WFC3 UVIS Detector Performance

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Abstract

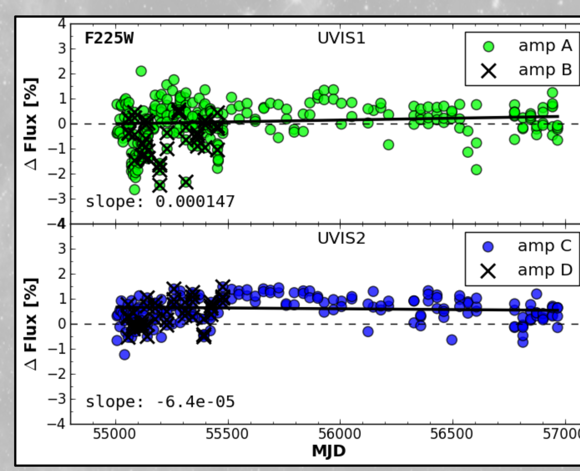
The Wide Field Camera 3 (WFC3) is a fourth-generation imaging instrument installed on the Hubble Space Telescope (HST) during Servicing Mission 4 (SM4) in May 2009. WFC3 has two observational channels, UV/visible (UVIS) and infrared (IR); both have been performing well on-orbit. Since installation, the WFC3 team has been diligent in monitoring the performance of both detectors. The UVIS channel consists of two e2v, backside illuminated, 2Kx4K CCDs arranged in a 2x1 mosaic. We present results from some of the monitoring programs used to check various aspects of the UVIS detector. We discuss the growth trend of hot pixels and the efficacy of regular anneals in controlling the hot pixel population. We detail a pixel population with lowered-sensitivity that evolves during the time between anneals, and is largely reset by each anneal procedure. We discuss the stability of the post-flash LED lamp, used and recommended for CTE mitigation in observations with less than 12 e-/pixel backgrounds. Finally, we summarize long-term photometric trends of the UVIS detector, as well as the absolute gain measurement, used as a proxy for the on-orbit evolution of the UVIS channel.

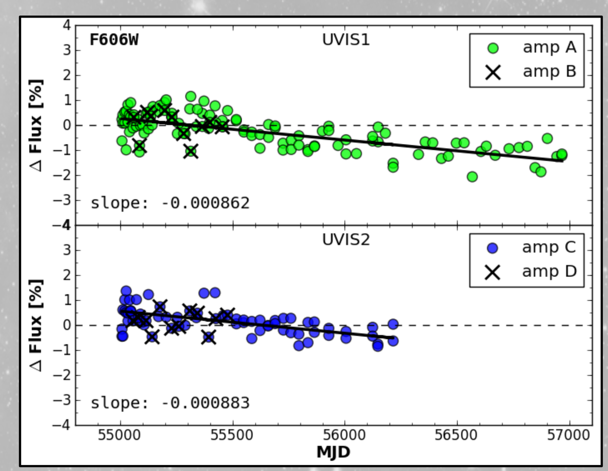
Photometric Trends

- Causes for these photometric trends are currently unknown but are being investigated by the WFC3 Team

Table: Throughput change (percent per year) for subset of UVIS filters for amplifiers A and C. Throughput change varies with filter and have formal errors of < 0.001.

Filter	Amp	Obs Period	Throughput Change (%/year)
F218W	A	6/2009-11/2014	0.101
	C	6/2009-11/2014	0.008
F225W	A	6/2009-11/2014	0.054
	C	6/2009-11/2014	-0.024
F275W	A	6/2009-11/2014	-0.022
	C	6/2009-11/2014	-0.014
F336W	A	6/2009-11/2014	0.004
	C	6/2009-11/2014	-0.007
F390M	A	6/2009-10/2012	-0.288
	C	6/2009-10/2012	0.038
F390W	A	6/2009-10/2012	-0.167
	C	6/2009-10/2012	-0.159
F438W	A	6/2009-11/2014	-0.171
	C	6/2009-11/2014	-0.161
F467M	A	6/2009-10/2012	-0.338
	C	6/2009-10/2012	-0.104
F475W	A	8/2009-10/2012	-0.382
	C	8/2009-10/2012	-0.156
F547M	A	8/2009-10/2012	-0.360
	C	8/2009-10/2012	-0.145
F555W	A	11/2010-10/2014	-0.250
	C	11/2010-10/2014	-0.132
F606W	A	6/2009-11/2014	-0.315
	C	6/2009-11/2014	-0.322
F814W	A	6/2009-11/2014	-0.163
	C	6/2009-11/2014	-0.126
F850LP	A	11/2010-10/2014	-0.076
	C	11/2010-10/2014	-0.130



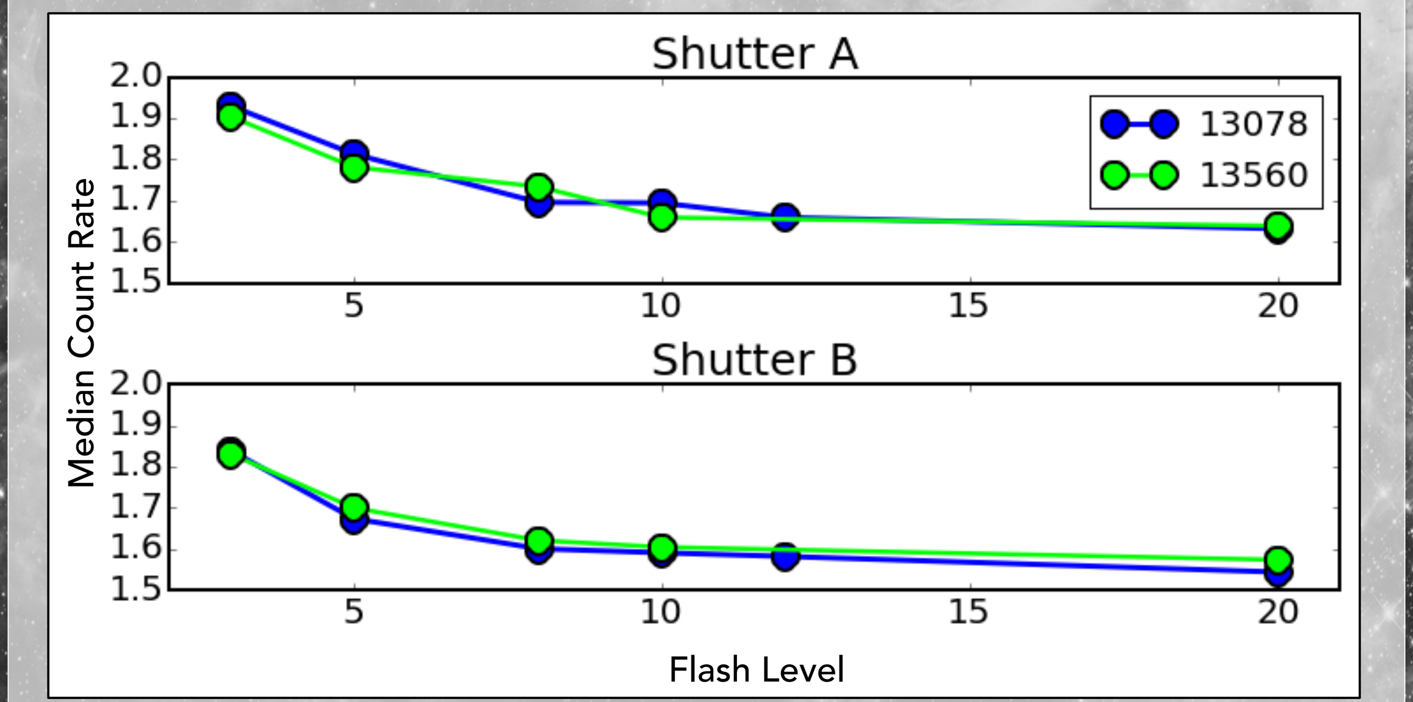


Figures: Percent difference in flux as a function of time. UV filters (e.g. F225W) show total throughput growth, while redder filters (e.g. F606W) show total throughput decline. The cause is still under investigation.

Post-Flash

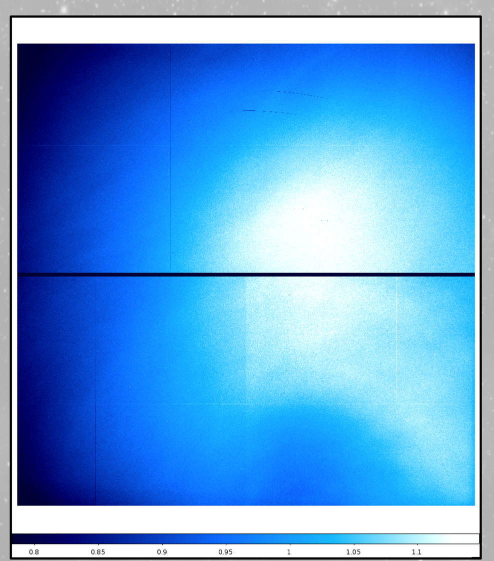
The post-flash image file (FLSFILE) is utilized to calibrate observations that have taken advantage of the post-flash feature for CTE mitigation.

- Monitoring of post-flash LED shows no evidence of long-term variations
- ~5% variation between shutter blades A and B
- LED flash pattern ±20% variation across FOV
- Count rates for different flash levels are stable
- Illumination pattern is stable



The figure above shows the median count rate as a function of flash level for both shutter blades A and B over cycle 20* (PID 13078) and cycle 21** (PID 13560). The count rate from cycle 20 through cycle 21 for both shutters is stable across all flash levels.

*observation dates range 11/2012-11/2013
** observation dates range 12/2013-10/2014



Normalized post-flash reference file for shutter A, showing the illumination pattern. Lighter indicates more illumination and darker indicates less. The post-flash pattern shows ± 20% variation across the entire FOV.

Gain Stability

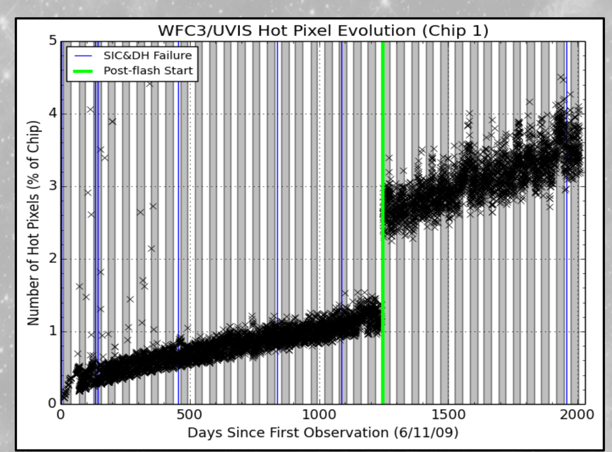
- Gain values for nominal setting of 1.5 e-/DN are stable through early cycle 22 compared to previous measurements (errors ~0.01e-/DN)

The table below shows the absolute gain values since Thermal Vac 3 (TV3,ground testing in 2008/2009) through December 2014.

Quadrant	Cy22 Dec	Cy21 Jun	Cy21 Dec	Cy20 Jun	Cy20 Dec	Cy19	Cy18	Cy17	SMOV	TV3
A	1.57	1.56	1.56	1.56	1.56	1.56	1.55	1.54	1.56	1.56
B	1.56	1.56	1.56	1.55	1.55	1.56	1.55	1.54	1.56	1.56
C	1.58	1.58	1.58	1.58	1.58	1.58	1.57	1.56	1.58	1.58
D	1.57	1.57	1.57	1.57	1.57	1.57	1.56	1.55	1.57	1.57

Hot Pixel Trends

- Long-term growth of hot pixels is currently ~100 pixels per chip per day (after post-flash start)
- ~3.3% of pixels in each chip are hot pixels (above 54 e-/hr)
- Monthly anneals erase 20-30% of hot pixel population



The figure to the left shows the hot pixel populations for chip 1. Time periods between anneals are represented by the gray/white regions. The green line represents the start of post-flashing the darks used to measure the hot pixel population. Prior to post-flashing, many hot pixels were undetectable due to CTE losses; now they survive the readout and are detected as hot.

Information and Resources

For more information see WFC3 Instrument Science Reports:
http://www.stsci.edu/hst/wfc3/documents/ISRs/

WFC3 ISR 2014-20; Update on the WFC3/UVIS Stability and Contamination Monitor
WFC3 ISR 2014-18; Pixel-to-Pixel Flat Field Changes in WFC3/UVIS
WFC3 ISR 2014-05; WFC3 Cycle 20 Proposal 13168: UVIS Gain
WFC3 ISR 2014-04; WFC3 Cycle19 & 20 Dark Calibration I
WFC3 ISR 2013-12; WFC3 Post-Flash Calibration

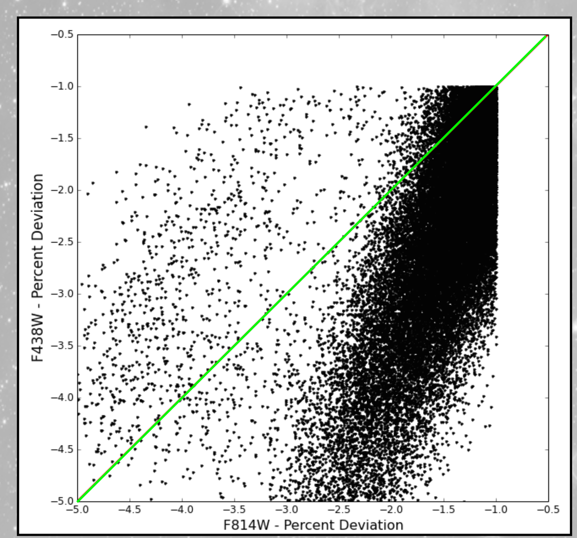
For additional questions contact help@stsci.edu

Low Sensitivity Pixels

During the time between anneals a population of pixels with lowered sensitivity develops.

General Population Characteristics

- Average sensitivity deficit of ~1-2%
- Most pixels are reset (~90%) after each anneal
- Almost exclusively a different set of pixels between each anneal
- Wavelength dependent
- UV filters are affected the most (i.e. more pixels affected, larger sensitivity drop, tend to be 2-3 pixels in size)
- Best mitigation option is to dither



On average the sensitivity deficit is 2 times greater in F438W than in F814W. The green line shows the 1:1 ratio of F438W and F814W. If there were no wavelength dependence, the population would be fit by this line.

- Low sensitivity population shows no significant increase from Cycle 20 to Cycle 21.

The figures to the right show the normalized low sensitivity pixel populations (<-2% deviation from median) in F438W (bottom) and F814W (top) over the course of Cycle 20 and Cycle 21. The vertical lines represent the monthly anneals. Both filters show ~90% of low sensitivity pixels reset after the annealing process.