XMASS experiment

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H.Ogawa for the XMASS collaboration

共同利用-C01

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使途　　共同研究者のための神岡研究施設への旅費

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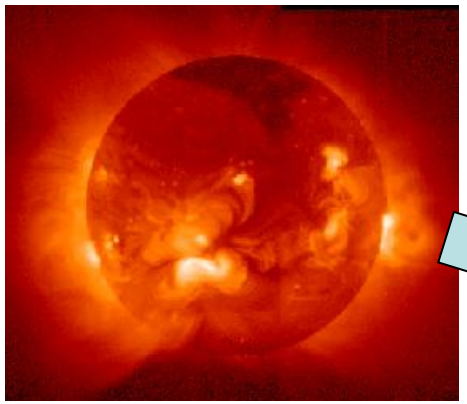
XMASS experiment

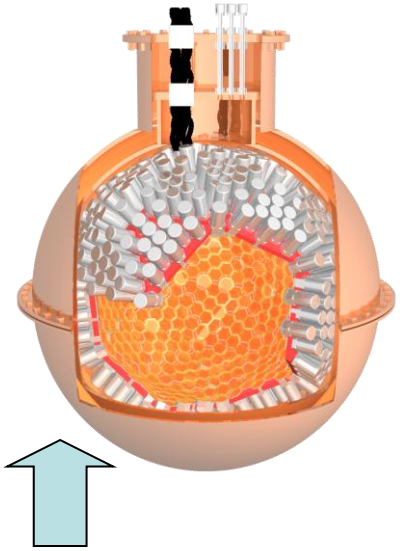
What is XMASS?

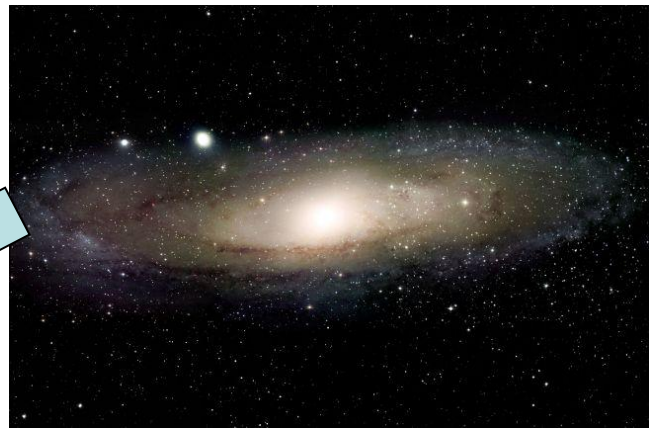
Multi purpose low-background and low-energy threshold experiment with liquid Xenon

- **X**enon detector for Weakly Interacting **MASS**ive Particles (**DM search**)
- **X**enon **MASS**ive detector for solar neutrino (**pp/^{7}Be**)
- **X**enon neutrino **MASS** detector (**ββ decay**)

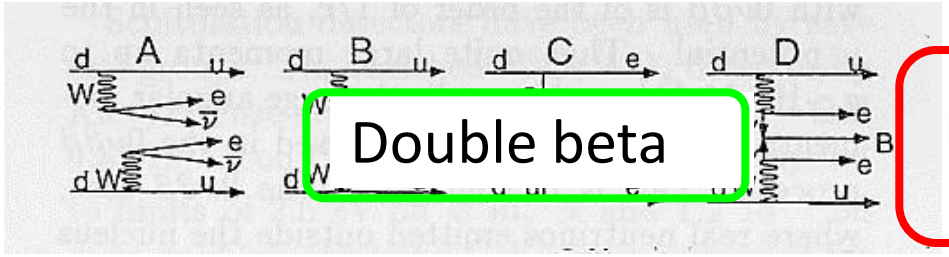


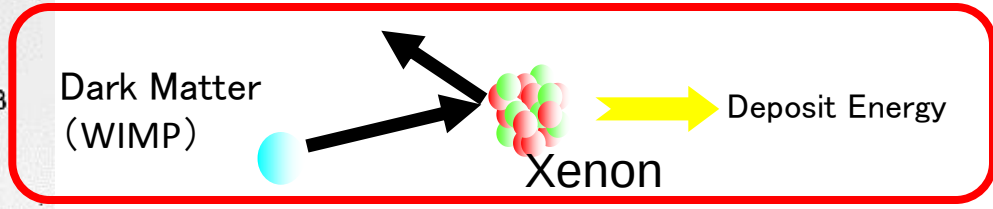
Solar neutrino





Dark matter





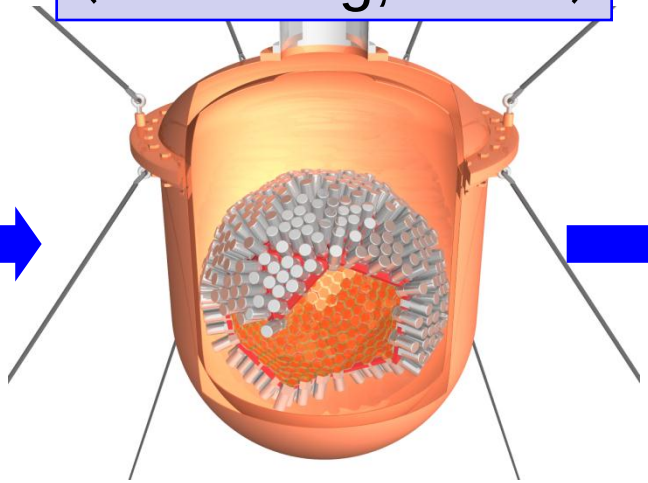
Three phases of the XMASS experiment

100kg Prototype
（FV:30kg, ~30cm）

Completed

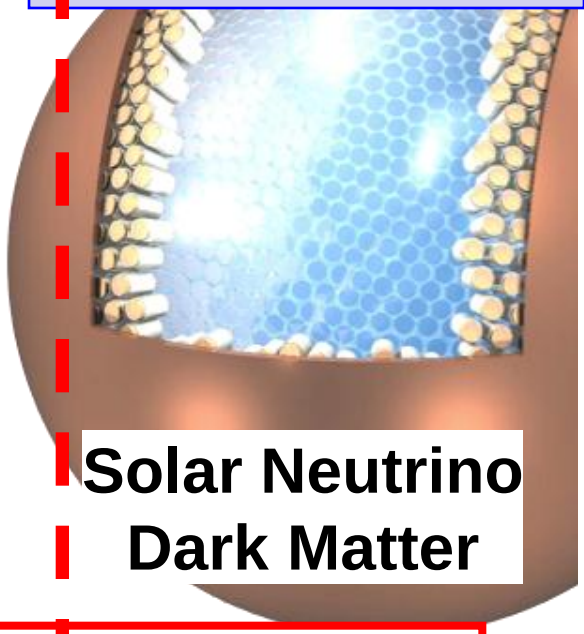
R&D

800kg Detector
（FV:100kg, 80cm）



Dark Matter

20ton Detector
（FV:10ton, ~2.5m）

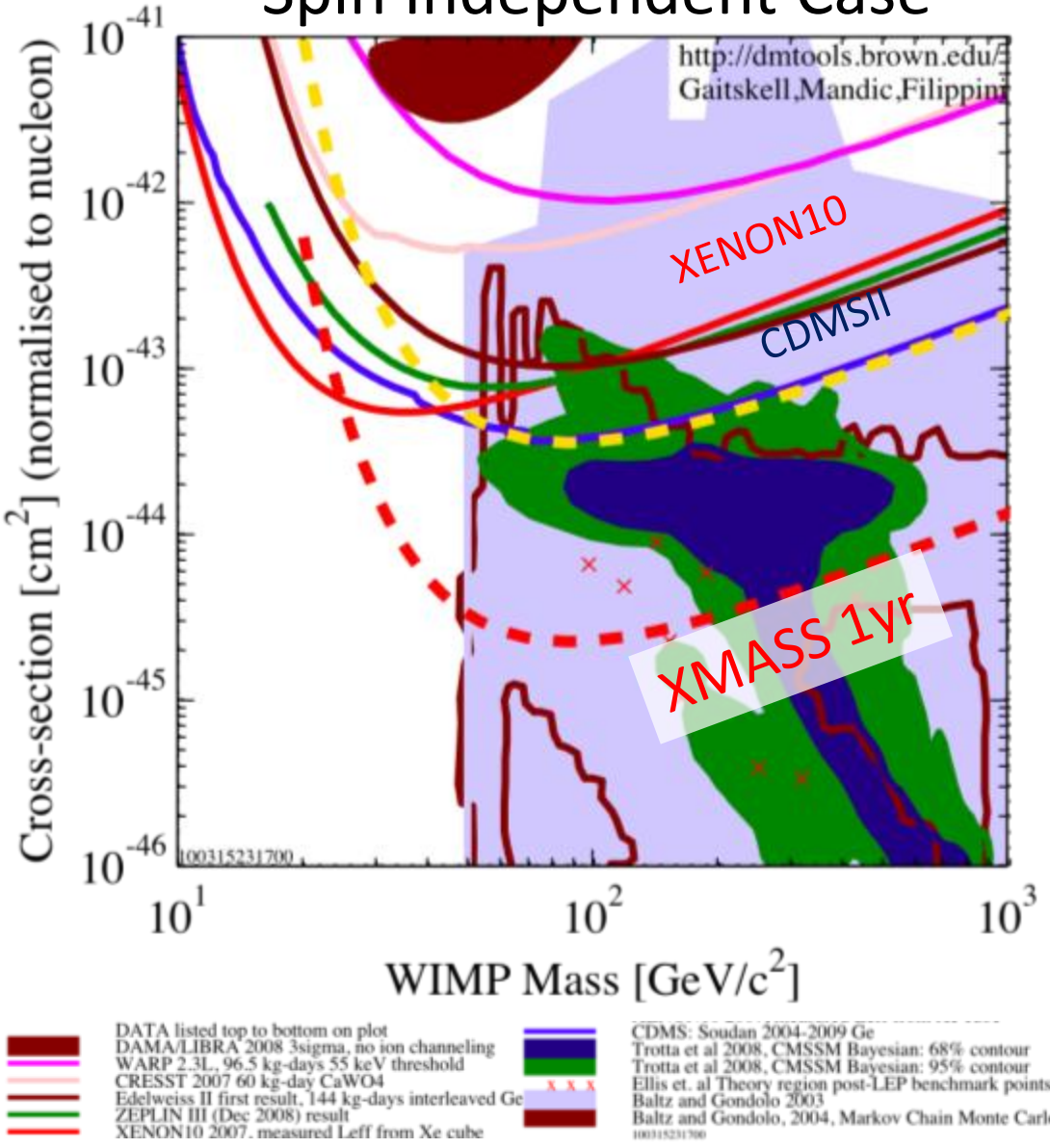


Solar Neutrino
Dark Matter

2007: Project was funded.
2010 Nov.-: Xenon filling was completed

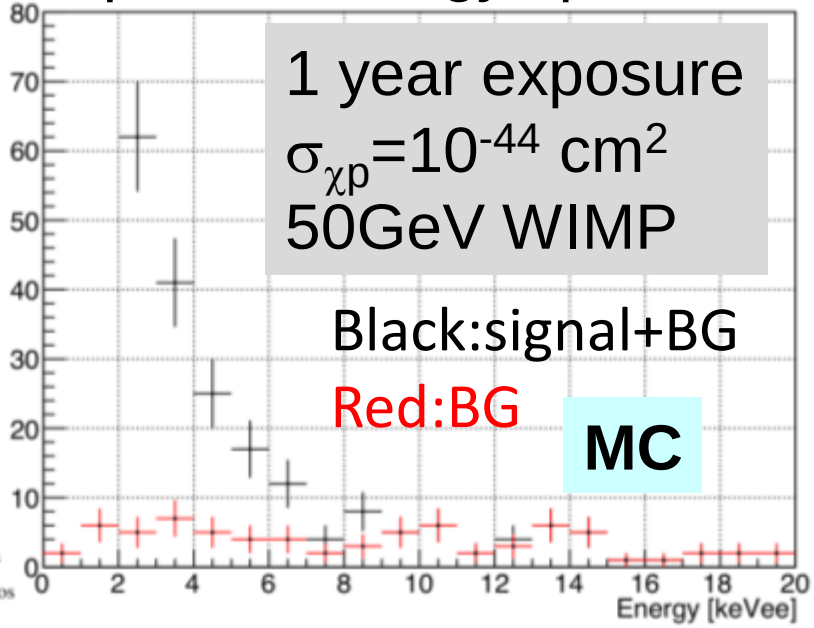
Expected sensitivity

Spin Independent Case



$\sigma_{\chi p}$>2x10^{-45} cm^2
for 50-100GeV WIMP, 90%C.L.
1yr exposure, 100kg FV,
BG: 1x10^{-4} /keV/d/kg
Scintillation efficiency: 0.2

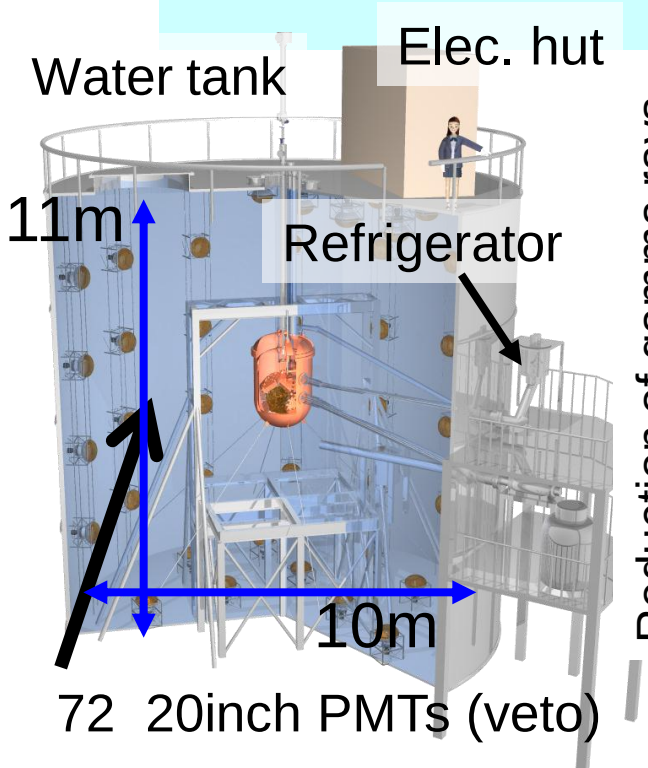
Expected energy spectrum

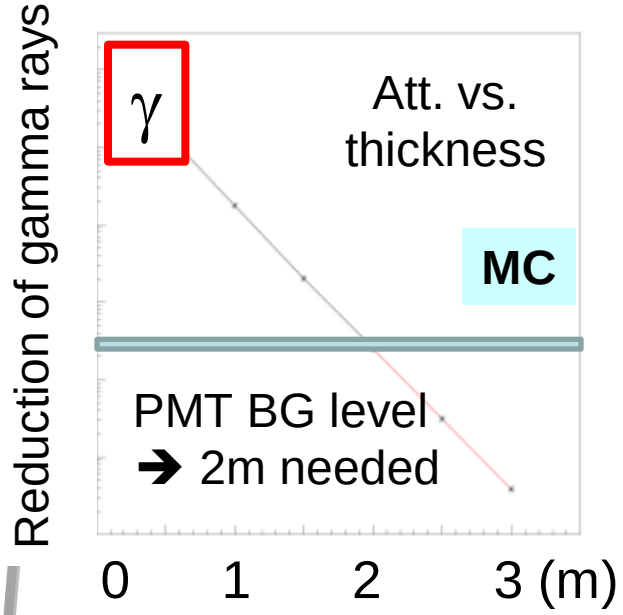


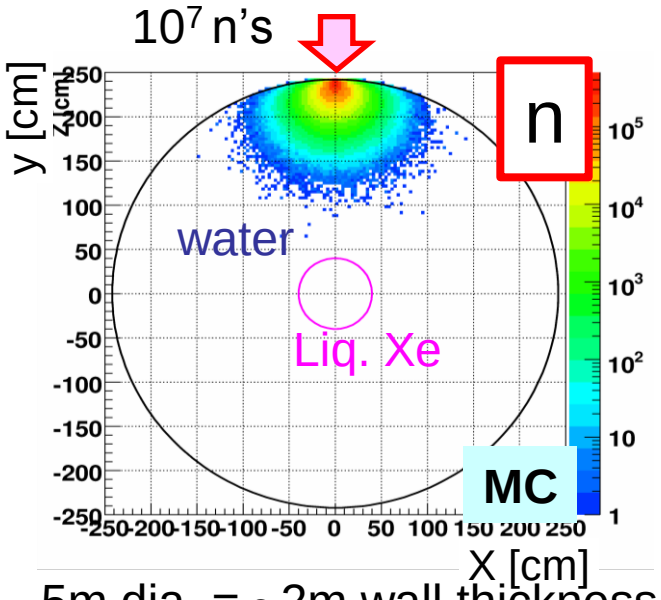
➢XMASS detector (from outside)

※Water tank and external background reduction:

- γ and n from rock are sufficiently reduced by a 2m thickness pure water tank:
  γ < γ from PMT, n << 10^{-4} /day/kg
- 10m dia. and 11m height water tank for future extensions.
- 72 20" PMTs for active veto for CR μ.

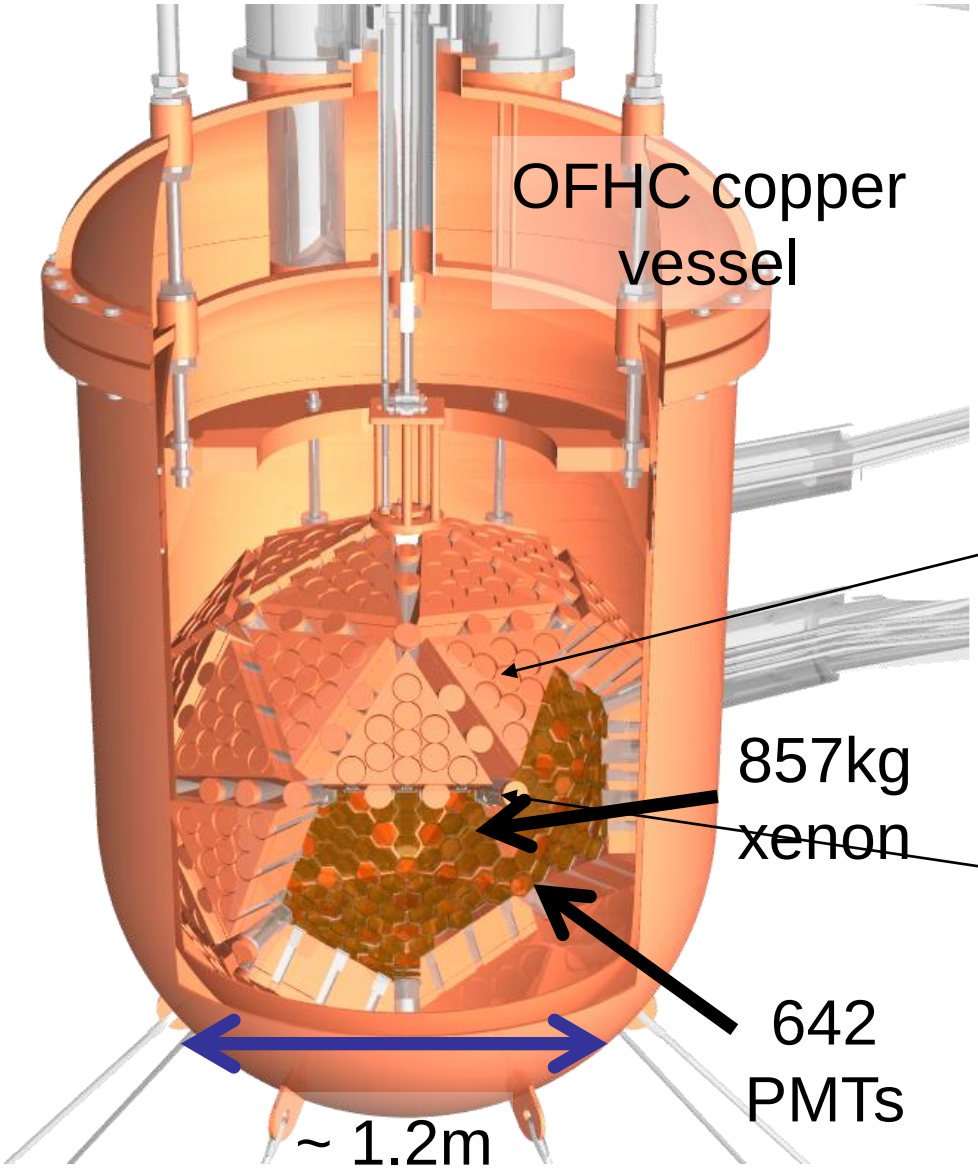






5m dia. = ~2m wall thickness

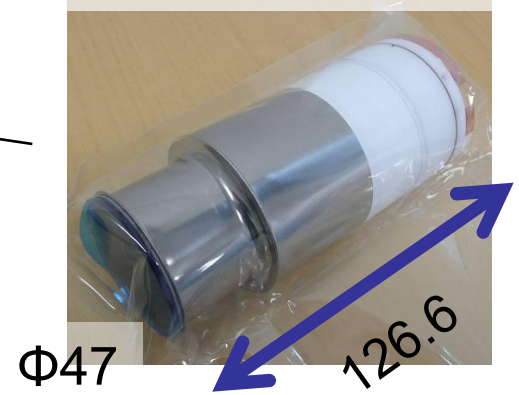
➢XMASS detector (main)



※We developed new ultra low RI PMT with Hamamatsu. (1/100 of ordinary one).

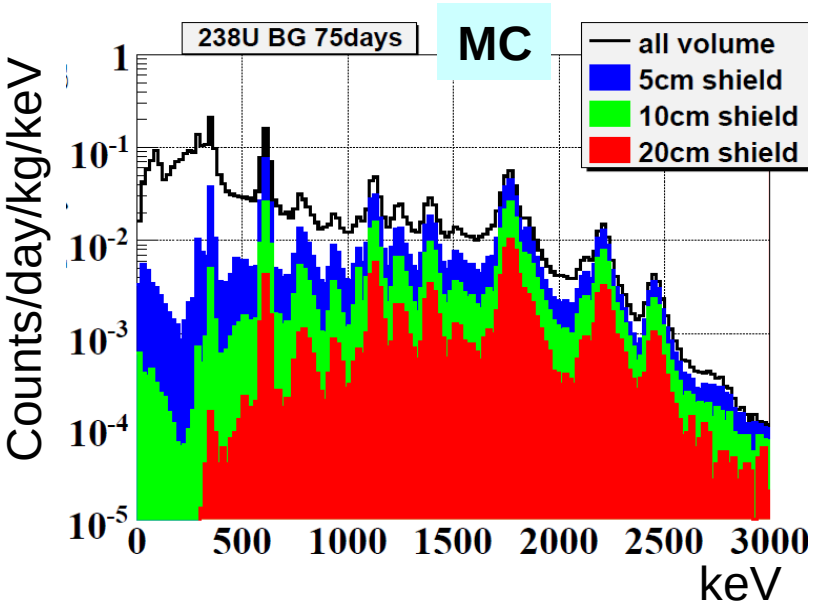
Hex: R10789-11

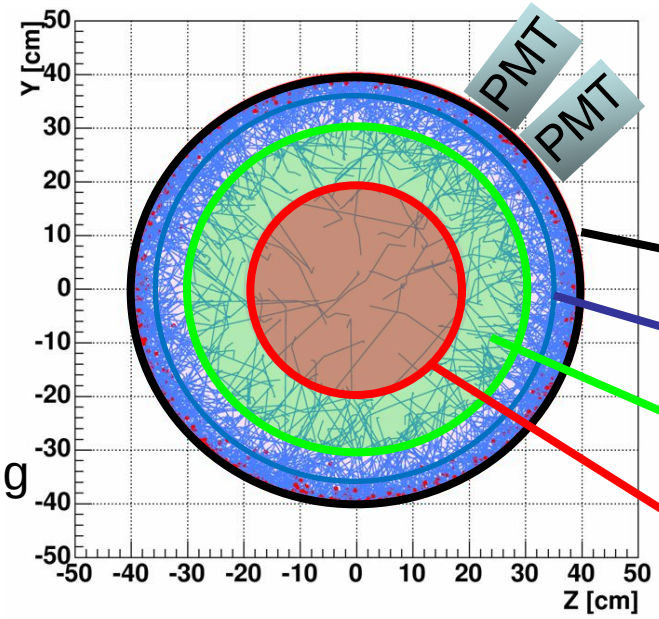
Round: R10789-11MOD



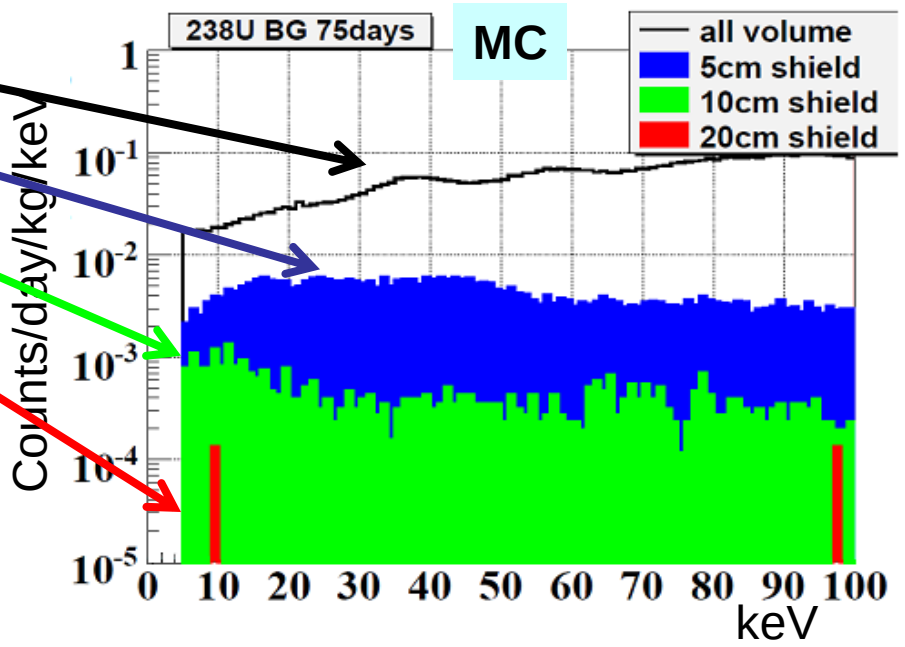
➢ Self-shielding for BG from PMTs (MC)

	BG/PMT [mBq]
U chain	0.70 +/- 0.28
Th chain	1.51 +/- 0.31
40K	< 5.10
60Co	2.92 +/- 0.16





γ tracking



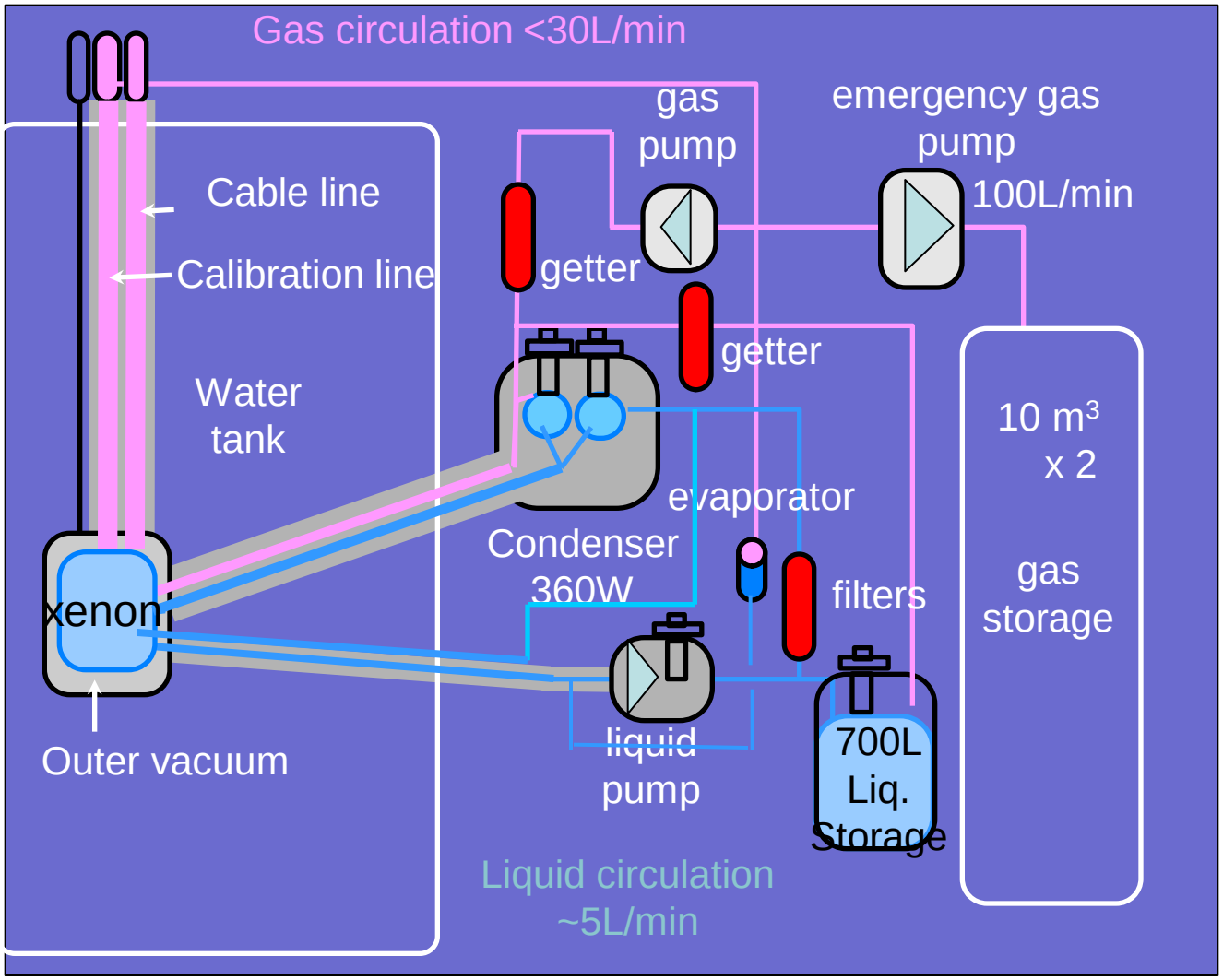
< 10^{-4} /keV/day/kg (100kg F.V.)

n contribution < 2.2×10^{-5}/d/kg

Cryogenic

XMASS circulation system

Gas phase: < 30 L/min
Liquid phase: ~ 5 L/min



700L liq.storage

Liquid pump

Electronics

※Previously used in super Kamiokande

Pre-amp card
(modified for XMASS)

PMT

12bit ADC/TDC (ATM)

Large energy range are covered

- TKO module
- ADC dynamic range : 0~400 pC
- TDC dynamic range : 0~1 usec

8bit Flash ADC

For pulse shape discrimination
in low energy

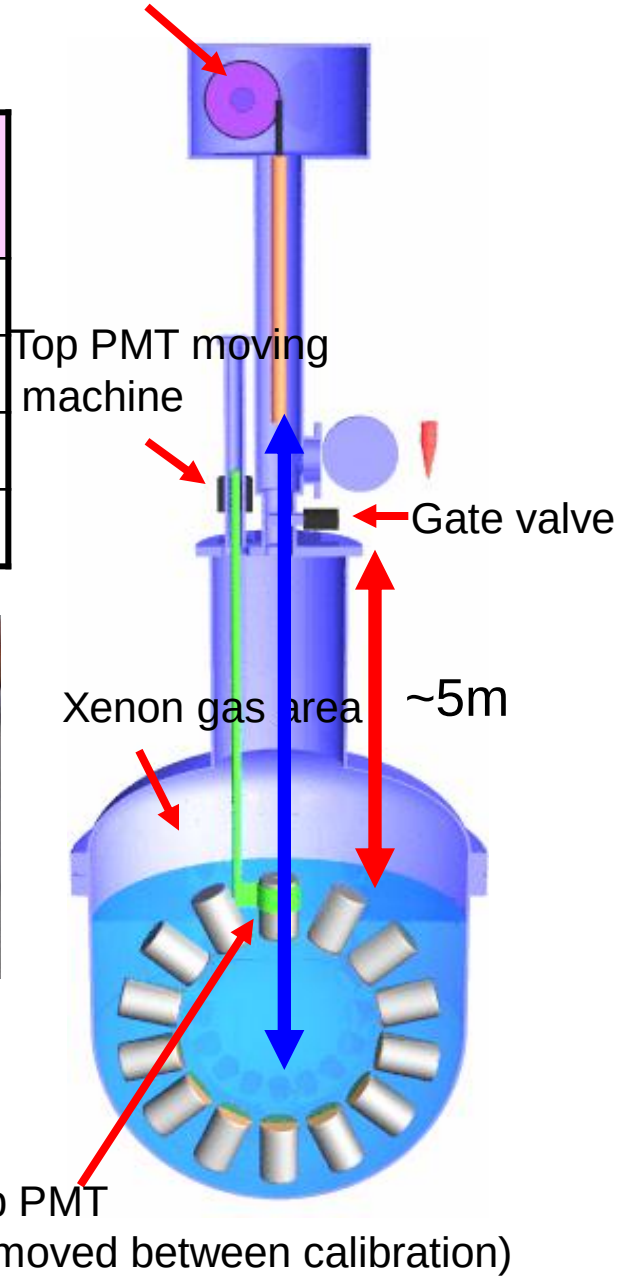
- dynamic range: 0~-1 V
- sampling rate : 500 MS/s
- sample number: 8,160
- time span : 16.32 usec

Calibration

Calibration sources

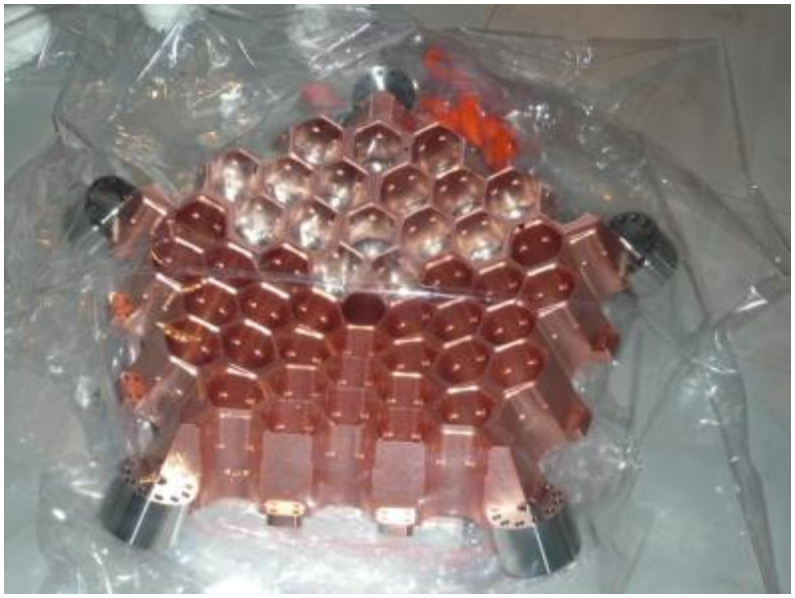
RI	energy [keV]	Intensity [Hz]	φ [mm]	package
(1) Fe-55	5.9	350	5	brass
(2) Cd-109	22, 25, 88	800	5	brass
(3) Am-241	59.5	485	0.15	SUS
(4) Co-57	122	100	0.21	SUS

RI source with holder adaptor(SUS304) OFCU

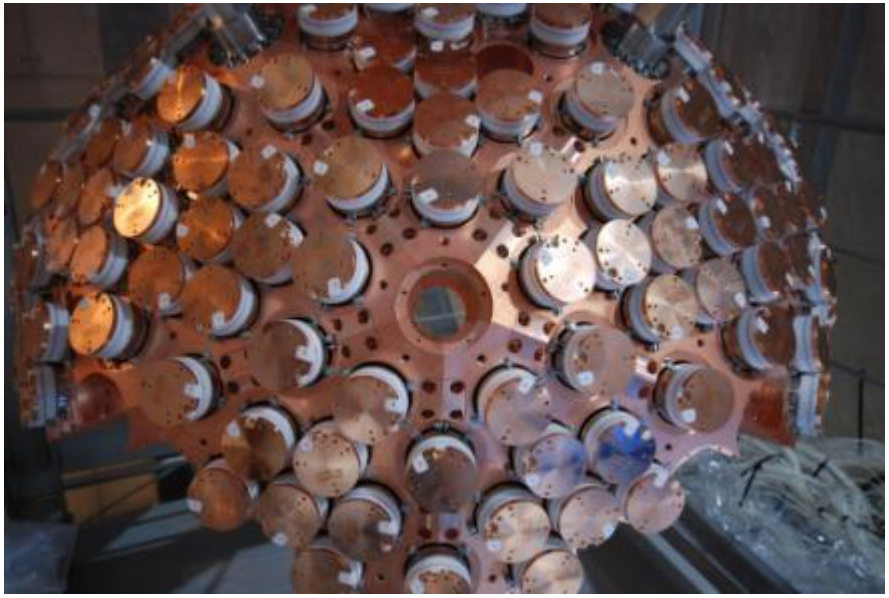


Detector Construction Nov. 2009-Sep 2010

Construction of the PMT holder: Nov. 2009

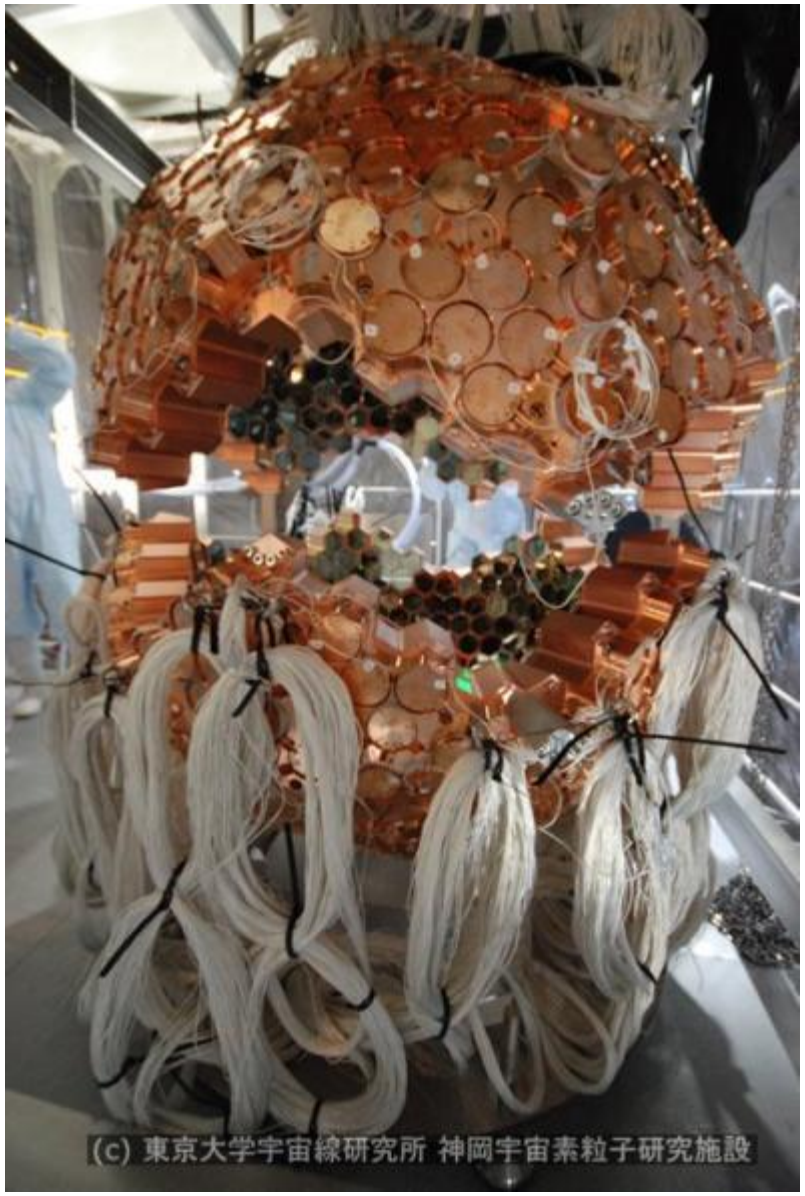


PMT installation: 311 for each half, 40 for boundary 2009-2010

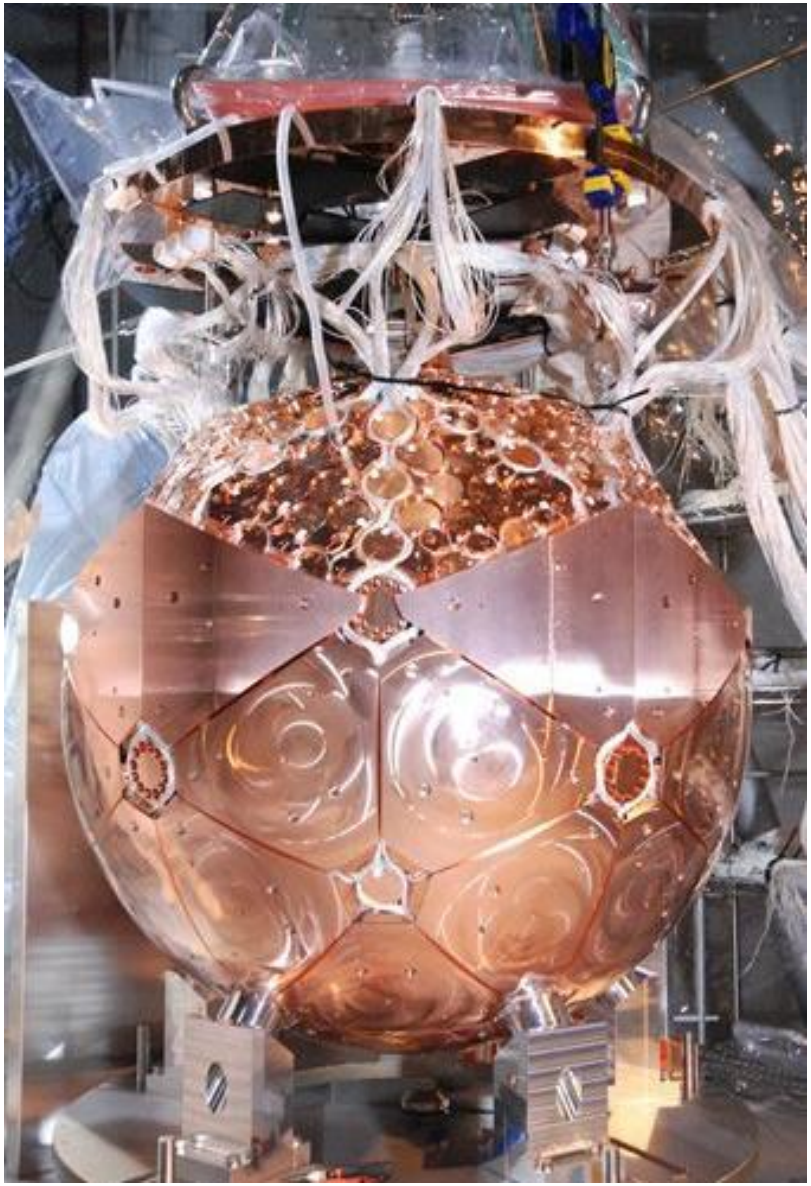


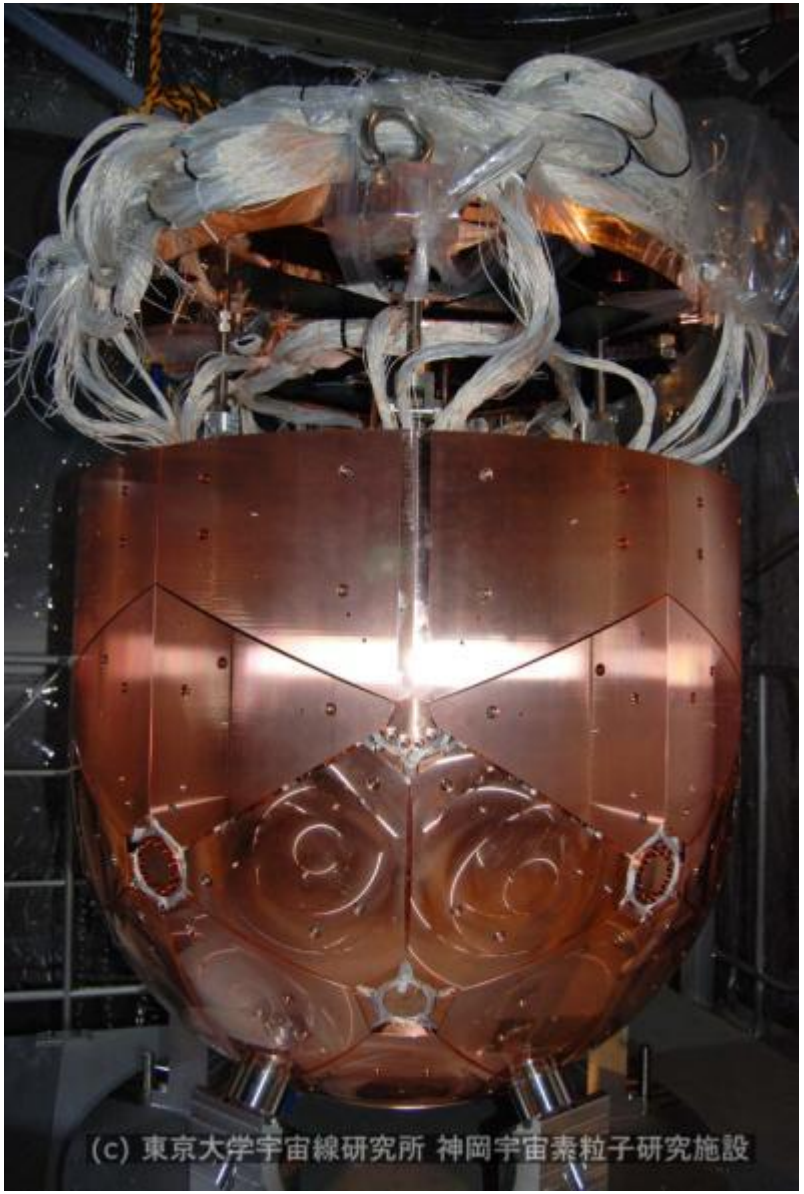
Cabling: 642 pairs of a coax and HV cable, each 13m length

Joining two halves

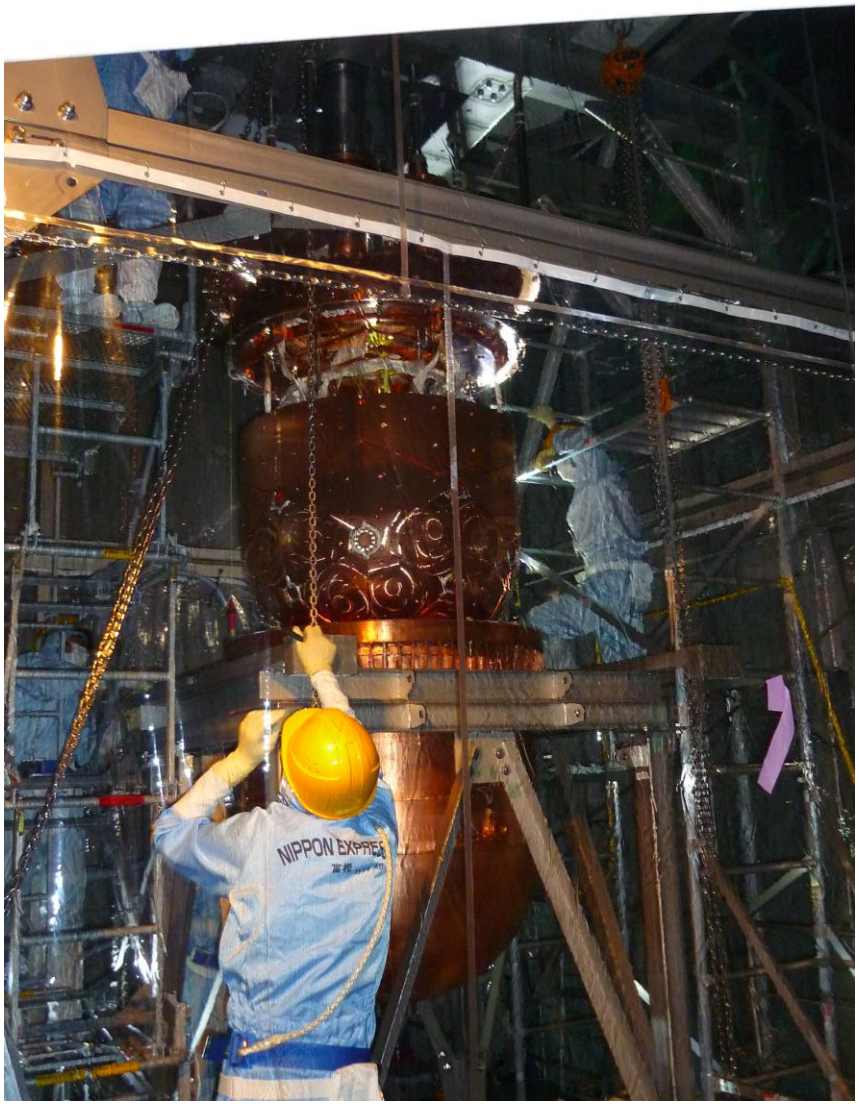


Filler attachment. Total 2.8ton: end of Feb. 2010





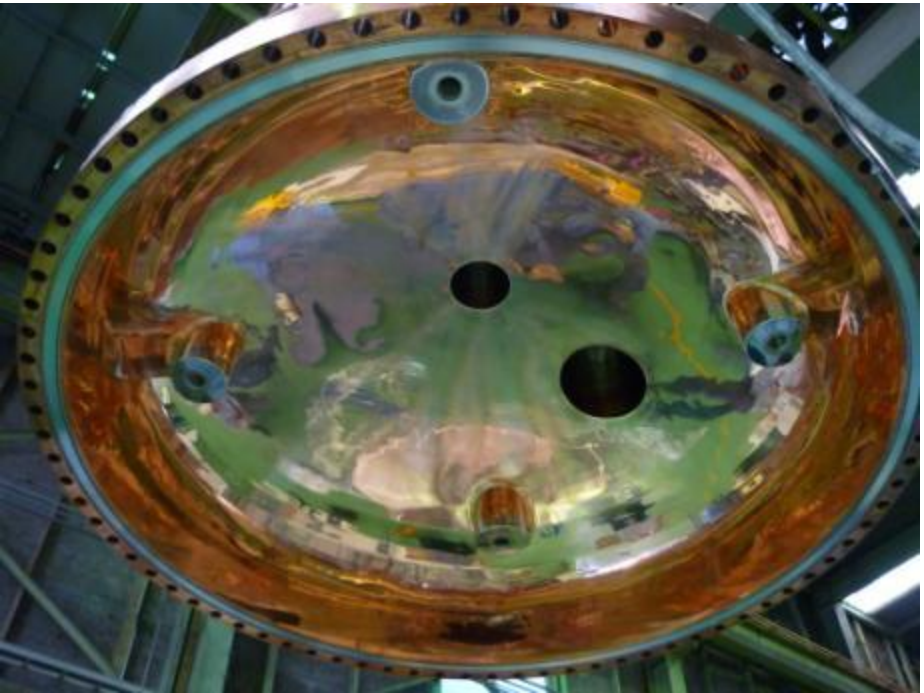
Closing the detector
Working inside clean booth



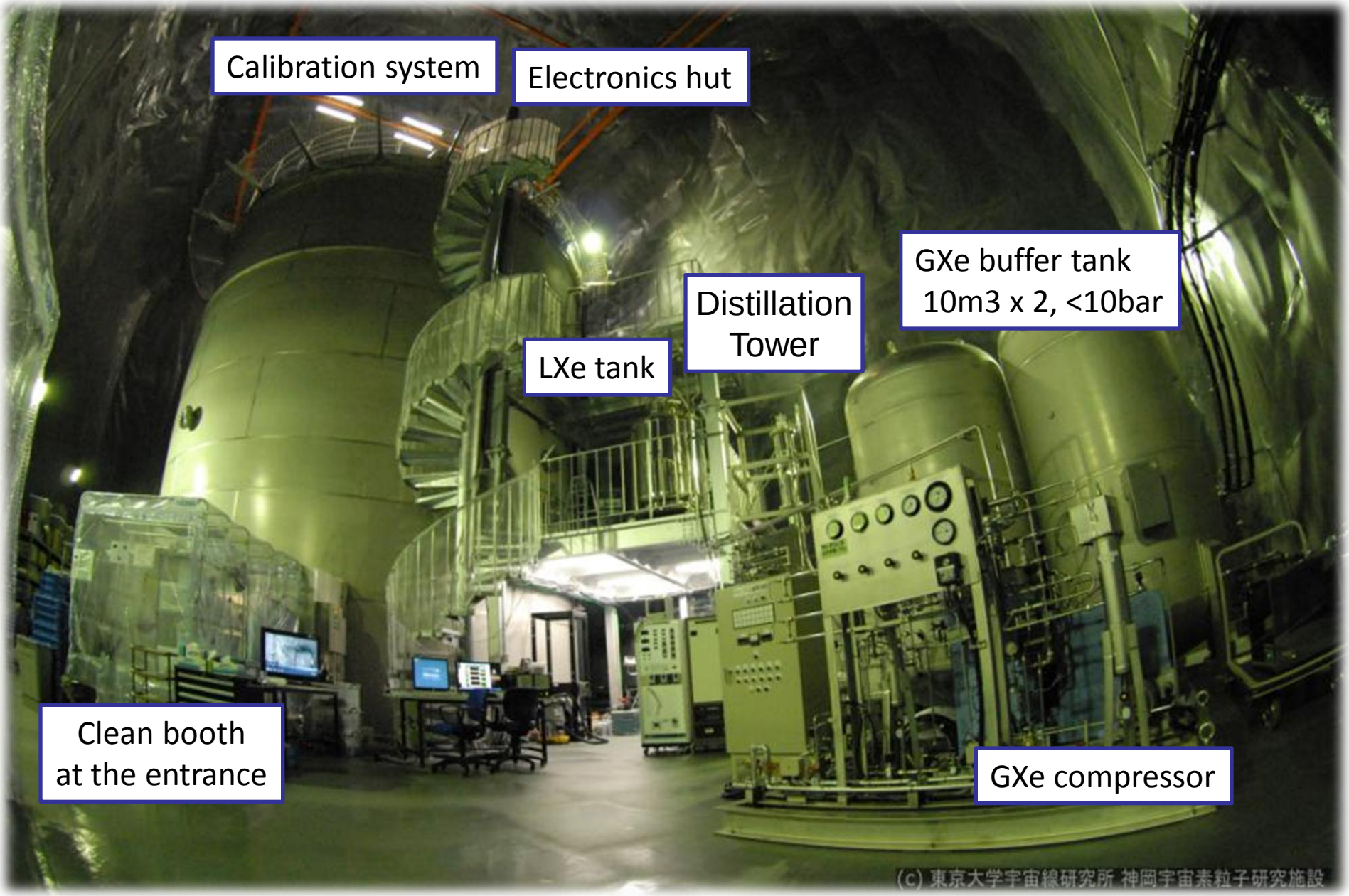
Closing the detector and OVC

Manufacturing detector vessel

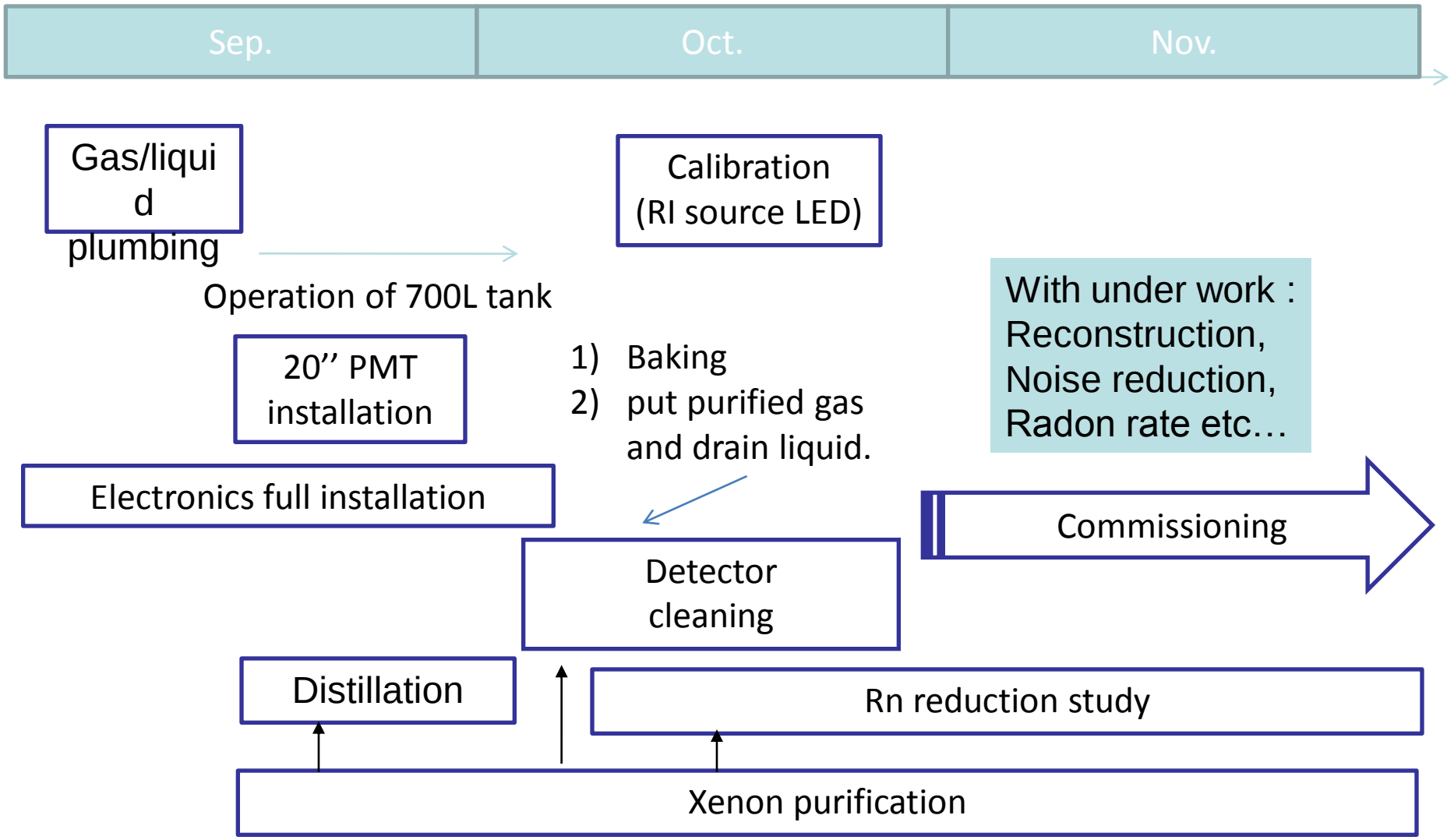
- A challenge: Manufacturing a large flange with soft OFHC copper. Inside: Electropolished
- Due to insufficient strength of its neck part, it needed to be reinforced by adding ribs.



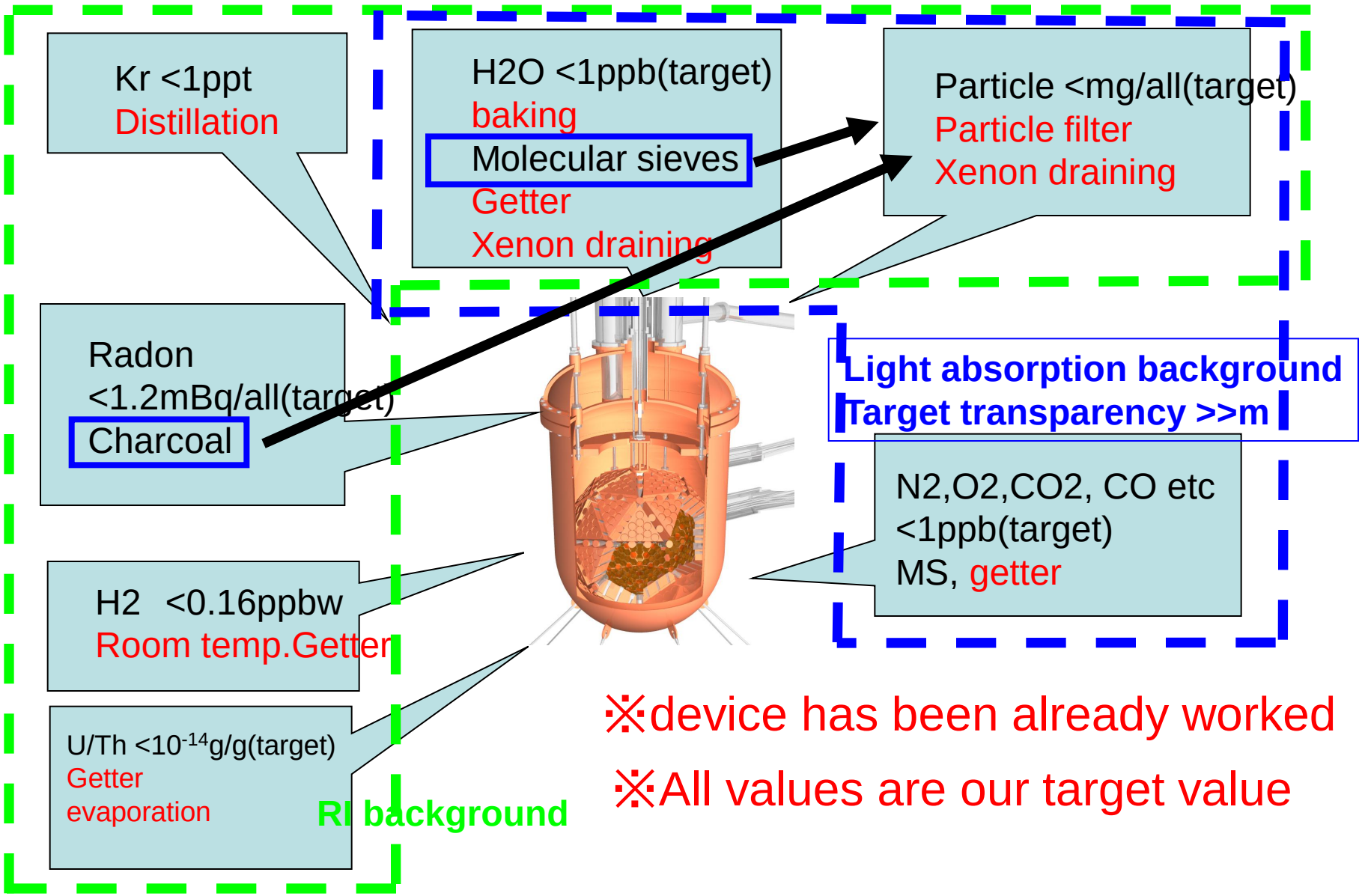
All preparation was ready in Sep.2010



Progress in last three months



Xenon purification



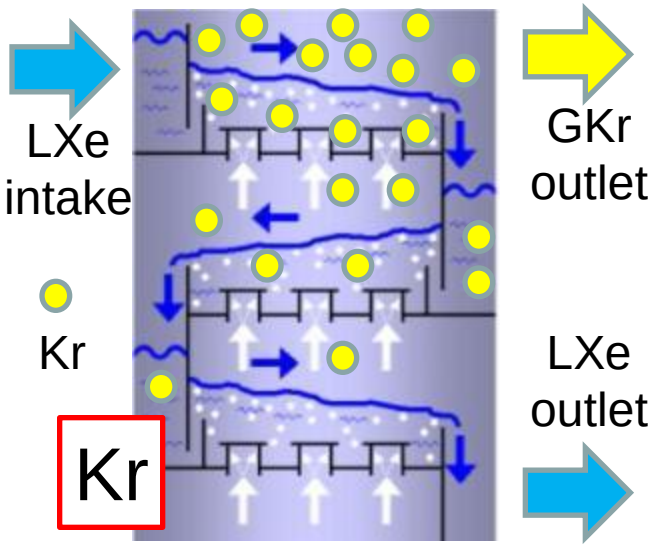
Internal BG (1) : Kr

Completed in 2010 Sep.

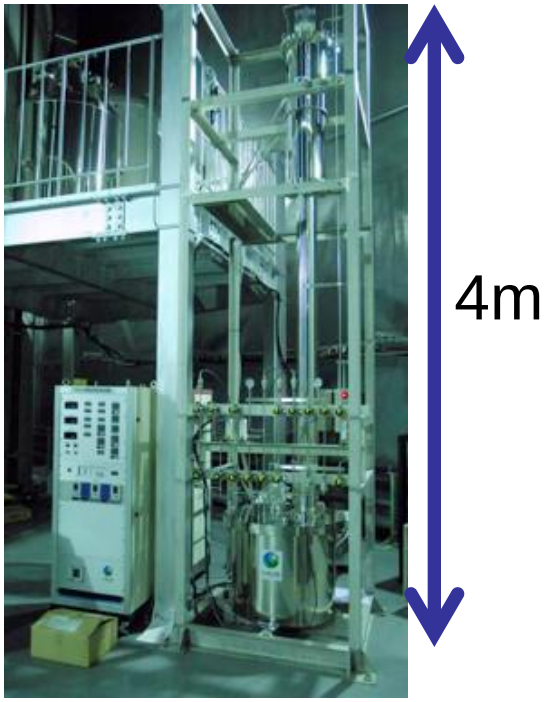
- Kr (^{85}Kr: Q_β=687keV, τ=10.8y) can be reduced by distillation.
- Our goal: Kr < 1ppt (↔ <10^{-5} /day/keV/kg)
- 5 order of magnitude reduction with 4.7kg/hr processing time was achieved. *K. Abe et al. for XMASS collab., Astropart. Phys. 31 (2009) 290*
- Target value can be achieved in 10 days for 1ton xenon. (0.1ppm → 1ppt(Our goal))

commercial

	Boiling point (@0.2MPa)
Xe	178 K
Kr	140~150 K



Distillation tower

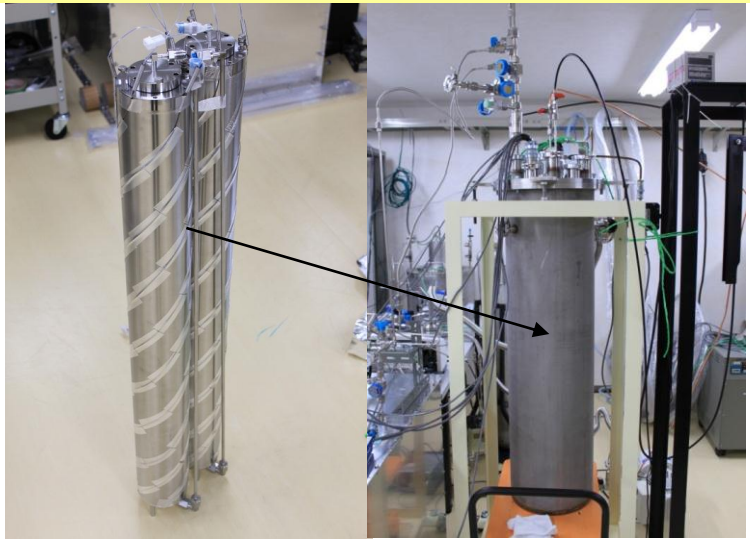


Internal BG (2) : Rn

Under study

- Measured Rn emanation rate from all materials is < 15mBq
- Our goal: ^{222}Rn < 1.2 mBq/ton (<2x10^{-5} dru (/kev/day/kg))
- Continuous Rn removal with xenon circulation is needed.

Gas phase removal :
Cooled charcoal can take Rn.
Rn removal system will be mounted in gas line.

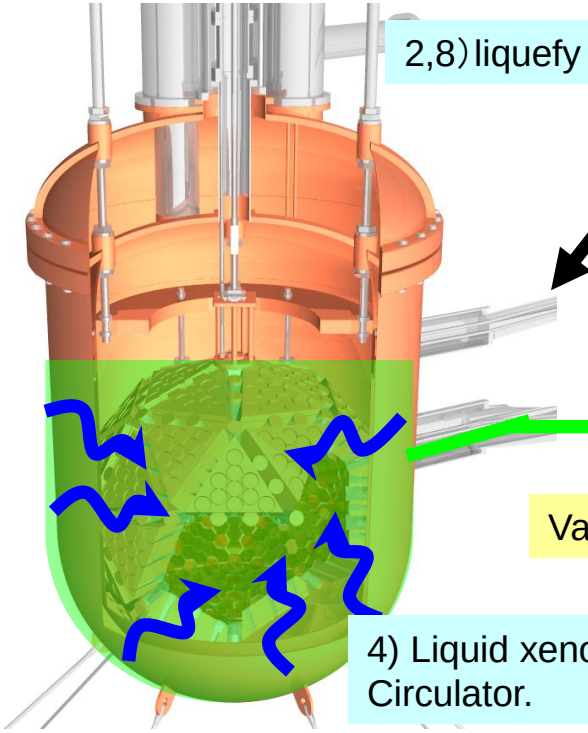


liquid phase removal :
Liquid circulator and filter will be used.
But removal method (material) is under study.
Particle problem remains.
We need more study.
If liquid removal is successful, We can take Rn speedy than gas removal

Detector cleaning : Drain the xenon from detector

10/24 & 10/31
Xenon filled in detector with 1136kg

10/19- & 10/26-
Start xenon filling from storage to detector
~9kg/hr



2,8）liquefy the xenon

1,7)Make gas and passing getter

getter

Xenon condence

Valve station

circulator

Liquid xenon storage tank

Filter housing

2F

4) Liquid xenon transfer using Circulator.

3）impurity take to xenon

5）take dust by all SUS particle filter

6）xenon collects to liq.xenon tank

10/25,2010 : liquid xenon was drained to storage ~300kg/hr

By this work, light yield increased about 16% (form 57Co source data)

summary

- The XMASS project aims to observe pp solar neutrinos, neutrinoless double beta decay, and dark matter signals. The 800kg detector is the first phase of the project.
- It is expected to have low background of $1x10^{-4}$ keV^{-1} $d^{-1}kg^{-1}$ in the 100kg FV and sensitivity for SI down to $2x10^{-45}cm^2$ with one year operation.
- We are now in the commissioning phase. Xenon draining work improved the total light yield ~16%