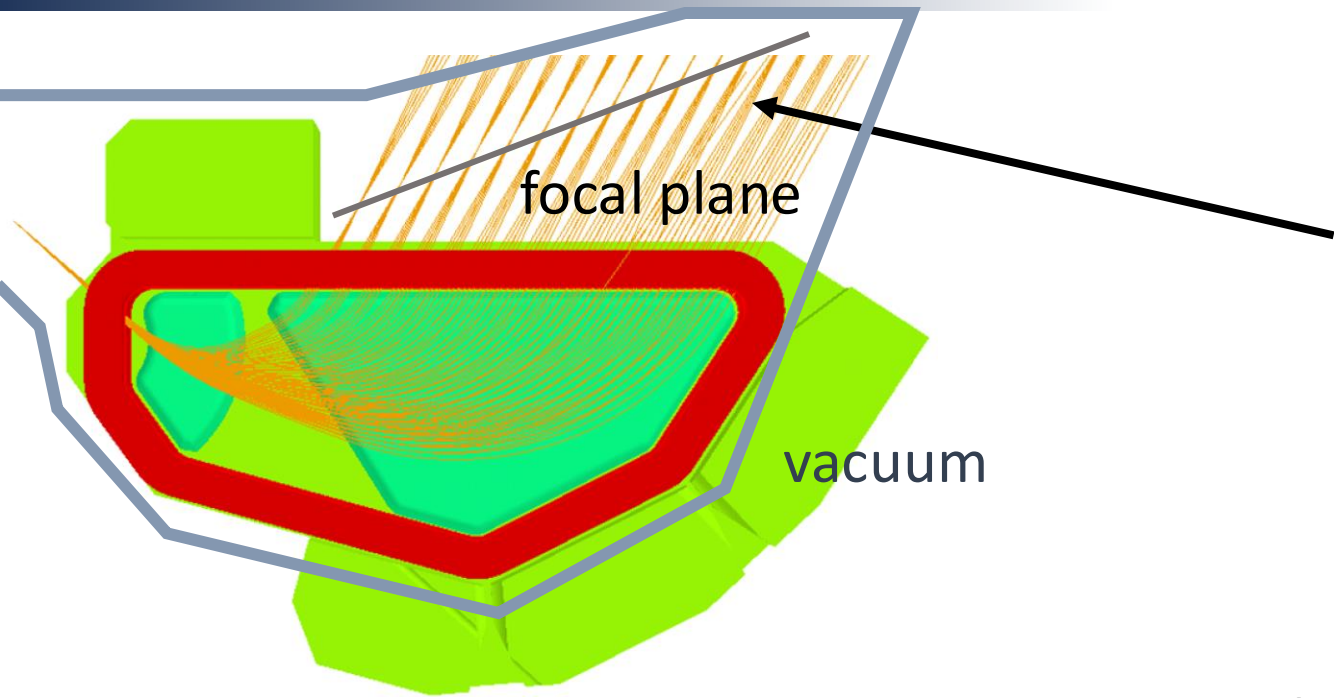
$$m({}^{A}_{\Lambda}Z) = \sqrt{m({}^{A}(Z+1))^2 + p_\pi^2} + \sqrt{m_\pi^2 + p_\pi^2}$$

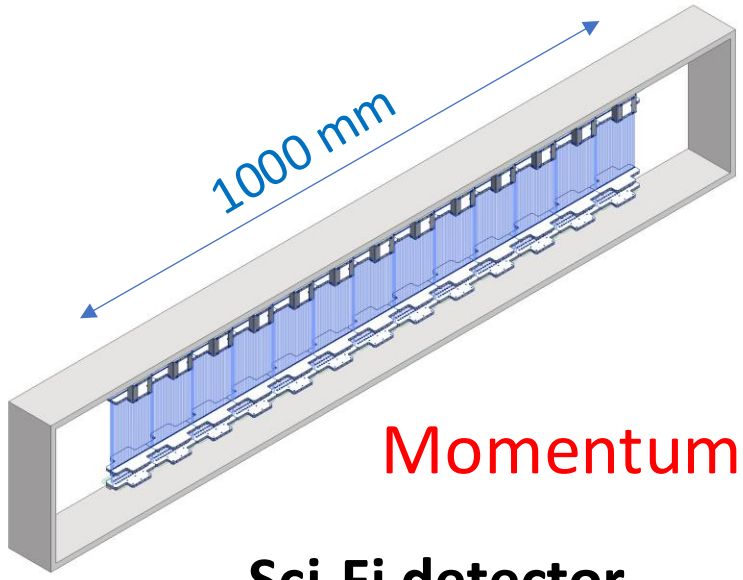
Momentum (p_π) measurement by Enge

- High resolution: a few 100 keV/c [FWHM]
- Good accuracy : a few 10 keV/c
- wide momentum bite: 80 – 140 MeV
- Backward angles

Kaon tag by HKS

ENGE design and Sci-Fi requirement





Momentum = Position !

Sci-Fi detector

Type	Hardware spectrometer
Central Momentum	~ 110 MeV/c
Momentum bite	+/- 30%
Dispersion	0.66 (MeV/c)/cm
Solid Angle	4 msr

expected resolution : $\Delta p/p \sim 4 \times 10^{-4}$

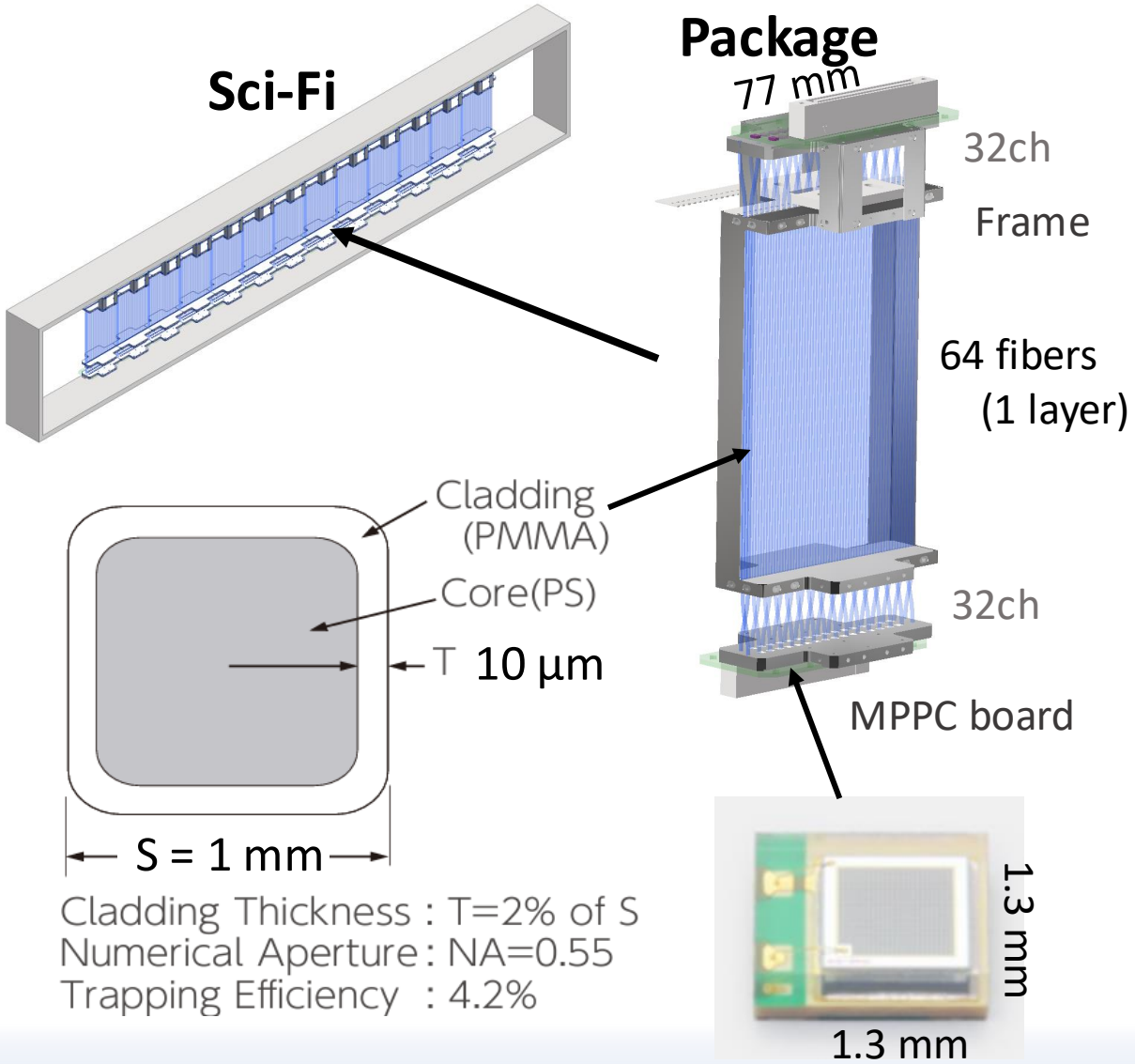
positional info. at focal-plane

1.2 mm pitch (80 keV/c)

momentum coverage : 78 ~ 140 MeV/c

1000 x 100 mm^2

Focal Plane Detector (Sci-Fi) design



Sci-Fi detector

- 1000 x 100 mm^2
- single layer
- 13 smaller packages

64-ch Package

- 1 x 1 mm^2 square fiber (Kuraray SCSF-78)
- 1.2 mm pitch (80 keV/ bin)
- 64 fibers/cell

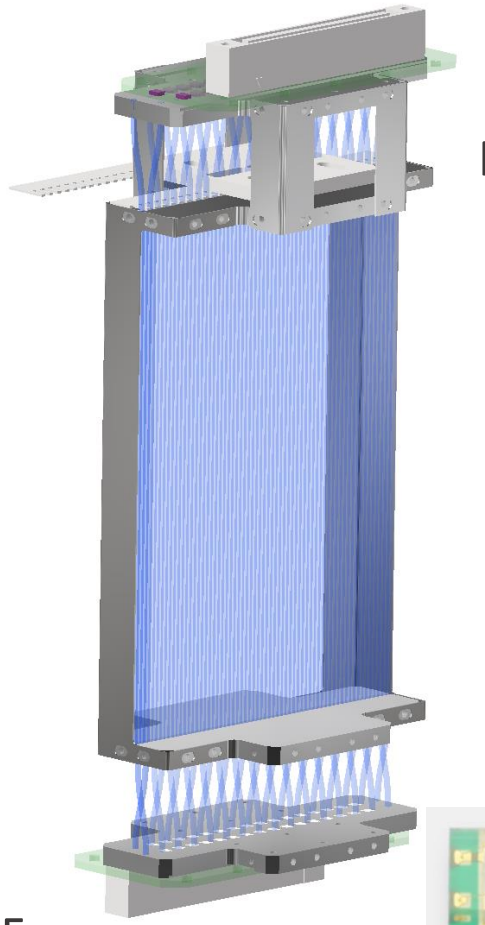
Photon Sensor : MPPC(SiPM)

- One-way readout for each fiber
- MPPC : Hamamatsu S13360-1350PE
- 1.3 x 1.3 mm^2

64 x 13 = 832 fibers, MPPCs in total

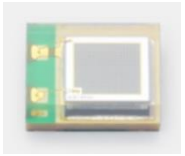
64-ch Fiber package

0.5 mm pitch coaxial (Hirose DF80)



Frame

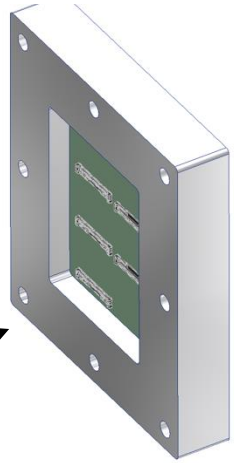
Frame
+ MPPC board



Analog out,
Thermal, Bias

40pin
coaxial

Signal port
on chamber



vacuum in Enge

+ 60 V Bias (common)

NIM-ASIROC Module on or under the platform

Analog out,
Thermal

34pin
Flat cable

64 ch x 13 modules

LVDS out

34 pin
Flat Cable

VETROC LR-TDC
@ SHMS

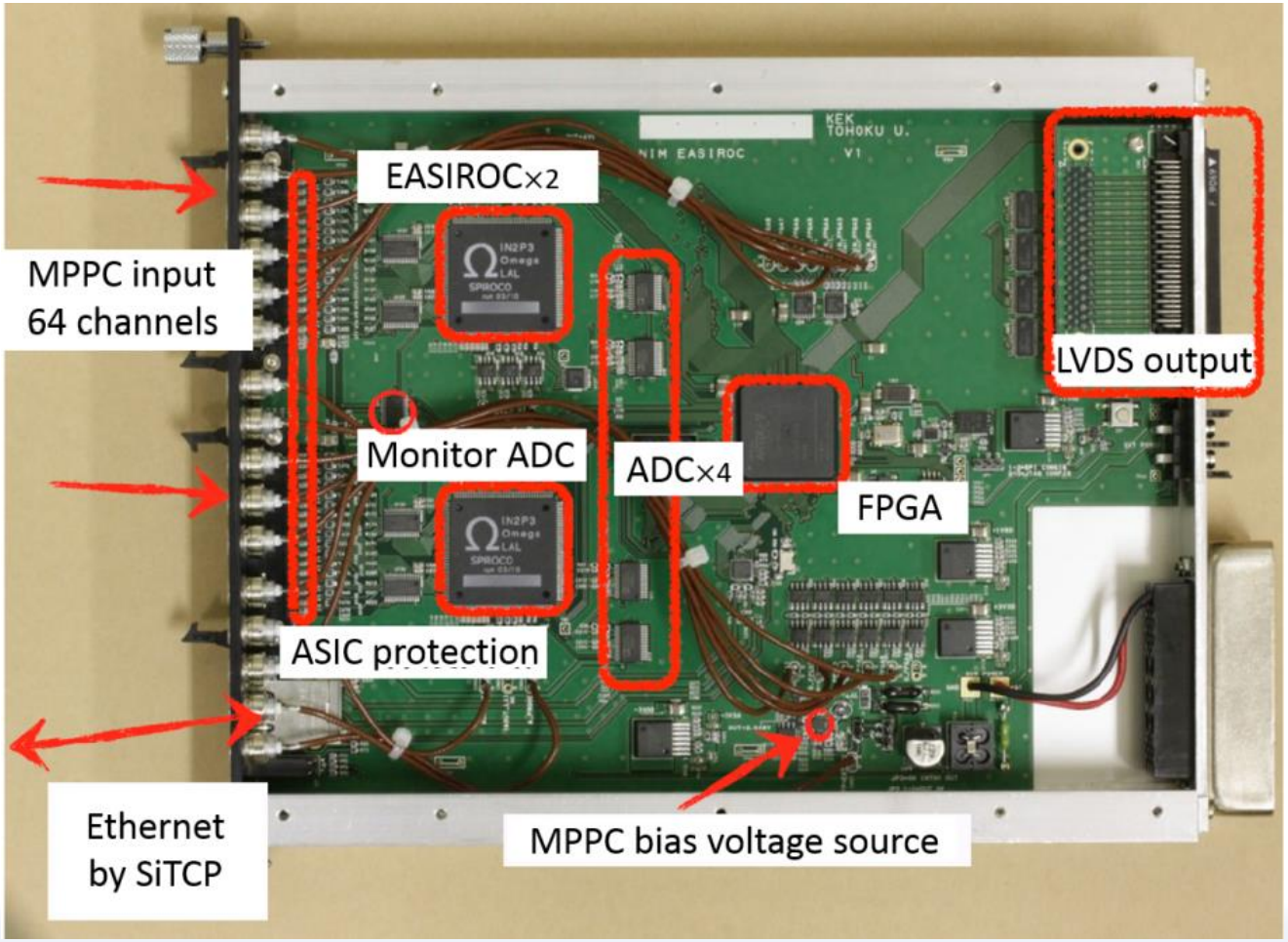
Readout – NIM-EASIROC module

EASIROC(ASIC) + FPGA + I/O module for MPPC
Developed and demonstrated for scintillating fiber detector at J-PARC

2 EASIROC ASIC
- Power : NIM crat or Cable
- 32 x 2 MPPC IN
- Preamp, Shaper
- Discriminator LVDS OUT
- 1 ns LSB Multi-hit TDC
- HV and threshold fine tuning in software

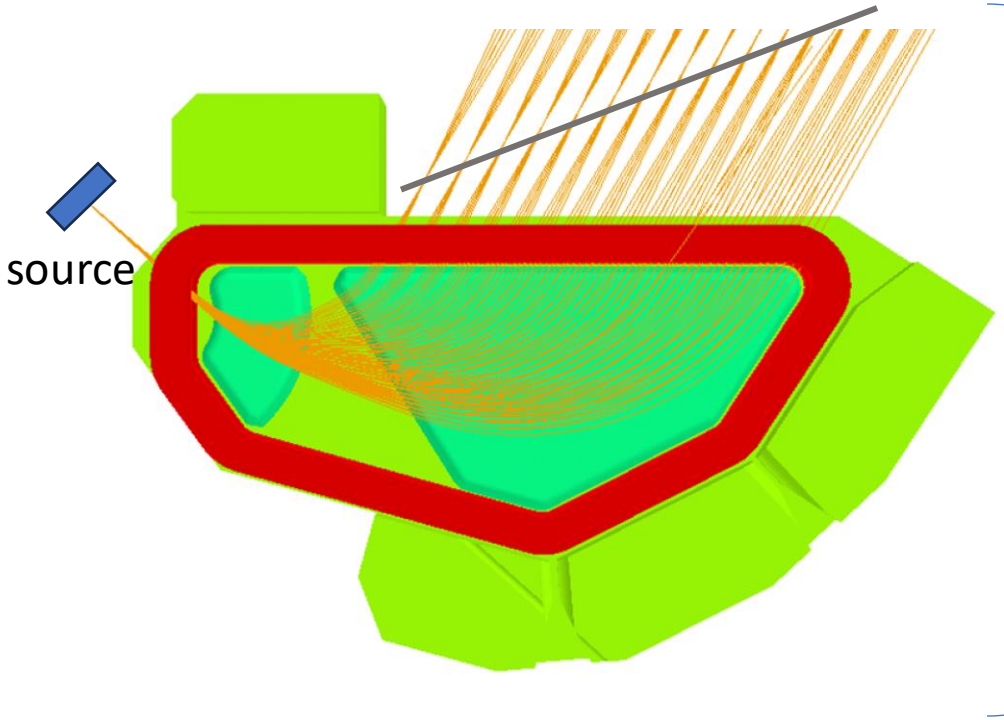
ADC
- 12-bit Pipe-line ADC
- 2 x 2

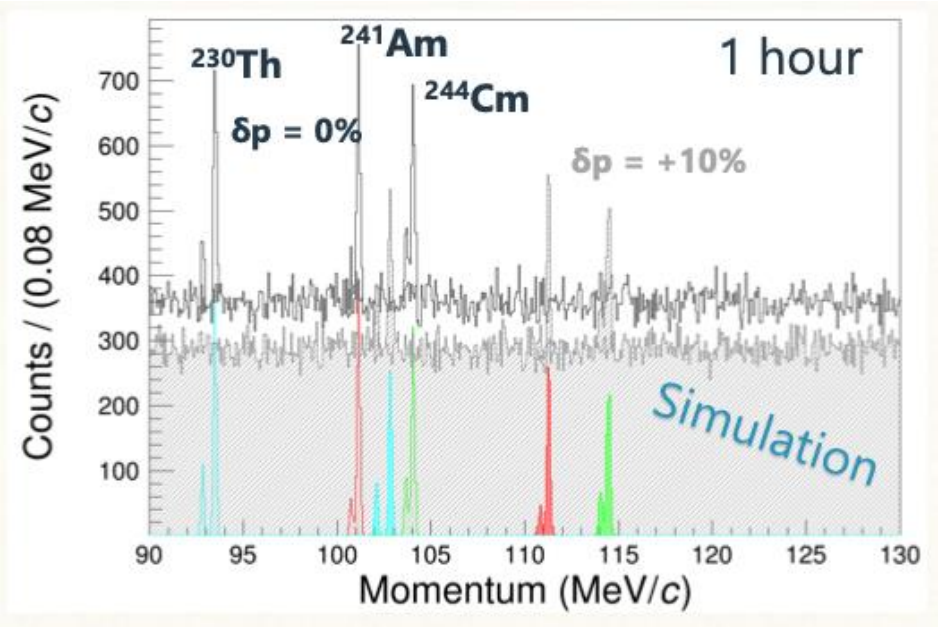
FPGA
- XC7A100T-2FGG676C



calibration with alpha source

Alignment of Sci-Fi along the focal plane
Calibrate fiber[ch] - momentum relation



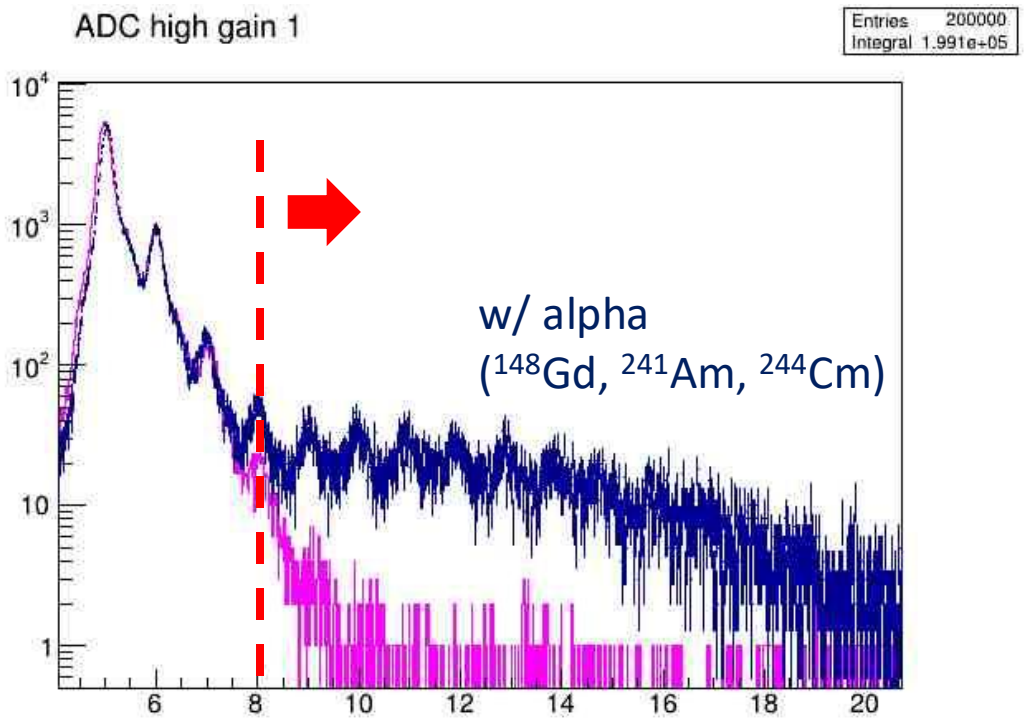


alpha source at target ladder
vacuum establishment
→ find Sci-Fi Z position & magnetic field

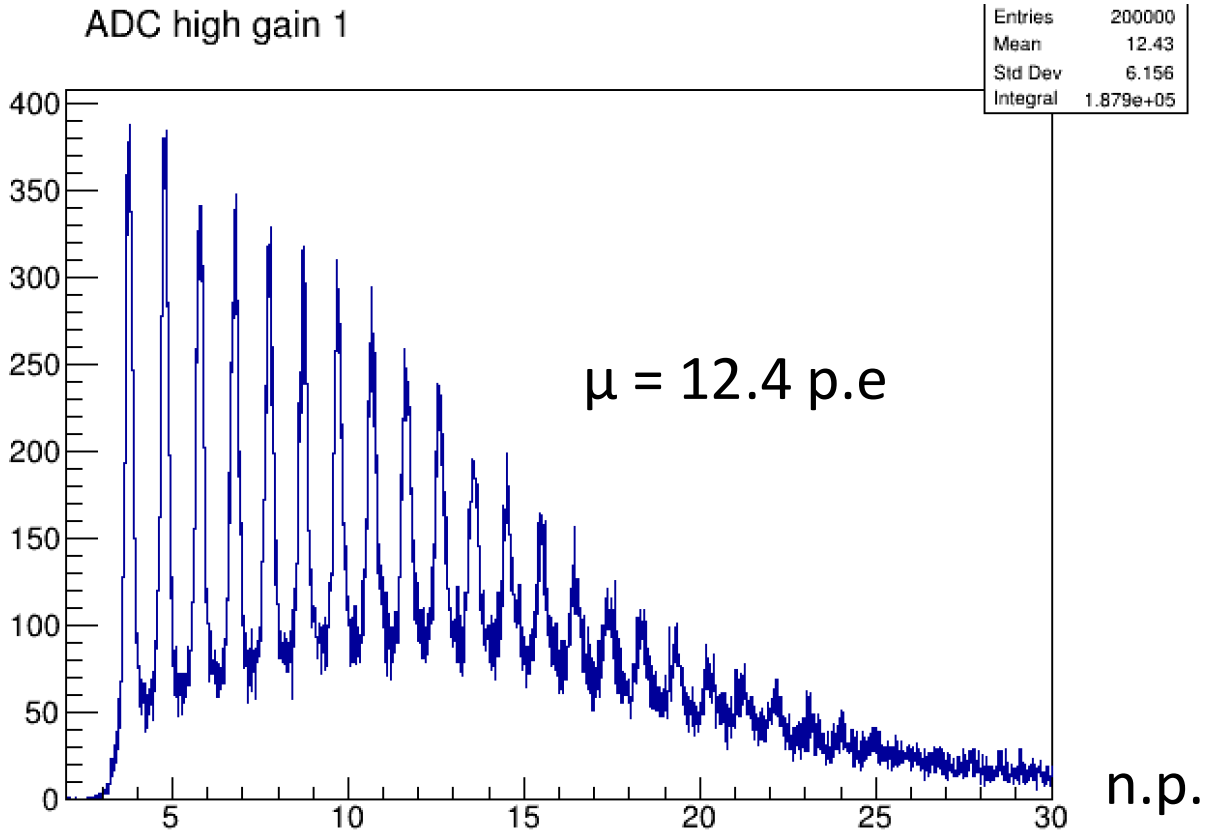
Sci-Fi requirement : alpha-ray sensitivity

single fiber test – N.P.E estimation

alpha-ray test for calibration

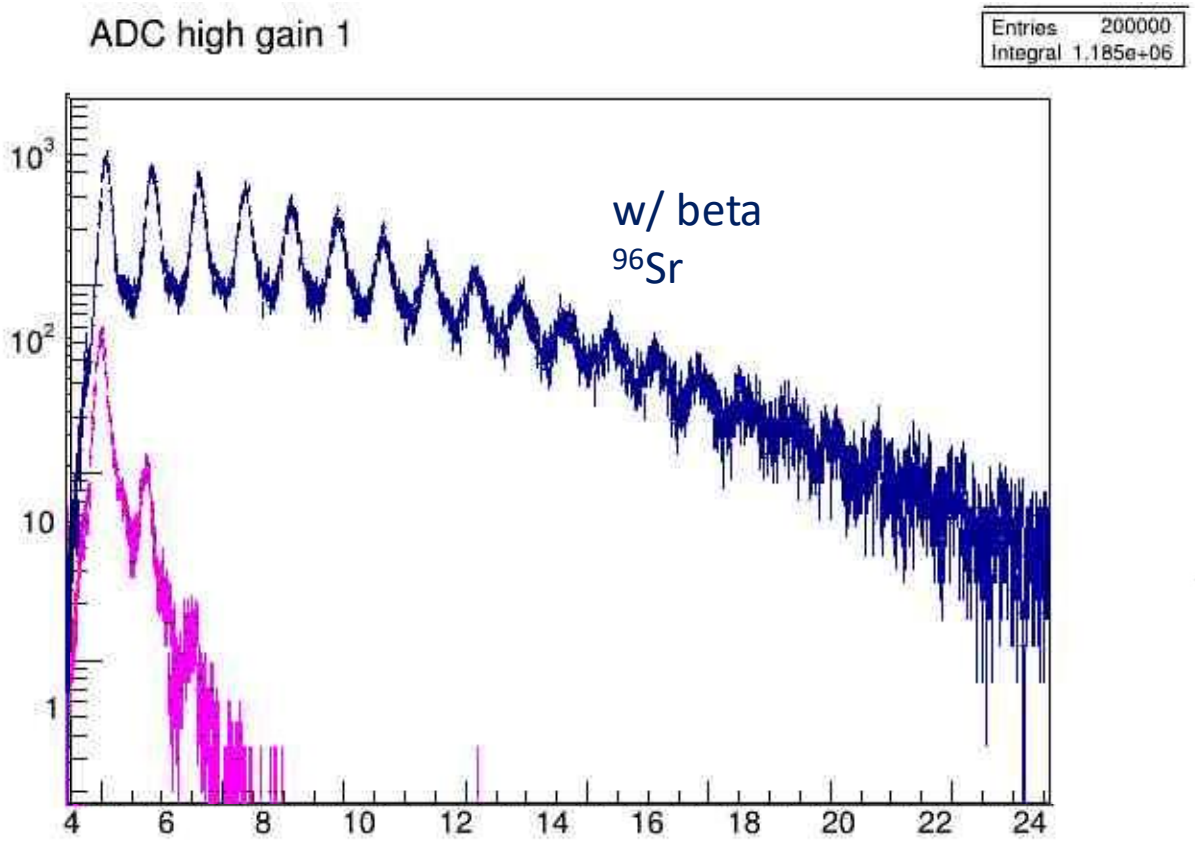


beta-ray test for π detection



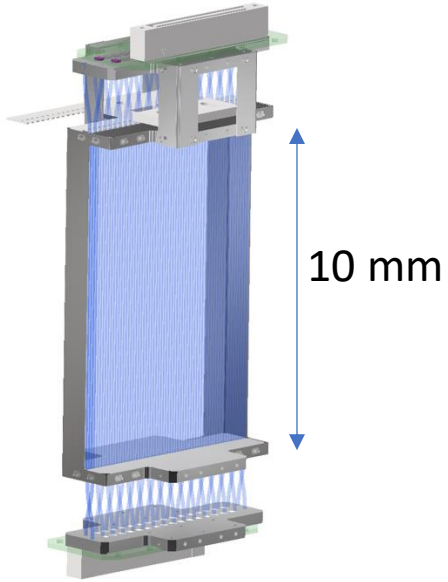
※ BG data is not available for this setup

beta ray test (preliminary)

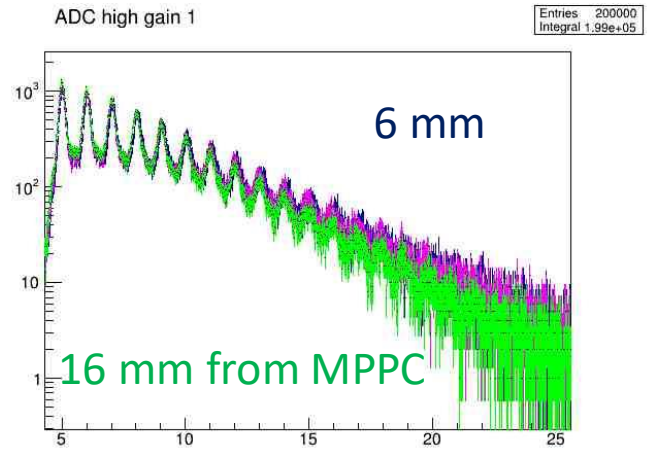


Signal discrimination is
expected to be achievable in principle

- need to measure efficiency
- possible effect of fiber-MPPC contact
- dark noise test



n.p.e. dep on y-position



mean value varies within roughly 10 %

Sci-Fi study

Single Fiber Test

[done] alpha-ray detection in vacuum

[done] hit position dependence

[pending] bending effect

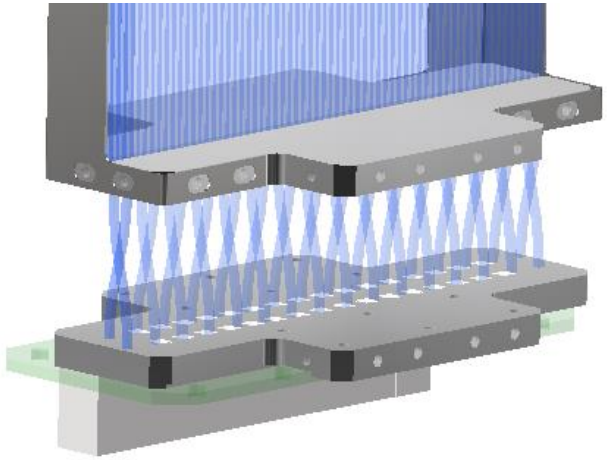
[pending] clad effect

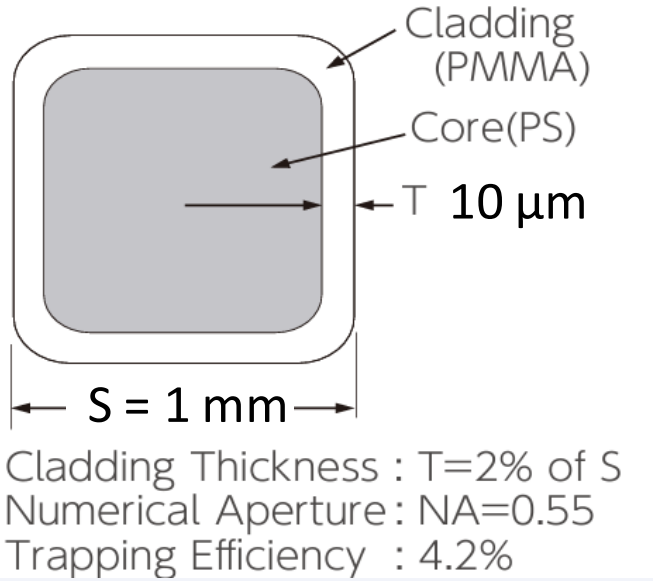
[pending] beta-ray efficiency (estimate π efficiency)

Package Test

[pending] cross talk

[pending] EASIROC full channel readout





Timeline

Ongoing

single fiber performance test with alpha- beta- source

2025

Purchase of MPPC, frame, mounting board, cables (~$20,000)
Mass production

2026

shipping to JLab
Performance check of all channels

2027

installation

Personnel :

S. Nagao, K. Nishi, S. Niwa