Correcting for the temperature dependence of ACIS CTI

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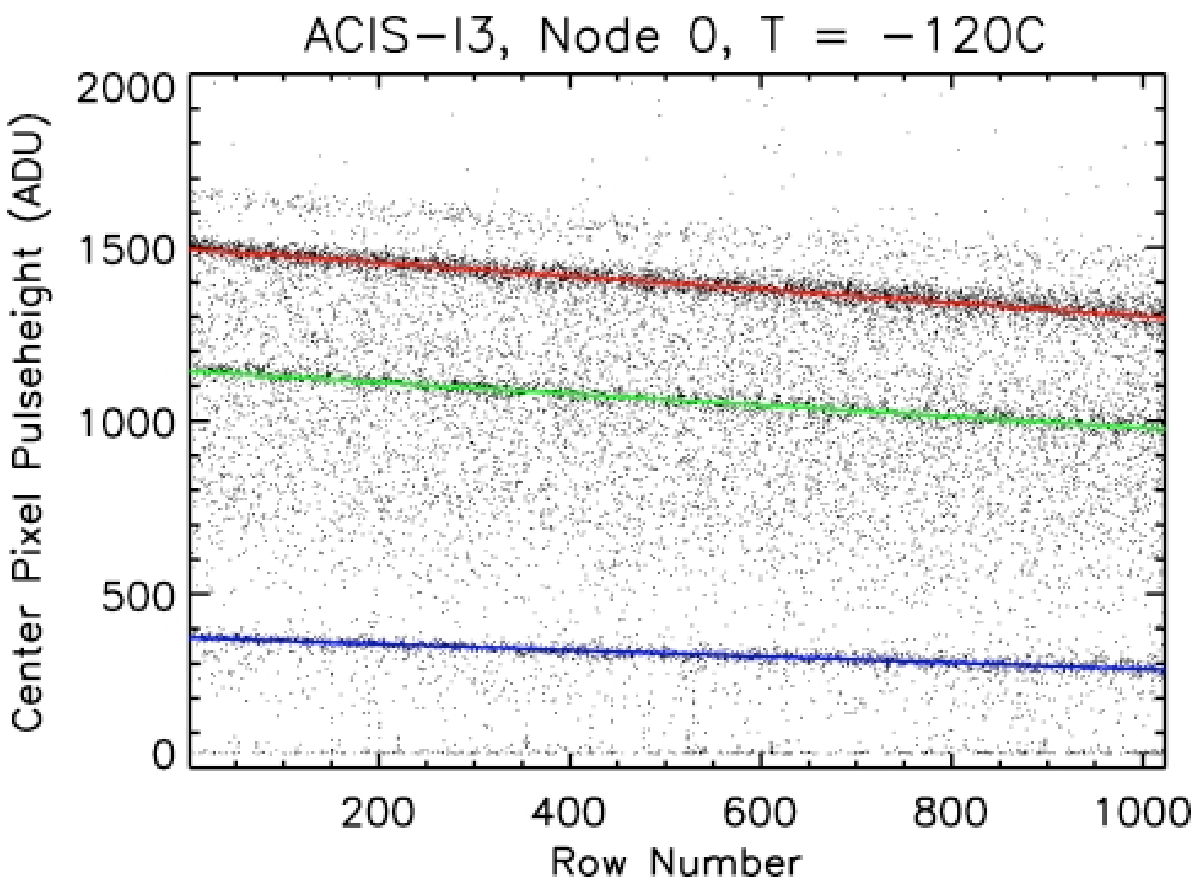
Summary

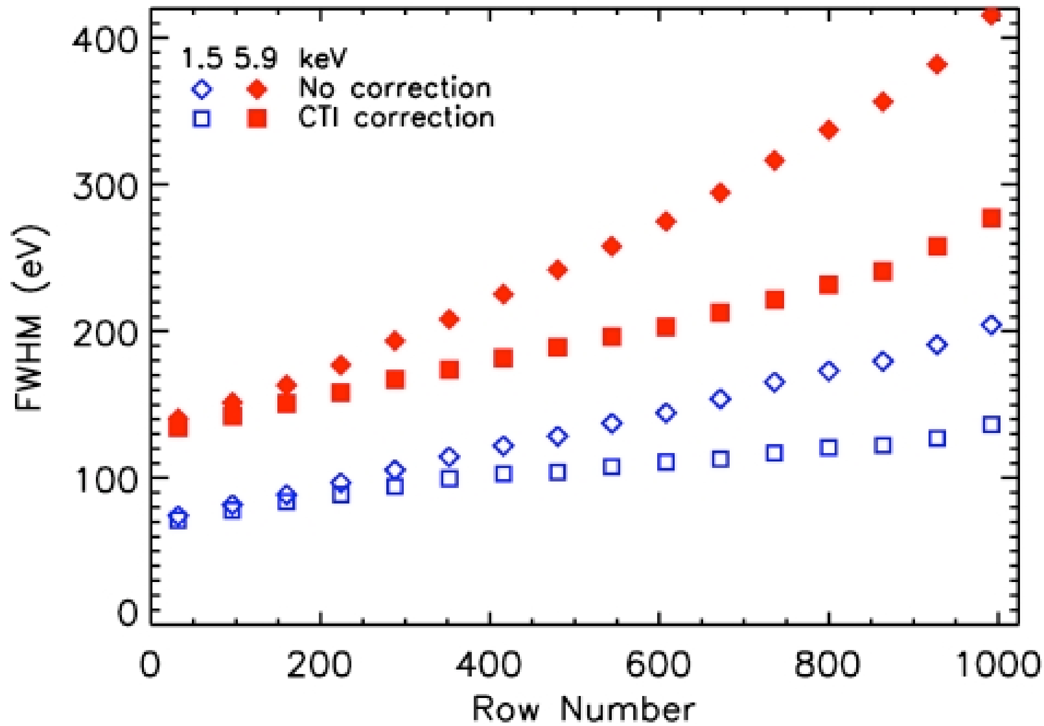
- ACIS CTI and the correction algorithm
- Temperature-dependent performance
- Focal plane temperature excursions
- Adjusting the correction model
- Performance of the adjusted algorithm

Charge transfer inefficiency: a reminder

- CTI, fractional charge loss per pixel transfer
- Linear fit to pulseheight vs row; CTI = (slope/intercept)

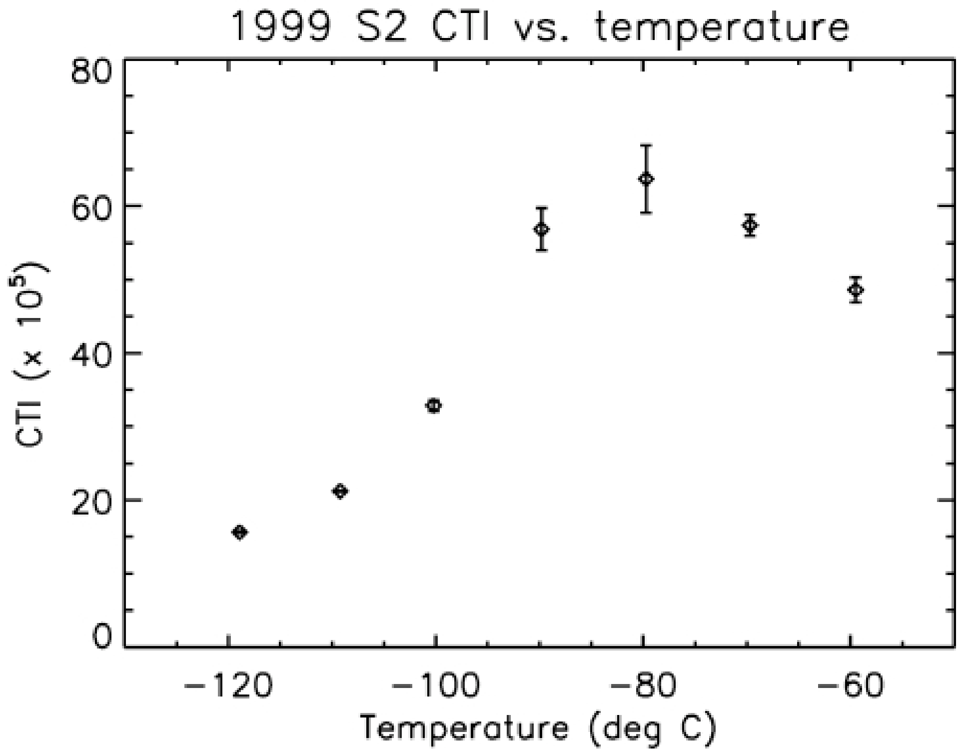


ACIS CTI correction



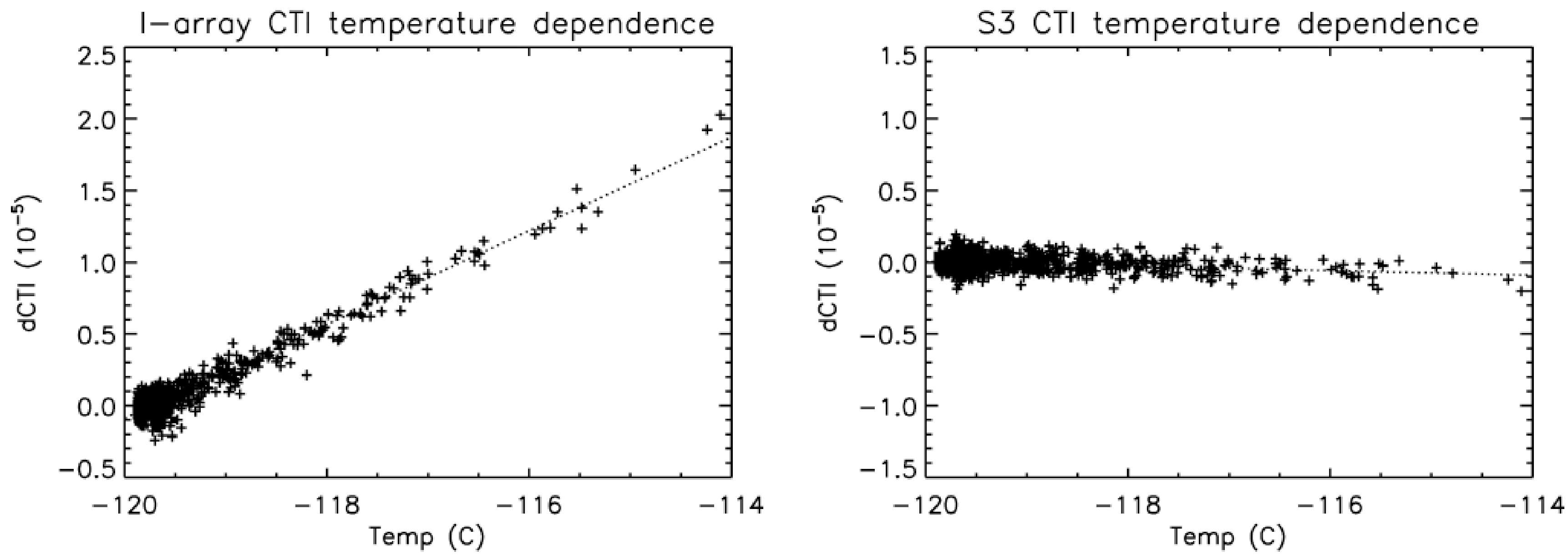
- Incorporated into Chandra data processing pipeline and *CIAO* tool `acis_process_events`
- Post-facto reconstruction of original X-ray event
- Removes position dependence of pulseheight
- Significantly improves spectral resolution and detector uniformity

CTI is temperature dependent



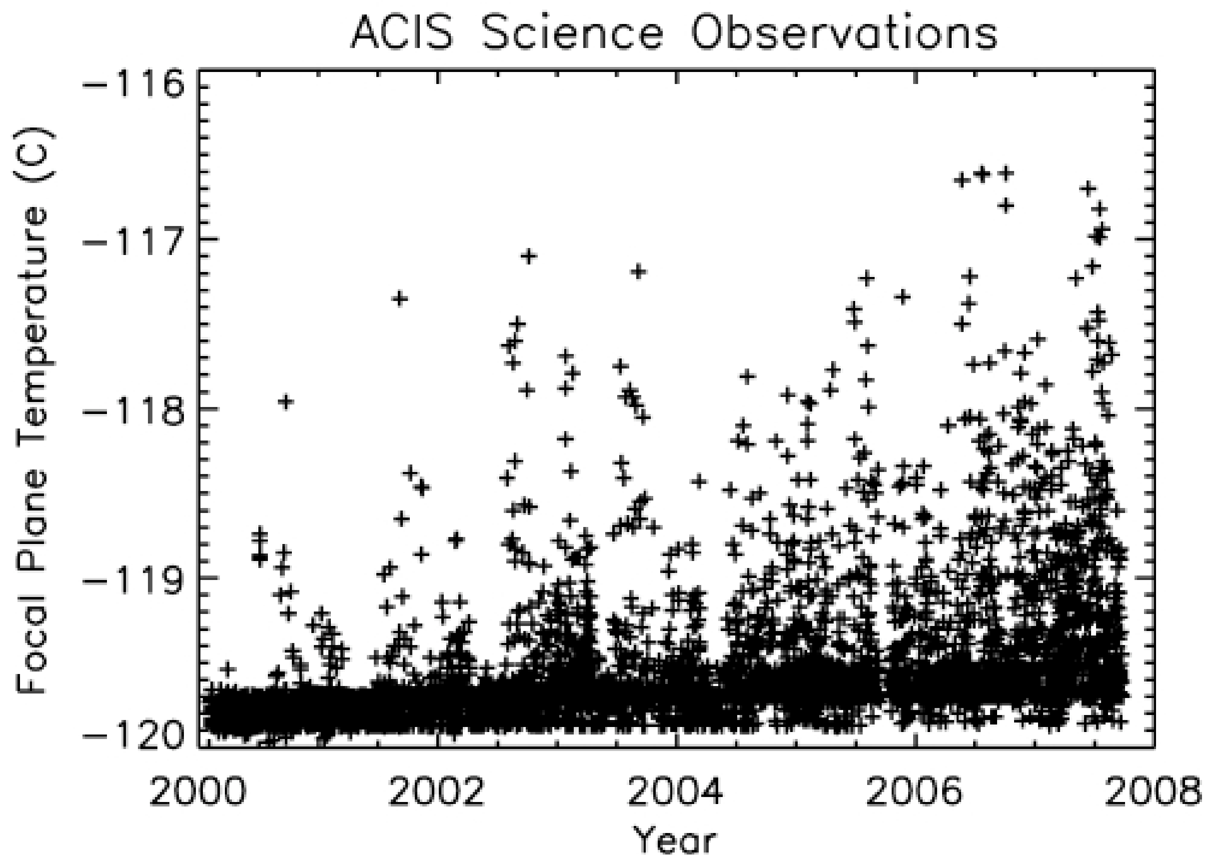
- Charge traps have temperature-dependent re-emission time constants
- Time constants that drop below pixel-to-pixel transfer time (40 μs) or above CCD frame time are benign
- Distribution of trap species determines overall CTI-temperature profile

CTI dependence on temperature



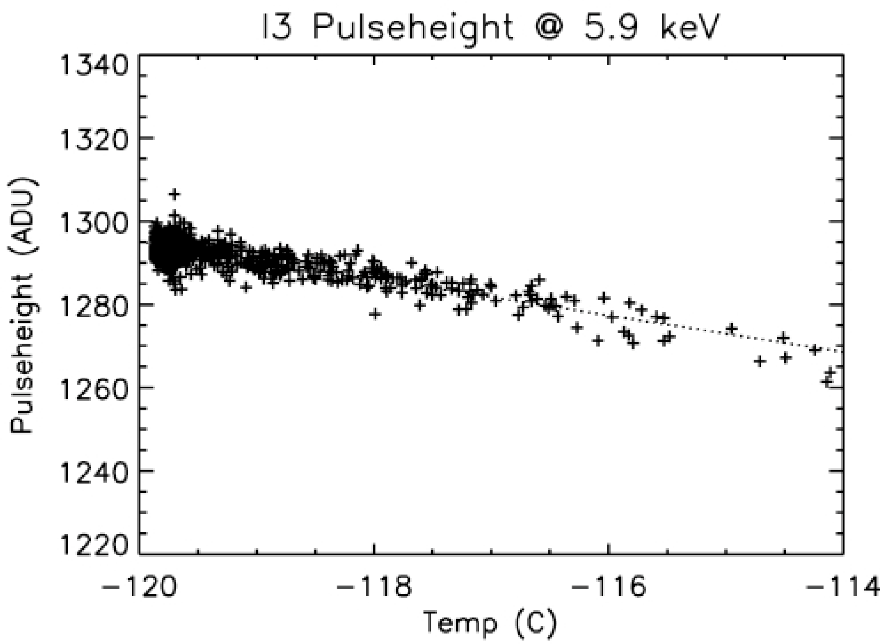
- dCTI/dT ~ +2% / deg (FI), –1% / deg (BI)
- Roughly linear for small temperature deviations
- Causes temperature dependent performance
- More important for FI than BI

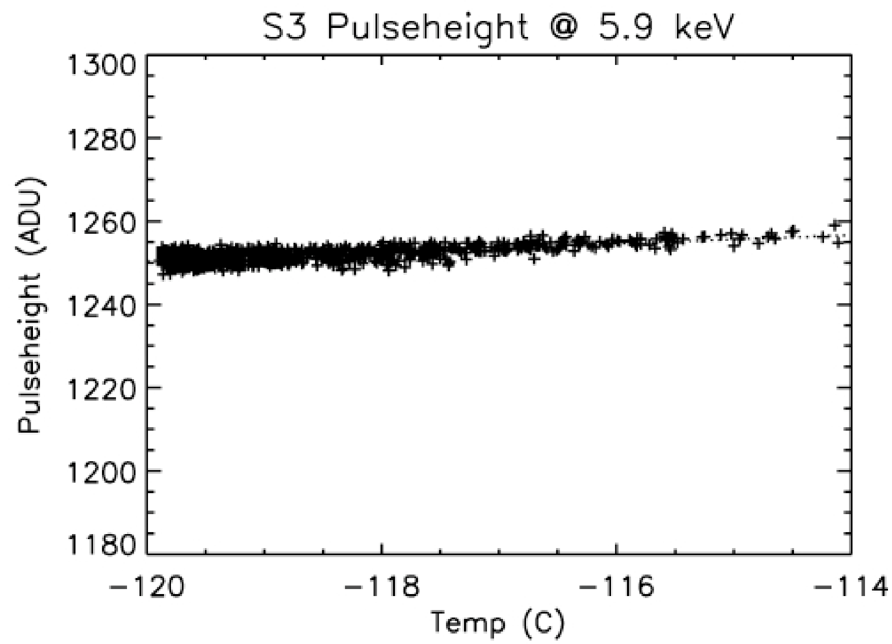
Focal plane temperature excursions



- ACIS cooling is less efficient in some Chandra orientations
  - Other spacecraft constraints not always favorable for ACIS
- Some aging of radiator surfaces, less efficient
- In 2000, 99% of observations < –119ºC; in 2006, 86%

Implications for calibration: gain



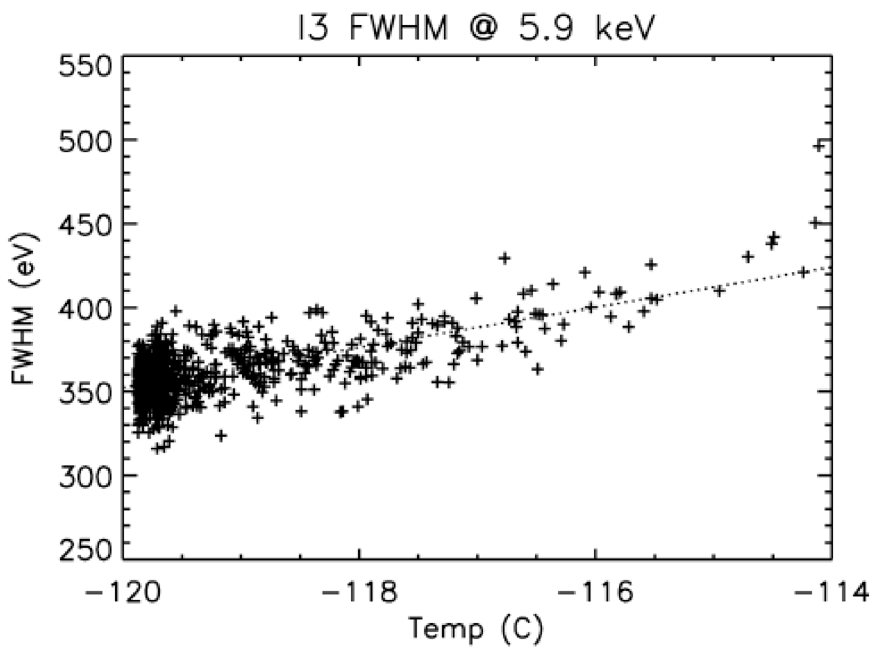


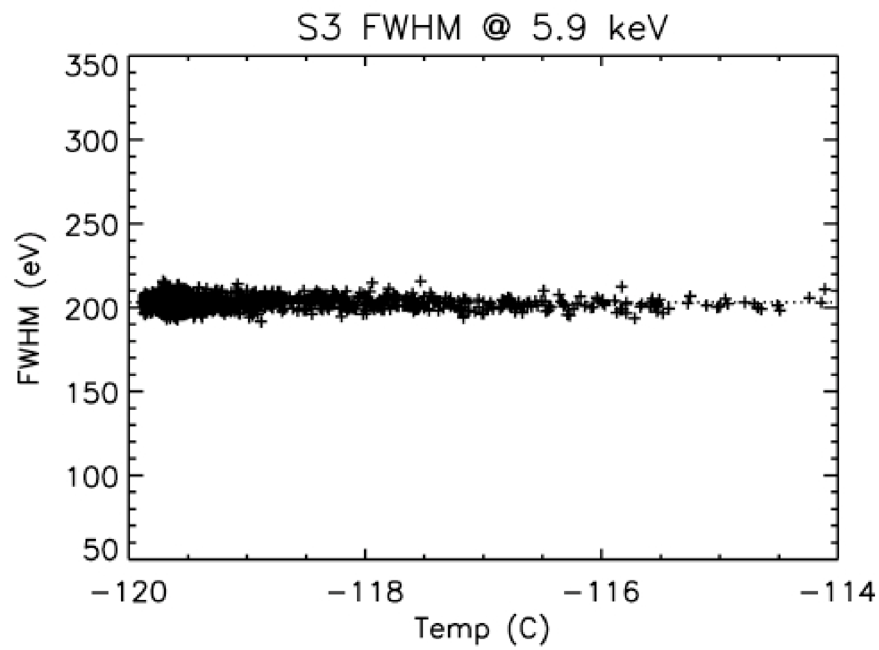
Temperature-dependent pulseheight change (% / deg)

	1.5 keV	6 keV
I3 (FI)	–0.7%	–0.4%
S3 (BI)	+0.2%	+0.1%

- Top 64 rows of CCD (worst case)
- Smaller effect at lower rows
- Calibration accuracy goal is 0.3%

Implications for calibration: line width





Temperature-dependent line width change (eV / deg)

	1.5 keV	6 keV
I3 (FI)	4 eV	11 eV
S3 (BI)	< 1 eV	< 1 eV

- Top 64 rows of CCD (worst case)
- Smaller effect at lower rows
- Negligible for ACIS-S3

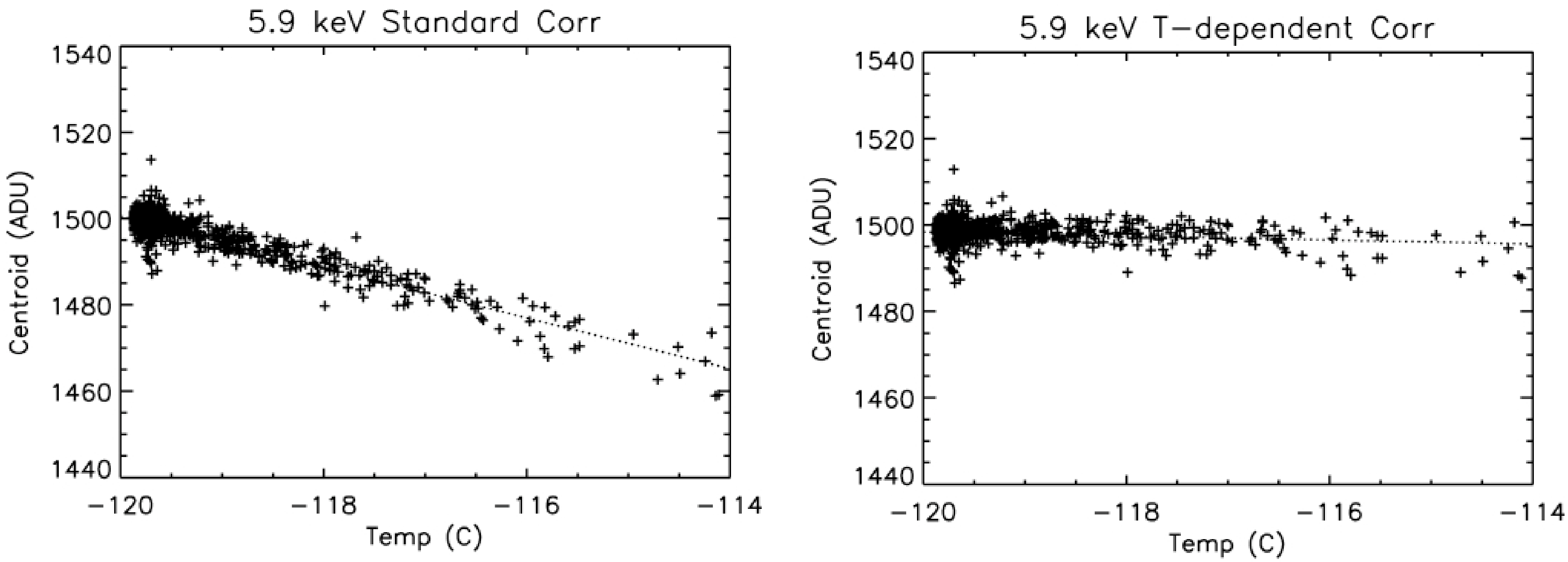
Implication for calibration: summary

- Significant gain change for some CCDs/locations
- Line width change is less important
- Warmer temperatures are uncontrolled
  - Variation within a single observation as high as 3-4°C
- Scientific impact varies:
  - High: line-rich spectrum, ACIS-I, high S/N
  - Low: continuum spectrum, ACIS-S3, low S/N

Charge loss model

- Separates energy and position dependence
- Energy dependence is related to the volume of the charge cloud, should not be strongly temperature dependent
- Spatial dependence and magnitude of charge loss stored as “trapmaps”
- Trapmap $\propto$ CTI
  - Use CTI-temperature dependence to adjust trapmap
- Tested two versions
  - Average observation temperature
  - Dynamic frame-by-frame temperature

Performance of adjusted corrector

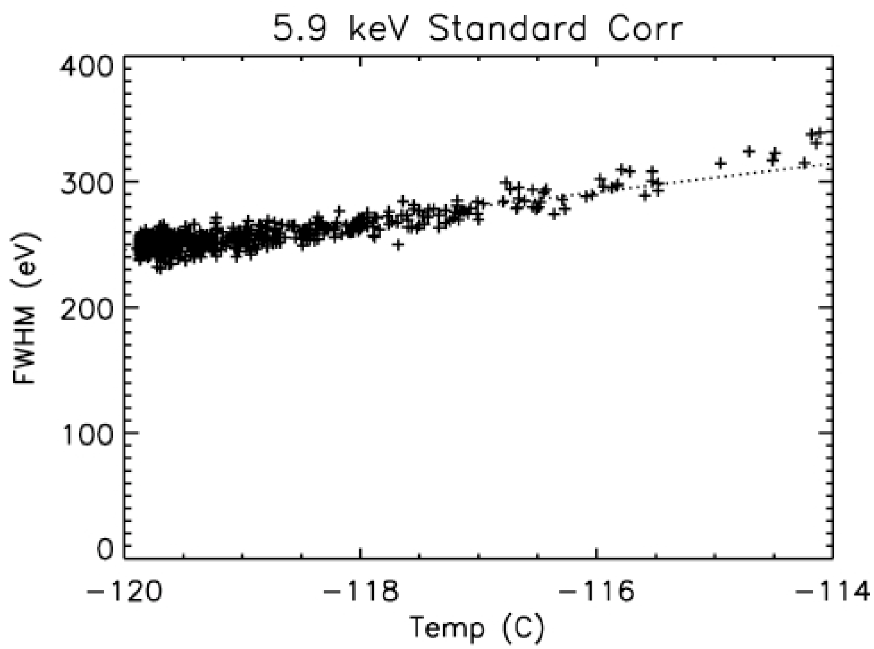


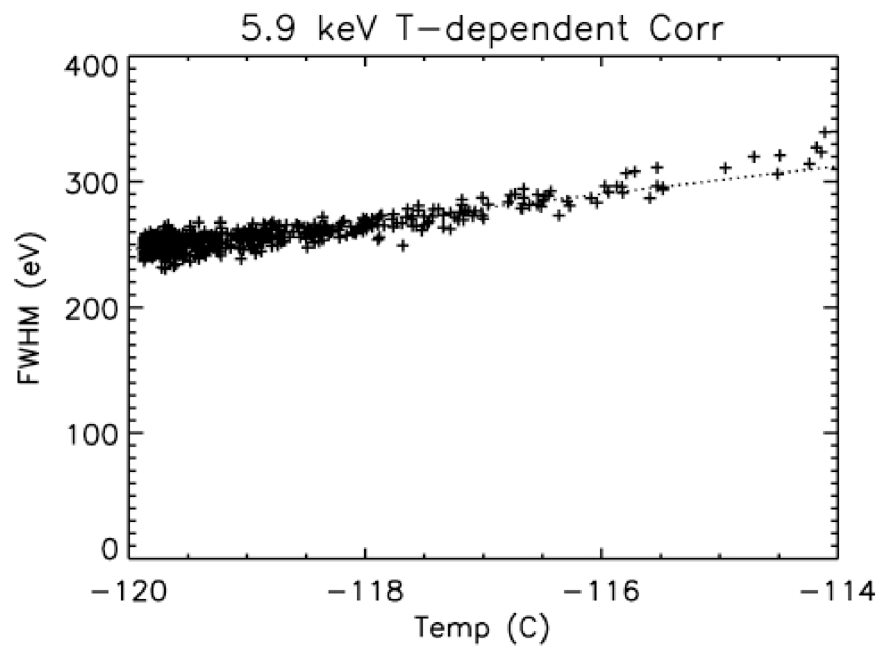
Temperature-dependent pulseheight change (% / deg)

	1.5 keV	6 keV
Standard	–0.7%	–0.4%
Average T	–0.04%	+0.1%
Dynamic T	–0.05%	+0.1%

- Reduces temperature dependence of pulseheight
- >99% of observations now within 0.3% pulseheight calibration goal
- Using mean temperature seems adequate

Performance of adjusted corrector





Temperature-dependent FWHM change (eV / deg)

	1.5 keV	6 keV
Standard	+3.8 eV	+11.2 eV
Average T	+3.2 eV	+11.4 eV
Dynamic T	+3.1 eV	+10.7 eV

- Very small reduction in temperature dependence of line width
- At 6 keV, dynamic temperature is better than average

Status of adjusted corrector

- New algorithm removes pulseheight dependence
  - Need to verify at energies < 1.5 keV
- New algorithm provides minimal improvement to line width
  - Magnitude of width change may be acceptable as is
- Not likely to be implemented in `a_p_e` soon
- Further work needed
  - Why is the FWHM improvement so small?
  - Do we need to follow the temperature variation? Is the mean good enough?
  - Can this be implemented as a gain tweak like t_gain?

ACIS temperature and you

- How to find the mean temperature of your observations?
  - Header of event list file *_evt2.fits
  - Keyword: FP_TEMP, in Kelvin
- How to view the temperature profile during your observations?
  - Mission timeline file *_mtl1.fits in secondary directory
  - Plot TIME vs FP_TEMP in your favorite plotting program
- Nominal calibrated temperature is –119.7°C