The XRISM [CX] Universe

Matteo Guainazzi (XRISM ESA Project Scientist)

On behalf od the XRISM Science Team

The enigma of the hour

G. De Chirico, 1910-11
[born in Volos]

Outline

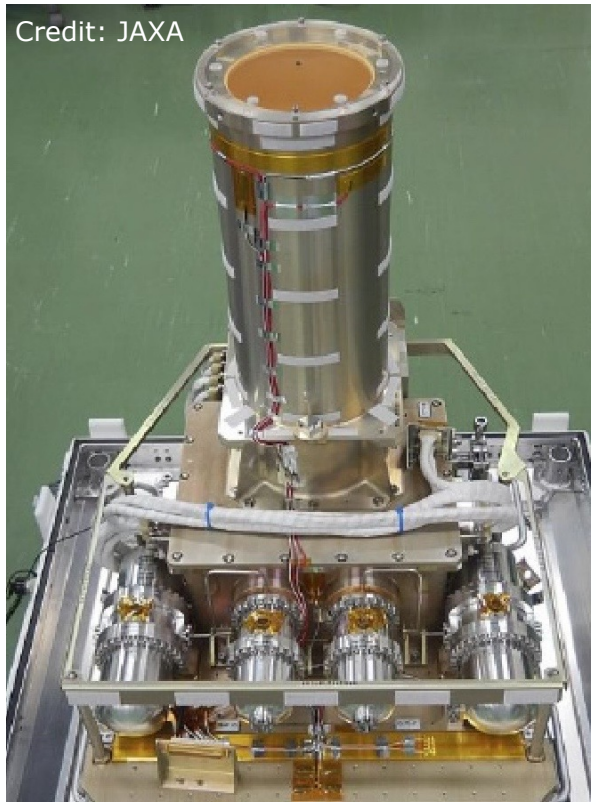
1. What is XRISM?
2. Predictions on Charge Exchange (CX) XRISM observations prior to launch
3. XRISM in-flight scientific performance and science highlights
4. First in-flight CX results (… plus more and better predictions for the future) – **mostly by L.Gu**

What is XRISM?

JAXA/NASA X-ray observatory (with ESA participation) aiming at

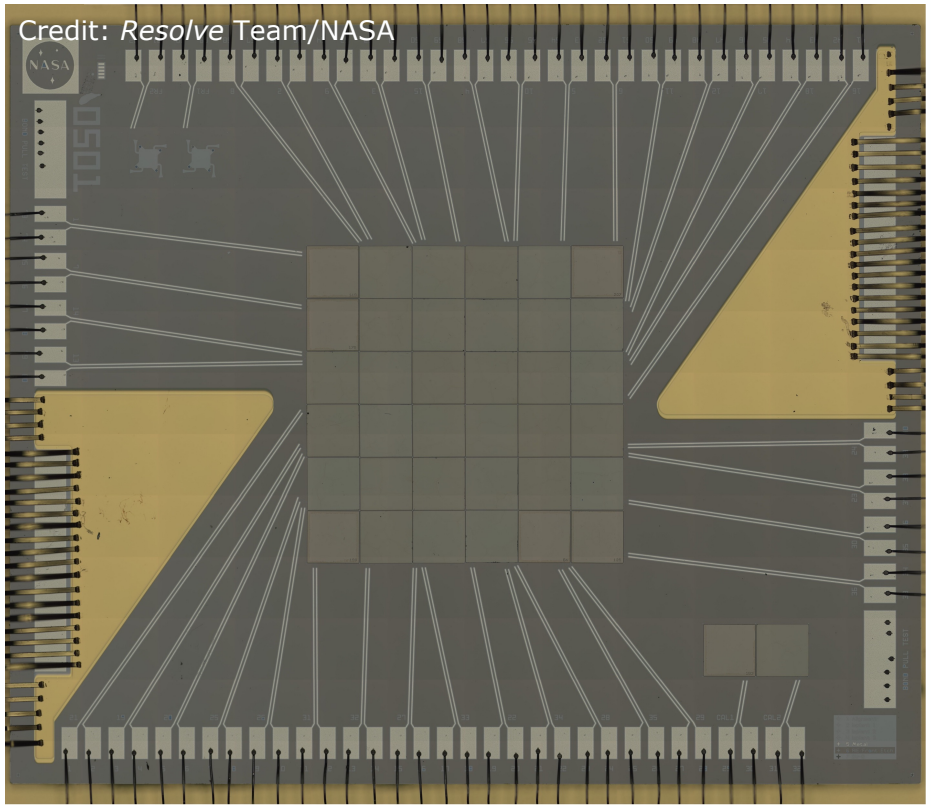
"Resolving astrophysical problems by precise high-resolution X-ray spectroscopy"

Xtend



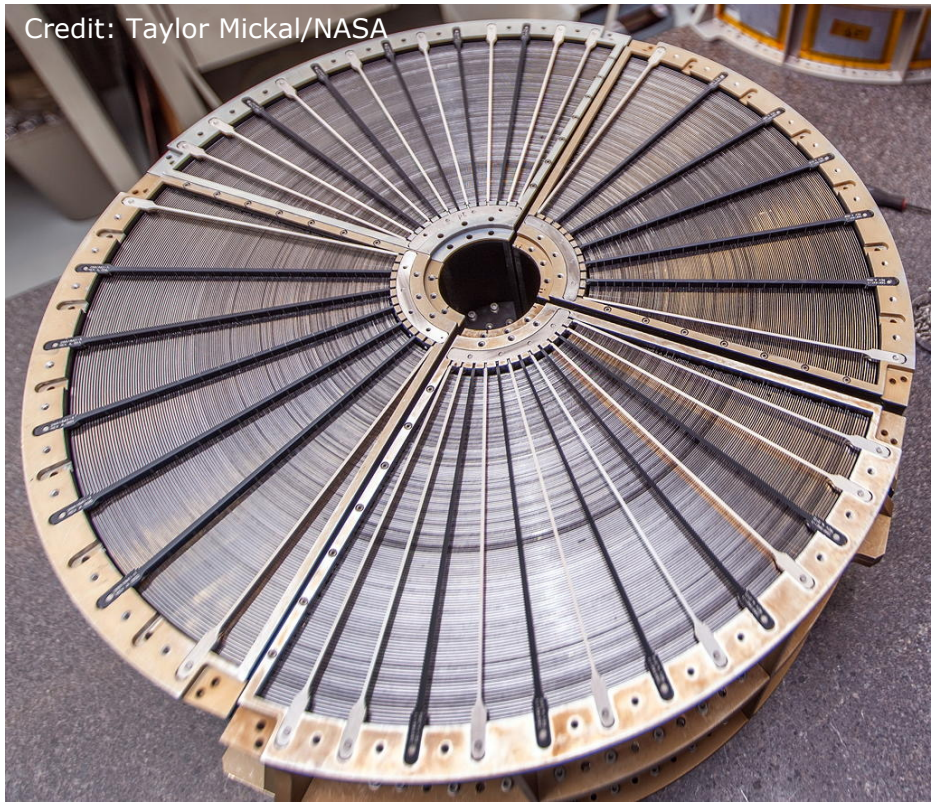
CCD – ~38'x38' field-of-view (FoV)

Resolve



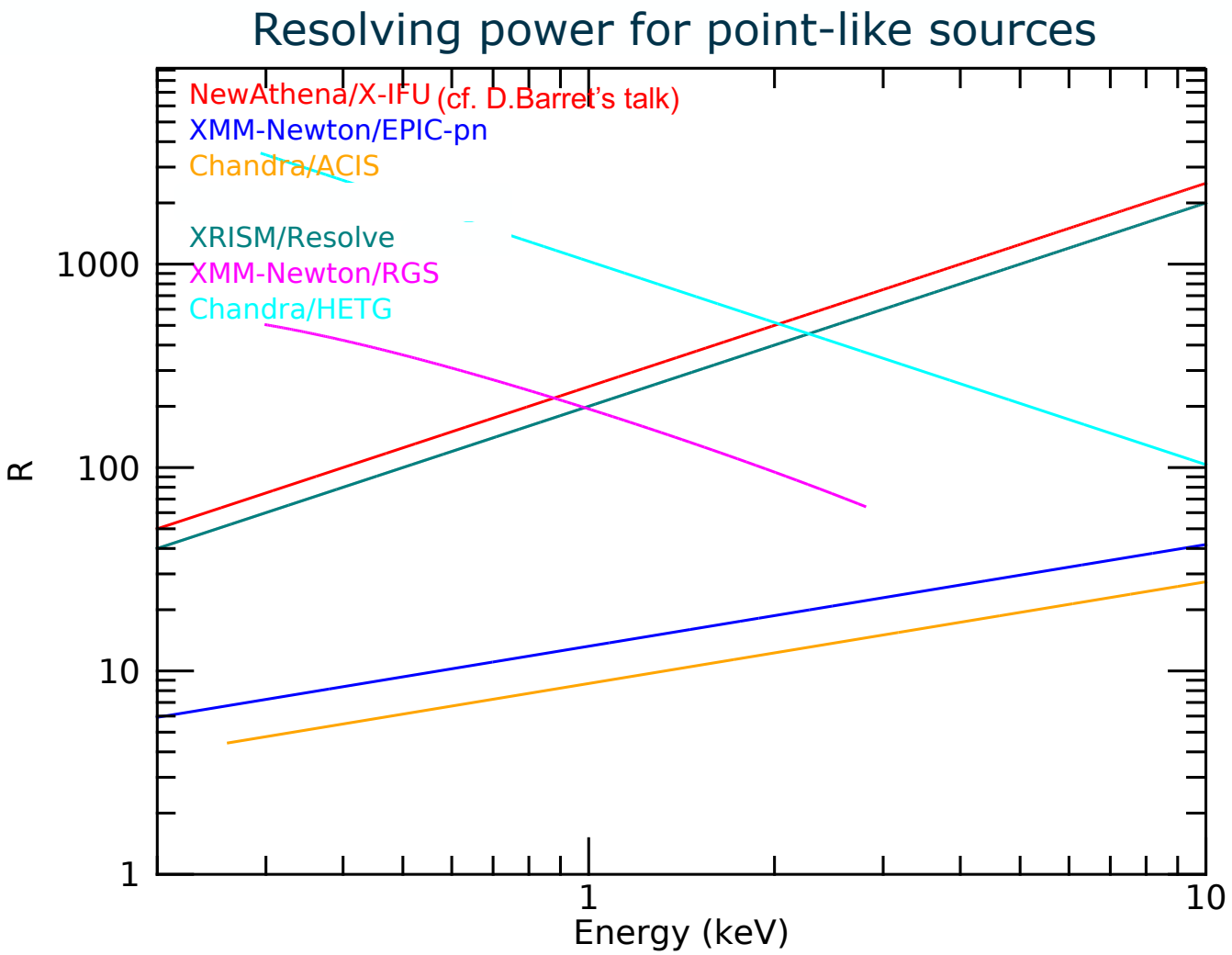
Micro-calorimeter - 35 pixels – ~3'x3' FoV

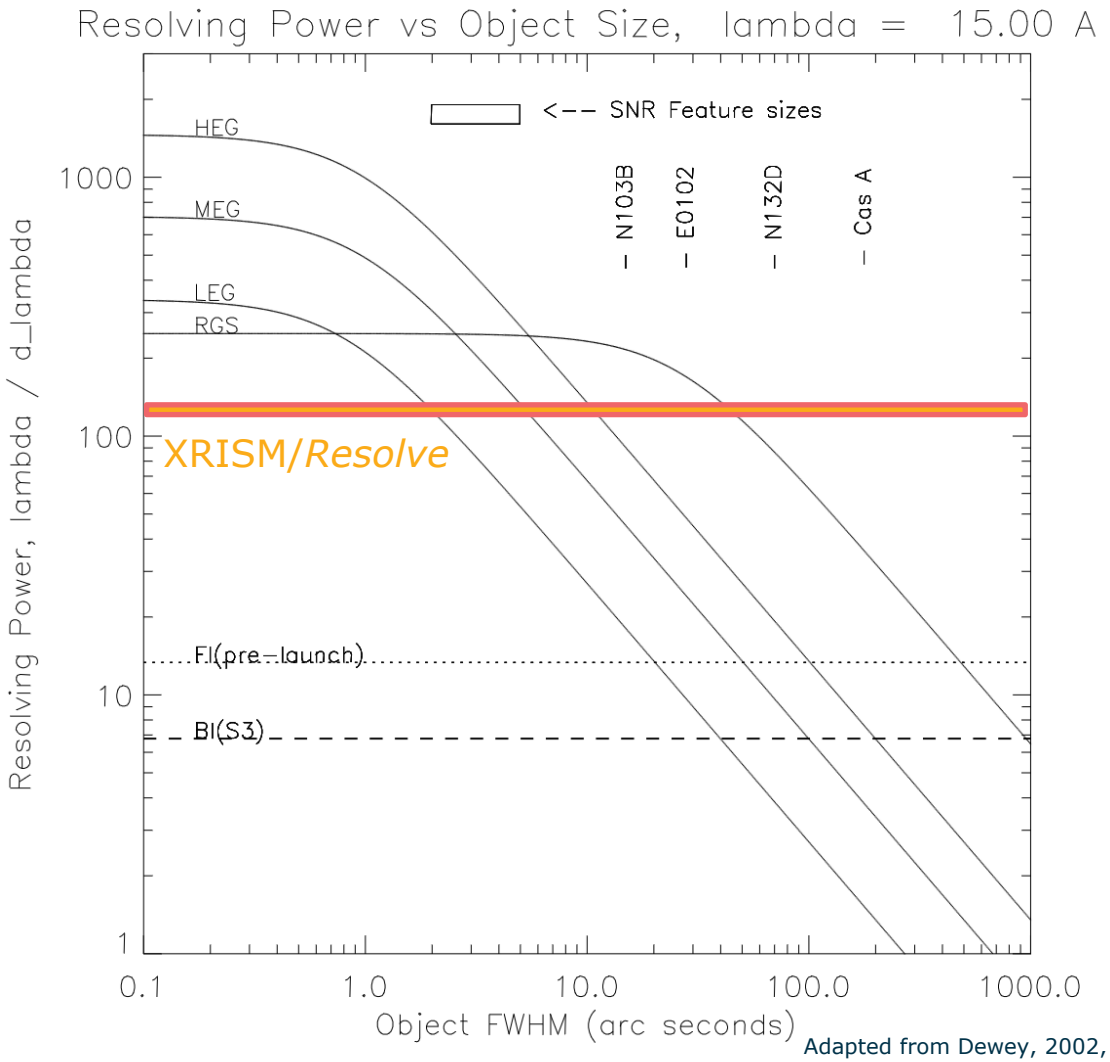
XMA



Two identical X-ray telescopes – 1.7 HPD

The XRISM spectroscopic revolution



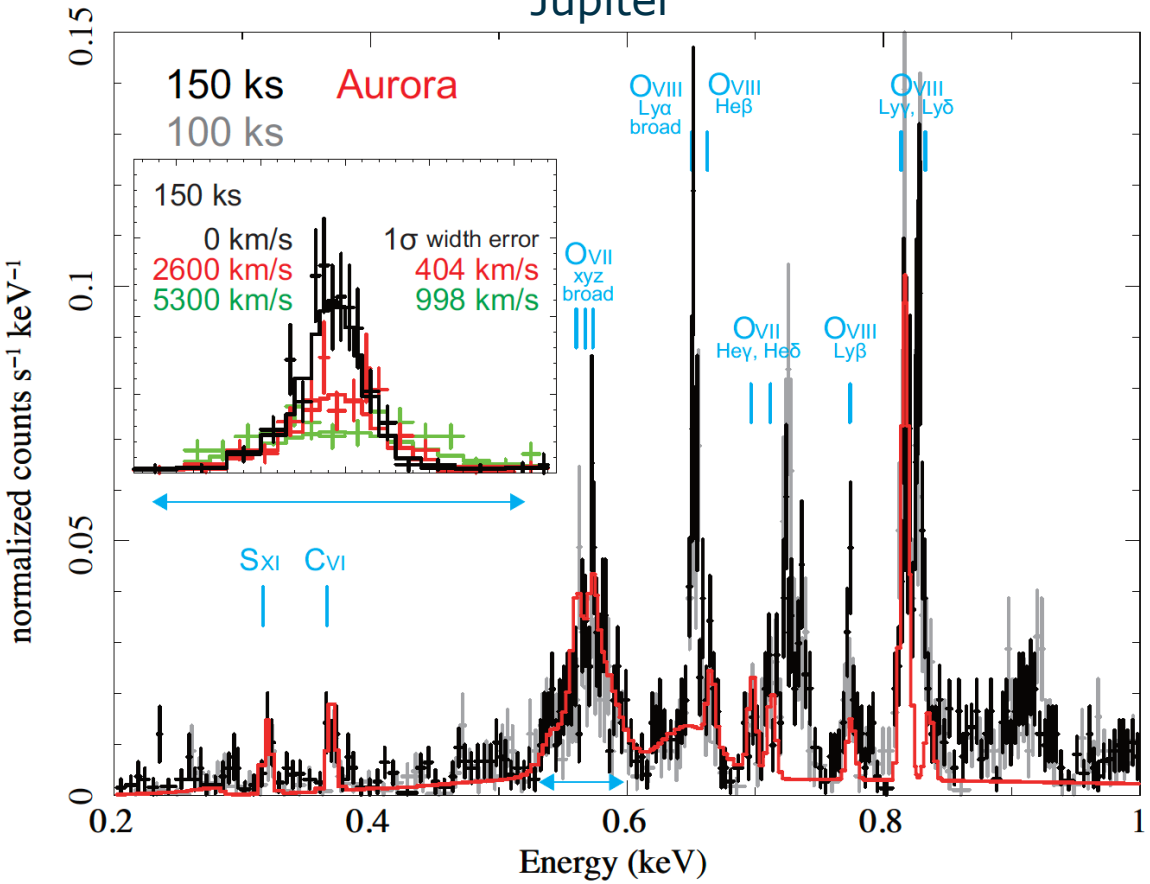


Adapted from Dewey, 2002,
High Resolution X-ray Spectroscopy with XMM-Newton and Chandra, Proceedings

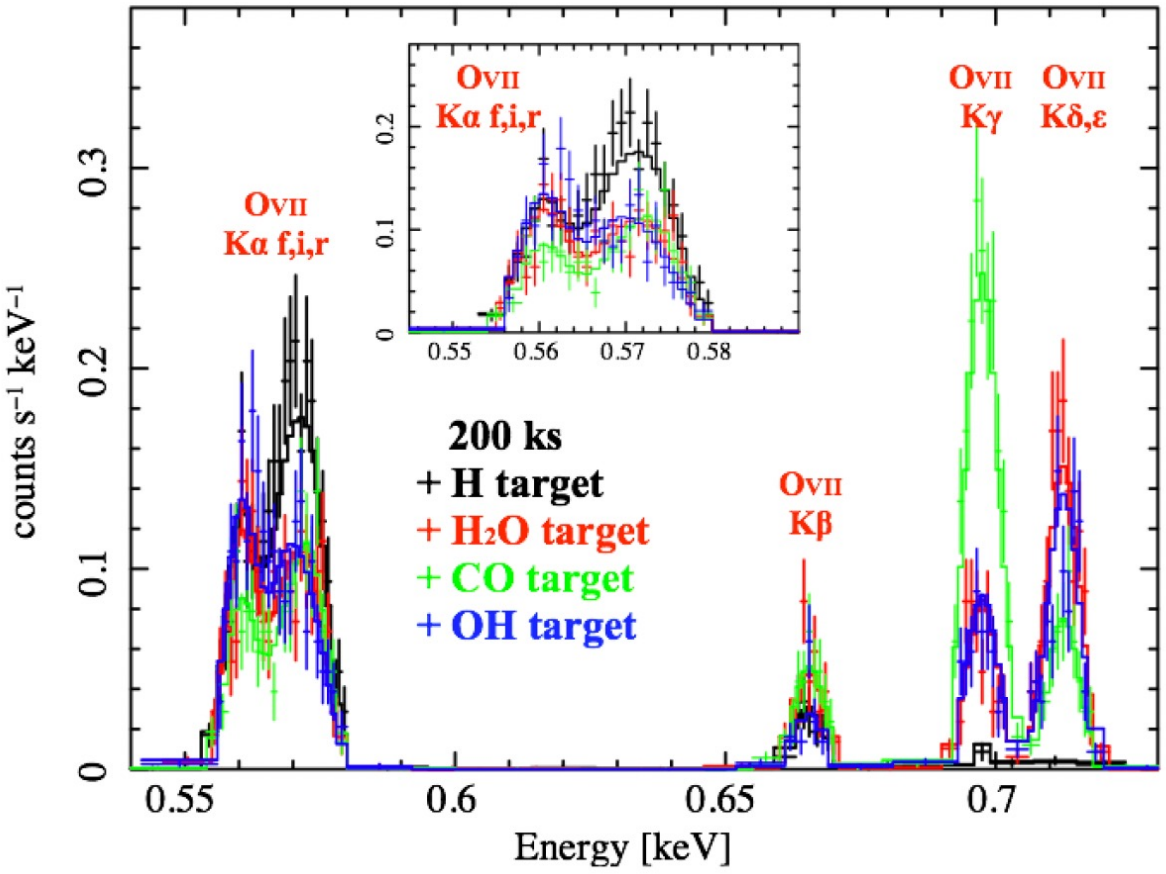
Pre-launch CX predictions: Solar system

Credit: Y. Ezoe (TMU) and the XRISM Science Team

Jupiter



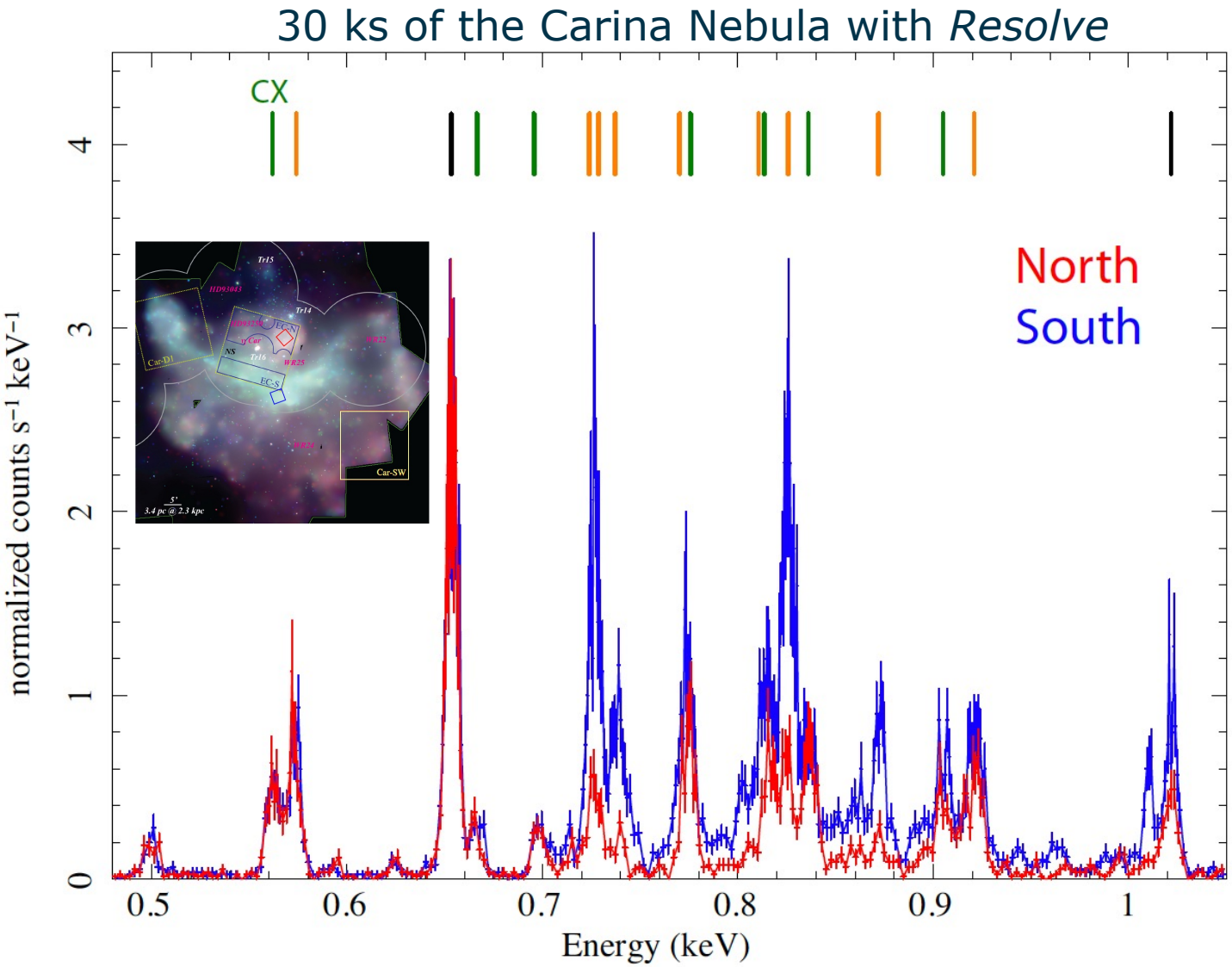
C/2017 K2



Origin and accelleration mechanism of ions

Nature of the neutral targets

Pre-launch CX predictions: stellar nebulae

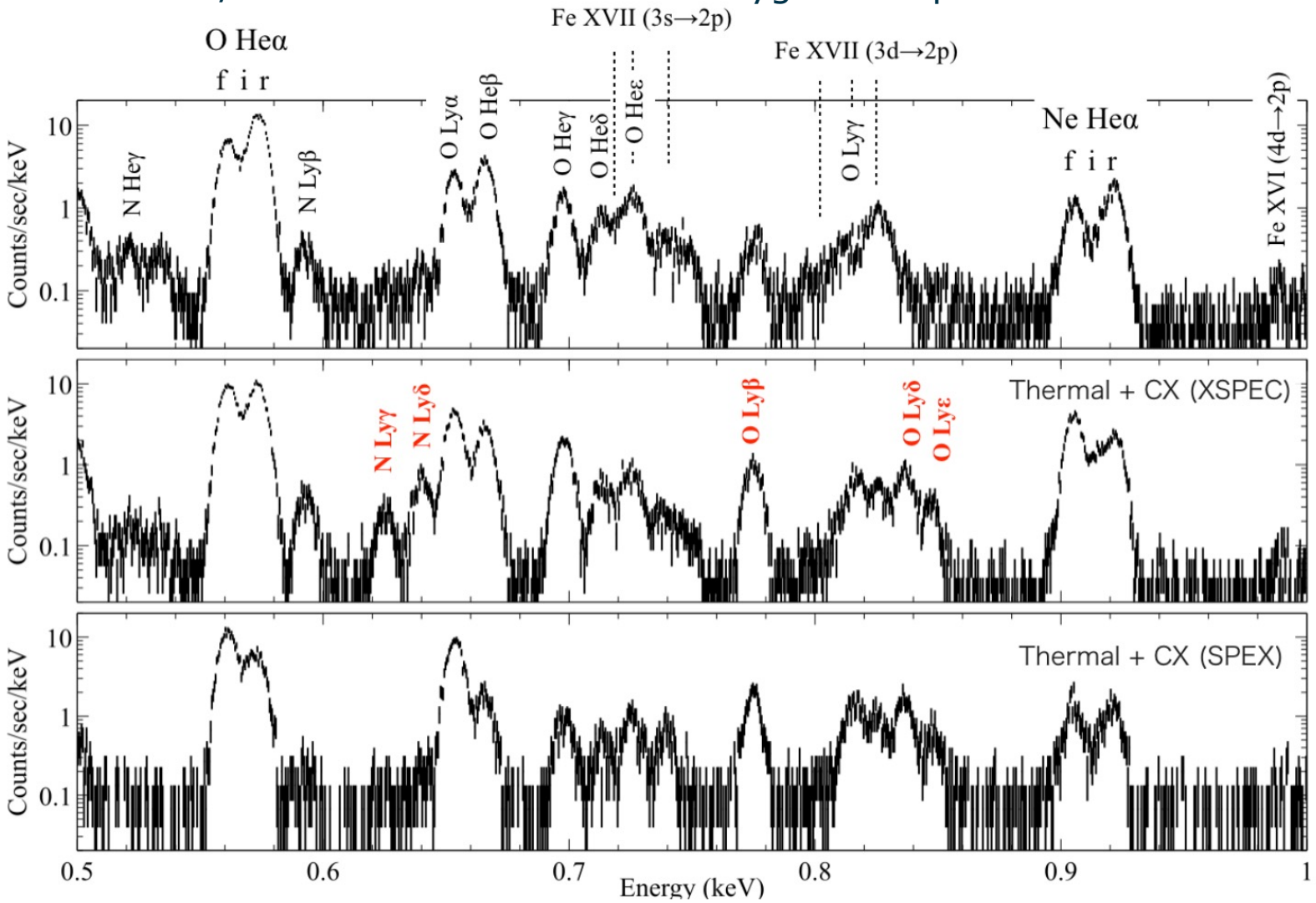


- Plasma conditions via He-like transitions
- **CX due to the interaction between hot gas and cold interstellar molecular clouds**
- Temperature distribution of key elements (N to Ni)
- Ultimately, ascertain the origin of the X-ray plasma

Credit: K. Hamaguchi (NASA/GSFC) and the XRISM Science Team

Pre-launch CX predictions: supernova remnants (SNR)

30 ks XRISM/Resolve observation of the Cygnus Loop



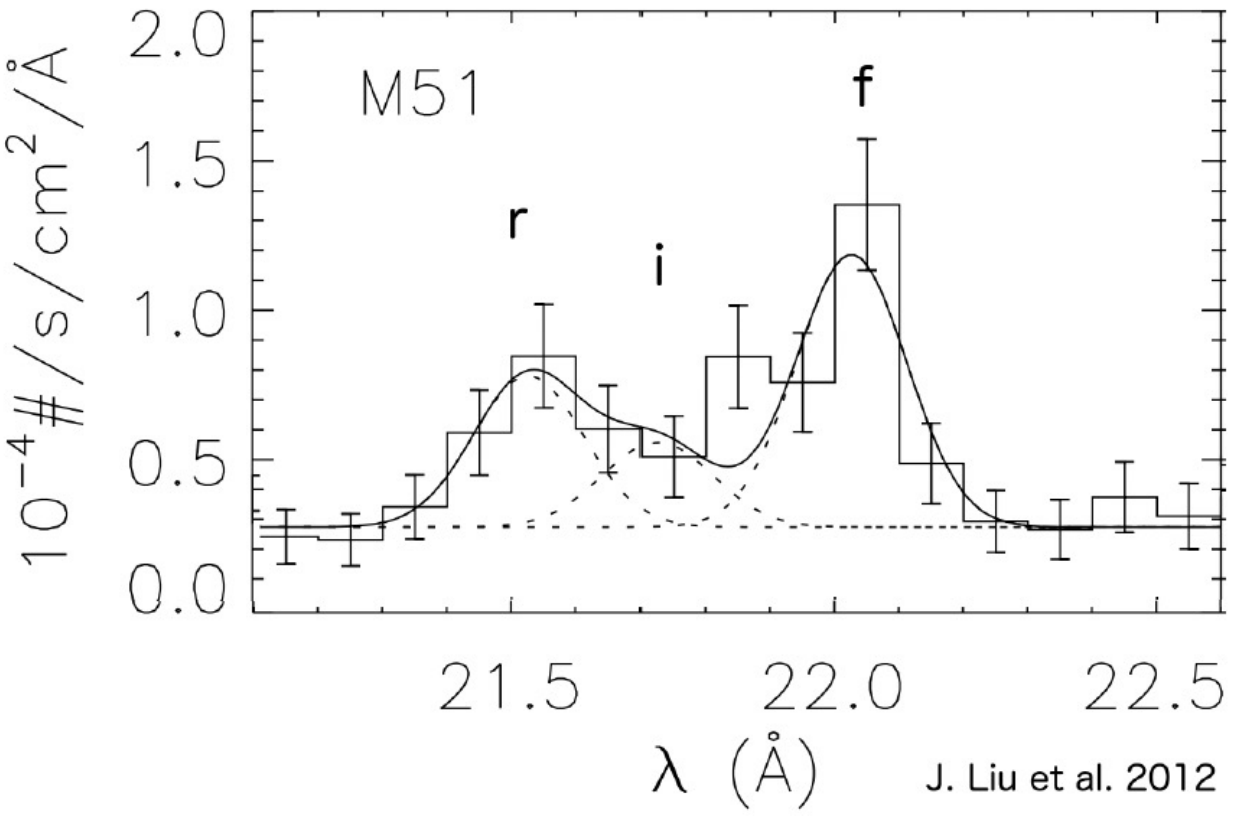
Credit: H. Uchida (Kyoto University) and the XRISM Science Team

- CX spatial distribution along the SNR radius
- Dependence of CX features from the environment (ambient density, forward shock speed, electron temperature, cold filaments)
- Characterization of collision velocity, ion fraction, target composition
- Ultimately, ascretain under which conditions CX occurs in SNRs

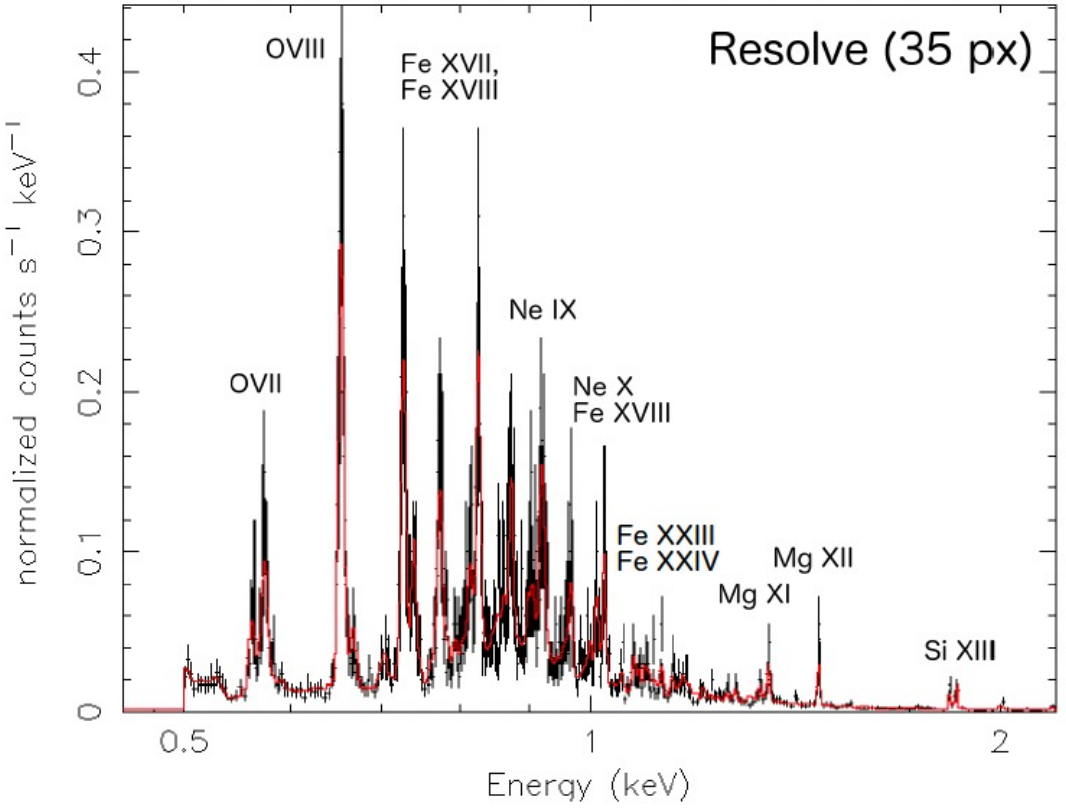
Credit: H. Uchida (Kyoto University) and the XRISM Science Team

Pre-launch CX predictions: galaxies

RGS spectrum of M51



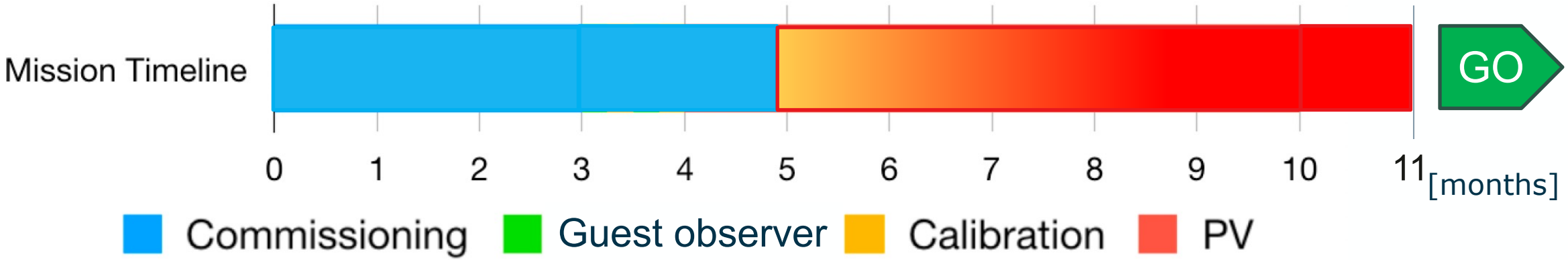
Predicted 160 ks
XRISM/*Resolve* spectrum



Credit: E. Hodges-Kluck (NASA/GSFC) and the XRISM Science Team

Mission status

- 7 September 2023: Launch (L)
- **L-L+5 months**: commissioning
  - Successfully **completed on 8 February 2024** (with one exception item, see later)
  - First light observations performed November/December 2024
- **L+5 months-L+11 months**: in-flight calibration and Performance Verification (PV) phases
- **L+11 months**: start of the Guest Observer (GO) program (8±7 August 2024)

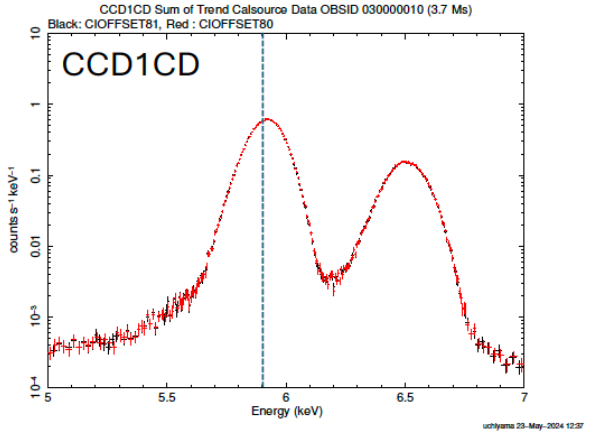


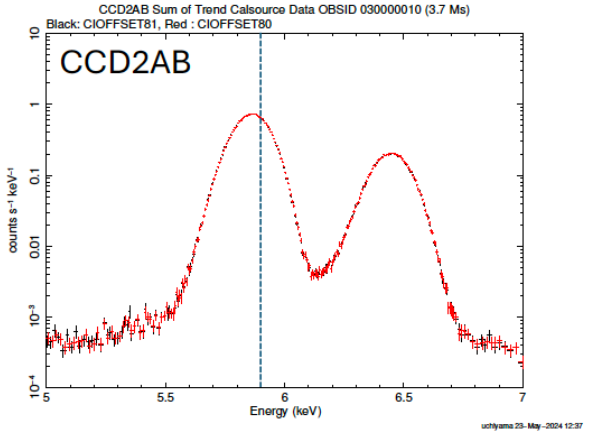
- ~130 observations so far, ~50 sky targets
  - Public schedule available from: `https://www.darts.isas.jaxa.jp/astro/xrism/`

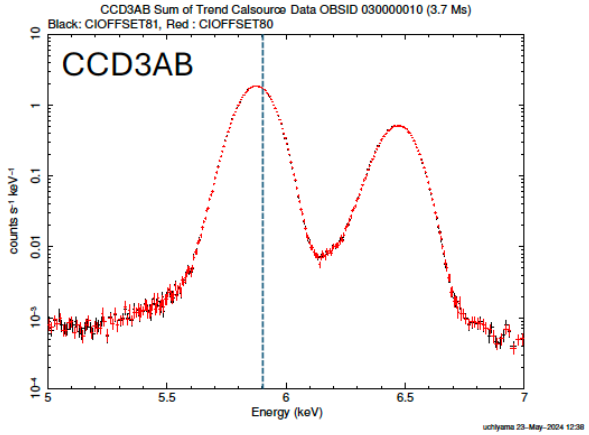
Xtend in-flight performance

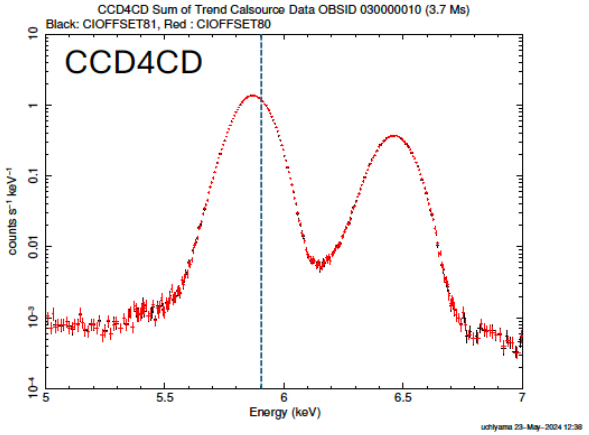
Credit: *Xtend* Team

Energy resolution exceeds requirements (200 eV)

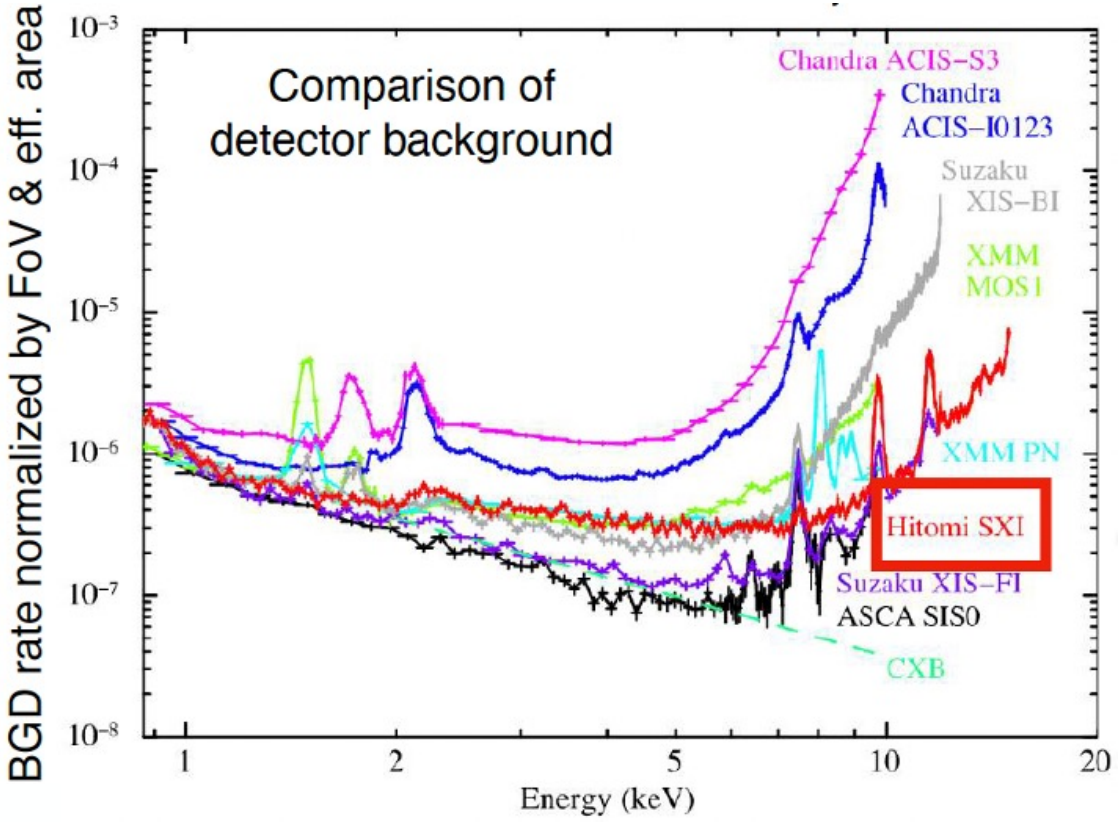








Non X-ray background similar to *Hitomi*/SXI

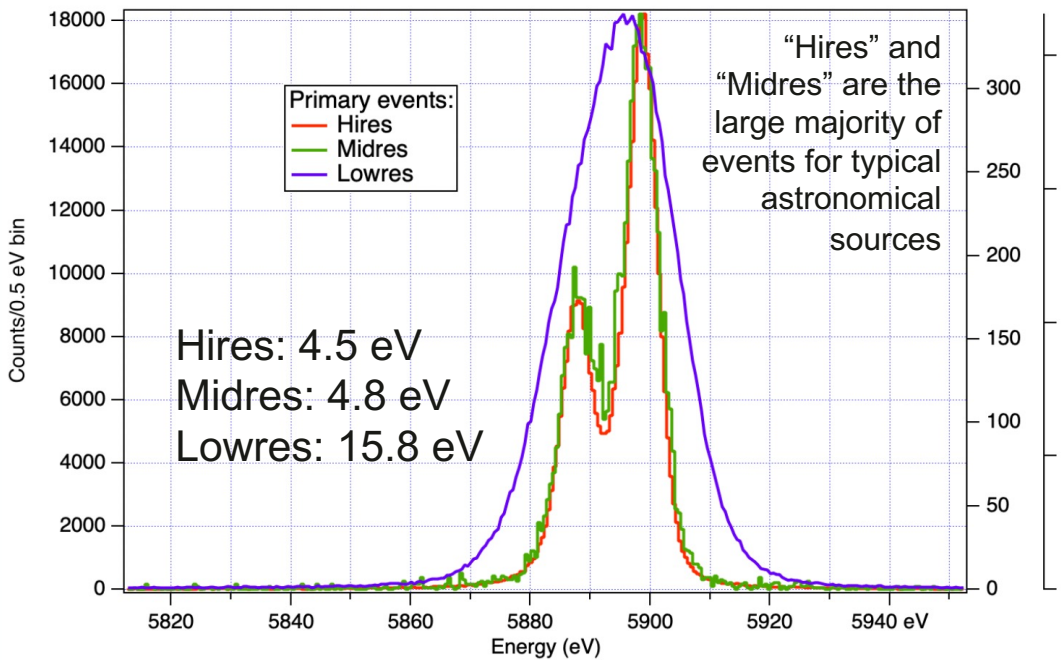


Nakajima et al., 2018, PASJ, 70, 21

Resolve in-flight performance

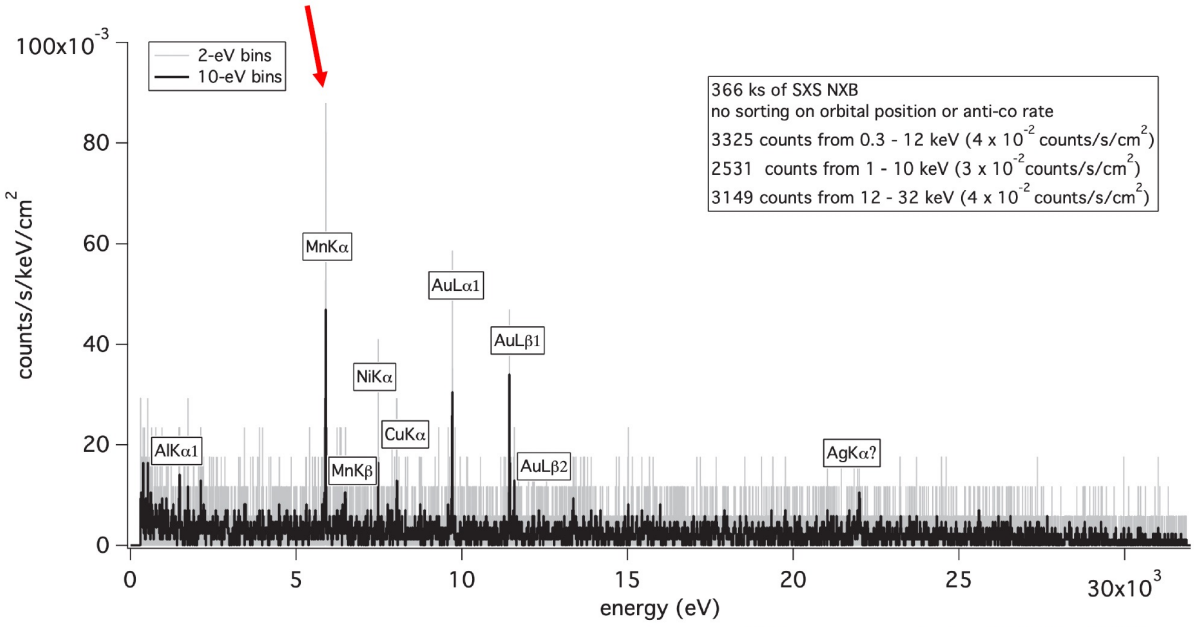
Credit: *Resolve* Team

Example from in-flight data:



[N.B.: Requirement (Hires): ≤7 eV]

Measured background from Hitomi/SXS. Early indications are that XRISM/Resolve is very similar, but Mn K line is not detected.

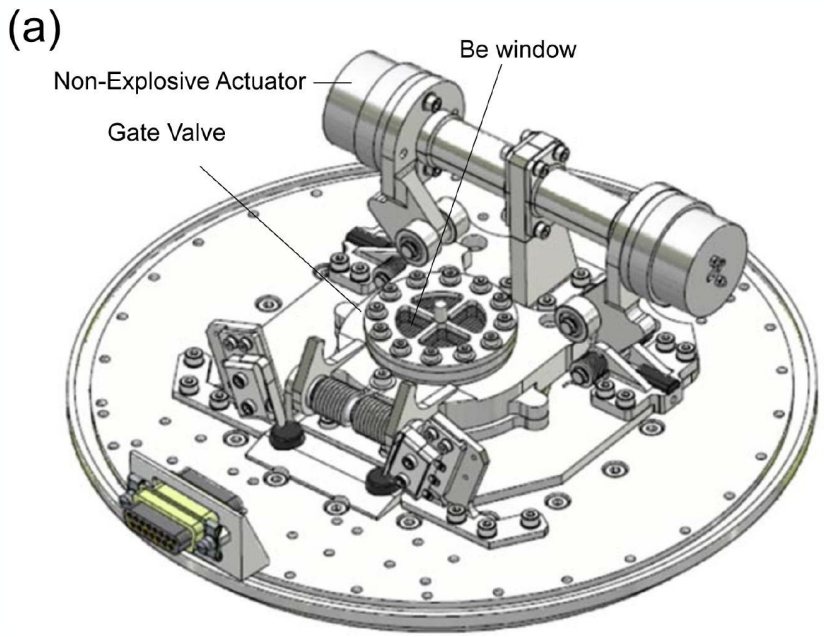


Kilbourne, et al., PASJ, 2018

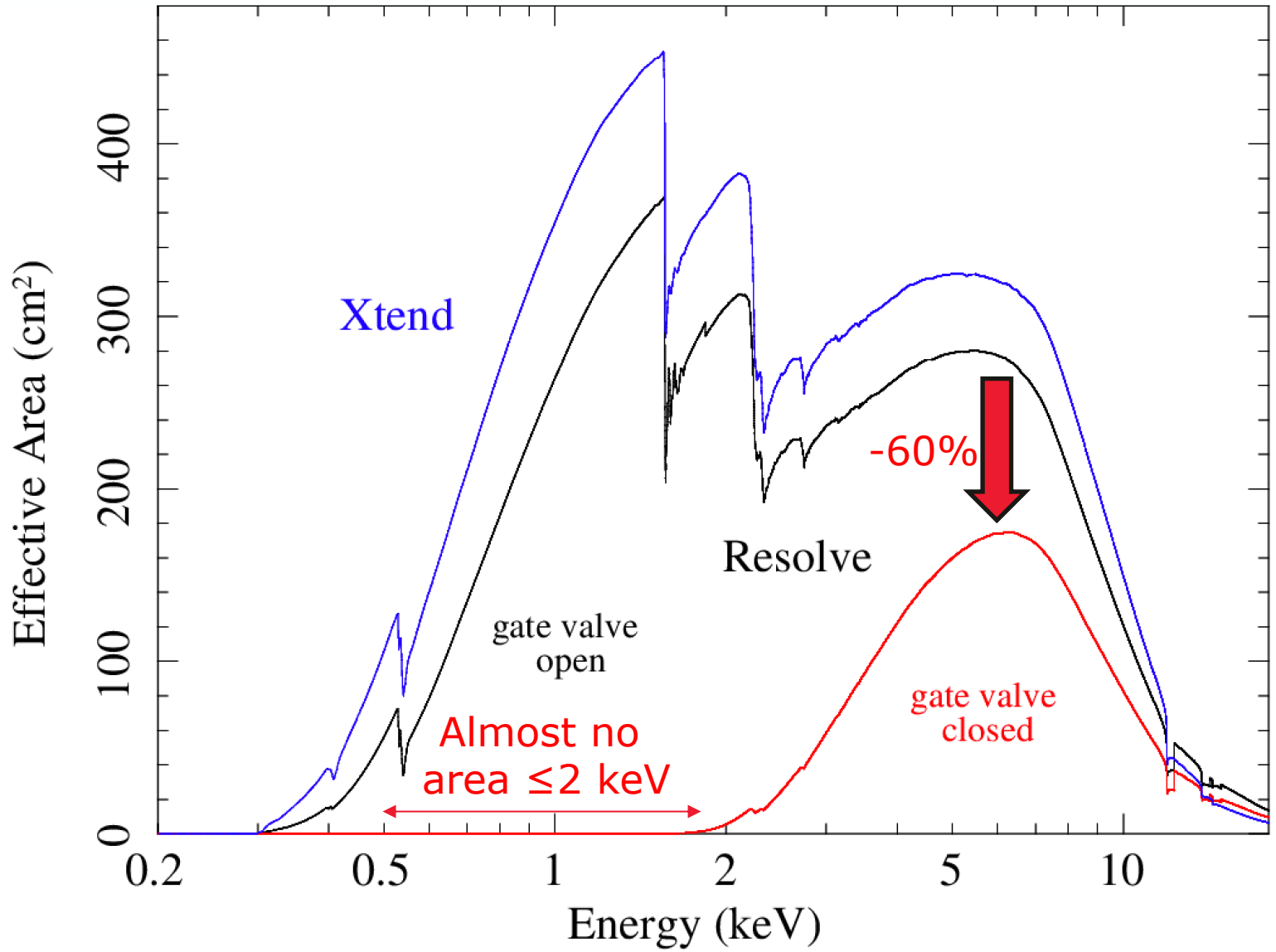
Gain reconstruction accuracy @6 keV: **~0.2 eV**

Resolve Gate Valve

Ezoe et al., 2020, Croygenics, 103016



- A "Gate Valve" protecting the Resolve dewar vacuum has not fully deployed yet
- JAXA/NASA are performing the risk assessment of a "special operation" to try and open it



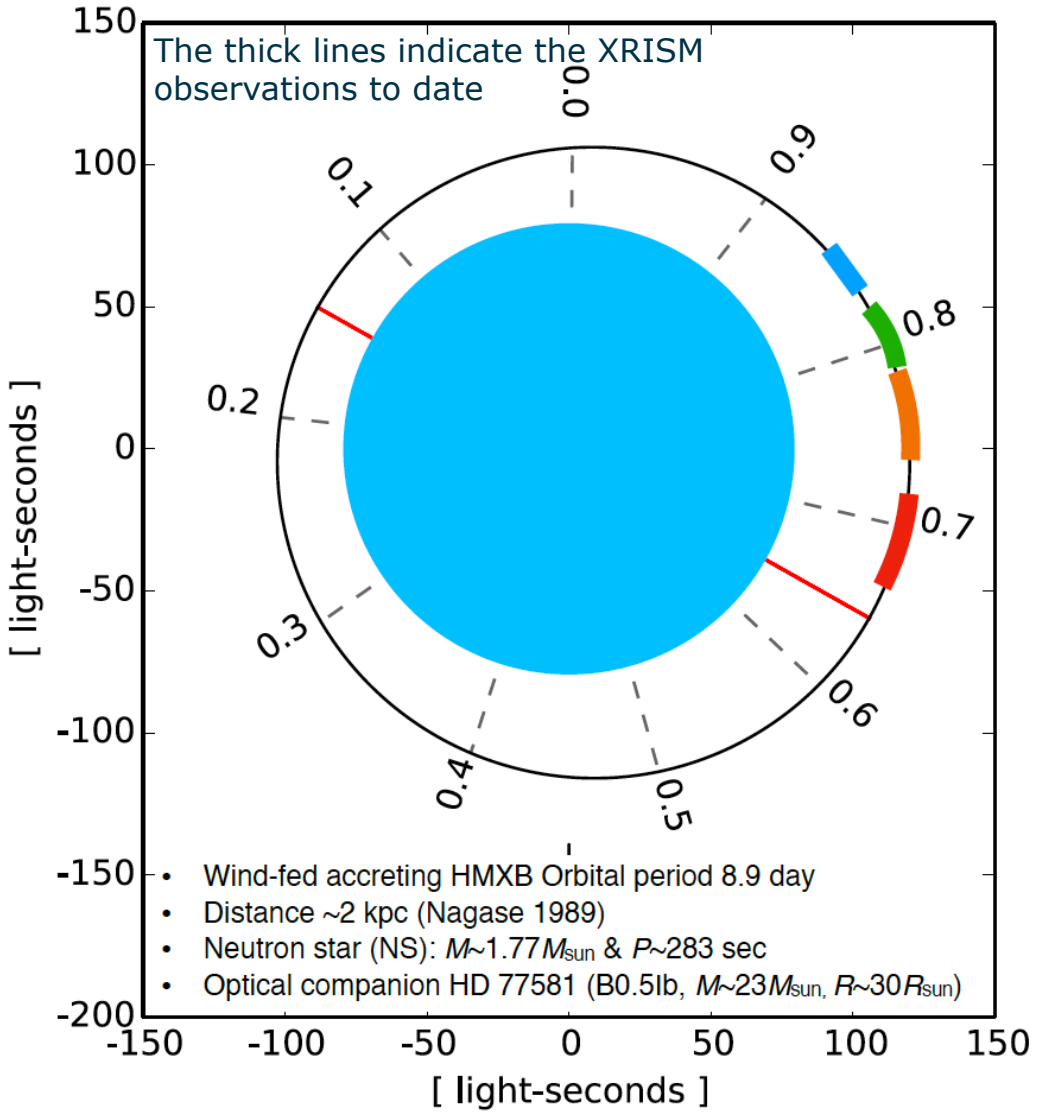
Do not forget *Xtend*!

Geocoronal SWCX emission during May solar storm

Embargoed

Credit: K. Fukushima (ISAS/JAXA) and the XRISM Science Team

XRISM Early Release Science (ERS): Vela X-1 (XRB)



Credit: T. Enoto (RIKEN) and the XRISM Science Team

Time-averaged *Resolve* spectrum

Embargoed

Spin- and orbital-phase spectroscopy possible

XRISM ERS: NGC4151 (Active Galactic Nucleus)

- Full tomography of the innermost AGN regions:
  - Torus
  - Broad Line Region
  - Accretion disk warp
- Simple dynamic structure of non-relativistic absorbers constrains outflow geometry and launch mechanism
- The quest for relativistic, (possibly) galaxy feedback driving outflows (UFOs) ultimatey solved by XRISM*!

*not shown in this slide

Credit: J. Miller (Un. Michigan) and the XRISM Science Team

XRISM ERS: Perseus (galaxy clusters)

- FeXXVI He-α turbulent velocity *accuracy* (statistic+systematic) ~10 (C0) to ~50 (O1) km s^{-1}
- FeXXVI He-α bulk velocoty *accuracy* <10 (C0) to ~40 (O1) km s^{-1}
- Abundances of Si to Ni *accuracy* <0.1 (C0), ~0.2 (C1), 0.3-0.5 (M1), ~0.3 on Ni (O1)
- CX signatures being searched

Credit: I. Zhuravleva (Un. Chicago) and the XRISM Science Team

SNRs with *Resolve*

Embargoed

SNRs with Resolve: close-up view of the FeXXV

XRISM ERS: N132D – first detection of CX

XRISM Collaboration, submitted.

Embargoed

See talk by L.Gu
this Thursday

Take-home messages

- **XRISM is performing superbly**. Many key science performance of *Resolve* and *Xtend* exceed the requirements

- **Several observations are revolutionizing fields as diverse as**: the launching mechanism and structure of outflows in compact objects; the structure model of AGN, the dynamic of baryons in the intra-cluster medium; the thermal structure of the shocked ejecta in SNR; the production and circulation of metals [to mention just a few…]

- While the lack of Resolve GV deployment severely hits CX science, **the first detection of CX in a SNR will be soon in the press!** (cf. talk by L. Gu this Thursday)

- **JAXA and NASA are performing a full risk assessment of a special operation aiming at opening the GV**. A plan to be communicated no earlier than summer 2024