The XARM mission status and Science operations plan

Y. Terada (Saitama U.; XARM Science Operations lead),

M. Tashiro (XARM PI),

M. Tsujimoto (XARM Resolve calibration),

M. Nobukawa (XARM Xtend calibration), K. Mori (XARM Xtend PE), and XARM pre-project team

XARM is the recovery mission of Hitomi

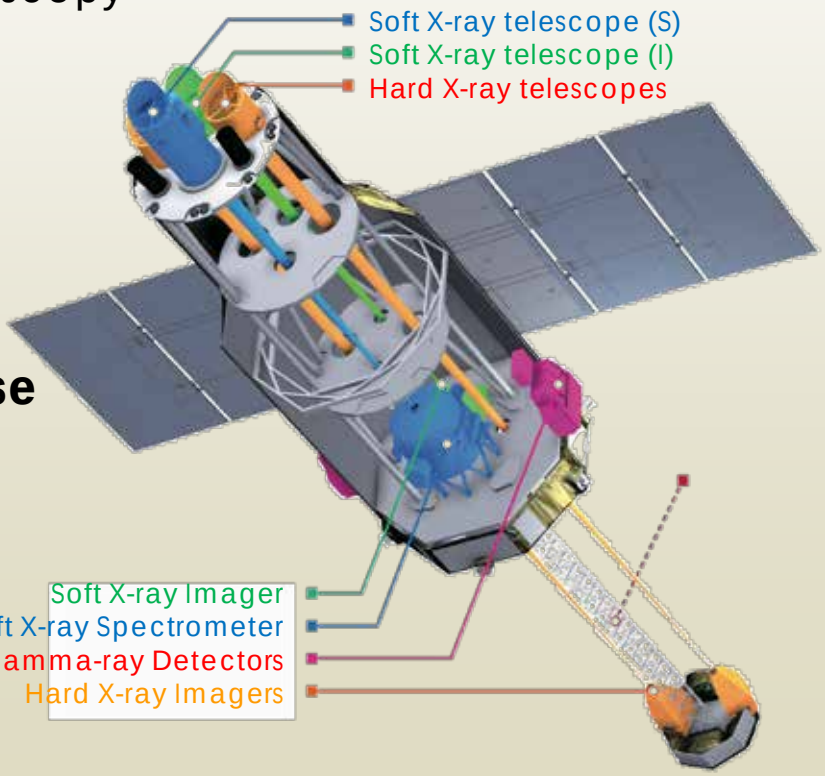
ASTRO-H/Hitomi Mission

- X-ray observation in 0.3 ~ 600 keV
  - ü High resolution spectroscopy
  - ü Wide FOV Imaging
  - ü Hard X-ray Imaging spectroscopy
  - ü Super sentive gamma-ray spectroscopy
- 2003 NeXT project
- 2005~ ASTRO-H mission
- 2016.2.17 Launch
- 2016.3.26 lost communication
- 2016.4.28 Operation terminated

Objects observed during check-out phase

- Perseus Cluster of galaxies
- N132D
- IGR J16318-4848
- RX J1856.5-3754
- G21.5-0.9
- Crab

(so call, IACHEC objects!!)



Scientific Outputs from Hitomi mission

11 papers

Perseus Cluster			
The Quiescent Intracluster Medium in the Core of the Perseus Cluster	A.Fabian	Nature	2016 July
Hitomi constraints on the 3.5 keV line in the Perseus galaxy cluster	M. Markevitch	ApJL	2016 July
Solar abundance ratios of the iron-peak elements in the Perseus cluster	H.Yamaguchi	Nature	2017 Nov
Measurements of resonant scattering in the Perseus cluster core with Hitomi SXS	K.Sato	PASJ	1710.04648
Atmospheric gas dynamics in the Perseus cluster observed with Hitomi	Y.Ichinohe	PASJ	1711.00240
NGC1275			
Hitomi Observation of Radio Galaxy NGC 1275: The First X-ray Microcalorimeter Spectroscopy of Fe-K{alpha} Line Emission from an Active Galactic Nucleus	H.Noda	PASJ	1711.06289
N132D			
Hitomi Observations of the LMC SNR N132D: Highly Redshifted X-ray Emission from Iron Ejecta	E.Miller	PASJ	1712.02365
RXJ1856-3754			
(calibration paper only)	--	--	--
IGR J16318-4848			
Glimpse of the highly obscured HMXB IGR J16318–4848 with Hitomi	H.Nakajima	PASJ	1711.07727
G21.5-0.9			
Hitomi X-ray Observation of the Pulsar Wind Nebula G21.5$-$0.9	H.Uchida	PASJ	1802.05068
Crab			
Search for Thermal X-ray Features from the Crab nebula with Hitomi Soft X-ray Spectrometer	M.Tsujimoto	PASJ	1707.00054
Hitomi X-ray studies of Giant Radio Pulses from the Crab pulsar	Y.Terada	PASJ	1707.08801

PASJ Hitomi Special Coming soon.

Instruments papers

	Title	Author	Special Issue
AH	The Hitomi (ASTRO-H) x-ray astronomy satellite	T. Takahashi	JATIS
SXS	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 onboard Hitomi	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. Fujimoto	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 assembly and blocking filters	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	JATIS
★	In-flight performance of the soft x-ray spectrometer detector system on Astro-H	F. S. Porter	JATIS
★	In-flight calibration of Hitomi Soft X-ray Spectrometer. (1) Background	C. A. 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
SXI	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
SXT ★	Ground-based x-ray calibration of the Astro-H/Hitomi soft x-ray telescopes	R. Iizuka	JATIS

★ Calibration, performance

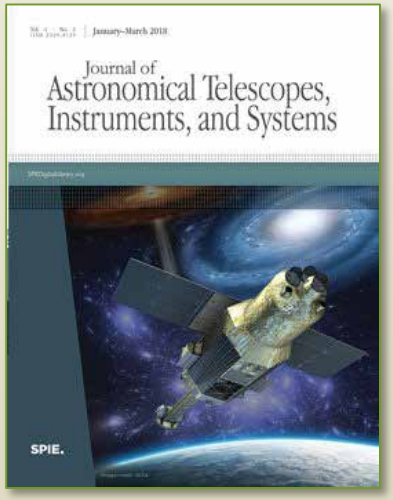
Continue.

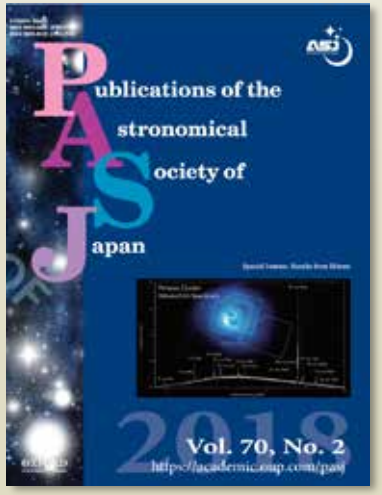
Instruments papers (cont.)

	Title	Author	Special Issue
HXI	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
HXT	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
CAMS	In-flight performance of the Canadian Astro-H Metrology System	L. Gallo et al.	JATIS
SGD ★	Design and performance of Soft Gamma-ray Detector onboard the Hitomi (ASTRO-H) satellite	H. Tajima	JATIS
Time ★	Time assignment system and its performance aboard the Hitomi satellite	Y. Terada	JATIS
Soft ★	Astro-H/Hitomi data analysis, processing, and archive	L. Angelini	JATIS

★ Calibration, performance

26 papers

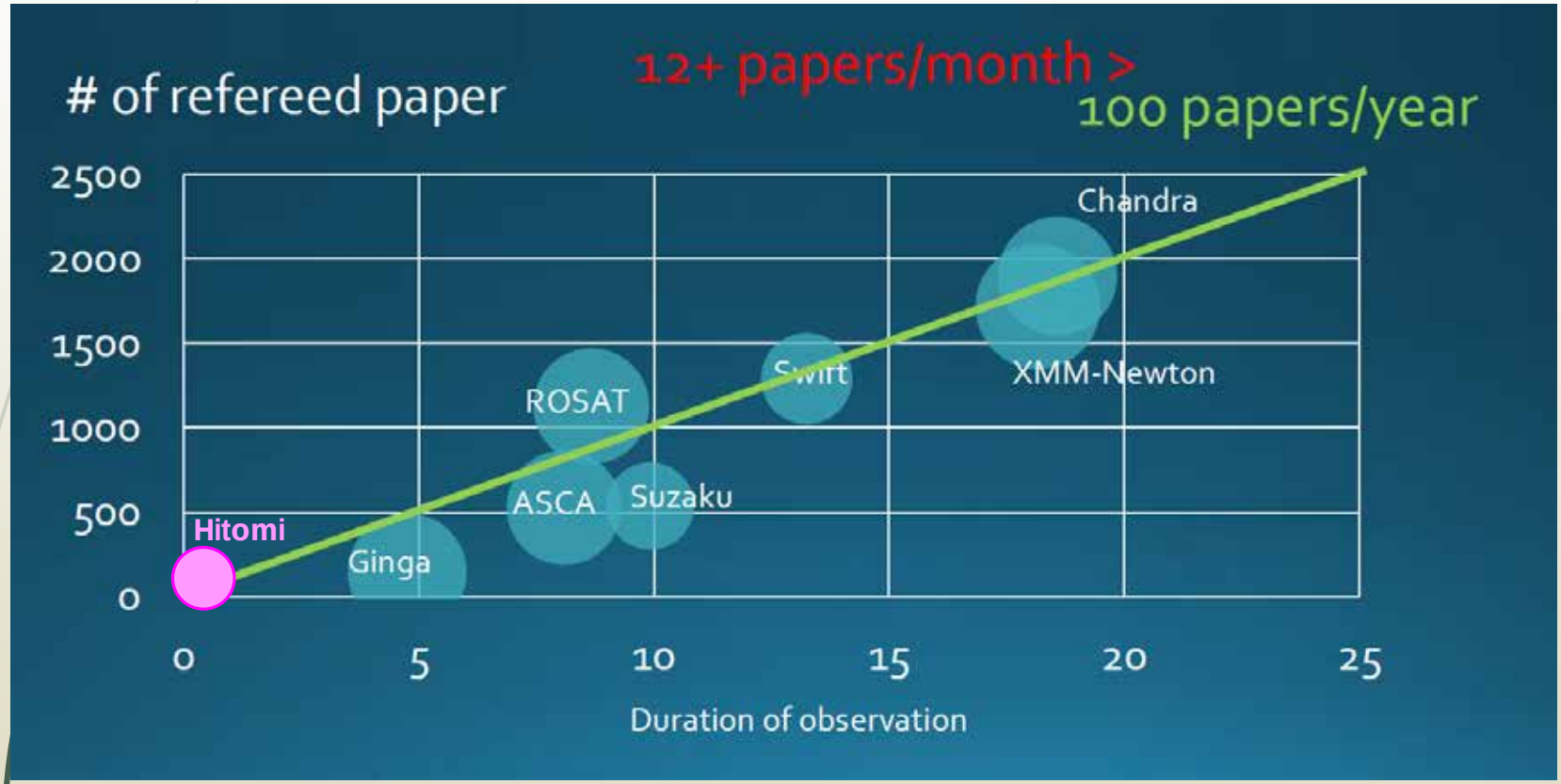




JATIS Hitomi Special On-line!

Paper Productivity

© M.Tashiro, (from HEAPA meeting 2018)

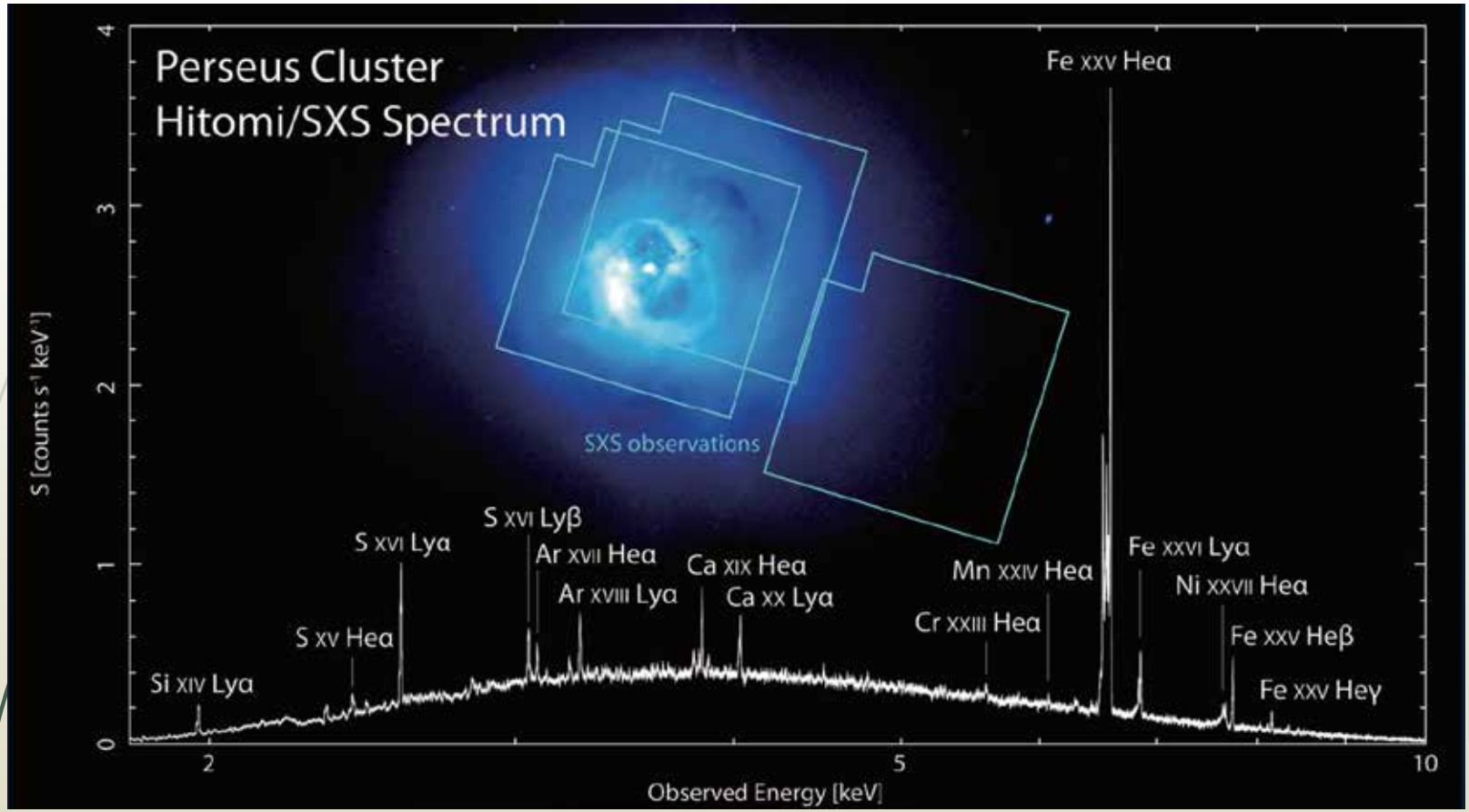


Hitomi after launch:

11 science papers / 1 month (operation) ~ 130 paper/year

Keeping this rate is grate!

Just we want to see ...



Challenge again,

X-ray Astronomy Recovery Mission (*XARM*)

(& to be a Pilot mission for ***Athena***)

XARM Instruments

Instrument	FOV/pix	ΔE (FWHM @6 keV)	Energy band
Resolve (XMA + X-ray micro calorimeter)	2.9′ □ / 6 x 6 pix	7 eV (goal 5 eV)	0.3 – 12 keV
Xtend (XMA + X-ray CCD)	38′ □/ 1280 x 1280 pix	< 250 eV at EOL (< 200 eV at BOL)	0.4 – 13 keV

Basically the same instruments as Hitomi,
but **no hard X-ray and soft gamma-ray instruments**.

XARM Mission status

JAXA PDR (during current IACHEC; now)
To be the XARM Project.

JAXA MDR/SRR (during last IACHEC)
JAXA pre-project start / NASA project start
NASA CDR
feasibility study & establish team structure
bus company RFP etc..

Hitomi Lessons
XARM proposal
JAXA-NASA collaboration

2016
Hitomi Failure
Investigation
Lessons & Close
XARM Proposal
NASA-JAXA
2017
2018
now
2019
Basic design
Detail design
Fabrication
Verifications & GND Calibration
2020s'
Launch & PV
GO Program
Next IACHEC in Japan

XARM team Japan kick off meeting on Dec. 26, 2017

Team structure & Science Outputs

Team Structure

- Project management by PM, PI, PE
- Sub-systems:
  - Resolve team, Xtend team (**Instrument teams**)
  - Bus system, GND system, and Mission Operation team (MOT)
  - **Science Operations team** (SOT) + Science Management Office

Next slide

Notes on Calibration activity

- Responsibilities of calibration activities are on instrument teams.
- SOT supports the calibration activity by instrument team(s);
  - Review of calibration requirement and recommendation
  - Support actual ground measurements
  - Management of in-orbit calibration plan & execution.

Science Management Office

- Mission PI/co-PI + Instrument PI + science category leads
- "XARM Participating Scientists" selected by agencies (NASA/JAXA/ESA)
- *PV-phase Collaborating-Scientists-Program is planed.*

Science Operations Team

Goal

- Enhance science outputs, supporting science operations by PI.
- Non volunteer base, well defined tasks until the end of mission.

Scopes in 4 categories

- Data & software:
  - Daily operations of planning of scientific objects, telemetry monitoring, pipeline processing and archive
- Instruments & performance:
  - Support calibration activities by instrument teams, management of in-orbit calibration plan & execution
  - Performance enhancement studies,
    - Systematic studies of behaver of instrument to have better analyses tools/methods required for scientific analyses
    - Simulation studies & behavior studies of instruments etc.
    - (instrumental studies what you in this room are doing now.)
- GO : User support
  - Proposal support/Operation support/Analyses support
  - Education of young astronomers, etc

Performance/calibration requirement

- **XARM Scientific Objectives**
  1. Structure formation of the Universe and evolution of clusters
  2. Circulation history of baryonic matters in the Universe
  3. Transport and circulation of energy in the Universe
  4. New science with unprecedented high resolution X-ray spectroscopy

Flow down

- **Mission Requirements + Success criteria**

Flow down

- **Design of Spacecraft and Instruments**
  - ü Design parameters of Resolve/Xtend
  - ü Calibration requirements

High resolution X-ray spectrometer									X-ray imaging spectrometer						
Angular resolution HPD ≦ 1.7 arcmin	Effective area ≧ 210 cm² @ 6 keV ≧ 160 cm² @ 1 keV	Field of view ≧ 2.9 arcmin×2.9 arcmin	Energy range of spectroscopy 0.3 - 12 keV	Absolute energy scale ≦ 2 eV	Energy resolution ≦ 7 eV FWHM @ 6 keV	Non X-ray background ≦ 2×10^{-3} c/s/keV/array	Highest photon rate per array to handle ≧ 150 c/s/array	Absolute time tagging accuracy ≦ 1 ms	Angular resolution HPD ≦ 1.7 arcmin pixel size ≦ 100 μm	Effective area ≧ 300 cm² @ 6 keV	Energy range of spectroscopy 0.4 - 13 keV	Field of view ≧ 30 arcmin×30 arcmin	Energy resolution ≦ 250 eV FWHM @ 6 keV	Non X-ray background ≦ 1×10^{-4} c/s/keV/arcmin²/cm² (continuum component at 5 – 10 keV)	assets

Flow down

- **Development Plan, Operation plan, and Calibration plan etc…**

Resolve Calibration Plan

Hitomi SXS Calibration results

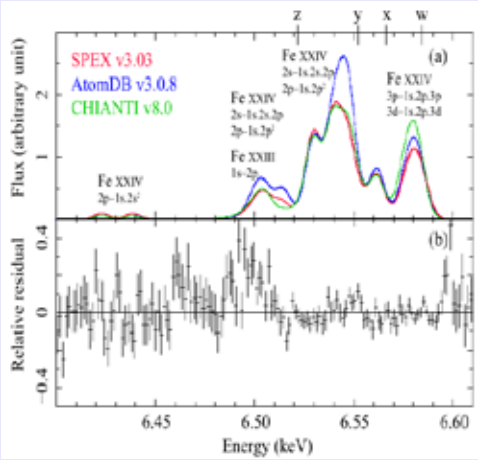
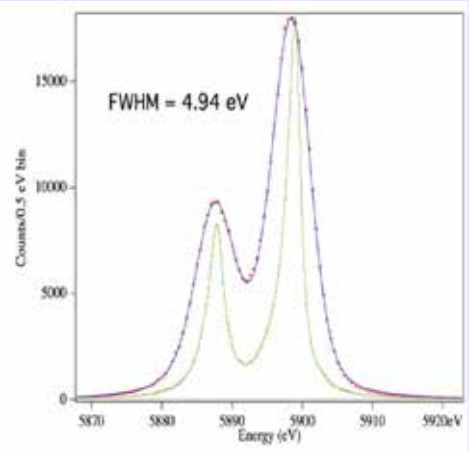
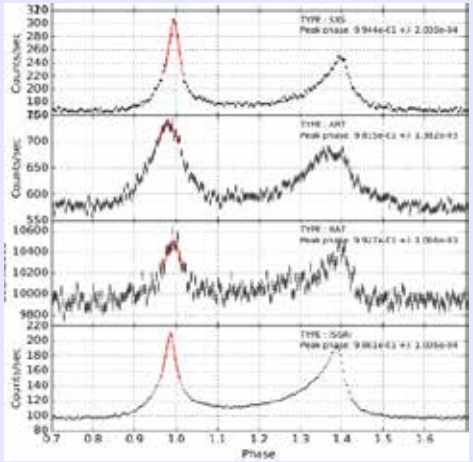
1. "Ground calibration of the Astro-H (Hitomi) soft x-ray spectrometer", Eckart+, 2018, JATIS, in press
2. "In-flight verification of the calibration and performance of the ASTRO-H (Hitomi) Soft X-ray Spectrometer", Leutenegger+, 2018, JATIS, in press
3. "In-flight Calibration of Hitomi Soft X-ray Spectrometer (1) Background", Kilbourne+, 2018, PASJ, in press
4. "In-flight Calibration of Hitomi Soft X-ray Spectrometer (2) PSF", Maeda+, 2018, PASJ, in press
5. "In-flight Calibration of Hitomi Soft X-ray Spectrometer (3) Effective Area", Tsujimoto+, 2018, PASJ, in press
6. "Atomic data and spectral modeling constraints from high-resolution X-ray observations of the Perseus cluster with Hitomi", Hitomi collaboration, 2018, PASJ, in press
7. "The Time Assignment System and Its Performance aboard the Hitomi Satellite", Terada+, 2018, PASJ, in press

Some more in prep. Very useful for future X-ray u-cal in-flight cal.

We appreciate IACHEC colleagues for timing cross-cal campaign and your calibration results (we cited many of your work!).

Resolve Calibration Plan

Hitomi SXS In-flight calibration Highlights

Cal item	Gain	ΔE	Abs timing
			
Data	Perseus	Onbaord ^{55}Fe	Crab
Req	< 2 eV	< 1 eV	< 10 ms
Achieved	< 2 eV	<< 1 eV(TBC)	~ 100 us
Ref	[6]	[2]	[2,7]

©M.Tsujimoto, and Resolve Team

Resolve Calibration Plan

XARM Resolve Calibration Plan

- Basically the same with SXS with some refinements based on SXS.
  - Gate valve will be calibrated similarly to other flight components: In SXS, GV planned to be opened before PV, but all science obs made before that, leaving the largest uncertainty.
  - Timing cal req'ed and planned better. micro-calorimeter is also good at timing.
  - Unified & Int'l team of detector, mirror, and MXS. They were separate in SXS. After all, cal can only be complete by evaluating end-to-end.
  - Better coordination with ray-tracing, plasma code groups. We found that they are the ultimate limit for some calibration items.
- Status
  - Cal requirements … Issued.
  - Cal plan (on ground) ⋯ issued & being executed. Some results ready by the next IACHEC meeting.
  - Cal plan (in orbit) ⋯ to be documented. Looking forward to discussing with IACHEC colleagues for cross-cal.

Xtend Calibration Plan

- On-ground

XMA calibration plan is included in Resolve.

Items	
Selection of FM CCDs	four CCD chips
Operation parameters	Microcode, bias voltage, ASIC gain, threshold, etc
Calibration parameters	Charge transfer efficiency, gain, energy resolution, etc
Performance Dependency on Radiation damage	Demonstration of radiation tolerance with proton radiation experiments

  - CALDB files for the initial phase in orbit will be prepared before launch.

- In-orbit (steady operation)
  - Calibration data will be taken from Fe-55 (5.9 keV line) and celestial objects (E0102-72, RX J1856, Perseus, TBD).
  - Regularly update CALDB files.

Thank you

Please come to Japan in the 14th IACHEC in 2019!

Voting for the date is on going.