



# Recent status of the XMASS project

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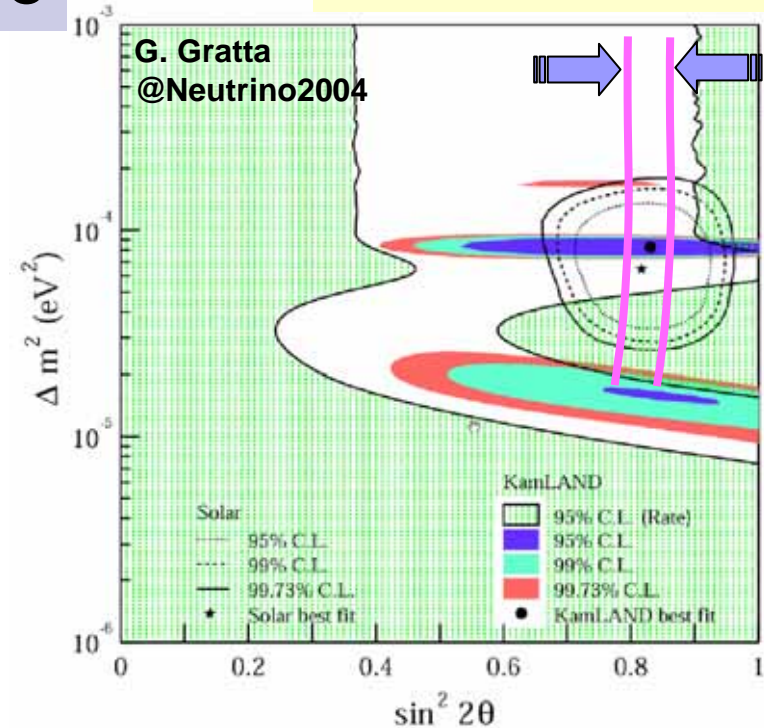
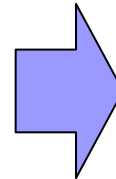
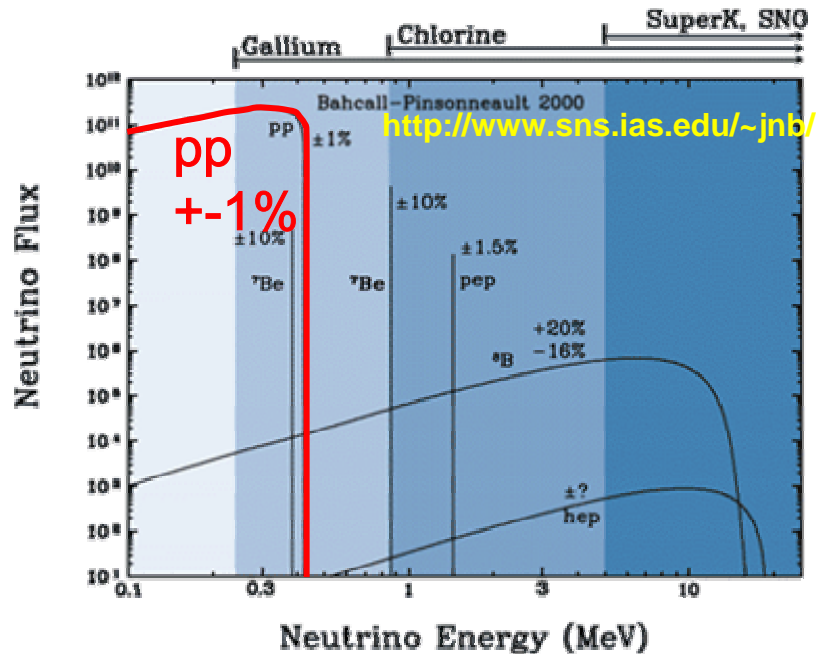
- Physics goals at XMASS
- Overview of XMASS
- Current status of R&D
- Summary

XMASS = a multi purpose detector to search **rare phenomena** under an ultra **low background** environment by using ultra pure **liquid xenon**

# Physics goals at XMASS

Measure  $pp \nu$  via  $\nu + e \rightarrow \nu + e$

XMASS FV 50 ton year (90%CL)



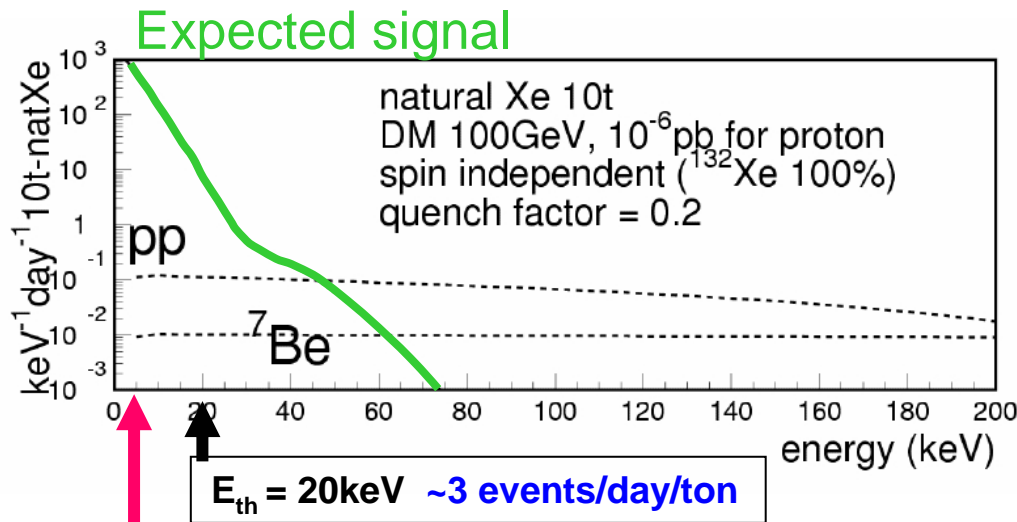
- Xenon MASSive Detector for Solar Neutrinos ( $pp/{}^7\text{Be}$ )
- Xenon Detector for Weakly Interacting MASSive Particles (Dark Matter Search)
- Xenon Neutrino MASS Detector (Double Beta Decay)

$2\nu\beta\beta$  life time should be measured  
Isotope separation would be needed

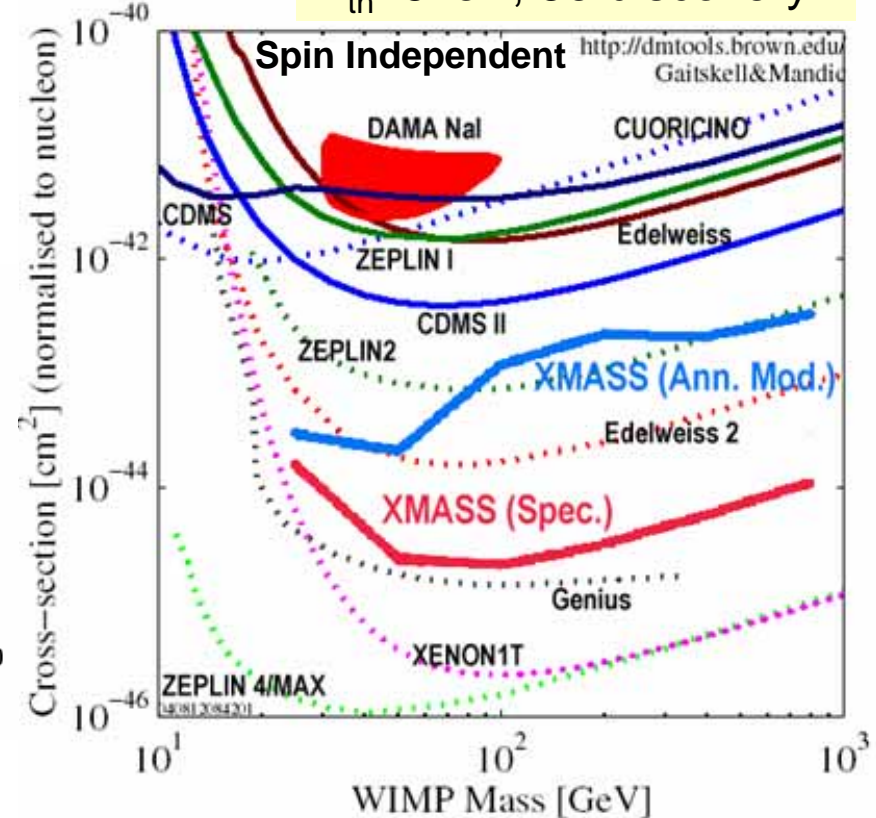
# Physics goals at XMASS

XMASS FV 0.5ton year  
 $E_{th}=5\text{keV}$ ,  $3\sigma$  discovery

Direct search via nuclear elastic scattering



$E_{th} = 5\text{keV} \sim 200 \text{ events/day/ton}$

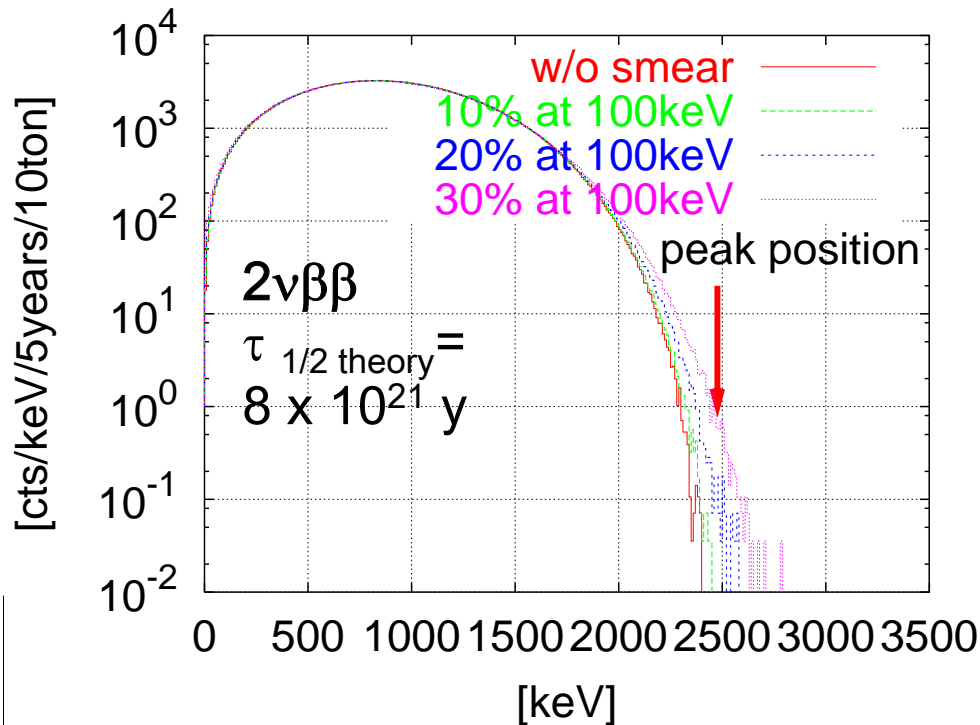


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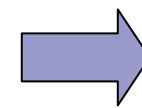
# Physics goals at XMASS



Q-Value: 2.48 MeV



- Search for  $0\nu\beta\beta$  ( $2\nu\beta\beta$ ) decay of  $^{136}\text{Xe}$  (na 8.87%)
- High purity and enriched Xe can be used.
- Energy region is different from solar  $\nu$  / DM.
- PMTs should not be placed near the detector.



**Need another design of the detector!**  
(low priority, at moment...)

■ Xenon Detector for weakly Interacting MASSive Particles (Dark Matter Search)

■ Xenon Neutrino **MASS** Detector (Double Beta Decay)

or Solar Neutrinos ( $pp/{}^7\text{Be}$ )



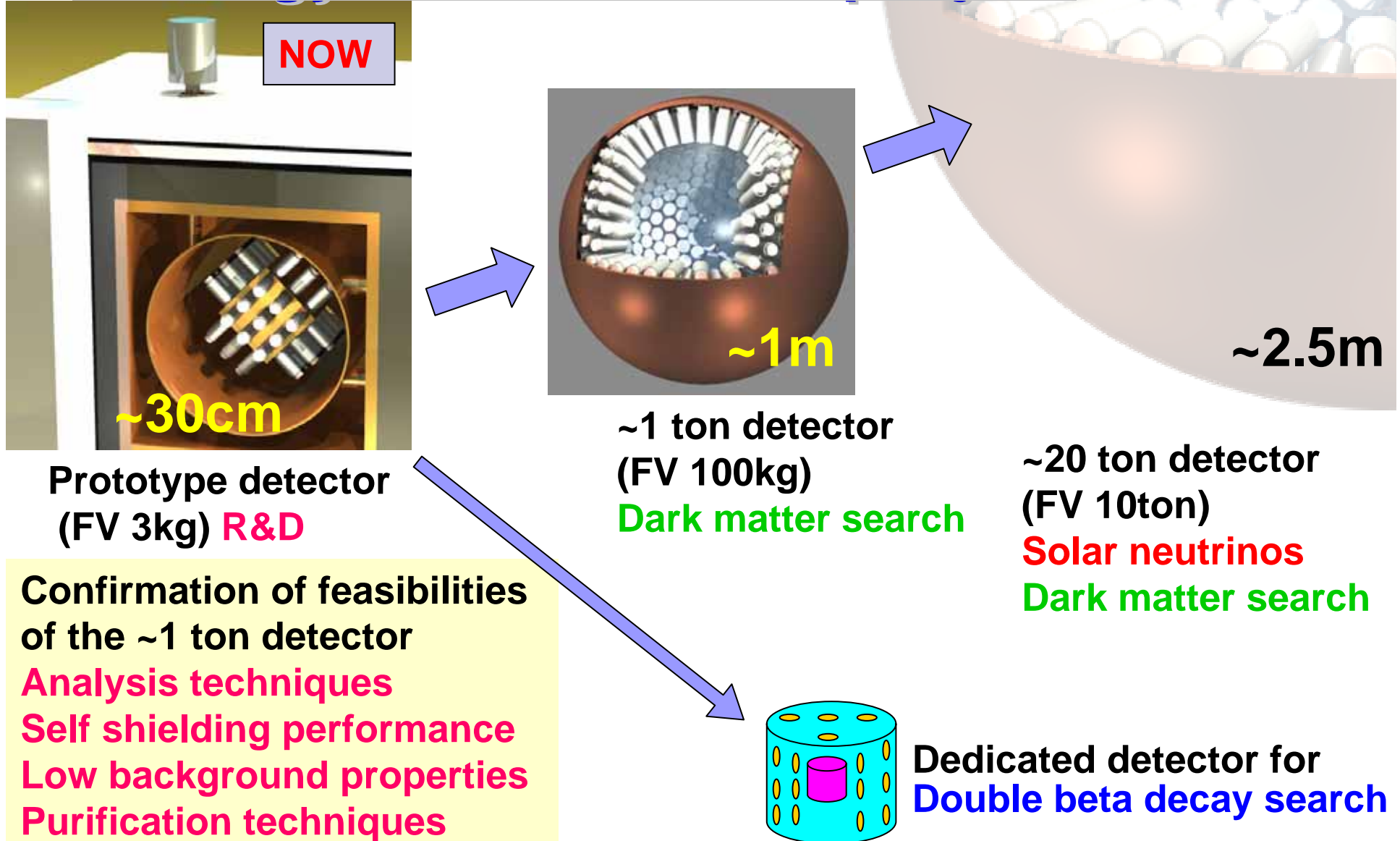
# Overview of XMASS

Strategy

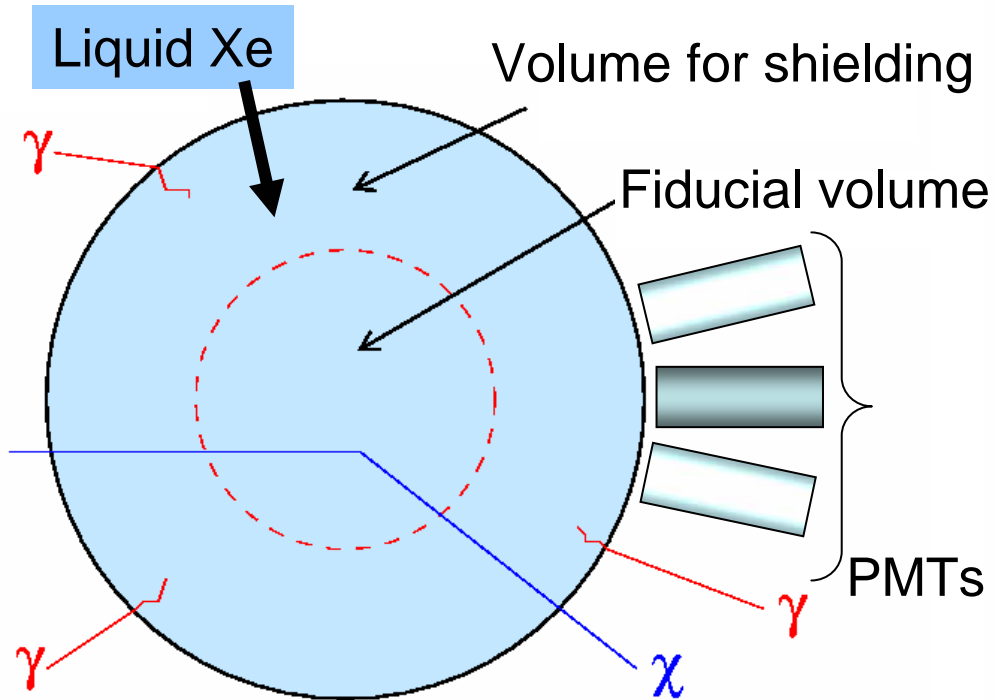
Key ideas

(self shielding, distillation)

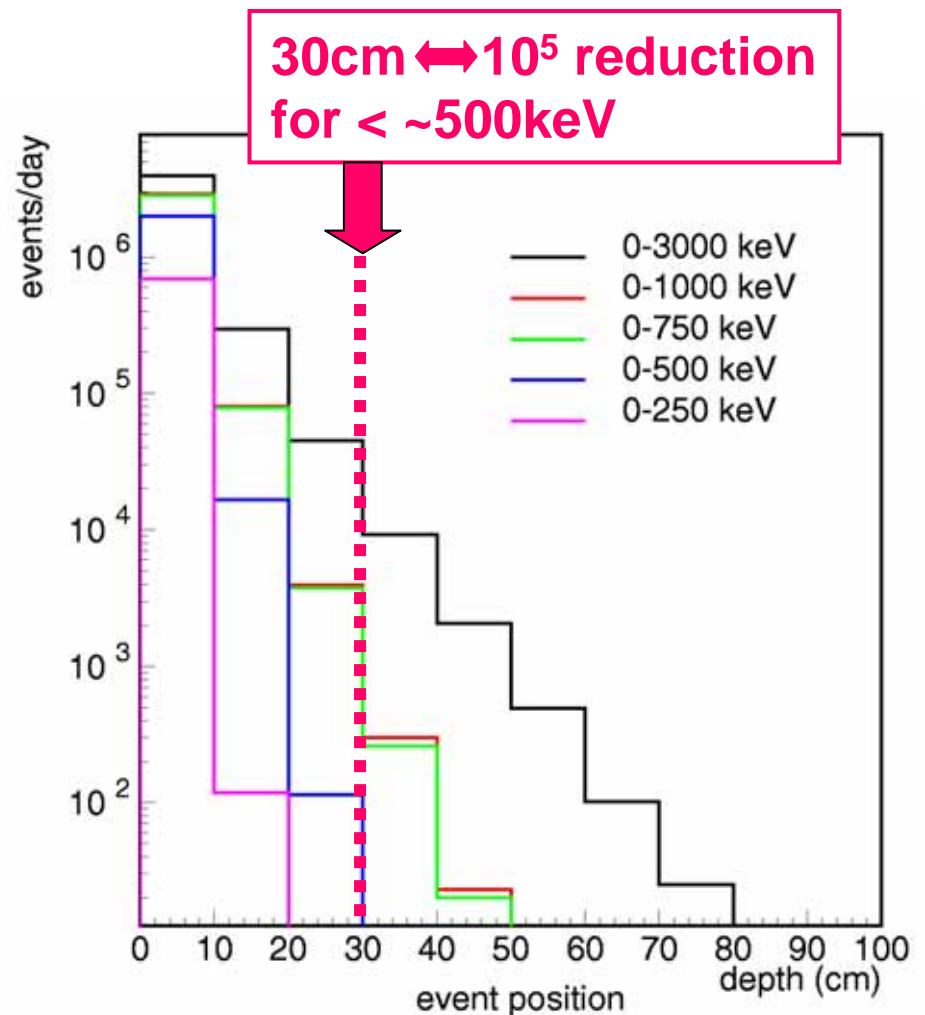
# Strategy of the XMASS project



# Self shielding



Reconstruct the vertex and energy based on PMTs information (light pattern)

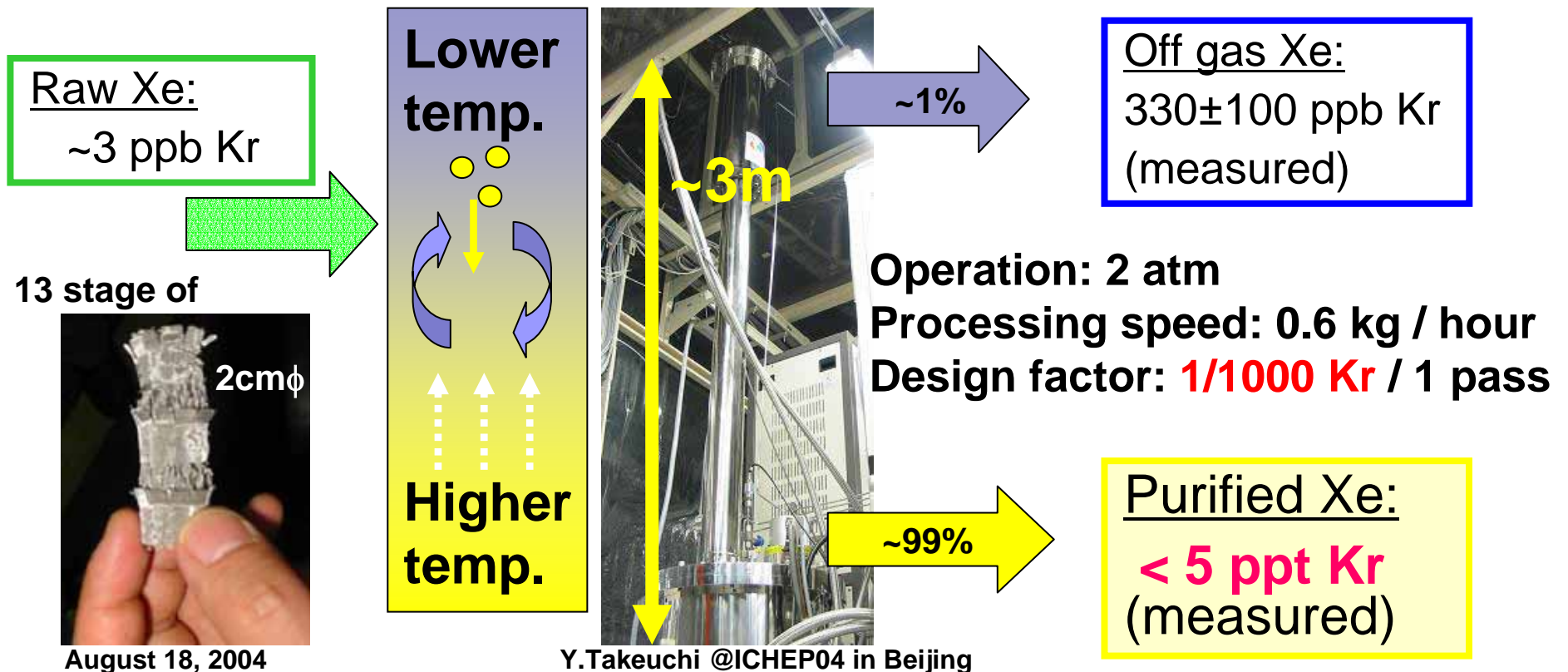


- Quite effective for the events below  $\sim 500$  keV (**pp  $\nu$**  & **DM**)
- Not effective for **double beta decay** experiment

# Distillation to remove Kr

- Very effective to eliminate internal impurities (<sup>85</sup>Kr, etc.)
- We have processed 100kg Xe in March '04

	Boiling point (@1 atm)
Xe	165K
Kr	120K





# Current status of R&D

Prototype detector

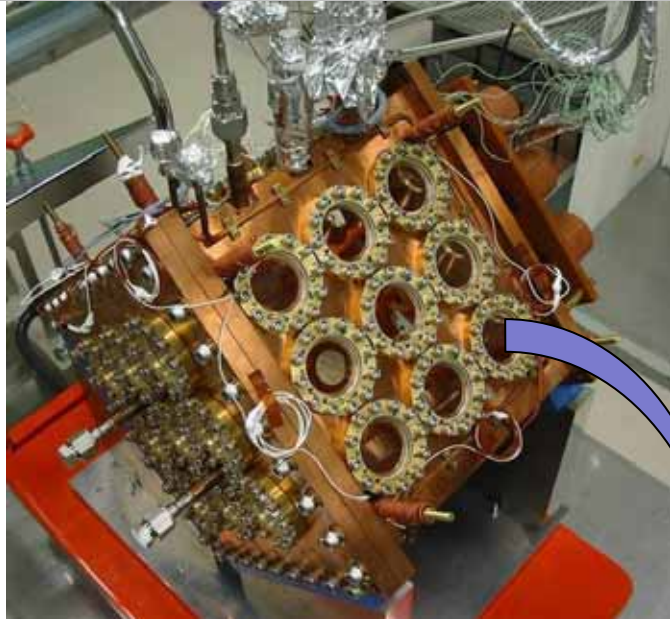
Results from test runs

Self shielding

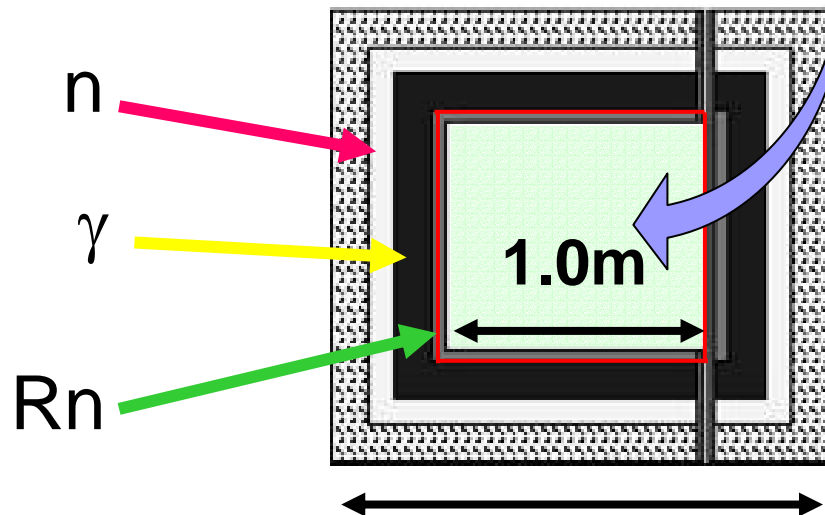
Internal background

External background

# XMASS prototype detector



- 30 liter liquid Xenon (~100kg)
- Oxygen free copper: (31cm)<sup>3</sup>
- 54 of low-BG 2-inch PMT
  - Photo coverage ~16%
- MgF<sub>2</sub> window
- 0.6 p.e. / keV



- Polyethylene (15cm)
- Boric acid (5cm)
- Lead (15cm)
- EVOH sheets (30mm)
- OFC (5cm)
- Rn free air (~3mBq/m<sup>3</sup>)

# Test runs with the prototype detector

## ■ December 2003 run

- First test run
- ~6 days (~2day normal runs for BG estimation)
- Test analysis tools
- Confirmation of the self shielding performance
- Measurements of the internal and external BGs

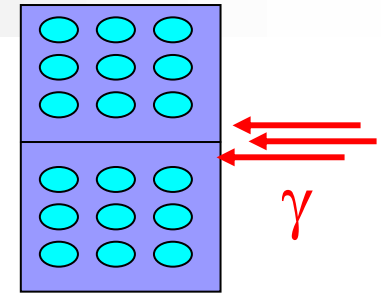
## ■ August 2004 run **NEW**

- August 3 ~ 11, 2004, 9days (~6day normal runs)
- Used purified xenon (by distillation)
- Longer baking time of the system
- New electronics (TDC, etc.)
- Re-measurements of the internal and external BGs

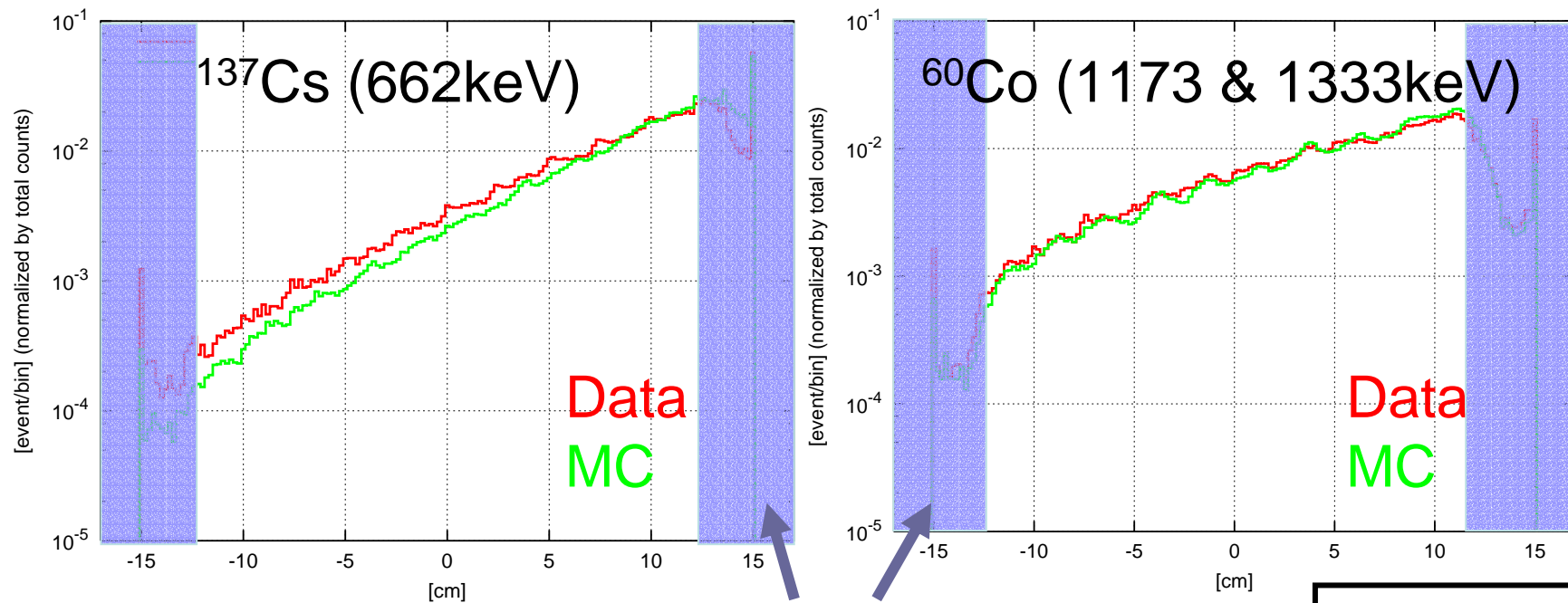
} ⇒ Photon yield  
x ~1.7

# Self shielding performance

Reconstructed vertex position of collimated source runs



Z = -15    Z = +15



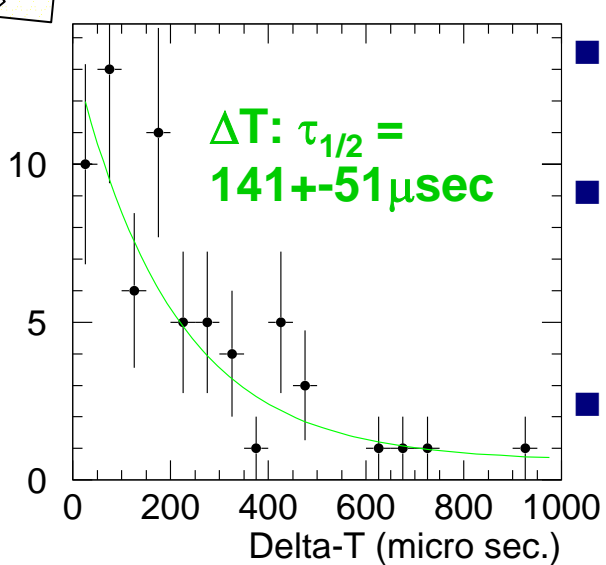
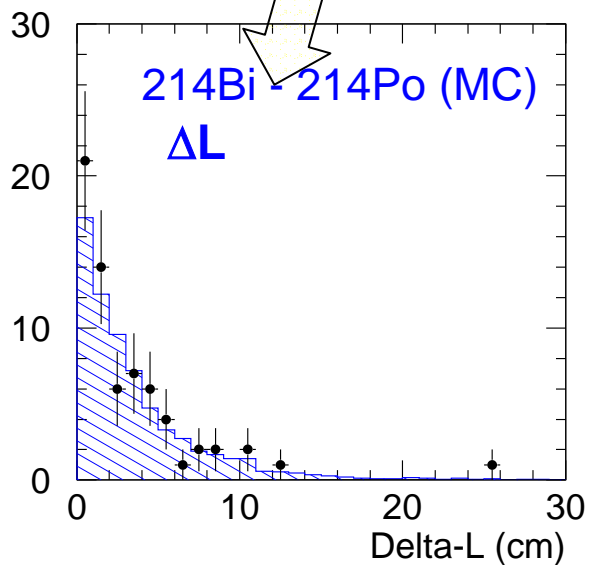
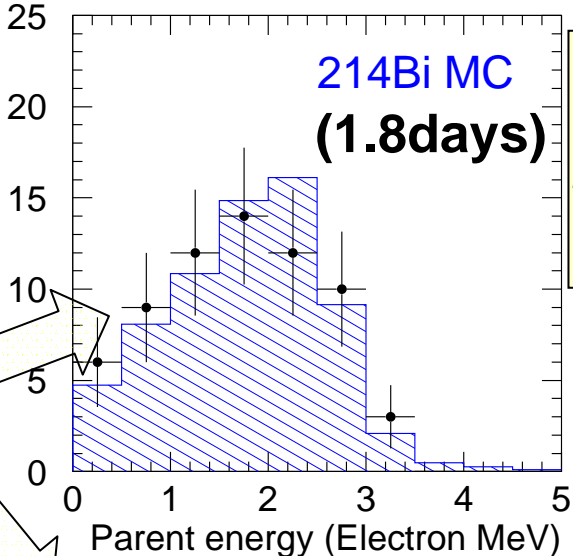
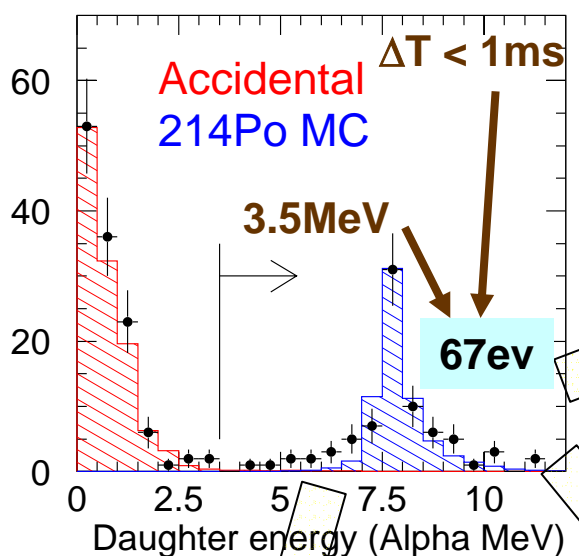
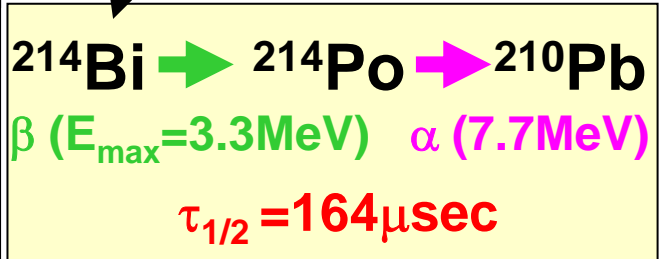
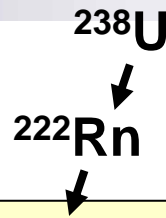
Remove events (PMT saturation)

Dec.03 run

- MC reproduces data very well
- We have demonstrated the self-shield actually works

# Internal BG source: $^{222}\text{Rn}$

Aug.04 run  
Preliminary



- 2 separate runs to check  $^{222}\text{Rn}$  decay ( $\tau_{1/2} = 3.8\text{day}$ )
- 4<sup>th</sup> Aug. 0.8day  
 $^{238}\text{U} = (72 \pm 11) \times 10^{-14} \text{ g/g}$
- 10<sup>th</sup> Aug. 1.0day  
 $^{238}\text{U} = (33 \pm 7) \times 10^{-14} \text{ g/g}$
- Consistent with expected  $^{222}\text{Rn}$  decay ( $(30 \pm 5) \times 10^{-14}$ )

Preliminary

# Internal background sources

## ■ Current results

**NEW** □  $^{238}\text{U}$ : =  $(33 \pm 7) \times 10^{-14}$  g/g

Factor ~30, but may decay out further

□  $^{232}\text{Th}$ : <  $63 \times 10^{-14}$  g/g

Factor <~30 (under further study)

**NEW** □ Kr: < 5ppt

Almost achieved by the distillation process

Goal (~1ton)

$1 \times 10^{-14}$  g/g

$2 \times 10^{-14}$  g/g

1 ppt

# External background sources

- Background level was estimated from known sources

- $\gamma$  rays from outside shield

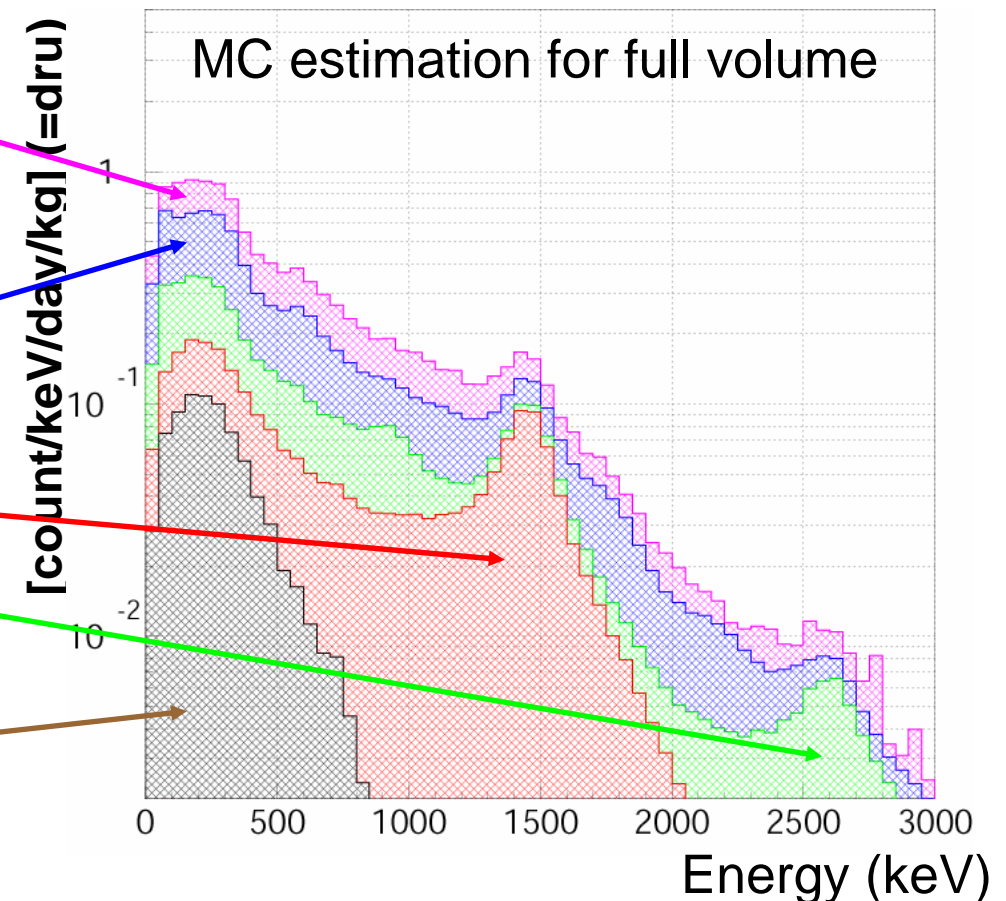
- PMTs origin

- $^{238}\text{U}$  series

- $^{40}\text{K}$

- $^{232}\text{Th}$  series

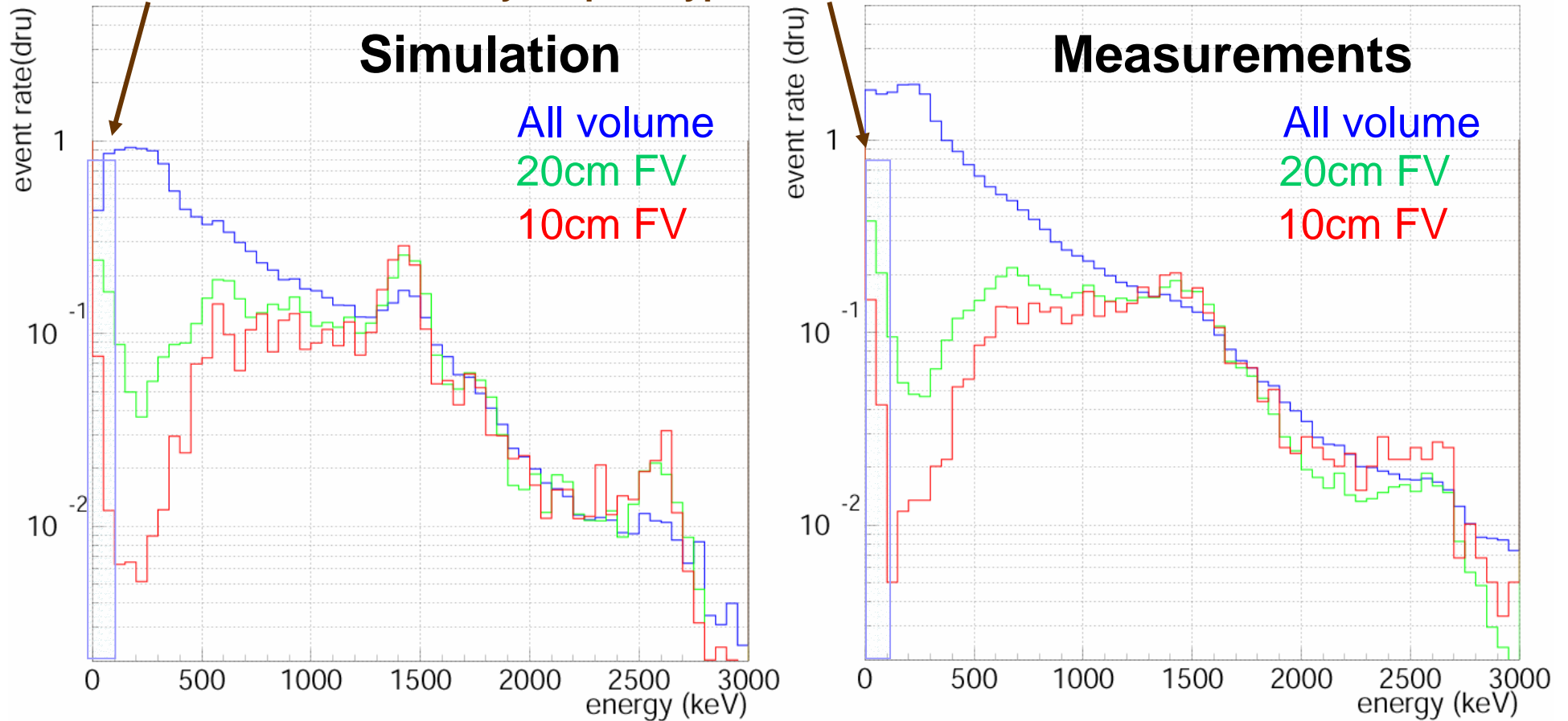
- $^{210}\text{Pb}$  in the lead shield



Aug.04 run  
Preliminary

# Measured background level

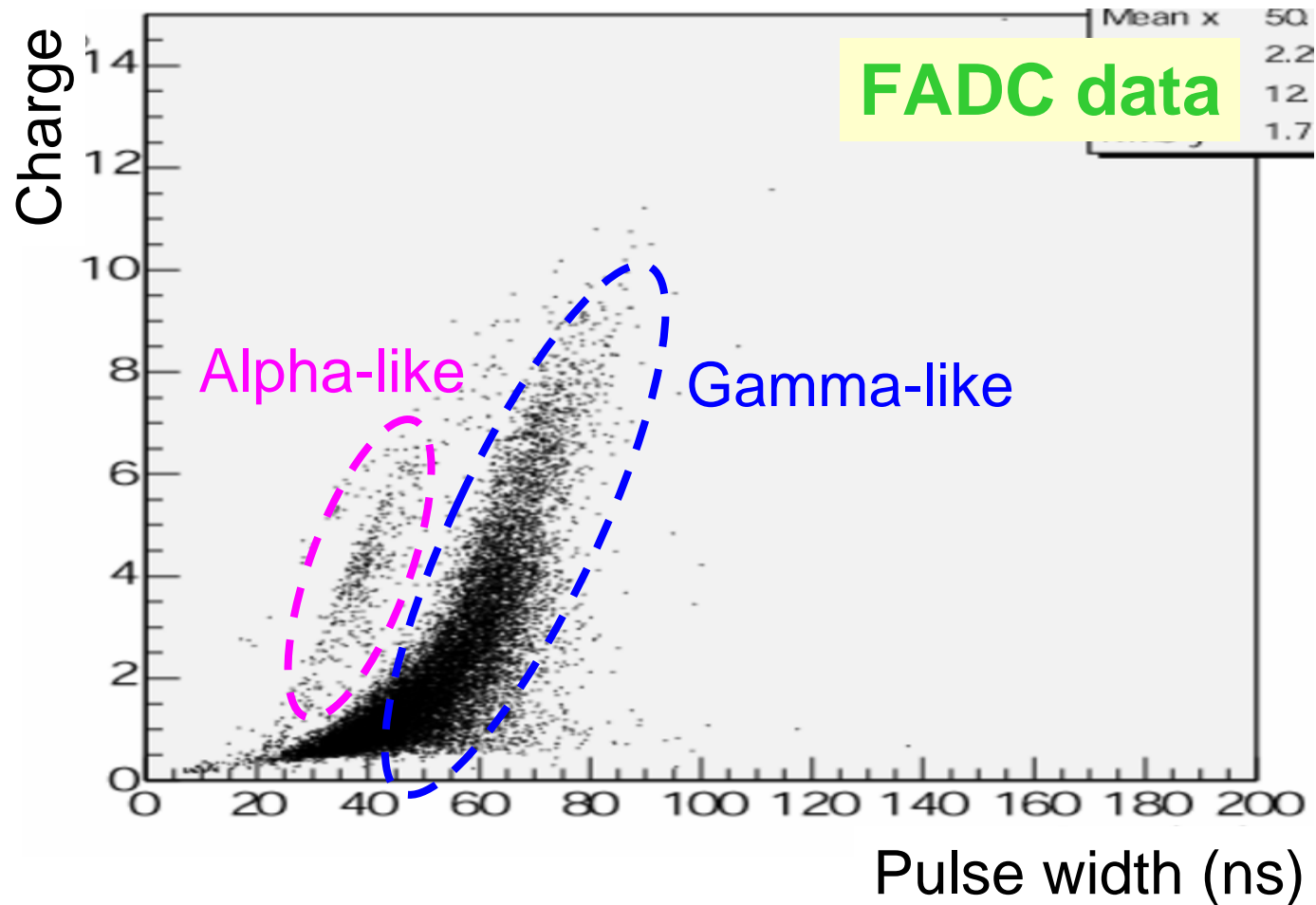
Geometrical effect only for prototype detector



- Self shielding works
- Good agreement with expectation (< factor 2)

Aug.04 run  
Preliminary

# Alpha vs Gamma separation



Alpha-gamma separation by using FADC wave form would be possible (under further investigation)



# Summary

- XMASS is aiming to search **rare phenomena** under an ultra **low background** environment by using ultra pure **liquid xenon**.
- 2<sup>nd</sup> test run with the prototype detector was just finished.
  - The data were taken using **distilled xenon** with low level krypton ( $\text{Kr/Xe} < 5\text{ppt}$ ).
  - Some part of remaining  **$^{222}\text{Rn}$**  in liquid xenon looks contaminated in outside of the chamber.
  - The **background level is consistent** with expectation within factor about 2.
- The next step ( $\sim 1\text{ton}$  scale) would be feasible, and a dark matter search around  **$10^{-44} \text{cm}^2$**  level would be possible.