In-orbit cross-calibration of the effective area and quantum efficiency of the Soft X-ray Imager for Xtend onboard XRISM

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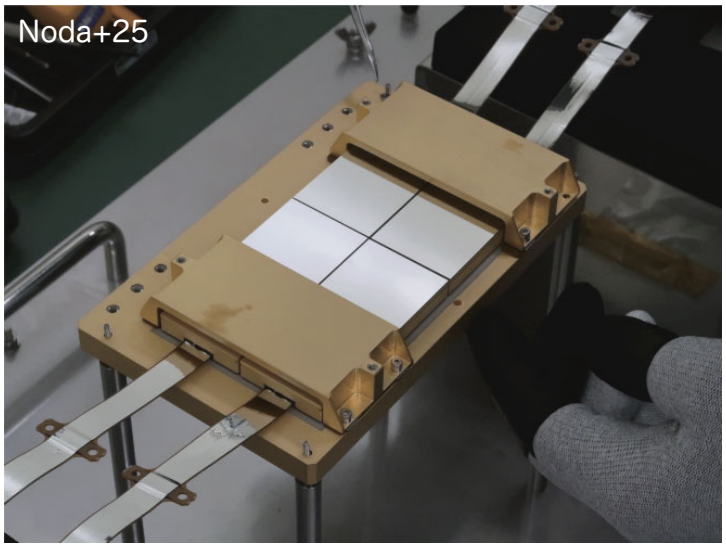
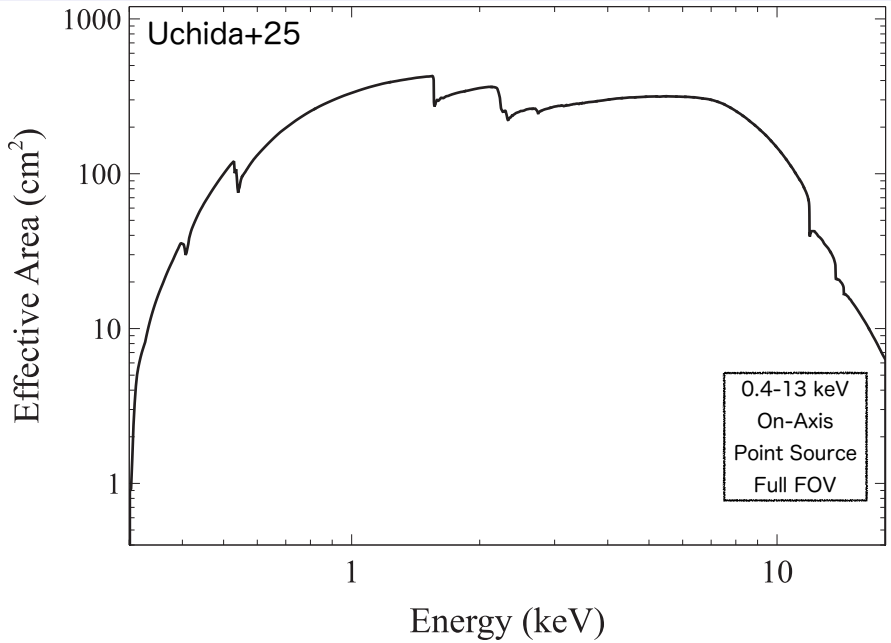
21 April, 2026, the 18th IACHEC meeting

Soft X-ray Imager (SXI) for Xtend onboard XRISM





- Soft X-ray Imager (SXI) for Xtend conducts 0.4−12 keV imaging observations with a wide Field of View of **38.5'×38.5'** and energy resolution of **170−180 eV at 5.9 keV.**
- In the current Caliblation Data Base (CALDB)[1], the effective area and quantum efficiency are estimated based on the ground test results[2]. Thanks to Contamination Blocking Filter (CBF), contamination is negligible at entire SXI[3].

[1] 20250915 ver: https://heasarc.gsfc.nasa.gov/docs/xrism/calib/
[2] See also Noda+25, PASJ, 77, S10 & Uchida+25, PASJ, 77, S23
[3] See https://iachec.org/wp-content/presentations/2025/contamination_higuchi.pdf

XRISM Calibration Observations

Parameter	Target	XRISM OBSID	Observation Date	Exposure
Ayşegül's Talk	3C273	000145000	2024-01-06	104 ks
		101004010	2025-01-05	35 ks
Effective Area		102004010	2026-01-14	37 ks
This Talk	PKS 2155-304	000127000	2023-12-07	106 ks
	G21.5-0.9	100001010	2024-03-17	67 ks
Quantum Efficiency	Cygnus Loop	100008010	2024-04-18	38 ks
	Perseus Cluster	000154000	2024-01-21	47 ks

- We observed the point sources **3C 273 & PKS 2155−304** and the diffuse source **G21.5−0.9** to cross-calibrate the **effective area**.
- We observed the diffuse sources **Cygnus Loop & the Perseus Cluster** to cross-calibrate the off-axis **quantum efficiency** of SXI (Cygnus Loop: 0.3−2 keV; Perseus Cluster: 2−7 keV).
- In this presentation, we focus on the results for G21.5−0.9, PKS 2155−304, and the Perseus Cluster[4].

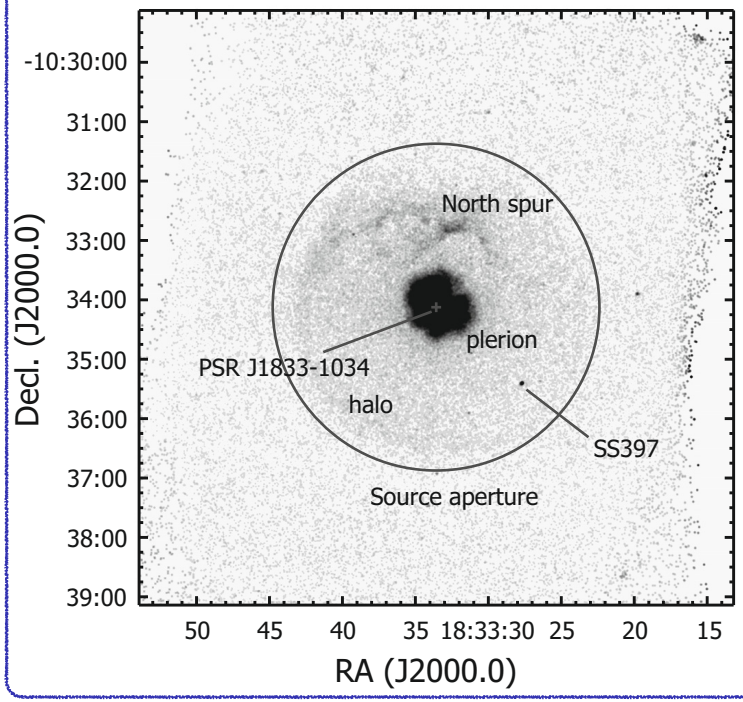
[4] Results for the Cygnus Loop and 3C 273 were presented at the 17th IACHEC meeting: https://iachec.org/wp-content/presentations/2025/xrism2_inoue.pdf

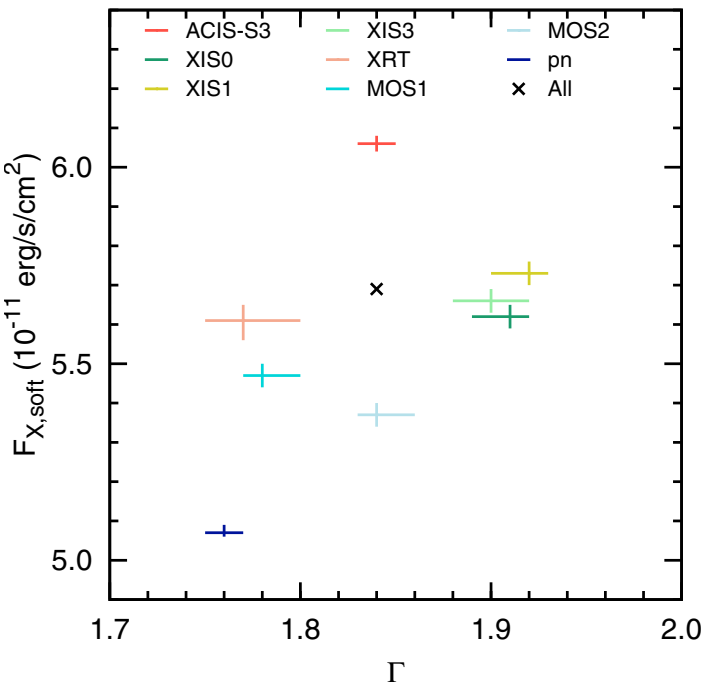
G21.5–09

(Effective Area of Diffuse Source)

Pulsar wind Nebula G21.5–09 as a calibration source

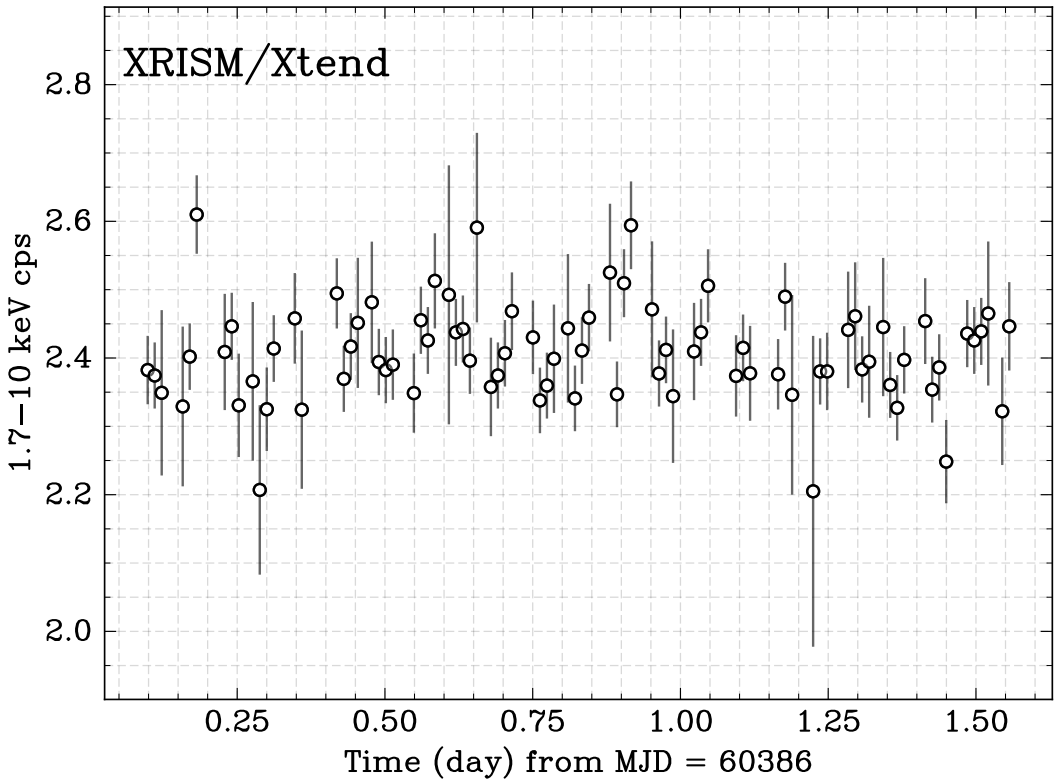
Tsujimoto+2011

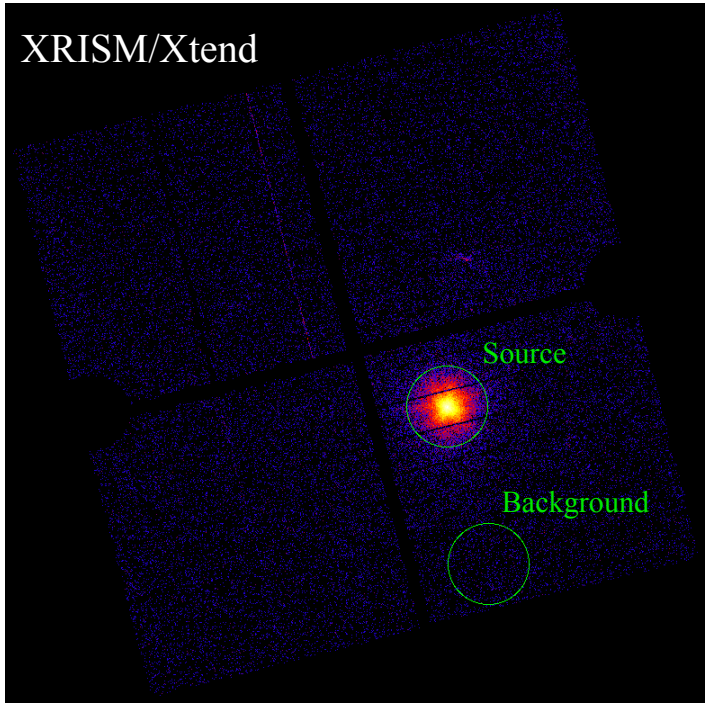




- G21.5–09 is a pulsar wind nebura and has been used as a calibration source for the effective area of many X-ray satellites (e.g., Tsujimoto+11).
- Features of this target as a calibration source is:
  - **Not** bright enough to cause pile-up
  - Stable flux and approximated as a simple spectral shape (power-law).
  - An **extended** source, but compact enough to fit within the field of view of any X-ray telescope.

XRISM Observations of G21.5–09

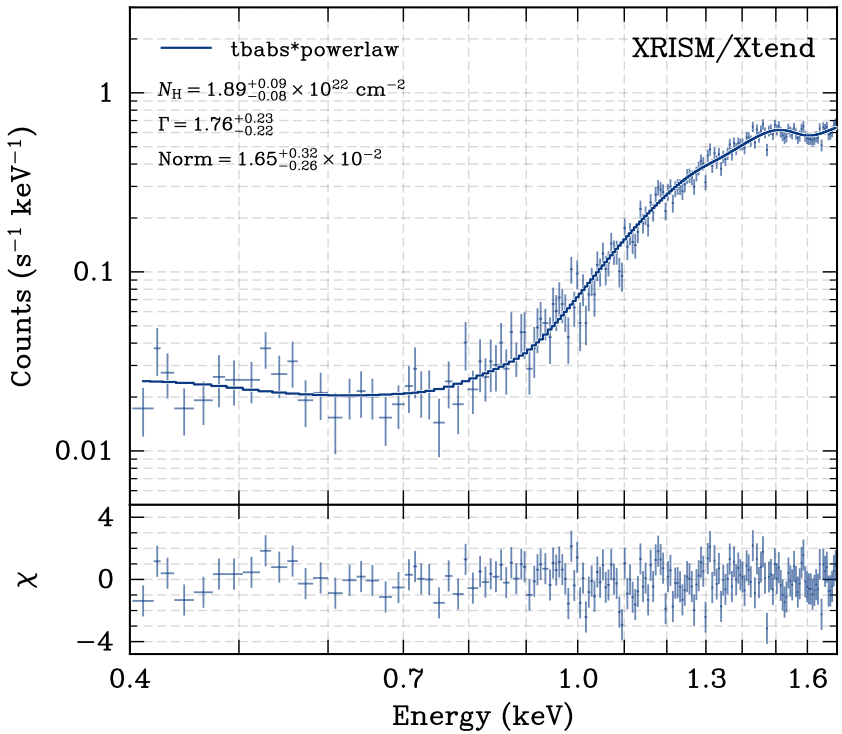


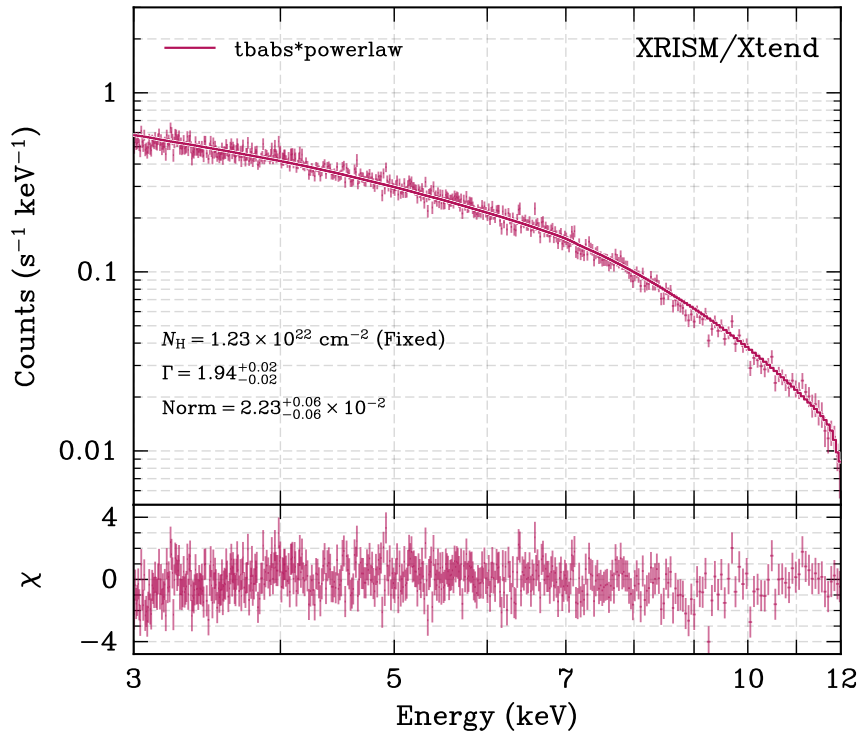


- G21.5–09 was observed with XRISM for 67 ks on March 17, 2024[5].
- XRISM/Xtend count-rate was stable during the observation.
- This was **not** coordinated observations with other X-ray satellites. We compared our results with archival data from XMM-Newton and NuSTAR[6].

[5] XRISM ObsID: 100001010
[6] XMM ObsID: 0890200101 (2021 Mar.), NuSTAR ObsID: 11101412002 (2025 Sep.)

Spectral fitting in 0.4–1.7 keV & 3–12 keV

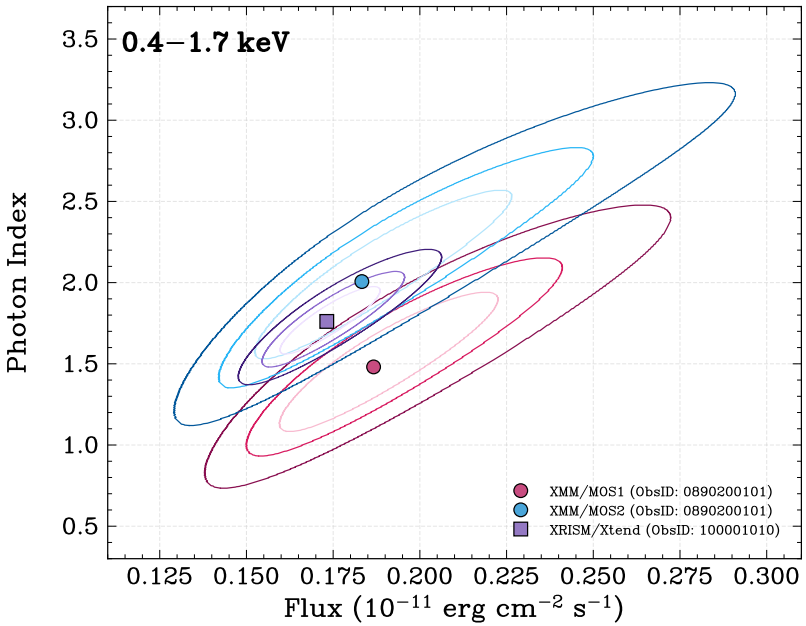


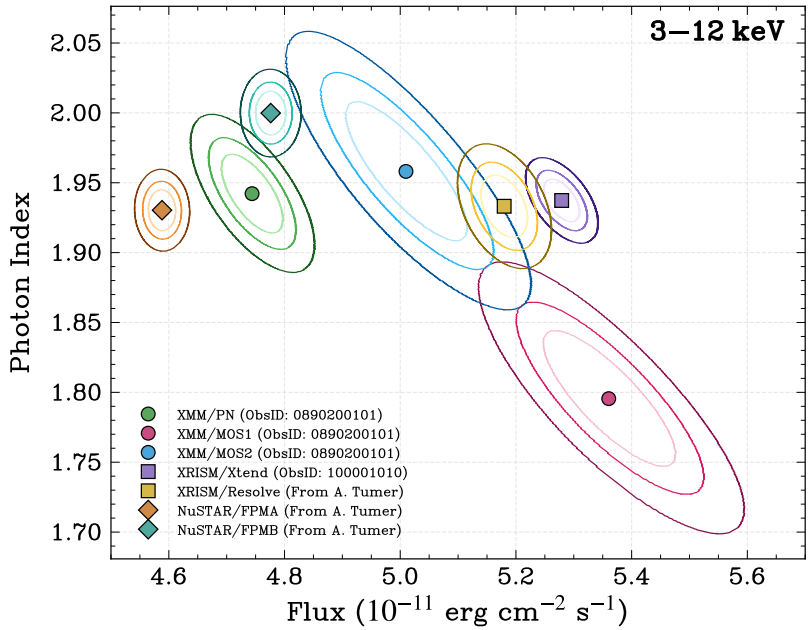


- Soft (0.4–1.7 keV) and hard (3–12 keV) spectra are fitted with the `powerlaw` model convolved with interstellar absorption (`tbabs`).
- N_H was set free and fixed[7] for soft and hard spectral analysis, respectively.
- Both band spectra were well reproduced with this model and Cash statistic.

[7] 1.23×10^{22} cm^{-2}, based on https://heasarc.gsfc.nasa.gov/cgi-bin/Tools/w3nh/w3nh.pl

Photon index vs. Flux Contour





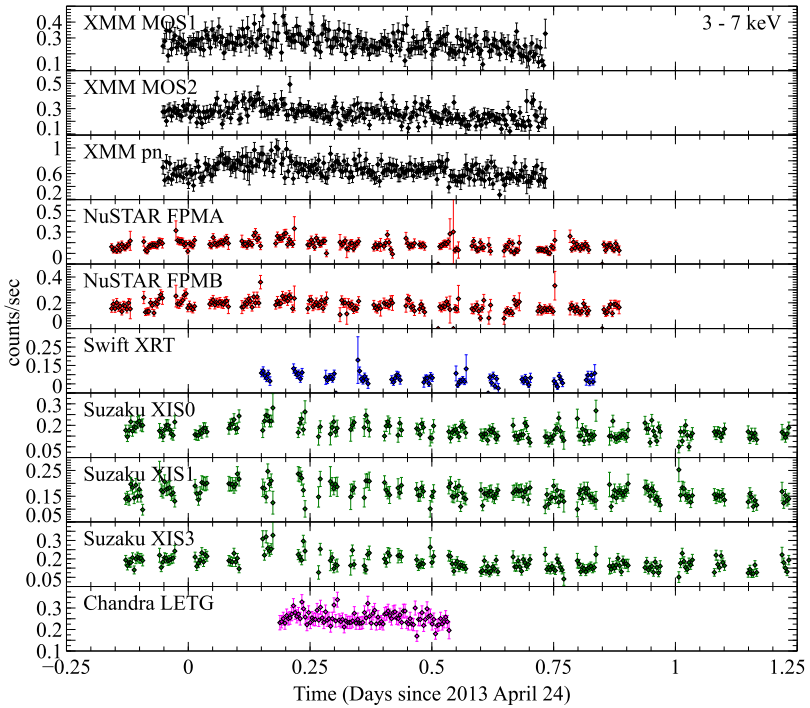
- In the soft band (0.4–1.7 keV), XRISM/Xtend, XMM/MOS1, and MOS2 are **consistent within the 3σ statistical uncertainties.**
- In the hard band (3–12 keV),
  1. The fluxes measured with Xtend, Resolve, XMM/MOS1, and MOS2 are **consistent within the 3σ statistical uncertainties.**
  2. The largest discrepancy is a $\sim$15% flux difference between XMM/MOS1 and NuSTAR/FPMA.
  3. There is a $\sim$5% flux difference between NuSTAR/FPMA and FPMB.

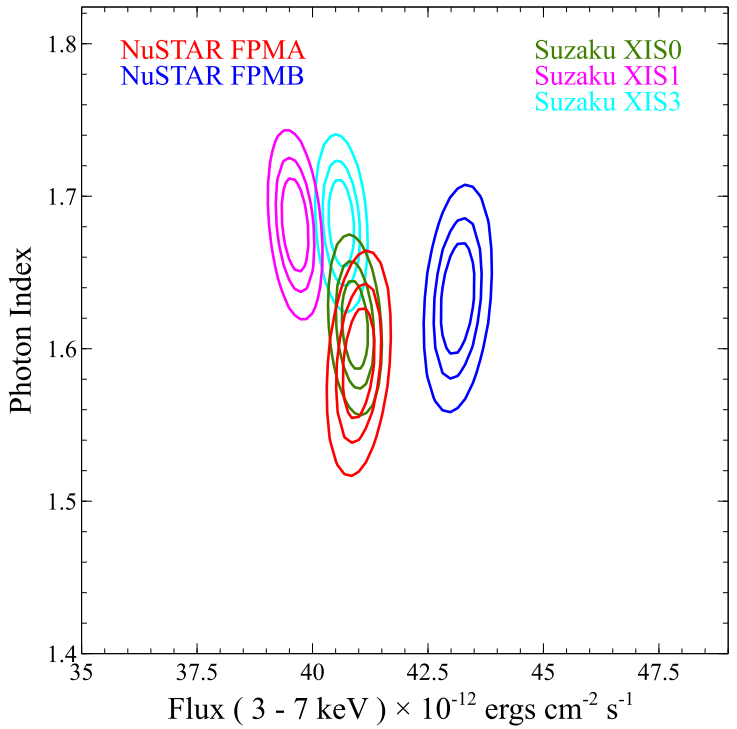
PKS 2155-304

(Effective Area of Point Source)

Blazar PKS 2155-304 as a calibration source

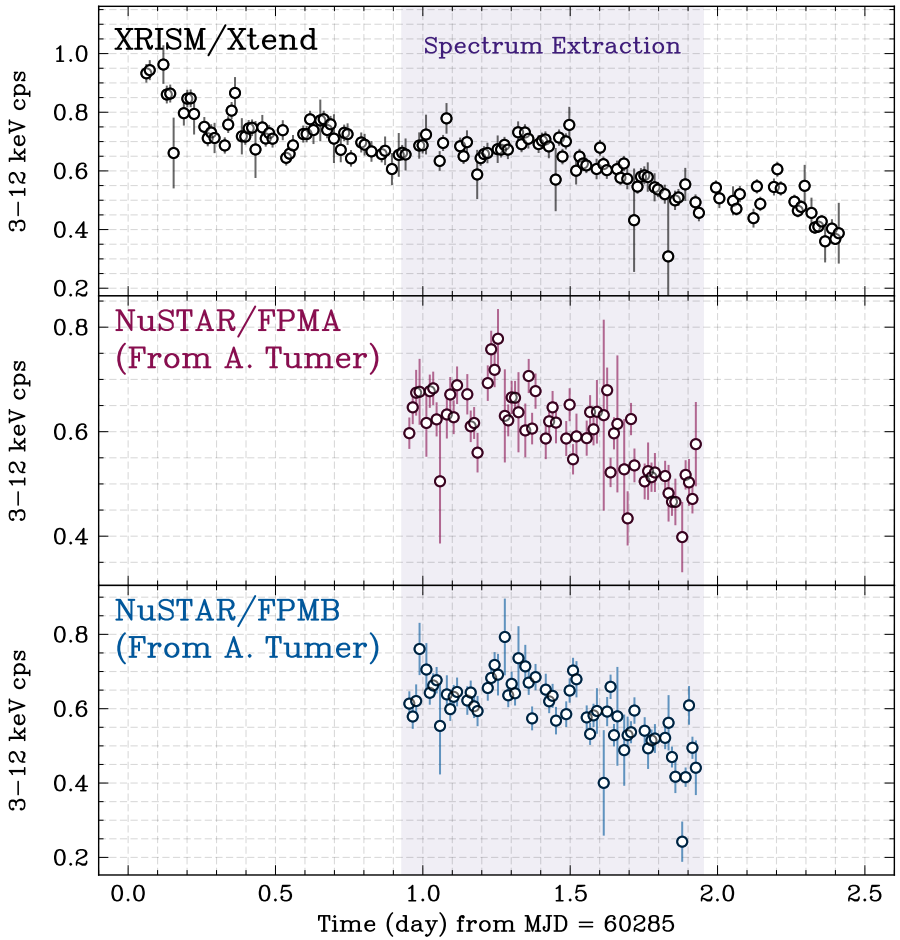
Madsen+2017

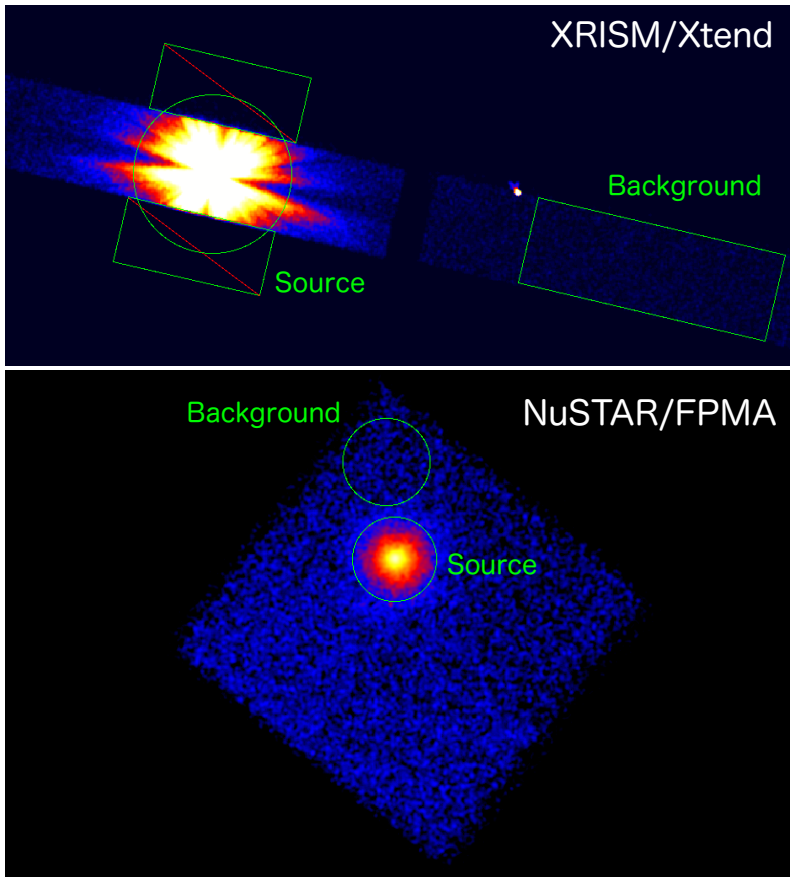




- PKS 2155−304 is a blazar and has been widely used as a calibration source for the effective area of X-ray satellites (e.g., Madsen+17).
- The features of this target as a calibration source are:
  - **Not** bright enough to cause pile-up with 1/8 window mode
  - A **point** source with stable flux and a simple spectral shape, `powerlaw`

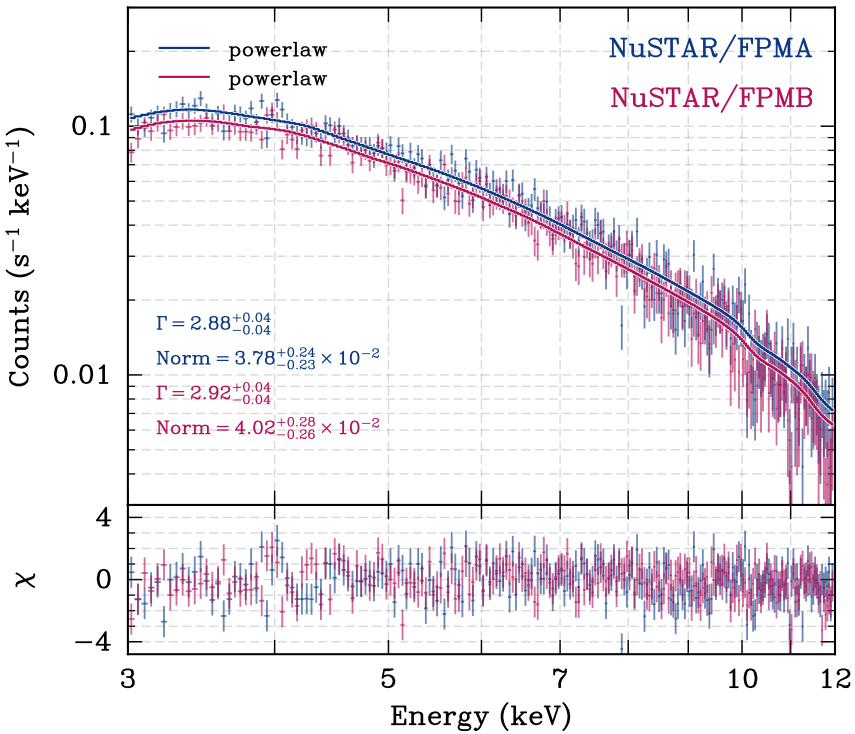
XRISM and NuSTAR Observations of PKS 2155-304

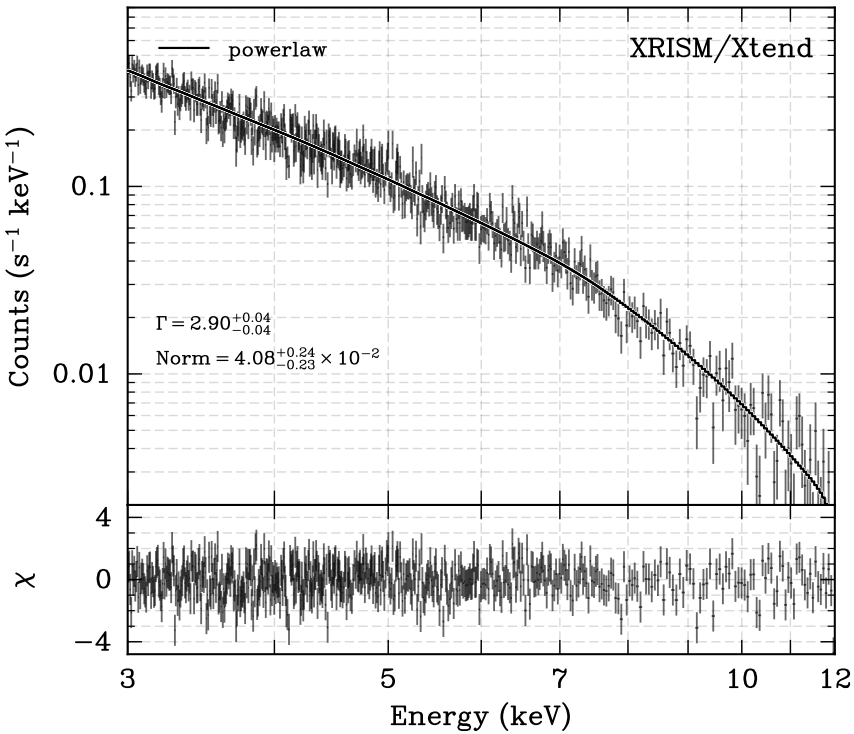




- PKS 2155−304 was observed with XRISM/Xtend with 1/8 window mode on 7 December 2023 for 106 ks, including 42 ks of overlap with NuSTAR.
- The source flux decreased slightly during the observation.
- We extracted spectra using the simultaneous XRISM–NuSTAR exposure.

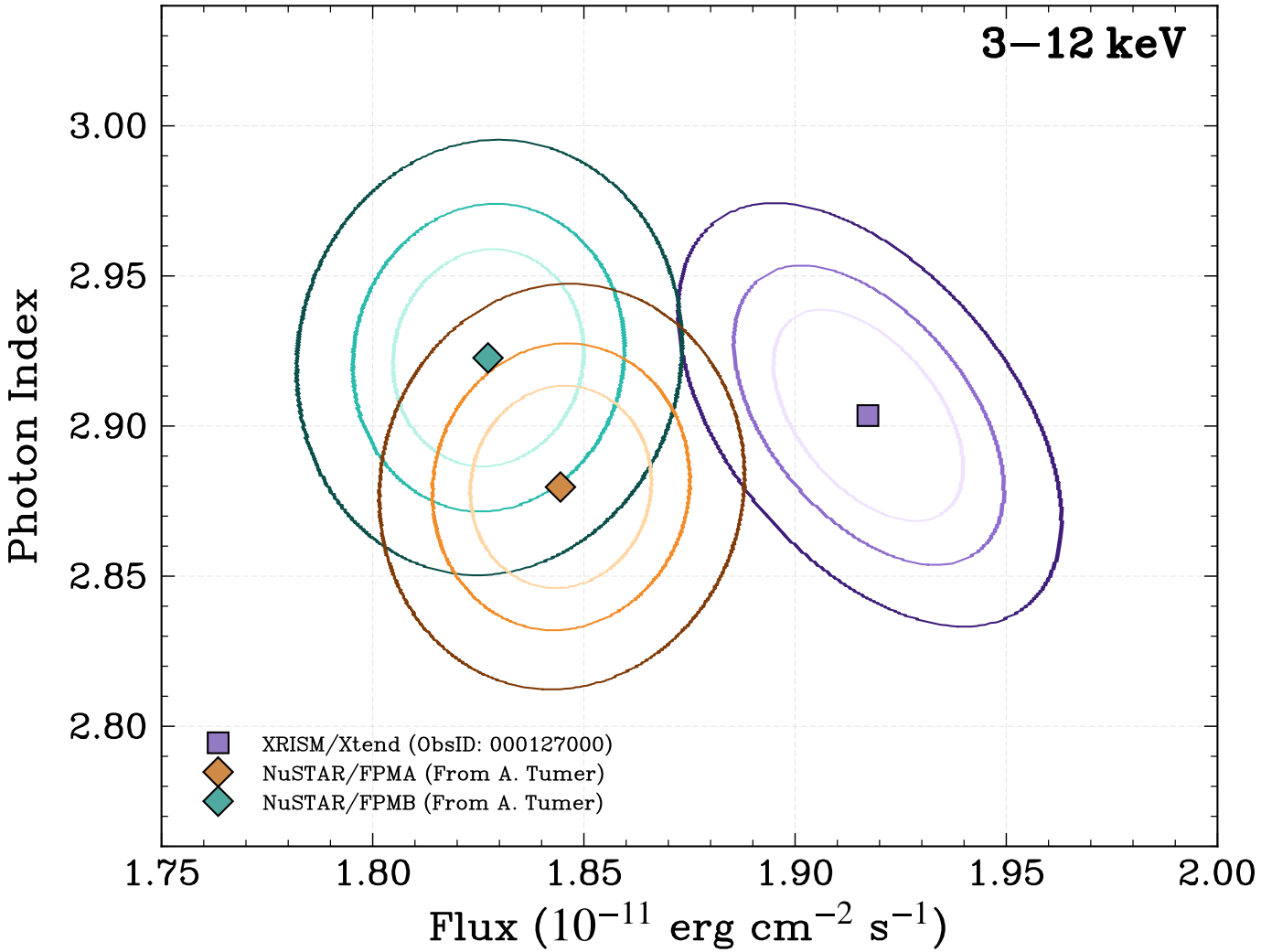
Spectral fitting in 3–12 keV





- The 3–12 keV spectra were fitted with a simple `powerlaw` model.
- Interstellar absorption (`tbabs`) model was not included.
- All spectra were well reproduced by this model using the Cash statistic.

Photon index vs. Flux Contour



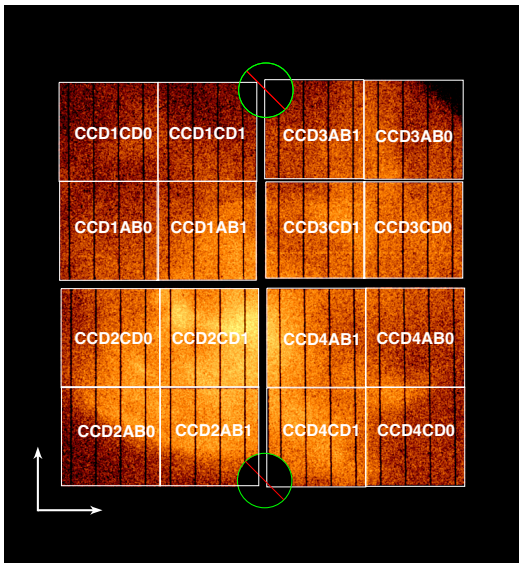
- All instruments (XRISM/Xtend, NuSTAR/FPMA, and NuSTAR/FPMB) are **consistent within the 3σ statistical uncertainties**, showing better agreement than for G21.5−0.9.

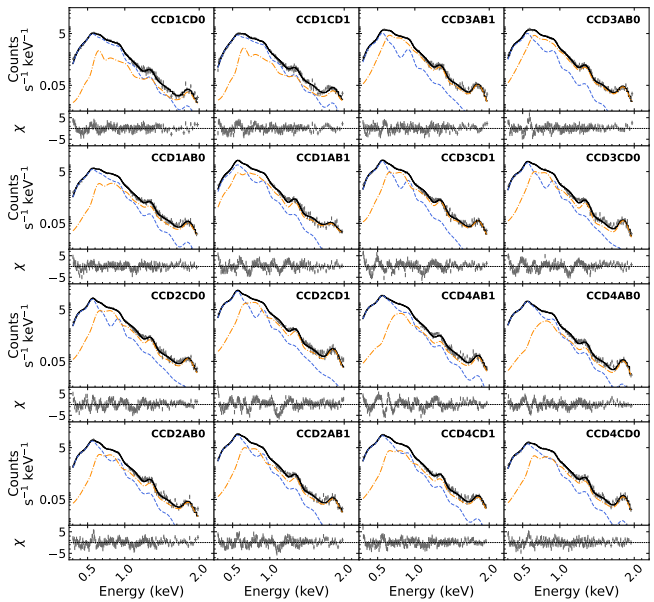
Perseus Cluster

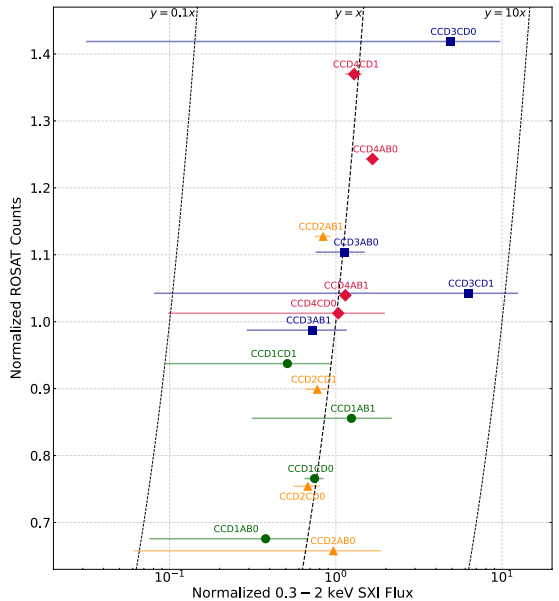
(2–7 keV Quantum Efficiency)

Calibration of quantum efficiency in soft and hard bands

Uchida, Inoue+2025



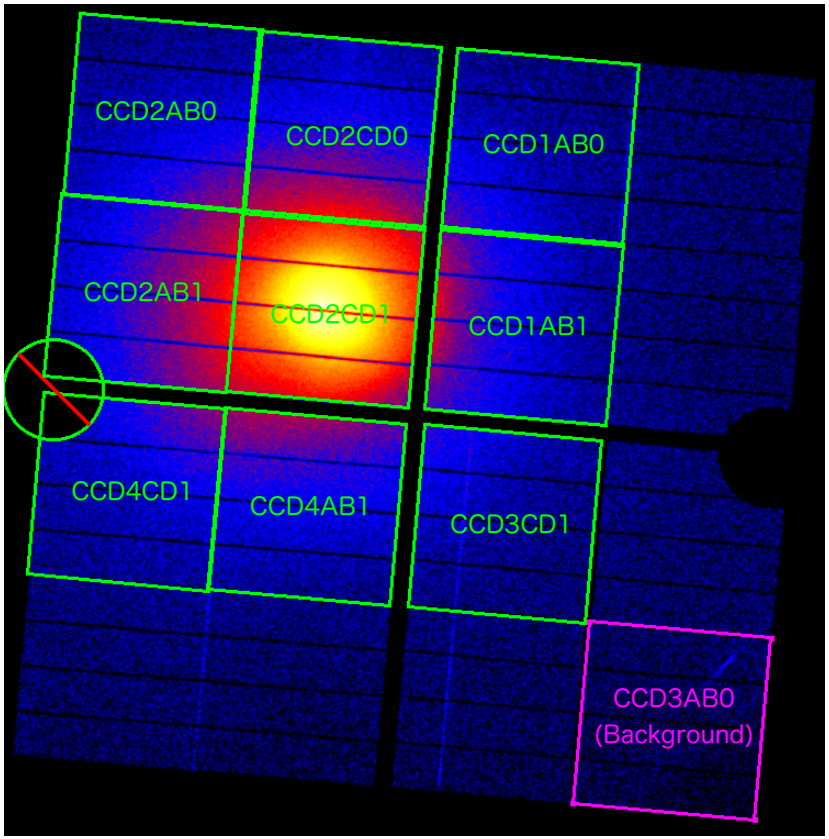


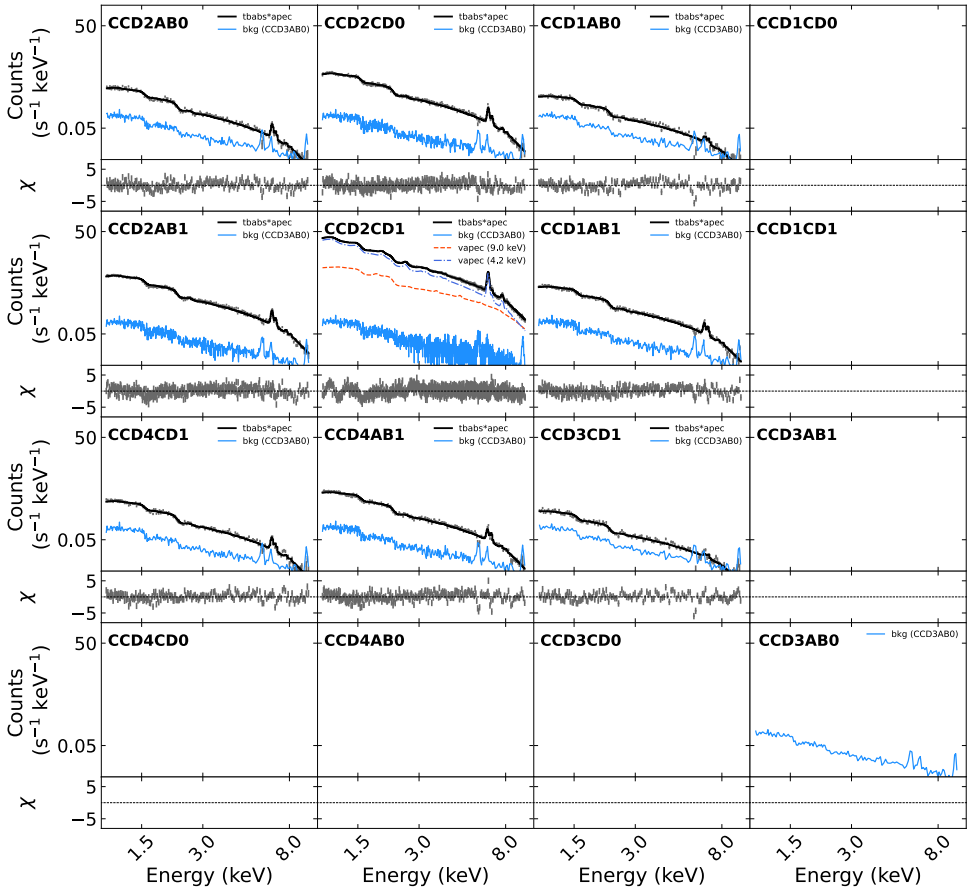


- We observed the Cygnus Loop with XRISM/Xtend and compared its flux distribution with ROSAT data.
- We found that the ROSAT and SXI **0.3–2 keV** flux distributions are consistent within 3σ over most of the field, indicating that the current CALDB provides an appropriate calibration of the quantum efficiency[6].
- To investigate whether the quantum efficiency is also properly calibrated in the hard band (**2–7 keV**), we observed the Perseus Cluster.

[6] Uchida+25 and https://iachec.org/wp-content/presentations/2025/xrism2_inoue.pdf

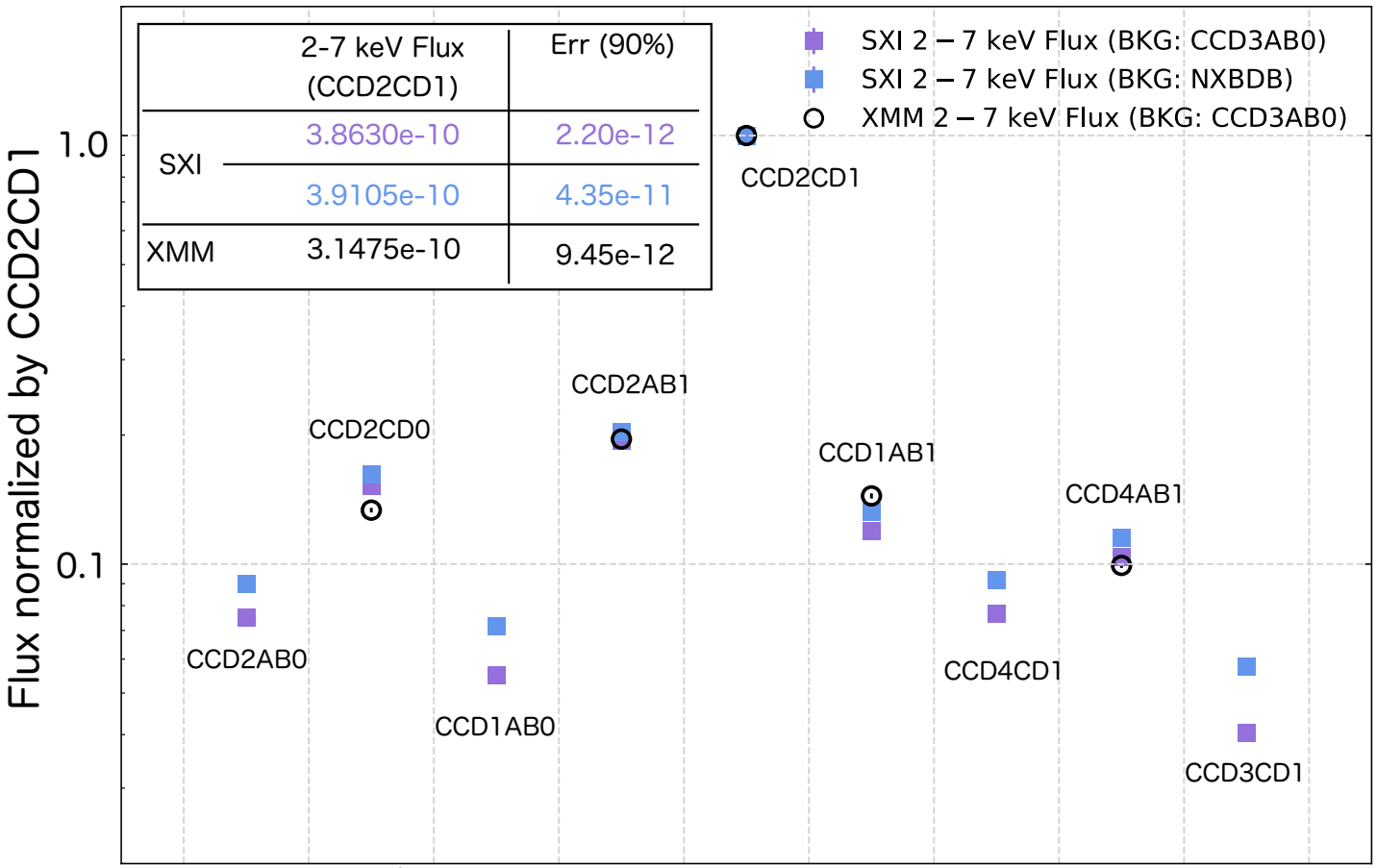
Calculating the flux for each 1/2 segment





- We measured the flux in each half-segment and compared it with XMM archival data to investigate the position dependence of the **2–7 keV** quantum efficiency of SXI.
- We used the spectrum from CCD3AB0 as the background and analyzed the 3×3 half-segments around the core of the Perseus Cluster.

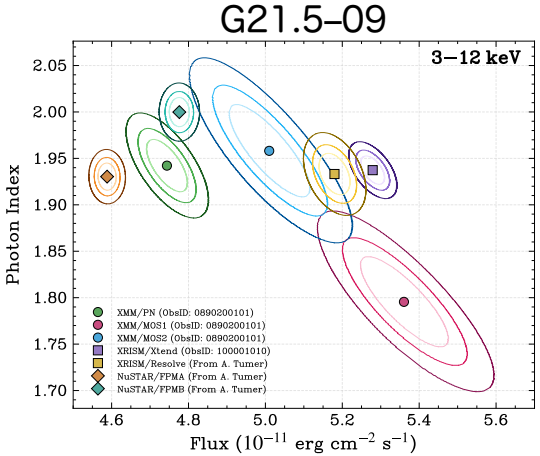
SXI 3 – 7 keV Flux vs. XMM 3 – 7 keV Flux

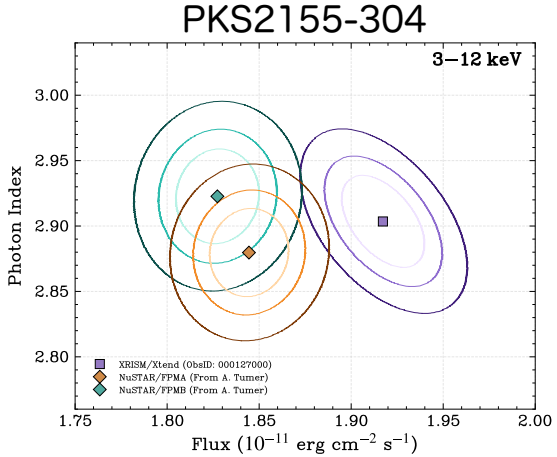


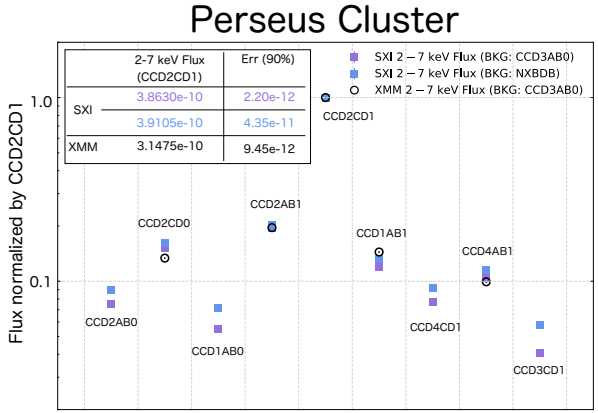
- The flux distribution is consistent between SXI and XMM in the regions investigated in this study, but the absolute SXI flux is 1.2 times higher than the XMM flux.
- We will investigate the quantum efficiency in regions not covered in this observation using future datasets.

Summary

- **The effective area of XRISM/Xtend is well calibrated.**
  - For the diffuse source G21.5−0.9, we found a flux discrepancy of ∼15% between XRISM/Xtend and NuSTAR/FPMA.
  - For the point source PKS 2155-304, XRISM/Xtend, NuSTAR/FPMA, and FPMB are consistent within the 3σ statistical uncertainties.
- **The quantum efficiency of XRISM/Xtend is well calibrated** in both the soft (0.3–2 keV) and hard (2–7 keV) bands.
  - However, the quantum efficiency of some off-axis regions has not yet been verified in the hard band.







Appendix