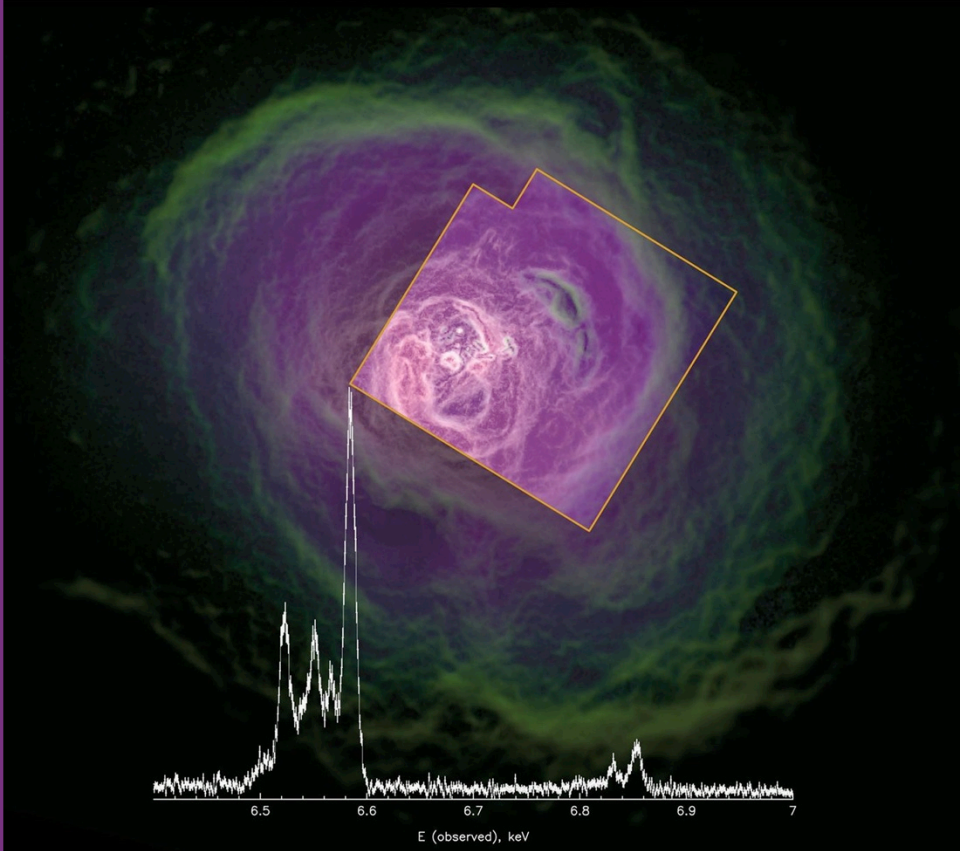
XRISM

X-ray Imaging and Spectroscopy Mission



Chandra image
Hitomi/SXS spectrum

The X-Ray Imaging and Spectroscopy Mission

Richard Kelley
NASA Goddard Space Flight Center

Memorial Symposium to Honor Riccardo Giacconi

Washington, DC
29-30 May 2019

Discovery of X-ray Emission from Clusters of Galaxies

X-ray emission from clusters of galaxies was first detected by Gursky et al., 1971 in the Uhuru X-ray sky survey

- Extended (~45 arcmin) source found associated with the Coma cluster.

Similar extended cluster X-ray sources were later discovered (e.g. Perseus, Virgo), but the spectra at the time were insufficient to distinguish between power law and thermal bremsstrahlung spectra.

Two possible mechanisms were proposed:

- Inverse Compton radiation from 3 K microwave background photons interacting with a relativistic electron population in the cluster (Brecher and Burbidge, 1972).

- Thermal bremsstrahlung from a hot isothermal gas (Lea et al., 1973).

Mon. Not. R. astr. Soc. (1976) **176,** *Short Communication,* 29P–34P.

ARIEL 5 OBSERVATIONS OF THE X-RAY SPECTRUM OF THE PERSEUS CLUSTER

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(Received 1976 February 12)

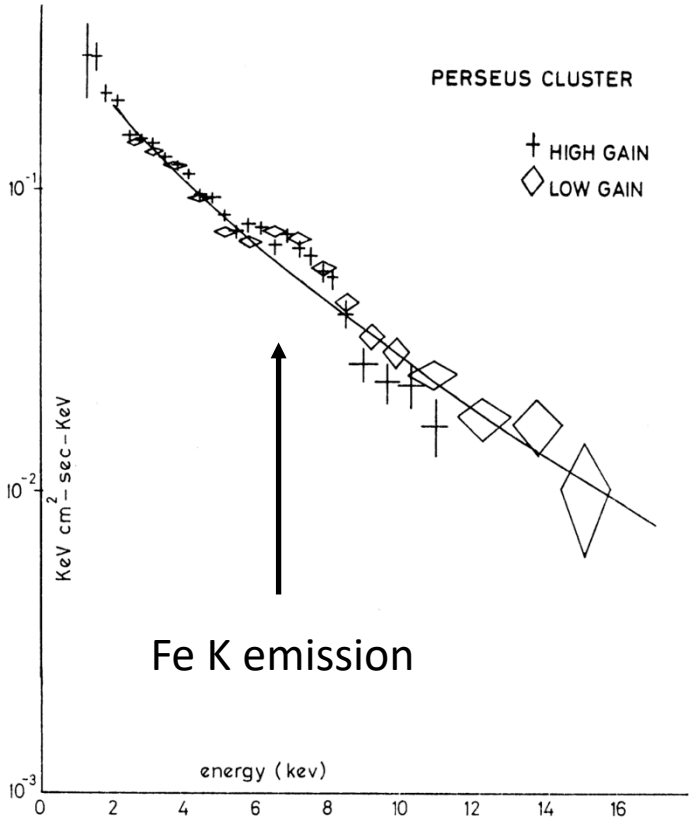
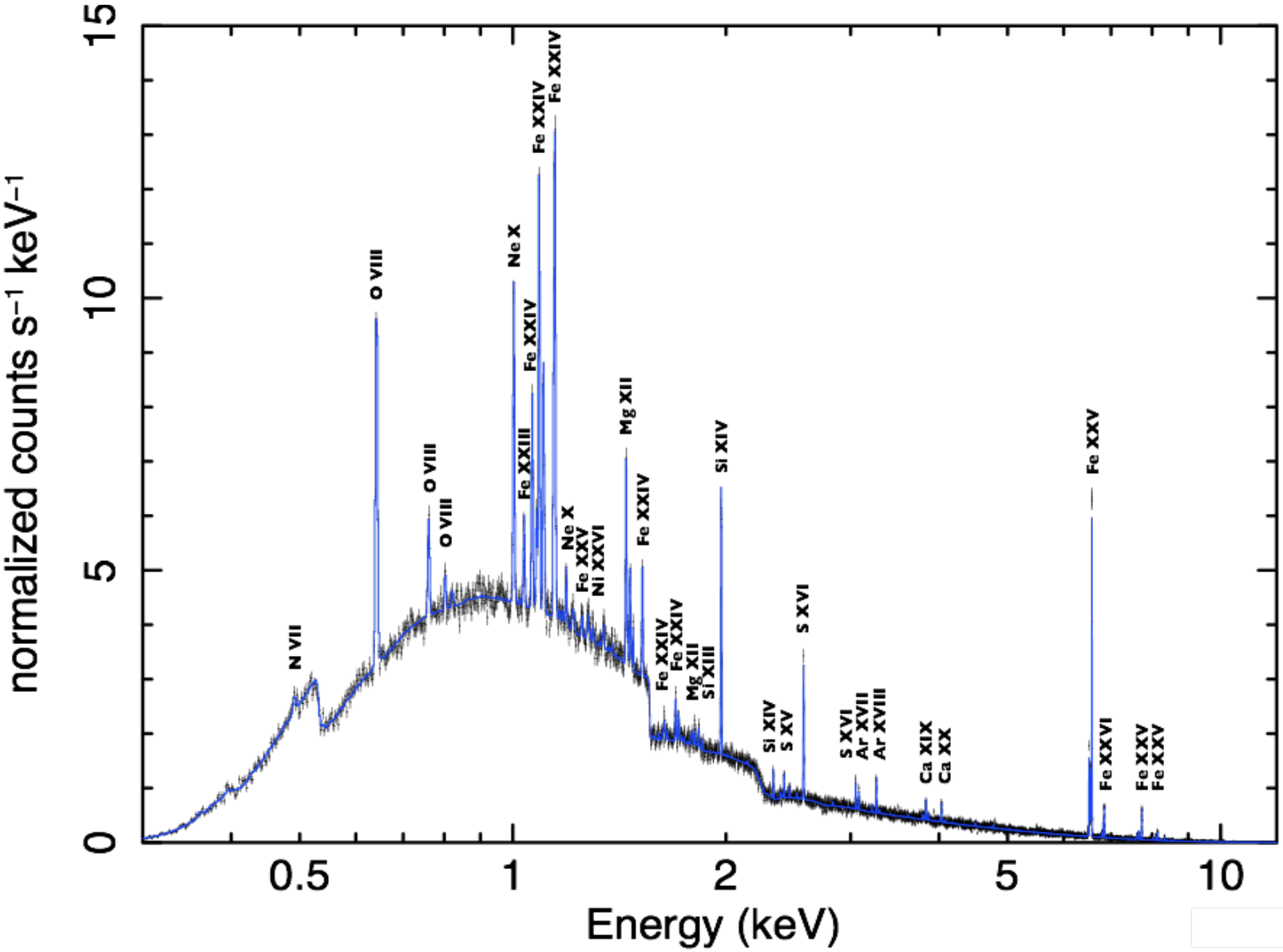


FIG. 1. *The Ariel 5 X-ray spectrum of the Perseus Cluster in the energy range 1·3–16 keV. The two detector gain modes are selected by ground command. The solid line represents the computed continuous spectrum from a Gull & Northover adiabatic gas sphere with central temperature* ($T(0)$) *32 keV and* $T_\infty = -4$ *keV. The emission feature at around 7 keV is visible in both gain modes.*

Expected X-ray spectrum of intra-cluster medium

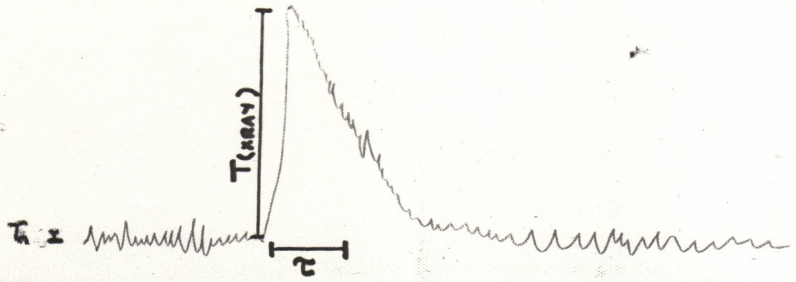


X-Ray Calorimeter (1982)

Bolometric X-Ray Spectrometer

H. Moseley and R. Mushotzky

- Theory and current experiments suggest sensitive bolometers can be used as x-ray detectors with the efficiency of imaging detectors and energy resolution exceeding that of current crystal spectrometers.
- We propose to produce and test such detectors to prove their utility as practical x-ray detectors.



$$T_{(XRAY)} = \frac{E_{(XRAY)}}{C_{BOL}} \quad K$$

$$T_n = \sqrt{\frac{4KT^2}{G}} \quad K/\sqrt{Hz}$$

$$\tau = C/G \quad sec.$$

Temperature History of Bolometer Hit by X-RAYS

Energy resolution of ~ 1 eV theoretically possible

The AXAF X-Ray Spectrometer (XRS)

A PROPOSAL FOR AN X-RAY SPECTROSCOPY
INVESTIGATION FOR THE AXAF OBSERVATORY

VOLUME 1: TECHNICAL PROPOSAL

Instrument Principal Investigator:

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WITH ADDITIONAL COLLABORATORS AT THE GODDARD SPACE FLIGHT CENTER AND THE UNIVERSITY OF WISCONSIN

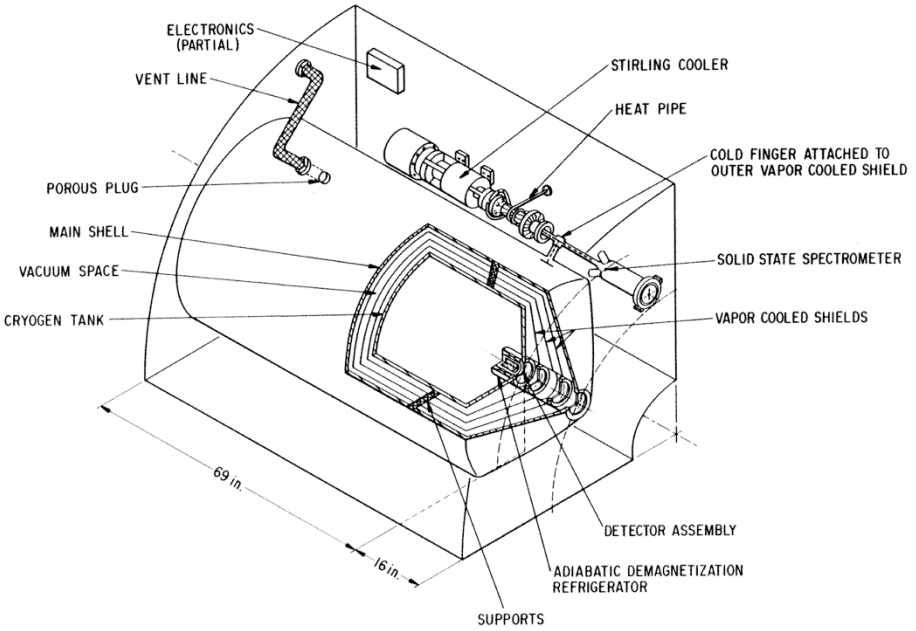
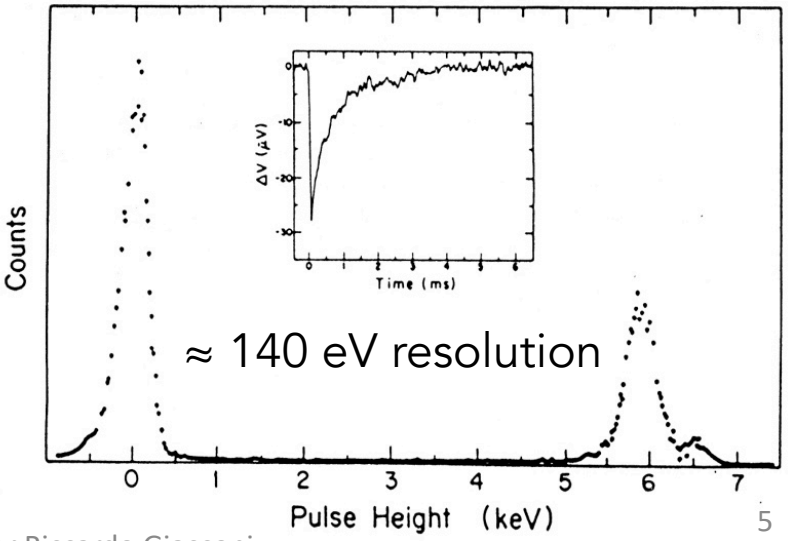
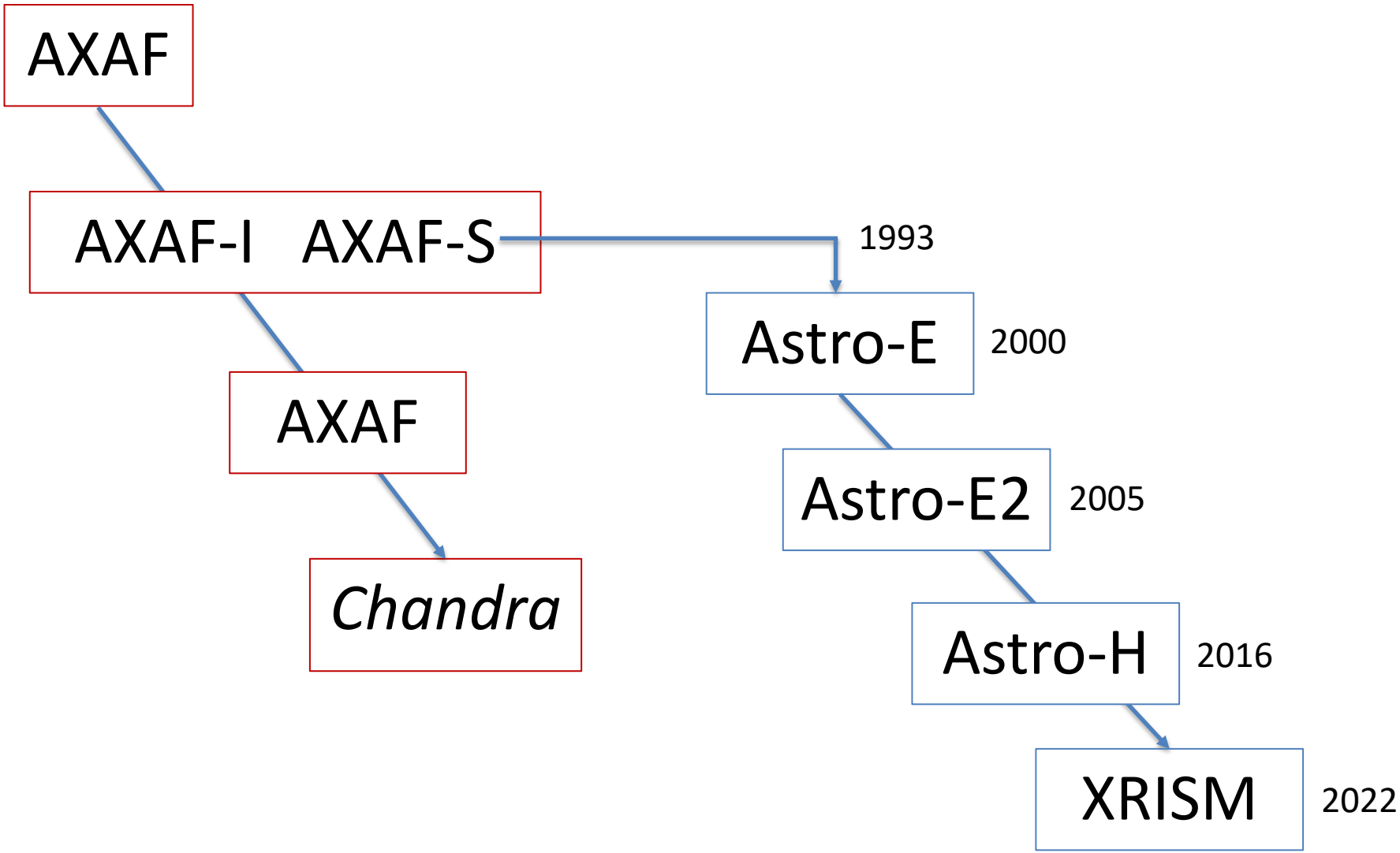


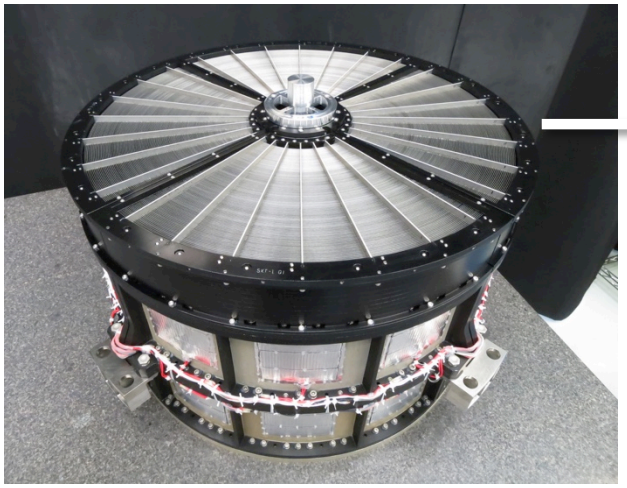
Fig. 1. Overall experiment layout



The "XRS" is History!



NASA Hardware Contributions to Astro-H



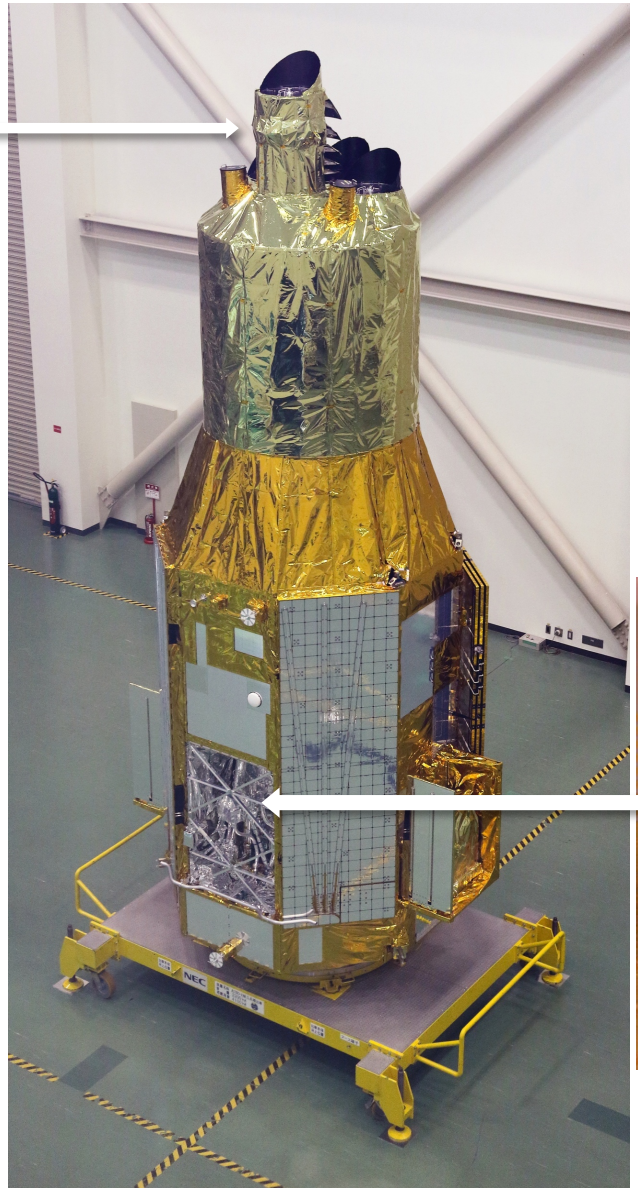
Soft X-Ray Telescope

5.6 m focal length – *fixed optical bench*

203 concentric shells (1624 individual reflectors)

Outer Diameter: 45 cm
Mass: CBE = 46 kg.

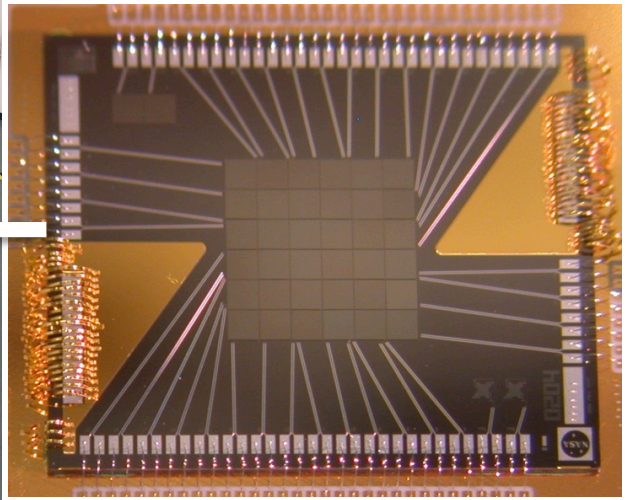
Half-Power Diameter of better than 1.2 arcmin



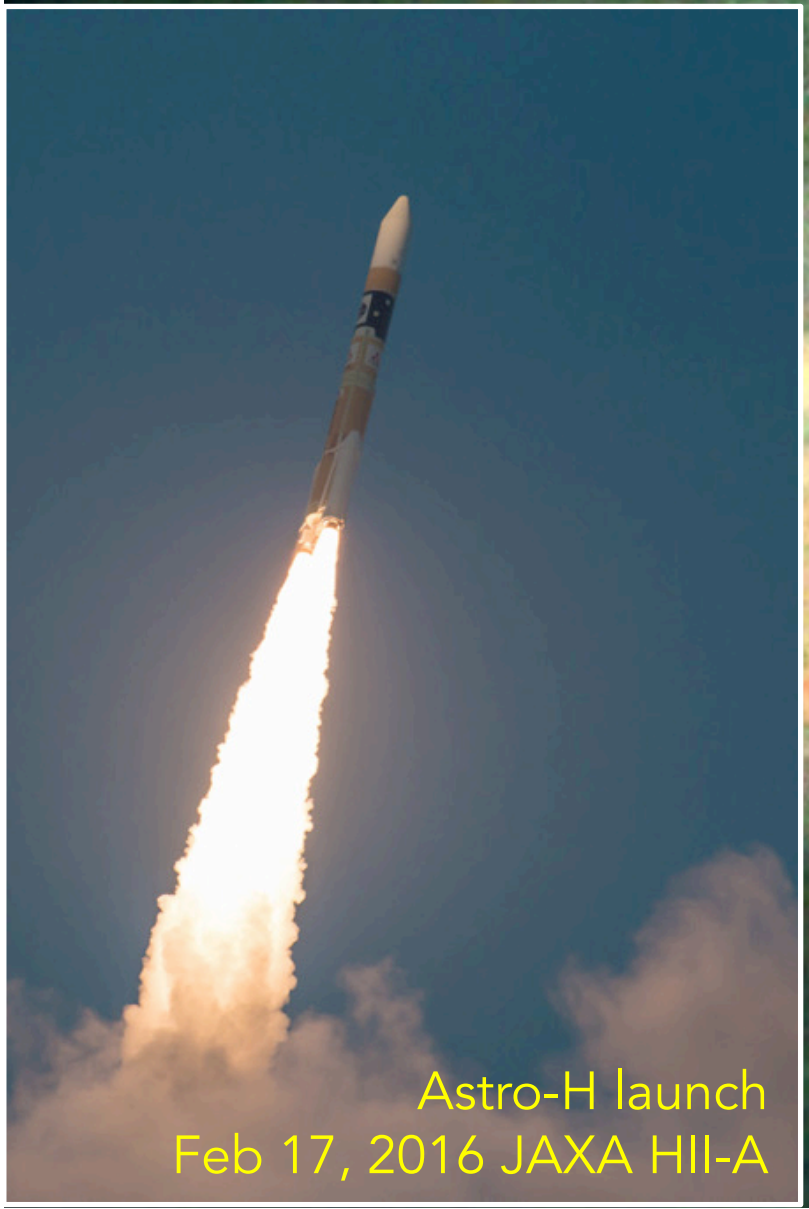
Soft X-Ray Spectrometer

SXS – energy resolution better than 4.9 eV at system level

6 x 6 array of 30″ x 30″ pixels (3 arcmin FOV)



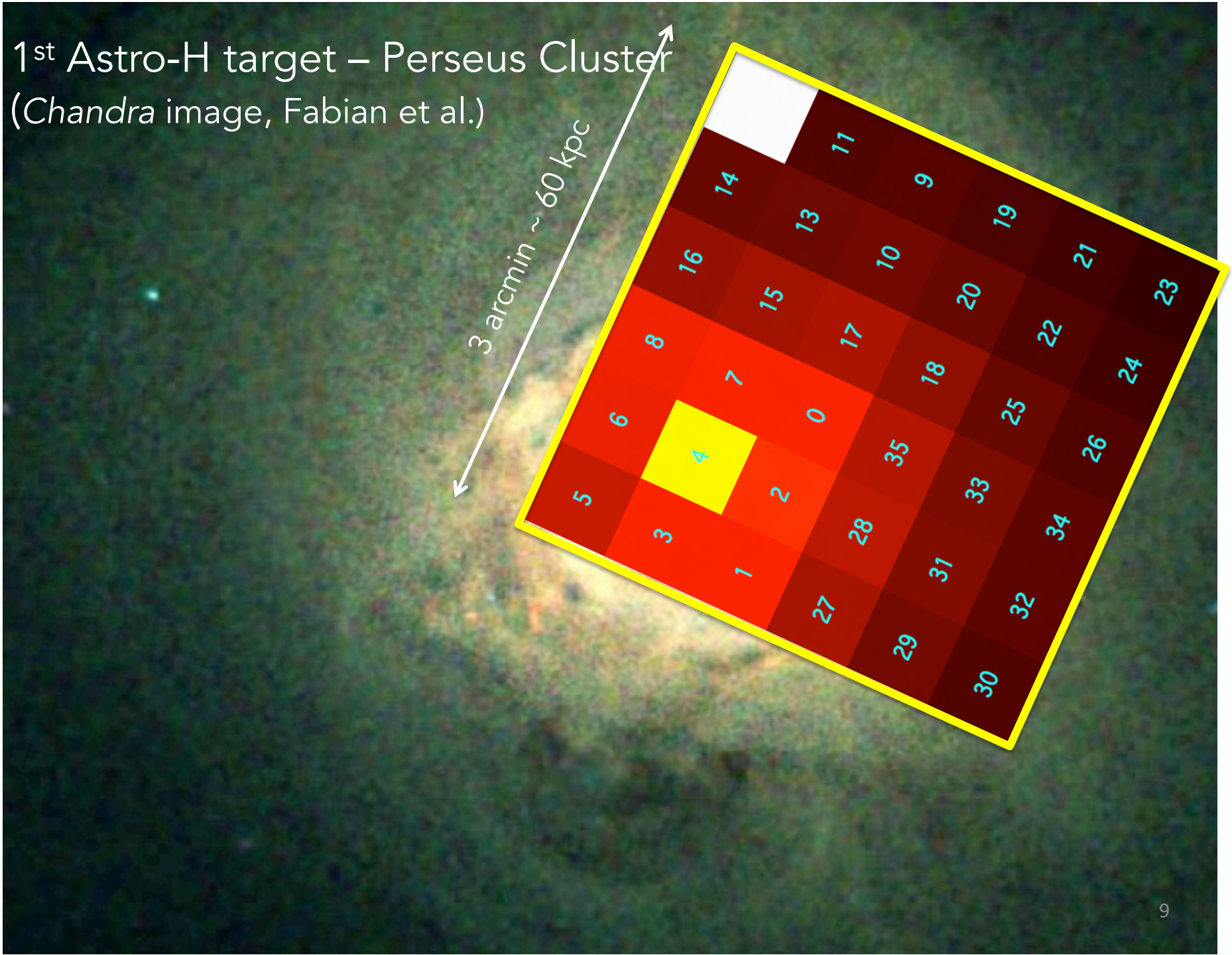
1st Astro-H target – Perseus Cluster
(*Chandra* image, Fabian et al.)



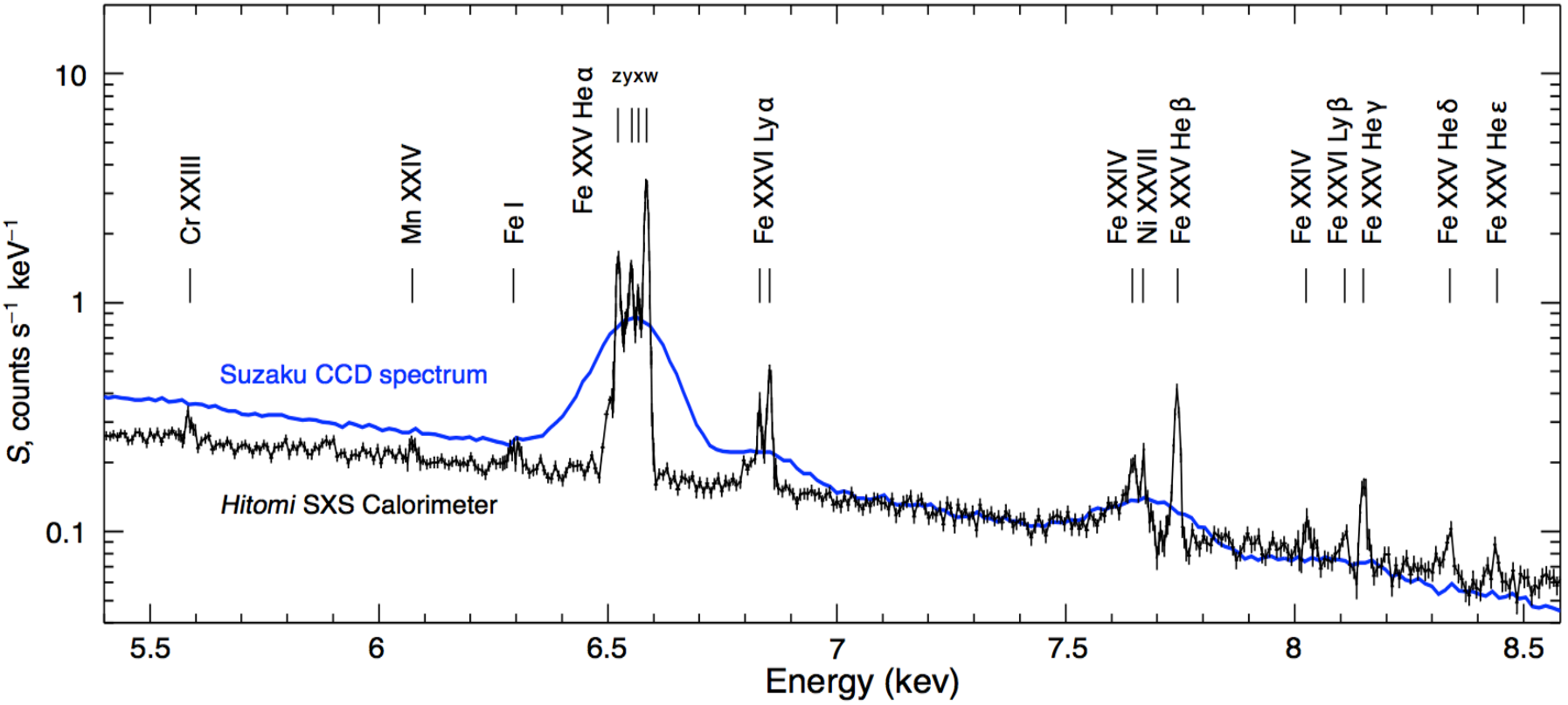
Astro-H launch
Feb 17, 2016 JAXA HII-A

1st Astro-H target – Perseus Cluster

(*Chandra* image, Fabian et al.)



Astro-H (*Hitomi*) SXS Spectrum of Perseus cluster

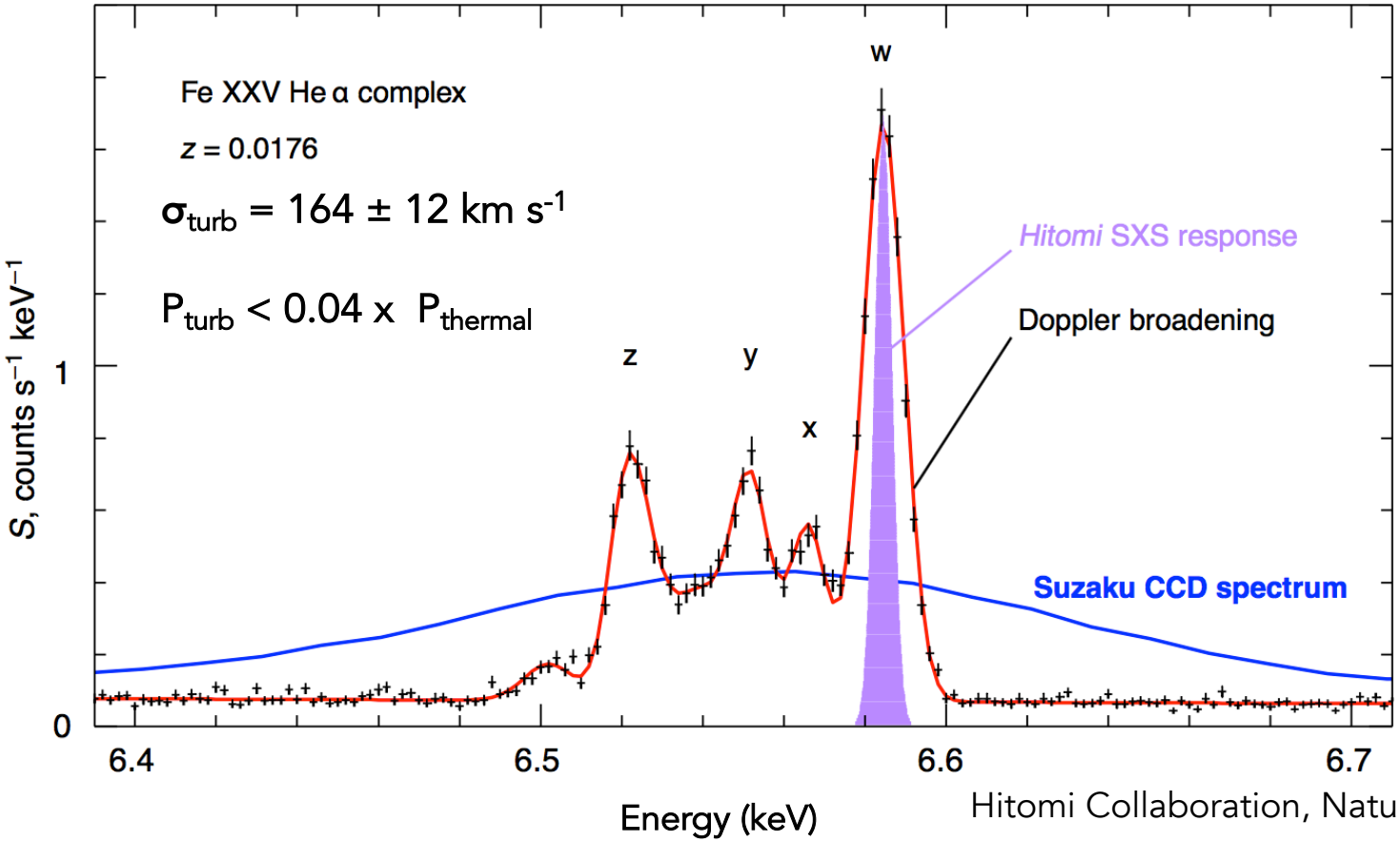


Hitomi Collaboration, Nature 2016

BLACK: *Hitomi* SXS (energy resolution 4.9 eV, FWHM)

BLUE: Best previous spectrum (Suzaku CCD; FWHM 140 eV)

Astro-H (*Hitomi*) SXS Spectrum of Perseus: He-like Fe



Hitomi Collaboration, Nature 2016

BLACK: *Hitomi* SXS data

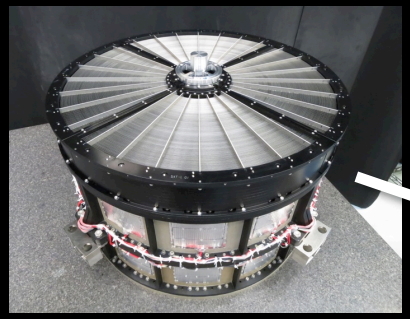
PURPLE: Hitomi SXS line response function

BLUE: Best previous spectrum (Suzaku CCD)

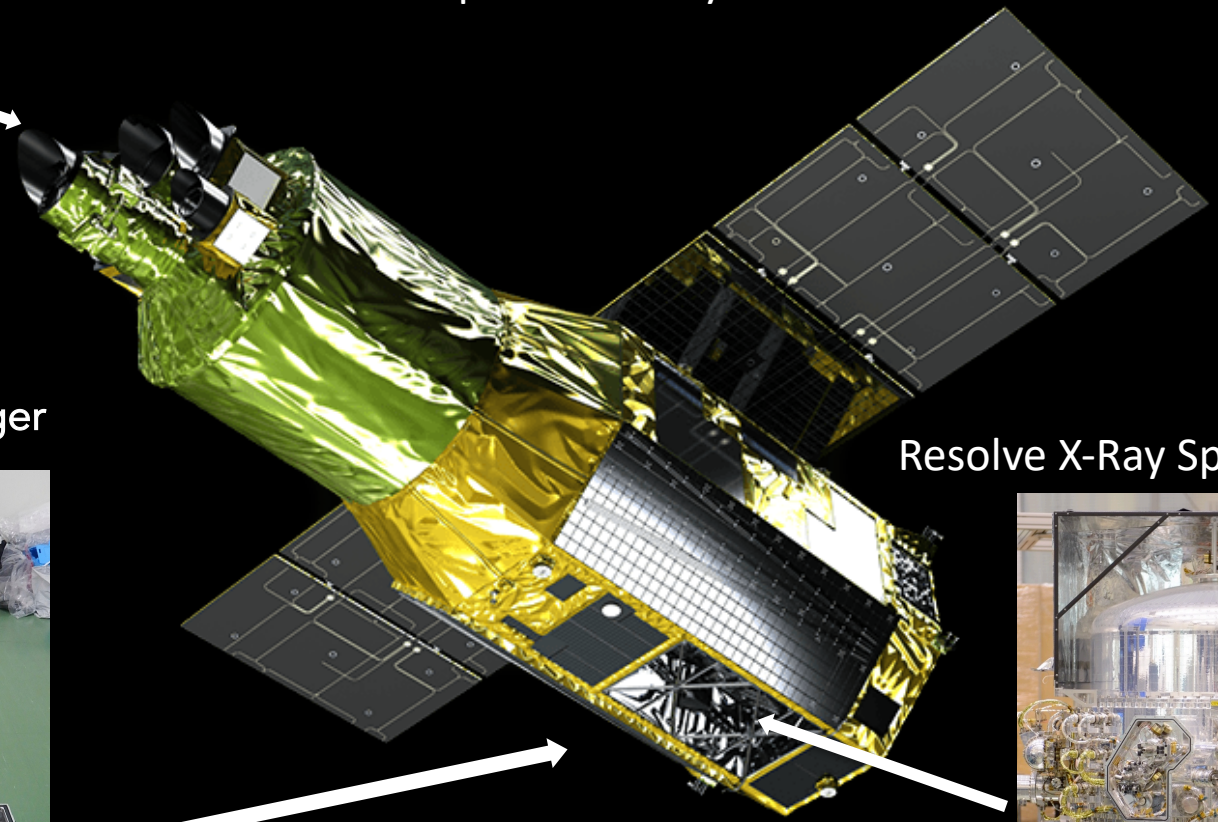
Notice how the high spectral resolution of Hitomi/SXS allows easy detection of the turbulent velocity broadening. This capability was eagerly anticipated for all nearby clusters.

The X-Ray Imaging and Spectroscopy Mission

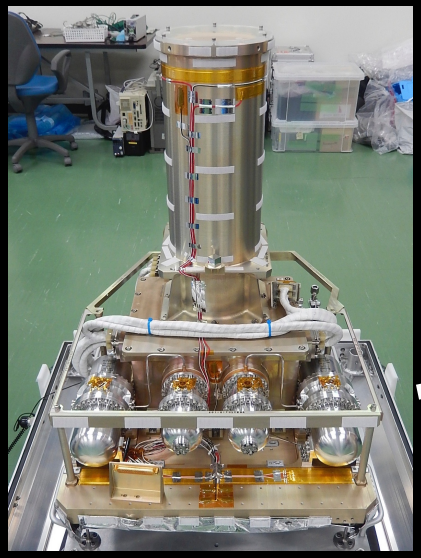
X-Ray Mirror Assemblies (2)



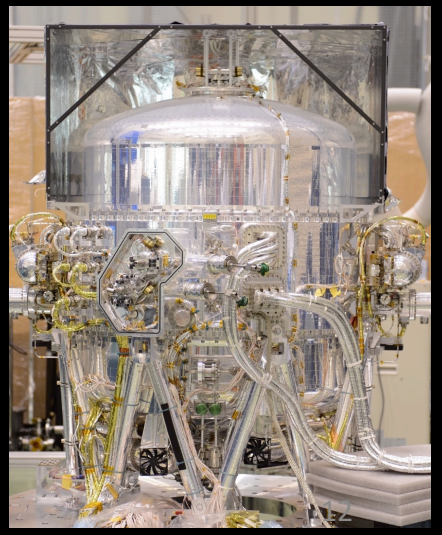
- Coming in 2022
- Incorporates many lessons learned from Astro-H



Xtend CCD Imager



Resolve X-Ray Spectrometer



US Access to XRISM

NASA to have access to ~ 44% of observing time and all data from *Resolve* and *Xtend* once in US archive (+1 year). JAXA and ESA have separate agreement on remainder.

NASA responsible for data pipeline and dissemination.

NASA *Participating Scientists* selected by NASA (science advisors):

Lia Corrales/U. Michigan
Erin Kara/MIT
Jon Miller/U. Michigan
Paul Plucinsky/SAO
Irina Zhuravleva/U. Chicago

Additional target *Collaborating Scientists* to be selected to support performance/verification phase (6 months duration following commissioning)

- It is anticipated that ~ 60 scientists will be selected to join target teams.
- AO for *Collaborating Scientists* to be released in late 2020.
- Negotiating early release data from a few targets shortly after commissioning.
- AO-1 released after commissioning (~ late Spring, 2022).

Giant leap: ATHENA will push capability all the way out to z ~ 1

- Contains very large fraction of all x-ray clusters
- 3168-pixel array, 2.5 eV resolution

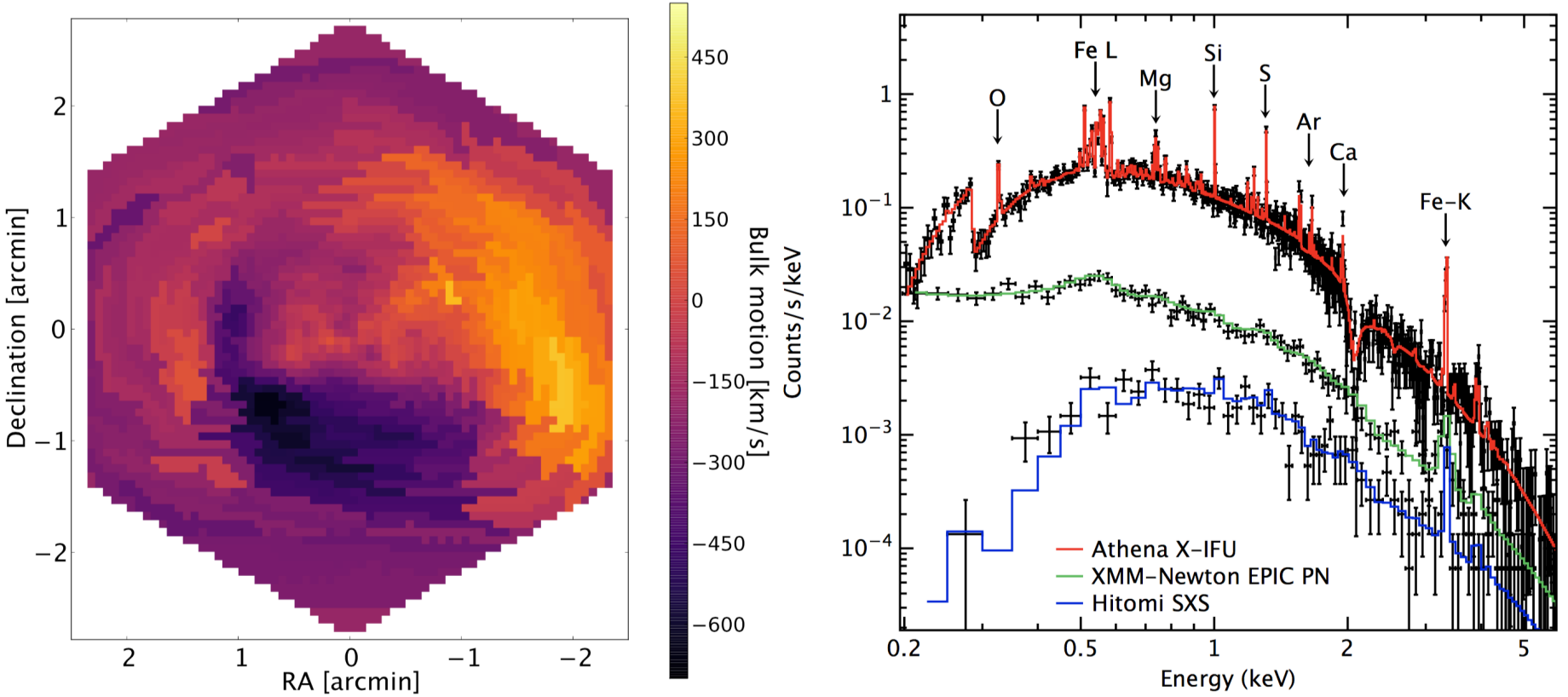


Figure 2. Left: Reconstructed bulk motion induced velocity field (in km/s) of the hot intra-cluster gas for a 50 kilo-seconds X-IFU observation of the central parts of a Perseus like cluster from the numerical simulations in Ref. 20. The cluster has the luminosity of Perseus but is considered at a redshift of 0.1. Right: Simulated X-IFU spectrum of a $z = 1$ galaxy group with $kT = 3$ keV and $L_X = 1 \times 10^{44}\,\mathrm{erg\,s^{-1}}$ for 50 ks. Emission lines from elements which are key to understand chemical evolution can be clearly seen.