XRISM: The X-Ray Imaging and Spectroscopy Mission

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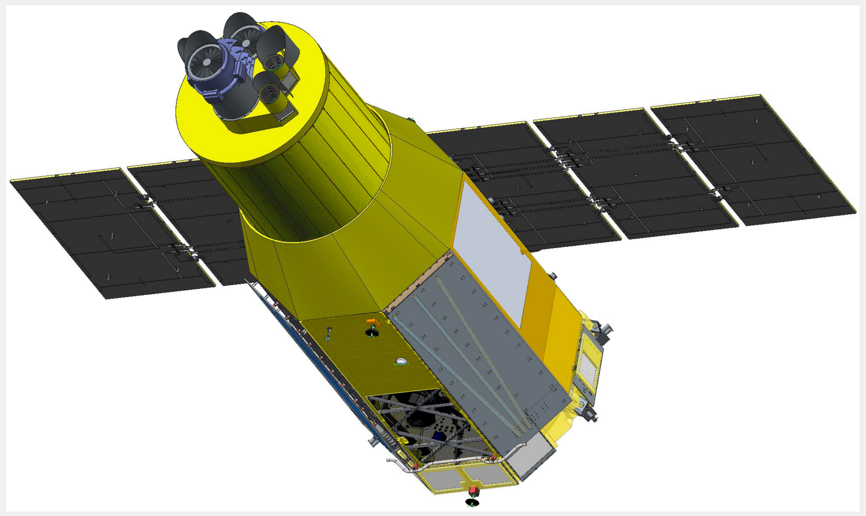
XRISM
X-RAY IMAGING AND SPECTROSCOPY MISSION

Executive Summary



XRISM (pronounced "krizz-em"), formerly the X-ray Astronomy Recovery Mission (XARM), is a JAXA/NASA collaborative mission with ESA participation. The objective of the mission is to investigate celestial X-ray objects in the Universe with high-throughput imaging and high-resolution spectroscopy. XRISM is expected to launch *in early 2022* on a JAXA H-IIA rocket.

The XRISM payload consists of two instruments:

Resolve: a soft X-ray spectrometer; designed to provide non-dispersive high-resolution X-ray spectroscopy. While the gratings on Chandra and XMM-Newton provide excellent spectral resolution for point sources, Resolve's strength is in extending this field of study to extended, diffuse sources.

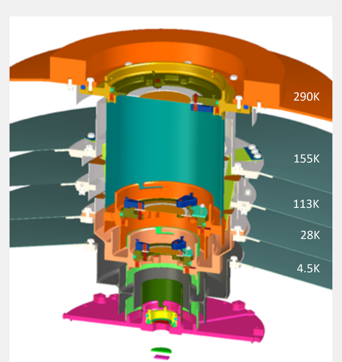
Xtend: a soft X-ray imager; represents the largest field of view among focal plane X-ray CCD cameras flown to space thus far. It provides imaging observations complimentary to the Resolve instrument.

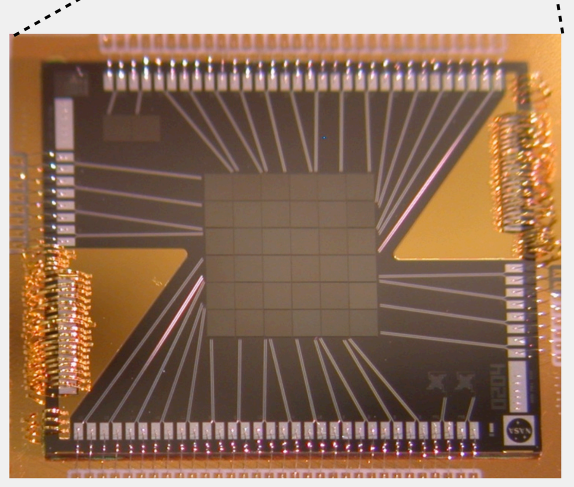
Development is ongoing almost as planned. Integrated system CDR will be held early next year.

XRISM Instruments

Parameter	Requirement	Hitomi Values
Energy resolution	7 eV (FWHM)	5.0 eV
Energy scale accuracy	± 2 eV	± 0.5 eV
Residual Background	2 x 10-3 counts/s/keV	0.8 x 10-3 counts/s/keV
Field of view	2.9 x 2.9 arcmin	same, by design
Angular resolution	1.7 arcmin (HPD)	1.2 arcmin
Effective area (1 keV)	> 160 cm²	250 cm²
Effective area (6 keV)	> 210 cm²	312 cm²
Cryogen-mode Lifetime	3 years	4.2 years (projected)
Operational Efficiency	> 90%	> 98%

Resolve





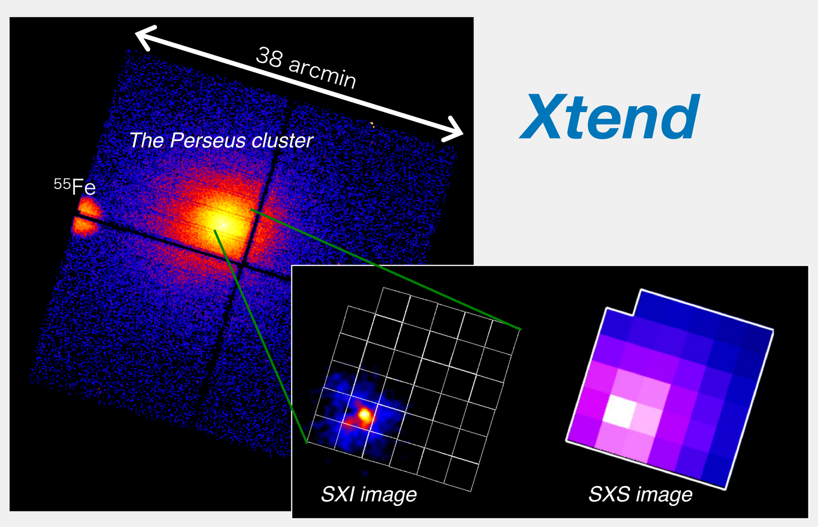
Resolve is a soft X-ray spectrometer, which combines a lightweight X-Ray Mirror Assembly paired with an X-ray micro-calorimeter spectrometer, and provides non-dispersive 5-7 eV energy resolution in the 0.3-12 keV bandpass with a field of view of about 3'. The detector is a 6x6 array of 30" pixels, seen at left.

The detector must be cooled to 50 mK to operate, achieved during the first several years of the mission with liquid helium and a 3-stage adiabatic demagnetization refrigerator (ADR). When the liquid helium is exhausted, a mechanical cooler will continue to cool the detector to 50 mK, with some reduction in operational efficiency.

Ground calibrations at GSFC was successfully done.

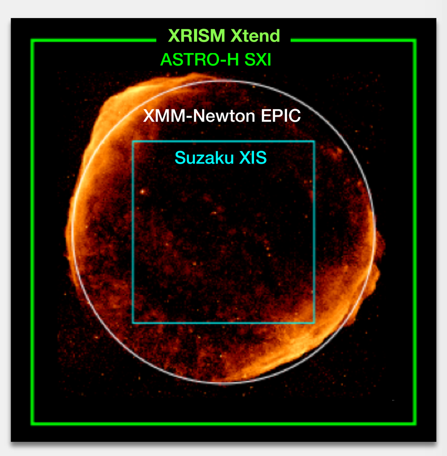
The sensor has been delivered to Japan and installation to the dewar is completed. Operation testing is now ongoing.

Xtend



Xtend is a soft X-ray imaging CCD detector that extends the field of the observatory to 38 arcmin over the energy range 0.4-13 keV, using an identical lightweight X-Ray Mirror Assembly.

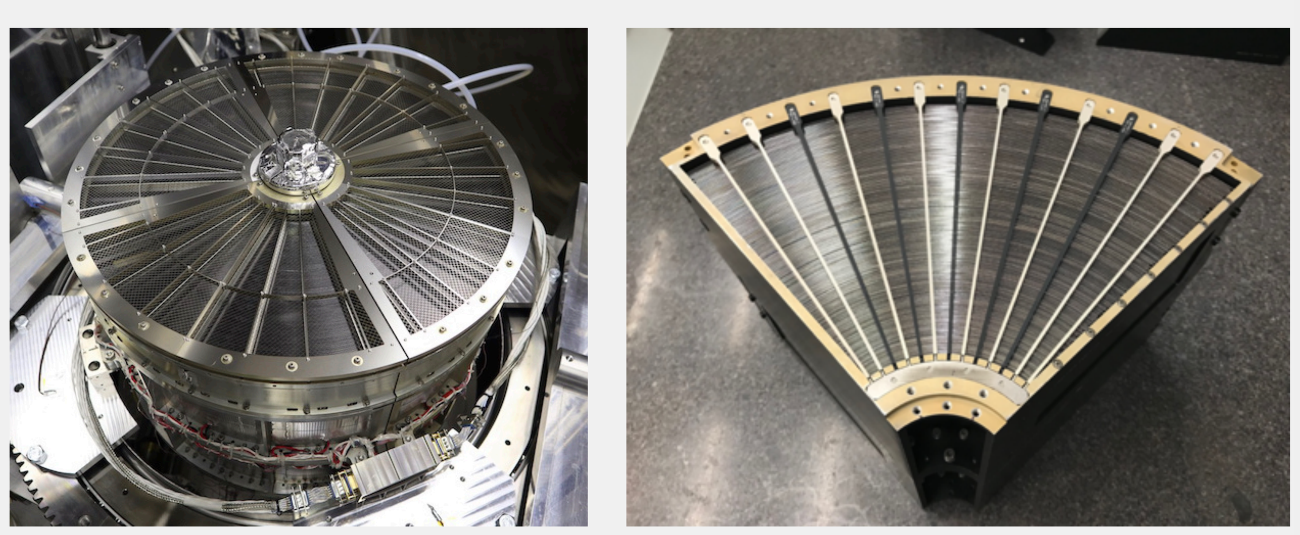
The array is a 2x2 mosaic of 4 chips that cover a field of view of 38' x 38'. The field of view contains the Resolve field, providing complementary information. The pixel scale for Xtend is 1.74".



The Xtend CCD sensor is now undergoing ground calibration. Good charge transfer efficiency (CTE) has been confirmed.

X-ray Mirror Assembly

- X-ray Mirror Assembly (XMA) design is basically the same as Hitomi SXT with further stray light reduction feature.
- XMA #1 has been completed and is currently undergoing environmental tests.
- The first X-ray test of the XMA #1 indicates its performance very similar to that of Hitomi SXT.
- XMA #2 will be completed in December 2019.
- Ground calibration of the XMA will be started around the end of January 2020 using the GSFC X-ray beamline.
- Two flight XMAs will be shipped to Japan by the end of 2020.



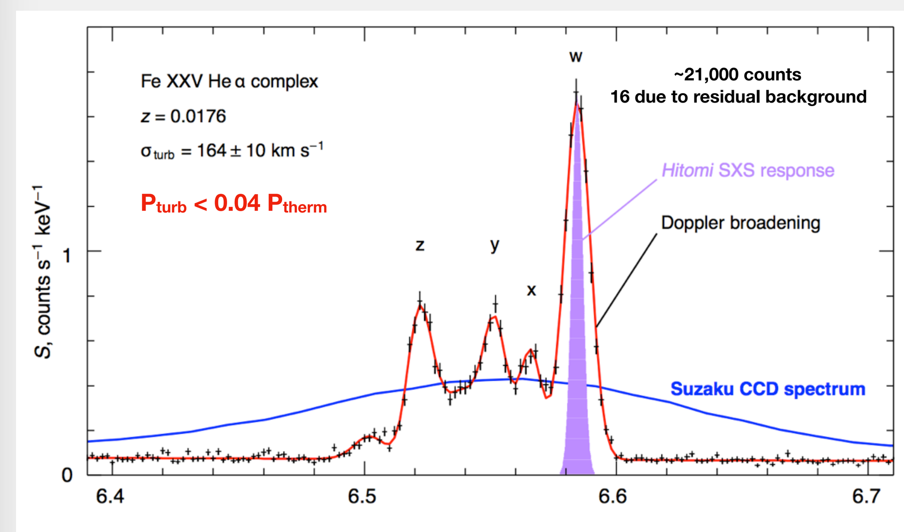
XRISM XMA first flight module (XMA #1) with 203 nested segments for each primary and secondary stage

Lessons Learned from Hitomi

Following the loss of the Hitomi (Astro-H) mission, JAXA/NASA/ESA developed a list of lessons learned that contains hundreds of items. Below are some of the most notable items on this list.

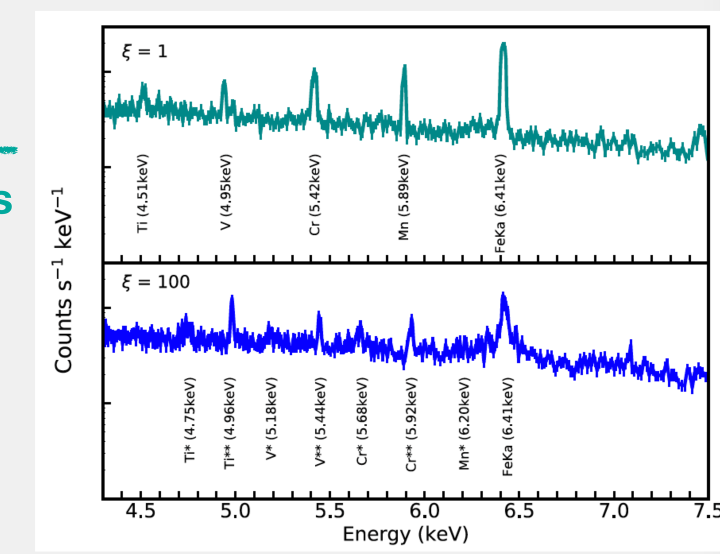
- Improved missions operations: more ground station coverage, more comprehensive analysis of house keeping telemetry in real time.
- Mission operations contractor separate from spacecraft development team.
- Spacecraft has three star trackers (vs. two for Hitomi) manufactured by Sodern (model 26).
- Sun sensor has wider field of view and will be continuously monitored.
- Higher level of NASA participation: in missions operations, overall systems engineering, etc.
- Improvements to loop heat pipes for Resolve dewar cryocoolers.
- Improved magnetic shielding of Resolve Stage 3 ADR magnet. This will increase the cooling power in cryogen-free mode, making it more efficient.
- Improved stray light light protection for both Resolve and Xtend.
- Modulated X-ray Source afterglow to enable lower background for Resolve when using MXS for in-flight calibration.

Science with XRISM

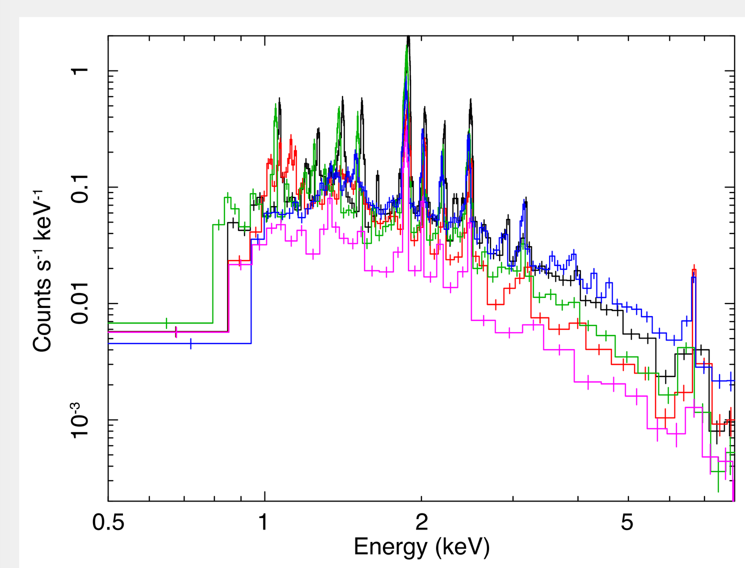


Hitomi spectrum of the Fe Kα region of the Perseus cluster. The lines are resolved, and show a broadening of ~160 km s⁻¹ due to turbulence. The gas pressure in the cluster due to turbulence is low compared to the thermal pressure of the gas. (See Hitomi Collaboration 2016, Nature, 535, 117)

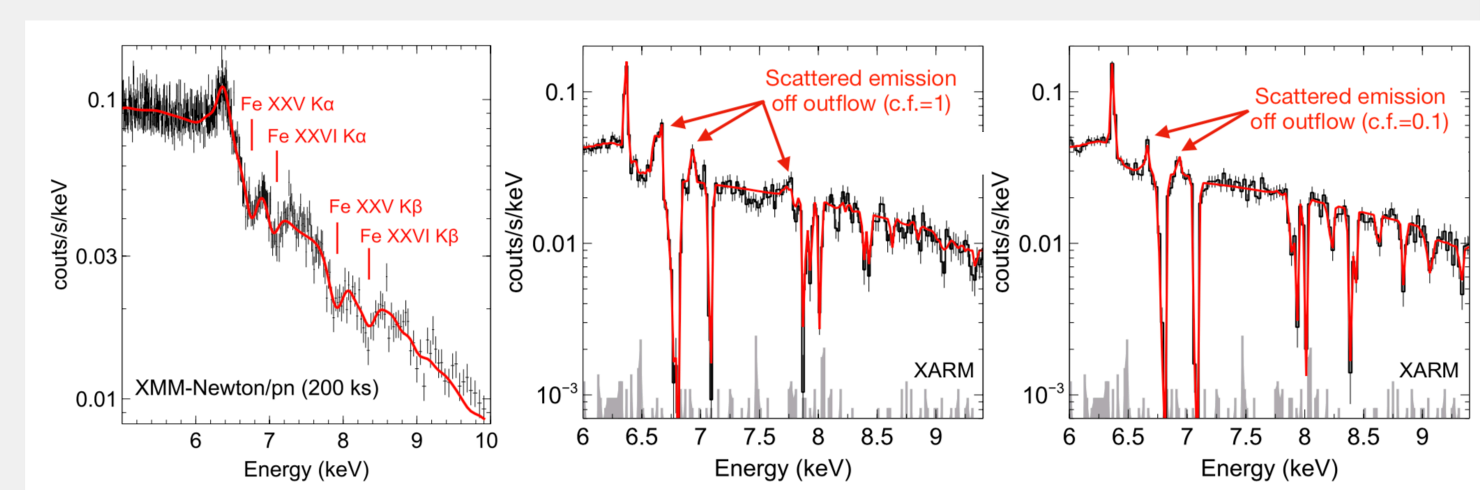
XRISM will make contributions to virtually every area of astrophysical research, and will be a vital part of the landscape of the 2020s. The mission will pave the way for future high-resolution X-ray spectroscopy observatories, and will revolutionize our understanding of the universe.



A 250 ks XRISM Resolve simulation of an AGN spectrum, with two different ionization fractions, showing emission lines from elements created via spallation — the bombardment of a heavy nucleus, such as iron, with energetic ions. (Simulations done by Luigi Gallo)



XRISM simulations of the supernova remnant Cas A. Supernovae are responsible for seeding the cosmos with heavy elements, and by studying the remnants left behind after these explosions, we can better quantify the amount and type of materials produced. (Simulations done by Jacco Vink)



XMM-Newton observations (left), and XRISM Resolve simulations (center, right) of an outflow from an AGN. With the spectral resolution of Resolve, these outflows can be studied not only through absorption, but also emission. This can lead to new constraints on the launching radius of the wind and the energetics of the outflow. (Simulations done by Erin Kara)

The XRISM Guest Scientist (XGS) Program

- The XGS program will allow for members of the whole astronomy community in the world to participate in the observation planning and data analysis of individual PV phase targets.
- Interested scientists may apply to the program by responding to solicitations from JAXA/NASA/ESA.
- Solicitation is expected to be released at least 12 months before the launch.
- Proposers to the program will apply to individual Target Teams, specifying the science that they would do for that particular target. The proposed science should enhance and/or complement the existing expertise of the target team. This expertise may include, but is not limited to: substantial theoretical insight, models for X-ray emission from the relevant astrophysical phenomena, unique or specialized data analysis techniques, or complementary data on the source from other observatories/wavebands.
- More details will be announced shortly.