Evolution of ACIS Response

Chandra Calibration Workshop
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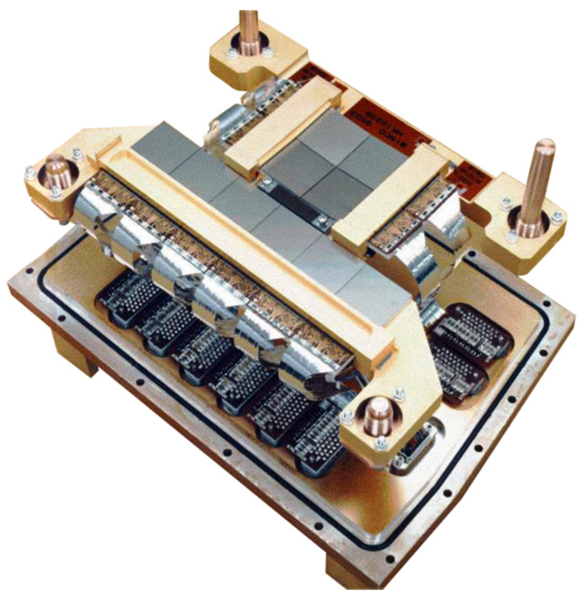
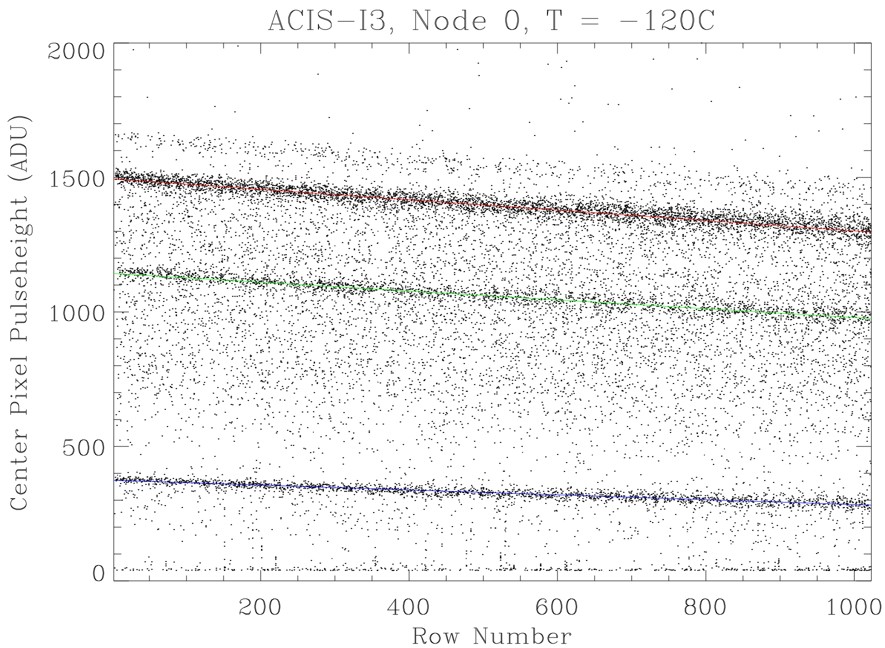
and the ACIS IPI team



- A brief introduction to CTI
- CTI evolution: FI and BI CCDs
- Detector gain evolution
- Effect on data analysis: Energy scale and spectral resolution
- Checking calibration validity

A Brief Intro to Charge Transfer Inefficiency



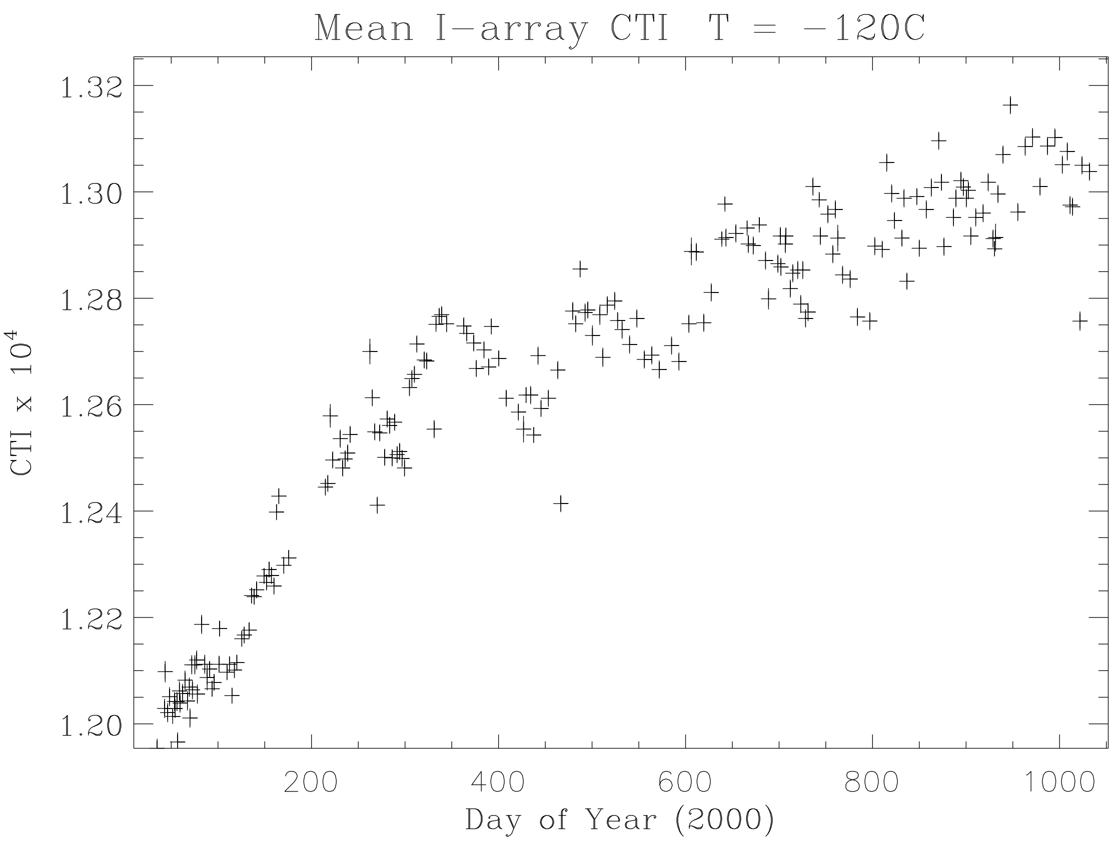
CTI, fractional charge loss per pixel, depends on

- Location of charge traps (imaging, framestore, serial arrays)
- Density of charge trapping sites
- Charge trap capture and re-emission properties
- Occupancy of charge traps

How does CTI influence performance?

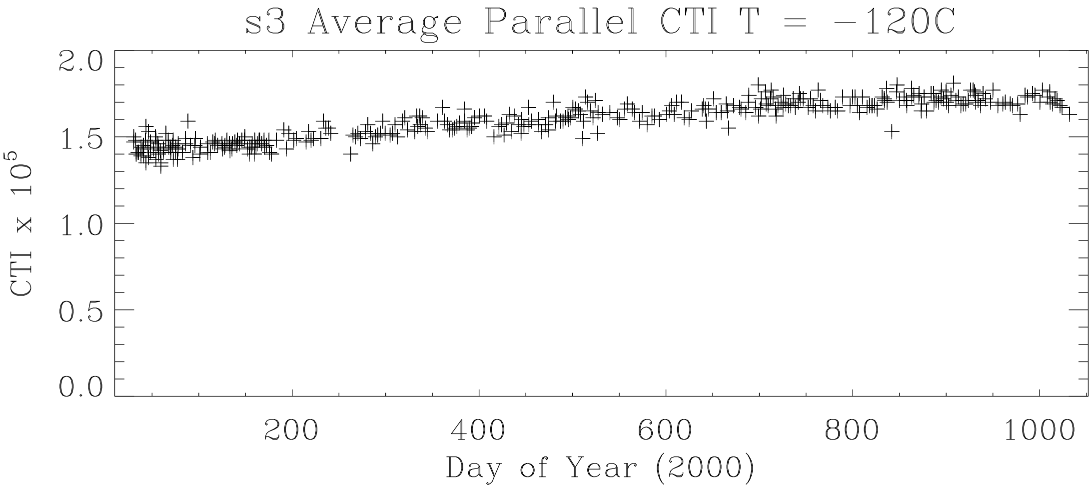
- Charge loss leads to position dependent gain
- Spectral resolution degradation from
  - Stochastic charge trapping/re-emission
  - Trap density nonuniformity
  - Variations in trap occupancy - sacrificial charge

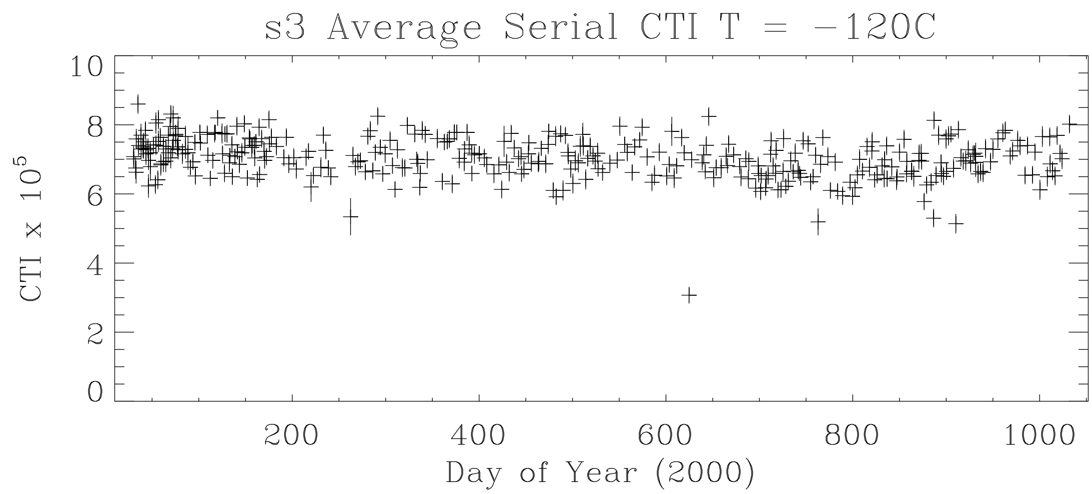
CTI Evolution: Front-illuminated CCDs



- Pre-launch CTI $< 3 \times 10^{-6}$
- After initial radiation damage
  - Parallel CTI $\sim 1 - 2 \times 10^{-4}$
  - Framestore and serial arrays undamaged
- Slow gradual increase over 3 years, ΔCTI $\sim 1 - 1.5 \times 10^{-5}$

CTI Evolution: Back-illuminated CCD

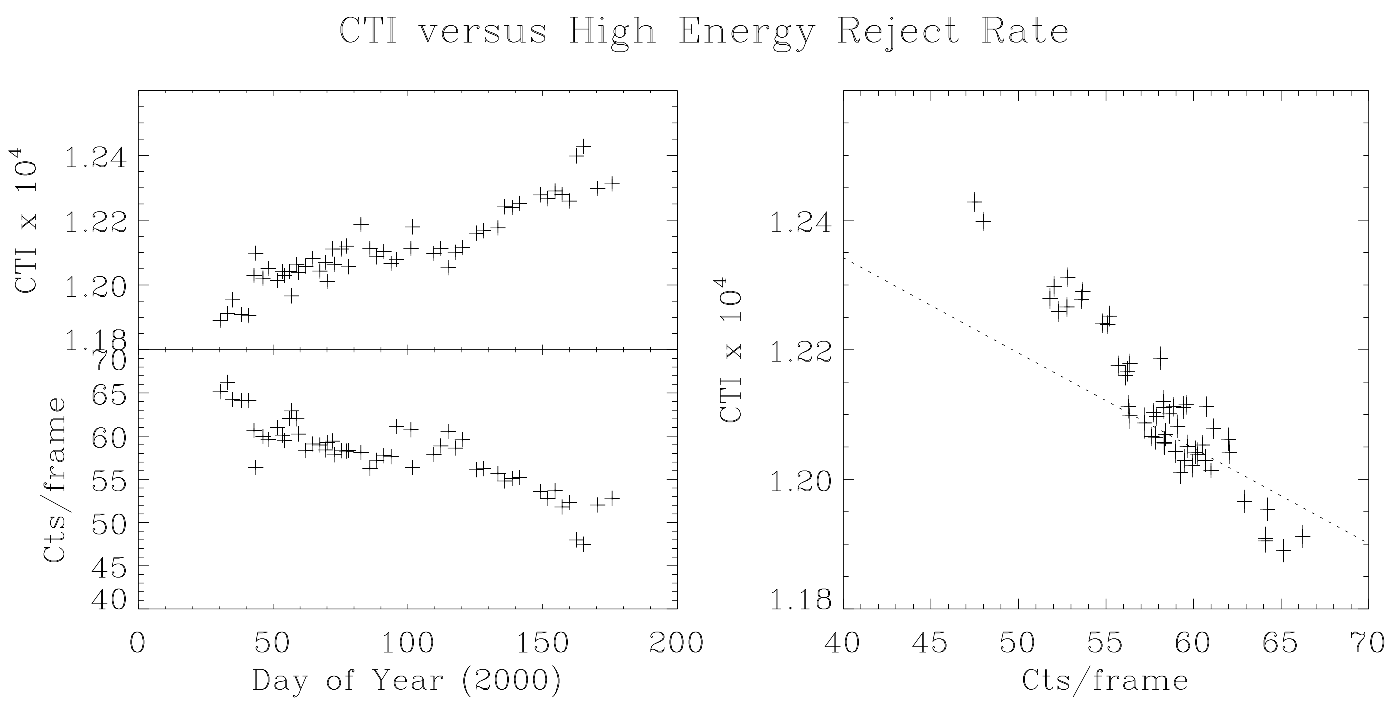




- Pre-launch
  - Parallel CTI $\sim 1.4 \times 10^{-5}$
  - Serial CTI $\sim 7 \times 10^{-5}$
  - Imaging, framestore and serial arrays
- Slow gradual increase over 3 years,
  - Parallel ΔCTI $\sim 3 \times 10^{-6}$
  - Serial ΔCTI $< 5 \times 10^{-6}$

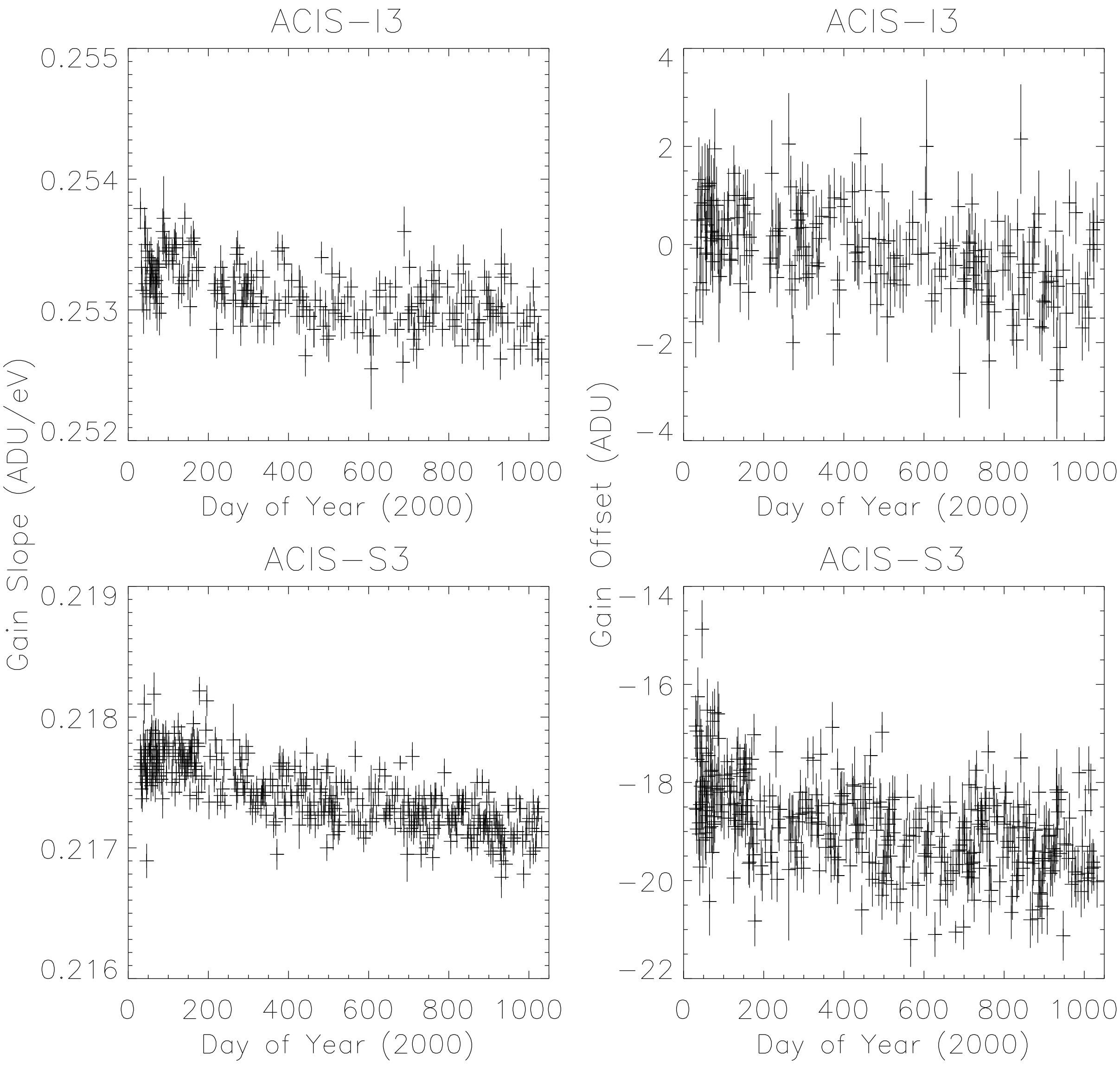
CTI Evolution: Sacrificial Charge

- Charge loss is dependent on density of empty charge traps
- Sacrificial charge – charge deposited along readout path of event fills electron traps, changes CTI
- Most sacrificial charge on ACIS is due to cosmic ray events
- Some apparent CTI changes are due to the changing background

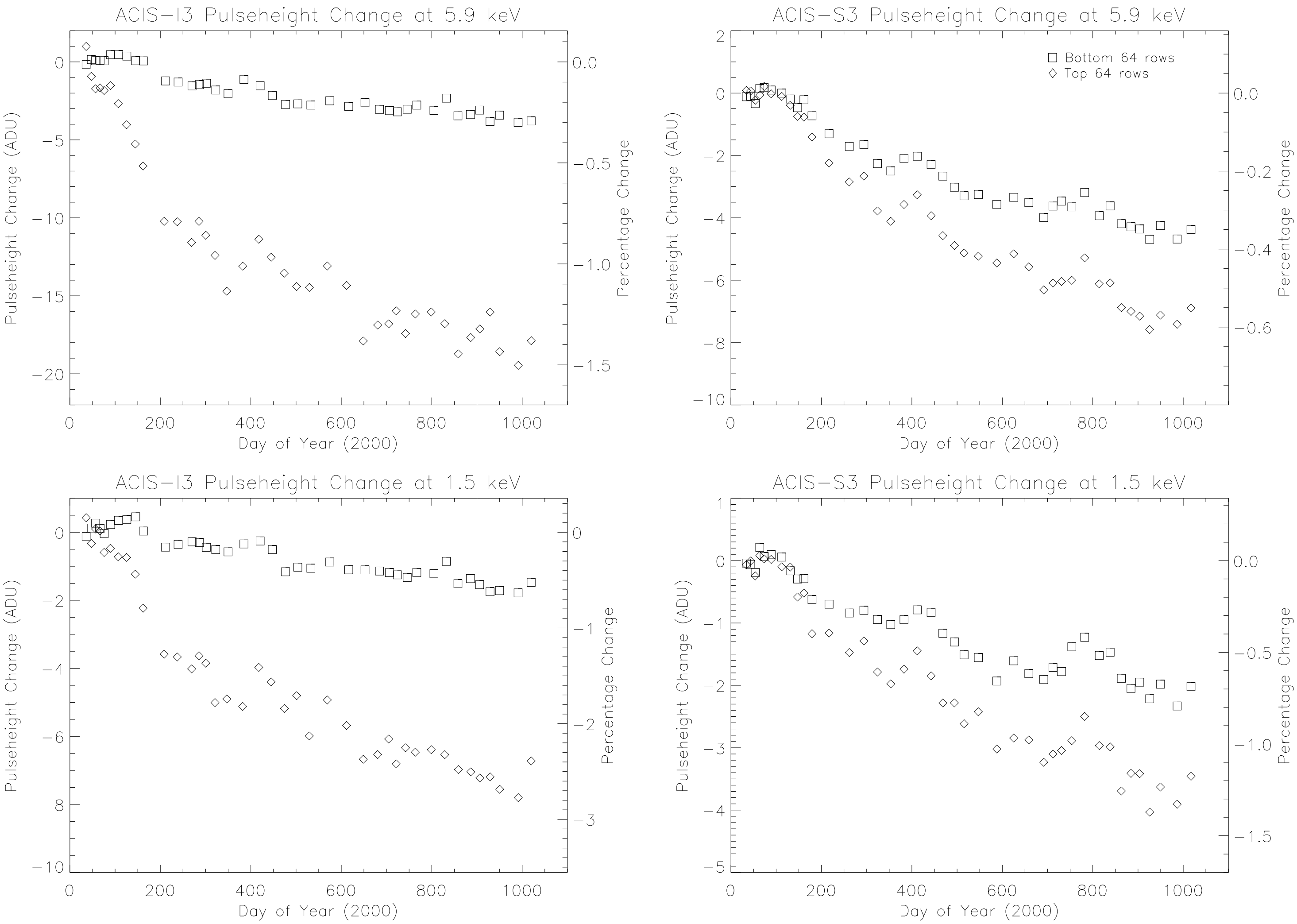


Detector Gain Evolution

- Detector gain measured near framestore, unrelated to CTI
- Linear fit to three energies (1.5, 4.5, 5.9 keV)
  PHA (ADU) = Gain (ADU/eV) * Energy (eV) + Offset (ADU)
- Slope and offset of linear gain fit are slowing decreasing



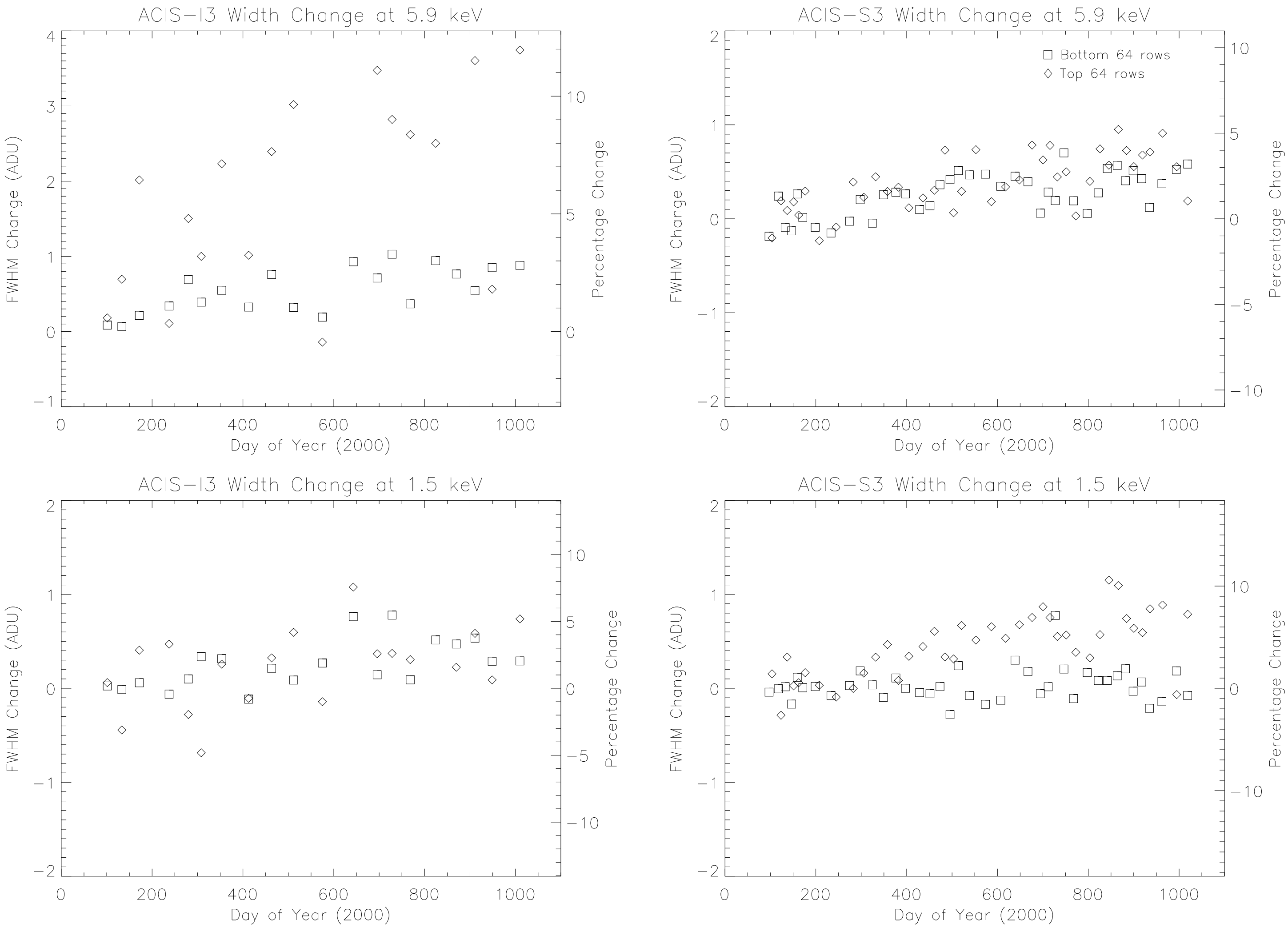
Effect on Data Analysis: Energy Scale



Position dependent pulseheight change Jan 2000 to Oct 2002

- ACIS–I3 FI CCD
  - 0.3 – 1.5 % at 5.9 keV
  - 0.5 – 2.7 % at 1.5 keV
- ACIS–S3 BI CCD
  - 0.4 – 0.6 % at 5.9 keV
  - 0.7 – 1.3 % at 1.5 keV

Effect on Data Analysis: Spectral Resolution



Position dependent resolution change Jan 2000 to Oct 2002

- ACIS–I3 FI CCD
  - 1 – 4 ADU (4 – 12 %) at 5.9 keV
  - $<$ 1 ADU ($\sim$ 7 %) at 1.5 keV
- ACIS–S3 BI CCD
  - $<$ 1 ADU ($\sim$ 5 %) at 5.9 keV
  - 0 – 1 ADU (0 – 9%) at 1.5 keV

Checking Calibration Validity

- Current ACIS reponse products are not time-dependent (but will be in the future)
- Response products will always be based on the "average" performance over some Δt
- Can use external calibration source to confirm validity of response products for a particular time period
- Cal source data taken twice an orbit

- Find cal source ObsID(s) close to science time
  - Avoid temperature excursions & experimental modes
  - Temporary listing of good cal source ObsIDs at: `http://space.mit.edu/~cgrant/obsids/`

- Retrieve cal source data from:
  - `cdaftp` (level 2 only, directory `er/`)
  - Provisional Retrieval Interface (level 1 and 2)

- Analyze using same extraction region and RMF as science target
- Fit line energies and widths
  Mn-Kα (5898 eV), Ti-Kα (4510 eV), Al-K (1487 eV)