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WFC3 Cycle 17 Calibration Program

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ABSTRACT

The WFC3 Cycle 17 Calibration Program, runs from the end of SMOV (Servicing Mission Orbital Verification) in mid August 2009 to 30 November 2010, and will measure and monitor the behavior of the WFC3/UVIS and WFC3/IR channels. Calibration programs include characterization of geometric distortion, zeropoints, sensitivity, and filter transformations; daily monitors for detector gain, darks and biases; monthly anneals (CCDs), "bowtie" pinning every other day, as well as checks on persistence on the IR detector (MCT), count rate nonlinearity, and flats. For Cycle 17, a total of 256 external orbits and over two thousand internal orbits will be used.

Introduction

Wide Field Camera 3 (WFC3) was successfully installed in the Hubble Space Telescope's radial instrument bay during Servicing Mission 4 (SM4) in May 2009. After the completion of SM4, WFC3 will undergo a 12-week commissioning phase, SMOV4 (service mission orbital verification). Cycle 17 science observations will begin as soon possible after SMOV4, beginning on or before 1 August 2009 and extending to October 2010. WFC3 calibration data will be acquired throughout Cycle17.

WFC3 consists of two independent channels. Each channel has its own optical, mechanical and electronic components. UVIS optical elements include 62 filters and one grism, while the IR channel has 15 filters and 2 grisms. Both CCDs have 2048x4096 pixels and a spatial scale of 0.1

arcsec/pix, and sensitive to the near ultraviolet and optical wavelengths between ~200 to 1000 nm. The IR HgCdTe array has 2048x2048 pixels, and 0.13 arcsec/pixels with good quantum efficiency between ~800 to 1700 nm. A complete description of the instrument is contained in the WFC3 Instrument Handbook (Bond, H. E., and Kim Quijano, J., et al. 2007, "Wide Field Camera 3 Instrument Handbook, Version 1.0" (Baltimore: STScI), the WFC3 Data Handbook describes how WFC3 data are reduced (Kim Quijano, J., et al. 2009, "WFC3 Mini-Data Handbook", Version 1.0, (Baltimore: STScI).

A key feature of WFC3 is its panchromatic capabilities. With its two channels, and its wide-, intermediate- and narrow-band filters (63 in the UVIS and 15 in the IR) plus 3 grisms (1 in the UVIS and 2 in the IR), WFC3 will provide high-resolution, wide-field imaging over a broad wavelength range.

Objectives

The main objectives of the Cycle17 calibration program are to enable the imaging and grism modes for science by providing the best calibration possible to GOs (Guest Observers, or PIs). All 35 of the Cycle 17 calibration proposals were built based on the calibration needs of approved GO proposals, and are designed to monitor detector performance and provide calibration data for science. WFC3 uses over 50% of HST orbits in 53 programs (see Table 1) and distributed between the UVIS and IR channels as shown in Table 2. Most (97%) of UVIS exposures are direct images, 3% use the G280 grism; 91% of IR data are images, and 9% of exposures are taken with the two grisms.

Number of Exposures	Type of Observation
7528	All Observations
6494	Prime
1034	Coordinated Parallels
2304	SNAP

Table 1 Number of GO exposures using WFC3

Channel	Number of Exposures	As a Percent of Exposures	Type of Observation
WFC3/IR	3868	51.382	All Observations
WFC3/UVIS	3660	48.618	All Observations
WFC3/IR	3315	51.047	Prime
WFC3/UVIS	3179	48.953	Prime
WFC3/IR	553	53.482	Coordinated Parallels
WFC3/UVIS	481	46.518	Coordinated Parallels
WFC3/IR	372	16.146	SNAP
WFC3/UVIS	1932	83.854	SNAP

Table 2 Distribution of Usage between WFC3/IR and WFC3/UVIS Channels

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

Monitor Programs:

A major objective during Cycle 17 is to monitor the main properties of the instrument. These programs (darks, flats, biases, 'bowties', 'droplets') are continuations of the corresponding SMOV programs and are key to understanding the behavior and stability of the instrument during the 15-month cycle.

Monitor programs specific to the UVIS channel are:

- Daily biases and darks (Proposal 11905).
- Bowtie monitor (Proposal 11908) 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 monitor (Proposal 11907). The UV throughput is monitored via weekly standard star observations in a subset of key filters covering the wavelength range between 200-600nm and in the F606W, F814W filters as controls on the red end.

IR specific monitor programs are:

- Dark monitor (Proposal 11929). Dark current images are collected using all sample sequences that will be used in science observations. These observations will be used to monitor changes in the dark current of the WFC3-IR 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 17.

Photometry Programs:

The principal goals of the photometry programs are to deliver zeropoints for each of the GO-requested filters and grisms, measure the throughput of the two channels, provide L-flat and P-flat fields and deliver a fringe map for the UVIS. These programs are executed monthly (as for the zeropoints), or less frequently (as for the L-Flat programs).

- Zeropoints (Proposals 11904 and 11926) will be determined from observations of 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. Kalirai et al (ISR 2009-0003) provide a more detailed discussion of our photometry program.
- The corresponding spectral programs are 11936 and 11937 for the IR G140 and G180 grism, and Proposals 11934 and 11935 for the UVIS G280 grism.
- Flat fields (Proposals 11911 & 11912 (UVIS) and 11915 & 11928 (IR)) are obtained by observing internal tungsten lamps and through observations of dithered star fields.
- Fringing in the UVIS, particularly when using the narrow-band filters, can also affect photometry. See Proposal 11922.

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:

- IR Intrapixel sensitivity variation (IPSV) is one of the major factors limiting the photometric accuracy in IR detectors. Proposal 11916 will measure the IPSV by observing several thousand stars at different locations on the detector and on a pixel.
- Persistence (Proposal 11927) 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 better characterize the decay time.
- Linearity. IR detectors are inherently non-linear devices; hence, characterizing their non-linearity is important. Proposals 11931 and 11933 are designed to measure the count linearity ("regular linearity") and the Rate Dependent Non-linearity ("reciprocity failure" in photographic terms), respectively. If the latter is not taken in account, the effect is to make faint sources appear fainter than they should.

For the WFC3/UVIS CCDs, these include:

- Linearity. Although CCDs are generally considered linear devices, at very low light levels they can exhibit behavior that departs from linearity. Proposal 11925 is intended to measure the linearity of the CCDs in orbit.
- CCD Charge Transfer Efficiencies (CTE) degrade on orbit (see for example (ISR 05-03) and although we do not expect to see significant CTE losses in a new instrument, Proposal 11924 will obtain the first data set of a multi-cycle program to monitor and establish the effect of CTE-induced losses with time.

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:

- Image Quality of the UVIS (Proposal 11918) and IR (Proposal 11920) channels are periodically assessed in a few filters, at several positions on the detector. The encircled energy, FWHM, and sharpness for several aperture diameters are measured. This is effectively a measure of the PSF.
- Point Spread Function (PSF) wings of both channels are measured out to more than 5" from deep, saturated images of a bright star in Proposals 11919 (UVIS) and Proposal 11921 (IR)
- 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 11911 (UVIS) and Proposal 11928 (IR) also do double duty for the flatfield program.

- Stray light effects are measured for the two channels by “walking” a bright star at several positions just off the detector. Proposals 11932 (IR) and 11938 (UVIS) describe this program further.

Data, Analysis and Results

All analysis and results from the Cycle 17 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 17 Calibration Proposals

The complete list of WFC3 Cycle 17 calibration proposals are listed in Table 1, below, in order of WFC3 activity number (not assigned proposal IDs). Provided in Table 1 are WFC3 activity ID, the Proposal ID, Number of Orbits (External – on a target, Internal – during occultation), frequency with which the program is executed, the program observing cadence, accuracy goal and in the last column, 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 List of WFC3 Cycle 17 Calibration Proposals

WFC3 ID	Prop ID	Proposal Title	No. Orbits		Freq.	Cadence	Accuracy Goal	Notes
		PI	**Ext**	**Int**				
01	11903	UVIS Zero points. J. Kalirai	46		10x	Monthly	2% W, 5% M, N	Measure zero points and monitor throughput.
02	11905	UVIS CCD Daily Monitor. T. Borders		956	1/day		0.1 e- readnoise	Build daily & weekly superbias and superdark reference files, avoiding periods just before and after annealing.
03	11906	UVIS CCD Gain. C. Pavlovsky		18	3x	Mos. 4, 8, 12	<1% per quadrant	Determine the absolute gain per amplifier at nominal temperature.
04	11907	UVIS Bowtie Monitor. S. Baggett		231	1/day	Every other day	<1%	Minimize and neutralize "bowtie" effect. Every other day 10 min visits. Frequency may decrease.
05	11908	UVIS Contamination Monitor. S. Baggett	37	37	1/wk	Weekly	2%	Monitor contamination by measuring throughput in a subset of key filters using stars.
06	11912	UVIS Internal Flats. A. Rajan		90	5x	Quarterly	< 5%	Assess stability of flat field structure
07	11911	UVIS L-Flat & Geometric Distortion. E. Sabbi	30		2x	Early in cycle		Build L-flats using observations of a star cluster and measure geometric distortion
08	11918	UVIS Image Quality. L. Dressel	9		3x	Mos 3, 6, 9		Image stability assessment
09	11919	UVIS PSF Wings. L. Dressel	7		1x	Mid Cycle	>5arcsec radius	Evaluate PSF stability at 5 field points, in two filters.
11	11913	UVIS Filter Wedge Check. J. MacKenty	3		1x	Early	0.5 pixels at 633 nm.	Verify UVIS filters positions for image displacement
12	11938	UVIS Stray Light. L. Petro	4		1x	After SMOV	10%	Characterize stray light from bright sources outside FOV, verify gravitational stress release contribution
13	11925	UVIS Linearity S. Deustua	2	3	1x	1st Quarter	<5%, correctable to < 0.3%	Measure linear response, well depth at non-linearity onset, response curve through saturation in key filters.
14	11924	UVIS CTE Monitoring V. Platais	6	24	3x	Early, Mid, Late Cycle	<1% photometry, 1% pixel shift	Monitor CTE effects on photometry and astrometry, using standard star field.
15	11922	UVIS Fringing E. Sabbi	3		1x	Early	<1%	Monitor fringing in red UVIS filters, check fringing model.
16	11904	UVIS Droplets J. Kalirai	12	3	3x	Early, Mid, Late Cycle	<1%	Characterize and monitor effect of droplets on photometry.
17	11909	UVIS Hot Pixel Anneal. S. Baggett		105	15x	Monthly	< 0.1 e/pix, dark to 0.01 e/pix/hr	Fix hot pixels, by warming CCD.
18	11914	UVIS Earth Flats Pathfinder P. McCullough		50	1x	Late Cycle	1% relative	Determine pixel-to-pixel flat field of WFC3+OTA.
19	11926	IR Zero points. S. Deustua	28		14x	Monthly	2% W, 5% M & N	Measure and monitor IR zero points and throughput in all IR filters.

WFC3 ID	Prop ID	Proposal Title	No. Orbits		Freq.	Cadence	Accuracy Goal	Notes
		PI	Ext	Int				
20	11929	IR Dark Monitor. B. Hilbert		423	many	Weekly	0.1 e-	Monitor IR dark current and read noise. Create superdarks.
21	11930	IR Gain. B. Hilbert		8	3x	Early, Mid Cycle	5% per iteration	Determine effective electronic gain of MCT array through internal flats.
22	11931	IR Count Linearity. B. Hilbert	6	9	3x	Every 4 months	<5%, correctable to < 0.3%	Quantify non-linear behavior of IR detector, and determine corrections.
23	11915	IR Internal Flats. B. Hilbert		110	3x	Every 4 months	< 5%	Monitor IR flat stability
24	11928	IR L- Flat & Geometric Distortion. V. Platais	18		3x	Every 4 months	1%	Build L-flats using star field. Measure geometric distortion
25	11920	IR Image Quality. L. Dressel	6		3x	Mos 4, 8, 12	20 stars with high SNR	Assess overall image performance and stability and measure FGS-IR alignment.
26	11921	IR PSF Wings. L. Dressel	5		1x	Late in cycle	>5arcsec radius	Evaluate PSF stability at 5 field points, in two filters.
27	11913	IR Filter Wedge Check. J. MacKenty	2		1x	Early	0.5 pixel	Verify IR filters meet CEI spec. for image displacement
28	11932	IR Stray Light. L. Petro	4		1x	After SMOV	10%	Characterize stray light from bright sources outside FOV, verify gravitational stress release contribution.
29	11916	IR Intrapixel Sensitivity Variation. M. Wong	2		1x	Early	<0.2% rms precision photometry	Measure IPSV of array
30	11933	IR Rate Dependent Non-linearity. A. Riess	9		1x	mid-cycle	1%	Characterize rate dependent non-linearity by observing star cluster with wide range of star brightness.
31	11927	IR Persistence. S. Deustua	6	18	1x	Mos. 6		Measure and monitor persistence through observations of sparse star fields.
32	11917	IR Earth Flats Pathfinder. P. McCullough		50	1x	Late Cycle	1% relative	Determine pixel-to-pixel flat field of WFC3+OTA.
33	11934	UVIS G280 Flux Calibration. H. Bushouse	1		1x	Early	<10% in 1st orders	Establish flux calibration for G280 grisms, wrt spatial position in FOV
34	11935	UVIS G280 Wavelength Calibration. H. Bushouse	1		1x	Early	14 angstroms	Establish G280 wavelength calibration over FOV wrt position.
35	11936	IR Grism Flux Calibration. H. Bushouse	8		2x	Early	<5% in 1st order	Establish flux calibration for both IR grisms , wrt spatial position in FOV
36	11937	IR Grism Wavelength Calibration. H. Bushouse	2		1x	Early	1 pixel in 1st orders	Establish wavelength calibration over FOV wrt position for both IR grisms

Proposal ID 11903: WFC3 CYCLE 17 UVIS Zero points.

J. Kalirai, A.Rajan, A. Riess, E. Sabbi, S. Deustua

Through observations of calibrated white dwarf standard stars (GD153 and GD191B2B), this proposal will measure the photometric zero points in 53 of the 62 UVIS/WFC3 filters: the 18 broadband filters, 8 medium band filters, 16 narrowband filters, and 11 of the 20 quad filters (those used in Cycle 17). The expected accuracy is 1% in the broadband filters. For the medium and narrowband filters, we require an accuracy of a few percent, limited by the accuracy of the spectrophotometric calibration spectrum. These data will also be used to obtain accurate relative photometric precision with other HST instruments in the most popular WFC3/UVIS band passes. The solar analog secondary standard, P330E, will be observed in a subset of the filters to provide color corrections. Repeat observations in 16 of the most widely used Cycle 17 filters will be obtained once per month for the first three months, and then once every second month for the duration of Cycle 17, alternating and depending on target availability. These observations will enable monitoring of the stability of the photometric system. Photometric transformation equations will be calculated by comparing the photometry of stars in two globular clusters, 47 Tuc and NGC 2419, to previous measurements with other telescopes/instruments.

Standard stars in this program (see the table below) have historically been used for calibration of HST instruments including STIS, NICMOS, WFPC2, and ACS.

	Sp. Type	B	V	J	H	Temp
G191B2B	WD	11.45	11.77	12.55	12.66	61000 K
GD153	WD	13.06	13.35	14.07	14.19	39000 K
GD71	WD	12.78	13.03	13.74	13.86	32000 K
P330E	G0V	13.6	13.0			

Table 4 Target stars for this program.

Broadband observations of 47 Tuc overlapping the ACS field in Sirianni et al. (2005) will be used to calculate photometric transformation equations between the WFC3 filters and other systems, such as ACS and ground-based Johnson-Cousins. The 47 Tuc data provide abundant hot, blue stars for transforming the bluer filters of WFC3. Broadband observations of NGC2419 overlap the ACS field in Sirianni et al. (2005) and include a set of redder stars that are crucial to the photometric transformation between the redder WFC3 filters and space/ground based counterparts. The cluster is also very metal poor, and therefore allows a test of the dependencies of the equations on metallicity.

Proposal ID 11904: WFC3 UVIS Droplets

J. Kalirai, S. Deustua

This proposal characterizes the effects of the UIVS droplets on photometry by measuring the brightness of stars as they pass through the droplets. To characterize the effects of the contamination (i.e., droplets) on the UVIS window, we will observe a star cluster in three wide band filters (F225W, F555W, and F814W) and one narrow band filter (F502N) stepping the stars in the cluster across randomly located droplets. As we wish to characterize the affect of the droplets on photometry in both blue and red filters, we require a cluster with both hot and cool stars over the entire field of view. NGC 6752 is a nearby globular with a hot horizontal branch at V = 14-16, and a rich main sequence beginning at V = 17. Although the total population of HB stars may be larger in systems such as NGC 2419, NGC 6715, and NGC 2808, these are much further away and will not provide a high density of stars over the FOV as the droplets are located over the entire frame. A star cluster is also ideal for testing the effects of the droplets on large and small aperture photometry. The relative photometry must be accurate to better than 1% in order to track the variations due to position within a droplet.

There are three visits (initial, 7 days later, and 30 days later), of 4 orbits each. All visits use the same orientation and guide stars in order to scan the stars across the same positions on the detector each time, thus minimizing systematic errors. We select a blue (F225W), visible (F555W), and redder (F814W) filter to characterize the effects of the droplets with wavelength, as well as narrowband filter (F502N). The observations in F555W and F814W require 1 one orbit each given the five point line dither (in X) to move the star across the droplet features. Each step is 20 pixels and is executed with a simple UVISDITHERLINE pattern. The exposure time (550 s) is chosen to fill each orbit and will provide high S/N observations of a large part of the main sequence of the cluster. The observations in F225W are much shallower as the horizontal branch will saturate quickly, and therefore are also coupled with longer F502N observations at each dither point to maximize orbit efficiency. The combined dither pattern for this set of observations (6 points) requires two orbits. The first visit (01) consists of these four orbits of observations. At the end of this visit, we will obtain an internal flat field in the four filters to track any changes in the droplets. Due to the high f# of the beam, this may not be very useful. The exposure times for the Tungsten bulb (redder filters) and D2 bulb (F225W) are taken from ISR200821. A second D2 exposure is added in case the lamp delays in firing, which is does occasionally.

Proposal ID 11905:WFC3 CYCLE 17 UVIS CCD Daily Monitor.

T. Borders, S. Baggett

The main characteristics of the CCD, such as readnoise and warm/hot pixels will be measured and monitored over periods of days, weeks, and months. Expected accuracies are 0.1 e/pix for readnoise; any bowtie features in the darks should be detectable at the sub percent level. The behavior of the WFC3 UVIS CCD will be monitored daily with a set of full frame, four amp bias and dark frames. A smaller set of 2Kx4K subarray biases are acquired at less frequent intervals throughout the cycle to support subarray science observations. Biases and darks from this proposal, along with those from the anneal procedure (11909), will be used to generate the necessary superbias and superdark reference files for the calibration pipeline (CDBS), which will serve to correct all on orbit WFC3 UVIS science frames. As measured on the ground, the dark current rate at a flight temperature of 82C is about 0.5 e/hour on MEB2 for these CCDs (WFC3 ISR 200842, Martel et al.), well below the Contract End Item specification of less than 20 e/hour.

This program consists of two parts:

1. Full frame, four amp standard readout mode (ABCD, gain=1.5 e/DN, 1x1 bin) bias and dark frames are acquired daily in SAA-free passages to assess and monitor bad (warm, hot, dead) pixels, and readnoise. Each day, two visits of one orbit each will produce three biases and three darks. 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.). 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 complement the bowtie proposal, 11908.

2. Bias frames for the subarray UVIS12K4SUB (using the default amp B readout) are also added in the last visits to complete the list of CDBS reference files required for Cycle 17. This type of subarray includes physical overscan regions (23 columns at the beginning and 23 columns at the end). These subarray frames are obtained at regular intervals throughout Cycle 17.

Proposal ID 11906:WFC3 CYCLE 17 UVIS CCD Gain.

C. Pavlovsky, T. Borders, S. Baggett

The absolute gain of each quadrant for the nominal detector readout configuration (ABCD, gain=1.5 e/DN, bin=NONE) and for the two binned configurations (bin=2x2 and bin=3x3) at the on orbit operating temperature will be measured at three epochs spread throughout Cycle 17. The first epoch, at month 4, consists of 8 visits: 5 visits (5 orbits) to test bin=NONE, 2 visits (2 orbits) to test bin=2x2, and 1 visit (1 orbit) to test bin=3x3. Epoch 2, at month 8, and epoch 3, at month 12, are both repeats of the 5 visits, bin=NONE test in epoch 1. Each bin configuration is tested by taking 8 full frame (bin=none and bin=2x2) or 9 (bin=3x3) 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. All UVIS frames require transformations from DNs to e in the pipeline. This data is necessary to reduce data from other calibration programs and will be compared to data taken in TV3 during analysis. Bin=NONE was tested in TV3 as well as SMOV, Bin=2x2 and bin=3x3 were only tested in TV3, and all three datasets will be compared in analysis.

The count rate for the TUNG3 lamp with F645N was measured from ground TV3 frames. 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. No biases are taken because program 11905 takes daily biases that this program can use. 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 11907:WFC3 CYCLE 17 UVIS Contamination Monitor.

S. Baggett, T. Borders

The UV throughput of WFC3 during Cycle 17 is monitored via weekly standard star observations in a subset of key filters covering 200600nm and F606W, F814W as controls on the red end. Standard star data from the UV throughput monitor will be reduced using aperture photometry and results used to assess the throughput stability to 2% or better. Relative throughput levels will be tracked as a function of time and wavelength to search for any sign of contamination effects; the data will provide a measure of throughput levels as a function of time and wavelength, allowing for detection of the presence of possible contaminants.

Each iteration of the monitor will obtain subarray observations of a white dwarf standard in 11 filters at two different locations in the WFC3 field of view. One position will remain the same in all iterations (UVIS1C512ASUB) while the second location will vary each week, cycling through the other four amps (C512B, C512C, and C512D). Exposure times have been set to obtain S/N of at least 200 but well under the saturation level in each image; the resulting exposures are short, without crsplit. Four dithered images through F218W are obtained at each location each time while at least three (four, if the orbit visibility allows) dithered images are obtained in F225W and two dithered images in F275W; other filters are covered via single images. The primary target is GRW+70d5824.

In conjunction with the external images, full frames, four amp readout internal flatfields (F336W, F606W), using the Tungsten Lamp, are taken to provide a full FOV check.

A pair of visits, consisting of one external and one internal orbit, is run once a week for 14 weeks and then twice per month after that. The first iteration should start the week after the last SMOV contamination visit (proposal 11426). Each of the Cycle 17 anneal procedures (proposal 11909) should be preceded and followed by an iteration from this contamination proposal. Since the anneal itself takes nearly 1 full day, the window of the preanneal contamination iteration has been set to overlap the beginning of the anneal window by 2 days while the post anneal iteration has been set to overlap the end of the anneal window by 2 days.

Proposal ID 11908:WFC3 CYCLE 17 UVIS Bowtie Monitor.

S. Baggett, T. Borders

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 an overall QE offset across the entire CCD 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 flatfields in the F475X filter, grouped into a single short visit, will be taken once every other day. The first and third exposures are unsaturated, to allow a check for the presence of bowtie features, the second exposure is over-exposed to fill any traps and erase any bowtie . This filter was used during SMOV, chosen for its high throughput, blue bandpass, and location in one of the less-used wheels in the SOFA.

For this proposal, the CSM (channel select mechanism) is in the IR position; if it is not, nominal commanding will move it to the IR position before the UVIS internal flats are taken.

Proposal ID 11909:WFC3 CYCLE 17 UVIS Hot Pixel Anneal.

S. Baggett, T. Borders

Full-frame, unbinned UVIS bias and dark frames (3 and 5, 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. SEQ-WITHIN has been used to ensure that all four visits from a given anneal iteration (bias/darks, anneal, bowtie internal flats, bias/darks) execute in order. No WFC3 science imaging should be done between the pre- and post-anneal internals.

Due to thermal requirements, the IR detector must be warmed somewhat during a UVIS anneal but the warm-up 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 dark exposure is taken after each anneal. The SPARS50 sequence is used, one of the most-requested types in Cycle 17. 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 11911:WFC3 CYCLE 17 UVIS LFlats and Geometric Distortion.

E. Sabbi, V. Kozhurina-Platais, L. Dressel, M. Dulude

To obtain an adequate characterization of the flat field stability, we will acquire 9 pointings for each filter using a 3x3 box dither pattern. We will use dither steps of 40" (approximately 25% of the FOV) in either the x and/or y direction. The chosen pattern will also allow us to measure the CTE since POSTARGs along columns are included. By measuring relative changes in brightness of a star over different portions of the detector, we will determine local variations in the response of the UVIS CCDs induced by the telescope optics. The response, and hence L-Flat correction, of the remaining wide, medium and narrow-band UVIS, will be derived using a linear interpolation of the collected data

Proposal ID 11912:WFC3 CYCLE 17 UVIS Internal Flats.

A. Rajan, S. Baggett, E. Sabbi, J. Kim Quijano

This proposal assesses the stability of the flat field structure for the UVIS detector throughout Cycle 17. The data will be used to generate on-orbit updates for the delta-flat field reference files used in the WFC3 calibration pipeline, if significant changes in the flat structure are seen.

There are 42 full filters and 5 quad filters (each with 4 narrow bandpass filters), resulting in 62 filters. Flat fields will be obtained for all filters using the internal D2 and Tungsten lamps. They will be obtained at specific periods of about 10 weeks around the months of Oct (set A), Jan (set B), Apr (set C), Jul (set D), and Oct (set E). The proposal only lists 47 different spectral elements, since flats for the quad filters are designated as being obtained with the lowest count-rate filter in each quad. Due to the different exposure times needed for each filter in a quad, several exposures are needed to make up one flat.

Exposure times for each filter were derived after analysis of ground data obtained during Thermal Vacuum Test #3. Counts of at least 40,000 e- are expected for most of the flats.

Flux levels within the flat fields will be compared to those from SMOV data to evaluate the D2 and Tungsten lamp performance. Flat field illumination patterns will be analyzed for any changes compared to previous on-orbit images. The data will be used to generate on-orbit updates for the delta-flat field reference files used in the WFC3 calibration pipeline

Proposal ID 11913:WFC3 CYCLE 17 IR Filter Wedge Check.

J. MacKenty, E. Sabbi, T. Borders

The position of each IR filter will be checked to verify that the filters meet the CEI (Contract End Item) specification for image displacement. We will observe the cluster NGC 1859 with all full-frame IR filters using a subarray (IRSUB512) without moving the telescope. The relative displacement of the stars in each image will be measured from one filter to the next

We will observe the cluster NGC 1850 using the IR filters without moving the telescope to verify there is no image displacement. A series of images will be taken with all full-frame IR filters using a subarray (IRSUB512) in order to determine the relative displacement of the position of the stars in each image from one filter to the next. Analysis will consist of measuring the x and y position of the stars in each image. No spectral element shall relatively displace the image by more than 0.5 detector pixels or degrade the quality by more than 0.02 waves at 633 nm of the transmitted wavefront error.

Proposal ID 11914:WFC3 CYCLE 17 UVIS Earth Flats Pathfinder

P. McCullough, J. Kim Quijano

Visible-wavelength flat fields will be obtained by observing the dark side of the Earth during periods of full moon illumination. The observations will consist of full-frame streaked WFC3 UVIS images:. For each 22-min total exposure time in a single "dark-sky" orbit, we anticipate collecting 7000 e/pix in F606W or 4500 e/pix in F814W. To achieve Poisson S/N > 100 per pixel, we require at least 2 orbits of F606W and 3 orbits of F814W. For UVIS narrowband filters, exposures of 1 sec typically do not saturate on the sunlit Earth, so we will take sunlit Earth flats for three of the more-commonly used narrowband filters in Cycle 17 plus the long-wavelength quad filters.

ISR WFPC2 2008-01 shows that in a 300-sec exposure and a 0.10 arcsec x 0.10-arcsec pixels, the mean counts are 5373 e/pix in F606W and 3338 e/pix in F814W from full moon lit Earth. Given WFC3's UVIS throughput is twice that of WFPC2 at these wavelengths, and its pixel area 16% of WFPC2, in a 300-second exposure of moonlit Earth, we expect 1719 e/pix and 1068 e/pix in F606W and F814W respectively. During each orbit we will take three 7-min exposures, for a total of 21 minutes.

The accuracy of the flat fields obtained by this program should be comparable to or better than (in any respect) to those obtained by the gold standard methods (e.g. pixel-to-pixel flats from internal lamps or ground tests with low-spatial frequency corrections from photometry of a cluster stars). The accuracy goal is ~1% r.m.s. per pixel over the entire field of view. These observations will provide a comparison with flats derived via other techniques: L-flats from stellar observations, sky flats from stacked GO observations, TV3 flats, and internal flats using the calibration lamps.

This program is an experimental pathfinder for Cycle 18 calibration

Proposal ID 11915:WFC3 CYCLE 17 IR Internal Flats.

B. Hilbert, P. McCullough, S. Deustua

In this test, we will study the stability and structure of the IR channel flat field images through all filter elements in the WFC3-IR channel. Flats will be monitored 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.

Flat field ramps will be acquired through each of the 15 IR 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, and also in order to investigate and track any persistence effects resulting from the varying illumination levels on the IR detector. Breaking up the visits into many smaller segments would be undesirable in terms of the lamp's lifetime.

In order to facilitate scheduling, we have grouped the "first epoch" 37 visits into 4 sets of 10 visits each; each visit in a set executes within +-15 days of the first of that set. Visits of Epochs 2 and 3, will be scheduled 5 and 10 months after those of Epoch 1, in order to finish up before the end of Cycle 17, 15 months after its start, here assumed to be Aug 1, 2009. Note that some of the orbits in this proposal are longer than the nominal 30-minute internal calibration orbit duration. For one third of these long orbits, extending beyond 30 minutes is necessitated by the long exposure times needed for narrow band filters. For the other two thirds of the long orbits, even with efficient orbit packing, the orbit duration exceeds the 30-minute mark by only a few seconds.

These delta-flats will be used to correct temporal variations in the flat fields for WFC3 IR. Delta flats are perturbations on the flats generated by combining pixel-to-pixel TV3 CASTLE flats with on-orbit low spatial frequency "L-flats"; in concert these flats become calibration files for CDBS. By repeating the 37-visit sets three times in Cycle 17, we spread the program across the length of Cycle 17. The target electrons per pixel is 40, 000 - 60, 000, so that the Poisson noise of an individual pixel and a single exposure will be 0.5%, comparable to or smaller than any individual astronomical image made by WFC3 IR. With 7 well-exposed flats per filter per "epoch", the Poisson-limited noise after combining 7 individuals be ~2.5x smaller..

Proposal ID 11916:WFC3 CYCLE 17 IR Intrapixel Sensitivity Variation.

M. Wong, P. McCullough, J. Kim Quijano

In order to characterize the periodic intrapixel sensitivity variation (IPSV) of the WFC3 IR array, we will obtain full-frame IR observations of a star field in three band passes (F110W, F160W, and F098M) dithered on an NxN grid, where N=2 and N=3. The measurements will be used to quantify systematic trends in aperture photometry of stars with pixel phase, defined as (x mod 1, y mod 1), where (x,y) is the center of the stellar image at sub pixel precision.

During TV3 ground tests 100 observations of a single, well-exposed artificial star were made by drifting across ~20 pixels in 0.2 pixel steps, first in X and then in Y. At a level of ~1% there was no measurable IPSV (ISR WFC3 2008-29). A potential limitation of that work was the uncalibrated variability of the artificial star; typical stars will be more constant than a lamp. By taking observation of ~2500 stars (as in a globular cluster) and with 9 dithers we may expect 10x greater precision, or 0.1% measurement uncertainty of the IPSV. In general we use the method of Lauer (1999, PASP 111, 1434), and, following Anderson & King (2000, PASP 112, 1360) who emphasize the need for sub pixel dithering to remove the degeneracy between IPSV and stellar position, we chose N=2 for F110W and F160W, but N=3 for F098M, where we hope to have the most-easily detected IPSV because of the smaller PSF.

We selected a star field in Omega Centaurus that is dense enough to place many hundred stars per WFC3/IR FOV with a S/N > 100 in aperture photometry, but not so dense that aperture photometry will be compromised by blending of stars. The target is a lower-density field of view than those selected for geometric distortion (Proposal 119xx) or L-flats (Proposal 119XX).

Observations are made with three filters, F098M, F110W and F160W, to correct for PSF wavelength dependency on the IPSV and because these are the most frequently requested filters, We use a 2x2 or 3x3 grid for the dither pattern with 1/2 or 1/3 pixel pixel shifts in X and Y on the grid. With 8 (for 2x2 grid) or 9 (for 3x3) exposures of equal length per orbit, we will choose exposure times near 5 minutes to take advantage of the full visibility window of ~52 minutes. We use the SPARS25 sample sequence so that the data transfer matches the data acquisition.

Proposal ID 11917:WFC3 CYCLE 17 IR Earth Flats Pathfinder.

P. McCullough, J. Kim Quijano

This program is an experimental pathfinder for Cycle 18 calibration. (The WFC3 UVIS version of this is program 11914 and contains additional detail in its description).

Infrared-wavelength flat fields will be obtained by observing the dark side of the Earth during periods of full moon illumination. The observations will consist of full-frame, streaked WFC3 IR images. For each single "dark-sky" orbit, we expect Poisson S/N > 100 per pixel in each of three to five exposures, depending on sample sequence (SPARS25 or SPARS50). We do not use the sunlit Earth because it is too bright for the WFC3/IR full-frame minimum 3-second exposure time. Although observations of the totally eclipsed moon would be a likely target, they are too rare to be useful, even though the moon, subtending less than 0.25 square degrees, compared to Earth's steradian or more, would have very little scattered light compared to the Earth.

Program 11033 (WFPC2 ISR 2008-01) describes using the moonlit Earth for flat fields. We assume that between 1.0 and 1.7 microns reflected light dominates the surface brightness of the Earth as it does between 400 nm to 1000nm. The specific intensity at peak of bright clouds illuminated by sunlight is 5E-10 ergs/s/cm^2/Angstrom/arcsec^2 and 1E-15 in same units for moonlight illumination for a 5800 K blackbody spectrum (Cox et al 1987 (Figures 1 is correct; Figure 3's scale is 10x too bright). With these values, we can expect approximately 120 e/s/pix, or 80 sec required to produce Poisson-limited SNR = 100 per pixel, scaling from the expected count rate in the UVIS (see program 119XX). Because the mean flux is changing spatially and temporally, we expect to difference the counts from successive samples up the ramp of each exposure, and then recombine each of those images after renormalization to the instantaneous surface brightness, with outlier identification and rejection.

Observations of the moonlit Earth use two visits per each of the broad band filters, ,F105W, F110W, F125W, F140W and F160W. Each visit consists of 5 30-minute orbits. Visits are divided into two sets of five visits. We use SPARS25, NSAMP=9, in visits 1-5 for exposure time of 203 sec, five such exposures plus buffer dumps will fit into 30 minutes. In principle the flat fields should not depend on sample sequence; we test this with visits that use SPARS50, NSAMP=8 in visits 6-10 with three exposures per visit.

Proposal ID 11918:WFC3 CYCLE 17 UVIS Image Quality.

L. Dressel, M. Dulude, L. Petro

The UVIS imaging performance over the detector will be assessed every 4 months in two pass bands (F275W and F621M) to check for image stability, by examining the encircled energy, FWHM, and sharpness for several aperture diameters, 0.15, 0.20, 0.25, and 0.35 arcsec. (See ISR WFC3 2008-40. . The mean, rms, and rms of the mean will be determined for each metric. The values determined from each of the 4 exposures per filter within a visit will be compared to each other to see to what extent they are affected by "breathing". Values will be compared from visit to visit, starting with the values obtained during SMOV after the fine alignment has been performed, to see if the measures of the compactness of the PSF indicate degradation over time. The analysis will be repeated for stars on the inner part of the detector and stars on the outer part of the detector to check for differential degradation of the PSF.

The field around star 58 in the open cluster NGC188 is the chosen target because it is sufficiently dense to provide good sampling over the FOV while providing enough isolated stars to permit accurate PSF (point spread function) measurement. About 20 stars distributed over the detector will be measured in each exposure for each filter. NGC 188 is available year-round and used previously for ACS image quality assessment. The field is astrometric, and astrometric guide stars will be used, so that the plate scale and image orientation may also be determined (as in SMOV proposals 11436 and 11442).

Three visits, each consisting of 3 orbits, will be made at approximately 4, 8, and 12 months. Full frame images will be obtained at each of 4 POSTARG offset positions designed to improve sampling over the detector , using POSTARGs (0, 0), (0, plus minus 30), (plus minus 30, 0), and (plus minus 30, plus minus 30) in each filter (F275W and F621M). The size and signs of the POSTARGs have been selected to ensure good coverage of at least 20 stars distributed over the FOV.

Cycle 17 data will be analyzed using the code and techniques described in ISR WFC3 2008-40 (Hartig), and compared to both ground test (ISR WFC3 2008-40)and SMOV results .

Proposal ID 11919:WFC3 CYCLE 17 UVIS PSF Wings.

L. Dressel, L. Petro

The UVIS PSF wings will be evaluated at 5 field points, one near the field center and one at each of the four detector corners using the F275W and F625W filters to check for image stability. Subarray images of a moderately bright, isolated star will be obtained at each field position with a series of increasing exposure times designed to permit construction of a very high signal to noise PSF with sufficient dynamic range to evaluate the wing intensity out to >5 arcsec radius. Deep, saturated full frame images will also be obtained at each field point to permit evaluation of the wings at larger radii, as well as examination of potential stray light effects, image persistence and electronic cross-talk. (see SMOV program 11438). The results of the two programs will be compared.

For the near-center pointing, the aperture UVIS will be used to place the target 10 arcsec from the interchip gap. The corner pointings will be specified with POS TARGs used in combination with the aperture UVIS-CENTER. At each pointing, there will be a series of subarray exposures with increasing exposure times followed by a long full-frame exposure in one filter, then a repeat of this sequence in the other filter, but with a small offset in position. The exposure sequence and the offset between filters will minimize the effects of persistence (expected to be negligible for this detector). Single exposures are all 5 sec or longer, so the observed PSF (point spread function) is unlikely to be affected by the short-lived vibrations induced by shutter movement. Each series of subarray exposures is performed in an uninterrupted sequence to allow a straightforward combination of the exposures into a high SNR PSF with minimal smearing of the core.

The data will be analyzed using the code and techniques described in ISR WFC3 2008-40 (Hartig). Profiles of encircled energy will be compared to those obtained from the SMOV program 11438)

Proposal ID 11920:WFC3 CYCLE 17 IR Image Quality.

L. Dressel, M. Dulude, L. Petro

The IR imaging performance over the detector will be assessed periodically (every 4 months) in two pass bands to check for image stability. The field around star 58 in the open cluster NGC188 is the chosen target because it is sufficiently dense to provide good sampling over the FOV while providing enough isolated stars to permit accurate PSF (point spread function) measurement. It is available year-round and used previously for ACS image quality assessment. The field is astrometric, and astrometric guide stars will be used, so that the plate scale and image orientation may also be determined if necessary (as in SMOV proposals 11437 and 11443). Full frame images will be obtained at each of 4 POSTARG offset positions designed to improve sampling over the detector in F098M, F105W, and F160W. The PSFs will be sampled at 4 positions with sub pixel shifts in filters F164N and F127M.

This proposal is a periodic repeat (once every 4 months) of the visits in SMOV proposal 11437 (activity ID WFC3-24). The data will be analyzed using the code and techniques described in ISR WFC3 2008-41 (Hartig).

The specific PSF metrics to be examined are encircled energy for aperture diameter 0.25, 0.37, and 0.60 arcsec, FWHM, and sharpness. (See ISR WFC3 2008-41 tables 2 and 3 and preceding text.) ~20 stars distributed over the detector will be measured in each exposure for each filter. The mean, rms, and rms of the mean will be determined for each metric. The values determined from each of the 4 exposures per filter within a visit will be compared to each other to see to what extent they are affected by "breathing". Values will be compared from visit to visit, starting with the values obtained during SMOV after the fine alignment has been performed, to see if the measures of the compactness of the PSF indicate degradation over time. The analysis will be repeated for stars on the inner part of the detector and stars on the outer part of the detector to check for differential degradation of the PSF.

Full frame images of the field of NGC188 star 58 will be obtained with filters F164N and F127M at each of 4 dither positions designed to improve PSF sampling. Small offsets in the target position (1 arcsec in each coordinate) will be used to separate the locations of the PSFs in these two filters and the following filter in case of measureable persistence. Sampling of the field will be improved by larger POSTARG offsets in filters F160W, F098M, and F105W. Offset target positions (+/-10 arcsec in dec) are defined for the last two filters, to enable assessment of the level of persistence from saturated point source images and avoid its effects on the image quality measurement. Three visits, each consisting of 2 orbits, will be made at approximately 4, 8, and 12 months after the equivalent SMOV proposal, 11437. Astrometric guide stars will be used.

Proposal ID 11921:WFC3 CYCLE 17 IR PSF Wings.

L. Dressel, L. Petro

he IR PSF wings will be evaluated at 5 field points (near the field center and corners) in two filters (F098M and F160W) to check for image stability. Full frame images of a moderately bright, isolated star will be obtained at each field position with a series of increasing exposure times designed to permit construction of a very high SNR PSF with dynamic range sufficient to evaluate the wing intensity to >5 arcsec radius. The images will also permit examination of potential stray light effects, electronic cross-talk and image persistence. This is a repeat of SMOV activity WFC3-26 (program 11439.) The results of the two programs will be compared. The data will be analyzed using the code and techniques described in ISR WFC3 2008-41 (Hartig). Profiles of encircled energy will be compared to those obtained from program 11439

An isolated star will be observed at 5 points on the detector, near the center and the corners, through filters F098M and F160W, as in SMOV proposal 11439. At each location, a STEP timing sequence is used for one filter, a small offset is performed, and another STEP timing sequence is used for the other filter. The timing sequences have been chosen for their dynamic range, and the small offset minimizes the effects of persistence on the PSF (point spread function). For the central location, a larger offset between exposures with the two filters is used to move the target away from the point where the four quadrants meet at the center of the detector. Each PSF is read out by a single amplifier to a radius of at least 5 arcsec.

Proposal ID 11922:WFC3 CYCLE 17 UVIS Fringing

E. Sabbi, C. Pavlovsky

We will use multiple pointing observations of the globular cluster Omega Centauri (NGC 5139) to measure the impact of fringing pattern on accurate photometry of WFC3/UVIS data. . Omega Cen has been selected because of its flat and extended core (~2.5 arcmin). Therefore stellar density gradients will not be a problem in this kind of analysis. We will acquire 5 pointing observations along a 2 by 2 plus a central pointing dither pattern. We will use a step of 40" (approximately 25% of the FOV) in either x and/or y directions. The selected filters are F656N and F953N filters, which show very strong fringing patterns on TV3 flat fields (Sabbi, 2008; ISR WFC3 2008-012). By measuring relative changes in brightness of a star over different positions of the detector we will measure the impact of fringing on accurate photometry. This will allow us to verify the fringing model determined using TV3 data by comparing these results to the ground-based tests at several different wavelengths. The observing strategy has been designed to maximize orbit time and reduce the overhead.

Proposal ID 11923:WFC3 CYCLE 17 UVIS Filter Wedge Check.

J. MacKenty, E. Sabbi, T. Borders

The position of each UVIS filter will be checked to verify that the filters meet the CEI (Contract End Item) specification for image displacement. We will observe NGC1850 with all full-frame UVIS filters using a user defined 1024x1024 subarray, the quad filters will also use a specifically designed 1024x1024 subarray. We will also acquire one grism exposure.

We will observe NGC 1850 using the UVIS filters without moving the telescope. A series of images will be taken in order to determine the relative displacement of the position of the stars in each image from one filter to the next. Analysis will consist of measuring the x and y position of the stars in each image. No spectral element shall relatively displace the image by more than 0.5 detector pixels or degrade the quality by more than 0.02 waves at 633 nm of the transmitted wavefront error. Results will be summarized in an Instrument Science Report and the Instrument

Proposal ID 11924:WFC3 CYCLE 17 UVIS CTE Monitoring

V. Kozhurina-Platais, P. McCullough, L. Petro, A. Riess

This program has two components. The first consists of observations of the rich open cluster NGC6791 taken in three visits during Cycle 17, approximately 4-5 months apart to establish the CTE-induced losses with time. During each visit, observations are taken through the F606W and F502N filters with 3 pointings of half-FOV size dithers in both X and Y directions to characterize the parallel and serial CTE induced losses. Each pointing will consist of one short and one long exposure in each filter to ensure that the sky background is in the range between ~0 to ~50 e-/pixel. These values have been estimated from the analysis of 30-sec and 1000-sec ACS F606W images of NGC 6791, and scaled to the WFC3 response. The observation will be used to derive aperture photometry and centroid shift for each stars in this cluster and later to characterize the CTE induced losses in photometry and astrometry.

The analysis of CTE monitoring program will follow by method of Kozhurina-Platais et.al (2007, ACS-ISR-07-04). The ACS CTE monitoring program used globular clusters. Our concern is that the globular clusters have such high densities of stars that many pixels in the transfer column of a particular star will have been exposed to starlight prior to the charge transfer. Instead of that we propose to use the rich open cluster NGC 6791 to test the hypothesis that a sparser stellar field will give a more accurate determination of CTE. Analysis of a 30-sec ACS F606W image of NGC 6791 shows that there are ~3000 stars with FLUX > 1000 counts in the ACS/WFC FOV which is similar to the WFC3 UVIS FOV. Also, NGC 6791 has ecliptic latitude of 59 degrees, so it can be observed year round by HST. It is also contains the solar analog favorite of JWST (Diaz-Miller 2006; JWST-STScI- 000959, SM- 12). For Cycle 17, each visit consists of 2 orbits, 3 pointings and a total of 12 exposures (6 per filter). There are three visits during Cycle 17, therefore this program requires a total of 6 external orbits.

The second component of this program consists of internal tungsten lamp flat field observations of short exposures through three filters, F390M, F390W and F438W, in order obtain large range of illumination levels, namely 3000, 1000, 500, 250, and 100 electrons. The internal observation of flat fields with different levels of illumination will be used to monitor the CTE detector with time, by measuring the profiles into trailing over-scan region (EPER - extended pixel edge response), as it described by M. Robberto (2007, WFC-ISR-07-13) Internal observations with tungsten lamp are similar to exposures taken during the TV3 ground tests. 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 4-6 weeks apart, for a total of 24 internal orbits

The accuracy goal of this program is to measure the CTE-induced losses in photometry with a precision better than 1%, and in astrometry with precision to less then 5%.

Proposal ID 11925:WFC3 CYCLE 17 UVIS Linearity

S. Deustua, A. Rajan, S. M. Baggett

The linear response of the UVIS CCD detectors was measured during ground tests for count levels up to saturation. This proposal will measure the in-orbit linear response of the UVIS detectors by sampling over the response curve through saturation. This program uses exposures of a standard star field (NGC 1850) to measure the absolute values, and, exposures of a tungsten lamp to measure positional variations in response, following a similar procedure as the ground tests. All data are acquired using the standard gain setting of 1.5 e-/DN, and, through the F467M filter as it is a good compromise in terms of exposure time, enabling us to fit the observations into 3 internal orbits and 2 external orbits. Linearity response is independent of wavelength

The absolute calibration of the linear response is determined from point sources. A series of images of the cluster NGC 1850 are taken with different exposure times to cover a range of detector ADU levels. On average, stars in NGC 1850 range in brightness between V=14 and V=18, and, exposures between 10 and 500 seconds will sample the linear response curve. The target is centered on each UVIS CCD, so that the same stars are observed with both detectors, in order to compare the linearity curve of each detector. A total of 14 exposures in 2 orbits are obtained.

Flat fields are used to test for variations in linearity as a function of location on the detector. A series of flat field images will be taken at specific ADU levels, read out through subarrays through each amplifier. The table below lists N (number of exposures), ADU level (electrons), and Exposure time (seconds). At low ADU levels, multiple exposures are taken do build up the counting statistics.

Number of Exposures	Expected Count level ADU (e-)	ExpTime (sec)
10	100 e-	1
5	1000 e-	10
1	10000	100
1	20000	200
1	50000	500
1	70000	700
1	80000	800
1	90000	900

Accuracy Goal: Better than 5% (correctable to <0.3%) over the range 100 e- to 50000 e-.

Proposal ID 11926: WFC3 Cycle 17 IR Zeropoints

S. Deustua, J. Kalirai, E. Sabbi, A. Riess, A Rajan

We will measure and monitor IR filter zeropoints and sensitivity curves by observing either one of the white dwarf standard stars GD153 and GD71, and the solar analog star, P330E every month during Cycle 17. Because HST instruments have historically relied on the white dwarf G191B2B for zeropoint calibration, we shall observe it only once with the WFC3 IR detector, through the broad and medium band filters, as it is almost too bright for the WFC3 IR channel. We shall also observe the star cluster NGC 104 (47 Tuc) twice in Cycle 17 to check the IR-UVIS photometric scale, and, to check the color transformations against commonly used filter systems, e.g. 2MASS JHK.

We expect an accuracy of 2% in the broad band filter zeropoints relative to the HST photometric system, and 5% in the medium and narrowband filters. The HST white dwarf primary standards have been calibrated to 1% relative to WD models in the visible, and to approximately 2% in the near infrared (cf. Bohlin ISRs). Our WFC3/IR observations will have very high signal to noise, SNR>100, so the use of three standards should be sufficient to obtain this accuracy in the W bands. For the medium and narrow bands, the interplay between spectral features and bandpass shape will limit the accuracy.

1. The first part of the program relies on monthly observations of GD153 and GD71, hot white dwarf standard stars and the solar analog standard, P330E, in all of the IR filters. This will provide a) determination of the zeropoints to high accuracy, b) sensitivity trend monitor of the IR channel, and c) characterization of photometric uncertainties and repeatability. G191B2B will be observed once as a crosscheck with NICMOS.

2. The second part of the program will determine the color correction for each bandpass and the photometric scale across WFC3 channels using observations of P330E and 47 Tuc.

We use 16 orbits to observe the white dwarfs: 8 for GD71, 7 for GD153 and 1 for G191B2B. P3330E is observed 10 times during Cycle 17, for a total of 10 orbits. 47 Tuc is observed twice, for a total of 2 orbits. Each instance requires one orbit. Per visit, standard stars are observed at least twice per filter, dithered by 1 arcsec to avoid persistence effects; and in subarray mode, either 128x128, 256x256 or 512x512 using RAPID or SPARS10 sample sequences as appropriate to achieve the minimum SNR = 100 without saturating. G191B2B observations use the 64x64 subarray mode.

Visit Pairs	Targets	
Visit 1, 2	GD71	P330E
Visit 3, 4	GD71	P330E
Visit 5, 6	G191B2B	GD71
Visit 7, 8	GD153	P330E
Visit 9, 10	GD153	P330E
Visit 11, 12	GD153	P330E
Visit 13, 14	GD153	GD71
Visit 15, 16	47Tuc	GD153
Visit 17, 18	GD153	P330E
Visit 19, 20	GD153	P330E
Visit 21, 22	GD153	P330E
Visit 23, 24	GD71	P330E
Visit 25, 26	47Tuc	GD71
Visit 27, 28	GD71	P330E

Proposal ID 11927:WFC3 CYCLE 17 IR Persistence.

S. Deustua, P. McCullough, C. Pavlovsky

During thermal vacuum test 3 (TV3), we tested for persistence of the infrared flight detector of WFC3 by positioning a simulated star at 16 distinct locations on the focal plane, and, reading the detector in full-array (1024x1024 pixel) mode. Short exposures through a filter alternated with longer exposure darks taken with the opaque blank, the purpose of which was to control the fluence on the illuminated pixels and not allow photons to land on the detector during readouts. These ground tests indicate charge persistence lasts up to 4 hours.

During Cycle 17, we shall measure persistence by acquiring a pair of short exposures in F110W of a sparse star field in NGC 6791 during one orbit, which is followed by a series of darks for the next 3 consecutive orbits, in and out of occultation with RAPID, NSAMP=15. The sacrificial subarray dark after the second short-exposure visits is important only in order to force the full-frame readouts to occur with the detector protected from starlight. This way, pixels associated with a given star will be exposed the same amount in the two dithered positions; without this sacrificial dark, the readout of the first short exposure will inadvertently flood the detector with starlight at the second dither position. During the next visit, the same pattern is followed but using longer exposure times, SPARS25, NSAMP=15, for the illuminated frames to get 10x greater fluence than in the previous visit. Many stars will push their pixels past saturation. In both cases, the darks use SPARS50 NSAMP=15.

Because the star field contains many stars, we gain a multiplex advantage in the placement of point sources of various brightnessess on the detector. Between each of the two exposures, we shift by 10 arcsec to disentangle whether any anomalous persistence for a few (presumably brightest) stars is due to their brightness or the pixels they happened to land on.

This pattern is repeated a total of three times during the cycle, once early, once in mid cycle and once about 2/3 into the cycle.

Proposal ID 11928:WFC3 CYCLE 17 IR L Flat and Geometric Distortion.

V. Kozhurina-Platais, M. Dulude, J. S. Kalirai, P. McCullough

Multiple observations of globular cluster Omega Cen at multiple infrared wavelengths of IR detector will be used to derive filter dependency of low-frequency sensitivity (LFlats fields) across of IR detector and its time variation. Additionally, the same data will be also used to derive filter-dependant geometric distortion of the detector and its time-dependency

The 9 dither pointing (3x3) across the IR detector with the size of 1/4-FOV is necessary to derive relative changes in brightness, low-frequency variations in the IR detector response (LFlats) and verify the geometric distortion of IR after SMOV. 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 IR detector (L-flats) and filter-dependency of the geometric distortion. 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.

The same observations will be used to monitor potential changes in sensitivity of IR detector and potential time-dependency of the geometric distortion. Because of that, the observations of Omega Cen are taken three times per year at 3-4 months interval. Thus, we propose three visits per one epoch, spread across Cycle 17, early, middle and late epochs. At each visit we propose to observe with all 5 filters, and three pointing of 3x3 dither grid, for a total of 15 external exposures per visit utilizing two HST orbits. Finally, with nine visits, this program requires 18 external orbits total for Cycle 17.

The product of this calibration will be low-frequency variation cross IR detector as reference files (LFLTFILE -low order flat) for use in HST/WFC3 calibration pipeline. The same data will be used to produce filter-dependant geometric distortion as a reference files (DGEOFILE - distortion correction image), which will be used in HST/WFC3 calibration pipeline and Multidrizzle. The accuracy of L-flat filed reference files will be at about 1% and the same accuracy for distortion correction images.

Proposal ID 11929:WFC3 CYCLE 17 IR Dark Monitor.

B. Hilbert, P. McCullough, M. Dulude

Analyses of ground test data showed that dark current signals are more reliably removed from science data using darks taken with the same exposure sequences as the science data, than with a single dark current image scaled by desired exposure time. Therefore, dark current images must be collected using all sample sequences that will be used in science observations. These observations will be used to monitor changes in the dark current of the WFC3-IR 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 17. For each sample sequence/array size combination, a median ramp will be created and delivered to the calibration database system (CDBS).

The frequency of observation for each sample sequence is based upon the number of Cycle 17 GO requests for that sample sequence. Four series of observations will be made:

Sample Sequence	Frequency of dark current ramps
1) the two most requested sample sequences SPARS50 SPARS100	 4x per 2 week period 3x per 2 week period
2) For the three next most popular sample sequences SPARS25 STEP25 STEP50	2 per 2-week period.
3) Less frequently used Cycle 17 sample sequences, e.g. RAPID, SPARS10, SPARS200, STEP100, STEP200, and STEP400	1x per 2 week period
4) Subarray configurations including • 64 x 64 pixel RAPID • 128 x 128 pixel RAPID, SPARS10 • 256 x 256 pixel RAPID, SPARS10, SPARS25 • 512 x 512 pixel RAPID, SPARS25, STEP25	1x per 2 week period

This series of dark current ramps will be used to create and deliver calibration files for each sample sequence/subarray combination.

The accuracy of the final dark current calibration ramps will vary with sample sequence as we are collecting a different number of ramps for each. Variations in the signal to noise level will be between ~10 to >100. The measured dark rate in these data will be compared with CEI Specification 4.4.8.3, which states that the total dark current in the IR channel should be less than 0.4 e-/sec/pixel.

Proposal ID 11930:WFC3 CYCLE 17 IR Gain.

B. Hilbert, P. McCullough, M. Dulude

The gain of the WFC3 IR channel 3 will be measured from internal flat fields. Based on ground testing results we shall obtain flat field ramps to create photon transfer curves and measure the gain. By using two filters with similar central wavelengths but different bandwidths, we will be able to search for any flux-dependent changes in the gain measurement. By collecting pairs of flat fields, we can generate photon transfer curves, measure the true gain of the system, and propagate these values into the data reduction pipeline for WFC3-IR.

This will provide the proper factor for converting science data into units of electrons.
We will collect flat field ramps in pairs, using the same strategy as for ground testing, and which, should give directly comparable results. Exposure times have been chosen to keep the signal below the level where persistence will have a large effect on the data. Initially we collect 2 pairs of ramps, one each through the F140W and F139M filters. The pattern of observations and data dumps for this orbit match that used in ground testing, and should provide a direct comparison to those results. The first orbit consists of darks only three orbits alternate between F139M and F140W exposures, 2 orbits expose only F139M, 1 orbit only for F140W and 1 orbit only for F153M. By using multiple filters, we vary the flux level on the detector, which allows us to look for flux dependence on the final calculated gain values. Orbits are built to check for systematic effects on the gain resulting from the order in which data are taken, and the set of tungsten lamp exposures with the F153M filters will be used to sample the low signal level regime, where ground tests provided the most reliable gain. measurements

Gain values for each quadrant of the detector will be calculated separately for each pair of ramps. From a given pair of ramps, we will construct a photon transfer curve, plotting the measured mean signal versus variance for each read. A best-fit line to this plot will produce the measured gain value. The expected accuracy of the final calculated gain values is ~2%, based on results from ground testing. (see WFC3 ISR 2008-50) Using the data collected in Cycle 17, we will calculate effective gain values for the IR channel, which will be collected in the CCDTAB file, which is used in the CALWF3 pipeline for data reduction. With data being collected at three separate intervals in Cycle 17, we will also monitor the effective gain in the IR channel for any changes over time. All results will be published in an ISR.

Proposal ID 11931:WFC3 CYCLE 17 IR Count Linearity.

B. Hilbert, P. McCullough, M. Dulude

The non linear response of each detector pixel will be determined using tungsten lamp flat fields, while point source photometric behavior will be studied using observations of the globular cluster, 47 Tuc.

Flat field data through the F098M filter, using the internal tungsten calibration lamp, and obtained with a 15-read, SPARS 25 sample sequence, will allow the pixel-by-pixel examination of the IR detector's non-linearity over the array up to saturation. Observations of 47 Tuc will be used to study point source non-linearity behavior of the detector. For these observations, we collect ramps in pairs, with four pairs per orbit. Each pair is composed of 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 non-linearity 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 non-linearity, 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 non-linearity test performed on ACS, and detailed in ACS ISR 2004-01 by R. Gilliland.

Based on previous ground test results (detailed in WFC3 ISR 2008-39), we hope to calculate correction coefficients capable of correcting measured signals to better than several percent non-linearity.

Proposal ID 11932:WFC3 CYCLE 17 IR Stray Light.

L. Petro, M. Dulude

Structures outside the optical path of the detector FOV and the surfaces of optical elements could scatter significant light from bright sources onto the IR FPA. Such structures are oversized by typically a few mm relative to the FOV's beam. The beam footprint of a source outside the FOV can overlap the edges of those structures, which will cause light to be scattered onto the detector. During ground test, it was found that one per cent of the signal from a target imaged onto the edge of the detector was scattered into an approximately 10 pixel by 100 pixel flare. This on orbit test will: 1) verify that release of gravitational stress has not changed the detector mask, 2) assess the far wing stray light from a sources outside the detector FOV, 3) note any sources of stray light in the near and far field that were not noted during ground test, and 4) assess the surface brightness of the off-detector target PSF relative to the on-detector PSF.

The test will be comprised of two sets of exposures in the most sensitive filter (F110W). The first set is comprised of exposures of a moderately bright star in 4 4-position fine scans just outside the detector field of view. The second set is comprised of exposures of a very bright star at 3 positions far from the field of view. The 4-position scans of a 13.3-mag star will be made perpendicular to the 4 the edges of the detector. Those exposures will be full-frame, SPARS50, NSAMP=6 (253 sec) or 8 (353 sec). The far-field exposures will be 703-second and 1403-second exposures of a very bright target (V=0) at each of the 3 field positions. A matching exposure of the sky is taken for the far-field exposures.

Knowledge of stray light from sources outside the detector FOV will benefit planning science observations in crowded fields.

The pointing is controlled with a primary S/C POINTING exposure with 1-second exposure time. The WFC3 exposures are obtained in parallel and, of course, greatly exceed the primary exposure time. The APT WARNING is to be expected and is acceptable. Visit 03 scans the far-field stray light, placing the 0th mag target at 6, 3, and 1 arcminutes, respectively, along the WFC3 +X-POSTARG axis, which is toward NICMOS. Therefore, during this visit the NICMOS BLANK filter should be in place and no exposures, expect possibly DARK, should be taken (per discussions with NICMOS team). Also, per discussions with HST-MO, other SIs should not be operated without specific authorization.

The geometry of the scan is controlled by placing the exposures of each of the two scientific sets in two respective visits. Within the visits, the exposures are ordered from faint to bright signals. The 26-deg Bright Earth Limb Avoidance Angle is intended to prevent Earth stray light being a source of systematic error. Guide stars should be selected to avoid the part of the FGS FOV near Visit 03, the visit exposing the 0th-mag star.

Proposal ID 11933:WFC3 CYCLE 17 IR Rate Dependent Nonlinearity.

A. Riess, S. Deustua, L. D. Petro, P. McCullough, B. Hilbert

The NICMOS count rate non-linearity known as the Bohlin Effect has revealed that the apparent flux of a source observed by NICMOS is not a simple, linear function. The effect has been characterized by observations of star clusters observed with and without additional background from the internal lamps. As this is method is not possible with the WFC3/IR configuration we will rely instead on the bright Earth limb to provide additional background.

We will acquire two sets of data for the star cluster 47 Tuc, where the cluster is observed repeatedly through out a complete HST orbit in the two most commonly used filters, F110W and F160W. The first set is taken with the closest approach to the bright Earth at 13.5 degrees, the closest approach allowed while retaining FGS guiding. The second set has the bright Earth closest approach at 15.5 degrees. One orbit on NGC 1850 duplicates the NICMOS field for which the linearity of the field has been established.

47 Tuc was selected as it is rich enough for good statistics, yet sufficiently sparse to make good sky measurements. The bright Earth has sufficient flux to provide significant change in the count rate when compared to just the 47 Tuc stars. Observing 47 Tuc simultaneously with the bright Earth provides at least two different background levels to explore the count-rate non-linearity No dithering is done as this is pixel-to-pixel difference measure.

Observations of 47 Tuc are obtained on the day and night side of Earth-skimming orbits. near the orbital pole, to add bright Earth background light and thereby test for count rate non-linearity. i.e.

$$\mathrm{cr}_{BE} - \mathrm{cr}_{dark} = (f_{obj} + f_{sky1} + f_{BE})^{\alpha} - (f_{obj} + f_{sky2})^{\alpha}$$

$$OR$$

$$\mathrm{cr}_{BE} - \mathrm{cr}_{dark} = (f_{obj} + f_{BE})^{\alpha} - (f_{obj})^{\alpha} \; for \; f_{sky} << f_{obj}$$

and then solve for α.

Proposal ID 11934:UVIS G280 Flux Calibration.

H. Bushouse, H. Kuntschner, J.R. Walsh, M. Kuemmel

Flux calibration, image displacement, and spectral trace of the UVIS G280 grism will be established using observations of the HST flux standard start GD71. Accompanying direct exposures will provide the image displacement measurements and 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 derived.

We will obtain observations of the HST primary flux standard star GD71 in order to establish the flux calibration of the UVIS G280 grism and also provide image displacement and spectral trace information. The standard star will be observed at a central position for each of the two CCD chips, as well as near the center of the whole UVIS field of view, in sequences of three exposures: 2 direct images in the F200LP and F300X filters, followed by the G280 dispersed exposure. The direct images are needed to establish the image displacement and wavelength zero-point. We will not consider field-dependent variations in the flux calibration because this would require many more orbits. Furthermore, there is only one GO snapshot program in Cycle 17 that uses the G280 and in that program a single target will be placed at the same field position in each exposure. Bias exposures are also obtained to support the off-nominal chip 2subarray readouts that will be used.

Determining the sensitivity curve of the G280 grism is a fundamental calibration of the grism mode that will be needed to calibrate science observations using the G280. The ratio of the known GD71 flux distribution to the observed count rate spectrum determines the inverse sensitivity curve for the G280 instrument mode. Application of this sensitivity curve to all otherG280 spectra places those spectra on an absolute flux scale. The spectral trace and image offset information that will be derived from the GD71 continuum spectrum is needed as input to the ST-ECF aXe spectral extraction software, in order to guide the extraction of all spectral data from G280 images. The goal is to calibrate the G280 sensitivity curve of the G280 to <10% (1-sigma) over the wavelength range 1900-3500 A in the +1 and -1 orders. Sensitivity curves will also be established for higher orders, but with reduced accuracy.

Proposal ID 11935:UVIS G280 Wavelength Calibration.

H. Bushouse, H. Kuntschner, J.R. Walsh, M. Kuemmel

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. The goal of this program is to establish the dispersion of the G280 - at the observed field locations - to an accuracy of about 1 pixel (~14 A) in the +1 and -1 spectral orders.

We will obtain observations of the Wolf Rayet star WR14, which shows several strong emission lines over the relevant wavelength range of the G280 grism (1900-3500A). WR14 will be observed at a central position on each of the two CCD chips and at the center of the UVIS field, to establish a wavelength calibration of the +1 and -1 spectral orders. The target will be observed in sequences of three exposures: 2 direct images in the F200LP and F300X filters, followed by a G280 dispersed exposure. The direct images are needed to establish the wavelength zero-point of the dispersed exposures. We will not consider field-dependent variations in the wavelength calibration because this would require many more orbits. Furthermore, there is only one GO snapshot program in Cycle 17 that uses the G280 and for this program the single target for each snap exposure will be placed at the same position in the field.

Determining the dispersion of the G280 grism is a fundamental calibration of the grism mode that will be needed to calibrate science observations using the G280. The relative image positions of the WR14 emission lines are compared with their known wavelengths to determine the dispersion solution, which is then used in the ST-ECF aXe spectral extraction and calibration software to determine wavelength solutions for all G280 science program observations. There are not very many good wavelength calibrators available in this wavelength range. WR14 has a few, irregularly spaced emission lines, so it will not provide sufficient sampling to determine the fine-scale dispersion. A detailed, finely sampled dispersion solution was computed during WFC3 ground tests at the same 3 field locations at which these observations will be done (center of each chip and center of the field). The WR14 observations will therefore provide information on significant changes, if any, in the dispersion solution that may occur as a result of launch and gravity release of WFC3.

Proposal ID 11936:WFC3 CYCLE 17 IR Grism Flux Calibration.

H. Bushouse, H. Kuntschner, J.R. Walsh, M. Kuemmel

This program will determine image displacement, spectral trace and flux calibration for the 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 9-point pattern in the IR field of view, which will provide the necessary image displacement, spectral trace, and throughput measurements.

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 flat field 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 zero-point 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 9-point exposure patterns within the FOV. POSTARGs are also used at the central exposure of each pattern in order to shift the location of the first-order spectrum so that it is near the center of the FOV.

Standard star observations with the grisms must be used to establish the on-orbit flux calibration for the grism modes. Large-scale variations in overall instrument sensitivity over the field of view must be calibrated by mapping the variations in grism flux calibration over the FOV. This is vital for calibrating multi-object spectroscopic (MOS) observations, where targets of interest will be distributed over the entire FOV. The ratio of the known flux distribution of GD71 to the observed G102 and G141 spectra will produce an inverse sensitivity curve for each grism mode. This sensitivity curve will then be used within the ST-ECF aXe spectra extraction and calibration software to place all WFC3 IR grism observations on an absolute flux scale. The spectral trace and image-offset information that will be derived from the GD71 observations are also needed as input to the aXe software, in order to guide the extraction of target spectra. The goal is to calibrate the G102 and G141 sensitivity curves to <5% (1 sigma) over the wavelength ranges in which the grism throughputs are more than 10% of their maxima in the +1st spectral order. Higher orders will also be calibrated, but with reduced accuracy. The complete set of calibration observations for each grism will be executed twice throughout Cycle 17. The first set of observations (visits 1 and 2) should be scheduled as early as possible in Cycle 17 in order to make this basic calibration available to the community and enable the use of data-reduction software for WFC3 IR. The second set of observations (visits 3 and 4) should be scheduled sometime within the second half of Cycle 17, in order to check for temporal changes in the calibration.

Proposal ID 11937:WFC3 CYCLE 17 IR Grism Wavelength Calibration.

H. Bushouse, H. Kuntschner, J.R. Walsh, M. Kuemmel

This program will determine the wavelength calibration for the two IR G102 and G141 grisms as a function of spatial position within the field of view. The planetary nebula Vy2-2 will be observed in a 9-point pattern in the IR field of view, which will provide FoV-dependent dispersion maps for the G102 and G141 grisms. The goal of this program is to provide a wavelength calibration for each grism that is accurate to about 1 pixel (corresponding to 25A and 45 A for the G102 and G141, respectively) over 90% of the FoV for the 1st spectral orders. Higher spectral orders will also be calibrated, but with reduced accuracy

Observations of a wavelength calibrator are necessary to establish the on-orbit dispersion for the grism modes. Large-scale variations in dispersion over the field of view, due to instrumental geometric distortion, must also be determined. This is vital for calibrating multi-object spectroscopic (MOS) observations, where targets of interest will be distributed over the entire FOV. The dispersion solution is determined by deriving the relation between the relative pixel positions of emission lines in the Vy2-2 spectrum and their known wavelengths. The derived dispersion solutions will be used within the ST-ECF aXe spectral extraction and calibration software package to assign wavelength scales to all WFC3 IR grism spectra.

The 9 positions will be distributed in a 3x3 grid within the field of view and will provide a map of spatial variations of the grism dispersions. All dispersed exposures will be preceded by two direct images, in order to measure the source offsets between direct and dispersed modes, which establishes the wavelength zero-point for each dispersed image. For G102 observations, the F098M and F105W filters will be used for the accompanying direct exposures, while for G141 observations, the F140W and F160W filters will be used. 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 9-point exposure patterns within the FOV, and to shift the location of the first-order spectrum so that it is near the center of the FOV.

This program will be executed once, early in Cycle 17.

Proposal ID 11938:WFC3 CYCLE 17 UVIS Stray Light.

L. Petro, T. Borders

Structures outside the optical path of the detector FOV and the surfaces of optical elements could scatter significant light from bright sources onto the UVIS CCD. Because such structures are larger than the FOV beam by a few mm, and, the beam outside the FOV can overlap the edges of those structures, which can cause light to be scattered onto the detector. Knowledge of stray light from sources outside the detector FOV will benefit science observations planning in crowded fields and high-contrast imaging. This program will:

1. 1) verify that release of gravitational stress has not changed the detector mask by comparing to similar ground tests,
2. 2) assess any stray light effects from sources outside the CCD FOV
3. 3) note any new sources of stray light in the near and far field not detected during ground tests.
4. 4) assess the surface brightness of the off-chip target PSF relative to the on-chip PSF.

This scattered light test consists of two sets of exposures in the most sensitive UVIS filter, F606W. The first set uses a moderately bright star in a fine scan just outside the detector field of view. The near-field scan is comprised of 4-position scans of a 13.3-mag star made perpendicular to the edge of the CCD across the four edges of the optical mask. The CR-SPLIT=NO exposures are 100-second exposures in a 1024x1024 sub-array readout. A pointing check exposure is taken for each of the four edge scans, which places the target onto the active area of the CCD. The second set is comprised of exposures of a very bright star at 3 positions far outside the field of the detector.. The far-field exposures will be 2 dithered, 360-second, CR-SPLIT=NO exposures of a very bright target (V=0) at each of the 3 field positions (a total of 6 exposures). A matching exposure of the sky 1 deg from the 0-mag star is taken as a background measurement for the far-field exposures. Within the visits, the exposures are ordered from faint to bright signals.