Status of ASTRO-H

Yoshito HABA@Nagoya University
ASTRO-H Hard X-ray Telescope Team

Outline

- Overview of ASTRO-H Mission
- Current Status of ASTRO-H
- Status and topics of each instrument
- Future master schedule

ASTRO-H Mission

Launch site: Tanegashima Space Center
Launch Vehicle: JAXA H-2A Rocket
Orbit Altitude: 550 km
Orbit Type: Approximate circular orbit
Orbit Inclination: 31 degrees
Orbit Period: 96 minutes
Launch: 2014

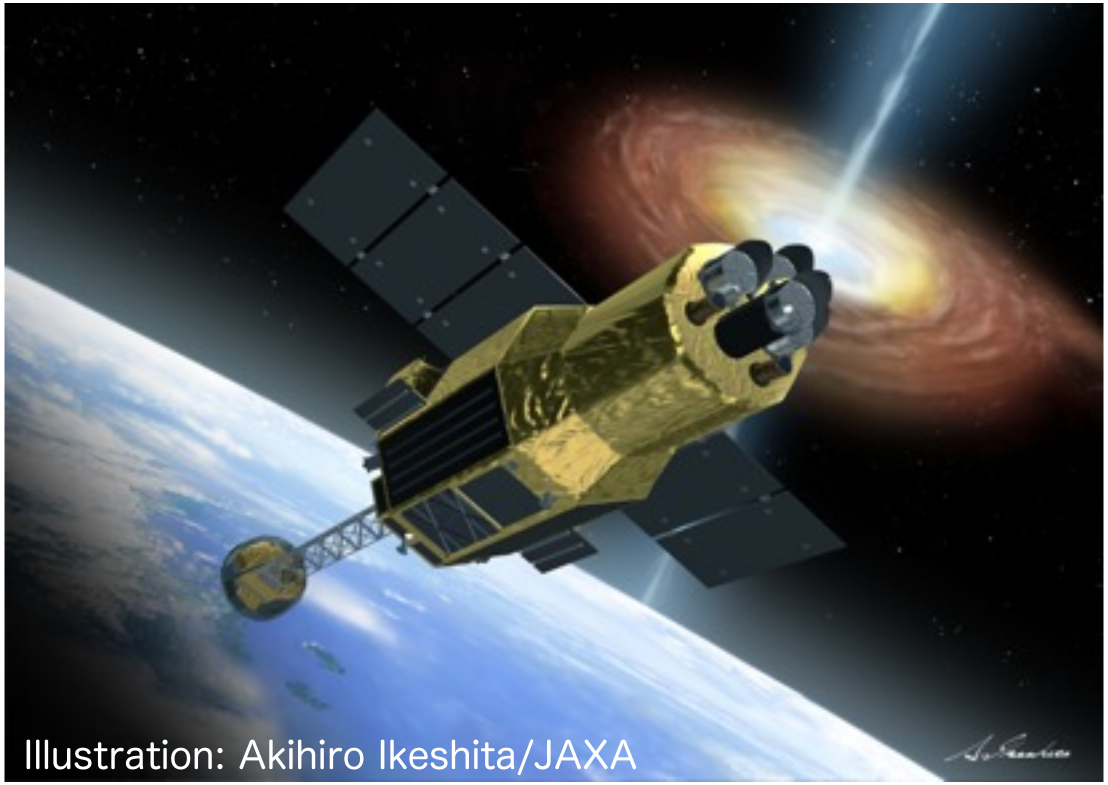


Illustration: Akihiro Ikeshita/JAXA

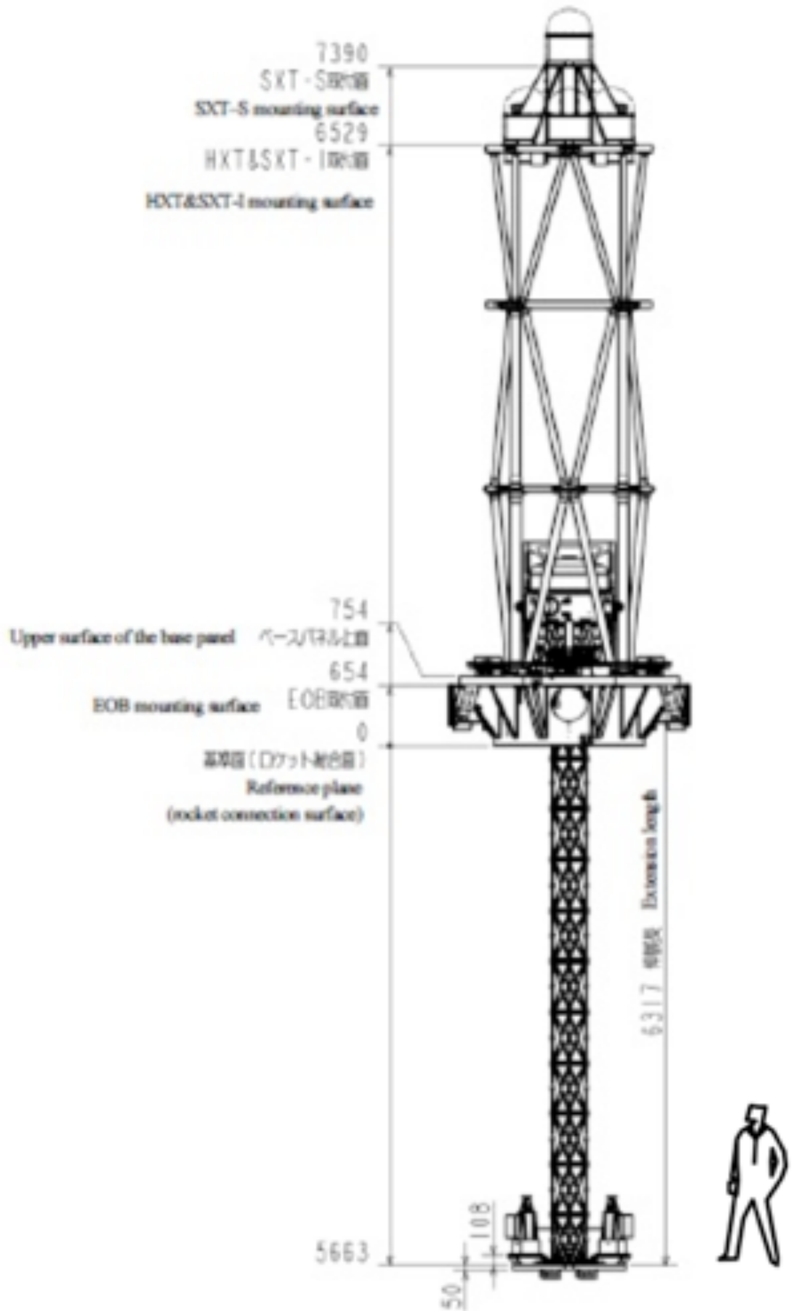
Key Features

1. High resolution spectroscopy with the micro-calorimeter
2. Imaging capability with hard X-ray telescope + hard X-ray imager
3. High sensitive wide-band spectroscopy from 0.3 to 600 keV

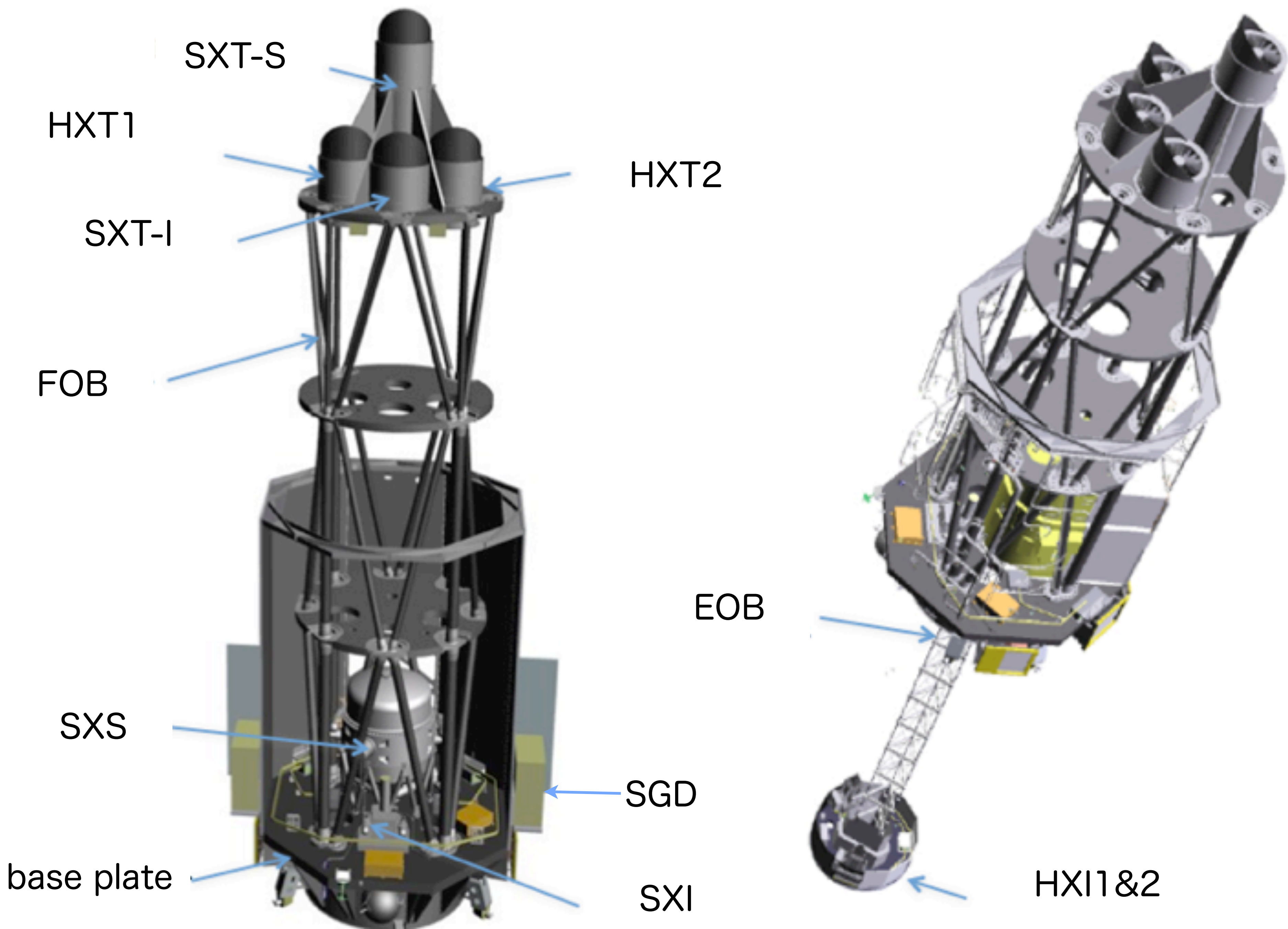
Scientific Objectives

1. Revealing the large-scale structure and its evolution of the Universe
2. Understanding the extreme condition in the Universe
3. Exploring the diverse phenomena of non-thermal Universe
4. Elucidating dark matter and dark energy

ASTRO-H Mission



Instruments onboard ASTRO-H



Current Status of ASTRO-H

- Many sub-system Critical Design Reviews (CDRs) were held before production of flight model (FM)
- System CDR is divided into two steps (CDR1 and CDR2)
- Reason for the necessity of CDR1
  - ASTRO-H is very large and complex satellite compared with past missions (e.g., one sub-system corresponds to one mission). This means that a change of design in a sub-system possibly impacts on whole system. In order to avoid such a situation, I/F between system and sub-system should be fixed as early as possible. CDR1, therefore, should be done before the Mechanical/Thermal test (MTM/TTM) of the S. C.
  - CDR2 will be done after MTM/TTM
- System CDR1 was done on Feb. 8 & 10 in 2012

Results of CDR1

We Passed!

Based on carefully prepared design reports by the team members, the reviewers recognize the size and complexity of the satellite (And of course, the importance of the mission). The reviewers all agree that we need to go ahead for further testing, since we can verify our design, only through thermal distortion, TTM MTM and micro-vibration tests.

Flight model production phase

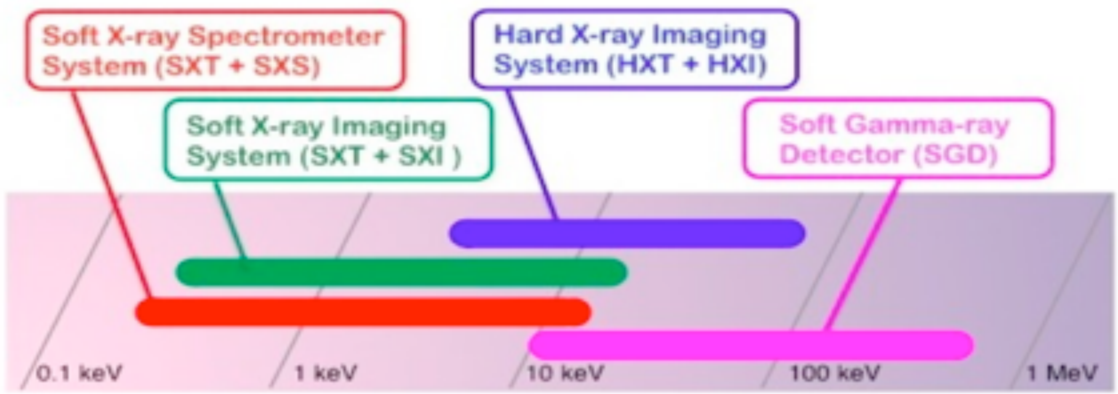
&

Preparation of test model for TTM/MTM

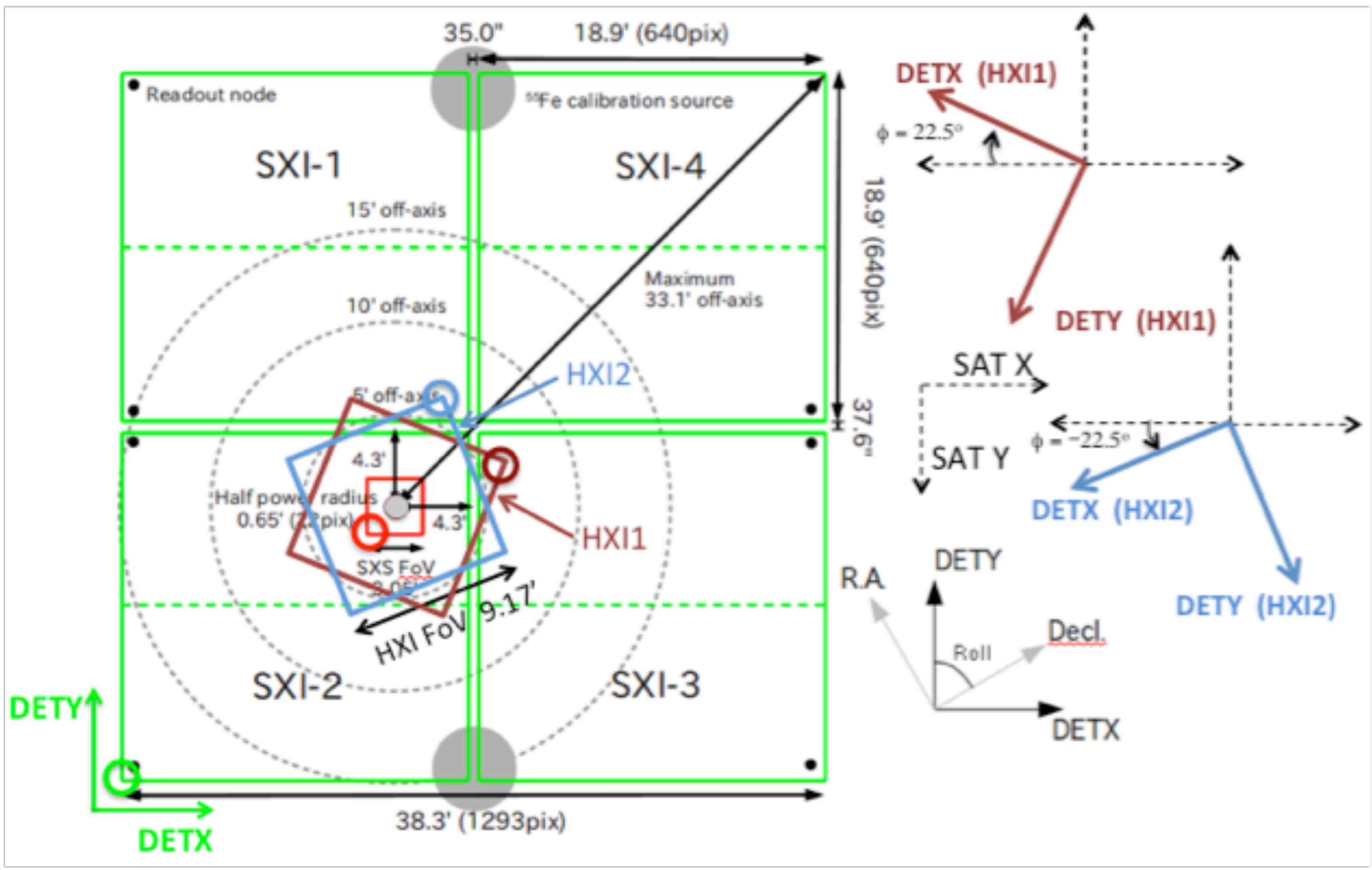
Current Status and/or Topics of Each Instrument

Instruments Overview

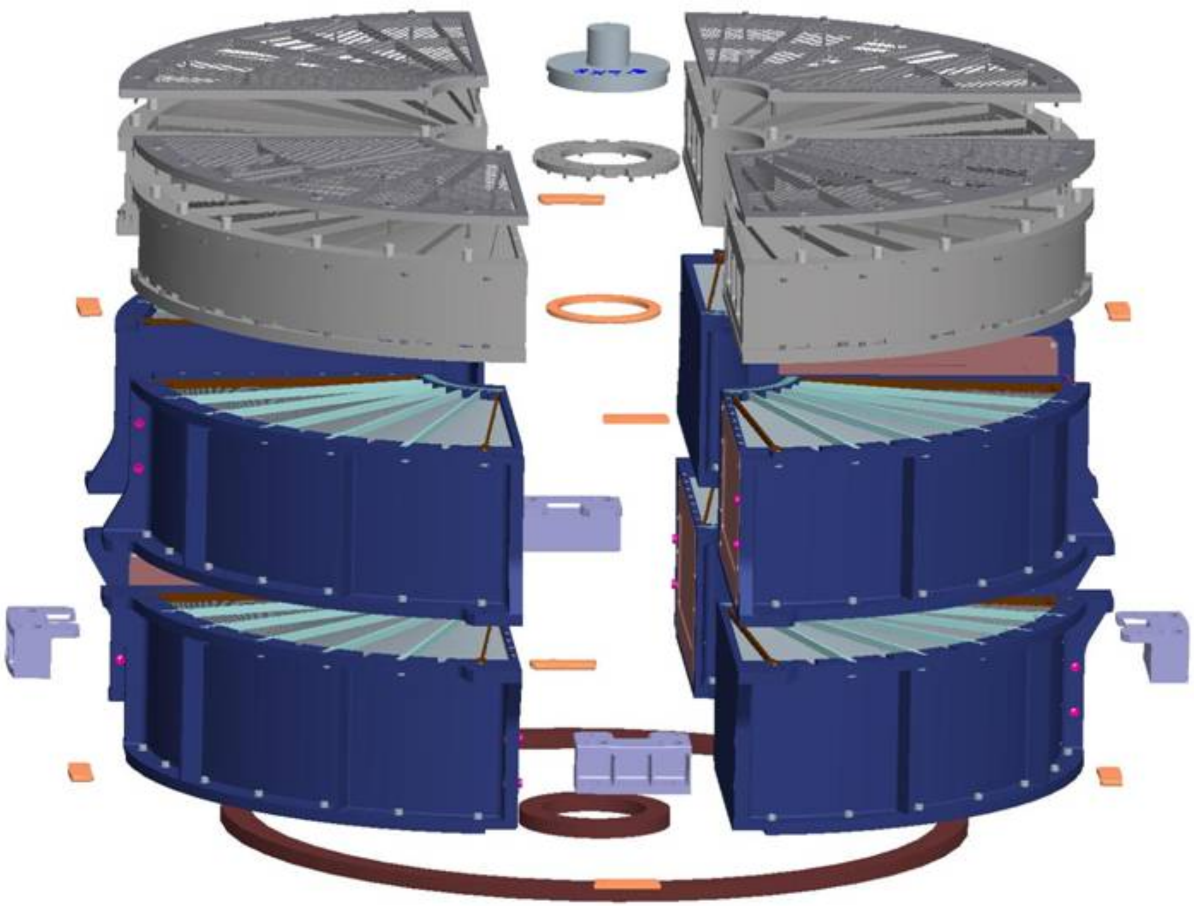
Energy Coverage



FoV Coverage



SXT Basic Design

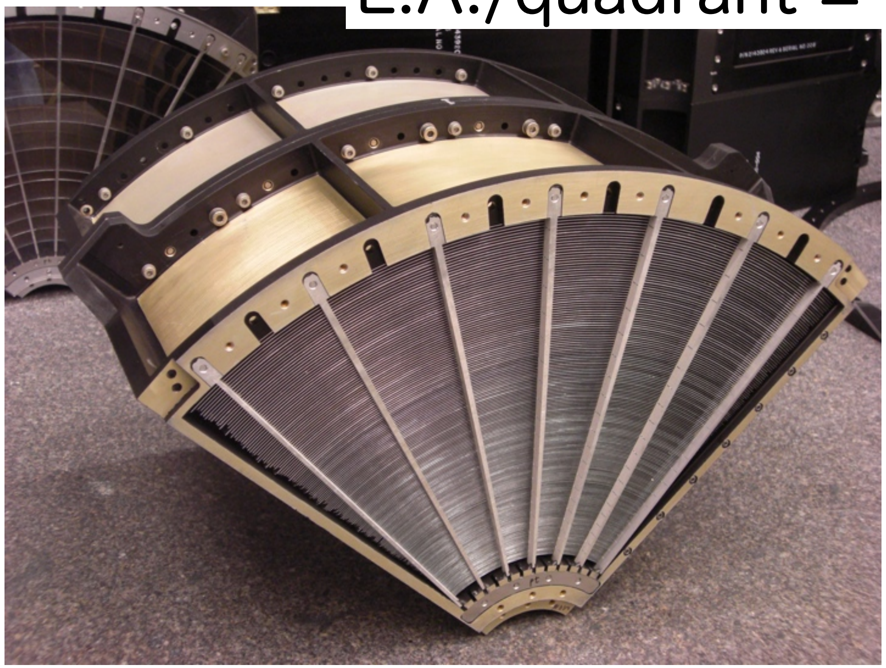


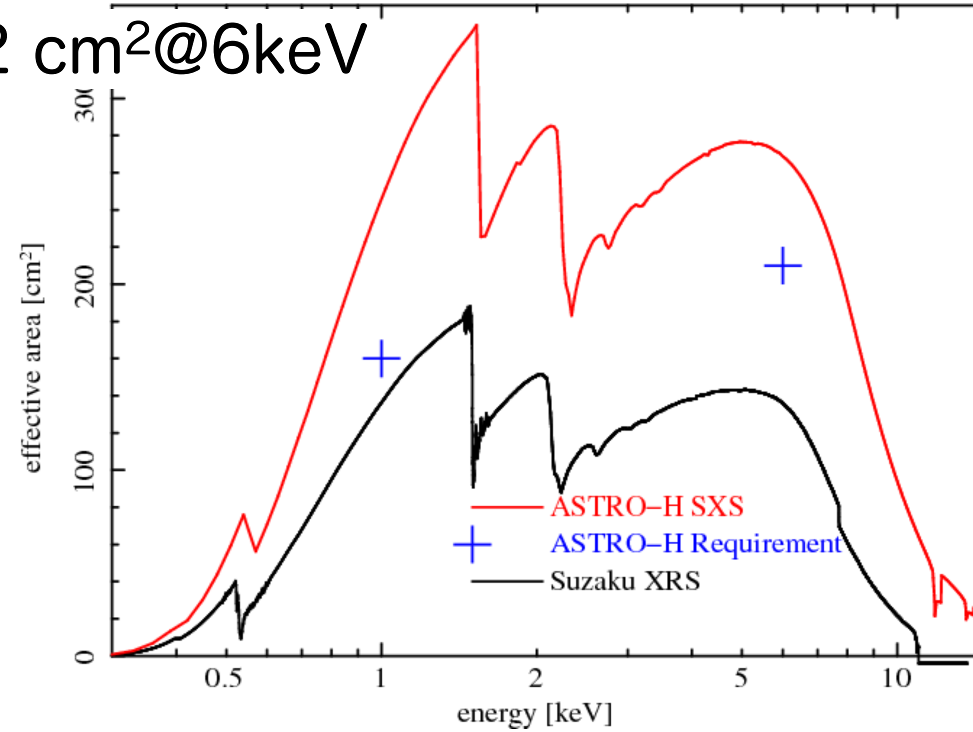
SXT-S for micro-calorimeter
SXT-I for X-ray CCD

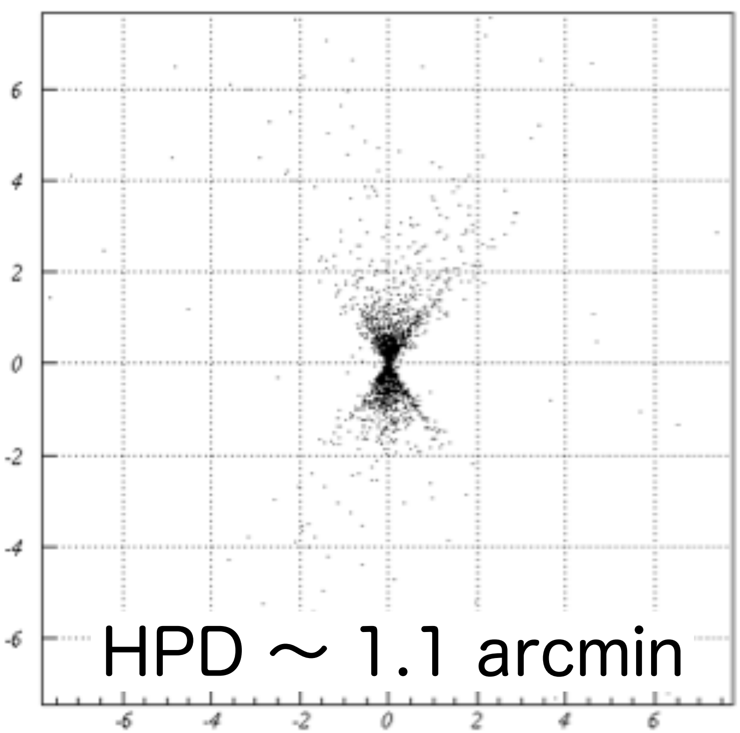
Parameter	Value
Diameter	45 cm
Focal length	5.6 m
# of nested shells	203
reflector surface	Au mono-layer
Pre-collimator blade height	65 mm
Blade thickness	0.12 mm
Thermal shield thickness	Al 0.03 um + Polyimide 0.2 um

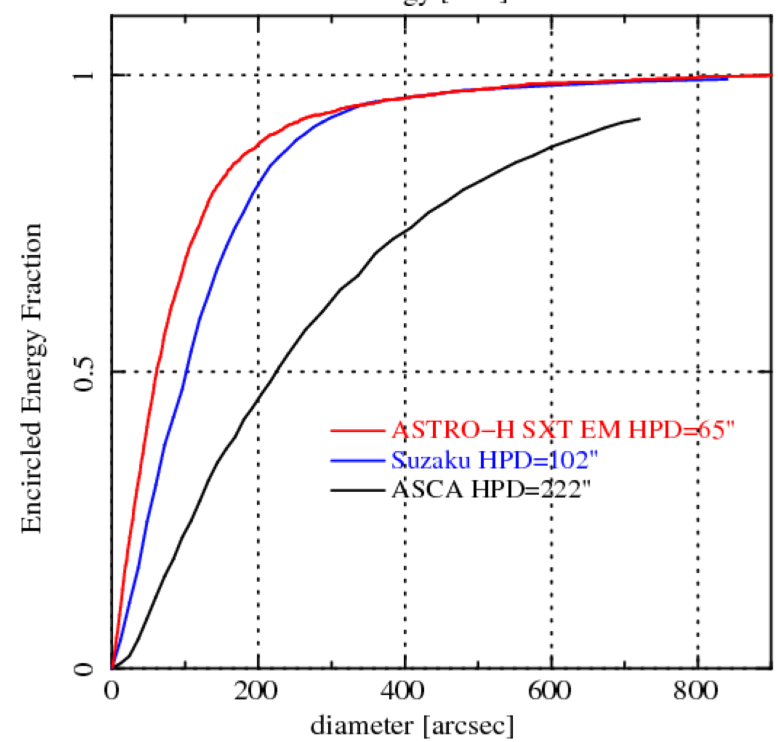
SXT EM Test Results

E.A./quadrant = 122 cm^2@6keV

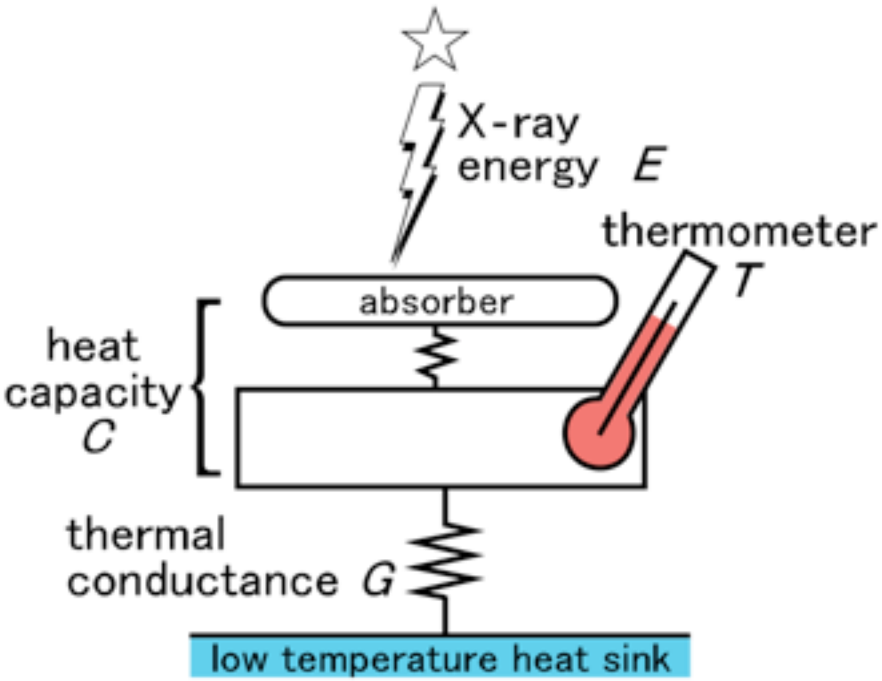


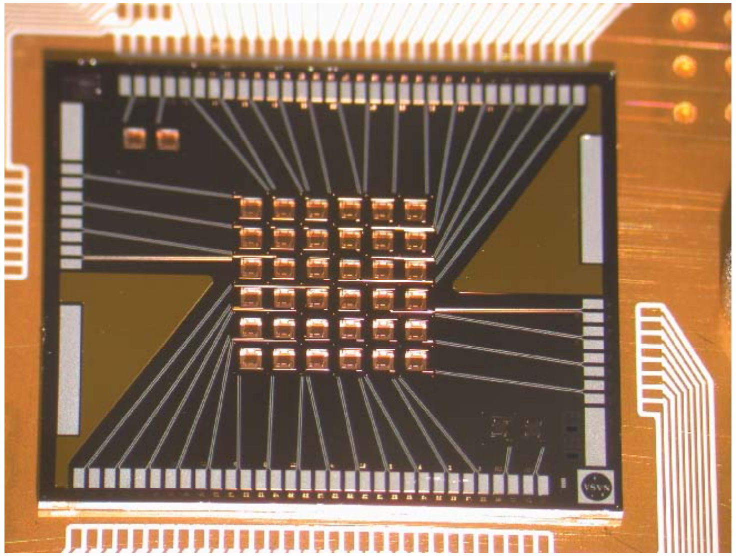






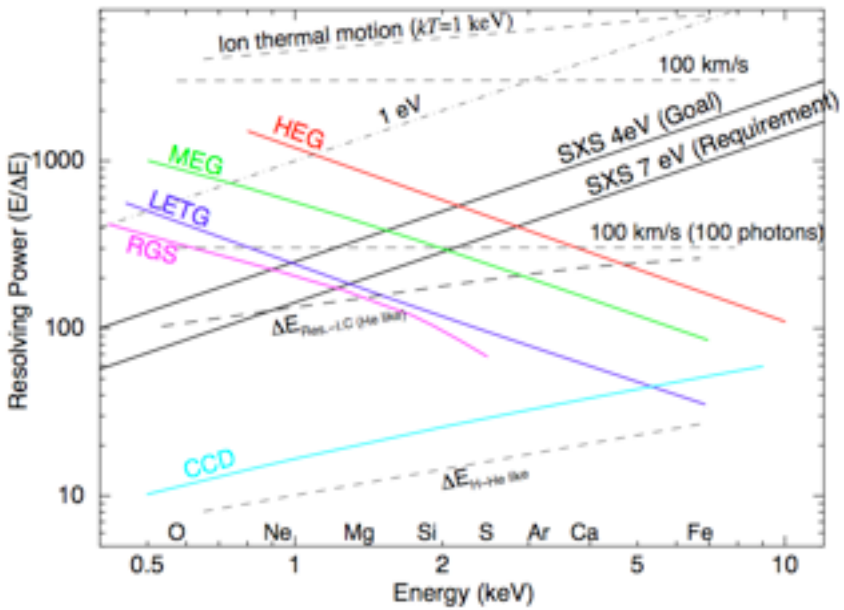
SXS Design

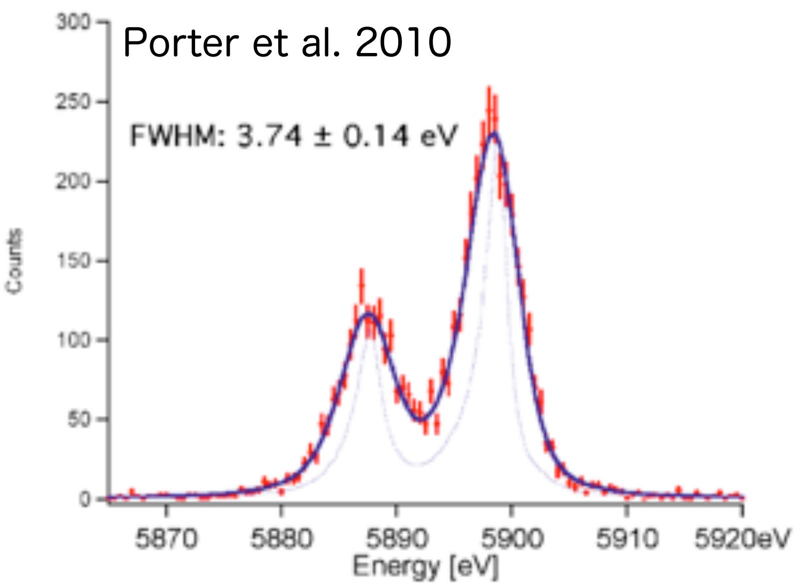




Parameter	Value
Operating Temperature	50 mK
Pixel size	814 x 814 um
Pixel pitch	832 um
Pixel format	6 x 6
Field of view	3.05’ x 3.05’
X-ray absorber	HgTe, 8 um thickness
Optical Blocking filters	5 filters, polyimide (460 um) + Al (400 nm) total, Si mesh on two filters

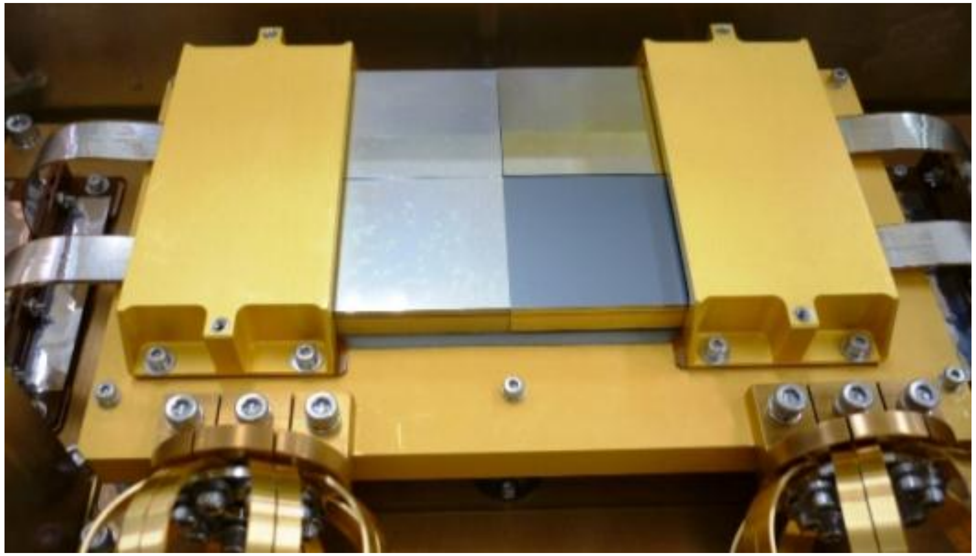
SXS Current Status





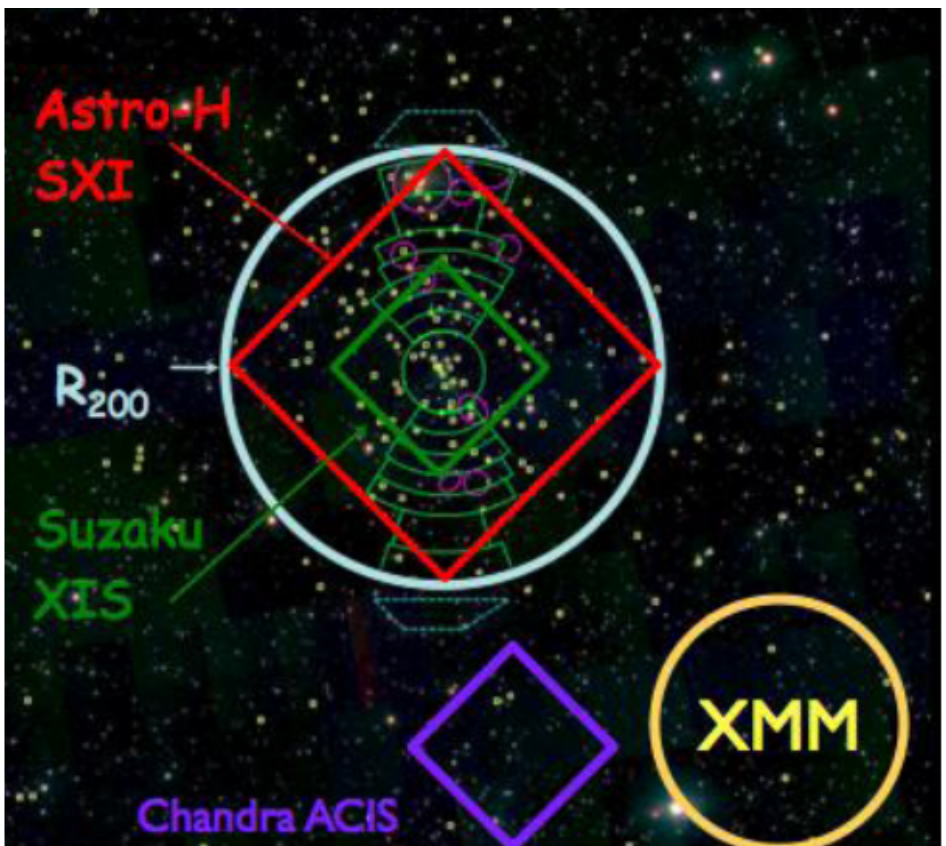
Parameter	Requirement	Goal
Energy range	0.3 - 12 keV	
Energy resolution	7 eV	4 eV
Array format	6 x 6	
Field of view	2.9’ x 2.9’	
Effective area	160 cm^2@1 keV 210 cm^2@6 keV	
Lifetime	3 years	5 years
Time assign accuracy	80 us	
Max count rate	150 c/s/array	
Energy scale cal. accuracy	2 eV	1 eV

SXI Design



CCD format (1chip)

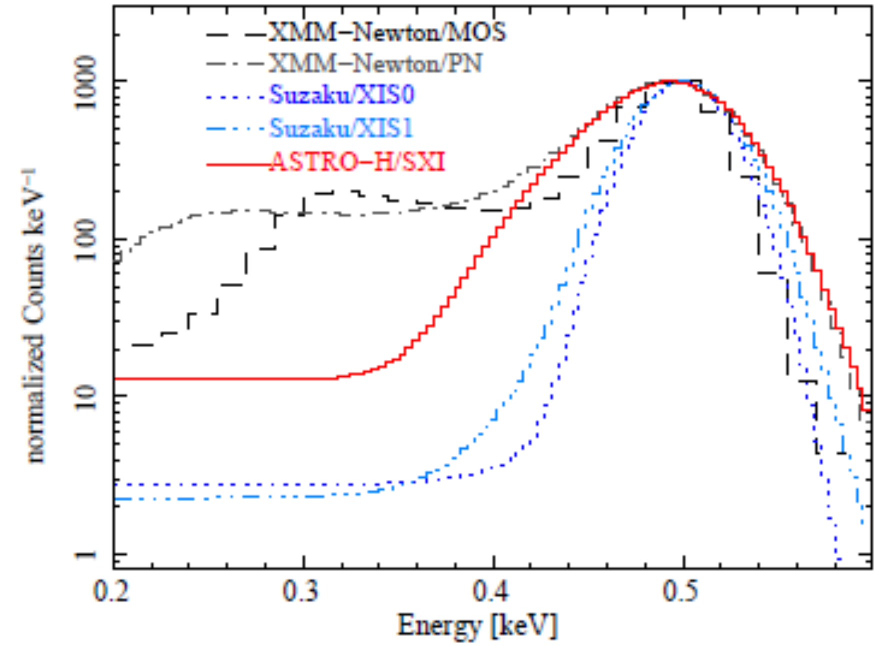
- Imaging area: 31 x 31 mm^2
- pixel format: 1280 x 1280
- pixel size: 24 x 24 um
- Si thickness: 200 um

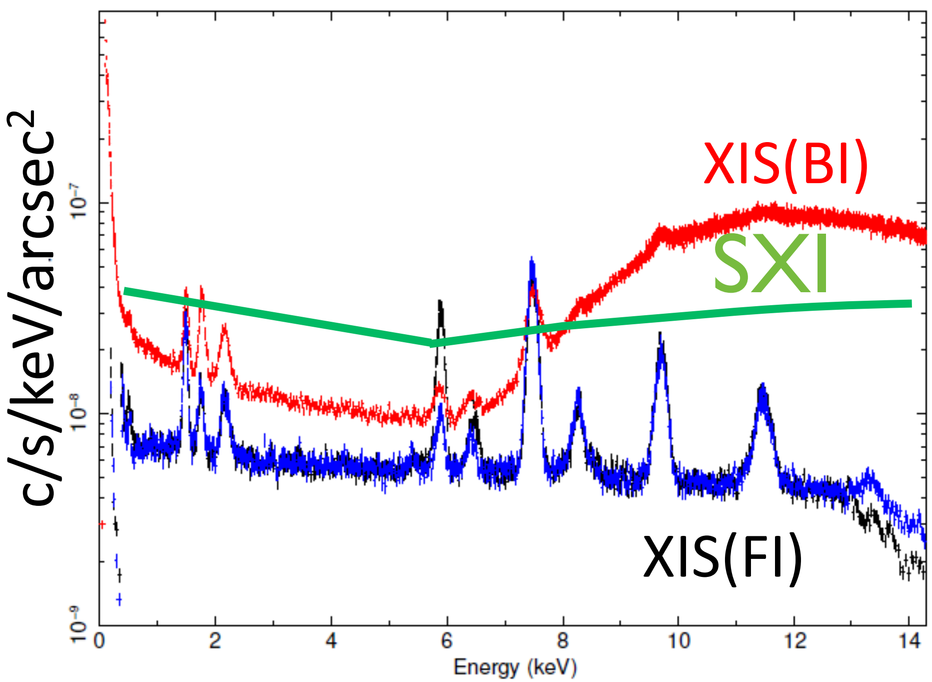


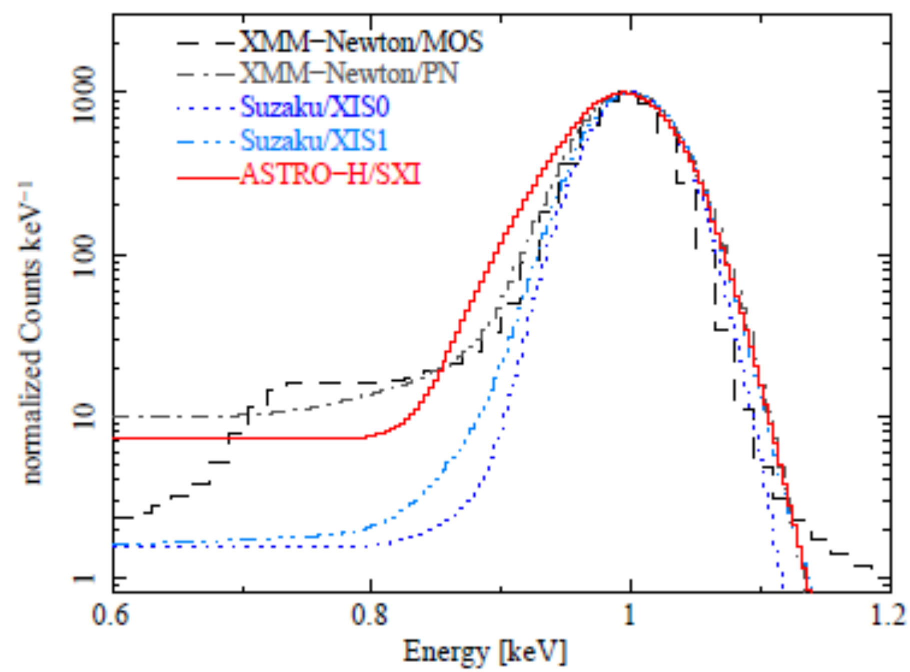
Large FoV (38 x 38 $arcmin^2$)
Low/stable background
→ suitable for studying diffuse sources

SXI Current Status

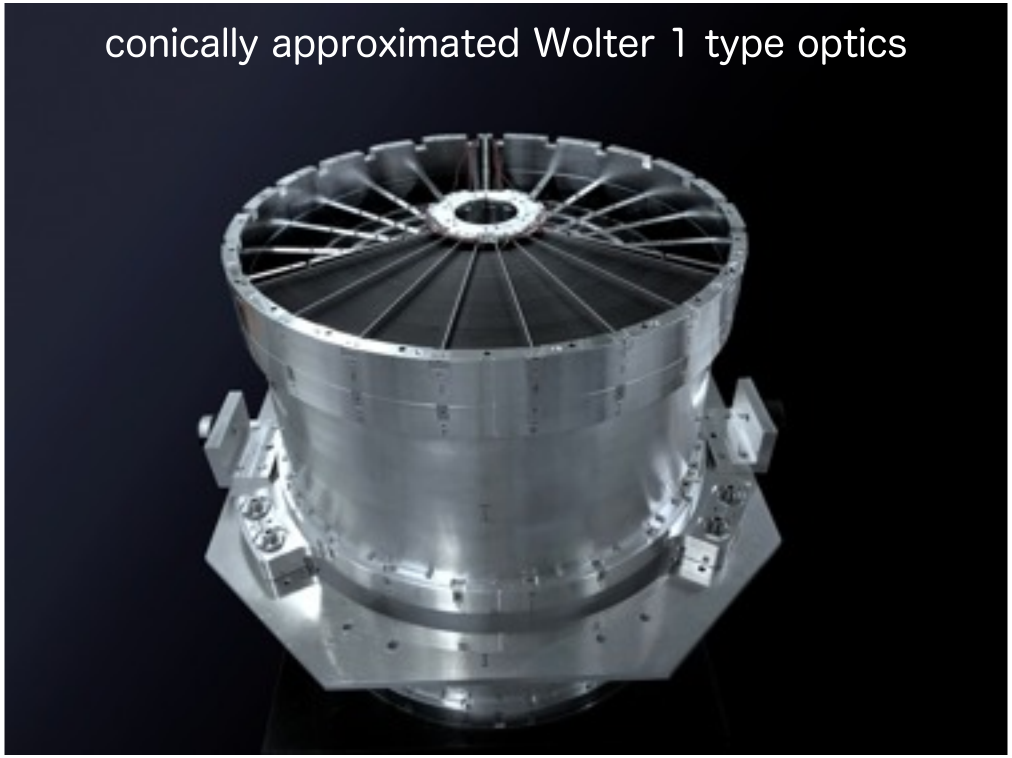
- Low energy tail of SXI is slightly higher than that of XIS
- Background level is also higher (by a factor of 4) below 8 keV
- Above 8 keV, considerably amount of background is suppressed

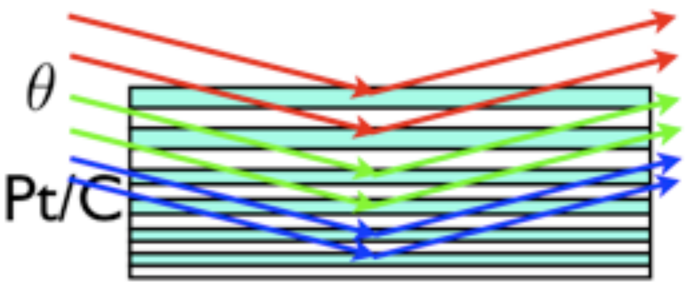






HXT Basic Design





Depth-graded multilayer
Bragg reflection

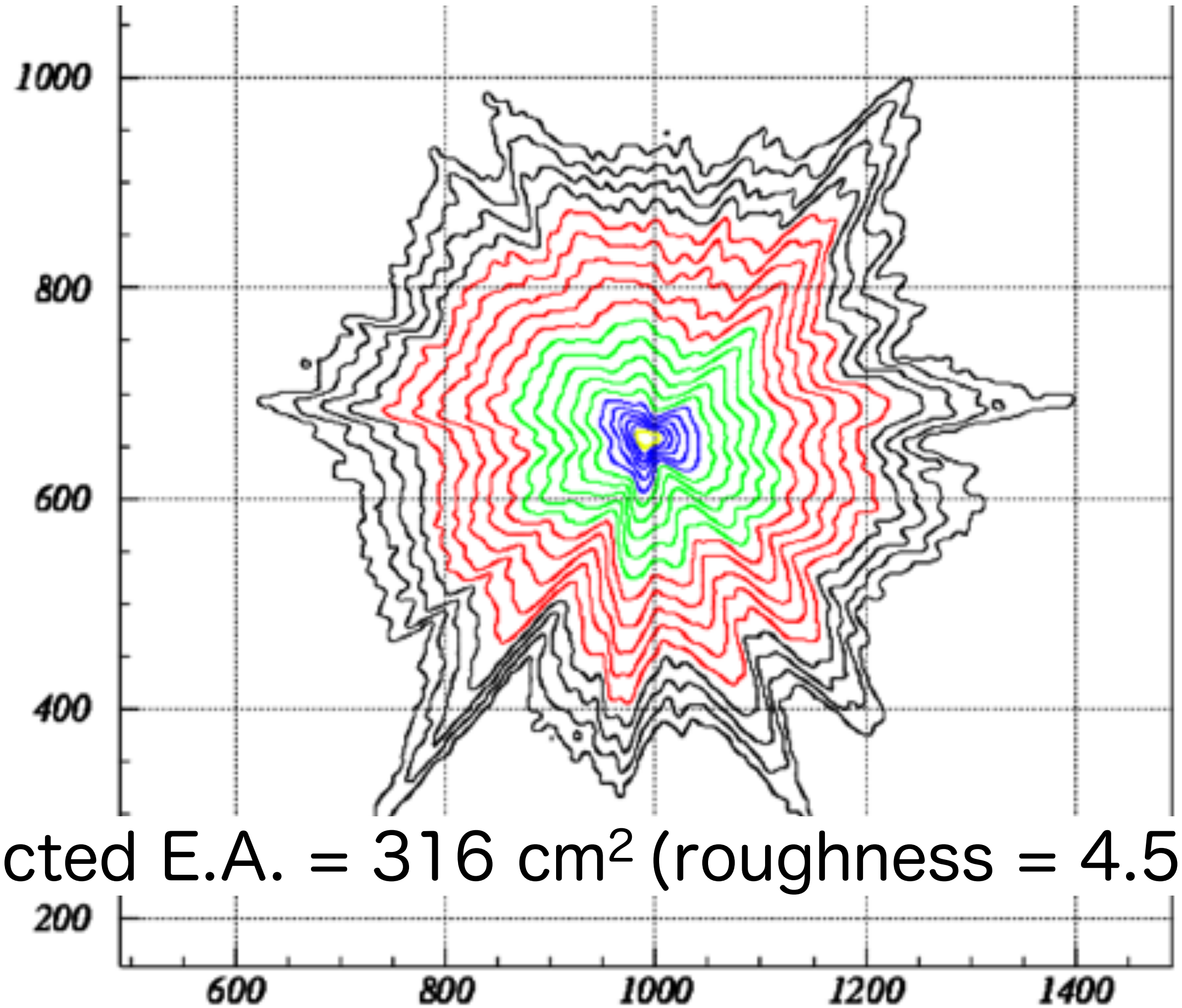
$$2d[\text{Å}]\sin\theta = m\frac{12.39}{E[\text{keV}]}$$

Parameter	Value
Diameter	45 cm
Focal length	12 m
# of nested shells	213
reflector surface	Pt/C depth-graded multilayer
Pre-collimator blade height	50 mm
Blade thickness	0.15 mm
Thermal shield thickness	Al 0.03 um + PET 5 um

HXT Current Status

BBM (30% reflectors) test results

HPD = 1.78’, E.A. = 65.1 cm^2@30 keV

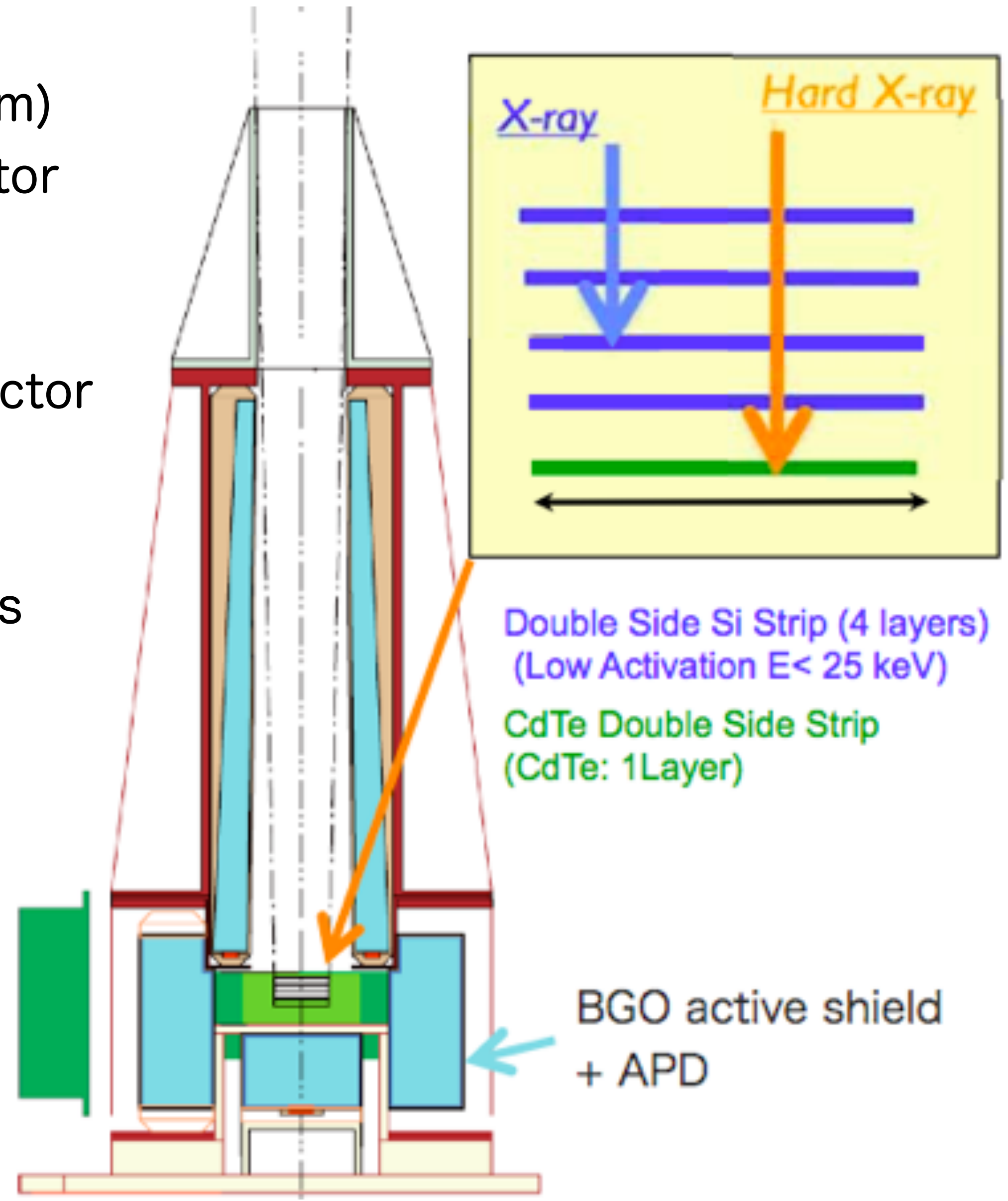


→ expected E.A. = 316 cm^2 (roughness = 4.5Å)@30 keV

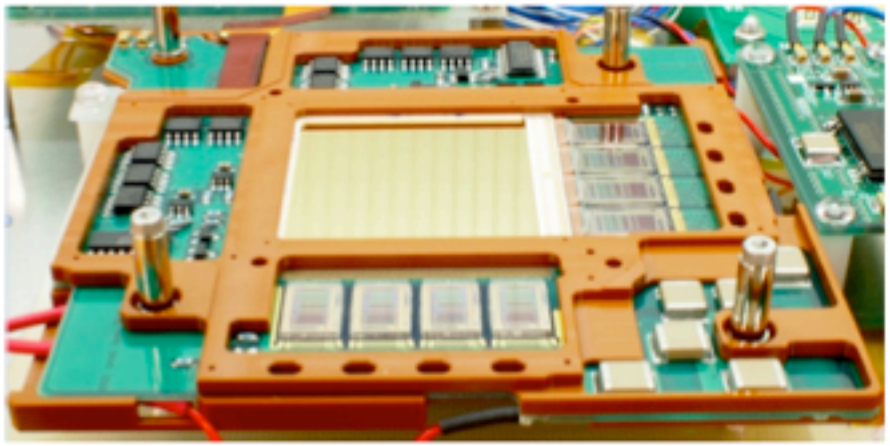
- End of Feb. 2012, all reflectors needed for HXT1 were completed!
- Now under assembly, and the ground calibration will start in this April.

HXI Design

- Fine position resolution (250 um = 4”@12 m)
  - Double-sided strip semiconductor detector
  - 128ch to cover 32 mm (FOV ~ 9’)
- High detection efficiency up to 80 keV
  - Multi-layer of double sided silicon detector
  - Employment of CdTe-DSD
- Good energy resolution
  - Low-noise signal processing electronics
  - Analog ASIC (low-power)
- Low detector background
  - Active shielding (Suzaku-HXD)
  - Hybrid structure of Si + CdTe
  - APD readout of BGO (high-voltage, compact, modularization)
- ^{241}Am used for energy/gain calibration



HXI BBM Test Results

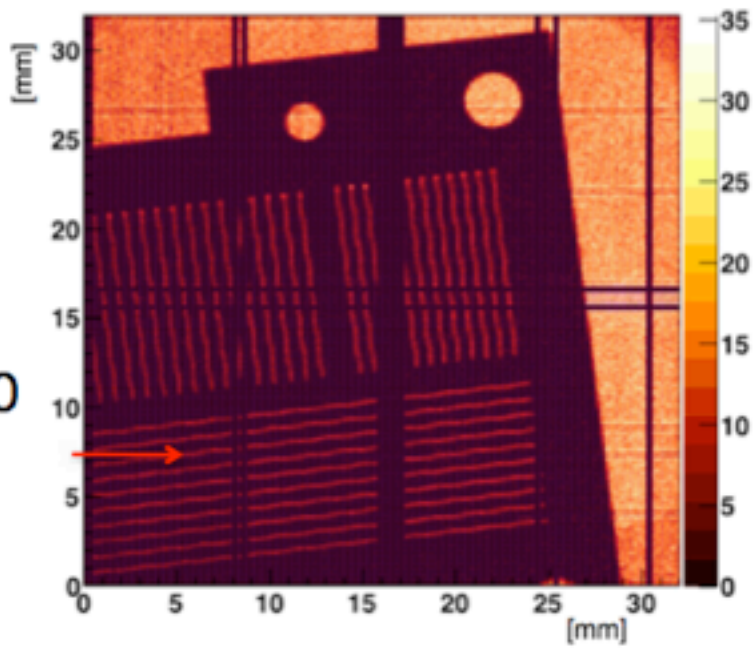


- CdTe-DSD BBM
  - 0.75 mm thickness, 250 um pix
  - Hard X-ray image is obtained successfully
  - Energy resolution ΔE = 1.6 keV (FWHM)

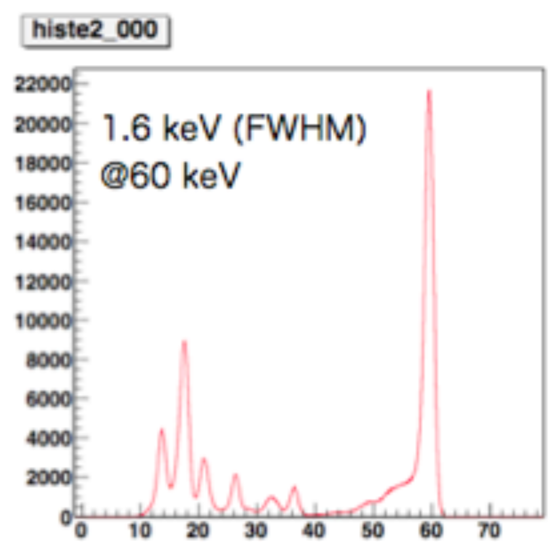
^{241}Am image

Operation @
-20C, bias 250V

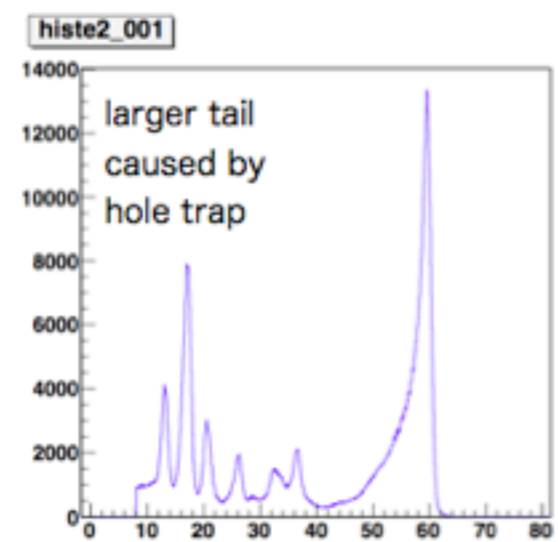
100
um
slit



Al=anode side

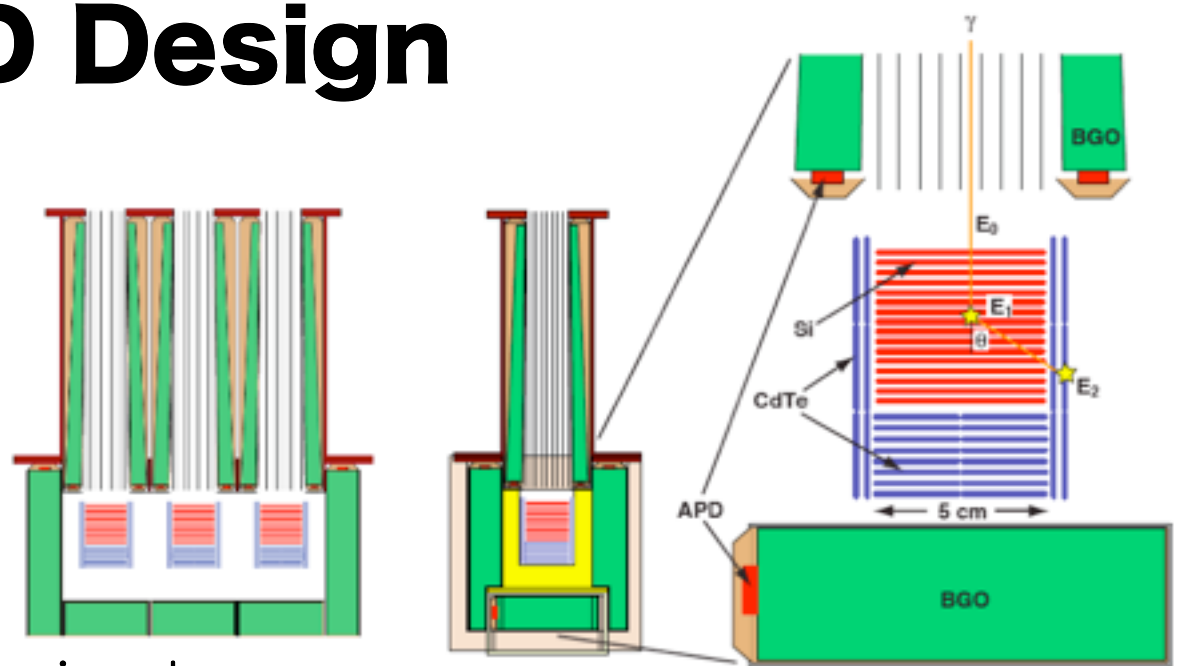


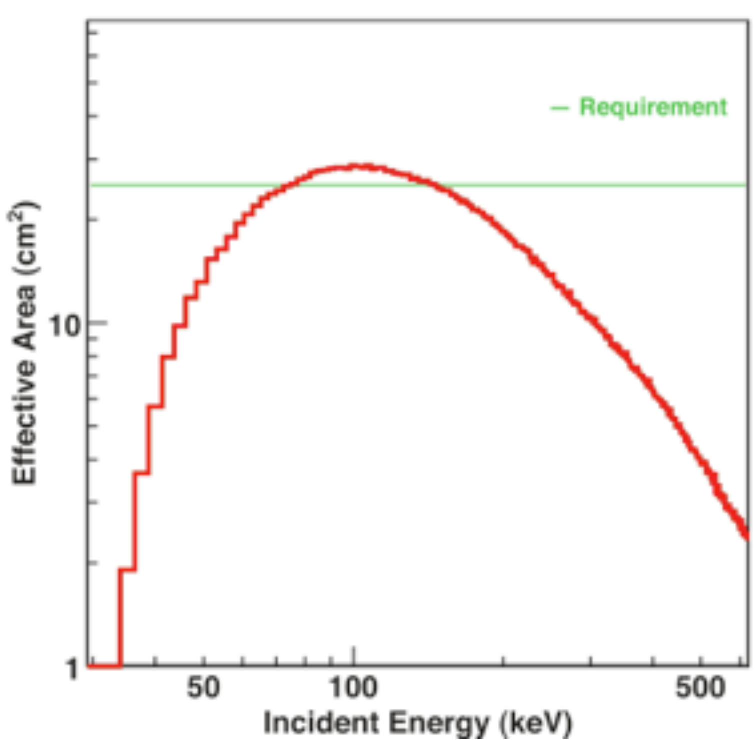
Pt=cathode side

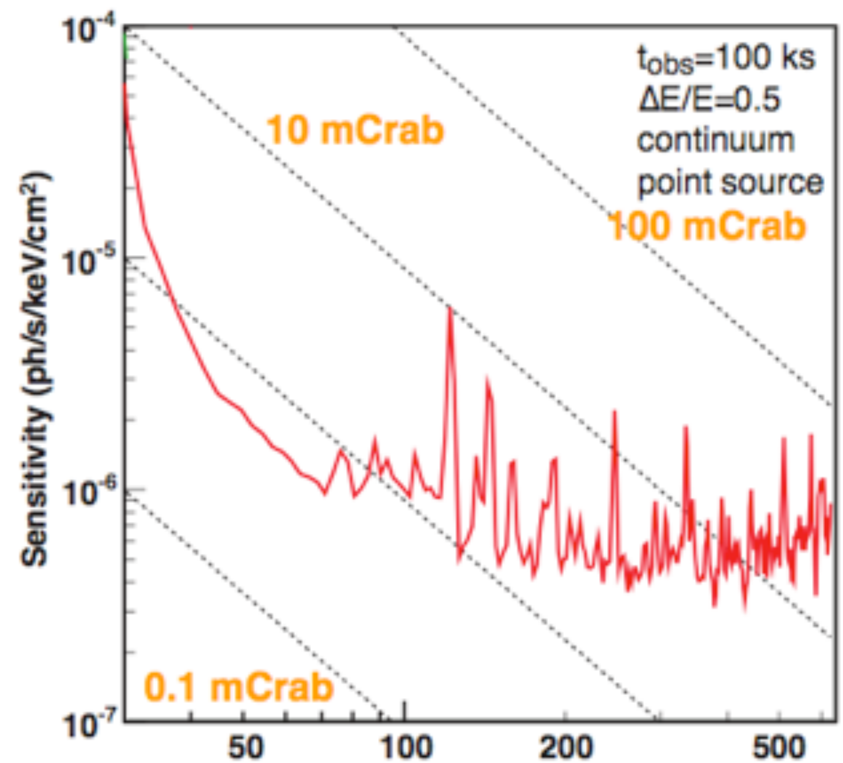


SGD Design

- Compton cameras
  - Compton kinematics
  - energy coverage 10-600 keV
- BGO active shield
- Fine collimator
  - Narrow field of view ~0.55 deg.
- SGD-WAM (Wide-band All-sky Monitor)
- Activation lines are used for energy/gain cal.

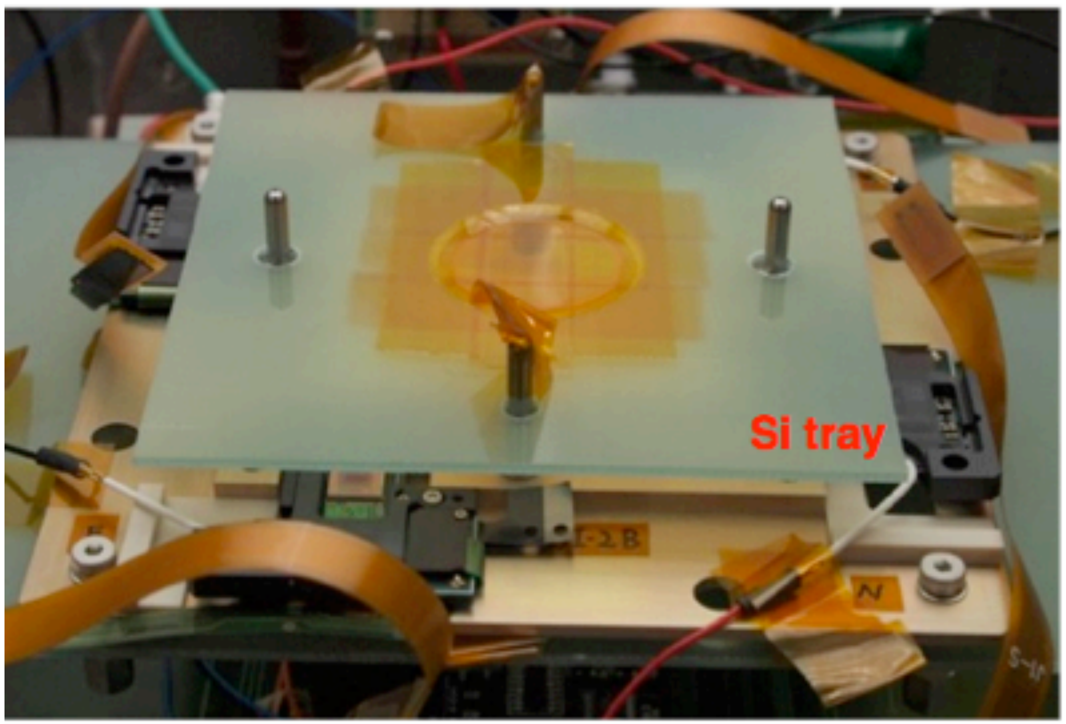


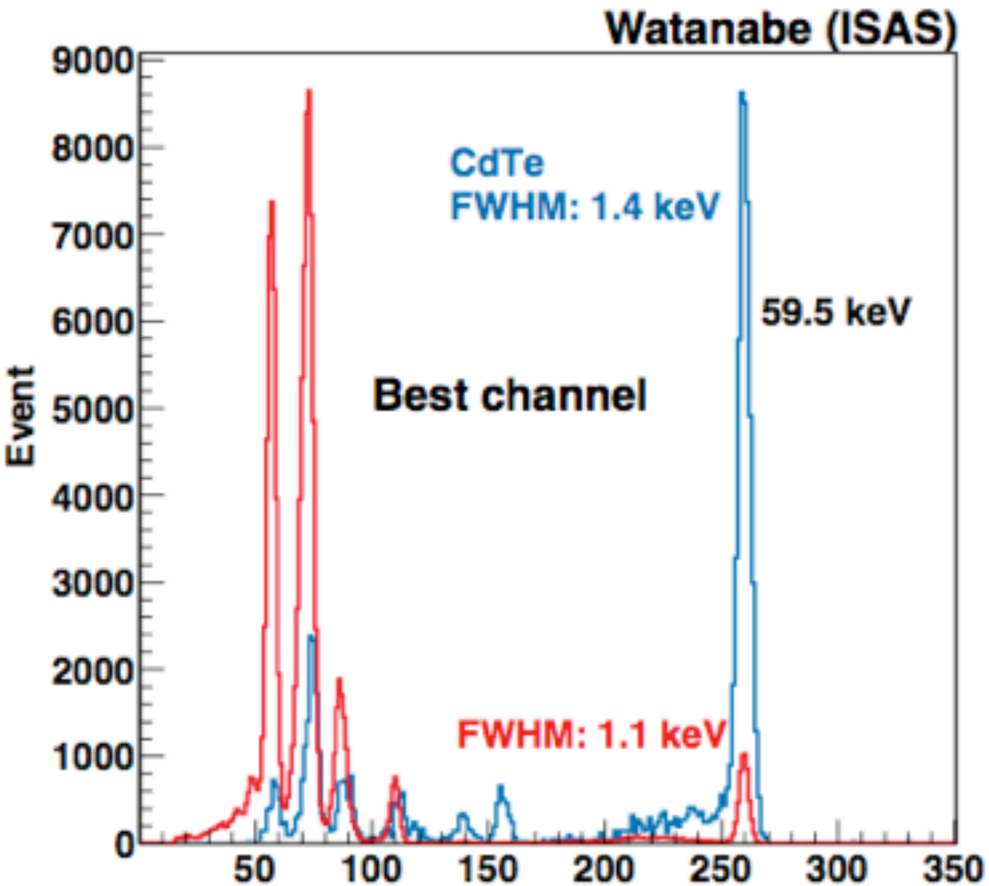




SGD Test Results

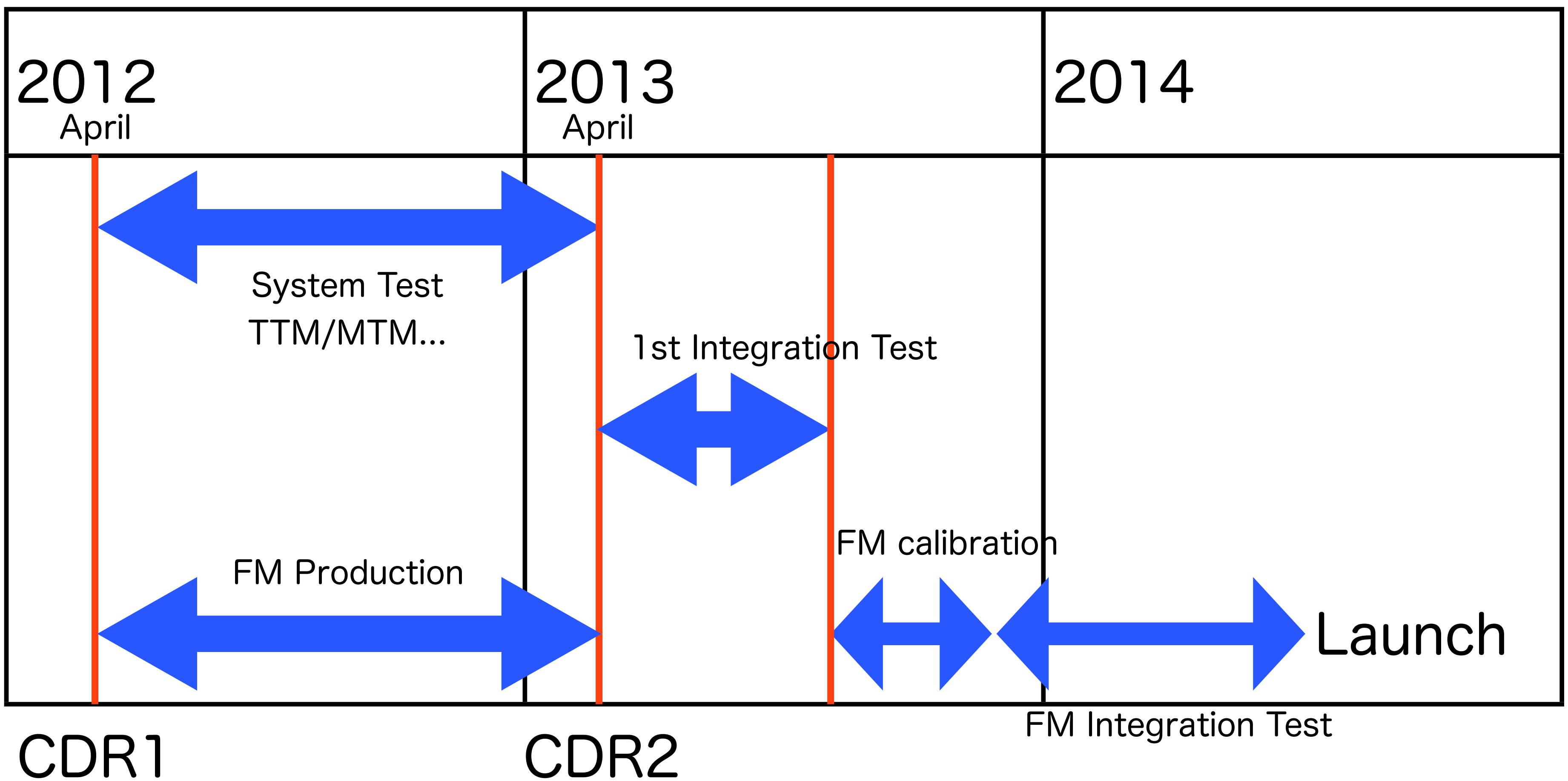
- Production of prototype (final design) SGD modules started
  - Robust performance even with long flexible cable (much longer than flight hardware)
  - consistent with expected performance





Master Schedule

Due to the north-Japan earth quake (2011/Mar/11), we have decided to revise the master schedule of ASTRO-H.
Test facilities in the Tsukuba test center got severe damages by the earth quake (Broken ceilings and walls in these buildings). The recovery process is still on going. The facilities will be open again from April 2012.



Summary

- We passed CDR1 (1st Critical Design Review)
- Starting pFM/FM production & mechanical/thermal test
- Ground measurements of BBM/EM
- Next important review is CDR2
- Launch planned for middle of 2014