B04
High Resolution X-ray Spectroscopy to Search DM

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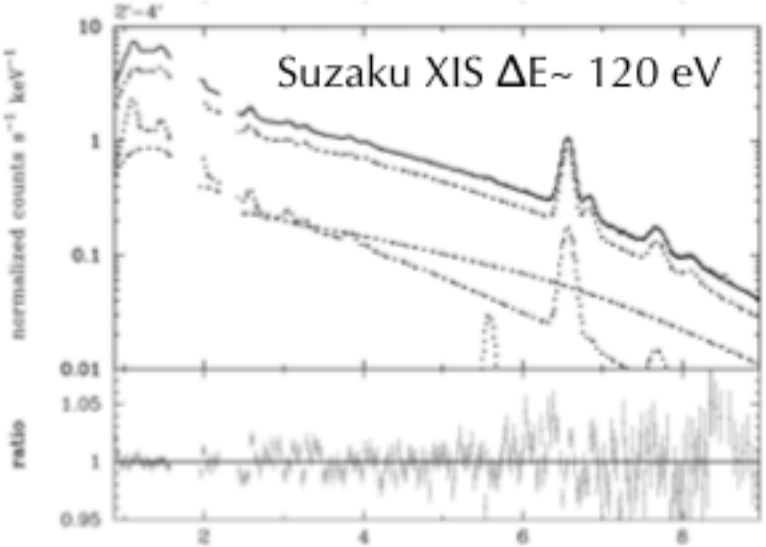
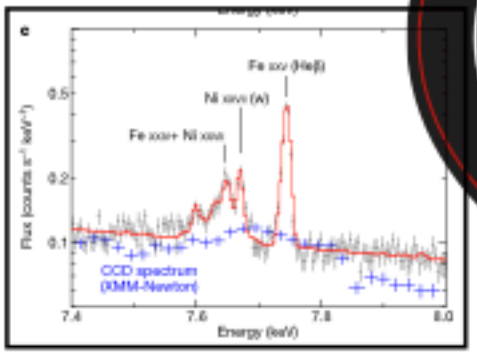
Purpose of B04 research group

Fine X-ray spectroscopy utilizing microcalorimeters will open innovative observation and measurement.

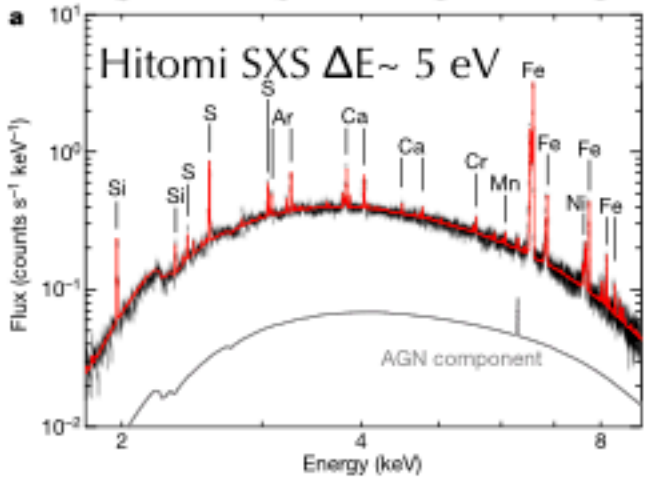
X-ray Energy spectra of Perseus clusters of galaxies



(Tamura + 2009)



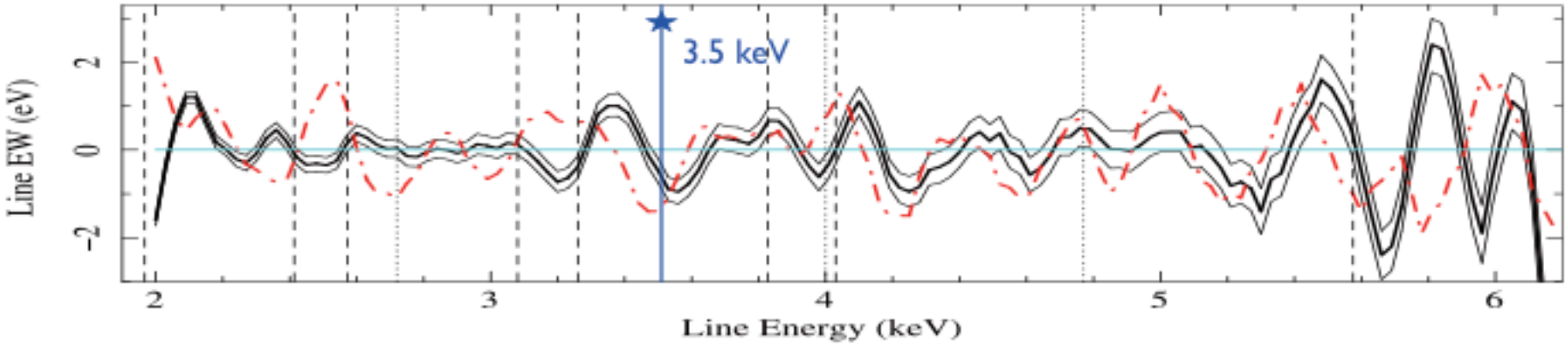
XRISM will launch in FY2022 !

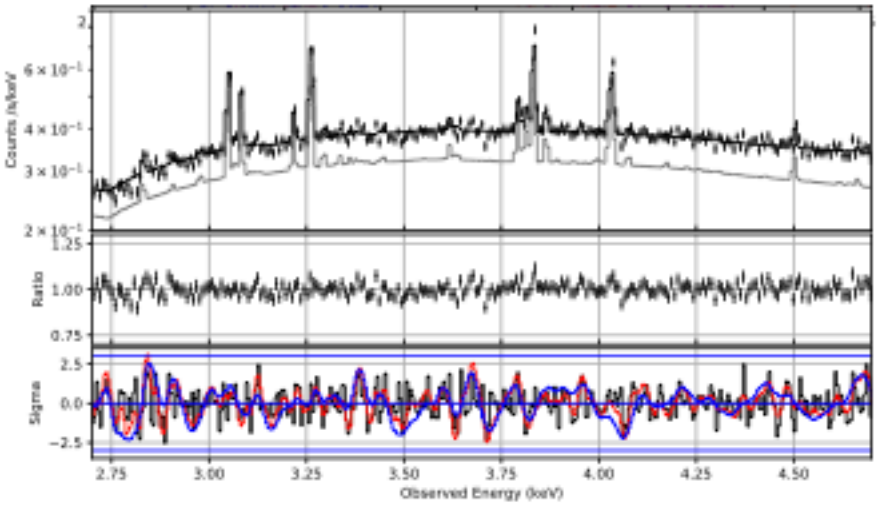


(Hitomi collab. 2016)

Improvement in DM sensitivity

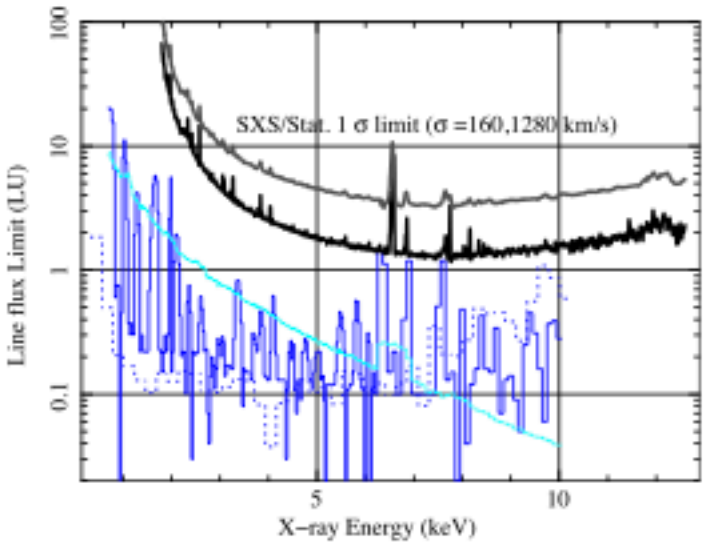
Tamura et al. 2015
U.L. for 3.5 keV line by Perseus Cluster by Suzaku CCD





Tamura et al. 2019
by Hitomi calorimeter

set U.L.for line width (160/1280 km/s)
and intensity



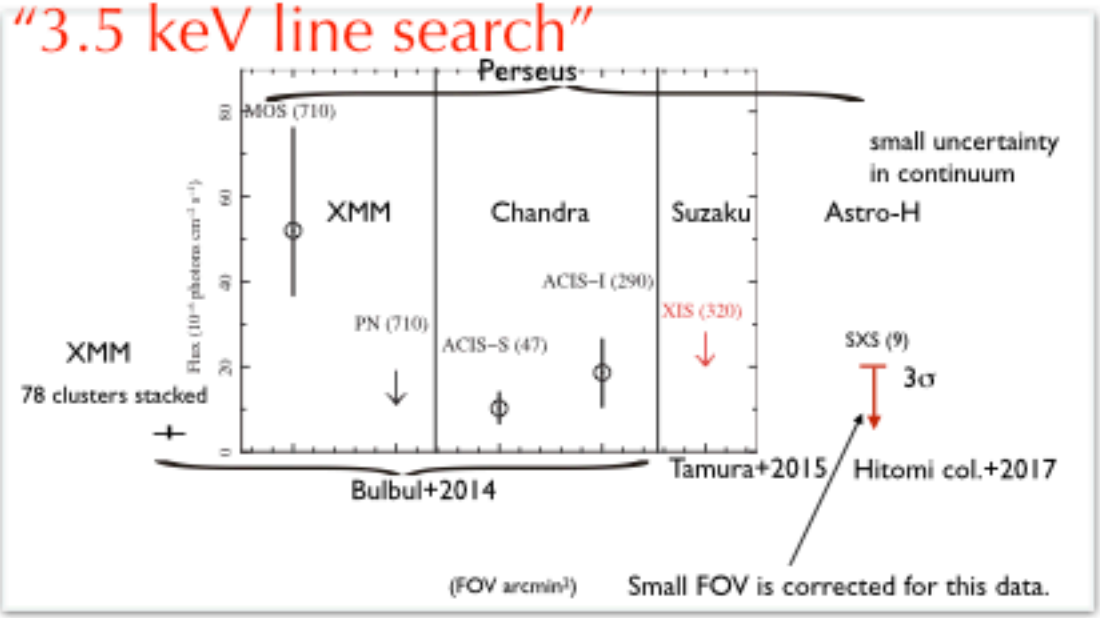
Statistical Limit: $$\frac{S}{N} \propto \frac{M_{DM} A \Omega T}{\sqrt{(A\Omega B_{sky} + B_{inst}) T \Delta E}}$$

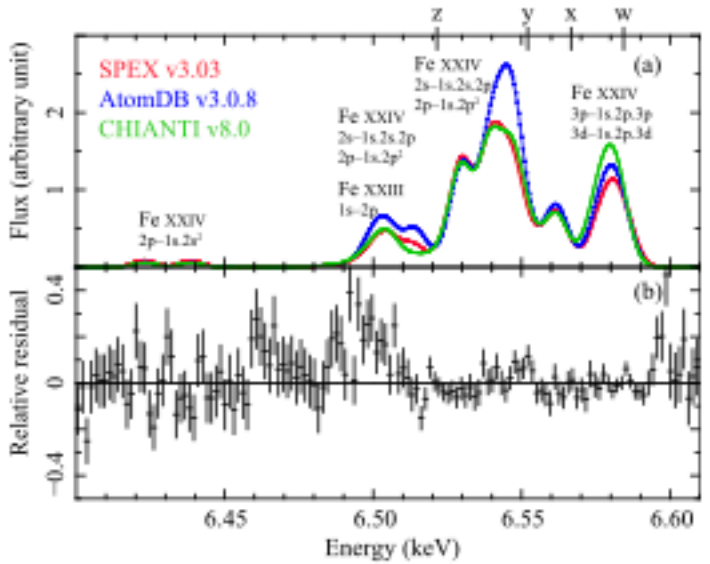
Energy resolution

Systematic Limit: Understanding the plasma emission and instrumental response

FoV(AΩ) of Resolve is much smaller than CCDs, but fine spectroscopy will decrease the systematic errors of foreground celestial emission.

"3.5 keV line search"





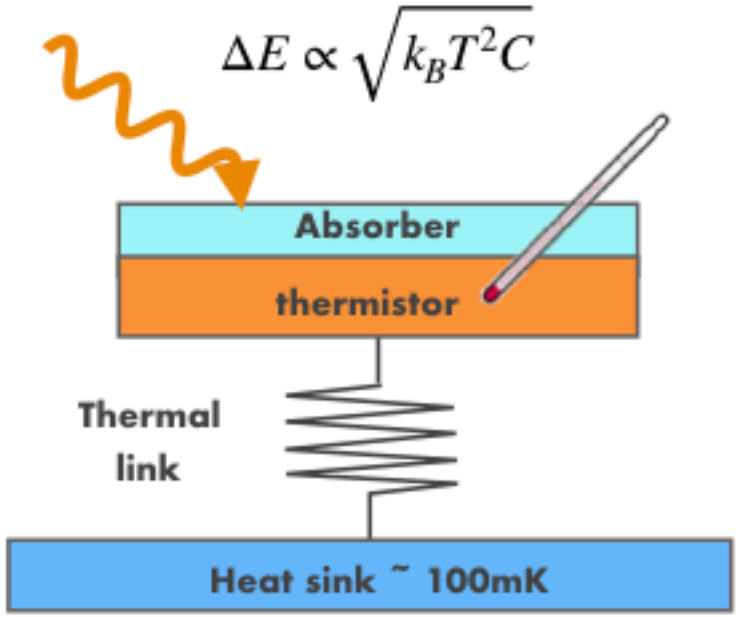
(Hitomi collaboration 2018)

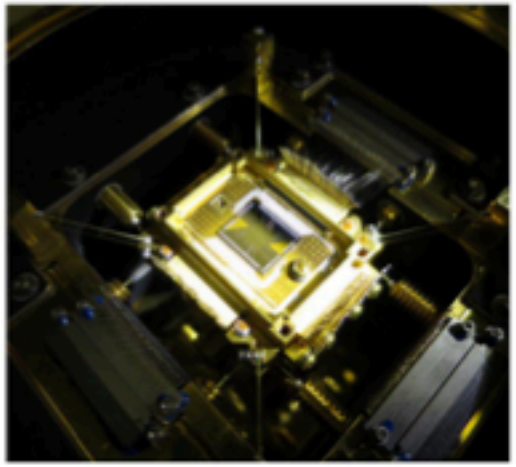
Observation by XRISM

- After the launch, 1month checkout + calibration, 6 months (~ 6Ms) of PV (Performance Verification) +calibration are planned. After that , Guest Observer (GO) phase will start.
  - PV target list is still under discussion based on internal proposals, but will be open in this spring.
  - XRISM science team member will be allowed to access all PV data, and target team will be organized.
  - DM study will not be explicitly included in PV, but we will use several observations with improved understandings of systematic errors.
- GO program will be open proposal framework, which is also under discussion.

Stay tuned to coming announce from XRISM ! (PI:Tashiro)

μCalorimeters —innovative detector—



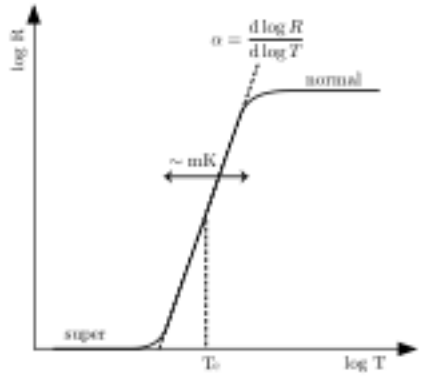


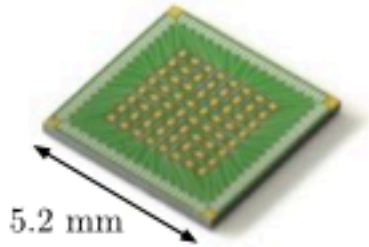
Hitomi SXS sensor
32 pixel array with
ion-implanted Si thermister
(Takahashi+2016)

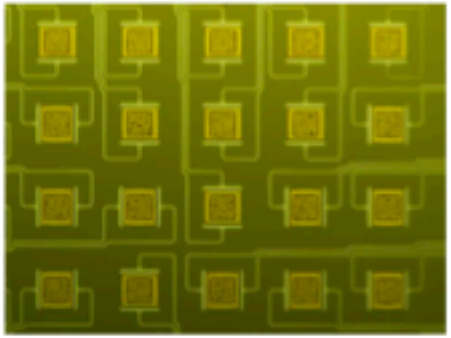
$R \propto \exp\sqrt{T_0/T}$

ΔE~ 5eV

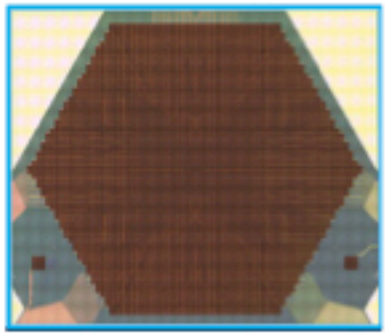
Transition Edge Sensor (TES)







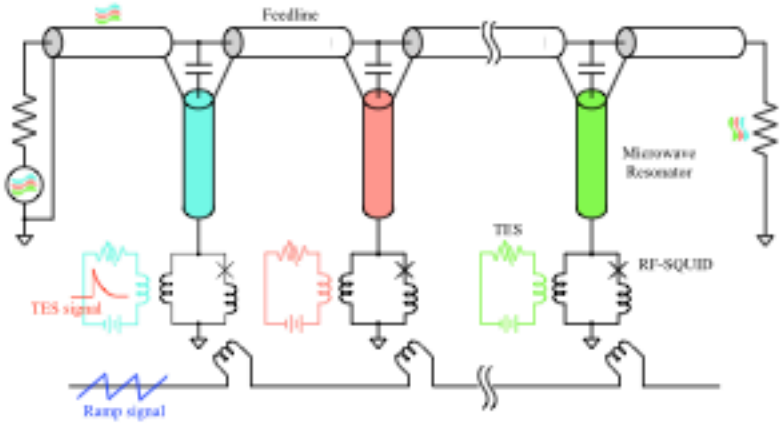
ISAS in-house 64 pix array

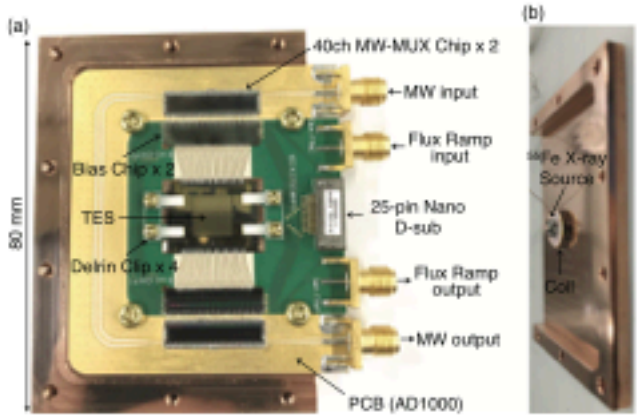


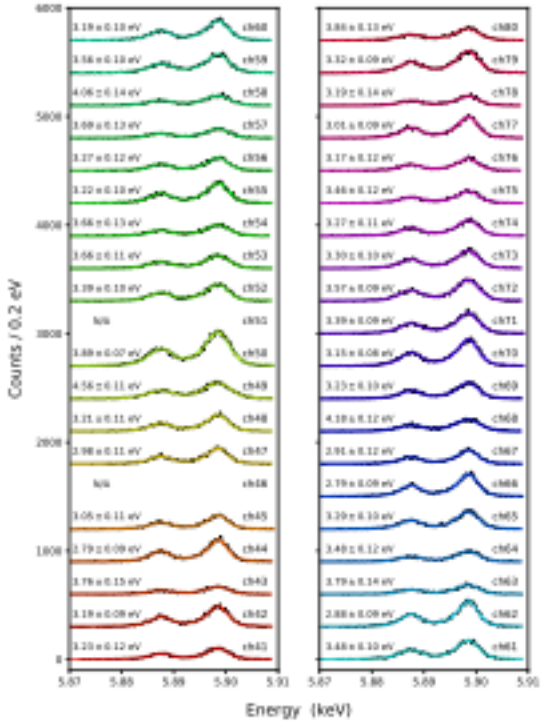
Athena 3840 array image

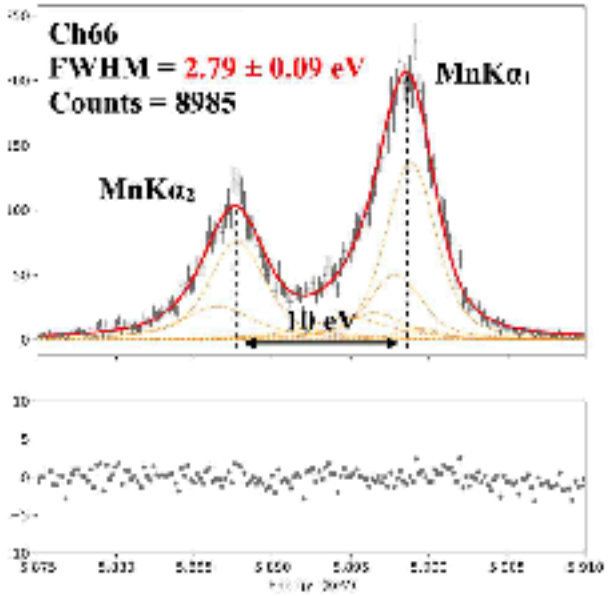
ΔE~ 2.5eV

TES array readout :Microwave SQUID MUX





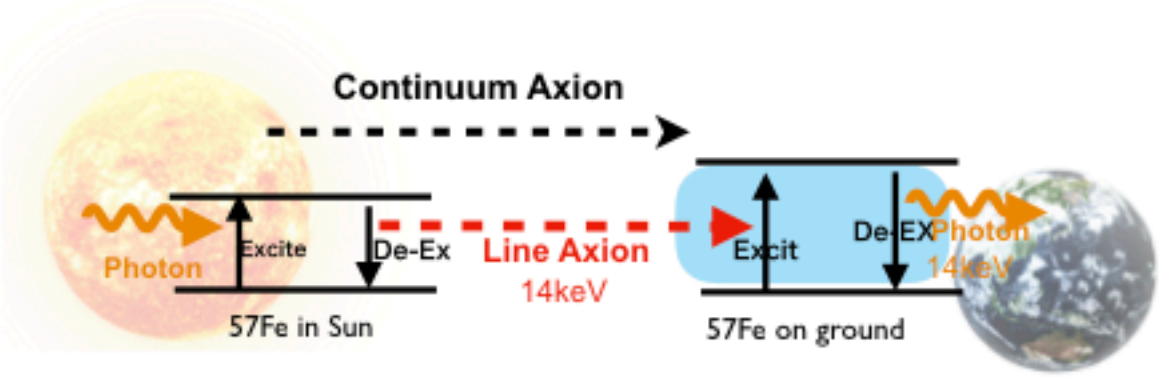




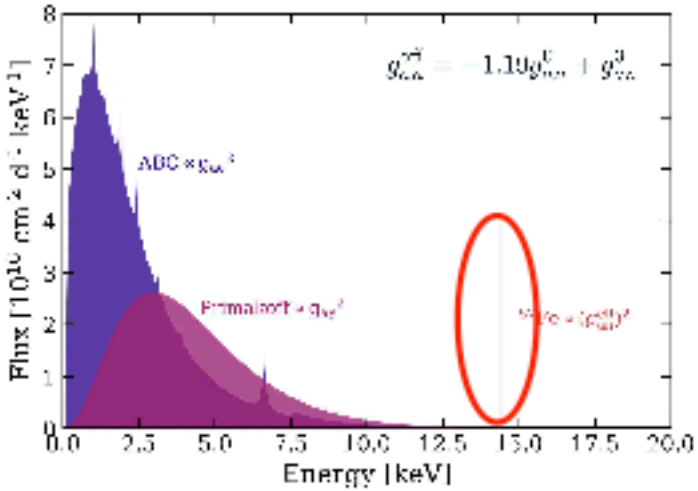
Read 40 pixels by one line and obtain <3 eV resolution
No. of pixel is now limited by bandwidth of low noise amplifier
→will be improved

Nakashima ph.D. thesis, Nakashima+ 2020

Solar axion of quantized energy

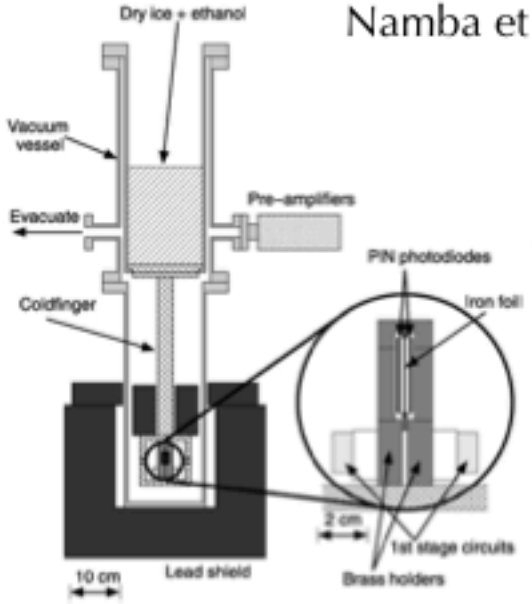


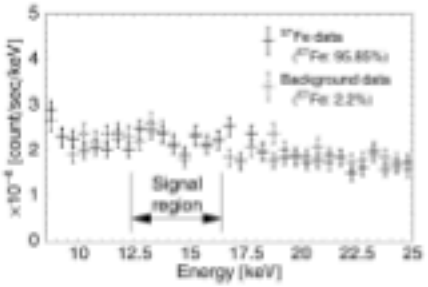
(Moriyama 1995)

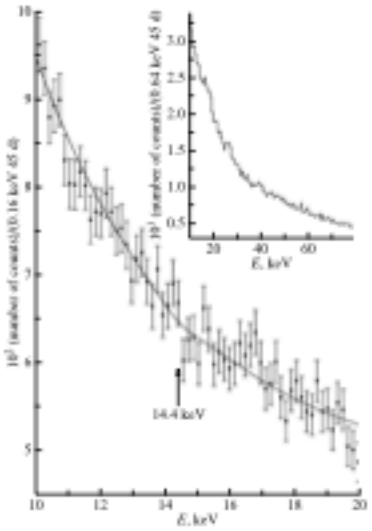


Expected Solar axion (XENON1T presentation)

57Fe foil + Si(PIN)
Namba et al. 2007





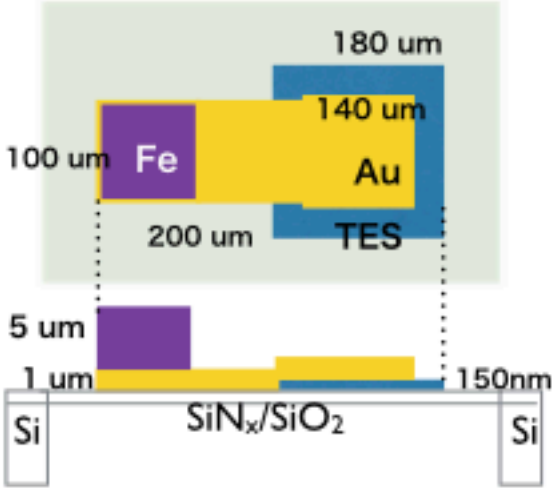


Si(Li)
Derbin et al. 2010

TES with 57Fe absorber

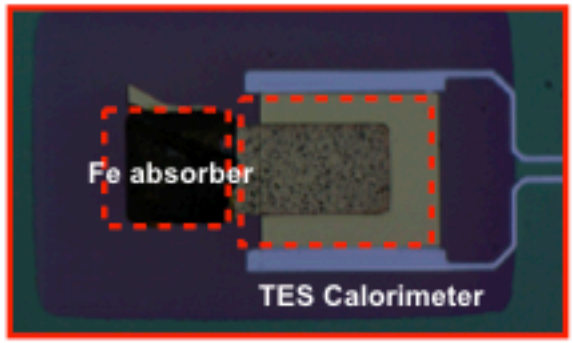
57Fe as absorbers of TES array

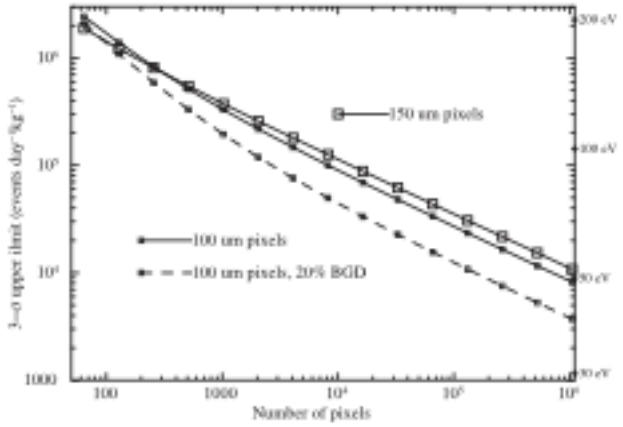
- Fine energy resolution
- Improve efficiency
- Line energy &daily modulation will give clear identification of Solar axion.



Magnetism of Fe affect TES, thus special geometry is required.

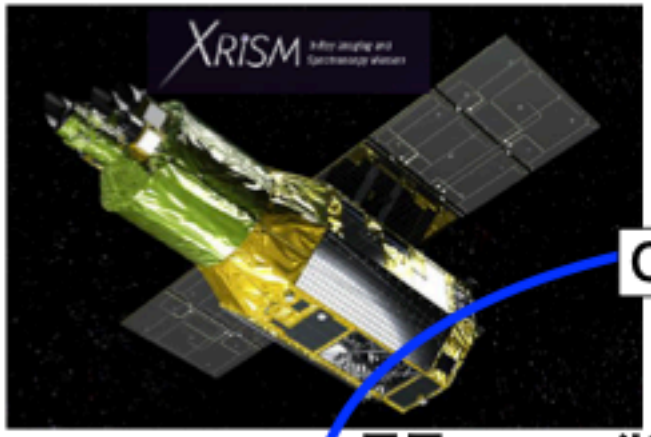
test sample with 56Fe absorber

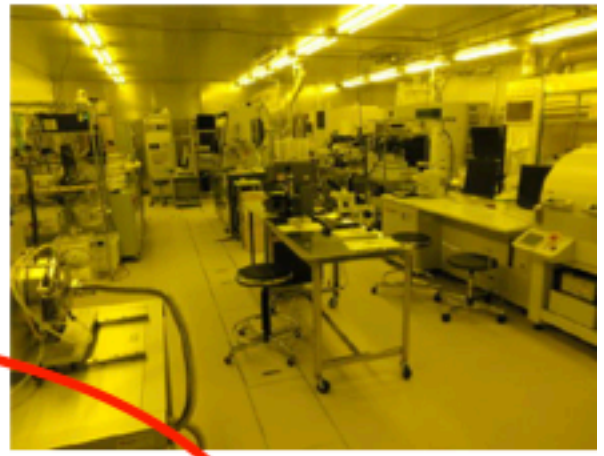




(Yagi Master thesis 2021)

Team Members





nano-electronics clean room
at ISAS

Observation

T.Tamura(ISAS)
A.Simionescue
(IPMU/SRON)

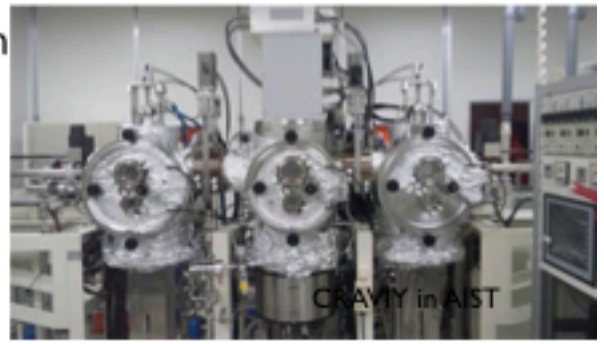
Direct Search

T.Hayashi(ISAS)
S.Kohjiro
F.Hirayama
(AIST)

N.Yamasaki(ISAS)
K.Sato(Saitama)
K.Mitsuda(NAOJ)

Dark Matter Search by
Observational Astrophysics

Dark Matter Search
by Particle Physics



JAXA KAVLI IPMU SRON 国立天文台 NAOJ National Astronomical Observatory of Japan Saitama University 埼玉大学 産総研

Expected output and outcomes from this research

- Utilize a new X-ray satellite "XRISM" to study DM.
  - Careful evaluation of background and response
  - Need observation strategy, blank sky/clusters/dwarfs ?
- Utilize a novel technology to search Solar axions
  - Large array specialized to Solar axions
- Expectation to new collaboration
  - DM models which make signals in X-ray band
    (Past study: sterile ν, axion like particles, moduli etc.)
  - New astrophysical approach ? ex. DM map by weak lens & X-ray
  - New direct search channel ?
  - Technology to improve TES performance (ex. low-T devices, RT waveform processing) and application (ex. material analysis, MKIDs.)