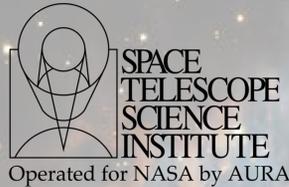
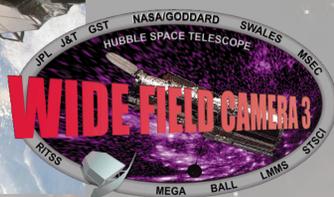




WFC3: News Regarding IR Backgrounds, Spatial Scans, and Cycle 22 Phase 2 Advice



John W. MacKenty and the WFC3 Team

122.06



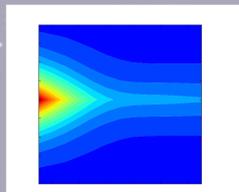
Summary

WFC3 continues to perform nominally.

- Photometric zero points (including UV) are stable to ~1% since 8/2009
- Astrometric calibration is stable and dominated by Telescope “breathing”
- UVIS CCD Detectors CTE declining as expected with radiation damage
- IR Detector shows essentially zero evolution of its performance in flight

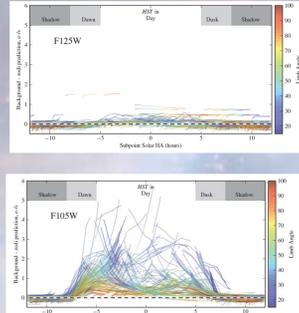
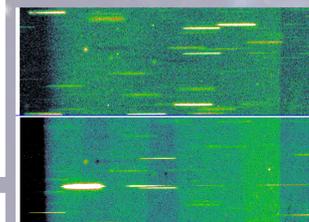
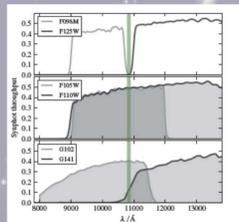
WFC3 Infrared Background Variations

- A key feature of the IR Channel
→ GRISMS and Wide Filters are Zodiacal background limited
- Nominal Backgrounds: 0.5 to 1.0 e-/pixel
• **SOMETIMES:** brighter (up to 3 to 5e-/s) and non-uniform backgrounds are observed!



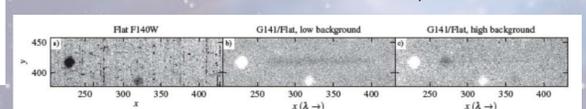
- Caused by:
 - Pointing traversing central part of zodiacal cloud
 - $\sim 80^\circ$ sun angle near ecliptic plane
 - Long dwells near bright earth limb (i.e. CVZ or near CVZ situations).

Inclusion of He I 10830Å line within the passbands of G102, G141, F105W, F110W



Above (left): Variation in G141 background seen between two exposures.
Above (right): Instantaneous background in F125W and F105W as function of orbital position and limb angle (color coded)

Below: He I 10830Å line seen in silhouette due to dust particles on CSM mirror.



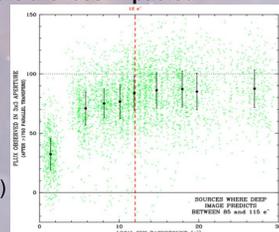
CCD Charge Transfer Efficiency Decline Mitigation Options

- The WFC3/UVIS CCD detectors experience an inevitable decline in charge transfer efficiency due to radiation damage in the space environment
- Results in Loss of S/N for faint sources; charge trailing; photometric & astrometric errors
- Observers have several options to mitigate and correct for CTE decline:

1) Sources placed near the readout amplifiers in the corners are less impacted

2) Post-Flash (i.e. Background Enhancement)

- Recommended **option** for Cycle 20+
- 10-12 e- per pixel restores most CTE (%80%)
- Benefits: recovers faint sources, better darks
- Cost: increased effective noise from 3.1e- to 4.6e-



3) Post-Observation Corrections

- Pixel Based Charge Transfer Model (Anderson&Bedin)
- Benefits: Restores trailed charge to correct locations
- Limitation: Cannot recover lost S/N
- Available for post-processing at http://www.stsci.edu/hst/wfc3/ins_performance/CTE/
- To be included in OPUS pipeline in late 2014

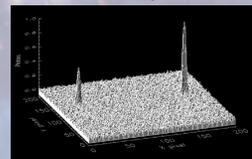
WFC3 Spatial Scans

Spatial Scans allow the light from astronomical objects to be trailed across the WFC3 detectors in a predictable and repeatable manner during exposures at rates up to 4.8 arc seconds per second (FGS control) and 7.8 "/s (GYRO control).

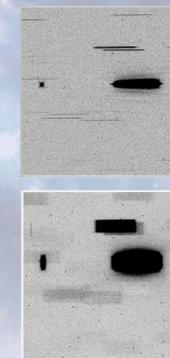
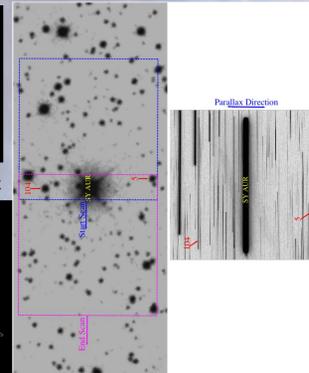
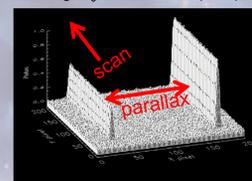
Enables:

- Significantly increased S/N observations – especially for infrared spectroscopy of bright sources (e.g. exo-planet transits)
- Higher precision astrometric measurements orthogonal to the scan direction (measurements to <30 micro-arc seconds)
- Opportunity to observe brighter sources (especially with the IR detector– 0th mag achieved with Grism in -1 order)
- Flat field verification and improvement of mid-spatial frequency residuals in near UV CCD flats

Imaging, PSF $\sigma_0=0.01$ pix

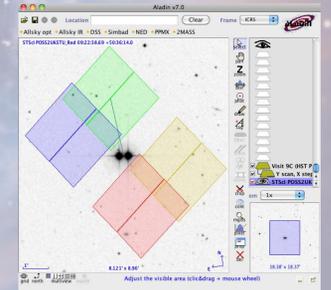


Scanning, $\sigma_0=0.01/\sqrt{N}$ samples pix



•Left: IR Grism Spectra (Stationary and Scan)
• Right: Astronomer Proposal Tool now supports and visualizes scans.

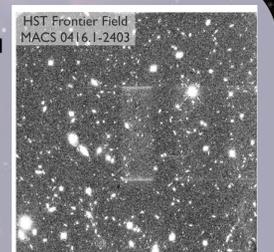
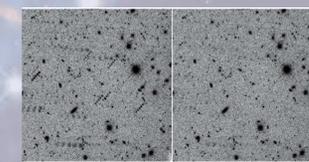
•Below: Superposition of multiple scans of a pair of bright stars provides path for improved correction of 3-5% mid-spatial frequency residuals in UV flat fields.



- Precision of centroiding of bright stars is 0.01 pix (400 μ s)
- Scans over several 1000s pixels → factor of >10 better (reaching ~25 μ s)
- Exceeds FGS precision and compares favorably with GAIA
- Successful measurement of Cepheid parallax to ~2 kpc (with 5 kpc possible)
• See Riess, Casertano, Anderson, MacKenty, Filippenko 2014 Ap.J. 785,161 (arXiv:1401.0484)

Image Persistence and Charge Trapping in IR Detectors

- The WFC3/IR detector has excess dark currents for several hours following exposures to >50% full well
- Produces a typical signal ~0.3 e-/s after 1000 seconds from bright sources
- This is a **complex** charge trapping behavior
- Dependent upon flux and total charge
- Long decay tail (may resurrect with additional flux)
- Non-linearity and non-repeatability for observations of bright sources



Mitigation Approaches:

- 1) Users should dither IR images
- 2) STScI manually identifies the majority of the “worst events” in advance and attempts to preclude other IR observations during several subsequent orbits
- 3) STScI now provides a **predicted** residual image for every WFC3/IR observation within 7 days of your observations
• See: <http://archive.stsci.edu/psps/persist/search.php>

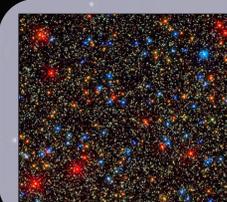
Improved Instrument Calibrations

- UVIS Photometry
 - Independent solutions for UVIS CCD detectors coming Feb 2014.
- UVIS Astrometry
 - Two-dimensional corrections for photo-lithographic pattern in place
 - Filter specific corrections being developed in 2014.
- UVIS Darks improved by use of Post-Flash (better discrimination of hot pixels).
- IR Spectroscopy
 - Wavelength calibration in PN IC5117 removed small offset between Grisms.
- IR Linearity and Persistence
 - Studies in Cycle 21 to understand impacts of charge trapping on precision photometric observations of bright sources
- UVIS Shutter Blade selection now available for short exposures
 - Permits observer to obtain best possible PSF (i.e. less vibration)
- Annual WFC3 Calibration Plan documented in WFC3 Instrument Science Reports and summarized in Appendix of WFC3 Instrument Handbook –inputs always welcome!
• Cycle 21 = 98 External and 1907 Internal Orbits

Program Title	Ext. Orbits	Int. Orbits	Program Title	Ext. Orbits	Int. Orbits
UVIS anneal	0	85	IR persistence model tests*	8	8
UVIS bowtie monitor*	0	243	Trapping mitigation in spatial scan observations of exoplanets*	15	0
UVIS CCD daily monitor*	0	644	WFC3 contamination & stability monitor	10	0
UVIS CCD un-flashed monitor*	0	140	WFC3 UVIS & IR photometry*	18	0
UVIS post-flash monitor	0	60	IR Grism: cross checking sensitivity function of hot and cool star*	1	0
UVIS CCD gain stability	0	18	UVIS Grism: flux calibration*	2	0
IR dark monitor	0	95	UVIS Grism: wavelengths calibration & stability*	2	0
IR linearity monitor	3	9	IR Grisms: flux calibration*	4	0
IR gain monitor	0	16	IR Grisms: wavelengths calibration & stability*	4	0
UVIS CTI monitor (EPER)	0	12	IR Grisms sky characterization*	2	20
UVIS CTE monitor (star cluster)*	6	0	Recalibration of the IR Grism wavelength ZPs*	2	0
CTE characterization with post-flashed darks*	0	15	UV flats via spatial scan*	8	0
Characterization of the charge-level dependence of CTE losses*	0	13	UV flat field validation*	4	0
Characterization of UVIS traps with CI*	0	72	CCD anomalous QE pixels*	0	24
UVIS & IR geometric distortion	6	0	UVIS internal flats	0	15
High precision astrometry*	3	0	IR internal flats	0	18
			CSM monitor with earth flats*	0	400

Abstract

We report on recent developments in the characterization and calibration of the Hubble Space Telescope’s Wide Field Camera 3. Installed in 2009 during HST Servicing Mission 4, WFC3 continues as the most used instrument on the observatory with stable performance and steady improvements in its photometric, flat field, dark current, and astrometric calibrations. An important recent development is the recognition of the impact of the Helium 1.083 micron emission line from the upper atmosphere. This sometimes results in significant background variations of factors of 3 to 5 higher than the nominal zodiacal light background in the F105W, F110W, G102, and G141 spectral elements. We also report on progress in using observatory level spatial scans to achieve higher dynamic range observations, to obtain higher precision and more efficient photometric measurements of bright sources, to improve our knowledge of the flat fields, and to increase the precision of astrometric measurements.



Additional Information:

<http://www.stsci.edu/hst/wfc3>
<http://www.stsci.edu/hst/wfc3/documents/ISRs>
 and (...documents/meeting_posters/...)
 and Posters 122.03, .04, and .05

Questions and Support: help@stsci.edu