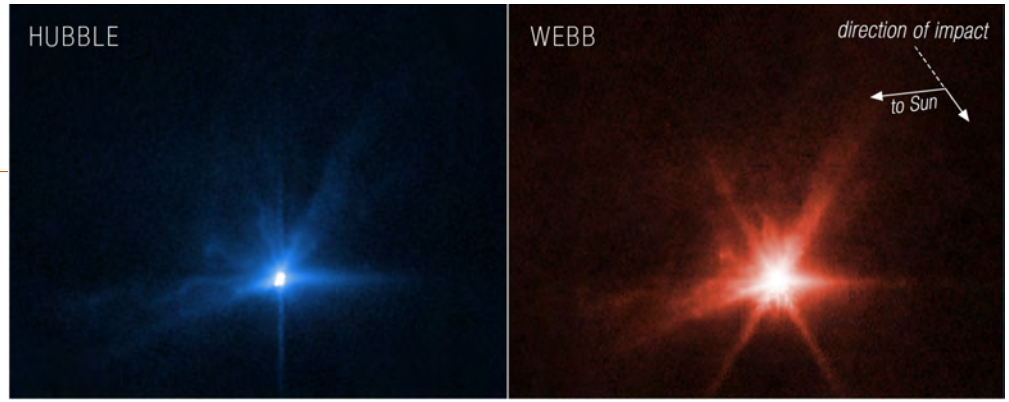
HST Mission Office Report

Tom Brown

STUC – 20 Oct 2022

Summary

- Hubble and Webb working well together both operationally and scientifically (right)
- SpaceX / NASA / STScI study underway
  - Boost and possibly service
- Cycle 31 has a few changes
  - Shorter cycle
  - New ACS spectropolarimetry mode
  - New Minimally Disruptive ToO category
- Hubble Senior Review feedback
  - Overall evaluation was extremely positive
  - Funding relief but not full over-guide request
  - Will involve community in mission evolution
- Long-range plan
- Instrument support



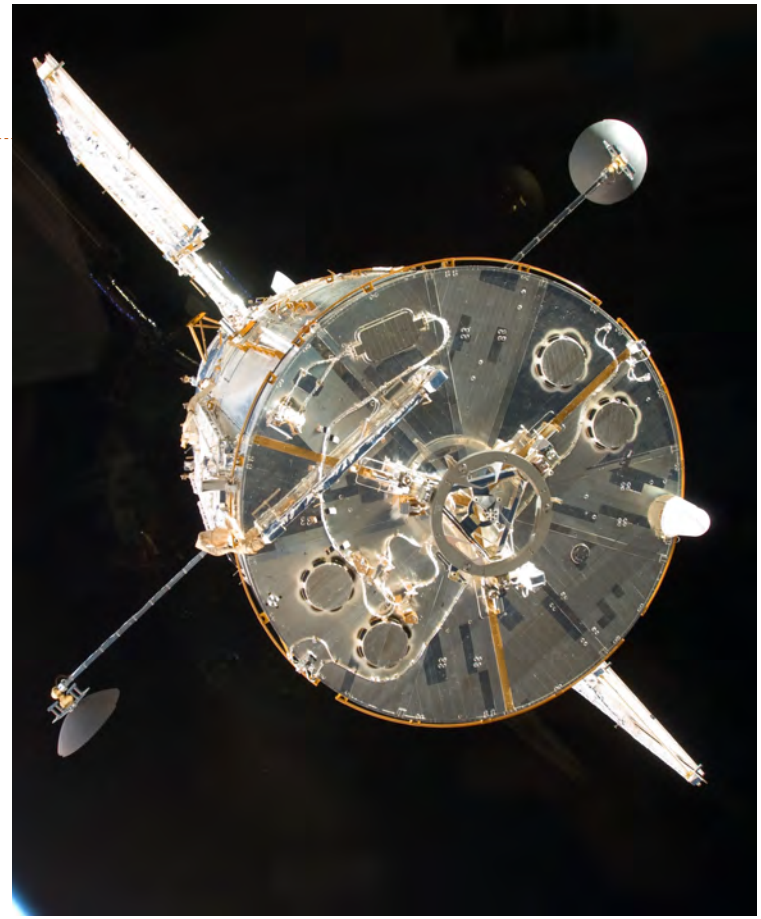
Hubble WFC3 F350LP Webb NIRCam F070W
DART impact
STScI 2022-047

Interacting galaxies VV191

Hubble & Webb Composite

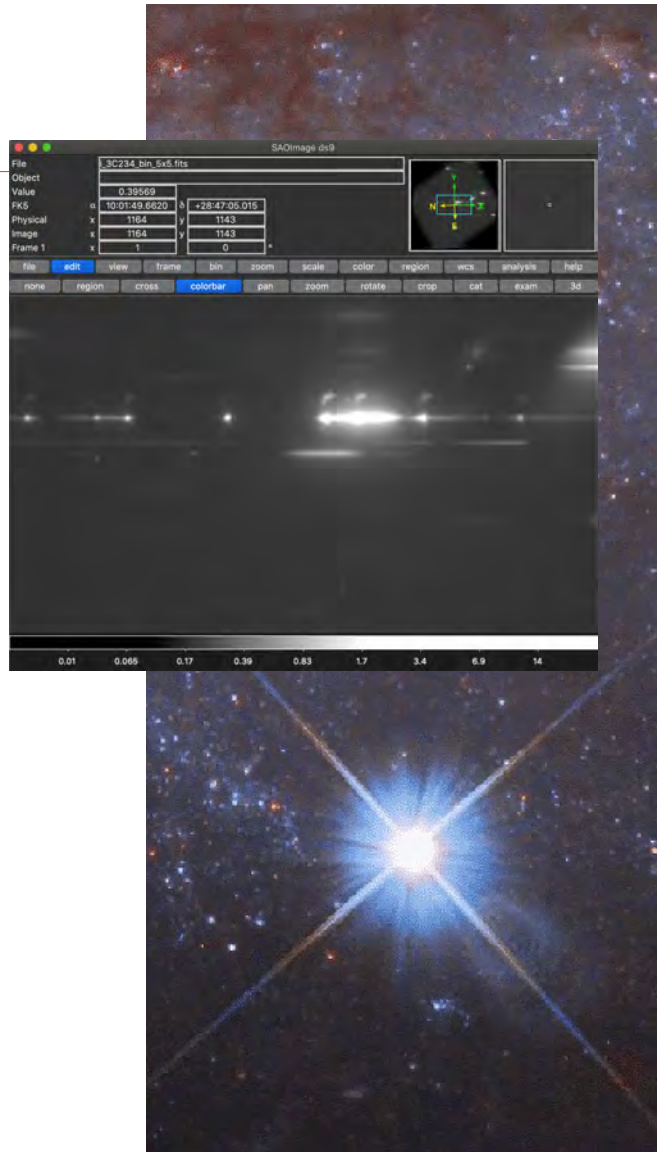
SpaceX / NASA / STScI Study

- Hubble currently at 535 km, down from maximum altitude of 615 km
- Orbit is stable to 2034 minimum and 2037 50%
  - Date moves earlier with increasing solar activity
  - If solar activity is high, Hubble may temporarily graze the "science floor" for a couple years starting in late 2023, incurring some operational limitations
- Instruments degrading gracefully
  - Pointing control system is a more significant concern
- Demand and productivity near all time highs, and expecting to increase with cross-facility synergies this decade (Webb, Rubin, Roman, transients, gravitational waves, etc.)
  - Unique capabilities not matched or exceeded for many years
  - This effort potentially closes the gap to next mission (Astro2020)
  - Particularly true if we can mitigate degradation
- Current obligation is for controlled reentry or boost to parking orbit
  - This effort could potentially forestall that need with boost



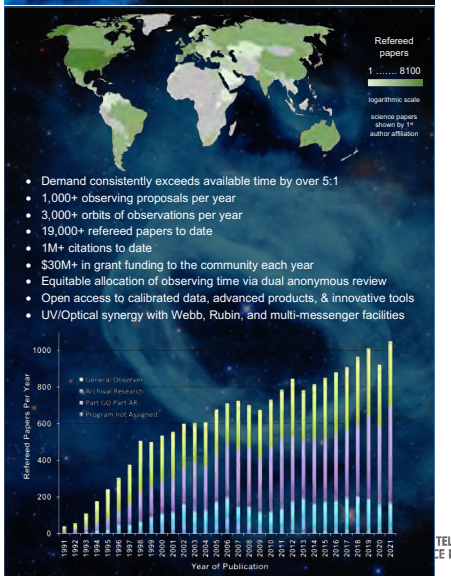
Cycle 31

- As discussed previously, deadlines for Hubble Cycles 30 & 31 shifted to accommodate Webb Cycle 2
- Cycle 31 will be 10 months (1 Dec 2023 – 30 Sep 2024)
- Cycle 31 Deadlines
  - Phase I: 24 May 2023
  - Phase II: 15 Sep 2023
  - Two mid-cycle deadlines TBD
- 2300 orbits available to this call
- New ACS mode: spectropolarimetry (also see May 2022 STUC)
  - Cross G800L grism with POL0V/POL60V/POL120V
- New ToO category: Thursday ToOs (also see May 2022 STUC)
  - One ”Flexible Thursday” a month (Thu UT 12:00 – Fri UT 12:00)
  - Activation by Tue UT 06:00 preceding Flexible Thursday
  - No bright-object protection modes (COS, STIS FUV or NUV, ACS SBC)



Hubble Senior Review Feedback

- Ratings
  - Science Merit: Excellent
  - Relevance & Responsiveness: Excellent / Very Good
  - Technical Capability & Cost Reasonableness: Very good
  - Overall: Excellent / Very good
- Praised scientific productivity & relevance across field
- Noted operational costs are at minimum to maintain scientific productivity
- Recommended community engagement on science operations as mission evolves through the decade
- Did not provide full over-guide request but removes NASA Hubble Fellow Program from Hubble starting with FY24 $98.3M budget




Long Range Plan Status
Prepared by Dave Adler

Long Range Plan

Cycle 30 update

- The HST Cycle 30 LRP was released on August 26, 2022; it began on October 1

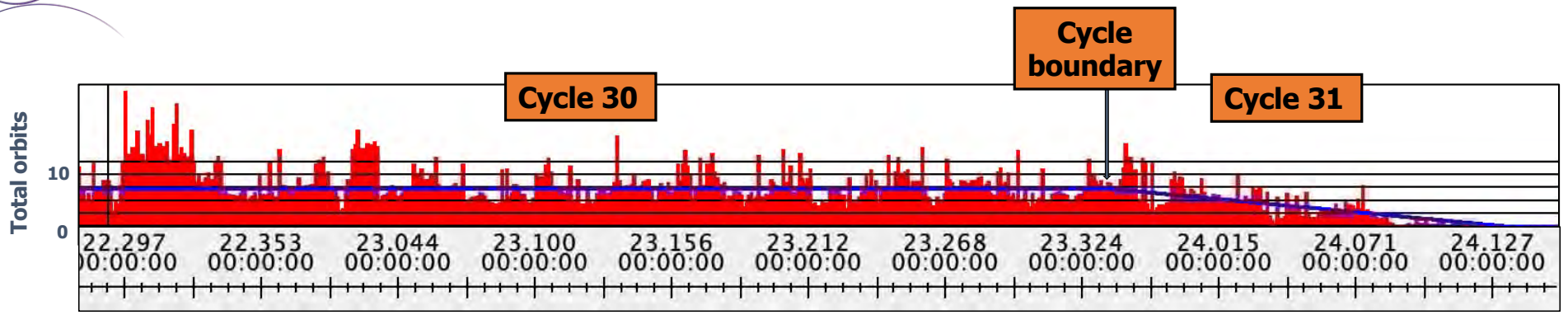
Comparison to previous cycles

- **Cycle 29** averaged 77.6 orbits/week over 53 weeks
  - Without down-time in fall 2021, average would be 82.1 orbits over 49 weeks
- **Cycle 28:** 75.1 orbits/week (five week Side-switch downtime)
- **Cycles 17-27**: averaged 80-85 orbits/week

Previous Cycle Completeness

- **Cycle 25 and 26**: finished this past summer
- **Cycle 27**: 23 orbits left, some as late as spring 2023
  - 16 from program 15936 **(PI: Kelly)**

Long Range Plan



Cycle 30 LRP features

- Cycle 30 is 14 months long to avoid conflict with JWST Cycle 2 preparation
- Most of October 2022 is made up of Cycle 29 (and earlier) observations
- Starting in November, plan of ~8 orbits/day leaves room for
  - Currently unschedulable programs
  - Two mid-cycle campaigns
  - ToOs, Director's Discretionary programs, HOPRs, etc.

Long Range Plan Highlights – Exoplanet Programs

Cycle 27

- 2 programs (9 orbits) remain

Cycle 28

- 20 programs (279 orbits)
- 4 programs (51 orbits) planned and 1 program (20 orbits) unplanned

Cycle 29

- 21 programs (403 orbits)
- 13 programs (179 orbits) contain period/phase constraints, limiting scheduling opportunities
  - 75 orbits executed, 78 orbits planned, 26 orbits unplanned

Cycle 30

- 13 programs (397 orbits)

Highlights:

- HUSTLE: Hubble Ultraviolet-optical Survey of Transiting Legacy Exoplanets (Wakeford, 122 orbits)
- SPACE: a Sub-neptune Planetary Atmosphere Characterization Experiment (Kreidberg, 116 orbits)

Long Range Plan Highlights – Solar System Programs

Cycle 29:

- 2 programs (17 orbits) remaining
  - OPAL Jupiter (Simon, 13 orbits) delayed to November due to conflicts
  - Uranus (Sromovsky, 4 orbits) planned in November

Cycle 30:

- 12 programs (198 orbits) currently planned
- Highlights
  - A combined HST and JWST study of the composition of the faintest trans-Neptunian objects: Testing hypotheses for the formation of the Solar System (Trilling, 99 orbits)
  - OPAL: Outer Planet Atmospheres Legacy (Simon, 41 orbits)
  - Observing Jupiter's FUV auroras during the Juno Extended Mission (Nichols, 12 orbits)
  - Observing the Ice Giants with Hubble WFC3 to Enhance Cycle 1 James Webb Space Telescope Data (Rowe-Gurney, 12 orbits)
  - Unravelling the auroral diversity and magnetospheric dynamics of Uranus while approaching solstice(Cartwright, 16 orbits)

Long Range Plan Highlights – Other Remaining Cycle 29 Programs

Two large M31 programs:

- Mapping Andromeda's Inner Circumgalactic Medium (Lehner, 137 orbits)
  - 135 executed, 2 left (HOPR)
- The Panchromatic Hubble Andromeda Southern Treasury (Williams, 195 orbits)
  - 140 executed, 55 left

Reverberation program:

- Shedding light on light echoes: mapping the accretion disk & broad line region in Mrk 279 (Chelouche, 50 orbits)
- All visits in a 40-day period, with a visit every 0.7-0.9 days
- STIS MAMAs that can only schedule in SAA-free times
- Planned for November/December 2022
- PI has agreed to spacing visits 0.7 – 1.2 days apart

Joint HST-JWST TNO search

- A combined HST and JWST study of the composition of the faintest trans-Neptunian objects (Trilling, 99 orbits)
- Must be done with minimal interruption, over 10-11 days
- Simultaneous coordination with 45-hour JWST program
- Currently planned for January 2023

HST UV Legacy Library of Young Stars as Essential Standards (ULLYSES)

Program(s)	alloc	progs	Exec/sched by 10/16/22	Planned before 10/1/23	Planned after 10/1/23	comment
C27 Dwarf Galaxy	6	1	6	0	0	complete
C27 LMC	75	8	71	0	0	complete
C27 SMC	69	6	69	0	0	complete
C28 Galactic low-mass stars	106	7	105	0	0	complete
C28 LMC	64	6	61	0	0	complete
C28 SMC	100	6	89	0	0	complete
C28 T-Tauri	107	7	107	0	0	complete
C28 NGC 3109	9	1	9	0	0	complete
C29 LMC	99	16	35	43	0	21 not in LRP
C29 SMC	41	8	24	12	0	5 not in LRP
C29 T-Tauri	274	18	247	24	0	3 not in LRP
C29 Sextans A	20	1	0	20	0	

Large and Treasury programs

Remaining Cycle 27-28 Large Programs

PI	alloc	Exec/sched by 10/16/22	Planned before 10/1/23	Planned after 10/1/23	comment
Kelly	192	144	16	32	16 orbit sets
Sabbi	84	72	11	0	GULP; 1 not in plan

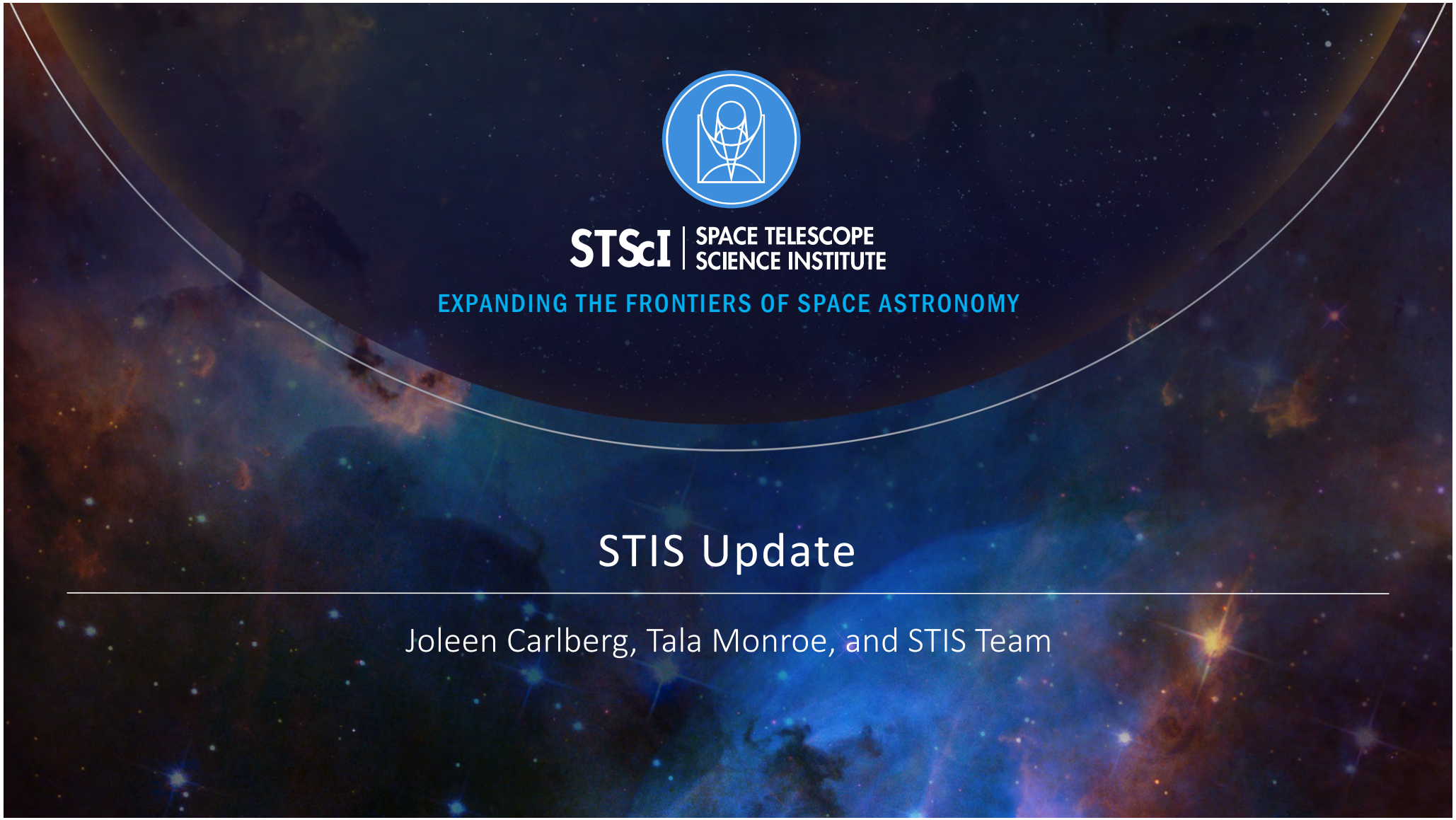
Remaining Cycle 29 Large Programs

PI	alloc	Exec/sched by 10/16/22	Planned before 10/1/23	Planned after 10/1/23	comment
Pala	118	38	11	0	22 orbits of ToO; 69 not in LRP
Levan	22	0	0	0	ToO; 22 not in LRP
Youngblood	110	60	44	0	Exoplanets; 6 not in LRP
Trilling	99	0	0	99	TNOs; JWST-coord
Lehner	137	135	2	0	M31
Williams	195	140	55	0	M31-PHAST

Large and Treasury programs

Cycle 30 Large Programs

PI	alloc	Exec/sched by 10/16/22	Planned before 10/1/23	Planned after 10/1/23	comment
Hayes	119	0	71	47	LaCOS
Borthakur	80	0	35	45	
Reindl	130	0	112	18	
Bowen	96	4	21	71	
Foley	105	0	0	0	ToO - Sn
Wakeford	122	0	0	0	HUSTLE – exoplanets; none in LRP
Kreidberg	116	0	67	28	SPACE – exoplanets; 21 not in LRP



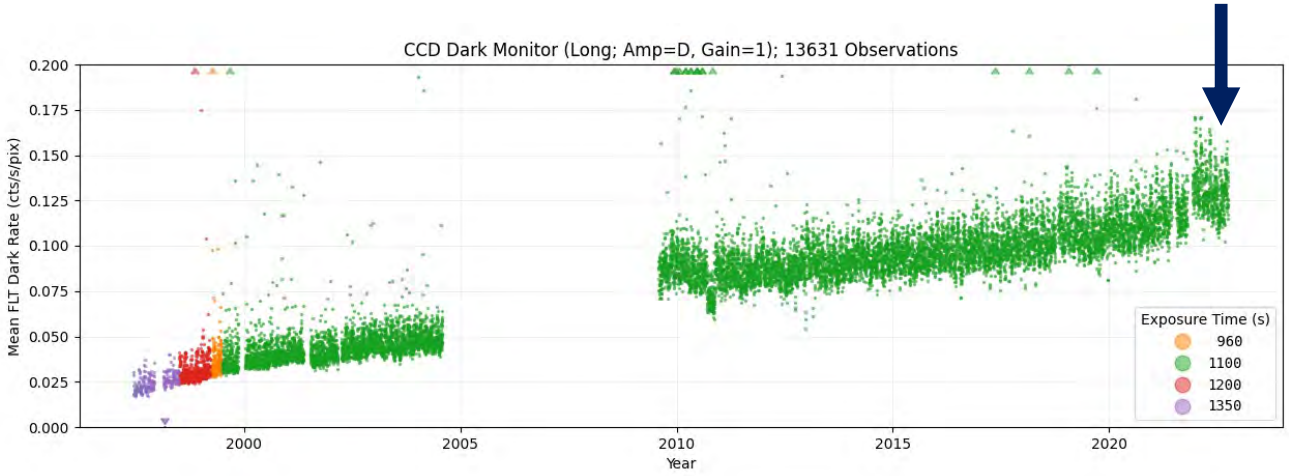
STIS Update

Joleen Carlberg, Tala Monroe, and STIS Team

STIS Status

General Status

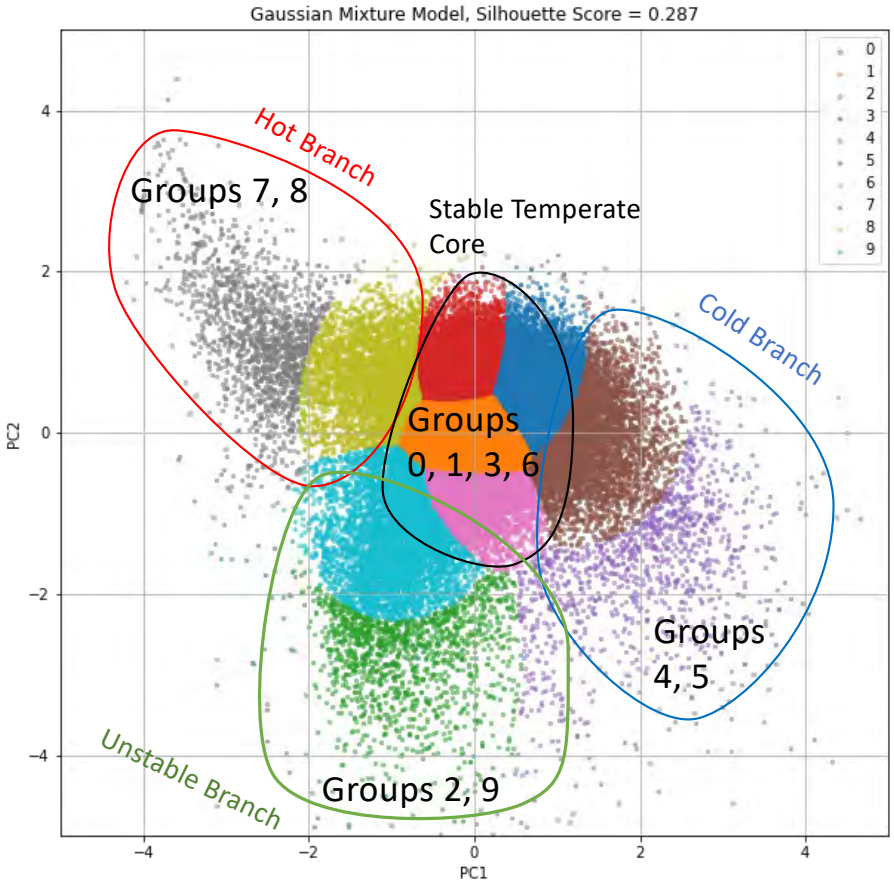
- STIS operating nominally:
  - Previously reported elevation in CCD dark rate trending back to normal levels
  - Elevated dark occurred after the Fall 2021 observatory anomaly and was accompanied by elevated CCD housing temperature



Documentation

- Published 3 ISRs & 1 STAN (July 2022)
  - ISR 2022-04: **Recalibration of the STIS E140M Sensitivity Curve** (J. Carlberg et al.)
  - ISR 2022-05: **Scattered Light in STIS Grating G230LB** (G. Worthy, GO of 16188)
  - ISR 2022-06: **Flux Repeatability of FUV-MAMA Spectra as a Function of Cross-dispersion Position** (L. dos Santos)

Project Highlight: Exploratory Pixel History Project

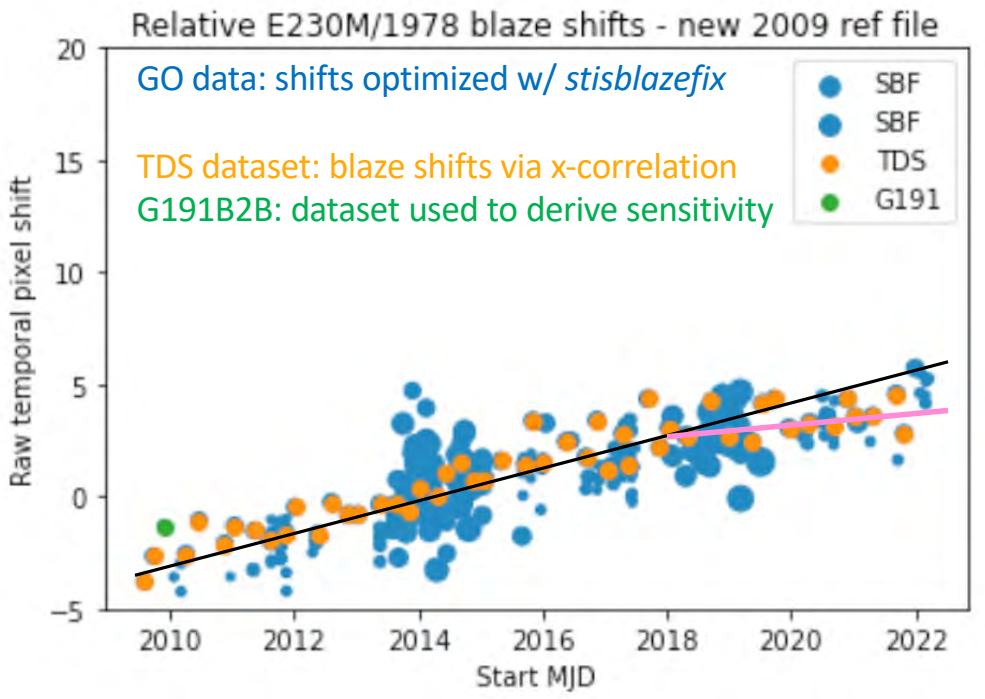


Unsupervised Machine Learning: Clustering

- In a single anneal, pixels grouped in a 2D principal component space
- Behavior in groups/branches identified by eye
  - ~65% of pixels are in a core group
  - ~10% are along “hot” branch
  - ~12% are along “cold” branch
  - ~13% are along ”unstable” branch
- **Key result comparing 2 anneals**:
  - pixels in “core” and “hot branch” groups largely insensitive to anneals
  - pixels in “unstable” and “cold branch” sensitive to anneals (i.e., change groups)
- **Future**: new technical staff will focus on CCD behavior this year

Echelle Behavior: Need for improved Blaze Shift Corrections

- Flux recalibration of echelle modes requires re-deriving blaze shift coefficients
- **E230M** needs two different time coefficients: shallower slope in recent times
- **E140M** also requires multiple coefficients (ISR 2022-04)
- Currently, this is achieved by using multiple PHOTTAB reference files with different USEAFTER dates
- **New**: To capture this more complex behavior moving forward, blaze shift coefficients will be moved to a new reference file



Future: Work continues on the flux recalibration effort for the echelle, imaging, and M modes

https://www.stsci.edu/hst/instrumentation/stis/flux-recalibration

WFC3 Update

Sylvia Baggett, Annalisa Calamida, and WFC3 Team

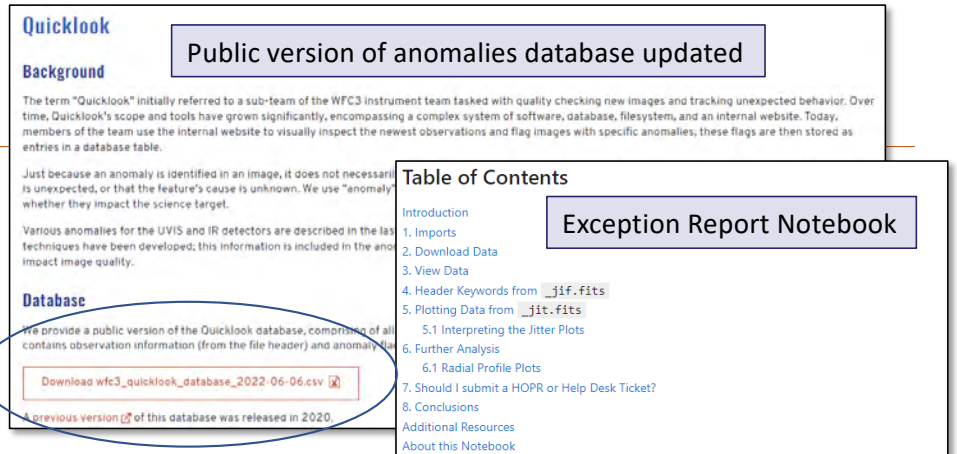
WFC3 Highlights

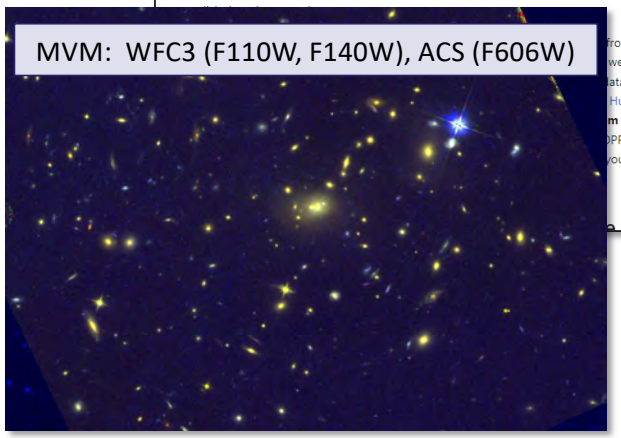
WFC3 operating nominally

- 320,000 WFC3 images in MAST archive
- Quicklook performing well after infrastructure updates
  - All data received inspected daily
  - Routine monitors remain nominal
  - Updated version of public anomalies database released

- Jupyter notebook for GOs with Exception Reports (github: WFC3Library/notebooks/exception_report)
  - Help observers assess quality of data / evaluate need for HOPR
  - Workflow includes MAST retrieval, viewing images and headers, interpreting jitter file information, generating radial profiles

- Hubble Advanced Products (with ACS and DMD)
  - Single-visit & multi-visit mosaics (SVM, MVM) released
  - Improved alignments, to GAIA eDR3 when possible
  - Images drizzled onto same north-up grid
  - ISR 2022-06



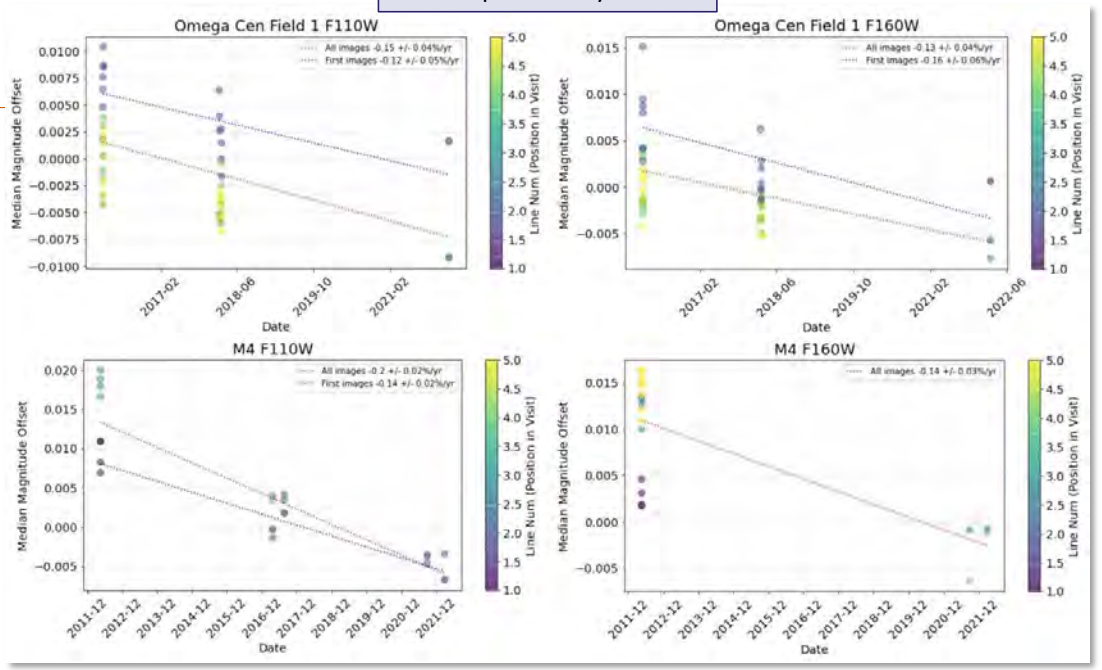


WFC3 Highlights

IR sensitivity monitoring

- Stare mode, cluster targets
- Declines are -0.1 to -0.2%/yr (ISR under review)
- Slopes depend on filter, target, time range, and order of exposure within visit
    - Slopes based on first images generally lower than slopes based on all images and likely representative of the true sensitivity
- Early epoch data sometimes more strongly affected by persistence from preceding unrelated proposals (mitigations refined later) which increases measured fluxes in all images
- No trends are detectable in standard star data due to large scatter although the data, along with SEDs, are used for computing zero points

Relative photometry in the IR



Target	Filter	Median Slope	Median Slope (first images)
47 Tuc	F160W	-0.12%/yr	-0.10%/yr
M-4	F110W	-0.20%/yr	-0.14%/yr
M-4	F160W	-0.14%/yr	N/A
ω Cen	F110W	-0.15%/yr	-0.13%/yr
ω Cen	F160W	-0.13%/yr	-0.16%/yr
ω Cen core	F160W	-0.20%/yr	0.0%/yr
Average*	Both	-0.15%/yr	-0.13%/yr

* Excluding ω Cen core

WFC3 Highlights

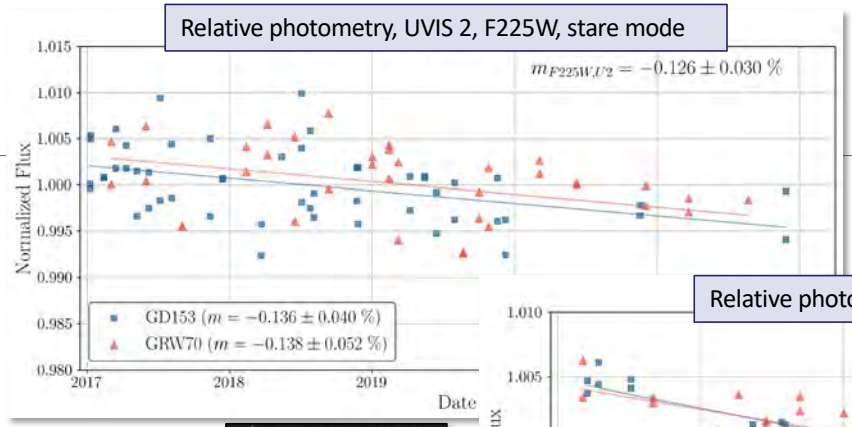
UVIS sensitivity monitoring

- Use of stare and scan modes
- Trends range -0.1 to -0.2%/yr depends on filter, chip (ISR 2022-04)
- Some reduction in decline after 2020
- Stare & scan results agree to ~0.05% (figure at lower right). Exceptions (e.g. F275W in A amp, F606W) attributed to higher uncertainty due to limited time range of data

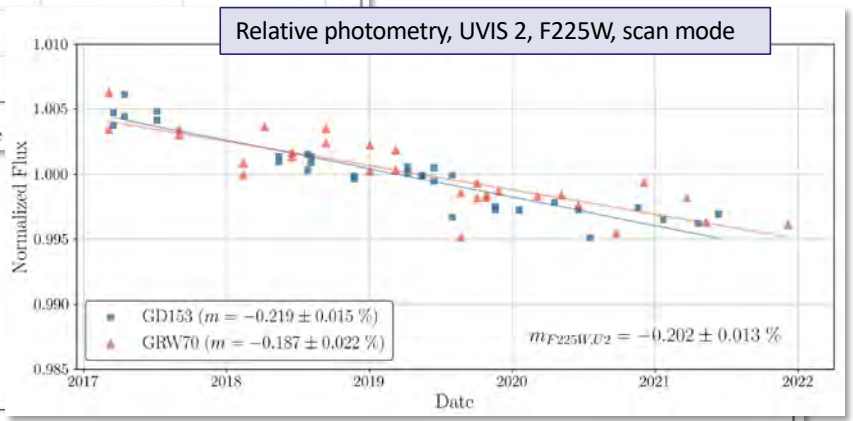
UVIS CTE losses

- Now 0.1-0.25 mag for sources far from the amp (10^4 to 10^3 e- in 3-pix radius aperture) in images with 20e-/pix background
- Pixel-based CTE correction reduces those losses to 0.02-0.1 mag

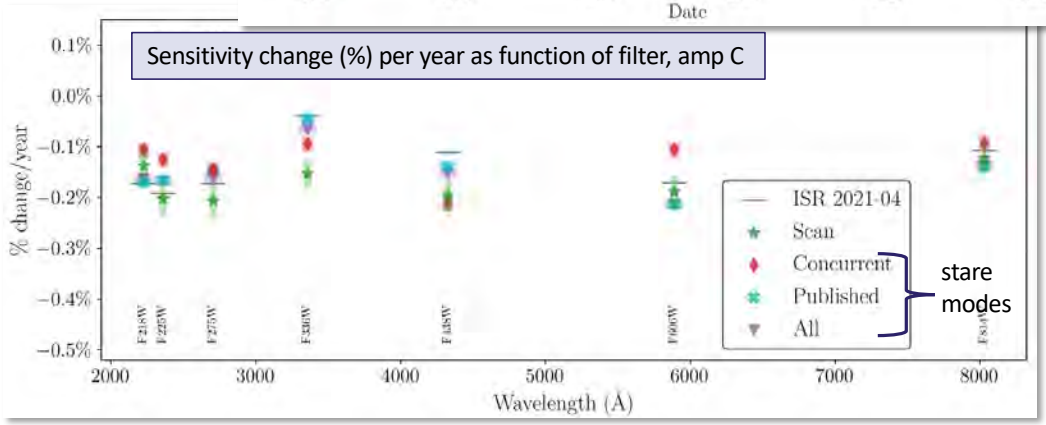
Relative photometry, UVIS 2, F225W, stare mode



Relative photometry, UVIS 2, F225W, scan mode



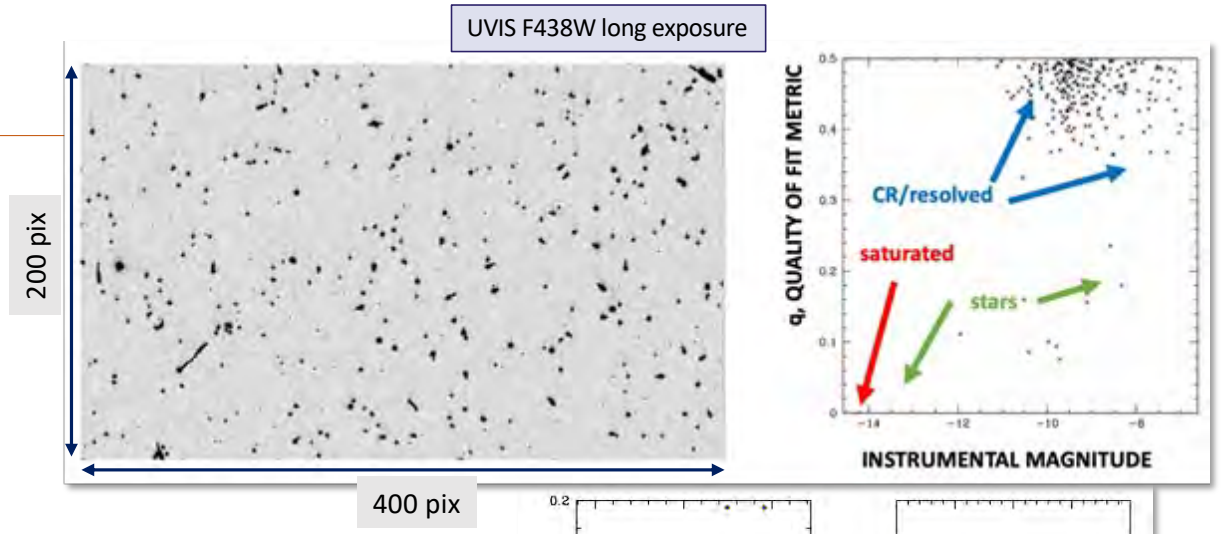
Sensitivity change (%) per year as function of filter, amp C



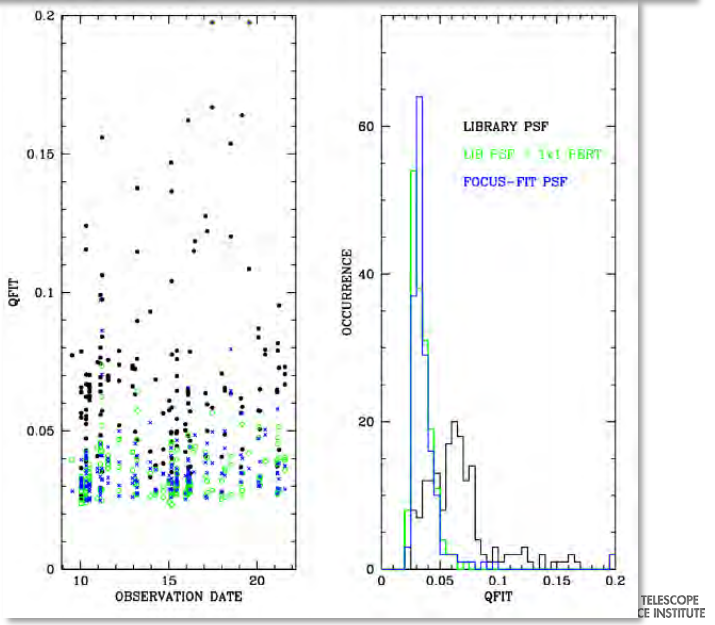
WFC3 Highlights

Hst1pass for HST detectors (ISR 2022-05)

- UVIS, IR, ACS WFC and HRC, WFPC2
- ePSF photometry + astrometry without compromising on sampling (drizzling: preserves flux but resamples pixels)
- Precision: S/N>50 to ~1 mas (0.02pix)

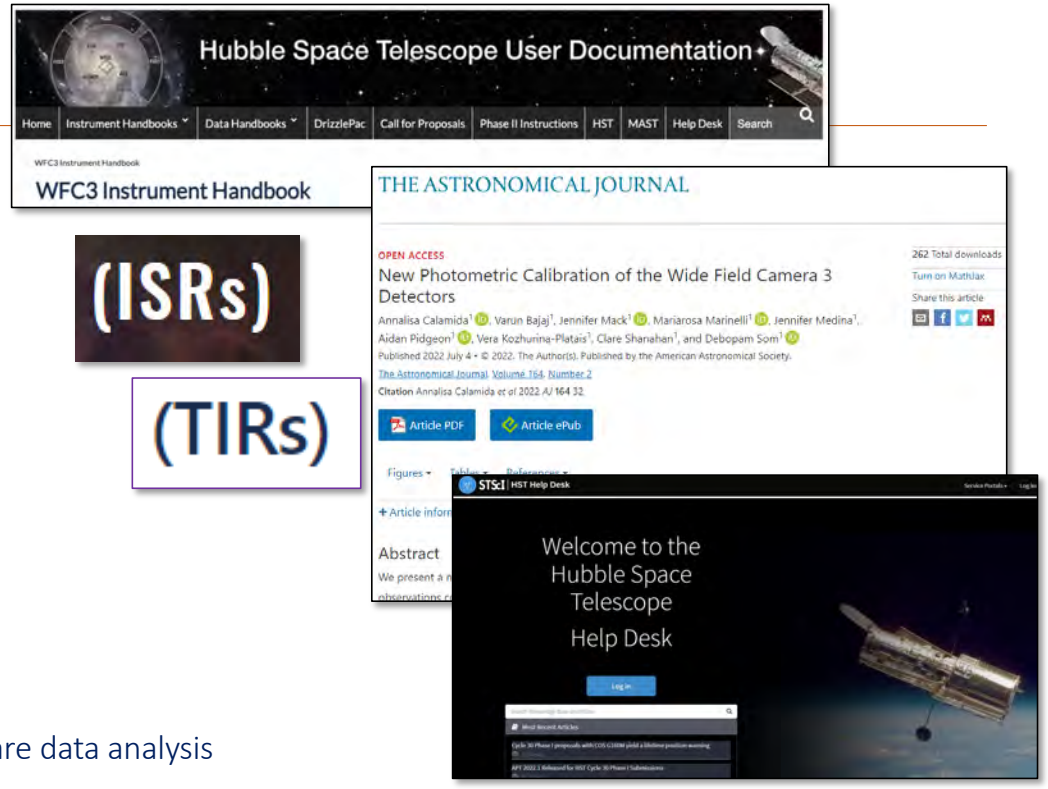


- Inputs: star finding parameters, ePSF library, distortion solutions, images
- Outputs: star lists with astrometry, photometry, quality of fit (q), and more
- Q parameter identifies stars (figure at top)
- Other options available
  - Aperture photometry instead of ePSF
  - Artificial star tests
  - PSF optimization (perturbation or focus-diverse, figure at right)
  - Saturated star recovery
  - Application of table-based CTE corrections
  - Ability to handle non-HST exposures



User support/documentation

- CS reviews / helpdesk
- Instrument Handbook (Jan 2023)
- STAN in June 2022 (next one: Oct 2022)
- AAS meeting June 2022
  - hst1pass: One Pass PSF Photometry for HST Detectors
  - HST's Wide Field Camera 3 in 2022
  - Key Improvements in the HST/WFC3 User Experience
- Software
  - Jupyter notebook for observers with an Exception Report
  - Internal notebooks: scan data analysis, improvements to stare data analysis
- Reports
  - AJ 164,32 Photometric Calibration of the WFC3 Detectors (Calamida et al.)
  - ISR 2022-06 Improved Absolute Astrometry for ACS and WFC3 Data Products (Mack et al.)
  - ISR 2022-05 One-Pass HST Photometry with hst1pass (Anderson)
  - ISR 2022-04 Monitoring UVIS Photometric Sensitivity with Spatial Scans (Marinelli et al.)
  - TIR 2022-02 Updates to the UVIS Staring Mode Photometry Pipeline
  - TIR 2022-01 Requirements for calwf3 updates to address IR TVB



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EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

COS Update

Marc Rafelski, Bethan James, and COS team

COS General Updates

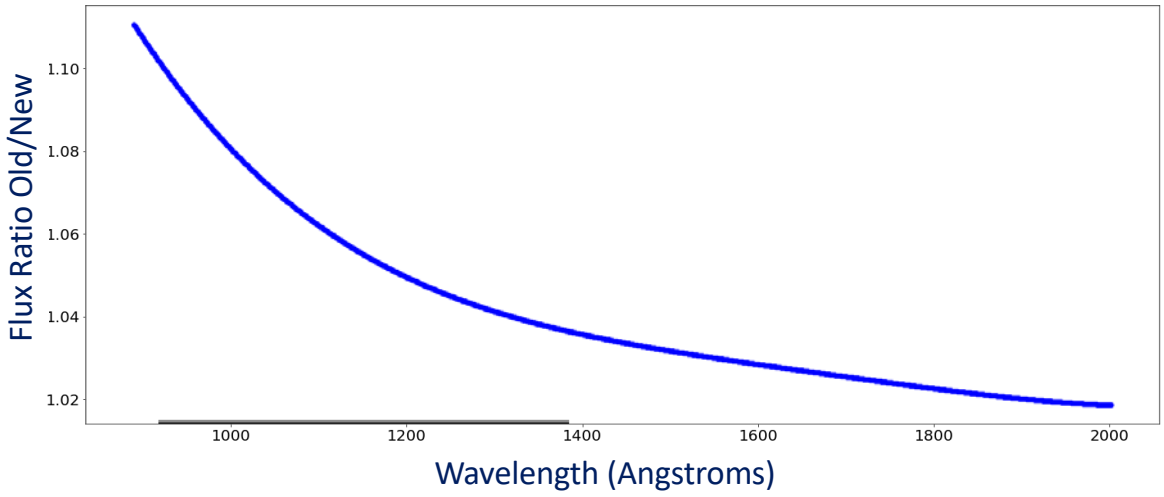
- COS status updates
  - LP6 began operations with Cycle 30 on October 3, 2022
  - Time Dependent Sensitivity trends constant. Reached 5% flux calibration spec, update planned soon
  - FUV dark rate increased to ~14-39% over nominal, 5-20% over last reported 6 months ago
  - NUV dark rate increased to 3% over nominal, -3% since last report 6 months ago
  - Anomalous gain sag at LP5 resulted in sudden decrease of 2 pulse height bins (1 year of life)
  - Spectral Shift; home position moved back to 1291 from 1222, further mitigations under consideration
- New reference files:
  - NUV FLUXTAB (new CALSPEC models and Vega zeropoint)
  - SPOTTAB to mask transient hotspot in science region of LP4
  - NUV XTRACTAB with updated background regions avoid subtracting the source for extended targets
  - LP6 FUV reference files and LP6 BPIXTAB
- Documentation since April 2022:
  - 2 STANS, 11 ISRs, 2 AAS presentations, 1 SPIE presentation, 1 Science with the HST and JWST

Lifetime Position 6 (G160M) started with Cycle 30 on October 3 2022

	LP6 Activity	Programs	Status
Enabling Phase	FSW & commanding	N/A	Complete
	SIAF	N/A	Complete
	TRANS	N/A	Complete
	APT	N/A	Complete
	End to End test	N/A	Complete
	LP6 Pipeline	N/A	Complete
	Focus	16850	Complete
	Target Placement	16849	Complete
	Target ACQ Parameters (FUV spectroscopic ACQs)	16851	Complete
Calibration Phase	Profiles and Traces	16906	Complete
	Sensitivities and Flat Fields	16906	Complete
	Spatial Resolution	16906	Complete
	Spectral Resolution	16907	Complete
	Dispersion Solutions	16908, 16907, 16909	Complete
	Lamp Templates	16909	Complete
	Gain Maps	**16910**	**Data taken**
	Code V model LSFs and PSFs	N/A	Complete
	Bad Pixel Table	16829, 16472	Complete

Flux calibration with new CALSPEC models updated

- CALSPEC non-local thermodynamic equilibrium models updated for new white dwarf standards and new Vega zeropoint (Bohlin et al. 2020 ApJ 160,21)
- Obtained and validated a new model for our primary flux calibrator WD 0308-565
- Model fluxes increased, resulting in decreased sensitivities
- New Photometric Throughput Table (FLUXTAB) delivered for FUV and NUV



Future Work FY23

- Continue Spectral Shift investigation and solution
- Hubble Spectroscopic Legacy Archive (HSLA) revamp including both COS and STIS
  - This is a project that will span multiple years
  - Each phase will provide additional co-addition products and improvements to interface
- Update time dependent sensitivity (new slope and/or break point)
- Implement HV sensitivity correction in pipeline
- Implement geometric and walk correction
- Cycle 30 calibration programs and contact scientist support
- Develop, upgrade, and document additional monitors, such as a new hot spot monitor
- Support Pandeia ETC development

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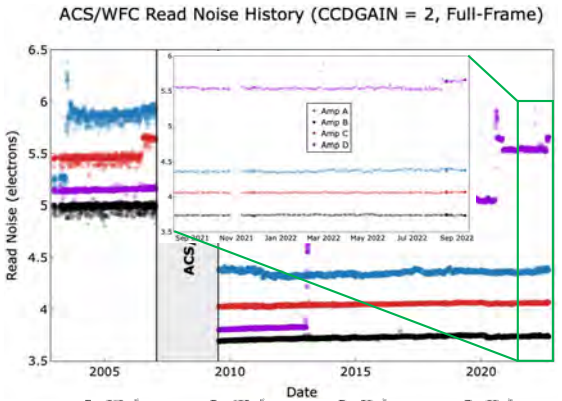
EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

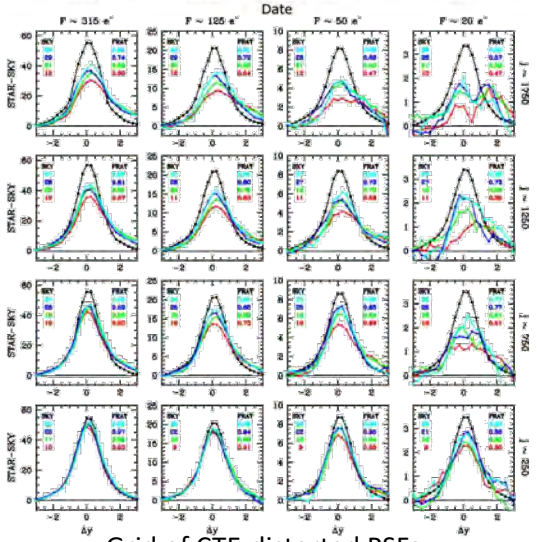
ACS Update

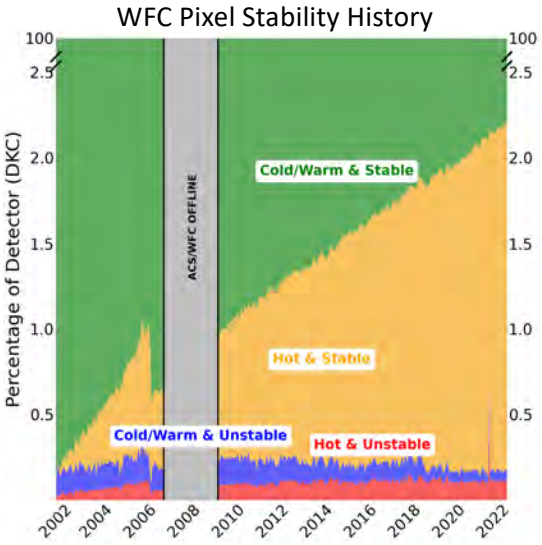
Norman Grogin, Roberto Avila, and ACS Team

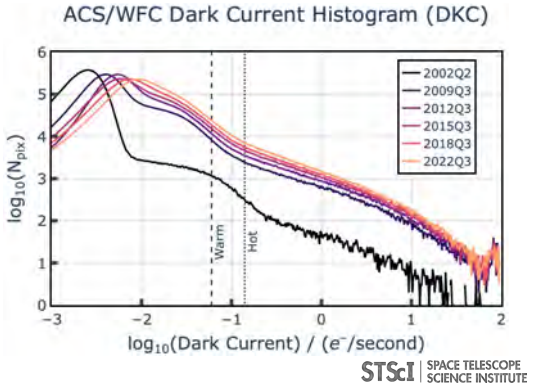
ACS Developments since the May'22 STUC Meeting

- ACS continues to operate nominally
  - Celebrated 20 yrs service in Mar'22)
- Largely stable WFC readnoise (upper left), with small AmpD jump of +0.1e$^-$ in August 2022 (inset zoom)
- WFC pixel stability monitoring (upper right) shows steady 99.8% usability
- Quantification of WFC PSF distortion during readout, due to poor charge-transfer efficiency (CTE; lower left)
- WFC dark current (lower right) and CTE continue expected gradual trending









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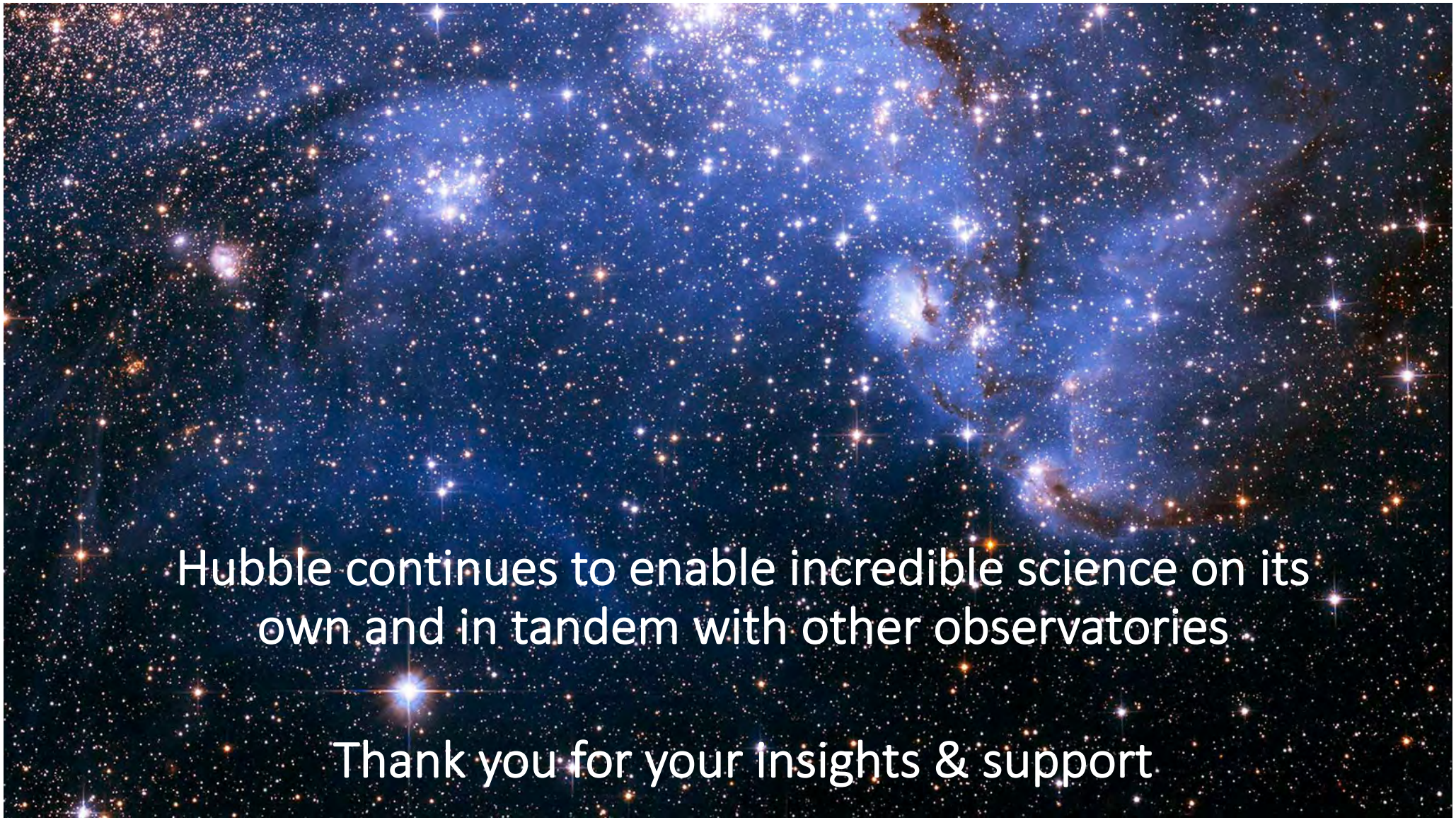
Highlights of ACS Recent & Ongoing Work

- Quantification of WFC PSF distortion caused by degraded CTE during CCD readout
  - Short/long exposures of Omega Cen, to generate PSF grids vs. flux/background/Y (see prior slide)
  - Results will advise GOs on obsv. planning, and on CTE-correcting completeness-limit estimates
- Using ACS/WFC CALSTIS-standard photometry to better correct for STIS CTE losses
  - STIS CTE parameters were last pinned in 2006; potential trouble for new, fainter CALSTIS standards
  - Flux deviations, reaching 5%, identified and corrected over most of the G430L and G750L ranges
- Streamlining ACS point-source photometry: `hst1pass` and WFC PSF Library
  - First public release of `hst1pass` software in Summer 2022, accompanied by ACS&WFC3 joint ISR.
  - ACS Team now in advanced stages of developing WFC spatially-variable PSF webtool for GOs
- Commissioning nearly complete for new mode: spectropolarimetry
  - WFC grism (G800L) crossed with polarizers (POL0V, POL60V, POL120V)
  - Cycle 31 CfP will advertise optical (5500–8000Å) grism spectropolarimetry

New ACS Documentation since the May'22 STUC Meeting

- ISR ACS 2022-02 : "One-Pass HST Photometry with `hst1pass`" (Anderson)
- ISR ACS 2022-03 : "Improved Absolute Astrometry for ACS and WFC3 Data Products" (Mack et al.)
- ISR ACS 2022-04 : "The Impact of CTE on Faint Sources in ACS" (Anderson, in press)
- ISR ACS 2022-05 : "Update of the STIS CTE Correction Formula for Spectra" (Bohlin & Lockwood, in press)
- ISR ACS 2022-06 : "Fading Hot Pixels in ACS/WFC" (Ryon et al., in press)
- ACS STAN (Oct'2022) : Notifications regarding CALACS, `acstools`, APT dither pattern specifications, and WFC observed background-rates visavis ACS ETC


Hubble continues to enable incredible science on its own and in tandem with other observatories
Thank you for your insights & support