WFC3 Cycle 26 Calibration

J. Mack, E. Sabbi, S. Baggett & the WFC3 Team
31 May 2018

- Routine observations for 22 monitoring programs:

  These have the same cadence as Cycle 25
  (orbit totals may vary slightly due to cycle boundaries)

- Modified observations for 1 monitoring program:

  - UVIS & IR photometry (add 1 orbit to reinstate a 3rd white dwarf in the IR)

- New calibration via 2 programs:

  - WFC3 Focus cross-calibration
  - Short-term IR persistence

Cycle 26 Boundaries: Nov 5, 2018 - Nov 3, 2019

Orbit Request by Cycle

**Calibration from prior cycles may be found at: http://www.stsci.edu/hst/wfc3/calibration

Cycle		External	Internal
CY26	Monitor	49	1512
	New Calibration*	6	2
	Total	55	1514
CY25	Monitor	48	1509
	New Calibration*	12	3
	Total	60	1512
Cy24	Monitor	50	1522
	New Calibration*	19	35
	Total	69	1557
Cy23	Monitor	52	1511
	New Calibration*	46	108
	Total	98	1619

*Cycle 26 New
- Persistence= 2e+2i
- Focus = 4e

*Cycle 25 New
- UVIS Color Terms= 8e
- Persistence= 3e+3i
- IR CRNL=1e

*Cycle 24 New
- CTE= 2e+15i
- GRW with STIS= 4e
- Contamination= 6e
- IR Linearity= 7e
- Sink pixels= 20i

*Cycle 23 New
- Persistence= 16e+108i
- UVIS Distortion= 30e
- -1st Grism= 2e

WFC3 CY26 Calibration

*** New for Cycle 26**

	ID	PI	Program Title	Ext	Int	ID	PI	Program Title	Ext	Int	
UVIS CCD	15567	*Baggett*	WFC3 UVIS Anneal	0	79	15582	*Deustua*	WFC3 UVIS & IR Photometry	12	0	Photometry
	15568	*Kurtz*	WFC3 UVIS Bowtie Monitor	0	132	15583	*McCullough*	WFC3 UVIS Contamination Monitor (staring and scans)	20	0	
	15569-15571	*Martlin*	WFC3 UVIS CCD Daily Monitor (Darks & Biases)	0	642	15584	*Sahu*	WFC3 UVIS Shutter Monitoring	0	1	
	15572	*Khandrika*	WFC3 UVIS CCD Unflashed (CTE) Monitor	0	130	15585	*Dressel*	**WFC3 Focus Cross-Calibration***	4	0	Focus
	15573	*Martlin*	WFC3 UVIS Post-flash Monitor	0	60						
	15574	*Fowler*	WFC3 UVIS CCD Gain Stability	0	18	15586	*Pirzkal*	WFC3 IR Grism Wavelength Calibration	1	0	Grisms
CTE	15575	*Fowler*	WFC3 UVIS CTI Monitor (EPER)	0	12	15587	*Pirzkal*	WFC3 IR Grism Flux/Trace Calibration	1	0	
	15576	*Kurtz*	WFC3 UVIS CTE Monitor (Star Cluster)	8	0	15588	*Pirzkal*	WFC3 UVIS Grism Wavelength Calibration	1	0	
	15577	*Medina*	WFC3 Characterization of UVIS Traps with Charge Injection	0	39	15589	*Shanahan*	WFC3 UVIS Pixel-to-Pixel QE Variations via Internal Flats	0	45	Flats
IR Detector	15578	*Sunnquist*	WFC3 IR Dark Monitor	0	97	15590	*Medina*	WFC3 UVIS Internal Flats	0	13	
	15579	*Gennaro*	WFC3 IR Linearity Monitor	0	10	15591	*Ryan*	WFC3 IR Internal Flats	0	18	
	15580	*Khandrika*	WFC3 IR Gain Monitor	0	16	15592	*Sunnquist*	WFC3 CSM Monitor with Earth Flats	0	200	
Persistence	15581	*Gennaro*	**WFC3 Short-term IR Persistence ***	2	2	15593	*Platais*	WFC3 Astrometric Scale Monitoring	6	0	Astrometry

WFC3 CY25 Calibration

*** New for Cycle 25**

	ID	PI	Program Title	Ext	Int	ID	PI	Program Title	Ext	Int	
UVIS CCD	14978	*Baggett*	UVIS anneal	0	79	14992	*Deustua*	WFC3 UVIS & IR photometry	11	0	Photometry
	14979	*Kurtz*	UVIS bowtie monitor	0	132	15398	*McCullough*	UVIS contamination monitor (staring and scans)	20	0	
	14980-14982	*Martlin*	UVIS CCD daily monitor (darks & biases)	0	642	15397	Sahu	UVIS shutter monitoring	0	1	
	14983	*Khandrika*	UVIS CCD un-flashed (CTE) monitor	0	130	15399	*Calamida*	**UVIS Supplemental Photometry: Color Terms & Revisiting M512C ***	8	0	
	14984	*Martlin*	UVIS post-flash monitor	0	60	15408	*MacKenty*	**Using the WFC3 internal lamp for calibrating the IR CRNL ***	1	0	
	14985	*Fowler*	UVIS CCD gain stability	0	18	14993	*Pirzkal*	WFC3 IR grisms wavelength calibration	1	0	Grisms
CTE	14989	*Fowler*	UVIS CTI monitor (EPER)	0	12	14994	*Pirzkal*	WFC3 IR grisms flux/trace calibration	1	0	
	14990	*Fowler*	UVIS CTE monitor (star cluster)	8	0	14995	*Brammer*	WFC3 UVIS grism wavelength calibration	1	0	
	14991	*Kurtz*	Characterization of UVIS traps with CI	0	36	14996	*Mckay*	UVIS Pixel-to-Pixel QE Variations via Internal Flats	0	45	Flats
IR Detector	14986	*Sunnquist*	IR dark monitor	0	97	14997	*Mckay*	UVIS internal flats	0	13	
	14987	*Shanahan*	IR linearity monitor	0	10	14998	*Kurtz*	IR internal flats	0	18	
	14988	*Shanahan*	IR gain monitor	0	16	14999	*Sunnquist*	CSM monitor with Earth flats	0	200	
Persistence	15400	*Stevenson*	**Mitigating Persistence for Time-Series Obs ***	3	3	15000	*Platais*	Astrometric scale monitoring	6	0	Astrometry

New WFC3 Calibration

- WFC3 Focus Cross-calibration: F410M to F606W

    4 external orbits = 1 orbit per visit * 4 epochs (every ~3 months)

- WFC3 Short Term IR Persistence

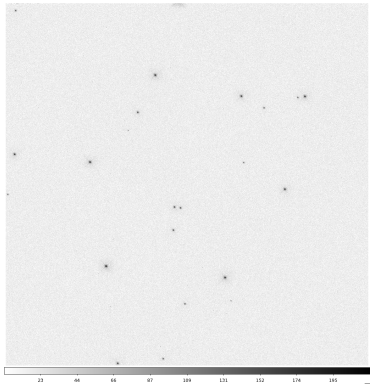
    2 external + 2 internal orbits (staring + scan)

WFC3 Focus Cross-calibration: F410M to F606W

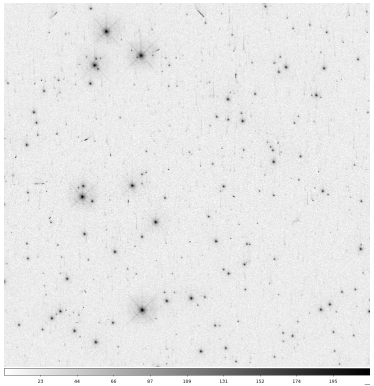
**NEW for Cycle 26

Orbits	External: 4 Internal: 0
PI, Co-I's	Dressel, Anderson, Lallo
Purpose	Cross-calibrate the HST focus in two WFC3/UVIS filters using interleaved exposures in F410M and F606W. This program will supplement the existing CAL/OTA Focus program, which executes every 2 months in F410M, and will allow us to tie the observations to the WFC3 PSF database and 'phylo' plots which have many more F606W observations.
Description	The bimonthly HST/OTA Focus Monitor uses WFC3/UVIS filter F410M to take shallow subarray exposures of the sparse open cluster NGC188. Phase retrieval (PR) is performed on the stellar images to measure the focus of each exposure in equivalent secondary mirror despace. These focus measurements are used to track the evolution of the focus over months and years. We have combined some of the recent PR results with PR analysis of F410M parallel (to STIS) exposures of a field near 47 Tuc to relate Anderson's phylo PSF metric to despace. This calibration has been applied to additional F410M exposures to track focus evolution, but similar calibration of a much more commonly used UVIS filter, F606W, can greatly improve our ability to perform this tracking. We need to observe a rich cluster with interleaved exposures in F410M and F606W to perform the calibration accurately and efficiently.
Resources: Observations	4 orbits = 1 visit per epoch * 4 epochs. Six deep F410M exposures can be interleaved with five F606W exposures in a single orbit. We propose 4 visits spread over cycle 26 to sample the breathing curve over different ranges of focus. The exposures should be non-interruptible to maximize the number of F606W exposures that can be interpolated across with standard F410M focus measurements. The visits should be interspersed among the bi-monthly visits in the CAL/OTA Focus program to contribute to the tracking of focus trends using F410M.
Resources: Analysis	Supports 100% of UVIS & IR programs. The PI will measure the focus of the F410M exposures using the techniques employed in the CAL/OTA Focus monitor, then use the measured F410M and interpolated F606W focus to calibrate the relationship between focus and Anderson's 'phylo' metrics for F410M and F606W. Anderson will continue to maintain and develop the WFC3 PSF database. Lallo will continue to be involved in PR analysis via the OTA focus monitor.
Products	Improved calibration and new calibration of the phylo-metric-to-focus relation for F410M and F606W, respectively.
Accuracy Goals	Conversion of phylo metric to despace with rms (despace - linear fit) ~ 0.7 microns (including interpolation errors)
Prior Results, ISRs	PR measurements of focus using F410M from the STIS Focus Parallel Measurements programs (STIS ISR 2016-02) and from the standard OTA Focus Monitor. Calibration of the phylo-metric-to-focus relation using these exposures.
Prior Cycle IDs	CAL/OTA: 15001, 14866, 14451; CAL/STIS: 14830, 14425, 14063

WFC3 Focus Cross-calibration: F410M to F606W



Current CAL/OTA field:
NGC188, F410M (228 s)

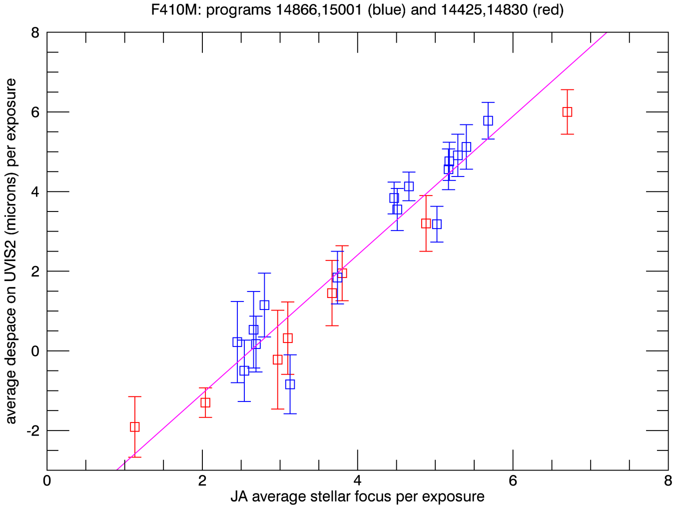


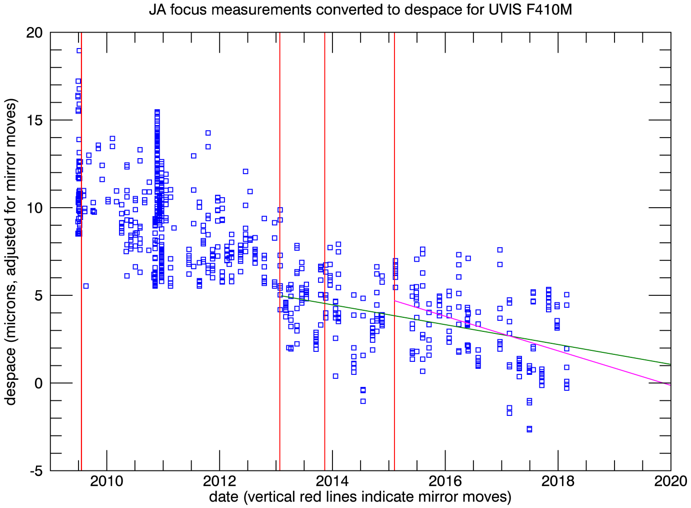
Proposed (STIS field):
47 Tuc Field, F410M (360 s)

The 'HST/OTA Focus Monitor' currently acquires a series of half-chip exposures of NGC188 (50 s in F410M) for phase retrieval (PR) analysis of focus.

The 'STIS Focus Parallel Measurements' programs have acquired series of full detector UVIS exposures of a field 6' NE of 47 Tuc (360 s in F410M).

PR analysis from both programs has been used to relate Anderson's phylo metric to despace (lower left). This relationship has been applied to both UVIS GO and calibration data to track the focus over time (lower right).





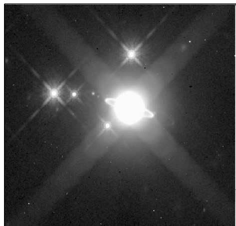
The 47 Tuc field will provide ~100 stars with peak counts >3% full well on the UVIS2 half-chip subarray in F410M in 185 sec. Exposures of equal depth in F606W can be made in 12 sec. Six exposures in F410M can be interleaved with five exposures in F606W in one orbit. PR focus measurements of the F410M exposures will be interpolated to the times of the F606W exposures. Plots like those above will be made for F410M and for F606W. We propose to make 4 one-orbit visits spread over cycle 26 to sample the breathing curve over different ranges of focus and thus increase the focus range that can be calibrated.

WFC3 Short-term IR persistence

*NEW for Cycle 26

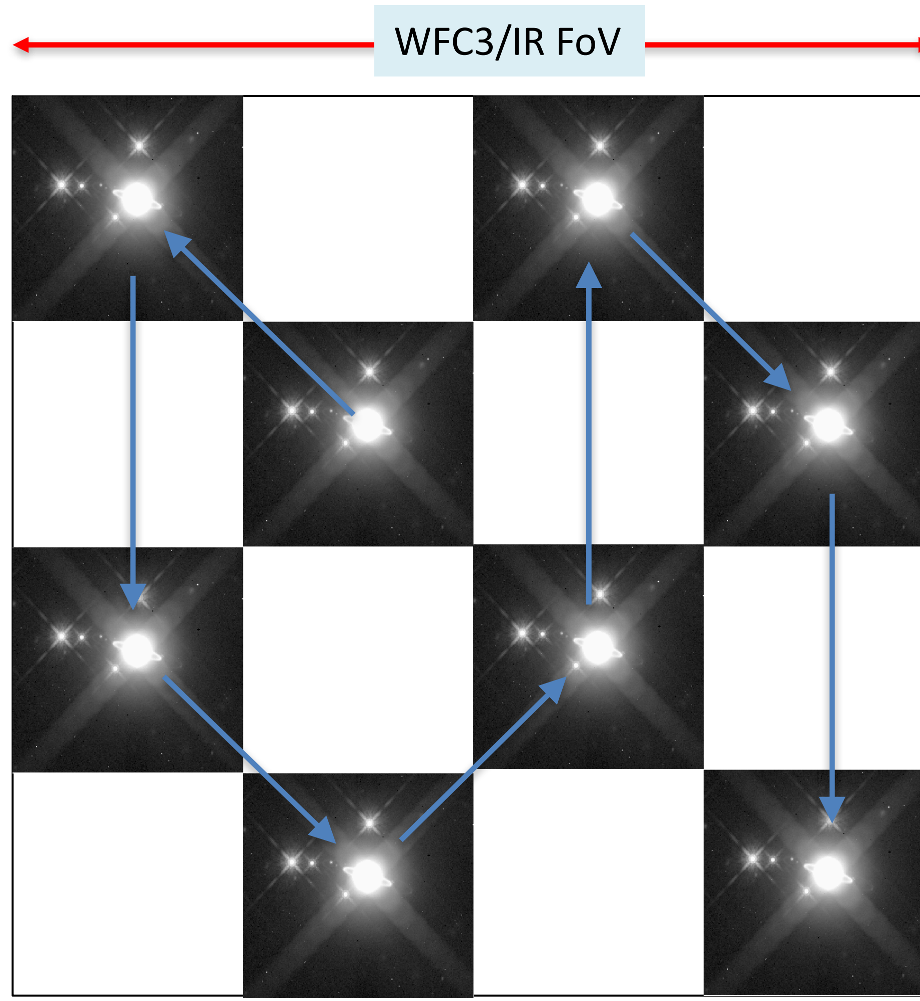
Orbits	External: 2 Internal: 2
PI, Co-I's	Gennaro, Bajaj, Baggett, McCullough, Stevenson
Purpose	Persistence in the IR channel decays as a power law with time for t> 300 s. Using data from Program 14016 (target: the star cluster Westerlund 1), we have observed a tapering of the power law at short times. The analysis of those data is however limited to the darks. The externals proved to suffer of too much crowding, thus making it hard to measure the local background and the persistence signal on top of it. In order to truly exploit the externals and reach the shortest allowed times, we propose to observe a more compact target. This will allow us to have a larger "free" portion of the IR detector, to obtain better sky measurements.
Description	This program consists of multiple multi-accum exposures of Uranus in F127M stepped by ~30 arcsec between exposures. By dithering the detector, we will be able to measure the persistence in pixels stimulated in earlier exposures. The multi-accum exposures are followed by a series of darks to measure the persistence. The darks extend for ~4000 seconds after the externals
Resources: Observations	4 orbits = 1 external (staring mode) + 1 internal (darks) + 1 external (scanning mode) + 1 internal (darks) The external exposures and darks must be carried out as non-interruptible exposures.
Resources: Analysis	Supports all IR programs with bright targets in the field
Products	Improved understanding of short term decay for one specific timing sequence and fluence level
Accuracy Goals	
Prior Results, ISRs	ISR 2018-05: A characterization of persistence at short times in the WFC3/IR detector The prior target, Westerlund 1, is too crowded. A more compact object such a solar system planet will allow i) better background estimates and ii) thanks to larger dithers, while keeping the target within the FoV, we can avoid re-illuminating pixels with bright stimuli (an other problem of the crowded Westerlund 1 target)
Prior Cycle IDs	14016

WFC3 Short-term IR persistence



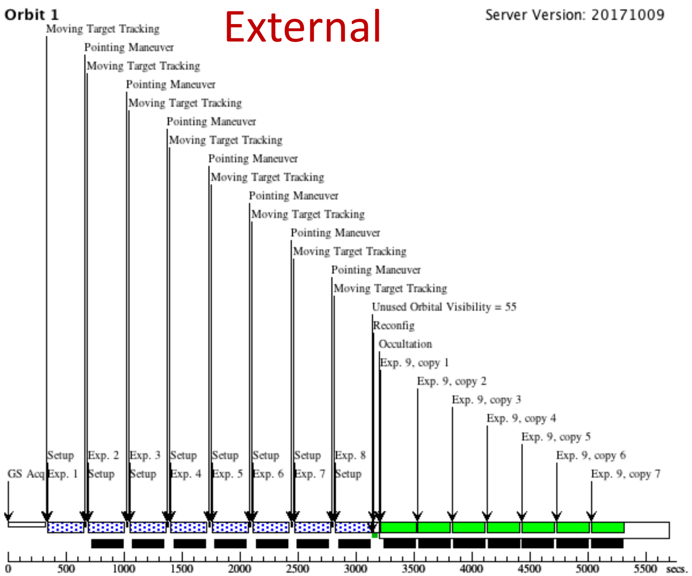
An existing WFC3/IR image of Uranus F125W, IRSUB256

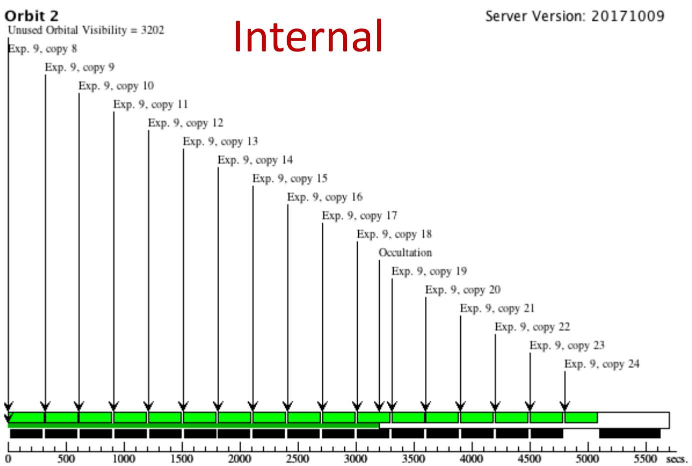
- The measured flux in F125W from the planet is ~5500 e-/s per WFC3/IR pixel
- The number of “useful” stimuli pixels is ~1000 (the moons also provide useful stimuli)
- Using F127M we should reduce the flux by ¼, w.r.t. F125W, providing a fluence of 5 full-wells in a 280 second exposure (NSAMP=12, SAMP-SEQ = SPARS25)



A possible sequence, followed by darks

WFC3 Short-term IR persistence





Mock-up of Phase II

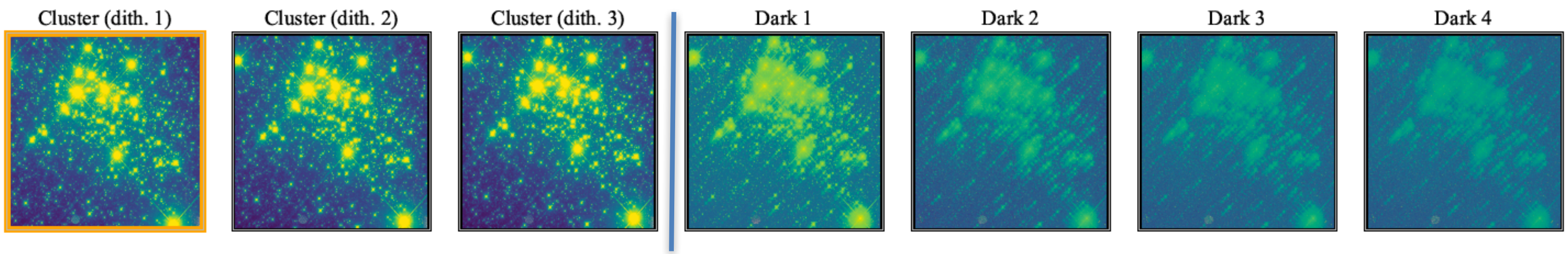
- 8 dithers with SPARS25 (equal time intervals) and NSAMP=12 can be packaged into 1 external orbit
- Given the overheads, the shortest time sampled will be ~55 seconds after the stimulus
- For homogeneity and easier analysis, the dark read sequences will be the same as for the externals

WFC3 Short-term IR persistence

ISR 2018-05

Westerlund 1 observations from Program 14016

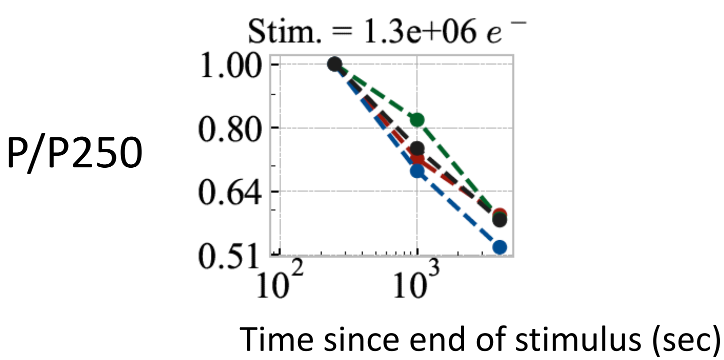
This field is too crowded to do an accurate measurement of persistence at short timescales.
Systematic errors are large due to difficulty accurately estimating the sky level for each source



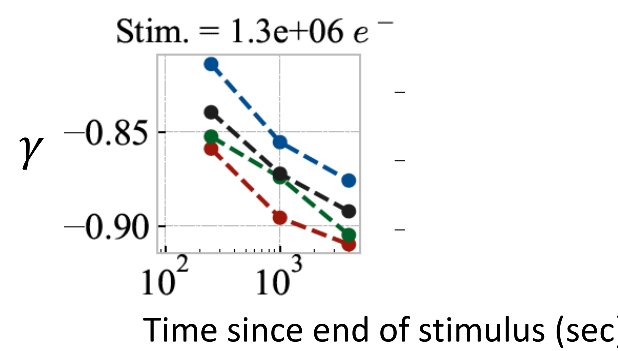
Power law fit overpredicts persistence for δt<300 sec

(This agrees with earlier findings from Long et al.)

P250=(model fit up to 250sec) overpredicts level for later times (since end of stimulus)



Gamma (slope of power law) steepens when later times are included in the fit



WFC3 Monitoring Programs

UVIS CCDs

Same cadence as the prior cycle

Monitor the health and stability of UVIS channel via the following calibration:

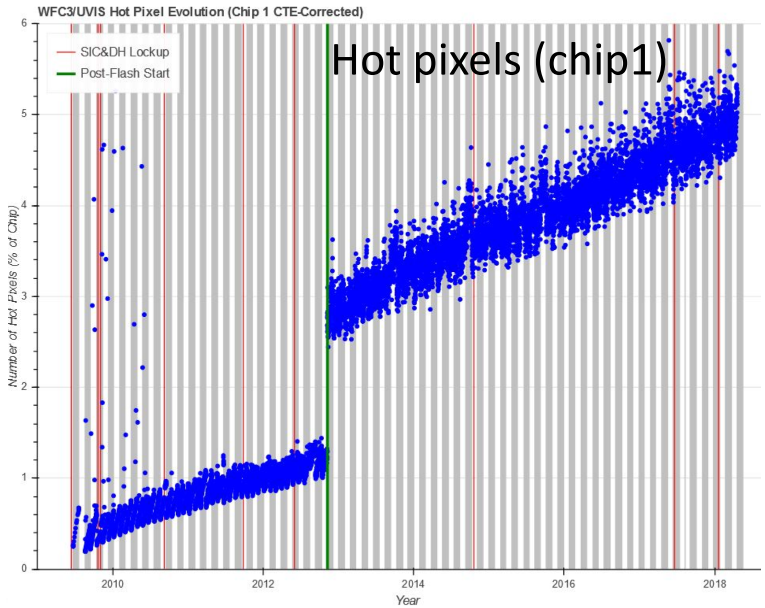
- Perform an anneal of the detector every month
  79 internal = 6 orbits/anneal * 13 anneals + 1 IR dark contingency
- Mitigate hysteresis (bowtie) by conditioning the detector via a series of unsaturated and saturated internal flats
  132 internal = 122 orbits (1 every 3 days) + 10 contingency for SIC&DH lockups
- Perform daily monitoring of the CCDs using a series of dark & biases. Provide updated darks & hot pixel maps
  642 internal = 91 four-day cycles * 7 orbits/cycle = 637 internal orbits + 5 contingency
- Assess how well post-flash is mitigating CTE with time using a series of unflashed darks
  130 internal = 10 orbits/anneal * 13 anneals
- Monitor the stability of the post-flash LED with time
  60 internal = 12 iterations * 3 orbits (pattern + brightness checks) + 12 (ref_files) + 12 contingency
- Verify the gain stability in all 4 UVIS quadrants for each binning mode using internal flats over a range of exposures
  18 internal = 9 orbits * 2 epochs

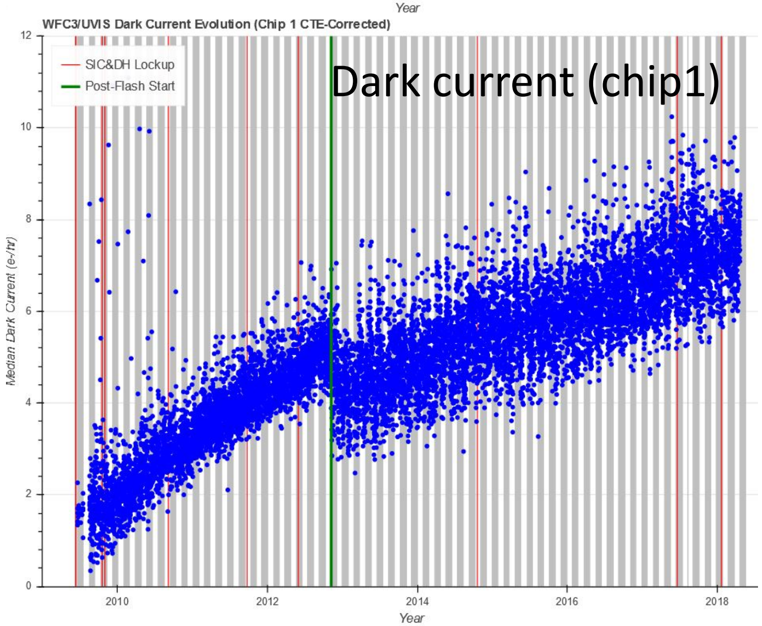
WFC3/UVIS Anneal

Orbits	External: 0 Internal: 79
PI, Co-I's	Baggett, Martlin, Bourque, Khandrika
Purpose	Perform regular anneal procedures to 1) repair hot pixels and 2) acquire internal exposures to assess the anneal's effectiveness as well as produce reference files for the calibration pipeline.
Description	WFC3 anneals are performed every 28 days, a cadence which interleaves the WFC3 procedure with those from other instruments, one instrument per week. Internal biases as well as darks are taken before and after each procedure to provide a check of bias level, read noise, global dark current, and hot pixel population. A bowtie visit is acquired immediately after each anneal to provide a hysteresis-neutralizing image as well as verify that any hysteresis present has been successfully quenched. The Cycle 25 WFC3 anneals have been performed keeping the IR detector cold (IRTEMP=COLD). In Cycle 26, one iteration may be executed according to the original anneal procedure commanding which includes a partial warming of the IR detector; in that event, one post-anneal IR dark will be needed.
Resources: Observations	79 total = (13 iterations * 6 orbits/iteration) + 1 orbit. Each iteration requires 6 orbits (2 before/2 after each anneal for biases/darks + 1 orbit for the anneal itself + 1 orbit for the attached post-anneal bowtie visit). Seamless continuity across the cycle boundary requires 13 anneals. One orbit for 1 IR dark to be taken *only* in the event an original anneal procedure (warming the IR detector) is performed in Cycle 26.
Resources: Analysis	Supports 100% of UVIS programs
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_darks QL plots, tables: read noise, dark current, hot pixels. Data in use for pixel history analysis. Daily superdarks (CTE-corrected and un-CTE-corrected) and yearly superbiases for calibration pipeline.
Accuracy Goals	Readnoise to <1%; dark reference files ~2e-/hr rms; bias reference files <1e- rms
Prior Results, ISRs	ISR 2017-23 (New Bias Reffiles); ISR 2017-17(Read Noise) In progress: pixel history analysis.
Prior Cycle IDs	12343, 12687, 13071, 13554, 14000, 14366, 14529, 14978, 15567

WFC3/UVIS Anneal

Quicklook https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_darks

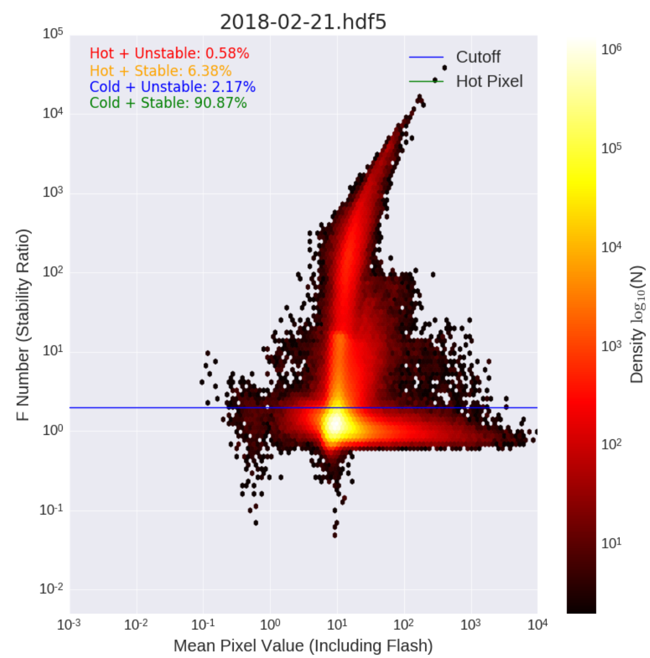




Reference files for CRDS

- biasfile ---- Bias Frame
  - hst_wfc3_biasfile_0254.rmap
- darkfile ---- Dark Frame
  - hst_wfc3_darkfile_0369.rmap
- drkcfile ---- Cte Corrected Dark
  - hst_wfc3_drkcfile_0079.rmap

Pixel history analysis

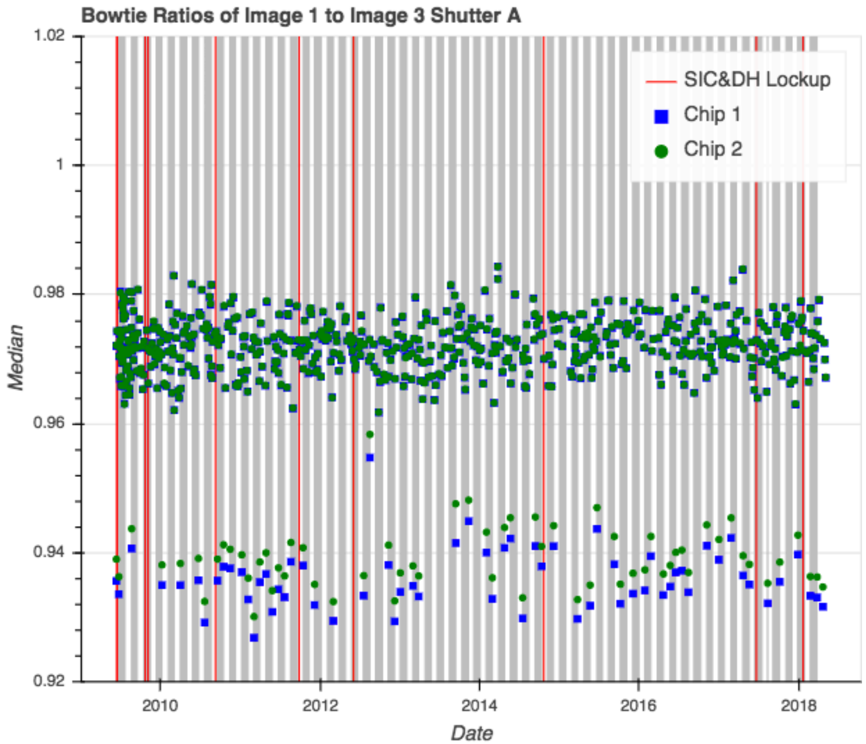


UVIS Bowtie Monitor

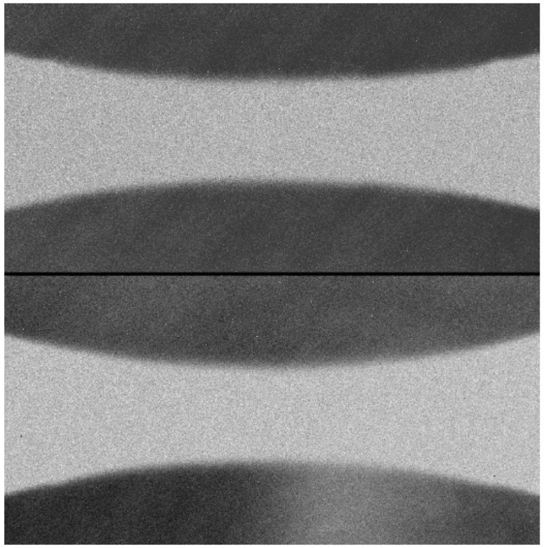
Orbits	External:0 Internal: 132
PI, Co-I's	Kurtz, Baggett, Sunnquist, Khandrika
Purpose	Condition UVIS detector for science observing. During TV internal flat testing, it was discovered that the UVIS detector exhibits occasional low-level (~1%) quantum efficiency offsets (i.e. hysteresis) across both chips, an effect dubbed 'bowtie' due to its unique shape in the image ratios. The ground tests revealed that hysteresis can be negated by overexposing the detector by several times the full well. This multi-cycle monitoring program was developed to detect and mitigate UVIS hysteresis on orbit.
Description	Each visit acquires a set of three 3X3 binned internal Tungsten flats. These include (1) an unsaturated image to check for hysteresis features, (2) a saturated 'QE pinning' exposure to fill traps and mitigate QE offsets, and (3) an additional unsaturated image to assess the hysteresis removal efficiency. The F475X filter was selected for (1) its high throughput, (2) its bandpass (<700nm), which is known to mitigate hysteresis and (3) its status as a low-priority filter for science observations.
Resources: Observations	365/3 days= 122 orbits + 10 extra for SIC&DH lockups Three internal flats every 3 days using the F475X filter.
Resources: Analysis	Supports 100% of UVIS programs Analysis includes inspecting unsaturated frames and image ratios, identifying trends in image ratios over time, quantifying the efficiency of the neutralizing exposure, and investigating anomalies. Investigate shutter 'strobe effect.'
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_bowtie Ratio of the first to the third image in a set visit. Plot to track the bowtie with time.
Accuracy Goals	
Prior Results, ISRs	ISR 2018-xx in prep. (UVIS Shutter). ISR 2017-08 (Relative Gain) ISR 2013-09 (Bowtie), ISR 2009-24 (Bowtie)
Prior Cycle IDs	12344, 12688, 13072, 13555, 14001, 14367, 14530, 14979, 15568

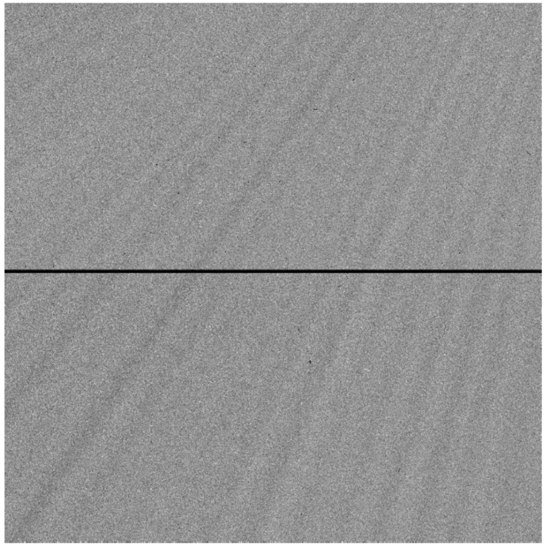
UVIS Bowtie Monitor

Quicklook:
https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_bowtie



Bowtie effect (im1/im3)





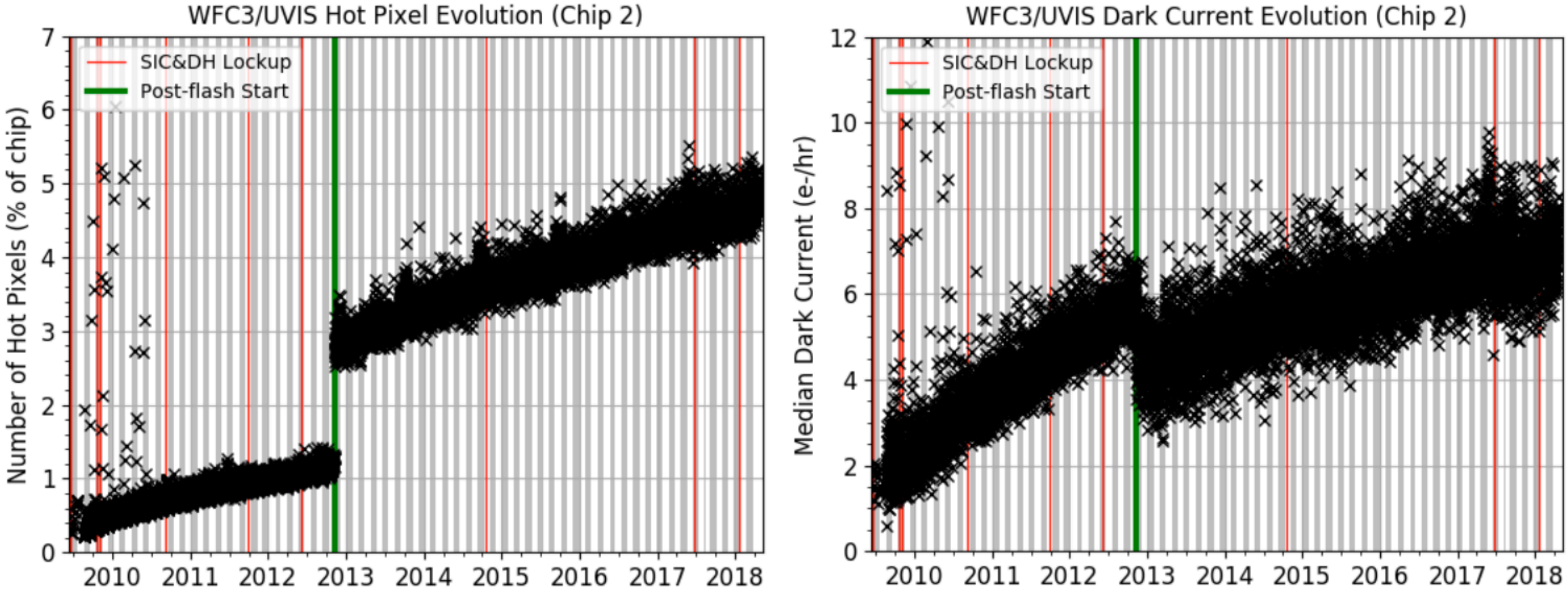
Shutter strobe effect: (variation in blade speed) Stretch is +/- 0.25%

UVIS CCD Daily Monitor A,B,C

Orbits	External: 0 Internal: 642
PI, Co-I's	Martlin, Khandrika
Purpose	Continue to monitor the behavior of the UVIS CCDs with a daily set of bias and/or dark frames. These data will be used to generate bias and dark reference files for CRDS. These reference files are used to calibrate all WFC3/UVIS images.
Description	The internals are acquired using a pattern of single-orbit visits repeated every 4 days (see below). All darks are 900 seconds in duration and all exposures are post-flashed. A small number of un-flashed darks are requested in a separate proposal. Day1 – 2 visits: one with 2 biases, one with 2 darks. Day2 – 2 visits: each with 2 darks Day3 – 1 visit: 2 darks. Day4 – 2 visits: each with 2 darks. All non-Day1-Visit-darks use "no-move" darks (i.e. TARGNAME=DARK-NM) in which the CSM is not moved to the IR position and a narrow-band filter configuration is employed to reduce any scattered light. Since Day1-Visit1 visits start with biases, and thus the CSM is in the IR position, these darks do not have to be "no-move" nor does a narrow filter have to be employed. Several different filters are used in order to distribute usage across multiple wheels to avoid overuse of any one.
Resources: Observations	642 orbits = (91 four-day cycles * 7 orbits/cycle) + 5 contingency orbits
Resources: Analysis	Supports 100% of UVIS programs
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_darks Reference files: Dark (*drk.fits, *dkc.fits) and bias (*bia.fits)
Accuracy Goals	
Prior Results, ISRs	ISR 2017-23: WFC3/UVIS: Bias Reference Files Analysis ISR 2014-04, ISR 2016-08 (darks), ISR 2015-13 (read noise)
Prior Cycle IDs	12342, 12689, 13073, 13556, 14002/03/04, 14368/69/70, 14531/32/33, 14980/81/82, 15569/70,71

UVIS CCD Daily Monitor A,B,C

Quicklook https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_darks



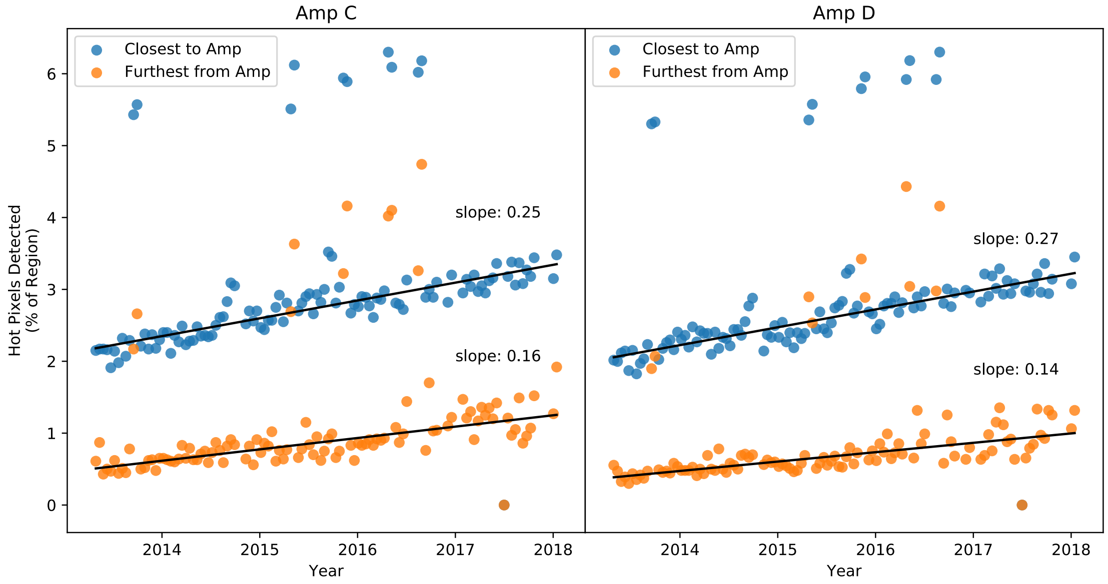
The CTE-corrected hot pixel evolution (left) and the CTE-corrected dark current evolution (right) for UVIS2 since the installation of WFC3. The gray/white regions indicate anneal cycles.
The green line is the implementation of post-flashing.

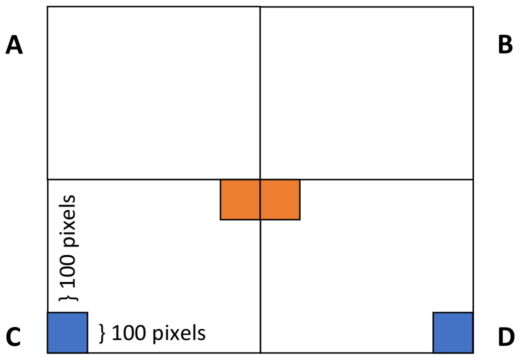
UVIS Un-flashed (CTE) Monitor

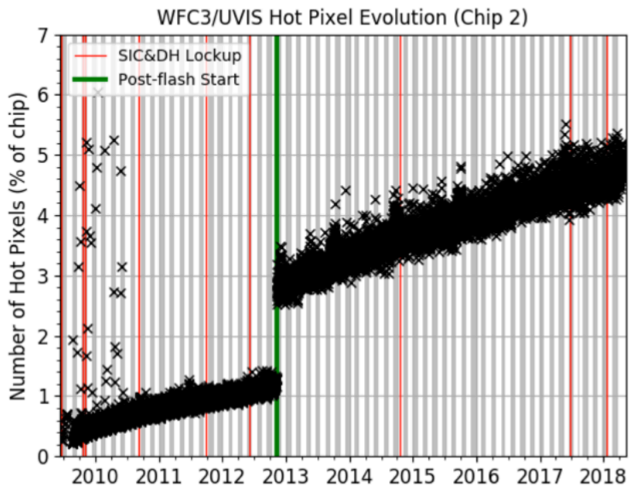
Orbits	External: 0 Internal: 130
PI, Co-I's	Khandrika, Medina, Baggett
Purpose	Obtain un-flashed darks to monitor how well the post-flash is mitigating CTE and to measure the growth of hot pixels observed exposures with low background
Description	Temporal changes in CTE losses and the efficacy of the post-flash mode are monitored by a series of WFC3/UVIS darks (with no post-flash) taken before and after the monthly UVIS anneal. A large number of internals are taken as part of a daily monitor of warm/hot pixel growth and read noise, however they are all post-flashed. Thus, a small number of un-flashed internals are required to monitor the changes in CTE losses over with time. When used conjunction with the post-flashed internals, the un-flashed internals allow for an assessment of how well the post-flash is mitigating the CTE losses.
Resources: Observations	130 orbits = 13 anneals * 10 orbits per anneal =(5 orbits pre-anneal + 5 orbits post-anneal, where each orbit consists of a single 900s dark)
Resources: Analysis	Supports 100% of UVIS programs, but provides the most value for data taken with low backgrounds
Products	Confirmation that post-flash is effectively mitigating CTE losses
Accuracy Goals	
Prior Results, ISRs	ISR 2018-xx, in prep. (Medina)
Prior Cycle IDs	Reduced data (see plot): 14005 (cy22=2014), 13559 (cy21=2013) Newer data: 15572 (cy26=2018), 14983 (cy25=2017), 14534 (cy24=2016), 14371 (cy23=2015)

UVIS Un-flashed (CTE) Monitor

Hot pixel fraction vs Date (near and far from readout amplifiers)







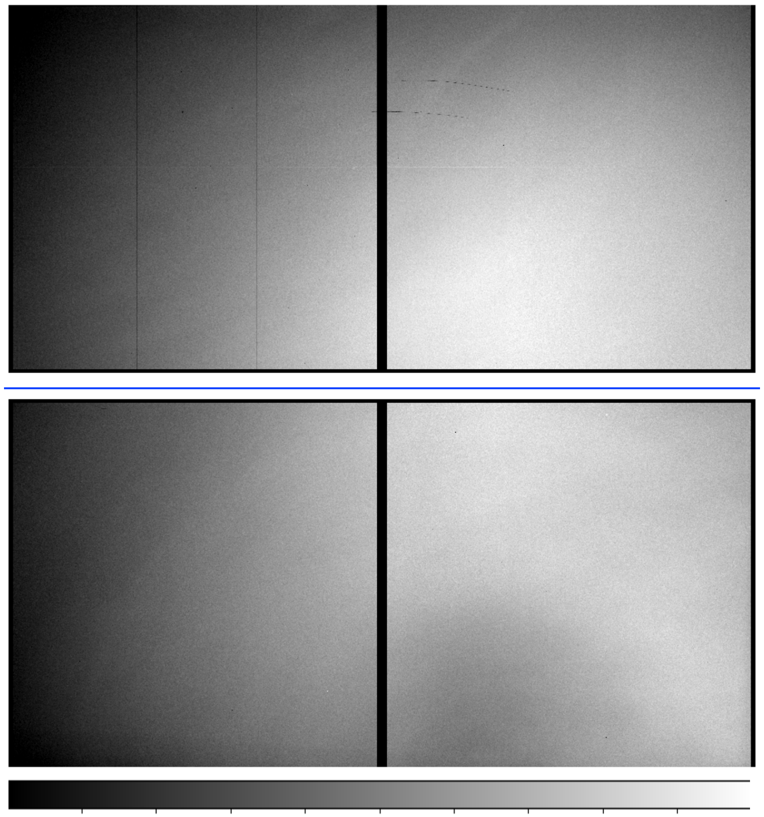
Comparison with Hot pixel fraction from Daily Monitor
(2009-2013 = Unflashed data)
(2013-2018 = Flashed data)

UVIS Post-Flash Monitor

Orbits	External: 0 Internal: 60
PI, Co-I's	Martlin, Kurtz, Khandrika
Purpose	The flux and illumination pattern of the post-flash LED is monitored over time. The data are used to also create a series of post-flash reference files for the calibration pipeline.
Description	Most observers with low-background (<12e-) data are now using the post-flash mode in WFC3/UVIS. We propose to continue the monthly monitoring of the lamp characteristics plus sufficient orbits to allow new generation of post-flash CRDS reference files to be created in the future. Each iteration of the monitor needs 3 orbits – two obtain high S/N flashed full-frames for both shutter blades to check for pattern changes. One obtains a 1kx1k subarray taken at a variety of post-flash levels to check on the brightness stability of the lamp. For the new reference files, 12 orbits are needed. Furthermore, in the event the LED illumination pattern changes more rapidly than expected 12 more orbits would be needed – if the pattern stays stable then they will not be needed.
Resources: Observations	60 orbits = 36+12+12 =3 orbits/month*12 months (brightness & pattern checks) +12 (new reference file) +12 (contingency)
Resources: Analysis	100% of UVIS programs (flash used to make darks) PI to analyze subarray data @12e, Co-I to analyze long ext medium current (used to make reffiles)
Products	Post-flash reference files FLSHFILE = (*fls.fits)
Accuracy Goals	
Prior Results, ISRs	ISR 2017-13 (FLS reference files), ISR 2017-03 (lamp stability) ISR 2013-12 (flash calibration), ISR 2003-01 (flash vs charge injection to mitigate CTE)
Prior Cycle IDs	13078, 13560, 14006, 14372, 14535, 14984, 15573

UVIS Post-Flash Monitor –

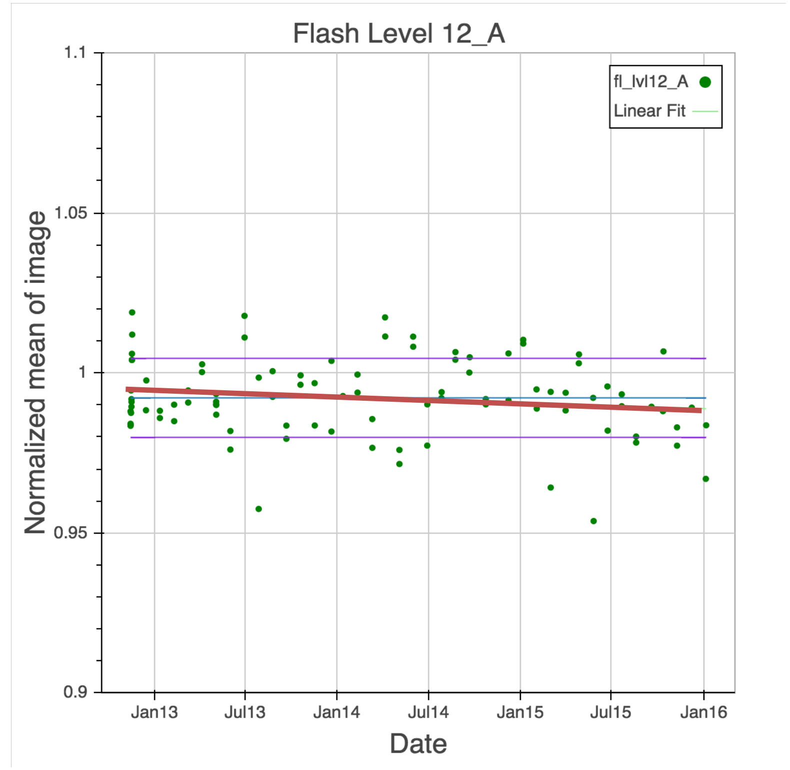
FLSHFILE Reference File:
Shutter A, Medium current



60 e-/s   90 e-/s

ISR 2017-13

Post-Flash LED Lamp Stability :
Normalized mean post-flash vs time with the flash level (12e-/pix). The maximum change (red line) is 0.4%/year, which is <1 e-/pix over 3 years.



ISR 2017-03

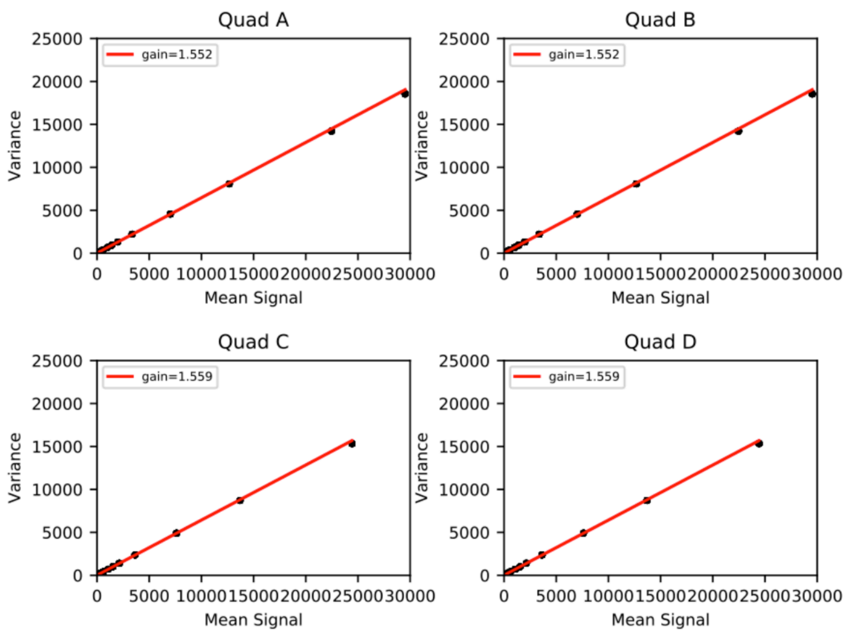
UVIS Gain Stability

Orbits	External: 0 Internal: 18
PI, Co-I's	Fowler, Martlin, Khandrika
Purpose	Monitor the absolute gain for the nominal detector count.
Description	Observations consist of 8 pairs of full-frame binned (2x2 and 3x3) and un-binned internal flats at nominal gain. Two epochs, 9 orbits each, are request to be taken ~6 months apart. Six of these orbits will be for sampling the unbinned mode in order to increase the sampling at the lower signal levels.
Resources: Observations	18 orbits = 2 epochs * 9 orbits per epoch Each epoch has 6 full-frame internal flatfields, and 3 binned exposures (2x2 and 3x3) taken in the F645N filter with the tungsten lamp, with varying exposure times.
Resources: Analysis	Supports 100% of UVIS programs Analysis using the standard mean-variance technique. Reduce any difference in the calibrated images across amplifiers for binned proposals. Reduction software requires removal of IRAF dependencies (linear fitting)
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_gain https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_bowtie Improved gain coefficients for CALWF3.
Accuracy Goals	Measure gain to better than 1%
Prior Results, ISRs	ISR 2016-13: (Cy23 Gain): Consistent to within ~1-2% of Cy22. ISR 2016-09, ISR 2015-05, ISR 2014-05, ISR 2013-02, ISR 2011-13, ISR 2009-29
Prior Cycle IDs	11906, 12346, 12690, 13168, 13561, 14007, 14373 (Cycle 23 ISR) 14536 (Cy24 within 1% of cy23), Cy25= 14985, Cy26=15574

UVIS Gain Stability

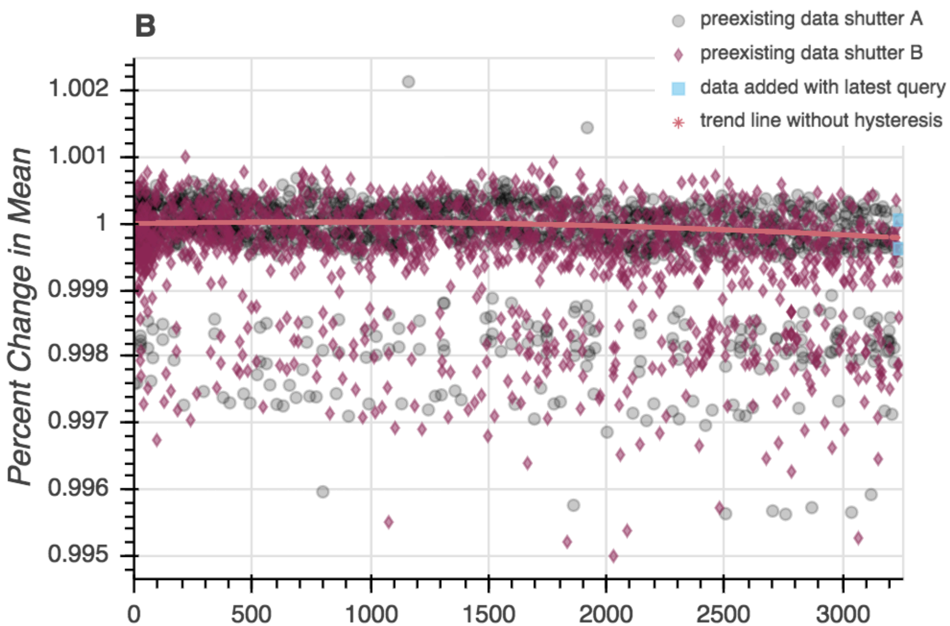
Quicklook:
https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_gain
https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_bowtie

Mean Signal (DN) vs Variance



Plots from June 2017 reduction

Gain Ratio Stability (amp B/A) vs Time (days)



CTE Characterization and Calibration

Same cadence as the prior cycle

As in Cycles 20–25, GOs can mitigate CTI effects using post-flash. To support these efforts we request the following calibration:

- Measure and monitor CTE via Extended Pixel Edge Response (EPER)
  12 internal = 2 orbits/epoch * 6 epochs

- Observe stellar fields characterized by different crowding (47 Tuc and one in NGC 6791) and background (0 to 12 electrons flash) to calibrate the photometric and astrometric CTI corrections.
  8 external = 4 orbits/epoch * 2 epochs

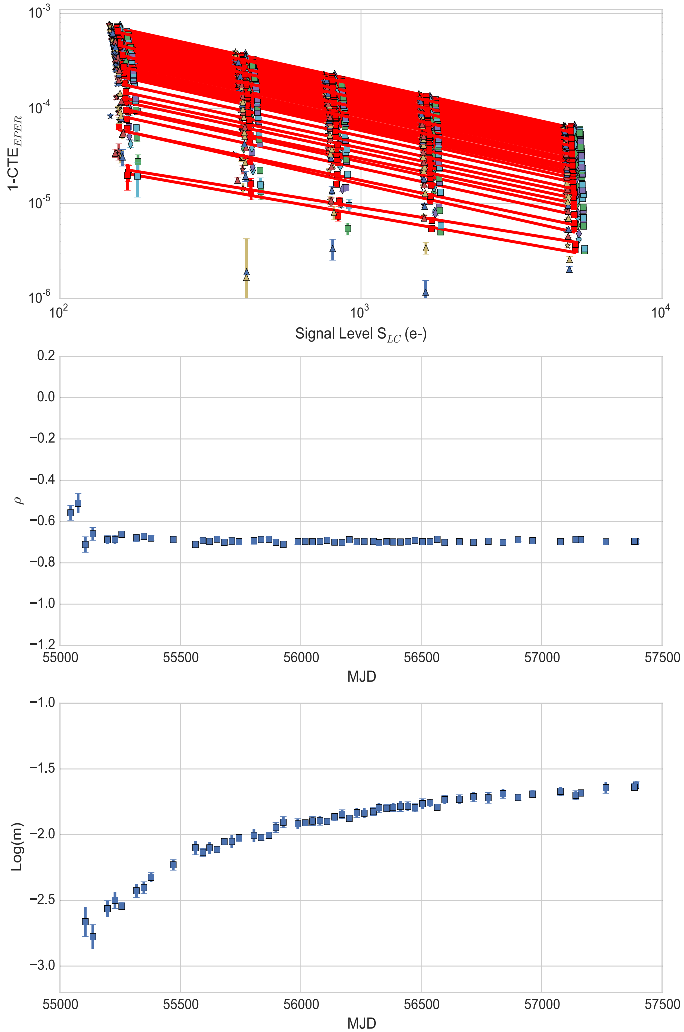
- Use charge-injected bias to monitor the length of the CTE trails. This information will be used as an input for J. Anderson's CTE algorithm.
  36+3 internal = 1 orbit every ~10 days (ADD ~3 orbits to cover Oct 2018 gap in Cy25)

WFC3/UVIS CTI Monitor (EPER)

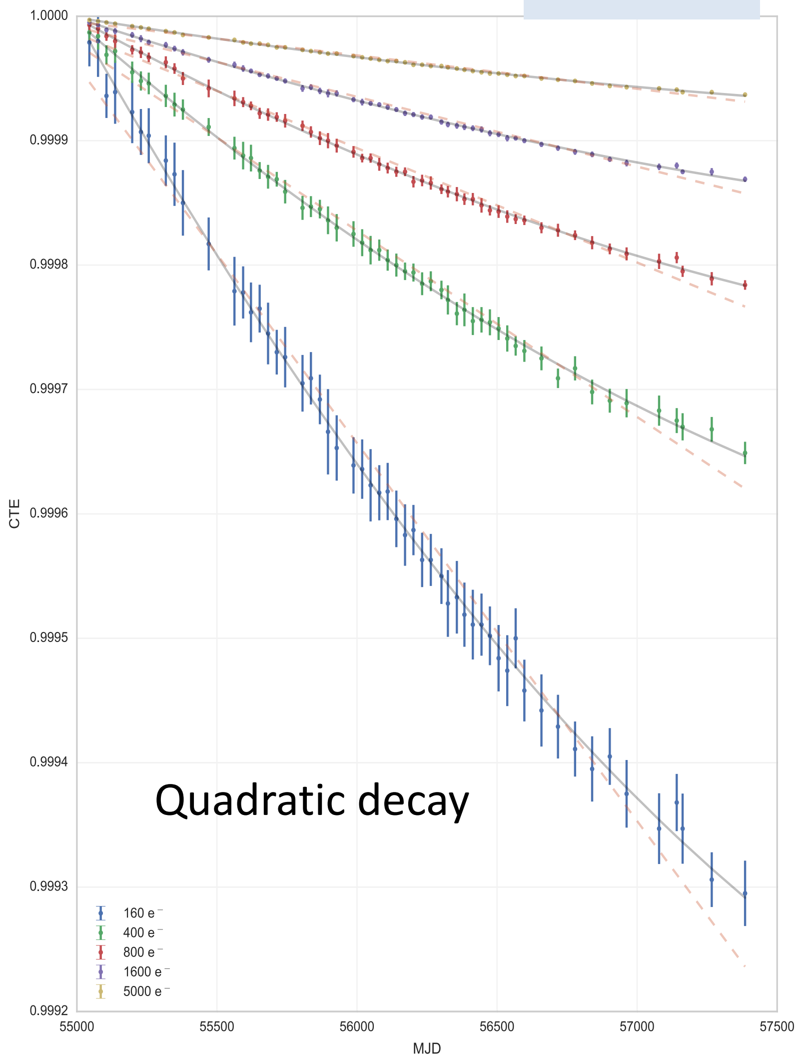
Orbits	External: 0 Internal: 12
PI, Co-I's	Fowler, Khandrika
Purpose	(1) Measure the UVIS CCD Charge Transfer Inefficiency (CTI) using the Extended Pixel Edge Response (EPER) method. (2) Assess CTE losses over time in a continuation of the multi-cycle CTE monitor.
Description	12 internal orbits (2 every other month) are used to assess the profiles of excess charge in the extended pixel region of the special EPER readout format and monitor the CTI of WFC3/UVIS. Each visit-pair obtains internal lamp flat field at a variety of illumination levels as well as two short dark exposures to be used as a bias measurement. A visit-pair is taken approximately every 9 weeks over the span of a year.
Resources: Observations	12 orbits = 6 epochs, each consisting of a 2 visit (orbit) pair Visit 1 = 1 dark+ 2 tungsten flats (F390M), Visit 2 = 1 dark+ 1 tungsten flats (F390W) + 2 tungsten flats (F438W).
Resources: Analysis	Supports 100% of UVIS observations, especially faint, low background targets Analysis of the extended overscan in comparison to science pixels in the EPER readout mode. Rewriting reduction software (currently in IDL) and tracking changes since 2016
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_eper
Accuracy Goals	
Prior Results, ISRs	ISR 2016-10: WFC3/UVIS EPER CTE Cycles Aug 2009 - Apr 2016 "The Cy23 results show that CTE has degraded by at most 0.07% in 7 years at any illumination level. The CTE degradation is found to be quadratic and seems to be settling with time." ISR 2013-03, ISR 2011-17, ISR 2009-10, ISR 2007-13
Prior Cycle IDs	11924, 12347, 12691, 13082, 13565, 14011, 14377 (Cy23) = in 2016 ISR More recent data: 14540, 14989, 15575

WFC3/UVIS CTI Monitor (EPER)

Quicklook: https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_make_eper



ISR 2016-10



WFC3/UVIS External CTE Monitor: Star Clusters

Orbits	External: 8 Internal: 0
PI, Co-I's	Kurtz (new PI), Fowler, Baggett
Purpose	Monitor CTE degradation as a function of epoch and source/observation parameters. Calibrate photometric corrections. Provide data to test and monitor the pixel-based CTE model.
Description	We continue (from Cy20), using post-flash to sample background levels and monitor the efficacy of the post-flash model for CTE mitigation. Exposures of NGC 6791 and 47 Tuc in F502N (~zero background) will monitor the maximum CTE in different field densities. Long exposures, dithered by 2000 pixels in detector Y, will measure absolute CTE. We sample various background levels to test whether the currently recommended level of 12 e- still yields the best charge transfer. The data are also used to test the effectiveness of the pixel-based CTE correction software.
Resources: Observations	8 orbits = 2 epochs * 4 orbits each Images in the F502N filter of the two star clusters NGC 104 and NGC 6791 with 0 and 12 flash level. (One orbit for NGC 6791 and three for 47 Tuc (observed in five different non-zero background level).
Resources: Analysis	Supports 100% of UVIS programs Analyze how the photometry of point sources within (dense and sparse) star clusters changes at different detector orientations. Test for overcorrection of pixel-based CTE correction in *flc files. Significant modifications required to data reduction pipeline, including IRAF dependency (e.g. centroiding)
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_external_cte CTE coefficients. Test of efficacy of pixel-based CTE correction, test of recommended background level.
Accuracy Goals	
Prior Results, ISRs	ISR 2017-09: 'External CTE Monitor: 2016 Updates on Coefficients and Analysis Pipeline' Results from 2017 noticed a 5-15% flux loss from CTE depending on source. ISR 2011-06, ISR 2012-09, ISR 2015-03, ISR 2016-17
Prior Cycle IDs	12379, 12692, 13083, 13566, 14012, 14378 (through 2016 in ISR) Pending analysis: 14541, 14990, 15576

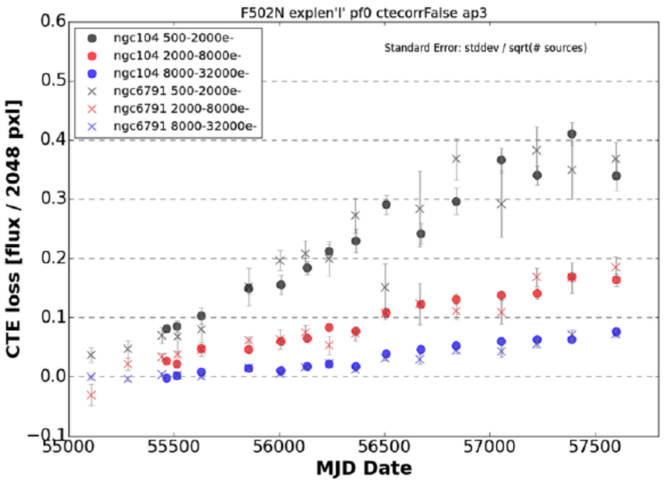
WFC3/UVIS External CTE Monitor: Star Clusters

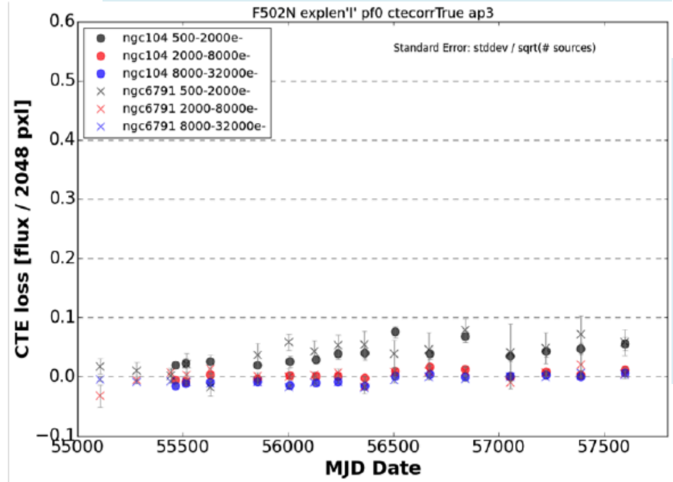
ISR 2017-09

No CTE-corr

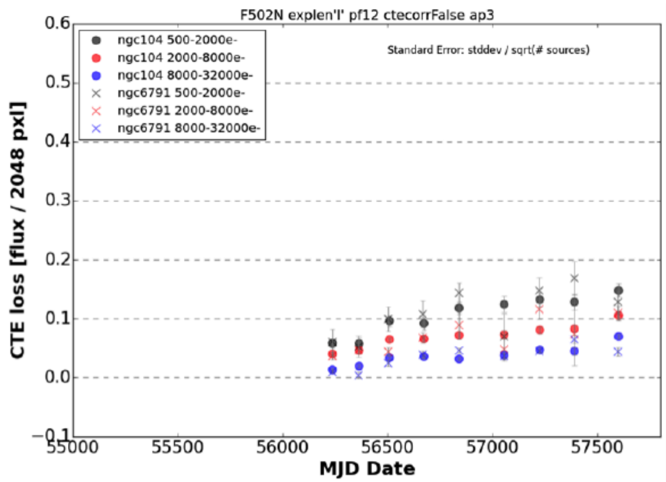
With pixel-based CTE-corr

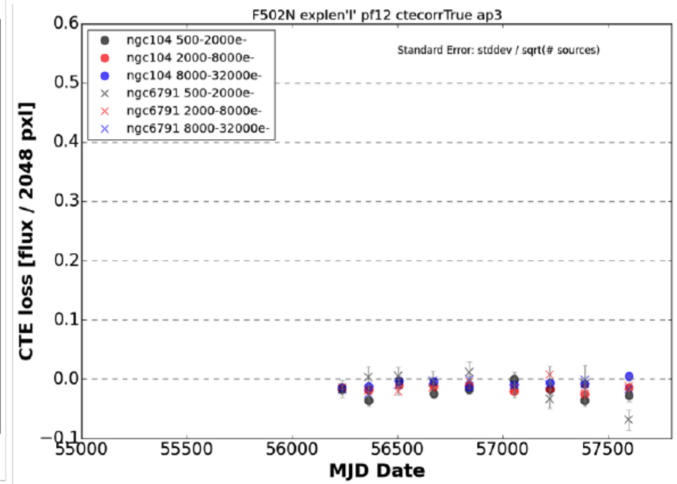
No post-flash





Post-flash: 12e-/pix





UVIS Traps with Charge Injection

Orbits	External:0 Internal: 36 + (3) (Cy25 is scheduled through Oct 1st. Need an extra month of data)
PI, Co-I's	Medina (new PI), Kurtz, Khandrika
Purpose	This program is designed to monitor the UVIS trap growth via charge-injected biases
Description	The charge transfer efficiency (CTE) of the WFC3/UVIS channel continues to decline as damage from radiation accumulates. One method to mitigate the impact of CTE losses is to apply a pixel-based CTE correction algorithm the images after they are acquired. An algorithm such as this requires a detailed knowledge of the traps, which capture and release charge during the image readouts. This program will identify and characterize the traps responsible for the charge losses, map their distributions across the chips, and monitor their growth over time.
Resources: Observations	36 orbits = 1 orbit of 'line 25' charge injected biases every 10 days + 3 orbits for cycle boundary mismatch To aid the schedulers, each visit will have a 5 day window to be executed.
Resources: Analysis	0% of GO programs currently use CI, but it is a useful way to monitor the CCD degradation. PI will utilize pixel history code developed by Bourque & Anderson. (Software still being developed)
Products	
Accuracy Goals	
Prior Results, ISRs	ISR 2011-02: WFC3/UVIS Charge Injection Behavior: Results of an Initial Test (Bushhouse) The team still needs to analyze the most recent data.
Prior Cycle IDs	ISR 2011: Program 12348, Pending reduction: 12693, 13084, 13569, 14013, 14379,14542, 14991, 15577

UVIS Traps with Charge Injection

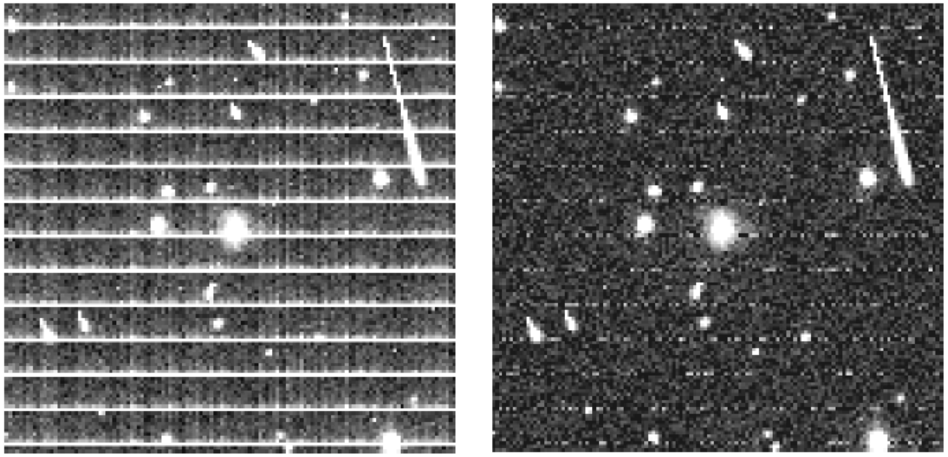
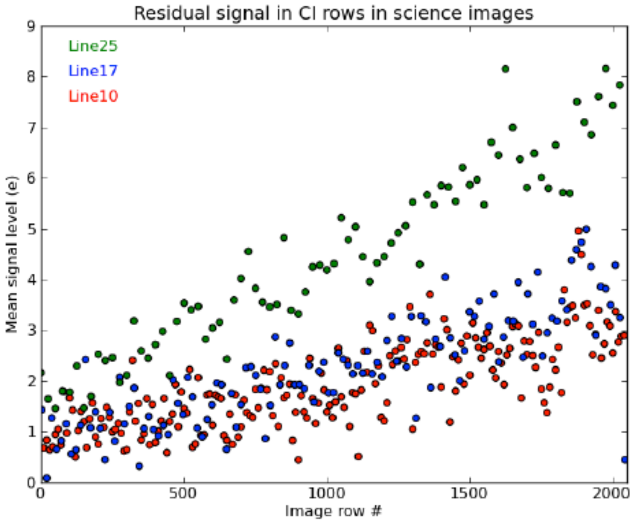


Figure 8: Portion of an NGC 104 exposure without (left) and with (right) CI subtraction. Both images are shown with a hard intensity stretch to highlight the low-level CI signal residuals.



2011-02

Figure 9: Mean residual signal in CI-subtracted rows of science images for each LINE mode. Only the data for CCD chip 2 is shown; chip 1 behavior is the same.

IR Detector

Same cadence as the prior cycle

Monitor the health and stability of IR channel and verify the non-linearity correction:

- Obtain IR darks. The number of orbits is dictated by observing modes most-requested by GOs.
  97 internal orbits = 26 orbits (SPARS200, every 2 weeks) + 71 orbits (other samp-seq/apertures)

- Monitor the IR non-linearity by obtaining saturated internal flats
  10 internal orbits = 10 orbits in F127M (half SPARS25, half SPARS10) * 1 epoch/year

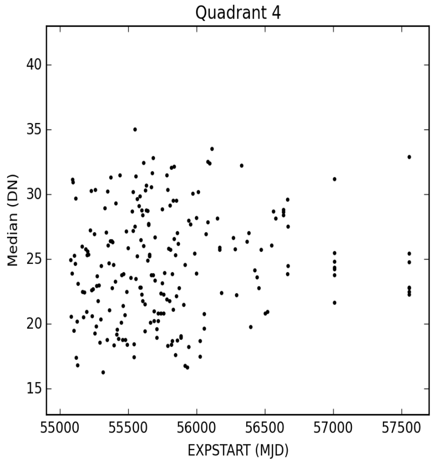
- Verify the stability of the IR channel gain via a series of lamp flats
  16 internal orbits = 8 orbits * 2 epochs/year

IR Dark Monitor

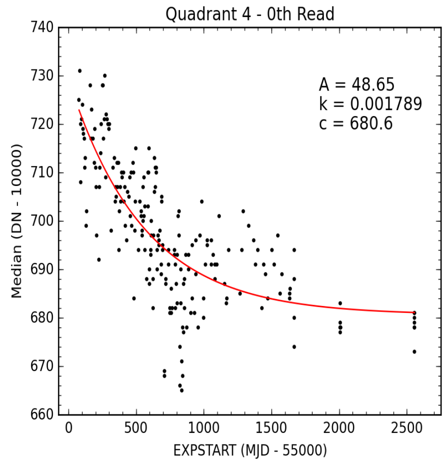
Orbits	External: 0 Internal: 97
PI, Co-I's	Sunnquist, Mckay, Ryan
Purpose	This program acquires a variety of WFC3/IR darks to support the removal and study of dark current. SPARS200 dark observations are periodically obtained to monitor trends in the bad pixels (hot, unstable, or dead), zeroth read level, and dark current. The remaining orbits collect dark ramps for generating stacked IR dark calibration files for use by the MAST pipeline.
Description	Full-frame and subarray dark images will be collected using each sample sequence. The total number of images collected over the course of the cycle for a given mode is based on the total number of input ramps used in the current superdark for that mode and the popularity of that mode in external science observations. The IR dark current has remained nearly unchanged since launch (ISR 2017-04) which allows for more relaxed scheduling constraints compared to older WFC3/IR dark monitor programs. With the exception of the SPARS200/Full-Frame hot-pixel monitoring observations (~every 2 weeks), the observations have no set scheduling parameters.
Resources: Observations	97 total orbits: 26 orbits of SPARS200 every 2 weeks + 71 orbits spread amongst the other 23 sample sequence/subarray combinations (weighted by usage, with each observed at least 2x/yr and up to 40x/yr) An 1800-sec, non-interruptible hold precedes the observations to protect from persistence.
Resources: Analysis	Supports 100% of IR programs Dark Analysis and BPIXTAB by the PI. DARKFILE delivery by Mckay. Bias levels monitored by QL.
Products	Updated IR dark calibration files (One DARKFILE for each SAMP-SEQ) and IR bad pixel table (BPIXTAB flags for hot pixels, bad in 0^{th} read, unstable)
Accuracy Goals	
Prior Results, ISRs	ISR 2017-24: A Predictive WFC3/IR Dark Current Model ISR 2017-04 (study of dark current variation, zeroth read levels, reference pixels), ISR 2014-06 (updated dark reference files), ISR 2012-11 (dark current stability).
Prior Cycle IDs	11929, 12349, 12695, 13077, 13562, 14008, 14374, 14537, 14986, 15578

IR Dark Monitor

Darks are used to monitor the median IR dark level (left), 0th read level (middle), and vertical reference pixel signal (right) over time. The variation in the median dark rates was studied in ISR 2017-04 and modeled using various WFC3 telemetry parameters in ISR 2017-24.

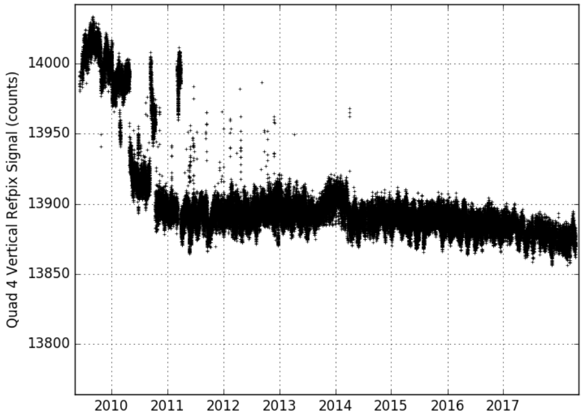


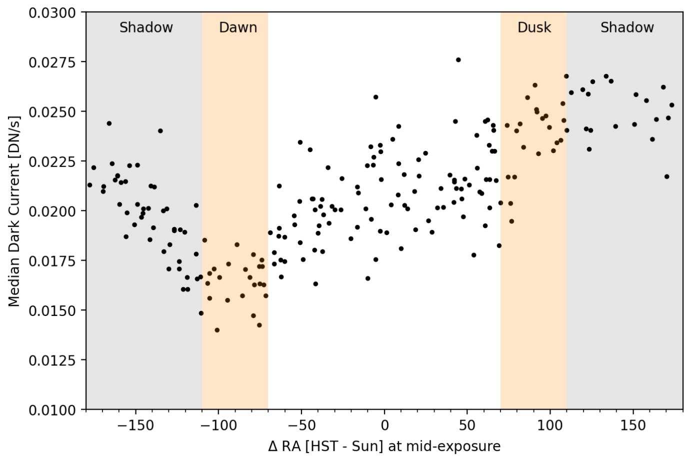
ISR 2017-04, Fig 7



ISR 2017-04, Fig 5

Quicklook:
https://wfc3ql.stsci.edu/automated_outputs/cal_ir_make_bias_plots

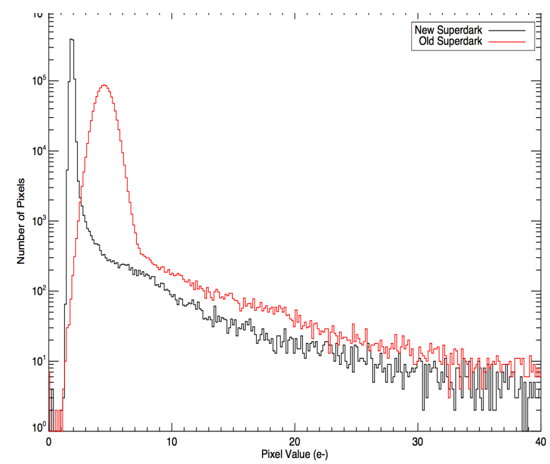




ISR 2017-24, Fig 4

ISR 2014-06, Fig 5

For most modes, the SNR in the improved reference files was ~3-11x higher than in the previous reference files; this reduced the mean error by 44% - 98%.

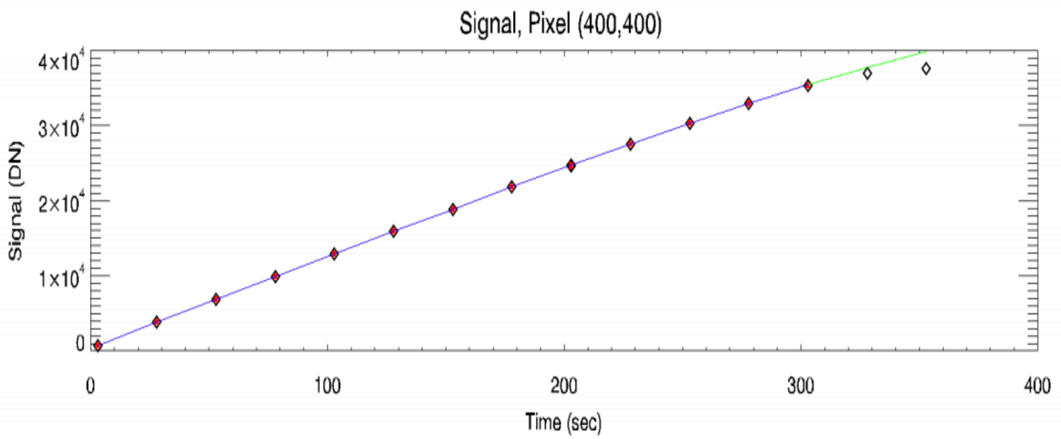


IR Linearity Monitor

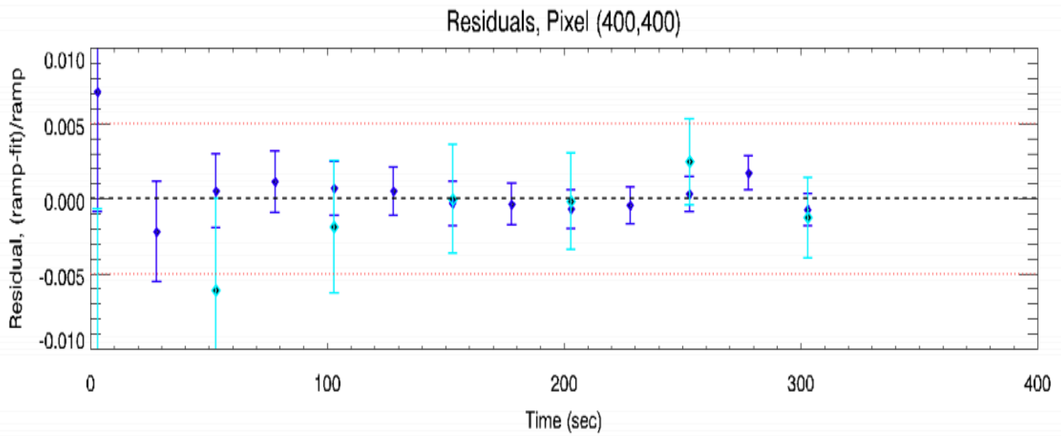
Orbits	External: Internal: 10
PI, Co-I's	Gennaro (new PI), Bajaj, Shanahan, Ryan
Purpose	Monitor the non-linearity of the WFC3/IR detector and track the stability over time
Description	HgCdTe detectors suffer from a non-linear response to incident flux. The calibration pipeline corrects for the effects of non-linearity. This monitor uses flat field ramps to characterize the non-linearity of each detector pixel.
Resources: Observations	10 internal orbits, once per year. Visits are identical in structure and consist of a dark observation followed by two internal flats using the Tungsten lamp through F126N (half SPARS10, half SPARS50) and F127M (half SPARS25, half SPARS10). The initial narrow band flat is used to ensure that the lamp is warm and stable in preparation for the F127M exposure, but not so bright to cause persistence. A trailing dark is obtained after the F127M flat to measure the persistence decay rate.
Resources: Analysis	Supports 100% of IR programs. For each pixel, a polynomial for the full ramp vs. time. The parameters of the appropriate fit are used to define an 'ideal' linear signal rate, and subsequently a measure of fractional linearity for each read. Another curve fit to the measured linearity and signal of each read with tunable parameters is used to find a correction for the non-linear response.
Products	NLINFILE reference file (*lin.fits)
Accuracy Goals	An accurate model of the detectors non-linearity is crucial to correctly calibrating out this effect in the pipeline.
Prior Results, ISRs	ISR 2014-17, Updated non-linearity calibration method for WFC/IR These results are not yet implemented in CALWF3 (This requires simultaneous delivery of IR zpts.)
Prior Cycle IDs	Reduced: Cy18-20: Programs 12352, 12696, 13079 Pending further analysis: Programs 13563, 14009, 14375, 14538, 14987, 15579

IR Linearity Monitor

(Hilbert, ISR 2014-17)



Polynomial fit to signal vs time
for a single detector pixel (red points)



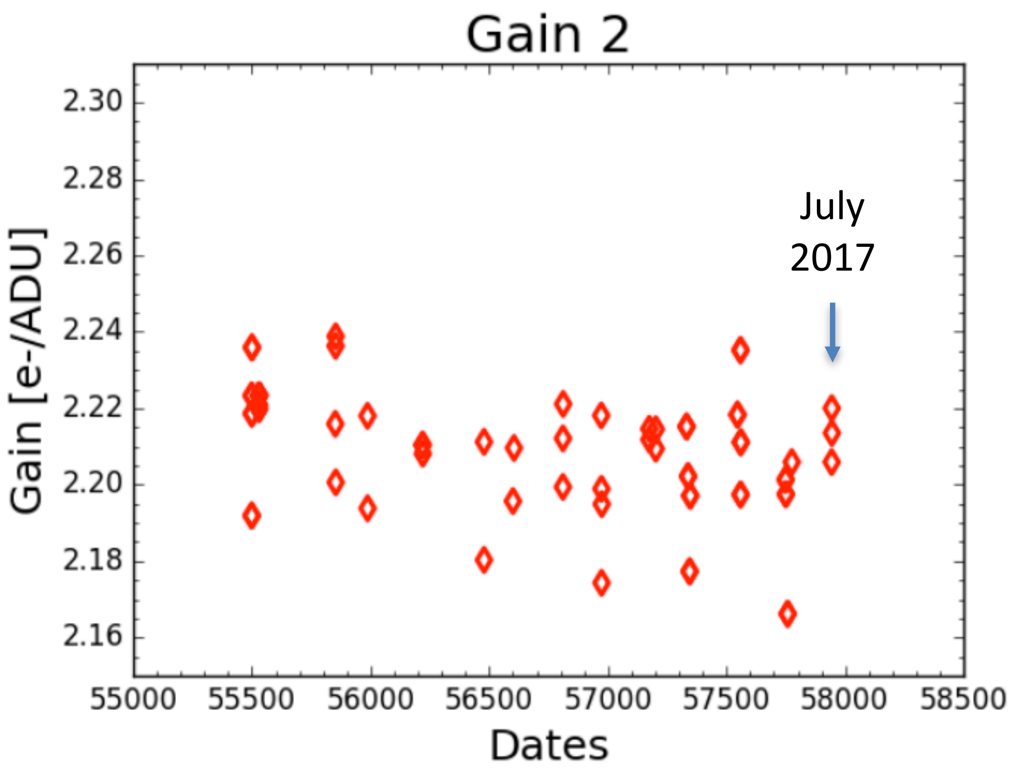
Fit residuals

IR Gain Monitor

Orbits	External: Internal: 16
PI, Co-I's	Khandrika (new PI), Shanahan, Baggett, Ryan
Purpose	Measure the gain in four quadrants of the IR detector twice a year.
Description	Gain, the scaling relation between analog digital units (ADU) and photoelectrons is a fundamental detector parameter. Gain can be measured using the mean-variance method on pairs of internal flats. For each quadrant of the ramp pairs, the mean-variance method is used to calculate the gain.
Resources: Observations	16 internal orbits, 8 in the summer and 8 in the winter. Each visit is identical and begins with a dark, allowing the BLANK to move into position before the lamp is turned on. The Tungsten lamp is turned on, and while the lamp warms a short warm up flat is taken through F126N to ensure a linear signal hits the detector for the duration of the long flat. Next, the long flat field ramp to be used in the gain measurement is taken. Finally, a trailing dark is taken to monitor persistence. Pairs of ramps are observed within 24 hours.
Resources: Analysis	Supports 100% of IR programs. Existing IDL software calculates the gain in each quadrant using the mean-variance method. Needs to be automated to run in QL.
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_ir_gain Measurements of the gain and scatter in gain measurements for each epoch of observations.
Accuracy Goals	The calibration pipeline depends on the gain to relate measured signal to physical units, so ensuring the pipeline value of the gain is consistent with the true detector gain is important to keep this scaling relation accurate
Prior Results, ISRs	ISR 2015-14: WFC3 IR Gain from 2010 to 2015 (cycles 17-22)
Prior Cycle IDs	11930, 12350, 12697, 13080, 13564, 14010 (=Cy 17-22) 14376, 14539, (Cy23,24 results in QL), 14988 (Cy25), 15580 (Cy26)

IR Gain Monitor

QuickLook: https://wfc3ql.stsci.edu/automated_outputs/cal_ir_gain



Gain is calculated via the mean-variance method for each ramp pair VS. MJD.

WFC3 Photometric performance

To verify the UVIS and IR photometric stability:

- Monitor the accuracy of the shutter mechanism after 9+ years of operation

  1 internal orbit (same as last cycle)

- Monitor the photometric throughput with wavelength using both staring mode and scans

  20 external orbits = (10 staring + 10 scans) every ~5 weeks for GRW+70 & GD153 (same as last cycle)

- Check the temporal stability of the zeropoints for both UVIS and IR detectors

  12 external orbits (=1 additional orbit from Cy25 to add GRW+70 in WFC3/IR)

  UVIS: 8 orbits = 4 stars * 2 amps/star * 1 orbit/amp in a subset of 12 filters
  IR: 4 orbits = 4 stars * 1 amp/star * 1 orbit/amp in all filters

UVIS Shutter Monitoring

Orbits	External: 0 Internal: 1
PI, Co-I's	Sahu, Baggett
Purpose	Monitor the performance of the UVIS shutter blades. The specific objectives are: (i) compare the photometric behavior of both shutter blades, for short vs long exposures (ii) check for any shutter shading effects
Description	Internal flats in each of the 4 amps will be used to monitor the repeatability and any shutter shading effects. We will continue to monitor the photometric behavior of blades A and B separately. Internal flats from the bowtie monitoring program provide an additional check of the shutter repeatability. Standard star observations from Cycles 23 & 24 show no noticeable difference in the performance of the shutter compared to SMOV, so no external orbits are requested this cycle.
Resources: Observations	1 internal orbit with the tungsten lamp on each of the 4 amplifiers.
Resources: Analysis	Supports 100% of UVIS programs. The analysis will be carried out by the PI. Internal tungsten lamp exposures will be used to check if count levels are consistent as expected from different exposure times and for both A and B blades.
Products	If the shutter shading is found to be significant, or if the performance of the 2 shutters is found to be different, this would require delivery a new reference file (e.g. SHADFILE) to correct for the behavior.
Accuracy Goals	Cross-calibrate shutters A and B to 0.2%. Monitor the stability to 0.1%
Prior Results, ISRs	From Cy25: The lamp brightness is continuing to decline. The counts from A and B are consistent for 1 and 17 sec exposures. For the 0.48 sec exposures, the results are ambiguous since the lamp was still brightening during the first exposure. (In Cy26, move these to the end of the orbit.) 2015-12 (Sahu), 2014-09 (Sahu), 2009-25 (Hilbert)
Prior Cycle IDs	11427 (SMOV), 14019 (Cy22), 14383 (Cy23), 14882 (Cy24), 15397 (Cy25), 15584 (Cy26)

UVIS Shutter Monitoring

ISR WFC3 2015-12: Internal Lamp exposures

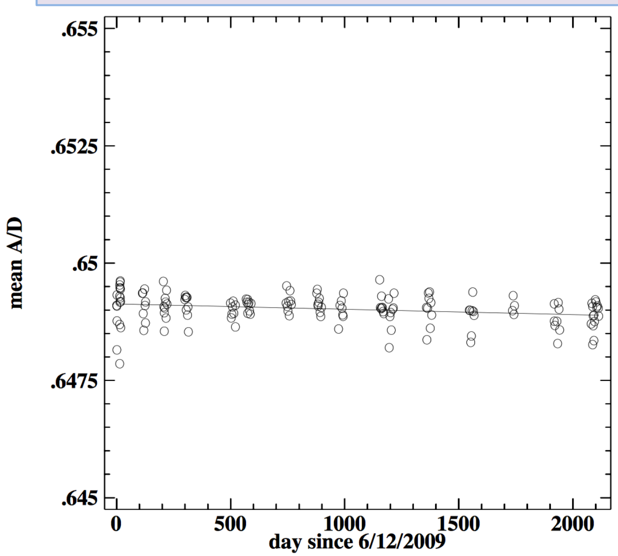
Count ratios as observed during SMOV and Cycle 23 remain constant for all 4 amplifiers, apart from an overall decline in the lamp, demonstrating that there is no change in the shutter shading compared to SMOV. The dispersion in the *long set of exposures (lower-right plot)* is consistent with the shutter shading reported by Hilbert (ISR 2009-25) at <0.1% rms.

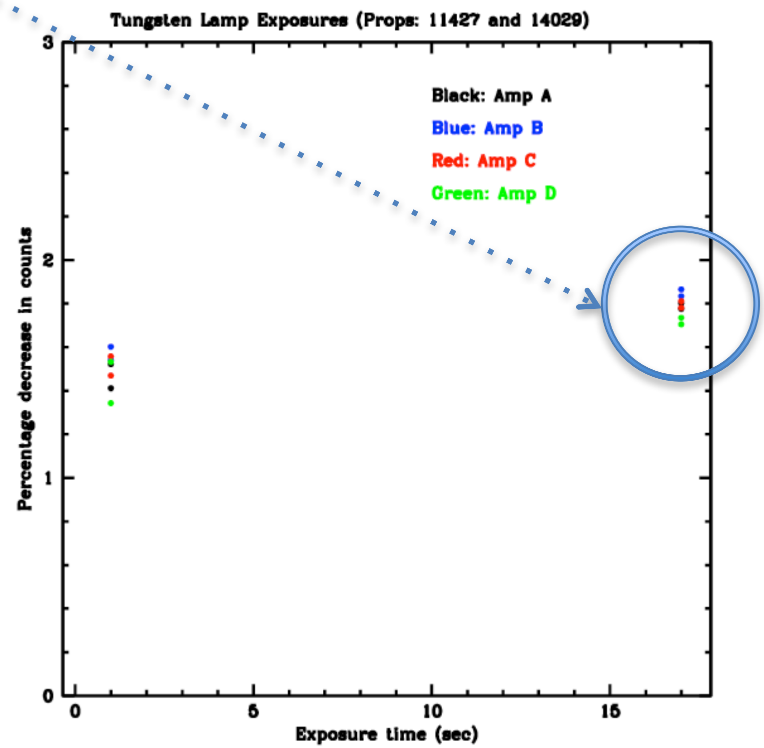
Table 1: Observed counts in different amplifiers

Filename	Shut-ter	Exp. time (s)	Av. Counts (A)	Av. Counts (B)	Av. Counts (C)	Av. Counts (D)
Program: 11427						
iaai01rtq_flt	A	1.00	1734.6	2044.0	2013.5	2464.2
iaai01ruq_flt	B	1.00	1730.2	2039.0	2008.0	2459.3
iaai01rwq_flt	A	17.00	29655.4	35020.6	34679.4	42286.3
iaai01rxq_flt	B	17.00	29657.3	35022.6	34682.7	42290.5
Program 14019:						
icr401keq_flt	B	1.00	1704.1	2006.6	1976.9	2421.8
icr401kfq_flt	A	1.00	1710.3	2012.7	1984.2	2431.3
icr401khq_flt	B	17.00	29127.7	34375.3	34060.1	41563.1
icr401kiq_flt	A	17.00	29133.6	34384.2	34067.3	41571.6

ISR WFC3-2015-12: Bowtie Monitor

No measurable variation in the A/B and C/D flux ratios is found over the WFC3 lifetime, confirming that shutter is stable to ~0.1%.



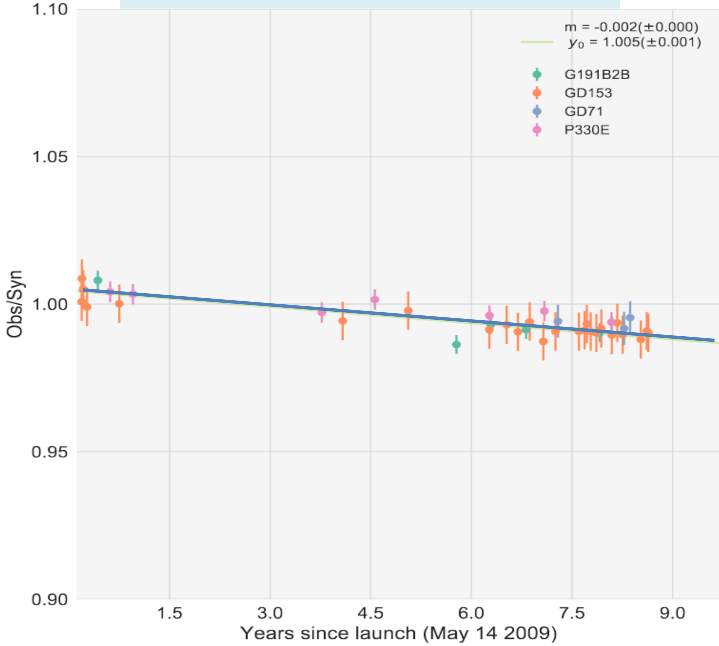


WFC3 UVIS and IR Photometry

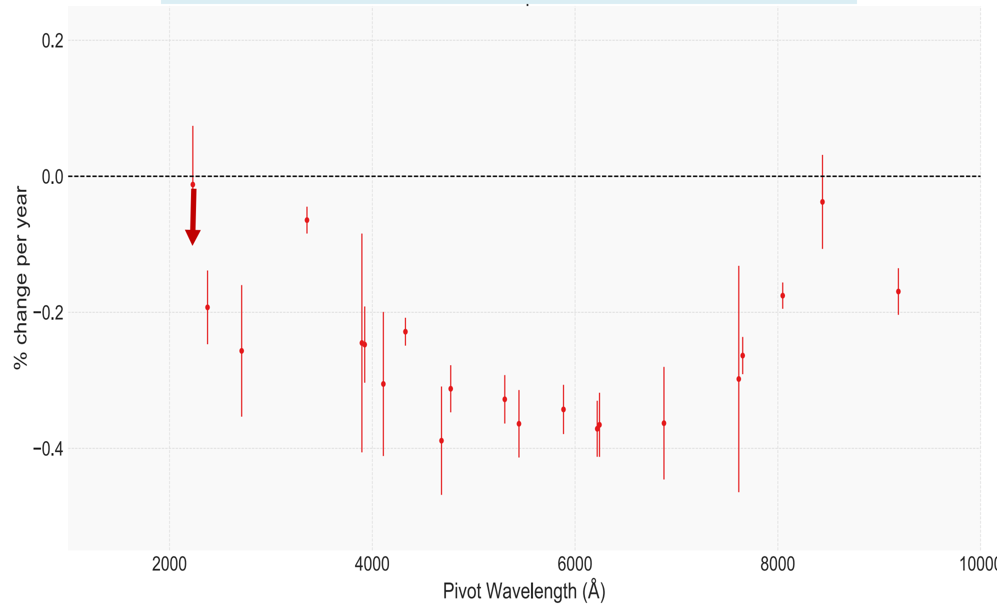
Orbits	External: 12 Internal: 0
PI, Co-I's	Deustua, Bajaj, Calamida, Khandrika, Mack
Purpose	Monitor the photometric throughput and stability, measure the inverse sensitivities and determine color term corrections for UVIS and IR filters as a function of time, detector position, and wavelength.
Description	***WFC3 UVIS**:* observe three white dwarf standards (GD71, GD153, GRW+70) and a G-type star (P330E) in a subset of broad- and medium-band filters using the corner subarrays. In Cy26, GRW+70 replaces G191B2B, which is too bright in many UVIS filters and which is not used for the IR photometric calibration. An improved spectrum of GRW was recently added to CALSPEC in August 2017 based on new STIS data from Cy24 (program 14871). This new target also allows for better synergy with the UVIS contamination program, which observes GD153 and GRW+70. ***WFC3 IR:*** observe GD153, GD71 and P330E in all IR imaging filters. (G191B2B was dropped in Cy20 because it is too bright.) Add 1 orbit of GRW+70 to reinstate a 3rd white dwarf and to provide overlap with the selected UVIS standards, which is important for cross-calibration of the two detectors.
Resources: Observations	UVIS: 8 orbits = 4 stars * 2 amps/star * 1 orbit/amp in a subset of 12 filters IR: 4 orbits = 4 stars * 1 amp/star * 1 orbit/amp in all filters
Resources: Analysis	This calibration supports 100% of UVIS & IR programs
Products	IMPHTTAB reference file, which populates the image header photometry keywords Synthetic photometry tables for use with PySynphot
Accuracy Goals	Improve UVIS accuracy to 1% statistical (current: 1.4%) and 1% absolute (relative to STIS, current: ~1.5%) Improve IR photometric accuracy to 1% statistical (current: ~3%) and 1% absolute (relative to STIS, current ~2-3%). Uncertainties for UVIS and IR narrow band filters are ~5%, for UVIS LP and X filters ~5%.
Prior Results, ISRs	ISRs 2018-xx, in prep: 1.) UVIS temporal stability, 2.) IR temporal stability, ISR 2018-08: UVIS color terms ISR 2018-02: Comparing the ACS/WFC and WFC3/UVIS Calibration and Photometry ISR 2017-14: WFC3/UVIS Updated 2017 Chip-Dependent Inverse Sensitivity Values ISR 2017-07: (UV photometry), ISR 2016-07: UVIS PySYNPHOT Files, ISR 2016-03: UVIS 2.0 IR Detector: 2009-30, 2009-37, 2011-08
Prior Cycle IDs	11450 (UVIS), 11451 (IR), 11903 (UVIS), 11926 (IR), 12334, 12699, 13089, 13575, 14021, 14384, 14871, 14883, 14992, 15582

WFC3 UVIS and IR Photometry

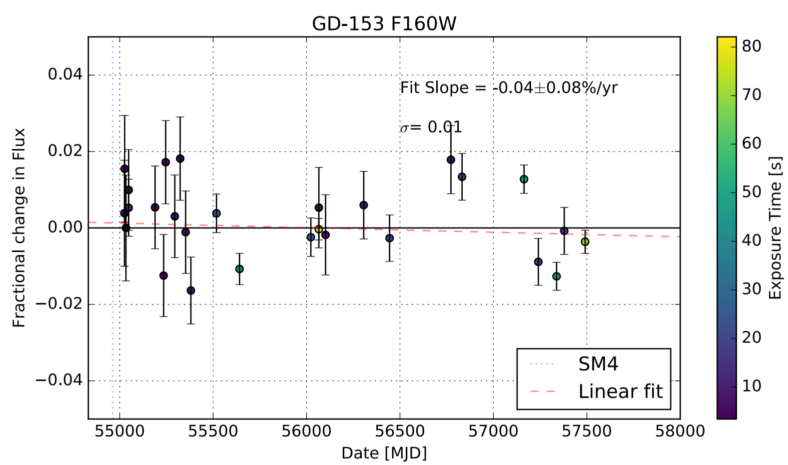
F814W temporal stability for UVIS1
Slope=0.2% loss per year



Sensitivity loss (% per yr) vs. wavelength for UVIS1
2018 Khandrika, in prep



IR F160W temporal stability
2018 Bajaj, in prep.

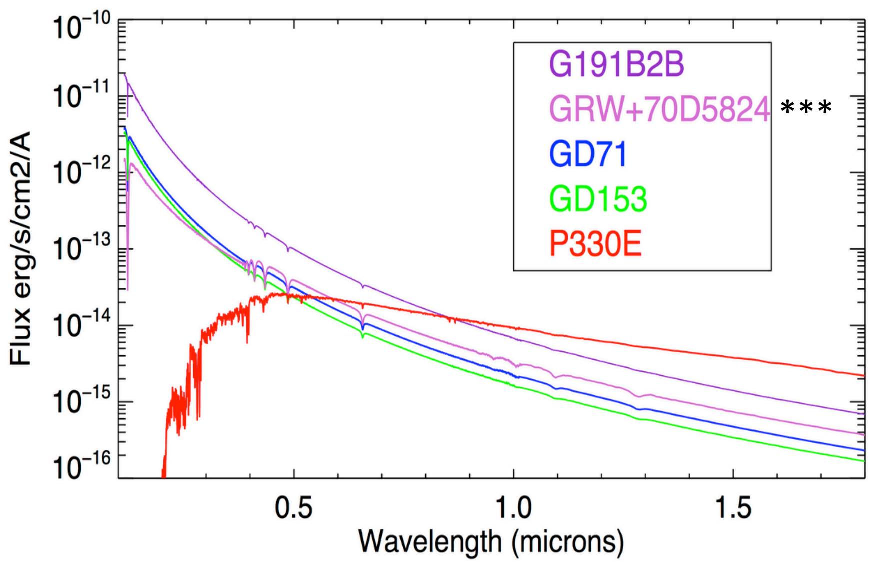


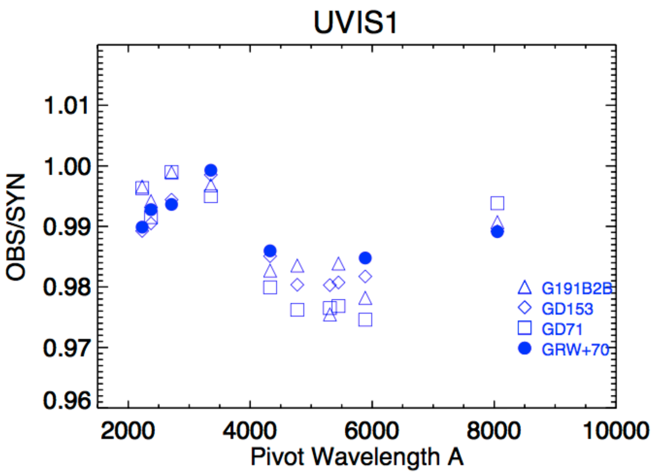
WFC3 UVIS and IR Photometry

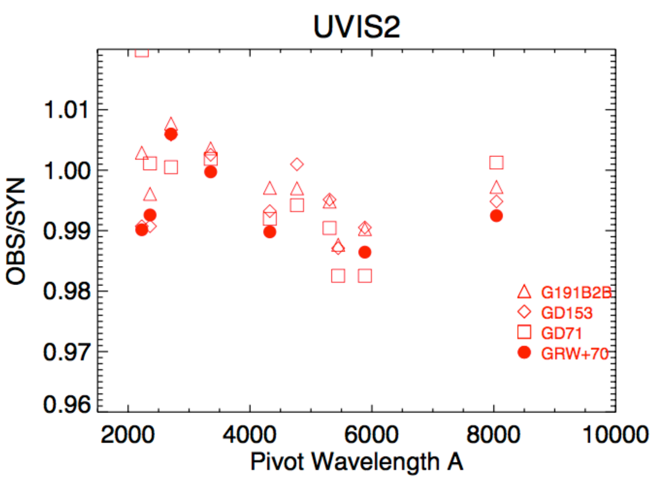
Comparison of UVIS photometry for 4 white dwarf standards. In this cycle, replace G191 with GRW+70, which has many more archival observations via the contamination monitor.

WFC3 Photometric Standards

An improved spectrum of GRW+70 was delivered to CALSPEC in 2017, based on new STIS data obtained in Cy24







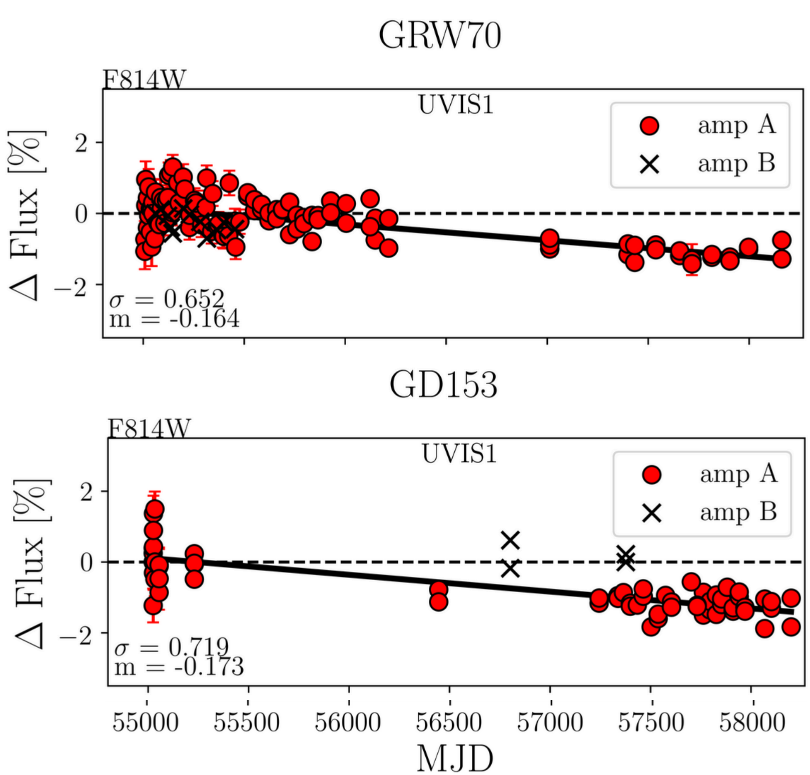
WFC3/UVIS Contamination Monitor

Orbits	External: 20 Internal: 0
PI, Co-I's	McCullough, Shanahan, Baggett
Purpose	Periodically measure the photometric throughput of WFC3. The data monitor the presence of possible contaminants on the optics via the flux of standard stars as a function of time and wavelength.
Description	Each visit obtains dithered or scanned subarray observations of a white dwarf standard star on both chips through a sub-sample of UVIS filters (including staring mode w/ grism G280). The white dwarf standard GRW+70D5824 has been used for past monitors and will be continued. A second white dwarf (GD153) was added in Cycle 23 with equal weight. This target has an added benefit of being schedulable throughout the year in 1-Gyro mode. The monitor cadence is deliberately out of sync with the monthly anneals in order to sample any anneal-related phase. Given the greater precision of the scanned mode (~5x improved over staring mode, we expect to gradually transition from staring mode to scanning mode, with this cycle providing validation and **contemporaneous data** to stitch the future scanned results to the past staring mode results.
Resources: Observations	10 visits, spaced as evenly as possible; 2 orbits/visit, staring & scanning for GD153 and GRW+70
Resources: Analysis	Supports 100% of UVIS programs (Staring mode data reduction is automated by quicklook software. Scanned mode is not.)
Products	https://wfc3ql.stsci.edu/automated_outputs/cal_uvis_setup_contam Annual ISR update and long-term time-dependent analytic prediction to adjust scientific results. Any time-dependent sensitivity with wavelength may be implemented via the IMPHTTAB reference file.
Accuracy Goals	Per epoch accuracy: 0.5% staring, 0.1% scanning.
Prior Results, ISRs	While no contamination of WFC3/UVIS has been detected in the past, small long-term changes are present in some filters (ISR 2014-20, ISR 2017-15) and are not due to shutter behavior (ISR 2015-12). Scanning mode has 0.1-0.2% r.m.s. repeatability (ISR 2017-21).
Prior Cycle IDs	11426, 11907, 12333, 12698, 13088, 13574, 14018, 14382, Cy24=14815 (staring)+14878 (scans), Cy25=15398 (staring + scans), Cy26=15583

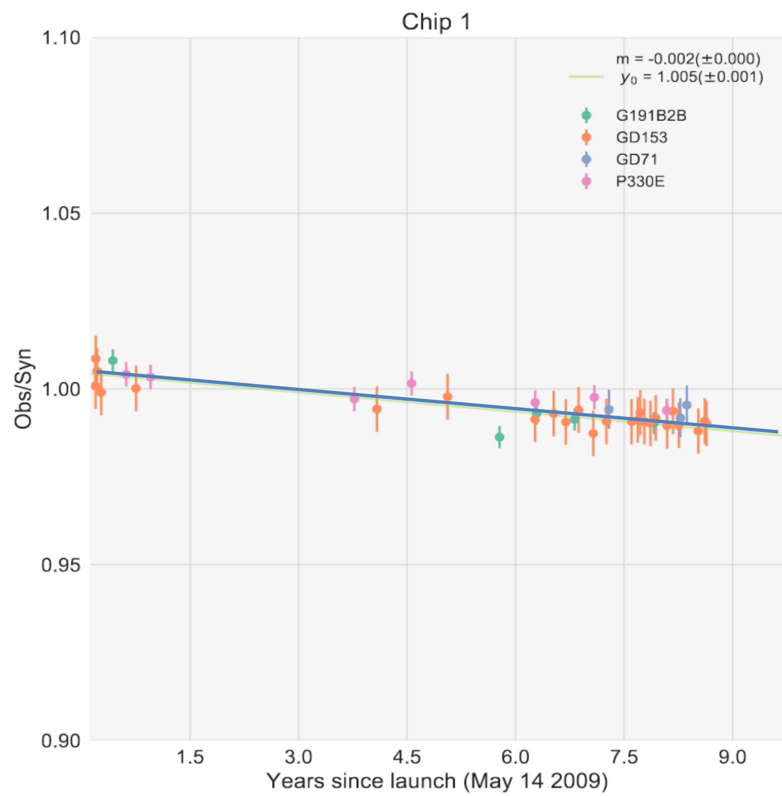
WFC3/UVIS Contamination Monitor

Comparison of results

Contamination Monitor
F814W sensitivity loss vs time
~0.2%/yr for GRW+70 (top) & GD153 (bottom)



Photometric Monitor
F814W sensitivity loss vs time
~0.2%/yr using a linear fit to all 4 standards



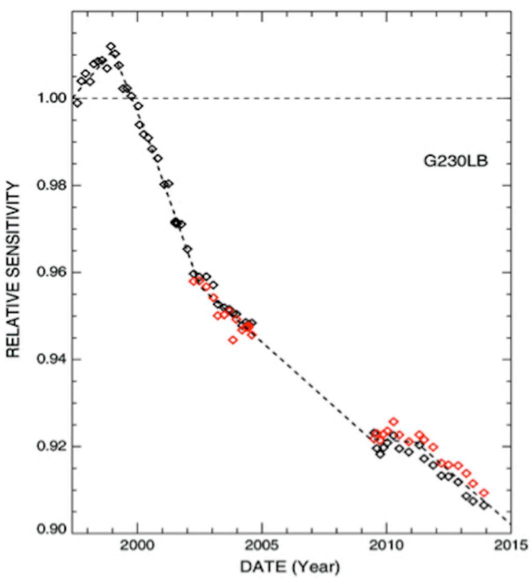
WFC3/UVIS Contamination Monitor

Comparison with STIS

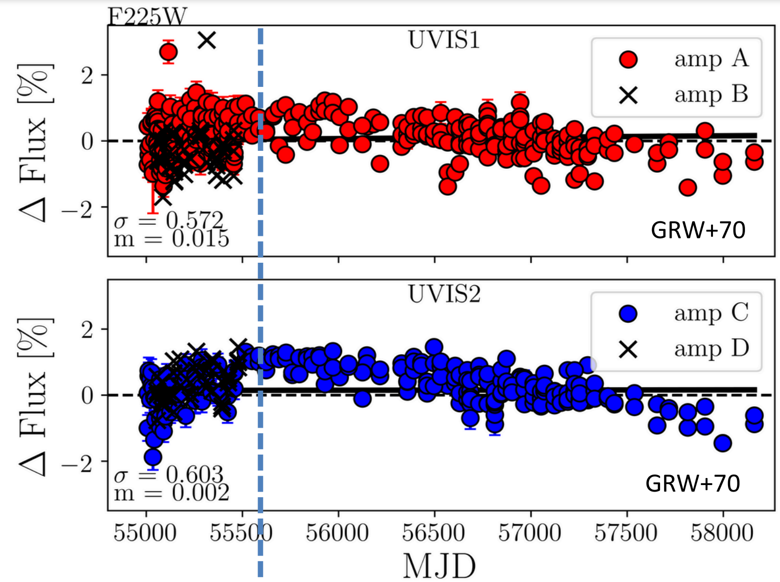
G230LB Sensitivity loss

Time-dependent calibration is based on multiple line segments

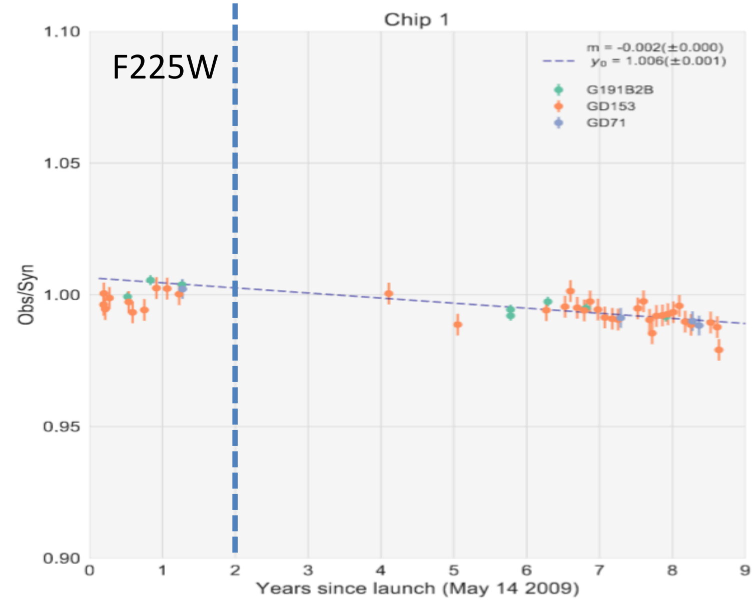
Increase in the first ~2 yrs due to evaporation of contaminants (Bohlin et al. 2014 PASP)



The contamination monitor fits a single line to the sensitivity loss with time, but a clear break is seen for UV filters at t~2 yrs.



The photometric monitor fits only data at t>2 yrs to estimate the slope (loss/year) for UV filters



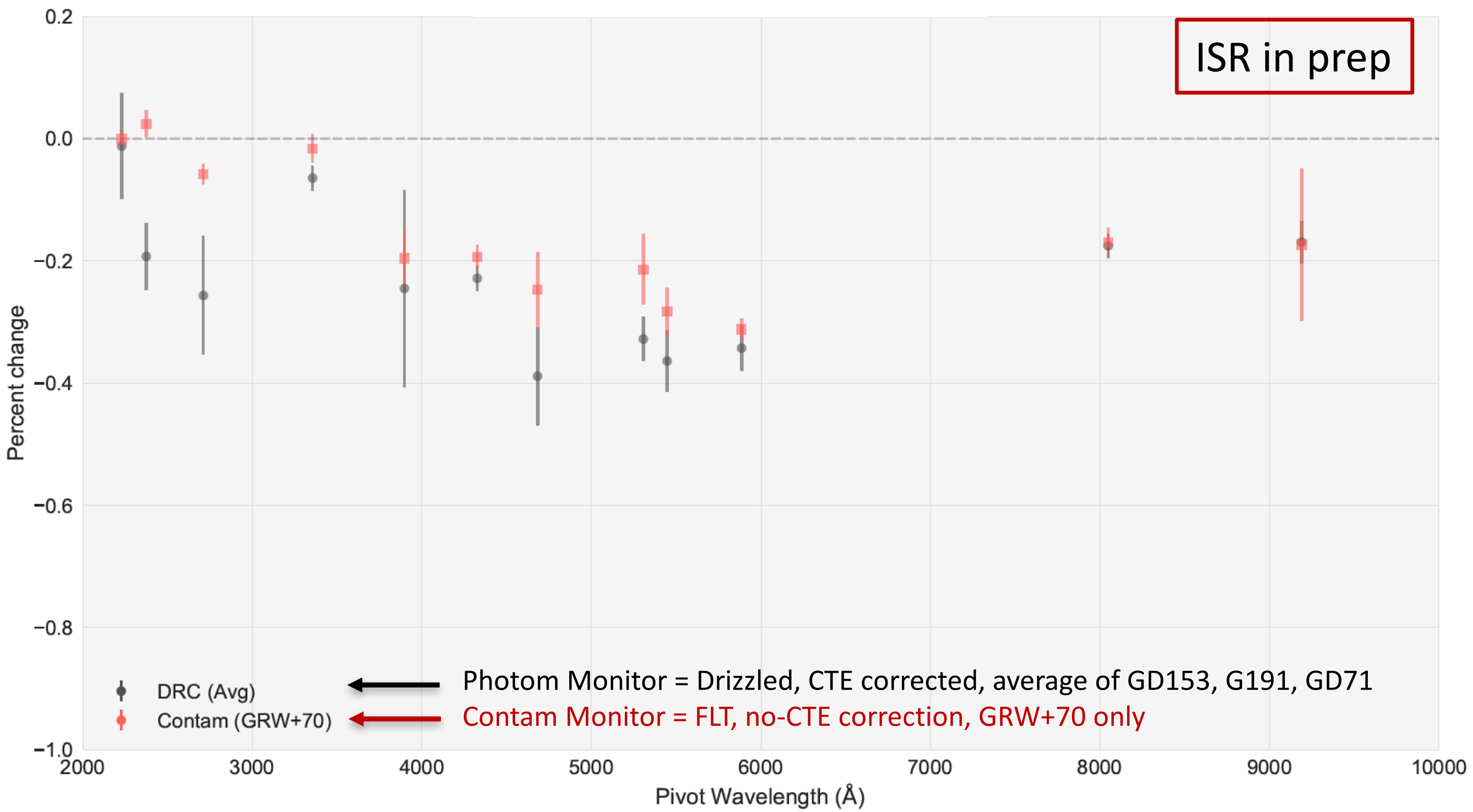
WFC3/UVIS Contamination Monitor

Comparison of results: Sensitivity loss (percent/year) vs. wavelength

→ Results are consistent despite using different white dwarf standards

Contam Monitor: UV losses are ~0.0%/year when fitting a single line to the decline vs time (previous slide)

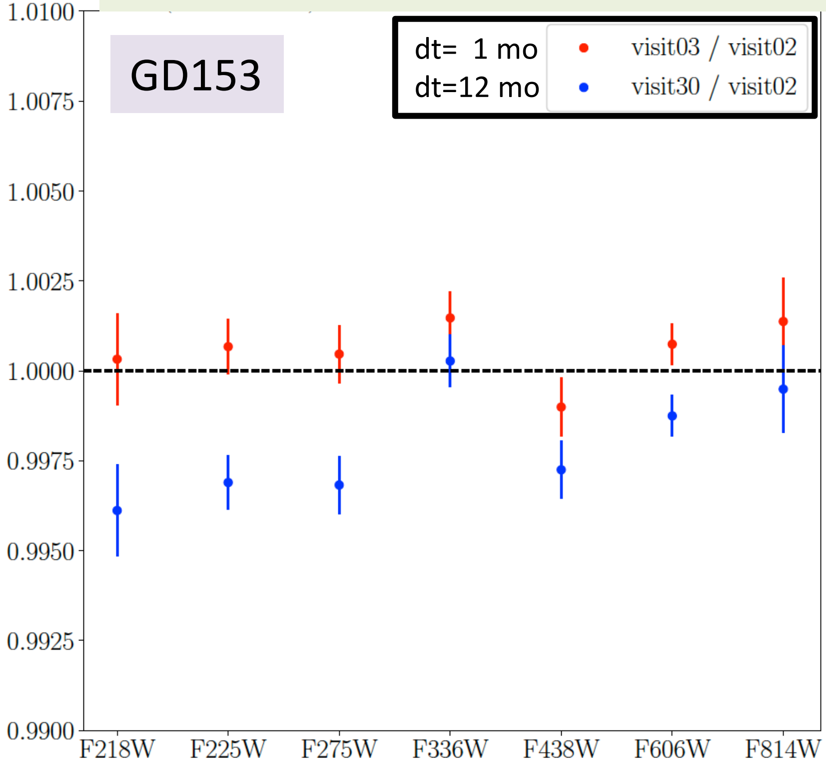
Photom Monitor: UV losses are larger (and more consistent with redder filters) when fitting a single line for t > 2yrs

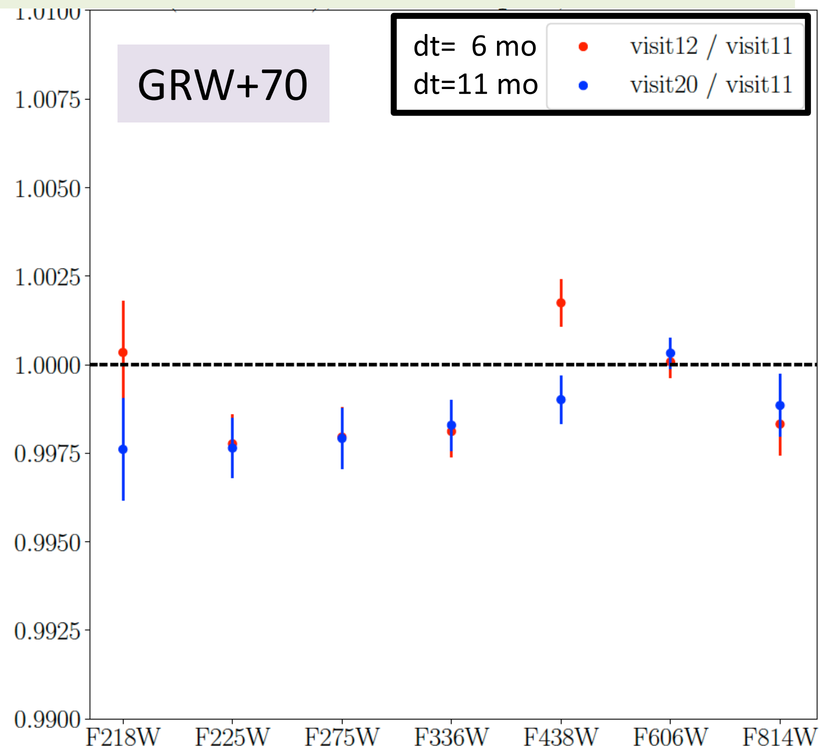


WFC3/UVIS Contamination Monitor

Scans (240 pixels in length):
Repeatability ~0.1 -0.2% for visits obtained close together in time
For observations ~1 year apart, losses are ~0.2%, consistent with results from staring mode.

Repeatability vs wavelength based upon the ratios of photometry in one visit compared to a reference.





WFC3 Grism Spectroscopy

Same cadence as the previous cycle

- Monitor and improve the flux calibration for both IR grisms
  1 orbit
- Monitor and improve the wavelength calibration for both IR grisms
  1 orbit
- Monitor the wavelength stability of the UVIS grism in both chips.
  1 orbit

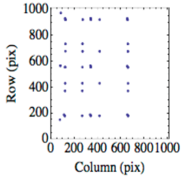
WFC3 IR Grism Wavelength Calibration & Stability

Orbits	External: 1 Internal: 0
PI, Co-I's	Pirzkal, Ryan
Purpose	Verify the temporal stability of the wavelength dispersion for the G102 and G141 grisms
Description	Grism G102 and G141 observations of VY2-2 will be obtained and reduce to verify that the dispersion of these grisms is not changing.
Resources: Observations	1 orbit = 1 pointing at the center of the field per grism
Resources: Analysis	Supports 30% of IR programs (grisms) Automated reduction software by PI
Products	New aXe configuration files, as needed http://www.stsci.edu/hst/wfc3/analysis/grism_obs/wfc3-grism-resources.html
Accuracy Goals	10 Å for G102; 20 Å for G141
Prior Results, ISRs	ISR 2017-01: A More Generalized Coordinate Transformation Approach for Grisms ISR 2016-15: Trace and Wavelength Calibrations of the WFC3 G102 and G141 IR Grisms ISR 2015-10: IR Grism Wavelength Solutions Using the Zero Order Image as the Reference Point
Prior Cycle IDs	12356, 12703, 13093, 13580, 14023, 14385, 14543, 14543, 14993, 15586

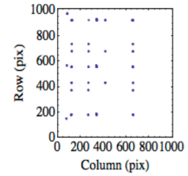
WFC3 IR Grism Wavelength Calibration & Stability

WFC3-ISR, 2016-15

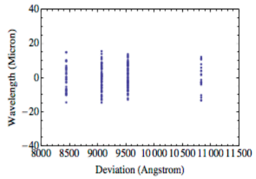
G102

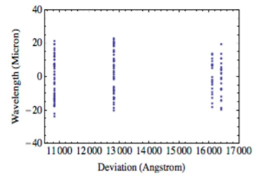


G141

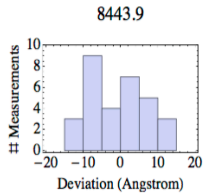


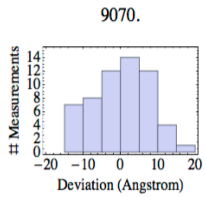
The location at which emission lines were extracted and measured (using the latest trace calibration)

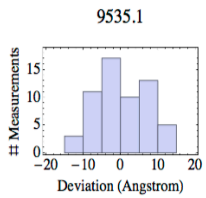


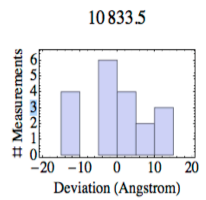


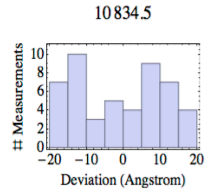
The difference between the fitted model of the wavelength dispersion and the fiducial wavelengths of the lines which were detected and measured.

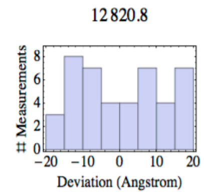


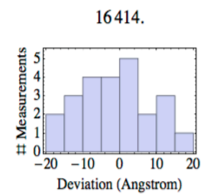


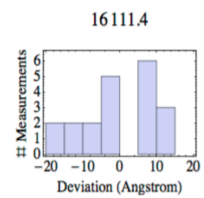












Histogram of the fit residuals, over the entire field of view, for each emission line measured:

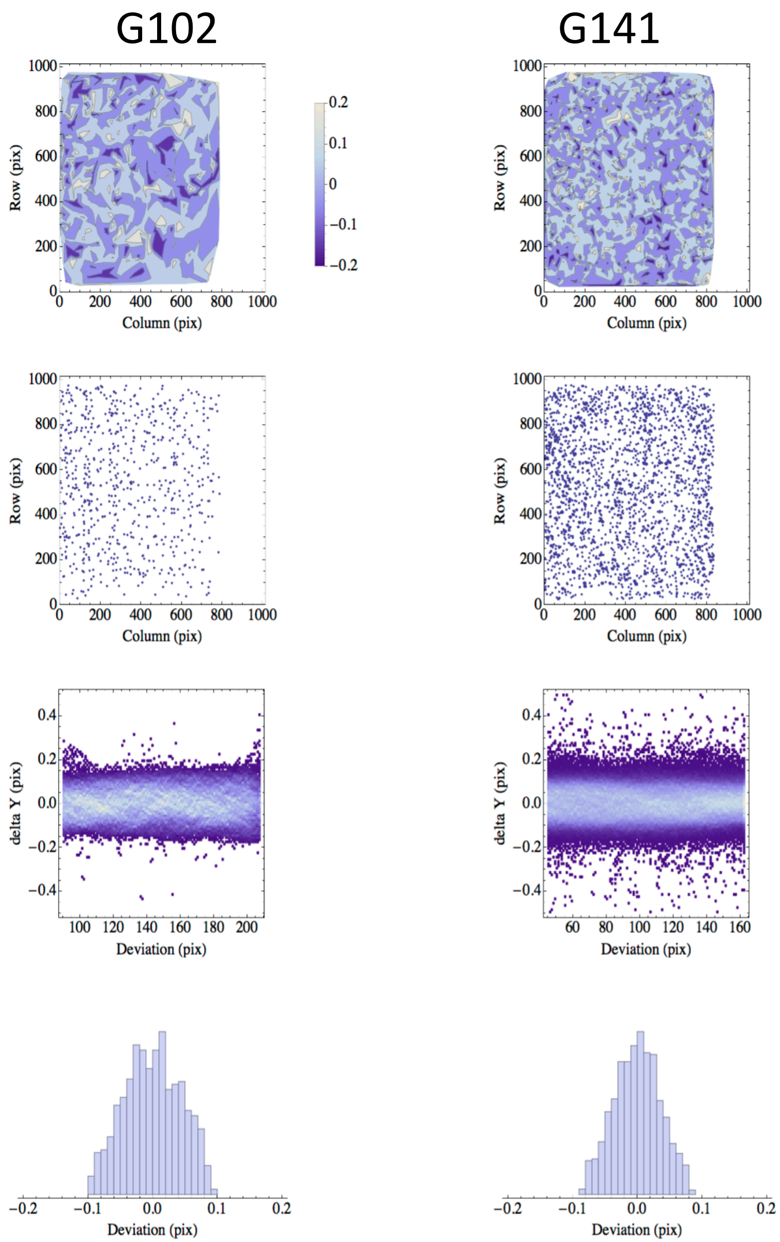
G102:		G141:	
O I	(8,443.9 A)	He I	(10,834.5 A)
[S III]	(9,070.0 A)	He I	(12,820.8 A)
[S III]	(9,535.1 A)	H I Br12	(16,414.0 A)
He I	(10,833.5 A)	H I Br13	(16,111.4 A)

WFC3 IR Grism Flux/Trace Calibration & Stability

Orbits	External: 1 Internal: 0
PI, Co-I's	Pirzkal, Ryan
Purpose	Verify the temporal stability of the G102 and G141 grisms trace solution and flux calibration
Description	Grism G102 and G141 observations of GD-153 will be obtained and reduce to verify that the dispersed traces of these grisms are not changing and that the sensitivity remains stable.
Resources: Observations	1 orbit = 1 pointing at the center of the field per grism
Resources: Analysis	Supports 30% of IR programs (grisms) Automated reduction software by PI
Products	New aXe configuration files, as needed http://www.stsci.edu/hst/wfc3/analysis/grism_obs/wfc3-grism-resources.html
Accuracy Goals	0.1 pixel
Prior Results, ISRs	ISR 2016-15: Trace and Wavelength Calibrations of the WFC3 G102 and G141 IR Grisms
Prior Cycle IDs	12357, 12702, 13092, 13579, 14024, 14386, 14544, 14994, 15587

WFC3 IR Grism Flux/Trace Calibration & Stability

WFC3-ISR, 2016-15



The 2D residual plots between the measurements and the trace models.

The object positions at which measurements were obtained.

The residuals of all measurements as a function of S along the trace.

The average error in the trace positions over the entire field of view.

UVIS Grism Wavelength Calibration and Stability

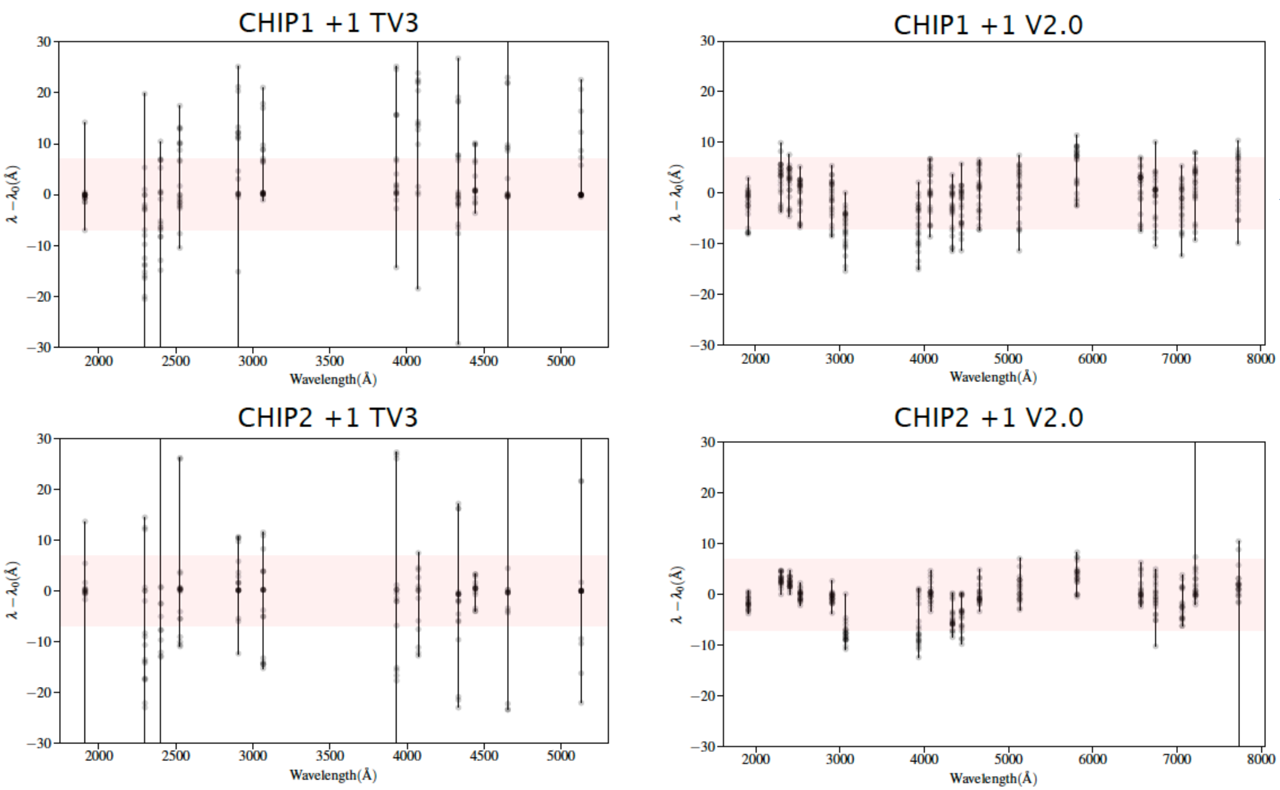
Orbits	External: 1 Internal: 0
PI, Co-I's	Pirzkal, Ryan
Purpose	Verify and refine the UVIS **wavelength** calibration, as necessary. These calibration will improve our ability to process currently archived data as well as support current and future UVIS parallel observations.
Description	Grism G280 spectra of WR-14 will be obtained to verify that the dispersion of this grism is not changing. This calibration supports the HST UV initiative.
Resources: Observations	1 orbit = 4 pointings (2 per CHIP). Two (2) positions on each CHIP will repeat the previously observed position (critical as they show +1 and -1 orders) and verify the stability of this mode.
Resources: Analysis	Supports 2% of UVIS programs (G280 filter)
Products	(Configuration files were updated on Oct 2015 to replace the 2009 values) http://www.stsci.edu/hst/wfc3/analysis/grism_obs/calibrations/wfc3_g280.html
Accuracy Goals	Establish the stability of the UVIS wavelength calibration to ~1 pixel (resolution element).
Prior Results, ISRs	ISR 2017-20: Trace and Wavelength Calibrations of the UVIS G280 +1/-1 Grism Orders ISR 2011-18, ISR 2009-01
Prior Cycle IDs	12359, 12705, 13091 (Included in 2017 ISR), 13578, 14025, 14387, 14545, 14995, 15588

UVIS Grism Wavelength Calibration and Stability

ISR 2017-20

Error in the emission line wavelengths for 1st order spectra, derived using:

- the original TV3 calibration (left)
- the latest 2017 calibration (right)



The shaded region represents one G280 resolution element (14A)

Flatfield Calibration

Same cadence as the prior cycle

- Monitor a population of UVIS pixels with anomalous low QE values

  45 internal orbits = 1 orbit*6 epochs (UV) + 3 orbits*13 epochs (VIS)

- Monitor the health of the UVIS filters via internal flats

  13 internal orbits = 3 orbits * 1 epoch (D_2, all UV filters)
  + 8 orbits * 1 epoch (Tungsten, all VIS filters)
  + 1 orbit * 2 epochs (Tungsten, subset VIS filters)

- Monitor the health of the IR filters via internal flats

  18 internal orbits = 6 orbits *2 exposures * 1 epoch (all filters)
  + 1 orbit *3 exposures * 2 epochs (broadband filters)

- Monitor the health of the CSM by observing the bright earth

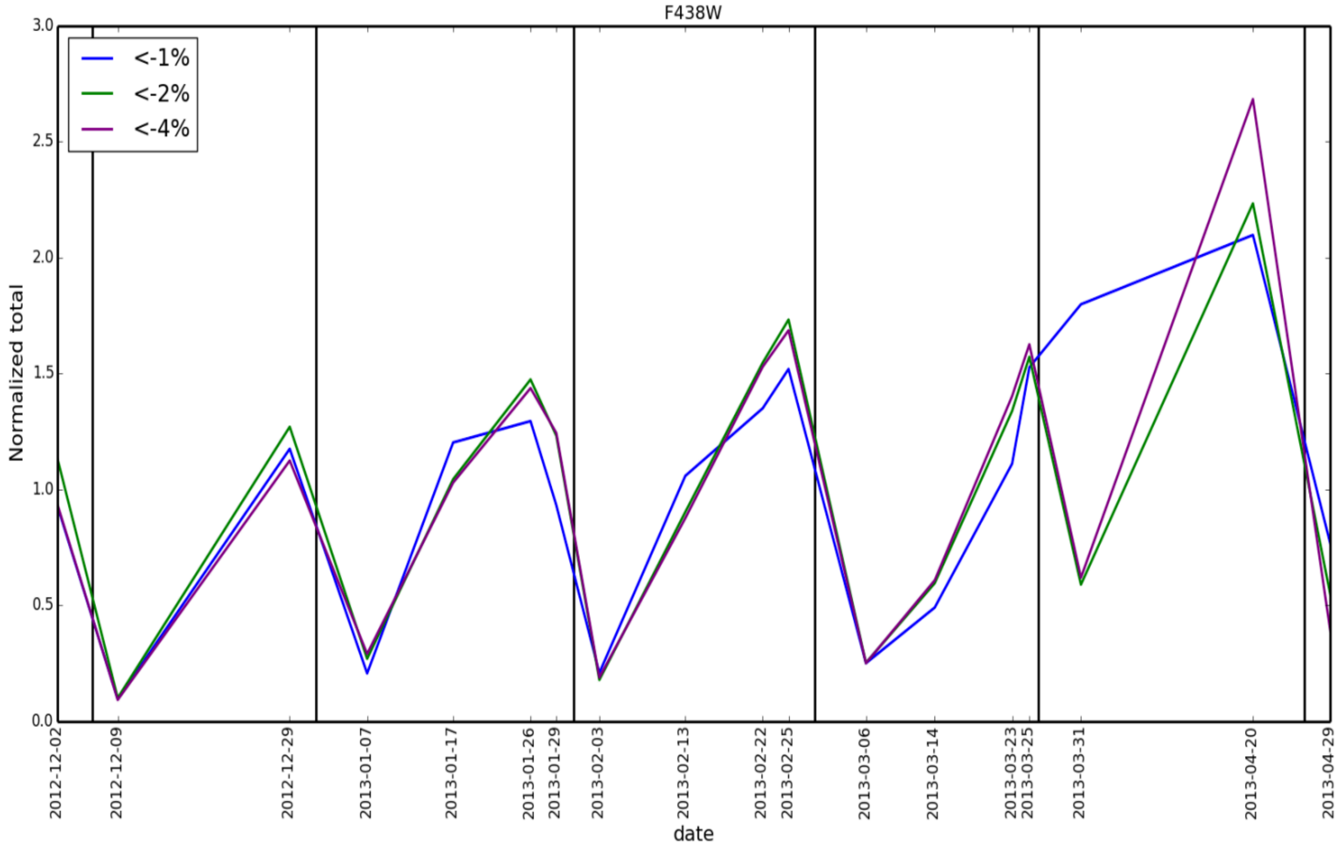
  200 internal orbits = At least one flat every time the CSM is moved.
  (Typical cadence is 1-2x/week)

WFC3 UVIS Pixel-to-Pixel QE Variations via Internal Flats Monitor

Orbits	External: 0 Internal: 45
PI, Co-I's	Shanahan (new PI), Mack, Khandrika
Purpose	To track the population of pixels that exhibit anomalous QE variations between anneals.
Description	This program monitors the randomly distributed population of pixels that exhibit anomalous QE variations between anneals, characterized by a sensitivity loss that is more pronounced in the blue than in the red. This population is unique for each anneal cycle and exhibits clustering in the UV. Internal flats are taken to monitor this population in the UV and Visible wavelengths.
Resources: Observations	45 internal orbits: UV = 1 orbit*6 epochs, VIS= 3 orbits*13 epochs For the UV, 6 orbits with the D2 lamp are taken in F225W and F336W, 1 orbit every other month in the week before the anneal. UV orbits require non-int sequences to minimize cycling of the D2 lamp. For the Visible filters, 3 orbits each anneal cycle (a week before the anneal, midway between anneals, and just after the anneal) are taken with the Tungsten lamp in F438W, F645N and F814W.
Resources: Analysis	Supports 100% of UVIS programs (No products are delivered, but this monitor allows an assessment of QE variations over time.) The PI has software tracking the deviation of individual pixels between cycles. This needs to be adapted to test more parameter space and to include the most recent data. One goal is to implement this in QuickLook for easy tracking.
Products	A tabulated population of anomalous pixels between anneals . With this, we may be able to deliver a time dependent mask to users.
Accuracy Goals	Track populations of low sensitivity pixels that vary by >1%, >2%, >4% for each filter
Prior Results, ISRs	ISR 2018-xx, in prep. (Shanahan) ISR 2014-18 "Pixel-to-Pixel Flat Field Changes in WFC3/UVIS" (Gunning)
Prior Cycle IDs	13169, 13585, (ISR-2014), 14027, 14389, 14546, 14996, 15589

WFC3 UVIS Pixel-to-Pixel QE Variations via Internal Flats Monitor

WFC3-2014-18



Normalized low sensitivity pixel population in F438W as a function of time. Anneals are indicated by black vertical lines.

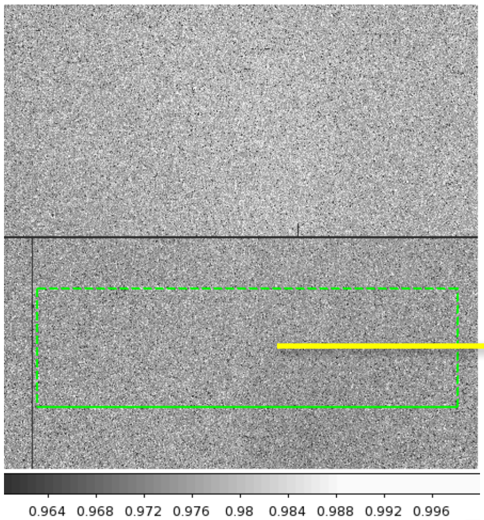
UVIS Internal Flats

Orbits	External: Internal: 13
PI, Co-I's	Medina (new PI), Mckay, Mack, Khandrika
Purpose	Monitor the stability of the UVIS pixel-to-pixel sensitivity in all filters by obtaining internal flat fields with the tungsten and deuterium lamps
Description	We will acquire internal flats in all UVIS filters and monitor the decay of the internal lamps
Resources: Observations	13 orbits = 3*(D_2) + 8*(Tungsten_all) + 2*(Tungsten_subset) This consists of 3 orbits with the D2 lamp for the filters F218W, F200LP, F225W, F275W, F280N, F300X, F336W, F343N, F373N, F390M, F390W, F395N, FQ232N, FQ243N, FQ378N, and FQ387N. Eight orbits with the Tungsten lamp will acquire the remaining 46 filters. Observations in the 4 filters, F390W, F438W, F606W, and F814W, with the Tungsten lamp will be repeated 2 times over the cycle for a total of 2 orbits.
Resources: Analysis	Supports 100% of UVIS programs, but no products are delivered. Check for stability in the pixel-to-pixel response. Search for prominent new features in each UVIS filters by comparing internal flats acquired over time. Track the decay of the calibration lamps
Products	
Accuracy Goals	Look for systematic changes exceeding 1%, after accounting for lamp decay
Prior Results, ISRs	ISR 2018-xx, in prep. (Mckay) 'UVIS Internal Flat stability" ISR 2010-03: "WFC3 SMOV Proposal 11432: UVIS Internal Flats"
Prior Cycle IDs	11432 (see 2010 ISR) Reduced, but not yet published: 11914, 12337, 12711, 13097, 13586, 14028, 14390, 14547, 14997, 15590

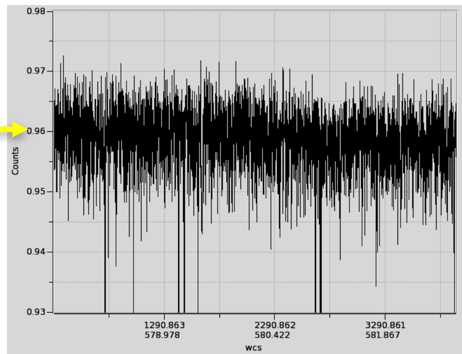
UVIS Internal Flats

ISR 2018-xx, in prep (Mckay et al)

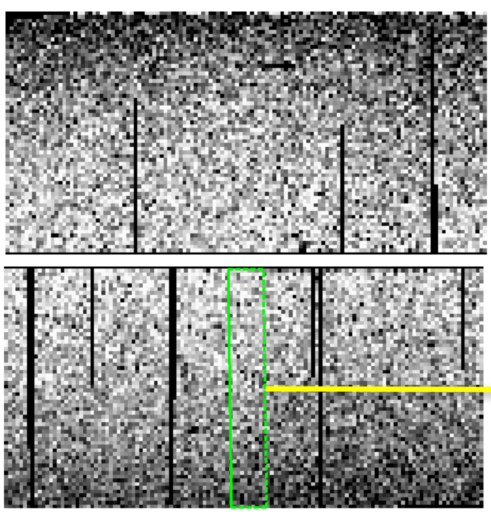
F606W 2017/ 2009 flat ratio



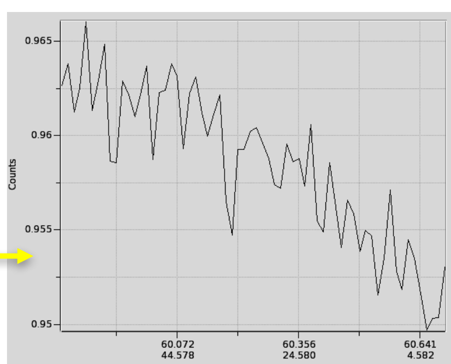
Horizontal Projection



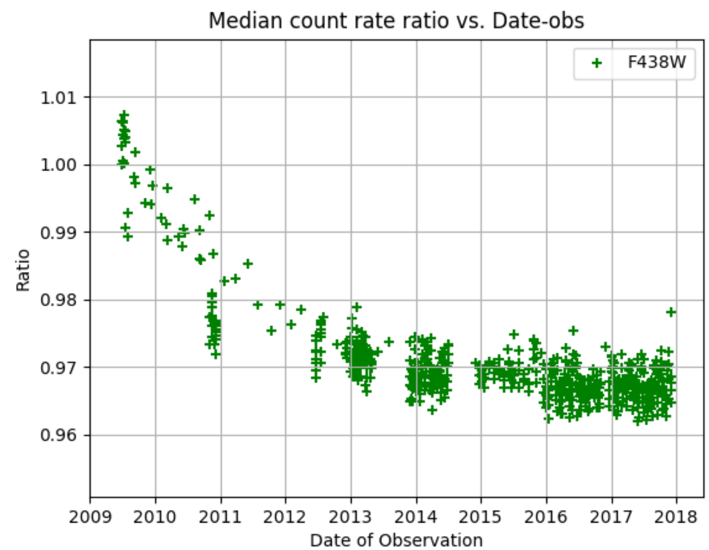
F606W 2017/ 2009 flat ratio (Binned x 32)



Vertical Projection



F438W Tungsten lamp decay

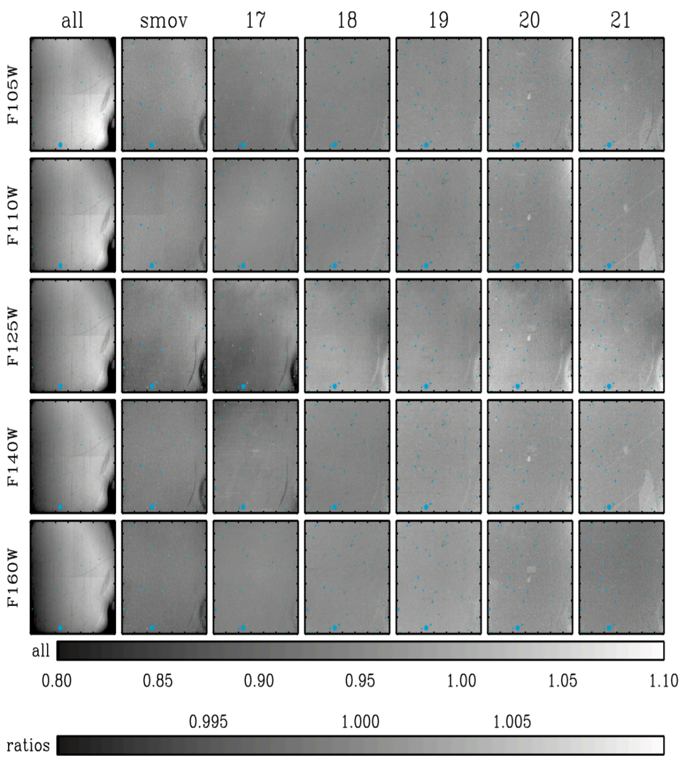


IR Internal Flats

Orbits	External:0 Internal: 18
PI, Co-I's	Ryan (new PI), Kurtz, Sunnquist
Purpose	Monitor the stability of the IR pixel-to-pixel sensitivity in all filters by obtaining internal flat fields with the tungsten lamp.
Description	In this program, we study the stability and structure of the IR channel flat field images through all filter elements. 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. This version contains a full set of IR filter exposures once in the middle of the cycle. In addition we will acquire 3 exposures in each of the 2 broadband filters F105W, F110W, F125W, F140W, and F160W twice during the cycle.
Resources: Observations	18 internals = (6 orbits*2 exposures)_all filters + (3 orbits *2exposures) Sample the full set of IR filters once in the middle of the cycle. This requires 6 orbits* 2 exp= 12 orbits. Sample a subset of broadband filters (F105W, F110W, F125W, F140W, and F160W) to monitor those flats 2 times during the cycle (early and near the end). This requires another 6 orbits = (2 epochs x 3 exposures). If time permits, obtain a short dark before the intflat to mitigate persistence.
Resources: Analysis	Supports 100% IR programs.
Products	Monitor the stability of the pixel-to-pixel response and track the decay of the calibration lamps. Use these data to update BPIXTABs (dead, unstable pixels) last modified in 2012
Accuracy Goals	
Prior Results, ISRs	Ryan et al (2015-11). Dahlen et al (2013-04). Hilbert et al (2009-42) Last BPIXTAB is from 2012; improved reference file in prep
Prior Cycle IDs	11433, 11915, 12338, 12712, 13098, 13587, 14029 ← 2015 ISR includes data through Cy22. 14391, 14548, 14998, 15591 ←Recent data is consistent with latest ISR.

IR Internal Flats

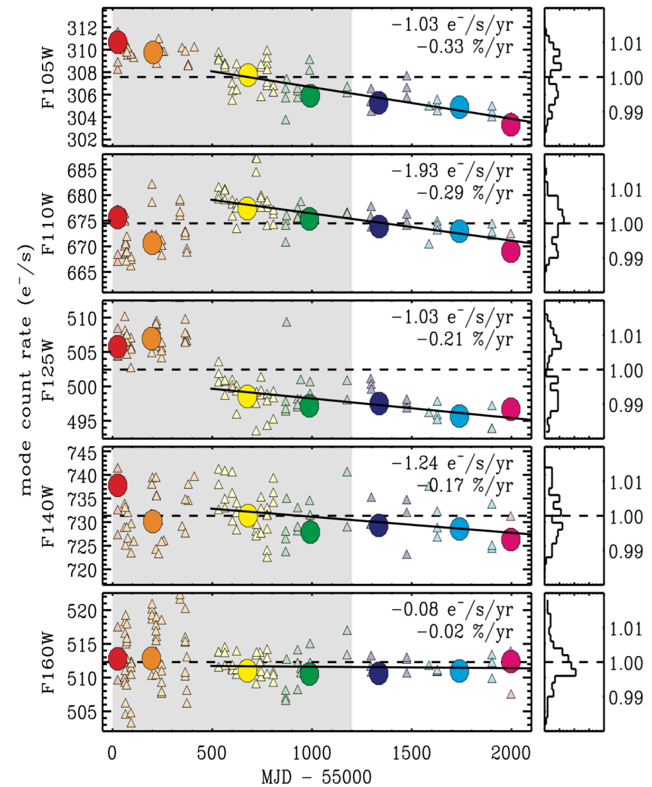
WFC3-ISR 2015-11



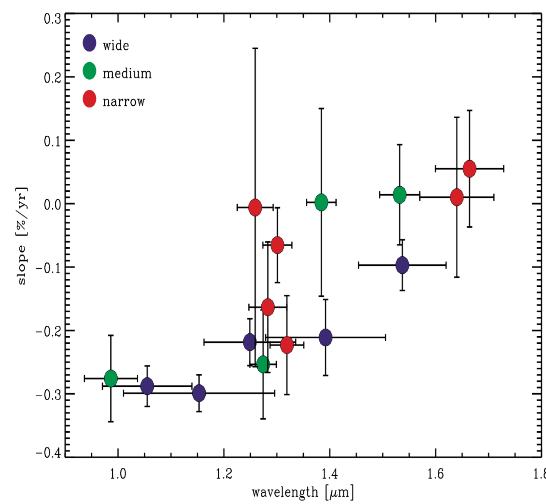
Column 1= Median flat using ALL data (SMOV-cy21) for five broadband filters

Columns 2-7= Ratio of the median stack (for a given cycle) to the cumulative stack

Mode count rate vs. time for 5 broadband filters. A steady decline is seen since Cy18



Slope of the mode count rate vs. wavelength (see top-right) for broad, medium, & narrow filters. The trend suggests a reddening of the tungsten lamp, consistent with lamp's aging.



WFC3 CSM Monitor with Earth Flats

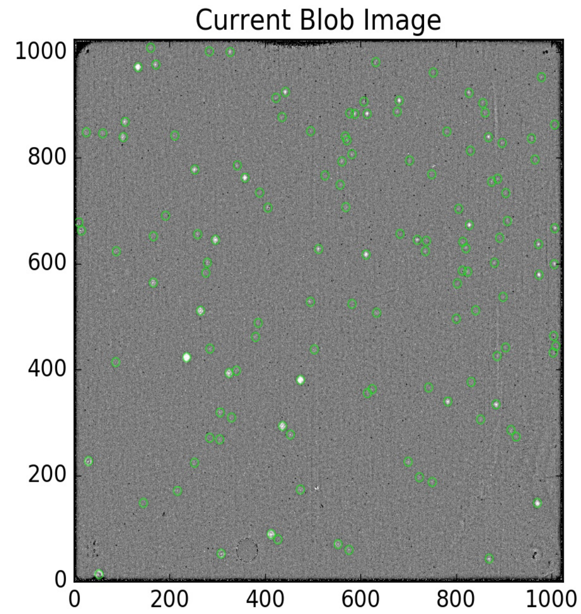
Orbits	External: Internal: 200
PI, Co-I's	Sunnquist, McCullough, Ryan
Purpose	Monitor the CSM angle and new blob appearances using earth flats.
Description	Take quick (~100 s) F153M exposures looking down at the dark Earth to use airglow as a uniform glowing screen. Use these images to detect new blobs and use the positions to track the CSM angle over time.
Resources: Observations	200 orbits: F153M, SPARS25, NSAMP=5 Obtain at least one flat every time the CSM is moved. Typical cadence is 1-2x/week, but gaps are expected when either the CSM doesn't move or when the schedule is over-constrained. Similar to prior cycles, after this program is implemented, all 14999 visits yet to be scheduled are cancelled and this new program picks up where it left off.
Resources: Analysis	Supports 100% of IR programs Monitoring to be carried out by the PI and Quicklook Team. Updates to the monitoring software/blob ISR to be completed by the PI. New reference files as new blobs appear.
Products	DQ flags (BPIXTAB, blobs only), DFLTFILE (future location of blob flags)
Accuracy Goals	
Prior Results, ISRs	ISR 2018-06: WFC3/IR Blob Monitoring ISR 2017-16: Possible Overlaps Between Blobs, Grism Apertures, and Dithers ISR 2015-06 (impact of blobs on WFC3/IR photometry), ISR 2014-21 (time-dependent blob flags/monitoring) ← ISR updated to include newest blobs, ISR 2012-15 (blob monitoring/color), ISR 2010-06 (blob monitoring/origin)
Prior Cycle IDs	14392,14549, 14999, 15592

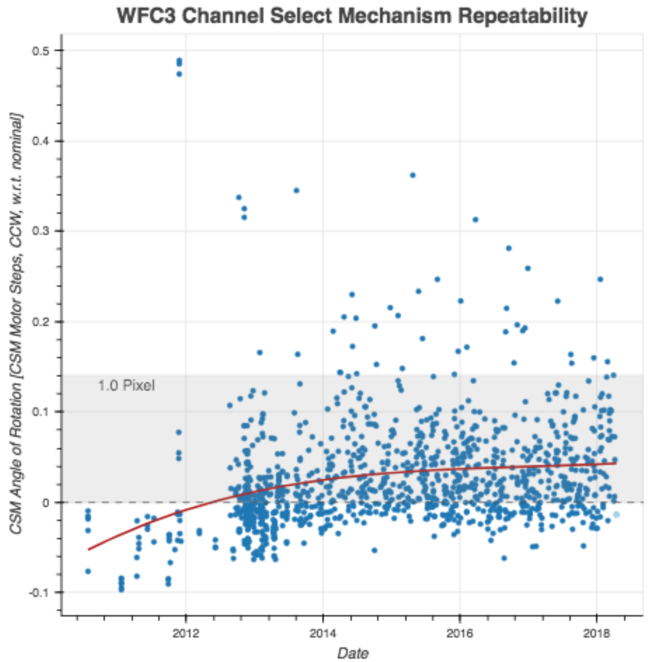
WFC3 CSM Monitor with Earth Flats

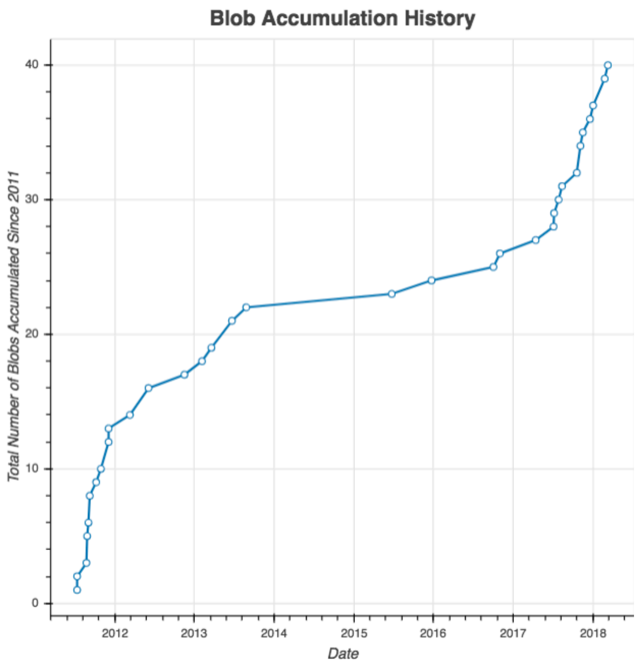
Quicklook CSM Monitor page:
https://wfc3ql.stsci.edu/automated_outputs/cal_ir_check_csm

New blobs are identified using the most recent dark earth flat (i.e. the "blob image", right)

The positions of these blobs are used to measure the CSM angle of rotation, which is used to ensure the CSM is operating as expected as new blobs form.







Astrometric Calibration

Same cadence as the prior cycle

- Monitor the temporal stability of the geometric distortion in both detectors

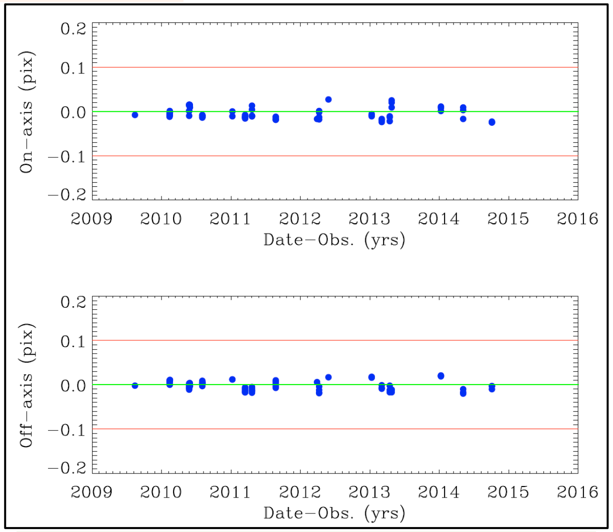
  6 internal orbits = 1 exposure *3 epochs (UVIS, F606W) + 1 exposure *3 epochs (IR, F160W)

WFC3 Astrometric Scale monitoring

Orbits	External: 6 Internal: 0
PI, Co-I's	Kozhurina-Platais, Martlin
Purpose	Continue monitoring the stability of the WFC3 geometric distortion over time.
Description	The standard astrometric catalog in the field of globular cluster Omega Cen has been used to examine the geometric distortion of UVIS and IR as a function of wavelength in multi-cycle calibration programs over the last 10 years on-orbit. All observations from these programs have been reduced and provide the multi-wavelength distortion in UVIS and IR. The geometric distortion coefficients implemented in the IDCTAB format are used in the HST pipeline to correct for ~7% distortion in WFC3 images down to <1%. Observations of Omega Cen taken in F606W (UVIS) and F160W (IR) during the last 10 years (>20 epochs in total) are used to look for time dependency and the effect of scale changes due to the thermal breathing. The purpose of the observations is to derive the skew (non-perpendicularity of X&Y axis) and scale terms and look for any secular changes.
Resources: Observations	6 orbits: 3 epochs each in F606W UVIS and F160W IR. Observations of Omega Cen will be observed with the same pointing in each detector, but with 3 different OTA roll-angles per orbit over 3 epochs: December 2018, March 2019 and June 2019.
Resources: Analysis	Supports 100% of UVIS & IR programs Measure accurate X&Y positions on drizzled images from each detector and solve 6-parameter transformation w.r.t Standard Astrometric Catalog or/and GAIA to calculate the scale parameters to be used for analysis of time-dependency.
Products	IDCTAB, NPOLFILE, D2IMFILE reference files Calibration of the geometric distortion (skew and scale parameters) with time. If needed, provide empirical linear time dependent corrections, similar to the ACS/WFC time-dependent skew (see ACS-ISR-15-06).
Accuracy Goals	Reduce uncertainty in the scale to 2 mas if there is time-dependent distortion.
Prior Results, ISRs	ISR 2018-10: Updates to the WFC3/UVIS Filter-Dependent and Geometric Distortions ISR 2018-09: WFC3/IR: Time Dependency of Linear Geometric Distortion ISR 2018-01: Accuracy of the HST Standard Astrometric Catalogs with respect to Gaia ISR 2014-12: Astrometric Correction for WFC3/UVIS Filter-Dependent Component of Distortion ISR 2015-02 shows that the UVIS distortion is stable over 9 years on-orbit within 0.05 pixels or 2 mas. ISR 2012-07: WFC3/UVIS and IR Multi-Wavelength Geometric Distortion ISR 2012-03 shows that the IR distortion is stable over 2 years on orbit within 0.1 pixel or 6mas.
Prior Cycle IDs	11911, 12094, 12353, 12714, 13100, 13570, 14031, 14393, 14550, 15000, 15593

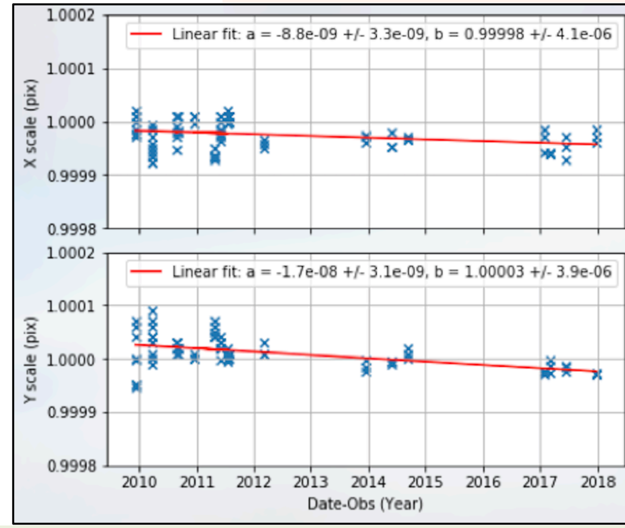
WFC3 Astrometric Scale monitoring

ISR 2015-02
UVIS skew vs time

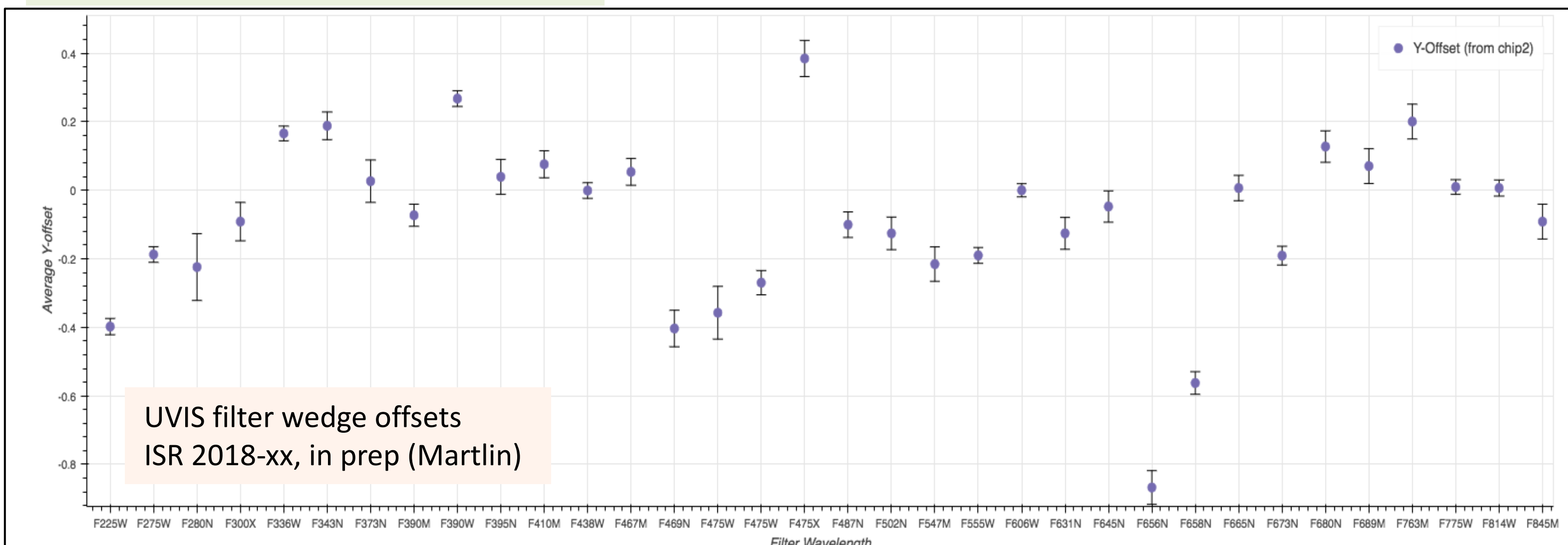


Each point has been scaled by 2048 to show the maximum effect at the edge of the UVIS detector. The distortion is stable to <0.05 pixels over 9 yrs.

ISR 2018-xx, in prep (Mckay)
IR plate scale vs time



For the maximum change at the edge of the IR detector, each point should be scaled by 512. The total change is = 9 yrs*(2e-8 pix/day*365d/yr) * 512 pix = 0.04 pix



UVIS filter wedge offsets
ISR 2018-xx, in prep (Martlin)