Instrument Science Report WFC3 2004-09

Preliminary Assessment of Image Persistence in the WFC3 UVIS CCD Detector

G. F. Hartig and S. Baggett
16 April 2004

ABSTRACT
We have performed an initial assessment of the level of residual image persistence in the WFC3 UVIS CCD flight detectors. As expected for the UVIS CCD architecture, no significant persistence effect is observed, from 250 to 810 nm, after delays of ~ 5 minutes.

Introduction

The flight UVIS CCD detector was installed in the WFC3 instrument in November 2003. This focal plane comprises two thinned, backside-illuminated Marconi (E2V) 2k x 4k CCDs, with 15 um pixels and backside treatment optimized for UV efficiency. The CCD amplifiers, bias and clocking circuitry and ADCs, nearly identical to those used for the ACS wide field channel, were installed in the instrument at about the same time as the flight detector, affording flight-like operation.

Significant residual images, with long time constants, are routinely observed in the lumogen-coated front-side-illuminated WFPC2 CCD images (Baggett, et al. 2000, and references therein). Since the time constant is relatively long (on the order of minutes), the residual images typically appear in subsequent images. In the case of WFPC2, the amount of charge trapped was found to be clearly correlated with the maximum intensity clocked through the pixel, an intensity level which was normally well below the pixel saturation level.

Such residual images are not expected in the WFC3 CCDs because they are backside illuminated devices, in which the epitaxial/substrate interface is removed during thinning, eliminating the putative source for residual bulk image, and since their inverted operation ameliorates deferred surface charge (Janesick, 2001). Similar CCDs, produced by SITe and flown on the HST STIS and ACS instruments, have not exhibited significant image persistence. Nevertheless, it is prudent to make an empirical assessment of the flight detectors, operated in flight-like manner, to assure no unexpected persistence behavior is present. We report on the first such check of the UVIS CCD residual image properties.

Procedure

The test data were obtained, as an extension of the PSF evaluation program, on 12 Dec 2003 with SMS VE02S05 (image rootnames IV0205xx; IDL database entries 1813:1876; quicklook log ID 2003346a). Highly saturated point source images were obtained at four field positions (two on each CCD), at four wavelengths (250, 350, 633 and 810 nm), followed by short (100-200 s) dark subarray images approximately centered on the point source. The latter were obtained about 4 minutes after the saturated exposure ended, with of order 10 Me^- accumulated in the point source image. The objective here was not to do an exhaustive measurement of persistence, but to assure that there was no strong effect that would impact WFC3 operations on-orbit, and to obtain a data set that could assist in planning future tests.

The detector was operated at –74C, the cold limit of the ambient test environment, rather than the nominal –83C; this difference may have a small effect on the image persistence results, as leakage of the charge traps responsible for persistence is likely to be temperature dependent. Further evaluation of persistence is planned during the thermal vacuum test, in which the detector should operate at its expected on-orbit temperature.

Results

The saturated point source image at 350 nm and the following 100 s dark exposure are shown in Figure 1. No remnant of the image is apparent to the eye in this dark exposure, which began about 450 s after the start of the saturated image readout.

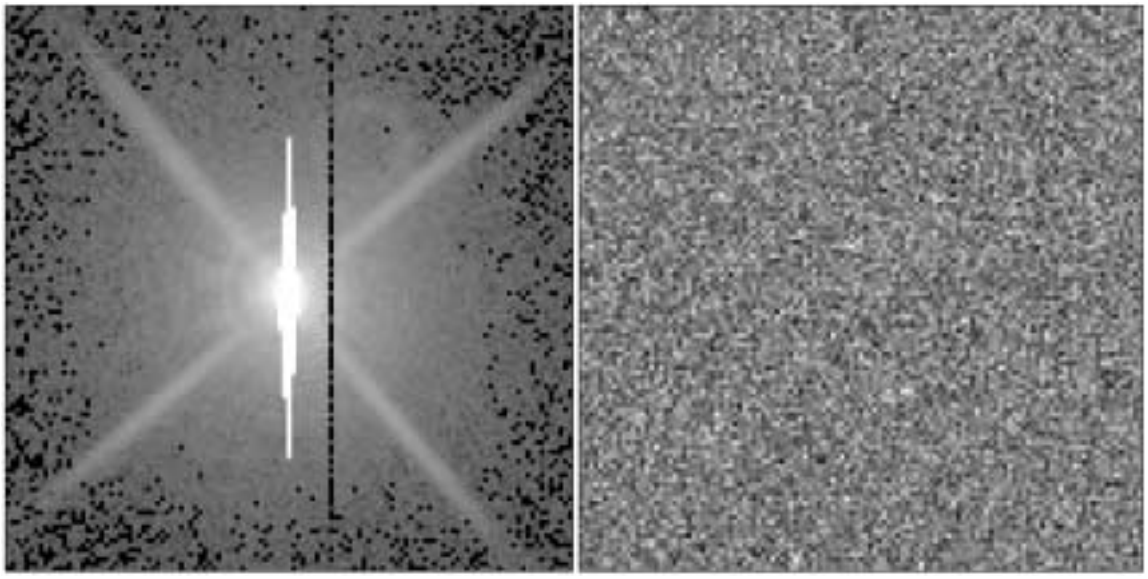

Figure 1. Highly saturated point source image at field point UV14 at 350 nm (left) and 100 s dark (right) at the same detector location, approximately 4 minutes later, showing no indication of image persistence.

Table 1 presents the quantitative results at the four wavelength/image-location combinations used for the persistence test. The flux in a 7x7 pixel box centered on the saturated image is shown in the column labeled F7, in millions of electrons; this was computed from a preceding unsaturated image with the same instrument/CASTLE configuration multiplied by the ratio of exposure time (50 or 100) and the gain (1.5 e^- /DN). The residual image flux, summed over the same 7x7 px box in the dark image taken ΔT (minutes) after the saturated image readout start, is listed as P7. To determine the significance of the residual, we have computed the flux in 1000 other 7x7 boxes in the dark image, at random positions (but constrained to be away from the image location and subarray edges). The resulting distribution is fit very well with a gaussian, with width (σ) shown in the last column; the center of the gaussian fit was used as the effective bias level subtracted from the residual image flux (P7). The σ values correspond to read noise of ~3.2 e^-, which compares well with other measurements. None of the residuals exceed 1.5 σ, indicating that no significant deferred image is present.

Table 1. Preliminary UVIS Flt 1 CCD Persistence Test Results

Chip	Amp	FPID	λ (nm)	F7 (Me^-)	ΔT (m)	P7 (e^-)	σ (e^-)
2	D	UV13	250	6.0	19.0	-30.5	22.7
1	B	UV14	350	12.0	4.1	28.4	23.0
2	C	UV15	633	33.1	4.0	-6.8	22.2
1	A	UV16	810	27.7	4.0	-4.6	24.1

Conclusion

On the basis of our analysis of this initial, incomplete look at the residual image behavior of the WFC3 UVIS CCDs, we conclude that no significant effect is present with the CCD operated at –74 C. A similar evaluation will be repeated in upcoming thermal-vacuum testing, with the CCD operated at its flight temperature (-83C).

References

Baggett, S., Biretta, J, and Hsu, J.C. “Update on Charge Trapping and CTE residual Images in WFPC2”, STScI WFPC2 ISR 00-03, 2000.

Janesick, James R. “Scientific Charge-Coupled Devices”, S.P.I.E., Bellingham, WA. 2001.