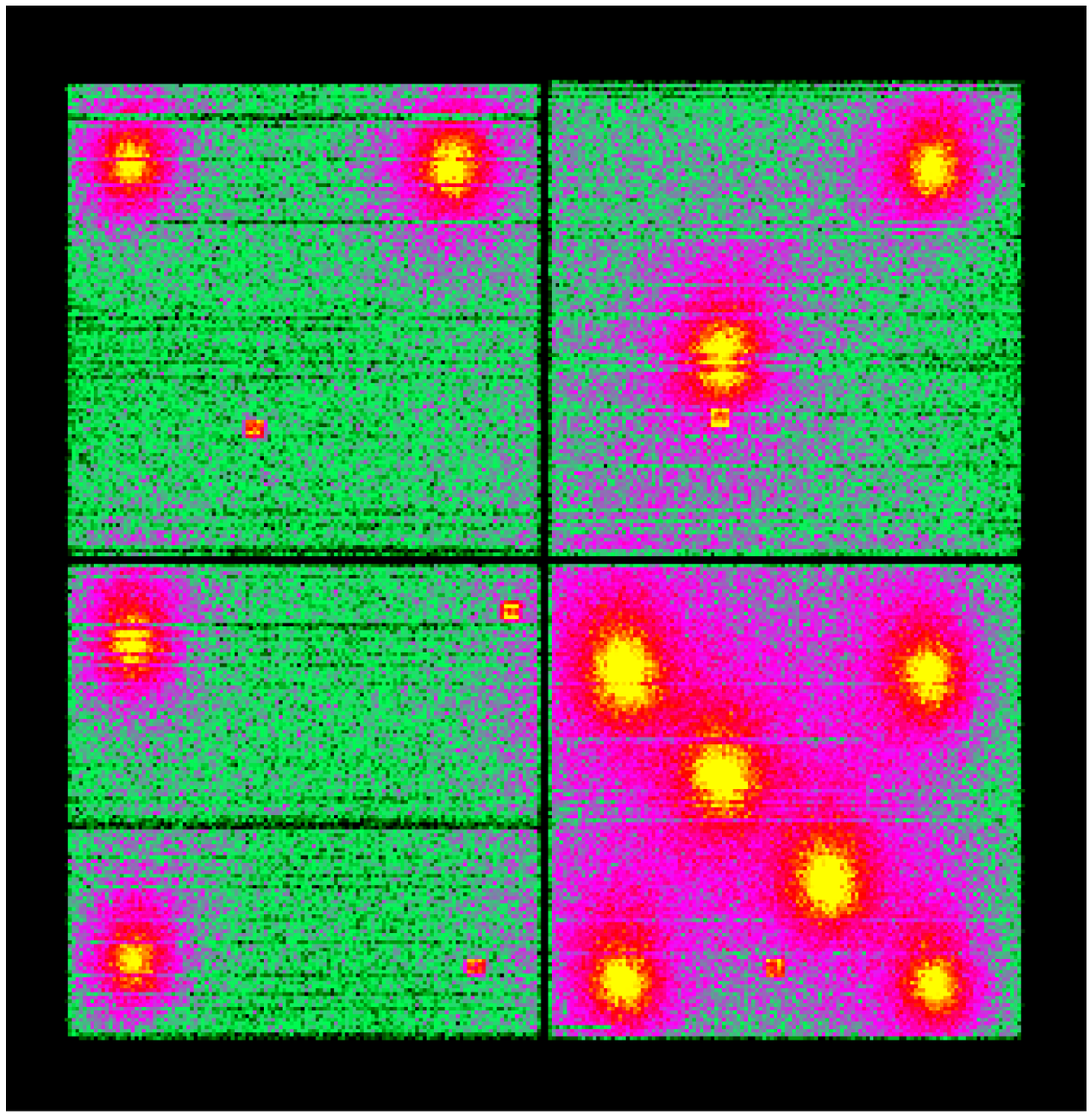
Chandra Calibration Status

CUC Meeting - Nov. 12 ,2021

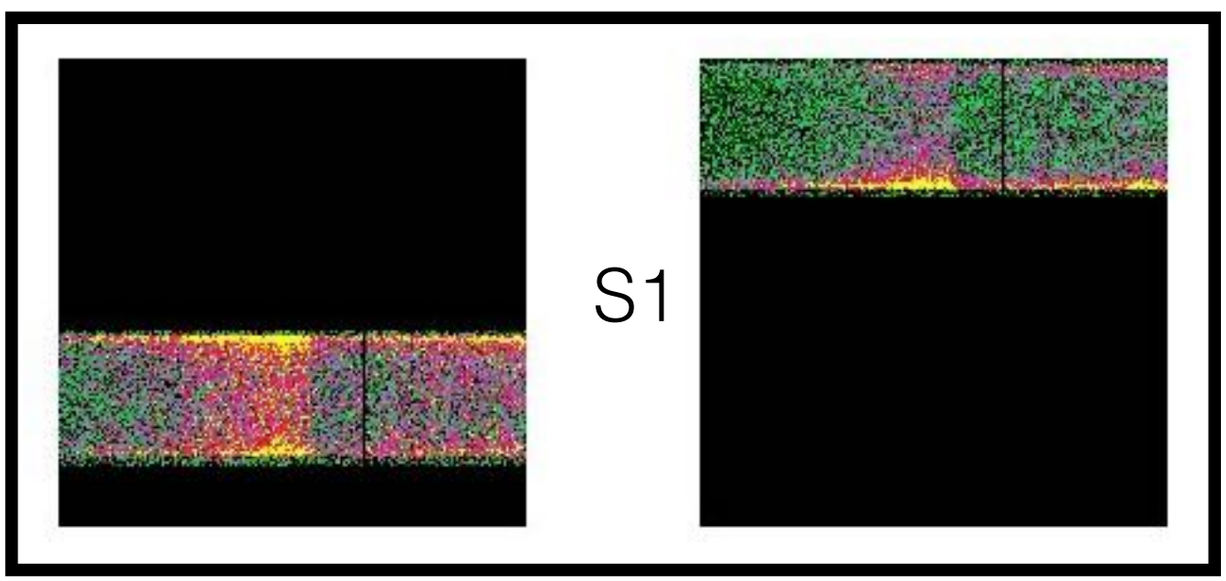
ACIS Contamination Model

A1795 Raster Scan on ACIS-I

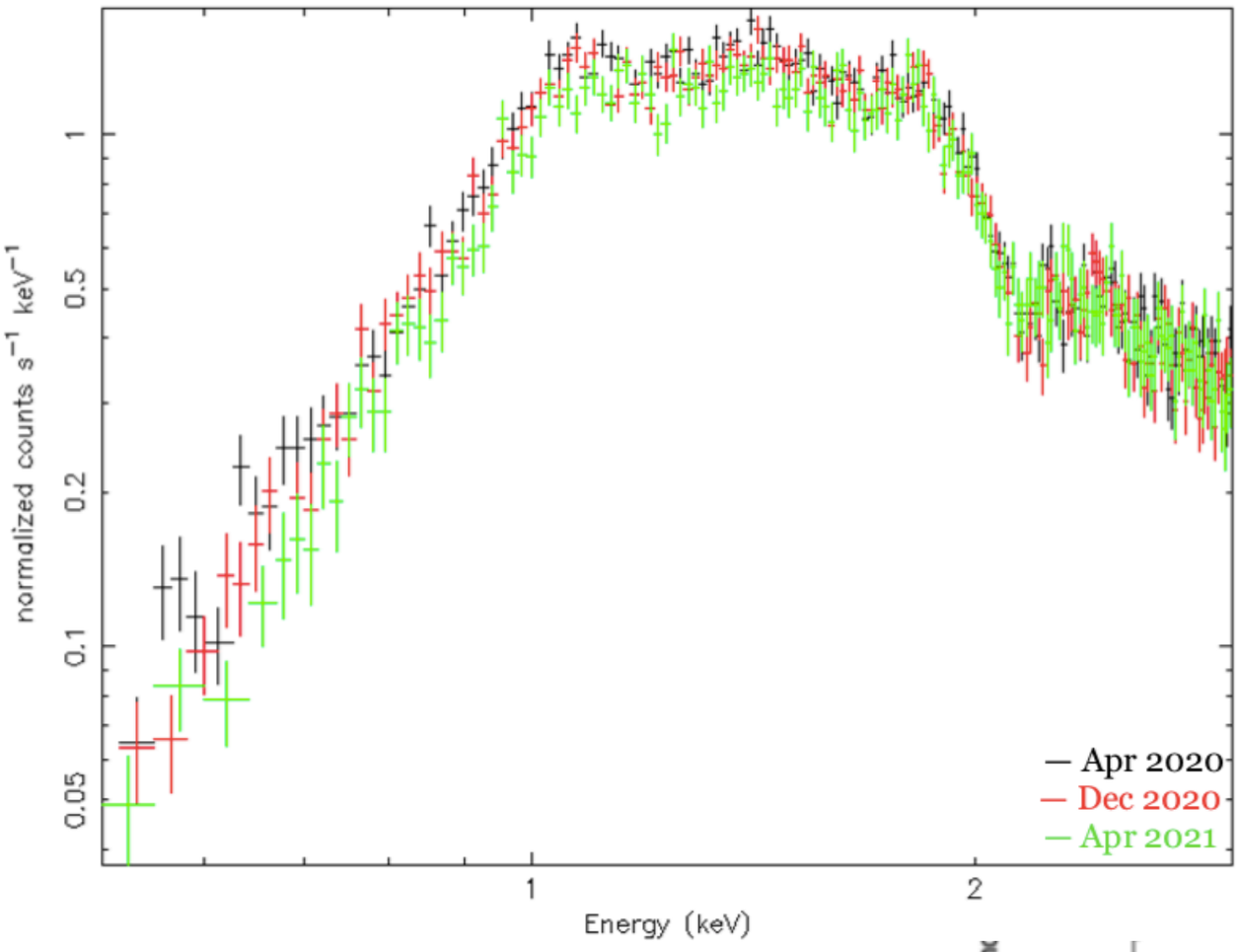


E0102-72

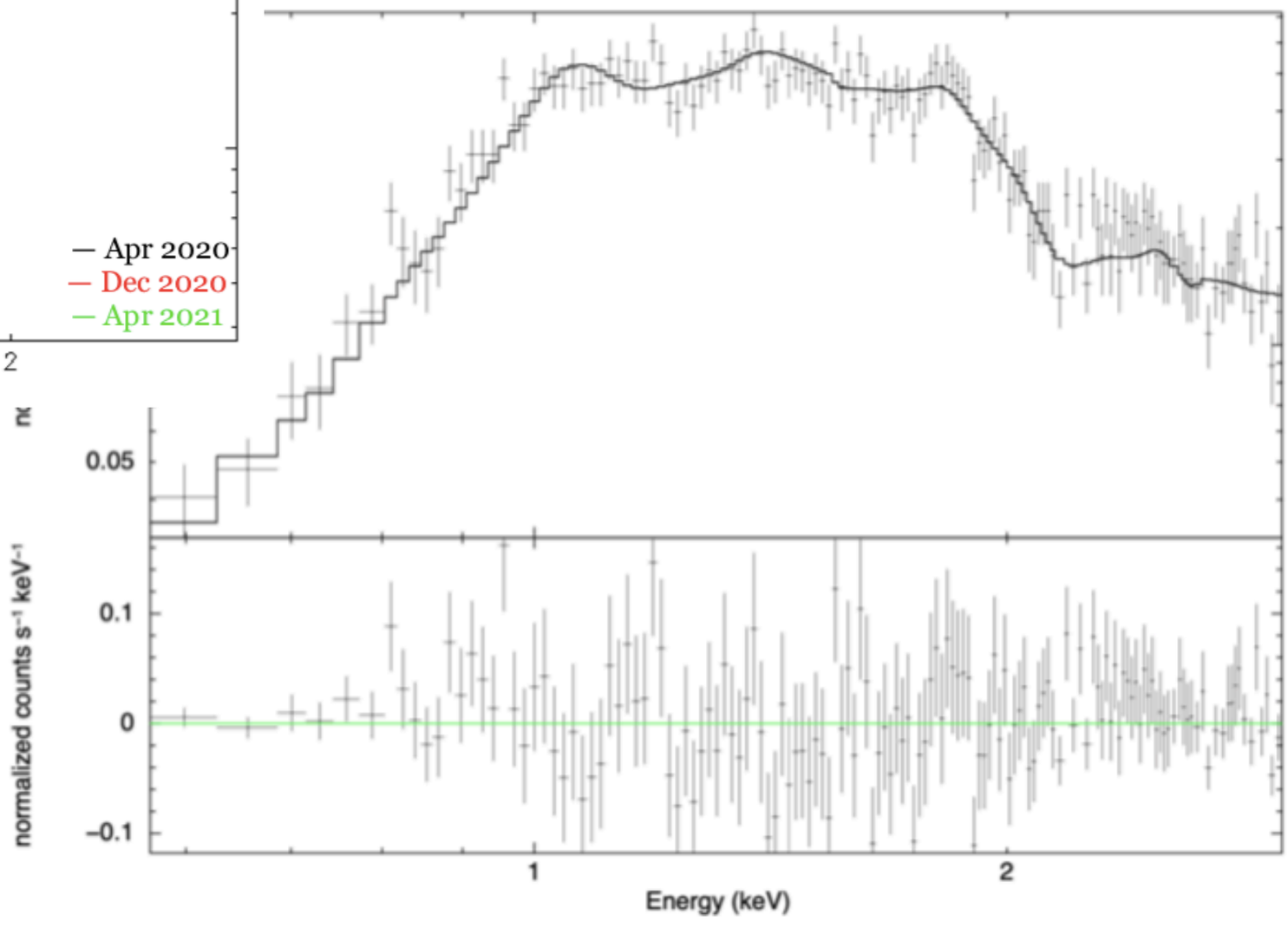
Big Dither LETG/ACIS-S observations of Mkn 421



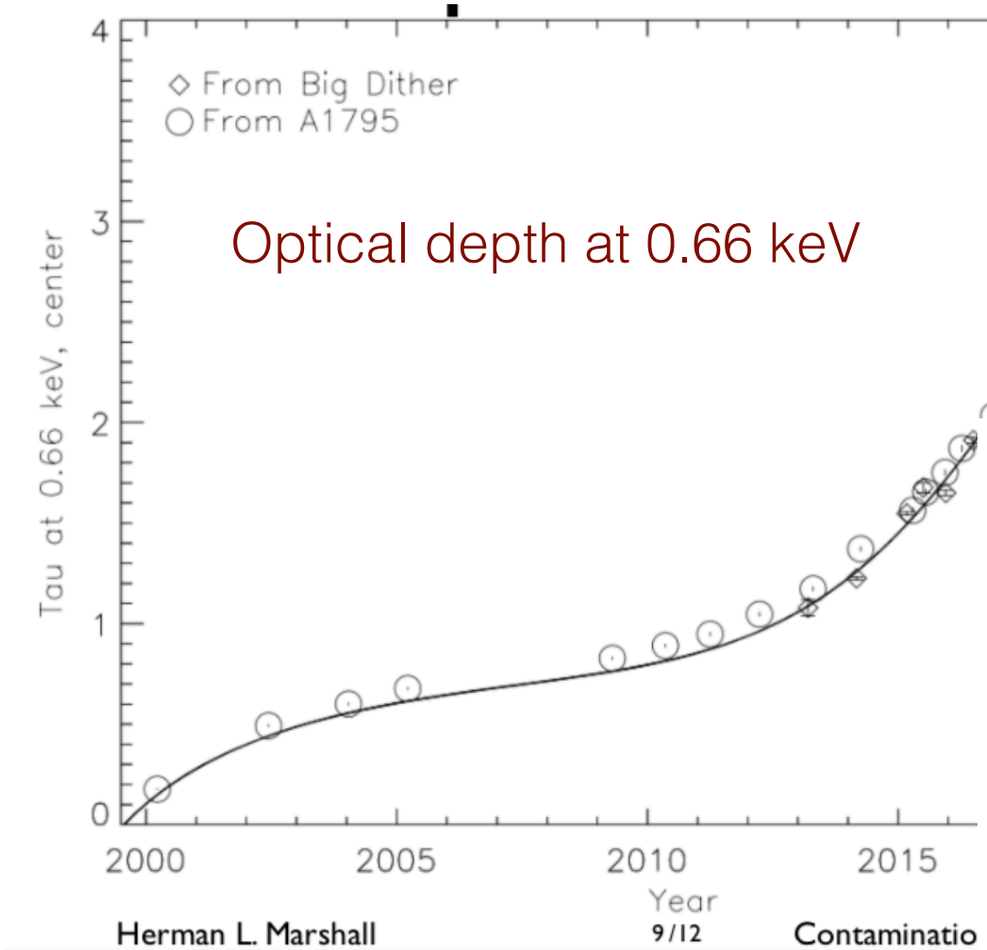
ACIS Contamination Model



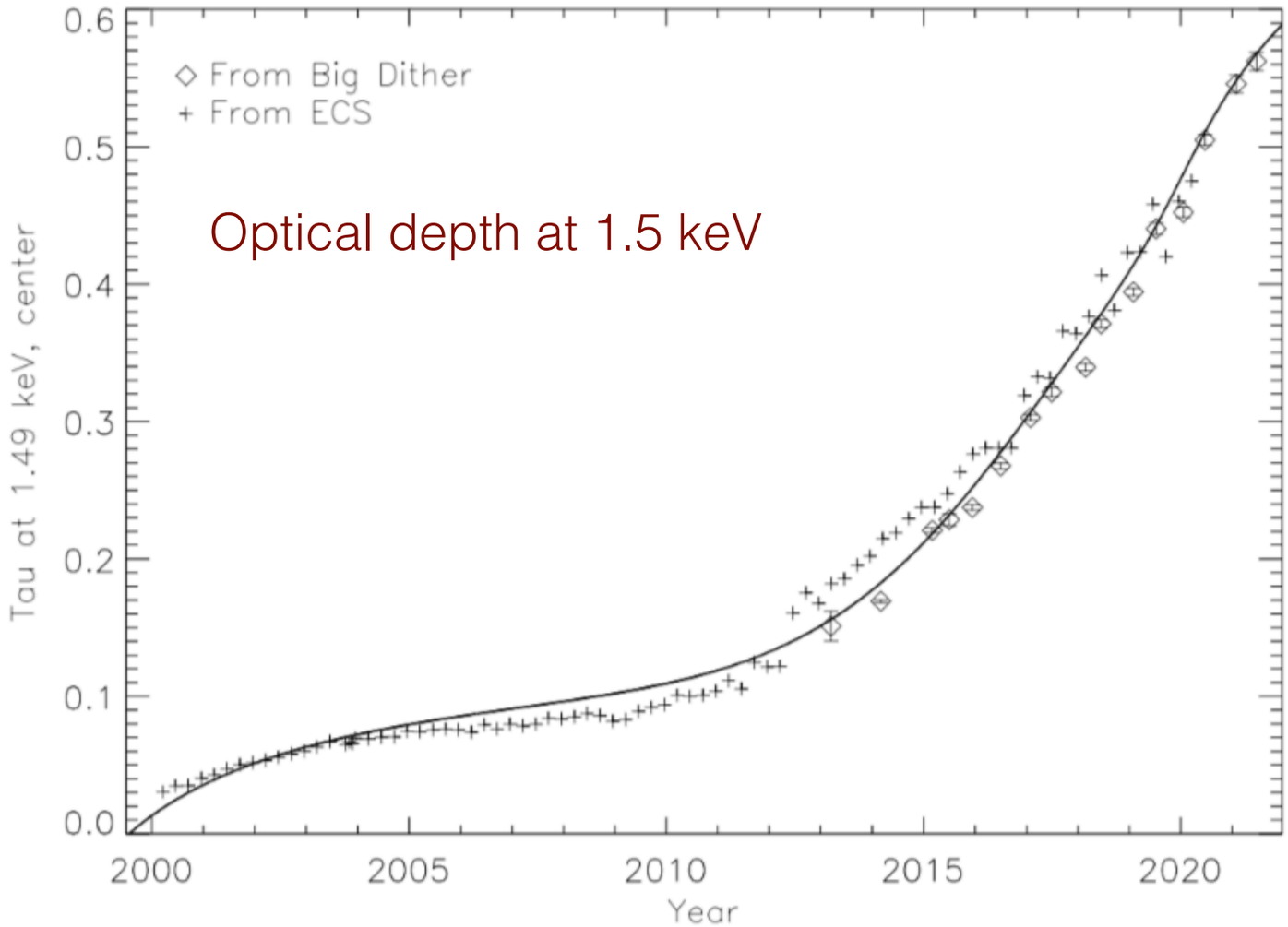
Solid line is the best-fit model to the first ACIS observation of A1795 (Dec. 1999) convolved with the CALDB version of the ACIS contamination model. The data is the S3 aim-point observation in April 2021.



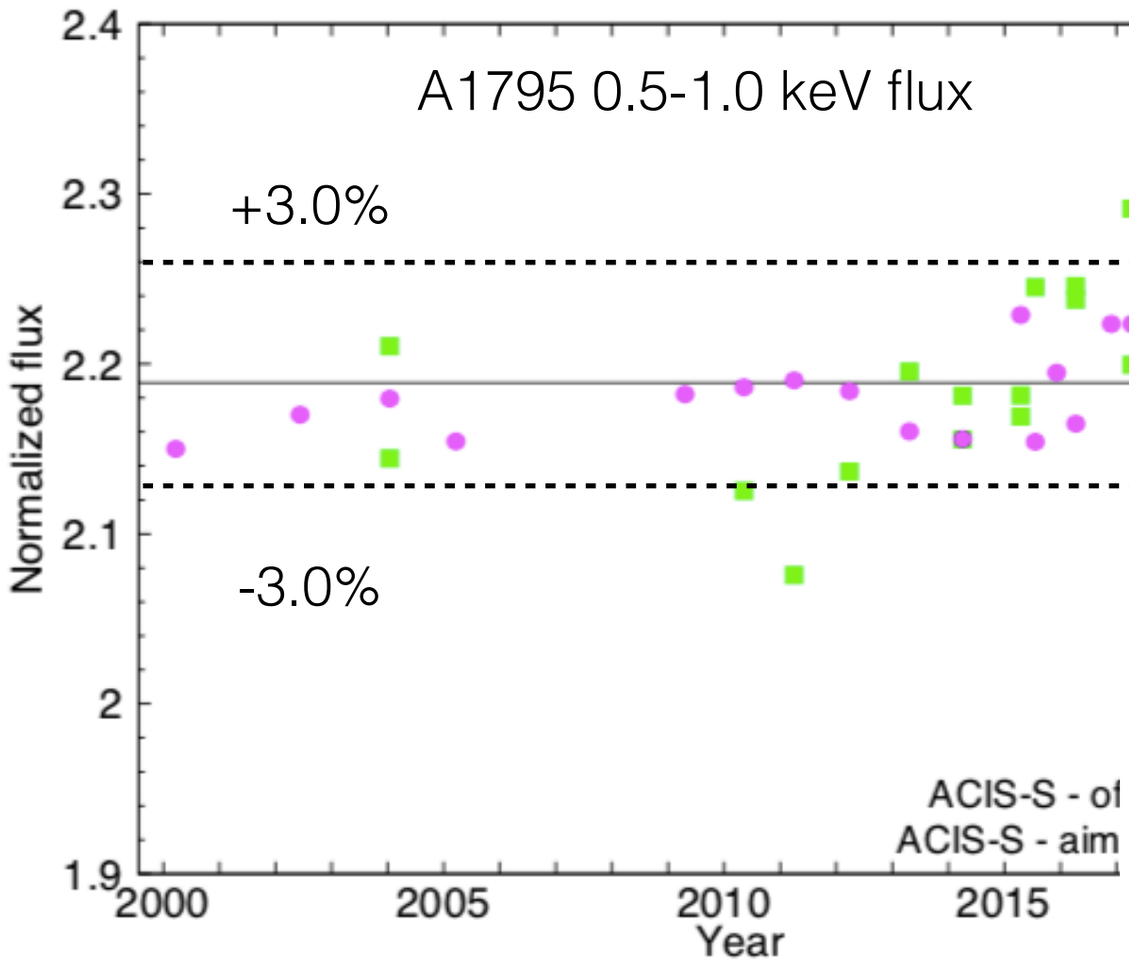
ACIS Contamination Model



Solid line is the current CALDB version
Of the ACIS Contamination Model.

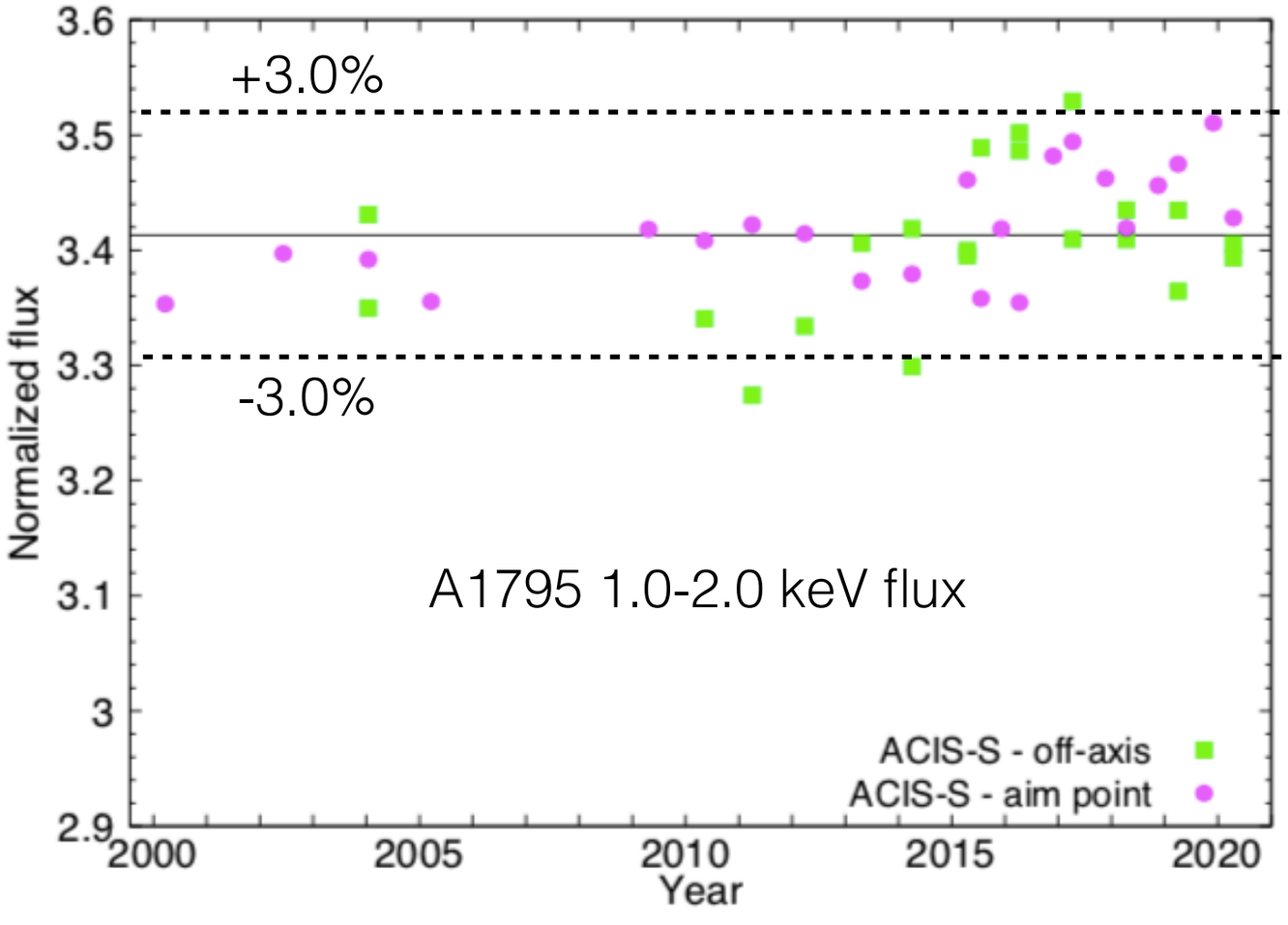


ACIS Contamination Model



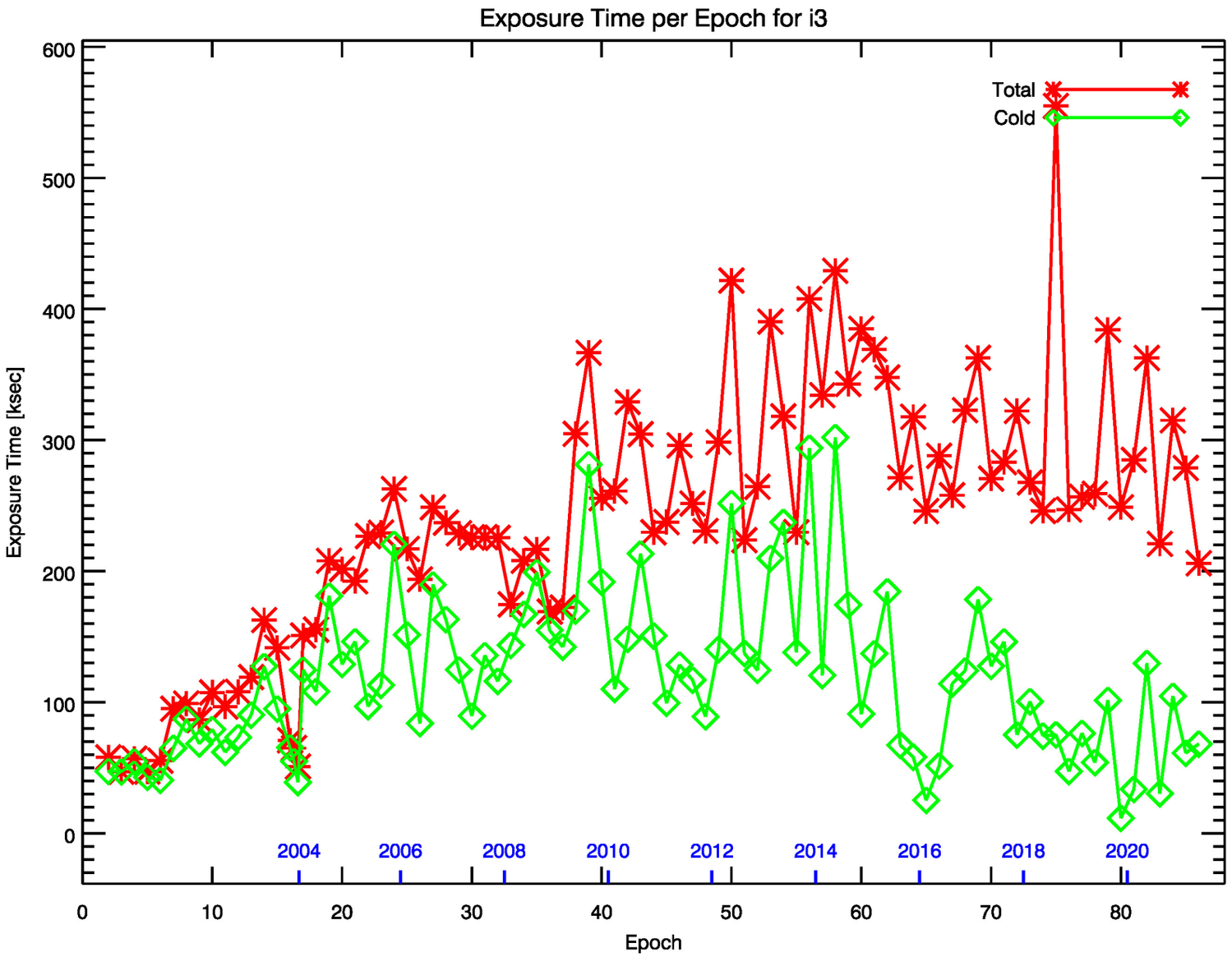
On-Axis ACIS-S3

Off-Axis ACIS-S3



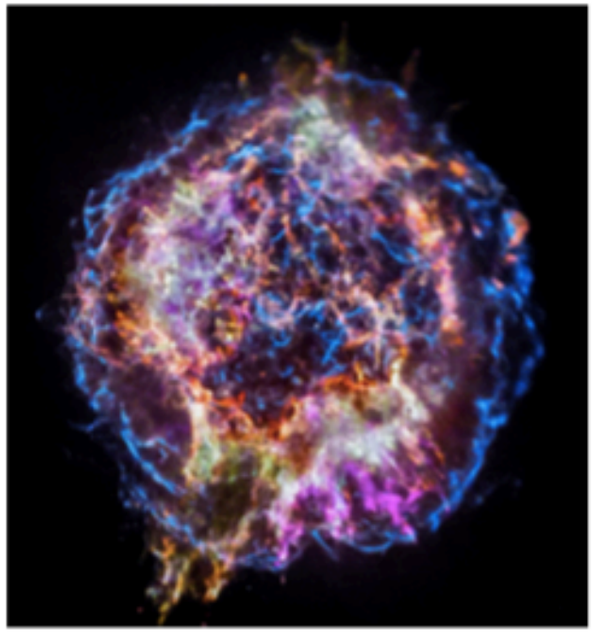
Based on these data, the calibration team decided to not release an update to the ACIS contamination model in 2021.

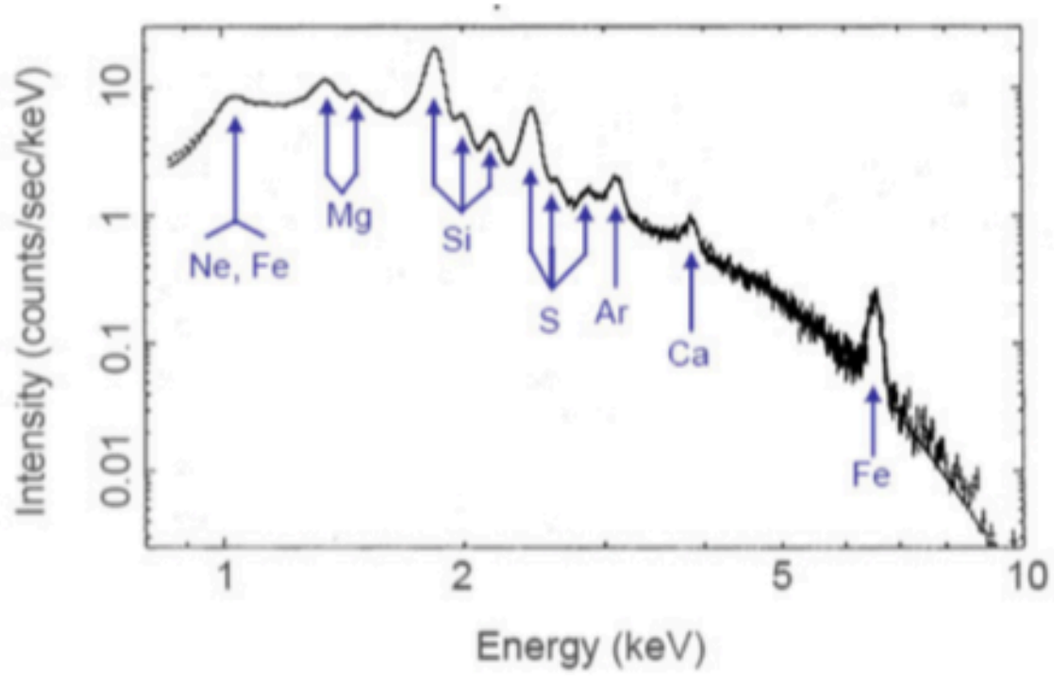
Lack of Cold ECS Data during RadZone Passages

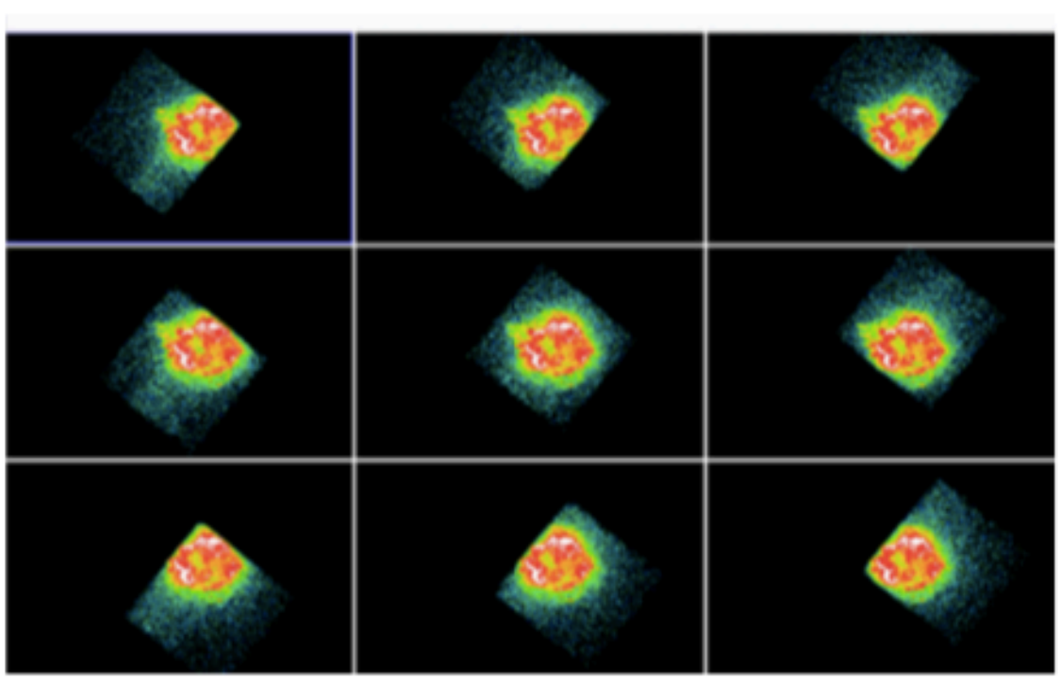


- 55Fe half-life = 2.71 yr
- Only ~25% of ECS data is cold (T < -117.2 C).
- This semester is on pace for 110 ksec of cold ECS data.
- To meet our calibration requirement on the ACIS gain of 0.3%, we need 280 ksec of cold ECS data.

Using Cas A to Calibrate the ACIS Gain



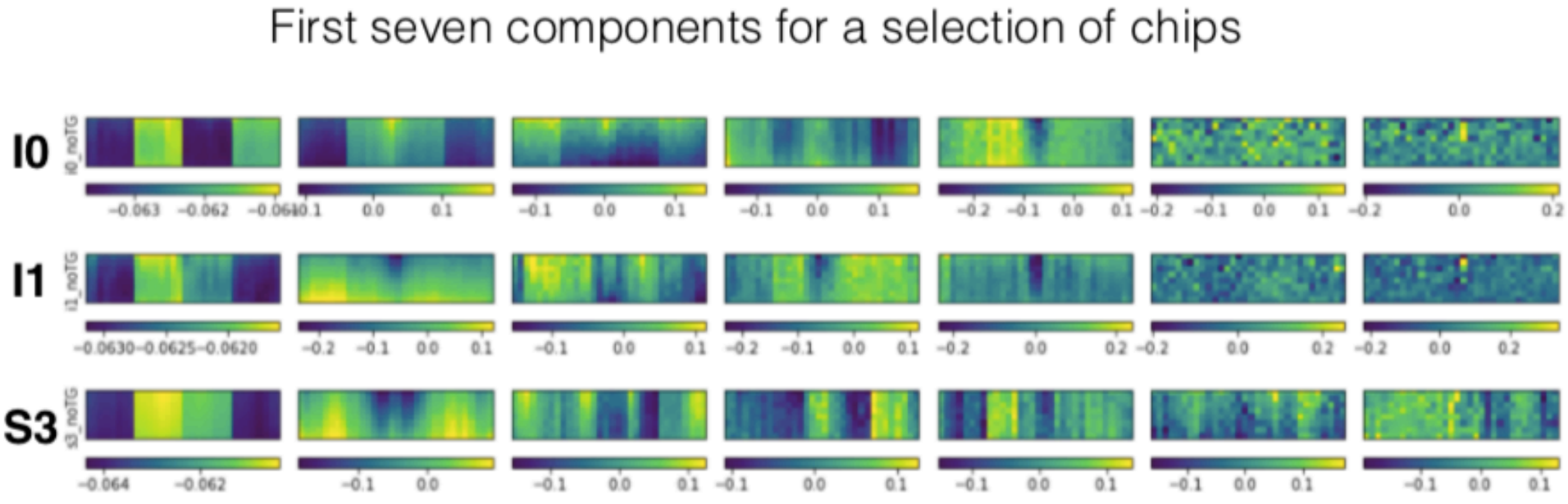




In July 2020, a 3 by 3 raster scan of Cas A on I3 was executed to determine how well the ACIS gain could be calibrated using Cas A. The nine exposures fully covered I3 with bright emission lines. Each exposure was 2 ksec.

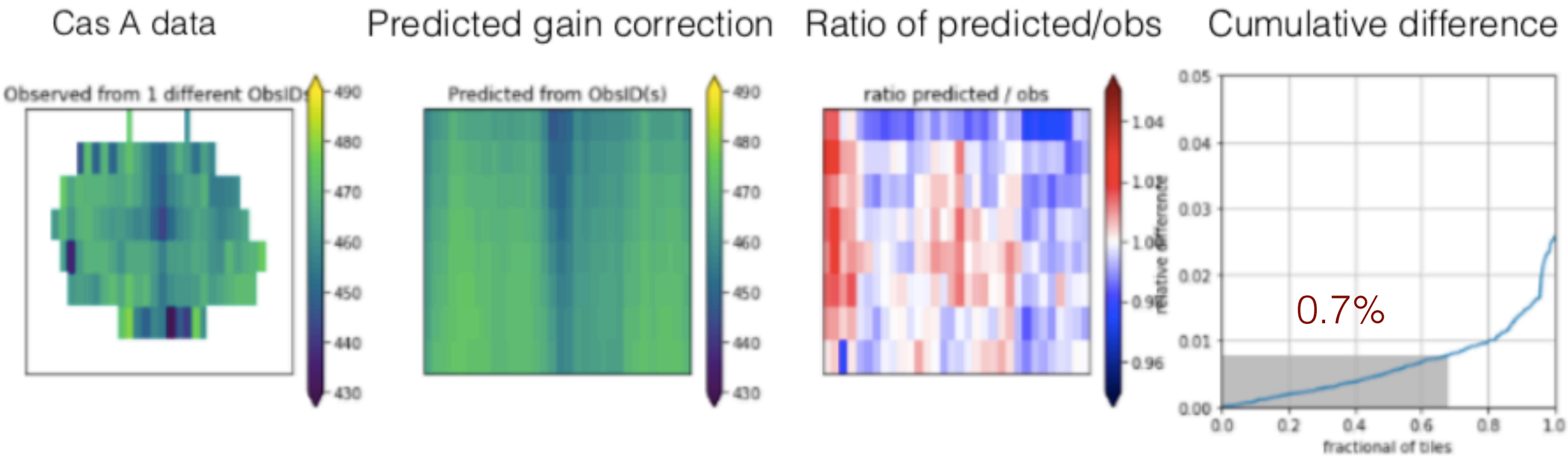
Using Cas A to Calibrate the ACIS Gain

A Principle Component Analysis (PCA) has been completed on all tgain files generated over the past 21 years. This study finds that the spatial structure of the tgain files is well modeled by the first four to five components.



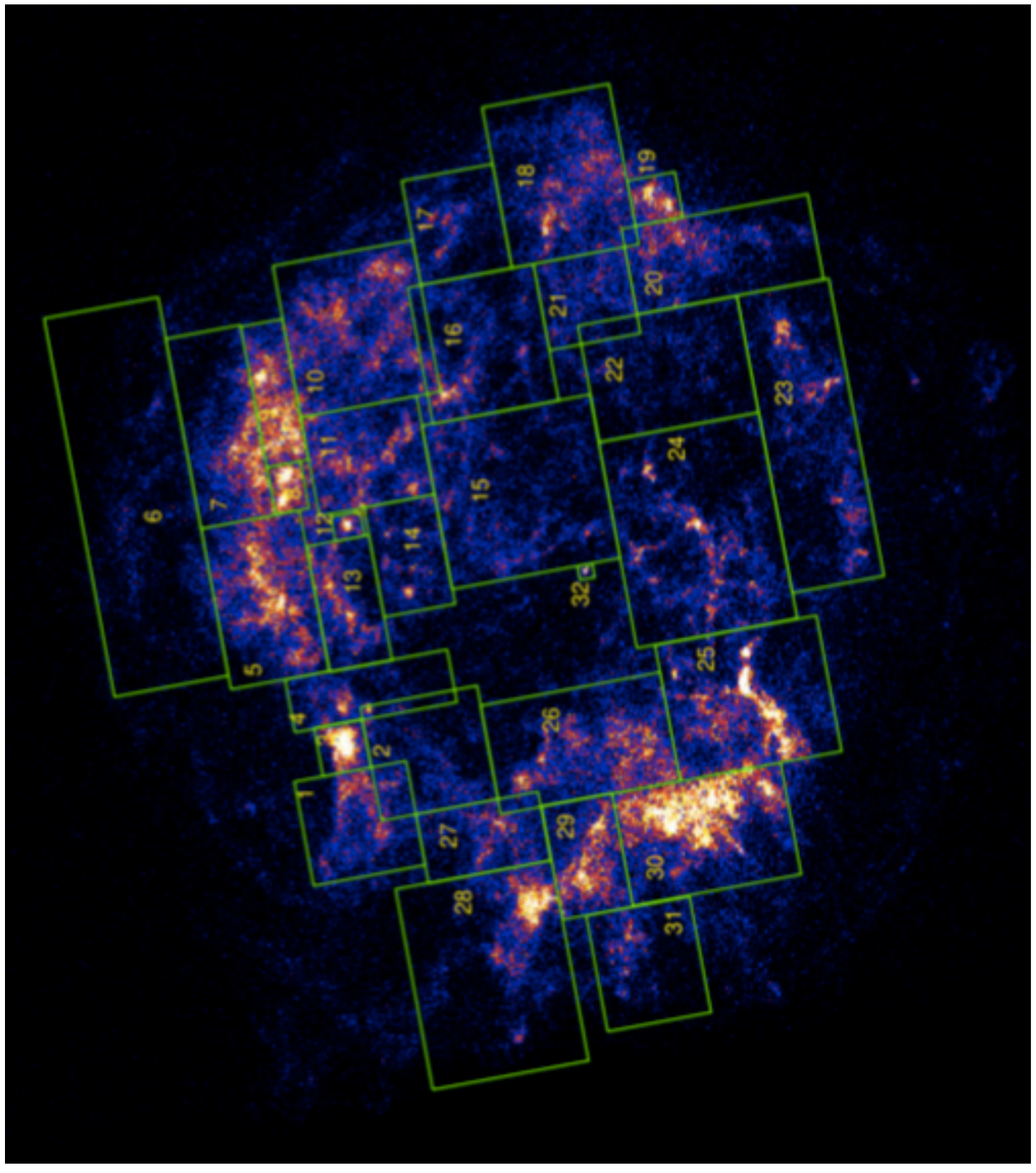
Using Cas A to Calibrate the ACIS Gain

To test the accuracy of the PCA results, a tgain file was generated using only the central pointing of Cas A combined with the PCA results. This tgain file was then compared with ECS-derived tgain file for this epoch..



RMS scatter in the gain using just the central Cas A pointing and the PCA results is ~0.7%. The rms scatter in previous tgain files, using the traditional ECS method, is 0.3%.

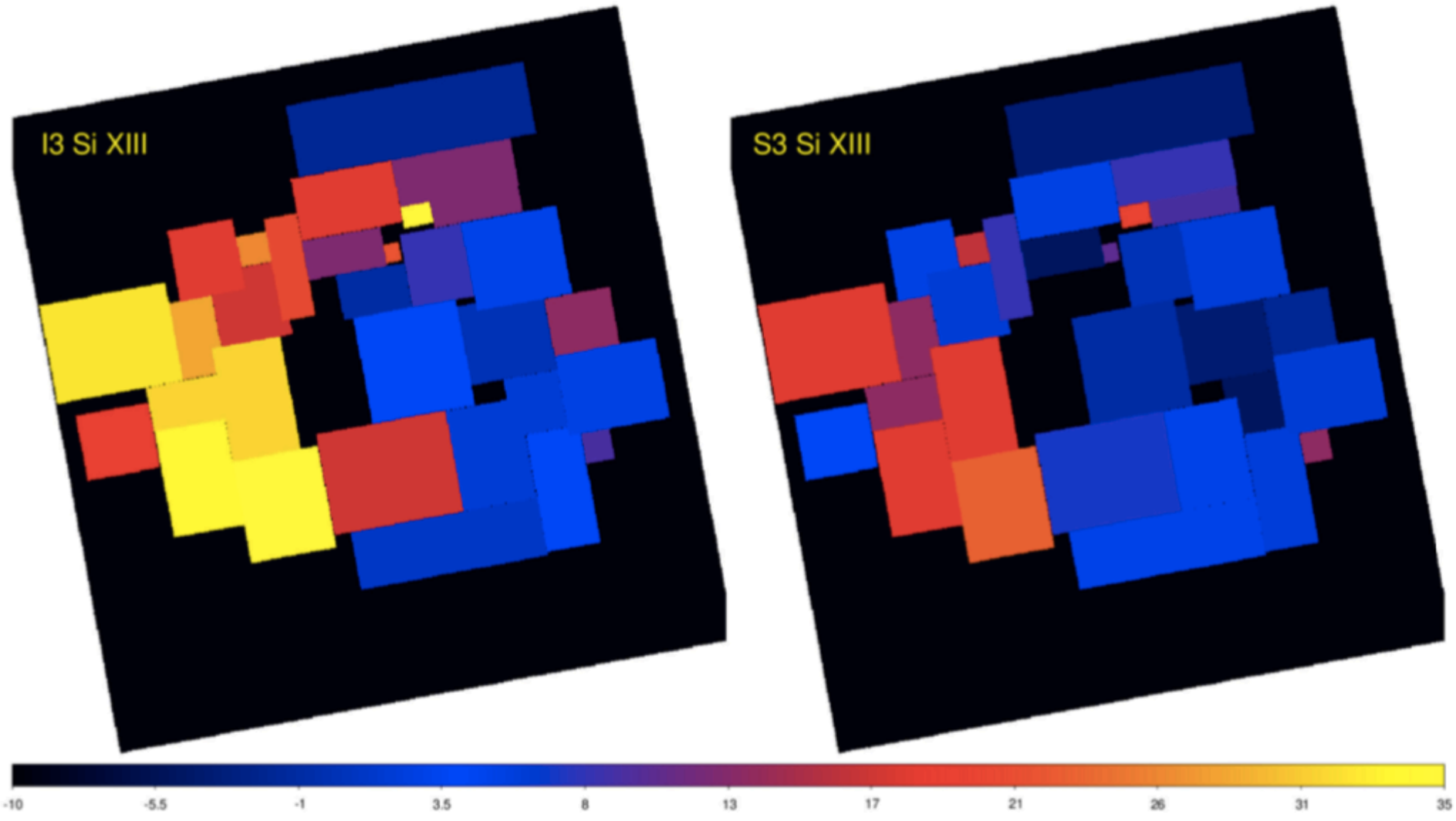
Using Cas A to Calibrate the ACIS Gain



The main issue with using Cas A as a gain calibration source is the bulk motions in the remnant.

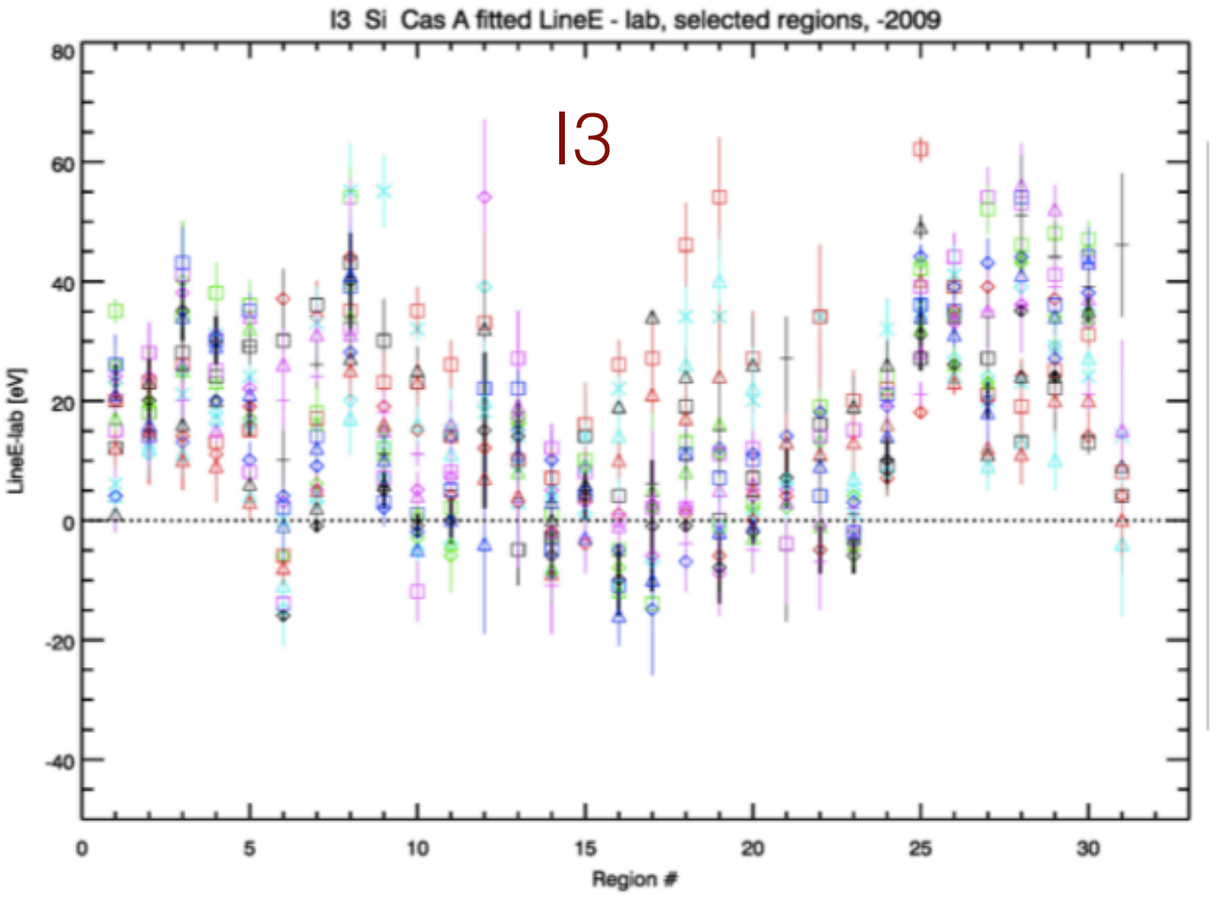
Using Cas A to Calibrate the ACIS Gain

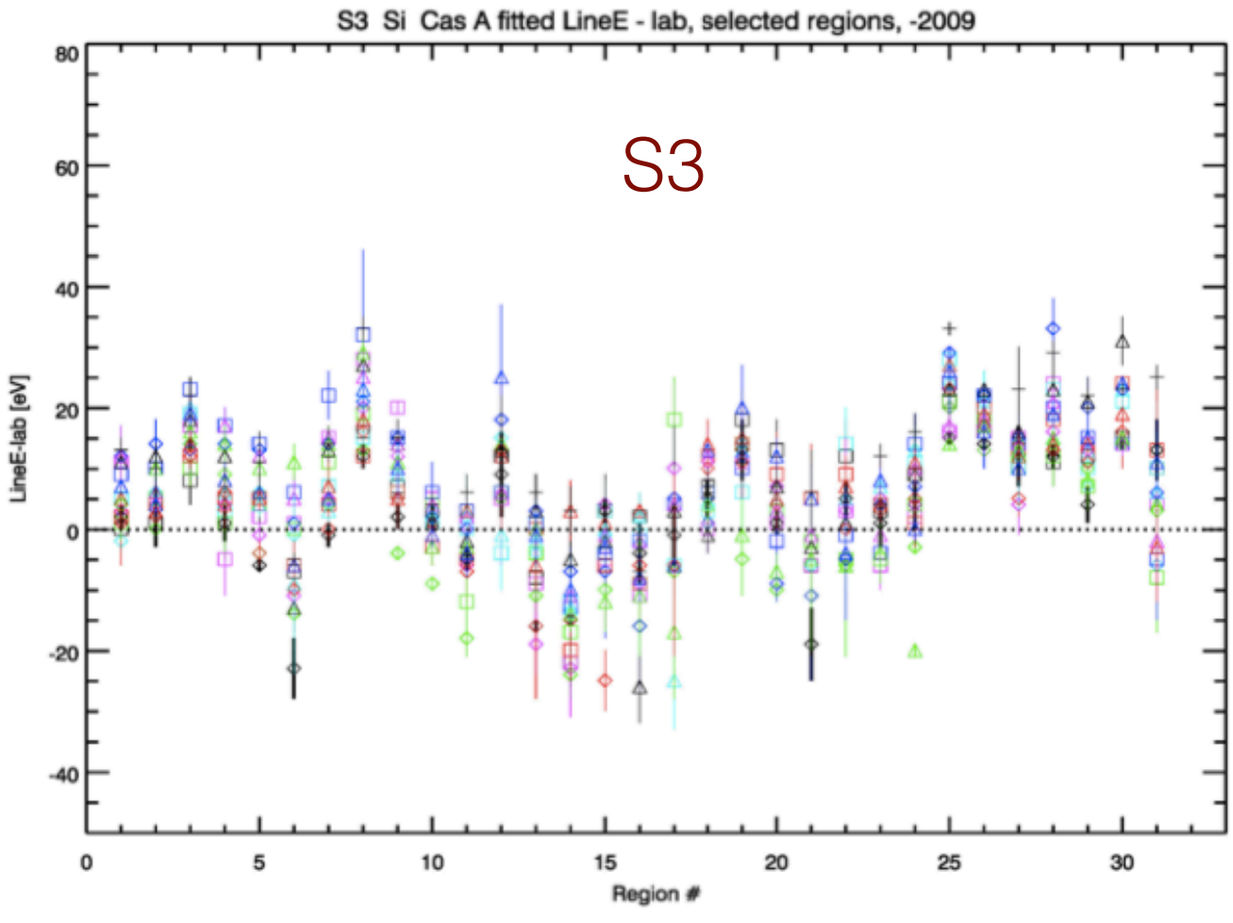
Si line centroid velocity maps



The I3 and S3 velocity maps have very similar spatial structure but there is a velocity off-set of about 0.5%.

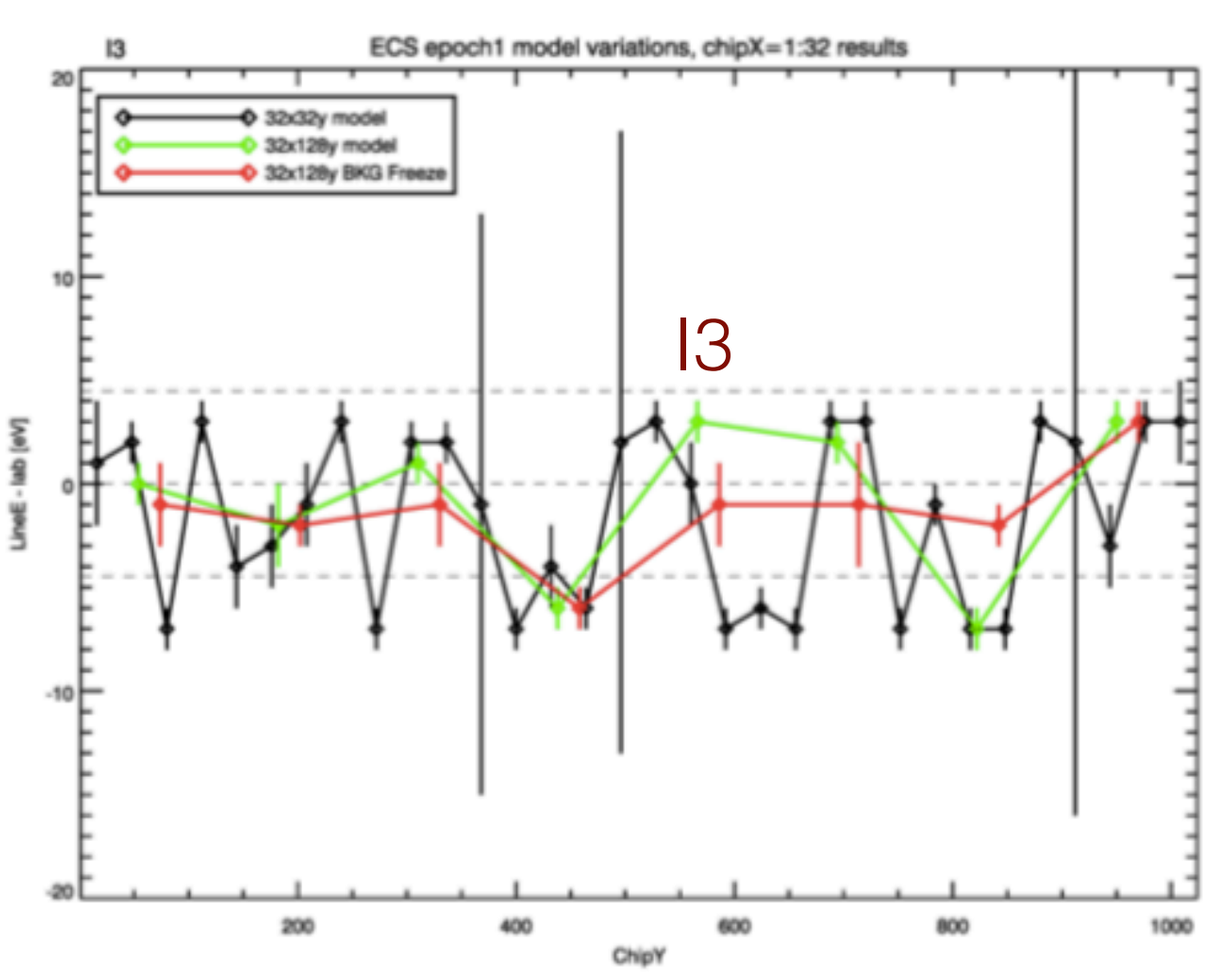
Using Cas A to Calibrate the ACIS Gain

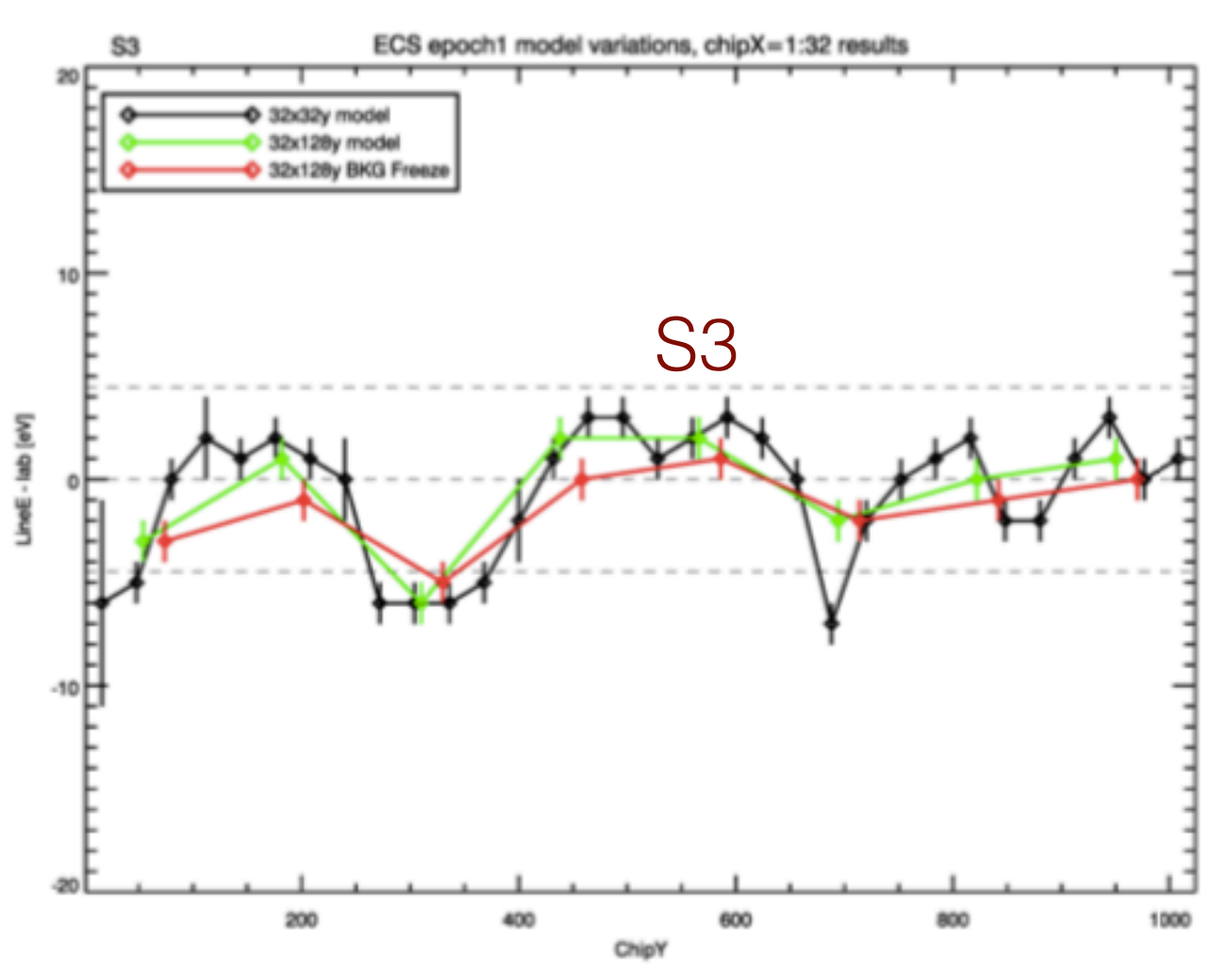




Gain off-set of about 10eV (0.5%) at Si (1.8 keV) between I3 and S3

Using Cas A to Calibrate the ACIS Gain





No gain off-set in the ECS AI line (1.5 keV) between I3 and S3

Future Plan for ACIS Gain Calibration

- It is difficult to determine the energy-dependence of the gain correction using only Cas A data due to the very faint Fe line.

- The calibration team will employ a hybrid method of generating tgain files using the Si (1.8 keV) and S I(2.4 keV) ines in Cas A, which are much brighter than the Al (1.5 keV) and Ti (4.5 keV) lines In the ECS, and the Mn (5.9 keV) line in the ECS (which will be brighter than the Fe line in Cas A until 2028).

- A full set of Cas A observations (2 ksec observation on each of the 10 chips) are scheduled for the Fall 2021 and Spring 2022.

- For the Fall 2021 and Spring 2022 semesters, a set of tgain files using just the ECS data and a set of hybrid tgain files will be generated and compared.

- If all goes well, only hybrid tgain files will be generated and released beyond the Fall 2022 semester

Question for the CUC

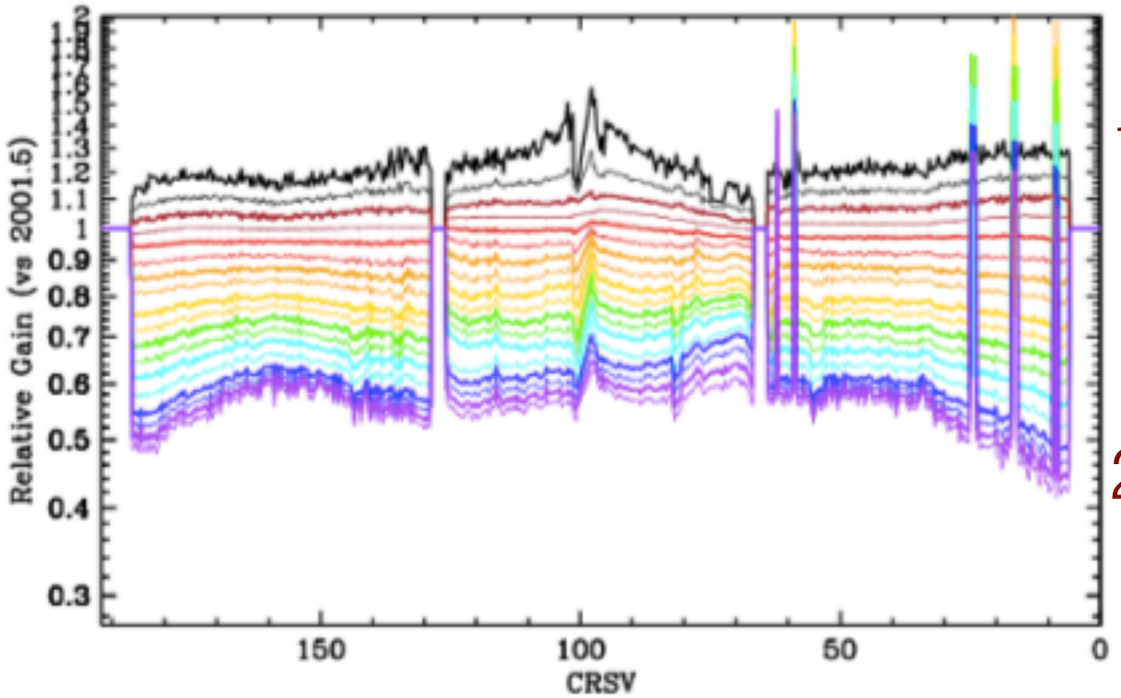
- The calibration team has been able to maintain a calibration requirement of 0.3% on the ACIS gain using only ECS data up to the present. Over the past year, this has required some cold ECS data to be taken during science operations. For the present semester, a total of 170 ksec would be needed to meet the calibration requirement of 0.3%. This could easily increase to approximately 700 ksec in two years.

- Switching to the hybrid method would not require much (if any) cold ECS data to be taken during science operations, but the uncertainty in the ACIS gain would increase to approximately 0.7%.

- Is there any science that justifies a reduction in observing efficiency of a few percent, or more, to maintain an uncertainty in the ACIS gain of 0.3%?

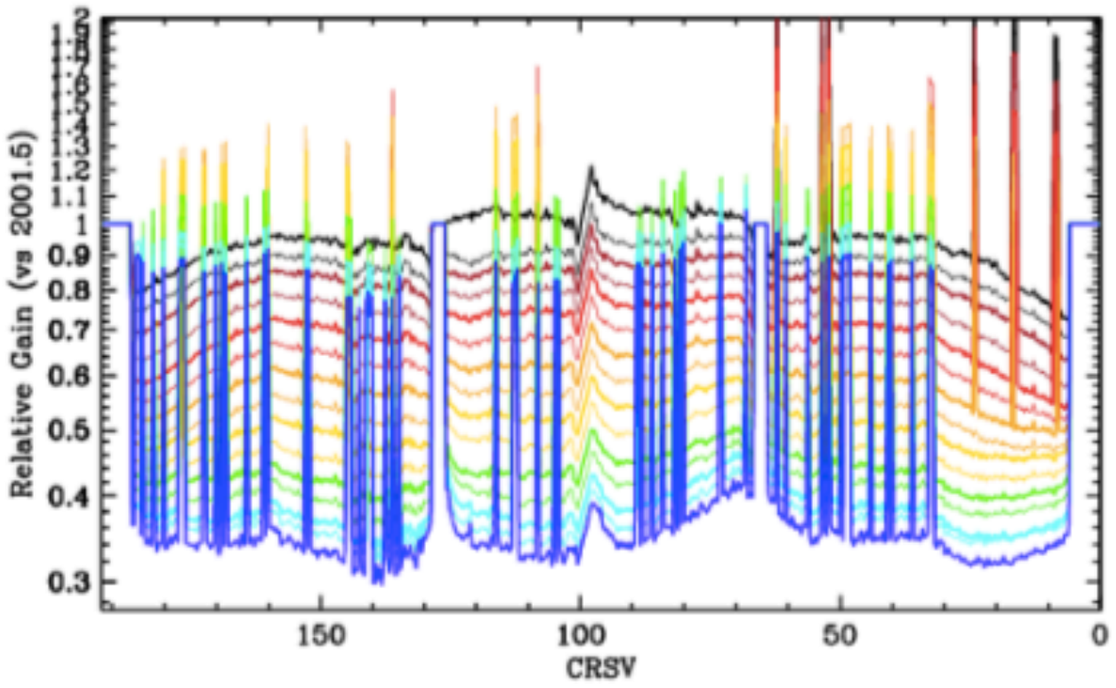
HRC and LETG Calibration

Decrease in HRC-S Gain



1999

2012

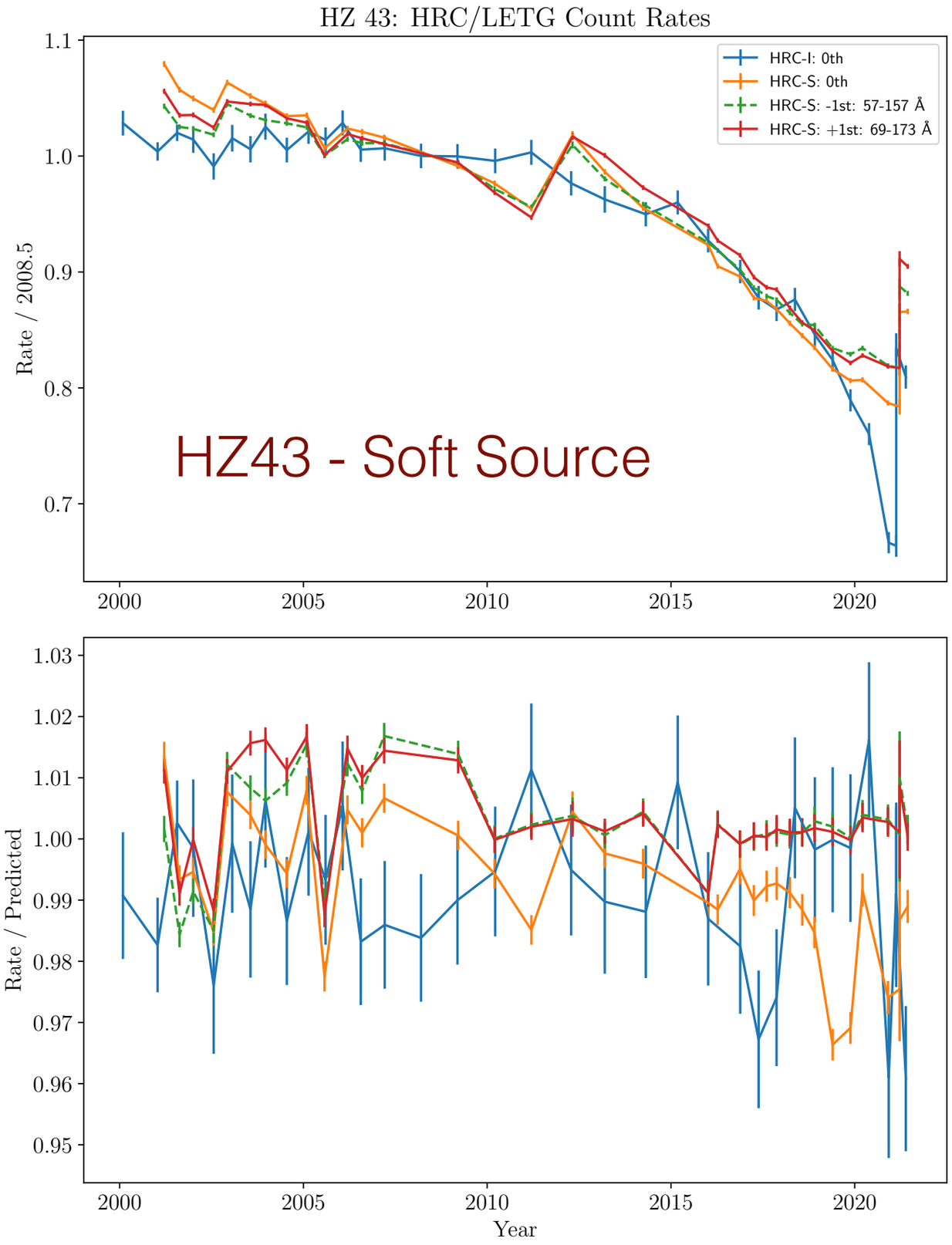


HRC-S high voltage was increased in 2012.

2012

2021

HRC-S/LETG Calibration



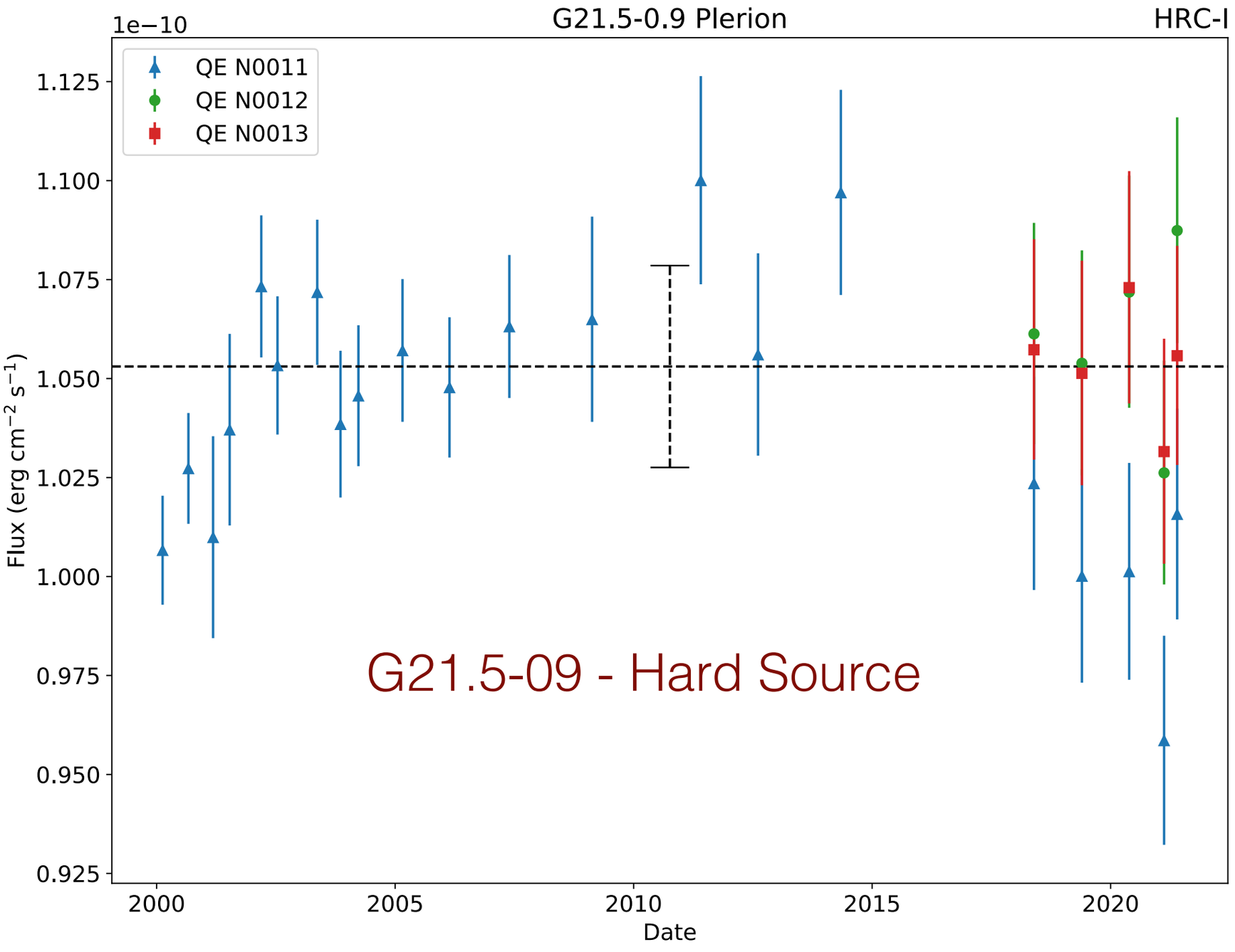
HRC-I HV was increased in Feb. 2021

HRC-S HV was increased in May 2021

The increase in HV for the HRC-I and HRC-S recovered 3-5 years of operations.

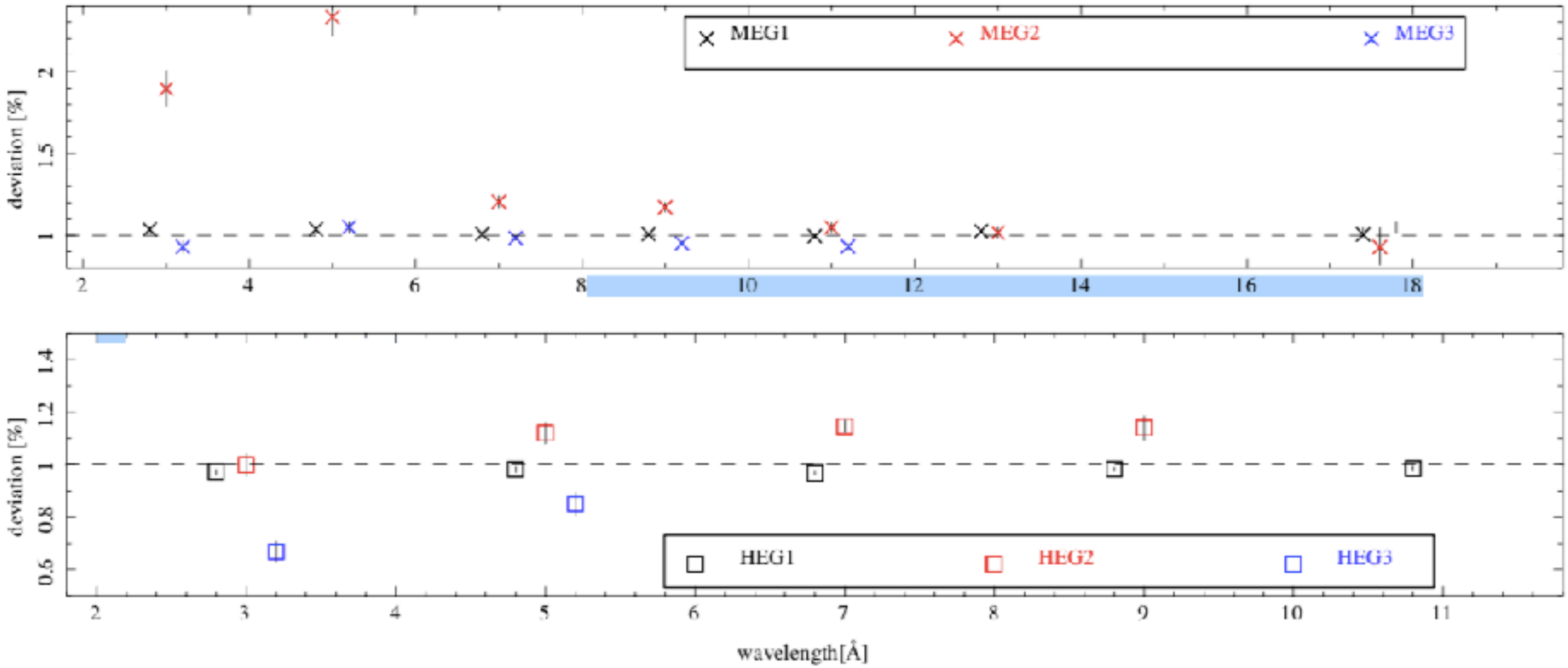
Using the CALDB versions of the HRC-I QE and the HRC-S QE and QEU produces fluxes consistent within 2% over the course of mission.

HRC-I Calibration



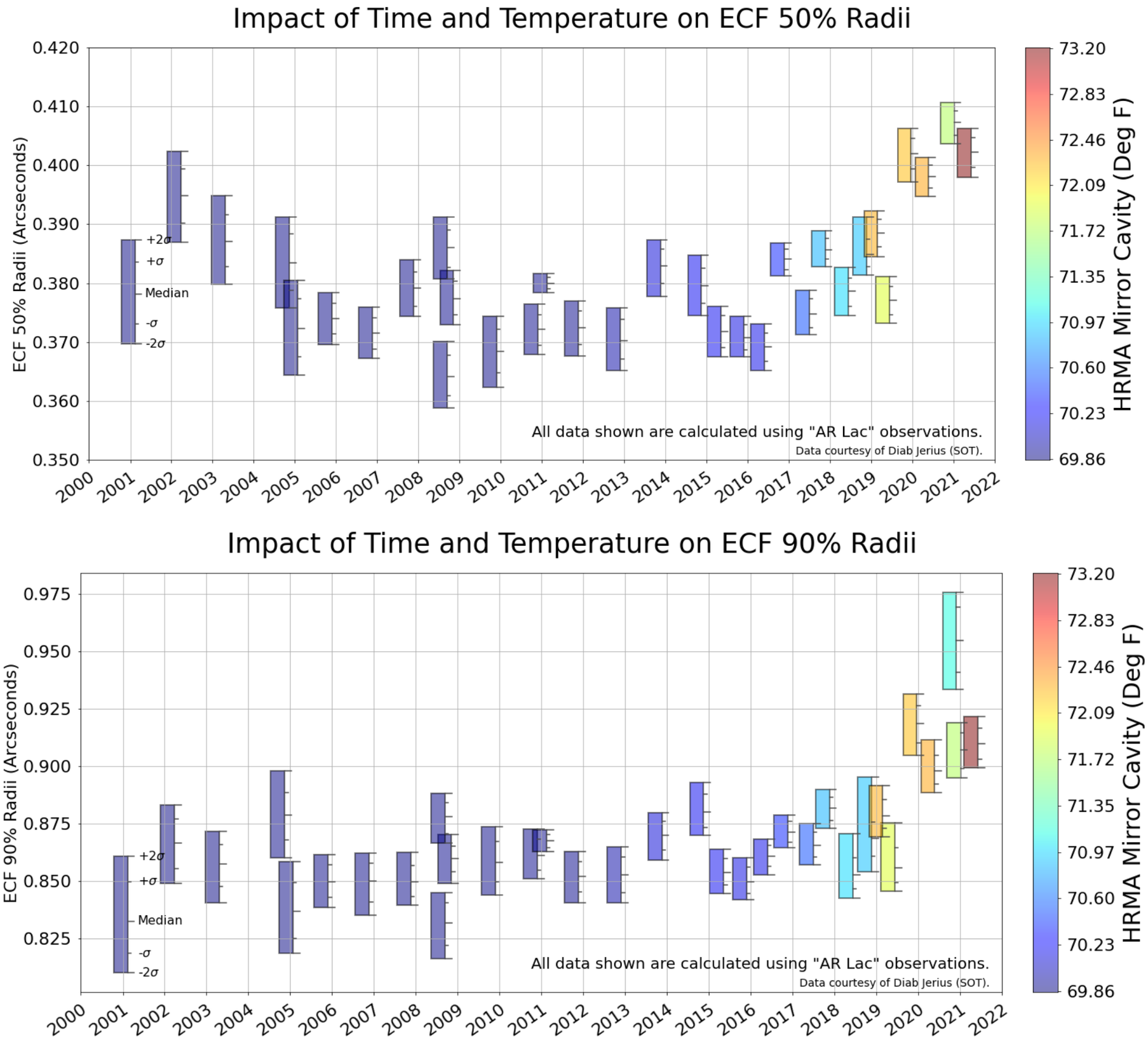
HETG Higher Order Cross-Calibration

These plots show the ratio of the MEG and HEG 1st, 2nd, and 3rd order data to the best-fit HETG1 model for 0.5 Msec of data on PKS2155-301.



A test version of the HEG and MEG higher order transmission efficiencies are currently being tested with other data sets.

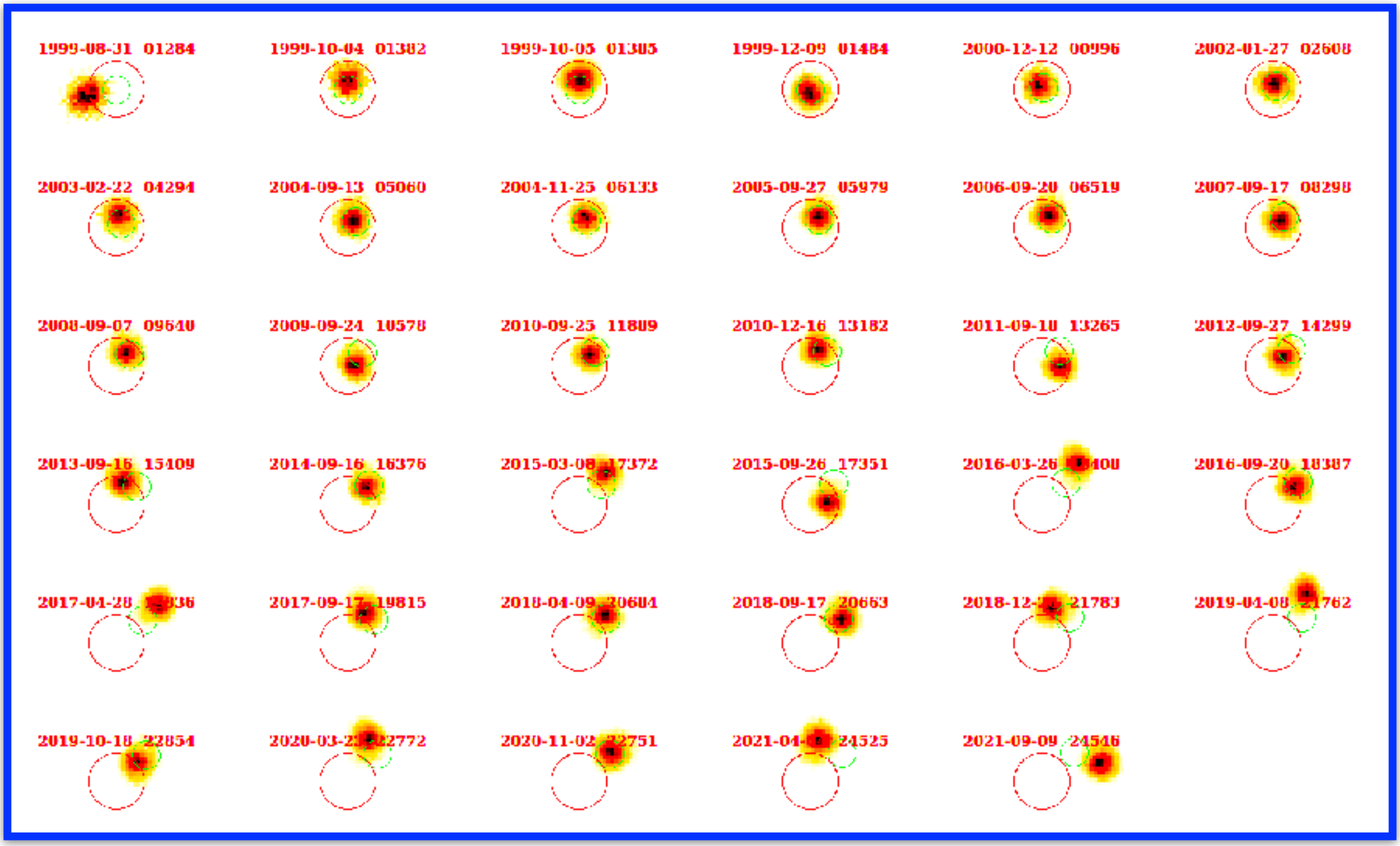
Monitoring the PSF



Semi-annual HRC-I observations of ARLac

Broadening of the PSF is not correlated with the HRMA temperature and is probably due to aspect.

Monitoring Astrometry



Present Calibration Activities

ACIS

- Monitor contamination and release updates as required.
- Continue to work on generating hybrid tgain file (Cas A plus Mn line from ECS),
- Generate a set of temperature-dependent rmfs and QEU maps.

HRC/LETG

- Monitor the QE, QE map, and gain of the HRC-I and HRC-S.
- Continue to release annual CALDB updates to the HRC-I and HRC-S.

HETG

- Continue to test updates to the HEG and MEG high order transmission efficiencies.
- Release updated HEG and MEG high order transmission efficiencies in early 2022.