



COS NUV Focus Sweep

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ABSTRACT

Program 13530 performed an NUV focus sweep during Cycle 21 in order to determine whether the COS focus has changed since it was originally measured in Program 11469 during SMOV. Nineteen NUV exposures of NGC188-41 were obtained during a single orbit while the OSM1 focus was moved over the range from -200 to +200 steps. The focus was found to be close to the initial value.

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1. Introduction

During Service Mission 4 Orbital Verification (SMOV), the COS NUV channel was focused via a multi-step process in Program 11469 (Hartig et al., 2010). Since maximizing the NUV image quality ensured that the FUV data quality was also optimized, this was a crucial part of the initial instrument commissioning process.

In the event of a switch to the COS Side 2 electronics, it is important to ensure that commanding the focus to the same value as on Side 1 results in no change of the mechanism position, since the focus is critical to the performance of the instrument. Thus, a NUV focus sweep test was included in Program 13192, the COS Side 2 Initial NUV Channel Checkout program, which will be run in the event of a side switch. A copy of the focus visit was also executed as the standalone Cycle 21 Program 13530 in order to determine if the best focus location had changed since the 2009 SMOV test.

2. Program Design and Execution

Program 13530, “COS NUV Focus Sweep”, was designed to perform a fine focus sweep modeled on the one done in SMOV Program 11469, Visit 94. It used the same target and methodology, adjusting the focus mechanism over a range of ± 200 focus steps while obtaining NUV images with MIRRORA. This range of mechanism positions was chosen to be large enough to cause the Full Width Half Maximum (FWHM) of the Point Spread Function (PSF) to vary by about a factor of two.

Table 1 List of science exposures in Program 13530

Exposure	Start Time	Focus Position (steps)	Breathing Correction (μm)	Corrected Focus (steps)
LCGN01Y3Q	9:33:30	-88.1	4.1	-166.4
LCGN01Y5Q	9:35:52	-290.1	4.0	-367.2
LCGN01Y7Q	9:38:07	-265.1	3.8	-338.8
LCGN01Y9Q	9:40:22	-241.1	3.6	-311.1
LCGN01YBQ	9:42:37	-214.1	3.4	-280.0
LCGN01YDQ	9:44:52	-189.1	3.2	-251.0
LCGN01YFQ	9:47:07	-165.1	3.1	-223.9
LCGN01YHQ	9:49:22	-140.1	2.9	-195.7
LCGN01YJQ	9:51:37	-115.1	2.7	-166.1
LCGN01YLQ	9:53:52	-91.1	2.4	-137.3
LCGN01YNQ	9:56:07	-64.1	2.2	-107.2
LCGN01YPQ	9:58:22	-39.1	2.1	-79.6
LCGN01YRQ	10:00:37	-14.1	2.0	-51.9
LCGN01YTQ	10:02:52	+12.1	1.8	-22.9
LCGN01YVQ	10:05:07	+35.1	1.7	+3.4
LCGN01YXQ	10:07:22	+62.1	1.4	+34.6
LCGN01YZQ	10:09:37	+86.1	1.2	+62.6
LCGN01Z1Q	10:11:52	+111.1	1.3	+86.6
LCGN01Z3Q	10:14:14	-88.1	1.3	-113.6

This program was executed on December 5, 2013. By then, more than four years had elapsed since installation of the instrument, so any initial outgassing of the structure should have been complete.

After an initial ACQ/IMAGE, nineteen 60 second exposures of NGC188-41 were obtained as the OSM1 was moved from a focus position of -200 to +200 in steps of 25. In addition, exposures at the beginning and the end of the scan were taken at the nominal focus position to help characterize any temporal variations of the instrument. This resulted in a total of 19 exposures (Table 1).

The data obtained were of good quality, with nearly 90,000 counts in each exposure. This was more than adequate to make accurate measurements of the width of each image.

3. Analysis and Conclusions

Figure 1 shows the 19 images obtained during the execution of this program. Overplotted on each is the projection in the X (red) and Y (blue) directions, and the FWHMs of Gaussian fits to each of these projections are labeled in the upper left corner. The first (upper left) and last (bottom right) exposures were taken at a relative focus value of zero, but the others show the progression from -200 to +200 focus steps. The absolute commanded focus value of OSM1 (LOMFSTP; a relative focus of zero corresponds to an absolute value of $\text{LOMFSTP} = -88.1$ steps, where 19.2 steps is $1 \mu\text{m}$) is shown in the upper right corner of each panel.

In addition to the position of the OSM1 focus mechanism, the total optical path to the detector is also affected by the focus change of the HST Optical Telescope Assembly (OTA) due to changes in the separation between the primary and secondary mirrors. The standard “breathing correction” supplied by the optics group (shown in Figure 2 for the time of these observations; see <http://www.stsci.edu/hst/observatory/focus>) was therefore applied in order to correct for this effect. The breathing-adjusted focus value (calculated for the mid-point of each exposure) is shown below the absolute focus position in the upper right of each panel in Figure 1 and also listed in Table 1.

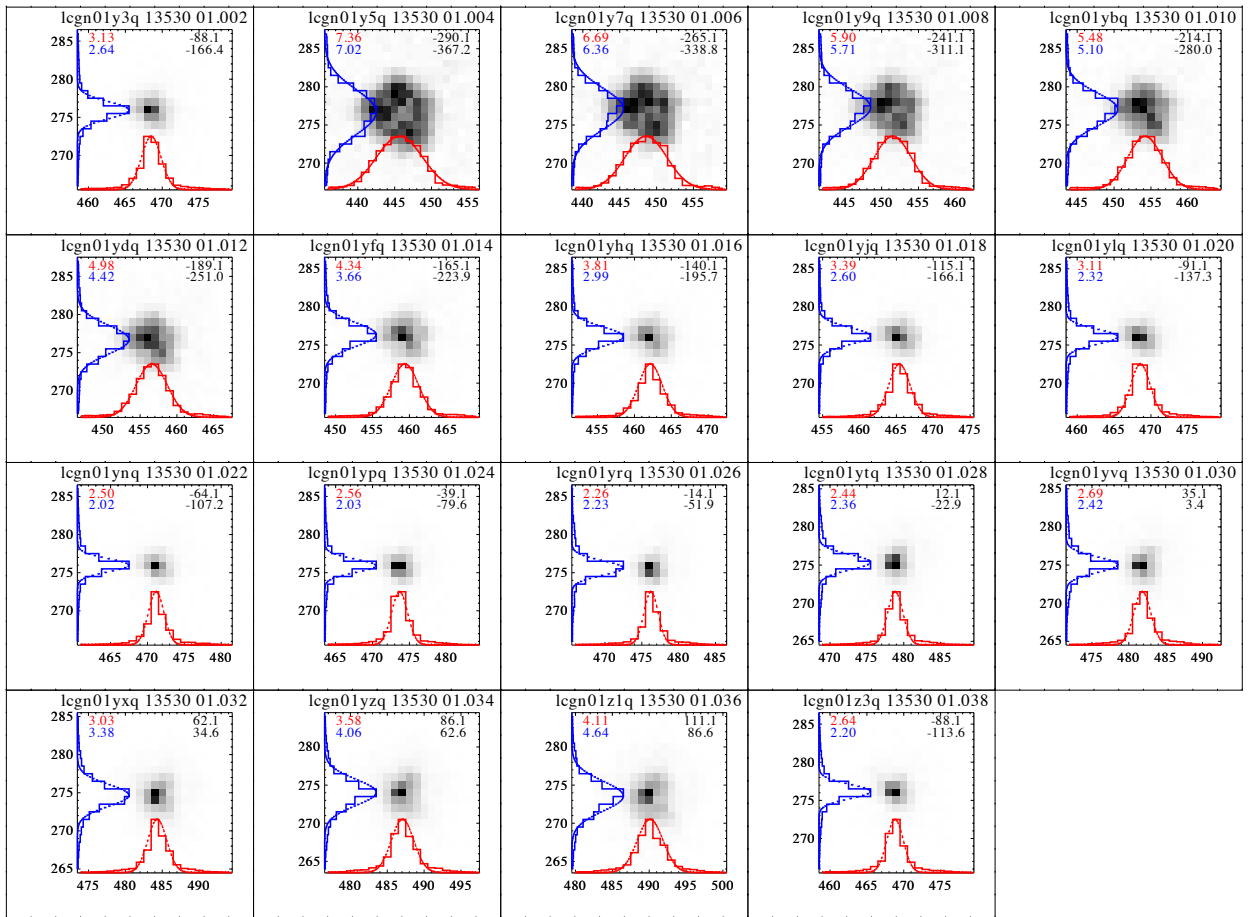


Figure 1 The 19 images taken during Program 13530, arranged in time order from upper left to lower right. The first and last image were taken at nominal focus, while the ones in between show changes of -200 to +200 focus steps. The FWHM of the x and y projections are shown in the upper left of each figure, and the focus position is shown in the upper right.

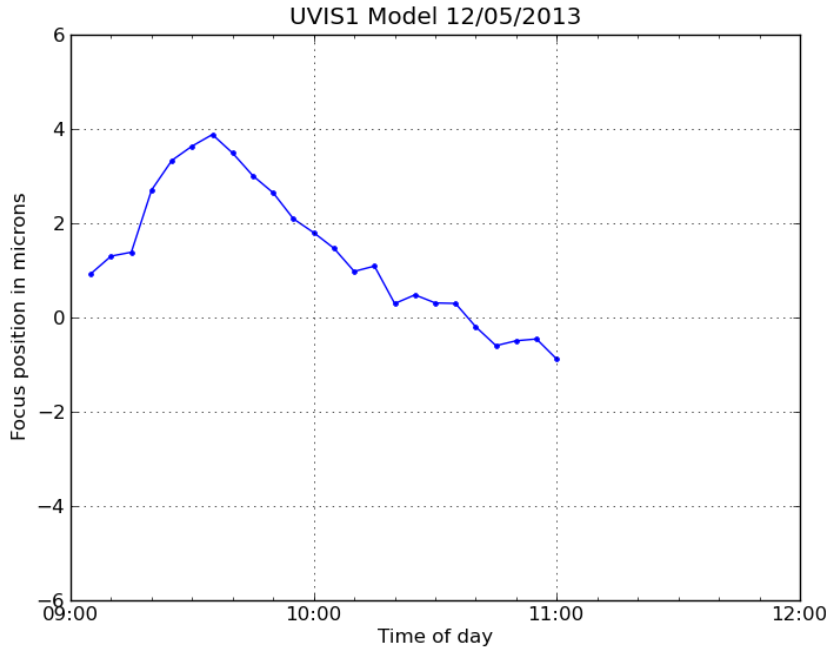


Figure 2 Breathing correction as a function of time during Program 13530. 19.2 focus steps corresponds to a 1 μm change in focus position.

The measured FWHM for each of the 19 exposures in both X and Y is plotted as a function of the breathing-adjusted focus values in Figure 3. Overlaid on this data is a quadratic fit in each axis, and the minimum of each curve is marked, along with the nominal absolute focus of -88.1 steps as determined during SMOV. Both X and Y show a focus value (-91 and -60 steps, respectively) that is similar to the SMOV number.

Given the uncertainties in the breathing model over a four year period, the measured focus position is in excellent agreement with the original value. Thus we conclude that there has been at most a negligible change in the NUV focus position from SMOV through 2013. Any future changes are likely to occur at a slower rate since the amount of structural change should be small at this point in the mission, so we can expect that the SMOV value of -88.1 will be correct when and if an electronics side switch occurs.

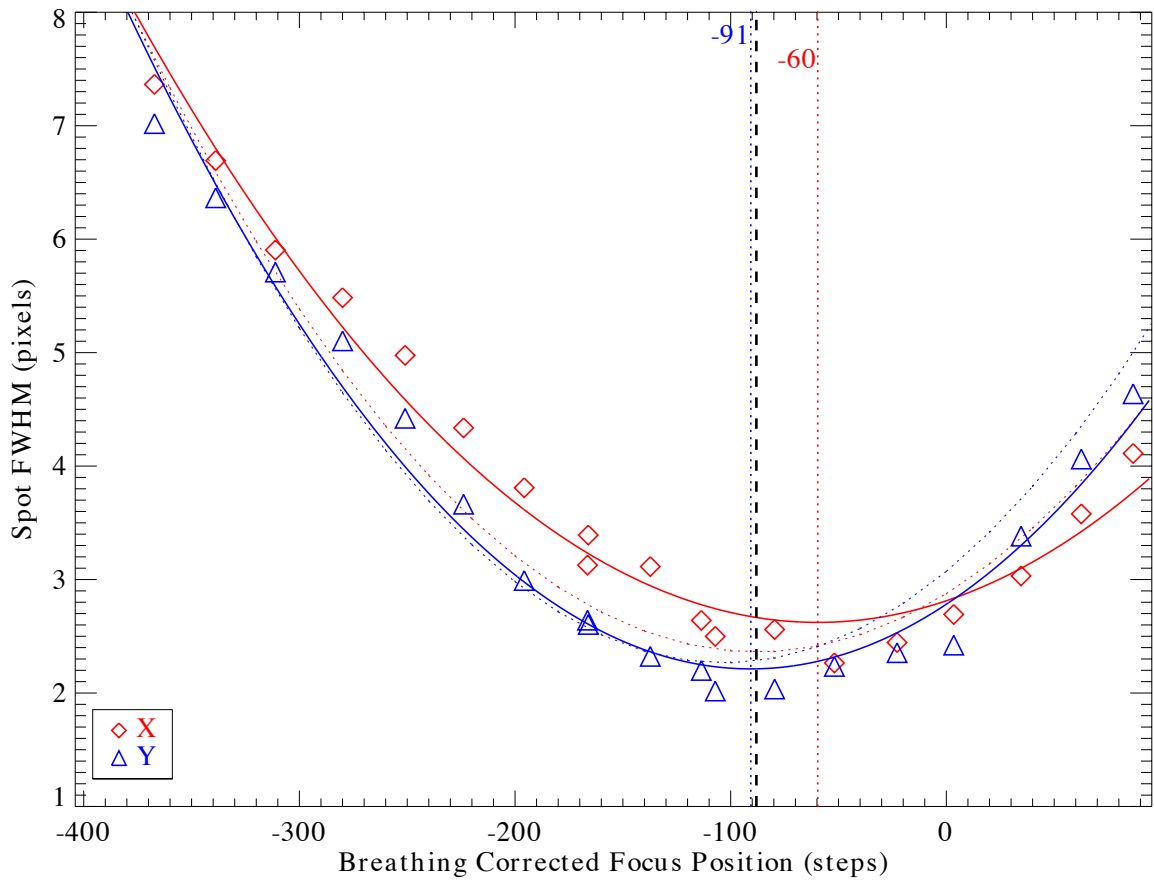


Figure 3 The measured FWHM in the X (red) and Y (blue) directions, using the breathing-corrected focus position. The minimum values of each curve are marked with vertical dotted lines, as is the nominal absolute focus value of -88.1.

Acknowledgements

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References

Hartig, G. F., et al. 2010, COS Instrument Science Report 2010-04, “SMOV: COS NUV On-orbit Optical Alignment”