Towards AMoRE-II
: Neutrinoless double-beta decay searching

Woo Tae Kim

(Center for Underground Physics, IBS)

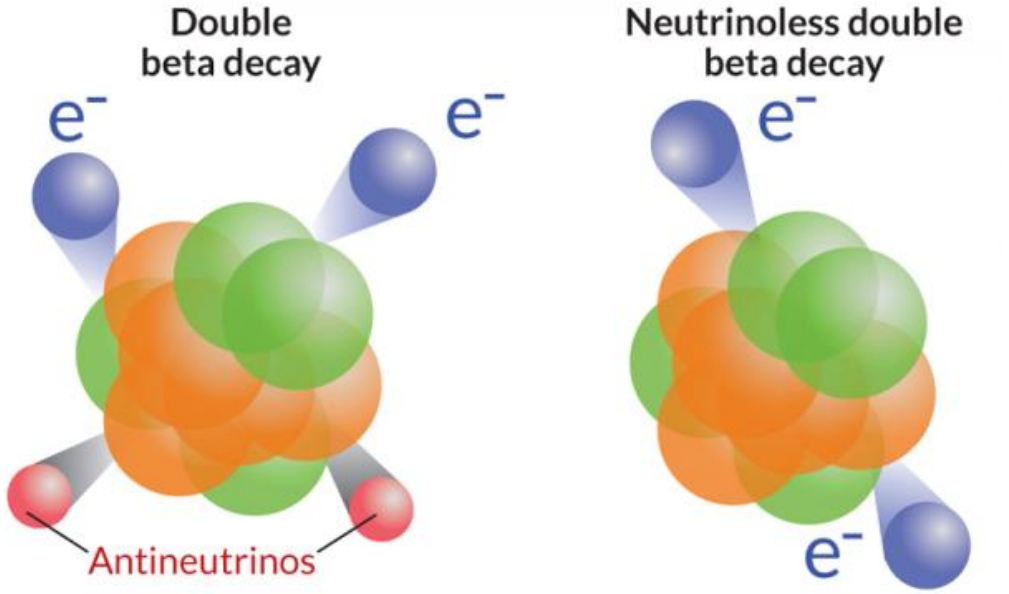
On behalf of the AMoRE collaboration

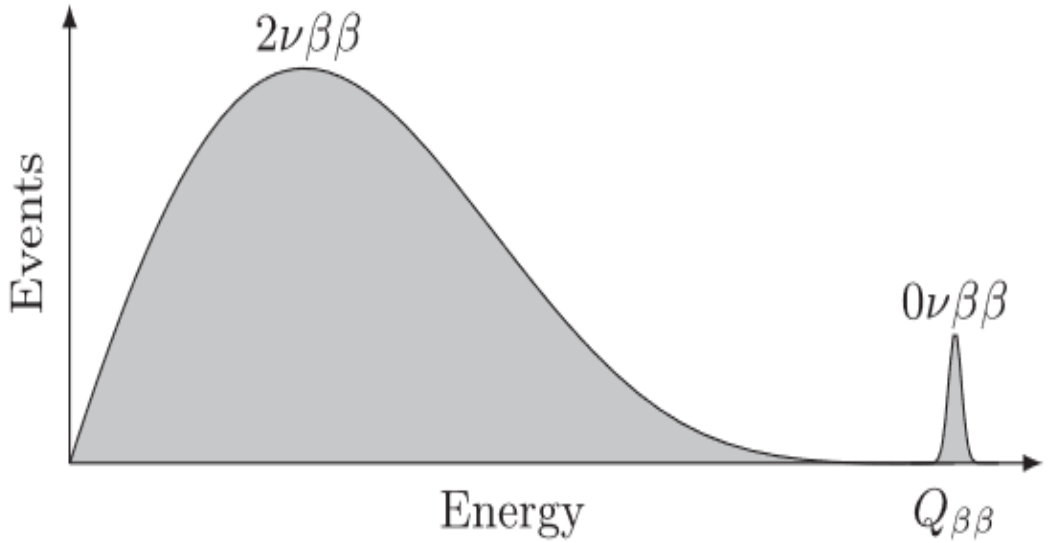
K-Neutrino Symposium 2026, CAU.

27th Oct 2026.

AMoRE (Advanced Molybdenum-based Rare Process Experiment)

: Searching for $0\nu\beta\beta$ decay of ^{100}Mo





- A Majorana particle (ν^M) is one that identical to its antiparticle : $\nu^M = \overline{\nu^M}$
- When the neutrinos are Majorana particles, there is no conserved lepton number.
- Can be able to define the neutrino type and absolute mass.

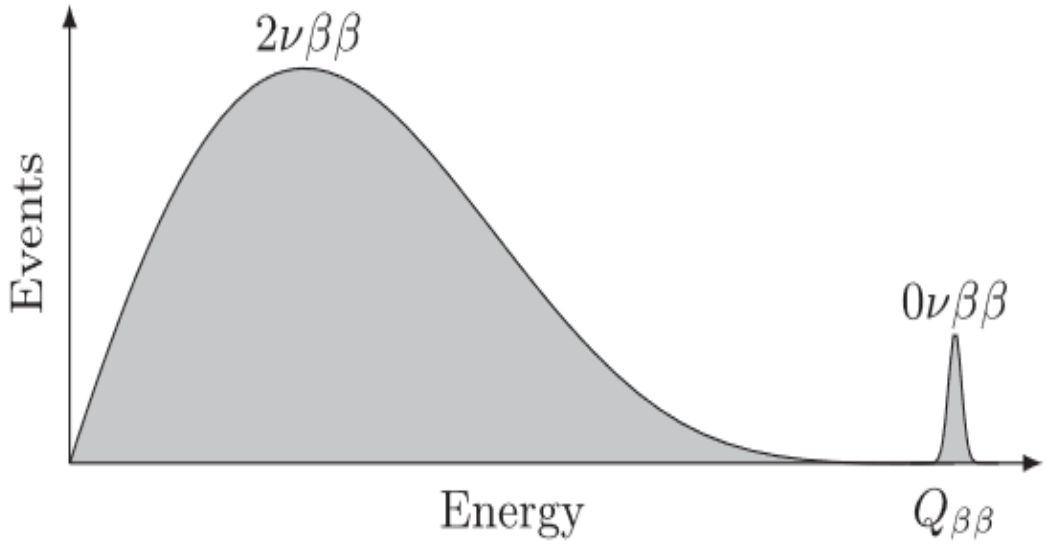
- Scintillating crystals (Li_2MoO_4, $CaMoO_4$, etc)
- High Q-value (3.034 MeV), placing the signal above most natural gamma ray background.
- Favorable predicted $0\nu\beta\beta$ decay rate, depending on the assumed decay mechanism and nuclear matrix elements.
- High natural isotopic abundance (9.7%).

AMoRE (Advanced Molybdenum-based Rare Process Experiment)

: Searching for $0\nu\beta\beta$ decay of ^{100}Mo

Nucl.	Q (keV)	Abun. (%)	Exp
^{48}Ca	4270.0	0.187	CANDLES
^{76}Ge	2039.1	7.8	LEGEND
^{82}Se	2997.9	9.2	CUPID-0
^{100}Mo	3034.4	9.6	CUPID-Mo, AMoRE
^{116}Cd	2813.4	7.6	AURORA
^{130}Te	2527.5	34.5	CUORE
^{136}Xe	2458.0	8.9	KamLAND-Zen
^{150}Nd	3371.4	5.6	NEMO-3

Bolometer, Scintillation, Ionization

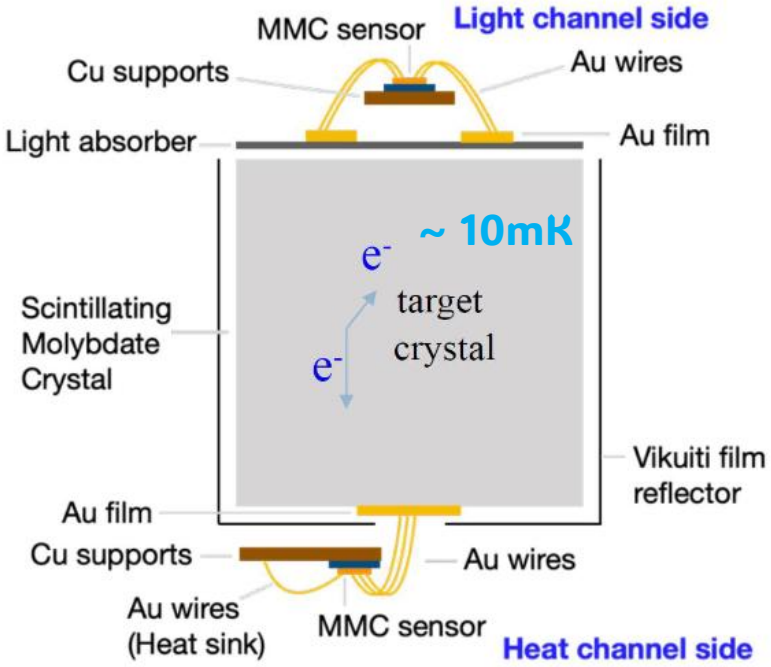


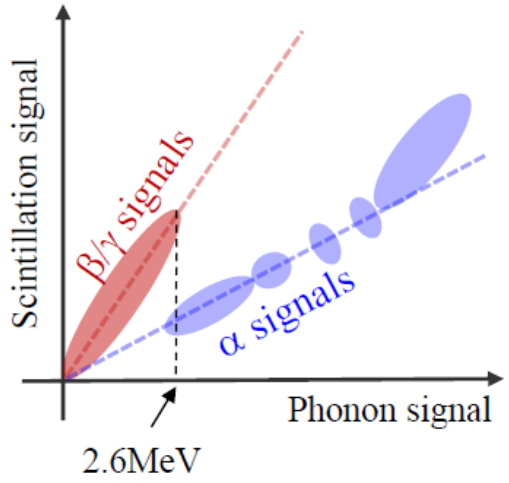
- Scintillating crystals (Li_2MoO_4, $CaMoO_4$, etc)
- High Q-value (3.034 MeV), placing the signal above most natural gamma ray background.
- Favorable predicted $0\nu\beta\beta$ decay rate, depending on the assumed decay mechanism and nuclear matrix elements.
- High natural isotopic abundance (9.7%).

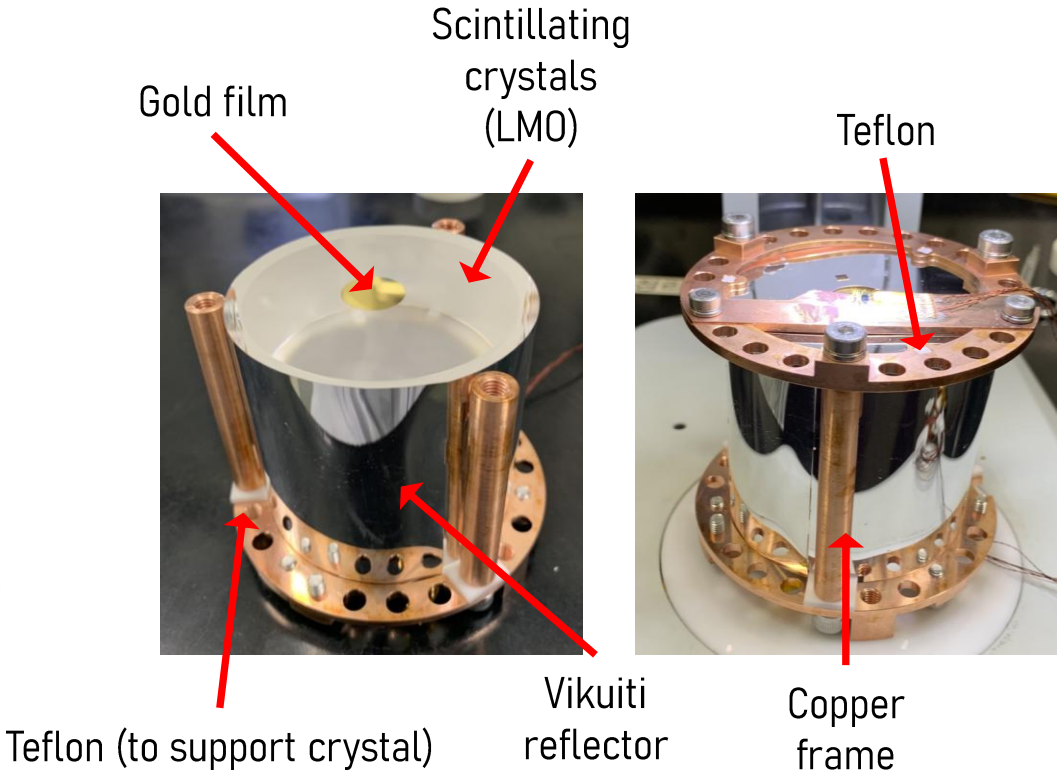
AMoRE Detector

: Measuring energy in Mo-based scintillating crystal at low temperature

$Energy \rightarrow Temperature$







- MMC (Metallic Magnetic Calorimeter) + SQUID (Superconducting QUantum Interference Device)
- Surface alphas are continuous in energy and can be rejected by scintillation measurement.

AMoRE Projects

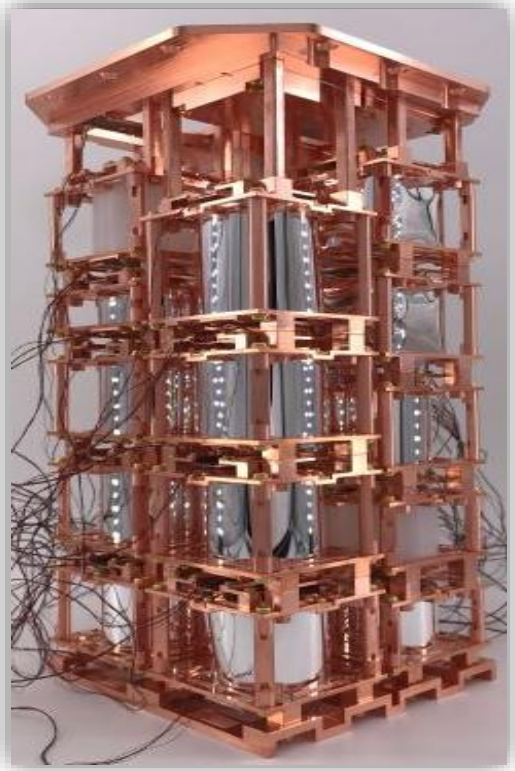
AMoRE-pilot (2015-2018)



- $^{48depl}Ca^{100}MoO_4$: 6 crystals 1.9 kg (0.9 kg ^{100}Mo)
- Yangyang Underground Lab (Y2L, 700m depth)
- Exposure time ~ 0.32 kg · year
- Background at ROI: ~ 0.5 counts/keV/kg/year
- $T_{1/2}^{0\nu} \geq 3.0\times10^{23}$ years at 90% C.L.

(Astroparticle Physics (2024), 102991)

AMoRE-I (2020-2023)



- 13 $^{48depl}Ca^{100}MoO_4$ + 5 $LI_2{}^{100}MoO_4$ crystals 6.2 kg (3.0 kg ^{100}Mo)
- Yangyang Underground Lab (Y2L, 700m depth)
- Exposure time: 3.89 kg_{100Mo} · year
- Background at ROI: 0.025 ± 0.002 counts/keV/kg/year
- $T_{1/2}^{0\nu} > 3.0\times10^{24}$ years at 90% C.L.

(Phys. Rev. Lett., 134, 082501 (2025))

AMoRE-II: stage-1 & stage-2



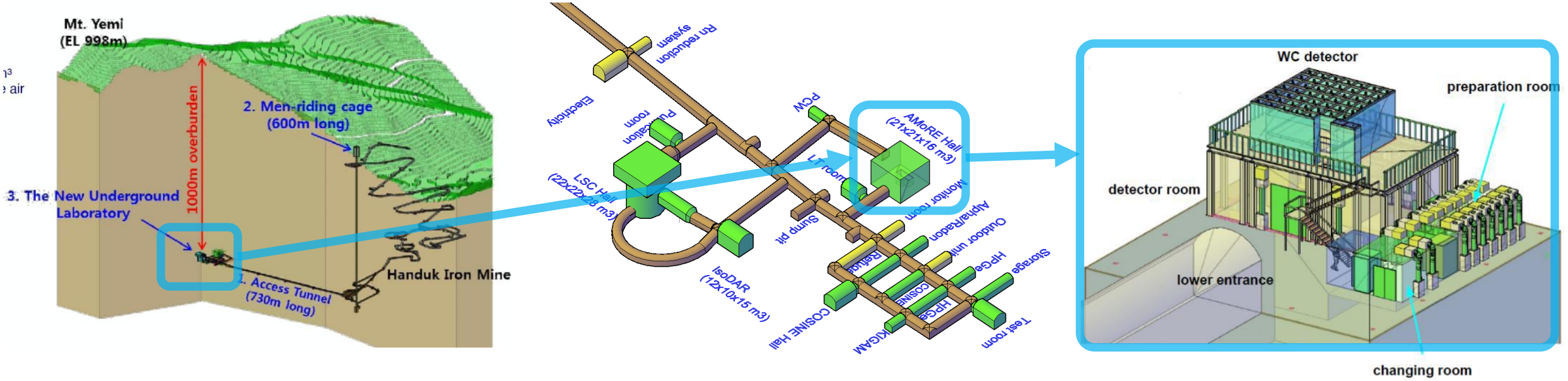
	Stage-1	Stage-2
Crystals	90 $Li_2{}^{100}MoO_4$	360 $Li_2{}^{100}MoO_4$ + $Ca^{100}MoO_4$
# of Tower	10 towers	40 towers
Crystal mass	28.8 kg	~ 160 kg
^{100}Mo mass	~15 kg	~ 86kg
# of Channel	180	720
Data taking date	From 2027	From 2028
location	Yemilab at jeongseon	
Goal of background at ROI	~ 10^{-4} Counts/keV/kg/year	

- **Status of Stage-1 tower assembly :**
  - ✓ Design and machining completed.
  - ✓ Tower parts cleaning done and detector plate was annealed.
  - ➢ Acid cleaning of the Tower plate are on going.

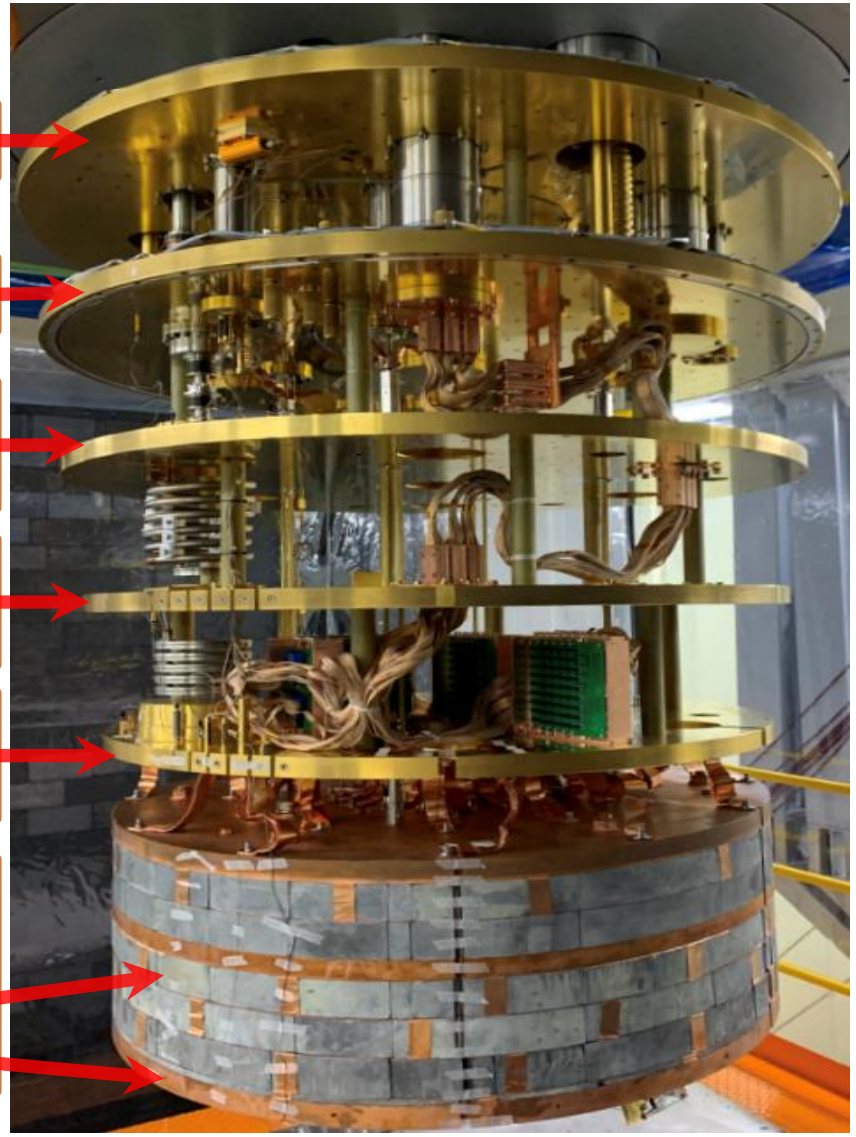
AMoRE-II in Yemilab

- New underground laboratory of Center for Underground Physics, IBS in Jeongseon, South Korea.
- Lab area ~3000 m^2 (10 times bigger than previous lab space, Y2L)
- Randon level at AMoRE hall < 150 Bq/m^3
- 1000 m vertical depth and over 3000 m^2 lab space





AMoRE-II dilution refrigerator

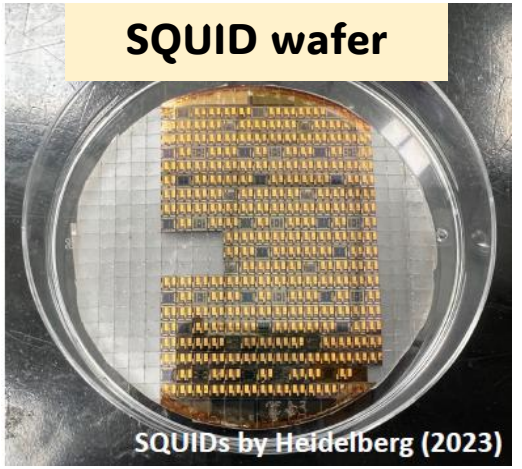


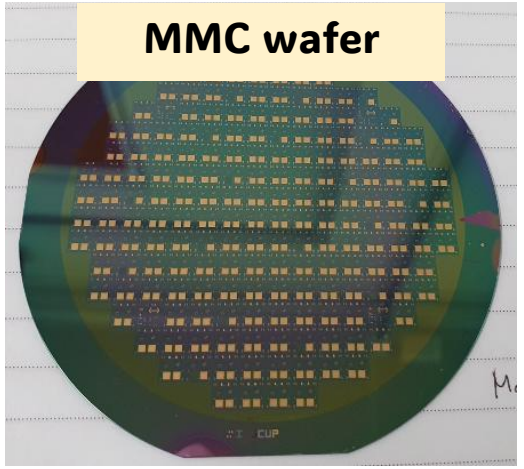
- Large dilution refrigerator from Leiden.
  - With Three Pulse Tube Refrigerators
  - Cooling power: 5 μW @ 10 mK (w/o wiring), ~ 2.7 μW @ 8 mK (w/ wiring)
  - Base temperature at H.Q (measured) : 6 mK (w/o wiring), 7 mK (w/ wiring)
  - Base temperature with LTS (Low temperature shield) : ~ 12 mK
- Including vibration damping systems.
- Cabling: 27 wires x 360 detectors.
- Several DR Performance tests are ongoing.

Detector preparation

- Sensor
  - MMCs: produced by IBS-CUP, SQUIDs: from PTB and Heidelberg University
  - 152 of 180 sensors (MMC + SQUID) passed testing
- Crystals (NIIC, CUP)
  - 318 crystals (315.4 kg) stored at CUP
  - All 366 crystals expected to be ready by early 2027
- Assembly
  - Detector assembly underway at Yemilab with a radon reduction system
- Storage
  - Maintain humidity below 1% during storage



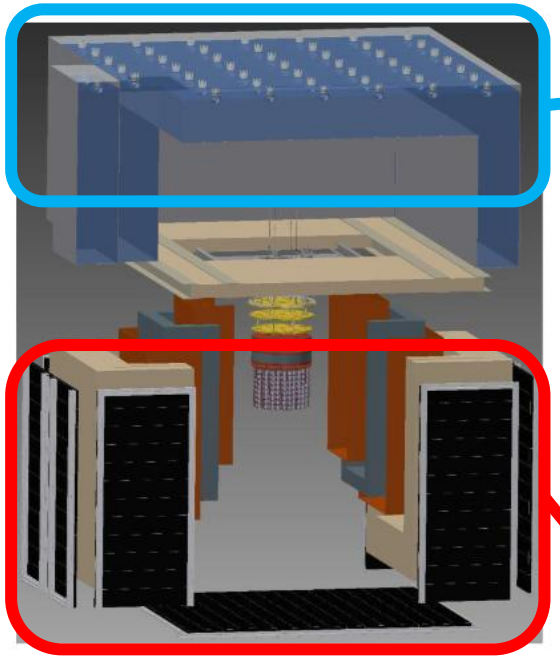


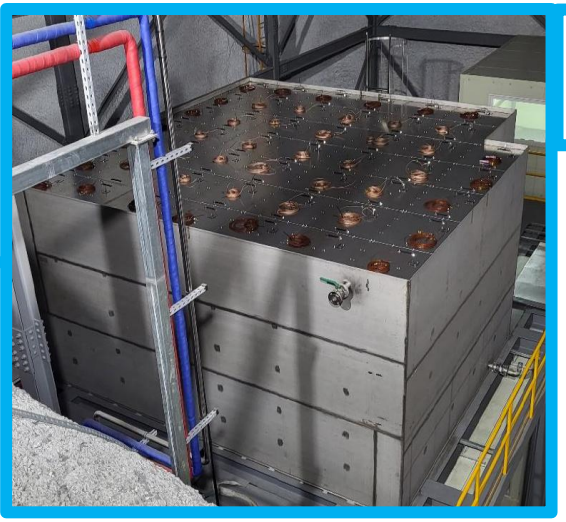


Muon veto detector system

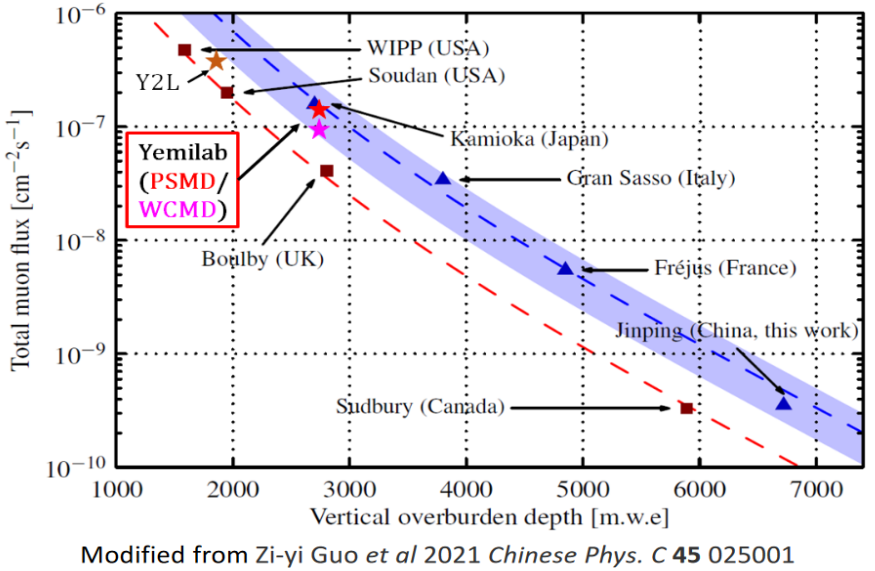
: Water Cherenkov detector + plastic scintillator detector combination

Water Cherenkov Muon Detectors (WCMD)





- Installed with 48 ea. 10-inch waterproof PMTs
- ~ 60 tonne of water



Modified from Zi-yi Guo *et al* 2021 *Chinese Phys. C* **45** 025001

- muon flux: $(1.01 \pm 0.01 \pm 0.12)\ 10^{-7}\ cm^{-2}\ s^{-1}$

Plastic Scintillator Muon Detector (PSMD) *(NIMA, 2022.167123)*

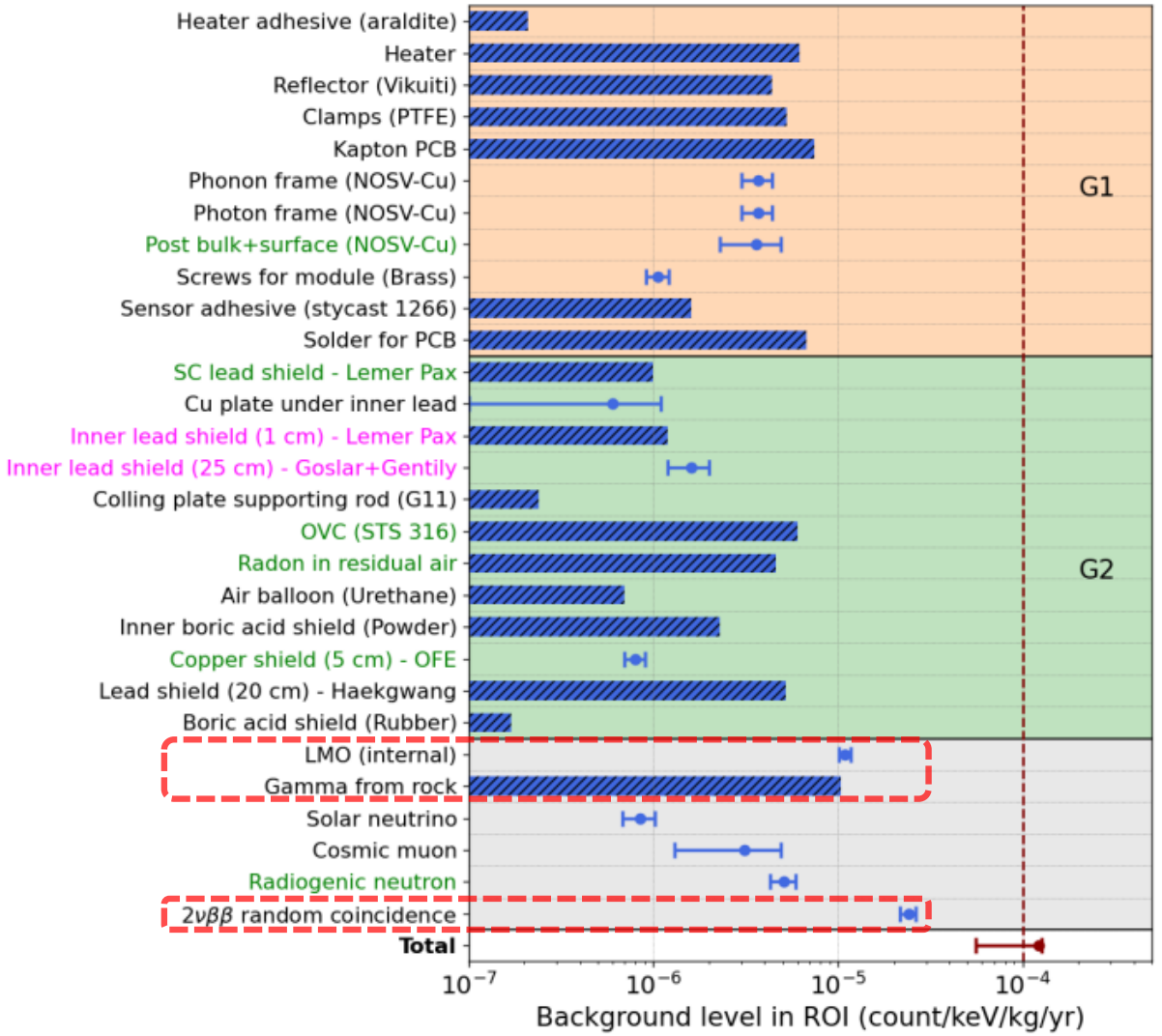


- Total 130 boxes.
- One box: 2 PS panels + wavelength-shifting fiber + 4 SiPMs

AMoRE-II Expected Background

- Expected Background in $0\nu\beta\beta$ ROI : **~ 10^{-4} ckky** (counts/kg/keV/yrs)

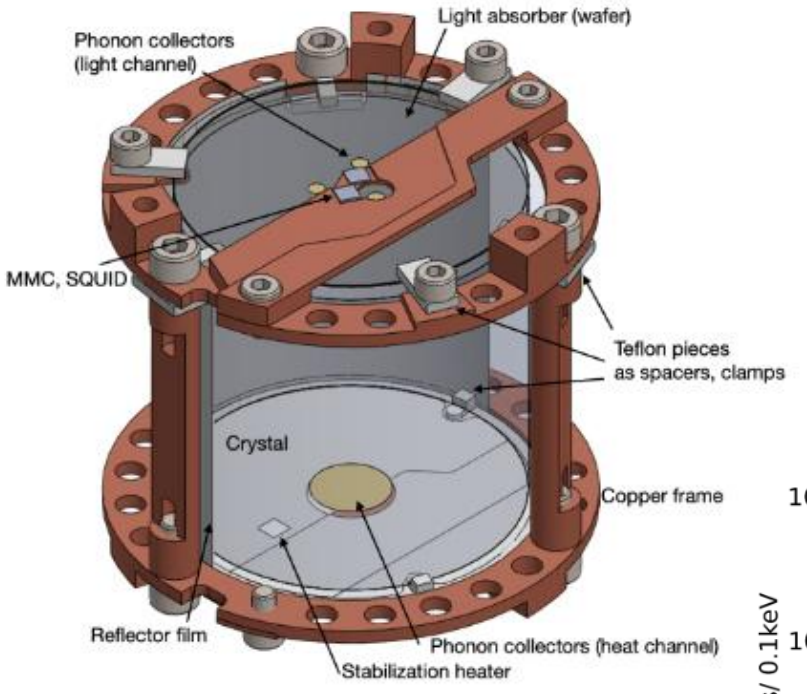
- **Main Background**
  - LMO internal: measured by AMoRE-I $Li_2{}^{100}MoO_4$ crystal
  - Gamma background from rock
  - $2\nu\beta\beta$ random coincidence: To reducing through various ways such as utilizing a light detector (Neganov-Luke light detector etc), machine learning and improvement heat channel,



R&D experiment for AMoRE-II

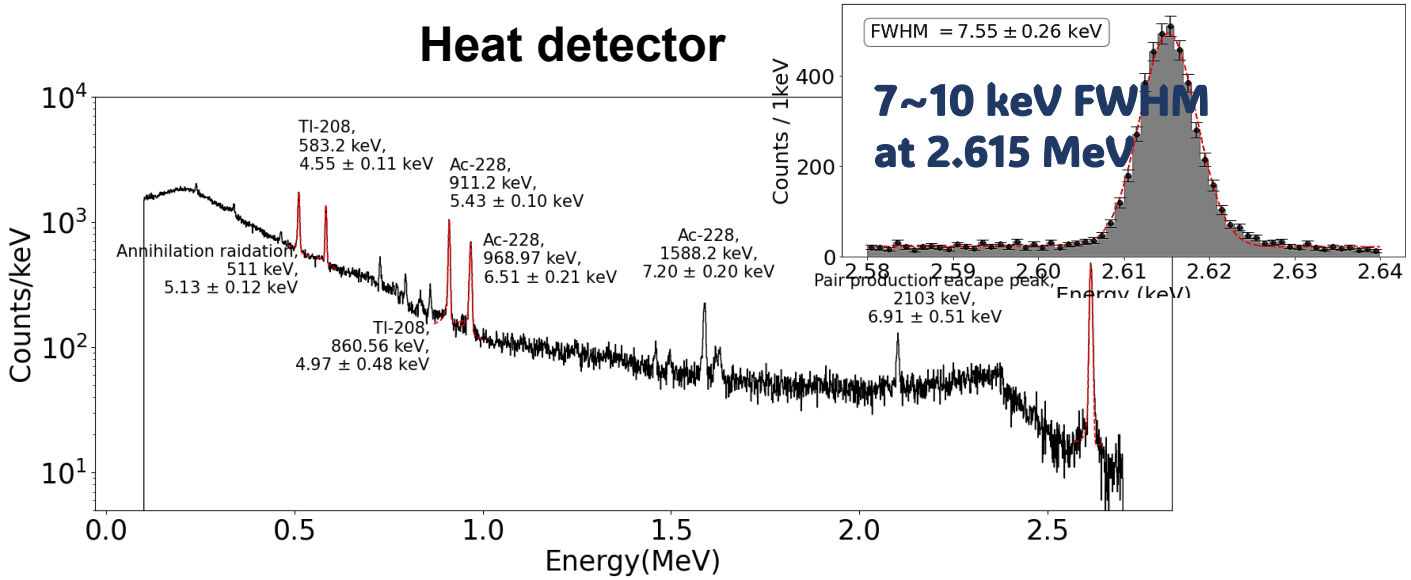
: Reaching FWHM < 10 keV at 3.034 MeV & Improving light detector performance

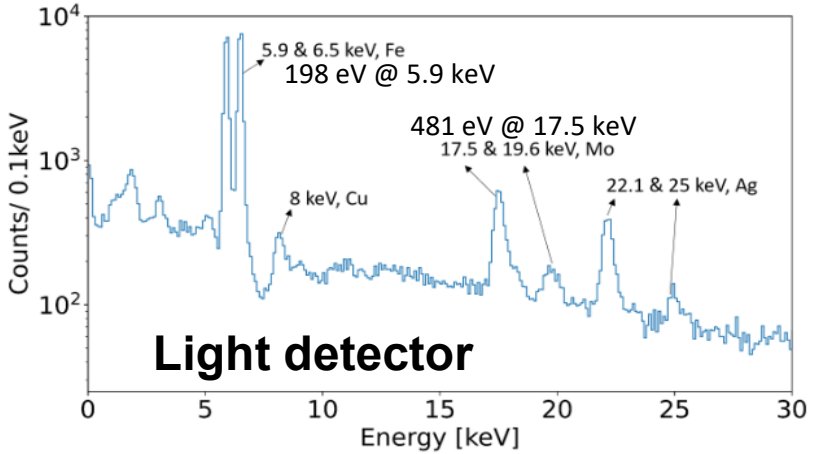
AMoRE-II detector design

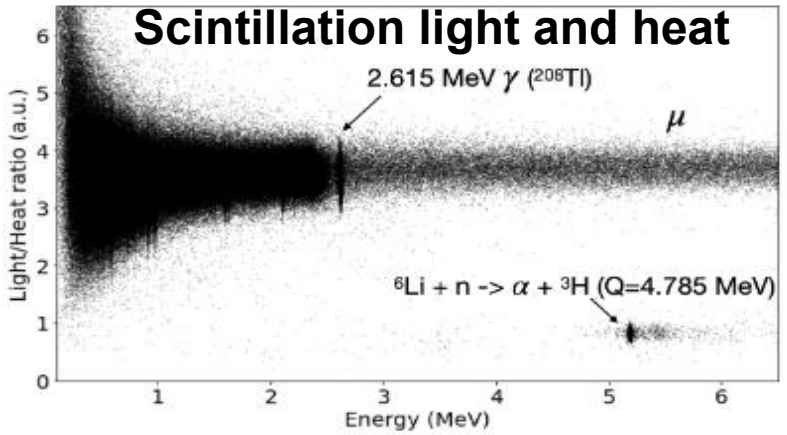


- ✓ Optimized detector design
- ✓ Crystal surface condition (polished, diffusive)
- ✓ Crystal size (5 cm × 5 cm, 6 cm × 6 cm (D × H))

Heat detector



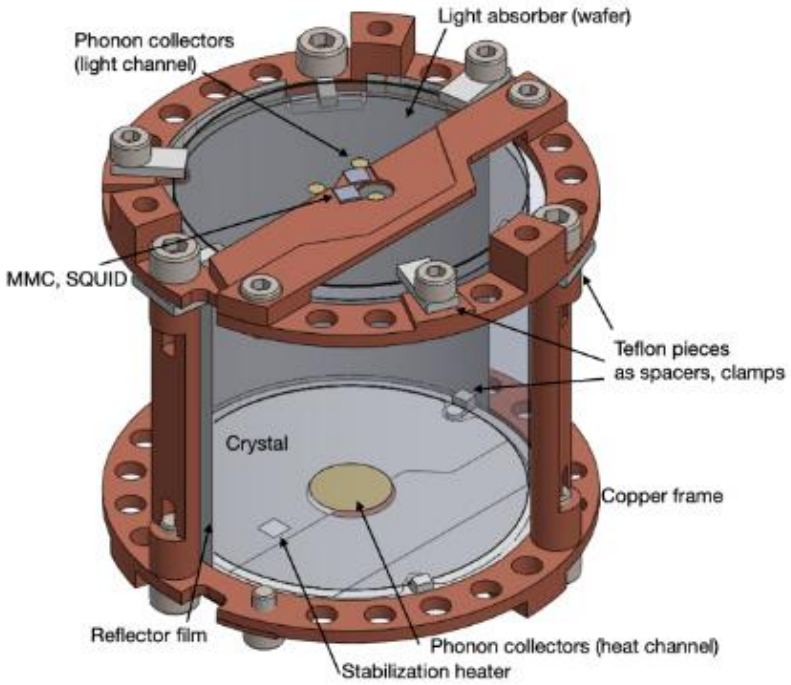




R&D experiment for AMoRE-II

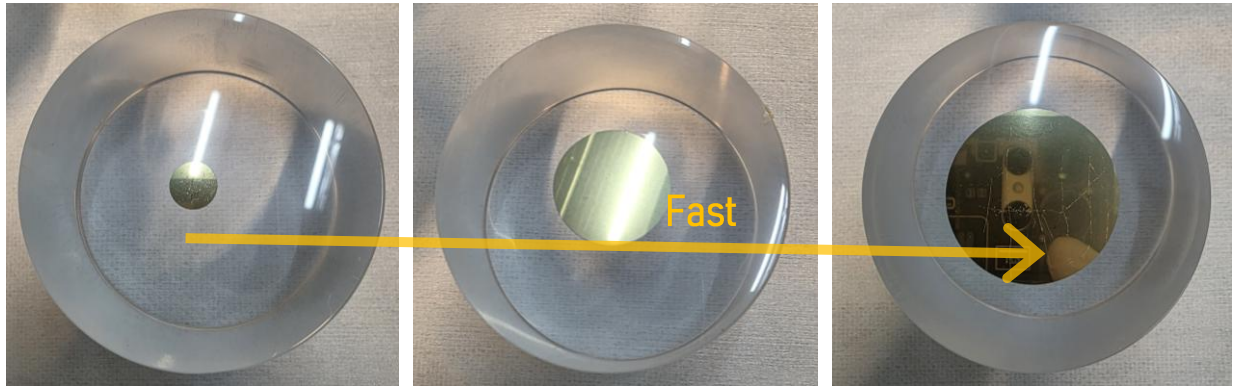
: For Next step, energy resolution and pulse shape

AMoRE-II detector design

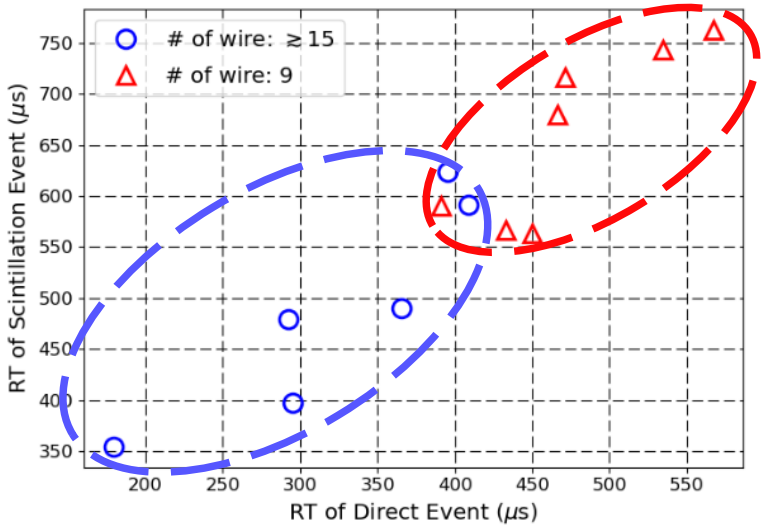


- ✓ Optimized detector design
- ✓ Crystal surface condition (polished, diffusive)
- ✓ Crystal size (5 cm × 5 cm, 6 cm × 6 cm (D × H))

Pulse shape depend on the size of phonon collector

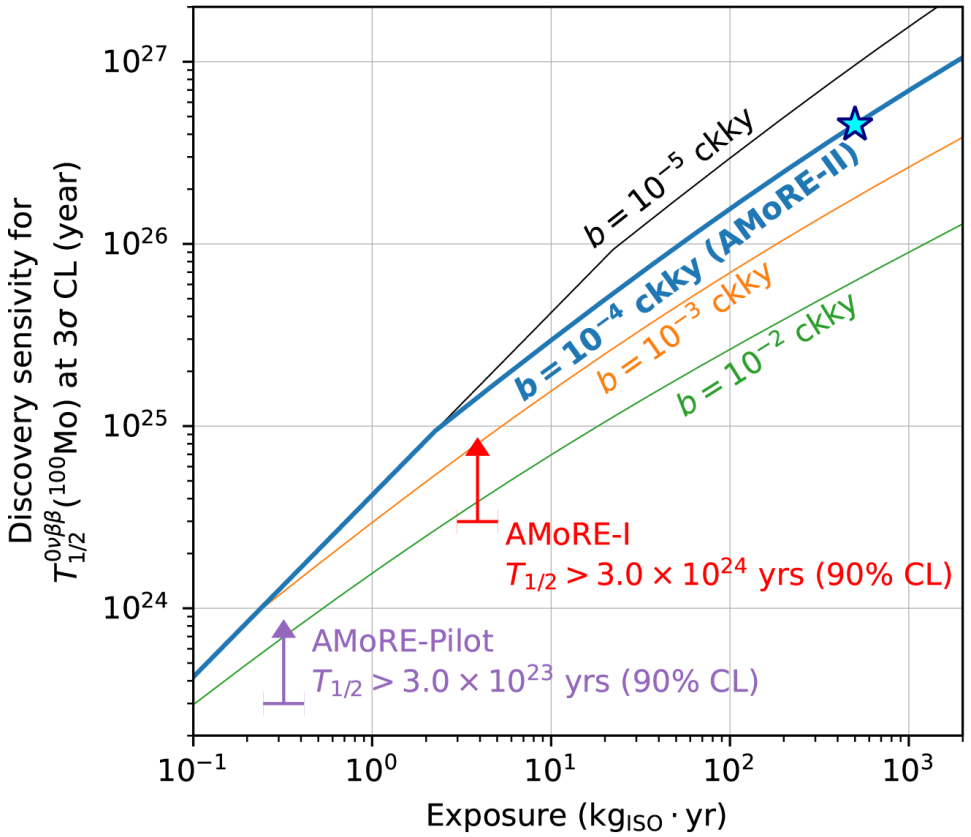


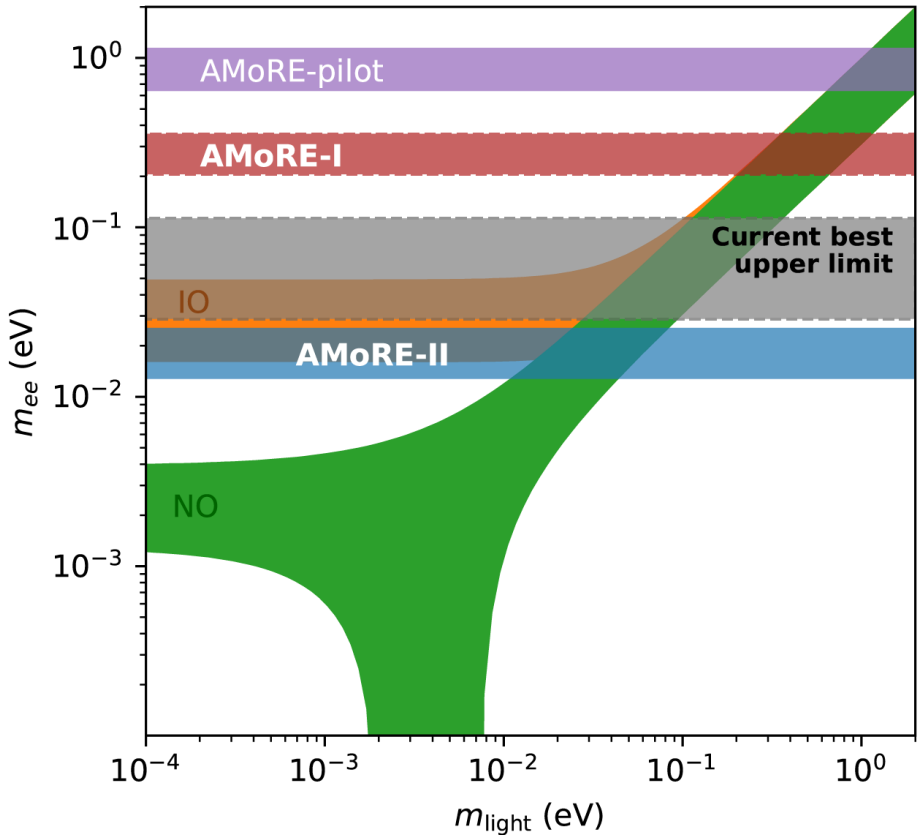
Light Detector



Optimization of heat detector phonon collector size and investigation of light detector signal response as a function of wire count are underway.

Sensitivity of AMoRE-II

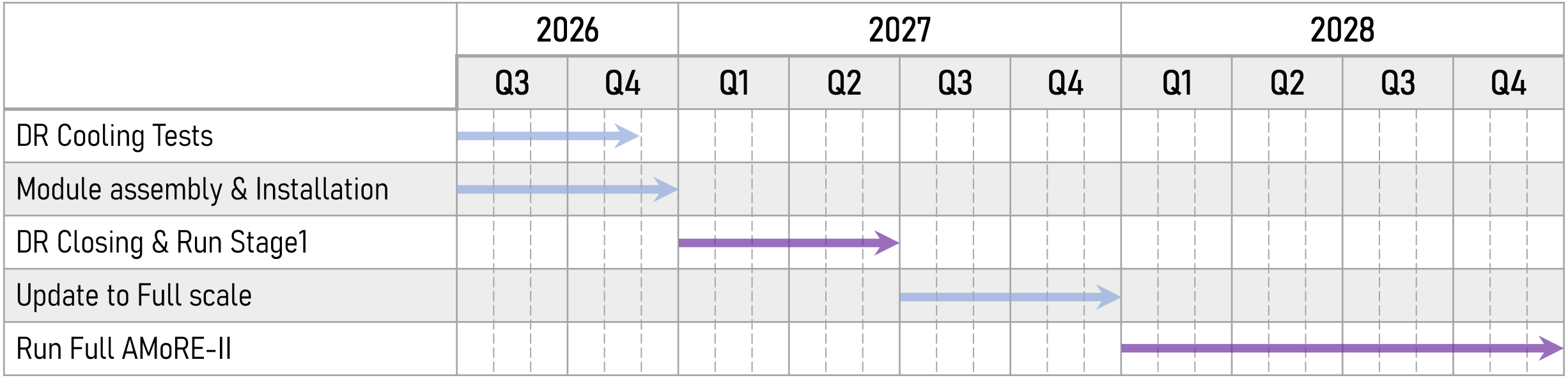




(By KamLAND-Zen Phys. Rev. Lett. 130 (2023) 051801)

- $T_{1/2}^{0\nu}$ ~ 4.5 x 10^{26} years with ~100 kg of ^{100}Mo with 5 years exposure with background level < 10^{-4} counts/keV/kg/year

Schedule and Summary



~12 mK cryostat	90 crystals	~ 85%	366 ea
w/ 3 t LT Shield(Pb)	Ready for Stage-1	Detectors assembled	Grown by NIIC, CUP



Thank you