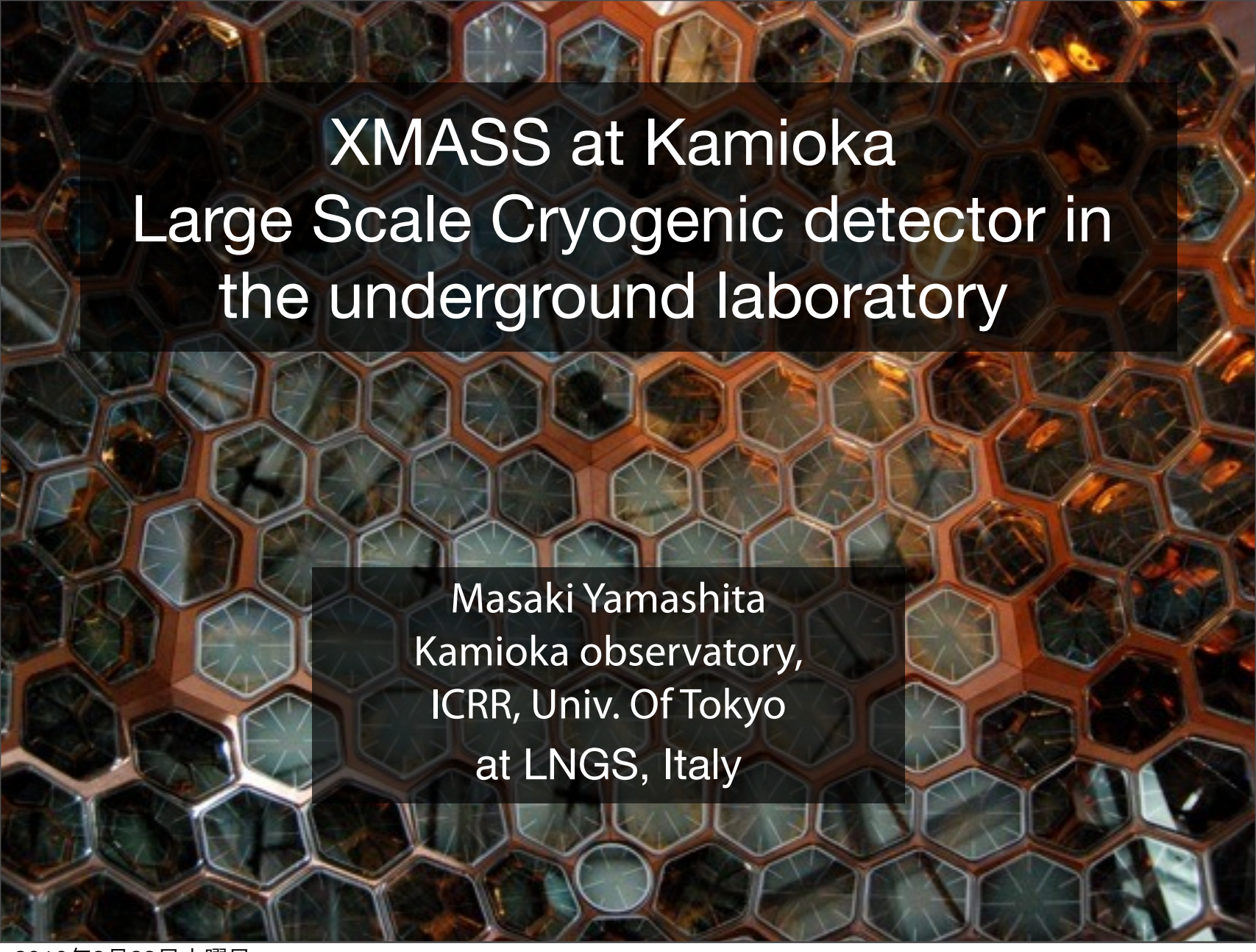


XMASS at Kamioka
Large Scale Cryogenic detector in the underground laboratory

Masaki Yamashita
Kamioka observatory,
ICRR, Univ. Of Tokyo
at LNGS, Italy

Outline

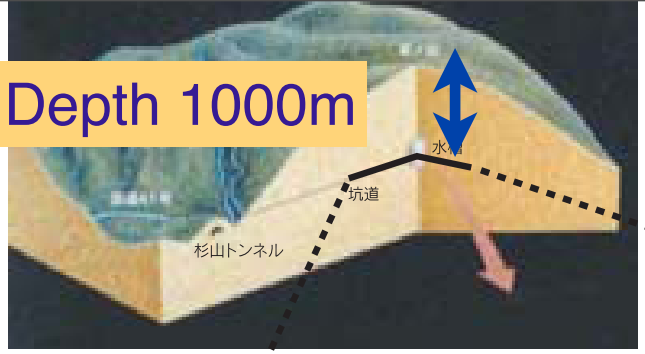
- Kamioka Observatory
- XMASS 800 kg liquid xenon detector
  - Experimental Hall
  - Water Tank
  - Cryogenics, gas/liquid line and Emergency
  - Detector and its Assembly
- Summary

- 20 researchers and 7 students.
- + collaborators from outside and inside of Japan.

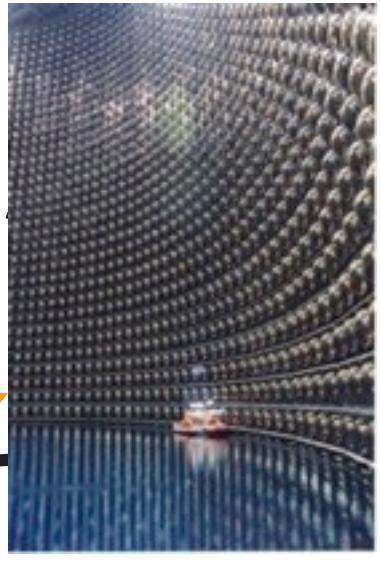
Location


Dormitory
Underground Lab
Office
Kamioka mine
300 km
Tokyo
RUSSIA
SOUTH KOREA
PACIFIC OCEAN

Kamioka Mine



2700 m.w.e



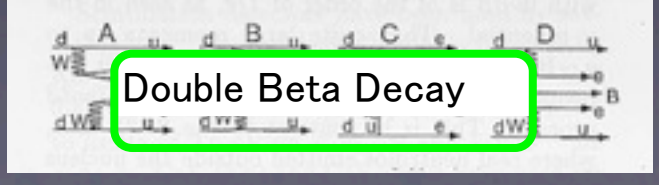
XMASS Experiment

Multi purpose low-background experiment with LXe.

- **Xenon MASSive detector for Solar neutrino (pp/^{7}Be)**
- **Xenon neutrino MASS detector (double beta decay)**
- **Xenon detector for Weakly Interacting MASSive Particles (DM)**

Solar Neutrino

Dark Matter



Double Beta Decay

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XMASS Collaboration

Dark Matter Search Experiment

Kamioka Observatory, ICRR, Univ. of Tokyo : Y. Suzuki, M. Nakahata, S. Moriyama, Y. Takeuchi, M. Yamashita, Y. Koshio, A. Takeda, K. Abe, H. Sekiya, H. Ogawa, K. Kobayashi, A. Minamino, K. Ueshima, M. Ikeda, Y. Nakajima

IPMU, University of Tokyo : Kai Martens

Saga University : H. Ohsumi

Tokai University : K. Nishijima, D. Motoki, D. Nishigaki

Gifu University : S. Tasaka

Waseda University : S. Suzuki, T. Doke, T. Takahashi

Yokohama National University : S. Nakamura, T. Sato, K. Miyamoto, K. Fujii

Miyagi University of Education : Y. Fukuda

STEL, Nagoya University : Y. Itow, K. Masuda, H. Uchida

Seoul National University : Soo-Bong Kim

Sejong University : Y. D. Kim, J. I. Lee, S. H. Moon

KRISS: Y. H. Kim

12 institutes and 37 researchers

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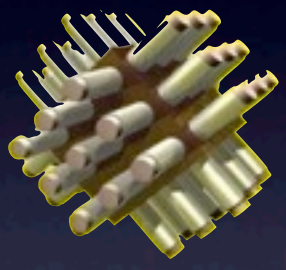
XMASS

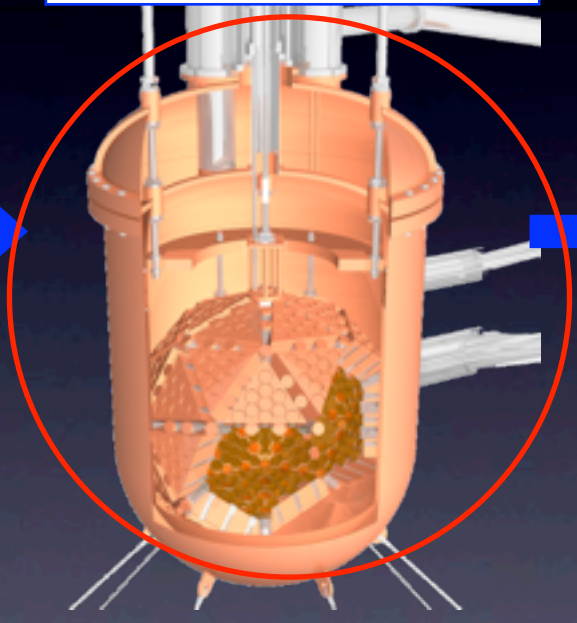
100kg Prototype
（FV:30kg、~30cm）



R&D

completed

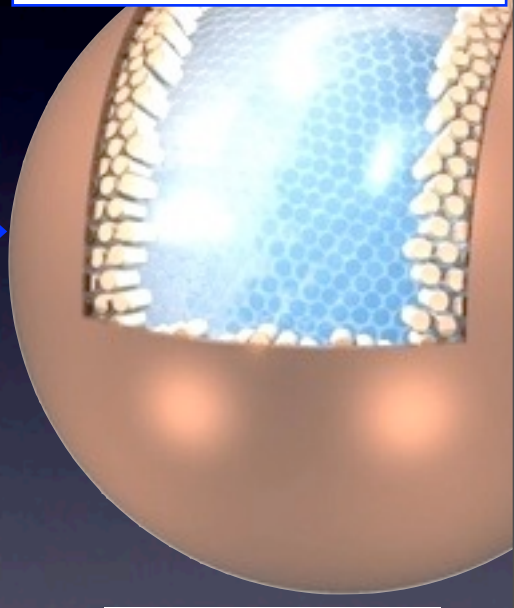
800kg Detector
（FV:100kg、80cm）



Dark Matter

2010 start

20ton Detector
（FV:10ton、~2.5m）



Solar neutrino
Dark Matter

Future

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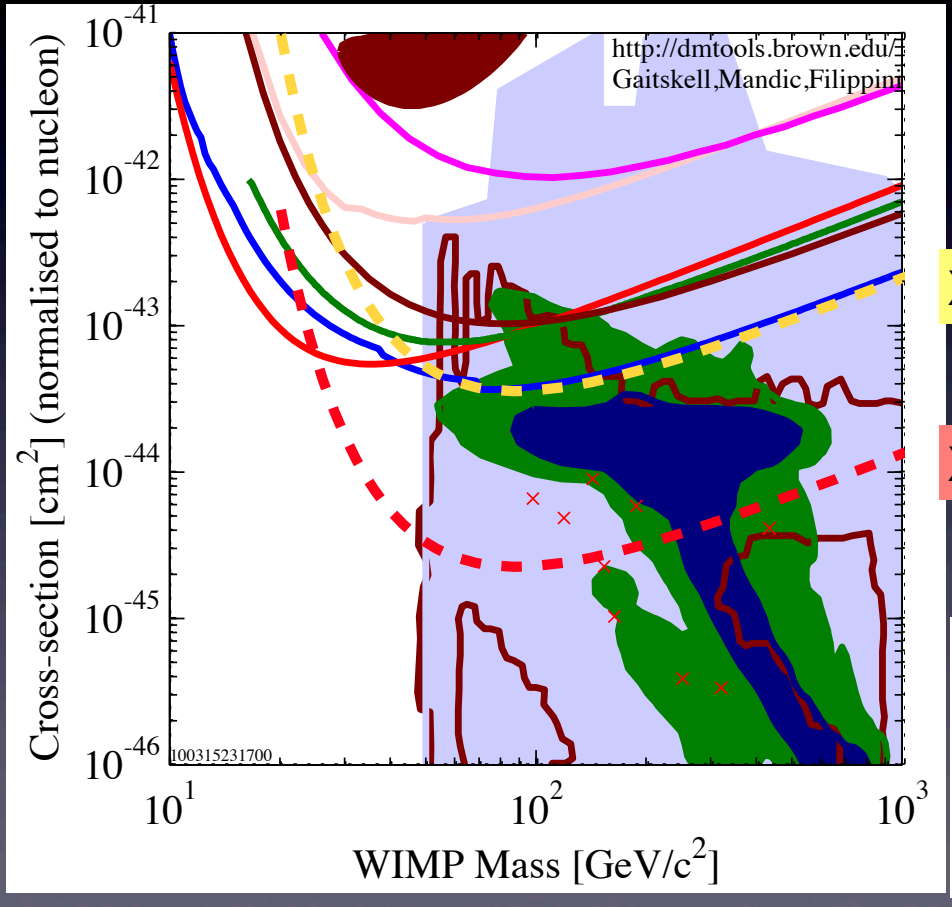
Sensitivity for SI case



10^{-4} dru, 100 kg fiducial

XMASS 800 kg 10 days

XMASS 800 kg 1 year

(flat bg assumed)

DATA listed top to bottom on plot
DAMA/LIBRA 2008 3sigma, no ion channeling
WARP 2.3L, 96.5 kg-days 55 keV threshold
CRESST 2007 60 kg-day CaWO4
Edelweiss II first result, 144 kg-days interleaved Ge
ZEPLIN III (Dec 2008) result
XENON10 2007, measured Leff from Xe cube
CDMS: Soudan 2004-2009 Ge
Trotta et al 2008, CMSSM Bayesian: 68% contour
Trotta et al 2008, CMSSM Bayesian: 95% contour
Ellis et. al Theory region post-LEP benchmark points
Baltz and Gondolo 2003
Baltz and Gondolo, 2004, Markov Chain Monte Carlos
100315231700

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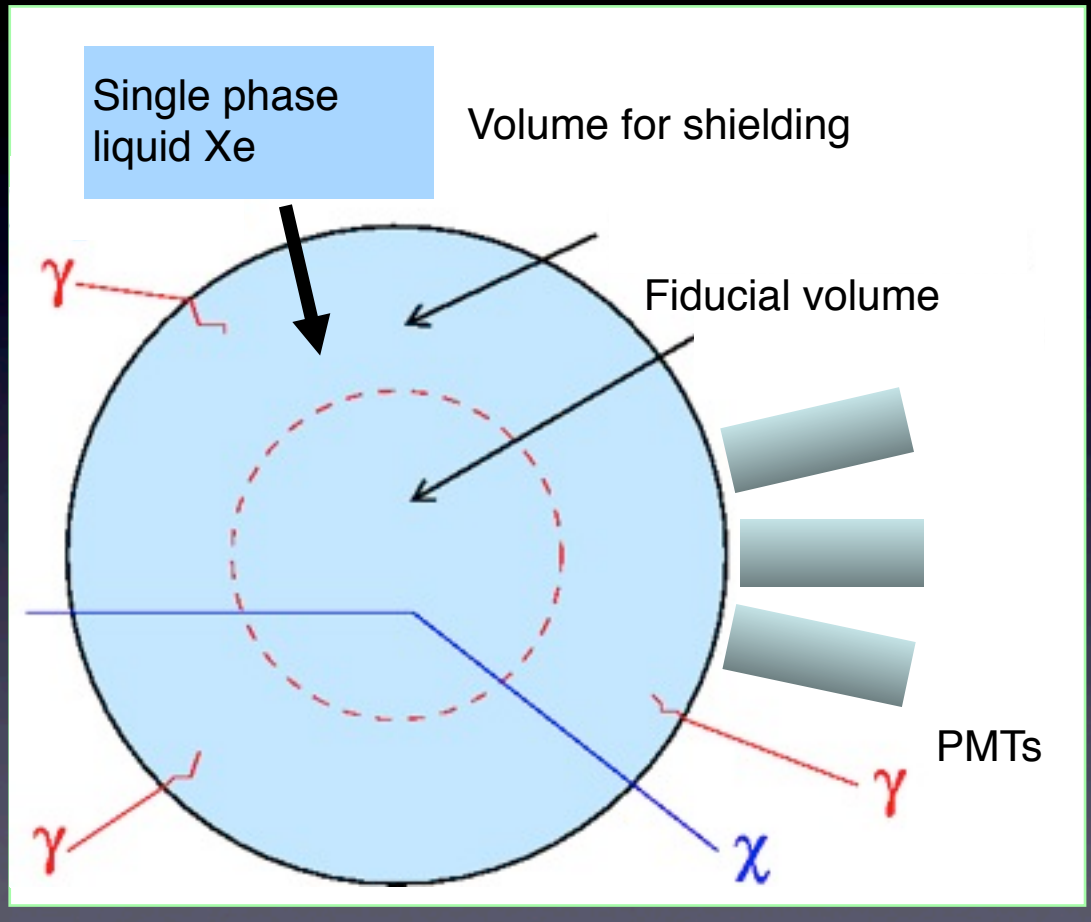
Concept of background reduction
Self-shielding



Low Background region near the center of the fiducial volume

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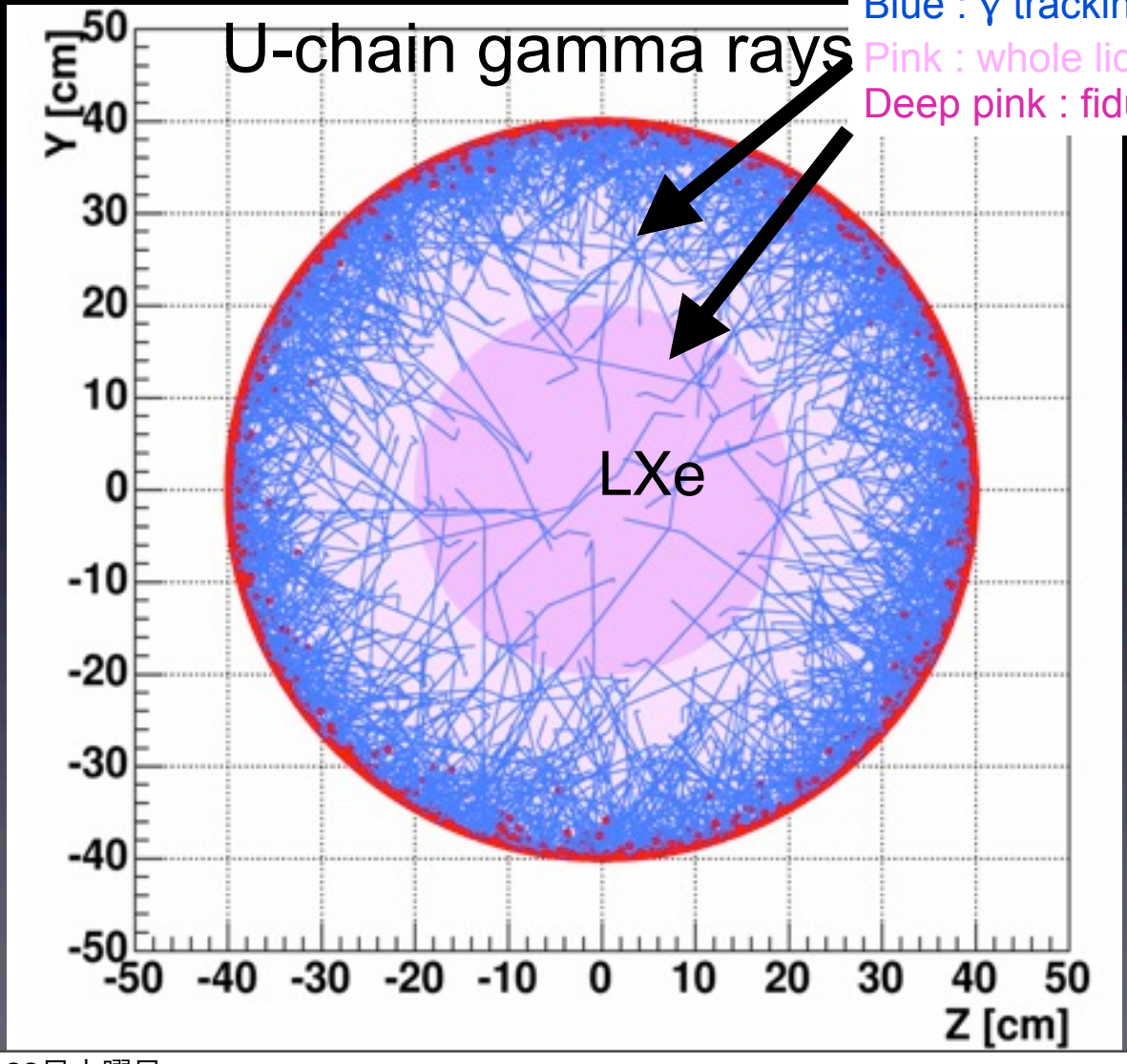
γ tracking MC from external to Xenon



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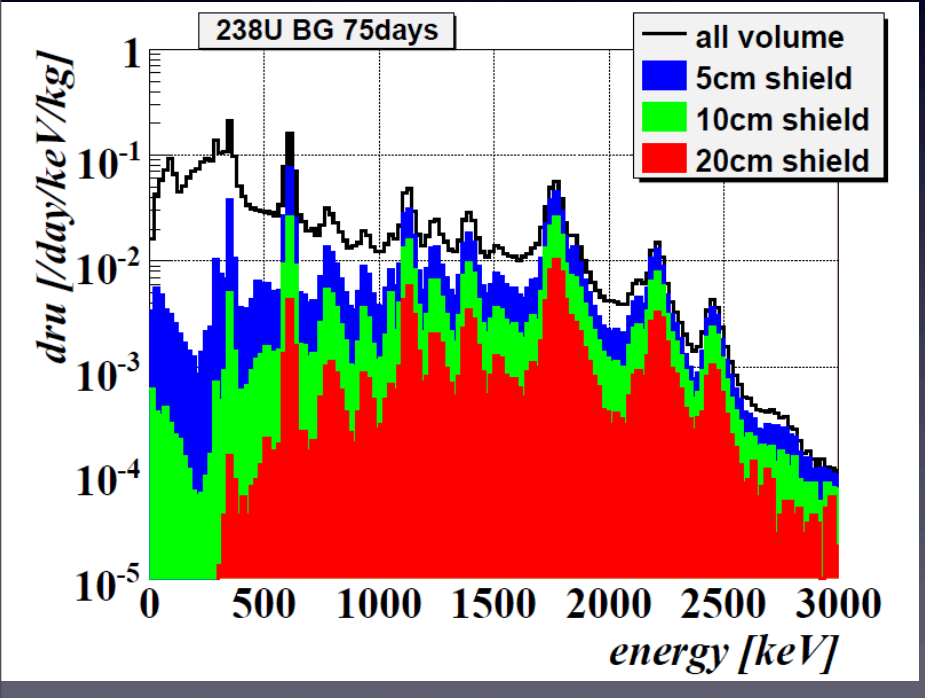
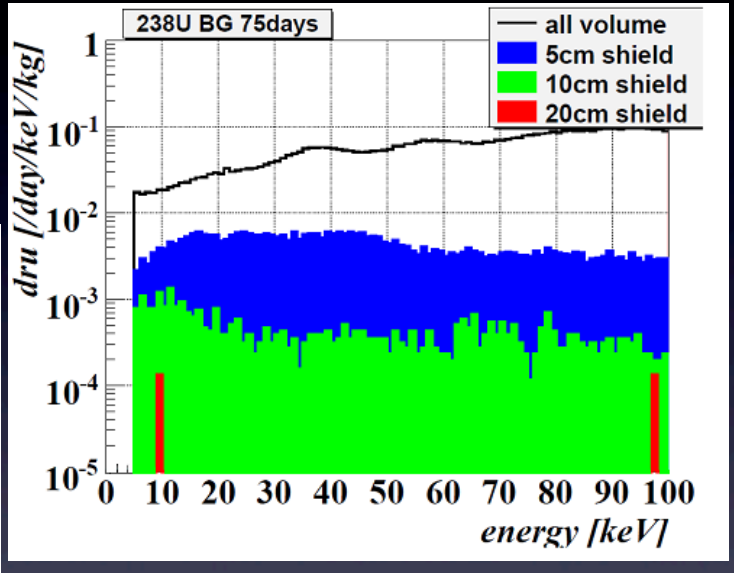
Concept of background reduction
Self-shielding

For 238U
Assumed 1.8mBq/PMT
Absorption 100cm, scattering 30cm





Background

Background in the 100 kg fiducial volume out of 1 ton.

- External
  - gamma
  - neutron

Water Shield

- Detector material
  - PMT+Base (2 inchi)
  - U/Th/^{40}K/^{60}Co
    (0.7/1.5/<5.1/2.9 mBq/PMT)

$<10^{-4}$ dru

- Internal
  - ^{85}Kr
    - <1ppt Kr required
    - 3 ppt is achieved

Distillation Tower

  - U/Th(Rn)
    - $<10^{-14}$ g/g required
    - U/Th 9±6/<23 x 10^{-14} g/g

MS, Charcoal
goal $<10^{-14}$ g/g

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PMT

XMASS PMT HISTORY

YEAR	2000	2002	2009
Model	Prototype	R8778	R10789
Material:Body	glass	Kovar	Kovar
QE	25%	25%	27-39%
RI:			
U [mBq/PMT]	*50*	*18±2*	*0.7 +/- 0.28*
Th [mBq/PMT]	*13*	*6.9±1.3*	*1.5 +/- 0.31*
^{40}K [mBq/PMT]	*610*	*140±20*	*<5.1*
^{60}Co [mBq/PMT]	*<1.8*	*5.5±0.9*	*2.9 +/- 0.16* with base

- ✓ Developed with Hamamatsu.
- ✓ This radioactivity level allow us to reach less than 10^{-4}/day/kev/kg .

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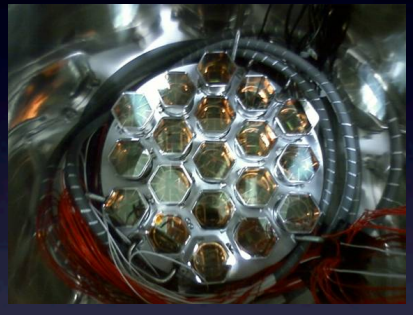
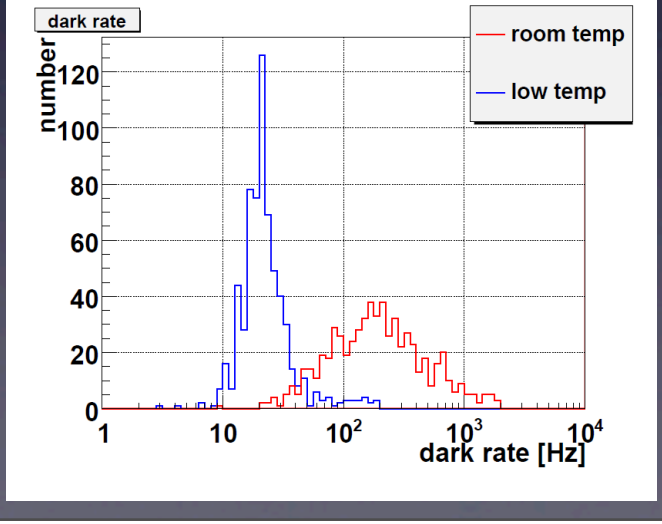
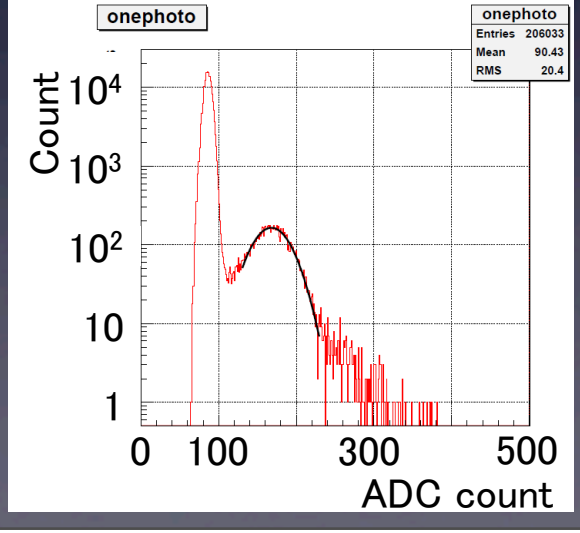
Test in low temperature

- ~200 Hz of dark current at room
- ~20 Hz of dark current at LXe temperature.
- Peak to Valley ratio ~ 4.0







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Water Tank

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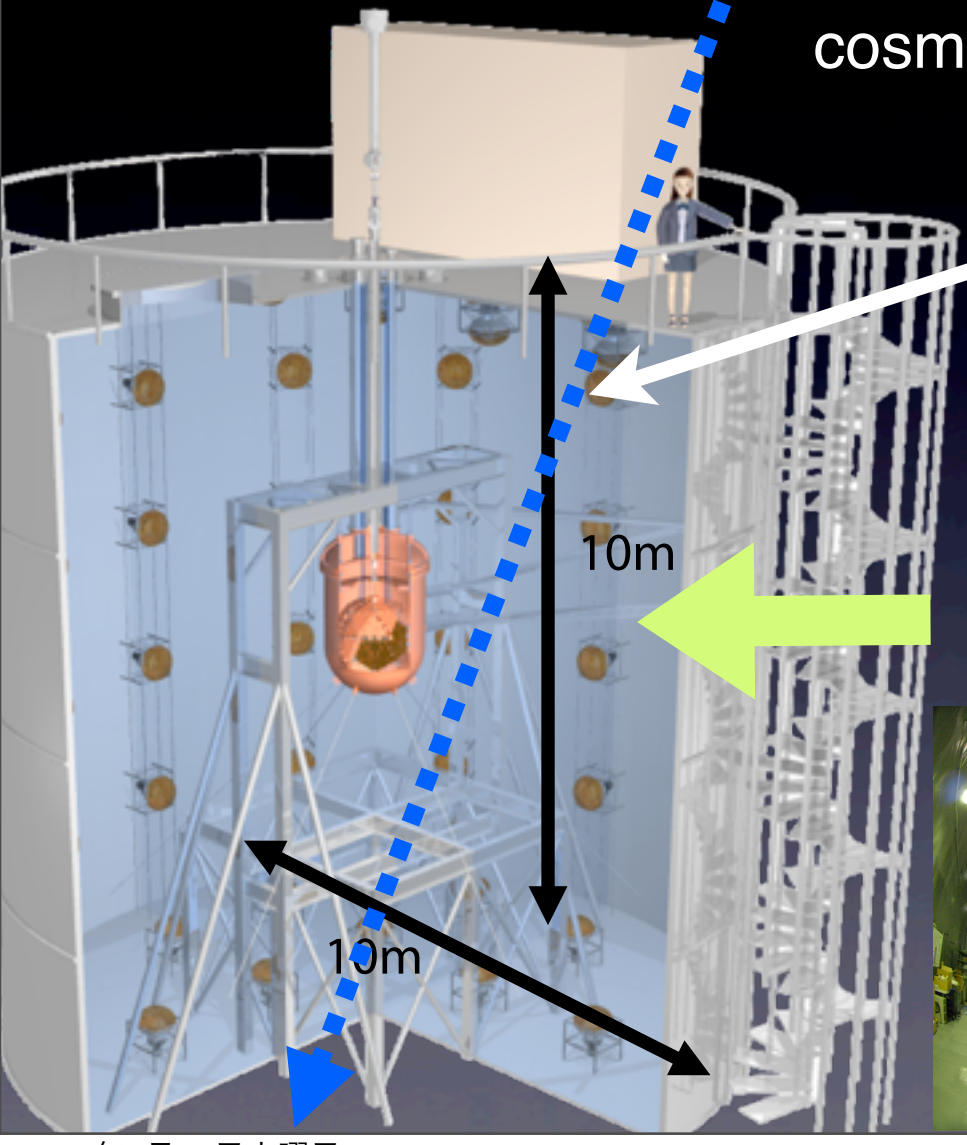
Water Tank

cosmic ray

70 PMTs (20 inch) to detect Cerenkov Light (same as SK)

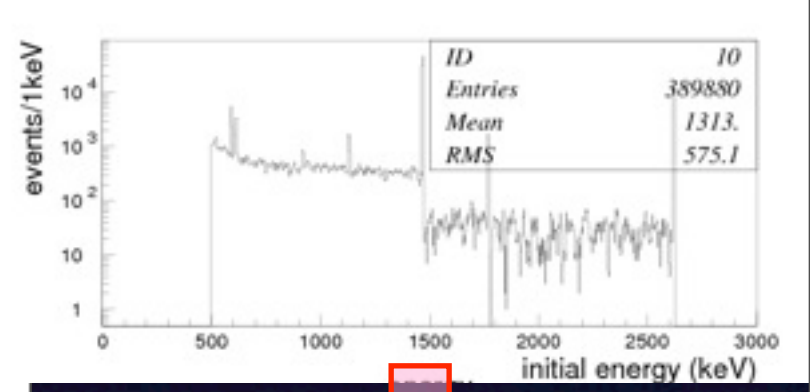
Active shield for muon induced events

Passive shield for γ and neutron from Rock

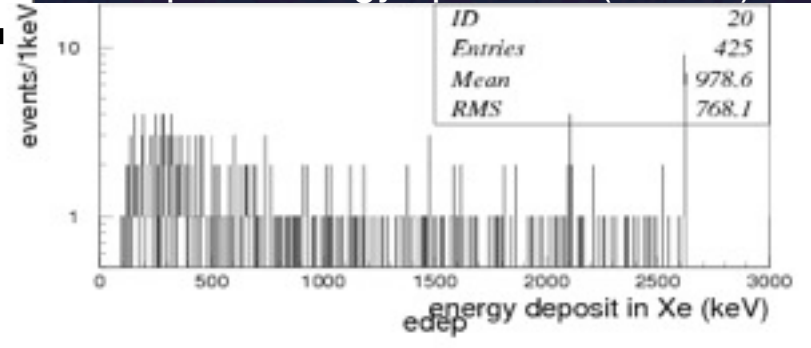


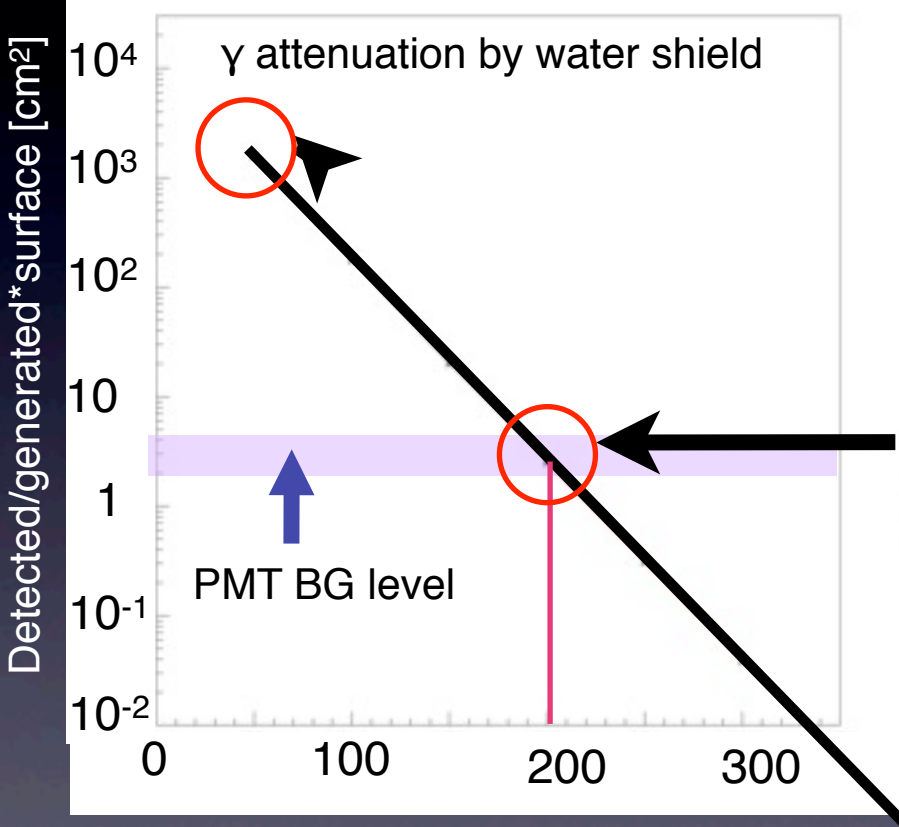
Water Shield:γ background

Initial energy spectrum from the rock



Deposit energy spectrum (200cm)





More than 200cm water is needed to reduce the BG to the PMT BG level

designed

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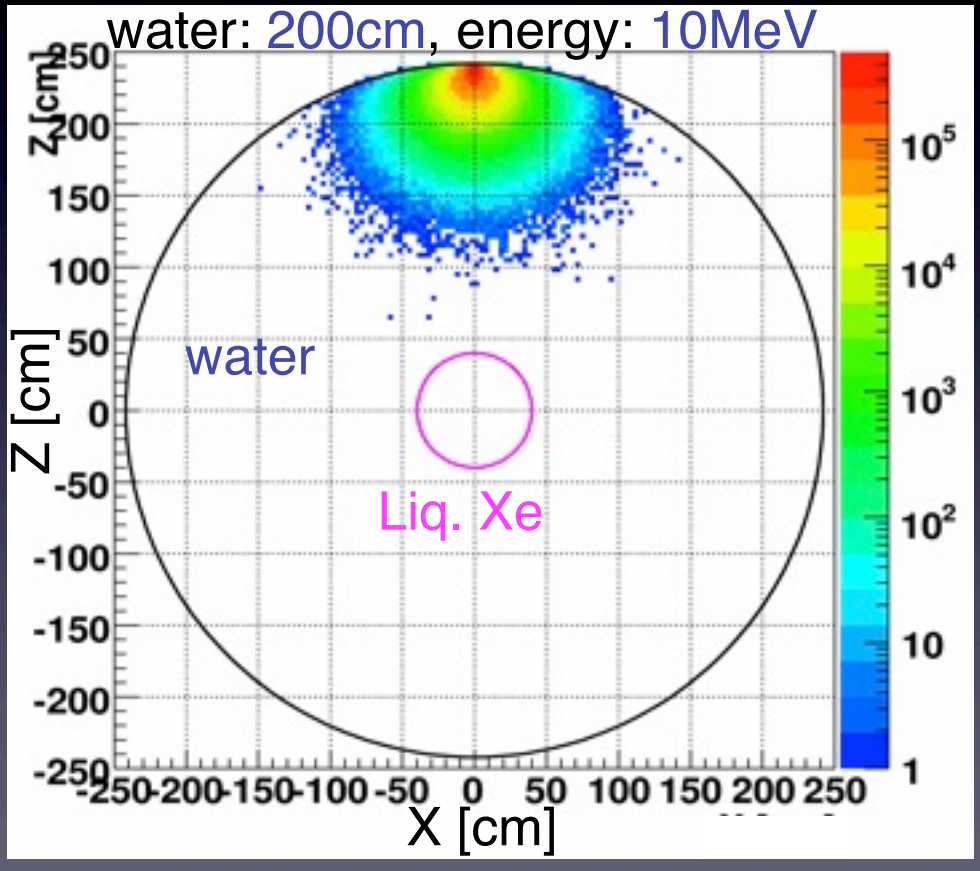
Water Shield: Fast neutron background

Fast n flux @Kamioka mine:
$(1.15 \pm 0.12) \times 10^{-5}$ /cm^2/sec



Assuming all neutron's energies are 10 MeV very conservatively

Generat:10^7 MC events, no event in Liq.Xe volume

$< 2 \times 10^{-4}$ counts/day/kg

200cm of water is enough to reduce the fast neutron

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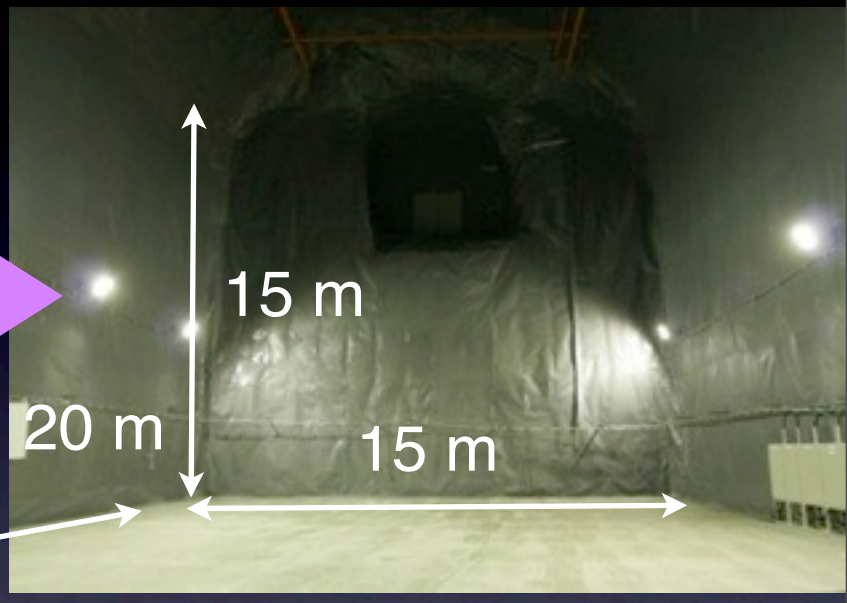
New Experimental Lab C

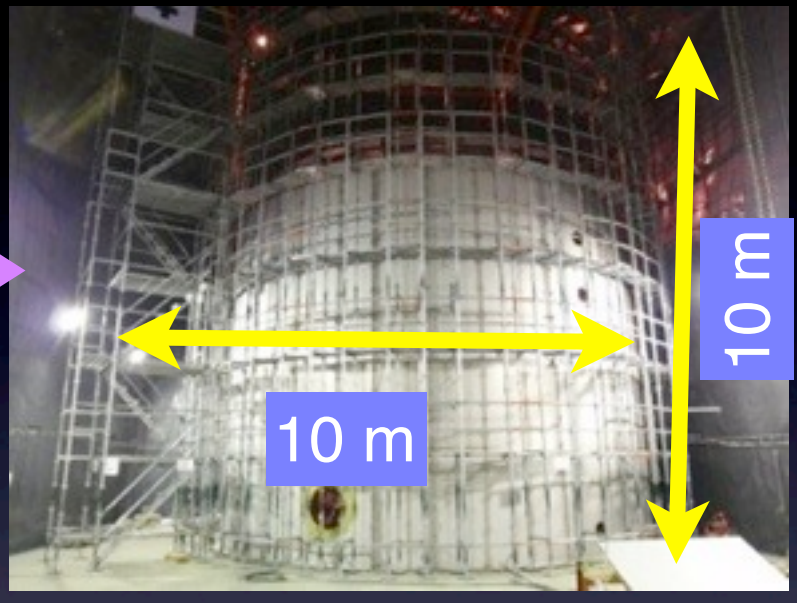


Excavation

Lab C for XMASS

- ✓ Excavation was started on 2007.
- ✓ Hall C was completed on 2008/08. (Urethan sheet, electricity, air from outside)

XMASS: Water Tank



First layer of Water Tank

- ✓ 2008/09 The construction of water tank was started.
- ✓ 2009/02 will be completed.
- ✓ 2009/08 Recirculation system of Pure water (5 ton/hour)

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water purification system

Experimental Hall

Rn: ~ 1mBq/m^3
5ton/hour

Distillation Tower

LXe Tank

Water Tank

Xenon Buffer Tank

entrance (clean room)

Cryogenics, gas/liquid line and Emergency

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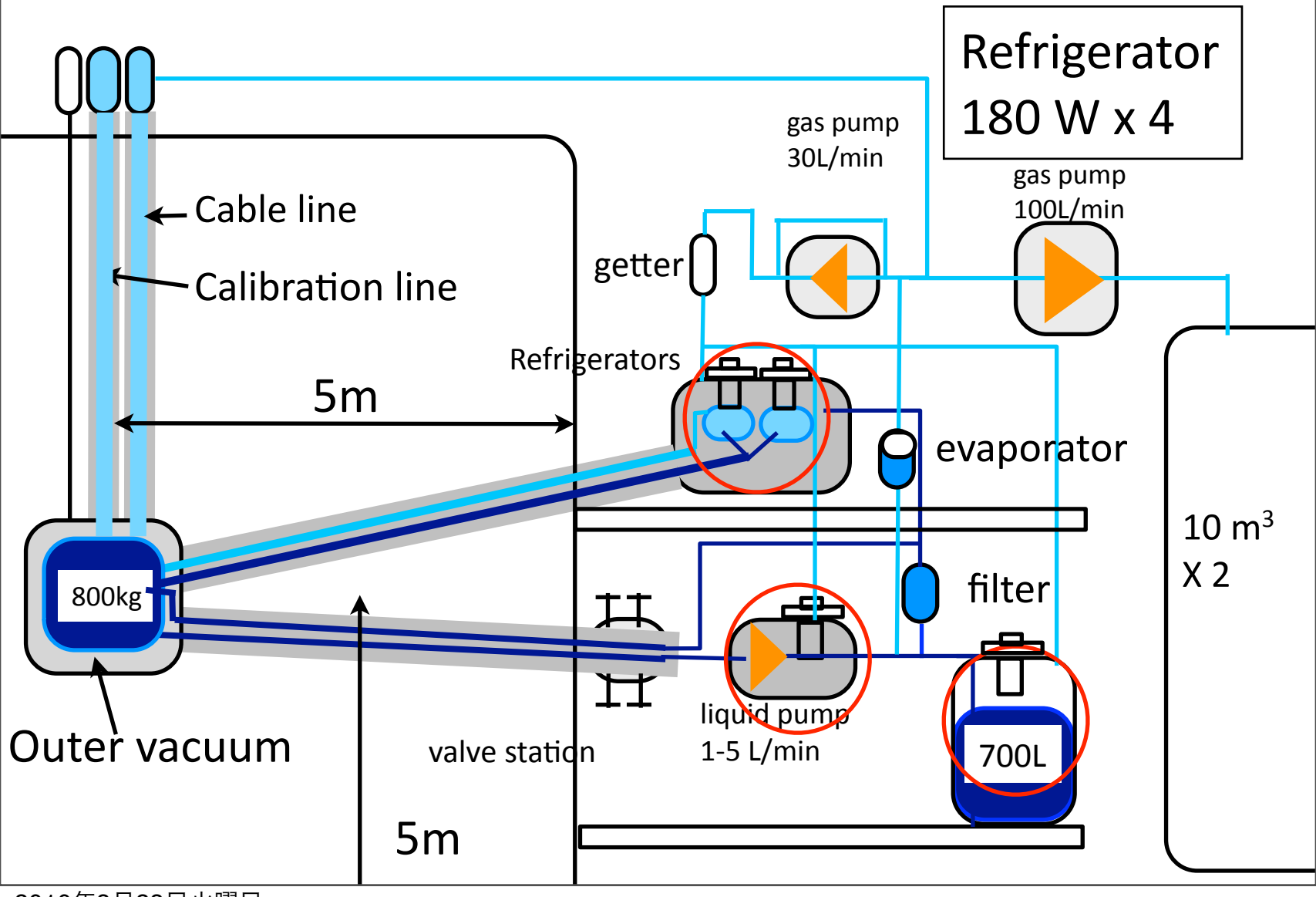
Cryogenics and gas/liquid xenon line



LXe storage(700L)

- Fast filling and recovering by transferring in liquid phase. (MEG experiment type)
- It is designed to transfer at speed of 5L/min in liquid by using liquid pump.
- For 1 ton of Xenon will be transferred about a few hours.
- Head load is designed to be 20 W.
  - It can be kept for 3 days without cooling power.

Re-condensation system

- 180 W refrigerator(PC150, Iwatani) X 2 = 360 W cooling power
  - same type is used in MEG and XENON100 experiment
- ~30 L/min of gas can be liquified.
- LN2 cooling coil for additional power or emergency.

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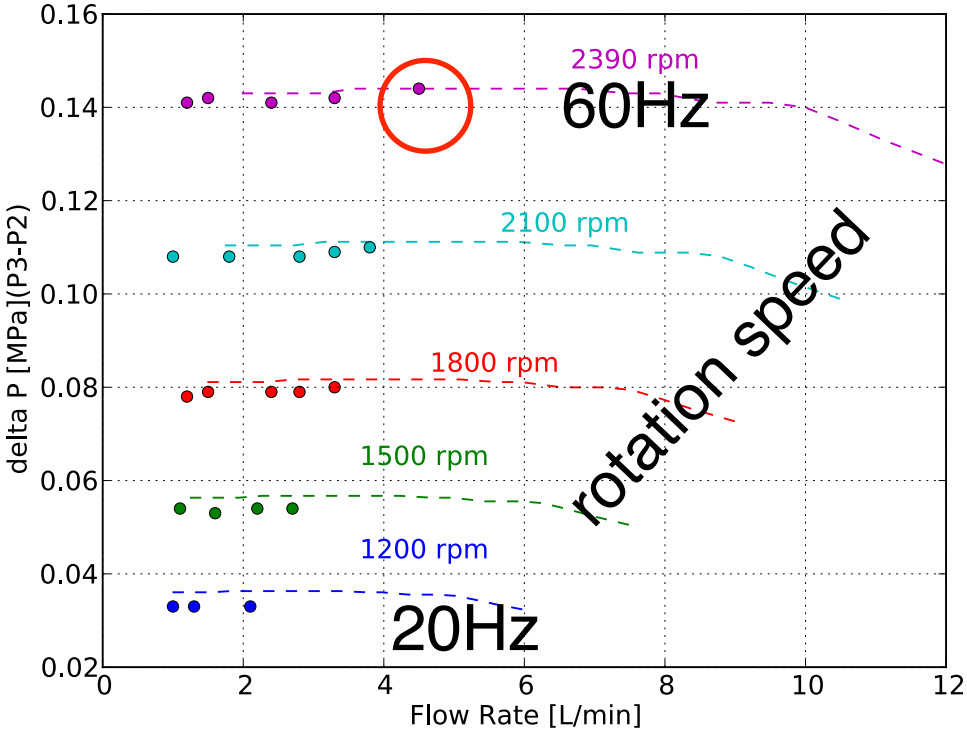
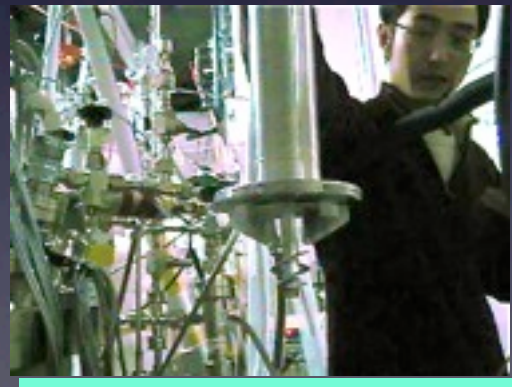
Recirculation in Liquid Phase



Circulator

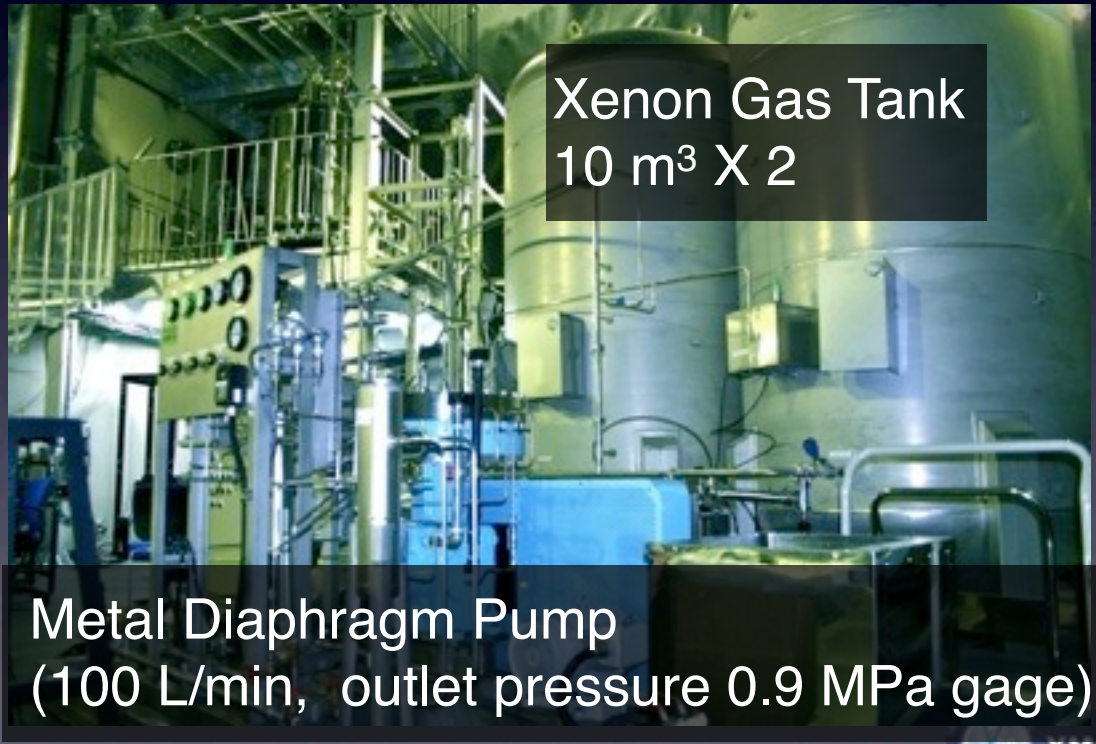


Liquid Pump (BNCP48)

- The liquid pump was worked as expected.
- 5L/min in liquid was achieved at ⊿P=0.14MPa.
- The study for the filters to remove H_2O or Rn is still work in progress. (MS, charcoal)

10 m^3 x 2 Xe tank

- 1 ton of xenon gas (170 m^3) is needed to be stored.
- In case of sudden pressure rise (> 0.18 MPa gage), the xenon gas will be automatically recovered by the metal compressor.



Distillation to reduce krypton in 2003

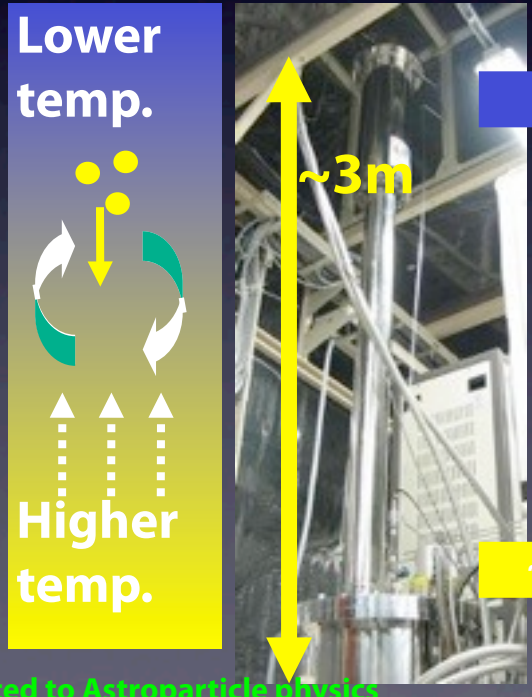
A distillation system was made and tested.
System specification:

Process speed: 0.6kg Xe/hour
Collection efficiency: > 99%
Kr concentration after process: < 1/1000

	Boiling point (@1 atm)
Xe	165K
Kr	120K

178±2K in tower

Original Xe:
~3 x 10^{-9} Kr



~1%

Off gas Xe:
330±100 x 10^{-9} Kr

~99%

Purified Xe:
(3.3±1.1) x 10^{-12} Kr

arXiv:0809.4413v2, submitted to Astroparticle physics

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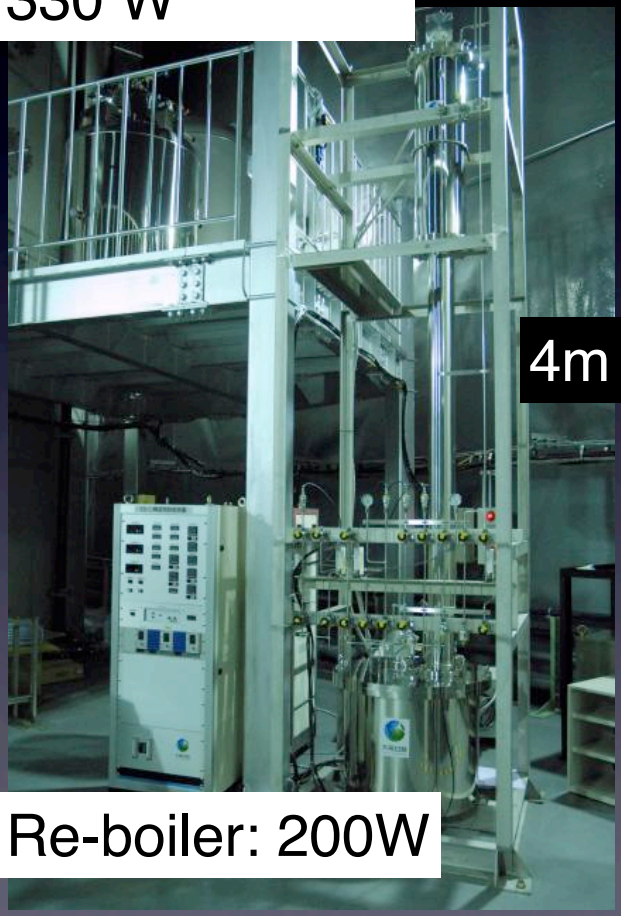
Distillation Tower (Upgrade)

Cooling Power:
330 W



Re-boiler: 200W

- 5kg/hour production
  - ~ 8 days for 1 ton
- >10^5 Kr reduction (goal < 1 ppt)

	2003	2009
Height	3 m	4m
production [kg/hr]	0.6	5
Kr Reduction	$1/10^3$	$1/10^5$

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Safety Issue

- Worst scenario which we can think of is the liquid xenon leak in the water tank. In this case, it is very difficult to recover all the xenon gas. So that we designed the mechanical structure in the water tank
  - safety factor 4 for earthquake situation. (usually x 2)
  - all the gas/liquid line is a double-wall tube.
- All the cryogenics has LN2 back up.
- Recovering
  - 5 L/min in liquid phase (700L LXe tank): 1hour
- Sudden pressure rise
  - 100L/min in gas phase(10 m^3 x 2 GXe tank): 28 hours

Detector and its Assembly

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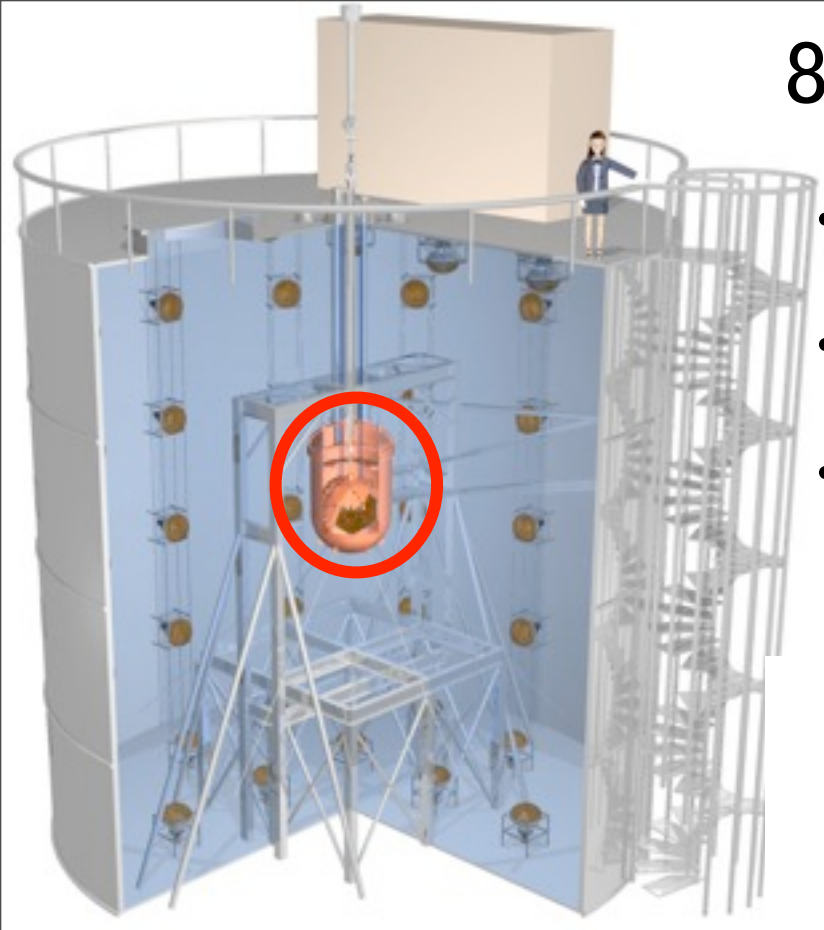
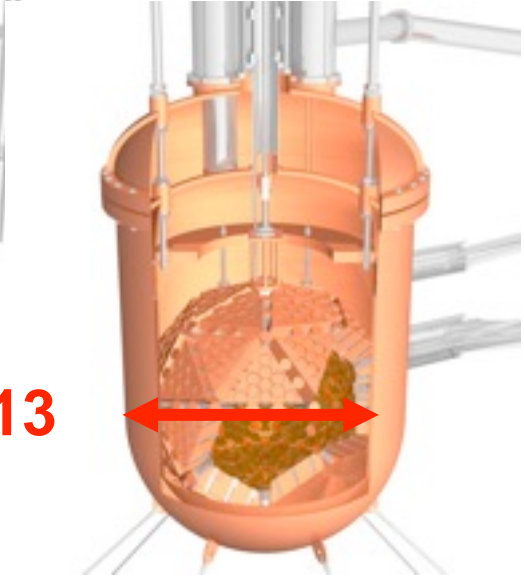
800 kg Detector

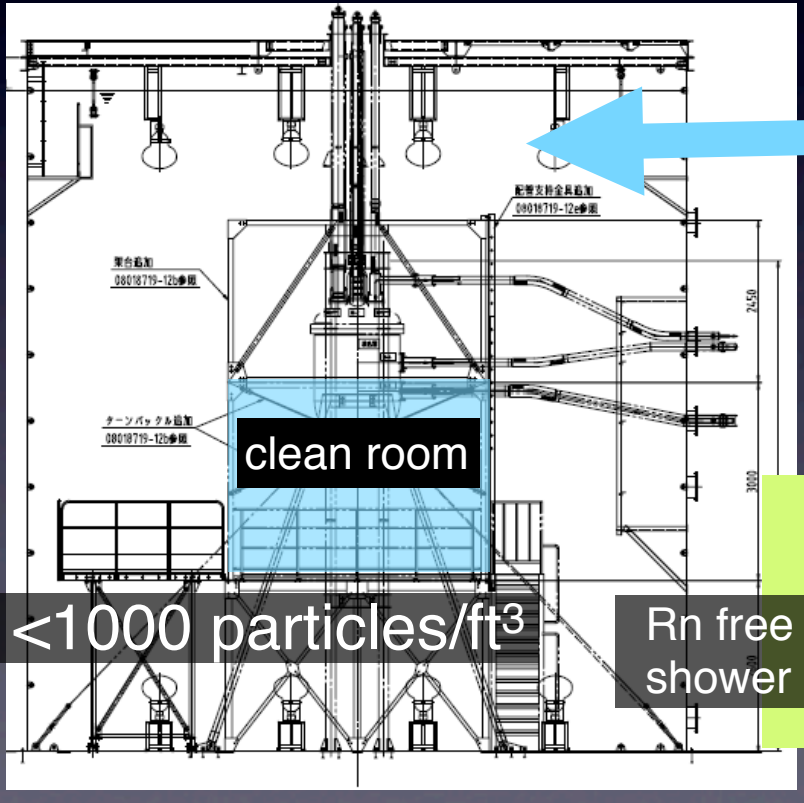


- The detector will be attached to SUS frame.
- diameter of the PMT holder is **Φ1113.**
- 2009/11 – 2010/02: PMT assembly and cabling.



clean room in tank

- Rn free air for tank and air shower room
- Rn level in the air ~10mBq/m3
- clean room in the water tank < class 1000 level



Rn free air

entrance

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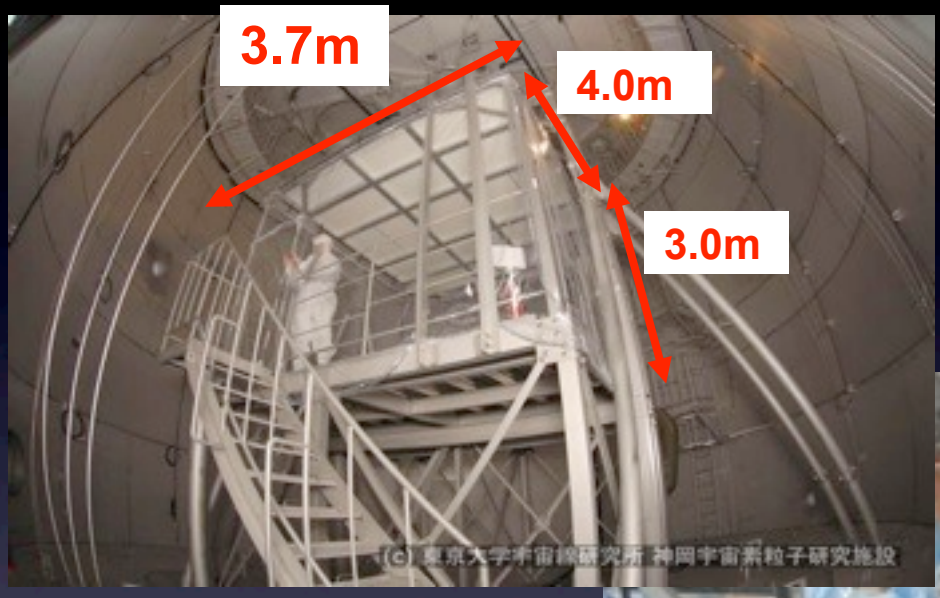
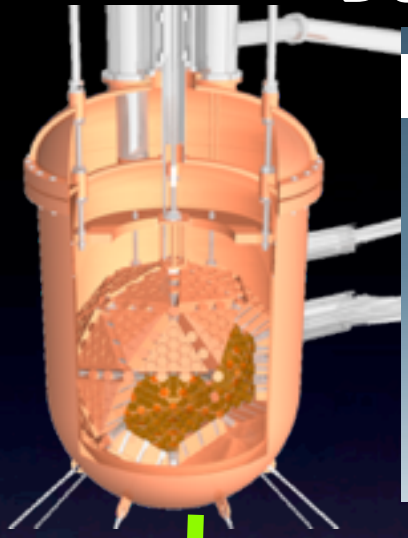
Clean Room in Water Tank

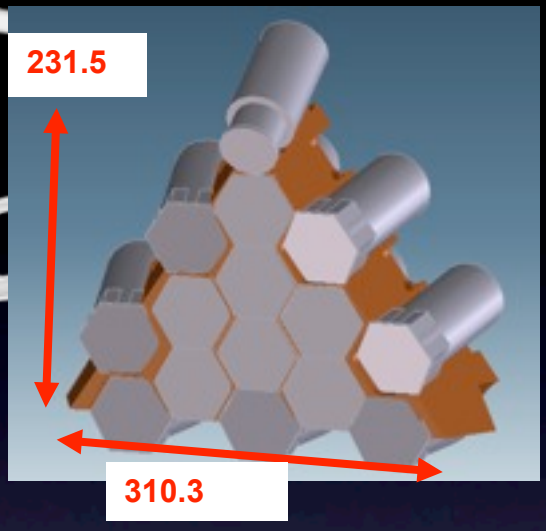
Stage for the assembly of detector



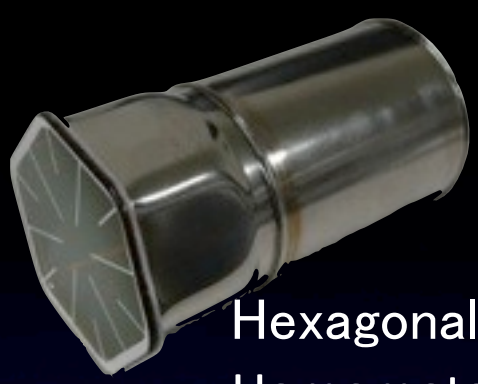
Clean Room in the Water Tank

Design of 800 kg Detector

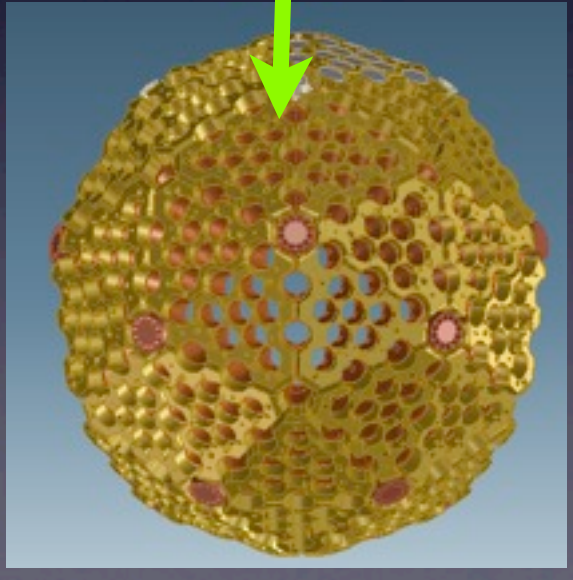


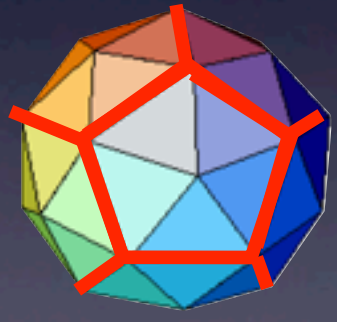


pentakisdodecahedron



Hexagonal PMT
Hamamatsu
R10789
QE 28-39%





- 60 triangle in total
- about 10PMT/triangle×60
- Total: 642 PMTs
- Photo coverage: 62%

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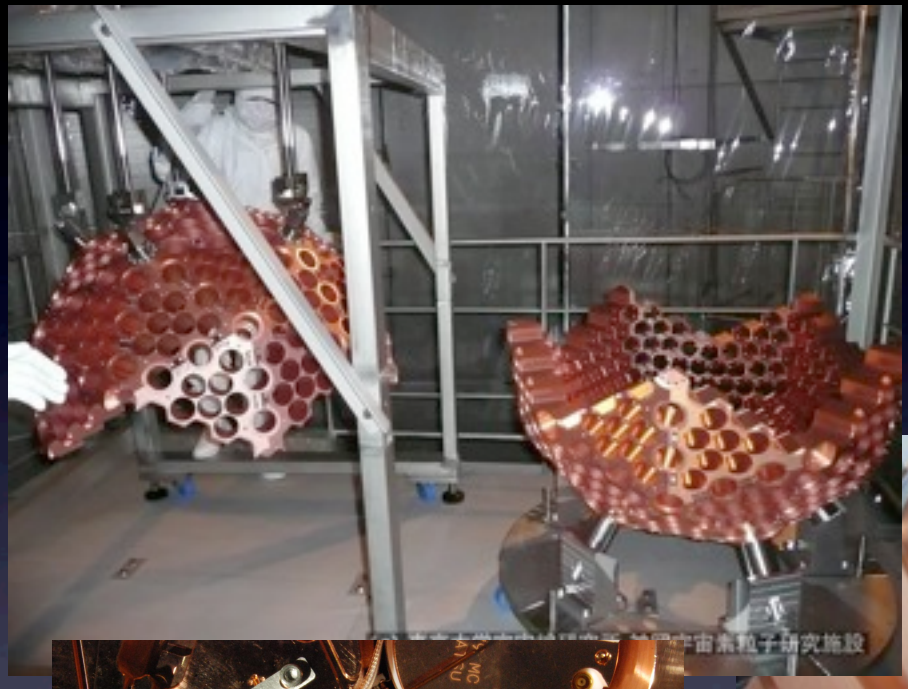
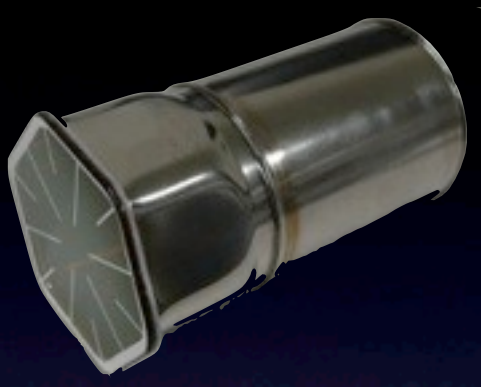
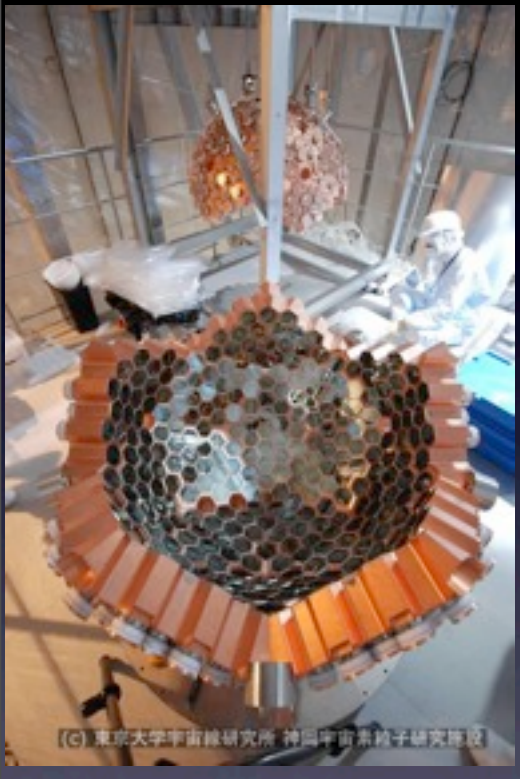





KA1135 MC
HAMAMATSU


(c) 東京大学宇宙線研究所 神岡宇宙素粒子研究施設

PMT Holder



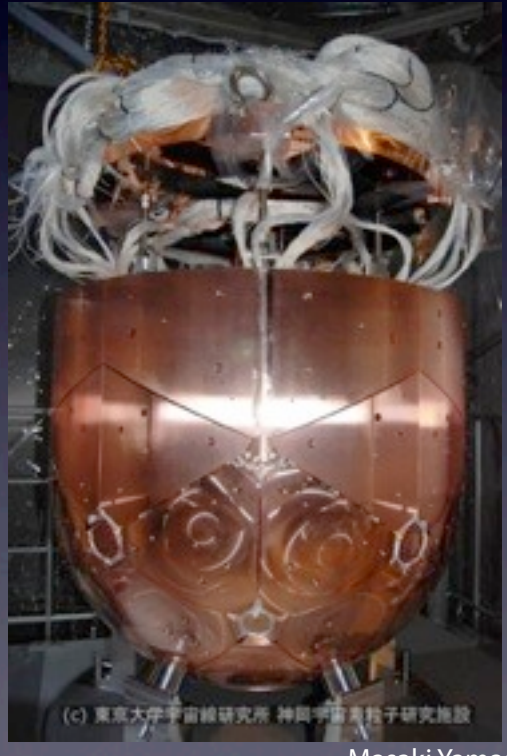
lower half

upper and lower half

Masaki Yamashita

Filler

- 1.2 ton of OFHC pieces to save 400 kg of LXe in the dead space.
- Total weight of the detector structure is 2.8 ton.



Masaki Yamashita

Summary

- XMASS 800 kg detector is under constructing at Kamioka. The goal is to reach a few x 10^{-45}cm^2 for spin independent case in one year.
- PMT assembly was completed and the detector vessel will be delivered in April and the installation will be finished in May.
- The WIMP search run will be started in this summer 2010 after the commissioning run.