

# XMASS, Status of 800 kg detector design

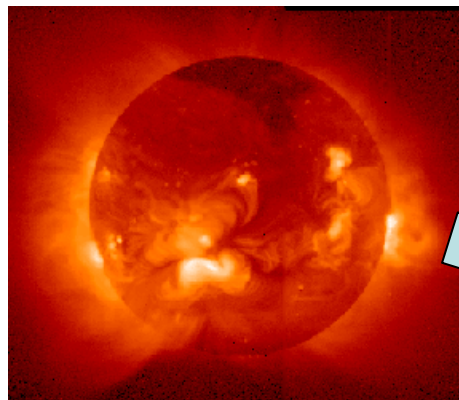
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Kamioka Observatory, ICRR,  
University of Tokyo

# 1. Introduction

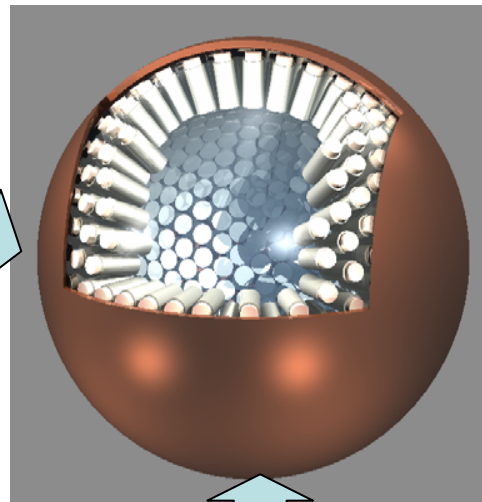
## ➤ What's XMASS

Multi purpose low-background experiment with liq. Xe

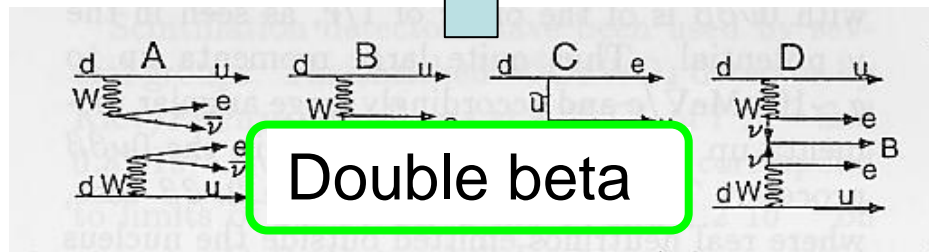
- **X**enon **MASS**ive detector for solar neutrino (**pp**/<sup>7</sup>**Be**)
- **X**enon neutrino **MASS** detector ( **$\beta\beta$  decay**)
- **X**enon detector for Weakly Interacting **MASS**ive Particles (**DM search**)



Solar neutrino



Dark matter

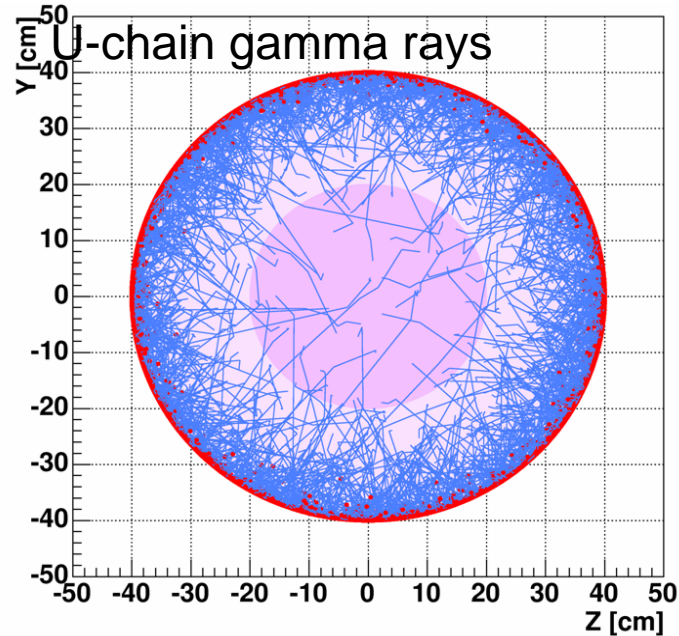


## ➤ Why liquid xenon

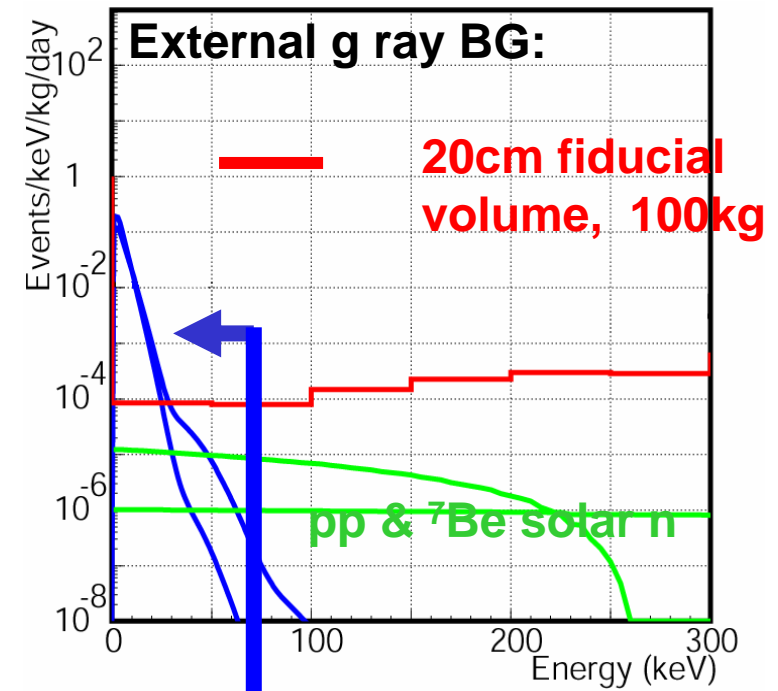
- **Large Z (=54)**  
**Self-shielding effect**
- **Large photon yield (~42 photons/keV ~ NaI(Tl))**  
**Low threshold**
- **High density (~3 g/cm<sup>3</sup>)**  
**Compact detector** (10 ton: sphere with diameter of ~2m)
- **Purification (distillation)**
- No long life radioactive isotope
- Scintillation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

# Target for 800kg : Dark Matter search

$\gamma$  tracking MC from external to Xenon



Blue :  $\gamma$  tracking  
Pink : whole liquid xenon  
Deep pink : fiducial volume



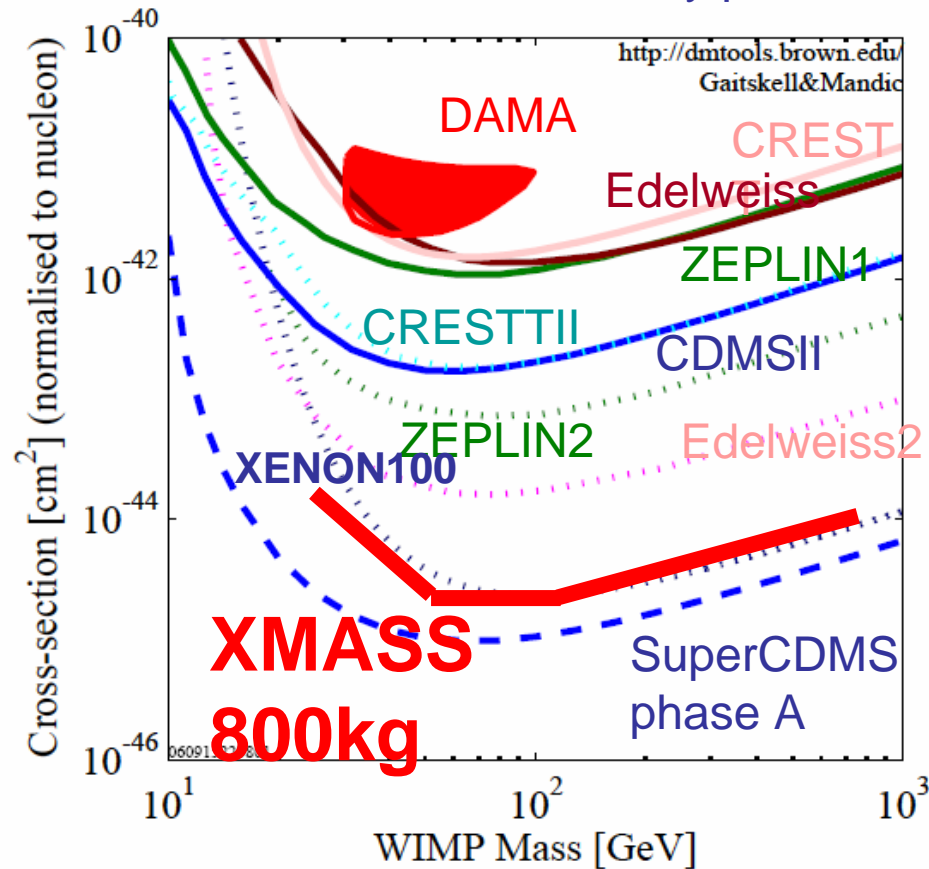
Expected dark matter signal  
(assuming  $10^{-42} \text{ cm}^2$ , Q.F.=0.2  
50GeV / 100GeV,)

## 1. Dark matter search

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

# Expected sensitivities

XMASS FV 0.5 ton year  
 Eth = 5 keVee~25 p.e., 3s discovery  
 w/o any pulse shape info.



- Large improvements will be expected  
 Two order higher than experimental  
 results so far.

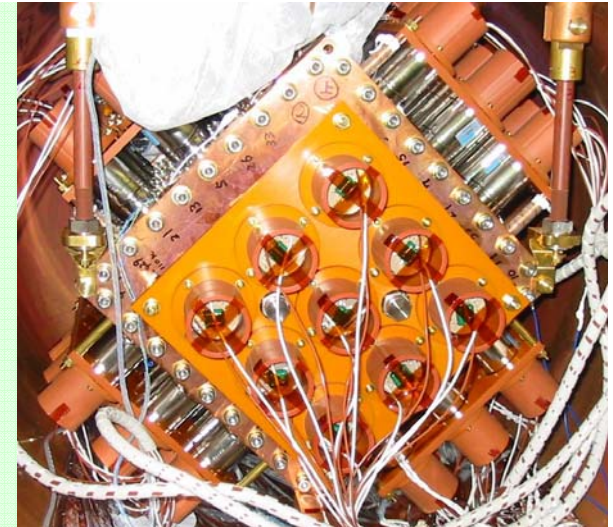
**$\sim 10^{-45} \text{ cm}^2$**

Plots except for XMASS:  
<http://dmtools.berkeley.edu>  
 Gaitskell & Mandic

## ➤ Status of 800 kg detector

- **Basic performances have been already confirmed using prototype detector**

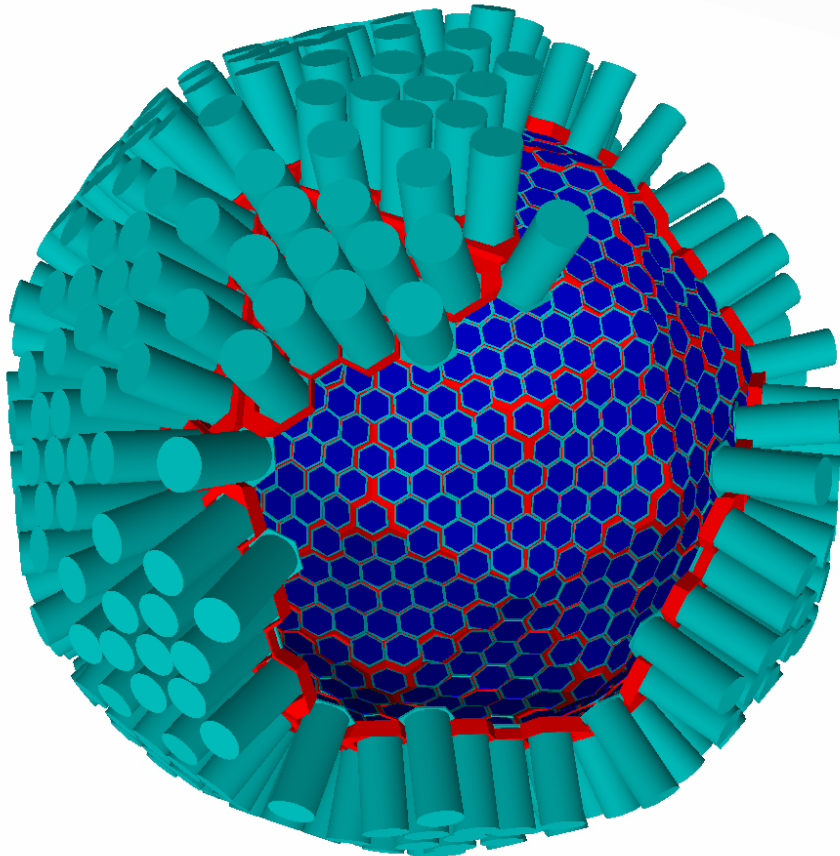
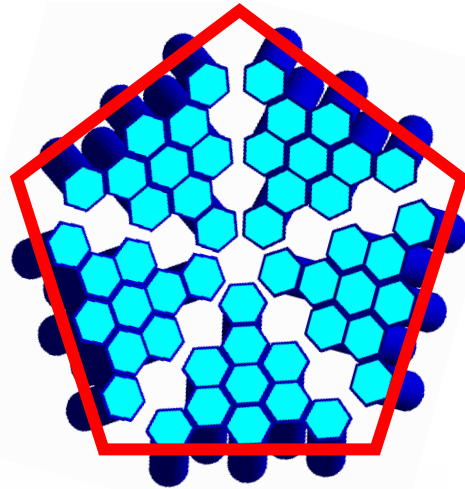
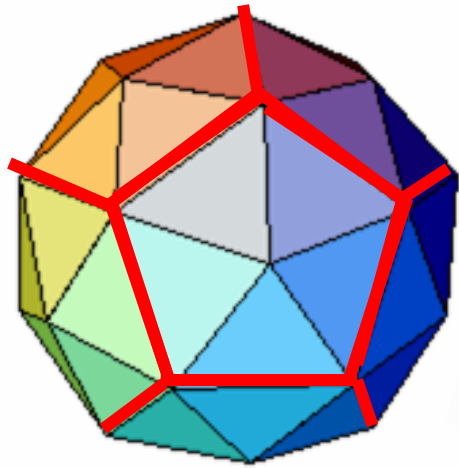
- ✓ Method to reconstruct the vertex and energy
- ✓ Self shielding power
- ✓ BG level



- **Detector design is going using MC**

- ✓ Structure and PMT arrangement (812 PMTs)
- ✓ Event reconstruction
- ✓ BG estimation

- **New excavation will be done soon**



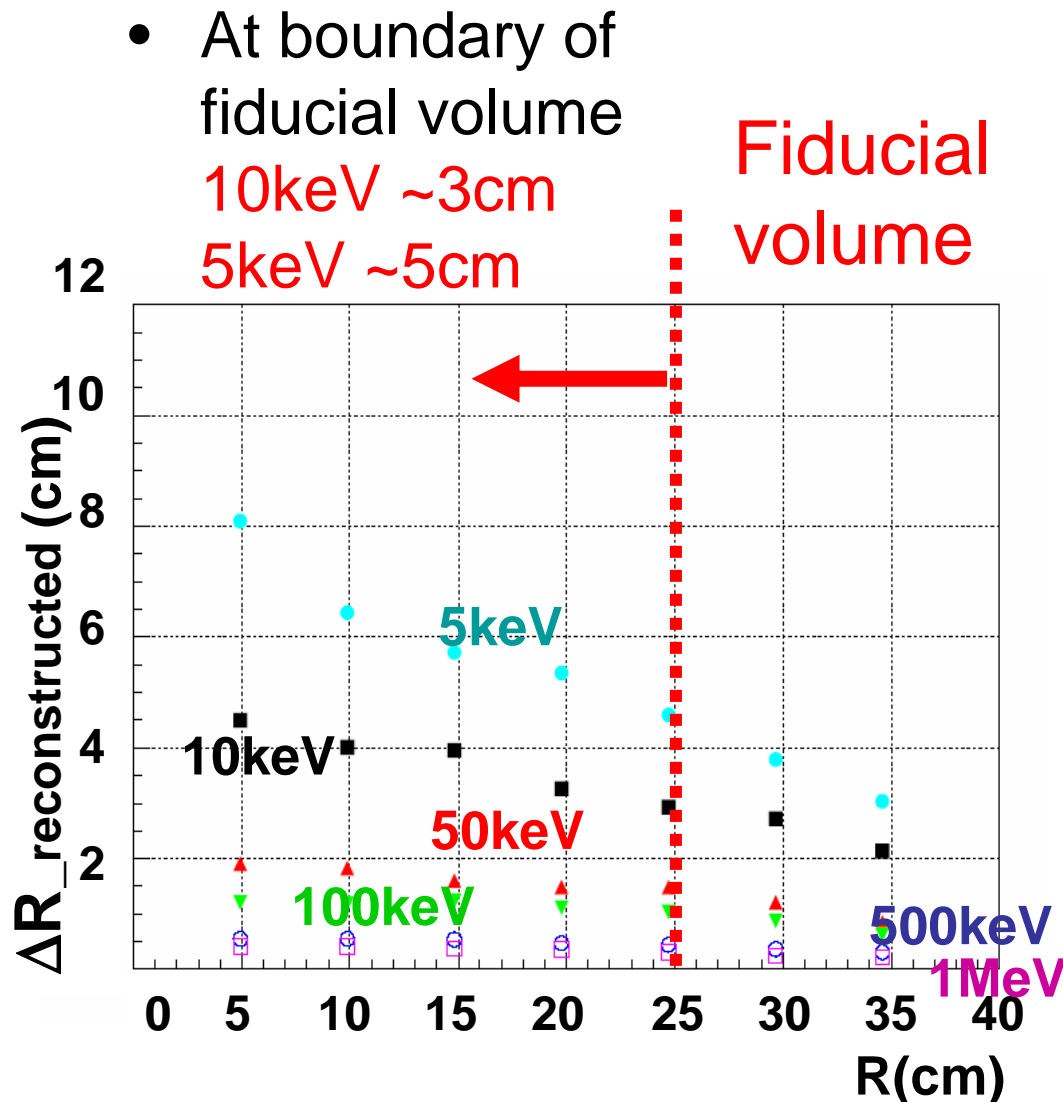
# Design of 800kg

## ① 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 volume is 25cm from center.
- PMTs are inside liquid xenon.

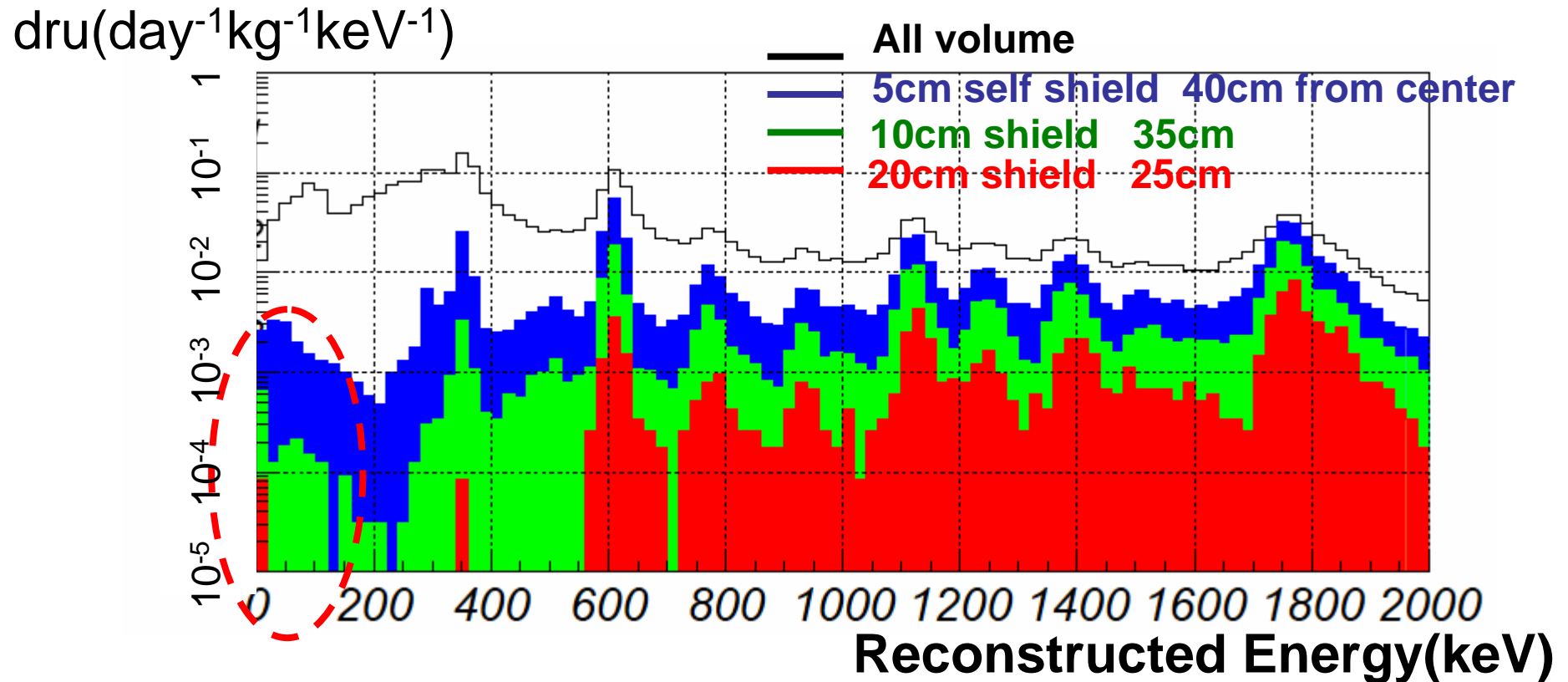
# Resolution of event reconstruction and BG estimation from MC

- In current design, performance of detector was estimated using Geant4 MC.
  - Resolution of position.
  - BG from PMTs
- Resolution
  - Using signals from the PMTs, vertex position is calculated so as to maximize likelihood.



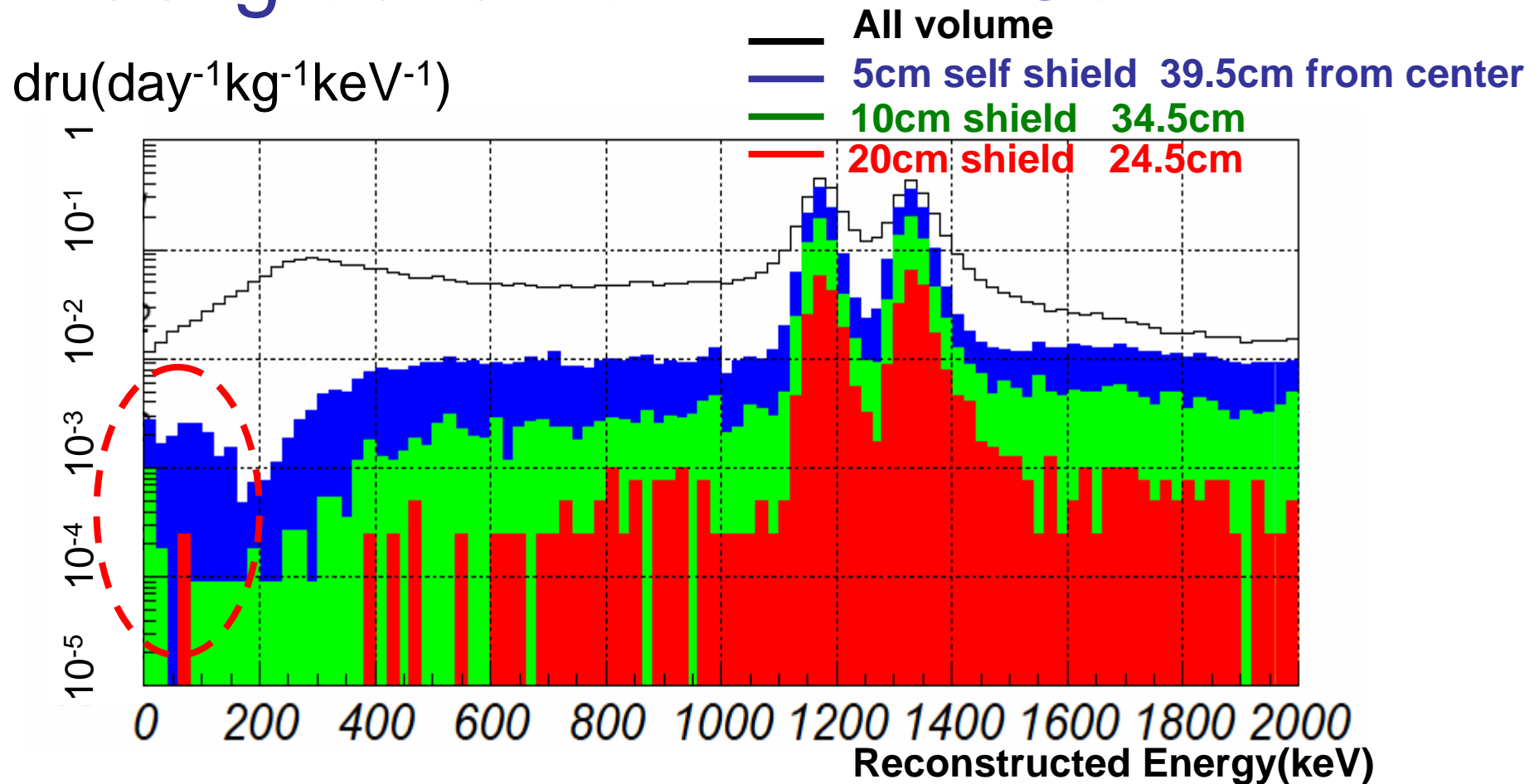


# Background from PMT $^{238}\text{U}$



- $1.8 \times 10^{-3}$  Bq/PMT
- $<100\text{keV}$ 
  - 5cm shield  $\sim 10^{-3}$  dru
  - 10cm shield  $\sim 10^{-4}$  dru
  - 20cm shield  $\sim 10^{-5}$  dru

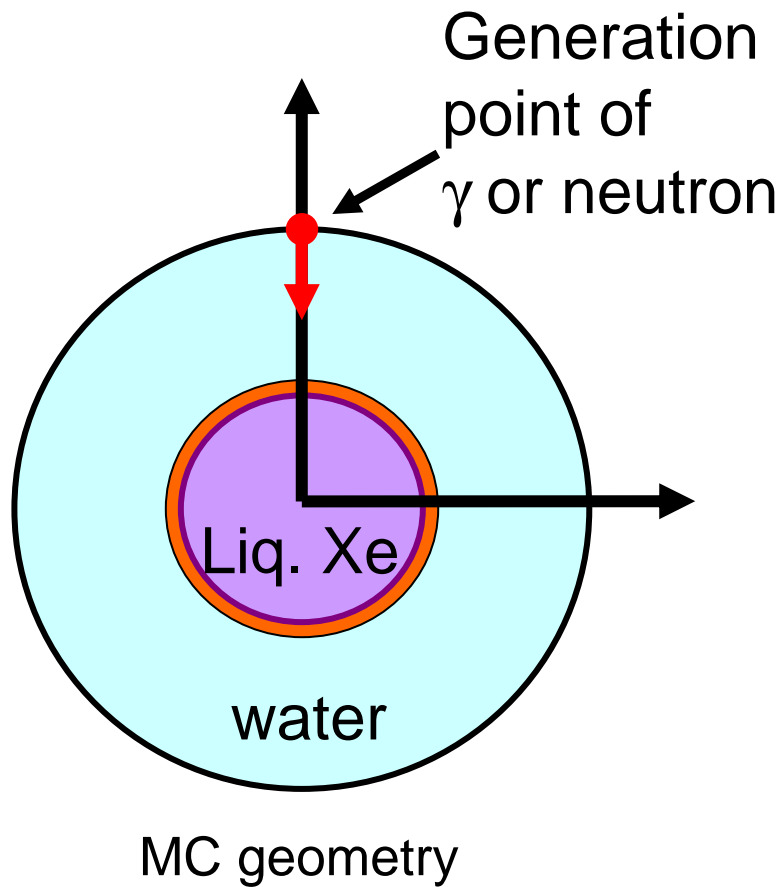
# Background from PMT $^{60}\text{Co}$



- $5.5 \times 10^{-3}$  Bq/PMT
- $<100\text{keV}$  same level as  $^{238}\text{U}$
- We can achieve  $10^{-5}$  dru level

## ➤ Design of 800 kg Detector

### ② Water shield for ambient $\gamma$ and fast neutron

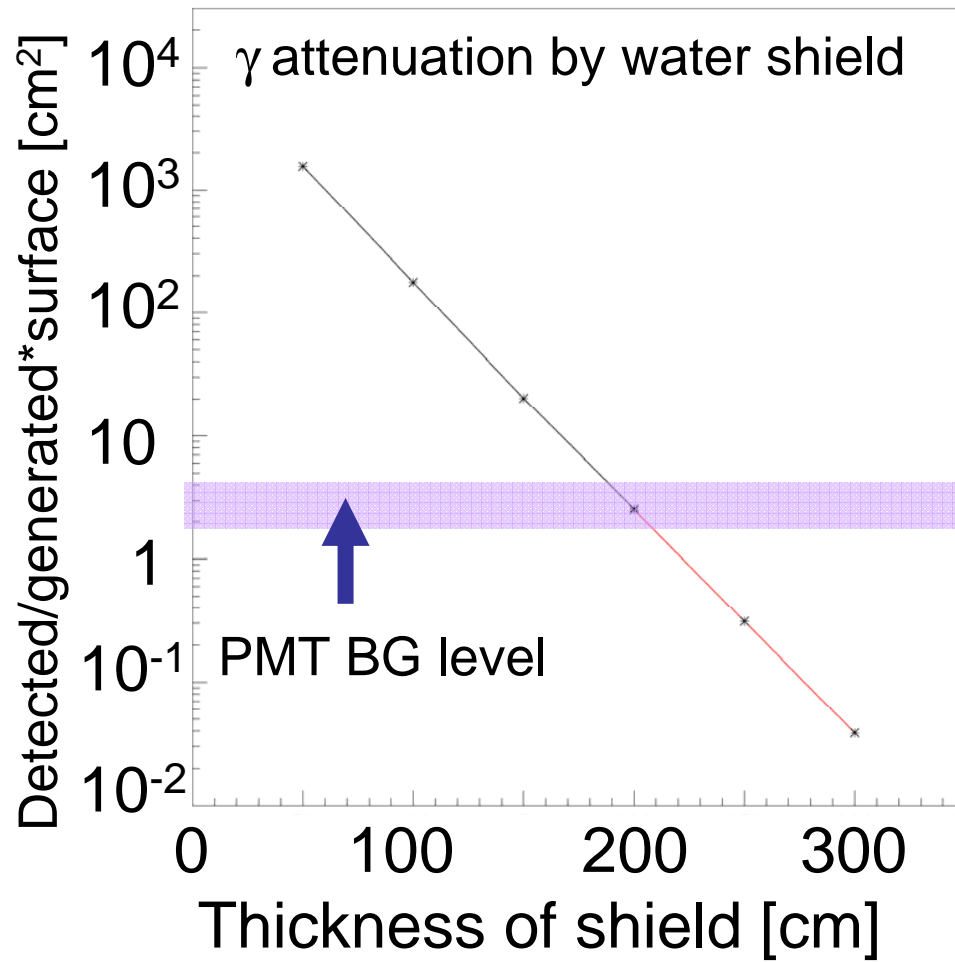


- Ambient background  $\gamma$  and neutron is another large background source.
- To reduce these background, use thick water shield.
- Estimated how thick shield is needed with simple simulation.

#### Configuration of the estimation

- Put 80cm diameter liquid Xe ball
- Assume copper vessel (2cm thickness)
- Assume several size of water shield 50, 100, 150, and 200cm thickness for liquid Xe

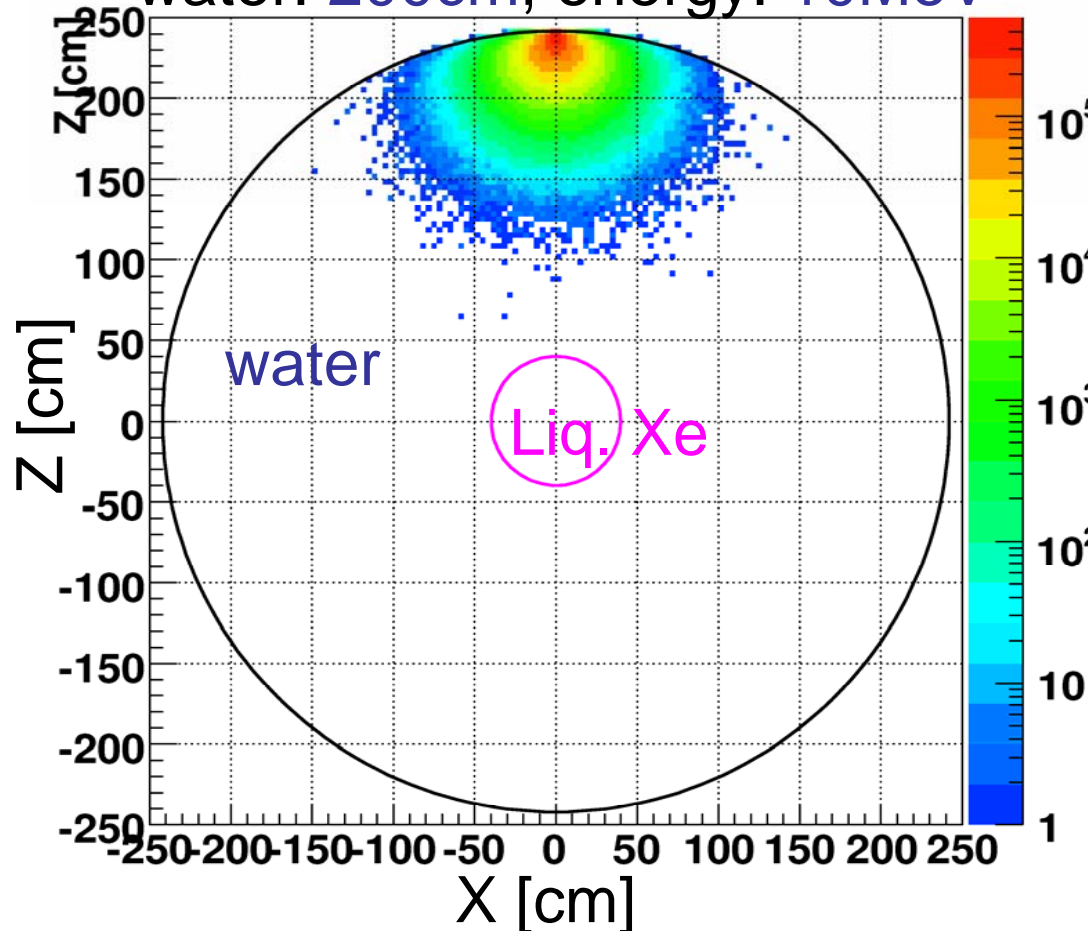
## ➤ $\gamma$ attenuation



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

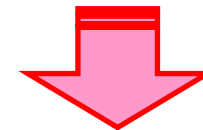
## ➤ Reach points of fast neutron

Reach points before thermalized  
water: 200cm, energy: 10MeV



Generation:  $10^7$

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



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

200cm of water is enough  
to reduce the fast neutron

# Summary

- XMASS 800kg detector
  - 1 ton liquid xenon, 90cm diameter, 60 triangles, 812 PMTs
  - BG level  $10^{-4}$  dru( $\text{day}^{-1}\text{kg}^{-1}\text{keV}^{-1}$ )
  - Dark matter search  $10^{-45}$   $\text{cm}^2$
- Detector design by simulation
  - Resolution of event reconstruction
    - 10keV  $\sim 3\text{cm}$  5keV  $\sim 5\text{cm}$  at boundary of fiducial volume
  - Background from PMT
    - $^{238}\text{U}$ ,  $^{60}\text{Co}$   $\sim 10^{-5}$  dru inside fiducial volume
  - Water shield for ambient  $\gamma$  and fast neutron
    - 200cm shield is enough