

The High Resolution X-ray Spectrometer, SXS, on the *Astro-H* mission

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ASTRO-H



Hard X-ray imaging Spectroscopy (2-80 keV)
Soft X-ray high-resolution Spectroscopy (FWHM $\leq 7\text{eV}$)

Evolution of super massive black holes

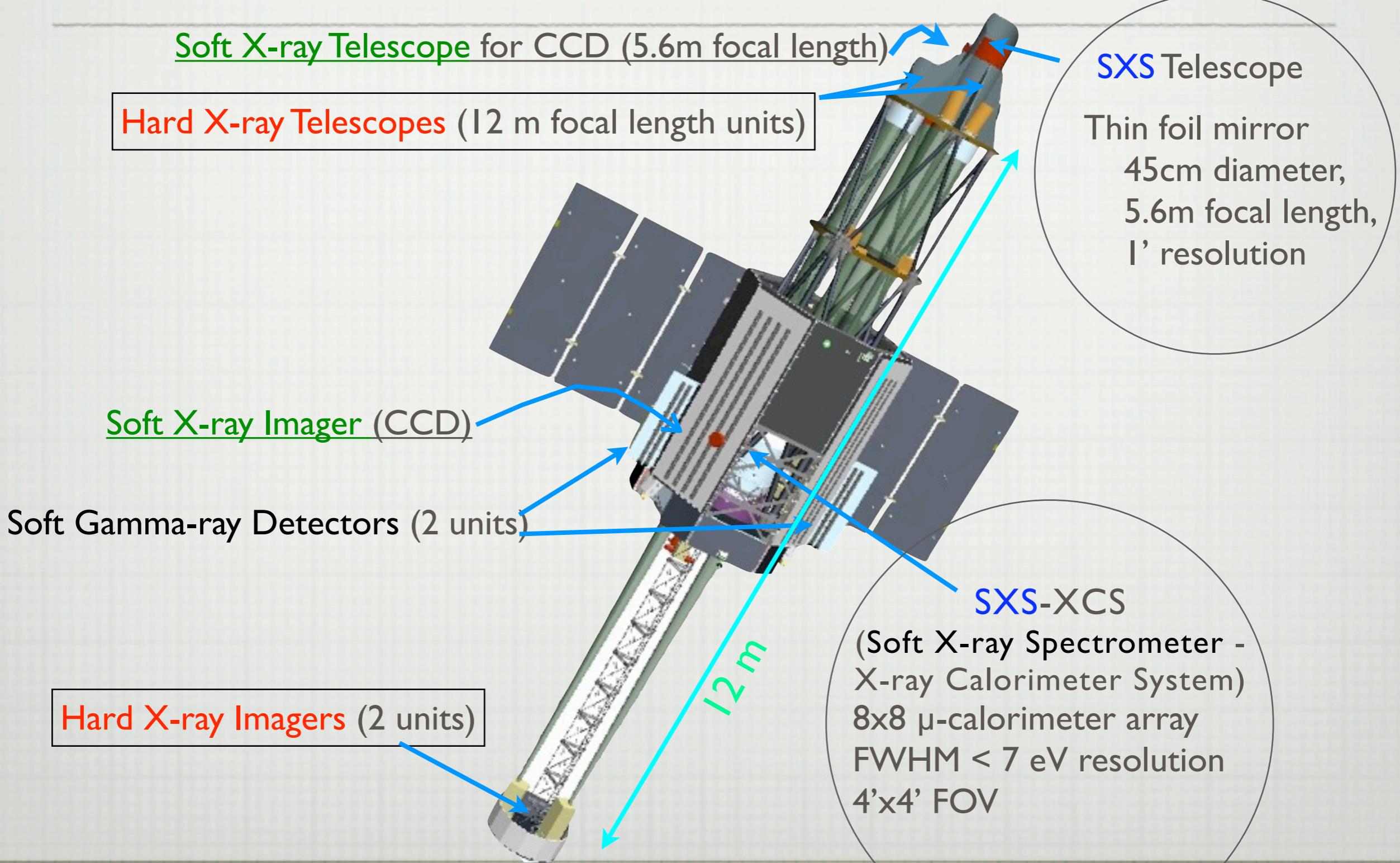
Evolution of clusters of galaxies

Accelerations in clusters and SNRs

Vicinity of black holes

Present status: phase B. Present expected launch date: JFY 2013.

Astro-H Science Payloads

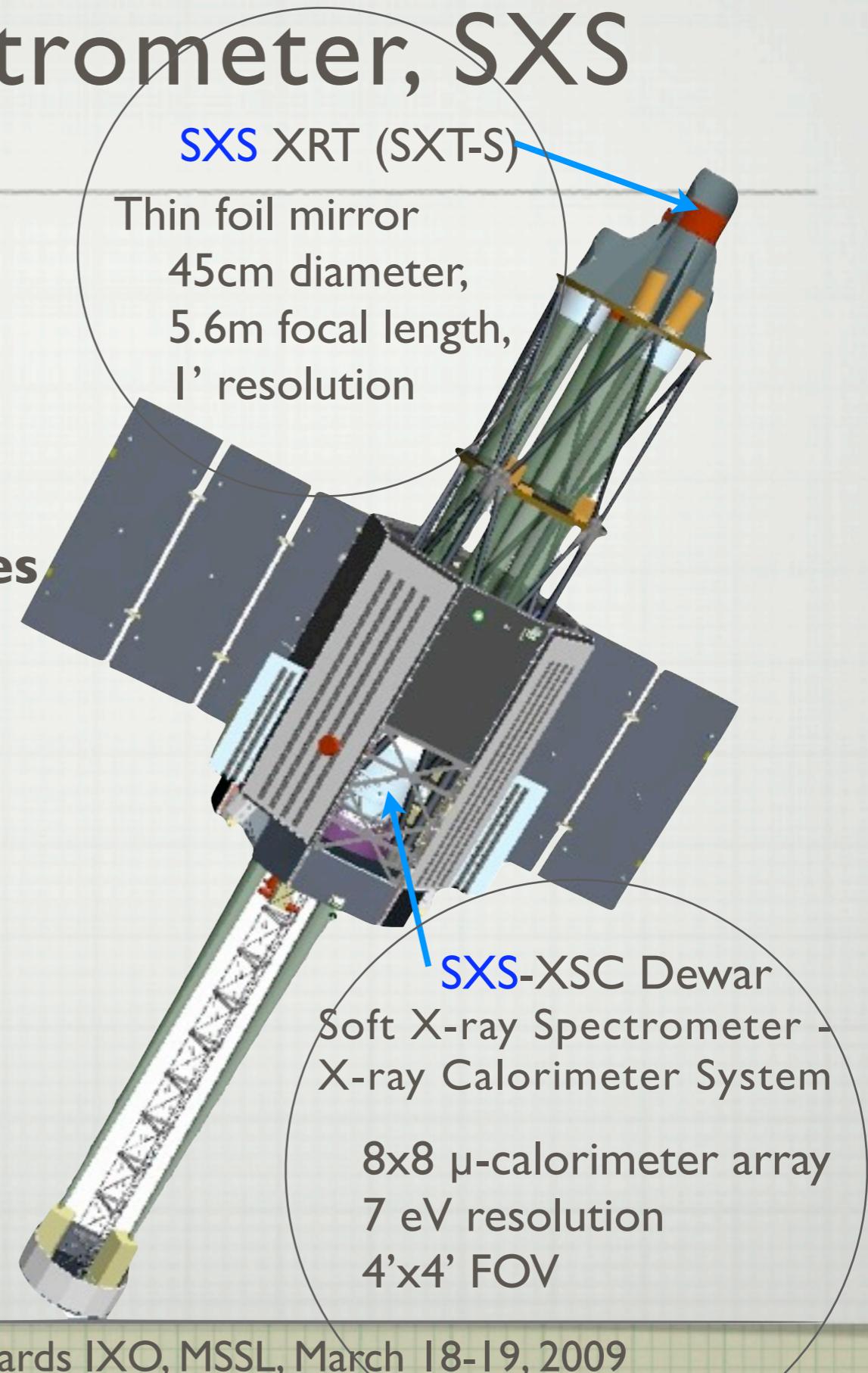
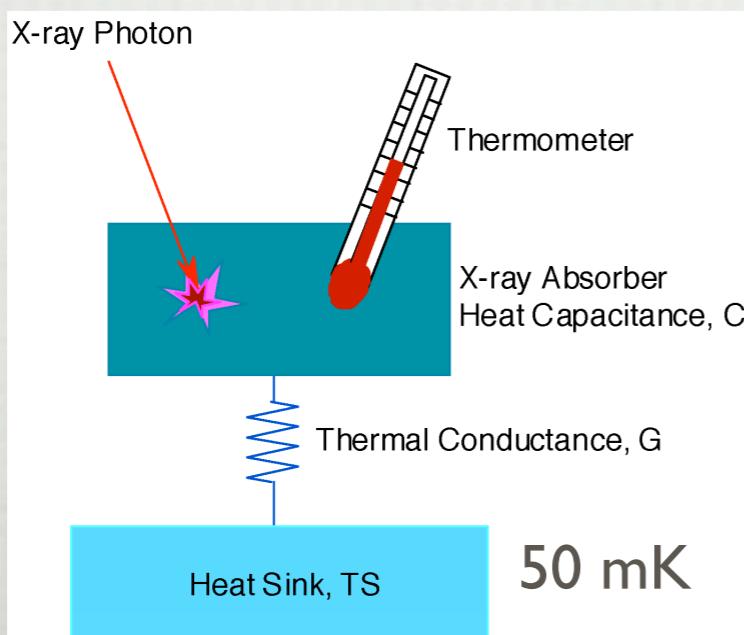


Soft X-ray Spectrometer, SXS

- **High resolution X-ray spectrometer using a microcalorimeter array**
- **High Energy resolution ($\text{FWHM} < 7\text{eV}$) and modest imaging (6x6 or 8x8) capabilities**

Microcalorimeters

High quantum efficiency
Imaging capability



Astro-H SXS collaboration

X-ray Calorimeter System (SXS-XCS)



ISAS/JAXA
ARD/JAXA
Tokyo Metropolitan University
Kanazawa University
Riken
Rikkyo University
Saitama University
National Inst. Material Science
Tsukuba University

Telescope (SXS-XRT)

ISAS/JAXA
Nagoya University
Tokyo Metropolitan University
Ehime University

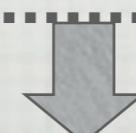


NASA/GSFC
University of Wisconsin
Yale University
NASA/AMES

NASA/GSFC



SRON
University of Geneva



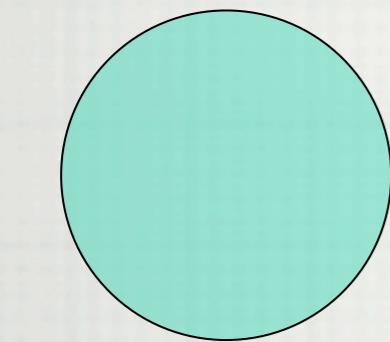
Participation to be decided.

SXS requirements and goal

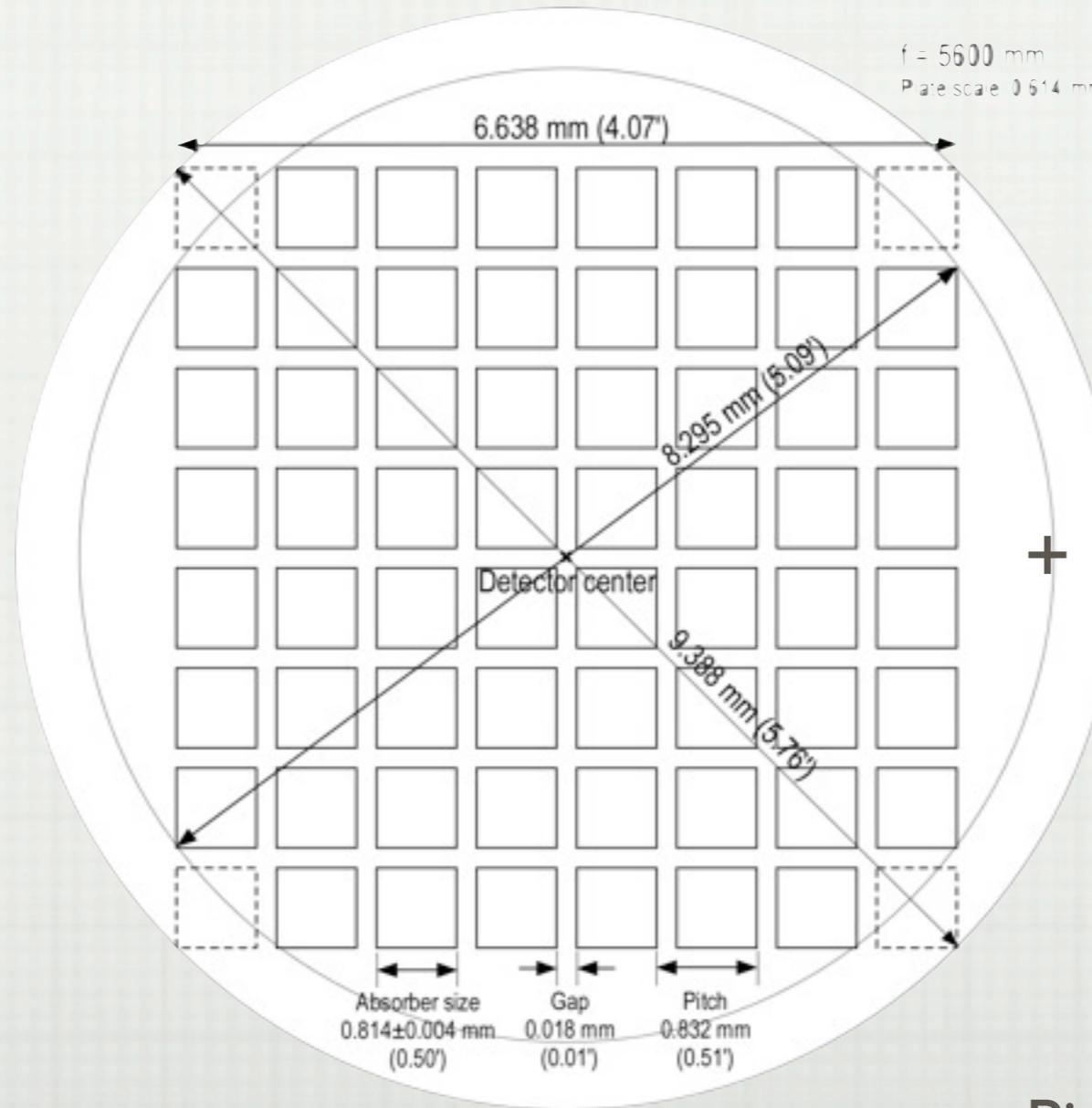
	Baseline	Goal	XRS
Pixel size	814 μm □		624 μm □
Array format (FOV)	6 × 6 (32 pixel readout)	8 × 8 (64 pixel readout)	6 × 6 (32 pixel readout)
Effective area@1keV	190 cm ²		136 cm ²
Effective area@7keV	225 cm ²		132 cm ²
Energy Resolution	7 eV	4 eV	(12 eV) 7 eV
Lifetime	3 years	> 5 years	(>2 years)

whole the SXS system is designed to handle 8x8 array

Field of View



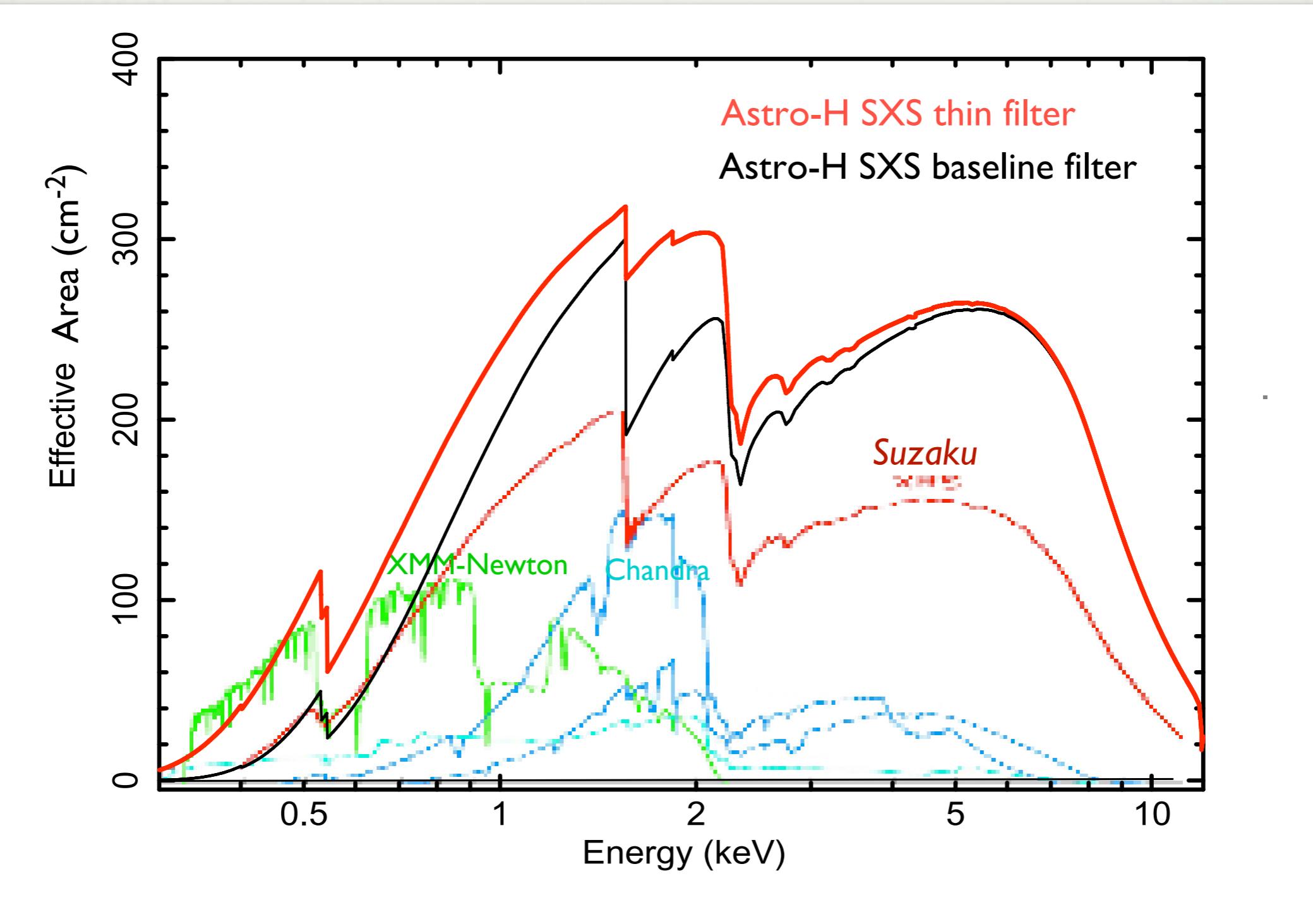
Telescope HPD
~ 1.3'



+ 4 calibration pixels

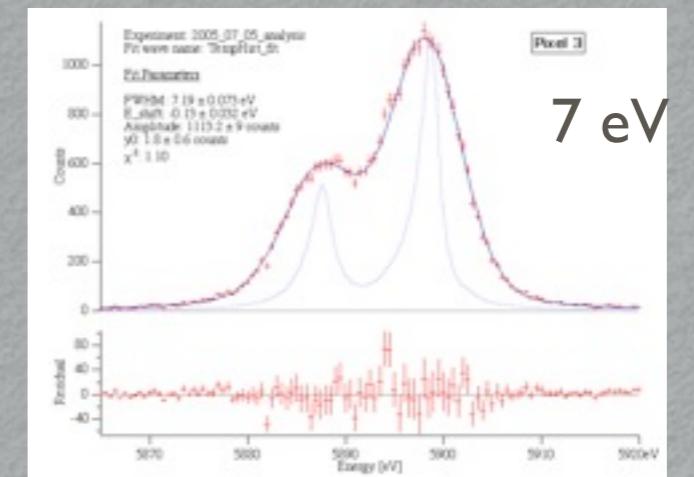
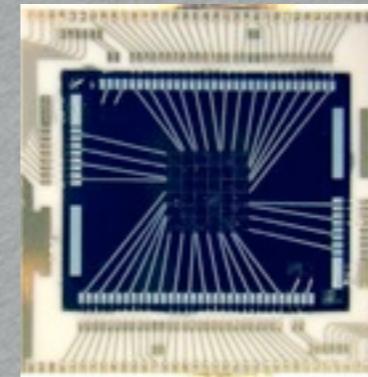
Pixel gap is not in scale.
Filling factor > 95%

Effective area



Energy resolution improvement

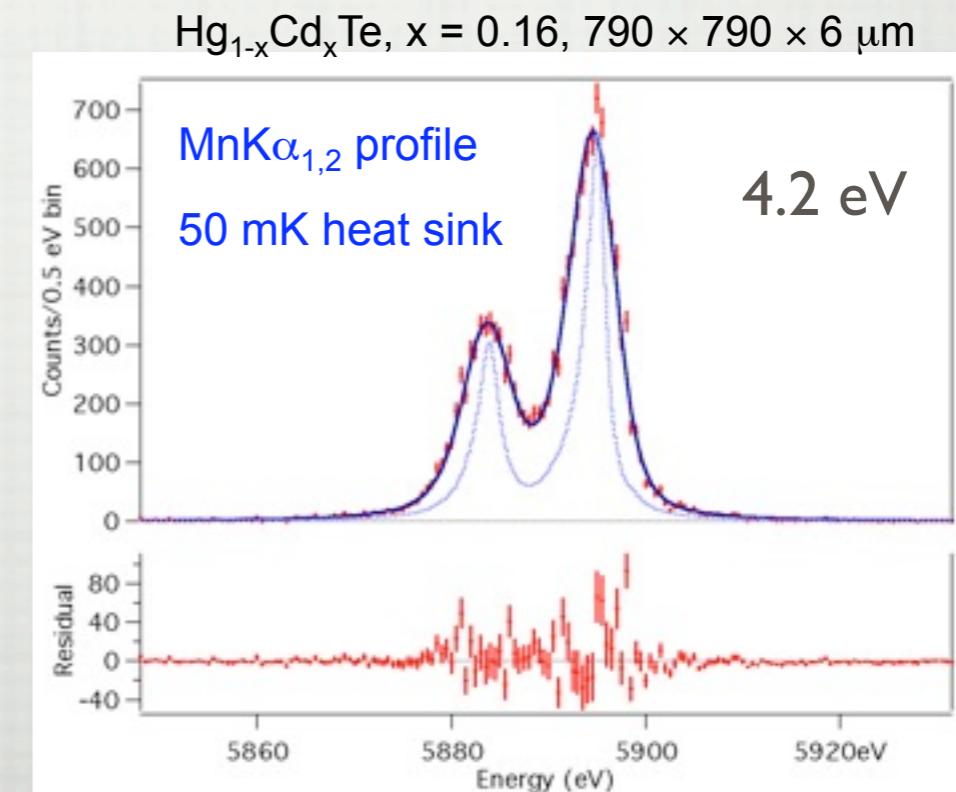
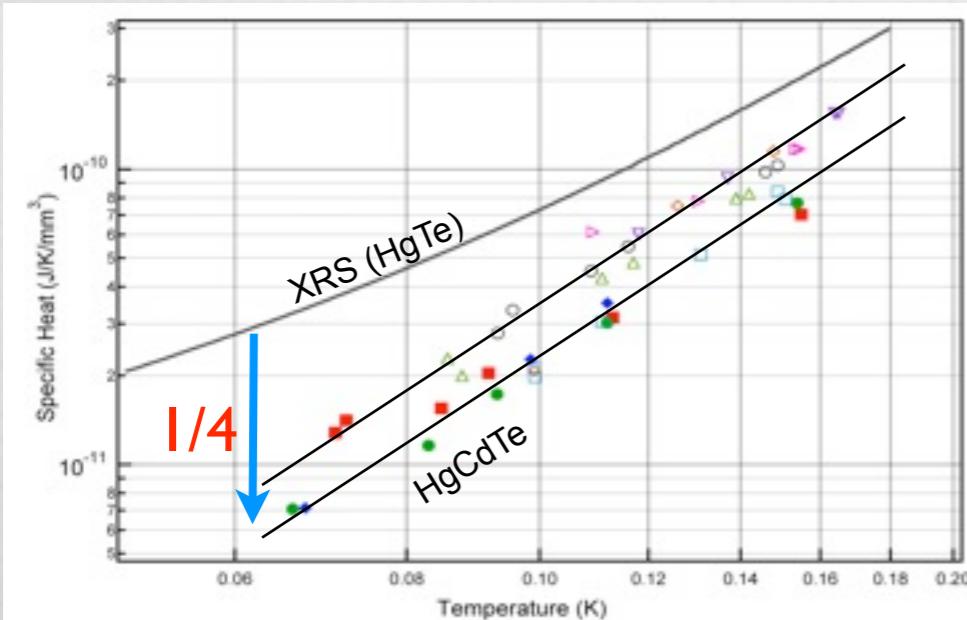
Suzaku XRS flight data
(Kelley+ 2007)



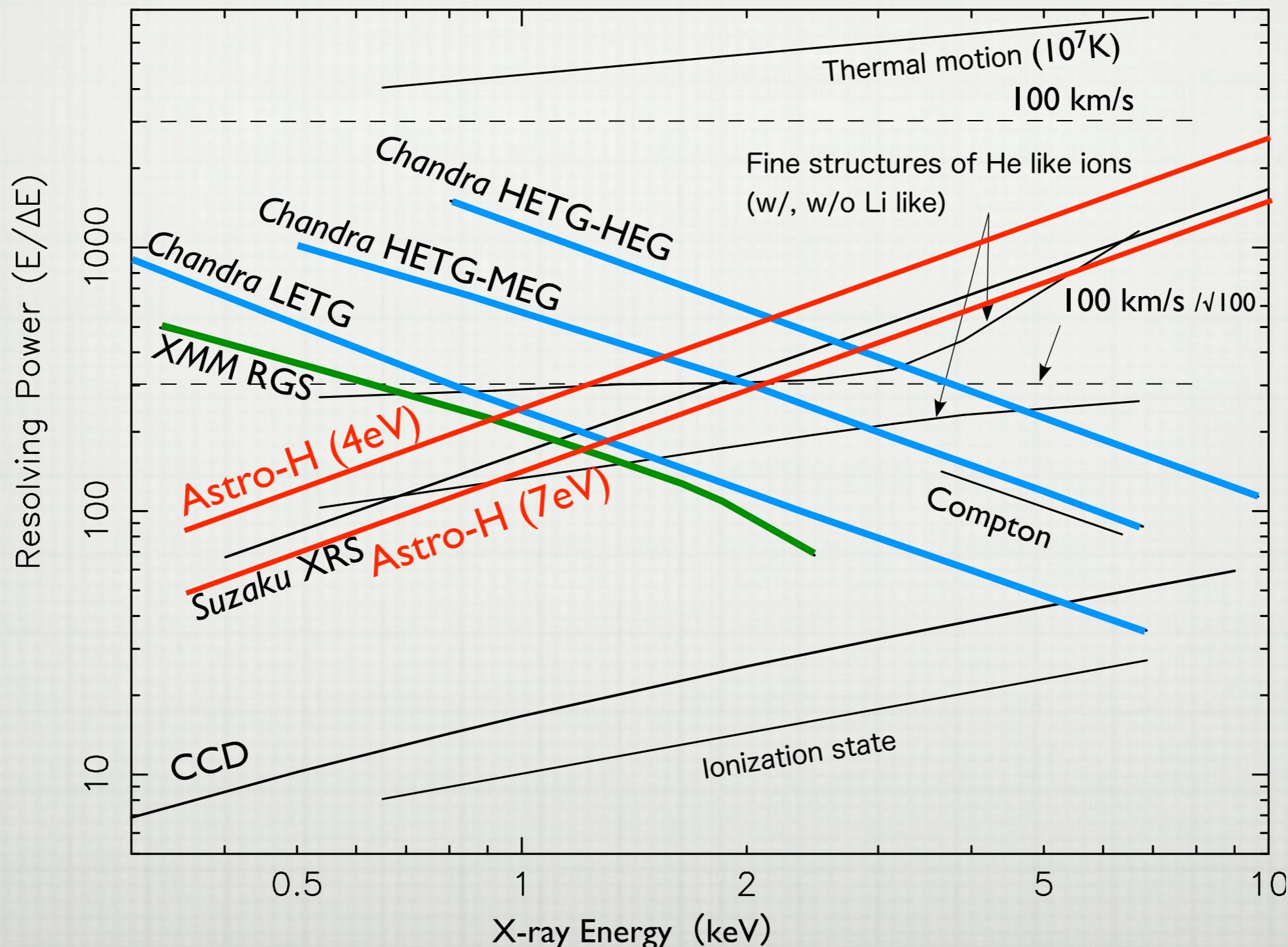
Improvement in energy resolution at laboratory level

(Kelley+ 2008)

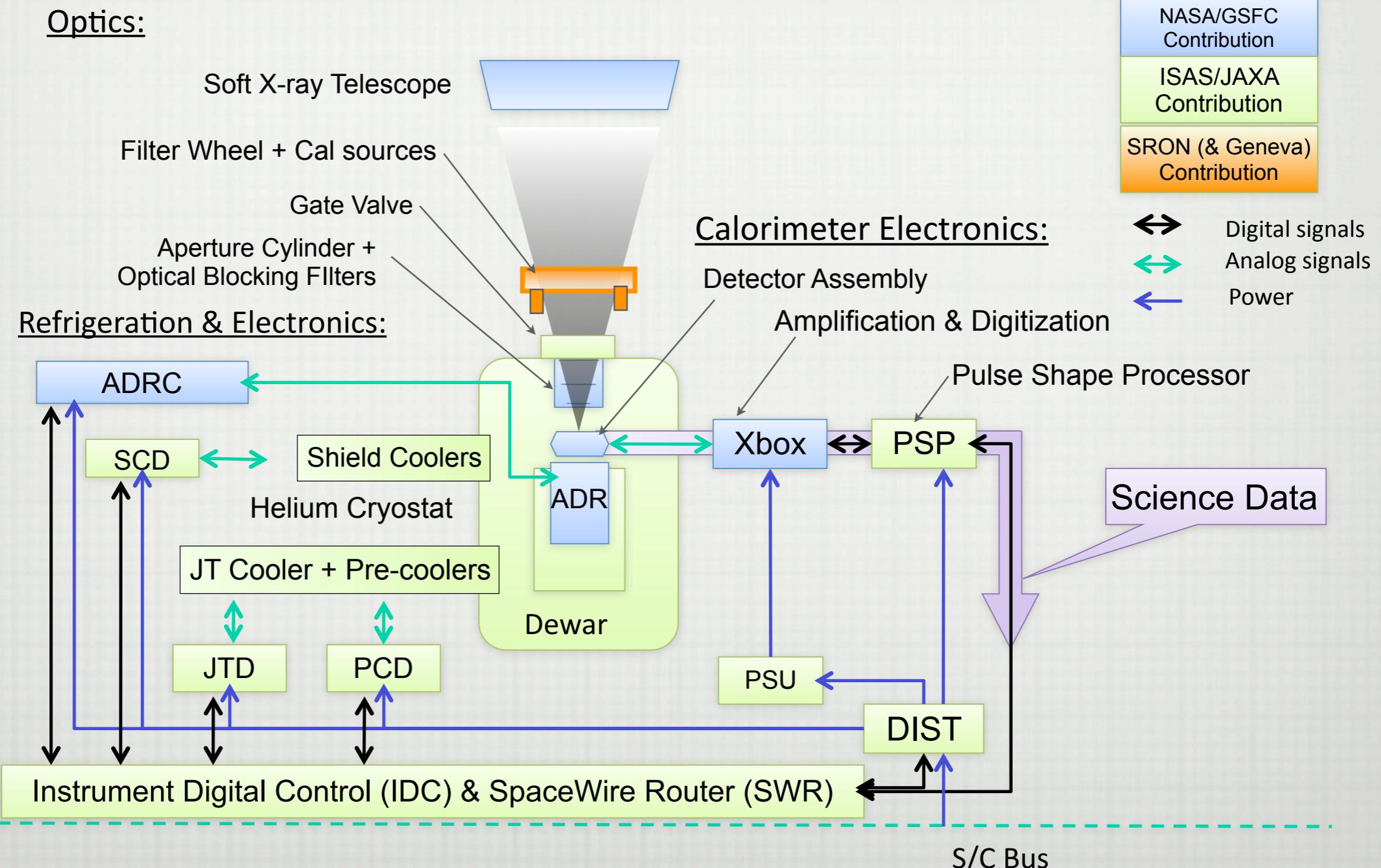
Lower operating temperature (60mK → 50mK)
Lower Heat Capacity (~factor 4)



Energy resolution



SXS system



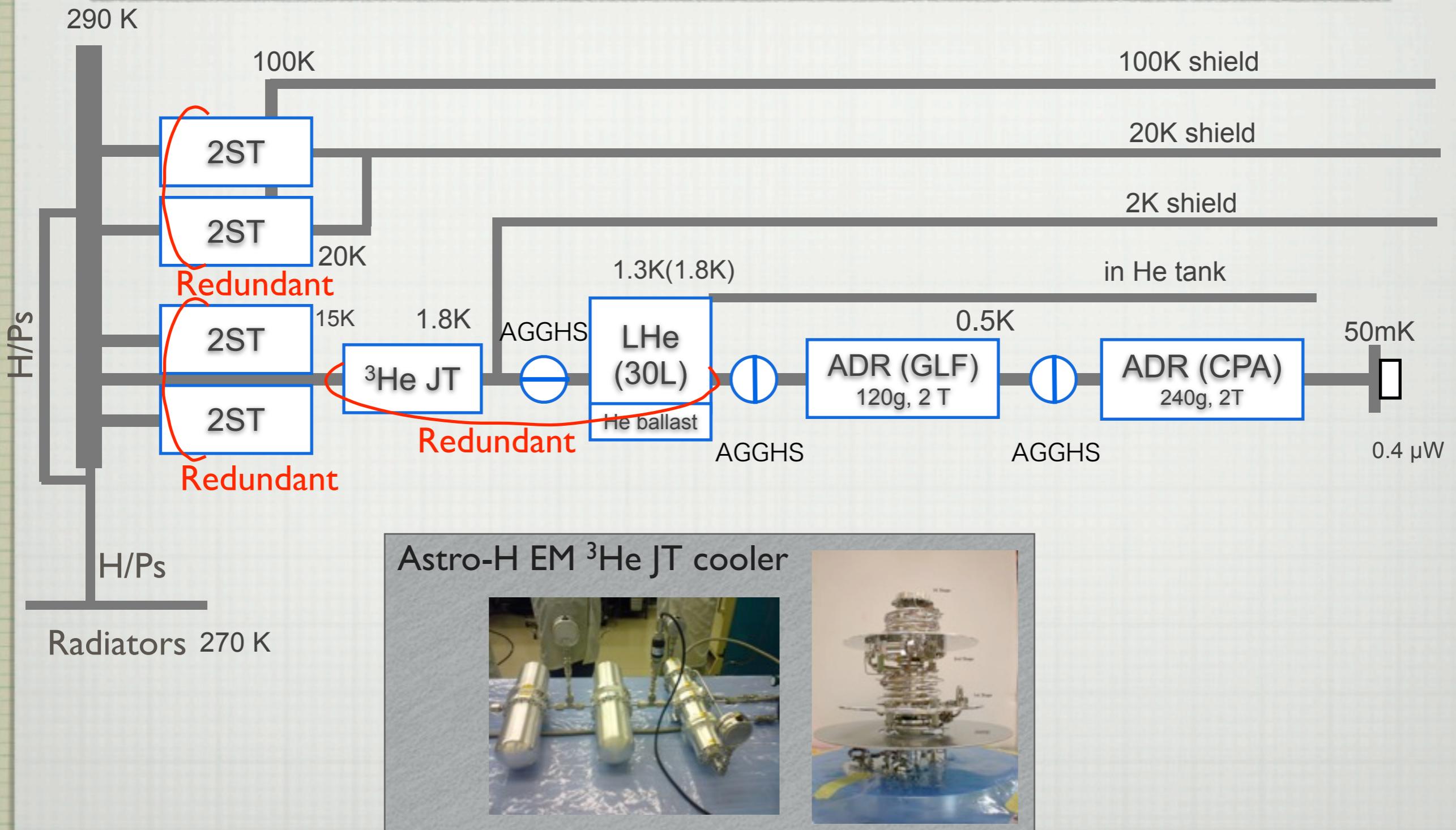
Cooling Requirements

	Requirement	Goal
Temperature @detector interface	47 mK	47 mK
Stability	1 μ K rms in 20s - 10min	0.5 μ K rms
Lifetime	3 years	5 years
Heat load from detector (FEA)	0.4 μ W @47mK 0.3mW @1.3K (He)* 15mW @32K (IVCS)	0.6 μ W @47mK

FEA = detector Front-End Assembly

* Dependent on IVCS temperature

Cooling system: Cooling chain



Cooling system: LHe expected life

	Case	Cooler Power (W)	Heat load to He tank (mW)	Lifetime of LHe (years)
1	Normal	Shield cooler 50x2 Precooler 50x2 JT 90	0.53 (0.3 from FEA)	5.7 ⁺
2	Failure of one shield cooler	Shield cooler 90x1 Precooler 50x2 JT 90	0.83 (0.6 from FEA)	3.6 ⁺
3	Failure of JT compressor	Shield cooler 90x2 Precooler 50x2 JT 0	0.96 (0.1 from FEA)	3.1
4	Failure of one JT precooler	Shield cooler 90x2 Precooler 90x1 JT 0	0.99 (0.1 from FEA)	3.0

+ Observation continues as far as ^3He JT cooler works

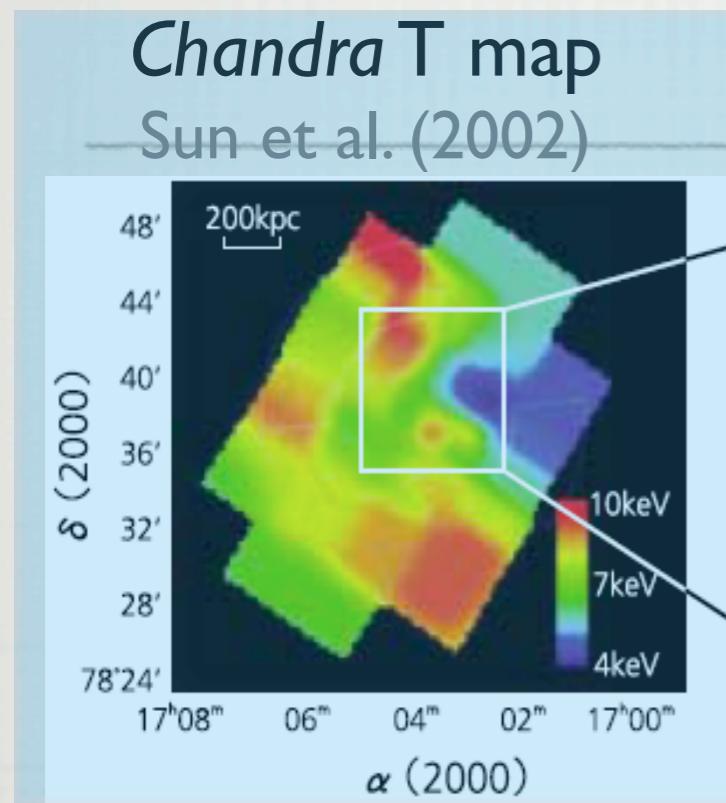
Science with the SXS

Ask people in this room

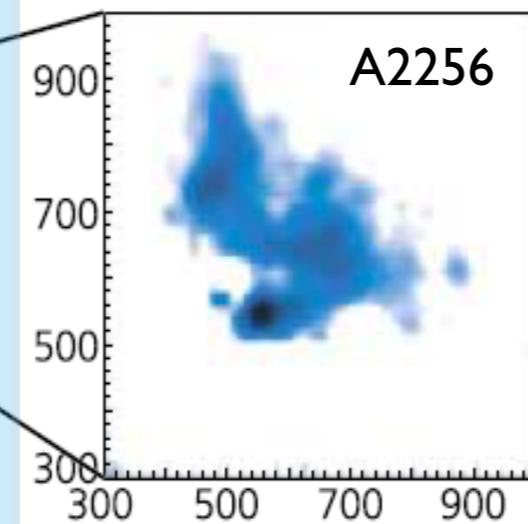
Main scientific objectives of the SXS

- **Energy budget of clusters of galaxies and SNRs**
 - **Thermal energy, bulk motion/turbulence energy, [and non-thermal energy by HXI]**
- **Gravitational potential and spin of black holes**
 - **Broad/narrow emission/absorption lines**
- **Chemical enrichment of ICM and IGM; when, where, how elements are created and dispersed?**
 - **N-Ni abundances of galaxies and clusters, resolving K and L lines**
- **Constraints on cosmological parameters from clusters**
 - **Precise determination of mass of ≥ 30 nearby clusters, by measuring temperature, pressure, and bulk motion/turbulence.**

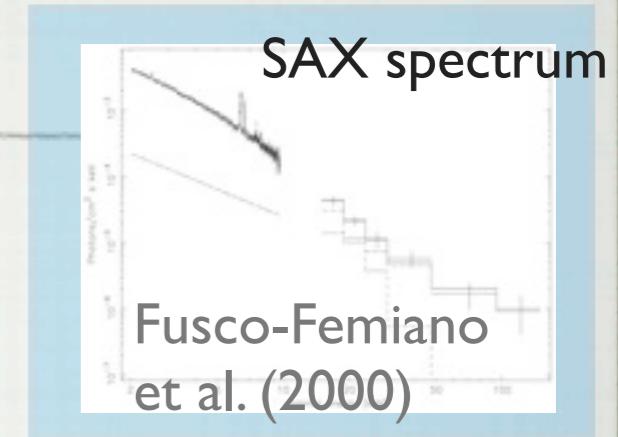
A simulated Astro-H observation



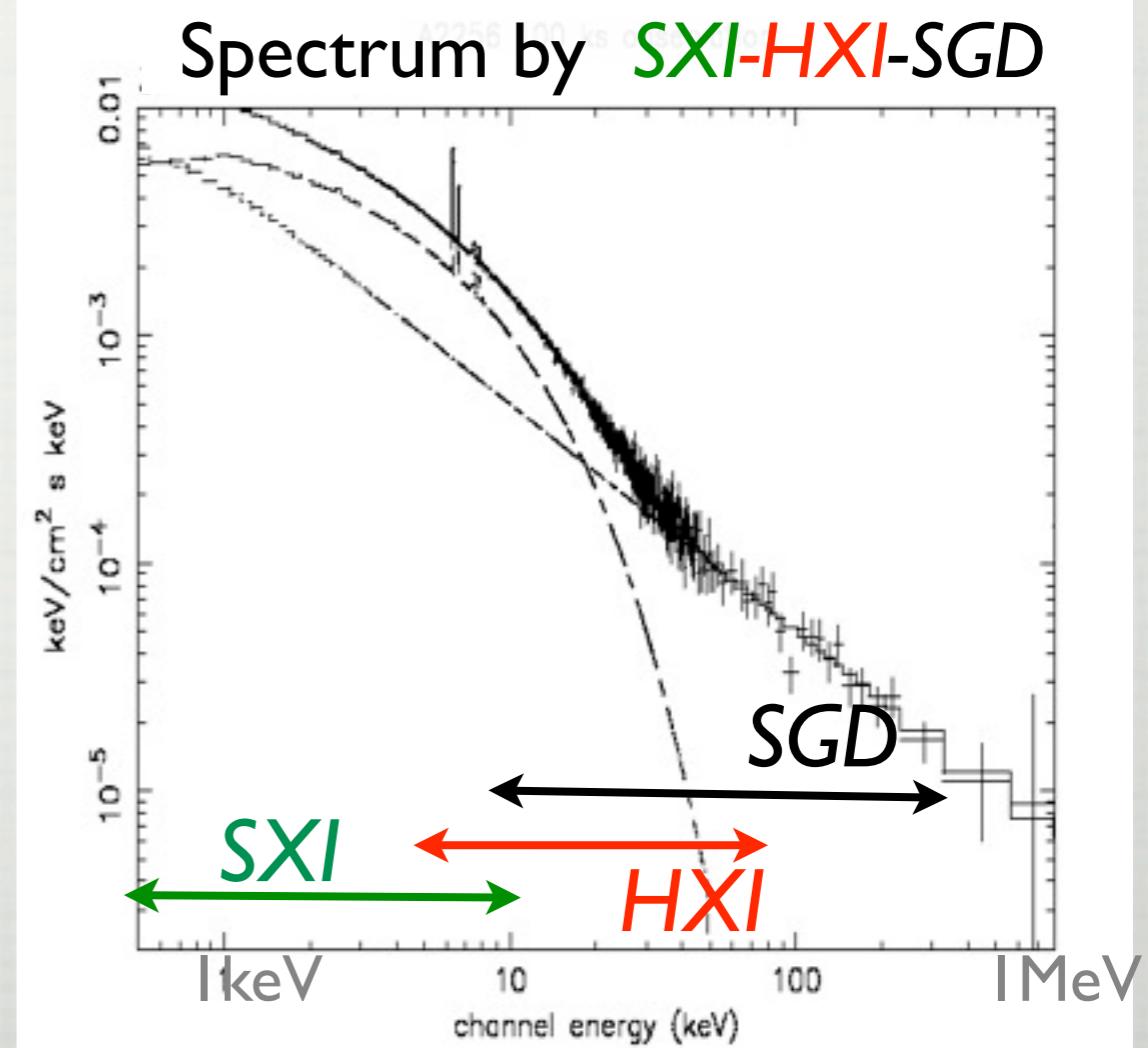
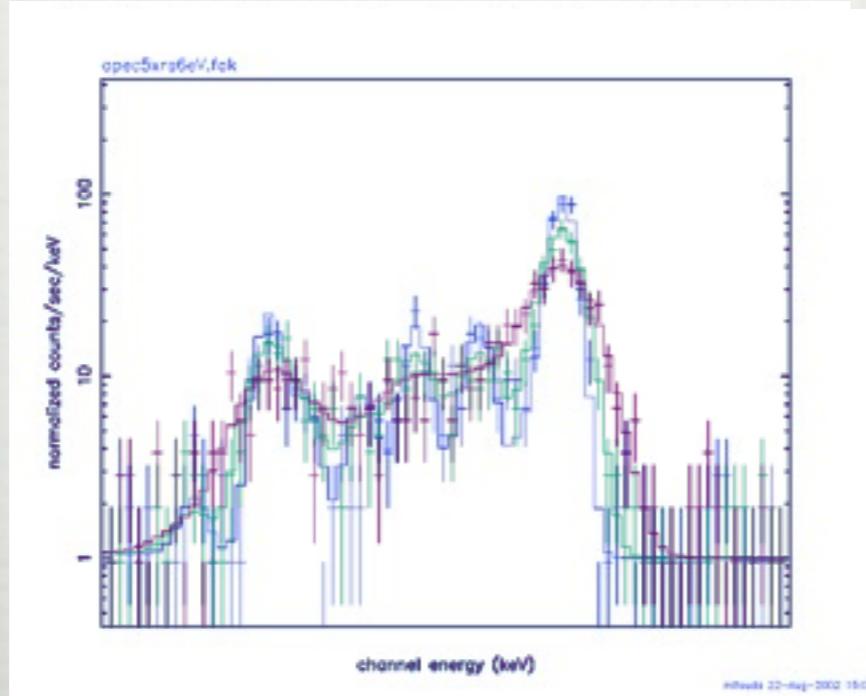
Cluster merger, A2256
HXT-HXI image
 $E > 10$ keV



- Imaging observation is crucial to discriminate out the AGN contribution.



Spectrum by Micro-calorimeter (SXS)



Summary

- **Astro-H is presently in phase-B, and expected to be launched in JFY 2013 (2012 summer or 2013 winter).**
- **The Soft X-ray Spectrometer (SXS) consists of a focusing X-ray telescope and a microcalorimeter-array, and is developed by Japan-US collaboration with European participation.**
 - **Effective area = 225cm² @ 7 keV**
 - **Energy resolution (FWHM) ≤ 7 eV**
 - **Field of view = 4.'1 x 4.'1 with 8x8 pixels**
 - **Operation life ≥ 3 years**
- **Main scientific objectives of the SXS**
 - **Energy budget of clusters and SNRs**
 - **Gravitational potential and spin of black holes**
 - **Chemical enrichment of ICM and IGM**
 - **Cosmological parameters from cluster mass**