The AMoRE Project
(Advanced Mo based Rare process Experiment)

NEUTRINO 2014

The AMoRE (Advanced Mo based Rare process Experiment) project is an international experiment to search for neutrinoless double beta decay of ^{100}Mo using cryogenic scintillating crystals. The detector is composed of $^{40}Ca^{100}MoO_4$ crystals (depleted in ^{48}Ca and enriched in ^{100}Mo) and metallic magnetic calorimeters as the target and sensor materials in the concept of source equal to detector. It is scheduled to build a large scale experiment with 200 kg $^{40}Ca^{100}MoO_4$ crystals in next 8 years. The effective Majorana neutrino mass for the proposed experiment is estimated to be 0.02-0.05 eV. An overview of current status is presented.

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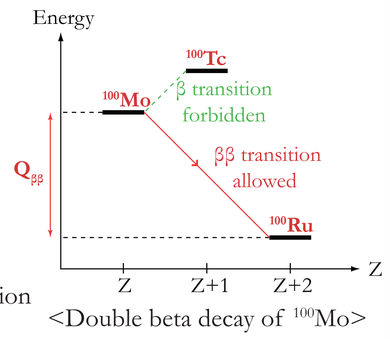
KyungPook National University, Daegu, Korea
Sejong University, Seoul, Korea
Seoul National University, Seoul, Korea
Ewha Womans University, Seoul, Korea
Chung-Ang University, Semyung University, Soongsil University, Korea
Institute for Theoretical and Experimental Physics, Moscow, Russia
JSC Fomos-Materials, Moscow, Russia
Baksan National Observatory, Kabardino-Balkarskaya Republic, Russia
Institute for Nuclear Research, Kyiv, Ukraine
Kirchhoff-Institute for Physics, Heidelberg University, Heidelberg, Germany
Tsinghua University, Beijing, China
Nakhon Rajabhat University, Thailand
Abdul Wali Khan University, Pakistan

Project overview

- Investigation of neutrinoless double beta decay of ^{100}Mo isotope:
  - ββ isotope can be produced in 10~100 kg scale (by centrifuges, in Russia and Netherlands)
  - Q = 3034 keV
  - $T_{1/2}(2\nu) = 7.1 \times 10^{18}$ years: requires high energy resolution. Fast rise time may reduce possible background from random coincidence signals.
  - Relatively short $T_{1/2}(0\nu)$ half life expected from theoretical calculation



<Double beta decay of ^{100}Mo>

- Possible dark matter search

$CaMoO_4$ crystals in cryogenic detection

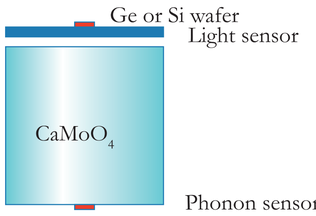
- Cryogenic scintillation detector based on $CaMoO_4$ single crystal
  - CaMoO4 sheelite-type self-activated scintillator
  - Melting temperature: 1445 ˚C (requires Pt or Ir crucibles)
  - Crystal growth technology: Chochralsky method

- Scintillation properties
  - Light yield (Low temp.): up to 30,000 photon/MeV, Largest light yield among Mo contained crystals
  - Emission peak at 9 K: 540 nm
  - Kinetics of scintillation light (main component): τ= 16 μs(300 K), 345 μs(6 K)
  - Transparency: 0.01 cm^{-1} at 520 nm

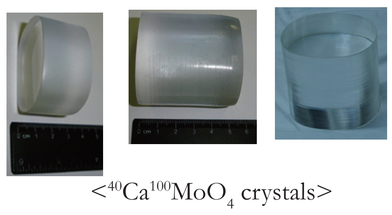
- Debye temperature: 438 K

$^{40}Ca^{100}MoO_4$ crystals

- ^{100}Mo Enrichment
  - High content of working isotope (Mo) in compound
  - Mo-100 isotope production:
    ECP (Electrochemical plant) Zelenogorsk, Russia
    URENCO, Almelo, Netherlands



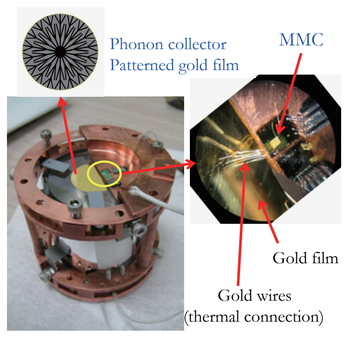
- ^{48}Ca Depletion
  - Minimize interference with 2νββ signals of ^{48}Ca
  - Ca-40 isotope production:
    ELEKTROCHIMPRIBOR, Lesnoy, Russia


<$^{40}Ca^{100}MoO_4$ crystals>

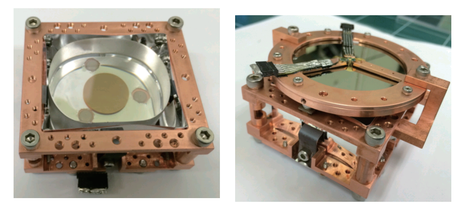
- $^{40}Ca^{100}MoO4$ single crystals grown by FOMOS materials

Low temperature experiment

(Details available at Poster 170)

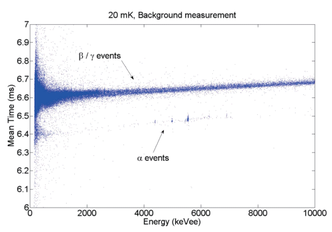


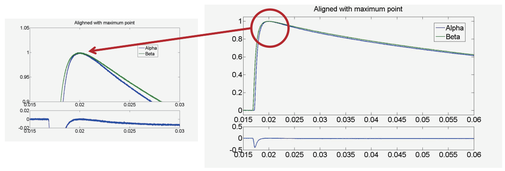
<216 g Natureal $CaMoO_4$ >


<196 g $^{40}Ca^{100}MoO_4$ >

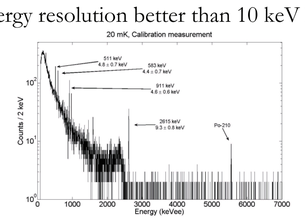
"Over-ground Measurement"

PSD with phonon sensor only

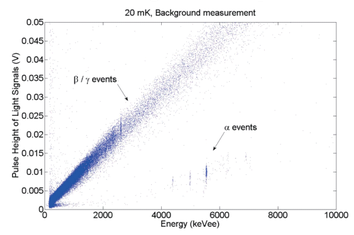




Energy resolution better than 10 keV FWHM



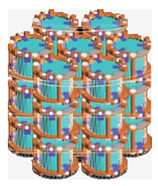
Phonon/Light Ratio Separatoin

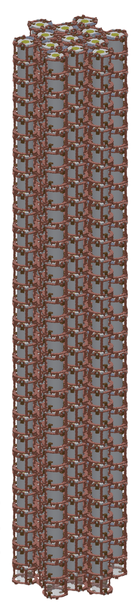


Prospect for the large scale project

Crystal: $^{40}Ca^{100}MoO_4$, doubly enriched scintillating crystals
^{100}Mo enrichment > 95%, ^{48}Ca depletion > 35 times
Temperature: 10-50 mK
Energy Resolution: 5 keV @ 3 MeV
(Now ~9keV in over-ground)
Single Detector Mass: 300-500g
AMoRE is fully funded for 10-year support

	AMoRE-10	AMoRE-200
Mass	10 kg	200 kg
Background (keV kg year) $^{-1}$ For zero bkg	10^{-2}	3×10^{-4}
Sensitivity(m_{ee}) (meV)	80-250	20-50
Schedule	July 2016	2019


CMO: ~ 300g
5 layers-7 columns
<AMoRE10, 2016>


Each Cell : D=70 mm, H=80 mm.
CMO (D=50mm, H=60mm, 506g)
30 layers(2.4 m height)-13 columns
or 20 layers(1.6 m height)-19 columns
<AMoRE200, 2019>

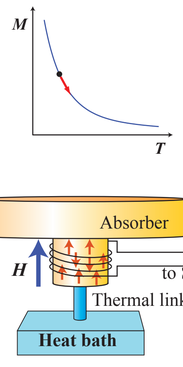
YangYang Underground Laboratory (Y2L)
- Located in a tunnel of Yangyang Pumped Storage Power Plant
  Korea Middleland Power Co.
- Minimum vertical depth : 700 m
- Access to the lab by car (~ 2km)

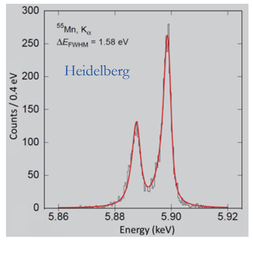
Experiments:
- KIMS: dark matter search experiment in operation
- AMoRE: 0νββ search experiment in preparation
  (additional laboratory space is being built)

We plan to construct new underground site with
1400 m overburden

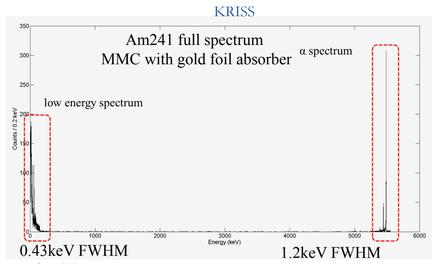
Matallic Magnetic Calorimeters (MMC) : Sensor Technology

- Paramagnetic material with superconducting measurement circuit
  - Au:Er, 100-1000 ppm Er in Au:
  - Weakly-interacting paramagnetic system,
  - Metallic host: fast thermalization (intrinsic τ < 1μs)
  - Measurement Principle:
    Energy(ΔE) → Temperature(ΔT) → Magnetization(ΔM)
    → Magnetic flux(ΔΦ) → Voltage(ΔV)
  - Good linerary, Fast, Absorber friendly
  - Recent sensor performance:
    1.6 eV FWHM for 6 keV x-rays
    1.2 keV FWHM for 5.5 MeV alphas
  - Applications:
    High resolution spectroscopies (x, γ, α, and Q)
    Direct detection of ν mass (ECHo)
    0νββ search (AMoRE)





KRISS



0.43keV FWHM
for 60keV γ

1.2keV FWHM
for 5.5MeV α