

The ASTRO-H project



Hiro MATSUMOTO (Nagoya University)
on behalf of the ASTRO-H team

Outline

- X-ray astronomy
- ASTRO-H
 - Precise Soft X-ray Spectroscopy
 - Soft X-ray Telescope (SXT) + Soft X-ray Spectrometer (SXS)
 - Soft X-ray Imaging Spectroscopy
 - SXT + Soft X-ray Imager (SXI)
 - Hard X-ray Imaging Spectroscopy
 - Hard X-ray Telescope (HXT) + Hard X-ray Imager (HXI)
 - Soft Gamma-ray Observation
 - Soft Gamma-ray Detector (SGD)
- Summary

X-ray Universe

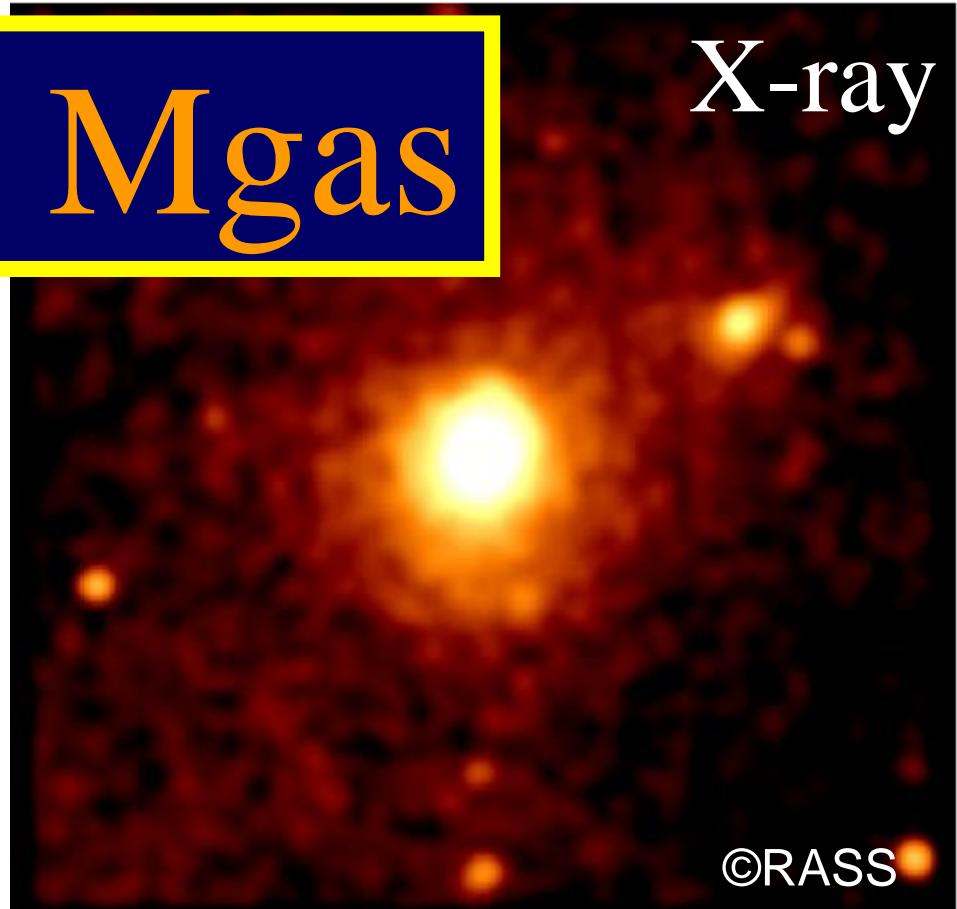
Optical



©SDSS

Cluster of galaxies

X-ray



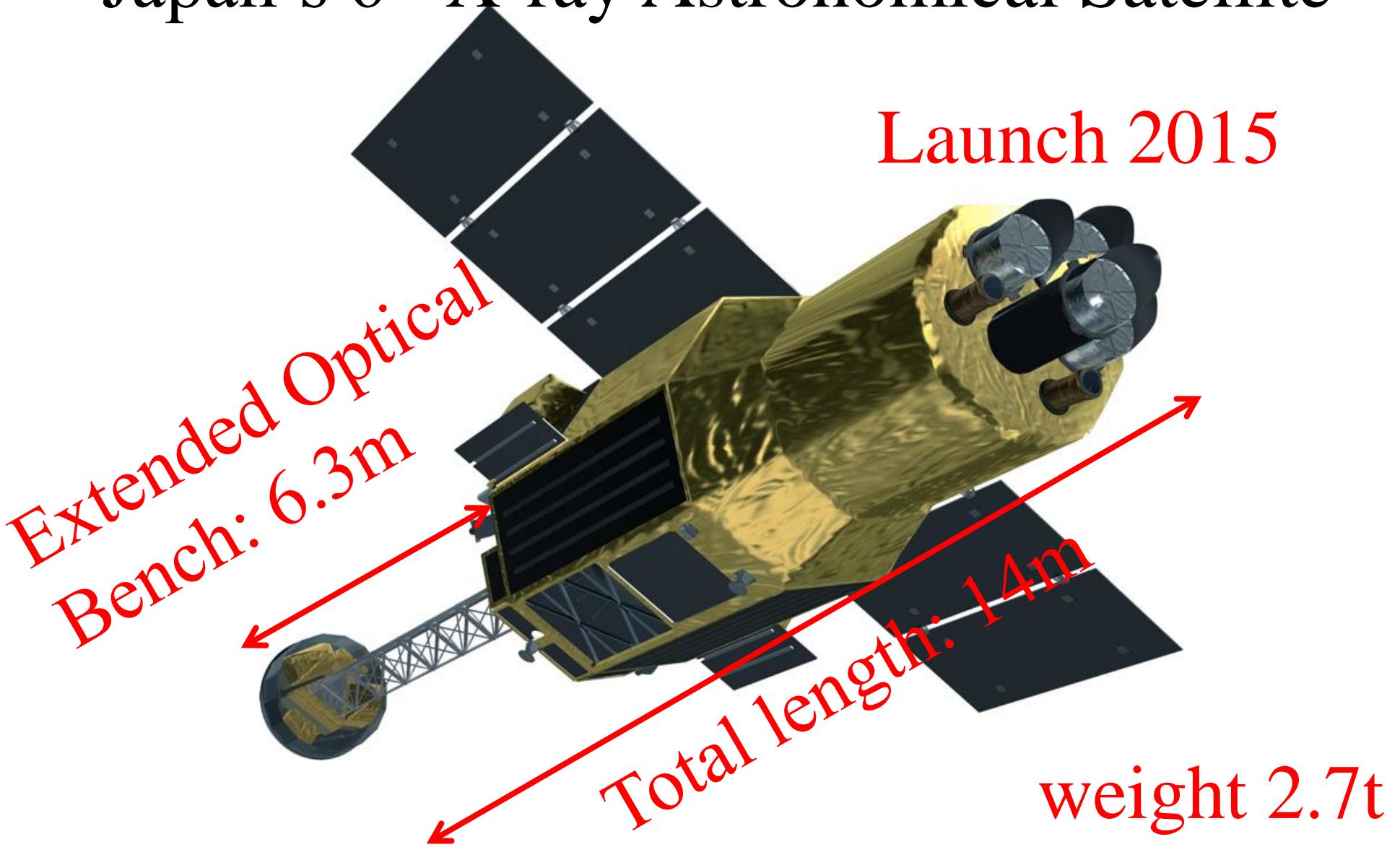
©RASS

hot gas

We would overlook real face without X-rays.

ASTRO-H Satellite

Japan's 6th X-ray Astronomical Satellite



International collaboration

More than 160 scientists from Japan/USA/Europe



The logo features a yellow satellite in space, with the text "X-RAY OBSERVATORY" in blue and "ASTRO-H" in large white letters.

Participating Institutions:

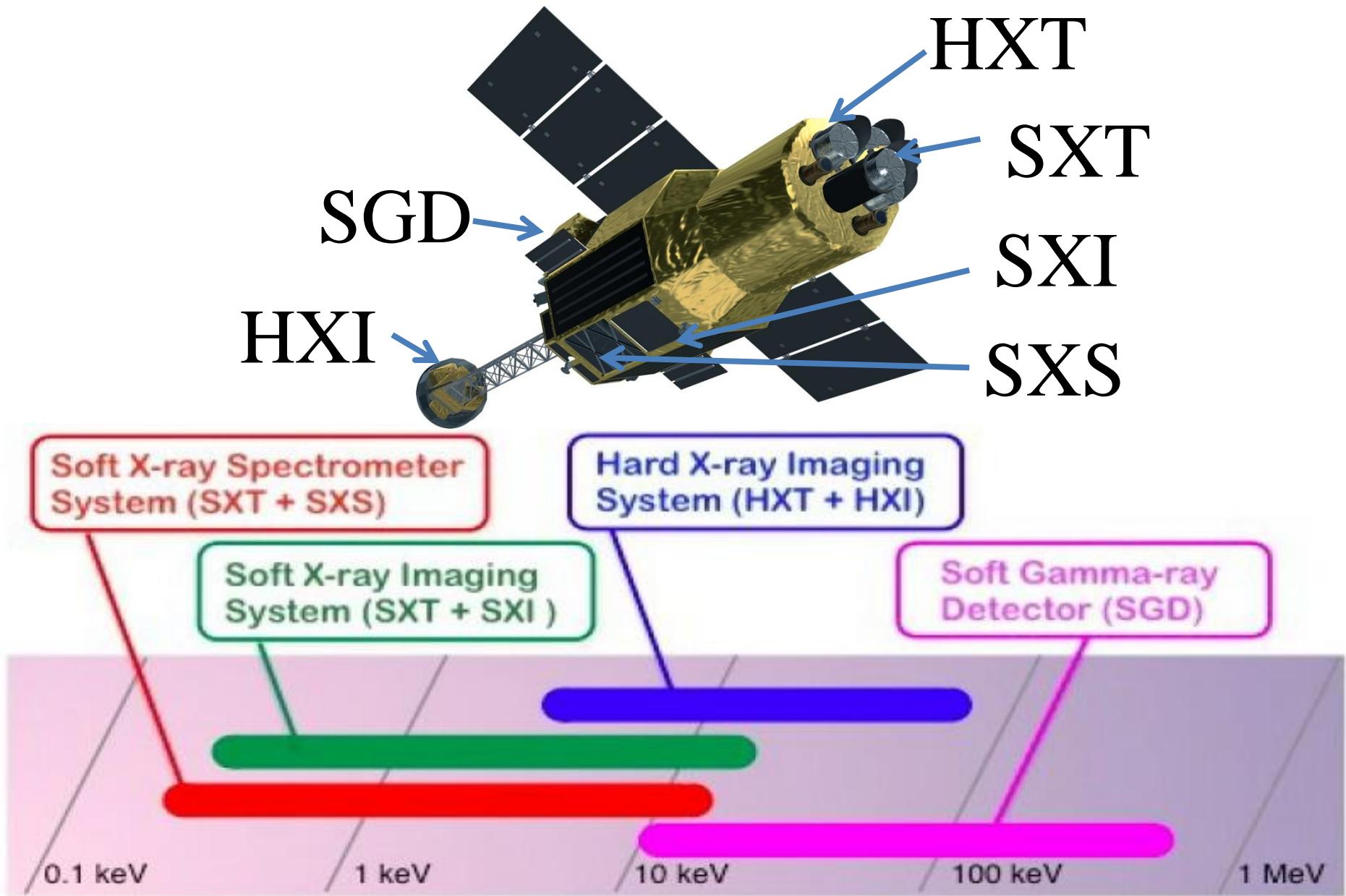
JAXA	Kanazawa U.	Rutgers U.
NASA	Kochi U. of Tech.	Saint Mary's U.
Aoyama Gakuin U.	Kobe U.	Saitama U.
U. of Cambridge	Kogakuin U.	Shibaura Inst. Tech.
CEA/DSM/IRFU	Kyoto U.	SRON
CfA/Harvard	LLNL	Stanford U./KIPAC
Chubu U.	U. of Manitoba	STScI
Chuo U.	U. of Maryland	Toho U.
Columbia U.	Miami U.	Tokyo Inst. Tech
CSA	U. of Michigan	Tokyo
Dublin Institute for Advanced Studies	MIT	Metropolitan U.
Durham U.	U. of Miyazaki	Tokyo U. of Sci.
Ehime U.	Nagoya U.	U. of Tokyo
ESA	Nara Women's U.	U. of Tsukuba
U. of Geneva	Nihon Fukushi U.	Waseda U.
Gunma Astronomical Observatory	Nihon U.	U. of Waterloo
Hiroshima U.	NIMS	U. of Wisconsin
JHU	Osaka U.	Yale U.
	RIKEN	
	Rikkyo U.	

Logos and Flags:

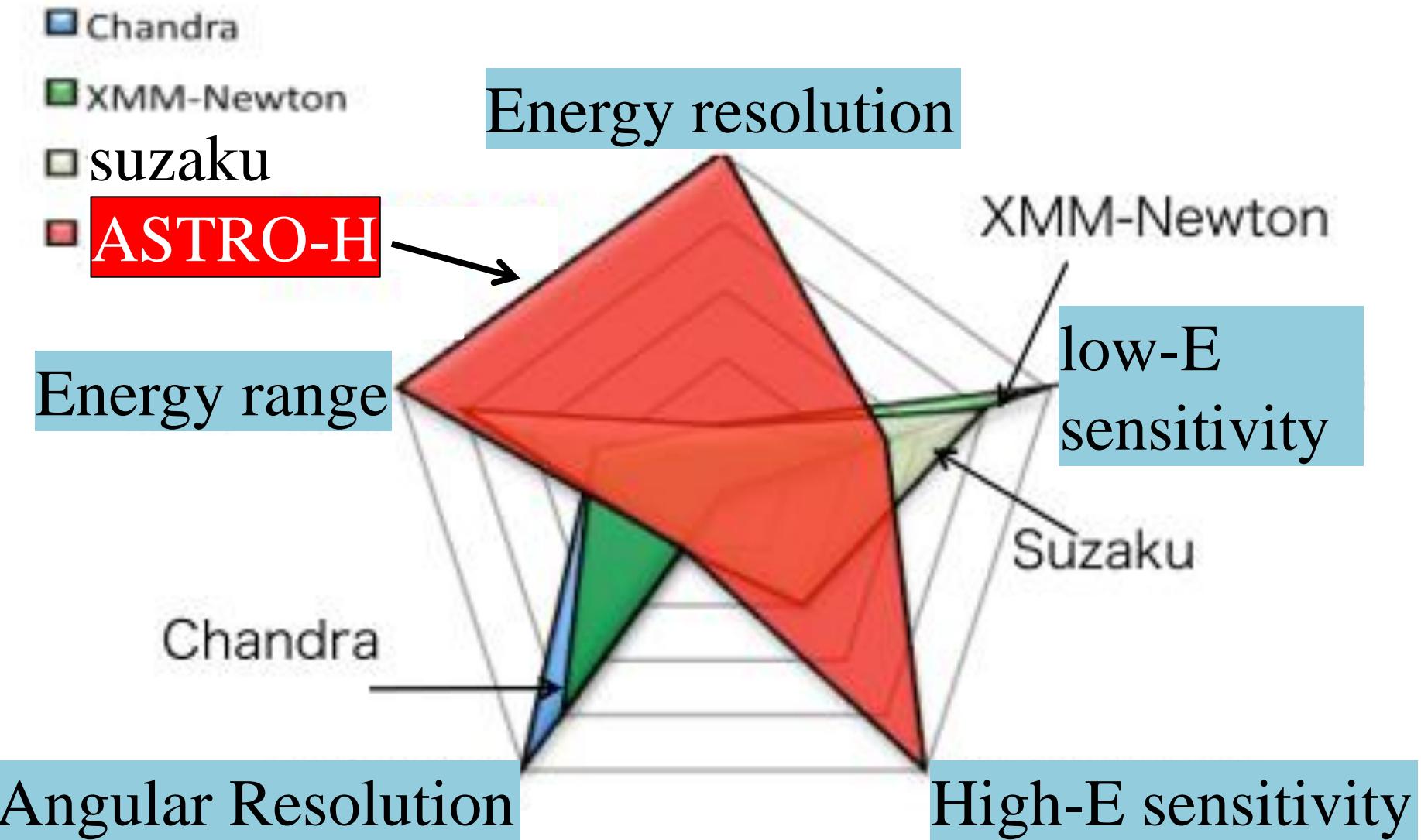
Logos for JAXA, NASA, and the European Space Agency (ESA) are displayed. Below the logos are flags representing the participating countries: Japan, USA, France, Netherlands, Switzerland, Canada, Ireland, and the United Kingdom.

2011.7.18

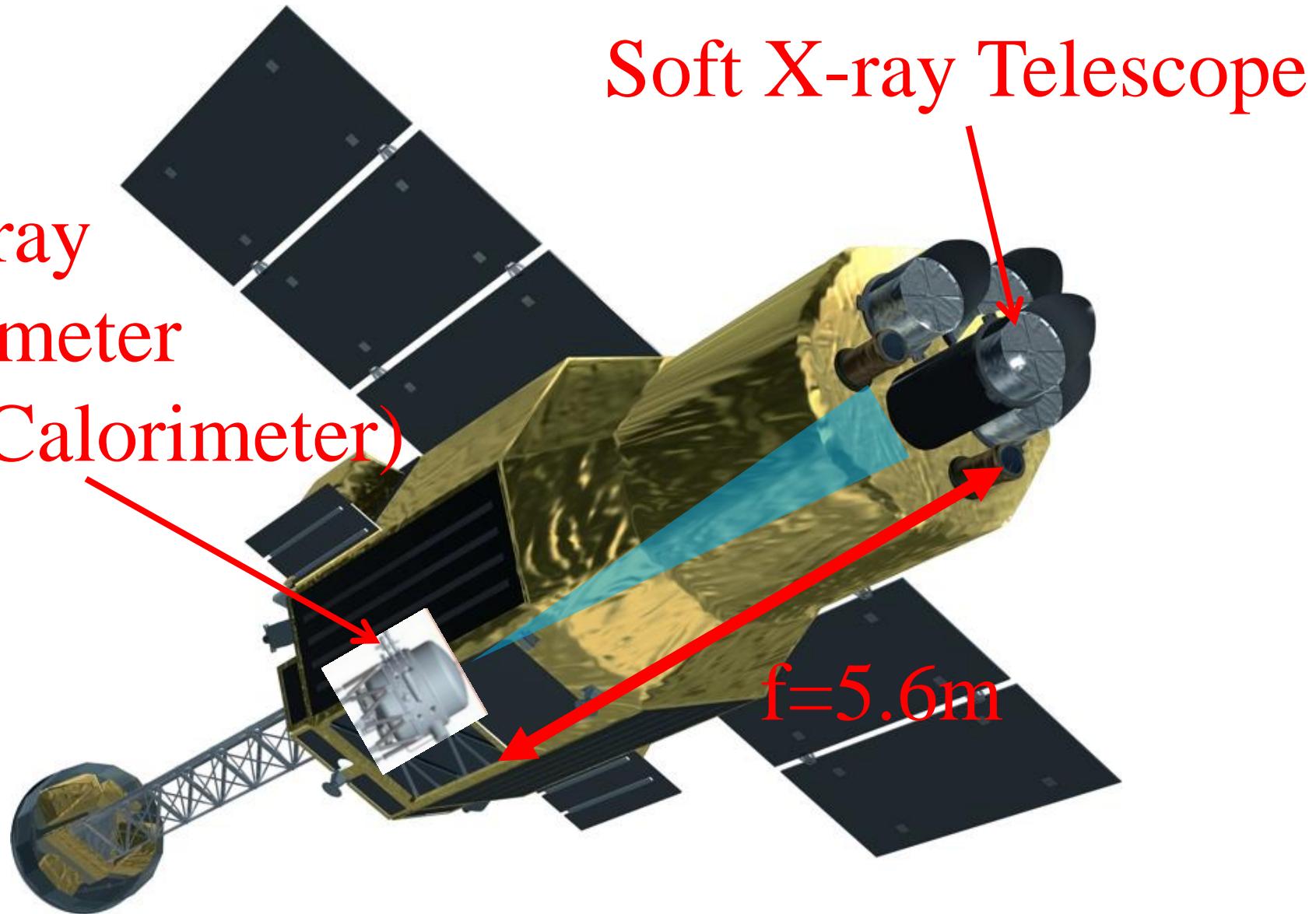
Wide energy range (0.3—600keV)



ASTRO-H vs other observatories



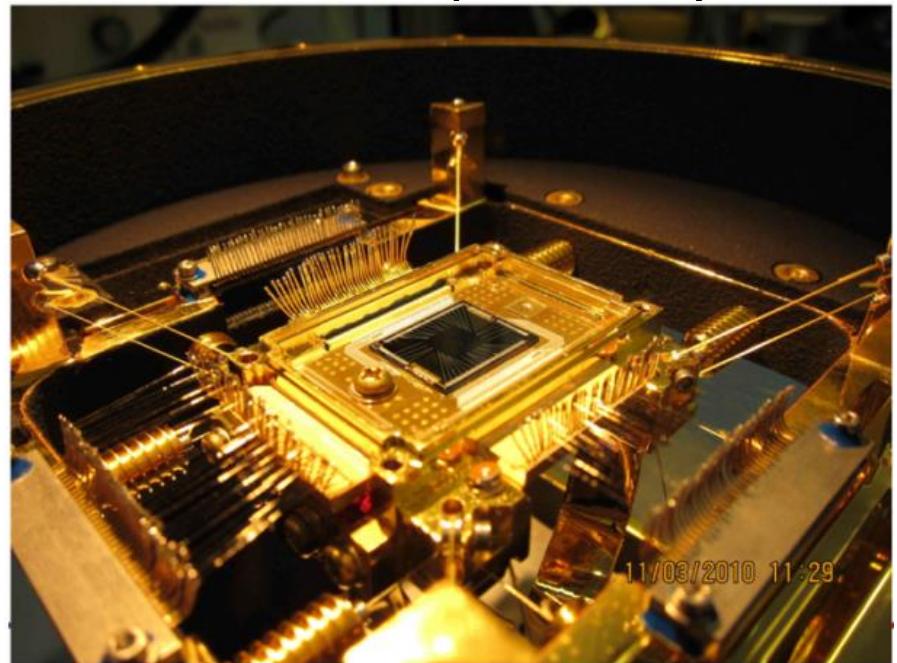
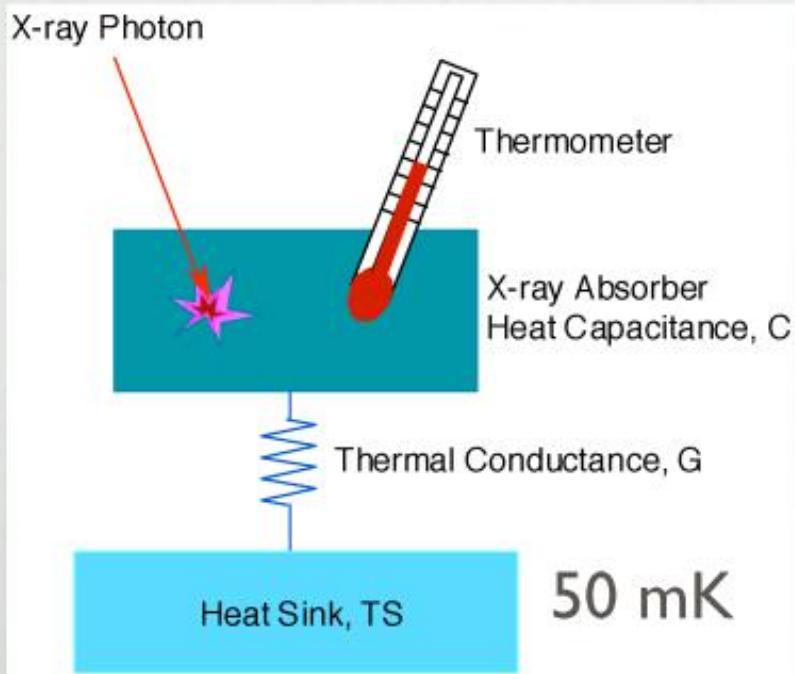
SXT + SXS (0.3—12keV)



Soft X-ray Spectrometer (SXS)

Microcalorimeters

High quantum efficiency
Imaging capability



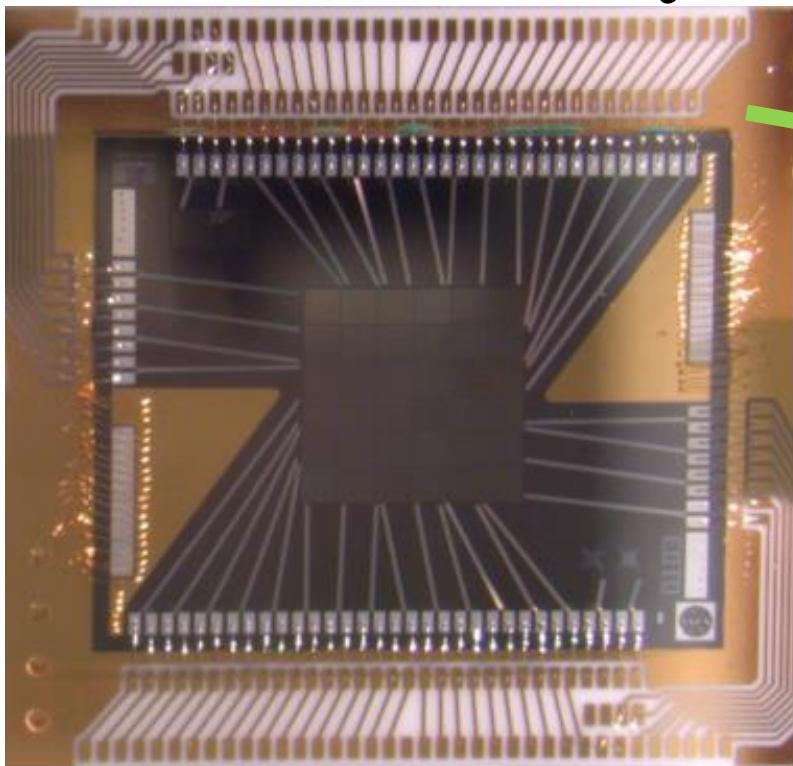
$$\Delta E < 7\text{eV}$$

(goal < 4eV)

High-energy resolution even for spatially extended objects (cf. gratings)

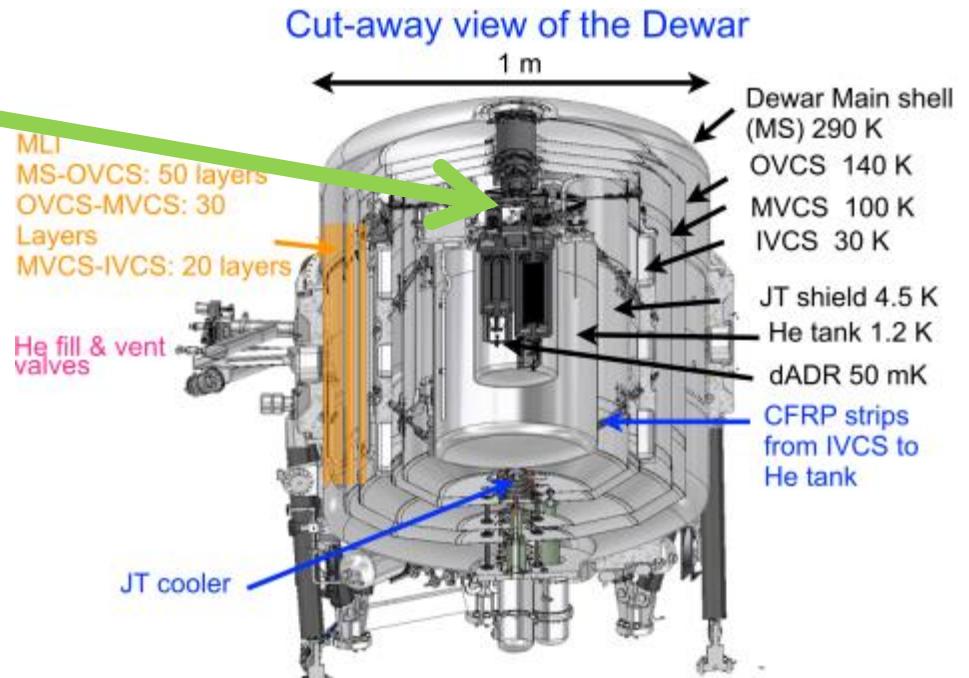
SXS

Detector array



6×6 pixels
FOV $3' \times 3'$

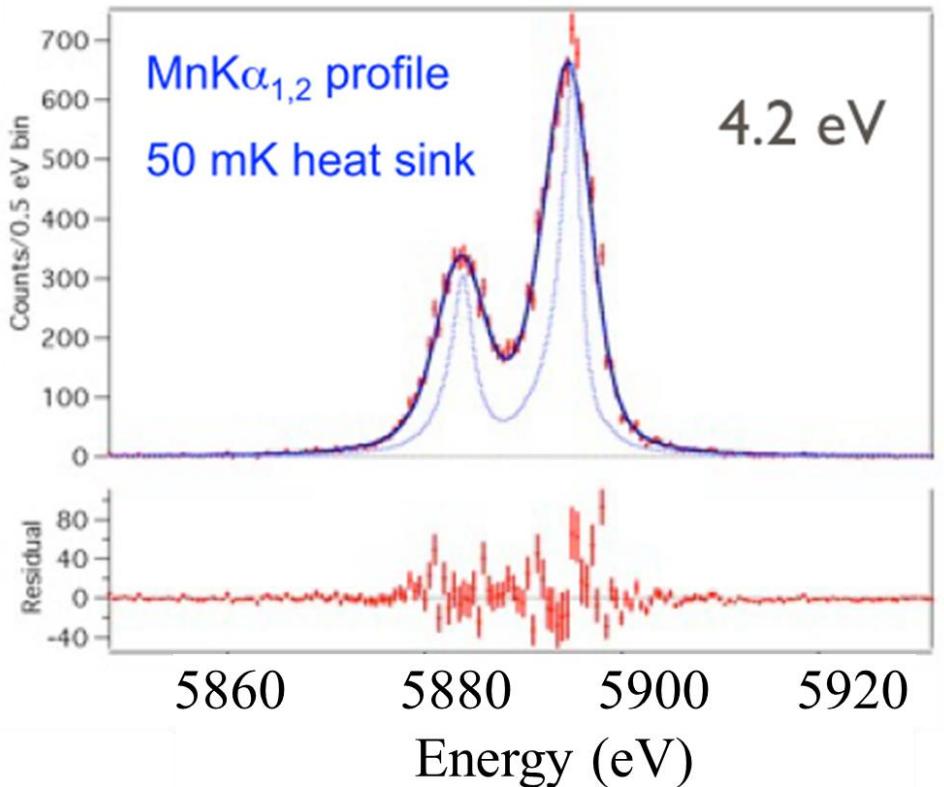
Cooling system



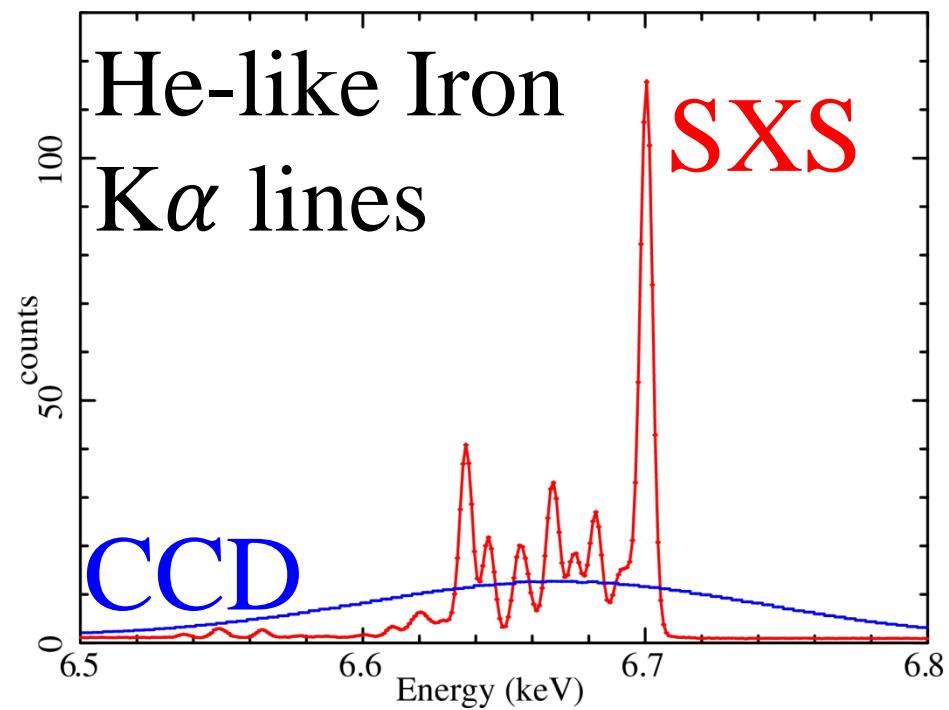
He+JT+ST
Life time > 3yrs
(goal >5yrs)

SXS Energy resolution

Ground Experiment



Simulation



SXS can distinguish fine structure
→ Measure physical parameters of plasma directly.

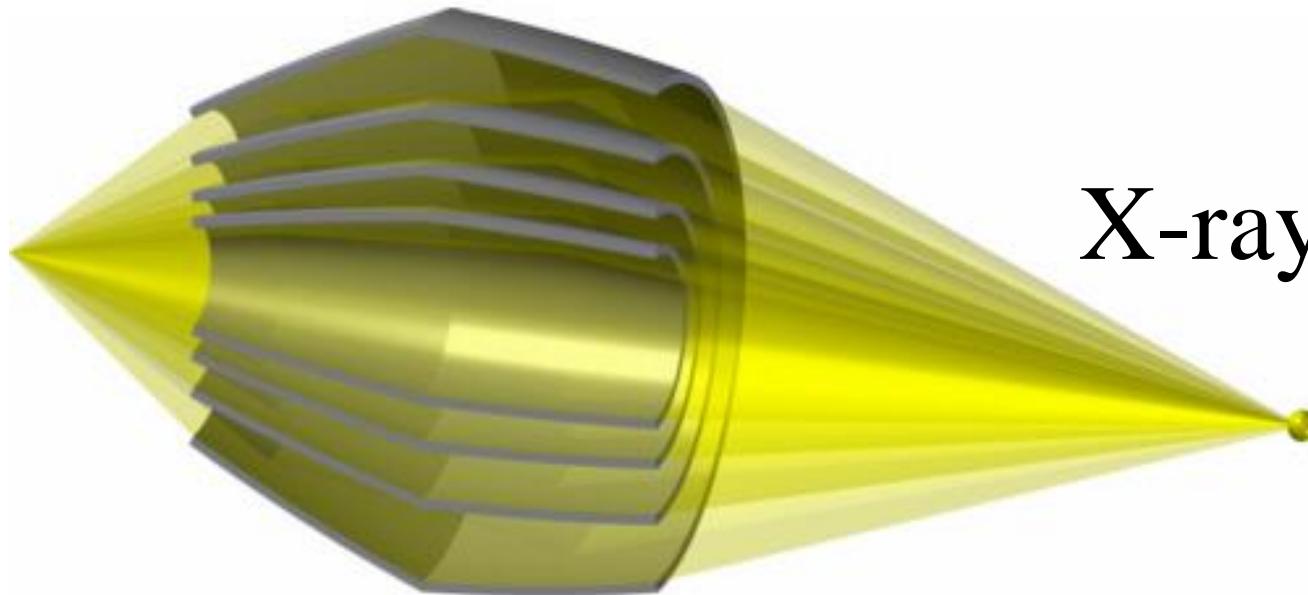
ASTRO-H XRT (SXT, HXT)

Wolter-I optics

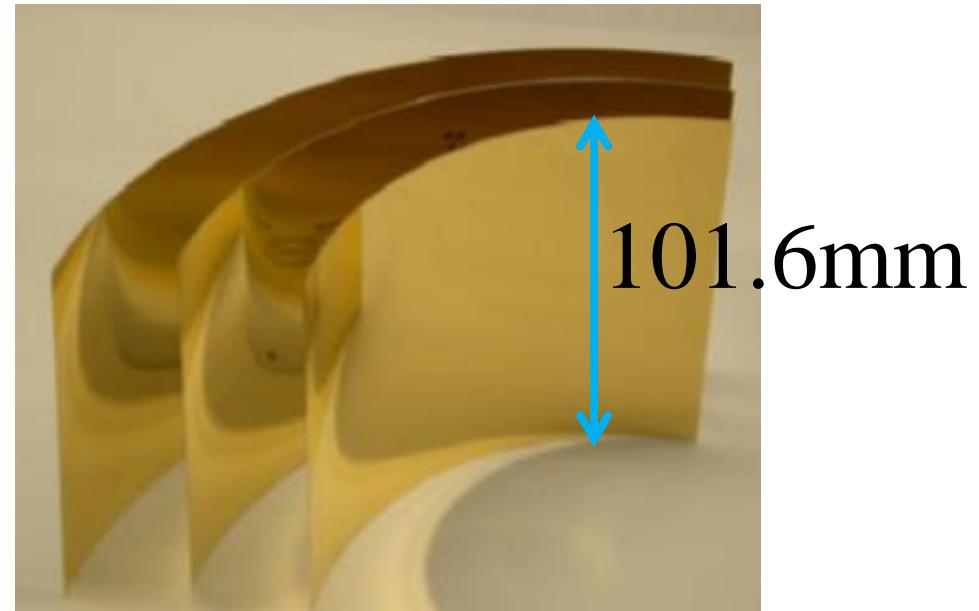
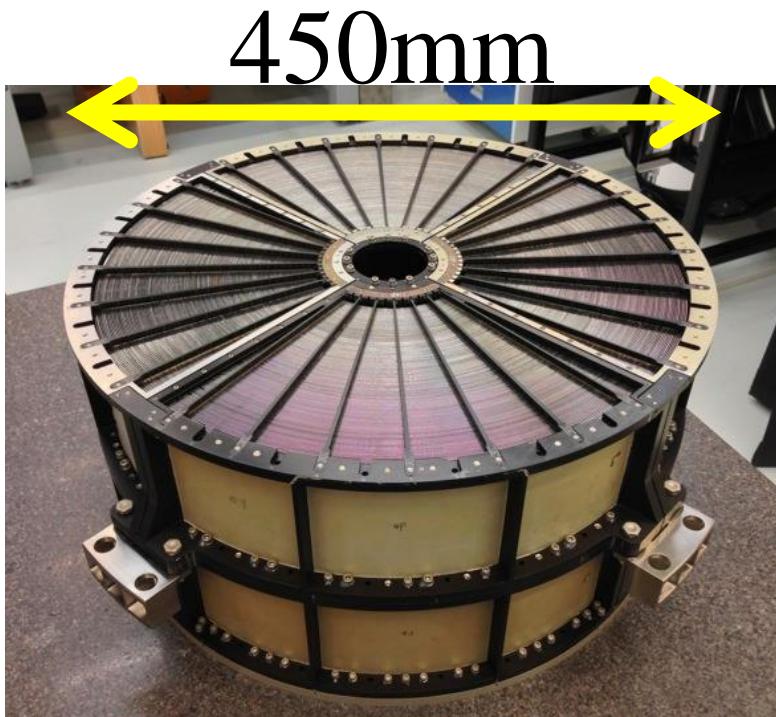
“Year ring” of foils

focus

X-ray source



Soft X-ray Telescope (SXT)



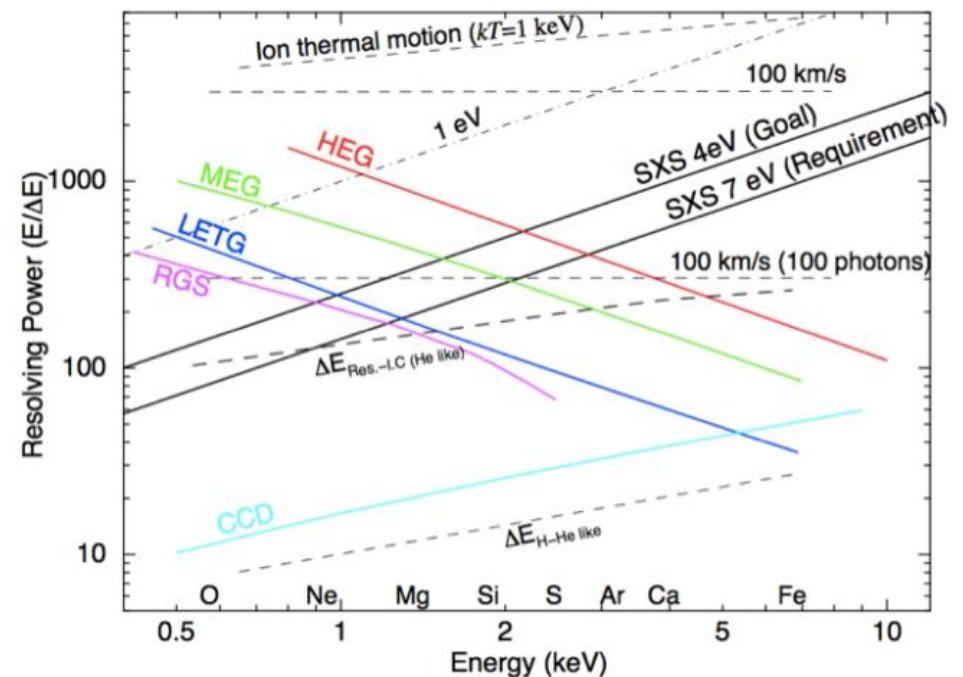
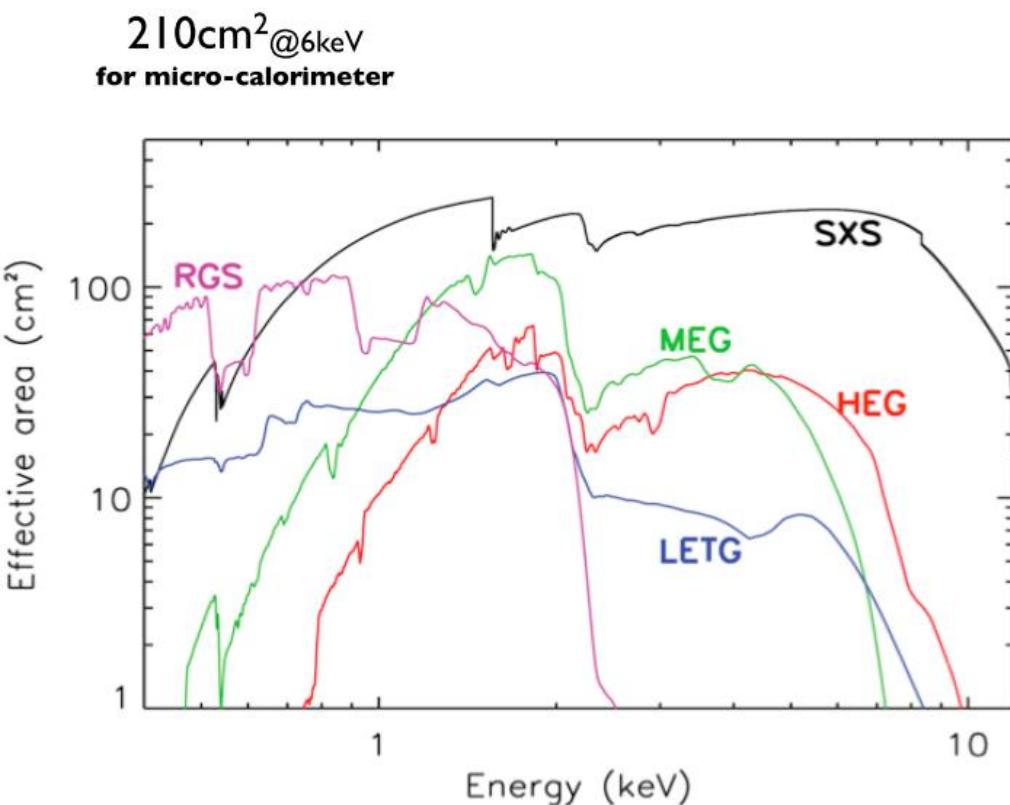
SXT-1 FM

203 nested shells

Au-coated Al foils
Total reflection

Angular resolution $\sim 1.3'$

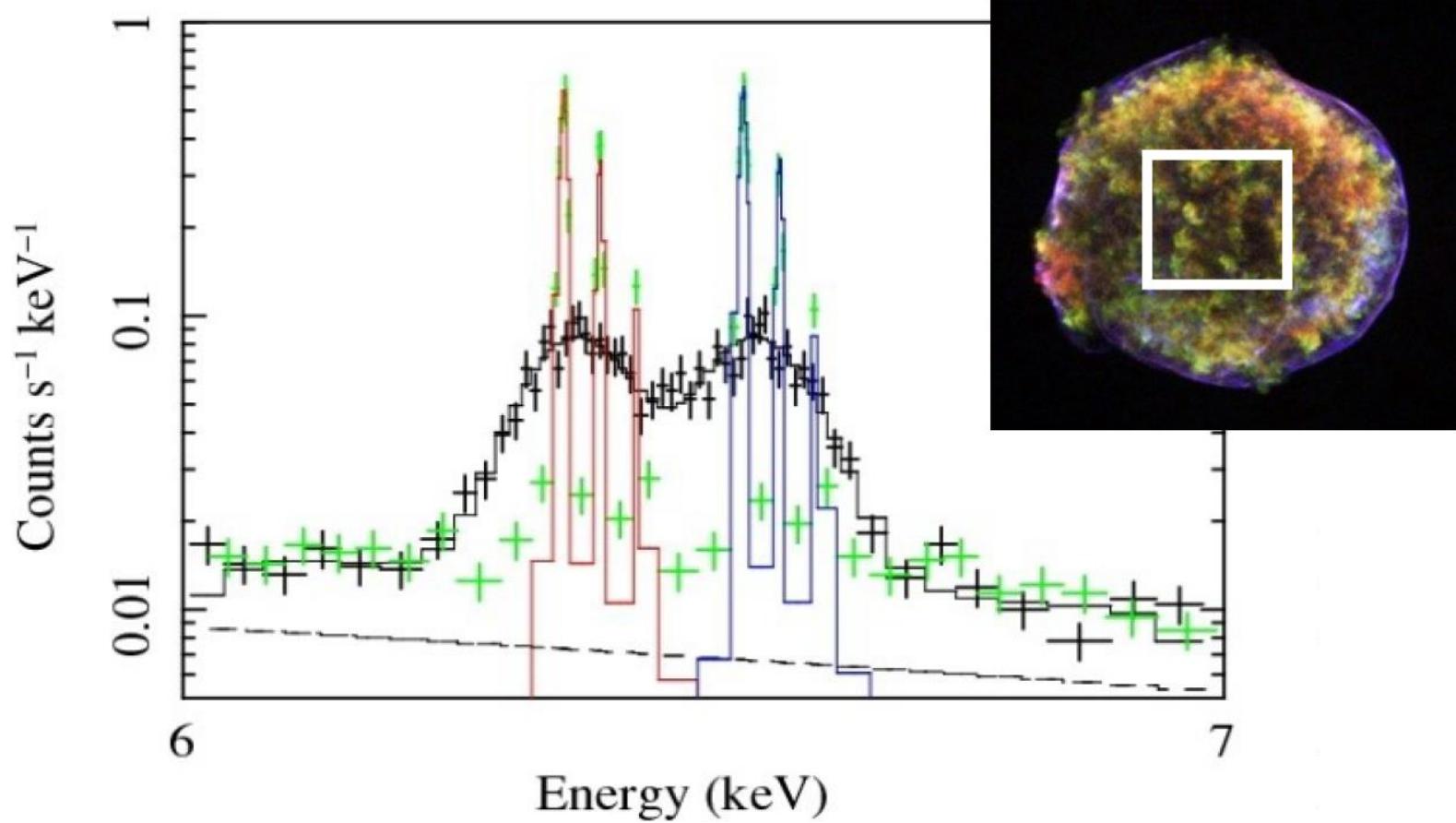
SXT+SXS vs other gratings



Good for dim objects, high-energy X-rays

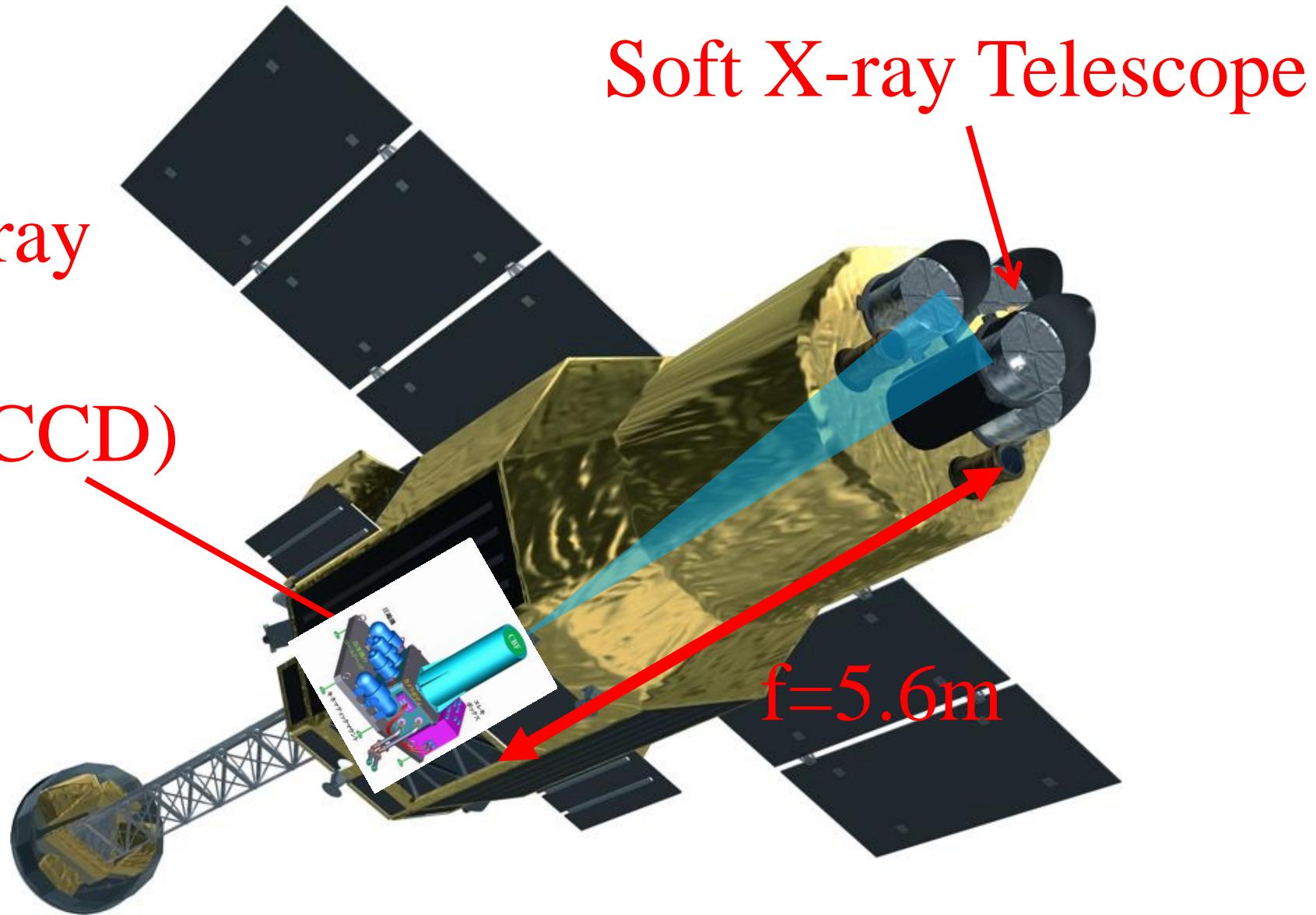
See Dynamic Universe!

Tycho SNR simulation



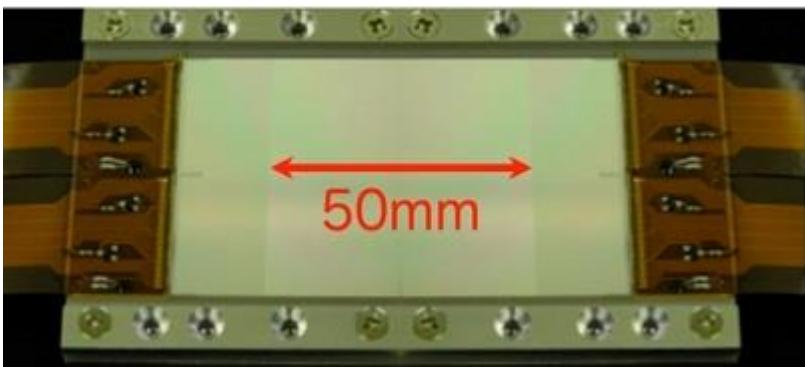
Gas expansion speed, ion temperature

SXT + SXI (0.3—12keV)

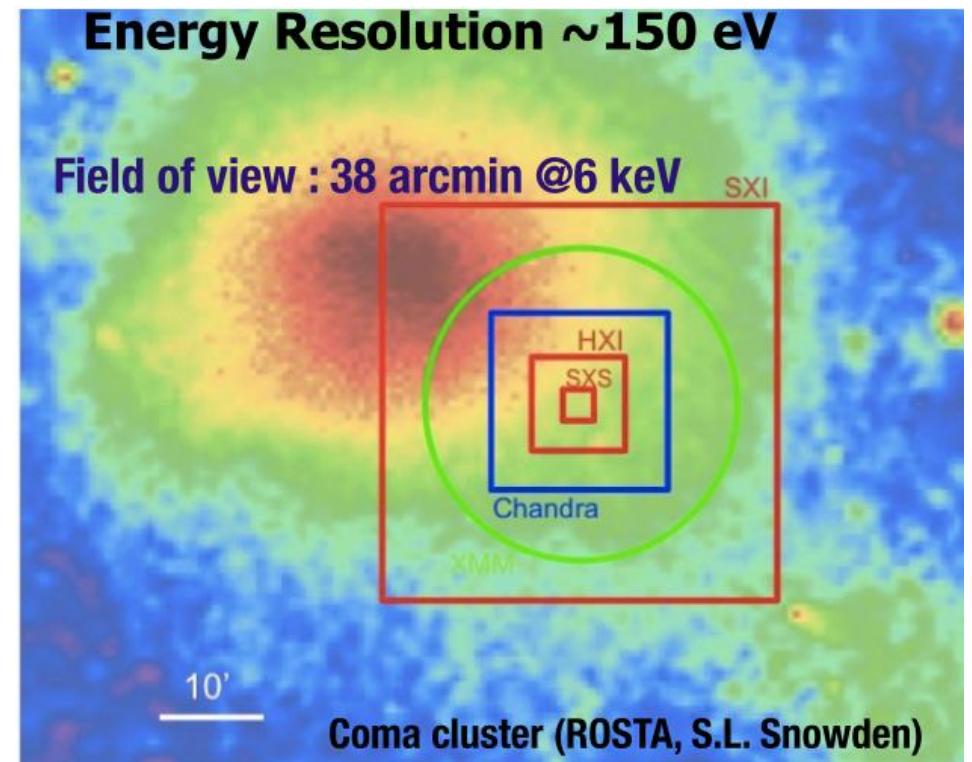


Soft X-ray Imager (SXI)

Pch X-ray CCD



Thick depletion layer
 $\sim 200\mu\text{m}$



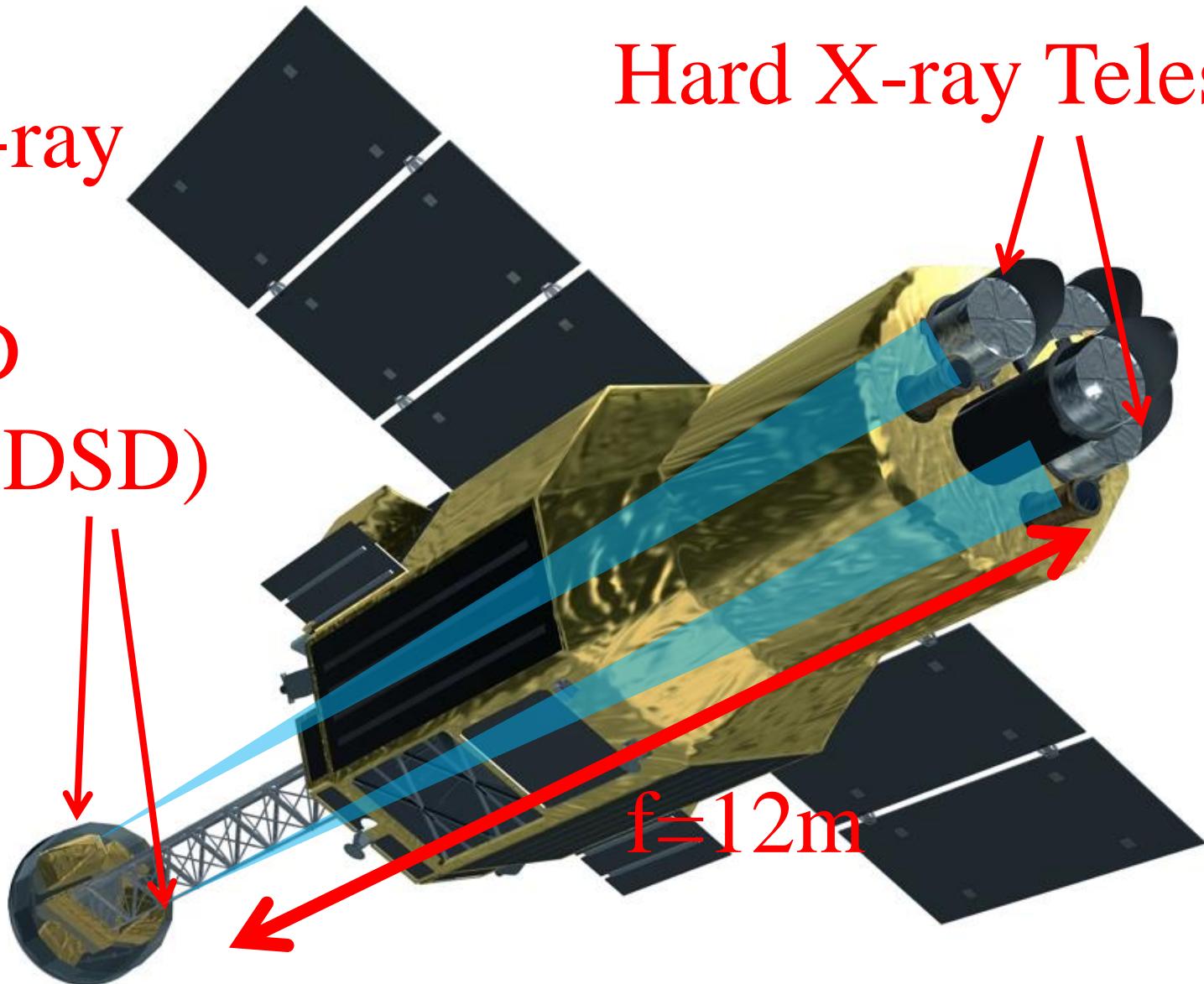
Moderate ΔE
($\sim 150\text{eV} @ 6\text{keV}$)

Largest FOV
 $38' \times 38'$

HXT + HXI (5—80keV)

Hard X-ray
Imager
(Si DSD
+ CdTe DSD)

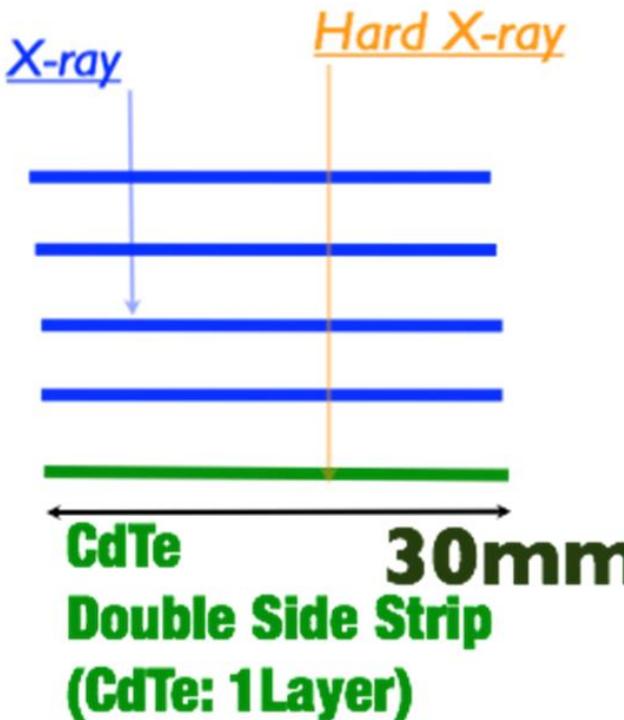
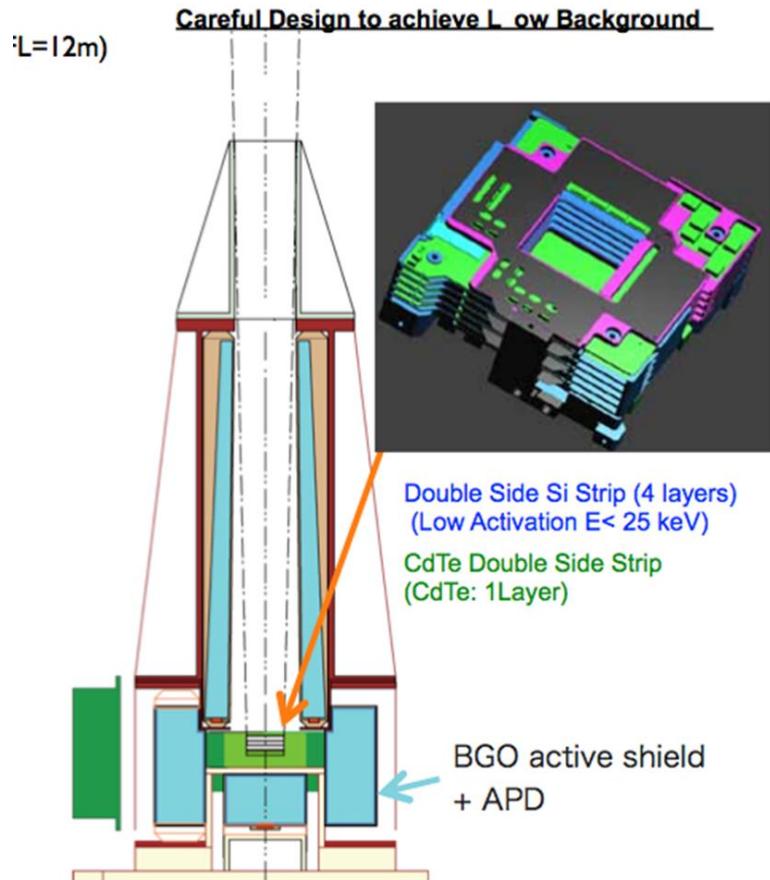
Hard X-ray Telescope



Hard X-ray Imager (HXI)

E<20 keV: Double-sided Si Strip Detector

E>20keV: Double-sided CdTe Strip Detector



FOV: 9' × 9'

Hard X-ray Telescope

45cm



HXT-1 FM

213 nested shells

Thin-foil mirror (t0.22mm)



Pt/C multilayer

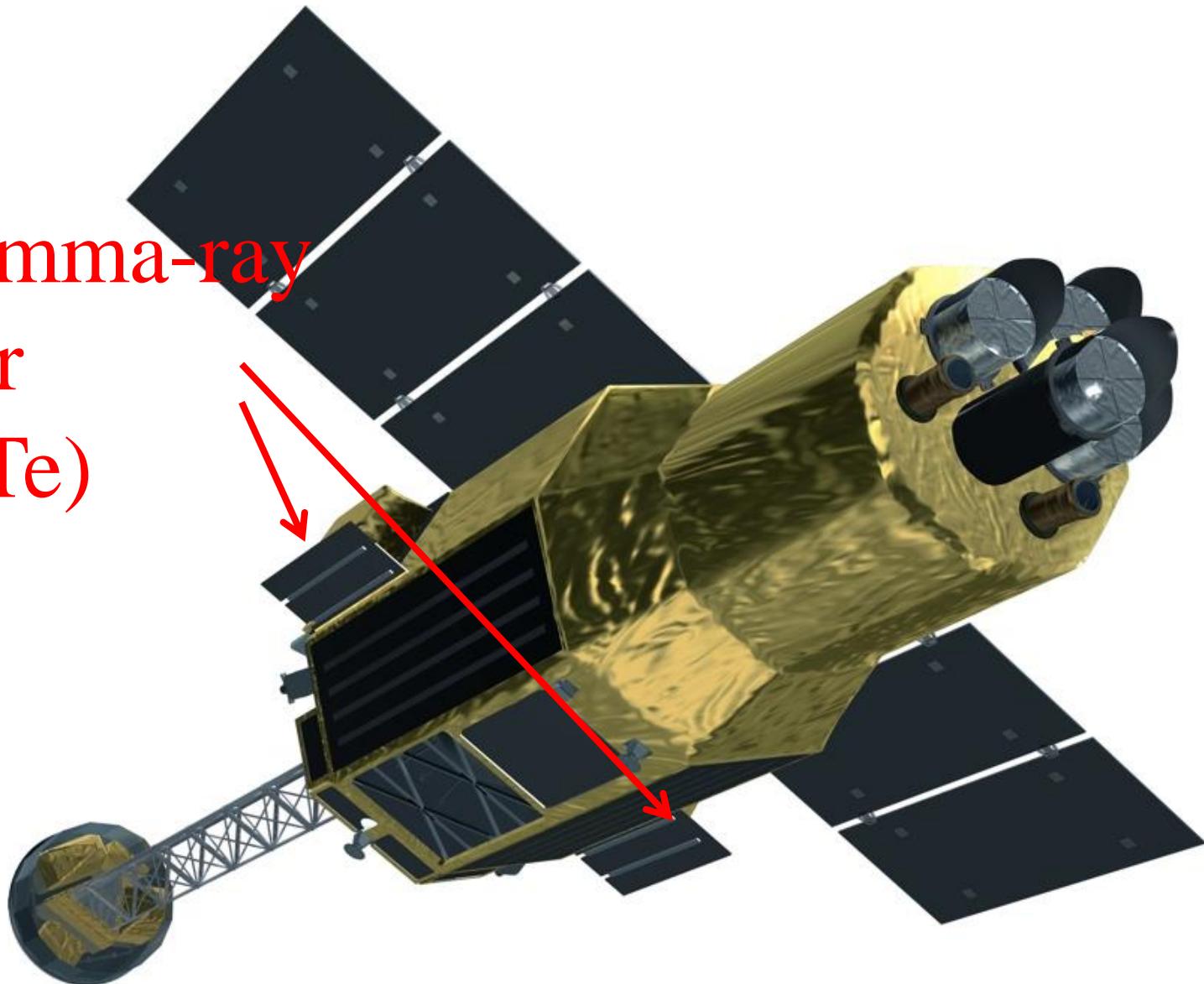
Bragg Reflection

E=5—80keV

Ang. Res. $\sim 1.9'$

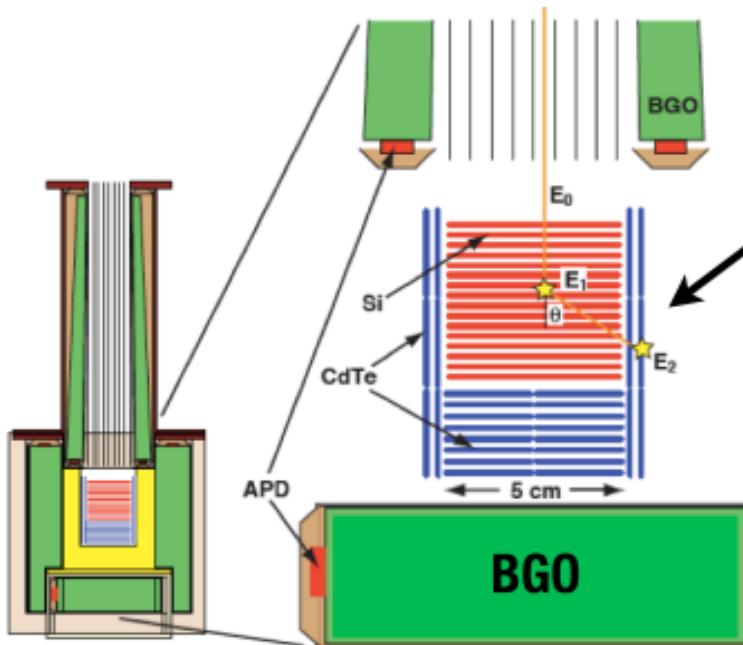
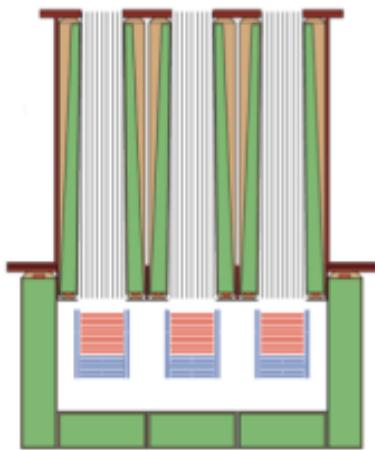
SGD (10—600keV)

Soft Gamma-ray
Detector
(Si+CdTe)



Soft Gamma-ray Detector (SGD)

- Si/CdTe Compton Camera
- Active shield of BGO



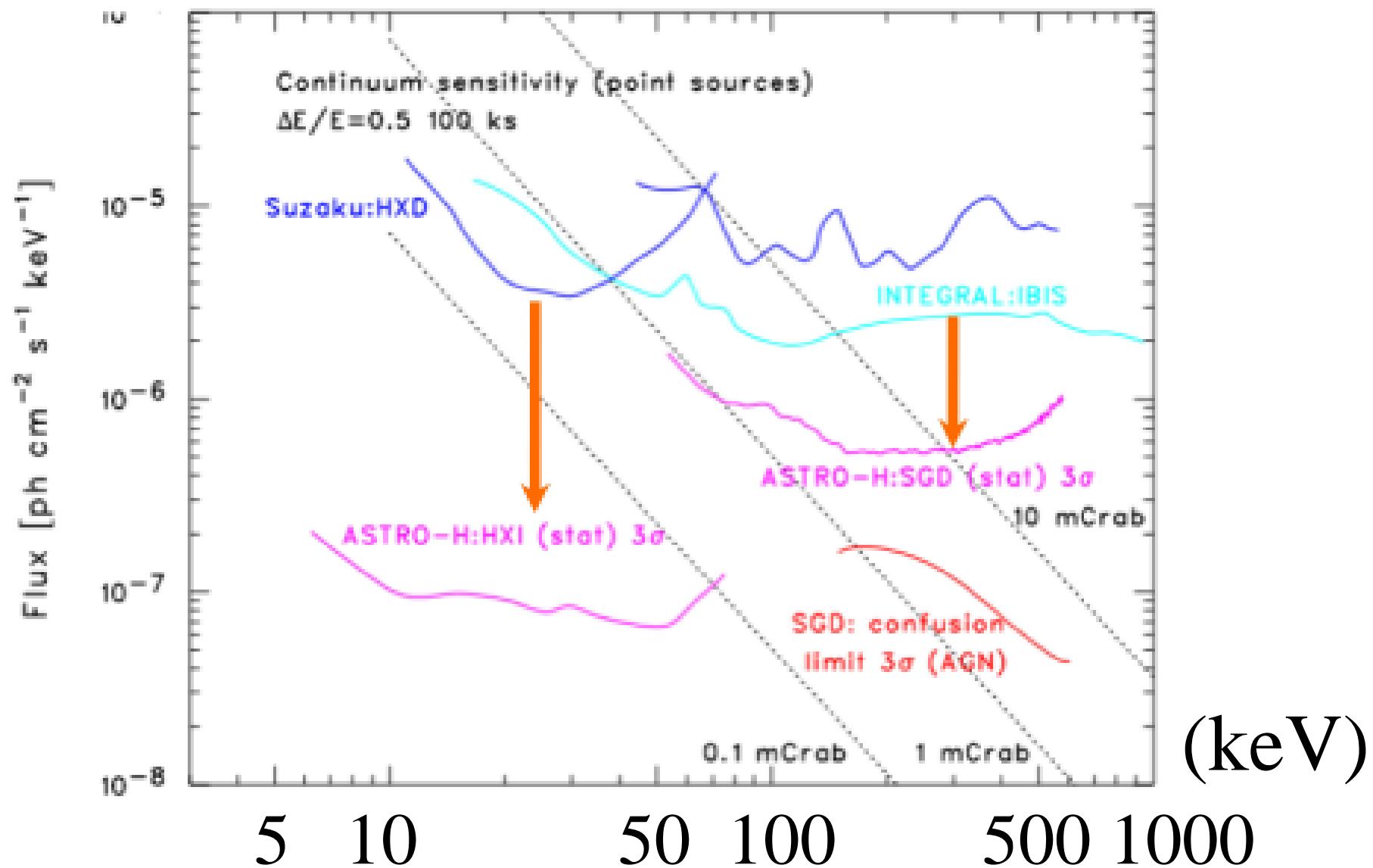
Si/CdTe Compton Camera
**(only select gamma-rays from
the FOV)**

Compton Kinematics

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

$$E_{\text{in}} = E_1 + E_2$$

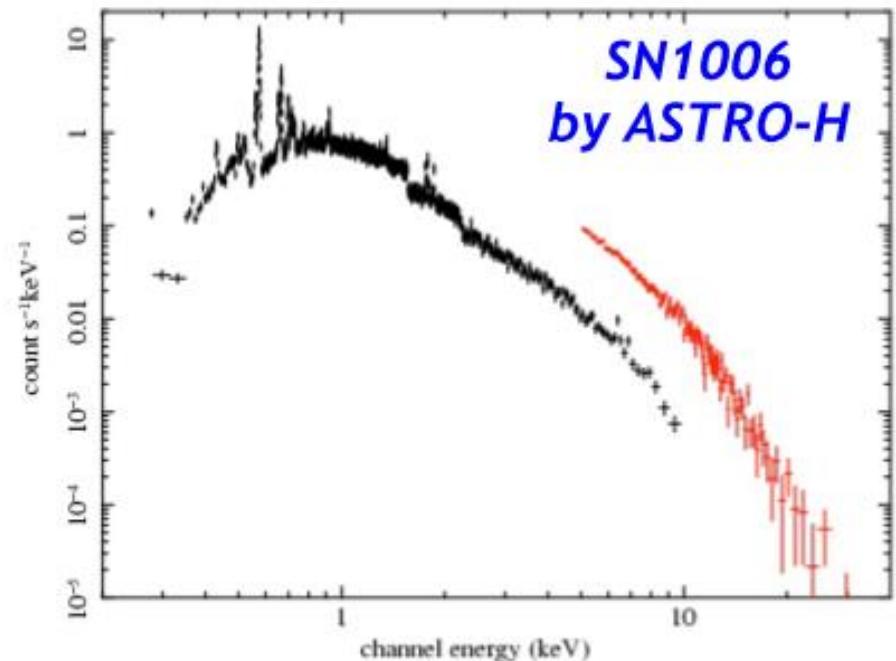
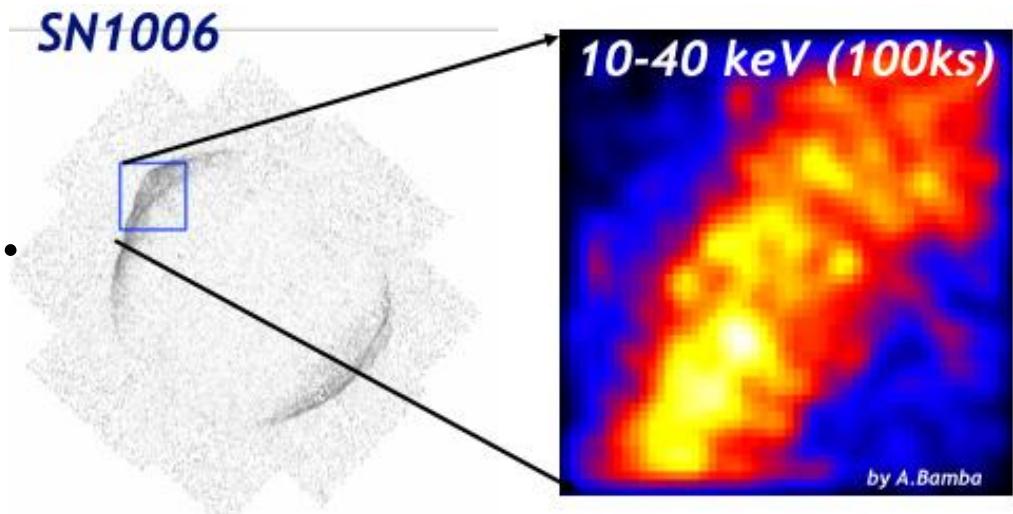
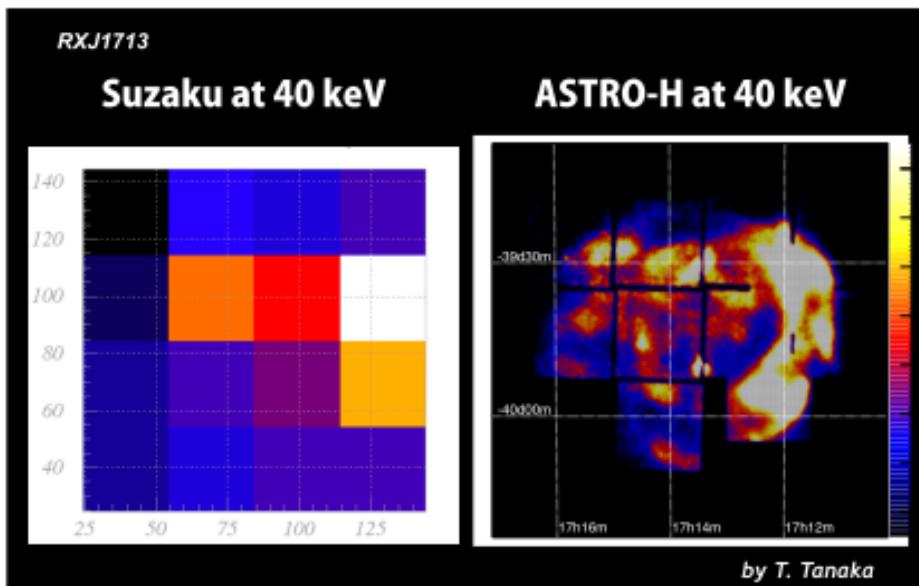
High Sensitivity for high-E X-rays



SNRs seen with HXI

Clarify the mechanism
of particle acceleration.

Y. Uchiyama's talk
Today's afternoon



ASTRO-H under test



ASTRO-H will be launched in 2015

Summary

- ASTRO-H carries four systems
 - SXT + SXS, SXT+SXI, HXT+HXI, SGD
 - Wide energy range
 - High energy resolution
 - High sensitivity for high-E X-rays
 - Wide FOV
- Many science topics can be addressed
- ASTRO-H will be launched in 2015

Visit <http://astro-h.isas.jaxa.jp/index.html.en>

backup

Properties	SXS	SXI	HXI	SGD (photo-abs)	SGD (Compton)
Effective area (cm ²)	50/225 (@0.5/6 keV)	214/360 (@0.5/6 keV)	300 (@30 keV)	150 (@30 keV)	20 (@100 keV)
Energy range (keV)	0.3-12.0	0.4-12.0	5-80	10-600	40-600
Angular resolution in HPD (arcmin)	1.3	1.3	1.7	N/A	N/A
Field of view (arcmin ²)	3.05x3.05	38x38	9x9	33x33 (<150 keV) 600x600 <td>33x33 (<150 keV) 600x600<br (>150="" kev)<="" td=""/></td>	33x33 (<150 keV) 600x600
Energy resolution in FWHM (eV)	5	150 (@6 keV)	< 2000 (@60 keV)	2000 (@40 keV)	4000 (@40 keV)
Timing resolution (s)	8x10 ⁻⁵	4	several x 10 ⁻⁵	several x 10 ⁻⁵	several x 10 ⁻⁵
Instrumental background (/s/keV/FoV)	2x10 ⁻³ /0.7x10 ⁻³ (@0.5/6 keV)	0.1/0.1 (@0.5/6 keV)	6x10 ⁻³ /2x10 ⁻⁴ (@10/50 keV) ¹ 2x10 ⁻³ /4x10 ⁻⁵ (@10/50 keV) ²		1x10 ⁻⁴ /1x10 ⁻⁵ (@100/600 keV)

¹4 layers, ²1 layer

Properties	SXT	HXT
Diameter (cm)	45	45
Focal length (m)	5.6	12
No. of nested shells	203	213
Reflector coating	Au	Pt/C multilayer
Thermal shield	Al (0.03 µm) + polyimide (0.2 µm)	Al (0.03 µm) + PET(5 µm)

Properties	SXT	HXT
A_{eff} (cm ²)	279/312 (@0.5/6keV)	338 (@30keV)
HPD (arcmin)	1.3	1.7
FoV (arcmin ²)	22.2 ² /19.8 ² (@0.5/6 keV)	6.4 ² /5.3 ² (@30/50keV)
Stray-light reduction rate	>99 (@30' off-axis)	>99 (@15'- 25' off-axis)
Thermal shield transmission (%)	70 (@0.5keV)	92 (@5 keV)

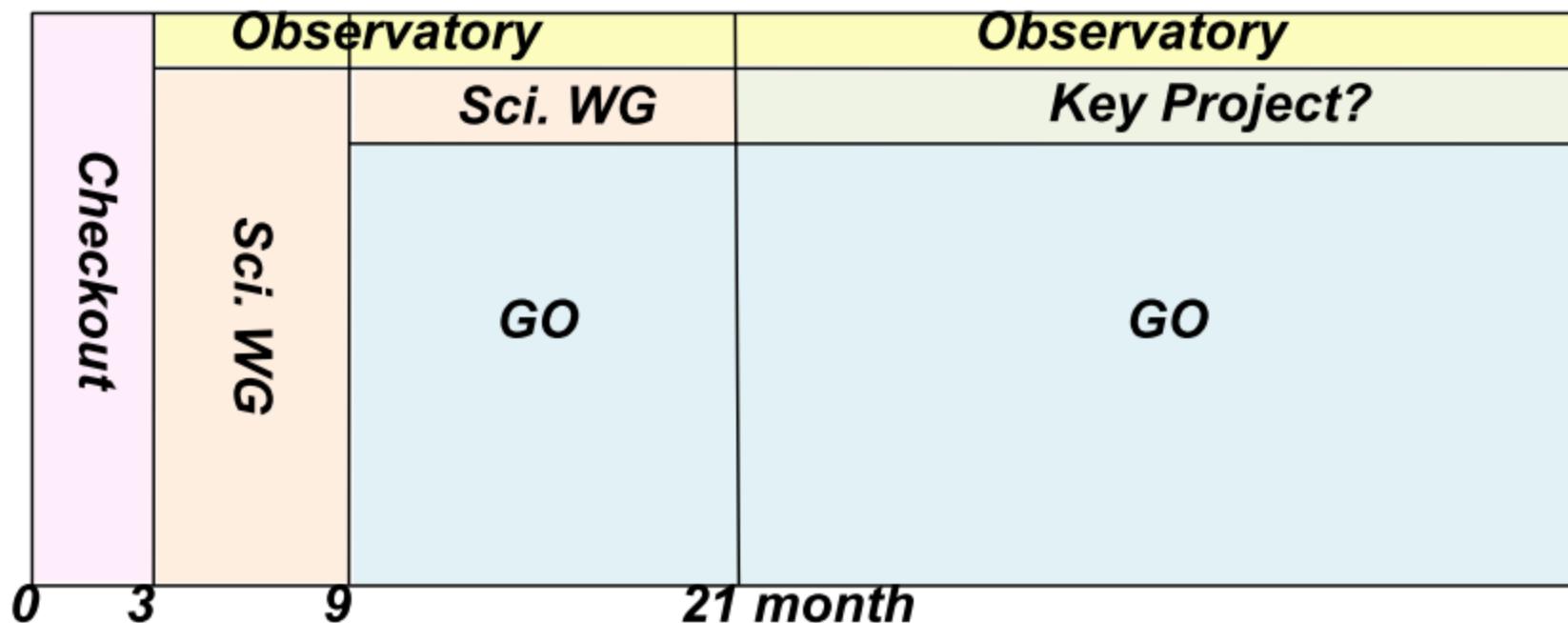
Phase 0 : 3 Months : Satellite/Instruments Check out (including Calibration))

Phase 1 : 6 Months : SWG 90 % (PV Phase) Observatory 10 %

Phase 2 : 12 Months : SWG Carry Over 15 %, GO 75 %, Observatory 10 %

Phase 3 : Rest of the mission : KeyProject 15 % (TBD) , GO 75 %, Observatory 10 %

Observatory 10 % = Calibration + T00 + Director's Time



Data policy among J/Europe/US in the GO time, would be similar to the Suzaku case. But we are planning to introduce key-project type and/or early-data-released type observations from early phase of the mission.