

# **Cross-Calibration of XRISM Resolve and Xtend with Several Nearby Galaxy Clusters**

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# Introduction

- Measuring the temperature of galaxy clusters.  
→crucial for mass estimation and, consequently, for cosmological studies.
- To enable reliable science with XRISM, it is essential to understand the detector characteristics.  
e.g.) XMM-Newton estimate lower temperatures than Chandra. (Schellenberger, et al. 2015)

The X-ray emission from galaxy clusters is stable over time, they are ideal for cross-calibration.

# Target Overview

We analyzed 38 XRISM observations of 15 galaxy clusters to investigate trends in the fitted parameters.

Cluster Name	Num. of Observations	Overview
A1413	1	relaxed moderate cool-core
A1795	2	strong cool-core
A1914	1	major merging
A2029	4	strong cool-core, relaxed
A2199	1	strong cool-core
A2319	1	major merging
A3395	1	bimodal merging
A3571	4	weak/no cool-core, relaxed
A3667	2	post-merger / cold-front archetype
Centaurus	1	strong cool-core
Coma	4	no cool-core, disturbed
Hydra	1	strong cool-core, AGN
Virgo	5	cool-core
PKS0745-19	1	strong cool-core
Perseus	9	strong cool-core

# Analysis

We analyzed the sky region corresponding to the Resolve FOV.

## Setups

- HEASoft v6.36 + CALDB 2025-09-15.
- Resolve RMF type is "X" (x-large).
- ARF: 6' FLATCIRCLE.
- pixel 12 and 27 was excluded.

## Model

tbabs \* baptec + NXB

- nH was fixed at galactic value
  - the velocity dispersion of Xtend was fixed at those of Resolve
- temperature is estimated from Fe line ratios, which are independent of the continuum shape.

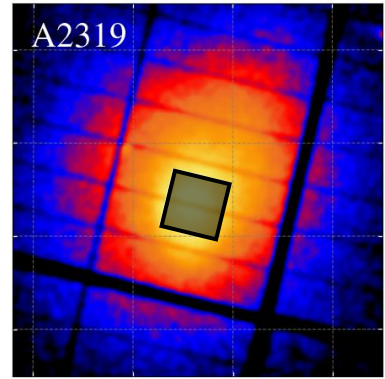
## Energy Band

Resolve : 2-12, 3-12, around Fe line (width 1 keV)

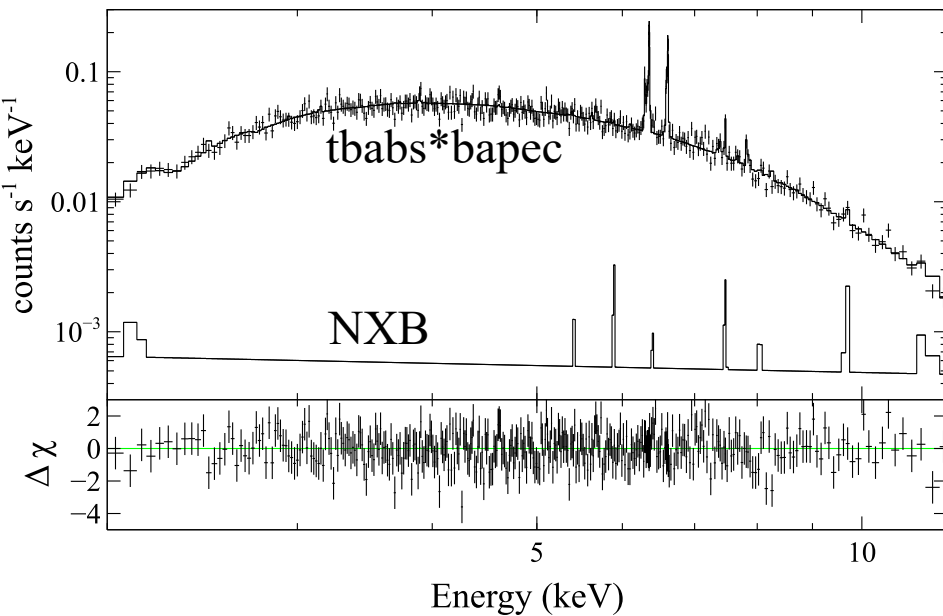
Xtend : 0.5-12, 2-12, 3-12 keV

We only used observations with C-stat./d.o.f. < 1.1

# Example: Abell 2319 center

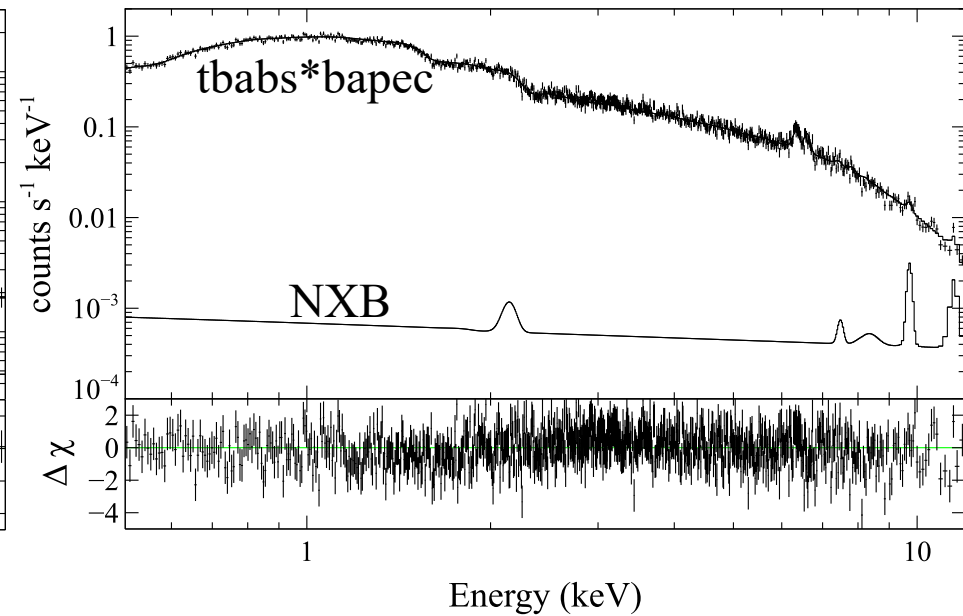


## Resolve (2-12 keV)



$$kT = 9.3 \pm 0.2 \text{ (keV)}$$
$$Abund = 0.45 \pm 0.02 \text{ (solar)}$$
$$norm = 0.211 \pm 0.003 \text{ (cm}^{-5}\text{)}$$

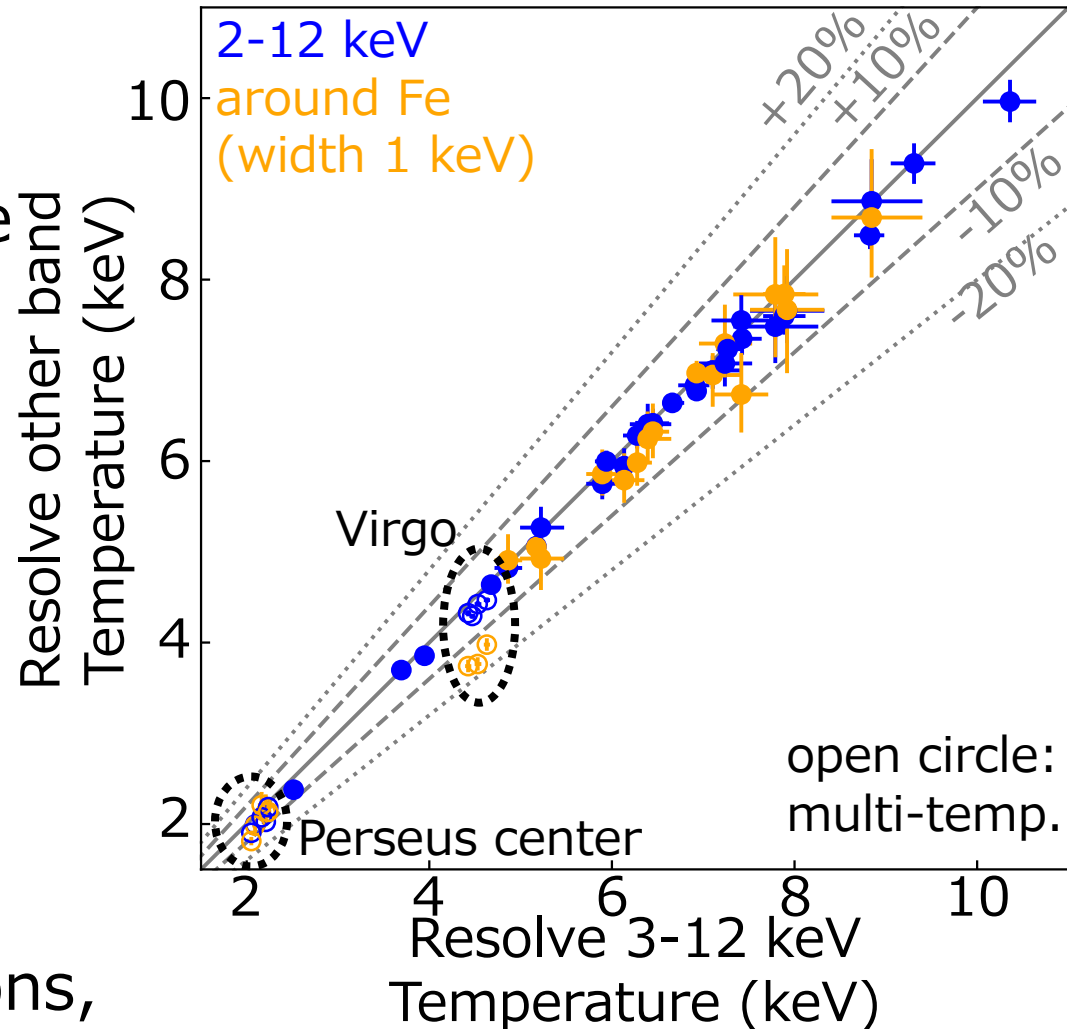
## Xtend (0.5-12 keV)



$$kT = 11.0 \pm 0.2 \text{ (keV)}$$
$$Abund = 0.47 \pm 0.03 \text{ (solar)}$$
$$norm = 0.200 \pm 0.001 \text{ (cm}^{-5}\text{)}$$

# Comparison in Resolve (Temperature)

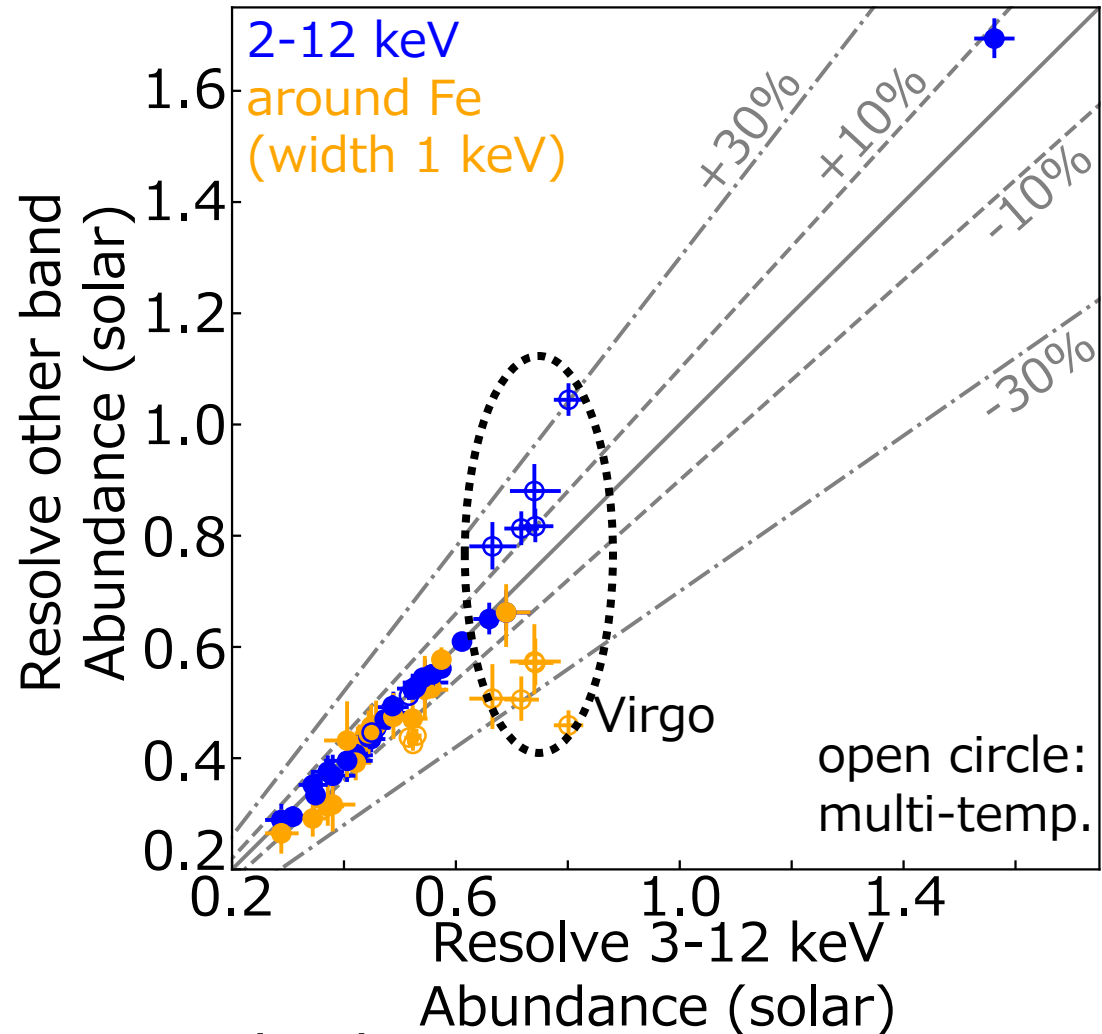
- **consistent** across all energy bands in Resolve within  $\pm 10\%$ .
- **Virgo** and the **central region of Perseus**, the Fe-line band gives temperatures about **20% lower** than the broader bands.



→ In these observations, the target contains regions that require a multi-temperature model, making it unsuitable for cross-calibration.

# Comparison in Resolve (Abundance)

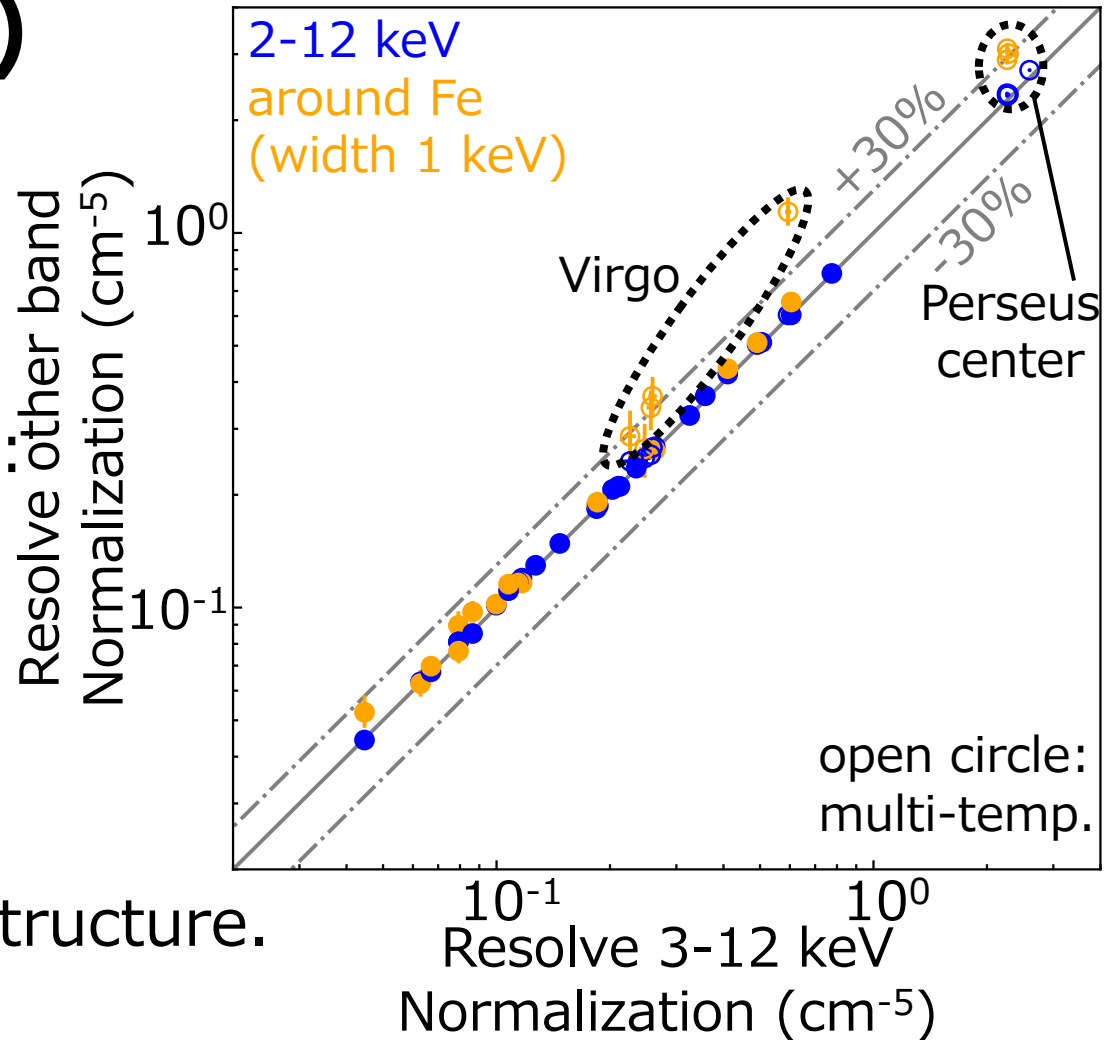
- **consistent** across all energy bands in Resolve within  $\pm 10\%$ .
- Virgo shows larger discrepancies among bands.  
→ caused by a **multi-temperature** structure, **non-solar abundances**, or both.



# Comparison in Resolve (Normalization)

- **consistent** across all energy bands in Resolve.

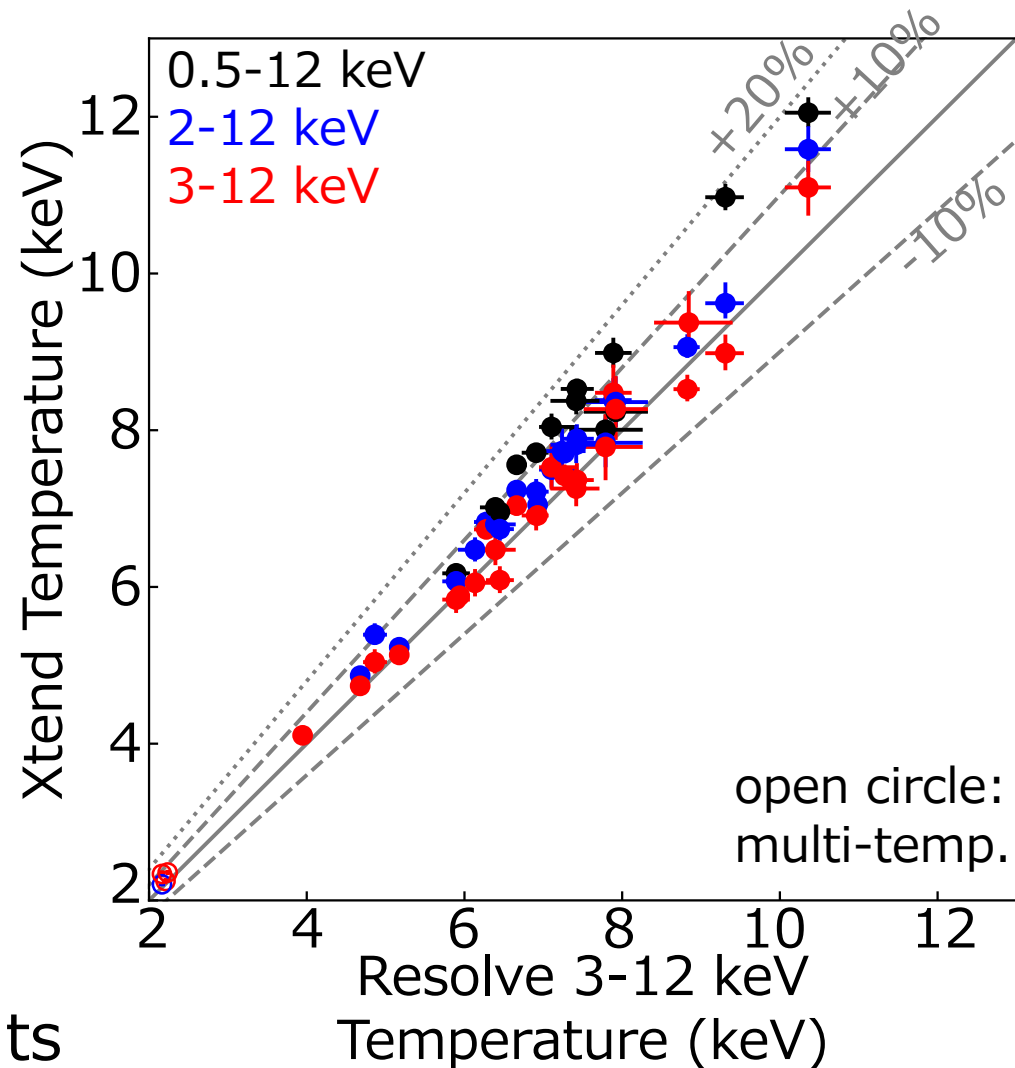
**Virgo & Perseus center:**  
the Fe-line band gives values about **30% higher** than the broad-band fits  
→ suggesting multi-temperature structure.



All parameters are generally consistent across all energy bands in Resolve.

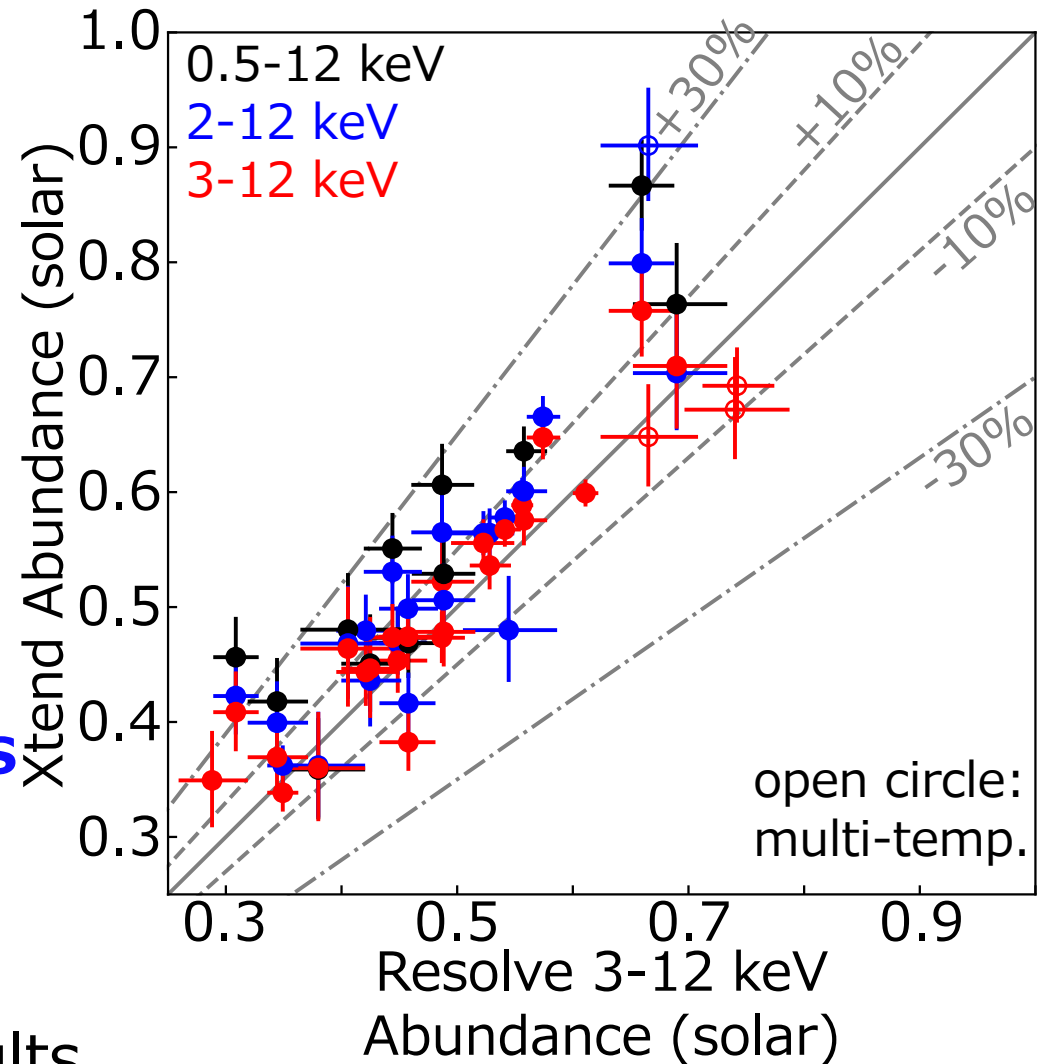
# Comparison of Resolve and Xtend (Temperature)

- Xtend temperatures in the **0.5–12 keV band** are about **10-20% higher** than Resolve.
- When using the **2–12 keV band reduces the difference** (~5-10% higher)
- the **3–12 keV band** results are almost **consistent** with Resolve.



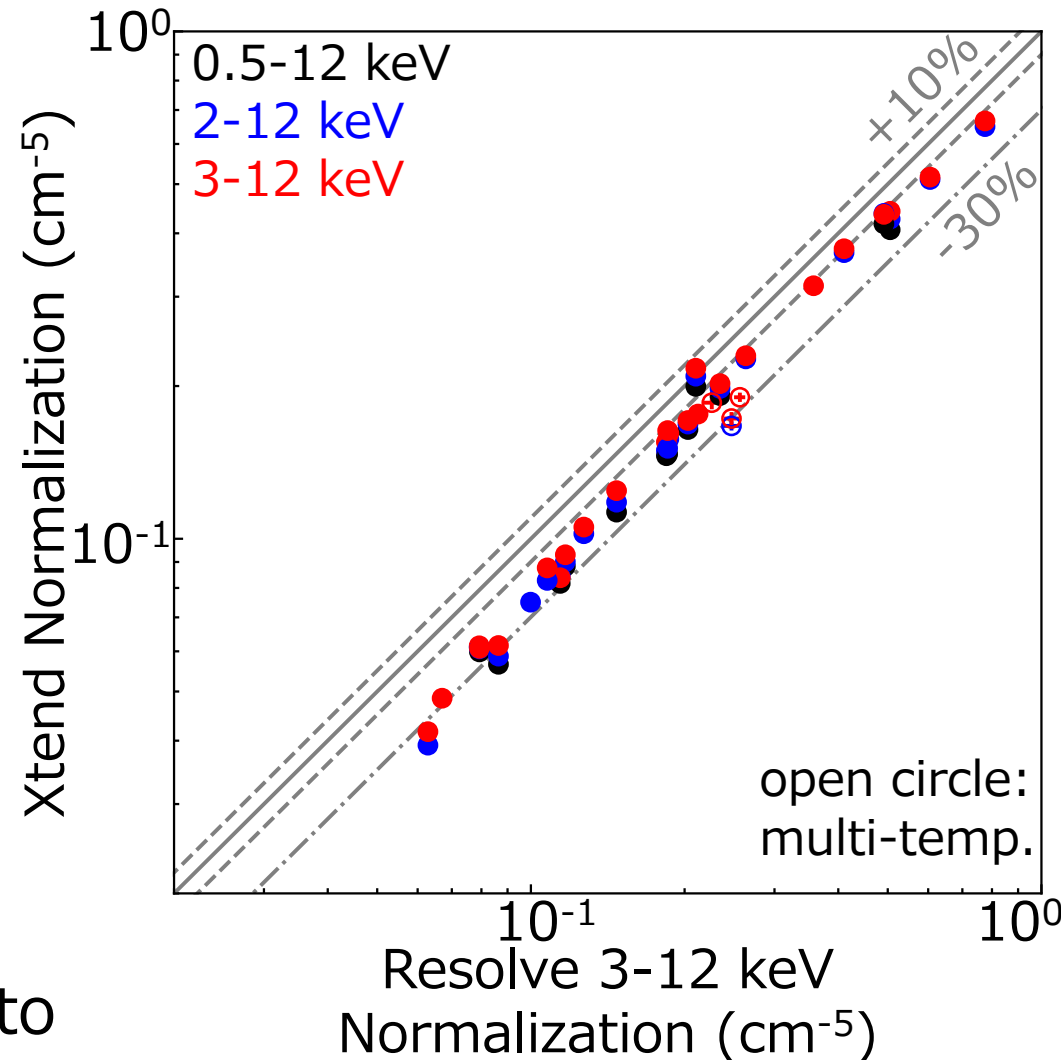
# Comparison of Resolve and Xtend (Abundance)

- Xtend abundances in the **0.5–12 keV band** are about **10-30% higher** than Resolve.
- When using the **2–12 keV band reduces the differences.** (~10% higher)
- the **3–12 keV band** results are almost **consistent** with Resolve.



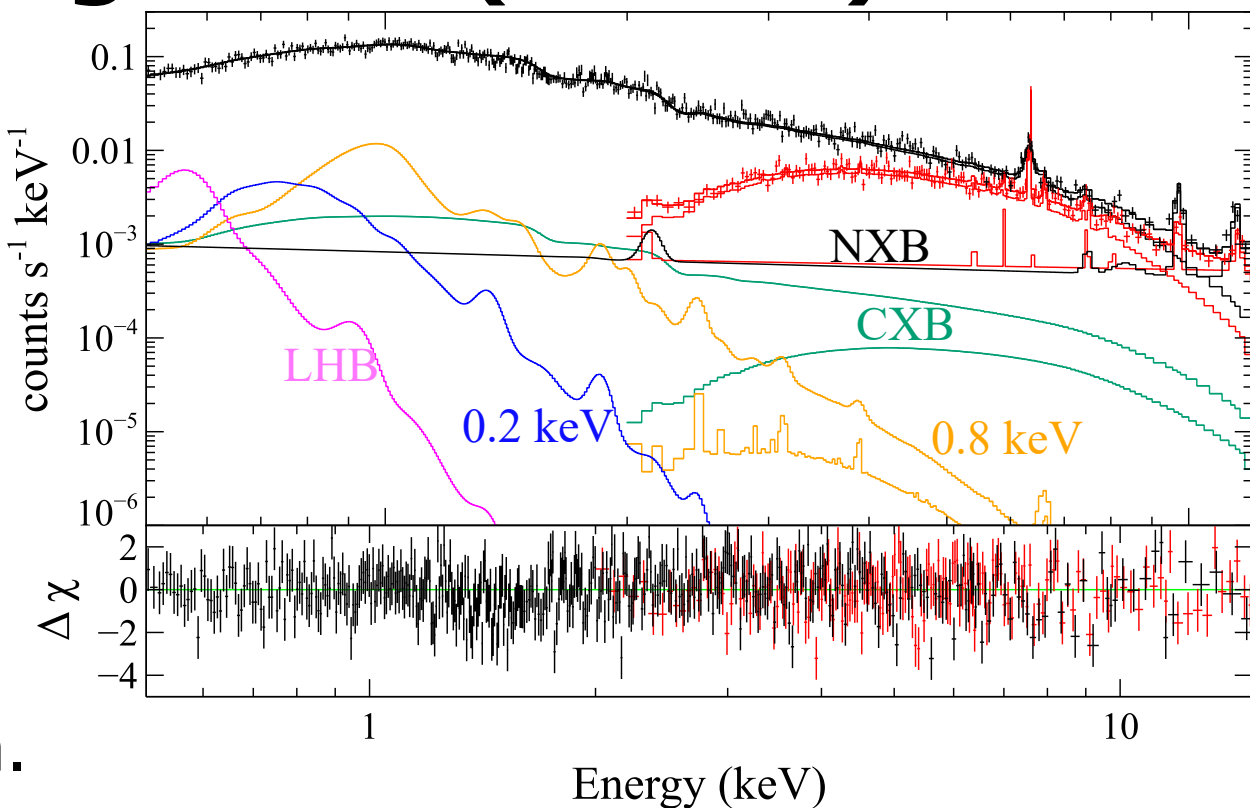
# Comparison of Resolve and Xtend (Normalization)

- Xtend normalizations in the **0.5–12 keV band** are about **10-30% lower** than Resolve.
- When using the **2–12 keV** or **3–12 keV bands** slightly reduces the discrepancy, but differences still remains.
- The differences appears to become larger for fainter objects.  
→ **caused by background estimation?**



# Effect of Background (A3395)

- We modeled 4 X-ray background components and fitted the spectra.
- BKG parameters were tied.
- ICM parameters were untied except for the velocity dispersion.



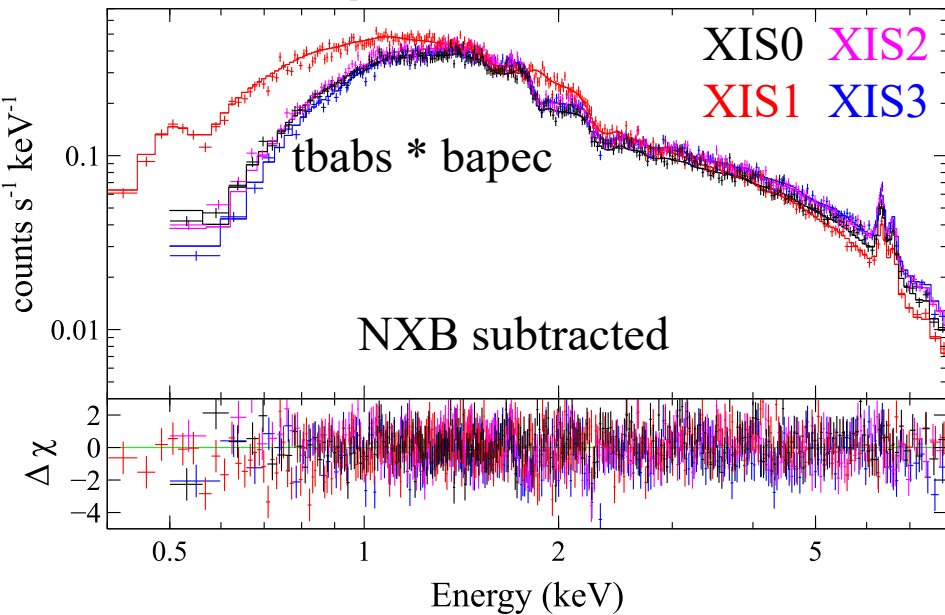
The discrepancy in the temperatures and normalizations cannot be explained by background effects alone?

	Xtend	Resolve
kT (keV)	$6.1 \pm 0.2$	$5.2 \pm 0.2$
Abundance (solar)	$0.41 \pm 0.04$	$0.38 \pm 0.03$
Norm ( $\times 10^{-2} \text{ cm}^{-5}$ )	$2.20^{+0.03}_{-0.01}$	$4.4 \pm 0.1$

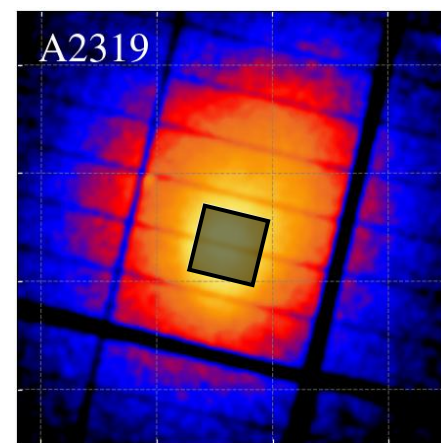
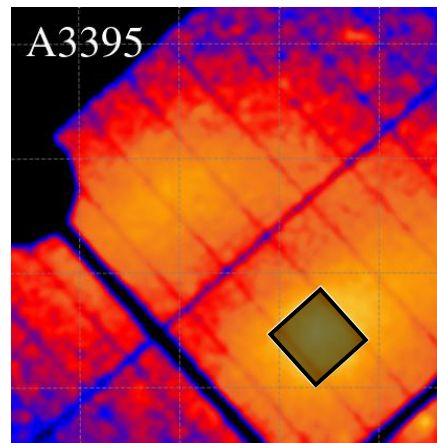
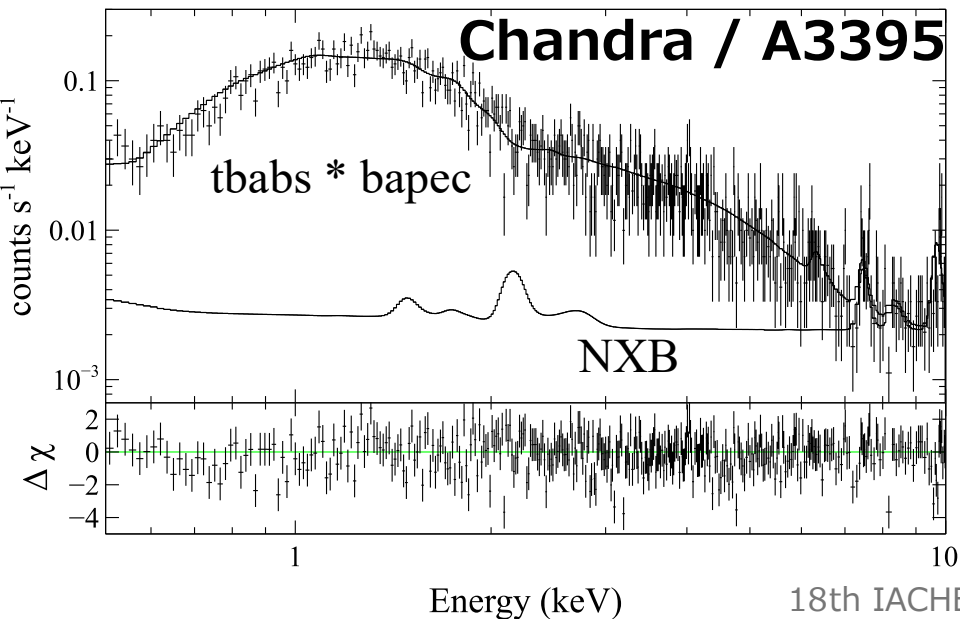
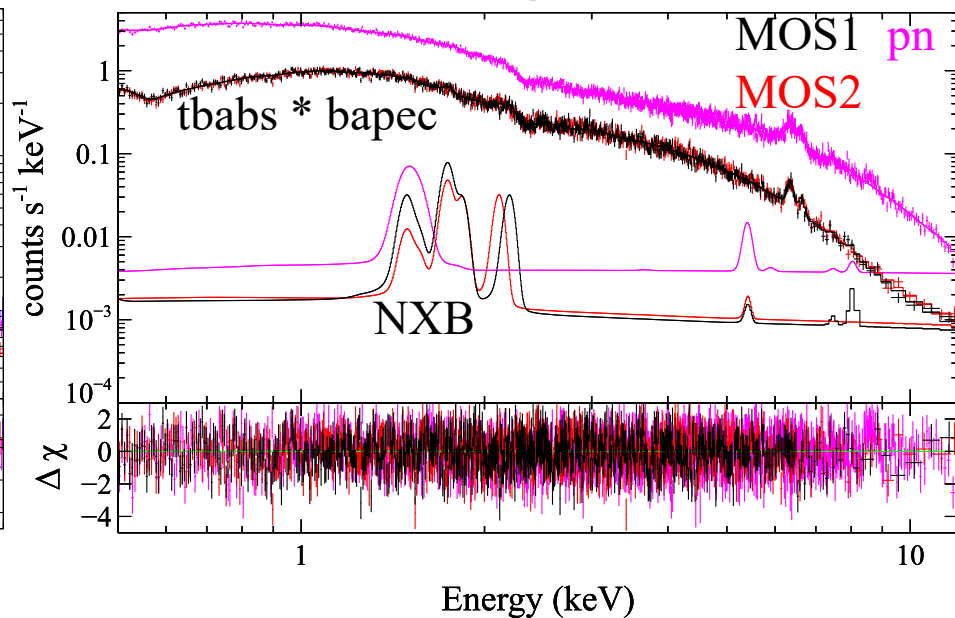
*~20% higher*  
*~50% lower*

# Example of spectra of other CCDs

## Suzaku / A2319



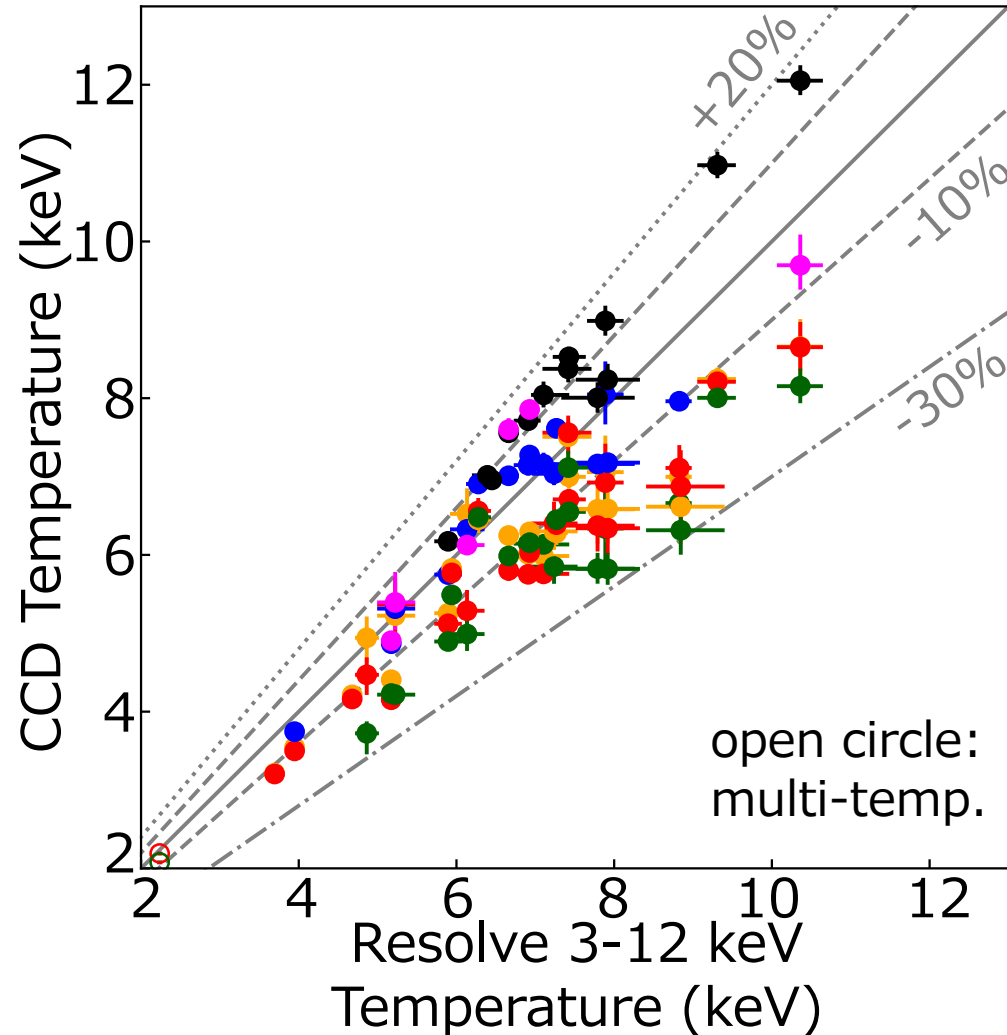
## XMM-Newton / A2319



# Comparison with Other CCDs (Temperature)

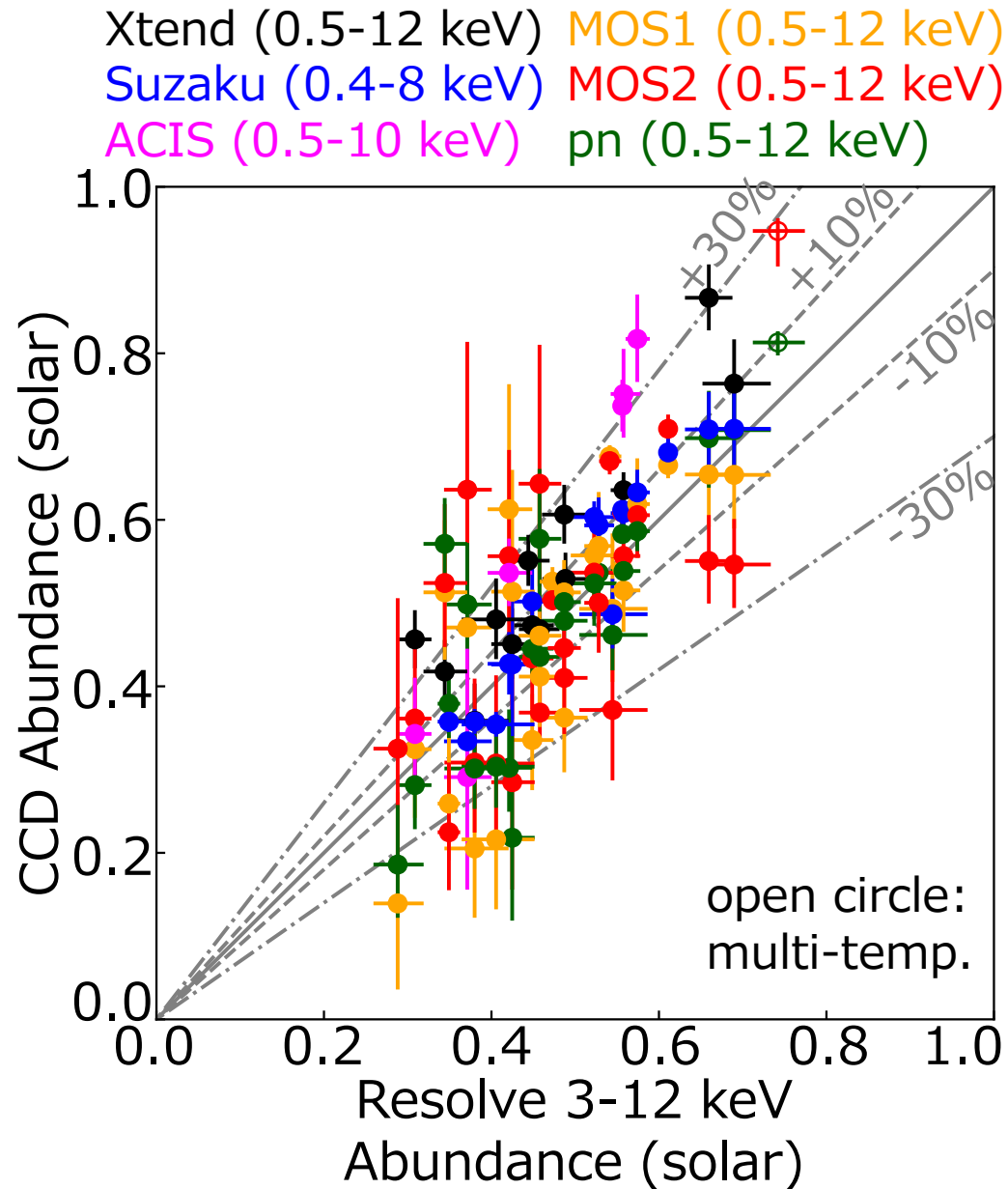
- **Suzaku and Chandra** are **consistent** with Resolve within  $\pm 10\%$ .
- **XMM-Newton** temperatures are about **10-30% lower** than Resolve.
- Even compared with other CCD instruments, **Xtend temperatures tend to be higher.**

Xtend (0.5-12 keV) MOS1 (0.5-12 keV)  
Suzaku (0.4-8 keV) MOS2 (0.5-12 keV)  
ACIS (0.5-10 keV) pn (0.5-12 keV)



# Comparison with Other CCDs (Abundance)

- **Suzaku** abundances are **consistent** with Resolve within  $\pm 10\%$ .
- **Chandra** abundances are about **10-30% higher** than Resolve.
- **XMM-Newton** abundances **differ** from Resolve by up to about 30%

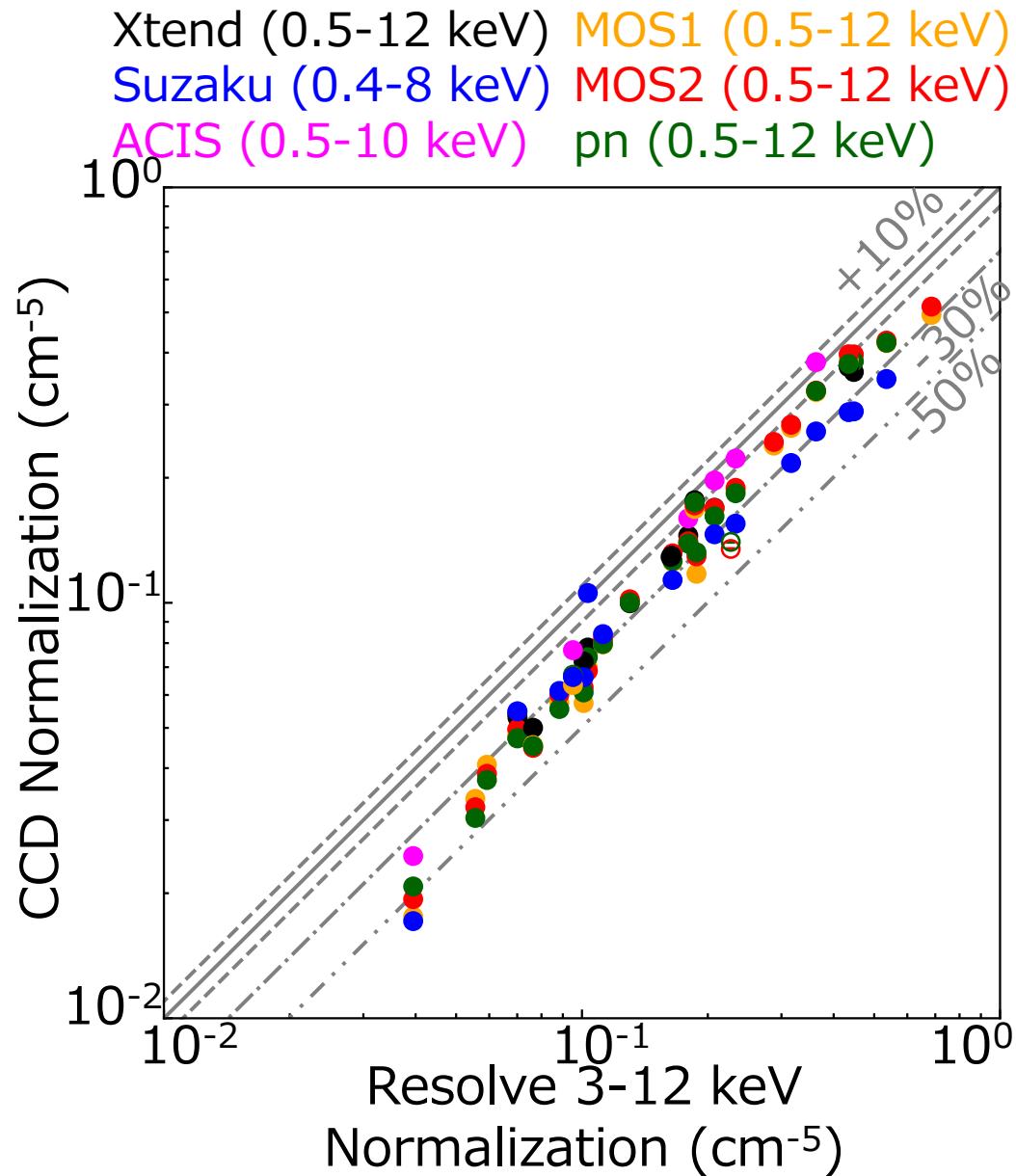


# Summary

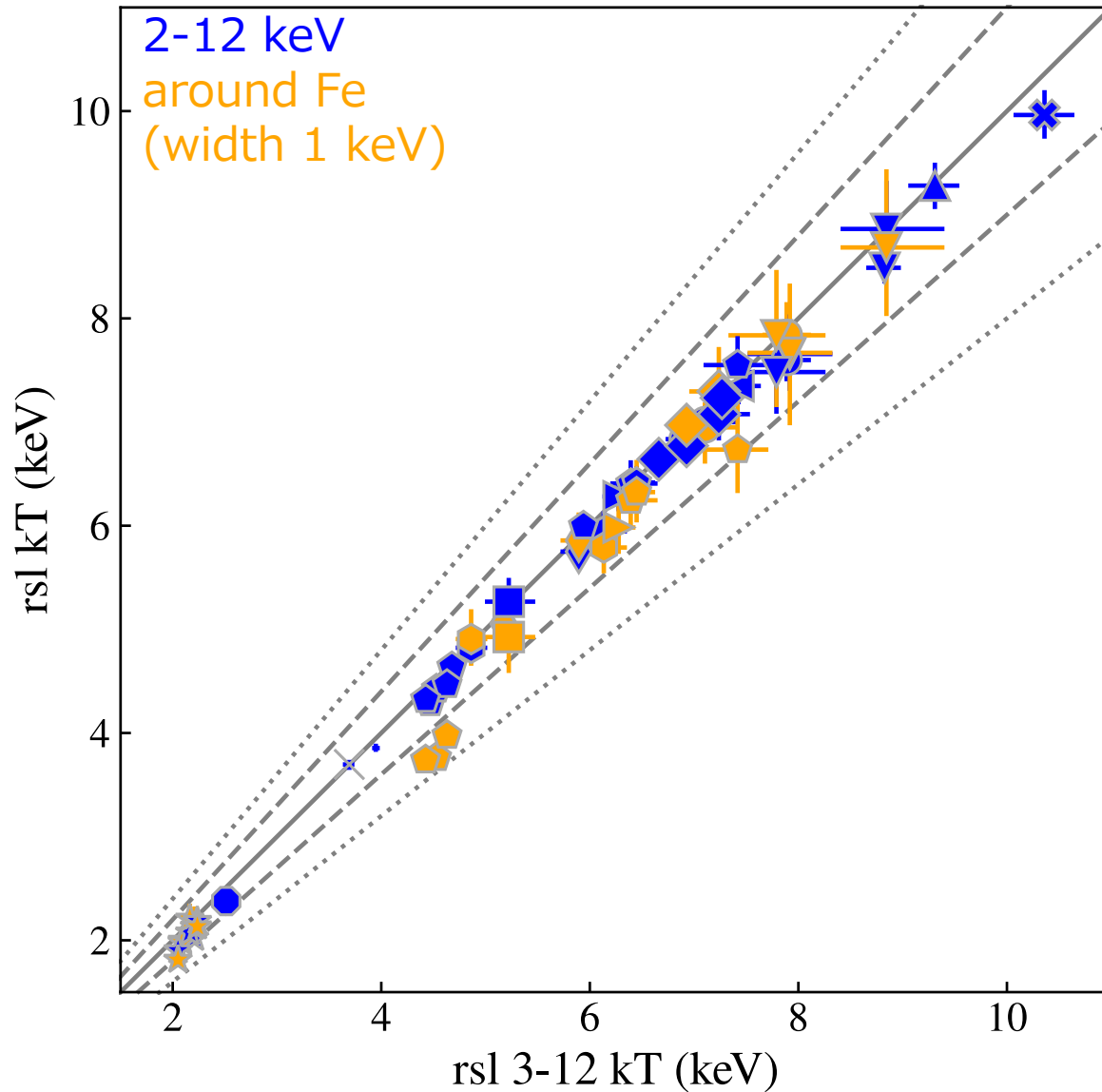
- We analyzed **38 observations** of **15 clusters** for compere fit parameter between Xtend & Resolve
- **All parameters (kT, Abund, norm) are consistent** across all energy bands in Resolve
- **Xtend kT and abundances** are about **20% higher** and **norms** are about **30% lower** from Resolve.  
→ These discrepancies cannot be explained by background effects alone.
- **Suzaku kT and abundances** are **consistent** with those measured with **Resolve**.
- **Chandra kT** are **consistent** with **Resolve** and abundances are **10-30% higher** than Resolve.
- **XMM kT** are about **10-30% lower** than Resolve and abundances **differ** from Resolve by up to about 30%

# Comparison with Other CCDs (Normalization)

- **Chandra** normalizations are most close from Resolve.  
( $\sim 10\%$ )
- **XMM-Newton** normalizations are **10-30% lower** than Resolve.
- **Suzaku** normalizations are **almost 30% lower** than Resolve.

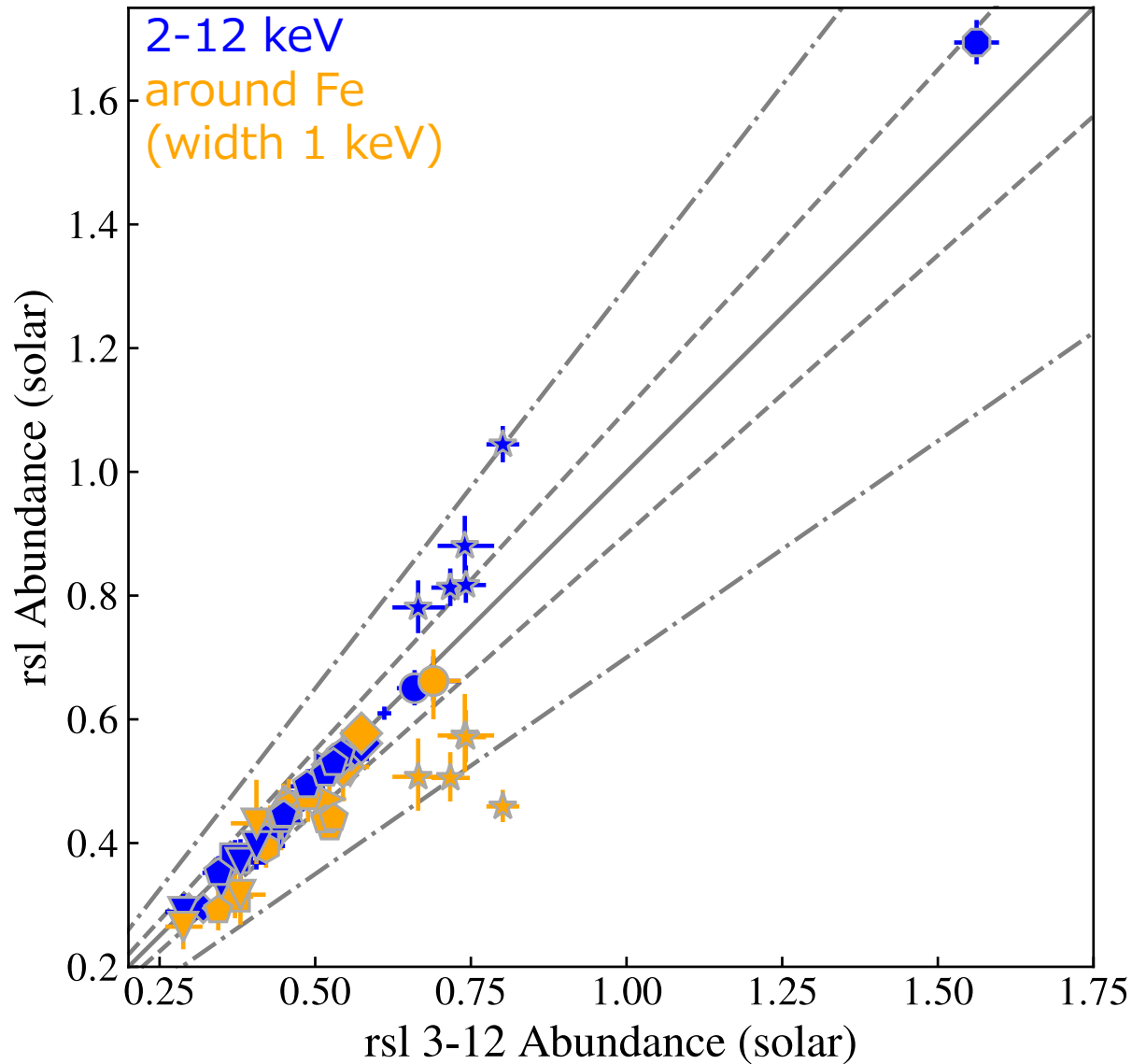


# Comparison in Resolve (Temperature)

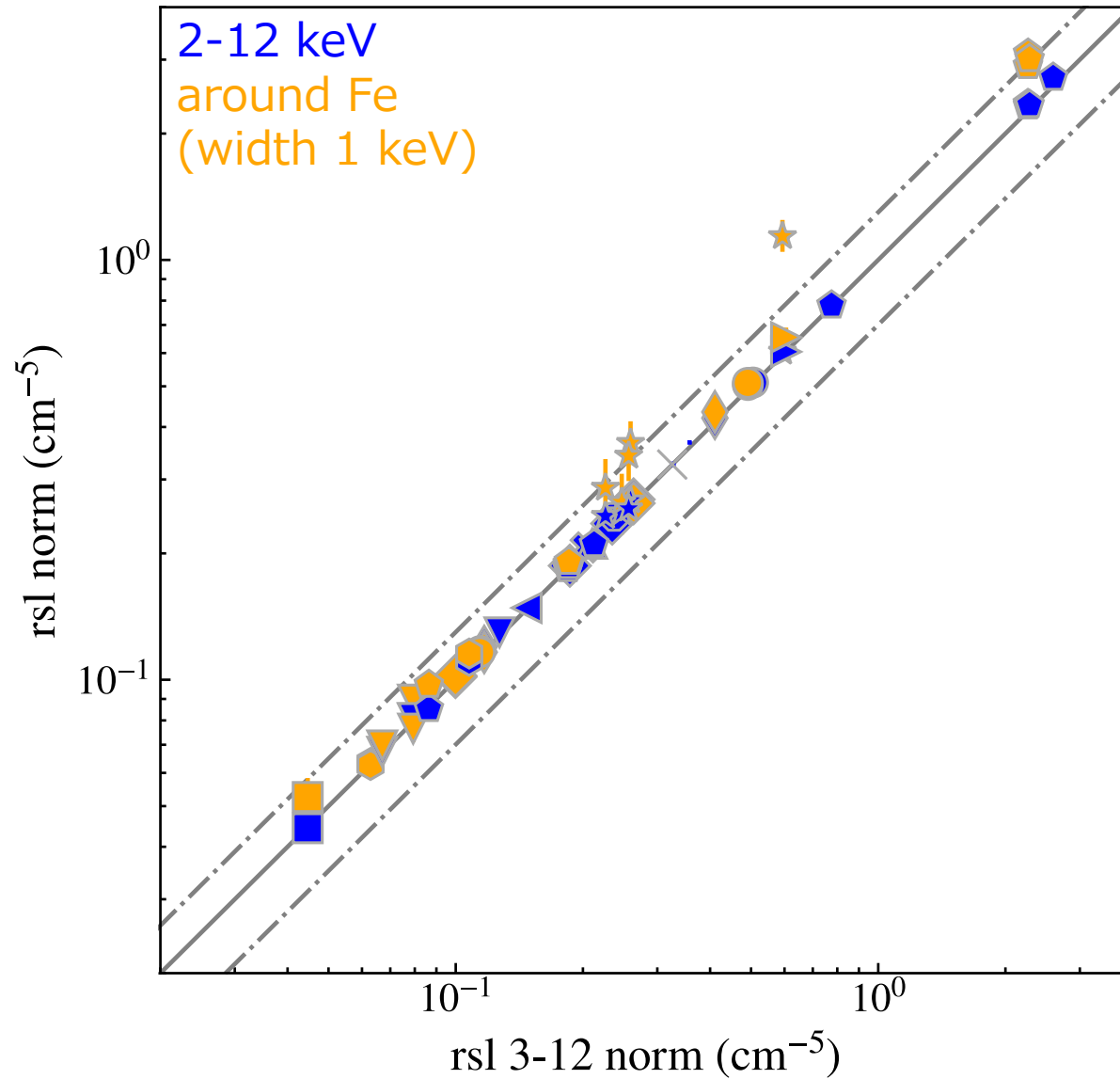


- Perseus
- ▶ PKS0745-19
- ★ M87
- ✕ HydraA
- ▼ Coma
- Centaurus
- A3667
- ◆ A3571
- A3395
- ▲ A2319
- A2199
- A2029
- ✱ A1914
- ◆ A1795
- ◀ A1413

# Comparison in Resolve (Abundance)

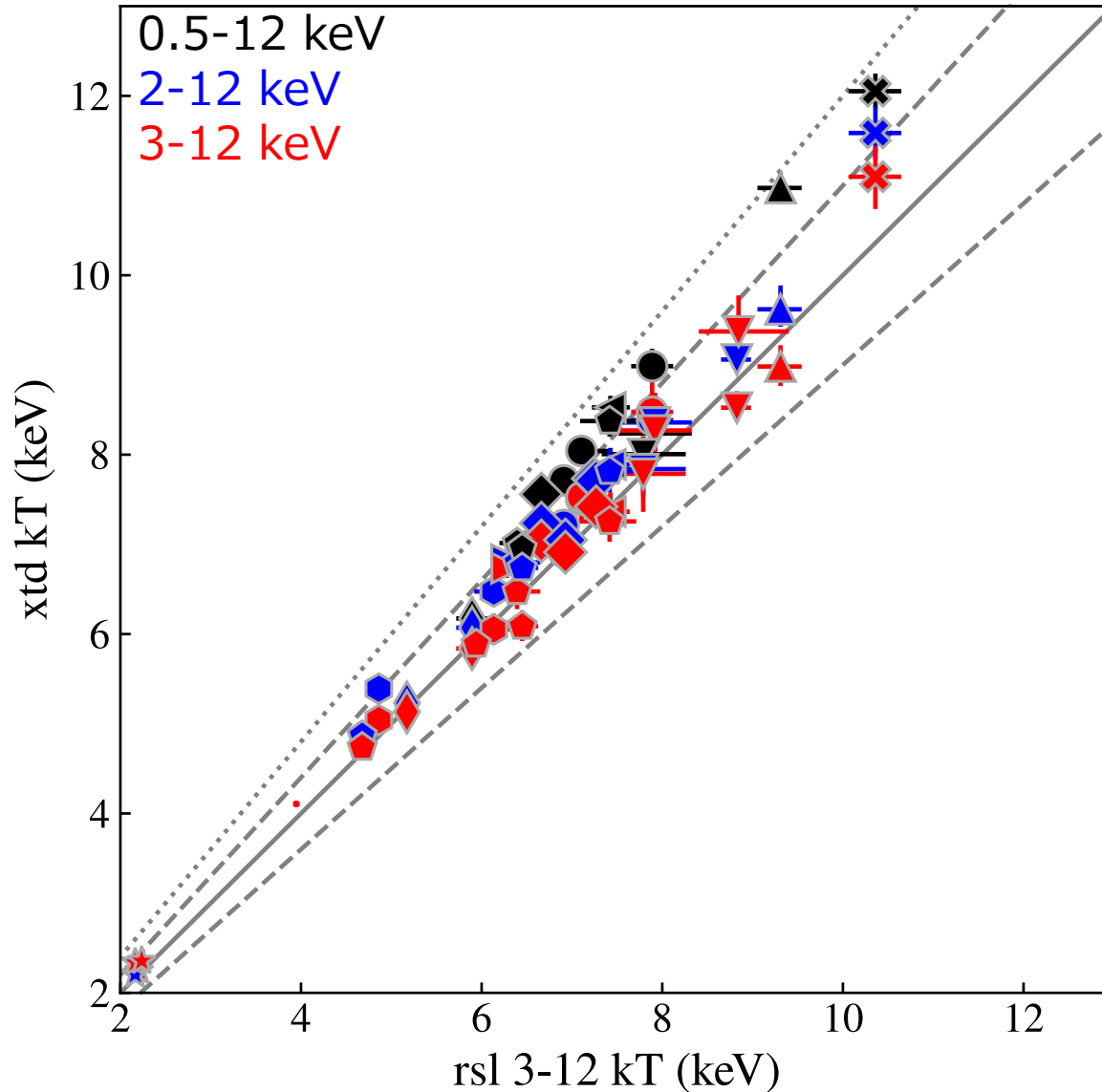


# Comparison in Resolve (Normalization)



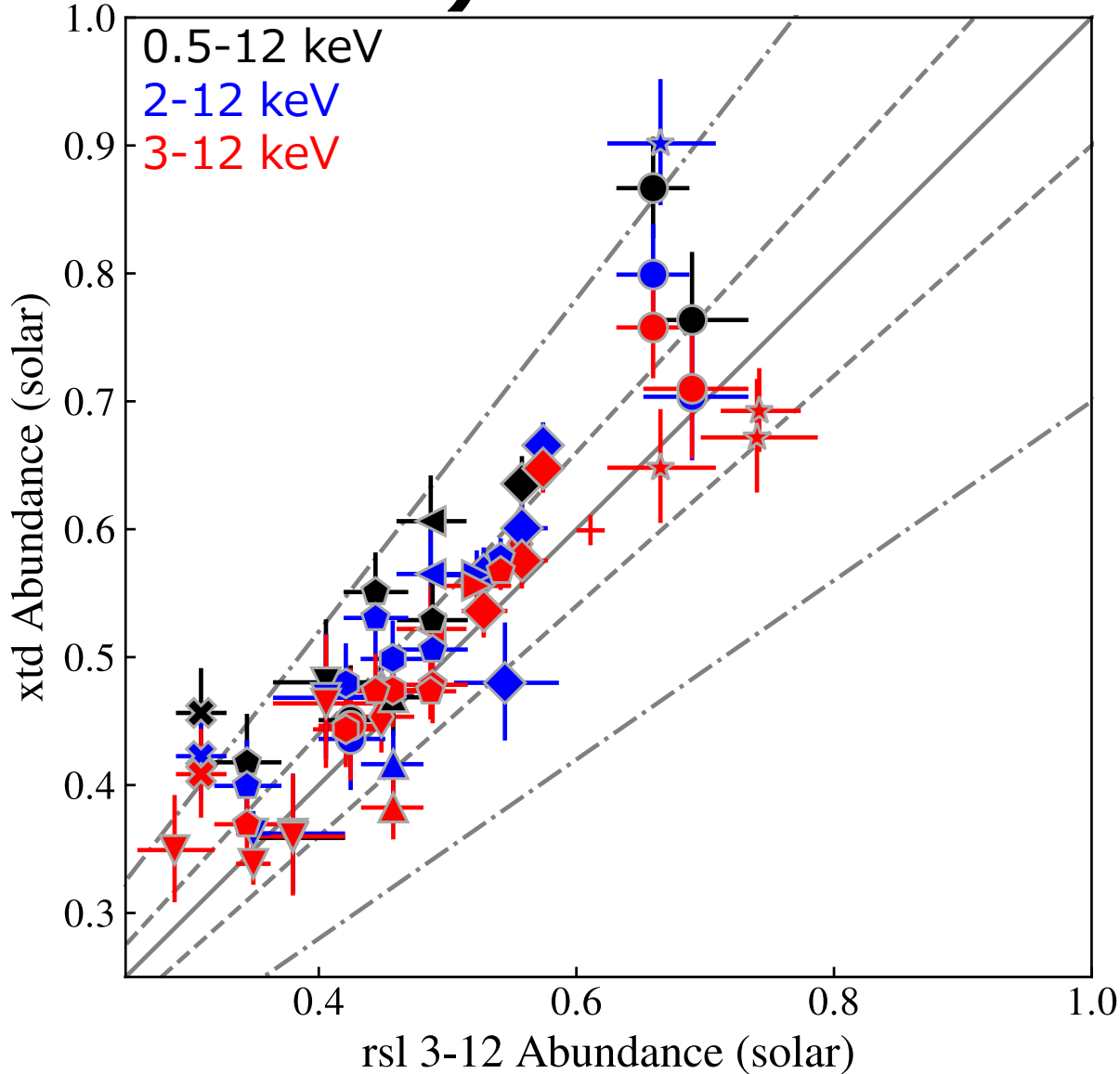
- Perseus
- ▶ PKS0745-19
- ★ M87
- × HydraA
- ▼ Coma
- Centaurus
- A3667
- ◆ A3571
- A3395
- ▲ A2319
- A2199
- A2029
- ✱ A1914
- ◆ A1795
- ◀ A1413

# Comparison of Resolve and Xtend (Temperature)



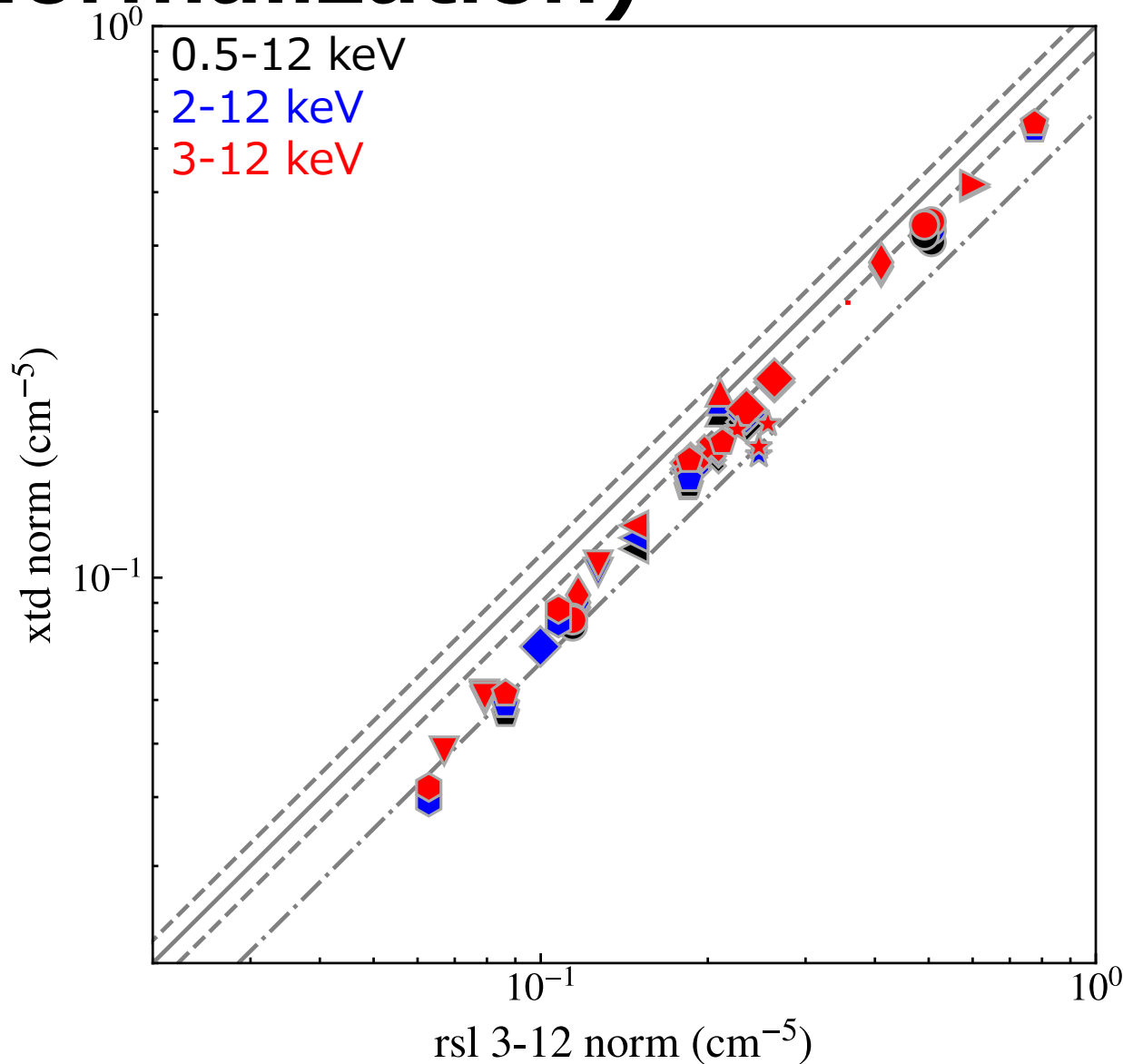
- Perseus
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- A2199
- A2029
- ✱ A1914
- ◆ A1795
- ◀ A1413

# Comparison of Resolve and Xtend (Abundance)



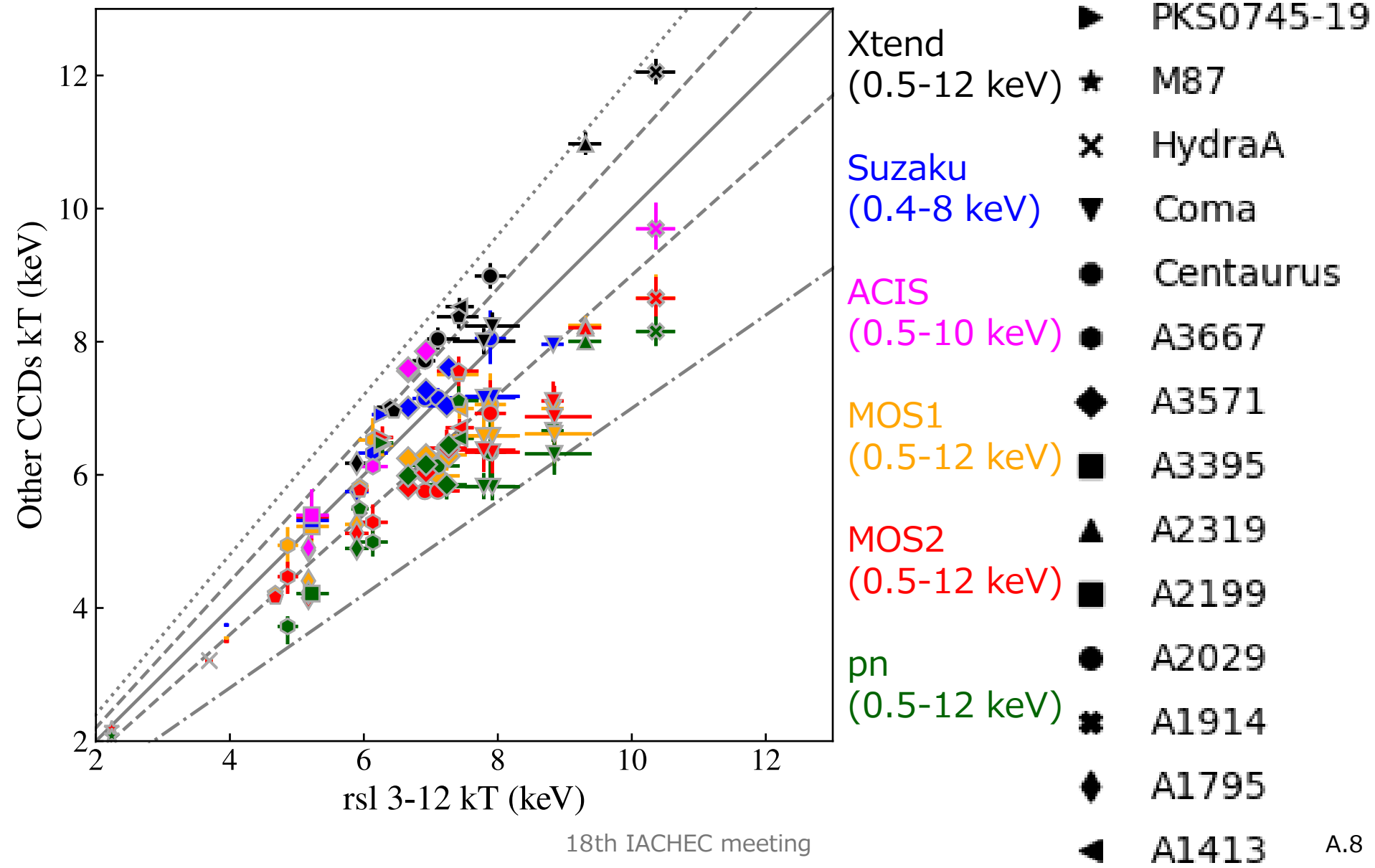
- Perseus
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- A2199
- A2029
- ✱ A1914
- ◆ A1795
- ◀ A1413

# Comparison of Resolve and Xtend (Normalization)

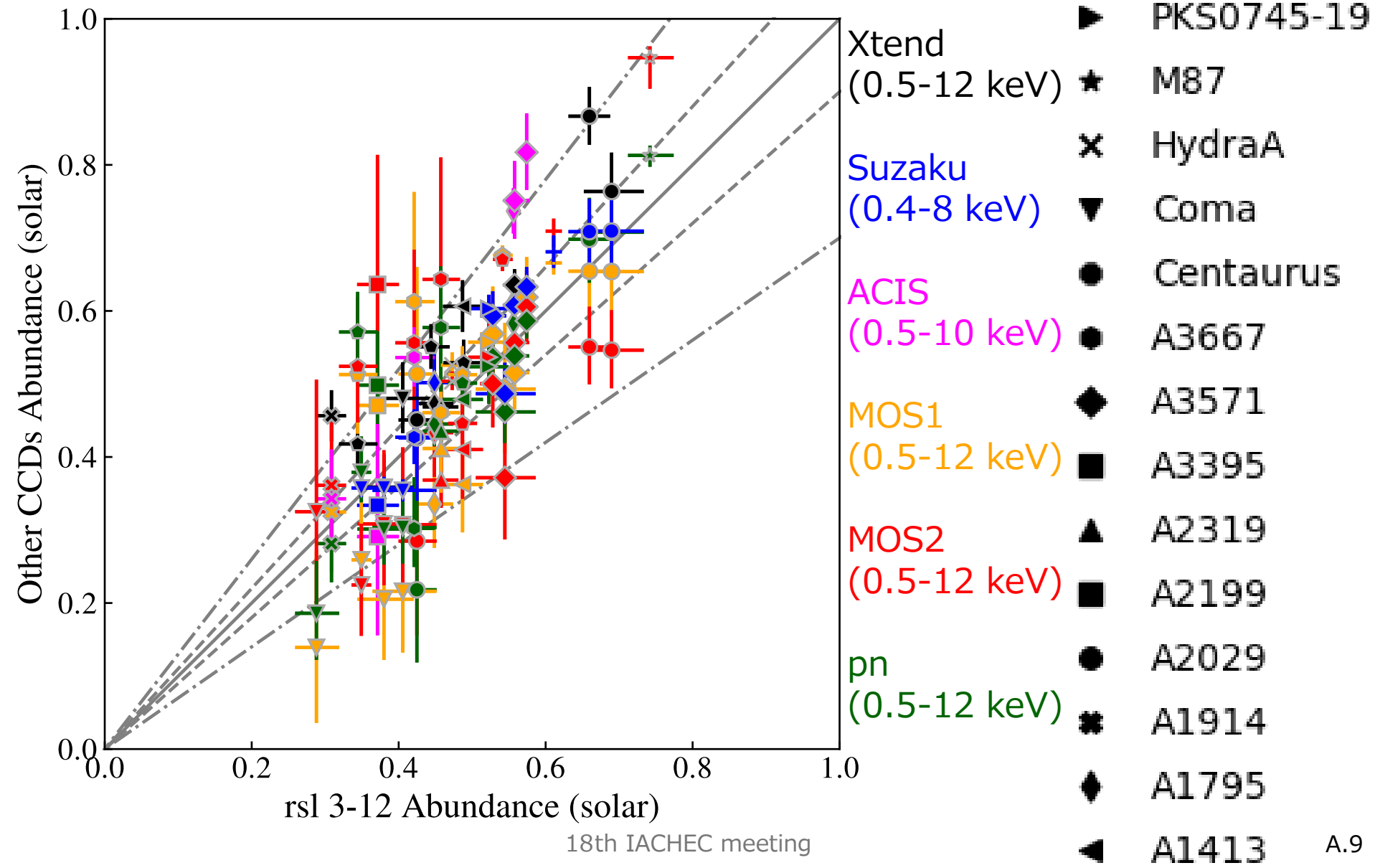


- Perseus
- ▶ PKS0745-19
- ★ M87
- × HydraA
- ▼ Coma
- Centaurus
- A3667
- ◆ A3571
- A3395
- ▲ A2319
- A2199
- A2029
- ✱ A1914
- ◆ A1795
- ◀ A1413

# Comparison with Other CCDs (Temperature)



# Comparison with Other CCDs (Abundance)



# Comparison with Other CCDs (Normalization)

