Instrument Science Report WFC3 2011-14

WFC3 Cycle 18 Calibration Program

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The WFC3 Cycle 18 Calibration Program runs from October 2010 through September 2011, and will measure and monitor the behavior of the WFC3/UVIS and WFC3/IR channels. Calibration programs include characterization of geometric distortion, zeropoints, sensitivity, flatfields and filter transformations; daily monitors for detector gain, darks and biases; monthly anneals (CCDs), "bowtie" pinning, as well as programs to improve the IR detector's persistence mitigation, and to better measure its count rate nonlinearity (reciprocity failure). New programs include developing spatial scanning capability, charge injection to mitigate CTE losses and zeropoint determination with an expanded set of standard stars.

Introduction

WFC3's UVIS and IR channels are independent – each has its own optical, mechanical and electronic components. WFC3/UVIS is sensitive between 200 nm and 1 micron, has 62 filters and one grism, and two-2048x4096 pixel CCDs with 0.1 arcsec/pixel. WFC3/IR has go0d quantum efficiency between 0.8 and 1.7 microns, 15 filters and 2 grisms, a 2048x2048 pixel HgCdTe array with 0.13 arcsec/pixel. A complete description of the instrument is contained in the WFC3 Instrument Handbook (Dressel, L 2010). The Data Handbook (Rajan et al 2011) describes how to reduce and analyze WFC3 data.

Objectives

The 35 Cycle 18 WFC3 calibration proposals were built to support the calibration needs of approved GO proposals, and are designed to monitor detector performance and provide the best possible calibration data for science. During Cycle 18, WFC3 GO programs use ~42% of HST GO orbits distributed over the three principal types, shown in Table 1. The distribution between UVIS and IR exposures is given in Table 2. A major difference between Cycle 17 and Cycle 18

GO programs is the preponderance of spectral modes compared to direct imaging, primarily with the G141 grism.

Program Type	**WFC3/IR**	**WFC3/UVIS**
Prime	79.1	20.9
Parallel	43.7	56.3
SNAP	64.6	35.4
All Observations	**77.5%**	**22.5%**

Table 1 Distribution of Programs between WFC3/IR and WFC3/UVIS Channels for GO Programs.

	WFC3/IR	**WFC3/UVIS**
Imaging	175	479
Spectroscopy	509	0
Percentage of GO HST Orbits	**21.4%**	**14.9%**

Table 2: Orbits allocated to WFC3/IR and WFC3/UVIS Channels for GO Programs, excluding Snapshots.

Calibration activities are divided into several categories as shown below. All the proposals are described individually in the last section.

Monitor Programs:

One of the objectives during Cycle 18 is to monitor the main properties of the instrument. These programs (darks, flats, biases, ‘bowties’, ‘droplets’) are continuations of the corresponding Cycle 17 programs and are key to understanding the behavior and stability of the instrument during the current cycle.

UVIS monitor programs:

- Biases and darks (Proposal 12342).
- Bowtie monitor (Proposal 12344) which corrects for an intermittent hysteresis effect in both CCDS by exposing the detectors to count level several times full well to fill the traps and effectively neutralize the “bowtie” effect.
- Contamination (Proposal 12333). The UV throughput is monitored via weekly standard star observations in a subset of key filters, as is the stability of the zeropoints.

- New in this is cycle is an aggressive effort to characterize the rate of degradation due to charge transfer effect (Proposals 12379 and 12347)

IR specific monitor programs:

- Dark monitor (Proposal 12349). Dark current images are collected using all sample sequences that will be used in science observations. These observations are used to monitor changes in the dark current of the WFC3IR channel on a day-to-day basis, and to build calibration dark current ramps for each of the sample sequences to be used by GOs in Cycle 18.

Photometry Programs:

The principal goals of the photometry programs are to deliver zeropoints for each of the GO requested filters and grisms, measure stability of the two channels and improve the accuracy of the flat fields. During this cycle we expanded the spectral types of the standard stars to include G-type and late dwarf stars.

- Photometry (Proposals 12334 and 12335) will be determined from observations of an expanded set of standard stars, including the HST white dwarf standards GD153, GD71, G191B2B, and the solar analog P330E. The same data will also be used to quantify and monitor WFC3 sensitivity and photometric stability. Color transformations are determined from observations of asterism.
- Spatial scanning is tested in Proposal 12336, which will enable observations of very bright object by moving the telescope across the FOV.
- Grism flux and wavelength calibrations are described in Proposals 12355, 12356, 12357, 12358 and 12359.
- Flat fields (Proposals 12337, 12338, 1233) are obtained by observing internal tungsten lamps and through observations of dithered star fields.

Detector Programs:

Detector characteristics that can affect the accuracy of photometry (or spectrophotometry in the case of grism observations) will be measured in orbit.

These include for the WFC3/IR Detector:

- Persistence (Proposal 12351) in the IR detector is a latent afterimage or residual image, which has a long decay time. It can persist for many hours, in spite of multiple readouts. Though it is more easily seen after observation of a bright source, even relatively faint targets can produce persistence. Our goal is to provide good persistence ‘calibration’ files to remove or mitigate most of the effect.
- Linearity. IR detectors are inherently nonlinear devices; hence, characterizing their nonlinearity is important. Proposal 12352 is designed to measure the count linearity (“regular linearity”)

For the WFC3/UVIS CCDs, these include:

- CCD Charge Transfer Efficiencies (CTE) degrade on orbit (see for example (ISR 0503) Proposals 12379 and 12347 will measure CTE. Proposal 12348 tests charge injection as a way to ameliorate the effect of CTE.

Image Quality Programs

These proposals are designed to check the image quality i.e. measure distortions, distribution of light from a point source and provide a cross check to possible focus changes that are not due to 'breathing', changes in focus caused by thermal effects as HST goes through its orbit. Included in this category are proposals to determine:

- Geometric Distortion of each channel (image quality proposals) is measured through observations of astrometric fields since the distortion is due as much to the optical design as the detector. The appropriate polynomial corrections are determined and then applied. (Proposal 12353).

Data, Analysis and Results

All analysis and results from the Cycle 18 Calibration Programs will be described in Instruments Science Reports (ISR) and will be available on the WFC3 web site. Where appropriate, results are used to update reference files, as well as the WFC3 Instrument Handbook and the WFC3 Data Handbook. Results from the photometric activities will be used to update the synphot tables; updates to the exposure time calculators will use these results, as well as those from the activities that measure detector characteristics.

WFC3 Cycle 18 Calibration Proposals

The complete list of WFC3 Cycle 18 calibration proposals are given below, in order of Proposal ID. Provided in Table 1 are the Proposal ID, Proposal Title, Number of Orbits (External – on a target, Internal – during occultation), frequency with which the program is executed, the program observing cadence, and comments.

Following the table, each proposal is summarized (one per page, in order of assigned Proposal ID) For more information and details on the observations, please read the Phase II descriptions, which can be obtained at http://www.stsci.edu/hst/scheduling/program_information.

Table 3 Cycle 18 WFC3Calibration Proposals

ID	Proposal Title	PI	No. of Orbits		Freq.	Comments
			Ext.	Int.		
	Cycle 18 Allocated Orbits		134	1719		
12333	UVIS&IR Zeropoint Stability Monitor	Baggett	22	0	24x	once every 5 weeks
12334	UVIS & IR Photometric Calibration	Kalirai	16	0	8x	1 star/orbit/channel
12335	IR Color Transformation with asterisms	Riess	4	0	1x	
12336	Scan Enabled Photometry	MacKenty	8	0	1x	4 orbits/channel
12337	UVIS Flat Field Stability	Rajan	0	25	6x	ever 2nd month
12338	IR Flat Field Stability Monitor	Viana	0	58	12	once per month
12339	UVIS LFlat Correction	Sabbi/TBD	14	0	1x	
12340	IR LFlat Correction	Dahlen	9	0	1x	
12341	IR Blob Photometry Test	Viana	2	0	1x	
12342	UVIS Darks and Bias Monitor	Borders	0	730	365x	2 orbits per day
12343	UVIS Anneal	Baggett	0	80	12	
12344	UVIS Bowtie Monitor	Borders	0	130	120x	every 3rd day + 10 orbits
12345	UVIS Long Darks Test	Petro	0	20	1x	
12346	UVIS CCD Gain Stability Test	Pavlovsky	0	10	2x	
12347	UVIS Internal CTE Monitor: EPER	Kozhurina Platais	0	24	2x	
12348	UVIS Charge Injection Test	Baggett	5	40	1x	
12349	IR Dark Monitor	Dulude	0	423	365x	
12350	IR Gain Monitor	Hilbert	0	16	1x	
12351	IR Persistence Experiments	Long	3	145	1x	
12352	IR Nonlinearity	Hilbert	6	18	2x	
12353	UVIS & IR Geometric Distortion Corrections	Kozhurina-Platais	10	0	2x	
12354	High Contrast Imaging	Gilliland	4	0	1x	
12355	IR Grism Wavelength and LSF Calibration	Pirzkal/	4	0	1x	
12356	IR Grism Wavelength Calibration Stability Test	Pirzkal	4	0	2x	
12357	IR Grism Flux Calibration Monitor	Bushouse	4	0	1x	
12358	IR Grism Lflat Correction and Independent 2D Wavelength Solution	Bushouse	4	0	1x	
12359	UVIS Grism Wavelength Calibration	Pirzkal	4	0	1x	
12379	UVIS CTE Monitor: Star Clusters	Noeske	11	0	2x	

Proposal ID 12333
UVIS Cycle 18 Photometric Monitor
S. M. Baggett, J. S. Kalirai, T. Borders H. A. Bushouse A. Rajan.

The photometric throughput of WFC3 during Cycle 18 is monitored via periodic standard star observations in a subset of key filters. The data provide a measure of the UVIS/IR flux stability as a function of time and wavelength as well as a check for the presence of possible contaminants.

The target for both channels in Cycle 18 is the white dwarf spectrophotometric standard GRW+70d5824. Two orbits are executed every 5 weeks plus, at the start of the cycle, 1 orbit each for IR filter and IR grism observations (visits 13 and 14) to link the Cycle 17 monitoring to Cycle 18. The visits are performed every 5 weeks, starting in November assuming the last iteration of Cycle 17 runs October 11-17. This cadence is deliberately out of phase with the monthly anneal procedures in order to sample a variety of times since anneal.

Each iteration of the monitor will obtain subarray observations of the standard star in a variety of filters in both UVIS and IR. The former will be done with the major UV and several visible filters, in both chips, as well as the G280 grism on chip 2 for a contamination measurement. IR channel imaging will be done with the IR G102 and G141 grisms along with as many IR filters as will fit within the remaining visibility period. GRW visits are 11/12, 21/22, through A1/A2; Visit 13/14 are one-time only IR observations of the standard GD71. Visit 13 consists of an iteration of one of the Cycle 17 GD71 visits (proposal 11926, visit 80), which acquires exposures in all IR filters using a 2-point dither. These data will allow a transition of Cycle 17 monitoring results over to the Cycle 18 monitoring, which uses GRW+70 for both UVIS and IR. POSTARGs performed in the previous cycle to place the target on a clean area of detector are used here as well. The F130N exposure has been moved out of the dither line pattern to shorten the orbit so it will schedule. Visit 14 consists of an iteration of a subset of exposures from the Cycle 17 IR grism proposal (11936, central and upper left pointings). Orients have been added to avoid spectral overlap from a bright nearby star which would occur ~80° and 260°.

Proposal ID 12334
UVIS & IR Photometric Zero Points
J. S. Kalirai, A. Rajan, S. Deustua

We are observing each of the standard stars for one orbit in several UVIS and IR W and M filters. These observations need to be high signal-to-noise to compare accurately (i.e., <1%) to SEDs for the stars. For most stars, we use the W band filters that span the full spectral range of WFC3 UVIS filters are F225W, F275W, F336W, F390W, F438W, F555W, F606W and F814W and IR filters are F098M, F110W, F125W, F140W and F160W. As required given exposure limitations imposed by the brightness of the stars, certain configurations differ from this default set. For example, for some of the faint and red stars, we decided not to observe in the bluest filters to avoid very long integrations. All observations are dithered and employ a subarray to minimize read out times. Exposure times were set to ensure a very high S/N (e.g., 60, 000 counts in peak pixel where possible) in most filters, using the WFC3 ETC and calspec spectrum of each star.

Proposal ID 12335
IR Asterisms
A. Riess, S. Deustua J. S. Kalirai, J. W. MacKenty

Observing asterisms for photometric calibration provides a "happy medium" between observing single stars, which are observable from the ground but lack statistics, and star clusters which have excellent statistics but are too crowded to observe from the ground. Asterisms in the IR for calibration have been less available than in the optical, e.g., Landolt's standard fields. While adhoc asterisms for calibration could be formed from 2MASS calibration, the photometric precision of 2MASS is relatively low, 0.020.05, for the fainter stars, m=913, that can still be observed without saturation in WFC3IR.

However, IR monitoring of variable phenomena (e.g., AGN SNe, stellar variables) from the ground has produced calibration of stars in asterisms with m=913 with a relative uncertainty of ~0.001 to 0.01 mag due to the high frequency of monitoring. We have selected 4 such asterisms to observe. Because the stars are bright we need to use subarrays of 64x64 or 128x128 to get read out short enough to avoid saturation. The observations are obtained in pairs of 3 close stars, i.e., 2x3=6 stars per orbit in F125W and F160W as well as a F555W full frame to verify astrometry. In all we expect to measure 24 stars with m=9 to 14. The goal is to provide 2 calibrations, an independent zeropoint and its uncertainty as well as a measure of count rate non-linearity. For the latter, an expected CRNL over 2 dex (5 mag) is expected to be ~0.02 mag.

Proposal ID 12336
Scan Enabled Photometry
J. W. MacKenty, P. McCullough

During Cycle 18 we will enable spatial scanning of bright sources. This program uses the FGS enabled scan rates.

Proposal ID 12337
UVIS Internal Flats
A. Rajan T. Dahlen N E. Sabbi NS. M. Baggett

This proposal is designed to monitor the stability of the UVIS detector as well as the tungsten lamp through cycle 18.

Every 2 months we will execute 4 internal orbits each 2 tungsten lamp and 2 deuterium lamp. These will be carried out over a period of 12 months till the end of cycle 18. Visits ending in 1 or 2 are tungsten lamp exposures; Visits ending in 3 or 4 are deuterium lamp exposures.

The visits are designed to cover the full UVIS spectral range of the detector.

Proposal ID 12338
IR Flat Field Stability Monitor
A. Viana, T. Dahlen

This is a continuation of programs 11433 (SMOV) and 11915 (Cy 17). In this program, we will study the stability and structure of the IR channel flat field images through all filter elements in the WFC3IR channel. Flats will be monitored, i.e. to capture any temporal trends in the flat fields, and delta flats produced. High signal observations will provide a map of the pixel-to-pixel flat field structure, as well as identify the positions of any dust particles. This version contains monthly monitoring of all broadband filters and one full set of all filters at the end of the cycle. A total of 54 internal orbits are used.

Flat field ramps will be acquired through each of the IR channel's 15 filters. The Tungsten lamp flux levels observed in Thermal Vacuum testing dictate sample sequences and exposure times. The order in which the filters are used within each visit and from visit to visit was optimized to allow the observations to fit within 30-minute orbits.

The set of 36 single orbit visits (Visit 01-12, 19-30, 37-48) will execute with 3 visits once every month. To facilitate scheduling, we allow observations to be executed during the 15 first days of each month. Each visit consists of one exposure of each of the IR broadband filters. Three exposures per filter and month will assure us good statistics and temporal sampling. The final 18 orbits (Visit 13-18, 31-36, 49-54) contains in total three exposures of all IR filters and is intended to allow a characterization also of medium and narrow band filters. These are scheduled to be executed within a 45-day period at the end of the cycle.

Proposal ID 12339
UVIS Lflat
E. Sabbi, T. Dahlen, J. Mack

Multiple pointing observations of the globular cluster Omega Centauri (NGC 5139) will be used to measure the filter dependent low frequency flat field (Lflat) corrections and stability for a key set of 5 broadband filters used by GO programs. The selected filters are F225W, F275W, F336W, F438W, F555W, F606W, F814W, and F850LP. By measuring relative changes in brightness of a star over different portions of the detector, we will determine local variations in the UVIS detector response. The broad wavelength range covered by these observations will allow us to derive the Lflat correction for the remaining wide, medium and narrow band UVIS filters.

The response, and hence LFlat correction, of the remaining wide, medium and narrowband UVIS, will be derived using a linear interpolation of the collected data. During Cycle 17 we observed Omega Centauri two times in the same filters, at two different orientation angles. The orientation angle selected for these observation will guarantee us that the new data will be at ~90 degree from the previous observations, and will allow to better sample low frequency variations in the corners of the UVIS channel.

The observing strategy has been designed to maximize orbit time, and reduce the overheads and the impact of buffer dumping. The large numbers of orbits devoted to this program do not allow us to acquire all the data in a single visit. However, to maximize the overlap among the pointings it is important that all the observations acquired during the three visits have the same orientation. Because the sensitivity of the detector can change with time it is also important that three visits are executed close together in time.

Proposal ID 12340
IR LFlat Correction
T. Dahlen, V. Kozhurina-Platais E. Sabbi

Observations of globular cluster Omega Cen at multiple infrared wavelengths of IR detector will be used to derive filter dependency of low frequency sensitivity (LFlat fields) across of IR detector. These observations complement the Cycle 17 observations by adding a fourth orientation to help get a symmetric and even coverage of the FOV. Also, special dither steps are included in this cycle to increase the statistics in the areas around the edges of the FOV.

The 9 dithers pointing (3x3) across the IR detector with the size of ¼ FOV is necessary to derive relative changes in brightness and low frequency variations in the IR detector response (LFlats). The multiple wavelength observations of Omega Cen through 3 wide band filters F110W, F125W, F160W, and two medium filters, F098M, F139M, are necessary to ensure the filter dependency of low frequency variations in the IR detector (LFlats). For each filter we require observational time which are optimized for stars in the magnitude range V=17-22 and each filters would be observed in one exposure in order to provide thousands stars from the low end at V=22, to the bright end. During Cycle 17, Omega Cen was observed at three different orientations. With this program we will complete the sample with the fourth orientation, which will assure a symmetric and even coverage of the detector. To increase the number of objects at the poorly sampled edges of the detector, we will also use a 4-point dither pattern that makes steps half the size of the detector. With this technique, we put the center of the object in each of the four corners.

Proposal ID 12341
IR Blob Photometry Test
A. Viana, N. Pirzkal

The WFC3 IR blobs are absorption regions caused by an unknown contaminant on the Channel Select Mechanism (CSM). In WFC ISR 2010-06 the blob absorption is shown to have a mean difference of 4% between F125W and F160W. The goal of this proposal is to more completely measure the wavelength dependence of the blob absorption. This is done by performing photometry on the HST standard star GD153 when it is placed on a blob in 4 different filters.

The HST photometric standard star (GD153, V_mag = 13.35) will be observed in 4 filters (F127M, F139M, F153M, F160W) at 12 different POSTARGs locations using the IRSUB512 aperture. The order of the observations specifies an exposure in each of the 4 filters at each POSTARGs position followed by a POSTARGs movement to the next position. This process repeats 12 times. These will be followed by a final observation in each filter at the aperture center (no POSTARGs) for a total of 52 exposures.

Proposal ID 12342
WFC3 UVIS CCD Daily Monitor
T. Borders, S. M. Baggett

The behavior of the WFC3 UVIS CCD will be monitored daily with a set of full frame, four amp bias and dark frames. The internals from this proposal, along with those from the anneal procedure (12343); will be used to generate the necessary superbias and superdark reference files for the calibration pipeline (CDBS).

This program consists of two parts:

1. Full frame, four amp readout bias and dark frames are acquired daily in SAA free passages throughout Cycle 18 to assess and monitor bad (warm, hot, dead) pixels, and readnoise. Clean frames will be produced with calwf3 and combined into superbiases and superdarks for delivery to the CDBS as described in WFC3 TIR 200801 (Martel et al.).

2. Readnoise will be measured from the overscan regions of individual bias frames as well as from science pixel areas from the difference images of pairs of biases. The location, growth and evolution of hot pixels will be monitored. The darks will also complement the flatfield bowtie search program 12344.

All frames are in standard readout mode (ABCD, gain=1.5 e/DN, 1x1). Frames are acquired with the following setup: Even day (5 images/day): Visit 1 (1 orbit): 2 Biases, 1 Dark (900 sec) Visit 2 (1 orbit): 2 Darks (900 sec) Odd day (4 images/day): Visit 3 (1 orbit): 2 Darks (900 sec) Visit 4 (1 orbit): 2 Darks (900 sec) The paired biases in Visit 1 are obtained consecutively for accurate measurement of the noise.

Proposal ID 12343
UVIS Hot Pixel Anneal
S. M. Baggett, T. Borders, R. L. Gilliland

The anneal procedures are performed every four weeks. Full frame, unbinned UVIS bias and dark frames (3 and 5 images, respectively) are obtained immediately prior to and following each anneal; the data provide a means of monitoring changes due to the detector warm-up. In addition, a bowtie monitor is run directly after the anneal, in the event that hysteresis effects were induced by the warm-up. SEQWITHIN has been used to ensure that all visits from a given anneal iteration execute in order. No WFC3 science imaging should be done between the pre and post anneal internals. The first two anneals (only) will have internal flatfield exposures taken immediately before and after the warm-up to allow an assessment of pixel-to-pixel temporal changes. Due to thermal requirements, the IR detector must be warmed somewhat during a UVIS anneal but the temperature change is kept to a minimum (128 to 90) in order to minimize cycling on the IR (a restricted item). To evaluate the state of the IR detector after it has been cooled back down, one SPARS50 dark exposure is taken after each anneal. The IR dark visit is included in this proposal (rather than e.g., in the dark monitor proposal) in order to ensure the post anneal linkage. It is placed in its own visit, following the post anneal UVIS darks, rather than included with the UVIS exposures, in the event it may need to be omitted for any reason.

Proposal ID 12344
Cycle 18: UVIS Bowtie Monitor
T. Borders, S. M. Baggett J. W. MacKenty

Ground testing revealed an intermittent hysteresis type effect in the UVIS detector (both CCDs) at the level of ~1%, lasting hours to days. Initially found via an unexpected bowtie shaped feature in flatfield ratios, subsequent lab tests on similar e2v devices have since shown that it is also present as simply an overall offset across the entire CCD, i.e., a QE offset without any discernable pattern. These lab tests have further revealed that overexposing the detector to count levels several times full well fills the traps and effectively neutralizes the bowtie. Each visit in this proposal acquires a set of three 3x3 binned internal flatfields: the first unsaturated image will be used to detect any bowtie, the second, highly exposed image will neutralize the bowtie if it is present, and the final image will allow for verification that the bowtie is gone.

A triplet of 3x3 binned internal calsystem flatfields in F475X, grouped into a single short visit, will be taken every 3rd day. The first image is unsaturated, to allow a check for the presence of bowtie features, the second image is overexposed to fill any traps and erase any bowtie, and the final image is unsaturated, to allow an assessment of the efficacy of the bowtie removal. The filter is the same as that used in SMOV, chosen for its high throughput, blue bandpass, and location in one of the less used wheels in the SOFA.

The frequency of the bowtie monitor may be reduced during Cycle 18, pending results.

Proposal ID 12345
UVIS Long Darks Test
L. D. Petro, S. M. Baggett, T. Borders

Darks during SMOV showed a systematically lower global dark rate as well as lower scatter when compared to the Cycle 17 darks. Those two sets of exposures differ in exposure time 1800 sec during SMOV and 900 sec during Cycle 17. Hypothetically, the effect could be caused by short duration stray light, say ~500 sec in duration. During the latter part of Cycle 17, operation of WFC3 was changed to additionally block the light path to the detector with the CSM. This program acquires a small number of darks at the longer SMOV exposure times (1800 sec) in order to check whether the effect repeats in the new operating mode.

One 1800 sec dark and two bias exposures are taken in each of twenty visits. The visits can be executed at any time, including during V1 Earth occultation, with any spacing, but should be executed within a 90 day interval.

Proposal ID 12346
WFC3 UVIS CCD Gain
C. Pavlovsky, T. Borders, S. M. Baggett

The absolute gain of each quadrant for the nominal detector readout configuration (ABCD, gain=1.5 e/DN, bin=NONE) will be measured at two epochs spread throughout Cycle 18, all orbits are internal. Both epochs consist of 5 visits (5 orbits). The gain will be measured by taking 8 full frame pairs of internal flat fields, illuminated with the UVIS default tungsten lamp (TUNG3) through F645N, over a full range of exposure levels to achieve count rates of ~500 to 50, 000e. This is a monitor program and is a continuation of program 11906 in Cycle 17.

The count rate for the TUNG3 lamp with F645N was measured in TV3 and Cycle 17. In the "raw" frames (no overscan bias subtraction), the count rate is approximately 428e/pix/s, assuming a gain of 1.56 e/DN. The full well of the CCD is roughly 75000 e (42000 DN). The integration times are therefore chosen such that the full range of exposure levels is covered with minimal gaps. Full frames match the observing mode of the majority of GO science, provide good statistics, and allow the gain variability to be checked across the FOV. The gain will be measured using the standard mean variance technique. Average and difference images from each flatfield pair will be created and mean variance plots will be constructed from the mean of the average image and the variance of the difference image. The inverse slope of the mean signal level versus the variance is the gain. The required accuracy for this program is 1%.

Proposal ID 12347
WFC3/UVIS internal CTE monitor
V. Kozhurina-Platais, S. M. Baggett L. D. Petro

WFC3/UVIS CCD detector Charge Transfer Inefficiency (CTI) will be measured with the EPER (Extended Pixel Edge Response) method using tungsten lamp flat field exposures.

This CTE monitoring program is the second of multicycle program to monitor and establish CTE losses over time.

The program consists of internal tungsten lamp flat field observations with short exposures through three filters F390M, F390W and F438W with different illumination levels of 200, 400, 800, 1600 and 5000 electrons. These observations will be used to monitor the CTE detector over time, by measuring the profiles into trailing overscan region (EPER extended pixel edge response), as described by Kozhurina-Platais (2009, WFC3 ISR 2009-10; 2010, "HST Calibration Workshop"). The internal observations with tungsten lamp are similar to exposures taken during Cycle 17 proposal (CAL_11924). Each visit consists of one orbit, and every 2 visits are grouped together so that all illumination levels are acquired in each pair of visits. Each group is repeated 12 times spaced approximately 46 weeks apart, for total of 24 internal orbits.

Proposal ID 12348
WFC3/UVIS charge injection test
S. M. Baggett, L. D. Petro R. L. Gilliland H. A. Bushouse

In preparation for making charge injection (CI) available to observers, this proposal will 1) confirm that the CI performs on orbit as it did on the ground, 2) provide an initial assessment of which CI mode is most effective (10, 17, 25 line or continuous), and 3) obtain a baseline calibration for each mode.

The outskirts of 47 Tuc (6' west) will be observed during five one orbit external visits; each visit employs a different charge injection mode (none, continuous, 10line, 17line, and 25line). Eight exposures fit within a single orbit, distributed as two short and two long exposures at each of two pointings offset by one chip width or half the total WFC3 field of view. Every long and short pair is also dithered by small amounts (~2.5) pixels in each direction to facilitate cosmic ray and bad pixel correction. The F502N filter is used to minimize the sky background, thereby maximizing charge transfer inefficiency effects. Use of the same guide star pair for each visit will keep the images on the pixels the same to better than 0.5 pixel. For each CI mode, 10 internal orbits are used to acquire the necessary calibration biases & darks (visits 30-69).

Proposal ID 12349
IR Dark Monitor
M. Dulude, B. Hilbert

Analysis of ground and on orbit observations has shown that dark current is most effectively removed from external science images when using a composite image created from number of dark calibration images taken with the same sample sequence, exposure time, and aperture.

Regular collection of dark calibration frames for all sample sequence/aperture size combinations used by Cycle 18 IR channel science observations is essential. They will be used to monitor variations in the dark current signal and will provide the input images necessary to generate timely, high quality composite dark calibration frames which will be delivered to the calibration database system (CDBS).

Proposal ID 12350
IR Gain Monitor
B. Hilbert

Significant difficulties were found in the Cycle 17 version of this proposal. Light leak, from times when the V1 limb angle was less than 0 degrees, contaminated a large percentage of the Cycle 17 data. Self-induced persistence from flat field observations was also a more significant effect than anticipated.

We therefore redesigned the observing strategy used to collect these data. Each of the 16 1orbit Visits is identical. A Visit begins with a short dark current observation. This is done in order to move the BLANK into position before the Tungsten lamp is turned on. We wish to avoid the situation where the Tungsten lamp is on and a grism or wide band filter rotates through the beam, as this is a potential source of persistence. The dark ramp will also serve as a check on any persistence signal present in the detector prior to our observations. After the dark ramp, the Tungsten lamp is turned on and we collect a short flat field observation. Results from Cycle 17 tests have shown that the Tungsten lamp requires 40 to 50 seconds in addition to the time given at the moment in to reach a stable flux output. The purpose of this short flat is to give the lamp time to reach equilibrium, as our data analysis depends on a linear signal reaching the detector for the duration of the observation. With a narrow band filter in the beam, this short flat should not trigger persistence. It can also be used to further monitor the lamp warm-up time. Finally, we collect a longer flat field ramp, which will be used for the gain calculation. This flat is designed to collect ~14, 000 DN per pixel, which is roughly half of full well. This minimizes the nonlinearity correction we need to make during data analysis, as well as limits the persistence on the detector that may be seen by the following observer.

In order to limit self induced persistence, we have also set up the Visits so that they are not back-to-back Cycle 17 data indicate that for these signal levels, persistence affects the measured signal rate (at the 0.5% level or above) for roughly 100 seconds after the observation has completed. By not having the Visits in this proposal occur consecutively, we hope to give this persistence time to relax between observations.

Proposal ID 12351
IR Persistence
K. S. Long, S. M. Baggett, S. Deustua, A. Riess

The IR detectors on WFC3 exhibit persistence when exposed to levels close to or exceeding saturation. The purpose of this calibration program is to better characterize the persistence in WFC3 so that a better model for removing persistence from images can be developed. Specific goals include (1) verifying that persistence behavior is identical when the IR array is exposed to light from stars and diffuse sources like the flat field lamp, (2) establishing that persistence is not changing with time, (3) determining whether persistence is a function not only of the depth to which a pixel is filled, but also how long the pixel is maintained at full well, and (4) verifying that persistence is not wavelength dependent. The observations involve tungsten lamp exposures followed by darks as well as exposures of Omega Cen.

This is a proposal to explore various aspects of persistence in the IR arrays Visits 1-3 are external visits followed by darks. They explore whether the arrays respond to stars as they do to the Tungsten lamp. The remainder of the visits consist of a dark, a tungsten lamp exposure, and a series of darks. The main differences in these visits are in the way the tungsten lamp exposures are taken. They test various aspect of persistence.

Visits 11-19 expose the detector to various exposure levels using the same approach as for Cycle 17. Visits 21-29 repeat this one month later, and Visit A1-A9 a month later still. This is to reflect the fact that we saw variability in the persistence in some of the Cycle 17 observations.

Visits 30-42 test whether the time a pixel is at a high level affects persistence. In these exposures the detector is rapidly raised to a saturated level, and the tungsten lamp is turned off by special commanding

Visits 61-72 also test whether the time a pixel is held at a high level affects persistence, but the method differs from the previous section. Here different filters are used with different exposure times to reach a certain saturated level. This is more like the way data are taken on external targets but is less flexible than the tests in Visits 30 and following.

Visits 81-92 test whether persistence is sensitive to the wavelength of the incident light. Two levels are tested 70, 000 e and 140, 000 e.

Proposal ID 12352
WFC3/IR Signal Nonlinearity Monitor
B. Hilbert

These observations will be used to monitor the signal nonlinearity of the IR channel, as well as to update the IR channel nonlinearity calibration reference file. The nonlinearity behavior of each pixel in the detector will be investigated through the use of full frame and subarray flat fields, while the photometric behavior of point sources will be studied using observations of 47 Tuc.

Two types of data will be collected for this proposal. First we will collect flat field data through the F127M filter, using the internal tungsten calibration lamp. These observations will allow for a pixel-by-pixel examination of the nonlinearity of the IR channel across the detector. These observations will be made with a 15-read, SPARS25 sample sequence, in order to allow all pixels in the IR channel to become saturated. In order to investigate any differences between full frame and subarray behavior, we also collect several internal flat fields using the 256x256 pixel subarray. We will also make observations of 47 Tuc, for the purposes of studying the point source nonlinearity behavior of the detector. For these observations, we collect ramps with two different exposure times. This leads to one low and one high signal ramp. Comparison of aperture photometry between the low and high signal ramps will provide a measure of the point source nonlinearity behavior. Observation times for these ramps are optimized for stars in the magnitude range V = 17-22. In the low signal ramps, stars with V = 17 should just reach full well, while those at V = 22 will have a SNR of ~30. In the high signal ramps, V = 20 stars should be saturated, and V = 22 stars will have a SNR of approximately 130. At these signal levels 47 Tuc should provide many sources for the analysis of the nonlinearity, from the low end at V = 22, to the bright end, where some sources will have signals well over full well. This observing strategy is modeled after the nonlinearity test performed on ACS, and detailed in ACS ISR 2004-01 by R. Gilliland.

Accurate photometry of WFC3IR images depends on a reliable nonlinearity calibration. The data collected for this proposal will provide the information necessary to monitor the nonlinearity behavior of the detector, as well as provide an update to the nonlinearity calibration file produced from ground testing data.

Proposal ID 12353
UVIS and IR Geometric Distortion Corrections
V. Kozhurina-Platais, L. D. Petro

The standard astrometric catalog in the field of globular cluster Omega Cen has been used to examine the geometric distortion of WFC3 UVIS and IR as function of wavelength in Cycle 17. All observations from Cycle 17 have been reduced and provide the multiwavelength geometric distortion in UVIS and IR detector. The newly derived geometric distortion coefficients in 10 UVIS and 5 IR filters are implemented in IDCTAB format to be used in HST pipeline to correct for ~7% distortion in WFC3 images down to 1%.

This proposal will observed Omega Cen through three uncalibrated UVIS filters (F475W, F390M and F350LP) and three uncalibrated IR filters (F105W, F140W and F153M) in order to derive the coefficients of the geometric distortion to be used in IDCTAB. The UVIS F606W filter and F160W IR filter will be used to monitor the stability of UVIS and IR geometric distortion and the effect of the scale change due to the thermal breathing.

The observation of Omega Cen through three uncalibrated UVIS and IR filters will be observed with the same pointing and orientation in the first epoch around December 2010, during the second epoch around July 2011, the observation with the same filters in UVIS and IR will be taken with the same pointing and orientation. The different orientations from two epochs will be used for a better constrain of geometric distortion in these three uncalibrated UVIS and IR filters. The UVIS F606W and IR F160W filter as a standard filter will be observed through the cycle in different roll angle of the OTA in three epochs with 3 months apart. The set of 13 exposures in F606W and F160W filters are sampled in the allowed full range of roll angles at the ecliptic latitude of Omega Cen, and ranged approximately from 120 to 360 degree. Six UVIS exposures in each of the two orbits will be observed in the following sequence of off nominal (~360 degree) roll angles: Orbit #3 +5, 0, -5 degree; Orbits #4 -10, -15, -20 degree. Six IR exposures in each of the two orbits will be observed in the following sequence of off nominal (~360 degree) roll angles: Orbit #5 +5, 0, -5 degree; Orbit #6 10, 15, 20 degree.

The next three UVIS exposures in one orbit will be observed in the following sequence of off nominal (~120 degree) roll angles - +10, +20, and +30 degree. The same for other three IR exposures in one orbit -+10, +20, +30 degree. In order to improve the schedule, a small range of roll is allowed at each specific roll angle. The order of the exposures in each orbit is specified by a SEQUENTIAL Special Requirement and the order of the orbits is specified by AFTER Special Requirements. To maintain accurate pointing control, 2-guide star acquisitions are used. If suitable guide stars can be found, the same pair of guide stars is used for all 22 exposures.

Proposal ID 12354
High Contrast Imaging
Ronald L. Gilliland, A. Rajan

The WFC3/UVIS capability to resolve near by neighbors will be quantified in pairs of narrow, medium and broadband filters using the 12th mag solar analog P041C. The WFC3/IR capability to do high contrast imaging on bright stars (V~6 mag) is being tested using a bright A5V star with V=6.86 mag, the star will be imaged in a single narrow band filter.

UVIS: The target star is P041C -- a well observed with HST solar analog at V = 12.00. The star is known from extensive FGS observations to be single down to the FGS limits at about 10 mas. In each of 6 filters (blue and red pairs) 4 dithered exposures are acquired with WFC3-UVIS-DITHER-BOX with each exposure reaching 80% of saturation. A 5th exposure is taken at twice the sum of the dithered exposures this will be oversaturated by a factor of about 6 to bring up the wings.

All exposures use the 1Kx1K subarray UVIS2-C1K1C-SUB. The long exposure for the narrowest filter, F487N needed to be truncated to 100s from desired 226.4s to fit within one orbit.

This will provide in each of filters F487N, F673N, F467M, F680N, F555W, and F775W a subpixel sampled dither set for allowing detailed PSF fit analysis to establish limits on faint companions in these S/N > 1000 images. The fifth exposure at a much longer exposure time provides the ability to reach to at least a delta magnitude of 9 outside of an arcsec. The analysis goal will be to establish for each filter a delta magnitude versus distance companion that could be detected at 2-sigma.

IR:

We are observing HD165459 a bright A type dwarf (V=6.86mag) in a single IR narrow band filter (F128N). The observing strategy and the filter choice were made keeping two limitations of the IR detector in mind, namely the lack of a shutter and the problem of persistence. We are primarily interested in exploring the capability of the WFC3/IR detector for detecting companions at greater than 0.5 arcsec from the star. Keeping this in mind we plan to saturate the inner half arc second of the PSFs, increasing the brightness in the wings. We chose a narrow band filter because the exposure time (~10s) needed to saturate the inner half is greater than the ~2.5s reset time of the IR detector compared to medium band filters with saturation times of ~2s. This ensures that the persistence caused by the continued exposure of the detector due to lack of a shutter will not blur out the region of interest. We are dithering the observations with very small steps of 0.5 pix to improve the spatial sampling of the PSFs while concurrently keeping the PSFs as stable as possible throughout the orbit. We include 2 rolls per orbit and also limit the total roll angle to less than 10 deg to permit flexible scheduling.

Proposal ID 12355
IR Grism Wavelength and LSF Calibration
N. Pirzkal, H. A. Bushouse

The Cycle 17 wavelength calibration proposals observed two Galactic planetary nebulae (PN) that, although compact, are resolved by WFC3 NIR. The derived dispersion solutions should be accurate but the zero point of the wavelength scale is sensitive to the derived center of the image of the object used for the wavelength reference point. In addition since the PN are resolved, the true spectral line spread function cannot be derived. A more distant PN, that is a true point source, is proposed as a target. Choosing a bright PN in M31 will ensure that its size is <~ 0.1arcsec, making it an excellent target for a determination of the wavelength zero point. Measuring the width of emission lines, as a function of wavelength will give unique information on the wavelength dependence of the line spread function.

Proposal ID 12356
IR Grism Wavelength Calibration Stability Test
N. Pirzkal, H. A. Bushouse

The HST primary flux standard GD71 will be observed with the G102 and G141 grisms at 9 different positions in the field of view for each grism. The 9 positions will be distributed in a 3x3 grid over the field of view. The grid of observations will be used to map spatial variations in the grism mode throughput and establish a low order flatfield for the grisms. Each dispersed exposure will be preceded by two direct images, in order to measure the source offsets between direct and dispersed modes and to establish the wavelength zeropoint for each dispersed exposure. For G102 observations, the F098M and F105W filters will be used for the accompanying direct exposures. For G141 observations, the F140W and F160W filters will be used for the accompanying direct exposures. The number of FPA readouts (nsamp) is minimized for each exposure in order to avoid as much visibility time lost to buffer dumps as possible. POSTARGs are used to produce the 9point exposure patterns within the FOV. POSTARGs are also used at the central exposure of the pattern in order to shift the location of the first order spectrum so that it is near the center of the FOV. Single exposures using each grism are also obtained with the target located at the nominal field positions of the IRSUB512 and IRSUB256 subarray apertures.

Proposal ID 12357
IR Grism Flux Calibration Monitor
H. A. Bushouse, N. Pirzkal

This program will measure image displacement, spectral trace, and flux calibration for the WFC3 IR G102 and G141 grisms as a function of spatial position within the field of view. The HST flux standard GD71 will be observed in a 9point pattern in the FoV. The derived image displacement, spectral trace, and throughput will be compared with Cycle 17 measurements to monitor for time evolution of any of these calibrations. This program is a repeat of the Cycle 17 program 11936, executing only 1 of the 2 iterations used in 11936.

The HST primary flux standard GD71 will be observed with the G102 and G141 grisms at 9 different positions in the field of view for each grism. The 9 positions will be distributed in a 3x3 grid over the field of view. The grid of observations will be used to map spatial variations in the grism mode throughput and establish a low order flatfield for the grisms. Each dispersed exposure will be preceded by two direct images, in order to measure the source offsets between direct and dispersed modes and to establish the wavelength zeropoint for each dispersed exposure. For G102 observations, the F098M and F105W filters will be used for the accompanying direct exposures. For G141 observations, the F140W and F160W filters will be used for the accompanying direct exposures. The number of FPA readouts (nsamp) is minimized for each exposure in order to avoid as much visibility time lost to buffer dumps as possible. POSTARGs are used to produce the 9point exposure patterns within the FOV. POSTARGs are also used at the central exposure of the pattern in order to shift the location of the first order spectrum so that it is near the center of the FOV. Single exposures using each grism are also obtained with the target located at the nominal field positions of the IRSUB512 and IRSUB256 subarray apertures.

Proposal ID 12358
IR Grism LFlat Correction and Independent 2D Wavelength Solution
H. A. Bushouse, N. Pirzkal

A star cluster containing K giants will be observed in a grid of positions within the IR field of view using each of the IR G102 and G141 grisms. These data will be used to provide both an Lflat correction for the IR grism modes and a more highly refined 2-d wavelength solution that what was derived in Cy17 from observations of a planetary nebula. Photometric analysis of the stellar spectra as a function of field position will determine the Lflat. Fitting models to the observed spectra will determine the 2-d wavelength solution.

An open cluster known to contain K giant stars will be observed at a total of 13 positions within the IR field of view, using 3x3 and 2x2 grids. The grid of observations will be used to map spatial variations in the grism mode throughput and establish a low order flatfield for the grisms, as well as to map out any 2d variations in the spectral line spread function (LSF). Each pair of dispersed exposures will be preceded by a direct image, in order to establish the wavelength zeropoint for the dispersed exposures. The F130N filter will be used for the accompanying direct exposures. A narrowband filter is needed to prevent saturation of these bright targets in the minimum available full frame readout time. The number of FPA readouts (nsamp) is minimized for each exposure in order to avoid as much visibility time lost to buffer dumps as possible. POSTARGs are used to produce the 13-point exposure patterns within the FOV. POSTARGs are also used to provide small dither steps between the two-grism exposures that are taken at each field position.

Proposal ID 12359
UVIS Grism Wavelength Calibration
N. Pirzkal, H. A. Bushouse

Wavelength calibration of the UVIS G280 grism will be established using observations of the Wolf-Rayet star WR14. Accompanying direct exposures will provide wavelength zeropoints for dispersed exposures. The calibrations will be obtained at the central position of each CCD chip and at the center of the UVIS field. No additional field dependent variations will be obtained. As many positions as possible are used to sample the whole detector and allow the calibration of the field dependence of the UVIS grism wavelength calibration.

Proposal ID 12379
UVIS CTE Monitor: Star Clusters
Kai G. Noeske (ESA), V. Kozhurina-Platais Ronald L. Gilliland

This program extends the Cycle 17 external CTE calibration (CAL/WFC3 ID 11924) program for WFC3/UVIS over Cycle 18. Targets are (i) the sparse cluster NGC 6791 observed in Cycle 17, to continue a consistent set of observations that allows to isolate the time evolution of the CTE, and (ii) a denser field in 47 Tuc (NGC 104). The latter will provide data to measure the dependence of the CTE on field crowding. It will also provide a consistent comparison between the CTE evolution of WFC3/UVIS and that of ACS/WFC at the same time into the flight (1 year), because ACS/WFC CTE data were based on 47 Tuc observations. Additional observations of 47 Tuc in the CVZ will provide a wide range of background levels to measure the background dependence of the UVIS CTE.

Goals are

- The continued monitoring of the time evolution of the WFC3/UVIS CTE,
- Establishing the detector X, Y dependence of the CTE,
- CTE dependence of the background level and
- An improved CTE correction model based on these measurements. These goals include CTE effects on both photometry and astrometry.