

# NICMOS Focus Monitoring in the Year Following SMOV 3b

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## ABSTRACT

*Monthly monitoring of the NICMOS focus since SMOV 3b, following the installation of the NICMOS Cooling System (NCS) has revealed stable and consistent focus measurements in all three cameras. The focus values for each camera, which were measured and uplinked to the Telescope during SMOV 3b are accurate and have not required any revision.*

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## Introduction

The optimal focus for each NICMOS camera was determined on a regular basis during Cycles 7 and 7N with the last of the pre-NCS focus measurements performed on January 4, 1999 (Suchkov et al. 1998) just before the depletion of NICMOS cryogen. All focus results can be found on the NICMOS web page (URL: <http://www.stsci.edu/hst/nicmos/performance/focus>). On May 3, 2002, during SMOV 3b, following the installation of the NICMOS Cooling System (NCS), a focus sweep was executed (Program ID: 8977). The focus was carefully measured from this data to obtain new post-NCS default focus positions for each camera (Schultz et al. 2002). Those focus measurements were uplinked to the telescope on May 9, 2002. Since then, the focus has been monitored on a monthly basis to ensure the stability of the focus and the accuracy of our SMOV 3b measurements.

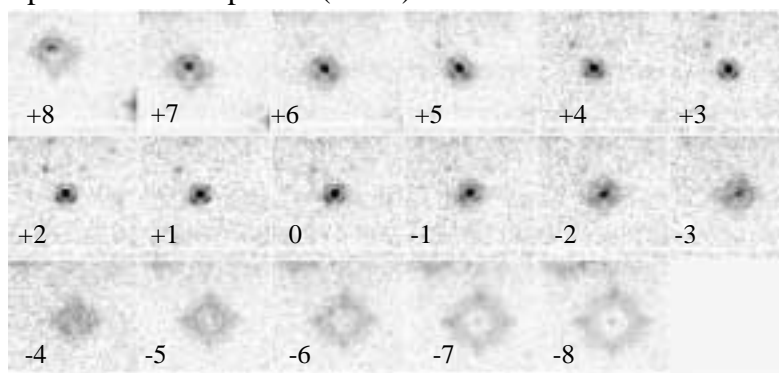
The NICMOS focus is adjusted by moving the Pupil Alignment Mechanism (PAM). Five NICMOS PAM states; PAM1, PAM2, PAM3, PAMI (CAMERA-FOCUS=1-2), and PAMC (coronagraphy), are managed for normal operation. In normal Camera 3 operation, the field offset mirror (FOM) is moved in concert with the PAM to alleviate the vignetting and thermal emission from the -Y edge of the FOV (FOMYPOS=-16). The focus interface

for NIC3 is beyond the adjustable range of the PAM (described in the NICMOS Instrument Handbook, Schultz et al. 2001), however NIC3 is currently closer to focus than it was during Cycle 7. During Cycle 7, the NIC3 focus fluctuated greatly and remained well beyond the range of motion of the PAM. Therefore a NIC3 campaign had to be executed in order to bring NIC3 into focus by moving the HST secondary mirror. Currently, the NIC3 focus is stable and is operating close to focus, thus providing science-caliber data. All five NICMOS PAM states were measured during SMOV 3b and uplinked to the telescope. The current monitoring program only measures PAM1, PAM2 and PAM3, since PAMI is simply derived from PAM1 and PAM2. PAMC was determined not to have changed since Cycle 7 and does not require monitoring.

## Data

The southern open star cluster NGC 3606, observed for the Cycle 7 focus monitor programs as well as for the SMOV 3b focus program, was observed monthly from June 2002-February 2003 (Program IDs: 8980, 9323, 9637). Focus sweep images were obtained separately (different visits) in each camera over a range of PAM focus settings, measured in millimeters of displacement from the mid-range of axial travel. Figure 1 depicts the effects of each mm of PAM movement on the NICMOS PSF. For Cameras 1 and 2, the sequence of observations is a series of images, in and out of focus, passing through best focus. Seventeen MULTIACCUM images were obtained over a range of +/- 8 mm of PAM travel in 1 mm increments. For Camera 3, the focus sweep was conducted at PAM settings of -0.5 mm to -9.5 mm of motion, and consisted of only ten MULTIACCUM images. The detectors were operated in a non-parallel mode, and no problems were reported in execution of any of the observations.

**Figure 1:** Example Focus Sweep Data (NIC1)



This figure shows the NIC1 focus sweep that executed on February 12, 2003. Each frame shows the amount of defocus at each PAM position along the sweep (shown in the bottom left corner in mm of PAM space). The NIC1 best focus is near +2 mm. Within 1 mm of best focus, the amount of encircled energy does not change noticeably, however the loss of encircled energy becomes significant beyond 2 mm of defocus.

## **Analysis**

The processed data sets were independently analyzed using the recovery of Zernike polynomial coefficients by phase retrieval. Phase retrieval is the process of deriving the aberrations in an optical system from an observed PSF image. The IDL phase retrieval software used at STScI (Krist and Burrows 1995) compares model PSFs to the observed one, optimizing the assumed Zernike-type aberrations (defocus, coma, astigmatism, etc.) using iterative, nonlinear least-squares fitting. This program is used to measure defocus (Z4) from images taken at each PAM position in a NICMOS focus sweep (Krist and Burrows 1997, Galas 1998, Roye and Schultz 2002). Corrections for defocus caused by telescope breathing are then applied. These Z4 values are transformed to equivalent (measured) PAM positions using conversion factors derived from optical ray tracing analyses. The measured PAM position is subtracted from the actual one, providing an estimate of the offset from best focus for each measurement. The mean offset is computed from all of these values, except in Cameras 1 and 2, where the few points near best focus are omitted because of focus sign ambiguities. All measurements are used for Camera 3, which historically has been sufficiently out of focus at all PAM positions to prevent such ambiguities. Because focus varies over the field of view in NICMOS (about 0.52mm in NIC1, about 1.69mm in NIC2 and about 1.04mm in NIC3, see Suchkov et al 1998) the best focus position is computed for the detector center using relations described in Suchkov et al. 1998 and the observed PSF position. The results of the Phase Retrieval measurements are stated in mm of PAM space (see Schultz et al 2002).

## **Results**

The results for the monitoring program to date are summarized in the table below (see Table 1 and Figure 2). The measurements are consistent with the default focus values which were derived during SMOV 3b. The default value for NIC3 is at the extent of the PAM range of motion, -9.5 mm, even though the actual focus lays slightly beyond this position. We have found in general that the current NIC3 focus is better than it was during Cycle 7. A slight downward trending in focus values leading up to November 2002 was due to trending of the HST secondary mirror. A secondary mirror move, executed on December 2, 2002 accounts for the sudden spike in the NICMOS focus values measured on December 6, 2002 (see Figure 2).

**Table 1.** Focus Monitor Results Measured using Phase Retrieval

Date	Post NCS NICMOS Focus History (mm of PAM space)			
	Proposal Number	NIC1	NIC2	NIC3
<b>DEFAULT</b>		<b>1.8</b>	<b>0.20</b>	<b>-9.50</b>
6/6/02	8980	1.79 (0.20)	0.10 (0.70)	-11.87 (0.90)
7/22/02	9323	2.06 (0.21)	0.63 (0.33)	-11.48 (0.56)
8/26/02	9323	1.85 (0.13)	0.13 (0.08)	-12.15 (0.43)
10/15/02	9637	1.94 (0.28)	-0.031 (0.23)	-11.67 (0.31)
10/28/02	9637	1.38 (0.32)	-0.228 (0.31)	-12.41 (0.09)
12/6/02	9637	2.40 (0.20)	0.27 (0.41)	-11.21 (0.14)
1/7/03	9637	2.26 (0.17)	0.55 (0.19)	-11.42 (0.16)
2/12/03	9637	2.11 (0.37)	0.19 (0.56)	-11.5 (0.08)

Focus measurements and associated error are listed for each focus sweep in mm of PAM space.

The top line states the default values, measured from the SMOV May 3, 2002 focus sweep and uplinked to the telescope on May 9, 2002. The defaults have not been changed since then.

## Conclusions

The NICMOS focus has remained stable and consistent since SMOV 3b. Slight downward trending of the focus in the fall of 2002 was due to drifting of the HST secondary mirror, which was corrected with a commanded move on December 2, 2002. This secondary mirror move caused the precipitous increase in focus measurements derived from the December 6 focus sweep data. The default focus values for each of the cameras, which were measured during SMOV 3b, have proven to be accurate. No updates in any of the focus values have been required.

The focus monitoring program 9637 will now continue on a bimonthly schedule, as the stability of the focus over the last nine months has obviated the need for continuing a monthly program. The next focus sweep is scheduled for April 8, 2003.

## References

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Table 2. Post-NCS NICMOS Focus History

