TV Measurements of the FOS Filter-Grating Wheel Repeatability

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Abstract

The repeatability of the FOS FGWA at the camera mirror was measured during the thermal vacuum testing at LMSC. The measured dispersion in image position on the detector demonstrates the need for LED-illuminated "aperture acquisition" in order to achieve accurate target acquisition into the small FOS apertures.

I. *Introduction*

The FOS filter-grating wheel assembly (FGWA) has a well-documented positioning repeatability problem, such that the location on the photocathode of the image from the dispersers or camera mirror varies each time the FGWA is rotated into position. The extent of this non-repeatability was first measured during the FOS TV-3 testing at MMDA in July, 1984, and reported, with additional results obtained in subsequent ambient testing, in CAL/FOS-012. It was later discovered that the repeatability could be significantly improved, though still failing to meet the level required for accurate target acquisition, if the FGWA is always rotated in the "forward" direction and followed by application of two extra (forward) motor steps (CAL/FOS-017). The degree of residual non-repeatability required the installation of the aperture illuminating blue LEDs and the necessary software modifications for their utilization to enable accurate target acquisition. Additional testing, performed in December, 1985, has shown that, even with the application of the extra motor steps, the FGWA must be rotated in one direction only, and that the preferred direction is "forward".

Nearly all of the testing described above was performed by measuring the positions of spectral lines in the dispersion direction only, thereby providing no measure of the repeatability in the Y direction. All of the results showing the improvement with the extra motor steps were obtained in this manner, in ambient conditions. Since the TV-3 tests showed significant variation in the degree of repeatability depending on FGWA element and also indicated that, for at least some of the elements, the repeatability was worse in TV than in ambient, we have performed an additional series of measurements during the recent TV/TB testing. These tests utilize the camera mirror, for which the repeatability requirement is most crucial (for target acquisition), and measure repeatability in both X and Y.

II. *Test Description*

Test segments YFGRA and YFGRB were run on the red and blue sides (respectively) of the FOS, each during both "cold" and "hot" balance portions of TV/TB. Each test consisted of nine successive positionings of the FWGA to the camera mirror (rotating in the forward direction, and applying two extra motor steps), starting from each of the other FGWA positions, followed by a fine map of the image of the lower of the A4 (0.1-PAIR) apertures. The maps were made with 85 Y-steps of $\sim$ 6 Y-base units, over the 26 diodes surrounding the image. The cross-strapped internal calibration lamp was used for illumination on the blue side and the TA LEDs on the red side; the source was turned on, then off, for each exposure, to minimize operation time. A sample of the raw image map, from the blue side, "hot" test, is shown in Figure 1.

III. *Reduction and Analysis*

The data were reduced by deriving profiles of the images in both the X and Y directions and then cross-correlating them to determine the relative shifts in each direction. The X and Y profiles were obtained by simply summing over the columns and rows, respectively, and normalizing to peak value of 1. The profiles of the first image were taken as the cross-correlation templates, samples of which (again from the blue side, "hot" test) are shown in Figure 2. Analysis of the cross-correlation technique shows that the relative positions found in this manner are accurate to within 1-2 microns. The results for each of the blue side and red side tests are shown in Figures 3 and 4, as plots of the relative image positions, in microns. No drift with time is apparent, and the blue side data appear to be random. However, a correlation between X and Y offset is apparent in the red side data, with some evidence for a bimodal distribution. This may indicate that the FGWA is flopping between two orientations about an axis intermediate between the X and Y axes.

A summary of the test results is presented in Table 1, along with some earlier data obtained in ambient, for comparison. Both the spread, or maximum separation of image positions, and the standard deviation (both in microns) are shown for each axis. As mentioned above, the ambient tests, which were made with the extra motor steps applied and the FGWA rotated in the forward direction, measured only the X direction scatter, and utilized seven different dispersers. The results shown are the mean spread and standard deviation over nine separate positionings of each of these dispersers.

The TV results for the blue side compare well, both during "hot" and "cold" balance, with the ambient measurements in the X direction; no degradation of performance is apparent when the FGWA is operated in flight conditions. However, the blue side Y direction repeatability, unmeasured in ambient, appears to be significantly worse than that in X. Furthermore, the red side performs consistently worse than the blue side, in both axes. Since the measured spreads are comparable to the projected size of the 0.1-PAIR apertures (14 μ), this degree of non-repeatability mandates the use of the LED-illuminated "aperture acquisition" technique for target acquisition into the smaller apertures. Sufficiently accurate target acquisition into the 0.5 arcsec and larger apertures can probably be performed directly, for most applications.

Table 1

FOS FGWA Repeatability Test Summary

Date	Environ.	Side	X Spread	X Std Dev	Y Spread	Y Std Dev
6 Mar 85	Ambient	Blue	10.2μ	3.2μ	–	–
9 Dec 85	Ambient	Blue	8.1	3.3	–	–
18 May 86	TV Hot	Blue	8.5	3.2	14.4μ	5.0μ
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

References

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

Hartig, G. 1985, CAL/FOS-017, *Improvements in Filter-Grating Wheel Repeatability.*

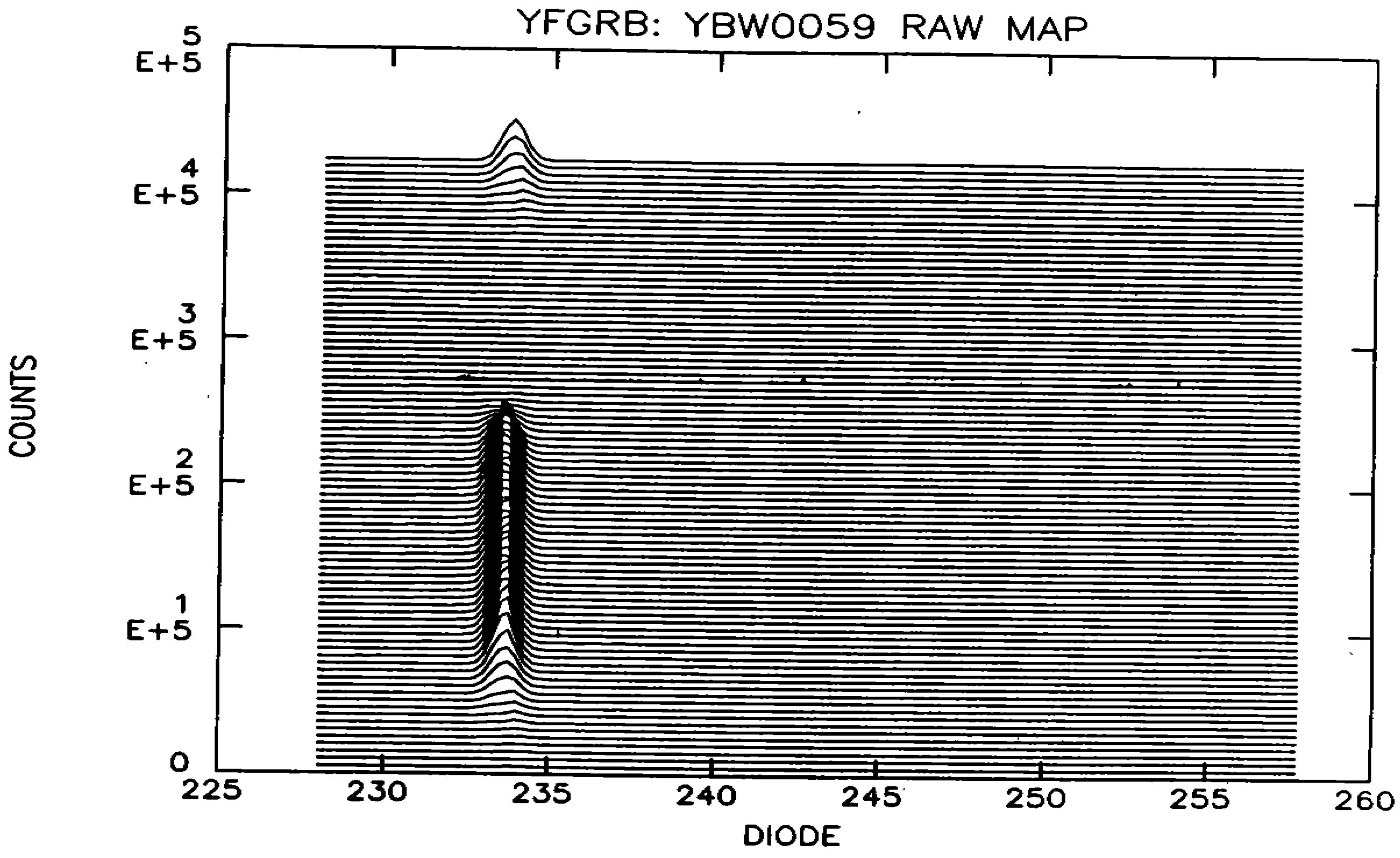
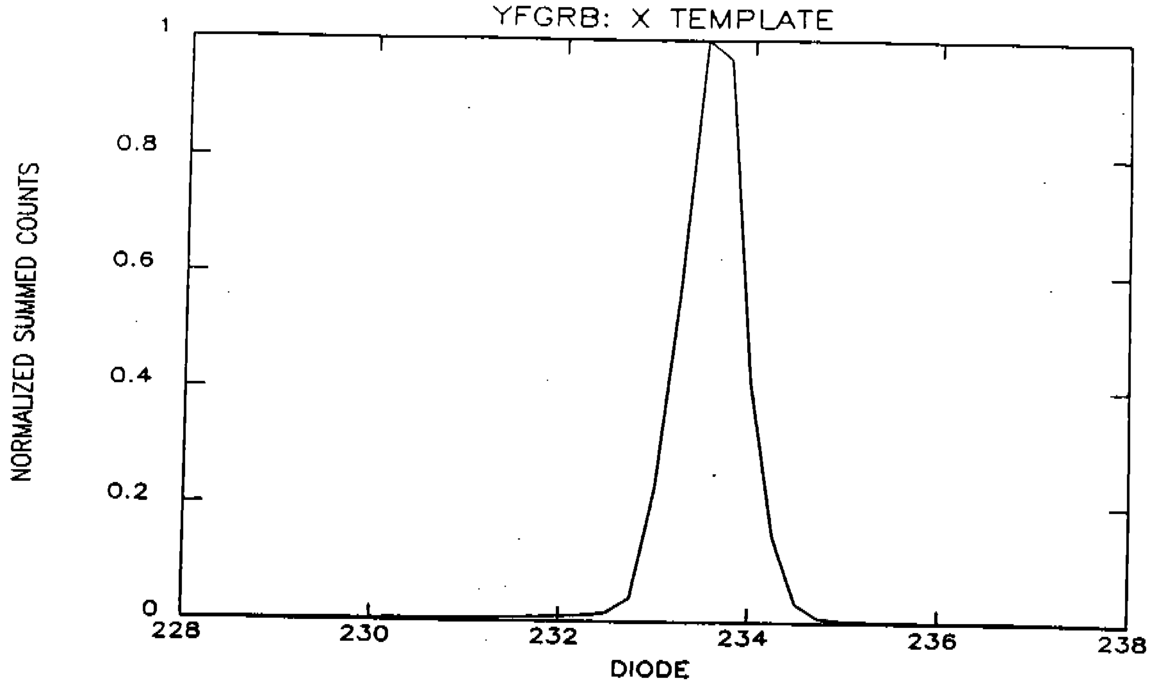


Figure 1. The 85 Y-step map of the lower 0.1 arcsec aperture image from the blue side, "hot" balance FGWA repeatability test. The upper aperture begins to appear at the top of the map, since the selected Y-base was higher than optimal.



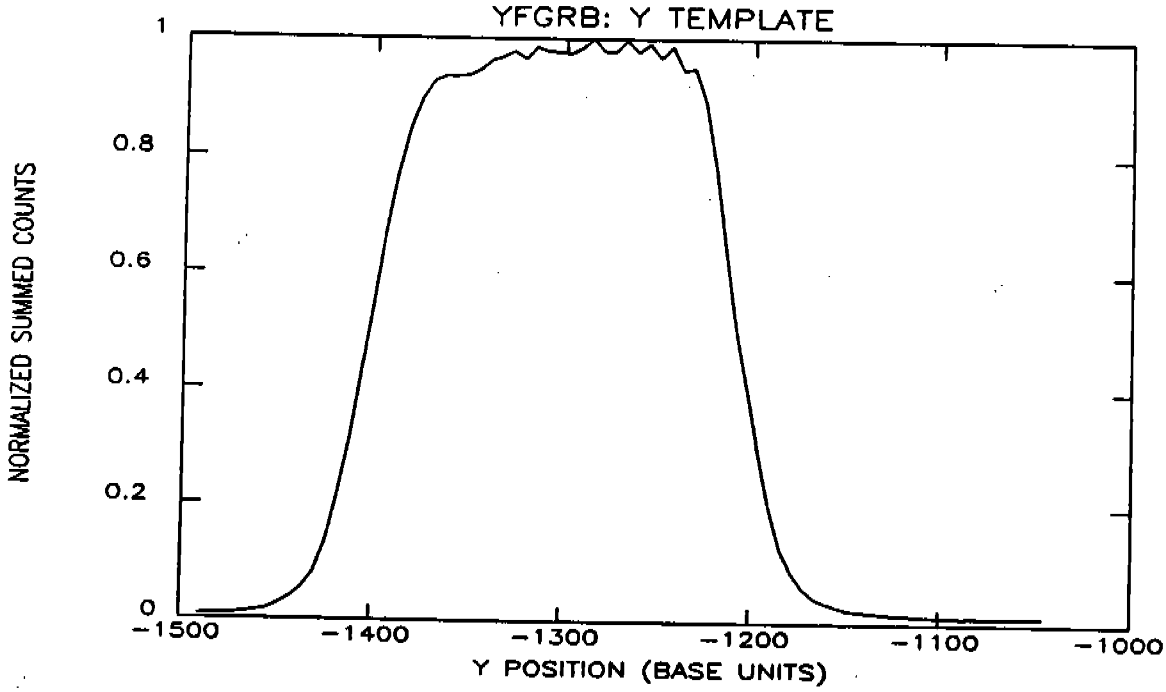
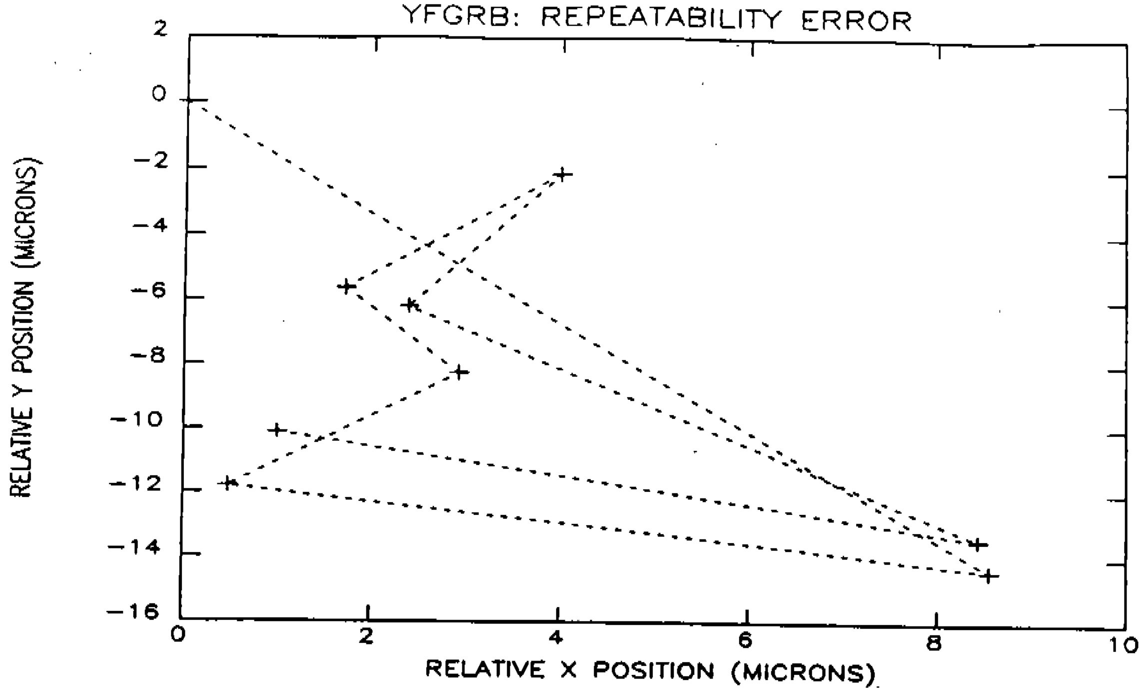


Figure 2. The "template" profiles extracted from the map of Figure 1, for X (top) and Y (bottom). Similar profiles from each of the nine image maps made for each test were cross-correlated to determine relative image position.



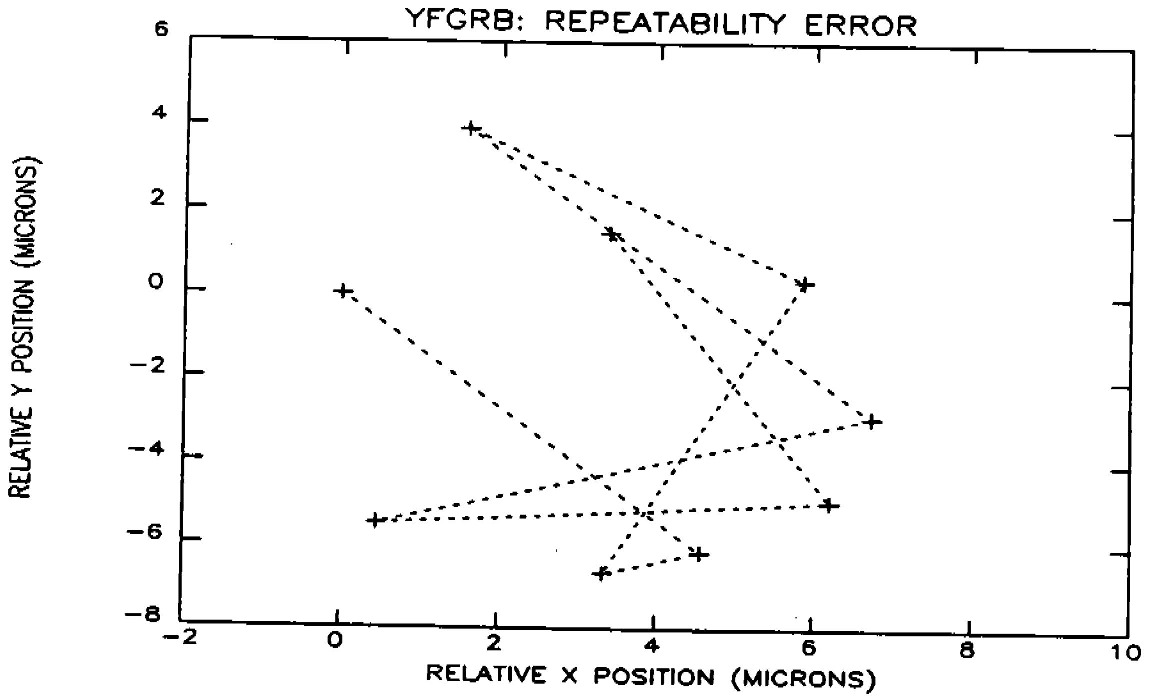
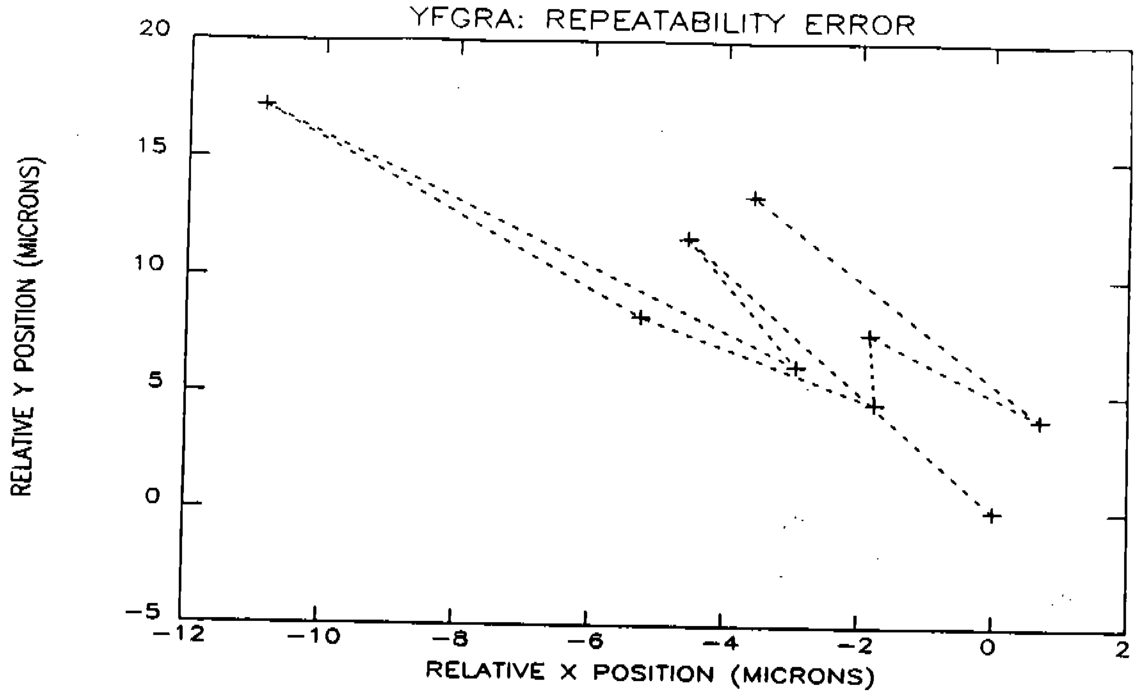


Figure 3. Relative image positions (μ) for the blue side "hot" (top) and "cold" (bottom) tests. No trend or X-Y correlation is apparent, and the dispersion compares well with previous tests made in ambient for other FGWA elements.



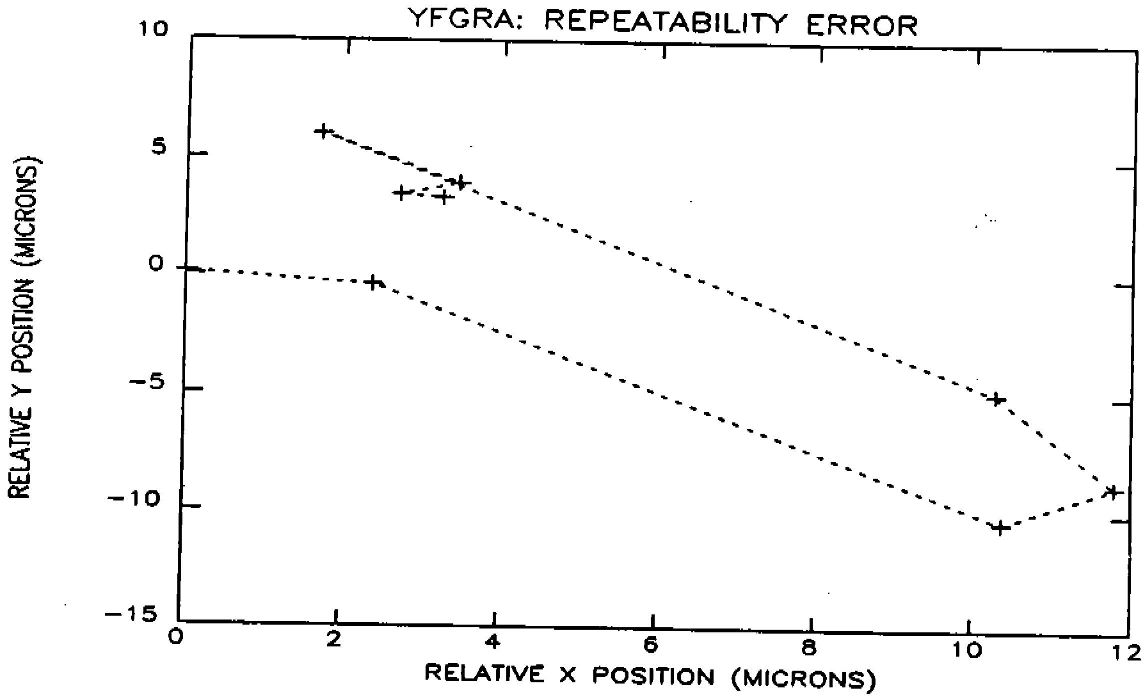


Figure 4. **Relative image positions (μ) for the red side "hot" (top) and "cold" (bottom) tests. Some evidence for X-Y correlation and a bimodal distribution is present. The dispersion is somewhat worse than is seen in the blue side.**