



Detector performance of the RENE experiment

DAEUN JUNG

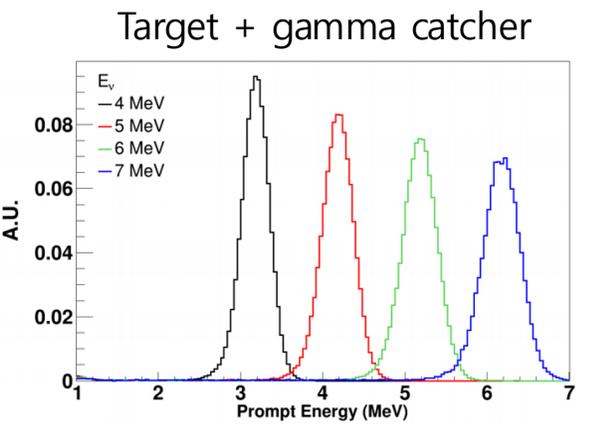
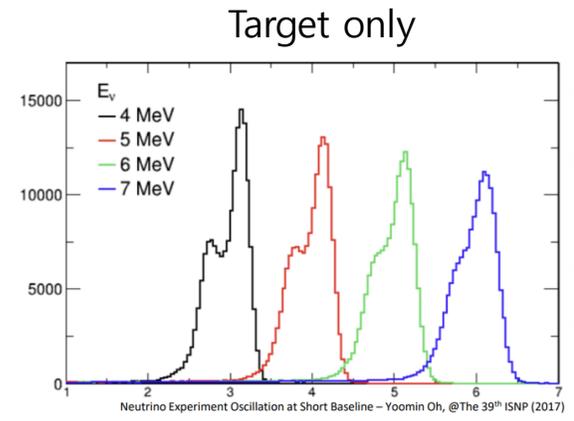
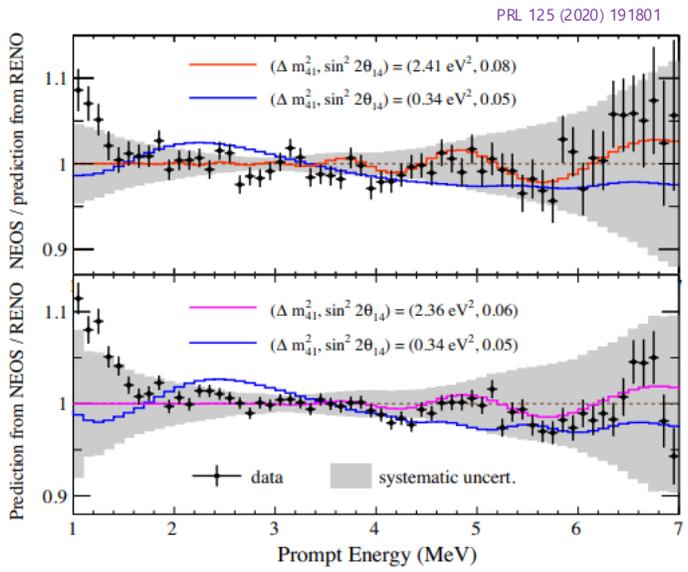
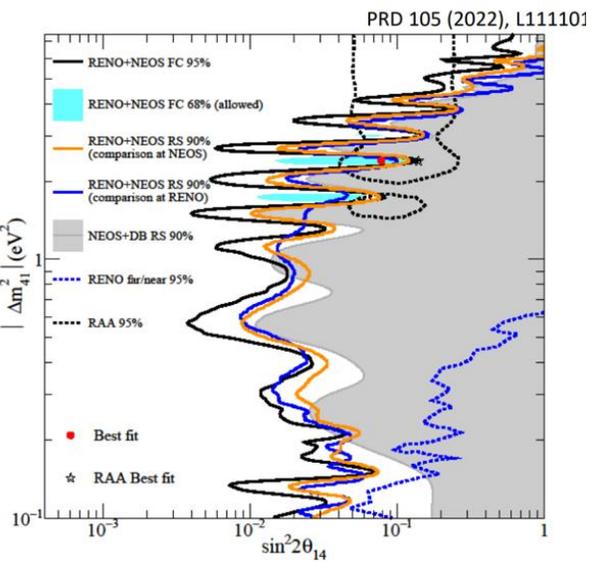
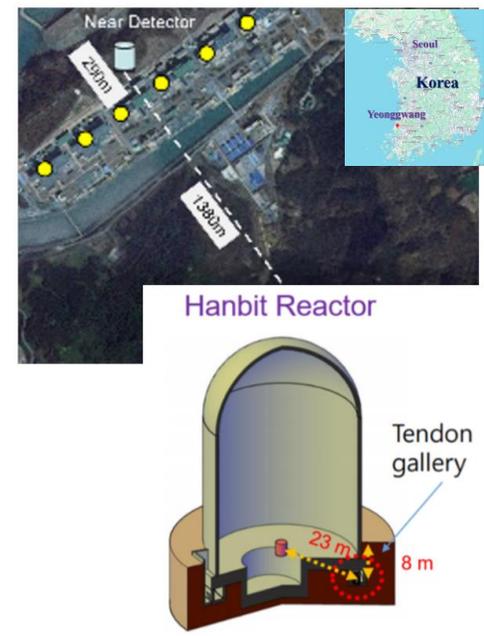
Chonnam National University
On behalf of the RENE experiment

Nov 10-14, 2025
BARYONS 2025 @ ICC JEJU KOREA

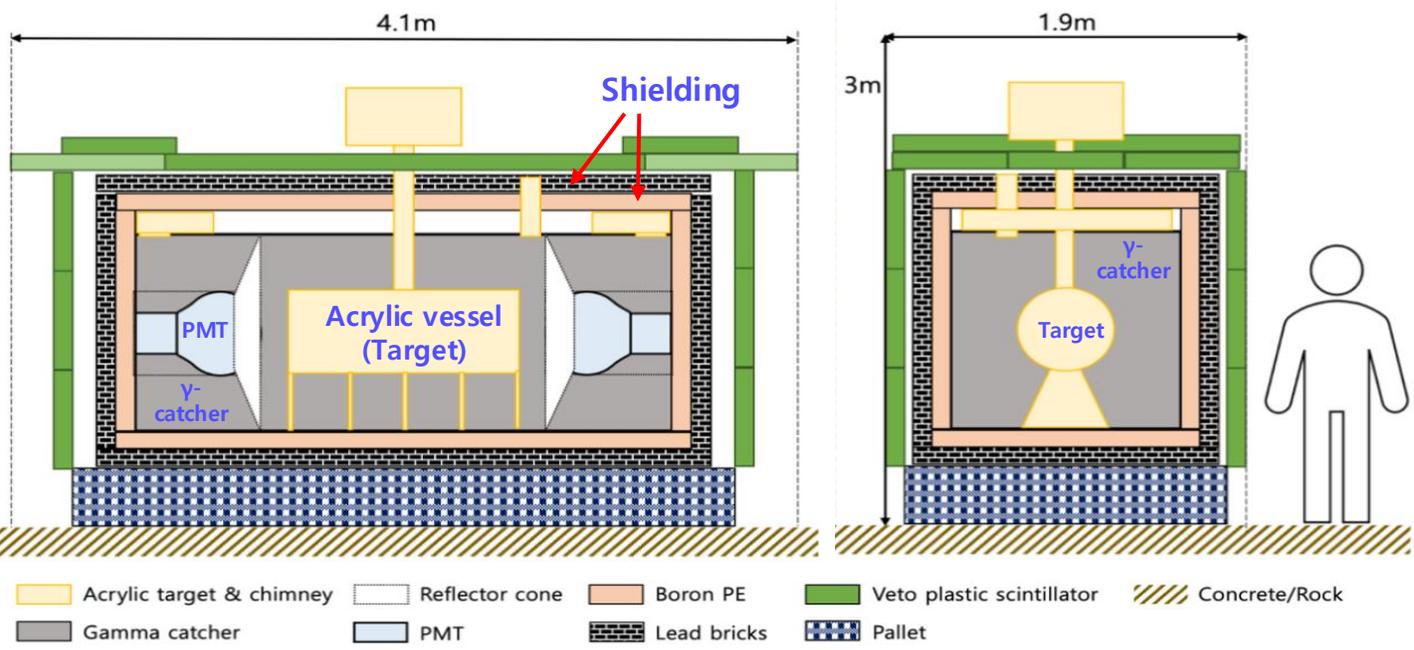


Motivation of the RENE experiment

- A joint analysis of RENO-NEOS improved the constraints on the oscillation parameters and gives a hint for sterile neutrino at $\Delta m_{41}^2 \sim 2 \text{ eV}^2$.
- This new short-baseline project, RENE, is targeting to be installed in the tendon gallery of a reactor at Hanbit Nuclear Power Plant, Yeonggwang at a baseline of $\sim 23\text{m}$ with improved resolution by surrounding the target with gamma catcher.



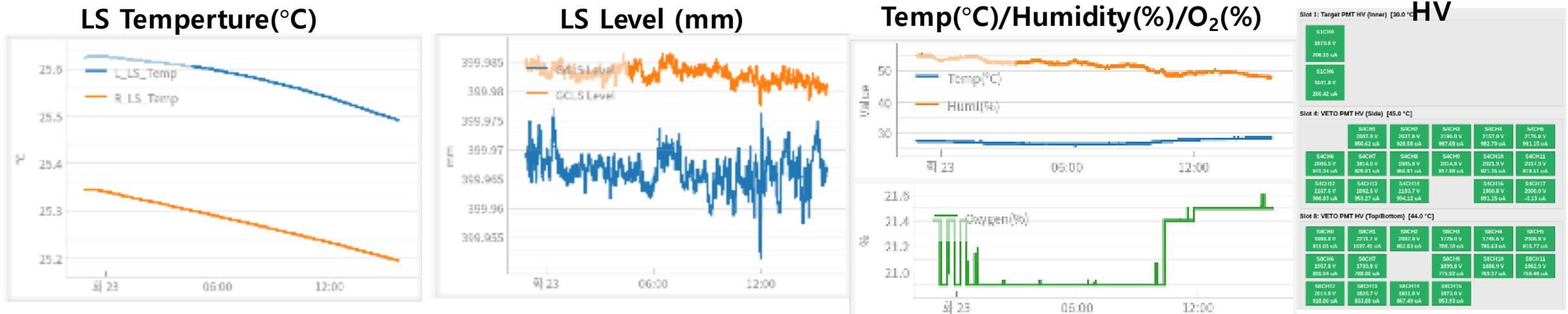
Detector structure



- **Target :**
0.5% Gadolinium loaded liquid Scintillator
Radius 27.5 cm, length 120 cm (0.245ton)
- **Gamma-catcher :**
280 cm × 120 cm × 120 cm
Box-shaped stainless steel filled with LS
2 20-inch PMTs(Photo Multiplier Tubes)
- **Veto detectors :**
15 Plastic Scintillator (EJ-200) panels
+ 30 2-inch PMTs
- **Passive shielding :**
Boronated and high-density polyethylene
plates, and lead bricks

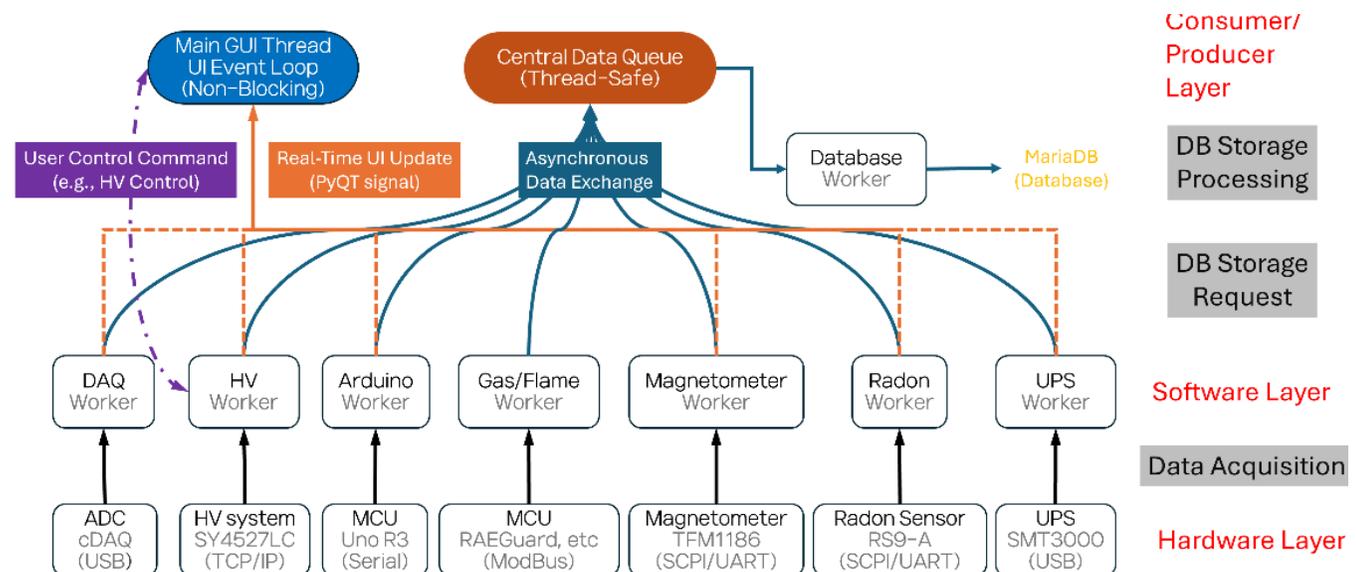
A commissioning run is currently being conducted at CNU

Monitoring DAQ conditions



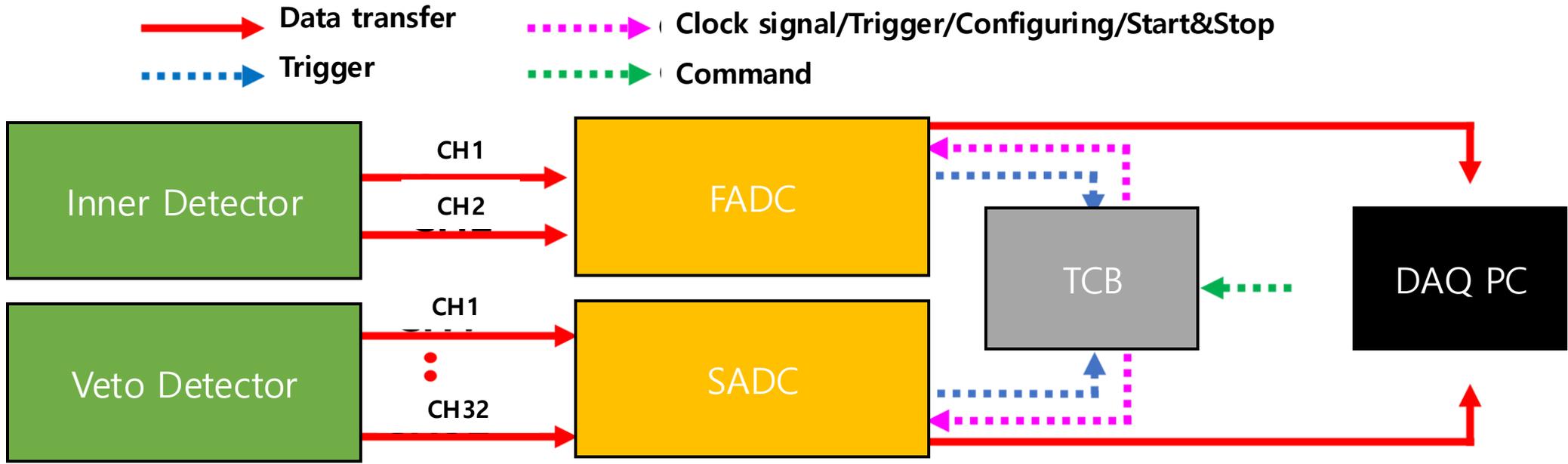
A monitoring system was developed to track environmental conditions and other factors that could influence data acquisition and detector response.

Architecture of RENE monitoring system



■ Data acquisition system

DAQ Schematic



FADC (Notice NKFADC500)

- 4+4 channels
- 12bit resolution
- 2.5 V_{pp} dynamic range
- 500MS/ch/s
- 4+4GB DRAM



SADC (NoticeM64ADC)

- 32 channels
- 12bit resolution
- 2 V_{pp} dynamic range
- 62.5MS/ch/s
- 4GB DRAM



Notice TCB

- Trigger Control board
- Make trigger & clock
- 40ADCs available
- RJ-45 port

Radioactive source calibration

Information of Radioactive sources



Source	True Energy [MeV]
^{137}Cs	0.662
^{65}Zn	1.115
^{40}K	1.461
^{60}Co	2.507
^{232}Th	2.615
^{252}Cf	2.223 (nH)
	~8 (nGd)

- Stability of detector performance
- Position dependence
- Energy dependence
- Energy conversion function

Data information

- Target : **GdLS 0.1%(commissioning)**
- Gamma catcher : LS
- 3D calibration
 - position :
 - along X-axis : 5 points on 120 cm
 - along Y axis : 5 points on 55cm
 - along Z-axis : 12points on 55cm
- About **1hour** per each position, each source

Calibration rod

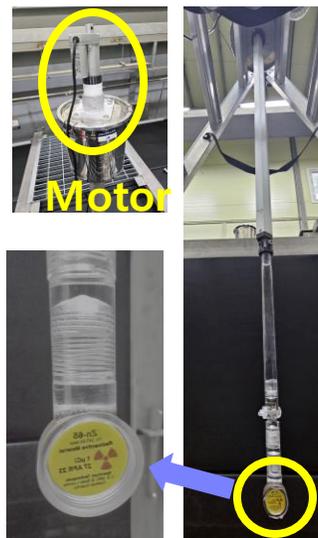
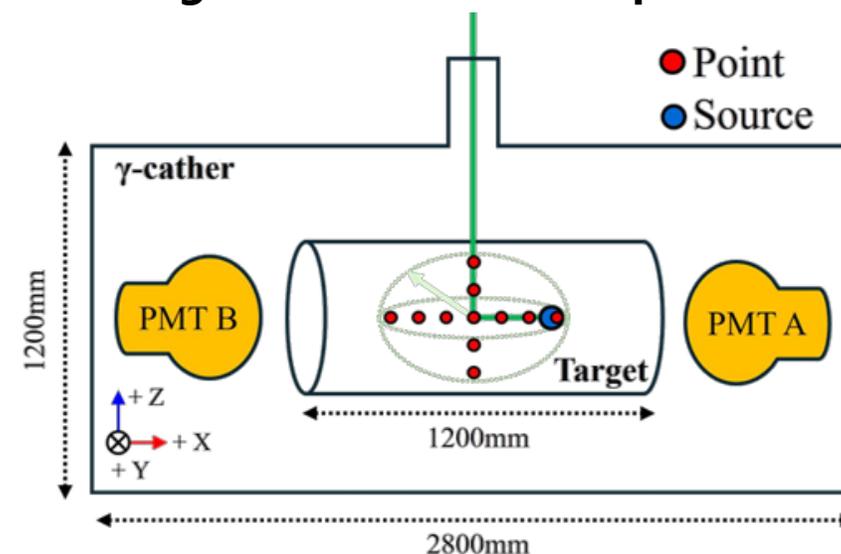
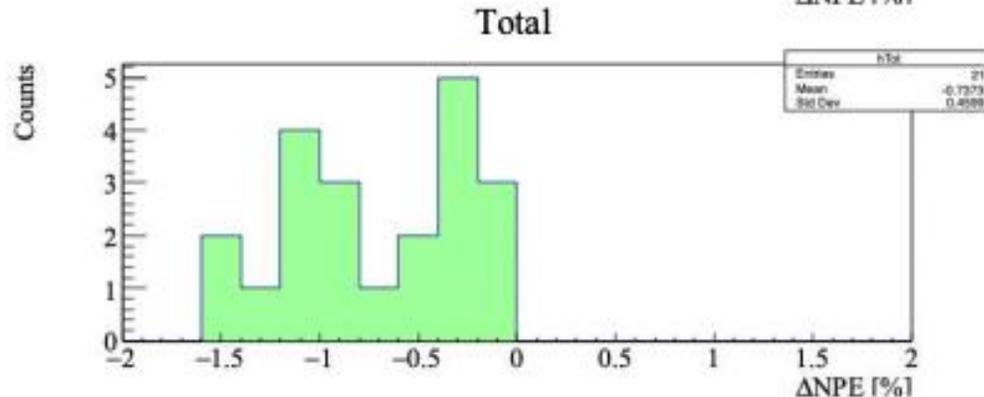
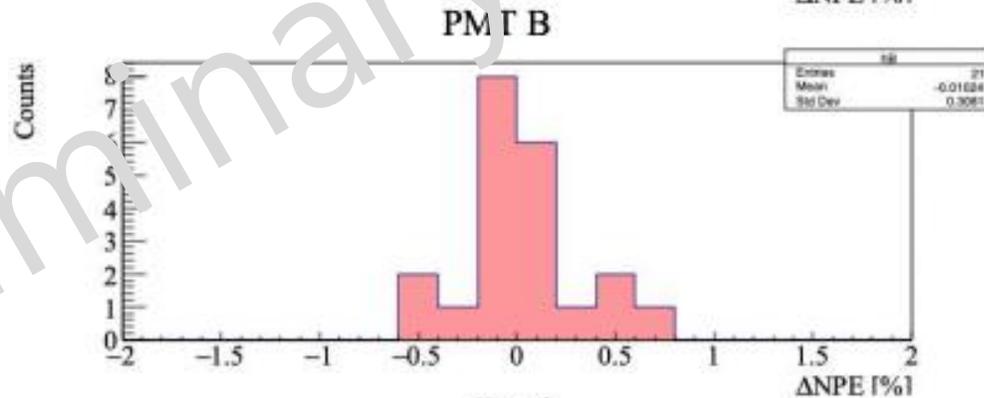
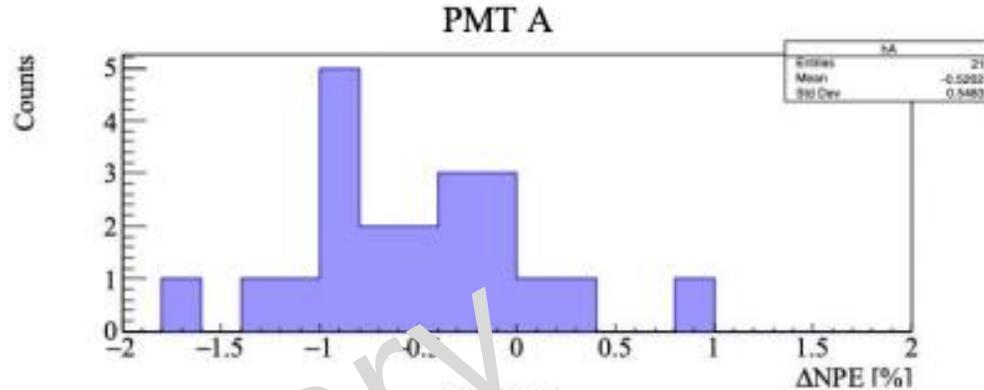
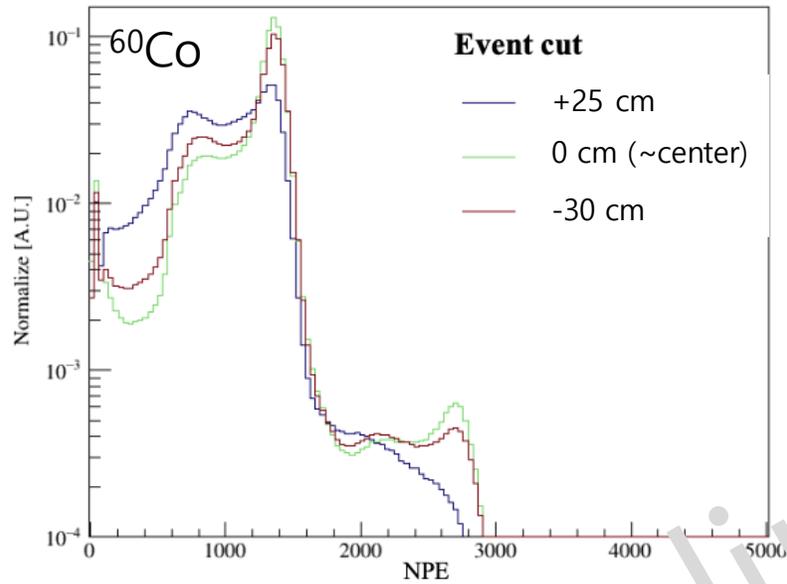


Diagram of the source position



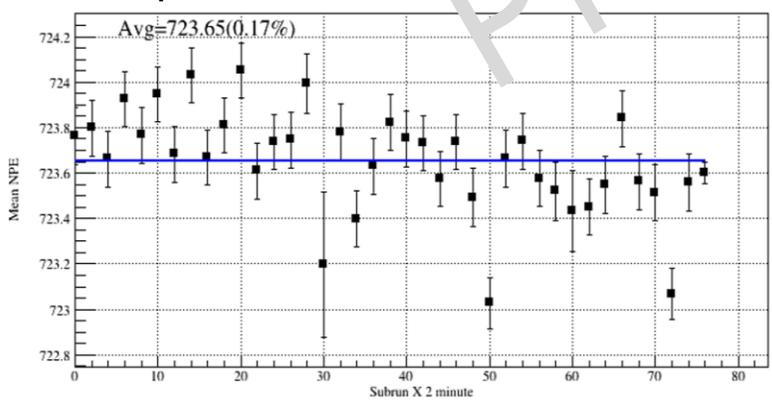
■ PMT stability check (Radioactive source)



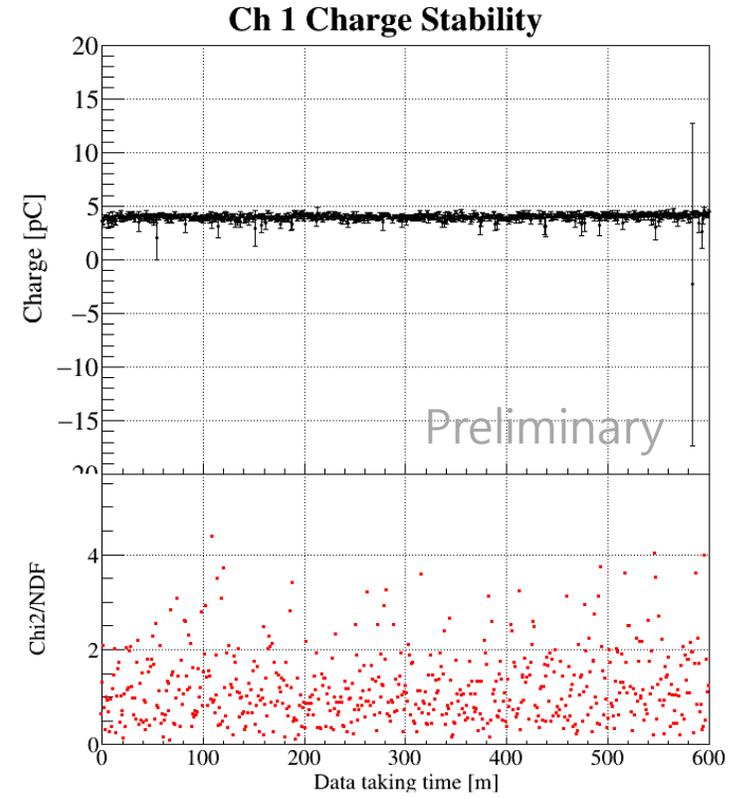
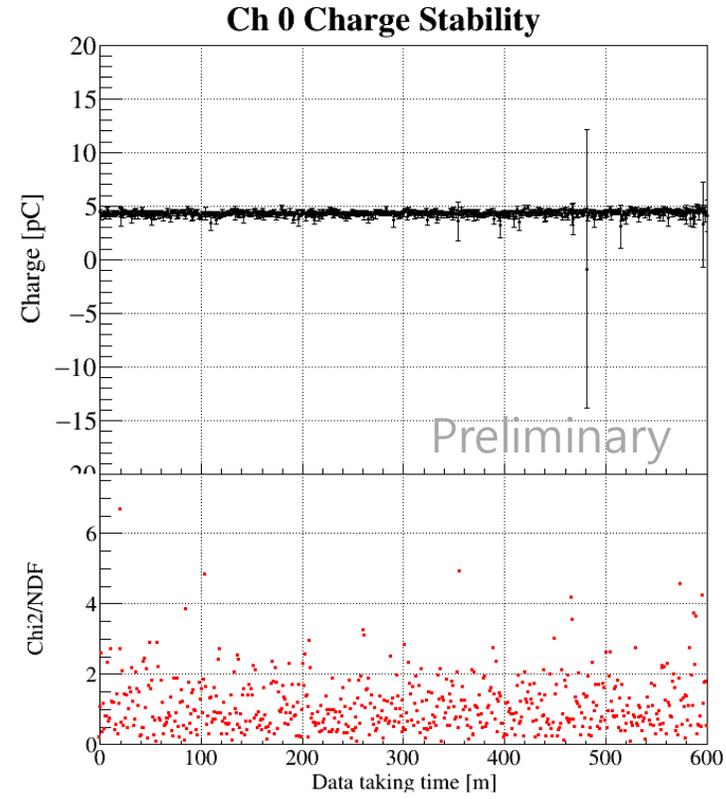
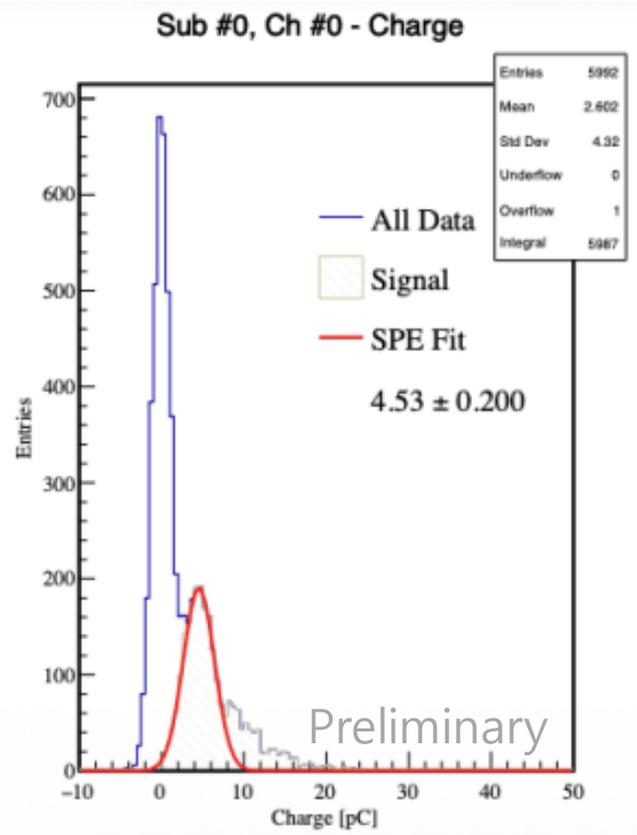
The average difference remains **below 1%** on the 1–2 hour timescale.

PMT A avg diff. : -0.52%
PMT B avg diff. : -0.01%
Total avg diff. : -0.74%

Npe @center for one PMT

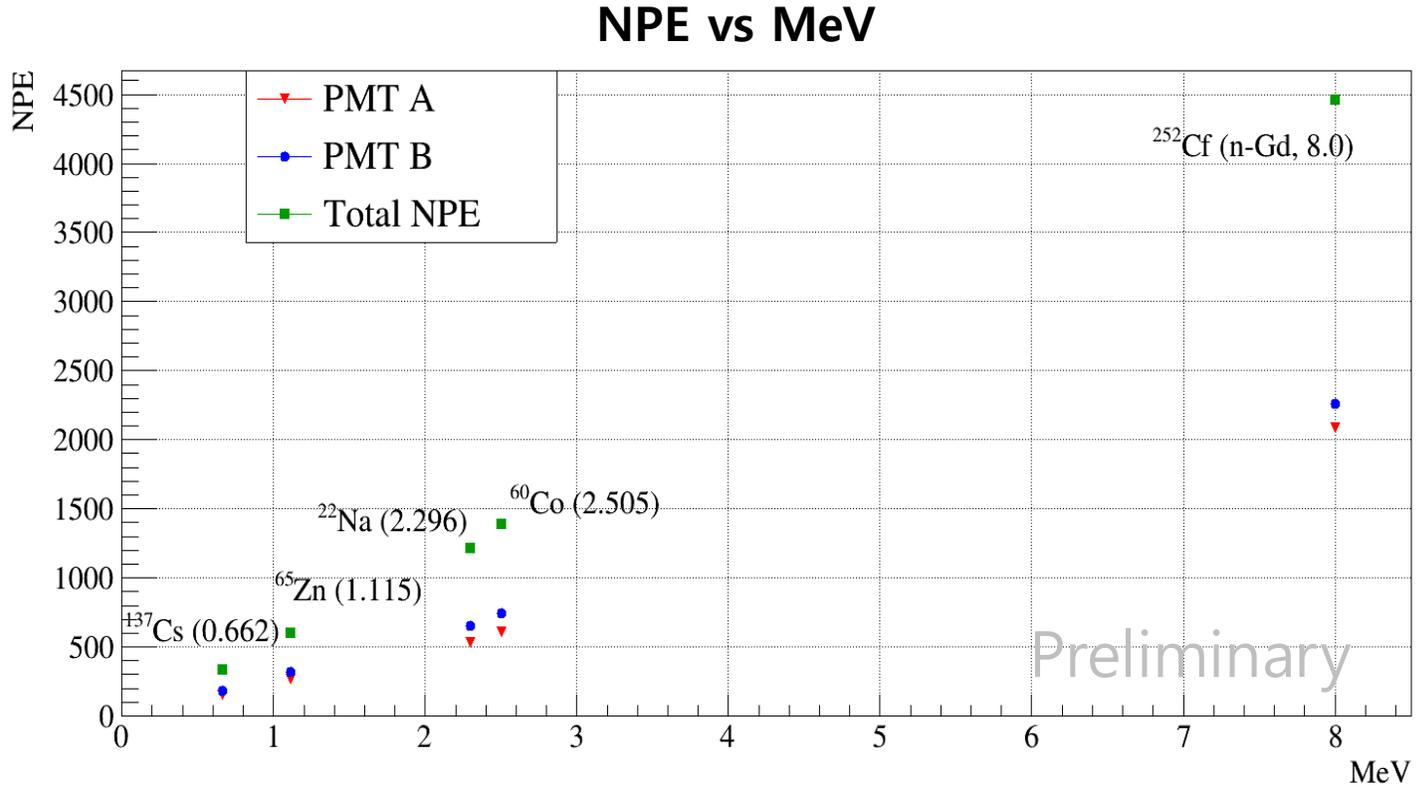
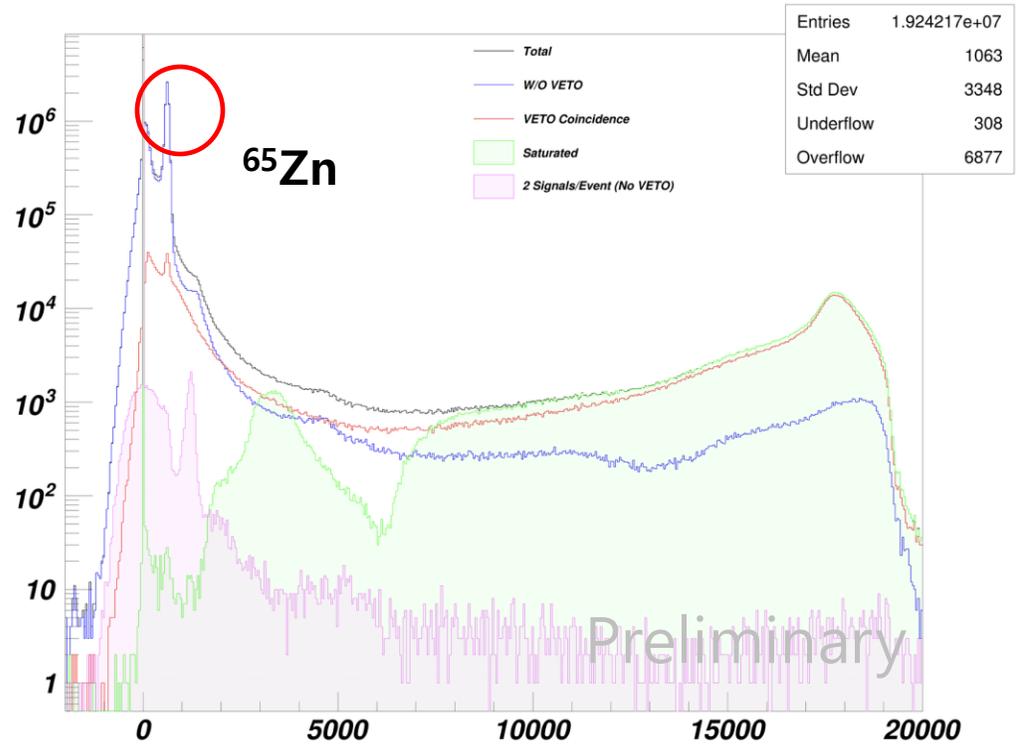


■ PMT stability check (LED)



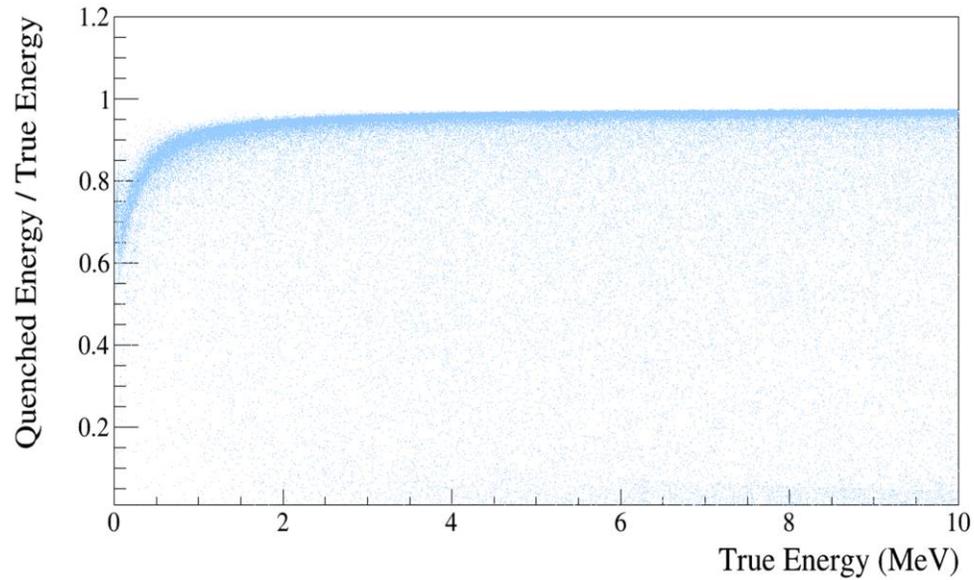
- An LED run was performed to check the PMT gain stability using single photoelectron signals.
- The gain was stable within 1% when both PMTs were operated at 2,000 V (PMT A: $G = 2.4 \times 10^7$, PMT B: $G = 2.7 \times 10^7$).
- The total duration of the measurement was 35.7 hours.

Source Calibration(NPE vs MeV)

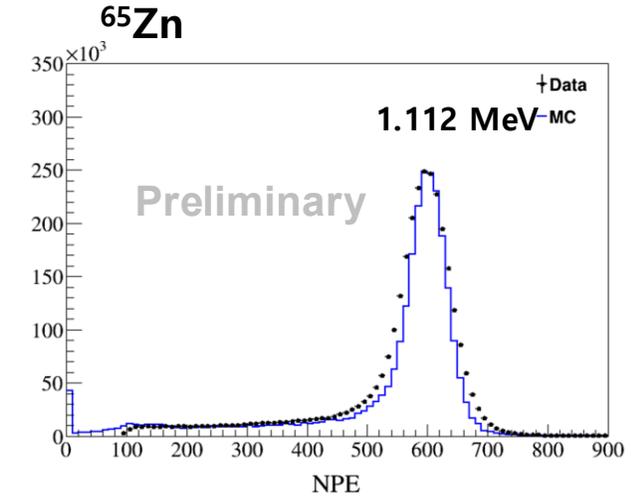
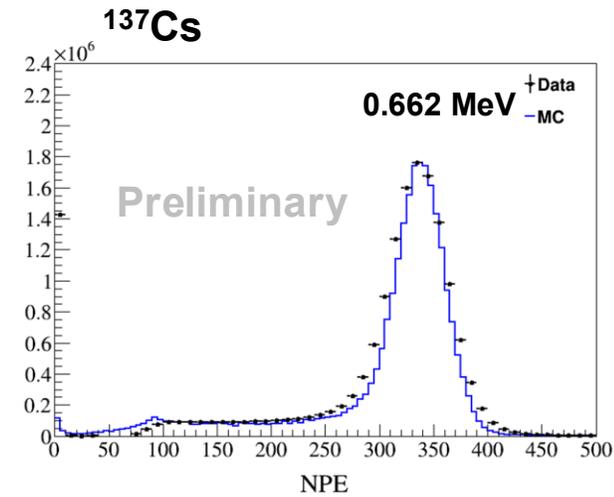


- The NPE-to-MeV conversion is based on 1.115 MeV from a ⁶⁵Zn source.
- Further studies are required on the applied correction and the theoretical conversion function.

Source Calibration in MC



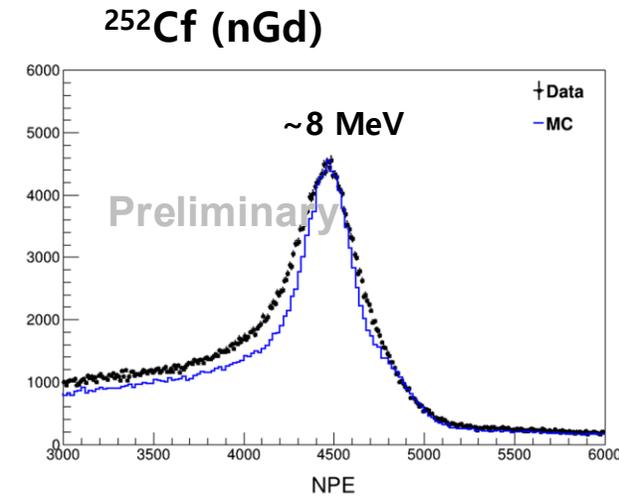
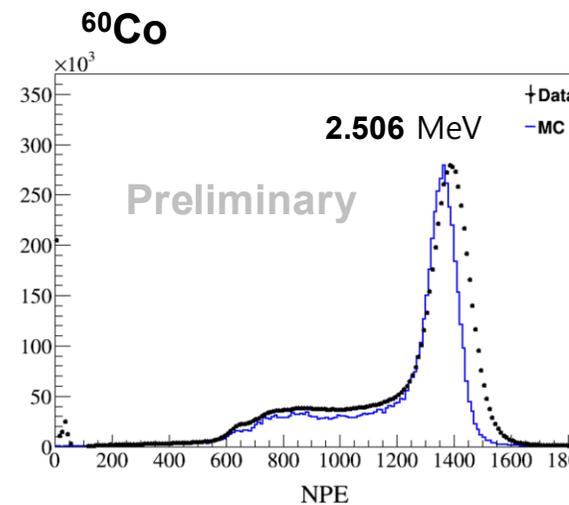
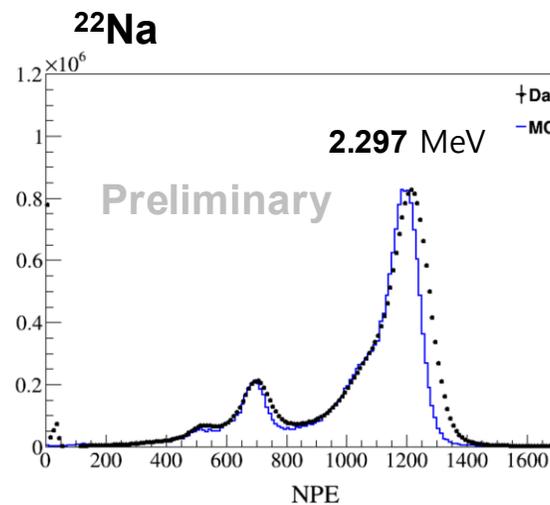
NPE spectra for Data vs MC



MC Simulation Conditions

- Light Yield: 8360 pe / MeV
- Birks' Constant (k_B) [1]:
 - Gd-LS: 0.124 mm / MeV
 - LS: 0.117 mm / MeV

$$\frac{dL}{dx} = \frac{S \cdot (dE/dx)}{1 + k_B \cdot (dE/dx)}$$

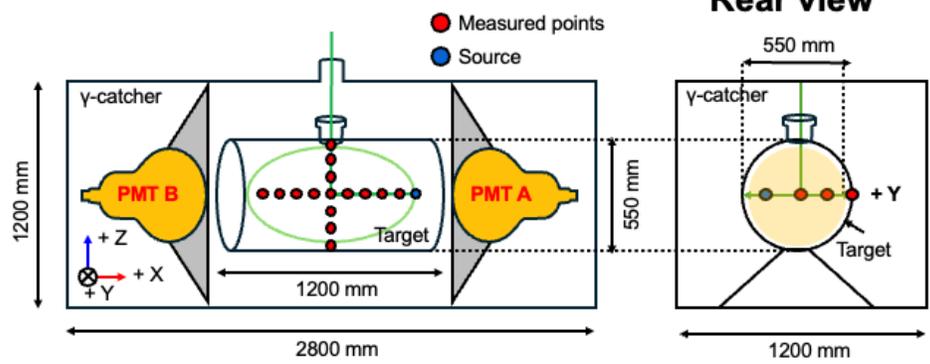


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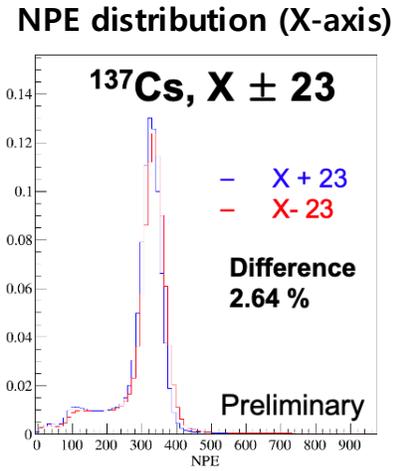
Average difference: 1.26%

Position dependence (Target)

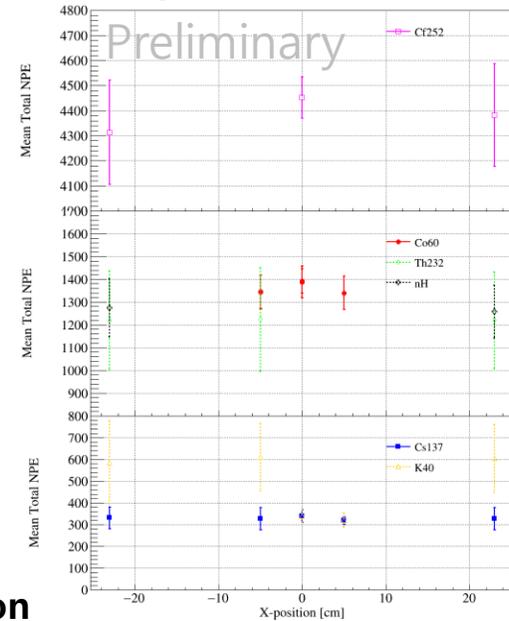
Diagram of the source position



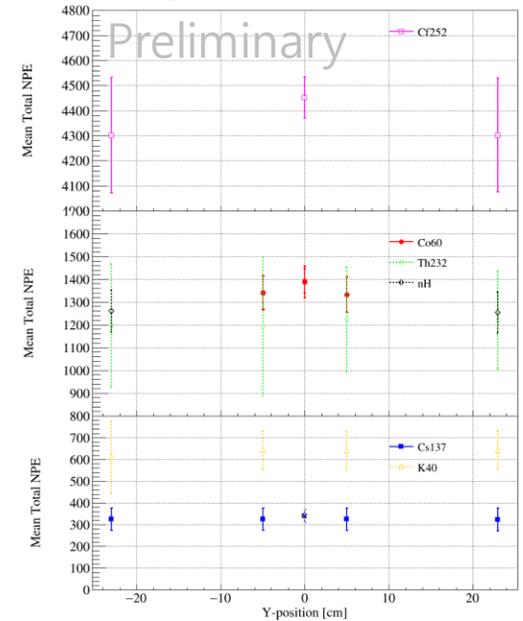
A 3D calibration along the X, Y, and Z axes



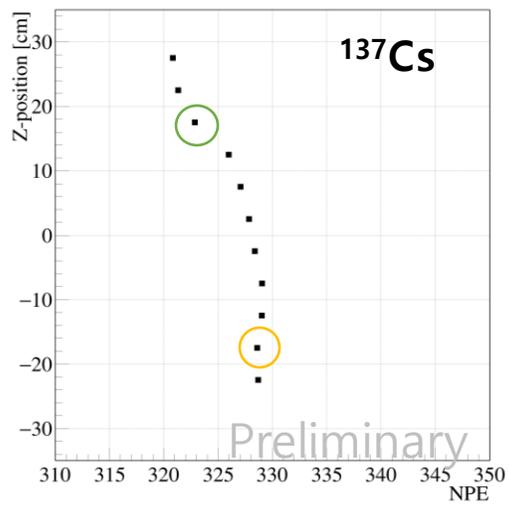
Response about X-axis



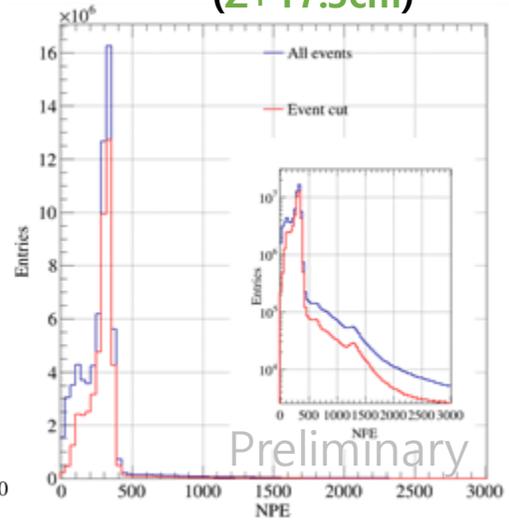
Response about Y-axis



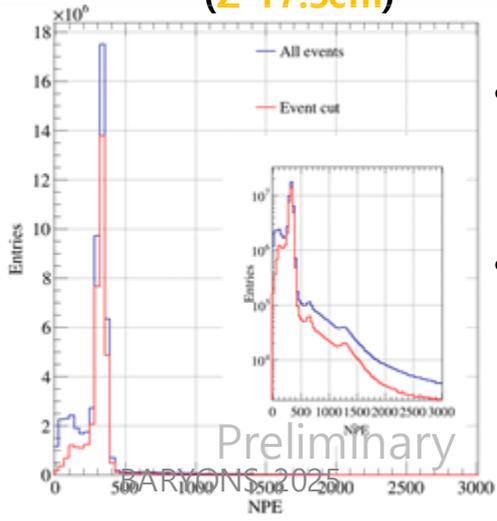
Response about Z-axis



NPE distribution (Z+17.5cm)



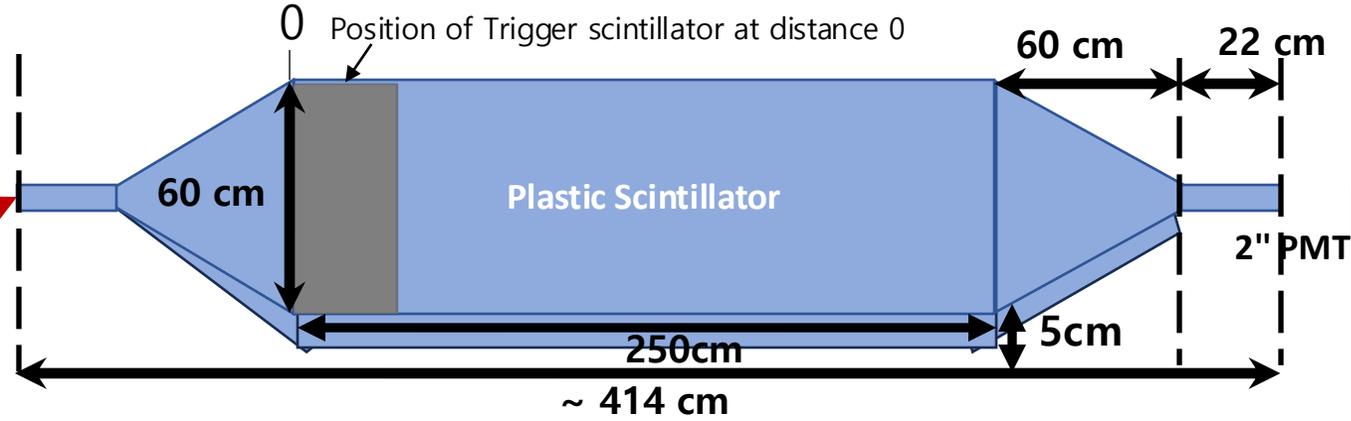
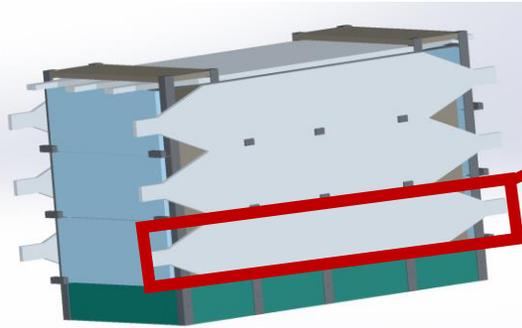
NPE distribution (Z-17.5cm)



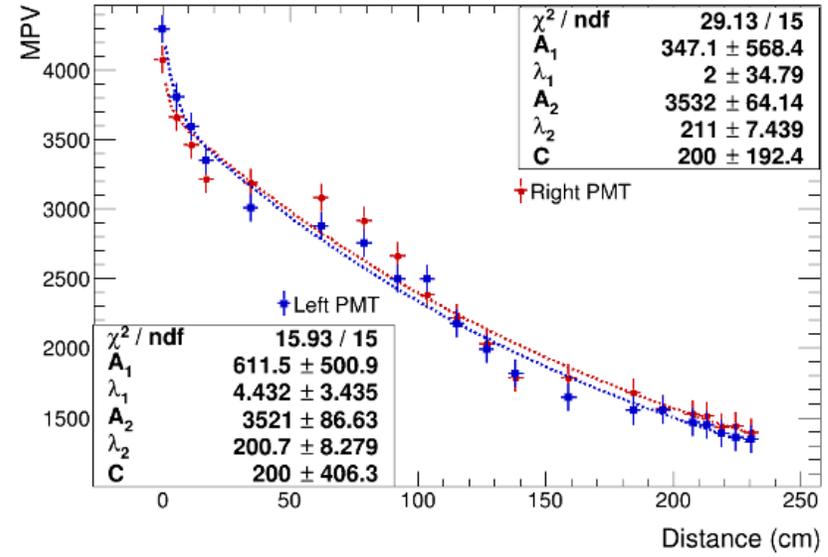
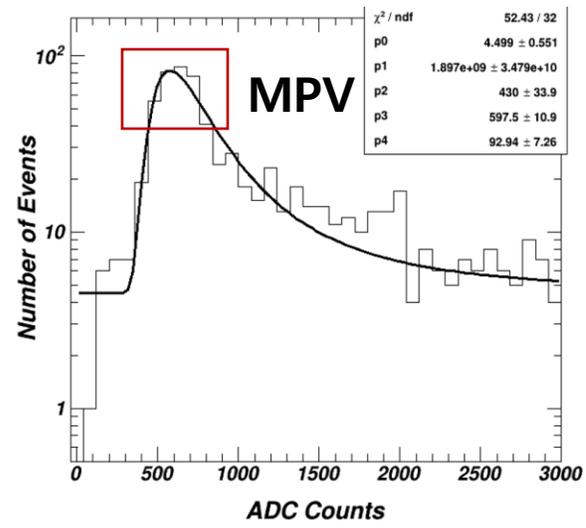
- The energy response is stable within 1% along X and Y, and up to 2.6% variation at maximum.
- The variation along the Z-axis is affected by the detector structure.

Position dependence (Veto)

RENE veto detector



Trigger plastic scintillator & PMTs



- Most probable value (MPV) :
A composite fitting function based on a Landau distribution on charge sum
- The minimum ionizing value of $dE/dx \sim 2 \text{ MeV}\cdot\text{cm}^2/\text{g}$

■ Summary

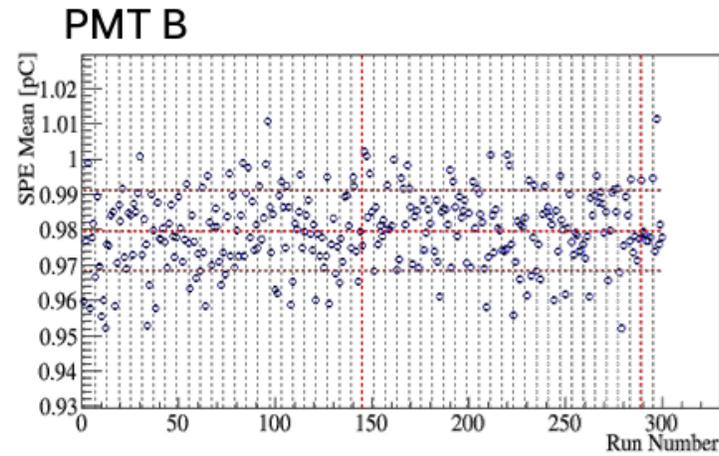
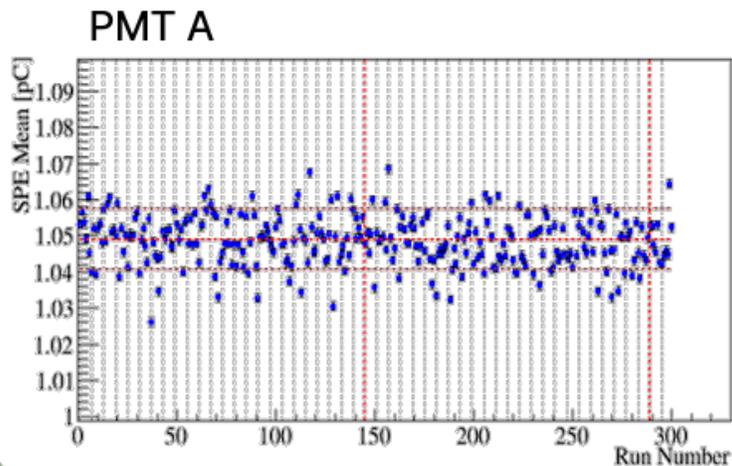
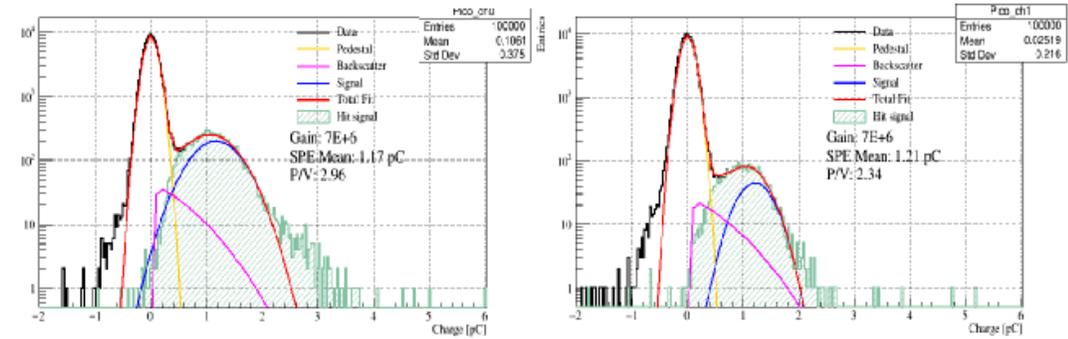
- The RENE experiment aims to search for sterile neutrinos in the $\Delta m_{41}^2 \sim 2 \text{ eV}^2$ region.
- RENE is currently under commissioning to evaluate and verify the detector performance.
- Stability tests using a radioactive source and LED runs confirmed gain stability within 1%.
- A position-dependent energy variation of a few percent was observed from the source calibration data especially on Z-axis.
- Further studies are ongoing to apply appropriate corrections and to obtain Energy conversion function.

BACKUP

PMT stability test

- Hamamatsu R12660 20-inch (Ref. Hamamatsu handbook)
 - Fast time response and high stability (TTS ~ 2 ns)
 - 30% quantum efficiency
- Characterized in a dark box using a pico-pulse laser
- Clear single photoelectron (SPE) peak and good afterpulse discrimination
- Position dependence test completed (center vs. edge).

Charge distribution at gain = 0.7×10^7



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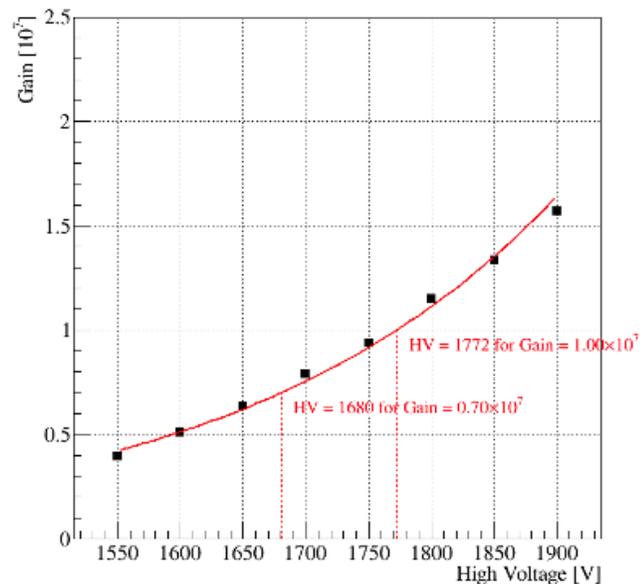


Dark box

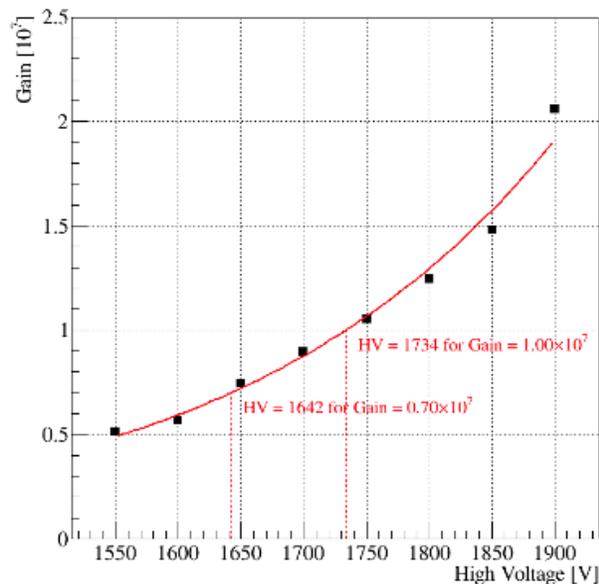


PMT Gain curve

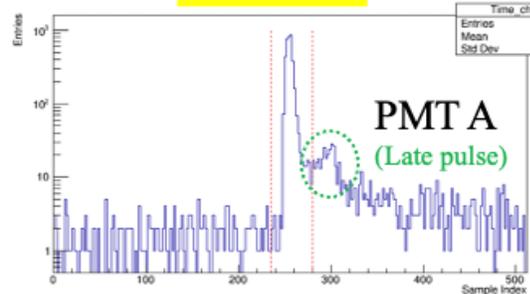
PMT #A



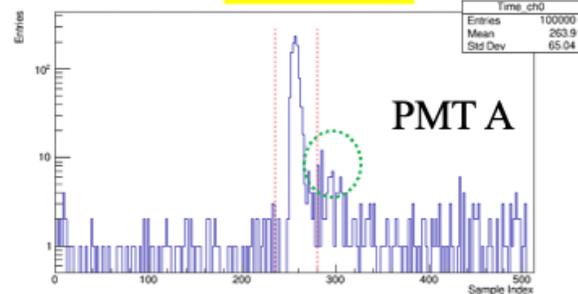
PMT #B



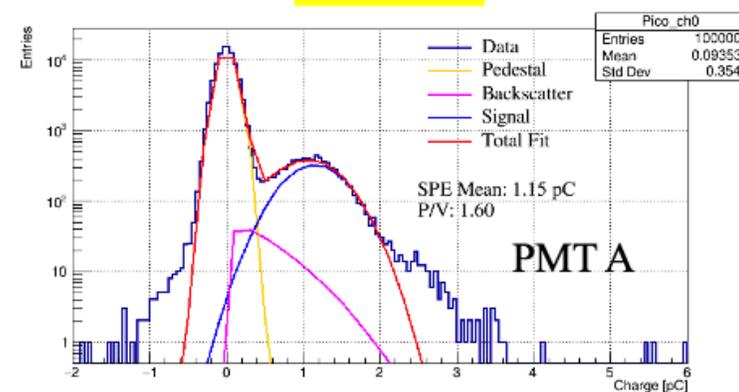
Gain 1E+7



Gain 7E+6



Gain 7E+6



Gain 1E+7

