Status of XMASS

June 29th , 2011

Y. Kishimoto for XMASS collaboration

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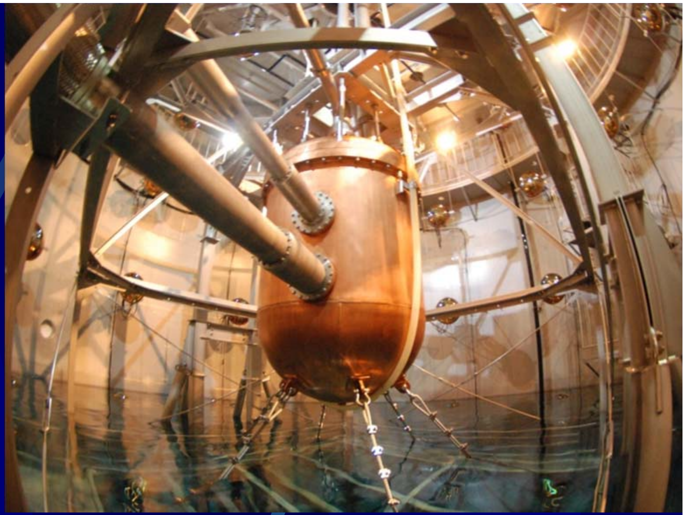

ABOUT XMASS PROJECT

XMASS collaboration

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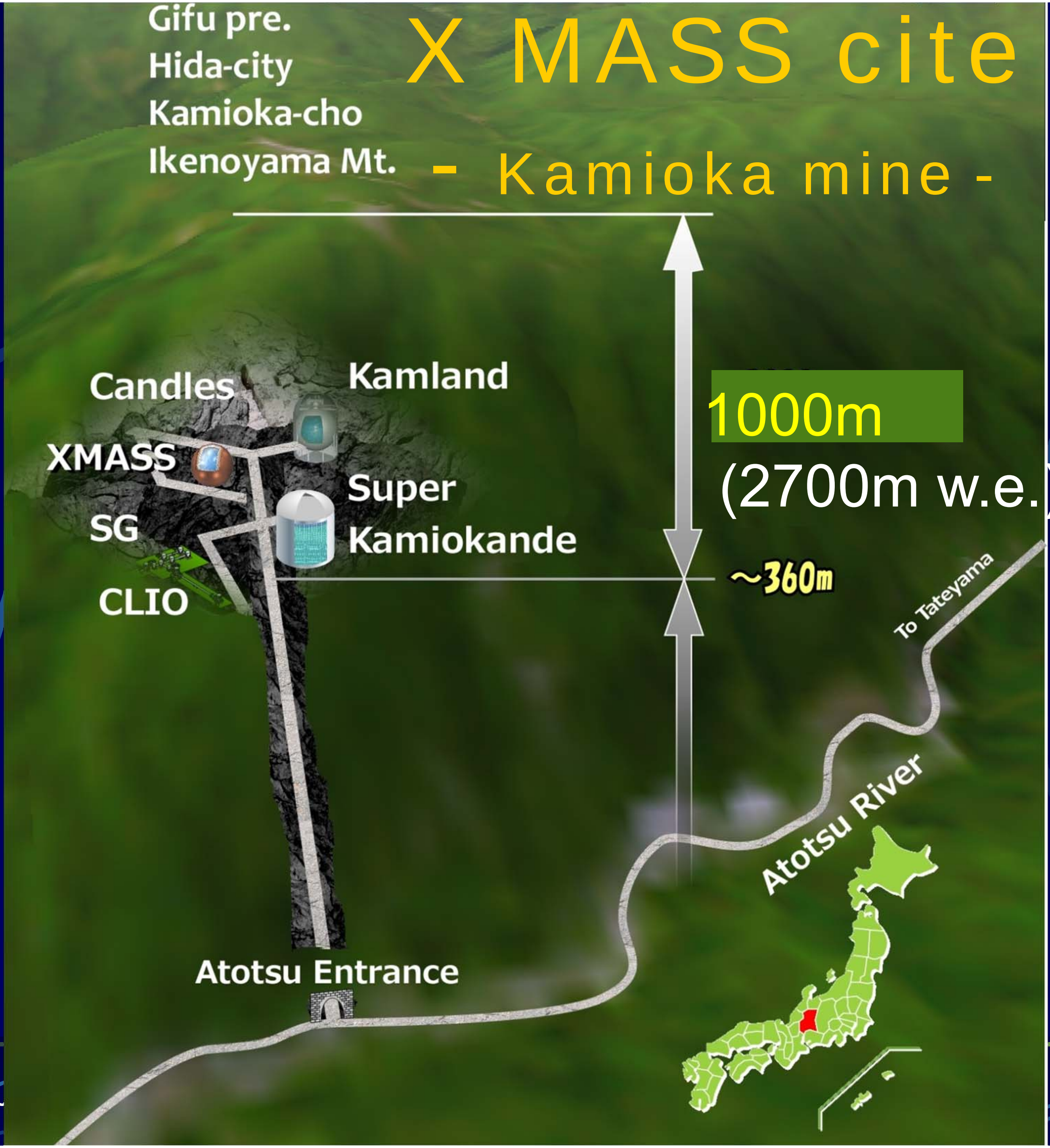
Sejong University : Y.D. Kim

KRISS: Y.H. Kim, M.K. Lee, K. B. Lee, J.S. Lee

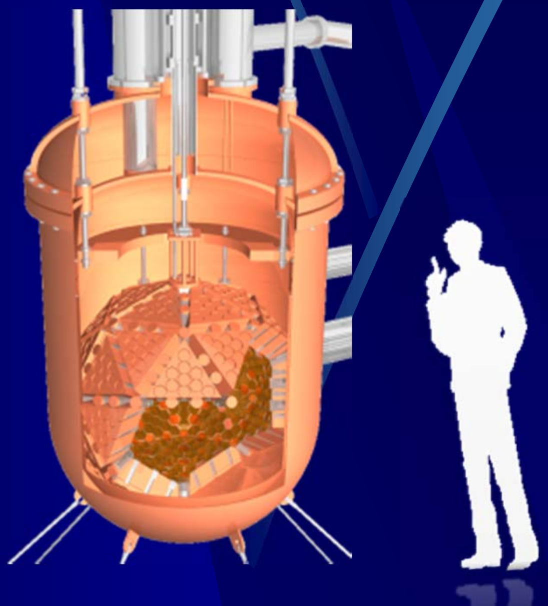
41 collaborators,
10 institutes

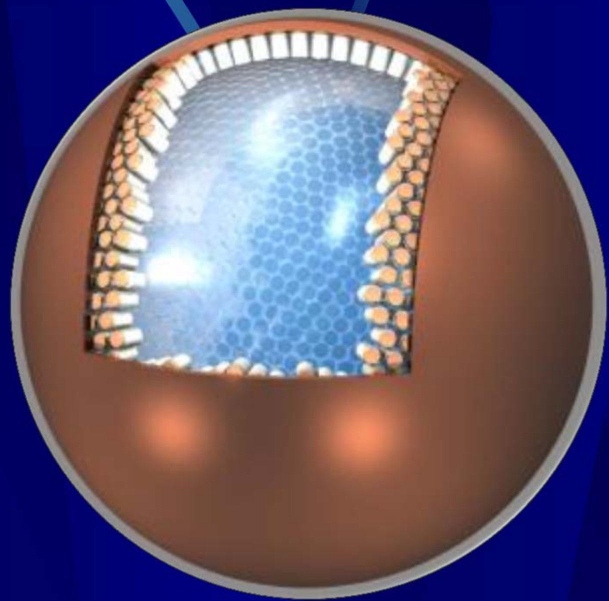
X MASS cite
- Kamioka mine -



The XMASS experiment

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

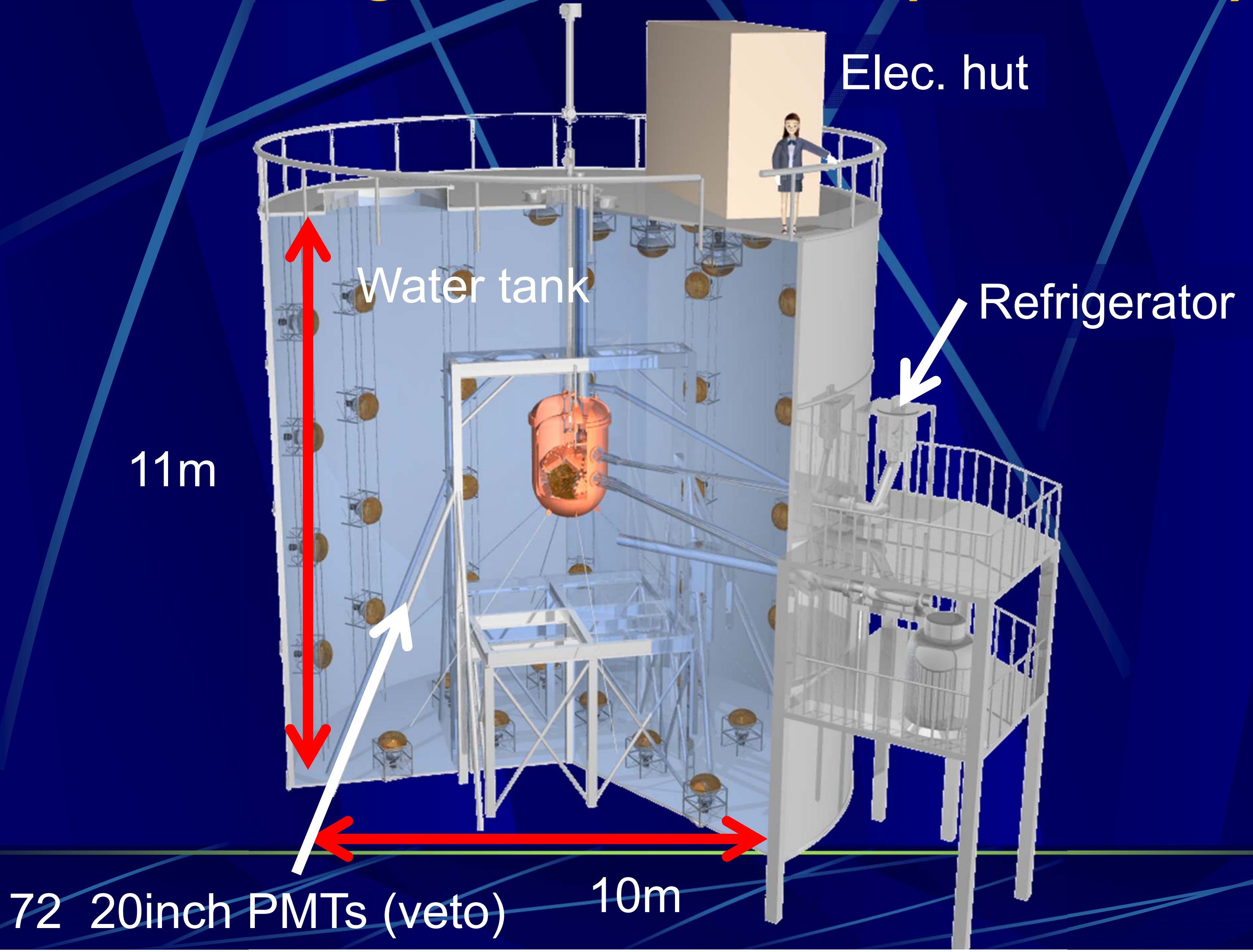




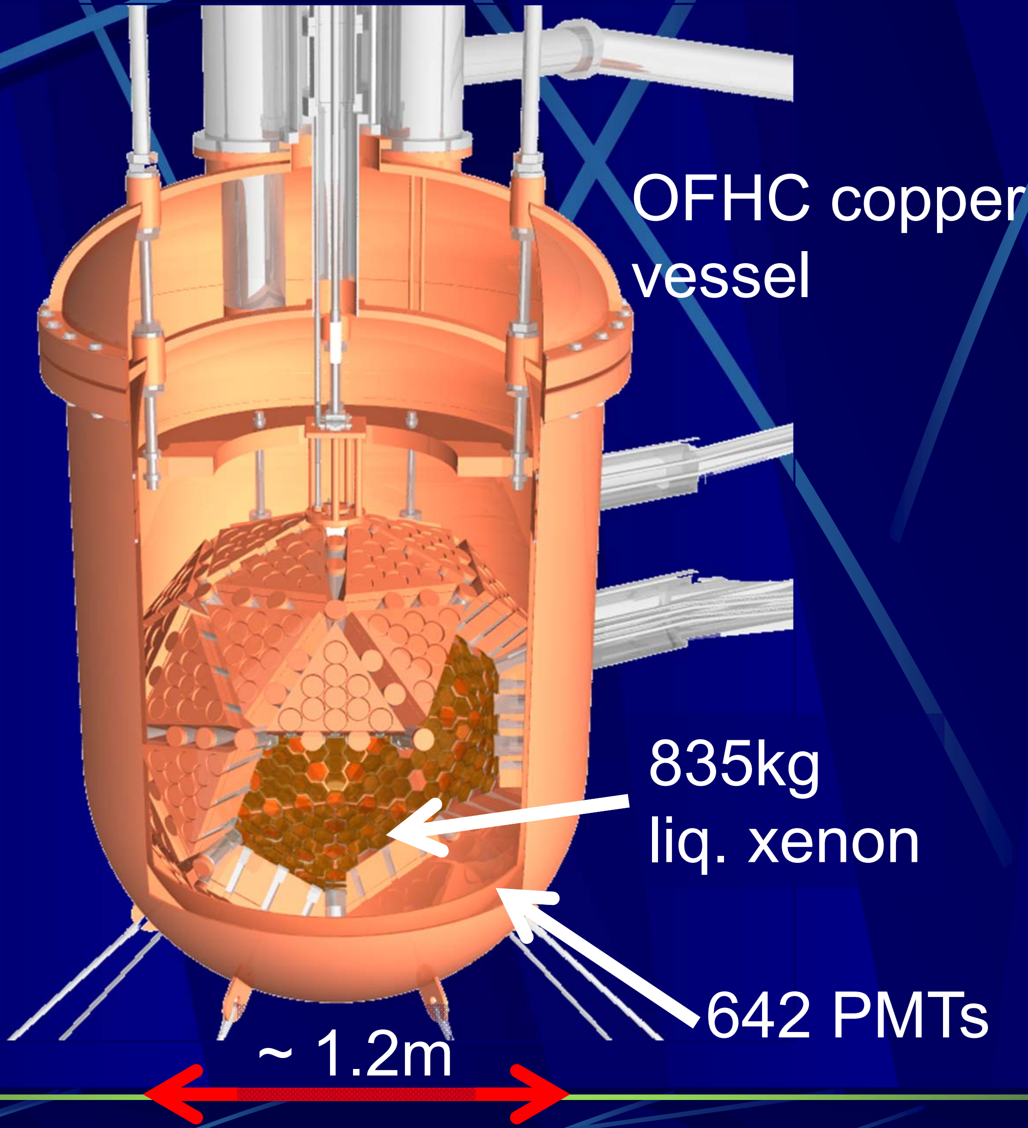
100kg FV (800kg LXe) ϕ 0.8m,
DM Current phase

10ton FV (24ton) ϕ 2.5m
Solar ν, $0\nu\beta\beta$, DM in future

800kg detector (OD+ID)



800kg detector (ID)

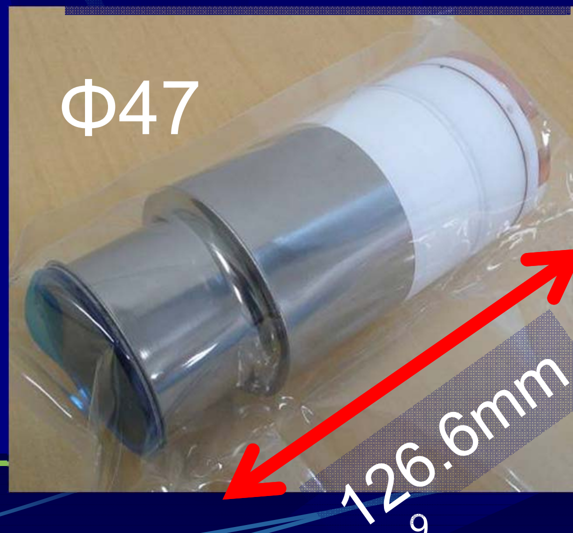


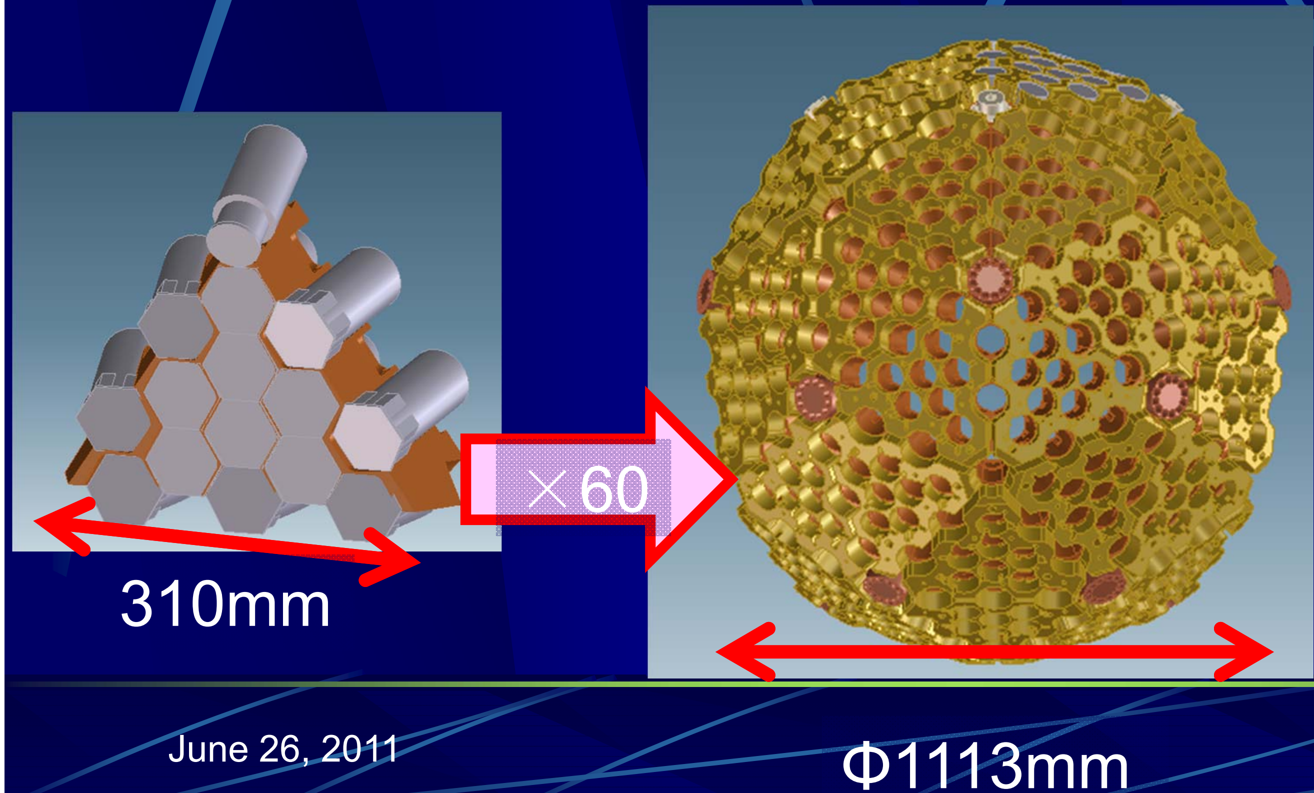
PMTs

- 642 PMTs :
  - 630 hex +12 round
- Q.E. : 28-39%
- Photo coverage: 62.4%

Hex: R10789-11

Round:
R10789-11MOD





DAQ hardware

Pre-amplifier card

PMT

12bit ADC/TDC (ATM)

To cover large energy range

- TKO module
- ADC dynamic range : 0~400 pC
- TDC dynamic range : 0~1 μsec

8bit Flash ADC (60PMTs)

For pulse shape discrimination in low energy

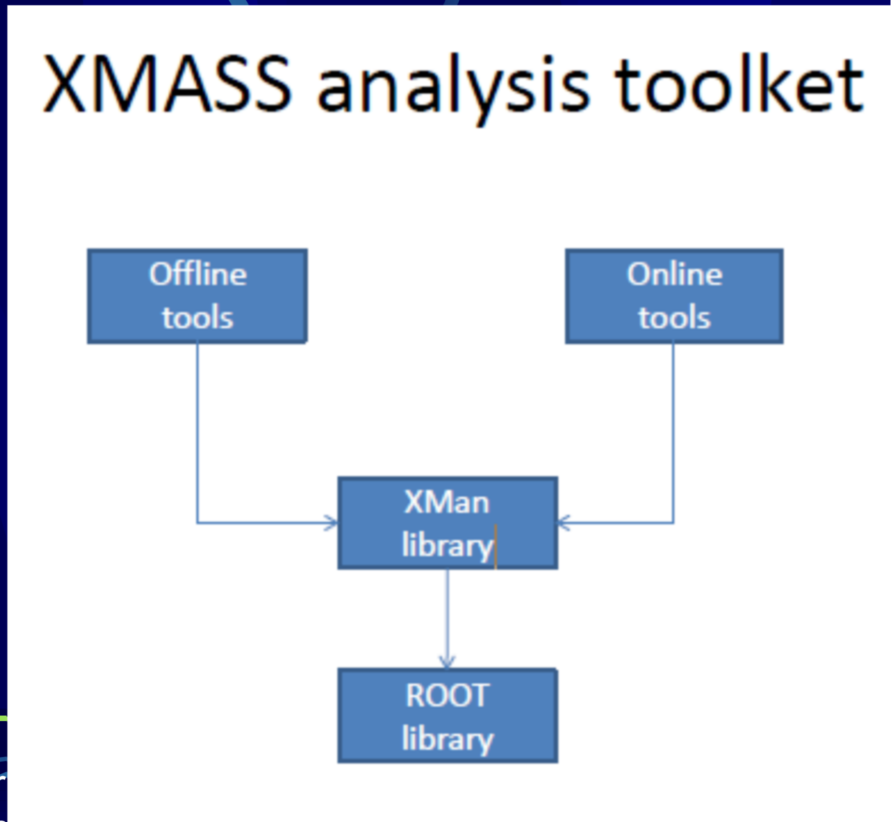
- dynamic range: 0~-1 V
- sampling rate : 500 MS/s
- sample number: 8,160
- time span : 16.32 μsec

New FADCs for 642PMTs in November

10bit 1GS/s, 1V dynamic range

Analysis tool

- "XMAN"
  - Tools for XMASS based on ROOT
- Online and Offline analysis
- MC data analysis

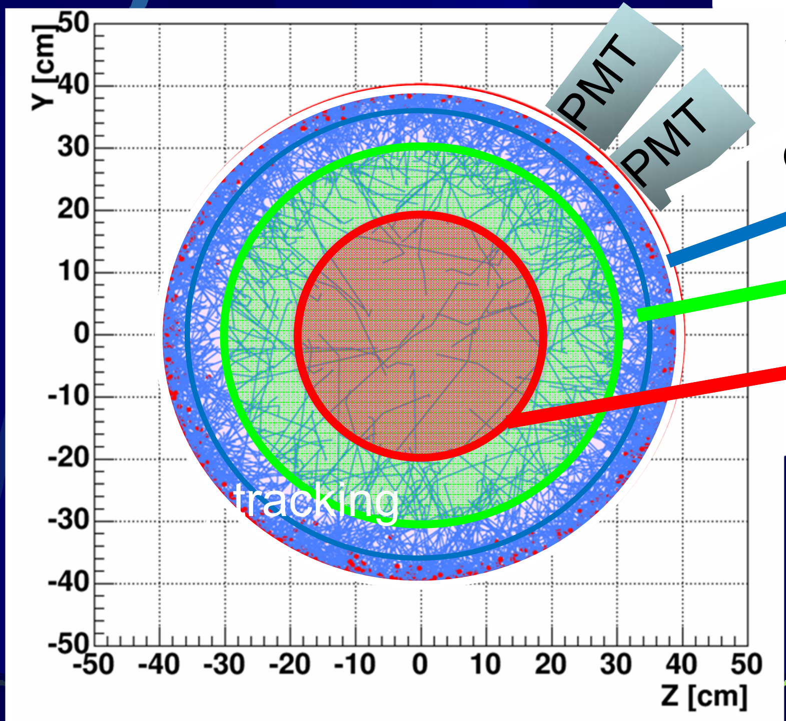


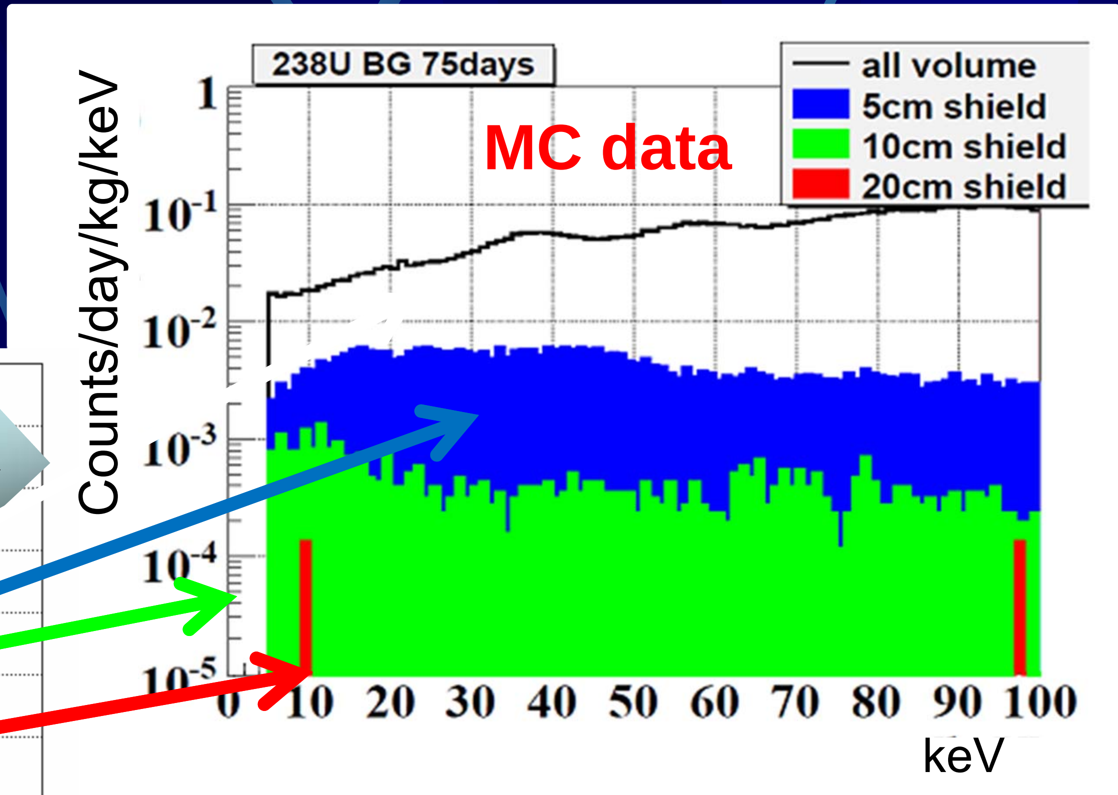
BG reduction (I)
- material selection -

- PMTs
  - ~1/10 of familiar PMTs
- OFHC cupper
  - They brought into the mine within one month after electro-refining.
- Other materials
  - All the components were selected with HPGe and ICP-MS.
    - >250 samples were measured.
  - →The total RI level is much lower than PMTs'.

BG reduction (II)
- self shielding -

	BG/PMT [mBq]
U chain	0.70 +/- 0.28
Th chain	1.51 +/- 0.31
^{40}K	< 5.10
^{60}Co	2.92 +/- 0.16



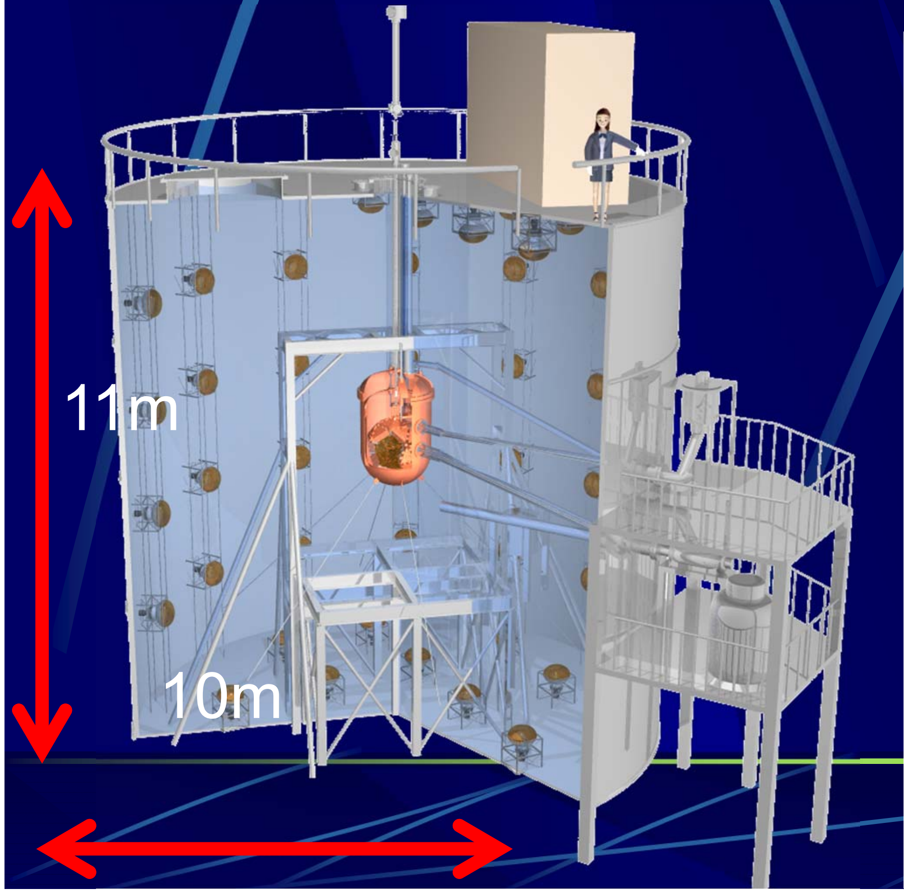


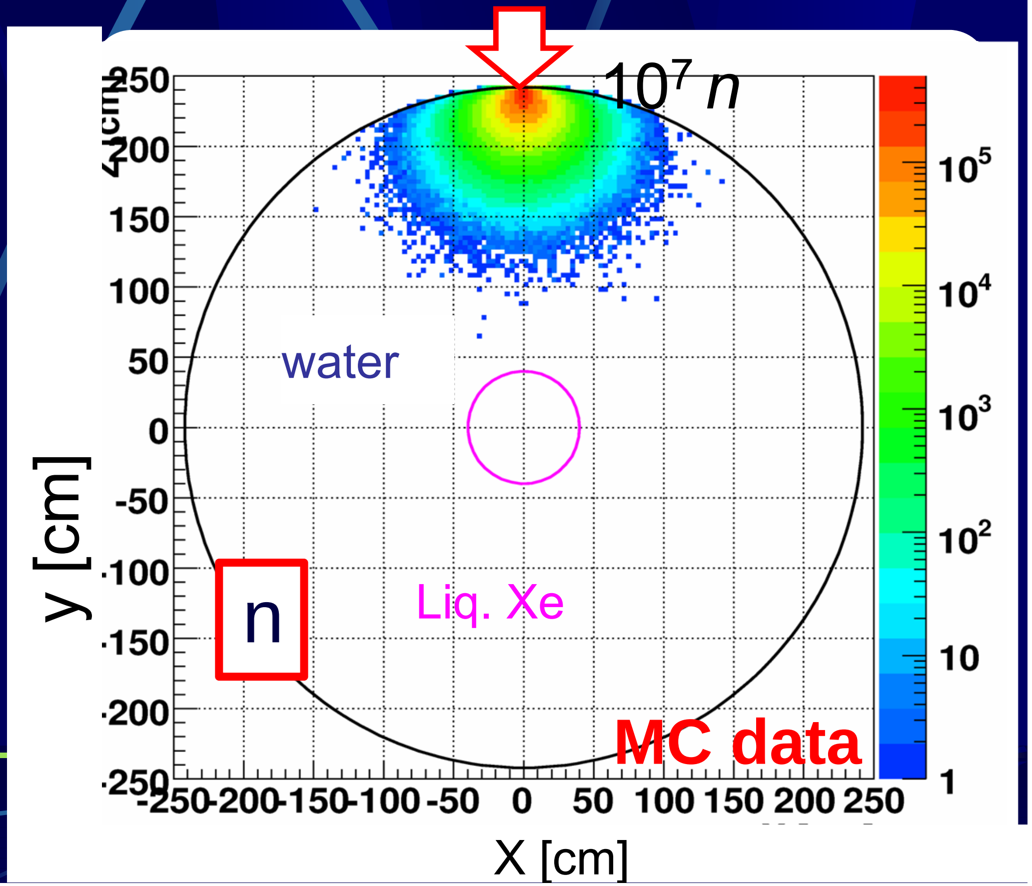
< 10^{-4} /keV/day/kg (100kg F.V.)

n contribution < 1.2×10^{-5}/d/kg/keV (5-10keV)

BG reduction (III)
- Large Water Cherenkov OD -

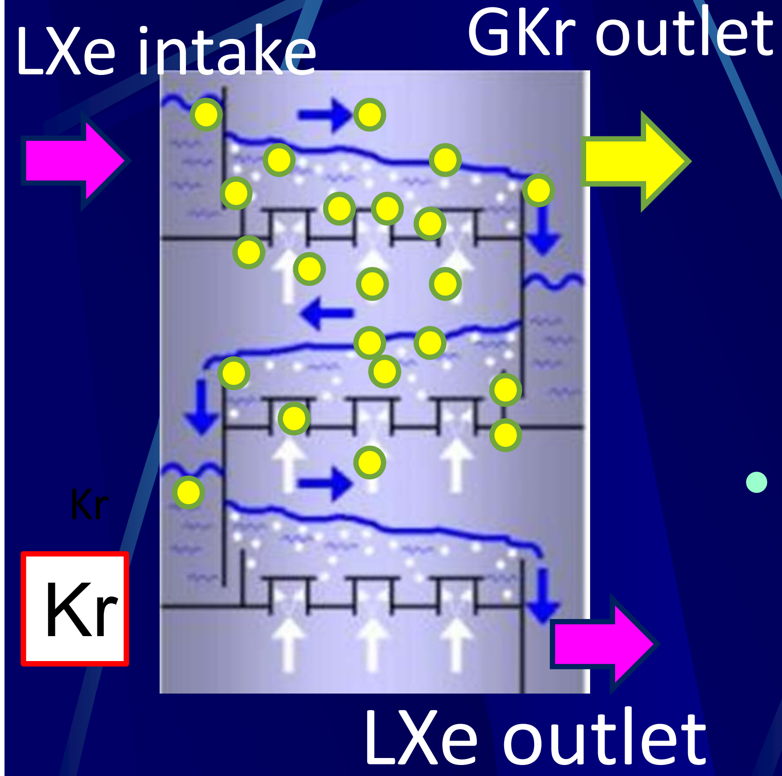
- OD with 72 20"-PMTs → active μ veto
- Large Vol. reduce γ and *n*





BG reduction(IV)

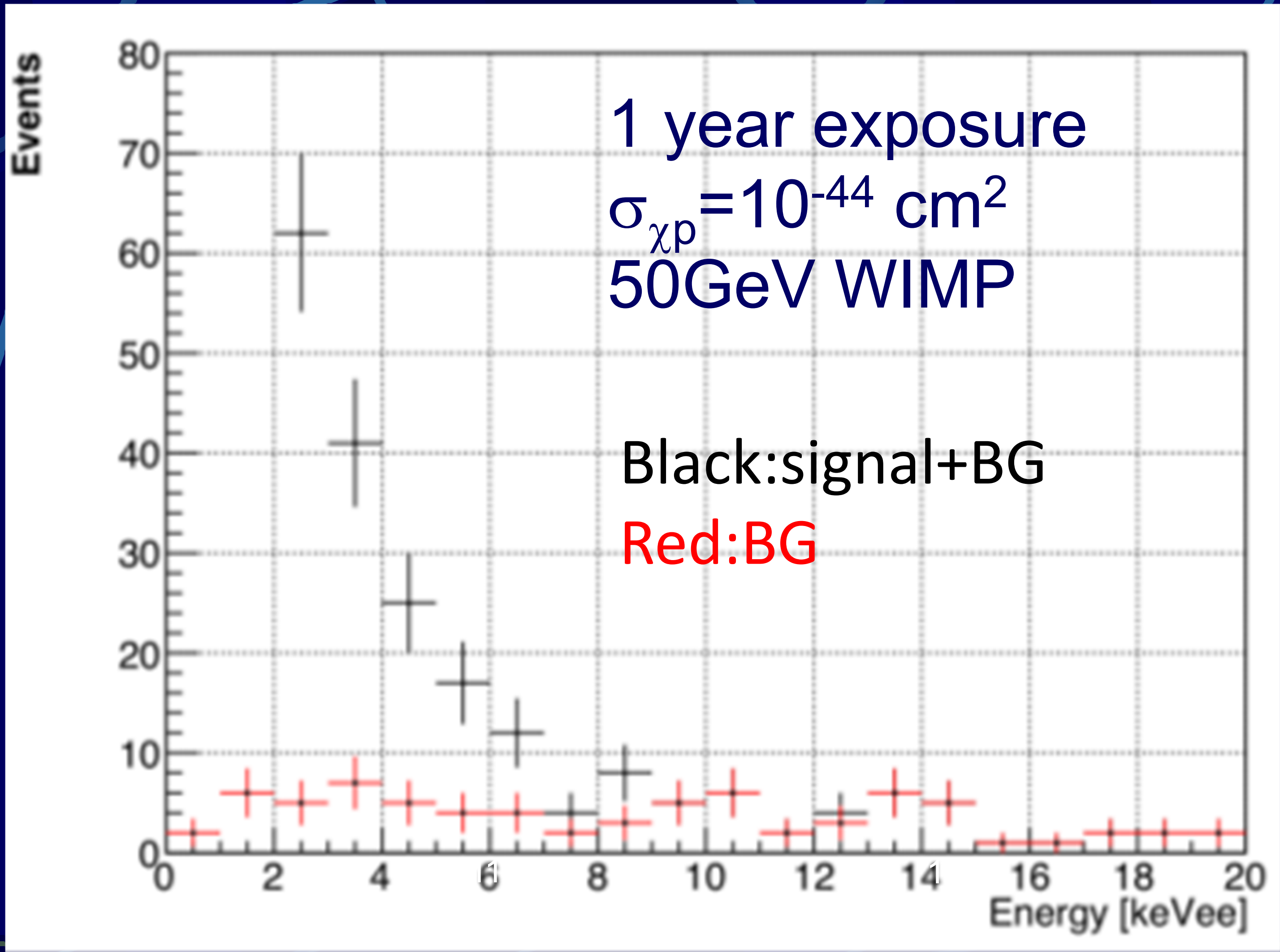
Xe purification



- Distillation:
  - 10^5 reduction for Kr (*)
    - 0.1ppm→1ppt for test sample
  - 1t of Xe was distilled at 10days before the filling.
- Other methods:
  - Getter
  - Filtering in liq. and gas phase is now under study for ^{222}Rn reduction.

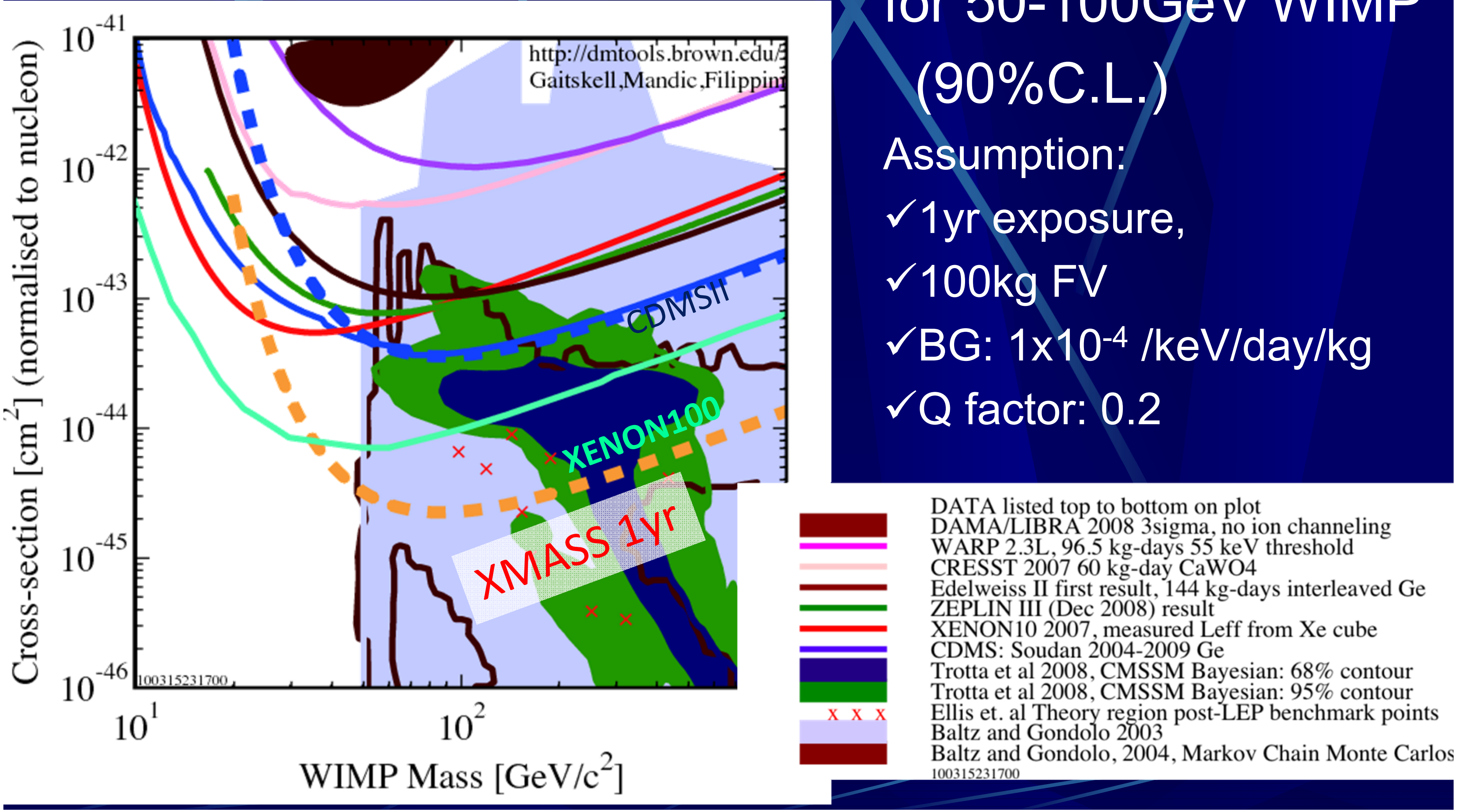
(*) K. Abe et al. for XMASS collab., Astropart. Phys. 31 (2009) 290

Expected spectrum



Expected sensitivity

Spin Independent

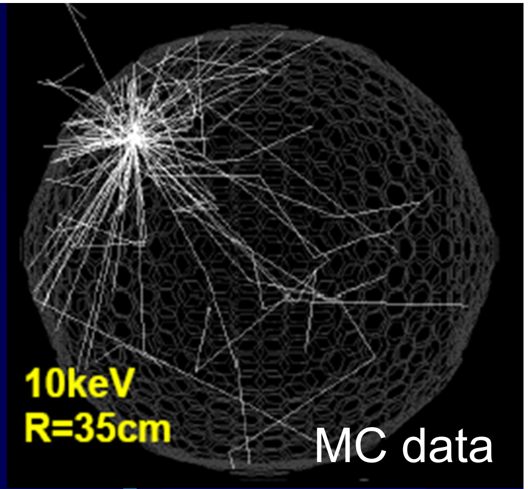


$\sigma_{cp} > 2x10^{-45}$ cm^2

for 50-100GeV WIMP (90%C.L.)

Assumption:

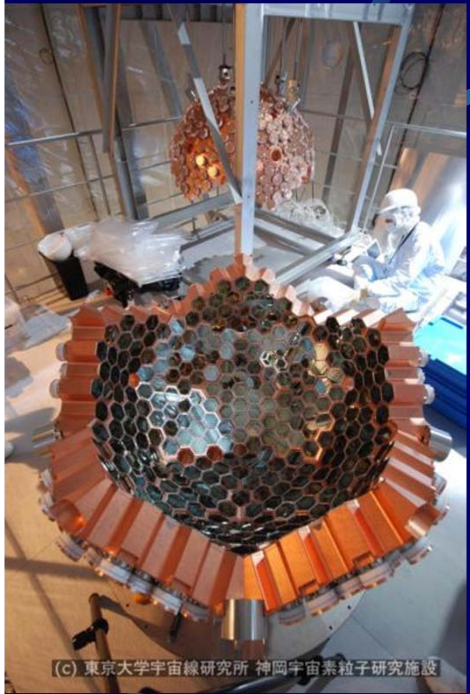
- ✓1yr exposure,
- ✓100kg FV
- ✓BG: $1x10^{-4}$ /keV/day/kg
- ✓Q factor: 0.2

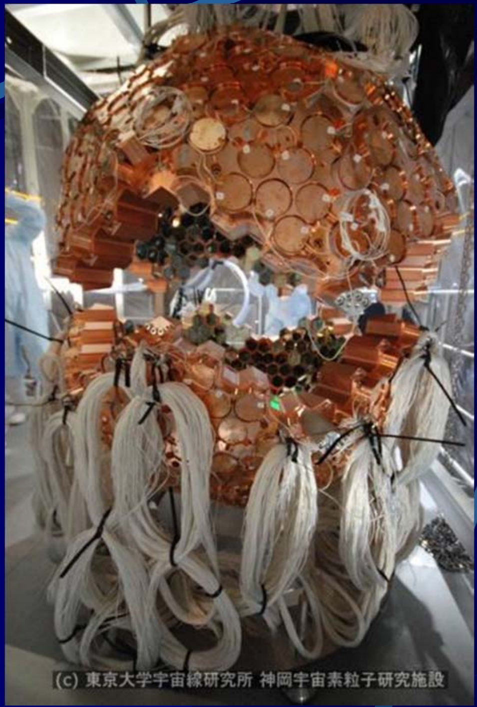


XMASS STATUS

- Performance check
- BG evaluation

Construction of XMASS



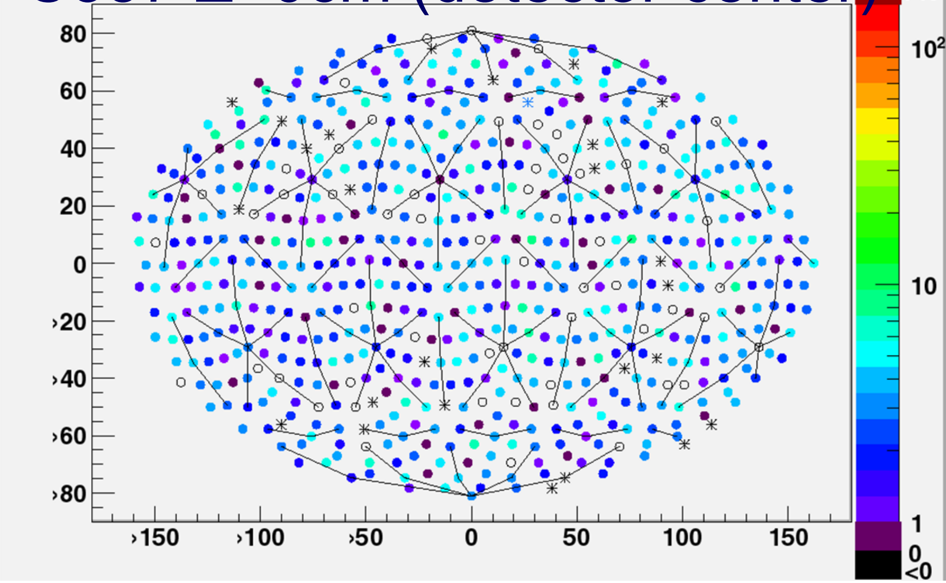


- 2010 Feb.: PMT installation was finished.
- 2010 Sep.: Detector assembly was finished.
- 2010 Sep.: Distillation and liq. xenon filling.

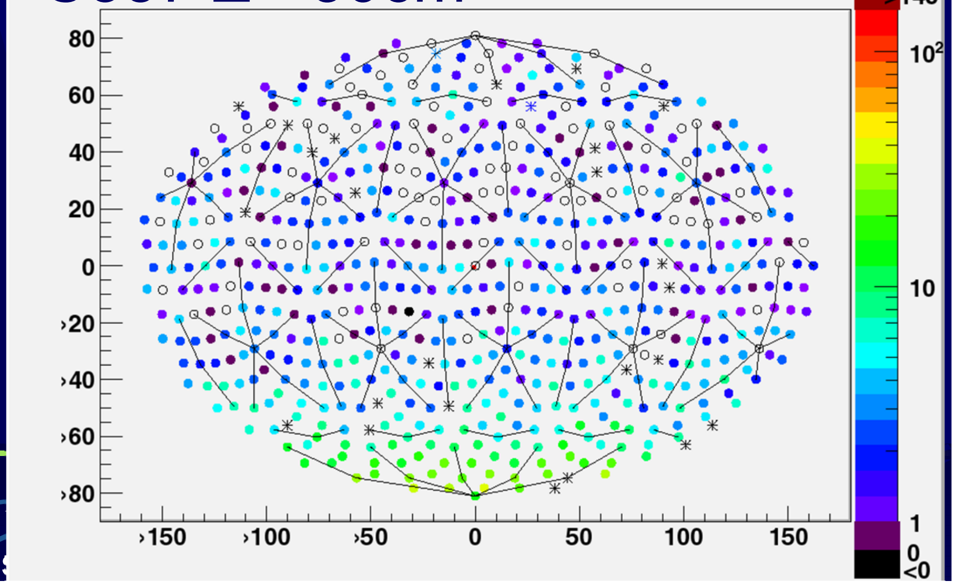
Current status of XMASS

- Everything was ready.
  - Detector itself
  - DAQ hardware and software
  - Calibration apparatus and so on
- 2010 Oct.→ Commissioning phase

Co57 Z=0cm (detector center)



Co57 Z=-30cm



Calibration system

- Features
  - <1mm precision
  - Reducing “shadowing” by thin wire source
- Sources
  - ^{57}Co, ^{241}Am, ^{109}Cd, ^{55}Fe, ^{137}Cs, …

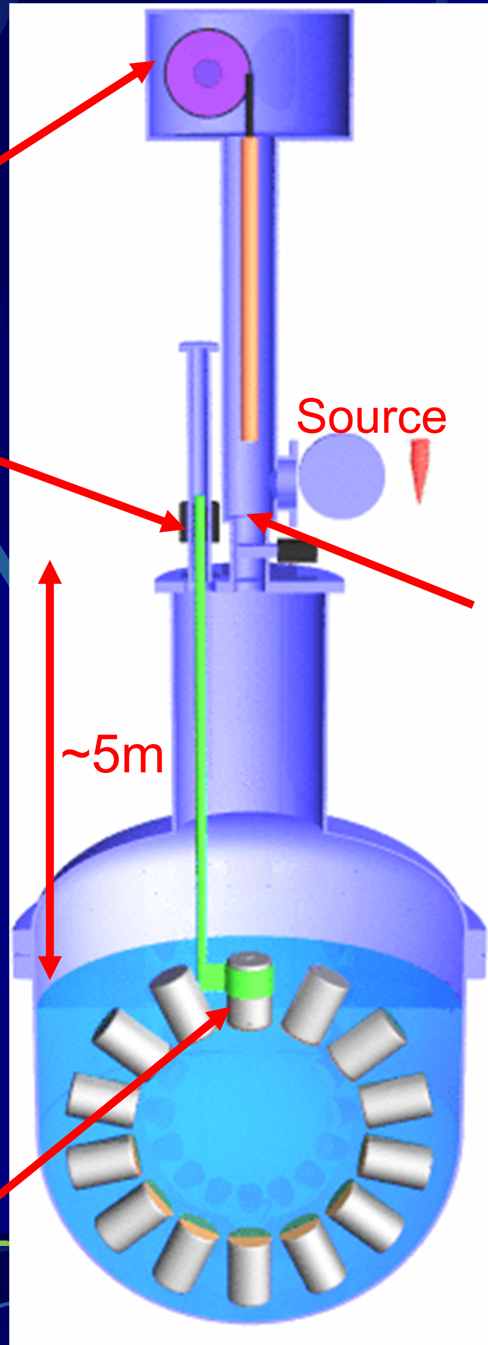
Source rod with a dummy source

Stepping Motor

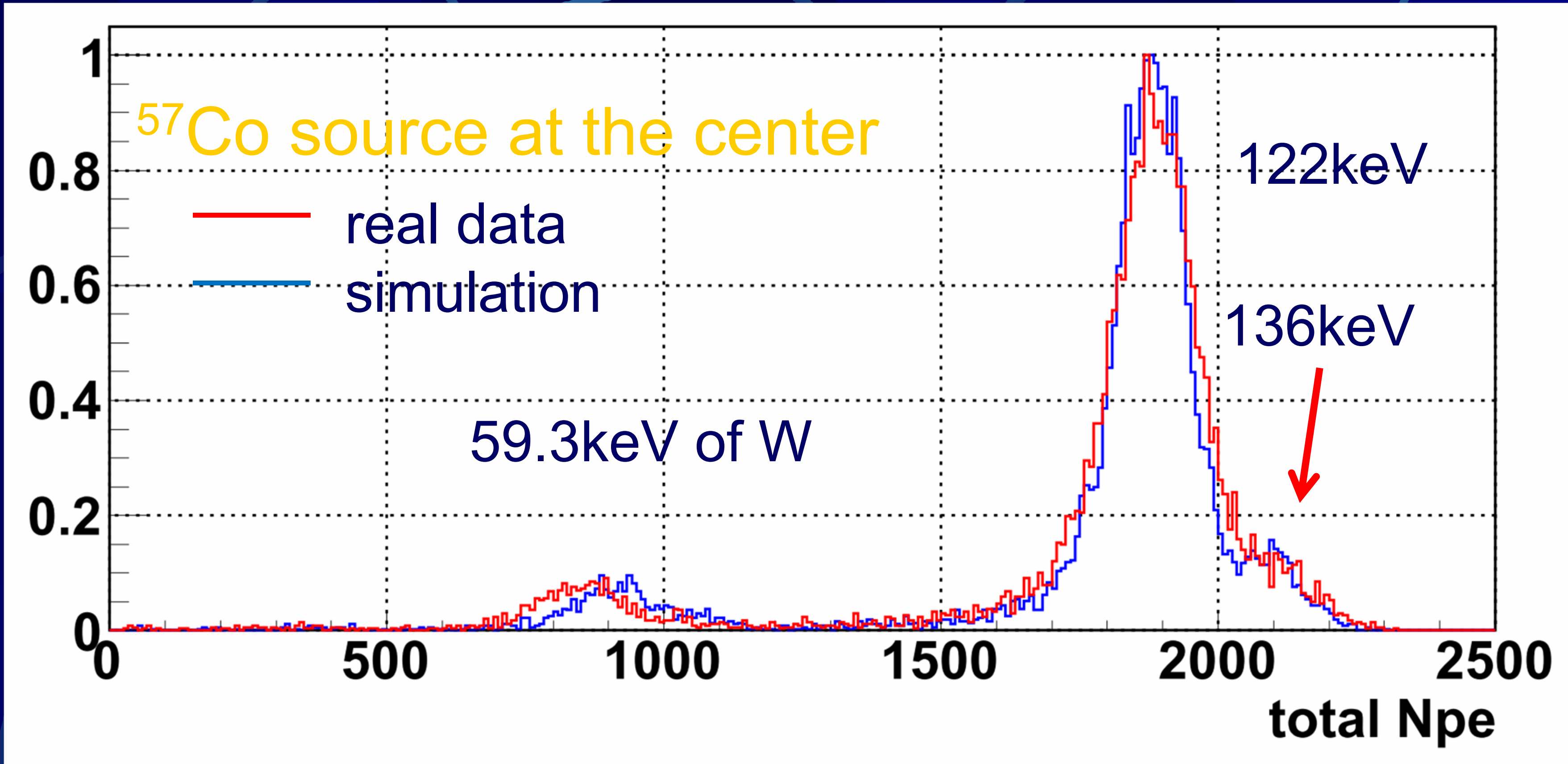
Linear Motion Feed-through

Gate valve

Top photo tube

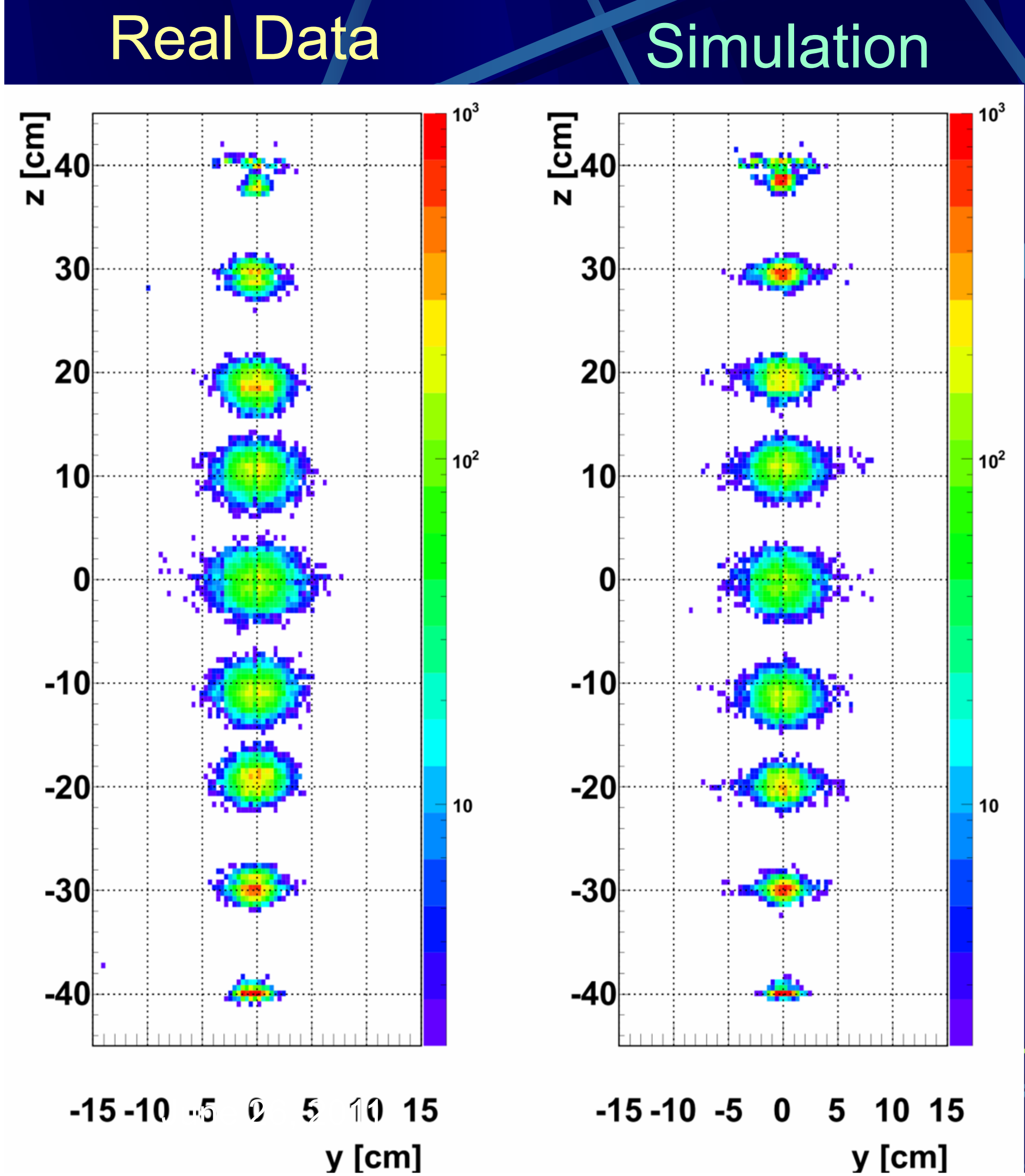


PE distribution



- High p.e. yield, 15.1+/-1.2p.e./keV, was obtained.
- The photo electron yield distribution was well reproduced by MC.

Vertex reconstruction



r is well reconstructed.

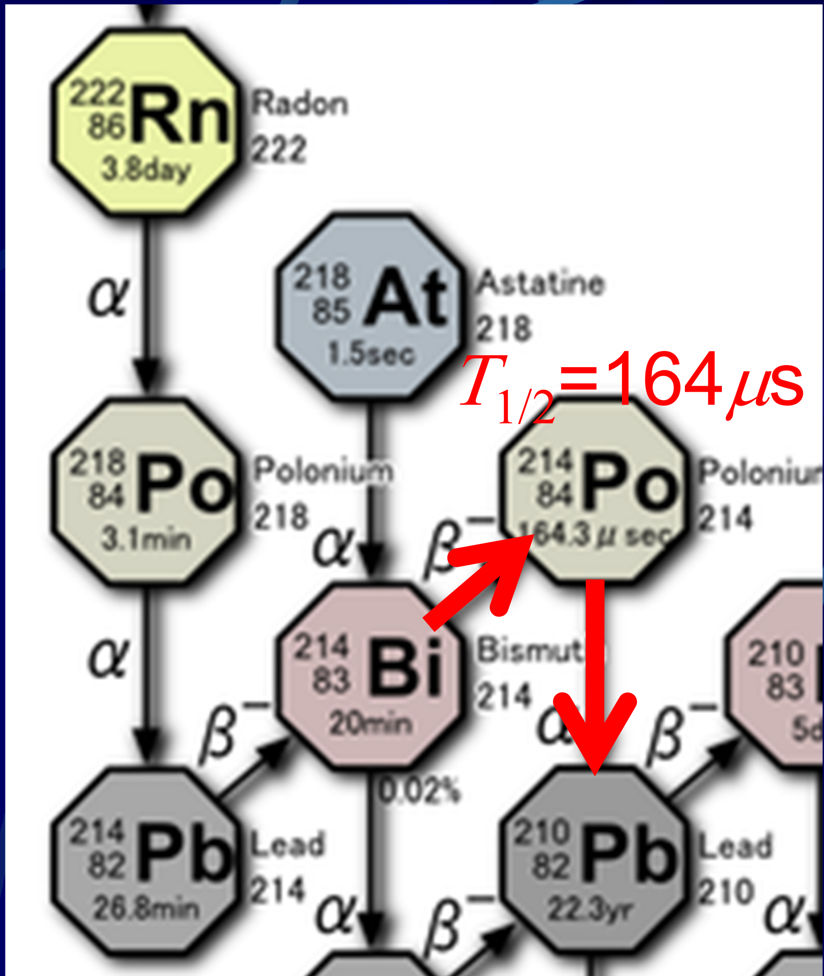
Δr is as expected by MC
1.4cm RMS @z=0cm
1.0cm RMS @+-20cm

For 122keV γ rays

Evaluation of internal BG

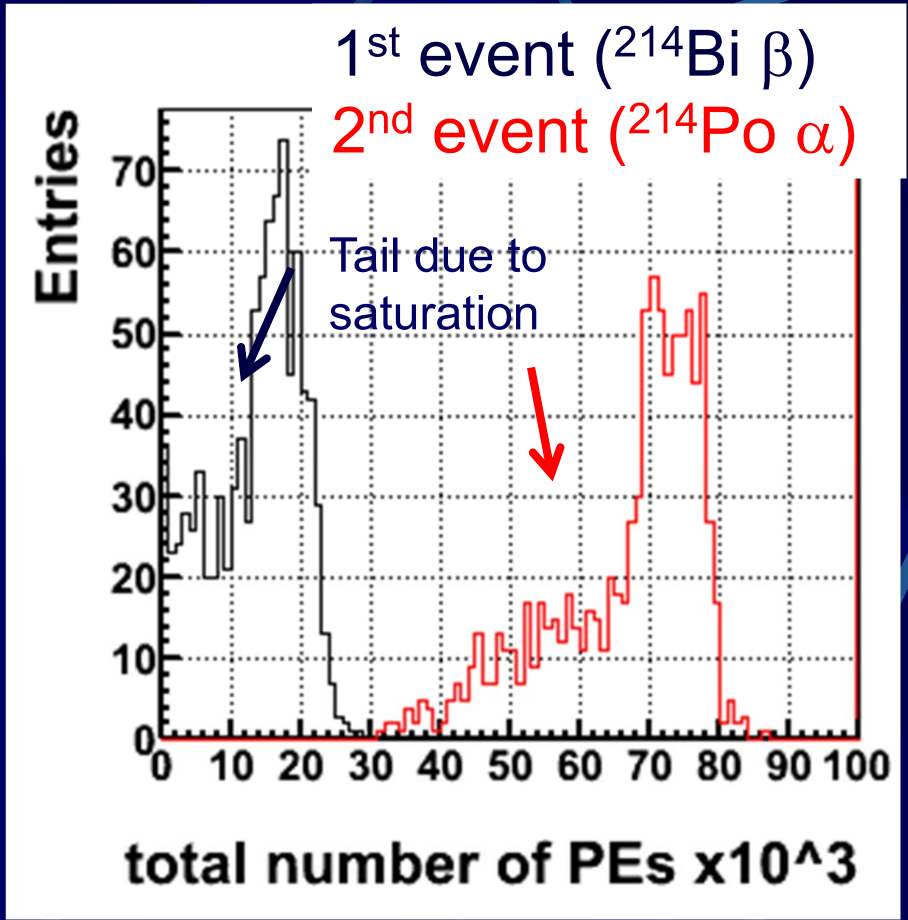
- External BG:
  - External BG (γ, n) can be effectively reduced by the water tank and the outer pert of LXe.
- Internal BG:
  - Internal BG must be reduced by other means.
  - ^{222}Rn, ^{220}Rn, and ^{85}Kr are our concern because they give low energy BG.

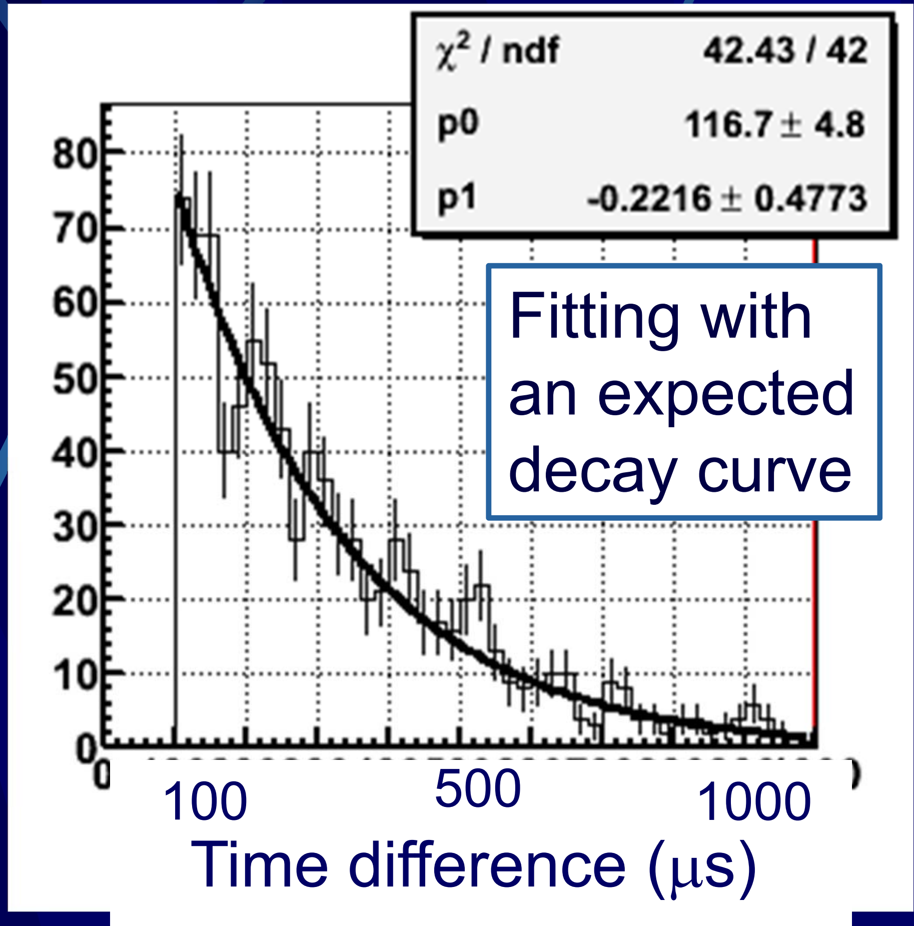
^{222}Rn measurement



- Delayed coincidence
  - $T_{1/2}$=164μs
- The 2nd α is very bright, so gain of 321 PMTs are reduced for wide dynamic range.

^{222}Rn Result





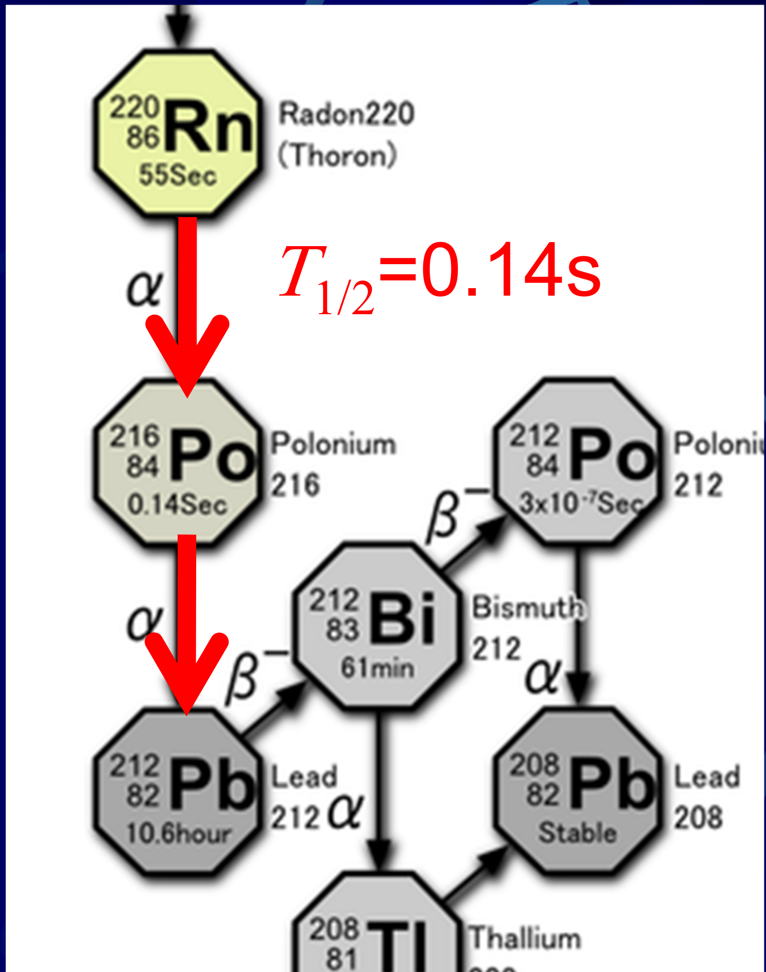
^{222}Rn=8.2(0.5)mBq in inner volume

Target value=1mBq.

→ Investigating event distribution

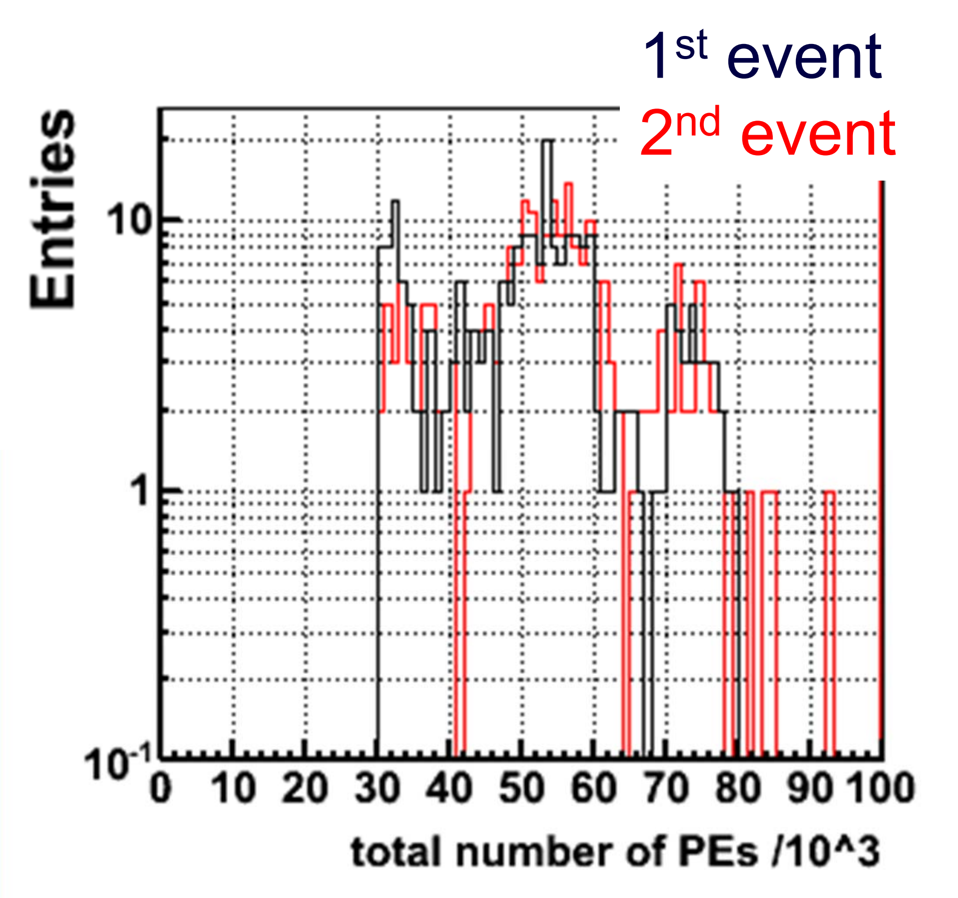
Considering measures to remove (Charcoal Trap)

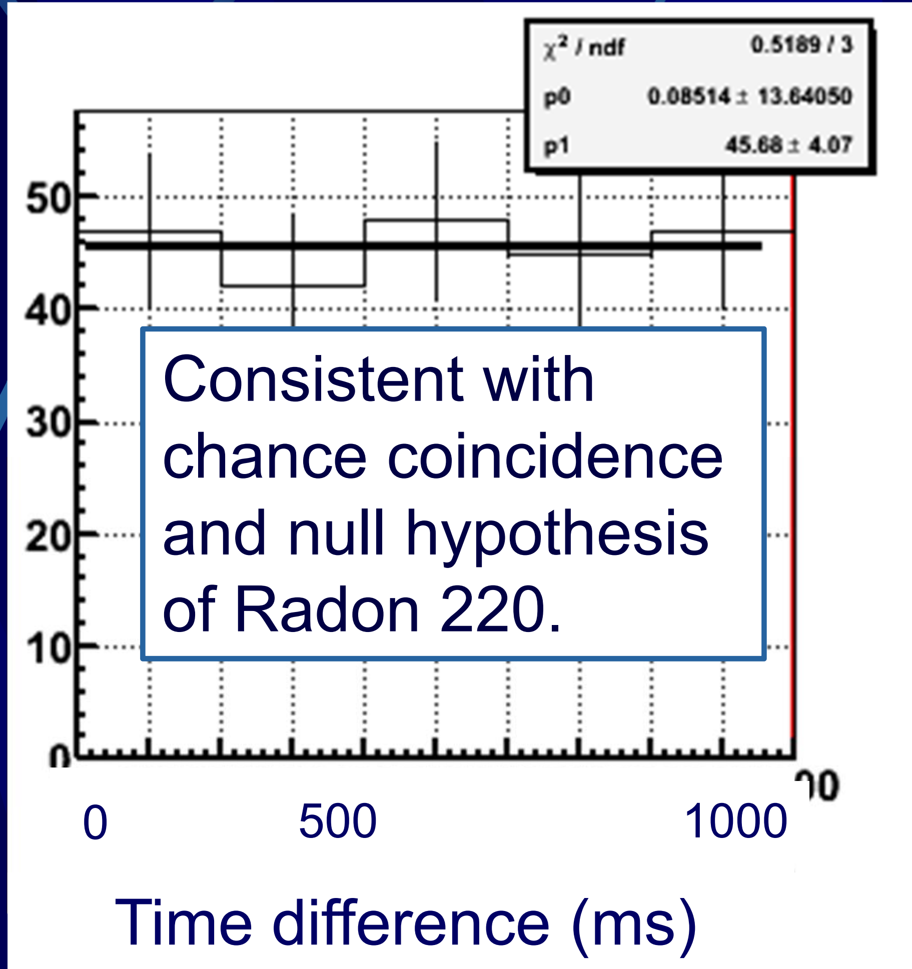
^{220}Rn measurement



- Delayed coincidence
  - $T_{1/2}$=0.14s

^{220}Rn Result



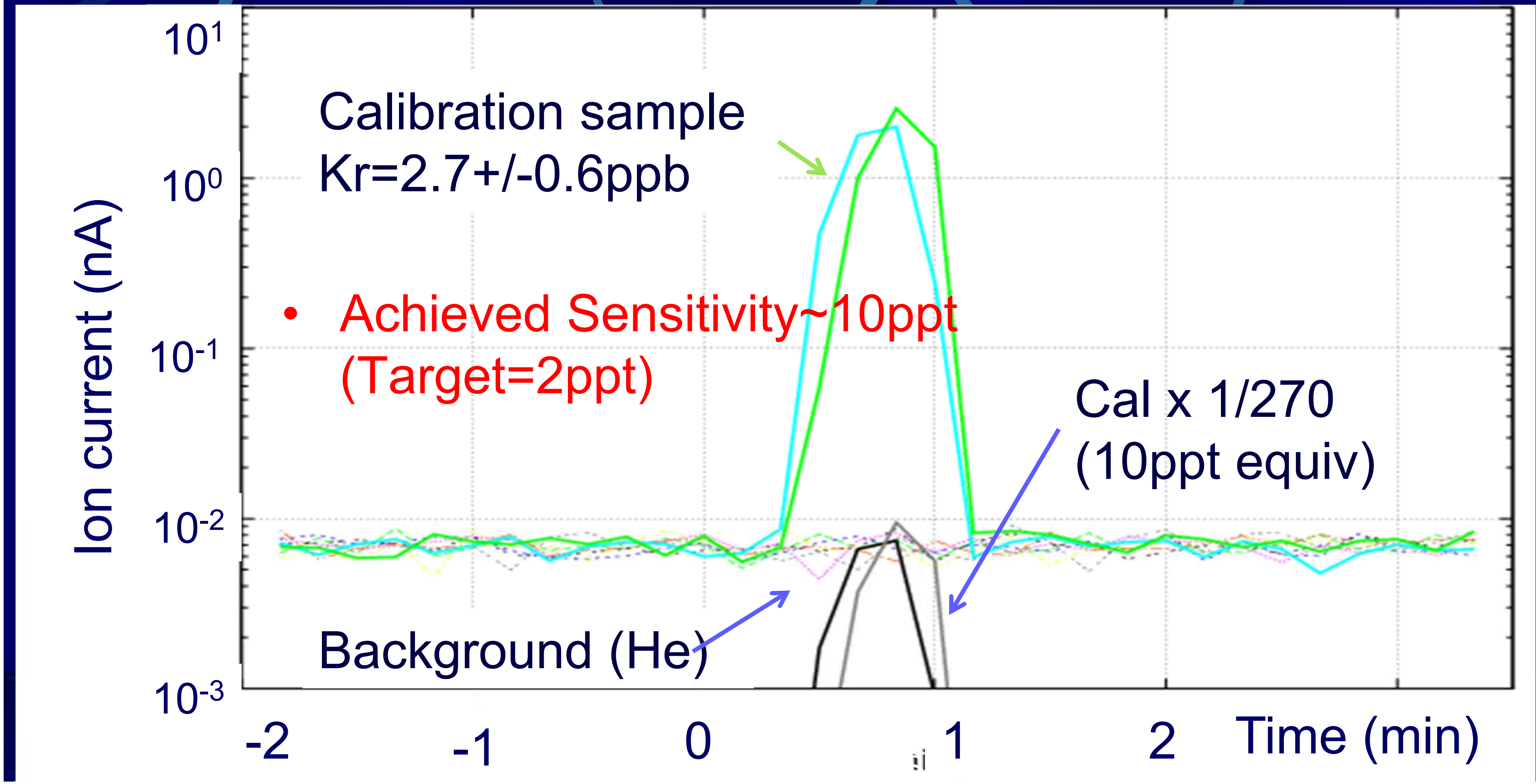


- ^{220}Rn<0.28mBq in inner volume

Lower than our target value=0.43mBq.

Kr measurement

- Gas Chromatography
  + Atmospheric Pressure Ionization Mass Spectrometer
- ^{85}Kr can be estimated with measured $^{85}Kr/Kr$

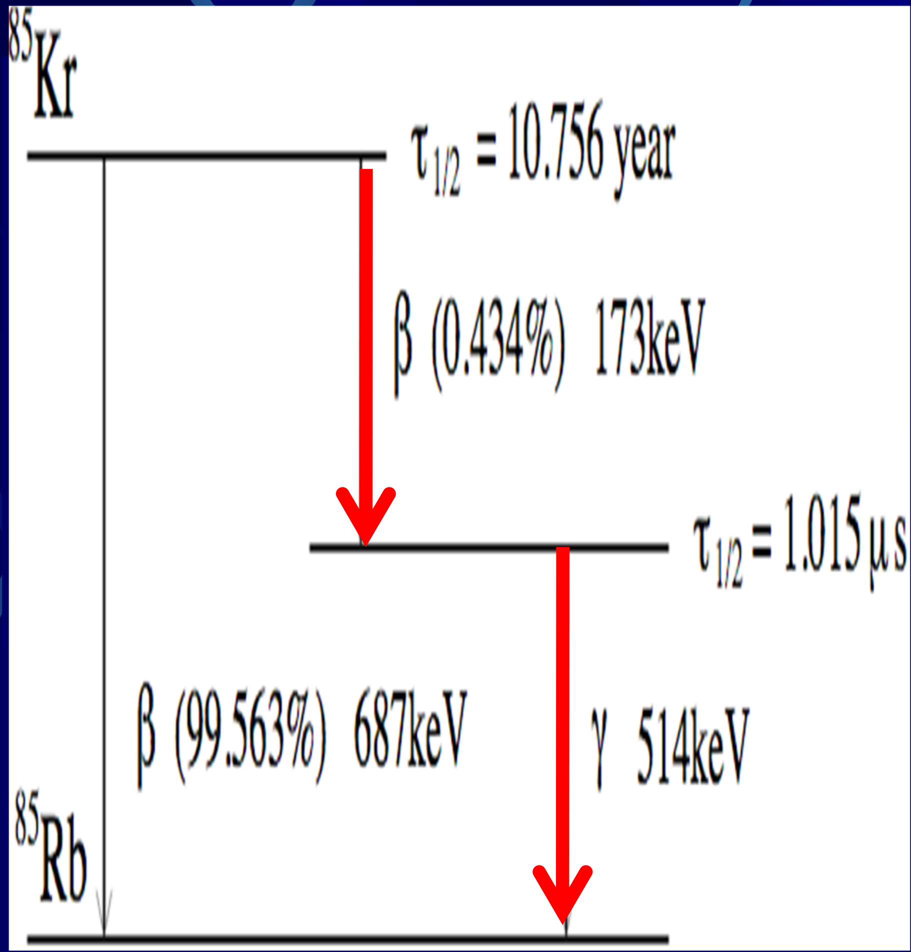


Kr measurement (II)

- Delayed coincident
- $T_{1/2}$=1.0μs → ^{85}Kr measurement with FADC

➢ New 650 FADCs in November

  ➢ They will boost our detailed studies.



Summary

- The XMASS 800kg detector is for DM search with the sensitivity $2\times10^{-45}cm^2$ (spin independent case).
- Construction of the 800kg detector finished.
- Commissioning runs are on going

  to confirm performance and BG properties.
  - Energy resolution and vertex resolution were as expected.
    - ~1cm position resolution and ~4% energy resolution for 122keV γ.
  - Radon background are close to the target values
  - Kr contamination will be evaluated soon.
- Results are coming after commissioning.

BACKUP SLIDES

Vertex reconstruction

- $L(\boldsymbol{r})=\Pi_{i=\mathrm{PMT}}\ exp(-\mu(i))\ \mu(i)^{n(i)}/n(i)!$
  - $\mu(i)=F(\boldsymbol{r}, i)/\Sigma_{i=\mathrm{PMT}}F(\boldsymbol{r}, i)$ X total NPE
  - $n(i)$= observed NPE in i-th PMT
  - $F(\boldsymbol{r}, i)$: Acceptance of i-th PMT
    - This is calculated by MC simulation.
- Find $\boldsymbol{r}$ which gives min. $\log L(\boldsymbol{r})$

Energy reconstruction

- Calculated from
  - observed NPE
  - and total acceptance $\Sigma_{i=\mathrm{PMT}} F(\boldsymbol{r}, i)$

Why LXe?

- High Atomic mass Xe (A~131) good for SI case ($\sigma \propto A^2$).
- Odd isotope (^{129}Xe (26.4%), ^{131}Xe (21.3%)) with large SD enhancement factors.
- High atomic number (Z=54) and density (ρ=~3g/cc)
  - -> Effective self-shielding.
  - -> Compact for large mass detector.
- High photon yield
- Easy to purify for both electro-negative and radioactive
- impurities.
- -> By circulation of Xe with getter for electro-negative.
- -> Distillation for ^{85}Kr removal.

Reconstructed energy

^{57}Co source at the center