# Low background techniques in XMASS

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1. XMASS experiment
2. Background reduction
3. Summary

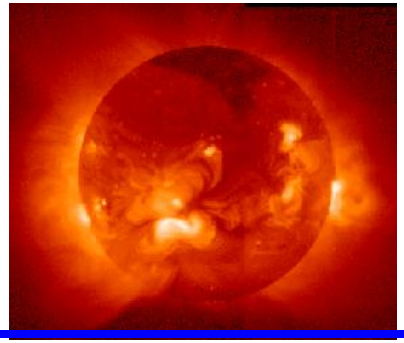
# 1. XMASS experiment

## ➢ What's XMASS

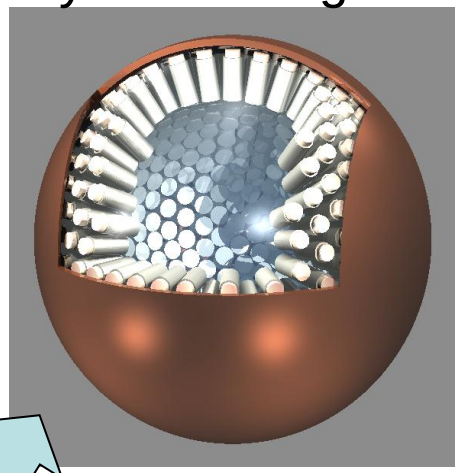
Multi purpose low-background experiment with liq. Xe

*Y. Suzuki et al., hep-ph/0008296*

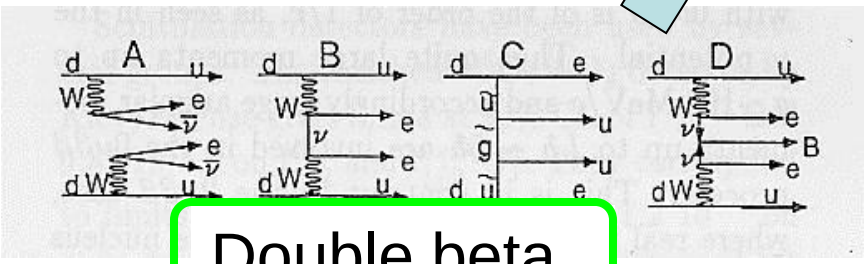
- **X**enon **MASS**ive detector for solar neutrino (**pp/$^{7}$Be**)
- **X**enon neutrino **MASS** detector (**ββ decay**)
- **X**enon detector for Weakly Interacting **MASS**ive Particles (**DM search**)



Solar neutrino



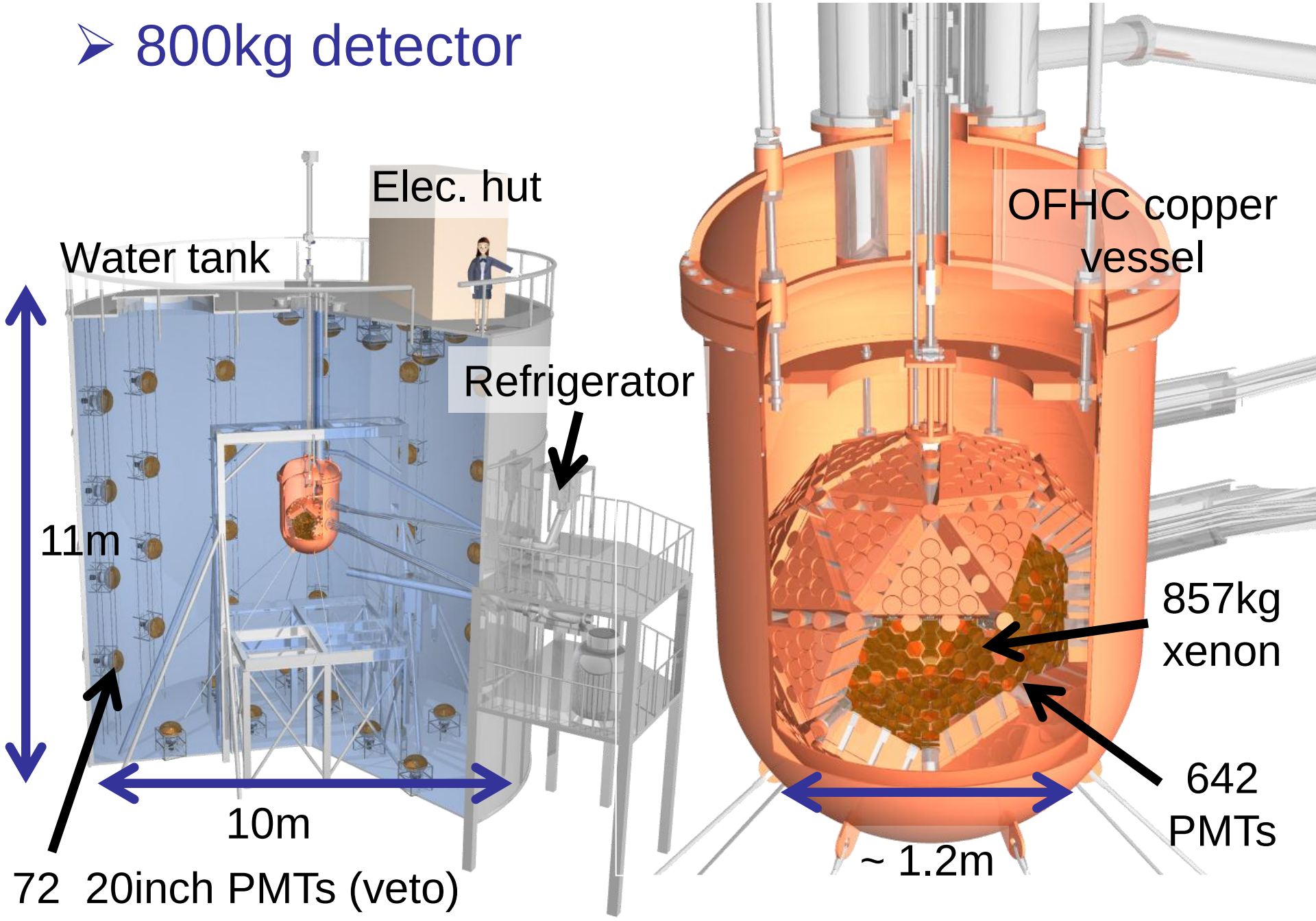
Dark matter




Double beta

As a 1st phase, an 800kg detector for dark matter search is under construction.

# ➢ 800kg detector

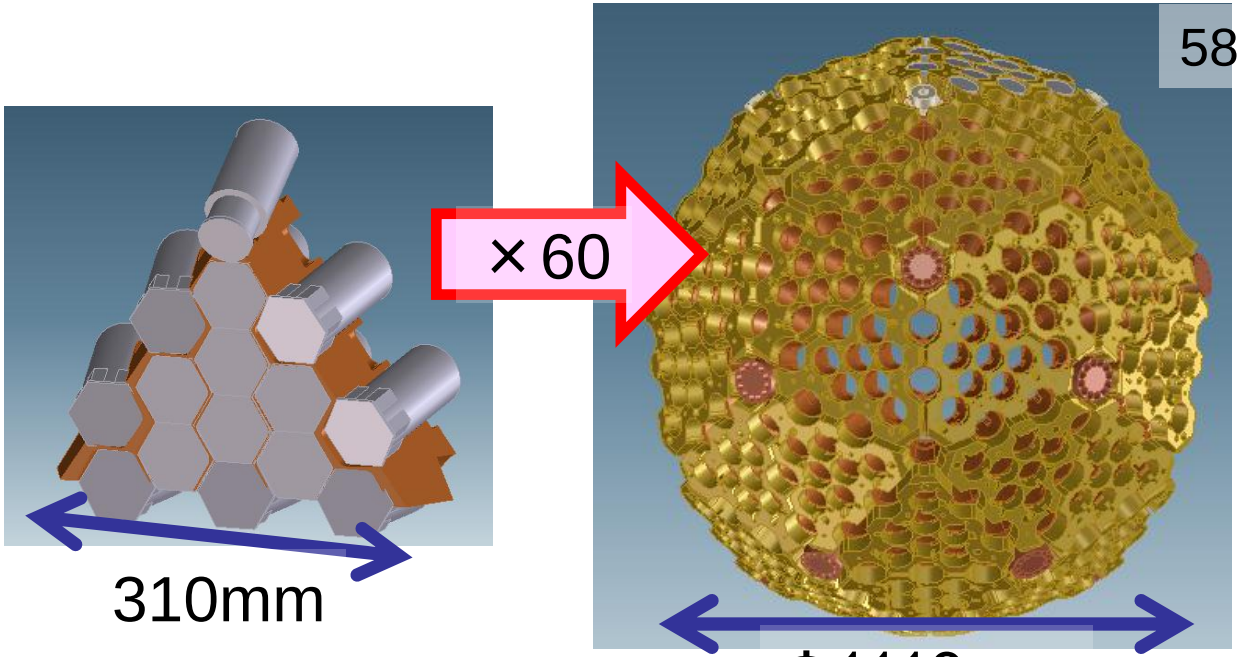


# ➢ Structure of the 800kg detector

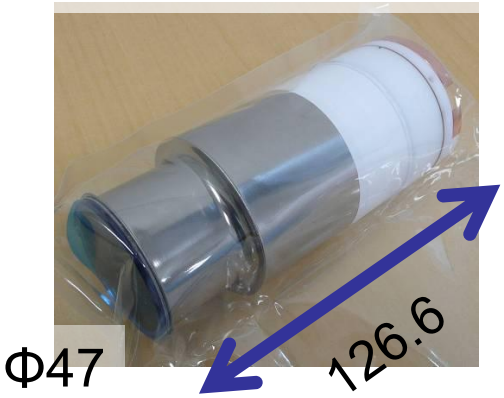
Single phase liquid Xenon detector

- 857kg of liquid xenon, 100kg in the fiducial volume
- 642 PMTs (630 hex +12 round)
- Q.E. : 28-39%
- Photo coverage:  62.4%
- 3D event reconstruction
- 5keVee threshold with 4.4pe/keVee

Hex: R10789-11


Round: R10789-11MOD



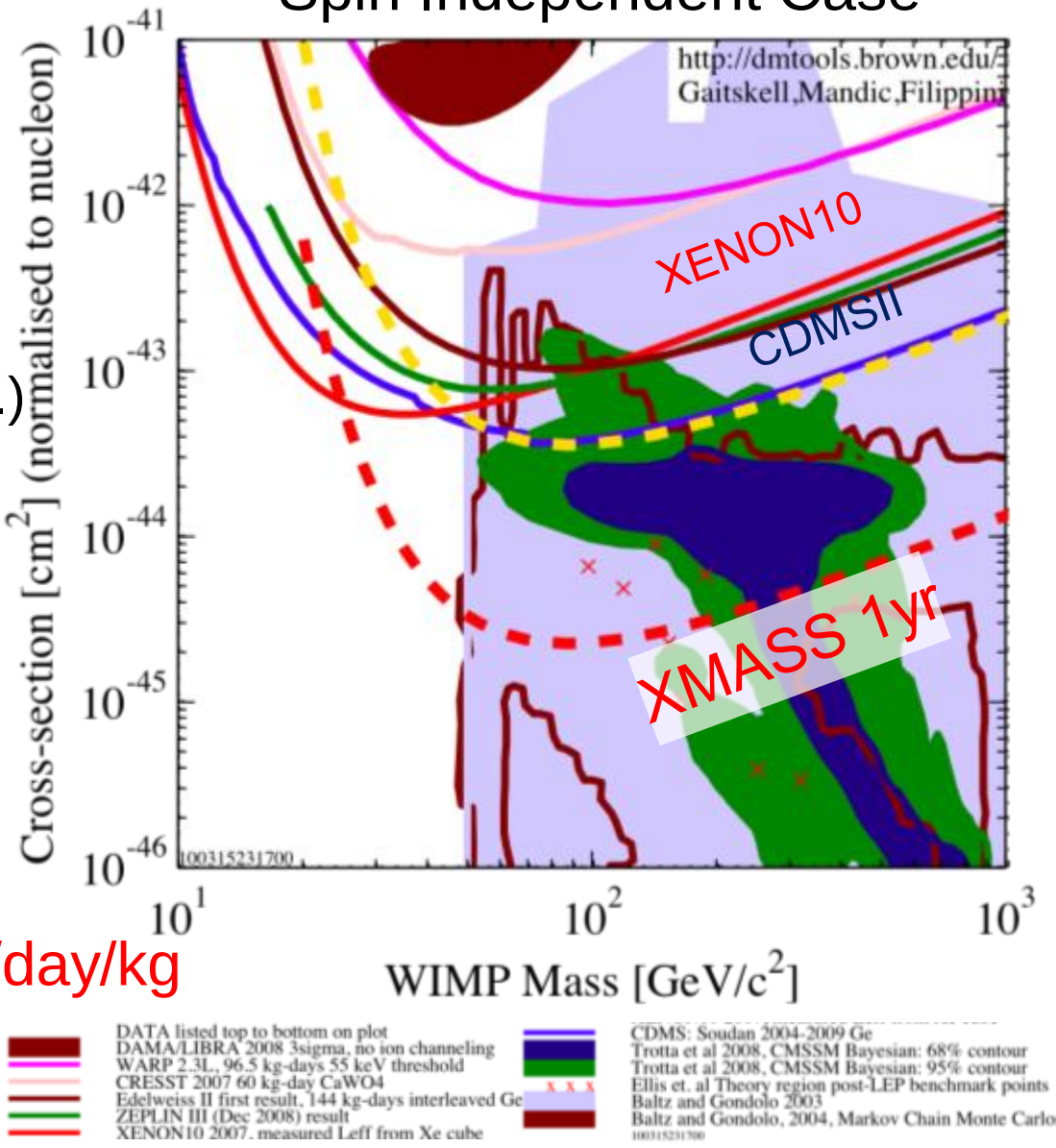
# ➢ Expected sensitivities

$\sigma_{\chi p} > 2 \times 10^{-45}$ cm$^2$

for 50-100GeV WIMP (90%C.L.)
1yr exposure, 100kg FV
BG: $1 \times 10^{-4}$ /keV/d/kg
Q factor: 0.2

How to achieve $1 \times 10^{-4}$ keV/day/kg BG level ?

Spin Independent Case



# 2. Background reduction

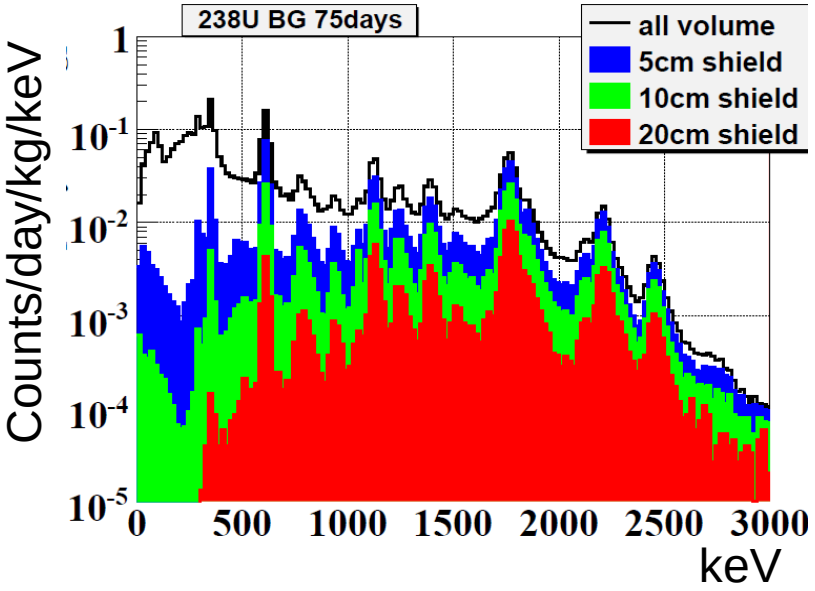
## (1) BG from detector materials

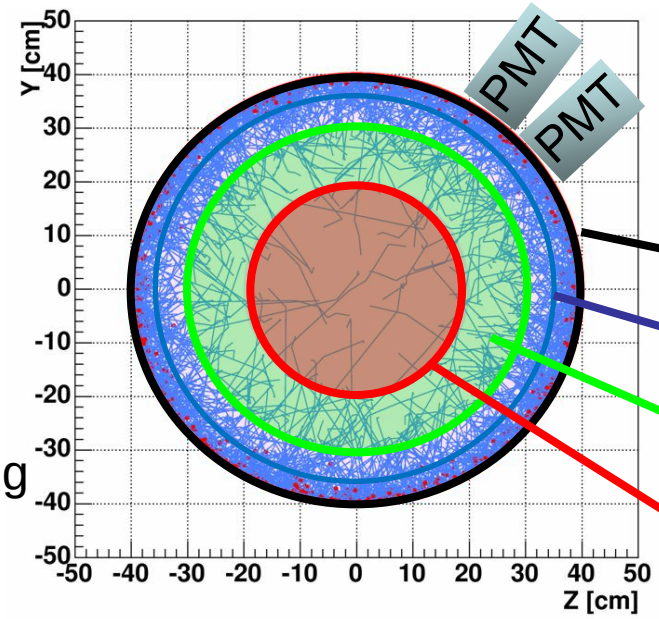
- 642 PMTs: Main BG source although RI level is 1/100 of ordinary PMT.
- OFHC copper: Bring in the mine < 1month after electrorefining (Mitsubishi Material Co.)
- Other materials: All the components were selected with HPGe and ICP-MS. (>250 samples were measured) The total RI level is much lower than PMT BG.

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

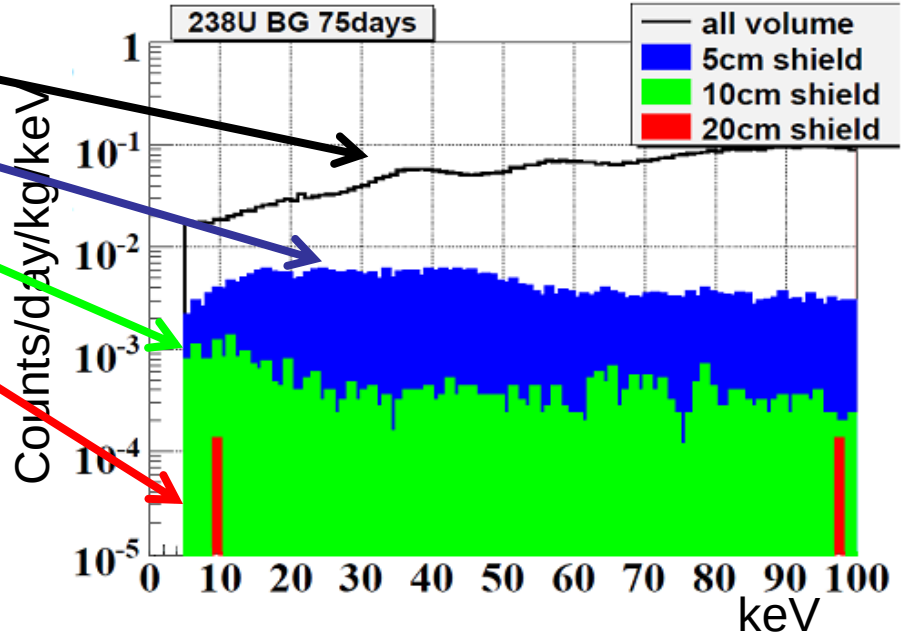
# ➢ Self-shielding for BG from PMTs

| | 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

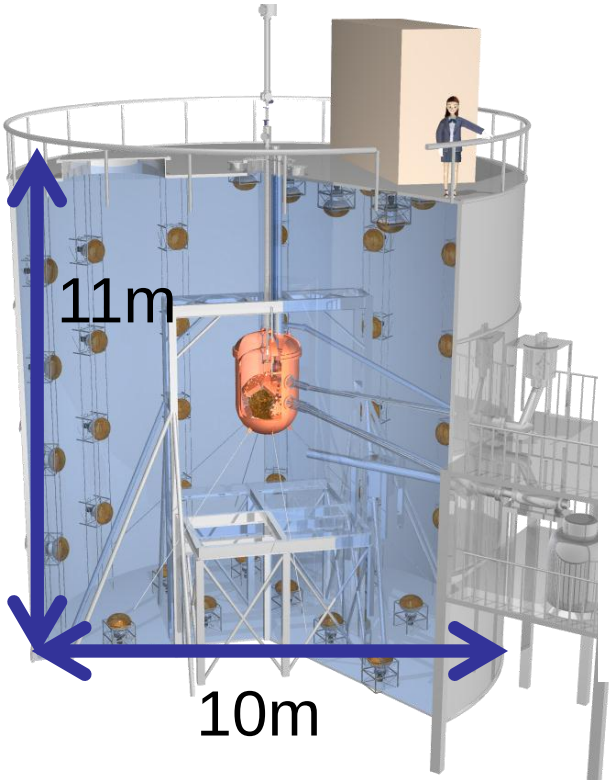


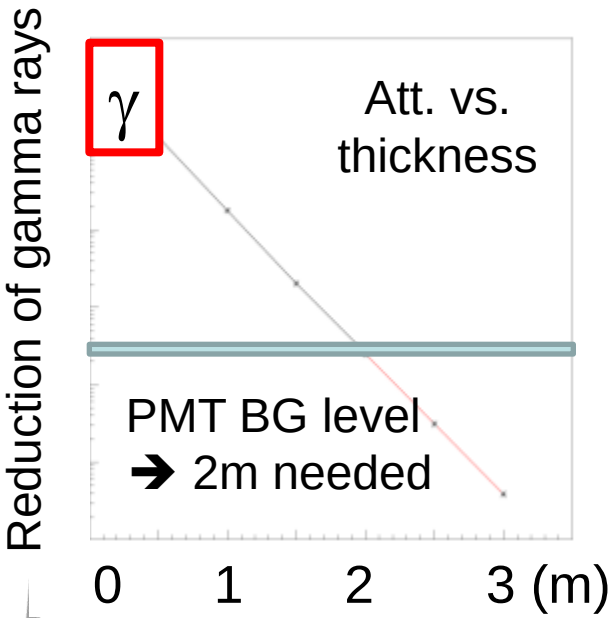

< $10^{-4}$ /keV/day/kg (100kg F.V.)

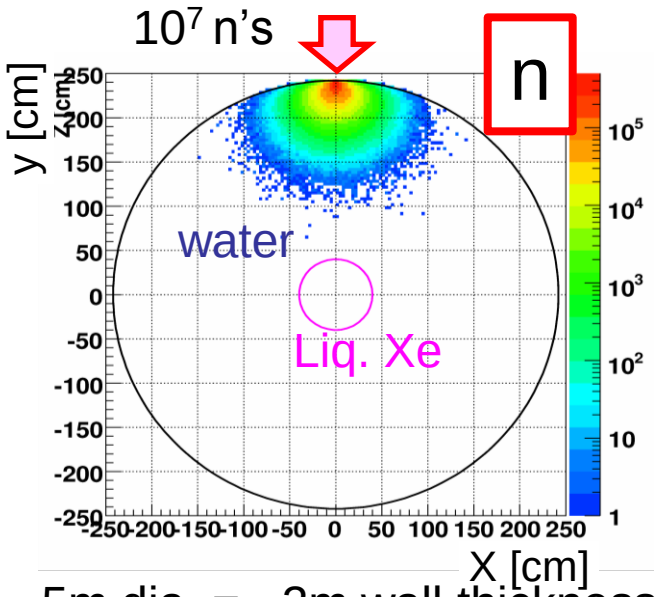
n contribution < $2.2 \times 10^{-5}$/d/kg

# (2) External BG (γ, n) from rock

- 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.



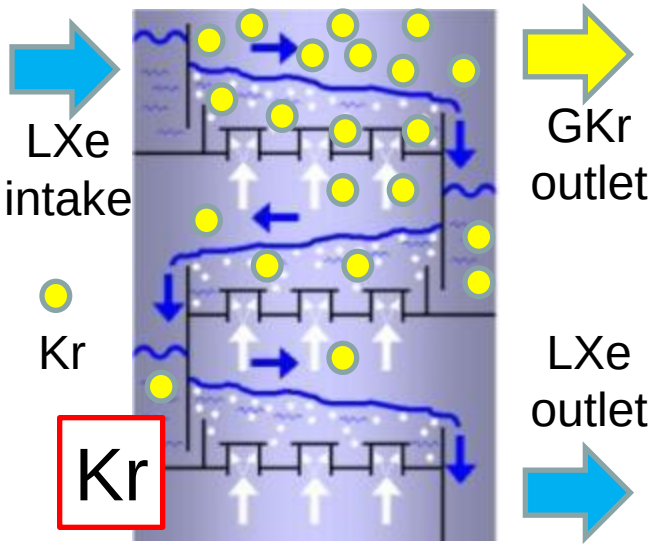

5m dia. = ~2m wall thickness

# (3) Internal BG (1) : Kr

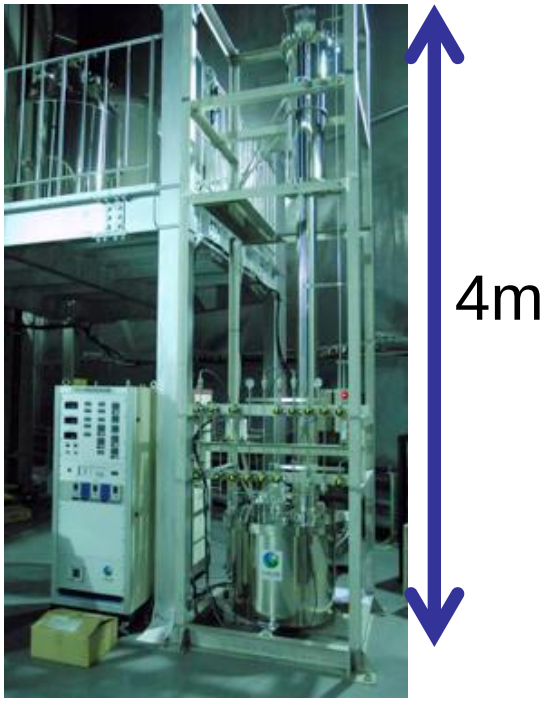
- Kr ($^{85}$Kr: $Q_\beta$=687keV, $\tau$=10.8y) can be reduced by distillation.
- Our goal: Kr < 1ppt (↔ $<10^{-5}$ /day/keV/kg)
- 5 order of magnitude reduction with 4.7kg/hr processing time was achieved. *K. Abe et al. for XMASS collab., Astropart. Phys. 31 (2009) 290*
- Target value can be achieved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

commercial

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




Distillation tower

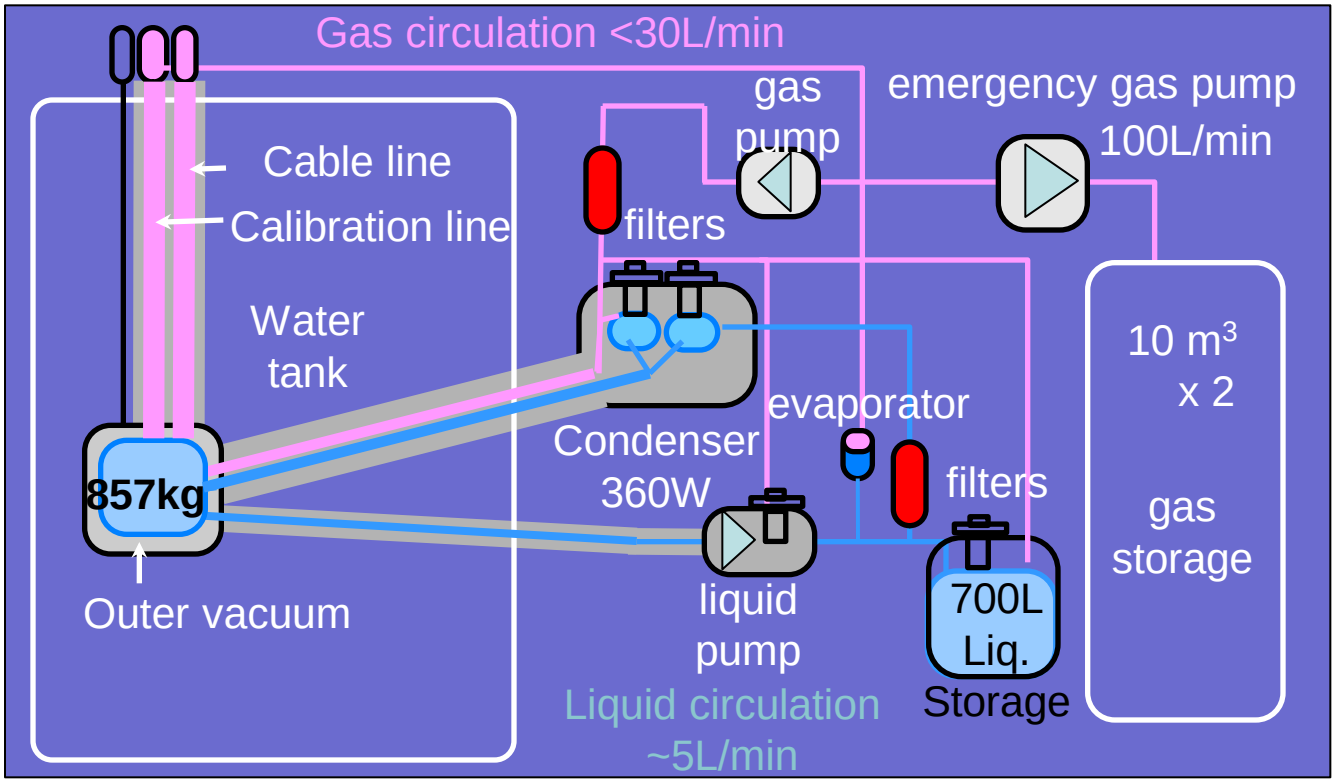


# (4) Internal BG (2) : Rn

- Measured Rn emanation rate from all materials is < 15mBq
- Our goal: $^{222}$Rn < 0.6 mBq/ton (<$10^{-5}$ /kev/day/kg)
- Continuous Rn removal with xenon circulation is needed.

XMASS circulation system

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



## ➢ Rn removal test in gas circulation

Charcoal housing

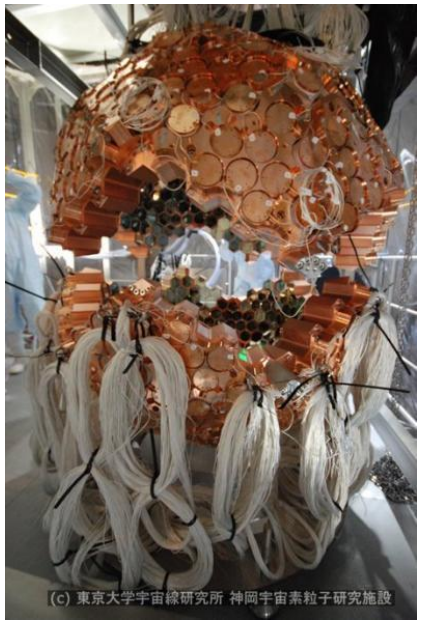
- Charcoal whose suitable hole size (~10 Å) was selected.
- Tested in -105℃, with 10Bq Rn in xenon.

- More than 85% Rn removal was achieved.
  (charcoal weight: 25g, trap length: 60cm, flow rate: 0.5L/min).
  Rn removal efficiency is now being improved with more suitable trap length and flow rate.
- In the case of Rn removal emanated from only gas phase, our goal (<0.6mBq) can be achieved with 1.0 L/mim flow rate.

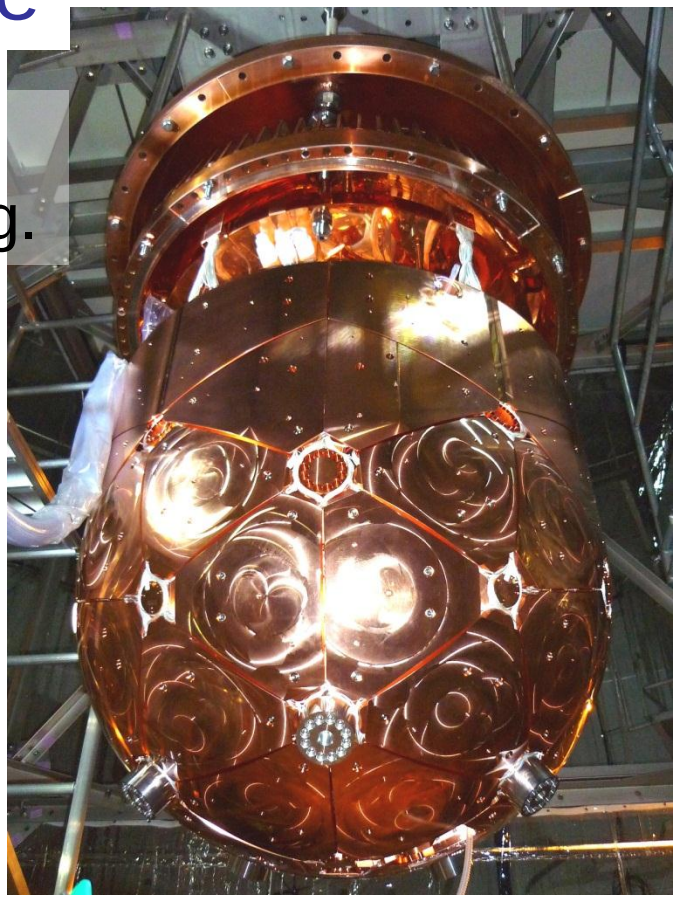
- Rn removal emanated from liquid phase is now under study.

# ➢ Current status and schedule

- All the parts of the 800kg detector is ready. Now, assembly work is going.







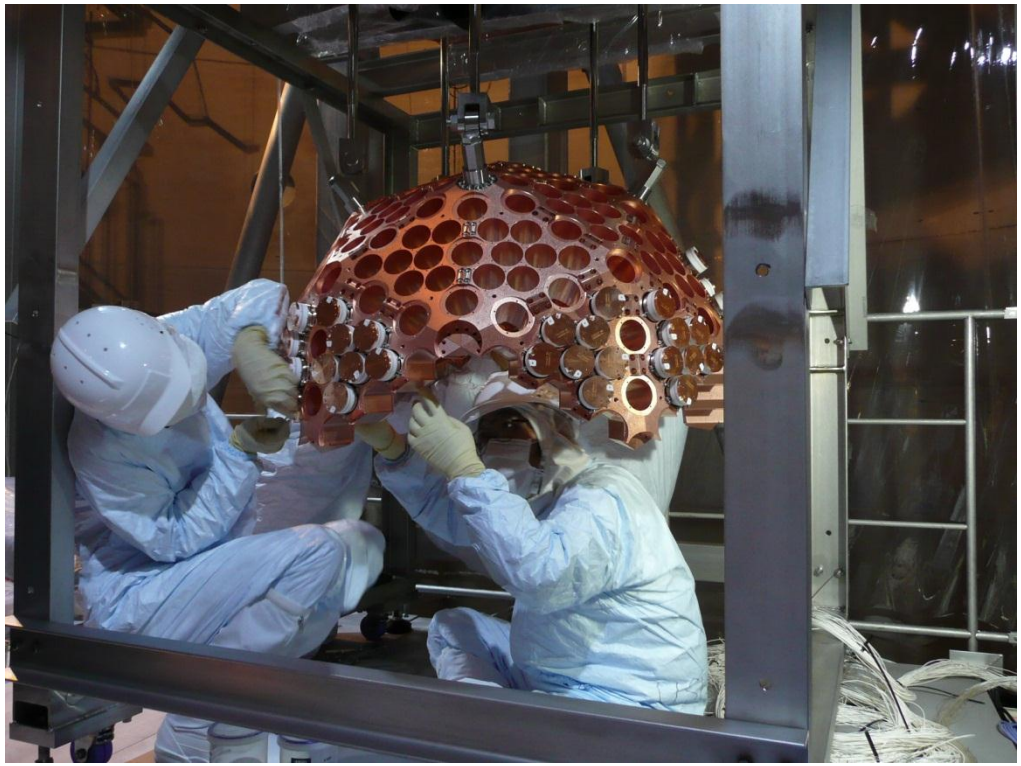
- Aug.- early Sep.: Detector assembly will be finished.
- Sep.: Distillation (Kr: 0.1ppm->1ppt). Evacuation of detector, water filling test, and liquid xenon filling will be done.
- Oct. : Gas and liquid circulation will start for reducing contamination. Data taking will start.

# 3. Summary

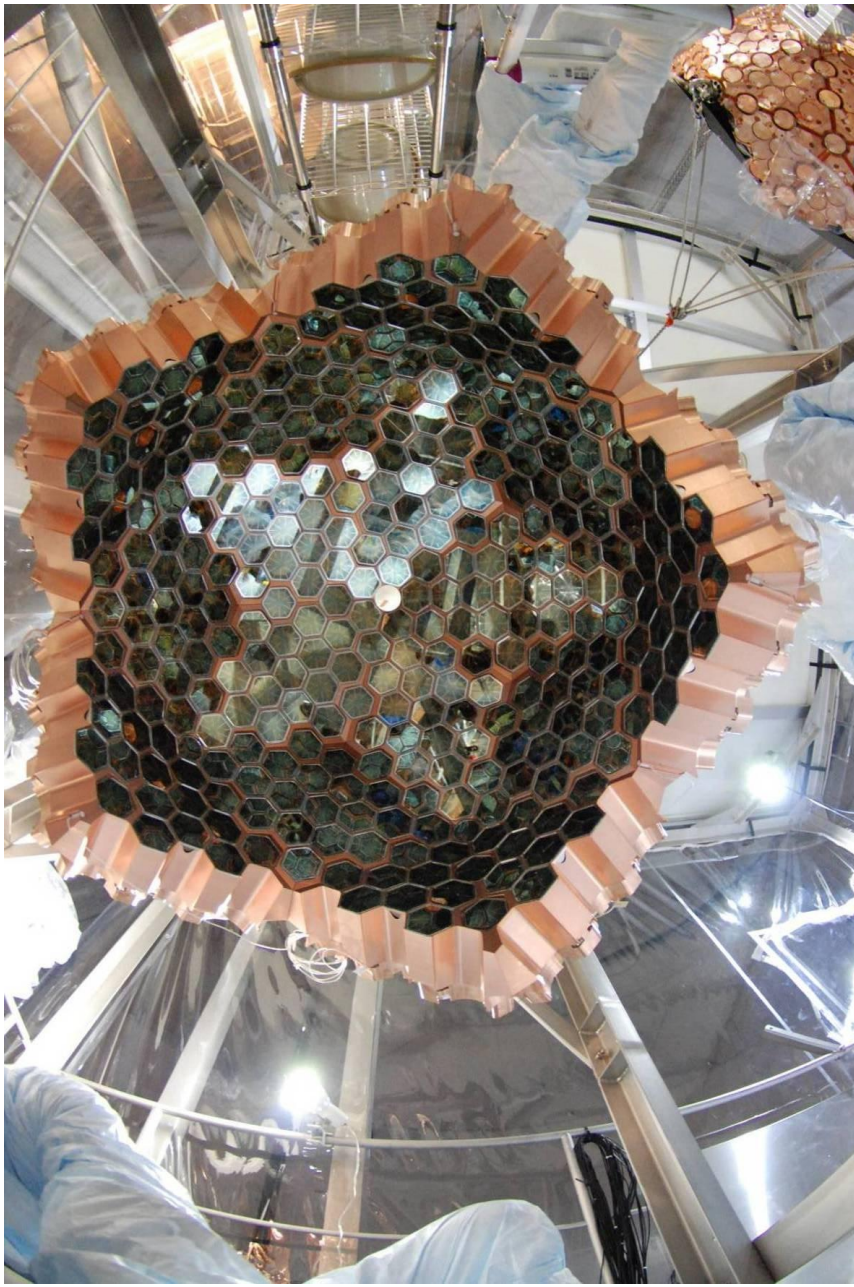
- Expected BG level: < $10^{-4}$ /keV/day/kg.
  (around threshold (~5keVee), 100kg FV)
- Expected sensitivity is $2 \times 10^{-45}$ $cm^2$ for SI interaction with one year operation.
- Detector assembly work will be finished by the beginning of September.
- Data taking will be started in October.

# *Backup*

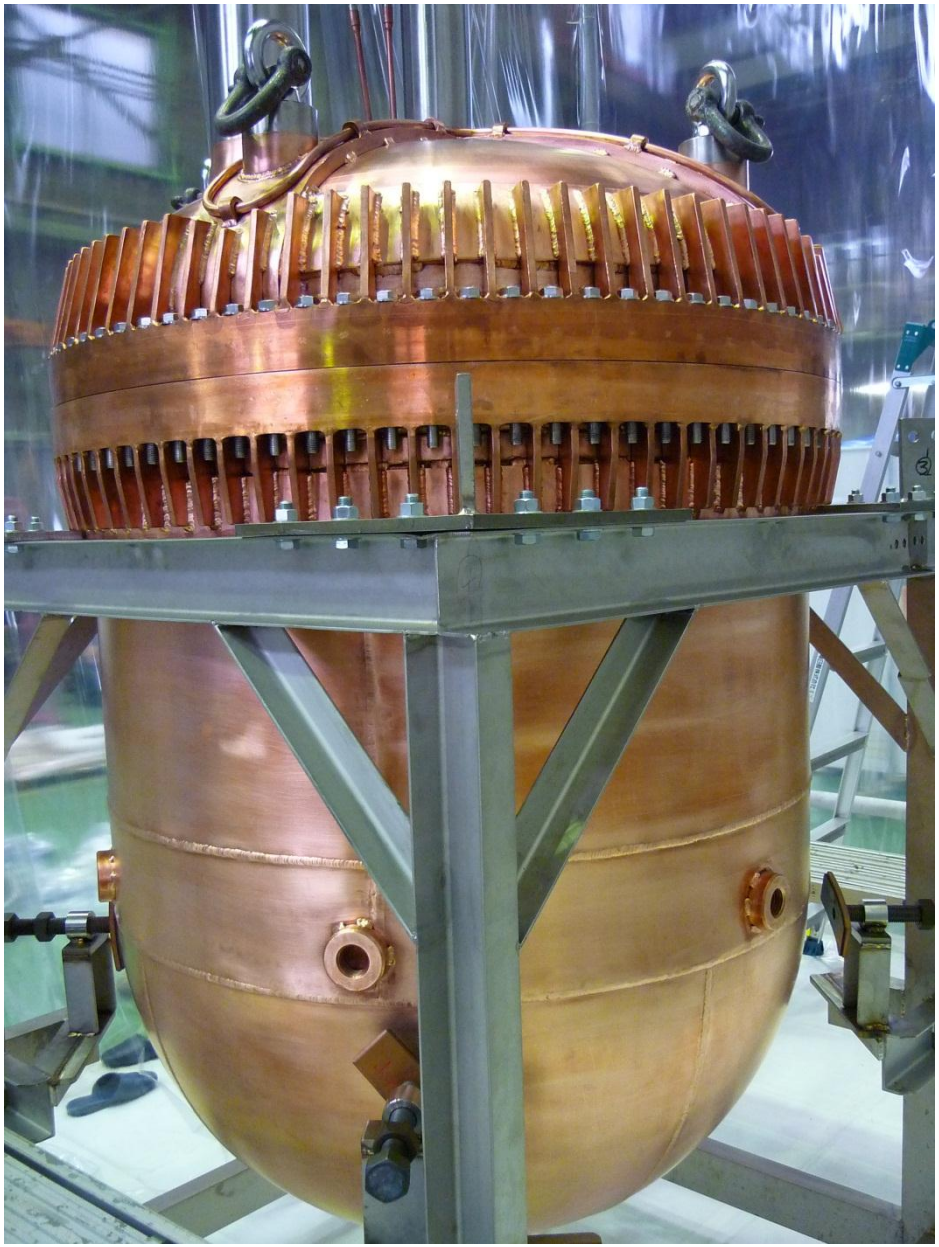
PMT installation to upper half sphere



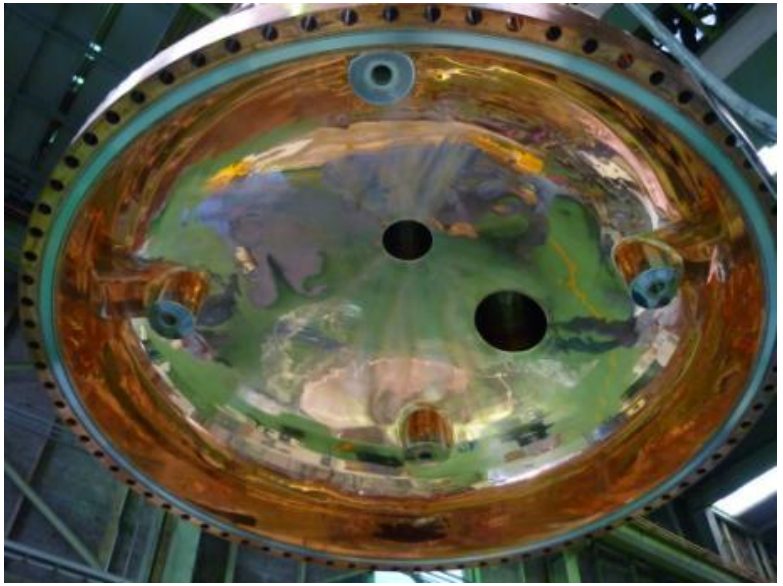
Upper sphere after all PMT installation



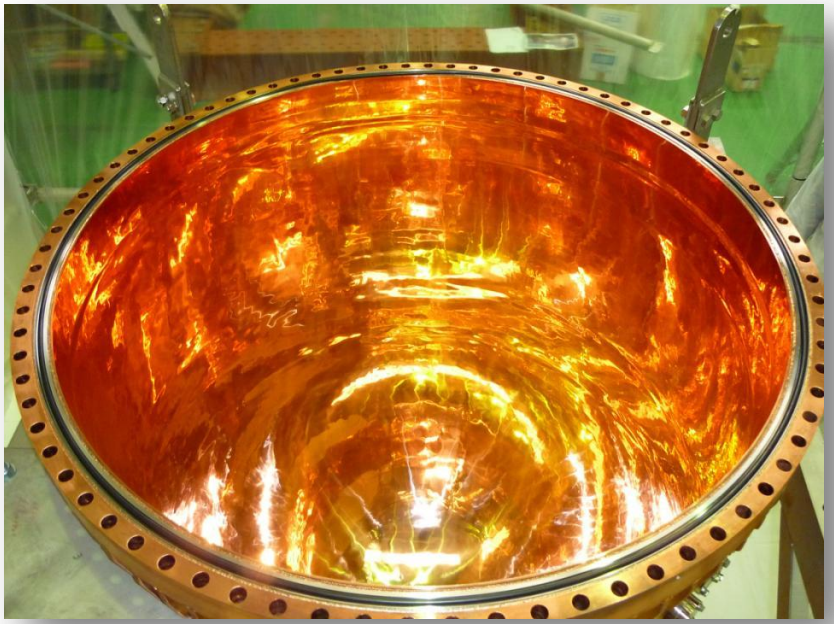
Inner Vacuum Chamber (IVC)



Upper part of IVC



Lower part of IVC



# ➢ Current status and schedule

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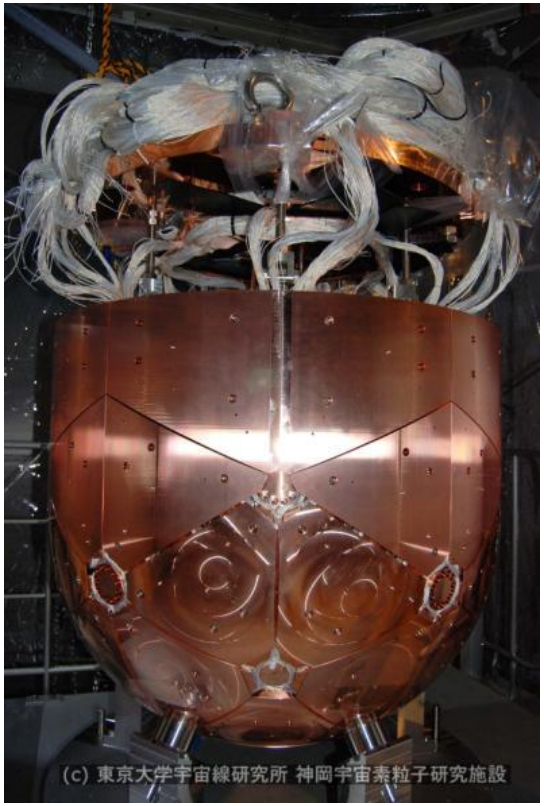
- Now, assembly work is going.

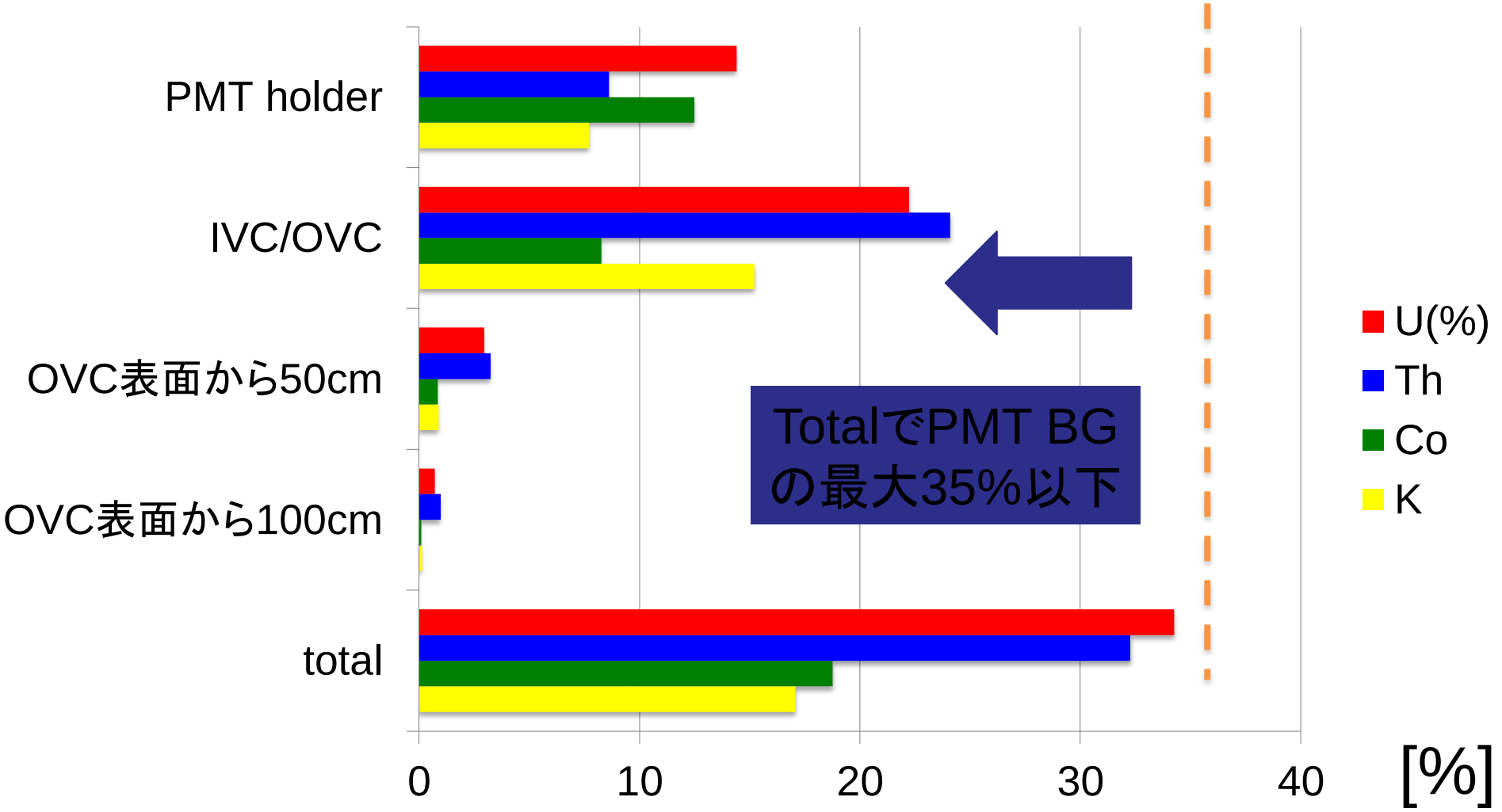




# RI measurement with HPGe

- 3 HPGe in the Kamioka mine are used


- All the components were measured used for XMASS detector.
- Number of sample measured is more than 250
- Sample is sealed inside the EVOH bag during measurement avoid lose Rn from sample.

# BG from other materials

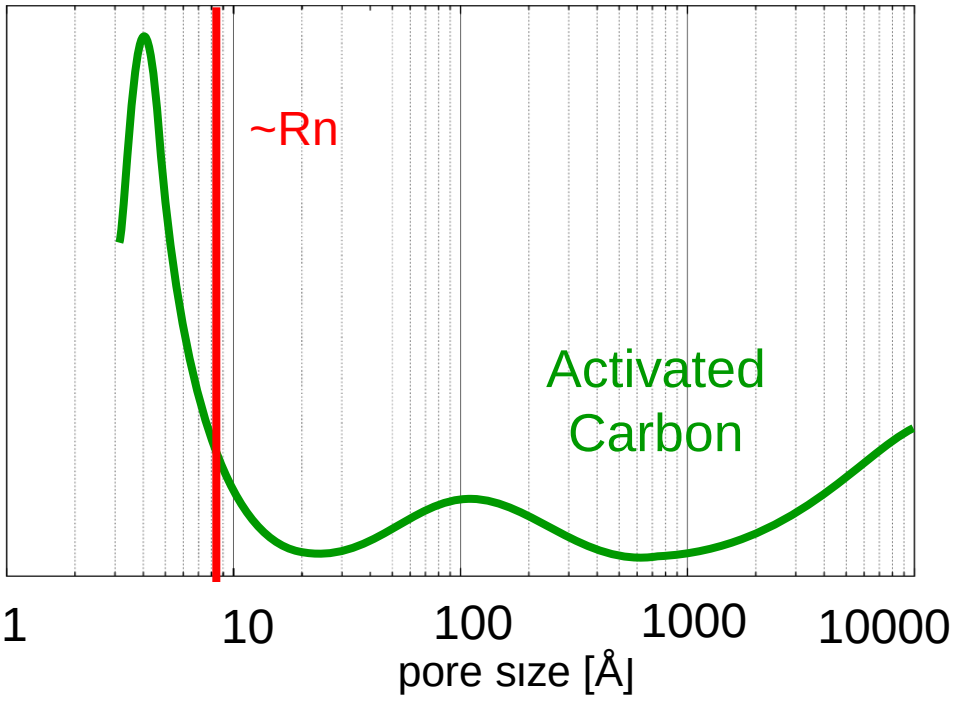



Comparing with PMT (642) BG

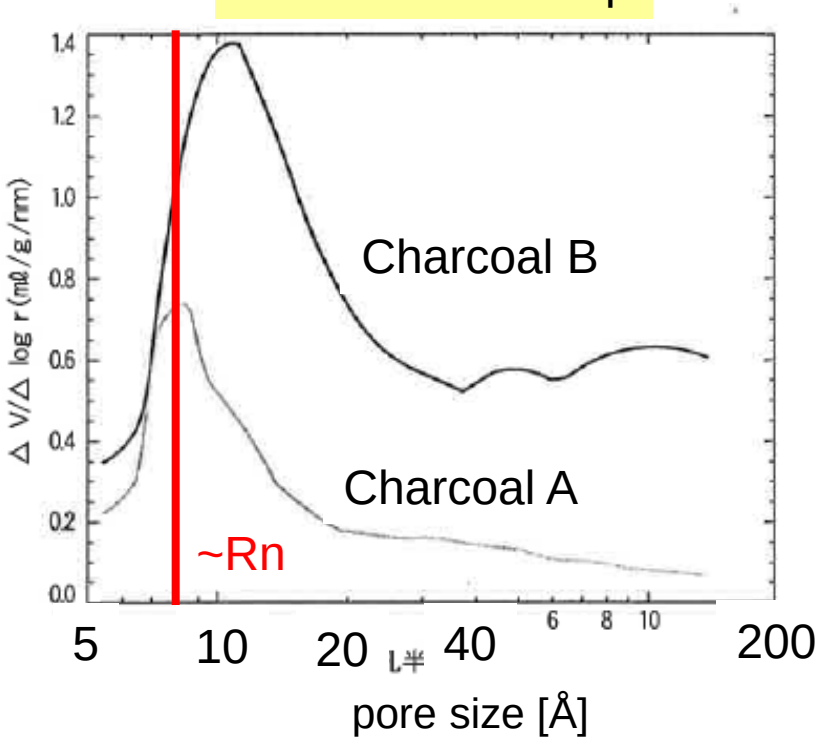
# ➢ Rn removal in gas circulation

- Charcoal whose suitable hole (10A) size was selected

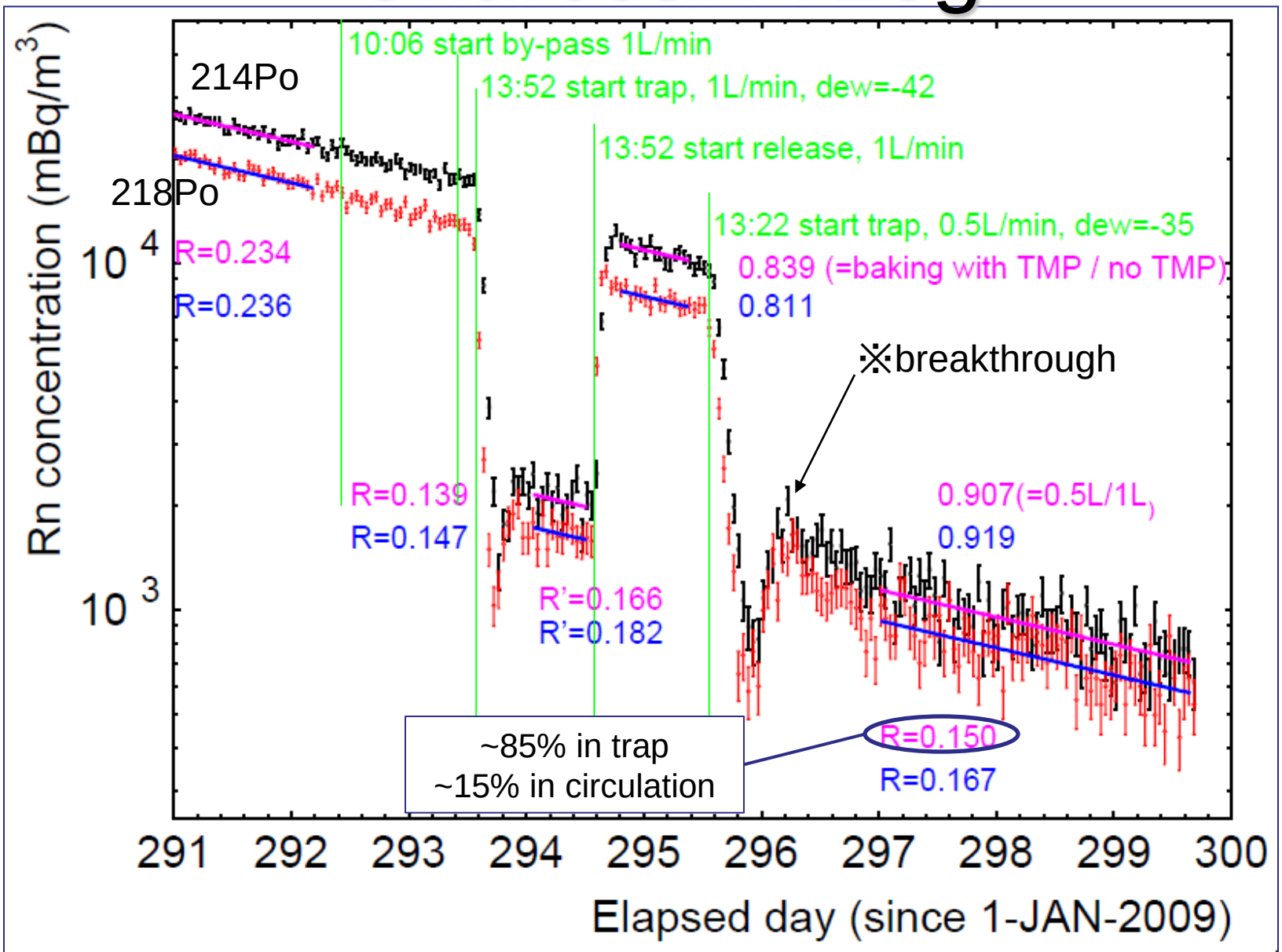
Example of usual charcoal




Used for our setup

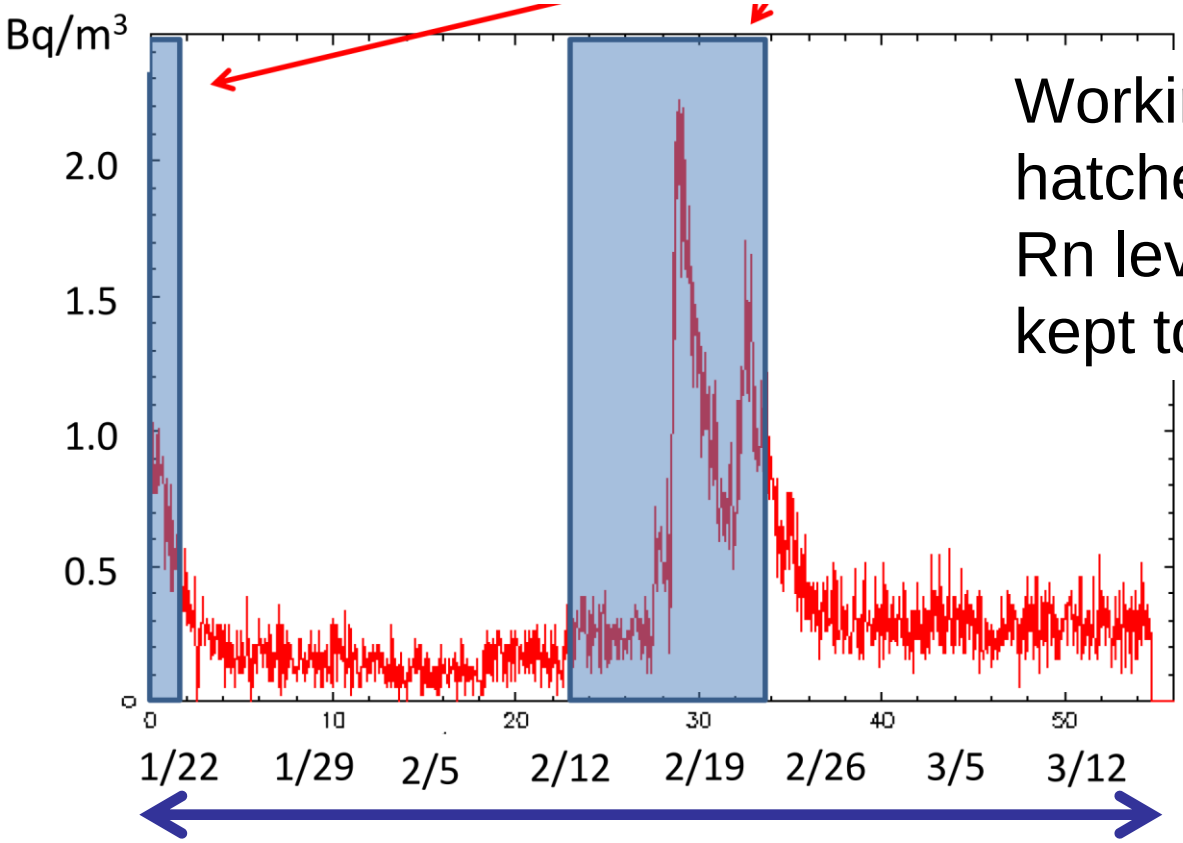


# Charcoal A 25g



# Rn level in the laboratory

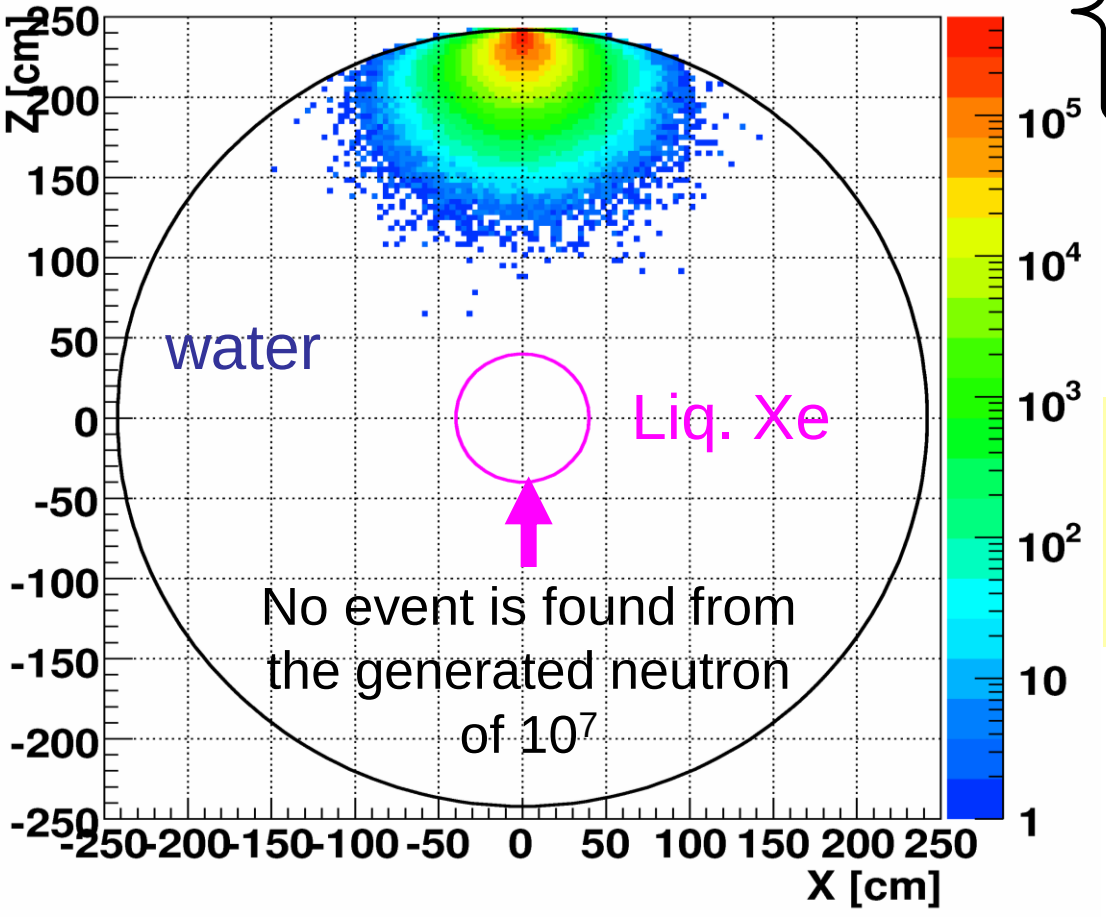
(1) Fresh air from outside the mine: ~20Bq/m$^3$ ~500m$^3$/hr
filled into the experimentall hall
(2) Rn free air: ~0.01Bq/m$^3$ ~20m$^3$/hr
filled into the water tank




Working period excluding hatched region,
Rn level inside the tank was kept to ~0.3 Bq/m$^3$.

# ➢ Neutron attenuation by water tank

water: 200cm, n: 10MeV




- Fast n flux @Kamioka mine:
  $(1.15 \pm 0.12) \times 10^{-5}$ /cm$^2$/sec
- Assuming all the energies are 10 MeV very conservatively

$< 10^{-4}$ counts/day/kg

200cm water is enough to reduce the BG to the PMT BG level