# Cycle 23 STIS Calibration Plan

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# Cycle 23 Instrument Usage Statistics Based on Approved Programs

- STIS orbits comprise ~14.3% of all GO prime orbits in Cycle 23

| Instruments | Prime Orbits Usage | SNAP Orbit Usage |
|---|---|---|
| ACS | 15.7% | 11.7% |
| COS | 18.0% | 7.3% |
| STIS | 14.3% | 6.7% |
| WFC3 | 52.0% | 74.3% |
| FGS | <0.01% | 0.0% |

# STIS Cycle 23 Usage Statistics for each Configuration/Mode

| Configuration/Mode | Percentage of STIS Prime Exposure Time | | Percentage of STIS SNAP Exposure Time | |
|---|---|---|---|---|
| | C22 | C23 | C22 | C23 |
| **CCD** | **26.4%** | **24.1%** | **100%** | **100%** |
| CCD/Imaging | 8.5% | 0.7% | -- | -- |
| CCD/Spectroscopy | 17.9% | 23.4% | 100% | 100% |
| **MAMA/FUV** | **42.1%** | **35.7%** | **--** | **--** |
| FUV/Imaging | 1.5% | 11.0% | --- | -- |
| FUV/Spectroscopy | 40.6% | 24.7% | -- | -- |
| **MAMA/NUV** | **31.5%** | **40.2%** | **--** | **--** |
| NUV/Imaging | 0.2% | 0.8% | --- | -- |
| NUV/Spectroscopy | 31.3% | 39.2% | -- | -- |

# STIS Cycle 23 Usage Statistics for each Grating/Mirror Combination

| Configuration/Mode | Grating/Mirror | Percentage of STIS Prime science Exposure Time | | Percentage of STIS SNAP science Exposure Time | |
|---|---|---|---|---|---|
| | | C22 | C22 | C22 | C23 |
| STIS/CCD | G230LB | 3.4% | 7.9% | --- | 59.7 |
| (24.1%) | G230MB | 0.03% | -- | --- | -- |
| | G430L | 1.9% | 6.4% | 52.1% | 15.7% |
| | G430M | 1.7% | 0.4% | --- | -- |
| | G750L | 9.4% | 7.6% | 47.9% | 24.6% |
| | G750M | 1.5% | 1.3% | --- | -- |
| | MIRROR/CORON | 8.5% | 0.7% | -- | -- |
| STIS/MAMA-FUV | E140H | 4.2% | 7.7% | --- | -- |
| (35.7%) | E140M | 12.6% | 4.4% | --- | -- |
| | G140L | 17.4% | 7.3% | -- | -- |
| | G140M | 6.4% | 5.3% | -- | -- |
| | MIRROR | 1.5% | 11.0% | --- | -- |
| STIS/MAMA-NUV | E230H | 0.7% | 14.8% | -- | -- |
| (40.2%) | E230M | 13.1% | 7.4% | --- | -- |
| | G230L | 17.4% | 17.2% | -- | -- |
| | MIRROR | 0.2% | 0.8% | --- | -- |

# STIS Calibration and Monitor Orbits Approved by Cycle

| | # of Programs | External Orbits | Parallel Orbits | Internal Orbits | Total Orbits |
|---|---|---|---|---|---|
| **Cycle 17** | 25 | 68 | 0 | 1816 | 1884 |
| **Cycle 18** | 20 | 22 | 0 | 1370 | 1392 |
| **Cycle 19** | 18 | 21 | 0 | 1418 | 1439 |
| **Cycle 20** | 20 | 21 | 0 | 1391 | 1412 |
| **Cycle 21** | 20 | 21 | 0 | 1392 | 1413 |
| **Cycle 22** | 19 | 21 | 0 | 1387 | 1408 |
| **Cycle 23** | 22 | 31* | 1 | 1380 | 1416 |

* 10 external orbits and 1 parallel orbit increase due to 3 new proposed CCD programs anticipated to be for Cycle 23 only.

# STIS Cycle 23 Calibration and Monitoring Orbits Approved

| Prop. ID | Title | External | External Parallel | Internal | Frequency (orbits x repeats) | Cycle 22 Allocation |
|---|---|---|---|---|---|---|
| **CCD Monitors** | | | | | | |
| | STIS CCD Performance Monitor | | | 14 | 2x7 | 14 |
| | STIS CCD Dark Monitor | | | 732 | 2x366 | 730 |
| | STIS CCD Bias and Read Noise Monitor | | | 370 | 1x183+1x183 + 1x4 | 369 |
| | STIS CCD Hot Pixel Annealing | | | 39* | 3x13 | 39 |
| | STIS CCD Spectroscopic Flat-Field Monitor | | | 19 | 1x10 +9 | 19 |
| | STIS CCD Imaging Flat-Field Monitor | | | 4 | 1x4 | 4 |
| | STIS CCD Spectroscopic Dispersion Solution Monitor | | | 3 | 3x1 | 3 |
| | STIS CCD Sparse Field CTE | | | 50 | 50x1 | 82 |
| | STIS CCD Full Field Sensitivity | 1 | | 16 | 17x1 | 1 |
| | STIS Slit Wheel Repeatability | | | 1 | 1x1 | 1 |
| | STIS CCD Spectroscopic Sensitivity Monitor | 5 | | | L 1x3, M 2x1 | 5 |
| | STIS CCD Amp A, C, & D Gains | | | 6 | 6x1 | - |
| | STIS Focus + Parallel Measurements◆ | 1 | 1 | | 1x1 | - |
| | STIS CCD Pushing Limits of BAR5 | 9 | | | 9x1 | - |
| **MAMA Monitors** | | | | | | |
| | STIS MAMA Spectroscopic Dispersion Solution Monitor | | | 7 | 7x1 | 7 |
| | STIS MAMA Full Field Sensitivity | 3 | | | 1x3 | 3 |
| | STIS MAMA Spectroscopic Sensitivity and Focus Monitor / COS Observations of Geocoronal Lyα Emission | 12 | | | 1x3/L, 1x1/M, 2x4/E | 12 |
| | STIS FUV MAMA Dark Monitor | | | 54 | 6x9 | 54 |
| | STIS NUV MAMA Dark Monitor | | | 52 | 2x26 | 52 |
| | STIS MAMA NUV Flat-Field Monitor | | | 11* | 1x11 | 11 |
| | STIS MAMA Fold Distribution | | | 2 | 2x1 | 2 |
| **Contingency program** | | | | | | |
| | STIS MAMA Anomalous Recovery | | | (6) | | (6) |
| **TOTAL** | **Cycle 23 orbit request** | 31 | 1 | 1380 + (6) | | Ext: 21 +0<br>Int: 1387+(6) |

* Internal parallel orbits > 1800s.

Green means "executing on alternating cycle only"

Red means new

( ) Indicates contingency orbits not included in Cycle 23 request.

◆PI involved in Wavelength working group; Phase II can be delayed to end of year.

Blue: change from last cycle

# STIS/CCD Programs

# STIS CCD Performance Monitor
# PI: Jo Taylor

| | |
|---|---|
| **Purpose** | Measure the baseline performance of the CCD detector. |
| **Description** | This program monitors the performance of the CCD detector on orbit for Amplifier D only. Bias and Flat Field exposures are taken to measure read noise, CTE (EPER test), spurious charge, and gain values with full frame observations. Bias exposures are also taken in sub-array readouts to check the bias level for ACQ and ACQ/PEAK observations. All orbits < 1800s. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time |
| **Resources Required: Observations** | 14 internal orbits performed in 2 groups of 7 |
| **Resources Required: Analysis** | 2 FTE weeks for analysis and documentation. |
| **Products** | Possible update of gain, bias level, and read noise values in ccdtab. Relative measure of CTI via the extended pixel edge response test. Possible flight software updates of table CCDBiasSubtractionValue. Summary in the end-of-cycle ISR and udpates to the STIS monitor webpages |
| **Accuracy Goals** | Readnoise to +/- 0.3 ADU, gain error < 0.08 ADU |
| **Scheduling & Special Requirements** | Visits occur every 6 months in Mar & Sept 2016 |
| **Changes from Cycle 22** | No changes. |

# STIS CCD Dark Monitor (Parts 1 & 2)
# PI: Jo Taylor

| | |
|---|---|
| **Purpose** | Monitor dark current for the STIS CCD |
| **Description** | Routine monitoring with Amp D and GAIN=1: obtain 2 visits per day comprising of 1 long (1100s) and 2 short (60s) dark exposures each in order to monitor CCD behavior and chart growth of hot and bad pixels. Check how well the anneals work for the CCD. All exposures are internals, fit in occultation and orbits are <1800s.<br>In addition to routine monitoring, one month of 60s daily darks with AMP=D are replaced with AMP=A 60s darks to conduct a measure of the absolute CTI as a function of the number of transfers in the STIS CCD using warm pixels and a direct comparison to typical AMP=D 60s darks. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time |
| **Resources Required: Observations** | 364 (part1) + 368 (part2) internal orbits <1800s. |
| **Resources Required: Analysis** | 4 FTE weeks; Retrieve and construct superdarks. These superdarks are compared to previous superdarks and the image statistics are checked to see if there are any anomalous statistical deviations. CTI analysis based on short darks is performed. |
| **Products** | Weekly CRDS reference files (superdarks); a summary in the end of cycle ISR and update of monitor webpage. |
| **Accuracy Goals** | Superdark rms < 0.012 e-/s. S/N > 1.0 per pixel in superdarks |
| **Scheduling & Special Requirements** | Two orbits per day. |
| **Changes from Cycle 22** | Two extra internal orbits were added to account for 2016 leap day. |

# STIS CCD Bias and Read Noise Monitor (Parts 1 & 2)
# PI: Jo Taylor

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|---|---|
| **Purpose** | Monitor the bias in the 1x1 bin settings at GAIN=1 and at GAIN=4 to build up high S/N super-biases and track the evolution of hot columns through nominal AMP D. Also acquire biases through AMPs A and C to use in combination with biases taken through AMP D for monitoring of the read noise. |
| **Description** | Take full frame bias exposures in the 1x1 bin settings at GAIN=1, and at GAIN = 4 with nominal AMP D. Take full frame biases through AMPs A and C at GAIN=1 & 4 as well for performing read noise monitoring. All exposures are internal and fit in occultation orbits. In addition to routine monitoring, during one month we use 4 additional internal orbits of GAIN=1, AMP A biases in support of absolute CTI measurements. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time |
| **Resources Required: Observations** | 183 (part1) + 187 (part2) internal orbits + 4 (CTI) internal orbits <1800s. |
| **Resources Required: Analysis** | 2 FTE weeks. Retrieve and construct superbiases. These are compared to previous superbiases and the image statistics are checked to see if there are any anomalous deviations. Biases with AMPs A & C allow for monitoring of the read noise. |
| **Products** | Weekly CRDS reference files (superbiases) and a summary in the end of cycle ISR. |
| **Accuracy Goals** | Superbias rms < 0.95 e- at GAIN=1 1x1 and rms < 1.13 e- at GAIN=4 1x1. S/N > 1 per pixel. |
| **Scheduling & Special Requirements** | One orbit per day for the routine monitor. The additional bias for AMP A should be taken the same month as the AMP A darks for CTI analysis. |
| **Changes from Cycle 22** | One extra internal orbit was added to account for 2016 leap day. |

# STIS CCD Hot Pixel Annealing
# PI: Jo Taylor

| | |
|---|---|
| **Purpose** | To anneal hot pixels. The effectiveness of the CCD hot pixel annealing is assessed by measuring the dark current behavior before and after annealing. |
| **Description** | The characteristics of the CCD will first be defined by a series of bias, dark and flat-field exposures taken before the anneal. The CCD thermoelectric cooler will be turned off to allow the CCD detector temperature to rise from ~ -80 C to +5 C. The CCD will be left in the uncooled state for approximately 12 hours. At the end of this period the thermoelectric cooler is turned back on and the CCD is cooled to its normal operating temperature. Since the CCD on Side-2 does not have thermistor, a 4 hour period, at a minimum, is necessary to ensure that the CCD is cool and stable. After the CCD has stabilized, bias, dark, and flat-field images will be repeated to check for changes in the CCD characteristics. The flat field exposures will permit evaluation of any window contamination acquired during the annealing period. Pure parallel mode. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time |
| **Resources Required: Observations** | 39 internal orbits and all orbits > 1800s. |
| **Resources Required: Analysis** | 2 FTE weeks. By comparing the number of hot pixels before and after the anneal we see if the hot pixels decrease and estimate the number of hot pixels that persist after the process. |
| **Products** | Hot pixel growth rate, median dark count rate, and a summary in the end of cycle ISR. |
| **Accuracy Goals** | Measure the growth rate of hot pixels to within 1% if possible. |
| **Scheduling & Special Requirements** | Pure parallel mode exposures. Anneals will execute every 4th week using 3 orbits. |
| **Changes from Cycle 22** | No changes |

# STIS CCD Spectroscopic Flat-Field Monitor
# PI: John Biretta

| | |
|---|---|
| **Purpose** | Obtain medium resolution grating flats to determine the pixel-to-pixel variation for spectroscopic observations and produce the cycle 23 reference p-flat (M and L modes). |
| **Description** | We use the tungsten lamp and the G430M grating to determine the pixel-to-pixel variation of the STIS CCD in spectroscopic mode. The flat exposures are taken with the 50CCD and 52x2 apertures at 5 offset positions in order to map -with a sufficient SNR- the whole sensitive area of the detector. The expected signal is ≥1.4E6 ADU/pixels; while the expected accuracy will be ≤1.5%. All orbits are less < 1800 s. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time. |
| **Resources Required: Observations** | 19 internal orbits <1800s |
| **Resources Required: Analysis** | 2.5 weeks FTE |
| **Products** | Reference files, summary in end of cycle ISR and ISR as applicable |
| **Accuracy Goals** | ≤1.5% flat field accuracy |
| **Scheduling & Special Requirements** | 9 orbits with G430M/5612 & 50CCD spread across the cycle; 1 visit every ~40 days<br>10 orbits with the G430M/5612 & 52x2 |
| **Changes from Cycle 22** | No changes |

# STIS CCD Imaging Flat-Field Monitor
# PI: John Biretta

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|---|---|
| **Purpose** | Collect high SNR white light imaging flats (aperture=50CCD) for monitoring purposes and to create a new reference p-flat for coronagraphic (and imaging) observations. |
| **Description** | Once every 3 months, obtain a series of imaging CCD flats using the MIRROR and the unfiltered 50CCD aperture. The 3 months cadence will allow us to keep monitoring possible (but unlikely) variations across the cycle; while the combined observations will allow us to obtain an average signal ~620000 ADU/pix (similarly to the past cycles) and create a high accuracy (~1%) imaging p-flat. The remaining time in each orbit/visit will be used to monitor the stability of the CORON aperture due to the MSM limited reproducibility. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time. |
| **Resources Required: Observations** | 4 internal orbits <1800s |
| **Resources Required: Analysis** | 4 weeks FTE |
| **Products** | Reference p-flat and TIR or ISR as relevant, summary in the end of cycle ISR |
| **Accuracy Goals** | ~1% flat field accuracy |
| **Scheduling & Special Requirements** | 1 orbit every 3 months. |
| **Changes from Cycle 22** | No changes |

# STIS CCD Spectroscopic Dispersion Solution Monitor
# PI: Molly Peeples

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|---|---|
| **Purpose** | To monitor the wavelength and spatial distortion maps for some configurations of the STIS/CCD. |
| **Description** | Internal wavecals will be obtained with all 6 gratings (G230LB, G230MB, G430L, G430M, G750L, G750M) supported for use with the CCD. All observations will be obtained with the 52x0.1 aperture, which maps to 2 pixels at the CCD. The HITM1 lamp will be used, rather than the LINE lamp. The HITM1 lamp has a more favorable spatial illumination pattern, dropping by only a factor of 3 at row 900, relative to the peak brightness at row 420. A comparison LINE lamp wavecal is however included with the G430L/4300 grating. All orbits < 1800s. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time. |
| **Resources Required: Observations** | 3 internal orbits < 1800s |
| **Resources Required: Analysis** | 4 FTE weeks |
| **Products** | Update wavelength dispersion reference file as needed, ISR, and a summary in the end of cycle ISR. |
| **Accuracy Goals** | 0.2 pixels; wavelength accuracy for row 900. Wavelength coefficients are tabulated every 32 rows in the CCD dispersion (_dsp) reference file. Exposure times in this program have typically been chosen to yield a S/N ratio of at least 10 per pixel in row 900 after combining 32 rows. This constraint must be satisfied in the left, middle, and right thirds of the image. Existing HITM1 wavecals were used to estimate exposure times assuming no significant degradation since Cycle 18. |
| **Scheduling & Special Requirements** | These observations are taken once per cycle |
| **Changes from Cycle 22** | No changes |

# STIS CCD Sparse Field CTE
# PI: Sean Lockwood

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|---|---|
| **Purpose** | Acquire an accurate correction for parallel register CTE losses that can be used for direct analysis of science data with negligible background. Perform measurements with GAIN=1 (this cycle), alternating with GAIN=4 every-other-cycle. |
| **Description** | The sparse field CTE will be measured via internal calibration lamp observations taken through narrow slits. The strategy of the test is as follows. Using the onboard tungsten lamp, narrow slit images are projected at different positions on the detector. At each position a series of exposures is taken alternating between the 'A' and 'C' amplifiers for readout. The further the charge needs to be shifted to be read out, the more charge it will lose. For the parallel CTE measurement, the test will use the cross disperser slits: 0.05x31NDB and 0.05x31NDA. In order to test the effects of different bias voltages the whole series of exposures are executed once for GAIN=1, and once for GAIN=4 every-other cycle; this process requires a total of 50 orbits per cycle which includes various sets of biases and darks as well. For the CTE pixel based correction, the test requires 8 orbits for darks read out with amplifier A. 43/50 orbits are < 1800s, with the remaining exceeding this limit by ~100s each in order to capture the full sequence of exposures required for best analysis. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time. |
| **Resources Required: Observations** | 50 internal orbits once per year. 43/50 orbits are < 1800s, with the remaining exceeding this limit by ~100s |
| **Resources Required: Analysis** | 3 FTE weeks |
| **Products** | Determine slope for time dependent correction of CTE, possible update of CCDTAB reference file, and summary in the end of cycle ISR. |
| **Accuracy Goals** | CTE correction coefficients will be determined to a relative accuracy of 1%. |
| **Scheduling & Special Requirements** | This program should execute in the October 2015 – January 2016 window, and should be taken consecutively. |
| **Changes from Cycle 22** | Reduced from 82 to 50 orbits by removing GAIN=4 data, which will alternate every-other cycle with GAIN=1 data. Rearranged remaining exposures to optimize program. 7 orbits now exceed 1800s limit. |

# STIS CCD Full-Field Sensitivity
# PI: John Debes

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|---|---|
| **Purpose** | To monitor CCD sensitivity over the whole field of view. |
| **Description** | Measure a photometric standard star field in Omega Cen in 50CCD annually to monitor CCD sensitivity over the whole field of view. Maintain the spacecraft orientation within a suitable range (+/- 5 degrees) to keep the same stars in the same part of the CCD for every measurement. These observations provide a check of the astrometric and PSF stability of the instrument over its full field of view.<br>In addition, internal biases and darks will be taken using AMP A to better calibrate photometric data using this amplifier in checks of empirical and pixel-based CTI corrections. Although this test is done using CCD imaging mode, the confirmation of detector stability and uniformity provided by this monitor is important for spectroscopic observations as well. All external orbits > 1800s, all internal orbits < 1800s. |
| **Fraction GO/GTO Programs Supported** | 24% |
| **Resources Required: Observations** | 1 external + 16 internal once per year (orbits < 1800s) |
| **Resources Required: Analysis** | 1 FTE week |
| **Products** | Summary in the end of cycle ISR |
| **Accuracy Goals** | 1% |
| **Scheduling & Special Requirements** | ORIENT 310.0D TO 310.0 D; BETWEEN 15-JAN-2016:00:00:00 AND 20-MAR-2016:00:00:00; 16 internal visits execution wihtin anneal period of the external visit |
| **Changes from Cycle 22** | Addition of 16 internal orbits to create contemporaneous dark and bias observations in AMP A for better photometric calibration of AMP A data for testing of empirical and pixel-based CTI corrections. |

# STIS Slit Wheel Repeatability
# PI: Audrey DiFelice

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|---|---|
| **Purpose** | To test the repeatability of slit wheel motions. |
| **Description** | A sequence of lamp spectra taken using grating G230MB and the three smallest long slits 52X0.1, 52X0.2, and 52X0.05. |
| **Fraction GO/GTO Programs Supported** | 100% |
| **Resources Required: Observations** | 1 internal orbit (24 exposures, ~40 minutes total) once per year |
| **Resources Required: Analysis** | 2 FTE days |
| **Products** | The average and maximum shifts observed in the dispersion and the spatial direction. Summary in end of cycle ISR |
| **Accuracy Goals** | Shifts should be smaller than 0.5 pixels. |
| **Scheduling & Special Requirements** | Between Nov 01-2015 and Jan 31 2016 |
| **Changes from Cycle 22** | No changes |

# STIS CCD Spectroscopic Sensitivity Monitor
# PI: TalaWanda Monroe

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|---|---|
| **Purpose** | Monitor the spectroscopic sensitivity of the STIS CCD using both low- and medium-resolution gratings to reveal contamination issues that may affect the spectroscopic throughput. |
| **Description** | This program will monitor the STIS CCD spectroscopic sensitivity using a high-declination spectroscopic calibration star (AGK+81D266). The results will be compared to previous observations to detect trends. The L modes will be observed at the nominal and E1 positions every four months with one orbit per visit. The M modes will be observed at the nominal and E1 positions as well, once per year with two orbits per visit. |
| **Fraction GO/GTO Programs Supported** | 24% |
| **Resources Required: Observations** | 5 external orbits |
| **Resources Required: Analysis** | 7 FTE weeks: 3 FTE weeks for sensitivity analysis, 2 weeks for ISR, 2 FTE weeks for CTE correction verification |
| **Products** | Updated STIS TDSTAB file, an ISR on STIS sensitivity monitoring, summary in end of cycle ISR |
| **Accuracy Goals** | Minimum signal to noise of 50 per resolution element at the least sensitive wavelength. |
| **Scheduling & Special Requirements** | 1 orbit every 4 months for L modes. 2 orbits/year for M modes. |
| **Changes from Cycle 22** | No changes |

# Special CCD Programs For Cycle 23

# STIS CCD Gains for AMPs A, C, & D
# PI: John Biretta

- Goal: Obtain an accurate measure of gains (e-/count) for GAIN=1 and 4 in AMPs A, C, & D

  ⇒ GAINs in AMP A & C last measured in 2000
  ⇒ Data obtained in routine monitors are not adequate

- Include *contemporaneous* AMP D data to get accurate gain relative to AMP A

  ⇒ Needed for CTI photometric tests, long-term calibration, health of instrument verification

Request: 2 internal orbits/AMP for total of 6 internal orbits

# STIS CCD Gains for AMPs A, C, & D
# PI: John Biretta

| | |
|---|---|
| **Purpose** | Measure supported gains of all CCD amplifiers. |
| **Description** | This program obtains pairs of internal flats at different exposure levels using the CCD A, C, & D amplifiers at both nominal gains1 and 4. Pairs of Biases are also obtained contemporaneously to measure accurate gains in non-default AMPs A & C .Accurate gains are needed relative to default AMP D for CTI-related calibrations. |
| **Fraction GO/GTO Programs Supported** | 24% of STIS total exposure time |
| **Resources Required: Observations** | 6 internal orbits |
| **Resources Required: Analysis** | 2 FTE weeks |
| **Products** | Update of gain values in ccdtab. ISR on gains; summary in end of Cycle ISR.<br>Gain values used for CTI-related analyses. |
| **Accuracy Goals** | Determine gains to 1% |
| **Scheduling & Special Requirements** | All visits within 24 hours, if possible, or taken within no more than 48h, to guard against possible time-dependent gain variations in AMPs A & C. |
| **Changes from Cycle 22** | New, special program for Cycle 23. Depending on analysis results, a repeat of this program might be considered in future cycles. |

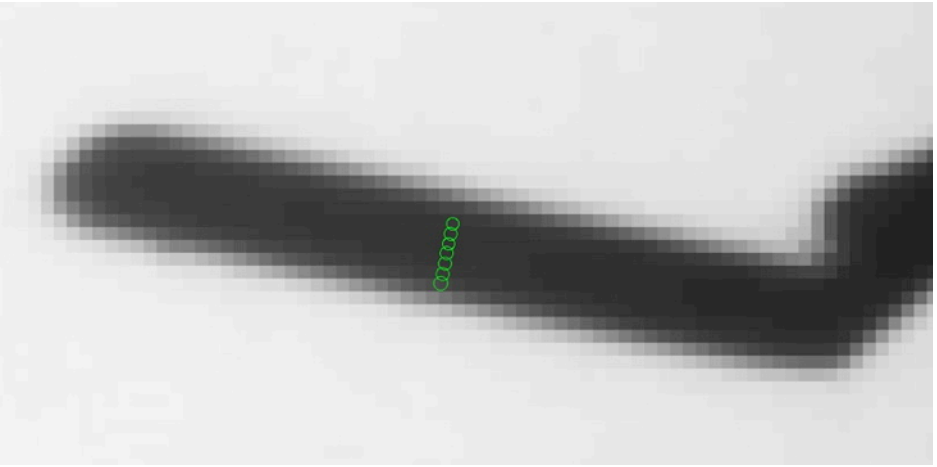
# STIS Focus Parallel Measurements
# PI: Charles Proffitt

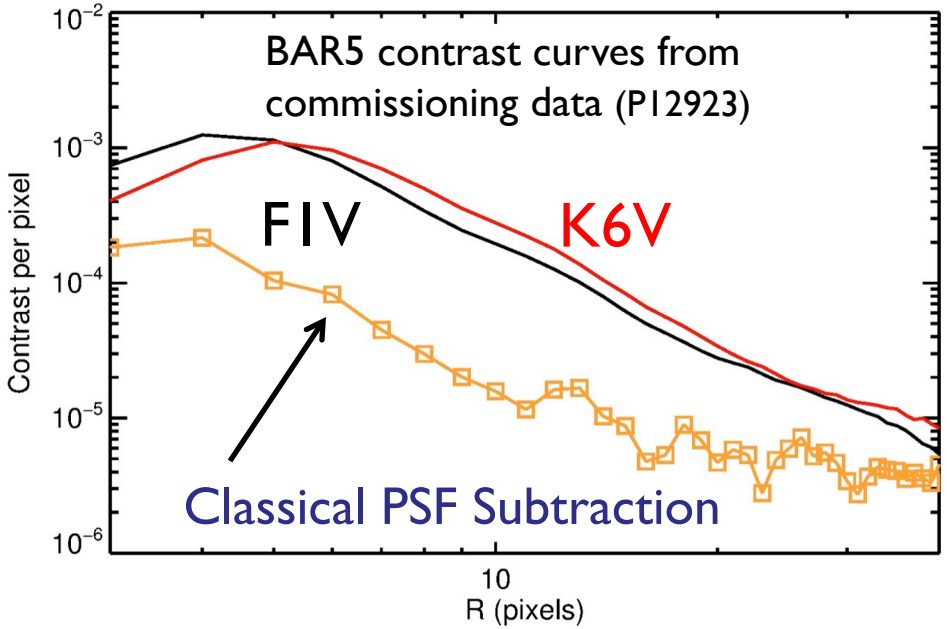
| | |
|---|---|
| **Purpose** | To determine the focus offset between the STIS OII filter and that of WFC3/UVIS and ACS/WFC. Will allow any long term secular changes in the relative focus of the three instruments to be determined. |
| **Description** | A UV bright star will be observed with STIS F28X50OII while parallel observations are done of a rich star field in 47 Tuc using WFC3 F410M and ACS F502N. The filters are chosen to allow phase retrieval to estimate the focus and other optical parameters from the PSF images. Simultaneous parallel observations allow a differential measure of the focus offset between the three instruments without having to rely on the accuracy of the breathing model. |
| **Fraction GO/GTO Programs Supported** | A 100% STIS programs are affected by the focus status |
| **Resources Required: Observations** | 1 external STIS orbit, WFC3 and ACS in parallel |
| **Resources Required: Analysis** | 2 FTE weeks |
| **Products** | A measurement of the focus offset between STIS and ACS and WFC3. |
| **Accuracy Goals** | < 1 micron of equivalent secondary mirror motion |
| **Scheduling & Special Requirements** | To use the same target and fields as used for visit P2 of 14063 will require ORIENT=255D, which will allow execution to occur between 25-May-2016 and 13-Jul-2016. |
| **Changes from Cycle 22** | New special program; repeat of visit P2 of the special Cycle 22 program 14063. Depending on analysis results, a repeat of this program might be considered in future cycles. |

# STIS CCD: Pushing the Limit of BAR5
# PI: John Debes

| | |
|---|---|
| **Purpose** | To quantify the limiting contrast at the inner working angle of the BAR5 occulter position |
| **Description** | The recently commissioned BAR5 occulting position in STIS promises potential high contrast imaging at small inner working angles, but its ultimate contrast capabilities have not yet been demonstrated. We propose to obtain 9 external orbits of a bright star to attempt photon-limited contrast via a combination of modern high contrast imaging techniques and post-processing to attempt photon-limited contrasts at the inner working angle of BAR5. Success will demonstrate several observing techniques that are proposed for JWST, increase STIS' ability to complement ground-based 2nd Generation AO-fed coronagraphs, and lay a foundation for coronagraphic observations with WFIRST/AFTA's coronagraphic instrument. |
| **Fraction GO/GTO Programs Supported** | 1-10% depending on cycle usage |
| **Resources Required: Observations** | 9 external orbits |
| **Resources Required: Analysis** | 3 FTE weeks of analysis; 2 FTE weeks for documentation |
| **Products** | Contrast curve for STIS BAR5 for community, STAN and ISR and a summary in the end of cycle ISR |
| **Accuracy Goals** | $10^{-7}$ Contrast or best achievable at inner working angle of 0.15” |
| **Scheduling & Special Requirements** | 9 separate spacecraft orientations are required; early scheduling is preferred to allow analysis and enabling of the new capability in Cycle 24. |
| **Changes from Cycle 22** | New special program for Cycle 23 only. |

# Pushing the Limit of BAR5 (cont.)






- Current STIS performance: ~$10^{-4}$ contrast at 0.25”
- NIR ground-based extreme-AO: ~$10^{-6}$ @ 0.18”
- WFIRST/AFTA CGI: $10^{-9}$ @ 0.18”

=> Push STIS performance to $10^{-7}$ contrast at 0.15”

# Benefits to Pushing Limits

- Enable new, discovery science with increase in contrast by 1-3 more orders of magnitude compared to current capability:
  - Compete with $10^{-6}$ contrast of SPHERE (visible polarized light)
  - Characterize exo-zodis out to 30+ pc
  - Enable pathfinding science for WFIRST/CGI & educate mission on post-processing techniques
- Demonstrate new observing strategies that would be otherwise too risky (orbit extensive) for any GO to propose.
- Contribute to building robust PSF library for BAR5 location within limited lifetime left in HST; STIS sole coronagraph still operating in space!
- Increasing contrast will require testing new post-processing techniques that are being investigated for JWST+WFIRST/AFTA
- We can build on the heritage of NICMOS post-processing techniques to enhance contrast—KLIP and extend to optical regime

# Observing Plan

- Target: Tau Ceti (V=3.5; G8) No expected detectable sources 0.2-2" (cold dust disk >55 AU or15", faint super-Earth planetary system <2 AU or 0.55") Easily schedules throughout Cycle (Oct '15-Mar '16; Jun-Sept '16)
- Observe star with 9 spacecraft orientations (spaced by ~20°; grouped in 3 sets of 3 visits) over cycle with sub-grid dithering behind bar to create ~100 PSF realizations with short exposures
- Contrast Goal: ~$10^{-7}$—defined by photon noise limit due to PSF wings and total exposure time
- With overheads, 9 external orbits required to attempt $10^{-7}$ contrast (360s integration time, SCHED=100); execute as early in Cy23 as possible to enable capability for Cy 24.
- Combination of Roll angles, sub-grid dithers (Lajoie et al., 2014), and post-processing with KLIP (Soummer et al, 2010) can provide near photon-limit performance

# STIS/MAMA Programs

# STIS MAMA Spectroscopic Dispersion Solution Monitor
# PI: Molly Peeples

| | |
|---|---|
| **Purpose** | To monitor the wavelength dispersion solutions of the STIS MAMA/FUV and MAMA/NUV detectors. |
| **Description** | Internal wavecals will be obtained in all gratings at primary and secondary central wavelengths chosen to cover Cycle 23 use. There is also overlap with choices of configurations used with previous calibration programs which will enable long-term monitoring. This program uses the LINE lamp for a total of approximately 8 hours, typically at a lamp current of 10 mA, consuming about 0.5% of the 15000 mAhour lifetime. Extra-deep wavecals are included for some echelle modes and for some first order modes to ensure detection of weak lines. All orbits < 1800s. |
| **Fraction GO/GTO Programs Supported** | 76% of STIS total exposure time. |
| **Resources Required: Observations** | 7 internal orbits < 1800s. |
| **Resources Required: Analysis** | 4 FTE weeks |
| **Products** | Update wavelength dispersion reference file as needed, ISR, and a summary in the end of cycle ISR. |
| **Accuracy Goals** | 0.1 pixels internal wavelength precision. |
| **Scheduling & Special Requirements** | These observations are taken once per cycle |
| **Changes from Cycle 22** | No changes. |

# STIS MAMA Full-Field Sensitivity
# PI: John Debes

| | |
|---|---|
| **Purpose** | To monitor the sensitivity of the FUV-MAMA and NUV-MAMA over the full field of view |
| **Description** | By observing the globular cluster NGC6681 once every year at roughly the same orientation, we will monitor the full-field sensitivity of the MAMA detectors and their astrometric and PSF stability. These observations will be used to look for contamination, throughput changes, or formation of color centers in the photocathode and window that might be missed by spectroscopic monitoring or difficult to interpret in flat-fielding. Although this test is done using MAMA imaging modes, the confirmation of detector stability and uniformity provided by this monitor is important for spectroscopic observations as well. All orbits > 1800s. |
| **Fraction GO/GTO Programs Supported** | 76% of STIS prime exposure time |
| **Resources Required: Observations** | 3 external orbits |
| **Resources Required: Analysis** | 1 FTE week |
| **Products** | Summary in the end of cycle ISR |
| **Accuracy Goals** | 1% |
| **Scheduling & Special Requirements** | Should roughly match most common orient from previous observations. ORIENT 260.0D TO 266.0 D; BEFORE 16-JUN-2016:00:00:00 |
| **Changes from Cycle 22** | No Changes |

# STIS MAMA Spectroscopic Sensitivity & Focus Monitor
# PI: TalaWanda Monroe

| | |
|---|---|
| **Purpose** | Monitor the sensitivity of each STIS MAMA grating mode to detect any changes due to contamination or other effects, and monitor the STIS focus in spectroscopic and imaging modes. |
| **Description** | - SENSITIVITY: Obtain exposures in each of the two low-resolution MAMA spectroscopic modes every 4 months, in each of the 2 medium-resolution modes once a year, and in each of the 5 echelle modes every 3 months, using unique calibration standards for each mode (L: GRW+70D5824, M: AGK+81D266, E: BD+28D4211), and compare the results to the first observations to detect any trends.<br>- FOCUS: For this cycle we will continue to monitor the STIS focus (small aperture throughput as a function of UV wavelength) with a slightly revised strategy by including a direct comparison between the G230LB 0.1X0.09 and 52x2 throughput, as well as a narrow band OII CCD image during each L-Mode visit. We will continue to also include an OII image with the M-mode visit.<br>- AIRGLOW: Whenever possible, COS/FUV airglow spectra will be obtained in parallel (see COS slides) |
| **Fraction GO/GTO Programs Supported** | Focus monitor: 100% of STIS exposures- Sensitivity monitor: 76% of STIS exposures- Airglow parallel: 45% COS exposures |
| **Resources Required: Observations** | 12 external orbits, 4 parallel COS orbits |
| **Resources Required: Analysis** | 6.5 FTE weeks: 3 FTE weeks for sensitivity analysis, 2 weeks for ISR, 1.5 for focus. No COS analysis planned. |
| **Products** | Updated STIS TDSTAB file and ISRs on STIS sensitivity monitoring and focus monitoring. Summary in the end of cycle ISR. |
| **Accuracy Goals** | Minimum signal to noise of 50 per resolution element at the least sensitive wavelength. 10% for focus changes. |
| **Scheduling & Special Requirements** | Visits need to be approximately equally spaced throughout the cycle. |
| **Changes from Cycle 22** | Enhanced focus monitoring strategy without increase to total orbit request. |

# STIS FUV MAMA Dark Monitor
# PI: Colin Cox

| | |
|---|---|
| **Purpose** | To monitor the dark rate in the STIS FUV detector to provide information for data analysis, IHB and ETC updates. Also to detect any large changes in instrument behavior which might indicate a problem. |
| **Description** | Six 1300s dark images are taken every six weeks. The exposures are distributed over about six hours from initial turn-on to characterize the rate increase as a function of turn-on time and temperature. |
| **Fraction GO/GTO Programs Supported** | 36% |
| **Resources Required: Observations** | 54 internal orbits |
| **Resources Required: Analysis** | 2.5 FTE week |
| **Products** | Individual and cumulative dark images. Update dark rates in ETC and IHB. Text file giving full rate history plus graphical representation, all maintained on STIS monitor web page. Summary in end of cycle ISR |
| **Accuracy Goals** | Each measurement will give a statistical uncertainty of less than 1% for the global dark rate |
| **Scheduling & Special Requirements** | All measurements taken in SAA free periods in six sequential orbits. This matches time-on range of typical GO observations |
| **Changes from Cycle 22** | No changes |

# STIS NUV MAMA Dark Monitor
# PI: Colin Cox

| | |
|---|---|
| **Purpose** | Monitor the dark rate in the STIS NUV MAMA to provide values for image processing, IHB and ETC updates and to detect any large changes which might indicate instrumental problems. |
| **Description** | Two 1300 second dark images are taken every two weeks. The images are taken about 6 hours apart to discriminate between long and short term changes. |
| **Fraction GO/GTO Programs Supported** | 40% |
| **Resources Required: Observations** | 52 internal orbits |
| **Resources Required: Analysis** | 2.5 FTE weeks |
| **Products** | ETC and IHB dark rate updates. Individual and cumulative dark rates. Master dark reference file. Refinements to model describing temporal and temperature effects. Text file giving continuously updated dark rate history and graphical representation, both maintained on STIS monitoring web page. Summary in end of cycle ISR |
| **Accuracy Goals** | Statistical accuracy of mean rate will be better than 1%. |
| **Scheduling & Special Requirements** | SAA free orbits covering a 6-hour period. |
| **Changes from Cycle 22** | No changes |

# STIS NUV-MAMA Spectroscopic Flat-Field Monitor
# PI: John Biretta

| | |
|---|---|
| **Purpose** | This program is aimed at obtaining NUV-MAMA flat-field observations to create a pixel-to-pixel flat (p-flat) with a SNR of ~100 per binned pixel. The flat is obtained with the DEUTERIUM lamp and the G230M grating. |
| **Description** | Experience shows that ~11 visits are sufficient to build a p-flat with the required SNR~100/pix. Actual instrument setup (central wavelength and slit width) and exposure time might change during the cycle in order to guarantee count-level ~250000-280000 cps/frame. NUV-MAMA p-flats are mode independent, so G230M p-flat will suffice for all NUV-MAMA spectroscopic and imaging programs. |
| **Fraction GO/GTO Programs Supported** | 40% of STIS total exposure time. |
| **Resources Required: Observations** | 11 internal orbits >1800s |
| **Resources Required: Analysis** | 4 weeks FTE |
| **Products** | Combine this and past cycle frames to produce a new reference p-flat and ISR, as applicable, summary in the end of cycle ISR |
| **Accuracy Goals** | 1% flat field accuracy per low-res pixel (2x2 high-res pixels) |
| **Scheduling & Special Requirements** | ~1 visit per month. Runs on alternate Cycles to save lamp lifetime. |
| **Changes from Cycle 22** | No changes. This program is run on odd numbered Cycles. |

# STIS MAMA Fold Distribution
# PI: Thomas Wheeler

| | |
|---|---|
| **Purpose** | The fold analysis provides a measurement of the distribution of charge cloud sizes incident upon the anode providing some measure of changes in the pulse-height distribution of the MCP and, therefore, MCP gain. |
| **Description** | While globally illuminating the detector with a flat field, the valid event (VE) rate counter is monitored, while various combinations of row and column folds are selected. |
| **Fraction GO/GTO Programs Supported** | 76% of STIS prime orbits |
| **Resources Required: Observations** | 2 internal orbits |
| **Resources Required: Analysis** | 0.5 FTE day. |
| **Products** | The results will be sent to the COS/STIS Team and V. Argabright of Ball Aerospace. |
| **Accuracy Goals** | N/A |
| **Scheduling & Special Requirements** | This proposal is executed annually. |
| **Changes from Cycle 22** | No changes. |

# Contingency Programs

# STIS MAMA Recovery from Anomalous Shutdown
# PI: Thomas Wheeler

| | |
|---|---|
| **Purpose** | Safe and orderly recovery of either MAMA detector from an anomalous shutdown. |
| **Description** | The recovery procedure consists of three separate tests (i.e. visits) to check the MAMA's health after an anomalous shutdown. Each must be successfully completed before proceeding onto the next. They are: (1) signal processing electronics check, (2) slow, intermediate voltage high-voltage ramp-up, and (3) ramp-up to full operating voltage. |
| **Fraction GO/GTO Programs Supported** | 76% of STIS prime orbits |
| **Resources Required: Observations** | 6 internal orbits |
| **Resources Required: Analysis** | If activated, 0.5 FTE day per test. |
| **Products** | For tests 1-3, only a Go/No-Go to proceed will be given. |
| **Accuracy Goals** | N/A |
| **Scheduling & Special Requirements** | This is a contingency proposal activated only in the event of an anomalous shutdown. This proposal is usually followed by the STIS MAMA Fold Distribution proposal. |
| **Changes from Cycle 22** | No changes |

# Back-up Slides

# Synergies between STIS Regular programs and STIS CTI effort

List of STIS CCD Monitor Exposures Relevant to this effort.

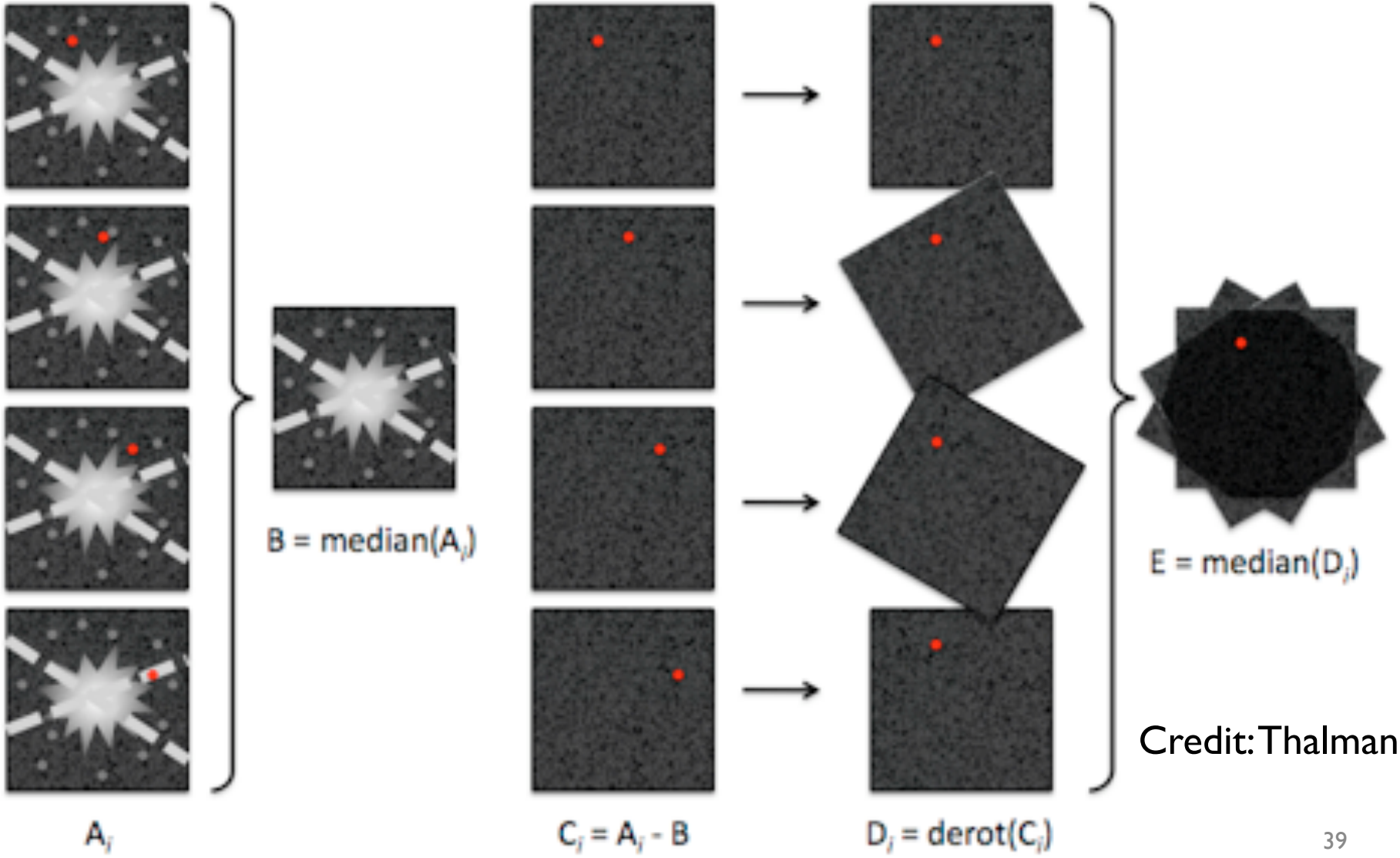
| Title | External Orbits | Internal Orbits | Target | Amplifier | Gain | Interval | Purpose / Notes |
|---|---|---|---|---|---|---|---|
| STIS CCD Performance Monitor | | 4 | Flats, Bias | D | 1, 2, 4, 8 | 6 months | CCD Gains; CCDTAB ref file. Gain 2 & 8 only once per yr. |
| | | 10 | Flats | D | 1 | 6 months | CTE via EPER method. CTE monitor plots. (Note 1) |
| STS CCD Dark Monitor | | 732 | Darks | D | 1 | 12 hours | Dark reference files. 1100s + 2x60s per visit. |
| | | | Darks | A | 1 | 12 hours | 60s dark 2x per day during 30 days in May 18 – July 6. (Note 2) |
| STIS CCD Bias & Read Noise Monitor | | 366 | Bias | D | 1, 4 | 1 day | 14 biases at gain =1 and 3 biases at gain=4 per day. Bias reference file. Read noise monitor. |
| | | | Bias | A, C | 1 | 1 day | 2 extra biases 3 days every 28 days. Read noise monitor. |
| | | | Bias | A, C | 4 | 1 day | 2 extra biases 3 days every 28 days. Read noise monitor. |
| | | | Bias | A | 1 | 1 day | 4 extra biases per day on 30 days May 18 – July 6. (Note 2) |
| | | 4 | Bias | A | 1 | 2 weeks | 21 extra biases 4 times between May 18 -- July 6. (Note 2) |
| STIS CCD Hot Pixel Annealing | | 39 | Darks, Bias | D | 1 | 28 days | Hot pixel monitor. 3 bias, 3 x 1100s darks before & after anneal |
| | | | Flats | D | 1, 4 | 28 days | Instrument health. 6 flats before & after each anneal |
| STIS CCD Spectroscopic Flats | | 19 | Flats | D | 4 | 40 days | P-Flat reference file |
| STIS CCD Imaging Flats | | 4 | Flats | D | 4 | 80 days | P-Flat reference file |
| STIS CCD Sparse Field CTE | | 36 | Lamp + Slit | A, C | 1 | Annual | ~400 exposures spread over Nov – Dec . (Note 3) |
| | | 8 | Darks | A, C | 1 | Annual | (1100s + 2x60s ) darks per Amp 4 times over Nov – Dec |
| | | 6 | Bias | A, C | 1 | Annual | 21 biases each Amp per day over 6 days in Nov – Dec. |
| STIS CCD Full Field Sensitivity | 1 | | Omega Cen | D | 4 | Annual | Typically observed in Jan – Mar (ORIENT 310D) |
| | | | Omega Cen | A, C | 4 | Annual | Typically observed in Jan – Mar (ORIENT 310D) |
| | | 2 | Bias | A | 1 | Annual | 21 biases 2x during week of Omega Cen data. (Note 4) |
| | | 14 | Darks | A | 1 | Annual | 14 x 1100s darks during week of Omega Cen data. (Note 4) |
| STIS CCD Gains for Amps A, C, & D | | 6 | Flats | A, C, D | 1, 4 | Once | Gains in non-default Amps. CCDTAB ref file. (Note 5) |

Notes:

(1) Extended Pixel Edge Response (EPER) method is engineering method to measure CTI (used for "CTE" monitor plots).
(2) Amp A 60s darks and biases are used to measure CTI parameters for pixel-based CTI correction method.
(3) Sparse Field CTE program uses internal spectral-like lamp exposures to measure CTI (used for early empirical work & test pixel-based corrections).
(4) Improve dark calibration of Amp A Omega Cen data for CTI work. Test CTI corrections by comparing Amp A vs. Amp D on Omega Cen.
(5) Gains in Amps A, C, & D needed for CTI work (Sparse Field, Omega Cen programs); Amp A & C last measured in 2000.

# Pushing the Limits of BAR5

## Angular Differential Imaging

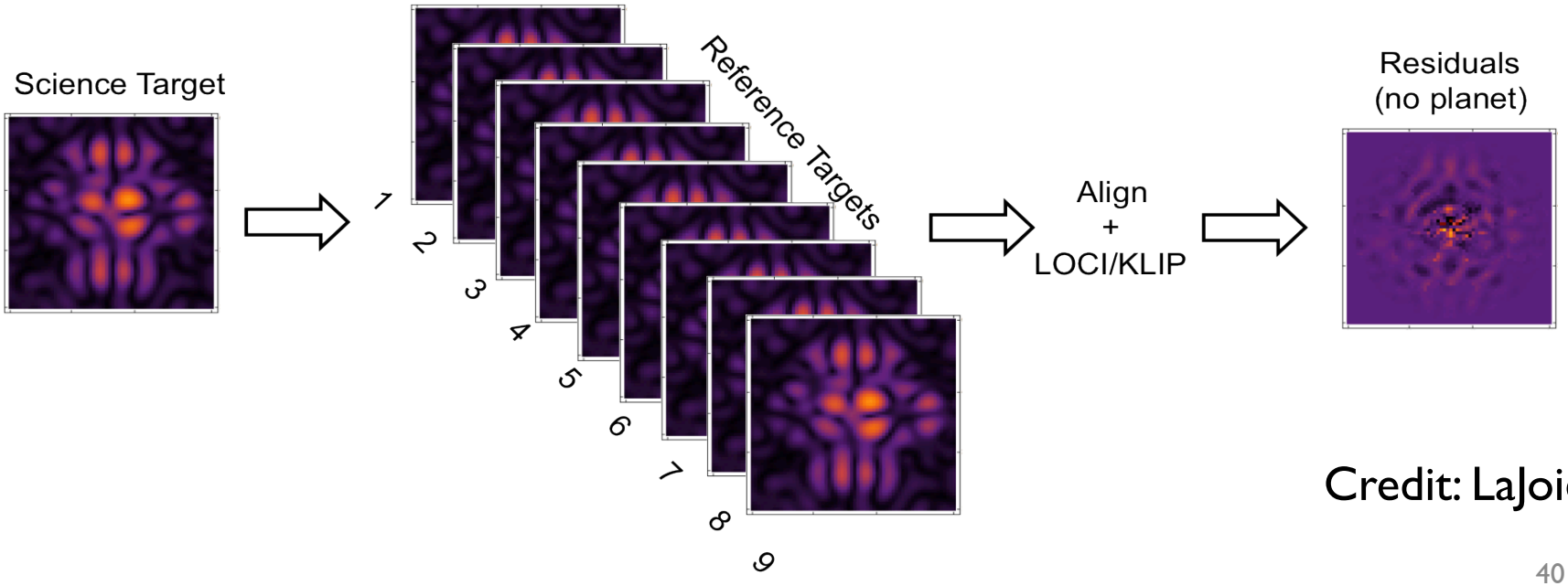



Credit: Thalmann

# Pushing the Limits of BAR5 (cont)

## Sub-pixel Grid Dithering

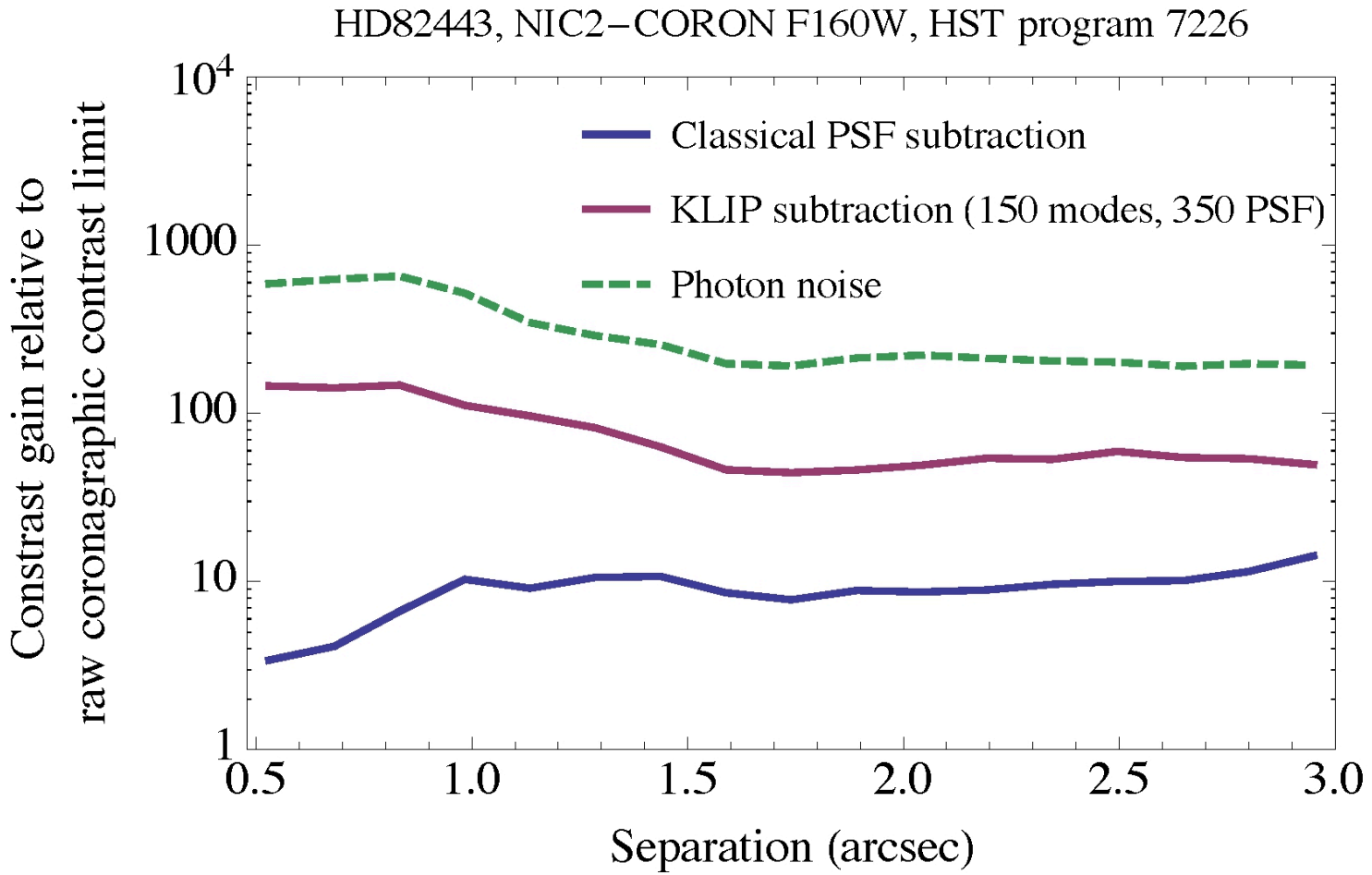
- Technique developed to mitigate contrast degradation for JWST/MIRI 4QPM
- Dither on sub-pixel grid with ~10 points to realize gain in contrast over classical PSF subtraction
- Works by combining dithering with post-processing (LOCI or KLIP)
- For JWST, the gain over classical techniques is 4-10x, depending on instrument, filter, and number of grid points
- More points is better: ~10 points appears to be sweet spot




Credit: LaJoie

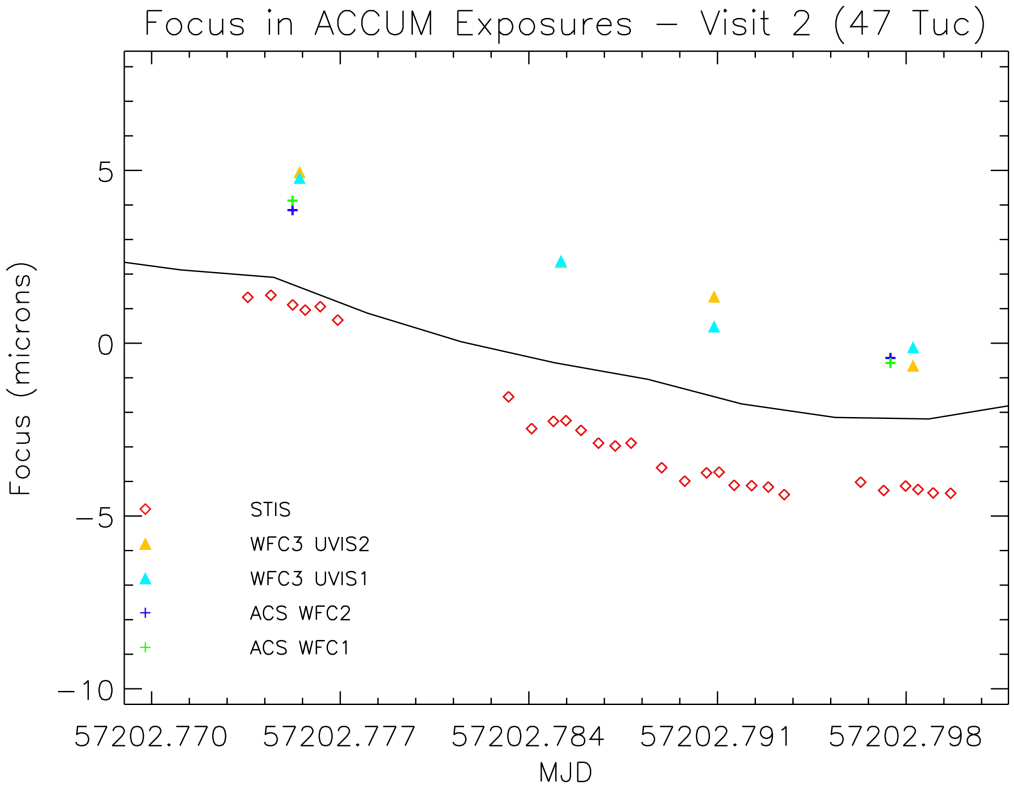
# Pushing the Limits of BAR5 (cont)

## KLIP Performance for NICMOS




Credit: Choquet

# STIS Focus Parallel Measurements




The focus offset between STIS F28X50OII images and other cameras can be used to monitor the stability of the STIS focus over time.

The WFC3 UVIS F410M images of 47 Tuc taken in program 14063 in July 2015 provide dozens of stars suitable for phase retrieval. The ACS WFC F502N images provide several additional stars.

- Repeating visit P2 of program 14063 will provide a direct measure of the stability of the STIS focus over time

- Repeating the exact pointing and exposures should provide a good differential measurement, regardless of any systematic uncertainties

- Taking parallel images with three instruments provides a measurement that is independent of the focus model