Direct Dark Matter Search with XMASS

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XMASS experiment

XMASS

Multi purpose low-background and low-energy threshold experiment with liquid Xenon

- Xenon detector for Weakly Interacting MASSive Particles (dark matter search)
- Xenon MASSive detector for solar neutrino (pp/\(^7\)Be)
- Xenon neutrino MASS detector (\(\beta\beta\) decay)

Purpose of the first phase is the dark matter search.

history of XMASS

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<td>Kavli IPMU, University of Tokyo</td>
<td>J. Liu, K. Martens, Y. Suzuki</td>
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<td>Kobe University</td>
<td>R. Fujita, K. Hosokawa, K. Miuchi, Y. Ohnishi, N. Oka, Y. Takeuchi</td>
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10 institutes, 39 collaborators
Kamioka mine

KamLAND

Super-K

CANDLES

XMASS

Lab2/EGad

IPMU Lab1

NEWAGE

CLIO

To: Atotsu mine entrance

~1000m underneath Mt. Ikenoyama

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XMASS detector

- Outer detector (water tank)
  - 72 20-inch PMTs for cosmic-ray muon veto.
  - Water is also passive shield for gamma-ray and neutron from rock/wall.
- Inner detector (Liquid Xe)
  - Liquid Xe surrounded by 642 2-inch PMTs
    - photo coverage: 62%
    - diameter: ~800mm
    - high light yield: 14.7 PE/keV

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NIM A716, 78-85, (2013)
--- result from commissioning run ---

1. Search for light WIMPs

- 6.7 days x 835 kg
- 0.3 keVee threshold


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2. 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*

*Axion-electric effect*

--- result from commissioning run ---

3. Search for $^{129}\text{Xe}$ inelastic scattering by WIMPs

- $\chi + ^{129}\text{Xe} \rightarrow \chi + ^{129}\text{Xe}^*$
- $^{129}\text{Xe}^* \rightarrow ^{129}\text{Xe} + \gamma (39.6\text{keV})$

- Natural abundance of $^{129}\text{Xe}$: 26.4%

Signal MC for 50GeV WIMP data (165.9 days)

- (1) = pre-selection
- (2) = (1) & radius cut
- (3) = (2) & timing cut
- (4) = (3) & band cut

Background level is $\sim 3 \times 10^{-4}\text{count/day/kev/kg}$.

Red: XMASS (90% C.L. stat. only)
Pink band: XMASS (w/ sys. error)
Black: DAMA LXe 2000 (90% C.L.)

PTEP 063C01 (2014)
--- result from commissioning run ---

4. 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

arXiv:1406.0502

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Detector refurbishment (RFB)

- We found RIs (210Pb, 238U) in the Aluminum sealing part of PMT (secular equiv. broken).
- Background 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.

Before RFB

After RFB

High purity Al is vaporized.
Photos of detector surface area

Before RFB

After RFB

detector inner surface

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We resumed data taking in Nov. 2013.

1 GS/s flash-ADC was installed to record waveforms of individual PMT.

We have accumulated 126 days data so far.

One order of magnitude reduction above 5 keVee in the entire volume achieved.
Improvement by RFB

- In addition to one order of magnitude reduction in >5keVee, huge background event can be reduced to ~1/10 with simple identification using max PE (maximum PE in one PMT) / total PE.

- Detail analysis is ongoing.

Big improvement

Normalized by live time

Band made by saturation in DAQ

event in the gap: low maxPE/totalPE

events in the PMT surface: high maxPE/totalPE

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XMASS 1.5 as a next step

- Larger detectors have many advantages. 1t FV (5t total).
  - Target sensitivity is $\sigma_{\text{Si}} < 10^{-46} \text{ cm}^2$ for 100 GeV WIMPs.
- Detector design is ongoing.
  - PMT
    - We can use U-free Al in hand.
    - New PMTs being developed help to identify surface events.
- Surface BG must be controlled.

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summary

- We have published / are publishing physics results with commissioning data
  - Light WIMPs
  - solar axions
  - $^{129}$Xe inelastic scattering by WIMPs
  - Bosonic super-WIMPs
- Detector refurbishment has been completed and we resumed data taking. Results will come in the near future.
- Designing of XMASS-1.5 is ongoing.