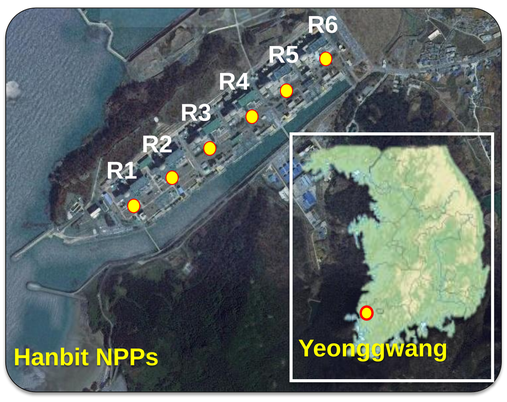
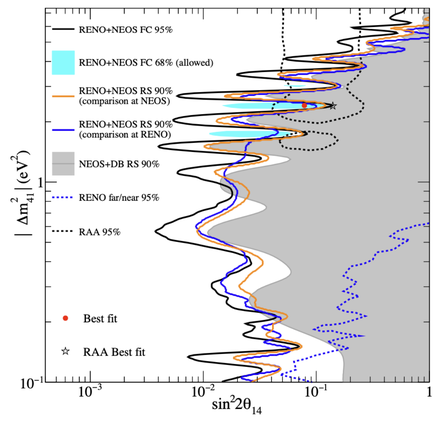
Simulation and Computing Status of RENE Experiment

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Introduction



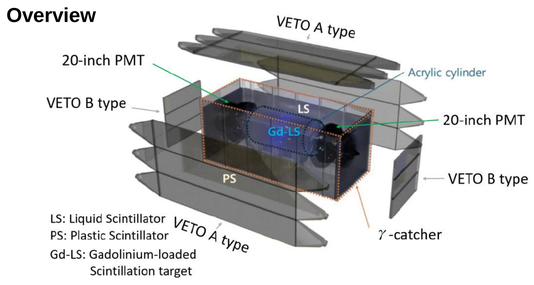


RENE (Reactor Experiment for Neutrinos and Exotics)

- Aim to search for the sterile neutrino at Δm^2_{41} ~2 eV².
- High-concentration 0.5% Gd-loaded liquid scintillator detector.
- The detector will be located at the Hanbit Nuclear Power Plant site in Yeonggwang, Korea.
- The short baseline from the reactor core provides sensitivity to the sterile neutrino search.

RENE Detector

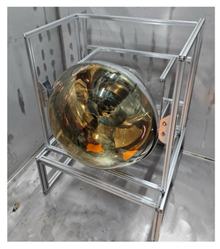
Overview



Target



20-inch PMT



Target

- Radius: 275 mm, Length: 1200 mm (Volume: 270 L)
- Gd-loaded liquid scintillator
  - Design concentration: 0.5%
  - Commissioning concentration: 0.1%
- 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

KHU



RENO Far Site



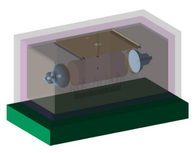
- A computing farm has been established at Kyung Hee University (KHU) to support the RENE experiment.
- About 144 TB of data are expected over two years, and 288 TB of storage has been secured.
- The RENE commissioning server has been in operation at the RENO far site.

RENE DAQ Automation Workflow

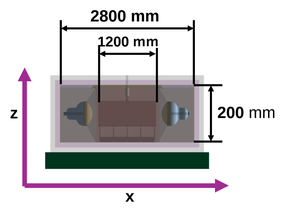
Detector (FADC · SADC) → Data Acquisition → Post-processing (merge → production) → Data Transfer → Storage

Simulation Geometry and Parameters

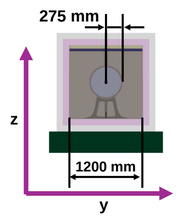
Perspective View



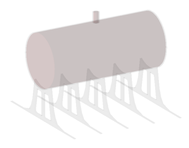
Side View



Front View



Target

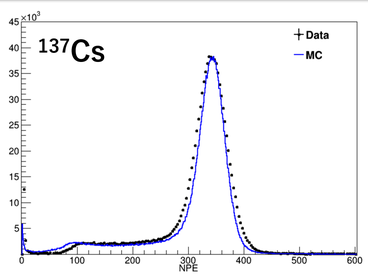


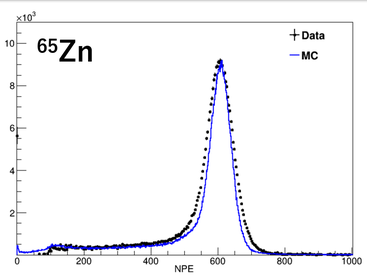
- **Parameters**
  - Gd concentration: 0.1% (commissioning)
  - Light yield: 9584 pe/MeV.
  - Teflon reflectance was implemented based on measured values.
  - Birks' law is applied to account for quenching effects.
- **Birks' law**

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

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

Comparison of MC Simulation with Gamma Source Data





- **Experiment:** Gamma-ray calibration sources were placed at the center of the target.
- **MC simulation:** The same conditions as in the experiment were applied.
- Average difference in peak positions: 1.26%.
- Data and MC show generally similar spectral shapes.

Comparison of MC Simulation with Neutron Source Data

Am-Be Source

Am-Be is a good candidate for an inverse beta decay (IBD)-like test sample.

- Am-Be produces a 4.4 MeV gamma ray and a neutron.
- It produces prompt and delayed signals similar to those of IBD events.

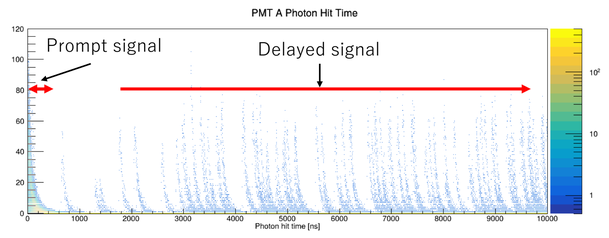
$$^{241}\mathrm{Am} \rightarrow {}^{237}\mathrm{Np} + \alpha$$

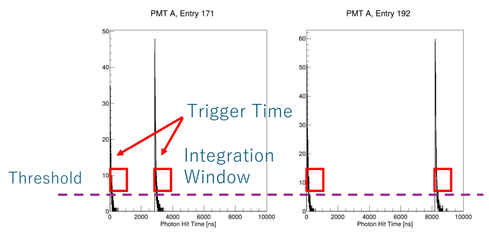
$$\alpha + {}^{9}\mathrm{Be} \rightarrow {}^{12}\mathrm{C}^{*} + \mathrm{n} \rightarrow \text{neutron capture} \rightarrow \text{Delayed signal}$$

$$^{12}\mathrm{C}^{*} \rightarrow {}^{12}\mathrm{C} + \gamma\ (4.44\mathrm{MeV}) \rightarrow \text{Prompt signal}$$

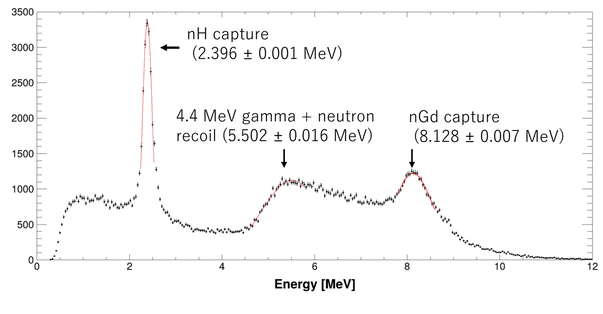
Signal Separation Mechanism in MC

- **An Am-Be source generator was used in the MC simulation.**
- **Prompt and delayed signals are separated based on the arrival times of optical photons at the PMTs.**





Overall MC Energy Spectrum of the Am-Be Source

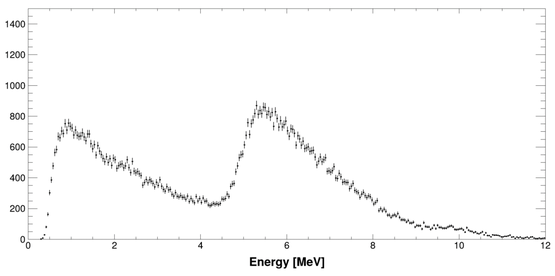


Prompt and delayed signals are clearly separated.

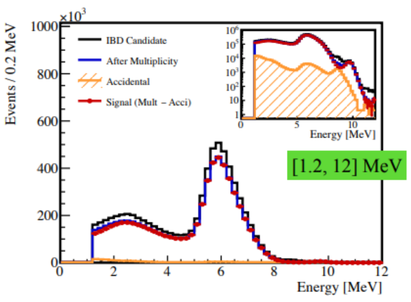
- **Prompt signal**: 5.5 MeV (4.4 MeV + neutron recoil energy)
- **Delayed signals**: ~2 MeV (nH) and ~8 MeV (nGd)

Energy Spectrum of the Am-Be Source: Comparison between MC and Data

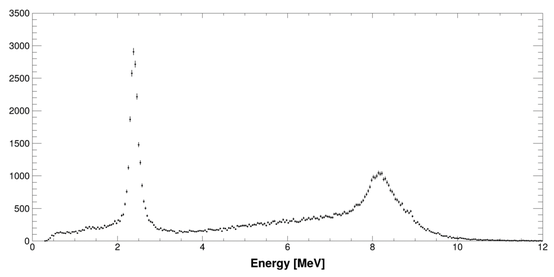
Prompt Signal in MC



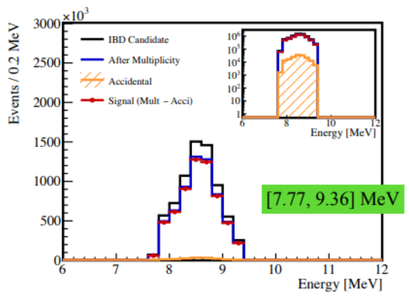
Prompt Signal in Data



Delayed Signal in MC



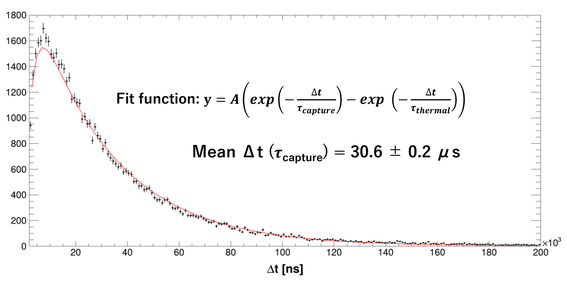
Delayed Signal in Data



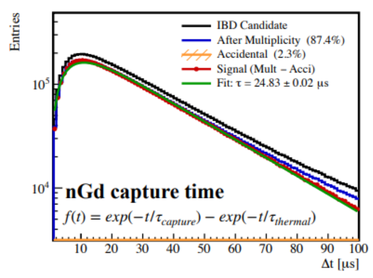
- **A clear ~8 MeV nGd capture peak is observed in the MC.**
- **This energy region is used to identify and pair events in the data.**

Prompt–Delayed Time Difference (nGd Capture)

MC: nGd Capture Time Distribution



Data: nGd Capture Time Distribution



- **The mean time is consistent with the expected nGd capture time (~30 μs at 0.1% Gd).**

Summary

- Computing infrastructure has been established to support RENE simulation and data storage.
- Am-Be MC simulations reproduce IBD-like prompt and delayed signals.
- The nGd capture time obtained from MC is consistent with the expected value (~30 μs at 0.1% Gd)..

Reference

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