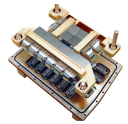


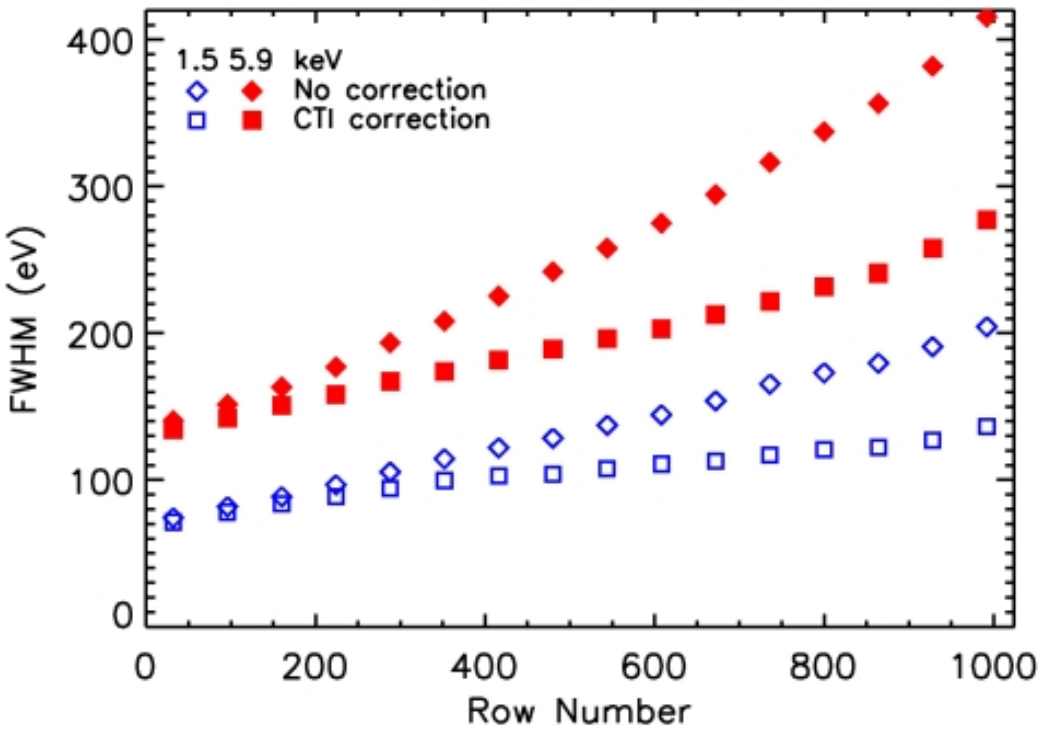
Developing contributed software to correct for the temperature dependence of ACIS CTI

Jennifer Posson-Brown (SAO), Catherine Grant (MIT),
Glenn Allen (MIT), Paul Plucinsky (SAO), Dale Graessle (SAO)
and the ACIS calibration team

Summary

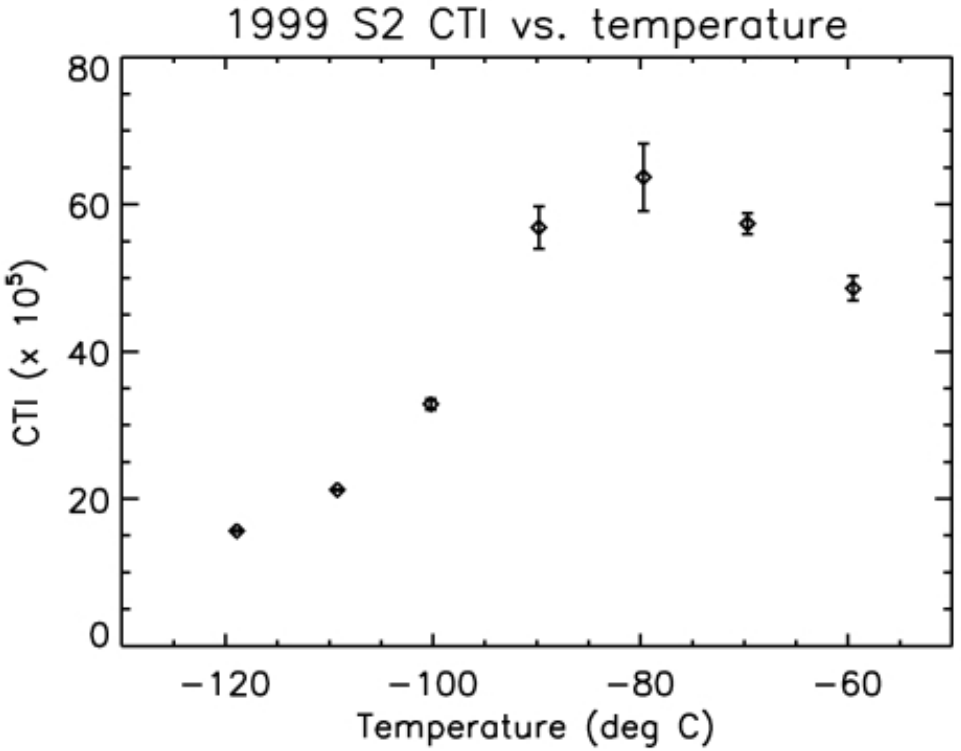
- Part I: Motivation and CTI model
  - Temperature-dependent performance
  - Focal plane temperature excursions
  - Adjusting the correction model
  - Performance of the adjusted algorithm
- Part II: Developing the contributed software

ACIS CTI correction



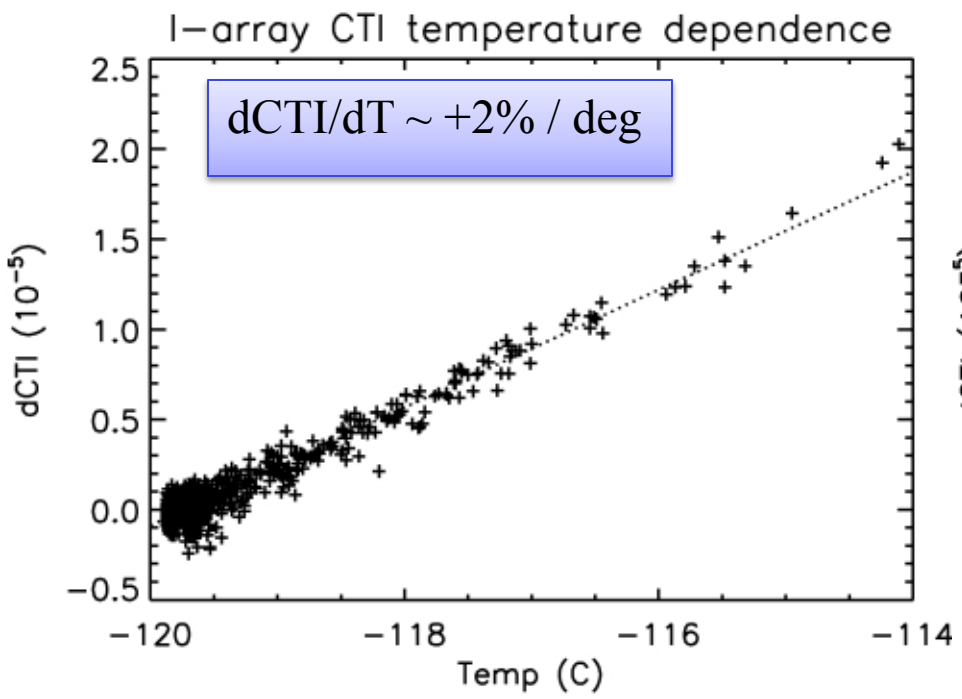
- Incorporated into *CIAO* tool `acis_process_events`
- Reconstruction of original X-ray event island
- Removes position dependence of pulseheight
- Significantly improves spectral resolution and detector uniformity
- Charge loss is stochastic – cannot recover all of lost performance

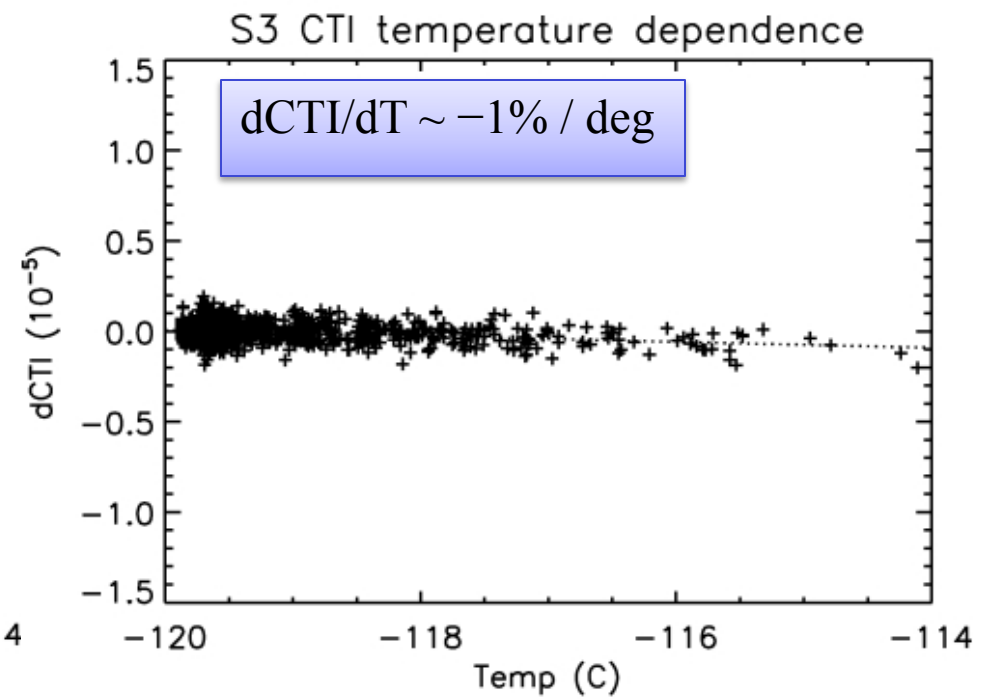
CTI is temperature dependent



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

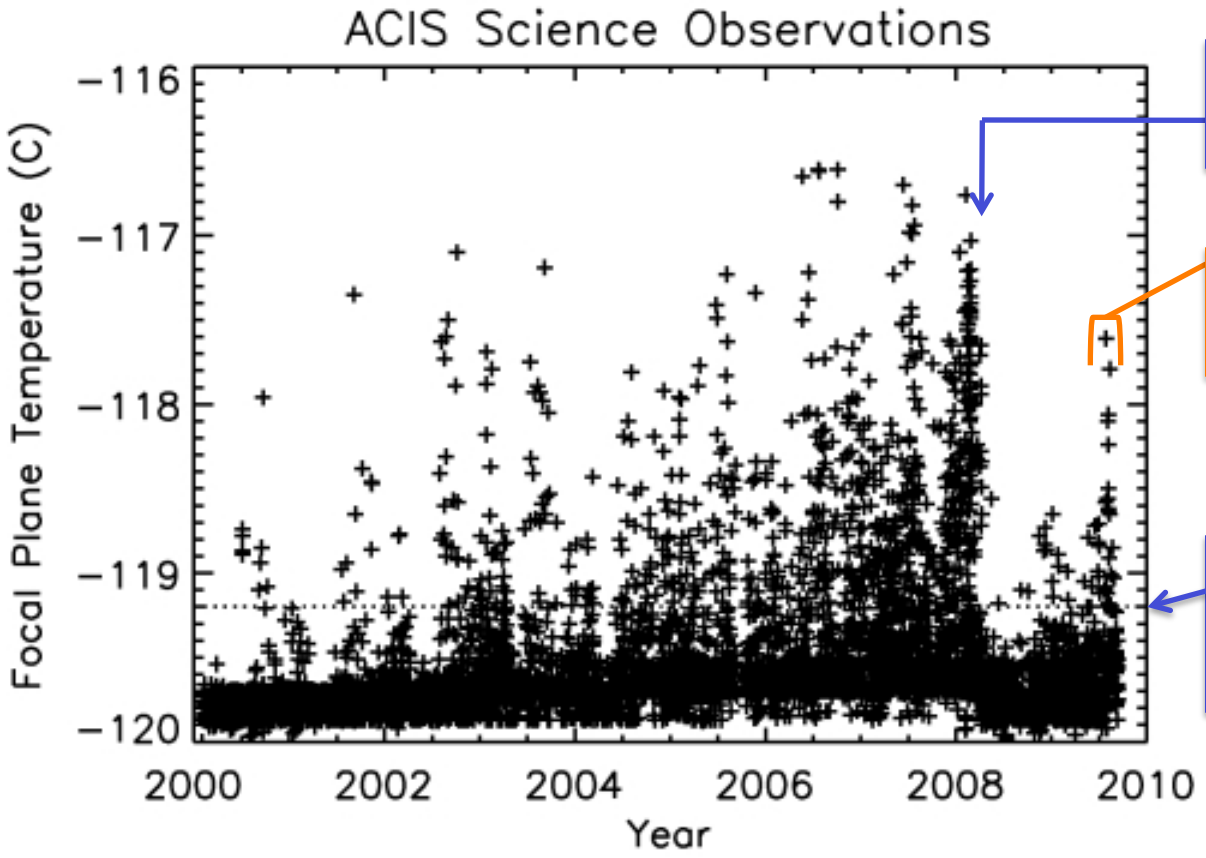
CTI dependence on temperature





- Charge traps have temperature dependent re-emission time constants
- Roughly linear for small temperature deviations
- Causes temperature dependent performance
- More important for FI than BI CCDs

Focal plane temperature excursions



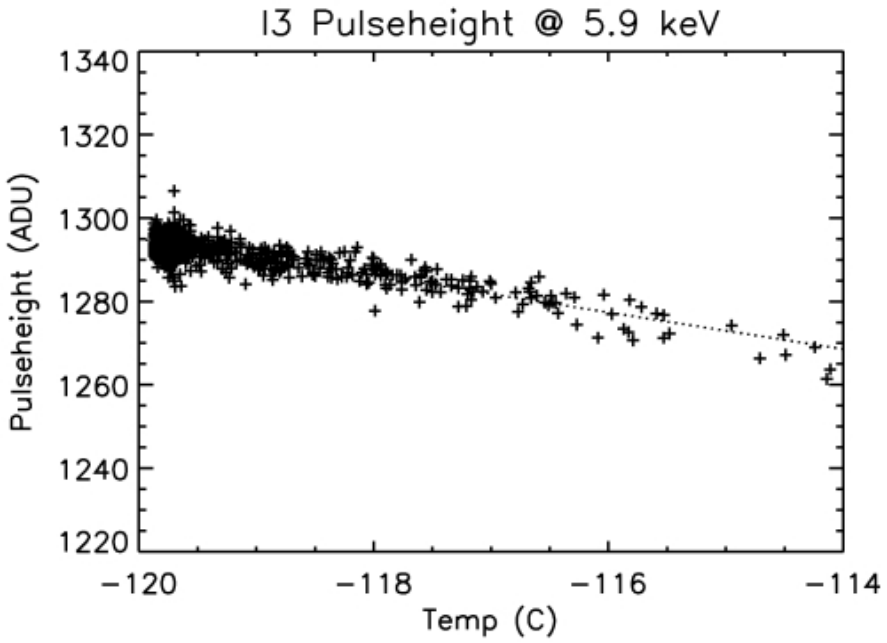
Detector housing heater permanently shutoff

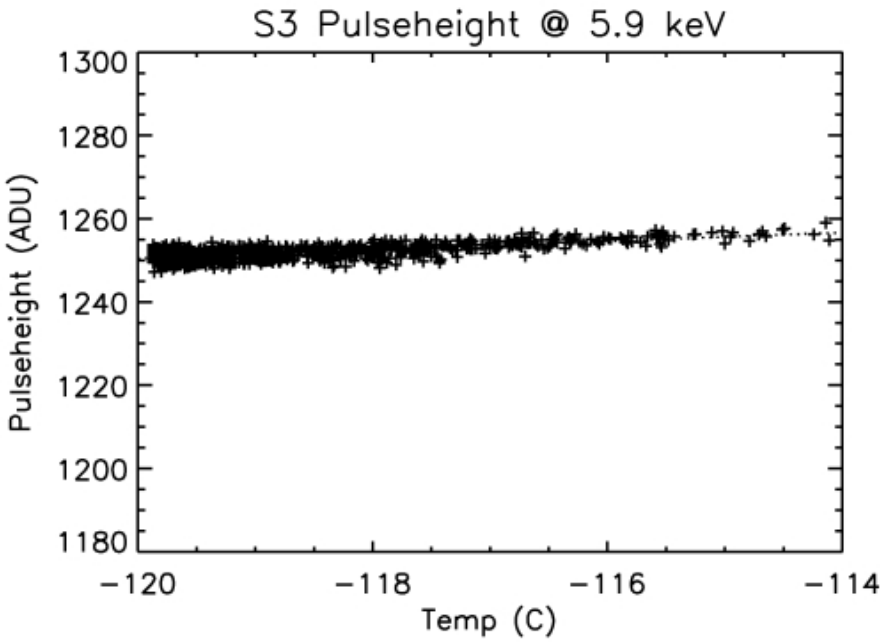
Exclusive "tail-sun" orientation

Gain calibration accuracy goal for I-array aimpoint met when T < –119.2ºC

- ACIS cooling is less efficient in some Chandra orientations
  - Other spacecraft constraints not always favorable for ACIS
- In 2000, 99% of observations < –119.2ºC; in 2007, 68%
- For more on temperature history and other mitigation strategies, see poster C.22 by C. Grant

Implications for calibration: gain



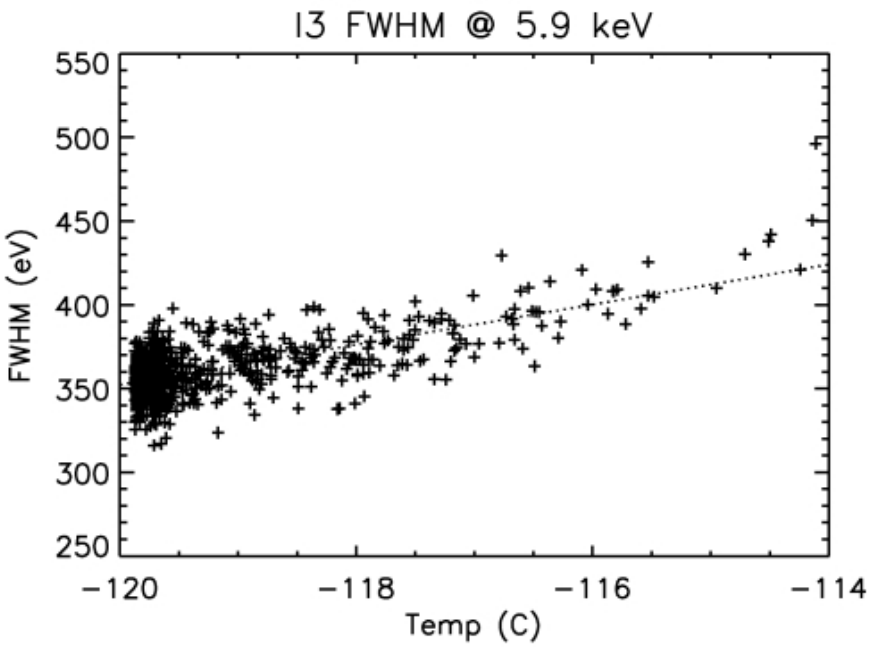


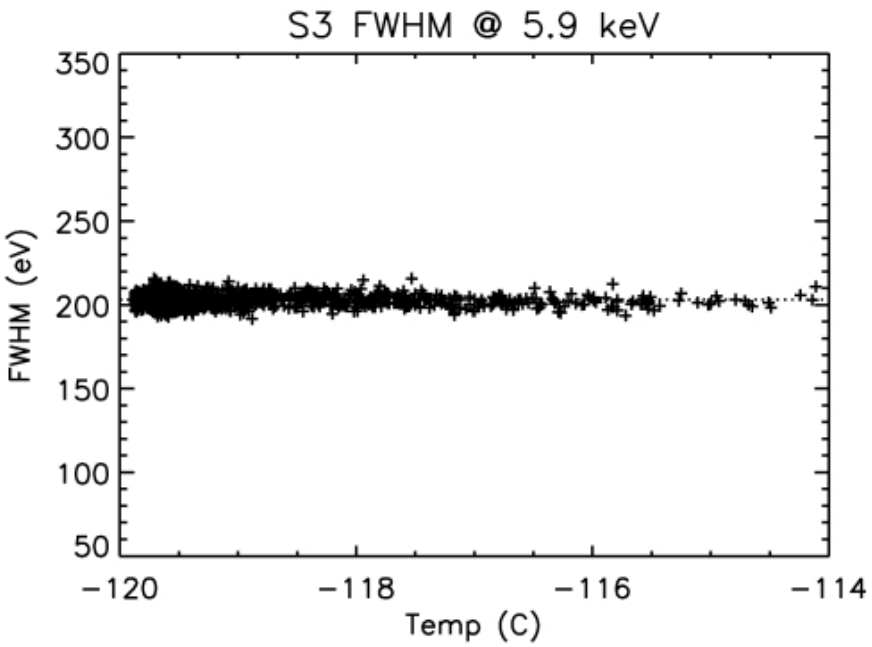
Temperature-dependent pulseheight change (% / deg)

	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



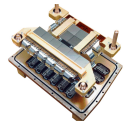


Temperature-dependent line width change (eV / deg)

	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

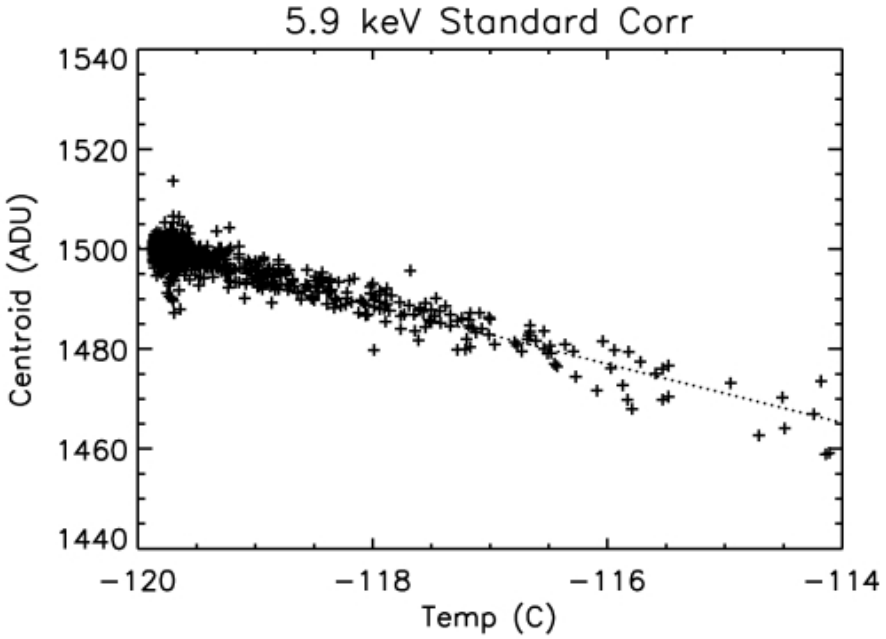


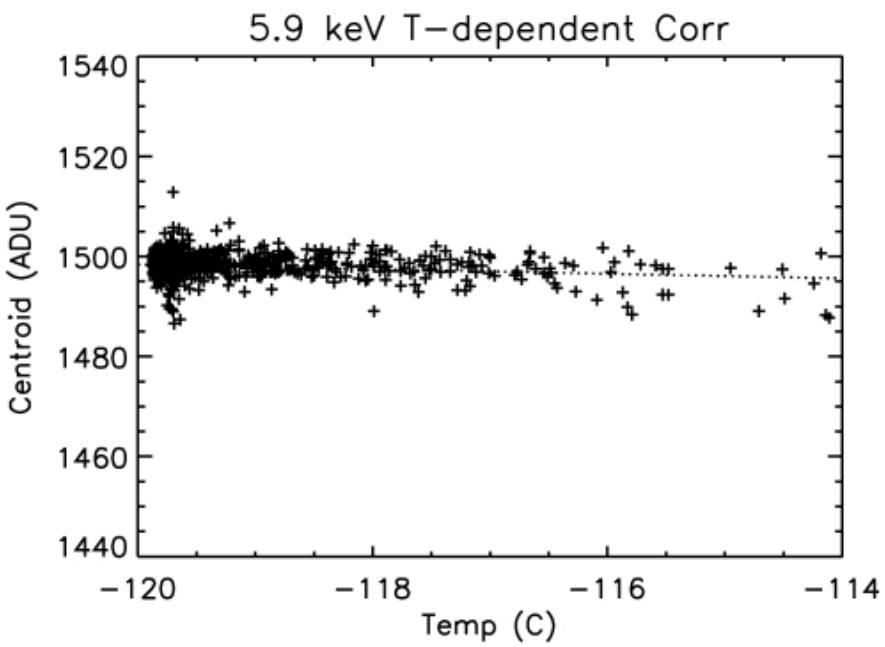
- Significant changes for some CCDs/locations
- Warmer temperatures are uncontrolled
  - Variation within a single observation as high as 3-4°C
- Scientific impact varies:
  - High: line-rich spectrum, ACIS-I, high S/N
  - Low: continuum spectrum, ACIS-S3, low S/N
- Possible mitigation strategies:
  - Turn off heaters (DH Apr ‘08, SIM FA6 testing now)
  - Add constraints on spacecraft pitch angle (complicates MP)
  - Increase nominal FP temperature (degrades FI CCD performance; requires lengthy recalibation)
  - Include temperature-dependence in CTI correction

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
- Position dependence and magnitude of charge loss stored as "trapmaps"
- Trapmap ∝ CTI
  - Use linear fit to CTI-temperature dependence to adjust trapmap for each CCD frame
  - Correction algorithm otherwise remains the same

Performance of adjusted corrector



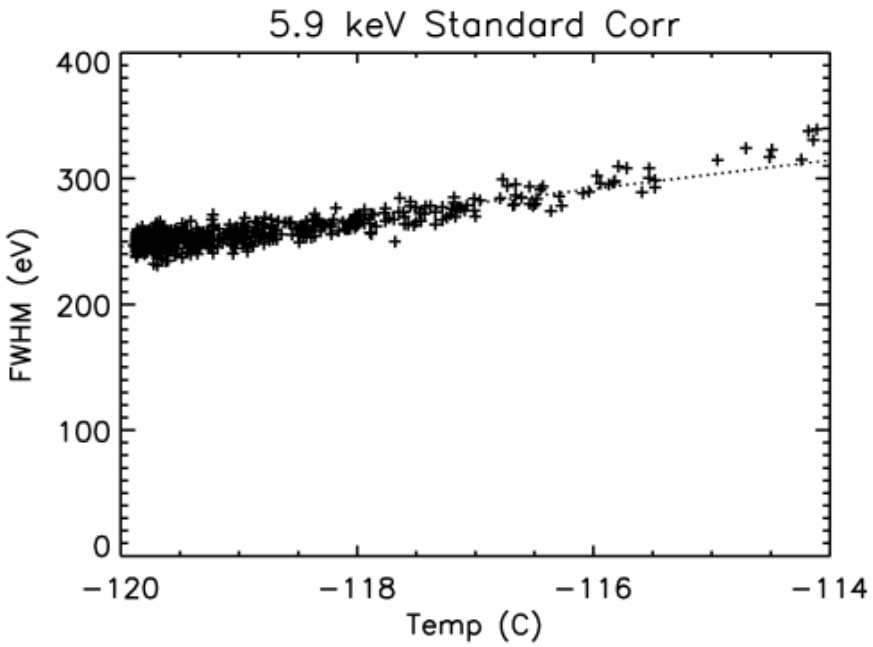


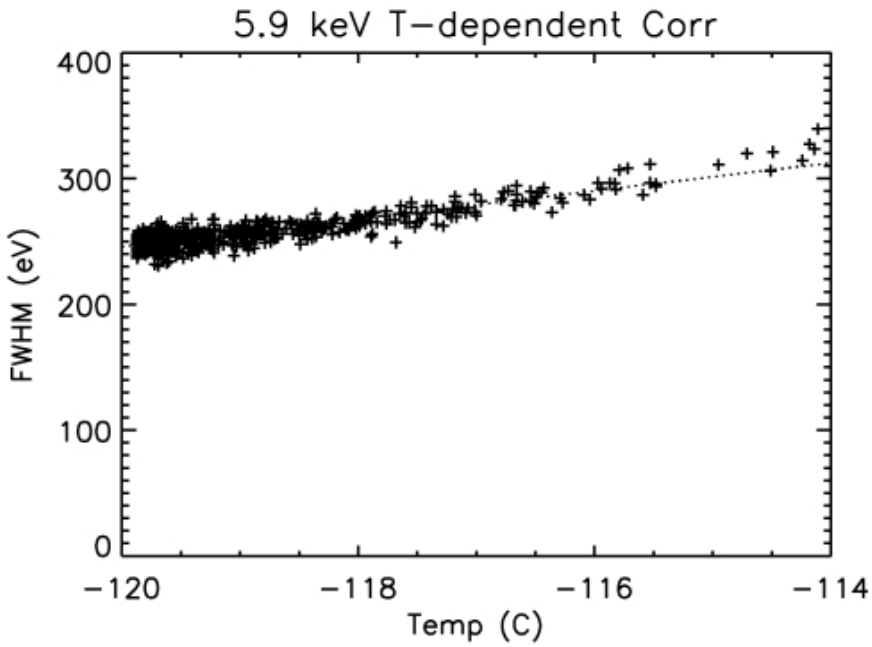
Temperature-dependent pulseheight change (% / deg)

	1.5 keV	6 keV
Standard	–0.7%	–0.4%
T-dependent	+0.03%	–0.07%

- Reduces temperature dependence of pulseheight
- >99% of observations now within 0.3% pulseheight calibration goal

Performance of adjusted corrector





Temperature-dependent FWHM change (eV / deg)

	1.5 keV	6 keV
Standard	+3.8 eV	+11.2 eV
T-dependent	+3.2 eV	+10.6 eV

- Very small reduction in temperature dependence of line width
- Stochastic charge loss – may not be possible to do much better