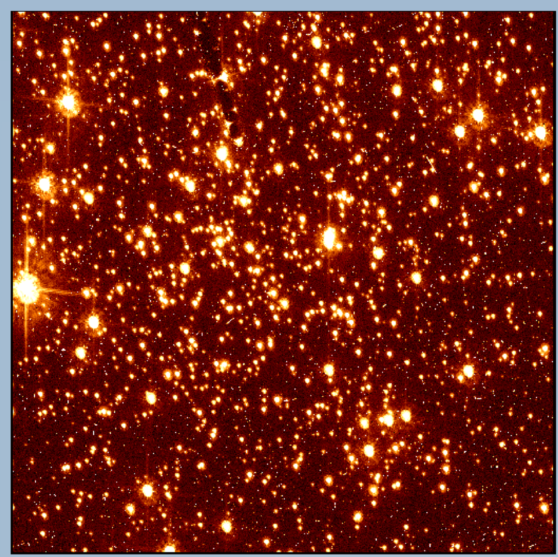

ACS 2 Gyro Mode Data Analysis

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A summary of PSF stability and pointing accuracy results from data taken during the 2-gyro transition in August 2005 is presented, along with a comparison of the August 2005 data to the February 2005 2 gyro test and 3 gyro data. Initial results show the PSF measurements agree with the previous 2 gyro test and 3 gyro data, FWHM (pixels): 2.036+/-0.039 compared to 3 gyro (Apr-Aug 2005)2.031+/-0.040. Pointing data shows the total shift rms (milliarcsec) to be 2.08 during August compared to 2.19 in 2 gyro mode. Final results including jitter, CVZ target and any anomalies are described.

BACKGROUND

The Hubble Space Telescope was transitioned to gyro mode on August 28, 2005 in order to conserve the lifetime of the gyroscopes. Testing has shown that observations taken in 2 gyro mode are essentially indistinguishable from 3 gyro mode. HST was originally designed to use three rate-sensing gyros to provide fine pointing control of the observatory during science observations. Currently, 4 out of 6 gyros on the telescope are functioning. Without a servicing mission it was projected that the HST gyros would continue to fail and the telescope would be left with too few gyros too point with by 2007. In order to extend the lifetime of the working gyros, one of the functioning gyros was turned off on August 28, 2005 and a new attitude control system that functions with only two gyros was activated. In this mode, two gyros are used in combination with the Fine Guidance Sensors, which provide the fine-pointing information for the third control axis, during science observations. This new observing mode is expected to extend the observing lifetime of the telescope by 8 months.

Two gyro mode was tested in February 2005 using the 2-4 gyro pair and produced nominal results. The decision was made by the HST Project to transition to 2 gyro mode.

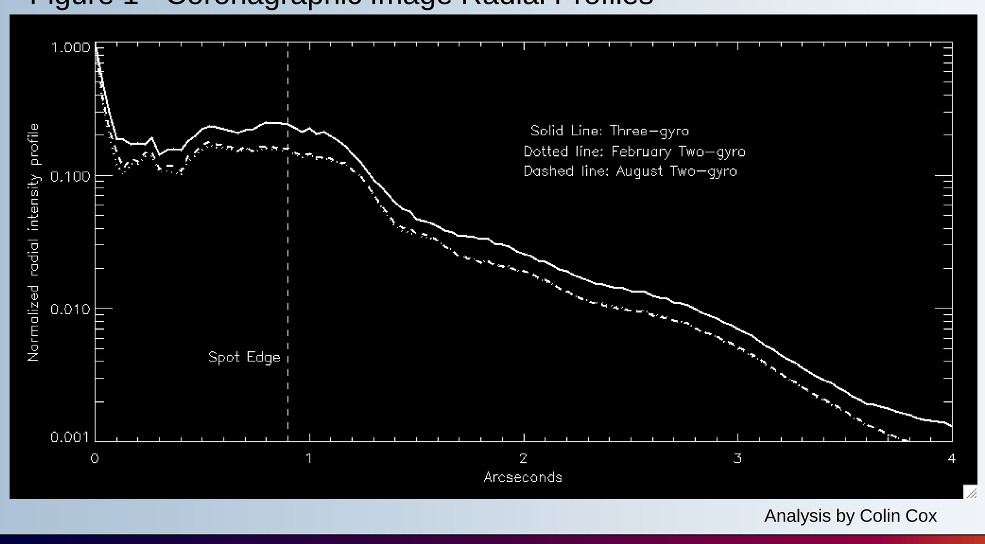
After the transition, on-orbit tests were executed for all the functioning instruments on HST. The ACS programs were designed to test the PSF and pointing stability, the coronagraphic performance and moving target tracking.

10458 - PSF, pointing stability and dither test
10459 - PSF, pointing stability for the CVZ target
10460 - Coronagraphic test
10461 - Moving Target - Mars

CORONAGRAPHY

The goal of the coronagraph test was to see if an object is attainable in 2 gyro mode to the same degree as in 3 gyro mode. This is dime by acquiring the target, placing it behind the occulting spot and measuring the scattered light around the spot. The test was done for both the 1.8 and 3.0 arcsec diameter spots. Comparing the scattered light to the amount of scattered light in the same observations done during 3 gyro mode will give an accurate estimate of the ability to accurately acquire the target. Since the spot location has been known to move by a few pixels every time it is moved into the light path, Earth flats were taken just in the following orbit so that the spot location could be accurately determined. Figure 1 shows the scattered light compared to 3 gyro mode. It is well within the range expected. Repeatability and a different roll angle were also tested and results were found to be nominal.

Figure 1 - Coronagraphic Image Radial Profiles

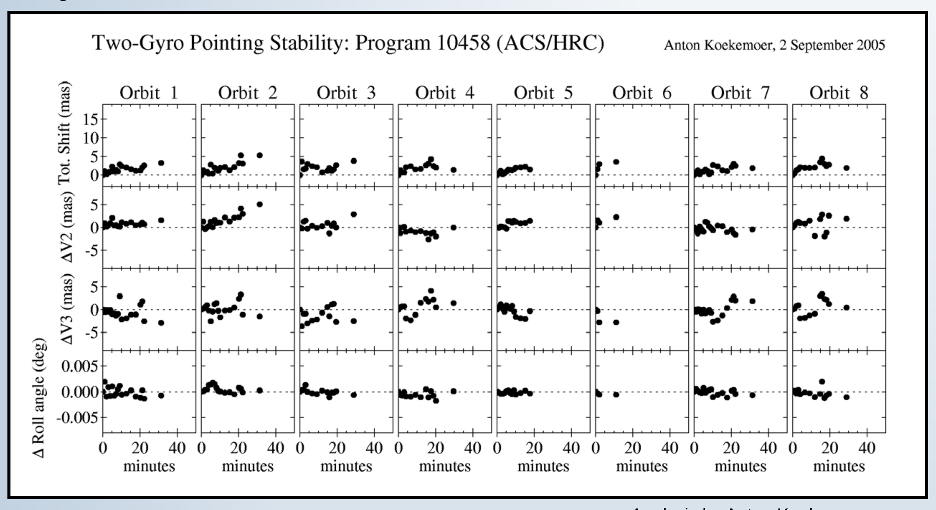


Analysis by Colin Cox

POINTING

The pointing stability within and across orbits was also investigated using data from proposal 10458. Table 1 compares the August test data with the data taken during the February test and the 3 gyro data.

Figure 2



Analysis by Anton Koekemoer

Table 1

	Total Shift rms (mas)	Roll Angle rms (mas)
2 gyro (February 2005 test)	2.29	0.00097
2 gyro (August 2005 test)	2.08	0.00070
3 gyro data	2.19	0.00093

The August data are in agreement with the February test and 3 gyro data. A further test of the pointing stability, running 10 exposures through the ACS pipeline, resulted in a successfully combined and undistorted Multidrizzle image. Figure 2 shows the pointing data across all 8 ACS/HRC orbits with respect to the total shift, the V2 and V3 axes and the roll angle.

For more on the pointing stability, see Anton Koekemoer's poster.

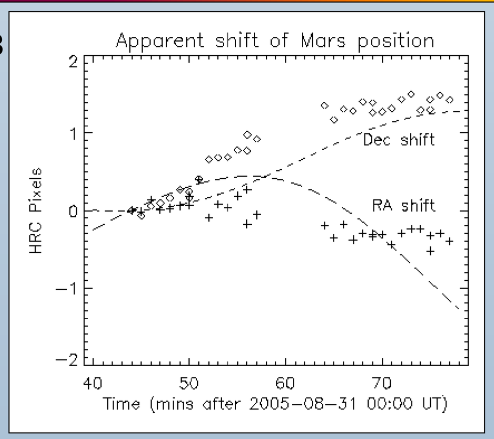
MOVING TARGET - MARS

To test HST's ability to track a moving target in 2 gyro mode, observations of Mars were taken in the weeks just prior to the 2 gyro mode switch-over as well as during the August test period so a direct comparison could be made.

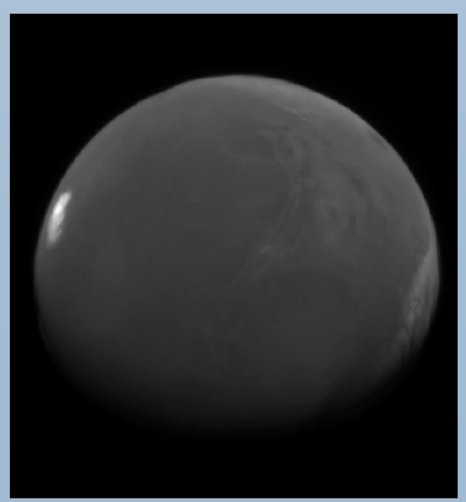
32 HRC exposures of Mars, each 0.3 seconds long, were taken in a single orbit using the F435W filter. The single filter was used to increase the stability. The images were cross correlated and the shifts in the limb were measured. The rotation of Mars, in addition to surface features, can be seen within an orbit, complicating this process.

The data are presented in Figure 3, the measured shifts along the RA and Dec directions compared to the expected shifts of HST's position along its orbit. The direction and scale of shifts agree, but small differences of ~16mas remain. The residuals are smaller than the unavoidable errors from in-track HST positional uncertainties.

Figure 3



Analysis by Charles Proffitt



PSF

Program 10458 to determine the characteristic 2 gyro PSF consisted of images of 3 dense globular clusters NGC 2298, NGC 1851 and NGC 6752. The ACS/HRC camera (pixel scale of 25 milliarcsec) and filter F555W was used to take exposures of 10, 100 and 500 seconds in a combination of dithered and CR-split exposures. The same observations were done with both bright (V~13) and faint (V~14) guide stars, to verify that the pointing control is stable when using a faint guide star.

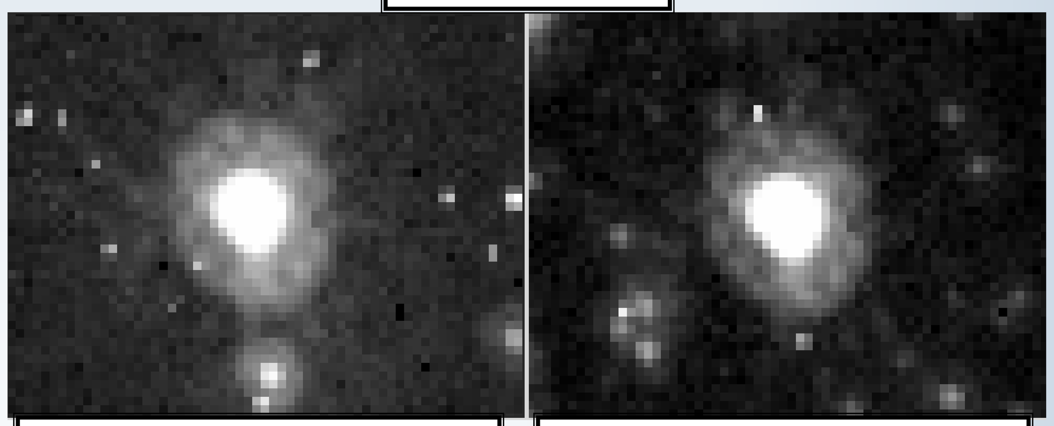
The 10458 observations tested the telescope's ability to reacquire guide stars across occultation, while program 10459 used the same observing sequence with NGC 2298 as a CVZ object to test the tracking over 90 minute orbits.

Analysis was done only on stars with S/N > 10. The photometry of these stars was measured at radii of 3 and 5 pixels. Stars that are not saturated and have accurate photometry were used to measure the x and y positions, ellipticity, position angle and FWHM.

Plots of the measured FWHM for the August test data, February test data and 3 gyro data are in Figure 4. The results were nominal.

Figure 5 shows the FWHM versus guide star magnitude. There is no dependence of the PSF on guide star magnitude.

ACS/HRC PSF



NGC 416 Aug 12 2005 3 gyro | NGC 2298 Aug 29 2005 2 gyro

Images are displayed in logarithmic scale. Cosmic ray rejection and correction for geometric distortion have not been applied.

Figure 5 - FWHM vs guide star magnitude

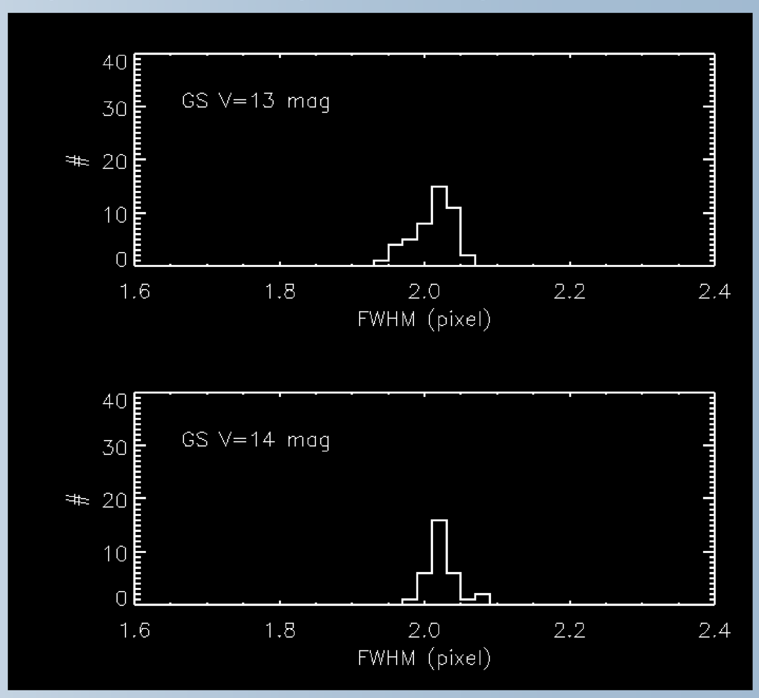
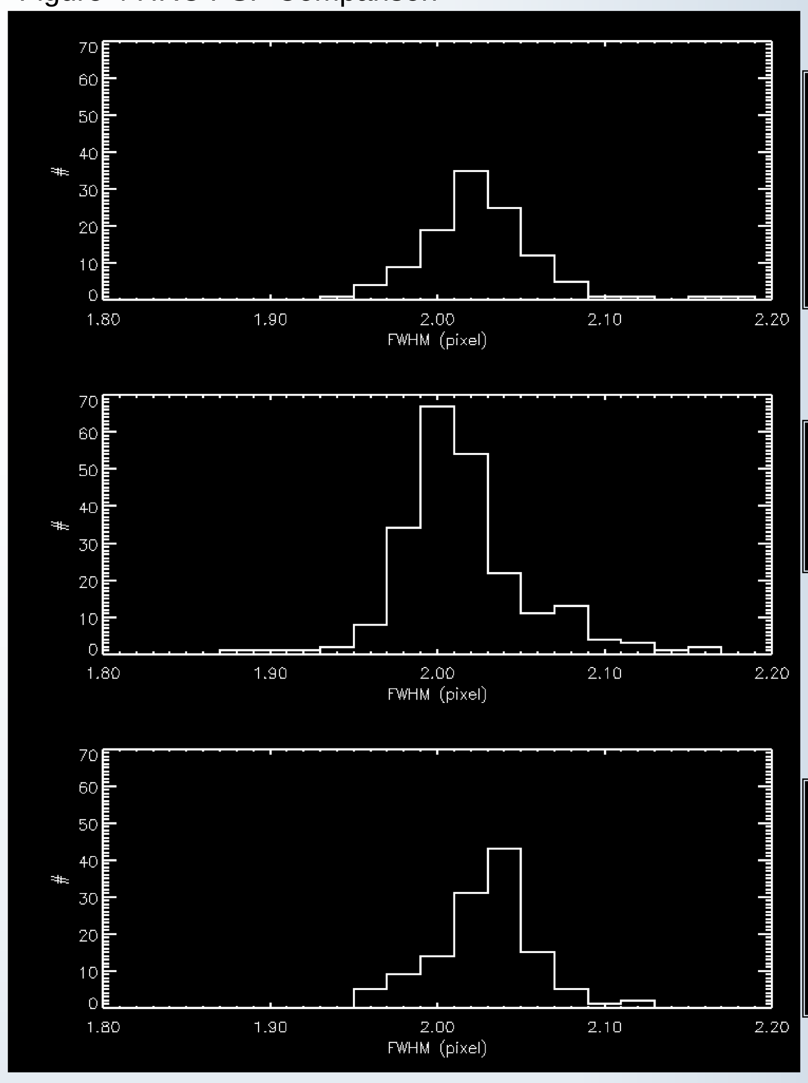


Figure 4 HRC PSF Comparison



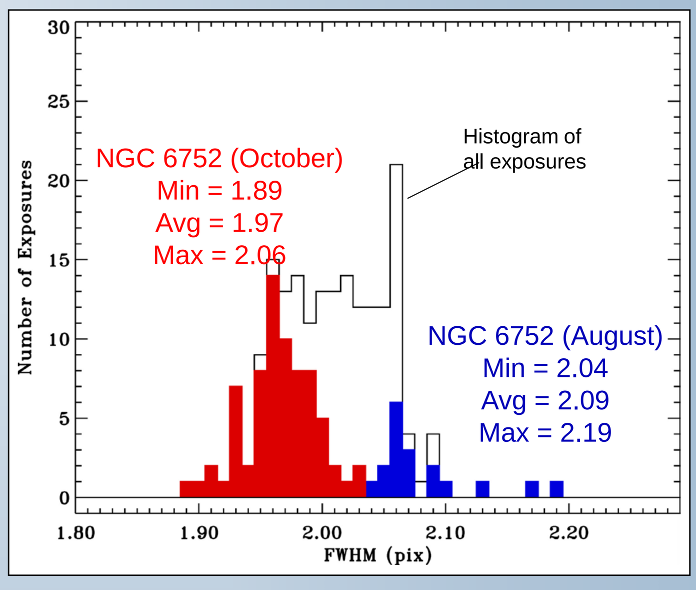
2 gyro: August 2005
144 frames
FWHM (pixels: 2.036+/-0.039
Min: 1.95
Max:2.19

2 gyro: February 2005
158 frames
FWHM (pixels: 2.009+/-0.026

3 gyro: Historical 2002-2004
124 frames
FWHM (pixels: 2.041+/-0.034
3 gyro (February 05) 1.987=/-0.016
3 gyro (Apr-Aug 05) 2.031+/-0.040

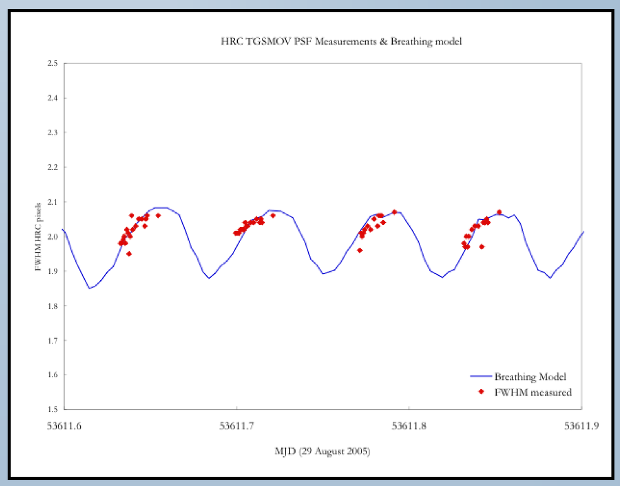
Analysis from the August test showed that the PSF for NGC 6752 was broader then the PSF of the other 2 targets. NGC 6752 was revisited in October 2005 as a CVZ object. In October the measured PSF was within the range of the other data (see Figure 6). The broader PSF measured in August was most likely due to the larger Sun angle of ~115 deg, while in October it was ~80 deg. For comparison the Sun angle for the other 2 clusters was ~70 deg and ~89 deg.

Figure 6



The August test also showed that the PSF gets broader over an individual orbit. This effect was larger than those expected from exposure time differences. The breathing model in Figure 7 shows the dependence is most likely due to normal changes in the focus caused by the breathing cycle of the telescope during an orbit.

Figure 7



Analysis by Matt Lallo

JITTER

The jitter data from the August and February 2 gyro tests are comparable to the 3 gyro jitter in Table 2. Jitter of this magnitude is hard to detect in science data.

Table 2

Mode	Gyro Set	Over All Exposures	RMS Jitter (milli-arcseconds)			
			10-sec Avg.	10-sec Peak	60-sec Avg.	60-sec Peak
Two-Gyro (Feb. 2005)	2-4	Mean / Max (454 exp.)	5.6 / 9.5	6.5 / 22.2	6.0 / 10.7	6.2 / 18.0
Two-Gyro (Aug. 2005)	1-2	Mean / Max (262 exp.)	3.3 / 5.3	3.9 / 11.7	3.4 / 4.9	3.6 / 5.3
Three-Gyro	1-2-4	Mean (24 exp.)	4.1	5.2	4.2	4.3

Data provided by B. Clapp (LMCO)

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