Chandra Calibration Status

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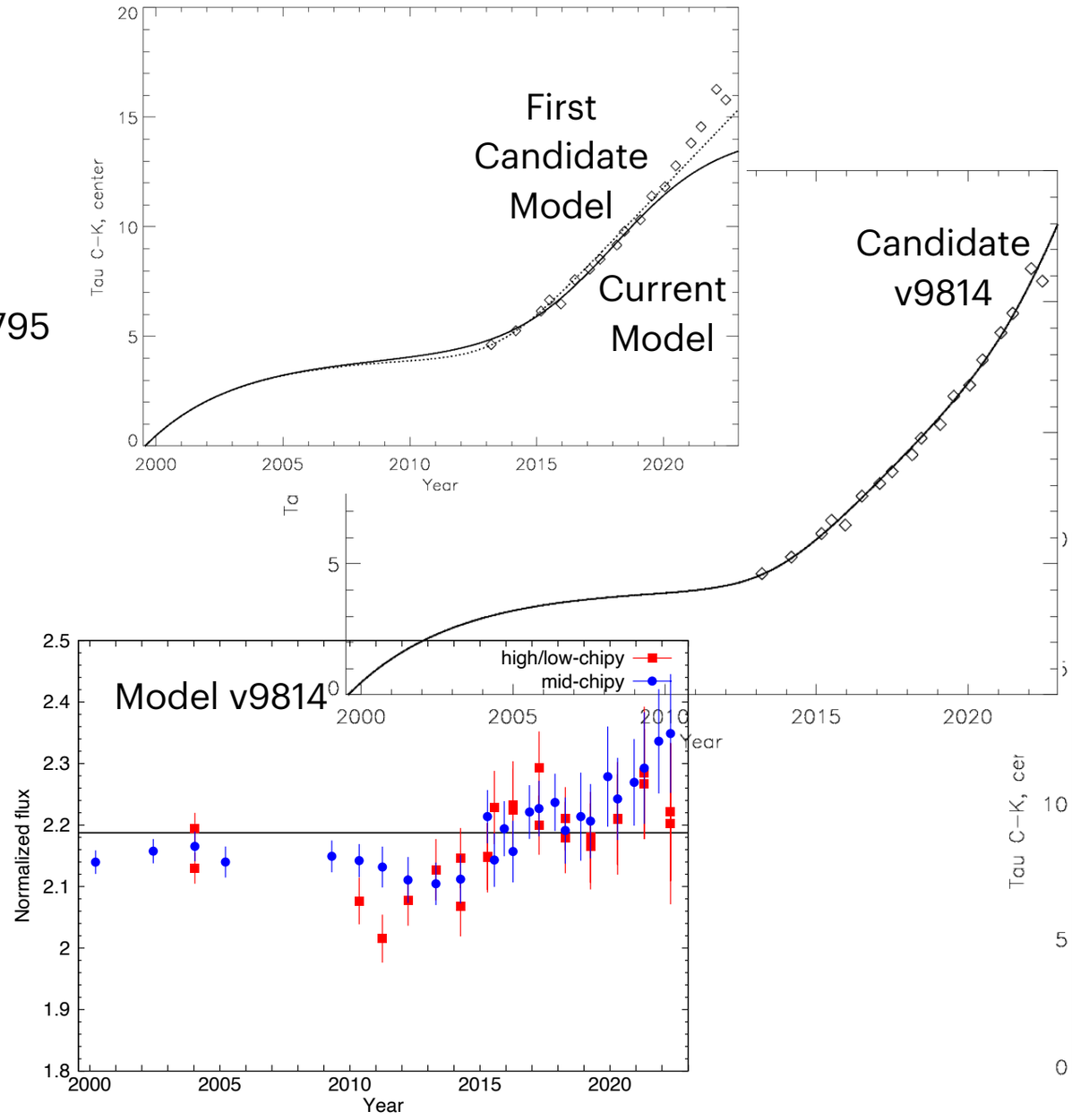
15th IACHEC Meeting - April 24, 2023

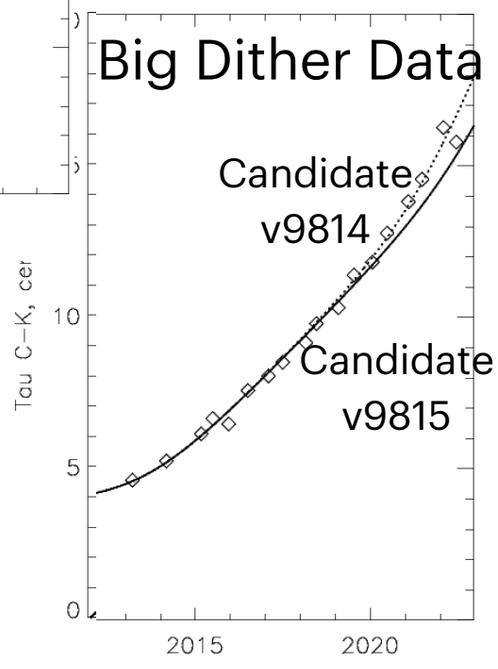
ACIS Contamination Model

Simplifying the Process

New Process

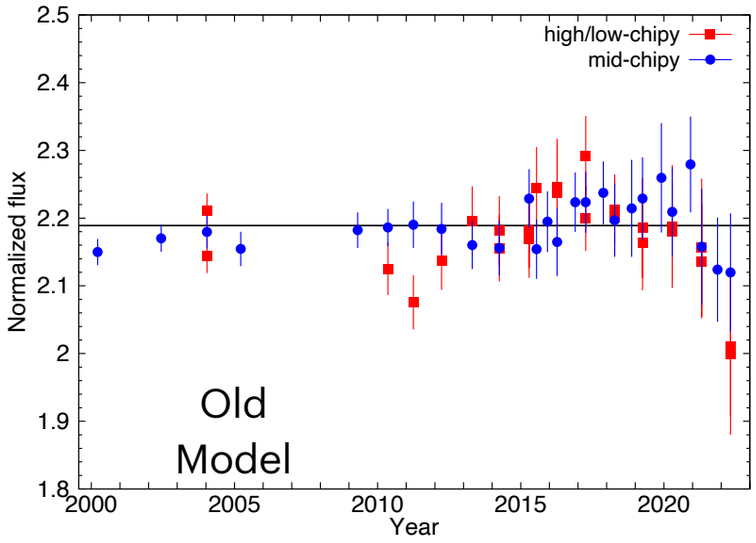
1. (HLM) construct candidate correction (v9814)
    A. remove tau0_C-K flattening
    B. check model against Big Dither & A1795
    C. check model against ECS Al-K data
    D. increase tau0_C-K
    E. No changes in tau1 models
2. (AB) test against A1795 data
3. (HLM) soften tau0 increase, make v9815
4. (PP,AB) check against 1E0102 and A1795

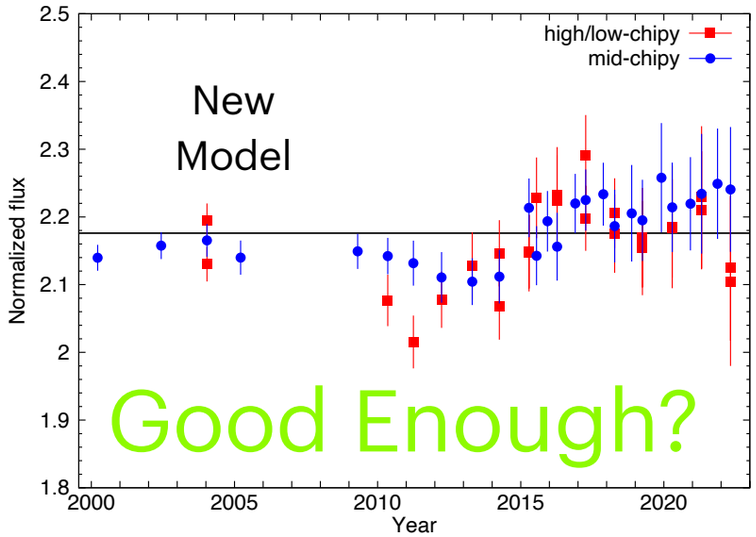




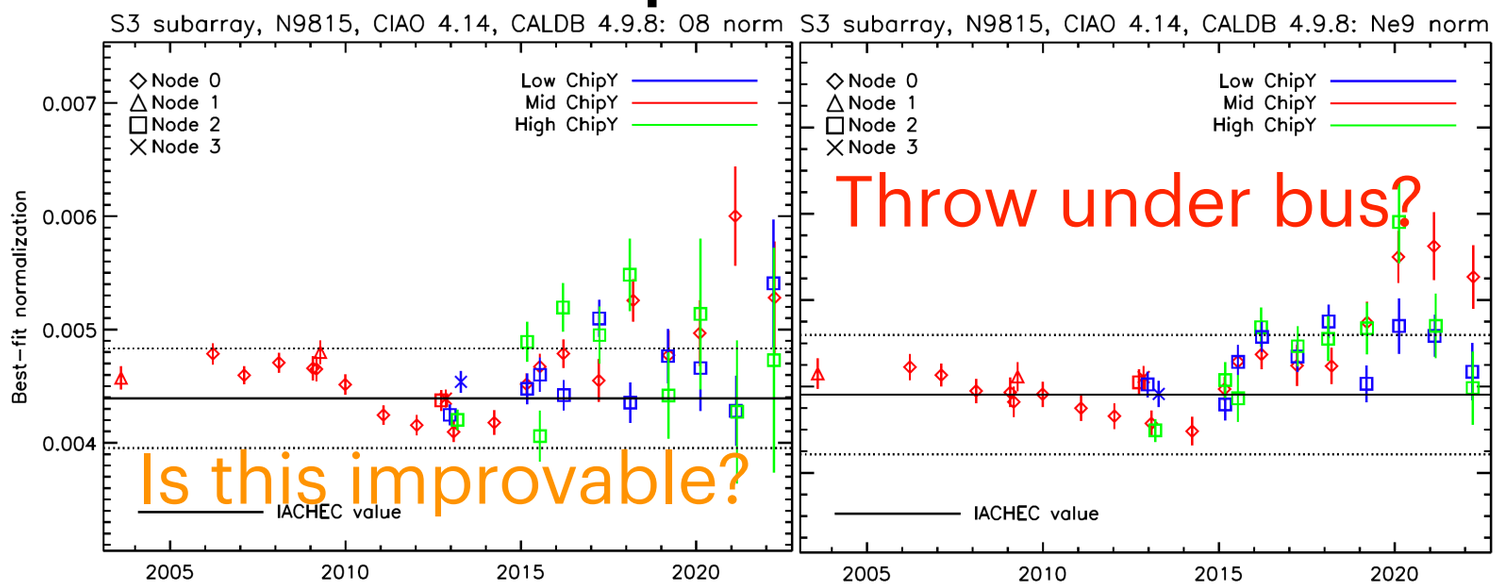
Step 4

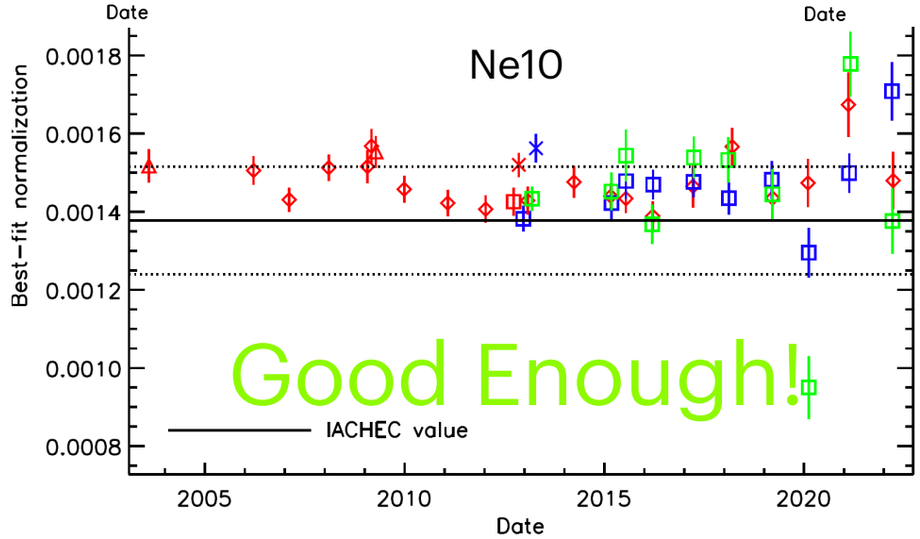
AB compares to A1795





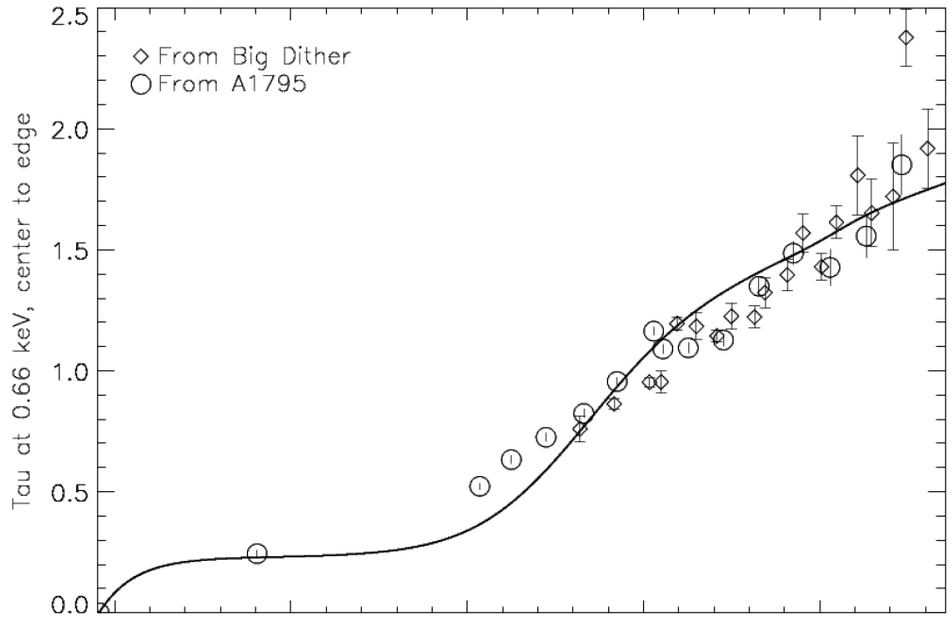
PP compares to 1E0102

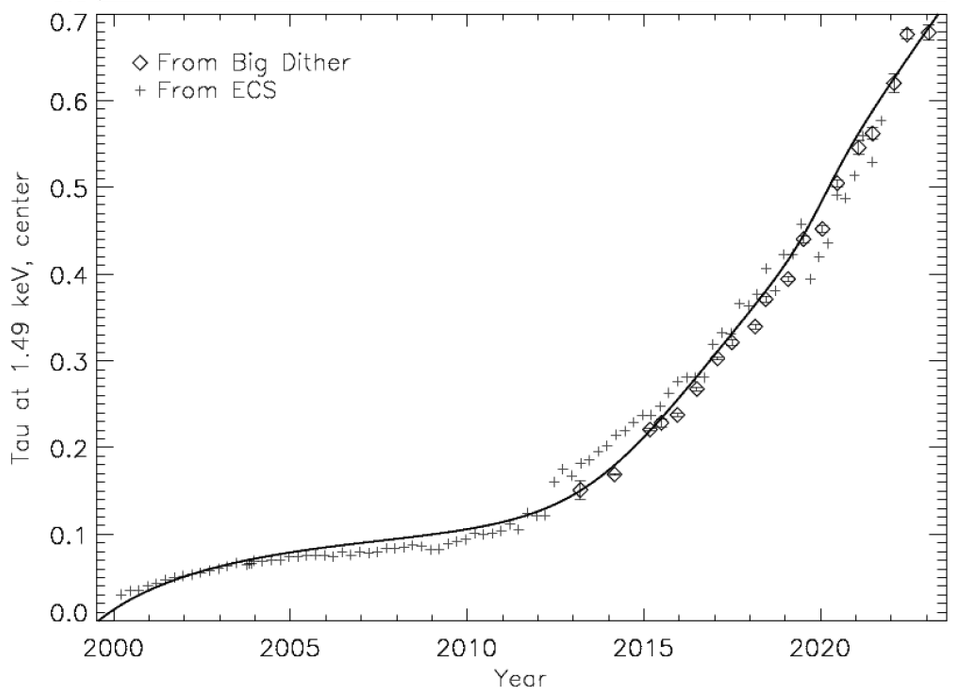




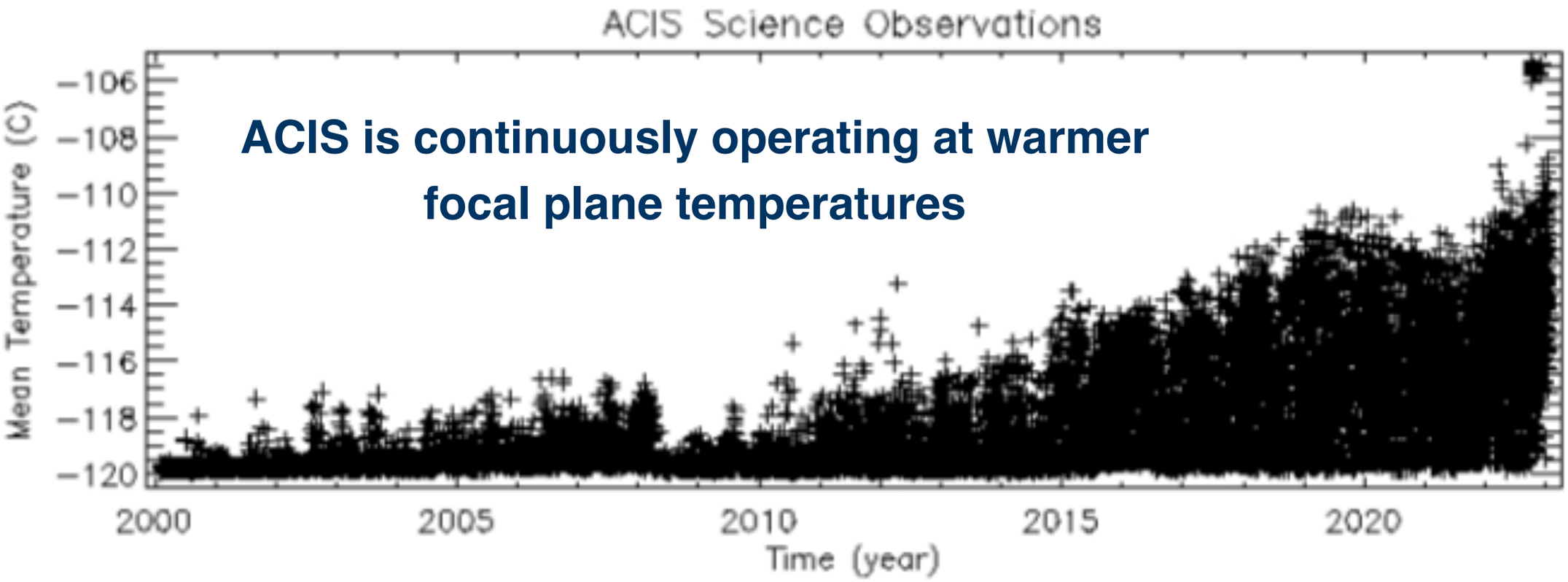
Summary: Accept Model v9815

- Results of testing v9815
    1. Good: Big Dither, A1795 tau, Ne10, ECS, incl. center-to-edge
    2. +5% overcorrecting A1795 fluxes after 2015
    3. -5% of A1795 fluxes at low rows in 2022, +5% in 2015-2021
    4. +10% (?) of O8 after 2015, no high/low issue
    5. +15% of Ne9 at mid rows since 2020, no high/low issues
- Hard to improve Ne9 without affecting Ne10
- A1795 fluxes are within errors of constant





Improving the CTI Correction at Warm Focal Plane Temperatures



ACIS is continuously operating at warmer focal plane temperatures

Charge Transfer Inefficiency (CTI) increases with temperature which affects the detector gain and spectral resolution

The ACIS CTI Correction Procedure

CTI correction ~ (temperature)(energy)(spatial)
All chips are calibrated separately

1) Temperature-dependence: Calibrated using the Mn line in the ECS data

Old Method: Uses a linear function of temperature.
New Method: Uses a quadratic function of temperature

2) Energy-dependence: Initially calibrated with ECS data.

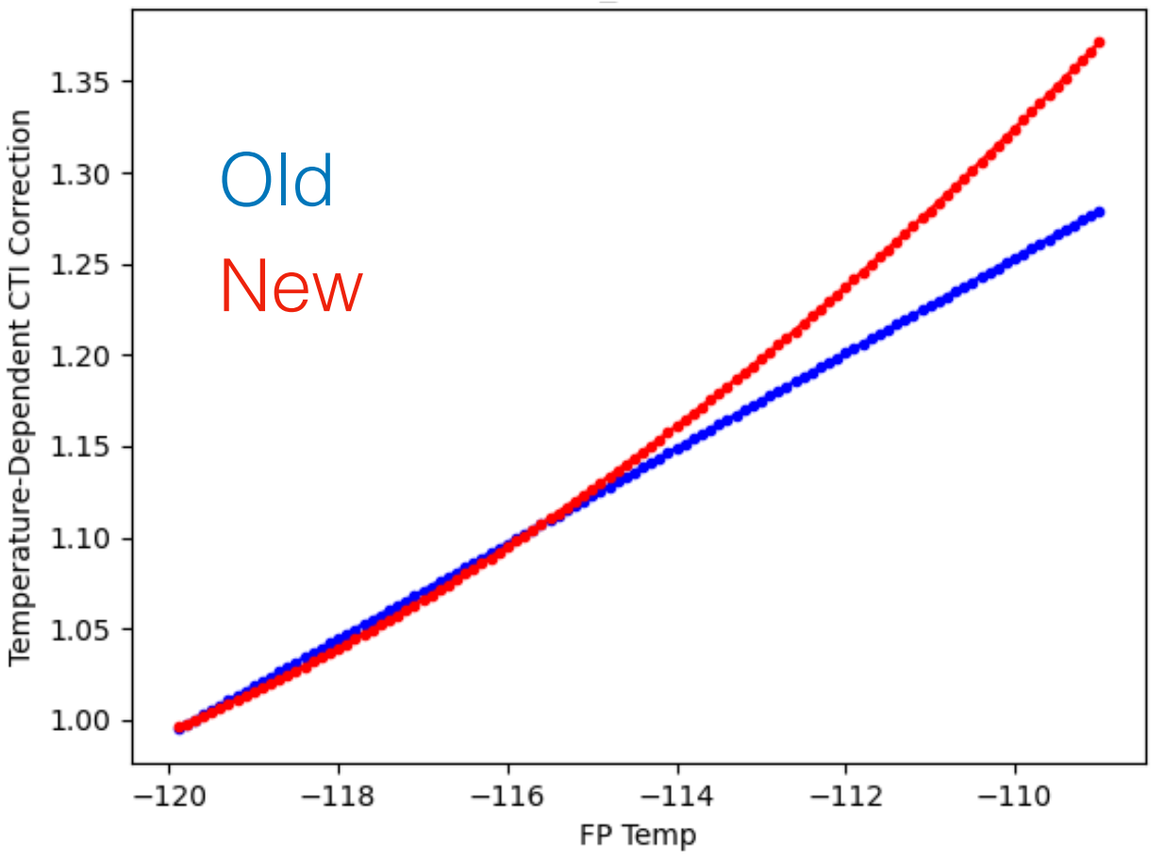
Old Method: Uses a single power-law for the energy-dependence at all temperatures (i.e. $\Delta Q \sim PHA^{a}$).
New Method: Uses different power-law indices at different temperatures (i.e., a=f(T)).

3) Spatial-dependence: Based on trap maps generated from ECS data

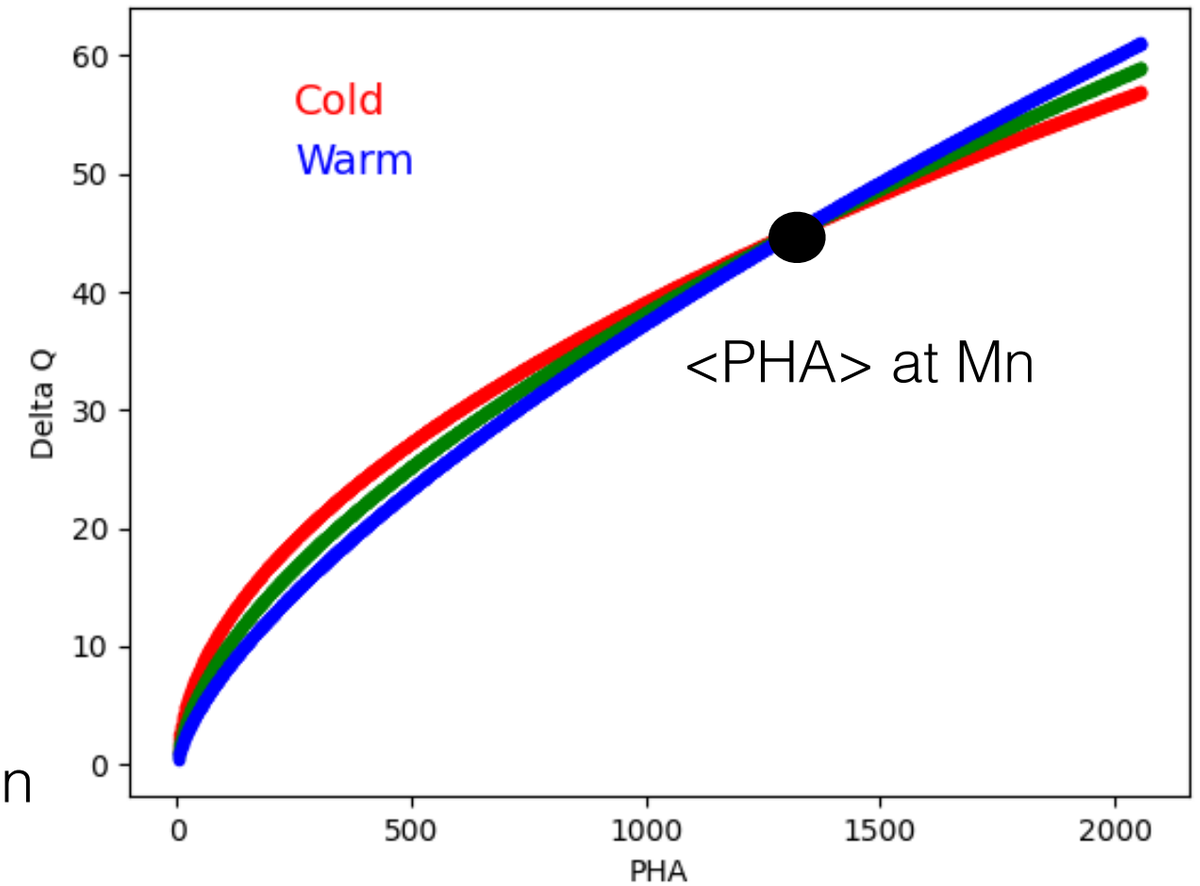
Old Method: Applies the same trap map at all temperatures.
New Method: Applies different trap maps at different temperatures.

ACIS CTI Correction

Temperature-Dependent Correction



Energy-Dependent Correction



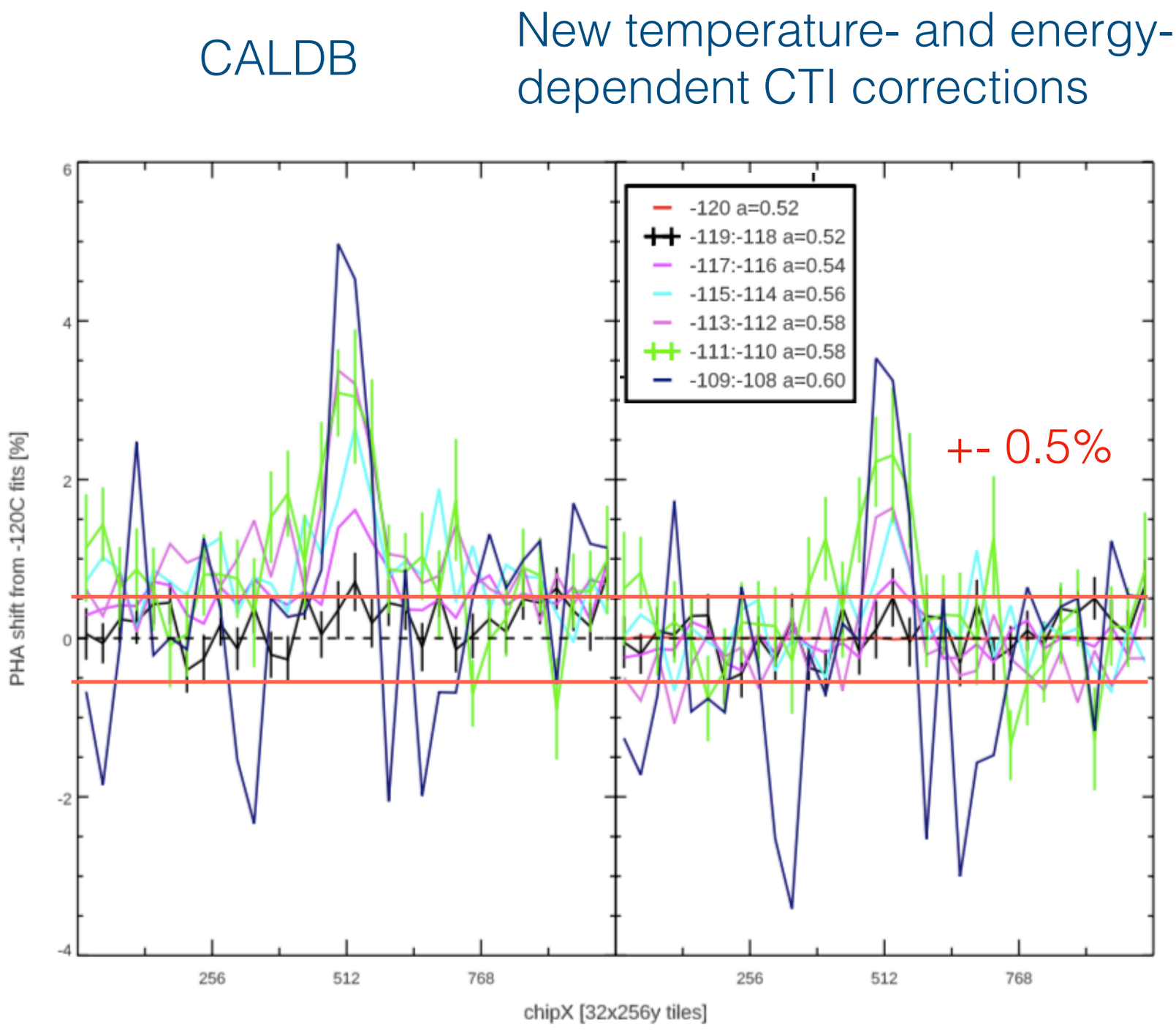
- Since the temperature-dependence is calibration at Mn, the energy-dependent corrections must pivot about the correction at Mn.

- Illustrative - actual energy-dependent corrections are more similar

Results with new Temperature and Energy CTI corrections

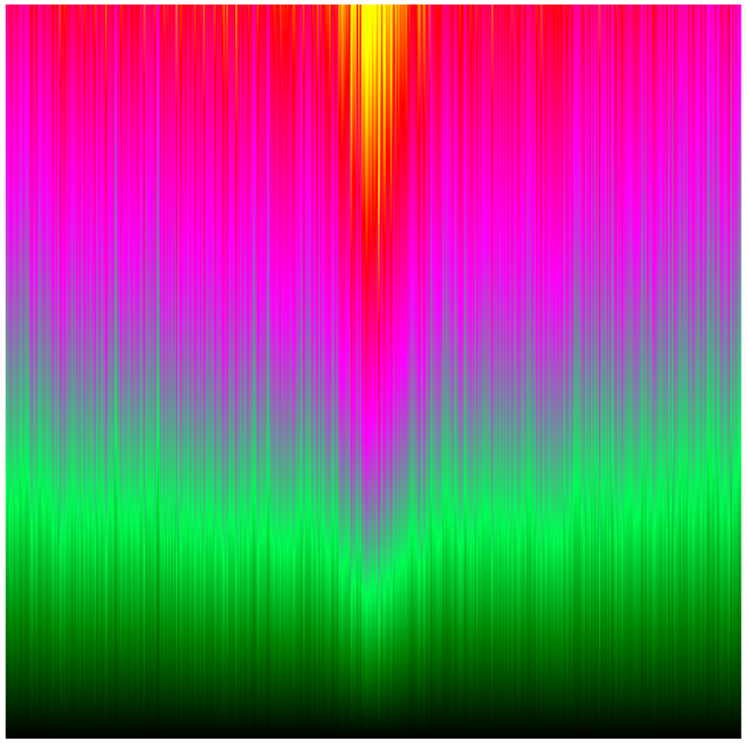
I1 at Al-Ka and chipy=769:1024

- CALDB overcorrects the data at Al at warm temperatures.
- New method produces good agreement at warmer temperatures.
- The data is still overcorrected in the middle of the chip.
- The data in the warmest temperature bin has the poorest statistics.



ACIS Trap Maps

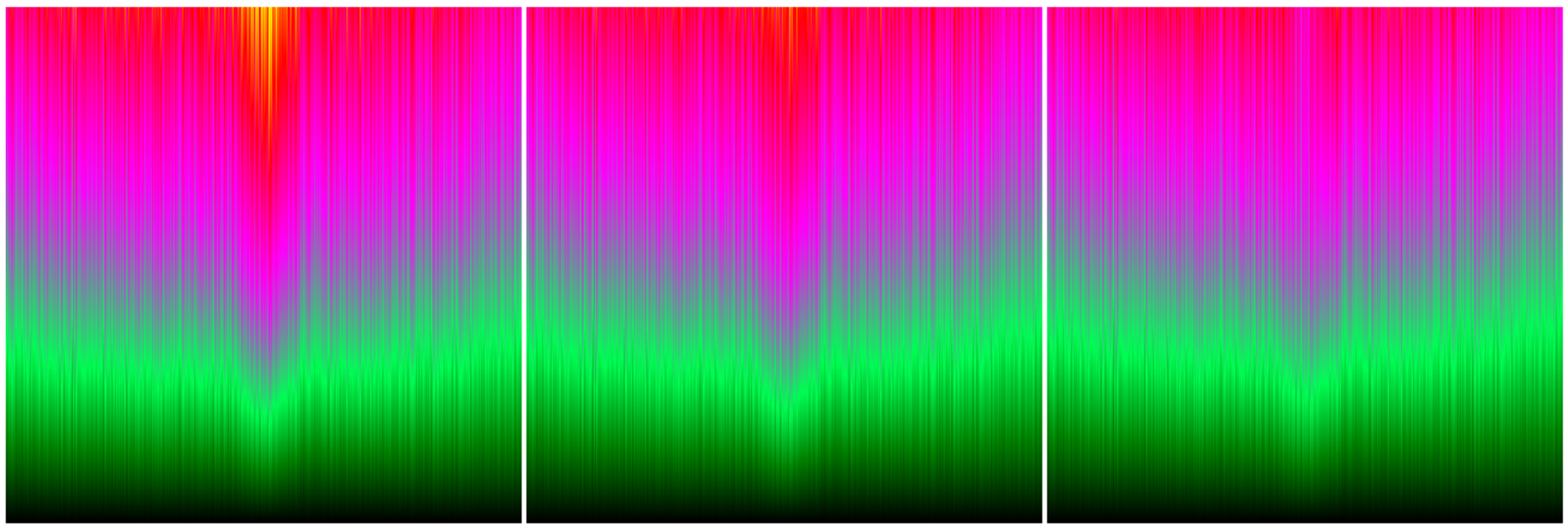
I1 trap map generated from ECS data taken at -120C early in the mission.



- To counter the gain overcorrection in the middle of the chips, a set of trap maps were created with reduced values in the middle of the trap maps.

- These images are for illustrative purposes. The actual trap maps used for different temperature data are much more similar.

Cold



Warm

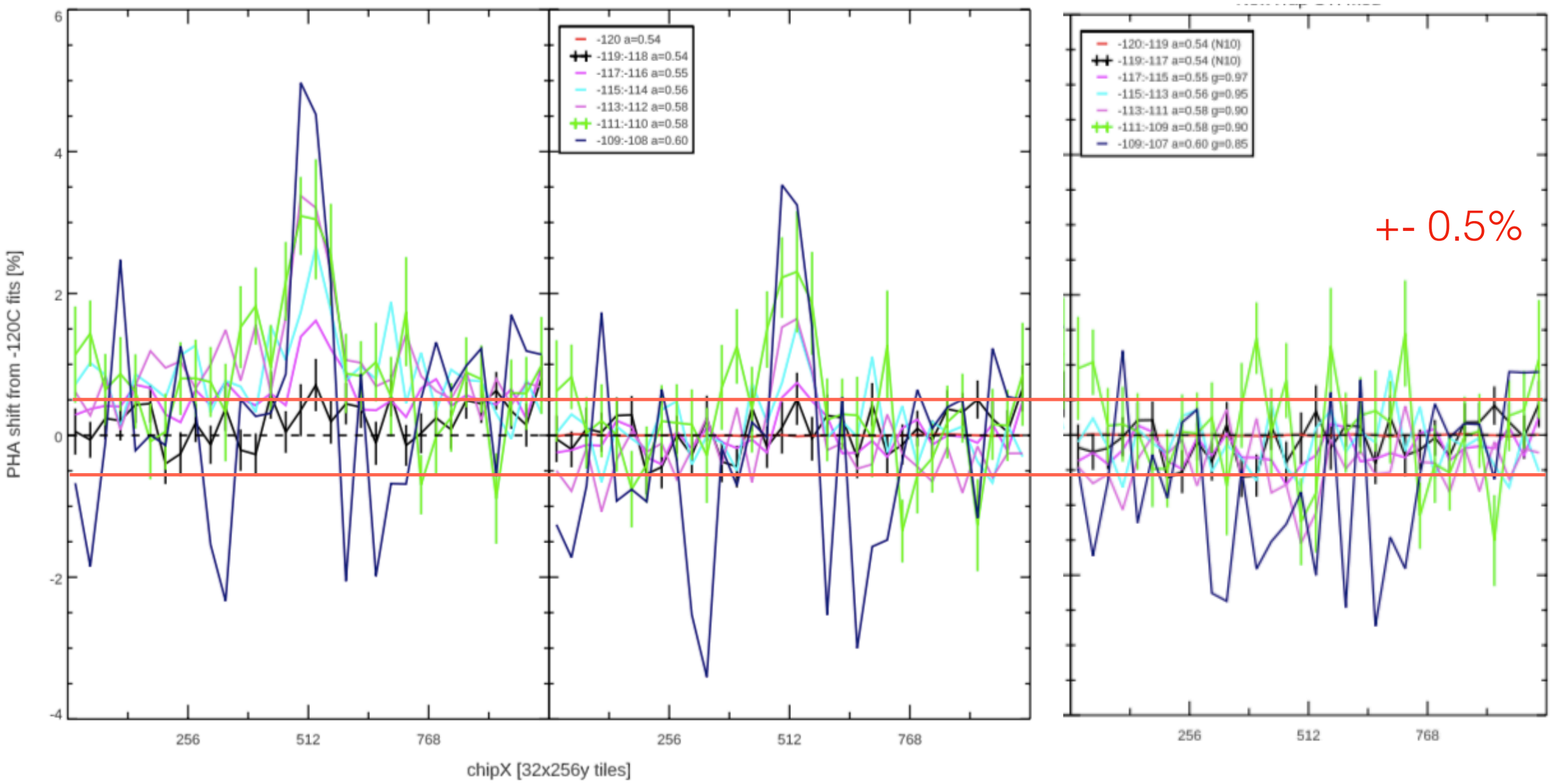
Including Different Trap Maps for Each Temperature Bin

I1 at Al-Ka and chipy=769:1024

CALDB

New temperature- and energy-dependent CTI corrections

Plus adjusted trap maps for each temperature bin

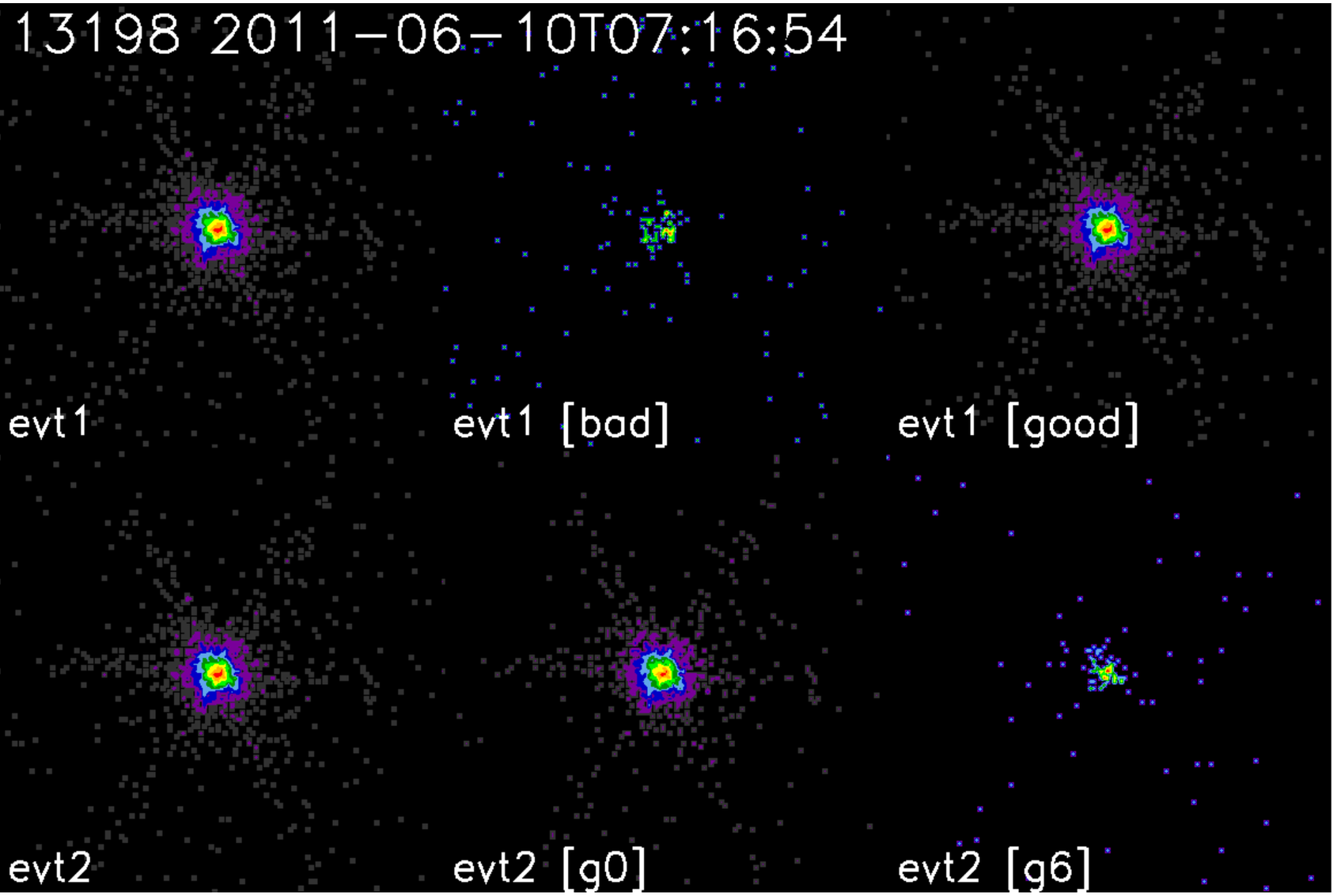


Further Work on CTI correction

- Work on calibrating the CTI correction between -120 and -109 C is essentially complete for chips I1 and I3.
- Perform similar analysis for chips I0, I2, S2, and S3 (i.e., the primary chips used for imaging).
- Generate a set of new CALDB products which will require a significant re-formating of the CALDB files.
- Create a script that applies the new CALDB files to science data.
- Release the new CALDB products along with the script that applies the new products.

The low-E ACIS PSF shows significantly increased broadening in recent years, apparently in step with the build-up of contamination

Konrad Dennerl and Scott Wolk found ACIS/LETG 0th order of RXJ 1856 was growing larger



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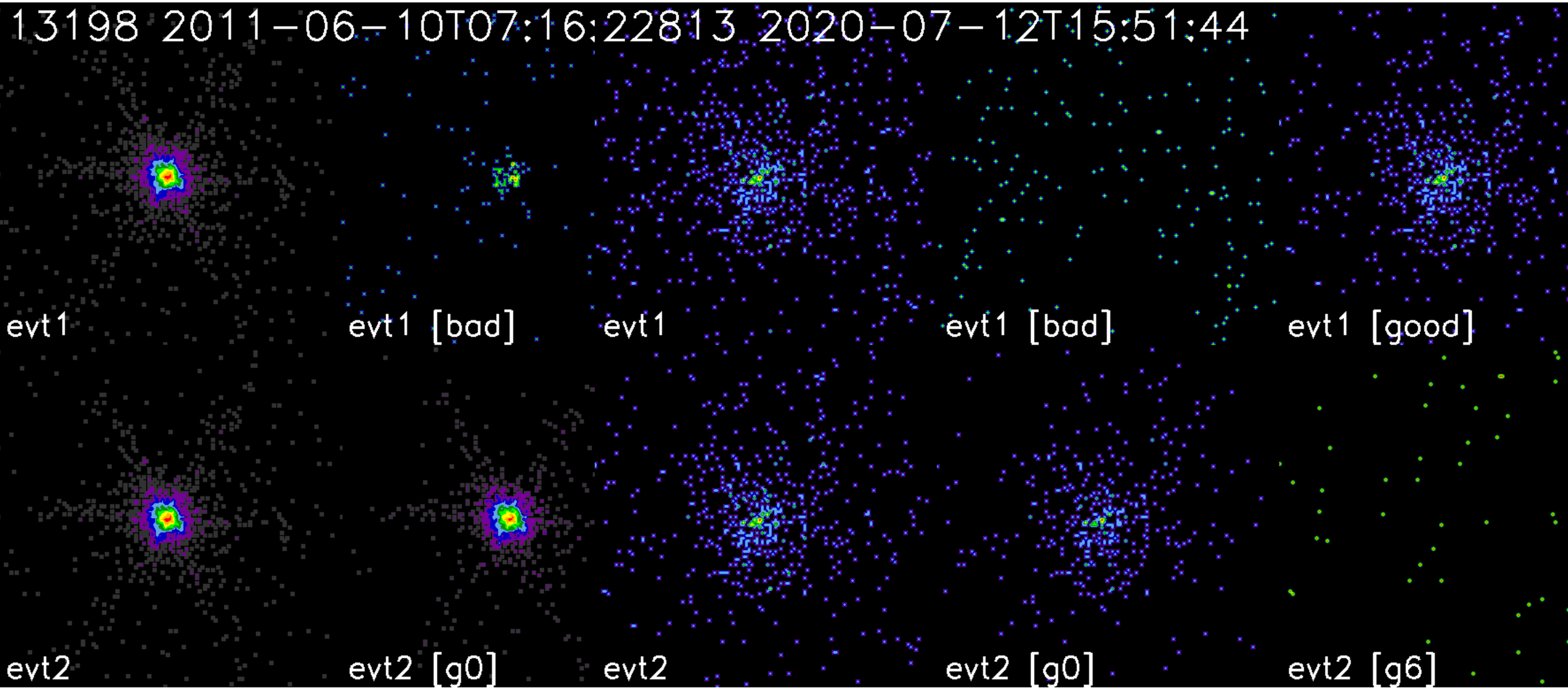
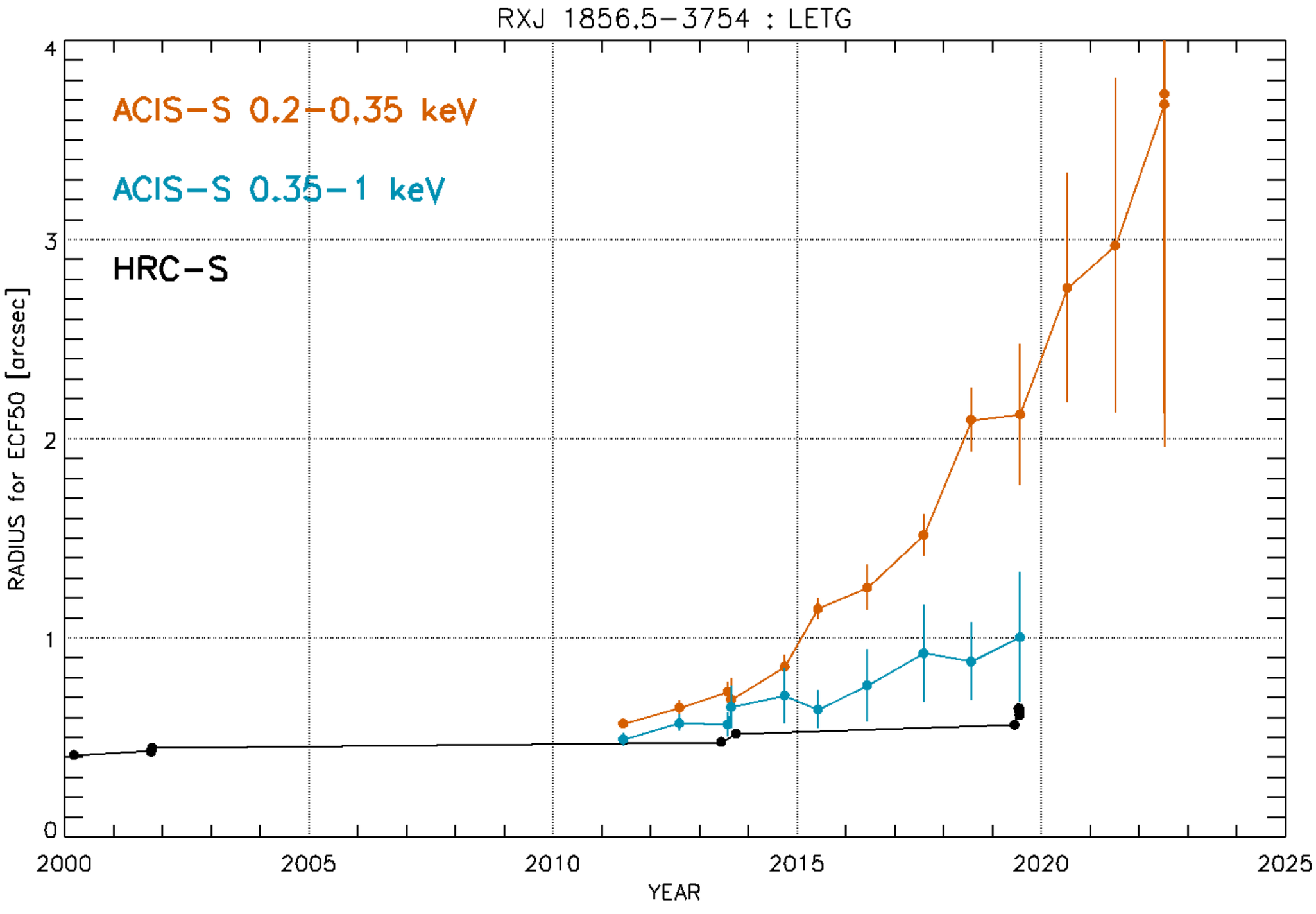
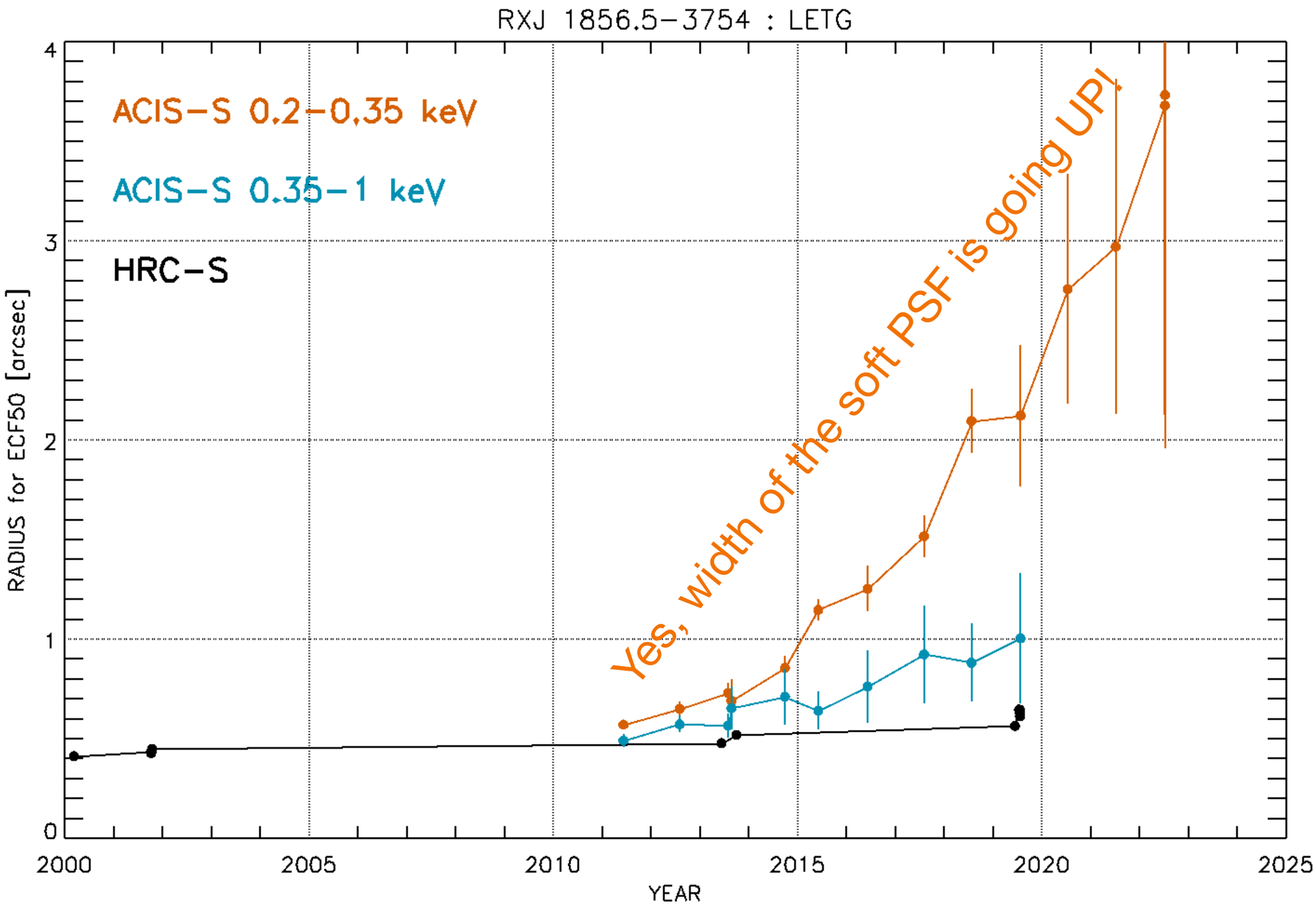
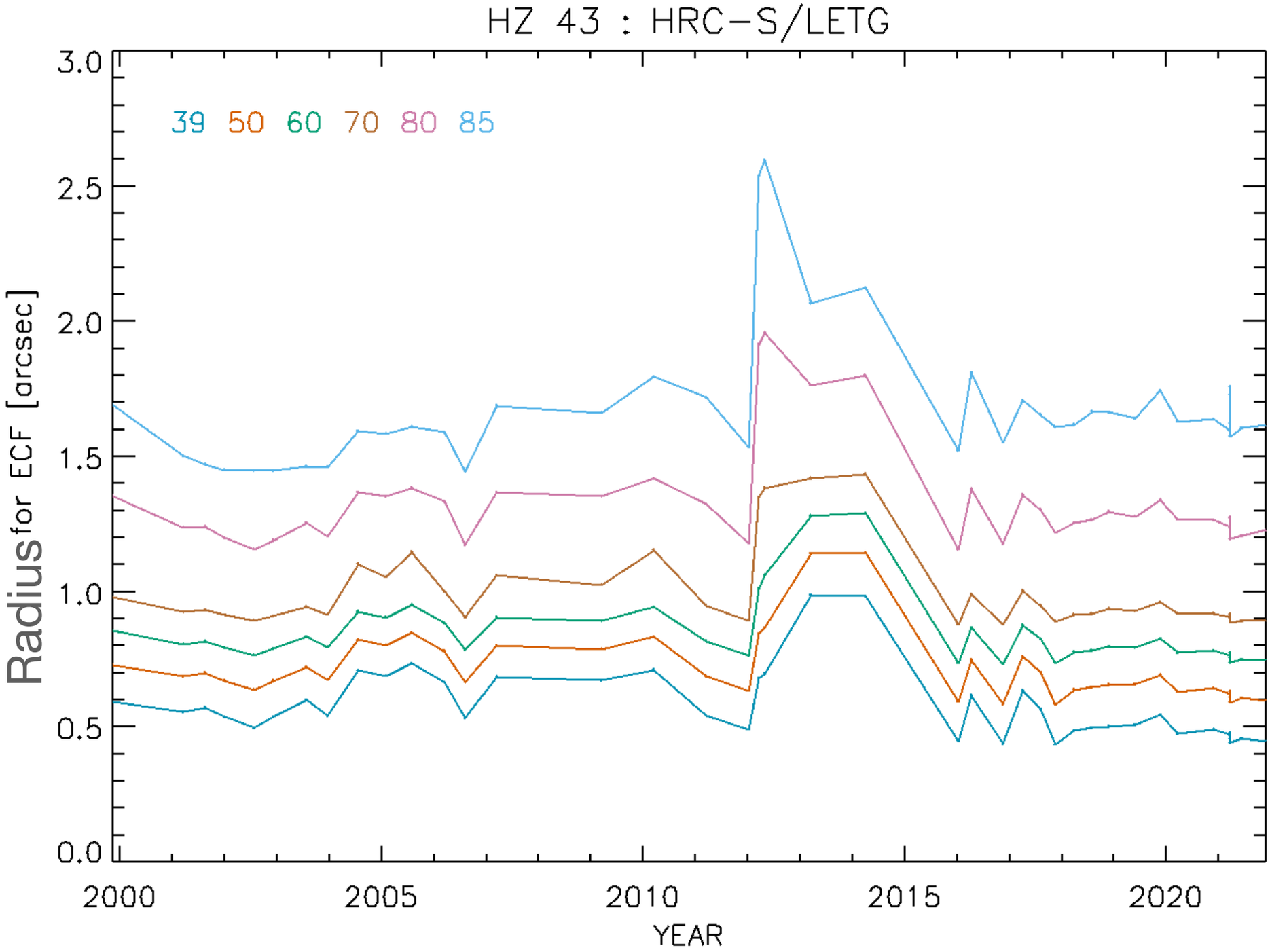



RXJ 1856.5−3754 : LETG
ACIS−S 0.2−0.35 keV
ACIS−S 0.35−1 keV
HRC−S
RADIUS for ECF50 [arcsec]
0
1
2
3
4
2000
2005
2010
2015
2020
2025
YEAR


RXJ 1856.5−3754 : LETG
ACIS−S 0.2−0.35 keV
ACIS−S 0.35−1 keV
HRC−S
Yes, width of the soft PSF is going UP!
RADIUS for ECF50 [arcsec]
YEAR
0
1
2
3
4
2000
2005
2010
2015
2020
2025


HZ 43 : HRC-S/LETG
39 50 60 70 80 85
Radius for ECF [arcsec]
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2000
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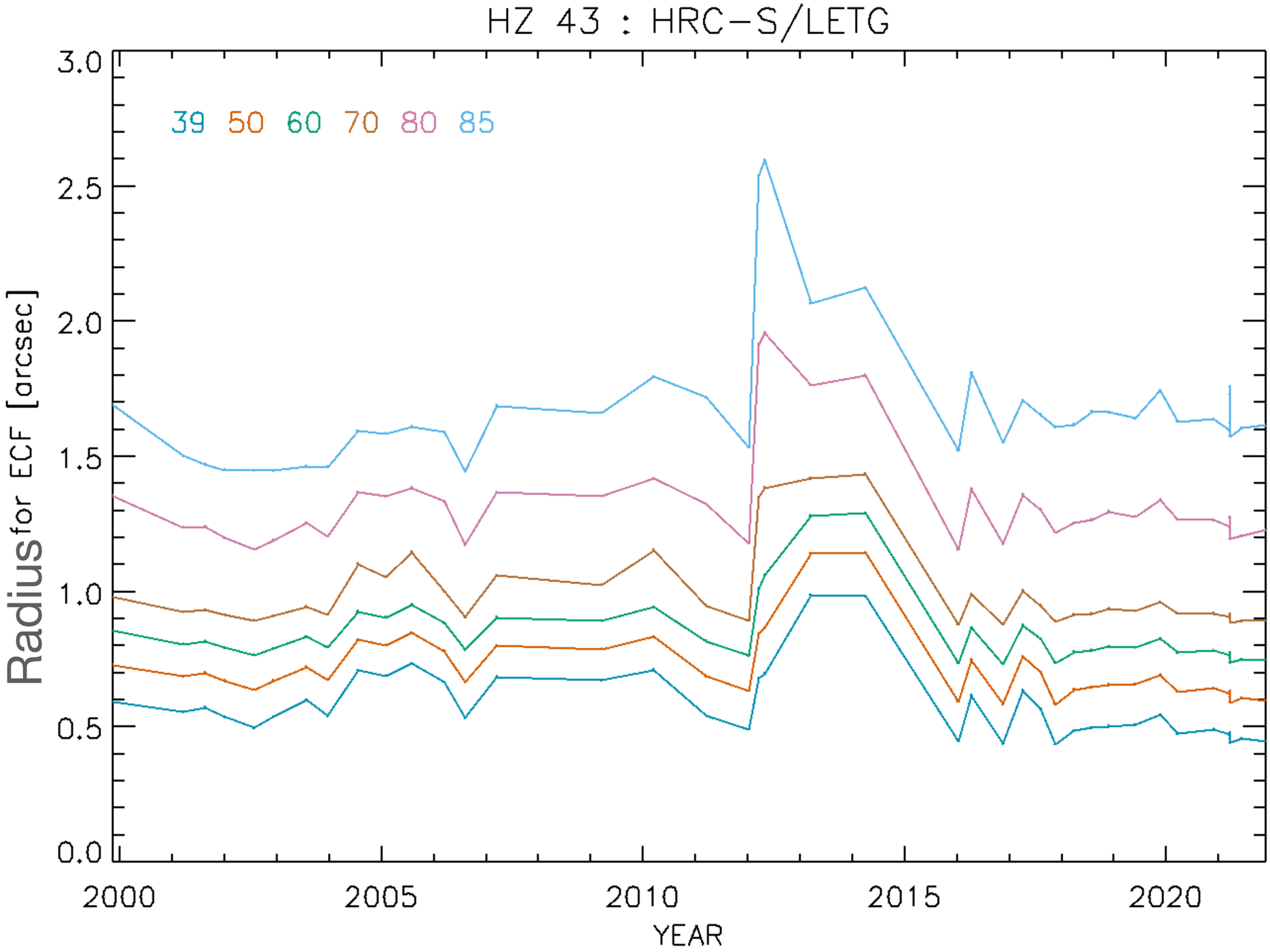
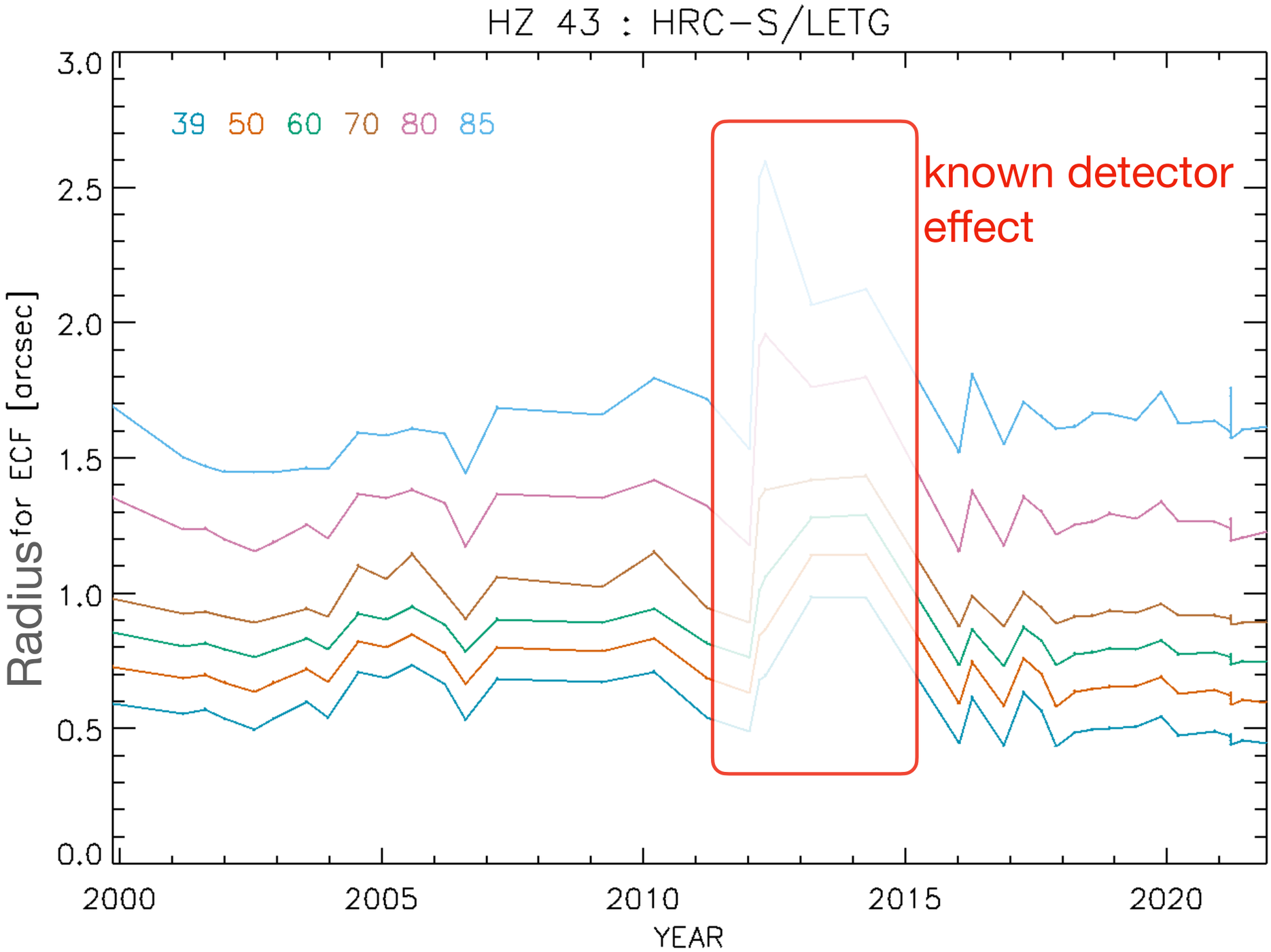


A different soft source with the HRC shows no trend in PSF size



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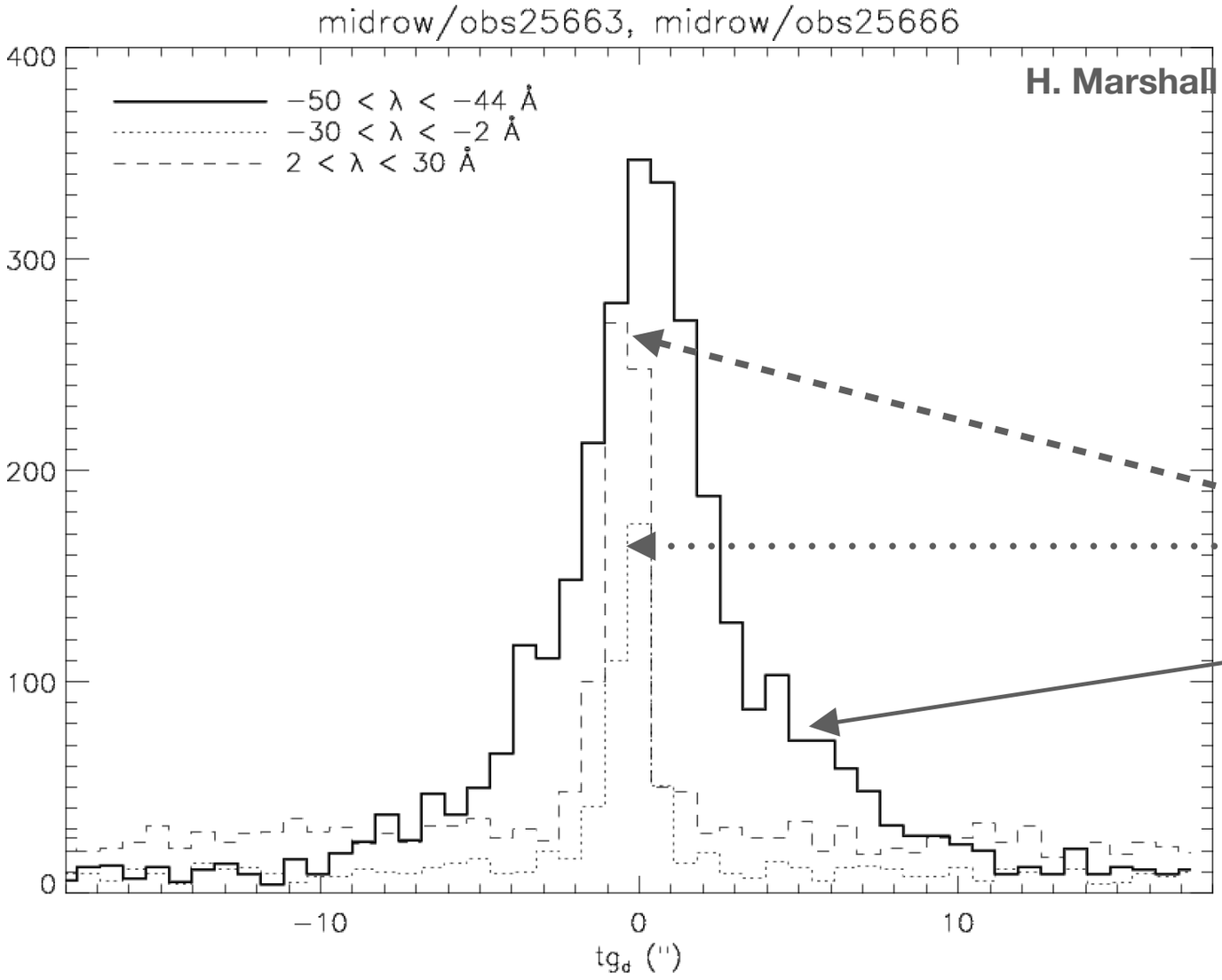
High Energy vs Low Energy

Cross-dispersion profiles show broader PSF below C K edge



Mkn 421

LETG dispersed events in different wavelength regions

Narrow PSF in 2-30 Å
Broader PSF at λ>44 Å

Binned at 0.72″ = 1.5 ACIS pixels

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- Unknown detector effect
  - Looking at: CC mode, FI vs BI, CSC

Important Note:

The HRC returned to science on April 10, 2023 after a 14 month hiatus. The HRC operated nominally during this observation and all subsequent observations. The first HRC calibration observation (G21.5) is scheduled for the week of May 1, 2023.

Other Chandra Calibration Presentations:

Concordance Model - Statistics WG - H. Marshall

Weak Features in high BG at high-res - Statistics WG - V. Kashyap

ACIS Contamination - Contamination WG - H. Marshall and A. Bogdan

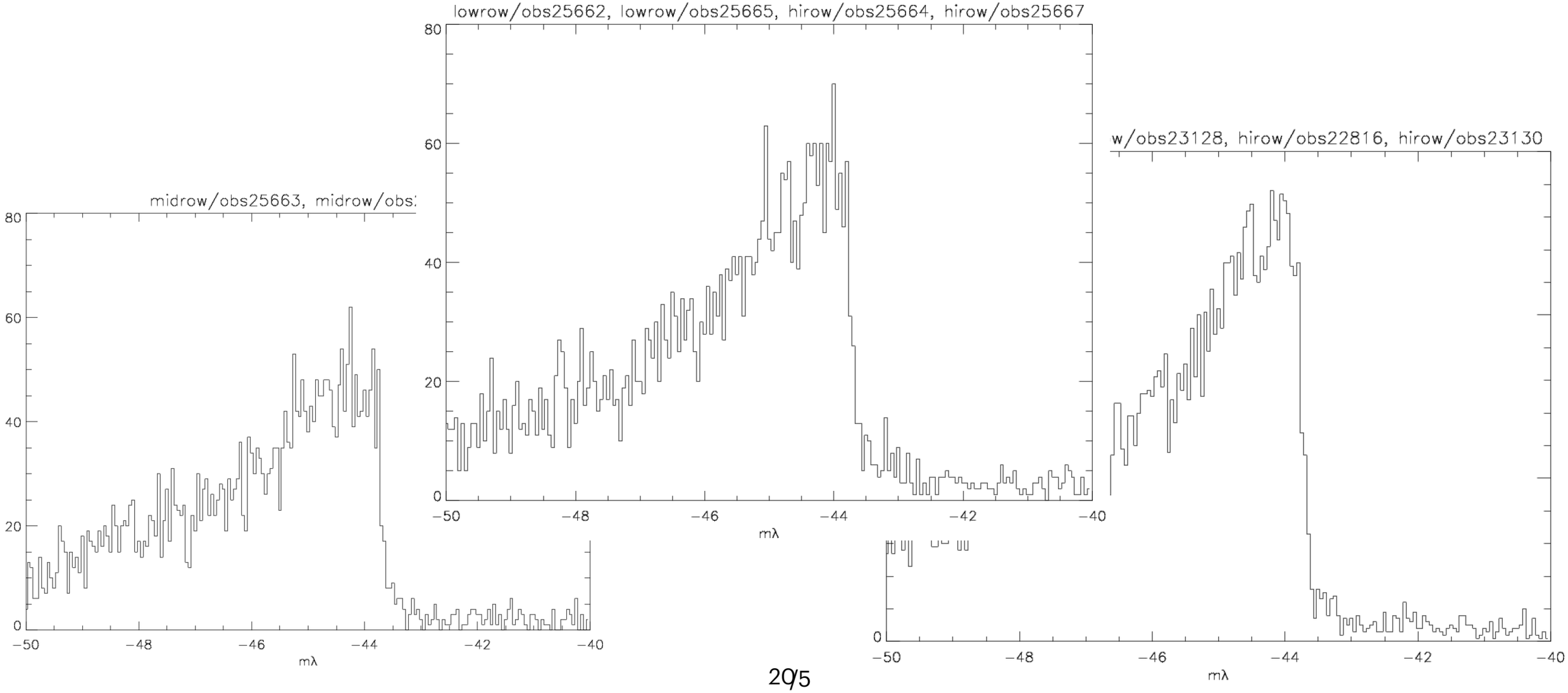
ACIS gain calibration with Cas A - Thermal WG - N. Durham

ACIS temperature-dependent RMFs - Detectors and BG WG - T. Gaetz

BACKUP SLIDES

Edge profiles

- Bin along spectrum at 0.05Å (LETGS resolution, ~2 ACIS pixels)



Broadening with Wavelength

- Unabsorbed core disappears with wavelength
- Scattered events have different wavelengths or paths?