HST/WFC3: Improvements to the UVIS Dark Calibration

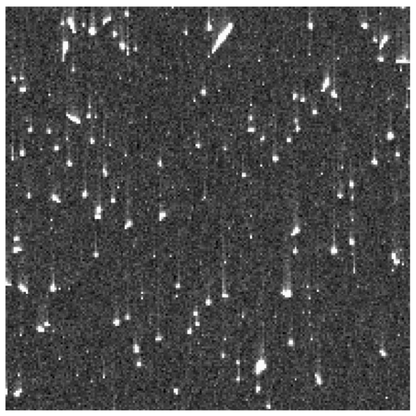
Matthew Bourque, Sylvia Baggett, Varun Bajaj, Catherine Martlin, and the WFC3 Team (STScI)

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

Abstract

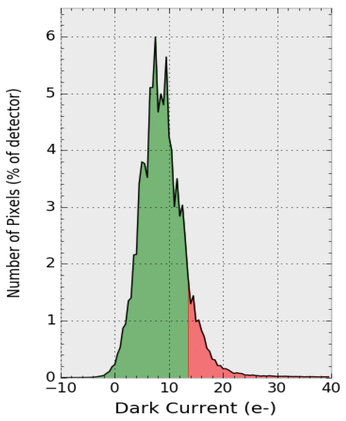
The Hubble Space Telescope (HST) Wide Field Camera 3 (WFC3) UVIS detector, comprised of two e2v CCDs, exhibits an inherent dark current (in the absence of any illumination) presently measured at ~8 e-/hr and increasing at ~1 e-/hr/yr. Additionally, detector degradation due to on-orbit radiation damage generates a continuously increasing though small population of hot pixels (dark current exceeding 54 e-/hr, currently ~4% of each chip). We present the results of the WFC3/UVIS dark calibration, which provides calibration files used as a correction for these detector characteristics. We also discuss the impacts that Charge Transfer Efficiency (CTE) losses and detector post-flashing have on the hot pixel population, as well as various improvements to the calibration procedure that were introduced in the CALWF3 v3.3 pipeline.

UVIS Dark Observations

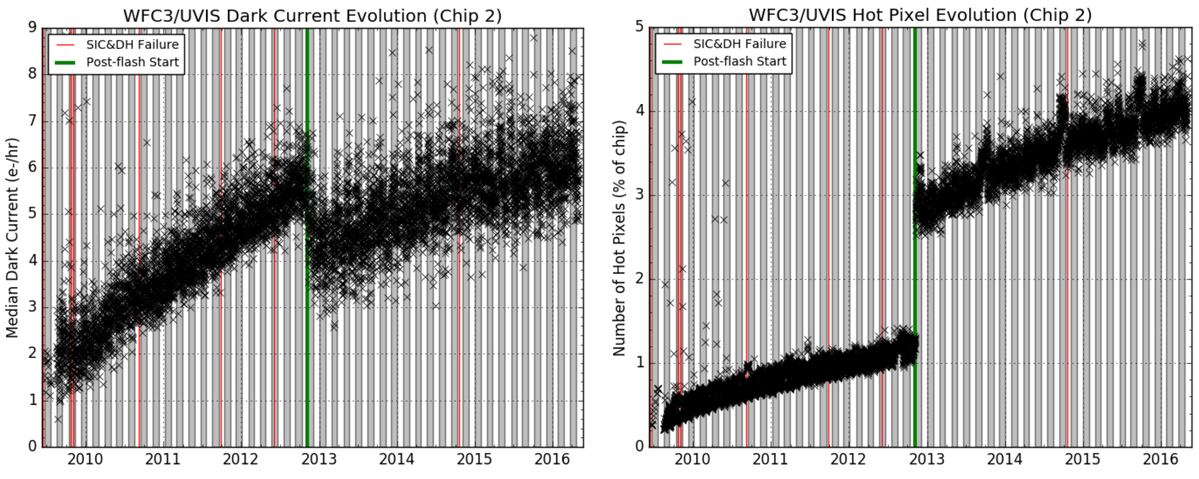


(Left) A 50x50 pixel region taken from a 900-second UVIS dark, showing the nominal features of background dark current, cosmic rays, and hot pixels (defined as pixels with dark current exceeding 54 e-/hr).

(Right) The distribution of pixel values in a 900-second UVIS dark. The pixels with values exceeding the 54 e-/hr threshold (13.5 e- in 900 sec) are shaded in red. Bin size is 0.5 e-.



Hot Pixels and Dark Current

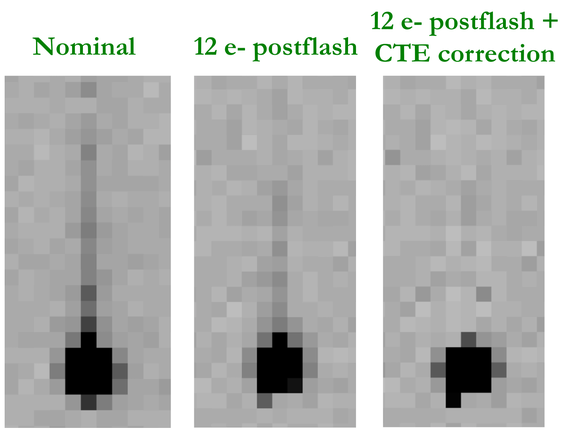


The median dark current (left) and number of hot pixels (right) over time for Chip 2 (Amps C & D). Dark current increases roughly 0.5 e-/hr/year and is currently ~8 e-/hr. Approximately 1000 new hot pixels above the 54 e-/hr threshold appear every day, currently occupying ~4% of each chip. Each month, the UVIS detector is warmed to +20C (shaded in gray/white regions), erasing 10-20% of the hot pixels.

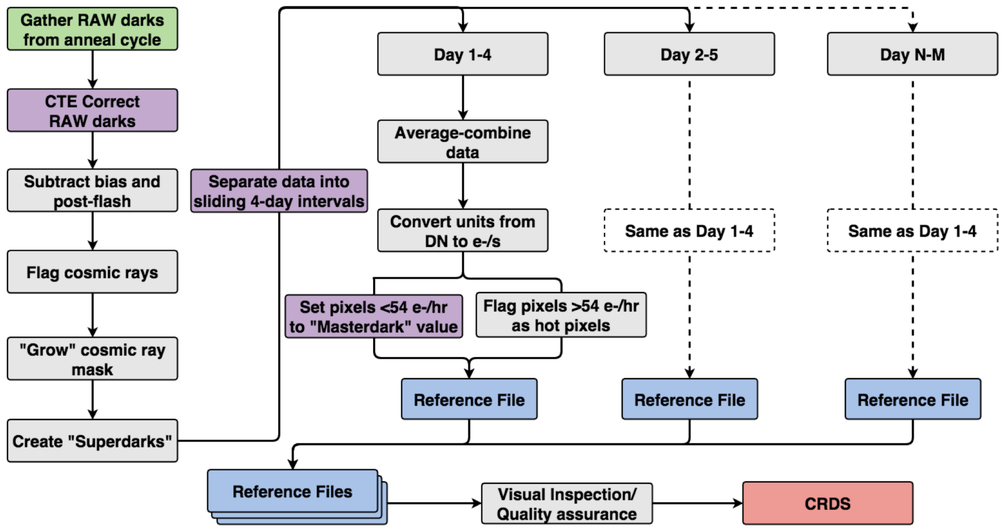
Charge Transfer Efficiency Mitigation

Cosmic rays and hot pixels lose signal during readout due to degraded CTE, a consequence of radiation damage. The lost signal is detected later in the readout and appears as extended source trails. CTE losses in UVIS dark observations are mitigated by:

- **Postflashing** - Introducing a 12 e-/pix total background signal during observation helps to release charge traps and preserve faint source signal.
- **CTE Correction** - An empirical pixel-based CTE correction (now implemented in the CALWF3 calibration pipeline v3.3, installed Feb 2016) helps to restore CTE losses.

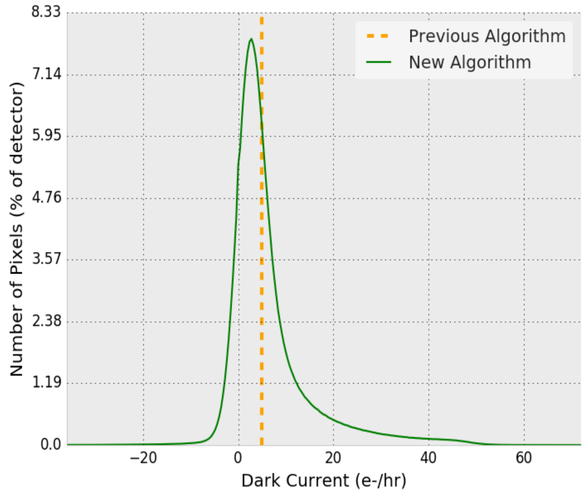


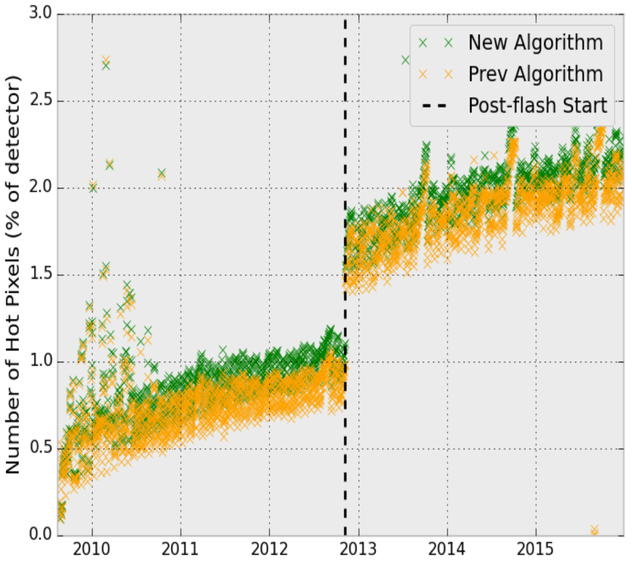
Improved Dark Calibration



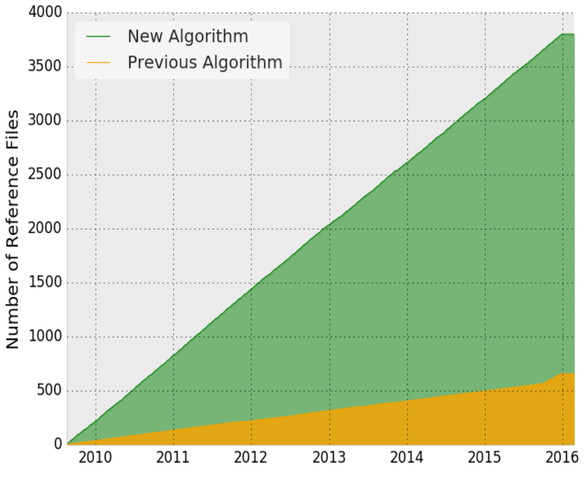
A new UVIS dark calibration algorithm (shown above) has been implemented in the release of CALWF3 v3.3. This update introduces several improvements (colored in magenta), which include:

- **CTE correcting input darks** - helps to mitigate background signal introduced by CTE trails of hot pixels and cosmic rays
- **Setting non-hot pixels to an anneal-cycle averaged "Masterdark" value** - instead of using the frame's median value (shown right)
- **Generating reference files for each day** - 4-day reference files are generated on a sliding window instead of a non-overlapping window, yielding a finer grid of dark reference files and a more accurate measure of hot pixels surrounding a given observation





The number of hot pixels present in dark reference files over time for darks generated from the previous algorithm (orange) and from the new algorithm (green). The CTE correction allows for the detection of hot pixels that otherwise would have been immeasurable due to CTE losses.



The cumulative number of dark reference files delivered to the Calibration Reference Data System (CRDS) from the start of Cycle 17 through the installation of CALWF3 v3.3 (02/23/2016) for reference files generated from the new algorithm (green, 3800 total) and from the previous algorithm (orange, 656 total). Observers with science data taken prior to the release of CALWF3 v3.3 may request their data through the Mikulski Archive for Space Telescopes (MAST) to obtain the improved products.

AAS 228th MEETING
AMERICAN ASTRONOMICAL SOCIETY
SAN DIEGO, CALIFORNIA • 12-16 JUNE 2016
Poster 216.04

References

- Accompanying ISR: M. Bourque & S. Baggett, "WFC3/UVIS Dark Calibration: Monitoring Results and Improvements to Dark Reference Files," WFC3 ISR 2016-08, April, 2016, available at www.stsci.edu/hst/wfc3/documents/ISRs/
- See related posters: 216.03 (Gosmeyer), 216.05 (Sabbi), 216.06 (Khandrika), and 216.15 (Bajaj)
- STScI Help Desk: help@stsci.edu