
Characterization and Correction of ACIS CTI in the Continuous Clocking Mode

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- A look at the CC-mode CTI performance
 - Facts & figures about the CC mode
 - Some scatterplots & spectra
 - Grade morphing
- Toy CTI corrector for CC-mode data
 - Trend of trailing pixel vs central pixel PHAS
 - Easily removed
 - Background suppressed by requiring $\text{uppix} < \text{centerpix} - 2\text{spl_thr}$
 - Nothing is done with other pixels in 3x3 island (yet)

CC mode facts and figures

- CHIPY info sacrificed in favor of timing
- CCDs clocked continuously at 2.85 msec per row
- cf. TE mode clocking rate of 41.12 μ sec per row
- Sensitive to longer-lived traps; there's much more charge recovery in trailing pixels in CC mode
- Lots of grade morphing into fltgrades with charge in trailing pixels. (e.g. grade 0 \mapsto grade 64)
- New CC bias algorithm implemented in flight software 6/14/2005, resulting in 2.1 ADU shift in bias. (We should calibrate this out eventually.)

Data:

- External Calibration Source data, keeping all but fltgrade 255
- HETG/ACIS and LETG/ACIS data in CC mode
- Some datasets are in graded CC mode.

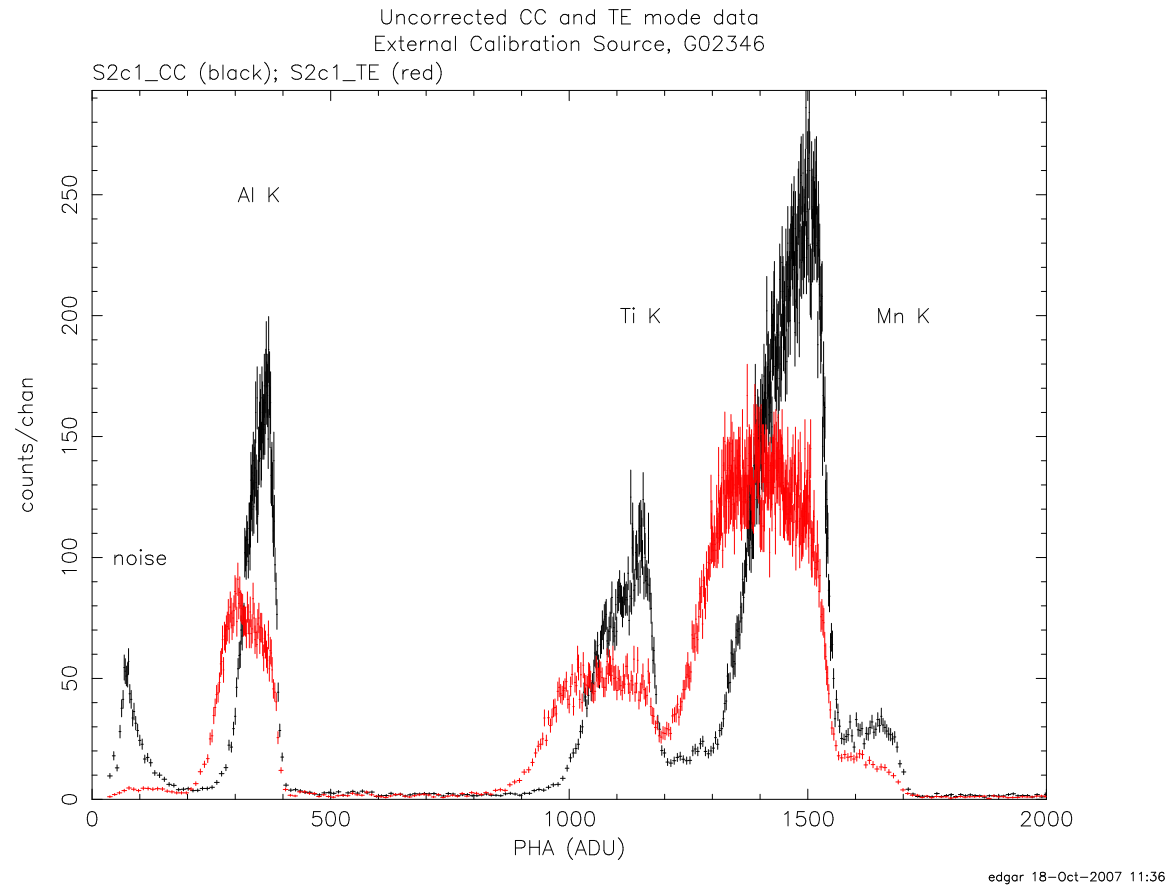


Figure 1: Uncorrected CC (black) and TE (red) mode spectra of the External Calibration Source. Note TE lines are wider (more total charge loss) and flat-topped (QE more uniform vs CHIPY?)

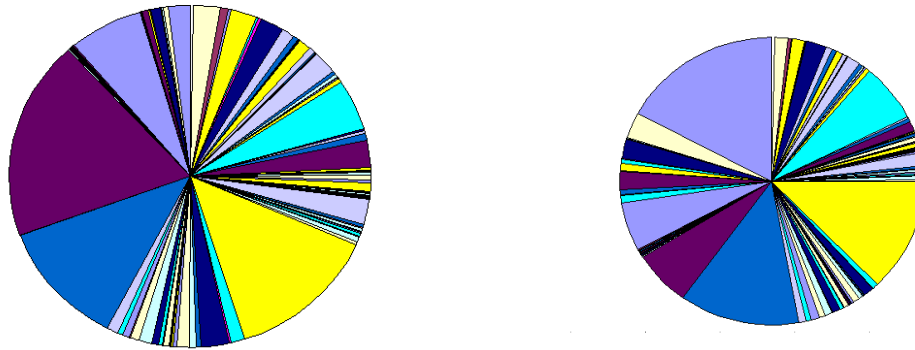


Figure 2: Pie charts of flight grade ratios in CC (left) and TE (right) modes

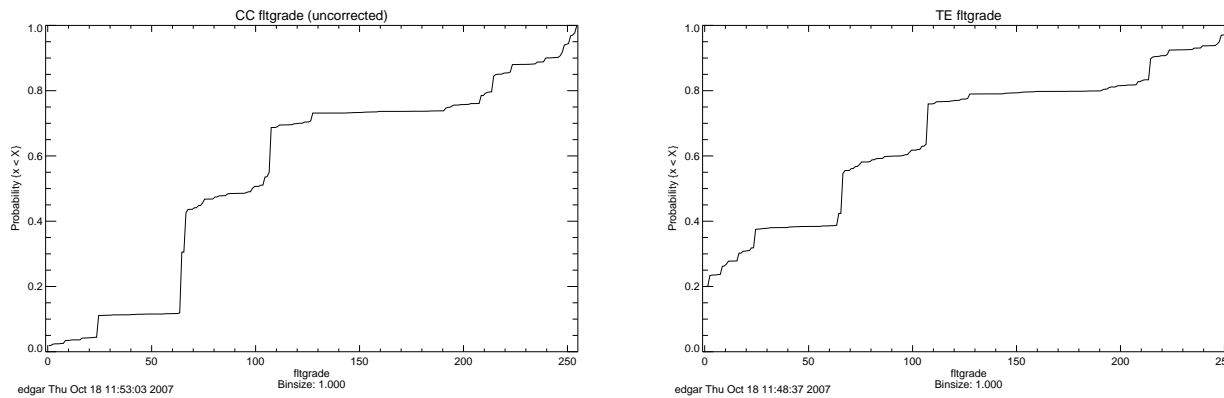
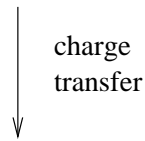


Figure 3: Cumulative distributions of flight grade ratios in CC (left) and TE (right) modes

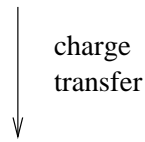
ACIS flight grade bits

32	64	128
8		16
1	2	4

ACIS flight grade 64



32		128
8		16
1	2	4



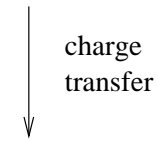
ACIS flight grades (fltgrade) record which of the 8 pixels surrounding a local maximum have charge in them, above the split threshold.

Many CC-mode events have charge in the upper pixel (fltgrade 64) or both upper and lower pixel (fltgrade 66)

Seven flight grades, including 66 and 255, are discarded on board.

ACIS fltgrade 66

32		128
8		16
1		4



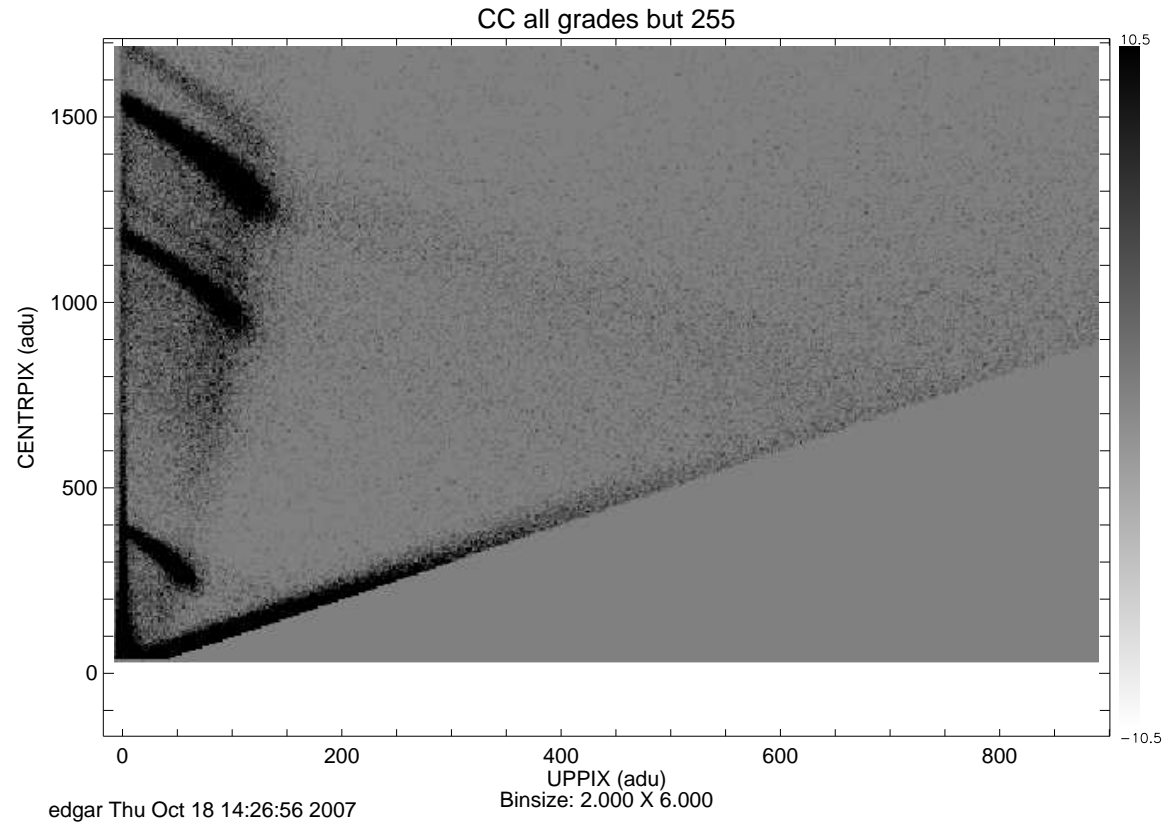


Figure 4: CC mode scatterplot: centerpix vs uppix. Note sloping spectral lines, indicating some charge lost from centerpix is recaptured in uppix.

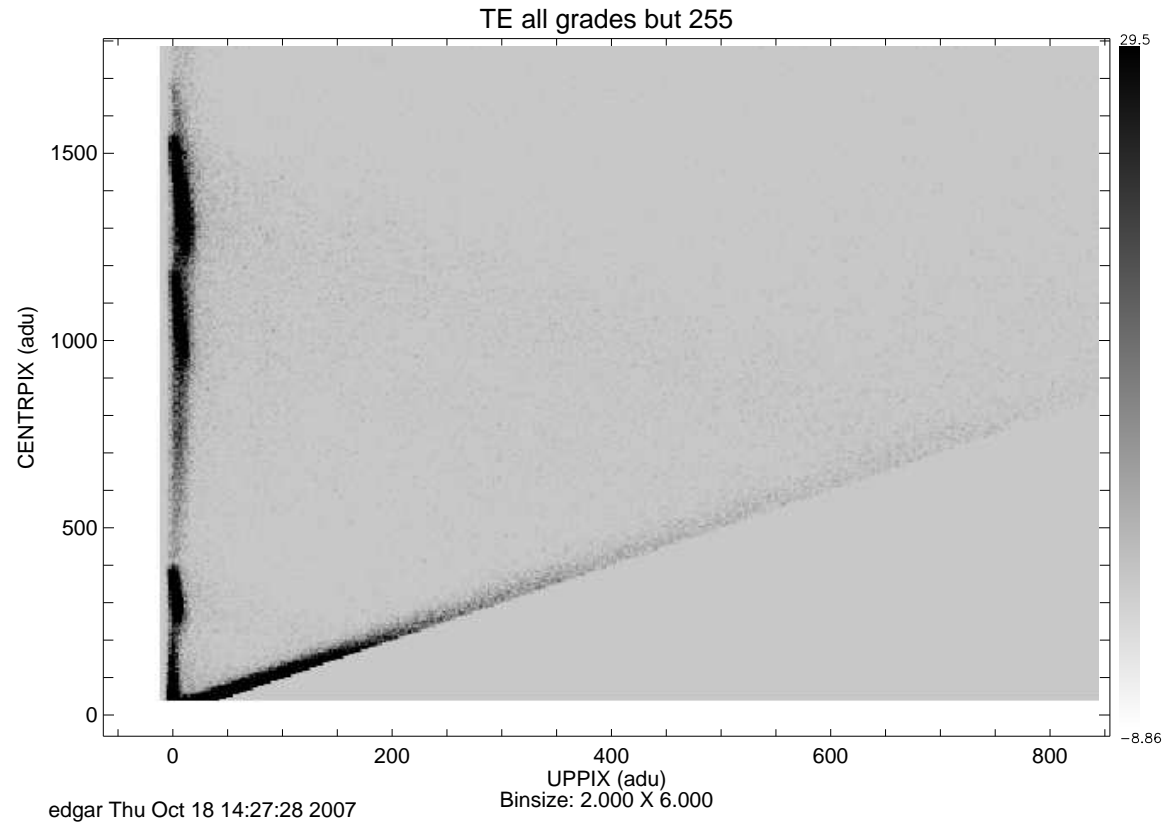


Figure 5: TE mode scatterplot: centerpix vs uppix. Steeply sloped spectral lines indicate charge lost from centerpix is mostly *not* recaptured.

Consider the CC-mode scatterplot of centerpix PHA vs. uppix PHA.

- Spectral resolution can be regained by rotating the figure
- Fitting trends in the strong lines shows a slope of about -2.2 for each
- i.e. For each 2.2 ADU of charge lost from centerpix, 1.0 ADU of charge is recovered in uppix
- There's a limiting maximum charge loss that varies as \sqrt{E} .
- There's a smattering of events with more charge in uppix; these may be native g64 events.
- There are many background events with $\text{uppix} \approx \text{centerpix}$

This suggests an algorithm:

- for charge in uppix up to max, replace at a ratio of 2.2/1.0 into centerpix
- Leave alone events with $\text{uppix} > \text{centerpix} - 2\text{spl_thr}$

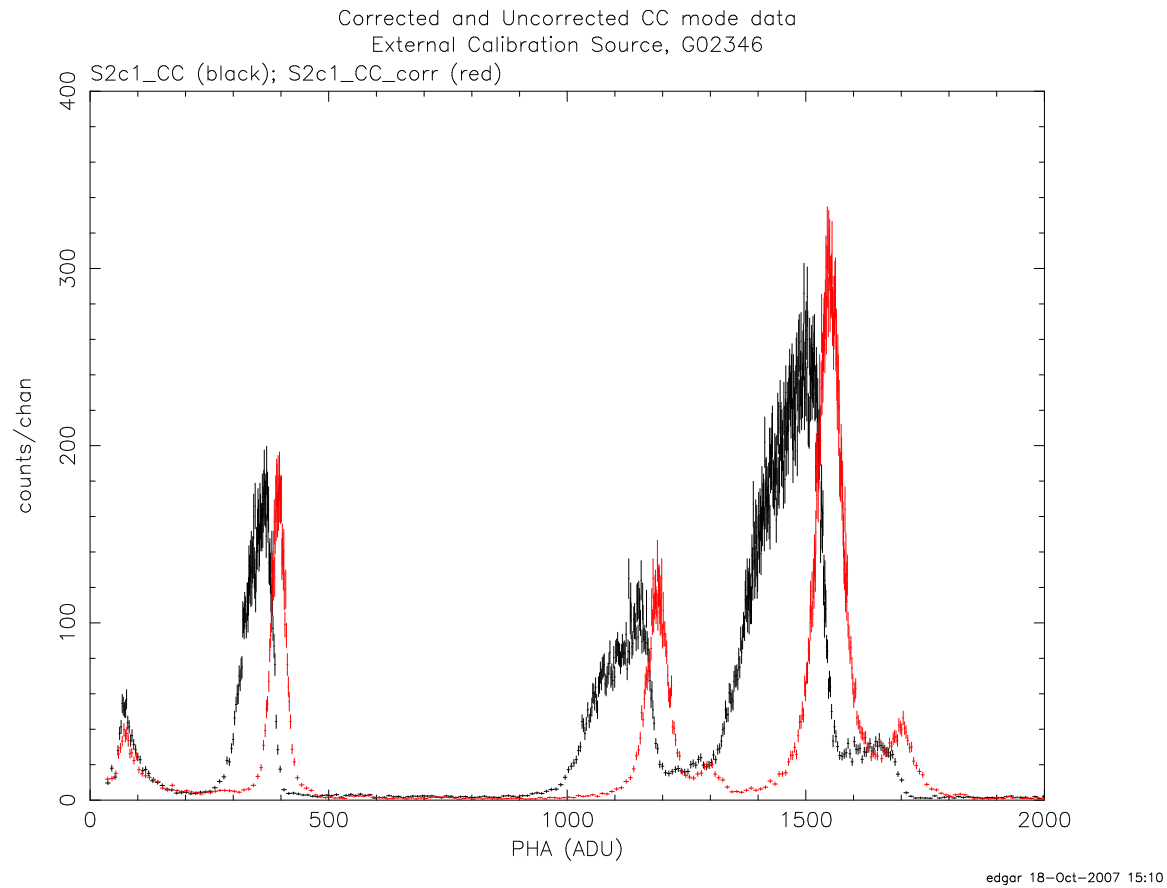
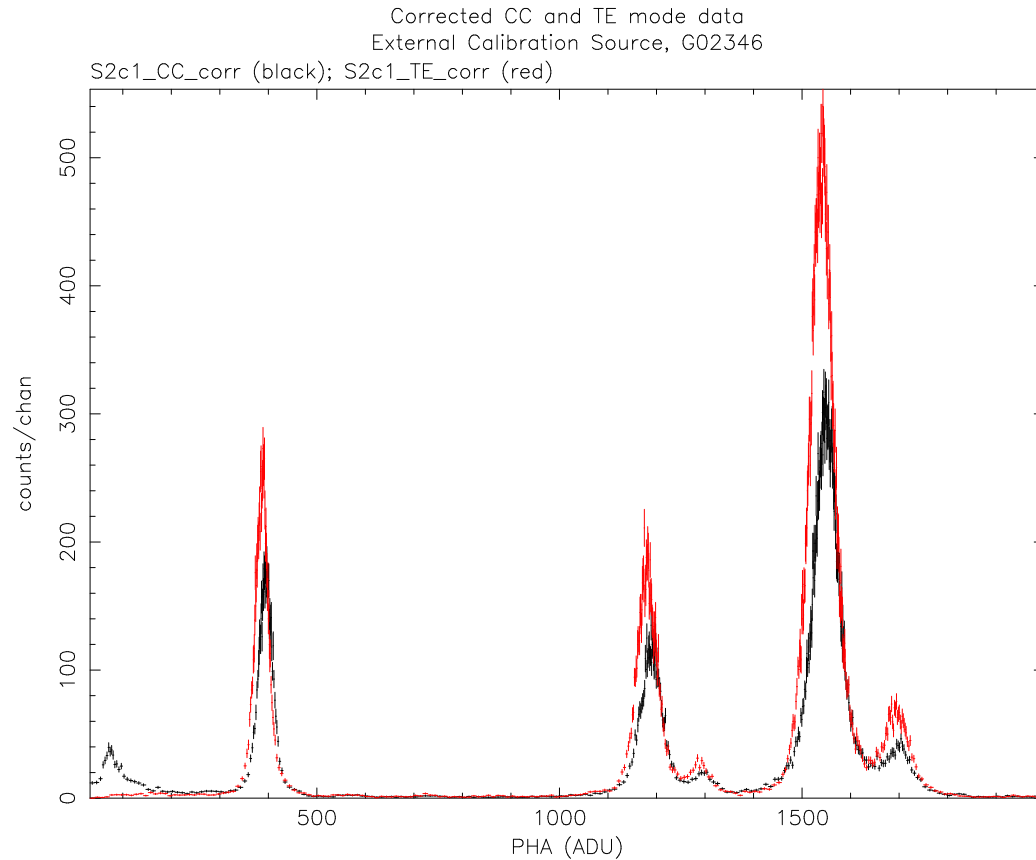


Figure 6: CC-mode spectra with and without CTI correction.



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Figure 7: CC and TE-mode spectra with CTI correction. Note comparable line profiles.

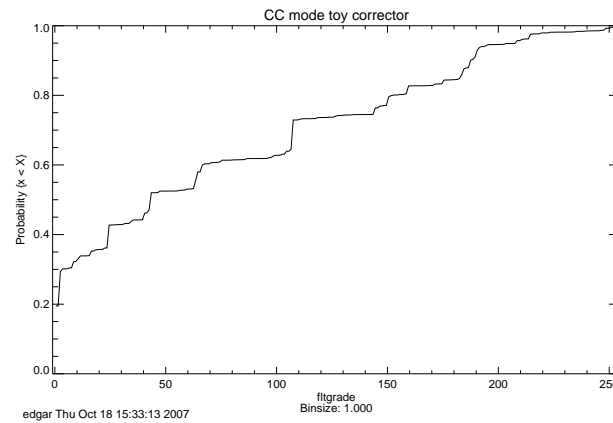
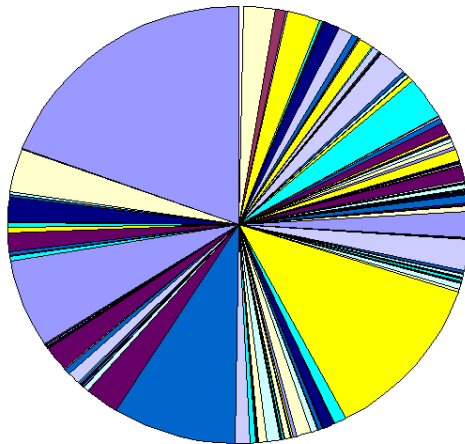
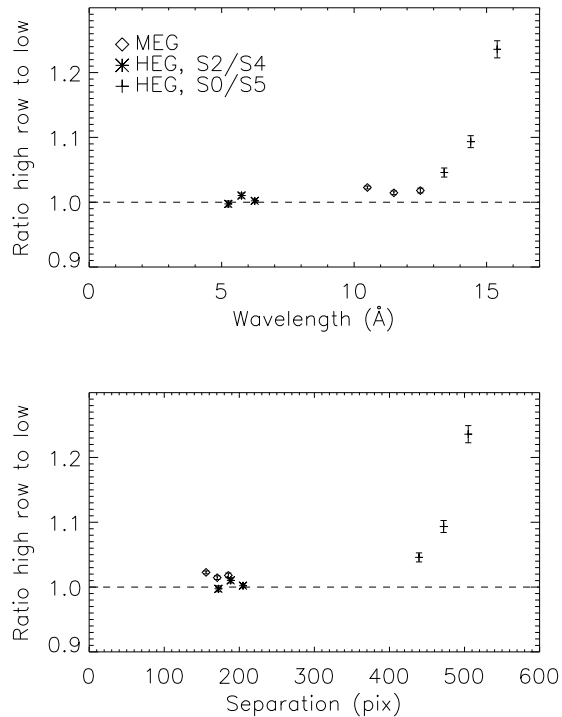


Figure 8: Grade ratios for toy corrector with CC mode data. Compare to TE mode in Figure 2.

ACIS CALDB products, and the CC mode:

- *Should* be same as TE:
 - contam, evtsp, grade, disp_reg, gtilim
 - qe (but maybe not qeu)
 - dead_area (same to first approx?)
- May well be different:
 - cti (new kinds of calibrations for toy corrector)
 - p2_resp (looks pretty similar with toy corrector)
 - gain, t_gain
 - osip
 - qeu – even the sign of the effect is unknown
- Dunno about:
 - bkgrnd
 - badpix (presumably only bad columns or really bright single pixels)
 - pimms (only if qeu or osip changes?)
- N/A or obsolete: fef, rmf, 2dpsf



Outstanding issues–QEU:

- Some real x-rays end up in flight grade 66, normally discarded onboard. The QE should be adjusted for this.
- Careful treatment of exposure time and what happens to events during (toy) CTI correction may shed light on the QE
- Sloping line tops in ECS spectra suggest some events are lost due to CTI.
- HETGS +1/-1 order ratio suggests some bad events are recovered to good grades by CTI.
- these last two effects have opposite sign, and magnitudes are not well understood at present.

Outstanding Issues (see also Norbert Schulz, this meeting)

- The existing osip files are probably adequate, even without CTI correction, in most circumstances.
- Most CC-mode data are taken with gratings. CHIPY coordinates can be reconstructed, after order sorting.
- The toy CTI corrector cannot be used with the CC-graded mode. But see Alexey Vikhlinin (this meeting) re: TE Graded mode CTI correction
- QEU needs to be looked at, as does QE (due to grade morphing into/out of g66)
- Grating data can be used to assess existing response & gain files
- Upcoming E0102 CC-mode observation can extend this work to lower energies
- Further work on CTI corrector, and calibration of other nodes & chips (so far just S2c1)
- Possible overcorrection of native g64 events produces a hump on the hard side of the Al K- α line profile.
- Careful examination of residual low-PHA noise may suggest solutions to this problem

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