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WFC3 Cycle 17 Proposal 11906: UVIS Gain

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ABSTRACT

This report sumarizes the gain results obtained from the Cycle 17 UVIS Gain proposal 11906 and compares the new results to measurements made using data obtained during ground testing before launch (TV3) and during the orbital verification testing performed after launch (SMOV). For all epochs, internal calibration flatfield data were used to calculate the gain, at a nominal gain setting of 1.5 e-/DN. The Cycle 17 values measured are 1.54, 1.54, 1.56, and 1.55 e-/DN, with errors <0.01 e-/DN from amps A, B,C,D respectively, within ~1% of previous values.

Introduction

The CCD gain is a measure of how many electrons are required to register as a count or data number (DN). Gain values are a key parameter for monitoring regularly since any significant changes in them can serve as an indicator of changes occurring in the camera. To facilitate the monitoring yet not use valuable external observing time, the measurements are made from internal flatfields, taken with the WFC3 calibration subsystem tungsten lamps. This report summarizes the data analysis method and results for Cycle 17, and compares them to previous measurements.

Data

Data for proposal 11906 consist of eight pairs of flatfields in the F645N filter taken at a range of exposure levels. All images were acquired in the default full-frame, four-amp, unbinned readout mode. The images used in this analysis are summarized in Table 1; shown are image rootname, observation date, exposure times, number of good pixels, the mean, standard deviation, and the median in DN of each of the two chips.

Table 1. Summary of images used for the Cycle 17 gain analysis; statistics are in units of DN. All images are full-frame, unbinned four-amp readouts taken in F645N aquired between Oct 15 – Oct 19, 2009.

			chip 1(amps A & B)				chip 2 (amps C & D)			
rootname	**date**	**Exp time (sec)**	**numpix**	**mean**	**stdev**	**median**	**numpix**	**mean**	**stdev**	**median**
ib9e01l8q	10-17-2009	117	8376762	33026.0	2654.0	33095.0	8387965	36087.0	3033.0	35905.0
ib9e01l9q	10-17-2009	117	8376365	33343.0	2679.0	33410.0	8389646	36438.0	3061.0	36256.0
ib9e06haq	10-19-2009	45	8388500	12535.0	1005.0	12563.0	8390994	13663.0	1162.0	13593.0
ib9e06hbq	10-19-2009	45	8388567	12723.0	1018.0	12747.0	8391170	13868.0	1177.0	13797.0
ib9e06hdq	10-19-2009	1	8377122	283.4	26.0	284.0	8384843	308.6	30.0	308.0
ib9e06heq	10-19-2009	1	8376980	283.9	26.0	284.0	8384803	307.9	30.0	307.0
ib9e07v1q	10-15-2009	12	8389023	3323.0	269.0	3330.0	8394947	3617.0	313.0	3597.0
ib9e07v2q	10-15-2009	12	8388914	3397.0	274.0	3403.0	8394684	3697.0	319.0	3677.0
ib9e07v4q	10-15-2009	5	8387943	1419.0	117.0	1421.0	8393699	1544.0	135.0	1535.0
ib9e07v5q	10-15-2009	5	8388135	1420.0	117.0	1422.0	8393503	1545.0	135.0	1536.0
ib9e08gjq	10-19-2009	25	8391771	6920.0	556.0	6934.0	8395603	7537.0	646.0	7497.0
ib9e08gkq	10-19-2009	25	8391857	7056.0	566.0	7071.0	8395410	7684.0	656.0	7645.0
ib9e08gmq	10-19-2009	2	8384550	568.0	49.0	571.0	8391052	618.3	56.0	614.0
ib9e08gnq	10-19-2009	2	8384165	566.6	49.0	567.0	8390000	616.3	56.0	612.0
ib9e10knq	10-17-2009	90	8384269	25204.0	2025.0	25256.0	8388364	27513.0	2320.0	27376.0
ib9e10koq	10-17-2009	90	8384036	25498.0	2046.0	25549.0	8388259	27834.0	2343.0	27722.0

All images were processed through the standard OPUS pipeline, generating the raw files, then processed with calwf3 version 1.4.1 (27-Apr-2009) for calibration. The calibration steps include the data quality initialization, the overscan correction, and the bias and dark file subtractions. Specificially, the reference files used were t2c1533si_bpx.fits, t291659mi_ccd.fits, q911321oi_osc.fits, 090611120_bia.fits, t3420177i_drk.fits, sky_mean_crr.fits for the bad pixel table, ccd table, overscan table, superbias file, superdark file and crrejtab, respectively. The superbias file for the nominal gain was a preliminary, on-orbit version generated from a stack of 120 individual bias frames. A special crrejtab file was used where sky= mean in order to achieve the best results for cosmic ray rejection.

Analysis

As with previous measurements of the WFC3 UVIS gain (Baggett & Borders 2009, Baggett 2008) the standard mean-variance technique was used. An average and a difference image were created from a pair of images taken in sequence in order to implement the mean-variance method. Flatfield pairs taken at the same exposure time were cosmic ray cleaned before creating the average and difference images. We flagged cosmic rays from pairs of images by comparing the data quality extention (DQ) with the science extension (SCI) so that cosmic rays were not considered in the statistical analysis. In the Baggett 2009, 2008, gain analysis the statistics were computed using 3 iterations of 3-sigma clipping in order to remove the effects of cosmic rays. However, the Baggett 2005 analysis on the Thermal Vacuum Testing 3 (TV3) data did not include sigma clipping as cosmic ray effects were minimal. In order to keep the analysis consistent with Baggett 2005 results, cosmic rays were flagged manually and no sigma clipping was used. The analysis of the SMOV data was re-computed so that the TV3, SMOV, and Cycle 17 data analysis procedures are consistent.

We implemented the mean-variance methodology to compute the nominal instrument gain by plotting the mean signal level versus the variance. The reciprocal of the slope of the resulting line is the gain in e-/DN. The mean levels were measured on the average images and the variance was taken from the difference images (standard deviation squared divided by 2). The statistics were measured from 400x400 pixel regions evenly spread across the detector (25 regions per quadrant). The resulting plots for Cycle 17 are shown in Figure 1. The measured gains are listed in Table 2 including the results for Cycle 17, the re-computed SMOV results with no sigma clipping and ignoring cosmic rays, Baggett 2009 SMOV results, and Baggett 2008 TV3 results.

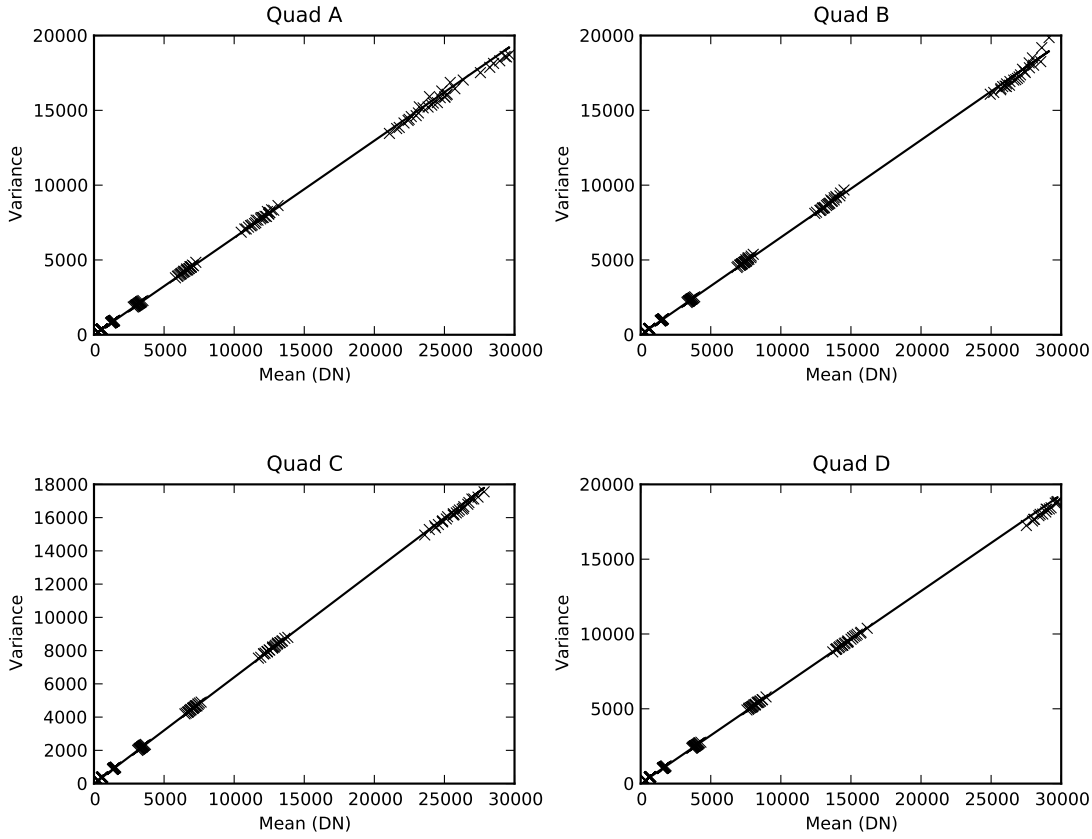
The first on-orbit SMOV results were initially reported as ~3% higher than those measured on the ground (Baggett & Borders 2009). The offset was later traced to the use of ground data procedures (simple sigma-clipping) for rejection of cosmic rays. While appropriate for the TV data, which have very few cosmic rays, the use of more standard cosmic ray rejection algorithms (calwf3 crrej) with the on-orbit SMOV data resulted in gain values which are within ~1% of the

ground data.

Table 2. Measured gains from the UVIS channel. The fit errors are <0.01 for all gain values listed.

	Cycle 17 (calwf3 wf3rej)	SMOV (calwf3 wf3rej)	SMOV (Baggett & Borders 2009)	TV3 (Baggett 2008)
quadrant	gain	gain	gain	gain
A	1.54	1.56	1.61	1.56
B	1.54	1.56	1.61	1.56
C	1.56	1.58	1.63	1.58
D	1.56	1.57	1.62	1.57

Figure 1: Cycle 17 mean-variance plots for the four UVIS quadrants, unbinned nominal gain 1.5 mode.



Conclusions

The gain for the nominal gain setting of 1.5 has been measured for Cycle 17. Values for A, B, C, and D quadrants respectively are: 1.54, 1.54, 1.56, and 1.55 e-/DN, with errors < 0.01 e-/DN. The gain values for SMOV have been recalculated with the same procedure used for the Cycle 17 data; the results from TV3, SMOV, and Cycle 17 are in agreement to within ~1%.

References

Baggett, S. and T. Borders, WFC3 ISR 2009-29, "WFC3 SMOV Proposal 11419: UVIS Gain"

Baggett, S., WFC3 ISR 2008-13, "WFC3 TV3 Testing: UVIS-1' Gain Results"