Instrument Science Report FOC-090

Results of the Cycle 4 FOC UV Throughput Monitoring Program

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ABSTRACT

This report describes the monitoring of the UV throughput of the FOC by observing a spectrophotometric standard star through four filter combinations. It is found that the observations through the F210M filter show a slight decline in sensitivity with time of approximately 4%/year. Observations through the other filters (F120M, F140M and F170M) show no significant trend. Comparison with measurements of the UV reflectivity of the WF/PC 1 pickoff mirror shows that the timescale for decay of contaminants in the hub region is of order 1 year.

1. Introduction

COSTAR has been in place now for almost 2 years. This has increased the number of reflecting surfaces in the FOC light path by from 5 to 7, so it is important to check that there is no consequent loss of performance, particularly in the UV sensitivity. This was emphasized by the discovery that the WF/PC1 pickoff mirror, when measured after its return to ground after the First Servicing Mission in December 1993, showed a reflectivity that was only 20% of that predicted in the 1200-1400 Å range. It had been hypothesized that this was due to molecular contaminants that were sticking to the pickoff mirror and polymerizing when subjected to direct ultraviolet light as would be present when HST looks at the sunlit earth, reflecting from cloud tops. It is important to know whether these contaminants are still present in the hub area. The FOC/COSTAR M1 mirrors are positioned in a similar part of the hub area to the WFPC pickoff mirror, and also look straight out of the HST barrel, so one might expect the contamination effects to be similar. Note that the FOC optics are behind the FOC shutter, so contamination effects of this sort on the

FOC optics are expected to be unimportant.

2. History

The UV throughput monitoring was covered in the pre-COSTAR timeframe by the Observatory Level Tests of Burrows (RPSS#3028) and Hasan (RPSS #2827 and 4153). Analysis of those data has already been reported in OTA Instrument Science Reports OTA 8-8.5. Briefly, it was found that only observations taken through the F140M filter showed any evidence for a drop in sensitivity, and this was ascribed to a change in the filter characteristics rather than any overall effect in the FOC or OTA.

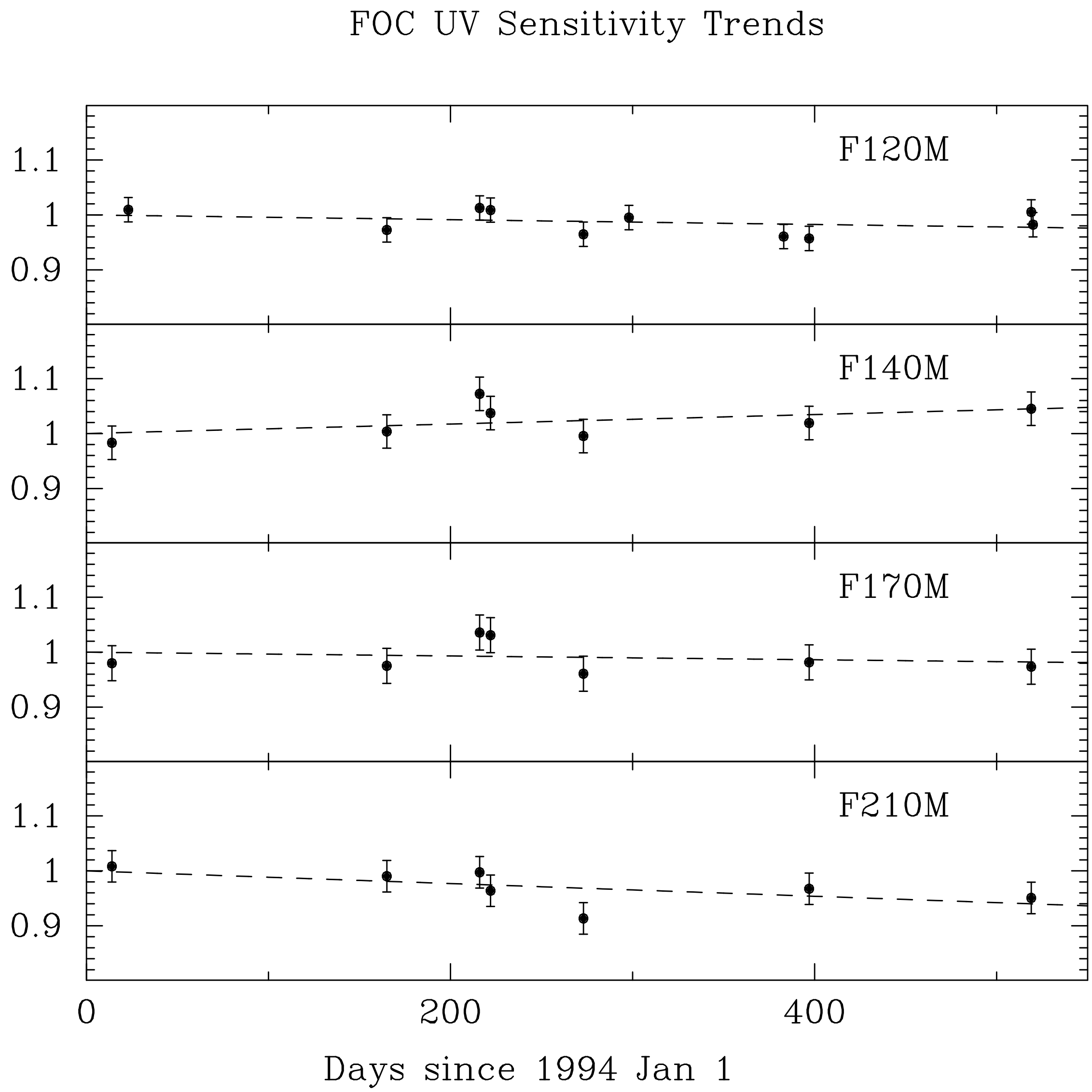
3. Observations, data reduction

For the Cycle 4 UV Sensitivity monitor, the same star was used as a target as had been used in the pre-COSTAR programs; BPM16274. Because of the correction of spherical aberration by COSTAR, additional neutral density filters had to be inserted to keep the count rate in the linear regime. In addition, to extend the dynamic range of the FOC, the 256x256 format was used rather than the 512x512 format that had been used in the past. There were also a few observations of the same star that were obtained for other programs: F120M images were taken as part of the PSF monitoring program (#5762) and the SMOV PSF Program (#4788), while F140M, F170M and F210M images had been taken for the SMOV Absolute Sensitivity Check Program (#4787). These latter exposures used the 512x512 format, so there is a small uncertainty, estimated to be approximately 3%, in the relative sensitivities of the 512x512 and 256x256 formats. The UV Throughput Monitoring Program (#5526) was designed to run every 4 months or so, but was also run a couple of times in August 1994 to verify the COSTAR DOB moves that were executed then to try and improve the FOC image quality. In all, 10 images using the F120M filter were analyzed, along with 7 each for the F140M, F170M and F210M filters.

The data were reduced in a straightforward way using a program originally written to analyze the FOC DQE data (as reported in FOC-085). Briefly the total counts within apertures of increasing size are calculated. The background is calculated by choosing that value that makes the encircled energy profile have zero net slope over a user-specified radial range. For this study, that range was chosen to be 40-60 pixels (0.574”-0.861”). The total flux interior to a fixed aperture size was then calculated; for this study I chose 20 pixels radius (0.287 arcsec). At these wavelengths, this procedure gave approximately 75% of the total flux in the star, but with relatively little sensitivity to the exact value of the adopted background. The observations are not subject to significant nonlinearities, and since the results are comparative, any small nonlinearities should be the same for each observation for a given filter combination.

The data are plotted as a function of time in Figure 1.

Figure 1: FOC UV sensitivity trends



Also overplotted are straight line fits to the data points. The normalization is chosen such that the fitted lines go through the point (1994 January 1, 1.0). Error bars were derived from the data by choosing the value that gives a reduced χ^2 of 1.0 for each filter set.

It can be seen that only the F210M filter appears to give results that show a significant trend with time; the values for the slopes in %/year and their uncertainties are given in Table 1.

Table 1. Results of the straight-line fits to the UV monitor data

Filter	Slope (%/year)	+/- (%)
F120M	-1.6	1.7
F140M	+3.2	2.8
F170M	-1.3	2.9
F210M	-4.2	2.6

From this, it is seen that only the F210M filter gives a significant downward trend of 4%/year, a trend that is not quite a 2σ effect. Further data points will be obtained during Cycle 5 to continue the monitoring.

4. Discussion

Since the installation of COSTAR, the GHRS has seen sensitivity changes of maybe 10-20 percent in the region shortward of 1200 Å. For the F120M observations here, only 2% of the detected flux comes from below 1200 Å, so these measurements are quite insensitive to changes in UV throughput below 1200Å.

Clearly the contamination rate for the FOC/COSTAR mirrors is considerably lower than was seen for the WF/PC pickoff mirror. In principle, one can assume an exponentially decreasing flux of contaminants and that the reflectivity is inversely proportional to the contaminant thickness to determine a time constant for the contaminant flux. Using the fact that WF/PC declined 80% from t=0 to 3.7 years, and that FOC+COSTAR has only declined by 3% at most from t=3.7 to 5 years, one can estimate that the time constant for decay of contaminants must be of order 1 year.

This could be important when considering the possibility of installation of a new FGS in the Second Servicing Mission in 1997. One of the conclusions from the Contamination Workshop held at STScI in June 1995 was that the most likely culprit for the source of contaminants that affected the WF/PC pickoff mirror was the FGSs. Installing a new FGS will ‘start the clock’ on the contamination again, and so unless the new FGS is significantly cleaner than those flown originally, and unless the process of replacement of the FGS can be done in a way that does not redistribute contaminants in the hub area, there is a real possibility that the UV performance of FOC, WFPC2 and STIS could be compromised.