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The HST Focus Monitor Program: 2019-2023

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ABSTRACT

We present phase retrieval measurements of the focus of the Hubble Space Telescope (HST) found using the WFC3/UVIS and ACS/WFC detectors from February 2019 to December 2023. From our analysis we predict that by the end of 2024 WFC3/UVIS will be at -0.66 micron despace and ACS/WFC will be at -1.48 micron despace.

1. Introduction

The focus of the Hubble Space Telescope (HST) has been monitored for many years using images from the ACS/WFC and WFC3/UVIS detectors (Niemi et al. 2010). The focus changes as the distance between the primary and secondary mirrors shrinks, attributed to desorption from HST's support structure. The secondary mirror can be commanded to move away from the primary mirror to restore the focus. This has been done on a number of occasions in the past to maintain appropriate focus for the science instruments. The history of secondary mirror moves is shown at https://www.stsci.edu/hst/instrumentation/focus-and-pointing/focus/secondary-mirror-moves. The last commanded move was executed on February 5, 2015. Here we present data acquired from February 2019 to December 2023 and analyze the rate of change of focus for each chip of the ACS/WFC and WFC3/UVIS detectors.

2. Observations

The observations were obtained in focus monitor calibration programs 15620, 16050, 16475, 16827, 17258, and 17364. Six visits to an open star cluster NGC 188 are made about every two months over the course of a year. In each visit, four 50-second subarray exposures are taken on each of the two chips that comprise WFC3/UVIS (filter F410M) and four 50-second non-subarray exposures are taken on ACS/WFC (filter F502N). This equals a total of twelve exposures per visit. During a visit, the observations on ACS/WFC are taken in parallel to the WFC3/UVIS exposures. Examples of the exposures are shown in Figure 1 (F410M) and Figure 2 (F502N).

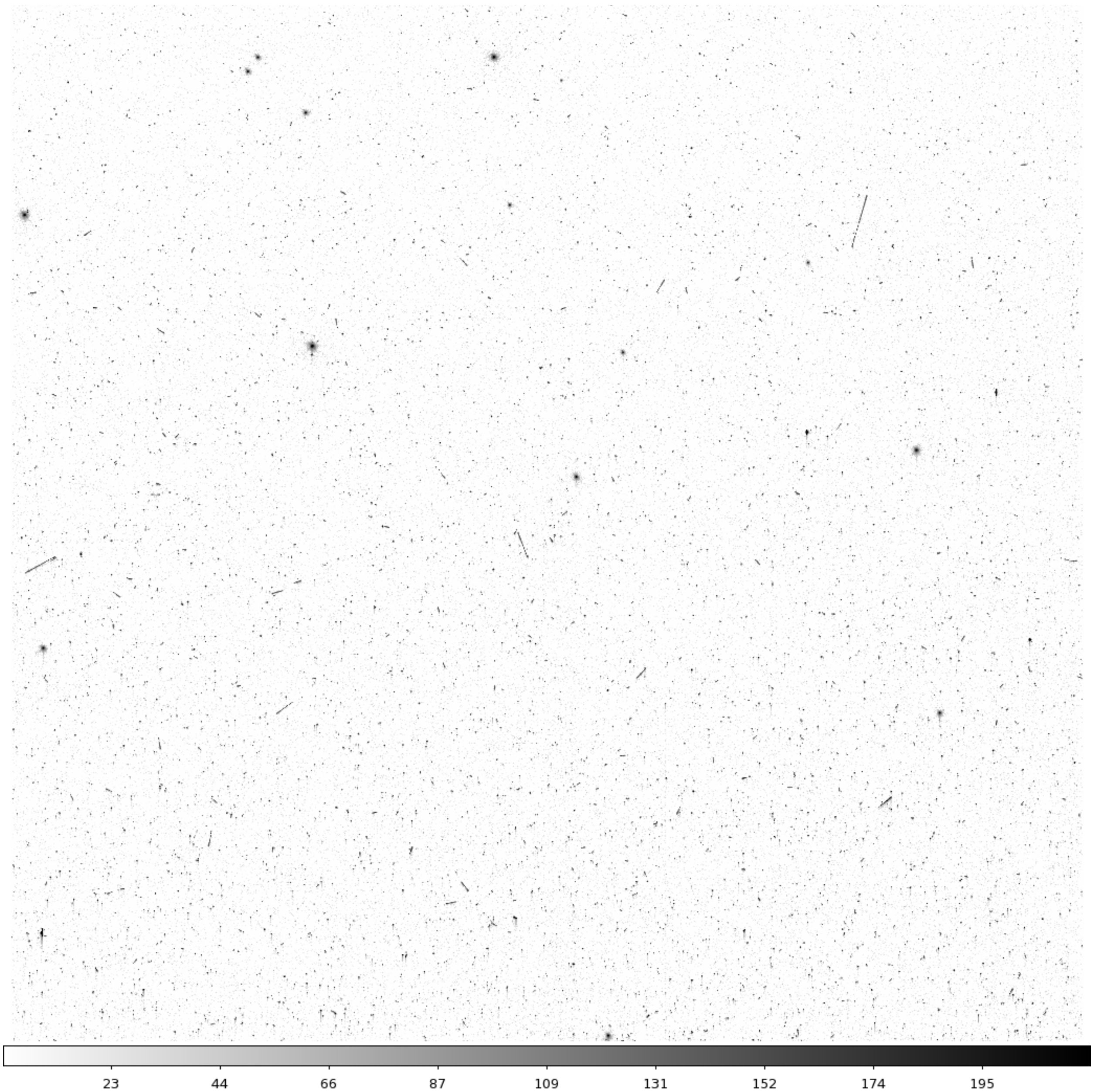

Figure 1: Example of an F410M exposure on WFC3/UVIS chip 1. The subarray is the full height of the chip and is centered on the chip.

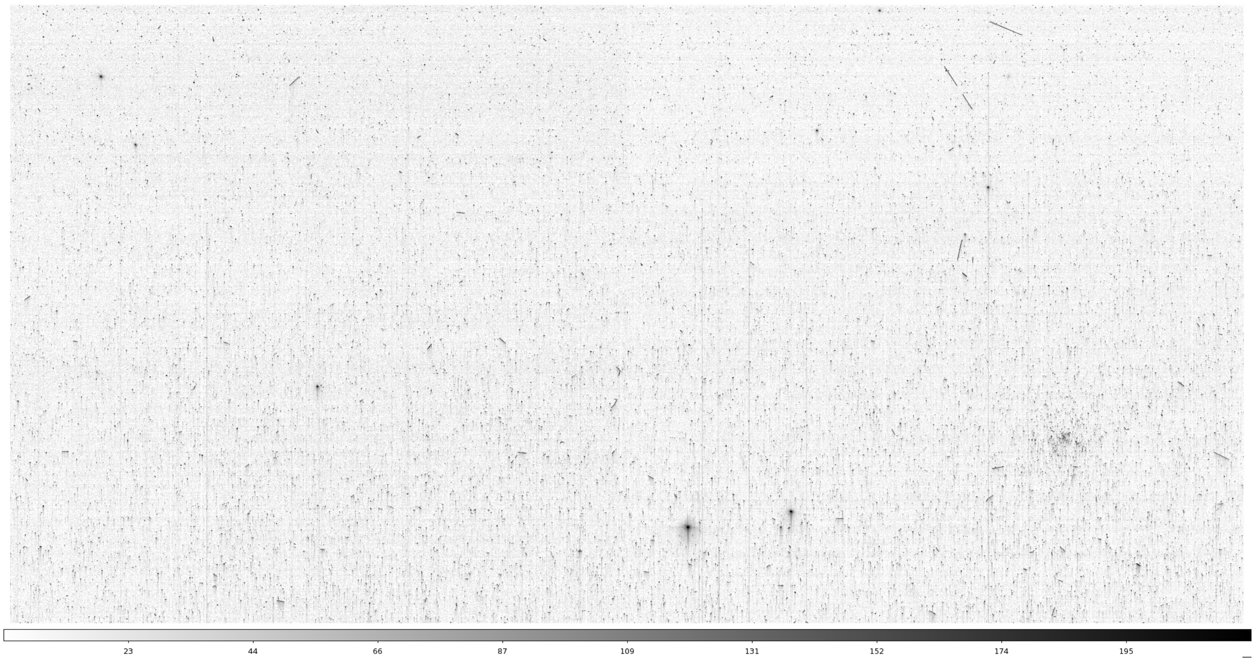

Figure 2: Example of an F502N exposure on ACS/WFC chip 2.

3. Analysis

Focus was measured for each exposure on each chip of each detector in a visit. Stars with more than 4000 electrons in the peak flux pixel, and with no saturated pixels in the PSF, are identified. Thumbnail science and DQI images (15 x 15 pixels) centered on the stars are extracted and tagged with markers for hot pixels, unstable pixels, and pixels with cosmic rays. These pixels are masked and therefore not used during phase retrieval. Phase retrieval is performed on the selected stars by fitting a model point spread function (PSF) to the data, fixing some parameters and allowing other parameters (like the focus) to change until the iterations provide no further improvements to the fit.

The parameters used in phase retrieval are Zernike polynomials, which are illustrated in Figure 1 of Niemi et al. (2010). For WFC3/UVIS the constraints X coma, Y coma, X astigmatism, Y astigmatism, and Spherical are fixed according to location on the chip. The X clover, Y clover, X ashtray, Y ashtray terms and the blur have fixed values for all locations on the chip. For the ACS/WFC chips, the Spherical, X clover, Y clover, X ashtray, Y ashtray, and fifth order spherical terms are fixed for all locations on the chip.

The average focus is computed for each visit and each detector, and plotted for comparison (see next section). A linear fit is then made to the data to monitor the rate of decrease of the focus with time.

4. Results and Conclusion

Results for the focus since February 2019 are presented as despace in units of microns for each detector in Figure 3. Despace is equivalent to the amount of change in the spacing between the primary and secondary mirrors that would result in an equivalent change in focus on a detector. The zero-focus crossing marks the time when the detector is on its best focus.

The linear fit for UVIS extends from +0.54 microns at 2019.0 to -0.66 microns at 2025.0. The fit implies a change in focus of -1.21 microns over 6 years, and a rate of change of -0.20 microns per year for UVIS.

The linear fit for ACS extends from -0.13 microns at 2019.0 to -1.48 microns at 2025.0. The fit implies a change in focus of -1.34 microns over 6 years, and a rate of change of -0.22 microns per year for ACS.

The mirror spacing is more consequential for UVIS than for the other instruments (Lallo et al. 2010). It is typically kept within 2 microns of best focus. Assuming the current rate of change in focus, by the end of 2024 WFC3/UVIS will be at -0.66 microns and ACS/WFC will be at -1.48 microns.

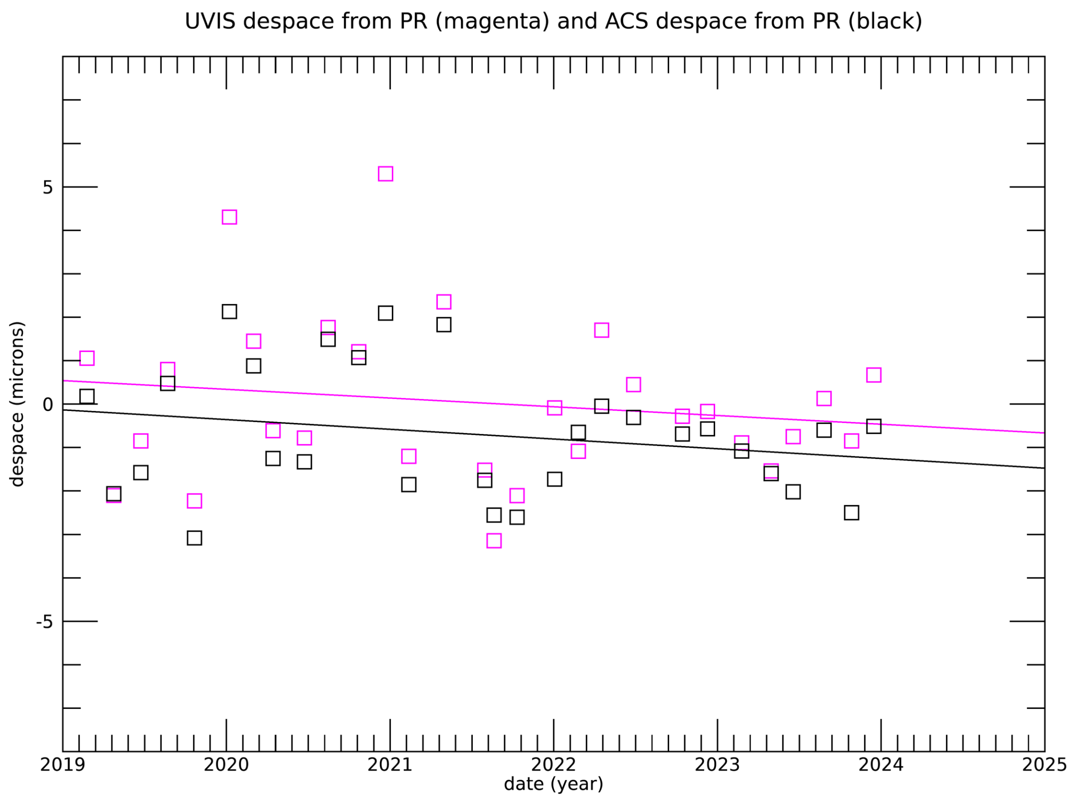

Figure 3: Despace as a function of date. (Points and fit for UVIS are magenta; points and fit for ACS are black.)

Acknowledgements

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5. References

Lallo, M., van der Marel, R., Cox, C., Hartig, G., and Niemi, S. *HST Focus in SMOV4: Strategy for OTA adjustment & SI Focus*, 2010, ISR TEL 2010-02.

Niemi, S., Lallo, M., Hartig, G., and Cox, C. *Phase Retrieval to Monitor HST Focus: I. WFC3 UVIS Software Implementation*, 2010, ISR TEL 2010-01.