AMORE

YEONGDUK KIM
DIRECTOR OF CUP

2019. 9. 27.

NEPLES 2019, KIAS

I will talk about

1. Overview of Double beta decay
   1. Motivation
   2. Current Status of experiments
2. AMoRE project
   1. Overview
   2. Current Status
   3. Future plan
   4. Schedule
3. Summary

Neutrino Properties known & still to be determined.

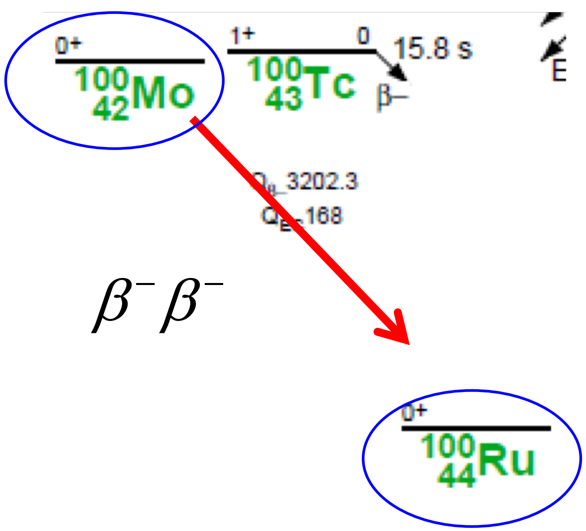
- Neutrinos are massive.
- Neutrinos are from Sun and Supernova
- All mixing angles and mass differences are measured.
- Mass Hierarchy ? (Normal Hierarchy is ~ 3 sigma)
- CP violation in lepton sector ? → Leptogenesis
- Mass scale ?
- Majorana nature ? – See-Saw mechanism.
- Sterile Neutrinos ? Dark Matter ?
- Cosmic Neutrino Backgrounds (CNB) Beginning

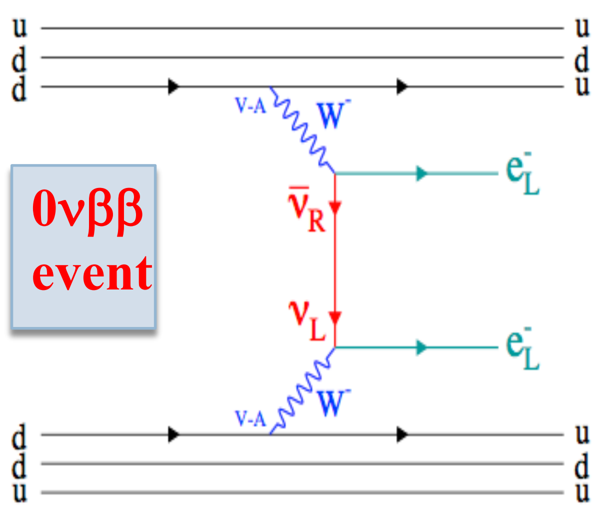
Search for Neutrinoless double beta decay (0νββ)

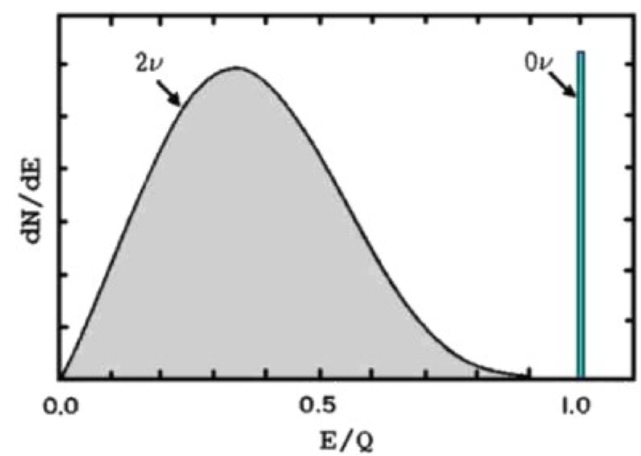
- **Observation of 0νββ will confirm**
  - Neutrinos are Majorana particles and have Majorana masses.
  - Lepton number non-conservation.
- **Observation of 0νββ will support more on**
  - See-Saw model of the neutrino mass.
  - Leptogenesis to account for the baryon asymmetry of the universe.

$$m_\nu \approx \frac{m_D^2}{m_N}$$

Most promising BSM Physics !

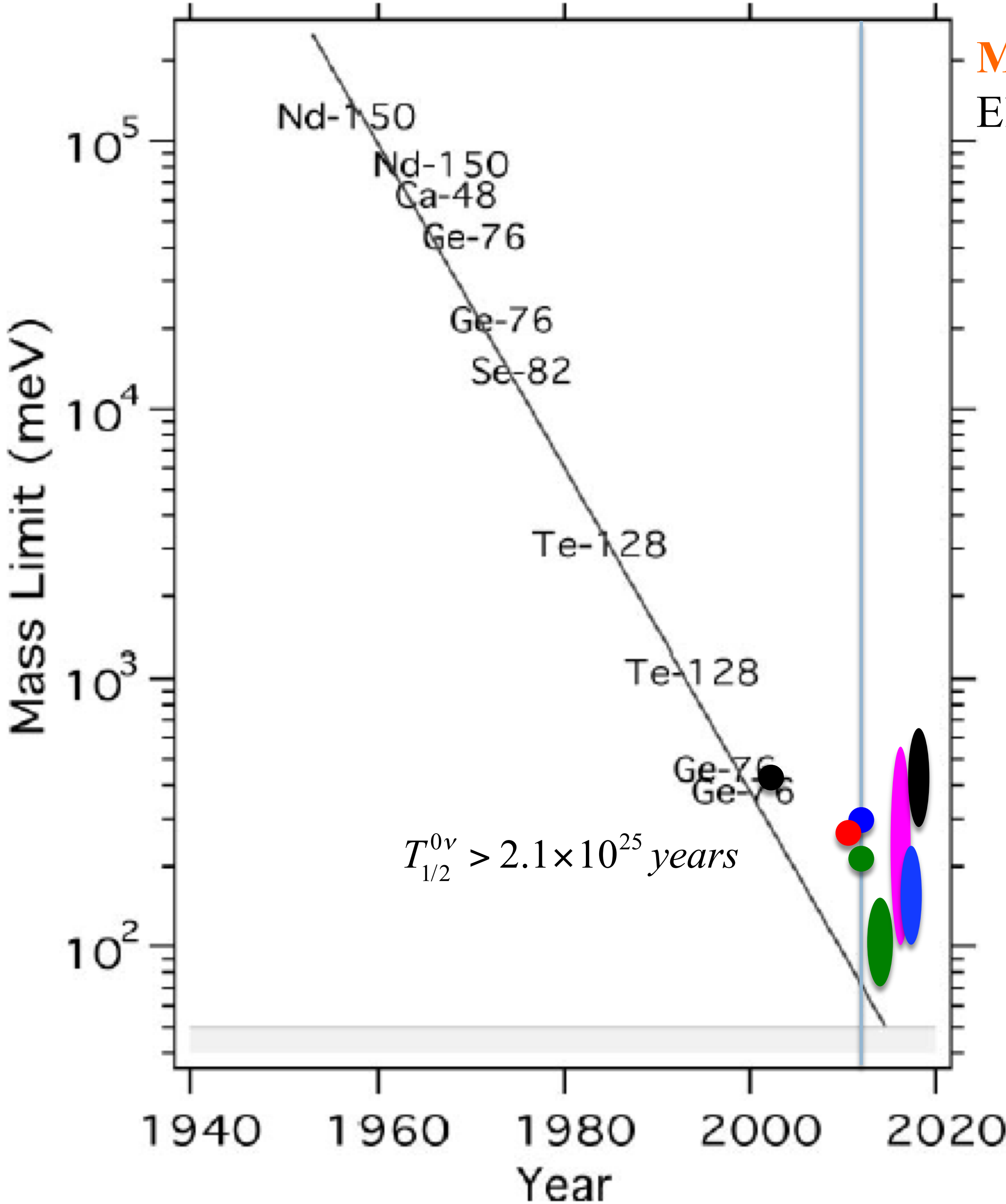






Moore's law for 0νββ ?

Elliott & Vogel, Ann, Phys. (2002)



^{136}Xe, EXO 2012.7

^{136}Xe, KAMLAND-ZEN, 2013.2

^{76}Ge, Gerda 2013.9

^{136}Xe, KAMLAND-ZEN, 2016.5

^{76}Ge, Gerda 2018.9

^{130}Te, CUORE 2018

^{82}Se, CUPID 2019

Current best results for 0νββ

Nucl.	Q (keV)	Abun. (%)	$T^{2\nu}_{1/2}$ (10^{20} Y)	Exp	$T^{0\nu}_{1/2}$ (10^{24} Y)	M (eV)	Ref.
^{48}Ca	4270.0	0.187	0.53(0.1)	CANDLES	> 0.058	<3.1-15.4	PRC 78 058501 (2008)
^{76}Ge	2039.1	7.8	18.8(0.8)	GERDA-II	>80	<0.12-0.26	PRL 120, 132503 (2018)
^{82}Se	2997.9	9.2	0.93(0.05)	CUPID-0	> 3.5	<0.31-0.64	PRL123, 032501 (2019)
^{100}Mo	3034.4	9.6	0.0688(0.0025)	NEMO-3	>1.1	<0.33-0.62	PRD89, 111101 (2014)
^{116}Cd	2813.4	7.6	0.269(0.009)	AURORA	> 0.19	<1-1.8	nulc-ex/1601.05578.
^{130}Te	2527.5	34.5	7.91(0.21)	CUORE	> 15	<0.11-0.52	PRL120, 132501 (2018)
^{136}Xe	2458.0	8.9	21.8(0.5)	KamLAND -Zen	> 107	<0.06-0.16	PRL117, 082503 (2016)
^{150}Nd	3371.4	5.6	0.0934(0.0065)	NEMO-3	> 0.02	<1.6-5.3	PRD 94 072003 (2016)

Neutrino mass from 0νββ experiment

- Half-lifves of 0νββ depends on phase factor, matrix element and effective neutrino mass for the simplest light neutrino exchange model.
- Effective neutrino mass depends on mass hierarchy. However, since normal hierarch y is preferred with ~ 3 sigma, it is reasonable not to emphasize mass range from inve rted hierarchy.

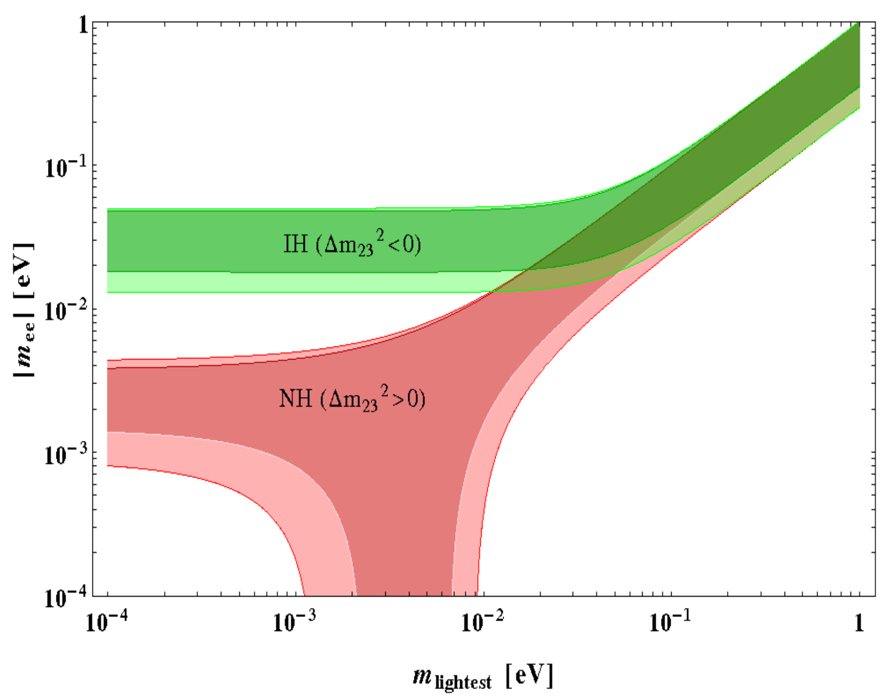
Phase factor

$$\left[T_{1/2}^{0\nu}\right]^{-1} = G_{0\nu}\left|M_{0\nu}\right|^2\left(\frac{m_{\beta\beta}}{m_e}\right)^2$$

Half-life Measured **Nuclear Matrix Element** **Neutrino Mass**

$$m_{\beta\beta} = U_{e1}^2 m_1 + U_{e2}^2 m_2 + U_{e3}^2 m_3$$

$$T_{1/2}^{0\nu} \rightarrow m_{\beta\beta}$$



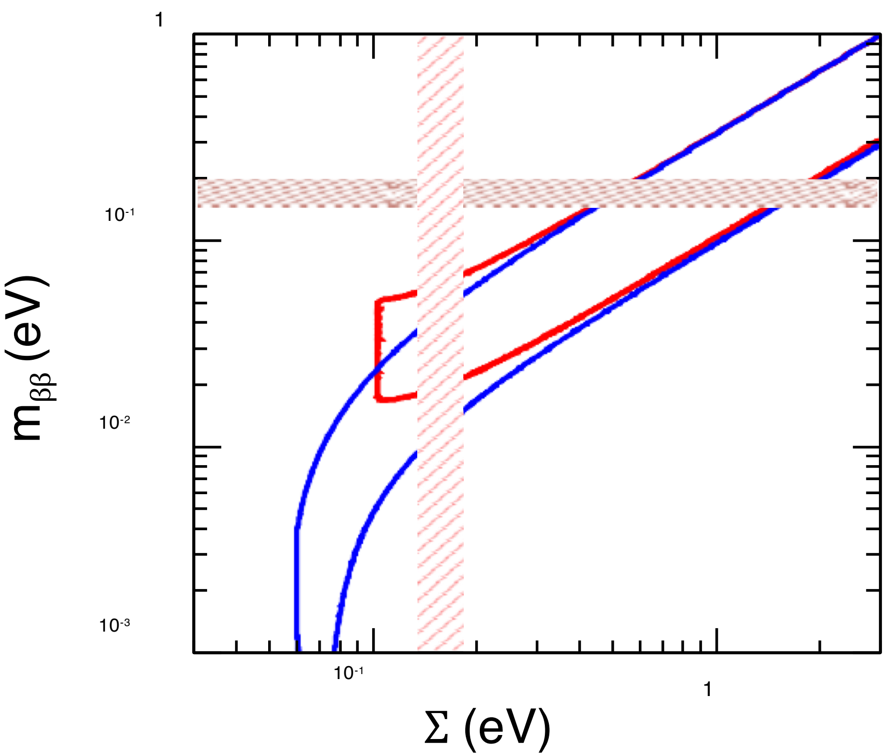
Current Mass Limits

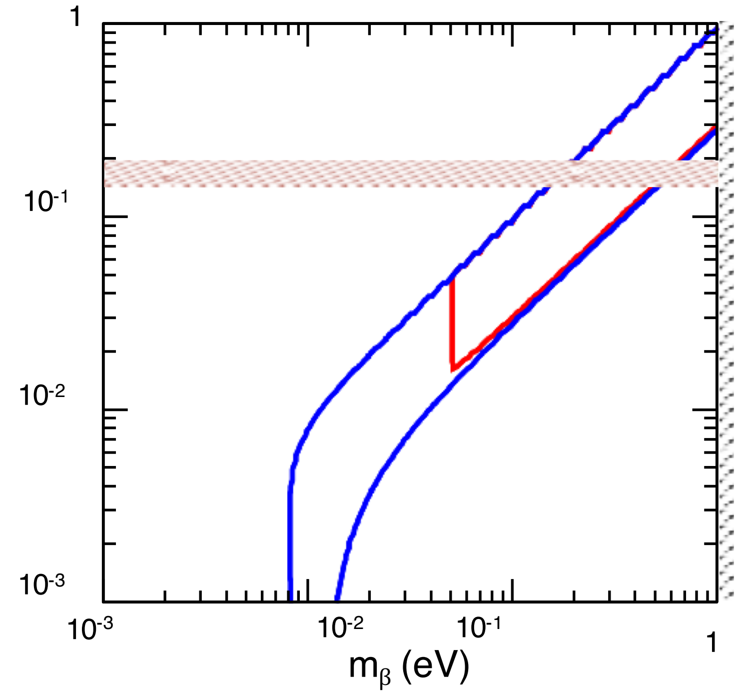
- Both double beta and cosmological limits have got severe.

Lisi, Taup 2019

KATRIN

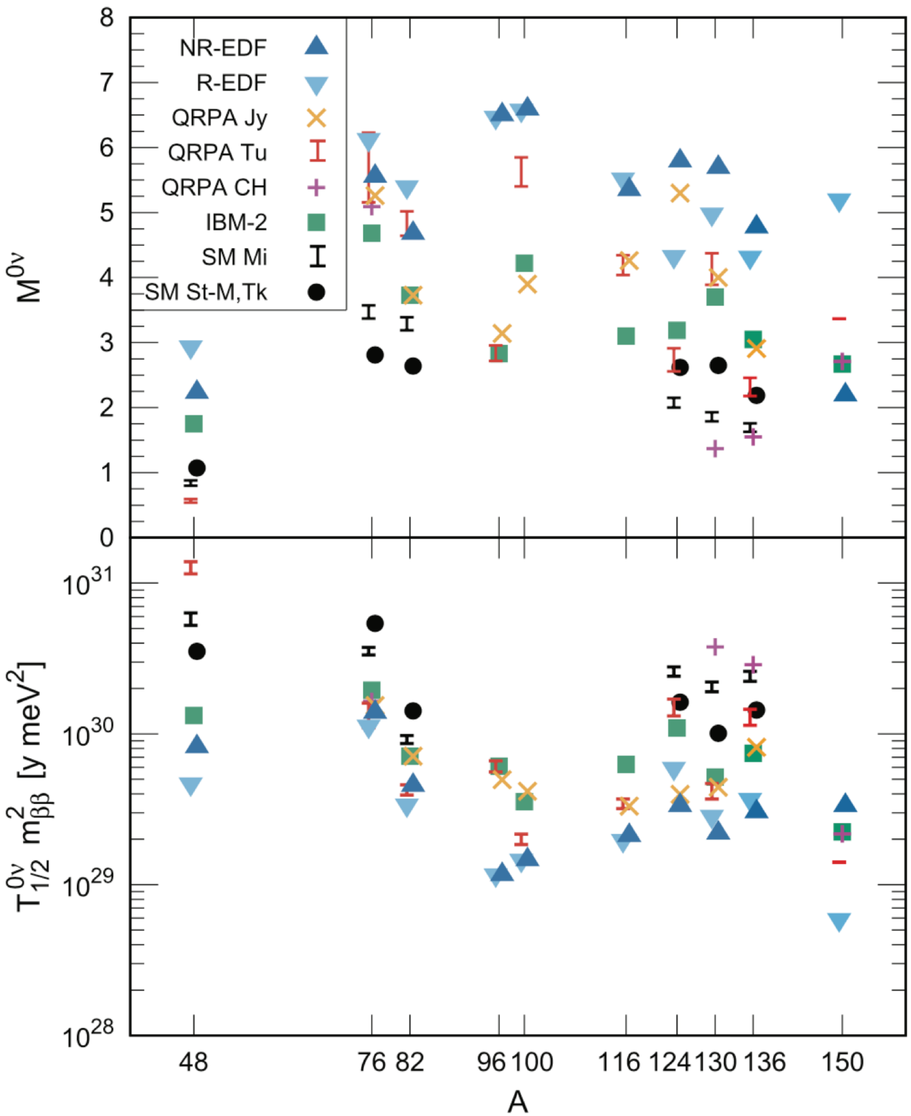
m(ν) < 1.1 eV (90% CL)





Matrix Elements

Engel and Menendez, Rep. Prog. Phys. 80, 046301 (2017)

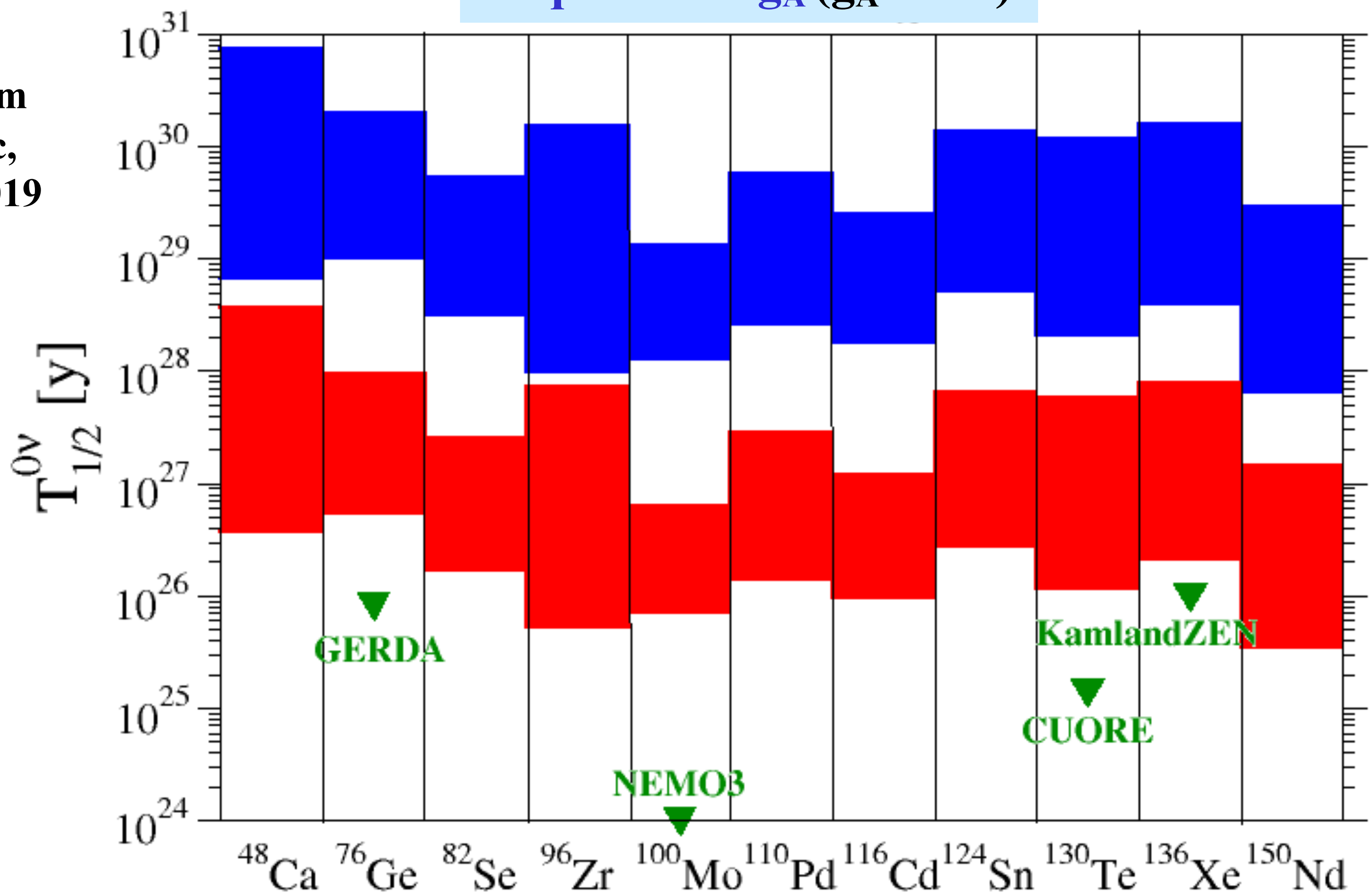


- An uncertainty of a factor of three in the matrix element corresponds to nearly an order of magnitude uncertainty in the amount of material required.
- The expected lifetime for neutrinoless DBD differs about factor up to 5 with average values of different models.

$0\nu\beta\beta$ –half lives for NH and IH with included uncertainties in NMEe

unquenched g_A (g_A=1.27)

Slide from Simkovic, TAUP 2019



NH: $m_1 \ll m_2 \ll m_3 \quad m_3 \simeq \sqrt{\Delta m^2}$

$m_1 \ll \sqrt{\delta m^2}. \quad m_2 \simeq \sqrt{\delta m^2}$

$1.4 \text{ meV} \leq m_{\beta\beta} \leq 3.6 \text{ meV}$

IH: $m_3 \ll m_1 < m_2 \quad m_1 \simeq m_2 \simeq \sqrt{\Delta m^2}$

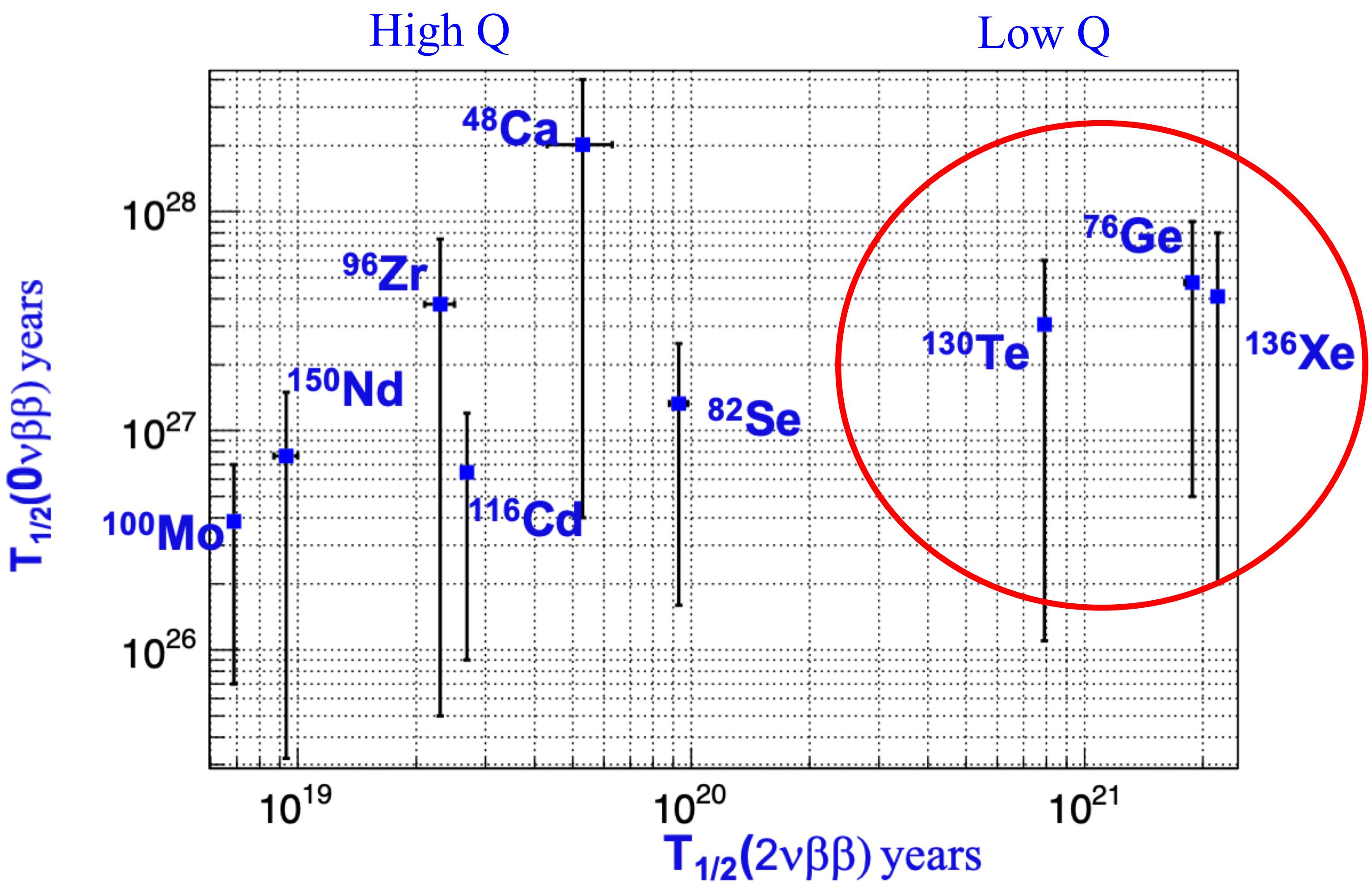
$m_3 \ll \sqrt{\Delta m^2}$

$20 \text{ meV} \leq m_{\beta\beta} \leq 49 \text{ meV}$

Lightest ν-mass equal to zero

0νββ vs 2νββ T(1/2)

- **A correlation between** 2νββ **half-life(measured) vs** 0νββ half-life calculated with various models for inverted mass hierarchy(20-49 meV).
- **Often, it is said that there is no relation between two and zero matrix elements.**

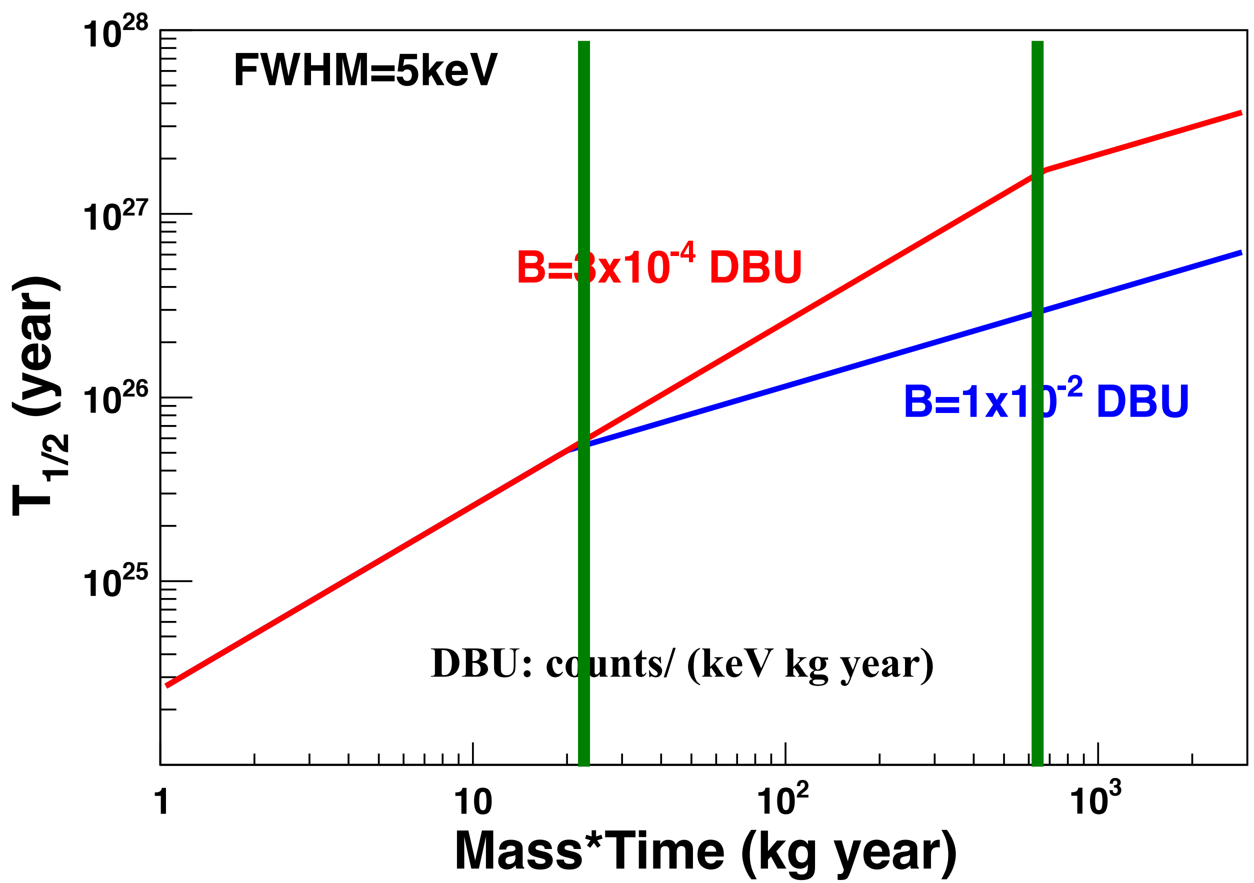


“zero” Backgrounds

- If “zero” backgrounds in ROI(Region of Interests), the half-life limits are proportional to the detector mass and DAQ time. If finite backgrounds, sqrt (MT).

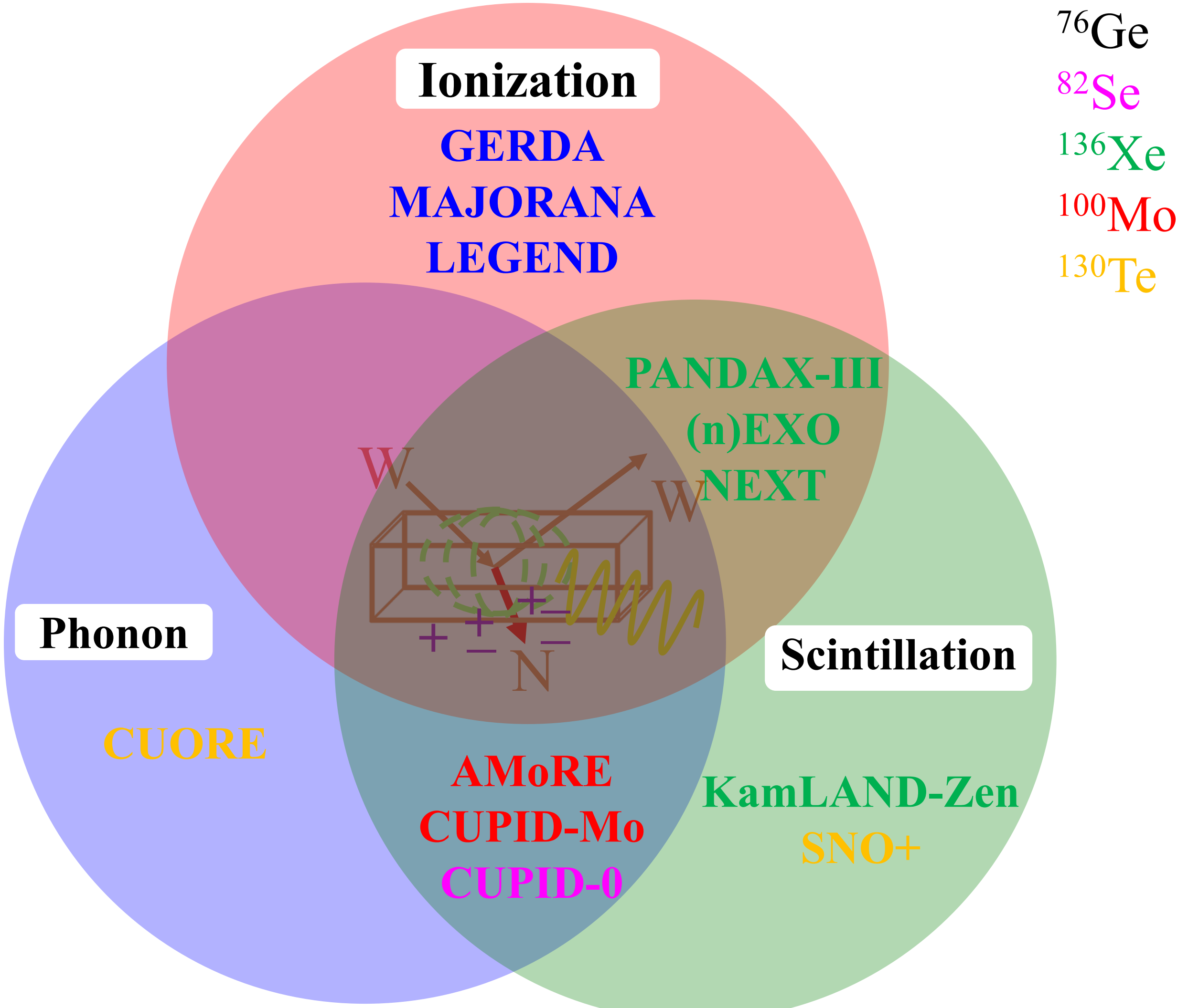
$T^{0\nu}_{1/2} \propto MT\ (for\ zero\ backgronds)$

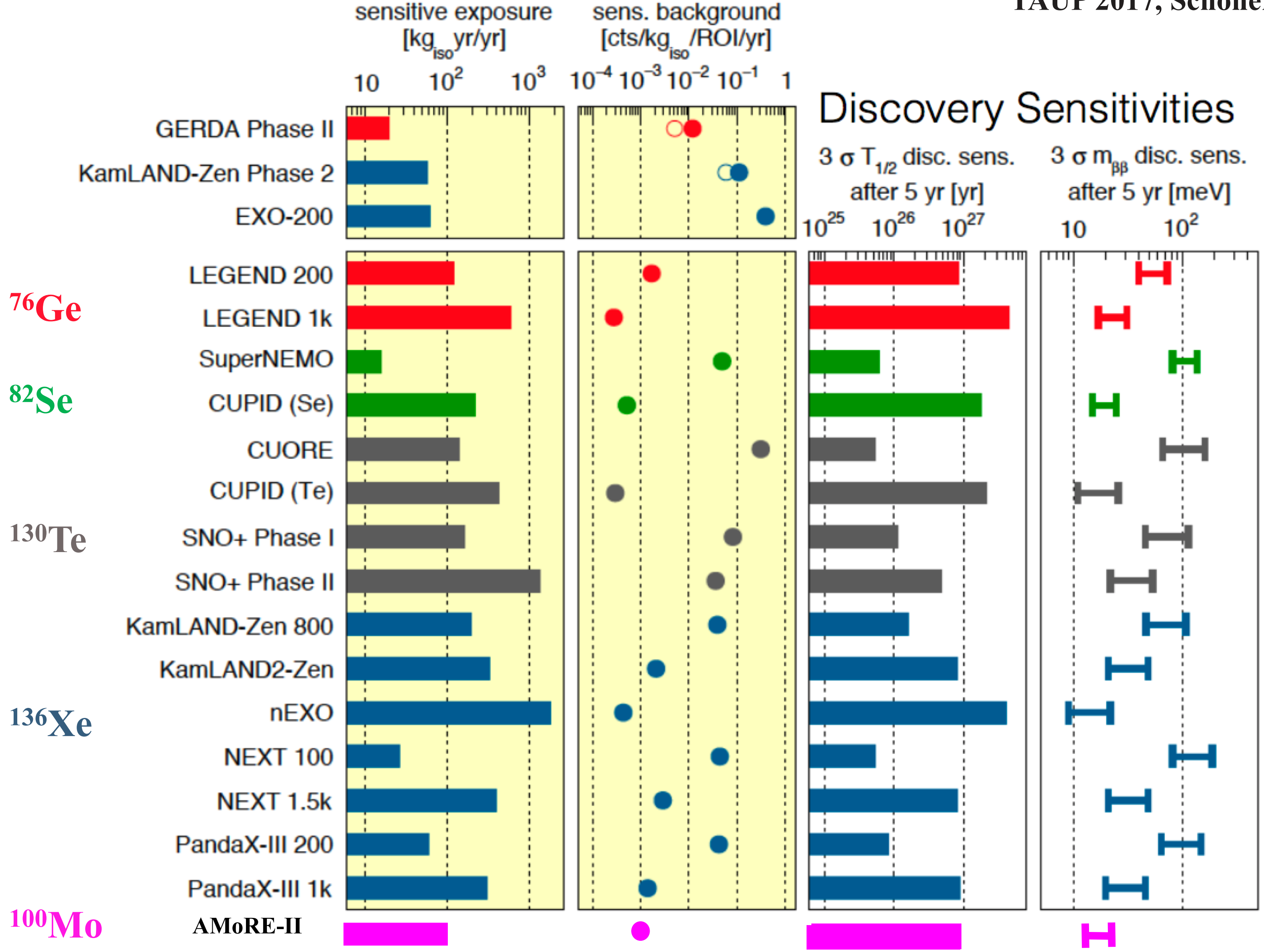
$T^{0\nu}_{1/2} \propto \sqrt{\frac{MT}{b\Delta E}}$(for finite backgrounds)



Detector Techniques for 0νββ

Similar techniques are used as direct dark matter experiments



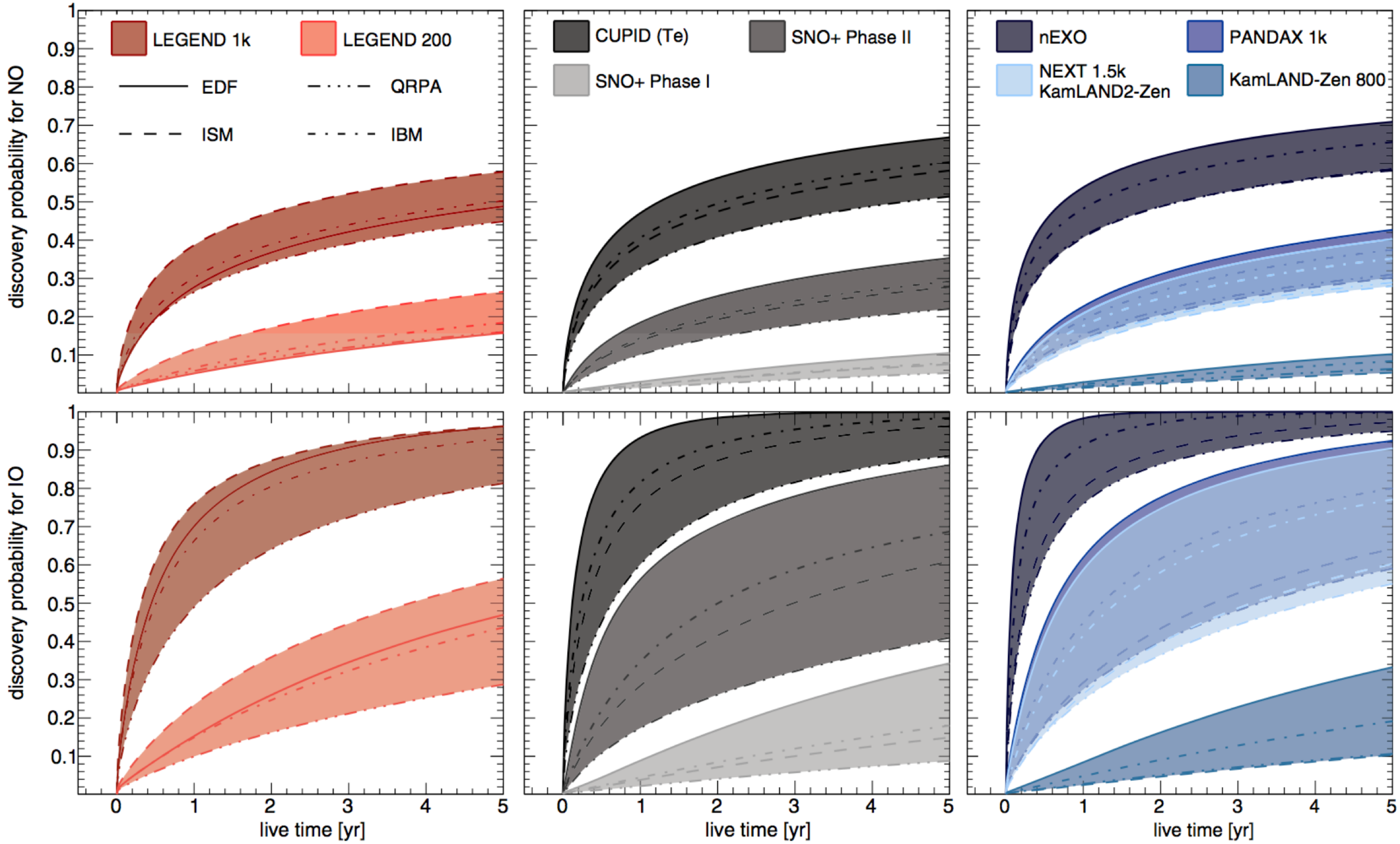


Discovery Sensitivities
sensitive exposure [kg$_{iso}$ yr/yr]
10
10^2
10^3
sens. background [cts/kg$_{iso}$/ROI/yr]
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
3 σ $T_{1/2}$ disc. sens. after 5 yr [yr]
10^{25}
10^{26}
10^{27}
3 σ $m_{ββ}$ disc. sens. after 5 yr [meV]
10
10^2
GERDA Phase II
KamLAND-Zen Phase 2
EXO-200
^{76}Ge
LEGEND 200
LEGEND 1k
^{82}Se
SuperNEMO
CUPID (Se)
^{130}Te
CUORE
CUPID (Te)
SNO+ Phase I
SNO+ Phase II
^{136}Xe
KamLAND-Zen 800
KamLAND2-Zen
nEXO
NEXT 100
NEXT 1.5k
PandaX-III 200
PandaX-III 1k
^{100}Mo
AMoRE-II

Discovery probability

- Discovery probability for NO and IO assuming logarithmic mass distribution and flat in the angles and phases.
- Even normal hierarchy, the probability is high ~ 50% in 5 years for next generation experiments.

Agostini, PRD 96, 053001 (2017)



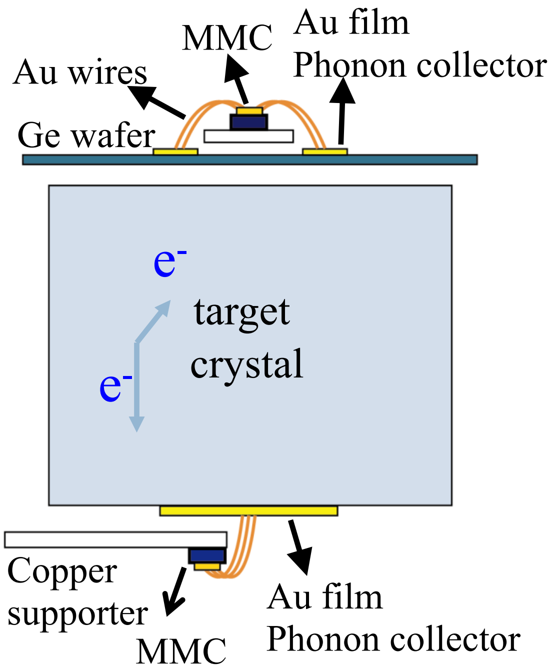
AMoRE Collaboration

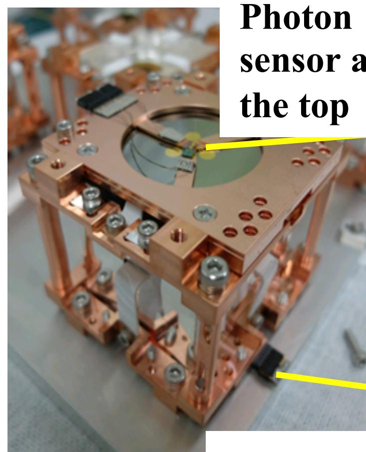
- **Total 105 members from 23 institutes at 8 countries.**
- **Two meetings per year.**

Korea	CUP, Institute of Basic Science (CUP)		
	Kyungpook National University (KNU)	11	Simulation, Crystal Tests
	Soongsil University (SSU)	3	Theory
	Seoul National University (SNU)	4	Low Temp., Data Analysis
	Ehwa Womans University (EWU)	3	HPGe
	Semyung University (SMU)	1	
	KRISS	3	DR, Cryostat
	Sejong University (SJU)	3	Data Analysis, Muon
	Chung-Ang University (CAU)	3	Theory
Russia	JSC FOMOS-Materials (FOMOS)	2	CMO crystals
	Baksan Neutrino Observatory of INR RAS (BNO)	8	HPGe, Simulation
	National Research Nuclear University (NRNU)	1	Backgrounds, Crystals
	Nikolaev Institute of Inorganic Chemistry (NIIC)	3	Enriched Crystal
Germany	Physikalisch-Technische Bundesanstalt (PTB)	2	SQUID
	Kirchhoff-Institute for Physics (KIP)	3	MMC, Photon Detector
Ukraine	Institute for Nuclear Research (INR)	7	Simulation, Background
China	Tsinghua University (THU)	3	
Thailand	Nakhon Pathom Rajabhat University (NPRU)	6	
Indonesia	Institut Teknologi Bandung (ITB)	2	Muon Veto
	University of Mataram (UM)	1	
Pakistan	Abdul Wali Khan University (AWKUM)	1	
	Kohat University of Science and Technology (KUST)	2	

Principle of AMoRE Detector

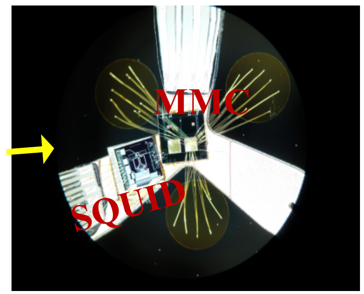
- Use Mo containing Scintillating Bolometer : $(^{40}Ca,X)^{100}MoO_4$ + MMC
- For Each crystal, phonon and photon sensors made of MMCs+SQUIDs to separate alphas (background) and betas (signal). Highly Technical !

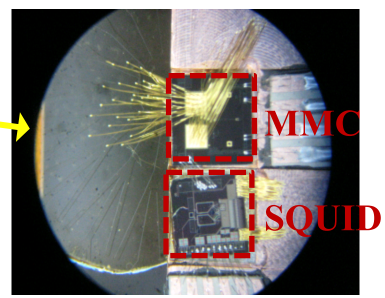


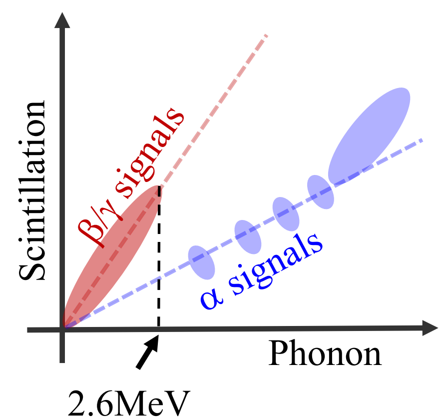


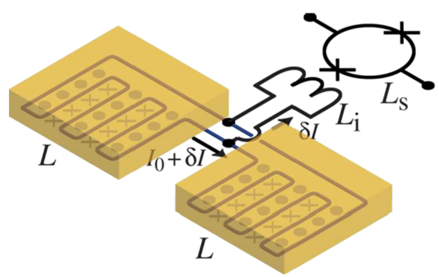
Photon sensor at the top

Phonon sensor at the bottom



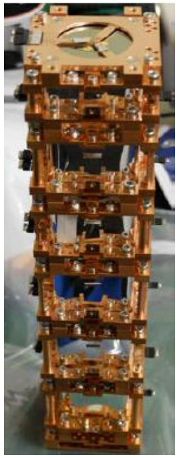






MMC: Metallic Magnetic Calorimeter

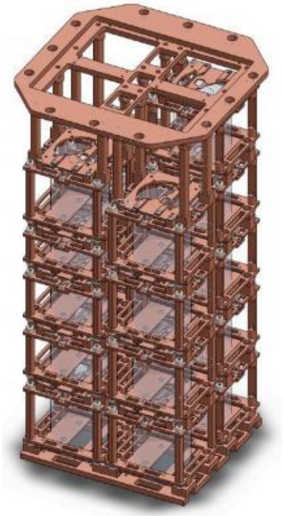
Planned Phases of AMoRE Project



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

~ 1.9 kg

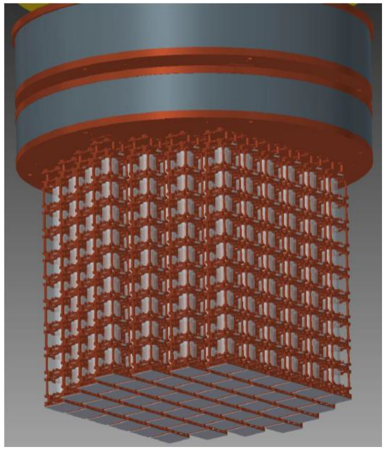
AMoRE Pilot



$^{40}Ca(Li)^{100}MoO_4$

~ 6 kg

AMoRE-I



$(^{40}Ca,Li)^{100}MoO_4$

200 kg

AMoRE-II

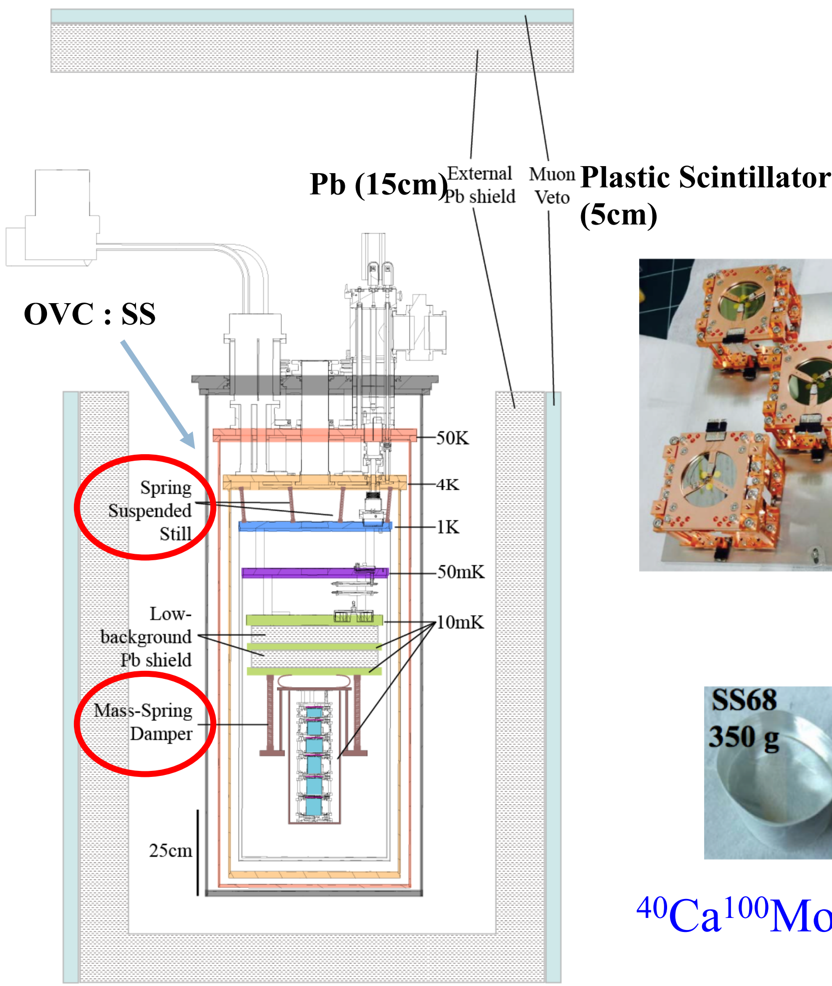
ckky : counts/ (keV kg year)

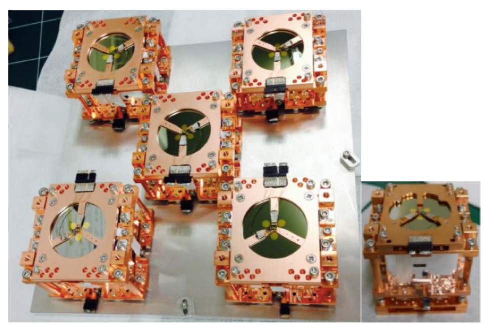
	AMoRE-Pilot	AMoRE-I	AMoRE-II
Crystal Mass (kg)	1.9	6	200
Backgrounds(ckky)	10^{-2}	10^{-3}	10^{-4}
$T_{1/2}$(year)	1.1×10^{24}	8.2×10^{24}	8.2×10^{26}
m_{bb} (meV)	380-719	130-250	13-25
Schedule	2015-2018	2019-2022	2022-2026

It took long time to get ready for AMoRE-II !

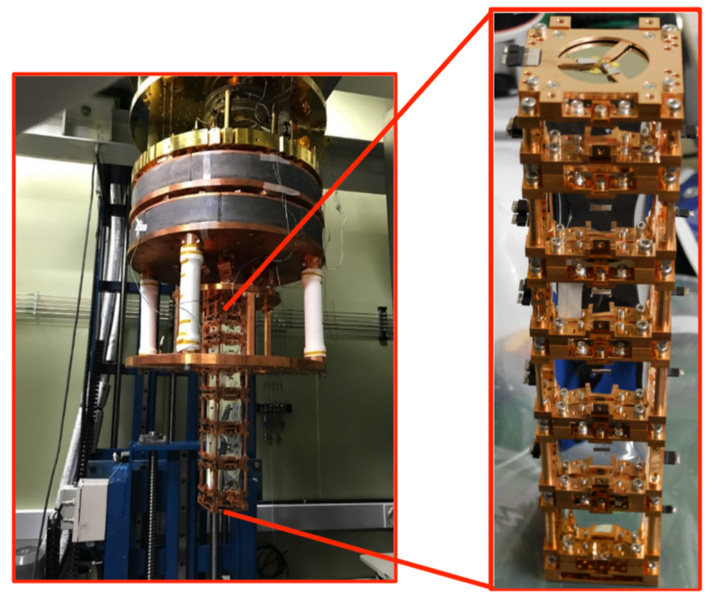
AMoRE-Pilot Setup

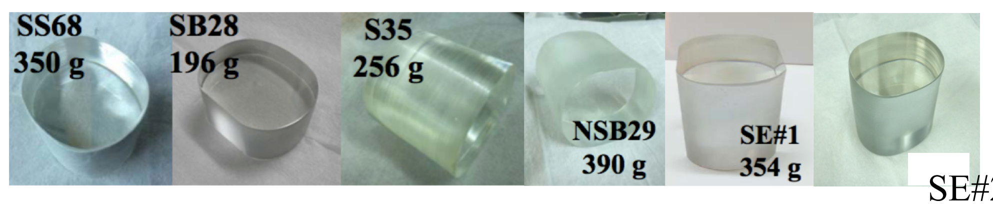
- To demonstrate the detection principle and low backgrounds.
- 6 crystals making total mass 1.89 kg.
- Two vibration reduction systems are installed.





12 detector channels
(6 heat detectors + 6 light detectors)



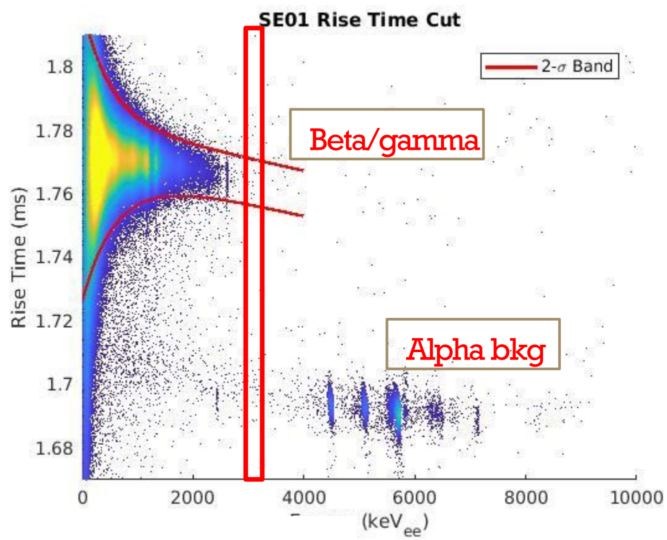


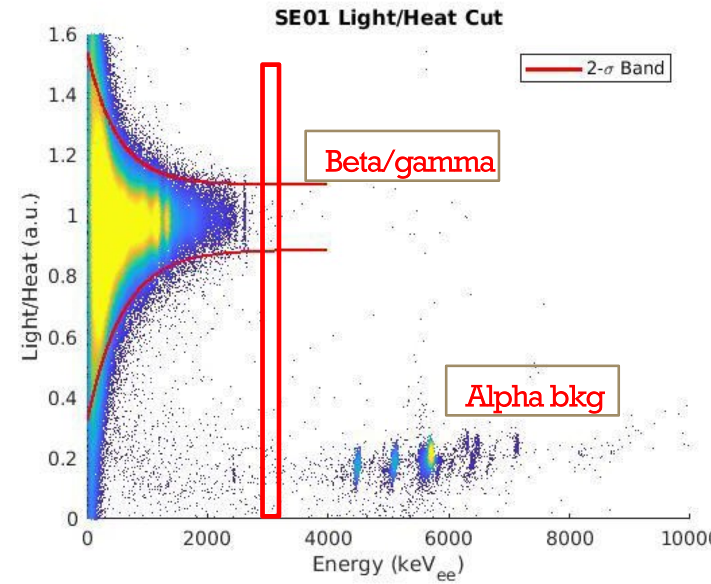
$^{40}Ca^{100}MoO_4$ crystals from Russian company, FOMOS.

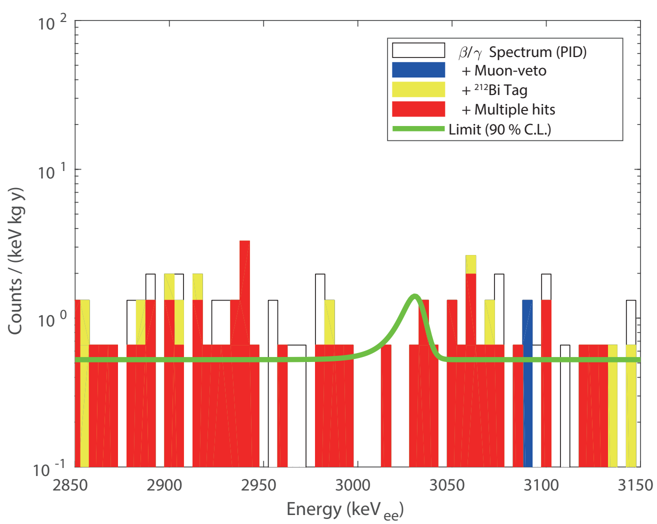
Demonstration of Detector Performance

Alpha Backgrounds are effectively rejected with PSD & Light/Heat raio.

arXiv:1903.09483, Accepted to EPJC







- 111 (kg day) exposure.

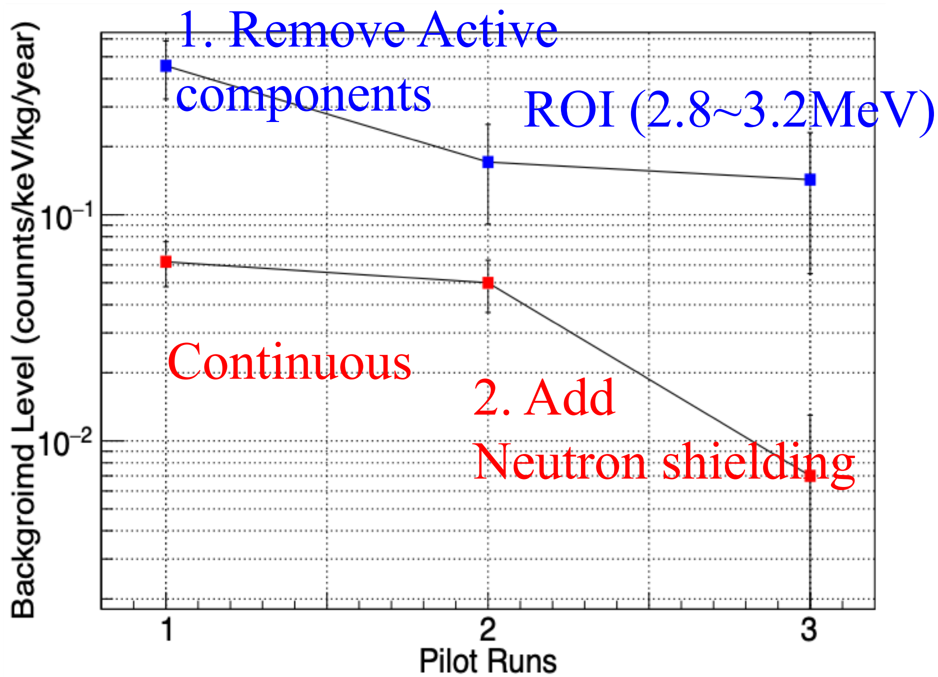
→ Final background level : 0.55 ckky

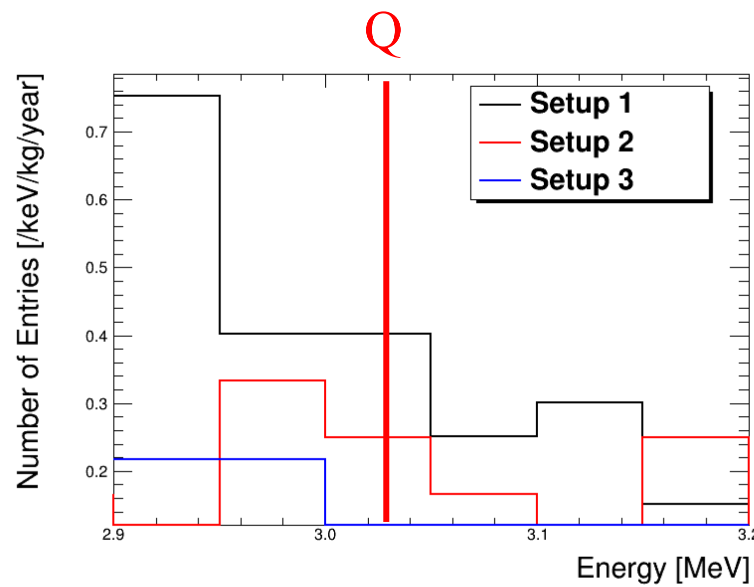
→ $T_{1/2}^{0\nu} > 9.5\times10^{22} years$

NEMO best limit $1.1\times10^{24} years$

Background reduction

Two major background sources are removed.



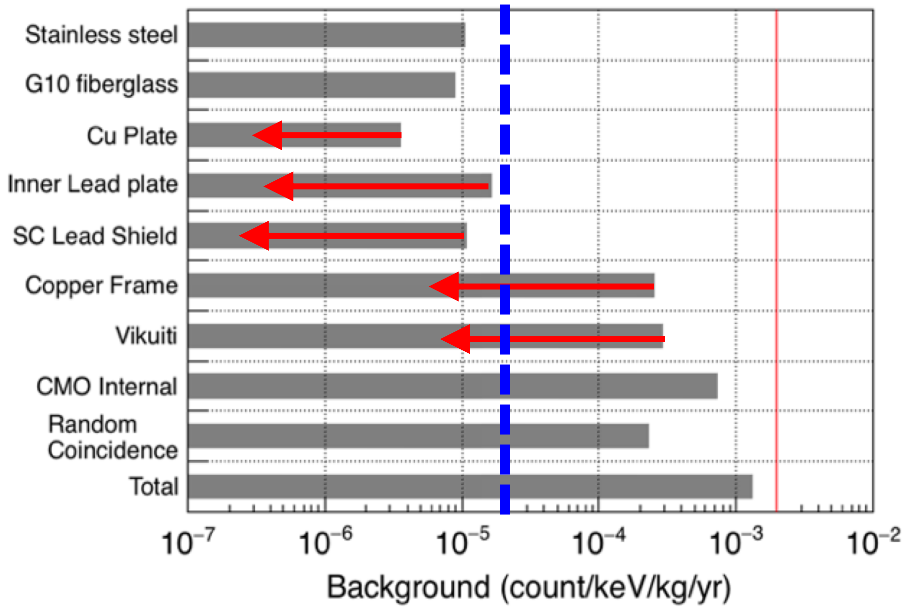


The goal for AMoRE-I starting this Oct. is to understand the background better. More shielding are added for this test.

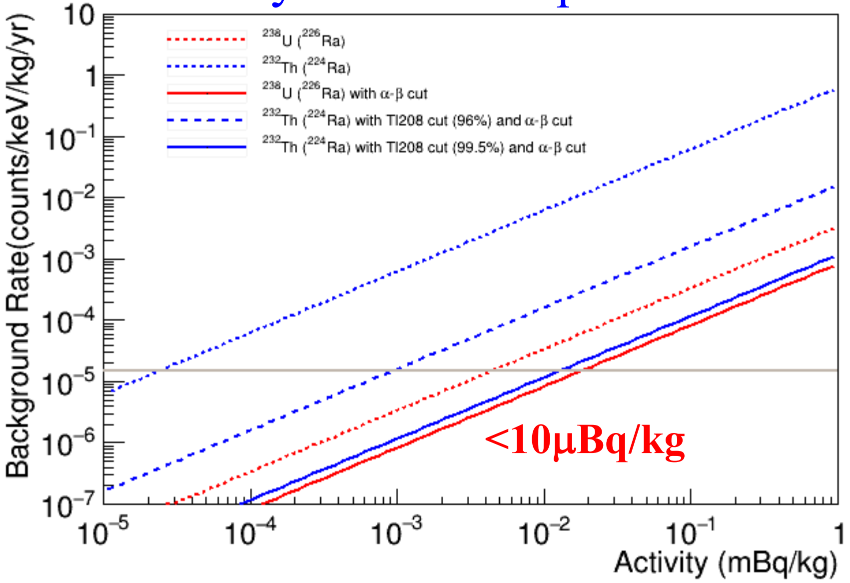
Estimation for AMoRE-II backgrounds

- Tried to identify critical components in the setup for AMoRE-II experiment.
- For AMoRE-II, the Crystal Bulk activity for zero background has been set.

AMoRE-II requirement

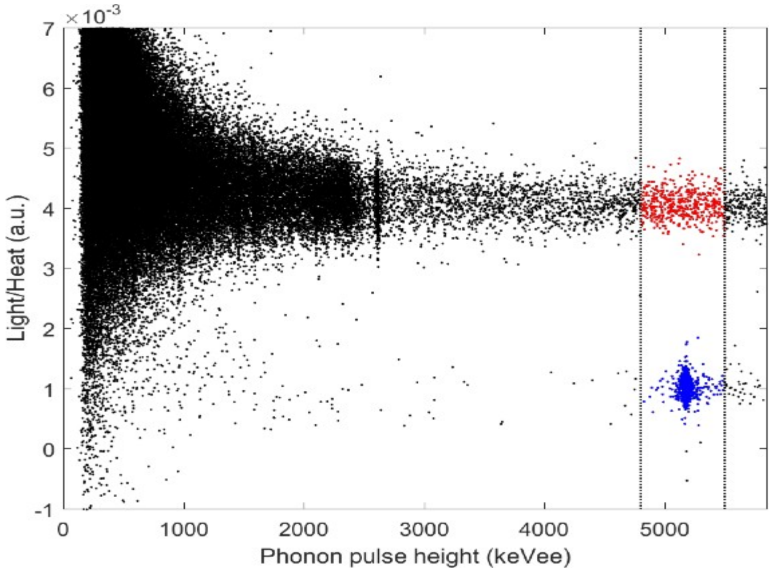


Crystal Bulk requirement



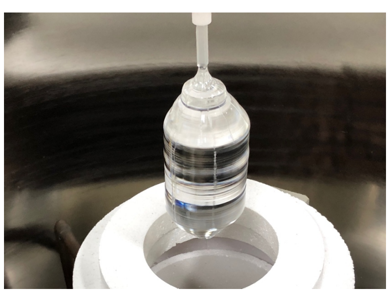
$Li_2{}^{100}MoO_4$ Crystal Test for AMoRE-II

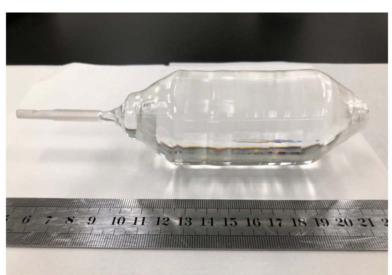
- $Li_2{}^{100}MoO_4$ crystal is considered rather than $^{40}Ca^{100}MoO4$ crystal for AMoRE-II.
- Particle ID seem to be satisfactory.
- A problem of Au foil attachment. After a few months, the Au phonon collector seems unstable. Working on the solution.



Enriched $Li_2{}^{100}MoO_4$ crystal is grown successfully at CUP.

mass : 607.2 g
diameter : 50.0 ~ 51.3 mm

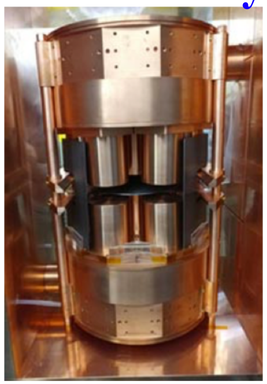




^{100}Mo decay to excited state

- Gamma rays from ^{100}Mo have been measured with HPGe-Array.
- **2νββ** to an excited state is observed !!
- Try to measure $0^+ \rightarrow 2^+$ decay for the first time !!

HPGe-Array



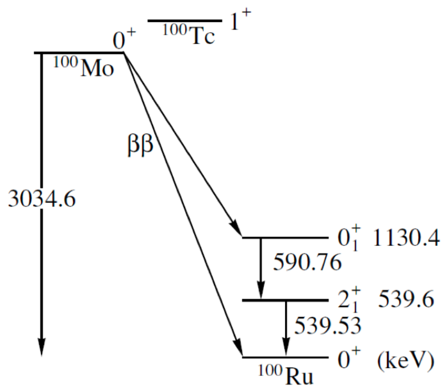
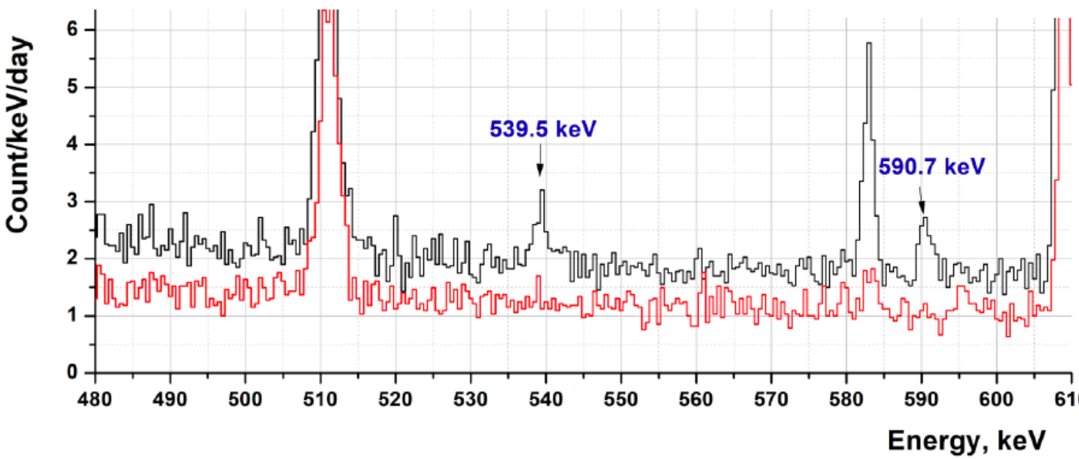


TABLE 1. Best present limits on $2\nu\beta\beta$ decay to the 2_1^+ excited state (limits at 90% C.L.). $E_{2\beta}$ is energy of 0^+ - 2_1^+ transition.

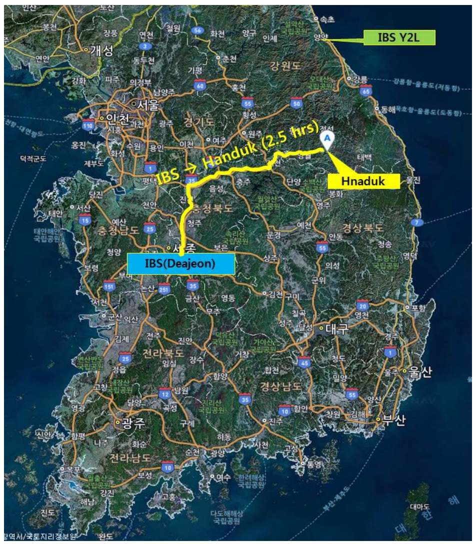
Isotope	$E_{2\beta}$, keV	$T_{1/2}$, y	Theory [23]	Theory [24]
^{48}Ca	3279.4	$> 1.8 \cdot 10^{20}$ [27]	$1.7 \cdot 10^{24}$	-
^{150}Nd	3037.4	$> 2.2 \cdot 10^{20}$ [28]	-	$7.2 \cdot 10^{24}$ [25]
^{96}Zr	2577.6	$> 7.9 \cdot 10^{19}$ [29]	$2.3 \cdot 10^{25}$	$(1.1 - 1.4) \cdot 10^{21}$ [26]
^{100}Mo	2494.9	$> 2.5 \cdot 10^{21}$ [11]	$1.2 \cdot 10^{25}$	$2 \cdot 10^{22}$ - 10^{23}
^{82}Se	2221.4	$> 1.0 \cdot 10^{22}$ [30]	$1.7 \cdot 10^{27}$	$(1.0 - 2.4) \cdot 10^{24}$ [26]
^{130}Te	1991.7	$> 2.8 \cdot 10^{21}$ [31]	$6.9 \cdot 10^{26}$	$(4.2 - 9.1) \cdot 10^{23}$
^{124}Sn	1689.9	$> 9.1 \cdot 10^{20}$ [32]	-	$(5.3 - 6.4) \cdot 10^{24}$
^{136}Xe	1639.3	$> 4.6 \cdot 10^{23}$ [33]	$3.9 \cdot 10^{26}$	$1.6 \cdot 10^{25}$ - $4.8 \cdot 10^{26}$
^{116}Cd	1519.9	$> 2.3 \cdot 10^{21}$ [34]	$3.4 \cdot 10^{26}$	$(2.5 - 5.2) \cdot 10^{24}$
^{76}Ge	1479.9	$> 1.6 \cdot 10^{23}$ [35]	$5.75 \cdot 10^{28}$	$(2.4 - 4.3) \cdot 10^{26}$ [26]



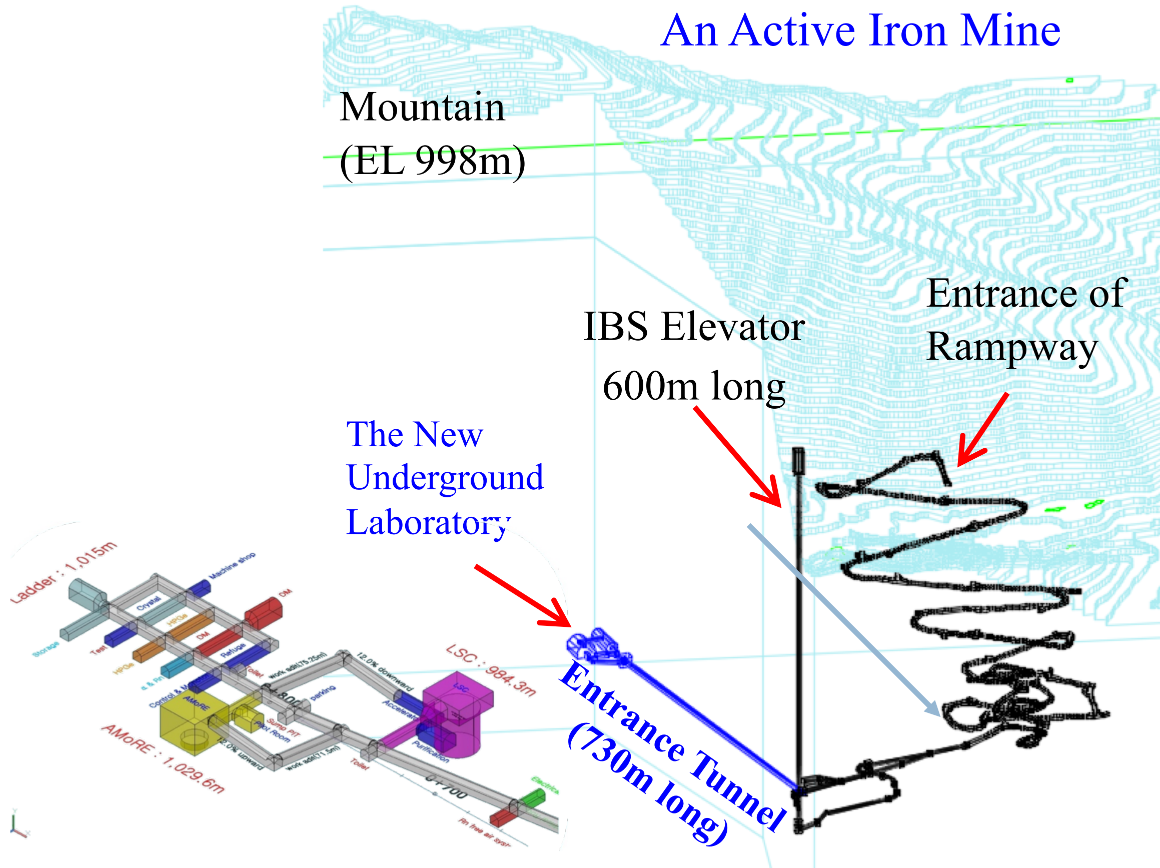
Yemilab for AMoRE-II

Center for Underground Physics

- **Important Concepts**
- **An independent entrance (vertical lift for human) from mine activity.**
- **The construction starts early of 2019 and be completed by end of 2020.**



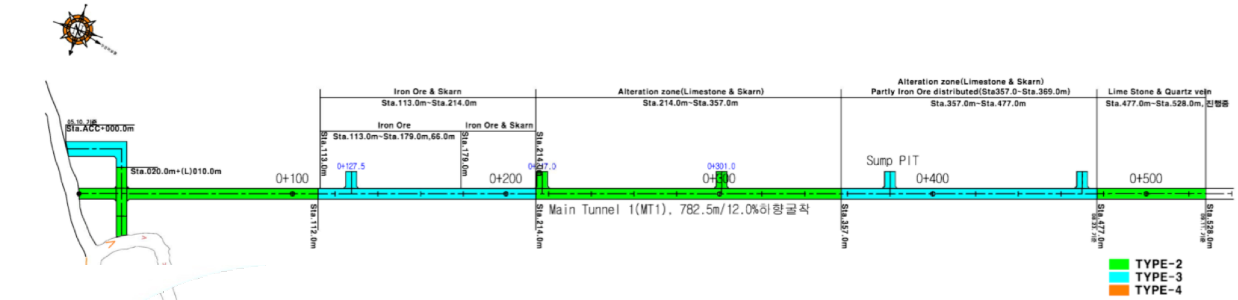
Bird's eye view of Handuk Iron Mine

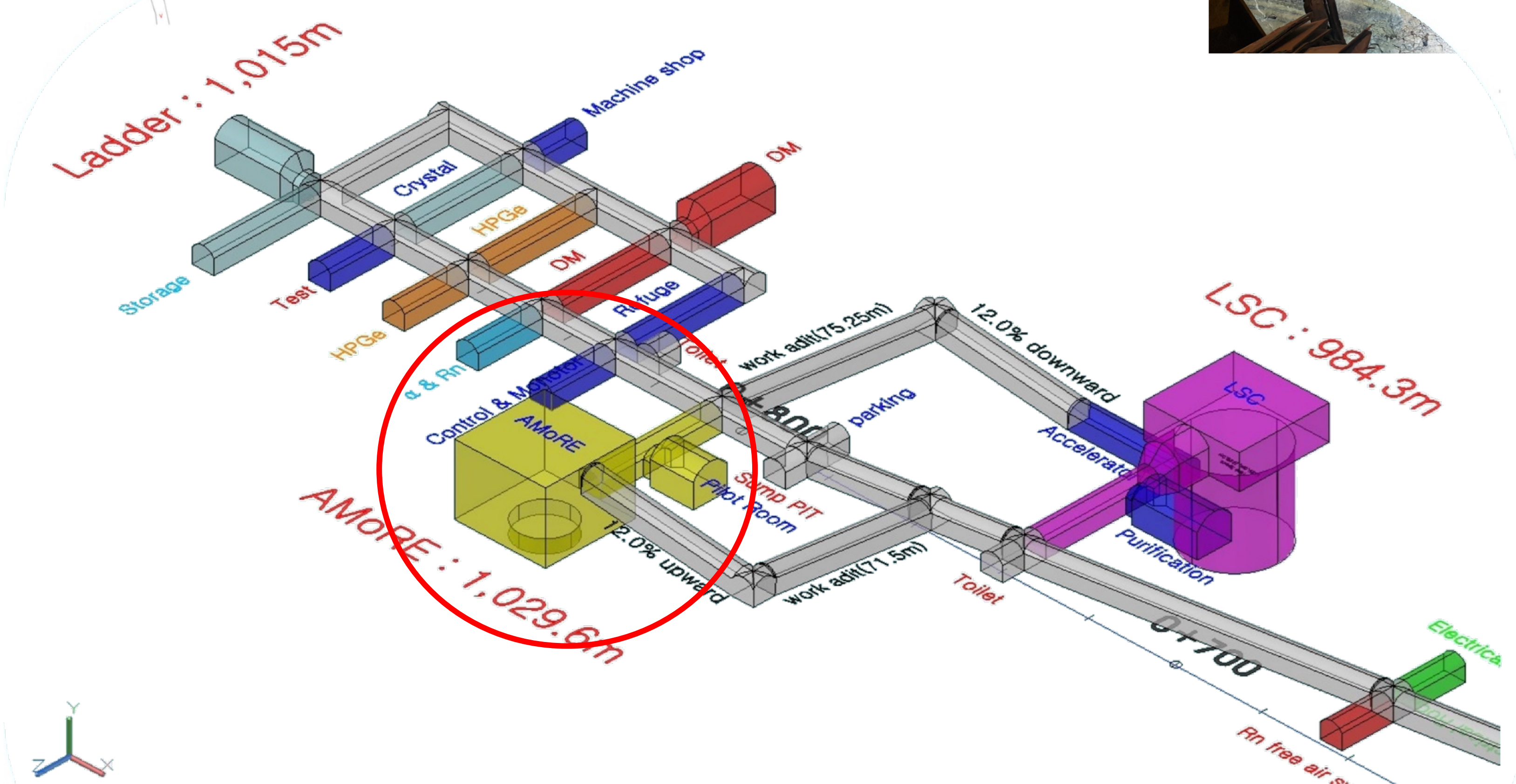


Large (>2000m²), deeper (1100m depth)

The floor plan

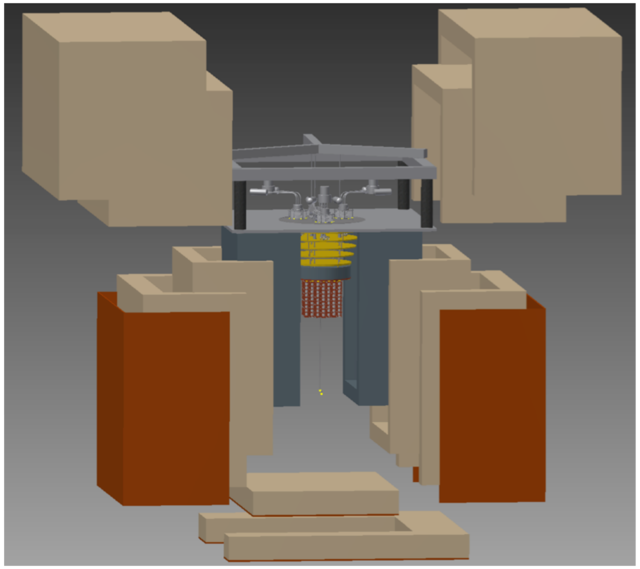
- ~ 600m tunnel is excavated at present.
- 8 experiments with 12 space, 10 utility rooms

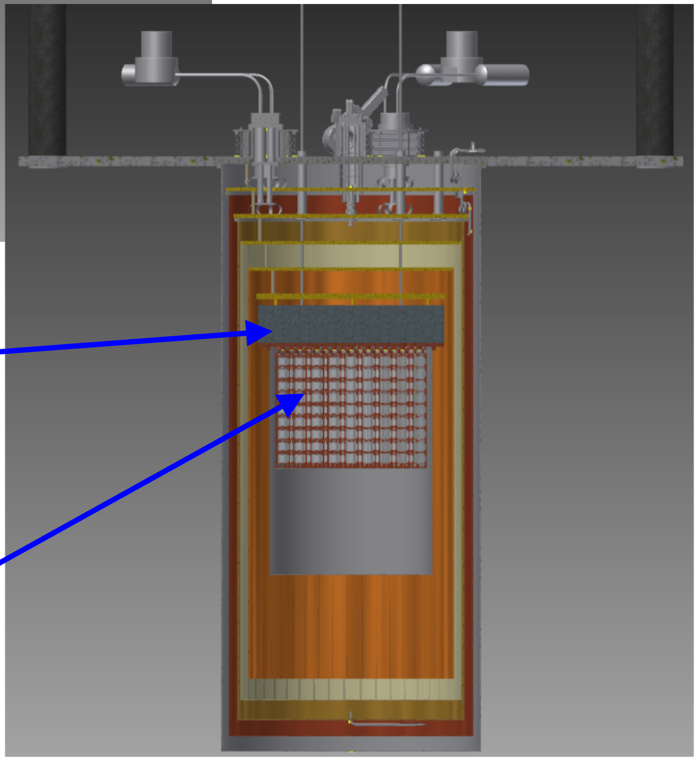




Design for AMoRE-II experiment

Tunnel
(20mx20mx16m(h))



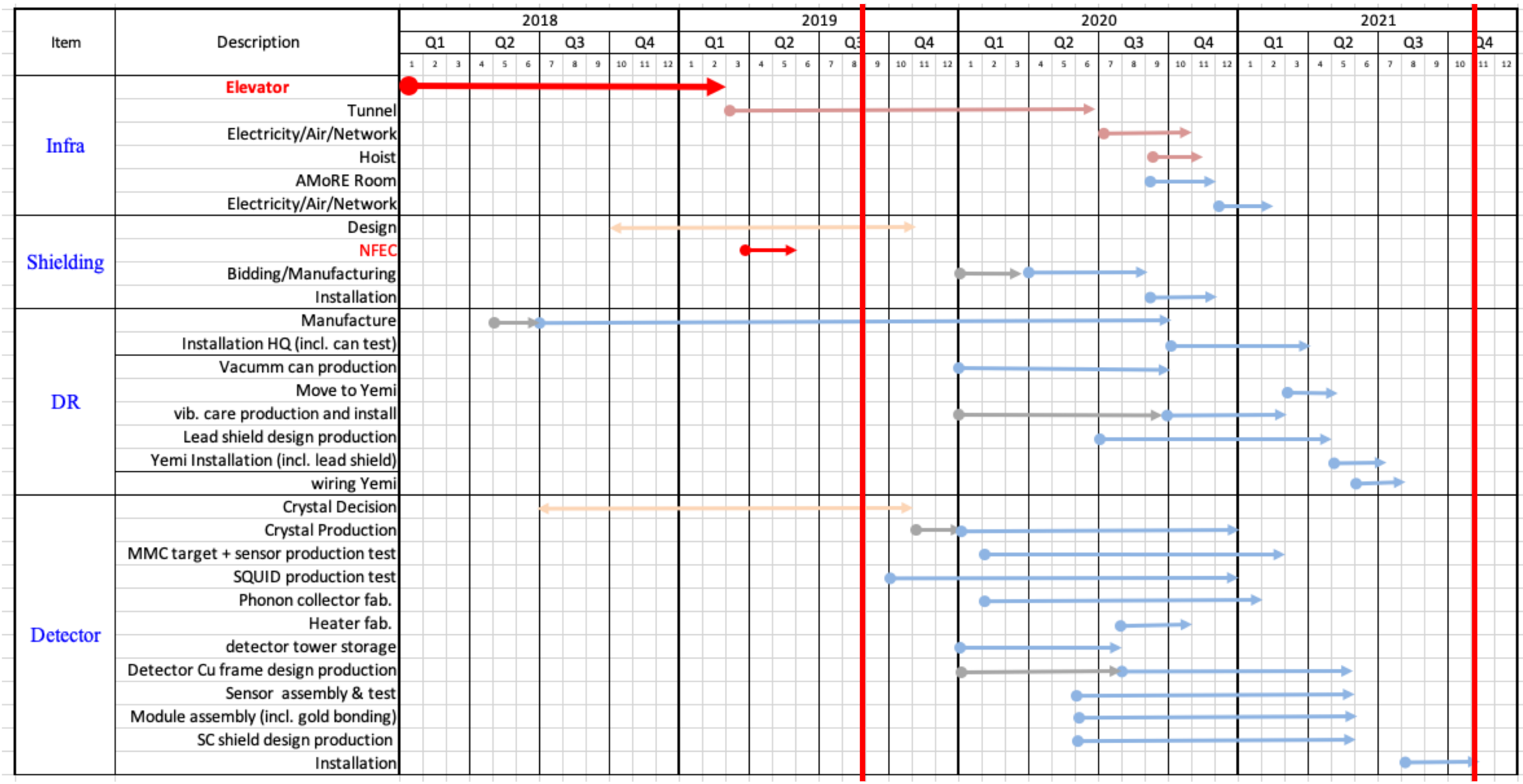


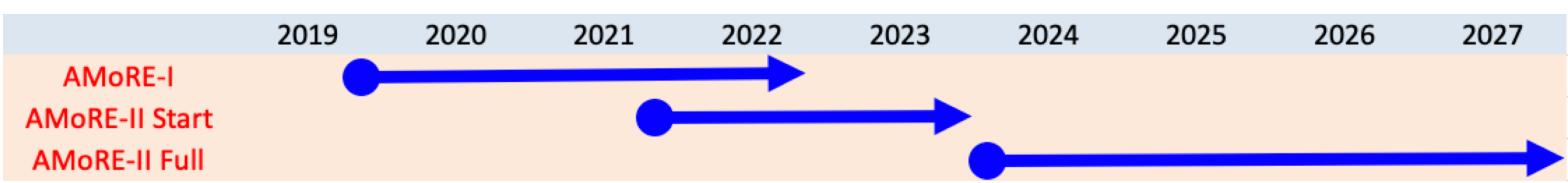
25 cm
Lead

200 kg
crystals

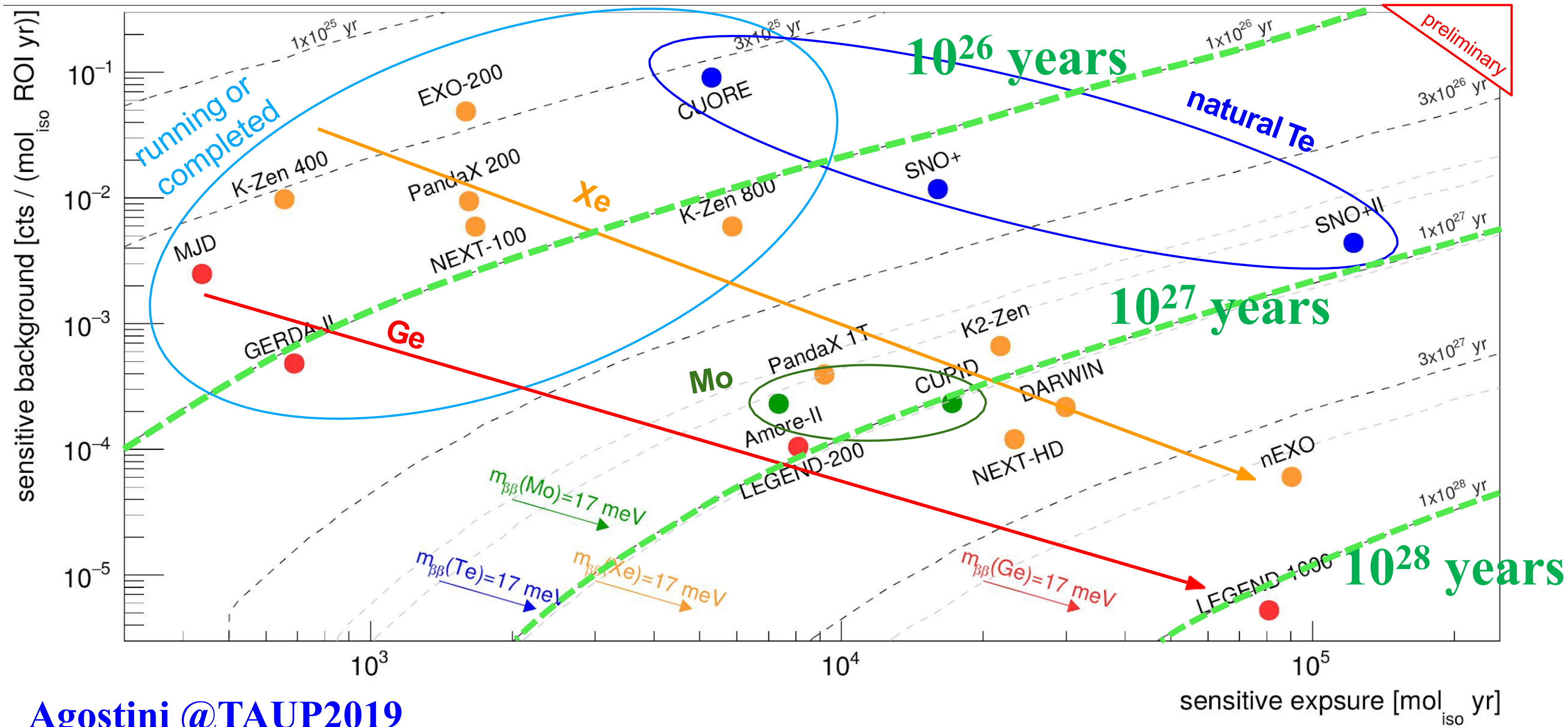
Schedule

Construct AMoRE-II until Oct. 2021, and Upgrade to 100 kg of ^{100}Mo by 2023.





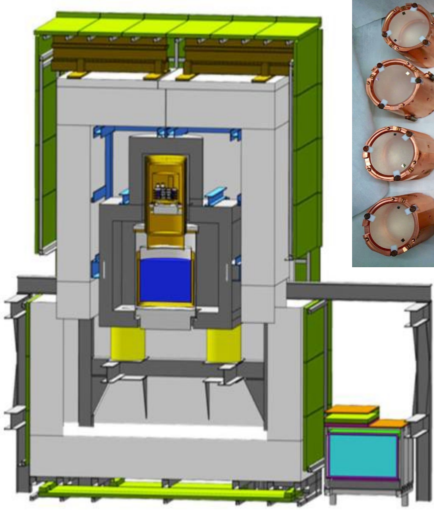
Comparison with other experiments.

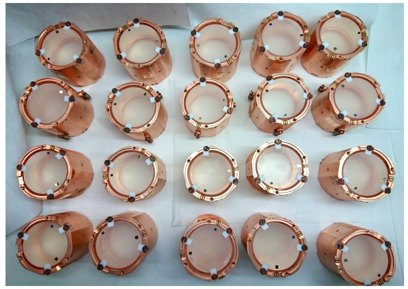


Agostini @TAUP2019

- AMoRE-II is comparable to CUPID, LEGEND-200, KamLAND2-ZEN.
- IBS(CUP) has a MOU with INFN(Gran Sasso) to collaborate between AMoRE and CUPID.

CUPID-Mo



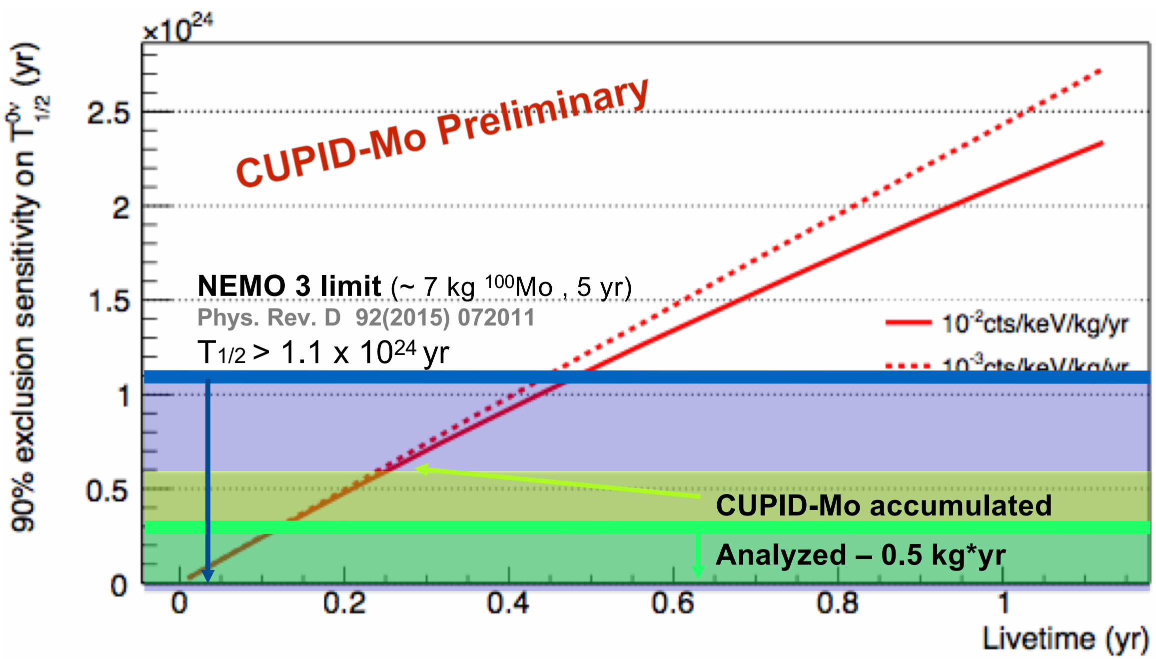


Operated at LSM by the EDELWEISS/CUPID-Mo collaborations, follow up of the LUMINEU experiment. 20 x ~210 g cylindrical enriched Li_2MoO_4 crystals

Schmidt @TAUP2019

$T_{1/2} > 3*10^{23}$ yr at 90% C.L with ~0.5 kg*yr exposure

(~0.27 kg*yr of ^{100}Mo), 81% signal acceptance



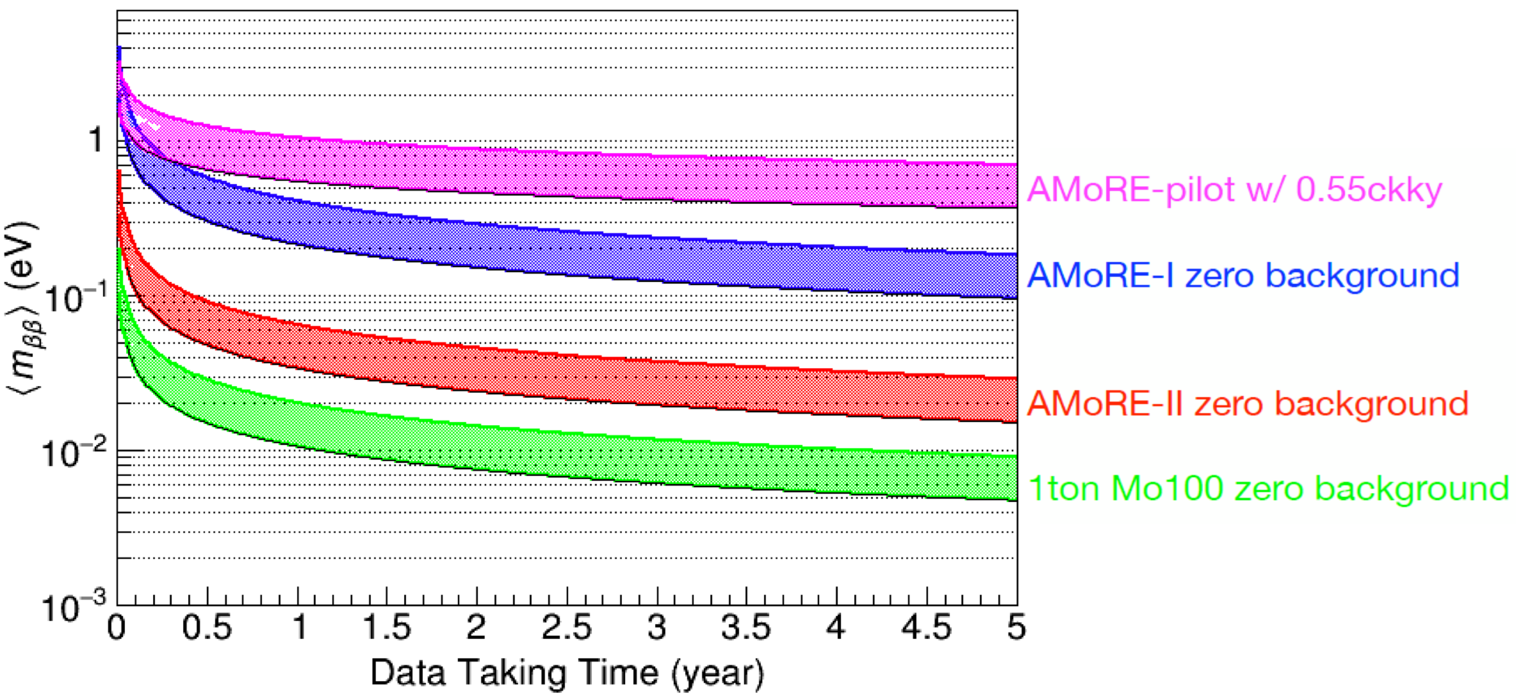
CUPID-Mo is similar to AMoRE and will be better to NEMO first.

Sensors are different; NTD vs MMC

Future

Modular expansion is possible.
After AMoRE-II, ton scale experiment can be done. ~ CUPID 1ton.

CUPID-Mo experiment at LNGS is a competitive project.
CUPID-Mo & AMoRE will collaborate for future combination in a way similar to Gerda and Majorana collaboration.



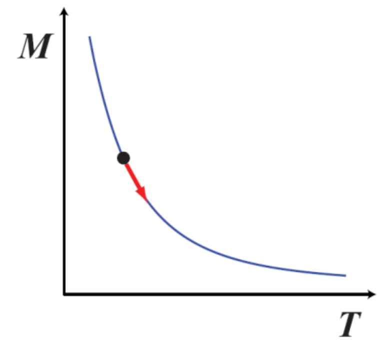
Summary

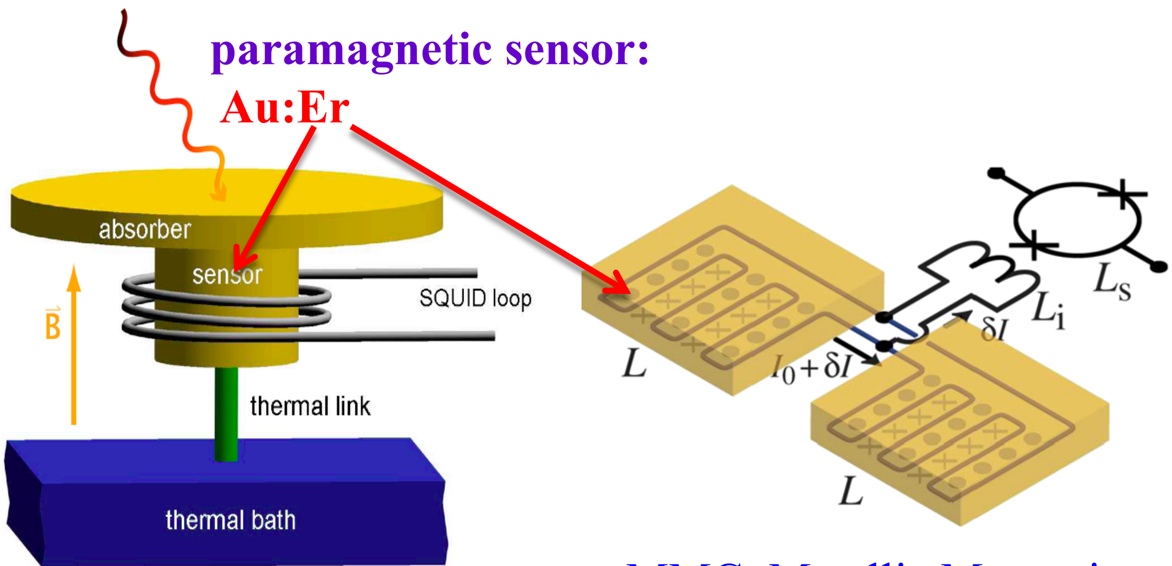
- AMoRE-II aim to be sensitive to 10^{27} year range for ^{100}Mo isotope. AMoRE-Pilot demonstrated detector performance and identified the background sources. Collaborative work with CUPID-Mo group is anticipated.
- AMoRE-II construction began and will be installed by end of 2021.
- AMoRE-II is the largest scale bolometer DBD experiment with concrete plan.
- Construction of Yemilab for AMoRE-II is going well.
- The LT technology for underground physics are developed and can be applied to other experiments, such as Low mass DM or SIMP search.

Thermal detectors at low Temp. for AMoRE

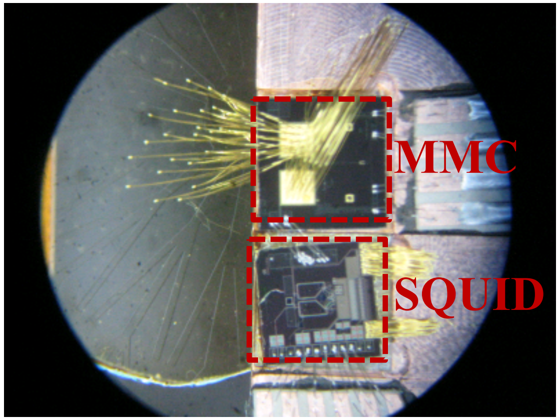
- Particle interaction is detected through a temperature change at mK temperature.

Energy (Heat) absorption
→ Change in Temperature in an absorber
→ Change in Magnetization in a paramagnetic alloy(Au,Ag:Er) in a constant magnetic field
→ Induced current measured with a SQUID.



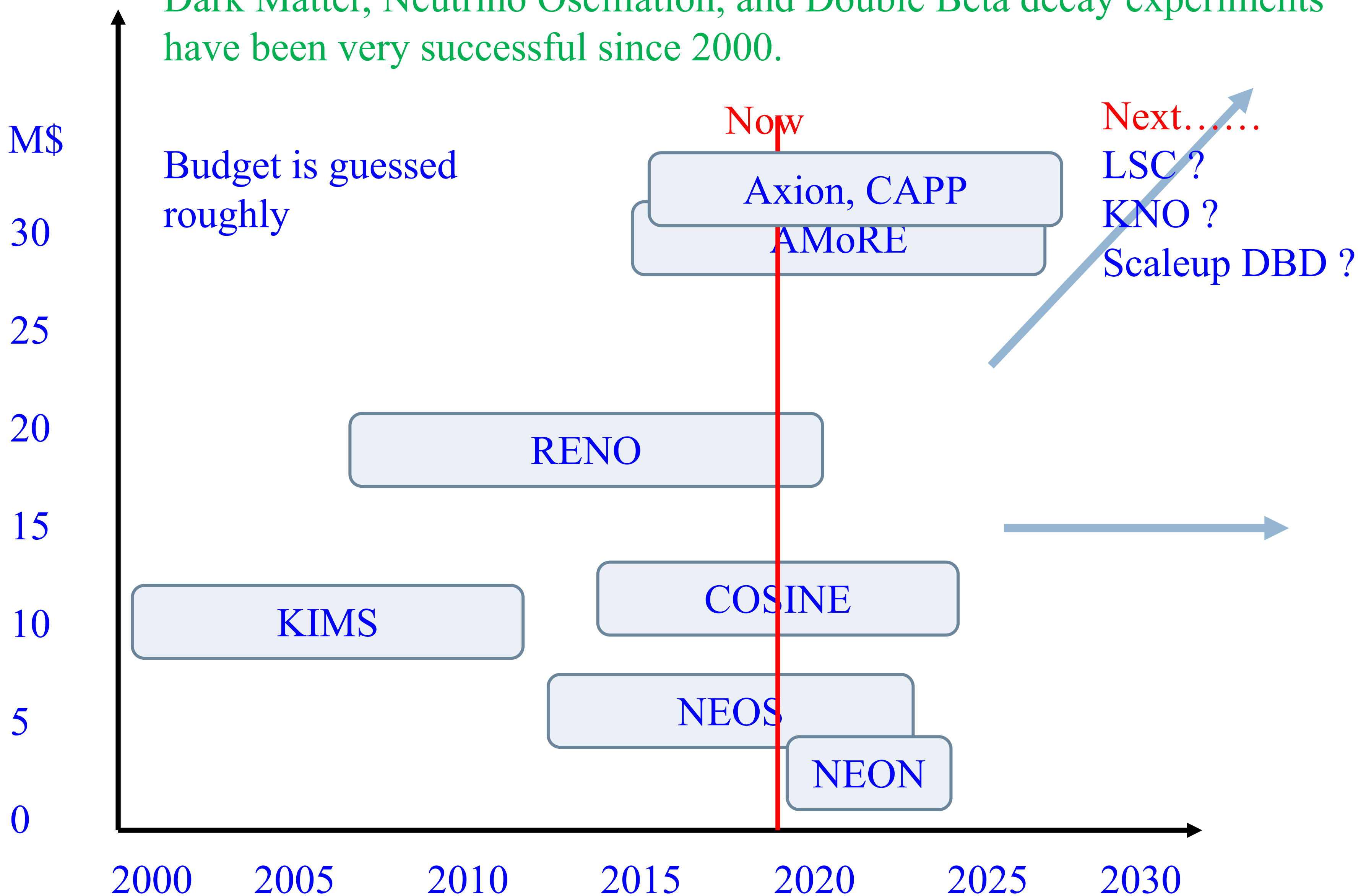


MMC: Metallic Magnetic Calorimeter



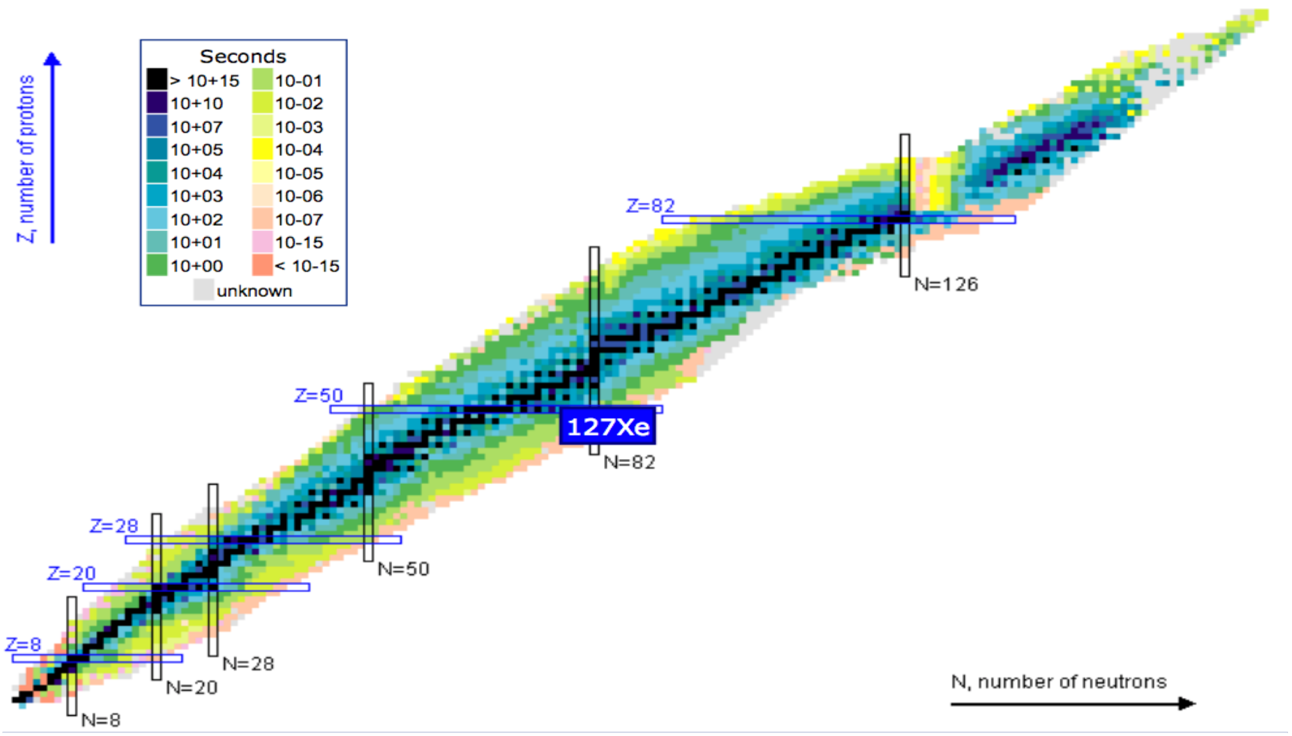
Non-accelerator Projects in Korea

Dark Matter, Neutrino Oscillation, and Double Beta decay experiments have been very successful since 2000.



Nuclear Chart

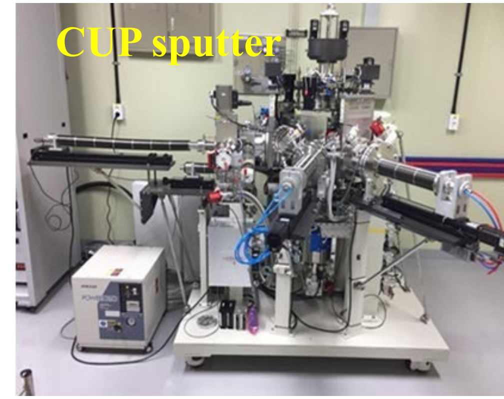
- How many nuclei are dangerous among ~ 3000 nuclei ? Go through all the nuclei to find potential dangerous nuclei.



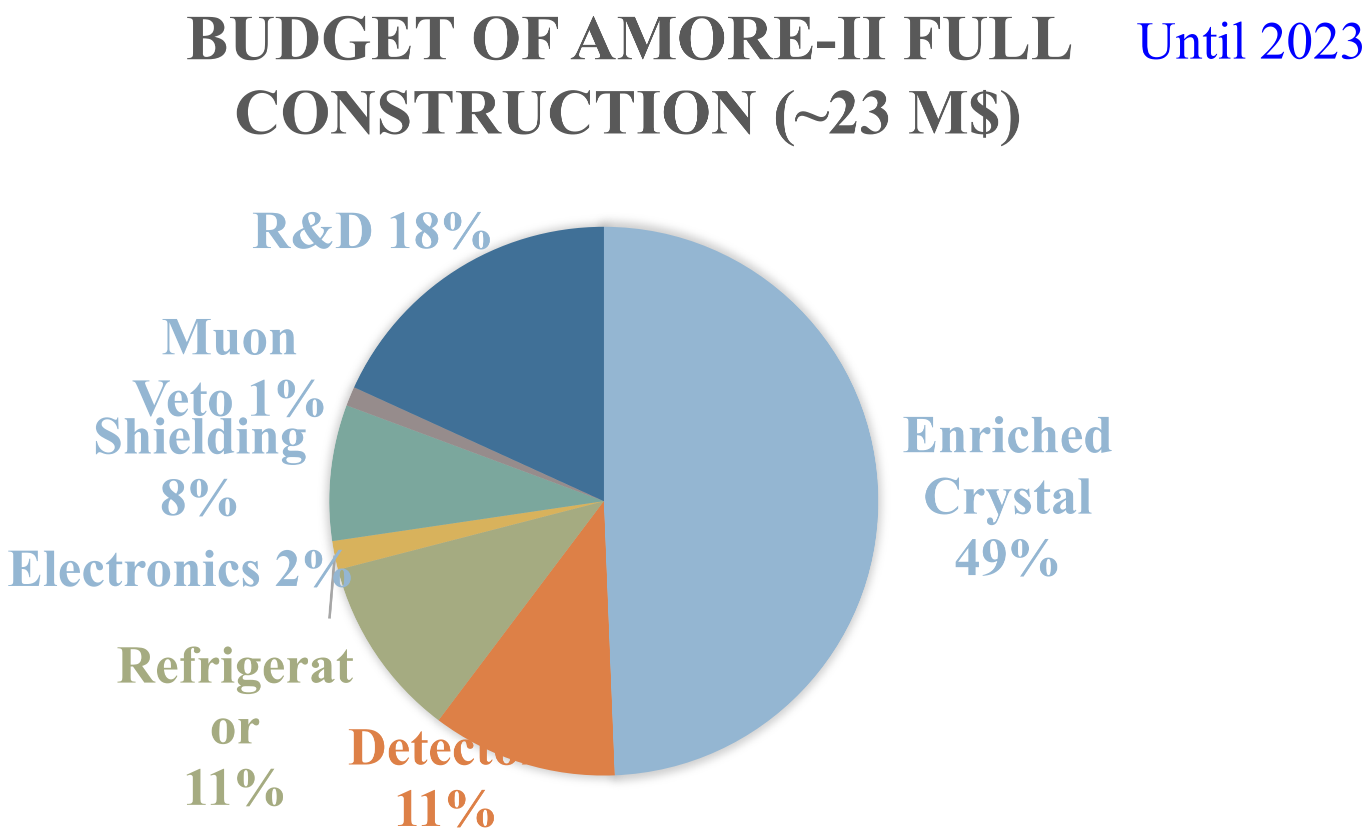
Fab facility for MMC @ CUP

CUP produces MMC sensors.
Squids are provided by our collaboragtors in Heidelberg group.

Fabrication facility	
Metal thin film system	Metallic magnetic calorimeter sputtering system
	Radon free environment e-beam evaporator system
Pattern lithography equipment	Maskless Micro Pattern Generator
	Dual Focus Micro-Pattern Mask Aligner
Metal film etching equipment	ICP-RIE (Inductively Coupled Plasma- Reactive Ion Etching) system
Insulation film growth equipment	LT-PECVD (Low-Temperature Plasma-enhanced chemical vapor deposition)
	Anodizing unit
Thick Au layer fabrication	Simple electroplating unit
Chip dicing	Dicing saw
Resist coating unit	Spin coating system Hot plate
Fabrication step verification	3D Measuring Laser Microscope
	Optic Microscope
Collector annealing system	Rapid thermal process system



Budget


BUDGET OF AMORE-II FULL CONSTRUCTION (~23 M$)
Until 2023
R&D 18%
Muon Veto 1%
Shielding 8%
Electronics 2%
Refrigerator 11%
Detector 11%
Enriched Crystal 49%

Work force for AMoRE-II

- Overall Planning — Yeongduk Kim, Hongjoo Kim
- LT — Yong-Hamb Kim
  - Crystal Tests — Jungho So, Seungcheon Kim
  - DR & Cryostat Design — Chanseok Kang
  - MMC & SQUIDS — Hejin Lee, Sora Kim, Jinha Jeon, Sanggon Kim
- Crystal — Moohyun Lee
  - Crystal growing — Sejin Na, Daeyon Kim, Jukyung Son
  - Purification — Olga, GeonA Sin
  - NIIC crystals — Schlegel
- Infra
  - Cryostat, Shielding — Chanseok Kang
  - Clean Room — Kangsoon Park
  - DAQ, Muon Veto — Jaison Lee
- Simulation — Eunjoo Jeon
- Data Analysis — Yoomin Oh
  - Developers — Kazalov, Youngsoo Yoon

\+ 13 students.

Ultra-pure Crystal R&D

Enriched $Li_2{}^{100}MoO_4$ crystal grown at CUP

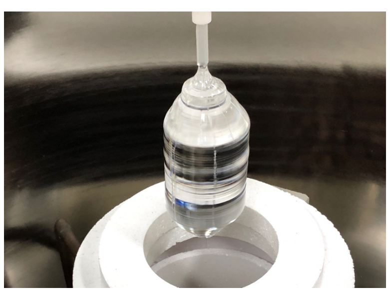
We have grown an enriched LMO crystal without any purification to check what level of contamination would be reached by only from crystal growing process.

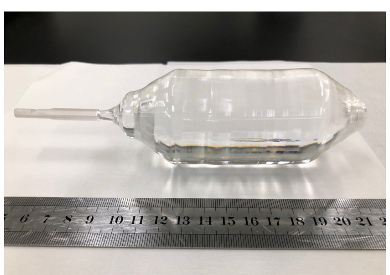
$Li_2CO_3 + MoO_3 \rightarrow Li_2MoO_4 + CO_2$

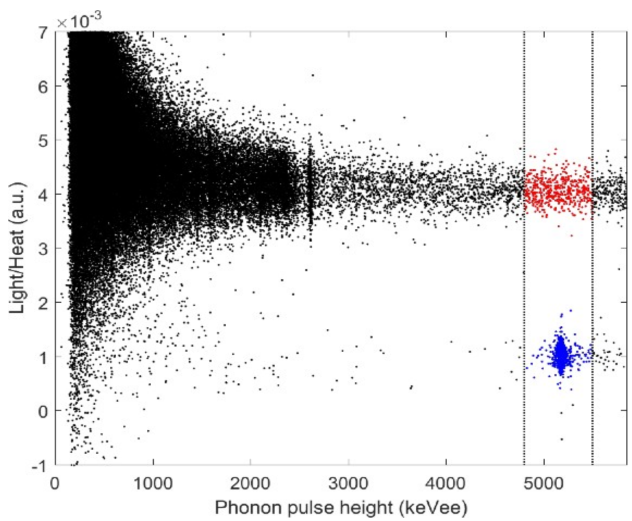
- Natural LMO tested at wet dilution refrigerator.
- 300 g crystal + MMC
- Light/Heat ratio gave DP~12.
- A problem of Au foil attachment. After a few months, the Au phonon collector seems unstable.

CZ02-L1803E

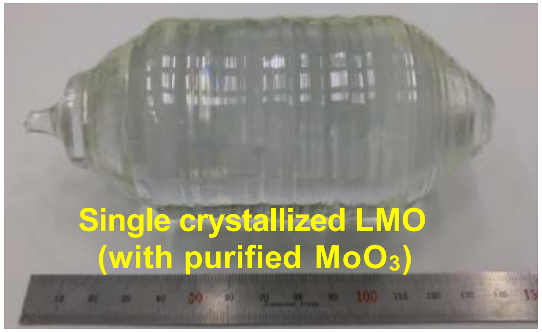
1. mass : 607.2 g (including seed)
2. diameter : 50.0 ~ 51.3 mm
3. Total length : 136.0 mm
4. Body length : 64.4 mm







Purities of CUP grown LMO crystals



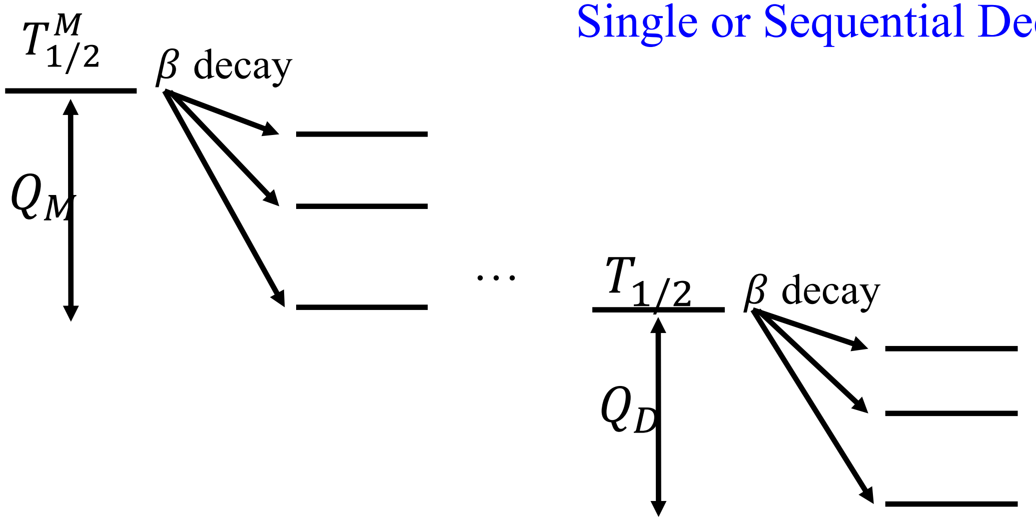
Element		Al	K	Ba	Sr	Pb	Th	U
No.	sample	(ppb)	(ppb)	(ppb)	(ppt)	(ppt)	(ppt)	(ppt)
Single crystallized natural LMO (w/o purification)								
CMD 113	L1701-1	48.1	347.3	5.445	<15	<300	<15	<16
CMD 113	L1701-2	21.7	449.2	5.401	75	<300	<15	<16
Single crystallized natural LMO (MoO_3 sublimed)								
CMD163.1	CZ02-L1706-T	<11	38	7.579	<50	<100	<8	<8
CMD163.2	CZ02-L1706-B	<11	83	9.617	<50	<100	<8	<8
Double crystallized natural LMO (MoO_3 sublimed)								
CMD191.1	CZ02-L1801-T	<11	<30	4.744	<50	<100	<8	<8
CMD191.2	CZ02-L1801-B	<11	<30	5.814	<50	<100	<8	<8
Enriched LMO (w/o purification)								
CMD00236.2	CZ02-L1803E-T	1437	<40	6.82	<31	<225	<6	<6
CMD00236.3	CZ02-L1803E-B	1484	<40	7.07	<31	<225	<6	<6
CMD00236.1	CZ02-L1803E-RM	3824	249	28.58	4110	12290	71	472

- Li2MoO4 crystal is pure enough for AMoRE-II.
- CUP can purify & Grow the crystals. Another provider for satisfactory crystal is AMoRE collaboration.

"Events" dangerous to DBD

- **There is no localized "event" with energy release > 2MeV other than nuclear decay, passing muons, and entering hadrons and gammas.**
- 2 conditions to be "dangerous nuclei" for ^{100}Mo experiment.
  1) 30 days < $T_{1/2}^{M}$ < 10^{11} years.
  2) β *decay with* Q_M or Q_D > 3.02MeV
- Go through all nuclei including isomers.

Single or Sequential Decay

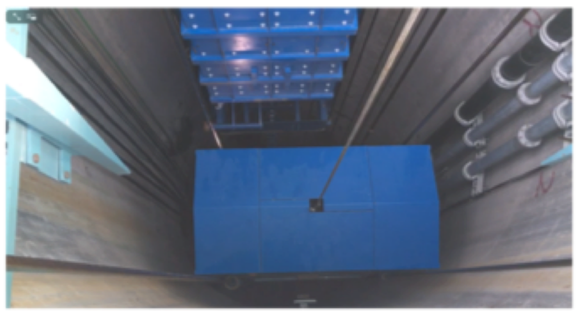


Results

El	Decay	$T_{1/2}$	Q	Mother	Chain	Comment
			MeV	N/A		
^{26}Al	EC	$7.4x10^5$y	4.004	N/A		Long lifetime
^{56}Co	EC	0.21y	4.567	N/A		Short lifetime
^{88}Y	EC	0.29y	3.623	^{88}Zr (0.23 y)		Short lifetime
^{106}Rh	B-	30s	4.004	^{106}Ru(1.02y)		
^{126}Sb	B-	12.5d	3.670	^{126}Sn($2.3x10^5$y)		Long lifetime
^{146}Eu	EC	4.61d	3.878	^{146}Gd (0.13 y)		Short lifetime
^{208}Tl	B-	3.05m	4.999	^{228}Th (1.91 y)	Th232	Main
^{209}Tl	B-	2.16m	3.970	^{233}U(159200y)	U233	2.1% branching
^{210}Tl	B-	1.3m	5.482	^{226}Ra(1600y)	U238	0.02% branching
^{214}Bi	B-	19.9m	3.269	^{226}Ra(1600y)	U238	Main

- Only Thorium and Uranium natural radioactivity are dangerous for Q> 3.02MeV. → Great advantage to run ^{100}Mo!
- ^{110m}Ag(3010.5 keV) doesn't contribute for Mo experiment.
- Cosmogenic excitation is negligible after 1 year at underground.

Construction



Background Modeling & Reduction

Active components harmful at ROI are identified.