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NICMOS Calibration Plans for Cycles 13 and 14

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Abstract.
This paper summarizes the NICMOS Calibration Plans for Cycles 13 and 14. These plans complement the SMOV3b, the Cycle 10 (interim), and the Cycles 11 and 12 (regular) calibration programs executed after the installation of the NICMOS Cooling System (NCS). The special calibrations on Cycle 13 were focussed on a follow up of the spectroscopic recalibration initiated in Cycle 12. This program led to the discovery of a possible count rate non-linearity, which has triggered a special program for Cycle 13 and a number of subsequent tests and calibrations during Cycle 14. At the time of writing this is a very active area of research. We also briefly comment on other calibrations defined to address other specific issues like: the autoreset test, the SPARS sequence tests, and the low-frequency flat residuals for NIC1. The calibration programs for the 2-Gyro campaigns are not included here, since they have been described elsewhere (see Sembach et al. 2006, in these proceedings). Further details and updates on specific programs can be found via the NICMOS web site.

1. Introduction

Since the installation of the NICMOS Cooling System (NCS) during the Servicing Mission 3b, NICMOS has shown a very stable behavior as a consequence of its well controlled operating temperature (Wiklind & Wheeler, 2006). This stable behavior has had an important impact on the calibration plans, which have evolved into three main directions. First, the frequency of some of the monitoring programs have been gradually reduced. Second, due to the instrument's improved stability, the systematic errors in the calibration have become relatively more important. Consequently a reduction in the systematic errors in the zero points and grism sensitivity curves has been pursued. Third, we have also studied the behavior of the instrument at extreme count rate regimes (e.g. UDF, very high S/N spectrophotometry). Apart from these generic lines, other calibrations to address specific problems (e.g. autoreset, new multi-accum sequences, etc.) have been also implemented. In the following paragraphs we will briefly comment on each of these categories, pointing out the most relevant aspects of the Cycles 13 and 14 Calibration Plans.

1.1. Monitor programs

As a consequence of the stable behavior shown by the instrument, the frequency of the different monitoring programs, which track the stability of key properties of the instrument (i.e. darks, flats, focus, photometry), have been gradually reduced between Cycles 10 and 13. Although the possibility was discussed of reducing the frequency of some programs even further by combining their information (e.g. photometric stability could, in principle, be checked using the photometric monitoring data), it was considered important to maintain homogeneity in the programs across cycles. During Cycle 13 the major reductions affected the flat and focus programs, whose frequency were cut by factors of 2 and 1.5, respectively. During Cycle 14 we maintained the same frequency as in Cycle 13 for all monitor programs.

However, the change to 2 Gyro operating mode for HST has reduced the visibility period of some of the objects traditionally used for some of these programs, like the photometric and focus monitor. Consequently we have added new objects to these programs (G191B2B as a new photometric standard and 47Tuc as a new focussing cluster).

1.2. Photometric and Spectrophotometric recalibrations

The more stable behavior of the detectors has led to the systematic errors playing a relatively more important role in limiting the actual accuracy of standard observations. Consequently we launched in Cycle 12 two programs (photometric and spectrophotometric re-calibrations) aimed at improving the systematic errors associated with the photometric zero-points and sensitivity curves with respect to those achieved during Cycle 7 and 7N. The photometric re-calibration expanded the number and type of stars used for obtaining the zero points for all filters. Similarly, the spectroscopic recalibration allowed a reanalysis of the sensitivity curves for the three grisms using a larger number and variety of stars. Several of the selected objects were common for the two proposals. Therefore, these data allowed a spectrophotometric recalibration by cross-checking results obtained independently from these modes (i.e. imaging/filters and spectroscopy/grism). This program (which included new faint calibrating stars) has led to the discovery of a possible count rate non-linearity. This effect, the so called 'Bohlin effect', is described in detail in Bohlin, Lindler, & Riess (2005). As a response to this effect, a special calibration program was implemented in Cycle 13, and several tests and calibrations have followed during Cycle 14. This effect is dependent on the count rate and thus affects observations in a source-dependent way, as we briefly describe below. The new data obtained with the photometric re-calibration program (as well as the larger set of data collected with the photometric monitoring programs) also suggested the possibility of some systematic residual associated with the position of the object in the field of view. During Cycles 7 and 7N the possible variation of the response (after flat-fielding) as a function of the position in the field of view was estimated to be small compared with the actual uncertainties in the photometry. However, with the current higher precision data this is unclear, and a study to analyze the low frequency flat residuals has been implemented in the Cycle 14 Calibration Plan. This will be done initially for camera 1 since the intra-pixel sensitivity effect on the photometry is smaller. Depending on the results of this program a similar one could be also implemented for cameras 2 and 3 (which require extensive dithering to average out this effect; Xu & Mobasher, 2003).

1.3. Calibrating the extremes: From the very high S/N regime to the UDF

During Cycles 12-14 the behavior of NICMOS at extreme count rate regimes has been investigated. On one hand a Cycle 12 calibration proposal lead by R. Gilliland was aimed at investigating the relative spectrophotometric accuracy of the instrument in the very high S/N regime. It was found that NICMOS can reach a relative precision of around 10^{-4} or even higher in time series observations (Gilliland and Arribas 2003). Further details can be found in Gilliland (2006). In the other extreme, the Hubble Ultra Deep Field observations imposed new calibration challenges. Details on these particular calibrations are discussed in Mobasher & Riess (2005) and Thompson (2006). Because objects in the UDF are observed at extremely low count rates (i.e. very different to those typical of standard stars observations), their calibration may be affected by the 'Bohlin effect' mentioned above. In order to understand better the origin of this reported non-linearity, a program which includes several tests has been implemented in the Cycle 14 Calibration Plan. These tests are: i) the measurement of the wavelength dependence of the persistence decay after an exposure of a bright star in a series of multi-accum dark frames, ii) the measure of the non-linearity dependence on the count rate by observing a field of stars in a sequence of lamp off/on, and so artificially increasing the background level (this will be done in imaging and grism modes), and iii) the photometric measurements of the faint standard stars

SNAP-2 and WD1657+343 (on which the NICMOS non-linearity was originally discovered using grism observations) will be repeated to obtain higher S/N. All these observations should clarify the origin of the non-linearity effect, and its possible relation with the UDF calibrations (de Jong 2006).

1.4. Specific calibrations

Other programs implemented in the calibration plans addressed more specific issues like:

i) *Delta-T program*: The goal of this program was to study the effects of the detector temperature on the darks. (This was a Cycle 12 calibration program implemented too late to be included in the standard calibration plan for this cycle).

ii) *Autoreset test*: This Cycle 13 calibration program is aimed at testing the short term temperature ripples in the NICMOS dewar.

iii) *New SPARS sequences*: This Cycle 14 program had the goal of testing the darks of the newly implemented SPARS multiaccum sequences.

Further details on the individual proposals may be found in the table below (see also Arribas et al. 2005), and via the standard HST and NICMOS web sites.

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Table 1: Cycle 13 and Cycle 14 calibration programs. Details on individual programs can be obtained via the HST-STScI web site at http://www.stsci.edu/hst

Activity title	ID (Cycle/Program)	Comments
Multiaccum Darks	10380 (C13), 10723(C14)	Monitor programs (monthly). Linear component of the dark current, shading, ampified glow.
Focus Stability	10382 (C13), 10724 (C14)	Monitor programs. NIC1 and NIC2 every 45 days. A new field (47Tuc) added in Cycle 14 to account for 2Gyro operations.
Photometric Stability	10381 (C13), 10725 (C14)	Monitor programs (montly visits). Same as in previous cycles (i.e. observations of P3003E with selected broad filters). A new object added in Cycle 14 to account for 2Gyro operations.
Flat Fields Stability	10379 (C13), 10728 (C14)	Monitor programs. Pointed lamp observations using selected filters.
Grism Recalibration: follow up	10383 (C13)	Special calibration program. Observations of the standard star BD+17 4708. Led to the discovery of a possible count rate nonlinearity.
Extreme count rates linearity test	10454 (C13)	Special calibration program. First response to the discovery of a possible count rate non-linearity.
Auto-reset test	10465 (C13)	Special calibration program to test the short term temperature ripples in the NICMOS dewar.
Non-linearity tests	10726 (C14)	Special calibration program. Includes several tests to analyze the count rate dependent non-linearity seen in NICMOS spectrophotometry.
Low-frequency flat residuals for NIC1	10727 (C14)	Special calibration program to better characterize the flat-field errors seen for camera 1 in the photometric monitoring data.
Test for newly implemented SPARS sequences	10721 (C14)	Special calibration program to measure the dark current of the new multiaccum sequences for the three NICMOS detectors.