Status of XMASS

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   - Liquid Xenon
   - Target
2. Status of 800 kg detector
   - Design
   - BG estimation
   - Schedule
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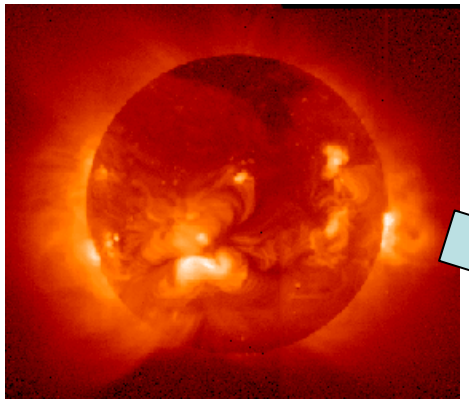
1. Introduction

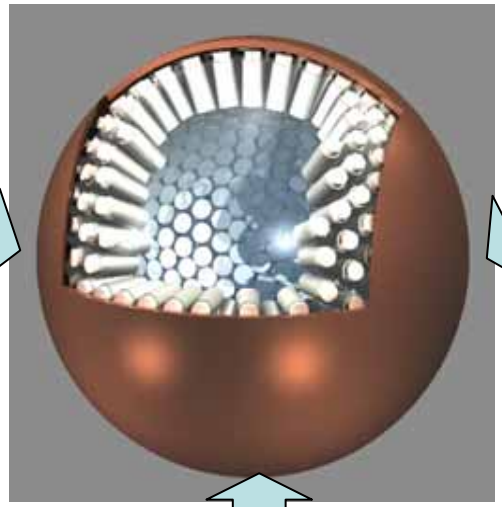
➢ What's XMASS

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

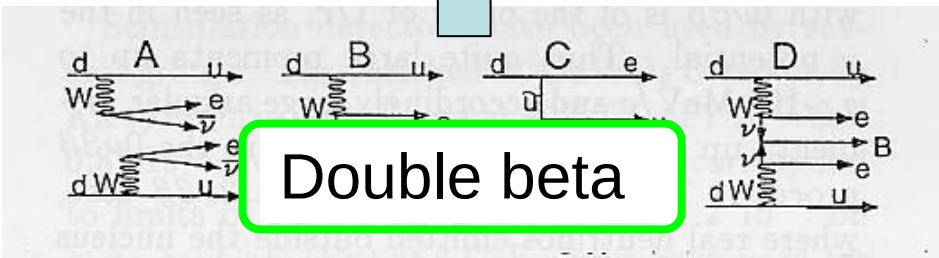
- **X**enon detector for Weakly Interacting **MASS**ive Particles (**DM search**)
- **X**enon **MASS**ive detector for solar neutrino (**pp/^{7}Be**)
- **X**enon neutrino **MASS** detector (**ββ decay**)



Solar neutrino



Dark matter



Double beta

➢ Why liquid xenon

- **Large Z (=54)**
  Shielding effect of itself is large.
- **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)
- Purification (distillation)
- No long life radioactive isotope
- Scintillation wavelength (175 nm, detected directly by PMT)

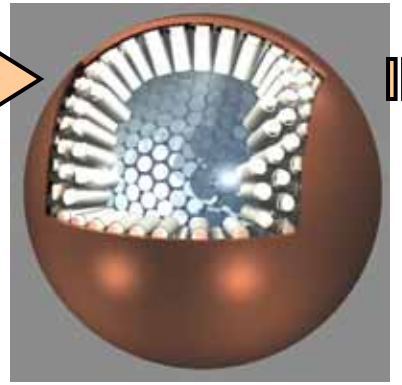
→ We can achieve low energy threshold and low background.

➢ Strategy of the scale-up

100kg detector

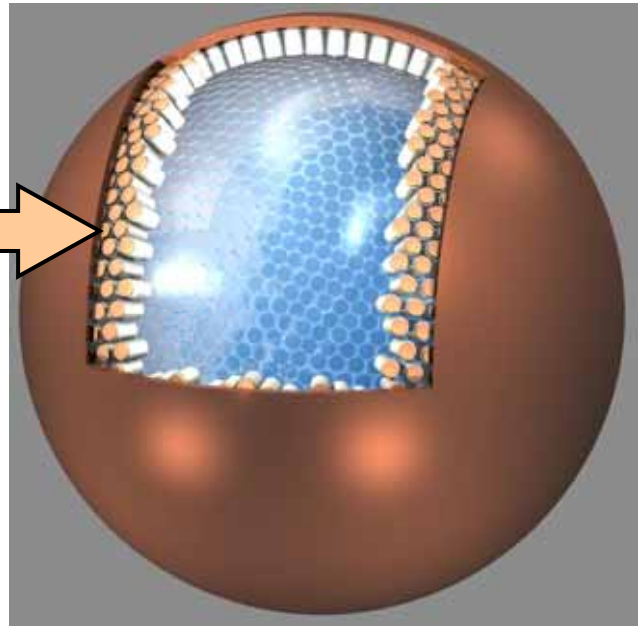
~30cm

800kg detector



~80cm

10 ton detector



~2.5m

R&D

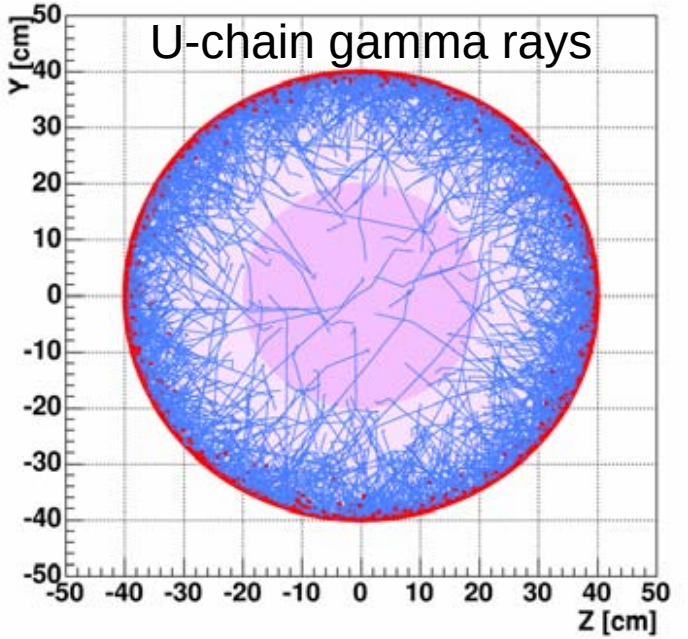
- ✓ position & energy reconstruction
- ✓ Self shielding power
- ✓ BG level

Dark matter search

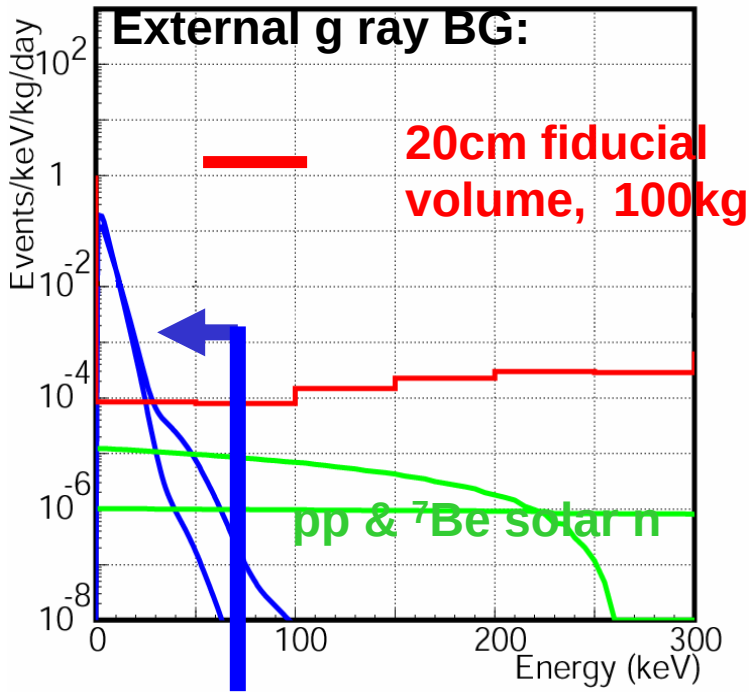
Multipurpose detector (solar neutrino, ββ …)

➢Target for 800kg : Dark Matter search

γ tracking MC from external to Xenon



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



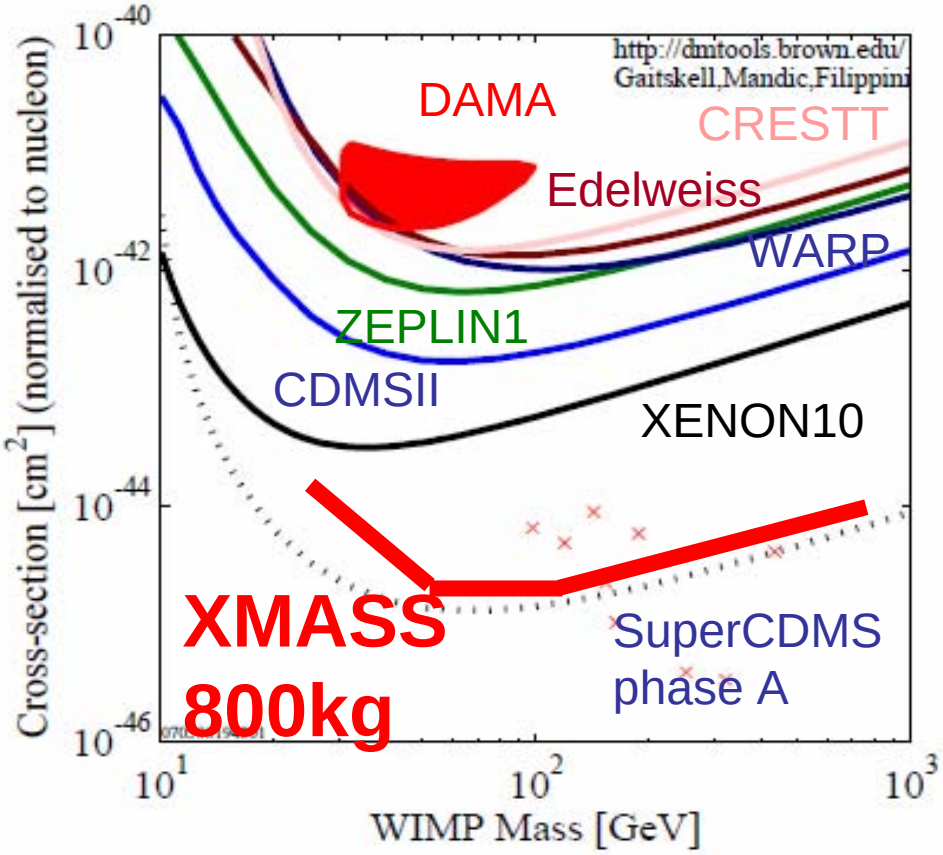
Expected dark matter signal (assuming 10^{-42} cm^2, Q.F.=0.2 50GeV / 100GeV,)

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.

➢Expected sensitivities



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

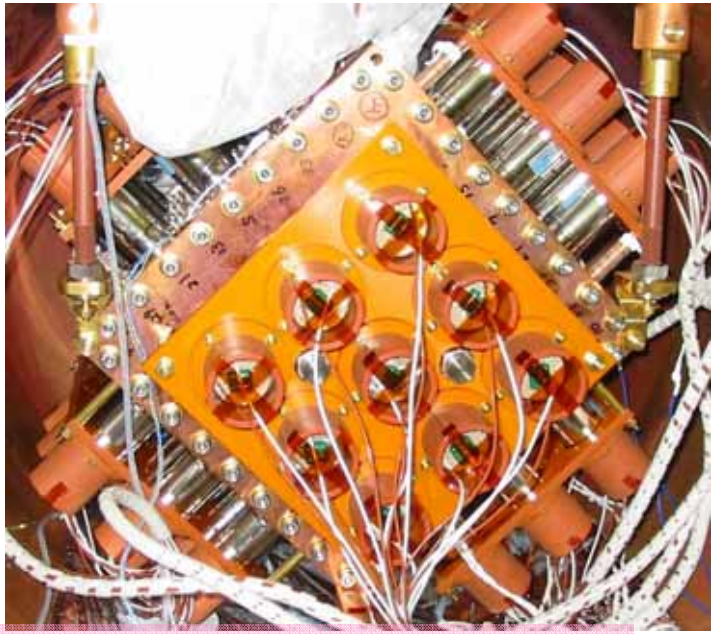
Plots except for XMASS:
http://dmtools.berkeley.edu
Gaitskell & Mandic

- Large improvements will be expected **~10^{-45} cm^2**

2. Status of 800 kg detector

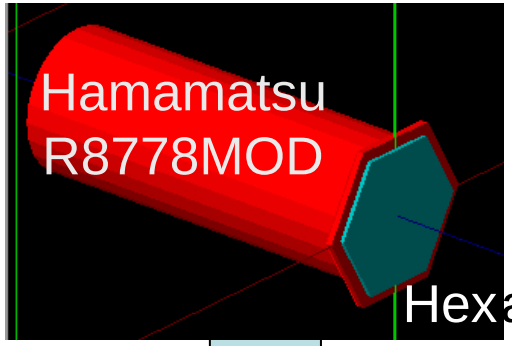
- **Basic performances have been already confirmed using 100kg detector**

  1. Method to reconstruct the vertex and energy
  2. Self shielding power
  3. BG level



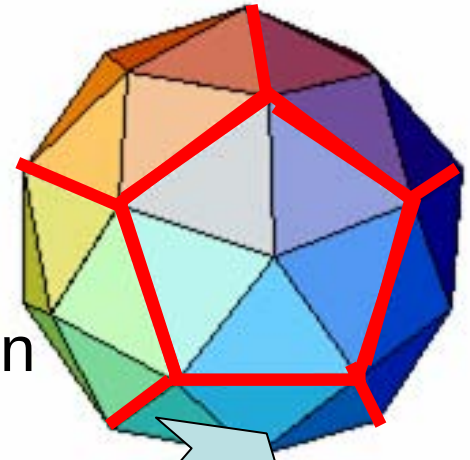
- **Detector design is going using MC**
  - ✓ Structure of detector
  - ✓ BG estimation
    - ✓ PMT gamma
    - ✓ external gamma and neutron

➢ Structure of 800 kg detector

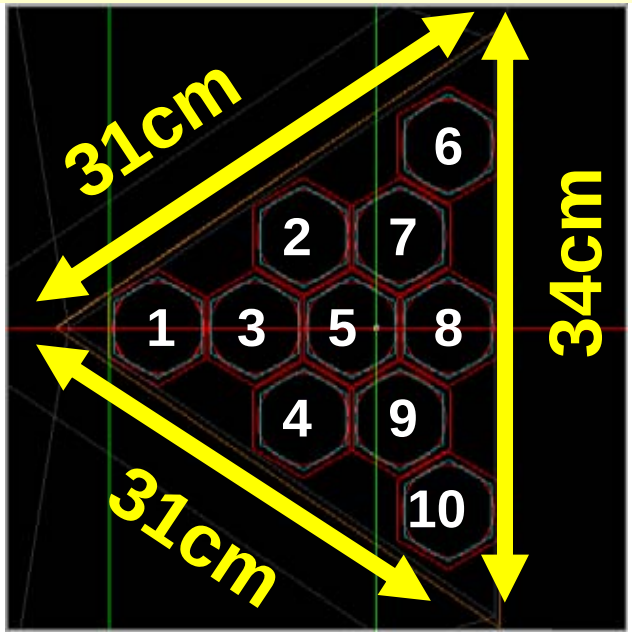


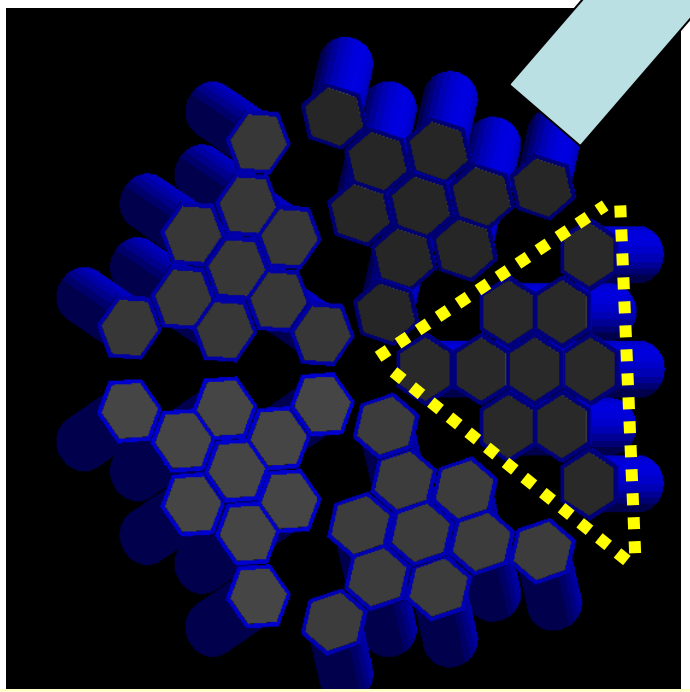
Hexagonal
quarts window

12 pyramids /
pentakisdodecahedron

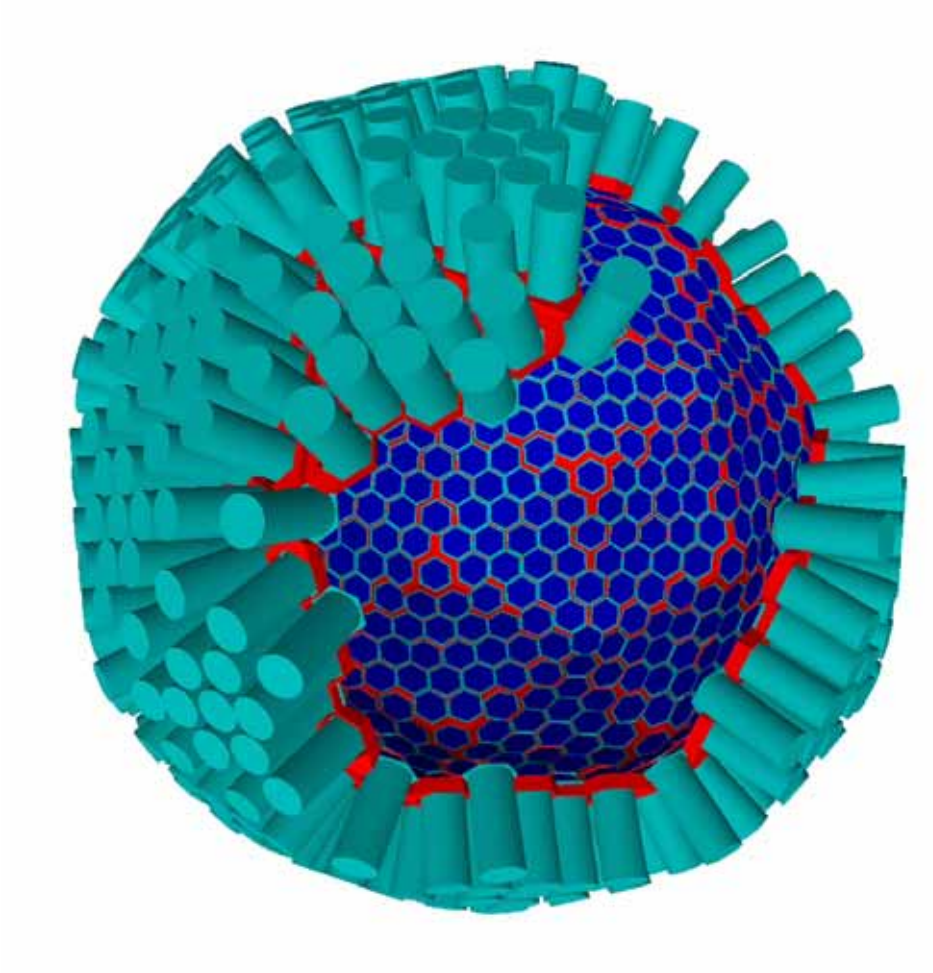


10 PMTs per 1 triangle





5 triangles make pentagonal pyramid



➢Structure of 800kg detector

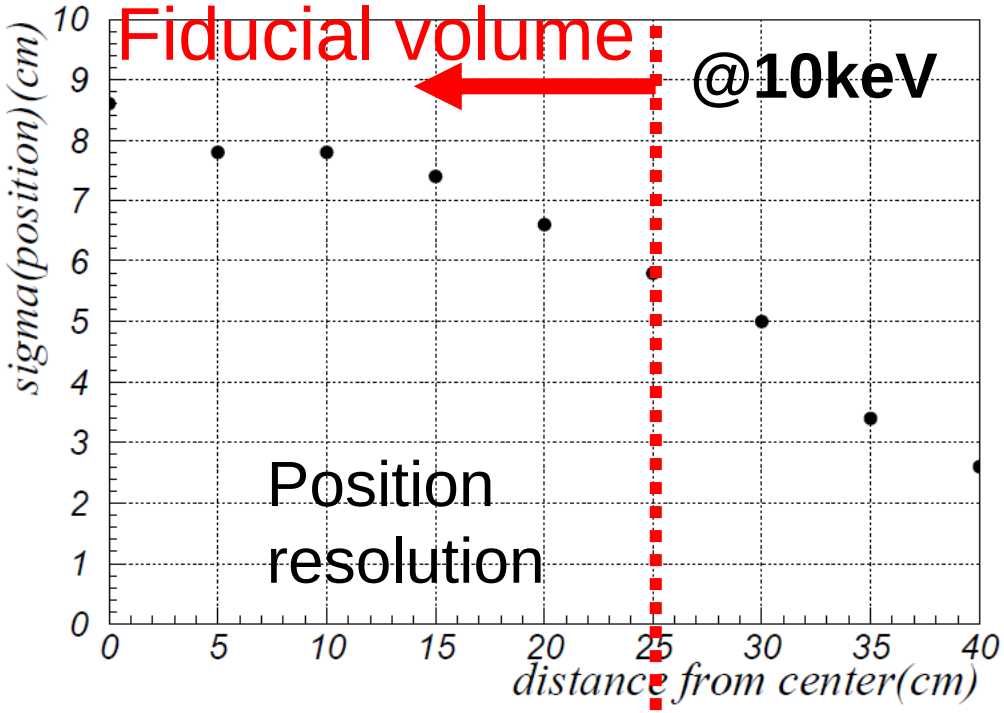
- 60 triangles
- 10 PMT/triangle x 60 = 600 PMTs
- + 212 PMTs in triangle boundary region
- Total 812 PMTs
- Photo coverage 67.0%
- Center to photocathode ~45cm
- Fiducial vloume is 25cm from center.
- PMTs are inside liquid xenon.

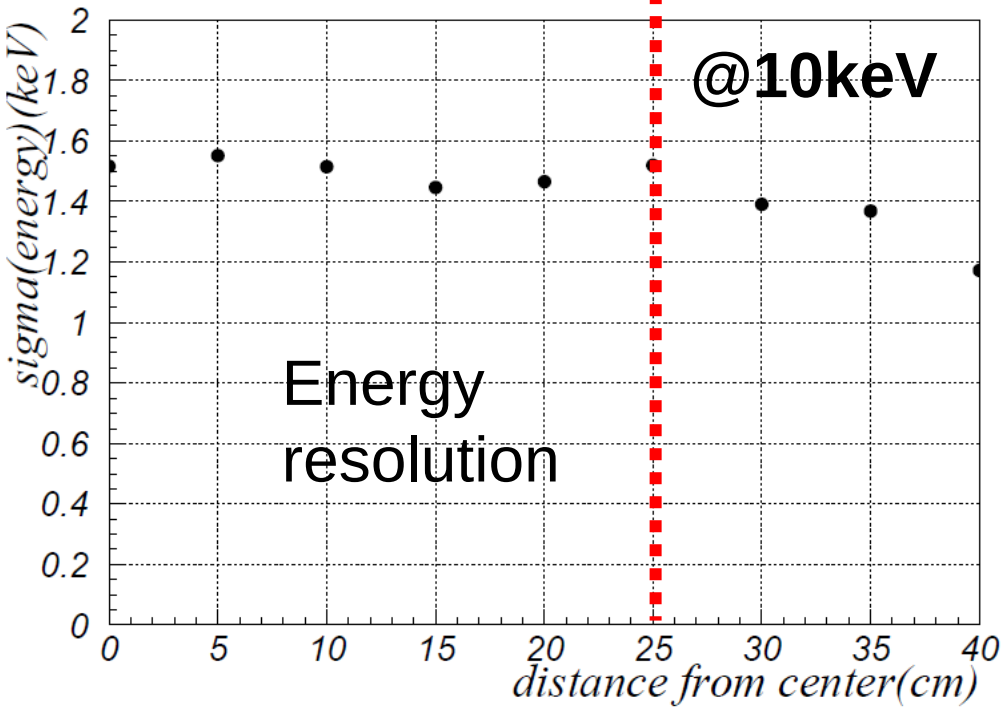
➢Background estimation

- By Geant4 Monte Carlo simulation
- PMT gamma background
  - Reduced by self shielding
  - Position reconstruction
  - U/Th/K/Co
- External gamma
  - Reduced by water shield
- Neutron
  - Reduced by water shield

➢PMT BG

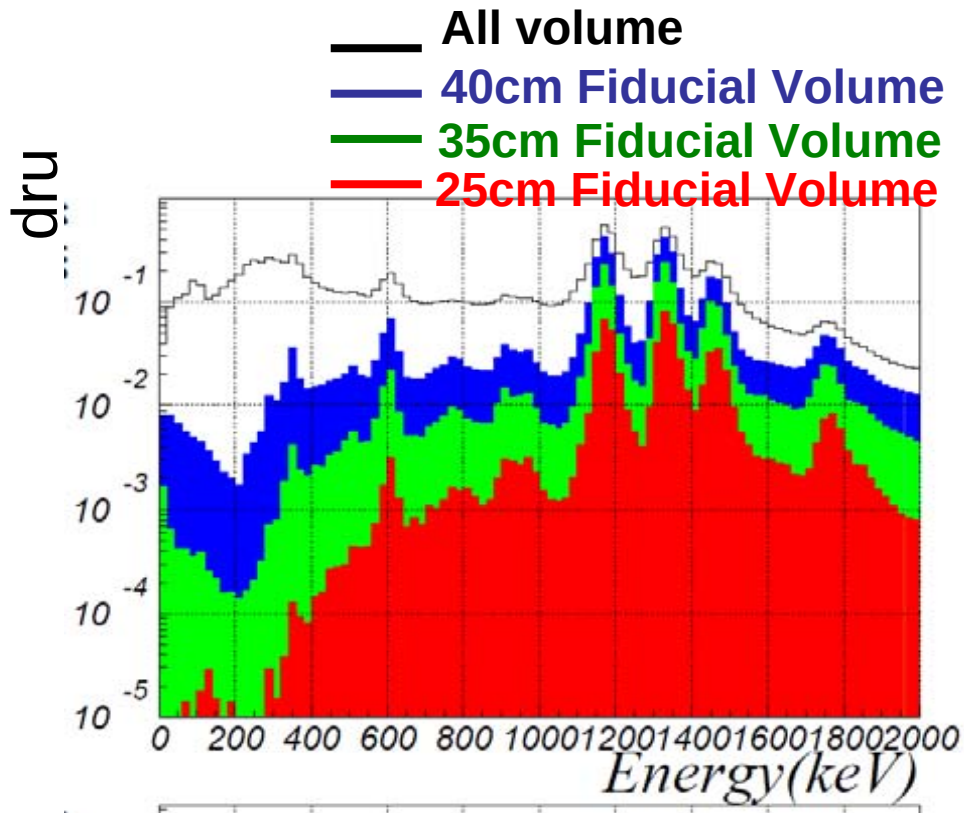
- Reconstruction of event
  - Key part for self shielding
  - Basic part is same as the one confirmed in 100kg detector.
  - Method
    - Make grid point at every certain lengths.
    - Make the p.e. map for all PMTs at the grid points.
    - Use the event data and this map, calculate the event's likelihood.
    - Answer is the point which gives the maximum likelihood.

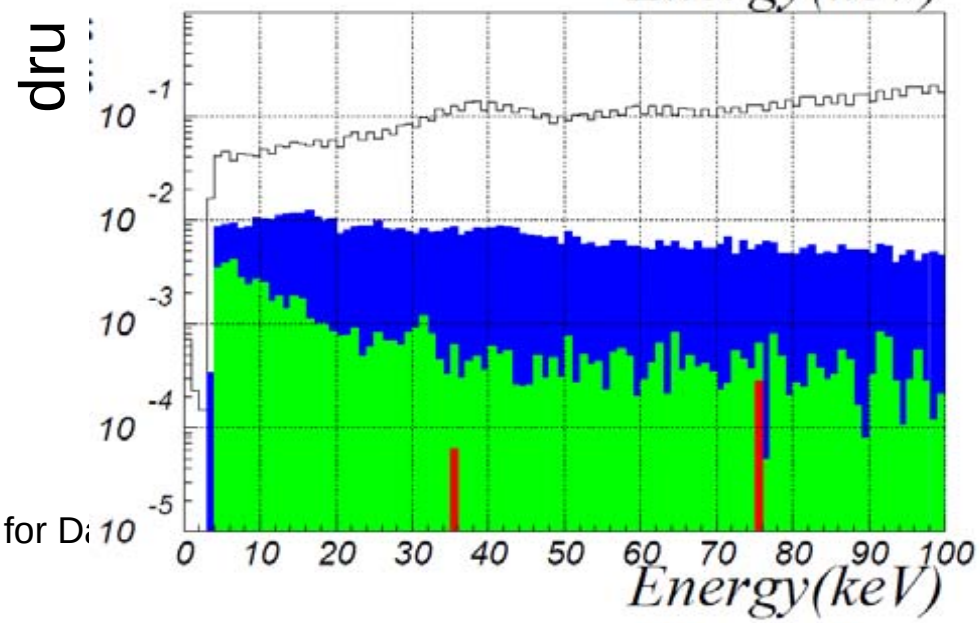




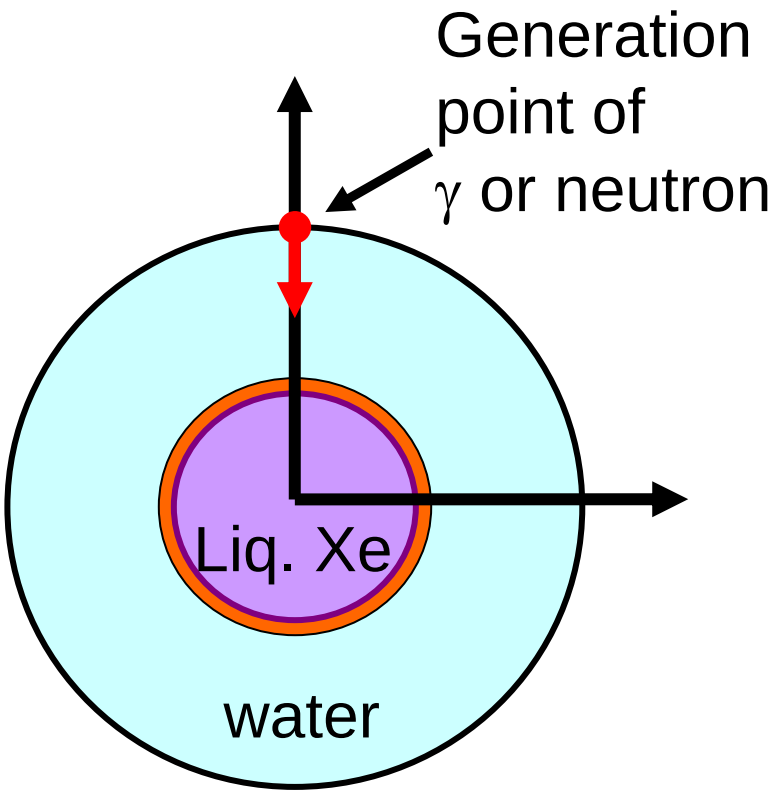
➢Estimated PMT BG

- 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} dru BG level.
- Below 100 keV, BG becomes <10^{-5} level.





➢External gamma and fast neutron



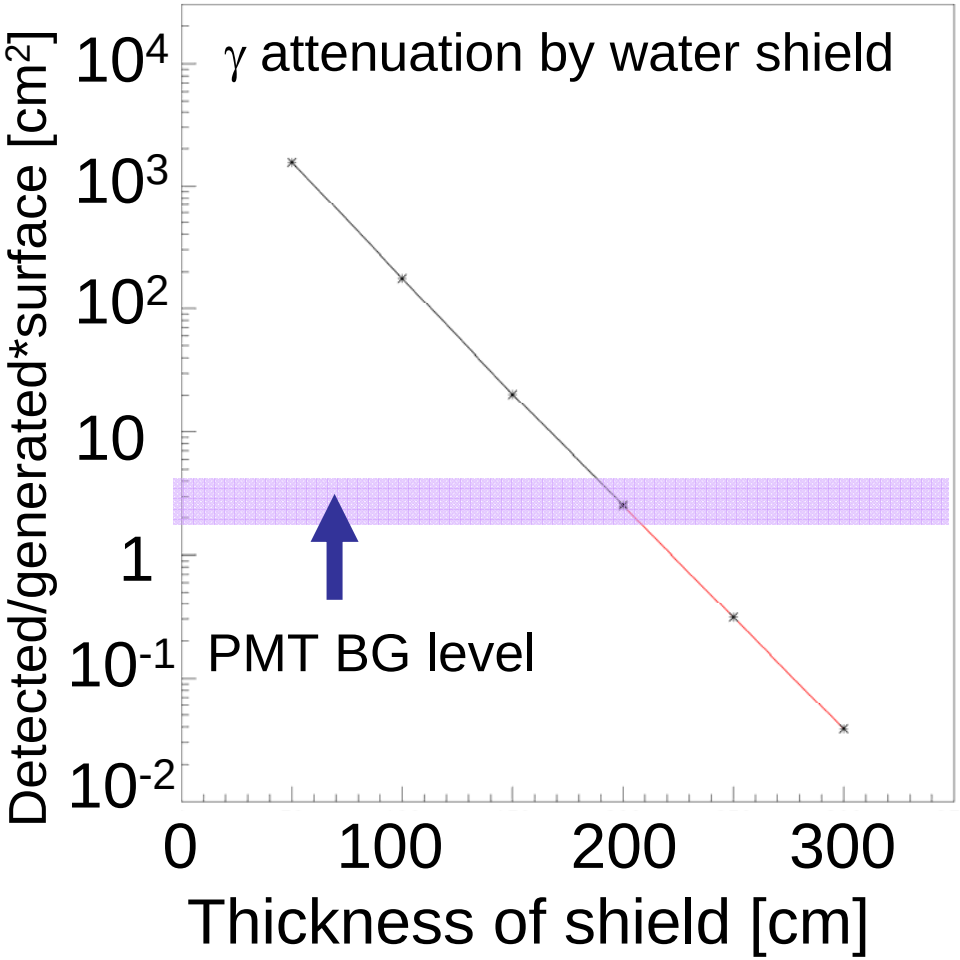
MC geometry

- External gamma and neutron are another large background sources.
- To reduce these background, use thick water shield.
- Thickness of shield is estimated with simple simulation.

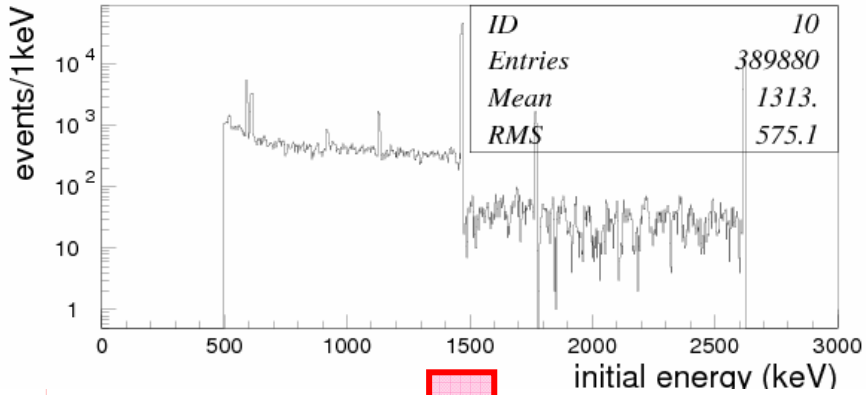
Configuration of the estimation

- **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**

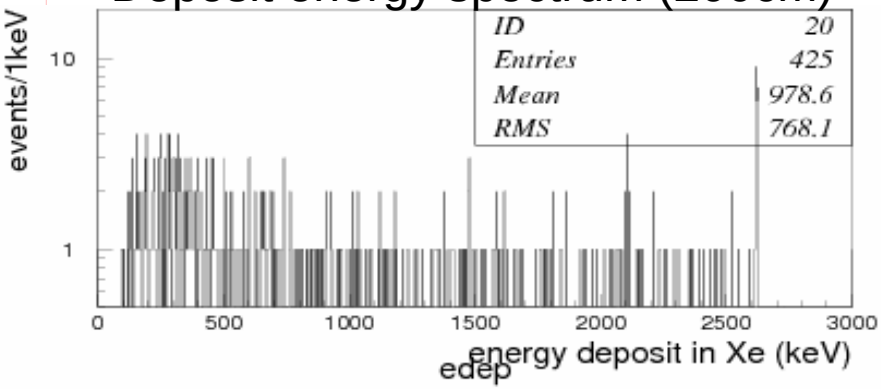
➢ γ attenuation



Initial energy spectrum from the rock



Deposit energy spectrum (200cm)

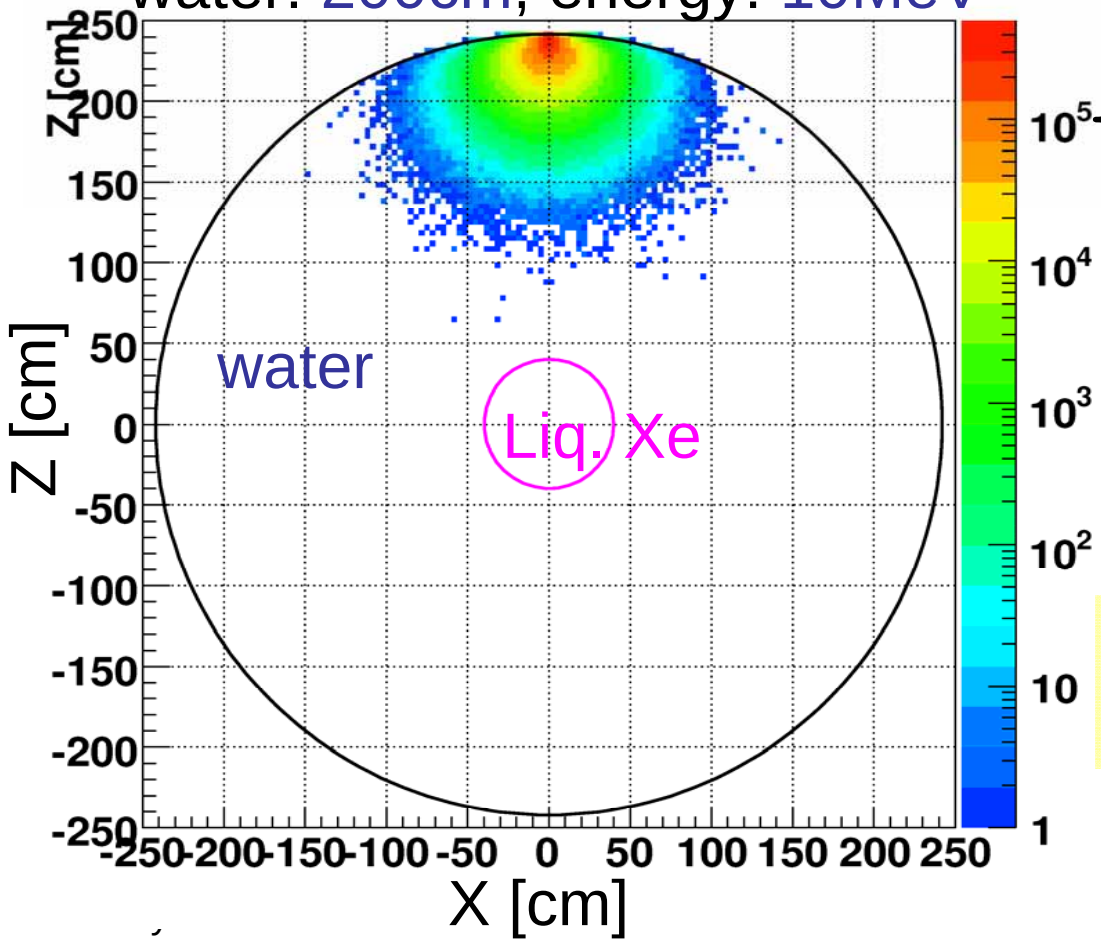


More than 200cm water is needed to reduce the BG to the PMT BG level

➢ 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^2/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

Schedule of 800 kg detector

- Budget funded in this year.
- We are starting detail design of the detector.
  - Detector structure
  - Purification system
  - Cooling system
  - Electronics and etc…..
- Excavation at Kamioka will be start soon.
- 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
  - External gamma and fast neutron
    - 200cm water shield is enough
- Schedule
  - Budget funded in this year.
  - Planning to construct the detector as soon as possible.
  - We want the collaborator who can work hard. If you have any interest, please contact us.