Long-term Stability of the WFC3 Post-Flash LED Lamp

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Abstract

We report the results of a study of the long-term stability of the LED lamp used in post-flashing WFC3/UVIS. Having analyzed 644 sub-array exposures taken over the course of just over 3 years we find no significant long-term trends in the LED lamp brightness. The average percentage change per year over all FLASH level and shutter combinations is found to be 0.15% per year with an uncertainty of +/- 0.24% per year. The maximum measured percentage change per year was 0.39% for the highest FLASH level of 20 e- on shutter A which would indicate a change of less than 1 e-/pixel over the roughly 3 years since post-flashing began.

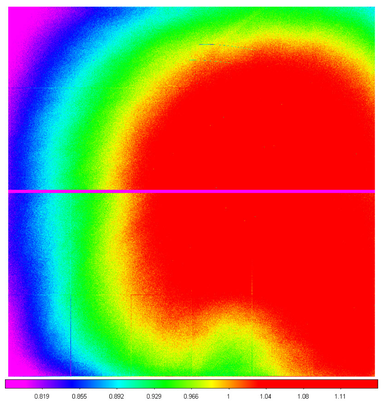
We recommend that users continue using the post-flash as they would have previously.

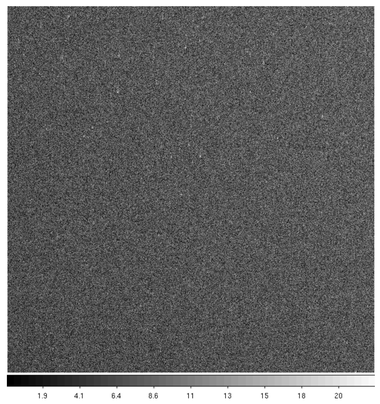
Introduction

Post-flashing a WFC3 UVIS image illuminates the shutter with an LED prior to readout to soak the CCD with a highly diffuse light filling charge traps and thus mitigating charge transfer efficiency (CTE) losses. A previous study of the LED lamp found no long term instability over 9 months of data (**Biretta and Baggett, 2013**). Here, we summarize a study of the LED lamp stability over 38 months (>3 years) of data.

Data and Methods

- Total data: 644 0.5-second darks flashed with LOW current at FLASH levels of 3, 5, 8, 10, 12 and 20 e-/pixel (chosen in **Biretta and Baggett, 2013**) taken with the C1K1C 1024x1024 sub-array.
- Each image was run through the CALWF3 pipeline (version 3.1.4) to perform the overscan, bias, and dark corrections and used LACOSMIC to remove cosmic rays.
- Then the mean of each image from a FLASH level/Shutter combination was normalized to the average of the mean of a small selection of images from the middle of our data date range before being plotted and fit with a linear trend line to test for dimming over time. See example plots in results section.

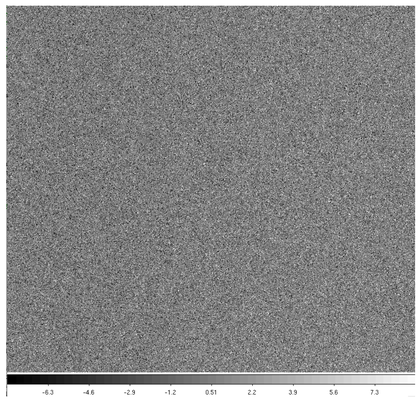




Left: The current normalized full frame post-flash image for shutter A. Our testing subarray is located in the lower left corner. The post-flash illumination pattern varies by +/- 20% across the field.
Right: A typical FLASH=12 post-flash C1K1C sub-array on shutter A applied to a 0.5 second sub-array dark (image icrz31jvq). The brightness scale runs from 0 to 22 e-/pixel. Cosmic rays have been removed by processing with LACOSMIC.

Outlier Points

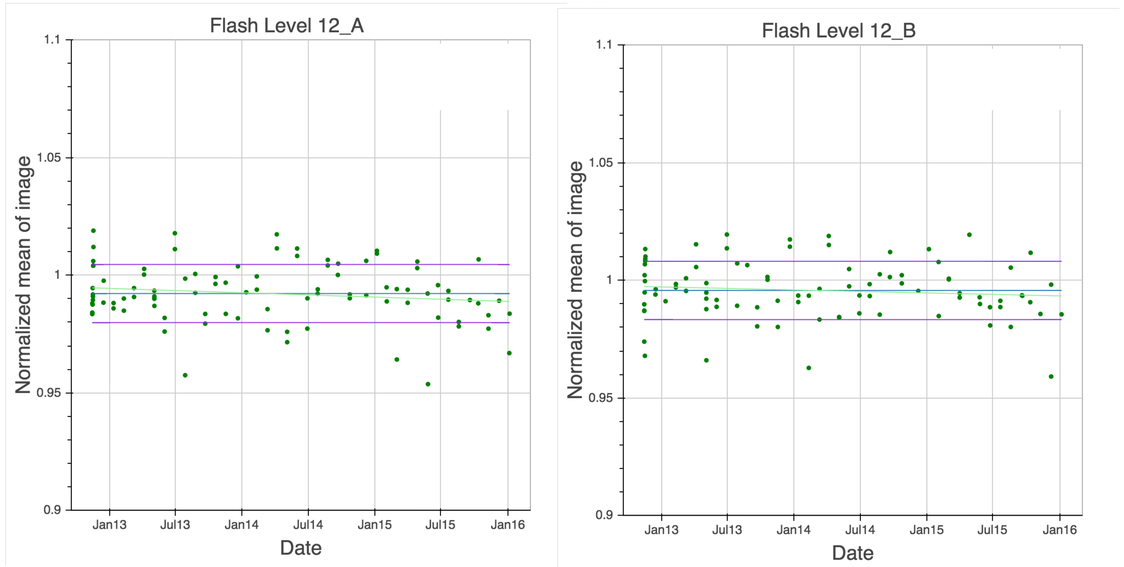
Upon inspection of the general trends of the LED lamp brightness over time it became clear that there were a series of individual images that differed by + 8% to - 5% from the average normalized mean in some subsets of our data, which is outside of our uncertainties of +/- 0.5%. **This indicated the possibility that our LED lamp is flashing slightly brighter or dimmer at seemingly random points.**



Left: Example of ratio of outlier image (ic6db3shq) to non-outlier image (ic6di3f0q). The scale goes from -8 e- to 8 e-. There are no visible patterns or shape to the ratio image indicating that there is no systematic issue causing these outliers to be dimmer or brighter than the average normalized mean measurements.

To test the outlier images we performed a visual inspection of the outlier files and created ratio files of the outlier images within a subset to all non-outlier images within the same subset in order to visually and numerically inspect whether there were any discernible patterns to indicate some systematic difference between outlier and non-outlier images. **As evidenced in the example above, no patterns were found in any images**.

Results



Above: Normalized mean post-flash over time for flash level 12 e-/pix (shutter A, B at left, right). Blue and purple lines: mean and +/- sigma, respectively. Green line is the linear fit of the data; uncertainties are less than +/- 0.05. These were made for all FLASH level/Shutter combinations.

Below: Mean of each normalized subset, the change in normalized mean counts by percent per year and their uncertainties for all sub-array FLASH/shutter subsets. The percent change per year is a measurement of the slope of the linear fit and their uncertainties and is converted from change in normalized mean count per day into a percent change per year

FLASH Level/ Shutter	Mean	Std. Dev.	Percent change per year	Uncertainty (percent per year)	Images Used
3A	1.011	0.027	-0.11	0.44	41
3B	0.995	0.022	-0.13	0.35	43
5A	0.999	0.017	-0.13	0.25	45
5B	1.000	0.018	0.14	0.28	42
8A	1.006	0.017	0.07	0.26	42
8B	1.004	0.015	-0.06	0.23	41
10A	1.001	0.016	-0.01	0.24	43
10B	0.996	0.013	0.24	0.21	41
12A	0.992	0.012	0.18	0.13	94
12B	0.996	0.013	0.13	0.13	89
20A	0.998	0.012	0.39	0.17	41
20B	0.998	0.011	0.24	0.17	40

Conclusions & Future Work

We have found no evidence for significant trends in the LED brightness over time for the 12 unique FLASH level/shutter combinations. The linear fits are on the order of 10^-6, or 0.03% per year, and all mean normalized count measurements are within a few tenths of a percent of 1.0. Overall, we measure the average percentage change per year over all FLASH level/shutter combinations to be 0.15% per year with an uncertainty of +/- 0.24% per year, for a change of less than half a percent over the slightly more than 3 years of data.

It will remain important to continue tracking the stability of the LED lamp. We are still well within the expected lifetime of the lamp and expect to see it remain stable as it has been here. A complimentary study on full-frame MEDIUM (i.e. high S/N) current post-flash images is also currently being completed (H. Kurtz et. al, 2017).

References

Biretta, J., and Baggett, S., ``WFC3 Post-Flash Calibration", WFC3 ISR 2013-12
Giavalisco, M. ``Minimizing CTE losses in the WFC3 CCDs: Post Flash vs. Charge Injection", WFC3 ISR 2003-01
Kurtz, H., and Baggett, S., ``Post-Flash Reference File", WFC3 ISR 2017, In Prep.
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This work is further expanded in **Martlin, C. and Baggett, S., 2017**.