CCD charge transfer efficiency of the Advanced Camera for Surveys

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Abstract

The CCDs of the Advanced Camera for Surveys (ACS) will suffer from declining charge transfer efficiency (CTE) as radiation damage from the space environment accumulates. We present preliminary results of our CTE monitoring efforts, now that ACS has been in orbit for about 10 months. While CTE is not expected to have a significant effect on Cycle 11 ACS science observations, we describe plans to mitigate and calibrate the effects of CTE loss as it becomes more severe with time.

CTE becomes a significant issue as flight CCDs age. This has been well-documented for *Hubble Space Telescope* instruments:
http://www.stsci.edu/hst/acs/performance/cte_workgroup/cte_papers.html

Monitoring CTE provides a forecast of the scientific "shelf-life" of flight CCDs -- important for prioritizing the science program of this limited resource.

Calibrating CTE for science data becomes essential to extending the useful lifetime of flight detectors. We plan to develop a robust CTE calibration for ACS science data, e.g. some function of pixel location (x,y), sky background, date, etc.

We obtain **internal** EPER and FPR data at many signal levels every 6 months, with a monthly check at only one signal level. CTE is also measured from the tails of cosmic rays and hot pixels in dark frames. The data presented here is from early inflight internal data, which is useful for monitoring the relative degradation of the detectors over time: just a first look at the small but already measureable CTE loss in the ACS detectors.

We have **external** observations of 47 Tuc planned for early 2003, which will help to characterize the effect of CTE loss on astronomical objects (photometry, astrometry, etc). This data will lead more directly to a CTE calibration for science data.

CTE monitoring

- Extended Pixel Edge Response (EPER), and First Pixel Response (FPR) tests
- Measuring the "deferred charge" tails of cosmic rays and hot pixels
- Effect on stars (photometry, astrometry, tails): observations of 47 Tuc planned for early 2003
- Correlation of preflight Fe^{55} data, and inflight ~1620e- signal level data

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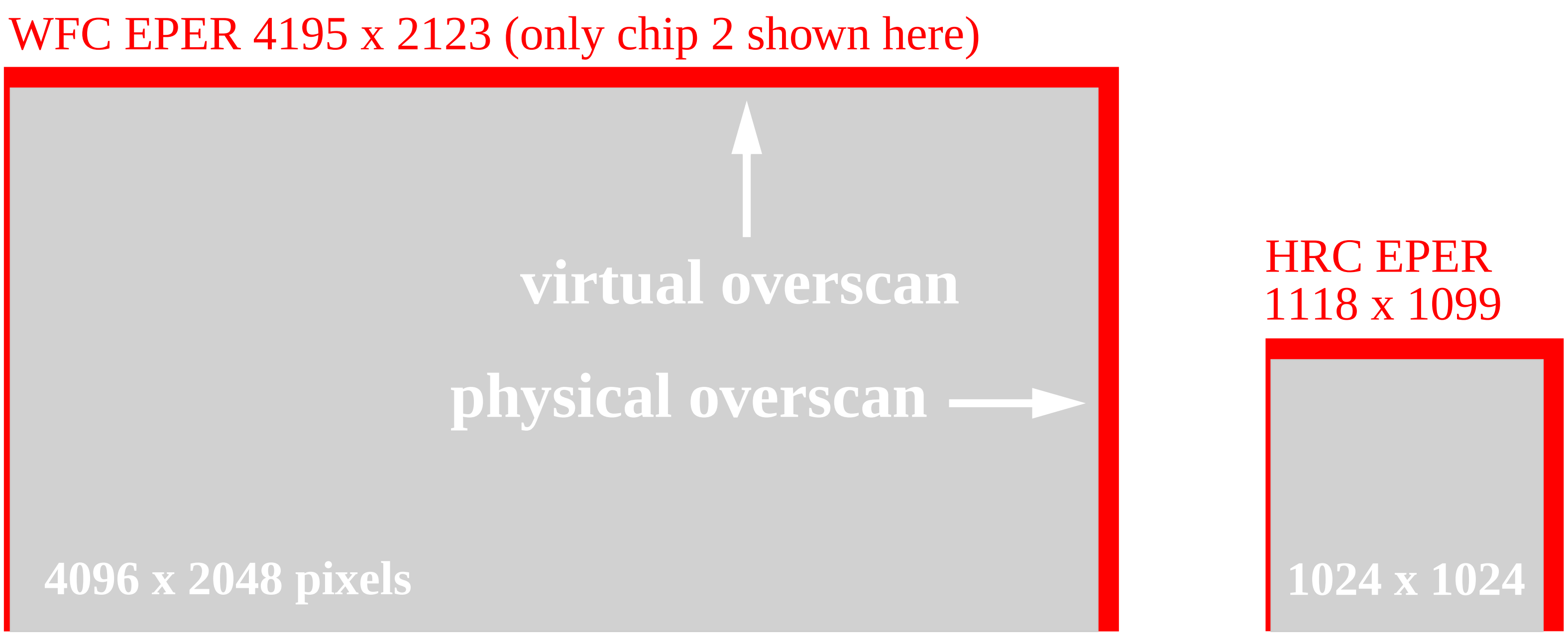
Extended Pixel Edge Response (EPER) test

A dark frame with a special clocking pattern that produces extra (75) trailing *physical* and *virtual* overscans, where "deferred charge" (trapped then released) is reclaimed to measure both *parallel* and *serial* CTE with one exposure.



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Serial First Pixel Response (FPR) test

A dark frame with a special clocking pattern. A *quick* readout of the first half of the chip, then a *normal* readout of the full chip creates an electronic "knife edge" in the center of the science array, where deferred charge is measured.

WFC serial FPR 4144 x 2068 (only chip 2 shown here)

HRC serial FPR
1062 x 1044

Preliminary results

The following plots show our preliminary inflight CTE measurements for the various **internal** CTE tests we have conducted to date. A declining CTE trend is clearly evident, which we will continue to monitor. CTE loss is most significant at low signal levels, where the trapped charge represents a larger fraction of the total charge.

The EPER plots show measurements made at various signal levels during preflight thermal vacuum testing at Ball Aerospace (upper), inflight data taken during Servicing Mission 3B Orbital Verification (SM3B/SMOV) in April 2002 (middle), and data taken during October 2002 as part of the routine Cycle 11 calibration program (lower).

The CTE measurements based on “deferred charge” tails of hot pixels and cosmic rays were made with inflight dark frames obtained since SM3B (March 2002).

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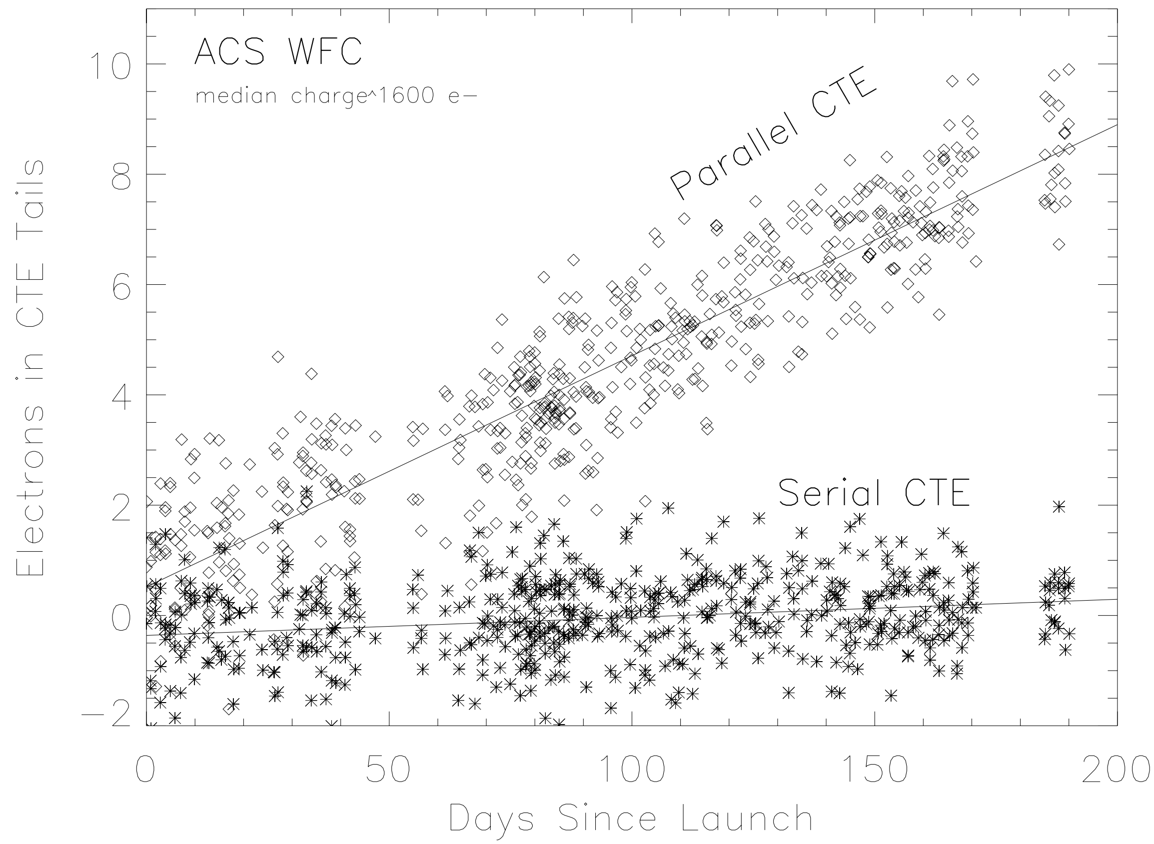
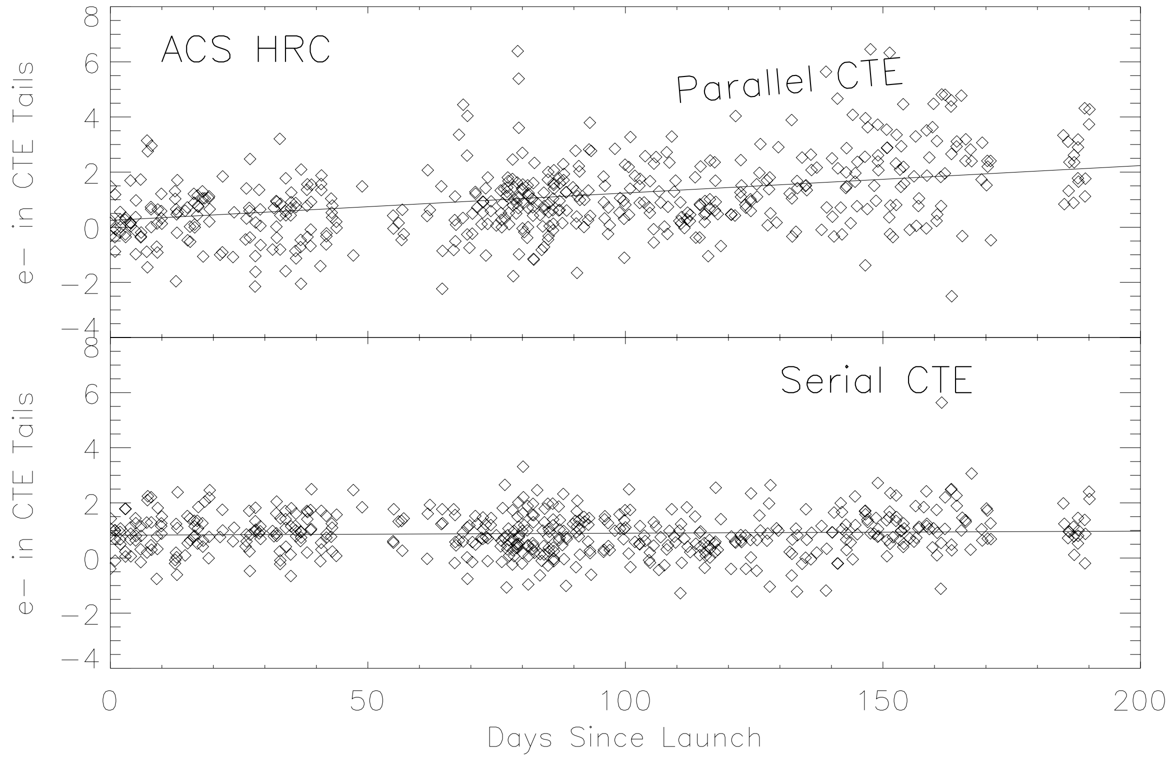
Early CTE trend for WFC from tails of hot pixels and cosmic rays



Early CTE trend for HRC from tails of hot pixels and cosmic rays.



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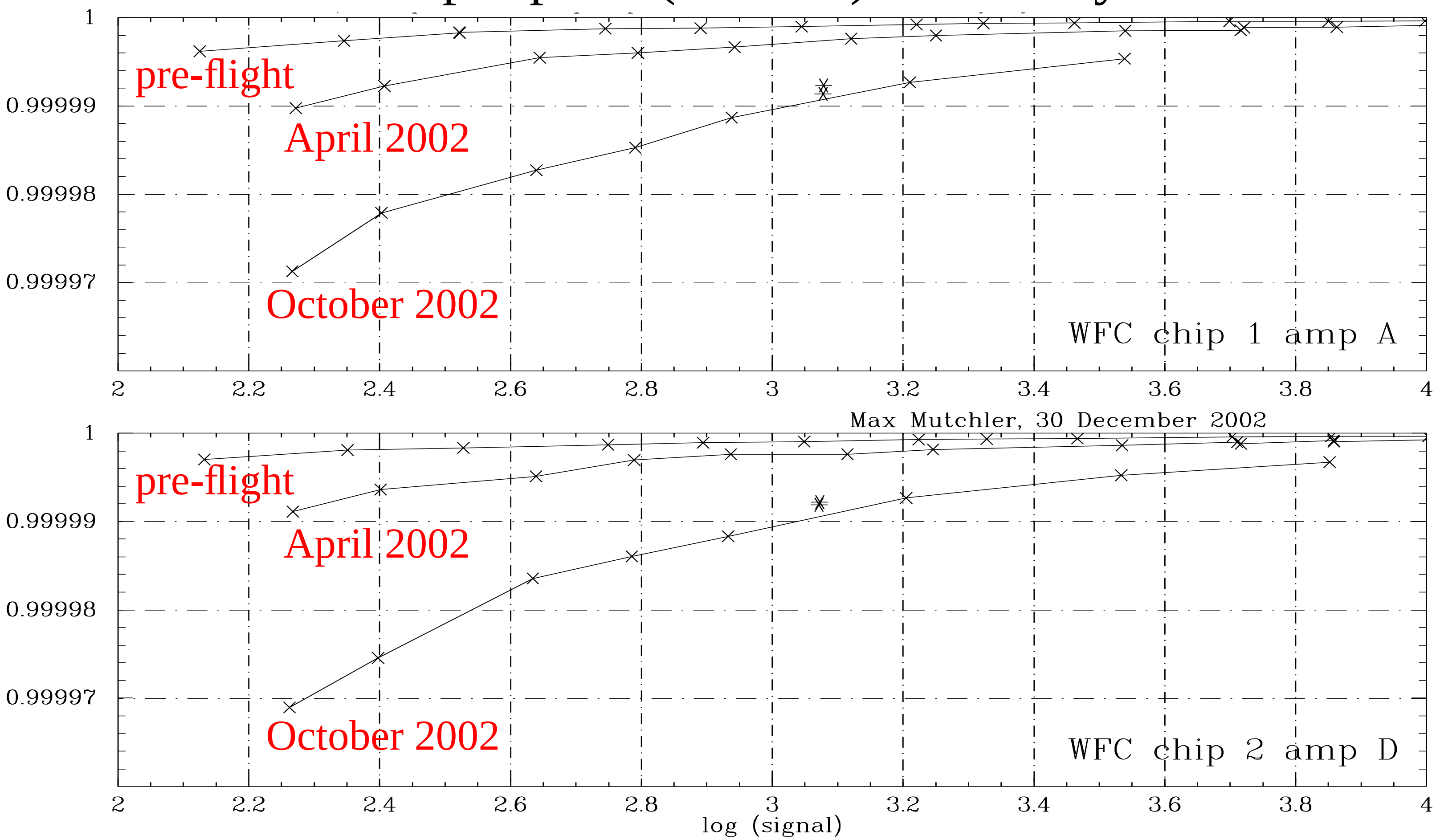
WFC CTE per pixel (transfer) from early EPER tests



Mitigation of CTE effects

We will soon obtain EPER and FPR data while the **temperature** of the ACS CCDs is raised from -77 C to -67 C. Determining CTE as a function of temperature will allow us to assess how much improvement can be expected from a change in the operating temperature of the detectors.

Pre-flashing the CCDs reduces the effect of CTE by essentially pre-filling the charge traps just prior to a science exposure. **Special apertures** near the CCD serial registers can also be defined and used, which minimize the clocking (number of pixel-to-pixel transfers) that each charge packet undergoes. These techniques are available to help mitigate the effect of declining CTE as the ACS detectors age.

For more information...

To follow our CTE monitoring and calibration efforts, bookmark the ACS website:

http://www.stsci.edu/hst/acs/

Also, subscribe to the ACS e-mail newsletter (STAN) by sending a message to **majordomo@stsci.edu** with a blank subject line, and in the body type:
[un]subscribe acs_news

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