Simulation and Computing Status of RENE Experiment

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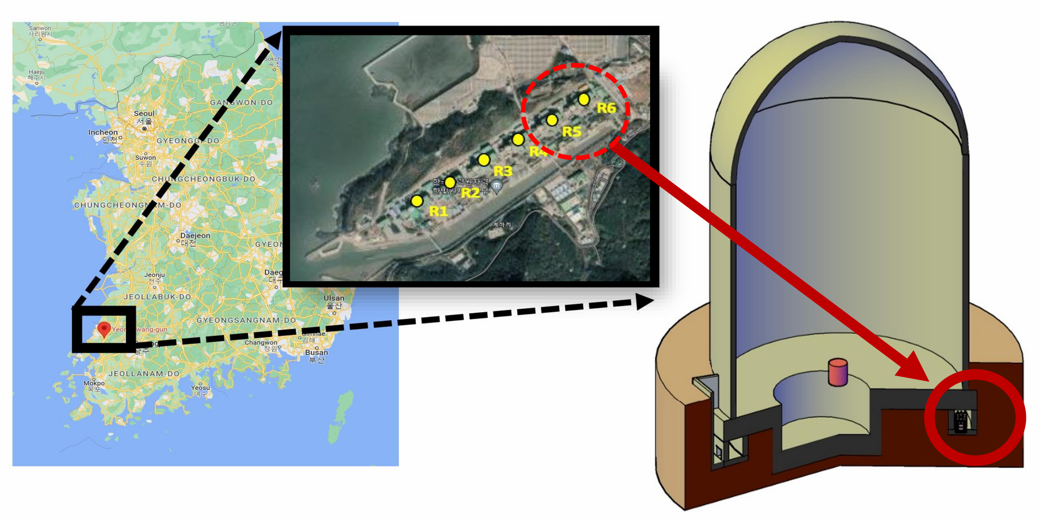
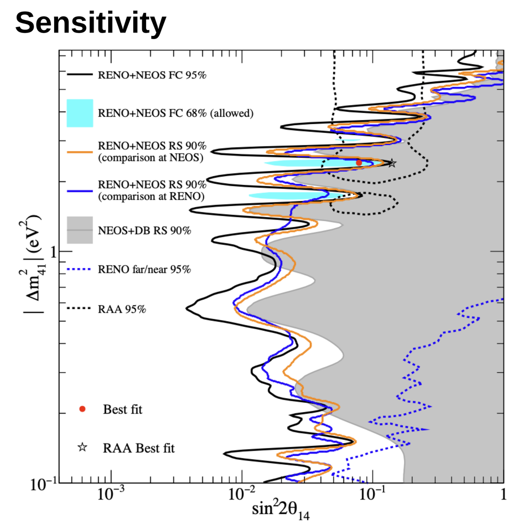
Introduction



Sensitivity

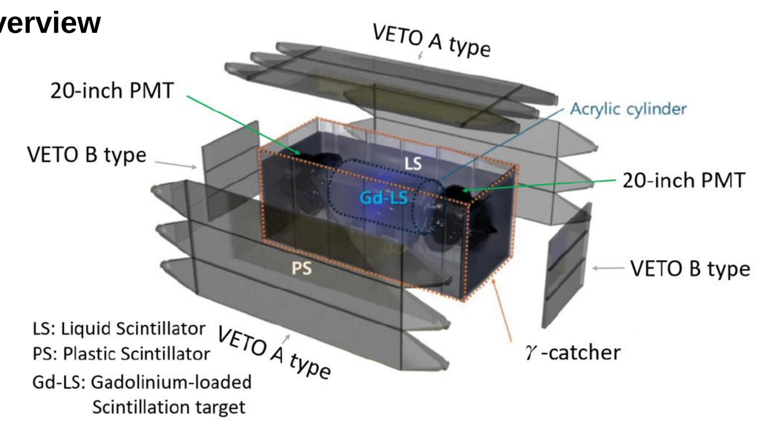


RENE (Reactor Experiment for Neutrinos and Exotics)

- Aim to search for the sterile neutrino at Δm^2_{41} ~2 eV^2.
- High-concentration 0.5% Gd-loaded liquid scintillator detector.
- The detector will be located in the tendon gallery of the Hanbit nuclear power plant in Yeonggwang.
- The baseline of ~ 24 meters is from the reactor core.
- The detector system is designed to ensure sufficient space for access in tendon gallery.

RENE Detector

Overview



Target

Gamma Catcher

Target

- Radius: 275 mm, Length: 1200 mm (Volume: 270 L)
- Gd-loaded liquid scintillator (Gd 0.5%)
- Made of acrylic (8 mm thick).

Gamma Catcher (GC)

- 2800 mm × 1200 mm × 1200 mm (Volume: 3308 L)
- Gd-undoped liquid scintillator
- Designed to prevent escaping gamma.
- Two 20-inch oil-proof Photomultiplier Tubes (PMTs, Hamamatsu R12860)

Veto System and Passive Shielding

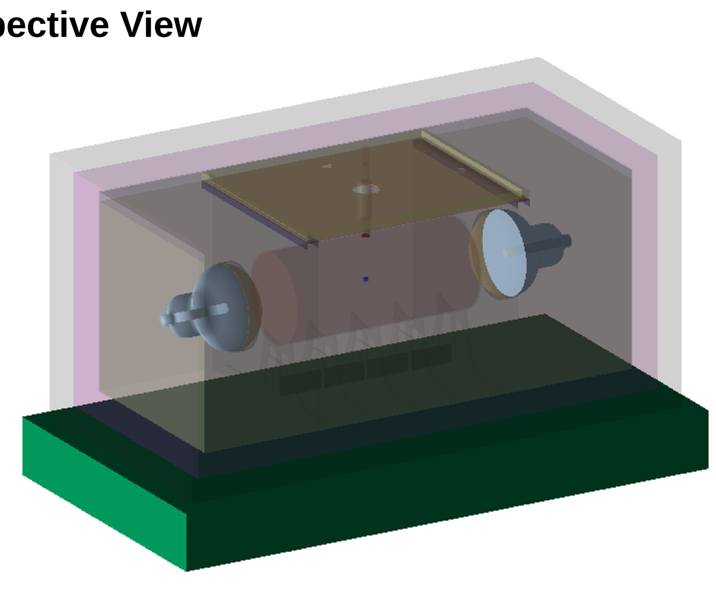
- The veto system surrounds the detector.
- Additional passive shielding layers (e.g., lead, borated polyethylene).

Computing Status for RENE

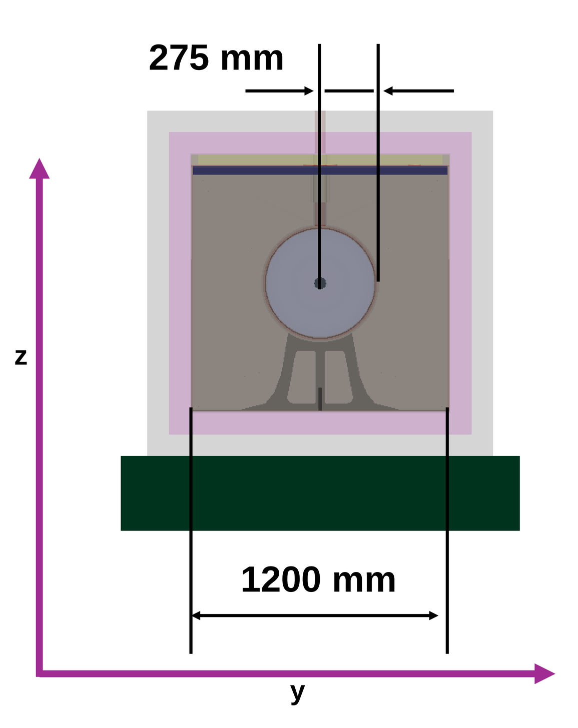
- Files have been transferred to Kyung Hee University server since November 26, 2024.
- As of Jun 17, 2025, 120 TB of data has been successfully stored.
- Due to security restrictions in the tendon gallery, raw data must be manually transferred via hard drives.
- Approximately 144 TB will be required over two years of data-taking.

Simulation Geometry and Parameters

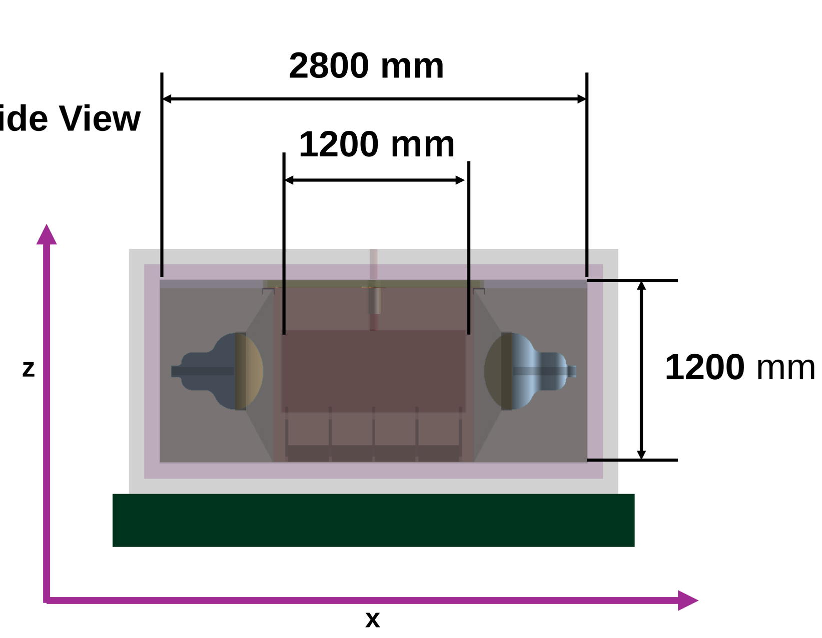
Perspective View



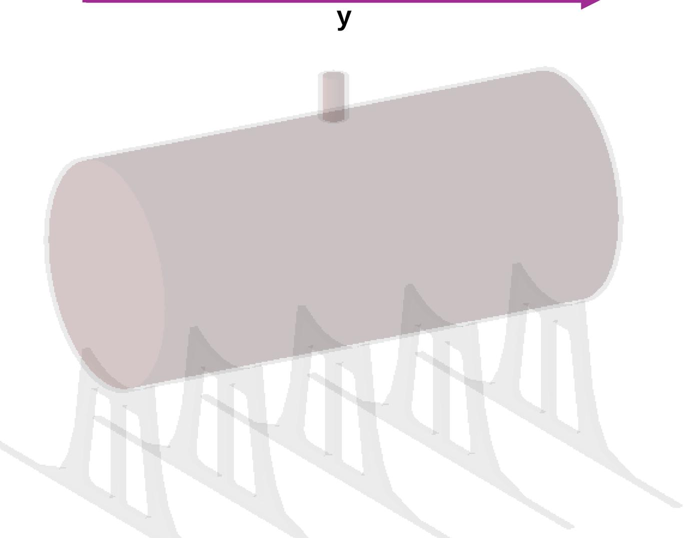
Front View



Side View



Target



- **Parameters**
  - Gd concentration: 0.1% (commissioning)
  - Light yield: 9584 pe/MeV.
  - Teflon reflectance was implemented based on measured values.
  - Birks' law is applied to account for quenching effects.
- **Birks' law**

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

- **Birks' Constant (kB) [1]:**
  - Gd-LS: 0.124 mm/MeV
  - LS: 0.117 mm/MeV

Comparison of MC Simulation with Experimental Data

Experimental Setup and MC Simulation Conditions

Experimental Radiation Source Data

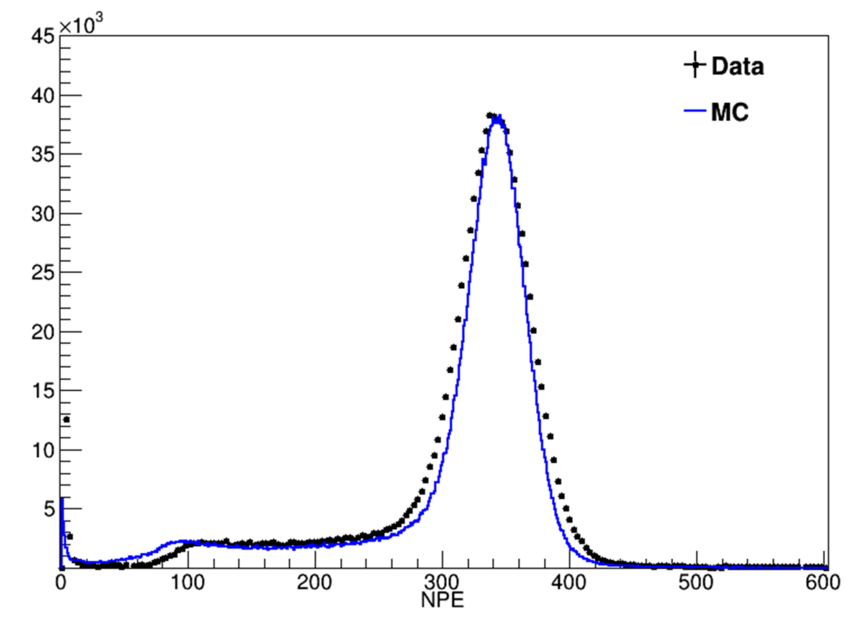
Source	Energy (MeV)	Type	Etc.
^{137}Cs	0.662	γ	Single Gamma
^{65}Zn	1.112	γ	Single Gamma
^{22}Na	1.275, 2.297	γ, e$^+$	Multiple Gamma
^{60}Co	1.1732, 1.3325	γ	Multiple Gamma
^{252}Cf	2.223, ~8	γ, n	Multiple Gamma

MC Simulation Conditions

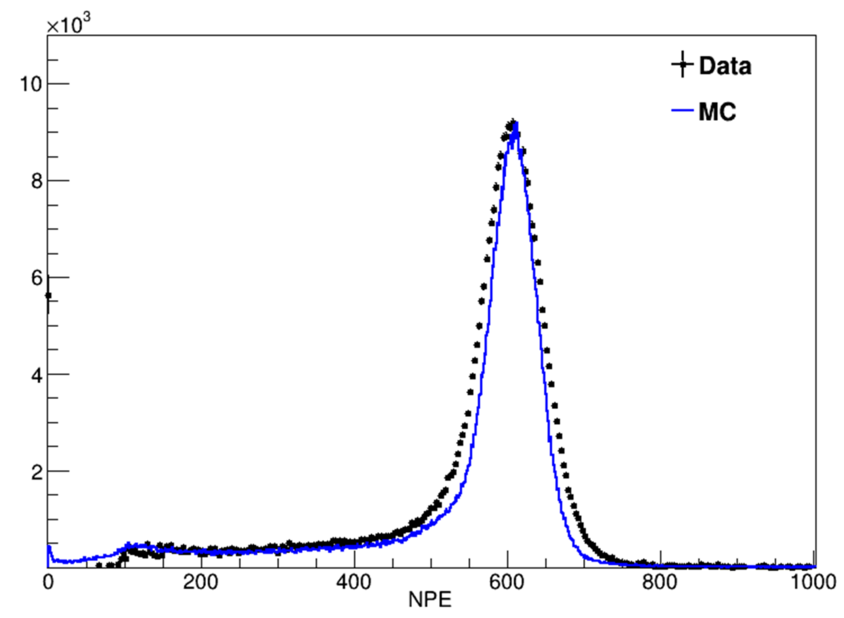
- Simulation implemented with the source placed at the detector center.
- Source holder and capsule implemented in the simulation
- Generated 100,000 events

NPE Spectra from MC and Data

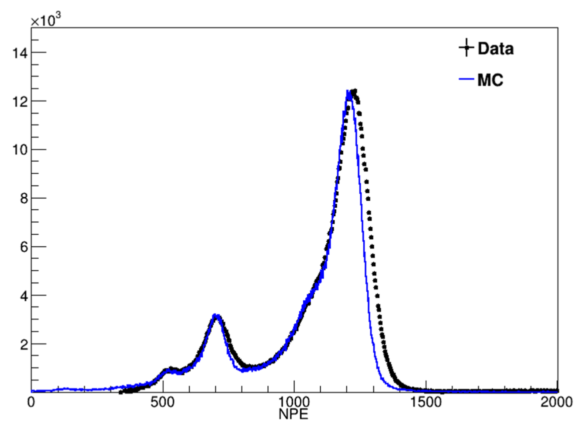
^{137}Cs



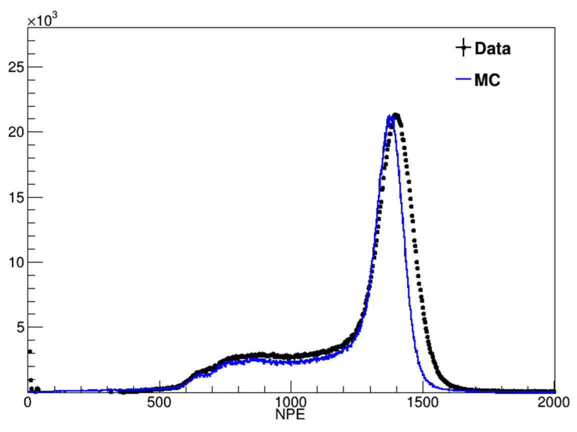
^{65}Zn



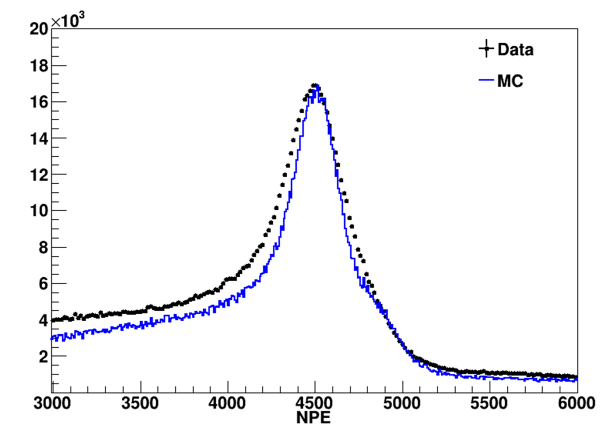
^{22}Na



^{60}Co



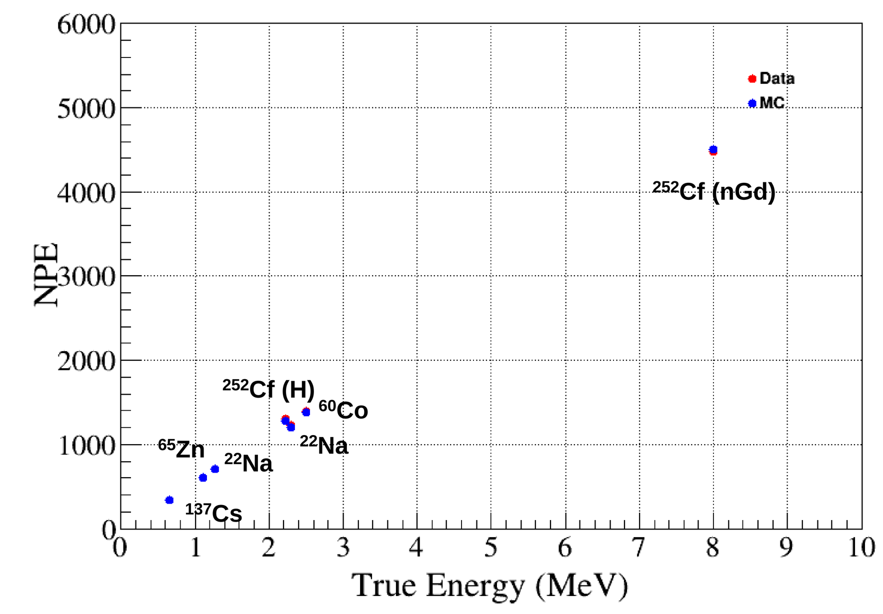
^{252}Cf (nGd)



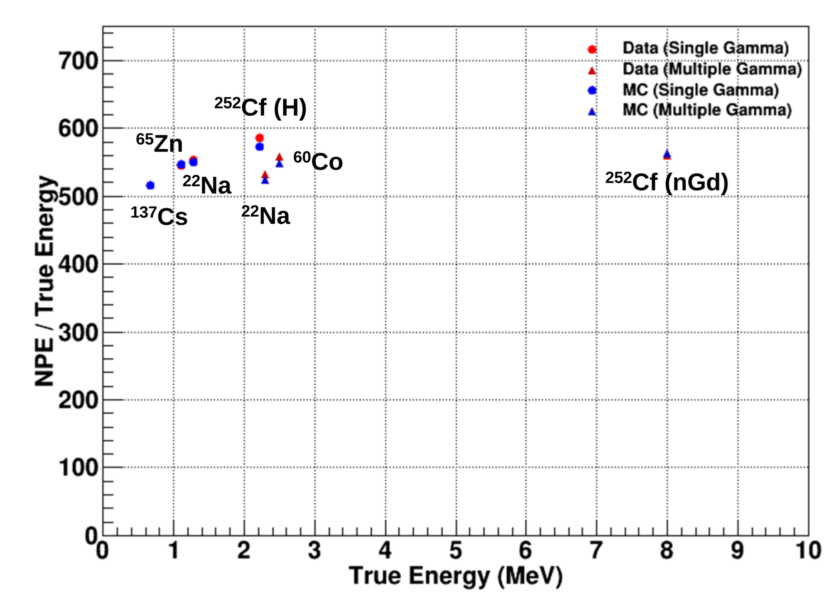
- The overall spectral shape and trend appear to show general agreement between the simulation and the data.

Comparison of NPE Peak Values between MC and Data

NPE vs. True Energy



NPE/True Energy vs. True Energy



NPE Peak Values (Data and MC)

	E_{True} (MeV)	NPE		
		Data	MC	$\frac{\lvert Data - MC\rvert}{MC} \times 100\,\%$
^{137}Cs	0.662	341.42 ± 0.04	341.7 ± 0.2	**0.09**
^{65}Zn	1.112	605.7 ± 0.1	607.2 ± 0.5	**0.24**
^{60}Co	2.506	1396.99 ± 0.09	1374.9 ± 0.8	**1.61**
^{22}Na	1.275	705.5 ± 0.3	701 ± 1	**0.70**
^{22}Na	2.297	1222.1 ± 0.2	1202.6 ± 0.8	**1.62**
^{252}Cf (nH)	2.223	1299 ± 3	1274.7 ± 0.8	**1.97**
^{252}Cf (nGd)	~8	4479 ± 2	4501.6 ± 1.6	**0.50**

- The NPE difference is at most approximately 2%, with an average around 1%.
- According to Birks' law, stronger quenching effects occur at lower energies compared to higher energies, and this behavior is observed in both data and simulation.

Summary & Plan

- Computing infrastructure supports RENE simulation and data storage.
- The NPE difference between data and MC is approximately 1% on average.
- Comparison with 3D calibration measurements is planned.
- Additional storage capacity is being prepared for future data handling.

Reference

[1] J. S. Park *et al., Nucl. Instrum. Methods Phys. Res. A* 707, 45–53 (2013)