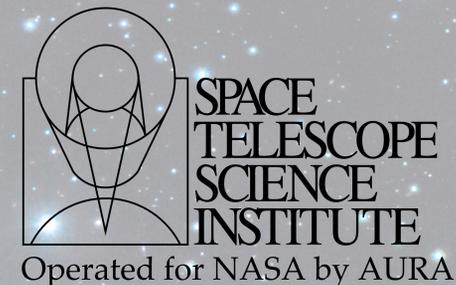




# Wide Field Camera 3: Trends in the UVIS Detector

Matthew Bourque, J. Anderson, S. Baggett, J. Biretta, S. Deustua, D. Hammer, K. Noeske, J. MacKenty, and the WFC3 Team (STScI)

222<sup>ND</sup> MEETING  
OF THE AMERICAN ASTRONOMICAL SOCIETY  
INDIANAPOLIS, INDIANA | 3-6 JUNE 2013  
Poster 316.11



## ABSTRACT

The Hubble Space Telescope (HST) Wide Field Camera 3 (WFC3) is a fourth-generation imaging instrument that was installed during Servicing Mission 4 in May 2009 and has performed well on-orbit since then. The UVIS channel, named for its ultraviolet and visible light detecting capabilities, is comprised of two e2v CCDs and is one of two channels available on WFC3. We present the results of some of the monitoring programs used to regularly assess the performance and calibration of the UVIS detector. We discuss the long-term growth in the number of hot pixels and the effectiveness of the anneal procedures in controlling that growth as well as provide a summary of the long-term evolution in dark current. We also summarize the UVIS Charge Transfer Efficiency (CTE) monitoring accomplished using both external and internal observations and provide recommendations for CTE mitigation. We describe a program to check for hysteresis in the detector and detail our method of successfully neutralizing any offset. Finally, we outline the routine photometric monitoring performed and provide an evaluation of the throughput stability of the UVIS channel. These and other trending programs will continue throughout and beyond HST's current proposal cycle as a means of evaluating the overall health and stability of WFC3/UVIS.

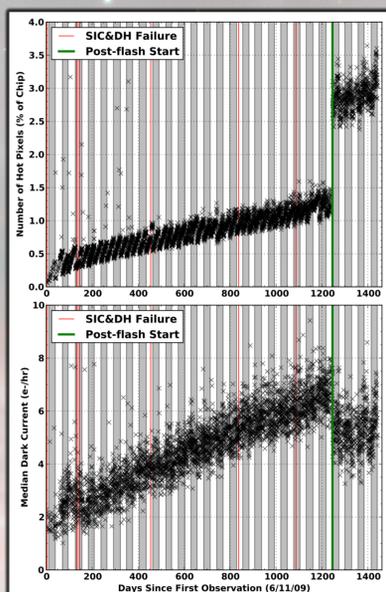
## HOT PIXELS AND DARK CURRENT

**Hot pixels and dark current increase with time.** About 1000 new hot pixels appear every day using a threshold of 54e-/hr, currently occupying ~3.0% of each chip. Median dark current increases ~1.4 e-/hr/year/pix and is currently ~5e-/hr/pix.

**UVIS anneals suppress hot pixels.** Each month, the UVIS detector is warmed to +20C, erasing 20-30% of the hot pixels. Long-term growth in hot pixels is currently ~35/chip/day.

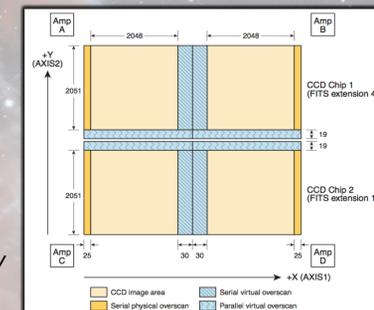
**Post-flashing the detector mitigates CTE.** Hot pixels in WFC3 darks contain extended trails caused by CTE losses. Since the 11/08/2012 (day 1246) UVIS anneal, darks have been post-flashed, i.e. a background of 12 e-/pix is introduced to each image. Post flashing preserves faint signal in pixels far from the amps that otherwise would have been undetectable due to the CTE losses. The result is a jump in the number of detected hot pixels after day 1246. The suppression of CTE trails by the post-flash also causes a commensurate reduction in the overall measured dark current.

**Figure 1** – Percentage of hot pixels (>54e-/hr)(top) and dark current (bottom) versus time for Chip 2 (Amps C & D). Monthly anneal intervals are represented by gray/white regions.



## UVIS CHANNEL

- Two 2k x 4k e2v thinned, back-illuminated CCDs at -83C
- Chips separated by ~35 pix or ~1.4"
- Field of View: 160" x 160", covering 200-1000 nm
- Standard Readout: full-frame via 4 amps
- Readnoise: ~3 e-; Gain: ~1.6 e-/DN; Full well: 63 – 72k e-
- Optional binning or subarray readouts
- *Post flash available for CTE loss mitigation; highly recommended for low-signal sources on low backgrounds*

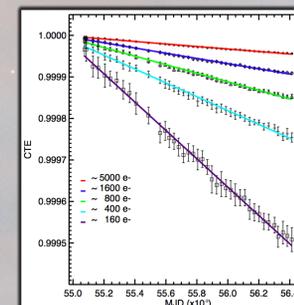


**Figure 4** – CCD readout configuration

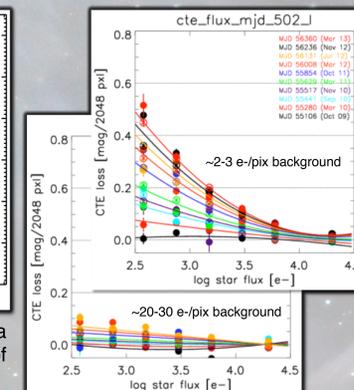
## CHARGE TRANSFER EFFICIENCY

**CTE declines with time due to radiation damage.** Figure 5 shows CTE as measured via the Extended Pixel Edge Response (EPER) technique; EPER CTE is now ~0.99955/pix after 3.3 years on orbit at lowest signal levels (~160 e-).

Figure 6 shows CTE losses for observations of star clusters NGC6791 and 47 Tuc, measured in 3-pixel apertures; losses are currently ~0.5 mag for 300 e- sources far from the amp in low background images. Losses are less for images with high backgrounds and/or brighter sources.



**Figure 5** – Internal CTE as a function of time for a range of signal levels.



**Figure 6** – CTE losses as a function of observation date and source flux.

**CTE mitigation options:** (See poster 316.12 for further details)

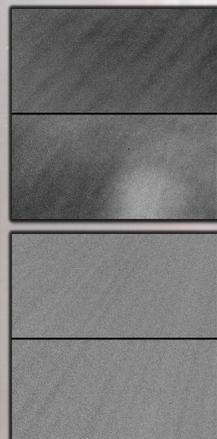
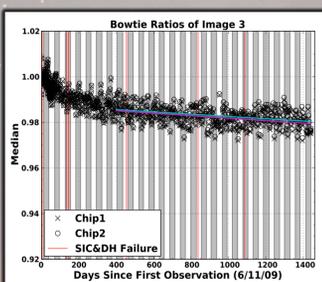
**Before data acquisition:** Positioning targets near the readout amplifiers ensures minimal CTE losses.

**During data acquisition:** Ensure images contain at least 12 e-/pix natural or post-flash background.

**After data acquisition:** A preliminary version of a pixel-based CTE correction is available as a standalone routine. The software operates on the "raw" images, utilizing the derived correction to produce CTE-corrected raw ("rac") and fit ("flc") images. The software and supporting documentation can be found at [http://www.stsci.edu/hst/wfc3/tools/cte\\_tools](http://www.stsci.edu/hst/wfc3/tools/cte_tools).

## NEUTRALIZING DETECTOR HYSTERESIS

Exp	Type	Filter	Exposure Time (s)
1	TUNGSTEN	F475X	1
2	TUNGSTEN	F475X	200
3	TUNGSTEN	F475X	1



**UVIS experiences intermittent hysteresis features.**

Ground data revealed a ~0.1-0.2% 'bowtie'-shaped hysteresis effect at -83C. Furthermore, GSFC DCL tests showed that a similar effect occurs in the form of a global uniform QE deficit when (1) power cycling the detector while cold or (2) cooling the detector in the dark.

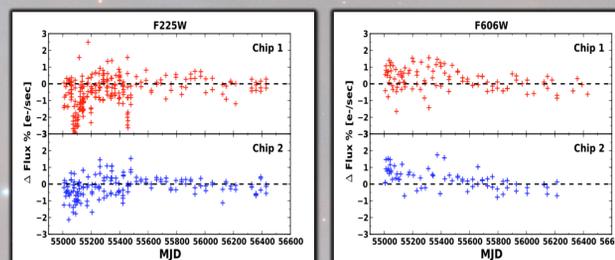
**Hysteresis is mitigated by saturating the detector.**

The QE offset can be neutralized by a saturated flat field, suppressing the hysteresis for days. On orbit, a QE offset is seen after each anneal, however, the chips are saturated via the internal lamps to mitigate the hysteresis (Fig 3). A 'bowtie monitoring' calibration program (Table 1) is used to correct for hysteresis between anneals and is monitored by examining image ratios (Fig 2).

**Long-term lamp output declines.** A linear fit of image 3/reference images since day 400 shows that the UVIS lamp output has been declining at a rate of 0.19±0.01%/year (Fig 2).

**Table 1** – Observational parameters for a single bowtie visit.  
**Figure 2 (left)** – Median values of the image3/reference image ratios versus time.  
**Figure 3 (right)** – An image 1/image 3 ratio (top) showing ~0.5% hysteresis effects and an image 3/constant ratio (bottom) showing that hysteresis has been neutralized.

## PHOTOMETRIC STABILITY



**Figure 7** – The stability of the F225W (left) and F606W (right) filters as a function of time. 1-sigma RMS scatter for both filters is 0.4% for data > MJD=55500 after clipping.

**Photometric throughput is stable.** Aperture photometry of external observations of white dwarf photometric standard stars placed on 512 pixel subarrays at the chip corners reveal that UVIS throughput since Nov 2010 (MJD=55500) is stable to ~0.4% in both the UV and the optical. Figure 7 shows the change in flux over time for the F225W (UV) and F606W (optical) filters, normalized to a 3-sigma clipped median value for images taken later than MJD = 55500, the date at which exposure times increased from 2.0 to 6.3 seconds and improved positional parameters were used.

## REFERENCES AND ADDITIONAL INFORMATION

- WFC3 Main Page: [www.stsci.edu/hst/wfc3](http://www.stsci.edu/hst/wfc3)
- WFC3 Instrument Handbook: [http://www.stsci.edu/hst/wfc3/documents/handbooks/currentIHB/wfc3\\_ihb.pdf](http://www.stsci.edu/hst/wfc3/documents/handbooks/currentIHB/wfc3_ihb.pdf)
- UVIS Performance Monitoring: [http://www.stsci.edu/hst/wfc3/ins\\_performance/monitoring/](http://www.stsci.edu/hst/wfc3/ins_performance/monitoring/)
- Detector Hysteresis: Bourque, M., & Baggett, S., "WFC3/UVIS Bowtie Monitor," WFC3 ISR 2013-09, 2013
- CTE: [http://www.stsci.edu/hst/wfc3/ins\\_performance/CTE/](http://www.stsci.edu/hst/wfc3/ins_performance/CTE/)
- Bourque, M., & Kozhurina-Platais, V., "WFC3/UVIS EPER CTE Measurement: Cycles 19 & 20," WFC3 ISR 2013-03, Feb, 2013
- Noeske, K., et al., "WFC3 UVIS Charge Transfer Efficiency," WFC3 ISR 2012-09, June, 2012
- Related Posters ([http://www.stsci.edu/hst/wfc3/documents/meeting\\_posters/aas222](http://www.stsci.edu/hst/wfc3/documents/meeting_posters/aas222)):
  - Wide Field Camera 3 – Phase II Proposal Update for Cycle 21; Heather Gunning (Session 316.12)
  - WFC3 Calibration Pipeline Update: Significant Changes and Improvements; Megan Sosey (Session 316.08)
- STScI Help Desk: [help@stsci.edu](mailto:help@stsci.edu)