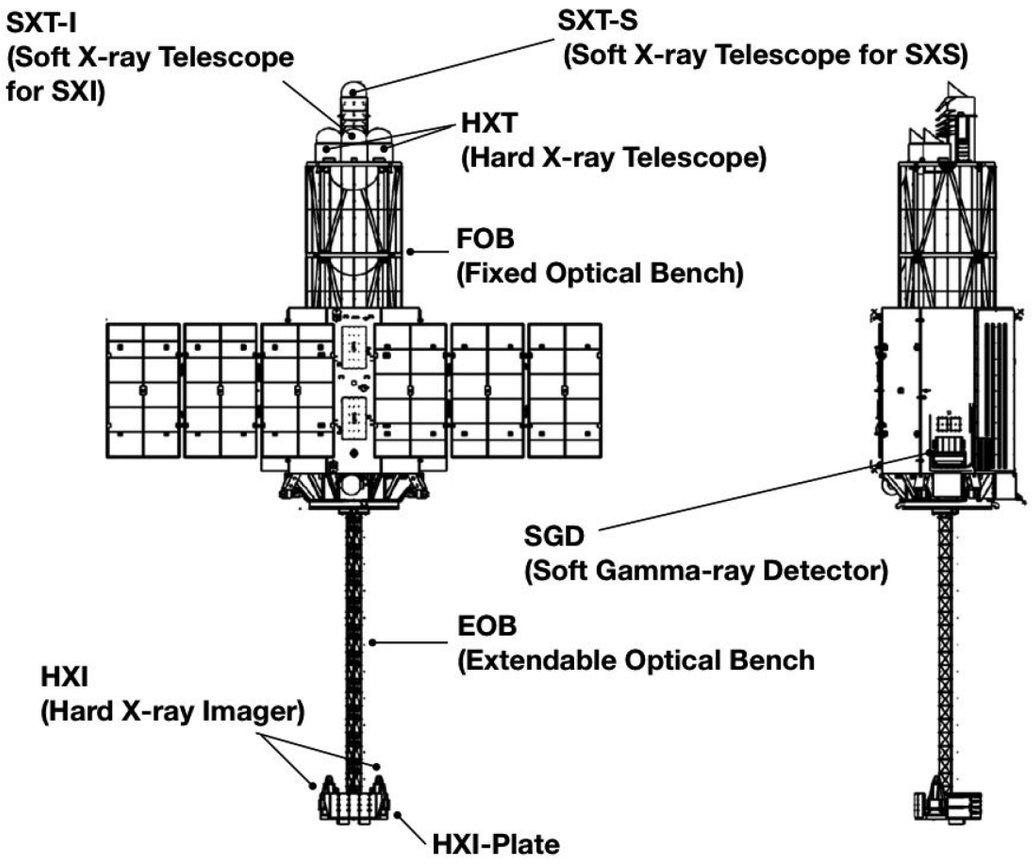
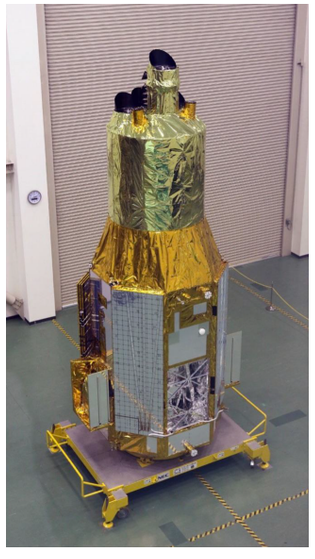
Science with ひとみ (*Hitomi*)

Matteo Guainazzi
[former *Hitomi* Operation Scientist at ISAS/JAXA]

Hitomi in a nutshell

Takahashi et al., 2016, SPIE, 9905, 0UT





Hitomi in the JAXA clean room at Tsukuba

- 6th in a series of X-ray observatories from Japan (a.k.a. ASTRO-H)
- International collaboration of 200+ scientists from Japan/US/Europe/Canada
- Designed for:
  - high-resolution imaging spectroscopy ($\Delta E \leq 5$ eV in 0.3-20 keV energy band)
  - hard X-ray (≤80 keV) focusing optics
  - broad-band coverage up to ~600 keV
- Successfully launched on February 17, 2016
- Critical operation phase completed on February 24, 2016 (extension of the EOB)
- Lost contact on March 26, 2016
- Mission declared lost on April 28, 2016

Hitomi observation plan

Takahashi et al., 2016, SPIE, 9905, 0UT

- Perseus (galaxy cluster): February 25-27, March 4-8
- N132D (Supernova Remnant): March 8-11
- IGRJ16318-4848 ([Be] High-Mass X-ray Binary): March 11-15
- RXJ1856-3754 (Isolated Neutron Star): March 17-19
- G21.5-0.9 (Supernova Remnant): March 19-23
- Crab (Supernova Remnant + pulsar): March 25
- ~~Mkn205 (Active Galactic Nucleus): March 26-…~~

Early science - commissioning and calibration

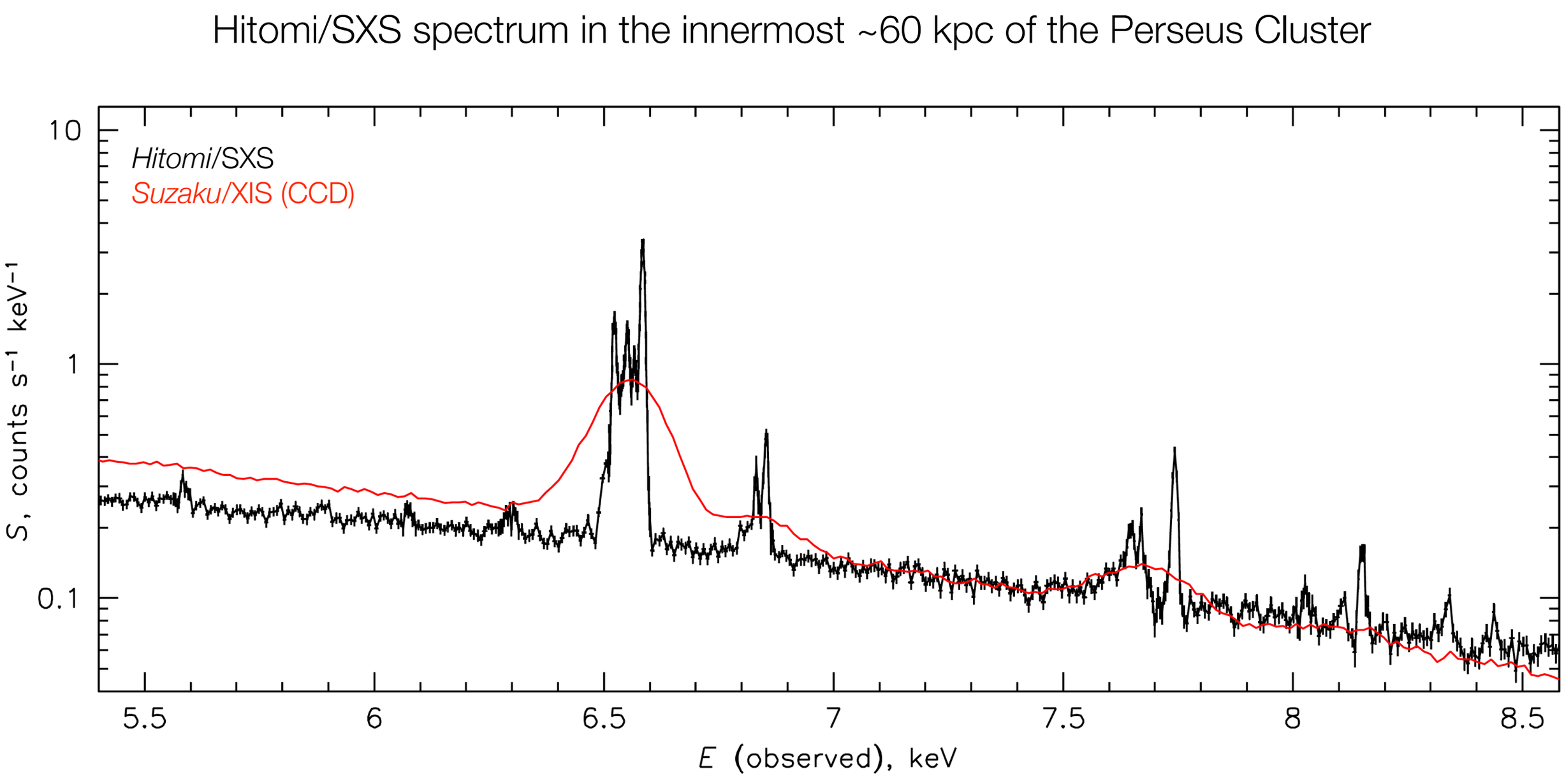
SSW10

LETTER

doi:10.1038/nature18627

The quiescent intracluster medium in the core of the Perseus cluster

The Hitomi collaboration*



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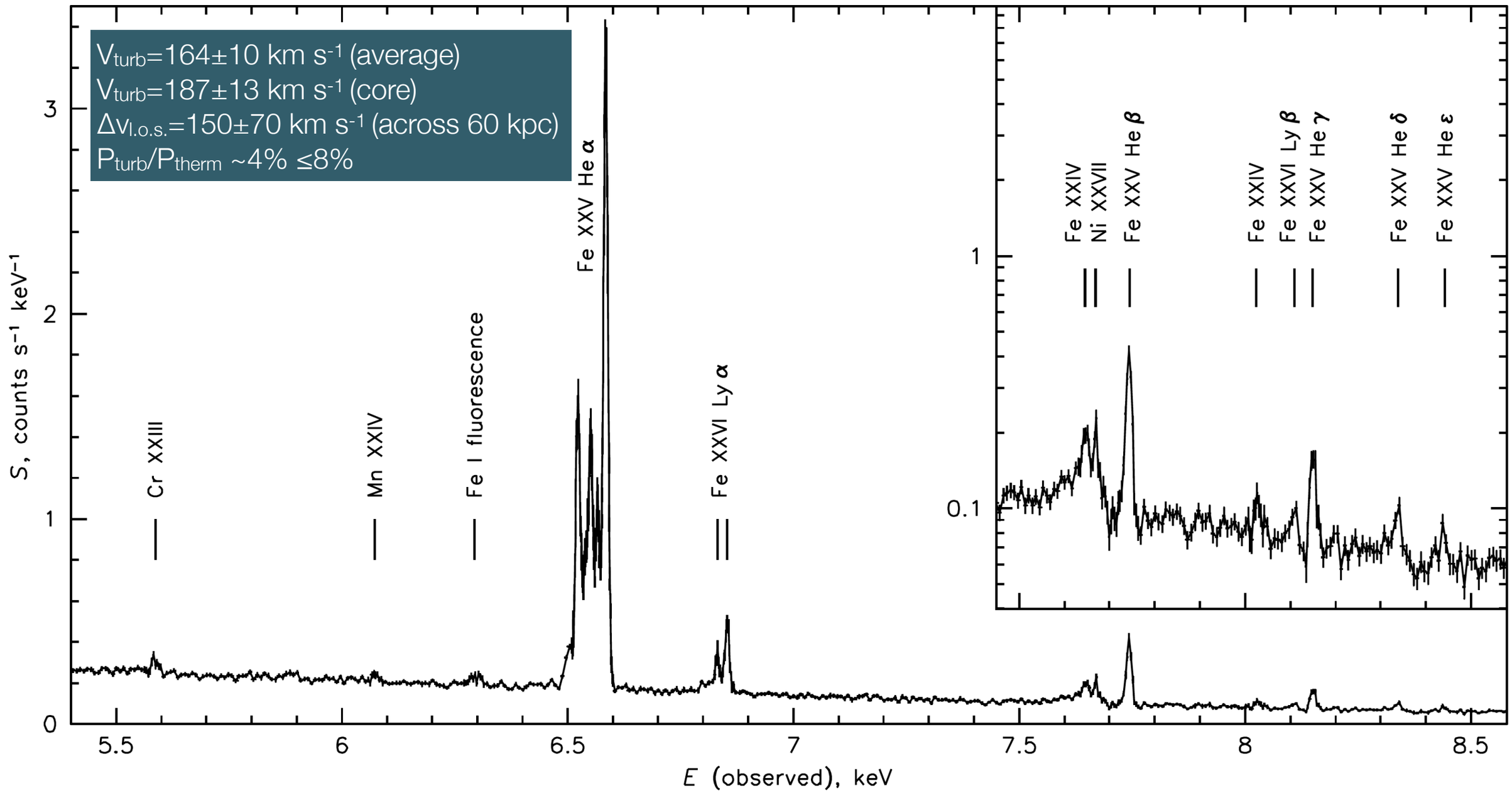

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Why is this important?

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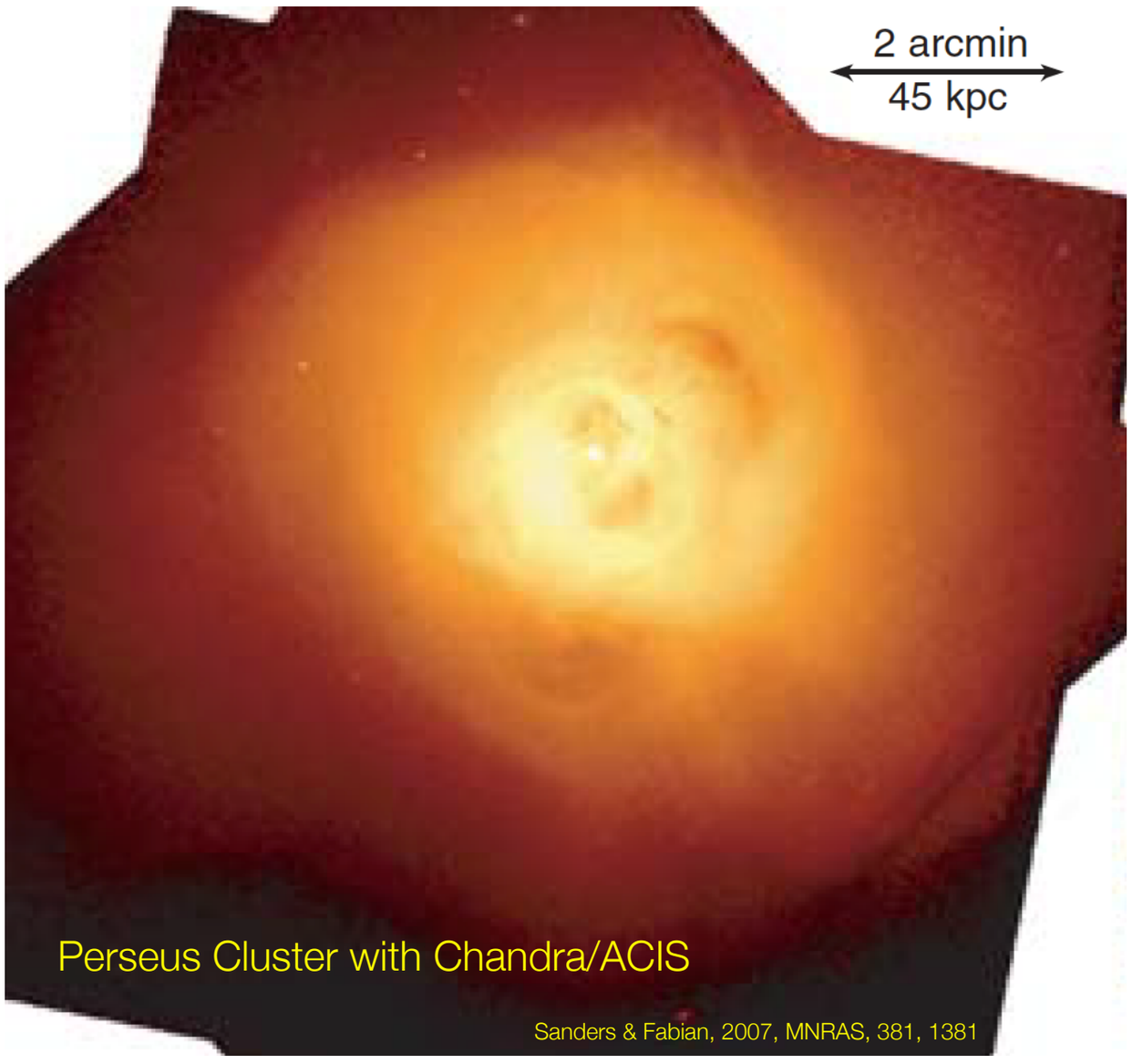
The SXS (non-dispersive micro-calorimeter) is the first X-ray instrument resolving emission lines in extended sources and measuring their Doppler broadening and shifts



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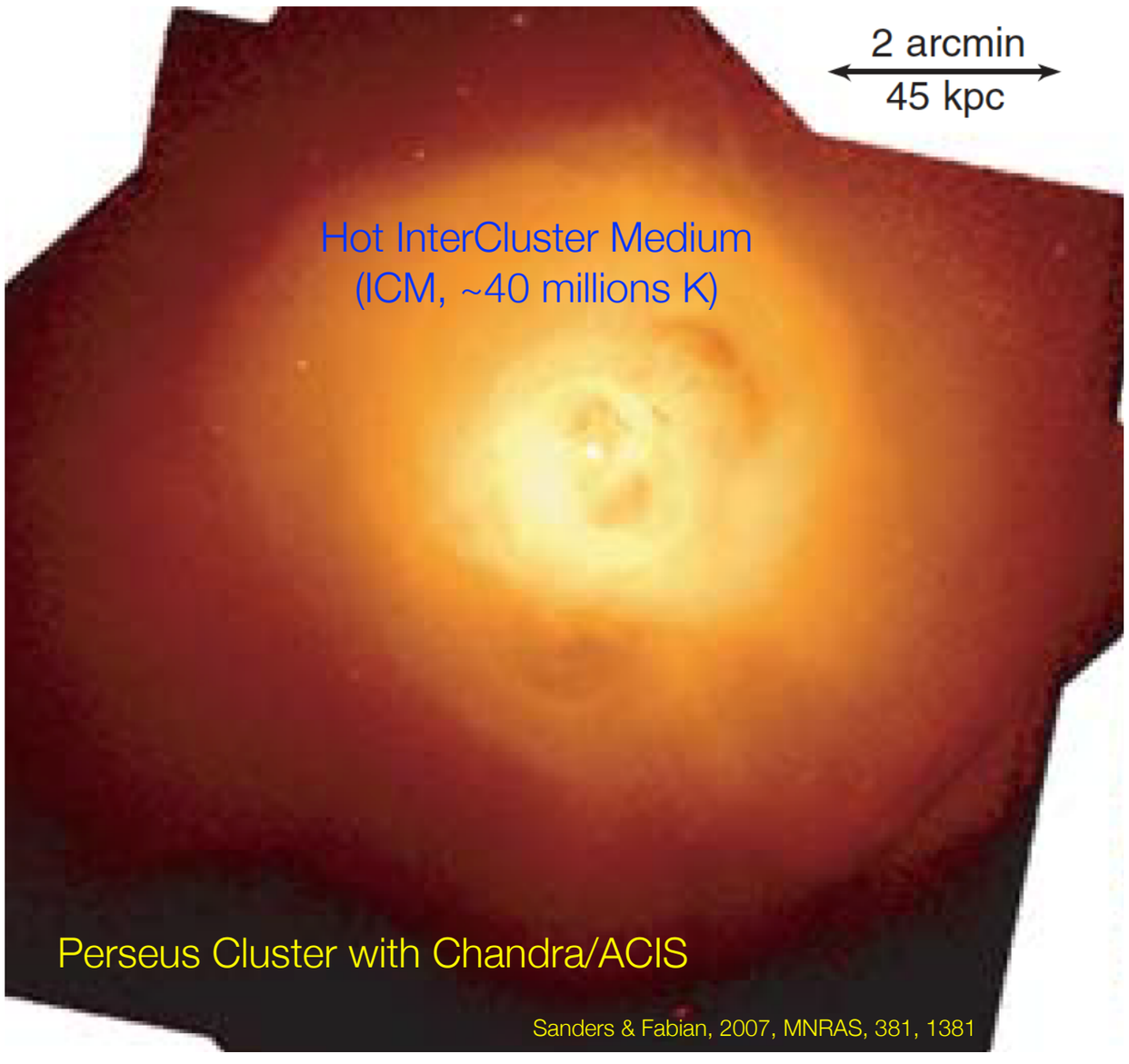

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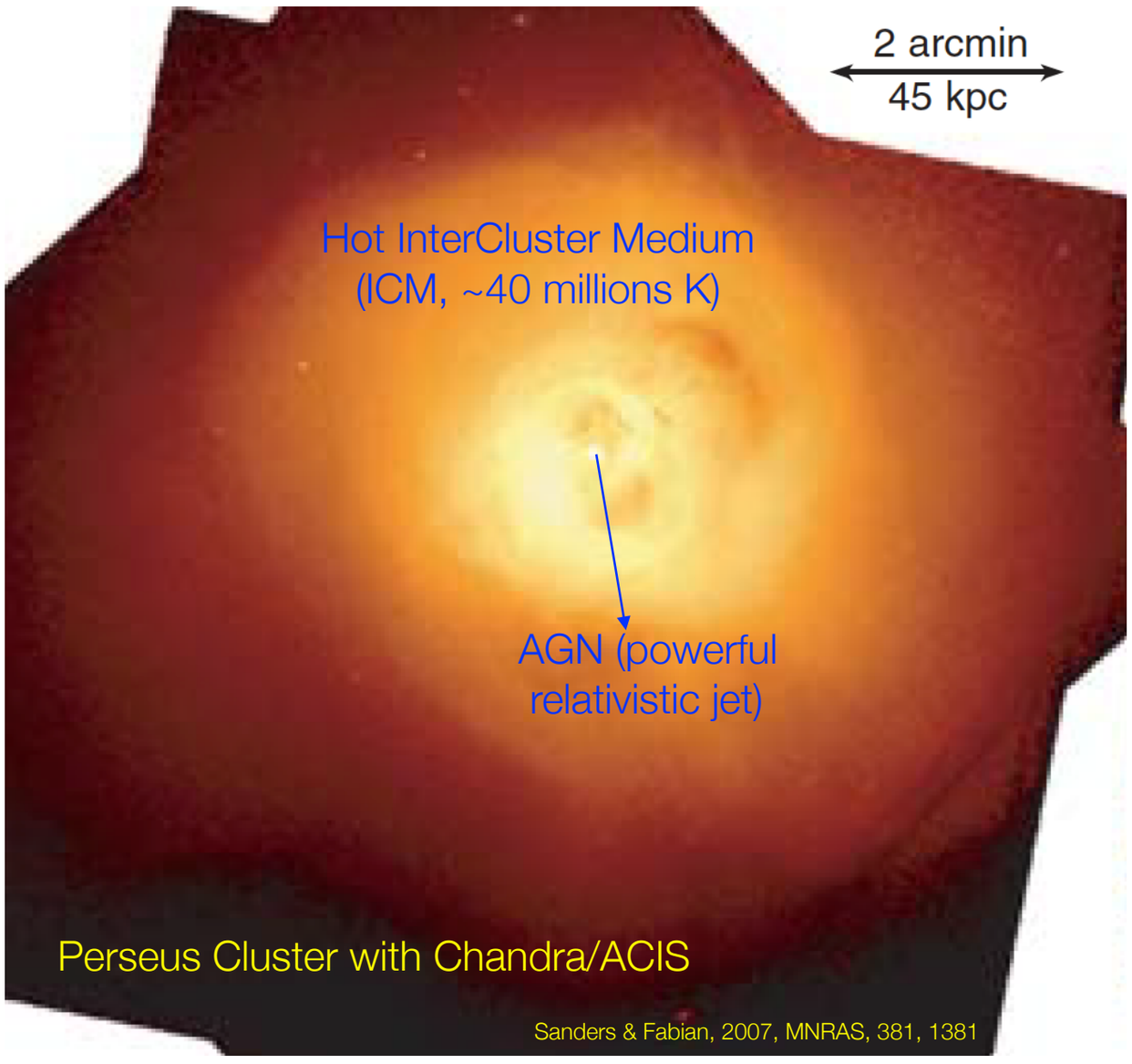

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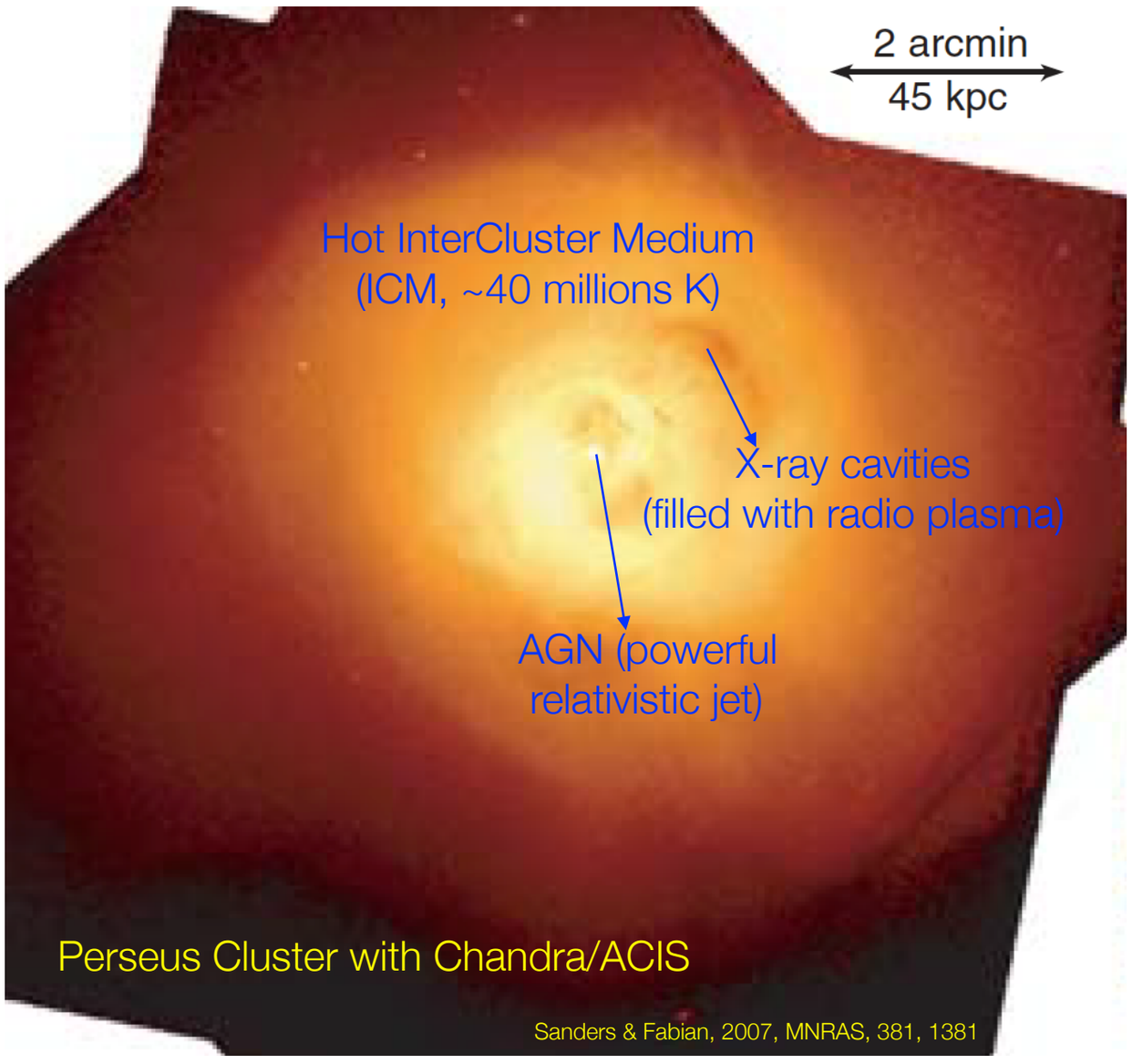

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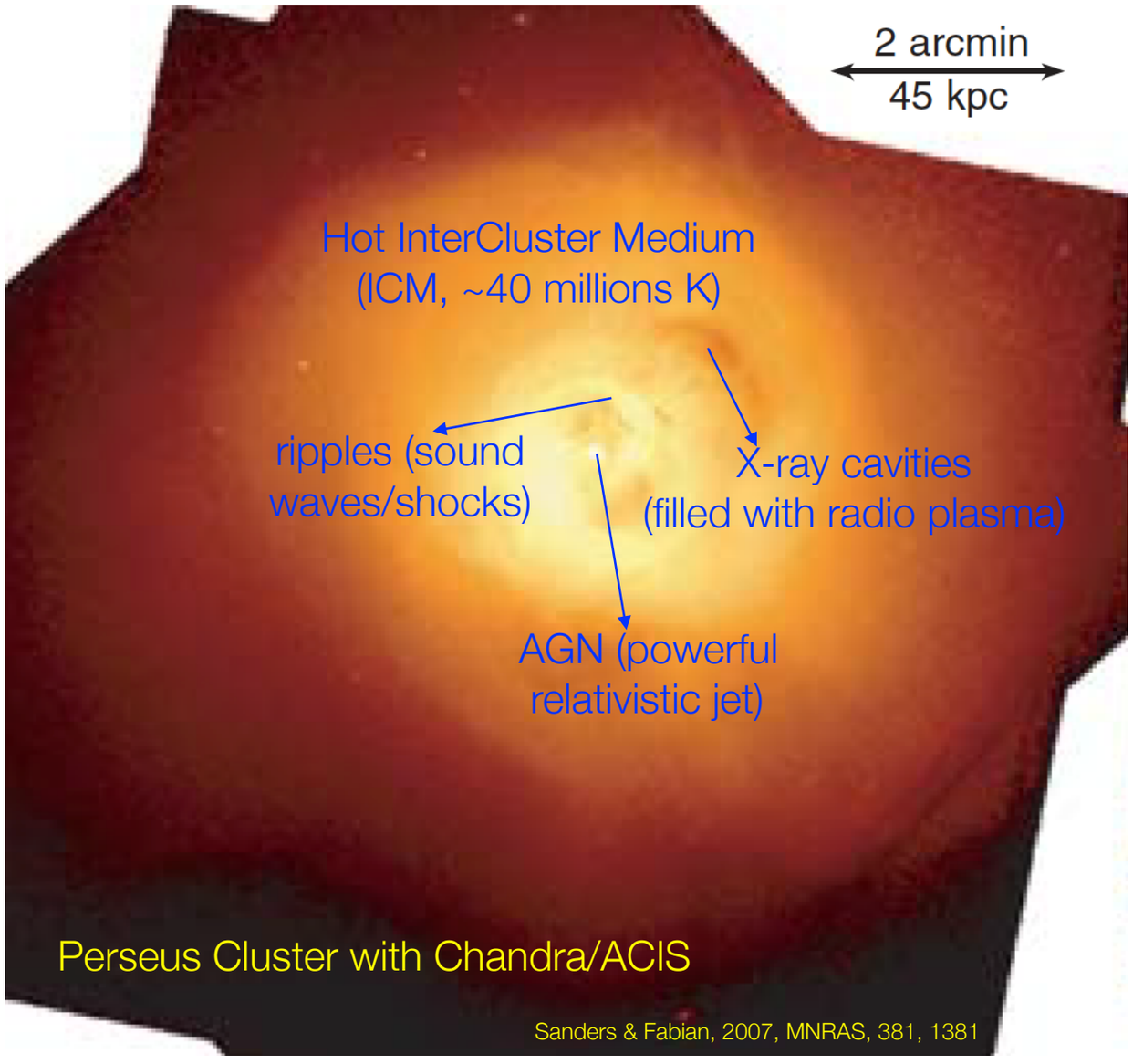

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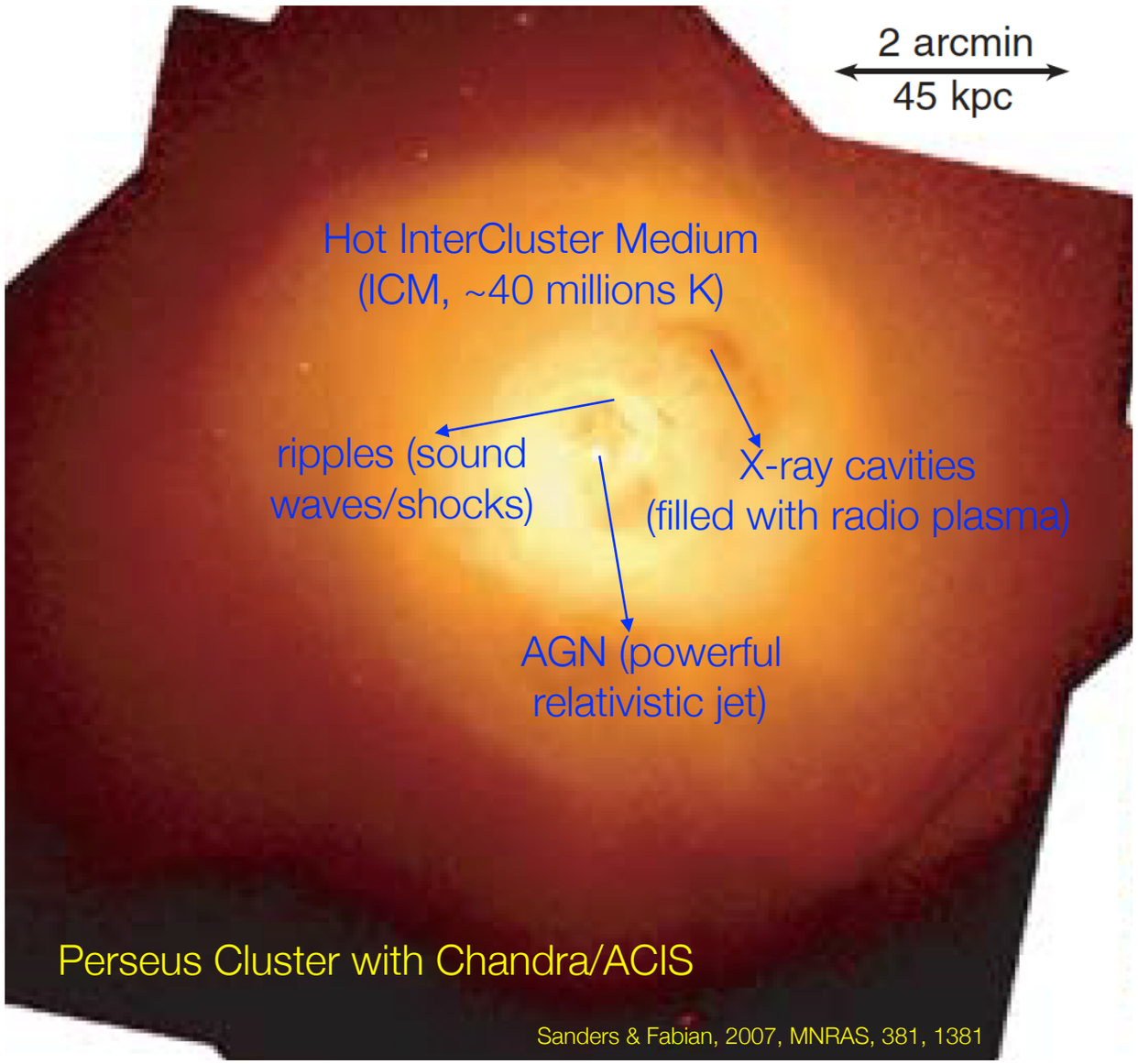


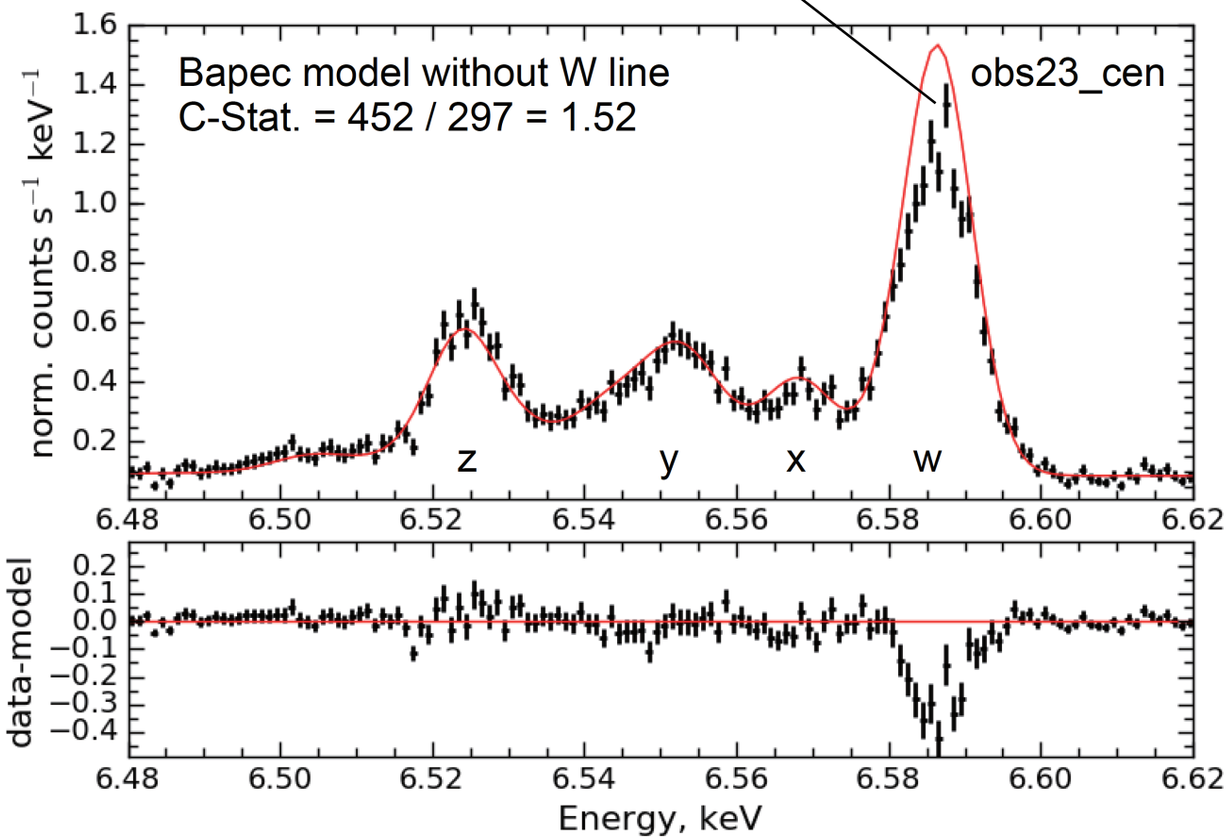
- Astrophysics: unexpected low level of turbulence despite vigorous AGN feedback
- Cosmology: corrections to hydrostatic equilibrium small → X-ray cluster mass function can be used a reliable cosmological probe

[See Maggie Lieu's talk for a different view]

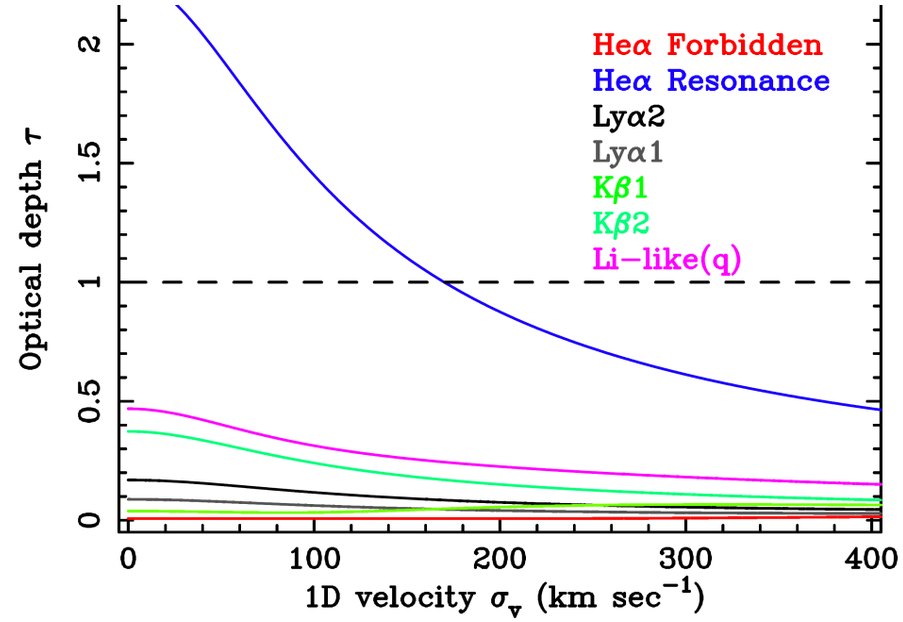
Resonant scattering in the ICM

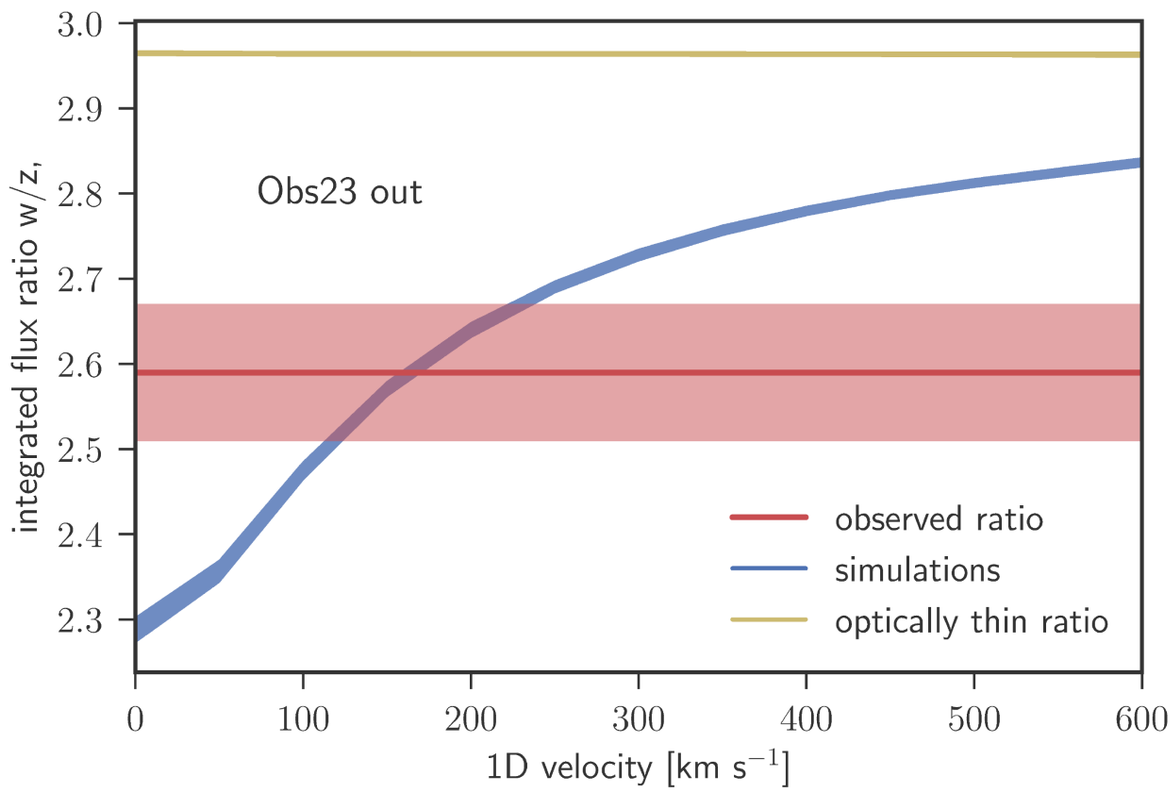
Hitomi Collaboration, 2017, arXiv:1710.04648

Resonant scattering in the FeXXV (Heα Resonance)



RS is sensitive to anisotropies of the velocity field, and small-scale motions and density inhomogeneities





SSW10

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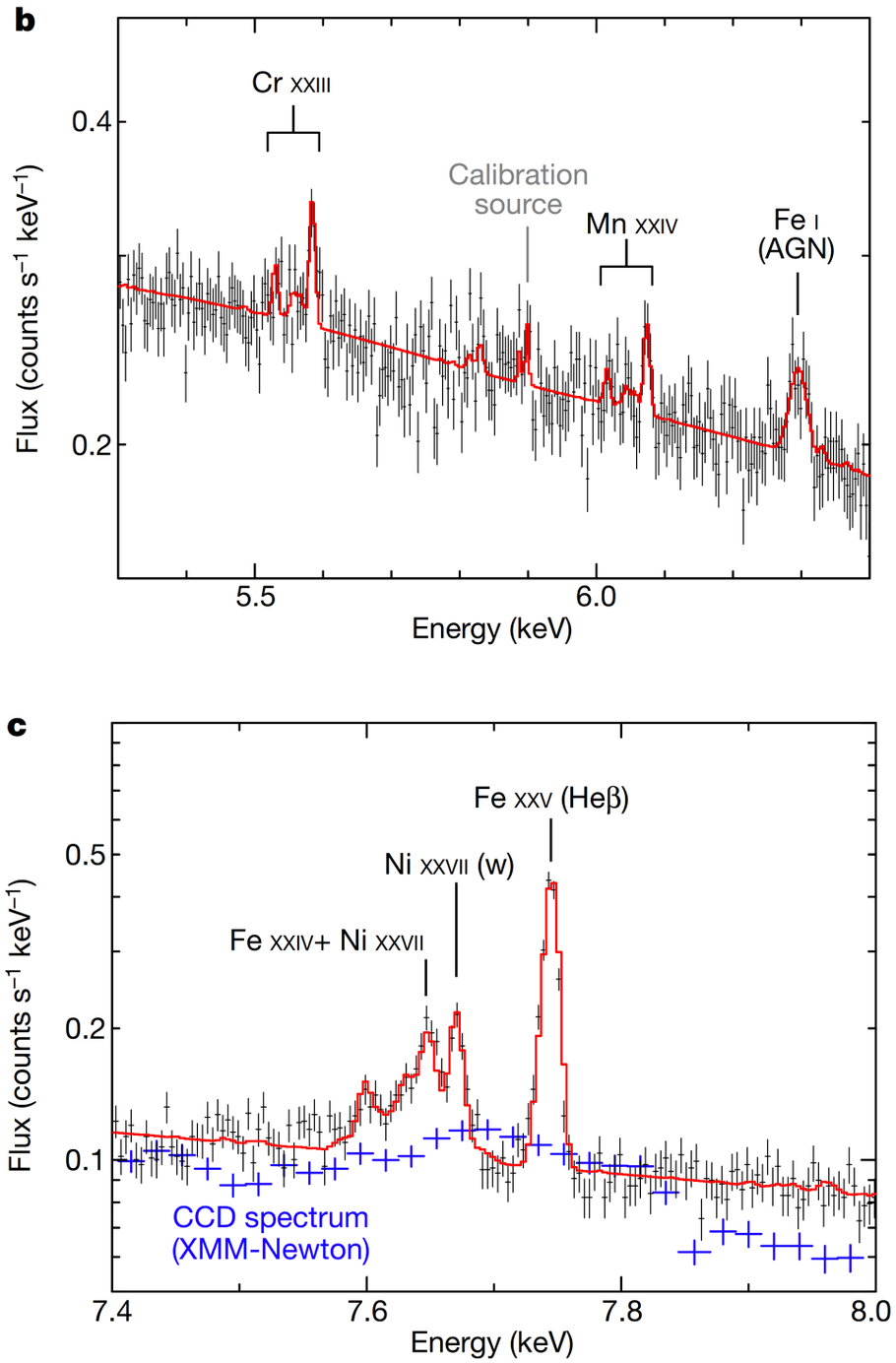
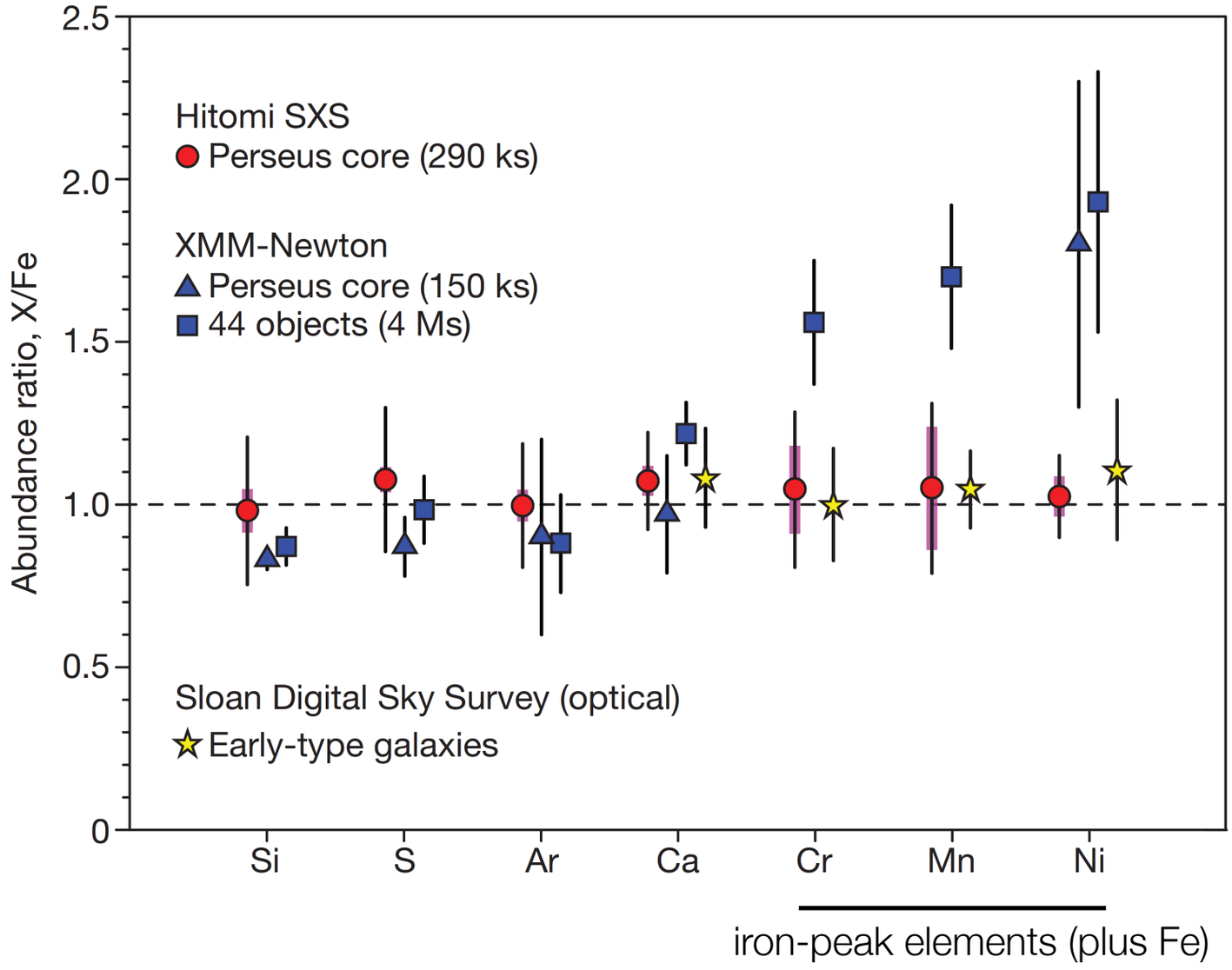
doi:10.1038/nature24301

Solar abundance ratios of the iron-peak elements in the Perseus cluster

Hitomi Collaboration*





Chemical composition of the Sun good indicator of the nature of the average type Ia supernova in the Universe

SSW10

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Solar abundance ratios of the iron-peak elements in the Perseus cluster

Hitomi Collaboration*

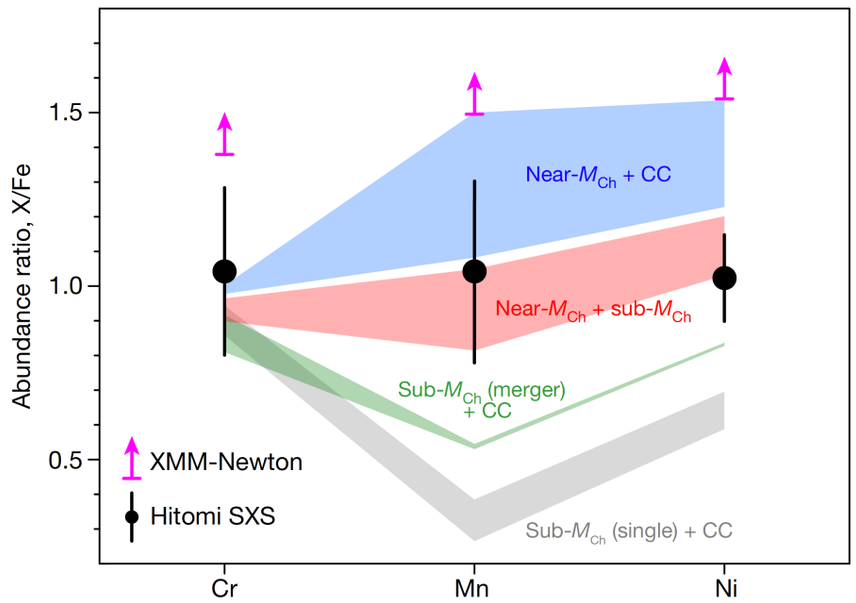
- The hot ICM is ~an isolated system in the potential dark matter potential well → large-scale clusters are representative of the Universe as a whole

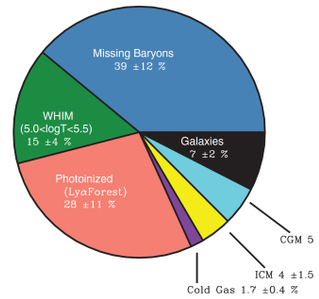
- Fe-peak elements are thought to be produced primarily by type Ia supernovae over cosmological times

- The Ni/Fe and Mn/Fe ratio depends the relative ratio of near-M_{ch} versus sub-M_{ch} explosions

- X-ray spectroscopy allow us to identify the dominant type Ia progenitor in clusters

- The average nature of type Ia supernovae is independent of the star formation of their host galaxies

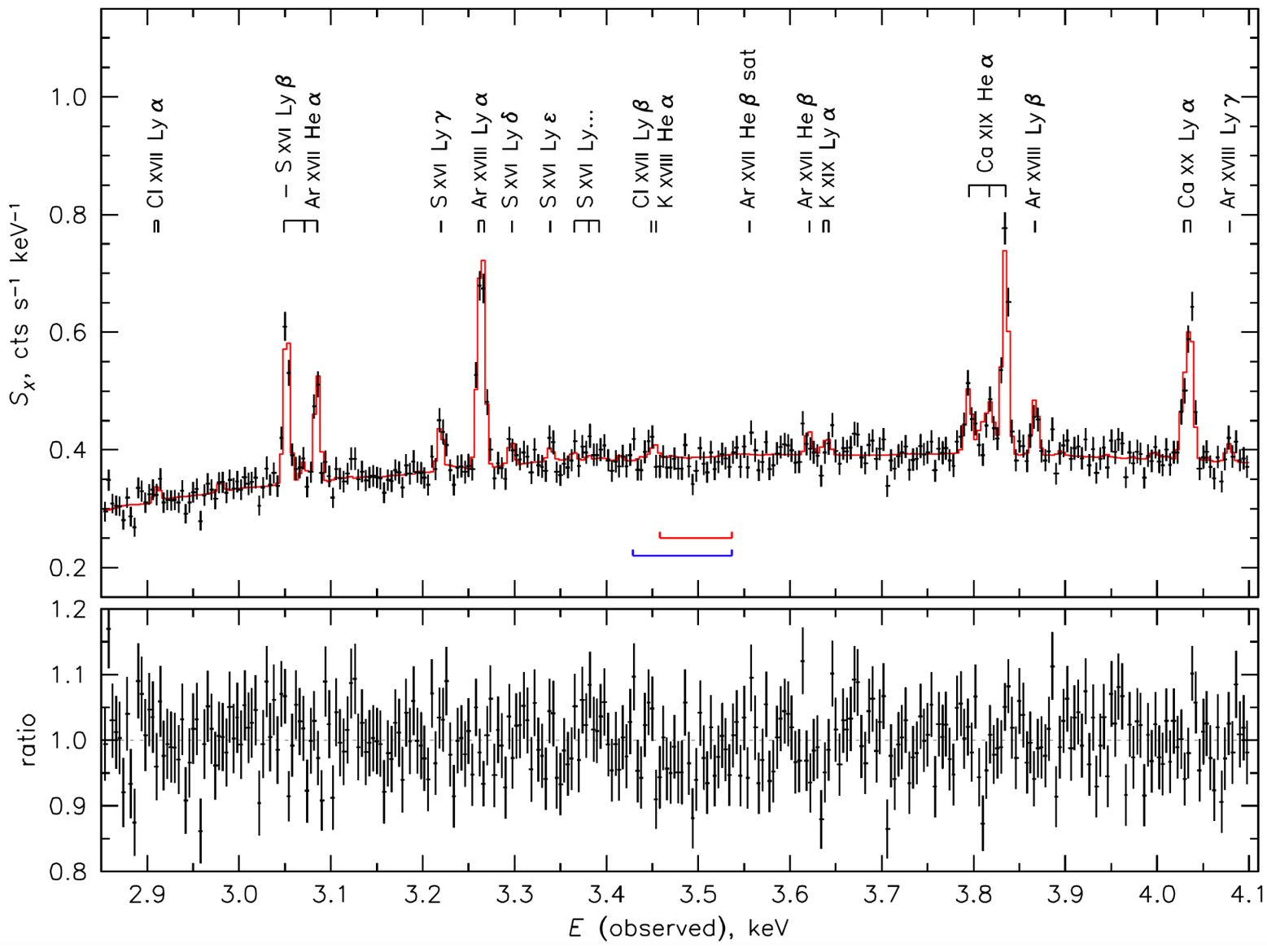


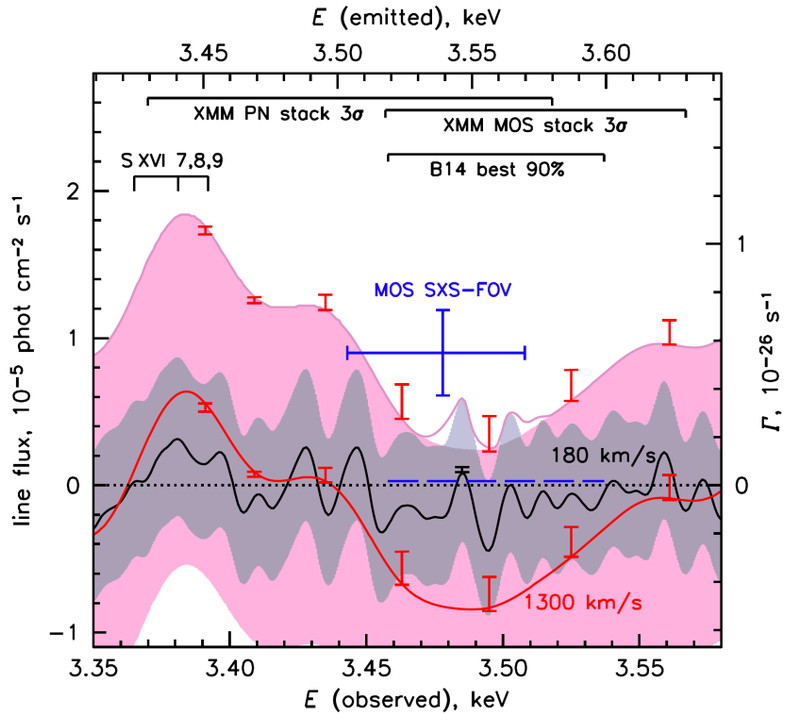


Search for Dark Matter candidates

Hitomi Collaboration, 2017, ApJL, 837, L15

An unidentified feature at ~3.5 keV observed by *Chandra* and XMM-Newton had been attributed to the decay of the “sterile neutrino” - one possible dark matter candidate



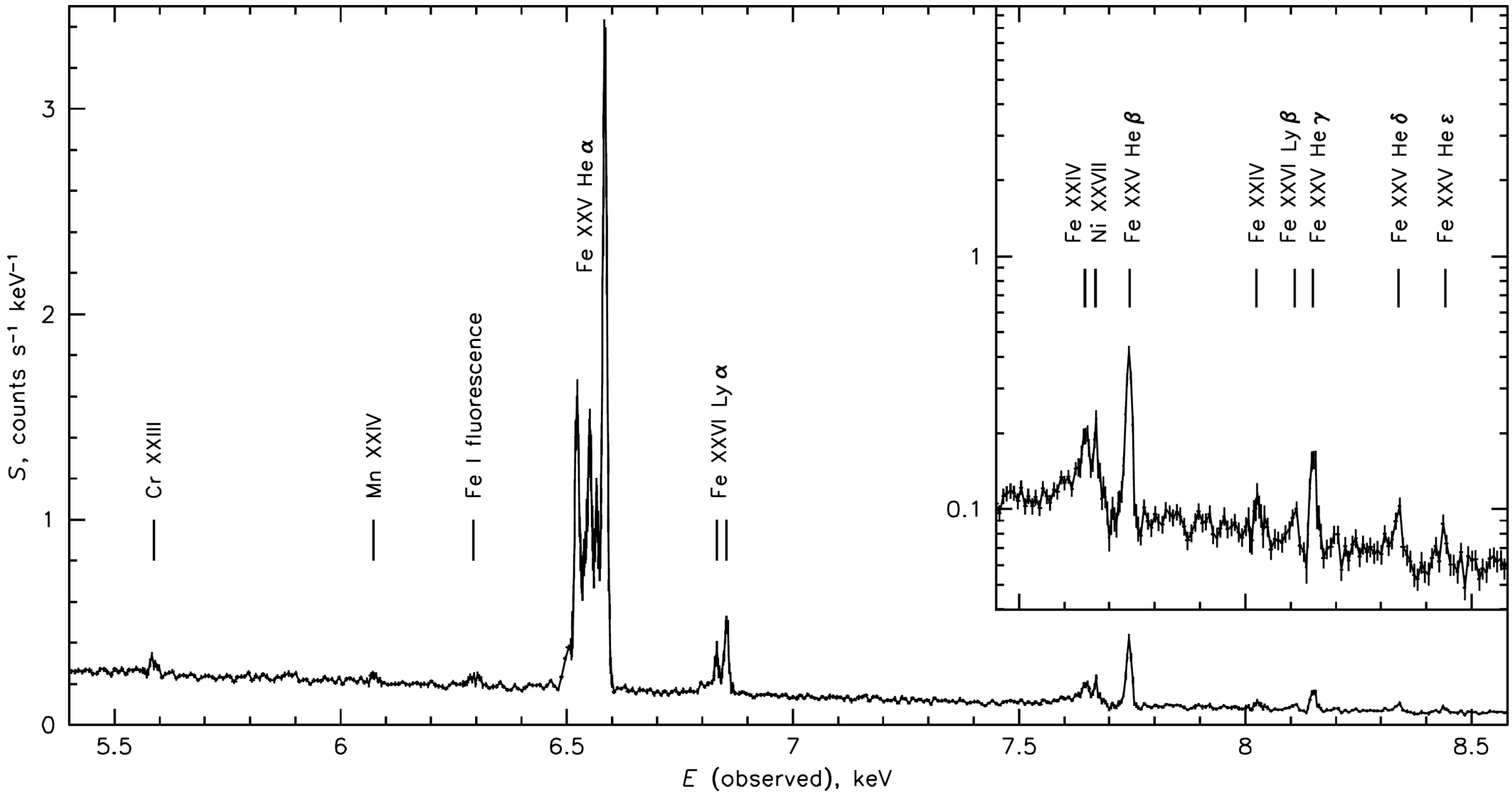


Claim dismissed by the SXS observation of Perseus

Where is the AGN?

Hitomi Collaboration, 2016, Nature, 535, 117

Hitomi/SXS spectrum in the innermost ~60 kpc of the Perseus Cluster



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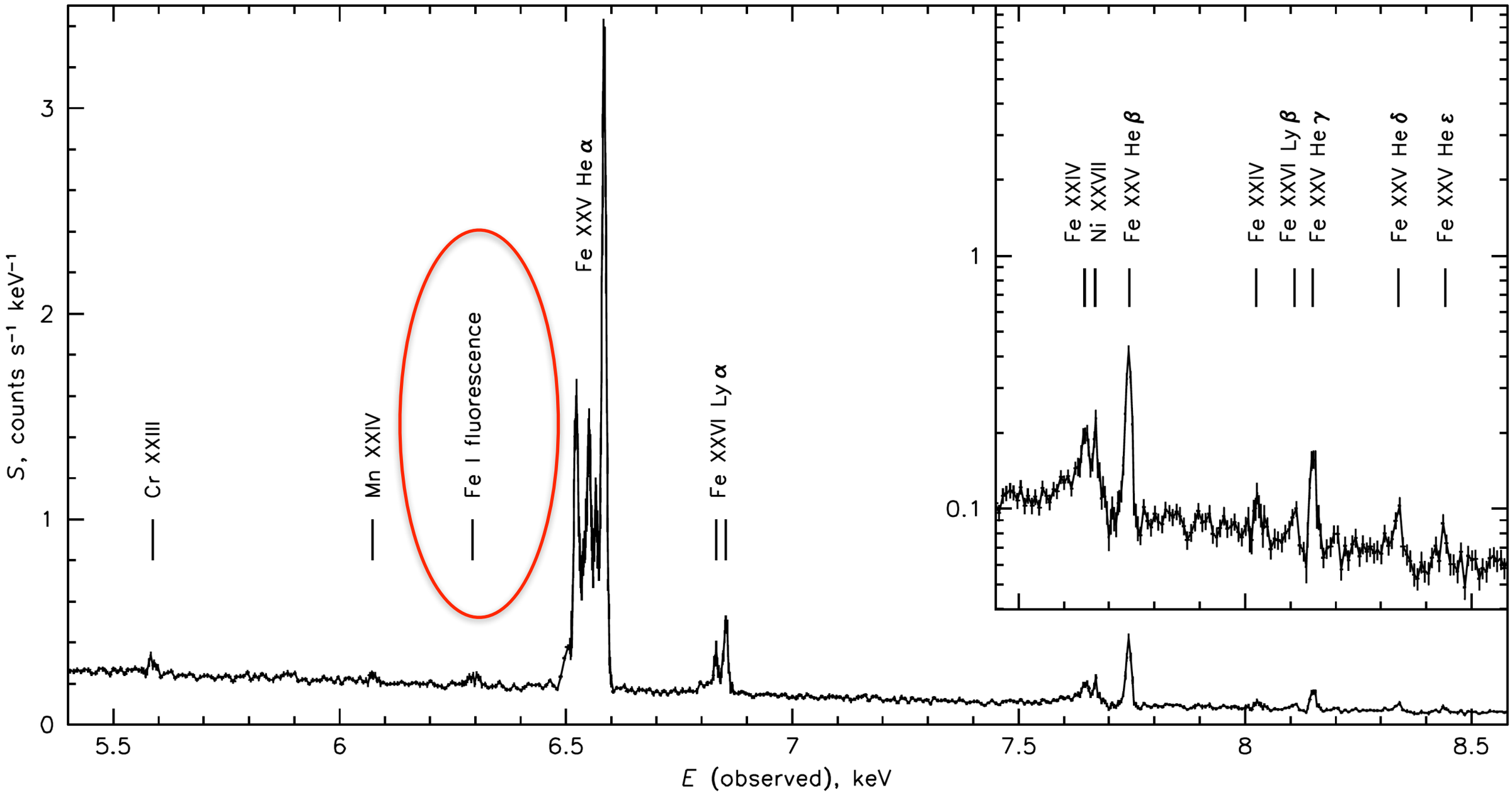
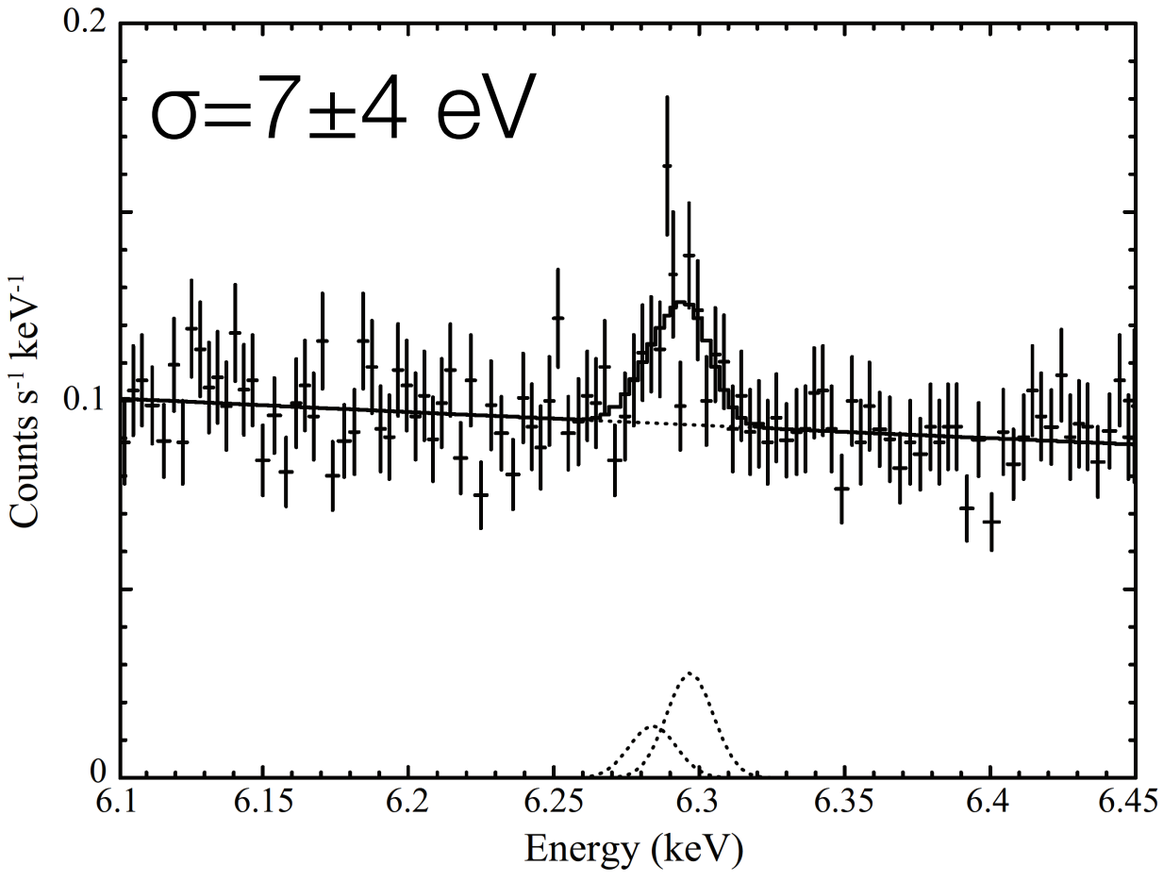


Origin of the FeI fluorescent line in NGC1275

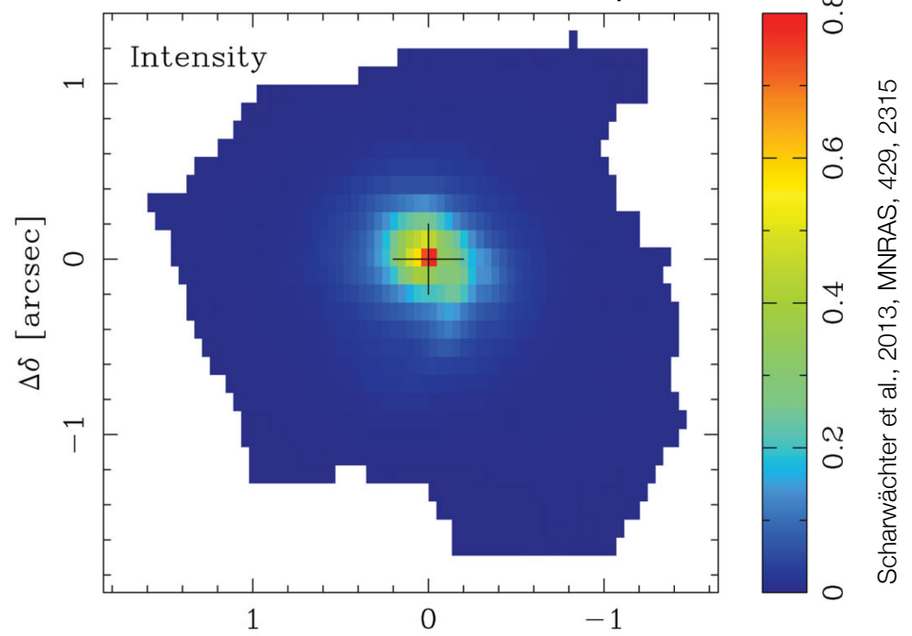
Hitomi Collaboration, in preparation



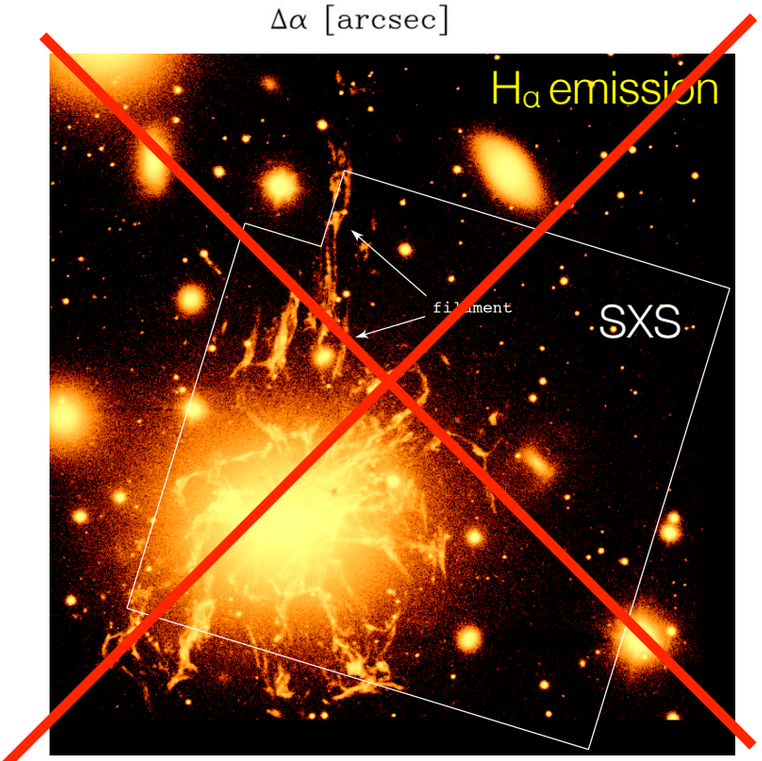
The width and intensity are consistent with being produced 6-45 pc from the black hole

no accretion disk, no Broad Line Region, no molecular filaments in the ICM

H_2 line image of the NGC1275 molecular disk ~50 pc



Schartmann et al., 2013, MNRAS, 429, 2315

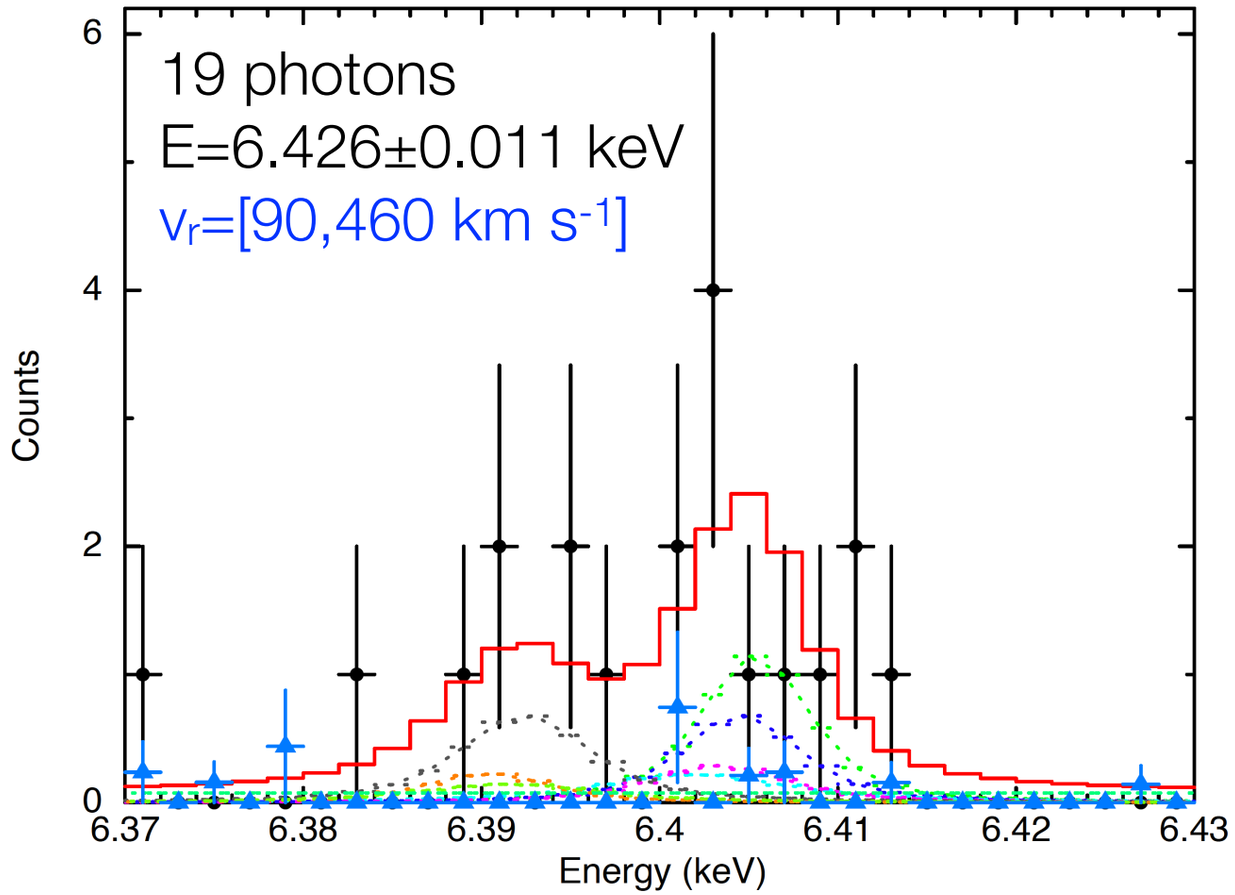


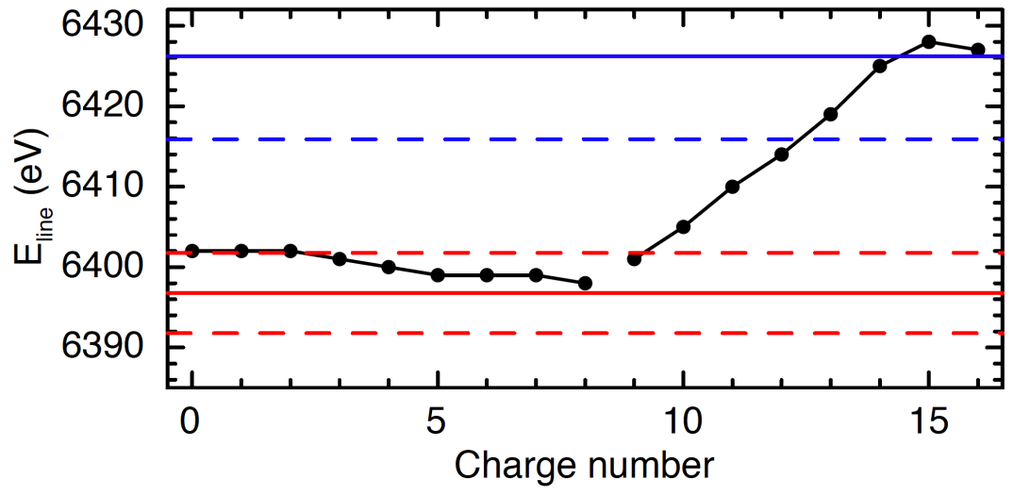
Conselice et al., 2001, AJ, 122, 2281

Origin of the Fe line in IGRJ16318-4848

Hitomi Collaboration, in preparation

[Fit results include the SXI ad HXI as well]





If coming from the stellar wind v_r~1000-1500 km s^{-1} → line coming from a small region close to the compact object (≤10^{13} cm - distance between star and compact object ~2x10^{13} cm)

“Future X-ray calorimetry missions, e.g. the X-ray Astronomy Recovery Mission (XARM) and Athena will be crucial to …”

XARM

- JAXA and NASA agreed to fly a mission to recovery the X-ray spectroscopy high-resolution science

- Payload:
  - Micro-calorimeter (Resolve)
    - ≤7 eV energy resolution in the 0.3-12 keV energy range, 3'x3' field-of-view
  - Large-field (~40'x40') CCD detectors (Xtend)
    - ≤170 eV resolution @6 keV
  - Soft X-ray telescope, ~1.3' Half Energy Width

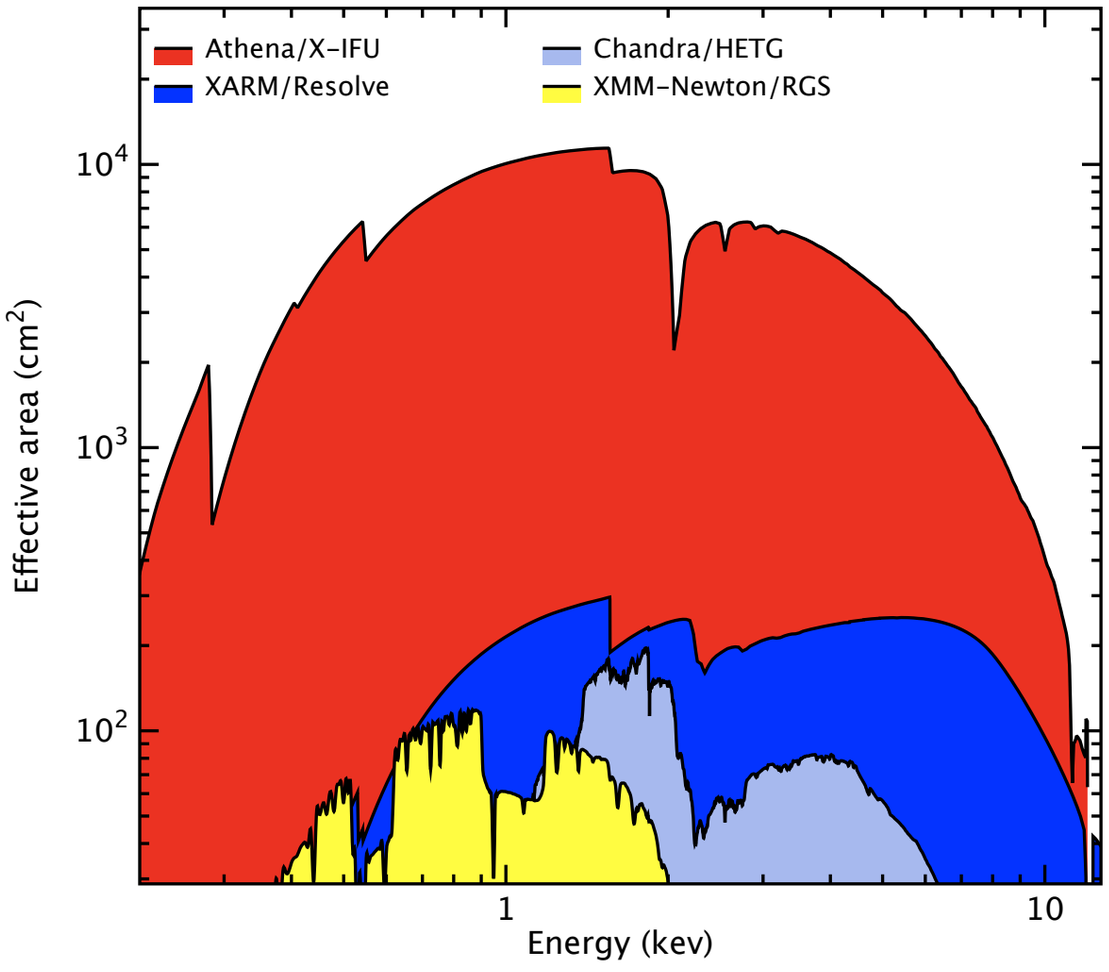
- Launch expected by the end of Japanese Fiscal Year 2020

- The 154th SPC meeting approved a MoO participation by the ESA Science Program

Athena

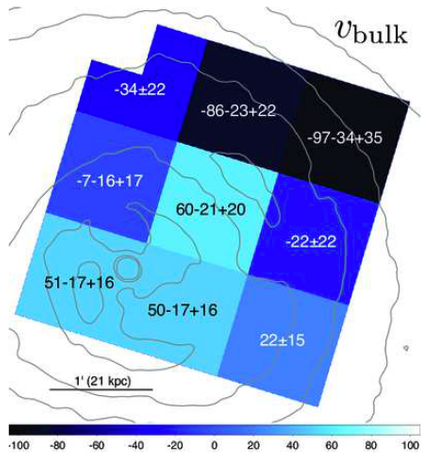
Courtesy D.Barret (IRAP)

Athena micro-calorimeter effective area vs. existing or planned high-resolution instruments

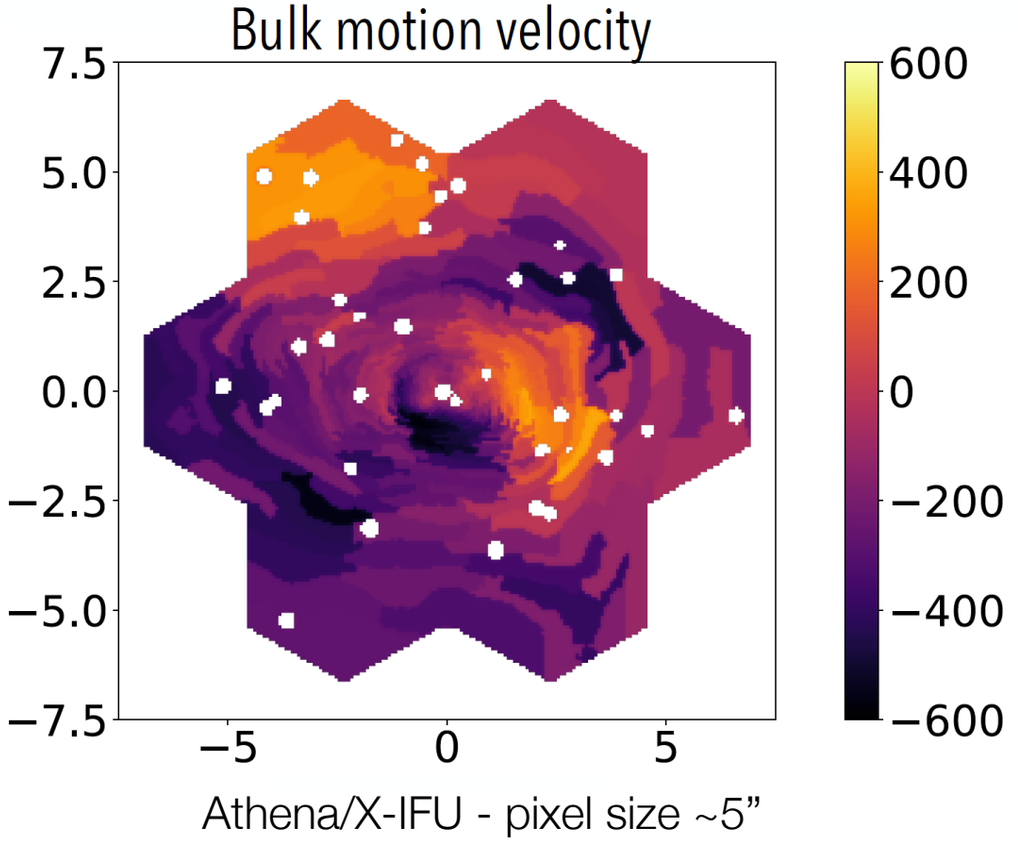


Baryons astrophysics in the local Universe (XARM)
→ history of large-scale structures (*Athena*)

Hitomi/SXS - pixel size ~30”



Hitomi Collaboration, 2017, arXiv:1710.04648



Courtesy E.Cucchetti (IRAP)

Athena/X-IFU - pixel size ~5”