Activity report of BO4

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Contents

- Solar axion search experiment
 - Summary of Test run result
 - Way forward to enlarge the area
 - Development of TES microcalorimter
 - Development of multiplex readout
- XRISM
 - Observation of clusters of galaxies and implications

Solar axion at 14.4 keV



Detection efficiency



µCalorimeters: detect heat dissipation





XRISM Resolve sensor 32 pixel array with ion-implanted Si thermister



 $\Delta E \sim 4.5 \text{ eV}$ in space !





"What is dark matter? - Comprehensive study of the huge discovery space in dark matter", 2025/Apr/24-25





A sample chip with 57Fe



A test run in early 202







Energy (keV)

Calibration





57Co RI was used as a calibration source with the 14.4 keV γ. 14.4 keV and Fe fluorescence lines are detected.







Comparison with past results

Namba (2007) obtained by 57Fe foil + Si PIN as $R < 2.33 \times 10^6$ c/day/kg(95 % U . L.)

Following the Moriyama (1995) formula, he assumed QCD axion of KSVZ model (heavy quark, $f_a P Q$ scaler) as

$$R = 3.1 \times 10^{2} / \text{day/kg} \left(\frac{10^{6} \text{ GeV}}{f_{a}} \right)^{4} C^{4}$$
$$m_{a} = \frac{\sqrt{z}}{1+z} \frac{f_{\pi}m_{\pi}}{f_{a}} = 1 \text{ eV} \frac{\sqrt{z}}{1+z} \frac{1.3 \times 10^{7}}{f_{a} / \text{GeV}}$$

 $m_a \propto 1/f_a \propto R^{1/4} \Rightarrow m_a < 1.0 \pm 0.04 \text{ keV}(95\% \text{ UL})$ xion rateの95%上側信頼限界

The result is shown by Yagi+ in ASC 2024.

Overlaid on PDG figure of g_{an}



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- Longer exposure > 100 days (x 10²)
- Huge absorber \Rightarrow NO ! large C \searrow Resolution

 \Rightarrow We need large format arrays. (x 10²⁺¹)

- Fabrication of TES array with 57Fe
- Readout large format array in refrigerator
- Reduce background (x 10¹)
 - Anti-counter

Processes to make TES microcalorimeters at ISAS/JAXA clean room



Fabrication of Ti/Au bilayer



Vapor deposition for Ti/Au TES procured by this 20H05857 in FT 2021.

Ti: electron beam heating Au: resistive heating in 1 vacuum chamber installed in ISAS CR.



We need to optimize thickness of Ti/Au to set the Tc and C









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A trial of Anti-counter



Fabricated by ISAS CR

Ikeda-san designed anti-counter utilizing TES referred Athena anti-counter (ex. Andrea + 2024). A large absorber of Si wafer (2.5-10 mm square) can detect Cosmic Rays.



Transition at ~ 150mK was measured, Irradiation test has not yet done.

Multiplex $38 \rightarrow 66$ pix simultaneously







Nakashima ph.D. thesis, Nakashima+ 2020

Now 80 pixel read-out system in 1.2 GHz BW (4.7-5.9 GHz) is working. 160-pixel in 2.4 GHz BW is under development.

 \Rightarrow 256 pix is achievable in 1 line with

4GHz BW it gives ~10 mW heat load @ 4K

 \Rightarrow ~ 1000 pix is feasible within current technology

LD400 dilution in Fuji hall

In April 2024



We need to install many components.



MWMUX and TES assembly



Cold stage and PCB board are designed and fabricated.

MWMUX04 in FY2024

Kikuchi, Hayakawa, Ikeda +

In 2024, 3 MWMUX chips with 40 channel each utilizing 4.0-4.6GHz, 6-8 GHz were fabricated and evaluated in AIST.



There are some fluctuations in coupling capacitance.

Room temp. electronics box





Copied from AIST design. Now waveforms from 40 pix are handled by 1 FPGA board.

Cold stage design and assembly



Ikeda and Sato designed the stage, and made in ISAS machine shop. Cooling test was finished.



HEMT amp, attenuator etc. are installed.

HEMT, circulator etc.

LNF LNC4_8F



Gain (dB)



Gain is consistent with the spec.

Cable loss and noise of the system is measured and consistent with the design.

A Picture at the end of FY 2024



XRISM !

A2029 (XRISM+2025, 10.3847/2041-8213/ada7cd) Centaurus(XRISM+2025, 10.1038/s41586-024-08561-z)

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Counts keV⁻¹



Resolve's energy resolution reaches $\sim 4.5 \text{ eV}$ (FWHM) Turbulence velocity in CoG is as small as < 150 km/s DM search for PV data is underway

Yin+2025 arXiv:2503.04726 Assuming "double peak" lines by the 2-body decay due to the Doppler shift by radial velocity.

 $d\Phi/dE_v[\gamma cm^{-2}s^{-1}]$

0.00006

0.00004

0.0000



a. Central

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Counts ke/ 0.2 b. Central

Zoom-in around He-a Fe

Coming Events

AO2 proposal by May 15th



Home > For Proposers

Home	For Proposers
News & Announcements	
About XRISM	Current AO announcement
For Proposons	
For Observers	Accepting GO Cycle 2 (AC-2) proposals. Due date: 2025/05/15 (May 15th) 18:20 JST
Analysis	Raferenaas
Helpdask	XFISM Cycle2.GO annoucement by JAXA (update 2025/2114) XFISM Cycle2.GO JAXA 公募文(2025/2114更能)(JAPANESE)
Useful links	Proposers' Observatory Guide (POG)
	Current AO ARK/RPS page
	Planning Observation
	ToO Requests
	Approved Target List
	Early Release Data



Summary

- Thanks to this Henkaku kakenhi "What is dark matter ?"
 - We have investigated a new method to search Solar axions utilizing TESs with 57Fe absorber.
 - A dedicated test chip was fabricated, tested, and proved to work as a detector. $m_a < 1.0 \pm 0.04 \text{ keV}(95\% \text{ UL})$
 - Nice TES is fabricated by a new evaporator and the Tc of the Ti/Au bilayer is understood and controllable.
 - To improve the sensitivity, the optimization of TES array and multiplexed readout is required. A ~160-channel readout MWMUX is installed in a refrigerator now. (A backup system is also ready.)
 - XRISM with a calorimeter array "Resolve" was launched in 2023. It achieved an energy resolution of 4.5 eV (FWHM) in orbit. New approach to search for DM will come widely.