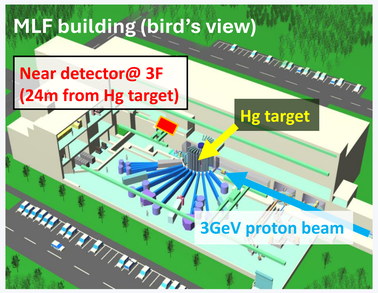
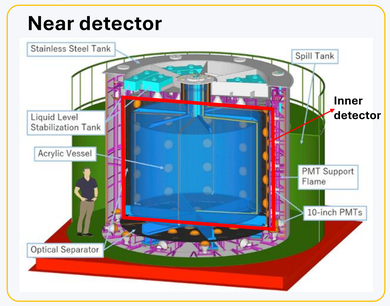
Energy Calibration of the JSNS^2 Near Detector Using Neutron Capture on Gadolinium

Wonsang Hwang, Kyung Hee University, on behalf of JSNS^2 / JSNS^2 – II collaboration

Introduction of JSNS^2 near detector

- The JSNS^2 (J-PARC Sterile Neutrino Search at the J-PARC Spallation Neutron Source) experiment searches for sterile neutrinos at a 24m baseline, targeting $\Delta m^2 \sim 1\ eV^2$.
- Excess of Inverse beta decay (IBD) signal is detected if sterile neutrinos exist.
- IBD: Prompt signal : **e+** , Delayed signal : **γ from neutron capture on Gd**





- JSNS^2 detector is a **liquid-scintillator-based detector**.
- 96 10" PMTs in the Inner Detector & 24 10" PMTs in the Veto.
- This detector is installed only during MLF beam operation periods and dismantled during beam shutdown periods. [1]
  (LS filling & extraction is necessary)

	Liquid	Volume
Target	Gadolinium loaded Liquid Scintillator (Gd-LS)+DIN(10%)	17 tons
γ-catcher & Veto	pure Liquid Scintillator (LS)	31 tons

Motivation & methodology of Energy Calibration

- The light yield can vary over time due to LS degradation and PMT conditions.
- Especially, an annual operation of detector may cause LS degradation.

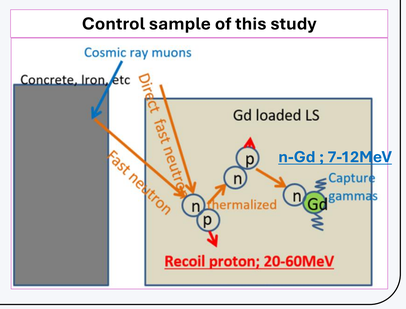
→ **Period-by-period monitoring of the light yield variation is important.**

- The position dependence also exists.

→ **It is also important to evaluate the spatial dependence of the light yield.**

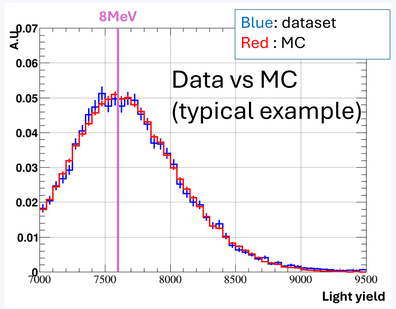
- These can shift the energy scale and bias physics analyses.
- In this poster, mean value of light yield change is shown.

- Time- & spatial-dependent light yield variations are evaluated using **n-Gd capture events** induced by cosmogenic fast neutrons.
- Advantages of the n-Gd sample
  - Independent of IBD signal
  - Clear gammas' peak around 8 MeV
  - Useful events for energy calibration



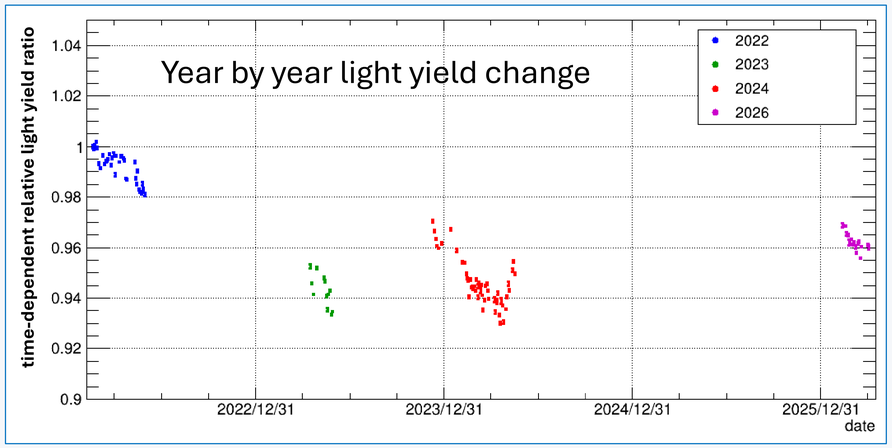
Time-dependent relative light yield measurement

- To study time-dependent variations, the data were divided into about 400-hour equivalent data. (1 point = about 15,000 events)
- The variation in each dataset was quantified by comparison with MC.



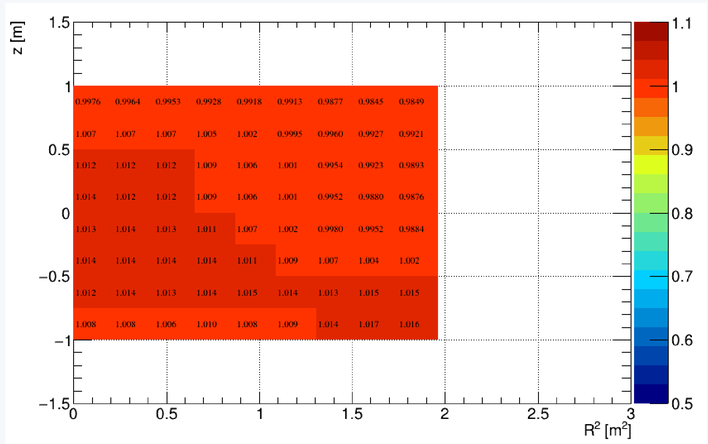
Light yield
=
4π emitted scintillation light by point source

I. The n-Gd reconstructed light yield distribution is prepared for each dataset.
II. Each dataset is compared with MC (data / MC).
III. The obtained scale values are compared using the first dataset.
IV. Then we got the time variation of light yield.



- The most left dataset is set to 1 (about 7760 light yield).
- **Within 7%** we keep light yield for 5 years.

Spatial-dependence



- X-axis is Radius^2 [m^2]
- Y-axis is Z [m]
- The fiducial volume (R<1.4m,|Z|<1m) is divided into 8 × 9 pixels. [2]
- **Within 1.6%** , all pixels in our fiducial volume have same light yield.

Summary

- The relative light yield stability at 8MeV of the JSNS^2 near detector was evaluated using n-Gd events.
- The time-dependent relative light yield is kept within 7% for five years.
- The spatial-dependent light yield variation was within 1.6% in the fiducial volume.
- These results demonstrate the stable light-yield response of the JSNS^2 near detector.
- Although the time- and spatial-dependent variations are small, corrections for these variations are applied in the current JSNS^2 analysis.

Plan

- These variations will be monitored for new data.

reference

[1] D. H. Lee et al., "First results from the search for an excess of anti-electron-neutrino events in JSNS^2," arXiv:2602.06274 [hep-ex], accepted by Phys. Rev. D.
[2] D. H. Lee et al., "Evaluation of the performance of the event reconstruction algorithms in the JSNS^2 experiment using a 252Cf calibration source," Nucl. Instrum. Meth. A 1072, 170216 (2025).