ISAI: The Investigating Solar Axion by Iron-57

Tomonori Ikeda,

Toshihiro Fujii[A], Takeshi Tsuru, Yuki Amano, Kazuho Amano, Masamune Matsuda, Hiromu Iwasaki, Mizuki Uenomachi, Kentaro Miuchi[B], Yoshiyuki Onuki[C], Yoshizumi Inoue[C], Akimichi Takeda[C]

Kyoto University, Osaka Metropolitan University[A],

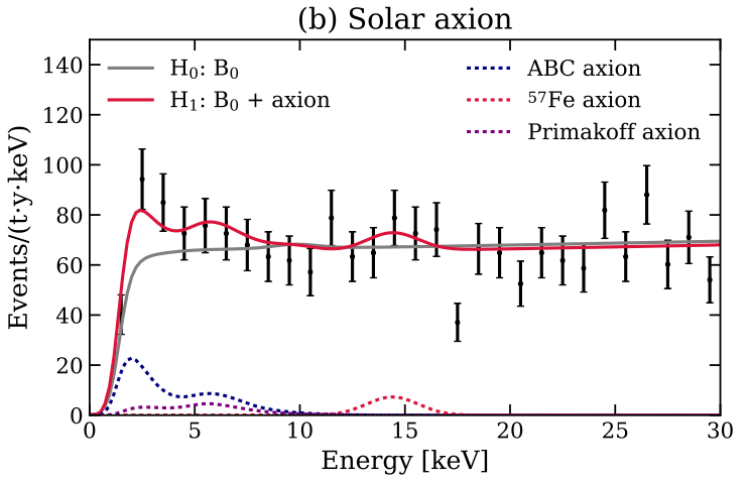
Kobe University[B], University of Tokyo[C]

14th International Conference on Identification of Dark Matter

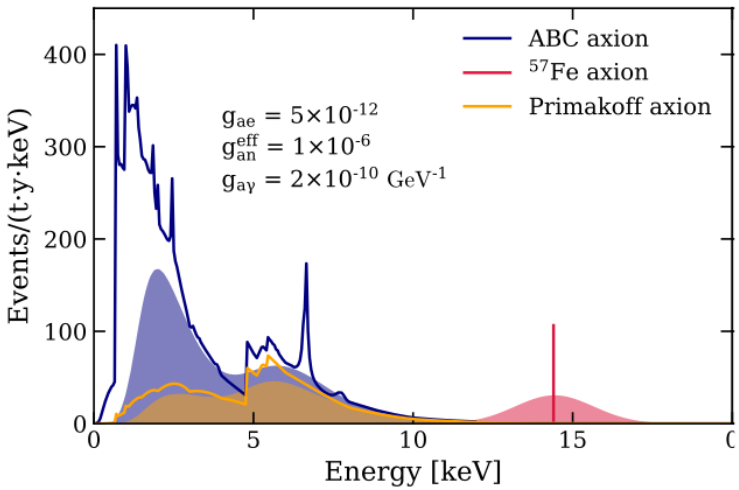
19 July 2022@Vienna, Austria

Solar axion

- ✓ Axion
  - Peccei-Quinn solution to the strong-CP problem
  - Different from particle dark matter : production & evolution
  - Axions would also be produced in the Sun
- ✓ Results from XENON1T in 2020
  - Phys. Rev. D 102, 072004 (2020)
  - 3 sigma signal from solar axion?
  - $m_a \sim$ 46-56 eV
- ➢ We test **the axion-nuclear reaction** (g_{aN}) and complement measurement.

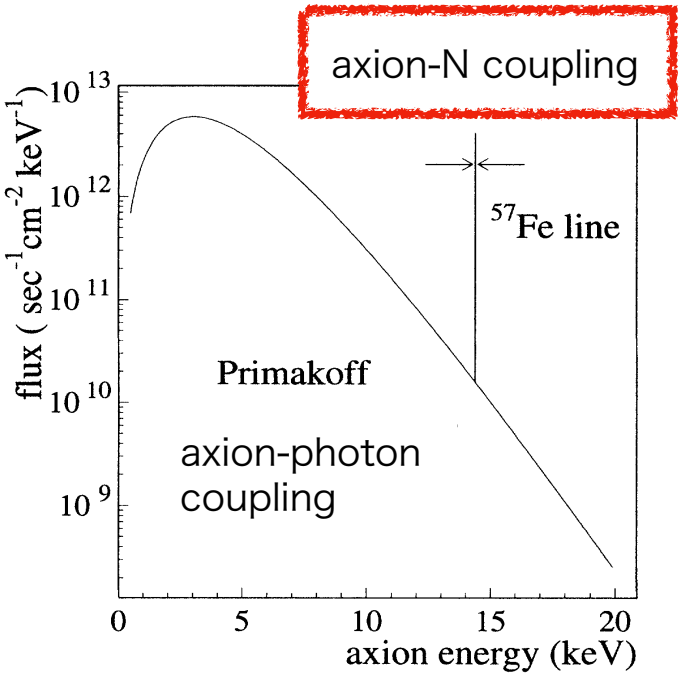


XENON1T collaboration, arXiv:2006.09721

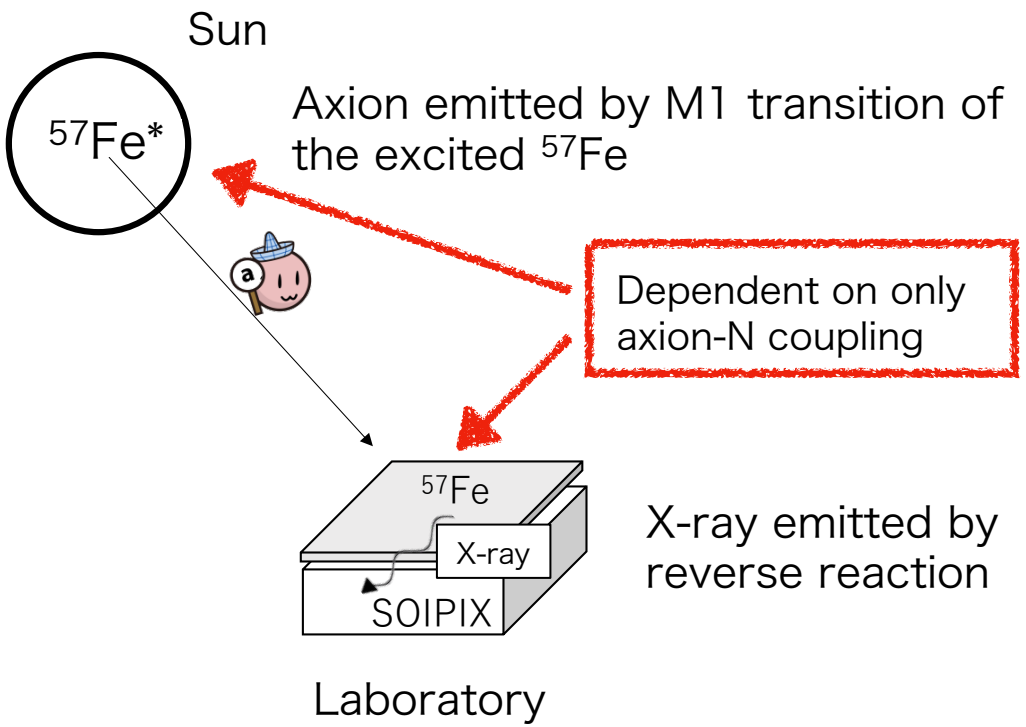


Solar Axion search using Iron-57

- ✓ Axions emitted by M1 transition of the excited ^{57}Fe in the Sun
- ✓ Detect X-rays from the reverse reaction in the ^{57}Fe enriched foil

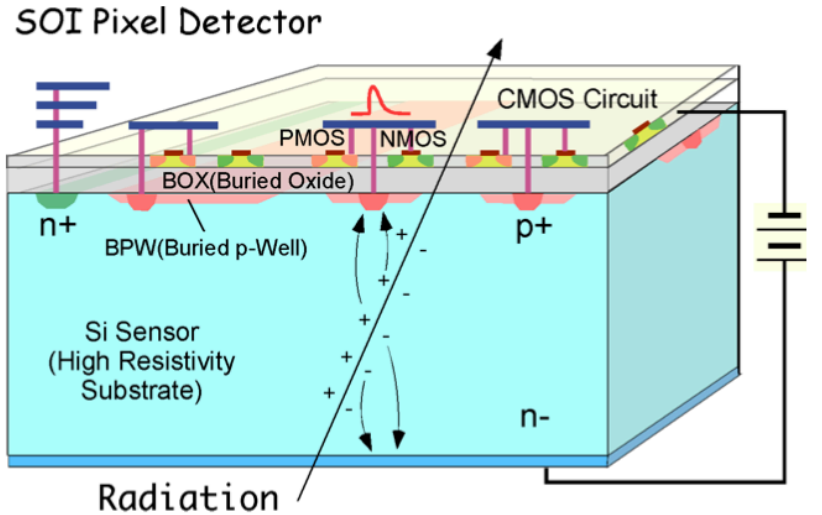


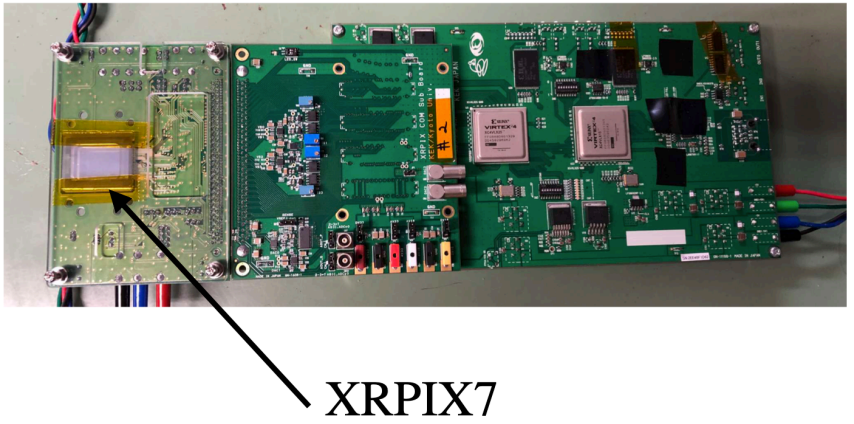
S. Moriyama, Phys.Rev.Lett. 75, 18 (1995)



Pixel type X-ray detector (XRPIX)

- ✓ XRPIX: SOI pixel sensor for the Japan led future X-ray astronomy mission
  - 24.6 mm × 15.3 mm × 300 um (608×384 pixels)
  - Each pixel has a trigger circuit which can achieve a 10 us time resolution
  - High energy resolution : 590 eV (FWHM) @14.4 keV
    - Goal : 250 eV FWHM
- ✓ Anti-coincidence enables to reduce cosmic-ray backgrounds

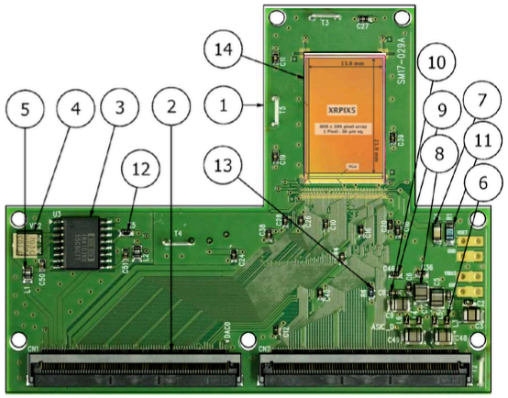




T.G. Tsuru et al., Proc. SPIE 10709, (2018)

Low-background readout system

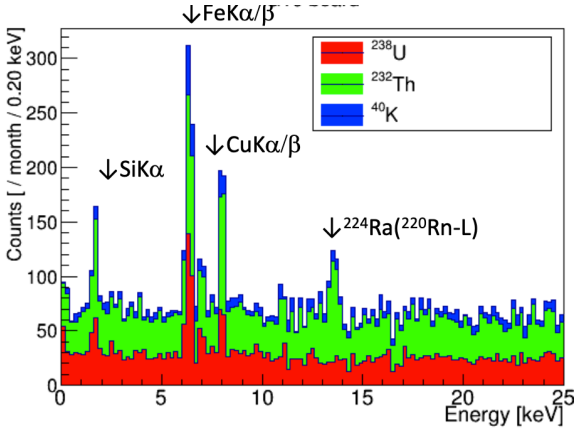
✓ Investigated the radioactive contamination in the former read-out board



	^{238}U(^{214}Bi)	^{232}Th(^{208}Tl)	^{40}K
Total (/board)	~64 mBq	~100 mBq	~76 mBq

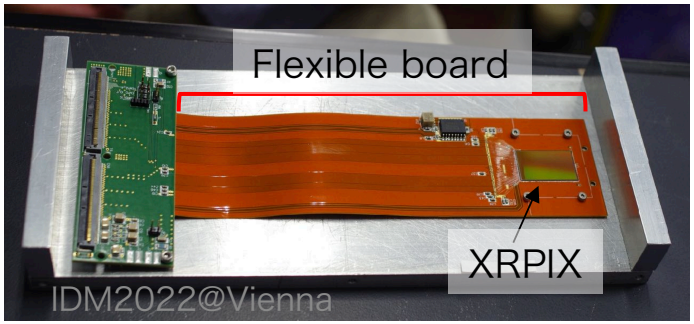
- Dominant radioactivities : ① G10 board

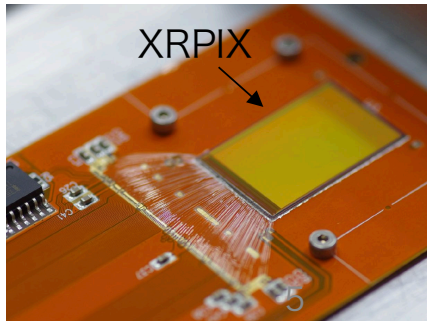
Background from G10 board by Geant4



Y. Onuki et al., NIM-A, 924, 448-451 (2019)

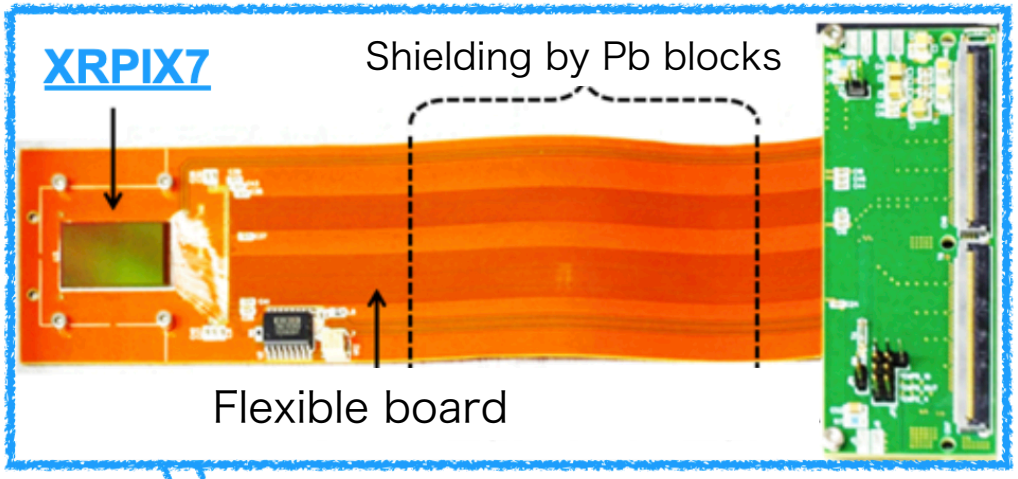
✓ Rigid flexible readout system
- Flexible part without the glass epoxy around the XRPIX sensor
- Rigid part far away XRPIX sensor
- We have already confirmed that is working

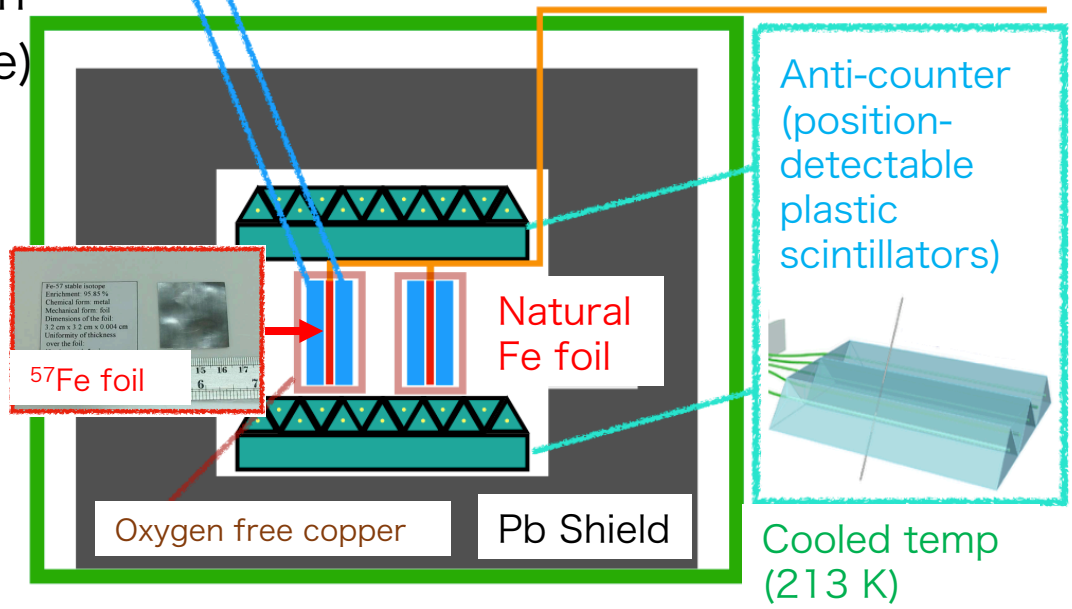




Detector design

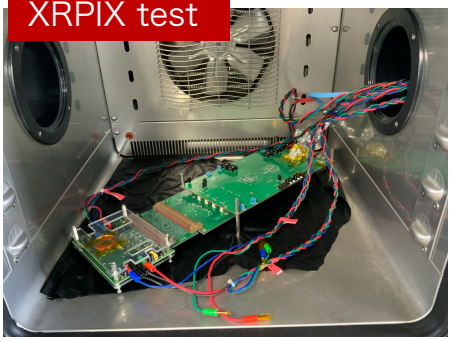
- ✓ 4 XRPIX with rigid flexible readout boards
  - Sandwich the ^{57}Fe enriched foil (127 mg, 95.85% enrichment)
  - Sandwich natural Fe foil for the background subtraction (2.119% natural abundance)
- ✓ Passive shields (Cu and Pb) in the thermostat bath
- ✓ Anti-coincidence by position-detectable plastic scintillators
- ➢ After commissioning for one month, we will start the scientific run

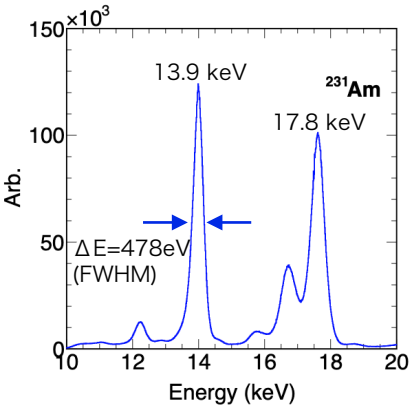


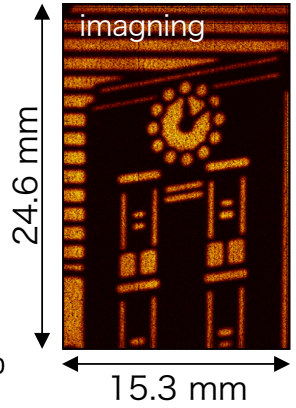


Status of ISAI

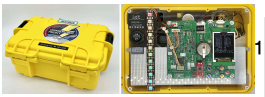
XRPIX test



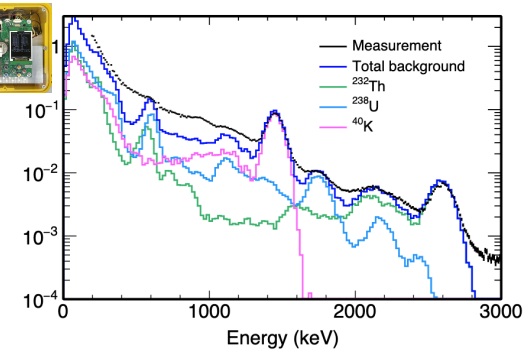




Measurement of ambient gamma-rays

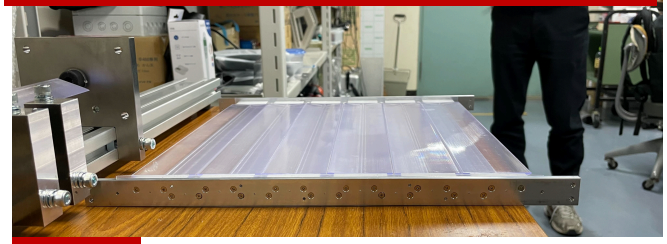


CoGaMo (CsI gamma-ray detector)



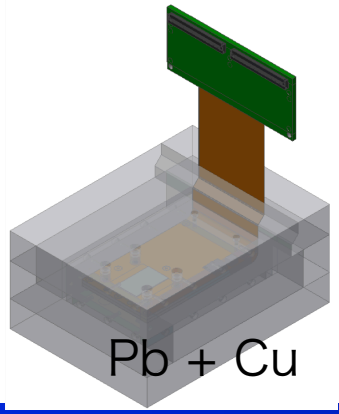
Clean booth & thermostat bath

Plastic scintillators under constructing

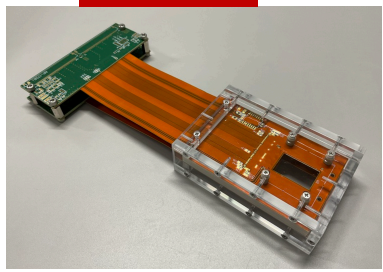


SiPMs

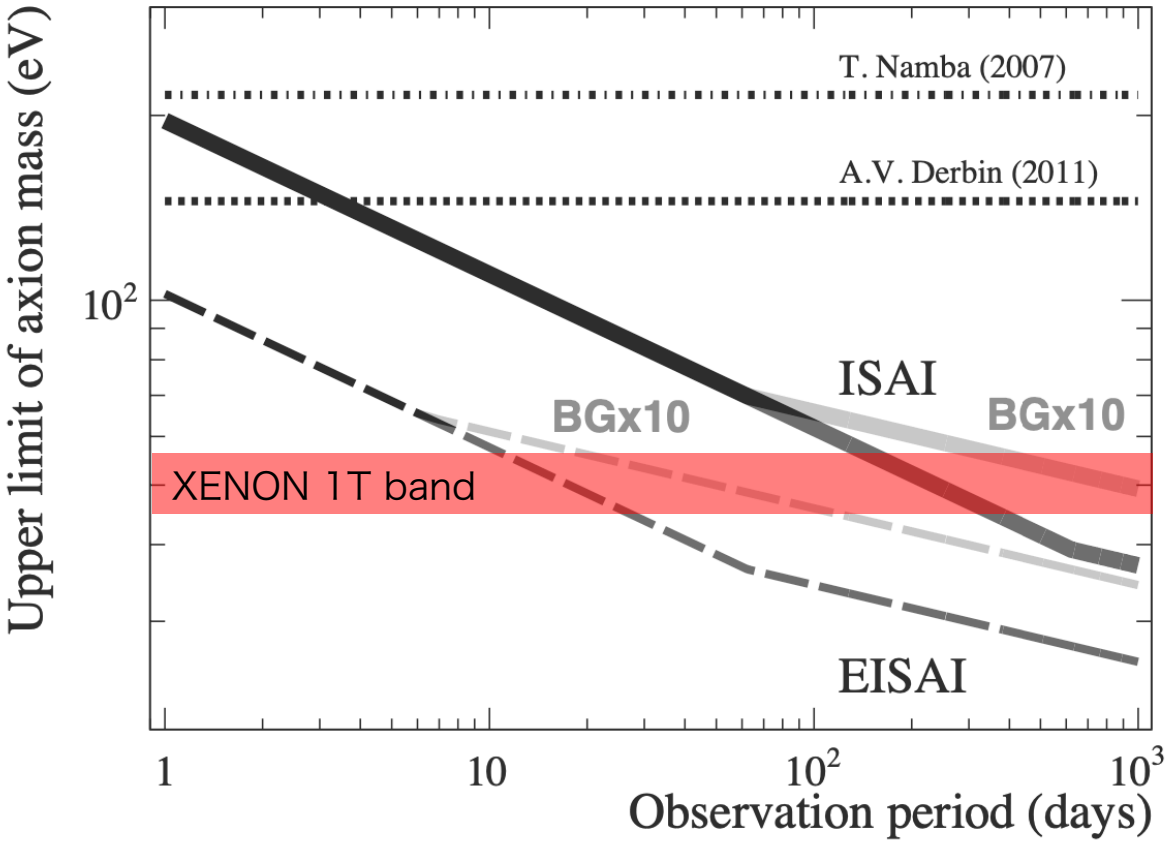
Passive shield design



Mock-up



Expected sensitivity



- ^{57}Fe mass : 127 mg
- Detection efficiency : 15% @14.4keV
- Energy resolution : 250 eV (FWHM)@14.4 keV
- Assuming only internal BG

- Expected reach of the XENON1T band in half year observation
- Discovery sensitivity of the 3.1 sigma significance in two year for 50 eV mass

Summary

- ✓ Investigating Solar Axion by Iron-57 : ISAI
  - Scientific goal is testing the axion-nuclear reaction (g_{aN}) and complement measurement from the XENON1T result
  - ISAI is using XRPIX sensor for the future X-ray astronomy mission
  - Background reduction by the low background readout system and anti-coincidence
  - We are going to start scientific observation from next year
  - Expected to reach the XENON1T band in half year observation