Towards AMoRE-II : Neutrinoless double-beta decay search with 100 kg of ^{100}Mo

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On behalf of the AMoRE collaboration

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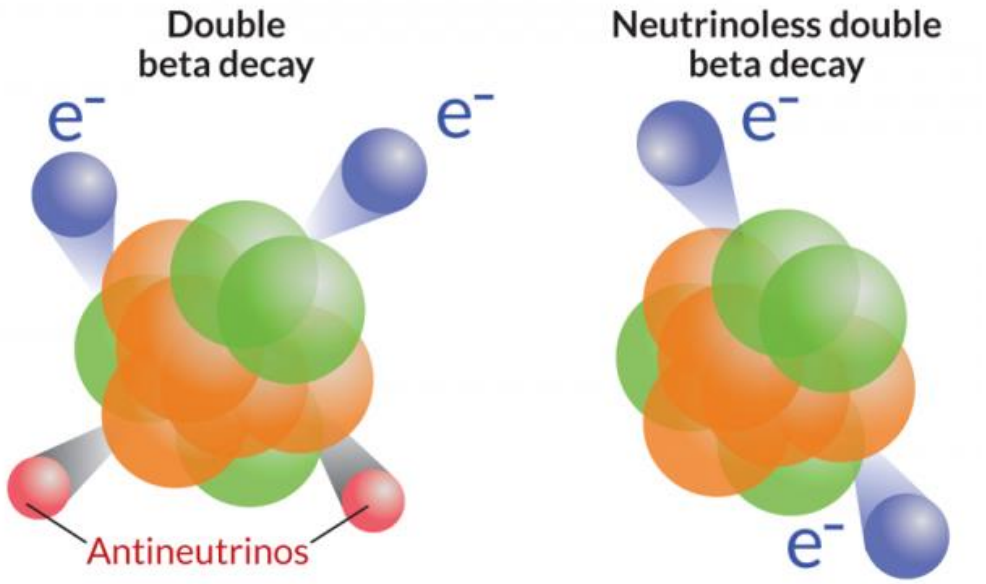
from 18th to 24th July 2024.

AMoRE

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



$(Z, A) \rightarrow (Z+2, A) + 2e^- + 2\bar{\nu}_e$

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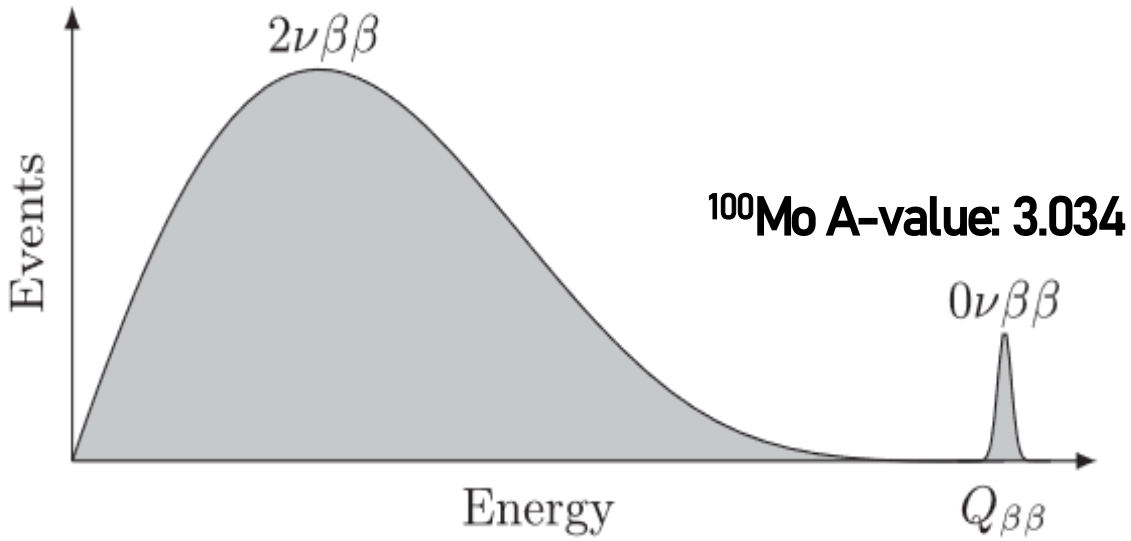


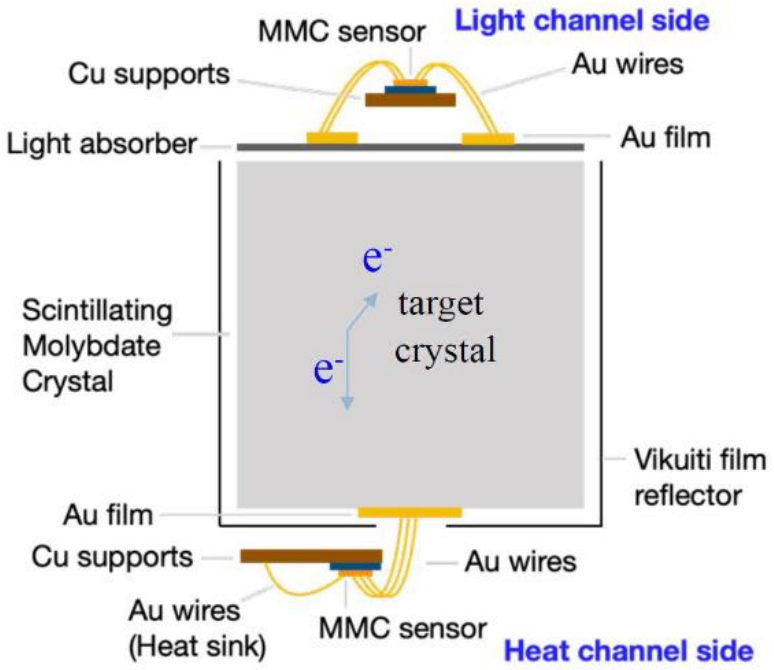
^{100}Mo A-value: 3.034 MeV

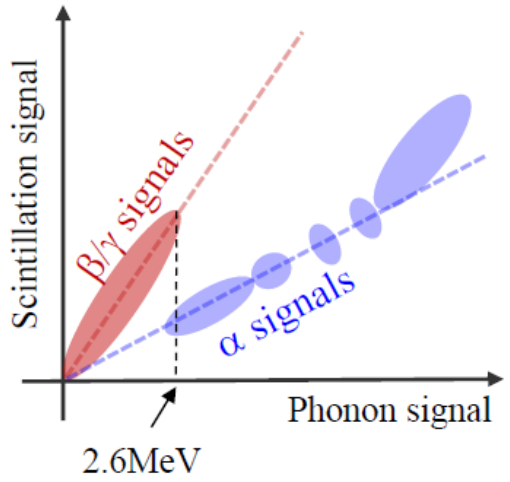
- Lepton-number violation
- The nature of neutrino mass (Dirac or Majorana ??)
- Type of neutrino mass hierarchy (normal or inverted)

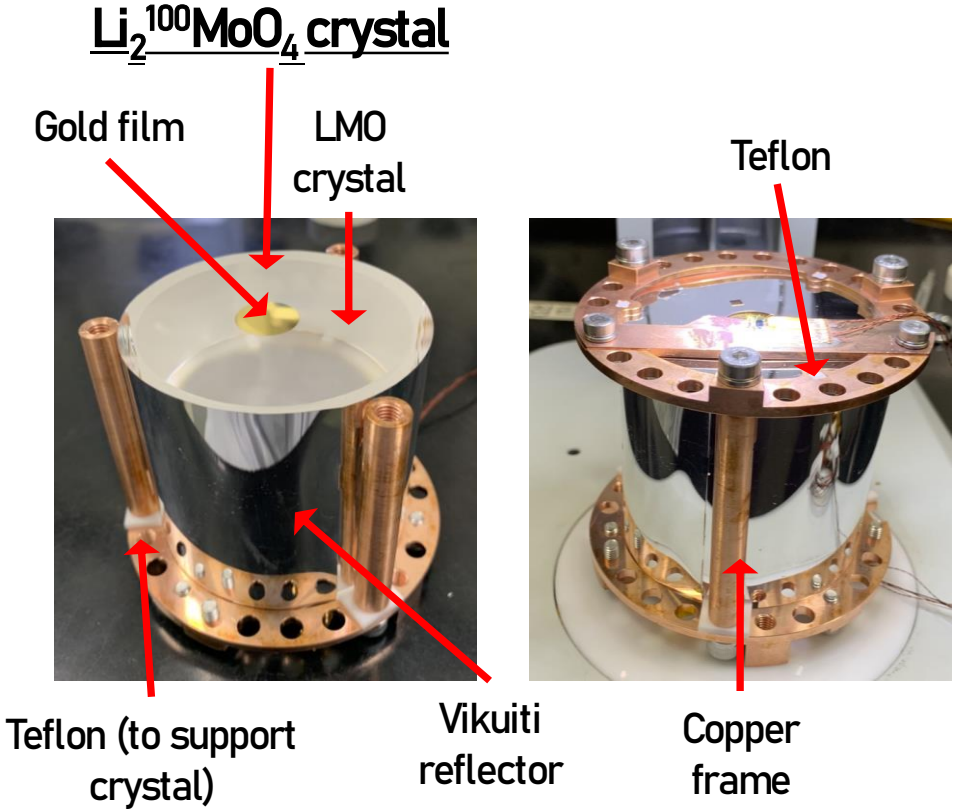
- ^{100}Mo (possible to be a scintillation crystal, e.g. Li_2MoO_4 or $CaMoO_4$)
- higher Q-value (3.034 MeV)
- Relatively short half-life expected from theoretical calculation.
- Relatively high natural abundance (9.7%)

AMoRE detector

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







- Surface alphas are continuous in energy and can be rejected by scintillation measurement with MMC+SQUID sensors.

AMoRE project

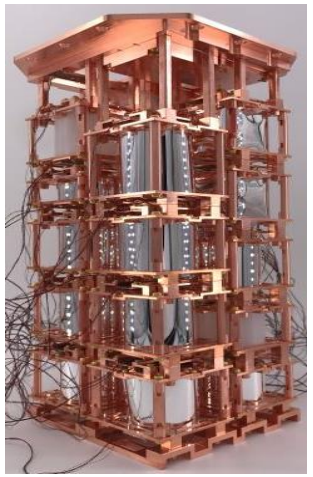
AMoRE-pilot (2015-2018)

- $^{48depl}Ca^{100}MoO_4$: 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
- $T_{1/2}^{0\nu} \geq 3.0 \times 10^{23}$ years at 90% C.L.

(Astroparticle Physics (2024),102991)

AMoRE-I (2020-2023)

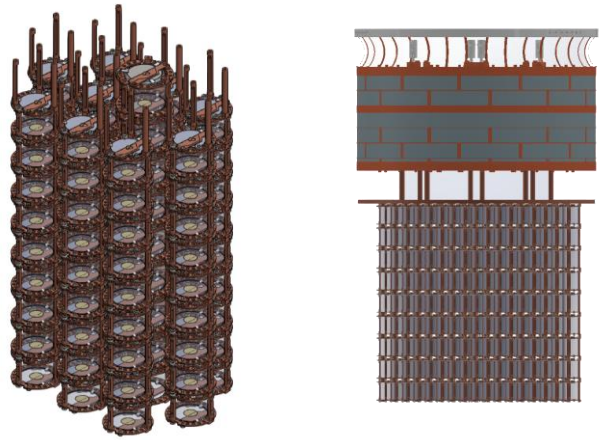


- 13 CMO + 5 $Li_2{}^{100}MoO_4$ crystals 6.2 kg (3.0 kg ^{100}Mo)
- Yangyang Underground Lab (Y2L, 700m depth)

- Exposure time: 3.89 kg_{100Mo} · year
- Background at ROI: 0.025 ± 0.002 counts/keV/kg/year
- $T_{1/2}^{0\nu} > 3.0 \times 10^{24}$ years at 90% C.L.

(arXiv:2407.05618)

AMoRE-II (2024-)

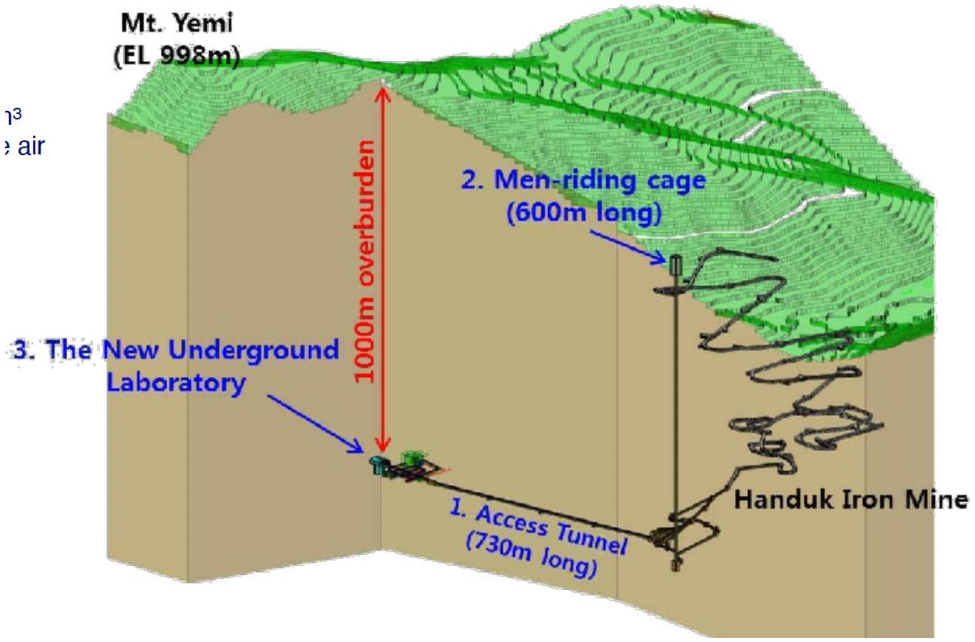


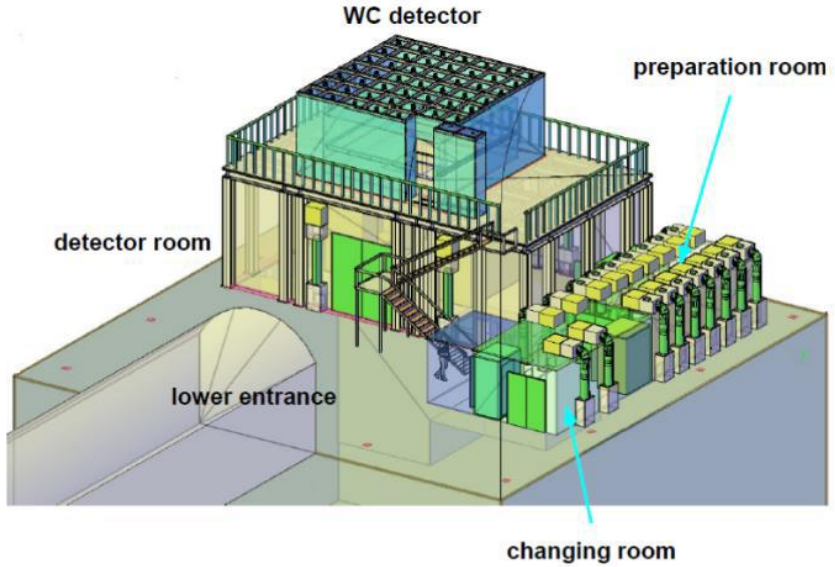
- Stage 1: 90 LMO crystals (~ 29 kg)
- Stage 2: 350 XMO crystals (~ 157 kg)
- ~ 90 kg of ^{100}Mo
- Yemilab (1000m depth)
- Goal of background at ROI: ~ 10^{-4} Counts/keV/kg/year

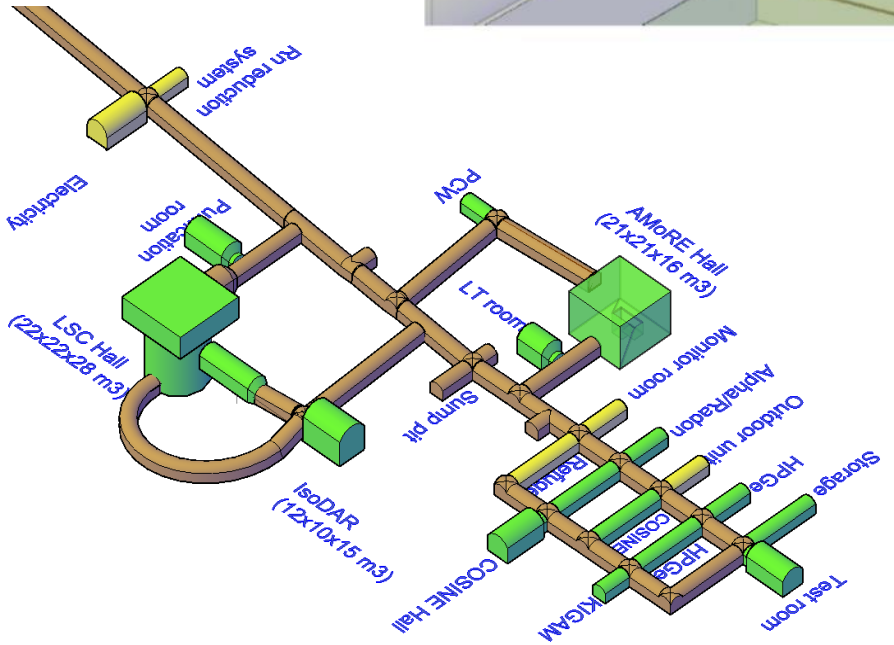
AMoRE-II in Yemilab

- New underground laboratory of Center for Underground Physics, IBS in Jeongseon, South Korea.

- 1000 m vertical depth and over 3000 m^2 lab space







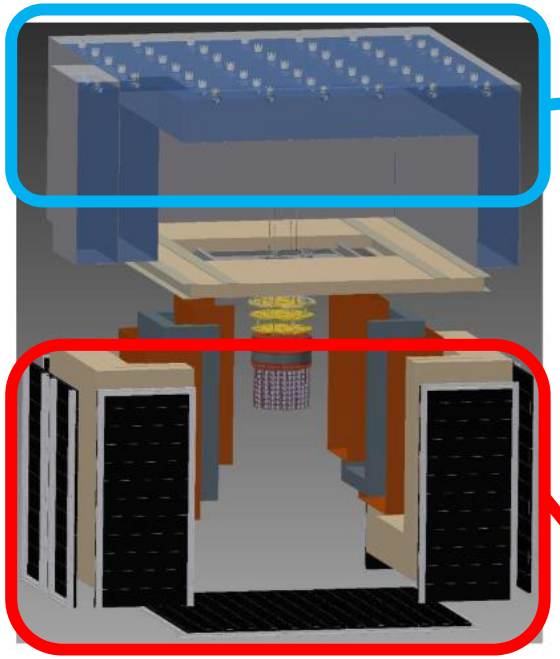
AMoRE-II Dilution Refrigerator

- 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 (measured) : 6 mK (w/o wiring), 8 mK (w/ wiring)
- Including vibration damping systems.
- Cabling: 27 wires x 360 detectors.

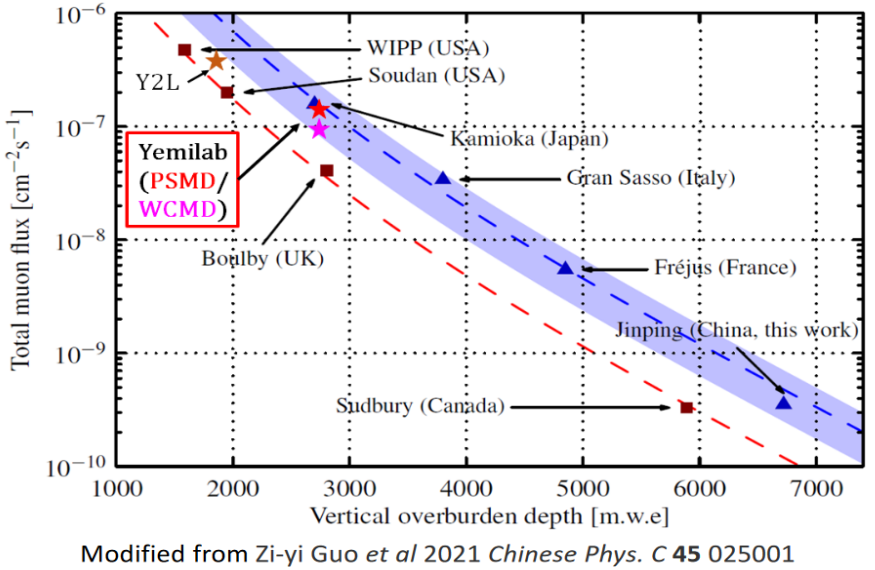
Muon veto detector system

: Water Cherenkov detector + plastic scintillator detector combination

Water Cherenkov Muon Detectors (WCMD)



- Installed with 48 ea. 8- & 10-inch PMT
- ~ 60 tonne of water



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

Preliminary muon flux measurement: ~ 10^{-7} cm^{-2} s^{-1}

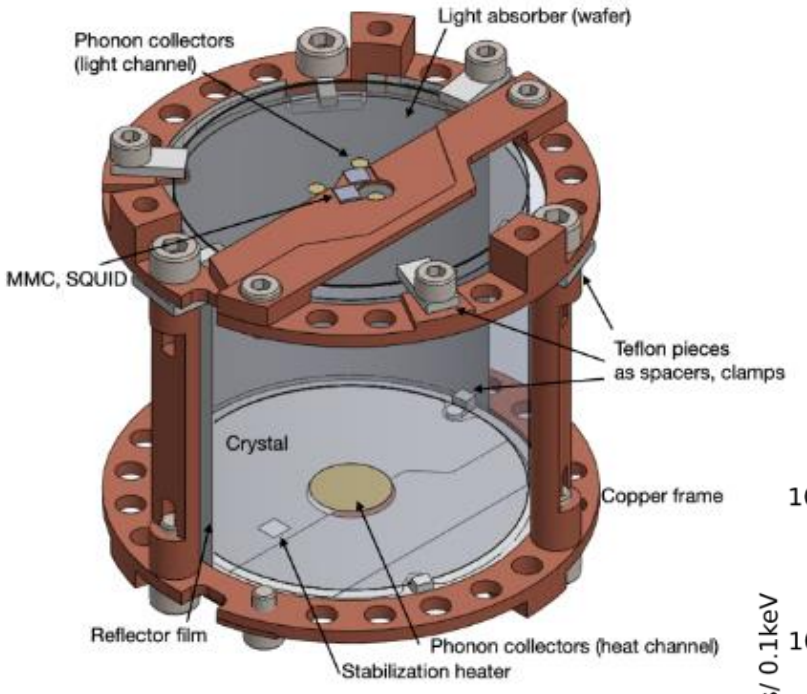
Plastic Scintillator Muon Detector (PSMD) *(NIMA, 2022.167123)*

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

R&D for AMoRE-II

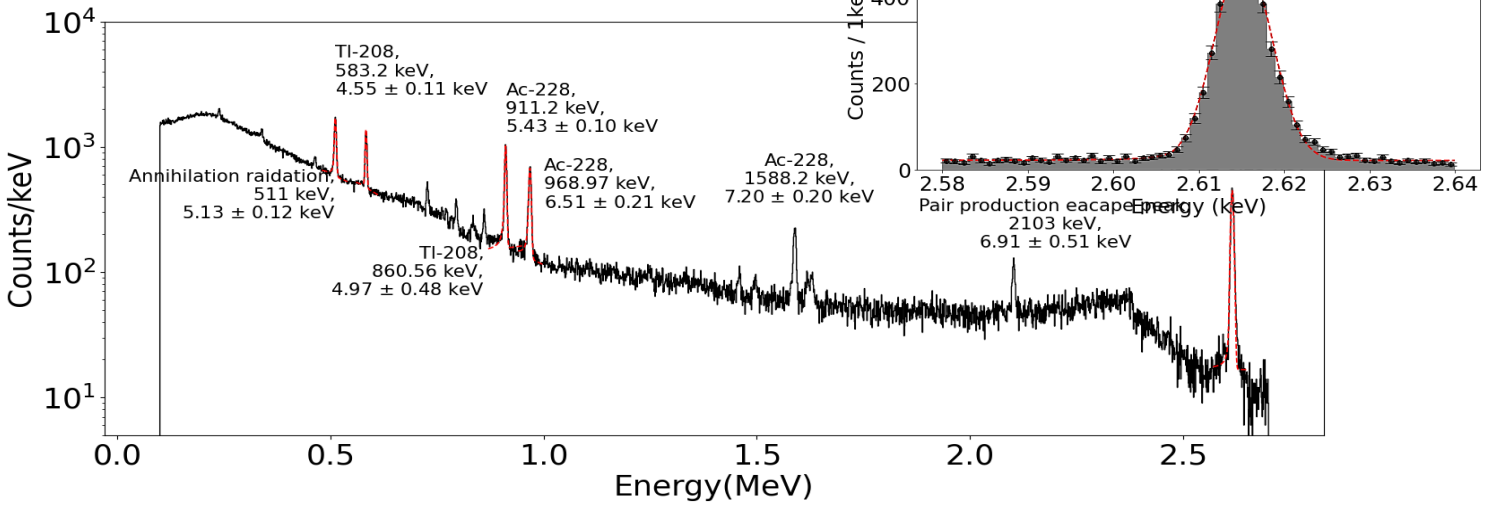
: Reaching FWHM < 10 keV at 3.034 MeV & Improving light detector performance

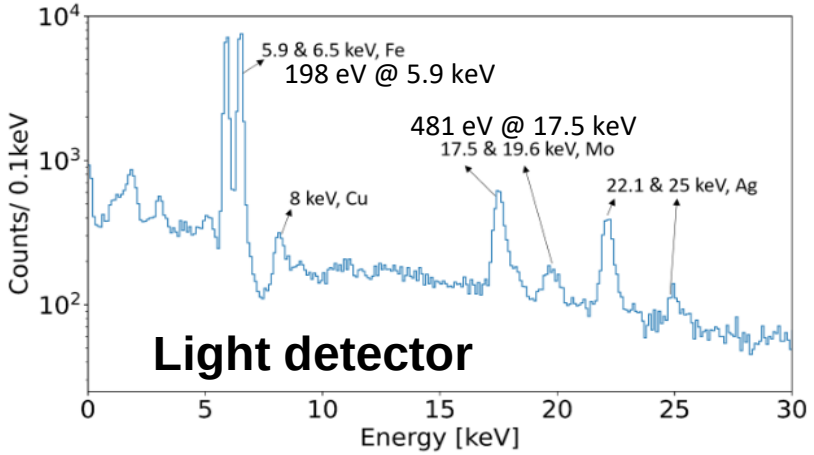
AMoRE-II detector design

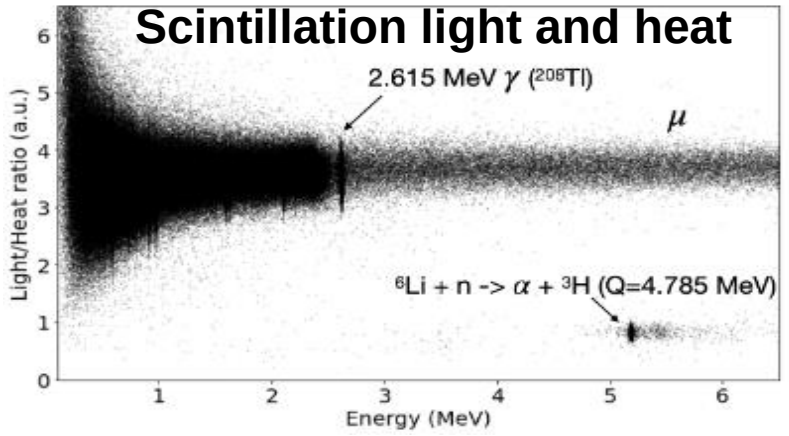


- Optimized detector design
- Crystal surface condition (polished, diffusive)
- Crystal size (5 cm × 5 cm, 6 cm × 6 cm (D × H))

Heat detector

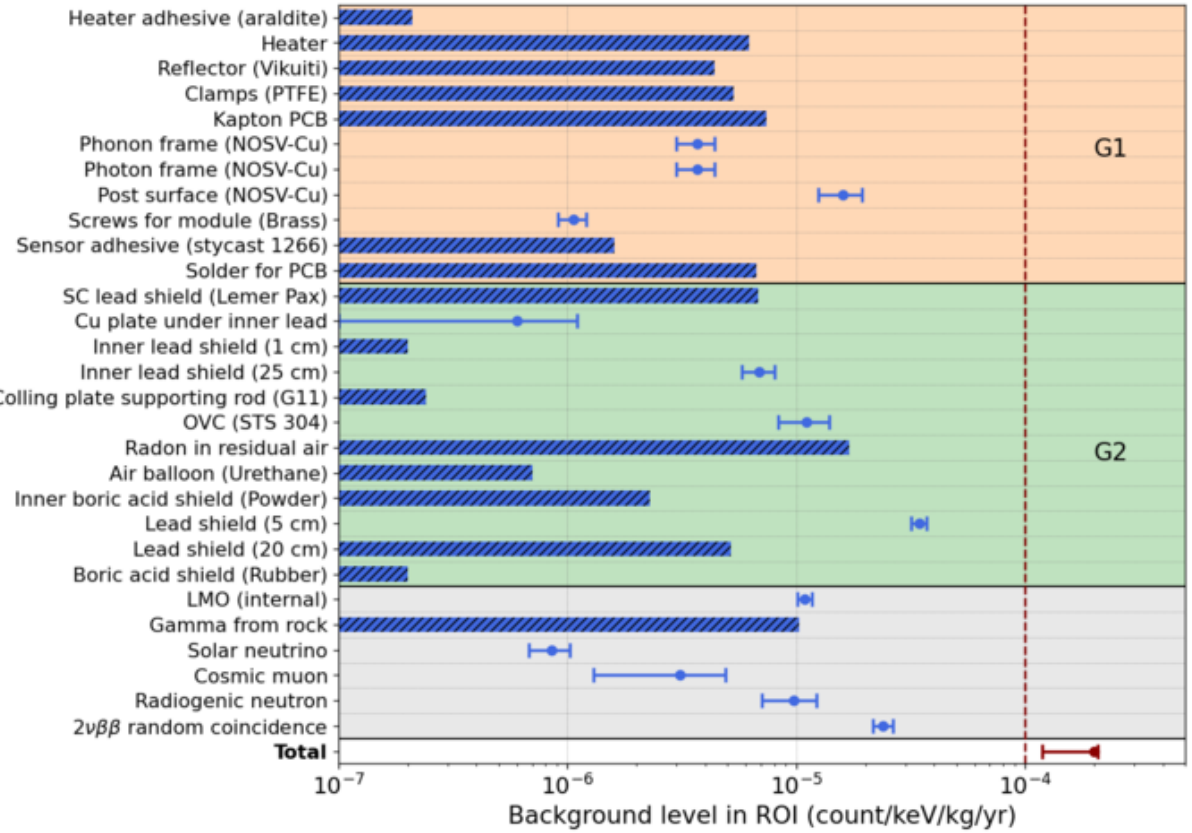


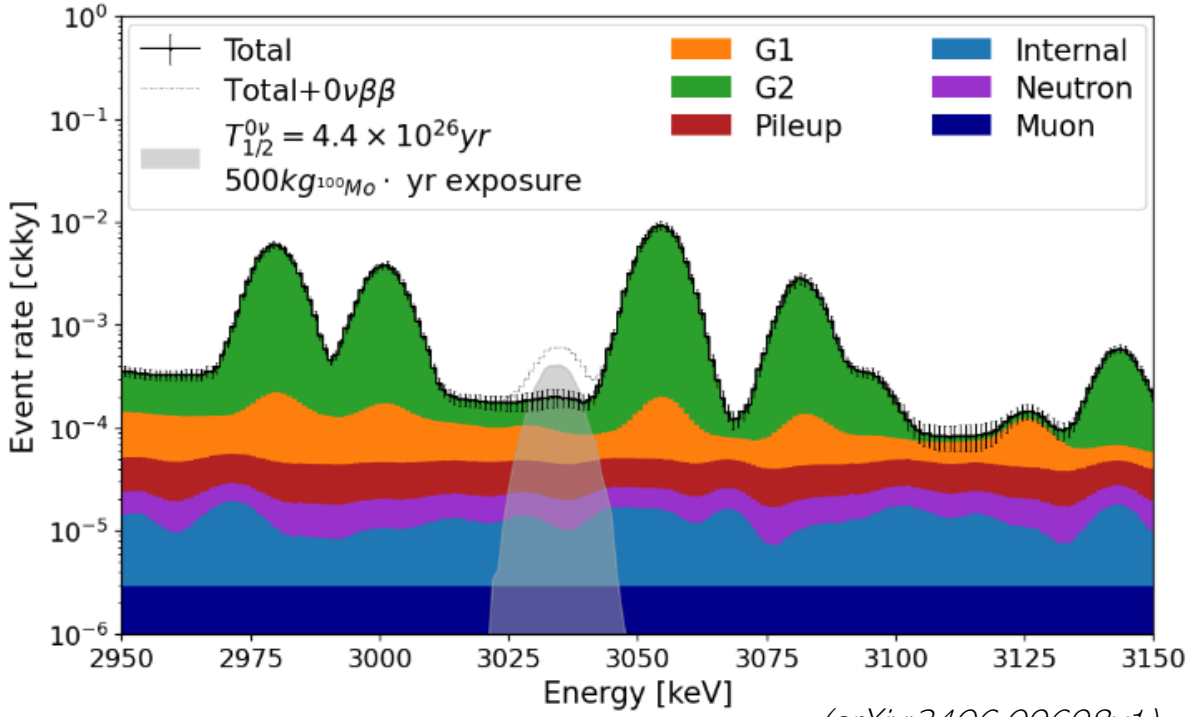




AMoRE-II background simulation study

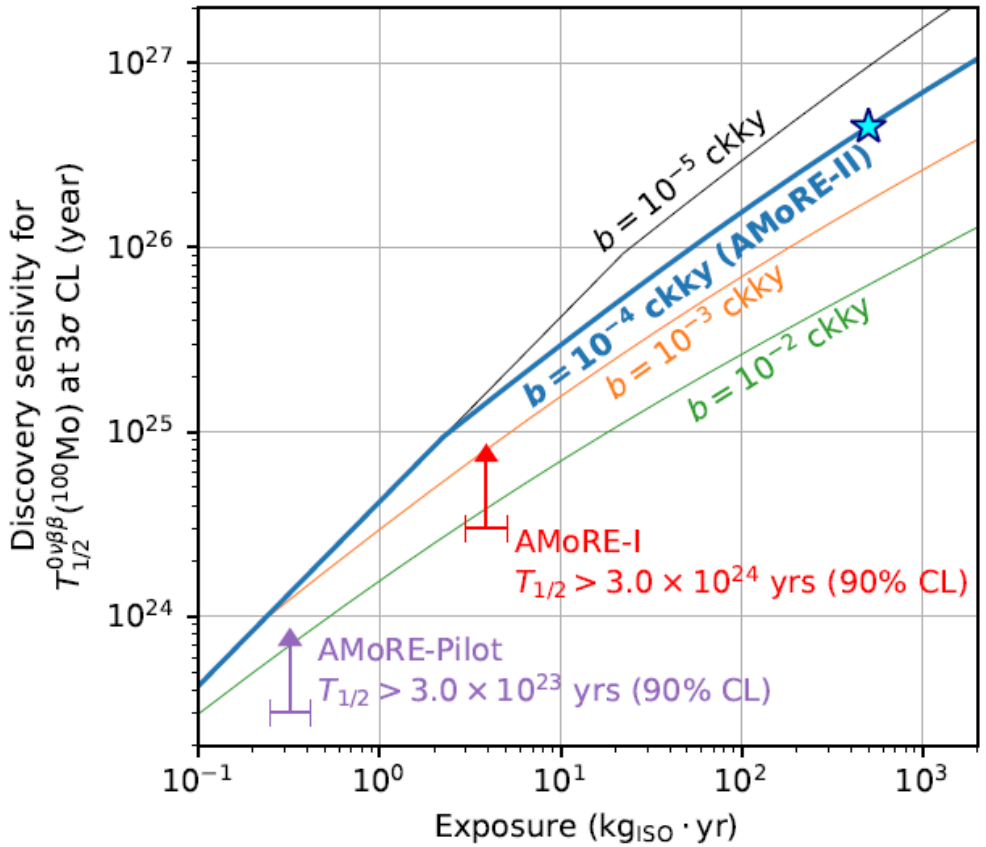
: Background of ~ 10^{-4} counts/keV/kg/year

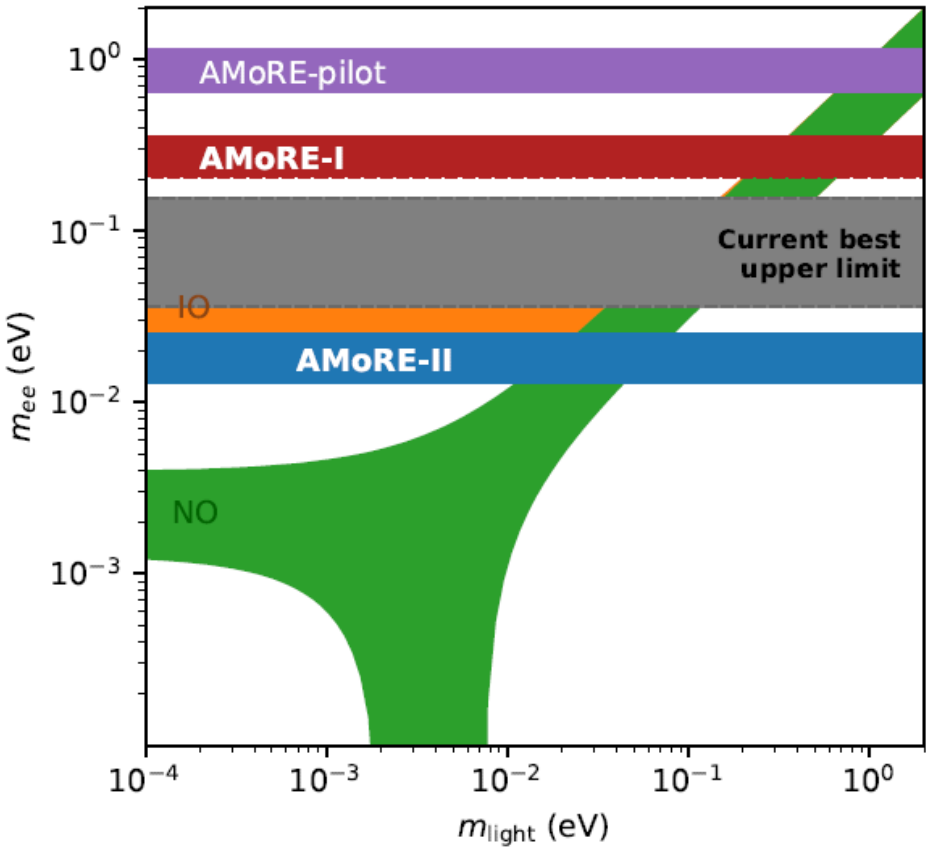




(arXiv:2406.09698v1)

Sensitivity of AMoRE-II





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

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

AMoRE-II will be running soon..

- AMoRE Hall is ready for detectors: Shielding (Pb, boric-acid, PE), Muon veto system(WCMDs, PSMDs), Cryostat, DAQ room

- Detector preparation room in operation: Class 100 clean room, Rn-free air, humidity control

- Assembling the detector modules are in progress.