The Astro-H Mission

Astro-H Overview

Astro-H will be a major international x-ray observatory.

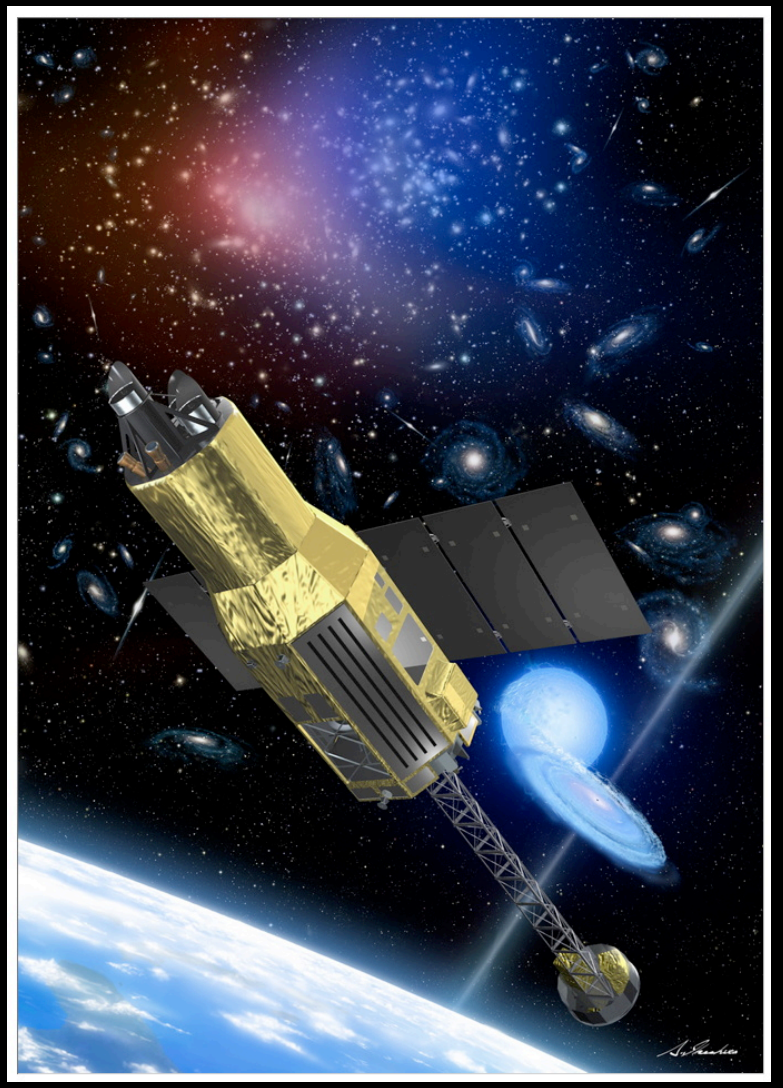
JAXA Mission with participation from NASA and ESA (through SRON)

Observing time will be made available to Japan, ESA and NASA communities.

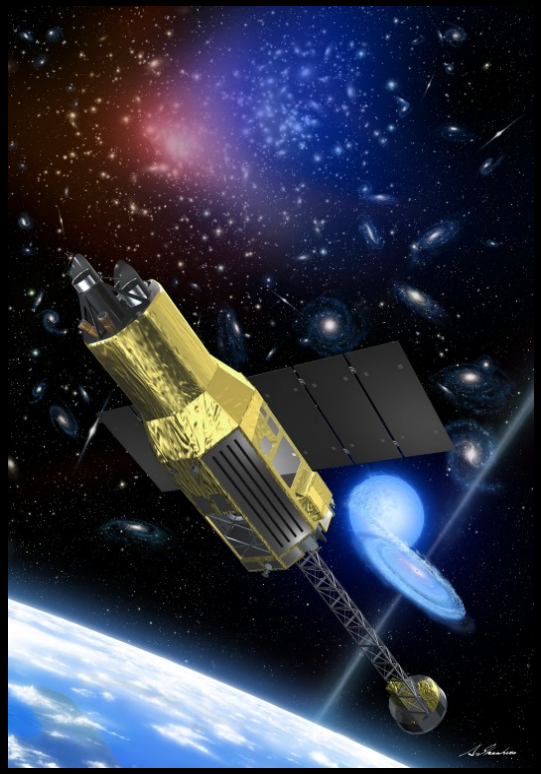
Mass ~ 2500 kg
Power ~ 3.5 kW (EOL)
Length ~ 14 m (when fully deployed)
Mission lifetime ~ 3 yr (required), 5 yr (goal)

Launched on Japanese H-IIA from Tanegashima
2014, 550 km, circular, 31 deg

Very broadband x-ray spectroscopy with high sensitivity.



Astro-H Objectives

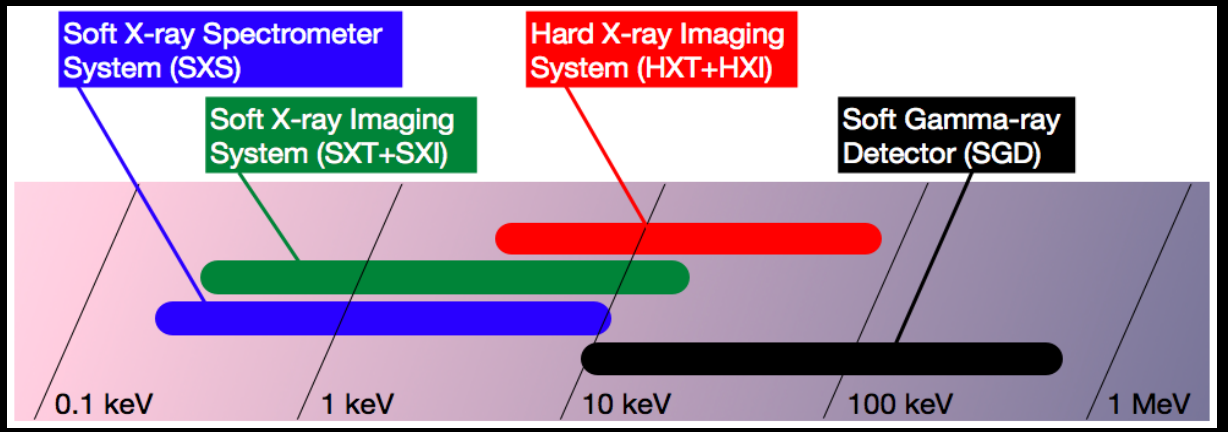


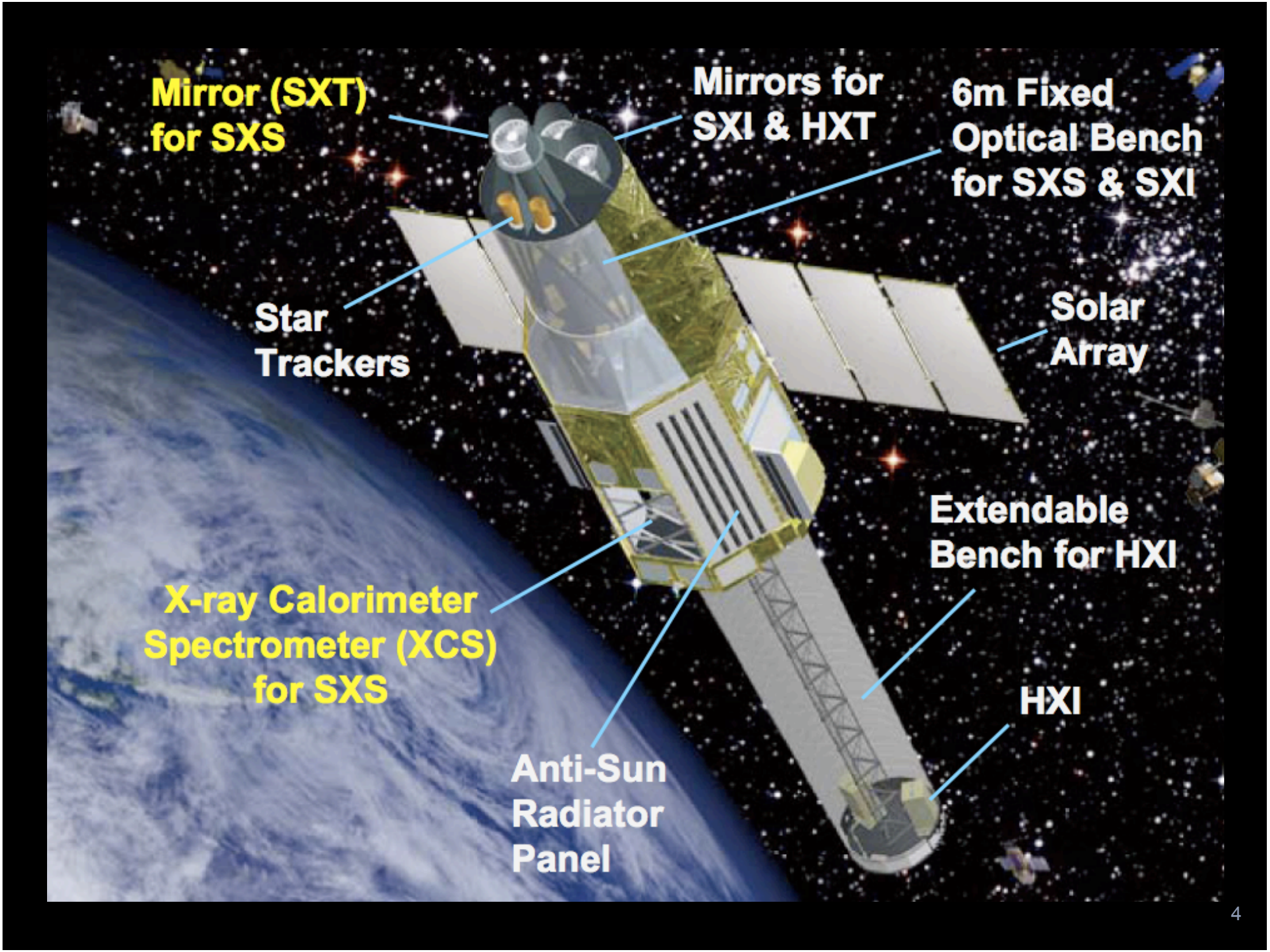
Scientific objectives :

- Revealing the large-scale structure and its evolution of the Universe
- Understanding the extreme conditions in the Universe
- Exploring the diverse phenomena of the non-thermal Universe
- Elucidating dark matter and dark energy

Key features :

- High resolution spectroscopy with X-Ray Microcalorimeter
- Hard X-ray focusing imaging
- High sensitive wide-band spectroscopy (0.3-600 keV)




Mirror (SXT) for SXS
Mirrors for SXI & HXT
6m Fixed Optical Bench for SXS & SXI
Star Trackers
Solar Array
Extendable Bench for HXI
X-ray Calorimeter Spectrometer (XCS) for SXS
HXI
Anti-Sun Radiator Panel

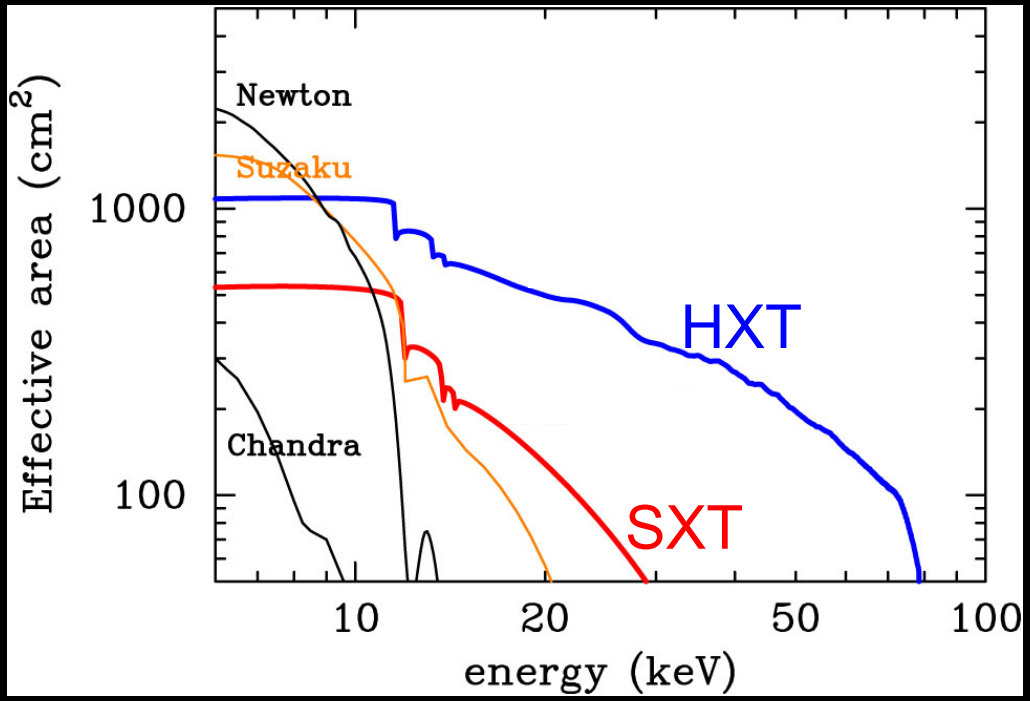
Design Parameters of Instruments

	Specifications **(Requirement)**
Hard X-ray Imaging System (HXT+HXI) 5-80 keV	Effective area : 300 cm^2 (@30 keV) Spatial resolution : 1.7 arcmin (HPD) Energy resolution : 2 keV Field of view : 9 $arcmin^2$ @30 keV
Soft X-ray Spectrometer System (SXT-S+SXS) 0.3-10 keV	Energy resolution : 7 eV Spatial resolution : 1.7 arcmin (HPD) Effective area : 210 cm^2 (@6 keV) Field of view : 3 $arcmin^2$ @6 keV
Soft X-ray Imaging System (SXT-I+SXI) 0.5-12 keV	Spatial resolution : 1.7 arcmin (HPD) Effective area : 360 cm^2 @6 keV Energy resolution : 150 eV Field of view : 38 $arcmin^2$ @6 keV
Soft γ-ray detector (SGD) 10-600 keV	Effective area : 100cm^2 @100 keV Energy resolution : 2 keV @40 keV Astrometric accuracy : <0.6 arcdeg (E<150 keV)

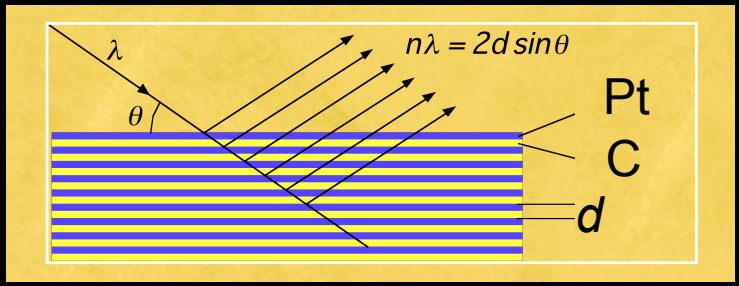
Hard X-ray Telescope (HXT) ISAS, Nagoya…

Imaging at Higher Energies

New Hard X-ray Telescope with large effective area



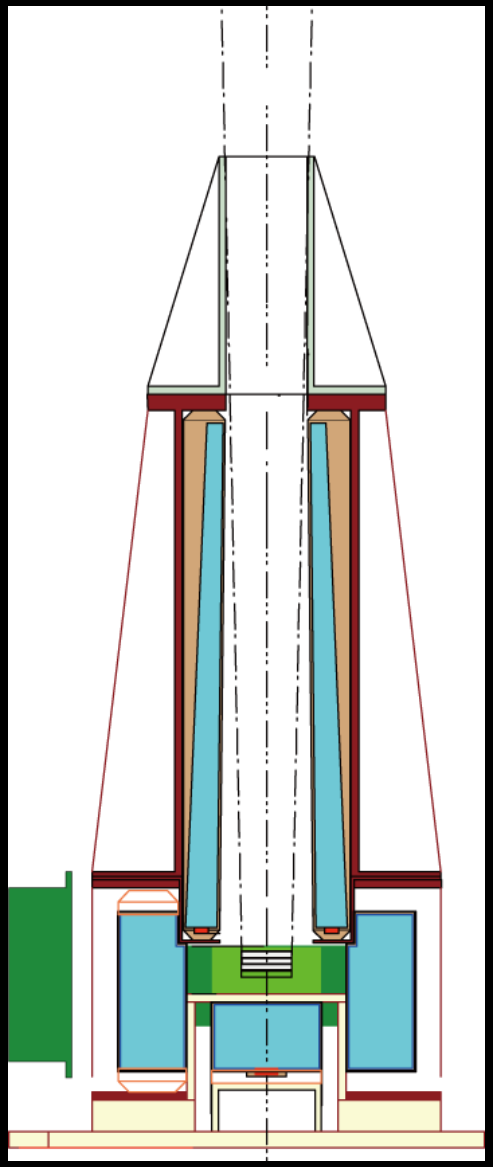
300 cm^2 @ 30 keV



Two Telescopes - 12 m f.l., 45 cm dia. mounted on the fixed optical bench

Hard X-ray Imager (HXI) ISAS, U. Tokyo…

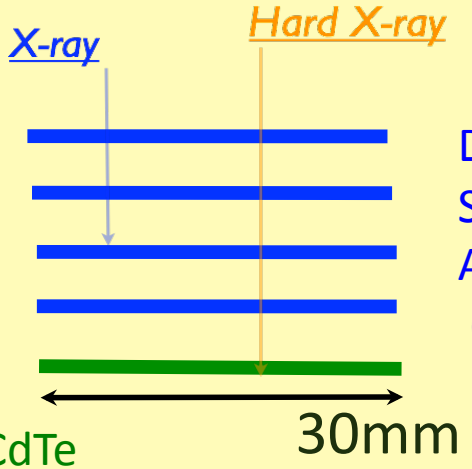
Cutting Edge Technology



Well-type BGO Active Shield (APD Readout)

Si/CdTe Hybrid Detector (Double Sided)

VERY Careful Design to achieve "Low Background"

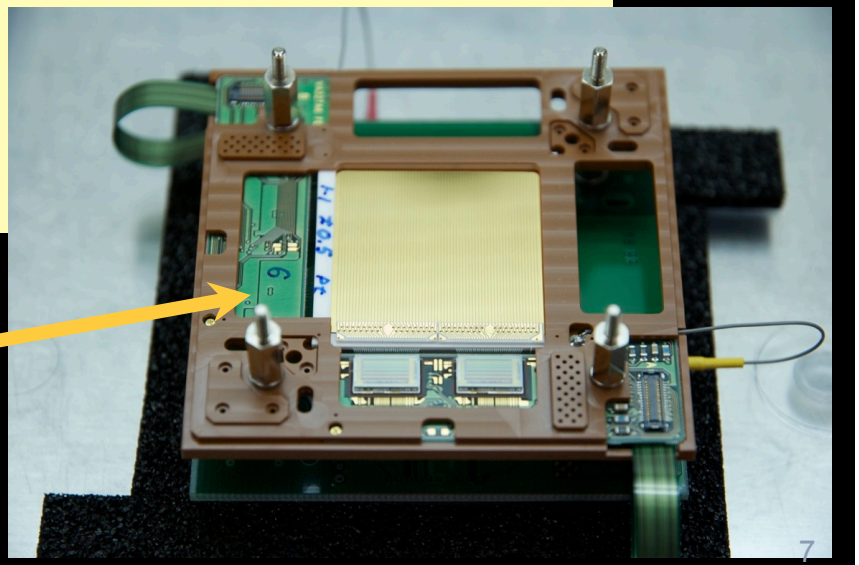


9x9 arcmin^2

Double Side Si Strip (Low Activation E< 25 keV) (DSSD: 4Layer)

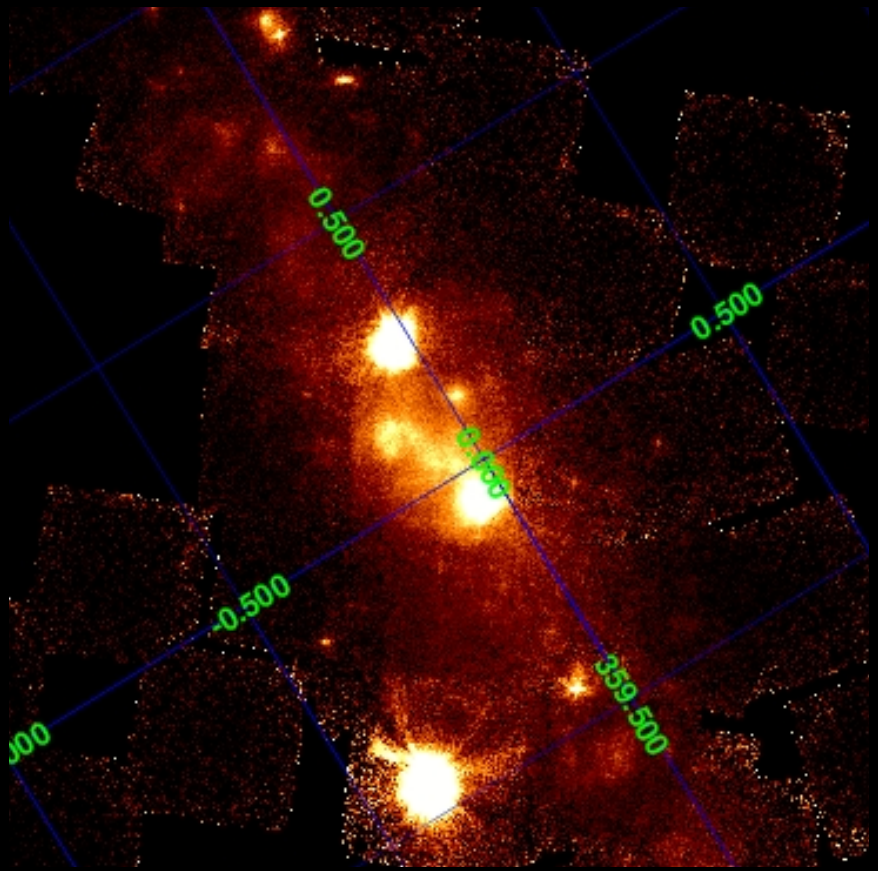
CdTe Double Side Strip (CdTe: 1Layer)

High Res. CdTe Diode (Cross Strips) 250 micron pitch



Simulation: Comparison with INTEGRAL/IBIS image

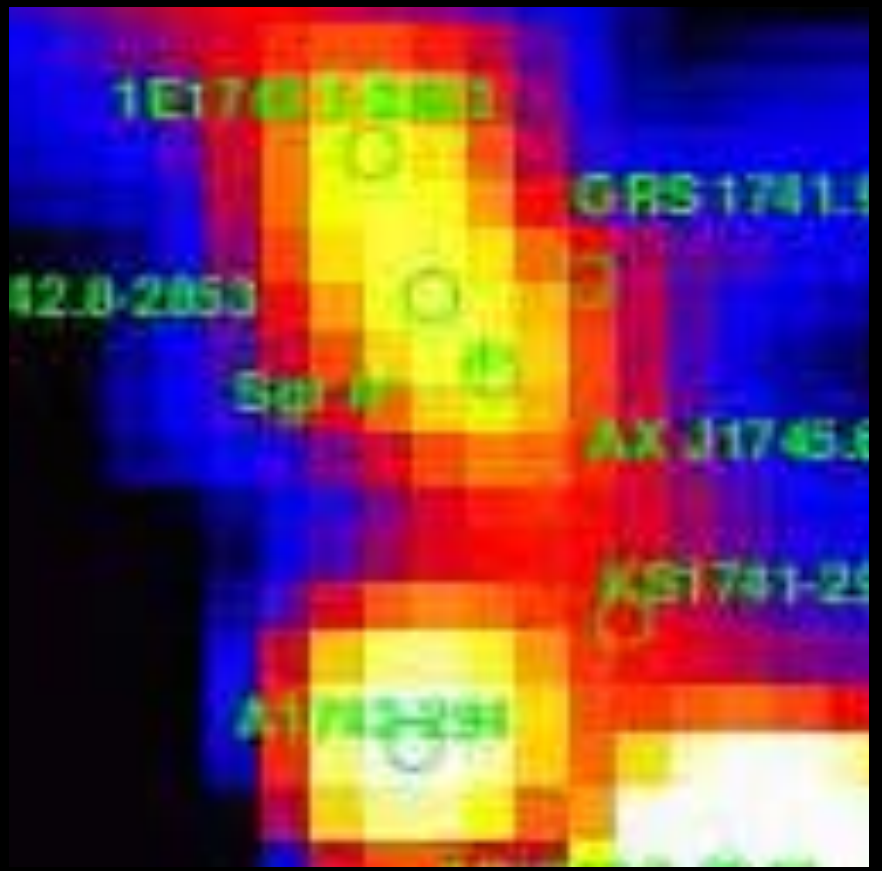
ASTRO-H HXI



100-150 ks/pointing

by A.Bamba

INTEGRAL IBIS



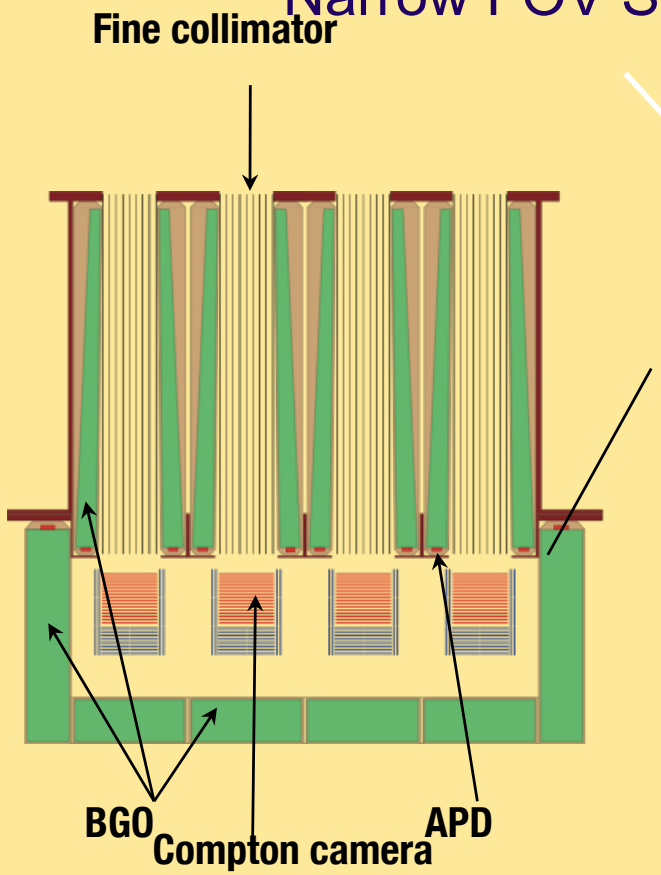
(Revnivtsev+04)

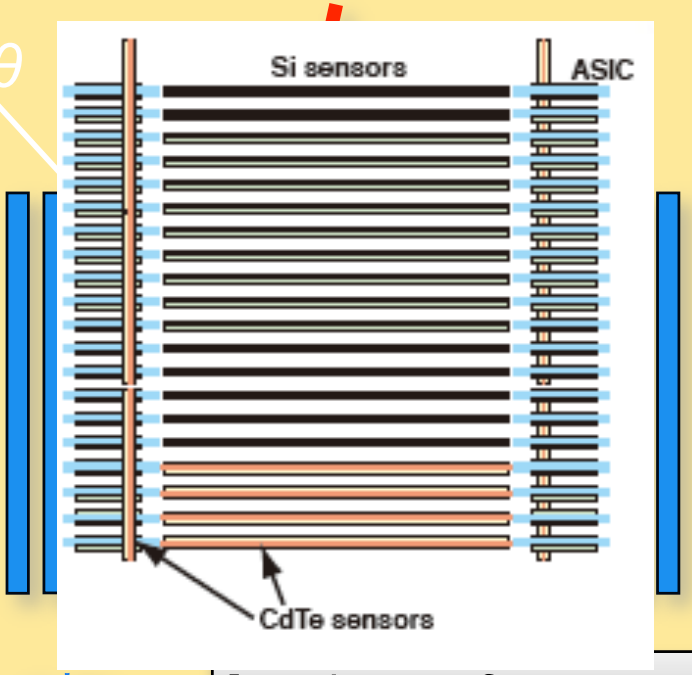
Soft Gamma-ray Detector (SGD) ISAS, U. Tokyo, Stanford…

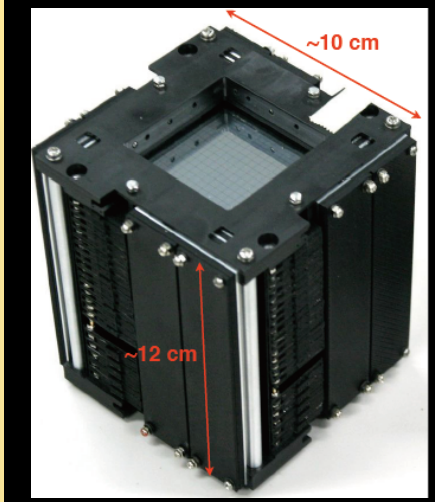
Higher sensitivity above 80 keV

Completely new approach for obtaining lower background

Narrow FOV Si/CdTe Compton Detector

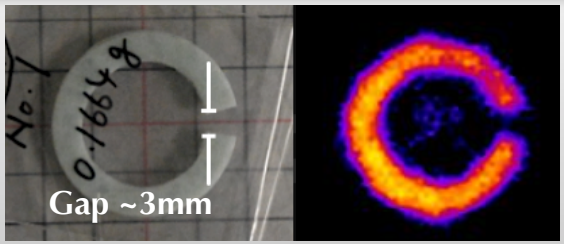






CdTe Pixels

Imaging performance



JAXA/Gunma U./JAEA(2008)

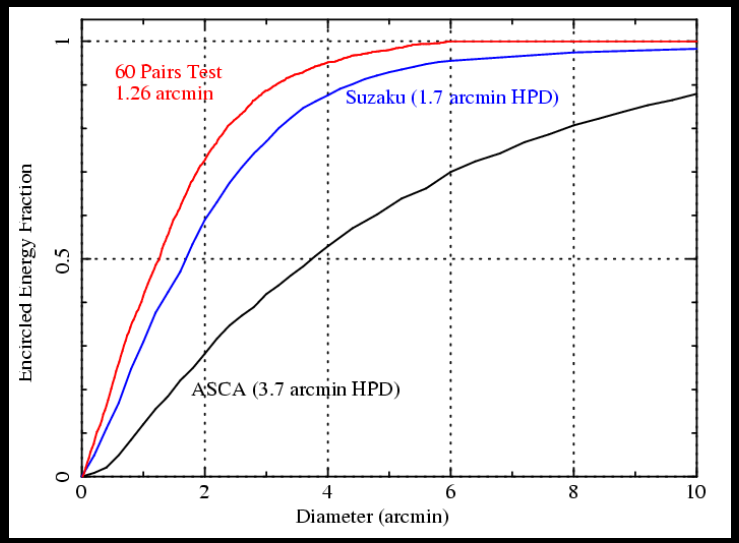
$$\cos\theta = 1 - m_e c^2 \left(\frac{1}{E_2} - \frac{1}{E_1 + E_2} \right)$$

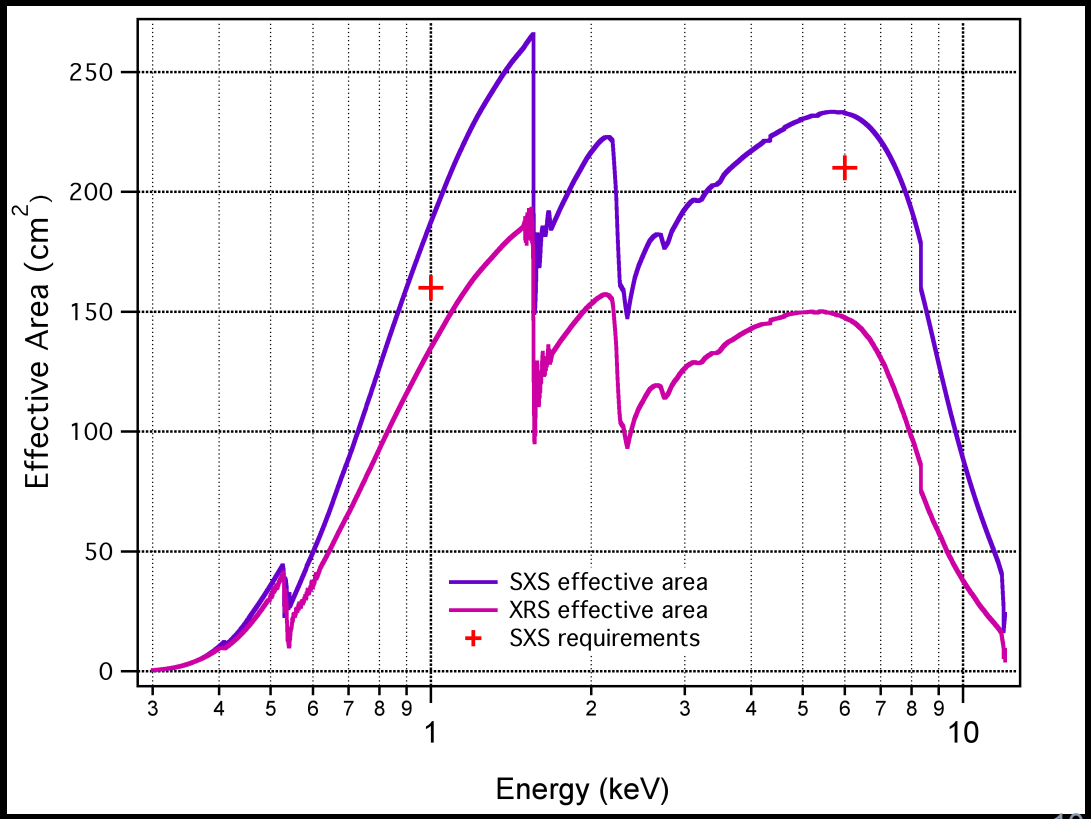
High throughput X-Ray mirror

5.6 m focal length – *fixed optical bench*

Outer Diameter – 45 cm

Half-Power Diameter of better than 1.7 arcmin

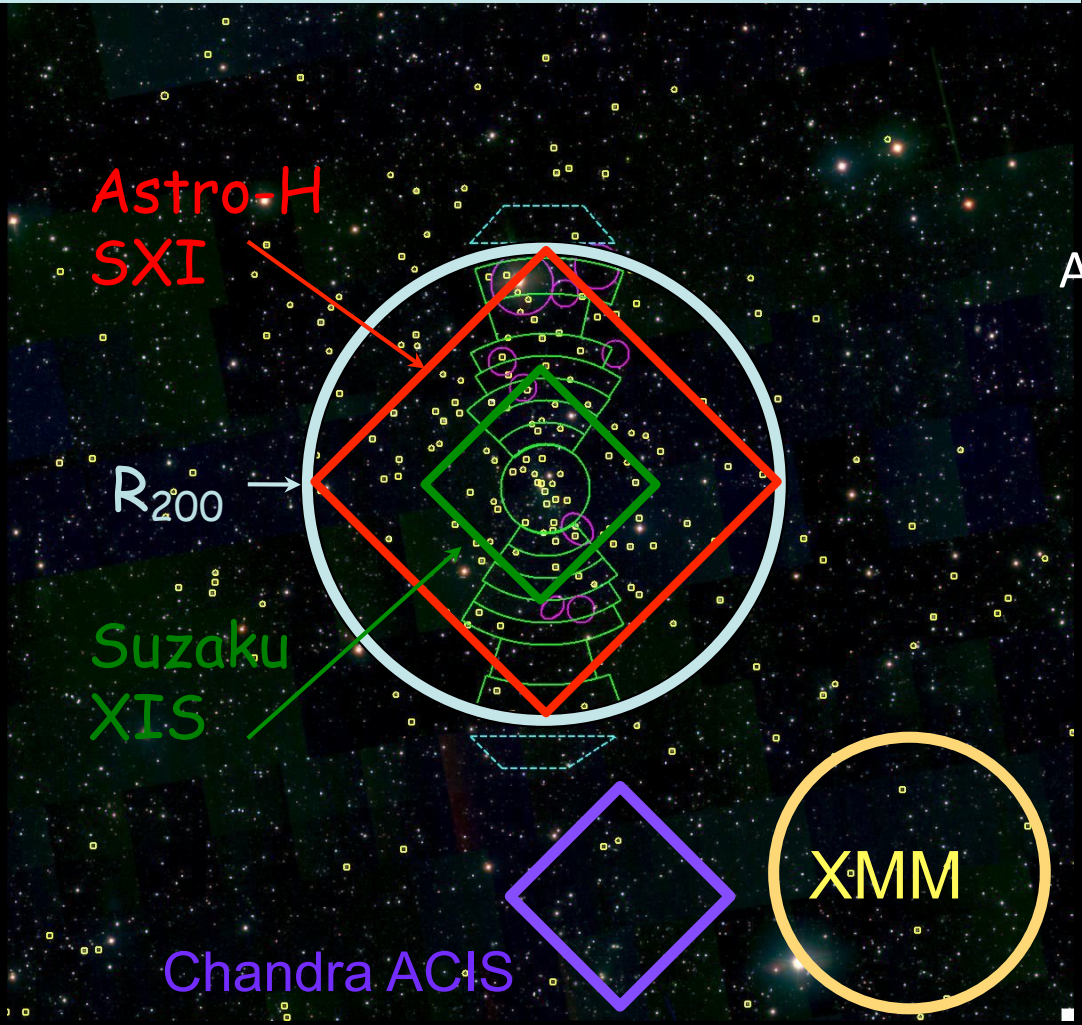




Soft X-ray Imager (SXI) ISAS, Osaka, Kyoto, …

Large FOV CCD (focal length 5.6m)

Astro-H SXI vs Suzaku XIS on A1795

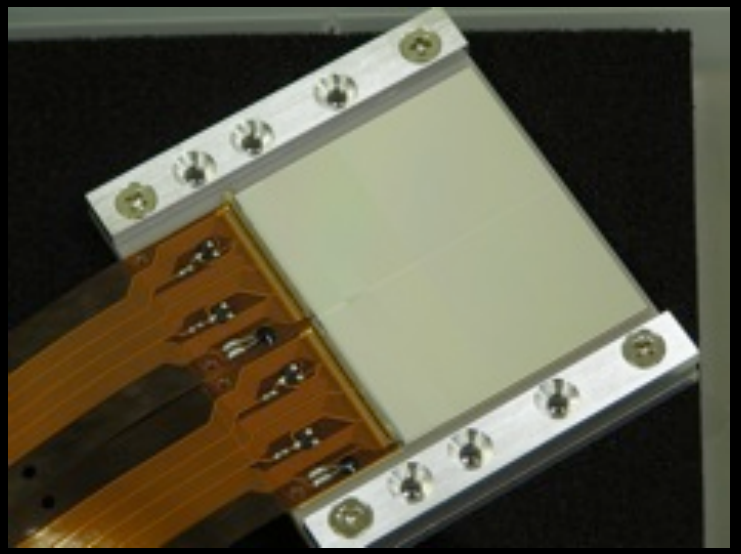


Energy resolution : 150 eV

Field of view : 38 arcmin @6 keV

4CCD chips/62x62mm^2

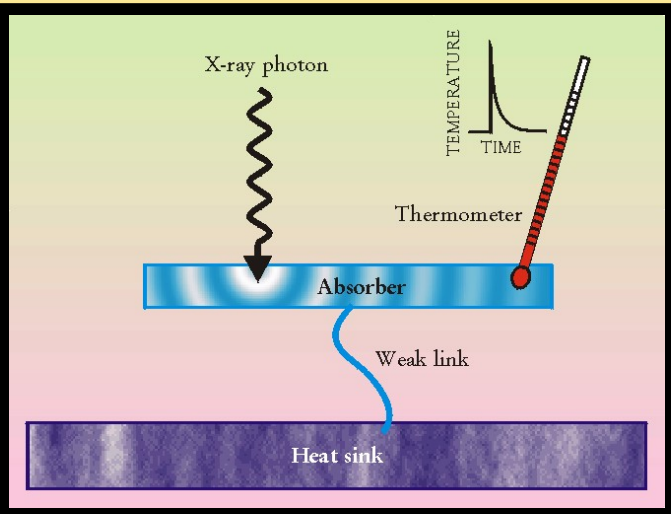
Angular resolution : 1.7 arcmin (HPD)
(requirement)



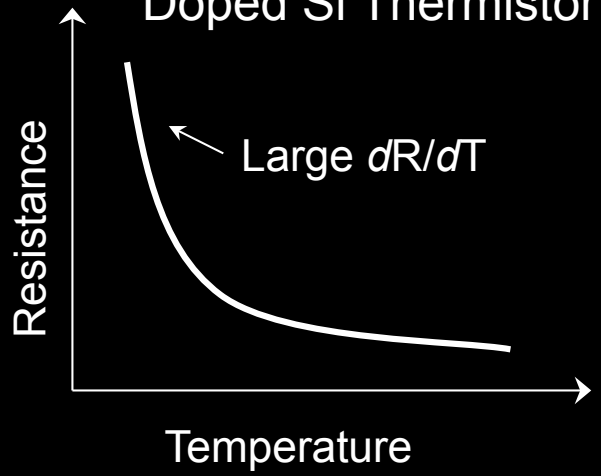
Hamamatsu Photonics

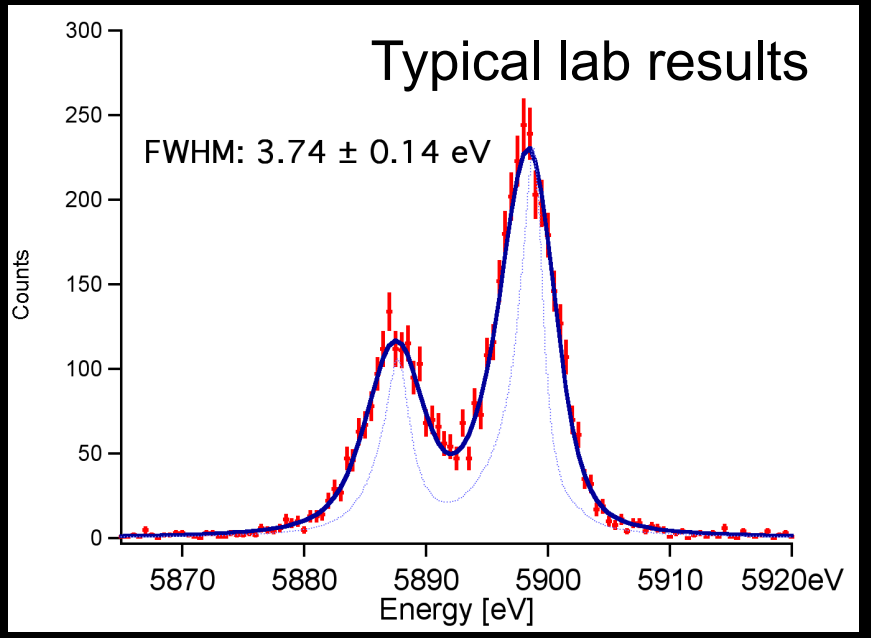
The X-Ray Calorimeter Spectrometer

Non-dispersive spectrometer



Doped Si Thermistor



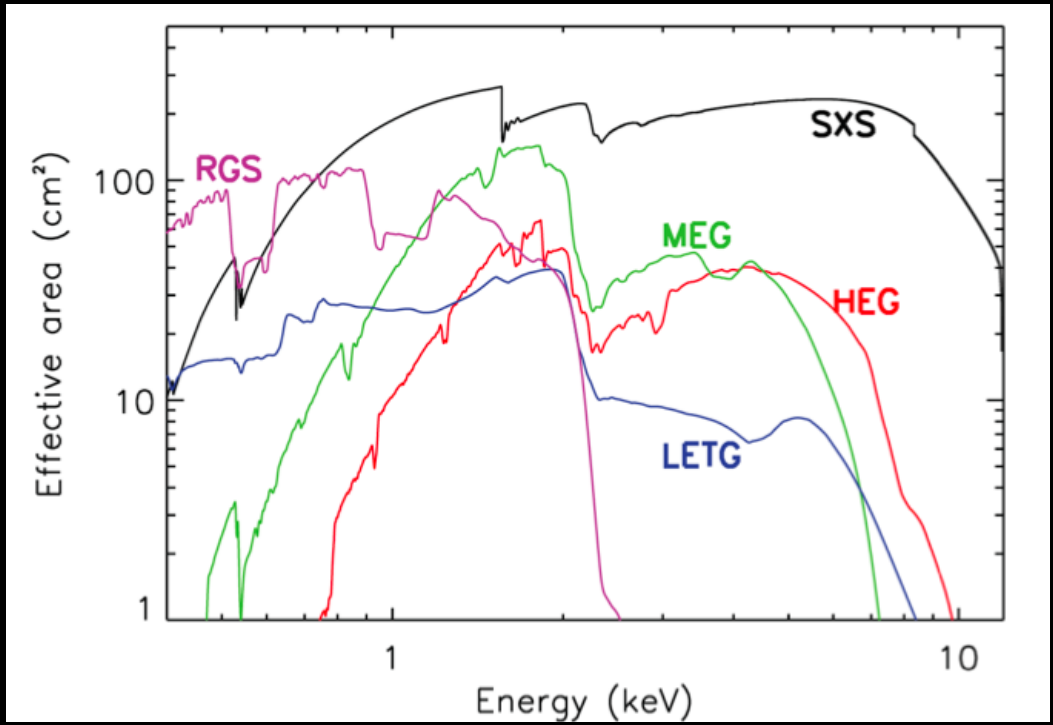


$$\Delta E_{FWHM} = 2.35\,\xi\sqrt{kT^2C}$$

- Energy resolution is limited by thermodynamics
- Energy resolution of several eV possible, nearly independent of energy.
- *SXS expected to have ~ 5 eV resolution at the system level. 6x6 array of 30 x 30" pixels*

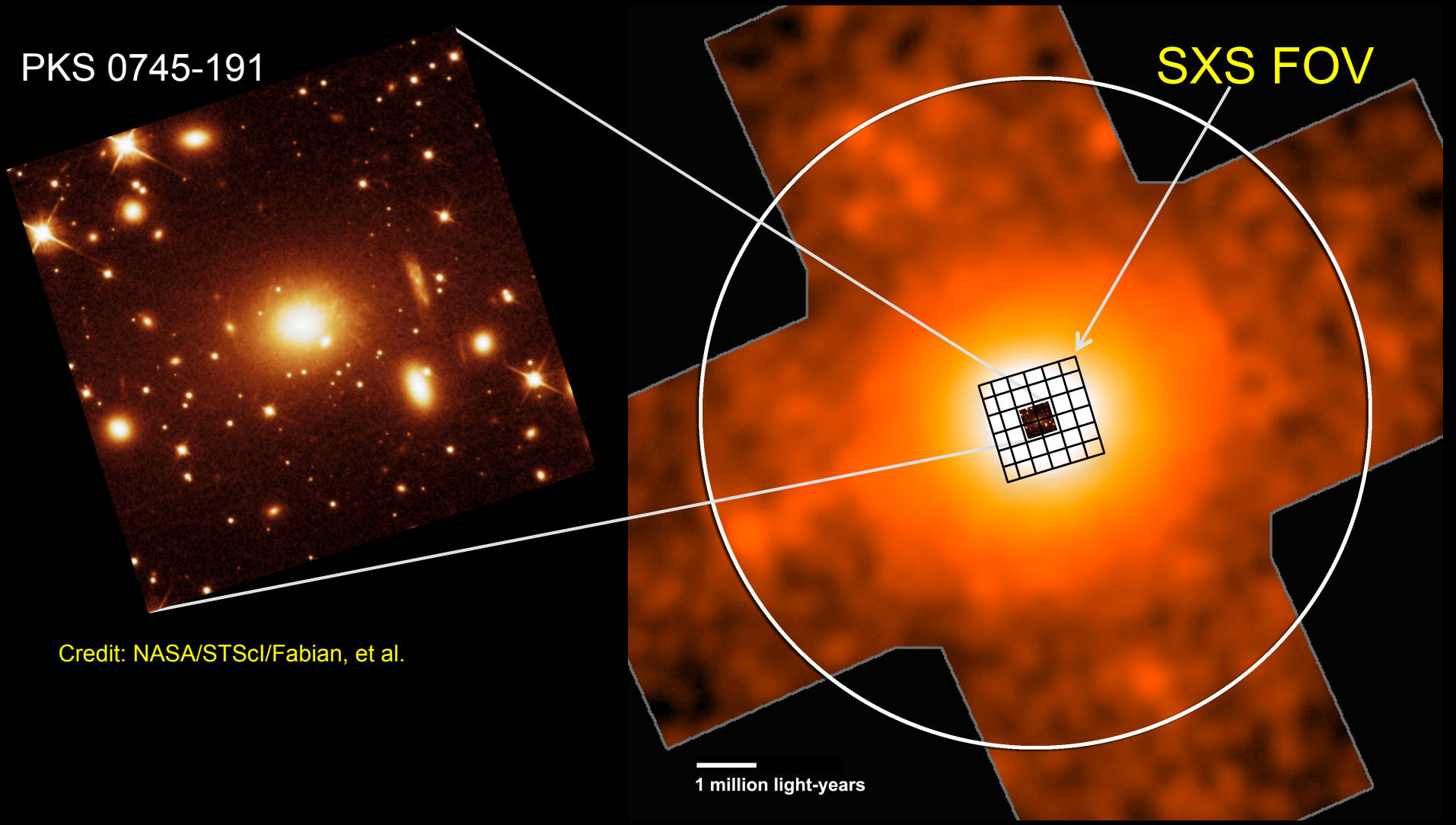
SXS Performance Requirements

	Requirements (/Goal)
Energy resolution	7 eV (FWHM) (4 eV(FWHM) Goal)
Energy range	0.3 - 12 keV
Background rate	1.5 x 10^{-3} cts/s/keV
Field of view	2.9 x 2.9 arcmin
Detector array	6 x 6
Absorber size	800 μm
Angular resolution	1.7 arcmin HPD
Effective area	160 / 210 cm^2 (at 1 / 6 keV)
Lifetime	3 years min / 5 years goal
Maximum count rate	150 cts/s
Energy scale accuracy	2 eV



Effective area: 210 cm^2 @ 6 keV

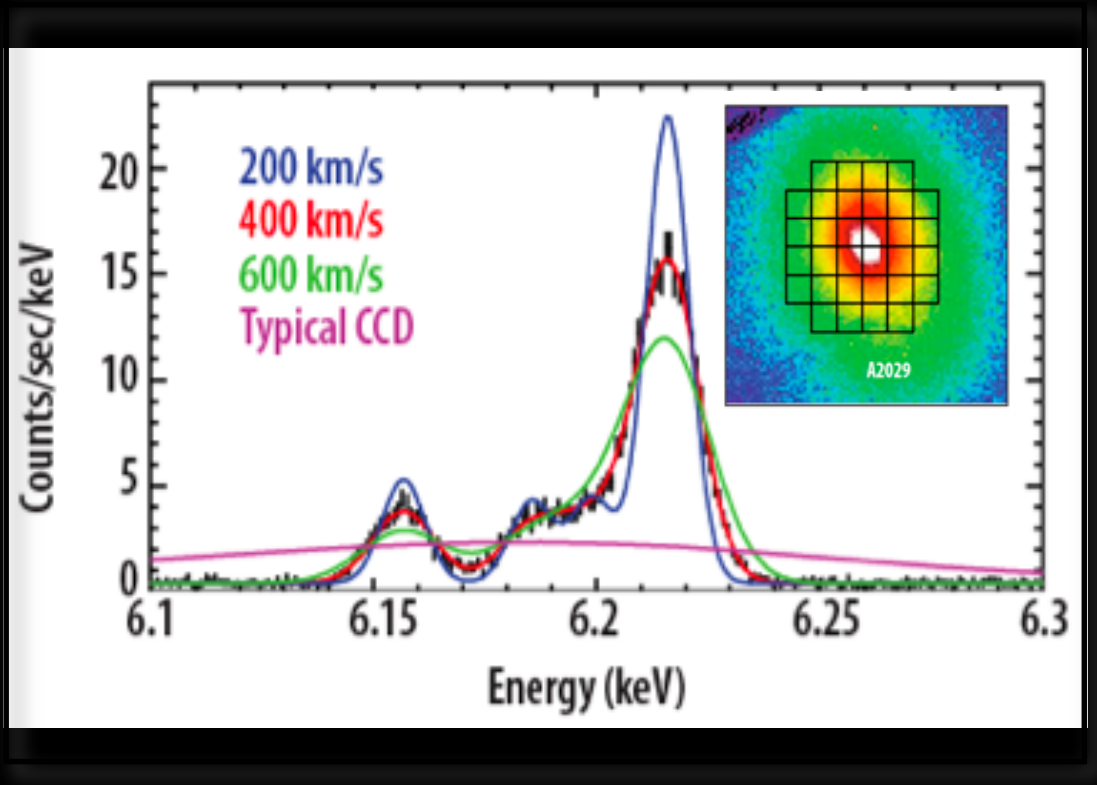
Clusters of Galaxies



Credit: NASA/STScI/Fabian, et al.

Credit: NASA/ISAS/Suzaku/M. George, et al.

High Resolution Spectroscopy by Astro-H



Astro-H can detect bulk velocity flow as small as 300 km/s in the brightest 30 hot clusters (kT > 5 keV).

Astro-H will advance X-ray astronomy to a new phase by revealing dynamical motions in all scales in the universe.

Summary

- Astro-H is now in Phase C in Japan and US. Instrument and mission CDRs scheduled for June-July 2011
- Japan, US and ESA GO Programs
- Launch planned for February 2014
- Wide-band/low-background & X-ray microcalorimeter resolution
- Large International Collaboration
    - (NASA/SRON/ESA/DAI/Geneva U. /CEA/CSA and more)
- Major high-energy astrophysics for the 2nd half of the coming decade that will complement other major observatories