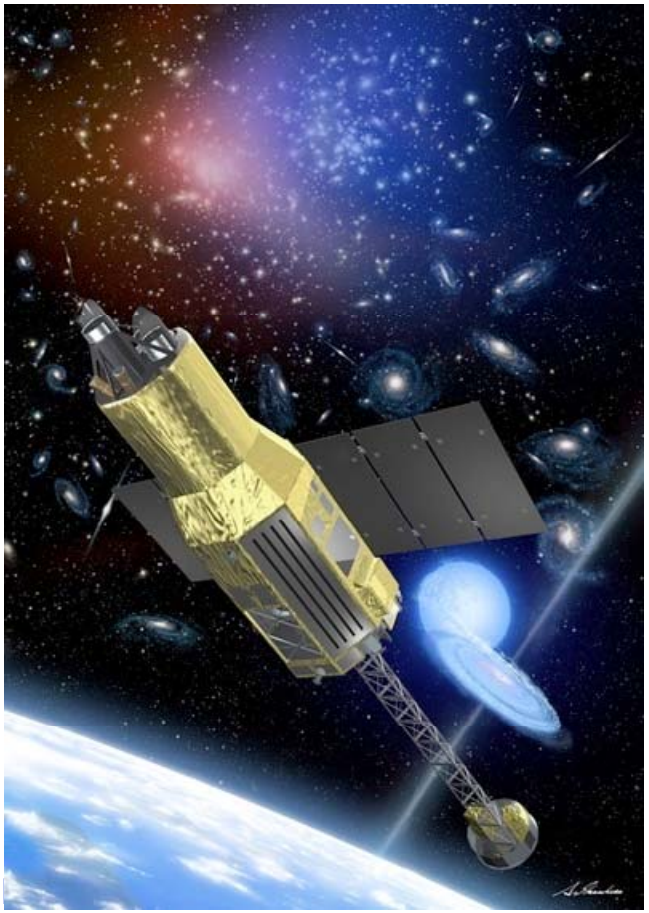
Development of the Soft Gamma-ray Detector on board ASTRO-H

ASTRO-H 衛星搭載軟ガンマ線検出器の開発(2012年度後半)



Mar 27, 2013

Hiroshima, JPS meeting

T. Mizuno, H. Tajima[A], Y. Fukazawa, S. Watanabe[B,C], H. Uchiyama[C], Y. Uchiyama[D], T. Enoto[E], M. Ohta[B], M. Ohno, H. Odaka[B], J. Kataoka[F], M. Kawaharada[B], M. Kokubun[B], G. Sato[B], R. Sato[B], T. Takahashi[B,C], H. Takahashi, S. Takeda[B], S. Tashiro[G], T. Tanaka[H], Y. Terada[G], K. Nakazawa[C], K. Nakamori[F], R. Brandford[D], K. Makishima[C], G. Madejski[D], K. Mori[B], Y. Yatsu[I], S. Yamada[E], T. Yuasa[B], D. Yonetoku[J], P. Laurent[K], O. Limousin[K], F. Lebrun[K] and the SGD team

広島大学，名大STE研[A], ISAS/JAXA[B], 東大理[C], KIPAC/Stanford[D], 理研[E], 早大理工[F], 埼大理[G], 京大理[H], 東工大理[I], 金沢大自[J], CEA-DSM-IRFU[K]

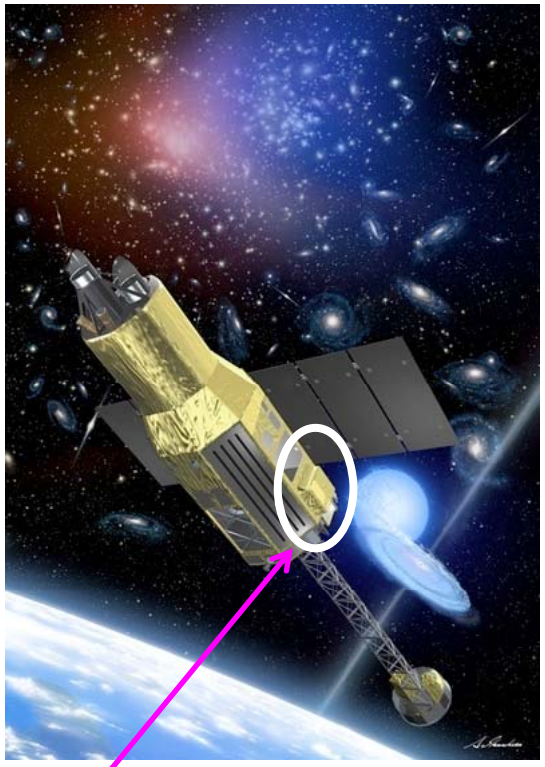
ASTRO-H & SGD

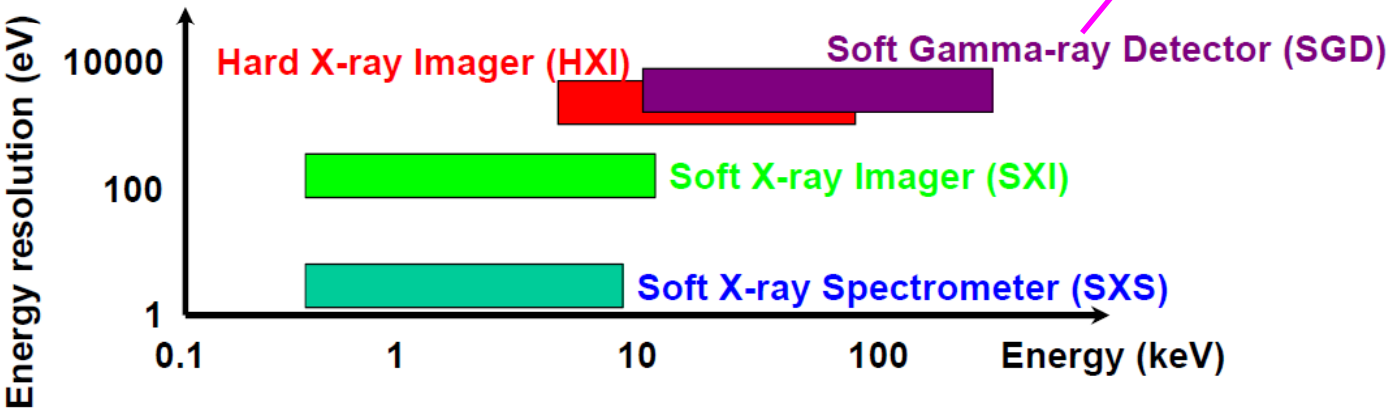
Objectives of ASTRO-H (#3)

- **The most sensitive wideband observation over an energy range from 0.3 to 600 keV**

Soft Gamma-ray Detector(SGD)

- **Highly-sensitive observation in 60-600 keV**
  - **narrow-FOV Compton Camera**
  - **extremely-low background**

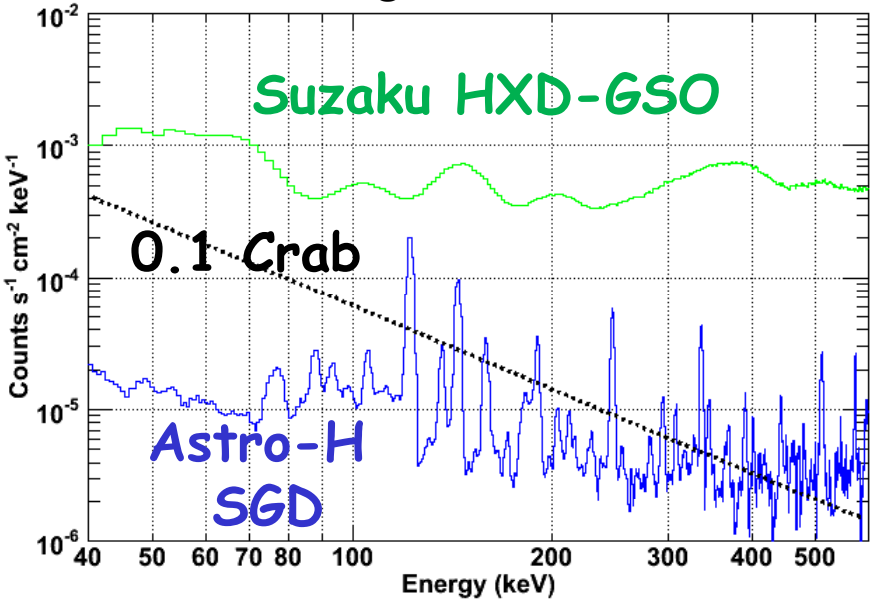




SGD Concept

- **Si-CdTe Compton Camera + BGO shiled**
- **Constrain incident angle using Compton kinematics**
  - **efficient background suppression**
  - **extra success: soft gamma-ray polarimetry**

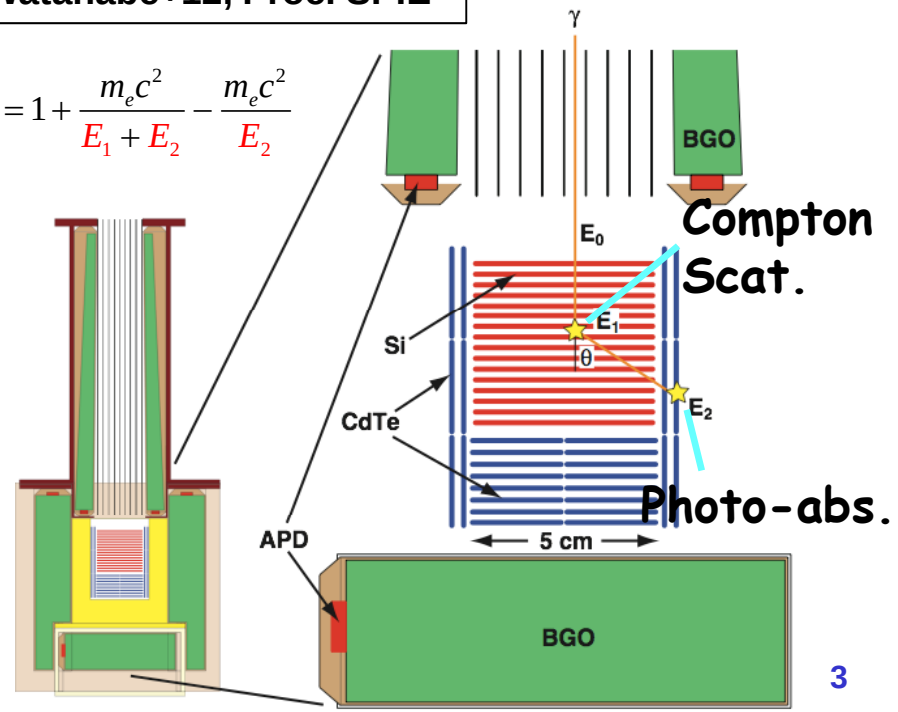
Background Level



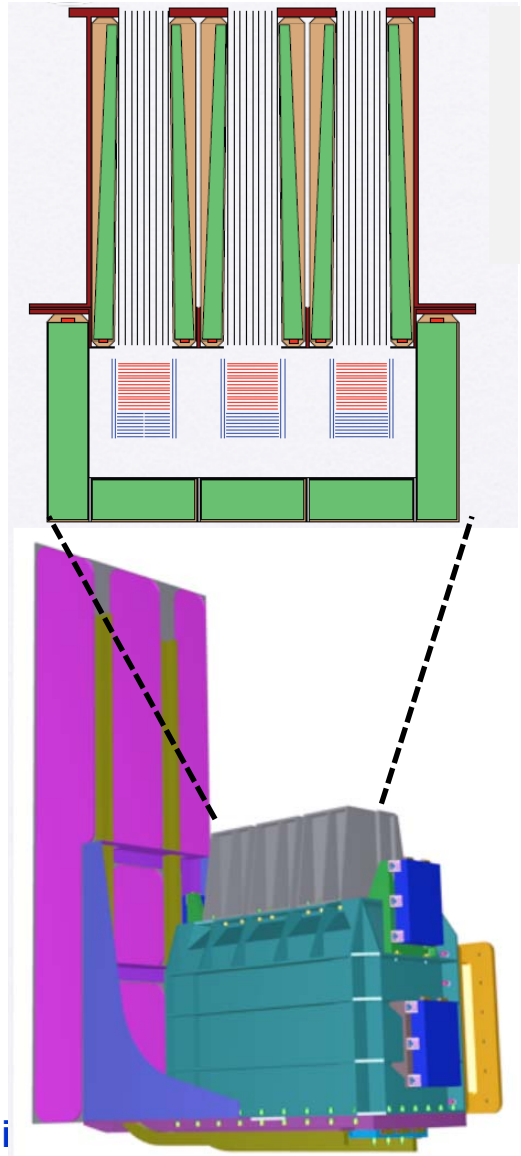
BG<=100 mCrab

Tajima+ 10, Proc. SPIE
Watanabe+12, Proc. SPIE

$$\cos\theta = 1 + \frac{m_e c^2}{E_1 + E_2} - \frac{m_e c^2}{E_2}$$



SGD System



- **Two SGDs on Astro-H**
  - **Compton Camera**
  - **BGO Active Shield**
    - **10 deg FOV**
    - **25 modules**
    - **read-out by APD**
  - **Fine Collimator**
    - **0.5 deg FOV (E<=150 keV)**
    - **reduce CXB/source confusion**
  - **Housing**
  - **Cooling System**
    - **keep CC/APD at -15~-20 ℃**
    - **heat pipe, radiator**
  - **SGD-AE**

SGD-S

Development in the second half of this fiscal year

(updates since 2012 Sep. JPS meeting, 14aSP-9)

- **SGD-S**
  - (done as of 2012 Sep.) vibration test (issue found), thermal balance test
  - **radiator support structure improvement, acoustic test, vibration test (scheduled on 2013 Mar.)**
- **Compton Camera**
  - (done as of 2012 Sep.) test of partial EM
  - **construction of full-EM, electric test, thermal-vacuum test, vibration test (scheduled on 2013 Mar.)**
- **BGO, APD**
  - **new method of gluing APD and BGO developed and tested**
  - **verification of signal processing firmware**
- **Fine Collimator**
  - **acceptance test preparation**
- **Other**
  - **internal release of the MDP (sensitivity of pol. measurement) calculation tool**

Development in the second half of this fiscal year

(updates since 2012 Sep. JPS meeting, 14aSP-9)

- **SGD-S** → Ohta+, 27pBE-11
  - (done as of 2012 Sep.) vibration test (issue found), thermal balance test
  - ⊖ radiator support structure improvement, acoustic test, vibration test (scheduled on 2013 Mar.)
- **Compton Camera**
  - (done as of 2012 Sep.) test of partial EM
  - ⊖ construction of full-EM, electric test, thermal-vacuum test, vibration test (scheduled on 2013 Mar.)
- **BGO, APD**
  - new method of gluing APD and BGO developed and tested
  - verification of signal processing firmware — Tokuda+, 27pBE-6
- **Fine Collimator**
  - acceptance test preparation — Kimura+, 27pBE-9
- **Other**
  - ⊖ internal release of the MDP (sensitivity of pol. measurement) calculation tool

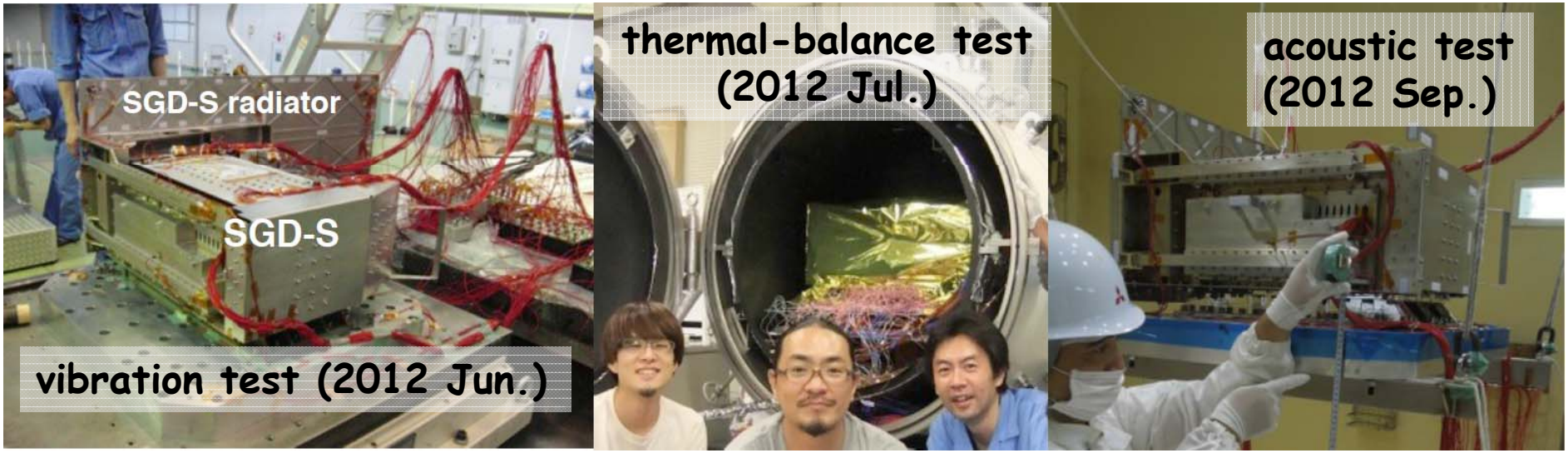
EM Test Status of SGD-S

(Ohta, Watanabe, Nakazawa, Noda, Ichinohe, MHI)

- **Vibration test**
  - issue found in radiator support
  - **improvement of the structure verified by an analysis. test scheduled on Mar. (see next)**
- Thermal-balance test: confirmation of thermal design
- **Acoustic test: no apparent damage. effects on FC evaluated**

Ohta+, 27pBE-11

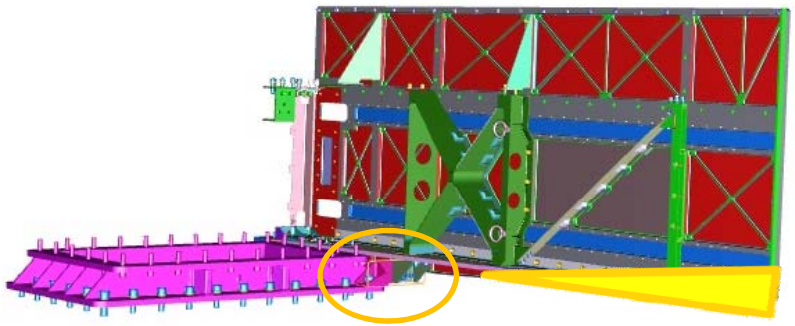
Kimura+, 27pBE-9



Radiator Support Structure

(Nakazawa, Ohta, Minesugi, Ishimura, MHI)

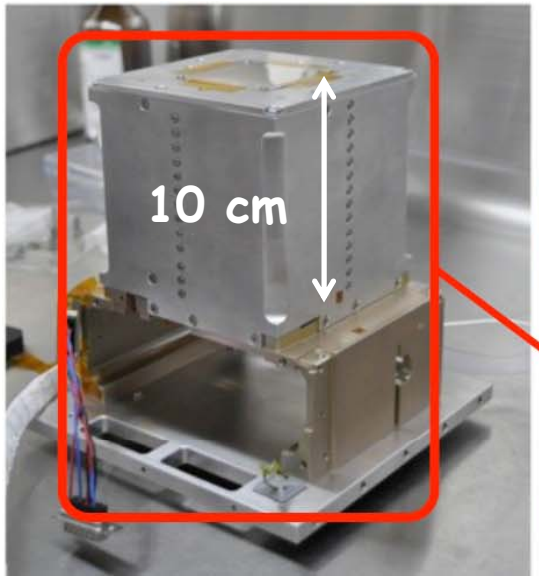
- **Issue found during SGD-S EM vibration test**
  - radiator structure had a high Q-value(>100) and low frequency (18, 34… Hz)
    - deformation of the radiator plate
    - risk of hitting against the satellite side panel
- **Improved radiator support structure**
  - rigidity increase of radiator and back-structure. cut the panel edge
  - addition of Ti-support plate between radiator and interface plate
  - strengthen housing bottom structure
- **Results by and analysis (@Q=50)**
  - higher resonance freq. (18 Hz->40 Hz, 34 Hz->59 Hz)
  - displacement: 24 mm < 64 mm (allowance)
- **V-test scheduled on Mar. to confirm the design**



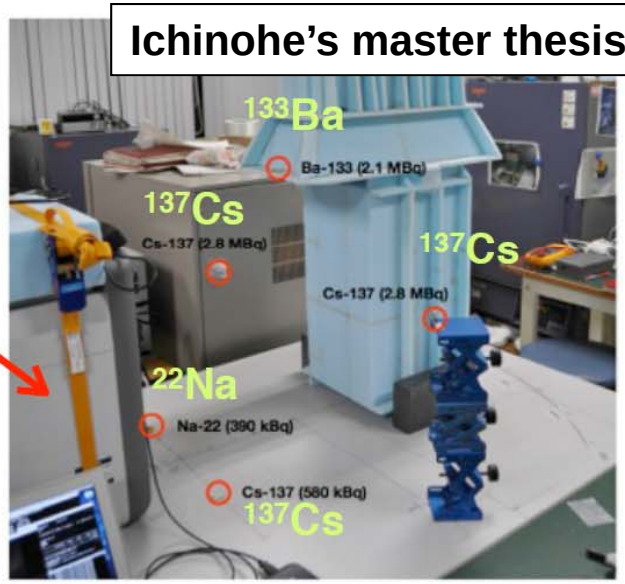
Full EM Compton Camera Electric Test

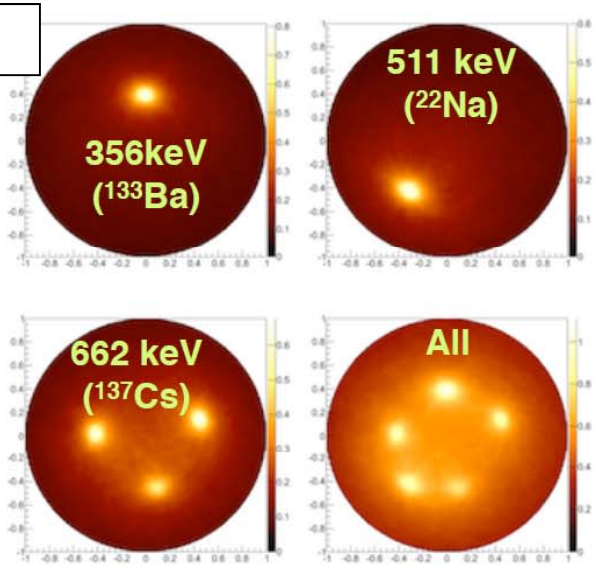
(Ichinohe, Takeda, Watanabe, Togo)

- **Configuration of full EM Compton Camera**
  - sensor module is the same as FM in terms of design and material
  - FPGA, some PCBs and passive parts are not space qualified
- **Fully functional except for one out of 8 side-CdTe modules**
  - fraction of bad channels (noisy, disconnected)
    - Si: ~0.03%, CdTe: ~2%
  - no degradation of energy resolution
- **Verification of imaging capability with Compton kinematics**



Ichinohe's master thesis

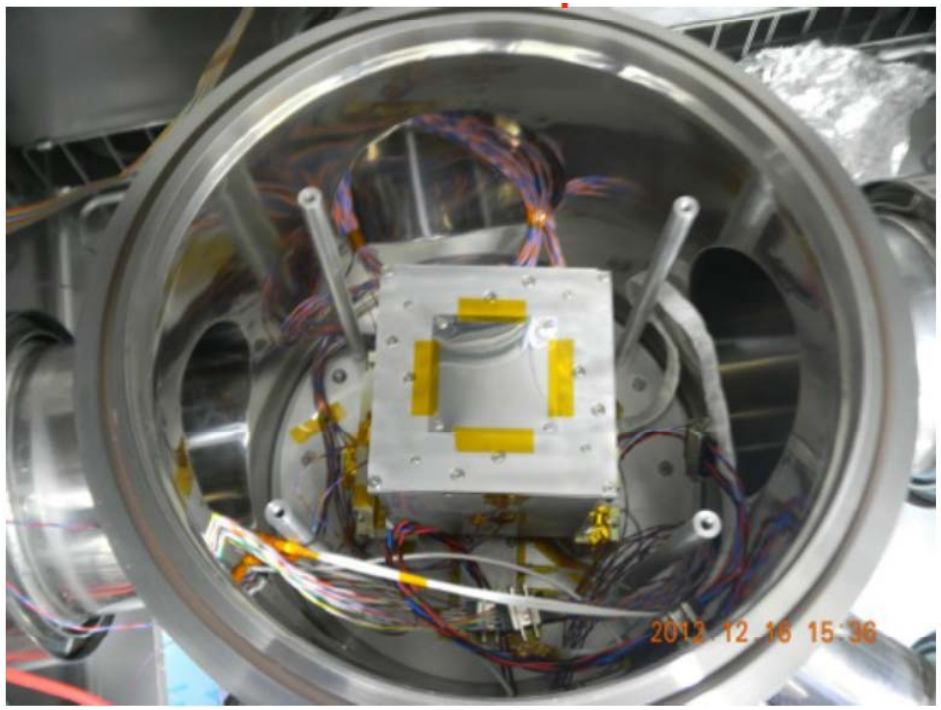




EM CC Thermal Vacuum Test

(Watanabe, Takeda, Nakamura, Furui)

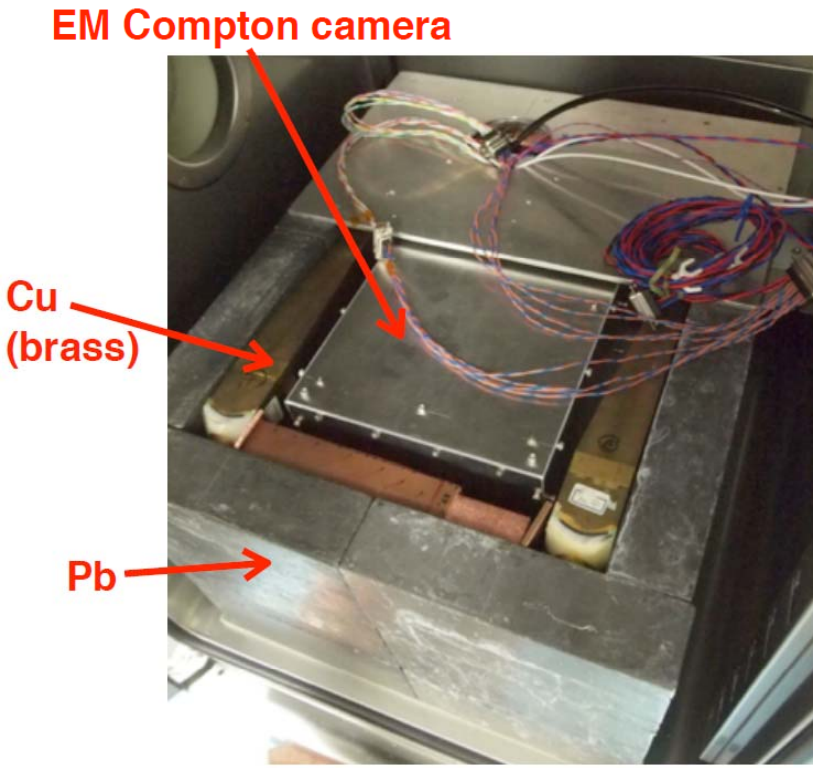
- **Thermal vacuum test in 2012 Dec. 14-28**
  - verification of thermal design and energy resolution in vacuum
  - continuous operation for several days

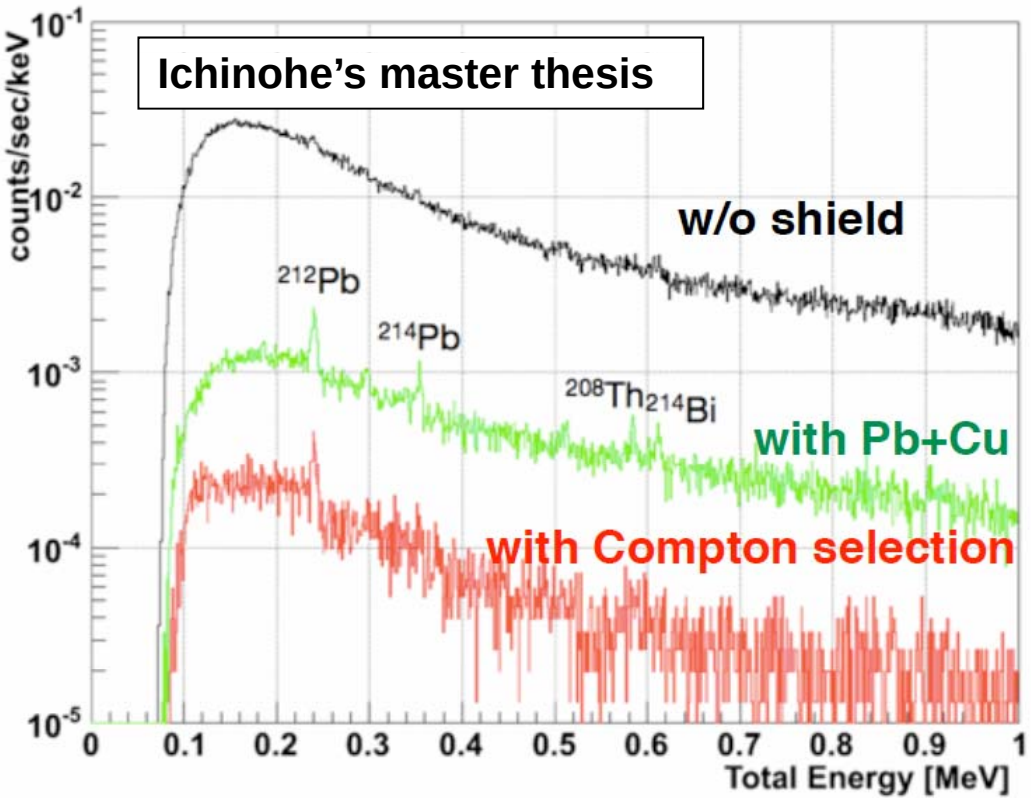


EM CC Internal Background

(Ichinohe, Takeda, Watanabe, Togo)

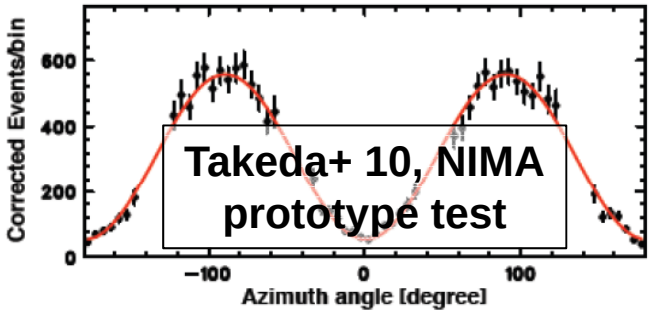
- **Verification of internal background level**
  - place Compton Camera inside passive shield (Pb+Cu)
  - no prominent radio isotope found



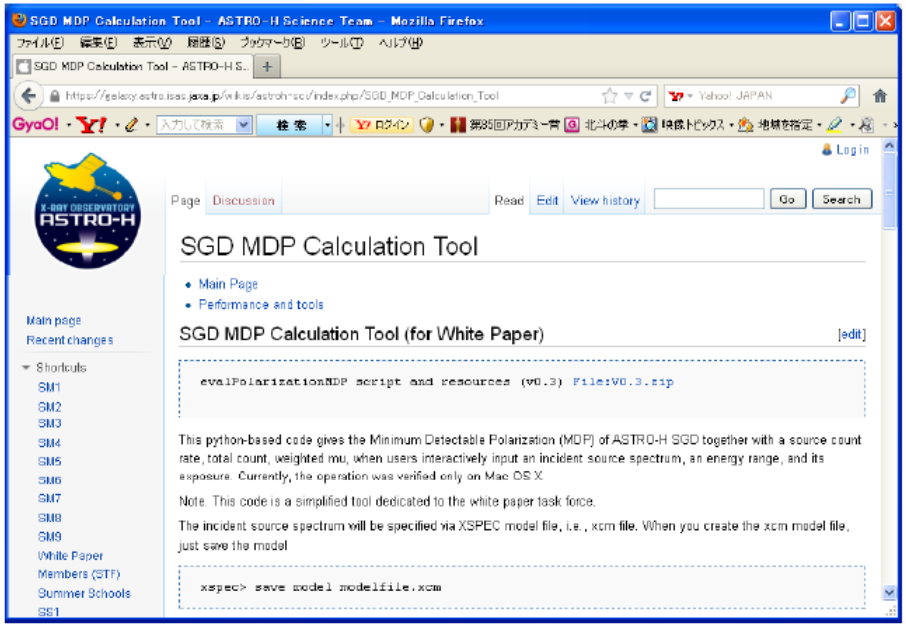


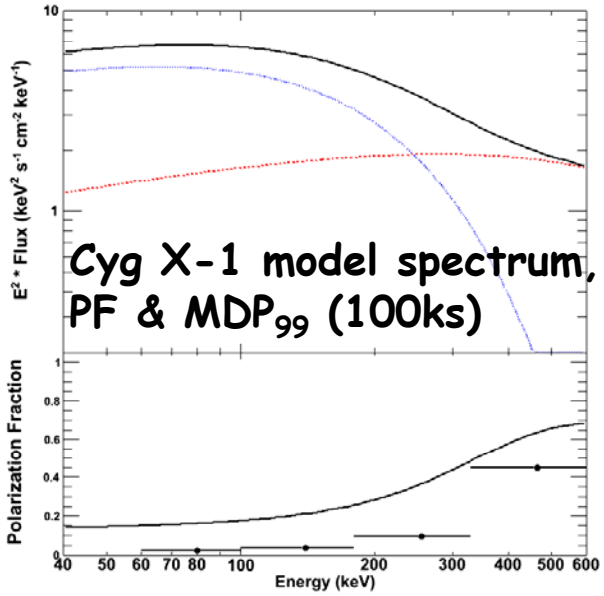
MDP Calculation Tool

- **SGD is a highly-sensitive spectrometer and polarimeter**
- **Internally release of a flexible tool to calculate MDP for user-defined spectrum and energy range**
  (available in *ASTRO-H Science Page*)



(Enoto and SGD team)





Summary

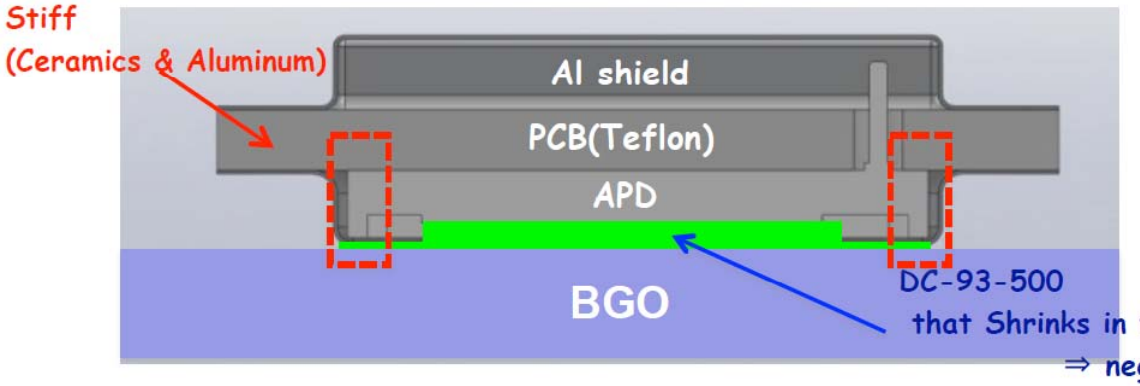
- **SGD-S**
  - vibration test, thermal balance test and acoustic test performed
  - issues on radiator structure being resolved and verified
- **Compton Camera**
  - 1st full EM constructed
  - electric and thermal vacuum test performed
  - internal background measured w/ passive shield
- **Preparation of each component**
  - FC, BGO, APD (method of gluing developed and tested)
- **Internal release of MDP evaluation tool**

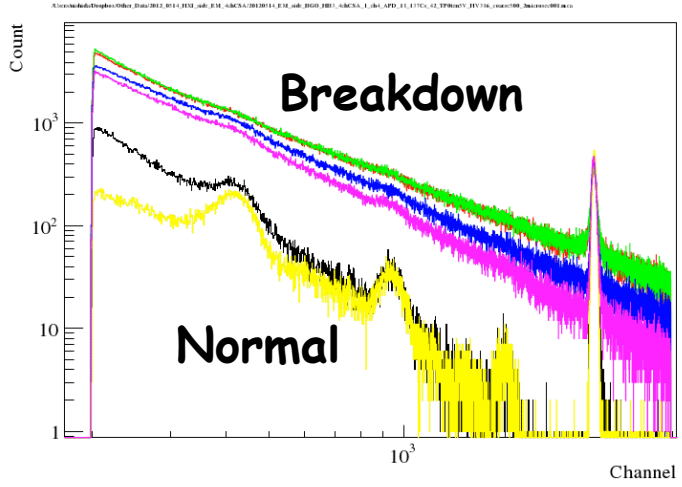
Thank you for your Attention

Backup Slides

APD-BGO Assembly Issues

- **I-V breakdown of APDs**
  - likely to be caused by cure induced shrinkage of DC-93-500 elastic adhesive (negative pressure)
- **Gluing of BGO and APD**
  - separation of glue at low temperature
  - caused by shrinkage of DC-93-500 at low temperature

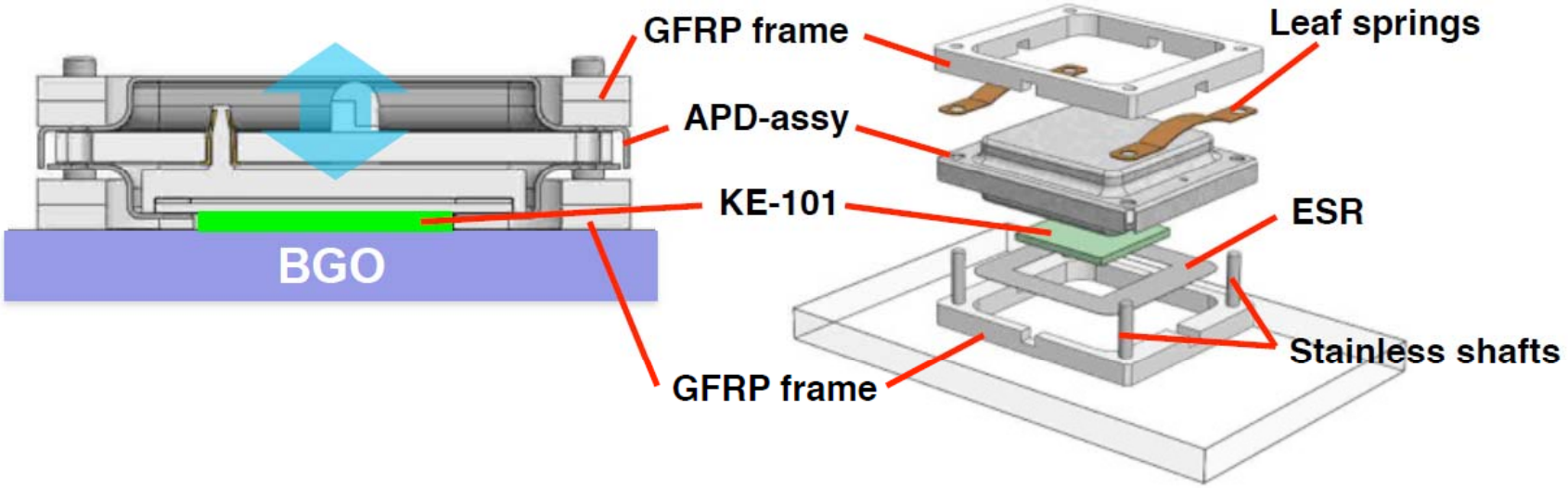




Solution for APD-BGO Assembly Issues

(Nakazawa, Sasano, Yatsu, Saito, Sato, Nakamori, Kataoka)

- **DC-93-500 => KE-101 (smaller cure induced shrinkage)**
- **New structures for releasing the negative stress**
  - **prototype passed**
    - **adhesive tests, vibration tests (QT+3dB), shock tests (QT), thermal cycle tests (-35~-40 ℃), low-temperature vacuum tests (-35℃) , electrical tests of APD (no breakdown)**



FM Fabrication, Test and Delivery Schedule