XRISM's View of Galaxy Clusters: New Insights and Recent Progress

Congyao Zhang (张从尧, Masaryk U.)

XRISM collaboration

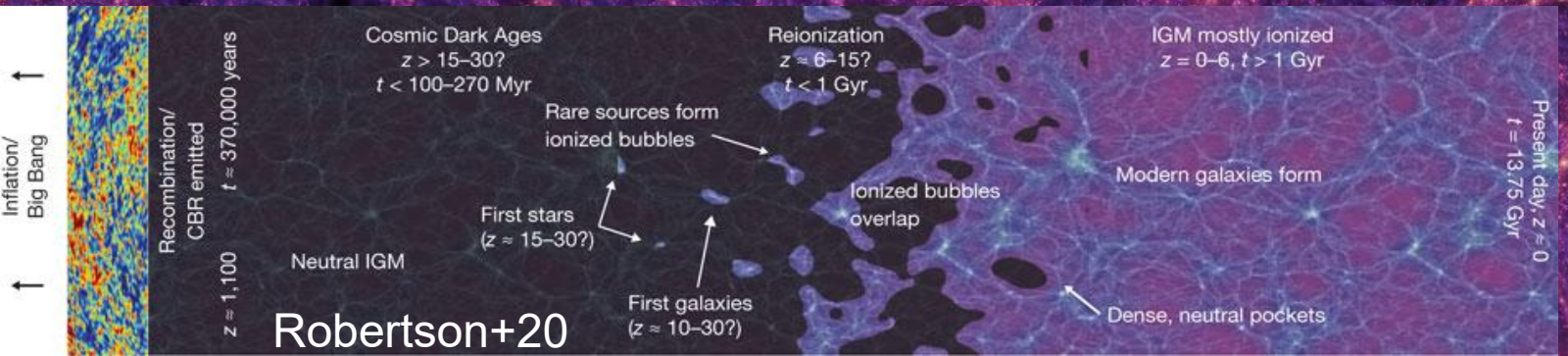
E. Churazov, W. Forman, N. Werner, M. Zaječek,
I. Zhuravleva, and many others

06/10/2026 @ Tatra

Dark matter distribution

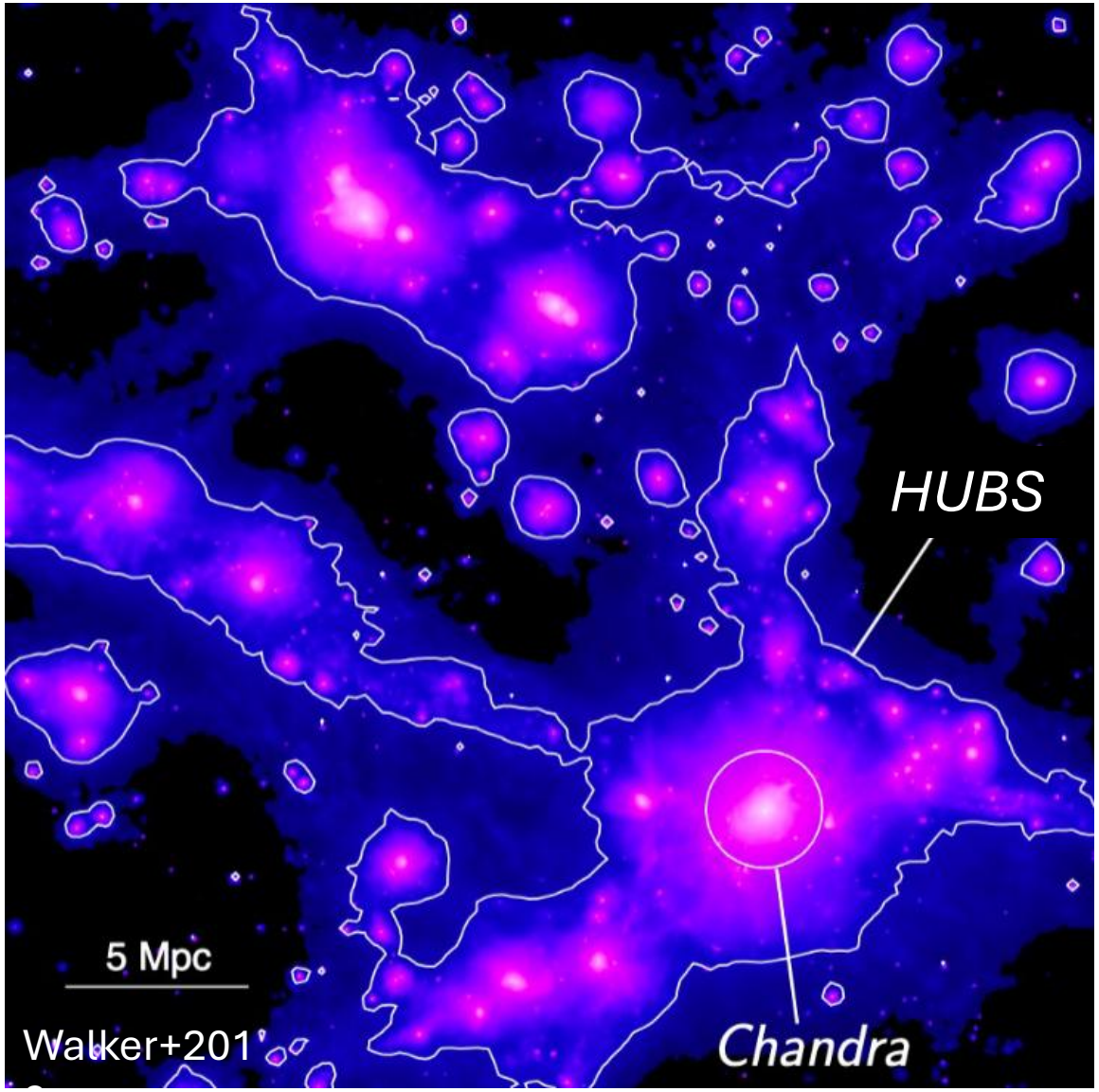
The Millennium Simulation

125 Mpc/h



Robertson+20

Hot gas atmospheres and their X-ray emissions



$$\frac{kT}{\mu m_p} \simeq \frac{GM}{R}$$

$$\simeq 5\mathrm{keV}\left(\frac{M}{5\times10^{14}M_\odot}\right)^{2/3}$$

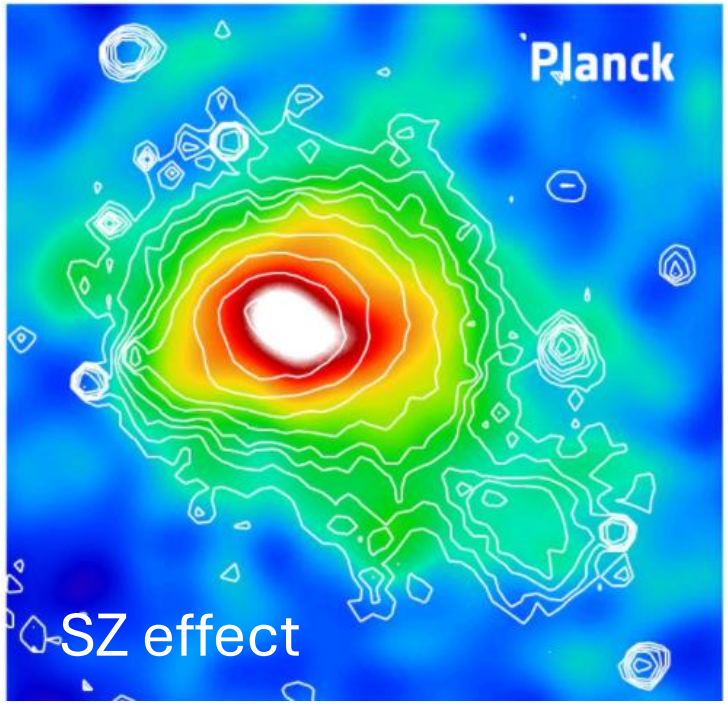
X-ray: 0.1 – 10 keV

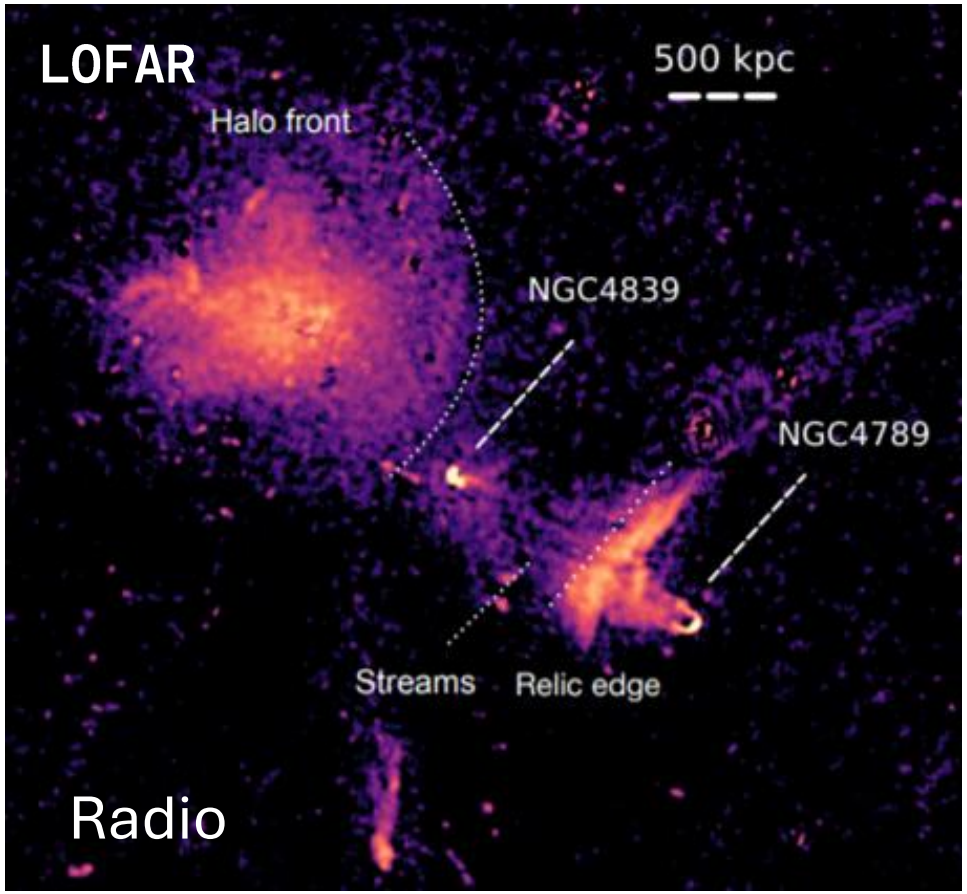
~ 10^6 – 10^8 K

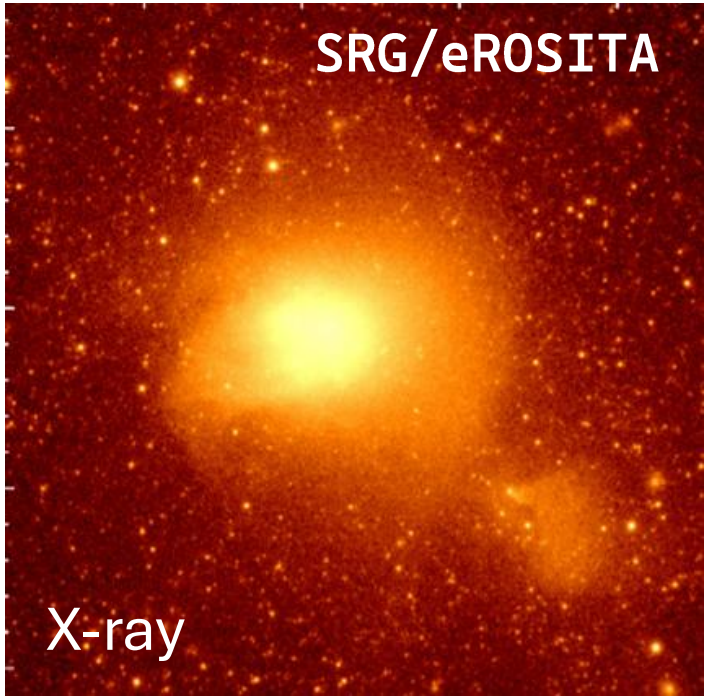
ICM, CGM, IGM

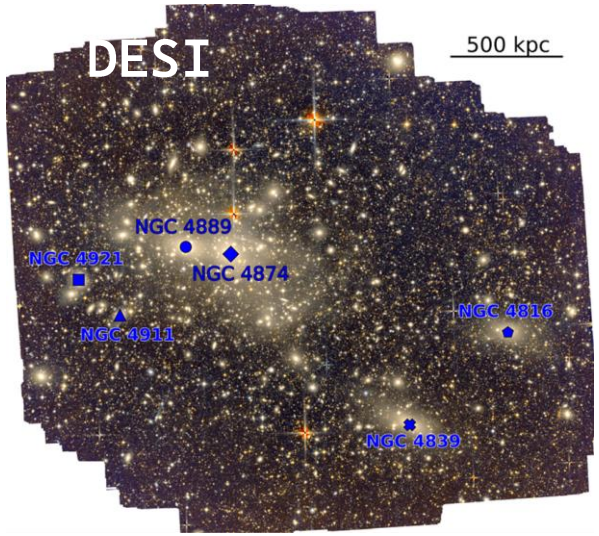
Multi-wavelength observations

The Coma cluster as an example







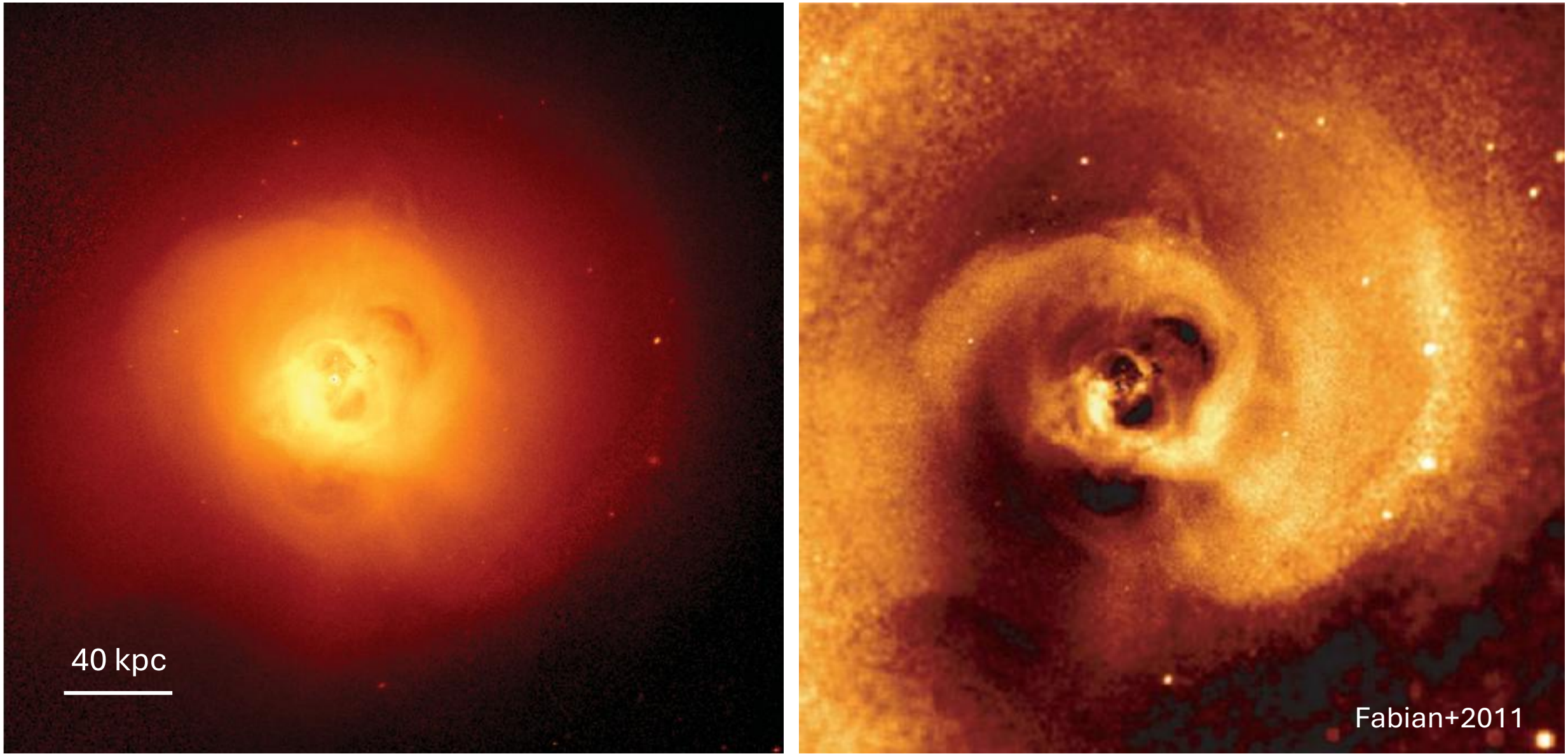


Optical

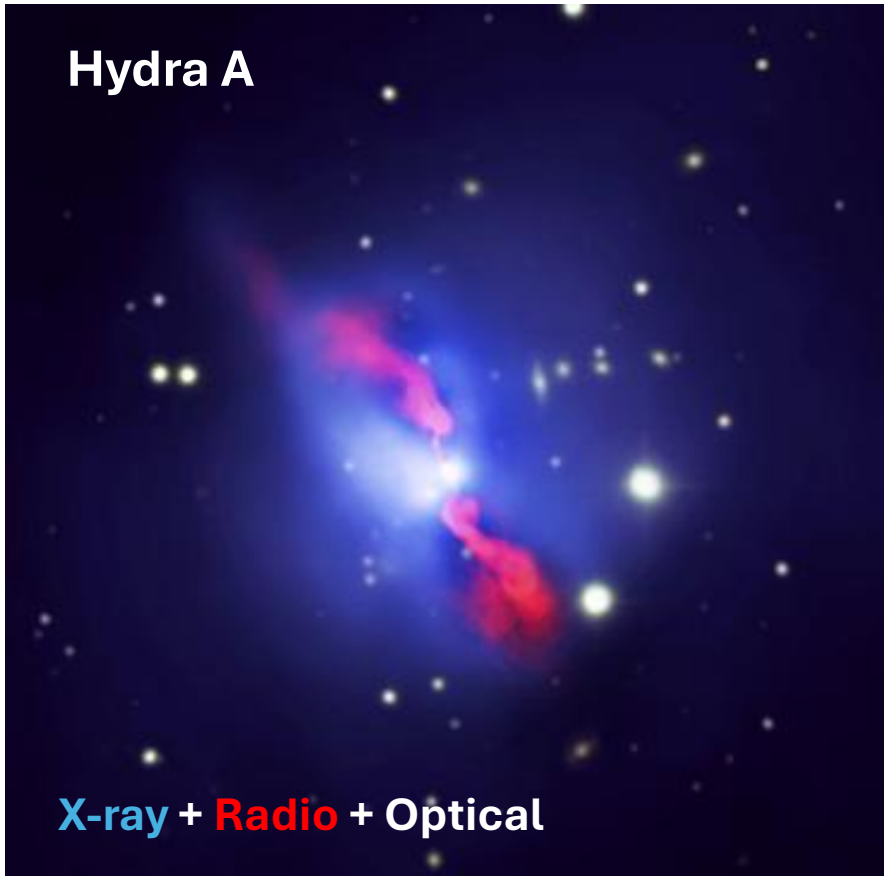
Churazov+2021, Bonafede+2021, Jiménez-Tej+2025

Planck : ESA/ LFI & HFI Consortia; ROSAT: MPE;
DSS image: NASA, ESA, and Digitized Sky Survey

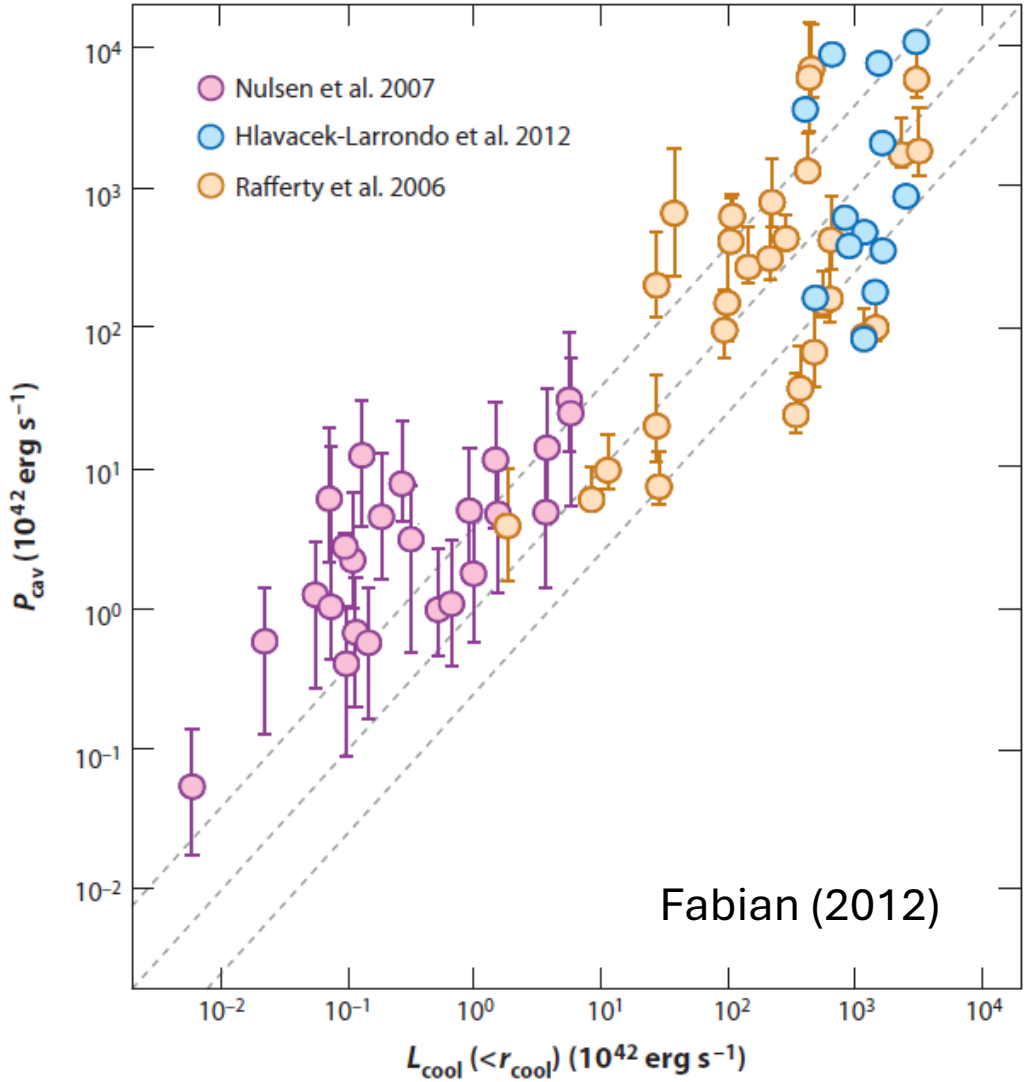
High-resolution Chandra X-ray image of the Perseus cluster



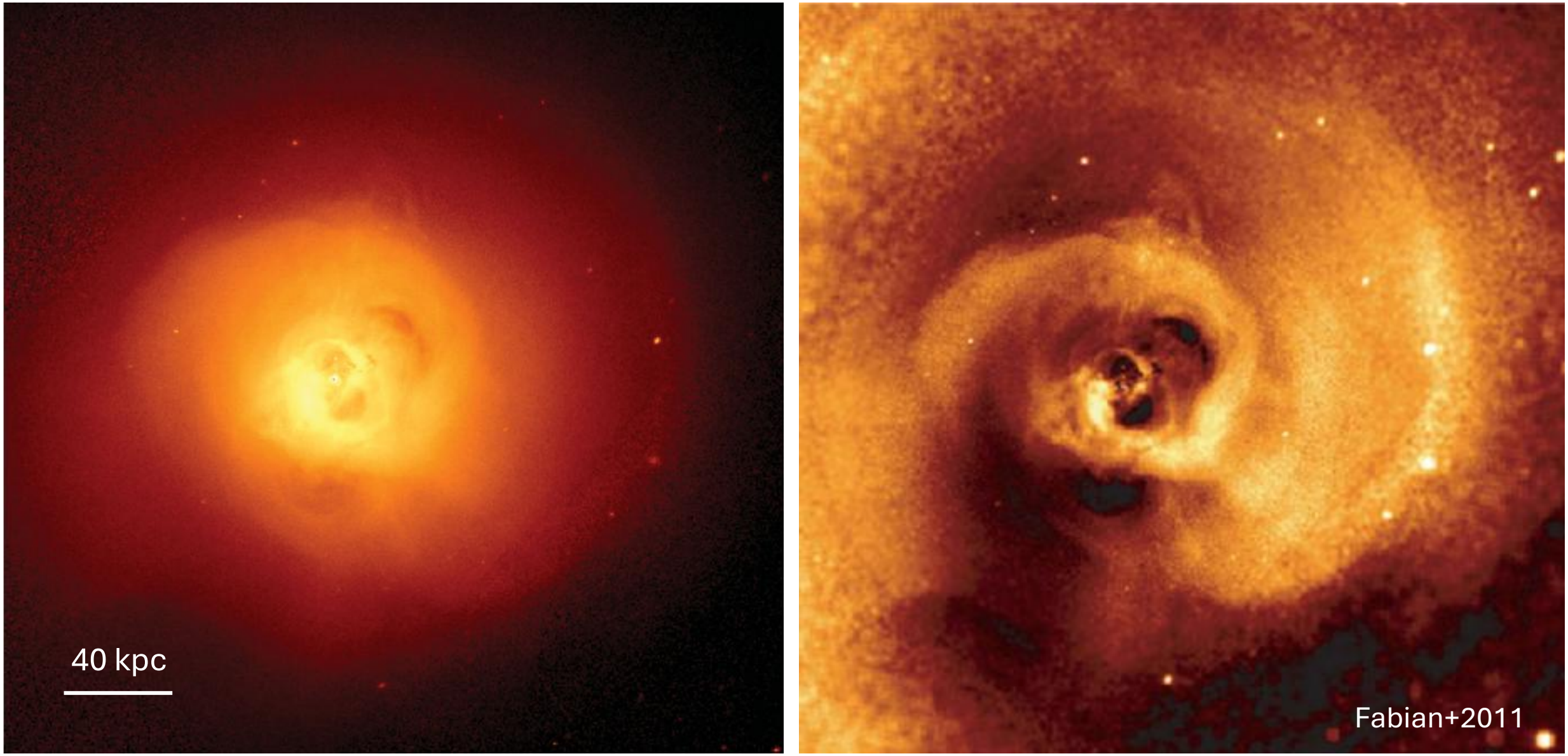
The power needed to inflate the bubbles is mostly sufficient to offset radiative cooling in the cluster core.



Credit: X-ray: NASA/CXC/U.Waterloo/C.Kirkpatrick et al.;
Radio: NSF/NRAO/VLA; Optical: CFHT/DSS

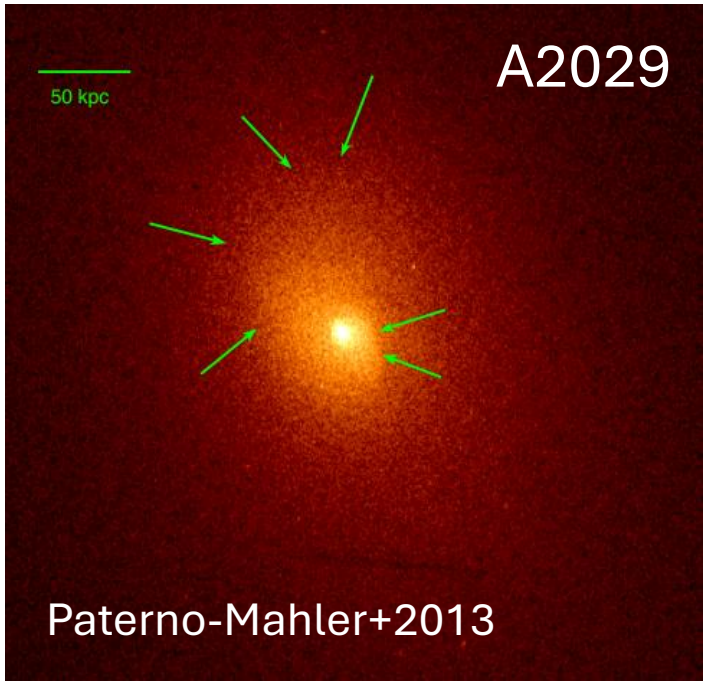


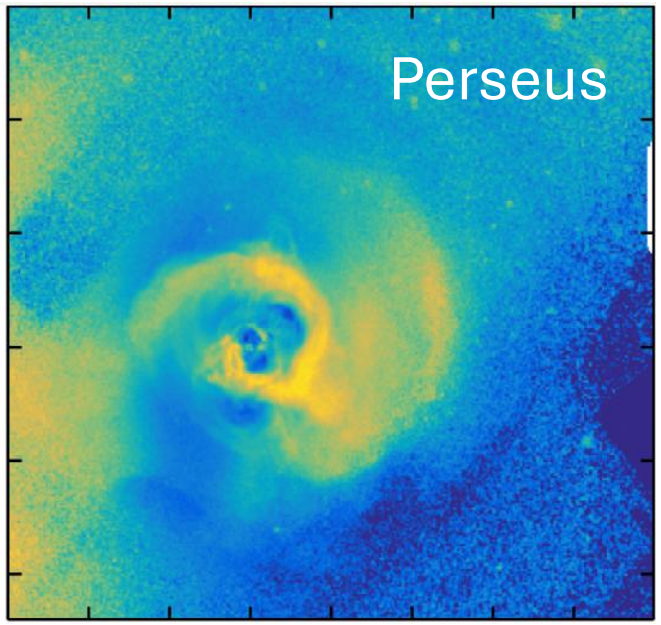
High-resolution Chandra X-ray image of the Perseus cluster

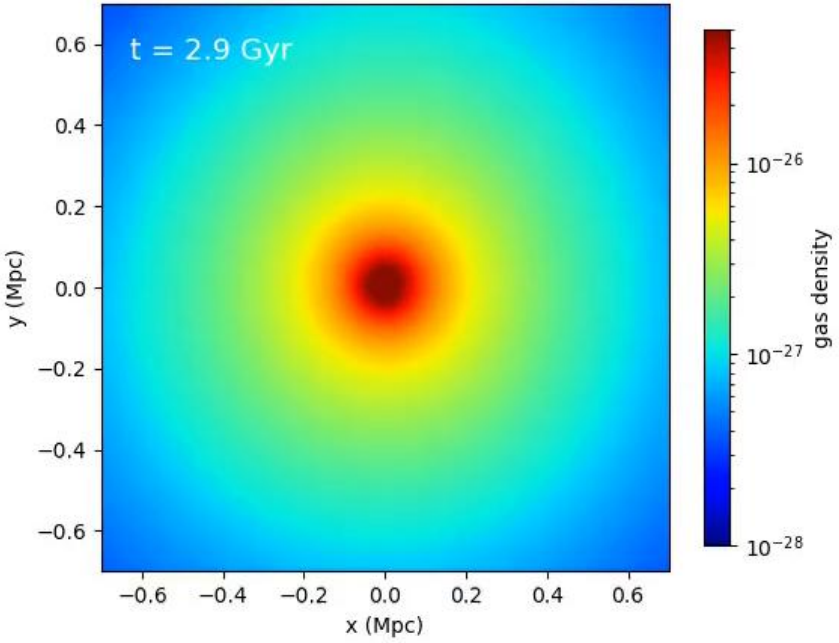


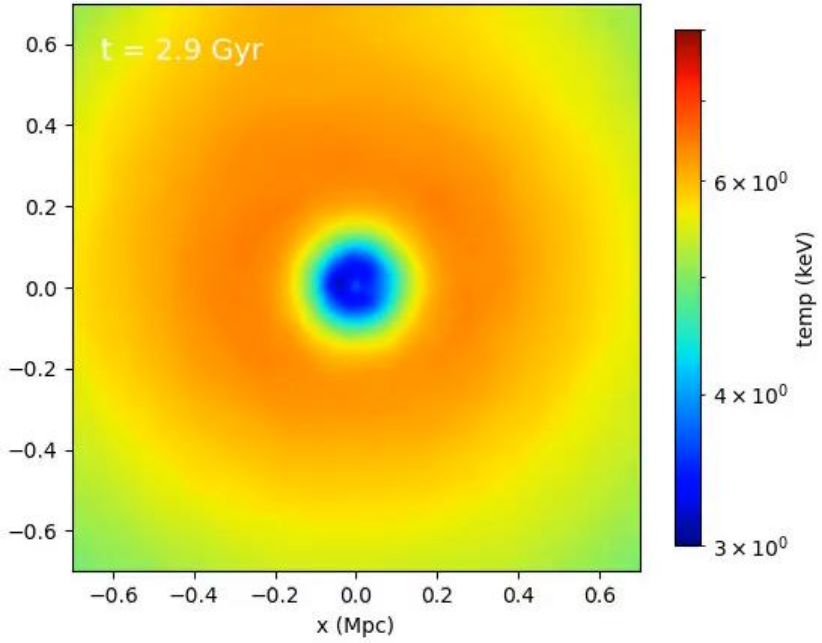
Sloshing: oscillations in the stratified atmosphere

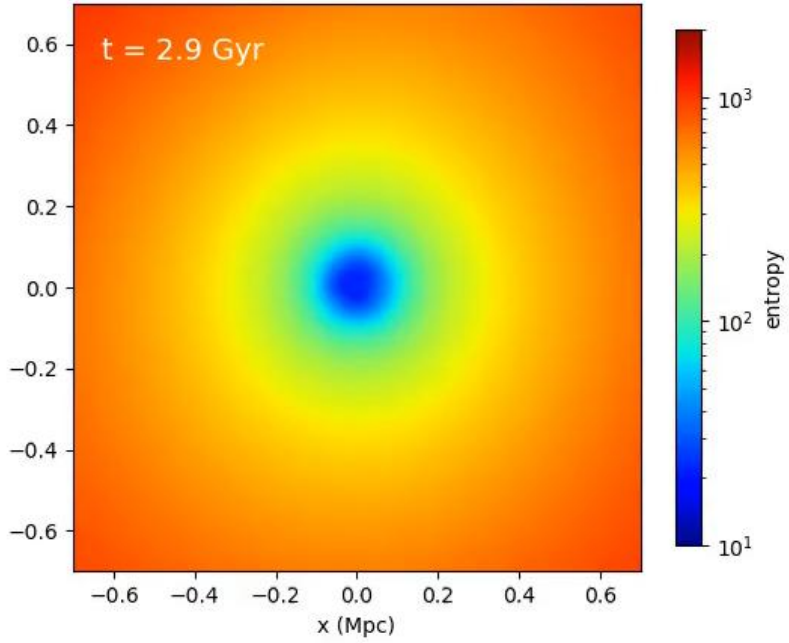




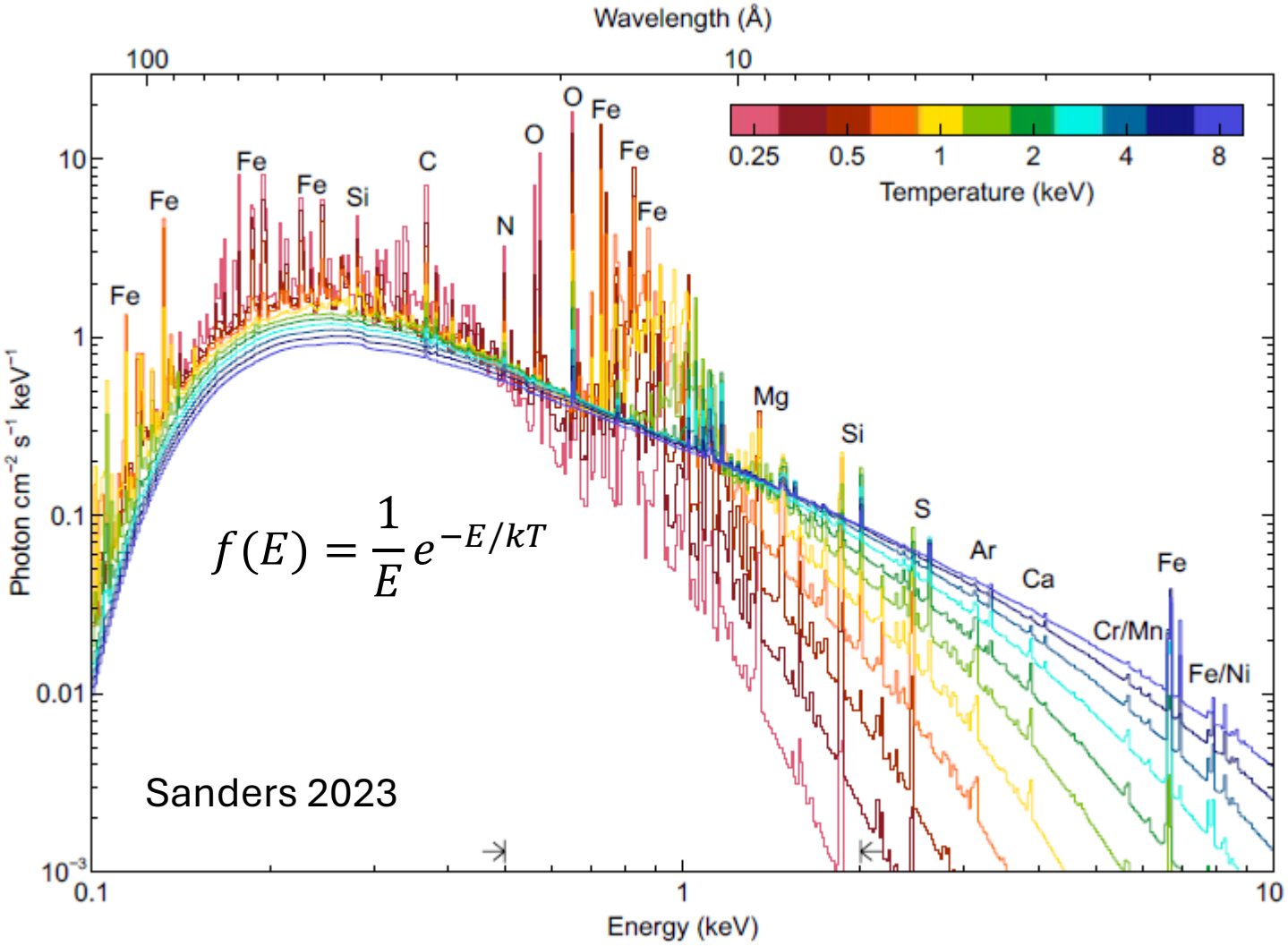




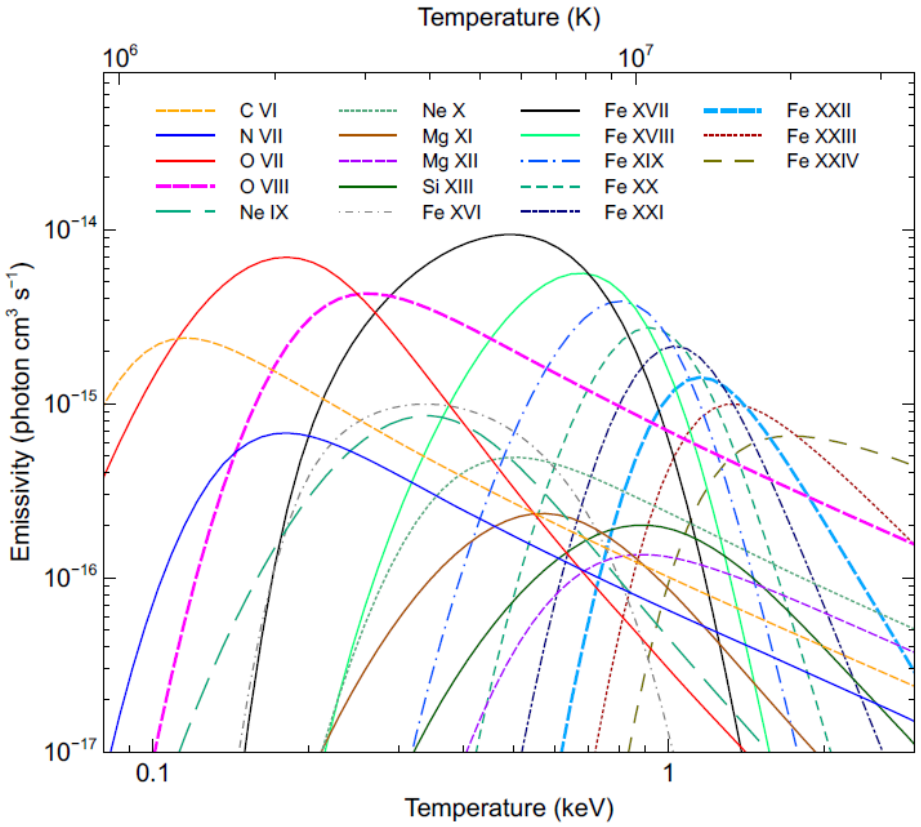




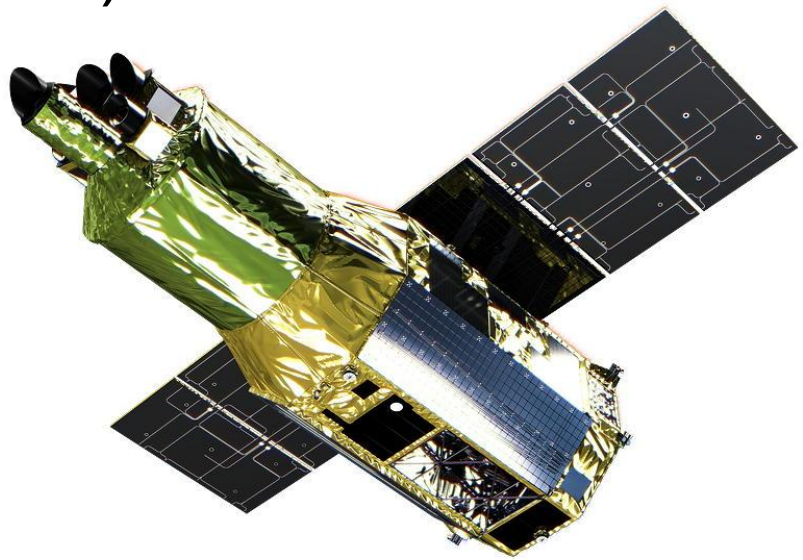
High-resolution X-ray spectroscopy (IFU in X-ray band)



Bremsstrahlung + collisional excitation

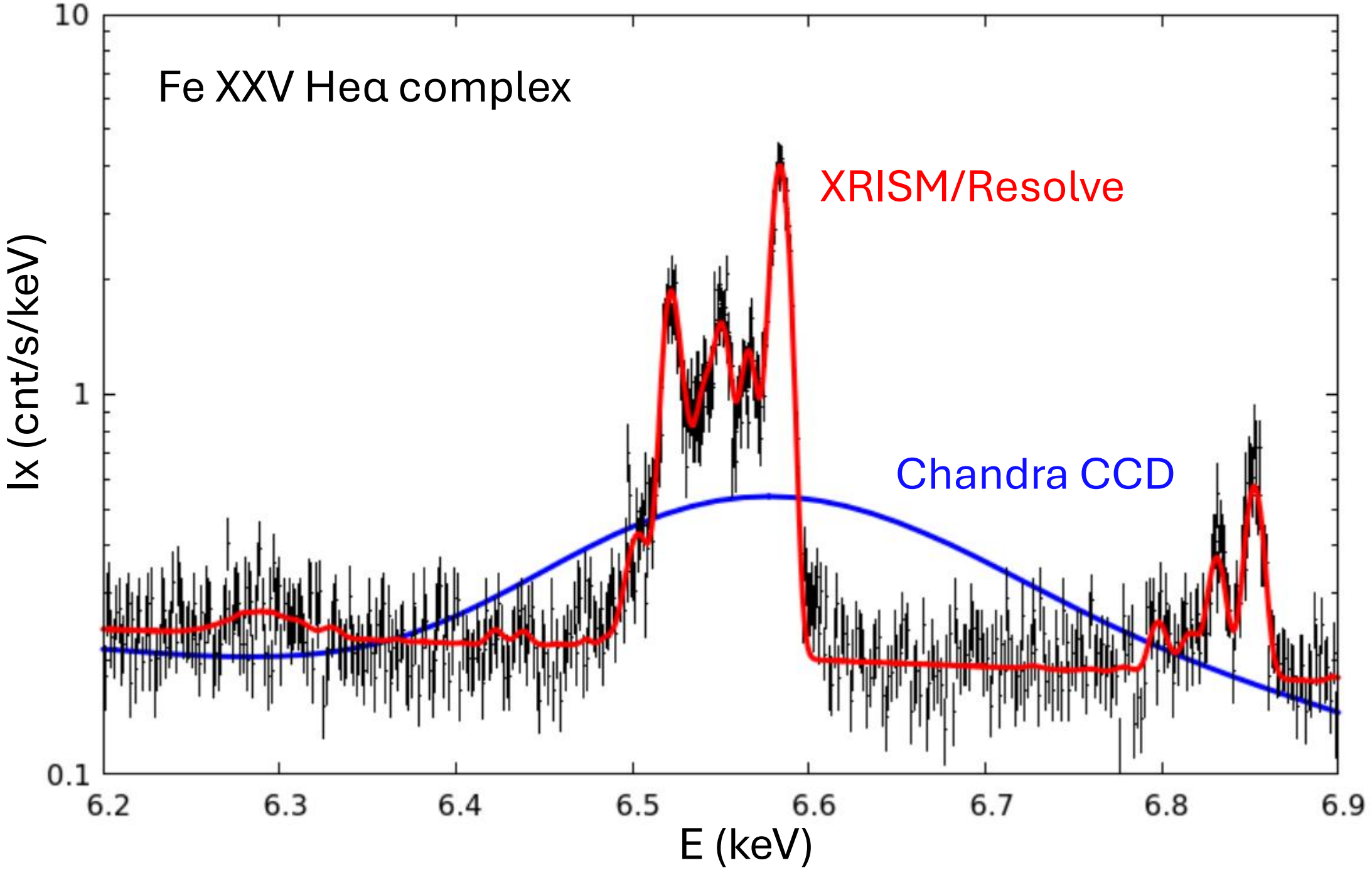


X-ray Imaging and Spectroscopy Mission (XRISM)

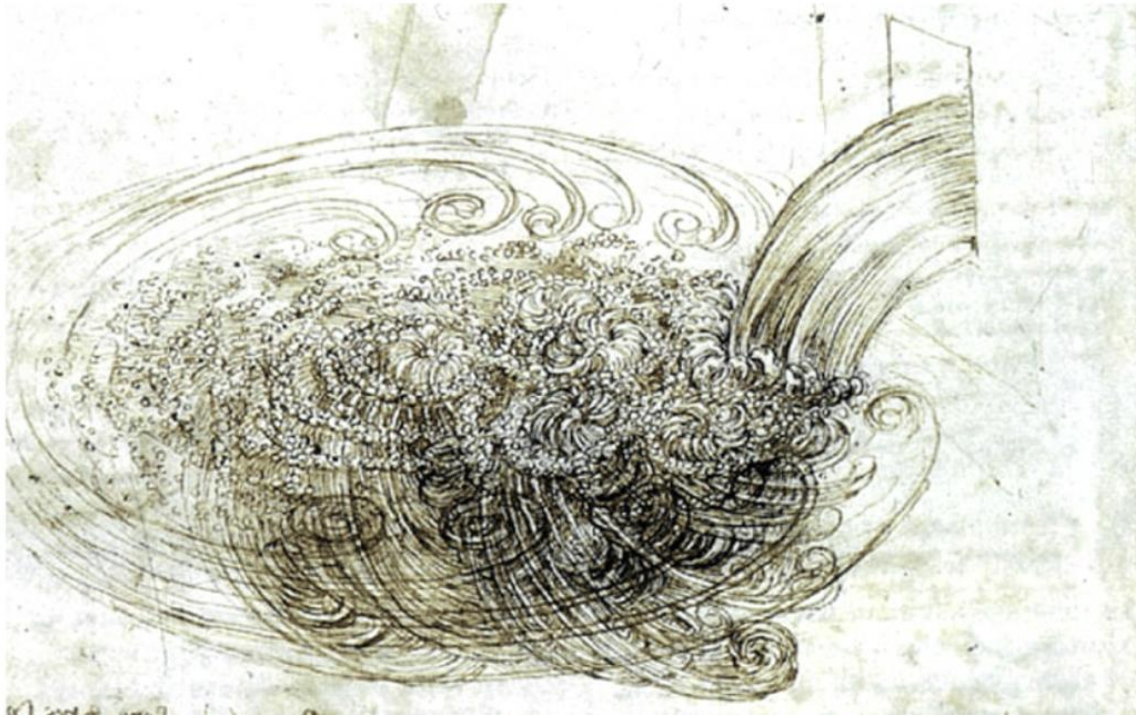


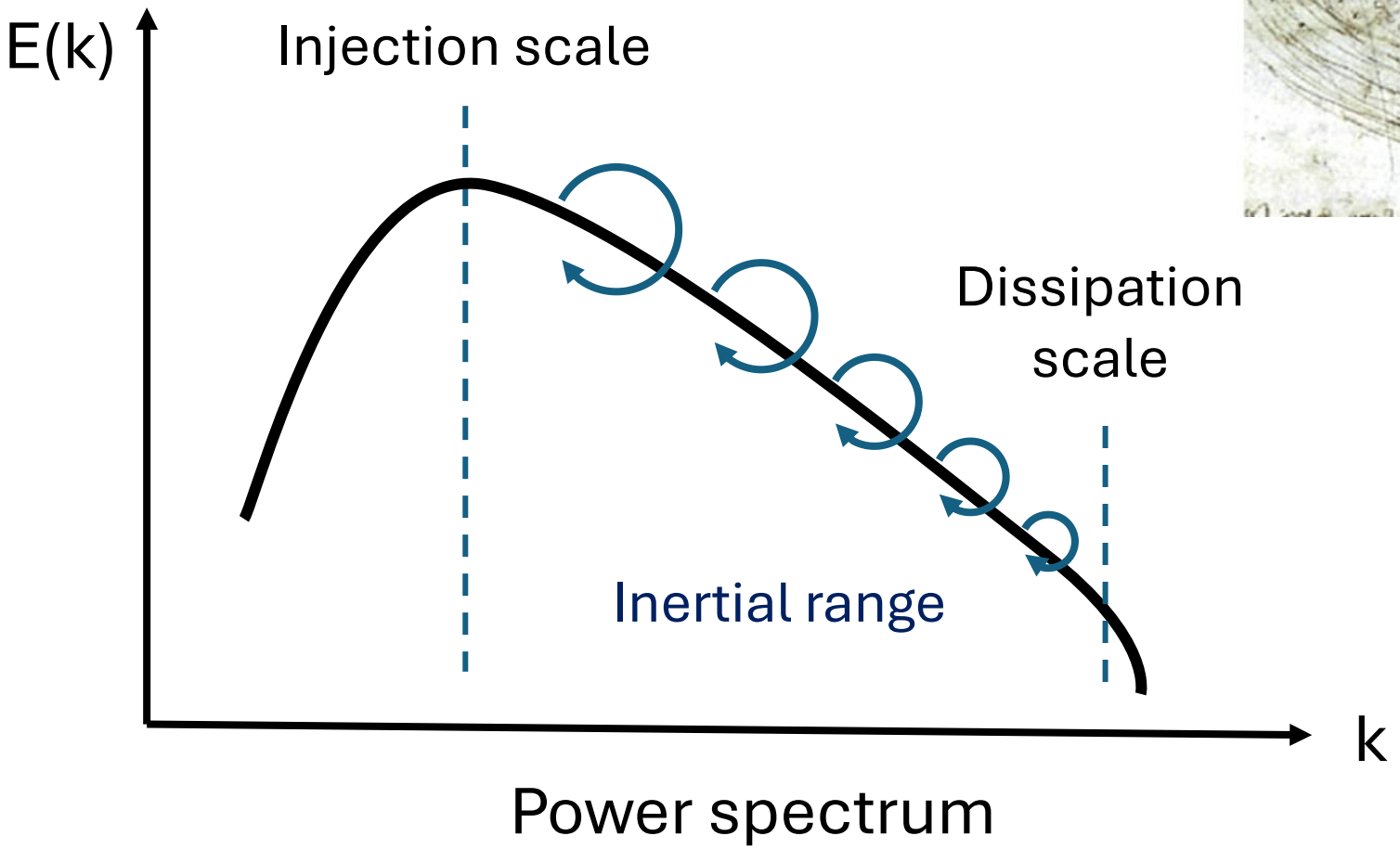
- Launch: Sep 7, 2023
- First light observations (Nov/Dec 2023)
- Feb 2024 – Aug 2024: In-flight calibration and Performance Verification (PV) phases
- Aug 2024: General Observer (GO) phase starts




Fe XXV Heα complex
XRISM/Resolve
Chandra CCD
10
1
0.1
Ix (cnt/s/keV)
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
E (keV)

Velocities and their spatial scales





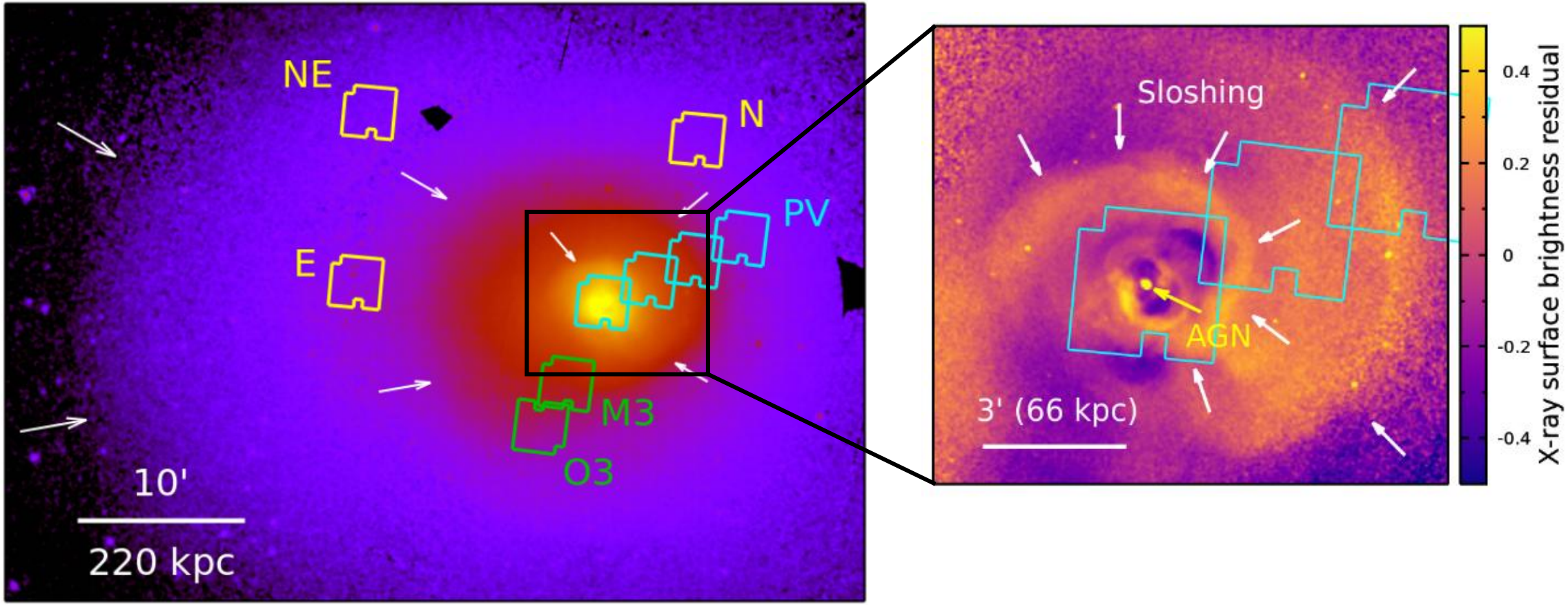
Energy dissipation rate

$$\varepsilon \propto \frac{u^3}{\ell}$$

The Perseus cluster

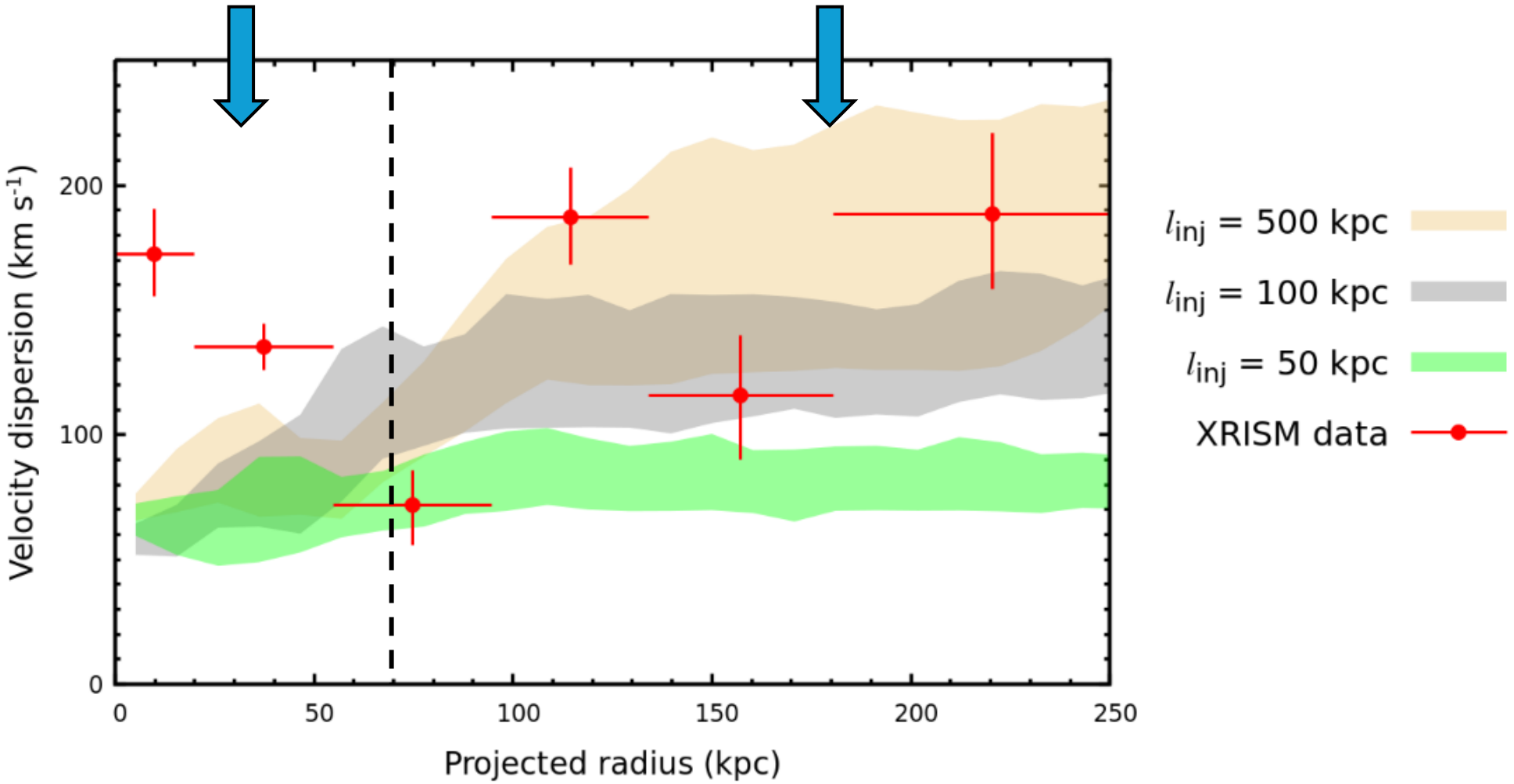
The brightest X-ray cluster

Nearly-relaxed, cool-core cluster, but with rich gaseous structures



AGN feedback

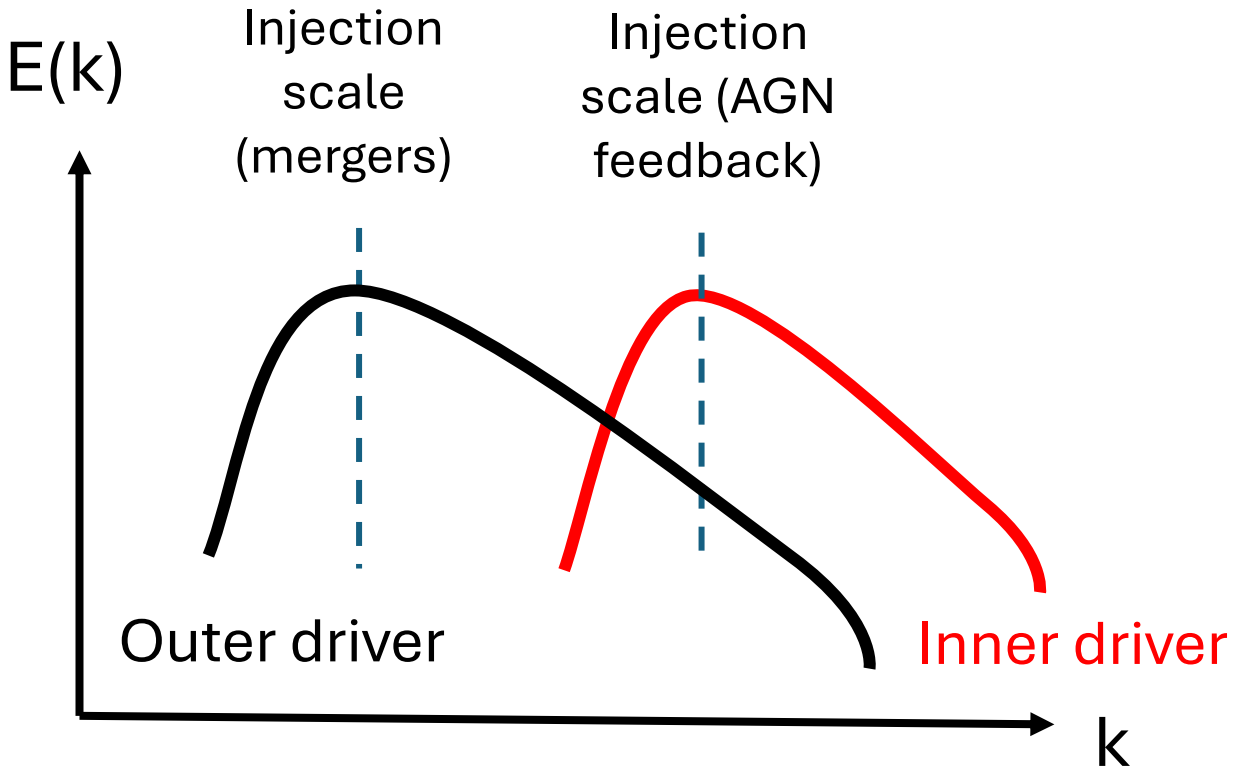
Cosmological environment (mergers)

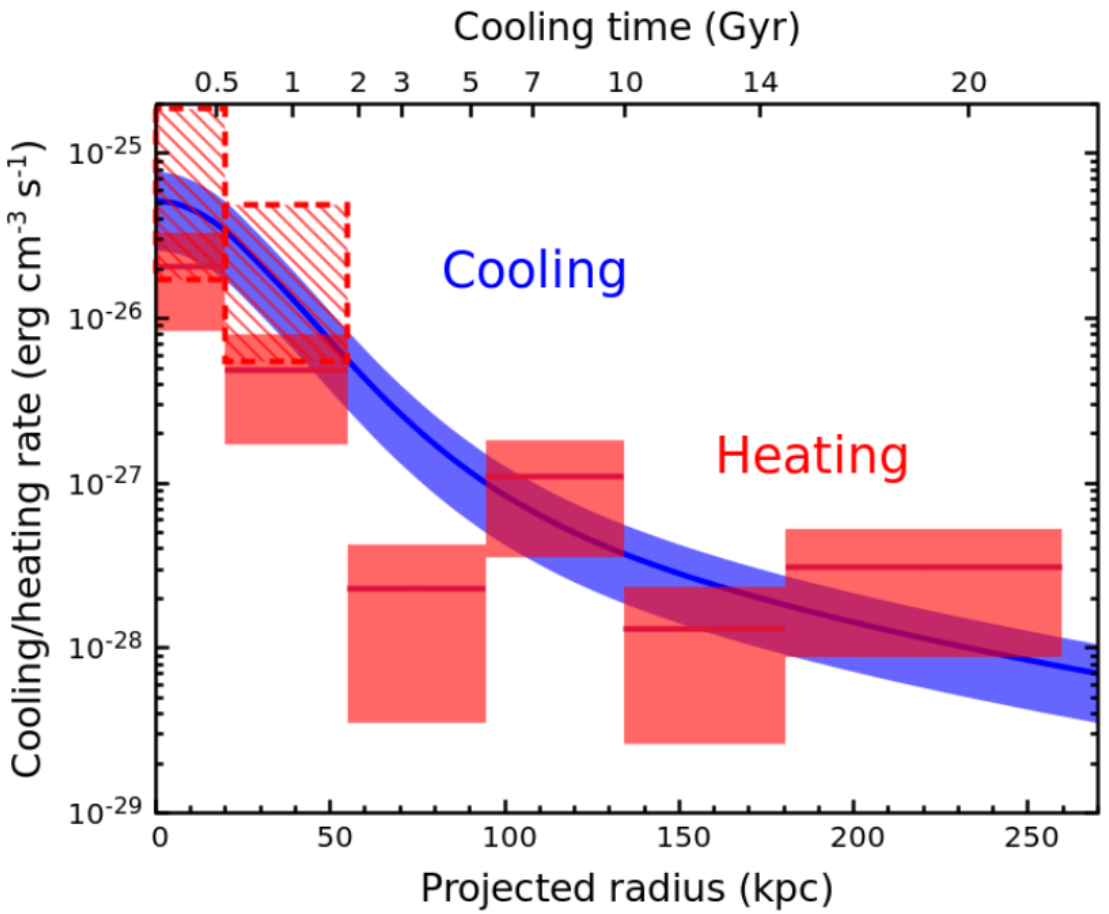


AGN feedback drives turbulence!

Nature 2026, XRISM Collaboration (C. Zhang, A. Heinrich, and I. Zhuravleva corresponding)

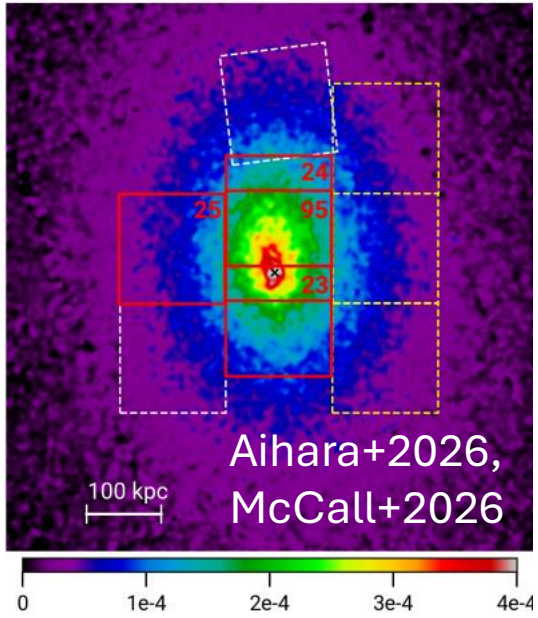
A double-cascade scenario



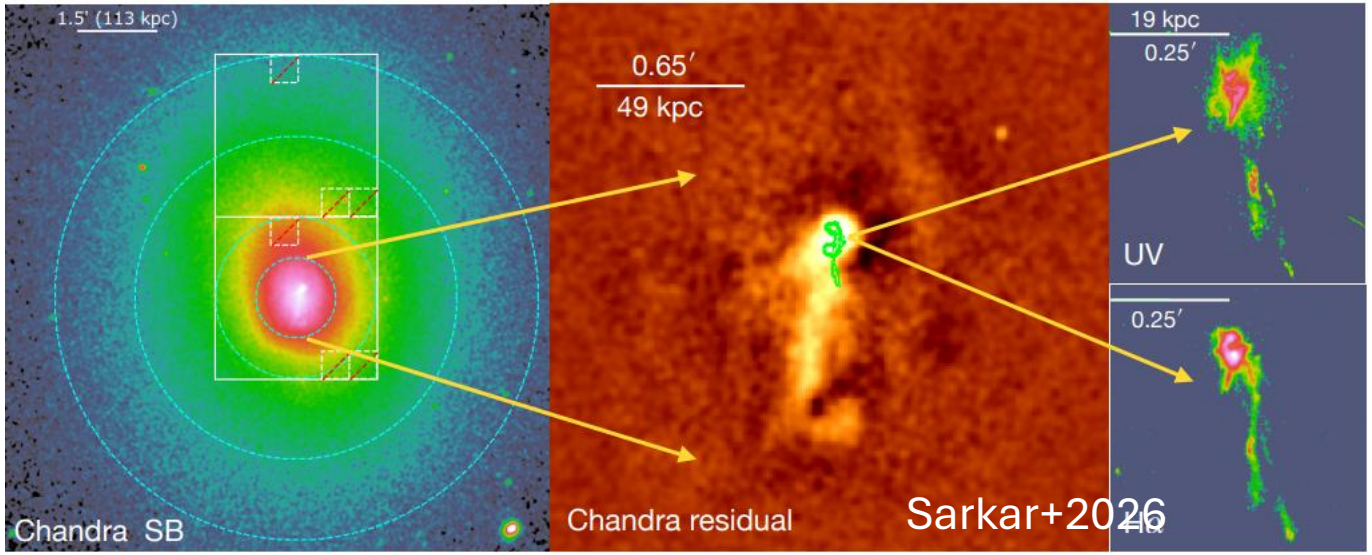


Turbulence likely plays a significant role in AGN feedback!

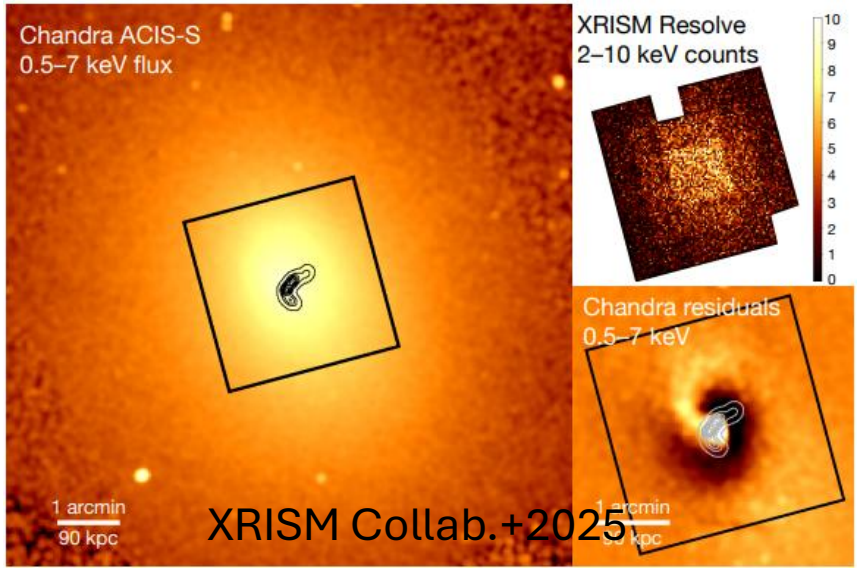
A3571: merger sloshing, no AGN feedback



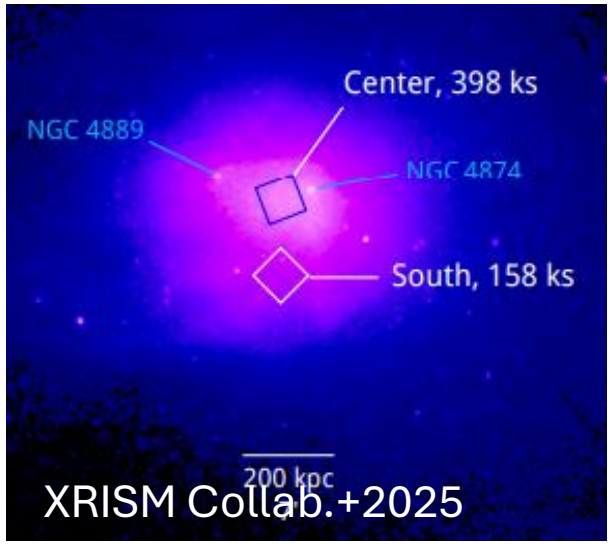
A1795: strong AGN feedback, no merger



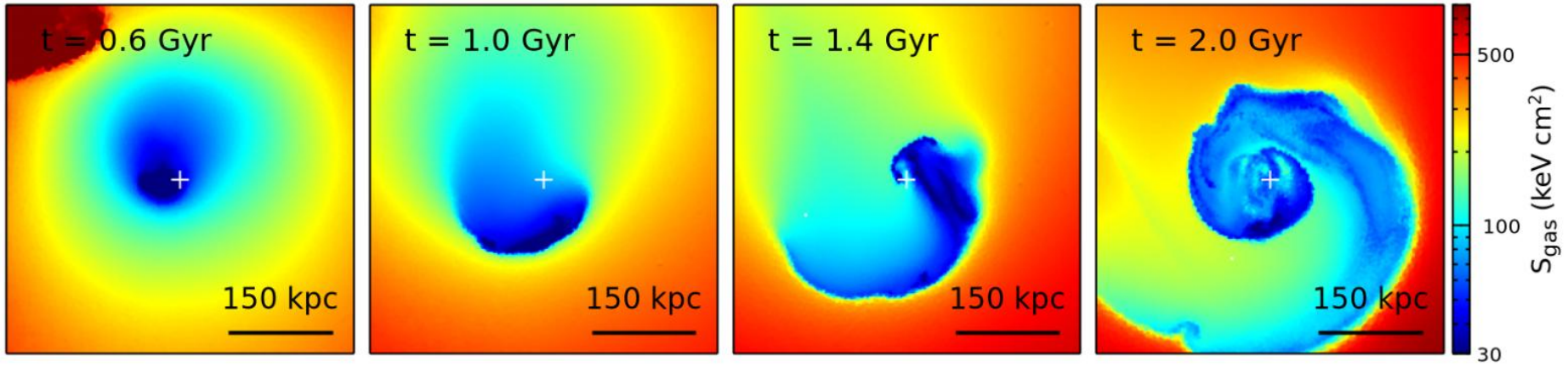
A2029: both AGN feedback and sloshing, but weak turbulence

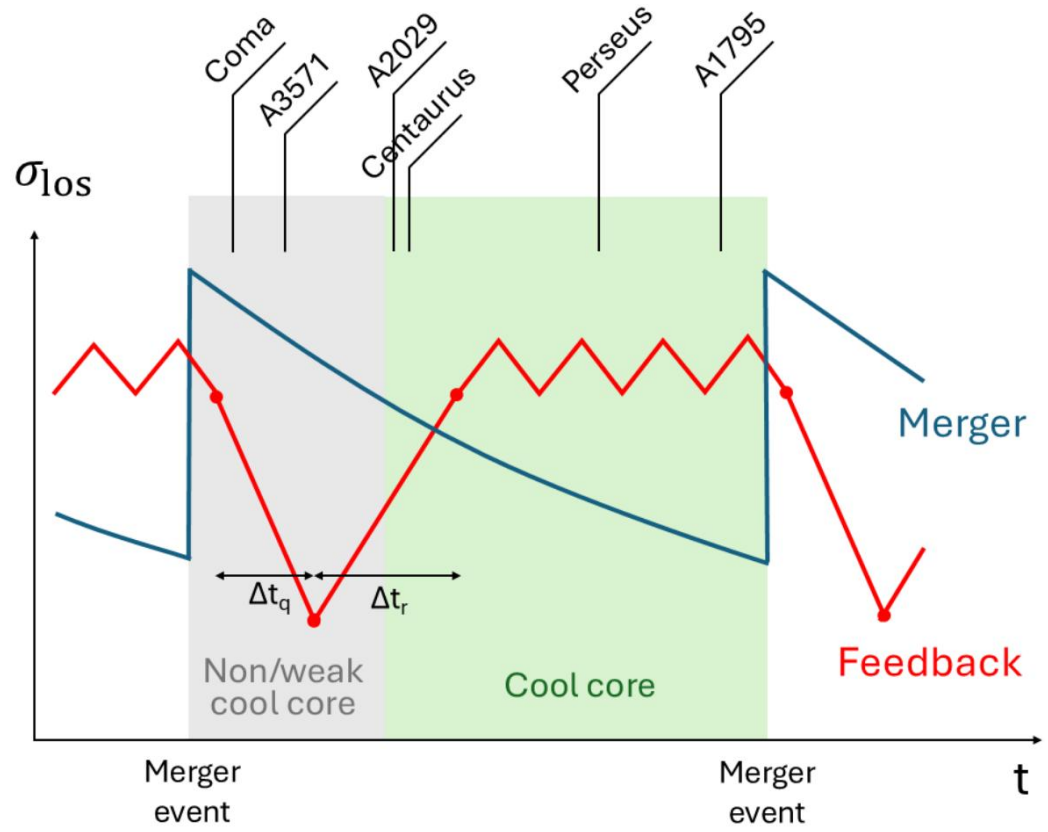


Coma: merger, non-cool core



A unified picture

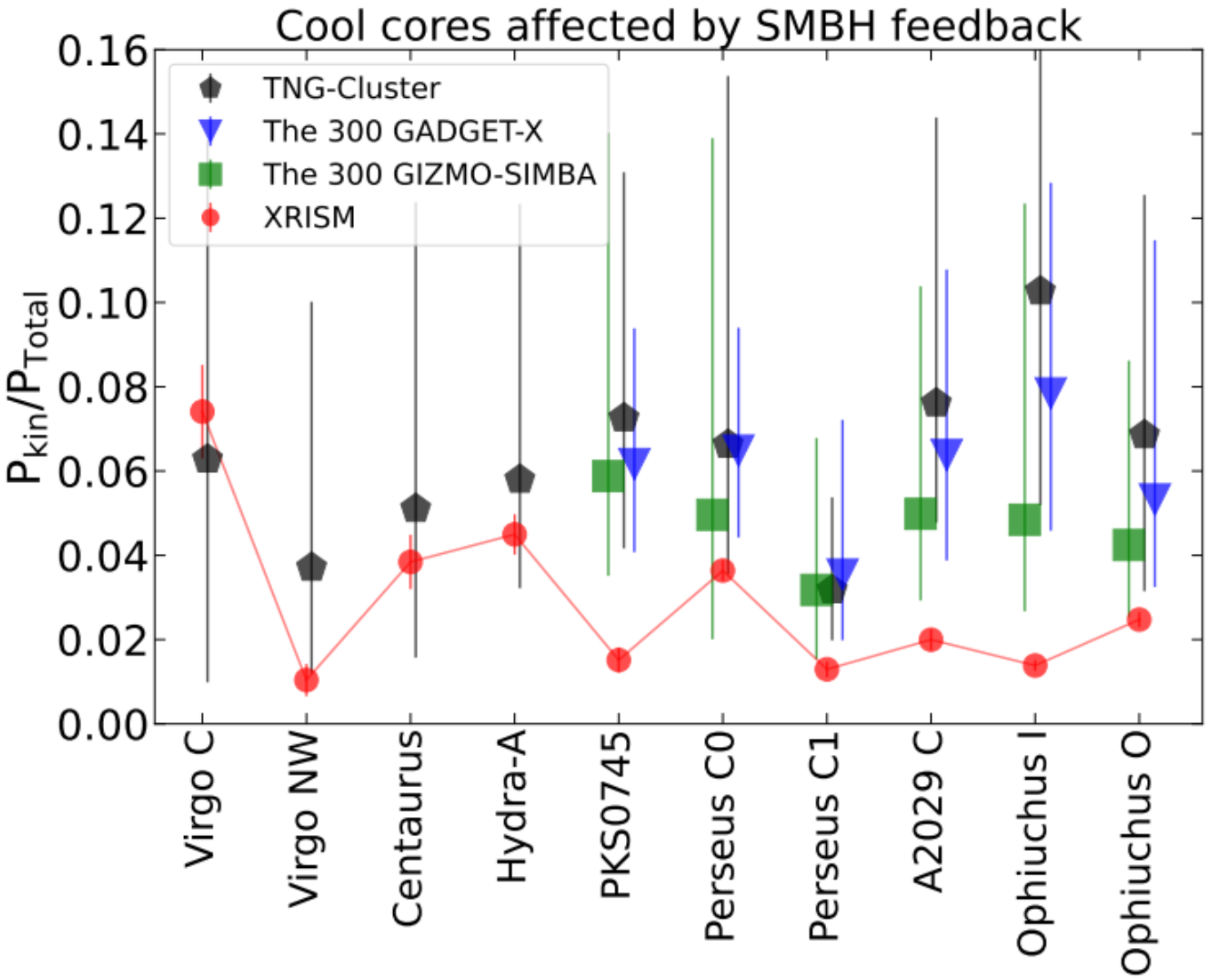




Zhang+ in prep.

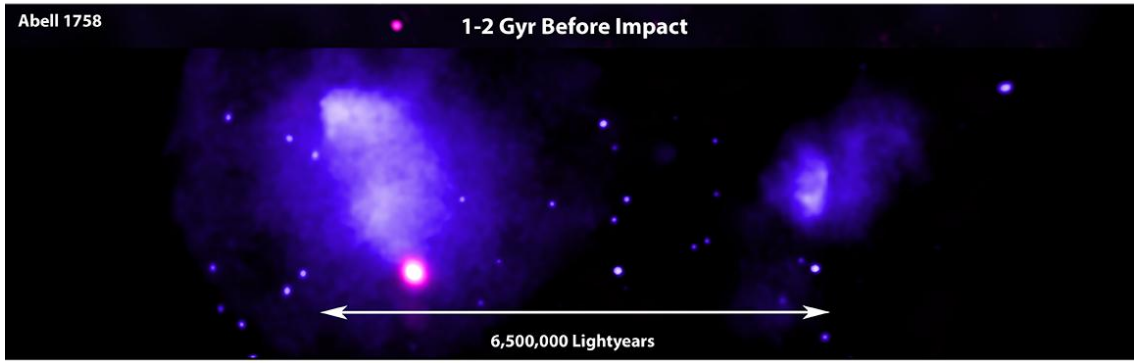
Nonthermal pressure fraction

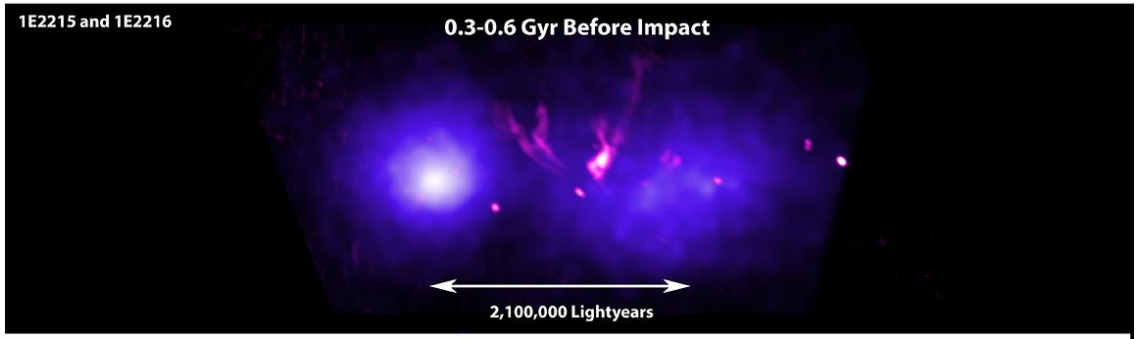
$$f_{\rm nth}(r) = \frac{P_{\rm nth}(r)}{P_{\rm gas}(r) + P_{\rm nth}(r)}$$

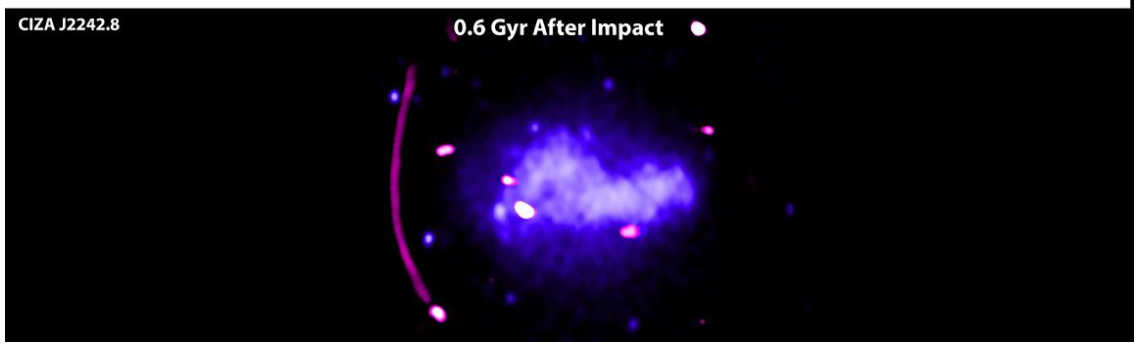


XRISM Collab. 2025

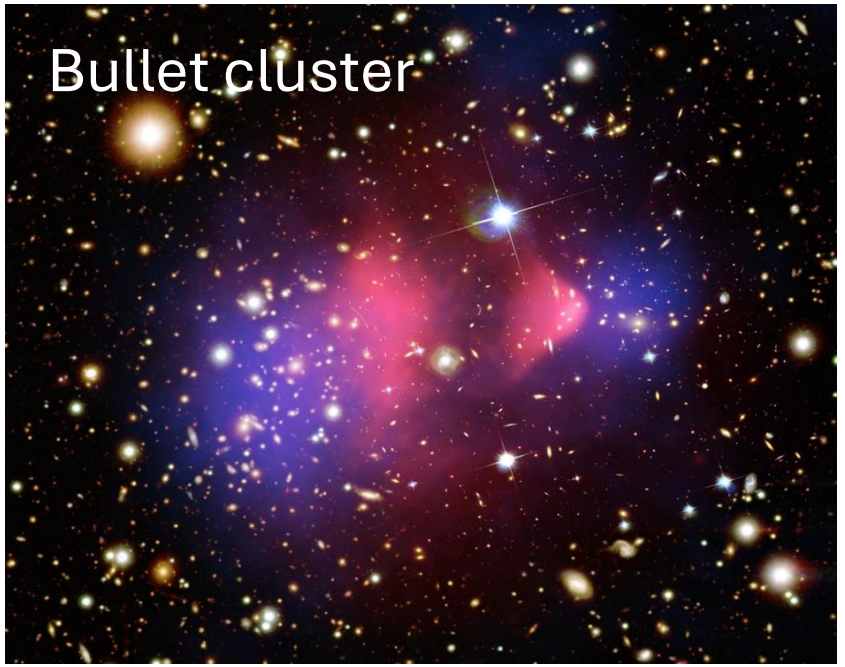


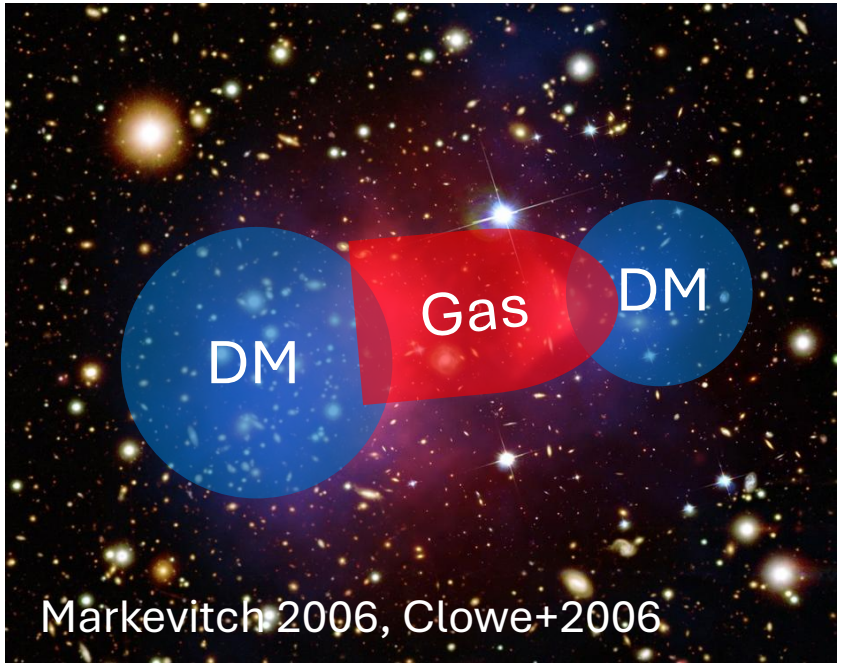




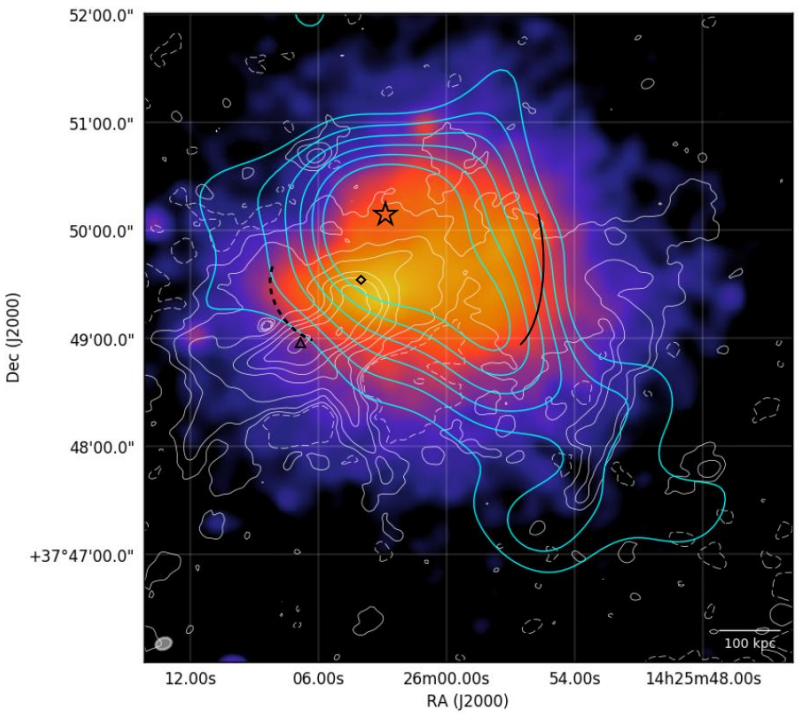


X-ray: NASA/CXC/RIKEN/ L. Gu et al; Radio: NCRA/TIFR/GMRT; Optical: SDSS

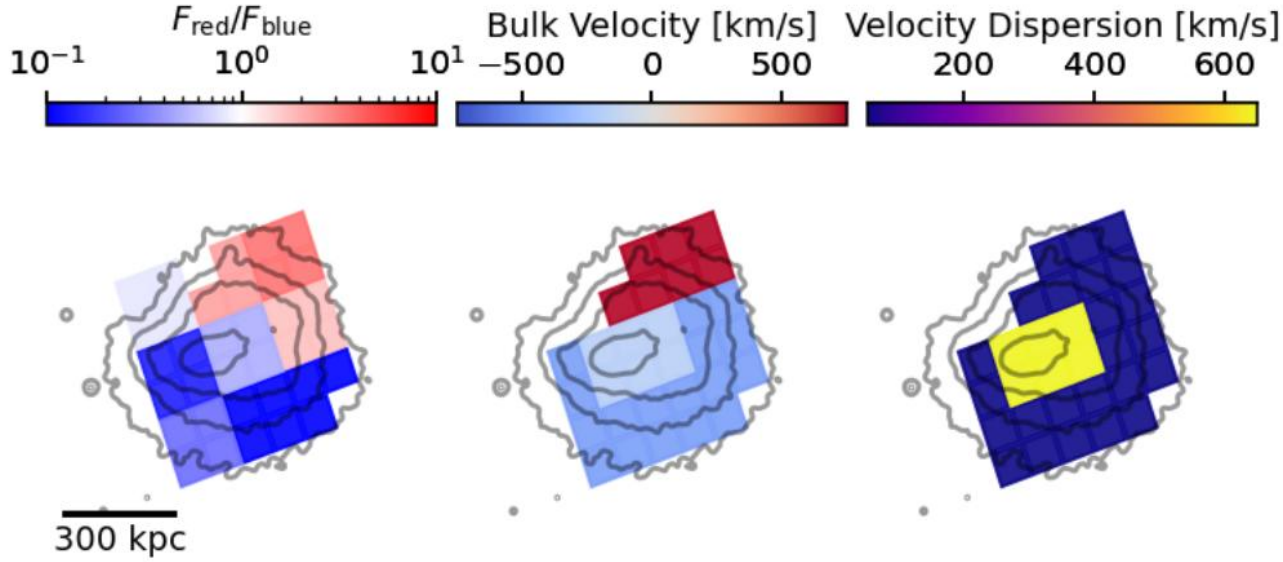




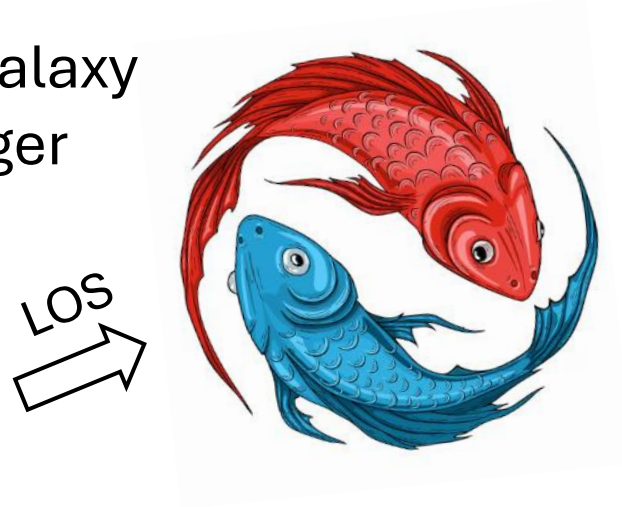
Abell 1914

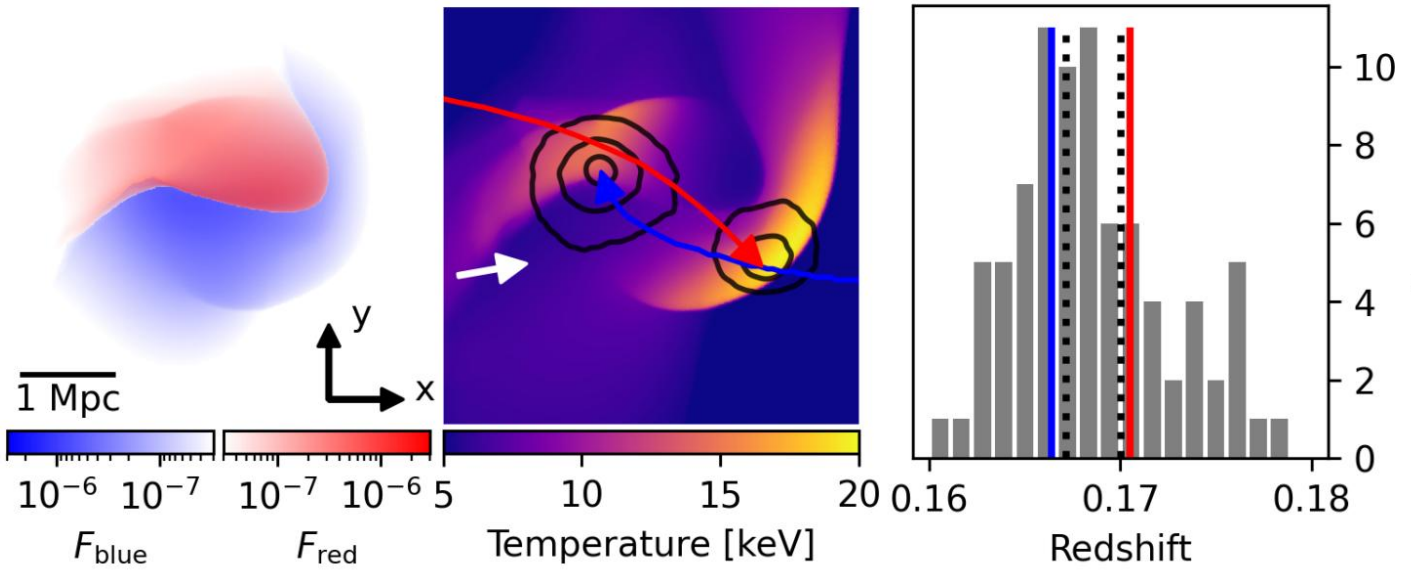


~1100 km/s pairwise velocity

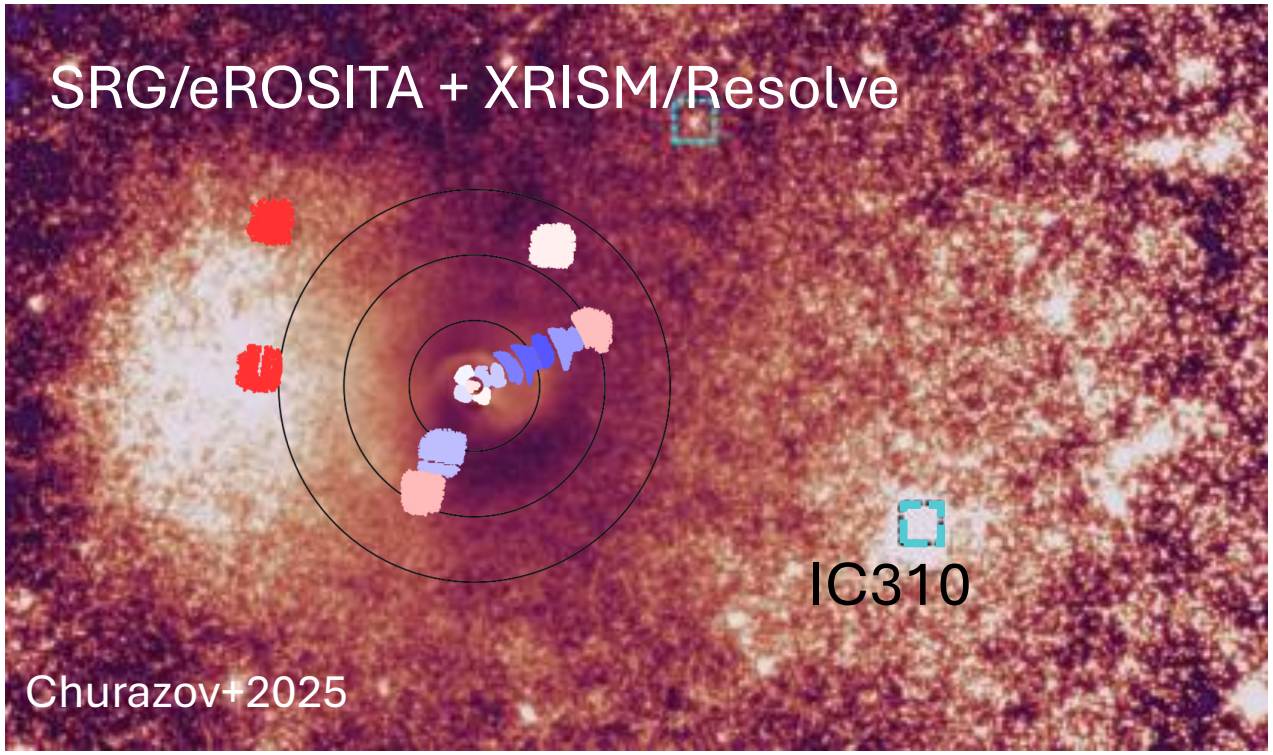


A Yin-Yang galaxy cluster merger

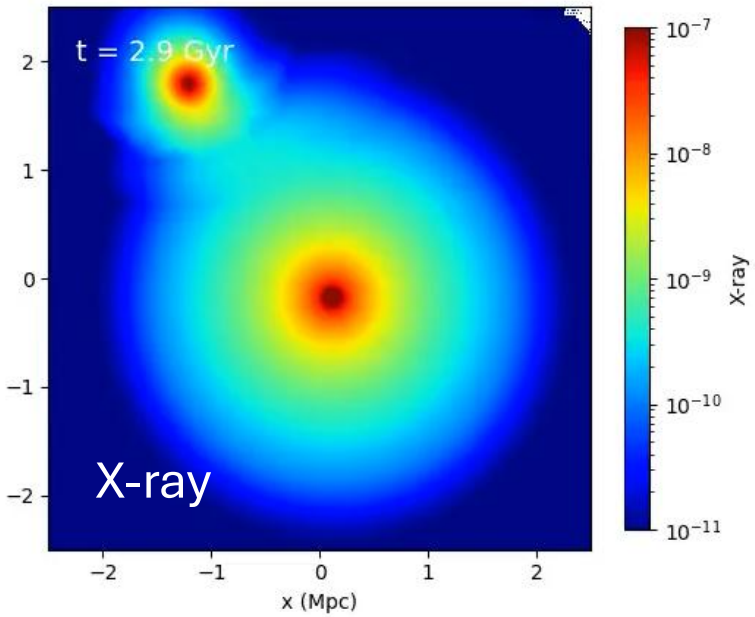


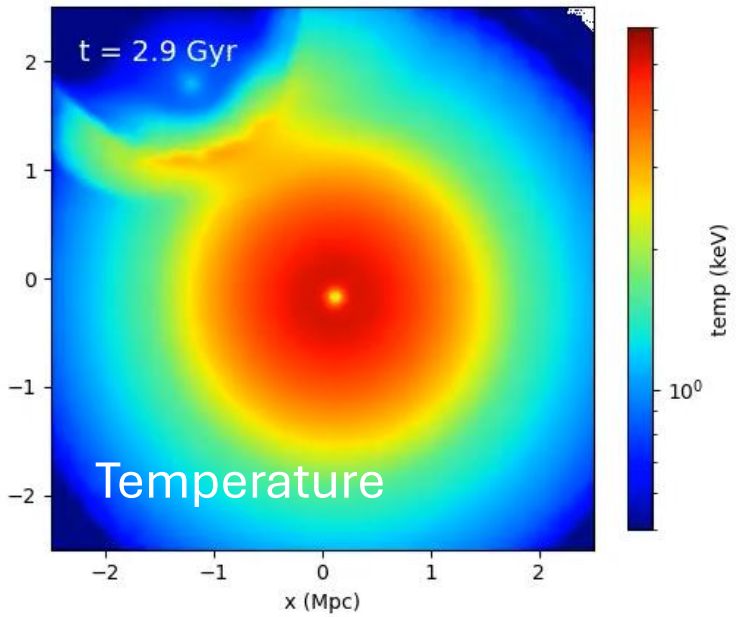


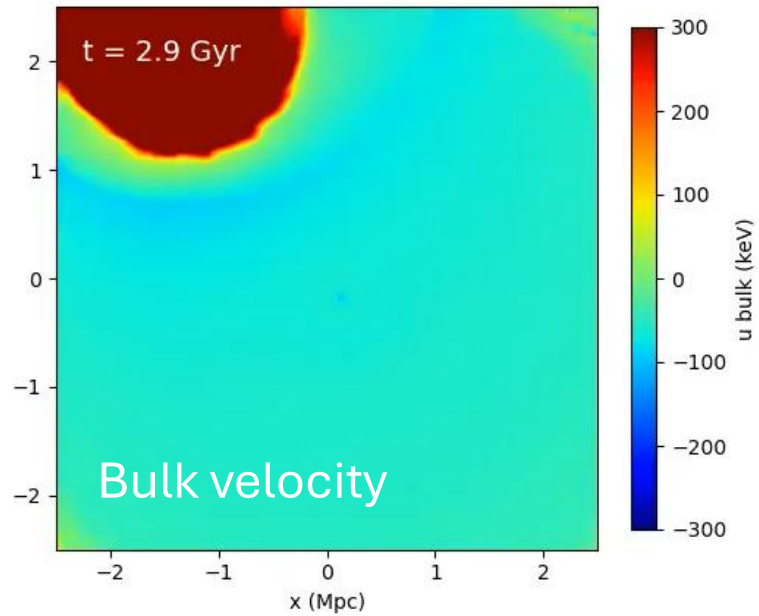
Heinrich+2025



At least two energetic mergers since z~1



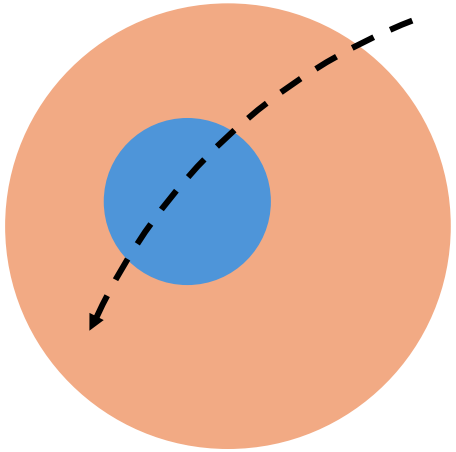


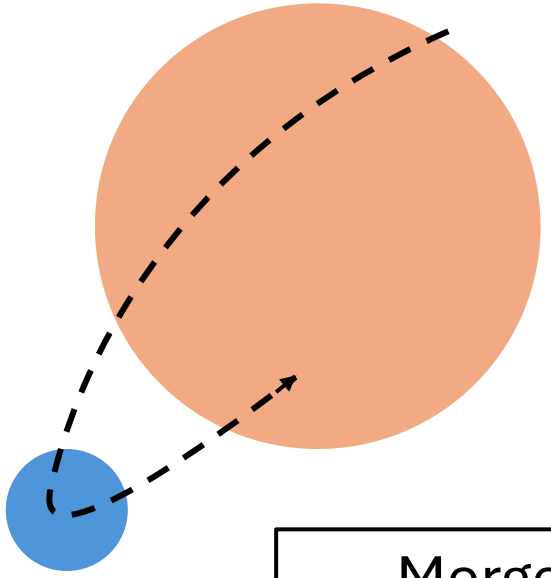


Primary core passage

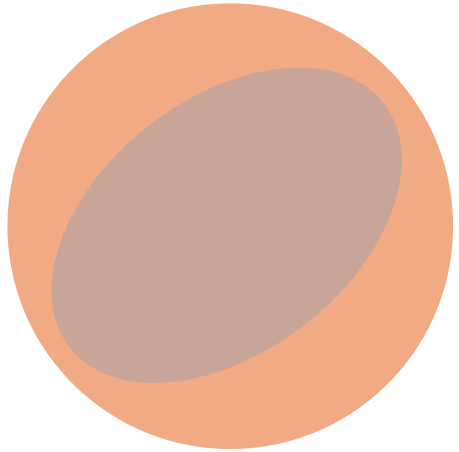
Apocentric passage

Relaxed

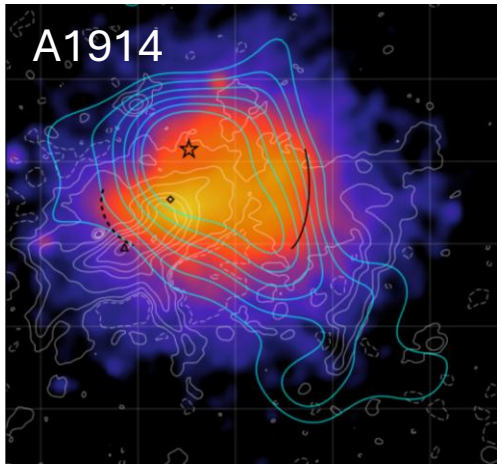


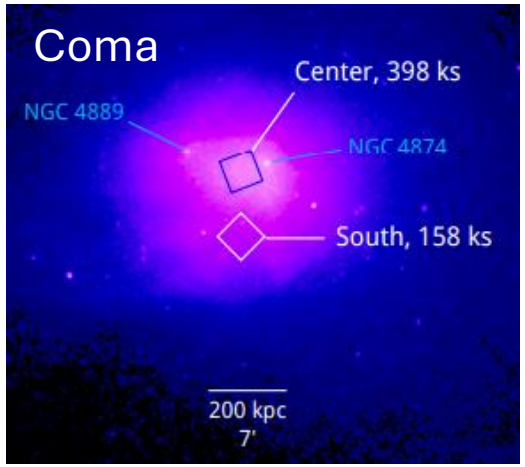


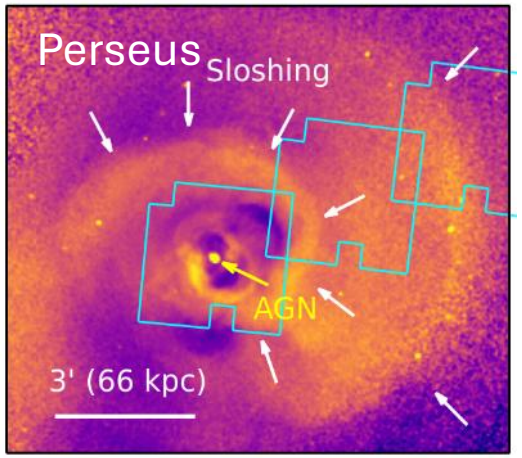
Multiple orbits

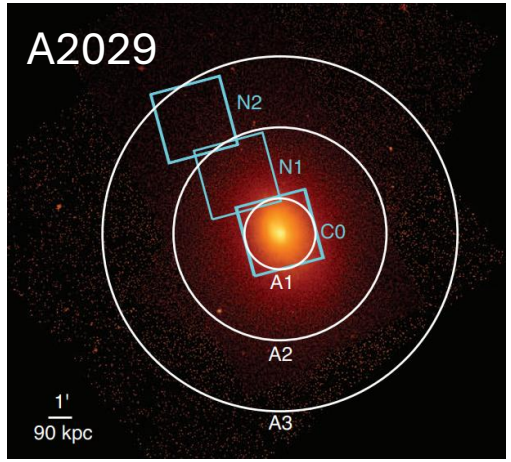


Merger evolution









Take home messages

- The era of high-resolution X-ray spectroscopy has already arrived.
- XRISM has delivered exciting results on ICM turbulence, nonthermal pressure, AGN feedback, radio halos, etc.
- All PV and a large part of GO1 data have been released.

