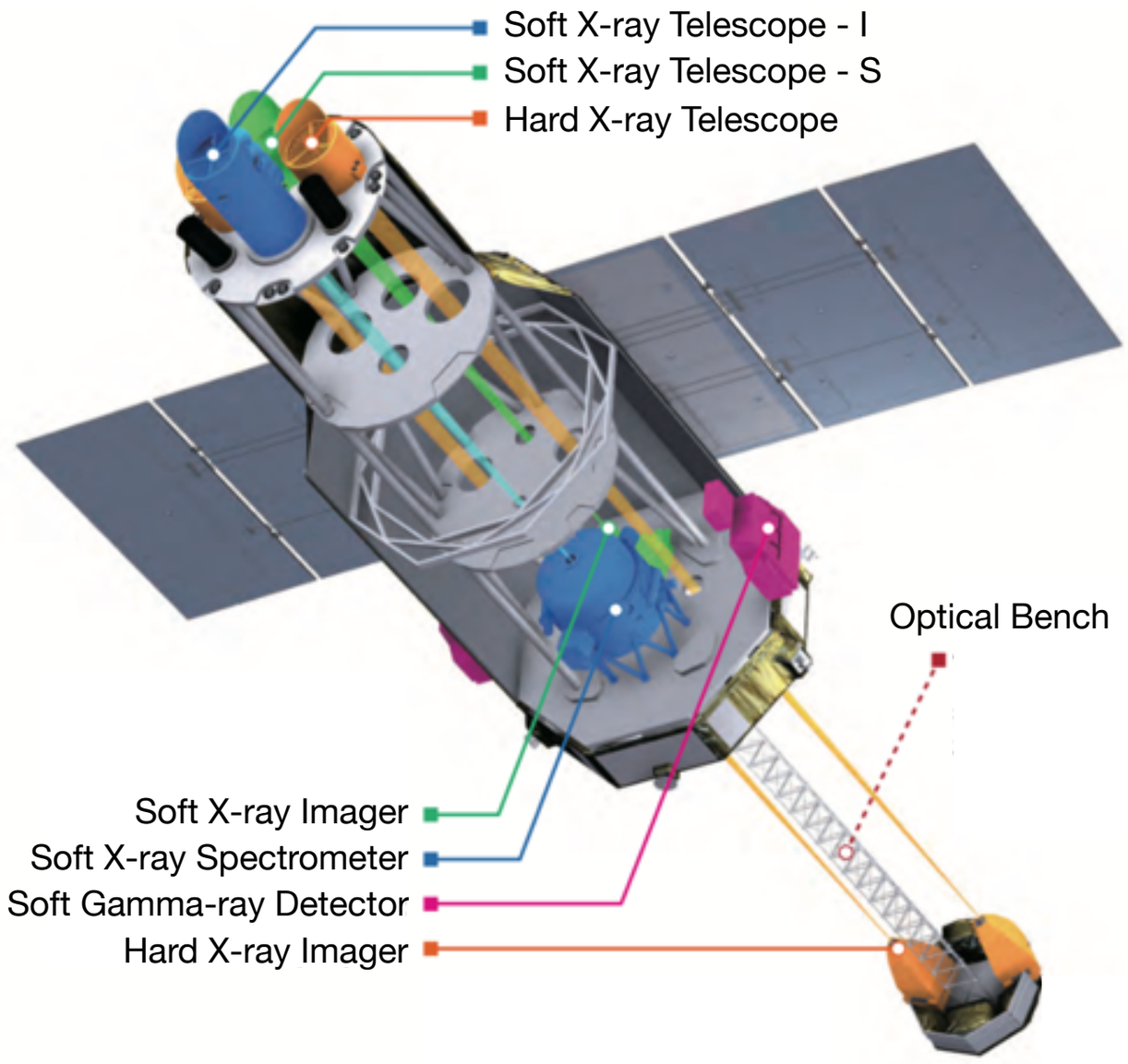
Status of the XARM mission

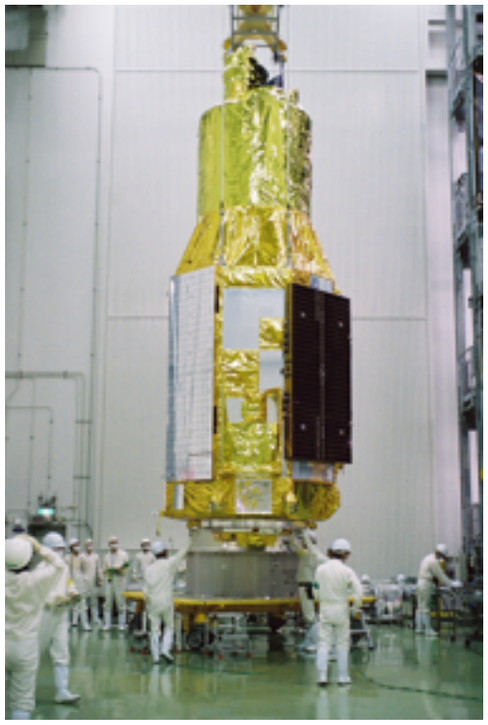
Shinya Nakashima
(RIKEN, XARM Resolve & science operations team)
on behalf of
Kyoko Matsushita and **XARM pre-project team**
(TUS, XARM science management office lead)

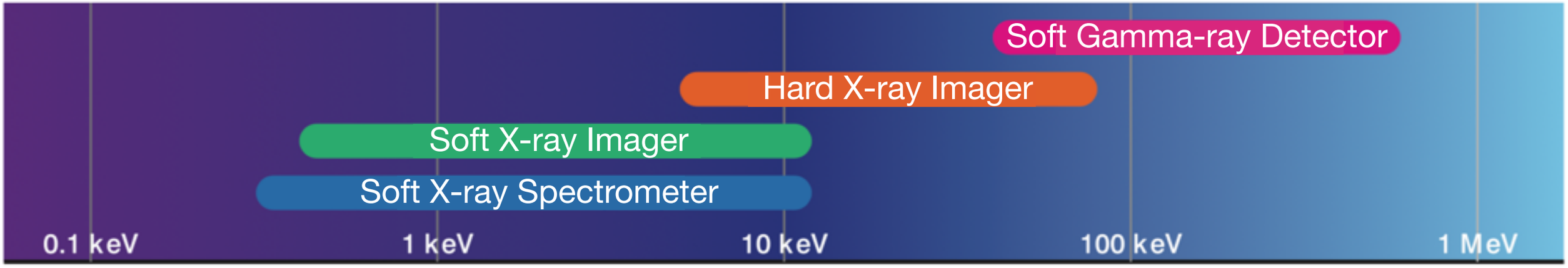
The eROSITA Consortium Meeting, 23-26 April 2018 (Garching, Germany)

Hitomi (ASTRO-H) observatory

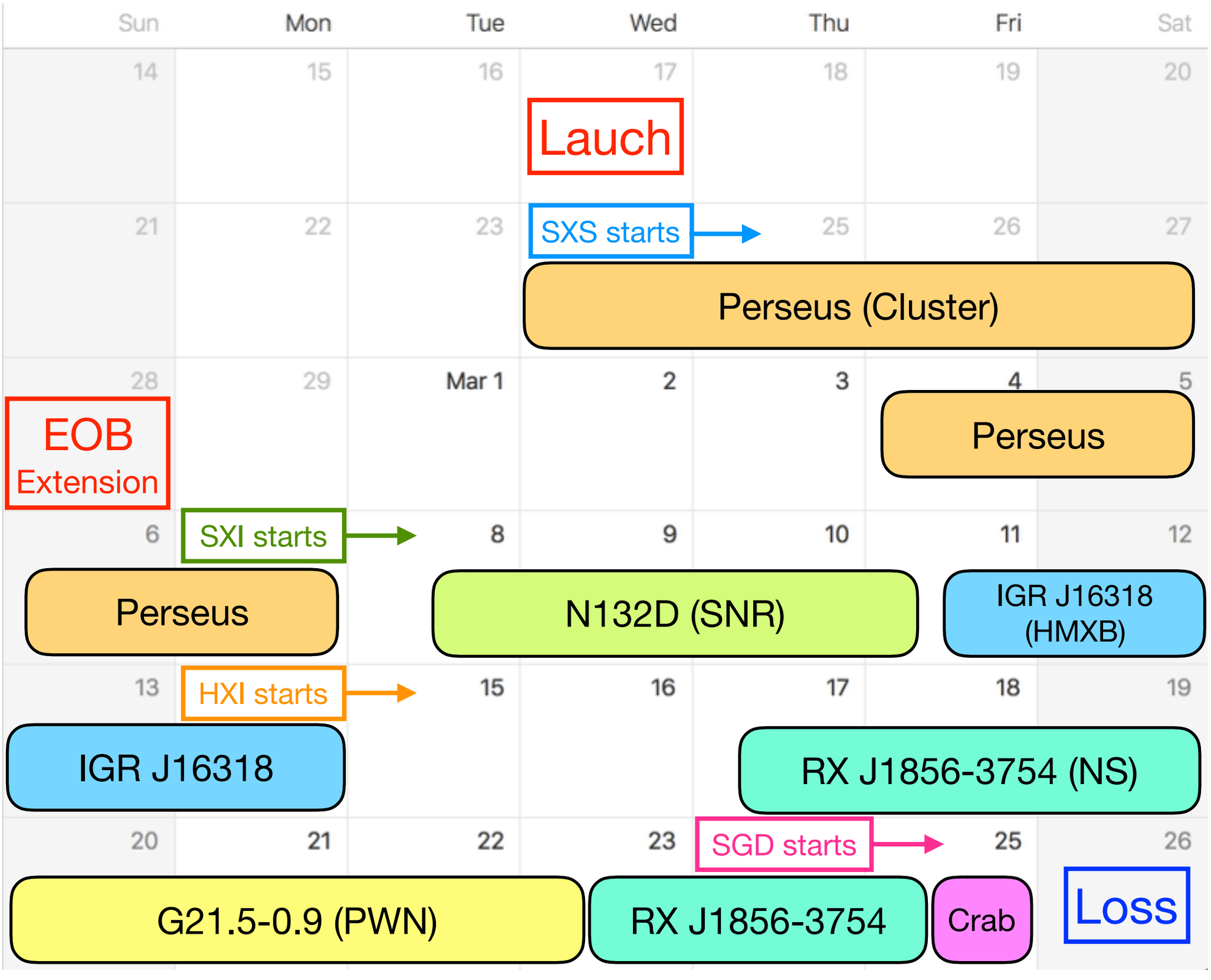


- Japanse 6th X-ray astronomy mission
- Collaboration with US, Europe, and Canada
- Project Started on 2008 Oct. 1st
- Launched on 2016 Feb. 17th

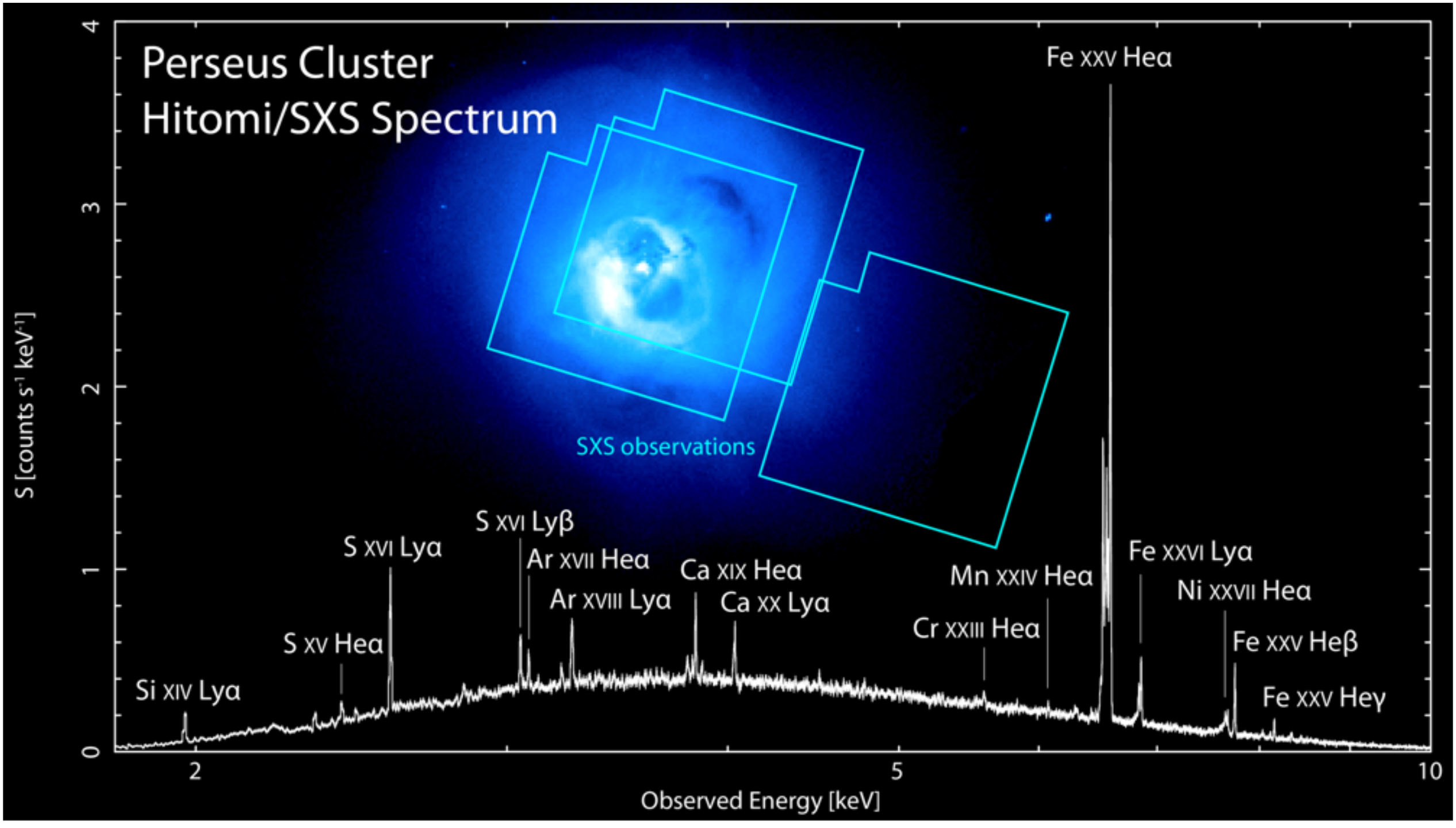




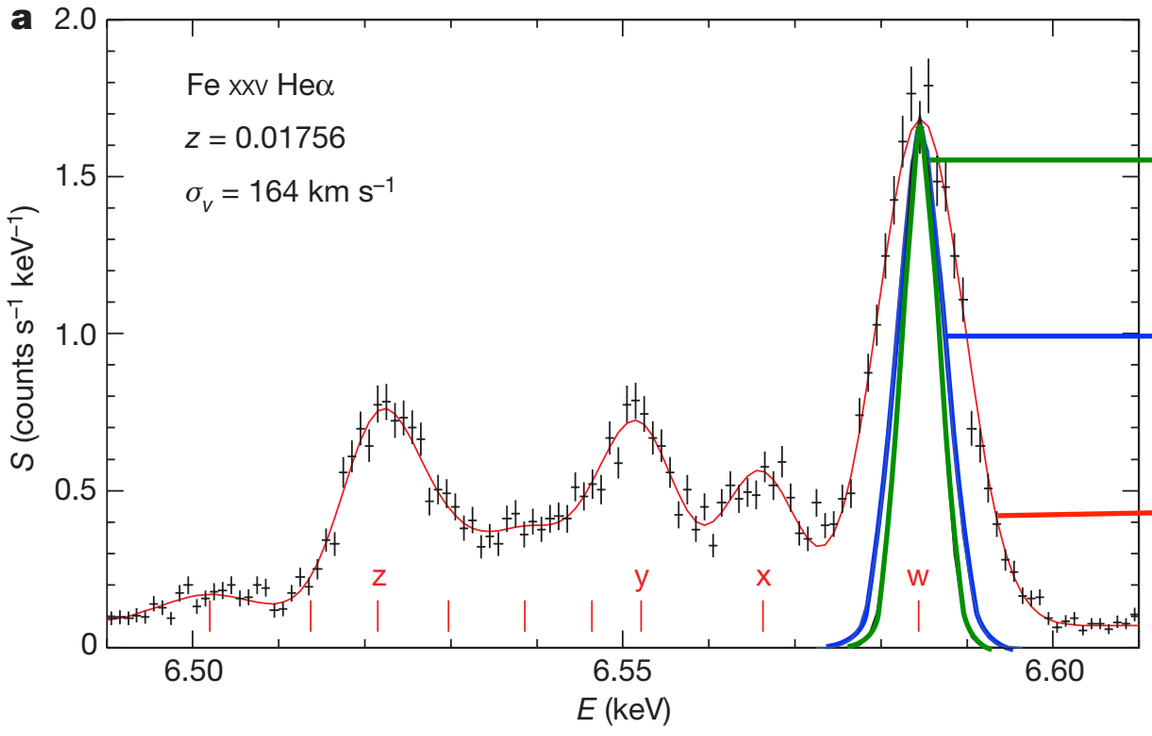
In-orbit operation of Hitomi



Spectrum of the Perseus cluster with SXS



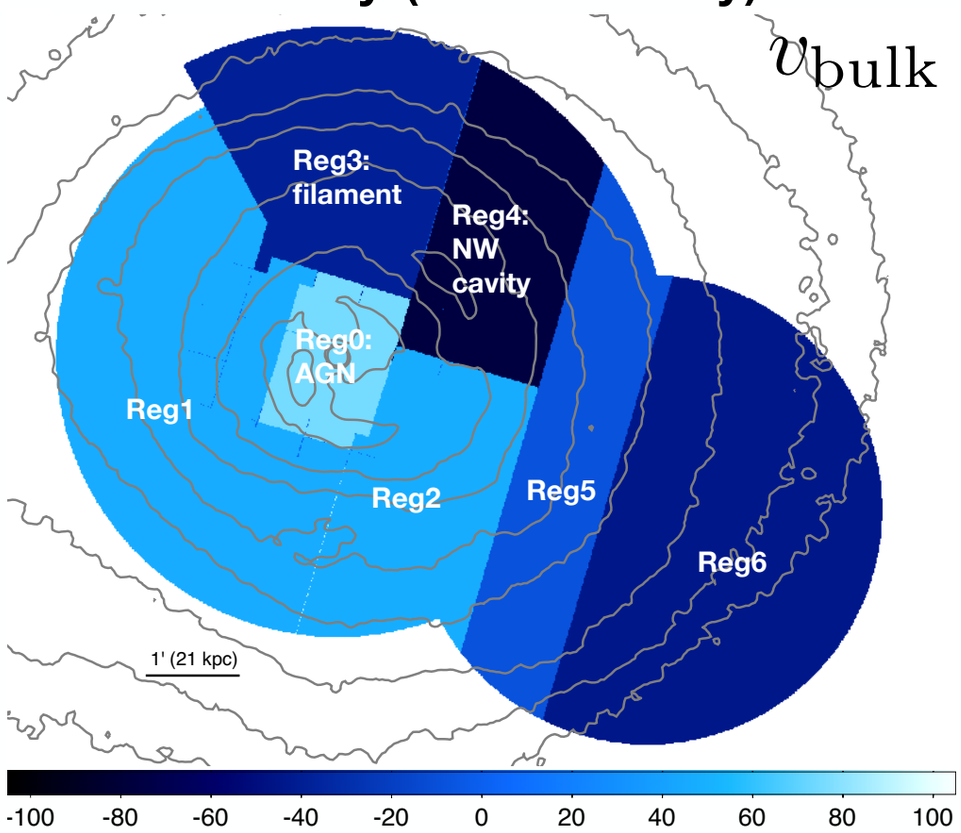
Velocity Measurement of ICM

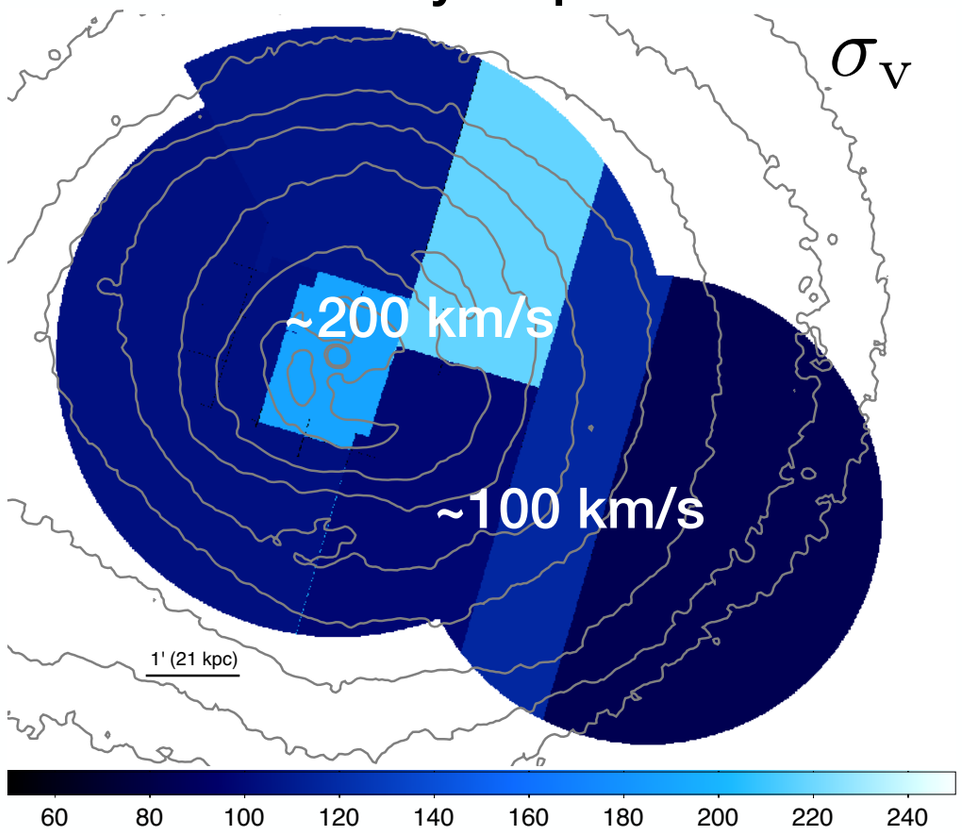


Instrumental resolution ~ 5eV

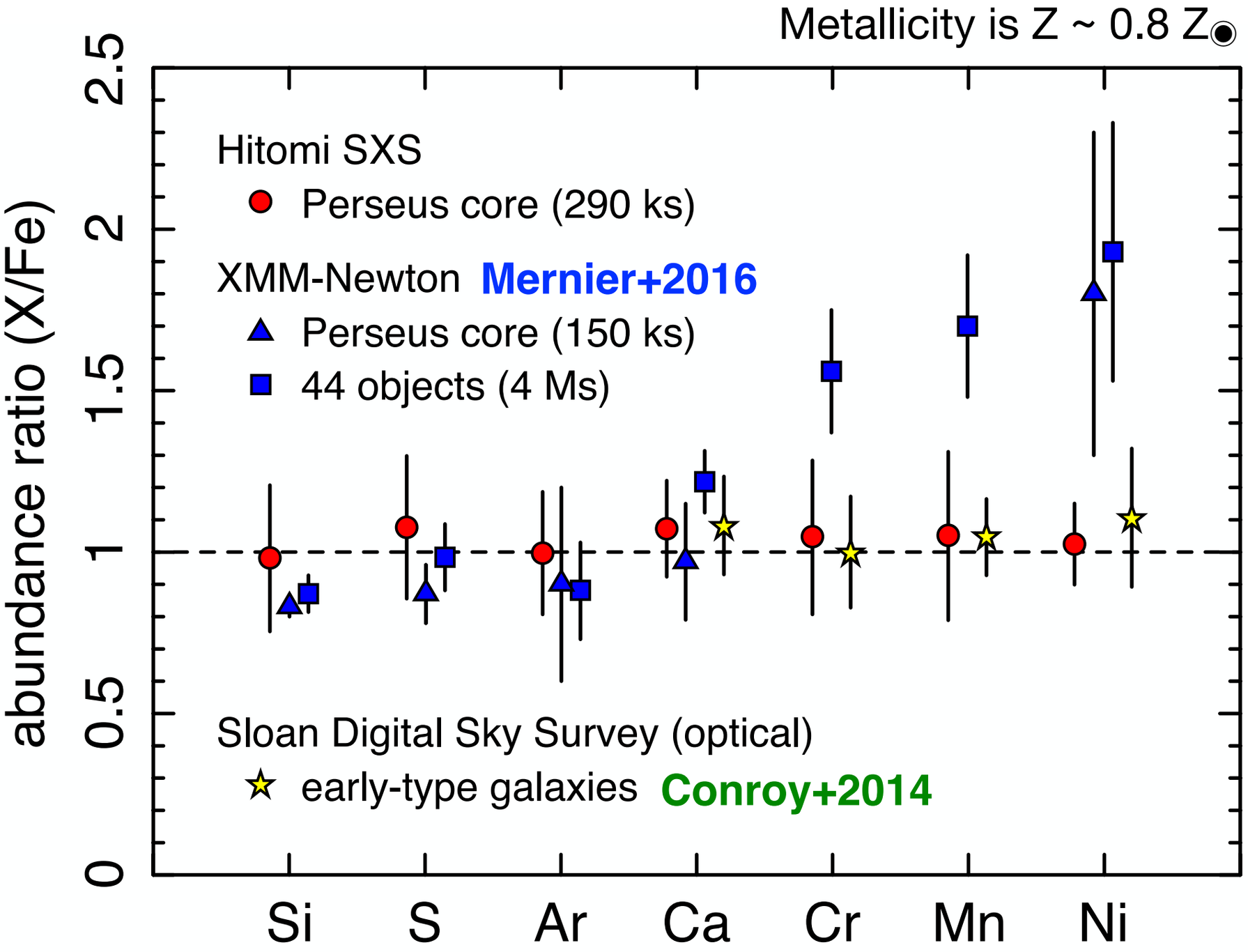
Thermal broadening ~ 1eV ~ 80 km/s

Observed broadening ~ 4 eV ~ 160 km/s



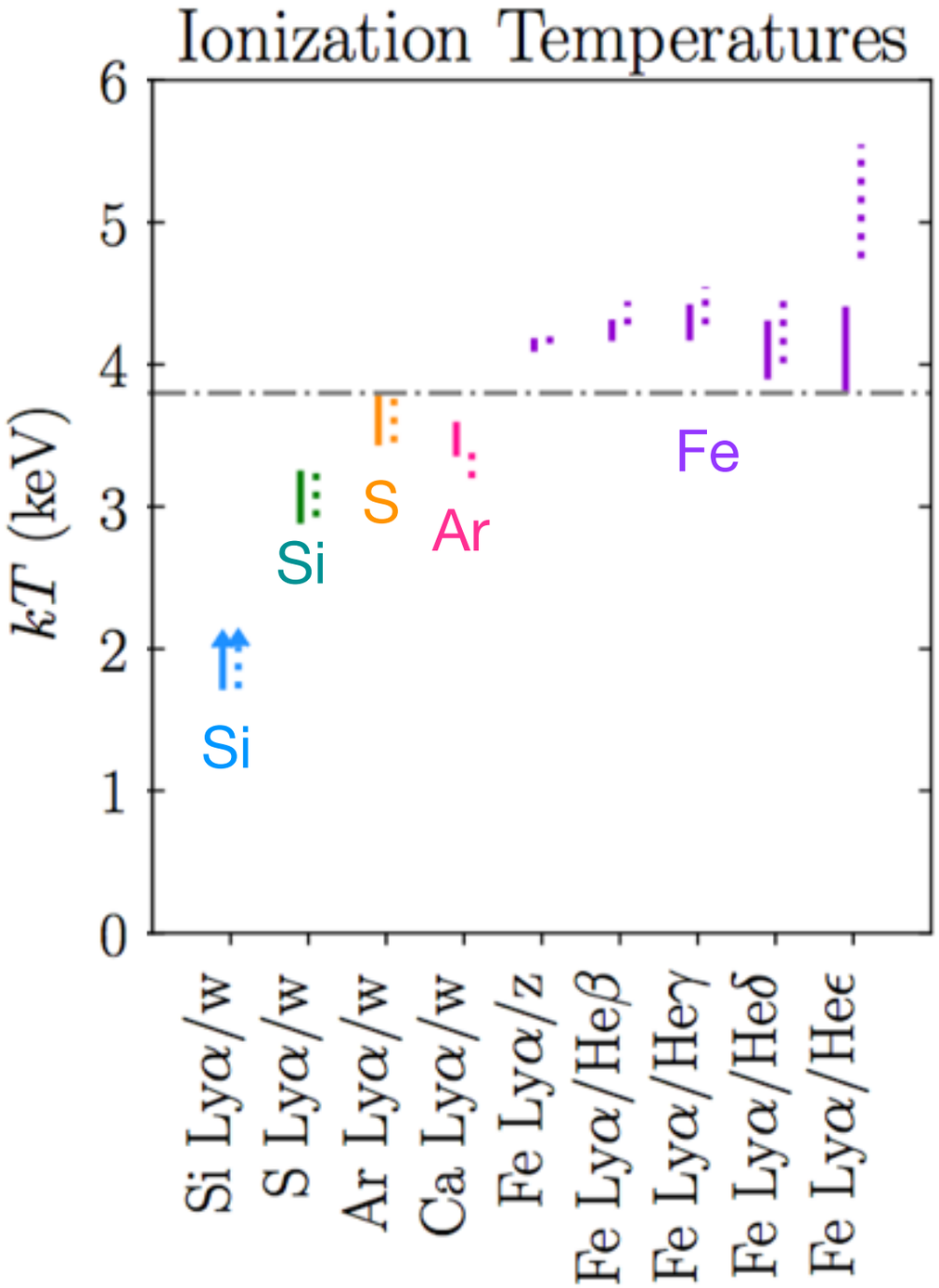


Metal Abundances in ICM

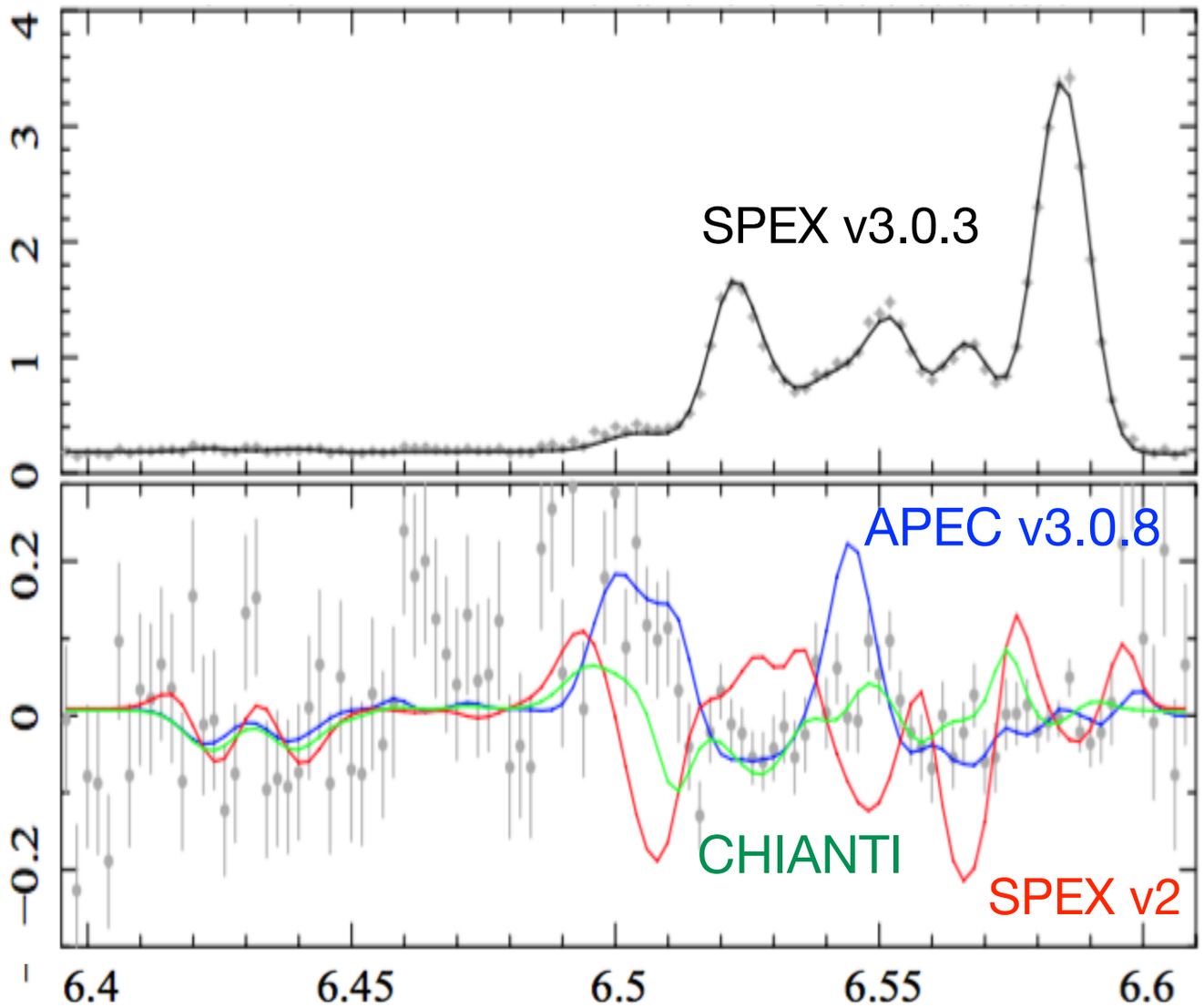


Abundance pattern is surprisingly consistent with the solar one!

Temperature Measurement & Plasma code



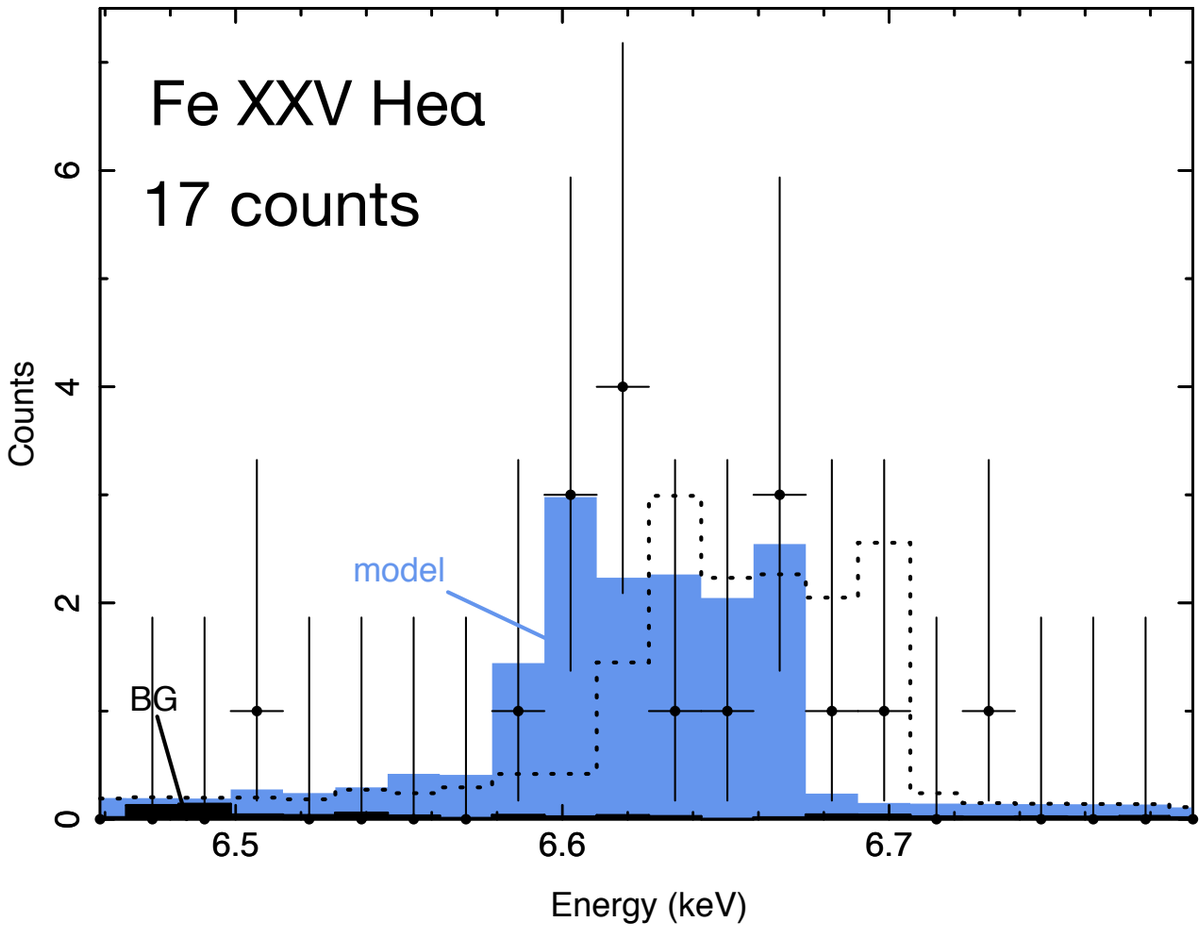
Temperature measurements w/ line ratios
=> consistent with the projection effect



Update of the SPEX and APEC
Comparison between the plasma codes

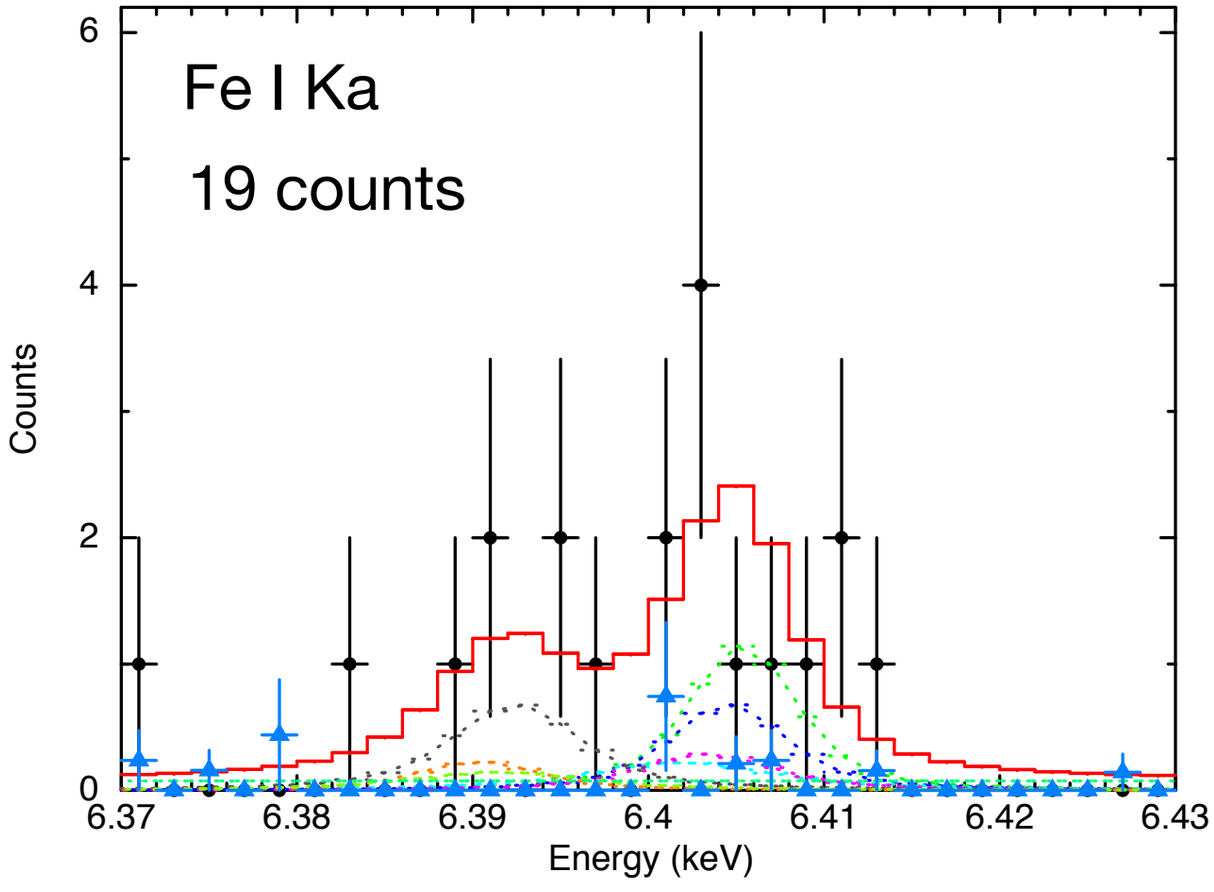
Results from Other Targets

N132 (SNR in LMC)



$V_{bulk} = 800^{+700}_{-750}$ km/s

IGR J16318-4848 (HMXB)



E = 6405.4 ± 2.5 eV

$V_{sigma} = 160^{+300}_{-70}$ km/s

Obtained significant constraints even at very low photon statistics!

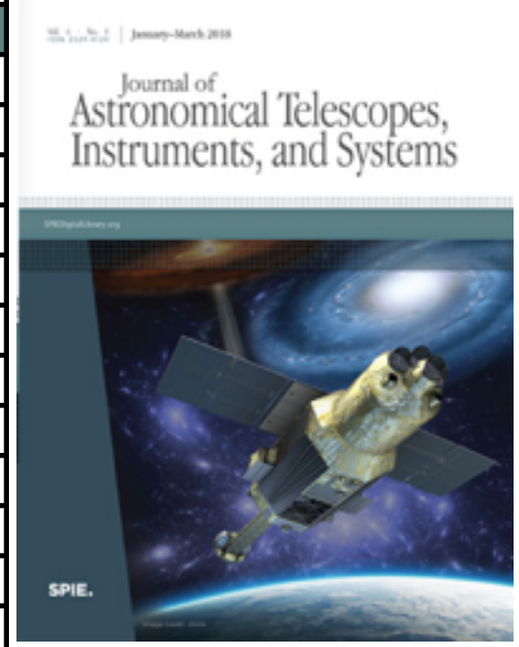
Published Scientific Papers

Perseus cluster		
The Queiscent Medium in the Core of the Perseus Cluster	A. Fabian	Nature
Hitomi constraints on the 3.5 keV line in the Perseus galaxy cluster	M. Markevitch	ApJL
Solar abundance ratios of the iron-peak elements in the Perseus cluster	H. Yamaguchi	Nature
Measurements of resonant scattering in the Perseus cluster core with Hitomi SXS	K. Sato	PASJ
Atmospheric gas dynamics in the Perseus cluster observed with Hitomi	Y. Ichinohe	PASJ
Temperature Structure in the Perseus Cluster Core Observed with Hitomi	S. Nakashima	PASJ
Hitomi Observation of Radio Galaxy NGC 1275: The First X-ray Microcalorimeter Spectroscopy of Fe-Kα Line Emission from an Active Galactic Nucleus	H. Noda	PASJ
Atomic data and spectral modeling constraints from high-resolution X-ray observations of the Perseus cluster with Hitomi	M. Sawada	PASJ
N132D		
Hitomi Observations of the LMC SNR N132D: Highly Redshifted X-ray Emission from Iron Ejecta	E. Miller	PASJ
IGR J16318-4848		
Glimpse of the highly obscured HMXB IGR J16318–4848 with Hitomi	H. Nakajima	PASJ
G21.5-0.9		
Hitomi X-ray Observation of the Pulsar Wind Nebula G21.5-0.9	H. Uchiyama	PASJ
Crab		
Search for Thermal X-ray Features from the Crab nebula with Hitomi Soft X-ray Spectrometer	M. Tsujimoto	PASJ
Hitomi X-ray studies of Giant Radio Pulses from the Crab pulsar	Y. Terada	PASJ

13 papers/
1 month obs. !

Published Instrument Papers

Mission		
The Hitomi (ASTRO-H) x-ray astronomy satellite	T. Takahashi	JATIS
Soft X-ray Spectrometer		
Thermal analyses for initial operations of the soft x-ray spectrometer onboard the Hitomi satellite	H. Noda	JATIS
Porous plug phase separator and superfluid film flow suppression system for the soft x-ray spectrometer	Y. Ezoe	JATIS
Calibration sources and filters of the soft x-ray spectrometer instrument on the Hitomi spacecraft	Cor P. de Vries	JATIS
In-orbit operation of the soft x-ray spectrometer onboard the Hitomi satellite	M. Tsujimoto	JATIS
Performance of the helium dewar and the cryocoolers of the Hitomi soft x-ray spectrometer	R. Fijimoto	JATIS
Design, implementation, and performance of the Astro-H SXS calorimeter array and anticoincidence detector	C. Kilbourne	JATIS
Design, implementation, and performance of the Astro-H soft x-ray spectrometer aperture	C. Kilbourne	JATIS
Vibration isolation system for cryocoolers of soft x-ray spectrometer on-board ASTRO-H (Hitomi)	Y. Takei	JATIS
In-flight performance of pulse-processing system of the ASTRO-H/Hitomi soft x-ray spectrometer	Y. Ishisaki	PASJ
In-flight performance of the soft x-ray spectrometer detector system on Astro-H	F. S. Porter	PASJ
In-flight calibration of Hitomi Soft X-ray Spectrometer. (1) Background	C. Kilbourne	PASJ
In-flight calibration of the Hitomi Soft X-ray Spectrometer. (2) Point spread function	Y. Maeda	PASJ
In-flight calibration of Hitomi Soft X-ray Spectrometer. (3) Effective area	M. Tsujimoto	PASJ
Soft X-ray Imager		
Soft X-ray Imager aboard Hitomi (ASTRO-H)	T. Tanaka	JATIS
In-orbit performance of the soft X-ray imaging system aboard Hitomi (ASTRO-H)	H. Nakajima	PASJ
Telescopes		
Ground-based x-ray calibration of the Astro-H/Hitomi soft x-ray telescopes	R. Iizuka	JATIS
Supermirror design for Hard X-Ray Telescopes on-board Hitomi (ASTRO-H)	K. Tamura	JATIS
On-ground calibration of the Hitomi Hard X-ray Telescopes	H. Mori	JATIS
In orbit performance of the Hard X-ray Telescope (HXT) on board the Hitomi (ASTRO-H) satellite	H. Matsumoto	JATIS
Hard X-ray Imager		
The hard x-ray imager onboard Hitomi (ASTRO-H)	K. Nakazawa	JATIS
In-orbit performance and calibration of the hard x-ray imager onboard Hitomi (ASTRO-H)	K. Hagino	JATIS
Soft Gamma-ray Detector		
Design and performance of Soft Gamma-ray Detector onboard the Hitomi (ASTRO-H) satellite	H. Tajima	JATIS
Others		
In-flight performance of the Canadian Astro-H Metrology System	L. Galo	JATIS
Time assignment system and its performance aboard the Hitomi satellite	Y. Terada	JATIS
Astro-H/Hitomi data analysis, processing, and archive	L. Angelini	JATIS



26 papers
JATIS and PASJ

Challenge again with

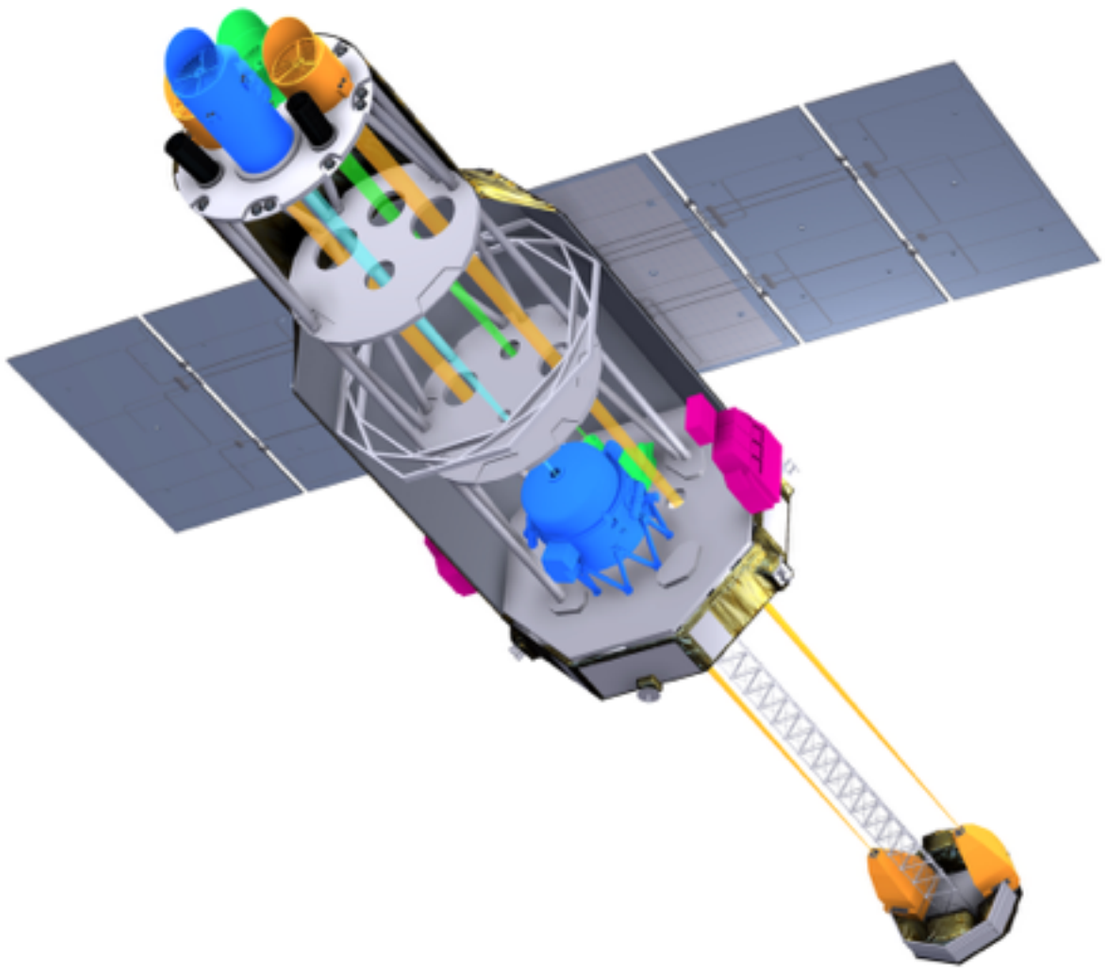
X-ray Astronomy Recovery Mission (XARM)

Scientific Objectives of XARM

- **“Structure formation of the Universe and evolution of clusters of galaxies”**
  - Bulk and turbulence motion in the ICM
- **“Circulation history of baryonic matters in the Universe”**
  - Metal abundances in the ICM and SNRs
  - Bulk motions in SNRs
- **“Transport and circulation of energy in the Universe”**
  - Properties of AGN tours
  - Velocity of AGN winds
- **“New science with unprecedented high resolution X-ray spectroscopy”**
  - Observe 100 typical targets per year

Mission Concept

Hitomi

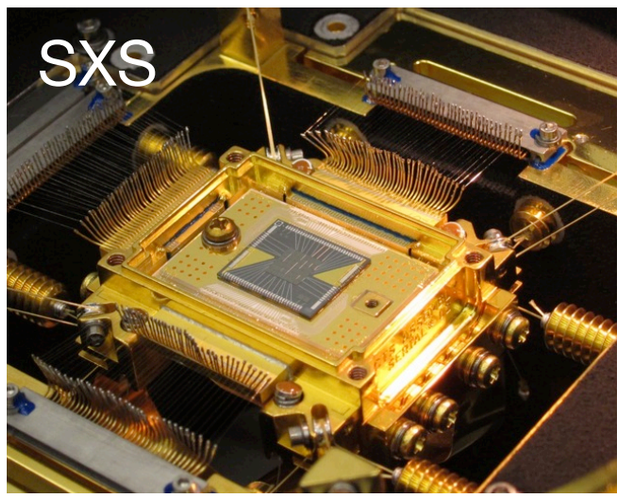


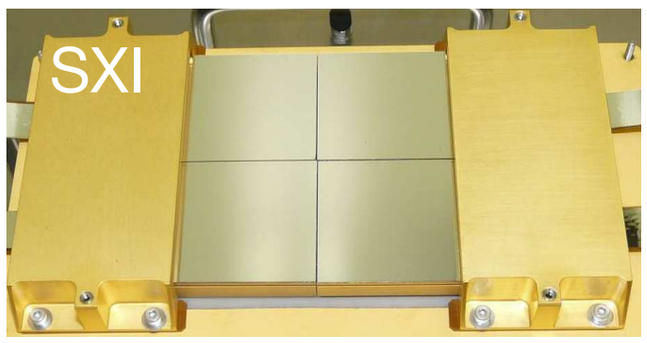
XARM

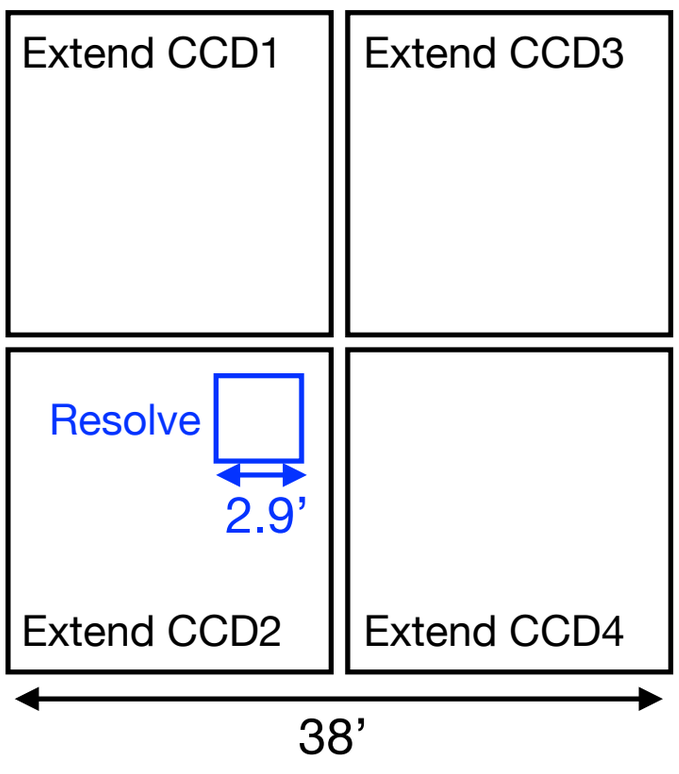
Almost same as Hitomi but w/o HXI & SGD

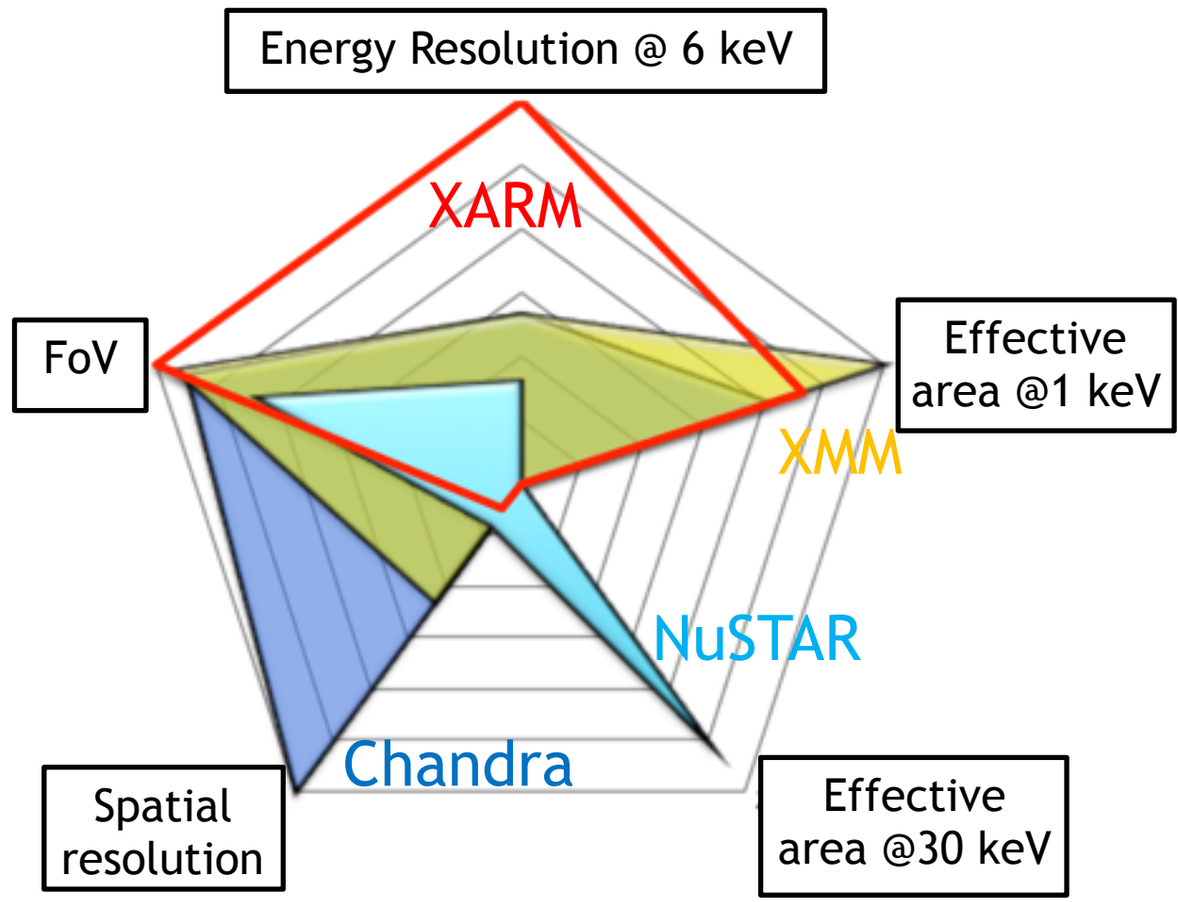
Mission Instruments

Instrument	FoV/pix	ΔE (FWHM @6 keV)	Energy band
SXS => Resolve (microcalorimeter)	2.9’ x 2.9’ / 6 x 6 pix	7 eV (goal 5 eV)	0.3 – 12 keV
SXI => Extend (CCD)	38’ x 38’ / 1280 x 1280 pix	< 250 eV at EoL (< 200 eV at BoL)	0.4 – 13 keV









International Collaboration

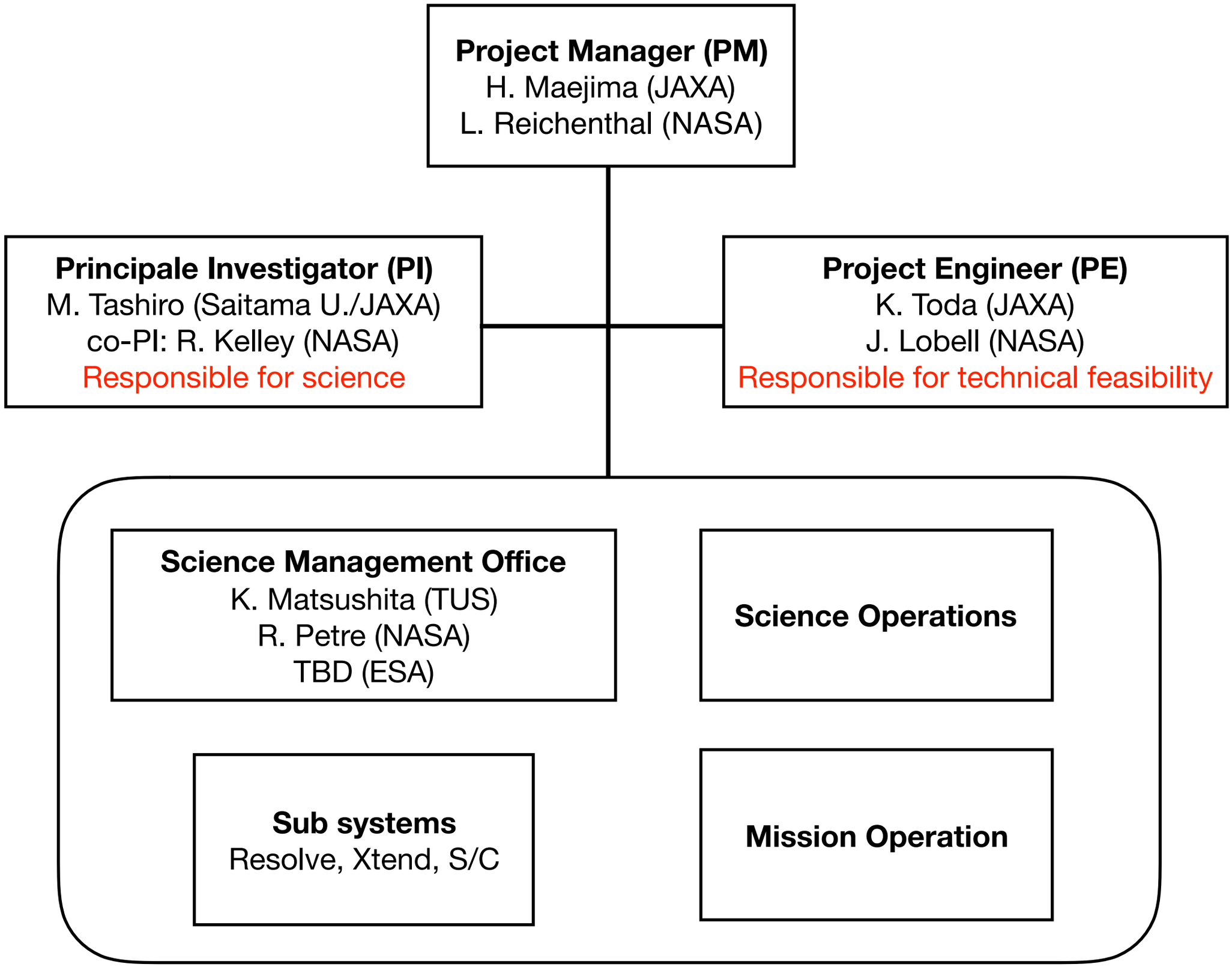
JAXA/NASA collaborative mission with ESA participants

Resolve (detector + mirror)
Xtend (mirror)
Data center

Space craft and Launcher
Resolve (cooling system)
Xtend (detector)
Operation

Resolve (filter wheel, LHP)

Team Structure



Schedule & Current Status

- JAXA MDR/SRR
- JAXA pre-project start / NASA project start
- NASA CDR

- JAXA SDR (now!)
- To be the XARM project

GO Program

2021 **Launch & PV**

2020 **Fabrication & Verification**

2019 **Detailed design phase**

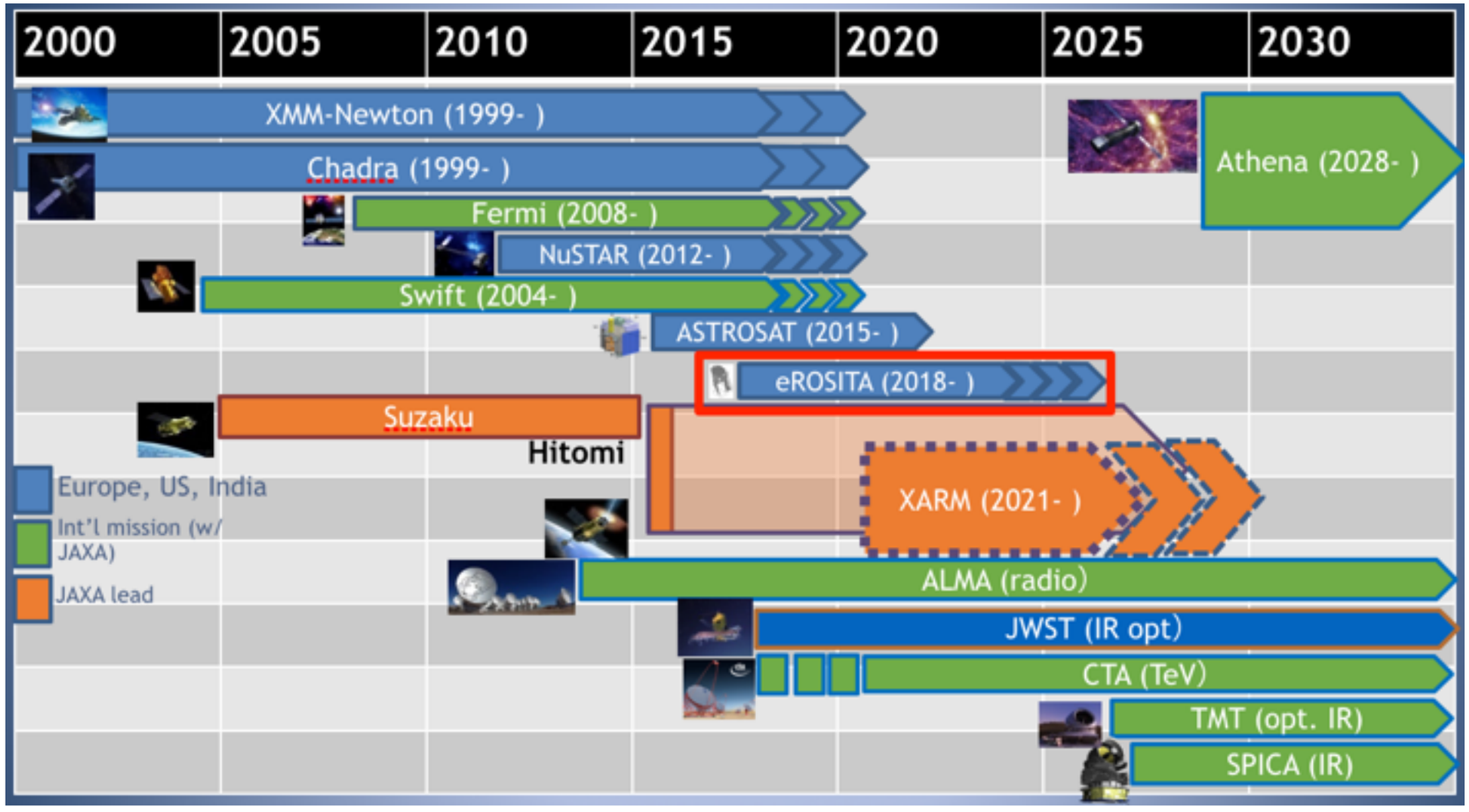
2018 **Basic design phase**

2017

2016

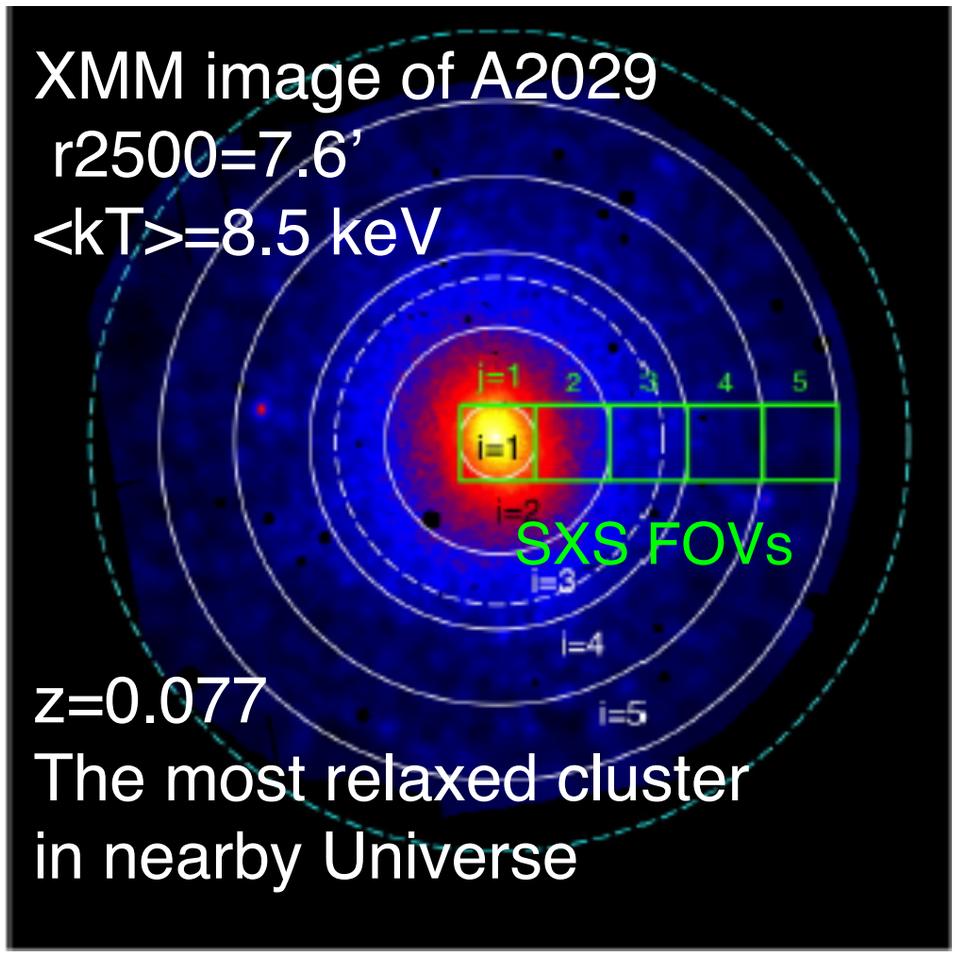
Hitomi Failure

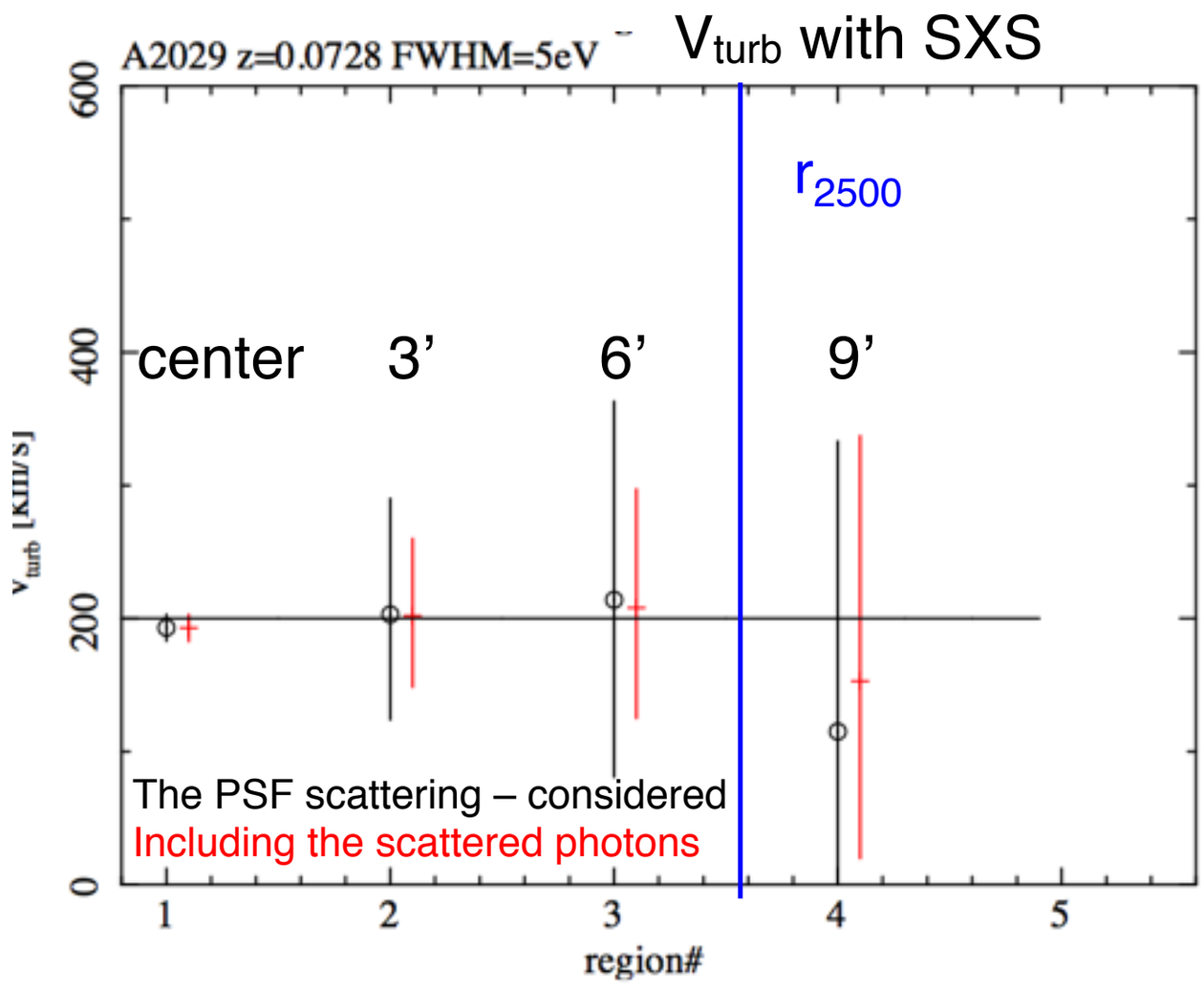
- Investigate Hitomi failure
- Summarize Hitomi LL
- XARM proposal as JAXA-NASA collaboration



Synergy with eROSITA

Precise mass estimation is necessary for cluster cosmology
=> Calibration of non-thermal pressure by XARM





Gas dynamics of relaxed clusters out to r2500

Summary

- Hitomi (ASTRO-H) observatory was lost only 1 month after the launch, but demonstrated the power of high resolution spectroscopy with microcalorimeter.
- X-ray Astronomy Recovery Mission (XARM) is ongoing as the JAXA-NASA collaboration with ESA participants.
- XARM has the micorcalorimeter (Resolve) and the CCD detector (Xtend), but no Hard X-ray Imager and Soft Gamma-ray Detector.
- XARM are going to be launched on 2021.
- Collaboration with eROSITA will be fruitful.