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WFC3 TV2 Testing: UVIS-2 Amp B Anomaly

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ABSTRACT

Thermal-vacuum (TV) level tests using the integrated WFC3 instrument were performed at Goddard Space Flight Center (GSFC) during the summer of 2007 with the designated flight-spare UVIS-2 detector in place. Routine data acquired during this TV revealed that amp B occasionally exhibited anomalous behavior. In particular, B-amp subarray readouts of point sources and flatfields at medium to high exposure levels showed smearing of the sources in the serial direction and pixels with count levels at precisely zero. Furthermore, in full-frame, four-amp readouts, with exposure levels near or beyond pixel saturation, quadrant B shows pixels with count levels dropping to zero although without any smearing effects. The issue was characterized further during TV and a potential fix identified: adjustment of the CCD last gate voltage. The fix has been validated with the UVIS-2 detector in WFC3 and was found to resolve the problem without apparent penalty, i.e., no adverse effect to amp A and no increase in readnoise. This report documents the characterization tests performed and the subsequent implementation and verification of the fix. Additional performance improvement may be achievable for extremely high exposure level images (>100x fullwell), by lowering the gate voltage 0.5-1 V for all amps; success in this case is not guaranteed, however, as the CCD output node threshold may be exceeded in these oversaturated images. Further test time would be required for confirmation.

Introduction

The integrated WFC3, with the flight spare UVIS-2 detector in place, recently underwent thermal-vacuum (TV) level testing in the GSFC Space Environment Simulator chamber.

Part of the TV tests involve acquiring science data in order to verify the basic operating modes of the instrument and to obtain detector and system level calibrations. For the UVIS channel, these data include a variety of images, both internals such as biases, darks, and calsystem flatfields, as well as external images, where the light sources (point source and flatfields) are provided by an optical stimulus (CASTLE) designed to simulate the HST OTA. During these calibration tests, occasional anomalous behavior was noted in quadrant B data. Initially, the effect was seen in subarray images of point sources at mid to high exposure level read out through amp B: the PSF would appear to be “smeared” in the serial direction. At higher exposure levels, counts in the center of the PSF would drop to exactly 0. To explore this issue more thoroughly, additional data were collected via SMS (UV04S12) and manual imaging, and select archival datasets were examined for any signs of the problem. The resulting list of symptoms led to the hypothesis that an adjustment of the last gate voltage would mitigate the problem; subsequent testing verified the success of that fix and confirmed that there are no adverse effects to the other amp (A) on the chip. The following sections present the results of the characterization of the problem, the details and verification of the repair, and a suggestion for further testing, should the UVIS-2 detector be designated as the flight detector.

Characterization

The symptoms of the B-amp anomaly as gleaned from the examined data can be summarized as follows; for reference, all images evaluated are tabulated in Appendix A.

- A point source placed in quad B and read out through amp B, with exposure level ~48K e^- and higher, smears in the serial direction.
- A point source placed in quad B and read out through amp B, with exposure level ~50K e^- or higher, exhibits smearing as well as pixels near the PSF center set to 0.
- The same point source (exhibiting smearing and 0-level pixels) placed in quad B and read out through amp A shows no sign of either problem.
- The same point source placed in quad B and read out through full-frame, four-amp ABCD, shows no sign of either problem.
- Point sources with high exposure levels (~70-80K e^-), placed in quad B and read out through full-frame four-amp ABCD, show no problems.
- Extremely high exposure level point sources (~100x fullwell) in full-frame, four-amp unbinned readouts show only the expected blooming, while four-amp binned readouts show smearing and zero-level pixels.
- The same point source placed in quad A and read out through amp A looks fine but a point source in quad A and read out through amp B shows the anomalous behavior.
- Both 10μ and 200μ (stimulus fiber diameter) point sources exhibit the problem.
- The effect is present at all locations tested in quadrant B.

- The bias offset levels and gain settings had no discernable effect on the issue.
- A subarray flatfield read out through amp B, with exposure level ~50K e^-, showed “streaks” in the serial direction. A full-frame, four-amp (ABCD) readout flatfield at ~15% higher exposure level shows no streaking in any quadrant.
- Full-frame, four-amp readout flatfields at very high exposure levels (~80K e^-) show counts in large regions dropping to zero in quadrant B only.

The figures below illustrate the symptoms of the UVIS-2 amp B anomaly. Figure 1 presents images of, and cuts through, typical point source images while Figure 2 provides examples of flatfield images. Note that the left and center flatfield images are 400x400 subsections, taken with the CASTLE stimulus. The flatfield shown at right is the entire B quadrant (2048x2051 pixels), taken with the WFC3 calibration subsystem; the 0-level pixels (white areas) are due to the amp B anomaly. The diffuse darker (higher countrate) features along the edge are likely due to scattering from the edges and corners of the filter in use, accentuated here by the divergent beam in the calsystem; flatfields with this filter taken with the standard CASTLE stimulus do not show these edge features.

Figure 1: Point source placed in quadrant B and read out through amp A (left), amp B (center), and amp B (right, longer exposure than center image). Top row are images displayed with an inverted stretch to highlight the problem areas; bottom row shows a horizontal cut through each image, in DN as function of column number.

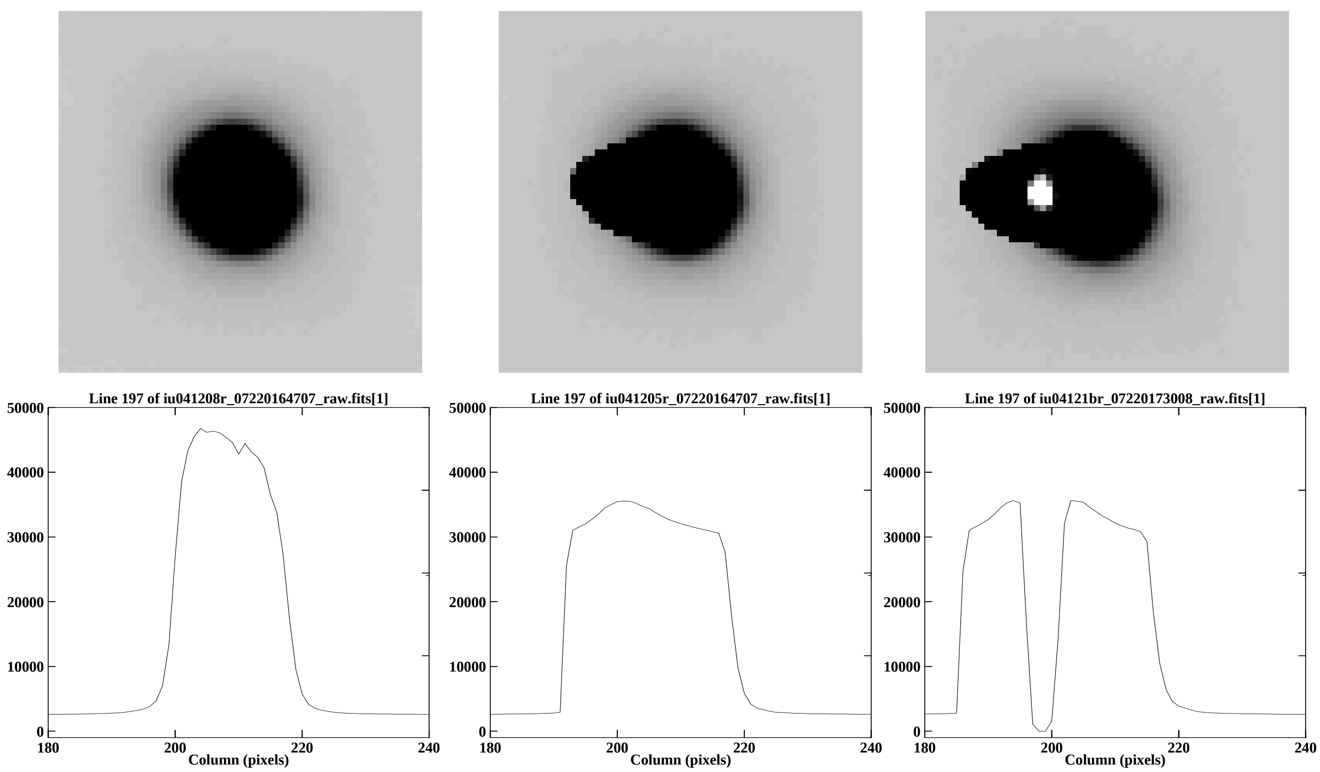
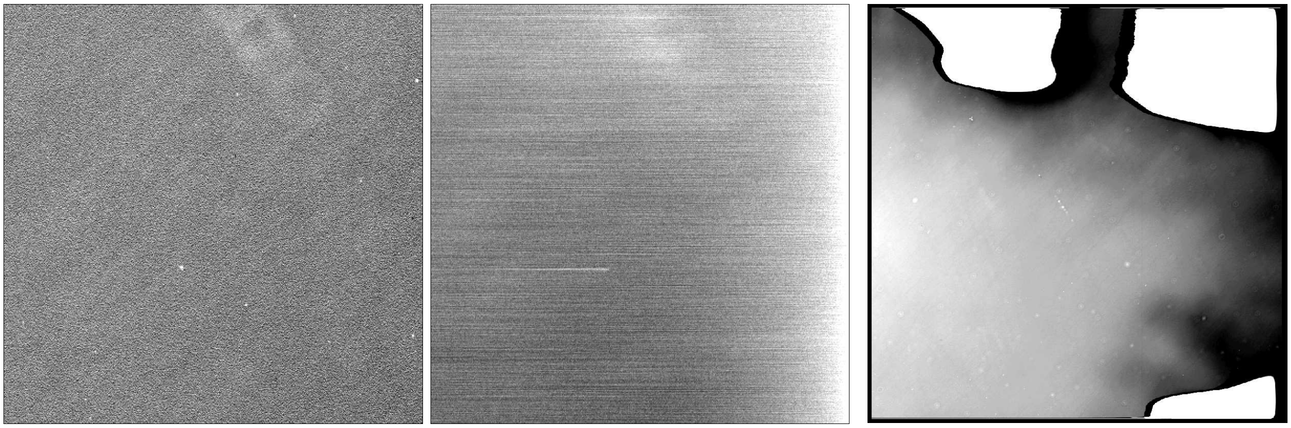


Figure 2: A 400x400 F555W subarray CASTLE flat read out through amp B (center) as compared to the corresponding 400x400 subsection of a four-amp readout F555W CASTLE flat (left). At right, quad B (2048x2051 pixels) from an over-exposed four-amp readout F410M calibration subsystem flatfield, illustrating the regions with zero pixels (white areas). Images displayed with an inverted color table and stretched to highlight features.



Given the behavior of the amp B anomaly, one possible operational workaround to the problem is to read out any amp B subarray data through amp A and to avoid placing targets with high exposure levels in quadrant B when four-amp read outs are in use. However, as some small amounts of test time became available during the WFC3 TV, the opportunity was taken to explore the issue and validate a potential fix.

Adjustment of UVIS-2 Amp B

During an exposure, photons strike the CCD and are converted to electrons which are collected and held within pixels until the readout. Each pixel possesses a set of gates, or electrodes; the WFC3 detectors have 3 gates per pixel. Changing the voltages of these gates. a process called ‘clocking’, changes the potential well profile, and since charge will migrate towards the deepest potential well, clocking is able to move the charge around. Careful manipulation of the clocking via a readout timing pattern provides precise control of the movement of the charge, transferring charge from one pixel to another. In WFC3, the readout process shifts the entire quadrant one row at a time; each time, the last row is moved up into the horizontal register at the end of the columns from where it is clocked out serially to the output amplifier. In the output amp, a floating diode converts the charge to a voltage (floating diffusion); off-chip, the difference between this voltage and a reference level is taken as the detected signal and passed to the analog to digital converter for conversion to DN (data number).

The streaking phenomenon observed in the UVIS-2 quadrant B was suspected to be due to two possible problems in this process: 1) poor charge transfer in the serial direction and/or 2) deferral of charge due to the last gate. In the first scenario, if the serial clocks do not have sufficient amplitude, they are unable to transfer charge efficiently and smearing will occur. This was tested in UVIS-2 by increasing the serial clocks voltage from the default of ~-7.5,-1V to ~ -7.5,+1V; the resulting images showed more smearing and zero-level pixels than they did with the original serial clocks voltage. In this case, setting the serial clocks too positive clearly reduced the detector's capacity to stop charge from flowing back and made the situation worse.

In the deferred charge scenario, if the last gate is set too high, then the charge is not being held after the transfer and it can leak back into the serial register once the summing well potential goes high again. This was tested in UVIS-2 by lowering the last gate voltage from ~ -5.5 to -6.0 V: subsequent images showed no smearing effects, regardless of whether the serial clocks were set at ~ -7.5 -1 or ~ -7.5, +1 V. Additional tweaks of the last gate voltage revealed some minor smearing effects at ~ -5.75 V, i.e., a full -6.0 V is required to eliminate the problem. In this case, lowering the last gate voltage created a barrier which prevented charge from flowing back (lower voltages generate a higher barrier because the WFC3 detectors are operated in an inverted MPP, or multi-phase pinned, mode in order to reduce dark signal and reduce the detector's sensitivity to ionizing radiation). Once a charge packet is pushed by the last gate with the summing well going low, it should stay at floating diffusion and not flow back. However, if the last gate voltage is too high, as it appeared to be with the default last gate voltage setting, it does not have enough negative potential to stop charge from flowing backwards.

The "hole" phenomenon, with pixels at exactly 0 DN, is suspected to occur when the amount of deferred charge is so large that the reset action is no longer effective, i.e., the reset level becomes similar to the sample level and thus the net difference approaches zero. In this case, fixing the deferred charge problem in the last gate addressed the zero-level pixels as well.

It should be noted that the CCDs in the UVIS-1 build (the planned flight detector), used during TV1, were operated with the same gate voltage used for UVIS-2 yet there were no readout anomalies in the TV1 data. This is attributed to the fact that during the manufacturing process, there is always some spread in parameters between individual devices. In addition, the hardware (the CCD electronics box and the detector head assembly) may differ slightly between UVIS-1 and UVIS-2, resulting in somewhat different values being applied to the device compared with what is sent or reported by the telemetry (and the source of the clock and gate voltage values used in this report). All of these factors can contribute to the disparate CCD behavior.

Effects of the UVIS-2 Amp B Adjustment

Due to the WFC3 design, both quadrants on a given chip use the same gate voltage, thus any changes implemented in order to fix the anomaly in quadrant B must not have a negative impact to quadrant A observations. Given the success of the gate voltage fix for amp B and taking advantage of an available window of opportunity in the TV test schedule, further data were collected to verify that there were no unintended adverse side-effects to the amp B repair: a set of flatfields for the calculation of a gain value, a set of biases for computing readnoise, and a set of point source linearity data to further confirm the fix.

Gain at the new voltage setting was measured using the mean-variance method used previously for images taken at the default gain setting (Baggett, ISR 2007-19). The resulting gain values are summarized in Table 1 while the specific images used for the measurement are listed in Table 4 in the Appendix. The gain in quadrant B was found to be slightly lower, by ~2%, with the new gate voltage than it was with the default voltage (1.51 e-/DN vs 1.54 e-/DN); the gain for other quadrants was within 1% of what it had been at the default voltage.

Readnoise was measured from both the overcan and science pixels areas, following the procedure used with previous data (Baggett, ISR 2007-15). The results are summarized in Table 2 below. At gain 1.5, the readnoise at the new and default gate voltages was the same to within ~1%. At gain 1.0, quadrant B shows a slightly lower readnoise (~2%) with the new voltage setting. Additional data would help to verify that the readnoise is indeed slightly lower with the new gate voltage; we note that at ambient temperatures (CCD ~ -58C), the quadrant B readnoise value was ~3% higher in images taken with the new gate voltage setting than in those taken with the default voltage setting (3.21 e^- vs 3.13 e^-).

Table 1. Comparison of gain for the new and default gate voltage settings, at -78C.

	quad A	**quad B**	**quad C**	**quad D**	**quad A**	**quad B**	**quad C**	**quad D**
default gate voltage	1.57	1.54	1.63	1.59	1.07	1.07	1.11	1.08
new gate voltage	1.55	1.51	1.62	1.58	1.05	1.05	1.10	1.07
relative change (new/default)	0.99	0.98	0.99	0.99	0.98	0.98	1.00	0.99

Table 2. Comparison of readnoise, in electrons, for the new and default gate voltage settings at -78C, for both the gain 1.0 and gain 1.5 settings.

quadrant	gain	area	RN (new)	error	RN (default)	error	new/default
A	1.	science pixels	2.88	0.02	2.90	0.01	0.99
B	1.	science pixels	2.86	0.00	2.89	0.00	0.99
C	1.	science pixels	2.92	0.01	2.94	0.00	0.99
D	1.	science pixels	3.04	0.01	3.04	0.02	1.00
A	1.	overscan pixels	2.86	0.04	2.88	0.04	0.99
B	1.	overscan pixels	2.85	0.01	2.87	0.01	0.99
C	1.	overscan pixels	2.89	0.01	2.91	0.01	0.99
D	1.	overscan pixels	3.01	0.01	3.01	0.04	1.00
A	1.5	science pixels	3.07	0.00	3.10	0.03	0.99
B	1.5	science pixels	3.04	0.03	3.04	0.04	1.00
C	1.5	science pixels	3.10	0.01	3.12	0.01	0.99
D	1.5	science pixels	3.18	0.04	3.21	0.01	0.99
A	1.5	overscan pixels	3.05	0.01	3.07	0.07	0.99
B	1.5	overscan pixels	3.03	0.05	3.02	0.05	1.00
C	1.5	overscan pixels	3.09	0.02	3.11	0.02	0.99
D	1.5	overscan pixels	3.14	0.04	3.17	0.01	0.99

In order to confirm that the new gate voltage was not introducing a problem at another exposure level, a small set of point source data were taken using the CASTLE 200 micron spot, covering a range of exposure levels, from ~100DN up to >50K DN per peak pixel (DN level after removal of bias overscan). Images were examined visually and via contour plots: the source was well-behaved and showed no evidence of smearing at any of the exposure levels. A check of the pixels values in all the raw images yielded no cases of pixels with value equal to zero.

Figure 3 compares contour plots at low, mid, and high exposure levels, with the default voltage and the new voltage setting. At low exposure levels, images at both gate voltages appear to be fine. At mid-range exposure levels, the default gate voltage image is starting to show some asymmetry towards the left while the PSF at the new gate voltage is still fine (the slight asymmetry towards the upper left in the PSF is due to CASTLE, not the amp readout). Once high exposure levels are reached (>50 K DN), the default gate voltage image clearly shows smearing as well as zero-level pixels; the new voltage image shows only the expected elongation along the columns due to the onset of some blooming due to saturated pixels.

As a final check, the linearity results for the default and new gate voltage data were compared, by examining the behavior of individual pixels as the exposure level is increased. As expected, the new voltage results in a much-improved performance, as shown in Figure 4. The original default gate voltage images were linear only up to about 25K DN (37.5K e^-). The new gate voltage nearly doubles that range: the linearity is excellent, deviating by more than 5% only beyond ~50K DN (~75K e^-)

Figure 3: Contour plots from several images taken at the default gate voltage (top row) and new gate voltage (bottom row). Exposure levels run from very low (left), medium (middle) to high (right)..

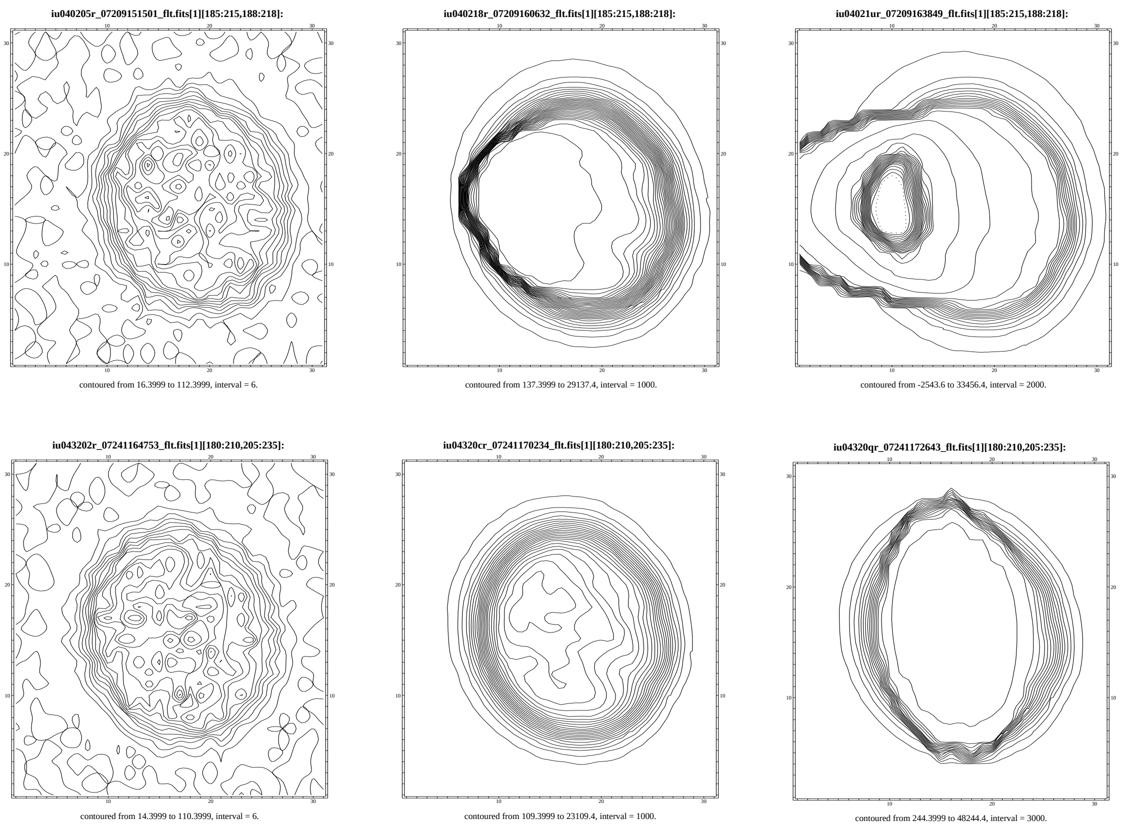
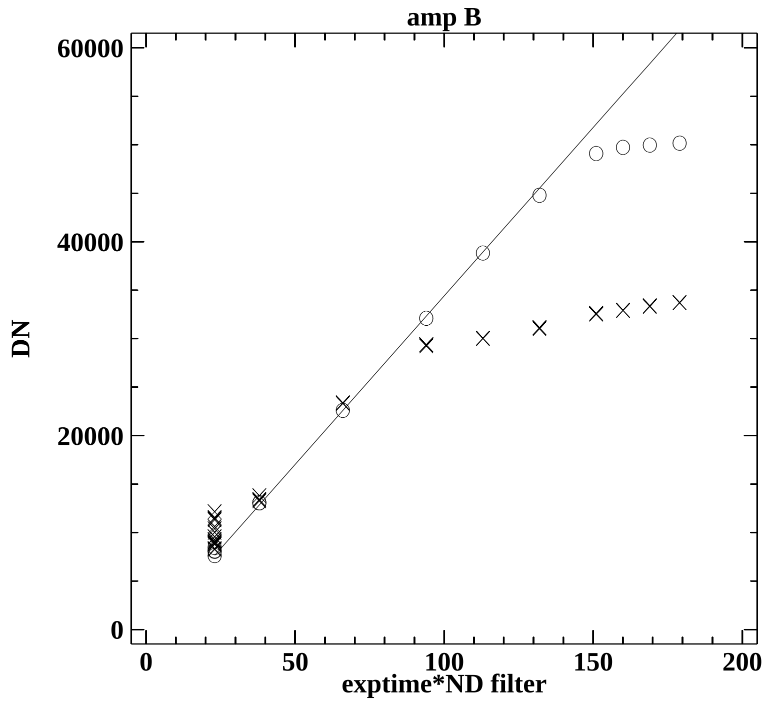


Figure 4: Amp B linearity behavior, for default gate voltage images (crosses) and new gate voltage images (circles), with linear fit to the latter (excluding the last four points).

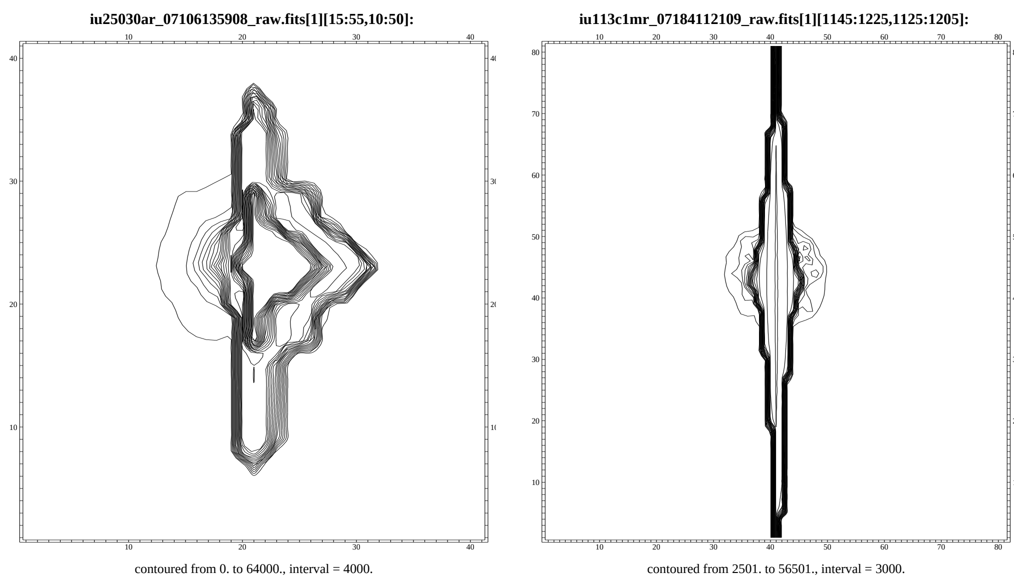


Future Improvements

We end this report with a note about possible further adjustments for consideration. Examination of full-frame, four-amp binned readouts of extremely saturated sources (100 x fullwell or more) revealed evidence of smearing and zero-level pixels. The effect is present in a relatively small number of images taken during the first part of TV (and listed Table 3 of the Appendix); in addition, smearing and zero-level pixels were noted (T.Brown, priv.comm.) in a much more extensive image set acquired near the end of TV as part of a campaign to map out the UVIS glint (Brown, ISR 2007-21). At these intense illumination levels, the effect appears in point sources placed in any of the four quadrants and is not limited to subarray readouts. Figure 4 shows examples from quadrant C: a point source taken in full-frame, four-amp 2x2 binned mode and a point source taken in full-frame, four-amp unbinned mode; exposure levels were ~10^7 e^-/pix and ~$3x10^6$ e^-/pix, respectively. The smearing and zero-level pixels are apparent in the binned image; the unbinned image exhibits only the expected vertical blooming. It is unclear if the unbinned image shows no effect because of its lower exposure level and/or because it is unbinned.

If UVIS-2 should be flown (at the time of this writing, UVIS-2 is the spare detector), it would be worth trying a lower last gate voltage for both chips in order to determine if further improvements are possible. Lowering the gate voltage is not expected to cause any other detrimental effects but may very well be able to remove the observed distortions and zero-level pixels in the binned images (and unbinned, if present). Note, however, that success of the fix is less clear in these extreme cases: pushing such high signal levels onto the CCD output node will eventually cause a saturation effect quite similar to the one observed and shown in Figure 5; the threshold for onset of this event in these devices is unknown. The best course of action would be to lower the last gate voltage by 0.5-1.0V for both chips and retake the highly-exposed frames to check whether the situation can be improved.

Figure 5: Contour plots of extremely saturated PSFs in quadrant C. At left, a 40x40 pixel region from full-frame, four-amp readout taken in 2x2 binned mode; at right, an 80x80 pixel region from full-frame, four-amp readout taken in unbinned mode. Exposure levels are estimated at more than 10^7 e^-/pix (left) and about ~$3x10^6$ (right).



Summary

The UVIS-2 amp B anomaly has been described; the fix, a lowering of the last gate voltage, was tested and confirmed successful on the instrument. The adjustment addresses the problem without any negative side-effects: images from amp A retain their excellent quality and there is no increase in readnoise. With an additional small reduction of the last gate voltage *in all amps*, there is potential for, though no guarantee of, further incremental improvement for full-frame, four-amp readout images containing extremely saturated sources (>100x fullwell). Additional test time would be required for explore the possibility.

Acknowledgements

Thanks are due to all the WFC3 team members, at GSFC and STScI, who made the thermal vacuum tests possible, including those on shift performing science and quicklook.

References

Baggett, S., “WFC3 Ambient2 Testing: UVIS Readnoise,” WFC3 Instrument Science Report 2007-15, May 2007.

Baggett, S., “WFC3 TV2 Testing: UVIS-2 Gain Results,” WFC3 Instrument Science Report 2007-19, Sep 2007.

Brown, T., “WFC3 TV2 Testing: UVIS Channel Glint,” WFC3 Instrument Science Report 2007-21, Oct 2007.

Appendix A.

Table 3. Images used in characterization and testing of UVIS-2 amp B. Gain, bias offset level, binning, clock and gate voltage settings are default (1.5; 3; 1x1; ~ -7.5, -1; ~ -6, respectively) unless noted otherwise. Column labeled 'M' denotes instrument side (1 or 2)l while eff indicates whether smearing (s) effect or zero-level pixels (0) are present in the image (dash denotes no effect).

tv num	image name	location	exp time	M	temp	amp	xsize	ysize	eff	comment
41457	iu041201r_07220151037	uv14	0.0	2	-77.9	b	400	400	na	bias
41458	iu041202r_07220151037	uv14	0.0	2	-78.1	a	400	400	na	bias
41459	iu041203r_07220164707	uv14	0.0	2	-78.1	b	4142	2050	na	bias
41460	iu041204r_07220164707	uv14	0.0	2	-77.9	a	4142	2050	na	bias
41461	iu041205r_07220164707	uv14	151.0	2	-77.9	b	400	400	s	center of B quad
41462	iu041207r_07220164707	uv14	151.0	2	-77.9	b	4142	2050	s	
41463	iu041208r_07220164707	uv14	151.0	2	-78.1	a	400	400	--	
41464	iu041209r_07220164707	uv14	151.0	2	-78.3	b	400	400	s	gain 1
41465	iu04120ar_07220164707	uv14	151.0	2	-77.9	a	400	400	--	gain 1
41466	iu04120br_07220164707	uv14	151.0	2	-78.1	b	400	400	s	gain 2
41467	iu04120cr_07220164707	uv14	151.0	2	-78.1	a	400	400	--	gain 2
41468	iu04120dr_07220164707	uv14	151.0	2	-78.1	b	400	400	s	gain 4
41469	iu04120er_07220164707	uv14	151.0	2	-78.3	a	400	400	--	gain 4
41470	iu04120fr_07220164707	uv14	151.0	2	-78.1	b	400	400	s	offset 0
41471	iu04120gr_07220164707	uv14	151.0	2	-78.1	b	400	400	s	obbset 1
41472	iu04120hr_07220164707	uv14	151.0	2	-78.3	b	400	400	s	offset 2
41473	iu04120ir_07220164707	uv14	151.0	2	-77.9	a	400	400	--	offset 2
41474	iu04120jr_07220164707	uv14	151.0	2	-78.1	b	400	400	s	offset 4
41475	iu04120kr_07220164707	uv14	151.0	2	-77.9	a	400	400	--	offset 4
41476	iu04120lr_07220164707	uv14	151.0	2	-77.9	b	400	400	s	offset 5
41477	iu04120mr_07220164707	uv14	151.0	2	-78.1	b	400	400	s	offset 6
41478	iu04120nr_07220164707	uv14	151.0	2	-77.9	b	400	400	s0	offset=7; background filled with 0-level pixels

tv num	image name	location	exp time	M	temp	amp	xsize	ysize	eff	comment
41479	iu04120or_07220164707	uv14	37.8	2	-78.3	abcd	2102	2070	--	binned 2x2
41480	iu04120pr_07220164707	uv14	16.8	2	-78.3	abcd	1402	1380	--	binned 3x3
41481	iu04120qr_07220164707	uv02	121.0	2	-78.1	b	400	400	s	lower left in B quad
41482	iu04120rr_07220164707	uv02	151.0	2	-78.1	b	400	400	s	
41483	iu04120sr_07220164707	uv02	181.0	2	-78.1	b	400	400	s0	
41484	iu04120tr_07220164707	uv04	121.0	2	-78.3	b	400	400	s	lower right in B quad
41485	iu04120ur_07220164707	uv04	151.0	2	-77.9	b	400	400	s	
41486	iu04120vr_07220164707	uv04	181.0	2	-78.1	b	400	400	s0	
41487	iu04120wr_07220164707	uv10	121.0	2	-78.1	b	400	400	s	upper left in B quad
41488	iu04120yr_07220170208	uv10	151.0	2	-78.1	b	400	400	s	
41489	iu04120zr_07220170800	uv10	181.0	2	-78.1	b	400	400	s0	
41490	iu041211r_07220171050	uv12	121.0	2	-77.9	b	400	400	s	upper right in B quad
41491	iu041213r_07220171410	uv12	151.0	2	-78.1	b	400	400	s	
41492	iu041215r_07220172002	uv12	181.0	2	-77.9	b	400	400	s0	
41493	iu041217r_07220172254	uv16	121.0	2	-77.9	b	400	400	s	center of A quad
41494	iu041219r_07220172616	uv16	151.0	2	-78.3	b	400	400	s	
41495	iu04121br_07220173008	uv16	181.0	2	-77.9	b	400	400	s0	
41496	iu04121dr_07220173357	uv16	180.0	2	-78.1	a	400	400	--	center of A quad
41497	iu04121fr_07220173814	uv16	210.0	2	-78.1	a	400	400	--	
41498	iu04121hr_07220174301	uv16	240.0	2	-77.9	a	400	400	--	some vertical blooming
41499	iu04121jr_07220174728	uv16	220.0	2	-77.9	a	400	400	--	some vertical blooming
41500	iu04121lr_07220175145	uv16	210.0	2	-78.3	b	400	400	s0	
41501	iu04121nr_07220175632	uv16	240.0	2	-78.3	b	400	400	s0	
41502	iu04121pr_07220181238	uv16	270.0	2	-78.1	b	400	400	s0	
41503	iu04121rr_07220181238	uv14	15.0	2	-78.1	b	400	400	--	center of B quad

tv num	image name	location	exp time	M	temp	amp	xsize	ysize	eff	comment
41504	iu04121sr_07220181238	uv14	20.0	2	-78.1	b	400	400	--	
41505	iu04121tr_07220181238	uv14	25.0	2	-78.1	b	400	400	?-	poss.very slight smearing
41506	iu04121ur_07220183704	uv14	30.0	2	-77.9	b	400	400	?-	poss.very slight smearing
41507	iu04121vr_07220183704	uv14	40.0	2	-78.1	b	400	400	s-	
41508	iu04121wr_07220183704	uv14	60.0	2	-78.3	b	4142	2050	s-	
41509	iu04121yr_07220183704	flat	9.5	2	-78.3	b	400	400	s	
32530	iu20040pr_07184014317	flat	11.0	2	-78.3	abcd	4206	4140	--	
41510	iu04121zr_07220183704	flat	11.0	2	-77.9	b	400	400	0	image all zeros
41511	iu041220r_07220183704	flat	12.0	2	-78.4	b	400	400	0	image all zeros
41512	iu041221r_07220183704	flat	13.0	2	-78.1	b	400	400	0	image all zeros
41513	iu041222r_07220183704	flat	16.0	2	-78.1	b	400	400	0	image all zeros
41514	iu041223r_07220183704	flat	21.0	2	-77.9	b	400	400	0	image all zeros
41515	iu041224r_07220183704	uv14	0.0	2	-78.1	b	400	400	--	bias
41516	iu041225r_07220183704	uv16	0.0	2	-78.3	a	400	400	--	bias
41517	iu041226r_07220183704	chip2	0.0	2	-78.3	b	4142	2050	--	bias
41518	iu041227r_07220183704	chip2	0.0	2	-78.1	a	4142	2050	--	bias
41519	iu041228r_07220185323	uv14	151.0	2	-77.9	abcd	4206	4140	--	center of B quad
35395	iu112c1hr_07195142349	uv14	20.0	1	-78.3	abcd	4206	4140	--	max pix ~76K e-
35396	iu112c1ir_07195142349	uv14	20.0	1	-78.1	abcd	4206	4140	--	max pix ~76K e-
35398	iu112c1mr_07195153116	uv14	200.0	1	-78.3	abcd	4206	4140	--	max pix ~78K e-
35399	iu112c1nr_07195153116	uv14	200.0	1	-78.1	abcd	4206	4140	--	max pix ~78K e-
35463	iu114c1hr_07195185413	uv16	10.0	1	-77.9	abcd	4206	4140	--	center of A quad
35464	iu114c1ir_07195185413	uv16	10.0	1	-78.1	abcd	4206	4140	--	
35465	iu114c1kr_07195190931	uv16	100.0	1	-78.5	abcd	4206	4140	--	
35466	iu114c1mr_07195194322	uv16	100.0	1	-78.1	abcd	4206	4140	--	
35467	iu114c1nr_07195194322	uv16	100.0	1	-78.3	abcd	4206	4140	--	
32600	iu113c1hr_07184103154	uv15	10.0	2	-78.1	abcd	4206	4140	--	center of C quad

tv num	image name	location	exp time	M	temp	amp	xsize	ysize	eff	comment
32601	iu113c1ir_07184103154	uv15	10.0	2	-77.9	abcd	4206	4140	--	
32602	iu113c1kr_07184104712	uv15	100.0	2	-78.3	abcd	4206	4140	--	
32603	iu113c1mr_07184112109	uv15	100.0	2	-78.1	abcd	4206	4140	--	
32604	iu113c1nr_07184112109	uv15	100.0	2	-78.3	abcd	4206	4140	--	
32661	iu111c1hr_07184133413	uv13	200.0	2	-78.3	abcd	4206	4140	--	center of D quad
32662	iu111c1ir_07184133413	uv13	200.0	2	-78.3	abcd	4206	4140	--	
32663	iu111c1kr_07184135111	uv13	200.0	2	-78.1	abcd	4206	4140	--	
32664	iu111c1mr_07184150820	uv13	1000.0	2	-78.1	abcd	4206	4140	--	
32665	iu111c1nr_07184150820	uv13	1000.0	2	-78.1	abcd	4206	4140	--	
35614	iu251a1jr_07196032029	0,-200	200.0	1	-78.5	abcd	2102	2070	s?0	target in D; 2x2 binning
35790	iu253a0ar_07196213934	-2000,-2000	100.0	1	-78.1	abcd	2102	2070	s?0	target in C; 2x2 binning
35792	iu253a0er_07196221349	+2000,-2000	100.0	1	-77.9	abcd	2102	2070	s?0	target in D; 2x2 binning
35807	iu253a0vr_07196233101	-1000,-2000	100.0	1	-78.1	abcd	2102	2070	s?0	target in C; 2x2 binning
35811	iu253a10r_07197000621	+1000,-2000	100.0	1	-78.3	abcd	2102	2070	s?0	target in D; 2x2 binning
29003	iu23150ar_07109155009	D2 flat	2000.0	1	-53.6	abcd	4206	4140	-0	
41189	iu231306r_07219025646	tungsten flat	2000.0	2	-78.1	abcd	4206	4140	-0	lamp 1
41198	iu23130kr_07219051342	tungsten flat	284.0	2	-78.3	abcd	4206	4140	-0	lamp 1
35463	iu114c1hr_07195185413	uv16	10.0	1	-77.9	abcd	4206	4140	--	saturated
35464	iu114c1ir_07195185413	uv16	10.0	1	-78.1	abcd	4206	4140	--	saturated
35465	iu114c1kr_07195190931	uv16	100.0	1	-78.5	abcd	4206	4140	--	highly saturated
35466	iu114c1mr_07195194322	uv16	100.0	1	-78.1	abcd	4206	4140	--	highly saturated
35467	iu114c1nr_07195194322	uv16	100.0	1	-78.3	abcd	4206	4140	--	highly saturated
32600	iu113c1hr_07184103154	uv15	10.0	2	-78.1	abcd	4206	4140	--	saturated
32601	iu113c1ir_07184103154	uv15	10.0	2	-77.9	abcd	4206	4140	--	saturated
32602	iu113c1kr_07184104712	uv15	100.0	2	-78.3	abcd	4206	4140	--	highly saturated
32603	iu113c1mr_07184112109	uv15	100.0	2	-78.1	abcd	4206	4140	--	highly saturated
32604	iu113c1nr_07184112109	uv15	100.0	2	-78.3	abcd	4206	4140	--	highly saturated
32661	iu111c1hr_07184133413	uv13	200.0	2	-78.3	abcd	4206	4140	--	saturated
32662	iu111c1ir_07184133413	uv13	200.0	2	-78.3	abcd	4206	4140	--	saturated

tv num	image name	location	exp time	M	temp	amp	xsize	ysize	eff	comment
32663	iu111c1kr_07184135111	uv13	200.0	2	-78.1	abcd	4206	4140	--	saturated
32664	iu111c1mr_07184150820	uv13	1000.0	2	-78.1	abcd	4206	4140	--	highly saturated
32665	iu111c1nr_07184150820	uv13	1000.0	2	-78.1	abcd	4206	4140	--	highly saturated
28646	iu25030ar_07106135908	-2000,-2000	100.0	1	-53.8	abcd	2102	2070	s?0	target in C; 2x2 bin
28648	iu25030er_07106143003	+2000,-2000	100.0	1	-53.6	abcd	2102	2070	s?0	target in D; 2x2 bin
28663	iu25030vr_07106154446	-1000,-2000	100.0	1	-53.8	abcd	2102	2070	s?0	target in C; 2x2 bin
28667	iu250310r_07106161826	+1000,-2000	100.0	1	-54.0	abcd	2102	2070	s?0	target in D; 2x2 bin
35614	iu251a1jr_07196032029	0,-200	200.0	1	-78.5	abcd	2102	2070	s?0	target in D; 2x2 bin
35790	iu253a0ar_07196213934	-2000,-2000	100.0	1	-78.1	abcd	2102	2070	s?0	target in C; 2x2 bin
35792	iu253a0er_07196221349	+2000,-2000	100.0	1	-77.1	abcd	2102	2070	s?0	target in D; 2x2 bin
35807	iu253a0vr_07196233101	-1000,-2000	100.0	1	-78.1	abcd	2102	2070	s?0	target in C; 2x2 bin
35811	iu253a10r_07197000621	+1000,-2000	100.0	1	-78.3	abcd	2102	2070	s?0	target in D; 2x2 bin
41832	iu042200r_07241133458	uv14	151.0	1	-50.0	b	400	400	s0	clks -1, gate -5.5
41833	iu042201r_07241134038	uv14	181.0	1	-49.6	b	400	400	s0	clks -1, gate -5.5
41834	iu042202r_07241134519	uv14	151.0	1	-49.6	a	400	400	--	clks -1, gate -5.5
41835	iu042203r_07241135028	uv14	181.0	1	-50.0	a	400	400	--	clks -1, gate -5.5
41836	iu042200r_07241135808	uv14	151.0	1	-49.6	b	400	400	s0	clks -1, gate -5.5
41837	iu042200r_07241141418	uv14	151.0	1	-50.2	b	400	400	s0w	clks +1, gate -5.5
41838	iu042200r_07241142028	uv14	151.0	1	-49.6	b	400	400	--	clks +1, gate -6
41839	iu042200r_07241142718	uv14	151.0	1	-49.6	b	400	400	--	clks -1, tate -6
41840	iu042200r_07241143528	uv14	151.0	1	-49.8	b	400	400	s-	clks -1, tate -5.75
41841	iu042200r_07241144309	uv14	151.0	1	-50.0	b	400	400	--	clks -1, gate -6.25
41842	iu042202r_07241144958	uv14	151.0	1	-49.6	a	400	400	--	clks -1, gate -6
41843	iu042204r_07241150528	flat	9.5	1	-49.6	b	400	400	s-	clks -1, gate -5.5
41844	iu042204r_07241151118	flat	9.5	1	-49.6	b	400	400	--	clks -1, gate -6
41845	iu042210r_07241153118	flat	150.0	1	-49.6	abcd	4206	4140	--	clks -1, gate -5.5
41846	iu042210r_07241154629	flat	190.0	1	-49.8	abcd	4206	4140	--	clks -1, gate -5.5
41847	iu042210r_07241160039	flat	170.0	1	-49.6	abcd	4206	4140	--	clks -1, gate -5.5

tv num	image name	location	exp time	M	temp	amp	xsize	ysize	eff	comment
41849	iu043201r_07241164753	uv14	0.0	1	-50.0	b	400	400	--	clks -1, gate -6
41850	iu043202r_07241164753	uv14	23.0	1	-49.6	b	400	400	--	clks -1, gate -6
41851	iu043203r_07241164753	uv14	23.0	1	-49.6	b	400	400	--	clks -1, gate -6
41852	iu043204r_07241164753	uv14	23.0	1	-49.6	b	400	400	--	clks -1, gate -6
41853	iu043206r_07241165025	uv14	23.0	1	-49.6	b	400	400	--	clks -1, gate -6
41854	iu043207r_07241165656	uv14	267.0	1	-49.6	b	400	400	--	clks -1, gate -6
41855	iu043209r_07241165656	uv14	38.0	1	-49.6	b	400	400	--	clks -1, gate -6
41856	iu04320br_07241170037	uv14	38.0	1	-50.0	b	400	400	--	clks -1, gate -6
41857	iu04320cr_07241170234	uv14	66.0	1	-50.0	b	400	400	--	clks -1, gate -6
41858	iu04320er_07241170459	uv14	94.0	1	-50.2	b	400	400	--	clks -1, gate -6
41859	iu04320gr_07241170743	uv14	113.0	1	-49.6	b	400	400	--	clks -1, gate -6
41860	iu04320ir_07241171046	uv14	132.0	1	-50.0	b	400	400	--	clks -1, gate -6
41861	iu04320kr_07241171408	uv14	151.0	1	-49.8	b	400	400	--	clks -1, gate -6
41862	iu04320mr_07241171739	uv14	160.0	1	-49.6	b	400	400	--	clks -1, gate -6
41863	iu04320or_07241172119	uv14	169.0	1	-50.0	b	400	400	--	clks -1, gate -6
41864	iu04320qr_07241172643	uv14	179.0	1	-50.0	b	400	400	--	clks -1, gate -6
41865	iu04320sr_07241172643	uv14	0.0	1	-50.2	b	400	400	--	clks -1, gate -6

Table 4. Files used for gain determinations, using new gate voltage setting (IULGATAB ~-6) and default clock settings (IUS2BHI / IUS3BHI ~ -7, -1V). Images were all full-frame, four-amp readouts, with offset=3, binning=1, WFC3 side 1 (MEB1), and CCD temperature -78^{o} C. Flats were taken with F606W, using CASTLE tungsten lamp with OSFILT0=LP340 and OSFILT2=OPEN. Shown are the imagenames, tv number, observation date and time, exposure time, CASTLE OSFILT1, and median level (in DN).

Image Name	tvnum	date-obs	exptime	OSFILT1	gain setting	median (DN)
iu050401r_07248050605	41936	2007-09-05 05:00:23	0. (bias)	ND1,SN01	1.5	1.41
iu050402r_07248050605	41937	2007-09-05 05:03:24	14.3	ND1,SN01	1.5	400.15
iu050404r_07248052344	41938	2007-09-05 05:17:38	14.3	ND1,SN01	1.5	398.22
iu050405r_07248052344	41939	2007-09-05 05:20:06	71.4	ND1,SN01	1.5	1963.48
iu050407r_07248054259	41940	2007-09-05 05:34:45	71.4	ND1,SN01	1.5	1960.97
iu050408r_07248054259	41941	2007-09-05 05:38:10	143.	ND1,SN01	1.5	3917.86
iu05040ar_07248060226	41942	2007-09-05 05:54:00	143.	ND1,SN01	1.5	3918.36
iu05040br_07248060226	41943	2007-09-05 05:59:33	26.7	OPEN1	1.5	6629.03
iu05040dr_07248061913	41944	2007-09-05 06:13:27	26.7	OPEN1	1.5	6640.52
iu05040er_07248061913	41945	2007-09-05 06:16:07	39.2	OPEN1	1.5	9742.80
iu05040gr_07248063627	41946	2007-09-05 06:30:14	39.2	OPEN1	1.5	9785.90
iu05040hr_07248063627	41947	2007-09-05 06:33:07	53.4	OPEN1	1.5	13340.85
iu05040jr_07248065341	41948	2007-09-05 06:47:28	53.4	OPEN1	1.5	13287.75
iu05040kr_07248065341	41949	2007-09-05 06:50:35	39.2	OPEN1	1.0	14342.40
iu05040mr_07248071056	41950	2007-09-05 07:04:42	39.2	OPEN1	1.0	14341.45
iu05040nr_07248071056	41951	2007-09-05 07:07:44	0. (bias)	OPEN1	1.0	1.57

Table 5. Files used for readnoise determinations. Images were all full-frame, four-amp readouts, with offset=3, binning-1, WFC3 side 1 (MEB1), and CCD temperature -78^{o} C. Serial clocks were at their default settings (~ -7.5, -1).

image name	tvnum	date-obs	gain	gate voltage
iu010701r_i0724723345	41902	2007-09-04 23:30:24.04	1.5	-6.0156
iu010702r_i0724723345	41903	2007-09-04 23:32:28.04	1.5	-6.0156
iu010704r_i0724723501	41904	2007-09-04 23:45:46.06	1.5	-6.0156
iu010705r_i0724723501	41905	2007-09-04 23:47:50.06	1.5	-6.0156
iu010707r_i0724800062	41906	2007-09-05 00:01:07.04	1.5	-6.0156
iu010708r_i0724800062	41907	2007-09-05 00:03:11.04	1.5	-6.0156
iu011701r_i0724800285	41908	2007-09-05 00:24:23.04	1.0	-6.0156
iu011702r_i0724800285	41909	2007-09-05 00:26:27.04	1.0	-6.0156
iu011704r_i0724800441	41910	2007-09-05 00:39:45.06	1.0	-6.0156
iu011705r_i0724800441	41911	2007-09-05 00:41:49.06	1.0	-6.0156
iu011707r_i0724801002	41912	2007-09-05 00:55:07.04	1.0	-6.0156
iu011708r_i0724801002	41913	2007-09-05 00:57:11.04	1.0	-6.0156
iu010701r_i0724801515	41918	2007-09-05 01:47:23.04	1.5	-5.46872
iu010702r_i0724801515	41919	2007-09-05 01:49:27.04	1.5	-5.46872
iu010704r_i0724802071	41920	2007-09-05 02:02:45.06	1.5	-5.46872
iu010705r_i0724802071	41921	2007-09-05 02:04:49.06	1.5	-5.46872
iu010707r_i0724802232	41922	2007-09-05 02:18:07.04	1.5	-5.46872
iu010708r_i0724802232	41923	2007-09-05 02:20:11.04	1.5	-5.46872
iu011701r_i0724802465	41924	2007-09-05 02:42:23.04	1.0	-5.46872
iu011702r_i0724802465	41925	2007-09-05 02:44:27.04	1.0	-5.46872
iu011704r_i0724803021	41926	2007-09-05 02:57:45.06	1.0	-5.46872
iu011705r_i0724803021	41927	2007-09-05 02:59:49.06	1.0	-5.46872
iu011707r_i0724803182	41928	2007-09-05 03:13:07.04	1.0	-5.46872
iu011708r_i0724803182	41929	2007-09-05 03:15:11.04	1.0	-5.46872