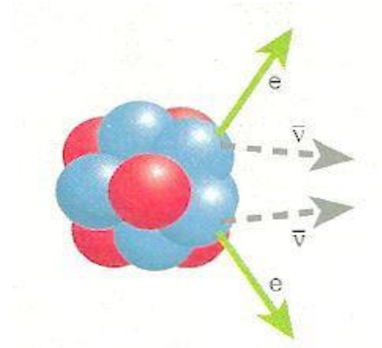
The AMoRE: Search for Neutrinoless Double Beta Decay in Mo-100

Abstract

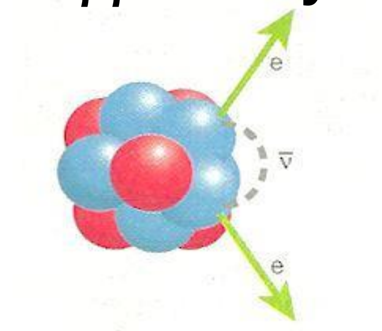
The AMoRE (Advanced Mo-based Rare process Experiment) collaboration is going to use calcium molybdate ($^{40}Ca^{100}MoO_4$) crystals to search for neutrinoless double-beta decay (DBD) of Mo-100 using a cryogenic technique with Mo-100 enriched and Ca-48 depleted calcium at the underground laboratory in Korea. This experiment will employ calcium molybdate crystals as source equal to detector which is composed of scintillating bolometers and light sensors operating at milli-Kelvin temperature. Simultaneous and fast detection capabilities of phonon and light signals, and excellent energy resolution of the detector in AMoRE would provide a powerful means not only to identify DBD but also to reject background events mainly due to random coincidence events of two neutrino double beta decay of Mo-100 and environmental radioactivity. In its first phase, the AMoRE will use about 10 kg of calcium molybdate crystals and will ultimately use about 200 kg of crystals to reach half-life sensitivity of about 10^{26} years and thus mass sensitivity of about 20 to 50 meV for the effective Majorana neutrino mass. Recent progress on the detector developments at room and milli-Kelvin temperature as well as background study based on simulations will be presented.

1. Neutrinoless Double Beta Decay (0νββ *decay)*

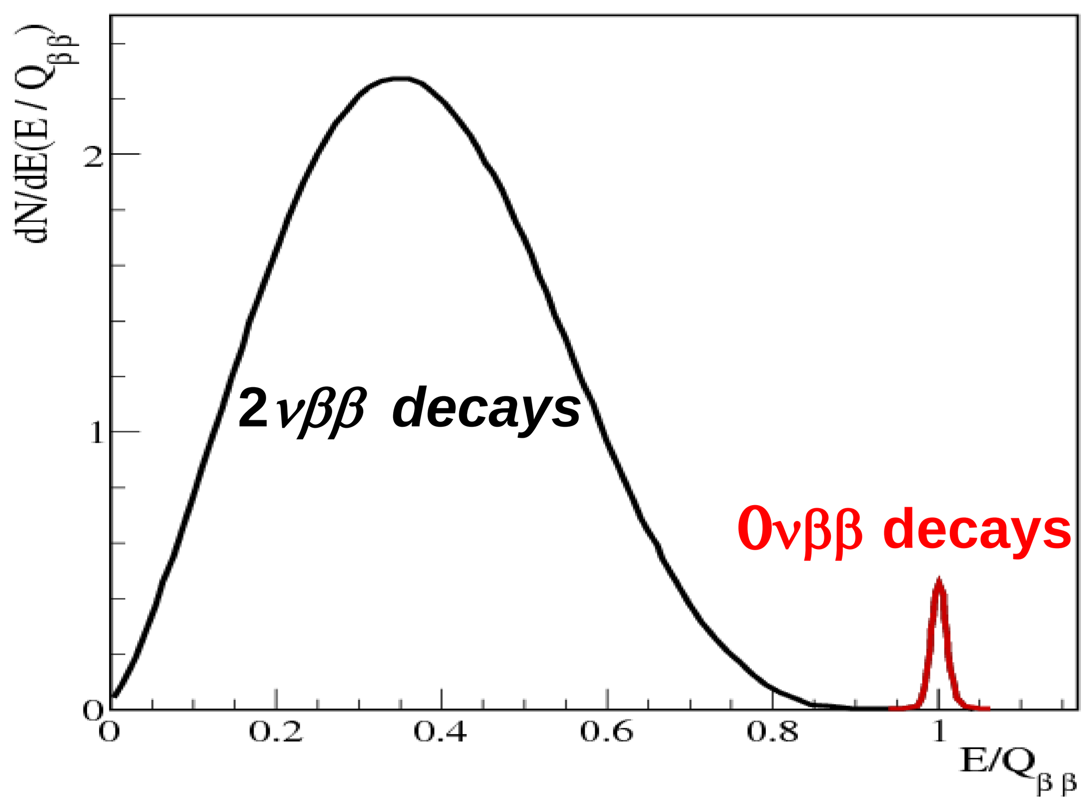
- In S.M., this is forbidden decays because of ΔL = 2.
- If neutrino is a Majorana particle, 0νββ decay is possible.
- Observation of this decay will determine the absolute mass scale of ν and neutrino is a Majorana particle.



2νββ decays



0νββ decays



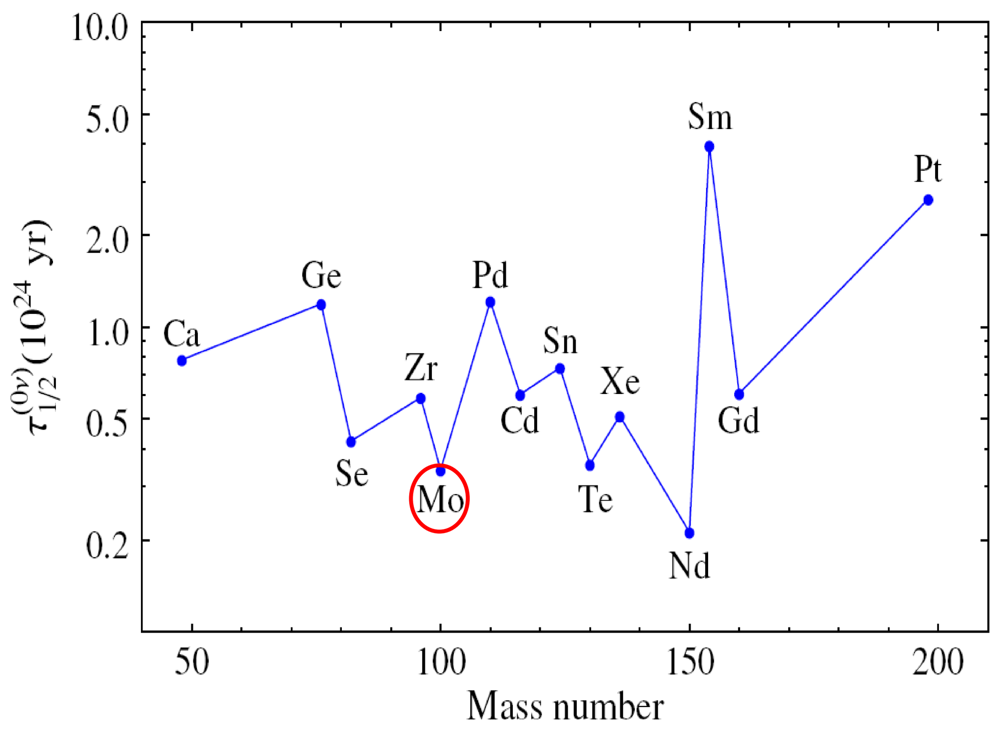
2. Why we use $^{40}Ca^{100}MoO_4$ crystals for 0νββ decays ?

- ^{100}Mo has larger Q-value (3034 keV) than other candidates and relatively high natural abundance (~10%).
- The life time of 0νββ decays of ^{100}Mo is relatively high.
- It is a scintillating crystal.
- The $CaMoO_4$ crystal can be used as source (0νββ decays from ^{100}Mo*)* equal to detector.
- Heat capacity of the crystal is small. -> suited for phonon detection.

In AMoRE, we will detect both light and heat signals simultaneously to remove background significantly (~ 0 background).

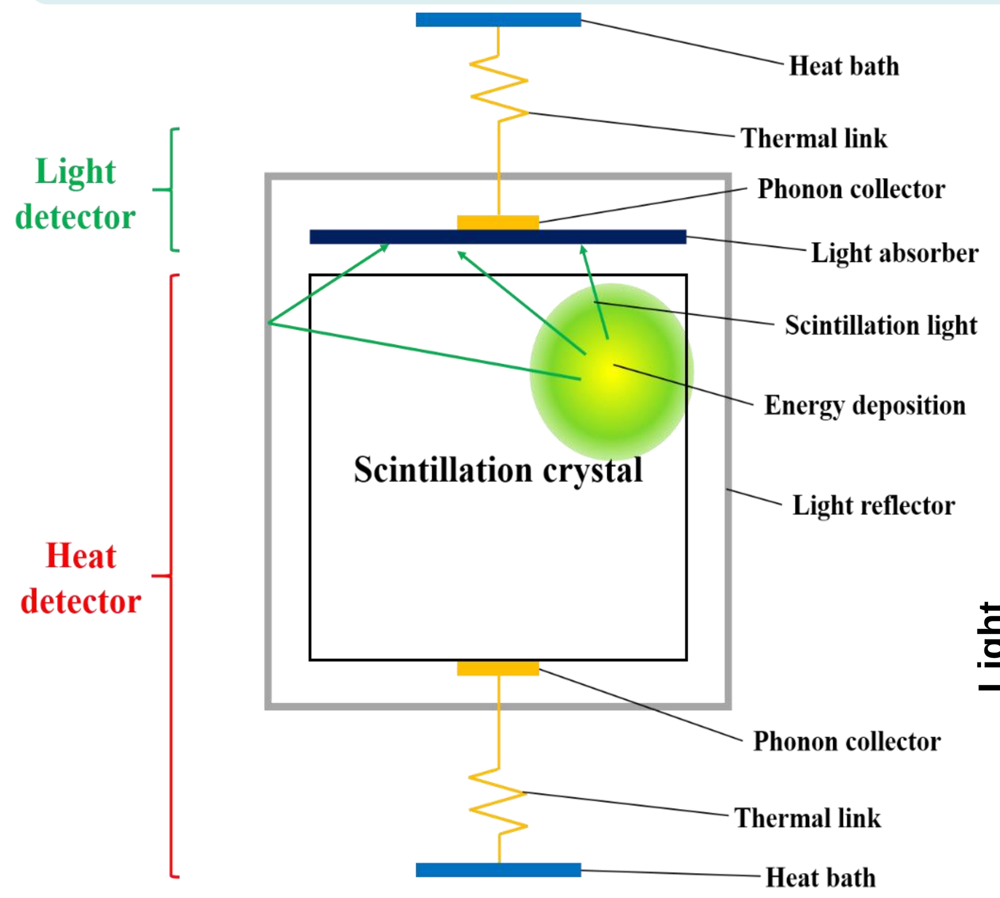
Candidates	$Q_{\beta\beta}$(MeV)	N.A. (%)
$^{48}Ca \rightarrow ^{48}Ti$	4.271	0.187
$^{76}Ge \rightarrow ^{76}Se$	2.040	7.8
$^{82}Se \rightarrow ^{82}Kr$	2.995	9.2
$^{96}Zr \rightarrow ^{96}Mo$	3.350	2.8
$^{100}Mo \rightarrow ^{100}Ru$	3.034	9.6
$^{110}Pd \rightarrow ^{110}Cd$	2.013	11.8
$^{116}Cd \rightarrow ^{116}Sn$	2.802	7.5
$^{124}Sn \rightarrow ^{124}Te$	2.228	5.64
$^{130}Te \rightarrow ^{130}Xe$	2.533	34.5
$^{136}Xe \rightarrow ^{136}Ba$	2.479	8.9
$^{150}Nd \rightarrow ^{150}Sm$	3.367	5.6

Theoretical life times of 0νββ decays for candidates

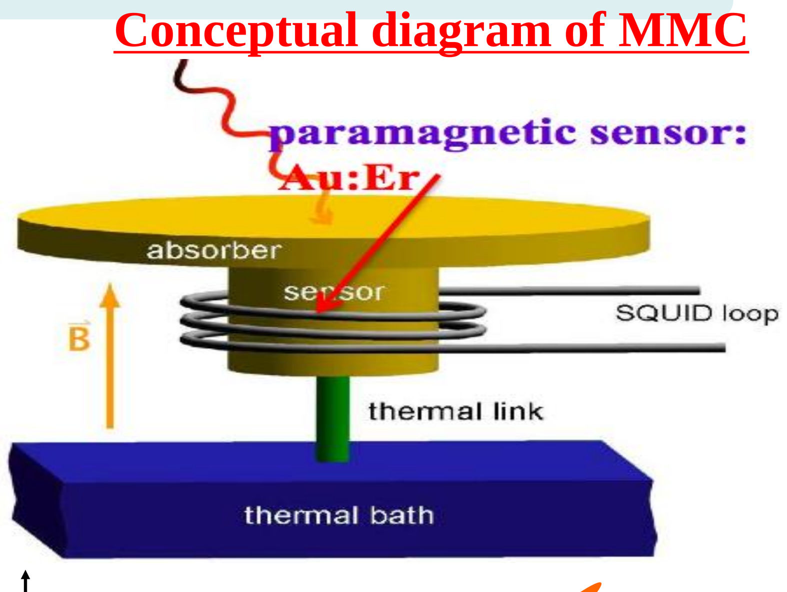


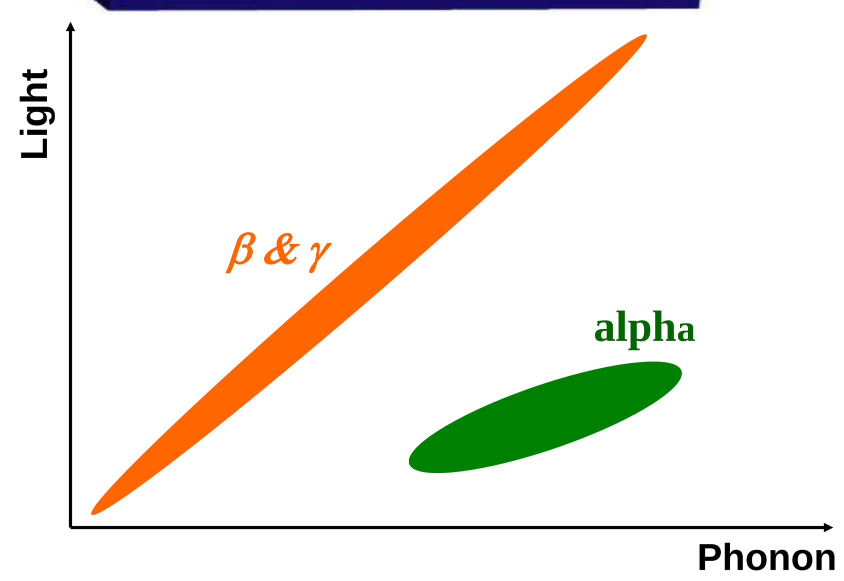
3. Detector concept for 0νββ decays in AMoRE

- Use enriched ^{100}Mo and ^{40}Ca with depleted ^{48}Ca for the crystal.
- $^{40}Ca^{100}MoO_4$ (source) + MMC (Metallic Magnetic Calorimeter) with SQUID readout.



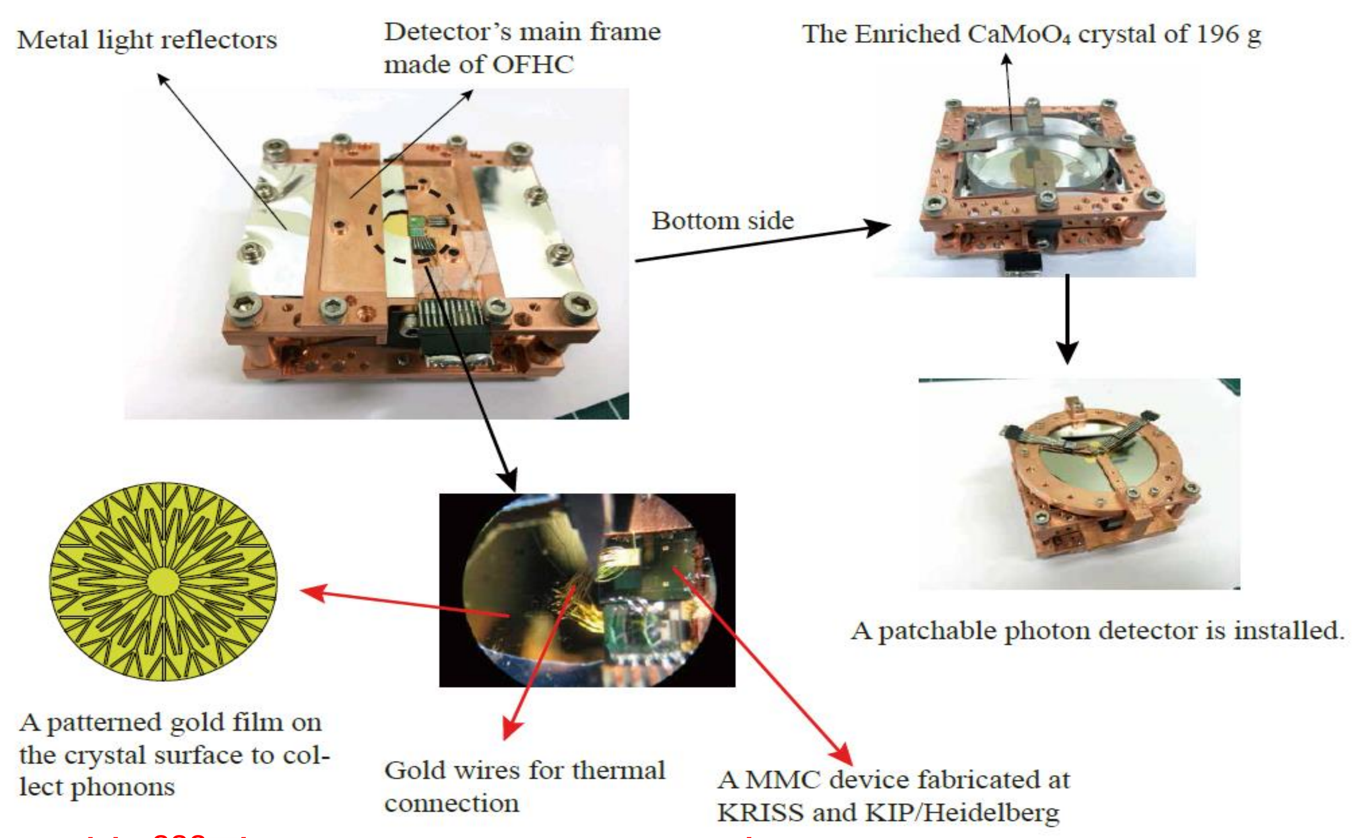
Conceptual diagram of MMC



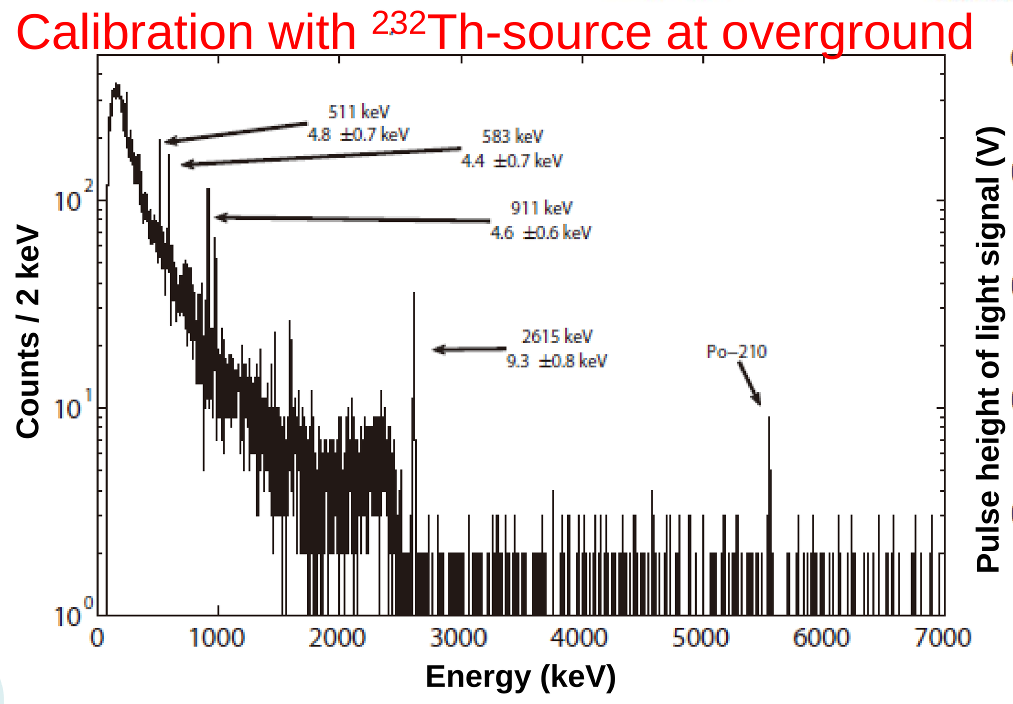


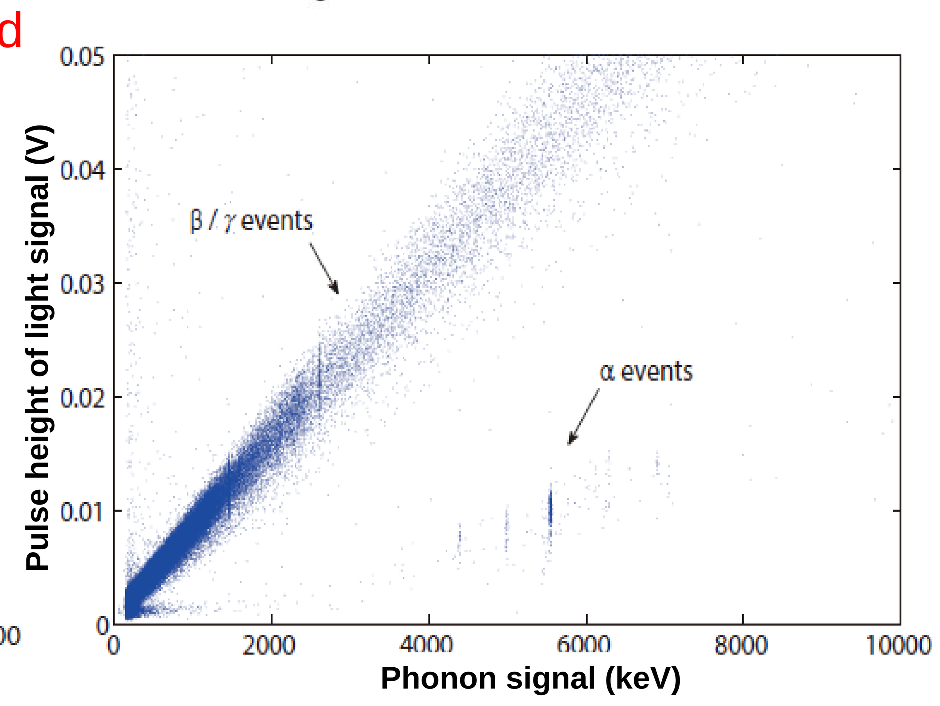
4. Detector design and performances

- The MMC sensor shows excellent energy resolutions (~9.3 keV at 2615 keV) and fast rising phonon-signal (~1 ms) compare to other low tem. sensors.
- α and β/γ events are well discriminated by simultaneous detection of both light and phonon signals.



Calibration with ^{232}Th-source at overground





5. Prospect for the AMoRE

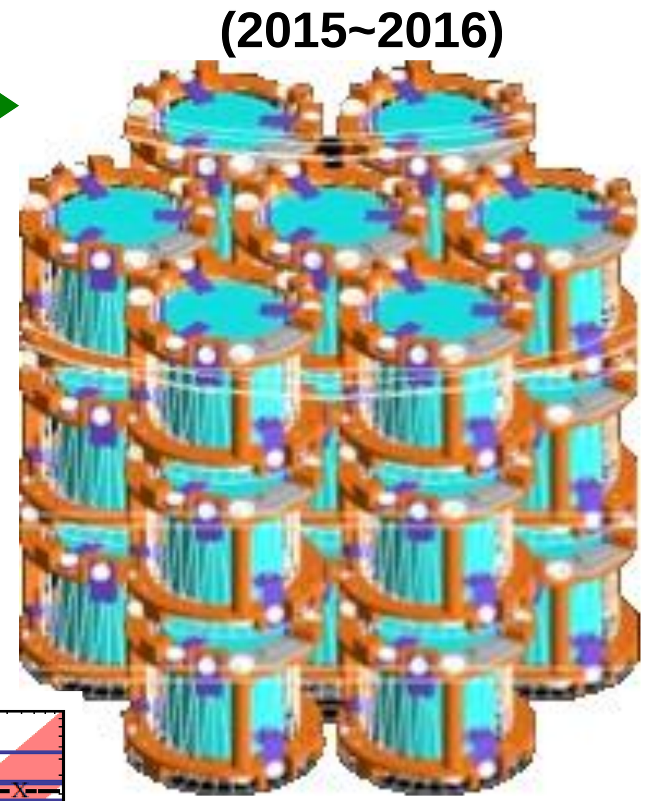
- In the 1st phase, the AMoRE will use about 10 kg of $CaMoO_4$ crystals and will ultimately use about 200 kg of the crystals (AMoRE-10 to AMoRE-200).
  -> It will probe the neutrino mass down to 20-50 meV.
- The detector installation of AMoRE-10 will begin in 2006 at YangYang underground laboratory.
- We are planning to construct a new underground lab. for AMoRE-200.
  -> deeper than current Lab.
- The AMoRE-200 will almost explore the inverted hierarchy region.

YangYang underground Lab.

- Located in a tunnel of pumped-storage power plant
- Minimum vertical depth: 700 m
- Experiments:
  KIMS (Dark matter search) and AMoRE

AMoRE (current)

AMoRE-10 (2015~2016)



AMoRE-200 (2018~2019)