# The XMASS experiment

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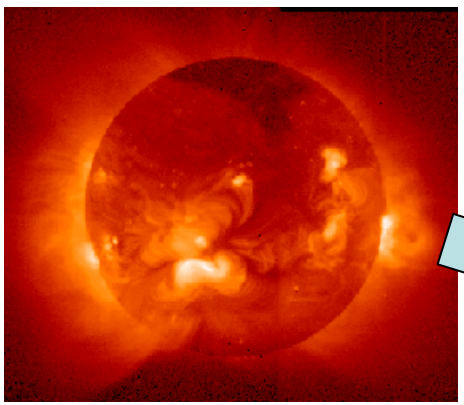
# 1. Introduction

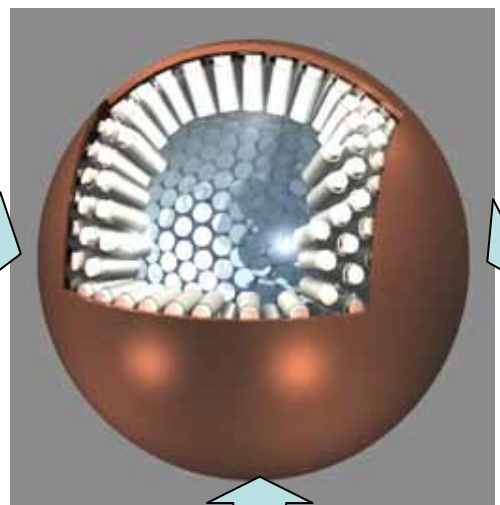
## ➢ What's XMASS

Multi purpose low-background and low-energy threshold experiment with liq. Xe

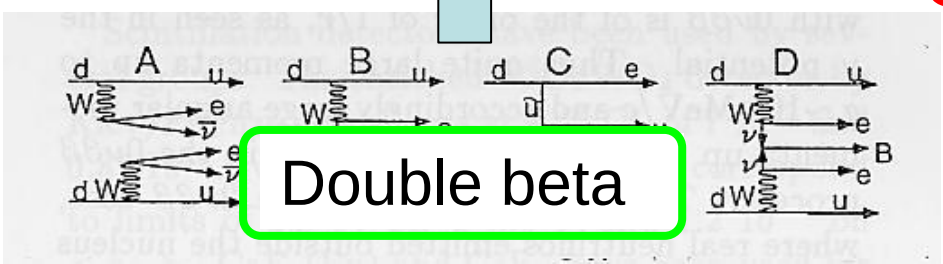
- **X**enon detector for Weakly Interacting **MASS**ive Particles (**DM search**)
- **X**enon **MASS**ive detector for solar neutrino (**pp/$^{7}$Be**)
- **X**enon neutrino **MASS** detector (**ββ decay**)



Solar neutrino



Dark matter




Double beta

# ➢ Why liquid xenon

- **Large photon yield (~42 photons/keV ~ NaI(Tl))**
  **Low threshold**
- **High density (~3 g/cm$^3$)**
  **Compact detector** (10 ton: sphere with diameter of ~2m)
- **Large Z (=54)**
  **Shielding effect of itself is large.**
- Purification (distillation)
- No long life radioactive isotope
- Scintillation wavelength (175 nm, detected directly by PMT)

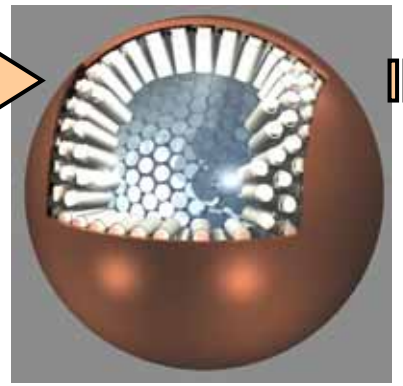
→ We can achieve low energy threshold and low background.

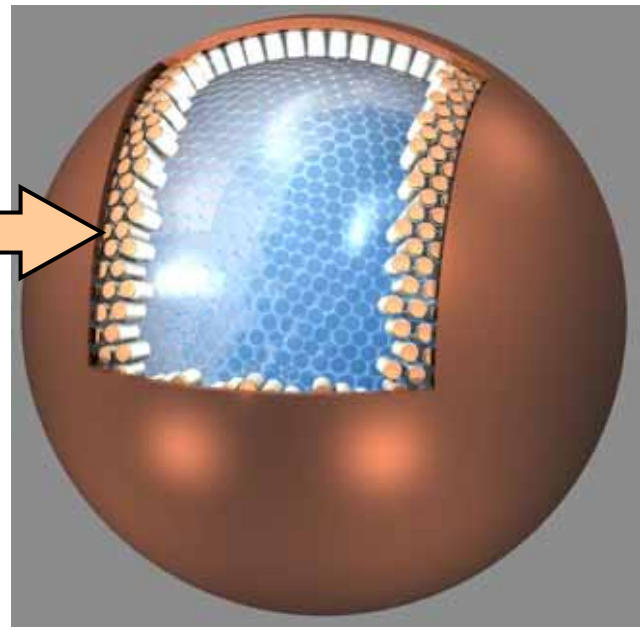
# ➢ XMASS Strategy of the scale-up

10 ton detector

100kg detector

800kg detector





~30cm

~80cm

~2.5m

R&D

- ✓ Self shielding power
- ✓ position & energy reconstruction
- ✓ BG level

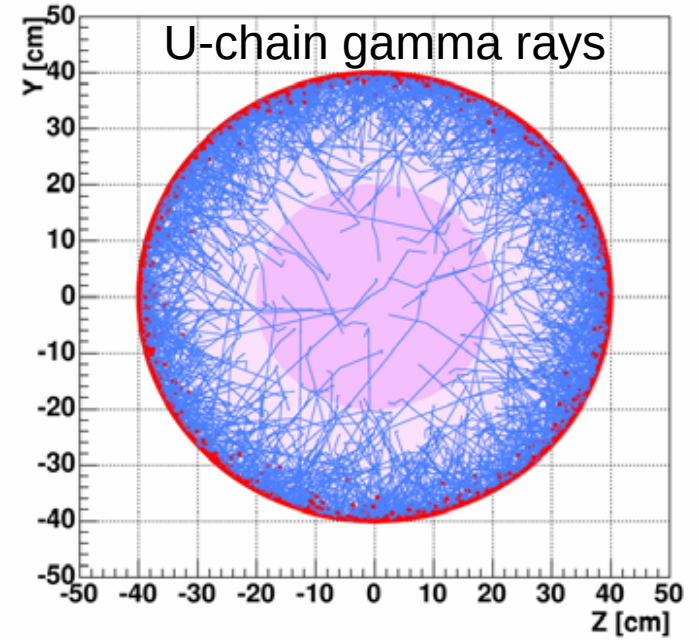
Dark matter search

Multipurpose detector

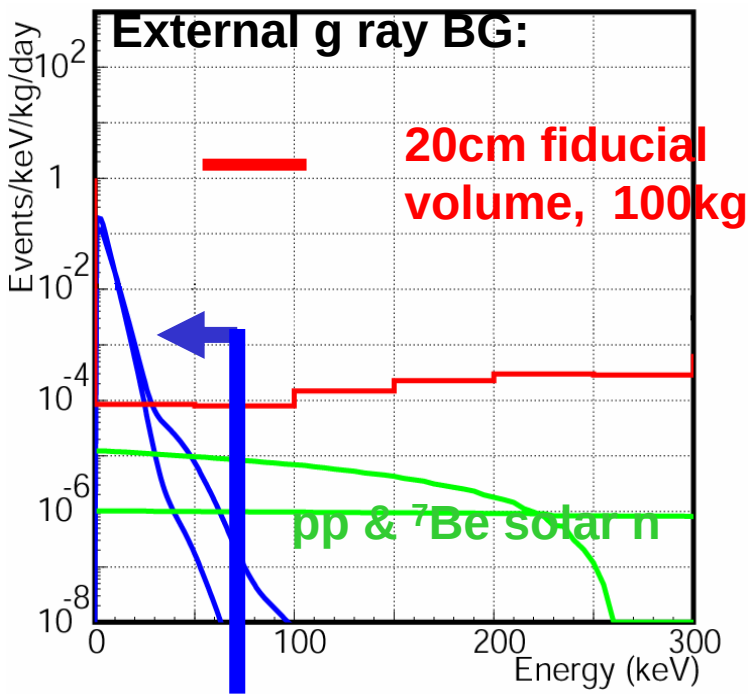
(solar neutrino, ββ …)

# ➢Target for 800kg : Dark Matter search

γ tracking MC from external to Xenon




Blue : γ tracking
Pink : whole liquid xenon
Deep pink : fiducial volume

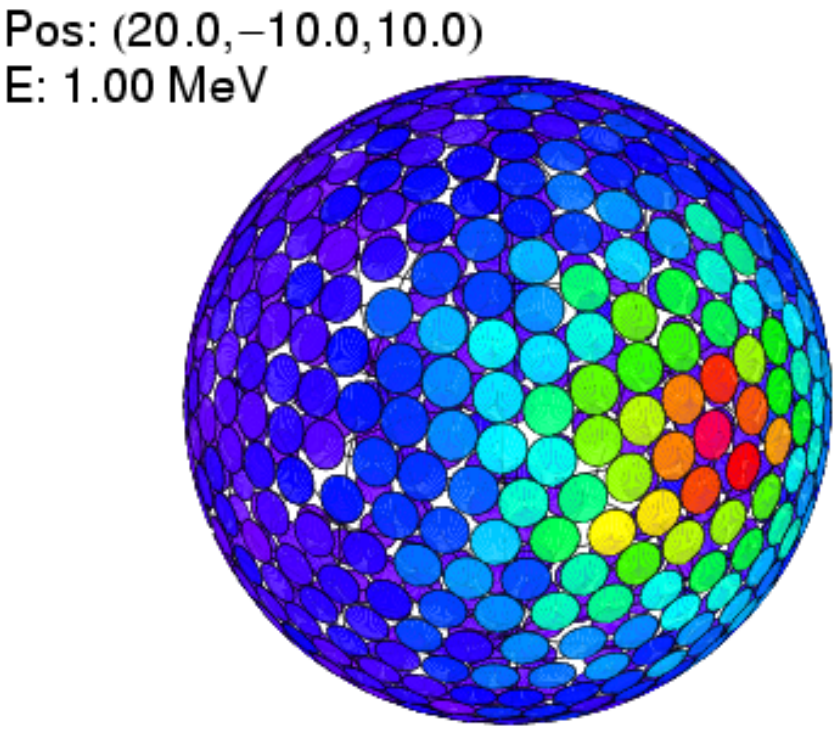


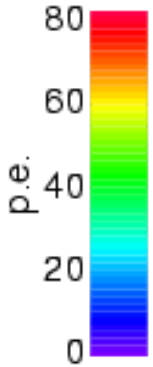

**Expected dark matter signal (assuming $10^{-42}$ cm$^2$, Q.F.=0.2 50GeV / 100GeV,)**

1. **Dark matter search**

    1. With liquid xenon ~1ton, reduce BG below 100 keV to $10^{-4}$/day/keV/kg by self shielding.
    2. Search the signal from dark matter in low energy region.

# ➢Vertex reconstruction

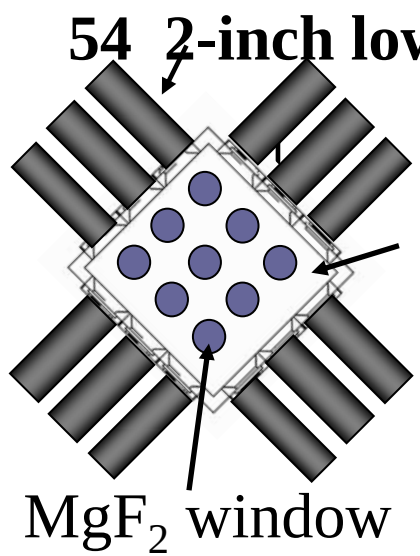



Large photoelectron Yield can be obtained ~4 p.e./keV

Accurate vertex Reconstruction based on light pattern possible

Confirmed in the 100kg detector.



# Reconstruction study with the prototype

## Reconstruction is performed by PMT charge pattern (not timing)

Calculate PMT acceptances from various positions by Monte Carlo.
Vtx.: compare acceptance map of F(x,y,z,i)

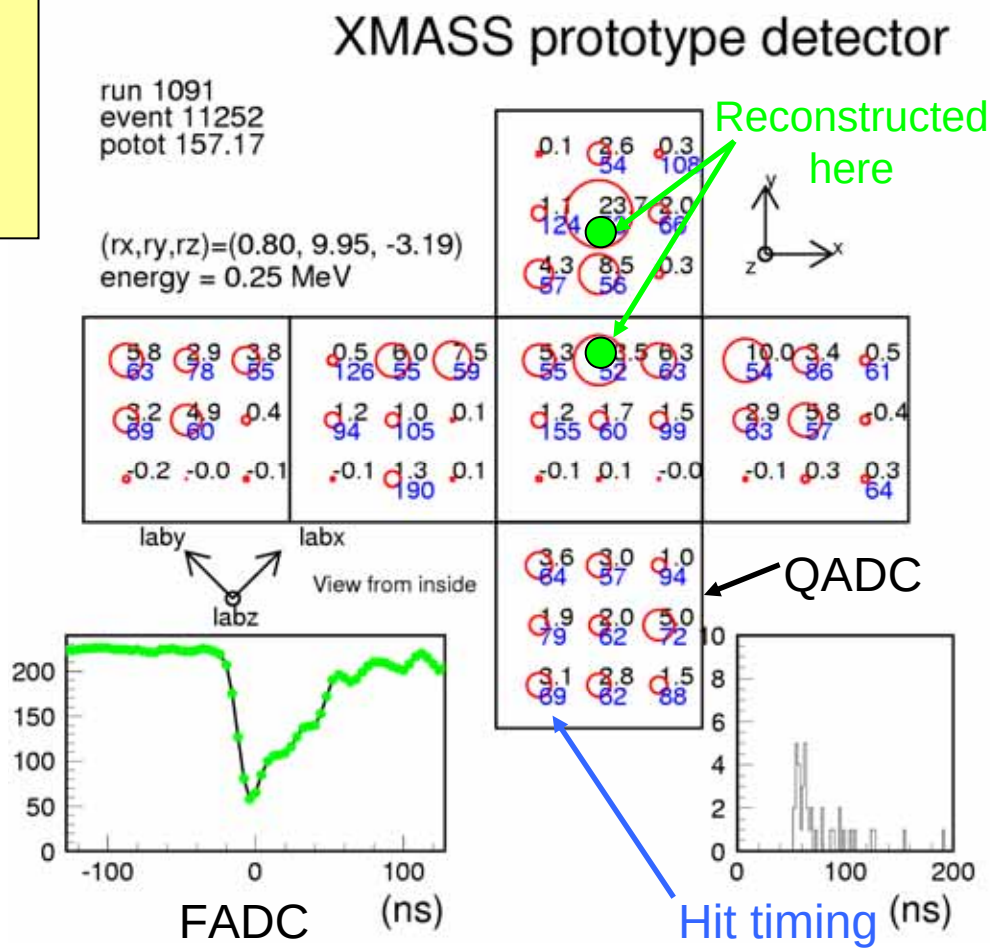
$$\mathrm{Log}(L) = \sum_{PMT} \mathrm{Log}\left(\frac{\exp(-\mu)\mu^n}{n!}\right)$$

L: likelihood

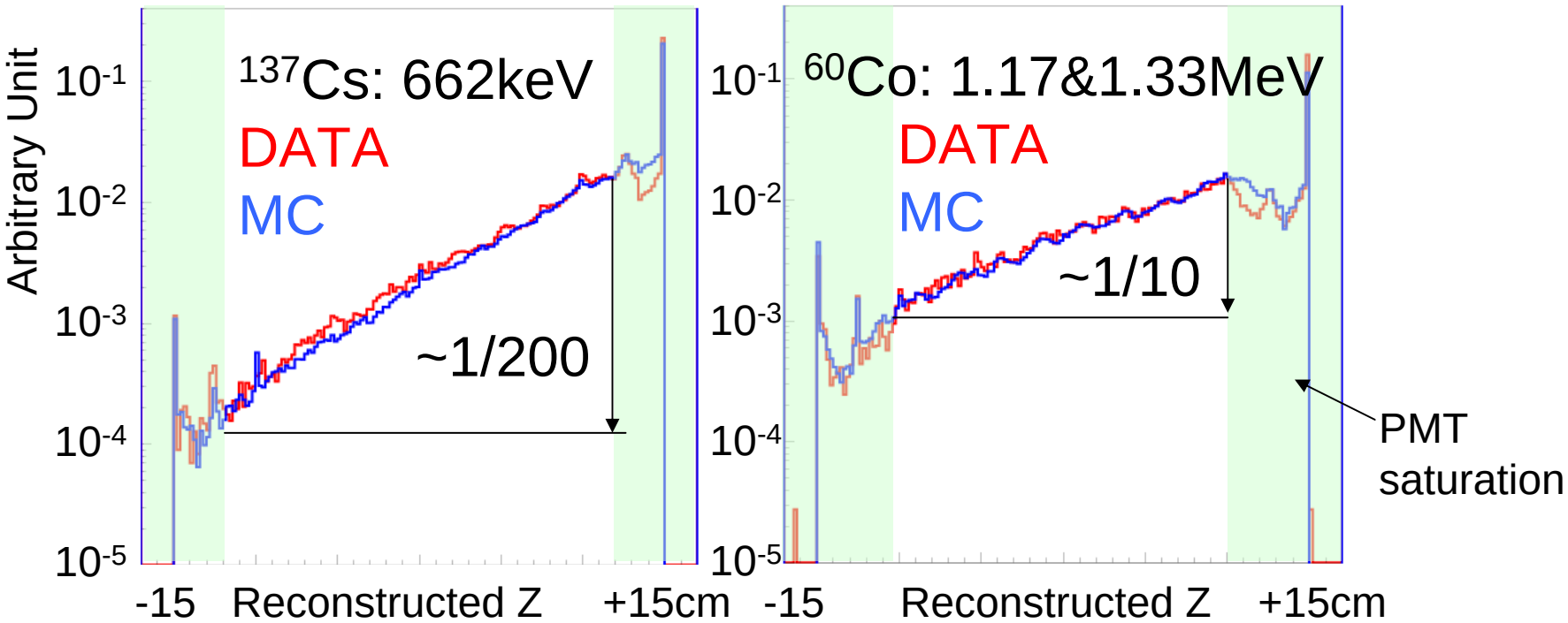
$\mu$ : $\dfrac{F(x,y,z,i)}{\Sigma\, F(x,y,z,i)}$ x total p.e.

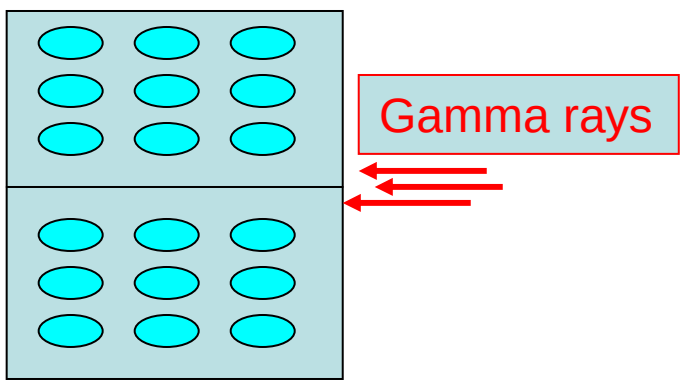
n: observed number of p.e.

Opened-up cube



# Demonstration with a prototype detector II

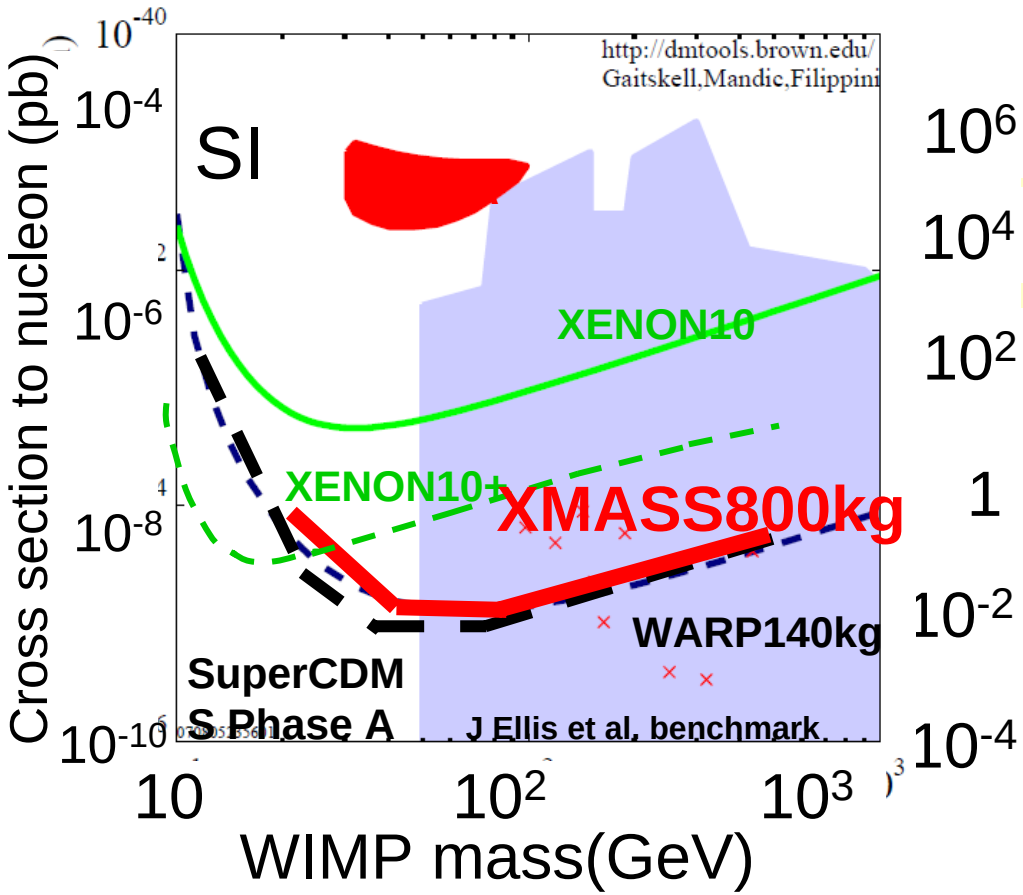



Confirmed Self shielding

>2 orders of magnitude agreements

# ➢Sensitivity of the 800kg detector



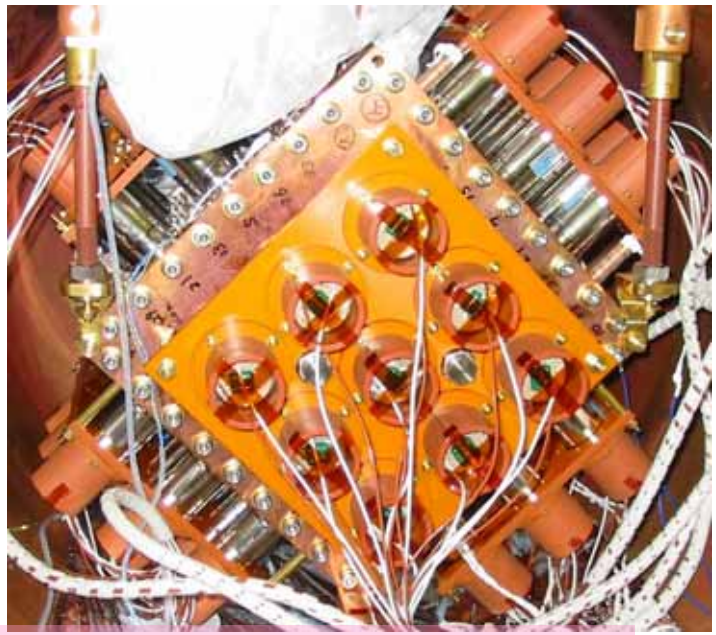

XMASS FV 0.5ton year
(100kg, 5yr)
3σ discovery

Plots exept for XMASS
http://dmtools.berkeley.edu
Gaitskell & Mandic

x ~100 sensitive than XENON10

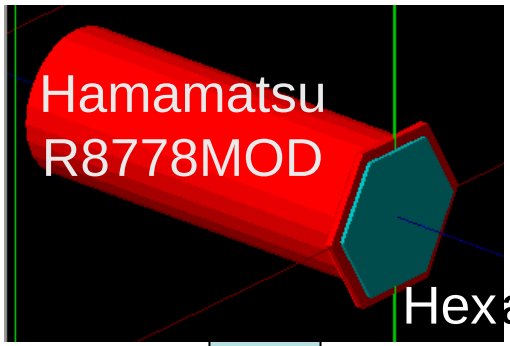
# 2. Status of XMASS 800 kg detector

- **Basic performances have been already confirmed using 100kg detector**
  1. Method to reconstruct the vertex and energy
  2. Self shielding power
  3. BG level



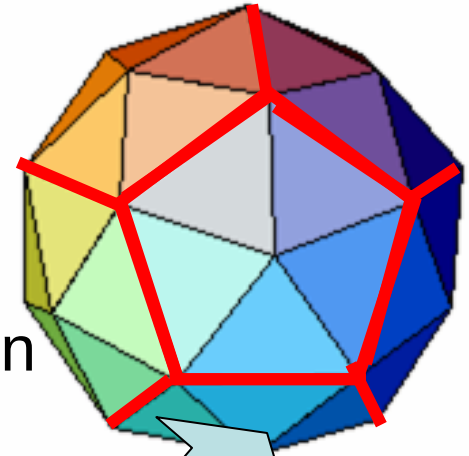
- **Detector design is going using MC**
  - ✓ Structure of detector
  - ✓ BG estimation
    - ✓ PMT gamma
    - ✓ external gamma and neutron
    - ✓Radioactive contamination in LXe

# ➢ Structure of 800 kg detector

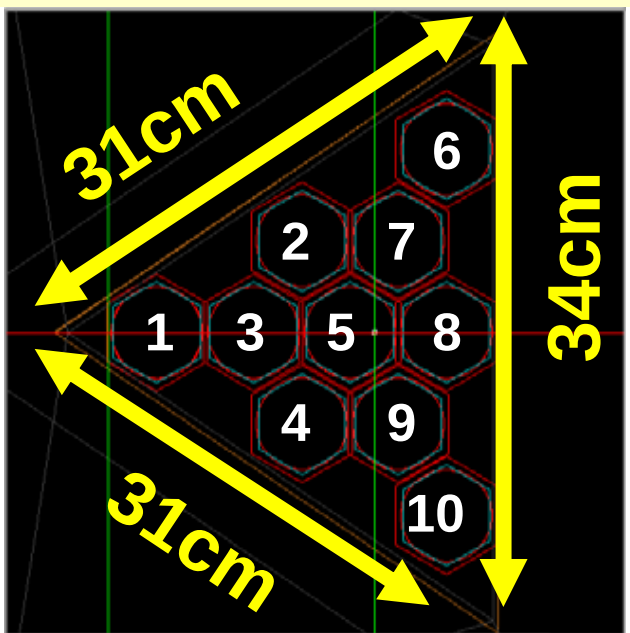


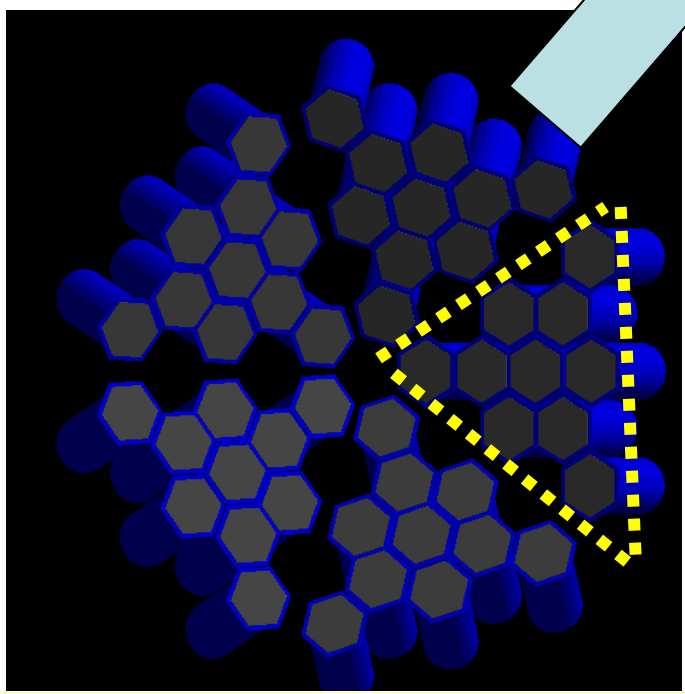

Hexagonal
quarts window

12 pyramids /
pentakisdodecahedron



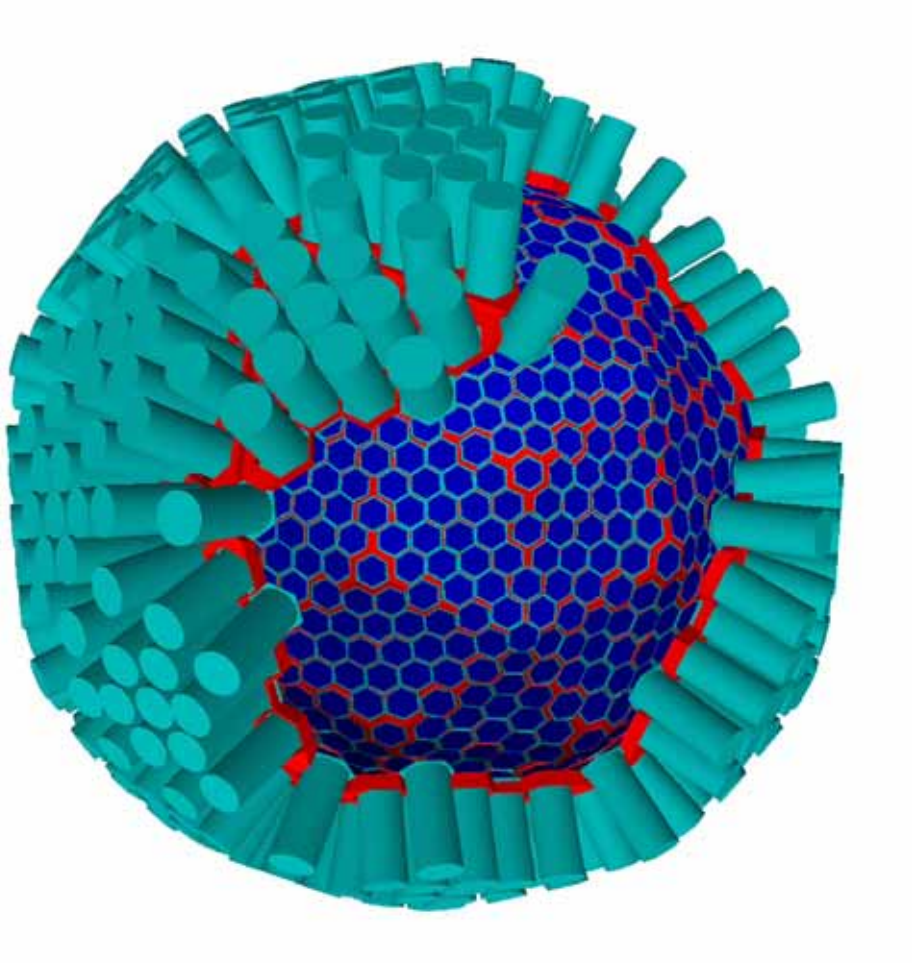
**10 PMTs per 1 triangle**



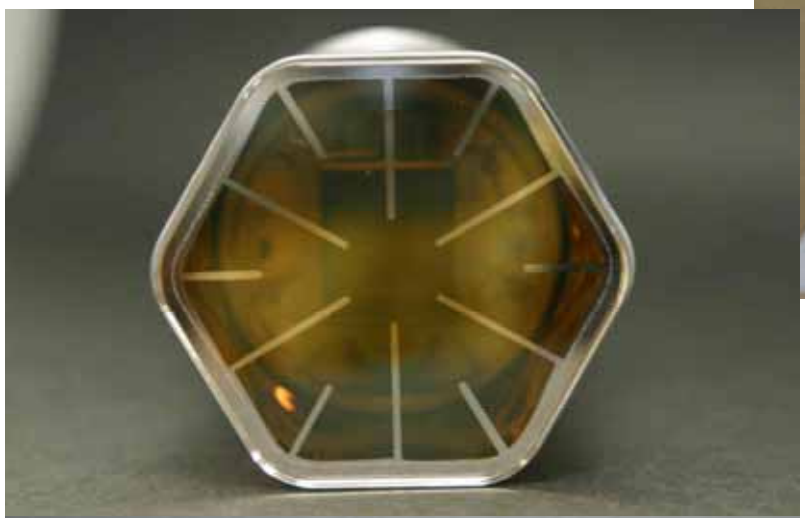



**5 triangles make pentagonal pyramid**

# ➢Structure of 800kg detector



- 60 triangles
- 10 PMT/triangle x 60 = 600 PMTs
- + 212 PMTs in triangle boundary region
- Total 812 PMTs
- Photo coverage 67.0%
- Center to photocathode ~45cm
- Fiducial vloume is 25cm from center.
- PMTs are inside liquid xenon.



Sep/12/2007

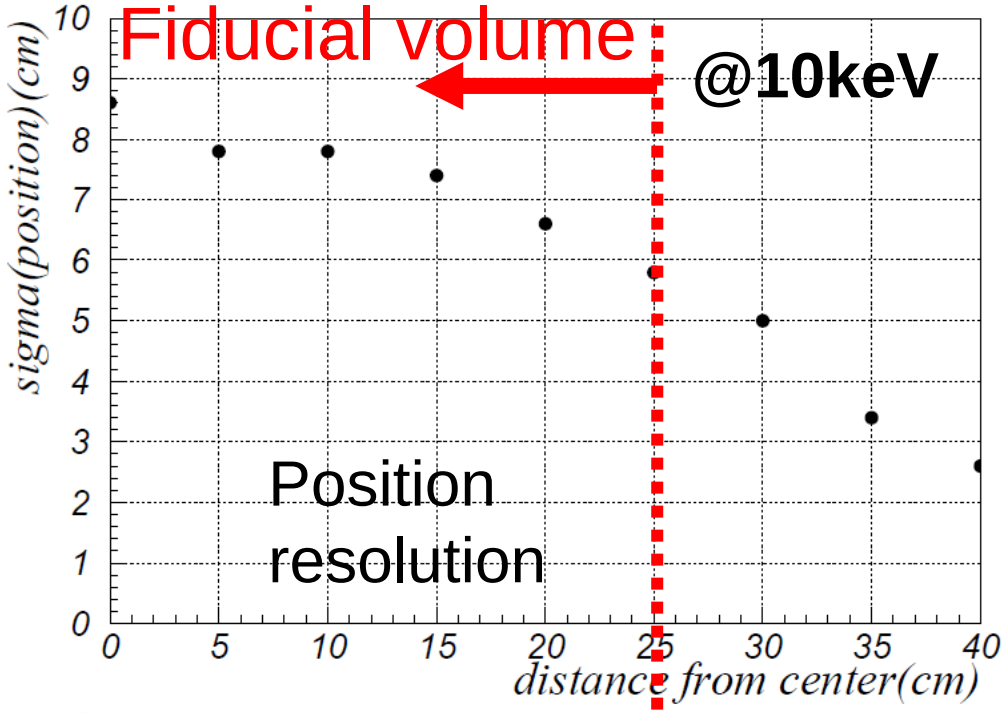
taup2007

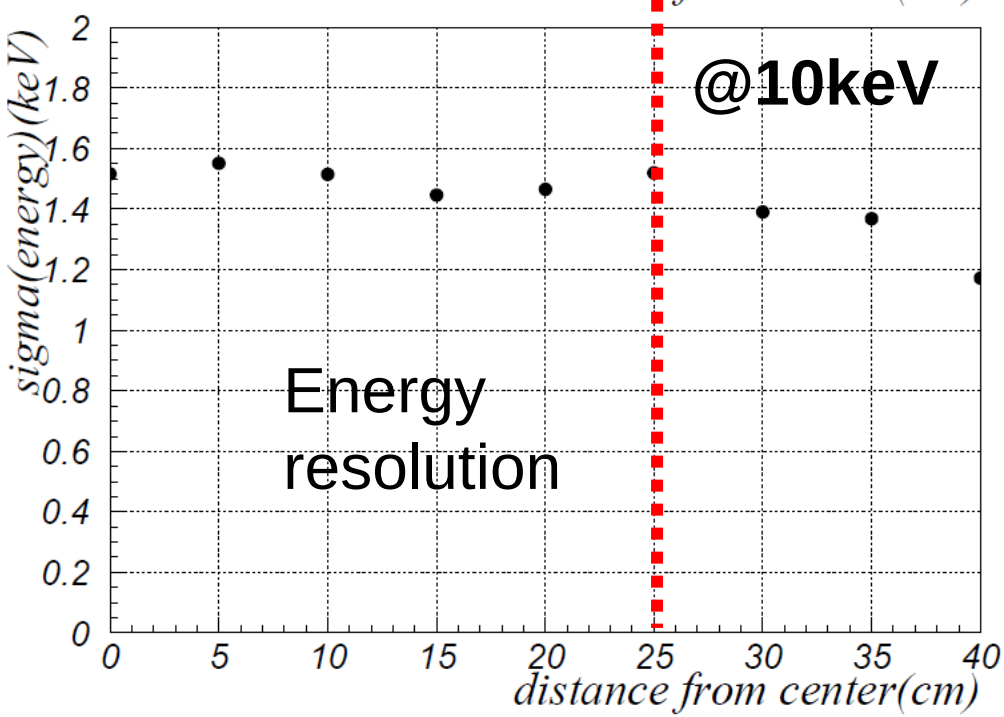
# ➢Background estimation

- PMT gamma background
  - Reduced by self shielding
  - Position reconstruction
  - U/Th/K/Co
- External gamma
  - Reduced by water shield
- Neutron
  - Reduced by water shield
- Radioactive contamination in LXe

# ➢PMT BG

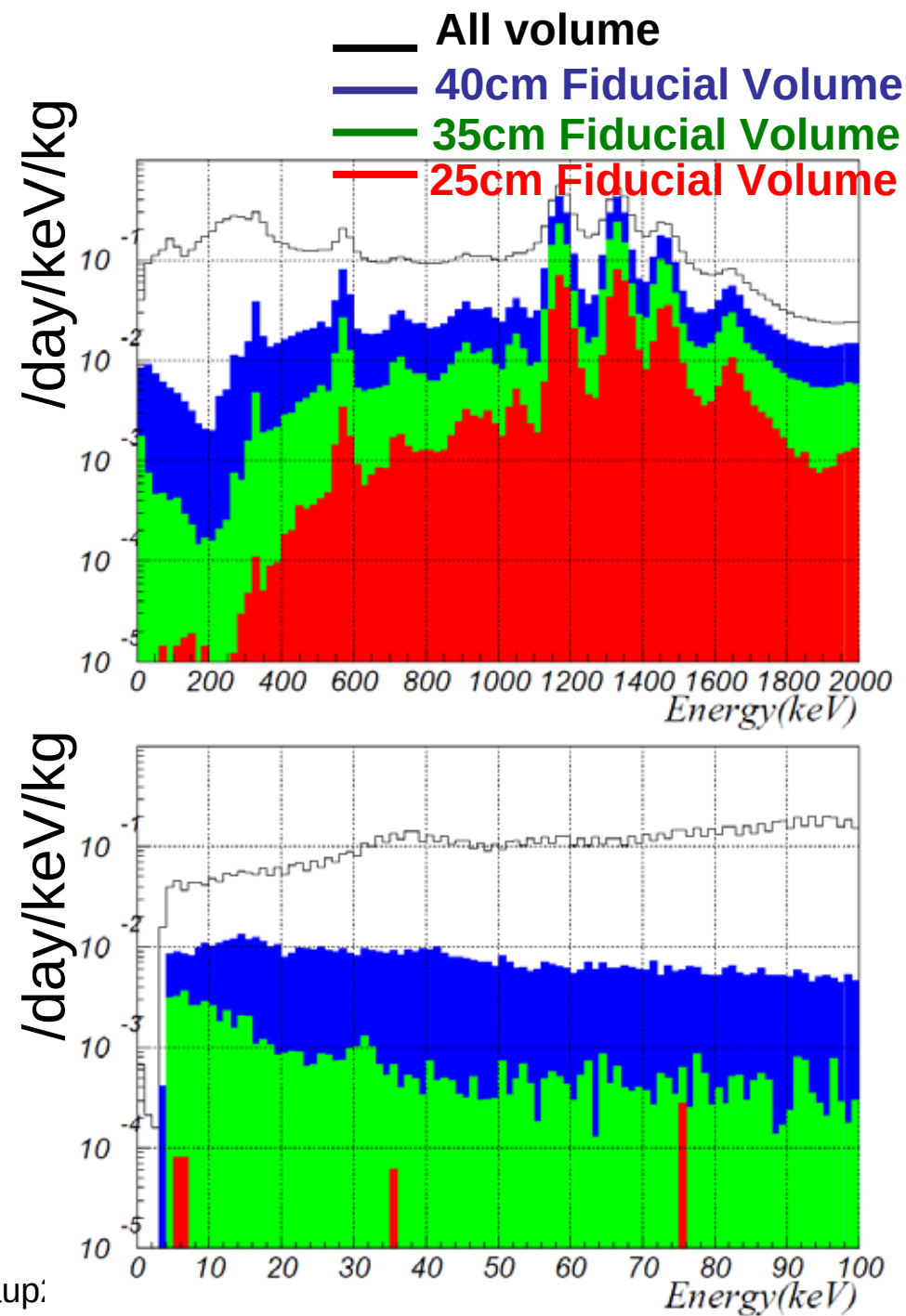
- Reconstruction of event
  - Key part for self shielding
  - Basic part is same as the one confirmed in 100kg detector.



# ➢Estimated PMT BG

- Activity of PMT
  - $^{238}$U chain 1.8x10$^{-3}$ Bq/PMT
  - $^{232}$Th chain 6.9x10$^{-4}$ Bq/PMT
  - $^{60}$Co 5.5x10$^{-3}$ Bq/PMT
  - $^{40}$K 1.4x10$^{-2}$ Bq/PMT
- Below 300 keV number of events in the 25cm fiducial volume decreases rapidly.
- Below 100 keV remaining events are few.
- Below 300keV, <10$^{-4}$ /day/keV/kg BG level.



# ➢Radioactive contamination in LXe

Internal origin of background
Target values to achieve our goal

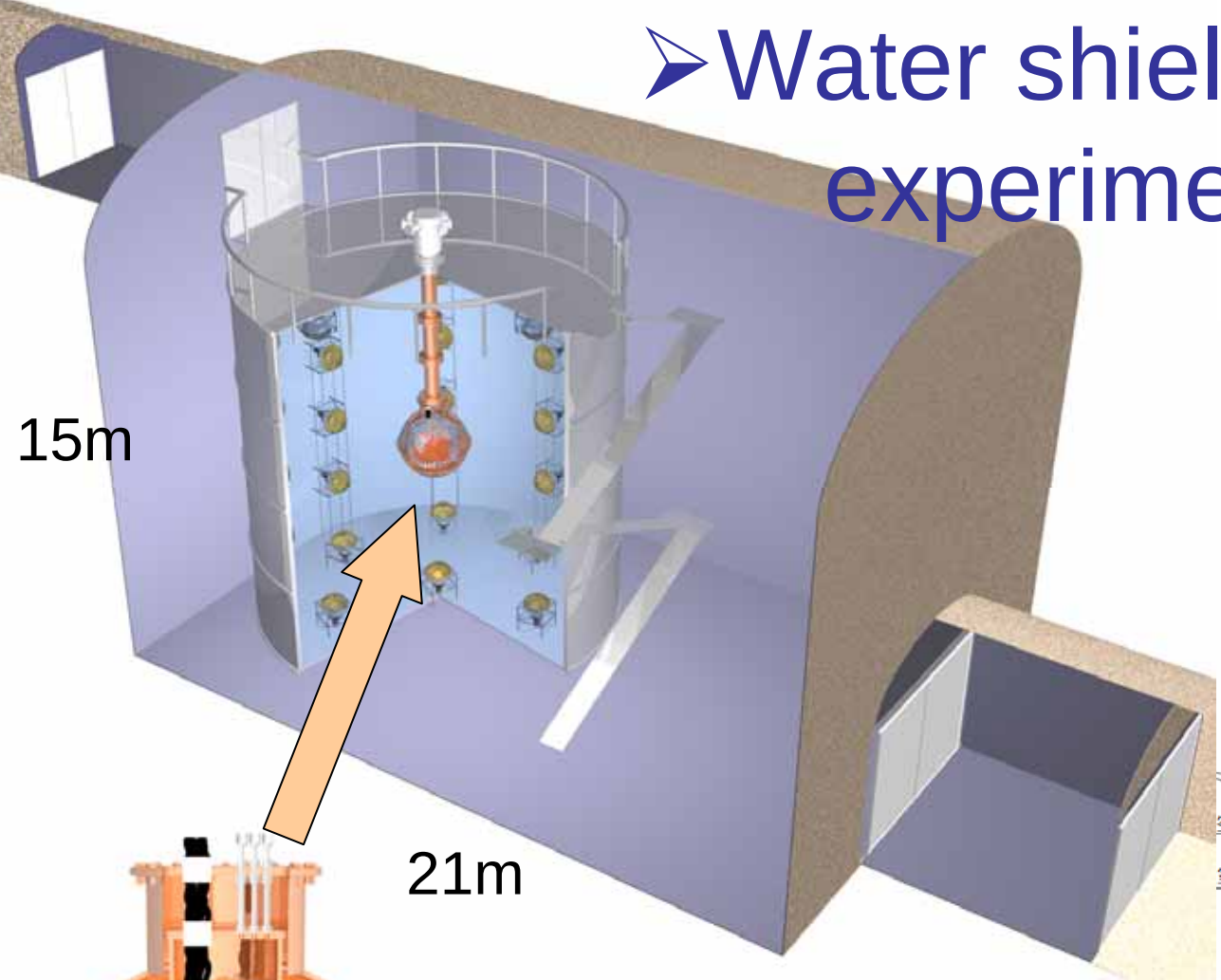
Measured with the prototype detector

$^{238}U$: < $1 \times 10^{-14}$ g/g
(~1decay/100kg/d)
$^{232}Th$: < $2 \times 10^{-14}$ g/g
(~1decay/100kg/d)
$^{85}Kr$: < 1ppt

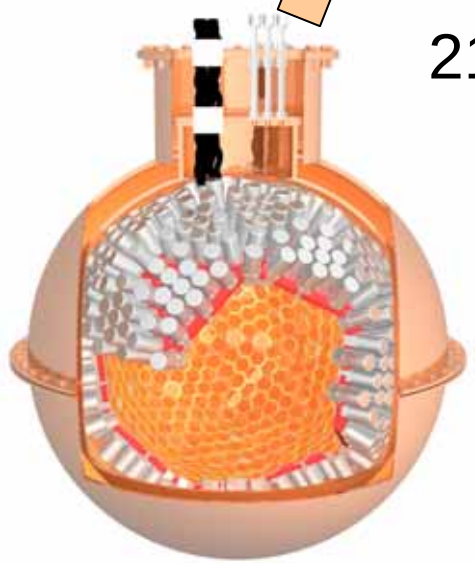
$(9 \pm 6) \times 10^{-14}$ g/g
Further reduction by filter
< $23 \times 10^{-14}$ g/g
Upper limit, use filter
$3.3 \pm 1.1$ ppt
by a prototype distillation tower

U, Th, Kr near to the goal. Within reach.

# ➢Water shield and a new experimental hall





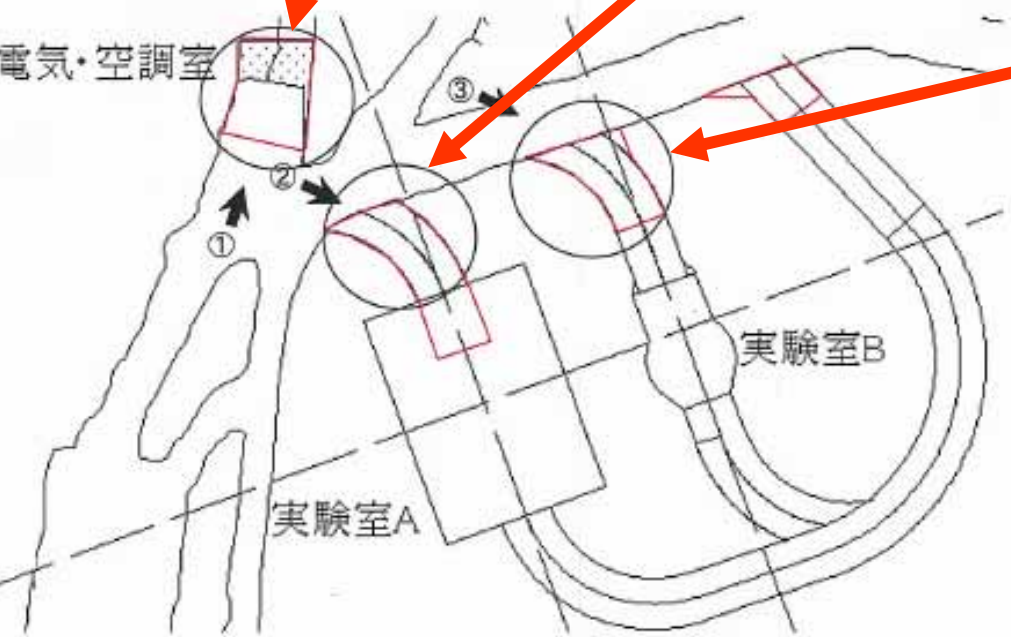


- n prod. in PMTs is estimated < γBG
- Passive for n from rock, active for n from CR μ
- Excavation started 7th Aug. and finish Feb.2008.

# Excavation status

①より望む

②より望む




③より望む

# Schedule of 800 kg detector

- Budget funded in this year.
- We are making detail design of the detector.
  - Structure, Detector, water shield, ….
  - Purification system
  - Cooling system
  - Electronics and etc…..
- Excavation at Kamioka started from this August, will be finished next February.
- Planning to finish the construction in two years.
- The measurements will be started from 2009.

# Summary

- XMASS 800kg detector
  - 1 ton liquid xenon, 90cm diameter, 60 triangles, 812 PMTs
  - Dark matter search $10^{-45}$ $cm^2$
- Detector design by simulation
  - Background from PMT
    - <~$10^{-5}$ dru inside fiducial volume
  - Contamination in LXe
    - Target level within reach
  - External gamma and fast neutron
    - Water shield reduce.
- Schedule
  - Budget funded in this year.
  - Planning to construct the detector as soon as possible.