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NICMOS Cycle 15 Baseline Calibration Plans

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ABSTRACT

This document summarizes the NICMOS Calibration Plans for Cycle 15. The monitoring programs from the previous Cycle 13 and 14 are carried out in Cycle 15. Additional calibration is included in order to improve the accuracy of previously archived NICMOS data.

Introduction

NICMOS has remained an very stable instrument ever since the NICMOS Cooling System (NCS) was installed during the Servicing Mission 3b. This has mainly been the result of the fact that the instrument temperature has been maintained nearly constant ever since (Wiklind & Wheeler, 2006; Bergeron 2006). In the past few cycles, such as Cycle 13 and 14, this has enabled the streamlining of the NICMOS calibration, reducing the number of required orbits to calibrate the various modes of NICMOS, while at the same time reducing the total calibration errors. The monitoring programs in particular have been significantly optimized. This remains true for Cycle 15. However, with the upcoming Servicing Mission 4, due to install new powerful instruments and which may cause NICMOS and the NCS to be temporarily switched off for an extended period of time, Cycle 15 was identified as being an opportune time to obtain new and better calibration. These new calibration proposals include a complete set of flat-field, an extensive photometric program in the near infrared, of both bright and faint sources, and a complete characterization of the count rate dependent non-linearity observed in NICMOS during the last few Cycles (De Jong 2006; Bohlin 2006). Cycle 15 plans also include calibration of temperature effects, plate scales, and geometric distortion. Hence, the total number of orbits dedicated to calibrating NICMOS for Cycle 15 is significantly larger than in previous Cycles.

Monitoring Programs

As for previous Cycles, and because NICMOS has been shown to have a very stable behavior for the past few years, the frequency of the monitoring programs, that track key instrumental effects (i.e. darks, flats, focus, and photometry), have been reduced from what it used to be in Cycle 10. The monitoring programs from Cycle 14 are carried over to Cycle 15 with little to no changes. Individual Cycle 15 Monitoring Programs are shown in Table 1. Together, they account for 39 Internal orbits (when NICMOS is used as the Prime HST instrument) and 39 External orbits (i.e. observations which can be obtained when another HST instrument is being used as Prime Instrument).

Special Programs

In order to ensure that NICMOS is calibrated as well as possible, we aim at calibrating many of the known NICMOS artifacts which we now believe to be the effects of temperature, charge persistence, and nonlinearities, all of which are amenable to characterization and calibration.

Starting in Cycle 15, and continuing in Cycle 16, the NICMOS calibration programs will encompass much more than the routine monitoring programs carried out in previous cycles. The new programs will address flat fielding, count-rate-dependent nonlinearity, temperature effects, plate scales, and geometric distortion. The planned observations will also improve the reliability of both the bright and faint photometric standards used for direct imaging and slitless spectroscopy. The Special Calibration Programs are summarized in Table 1.

The new flat-field calibration program (ID 11016) uses every filter available on all three NICMOS cameras. The goal is a flat-fielding accuracy of about 0.1%, more than an order of magnitude improvement over the current 2–3%. These new flat fields will be the first complete set obtained since Cycle 7—when NICMOS was originally installed on HST—and will significantly increase the pool of data available for investigating the effects of time and temperature on NICMOS flat fields.

One special calibration program (ID 11062) will further characterize the rate-dependent nonlinearity in the NIC3 camera (De Jong 2006; Bohlin 2006). Another (ID 11067) will re-derive the NICMOS plate scale and geometric distortion in all three cameras. Our aim is to update the distortion model with an accuracy of about 1/4 of a NIC2 pixel (i.e., at the level of about 18–19 milliarcsec).

We will obtain new observations of primary and secondary standards for grism spectroscopy and direct imaging (ID 11064). The goal is to obtain up-to-date sensitivity curves for all three grism modes. In addition to improving calibrations, this data will allow us to study the variations in NICMOS sensitivity over a baseline of about three to four years, and will also help to improve the wavelength-dependent model of the NIC3 count-rate-dependent nonlinearity.

The results of directly imaging a large set of infrared standard stars will be used to verify the spectroscopic calibration of the grism (ID 11061). Observations of the primary standards will calibrate the relative brightness of stars over a wide range of luminosities, which will afford

more accurate calibrations than the spectroscopic observations, directly and independently establishing faint infrared standards. In the future, the James Webb Space Telescope, as well as other current and future infrared observatories, will benefit from these improved photometric standards.

Further details on the individual proposals may be found in Table 1 and text below, and via the standard HST and NICMOS (<http://www.stsci.edu/hst/nicmos>) web sites.

References

Bergeron, E. 2006, The 2005 HST Calibration Workshop. Eds. A. Koekemoer, L. Dressel, P. Goudfrooij

Bohlin, R. 2006, NICMOS-ISR-2006-002

De Jong, R. 2006, NICMOS-ISR-2006-001

Wiklind, T., Wheeler, T. 2006, The 2005 HST Calibration Workshop. Eds. A. Koekemoer, L. Dressel, P. Goudfrooij, p. 169

NICMOS Cycle 15 Calibration Plan

ID	Proposal Title	P.I.	Frequency	Estimated Time (Orbits)		Notes
				"External"	"Internal"	
Routine Monitoring Programs						
11057	Multiacuum Darks	Pirzkal	monthly		36	Same as Cycle 14
11060	Photometry Stability	De Jong	bimonthly	18		Same as Cycle 14
11063	Focus Stability	Wikind	NIC1 and NIC2 every 3 months. NIC3 once	15		Same as Cycle 14
11059	Flats Stability	Pirzkal	quarterly	6		Same as Cycle 14
Special Calibration Programs						
11062	Non-linearity	De Jong	once	15		Lamp on/off non linearity measurements. NGC3603 with NIC1: F090M, F110W, F140W, F160W NIC2: F110W, F160W, F187W, F205W, and F222M NIC3: F110W, F150W, F160W, F175W, and F222M. P041C using the NIC3 G096, G141 and G206
11016	Flats	Pirzkal	once	20		New complete set of flat-fields
11064	Spectrophotometry	Bohlin	once	32		Primary IR standards (12). Secondary IR standards (14). Non linearity (6)
11061	Spectroscopic Standards Imaging	De Jong	once	20		Direct imaging observations with all 3 cameras with a range of filters of a significant number of stars
11067	Distortion	Koekemoer	once	8		NICMOS geometric distortion characterization
TOTAL TIME (including all executions)				134	36	

11057: Cycle 15 NICMOS dark current and shading profile

Purpose

The purpose of this proposal is to monitor the dark current and shading profile for all three NICMOS detectors throughout the duration of Cycle 15. This proposal is a slightly modified version of proposal 10380 of cycle 13 and 9993 of cycle 12 and is the same as Cycle 14.

Description

Each iteration of this proposal consists of 4 dark exposures of 1088s (sample sequence SPARS64 and NSAMP=23) for all 3 cameras. In addition, in order to characterize the shading profile of the NICMOS detectors, a set of 5 STEP256, NSAMP=12 sequences for each camera will be taken. This sequence will be repeated once a month for the duration of Cycle 15. This will allow the monitoring of the NICMOS detectors behavior as a function of time and temperature throughout Cycle 15.

Scheduling

Monthly. SAA free orbits

Products

Darks for all readout sequences

Accuracy Goals

4-5% per visit for the linear component of the dark current. In principle $S/N \sim 50$, but degradation due to CR lower this figure. $S/N \sim 35$ (12) for the amplifier glow at the corner (center).

11063: Cycle 15 Focus Monitoring

Purpose

The purpose of this proposal is to monitor the focus of all three camera throughout the duration of Cycle 15. This is a continuation of PID 10382.

Description

This program is a version of the standard focus sweep used since cycle 7. It has been modified to go deeper and uses more narrow filters for improved focus determination. Since Cycle 14 a new source has been added in order to accommodate 2-gyro mode: the open cluster NGC1850. The old target, the open cluster NGC3603, will be used whenever available and the new target used to fill the periods when NGC3603 is not visible. Steps: a) Use refined target field positions as determined from cycle 7 calibrations b) Use MULTIACCUM sequences of sufficient dynamic range to account for defocus c) Do a 17-point focus sweep, +/- 8mm about the PAM mechanical zeropoint for each cameras 1 and 2, in 1.0mm steps. d) Use PAM X/Y tilt and OTA offset slew compensations refined from previous focus monitoring/optical alignment activities.

Scheduling

Every 3 months for NIC1 and NIC2. Once for NIC3

Products

ISR, and update of focus as needed

Accuracy Goals

Best focus within 1 mm.

11060: NICMOS Photometric Stability Monitoring

Purpose

This NICMOS calibration proposal carries out photometric monitoring observations during Cycle 15. The format is the same as the Cycle 14 version of the program (10725).

Description

Photometric monitoring will be done for all three NICMOS cameras, using a subset of filters for each. The filters to be used are: NIC1: F090M F110W F160W F190N NIC2: F110W F160W F190N F222M NIC3: F110W F160W F222M These choices provide monitoring in the most commonly used broad band filters (F110W, F160W), plus a selection of additional filters spanning the wavelength range accessible to the detectors. F110W, F160W are common to all three cameras, and there is one long-wavelength filter in common for pairs of cameras (i.e., F190N for NIC1+2, F222M for NIC2+3). NIC1 F090M provides one check on behavior at the shortest wavelengths. All observations are done using a spiral dither pattern, with 4 dither points for NIC1 and NIC2, and 7 dithers for NIC3 (to help reduce intrapixel sensitivity effects on the photometry). The point spacings scale roughly by the camera field of view. The dither steps were somewhat increased compared to cycle 11 & 12 programs to improve the chance of getting photometry of all 4 quadrants. Using the default NIC1, NIC2 and NIC3 aperture positions, these patterns should avoid the middle row or column in the detectors. The integration times are set to achieve $S/N \approx 200-350$ in the standard photometry apertures for each exposure, while keeping peak pixel counts to $< 66\%$ of saturation. The NIC1/F190N observation has somewhat lower S/N (~ 110) per exposure, but this should be adequate (better S/N would require prohibitively long exposure times). NIC3/F110W may come slightly closer to saturation ($\sim 73\%$ according to the ETC). Visits are scheduled approximately every 8 weeks. With HST having switched to 2-gyro mode at the start of Cycle 14, calibration star G191B2B was added to the monitoring program as our normal target P330E is no longer observable throughout the year. Time windows are set using BETWEEN visit-level special requirements. Each visit is given a window of 14 days in which it can be scheduled.

Scheduling

Bi-monthly

Products

Internal report or ISR. Updated zero points for CDBS

Accuracy Goals

1-2%

11059: Cycle 15 NICMOS flat field monitor program

Purpose

A series of Camera 1, 2 and 3 flat fields will be obtained to monitor the health of the cameras throughout the duration of Cycle 15.

Description

Each 1 orbit visit will obtain pointed flat fields in each camera (NIC1 filters F110M, F110W, F160W; NIC2 filters F110W, F160W, F222M; NIC3 filters F110W, F160W, F222M). Some filters will be rotated through the sequence so that many filters will be used during the duration of Cycle 15. A four point dither pattern will be used to allow removal of background objects. At each dithered position, observations will be obtained with the lamp off and followed by lamp on observations. Every three months, well exposed observations will be taken to study the non-linearity corrections. The Cameras 1 and 2 will be used in parallel. For almost all the exposures, Lamp 1 (High Intensity) will be used.

Scheduling

Quarterly. SAA free orbits

Products

Internal report or ISR.

Accuracy Goals

1-2%

11062: NICMOS non-linearity tests

Purpose

This program incorporates a number of tests to analyze the count rate dependent non-linearity seen in NICMOS spectro-photometric observations. We will observe a field with stars of a range in luminosity in NGC3603 with NICMOS in NIC1: F090M, F110W, F140W, F160W NIC2: F110W, F160W, F187W, F205W, and F222M NIC3: F110W, F150W, F160W, F175W, and F222M. We will repeat the observations with flatfield lamp on, creating artificially high count-rates, allowing tests of NICMOS linearity as function of count rate. We first take exposures with the lamp off, then exposures with the lamp on, and repeat at the end with lamp off. Finally, we continue with taking darks during occultation. We will furthermore observe spectro-photometric standard P041C using the G096, G141, and G206 grisms in NIC3, and repeat the lamp off/on/off test to artificially create a high background.

Description

We will observe a field with stars of a range in luminosity in NGC3603 with NIC1: F090M, F110W, F140W, F160W NIC2: F110W, F160W, F187W, F205W, and F222M NIC3: F110W, F150W, F160W, F175W, and F222M. We will repeat the observations with flatfield lamp on, creating artificially high count-rates, allowing tests of NICMOS linearity as function of count rate. We first take exposures with the lamp off, then exposures with the lamp on, and repeat at the end with lamp off. Finally, we continue with taking darks during occultation. The field was chosen such that the brightest stars give count rates slightly higher than the lamp count rates, however many pixels in the PSF tails will have lower count rates. We put the cameras out of focus with the PAM, which will put more pixels in the intermediate count range and mitigate small jitter drift mismatches in the pixel-by-pixel analysis of the lamp on/off data. The exposures in F110W have to be so short that NIC1 and NIC2 can not be used in parallel due to the large number of buffer dumps, the other filters are used in parallel. We purposefully do not dither, such that everything can be simply differentially analyzed on a pixel-by-pixel basis. We will observe spectro-photometric standard P041C using the G096, G141 and G206 grisms in NIC3, and repeat the lamp off/on/off test to artificially create a high background

Scheduling

Once

Products

ISR

Accuracy Goals

The number of exposures obtained with lamp on is set such that individual pixels with count rates 1/10 of the lamp count rates will still have a S/N of 100 when all coadded, such that we can measure the expected 5% non-linearity with a 1% accuracy on 1 pixel.

11016: NICMOS Flats: narrow and broad filters for NIC1 (+ NIC2, NIC3 in parallel)

Purpose

This proposal obtains sequences of NICMOS narrow band filter flat fields for camera 1. In cameras 2 and 3, parallel observations will allow us to obtain high S/N flats for all spectral elements.

Description

External flat field observations will be obtained with NIC1 for all filters. The observations should be scheduled close in time. At each dithered position, repeats will be obtained for selected filter plus camera combinations with and without the lamp on. For all the exposures, Lamp 1 (High Intensity) will be used. Parallel observations in cameras 2 and 3 will allow us to obtain high S/N flats for all spectral elements.

Scheduling

Once

Products

ISR. New flat fields for CDBS

Accuracy Goals

1%

11064: Cycle 15 NICMOS Spectrophotometry Calibration Program

Purpose

Now that the spectrophotometric capabilities of the NICMOS grism have been established, cycle 15 observations are needed to refine the sensitivity estimates, to check for sensitivity loss with time, to improve the accuracy of the linearity correction, to improve the secondary flux standards by re-observation, and to expand the G206 data set now that the sky subtraction technique has been shown to produce useful fluxes for some of the fainter secondary standards. These faint secondary IR standards will be a significant step towards establishing flux standards for JWST, as well as for SNAP, Spitzer, and SOFIA.

Description

1. Re-observe the 3 primary WDs GD71, G191B2B, & GD153 twice each, once at the beginning and once near the end of the 18 month cycle. To date, we have only 2 observation of each star, while the corresponding STIS data set for these primary standards ranges from 6 to 23 obs. No observations exist for GD71 or GD153 with G206, so that the current G206 sensitivity is defined solely by G191B2B. Purposes: Refine sensitivities, measure sensitivity losses. Orbits: 2 for each of 6 visits = 12

2. Re-observe WD1057 & WD1657 plus another P041C lamp-on visit to improve the scatter in the non-linearity measurements per Fig. 8 of NIC ISR 2006-02. The WD stars require 2 orbits each, while the lamp-on test is done in one. The very faintest and most crucial standard WD1657 has 2 good visits already, so to substantially improve the S/N, two visits of two orbits are needed. Include G206 for P041C in the lamp-off baseline part of that orbit. Orbits: WD1057-2, WD1657-4, P041C-1 --> 7

3. Re-observe 9 secondary standards to improve S/N of the faint ones and to include G206 for all 9. BD+17 (3 observations) is not repeated in this cycle. Four are bright enough to do in one orbit: VB8, 2M0036+18, P330E, and P177D.

Scheduling

Once

Products

ISR.

Accuracy Goals

2%

11061: NICMOS Imaging of Grism Spectrophotometric Standards

Purpose

In this program we will take imaging observations with all 3 cameras with a range of filters of a significant number of stars that are part of the spectroscopic standard star project. These stars will form the fainter reference star backbone for programs as JWST, Sophia, and SNAP. With this program we will: 1. Accurately calibrate relative brightness of standard stars, which can be done more accurately with photometry than with spectroscopy. This has been proven to be vary valuable to straighten out the problems in the spectroscopic data reduction and calibrations so far. 2. Increase the number of stars over a large magnitude range to provide a more accurate cross check of our count rate dependent non-linearity correction 3. Include stars with radically different (very red) spectra to investigate whether the filter curves as measured before flight are still valid by comparing the throughput estimates from these stars to those used for the standard calibration. 4. Repeat a few standard star observations from cycle 7 and post-NCS installation SMOV, to increase the accuracy in the change in sensitivity measurement with just a few observations thanks to the long baseline.

Description

White Dwarf primary spectroscopic standards- GD71- GD153 These primary standard for the optical calibration of HST (with G191B2B) were observed regularly in cycle 7, but only GD71 once since. With a few observations we could significantly improve the accuracy of our photometric calibration and increase the time line of our calibration. These stars are a factor 5 fainter than our usual standards (P330E and G191B2B) and the count rate non-linearity should already be measurable at the shortest wavelengths. 3 orbits each NIC1: F090M, F110M, F110W, F145M, F160W, F165W, F190N NIC2: F110W, F160W, F165M, F187W, F190N, F205W, F207M, F222M NIC3: F110W, F160W, F190N, F222M Solar Analogs- P177D- P041C P177D was monitored cycle 7, but was only observed once since. P041C has been used in repeated lamp-on/off tests, but no photometry available. P041C is brighter than the usual photometric standards, providing an extra test for count rate non-linearity correction. 2 orbits each, with normal monitoring filters used on P330E and G191B2B NIC1: F090M F110W F160W F190N NIC2: F110W F160W F190N F222M NIC3: F110W F160W F222M Faint White Dwarfs- WD1657+343- WD1057+719 These very faint WDs provide the strongest cross-check of the non-linearity correction as determined from the lamp-on/off test 3 orbits each NIC1: F090M, F110W, F145M (WD1057), F160W NIC2: F110W, F160W, F165M (WD1057), F187W NIC3: F110W, F160W, F175W (WD1057) Red Stars- VB-8- 2M0838+18 2 orbits each These stars have very red spectra the will identify problems with the presumed filter throughput and detector QE curves in comparison with the other standard stars. VB-8 is significantly brighter than our photometric standards, 2M0838+18 fainter at especially the blue end. NIC1: F090M F110M F110W F160W F190N NIC2: F110W F160W F190N F222M NIC3: F110W F160W F222M

Scheduling

Once

Products

ISR.

Accuracy Goals

2%

11067: NICMOS distortion

Purpose

This proposal aims to provide an updated measurement of the NICMOS plate scale and geometric distortion solution. This was last measured in detail in 1997, with only one update post-NCS in 2002, and may have changed since if there have been long-term changes in the instrument. Observations of an astrometric field will be obtained in all three cameras, aiming to measure the optical plate scales at each of the detector focal planes with a precision of 1/4 of a Camera 2 pixel (i.e 18.8 mas).

Description

The selected astrometric field is the cluster NGC 1850, which was used previously to measure the NICMOS distortion and plate scale. MULTIACCUM exposures will be obtained using the F160W filter in the three cameras. The same observational strategy successfully used in the previous measurement of the distortion solution will be used here. The telescope will obtain 15 exposures (five positions per camera), so as to place the same group of stars in each quadrant and in the center of the chips. The twelve offset pointings will be offset from the central position by a quarter of the FOV in x and y (2.5 arcsec for NIC1; 5 arcsec for NIC2 and 12.5 arcsec for NIC3). Comparing the relative positions of the stars in each sector will yield the plate scale and distortions. Exposure times are such that 20-21 mag stars will be detected with a S/N of ~20. The program requires a total of 4 orbits (1 orbit for each of NIC2 and NIC3, and 2 orbits for NIC1).

Scheduling

Once

Products

ISR, possible updated distortion coefficients for all 3 cameras.

Accuracy Goals

18mas (1/4 NIC2 pixel), as for previous distortion calibration.