



# Yemilab

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On behalf of Yemilab Team

# Introduction

- Yangyang Underground Lab. (Y2L)
- A Short History of Yemilab
- Access to Yemilab
- Structure of Yemilab
  - Key Research Spaces and Experiments
  - Infrastructures
- Measurements



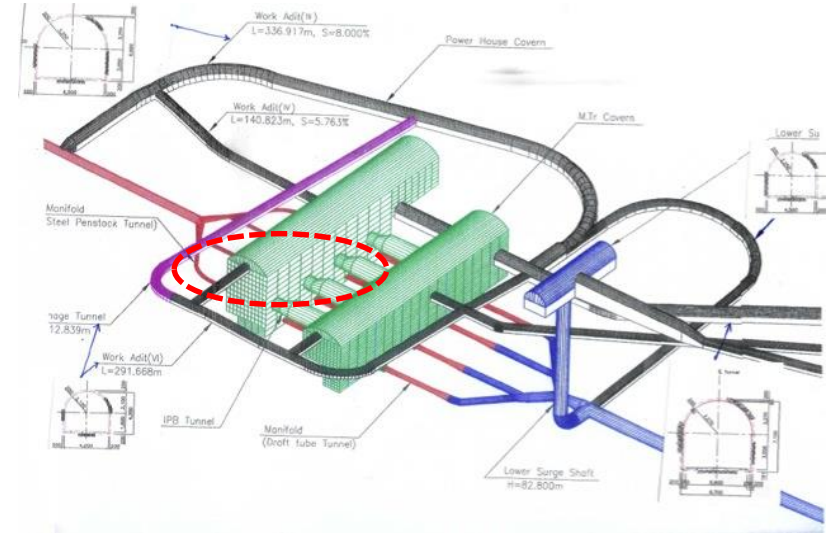
# Y2L



2024/11/18~20



1st IBS-INFN Workshop and 2nd Yemilab Workshop



## Y2L phase 1

- Since 2003 ~
- A6 tunnel
- Access by car for 2 km
- 600 m overburden
- 100 m<sup>2</sup> area

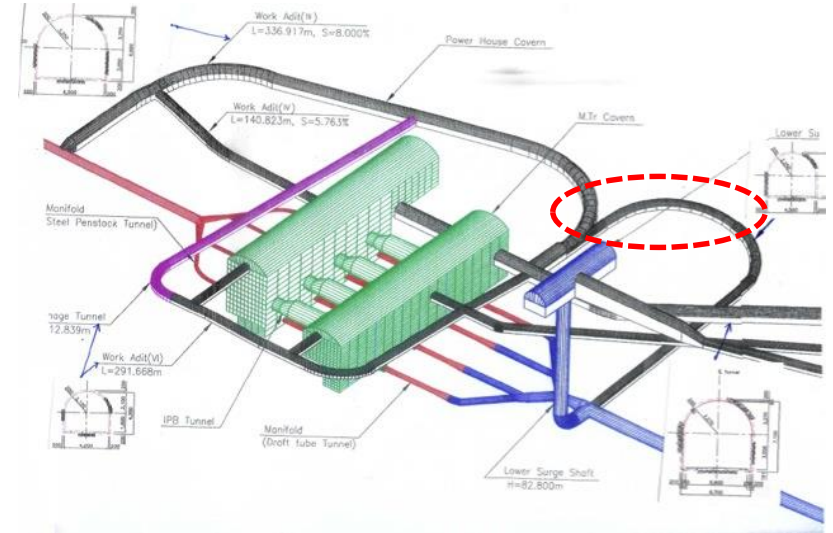
# Y2L



2024/11/18~20



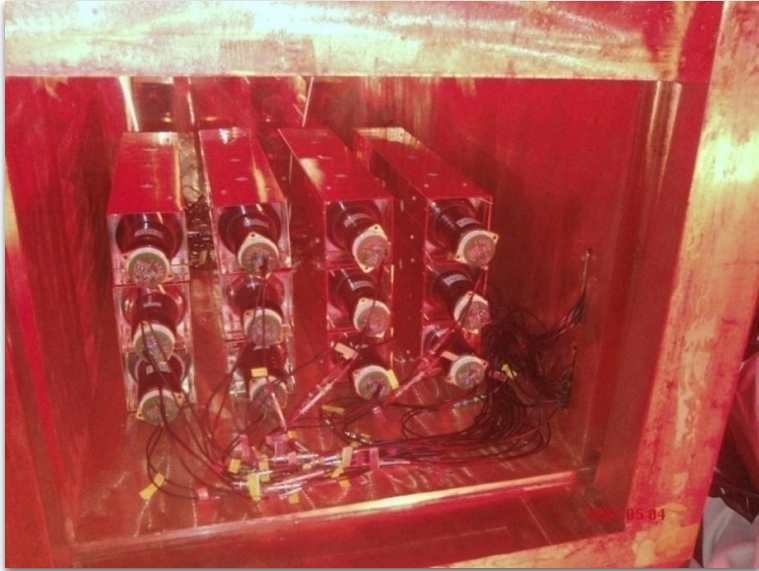
1st IBS-INFN Workshop and 2nd Yemilab Workshop



## Y2L phase 2

- 2013 ~ 2023 (IBS funding)
- 200 m<sup>2</sup> @ A5 tunnel
- total 300 m<sup>2</sup> area

# Experiments at Y2L



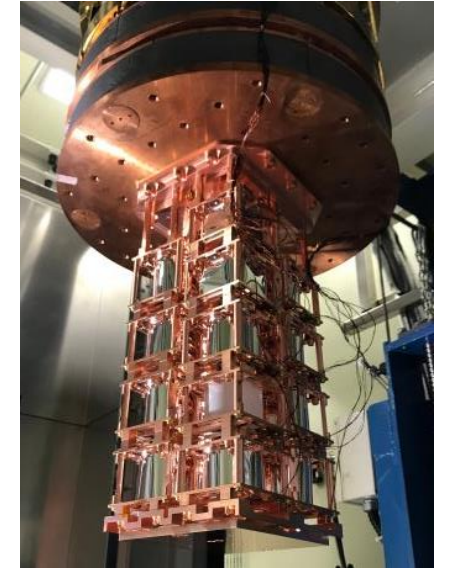
## KIMS Experiment

- Dark matter search
- CsI(Tl) scintillator



## COSINE-100 Experiment

- Dark matter search
- NaI(Tl) scintillator

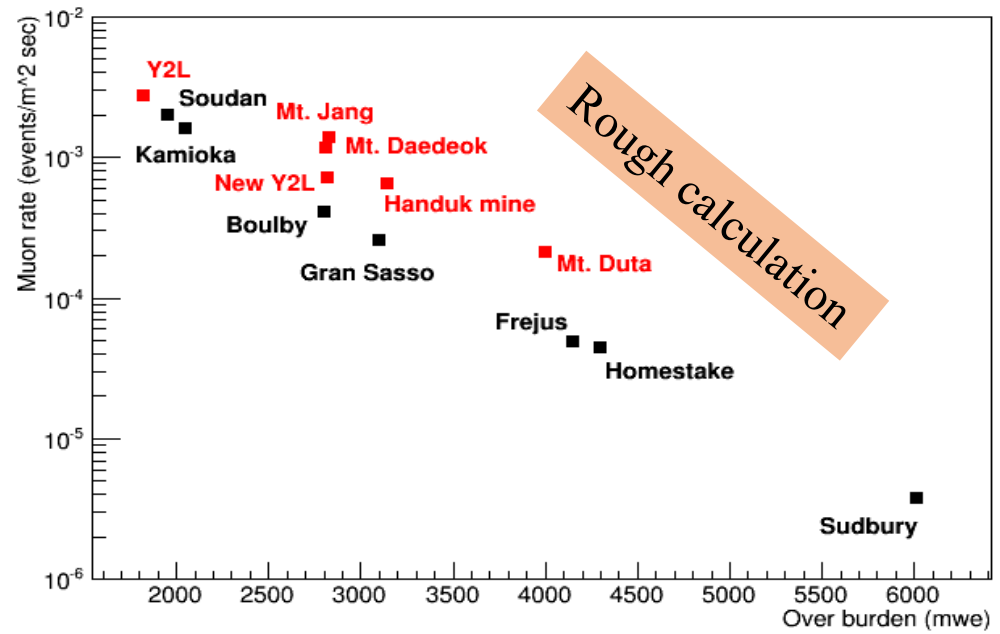
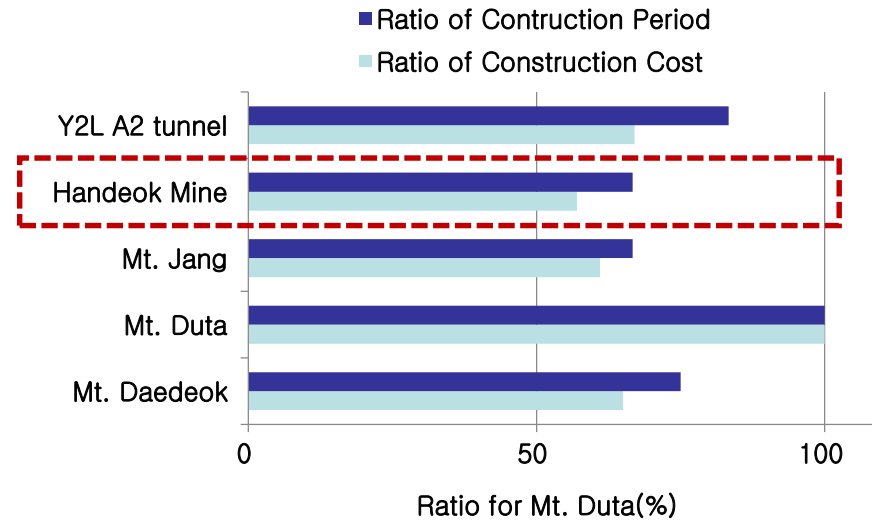
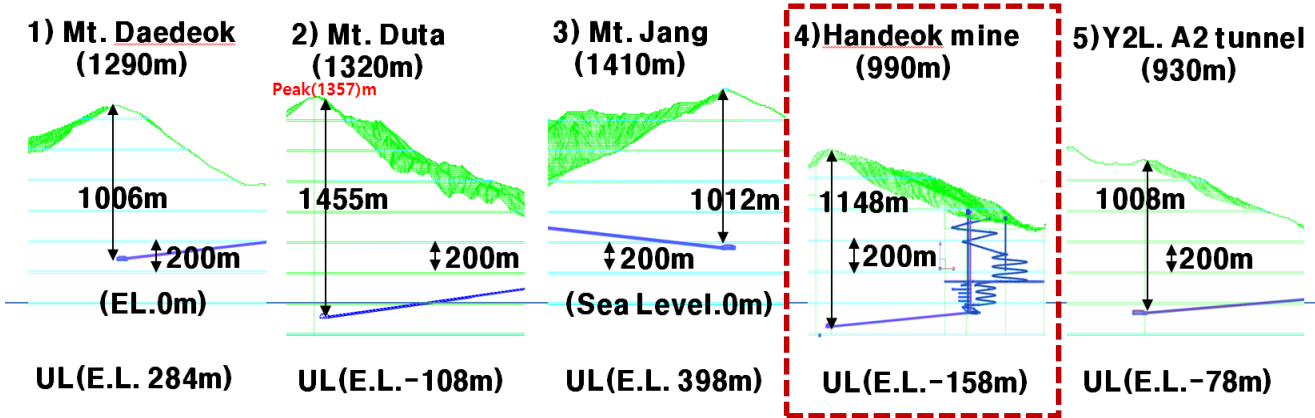


## AMoRE-pilot, I Experiment

- Neutrinoless double beta decay
- (Ca/Li)<sup>100</sup>MoO scintillator

and more ...

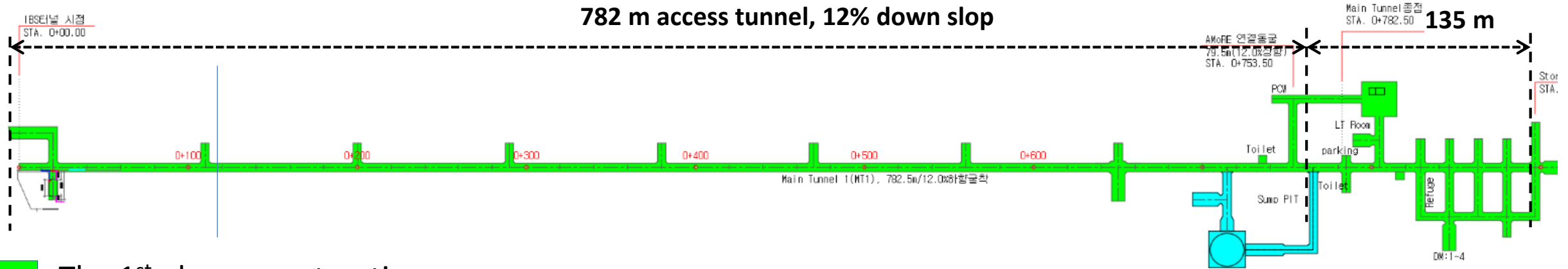
# A Short History of Yemilab



## Handeok mine **beneath Mount Yemi**

1. Cost effectiveness
2. Acceptable overburden (~1,000 m)
3. Limestone for less radioactivity

# A Short History of Yemilab



- The 1<sup>st</sup> phase construction
  - 2017. July ~ 2020. August
  - Cage installation in the shaft
  - Excavation : 2,000 m<sup>2</sup> (lab. area)

- The 2<sup>nd</sup> phase construction
  - 2021. May ~ 2022. July
  - excavation : 1,000 m<sup>2</sup>
  - Electricity and machinery
  - Ground office renovation



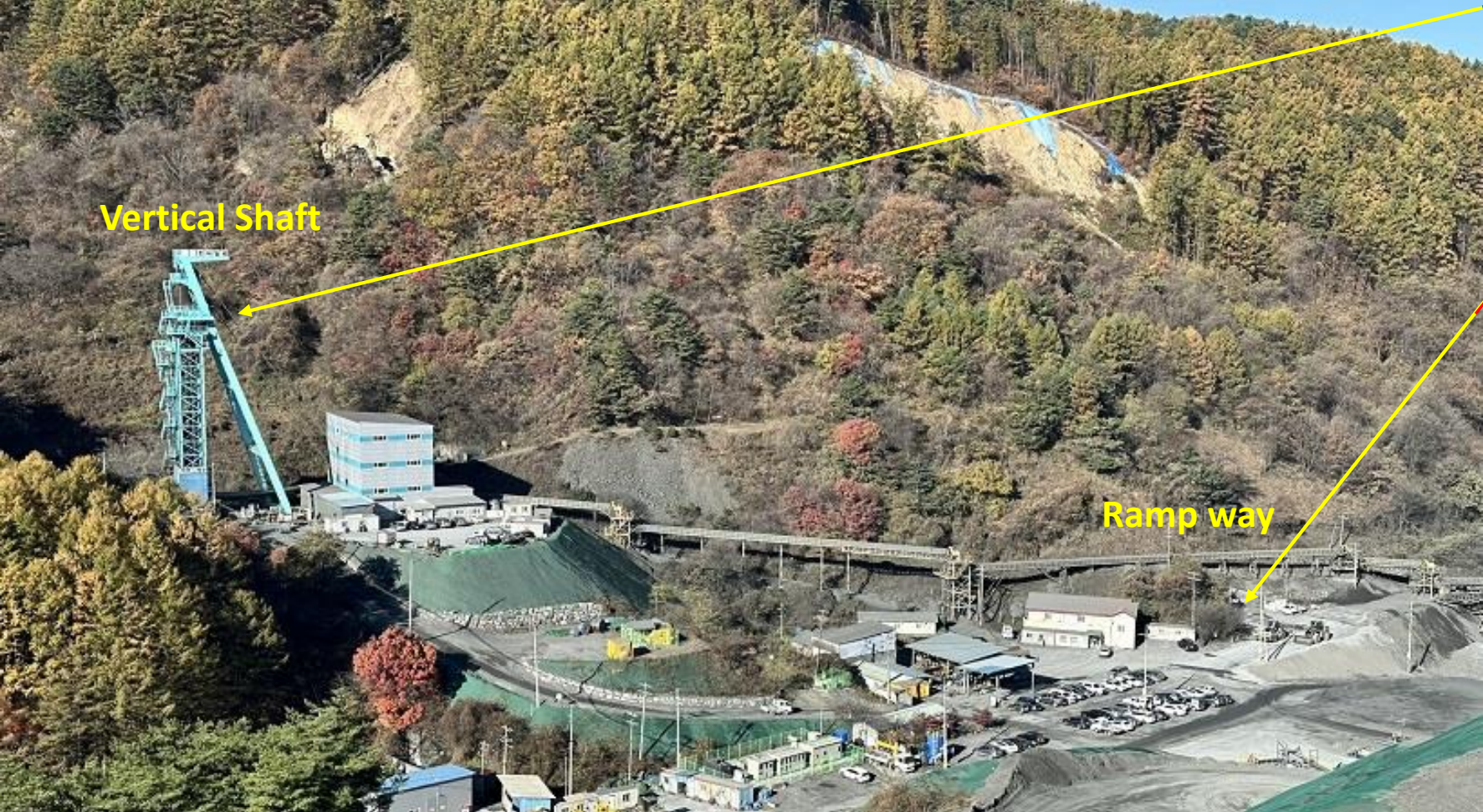
# A Short History of Yemilab



2022. Oct. **The construction completion ceremony**

2023. Aug. – 2024. Jan. **Y2L relocation to Yemilab**

# Access to Yemilab



# Access to Yemilab



Through 600-meter vertical shaft

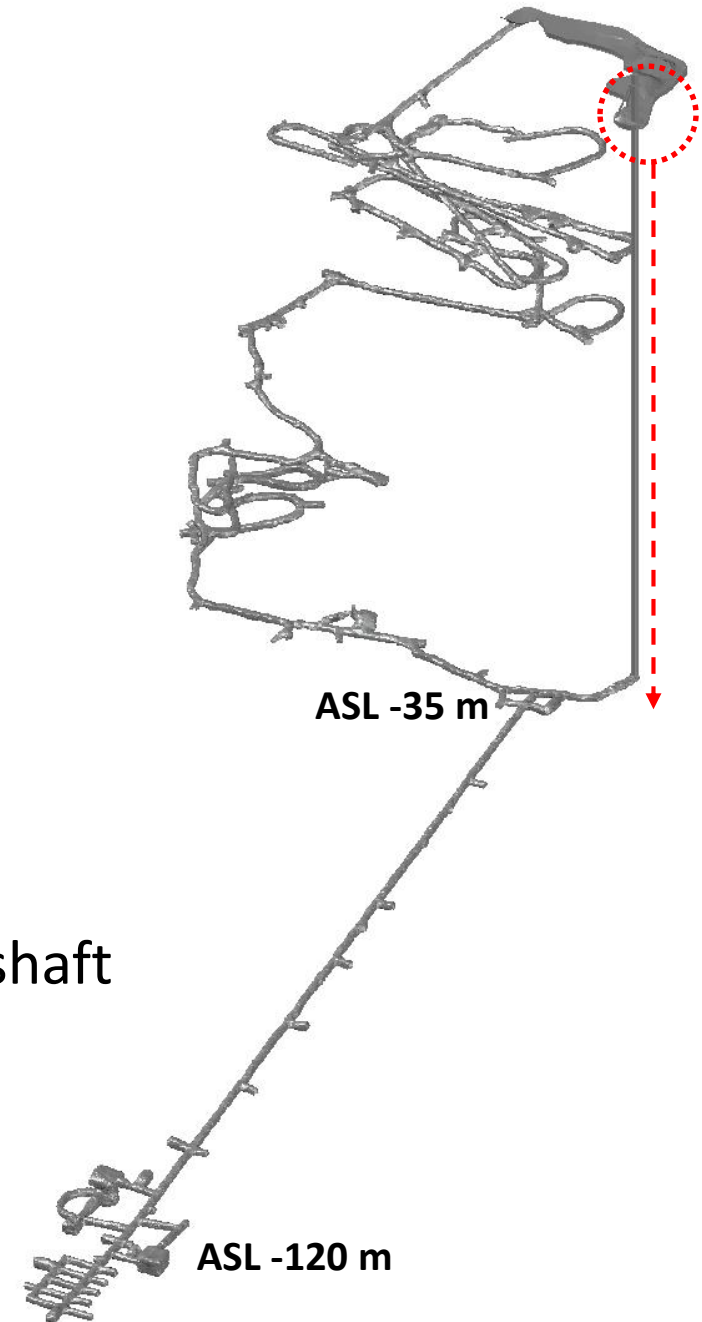
- $\Phi$  6 m, skip for transporting ore

Man riding cage

- Manufactured by SIEMAG

- 8 people, < 1.5 ton

- 4 m/s, 2.5 mins

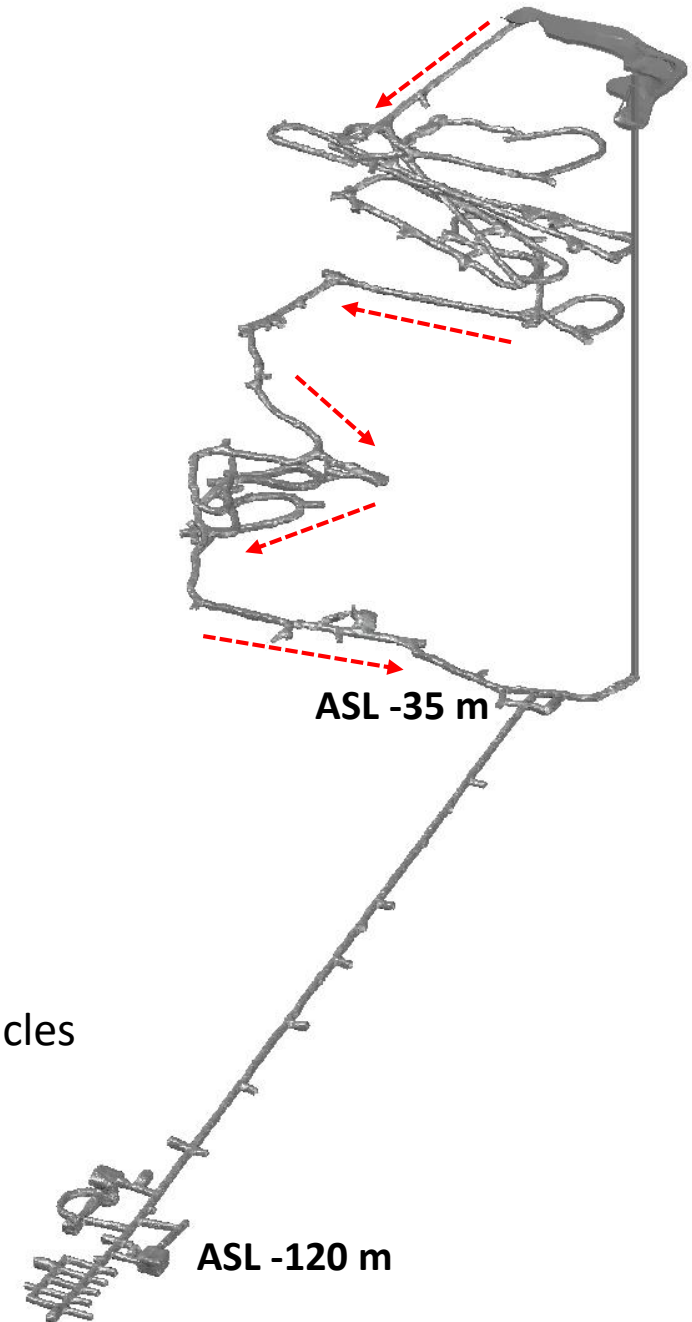


# Access to Yemilab

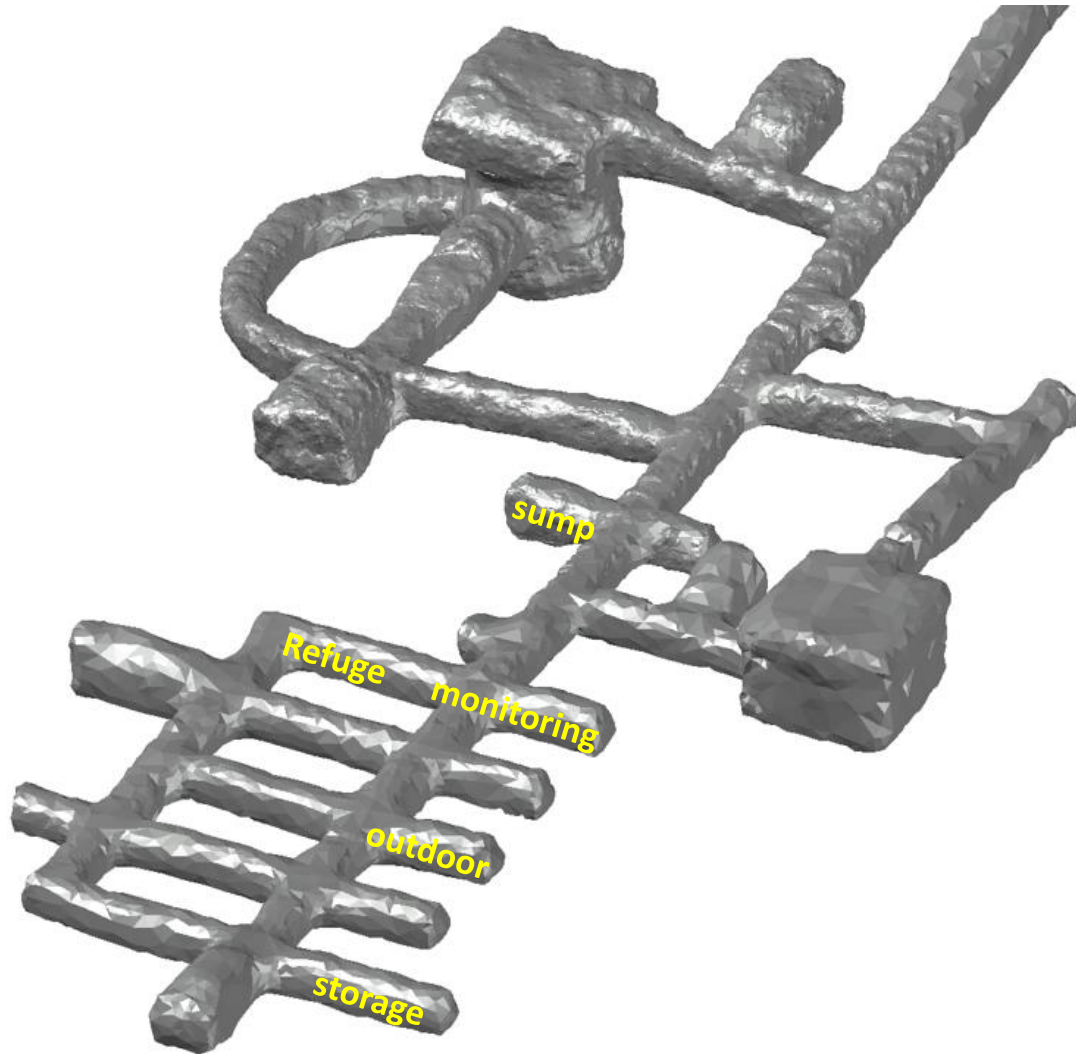


## Through ramp way

- Unpaved road used by mining vehicles
- ~6 km to Yemilab, 20 mins by car
- Transporting cargo
- 5 m x 5 m tunnel cross-section
- Radio communication

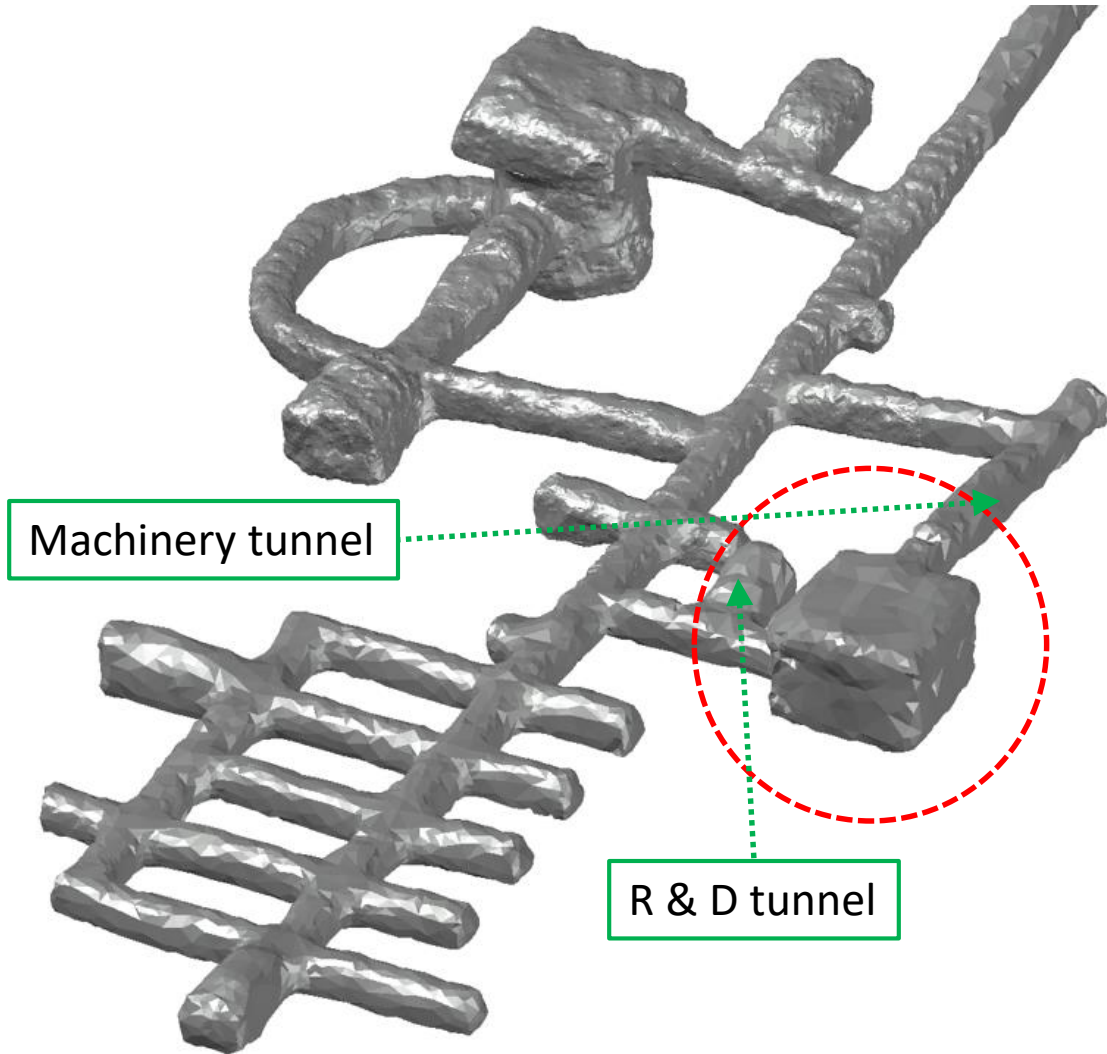


# Structure of Yemilab



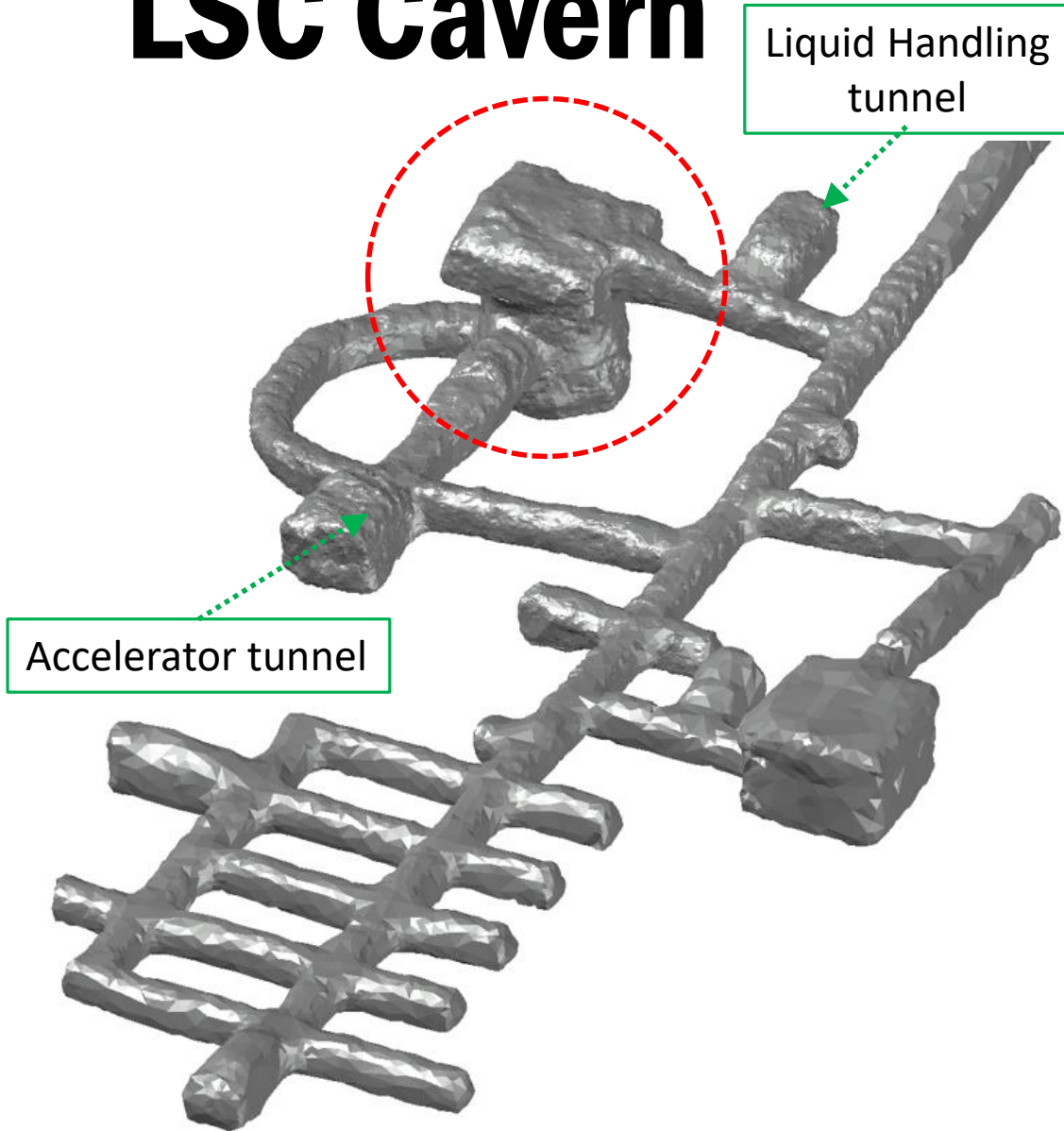
- ~800 m access tunnel
  - Machinery room (air supply/ventilation)
  - Electrical room
  - Water storage room
  - Sump
- Two large caverns
- Ladder type tunnels
  - COSINE
  - HPGe, KNU, ...
  - Refuge
  - Tunnel monitoring room
  - Outdoor unit room
  - General storage

# AMoRE Hall



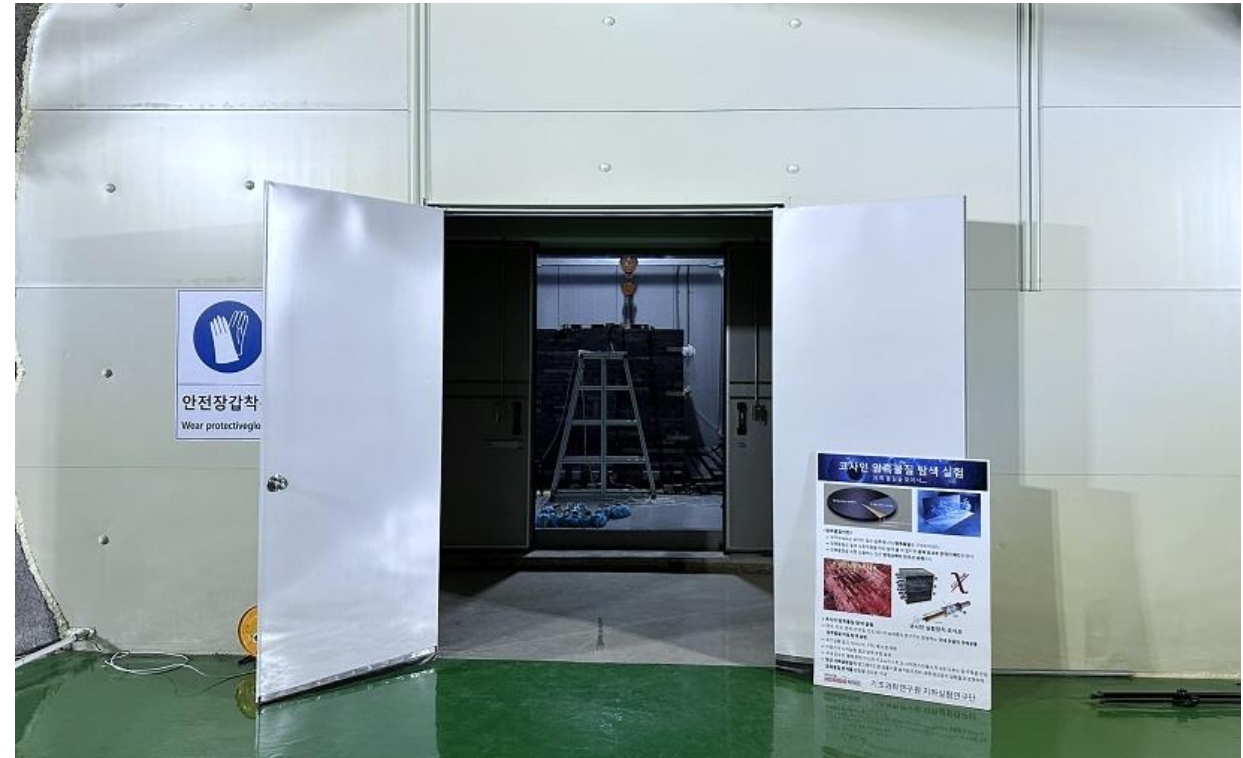
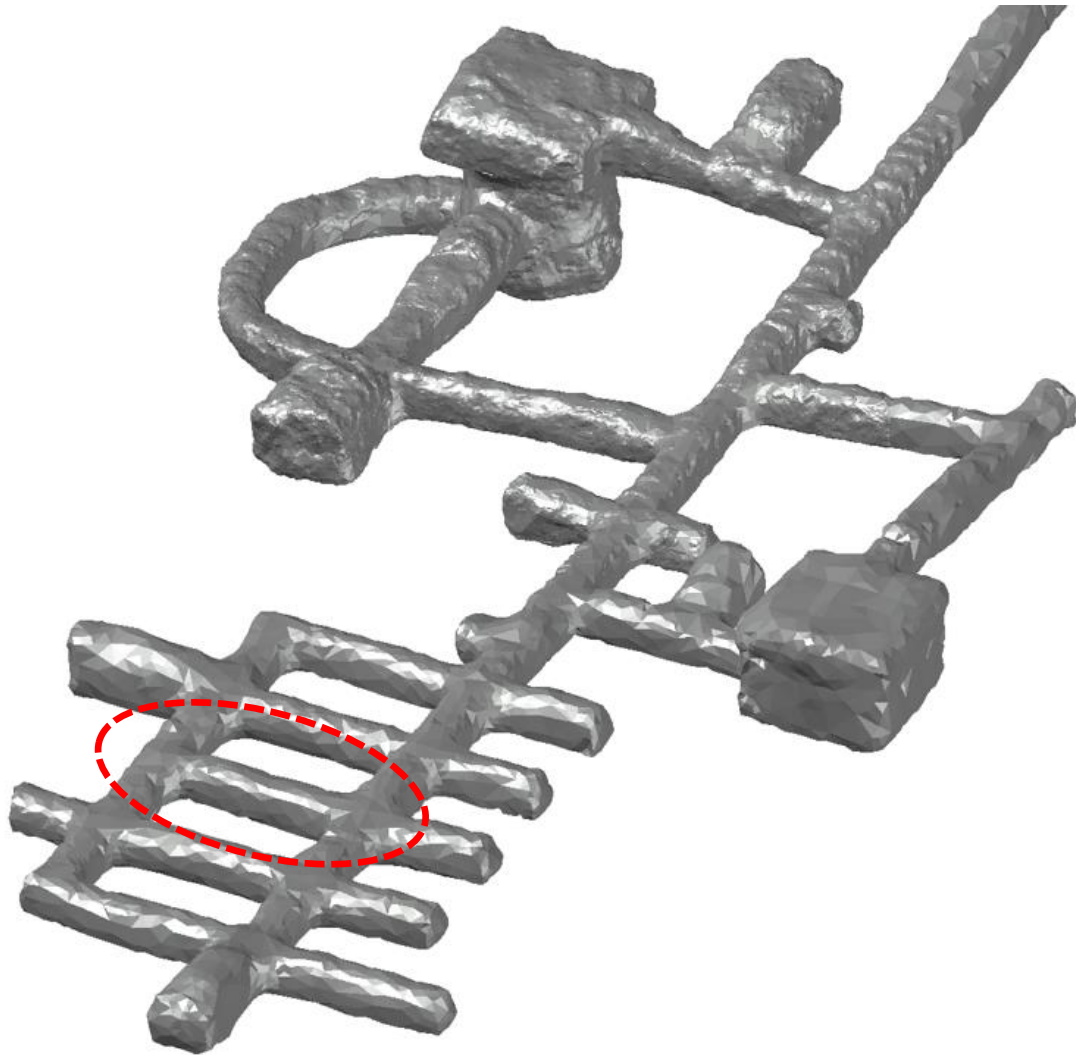
- **AMoRE-II** ( $0\nu\beta\beta$ )
- 21x21x15 m<sup>3</sup> and
  - R&D tunnel
  - Machinery tunnel (PCW, RRS, DI-water)
- 5 ton crane

# LSC Cavern



- For large liquid scintillator experiment
- Cylindrical shape,  $\Phi 20$  m x H28 m
  - Liquid handling tunnel
  - Accelerator tunnel (ex. IsoDAR)
- 10 ton crane

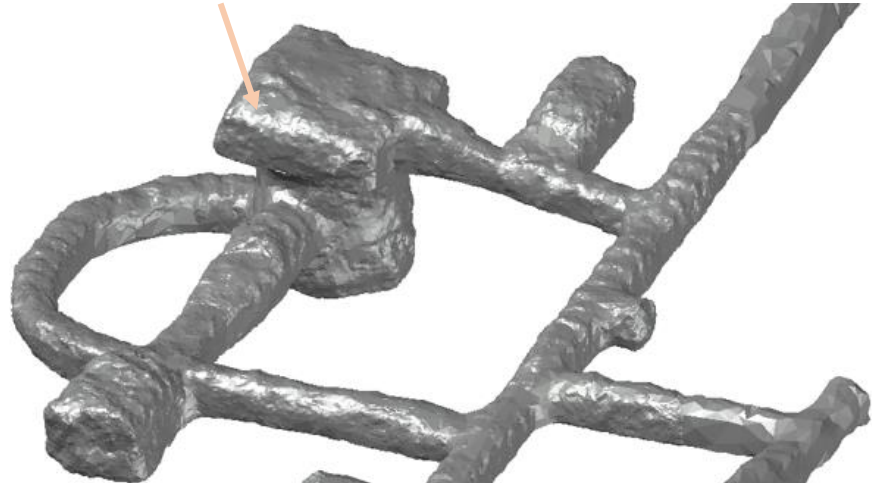
# COSINE Tunnel



- COSINE-100U (Dark Matter)
  - 5 x 5 x 25 m<sup>3</sup>
  - Freezer down to -30 °C

**4 Institutes**  
**1 University**  
**1 Company (startup)**  
**→ 11 research topics**

Institute for Basic Science  
 (Neutrino, future)

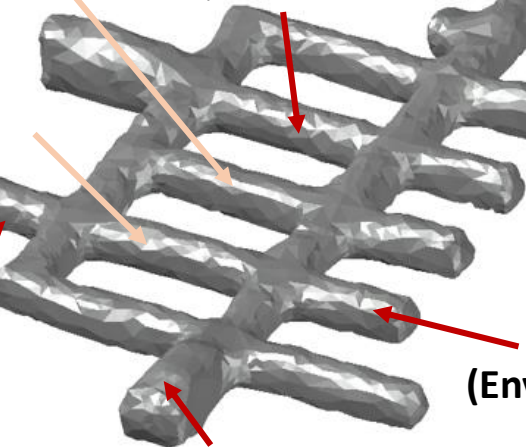


NIMS  
 ( $\mu$ Gravity)

Institute for Basic Science  
 (COSINE)

Institute for Basic Science  
 (HPGe, Alpha cou)

KIGAMS  
 (Geology)



KAERI  
 (Env. Radiation)

Kyungpook National University  
 (Positronium,  $0\nu\beta\beta$  decay R&D)

Institute for Basic Science  
 (AMoRE)

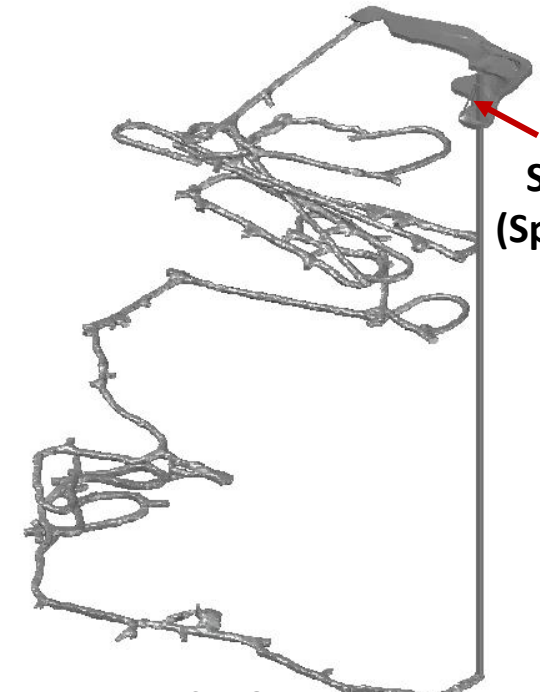
ASL -35 m

KMA  
 (Earthquake)

KIGAMS  
 (Space Planting)

ASL -120 m

Space Lintech  
 (Space medicine)



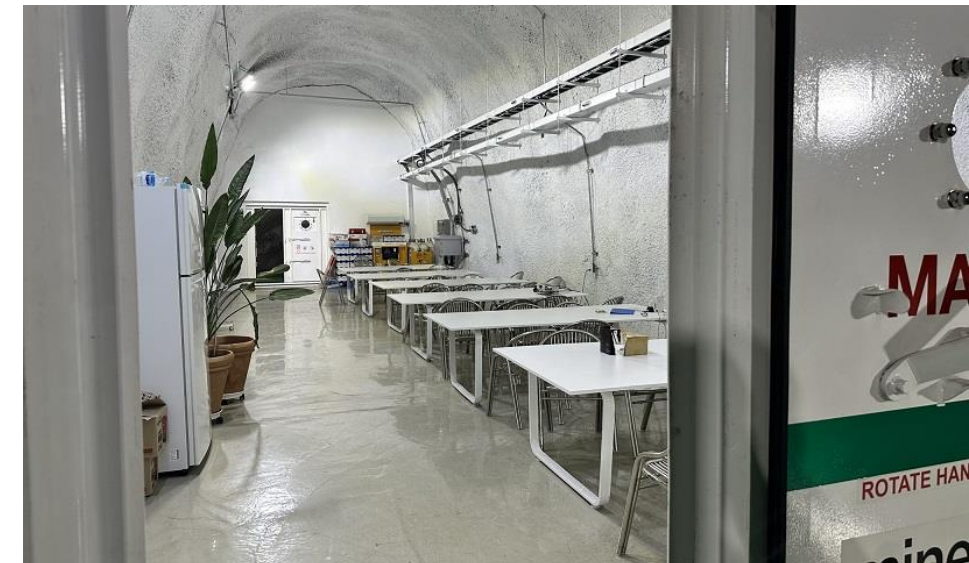
# Infrastructures

- Electricity
  - Ground: 2500 KVA
    - diesel backup generator (360 KW)
  - Underground: 2000 KVA from the ground
    - 2 UPSs (80 + 180 KVA)
- Air supply
  - 39,000 m<sup>3</sup>/h near vertical shaft for 6 changes per day
  - 6,000 (radon-less air) + 6,000 (return) m<sup>3</sup>/h at summer season
  - Air exhaust: 36,000 m<sup>3</sup>/h
- Communication
  - Full mobile communication (LTE)
  - 1 GB optical network to ground office
  - Radio communication for emergency



# Infrastructures

- Radon Reduction System (RRS)
  - 50 m<sup>3</sup>/h, 1/500 reduction
  - 200 m<sup>3</sup>/h RRS is under consideration
- LN2 generators for cryostat and HPGe
- Refuge
  - 40 people for 72 hours
  - Dried food, water, air, UPS, ...
  - Normally used as a dining hall or meeting room
- Groundwater: ~3 tons/day
  - 30 ton storage tank for domestic water
  - 90 ton sump for pumping out collected groundwater

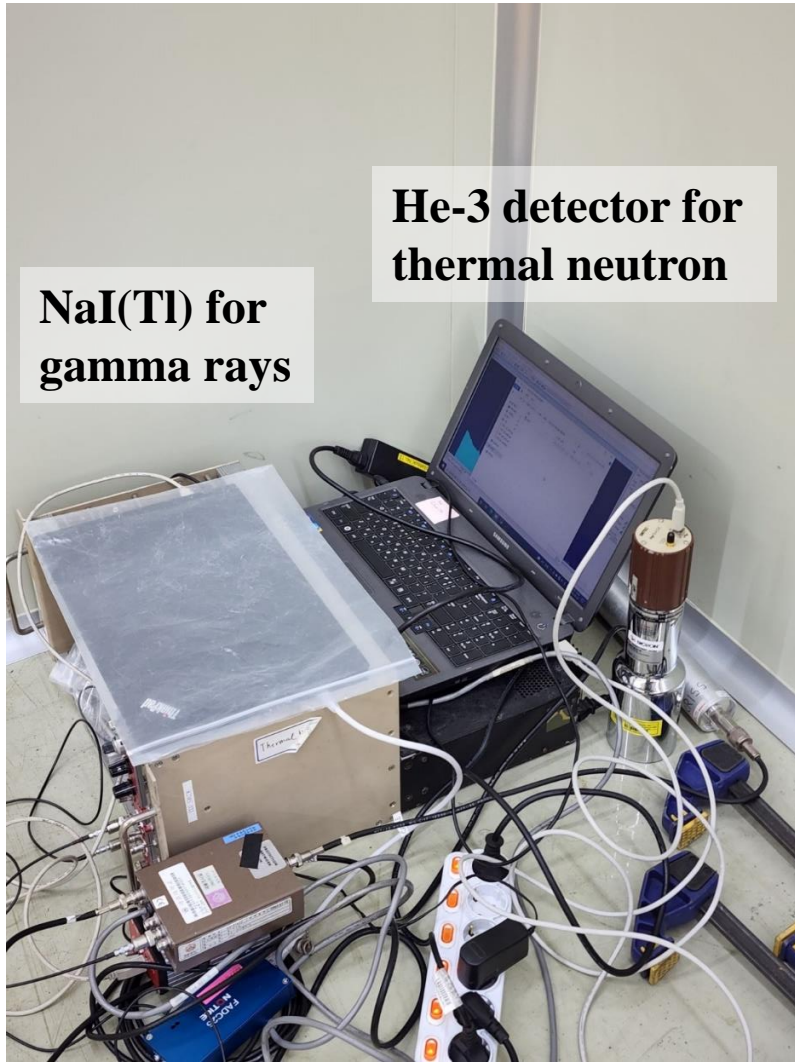


# Ground Office

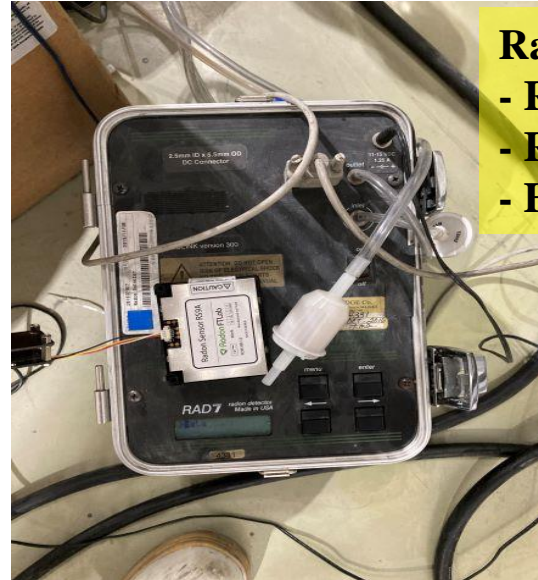


- 2.5 km from Handeok mine
- Offices, labs (general, chemistry), auditorium, recreation room, storage, ...

# Environmental monitoring



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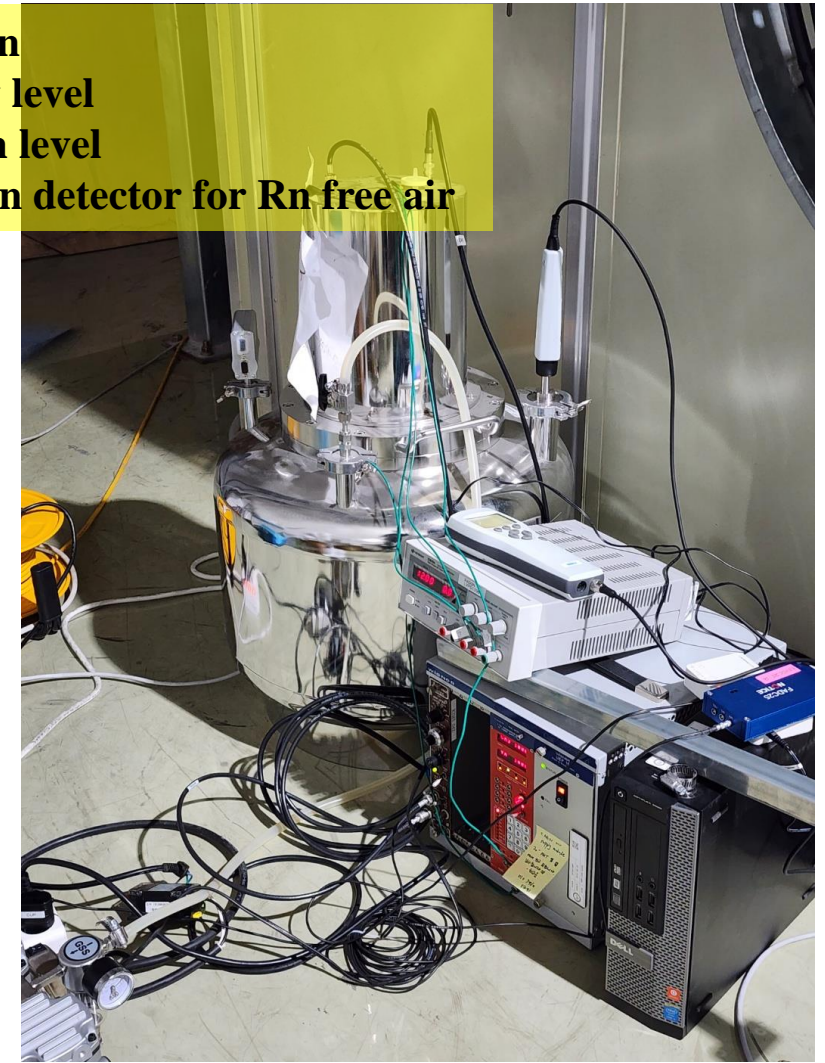


**Radon detection**

- RAD7 for low level
- RS9A for high level
- Homemade Rn detector for Rn free air



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# Environmental monitoring

## UA10

Calibration software  
Temp. : -40 ~ 80 °C  
Humidity : 5 ~ 95 %



## UA58-KFG-U

CO (~ 1,000 ppm)  
CO<sub>2</sub> (400 ~ 10,000 ppm)  
O<sub>2</sub> (0 ~ 25%)  
H<sub>2</sub>S (0 ~ 100 ppm)

## DSM101

PM1.0 / PM2.5 / PM10  
1~1,000 µg/m<sup>3</sup>



USB connection

Ethernet

Raspberry Pi-3

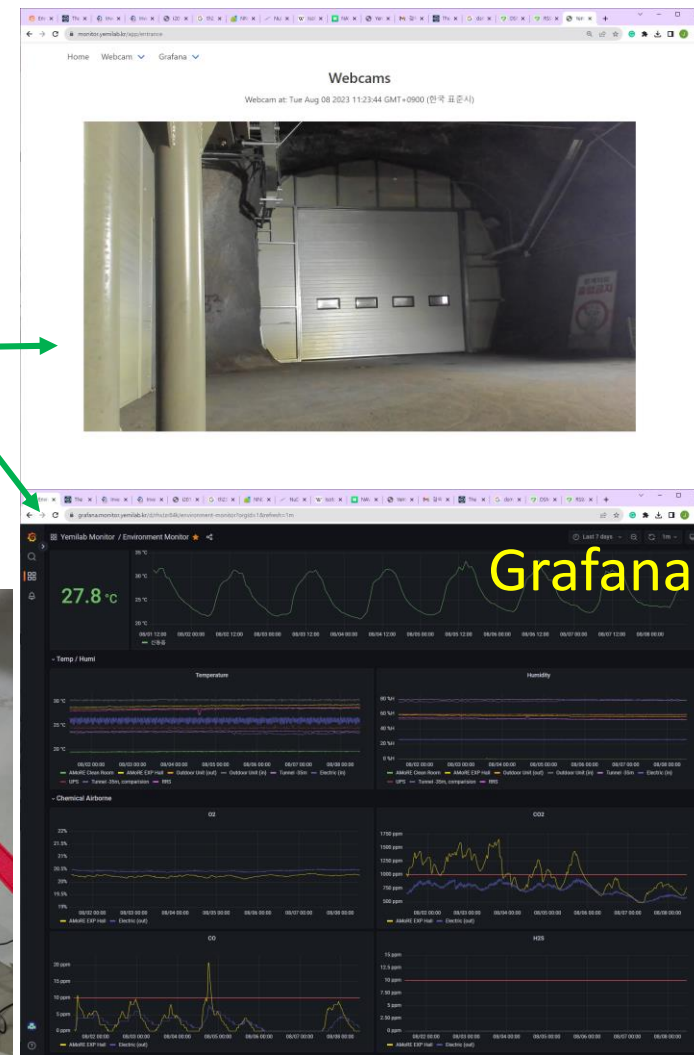


## RS9A

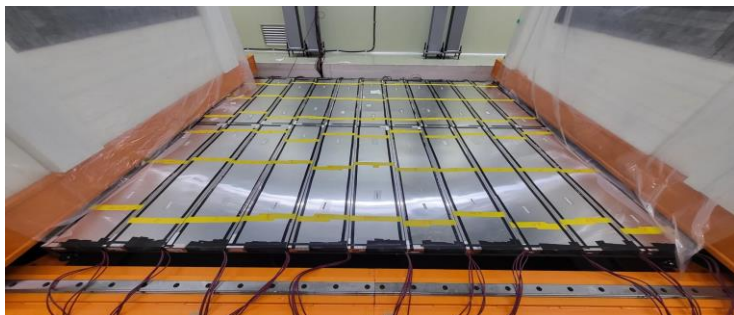
7 ~ 3700 Bq/m<sup>3</sup>  
±15% accuracy

## Webcam

1 picture / min



# Muon Flux

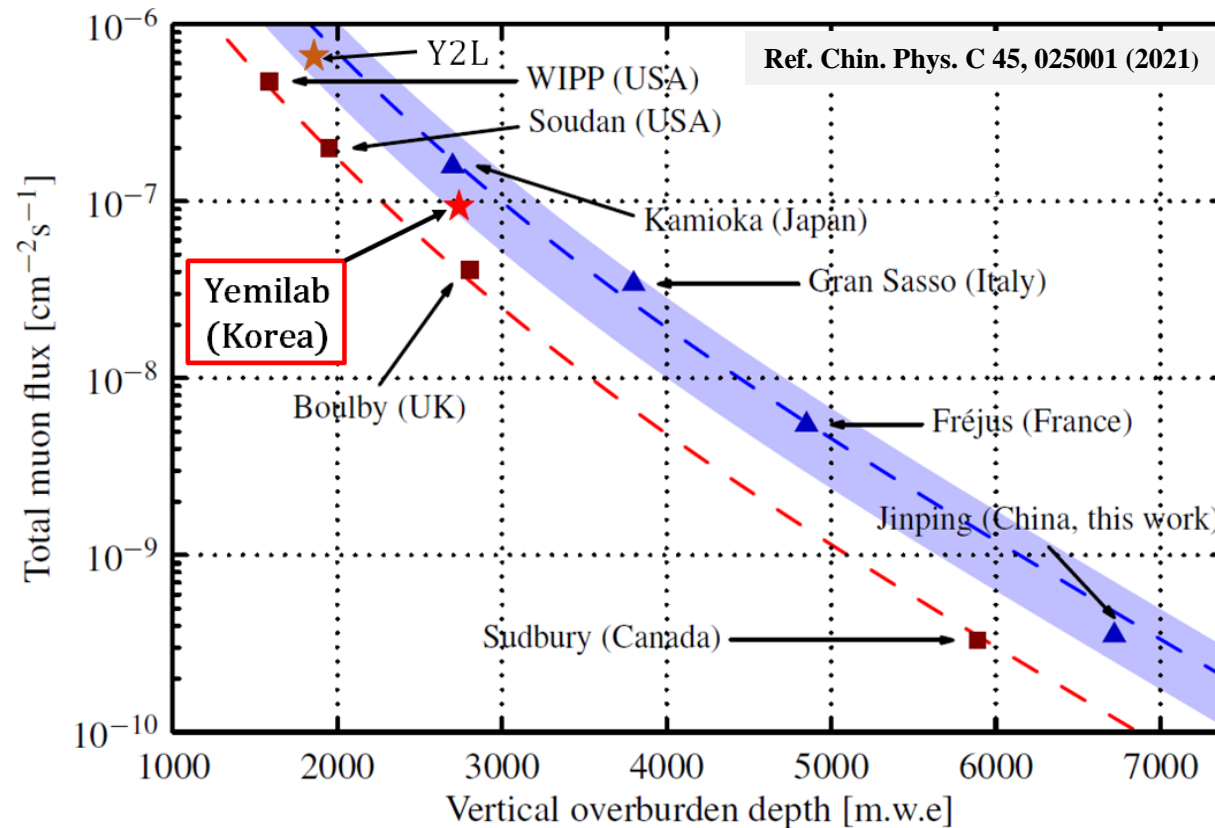
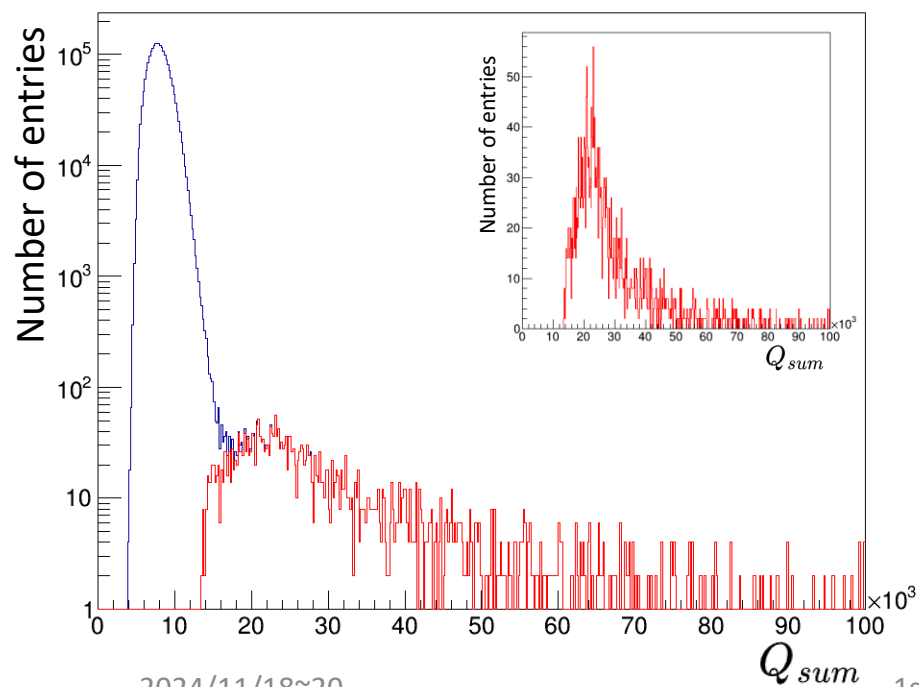


U.L.	Gran Sasso	SNO lab	SURF	Kamioka	Boulby	Yemilab
Depth (m.w.e.)	3,800	6,000	4,300	2,700	2,850	2,650
Volume (m <sup>3</sup> )	180,000	37,000	7,800	56,500	14,000	25,000

22 plastic scintillator panels (170 × 30 cm<sup>2</sup> for each, 11.2 m<sup>2</sup>)

Preliminary muon rate at AMORE Hall:  $8.8 \times 10^{-8}/\text{cm}^2/\text{sec}$

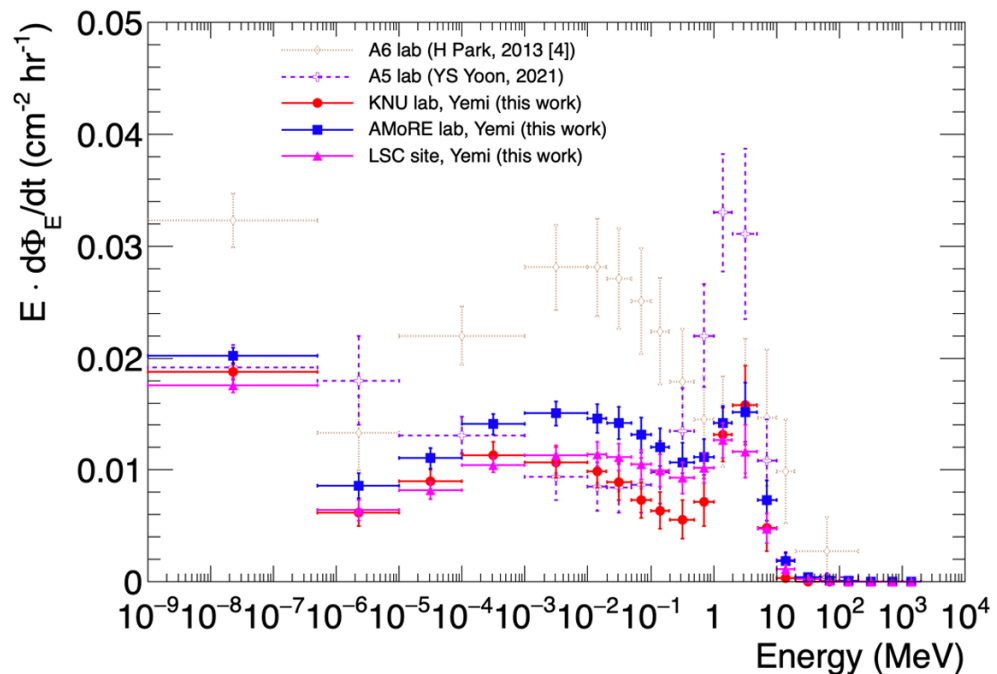
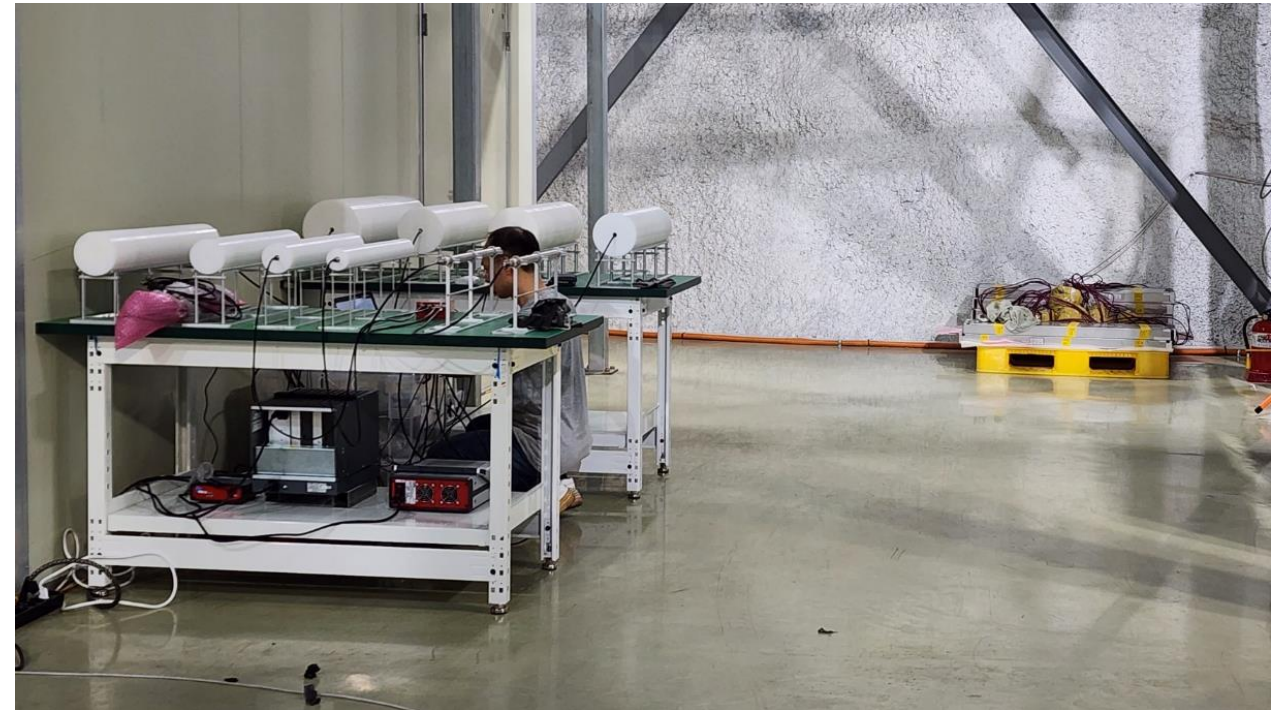
- Y2L:  $3.8 \times 10^{-7}/\text{cm}^2/\text{sec}$



# Neutron

[ $\times 10^{-6}/\text{cm}^2/\text{sec}$ ]

	Thermal	Fast (1~10MeV)	Total
Y2L A6	$24.2 \pm 1.8$	$4.2 \pm 0.9$	<b><math>67.2 \pm 2.2</math></b>
Y2L A5	$14.4 \pm 1.5$	$7.1 \pm 1.0$	<b><math>44.6 \pm 6.6</math></b>
Yemilab (AMoRE)	$15.1 \pm 0.5$	$3.4 \pm 0.4$	<b><math>40.1 \pm 1.0</math></b>
Yemilab (KNU)	$14.1 \pm 0.6$	$3.2 \pm 0.5$	<b><math>32.4 \pm 1.1</math></b>



- **Y2L : More moderation by equipment**
- **Yemilab : A few hundreds of tons Shotcrete**
  - ~ 180 tons on AMoRE cavern
  - High Rn level during summer season

# Radioactivity

HPGe	Bq/kg	<sup>226</sup> Ra	<sup>40</sup> K	<sup>228</sup> Ac	<sup>228</sup> Th	<sup>210</sup> Pb	<sup>54</sup> Mn
Rock		58.0±5.2	1,161±232.3	52.6±7.5	50.7±5.1	N. A.	N. A.
Cement		26.0±1.3	216.3±10.9	24.0±1.2	21.5±1.1	N. A.	0.36±0.02
Sand		24.6±1.2	848.9±42.5	57.0±2.9	53.5±2.7	N. A.	0.81±0.05
Stone		8.9±0.5	54.8±2.8	9.9±0.5	8.9±0.5	N. A.	0.13±0.01

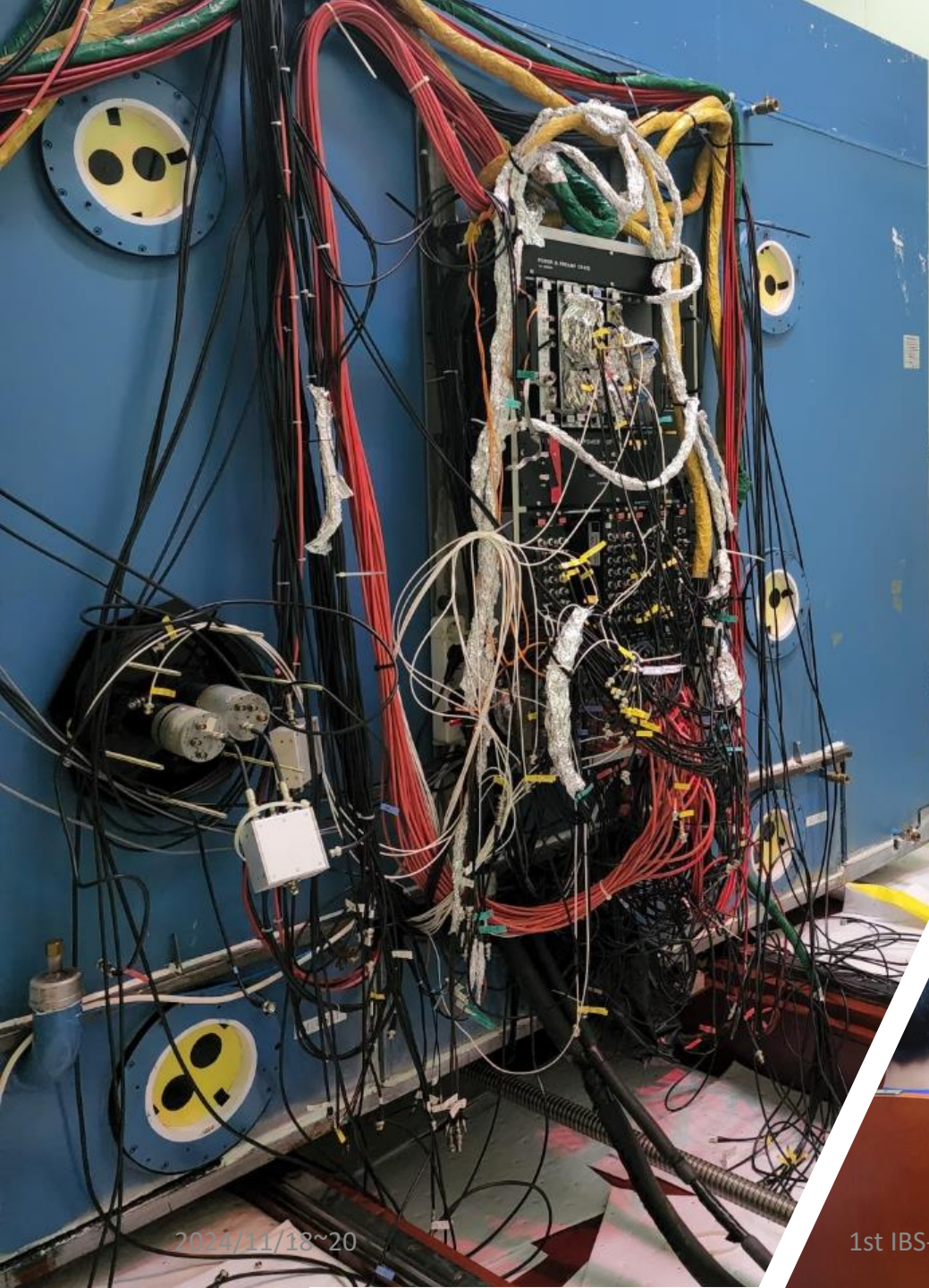
ICP-MS			<sup>238</sup> U	<sup>232</sup> Th	<sup>40</sup> K	Sample location
2020.08.19.	Handuk limestone A	KIGAM	1.17	3.43	11400	@ AMoRE Cavern top
	Handuk limestone B	KIGAM	0.68	3.50	13800	@ AMoRE Cavern left
	Handuk limestone C	KIGAM	0.66	2.87	10200	@ AMoRE Cavern right
average			<b>0.84</b> (10.4 Bq/kg)	<b>3.27</b> (13.3 Bq/kg)	<b>11800</b> (365.8 Bq/kg)	

HPGe **CMD424.1 Dust near Yemi cage 220802** Mass: 1.45 kg, M. day : 1 day CCI

<sup>226</sup> Ra( <sup>238</sup> U)	<sup>234</sup> Th	<sup>40</sup> K	<sup>228</sup> Ac	<sup>228</sup> Th	<sup>210</sup> Pb
24.61 ± 1.23 Bq/kg	28.12 ± 1.46 Bq/kg	226.08 ± 11.33 Bq/kg	15.21 ± 0.77 Bq/kg	13.61 ± 0.68 Bq/kg	17.82 ± 2.31 Bq/kg

**CMD424.2 Dust near AMoRE PCW 220803** Mass: 0.083 kg, M. day : 3 day CCI

<sup>226</sup> Ra( <sup>238</sup> U)	<sup>234</sup> Th	<sup>40</sup> K	<sup>228</sup> Ac	<sup>228</sup> Th	<sup>210</sup> Pb	<sup>54</sup> Mn
24.99 ± 1.26 Bq/kg	39.62 ± 2.15 Bq/kg	407.21 ± 20.52 Bq/kg	22.88 ± 1.18 Bq/kg	23.07 ± 1.16 Bq/kg	164.78 ± 9.17 Bq/kg	0.33 ± 0.04 Bq/kg

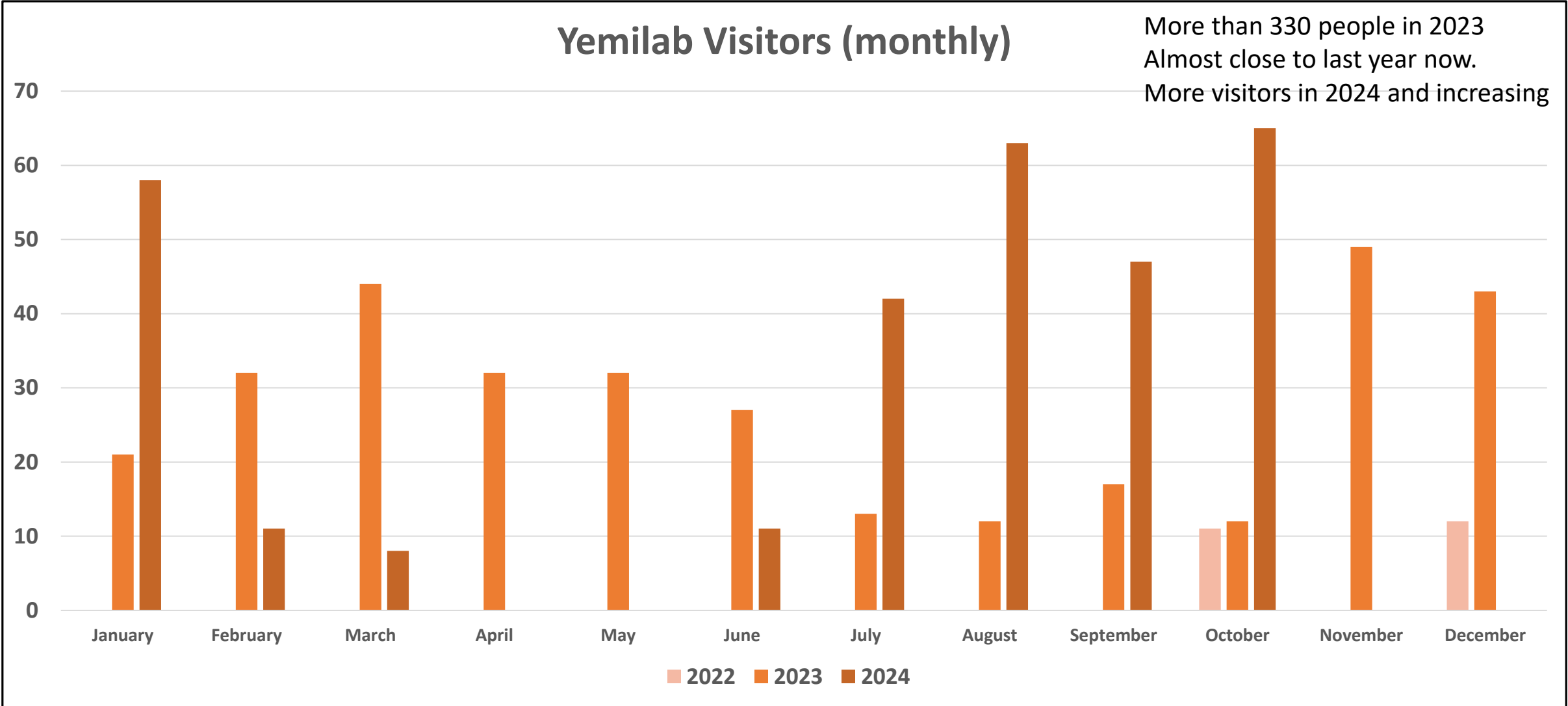


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# Visitors (non-scientific)



Thank you

谢谢您

CIAO