Low background techniques in XMASS

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1. XMASS experiment
2. Background reduction
3. Summary

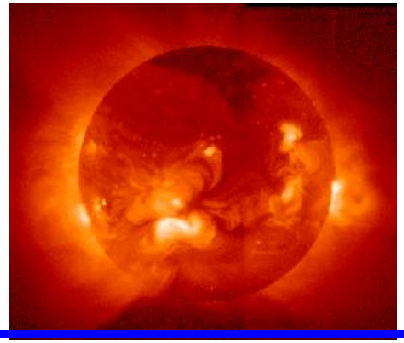
1. XMASS experiment

➢ What's XMASS

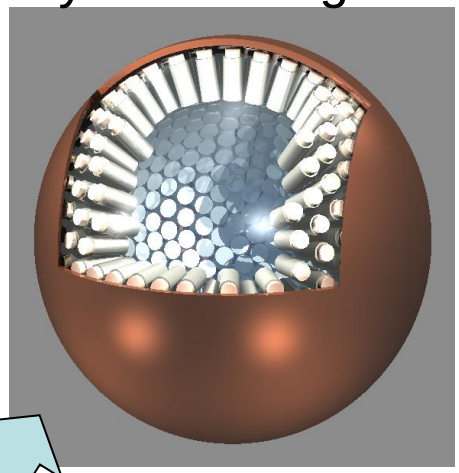
Multi purpose low-background experiment with liq. Xe

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

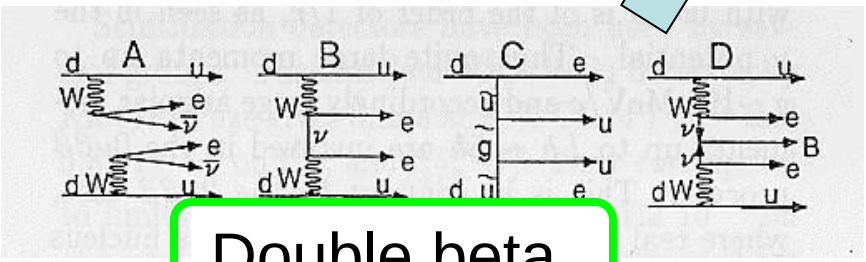
- **X**enon **MASS**ive detector for solar neutrino (**pp/^{7}Be**)
- **X**enon neutrino **MASS** detector (**ββ decay**)
- **X**enon detector for Weakly Interacting **MASS**ive Particles (**DM search**)



Solar neutrino



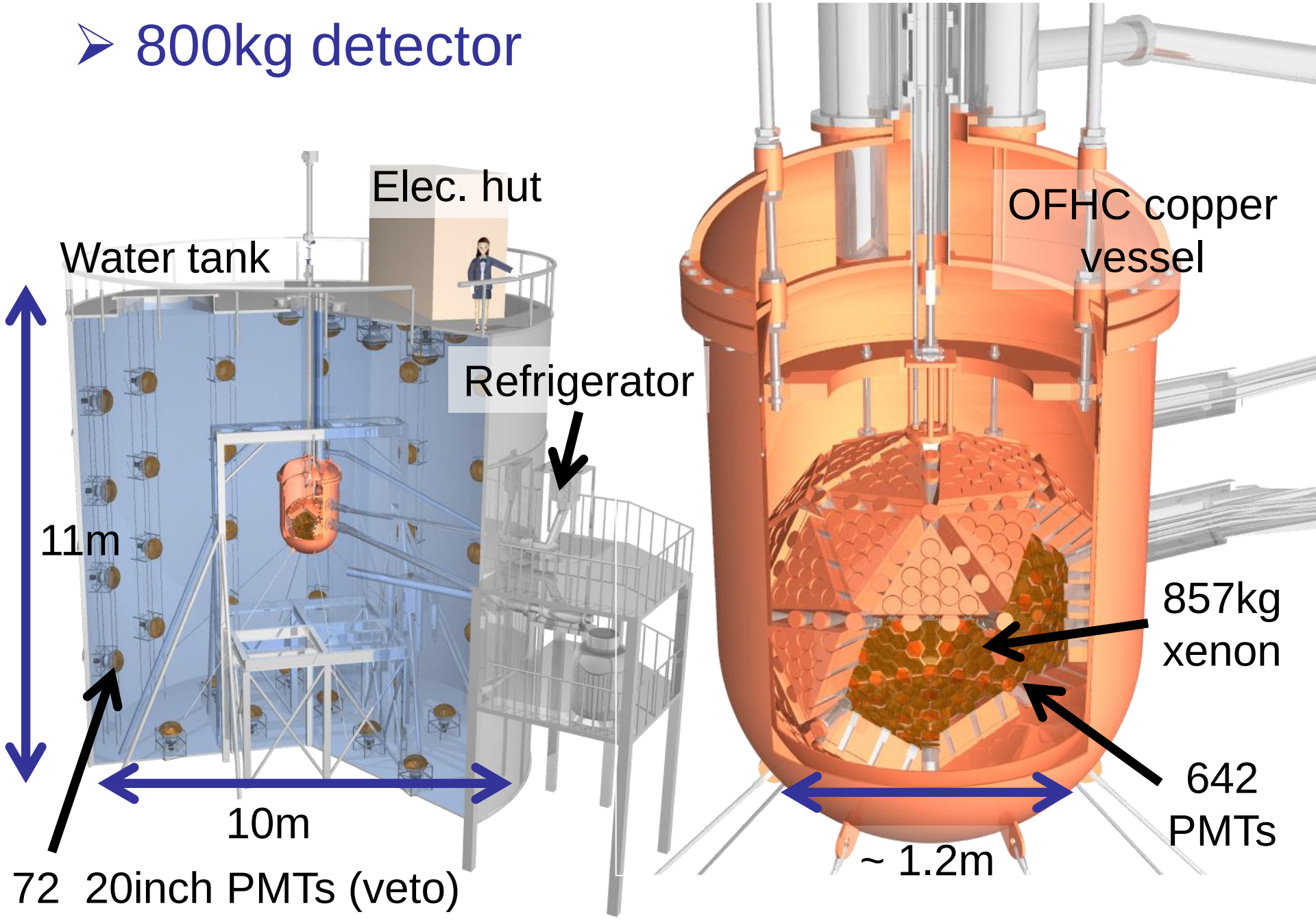
Dark matter



Double beta

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

➢ 800kg detector

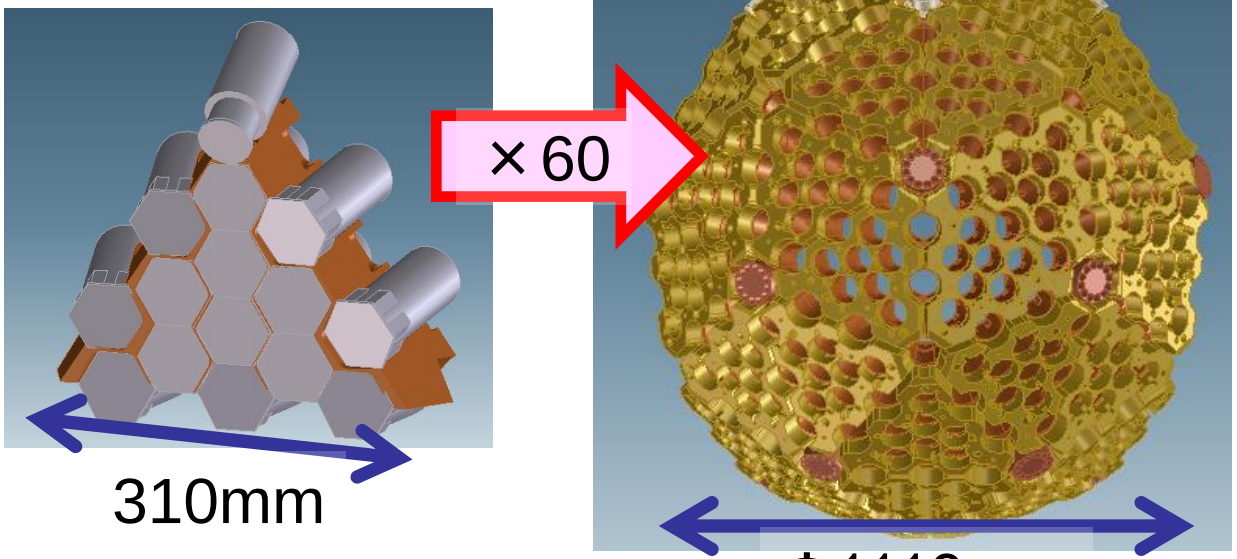


➢ Structure of the 800kg detector

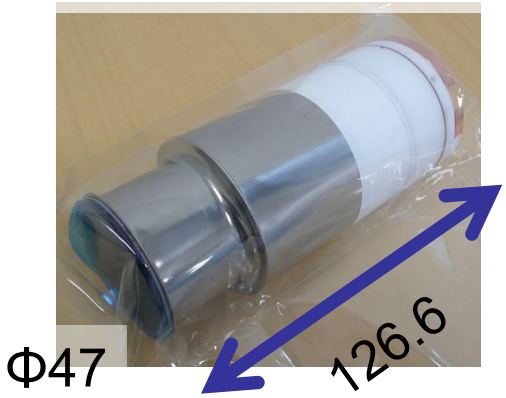
Single phase liquid Xenon detector

- 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



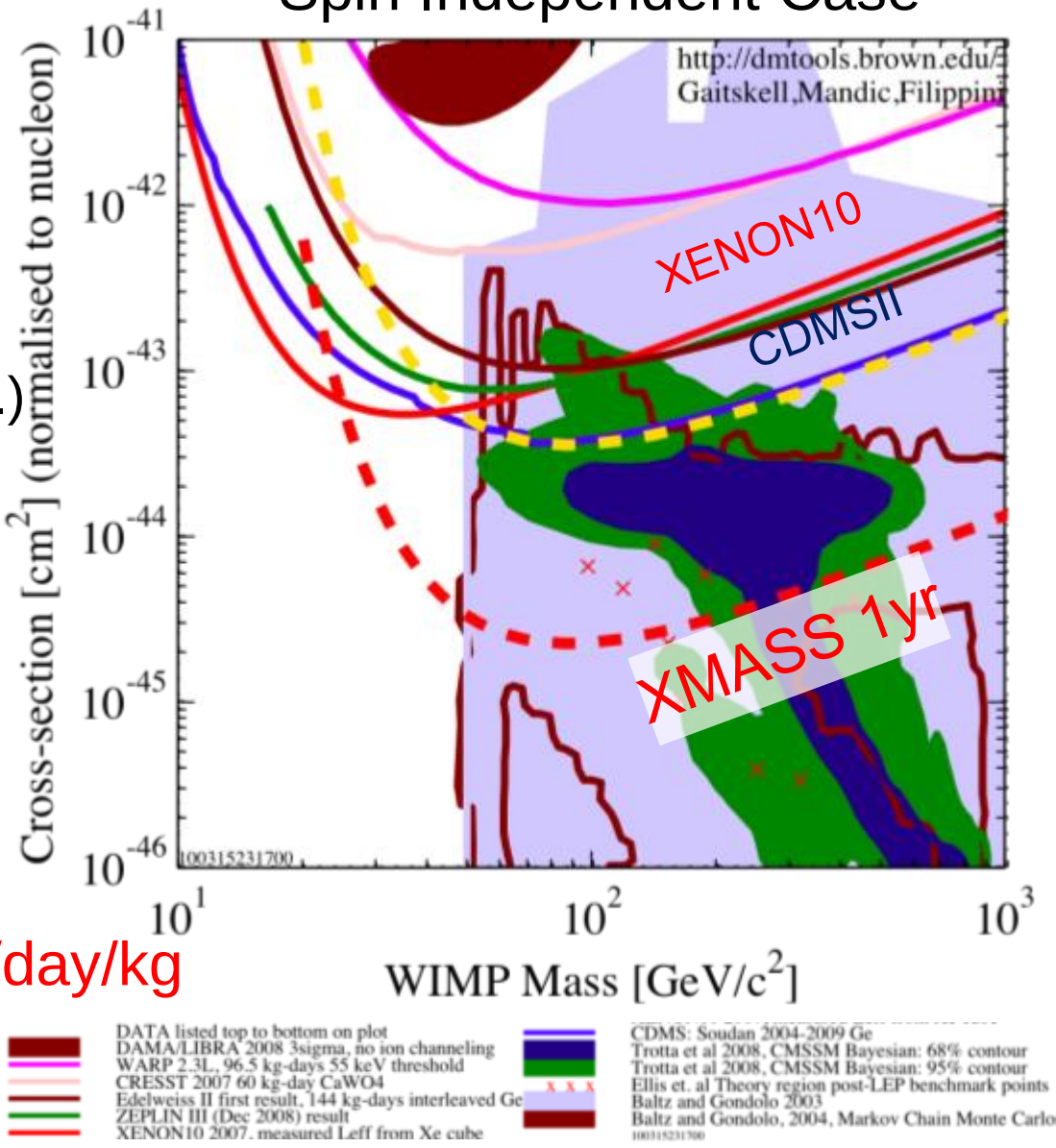
➢ Expected sensitivities

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

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

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

Spin Independent Case



2. Background reduction

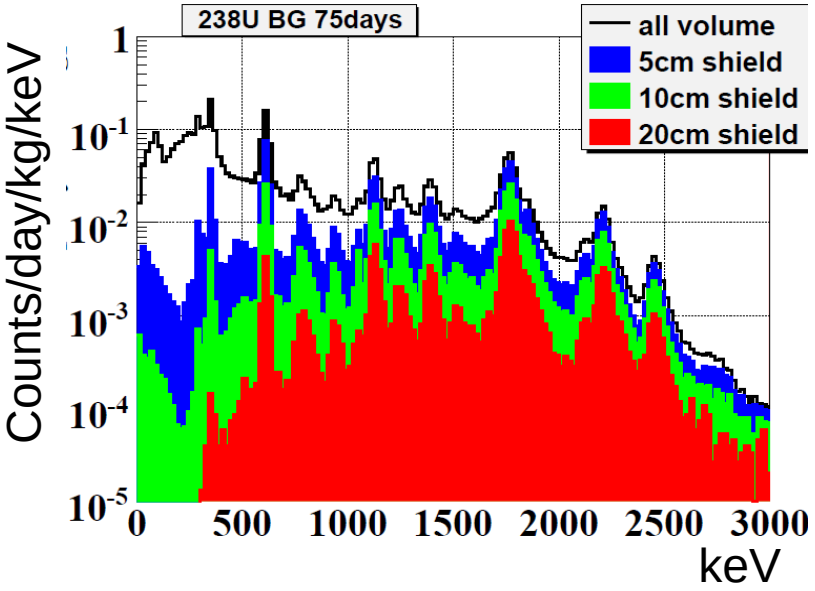
(1) BG from detector materials

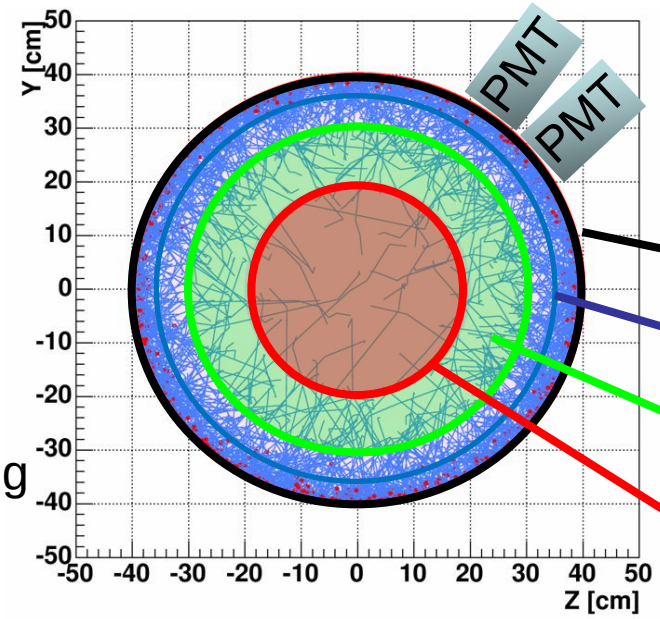
- 642 PMTs: Main BG source although RI level is 1/100 of ordinary PMT.
- OFHC copper: Bring in the mine < 1month after electrorefining (Mitsubishi Material Co.)
- Other materials: All the components were selected with HPGe and ICP-MS. (>250 samples were measured) The total RI level is much lower than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

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

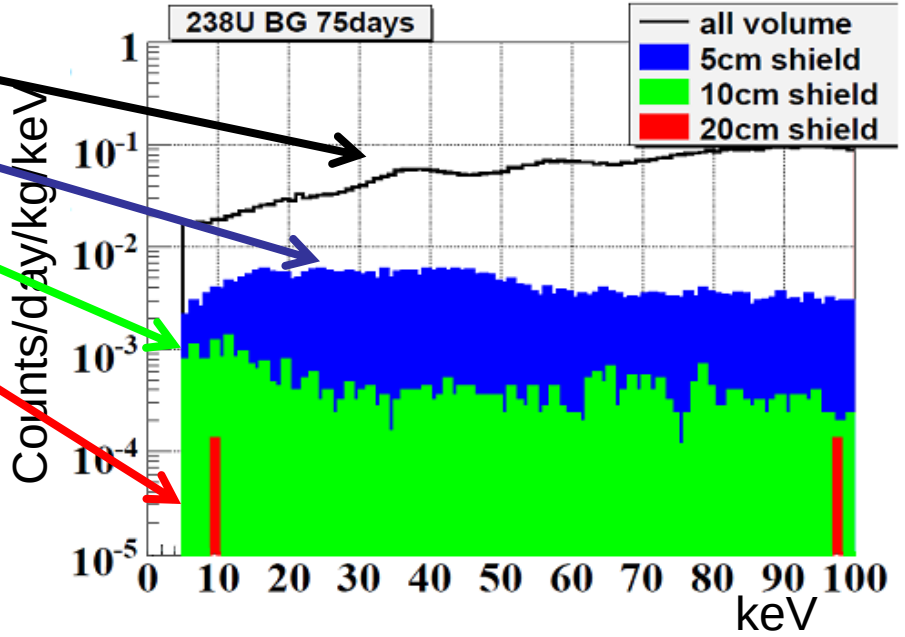
➢ Self-shielding for BG from PMTs

	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

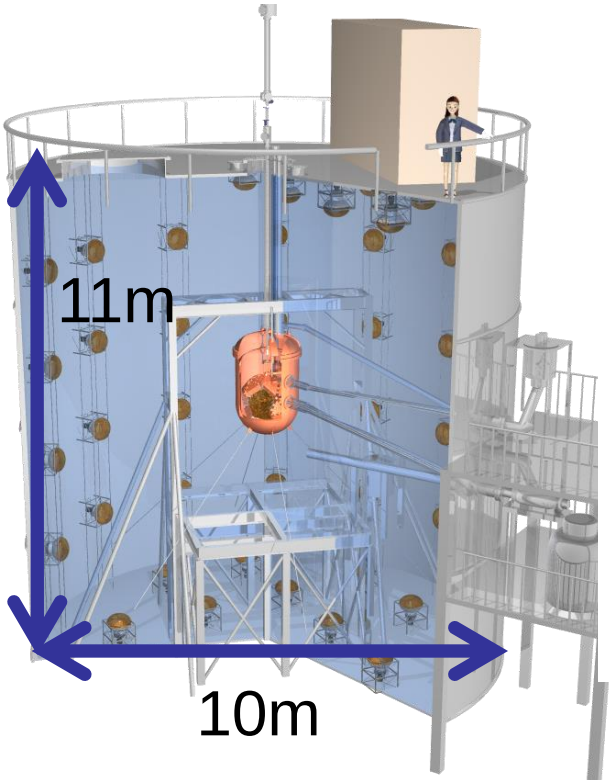


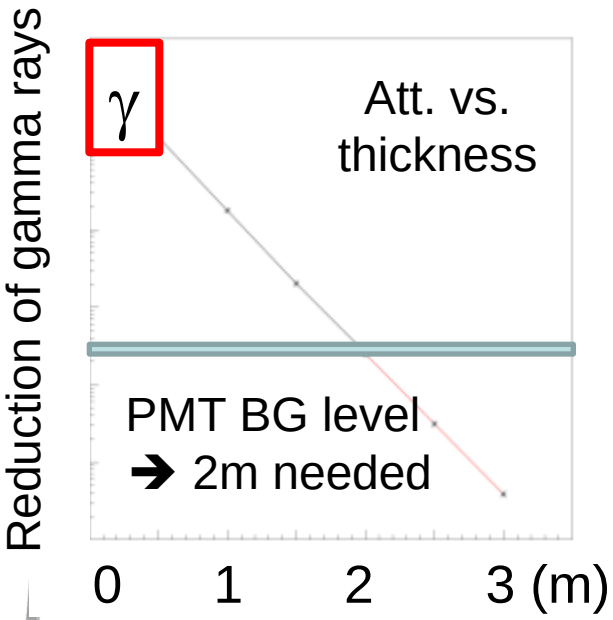
< 10^{-4} /keV/day/kg (100kg F.V.)

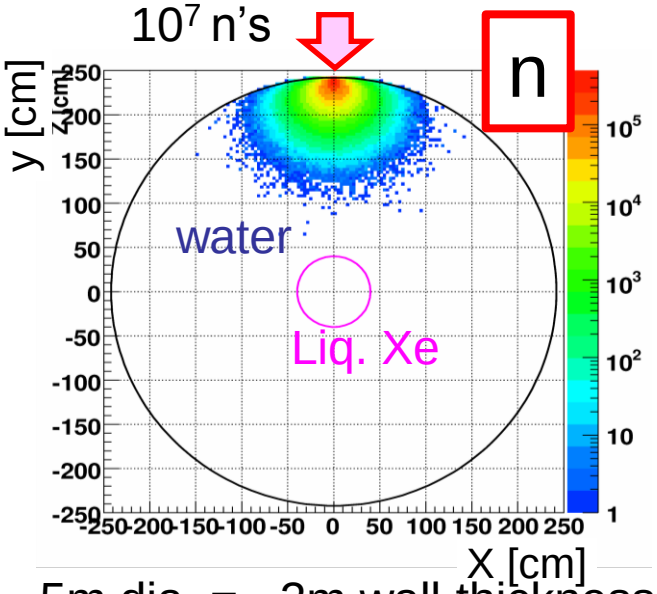
n contribution < 2.2×10^{-5}/d/kg

(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.







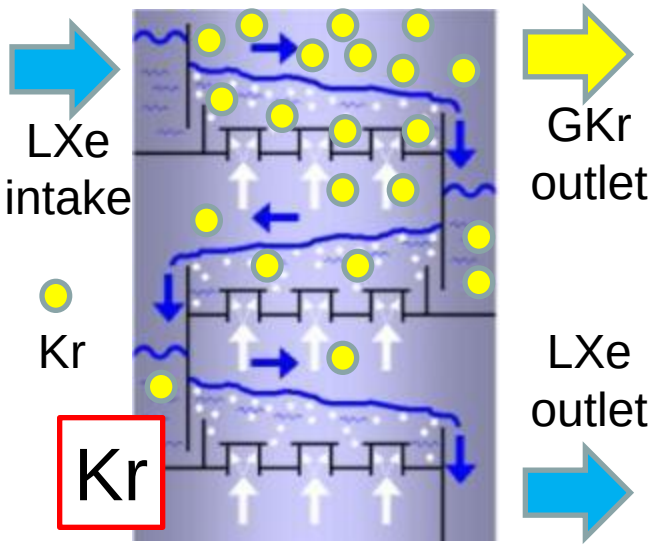
5m dia. = ~2m wall thickness

(3) Internal BG (1) : Kr

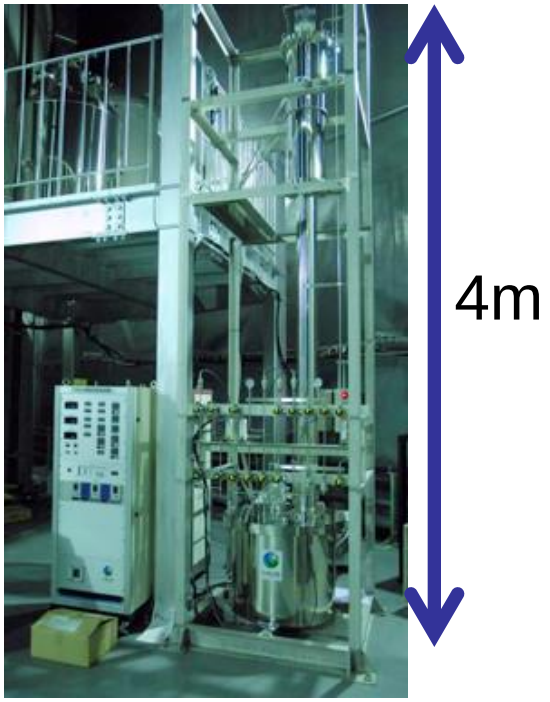
- Kr (^{85}Kr: Q_β=687keV, τ=10.8y) can be reduced by distillation.
- Our goal: Kr < 1ppt (↔ $<10^{-5}$ /day/keV/kg)
- 5 order of magnitude reduction with 4.7kg/hr processing time was achieved. *K. Abe et al. for XMASS collab., Astropart. Phys. 31 (2009) 290*
- Target value can be achieved in 10 days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

commercial

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



Distillation tower

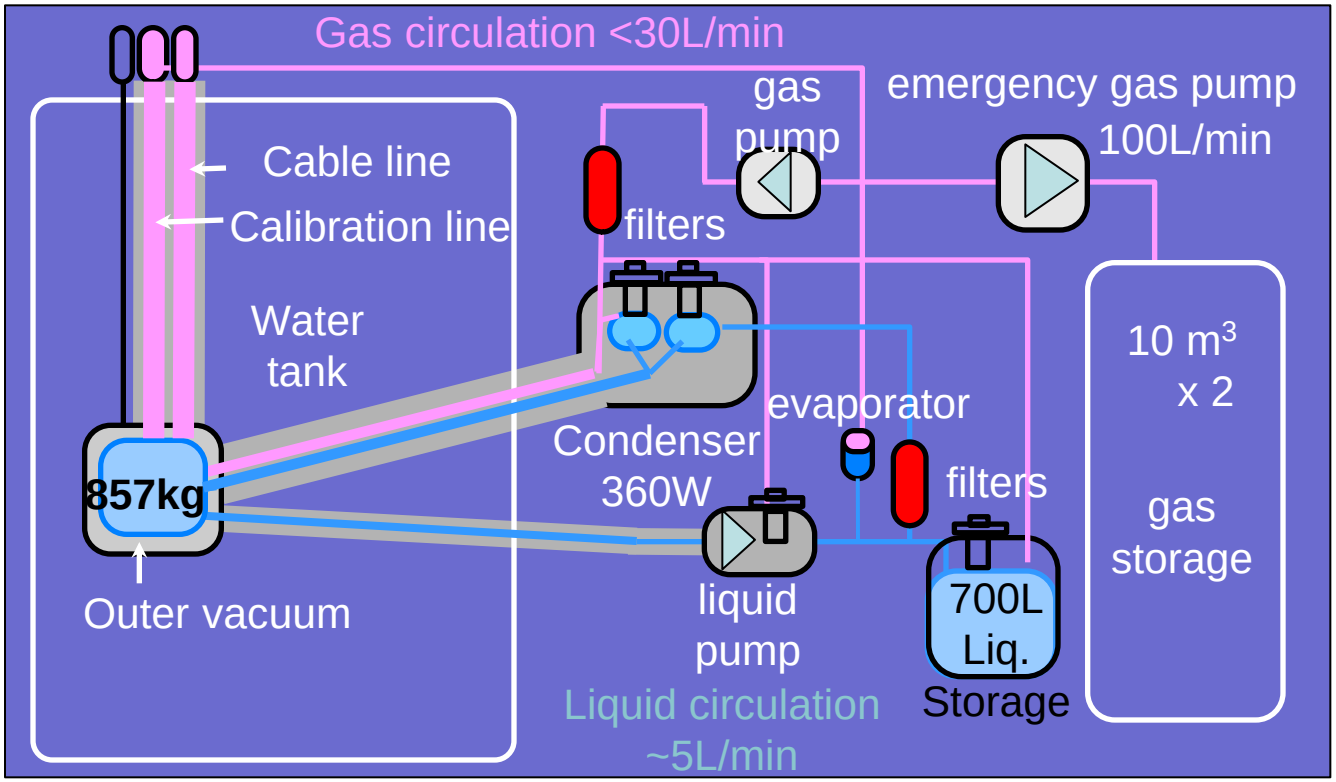


(4) Internal BG (2) : Rn

- 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

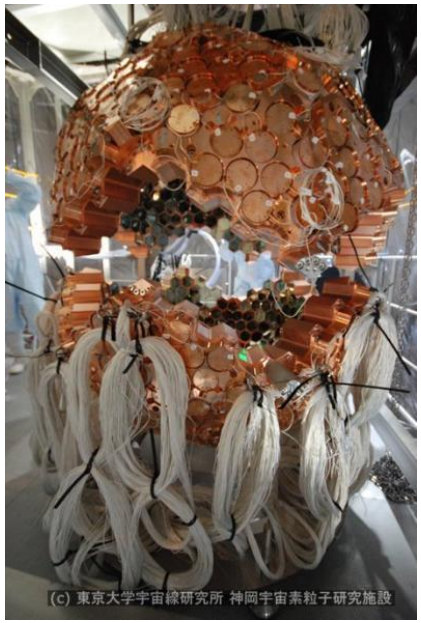
- Charcoal whose suitable hole size (~10 Å) was selected.
- Tested in -105℃, with 10Bq Rn in xenon.

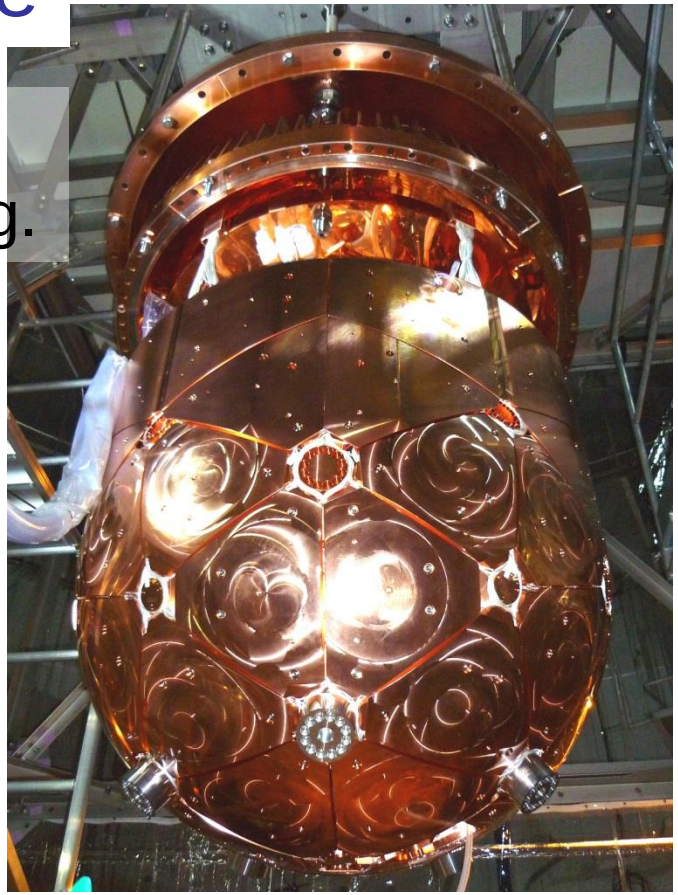
- More than 85% Rn removal was achieved.
  (charcoal weight: 25g, trap length: 60cm, flow rate: 0.5L/min).
  Rn removal efficiency is now being improved with more suitable trap length and flow rate.
- In the case of Rn removal emanated from only gas phase, our goal (<0.6mBq) can be achieved with 1.0 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 2×10^{-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

All the backup slides were removed for publication.