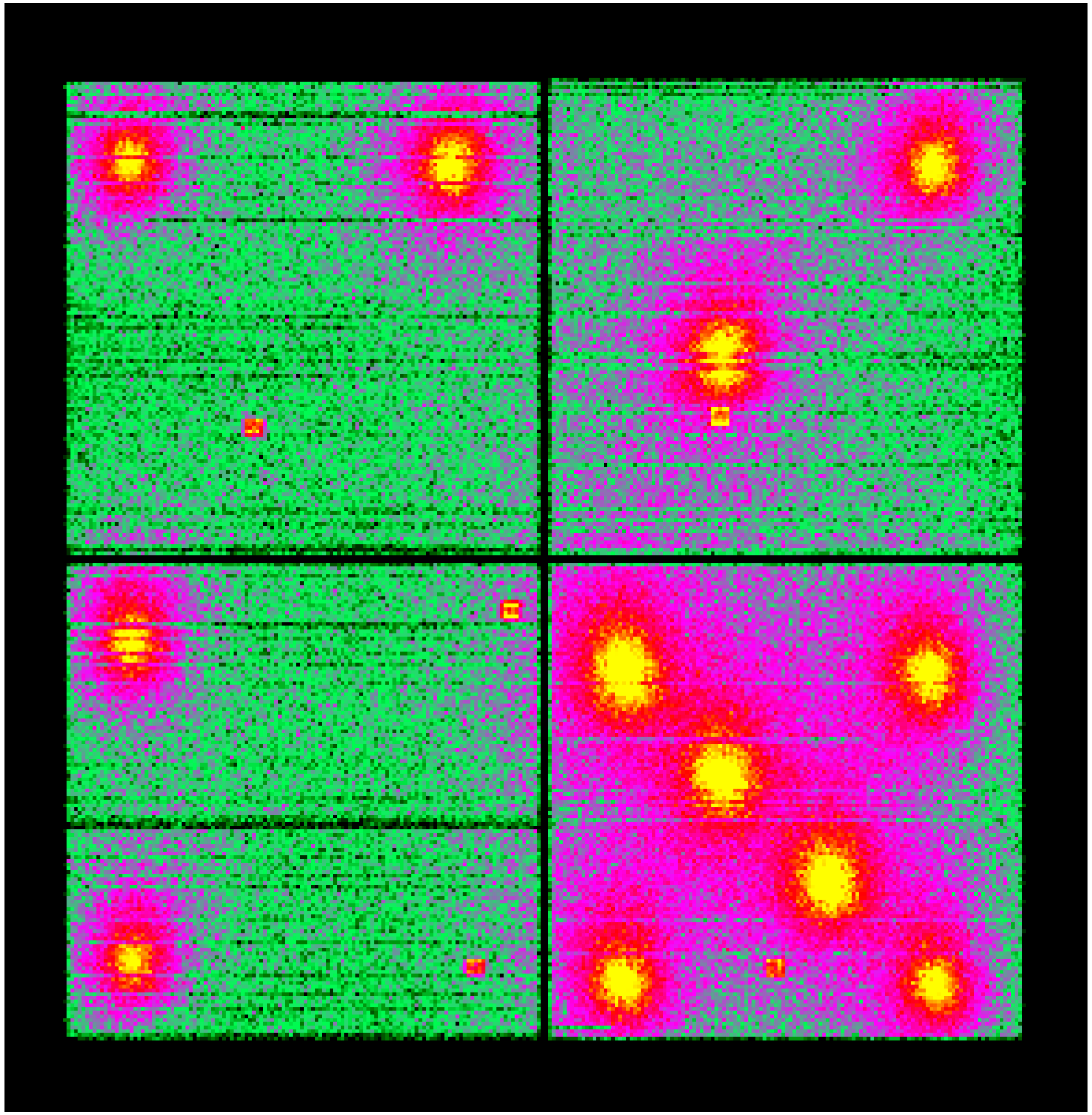
Chandra Calibration Status

CUC Meeting - Nov. 18 ,2022

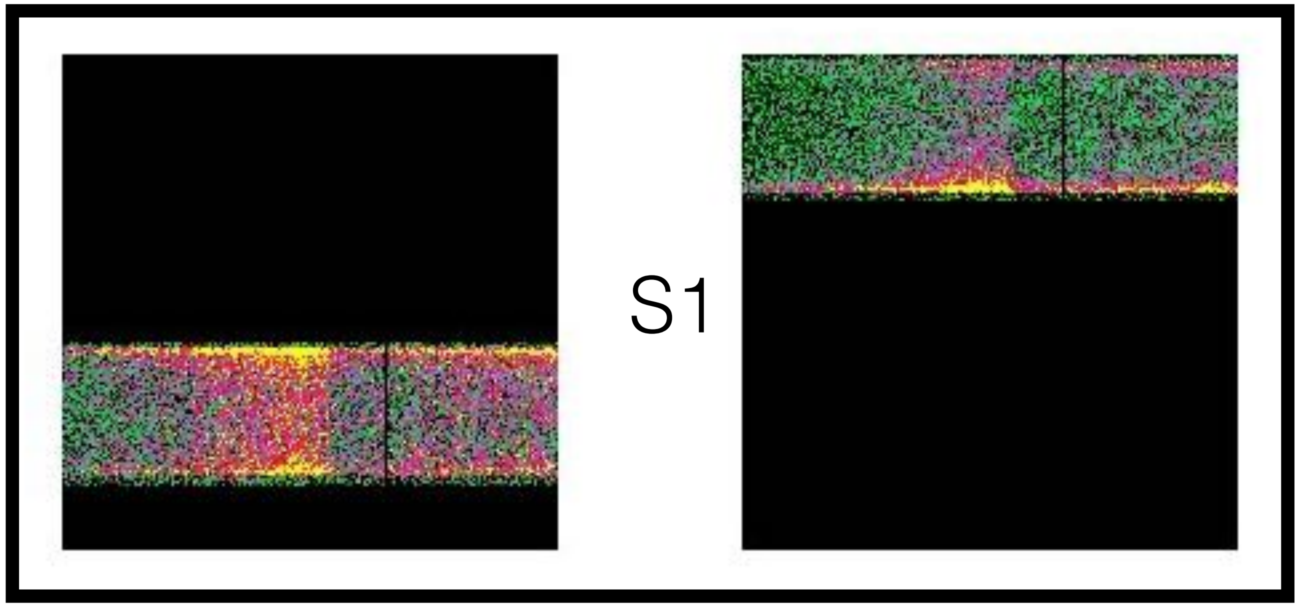
ACIS Contamination Model

E0102-72

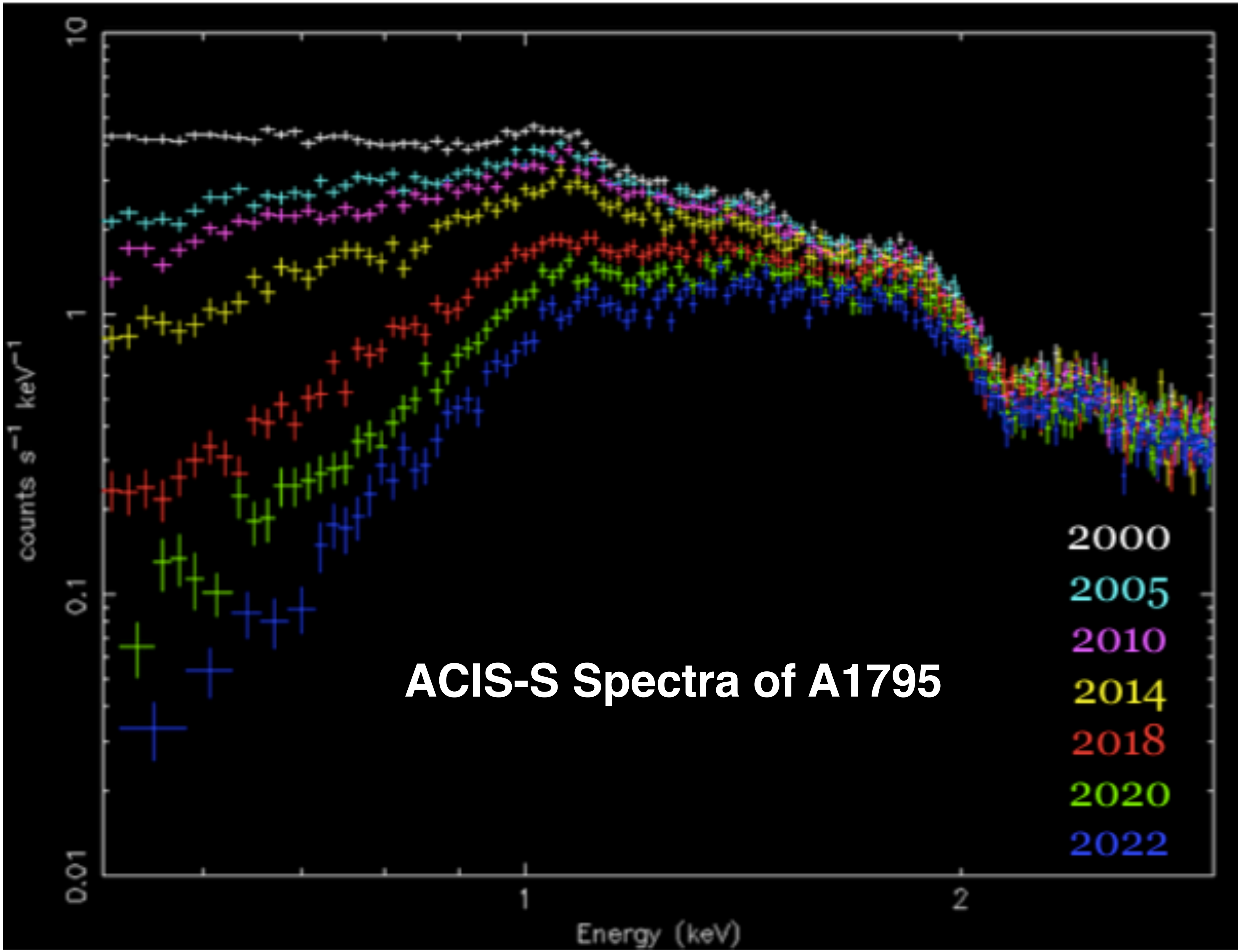
A1795 Raster Scan on ACIS-I



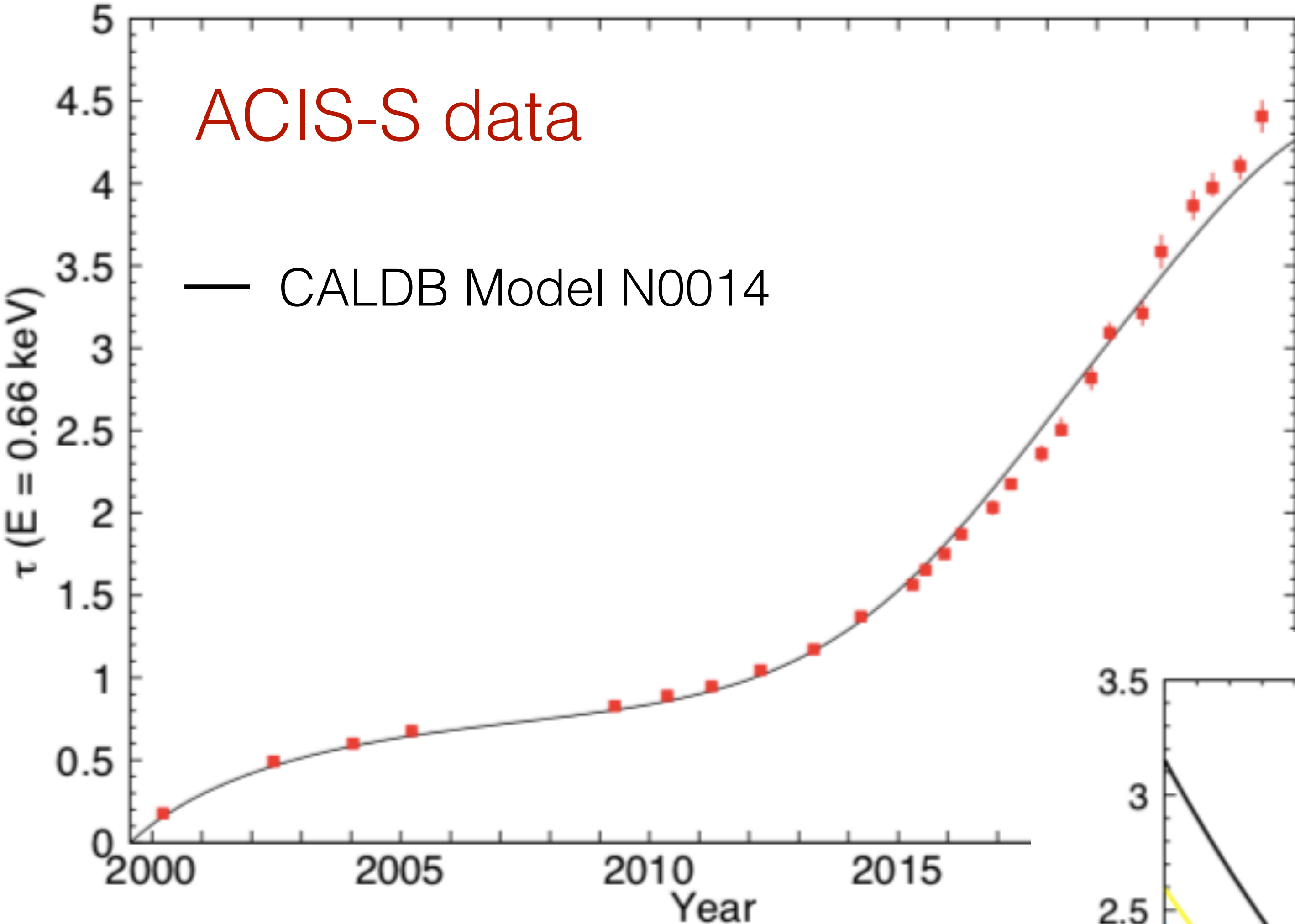
Big Dither LETG/ACIS-S observations of Mkn 421



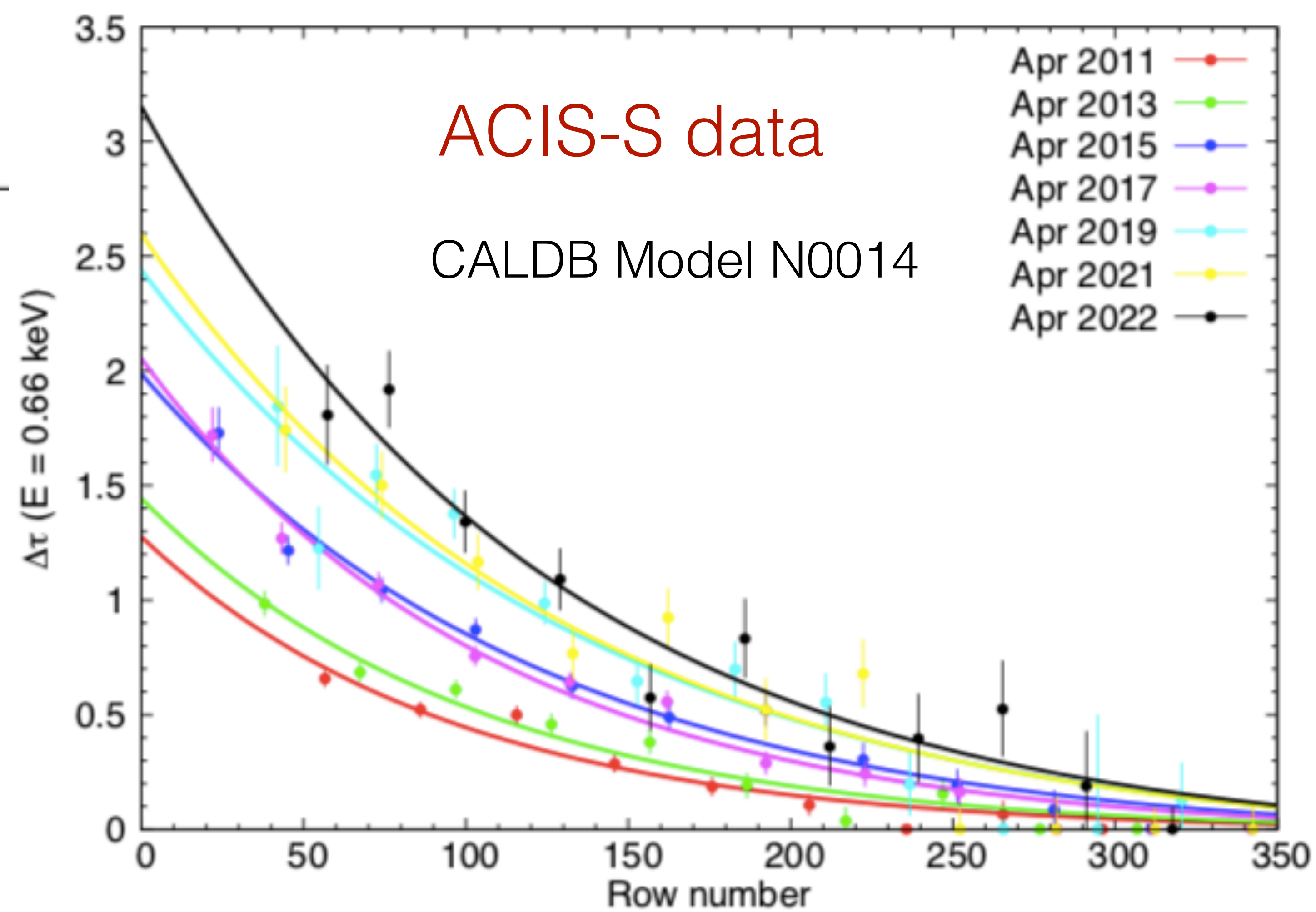
ACIS Contamination Model



ACIS Contamination Model

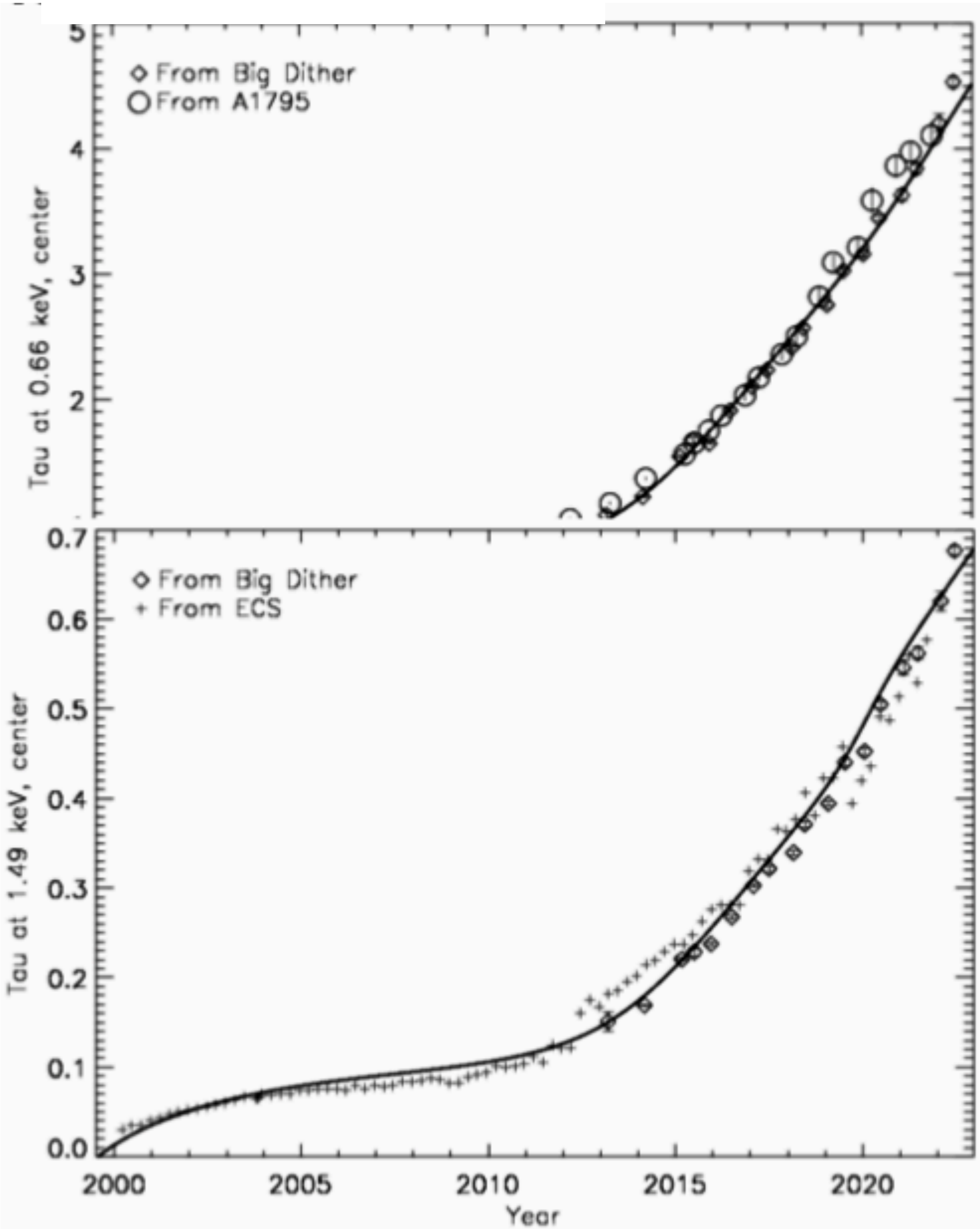


Abell 1795 Observations



Difference between the optical depth at rows 167 and 512

ACIS Contamination Model



Comparison of updated ACIS contamination model with A1795, Big Dither, and ECS (Al-Ka) data.

Version N0015 of the ACIS contamination model was released in CALDB 4.10.2 on Nov. 15, 2022

Limits on the Focal Plan Temperature for ACIS Observations

Focal Plane Temperature limits for ACIS Observations in AO-23

- ACIS-I3 FP TEMP < -112 C
- ACIS-S3 FP_TEMP < -111 C

Focal Plane Temperature limits for ACIS Observations in AO-24

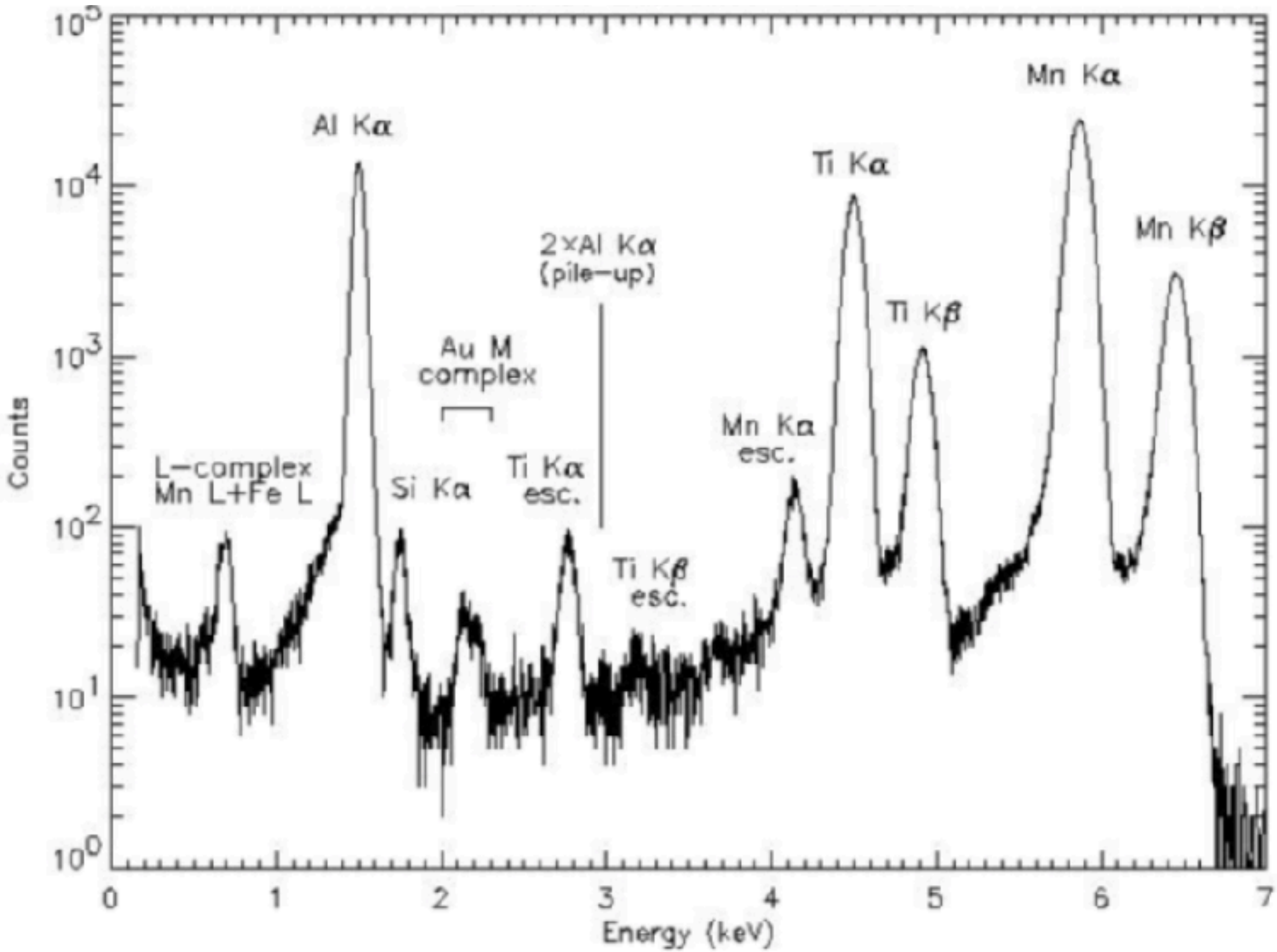
- ACIS-I3 FP TEMP < -109 C if number of counts < 1000
- ACIS-S3 FP_TEMP < -109 C if number of counts < 2000

For more than the critical number of counts the former FP Temperature limits apply.

For AO-24, approximately 60% of approved ACIS observations meet the limitations on counts.

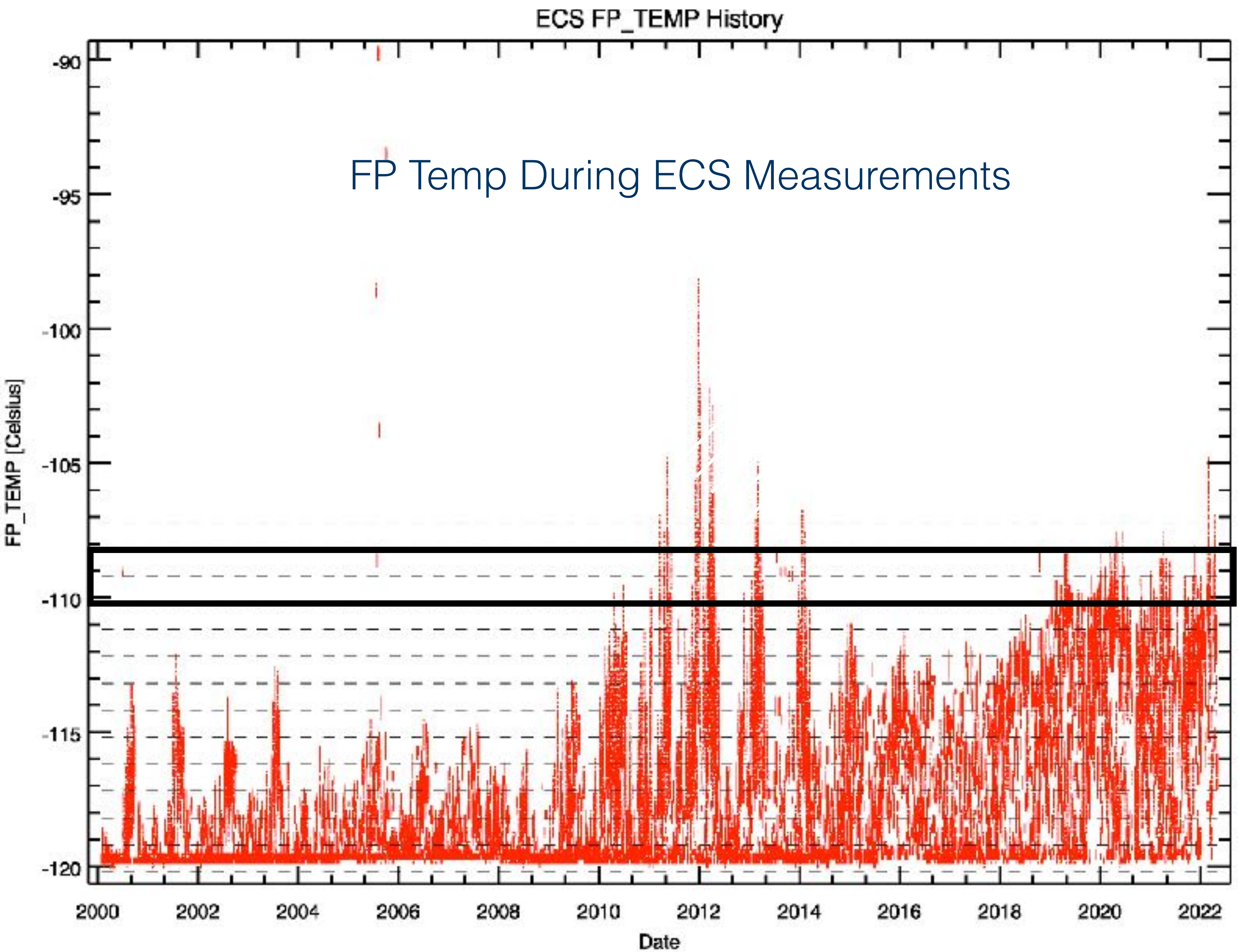
Why Limit ACIS Observations to an FP Temp of -109 C?

External Calibration Source (ECS)



Half-life = 2.7 yr

Why Limit ACIS Observations to an FP Temp of -109 C?



Data used to calibration ACIS at -109C (-110C:-108C)

Use Simulations to Determine the Maximum Number of Counts in Warm ACIS observations to Prevent the Publication of Bad Science

ACIS Calibration Off-Sets at -109C (Worst Case):

I3 - Gain off-set = 2% at aimpoint (1.5 keV), FWHM=130eV at -120C and 160eV at -109C

S3 - Gain off-set = 1% at aimpoint (1.5 keV), FWHM=105eV at -120C and 110eV at -109C

Primary Constraint:

- Line centroid- No blue shifted lines detected at more than 3sigma.

Uncertainty in Line Centroids

- Simulate data with -109 C response and fit with the CALDB response files.
- Simulate a Gaussian plus power-law spectrum.

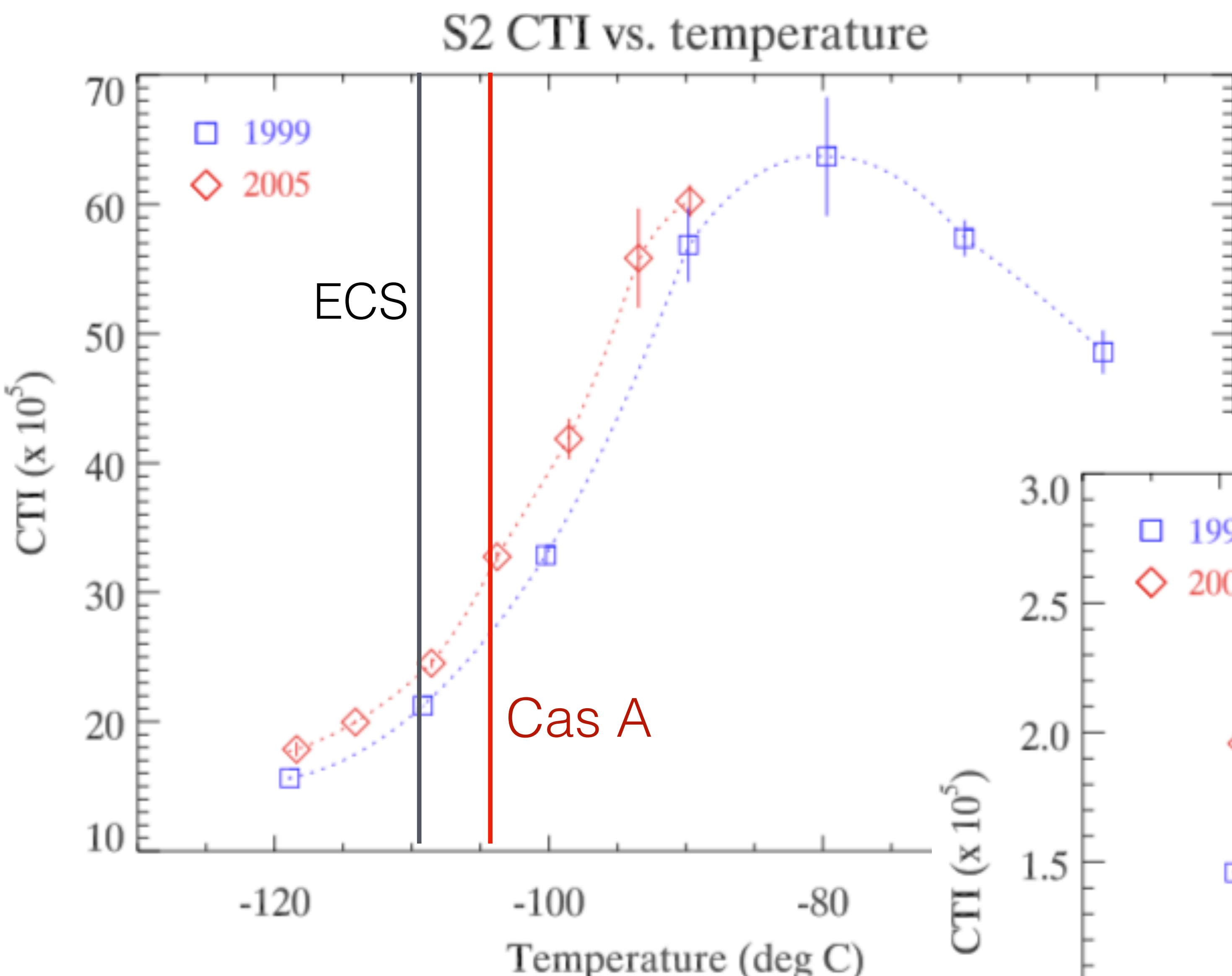
ACIS-I3

Continuum (Counts)	Line (Counts)	Sigma(%)	2.0/sigma
500	500	0.66	3.0
1000	500	1.4	1.4
250	500	0.3.	6.7

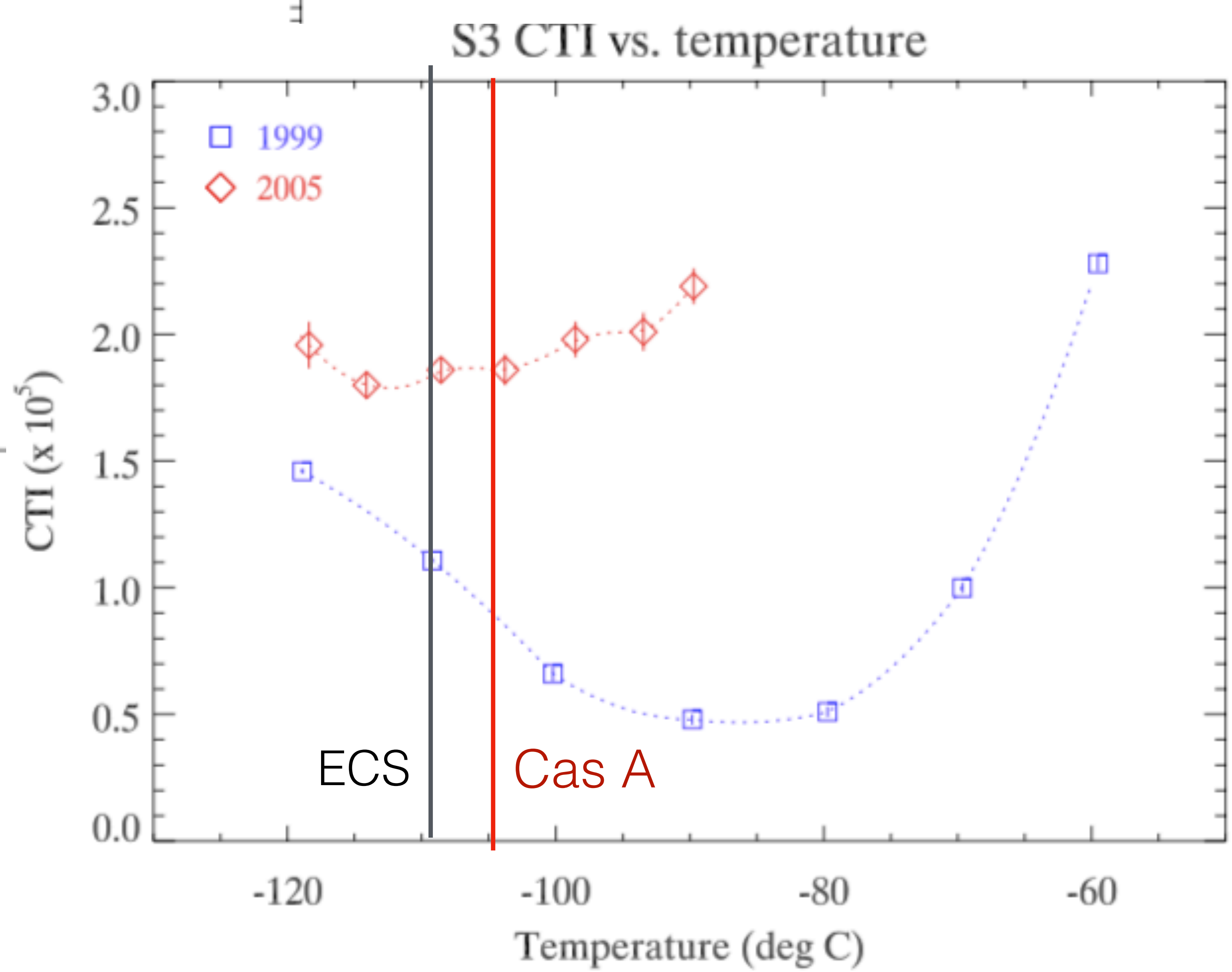
ACIS-S3

Continuum (Counts)	Line (Counts)	Sigma(%)	1.0/sigma
1000	1000	0.37	3.0

ACIS Gain Calibration at Warmer Temperatures



ACIS Gain driven by CTI correction



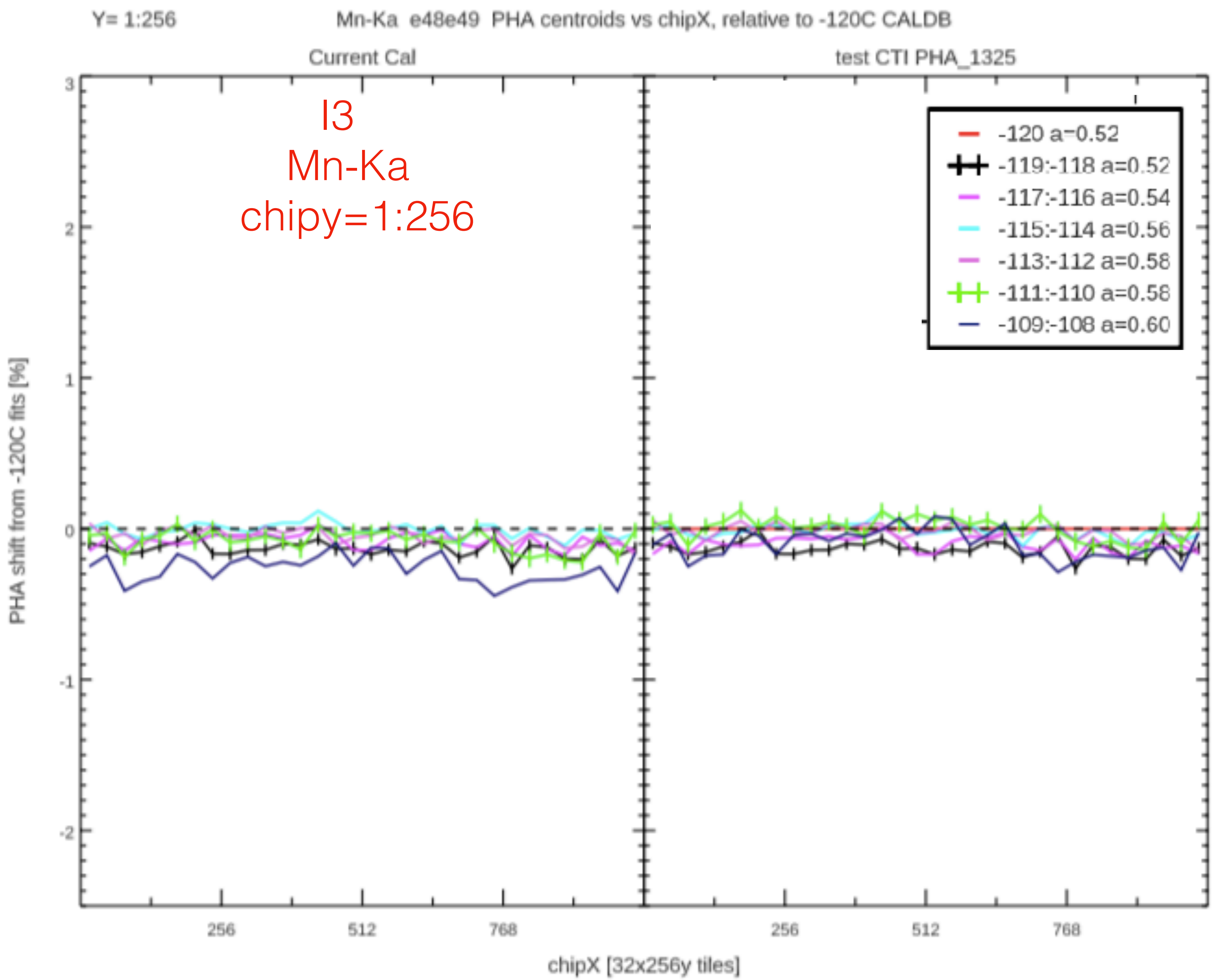
ACIS Gain Calibration up to -109 C Using the ECS

CTI Correction ~ (spatial)(temperature)(energy)

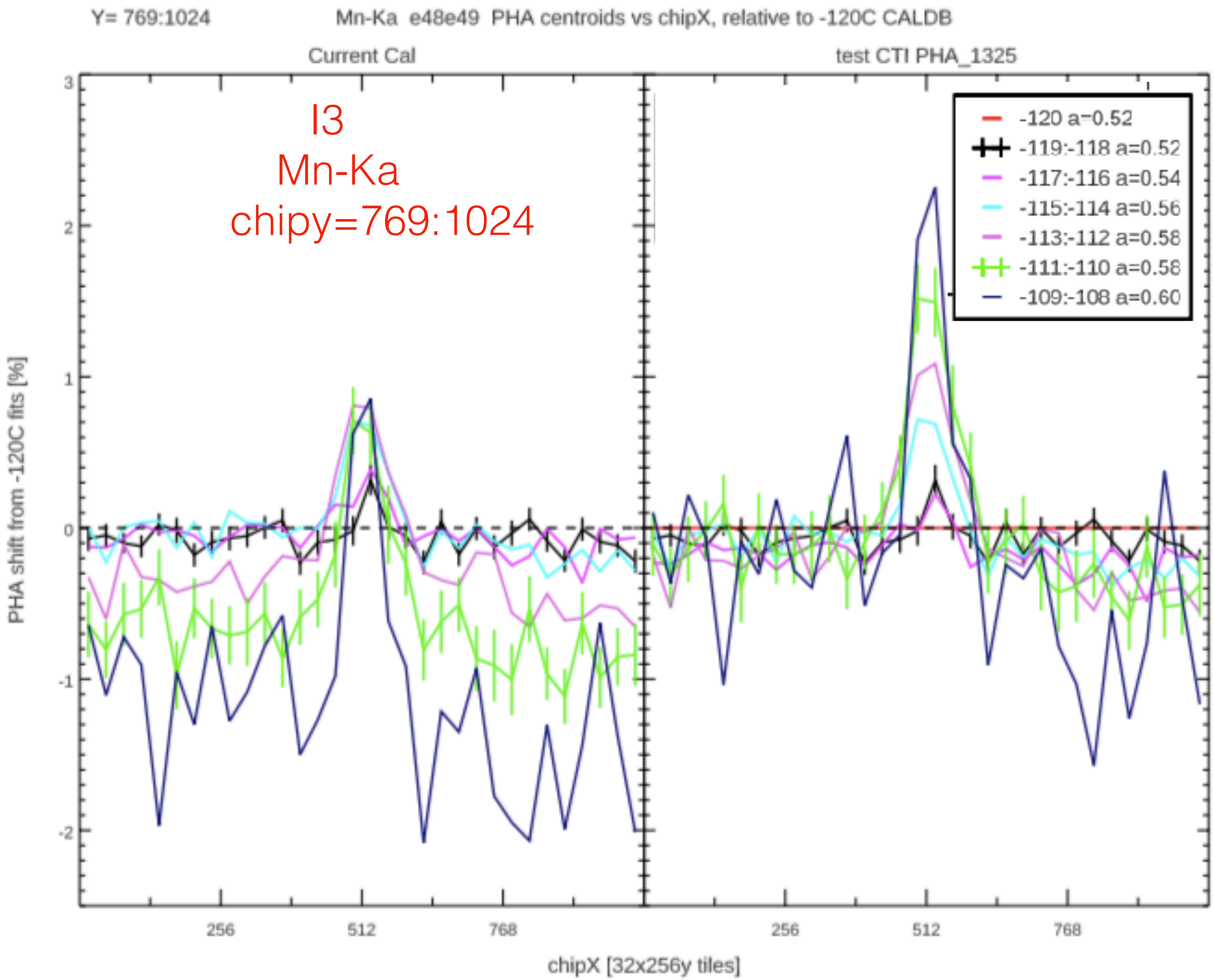
- Spatial correction is determined by the trap map.
- Temperature correction is approximated by a linear function in past CALDB versions of the CTI correction file. New test versions use a quadratic function.
- The energy correction assumes a single power-law for all temperatures in past CALDB versions of the CTI correction file. New test versions allow the energy dependence to vary with temperature. ($CTI_E \sim E^a$) where a varies with temperature).

Each chip is calibrated separately.

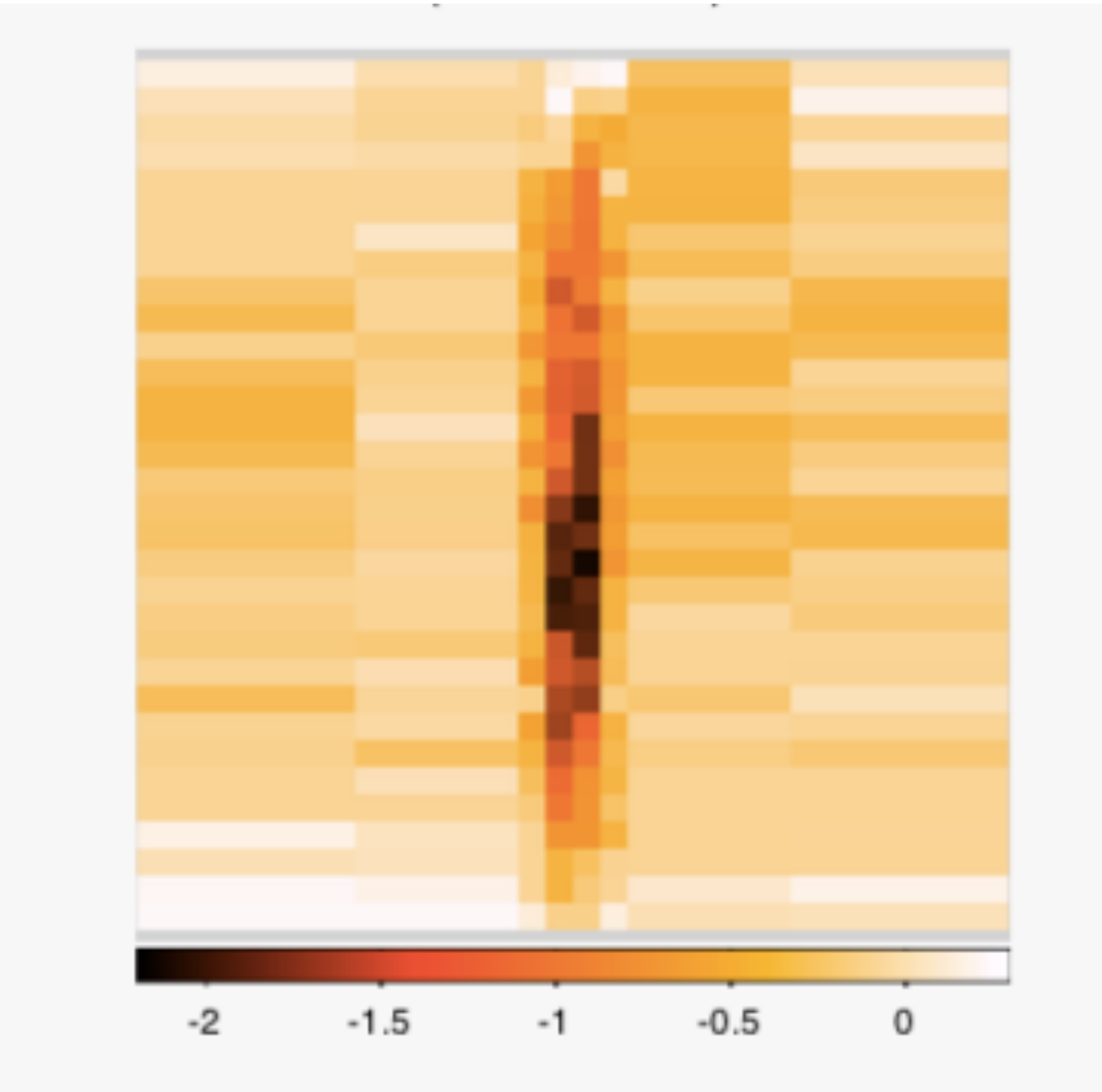
ACIS Gain Calibration at Warmer Temperatures



ACIS Gain Calibration at Warmer Temperatures



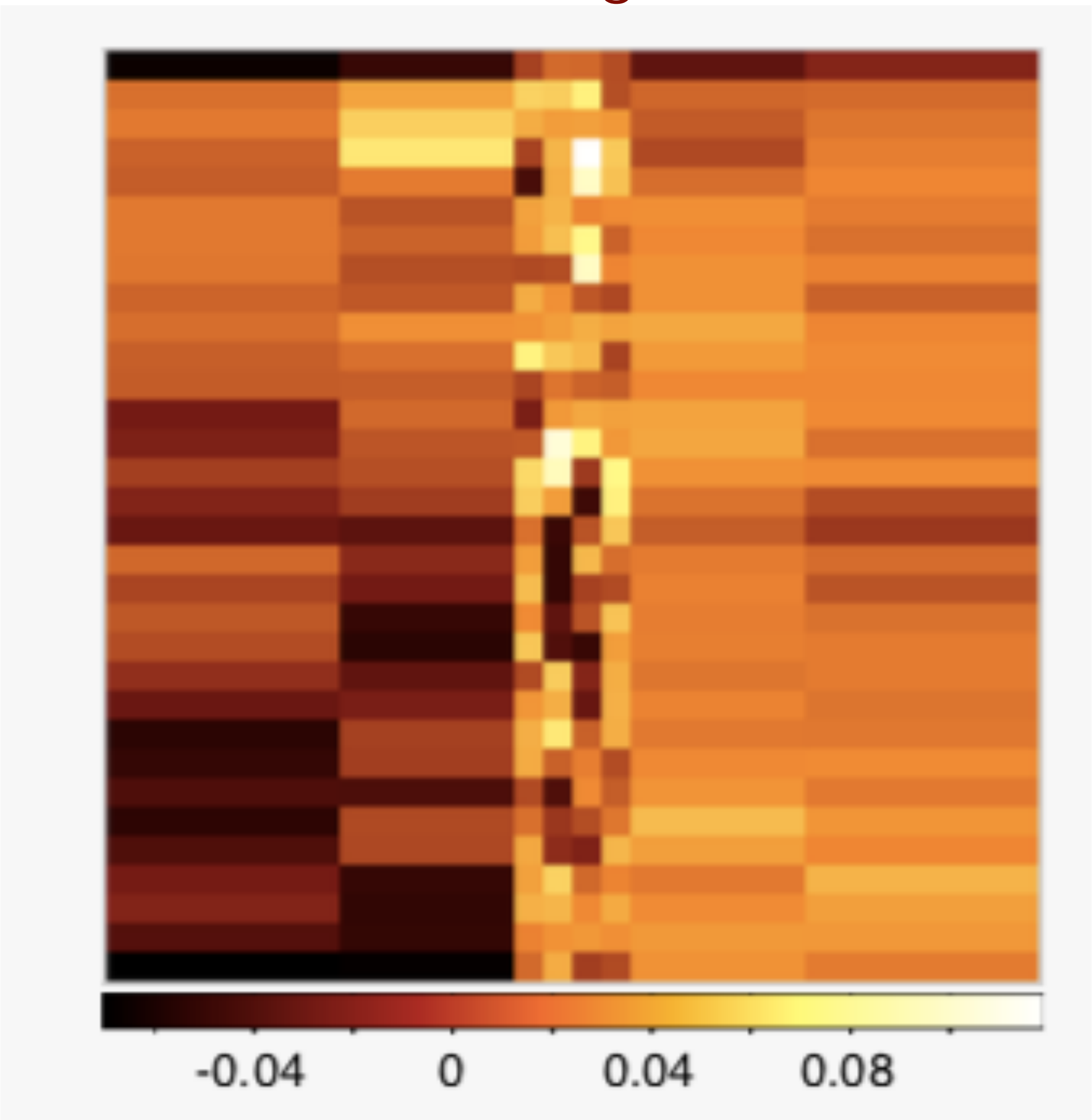
ACIS FI Gain Droop at -120 C



High resolution image of the “det_gain” file. This file is the detector gain during the first three months at an FP temp of -120 C. All gain corrections are made relative to this file.

There is a gain droop in the middle of the ACIS FI chips.

Corrected det_gain file



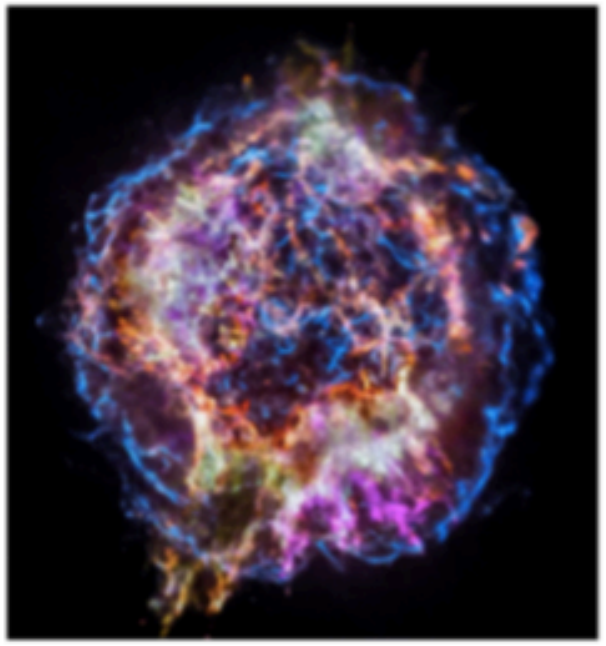
Plan for Calibrating ACIS up to -109 C with ECS Data

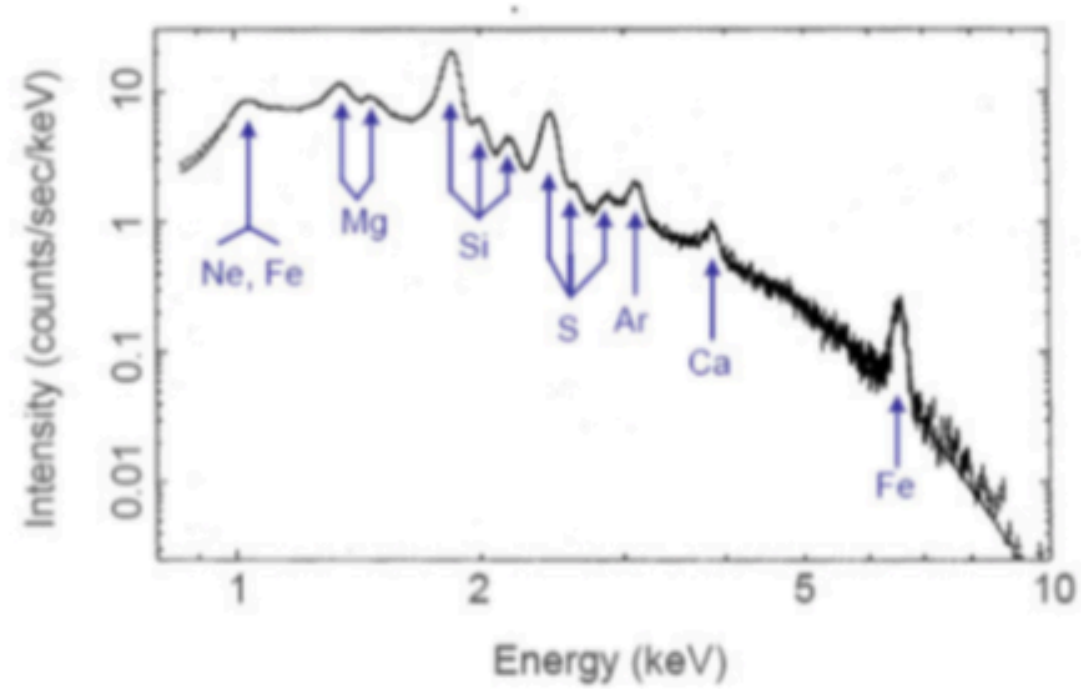
- Calibrate the six imaging chips (ACIS-I, S2, and S3) in 2 degree temperature bins between -120 and -108 C.
- Generate the following CALDB products for each temperature bin and each of the six chips.

1. CTI correction file
2. Spectral response file (p2_resp)
3. det_gain file
4. QEU (?)

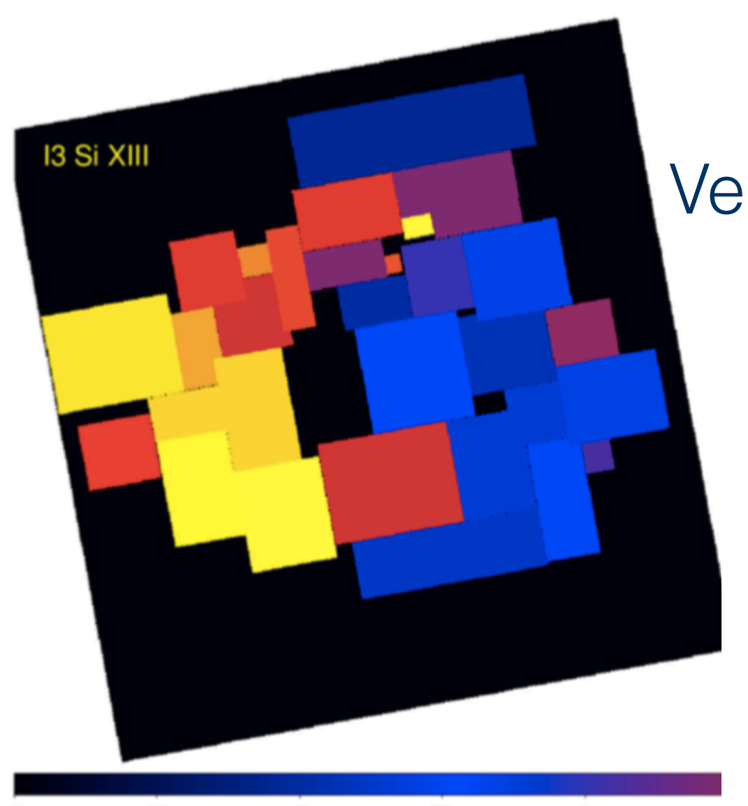
- Work with the CALDB Manager to establish the appropriate CALDB formats and nomenclature for all the new products.
- Work with SDS to develop a contributed software script that applies all the new CALDB products to ACIS data.
- Incorporate the new software into CIAO.

Calibrating ACIS above -109 C with Cas A





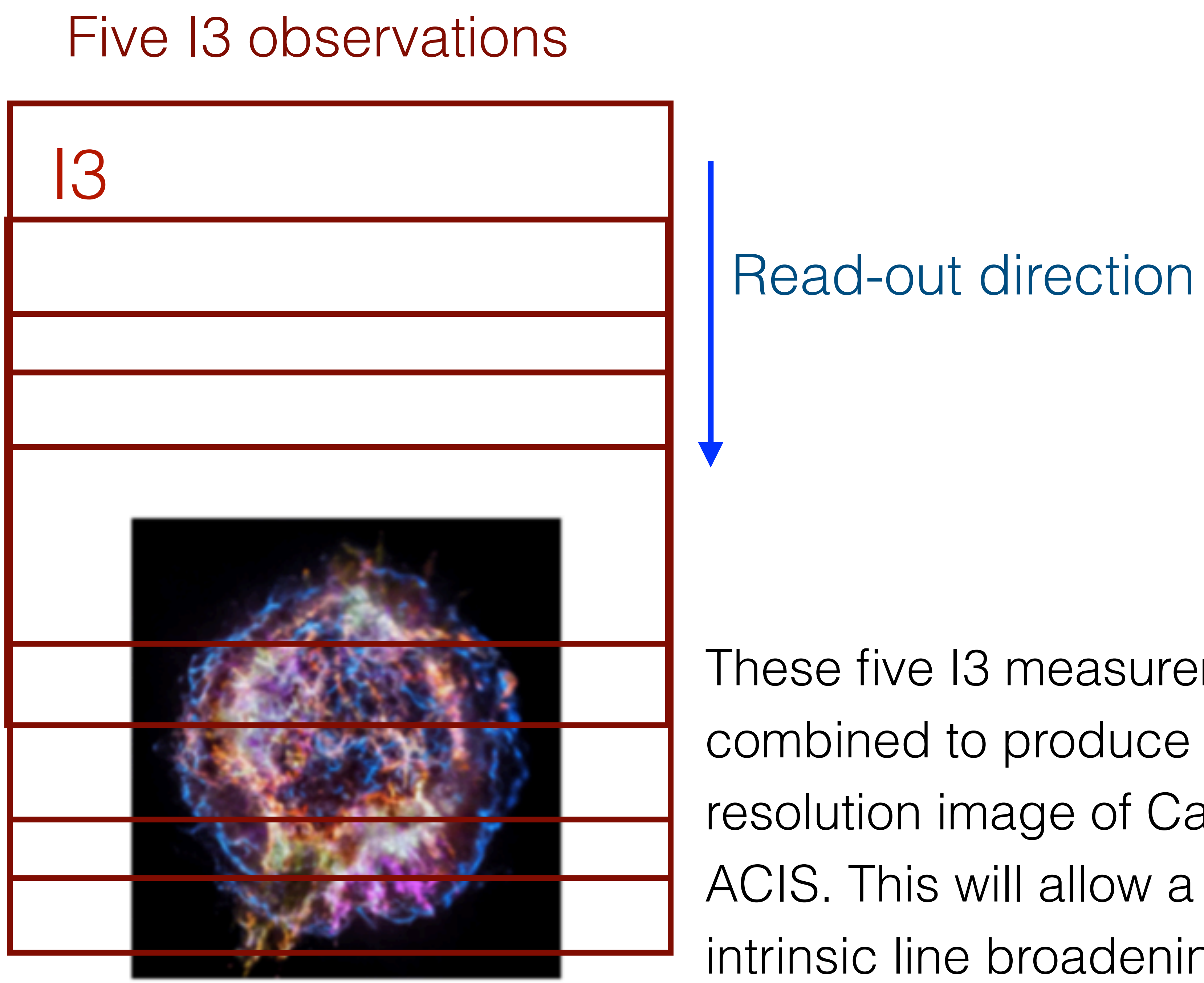
Cas A is very bright (~150 ct/s in FAINT Mode) with many strong emission lines.



Velocity map for I3 at Si.

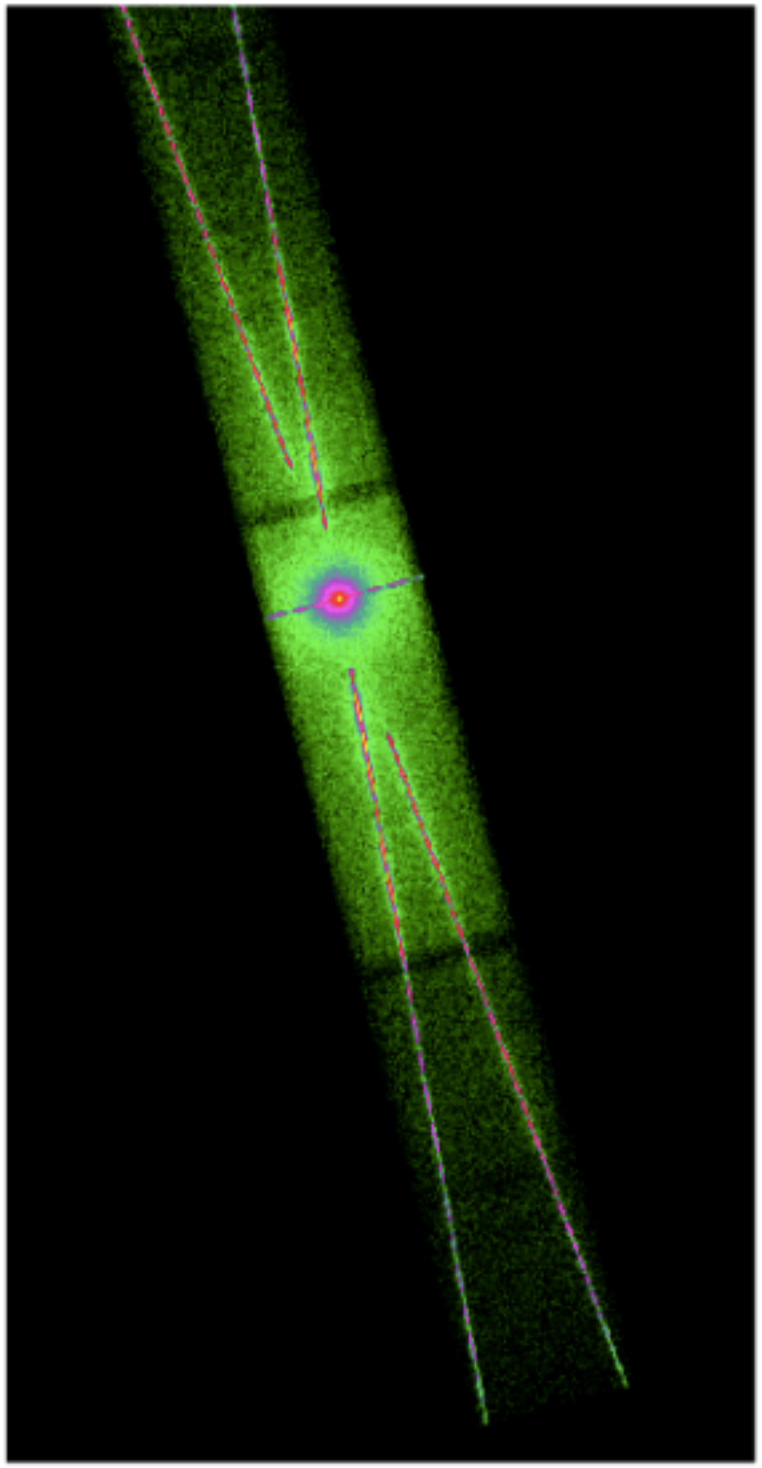
Due to the bulk motions of the gas in Cas A, the photon energies will be adjusted based on the velocity maps derived from -120 C observations. This is essential for deriving accurate gain maps.

Calibrating ACIS above -109 C with Cas A



These five I3 measurements will be combined to produce the highest energy resolution image of Cas A possible with ACIS. This will allow a measurement of the intrinsic line broadening in Cas A, which must be accounted for to accurately calibrate the energy resolution of the detectors at -105 C.

Calibrating ACIS above -109 C with GX 3+1



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Observe GX 3+1 with the HETG/ACIS-S at three different values of chipy (SIM_Z). These observations will be used to:

- Determine if HETG/ACIS-S observations can be done at -105 C.
- Measure the gain on a finely spaced energy grid.
- Measure the energy resolution on a finely space energy grid.
- Compare gratings results with Cas A data on S2 and S3.

Observing Plan to Calibrate ACIS at -105 C

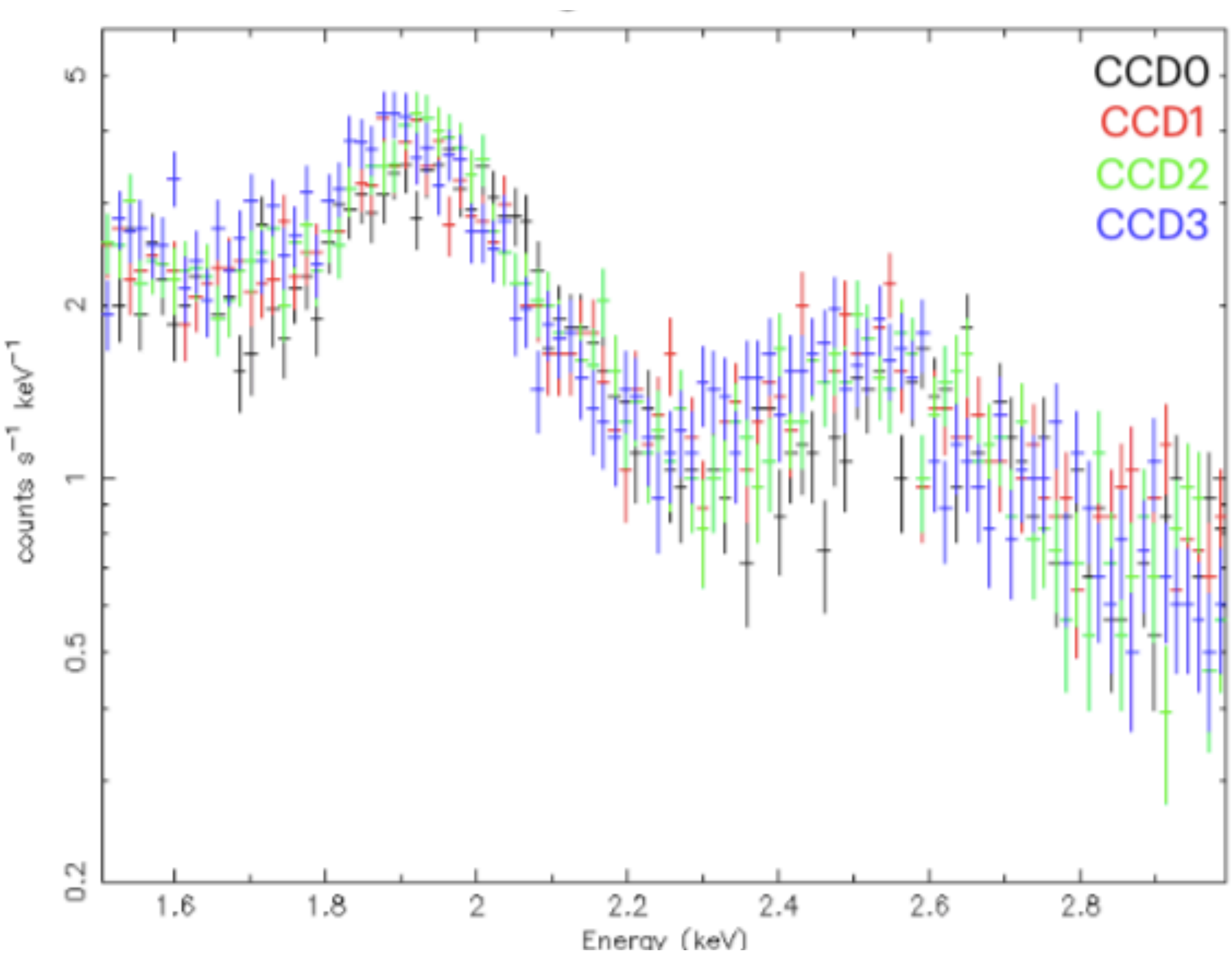
- Nine observations (3 by 3 raster scan) of Cas A for 2 ksec each on ACIS-I0, I1, I2, I3, and S2 plus one observation of Cas A for 2 ksec on S3. These observations will be used to calibrate the gain, energy resolution, and possibly the QEU map.

- Five observations of Cas A for 5 ksec each near the read-out of I3 (these can done at any temperature). These observations will used to measure the intrinsic line widths in Cas A.

- Three HETG/ACIS-S observations of GX 3+1 at different chipy for 10 ksec each. These observation will determine if HETG/ACIS-S observations can be executed at -105 C and measure the gain and energy resolution on S2 and S3 on a finer energy grid.

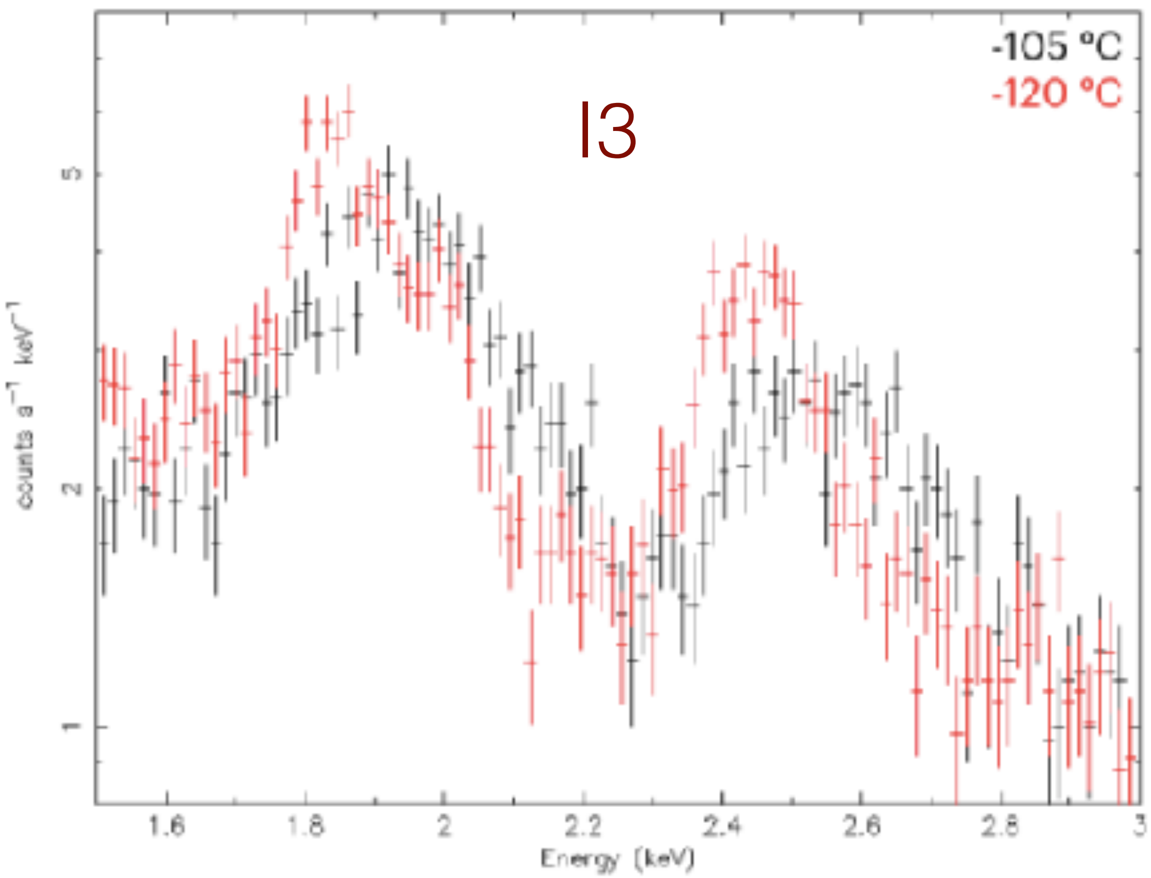
Preliminary Results from Cas A Observations at -105 C

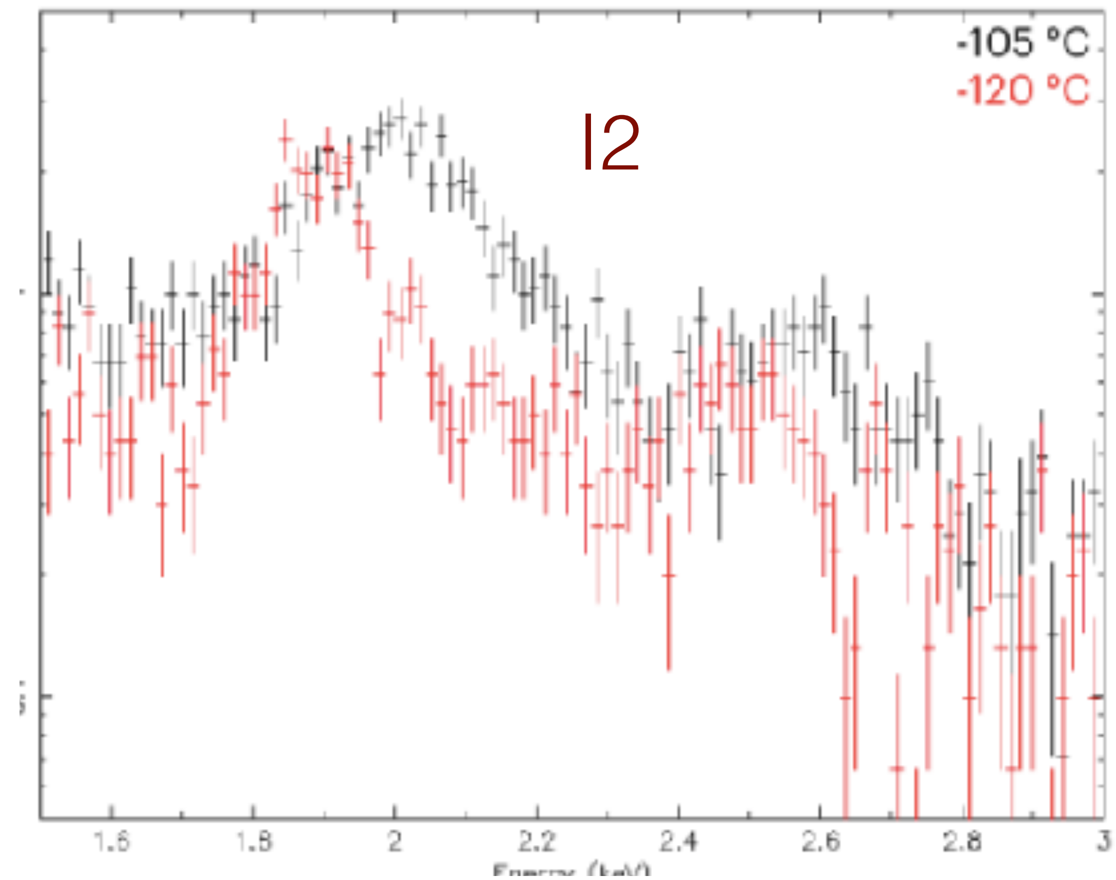
All four ACIIS-I chips near row=500



Preliminary Results from Cas A Observations at -105 C

Near row 750

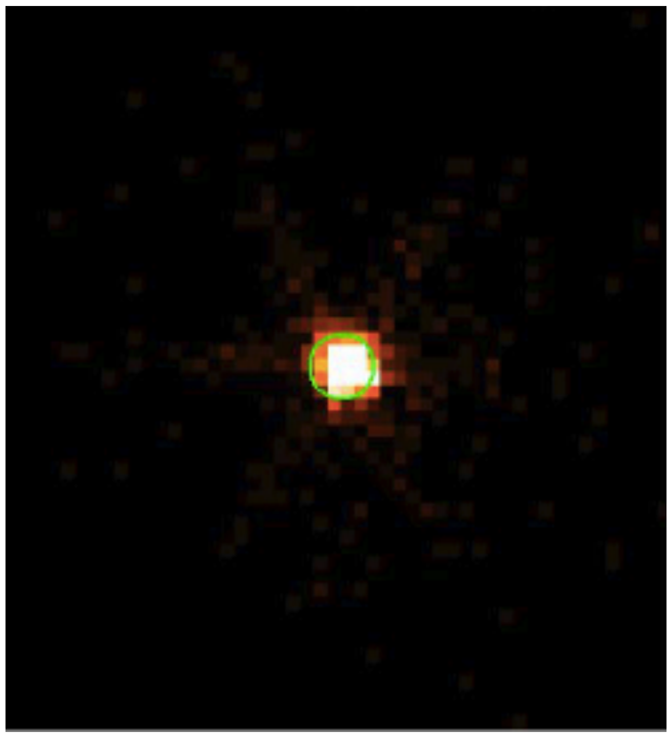




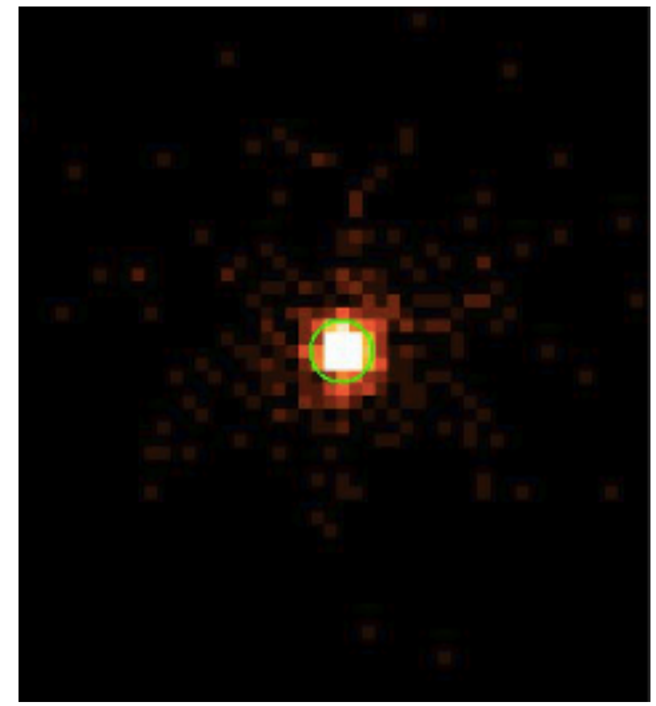
Broadening in the ACIS PSF at Low Energies

The calibration team has observed the isolated neutron star RXJ1856 every year since 2011 with the LETG/ACIS-S to monitor the build-up of contamination on the ACIS filters.

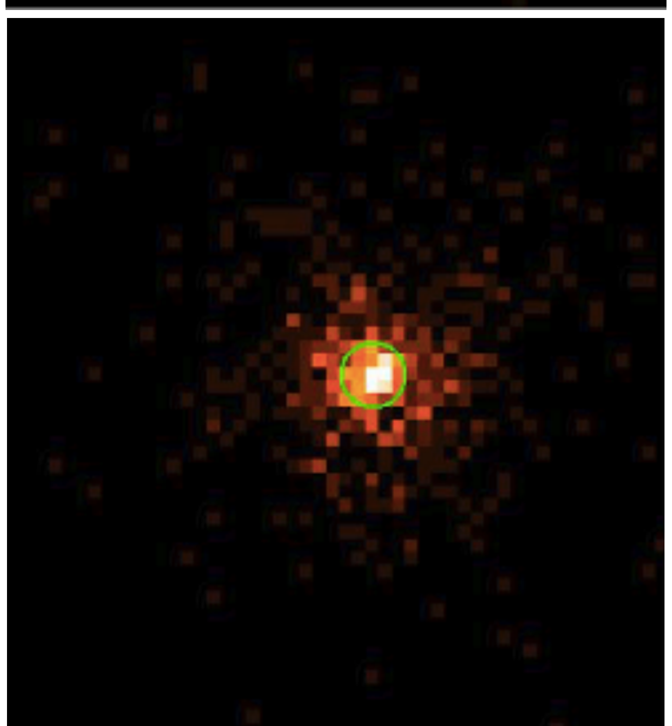
Zeroth order image in the 150-350eV band



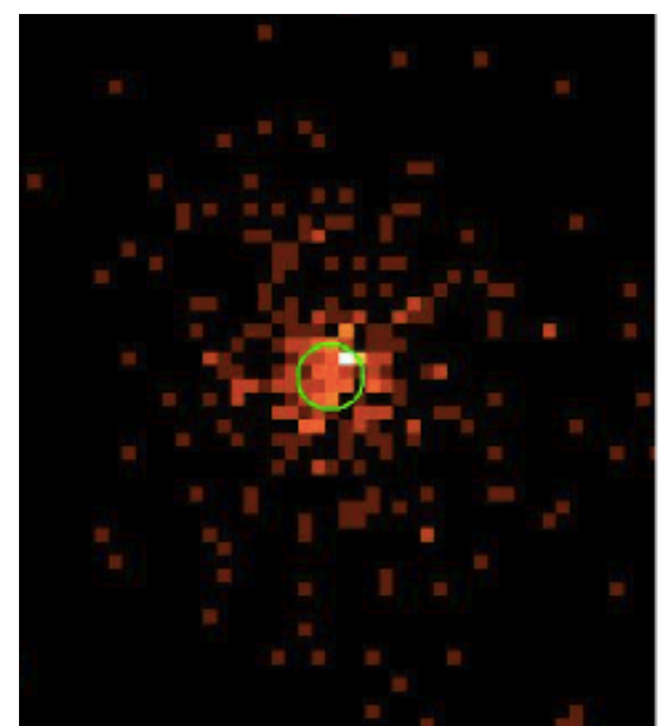
2011



2014

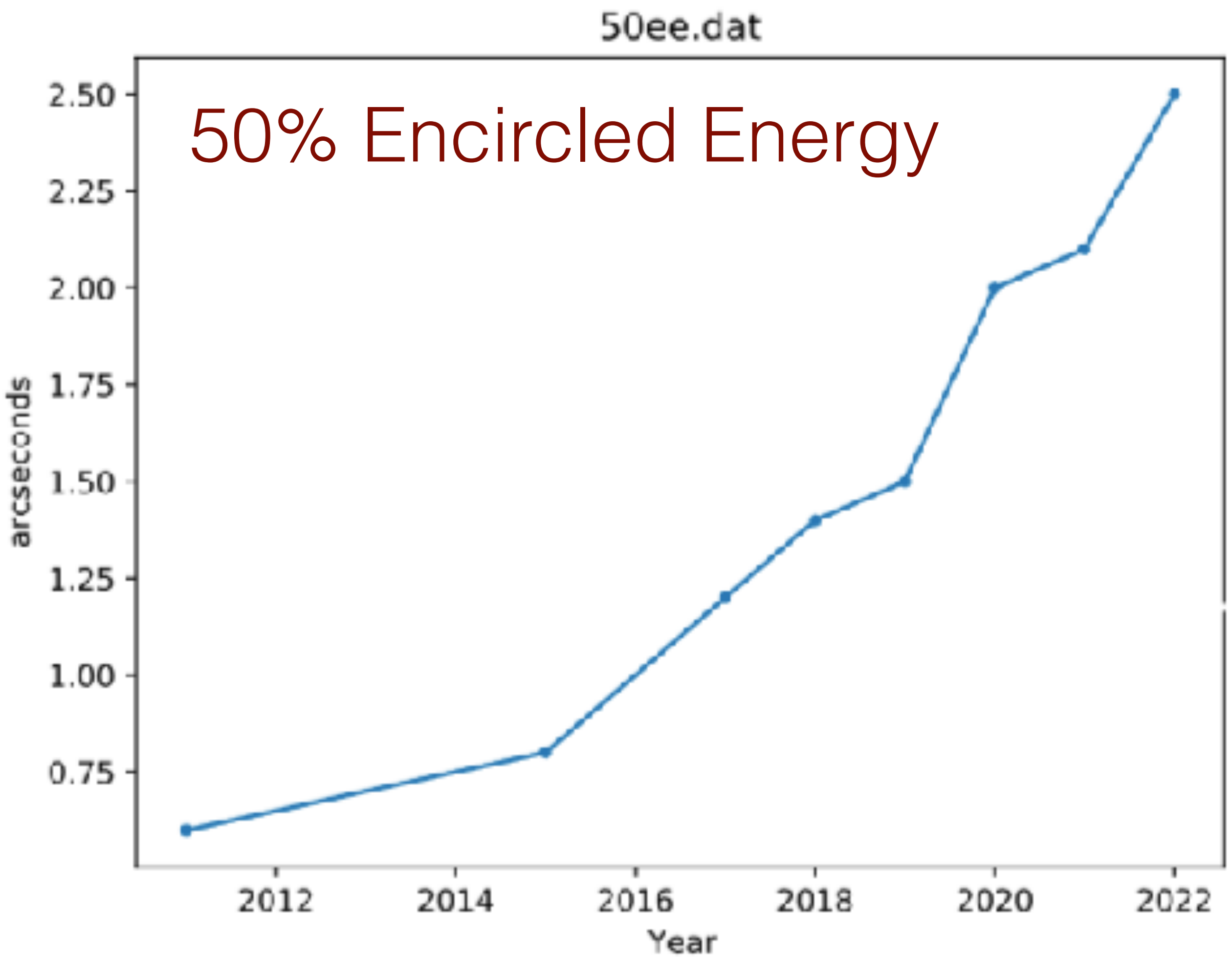


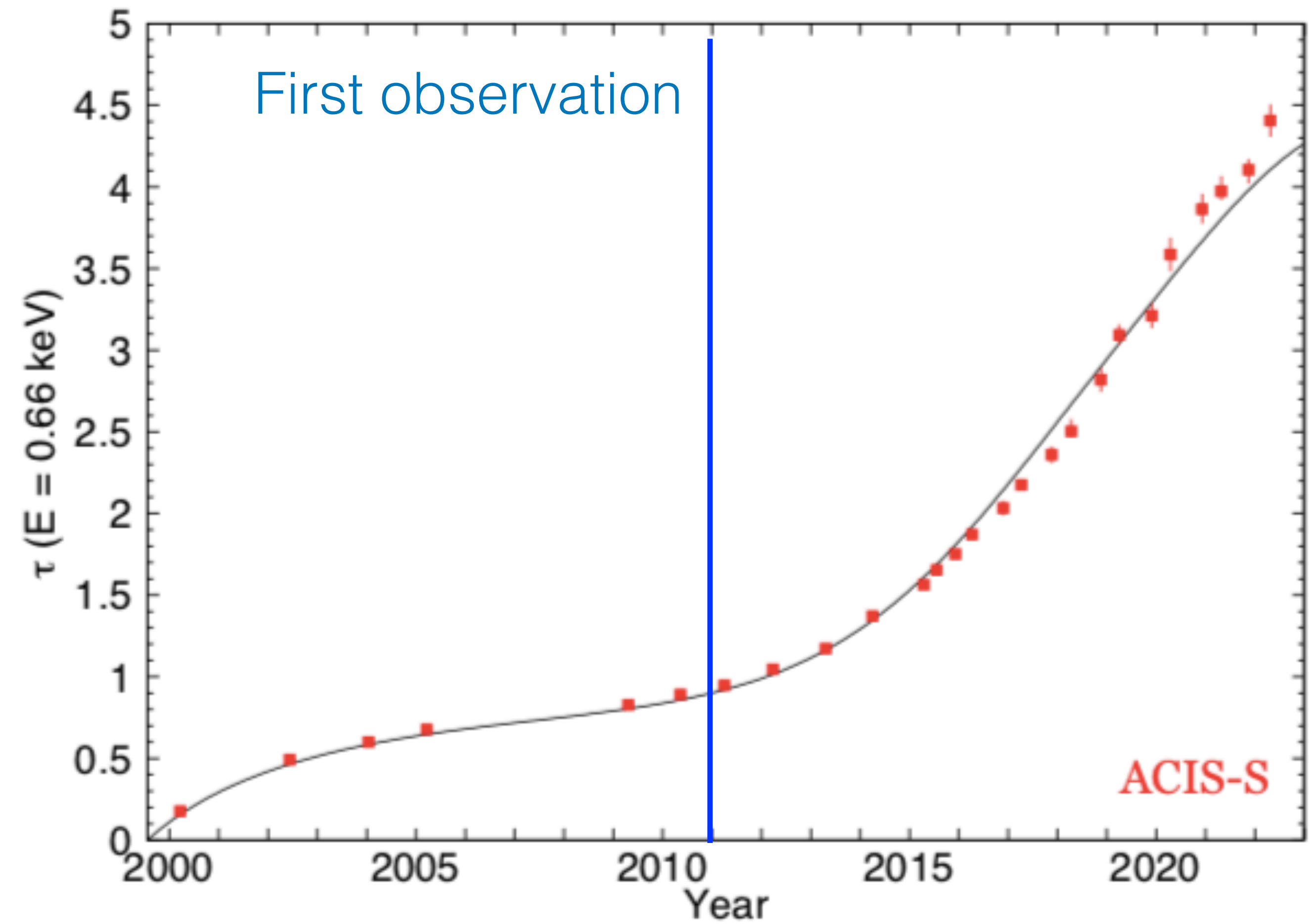
2018



2021

Broadening in the ACIS PSF at Low Energies





Broadening of the Low energy ACIS PSF is most likely due to the build-up of contamination on the ACIS filters. The effect is the most significant near the C K-edge (284eV).

Main questions still to be answered:

- What is the maximum energy this effect is measurable
- What is the physical cause.

Present and Future Calibration Activities

ACIS

- Continue to monitor the build-up of contamination on the ACIS filters and release updates to the contamination model as needed.
- Release a set of temperature-dependent calibration products for temperatures up to -109 C and eventually -105 C
- Continue to investigate the broadening of the low energy PSF

HRC/LETG

- Calibration program is scheduled to re-start in March 2023
- Measure the HRC-I PSF and the location of the optical axis once the HRC returns to science. These measurements were last done in September 2021
- Monitor the QE and gain of the HRC-I and HRC-S and release updated calibration products as needed.

HETG

- Post update to the HEG and MEG high order transmission along with the appropriate software on the Chandra contributed software page.