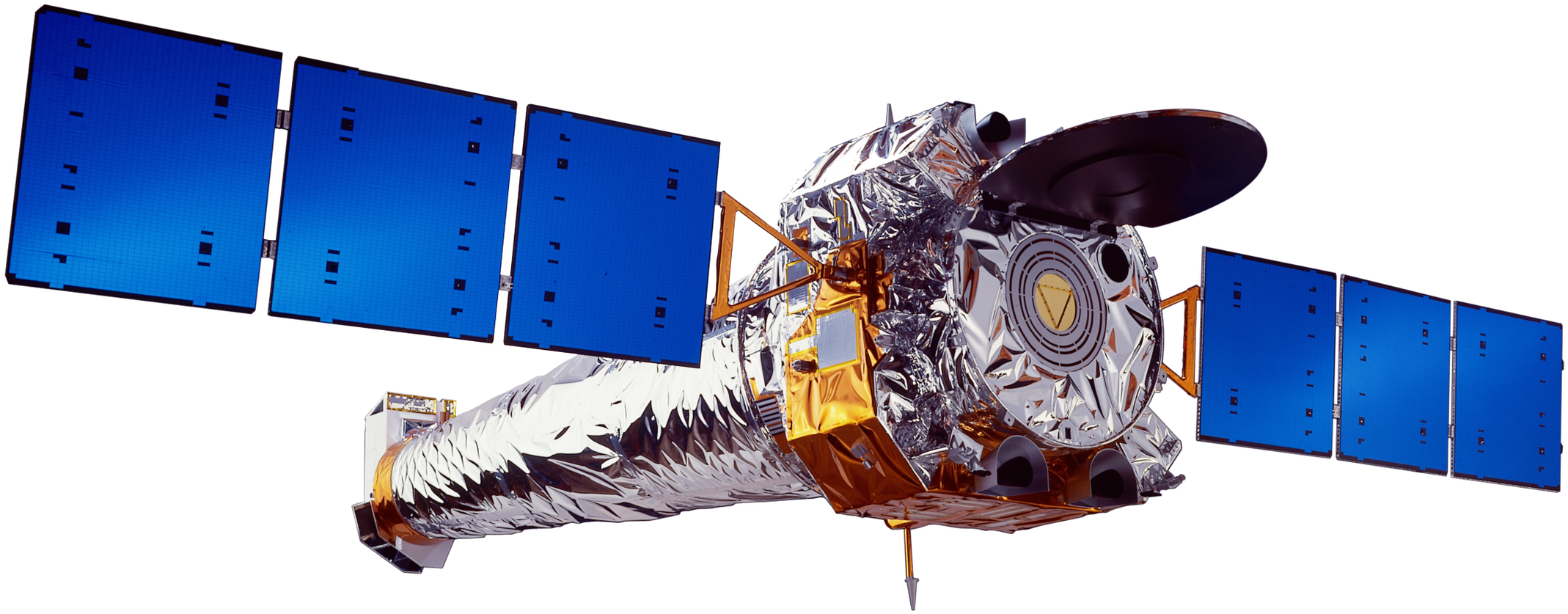


JEREMY DRAKE AND THE CXC CALIBRATION GROUP

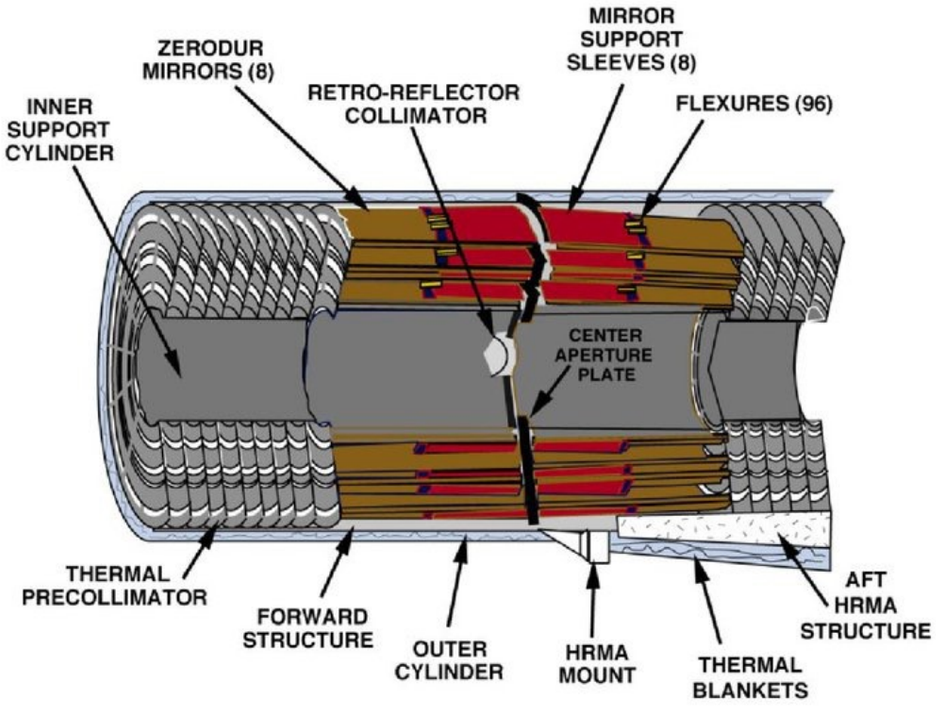
CHANDRA CALIBRATION STATUS

LAST CUC MEETING RECOMMENDATIONS

- **Continue to provide regular calibration status updates (this presentation)**
- **Continue to play an active role in IACHEC**
  - The calibration group appreciates the CUC's support for these activities; several scientists attended IACHEC 2019
  - IACHEC continues to be a valuable consortium for understanding our X-ray missions

CHANDRA HARDWARE COMPONENTS: ORDER OF PRESENTATION

1



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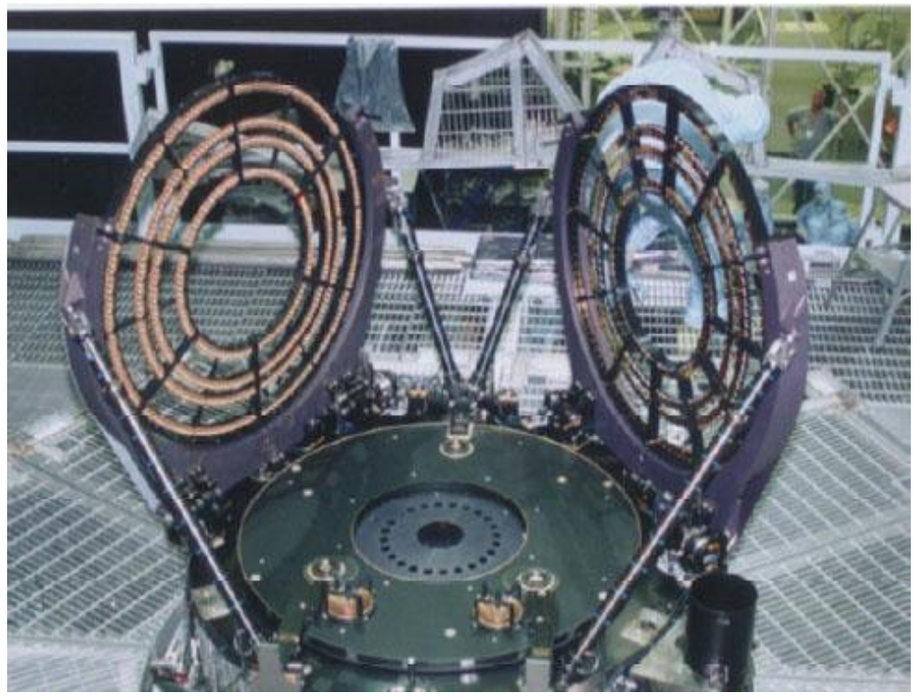

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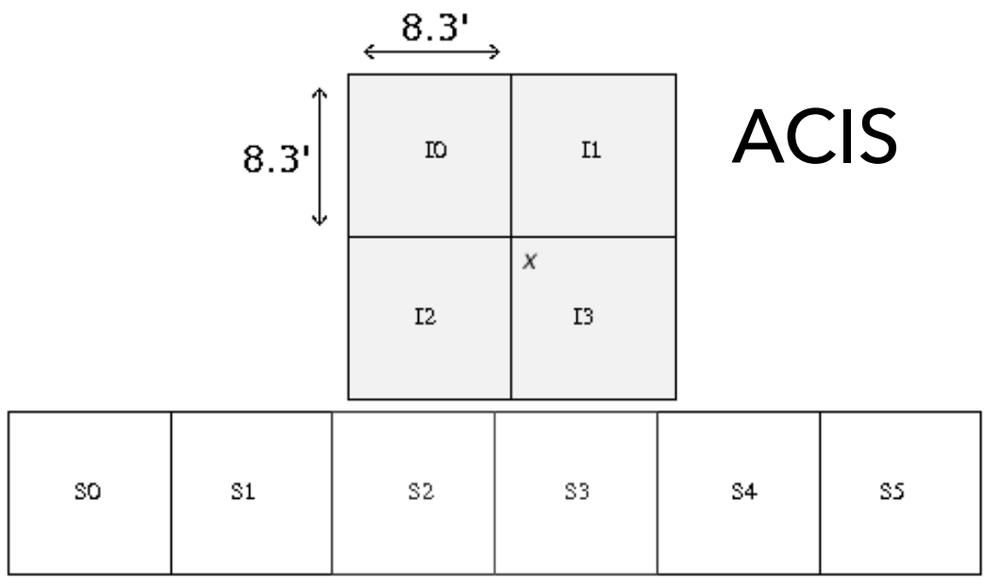
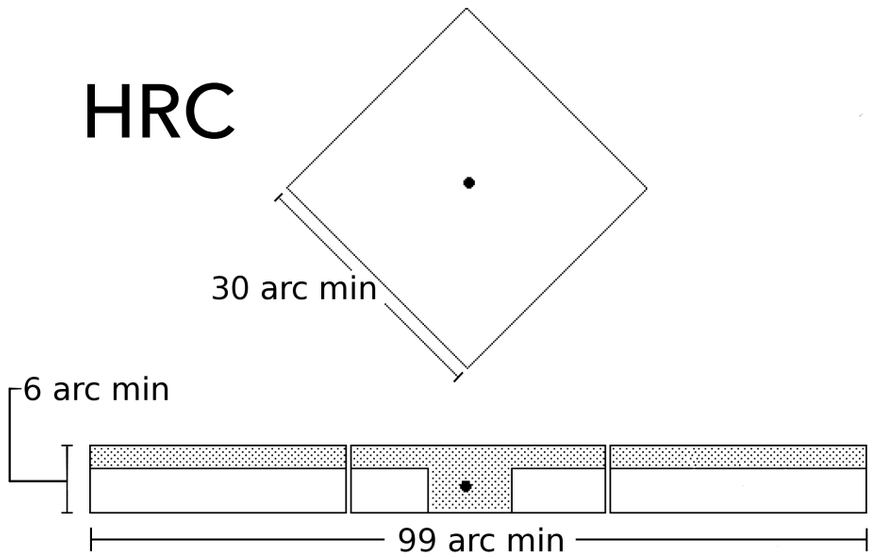


ACIS

4

HRC



CURRENT IN-FLIGHT CALIBRATION TARGET SUMMARY (~1.0 Ms)

TARGET	INSTRUMENT	PURPOSE
E0102-72 (SNR)	ACIS	CONTAM, GAIN, CROSS-CAL
A1795 (GAL CLUSTER)	ACIS	CONTAM, GAIN, CROSS-CAL
RXJ1856.5-3754 (ISOLATED NS)	LETG+ACIS	CONTAM
MKN 421 (BLAZAR)	HETGS, LETGS	CONTAM, EFF. AREA, CROSS-CAL
3C 273 (QSO)	HETGS	CROSS-CAL
AR LAC (ACTIVE BINARY)	HRC	PSF, GAIN
HZ43 (HOT WD)	LETG,HRC	EFFECTIVE AREA, QE, GAIN
CAPELLA (ACTIVE BINARY)	HETGS, LETGS	DISPERSION, LINE RESPONSE
VEGA (A0 V)	HRC	UVIS UV LEAK

OUTLINE

- **Main concern: secular change in both ACIS and HRC performance**
- Point Spread Function
  - Warm HRMA safe mode; EDSER/empirical PSFs update
- ACIS
  - T_GAIN file problem; mid-chip gain droop update; contamination update
- HETG 0th order throughput wrap up
- HRC-S,I
  - HRC-S QE & gain decline update
- Concordance cross-calibration project update
- New HRC-S thick/thin observing mode

HRMA: POINT SPREAD FUNCTION

SAFE MODE THERMAL EXCURSION (V. KASHYAP, D. JERIUS)

- Oct 10 2018 gyro glitch safe mode - HRMA temperature rose to 76 F, 5 degrees above nominal.
- RS CVn active binary HR1099 observed during “cool down” to monitor PSF

ALL FLAGGED GOOD

R90 [pix]

R85 [pix]

R64 [pix]

R39 [pix]

AR Lac 2005+ HR 1099

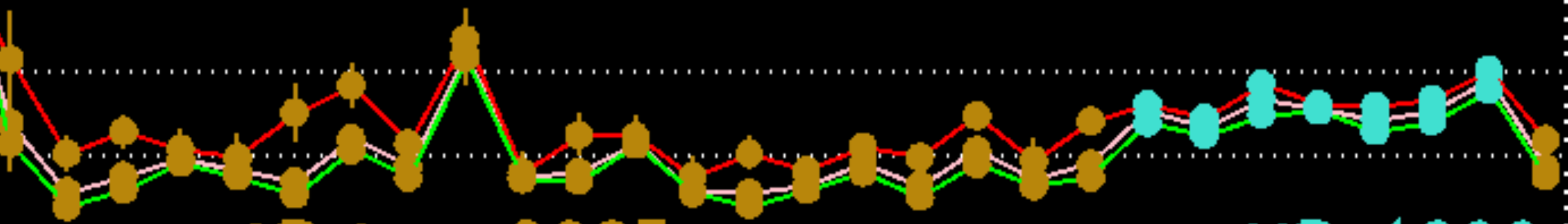
5.95+-0.095+-0.043 6.27+-0.077+-0.021

6.14+-0.125+-0.098 6.37+-0.078+-0.031

5.89+-0.096+-0.048 6.18+-0.077+-0.028

FLAGGED

GOOD



AR Lac 2005+

5.95+-0.095+-0.043

6.14+-0.125+-0.098

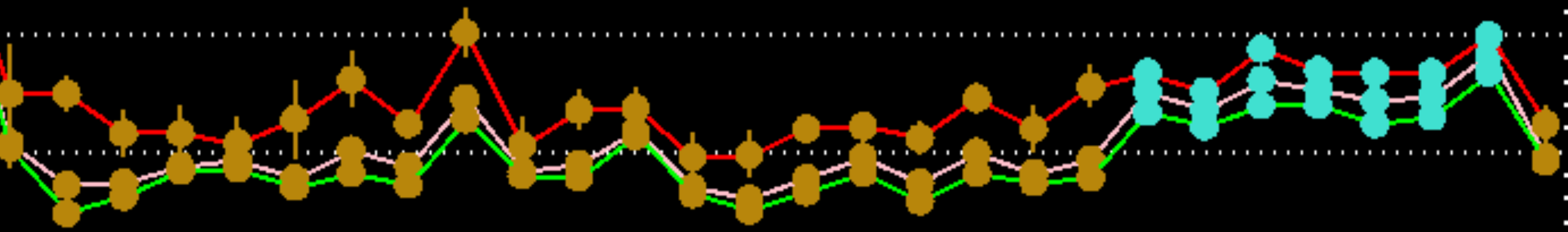
5.89+-0.096+-0.048

HR 1099

6.27+-0.077+-0.021

6.37+-0.078+-0.031

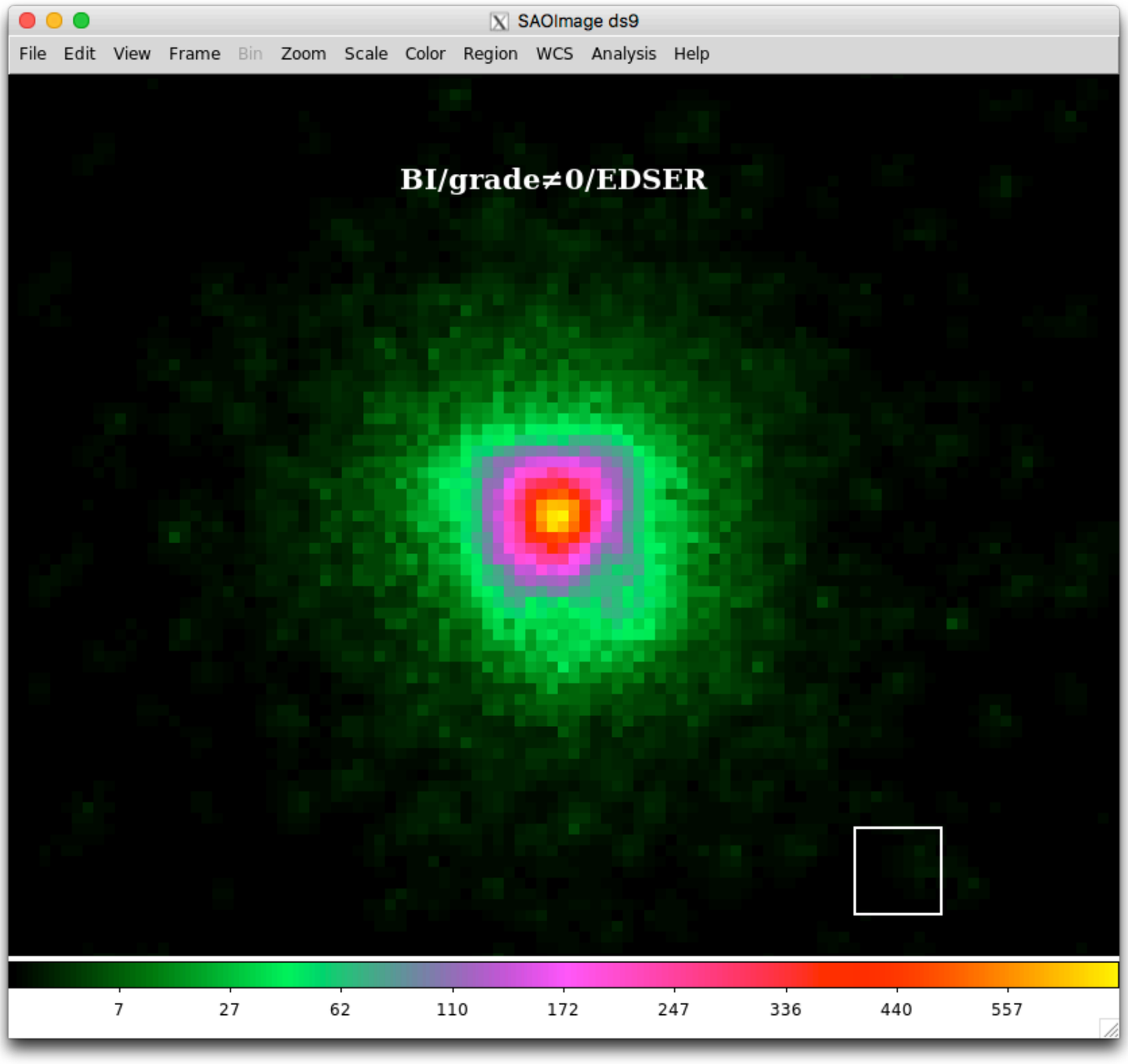
6.18+-0.077+-0.028



SAFE MODE THERMAL EXCURSION (V. KASHYAP, D. JERIUS)

- 0.3 HRC-I pixel increase observed in PSF for HR1099 (=0.08 ACIS pixels)
- **AR Lac subsequently observed at nominal temperature revealed a normal PSF; no detrimental effects**

ACIS EMPIRICAL PSF – NEEDS SRCEXTENT UPDATE (V. KASHYAP, P. ZHAO, D. JERIUS)

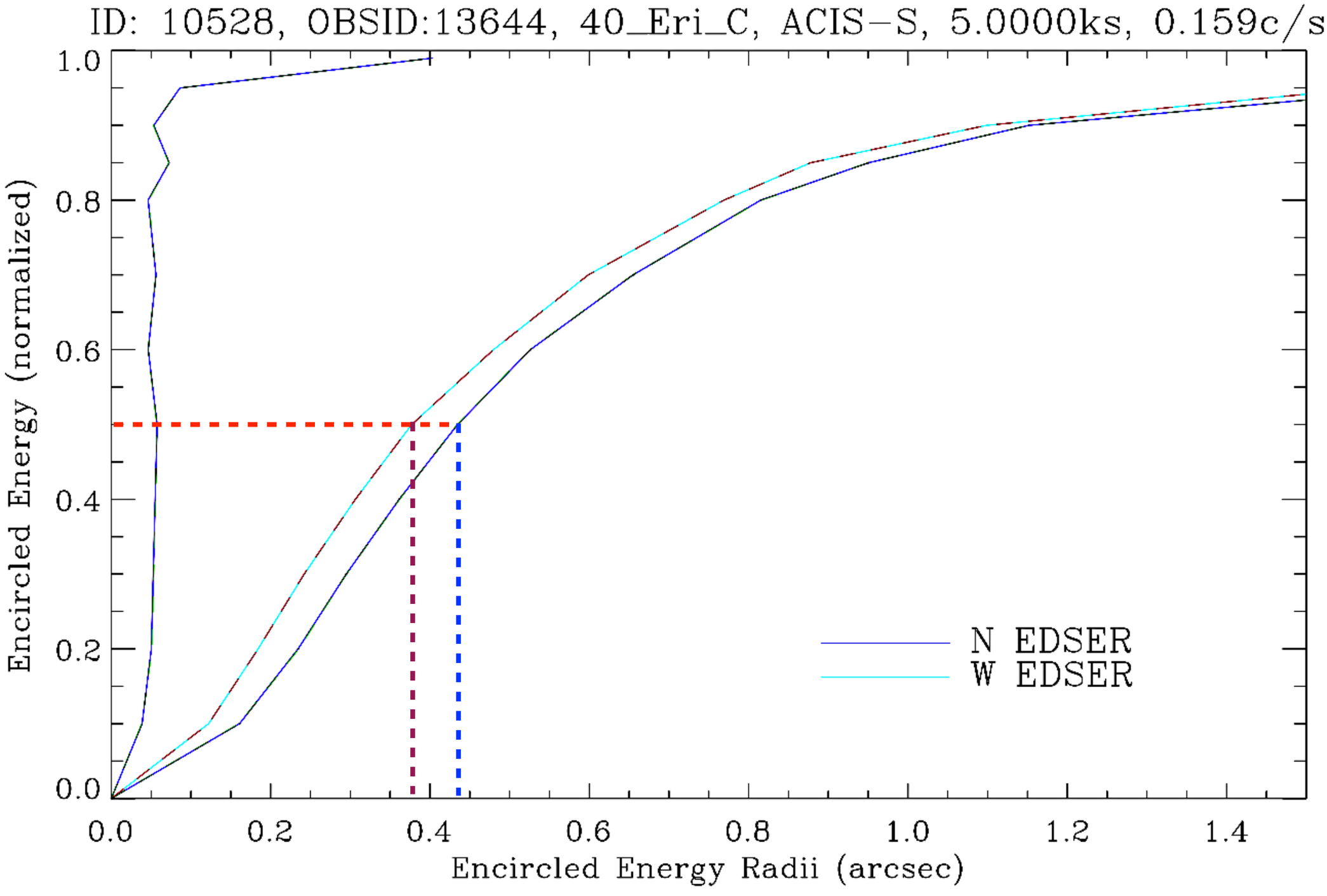


- Very challenging: requires on-axis known point sources bright enough to be useful but not piled up

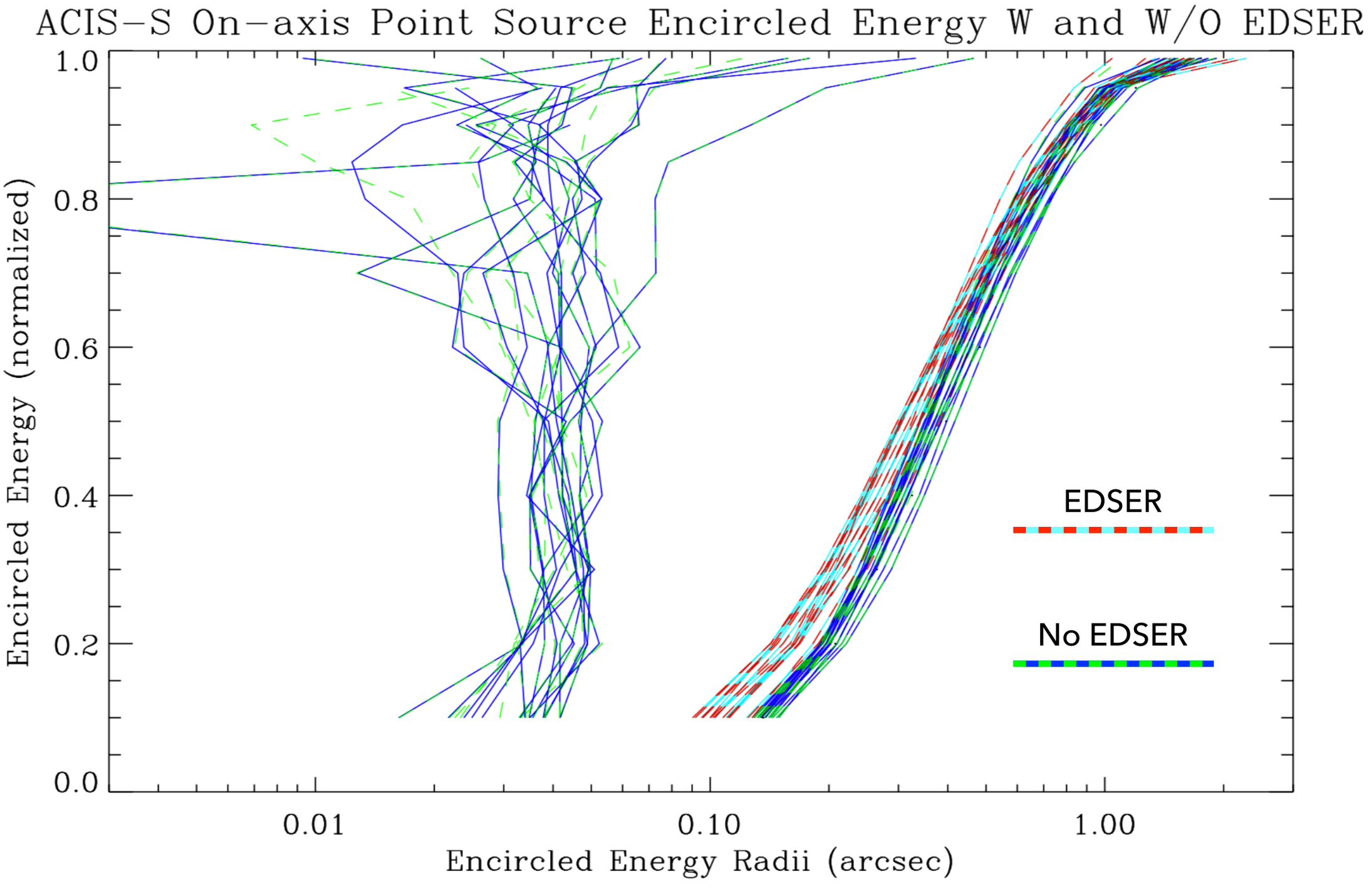
ACIS EMPIRICAL PSF – NEEDS SRCEXTENT UPDATE (V. KASHYAP, P. ZHAO, D. JERIUS)

- Were hoping for release as FITS images in 3+ energy bands c. Summer 2019
- Uses CSC `srcextent` for source selection + SDSS match up + Gaia for selecting stars
- Some CSC `srcextent` values found to be problematic
- Will re-commence when corrected `srcextents` have finished migrating to DB

CALIBRATING THE EDSER PSF (V. KASHYAP, P. ZHAO, D. JERIUS)



CALIBRATING THE EDSER PSF (V. KASHYAP, P. ZHAO, D. JERIUS)

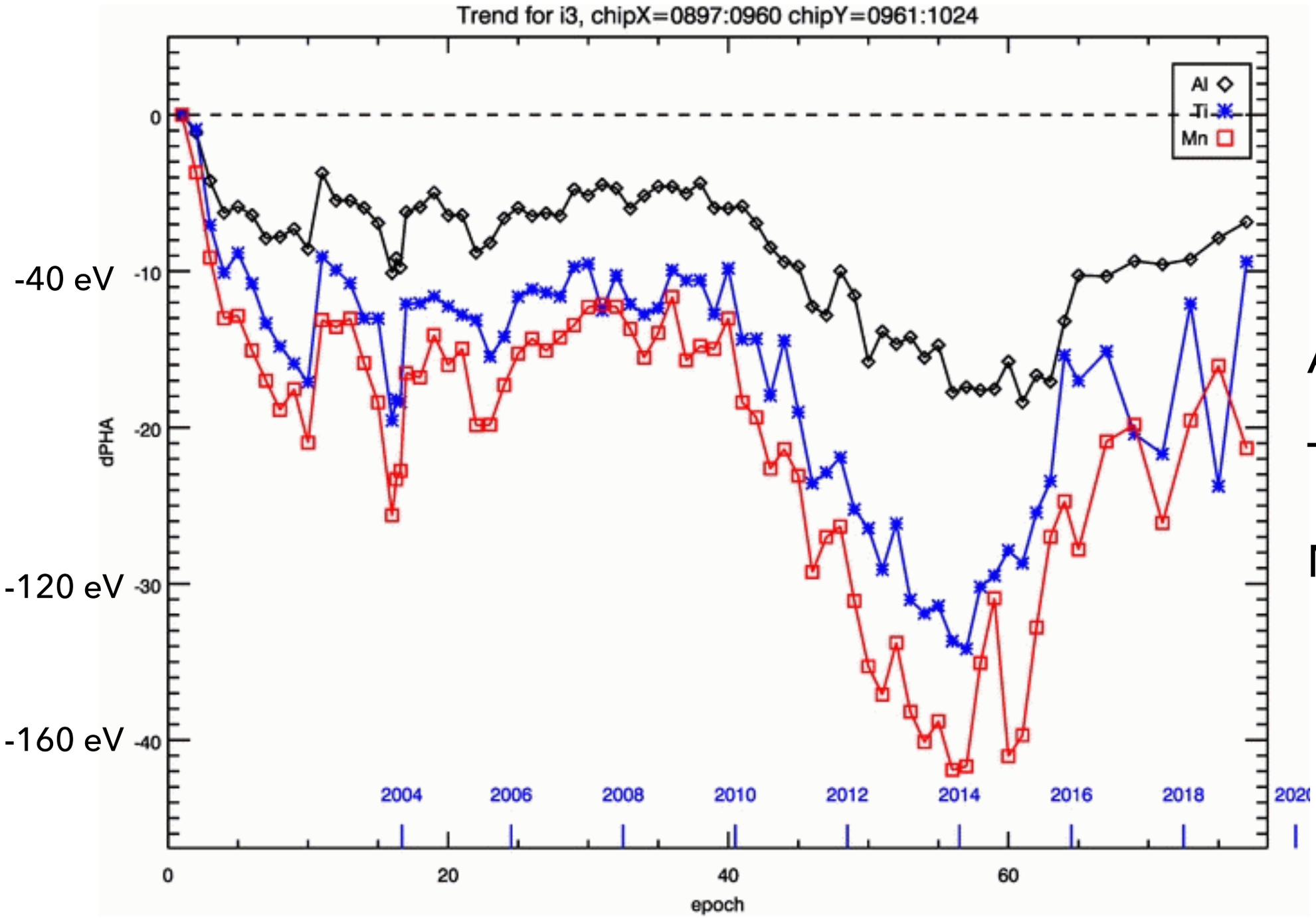


ADVANCED CCD IMAGING SPECTROMETER (ACIS)

T_GAIN FILE PROBLEM DISCOVERED!

- Time-dependent gain file since May 2019 release (CALDB 8.4.3, 8.4.4) found defective for ACIS I chips and ACIS-S S2 - alternate columns of 0's for epochs Aug 2018-July 2019

T_GAIN FILE PROBLEM DISCOVERED!



Al K 1.49 keV

Ti K 4.51 keV

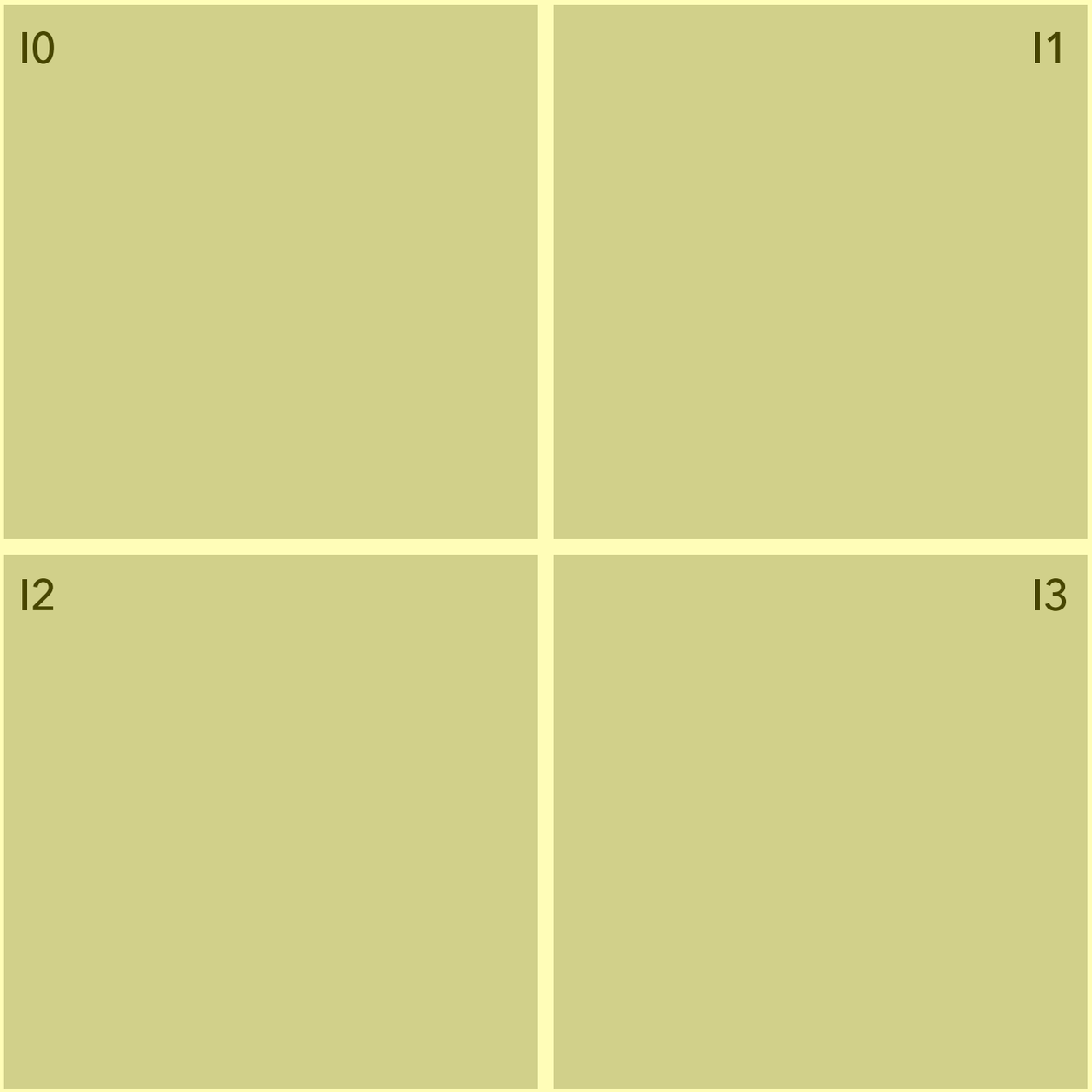
Mn K 5.90 keV

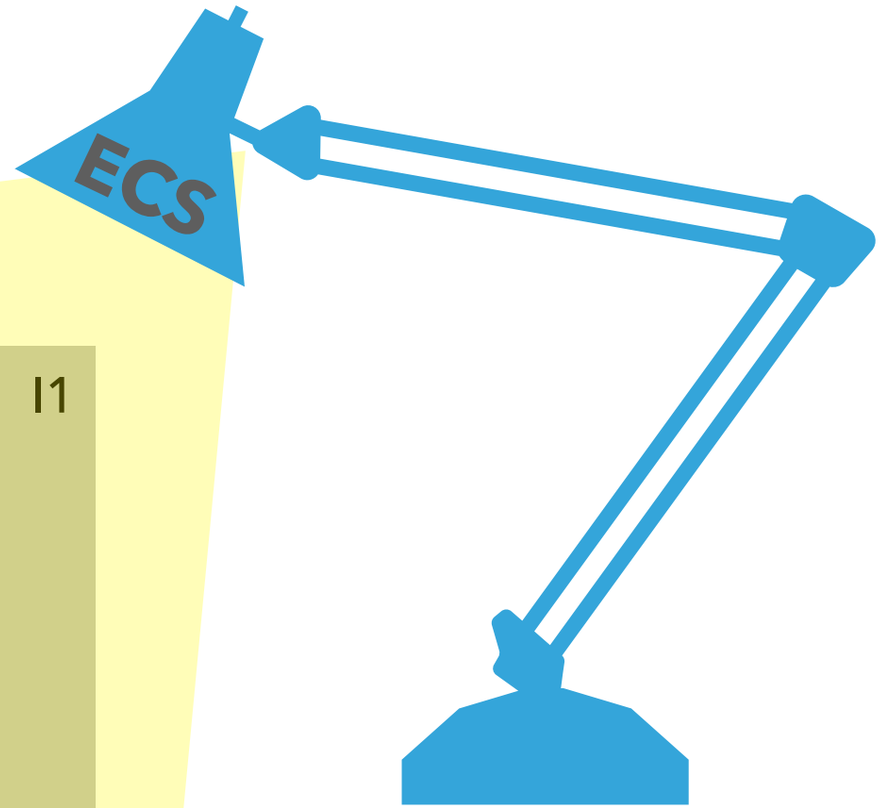
T_GAIN FILE PROBLEM DISCOVERED!

- ...resulted from change from 32x32 to 64x64 pix resolution of files
- Maximum effect ~30eV error in photon energy (1-2%)
- < 1% effect on HETG+ACIS fluxes (through order sorting)
- Fixed in CALDB emergency release 8.4.4.1 Sept 13 2019
- GOs of affected data being/already contacted + Chandra Announcments

MID-CHIP GAIN DROOP (T. GAETZ)

MID-CHIP GAIN DROOP (T. GAETZ)



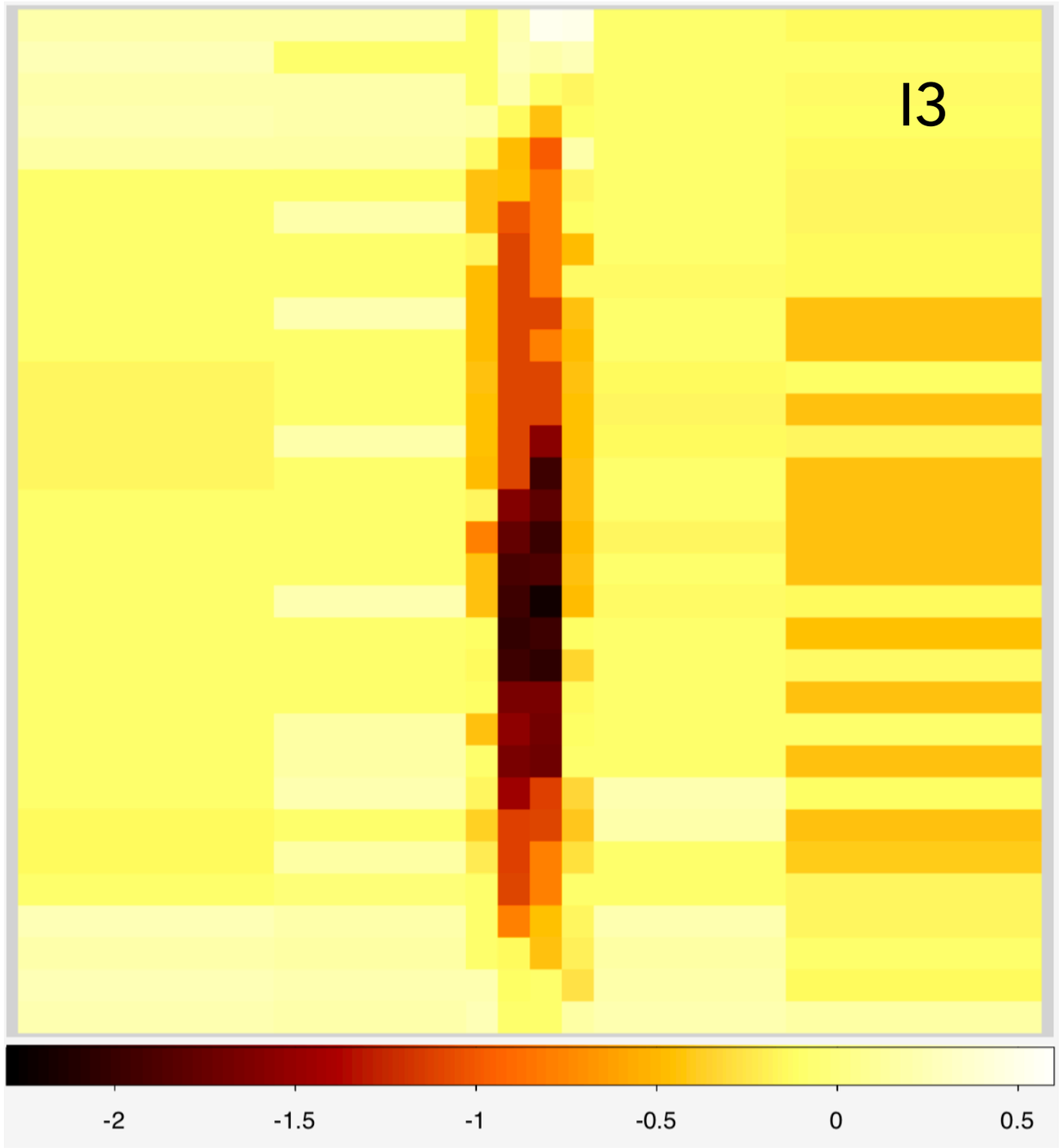


^{55}Fe source +
Al/Ti target

Mn K**α** (5.9 keV)
Ti K**α** (4.5 keV)
Al K**α** (1.5 keV)

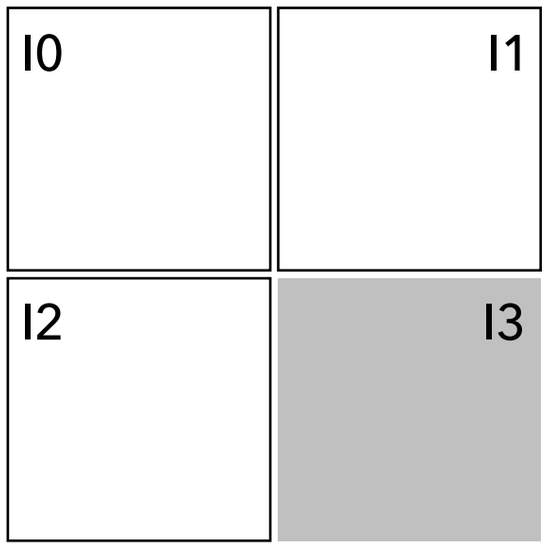
MID-CHIP GAIN DROOP (T. GAETZ)

Al K



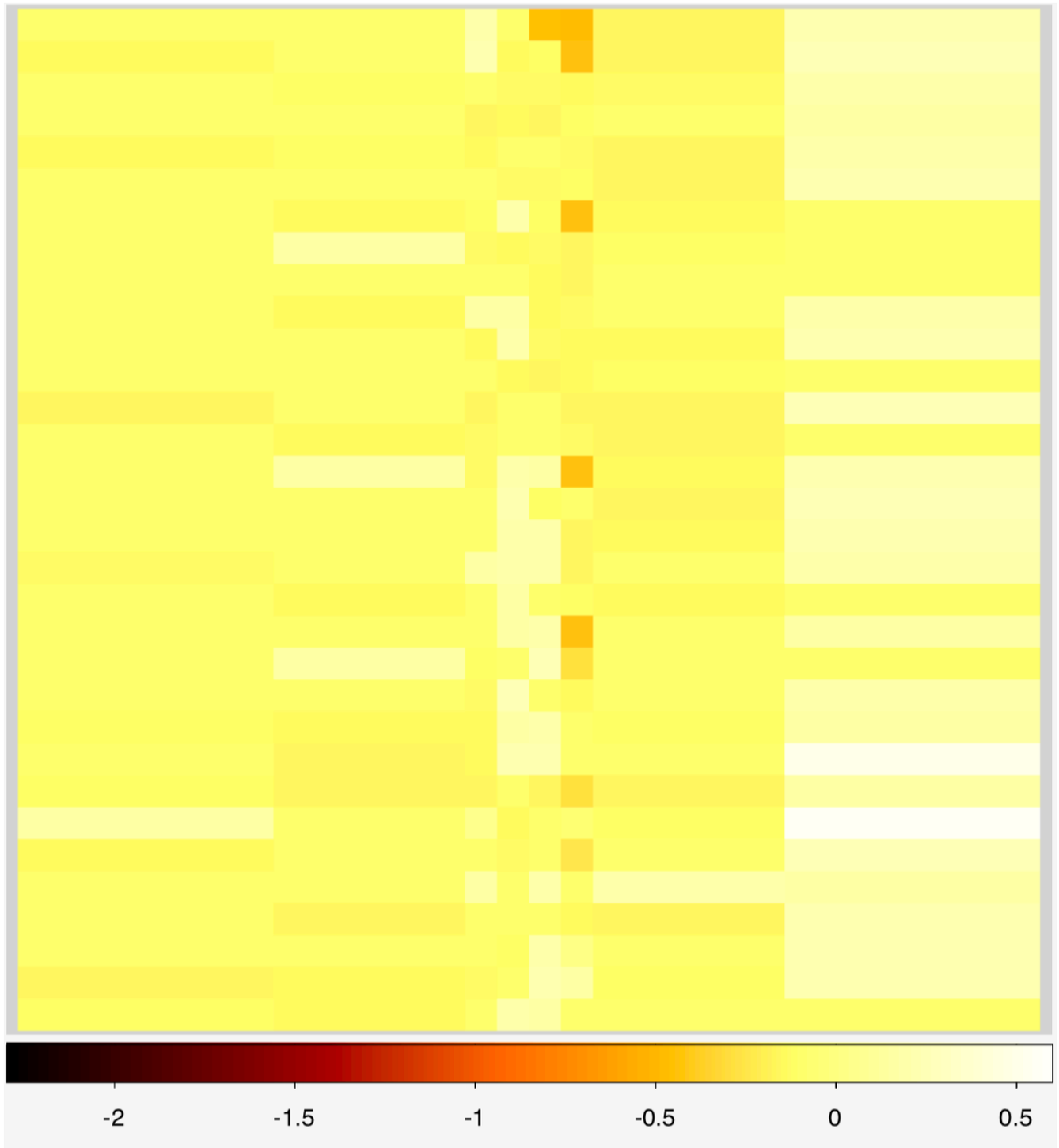
Epoch 1, -120.19 to -119.19 C

Current det_gain



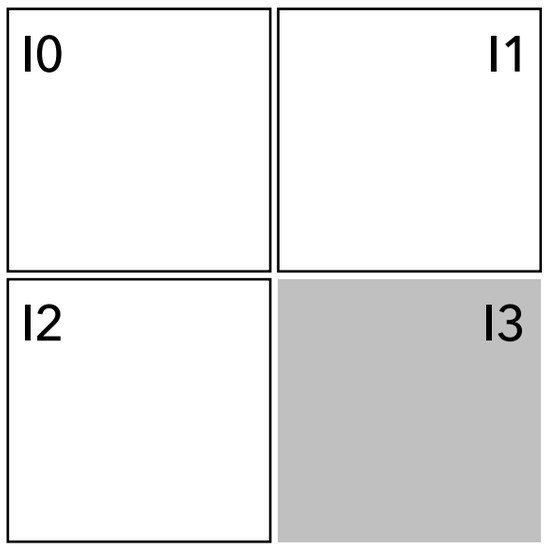
MID-CHIP GAIN DROOP (T. GAETZ)

Al K



Epoch 1, -120.19 to -119.19 C

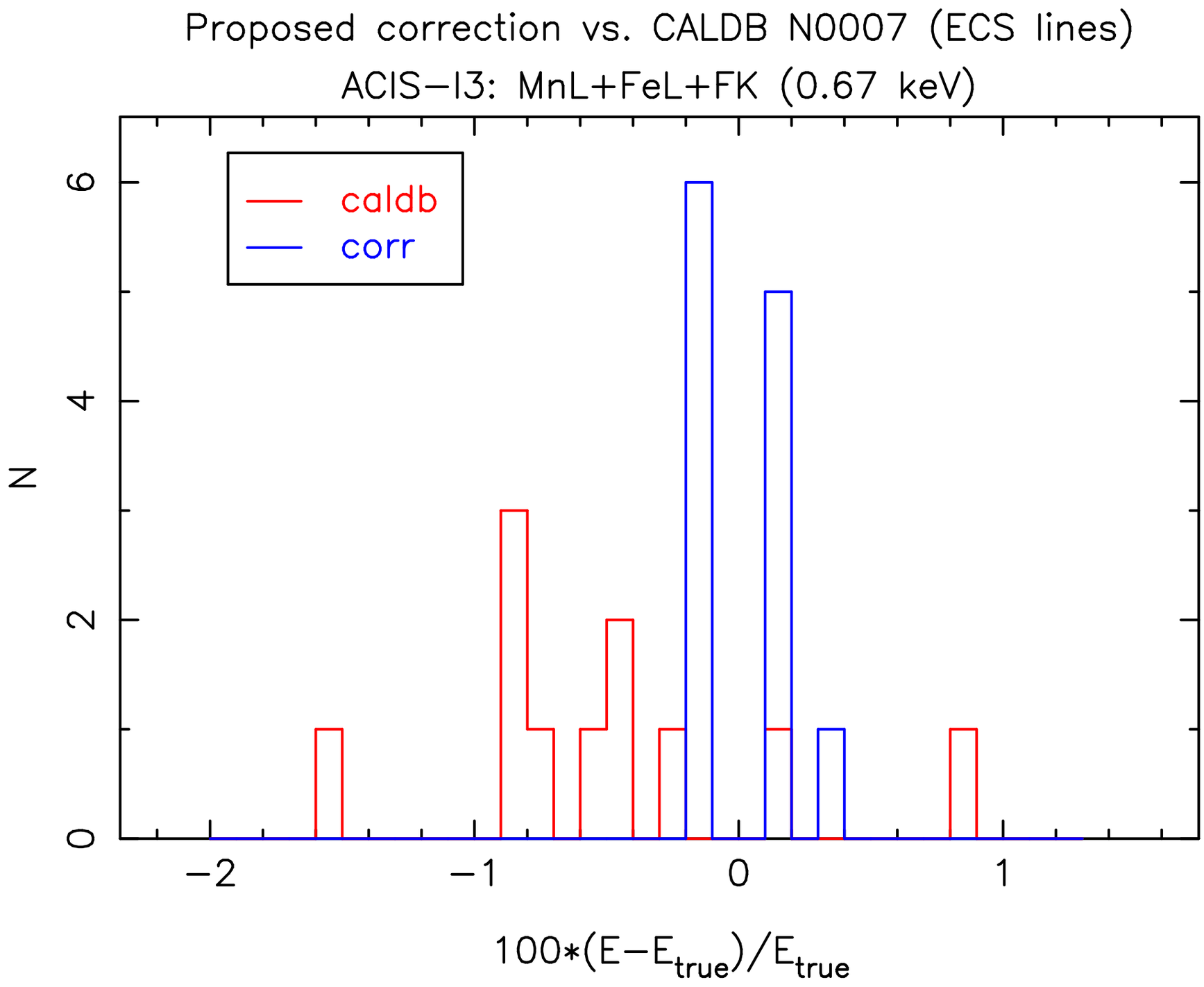
Trial I3 det_gain



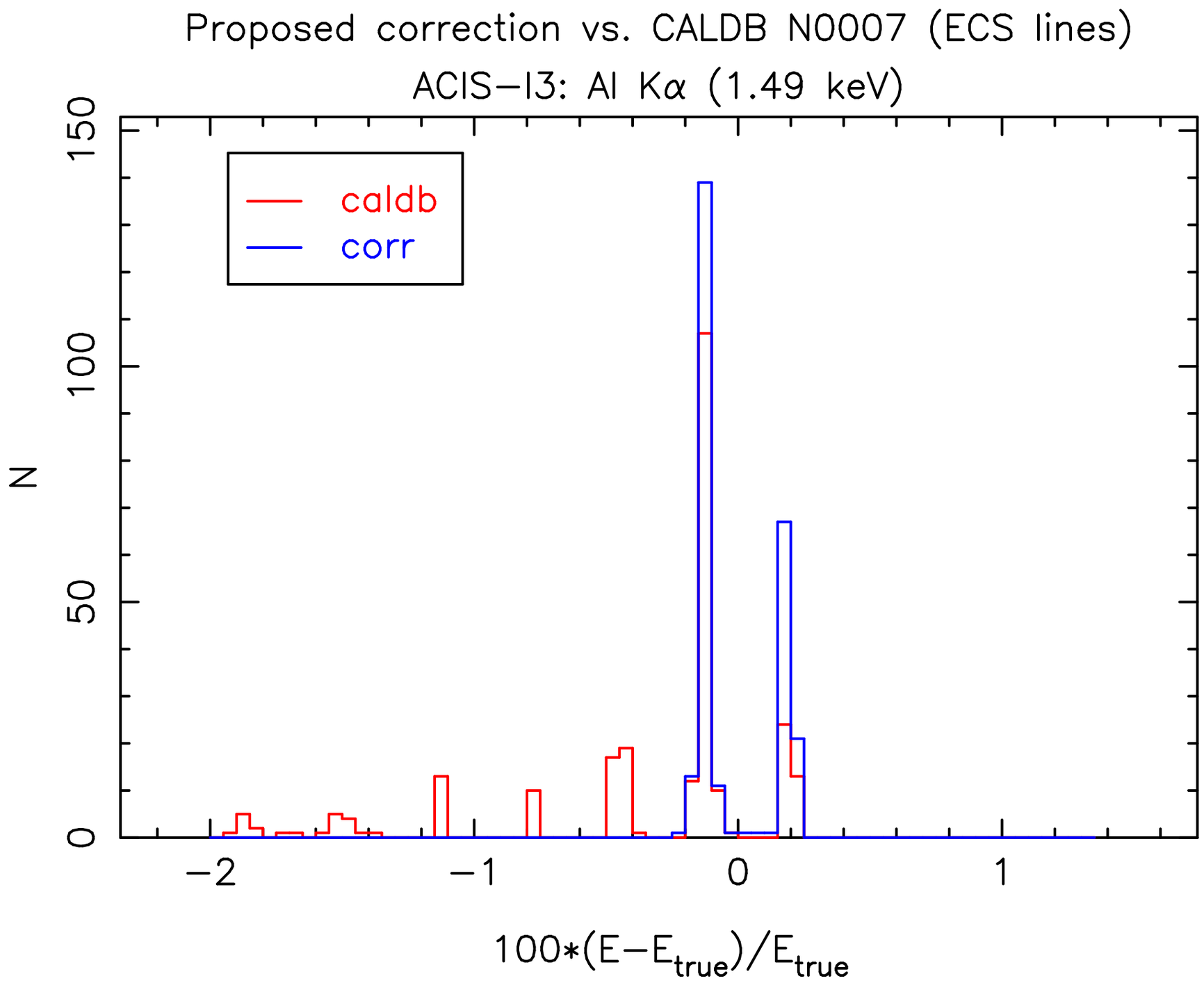
MID-CHIP GAIN DROOP (T. GAETZ)

- CUC 2018: Proof of concept trial det_gain for I3 almost ready
- Analysis has undergone further refinement, problems corrected, and been applied to the other FI chips: I0,I1,I2,S2
- Projected release Fall 2019 (from projected Spring 2019)

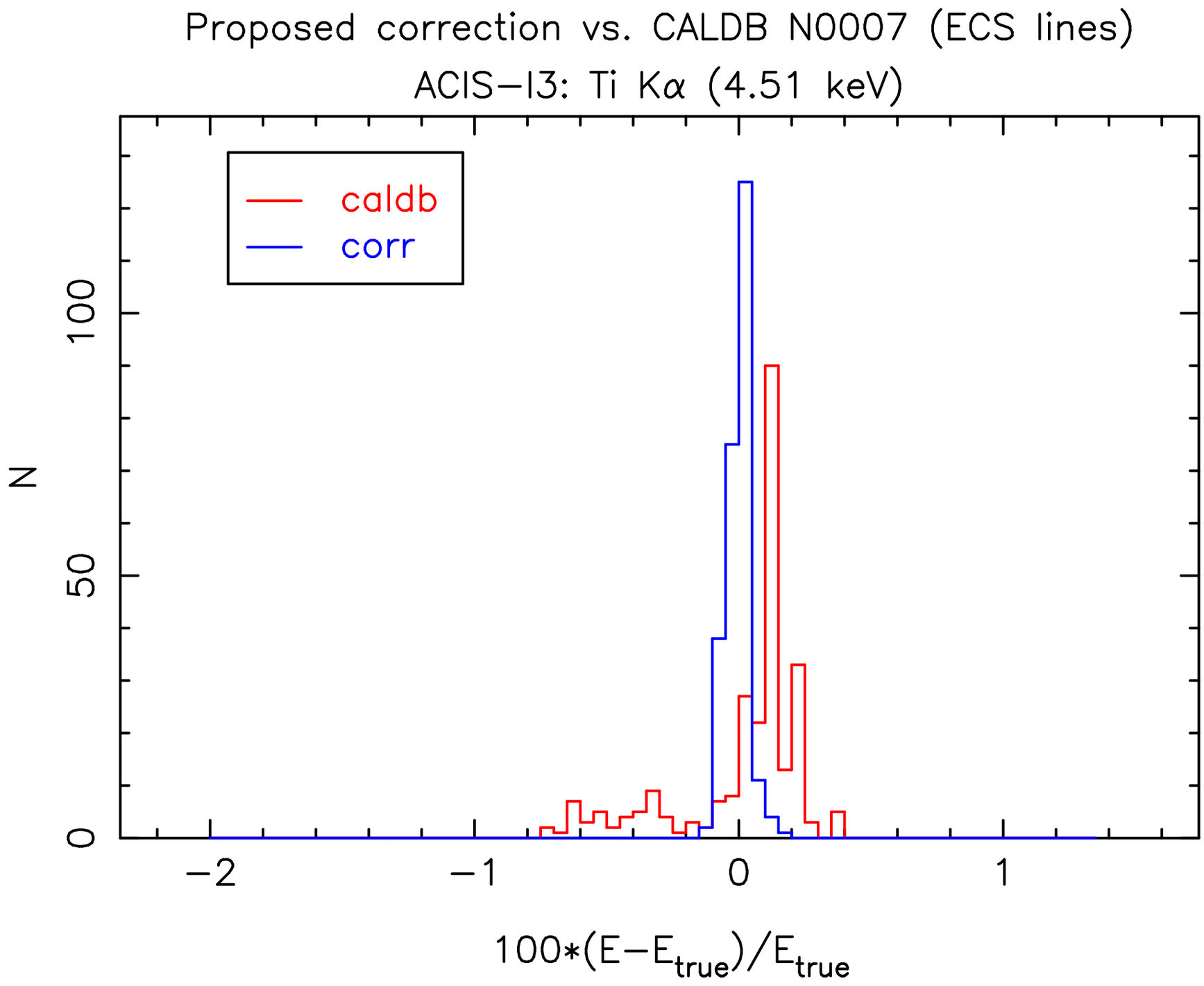
MID-CHIP GAIN DROOP (T. GAETZ)



MID-CHIP GAIN DROOP (T. GAETZ)



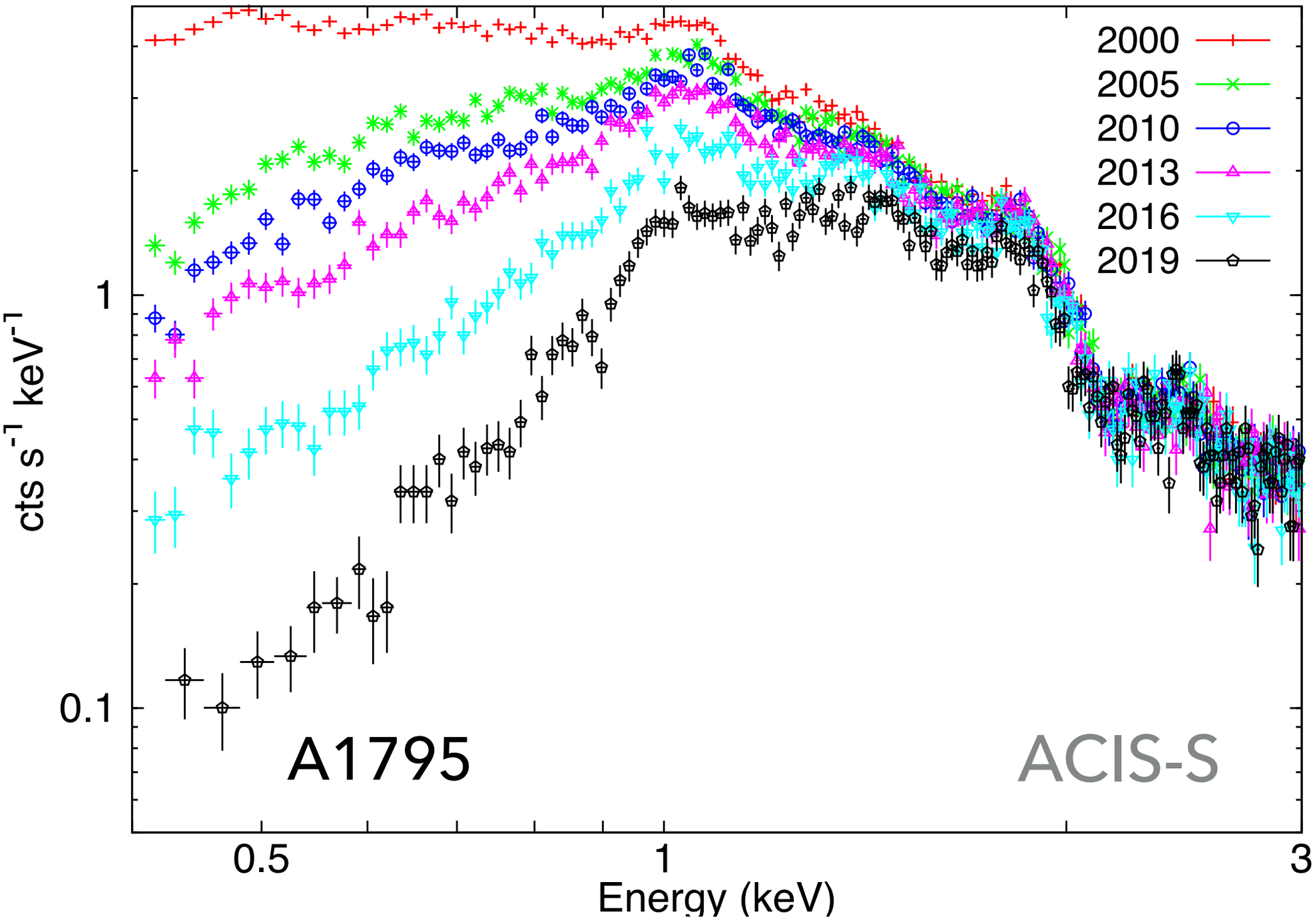
MID-CHIP GAIN DROOP (T. GAETZ)



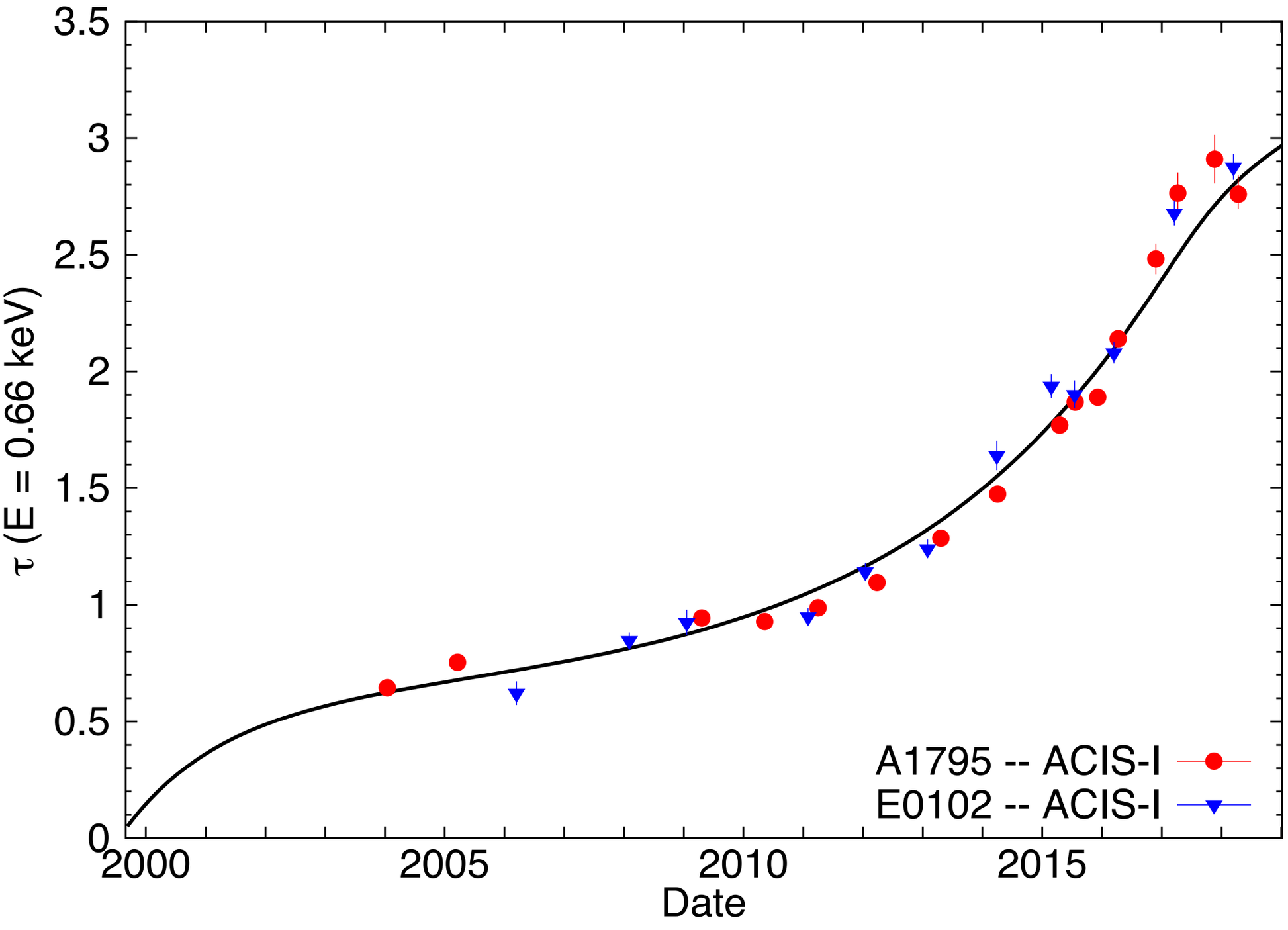
FILTER CONTAMINATION LAYER (A. BOGDAN, H. MARSHALL, P. PLUCINSKY ET AL)

- 2018 Hints of slowing of rate of accumulation on ACIS-I appear spurious :-(
- 2018 *Rate of accumulation* on ACIS-S was lower than the CALDB prediction; corrected in latest model released Oct 2018 CalDB 4.8.1

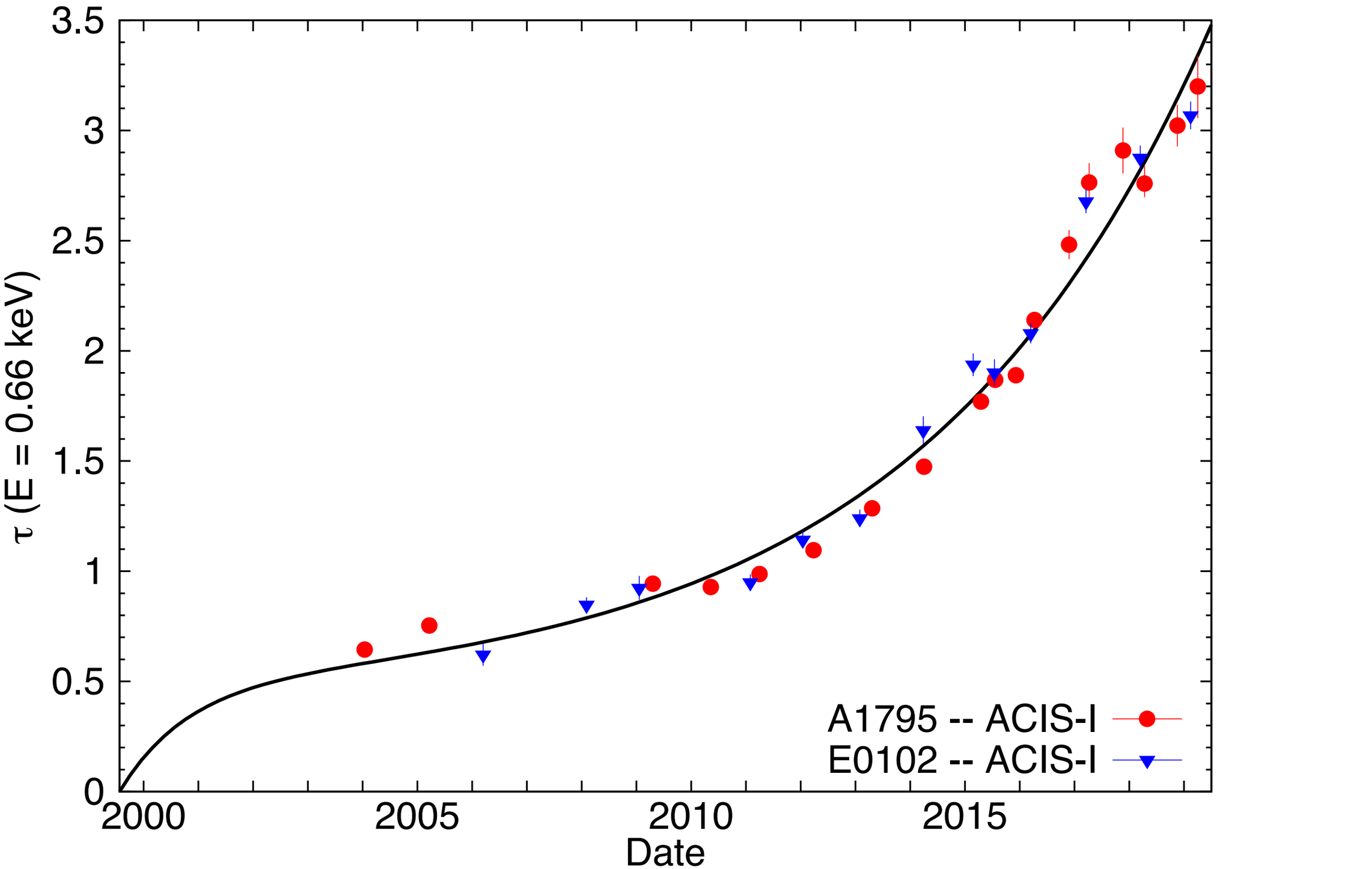
FILTER CONTAMINATION LAYER (A. BOGDAN, H. MARSHALL, P. PLUCINSKY ET AL)



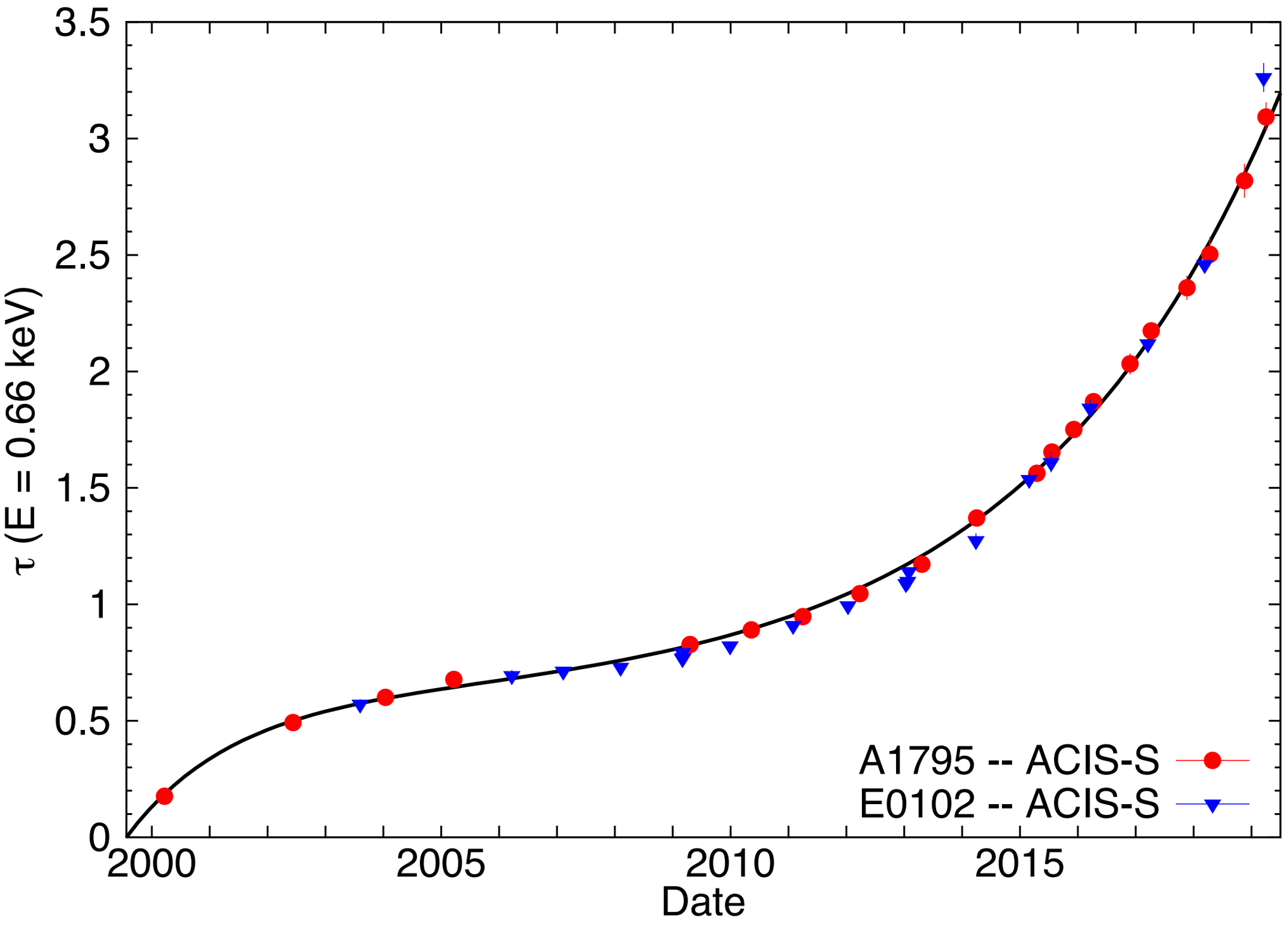
FILTER CONTAMINATION LAYER (A. BOGDAN, H. MARSHALL, P. PLUCINSKY ET AL)



FILTER CONTAMINATION LAYER (A. BOGDAN, H. MARSHALL, P. PLUCINSKY ET AL)



FILTER CONTAMINATION LAYER (A. BOGDAN, H. MARSHALL, P. PLUCINSKY ET AL)



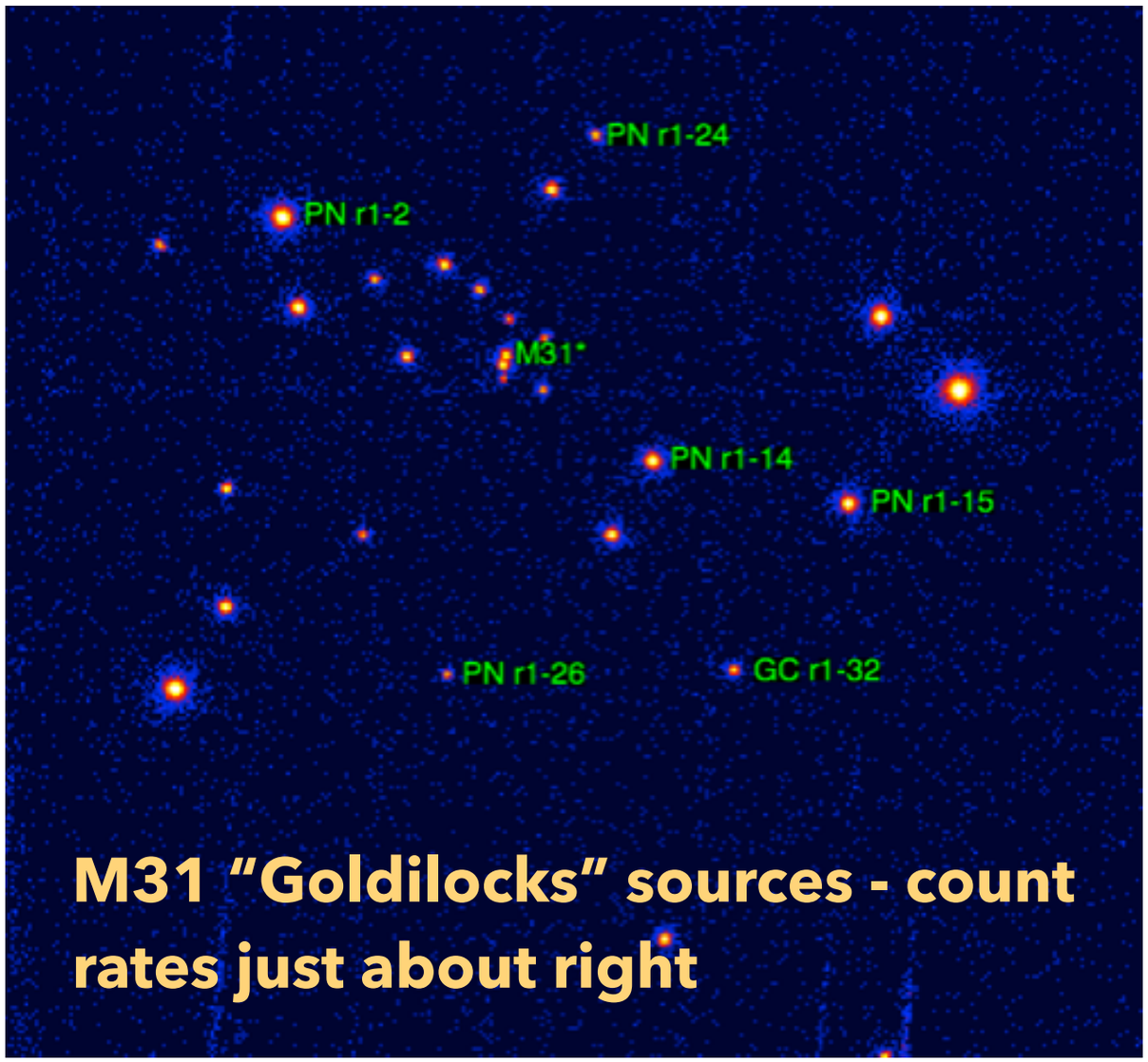
FILTER CONTAMINATION LAYER (A. BOGDAN, H. MARSHALL, P. PLUCINSKY ET AL)

- New time-dependent and spatial contamination model based on latest data is being tested, slated for Fall 2019 release

HETG 0TH ORDER CONCLUSION

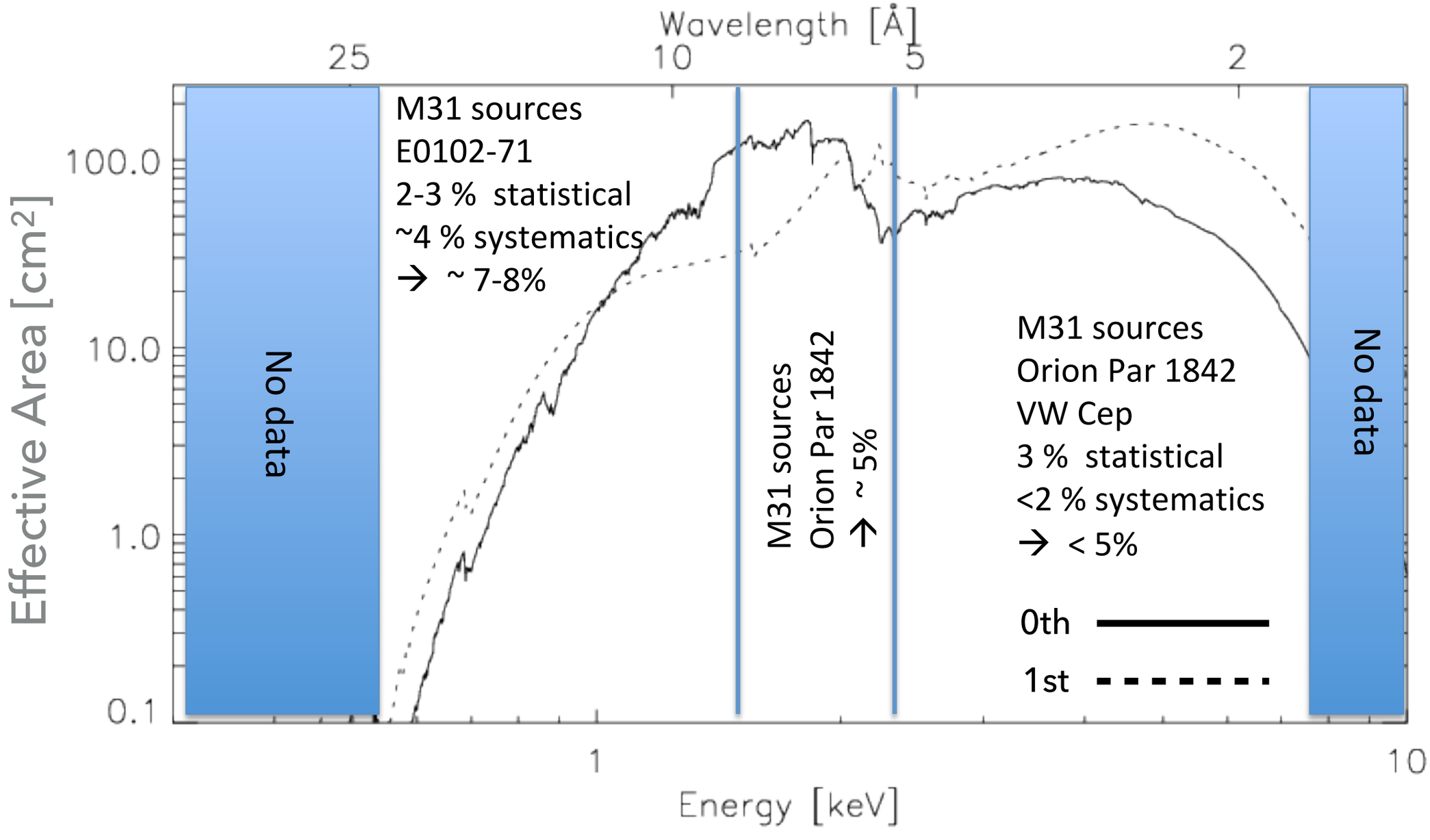
0TH ORDER EFFECTIVE AREA (NORBERT SCHULZ)

M31 center with Chandra HETG:



- CUC 2018: agreement between 0th and 1st order fluxes better than 10%
- Wrap up Spring 2019
- Study concluded

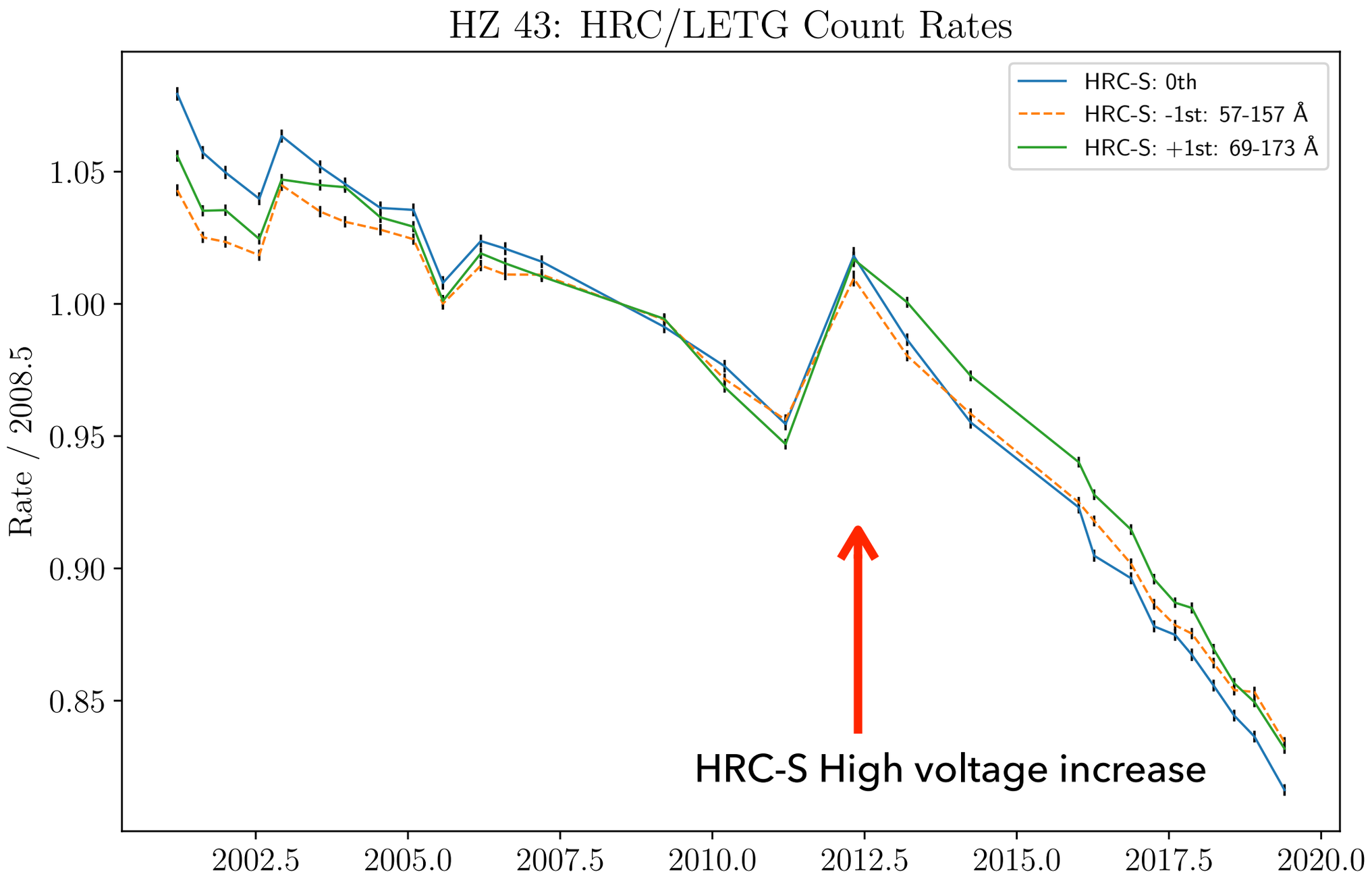
0TH ORDER EFFECTIVE AREA (NORBERT SCHULZ)



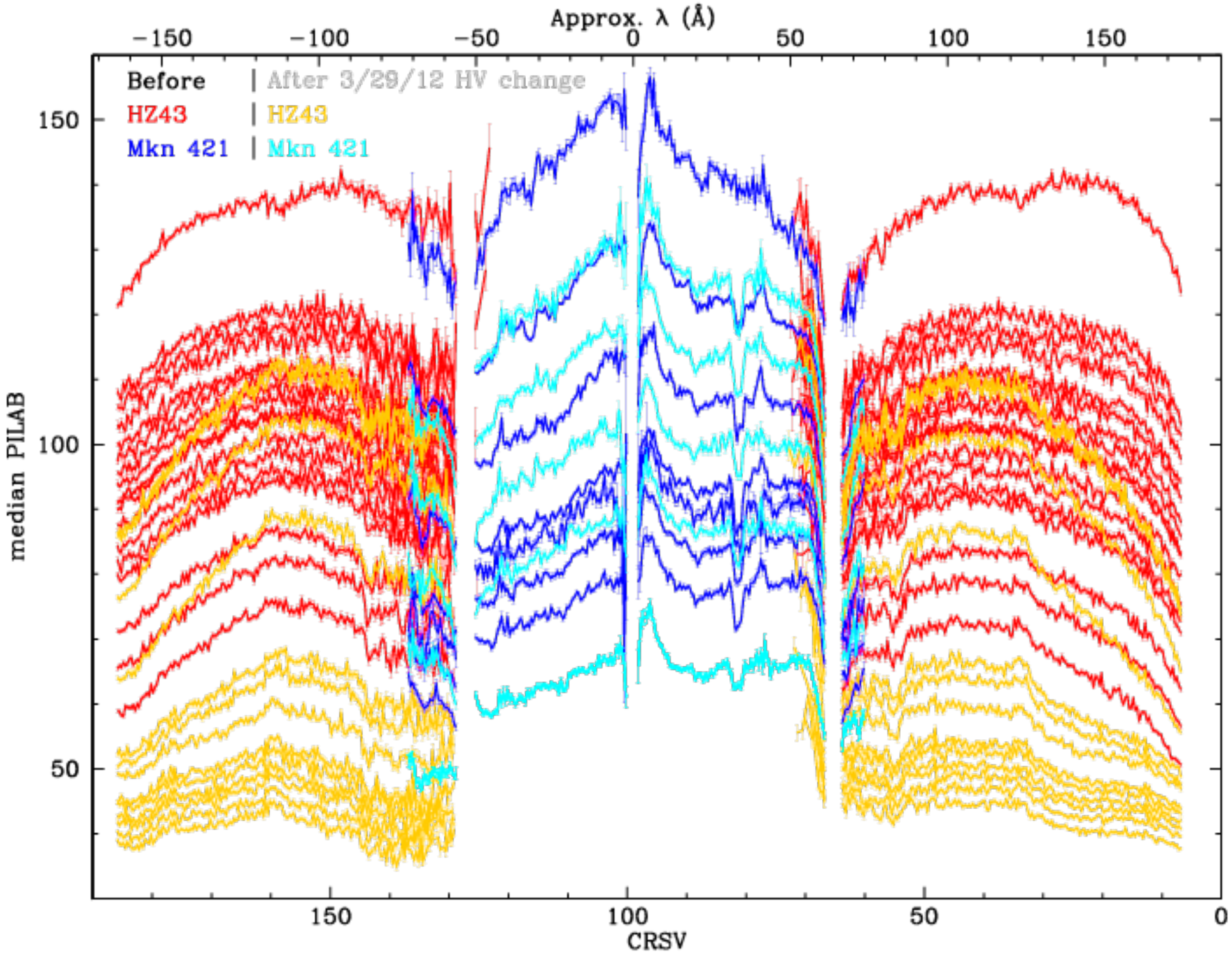
- **No correction to the diffraction efficiencies are required at this time: 0th and 1st orders consistent to within the statistical precision of the observations.**

HIGH RESOLUTION CAMERA

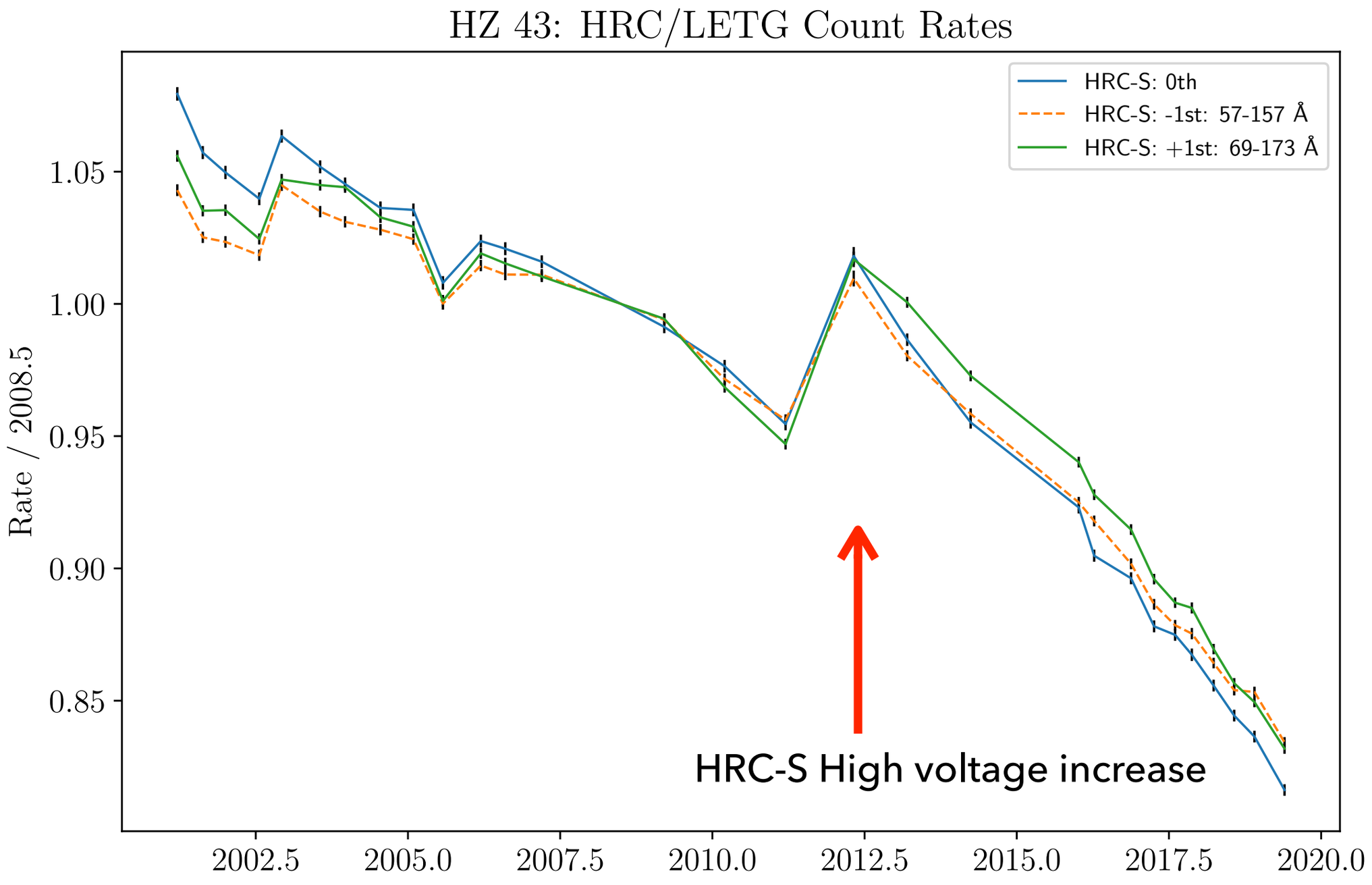
QUANTUM EFFICIENCY DECLINE (B. WARGELIN, P. RATZLAFF, V. KASHYAP, J. DRAKE)



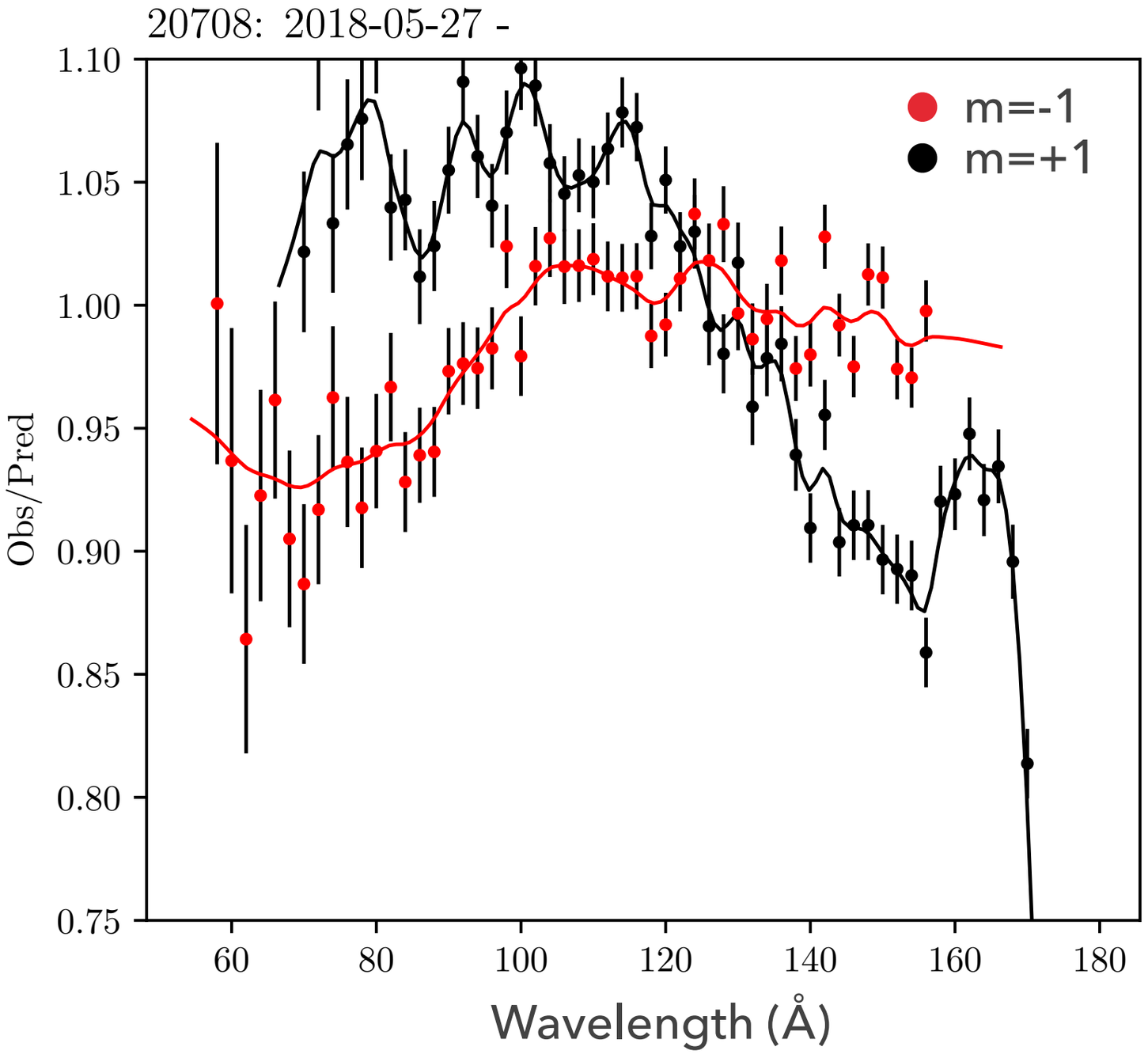
QUANTUM EFFICIENCY DECLINE (B. WARGELIN, P. RATZLAFF, V. KASHYAP, J. DRAKE)



QUANTUM EFFICIENCY DECLINE (B. WARGELIN, P. RATZLAFF, V. KASHYAP, J. DRAKE)



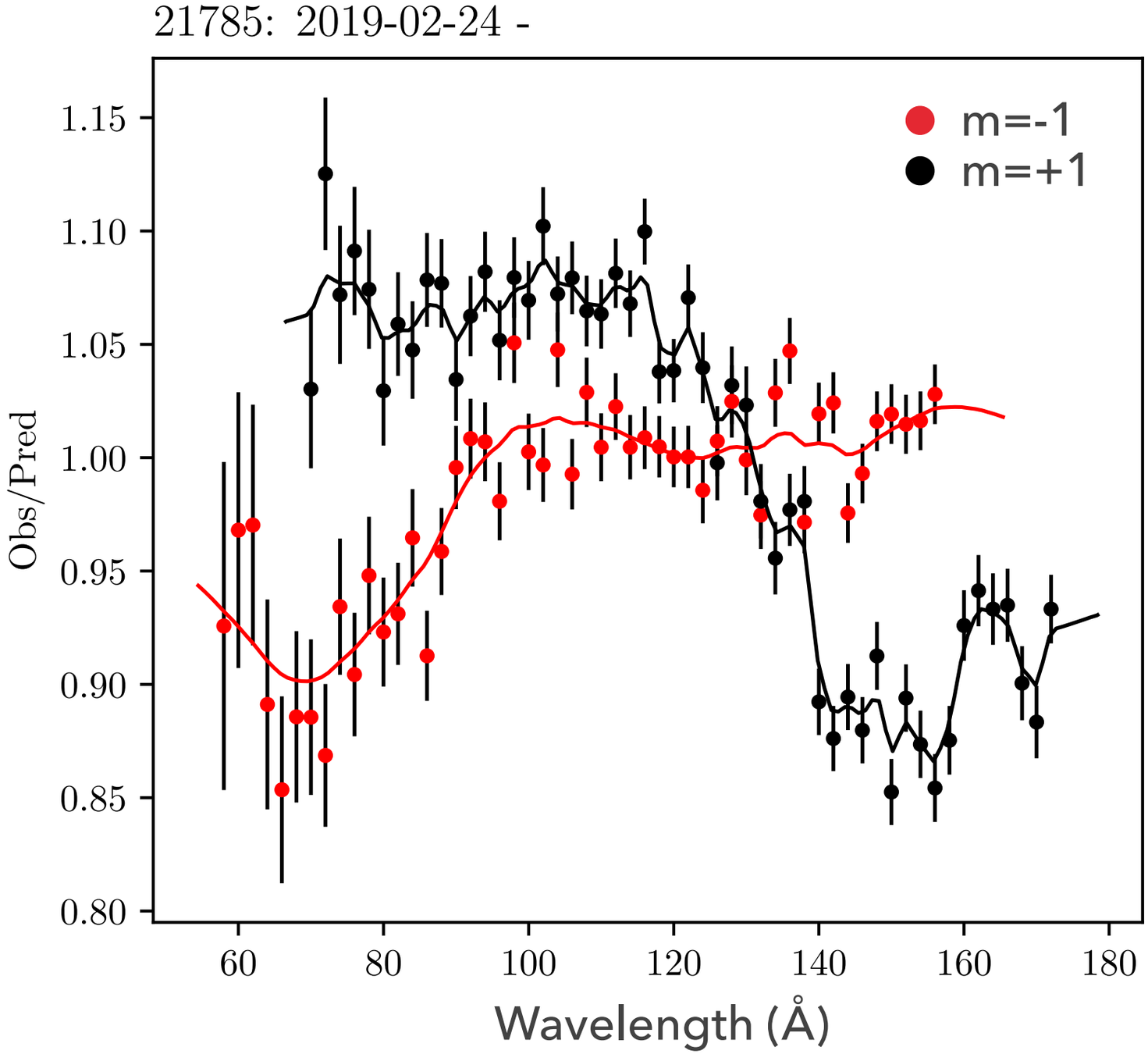
QUANTUM EFFICIENCY DECLINE (B. WARGELIN, P. RATZLAFF, V. KASHYAP, J. DRAKE)



HZ43 Empirical HRC-S QEU corrections:

- Defined relative to 0th order rate
- New QEU file every ~4 months (latest in CalDB 4.8.2 Sept 2019)

QUANTUM EFFICIENCY DECLINE (B. WARGELIN, P. RATZLAFF, V. KASHYAP, J. DRAKE)



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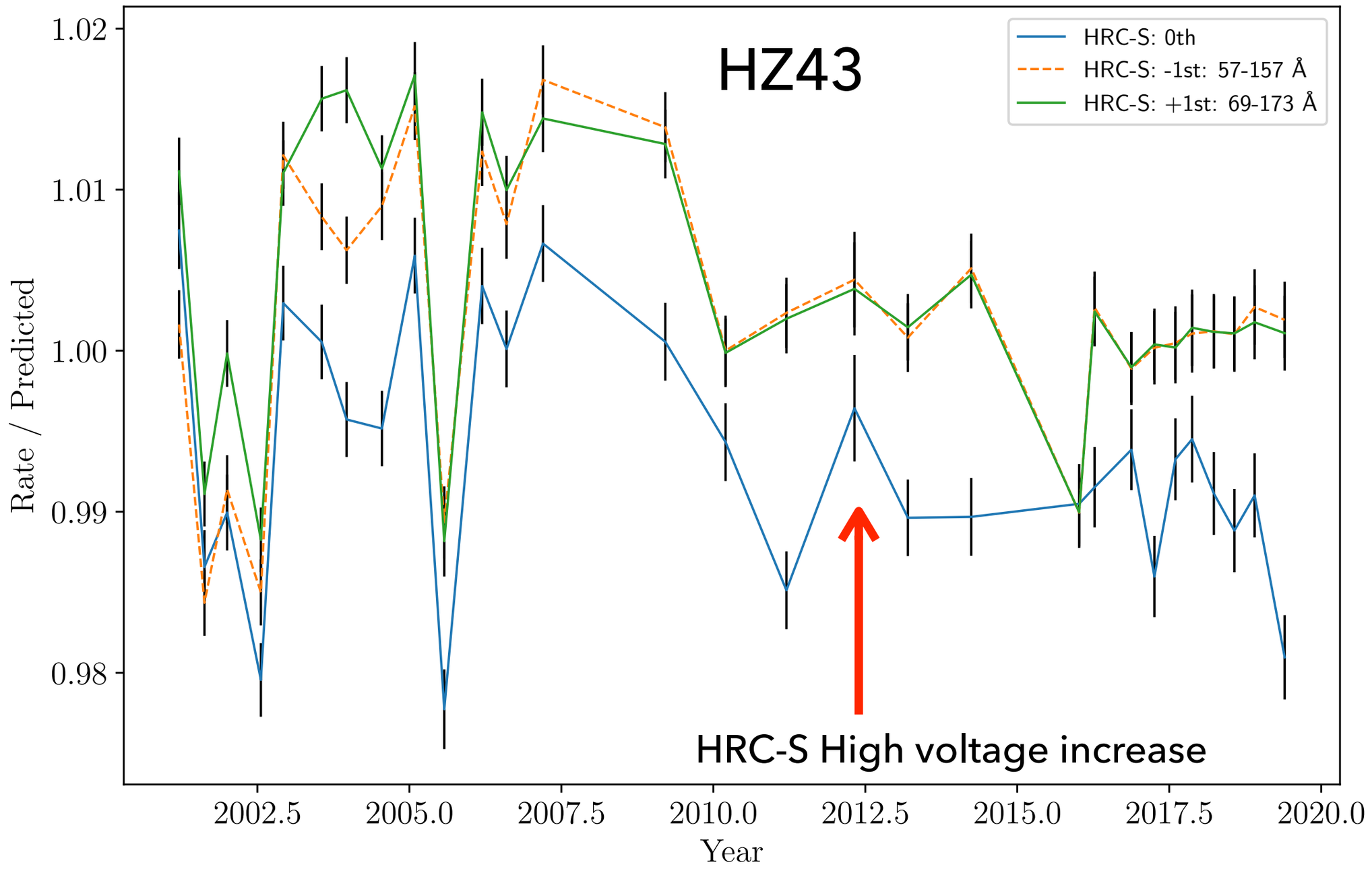
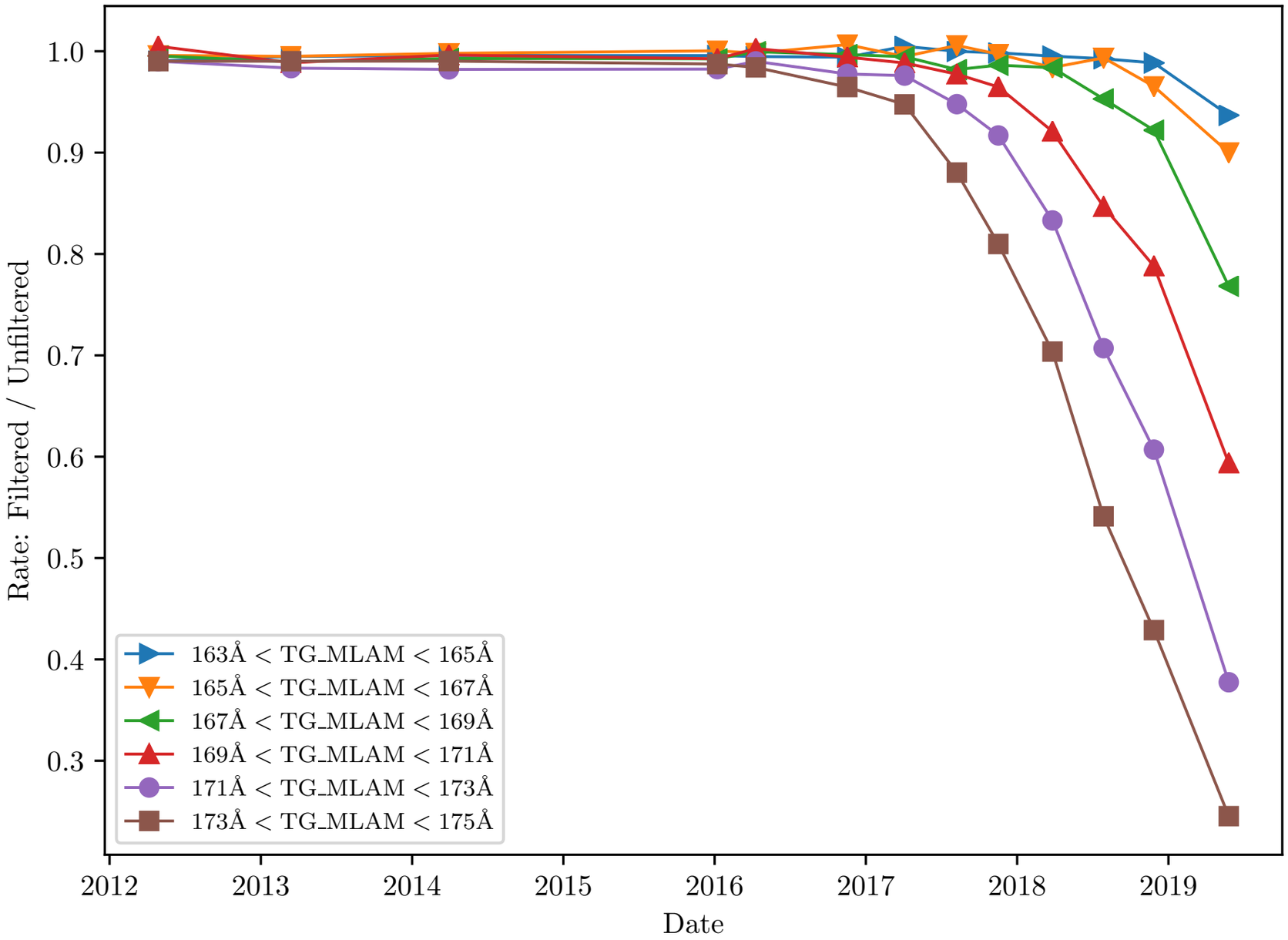


QUANTUM EFFICIENCY DECLINE (B. WARGELIN, P. RATZLAFF, V. KASHYAP, J. DRAKE)



- PHA-based background filter no longer viable at very longest wavelengths
- New gain calibration and BG filter anticipated Spring 2020

HRC-S HIGH VOLTAGE INCREASE?

- A high voltage increase can recover some gain and low E QE. BUT it carries some risk.
- Annual evaluation by CXC Calibration and HRC IPI team conclude: soon but not yet.
- Monitoring continues.

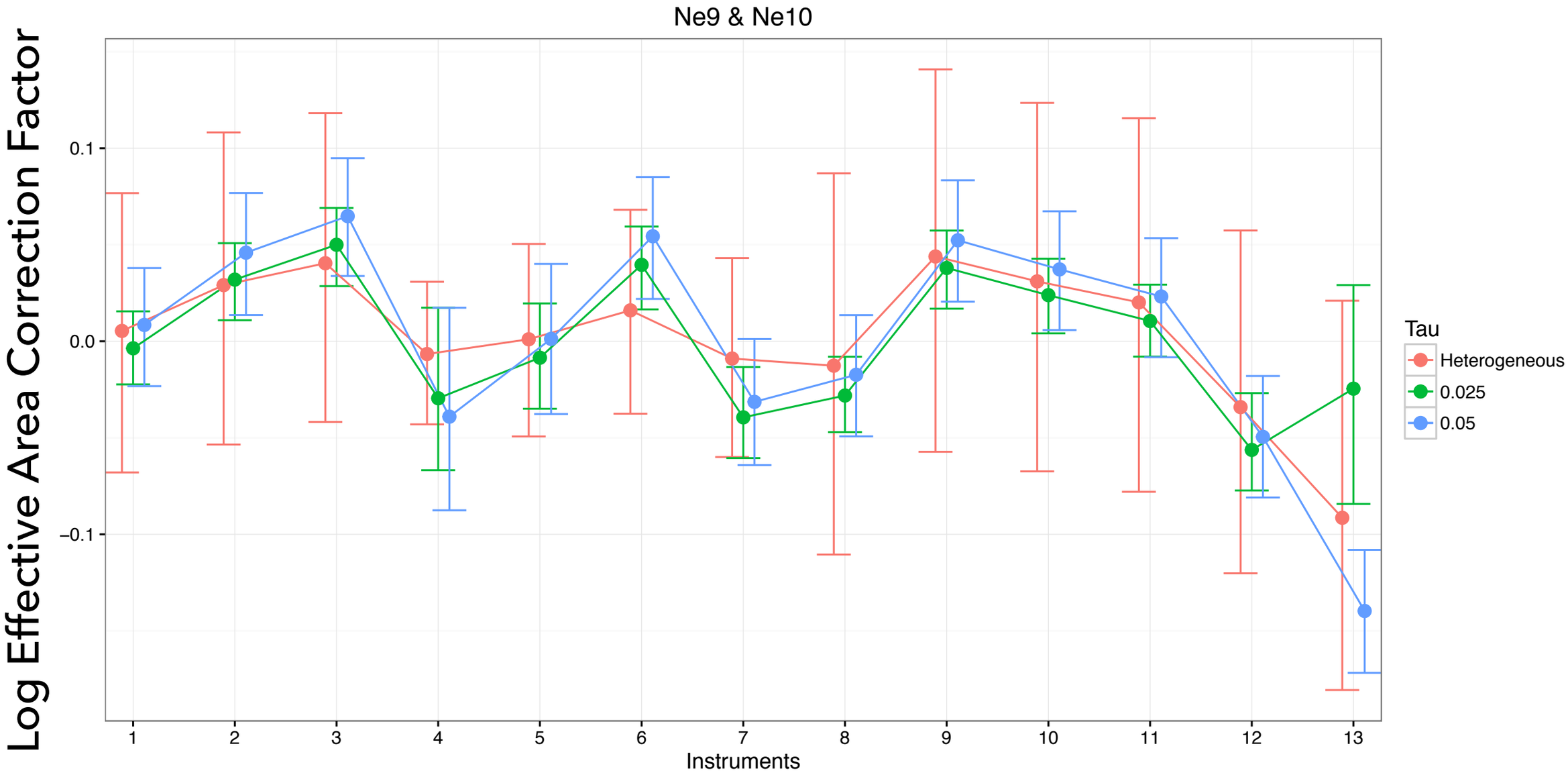
CONCORDANCE

CONCORDANCE

- Answer to “How to change effective areas given inconsistent derived fluxes from different instruments?”
- Method: “Multiplicative Shrinkage” (Chen+ 2019)
  - uses data from all missions + fractional uncertainties on prior EA to obtain the “true” flux and effective area corrections
- IACHEC scientists set uncertainties on prior EA
- Developed jointly with statistics academicians
- Working on new cross-cal data sets (Marshall+ 2020)

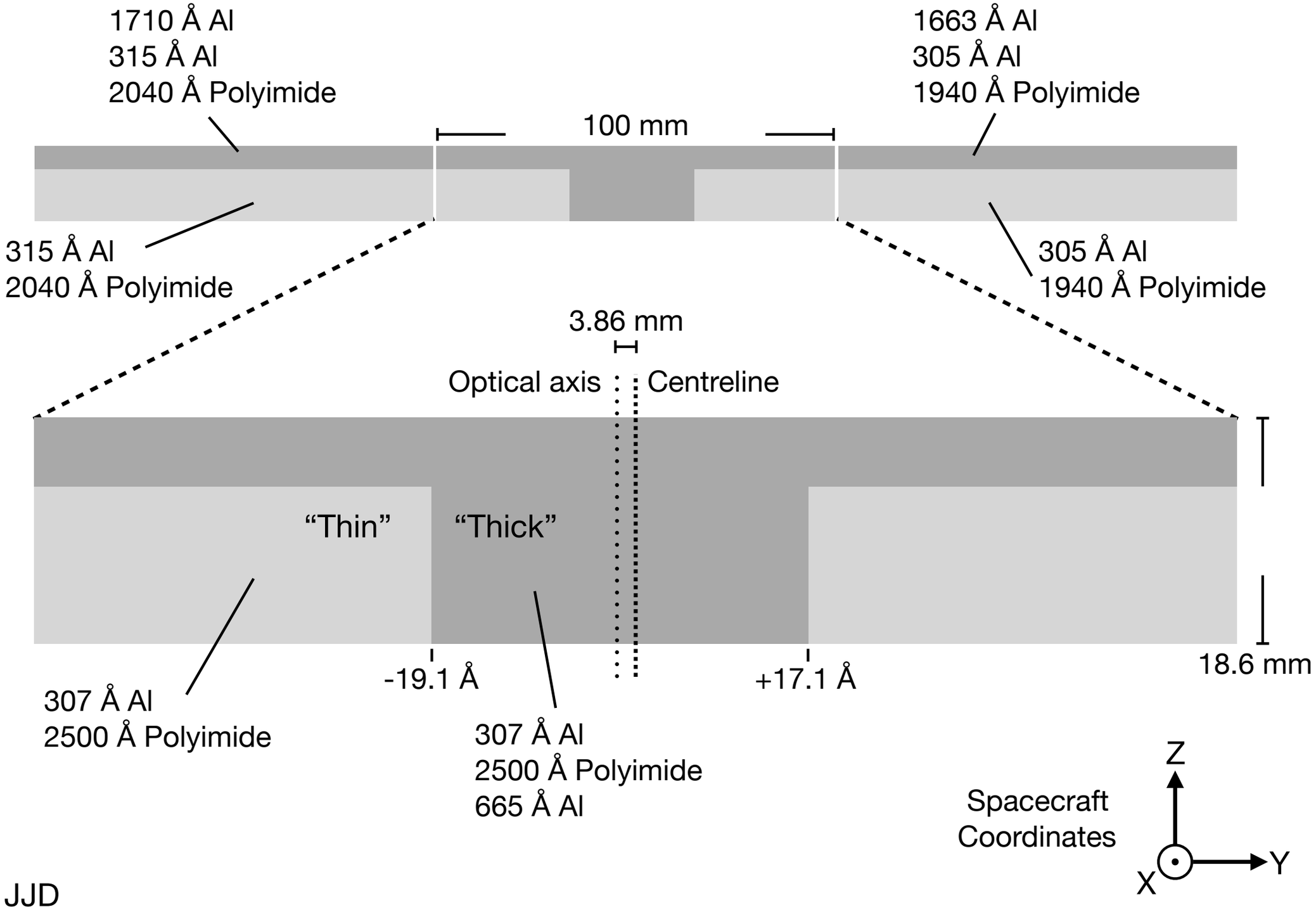
CONCORDANCE

Eg: Effective area corrections based on Ne line fluxes in SNR E0102

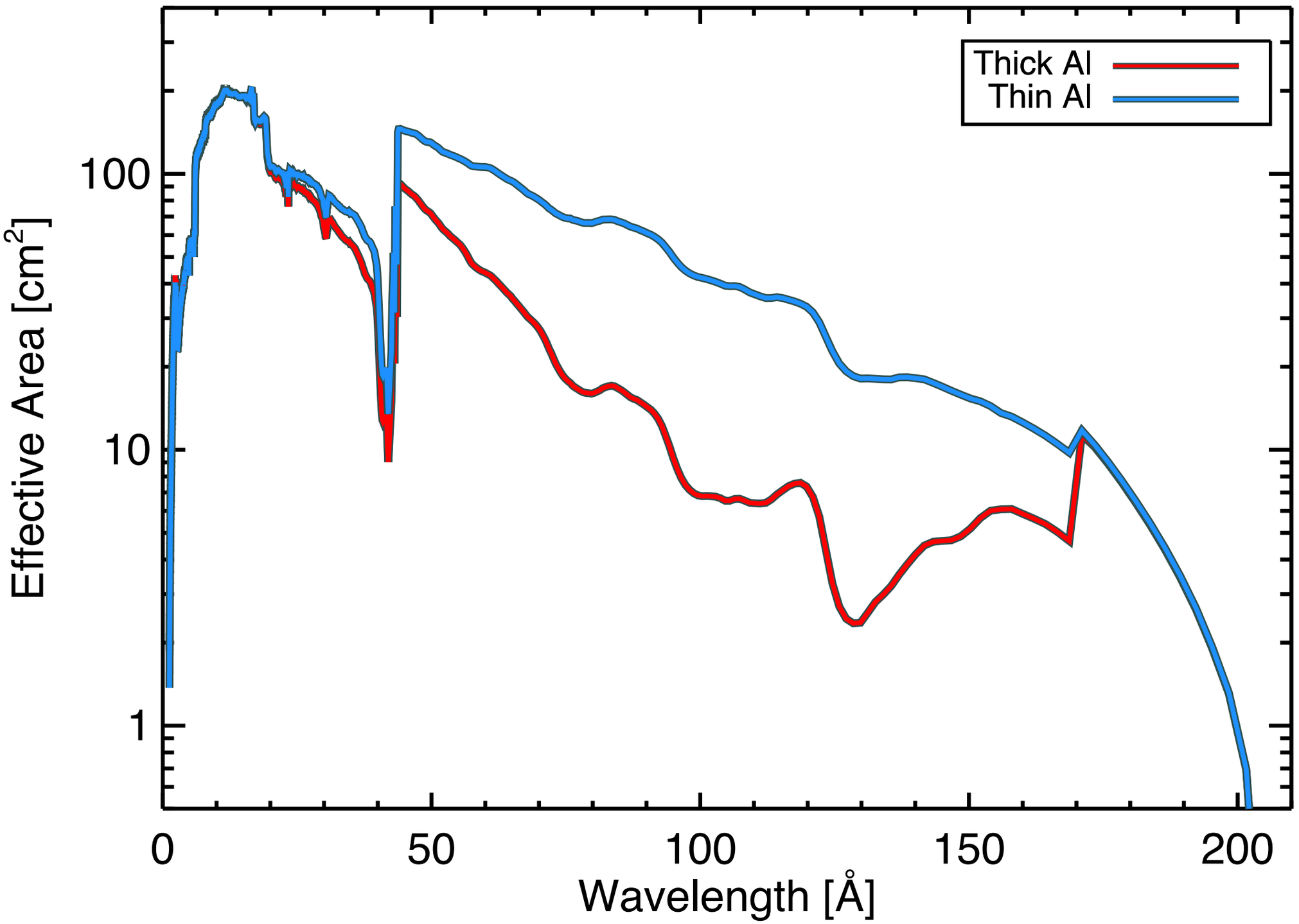


NEW FUTURE CALIBRATIONS

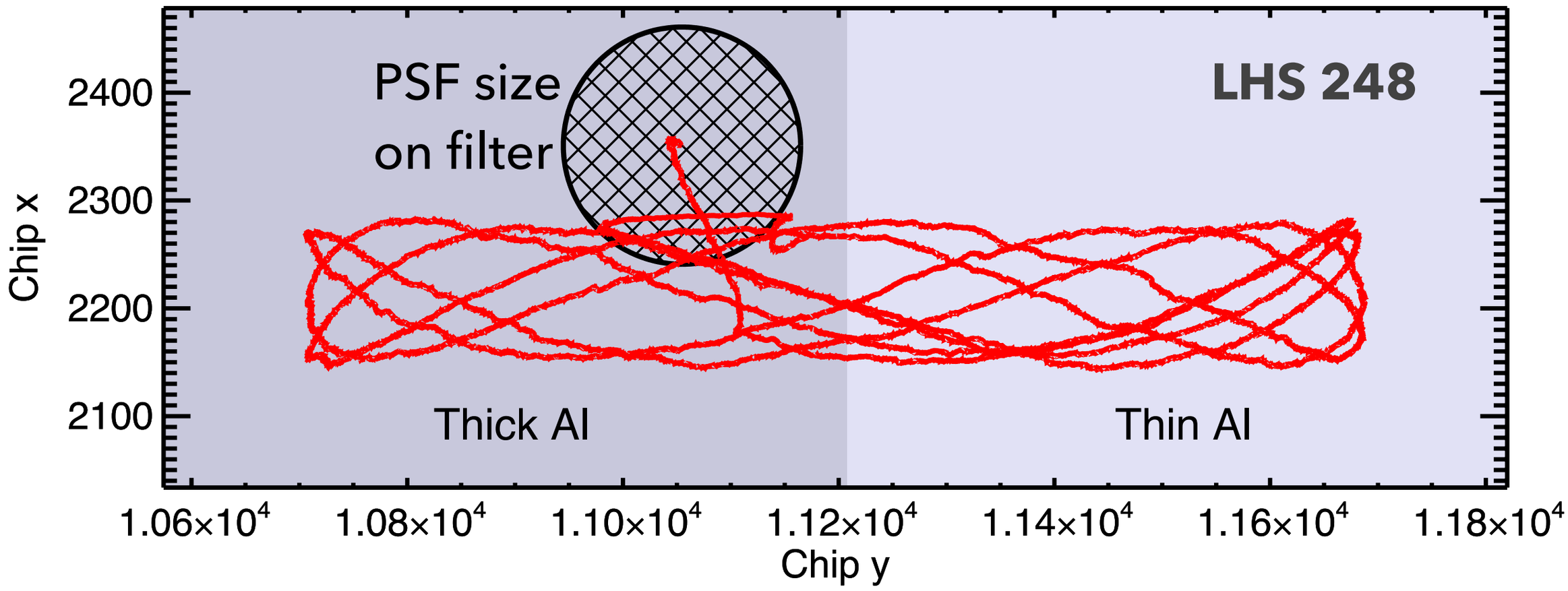
NEW HRC-S OBSERVING MODE



NEW HRC-S OBSERVING MODE



NEW HRC-S OBSERVING MODE



- Calibration of throughput and exact filter boundary with HZ43 underway; expected conclusion Winter 2020

SUMMARY AND FUTURE 1/2

- No detectable issues from warm HRMA safe hold
- On-axis empirical PSF and EDSER calibration underway but delayed; targeting Spring 2020 for release pending CSC `srcextent` corrections
- ACIS mid-chip gain droop new det_gain release c. Late Fall 2019
- Updated ACIS contamination model releases for I and S expected Fall 2019

SUMMARY AND FUTURE 2/2

- Continuing HRC-S QE secular changes calibrated; new HRC-S QE released Sept 2019 , new gain calibration and PHA background filter c. Spring 2020
- HV increase on HRC-S not yet, but probably early 2020s
- New HRC-S observing mode on thin Al filter being calibrated
- Progress with the Concordance project - getting closer to recommending calibration revisions for the different missions…

SUPPLEMENTARY MATERIAL

CALIBRATING THE EDSER PSF (V. KASHYAP, P. ZHAO, D. JERIUS)

- Energy-Dependent Subpixel Event Repositioning - ACIS images can be sharpened significantly at sub-pixel resolutions
- Applies corrections to event locations based on photon energy and event grade (Li et al. 2004, ApJ 610, 1204)
- BUT: EDSER'd PSFs have not yet been calibrated
- VERY challenging: requires on-axis known point sources bright enough to be useful but not piled up