Neutrino Experiment at Yemilab :

νEYE (new eye, νeutrino Experiment at YEmilab)

K-Neutrino Symposium 2026

Oct. 27, 2026

Chung-Ang University Art Center Art Hall

Eunil Won

Korea University, Oct. 27, 2026

νEYE web: https://sites.google.com/korea.ac.kr/the-nueye-telescope

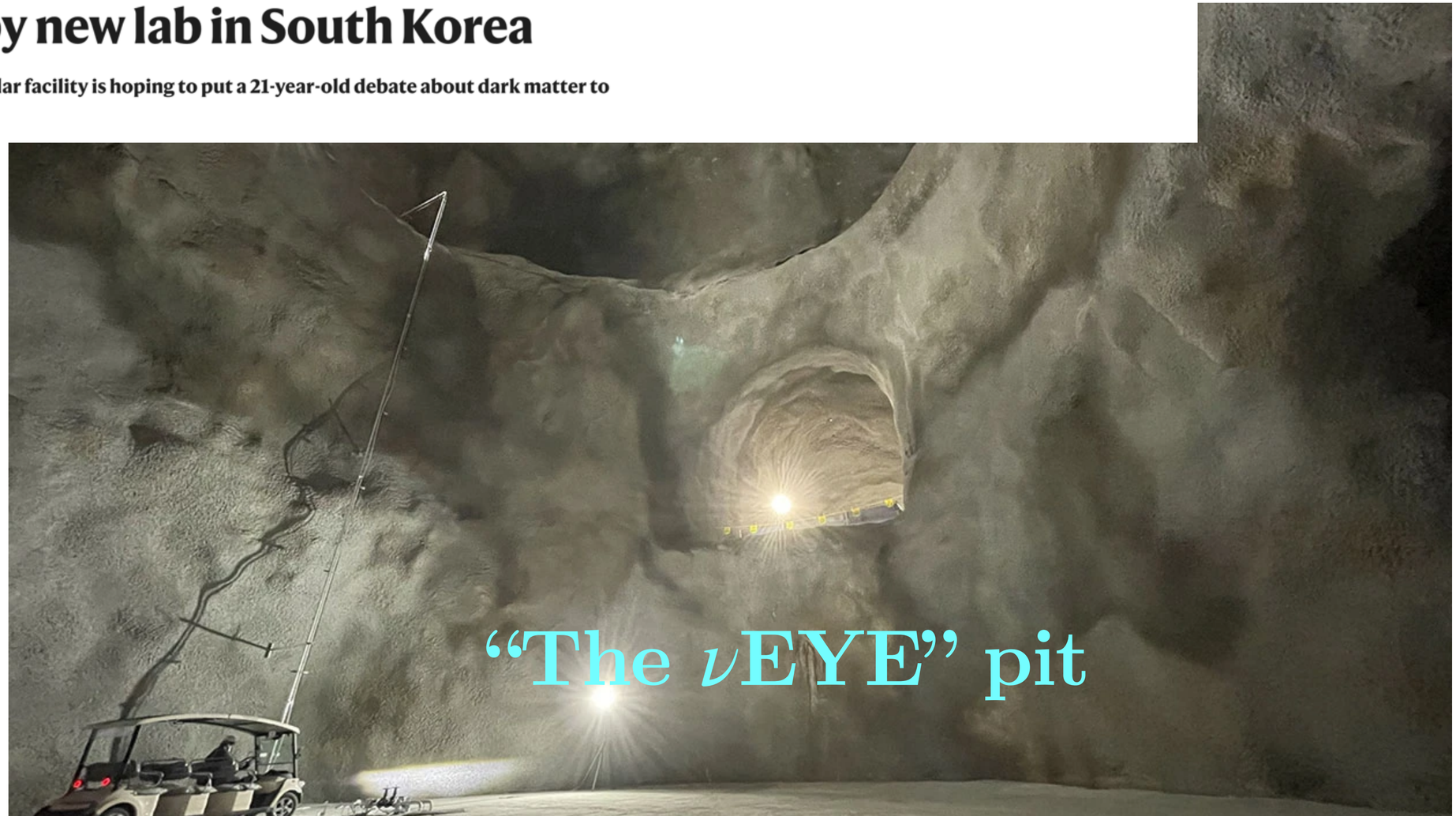
NEWS | 30 May 2024

Disputed dark-matter claim to be tested by new lab in South Korea

A multi-million dollar facility is hoping to put a 21-year-old debate about dark matter to rest.

A new underground facility in Korea (1000 m deep).
(https://arxiv.org/abs/2402.13708)

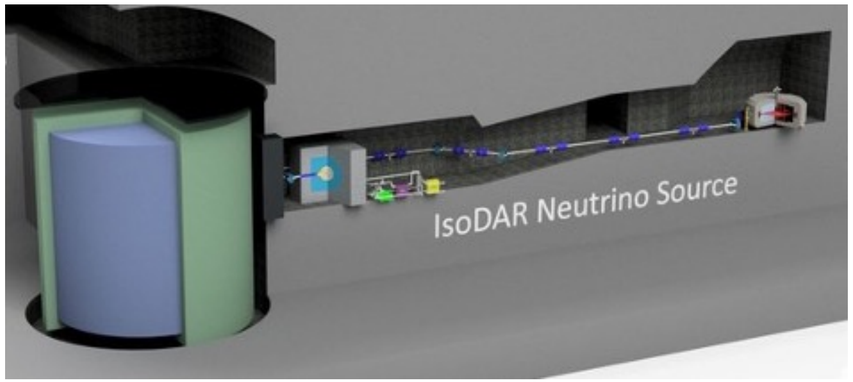
Yemilab "LSC center" can host $O(2)$ kilo tonne detector.



Selected Physics Cases

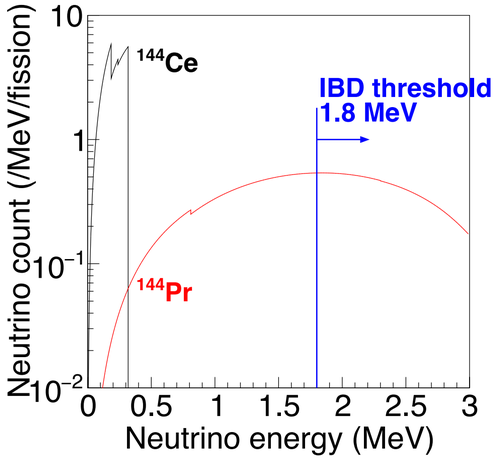
Sterile neutrino search with νEYE

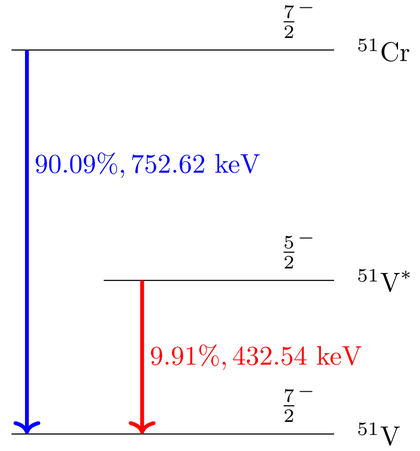
Option 1: Generation of neutrinos with high-intensity accelerator (IsoDAR).

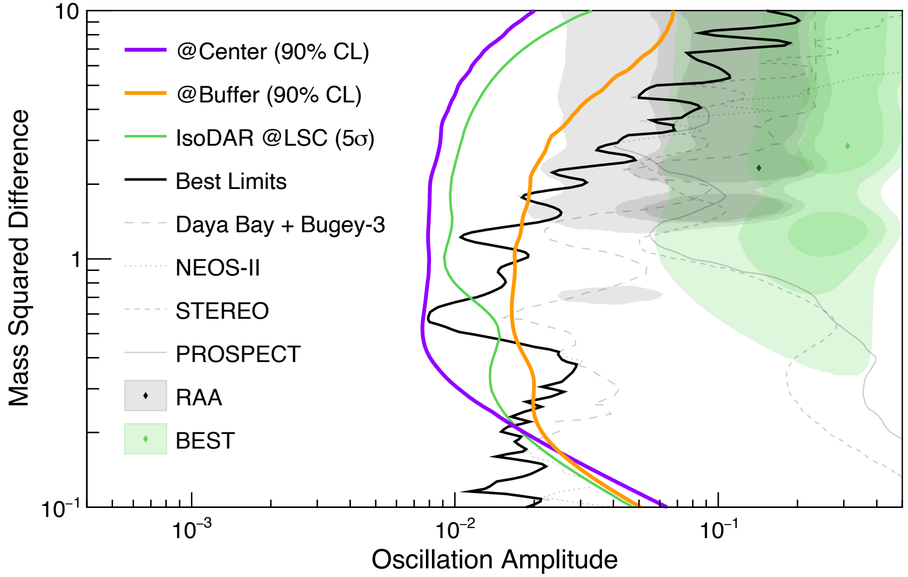


(Isotope Decay-At-Rest)

Option 2: use high activity radioactive source + in situ detection of signal.





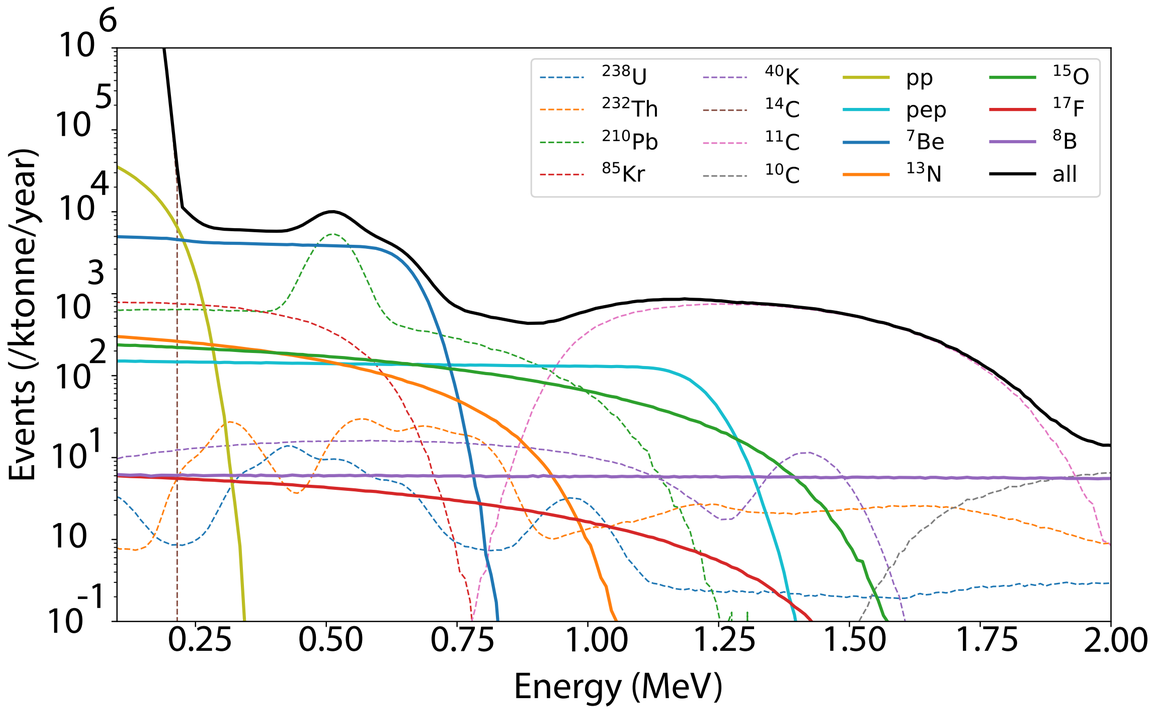


Both options allow us to confirm or rule out BEST result.

Solar neutrino physics with νEYE

Among possible topics, so called **observation of the "up-turn"** seems the most important.

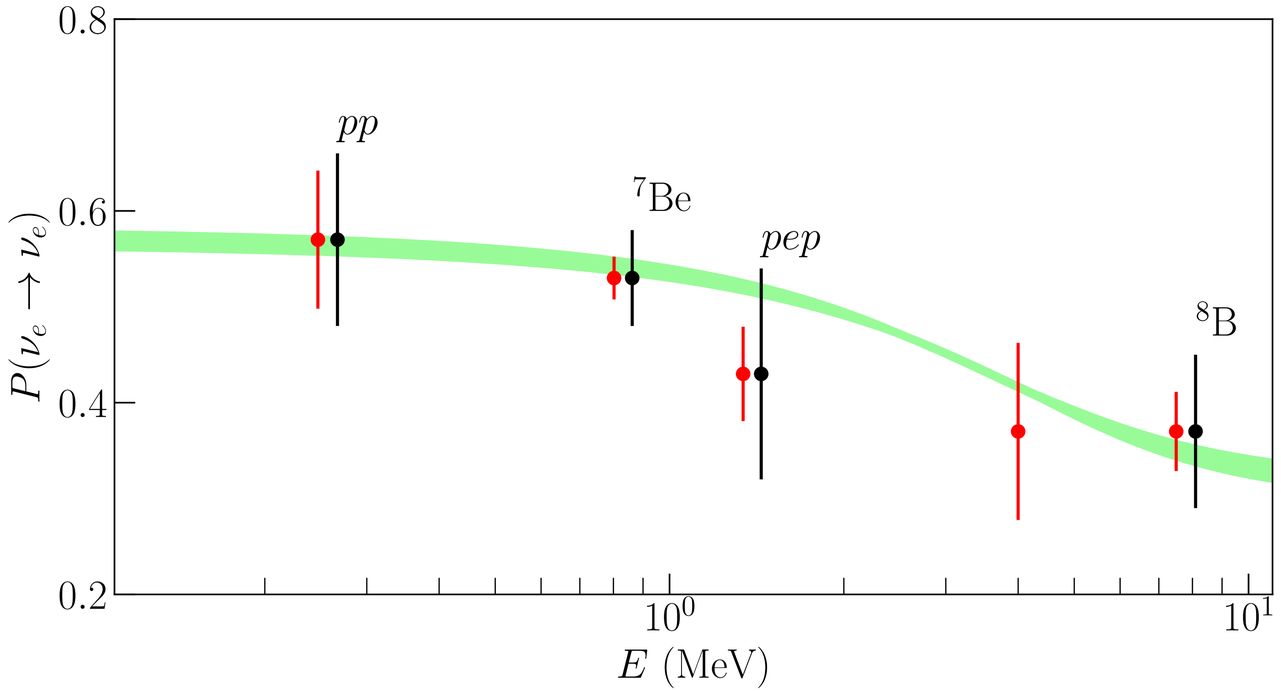
- Radio-purification is required.



Detailed understanding of signal/background (reduction of background) is critical.

For pp, error doesn't scale with $1/\sqrt{N}$ due to pile up of ^{14}C.

Red: νEYE
Black: Borexino

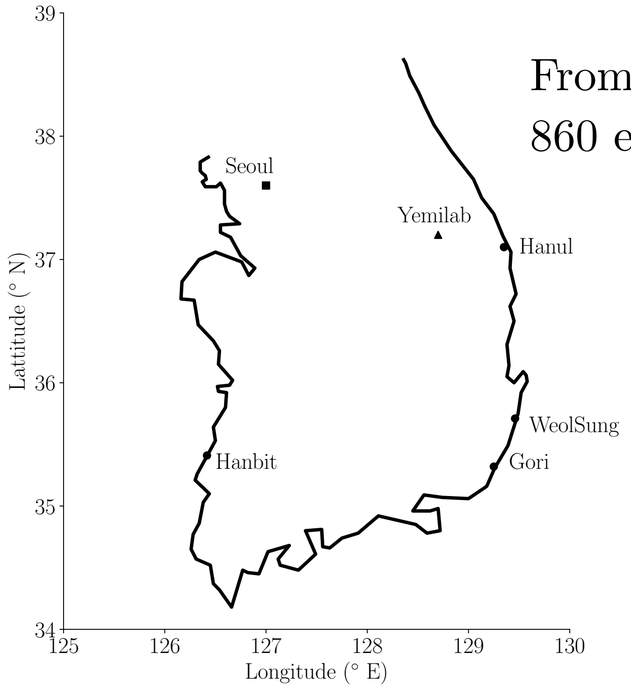


νEYE can provide points in this region.

Reactor neutrino with νEYE

The JUNO experiment will measure 3-ν oscillation parameters with high precision.
But JUNO findings **need to be validated**: the νEYE is also at the first minimum.

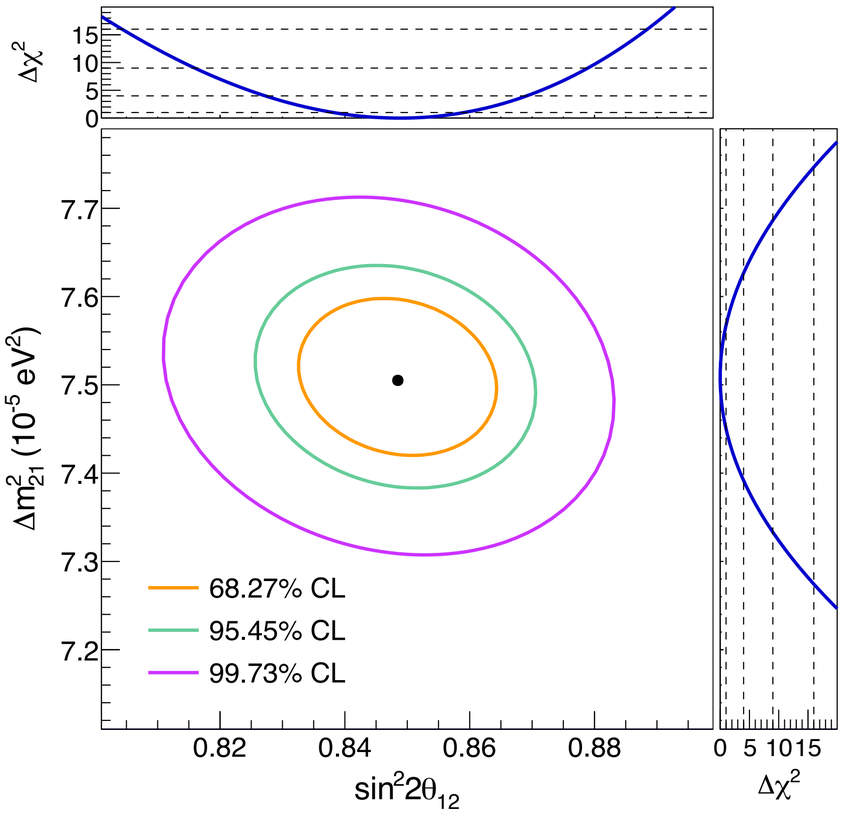
Will confirm JUNO finding.



From Hanul, we expect 860 events per year.

	Hanul	Wolsong	Gori	Hanbit
Thermal Power (GW)	20.8	11.8	21.3	16.9
Baseline (km)	65	180	216	282

νEYE sensitivity on Δm^2_{21} and $\sin^2 2\theta_{12}$



$\Delta m^2_{21} = (7.51 \pm 0.06) \times 10^{-5}$ eV^2 and $\sin^2 2\theta_{12}$
$= 0.848 \pm 0.010$ (all statistical error only)

Neutrinoless double beta decay with νEYE

At the end of the experiment, the νEYE telescope can be loaded with metal to allow a neutrino-less double beta decay experiment.

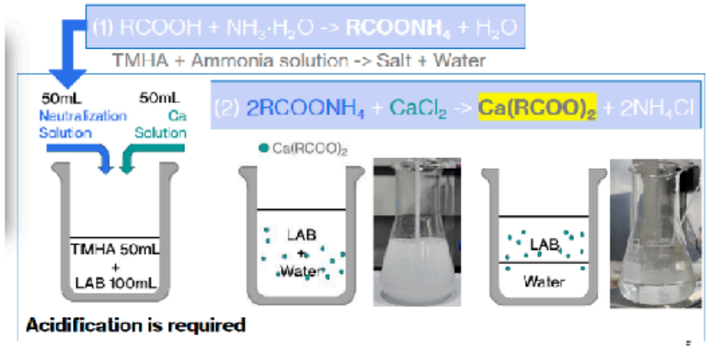
Candidate isotopes: Tin-124 (Q=2.2 MeV) or ^{130}Te (Q = 2.54 MeV). Recently Xe is also under consideration.

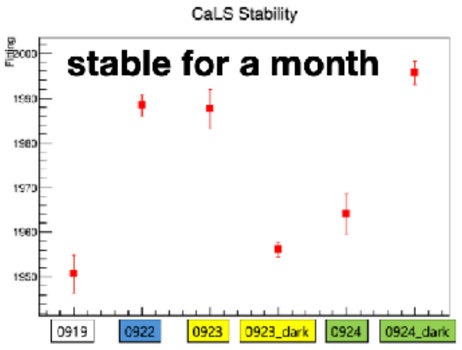
This topic requires a long-term R&D on the loading issues.

Current R&Ds and Sensitivity

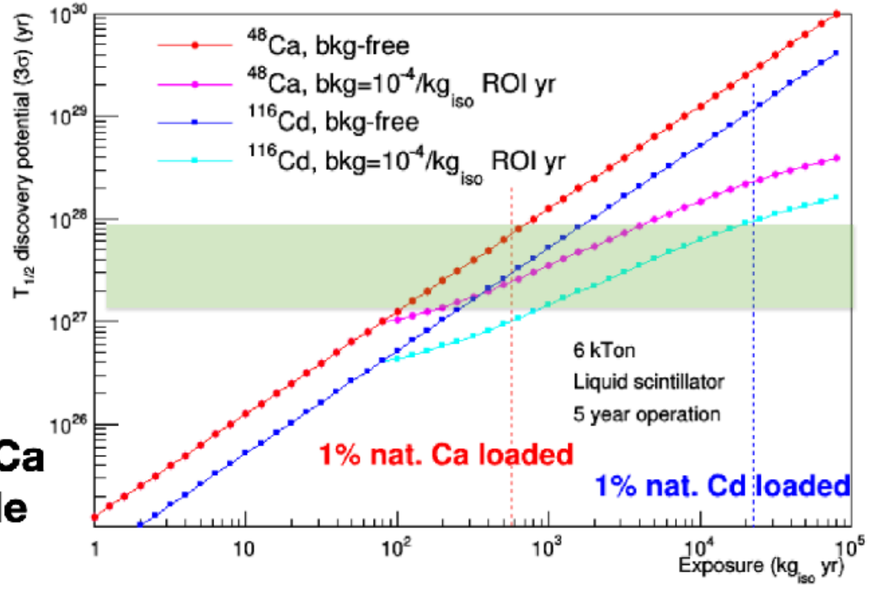
Example from CPNR workshop last week.
Chang Hyun Ha (CNU)
Idea: Isotope loading and extraction

https://indico.neutrino.or.kr/event/356/timetable/#20251024.detailed





R&D with KNU shows 2.8 g/L Ca loading possible

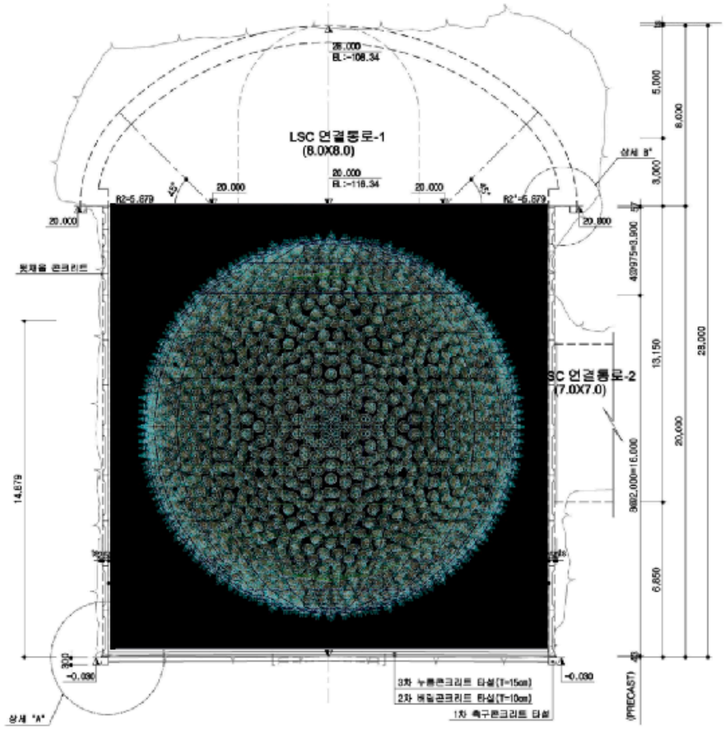


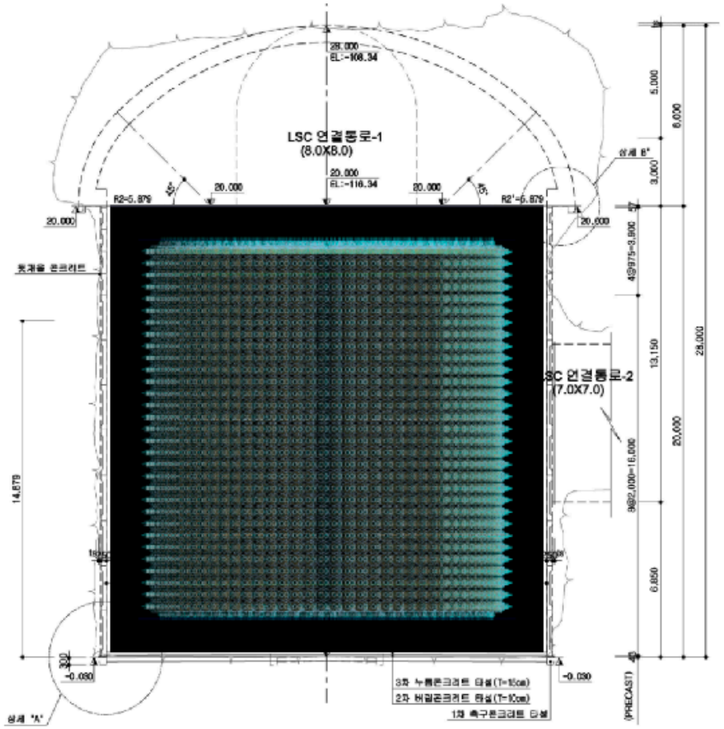
1% nat. Ca loading would give us 114kg * 5yr Exposure (bkg. better, mass lower)
For Cd, 22,500 kg yr exposure (higher mass, a bit of bkg will not be competitive),
For Se and Mo, somewhere in between.

Detector Design

Detector concept

A 2 kilo tonne liquid scintillator (the actual target-mass is smaller).
At this moment, we consider two options: **spherical** or **cylindrical**.





Shape	Cylindrical	Spherical
Radius (m)	7	7.25
Height (m)	14.5	-
Volume (m^3)	2232	1596
Mass (kg)	1920	1373
Number of PMTs	3700	3000

Size of buffer volume is under optimization.

Photodetector

Our primary choice for the photodetector is **photomultiplier** technology.
Another possible option: LAPPD - complication of readout, cost issues have to be resolved.
(https://sites.google.com/korea.ac.kr/the-nueye-telescope/pubpresentations)

In the market, we have three major choices.
- To reduce the cost, our primary choice becomes N6082 (8 inch) + "light concentrator".

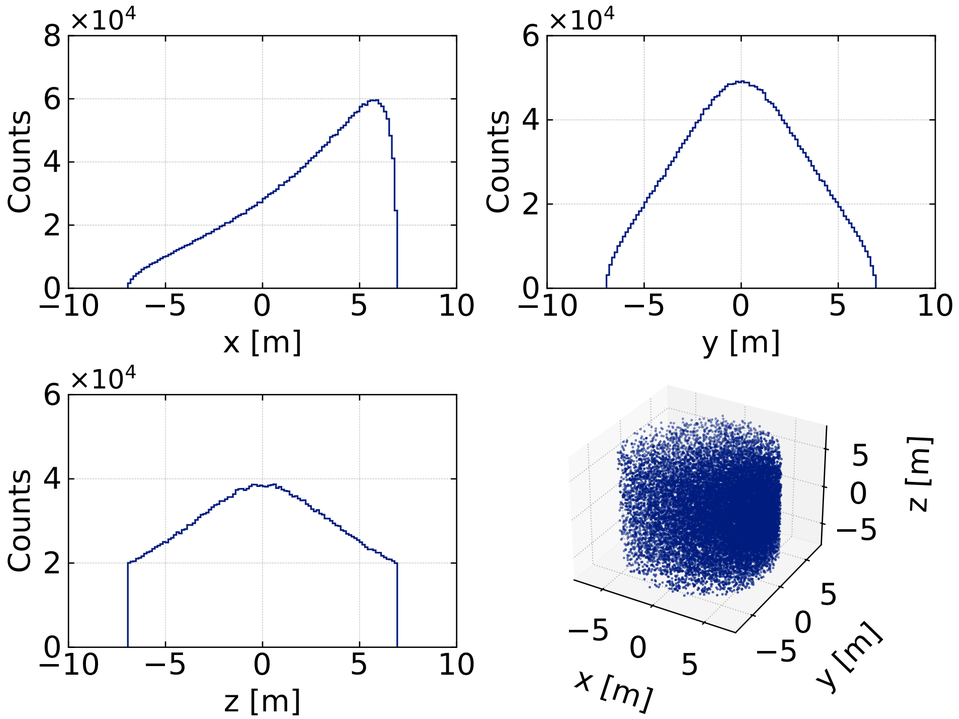
Model	R12860	N6203	N6082
Size (inch)	20	20	8
Peak wavelength (nm)	420	380	380
HV (V)	2000	1900	1750
Q.E. (%)	30	30	30
TTS (ns)	2.4	5	1.6
Supplier	Hamamatsu	NNVT	NNVT

North Night Vision Technology Co., Ltd. (NNVT)

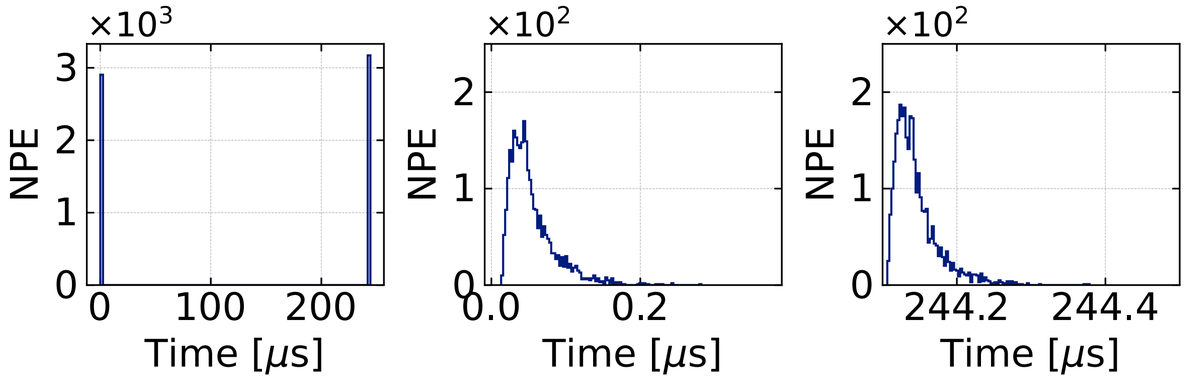
Software developments with Geant4

^{144}Ce $\bar{\nu}_e$ production simulation (Geant4) and reconstruction of inverse beta decays (IBD)

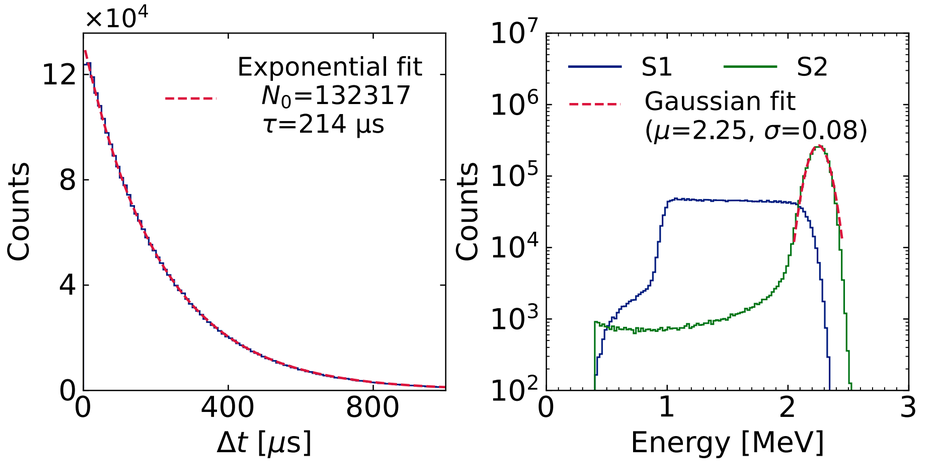
^{144}Ce at (9,0,0) m



Hit time distributions (S1, S2 together, S1 and S2 respectively)



Time difference btw S1 and S2 (left) and energy deposit (right)



IBD events trigger

- Require hits in 200 ns
- If NPE $>$ 400, all hits in 500 ns constitute first cluster (S1)
- Search for the second cluster (same condition, S2)

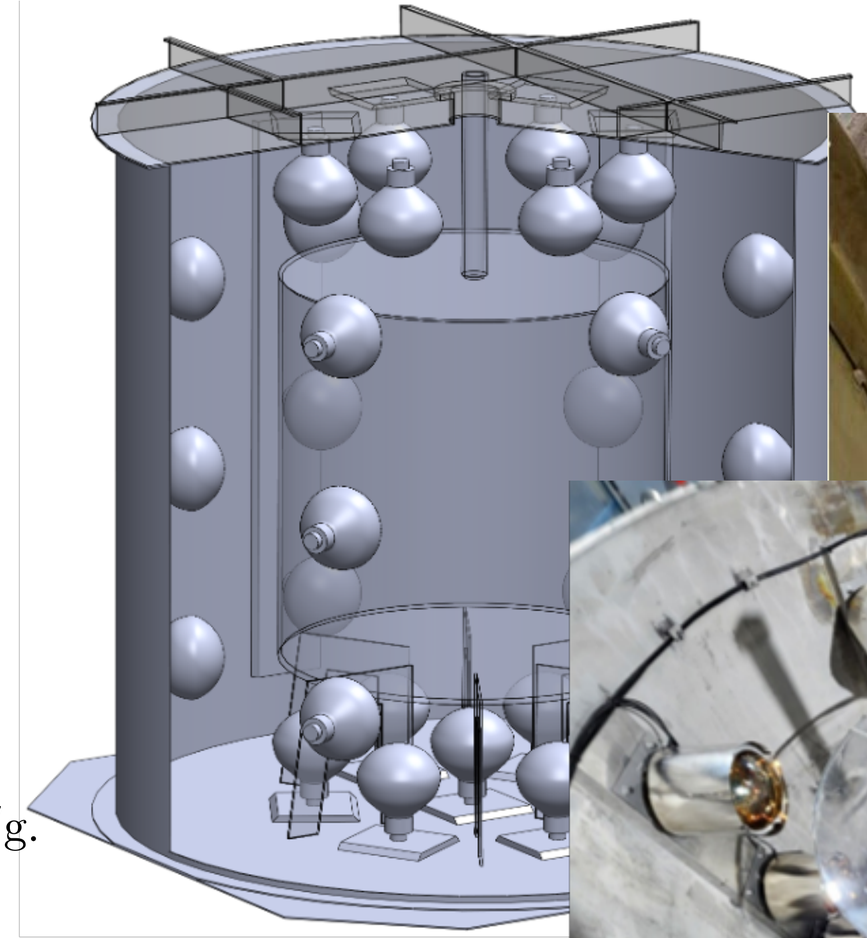
A prototype νEYE (1 tonne) construction

Volume : 1.2 m x 1.2 m acrylic tank: $O(1)$ tonne of LS.
Buffer : pure water or mineral oil.
PMTs : O(30-60) PMTs of 10" R7081.

DAQ and HV
- FADC: 500 MHz (to be purchased from Notice).
- CAEN A7435SP (some parts have to be purchased).

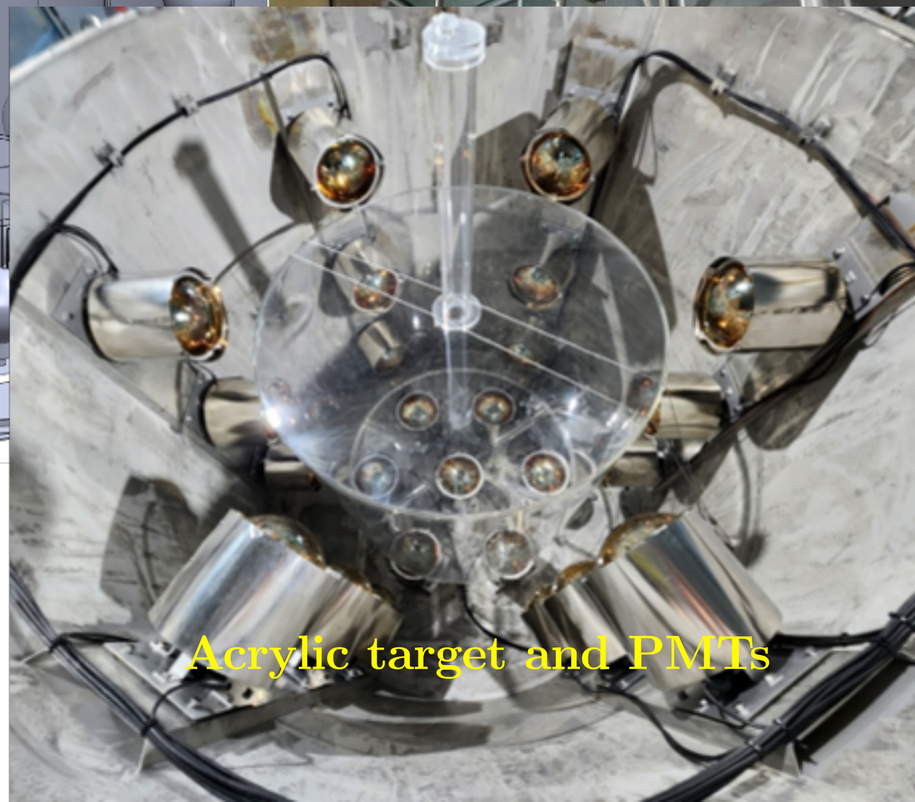
Purpose
- Study and optimize LS.
- Measure the intrinsic background : $10^{-13 \text{ or } -14}$ g/g.
- To provide feedback to full scale νEYE detector.
- Optimize and validate the Geant4 simulation.

Construction started from summer of 2025.



Upper side





Acrylic target and PMTs

- 1 tonne prototype preparation

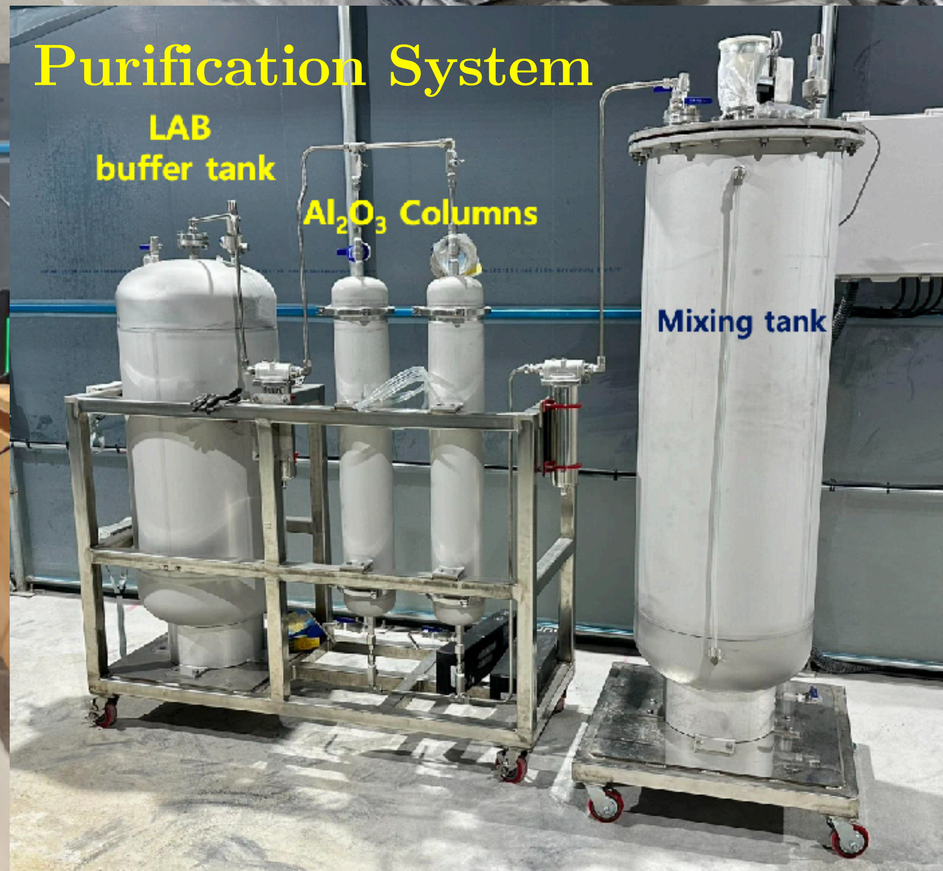
Tent, outer/iner containers
Purification system
Readout/DAQ all prepared.



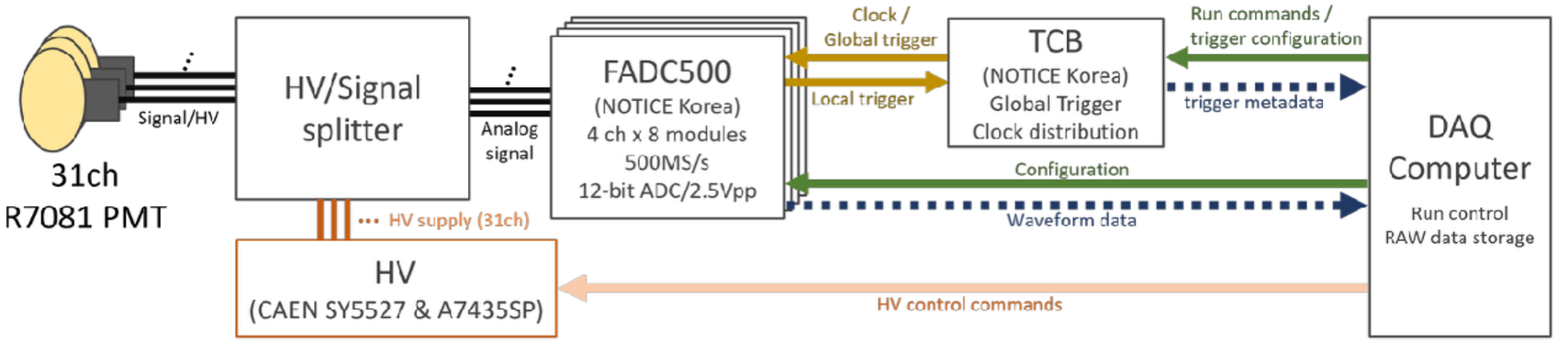


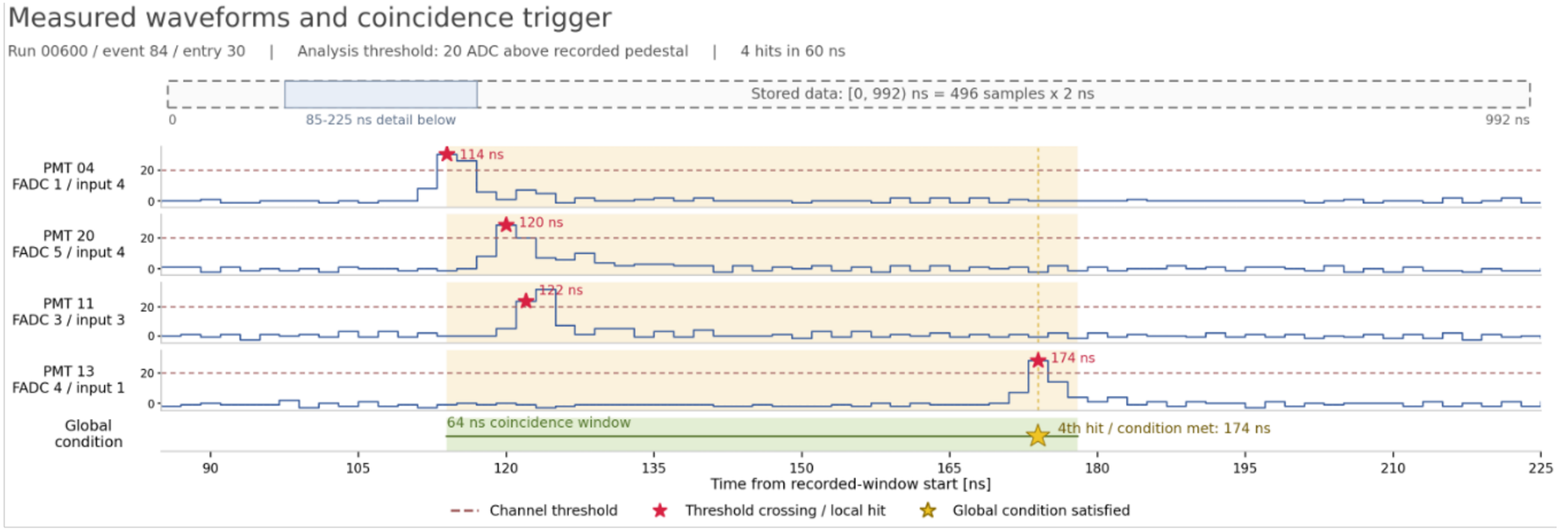






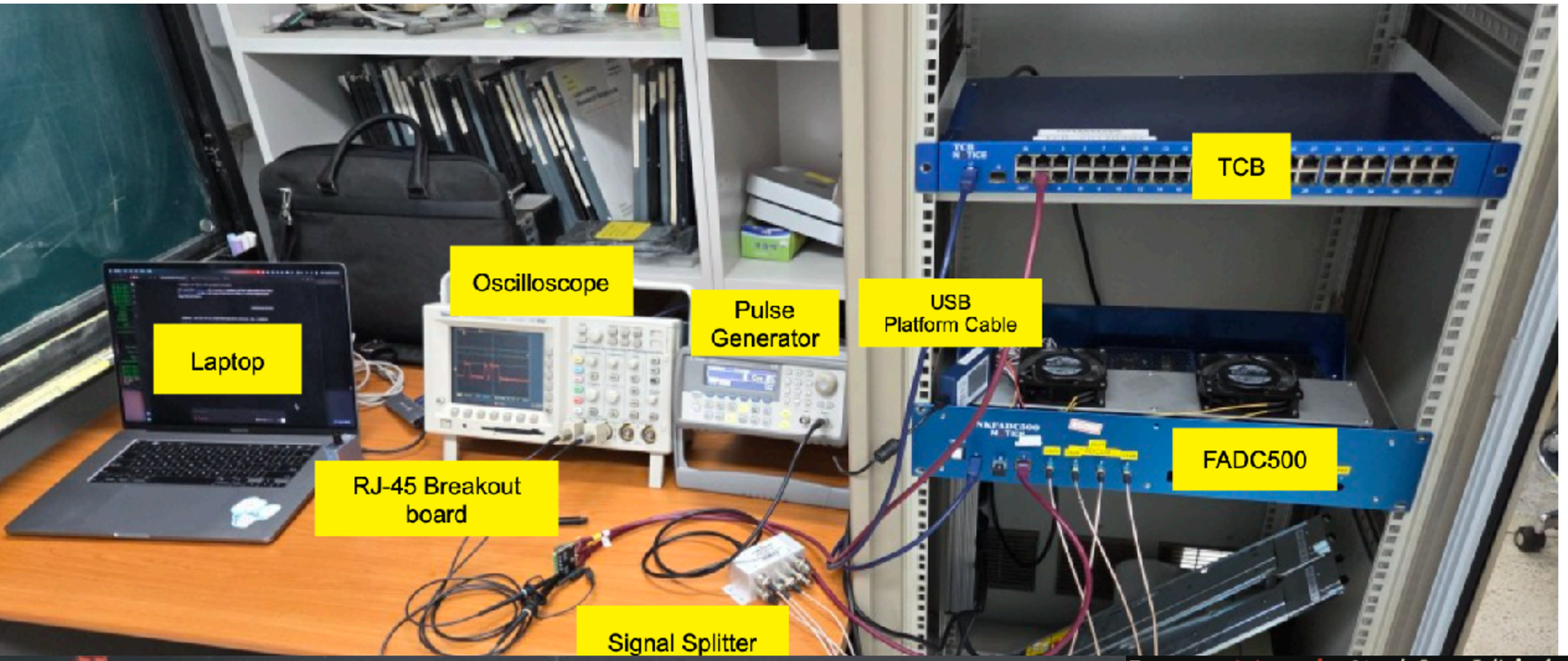
- 1 tonne prototype preparation







- Hardware test bench (Firmware debugging in Korea U+Notice)

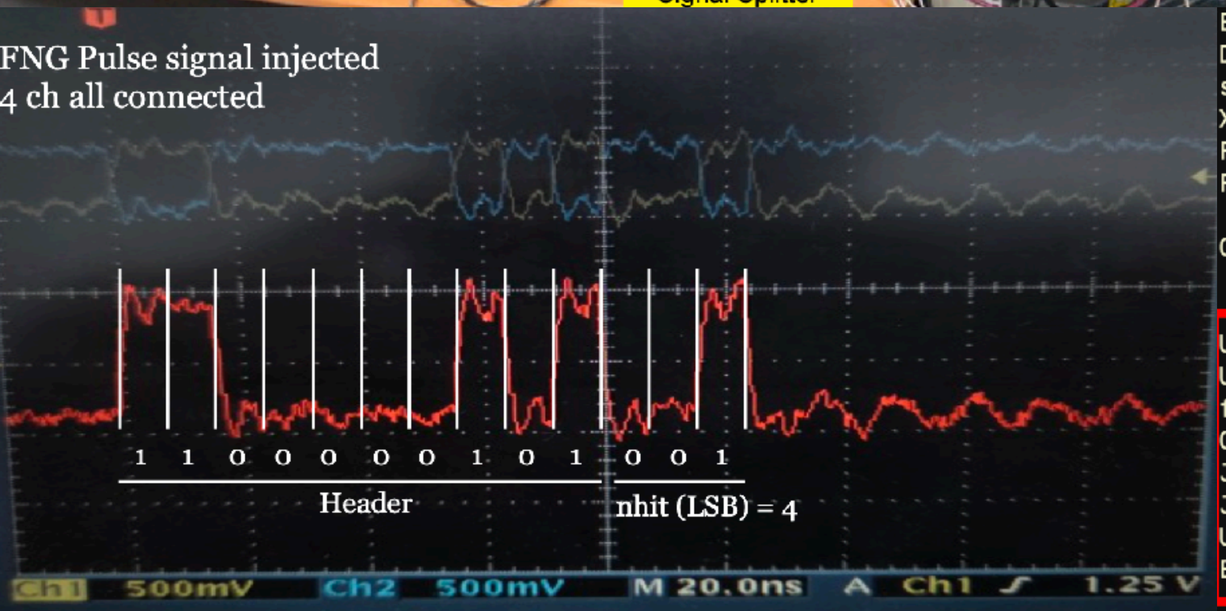


FPGA: upload via USB
CPLD: upload via JTAG

Single-bit level scope check!

Firmware version now in register.
Several bugs already fixed.

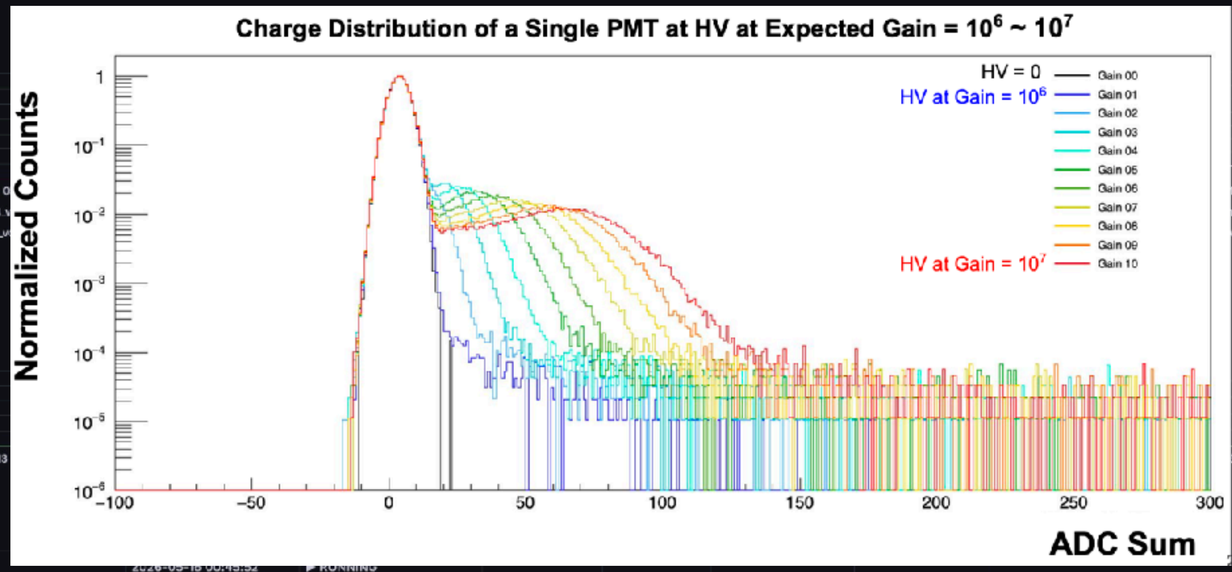
From user to developer !

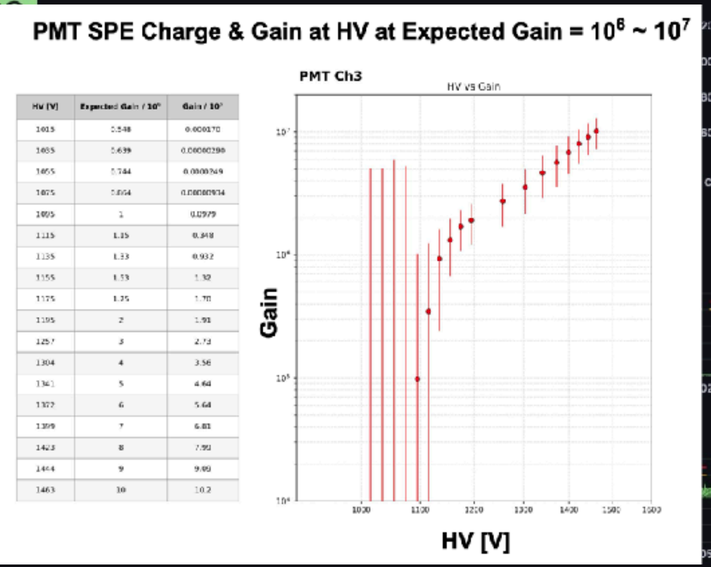



```
Eunwoo nkdaq_sim % ~/.local/bin/upc100-init
Done.
set_configuration(1): LIBUSB_SUCCESS / LIBUSB_TRANSFER_COMPLETED (0)
XC3SPROG (c) 2004-2011 xc3sprog project $Rev: 774 $ OS: Darwin
Free software: If you contribute nothing, expect nothing!
Feedback on success/failure/enhancement requests:
        http://sourceforge.net/mail/?group_id=170565
Check Sourceforge for updates:
        http://sourceforge.net/projects/xc3sprog/develop

Using built-in device list
Using /Users/jang-eun-u/.local/share/xc3sprog/cablelist.txt
firmware version = 0x0012 (18)
CPLD version = 0x0012 (18)
JTAG chainpos: 0 Device IDCODE = 0x16d8a093     Desc: XC2C128_VQ100
JTAG loc.:   0  IDCODE: 0x16d8a093  Desc:                XC2C128_VQ100 Rev: A  IR length:  8
USB Read Transactions: 2 Write Transactions: 5 Control Transaction 13
Eunwoo nkdaq_sim %
```

- Dry run: Apr. - May 2026
- Water run: Jun. - Sep. 2026
- Oct. - : LS run !!!

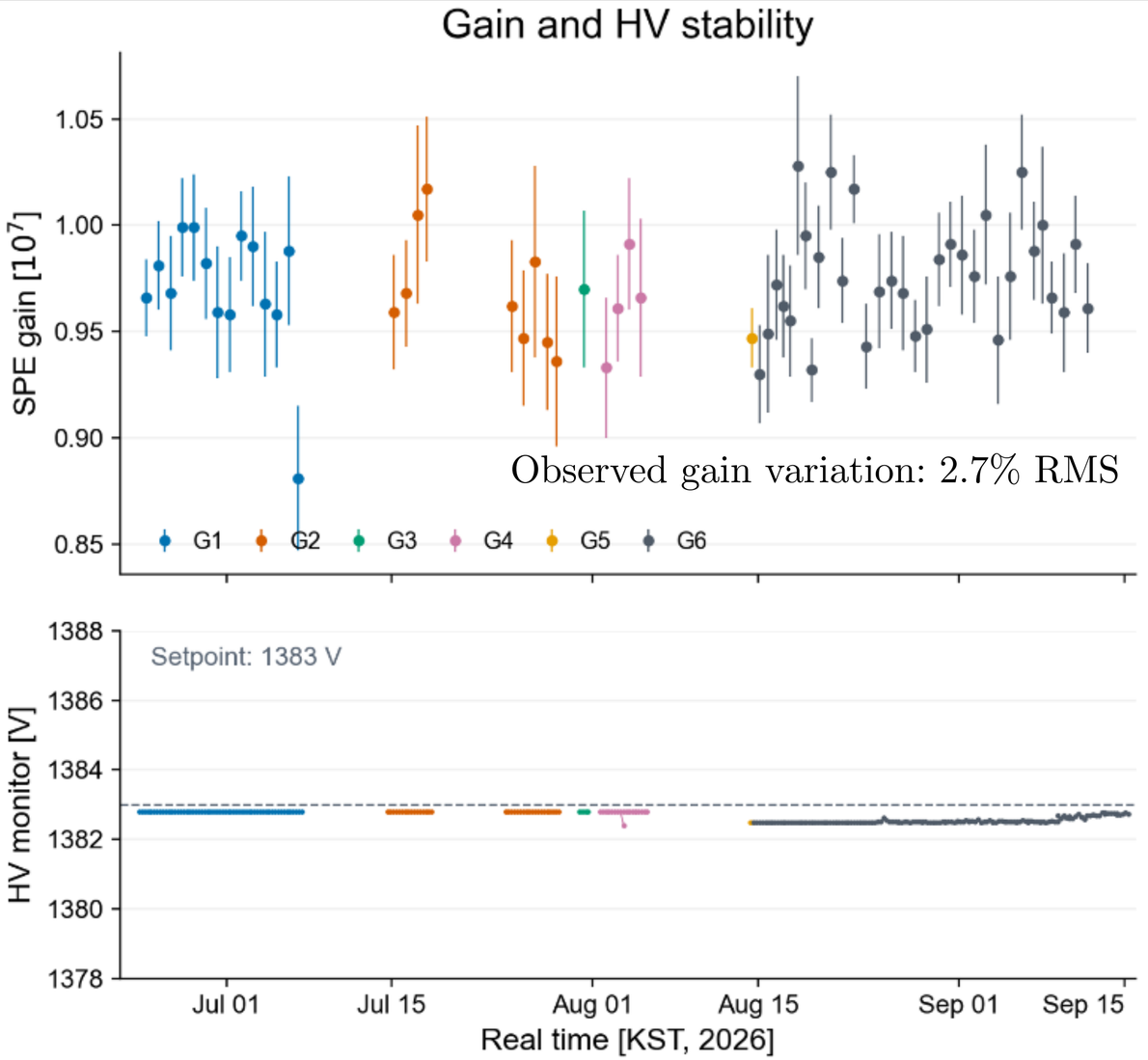


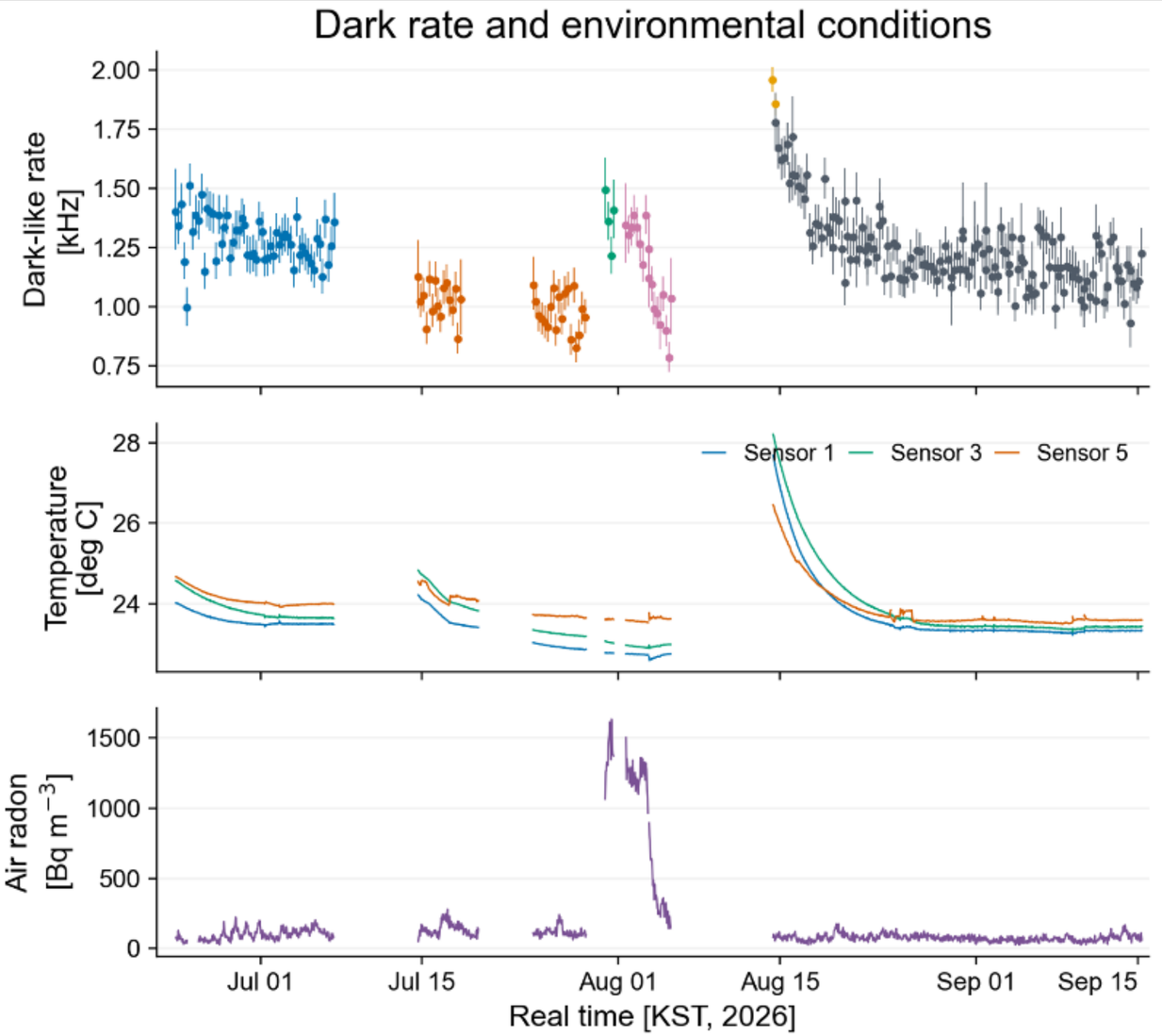


Run control and Monitoring

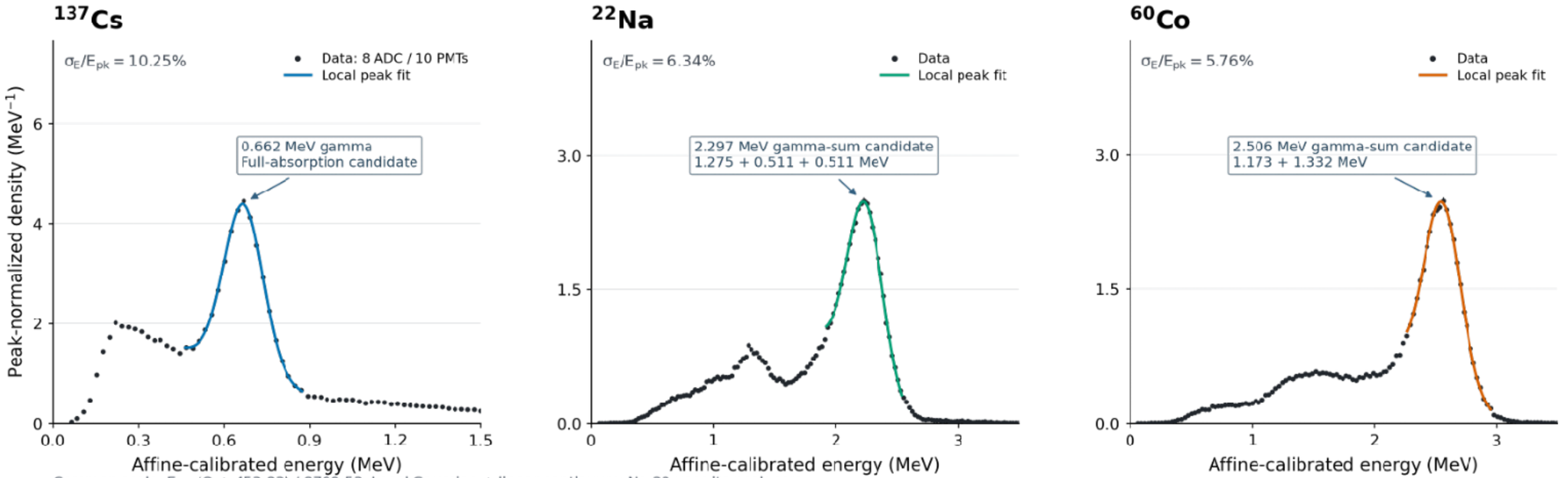
Details reported in KPS fall 2026

- Water Run

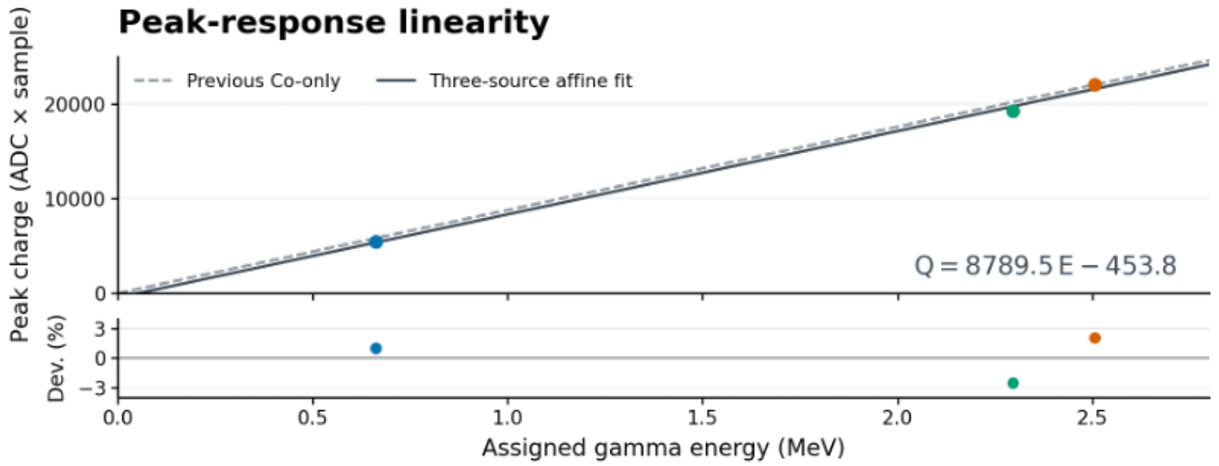

Gain and HV stability
SPE gain [10^7]
1.05
1.00
0.95
0.90
0.85
G1
G2
G3
G4
G5
G6
Observed gain variation: 2.7% RMS
HV monitor [V]
1388
1386
1384
1382
1380
1378
Setpoint: 1383 V
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Real time [KST, 2026]

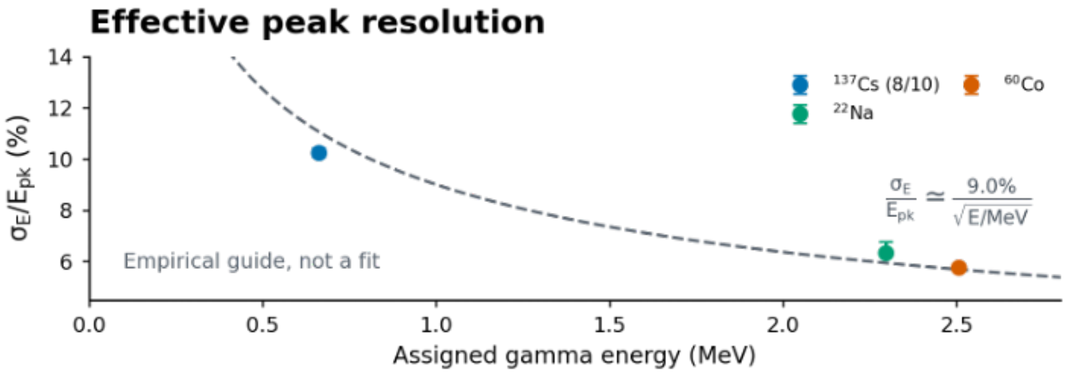

Dark rate and environmental conditions
Dark-like rate [kHz]
2.00
1.75
1.50
1.25
1.00
0.75
Temperature [deg C]
28
26
24
Sensor 1
Sensor 3
Sensor 5
Air radon [Bq m^-3]
1500
1000
500
0
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Real time [KST, 2026]

- First LS data with source !!! (14 Oct. 2026)



Common scale: E = (Q + 453.83) / 8789.53. Local Gaussian + linear continuum; Na-22 uses its peak core.
Peak-window normalization; statistical errors. Peak assignments and widths are preliminary; no MC used.





Bars: fit-range variation only; not total uncertainty.
Dashed: empirical trend guide, not an independent prediction.

CDR updated: Sep. 2026 (to include 1 tonne detector + other R&D)

[Submitted on 18 Jan 2026 (v1), last revised 9 Sep 2026 (this version, v2)]

The νEYE Neutrino Telescope: Conceptual Design Report

Shaomin Chen, YangHwan Ahn, Davide Franco, Fabio Mantovani, Aldo Ianni, Jiyong Choi, S. Gwon, K. K. Joo, Chang Hyon Ha, Kim Siyeon, Jong-Chul Park, M. Pac, Pouya Bakhti, Meshkat Rajaee, Seodong Shin, Young Ju Ko, Bo-Young Han, Jihoon Choi, B. R. Ko, HyangKyu Park, Gihan Hong, Jaebak Kim, Minseo Kim, Kyungmin Lee, E. Won, Jae Hyeok Yoo, J.Y. Cho, J.Y. Lee, D.W. Jeong, H.J. Kim, Sin Kyu Kang, Myung-Ki Cheoun, V. Kornoukhov, V. Kobychev, V.I. Tretyak, Steve Elliott, Jose R. Alonso, Janet M. Conrad, Michael H. Shaevitz, Joshua Spitz, Daniel Winklehner

The **νEYE** neutrino project leverages the existing large pit at Yemilab located in South Korea, to reveal the existence of sterile neutrino, the up-turn of the neutrinos from the Sun, and the first minimum of the neutrino oscillation over distances on the order of tens of kilometers for the first time. This initiative is expected to facilitate a wide range of significant scientific and technological advancements within both South Korean and international communities engaged in neutrino science and technology. The **νEYE** aims to investigate the largely unexplored sector of almost-massless lepton in the elementary particle physics in detail. The emphasis will be placed on the study of real time nuclear processes and reactions involving possible sterile neutrinos on timescales down to nanoseconds in ultra-high intense or radioactive neutrino beams for the first time in the world; the **νEYE** looks at to-be universal oscillation (``up-turn" in the electron neutrino survival probability) of neutrinos predicted by the three neutrino oscillation paradigm. This will confirm or deny our current understanding on the particle interactions of the lepton sector; and measurement of the first oscillation minimum between the first and second neutrinos in mass.

Comments: 27 figures
Subjects: **High Energy Physics - Experiment (hep-ex)**
Cite as: arXiv:2601.12569 **[hep-ex]**
(or arXiv:2601.12569v2 **[hep-ex]** for this version)
https://doi.org/10.48550/arXiv.2601.12569

Submission history

From: Eunil Won [view email]
[v1] Sun, 18 Jan 2026 20:17:47 UTC (21,481 KB)
[v2] Wed, 9 Sep 2026 05:46:21 UTC (40,017 KB)

Summary

The νEYE neutrino telescope: a multi-purpose, 2 kilo tonne LS detector @ Yemialb.

Selected physics cases are discussed.

- Sterile neutrino search.
- Solar neutrino: "up-turn" in the survival probability, metallicity (not discussed).
- Reactor neutrino: Yemilab is at the first minimum of Hanul reactor.
- $0\nu\beta\beta$ experiment R&D discussed.

Default designs of νEYE detector are presented.

- LS: slow LS (other options under consideration).
- PMT: 8/20 inch version + light concentrator (for now at least).
- Software : IBD, generators, $e^- - \nu_e$ scattering (not discussed).
- Alternative options.

One tonne prototype νEYE construction completed: **data analysis ahead.**

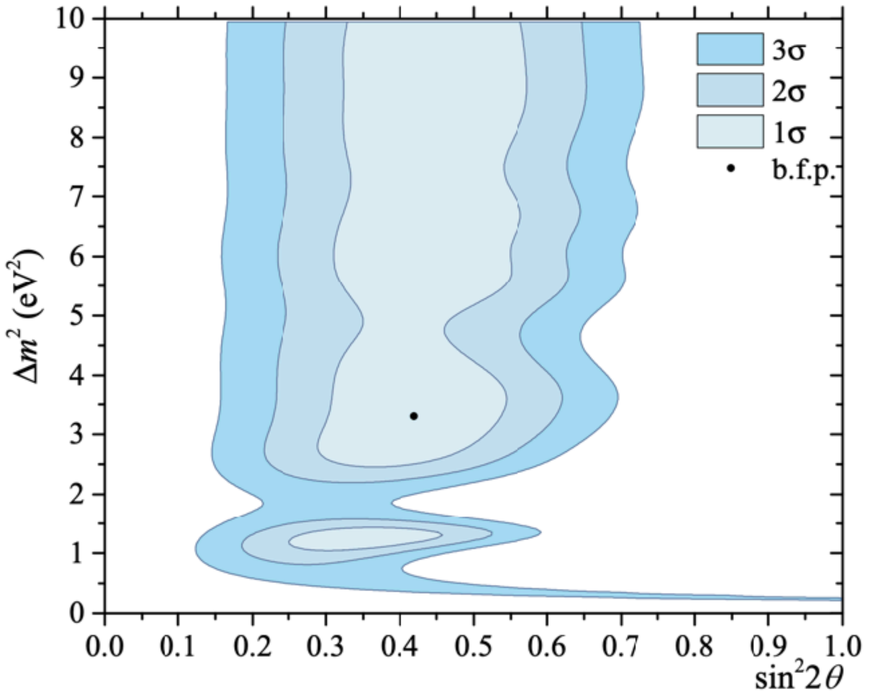
Summary of sterile neutrino search over the last 20 years

Since the LSND anomaly, a lot of efforts went into the search for the sterile neutrino.

- KARMEN (neutron spallation) did not confirm LSND.
- MiniBooNE ($\nu_e + \bar{\nu}_e$) compatible with LSND but with low energy excess.
- μBooNE disfavors MiniBooNE and LSND (not rule out completely).
- Daya Bay, RENO found deficit but likely due to flux calculation issue.
- NEOS, STEREO, PROSPECT, DANSS, SOLID: no evidence, Neutrino4 found arguable 3σ signal ($\Delta m^2 = 7\ eV^2$).

- SAGE, GALLEX (solar ν_e disappearance) found Gallium anomaly.
- Most recently BEST experiment claimed 4σ signal (3.4 MCi ^{51}Cr source, radiochemical method)

Has to to be resolved.



Baksan Experiment on Sterile Transitions (BEST)

Phys. Rev. Lett. 128, 232501 (2022)

Sterile neutrino? (Example: two talks in Neutrino2024) - a dark matter candidate

June 21, 2024 (v1) | Presentation | Open

Sterile ν: review of positive hints

Gorbunov, Dmitry

Plenary talk at the Neutrino 2024 conference. Session 14: Reactor neutrinos.

Part of Neutrino 2024 (Talks)

Uploaded on September 13, 2024

35 45

High Energy Physics – Experiment

[Submitted on 14 Jan 2025]

Experiment BEST-2 with 58Co neutrino source

V.N. Gavrin, V.V. Gorbachev, T.V. Ibragimova, V.A. Matveev

The article describes a new experiment with an artificial neutrino source 58Co on a gallium target GGNT (SAGE). The goal of the experiment is to study the gallium anomaly. The experiment makes it possible to find the parameters of oscillation transitions of electron neutrinos to sterile states in a wide range of parameters. Including the parameter {\Delta}m2, the experimental determination of which usually causes significant difficulties. An important feature of the experiment is the possibility of identifying the dependence of the gallium anomaly on the neutrino energy.

June 21, 2024 (v1) | Presentation | Open

Sterile ν: review of negative hints

Danilov, Mikhail

Plenary talk at the Neutrino 2024 conference. Session 14: Reactor neutrinos.

Part of Neutrino 2024 (Talks)

Uploaded on September 13, 2024

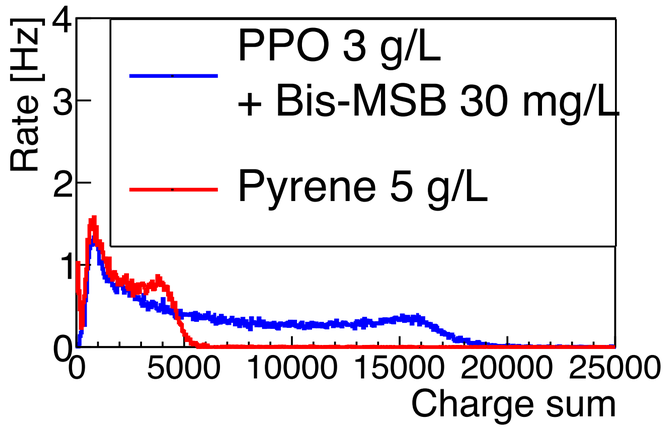
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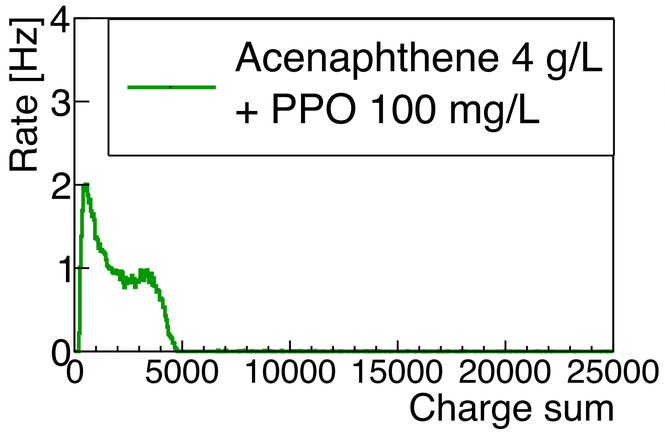
Some of you may be skeptical about sterile neutrino?

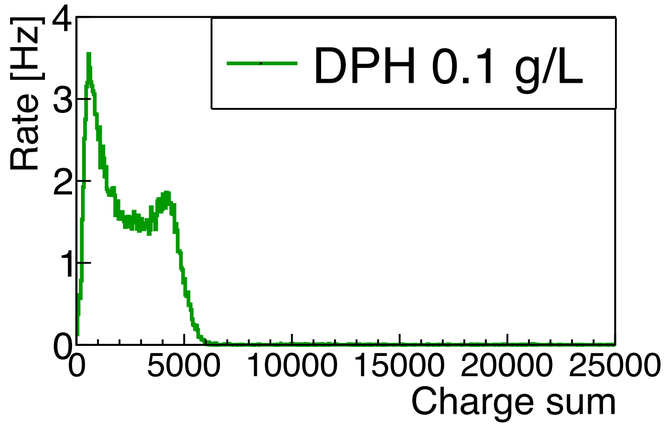
No problem but BEST results are to be resolved.

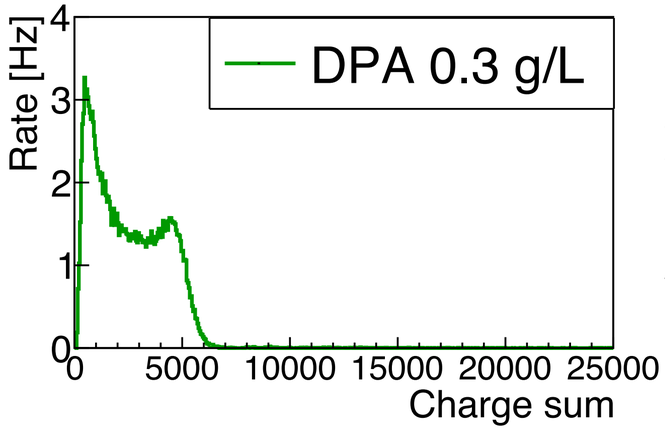
Target liquid scintillator

Our primary choice is "**slow scintillator**", to separate Cherenkov from scintillation.
A chemical lab was constructed to initiate this R&D @ Yemilab.









Light yield (LY) measurements.
- PPO + Bis-MSB shows the largest LY.
- Others show similar LY.

Detailed R&D status can be found from

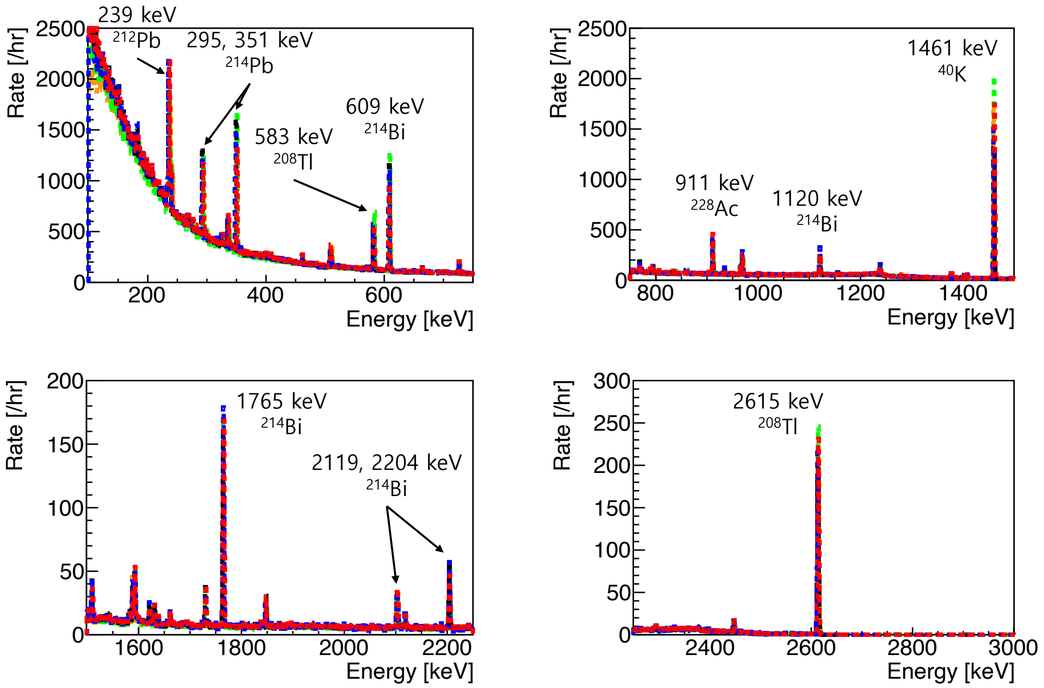
: https://sites.google.com/korea.ac.kr/the-nueye-telescope/pubpresentations

Environmental backgrounds @ Yemilab

At the Yemilab site, HPGe is utilized, to measure the radioactive background from rocks.

Bq/kg

	^{238}U	^{40}K	^{232}Th
Shotcrete	16.7 ± 0.6	447 ± 16	25.3 ± 0.6
Rock # 1	19 ± 2	618 ± 69	22 ± 2
Rock # 2	18 ± 2	872 ± 98	26 ± 2
Rock # 3	13 ± 1	561 ± 63	15 ± 1

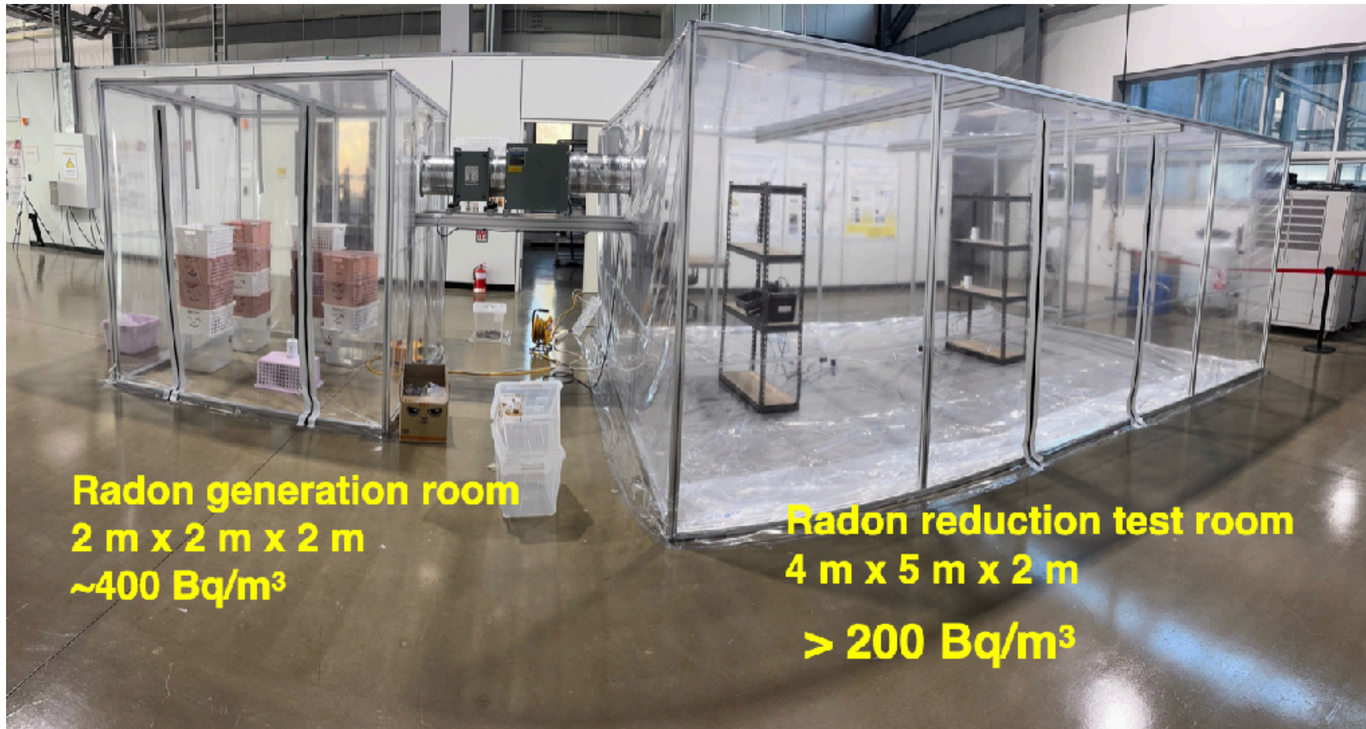


Measured Radon activity

Location	Radon level (Bq/m^3)
Up	68 ± 14
Middle	84 ± 19
Middle (opposite)	118 ± 12
Middle (low)	125 ± 21
Hall center	148 ± 17

Dedicated Radon reduction system is required.

We are exploring a new method: silver-ion exchanged zeolite (PTEP 2024 023C01) @ Korea U Sejong campus.



Software developments

- Early study: K. Lee et al, J. Korean Phys. Soc. **85**, 381–388 (2024), https://arxiv.org/abs/2401.13215

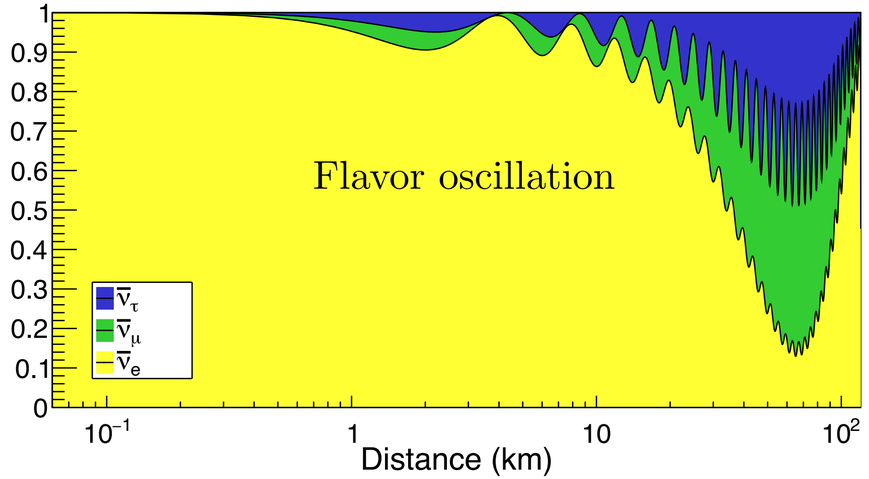
νOscillation

νOscillation: a software package for computation and simulation of neutrino propagation and interaction

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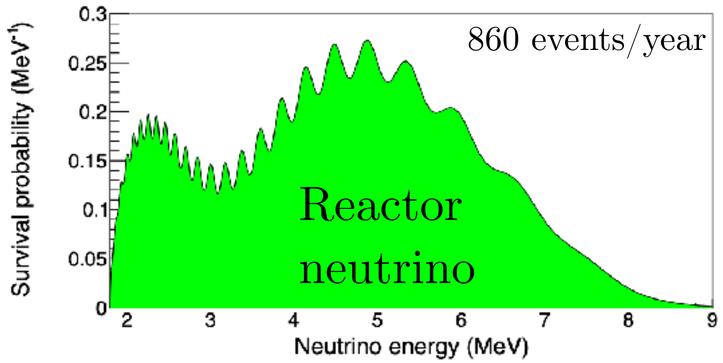
hysics, Institute for Basic Science, Daejeon 34047, Korea

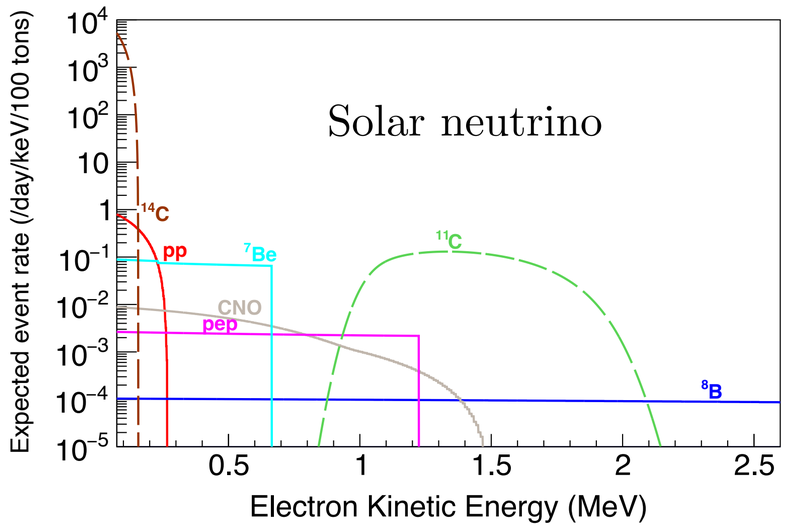


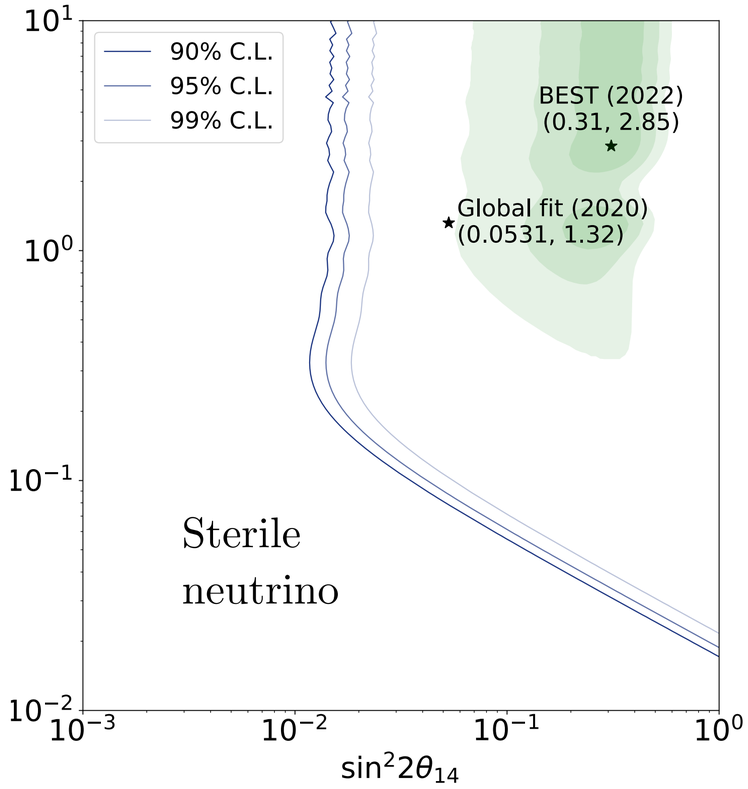
only phenomenon that cannot be explai
sterious neutrino interactions observed
nd ongoing or planned neutrino experi
ely on precise computations of neutrino

DRAFT

rom the sun, and the oscillation of
the neutrino oscillation with assuming a reactor located
at 53 km away from the detector.







Alternative Detector Technologies

Water based (WbLS) Technique

In Korea: Chunnam National U., Chung-Ang U., BNL and so on.

Opaque LS Technique (talk by Anatael Cabrera on Oct. 28)

- New concept: opaque liquid scintillator
- Created photons are confined locally (Rayleigh, Mie scatterings)
- Such photons are read out by optical fibers+silicon photomultipliers.

We look at potential for νEYE: R&D stated.
- (500 mL LAB + PPO 1.5 g) + parafin wax (10 g).
- Heating for 20 min. to melt the wax., and cool down.



νEYE web: https://sites.google.com/korea.ac.kr/the-nueye-telescope

http://nueye.korea.ac.kr

The NuEYE Experiment at Yemilab

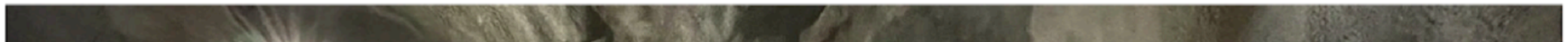
In September 2022, a new underground laboratory, Yemilab, was completed in Jeongseon, Gangwon Province in South Korea, with a depth of 1,000 m. In the laboratory, the largest site is the LSC Hall, combining a square dome measuring 22 m (width) by 22 m (length) by 8 m (height) on top, with a cylindrical pit having a diameter and depth of 20 m. The pit has a volume of 6,200 m^3 and serves as a multipurpose space for detectors. For a liquid type, about a 2 kilo-tonne detector can be hosted as an expample. The NuEYE experiment is a new proposed underground neutrino telescope at Yemilab for a multi-purpose neutrino science.

NEWS | 30 May 2024

Disputed dark-matter claim to be tested by new lab in South Korea

A multi-million dollar facility is hoping to put a 21-year-old debate about dark matter to rest.

By Gemma Conroy

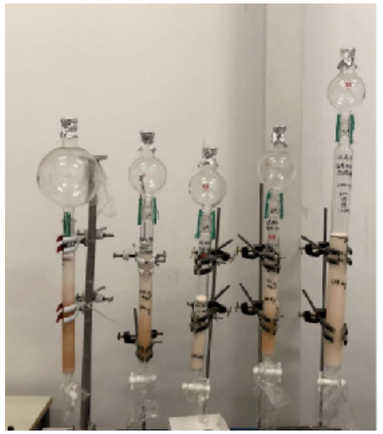


Radio-purification (for one tonne)

Filtration

Removes optical impurities.

Removal of U/Th and K.



Water extraction

Removes dissolved radioactive metal ions

K, U, Th, Pb removal

Inorganic impurities

Water extraction
Custom build.

Nitrogen gas stripping

Remove dissolved gases

Vacuum Distillation

Removes high boiling point impurities

Metal & Oxide, U/Th, K, Bi, Po/Pb





Now @ Yemilab

Glove box (see the picture on the right)

Other components are being purchased.