Status of AMoRE

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- **AMoRE goals & collaboration**
- **$^{40}Ca^{100}MoO_4$ crystal scintillators**
- **Cryogenic set-up & underground lab**
- **Monte Carlo simulation**
- **Current status & prospects**

AMoRE goals

(**A**dvanced **Mo**-based **R**are process **E**xperiment)

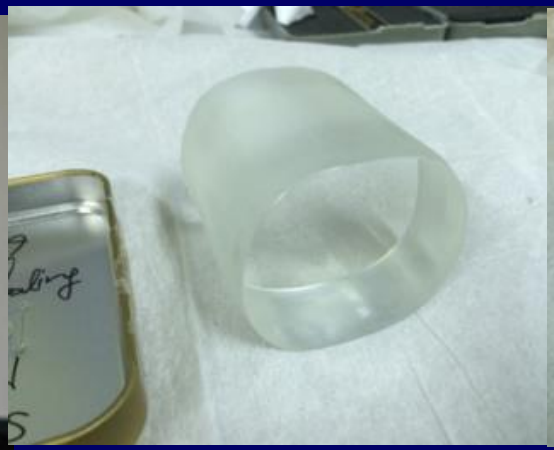
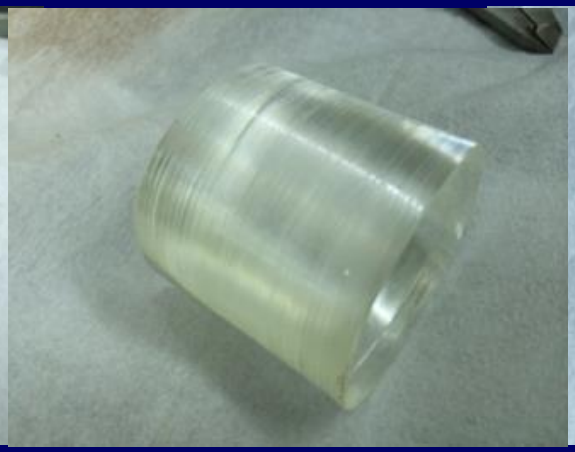
- Search for $0\nu2\beta$ decay of ^{100}Mo by using cryogenic $CaMoO_4$ scintillating bolometers on the level of the inverted hierarchy of neutrino mass
- Search for dark matter (WIMP)

3 steps:	$\lim T_{1/2}$
1. AMoRE pilot: ~ 1 kg of $^{40}Ca^{100}MoO_4$	~ 10^{24} yr
2. AMoRE 10: ~ 10 kg	~ 2×10^{25} yr
3. AMoRE 200: ~ 200 kg	~ 4×10^{26} yr

Collaboration

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

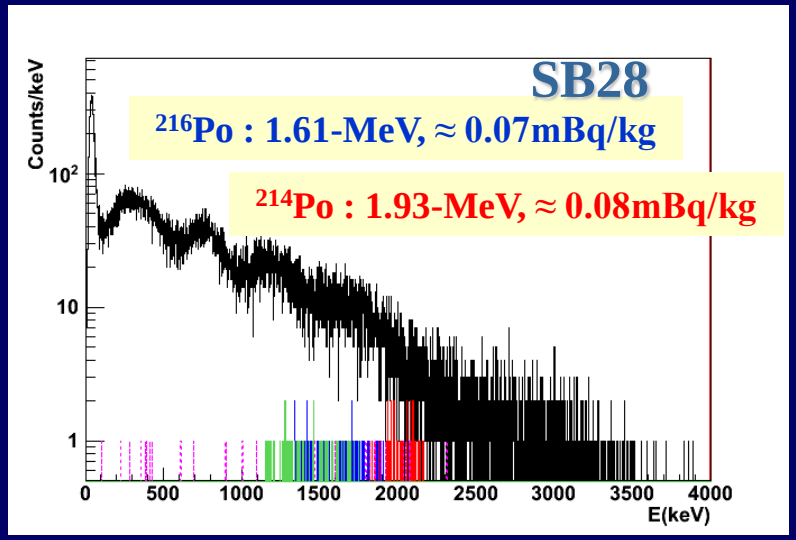
- **SB28**
  196 g
- **SB29**
  390 g
- **S35**
  256 g
- **SS68**
  350 g


One more crystal boule is already produced (SB81)

Radiopurity level of $^{40}Ca^{100}MoO_4$

(AMoRE 10 requirement: <0.05 mBq/kg for ^{226}Ra and ^{228}Th)



Fast β-α sub-chain in ^{226}Ra chain

^{214}Bi (Q_β = 3.27 MeV) → ^{214}Po (Q_β =7.83 MeV)

Fast α - α sub-chain in ^{228}Th chain

^{220}Rn (Q_β = 6.41 MeV) → ^{216}Po (Q_β = 6.91 MeV)

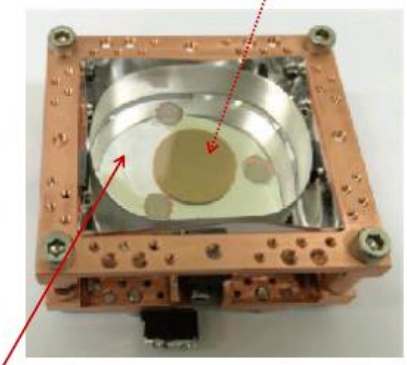
Radiopurity of already produced $^{40}Ca^{100}MoO_4$ crystals (mBq/kg)

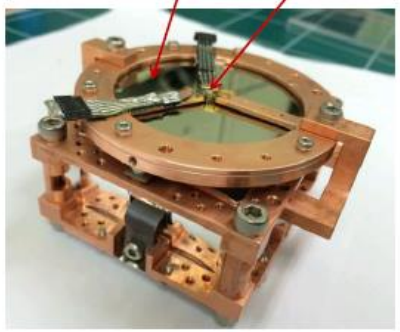
Chain	^{232}Th (^{228}Th)	^{235}U (^{227}Ac)	^{238}U (^{226}Ra)
S35	0.64	1.6	4.5
SB28	0.07	-	0.08
SB29	0.032	0.67	0.23
SS68	0.027	0.24	0.062

Purification of Mo and Ca, recovery of Ca and Mo from $CaMoO_4$

R&D of Mo and Ca purification and recovery of Ca and Mo from $CaMoO_4$ are in progress

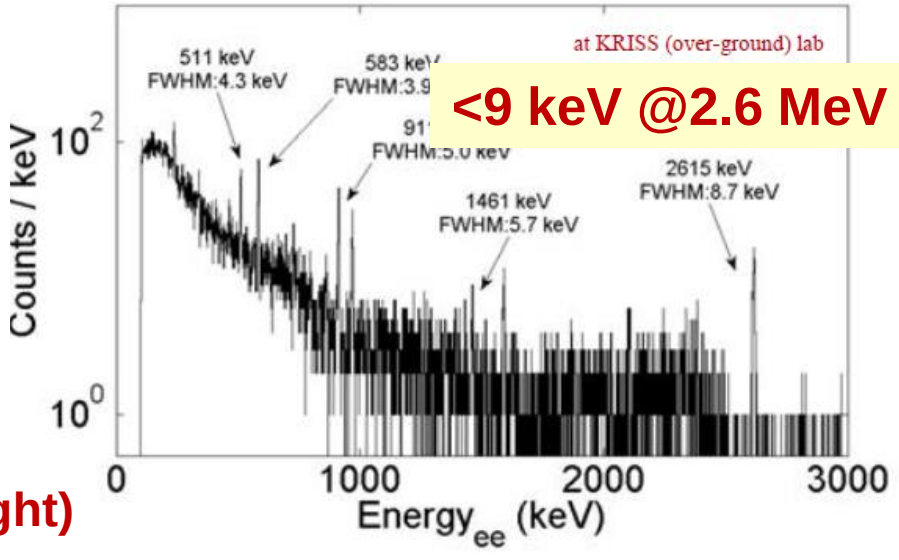
MMC cryogenic technique for AMoRE



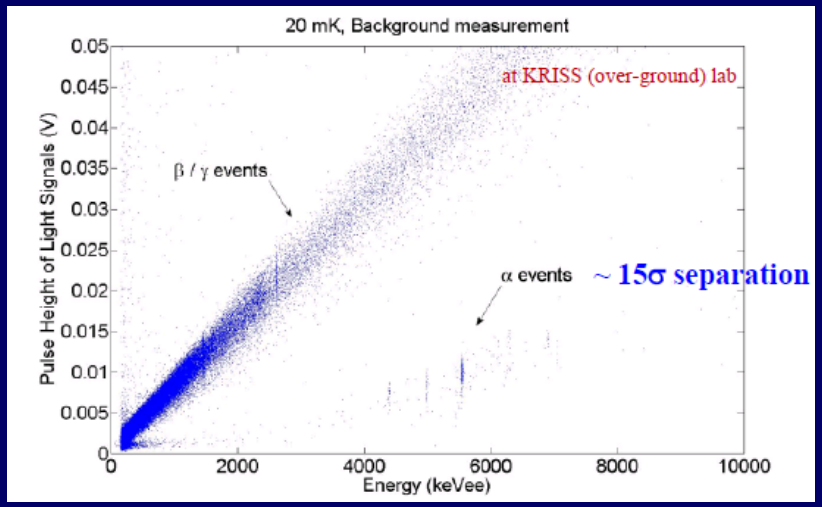


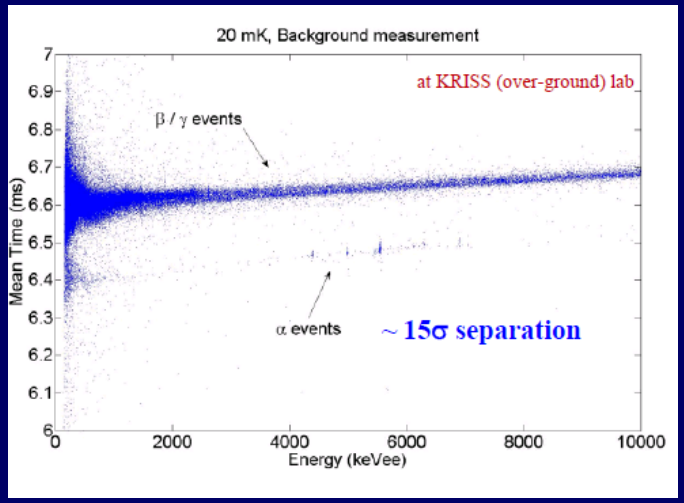
196 g $^{40}Ca^{100}MoO_4$
(doubly enriched crystal)

rise-time: ~ 0.5ms (heat), ~0.2 ms (light)



<9 keV @2.6 MeV





Excellent α/β separation

Yangyang(Y2L) Underground Laboratory

(Upper Dam)

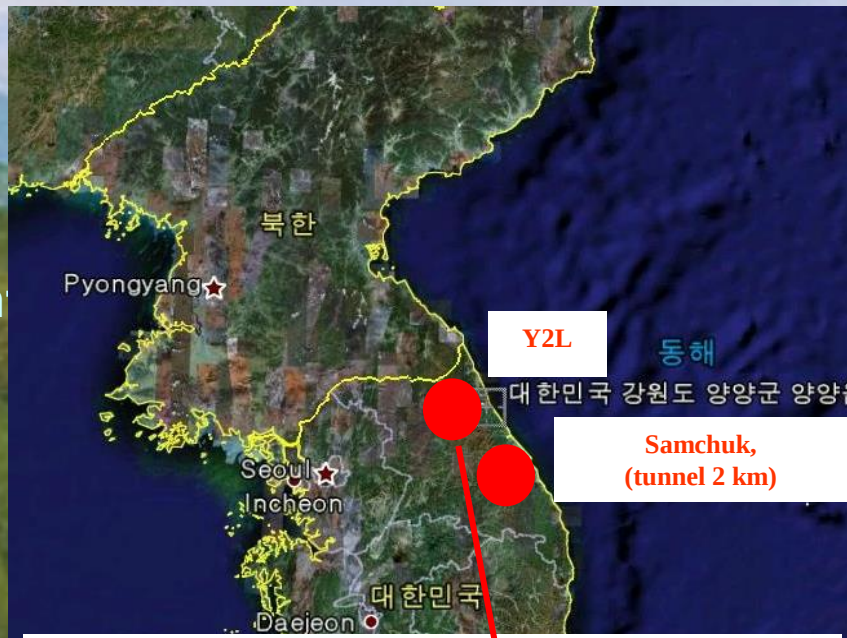
Korea Hydro & Nuclear Power Co.
Yangyang Pumped Storage Power Plan

1000m

700m

(Power Plant)

양양양수발전소

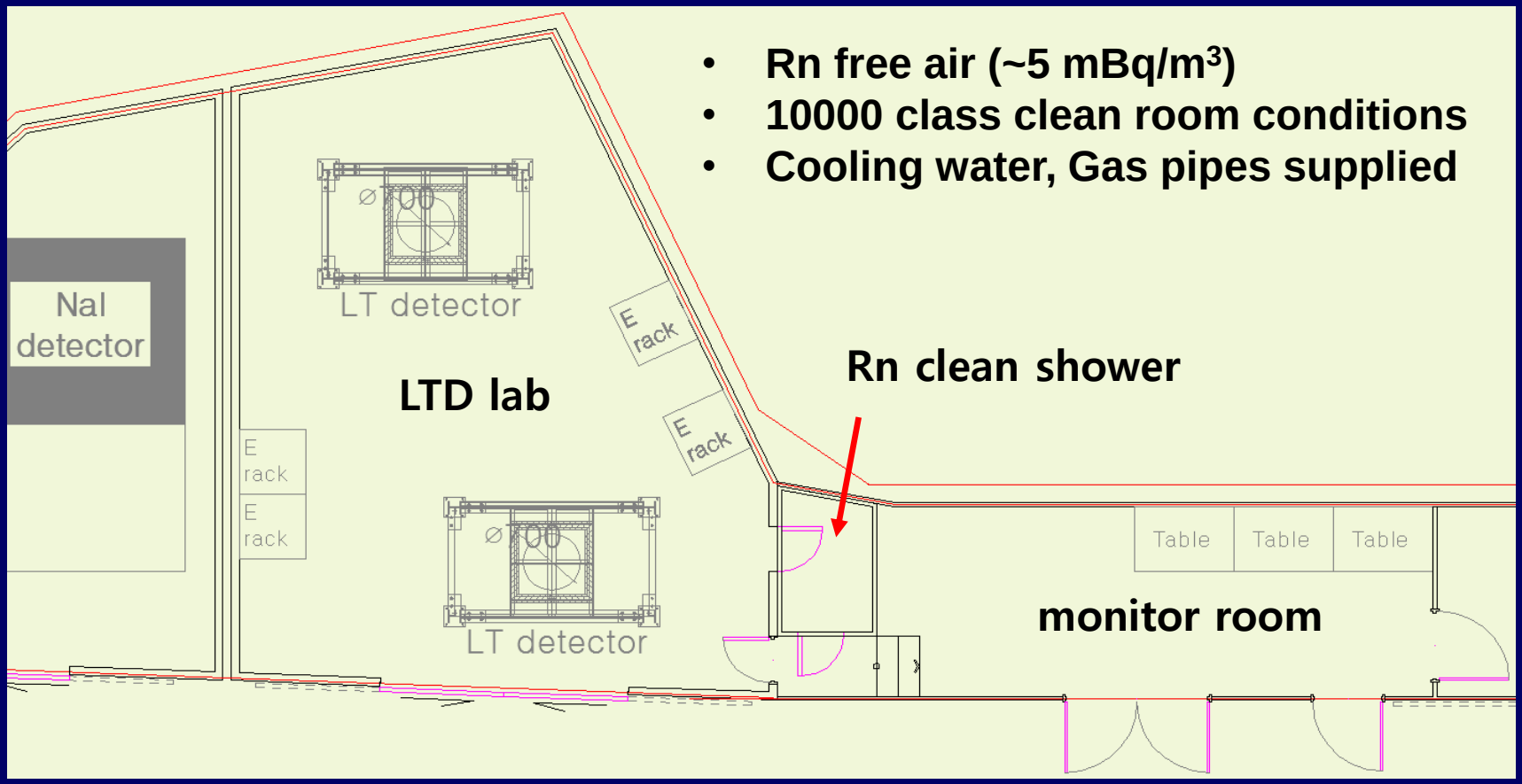


KIMS (Dark Matter Search)

AMoRE (Double Beta Decay Experiment)

Minimum depth : 700 m / Access to the lab by car (~2km)

Experimental space in A5 at YangYang

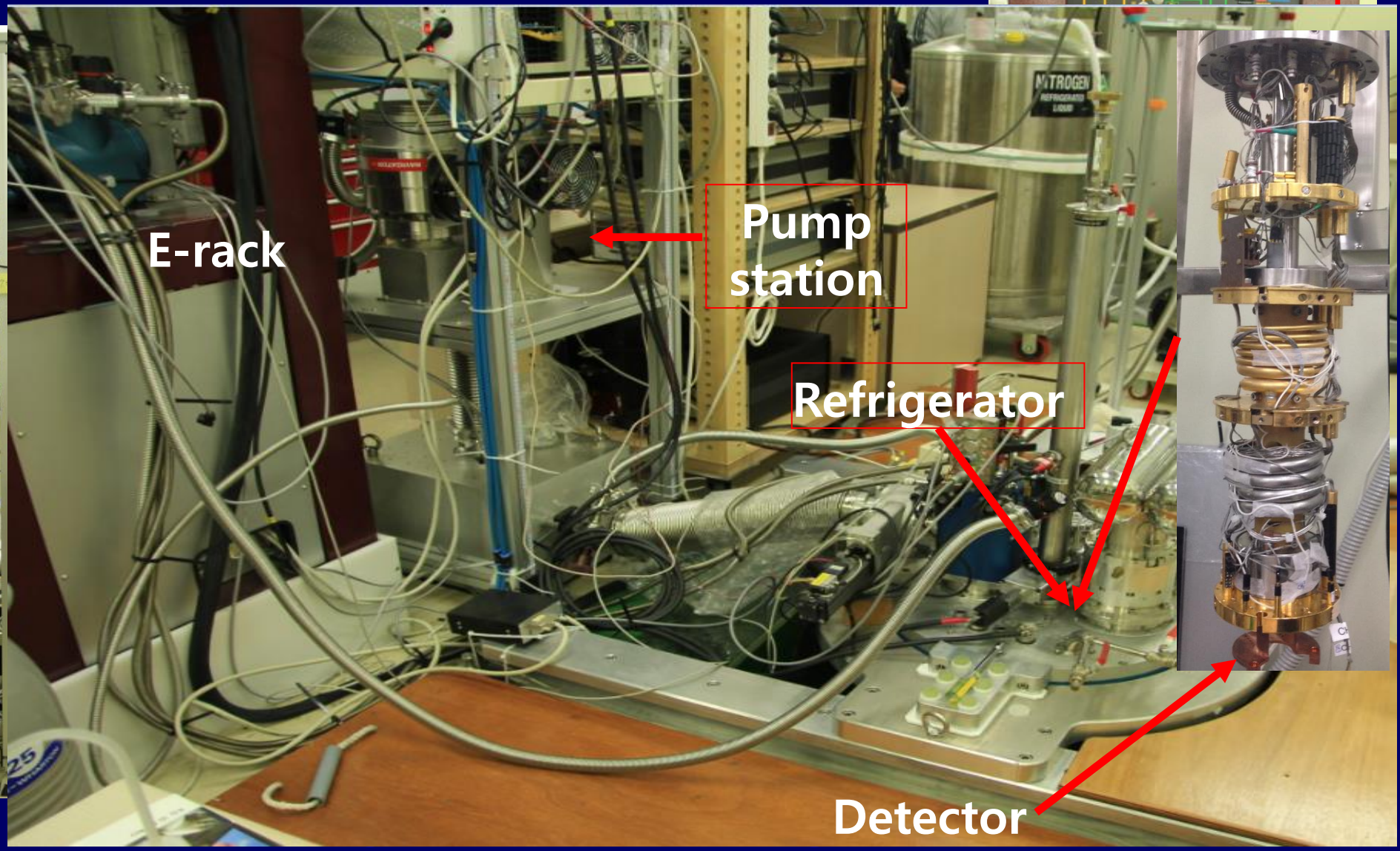


- Rn free air (~5 mBq/m^3)
- 10000 class clean room conditions
- Cooling water, Gas pipes supplied

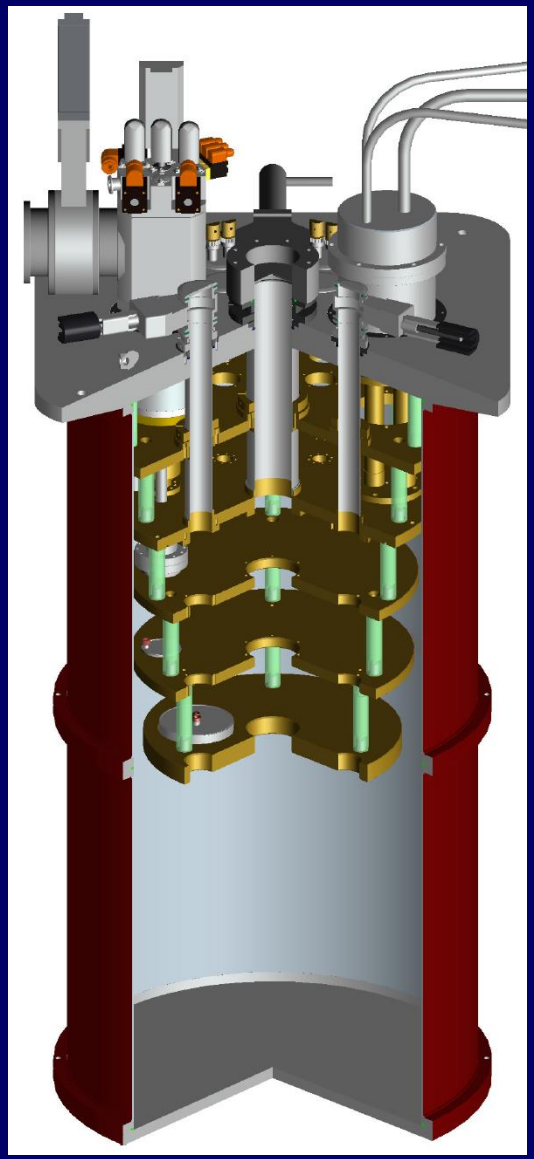
Area : lab (~ 43 m^2), monitor room (~ 16 m^2)

Rn clean shower (2 persons, 2 min)

Overall arrangement of cryogenic set-ups



Cryostat for AMoRE pilot (→ AMoRE 10)



Cryogen-free Dilution Refrigerator for AMoRE 10

Leiden Cryogenics (Netherland)

-Pulse Tube based CFDR

-Model : CF-1200-Maglev

-Minimum Temperature : <10 mK

-Cooling-power : 1.4 mW at 120 mK

-Cool-down time : ~ 20 hours with LN_2 precooling without any extra load

-Install and test cooling : Mid October 2014
(delay: beginning of December 2014)

Monte Carlo simulation (GEANT4)

Background source	Activity [μBq/kg]	Bg [10^{-4} cnt/keV/kg/yr]	Bg reduced by PSD [10^{-4} cnt/keV/kg/yr]
Tl-208, internal	10 (^{232}Th)	0.36	0.36
Tl-208, in Cu	16 (^{232}Th)	0.22	0.22
BiPo-214, internal	10	0.11 1)	≤ 0.01
BiPo-214, in Cu	60	1.8 1) 2)	≤ 0.18
BiPo-212, internal	10 (^{232}Th)	0.08 1)	≤ 0.01
BiPo-212, in Cu	16 (^{232}Th)	0.36 1) 2)	≤ 0.04
Y-88, internal	20	0.19	0.19
Random 2ν2β	8.7×10^{3} 3)	3.1 3)	1.2
Total		**6.2**	**≤ 2.2**

1) Can be reduced x0.1 by alpha/beta PSD

2) Can be reduced by Teflon coating of Cu (to remove surface α)

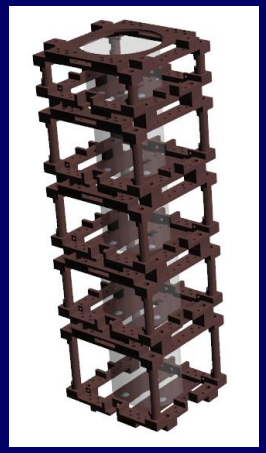
3) Can be reduced by pulse-shape discrimination

Muon background @Y2L : ~1.4e^{-4} cnt/keV/kg/yr

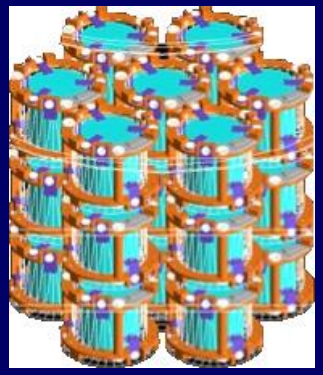
Current status

- Five $^{40}Ca^{100}MoO_4$ crystal (1.5 kg) scintillators are produced and tested (one crystal should to be tested soon)
- Radiopurity of 3 crystals satisfies the AMoRE 10 requirements
- The Yangyang underground lab is extended (+ two clean rooms 200 m^3, shield and supporting structure for cryostat, radon free atmosphere)
- Low background cryostat is expected to be delivered this week
- Data acquisition system and electronics are ready
- Start of AMoRE pilot run (1.2-1.5 kg of $^{40}Ca^{100}MoO_4$): January 2015

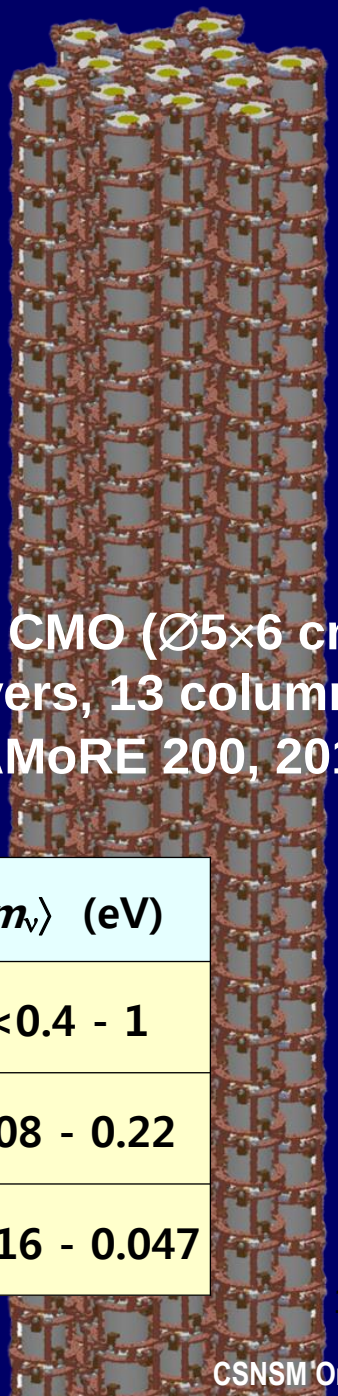
Schedule



5 CMO, ~ 1.2 kg
AMoRE Pilot, 2015



35 CMO, 0.3 kg
5 layers × 7 columns
AMoRE 10, 2016



390 CMO (∅5×6 cm)
30 layers, 13 columns
AMoRE 200, 2019

Stage	Start (run, yr)	Background (yr/keV/kg)	Sensitivity lim $T_{1/2}$ (yr)	$\langle m_\nu \rangle$ (eV)
AMoRE pilot	Jan. 2015 (1)	0.01	~10^{24}	<0.4 - 1
AMoRE 10	Sep. 2016 (3)	0.002	~2x10^{25}	0.08 - 0.22
AMoRE 200	Jan. 2019 (5)	0.0002	~4×10^{26}	0.016 - 0.047