XMASS Current Status I

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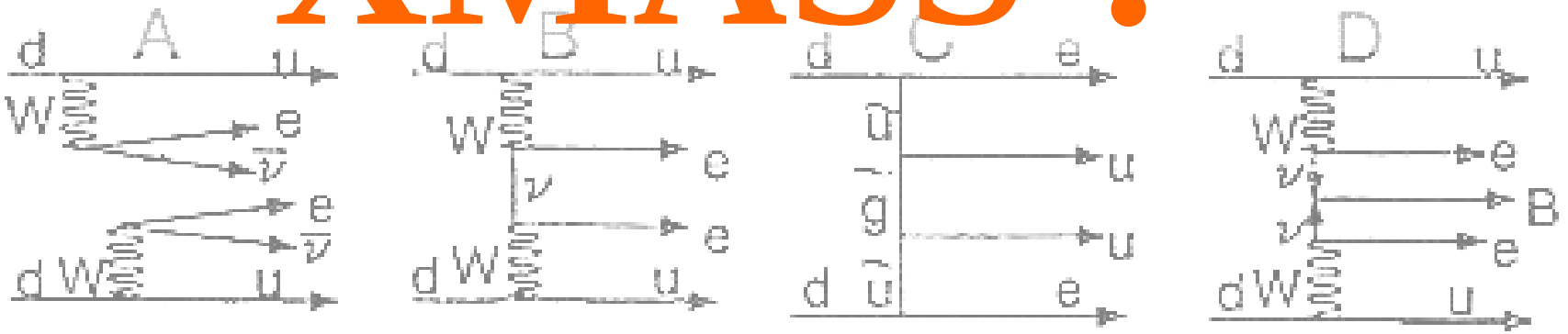
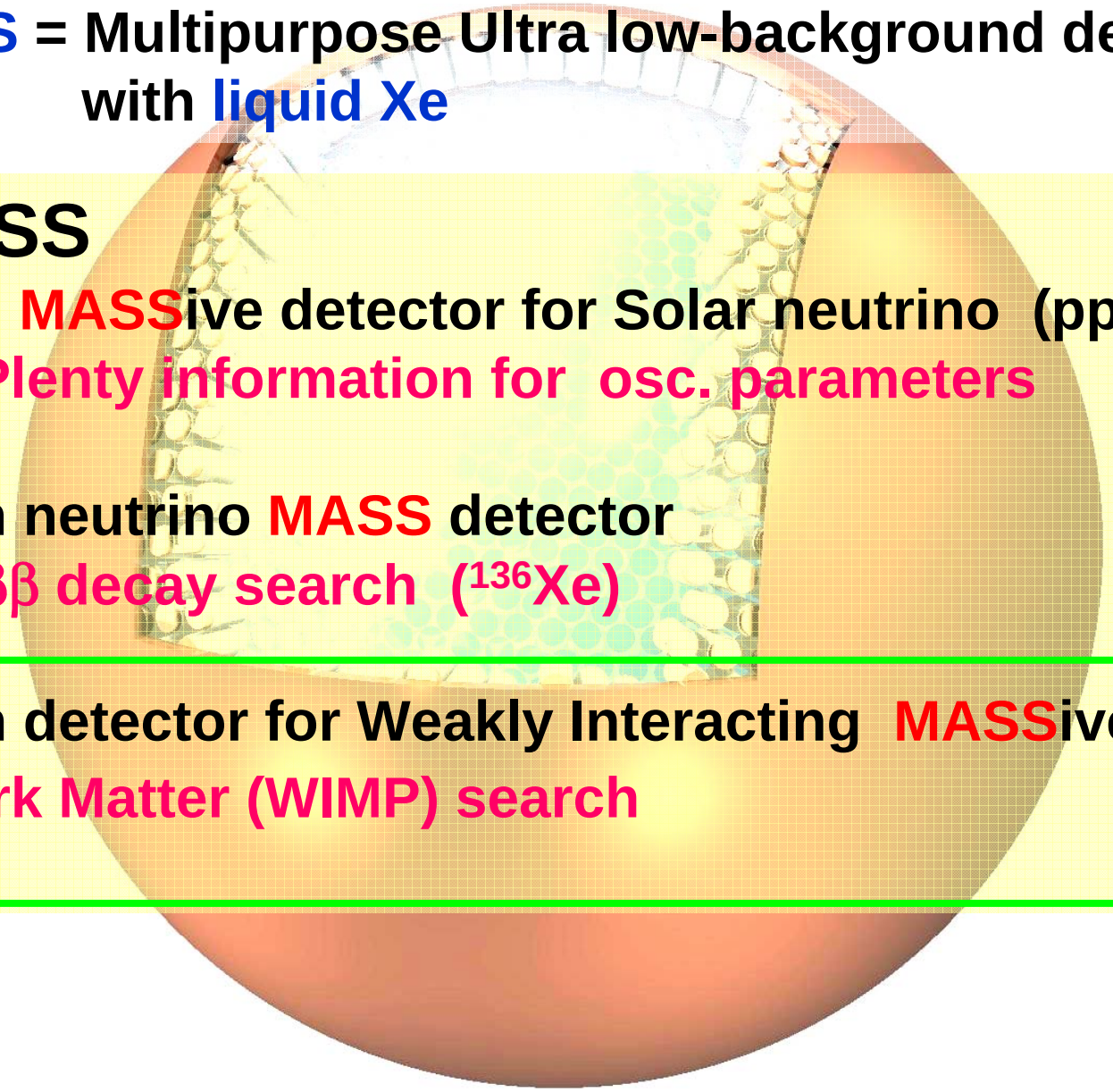
What is XMASS ?



XMASS Experiment

XMASS = Multipurpose Ultra low-background detector with liquid Xe



●XMASS

◎ **X**enon **MASS**ive detector for Solar neutrino (pp/^{7}Be)

→Plenty information for osc. parameters

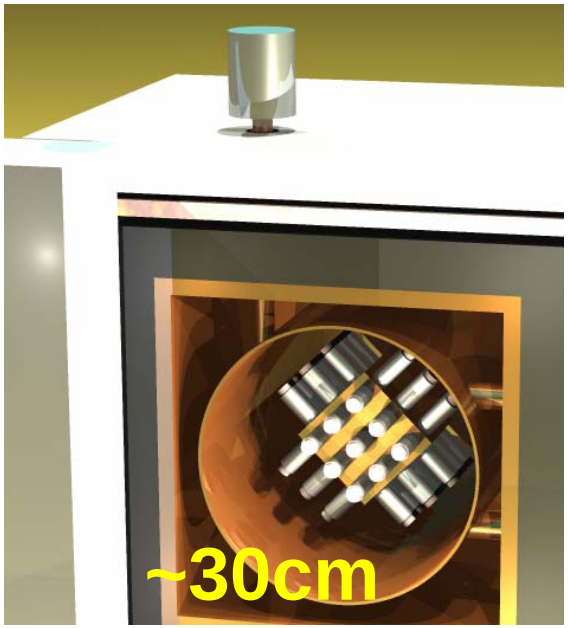
◎ **X**enon neutrino **MASS** detector

$0\nu\beta\beta$ decay search (^{136}Xe)

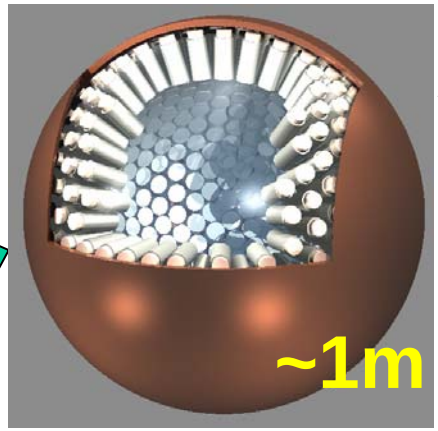
◎ **X**enon detector for Weakly Interacting **MASS**ive Particles

Dark Matter (WIMP) search

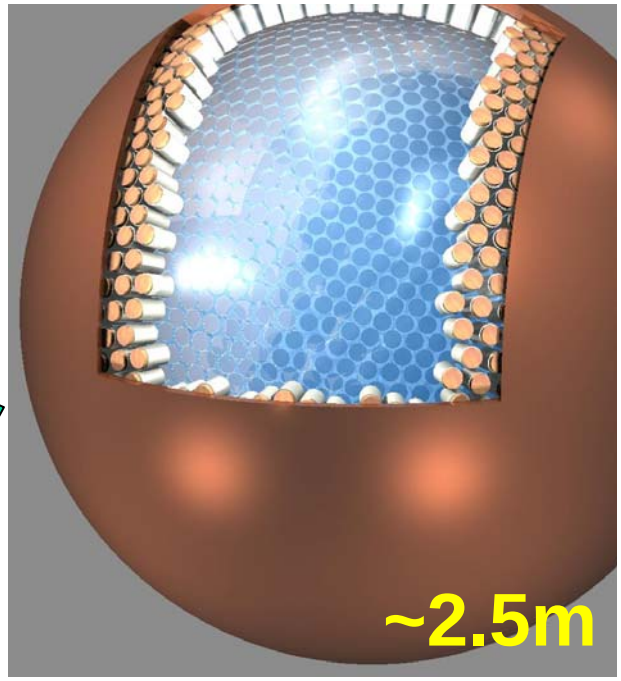
XMASS strategy



prototype detector
(FV 3kg) R&D



800kg detector
(FV 100kg)
DM search



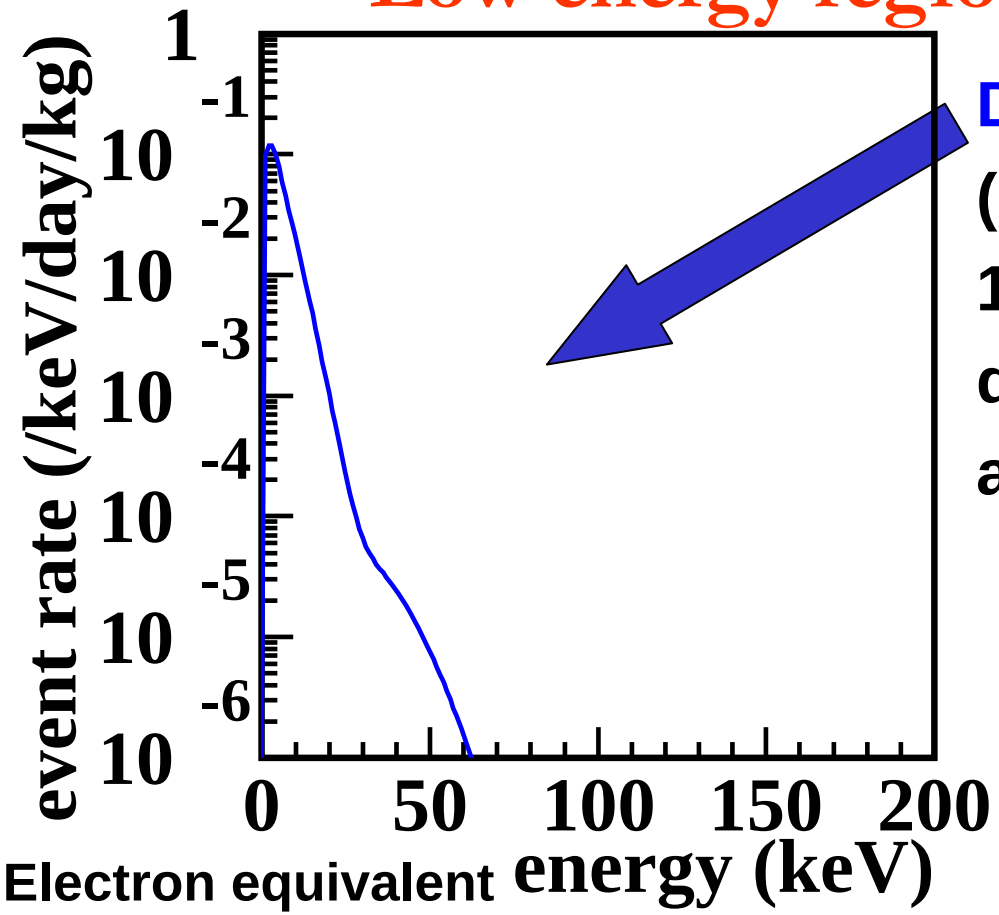
~20 ton detector
(FV 10ton)
Multi purpose

Now here.

We got good results for the next step!

DM signal
（Lq.Xe scintillator）

Low energy region ~ O(10 keV)



Dark matter signal

(SI, m_{DM}=100GeV , 10^{-6}pb for proton, quench factor = 0.2 assumed)

Request for detector：

- **Low threshold**
- **Low BG**

Advantages of liquid Xe scintillator

☆ **Large Atomic number (Z=54)**

→ **Self shielding for γ ray background**

☆ **Large photon yield (~42000photons/MeV ～ NaI(Tl))**

→ **Energy threshold can be lowered**

☆ **High density (3 g/cm^3)**

→ **Large mass detector with compact volume**

☆ **Higher boiling point (165 K)**

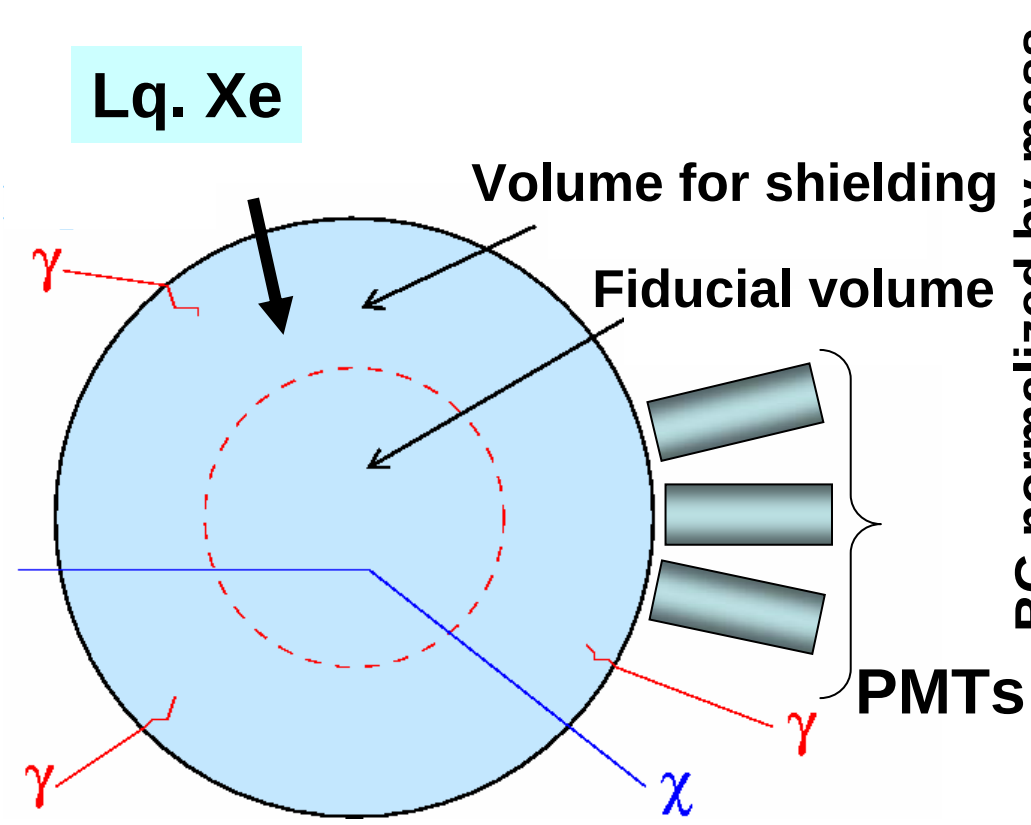
→ **Easy to liquefy**

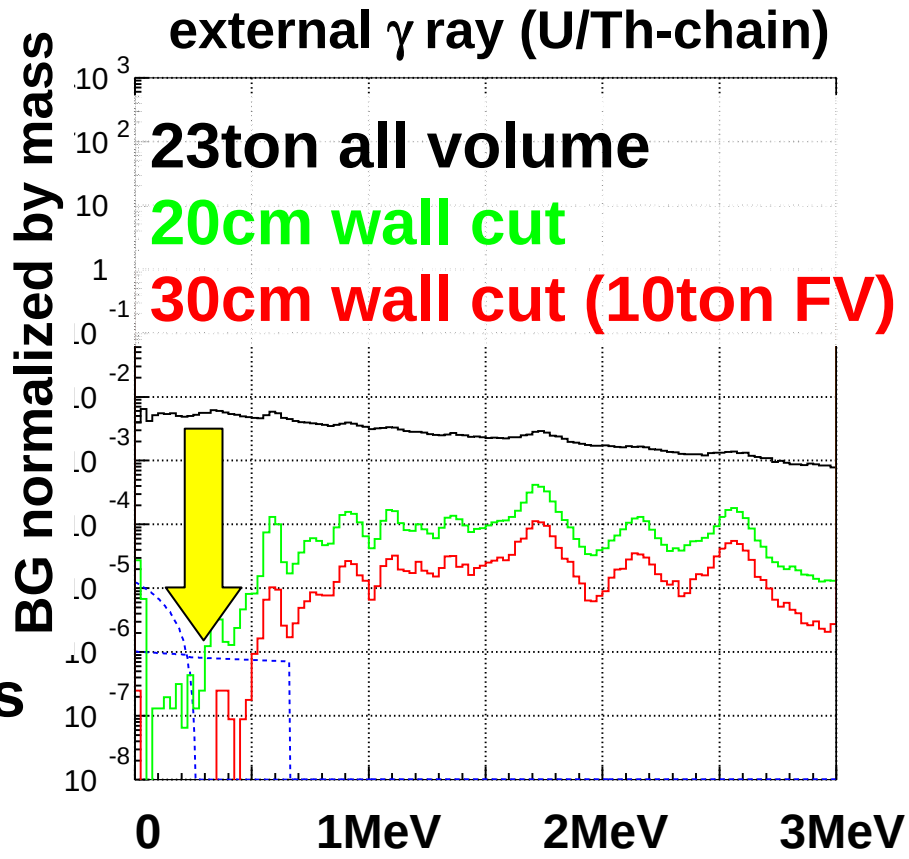
☆ **Liquid**

→ **Uniform detector possible (like SuperKamiokande)**

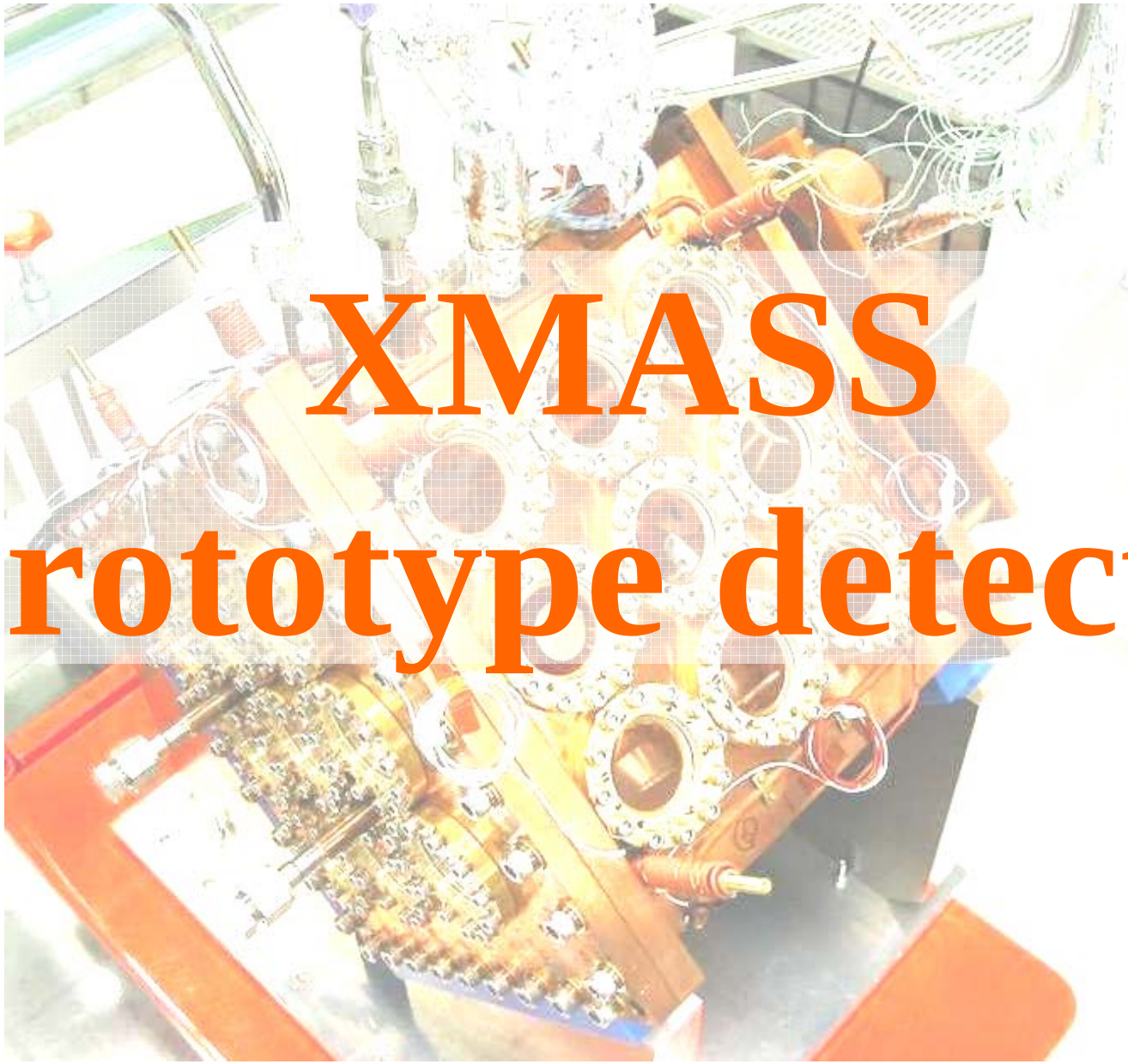
→ **Possible to purify during operation**

Key idea:Self shielding





Extra low BG @ detector center, low energy region



XMASS
Prototype detector

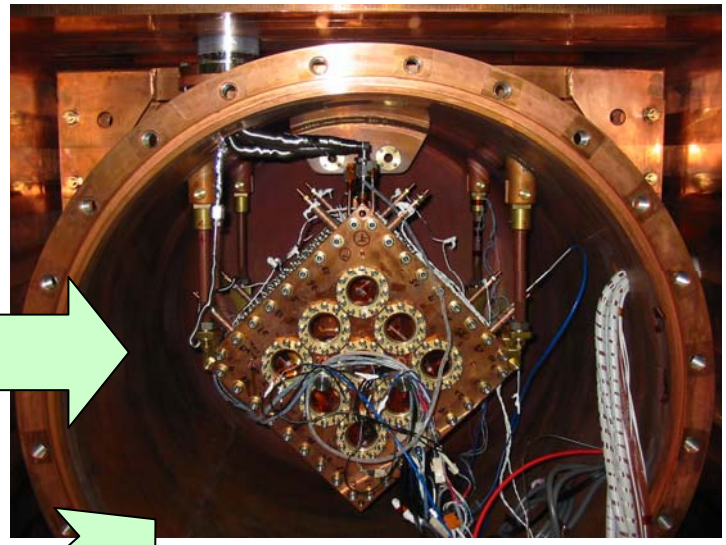
Targets of prototype detector

Confirmation of the 800kg detector performance estimation

- **Reconstruct vertex and energy of events**
- **Demonstrate the self shielding power for γ ray BG**
- **Understand the environmental BG inside the shield**
- **Measure a content of radioactive impurities in Xe**

3kg FV prototype detector

OFHC cubic chamber

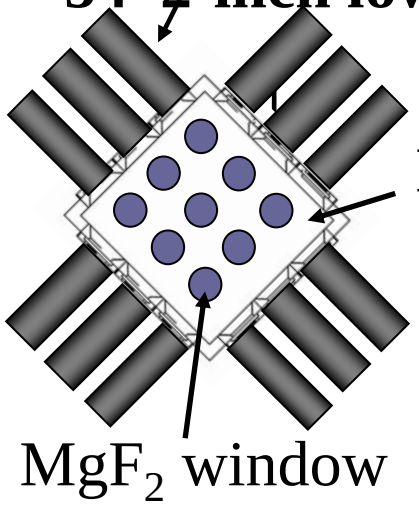


In the Kamioka Mine 2700 m.w.e. (near SK)

external BG shield

54 2-inch low BG PMTs

Hamamatsu R8778

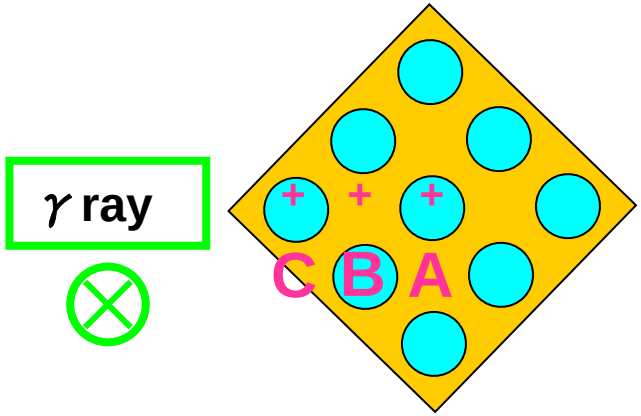


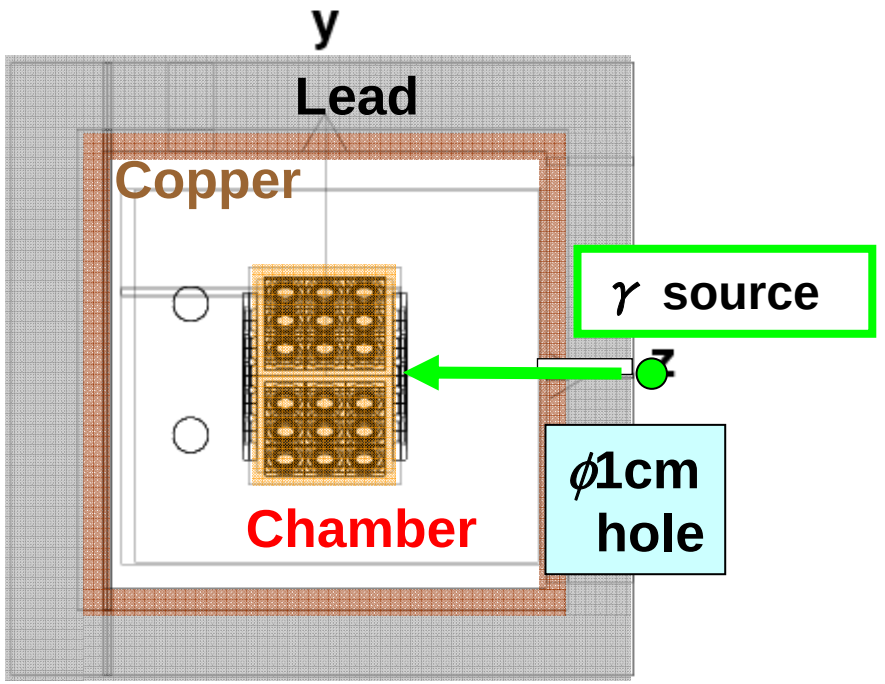
16% photo-coverage

Prototype detector data

Prototype 2nd run has done in Aug '04 (~9 days)

- γ source calibration
  - Reconstruction method
  - Self shielding power
- BG measurement
  - Environmental BG
  - Internal radioactive impurities

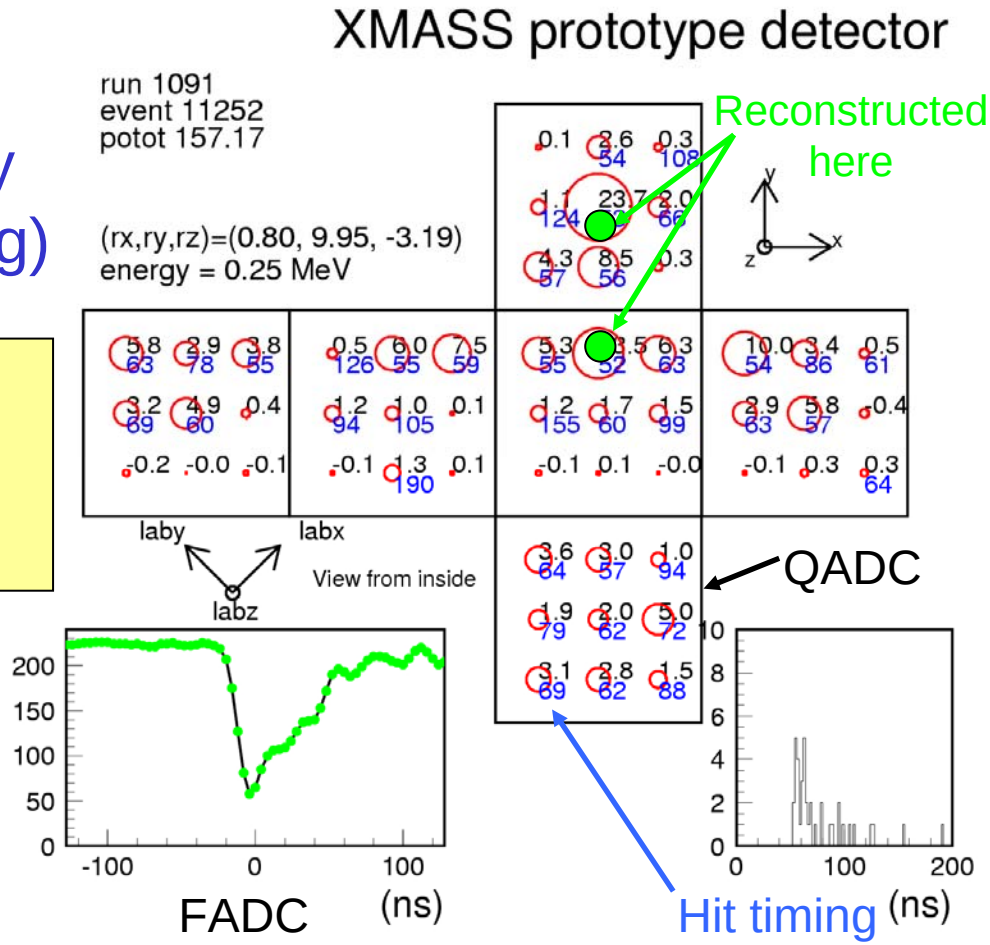




Vertex & energy reconstruction

Reconstruction is performed by PMT charge pattern (not timing)

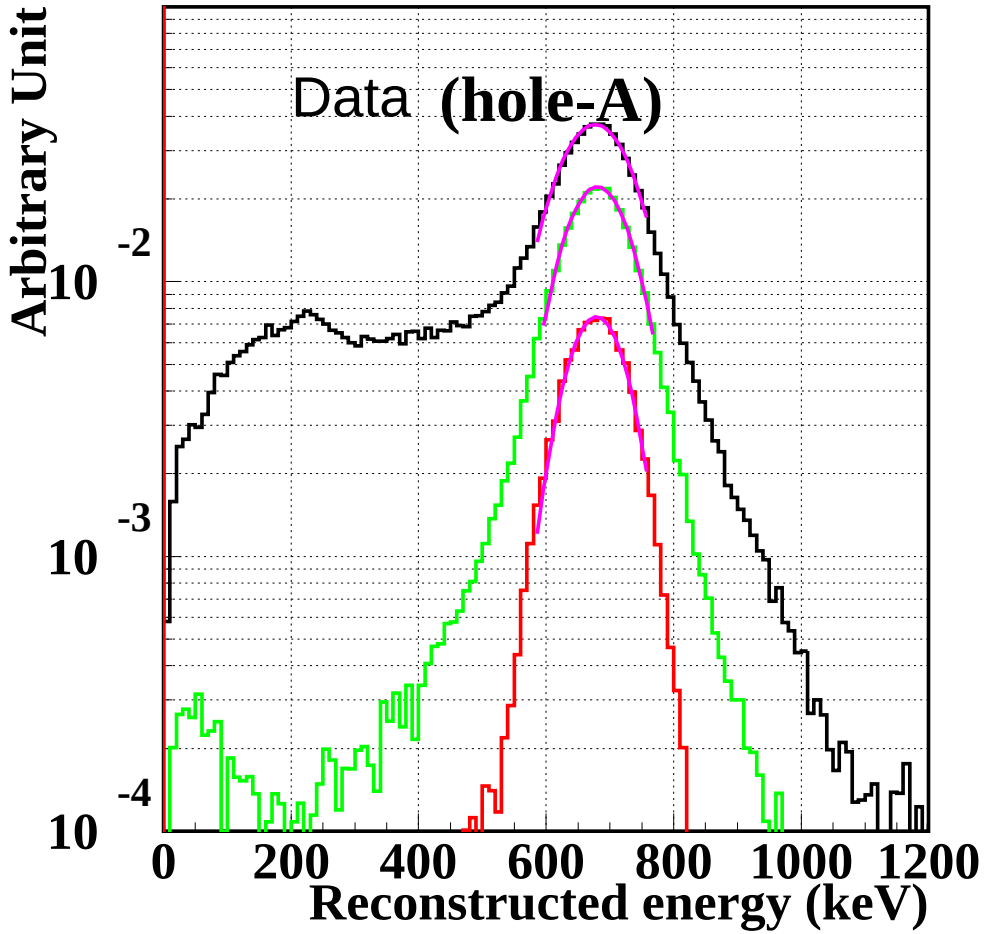
Calculate PMT acceptances from various vertices by Monte Carlo. **→Map**
Vtx.: compare acceptance map F(x,y,z,i)
Ene.: calc. from obs. p.e. & total accept.



=== Background event sample ===
QADC, FADC, and hit timing information are available for analysis

Calibration Run Ⅰ
(Energy reconstruction)

γ source : ^{137}Cs (662keV)

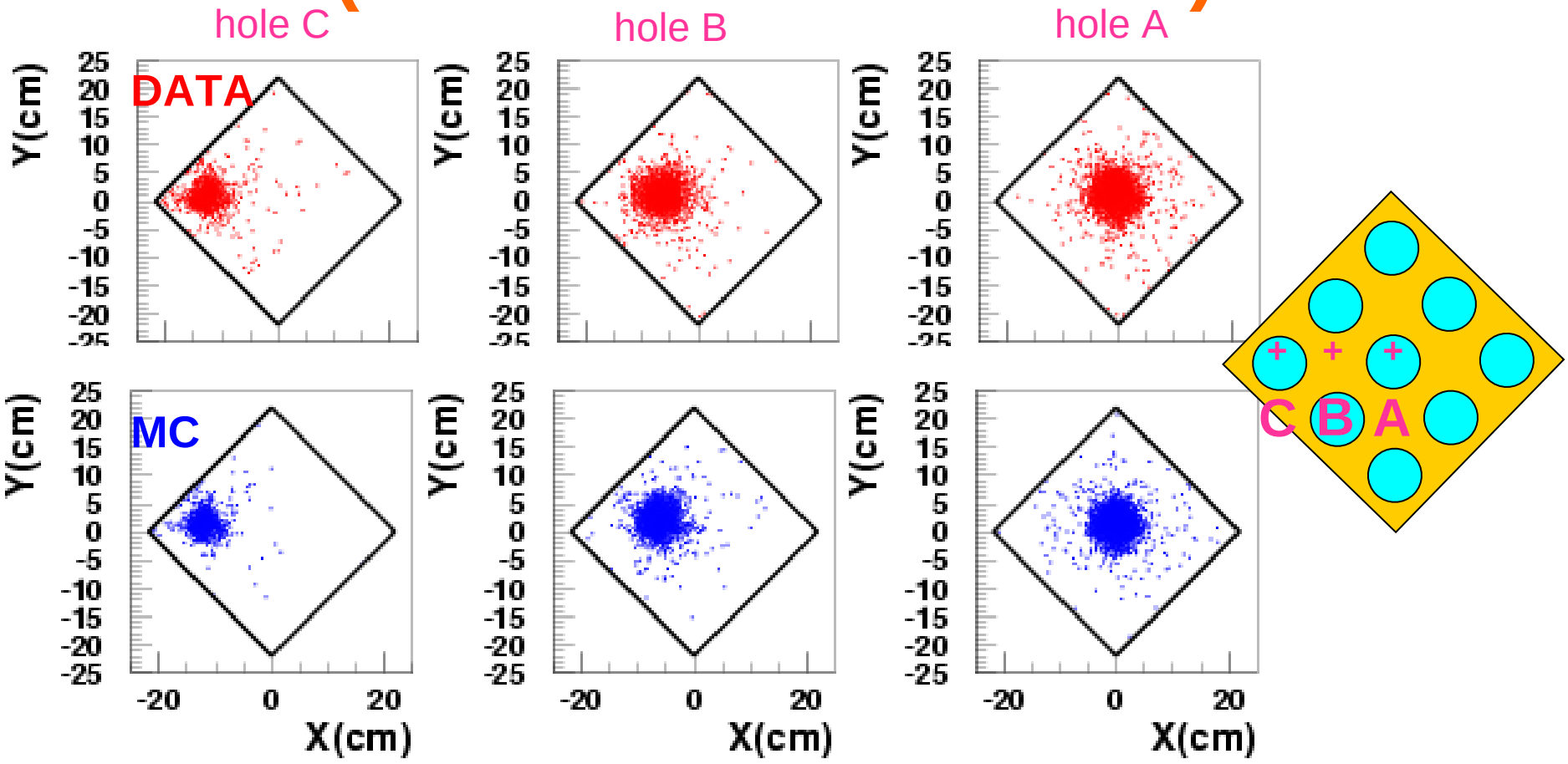


σ=65keV @Peak(662keV)

σ/E ~10%

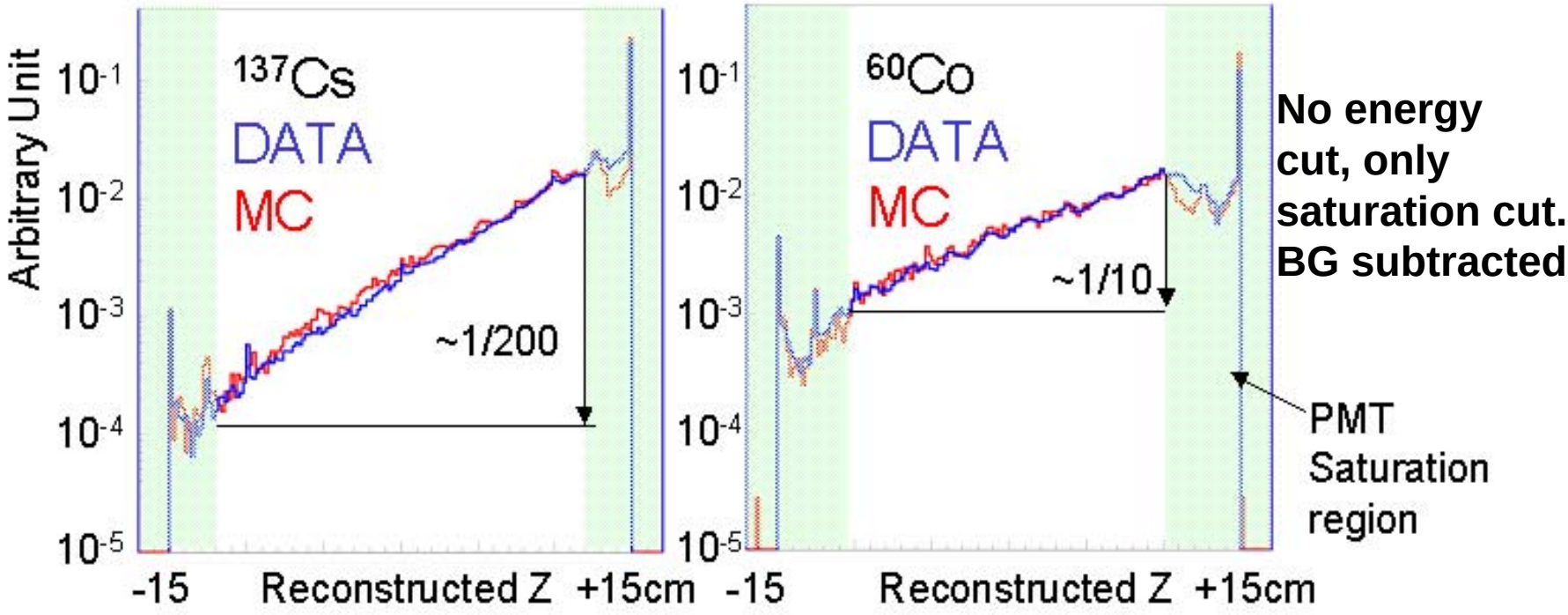
Energy reconstruction works well.

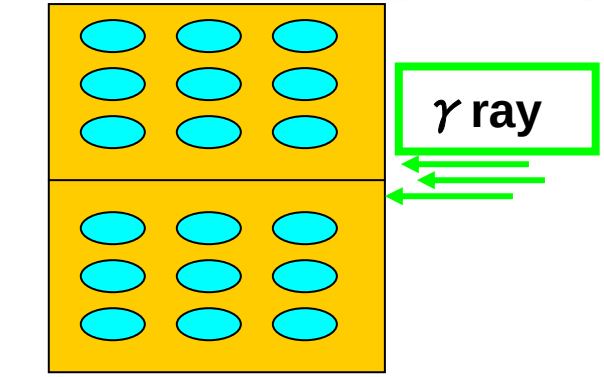
Calibration Run Ⅱ
(Vertex reconstruction)



Well reproduced. ⇒ **Reconstruction works well.**

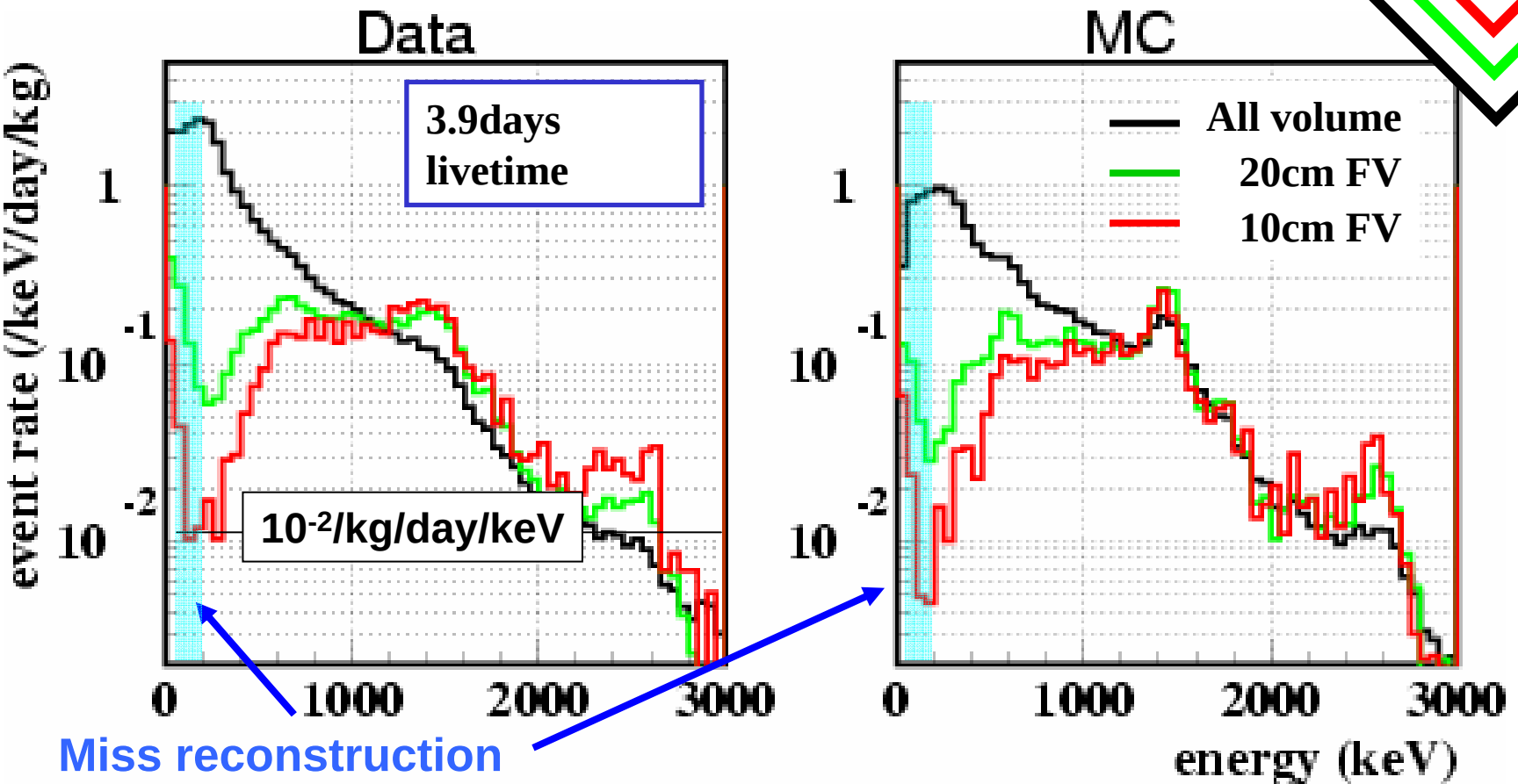
Calibration Run Ⅲ (Self shielding)





Self shield works as expected.

External BG measurement



Miss reconstruction

(only for prototype detector)

MC uses U/Th/K activity from PMTs, etc

- Good agreement (< factor 2)
- Self shield effect can be seen clearly.
- Very low background (10^{-2} /kg/day/keV@100-300 keV)

DAMA ~1/kg/day/keV @ a few keV

Internal BG measurement

- **U chain**

$^{238}U \cdots\rightarrow {}^{222}Rn$ ($\tau_{1/2}$=3.8day)

$^{214}Bi \rightarrow {}^{214}Po \rightarrow {}^{210}Pb$

$\tau_{1/2}$ =164μsec

$^{238}U=(72+-11)\times10^{-14}$ g/g (8/4)

$^{238}U(Bi/Po) = (33\pm7)\times10^{-14}$ g/g (8/10)

(radiation equilibrium assumed)

- **Th chain**

$^{232}Th \cdots\rightarrow {}^{220}Rn$

$^{212}Bi \rightarrow {}^{212}Po \rightarrow {}^{208}Pb$

$\tau_{1/2}$ =299nsec

$^{232}Th(Bi/Po) < 23\times10^{-14}$ g/g(90%CL)

(radiation equilibrium assumed)

- **Kr**

3.3±1.1 ppt mol/mol

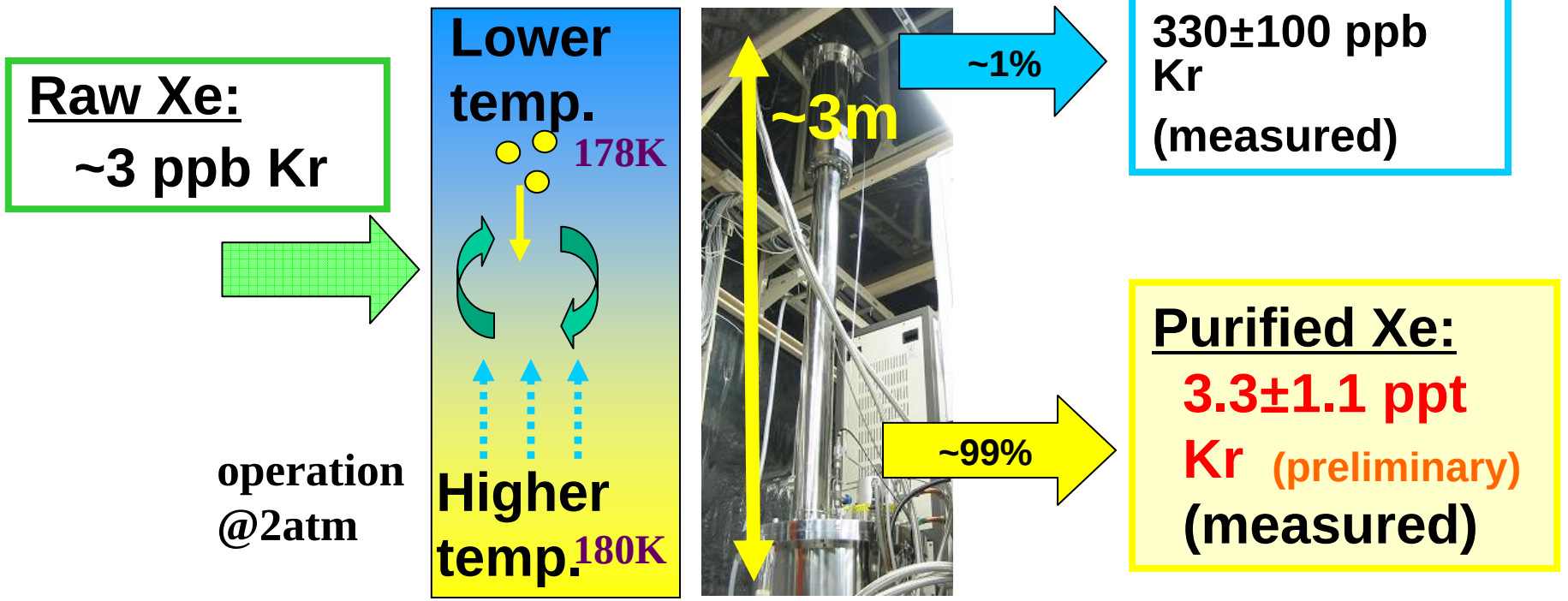
(Achieved by distillation)

Xe purification system

•Reduce internal impurities (^{85}Kr, etc.) by distillation.

	Boiling point (@2 atm)
Xe	178.1K
Kr	129.4K

•Processing speed: 0.6 kg / hour
•Design factor: 1/1000 Kr / 1 pass
•Purified Xe: Off gas = 99:1



Summary of BG measurement

Goal to look for DM by 800kg detector

- External γ ray BG = 10^{-2} event/keV/day/kg → ~10^{-4} [event /keV/day/kg]

➔increase volume (shelf shielding) PMT 1/100

- ^{238}U(Bi/Po): = $(33+-7)\times10^{-14}$ g/g → 1×10^{-14} g/g

➔decay out further & use filter 1/33

- ^{232}Th(Bi/Po): < 23×10^{-14} g/g (90%CL) → 2×10^{-14} g/g

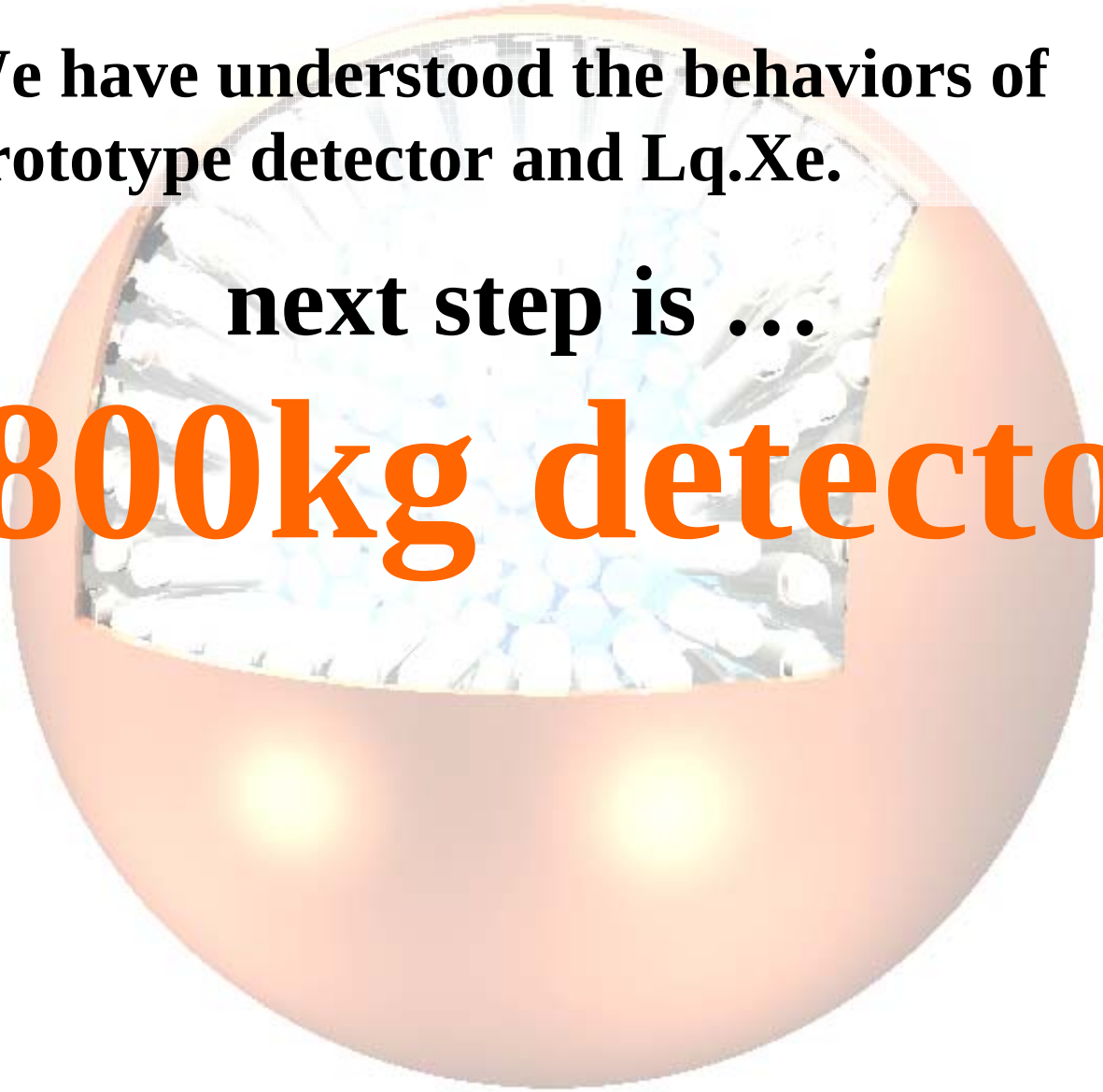
➔only upper limit. use filter 1/12

- Kr: = 3.3+-1.1ppt → 1 ppt

➔equivalent of purification 2 passes 1/3

Very near to the target level !!

We have understood the behaviors of prototype detector and Lq.Xe.

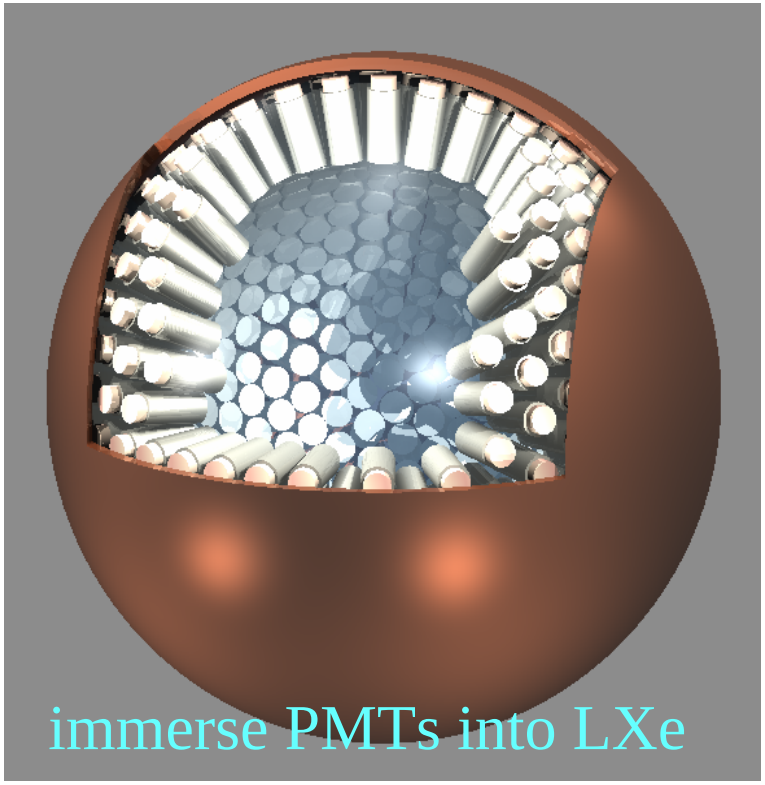


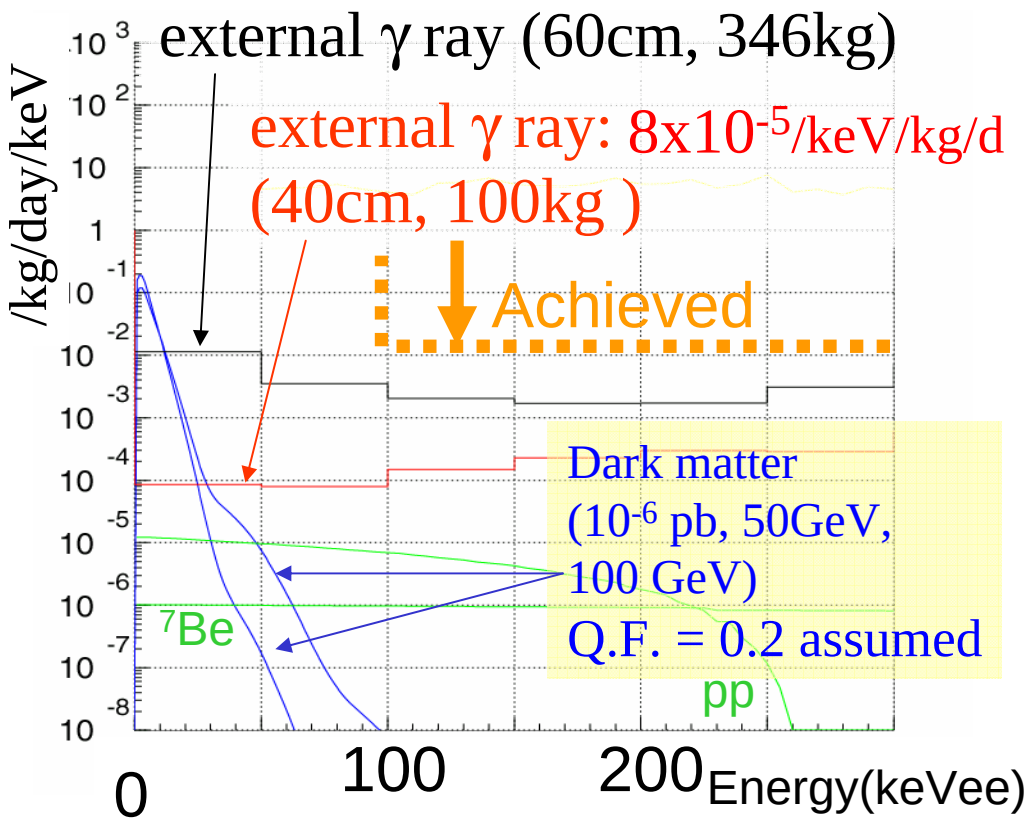
next step is …

800kg detector

800kg (100kg FV) detector

“Full” photo-sensitive,“Spherical” geometry detector

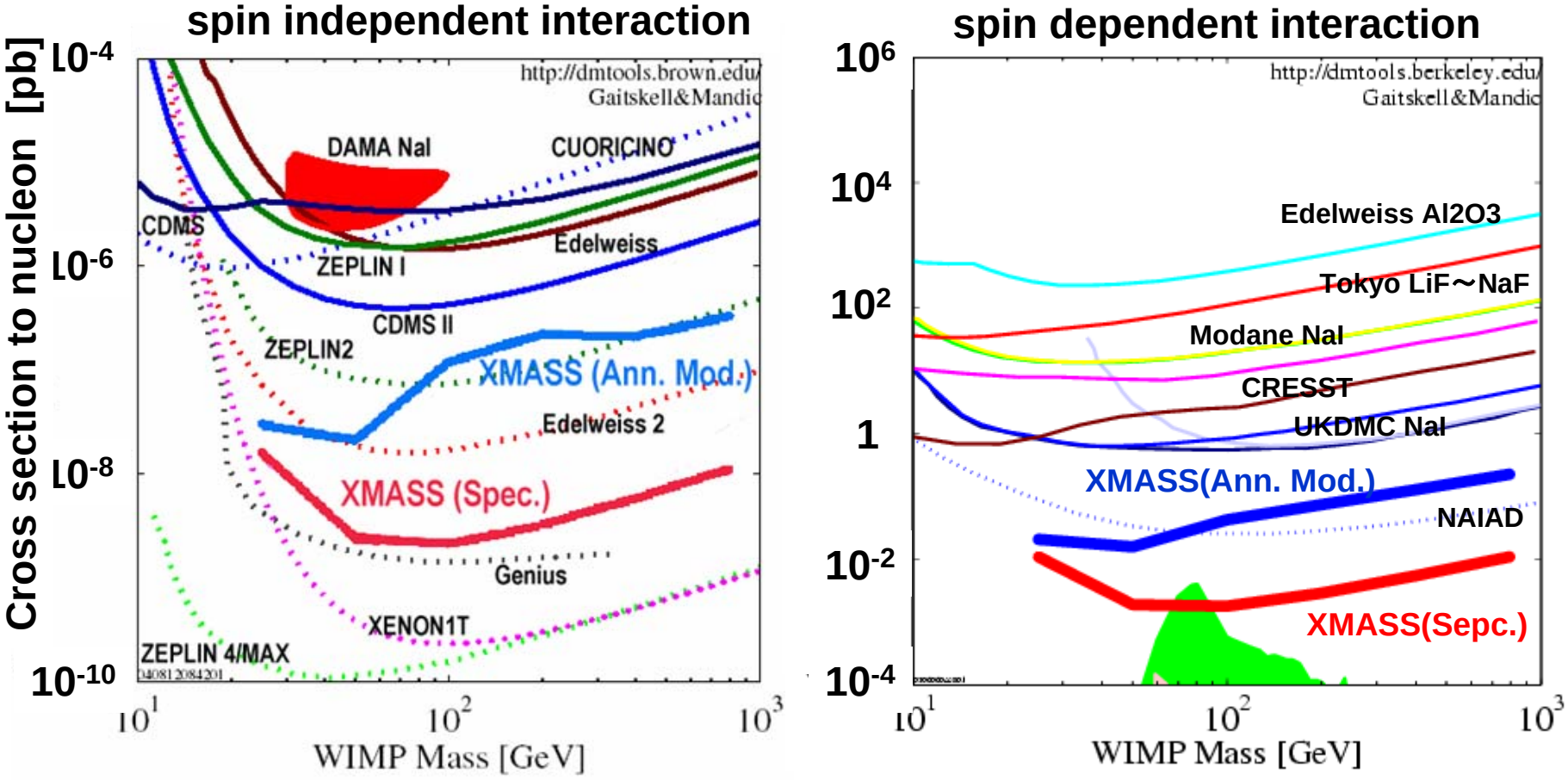




~800-2” PMTs (1/10 Low BG)
70% photo-coverage ~5p.e./keVee

Expected sensitivity for DM

XMASS FV 100kg, 5 year, E_{th}=5keVee~25p.e., 3σ discovery



⇒SI ~ 10^{-45}cm^2 = 10^{-9}pb , SD~ 10^{-39}cm^2= 10^{-3}pb

10^2 improvement of sensitivity !

We are planning to start very high sensitivity DM search within few years!