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WFC3 Thermal Vac Testing: UVIS Gain Results

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ABSTRACT

The integrated WFC3 instrument recently underwent testing under thermal vacuum (TV) conditions in the GSFC SES (Goddard Space Flight Center Space Environment Simulator). One of the tests was procedure UVIS03: relative gain as a function of temperature. Analysis of the UVIS03 data show that the gain ratios, relative to the nominal 1.5, are 1.01-1.04, 2.09-2.15, and 4.28-4.39 at a detector temperature of -82C. A check of the absolute gain of the nominal 1.5 setting was performed using flatfields from the linearity (UVIS05) test; gains were measured at 1.53, 1.52, 1.56, and 1.55, with errors <0.01, for quadrants A,B,C, and D.

Introduction

The purpose of the UVIS03 procedure is to measure the relative gain of the WFC3 UVIS flight detectors as a function of temperature, in order to provide background data should it be necessary to operate the detector at a non-default setting on-orbit. One iteration of UVIS03 consists of pairs of F606W external flatfields and biases taken at each gain. The original plan was to run UVIS03 at four temperatures (Tnom, Tnom+/-3K and Tnom+6K); however, as the thermal-vacuum testing performed in late 2004 was not intended as a full ground calibration of the instrument, data was taken at the nominal temperature only. The UVIS03 data is sufficient for relative gains only; in order to obtain a check of the absolute nominal gain, the mean-variance technique was used on flatfields taken as part of the linearity (UVIS05) procedure. This report summarizes the relative and absolute UVIS gains measured from UVIS03 and UVIS05.

Relative Gain

The relative gain measurements were made from UVIS03 data, consisting of four pairs of 60-second F606W flatfields taken on Oct. 2/3,2004, one pair at each gain (1.0, 1.5, 2.0, and 4.0). These were full-frame, unbinned, four amp readouts taken at bias offset level of 3, image entries 16399-16414. The UVIS detector temperature was -82C.

The images were processed through calwf3, performing the overscan correction (BLEV-CORR) only. The average of each pair of flatfields was taken; each average was ratio'd to the average gain 1.5 image and scaled by 1.5 (the nominal gain). The average and standard deviation were measured across the entire quadrant; no pixels were masked except for the two bad columns in quadrant B. The resulting gain ratios are listed in Table 1. There were no significant differences in the gain ratios using other processing techniques such as performing a bias file correction, taking the minimum instead of the average for each pair, or measuring statistics in 1/4 subsections of each quadrant.

Table 1. Gain ratios for the four quadrants, relative to gain 1.5.

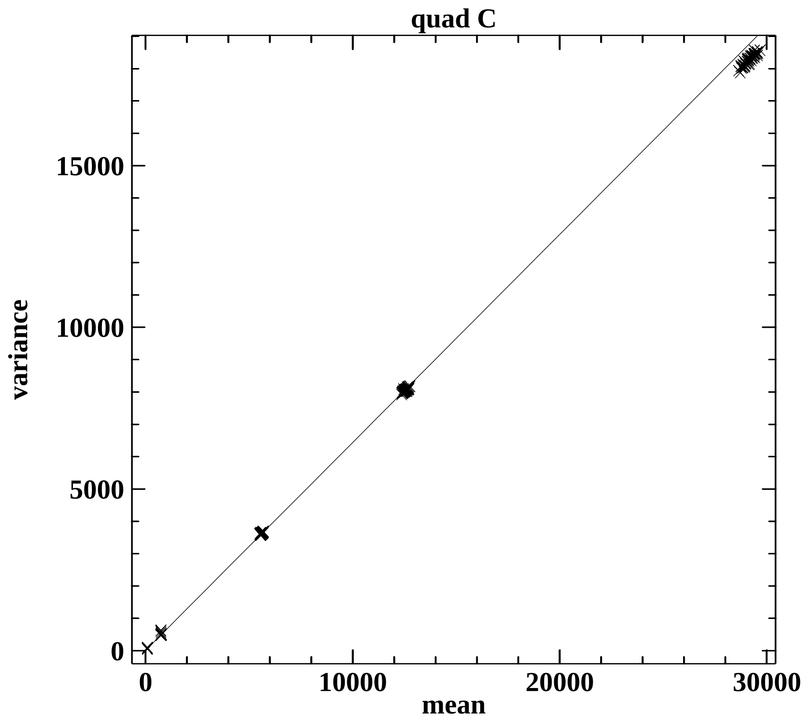
Quad	ave stddev	ave stddev	ave	stdev
A	1.02	0.01	2.09 0.01	4.28 0.02
B	1.04	0.01	2.15 0.01	4.39 0.02
C	1.01	0.01	2.10 0.01	4.28 0.02
D	1.02	0.01	2.10 0.01	4.30 0.02

Absolute Gain

To determine a gain value for the nominal gain 1.5 setting, the mean-variance method was used on a subset of the linearity (UVIS05) flatfields, a technique that can be summarized as follows. Assuming there are only two noise sources (photon noise, p, in e^-, and read-noise R in e^-), the total noise, or observed variance, in an image can be written as $(N/g)^2=(p/g)^2+(R/g)^2$ where g is the gain conversion in units of e^-/DN. Since photon noise is the square root of g*signal when the mean signal μ is in DN, the observed variance σ^2 can be rewritten as $\sigma^2 = (1/g) * \mu + (R/g)^2$. The inverse slope of a linear least squares fit to a plot of variances versus mean signal levels yields the gain.

Pairs of flatfields taken Sept. 30,2004 for the linearity procedure (UVIS05) were used. The available exposure levels were not evenly sampled (~80DN, ~700DN, 5K DN, 13K DN, and 30K DN); though not likely to be a problem, flatfields used for the gain calculation were restricted to those with <30K DN levels. The images were processed through calwf3, performing the overscan correction only. Average and difference images were formed from each flatfield pair and the mean-variance plot constructed from the means of the average images and the variances of the difference images (standard deviation divided by two). Statistics were measured in sixteen 400x400 pixel regions per quad; the figure below shows the plot for quadrant C. The gains were measured at 1.53, 1.52, 1.56, and 1.55 for quads A,B,C and D; gain errors (propagated from the errors in the slope of the linear fit) were <0.01 for all quads.

Figure 1: Mean-variance plot for quad C.



Conclusions

The gain ratios based upon UVIS03 data were found to be 1.01-1.04, 2.09-2.15, and 4.28-4.39. The nominal absolute gain, measured from some of the UVIS05 flatfields, was measured at 1.53, 1.52, 1.56, and 1.55 in quads A, B, C, and D, with errors <0.01.

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