Progress of COSINE-100U experiment

(COSINE-100U at Yemilab)

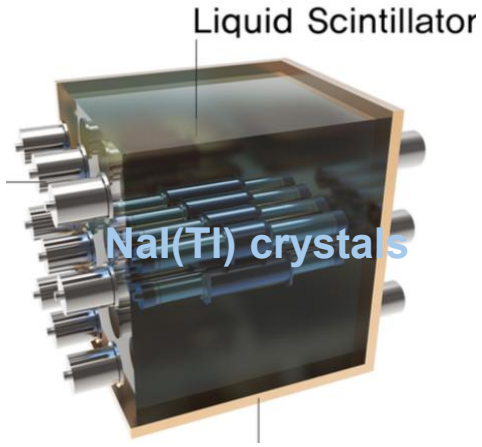
Doohyeok Lee

On behalf of the COSINE-100 collaboration

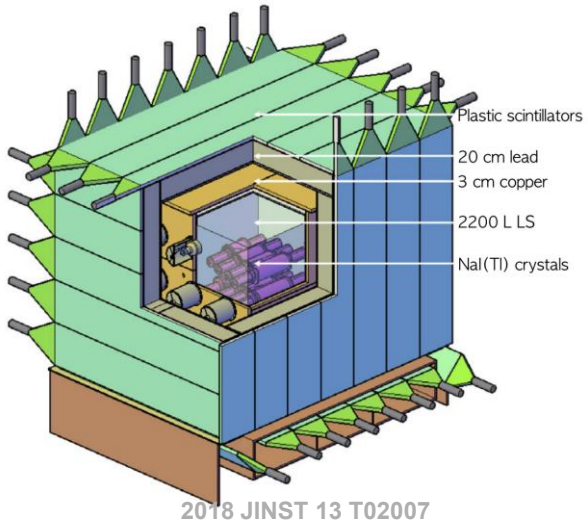
Department of Physics, Kyungpook National University

COSINE-100

COSINE-100 detector

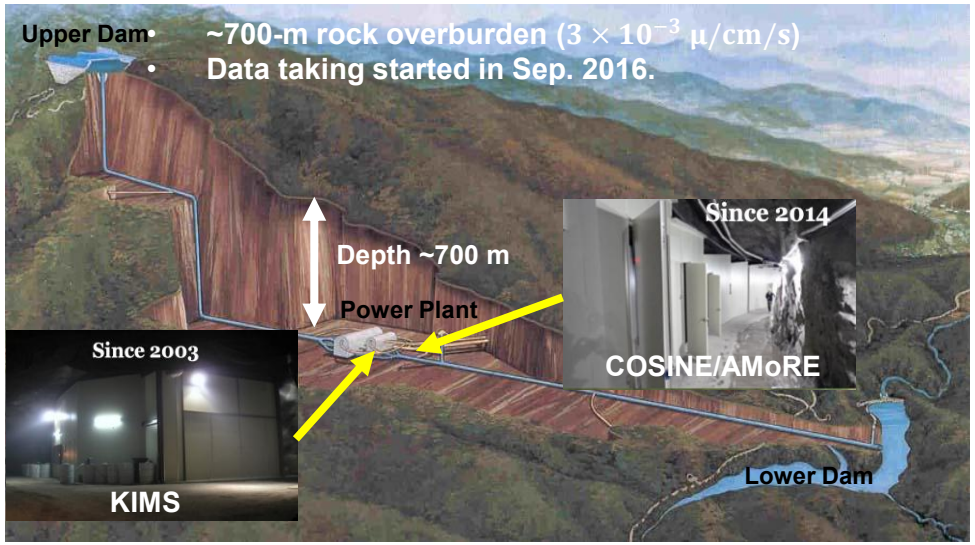


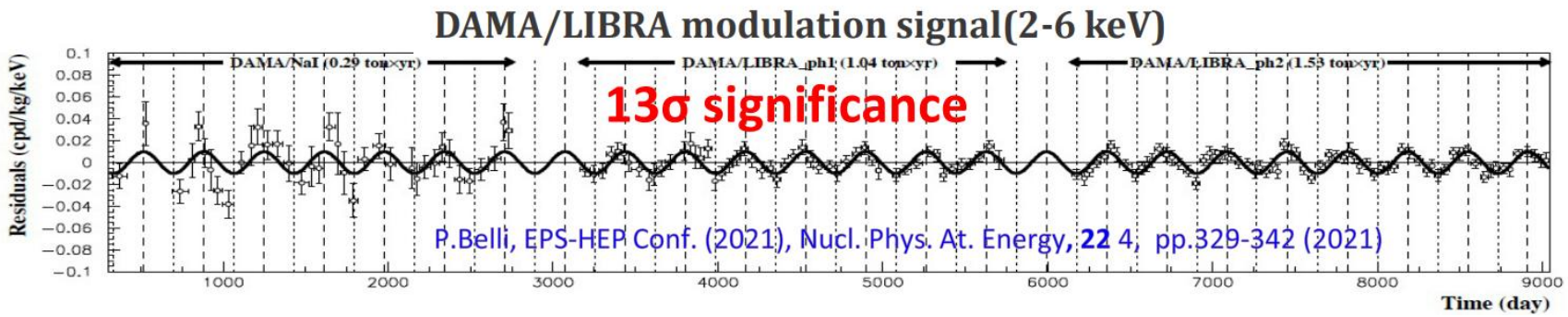
Nucl. Instrum. Meth. A 106, 165431 (2021)
Nucl. Instrum. Meth. A 851 103 (2017)



2018 JINST 13 T02007
Eur. Phys. J. C 78, 107 (2018)

Yangyang underground laboratory (Y2L), Korea

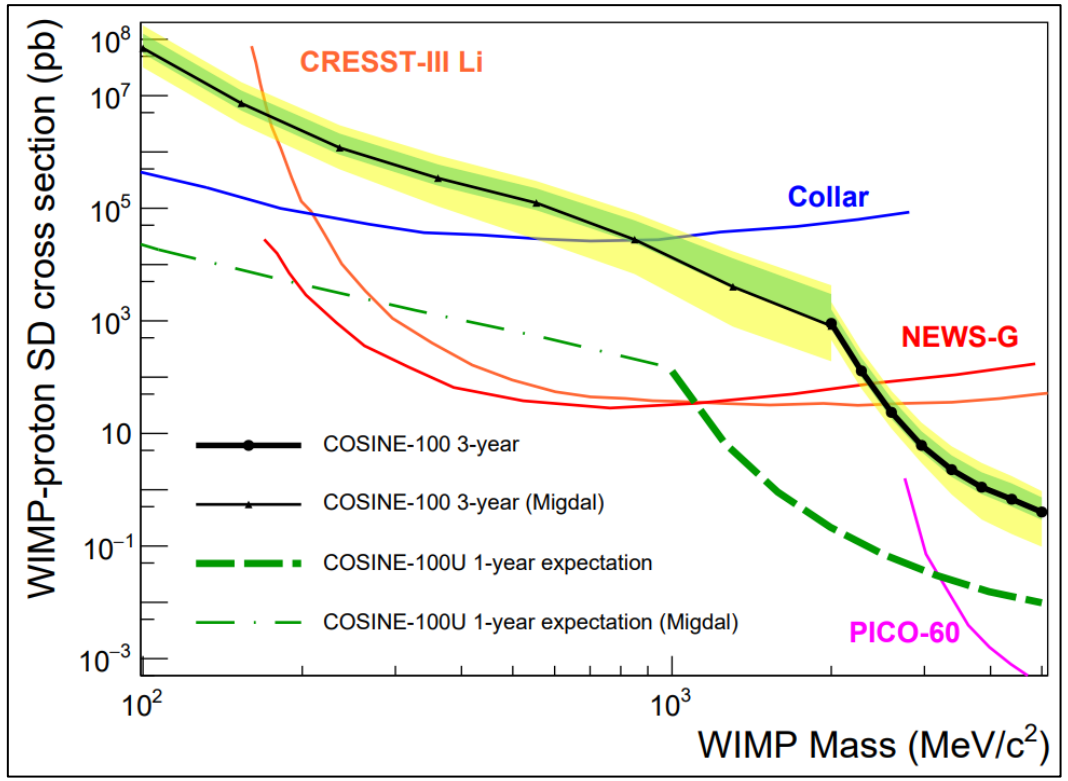




Details in Insoo's talk
25th Aug. 17:40~18:00

COSINE-100 Upgrade

arXiv:2501.13665



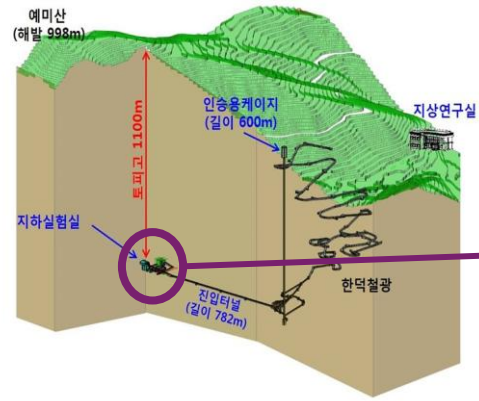
- For searching low mass WIMP

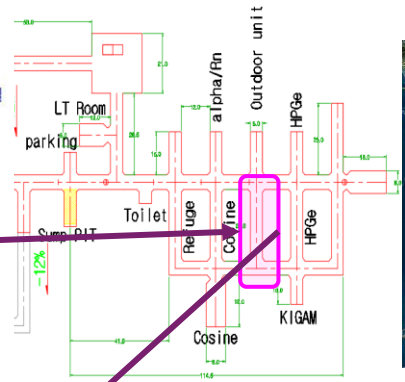
  WIMP : Weekly Interacting Massive Particles

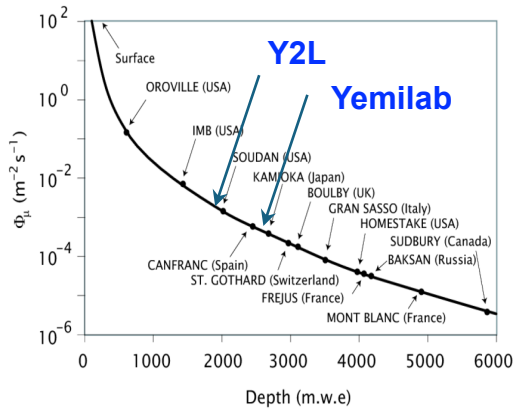
Park et al., Frontiers in Physics (2024)

Kim & Lee, AAPPS Bulletin (2024)

- Move COSINE-100 detector from Y2L (YangYang) to Yemilab (Jeongseon)

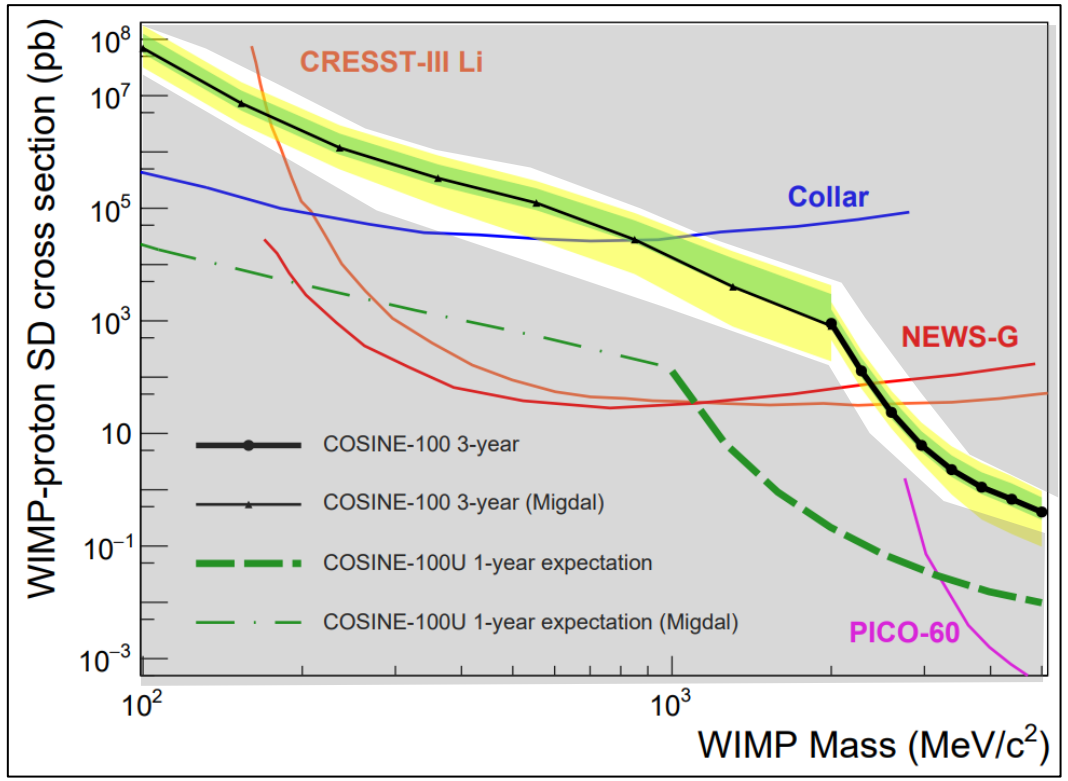






COSINE-100 Upgrade

arXiv:2501.13665



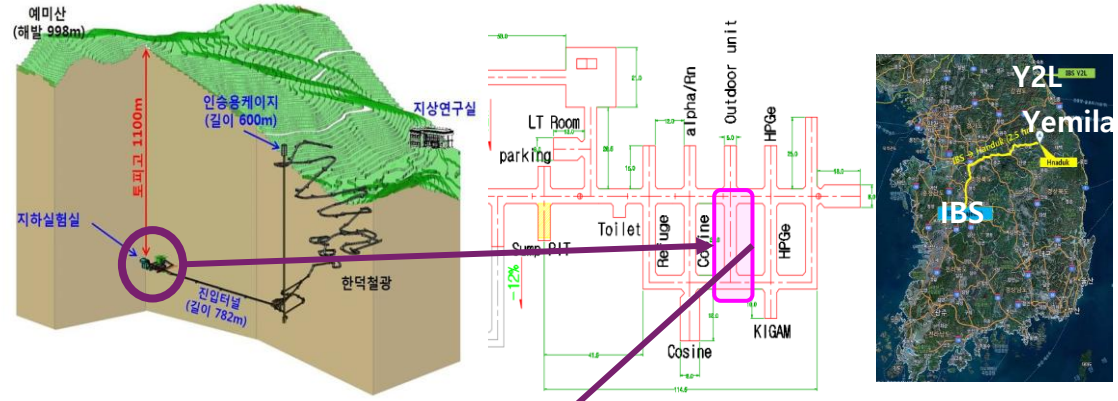
- For searching low mass WIMP

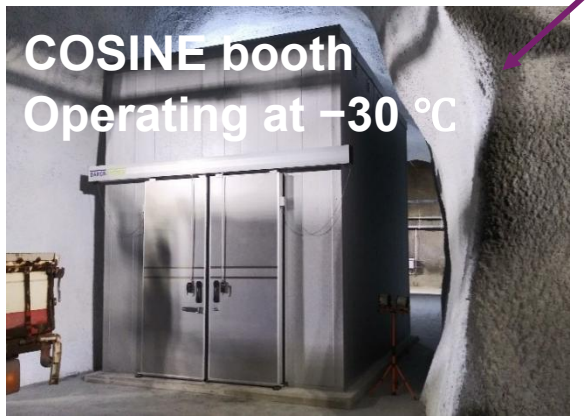
  WIMP : Weekly Interacting Massive Particles

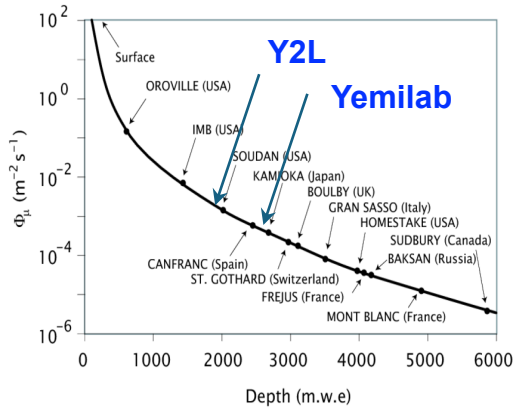
Park et al., Frontiers in Physics (2024)

Kim & Lee, AAPPS Bulletin (2024)

- Move COSINE-100 detector from Y2L (YangYang) to Yemilab (Jeongseon)

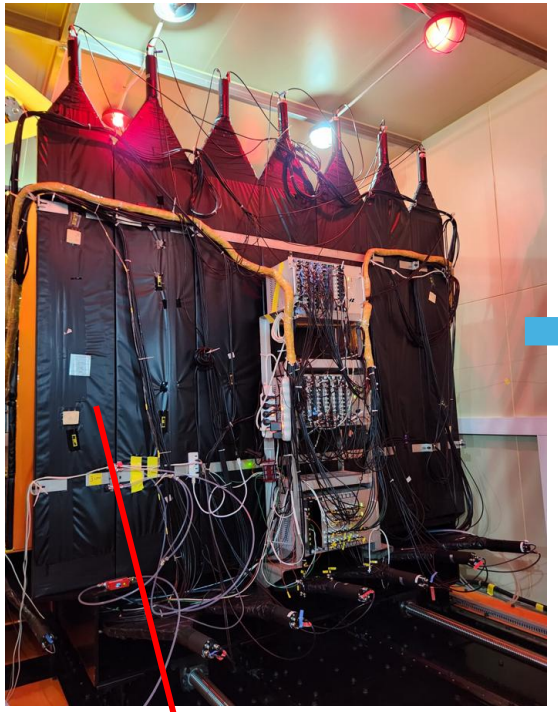




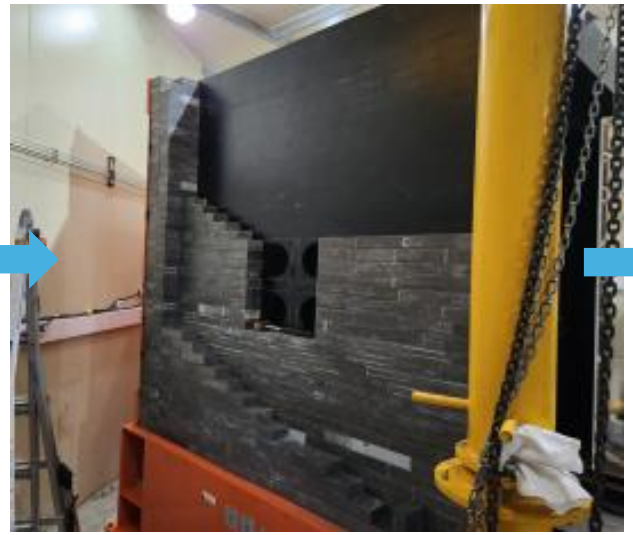


COSINE-100 Upgrade – move to Yemilab (Jeongseon)

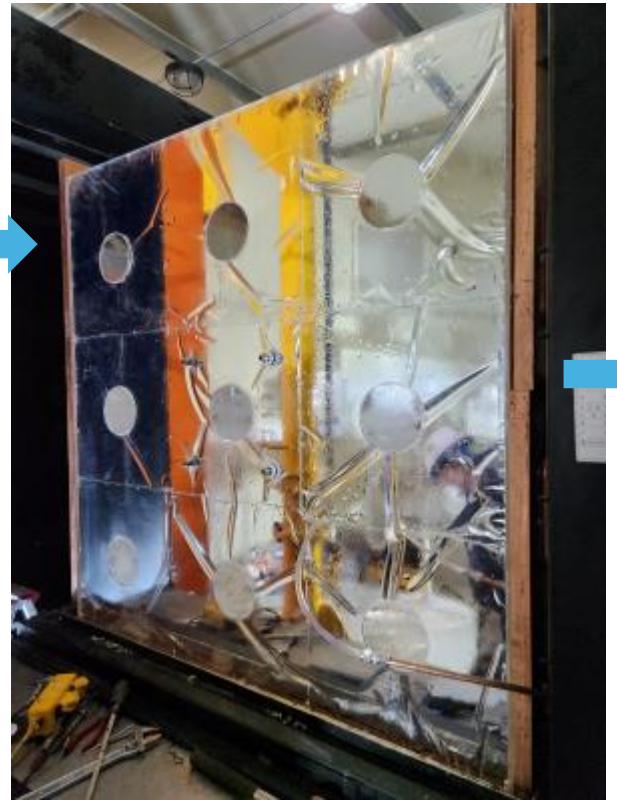
- Move COSINE-100 detector **from Y2L (YangYang, Korea)** to Yemilab (Jeongseon, Korea)

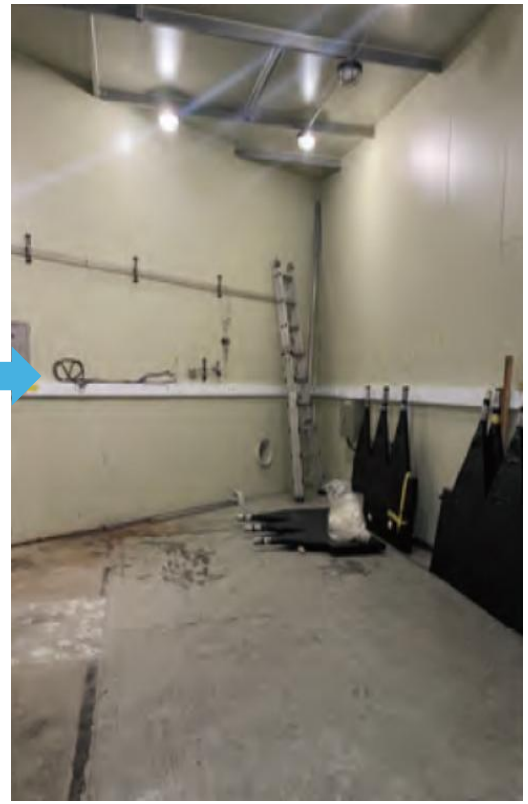


Plastic scintillator



Lead bricks



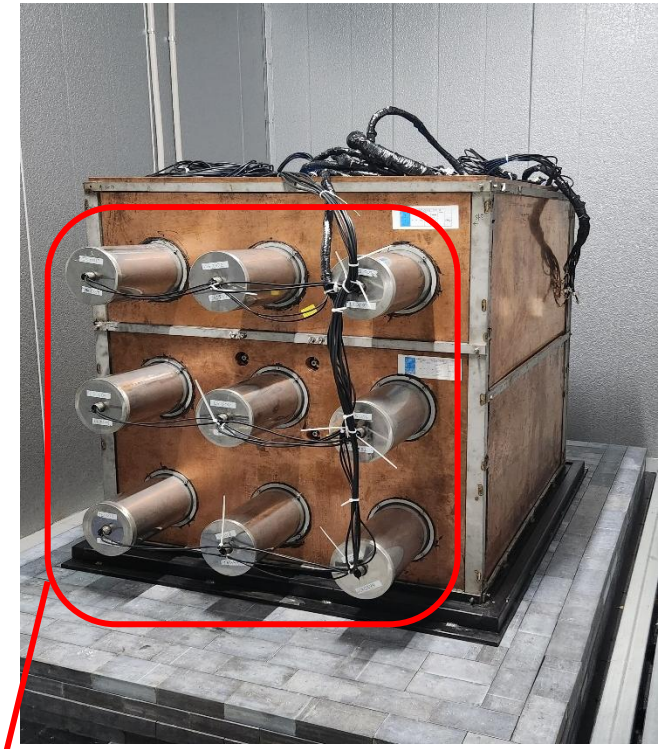


Copper & acrylic box

COSINE-100 Upgrade – move to Yemilab (Jeongseon)

- Move COSINE-100 detector from Y2L (YangYang, Korea) **to Yemilab (Jeongseon, Korea)**

Fridge room



Copper & acrylic box

Liquid Scintillator
PMT

Lead castle

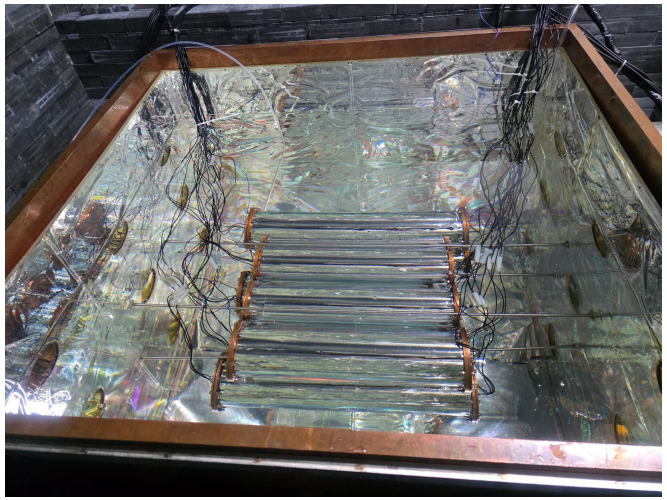
COSINE-100 Upgrade – move to Yemilab (Jeongseon)

- Move COSINE-100 detector from Y2L (YangYang, Korea) **to Yemilab (Jeongseon, Korea)**

20th May 2025

Crystal installation

26th May 2025



Install LS

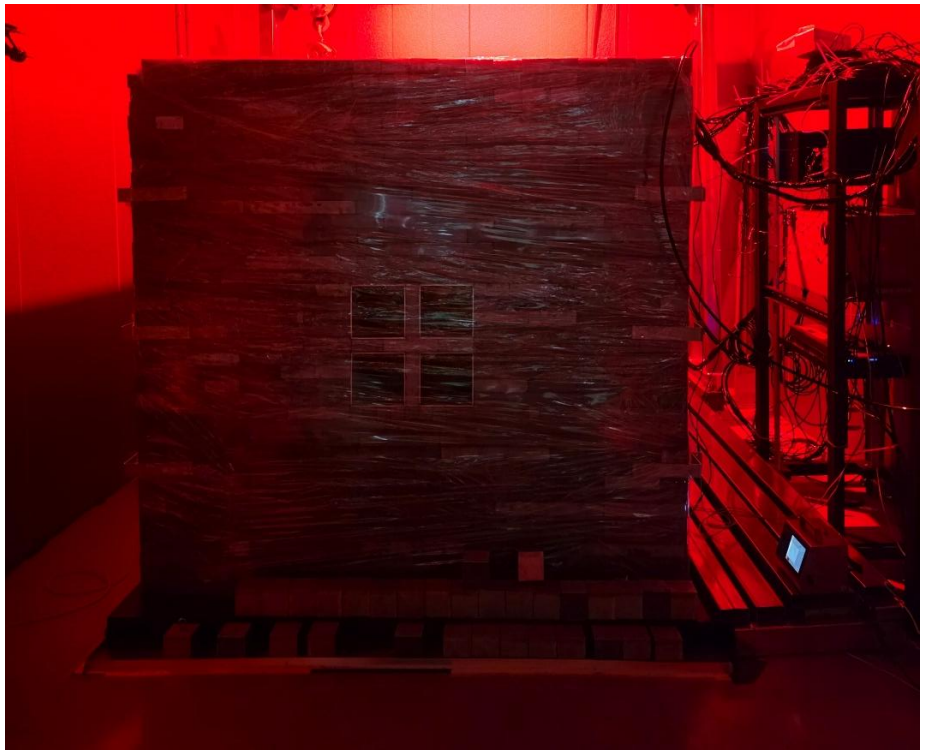
28th May 2025

Top lead installation

COSINE-100 Upgrade – move to Yemilab (Jeongseon)

- Move COSINE-100 detector from Y2L (YangYang, Korea) **to Yemilab (Jeongseon, Korea)**

- **Covered by wrapping tapes for stable dust and Rn**
- **Radon-reduction air is flushed through the inside of the lead.**



Inside Lead shielding

Inside Lead shielding

COSINE-100 Upgrade – move to Yemilab (Jeongseon)

- Move COSINE-100 detector from Y2L (YangYang, Korea) **to Yemilab (Jeongseon, Korea)**

Install the top lead
Covered by wrapping tape

28th July 2025

Install Plastic Scintillator

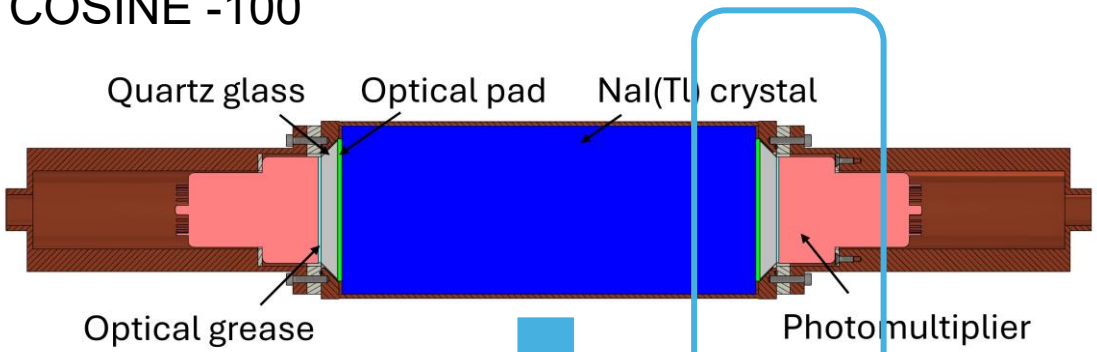
COS

- M

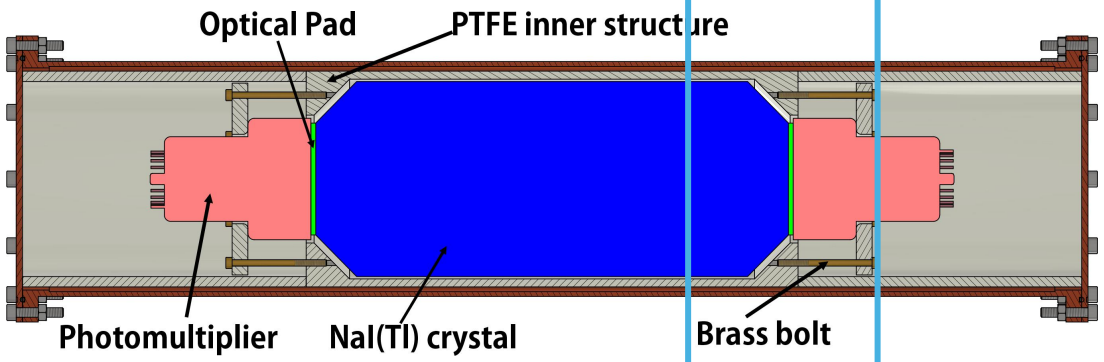
COSINE-100 Upgrade – new encapsulation

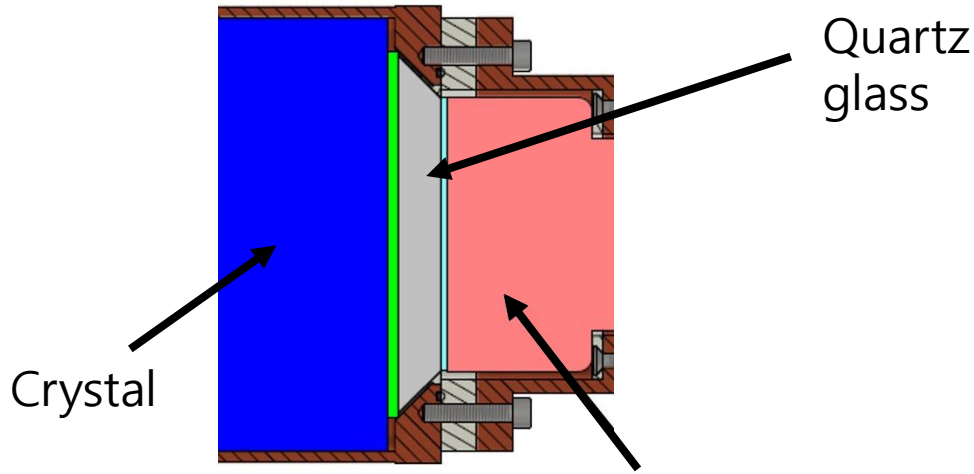
- **Direct attachment** of crystal to PMTs

COSINE -100

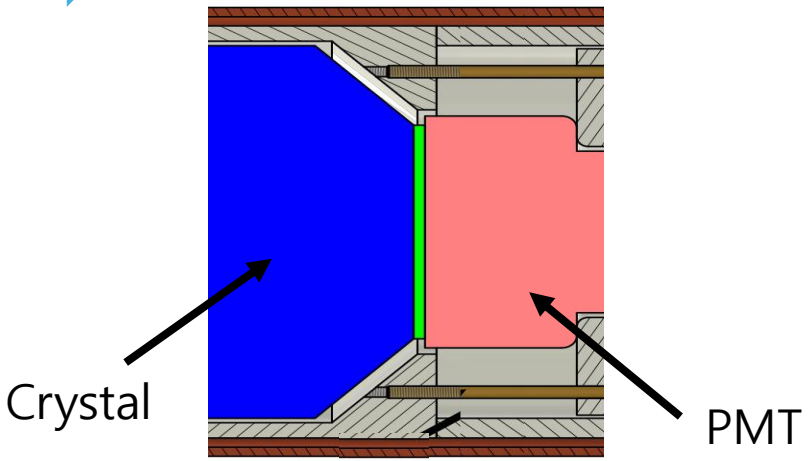


COSINE -100U



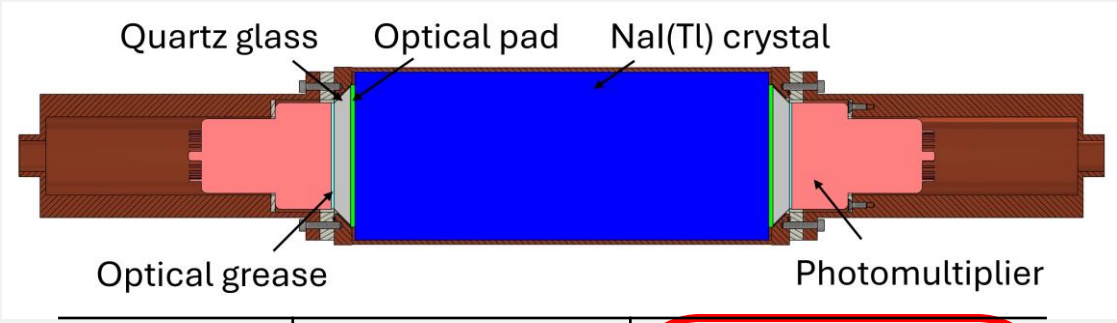


Directly attached w/o quartz!



COSINE-100 Upgrade – new encapsulation

- COSINE-100



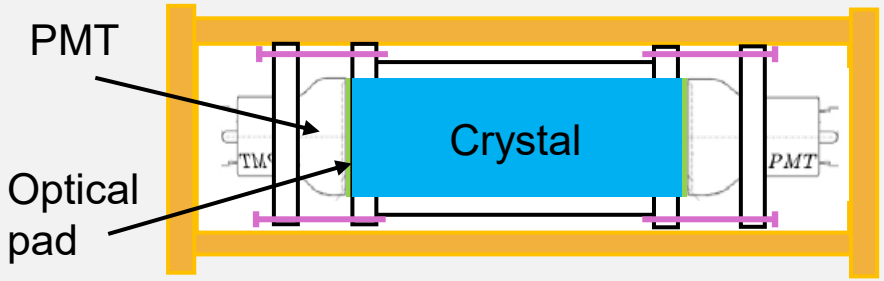
Crystal #	Size (inches)	Light Yield (p.e./keV)
1	5.0 x 7.0	14.9 ± 1.5
2	4.2 x 11.0	14.6 ± 1.5
3	4.2 x 11.0	15.5 ± 1.6
4	5.0 x 15.3	14.9 ± 1.5
5	5.0 x 15.2	7.3 ± 0.7
6	4.8 x 11.8	14.6 ± 1.5
7	4.8 x 11.8	14.0 ± 1.4
8	5.0 x 15.5	3.5 ± 0.3

Adhikari et al., European Physical Journal C (2018)

- NEON

Neutrino Elastic scattering Observation with NaI(Tl)

See Seohyun's talk 27th Aug. 18:00~18:20



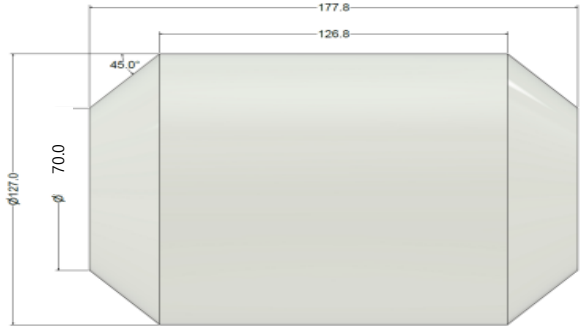
Crystal #	Size (inches)	Light Yield (p.e./keV)
1	3.0 x 4.0	22.0 ± 0.4
2	3.0 x 8.0	25.6 ± 1.1
3	3.0 x 4.0	21.8 ± 0.5
4	3.0 x 8.0	23.7 ± 0.4
5	3.0 x 8.0	22.4 ± 0.5
6	3.0 x 8.0	25.0 ± 0.5

Increased !

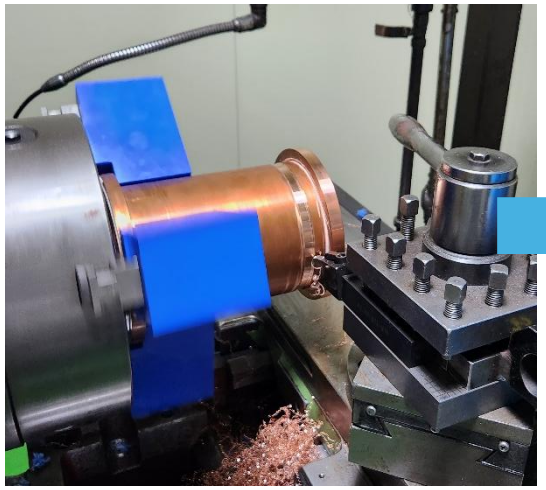
Choi et al., Journal of Instrumentation (2024)

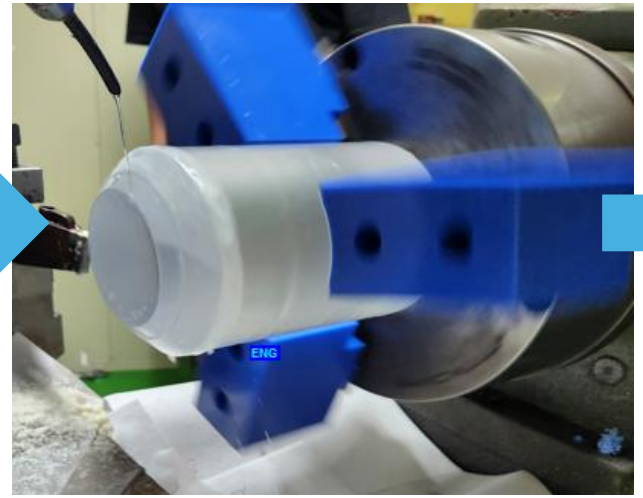
COSINE-100 Upgrade – crystal machining

- **Light-guide shape** on the edge of crystals



COSINE-100 Crystal #1





Removal of the copper case

Machining

Polishing

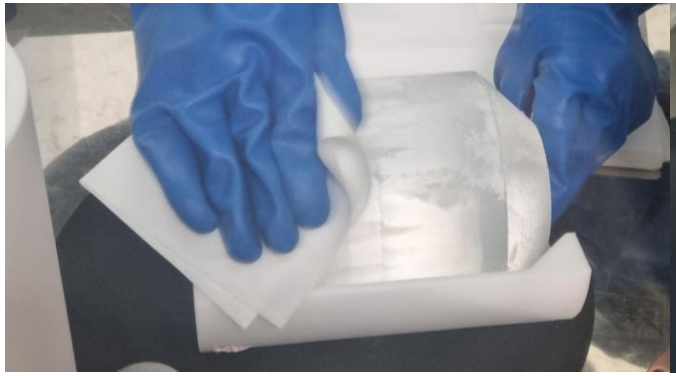
COSINE-100 Upgrade – crystal encapsulation

- **Crystal polishing**

1. Ethanol + KM wiper (WW-2109)
2. Ethanol + Ultima II wiper
3. Isopropanol + Ultima II wiper
4. Polishing pad (only end side)

→ Mineral oil & 3, 0.5 μm SiO_2

In glovebox (H_20 ~10 ppm, radon ~10 Bq/m^3)



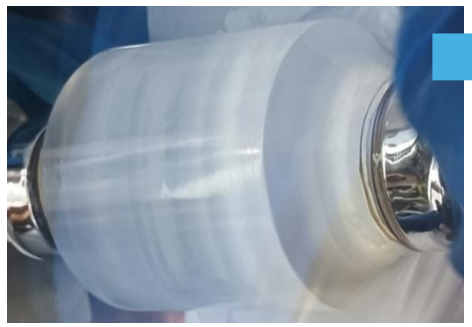
- **Encapsulation structure cleaning**

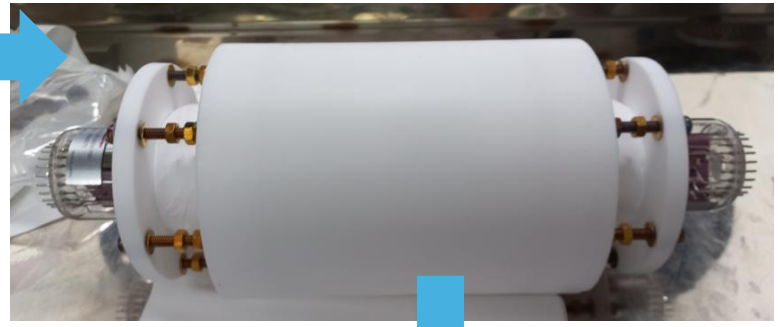
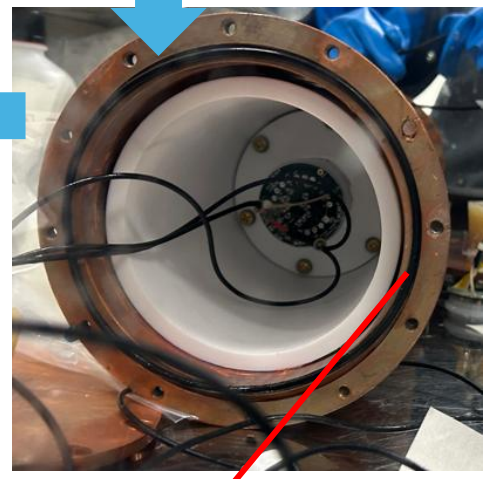
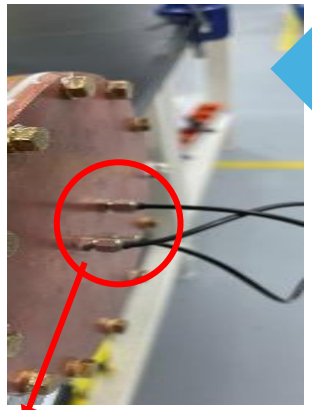
1. Cleaning of Copper & Teflon Structures, Bolts, and Nuts
   - Perform ultrasonic cleaning at 40 °C.
   - Step 1: Immerse in D.I. water with Citranox for 30 minutes.
   - Step 2: Immerse in D.I. water with Oxalic acid for 18 hours.
2. Rinsing
   - Rinse the cleaned parts thoroughly with flowing D.I. water to remove any remaining residues.
3. Oven Drying
   - Dry the cleaned parts in an oven
   - Vacuum oven: 120 °C for 12 hours.
   - Copper case: dry under nitrogen flow at 120 °C for 12 hours.
4. Additional drying inside the glovebox
   - Inside the glovebox, additionally dry the structures and PTFE sheets.
   - Before assembly, wipe the parts once more with IPA to remove contamination.

COSINE-100 Upgrade – crystal encapsulation

- **Crystal encapsulation**

COSINE-100 Crystal #1



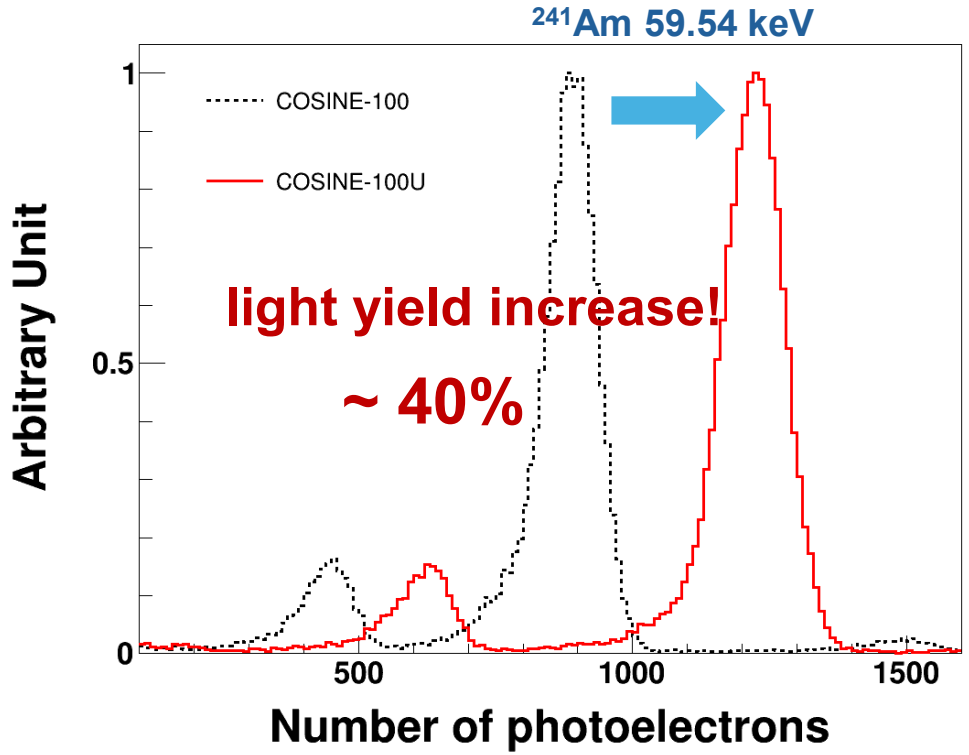

Cable gland

Viton O-ring

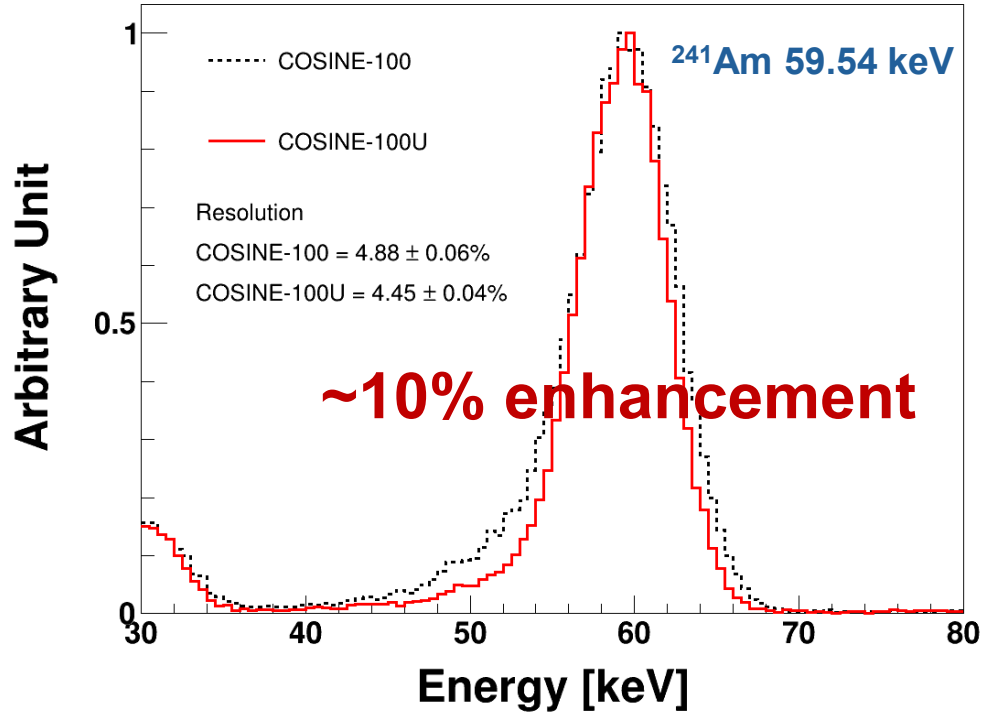
COSINE-100 Upgrade – Light yield & resolution

- **Light yield & resolution**

Crystal #7

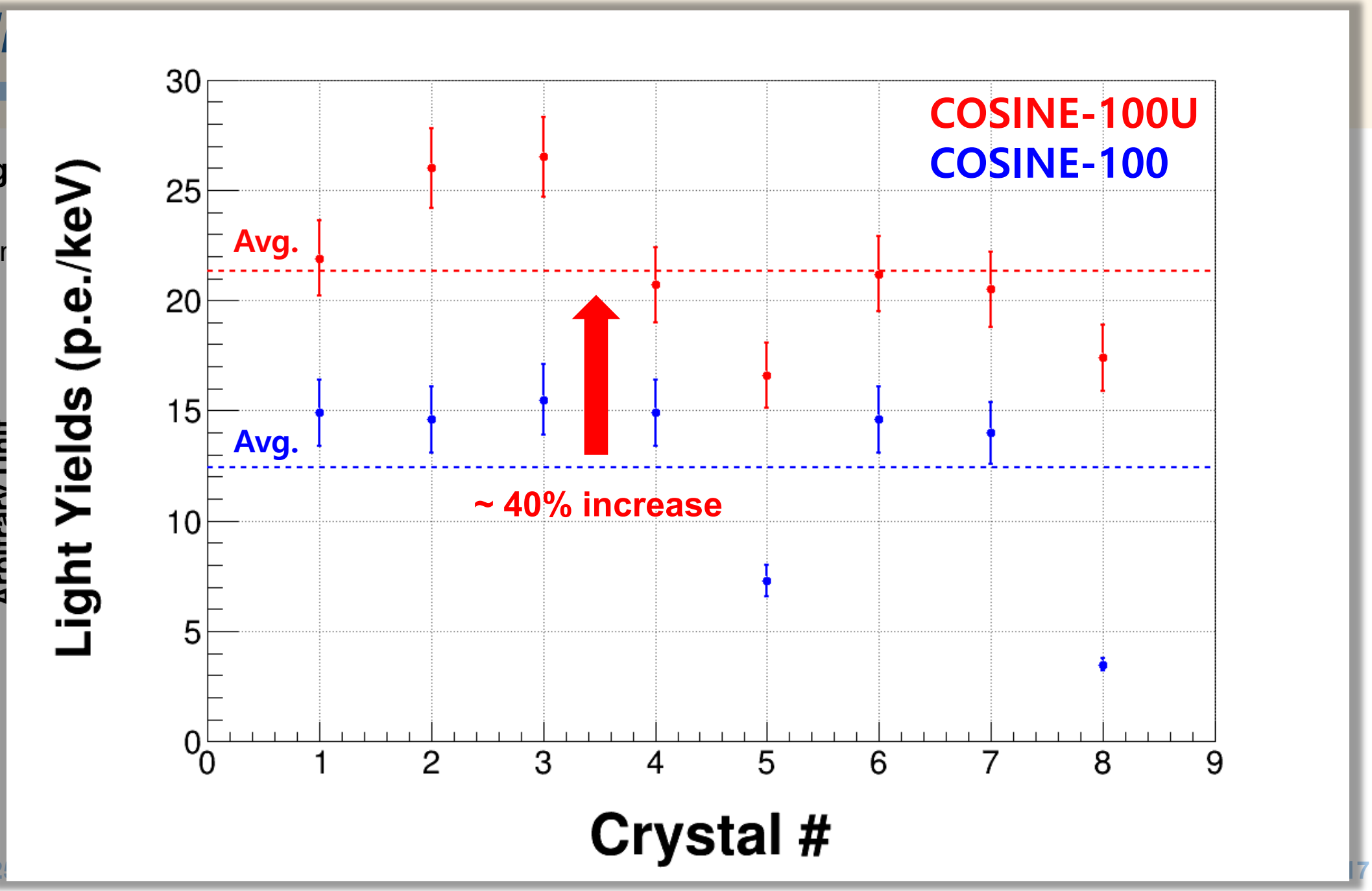


Lee et al., Communications Physics (2025)



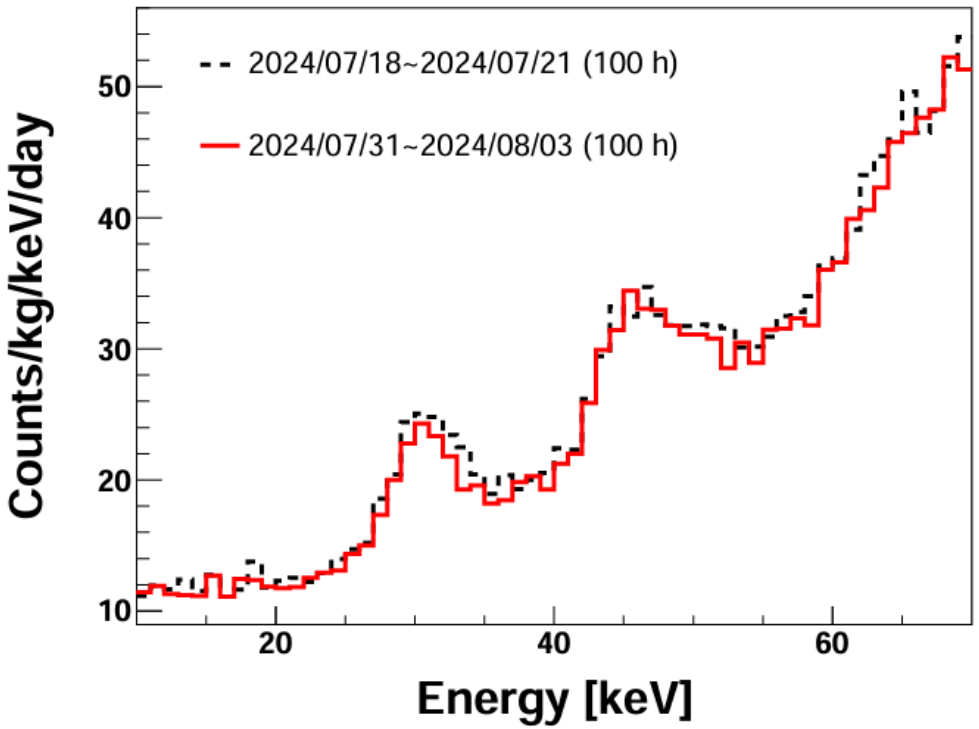
- Lig

Cr

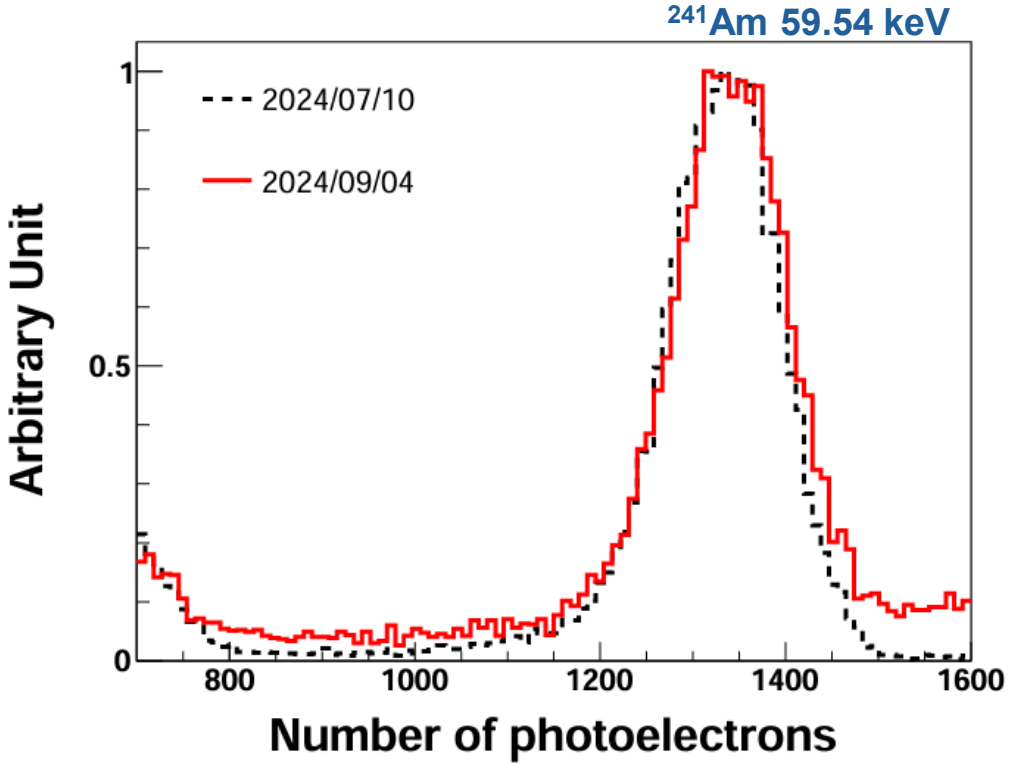

COSINE-100U
COSINE-100
Avg.
Avg.
~ 40% increase
Light Yields (p.e./keV)
Crystal #
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8
9

COSINE-100 Upgrade – Stability

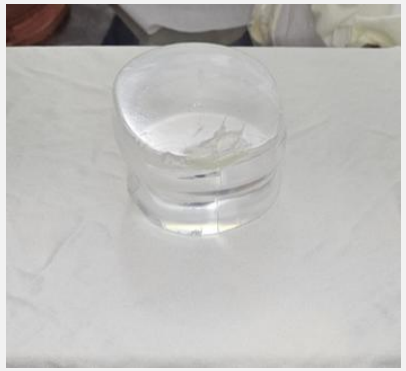
- **Stability**



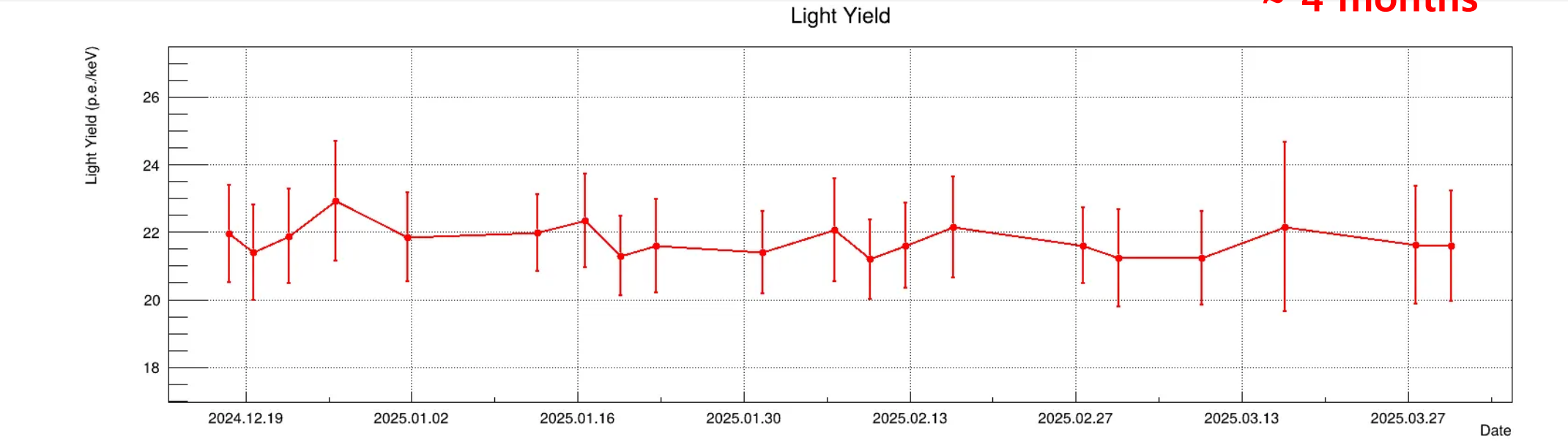
Lee et al., Communications Physics (2025)



COSINE-100 Upgrade – Stability

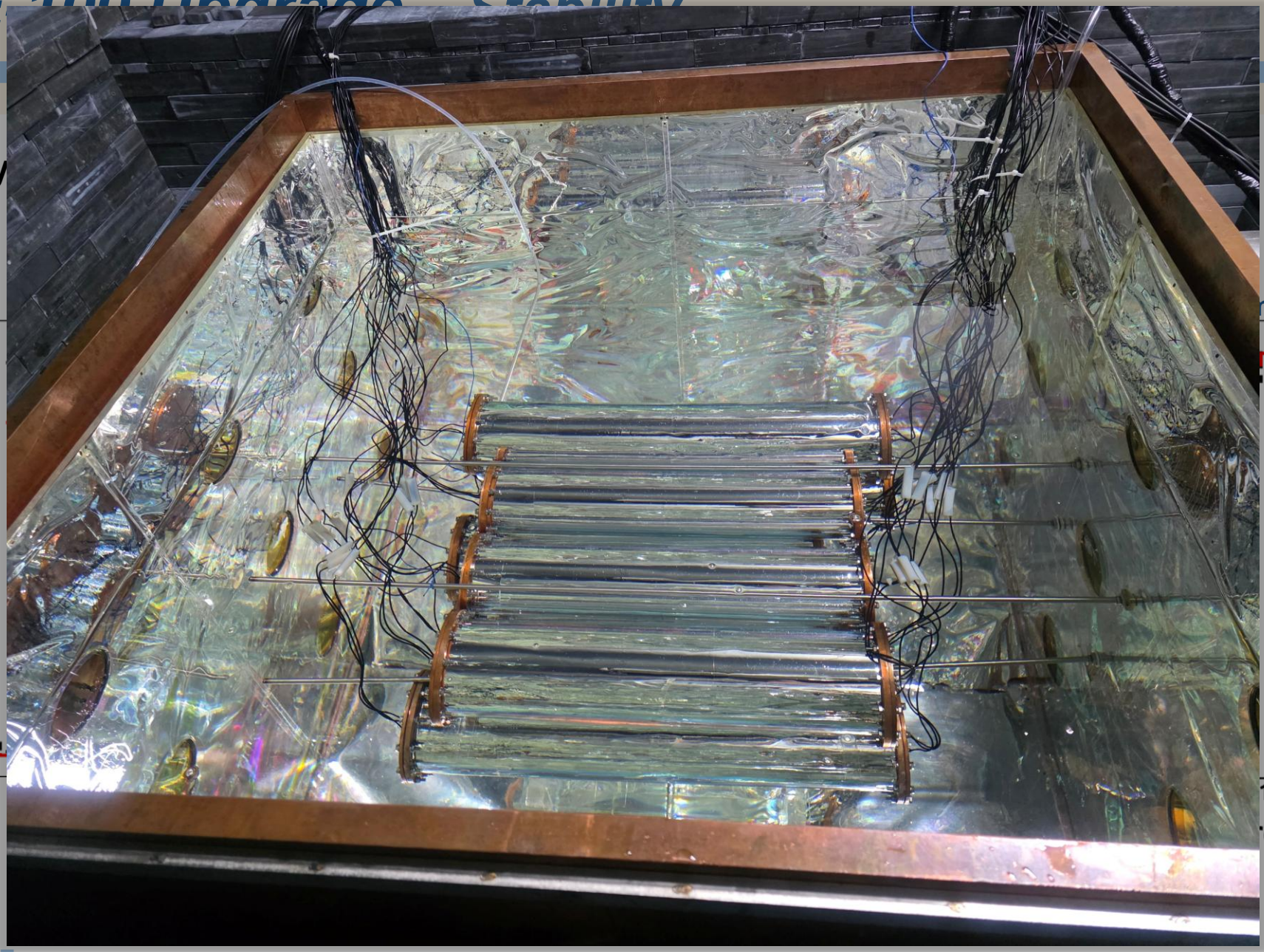


Enough stable!
~ 4 months

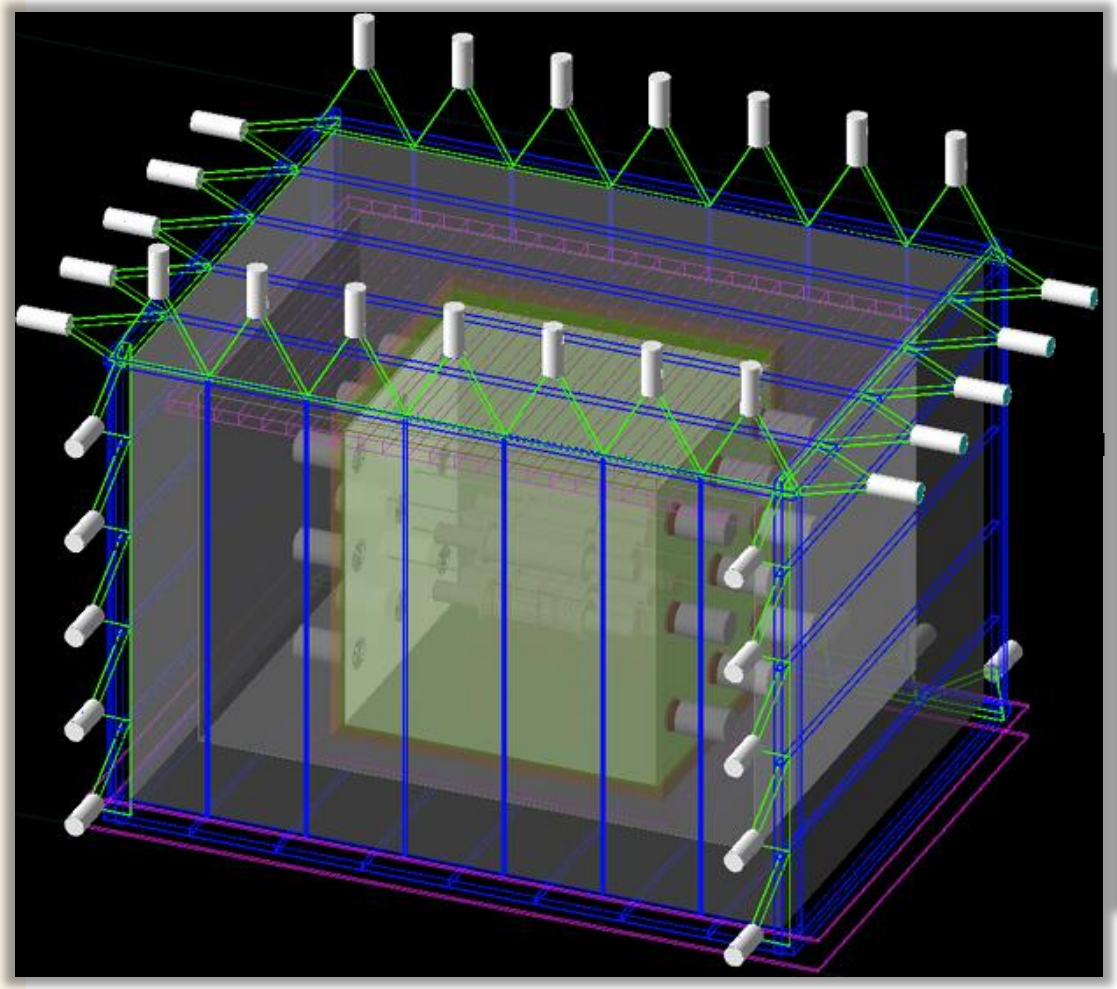


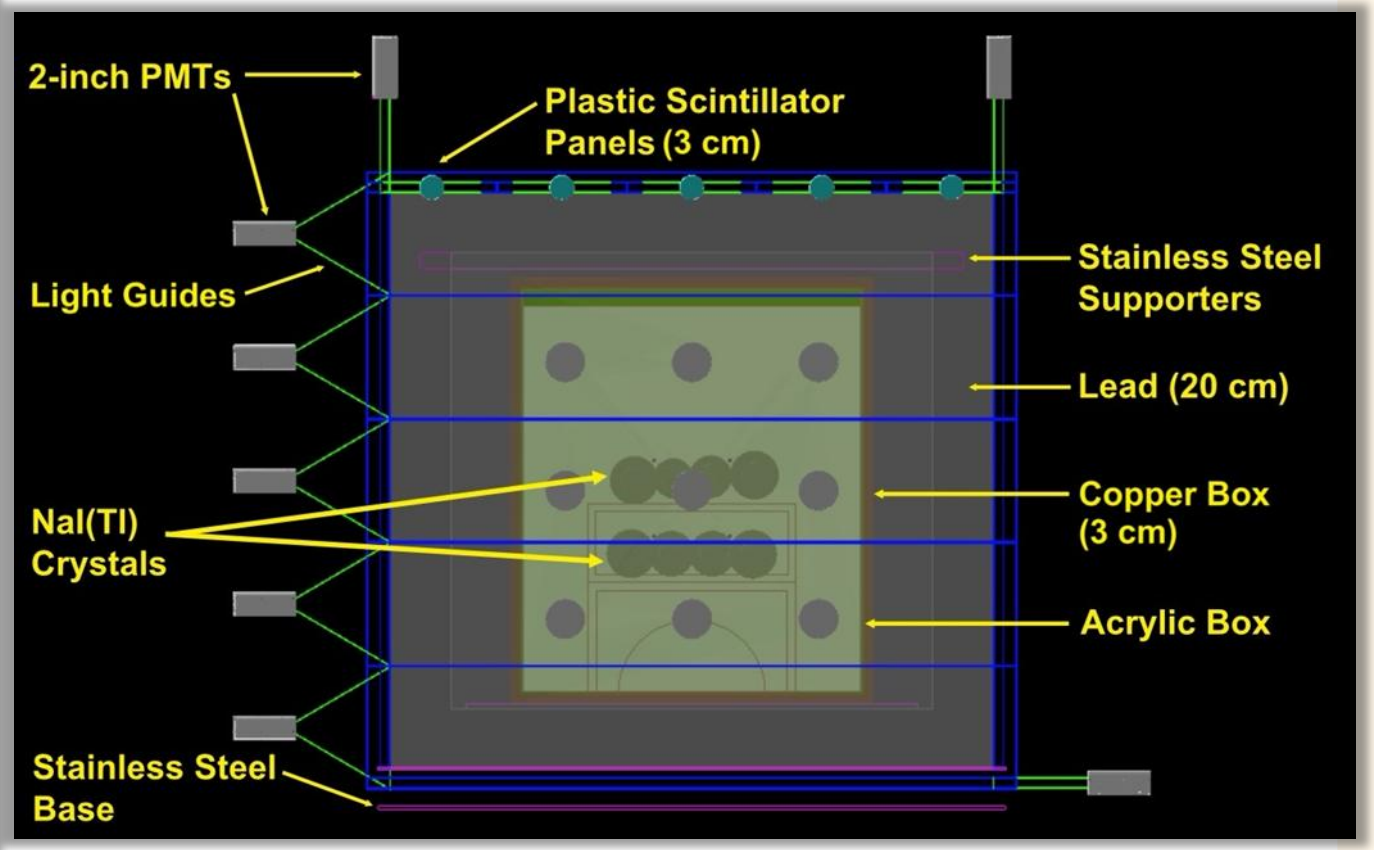
COSINE-100 Upgrade – Stability

- **Stability**

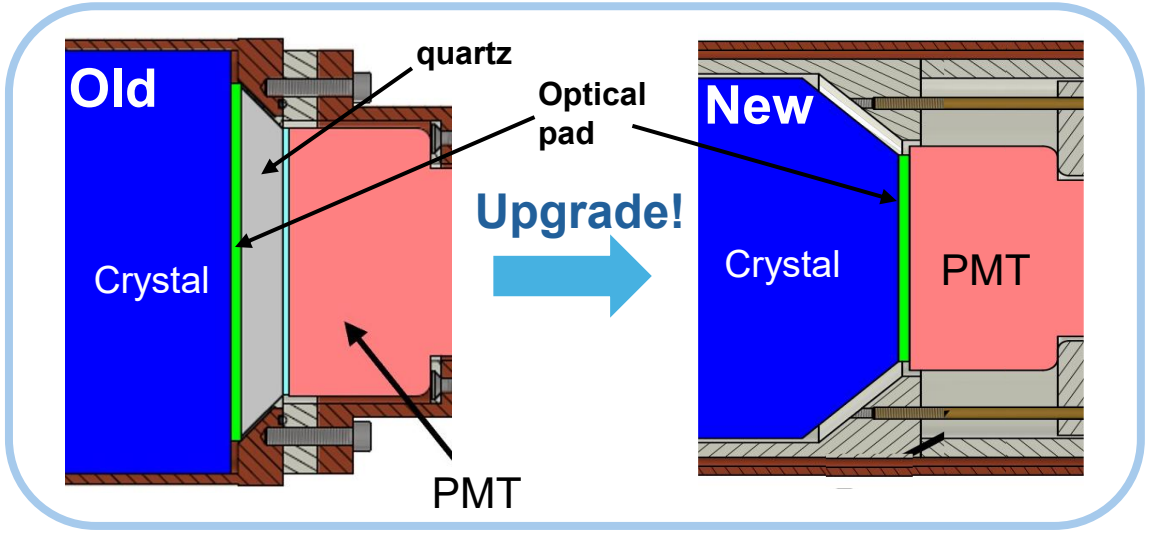


COSINE-100 Upgrade – Expected background

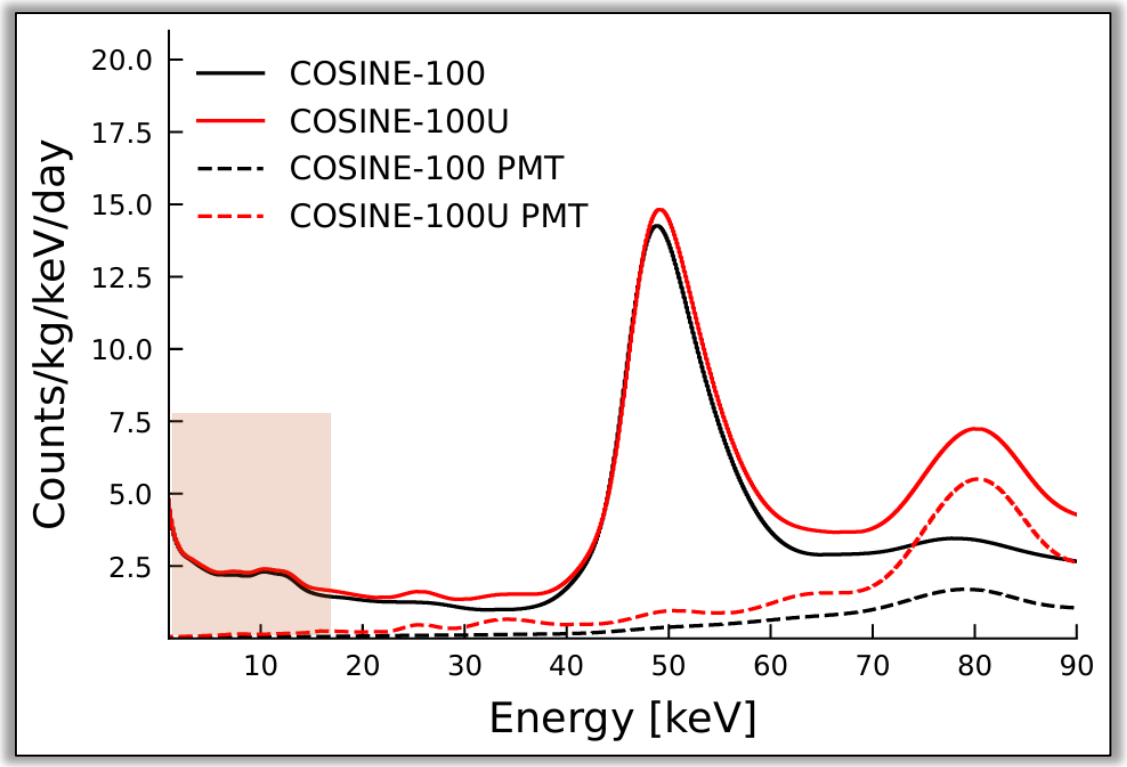




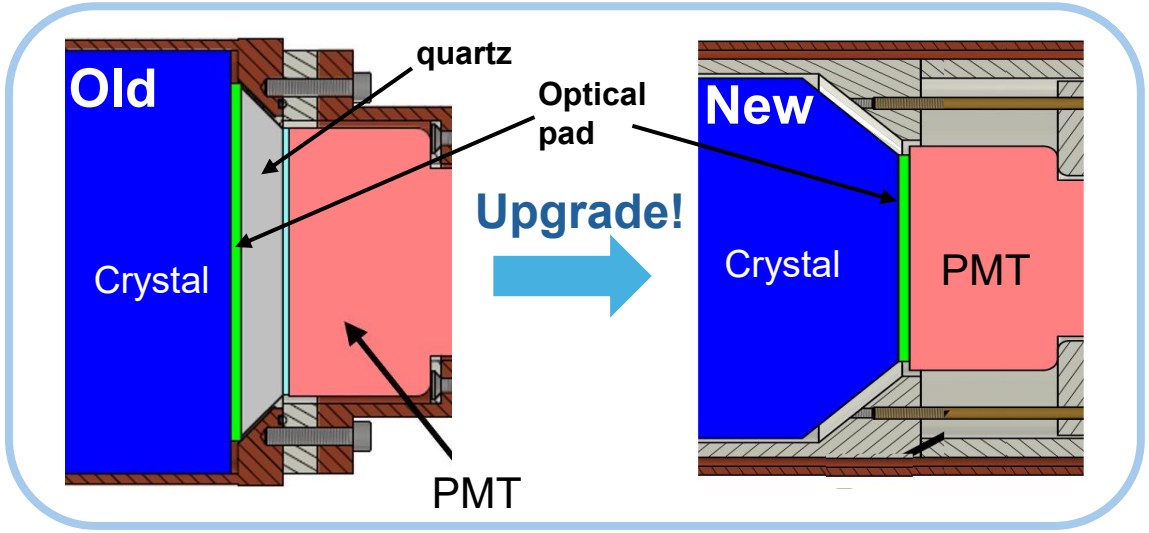
COSINE-100 Upgrade – Expected background



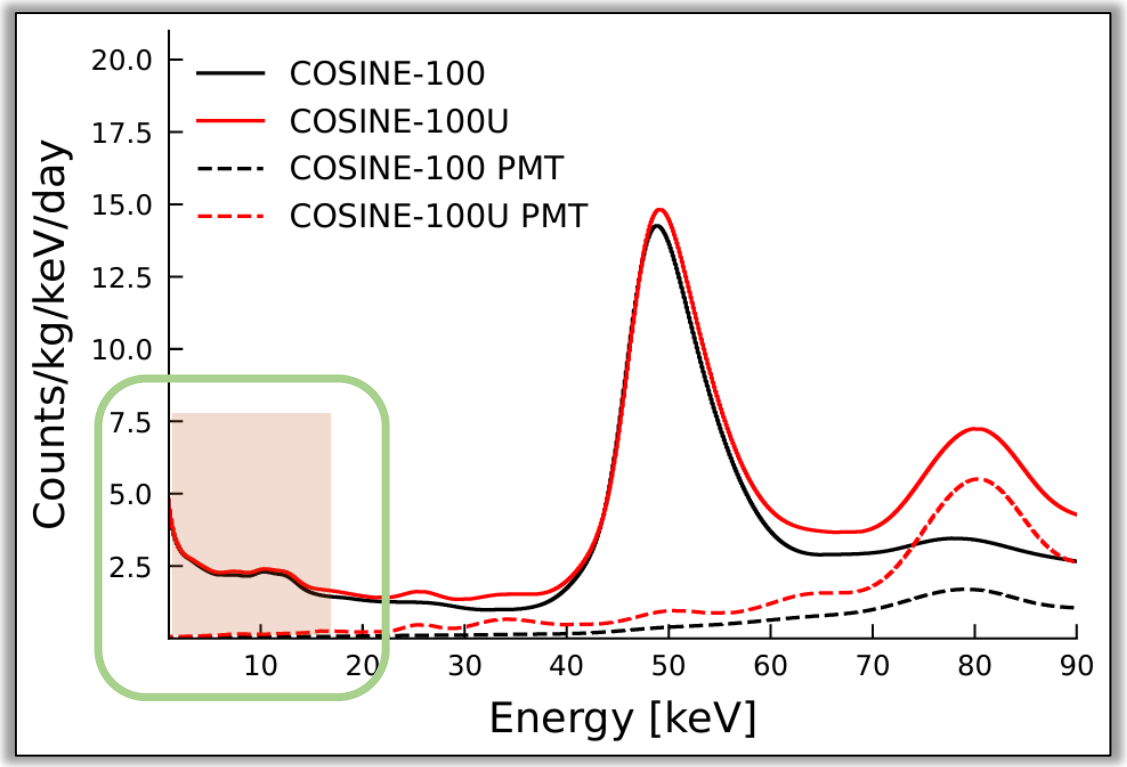
*Simulation data



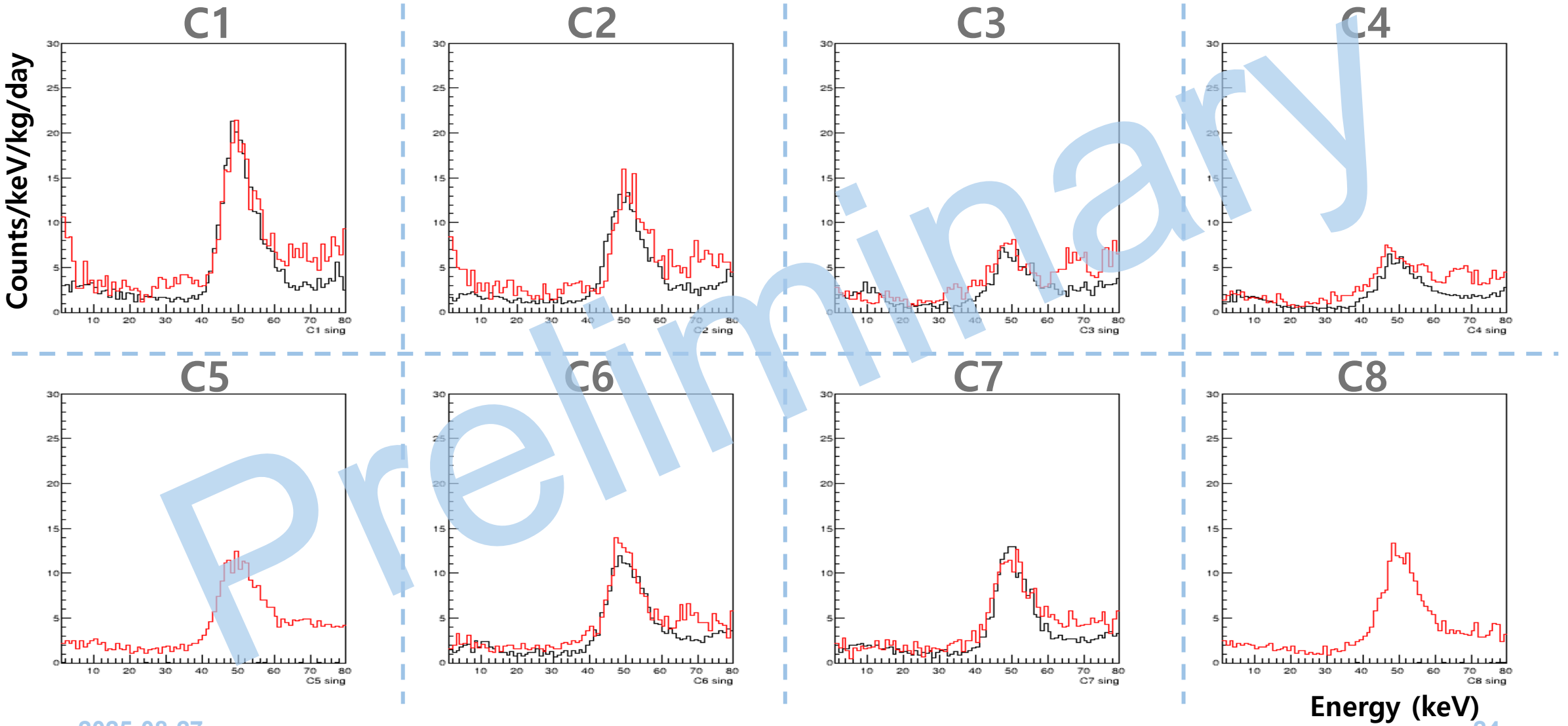
COSINE-100 Upgrade – Expected background



*Simulation data



COSINE-100 Upgrade – Initial data

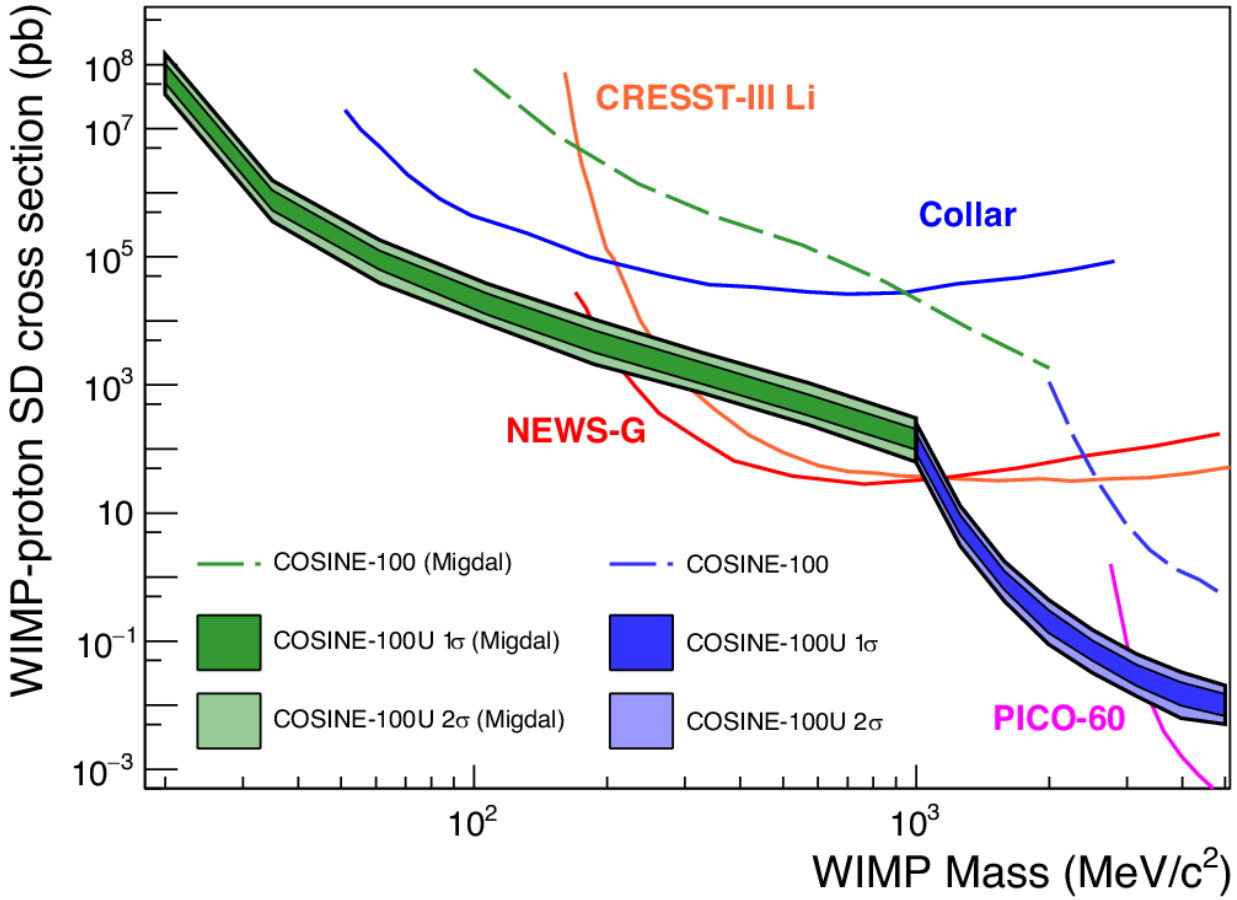


Preliminary

COSINE-100 Upgrade – Expected sensitivity

- Increased light yield (~ 20 p.e./keV)
- 8 crystals (~100 kg)
- 1-year exposure
- 5 NPE threshold (~ 0.25 keV)
- Expected background (COSINE-100U)

Lee et al., Communications Physics (2025)

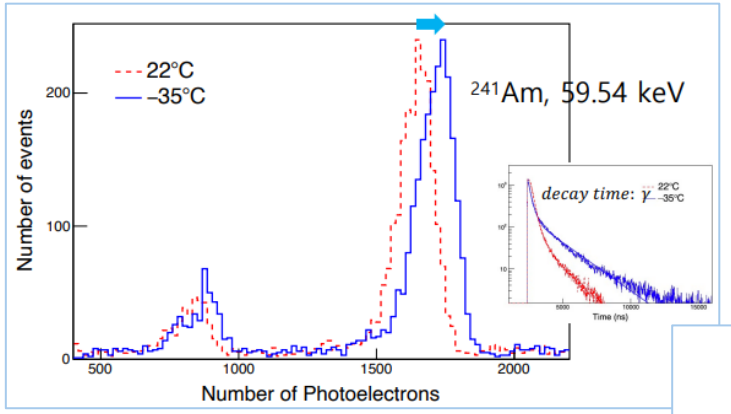


Expected Spin-Dependent WIMP Sensitivity

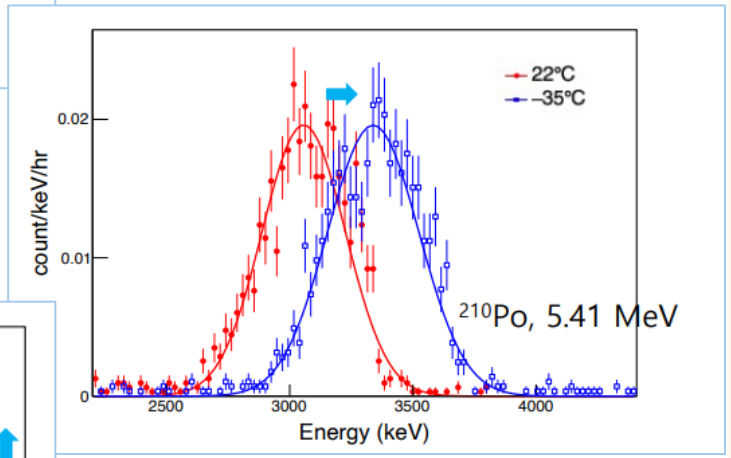
COSINE-100 Upgrade – −30℃ operation

- Operation at −30℃
  - ~ 4.7% increased light yield
  - ~ 9.3% increased QF for alpha
  - Improved n-γ discrimination

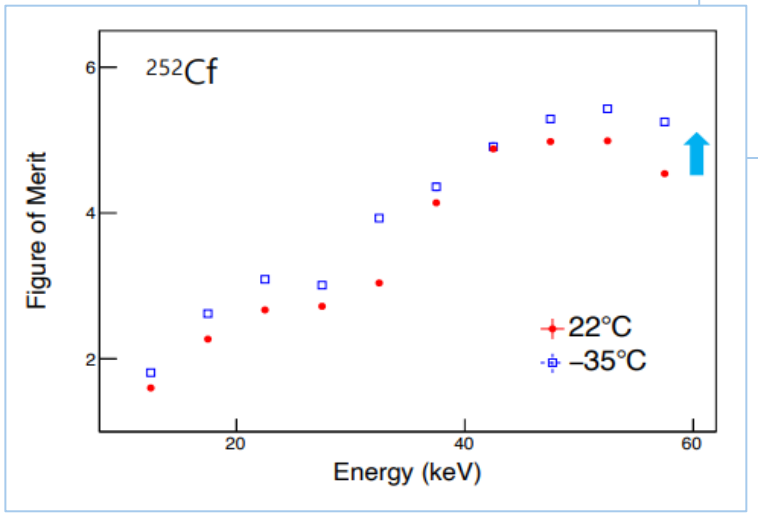
Astropart.Phys. 141 (2022) 102709



Light yield increasing



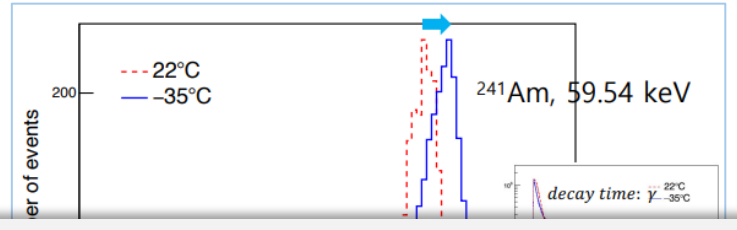
Quenching factor (α) increasing



Pulse Shape Discrimination (n-γ) improvement

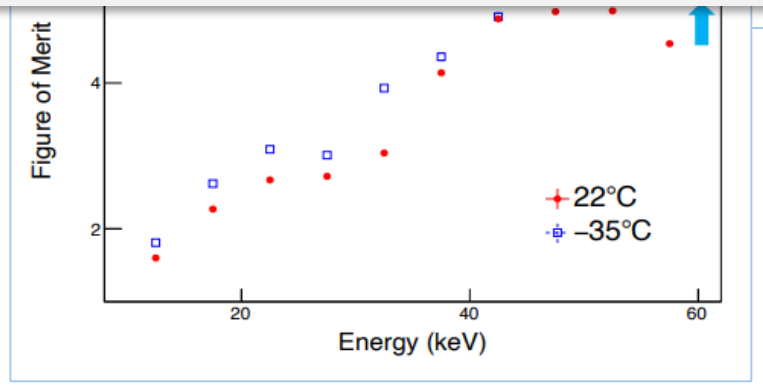
COSINE-100 Upgrade – −30℃ operation

- Operation at −30℃
  - ~ 4.7% increased light yield
  - ~ 9.3% increased QF for alpha
  - In



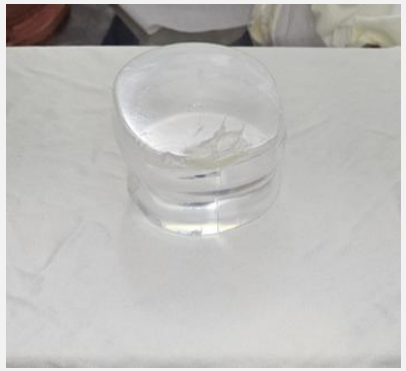
Light yield increasing

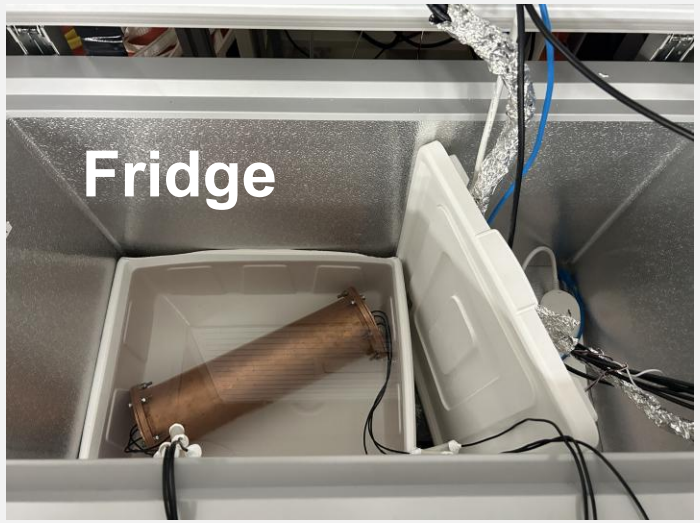
- Data taking in room temperature ~ 6 months.
  (Sep. 2025 ~ Feb. 2026)
- We are going to operate at −30 °C.
  (Mar. 2026 ~)



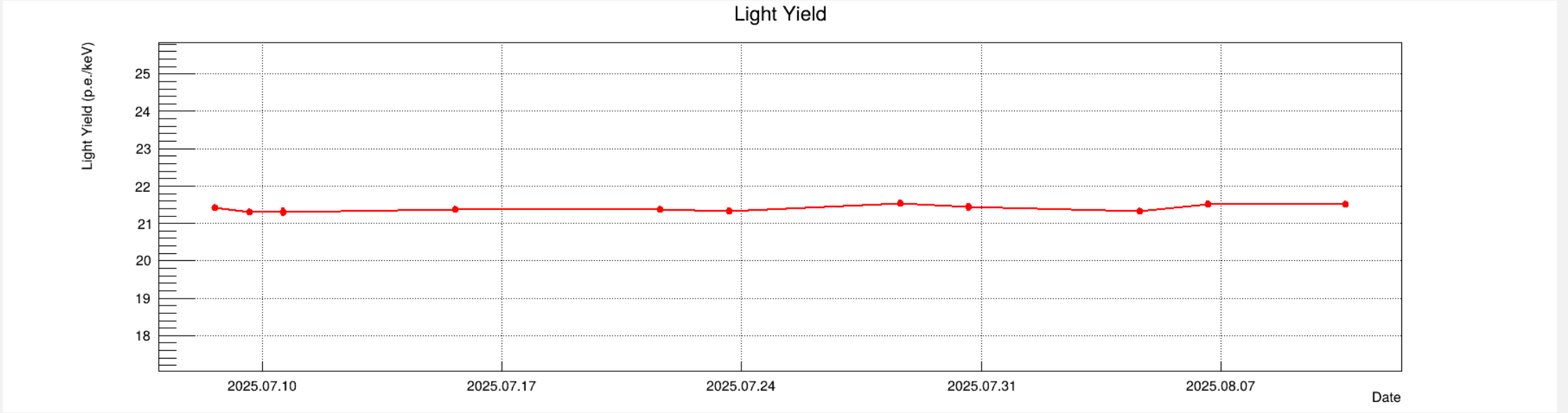
Pulse Shape Discrimination
(n-γ) improvement

COSINE-100 Upgrade – −30 ℃ operation



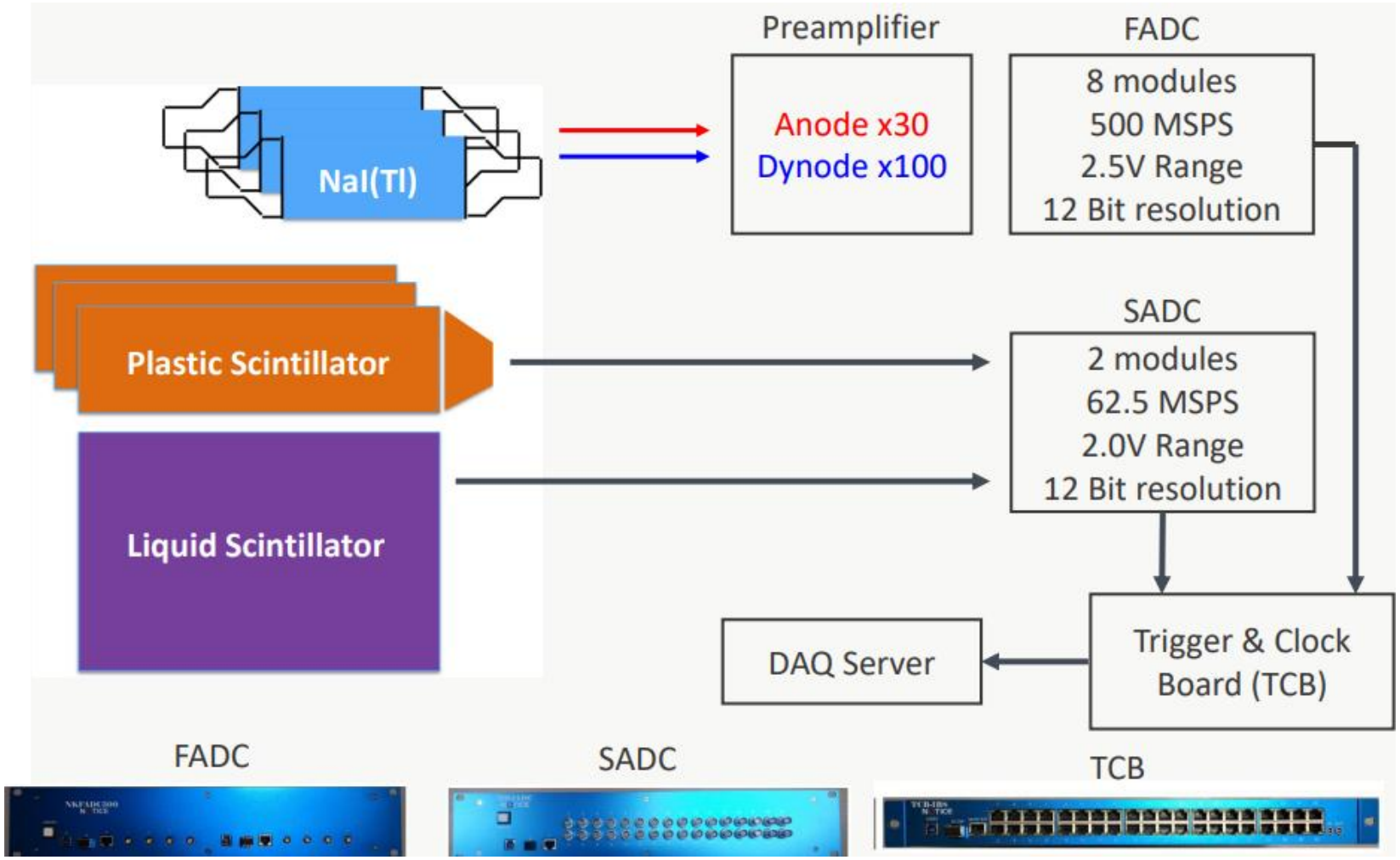


Test encapsulation stability at −30 ℃



COSINE-100 Upgrade – DAQ

Data flow block diagram

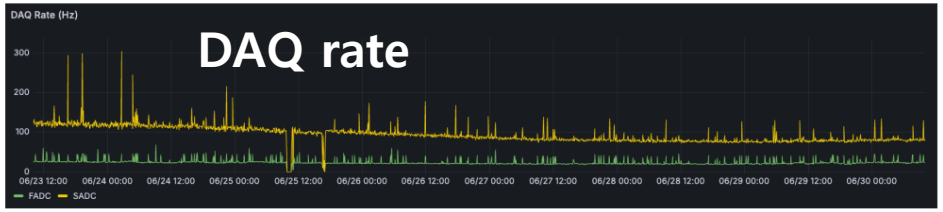


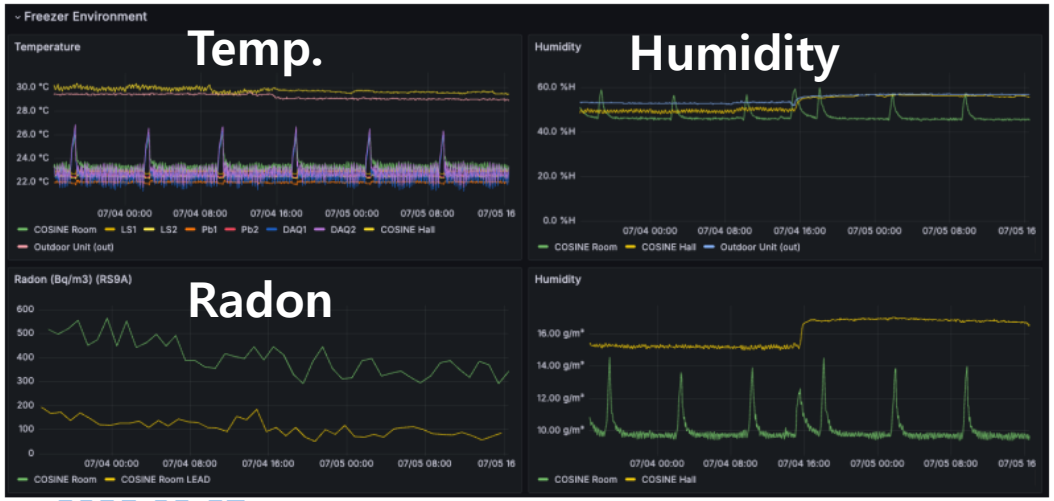
COSINE-100 Upgrade – Monitoring

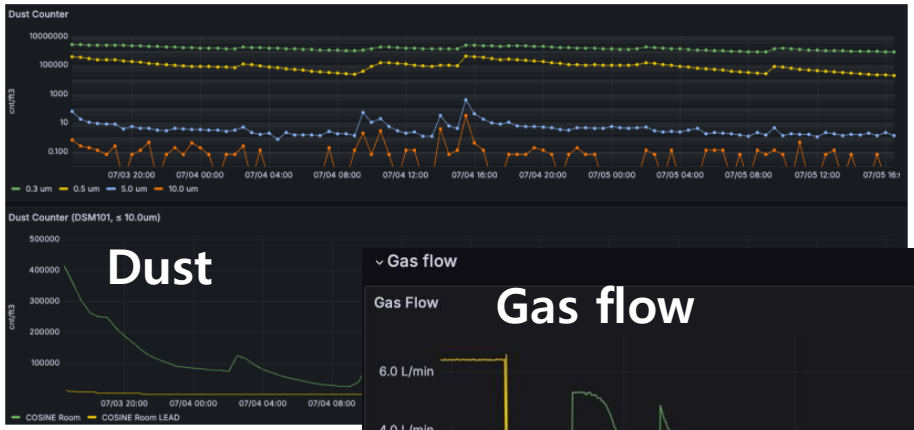
Environment monitoring in Grafana

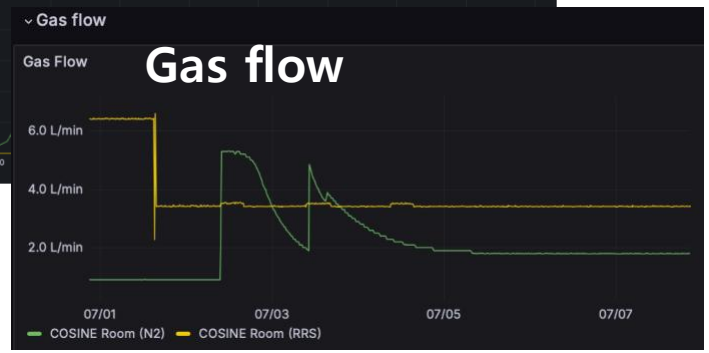
Run status & DAQ rate read from the log file.

'Off' when latest DAQ information is over 5-min









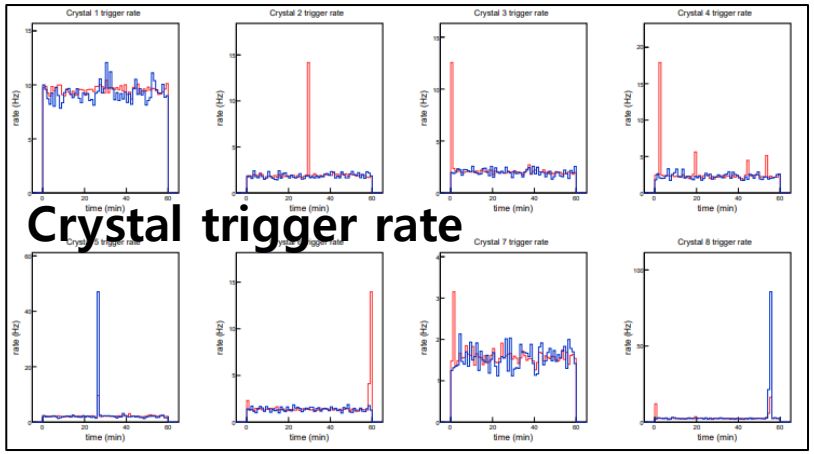
HV & Current

Computing status

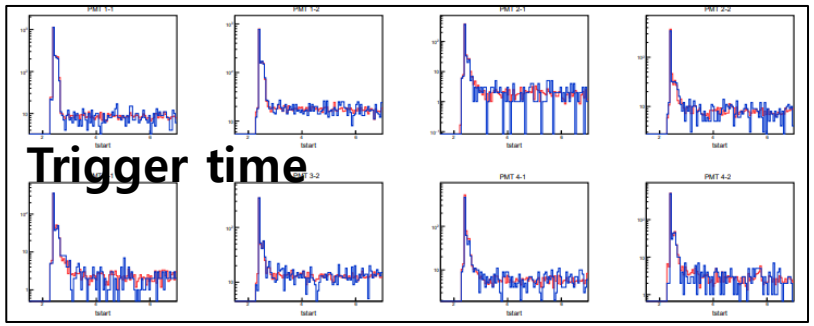
UPS status

COSINE-100 Upgrade – Monitoring

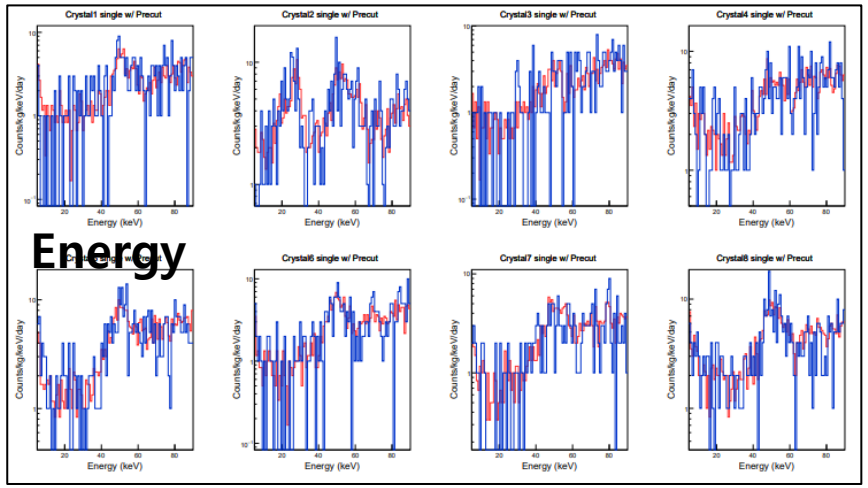
Data monitoring in Web



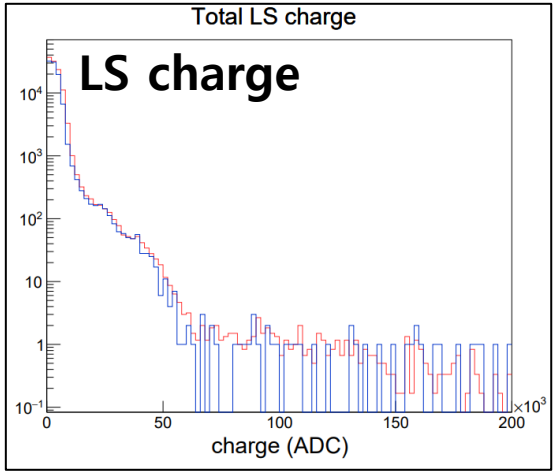
Crystal trigger rate



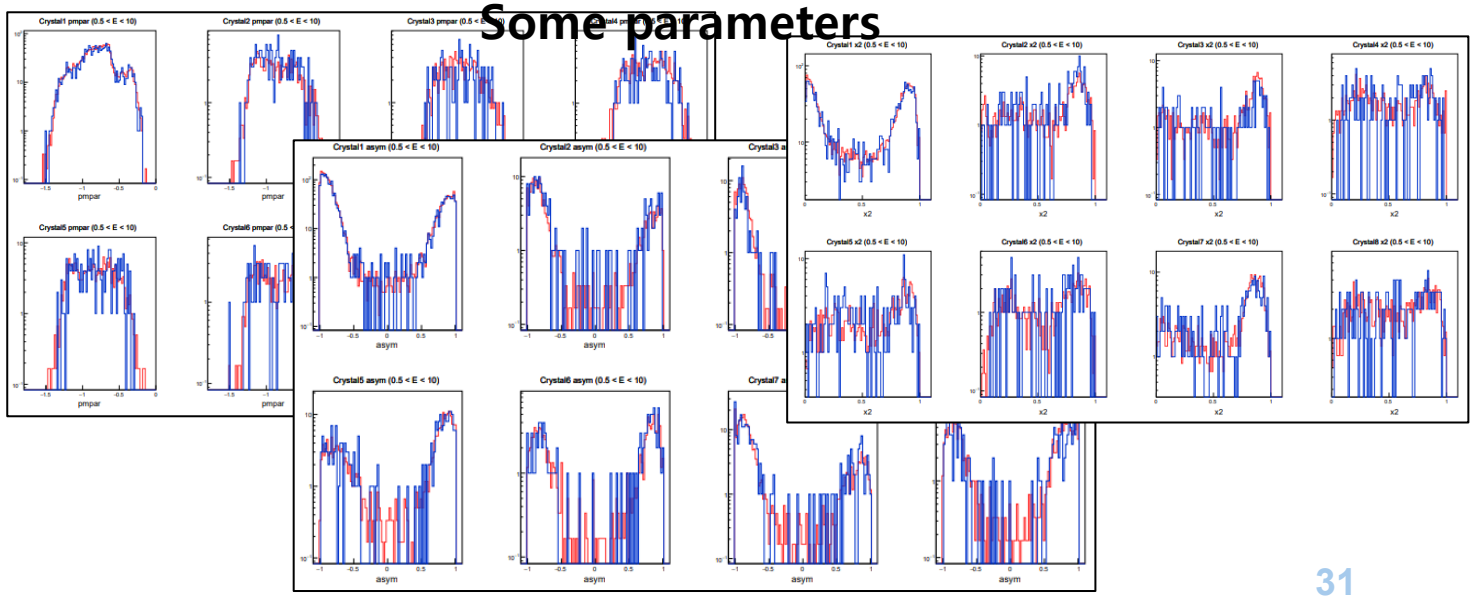
Trigger time



Energy

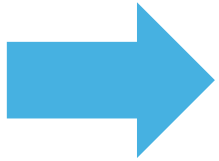


Some parameters



Summary

- **COSINE-100 Upgrade**
  - Move to Yemilab → lower background level
  - New encapsulation & crystal machining
    → light yield improve
  - Operating at −30℃ → light yield, QF & PSD improve



Increased sensitivity for low-mass dark matter!

Thank you

for listening!

Back up

LS production

- LS recipe

  LAB 1ℓ : PPO 3g : Bis-MSB 30mg

  LAB 2400ℓ : PPO 7200g : Bis-MSB 72g

- Master solution recipe (x12 concentrated)

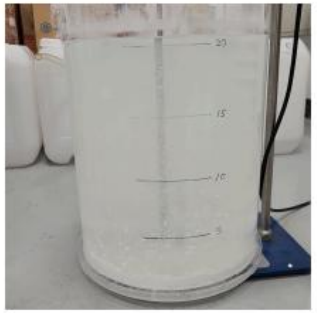
  LAB 200ℓ : PPO 7200g : Bis-MSB 72g

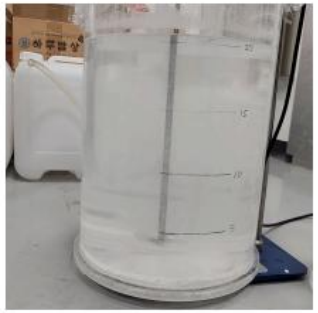
fluorescent material

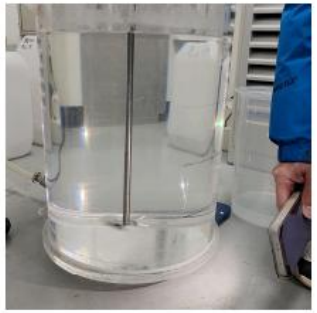
emission maximized at 380nm

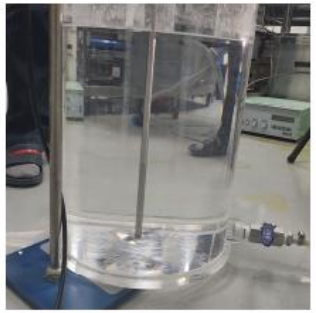
wavelength shifter (380nm→420nm)

Right after dropping → Blending done



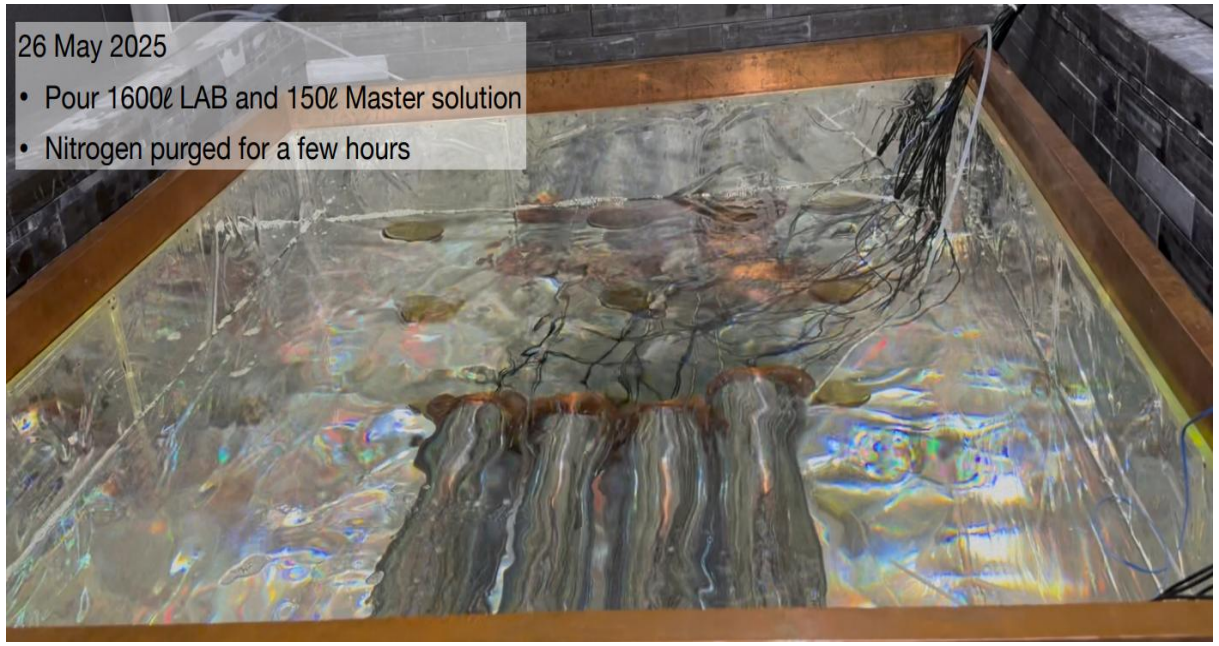






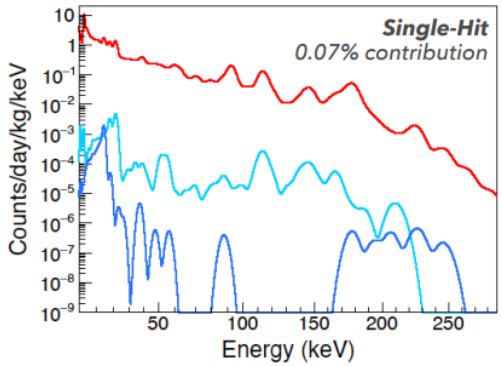
Day	No.	Bis-MSB	PPO
15 Jan 24	1	6.10	604.00
16 Jan 24	2	6.00	599.50
17 Jan 24	3	6.00	626.15
18 Jan 24	4	6.15	576.70
19 Jan 24	5	5.75	614.25
22 Jan 24	6	6.20	578.25
23 Jan 24	7	5.80	649.00
24 Jan 24	8	6.00	601.80
26 Jan 24	9	6.00	586.95
29 Jan 24	10	4.50	454.7
30 Jan 24	11	6.75	668.35
2 Feb 24	12	6.75	640.15
Total		**72g**	**7199.80g**

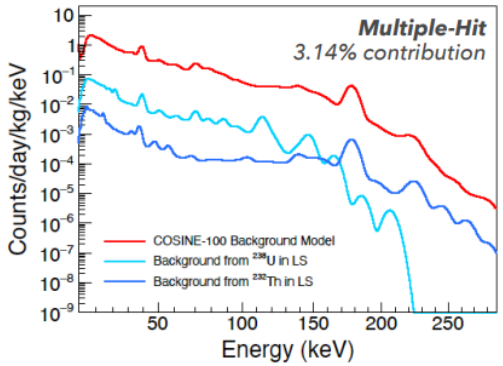
LS production



[unit : mBq/kg]

Nucleus	U-238	Th-232	K-40	Ac-228
Activity (HPGe)	< 0.90	< 0.74	< 7.39	< 2.01
Activity (this study)	0.091 ± 0.042	0.012 ± 0.007	-	-
(Ref.) COSINE-100	0.087	0.016		



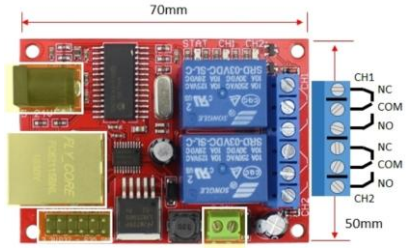


Back up

Electronics

- **DAQ**
  - **1 TCB**
  - **2 SADC** for **LS** and **Muon** PMTs
  - **8 FADC** for **NaI(Tl)** crystals
- **Servers**
  - At **fridge room**
    - **DAQ** server with SSD
    - **Monitoring** server with SSD
  - At **control room**
    - **Storage** server with 12 TB storage
    - **Testbench** server

Power controlled by TCP/IP **relay**

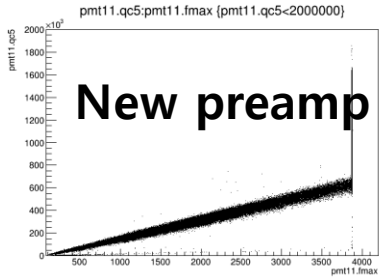


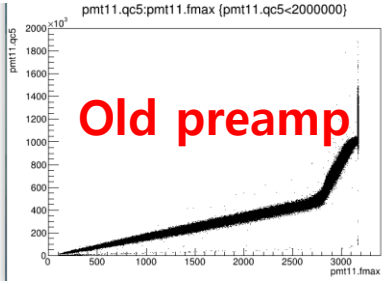
Provide **network directory** for data storage

Back up

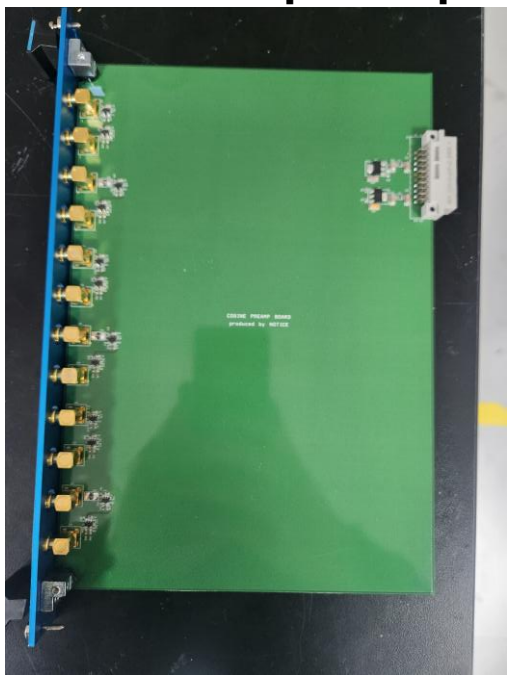
Electronics

- **New preamp**
  - **Same schematic** with COSINE-100 preamp
  - Change **input voltage** to **extend dynamic range**
    - 5V -> 6.5V
  - Remove offset control dial
  - **Optimize** channel distribution **to reduce crosstalk**





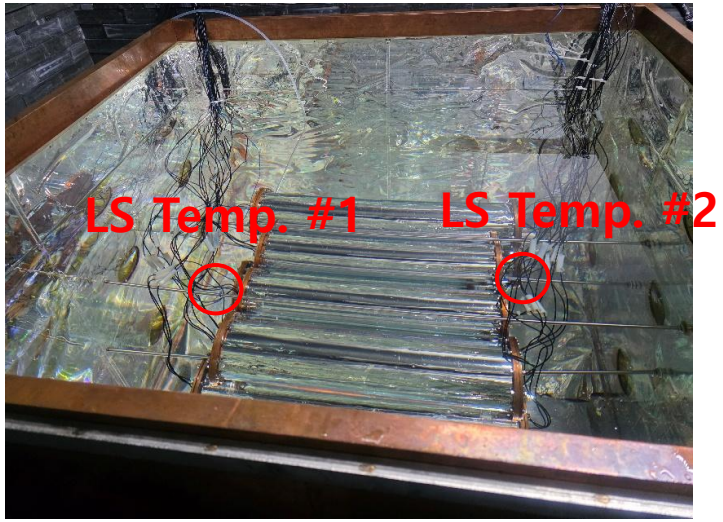
New preAmp



Back up

Electronics

- **Temperature** sensor
  - **ADAM-6018** (Ethernet module) with **Thermocouple cables**



Back up

Electronics

- **Humidity** sensor (UA10) @ **crate**
- **Radon** sensor (Rs9a)
  - At crate
  - Btw copper box and lead
- **Dust** counter
  - In front of crater (apexp3)
  - Btw copper box and lead (dsm101)
- **Flow** meters(vögtlin GSM)
  - For RRS and N2

GSM

dsm101

apexp3

UA10

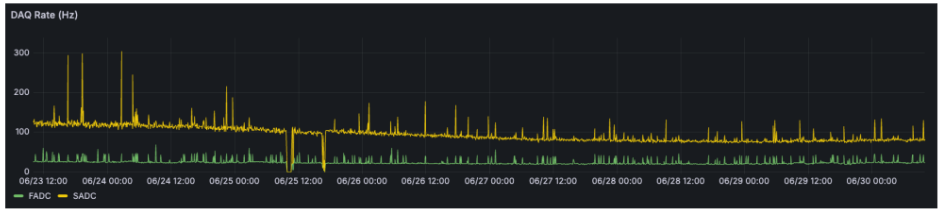
Rs9a

Back up

Environment monitoring in Grafana

Run status & DAQ rate read from the log file.

'Off' when latest DAQ information is over 5-min



HV & Current

Computing status

UPS status

Back up