
# The XMASS experiment

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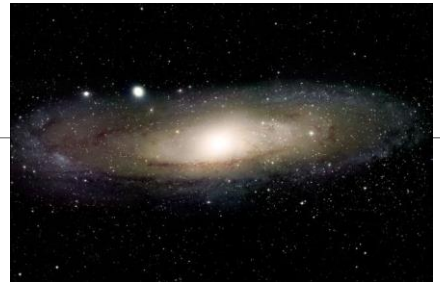
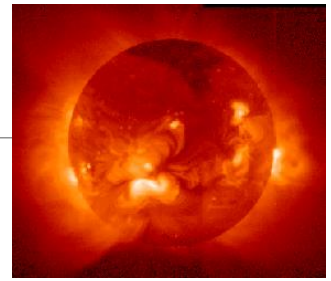
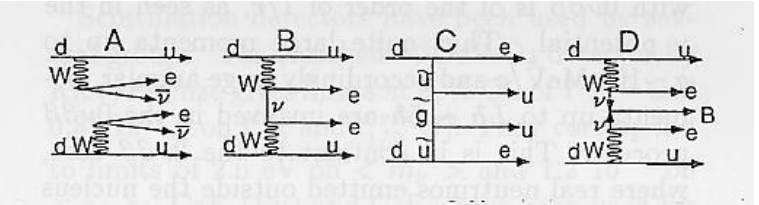
# Outline

- Introduction to XMASS
- Physics results from commissioning data
  - Light WIMPs
  - Solar axions
  - $^{129}$Xe inelastic scattering by WIMPs
  - Bosonic super-WIMPs
- Detector refurbishment and current status
- Future prospects

# The XMASS experiment







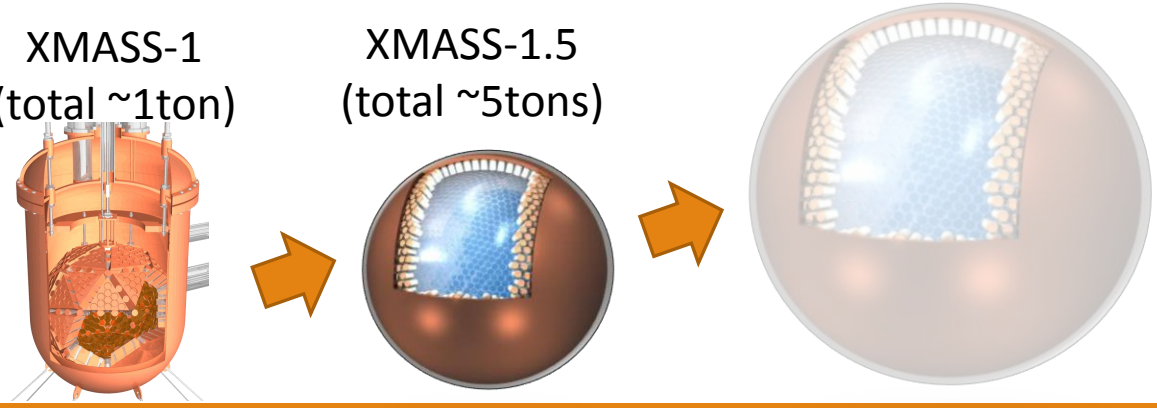

- Proposed as a multi purpose experiment with liquid Xenon
  - **X**enon detector for Weakly Interacting **MASS**ive Particles (**dark matter**)
  - **X**enon **MASS**ive detector for solar neutrino (**pp/$^{7}$Be solar neutrino**)
  - **X**enon neutrino **MASS** detector (**double beta decay**)
- Low energy threshold
- Sensitive to $e/\gamma$ events as well as nuclear recoil

  WIMPs (by elastic and $^{129}$Xe inelastic scattering),
  Solar axions, Bosonic super-WIMPs,
  Supernova neutrino burst, double electron capture, …
- Large target mass and its scalability

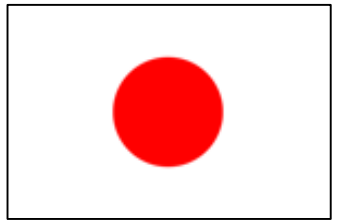
XMASS-1
(total ~1ton)

XMASS-1.5
(total ~5tons)

XMASS-2
(total ~24tons)



# The XMASS collaboration

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Miyagi University of Education: Y. Fukuda

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Sejong University: N. Y. Kim, Y. D. Kim

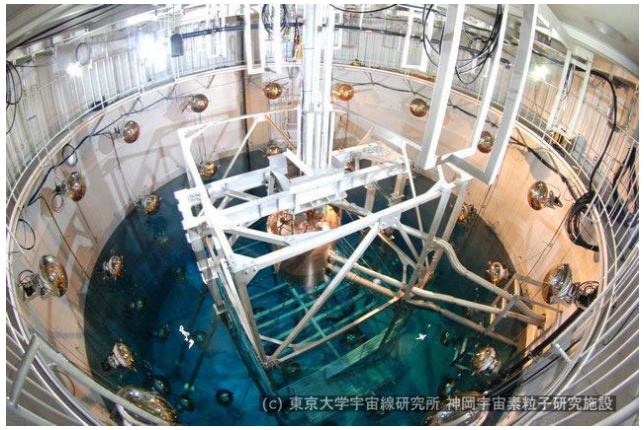
KRISS: Y. H. Kim, M. K. Lee, K. B. Lee, J. S. Lee


10 institutes

~40 physicists

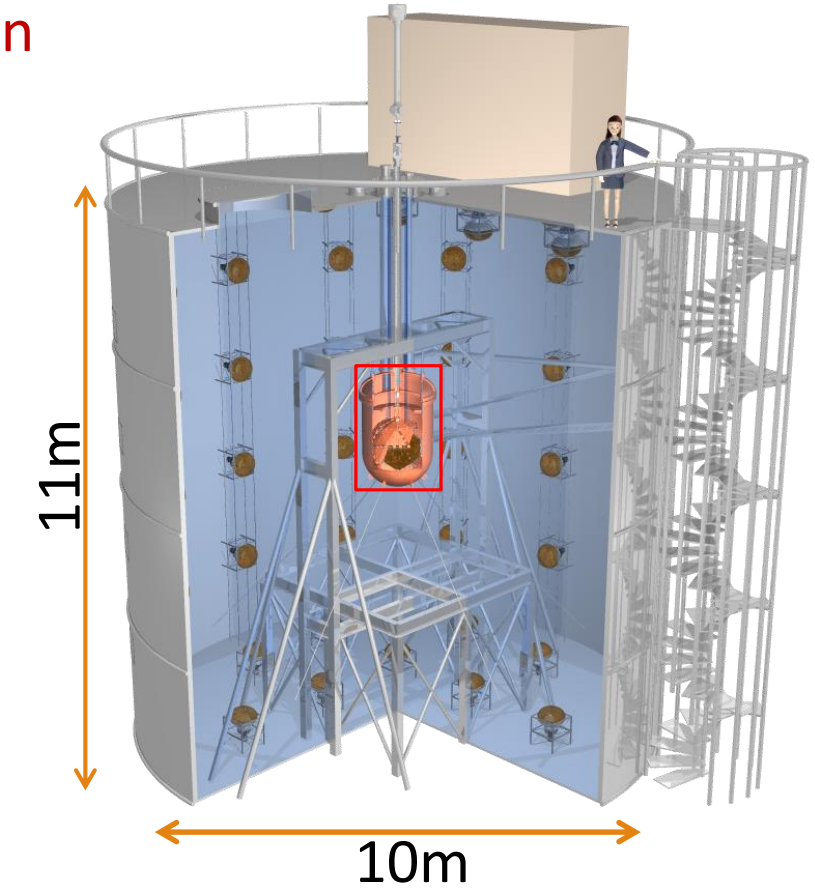
# History of XMASS-1

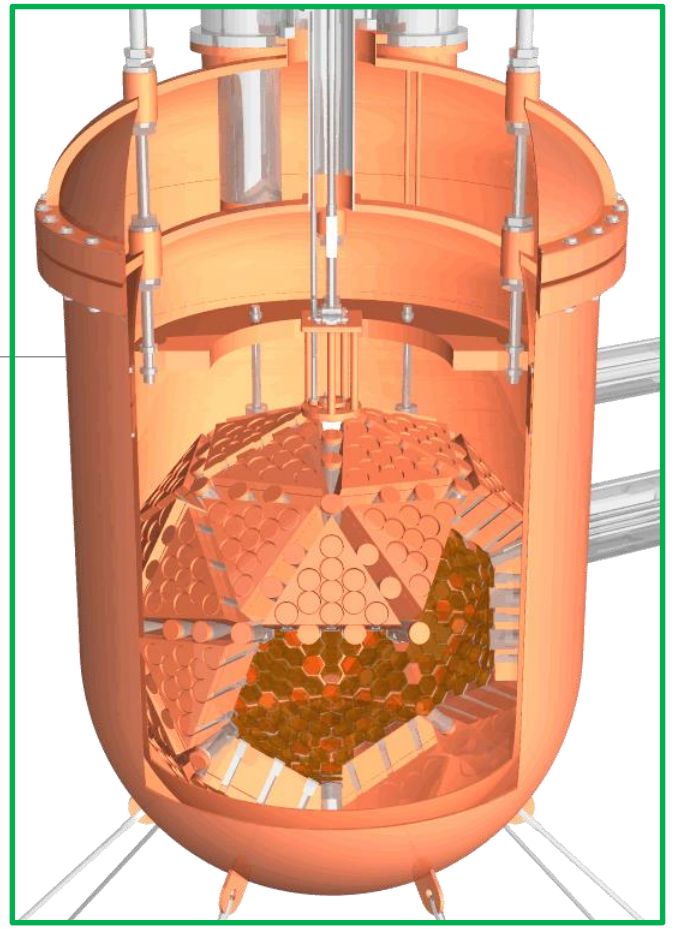
- Sep. 2010: Detector construction completed.
- Dec. 2010 – May. 2012: Commissioning data-taking
- Aug. 2012 – Oct. 2013: Detector refurbishment
- Nov. 2013 : data-taking resumed.




# The XMASS-1 detector

- Located in the Kamioka mine in Japan (~2,700m water equivalent)
- A single-phase detector employing ~830kg of liquid xenon
- Equipped with 642 PMTs
- Active water shield

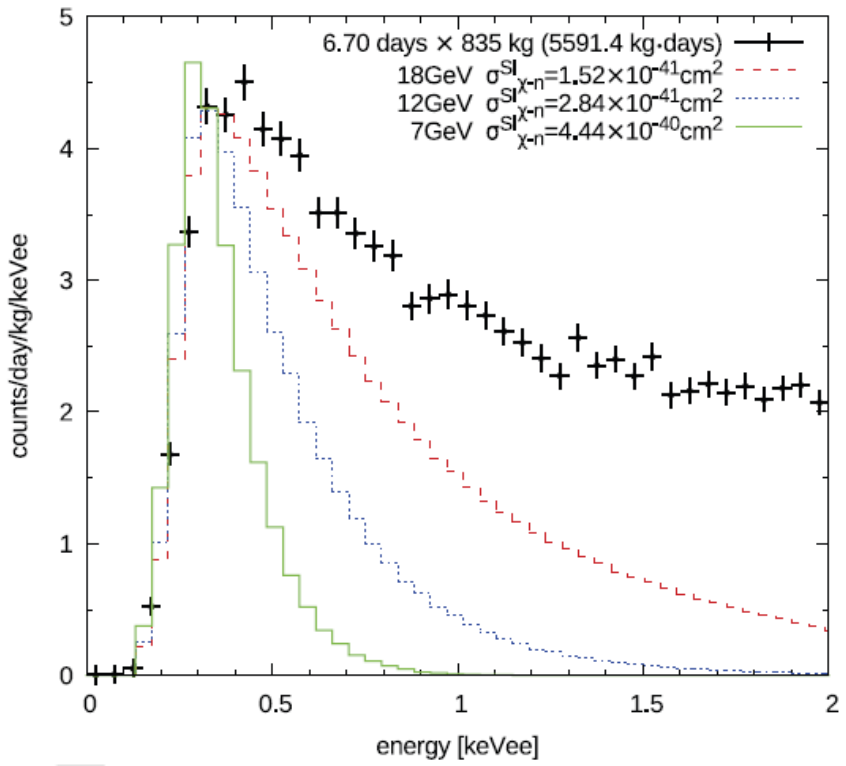


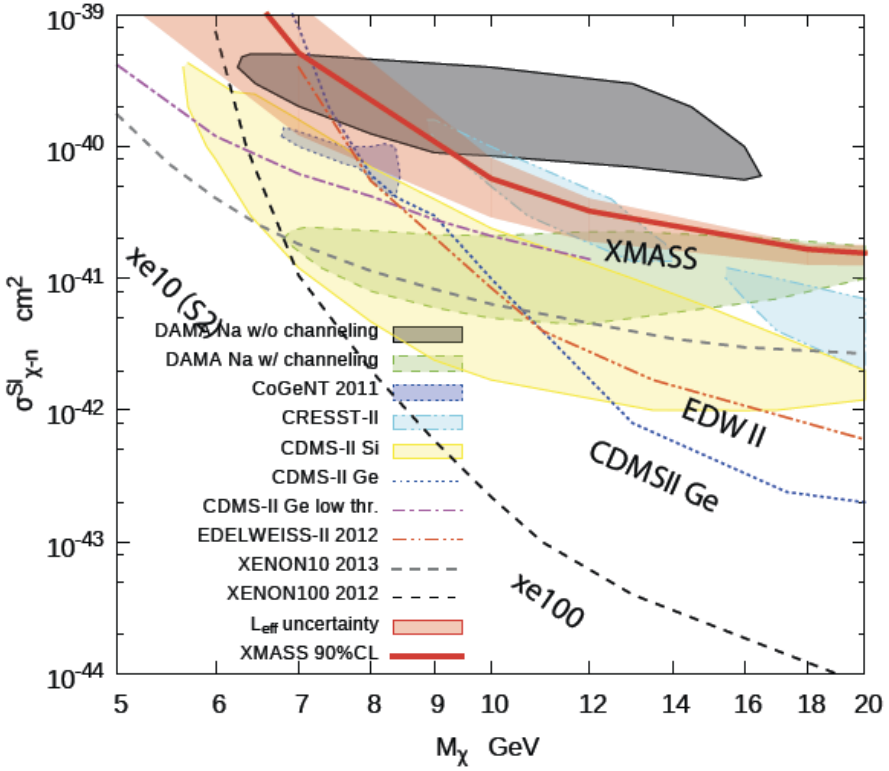



# Physics results from commissioning data

# Search for light WIMPs

- 6.7 days x 835 kg
- 0.3 keVee threshold



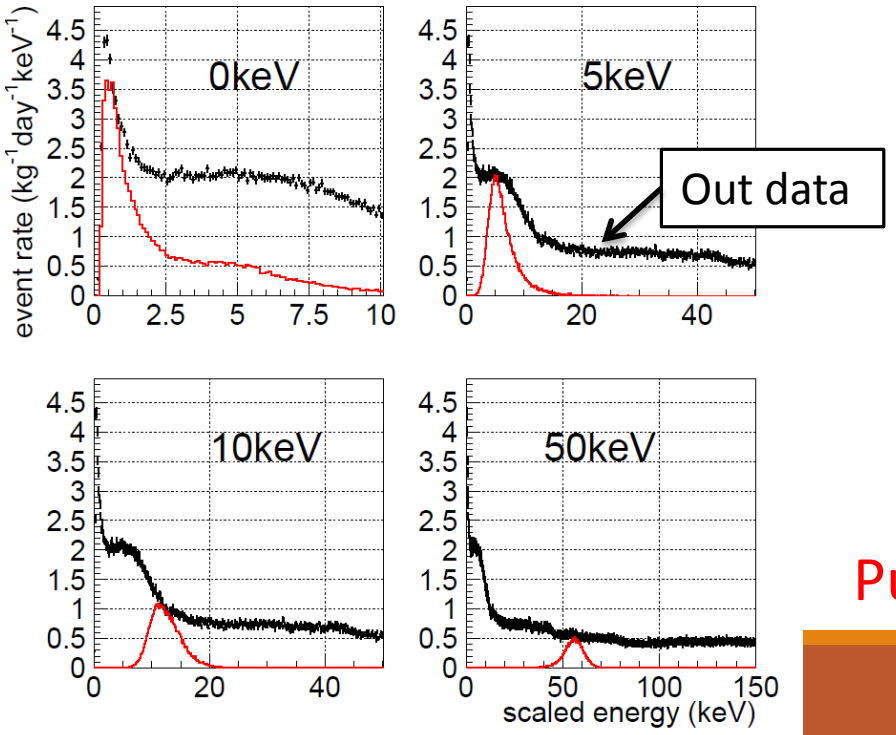

Published in Phys. Lett. B 719 78 (2013)

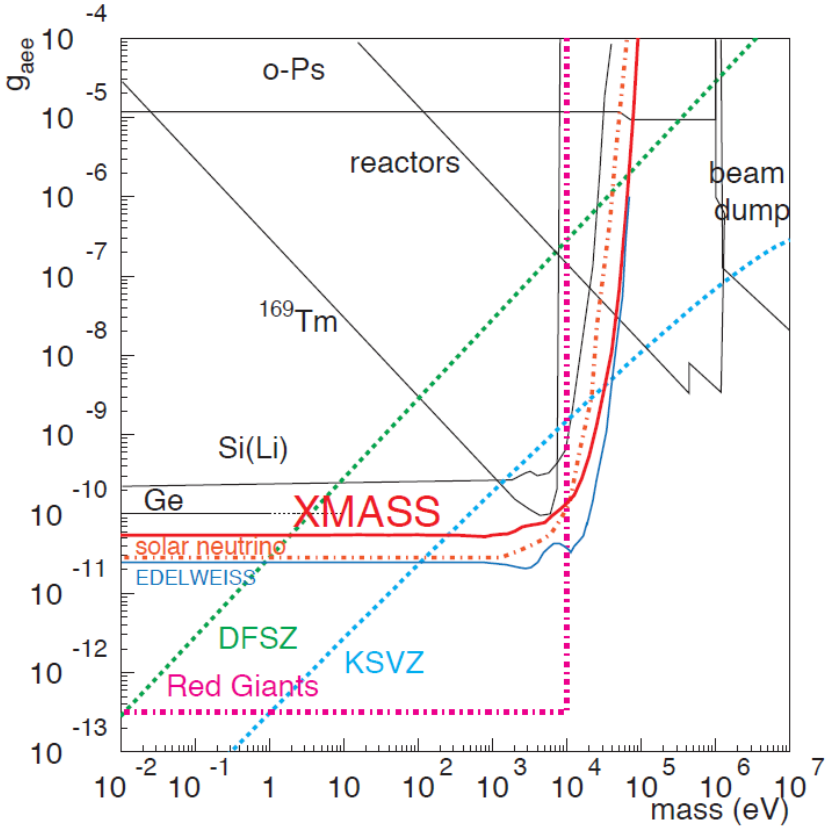
# Search for solar axions

- Axions can be produced in the sun by bremsstrahlung and Compton effect, and detected by axio-electric effect in XMASS.
- Used the same data set as the light WIMPs search.

Bremsstrahlung and Compton effect


Axio-electric effect

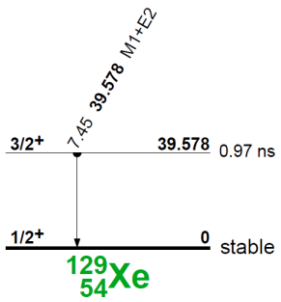



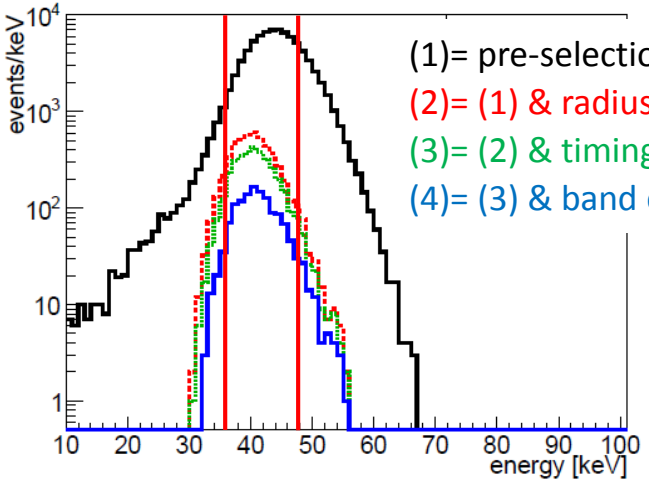

Published in Phys. Lett. B 724 46 (2013)

# Search for $^{129}$Xe inelastic scattering by WIMPs

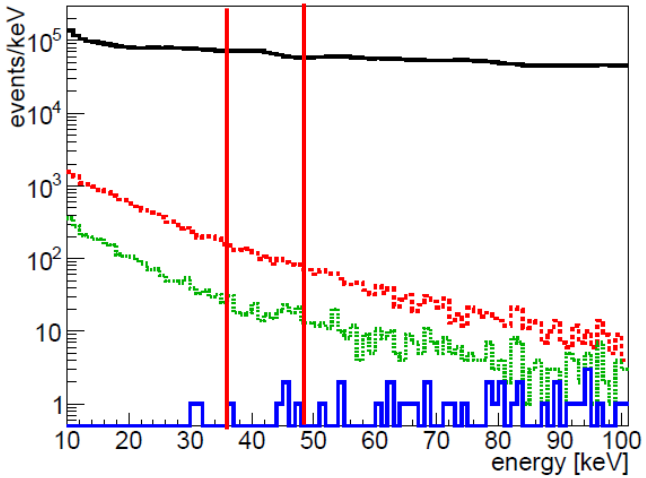
- $\chi + {}^{129}\mathrm{Xe} \rightarrow \chi + {}^{129}\mathrm{Xe}^*$
  ${}^{129}\mathrm{Xe}^* \rightarrow {}^{129}\mathrm{Xe} + \gamma$ (39.6keV)
- Natural abundance of $^{129}$Xe: 26.4%

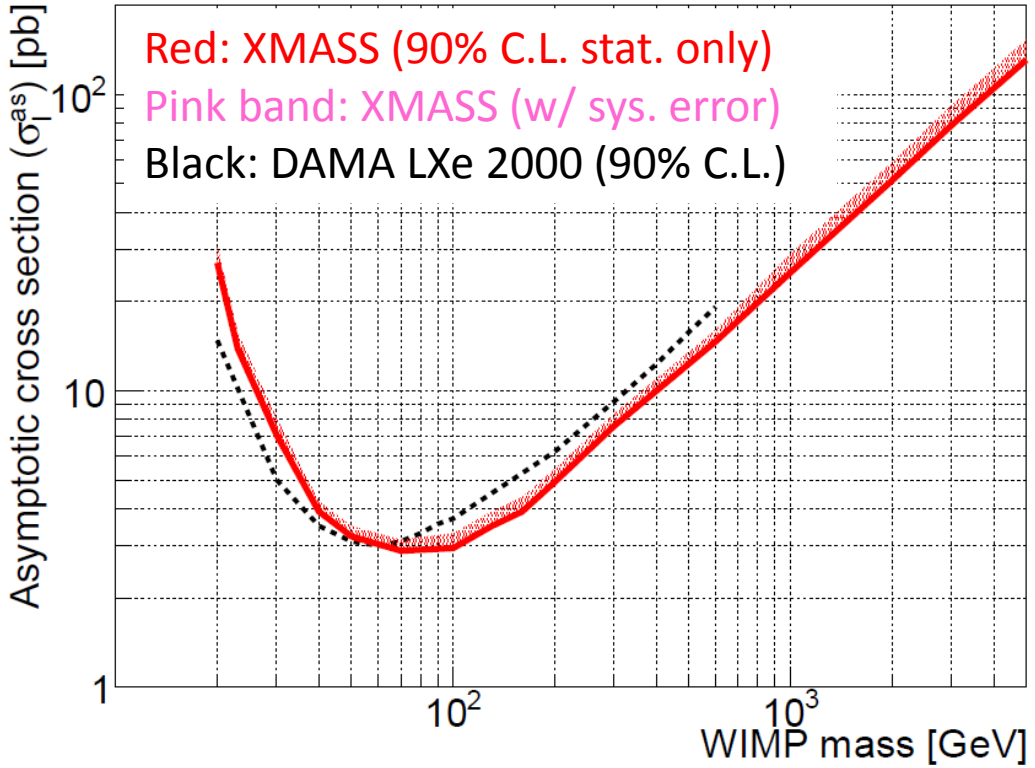



Signal MC for 50GeV WIMP




Observed data (165.9 days)



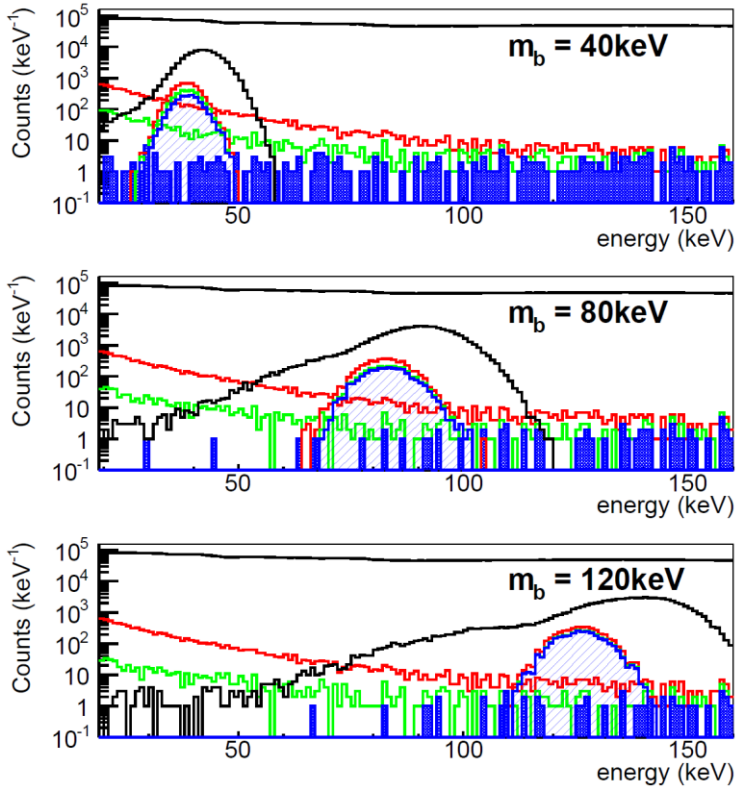



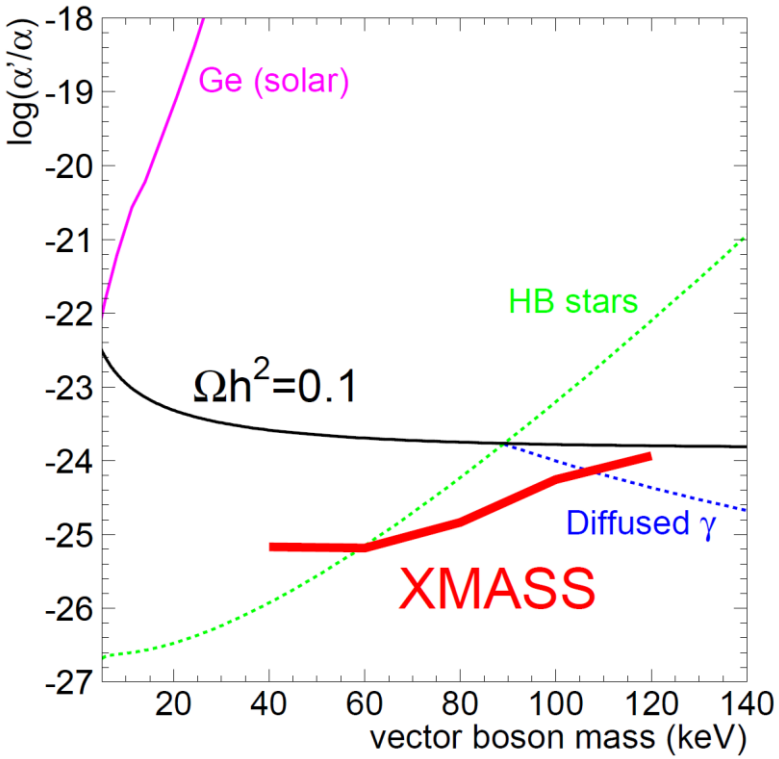

Achieved ~3x10$^{-4}$ dru @ a few 10's keV

Published in PTEP 063C01 (2014)

# Search for bosonic super-WIMPs

- Candidate for lighter dark matter
- Can be detected by absorption of the particle, which is similar to the photoelectric effect.
- Search for mono-energetic peak at the mass of the particle

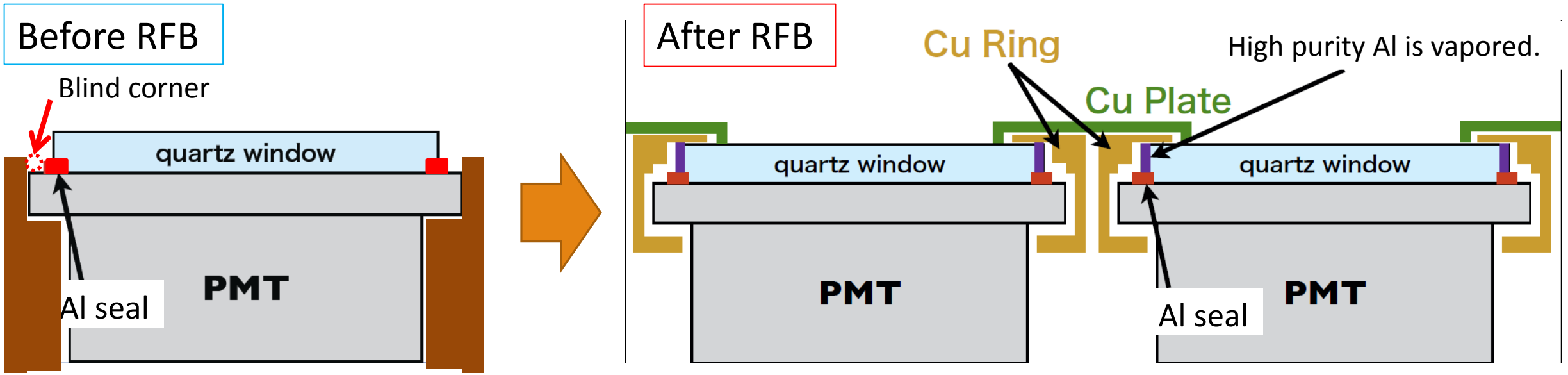

Limits on pseudoscaler boson coupling are also obtained.

arXiv:1406.0502

# Detector refurbishment and current status

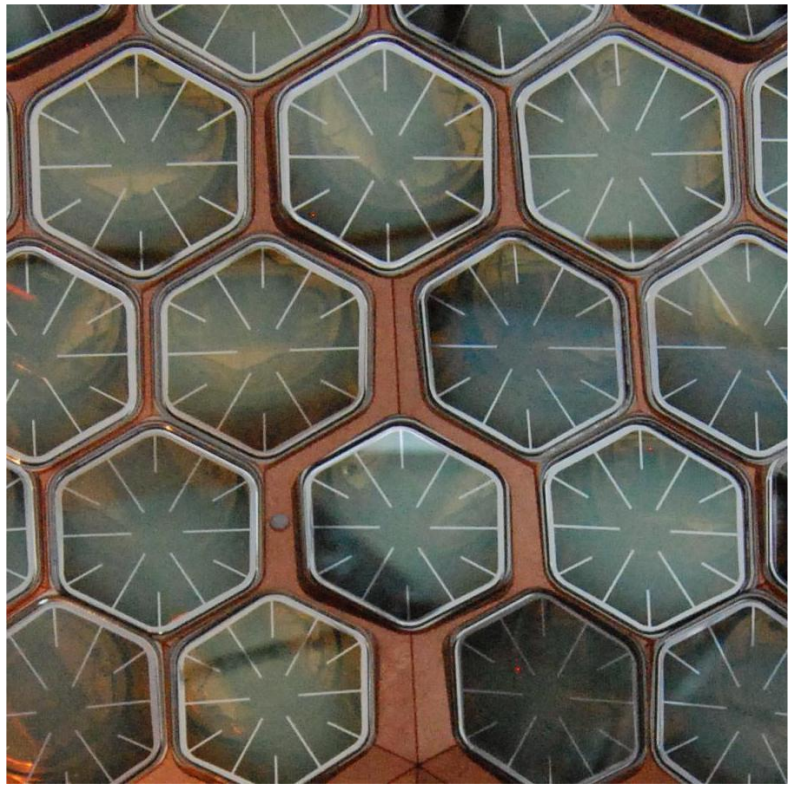
# Detector refurbishment

- Found RIs (210Pb, 238U) in the Aluminum seal of PMT.
- BG events at the blind corner of PMT are often misidentified as events in the fiducial volume.
- To reduce this background, new structures to cover this Al seal were installed.

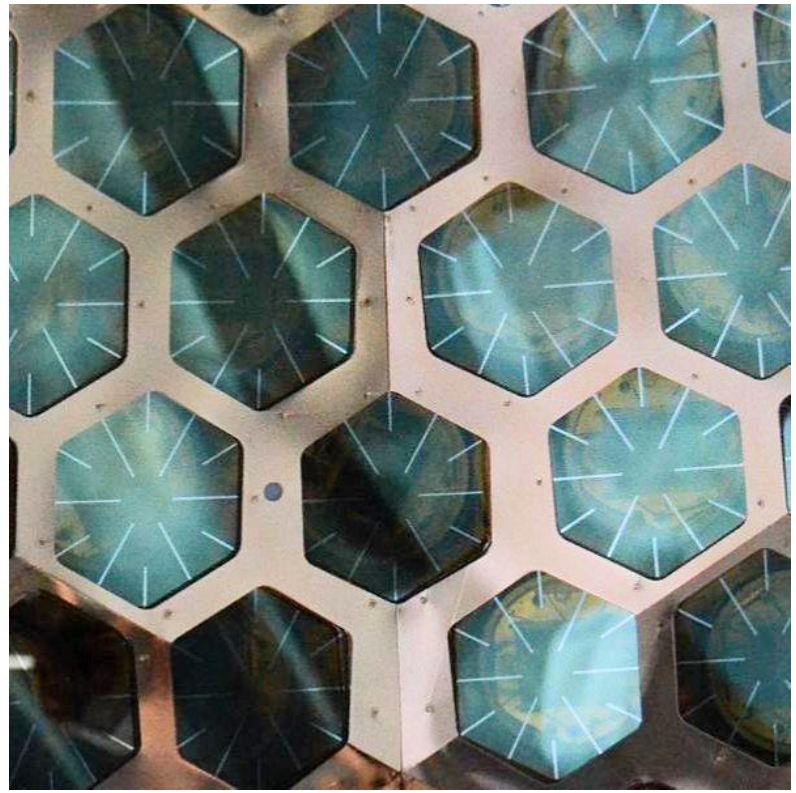


# Photos of detector inner surface

Before refurbishment

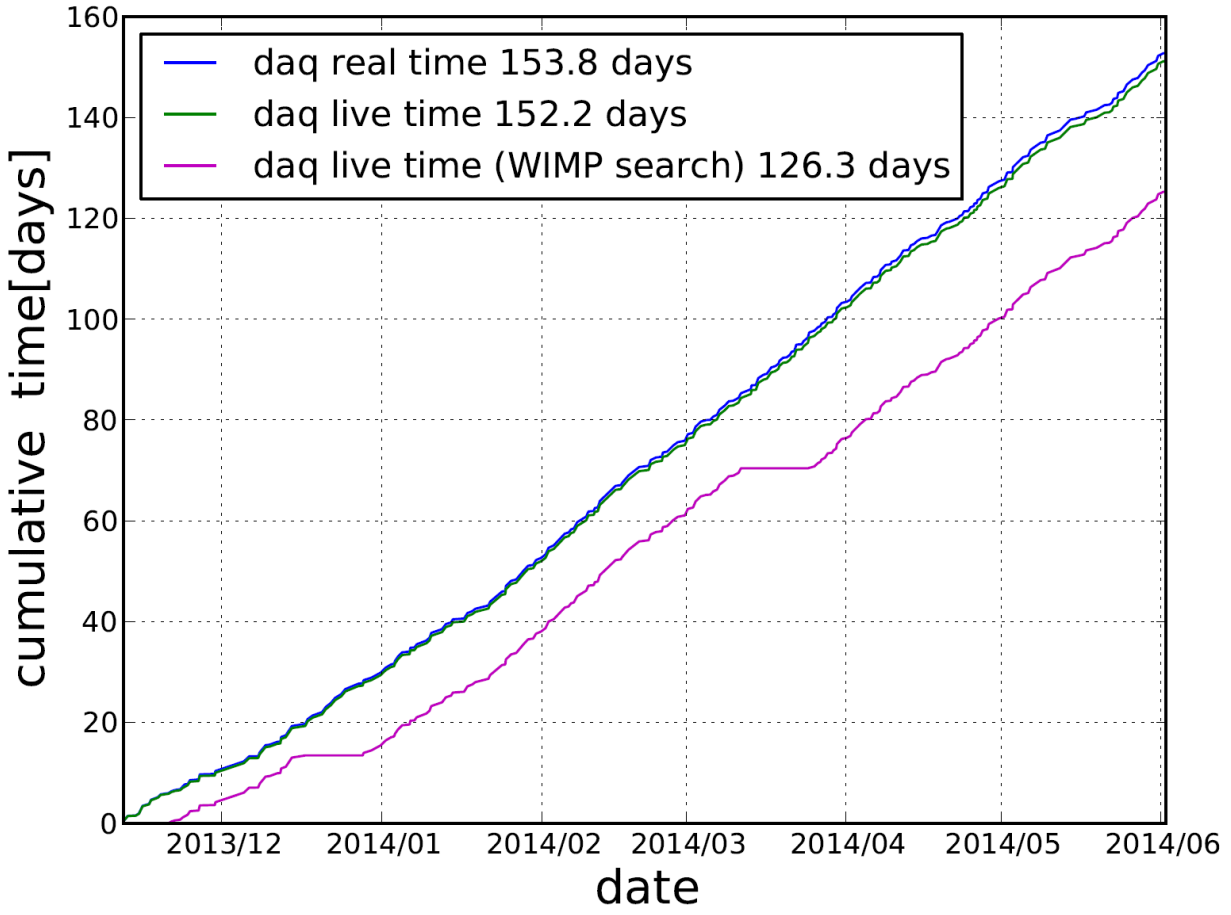


After refurbishment



# Data-taking with the refurbished detector

- We resumed data-taking in Nov. 2013.
- This time, 1GS/s flash-ADC was fully introduced to record waveforms of each PMT.
- Took several calibration data using gamma-ray and neutron sources to understand detector response.
- Already accumulated 126 days data for WIMP search.



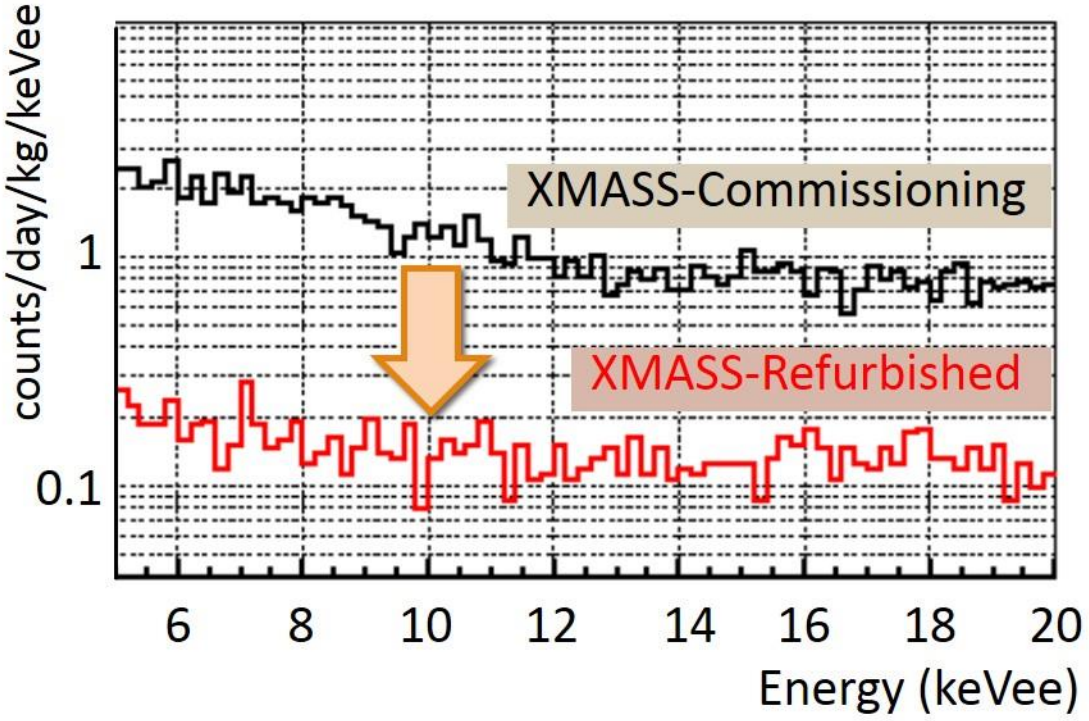
# Current status

- Understanding of detector response
- Understanding of reconstruction performance
- Understanding of BG
  - ➔ They are on-going

- Quick check of BG in entire volume
  One order of magnitude reduction above 5 keVee for entire volume achieved.

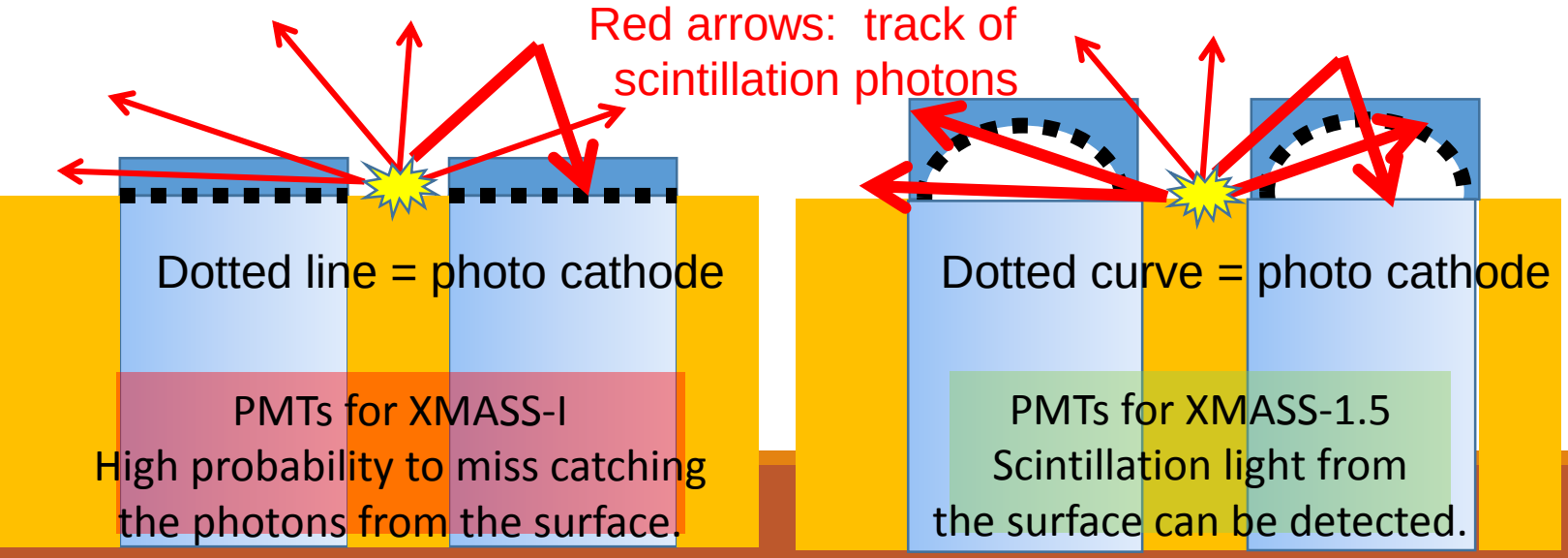
- Results will come in near future

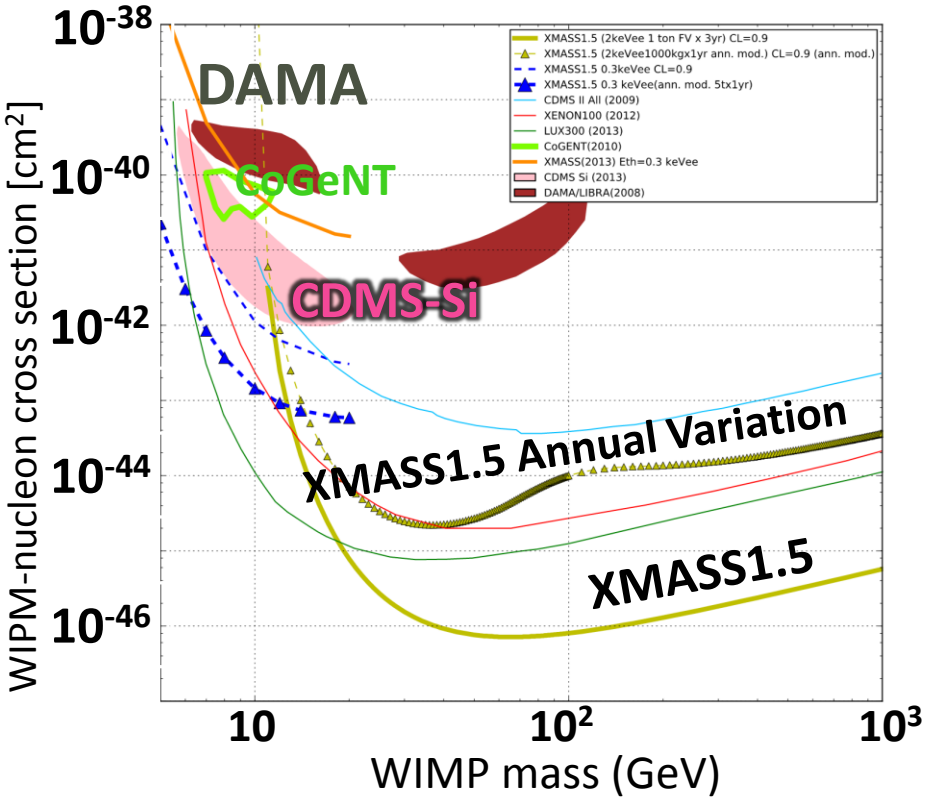
Energy spectra in entire volume (without position reconstruction)



# Future: XMASS-1.5

- Total 5 tons of liquid xenon (with fiducial mass of 1 ton)
- Target sensitivity for $\sigma_{SI}$ <$10^{-46}$ cm$^2$ for 100 GeV WIMPs
- Design of the detector is on-going



# Summary

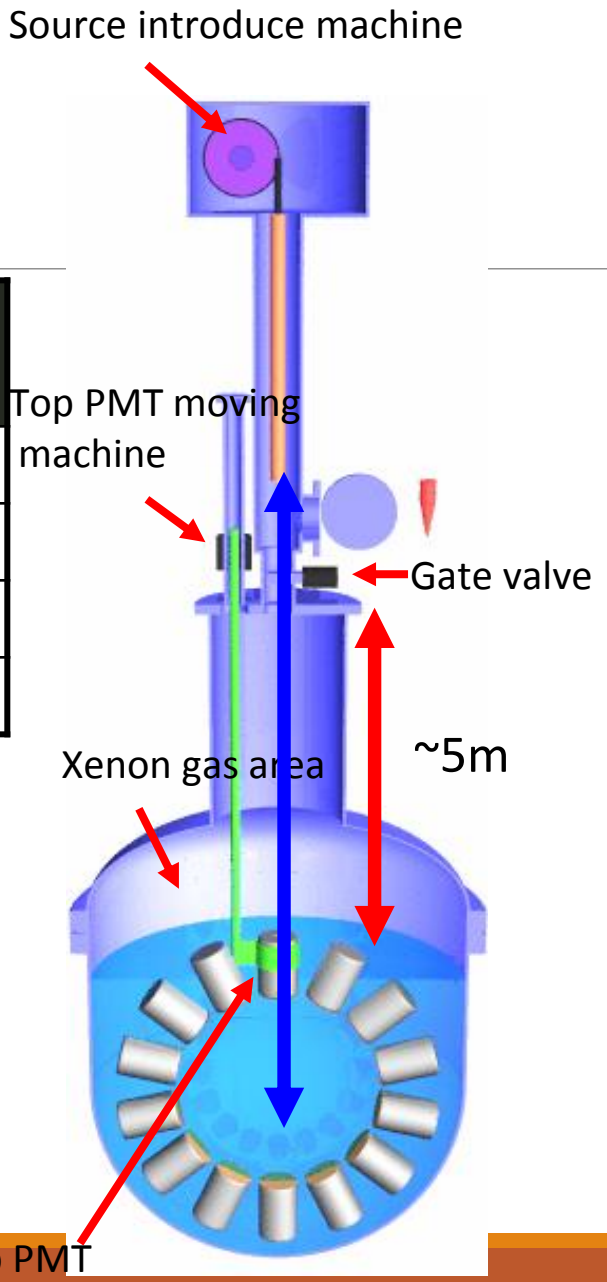
- Physics results from commissioning data
  - Light WIMPs : Published in Phys. Lett. B 719 78 (2013)
  - Solar axions : Published in Phys. Lett. B 724 46 (2013)
  - $^{129}$Xe inelastic scattering by WIMPs : Published in PTEP 063C01 (2014)
  - Bosonic super-WIMPs : arXiv:1406.0502
- Current status
  - Refurbishment of detector completed and data-taking resumed in Nov. 2013.
  - Results will come in near future.
- Future
  - Designing of XMASS-1.5 is on-going.

# Backup slides

# Calibration system

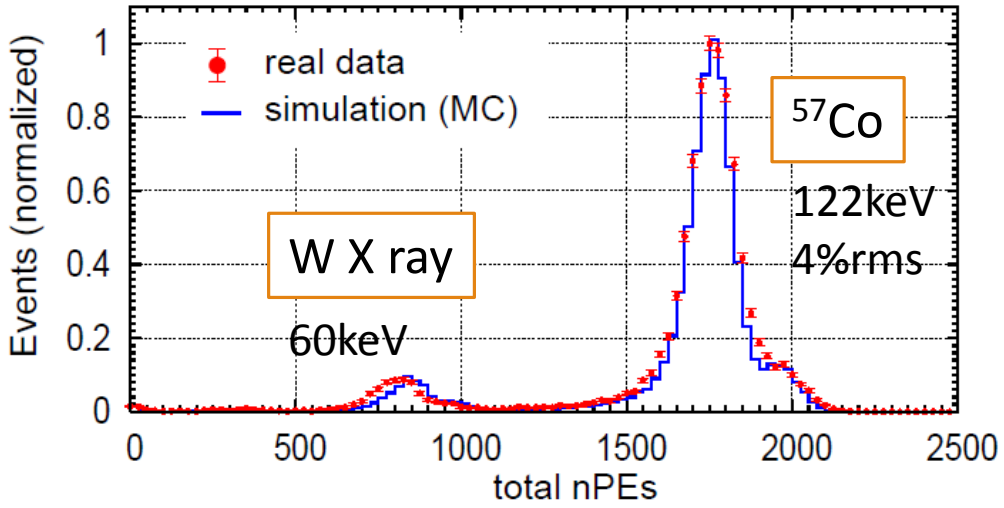
## RI sources

| | energy [keV] | RI [Hz] | φ [mm] | package |
|---|---|---|---|---|
| (1) Fe-55 | 5.9 | 350 | 5 | brass |
| (2) Cd-109 | 22, 25, 88 | 800 | 5 | brass |
| (3) Am-241 | 59.5 | 485 | 0.15 | SUS |
| (4) Co-57 | 122 | 100 | 0.21 | SUS |

# Detector response for a point-like source

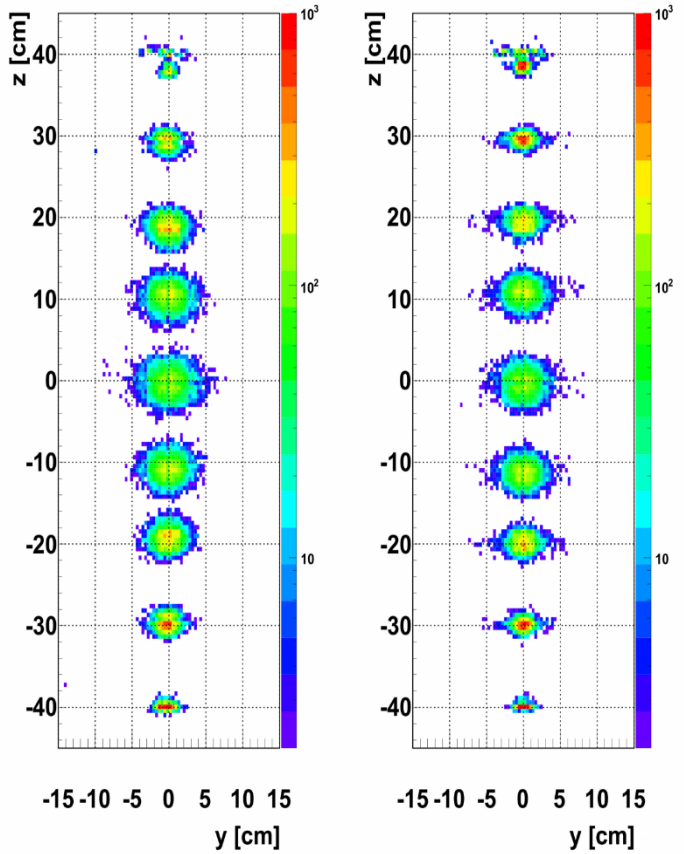
## Total photoelectron distribution



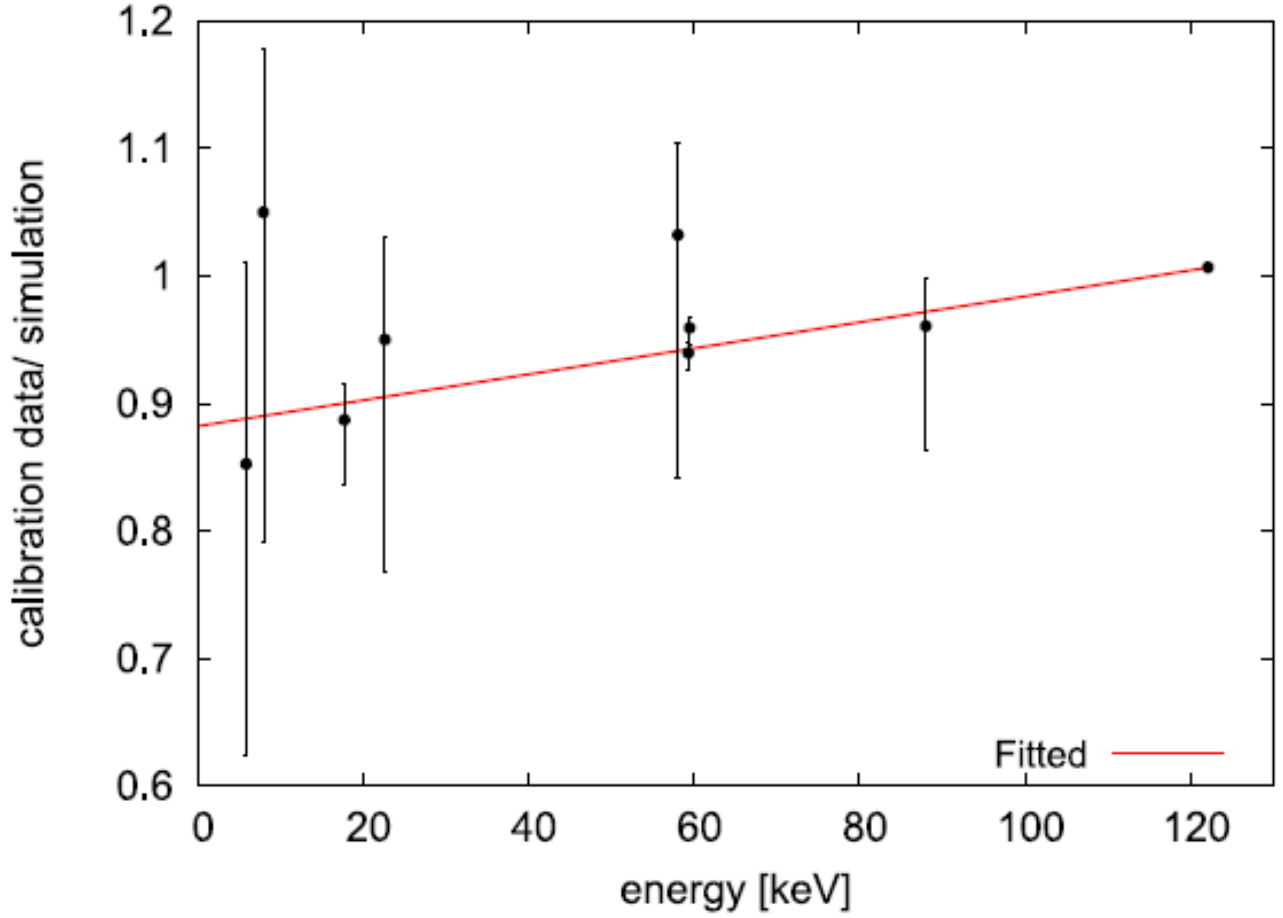

- $^{57}$Co source @ center gives a typical response of the detector.
- photo electron yield 14.7p.e./keV$_{ee}$
- The total pe and reconstructed vertex distributions were reproduced by a simulation well.

## Reconstructed vertex distribution

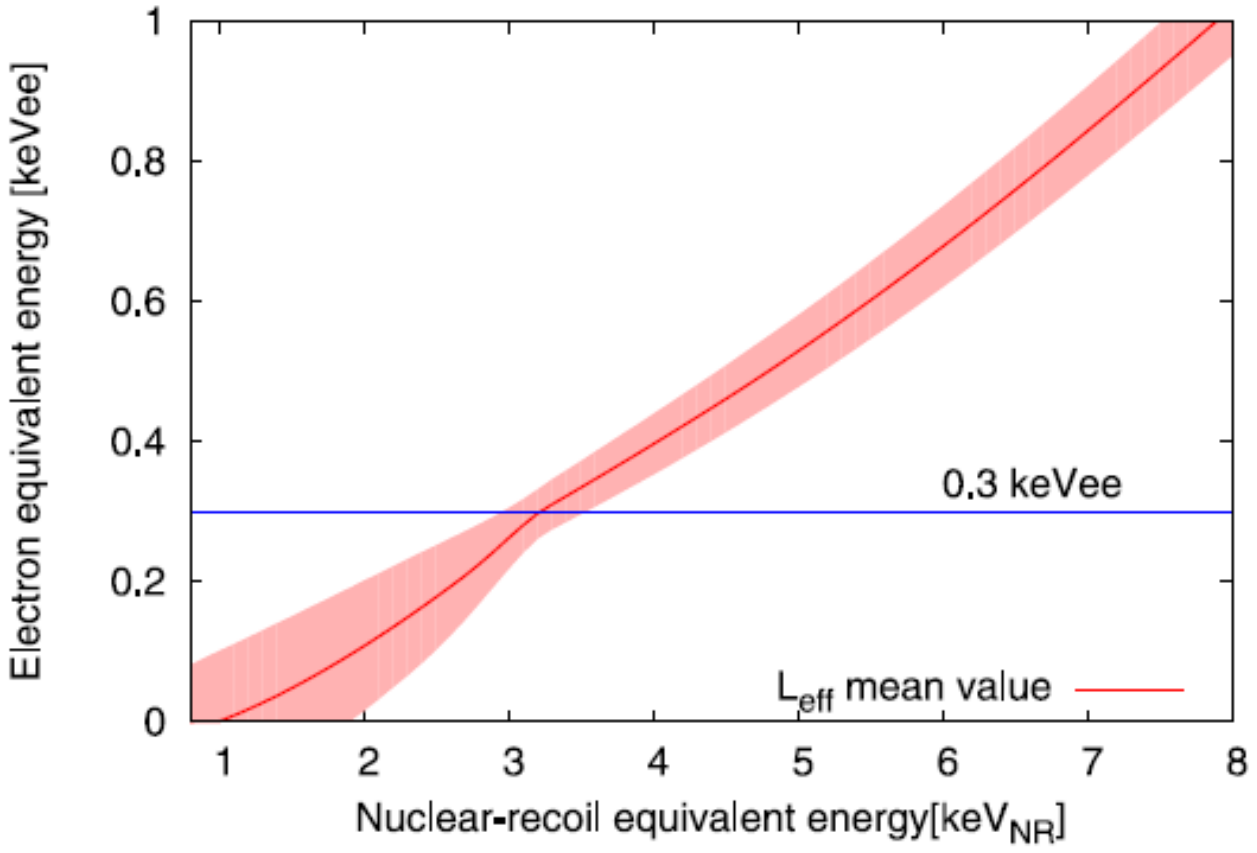
Real Data Simulation



# Energy scale calibration



# Leff


Electron equivalent energy [keVee]
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
0.3 keVee
$L_{eff}$ mean value
Nuclear-recoil equivalent energy[$keV_{NR}$]

# Trigger efficiency