FOS Filter-Grating Wheel Repeatability

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Abstract

The repeatability of the FOS Filter-Grating Wheel (FGW) was re-measured during the March 1988 calibration activities at LMSC. Measurements were made of the repeatability in both X and Y at the camera mirror positions on both red and blue sides, and in X for 7 dispersers on the blue side only. The FGW repeatability remains unsatisfactory, but has apparently not deteriorated since the previous measurements during the thermal/vacuum testing in 1986 and ambient testing in 1985.

I. Introduction

The well-documented failure of the FOS FGW to repeatably position its elements so that the images always fall at the same positions on the detectors was investigated again at LMSC in March, 1988. This was undertaken in order to determine if any changes in the repeatability performance occurred in the two year interval since previous measurements were made, possibly as a result of the relubrication of the mechanism gears, or from any effects that the extensive rework which was performed on the FOS may have had.

Two test procedures were used: YFGRCM, which measures the repeatability of the camera mirror positioning in both dispersion and cross-dispersion directions, was run on both sides of the FOS, and YFGWR1, which measures the repeatability in the dispersion direction only, for 7 dispersers, was run on the blue side. The former measurements are particularly important to gauge when special target acquisition (TA) techniques must be invoked to circumvent the non-repeatability problem, i.e., use of the aperture illuminating LEDs to determine the aperture image position. The YFGWR1 measurements indicate the ultimate accuracy of the standard FOS wavelength calibration.

II. Camera Mirror Repeatability

The test of FGW repeatability at the camera mirror, run on the red side on 12 March and on the blue side on 14 March, 1988, is identical to the those performed during thermal vacuum testing in 1986. A description of the measurement and analysis technique are included in CAL/FOS–033 (Hartig, 1986), along with the results of the TV tests. Briefly, the camera mirror image of the A4-lower aperture, illuminated by the TA LEDs, was mapped with fine Y-stepping after 9 separate FGW positionings, originating from each of the disperser positions. The FGW was always rotated in the forward direction, and two motor steps were applied after the normal positioning. The resulting images were cross-correlated to determine relative offsets in both the X (dispersion) and Y directions.

Results of the test are shown in Figure 1, in which the relative X and Y image locations are plotted, with numerical symbols indicating the order of the measurements. There is some evidence for a bimodal distribution in the red side data, similar to that intimated by the TV test results, as well as a possible X-Y correlation. It is also intriguing to note that, especially on the red side, the even numbered positionings are generally grouped away from the odd numbered ones, indicating that the repeatability might be improved if the FGW is rotated through more than a full turn between positionings. No explanation for these observations will be hazarded here!

Table 1 compares the current results with those obtained during TV. The spreads and standard deviations are similar indicating that no significant change to the repeatability performance has occurred. The spread over 9 positionings is approximately the same size as the smallest FOS entrance aperture (A4). Accurate positioning of targets into the smaller FOS apertures will clearly require use of the TA LEDs to determine the aperture image position.

III. Repeatability at Dispersers

The FGW repeatability in the dispersion direction was measured on 14 March, 1988, with 7 positionings at each of 7 dispersers on the blue side only (gratings G130H, G780H, and the camera mirror were excluded). The order of observations was chosen such that all combinations of initial and final FGW position (among the 7 selected dispersers) were included. The direction of rotation was always forward, and two motor steps were applied after normal positioning. Spectra of an external Pt-Cr/Ne hollow cathode lamp were obtained through the A4-lower aperture after each positioning. This test was very similar to the FGW repeatability tests run in ambient on the blue side in 1985, but the order of the positionings is somewhat different and the internal direct cal lamp was used for the earlier tests. Results of the March, 1985 tests are the subject of CAL/FOS–017 (Hartig, 1985); additional tests run on December 9, 1985, were mentioned in CAL/FOS–033. The latter tests compared the FGW performance for forward and reverse rotations, demonstrating that the forward direction is highly preferable.

The data were reduced by selecting a sharp, isolated line (near the center of the array if possible) for each disperser, and measuring its center for each positioning. 'Eyeball' estimates of the line centers, at the GSE graphics terminal, were used for the earlier tests. The 1988 test data were reduced using the mean of the FWHM points to determine the line positions. In order to assure that no systematic difference in the dispersion would result due to the different analysis techniques, a portion of the 1988 data was re-examined, using subjective estimation of the line centers with a graphics cursor; no significant differences were found. Table 2 presents the results of the 1985 and 1988 tests. Both the mean spread and standard deviation are very similar to the values measured in the previous forward direction tests. The reverse direction measurement demonstrated a nearly three-fold increase in dispersion; clearly, the FGW should always be rotated in the forward direction.

V. Conclusions

The repeatability properties of the FGW have not changed significantly since the previous ambient and thermal/vacuum tests were made. The rework performed on the FOS, including re-lubrication of the FGW gearing, has apparently had no effect on the repeatability, which remains somewhat unsatisfactory. This non-repeatability will require use of TA LED-assisted TA when the smaller FOS apertures are selected, and will likely be the dominant source of inaccuracy in the wavelength calibration of spectra obtained without contemporaneous cal lamp spectra.

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Table 1
FOS FGW Repeatability at Camera Mirror

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Date	Environ.	Side	X Spread	X Std Dev	Y Spread	Y Std Dev
18 May 86	TV Hot	Blue	8.5 μm	3.2 μm	14.4 μm	5.0 μm
23 May 86	TV Hot	Red	11.6	3.4	17.2	5.3
1 Jun 86	TV Cold	Red	11.8	4.4	16.4	5.9
9 Jun 86	TV Cold	Blue	6.7	2.5	10.6	3.8
12 Mar 88	Ambient	Red	17.4	6.5	6.9	3.1
14 Mar 88	Ambient	Blue	8.3	2.1	19.2	6.3

Table 2
FOS FGW Repeatability at Dispersers
Blue side, ambient environment

Date	Direction	X Spread	X Std Dev
6 Mar 85	Forward	10.2 μm	3.2 μm
9 Dec 85	Forward	8.1	3.3
9 Dec 85	Reverse	21.9	9.1
14 Mar 88	Forward	8.2	3.0

References

Hartig, G., Bohlin, R., Ford, H. and Harms, R. 1984. CAL/FOS–012, *FOS Filter-Grating Wheel Repeatability.*

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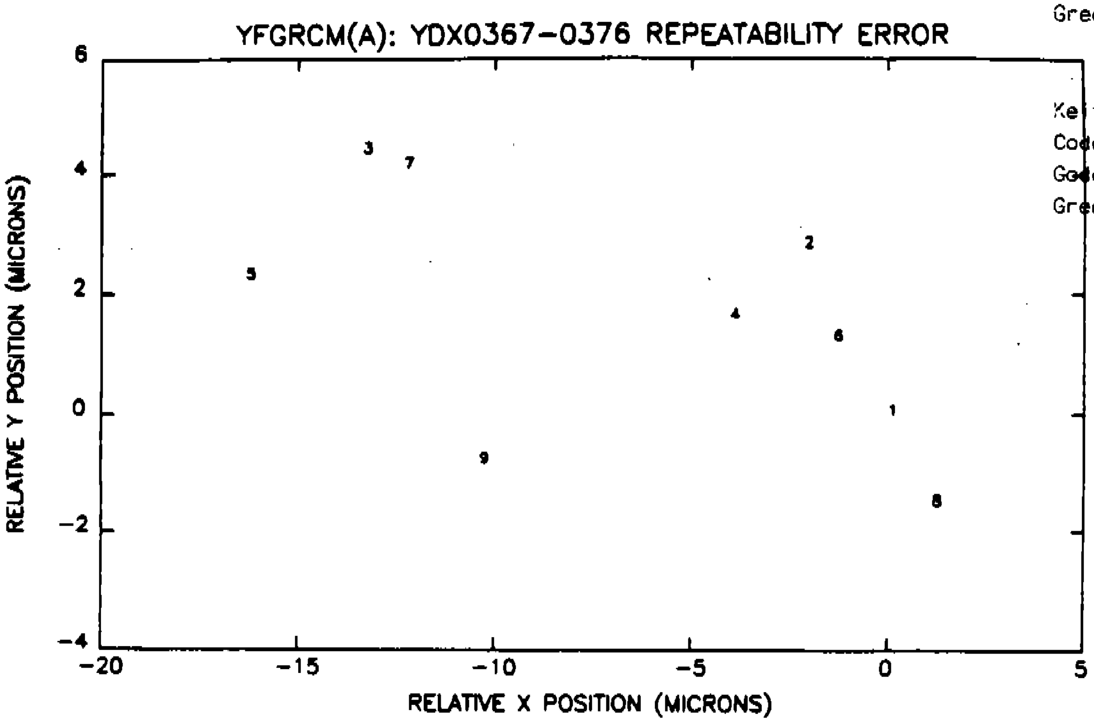

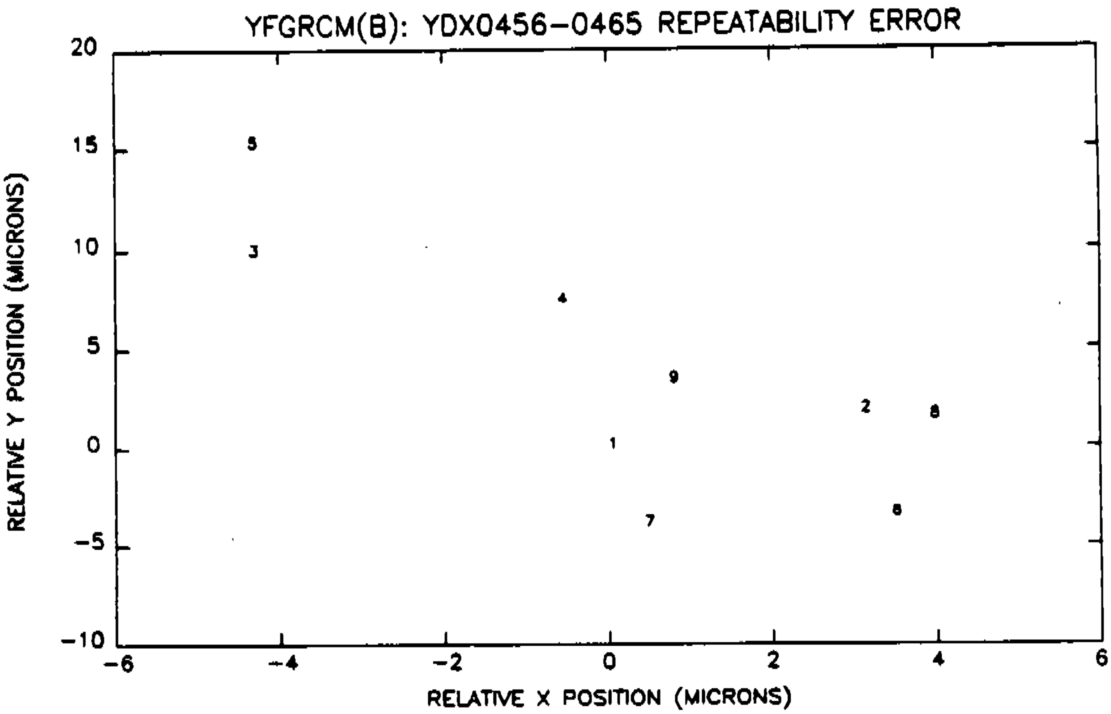

Figure 1. Relative image positions (μm) from the red side (top) and blue side (bottom) measurements of the FGW repeatability at the camera mirror. Some evidence for a bimodal distribution is apparent in the red side data, confirming a similar result from the measurements made during the thermal vacuum test in 1986. The dispersion compares well with previous tests.