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EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

HST Mission Office Report

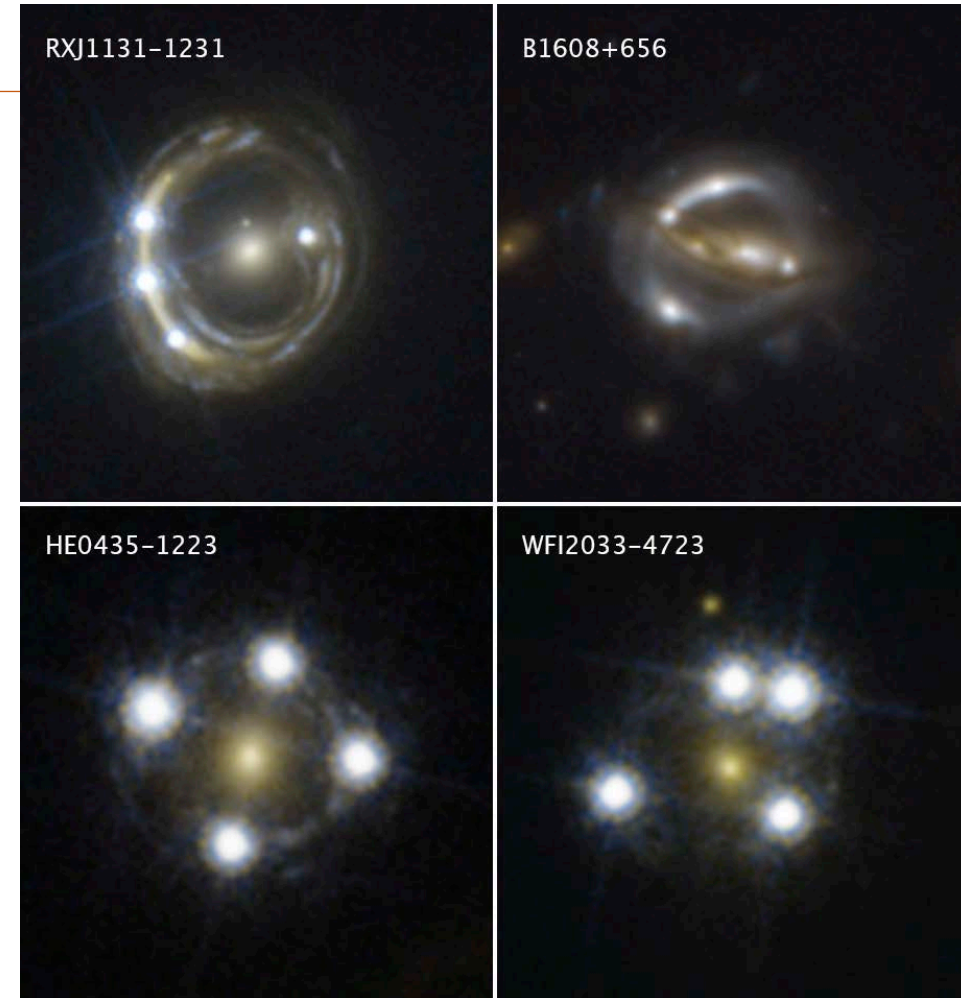
Tom Brown

STUC – 14 Apr 2020



Hubble Operations Proceeding Normally

- Hubble science operations has been fully remote since March 16 – no issues
- As long as STScI buildings have power, network, & payroll, all of the science operation functions can proceed via remote work indefinitely
 - Includes delivery of the weekly SMS (Science Mission Specification), plus any intercepts required for anomaly response, Targets of Opportunity, or re-planning of failed observations
 - Flight operations at GSFC requires small onsite footprint, but that footprint will continue while most of GSFC is in remote work posture
 - HST Mission Office is in frequent contact with all segments of science operations and flight operations to monitor the situation and re-prioritize work if needed, but no significant impacts so far

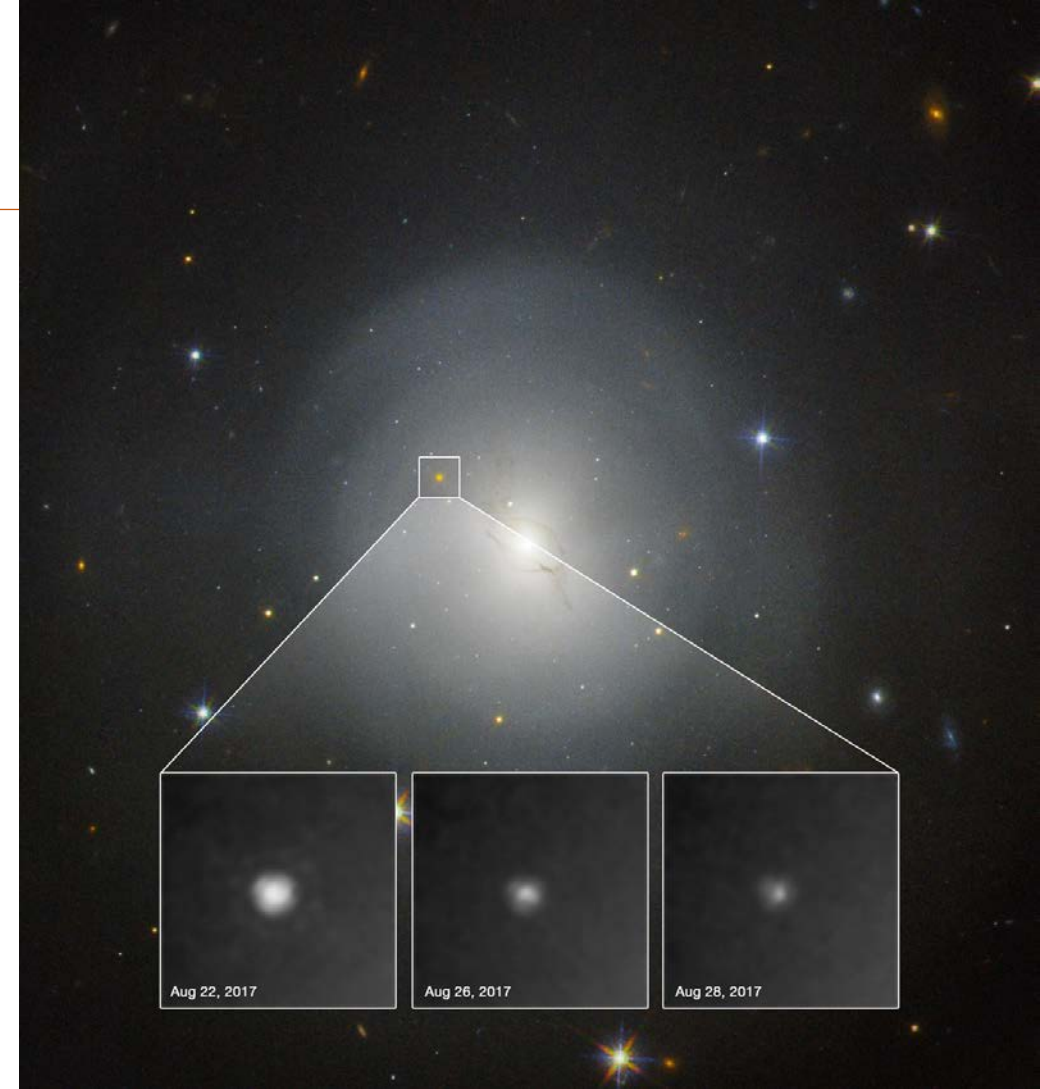


January 2020 Press release – independent measurement of H_0 using gravitational lenses yields value of 73 km/s/Mpc, close to the SNe value but discrepant with Planck.



Hubble Operations Proceeding Normally

- Not expecting ultra-rapid ToO from LIGO events now that LIGO has suspended
- However, on Wed April 1, at 3:15pm, Foley executed GO-15876 ultra-rapid ToO “Ultra-Rapid UV Spectroscopy of an Interacting Supernova Discovered by TESS”
 - Observations began 34 hours after official trigger (slightly quicker than advertised 36-48 hour turn-around time)
 - 19 orbits in ToO, with 14 replacing observations on the executing SMS (intercepted) and 5 replacing observations on the subsequent SMS
 - Some iteration with PI had to be truncated in order to execute quickly
 - Will use lessons learned from this trigger to help plan ultra-rapid ToOs going forward



Hubble observations of LIGO event in 2017



Cycle 28 Status

- HST Cycle 28 Call for Proposals deadline was March 6
 - Extended deadline of March 12 for proposers directly affected by COVID-19. Only a handful of proposers in this category.
 - 1,080 proposals received
 - ▶ 865 GO proposals for 22,519 orbits
 - ▶ 41 SNAP proposals
 - ▶ 174 AR proposals
 - Time Allocation Committee will be fully remote in May
 - We expect to award approximately 2,700 orbits
 - ▶ 1400 small
 - ▶ 700 medium
 - ▶ 600 large
 - ▶ Allocation is approximately 1,100 orbits less than that in a typical cycle because of the large Director's Discretionary time program ULLYSES, because we are accommodating a larger acquisition failure rate (approximately 5% instead of 1-2%), and due to a backlog of delayed observations from previous anomalies
- Cycle 27 is well underway and proceeding normally, with scheduling efficiency near typical levels of approximately 50-55% per week
- 3 HST safings in December (1 commanded vs measured attitude discrepancy, 2 SIC&DH lockups recovered quickly using relatively new procedure)

The poster features a large 'HST' logo at the top right. Below it, the text 'HUBBLE SPACE TELESCOPE CALL FOR PROPOSALS CYCLE 28' is prominently displayed in a serif font. To the left of this text is a circular diagram showing the HST's field of view divided into segments for different instruments: FGS3, STIS, COS, FGS1, ACS, WFC3, and NICMOS. The text 'December 2019 POLICIES, PROCEDURES, AND PHASE I PROPOSAL INSTRUCTIONS' is centered below the main title. At the bottom left, there are links: 'HELP_DESK', 'SITE MAP', 'HST WEBSITE', and 'REPORT WEBSITE PROBLEMS'. The bottom of the poster features logos for ST&I, ESA, Lockheed Martin, and NASA.

HST

HUBBLE SPACE TELESCOPE
CALL FOR PROPOSALS
CYCLE 28

December 2019
POLICIES, PROCEDURES, AND
PHASE I PROPOSAL INSTRUCTIONS

FGS3 STIS COS FGS1 ACS WFC3 NICMOS

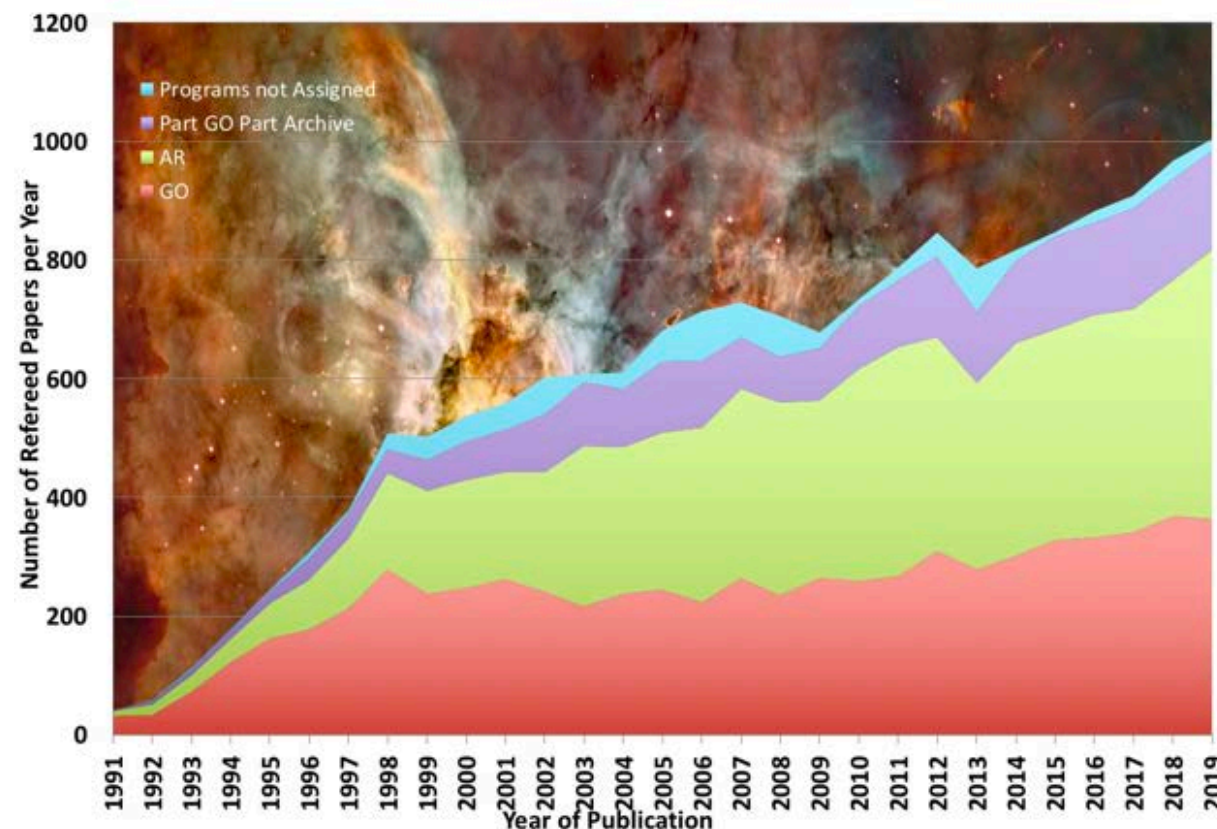
[HELP_DESK](#)
[SITE MAP](#)
[HST WEBSITE](#)
[REPORT WEBSITE PROBLEMS](#)

ST&I SPACE TELESCOPE SCIENCE INSTITUTE ESA LOCKHEED MARTIN NASA



Hubble Scientific Productivity Strong and Prominent

- 1000+ refereed papers per year
- 17,350+ refereed papers through 2019
- Over 60% entirely or partially based upon archive
- 875,000+ citations through 2019
- h-index = 299 through 2019
- ULLYSES large Director's Discretionary program released its targets to the community on Feb 19
- ULLYSES observations begin in Spring 2020
- Hubble 30th Anniversary April 24
 - Website and online events, including press release <https://hubblesite.org/hubble-30th-anniversary>
 - Image; visualization; lithograph
 - BBC hour-long special will be released
 - Public events delayed or canceled
national image unveiling; Baltimore Symphony Orchestra; National Air and Space Museum event; Dulles airport unveiling



- Michael Collins Trophy (formerly National Air & Space Museum trophy) awarded to Hubble Team on Feb 13

The background of the slide is a deep space image featuring a dense field of stars of various colors (blue, white, yellow) and a large, complex nebula with swirling clouds of gas and dust in shades of blue, purple, and brown. The text is centered over this image.

Long Range Plan Status

(Prepared by Dave Adler)



LRP: Current Status

Cycle 27 update

- Through the SMS ending 12 April 2020, 2450 orbits of science remaining in the LRP
- Includes the two Cycle 27 mid-cycle campaigns, but only 1 target (15 orbits) of ULLYSES

Cycle 27 averaging 86.0 orbits/week through first 28 weeks

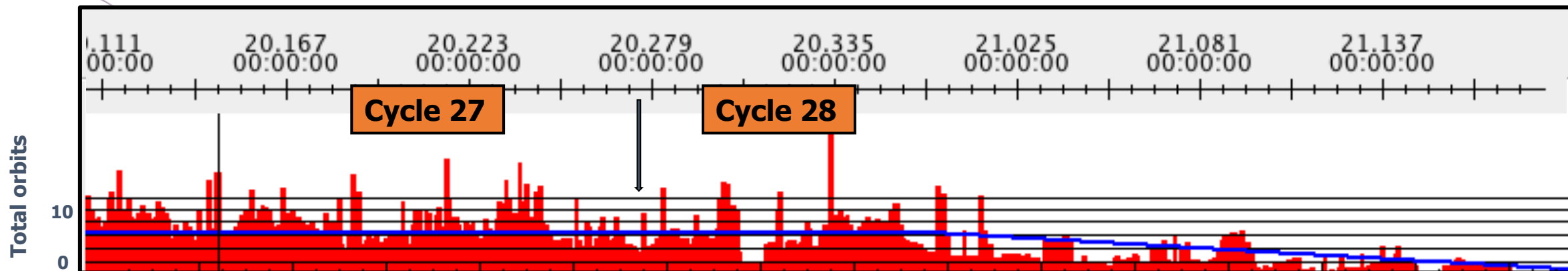
- Cycle 17-23: 84 orbits/week
- Cycle 24: 82 orbits/week
- Cycle 25: 85 orbits/week
- Cycle 26: 80 orbits/week (85 orbits/week if remove three weeks of down-time due to Gyro 2 failure)

Previous Cycle Completeness

- Cycle 25: 90 orbits remain, with windows through Dec 2020; most late visits are constrained HOPRs
- Cycle 26: 280 orbits remain, with windows into summer 2021



LRP: Current Status

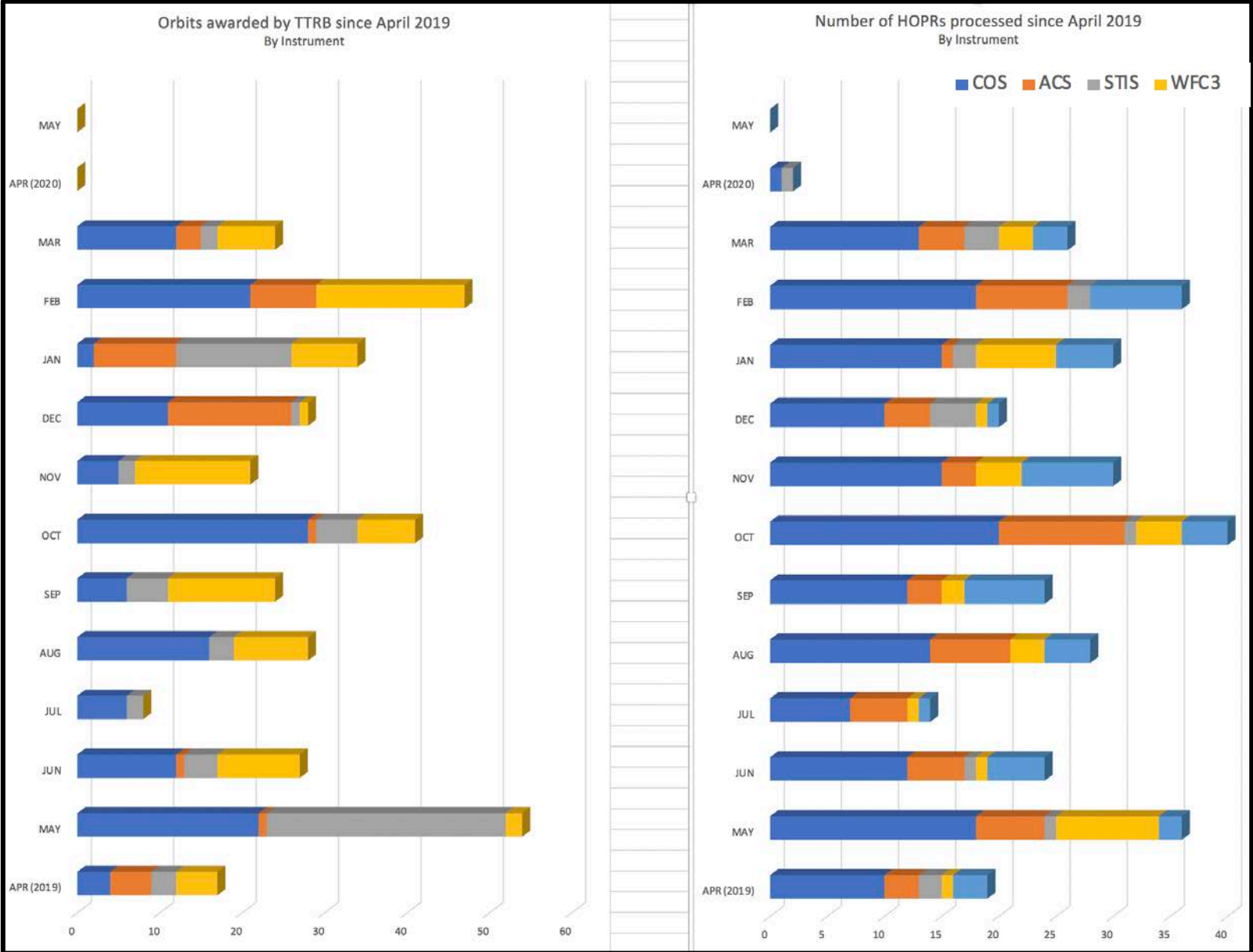


- **Second half of Cycle 27 undersubscribed by ~300 orbits**
 - Leaves room for ULLYSES, HOPRs, ToOs, etc
 - Will also pull up later-planned Cycle 27 as needed
 - Current cycle 27 tail (post October-2020) currently ~1000 orbits
- **Cycle 28 preparation will begin early**
 - TAC (fully remote) meeting earlier than usual (May) to avoid conflict with originally planned JWST TAC
 - With June 30 Phase II deadline, LRP will be built earlier than usual (early July)
 - Cycle will still begin on October 1



LRP: Recent activity

HOPR rate remains at ~7-10% over the past year



A deep space image featuring a dense field of stars and a prominent nebula with blue and purple hues. The text is centered over this background.

Cycle 27 statistics

(Prepared by Dave Adler)



LRP: Statistics

Exoplanet Programs: Highlights

- For exoplanets with tight period/phase constraints, planning windows outside the definitive ephemeris (10 weeks) are not reliable
- None in Cycle 26, while a few Cycle 25 and most Cycle 27 visits remain

Cycle 25

- 4 programs/65 orbits still active
- **deWit** (Cycle 25 Large): 81 of 114 complete, 33 orbits have no reliable windows (unchanged since 2019)
- **Crossfield** (Cycle 25 Large): 96 of 127 complete, 2 visits/10 orbits with reliable windows
- **Hedges** – 5 orbits planned in October 2020 (but no reliable windows)
- **Redfield** – 4 orbits remain (but no windows)

Cycle 27

- 17 programs/282 orbits remain, but most do not have windows within 10 week definitive ephemeris
- **Mikal-Evans** (Cycle 27 medium): 60 orbits total, with 30 consecutive 1-orbit visits in two sequences
- Other programs with 1-orbit visits that have to be sequenced in up to 10 straight orbits



LRP: Statistics

Solar System Programs: Highlights

- **Medium/Large Jupiter/Juno programs**
 - **Grodent** (Cycle 26 Medium): 52 of 54 orbits done, with a 2-orbit HOPR planned in April 2020
- **Europa Cycle 25 mid-cycle campaign**
 - **Roth**: 52 of 55 orbits done, with three orbits of HOPRs planned in August 2020
- **OPAL: Outer Planet Atmospheres Legacy**
 - Cycles 22-24: 29 total orbits per cycle on Jupiter, Saturn, Uranus, Neptune
 - Cycle 25-26: 41 total orbits per cycle
 - Cycle 27: 41 orbits planned
 - ▶ Uranus done in early November, Jupiter & Saturn planned in June 2020, Neptune planned in September 2020
- **Other planetary programs:**
 - **dePater**: 12 orbits on Jupiter, coordinated with the VLA
- **Comet Borisov:**
 - 8 programs (7 mid-cycle), 76 total orbits, 59 completed



Other Large/Medium highly constrained programs: Highlights

- **Kelly – Individual Stars as probes of Dark Matter**
 - Six sets of 16 consecutive orbits, with one set done, and another planned for April
- **Three active ultra-rapid ToOs**
 - Best-case turn-around, on-source 36-48 hours after receipt of Phase-II instructions
 - **Levan** – gravitational wave counterparts (one ultra-rapid among other ToOs)
 - **Cemco** – neutron star mergers
 - **Foley** – interactive supernova (recently activated)



Large/Treasury programs

C25/26 Program	alloc	Exec/sched by 4/12/20	Planned before 10/1/20	Planned after 10/1/20	comment
Crossfield - *	127	96	10*	21	
deWit - *	114	81	4*	20*	9 not in plan
Krauss	132	132	0	0	completed
Steinhardt	101	88	8	0	BUFFALO. 5 unplanned (ToO)
Freedman	54	54	0	0	completed
Jaskot	134	134	0	0	completed
Lee	122	93	19	7	3 not in plan
Levan (ToO)	45	1	0	0	Ultra-rapid ToO
Parker	206	194	10	1	1 not in plan
Peek	73	65	0	0	8 not in plan
Rafelski	90	87	3	0	3 HOPRs in September 2020
Riess	110	56	54	0	
Teplitz	164	116	45	3	

* - many exoplanet visits not planned, “in the bullpen” until observing windows become available.



Large/Treasury programs

C26 Program	alloc	Exec/sched by 4/12/20	Planned before 10/1/20	Planned after 10/1/20	comment
Berg	133	83	9	39	2 not in plan
Jha (ToO)	51	13	10	2	26 not in plan. C27 and 28
Kelly	96	16	48	32	
Roman-Duval	77	39	21	13	4 not in plan
Weisz	244	57	76	103	8 not in plan



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The Advanced Camera for Surveys: *Status Report*

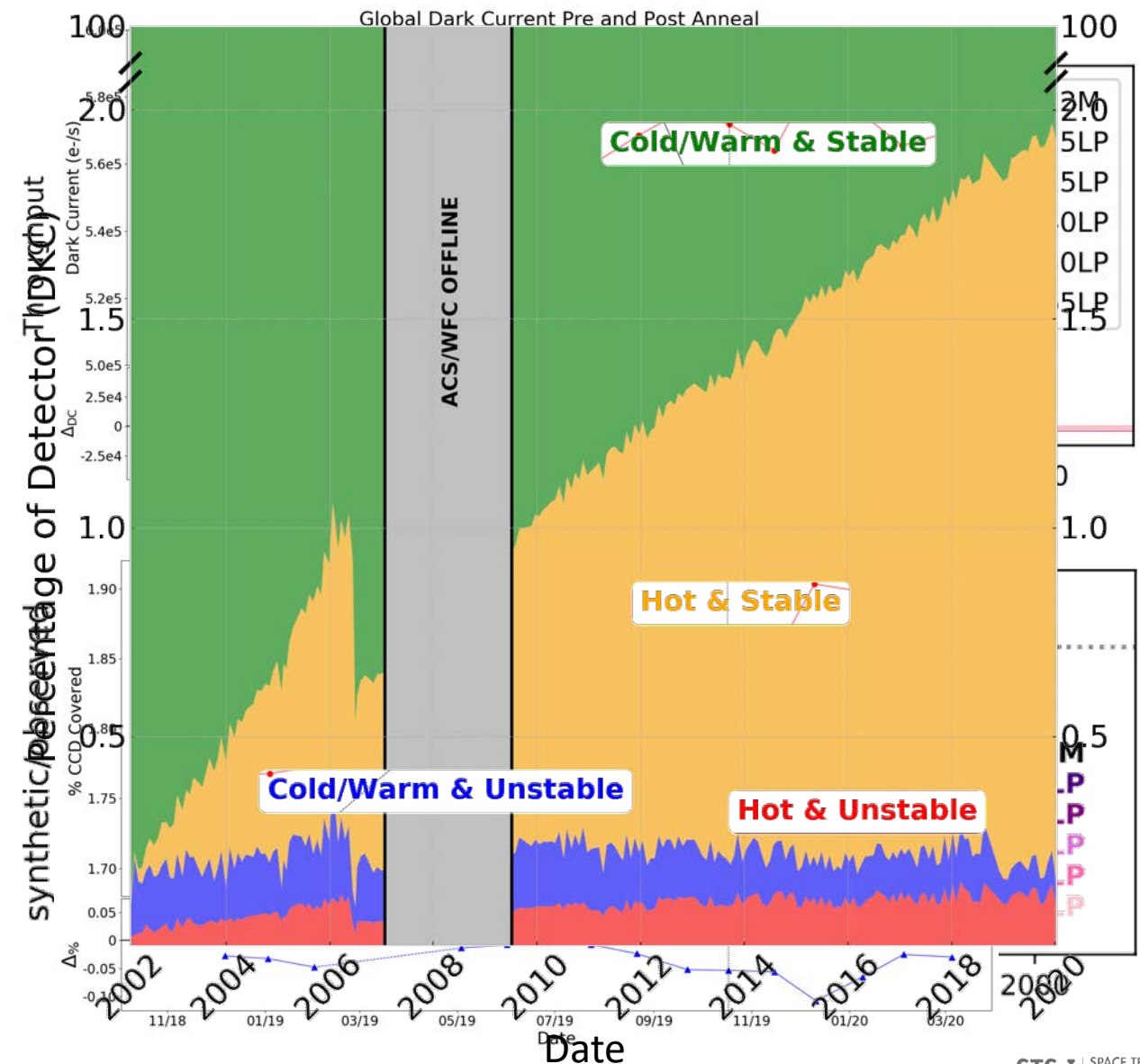
Prepared by Norman Grogin and the ACS Instrument Team

STUC Meeting, 14 April 2020



ACS Developments since the Nov'19 STUC Meeting

- ✓ ACS continues to operate nominally.
- Continued stable ACS/WFC readnoise; slow trending of dark current & CTE
- Long-term monitoring of CCD pixel stability shows steady 99.8% usability
- ACS/SBC $\approx 30\%$ (improved) sensitivity revision is extensively advertised, and propagated into ETC & BOP-checking
- “Reduced Operate Mode” annealing continues to perform well, solving the 1Q19 return-from-anneal ACS safings





ACS Ongoing & Planned Work

- ABS/SBC (+ STIS) observations are adding several NGC 6681 stars to CALSPEC
 - !! Approx. *9 mags fainter* than primary FUV stds; ranging from STmag = 15.5 – 17.5
- New Cyc27+ ACS CAL: pixCTE monitoring/refinement at low background levels
- New Cyc27+ ACS CAL: ω Cen astrom./photom. cross-calibration with WFC3/UVIS
- ACS/WFC spatially-dependent saturation flagging in CALACS ($\pm 10\%$ variation seen)
- Major improvements to DARKCORR in CALACS
 - More robust DARKTIME calculation and usage (from empirically-derived overheads)
 - Investigating potential improvement from taking 3 \times more, 3 \times shorter DARKs (& less FLASH)
- “High Dynamic Range” ACS/WFC Superdark
 - Selectively merging the 1000.5 sec and 0.5 sec calibration DARKs
 - Eliminates superdark saturated pixels and pixel-blooms; requires DARKCORR bloom-model



New ACS Documentation since the Nov'19 STUC Meeting

- Release of ACS Instrument Handbook for HST Cycle 28 (Ryon et al.)
- ISR ACS 2019-10 : “Bright Object Magnitude Limits for ACS/SBC and Color Corrections for All Three Channels” (Ryon et al.)
- ISR ACS 2020-01 : “Post-SM4 ACS/WFC L-Flats and Photometric Errors from Observations of Stellar Fields” (Cohen et al.)
- ISR ACS 2020-02 : “New and Improved Saturated Pixel Flagging for the ACS/WFC” (Cohen et al.)
- ISR ACS 2020-03 : “Irregularity in Ceiling of Analog-to-Digital Conversion for Post-SM4 ACS/WFC Images” (Cohen et al.)
- ISR ACS 2020-04 : “Accounting for Readout Dark in Superbiases II: Subarrays and Updated Readout Dark Measurement” (Ryon et al.)
- ISR ACS 2020-05 : “Anneal Efficacy in the ACS/WFC” (McDonald et al.)



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COS STUC Update

Marc Rafelski, Bethan James, and COS team



COS summary and outline

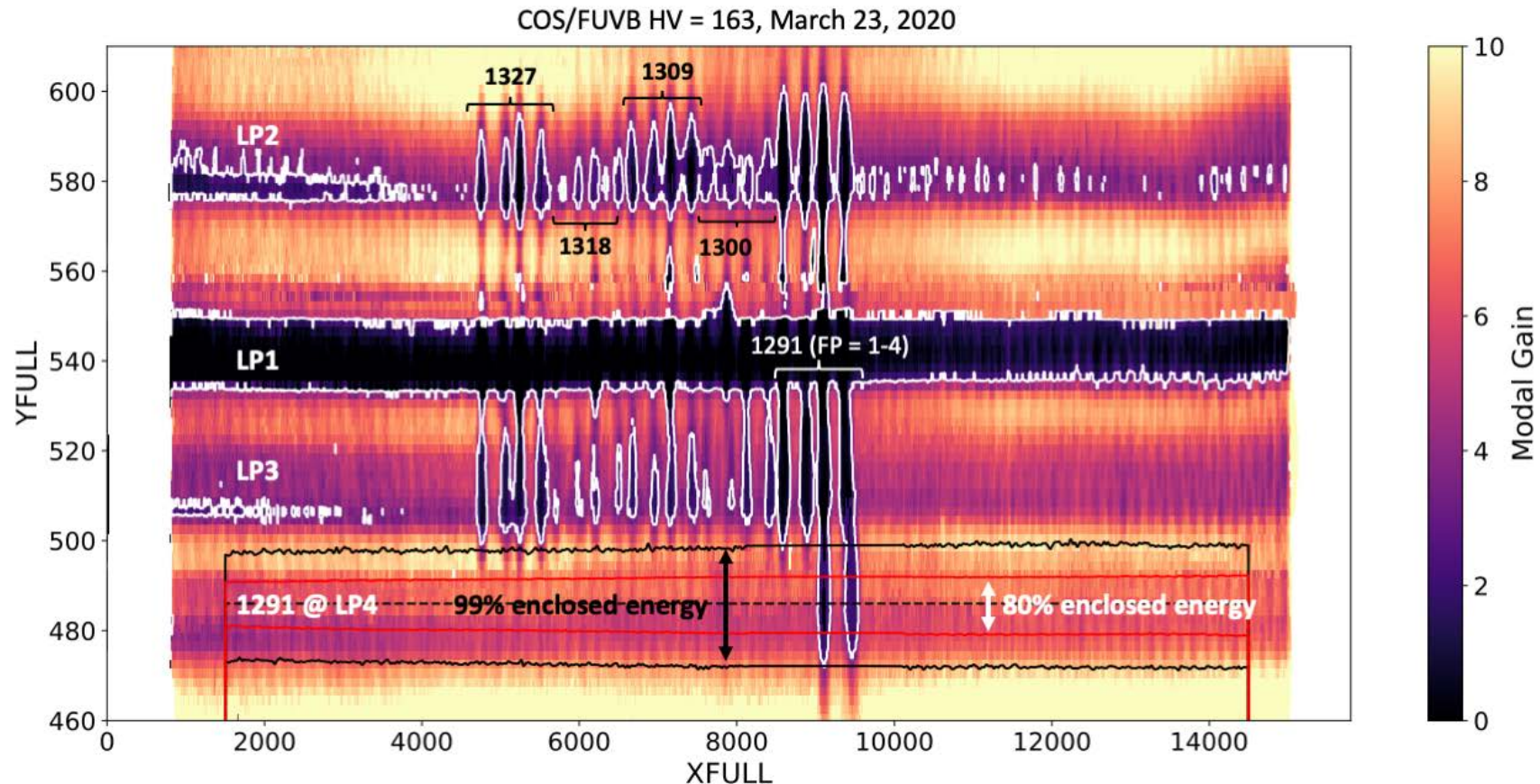
- COS is Operating Nominally
- New COS management
 - Branch Manager: Marc Rafelski
 - Deputy Branch Manager: Bethan James
- No new documentation since last STUC, 2 STANS released



Status of LP4 High Voltage (HV) setting (D. Sahnou and J. Roman-Duval)

COS has been at LP4 for ~2.5 years at the same HV setting

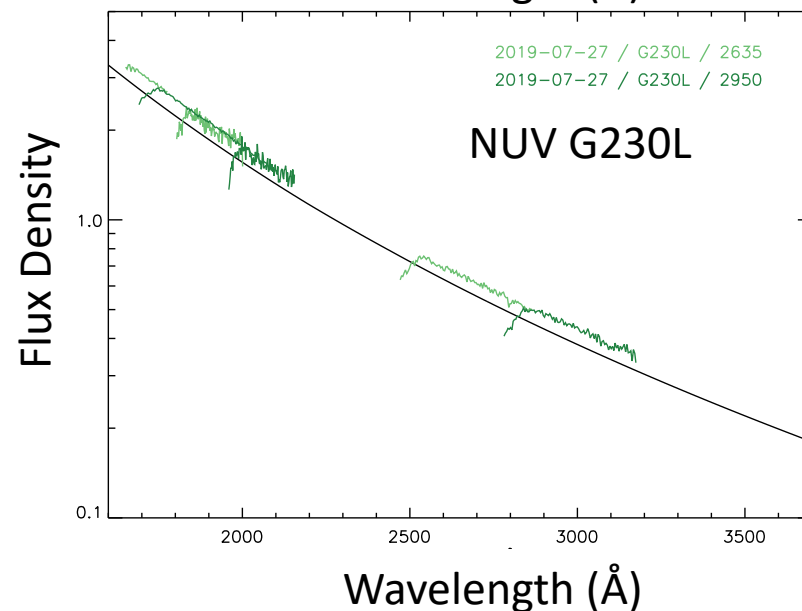
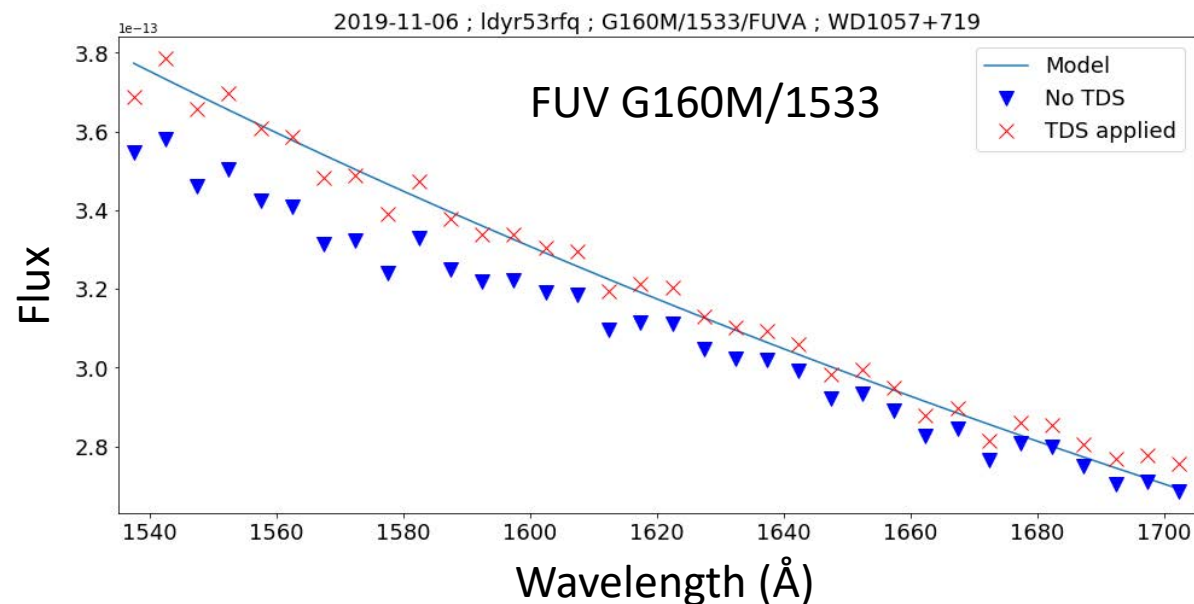
- 2025 strategy results in two holes, enabling us to remain at a HV until the modal gain of the continuum sags
- Expect to increase the HV for LP4 for the first time very soon; we are working on determining the exact date.





Time Dependent Sensitivity - TDS (FUV R. Sankrit, NUV W. Fischer)

- COS FUV modes G160M/1533 and G140L/800 introduced in Cycle 26 (Fall 2018), TDS monitoring initiated February 2019, TDSTAB reference file delivered on January 27, 2020
- A new FUV TDSTAB reference file for the normal and blue modes will be released late Spring 2020
- Current NUV TDS tab delivered in 2010
- Trends have remained \sim constant but slightly smaller than TDS values; after 10 years the difference has grown significantly and needs updating (+ October 2019 STAN to inform users)
- No impact to users from ETC perspective – ETC thinks NUV is less sensitive than it is

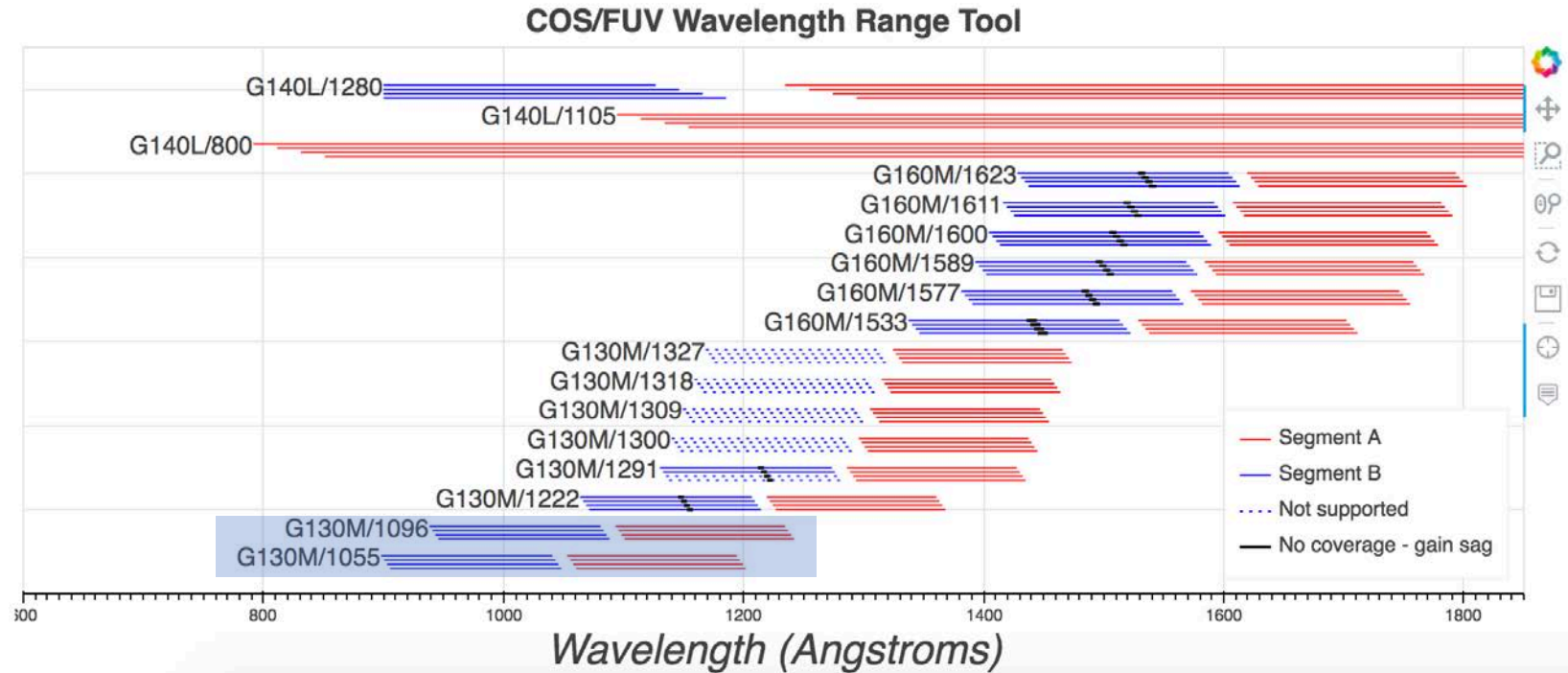




Blue Modes Recalibration (W. Fischer, C. Oliveira, S. Dieterich, K. Rowlands, N. Kumari)

Cenwaves 1055 and 1096

- Observed with G130M at LP2
- Extend G130M to shorter wavelengths than normal modes:
899–1196 Å, 940–1236 Å
- Typically not a highly used mode so calibration not up to date
- Cenwave 1096 will be used for massive stars in ULLYSES prompting the need for improved calibrations.



- We are improving the flux, time-dependent sensitivity, & wavelength calibrations of cenwaves 1055 and 1096 to bring their accuracy in line with those of the other G130M modes
- New reference files are expected before Cycle 28 begins



LP5 Feasibility Study

(Oliveira, Dashtamirova, James, Fox, Plesha, Rafelski, Roman-Duval, Sahnou)

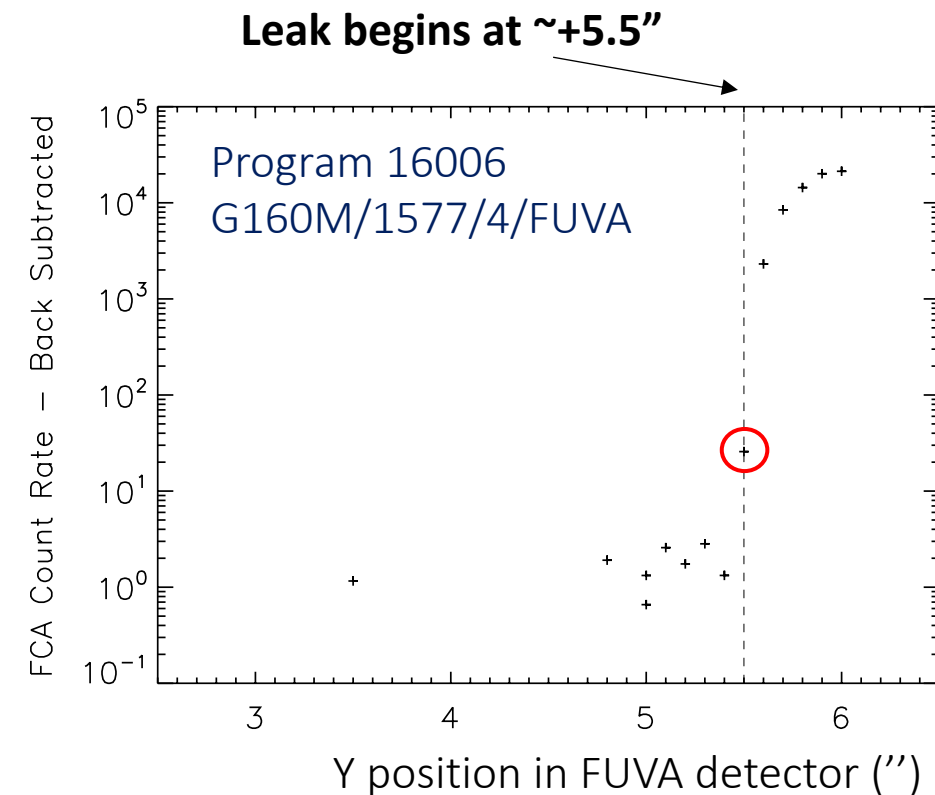
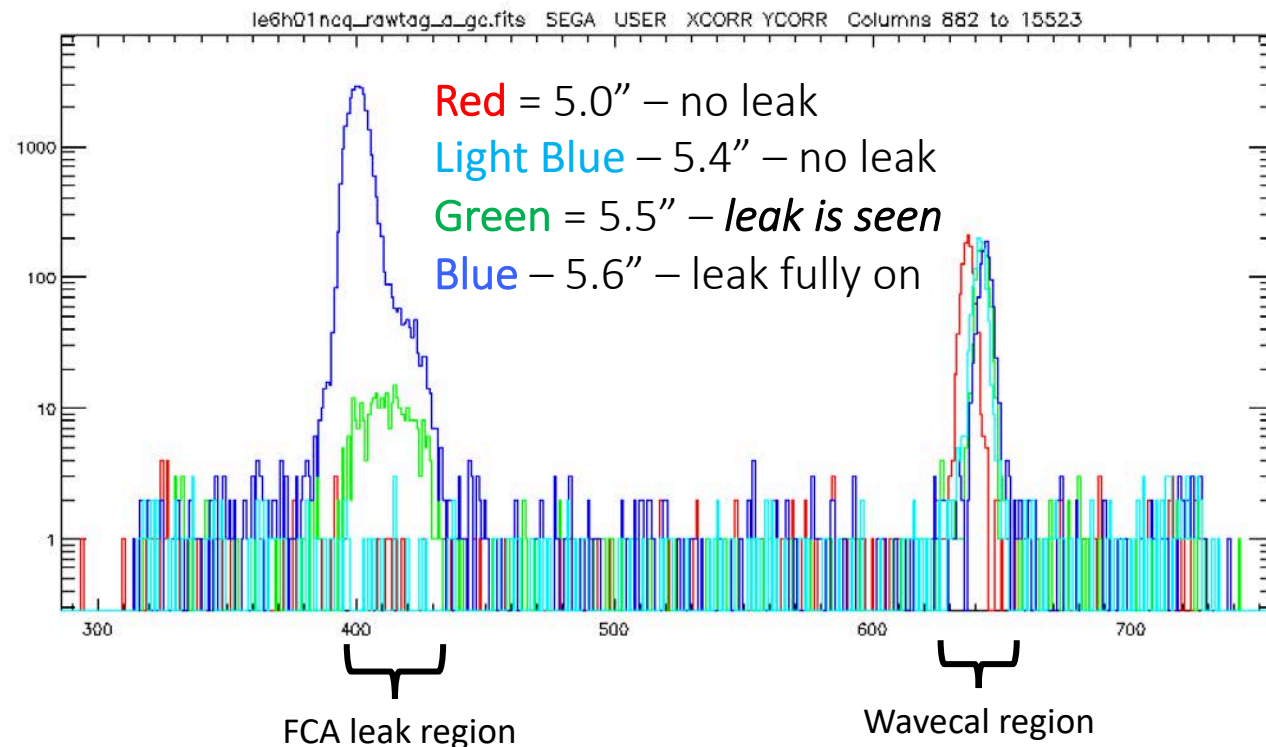
- COS2025 initiative prolongs lifetime of COS detector to ~2023 (ULLYSES not considered)
- Real estate near top of FUV detector is pristine but light leak appears when wavecal lamp is flashed
- A number of programs executed over last year to understand constraints on aperture placement with regards to (i) starting point of light leak, (ii) the gain in the region around LP5, and (iii) stability of the aperture mechanism when moving between different LPs

Program	Title	PI	Orbits	Executed on
15689	COS/FUV Mapping of FCA Light Leak Between +5" and +6"	C. Oliveira	1 int	Apr 2019
15711	Characterization of COS/FUV detector modal gain at Lifetime Position 5	D. Sahnou	4 int	June 2019
15983	COS/FUV Mapping of PtNe1 medium current to PtNe2 low current with G160M/1577/4	C. Oliveira	1 int	Aug 2019
16006	Mapping COS/FUV FCA Light Leak with PtNe1 Medium Current	C. Oliveira	1 int	Oct 2019
16052	Testing for Systematics When Moving the COS Aperture Block	B. James	3 int	Dec 2019
16106	Testing the COS/FUV Spectrum Placement at 5.4"	D. Sahnou	6 ext	In scheduling phase



LP5: Location of Light Leak and Implications for G130M

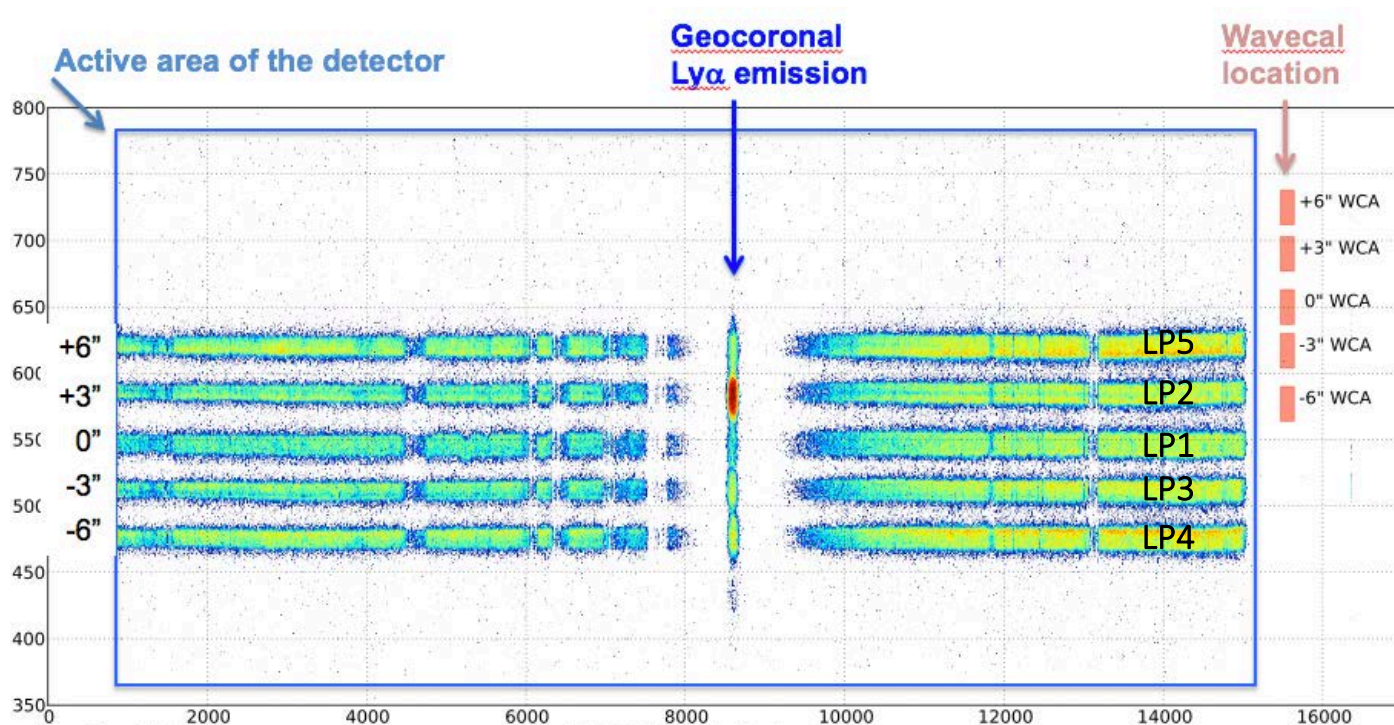
- Light Leak begins at +5.5", and +5.4" would have no light leak
- Can G130M grating be placed at 5.4" and avoid LP2 gain sag?
 - Program 16106 will evaluate this by obtaining external data at 5.4"
 - Also working on lifetime estimates at starting HV values at 5.4" vs. higher





LP5: Implications of Light Leak at +5.5" for G160M

- G160M grating projects lower on the detector – no wavecal data can be taken concurrently with science data
 - Current plan is to obtain wavecal at LP2 and science data at LP5 - some increase in overheads
 - Program 16052 concluded aperture mechanism has stability to support LP2 wavecal/LP5 science (next slide)
 - Typical sequence would be TA -> LP2 wave -> LP5 science -> LP2 wave, repeat sequence per exposure
 - There would be a maximum exposure time for science exposure so that drift can be properly corrected

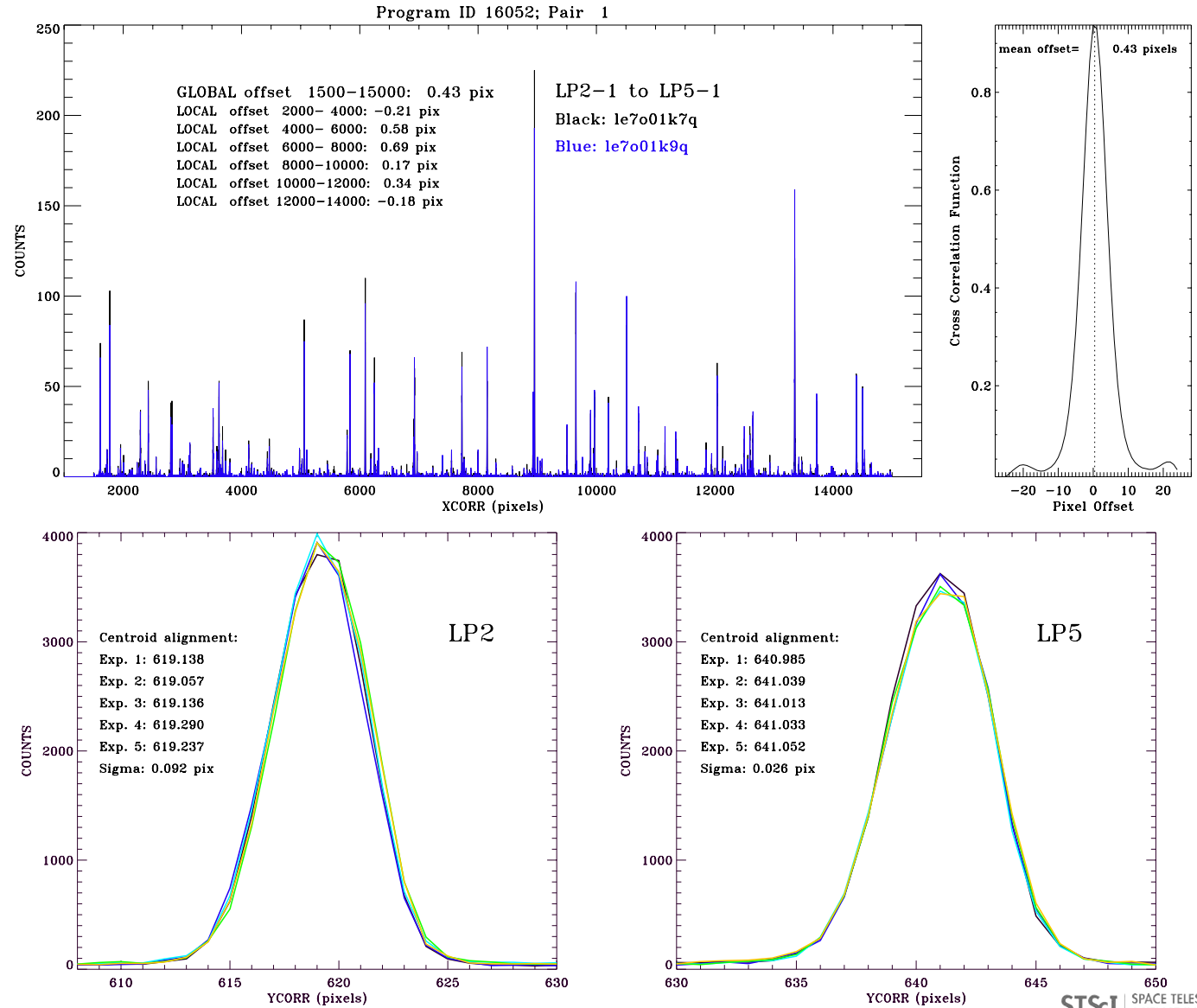


- 2-D image of G130M/FUV spectra at different LPs (left image)
- Other settings project at other slightly different locations



LP5: Stability of Aperture Mechanism (B. James & A. Fox)

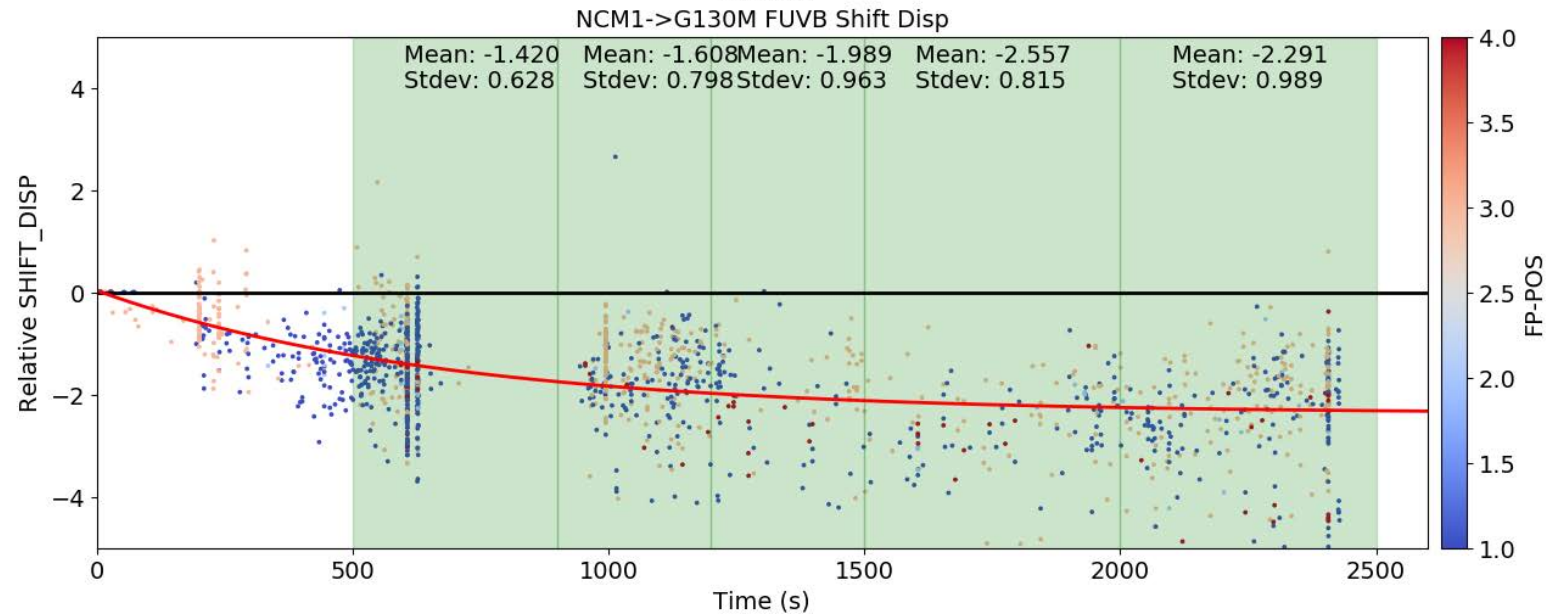
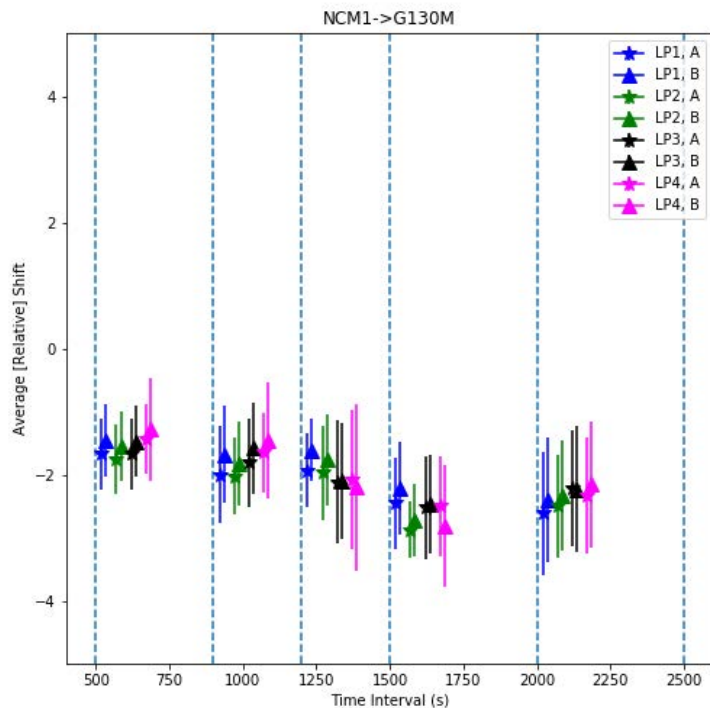
- Program 16052 checked the repeatability of the positions of the spectra between LP2 and LP5.
- Aperture movements only impact the spectral location in x and y by sub-pixel levels
- Calibrating data taken at one LP with lamp spectra taken at another LP is feasible
- This will have a minor-to-negligible effect on the spectral resolution
- There will be increased overheads which is being investigated





LP5: G130M and G160M Drift Study (D. Dashtamirova, B. James, K. Rowlands)

- Study of the nature of the drift to understand impact of obtaining wavecal and science data at different times
- Tagflash mode injects flashes of wavecal lamp at predetermined times in exposure and values are used to correct drift during exposure and overall shift
- The drift varies as a function of OSM movement
- We can flash at the beginning and end of each exposure and correct the drift and shift using a model
- Maximum exposure times vary on OSM movement, but range from 1500-2000s.





Future Work in FY20

- Complete Blue Modes Calibration
- Complete LP5 feasibility studies and commission new LP
- Detailed modeling/predictions of gain sag evolution vs. usage
- FUV cenwave dependent TDS
- Study of FUV TDS vs. HV
- Improved Monitors using new software framework



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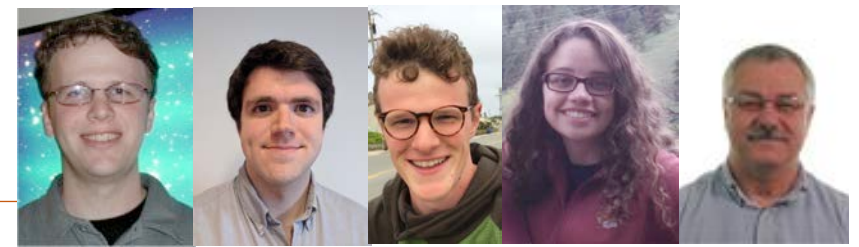
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STIS Update

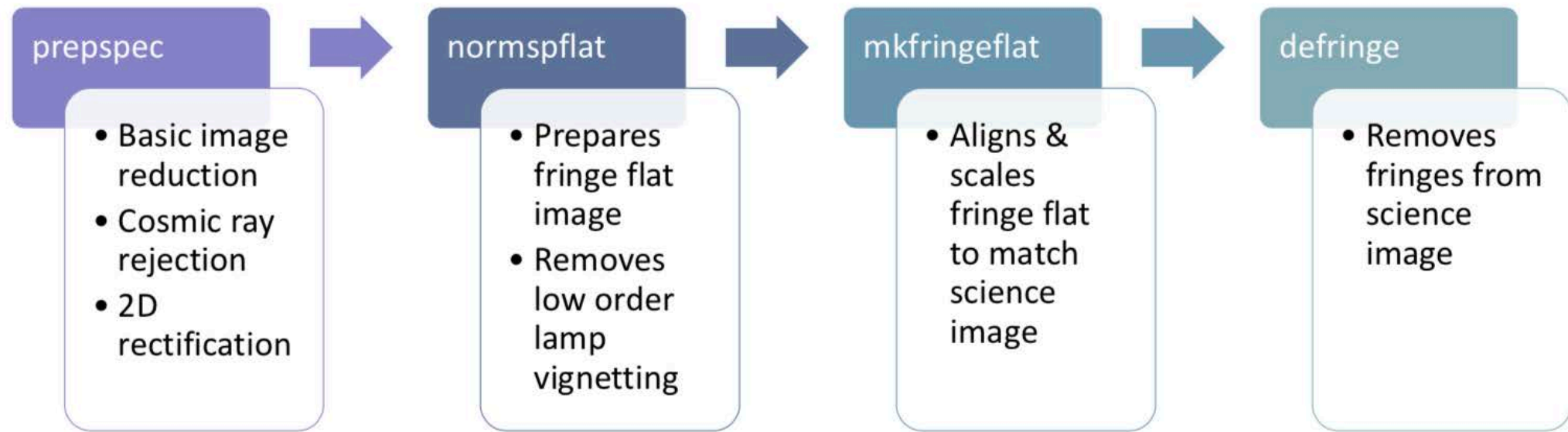
John Debes & Tala Monroe
for the STIS Team
STUC--14 April 2020



Software Updates: CCD Defringe

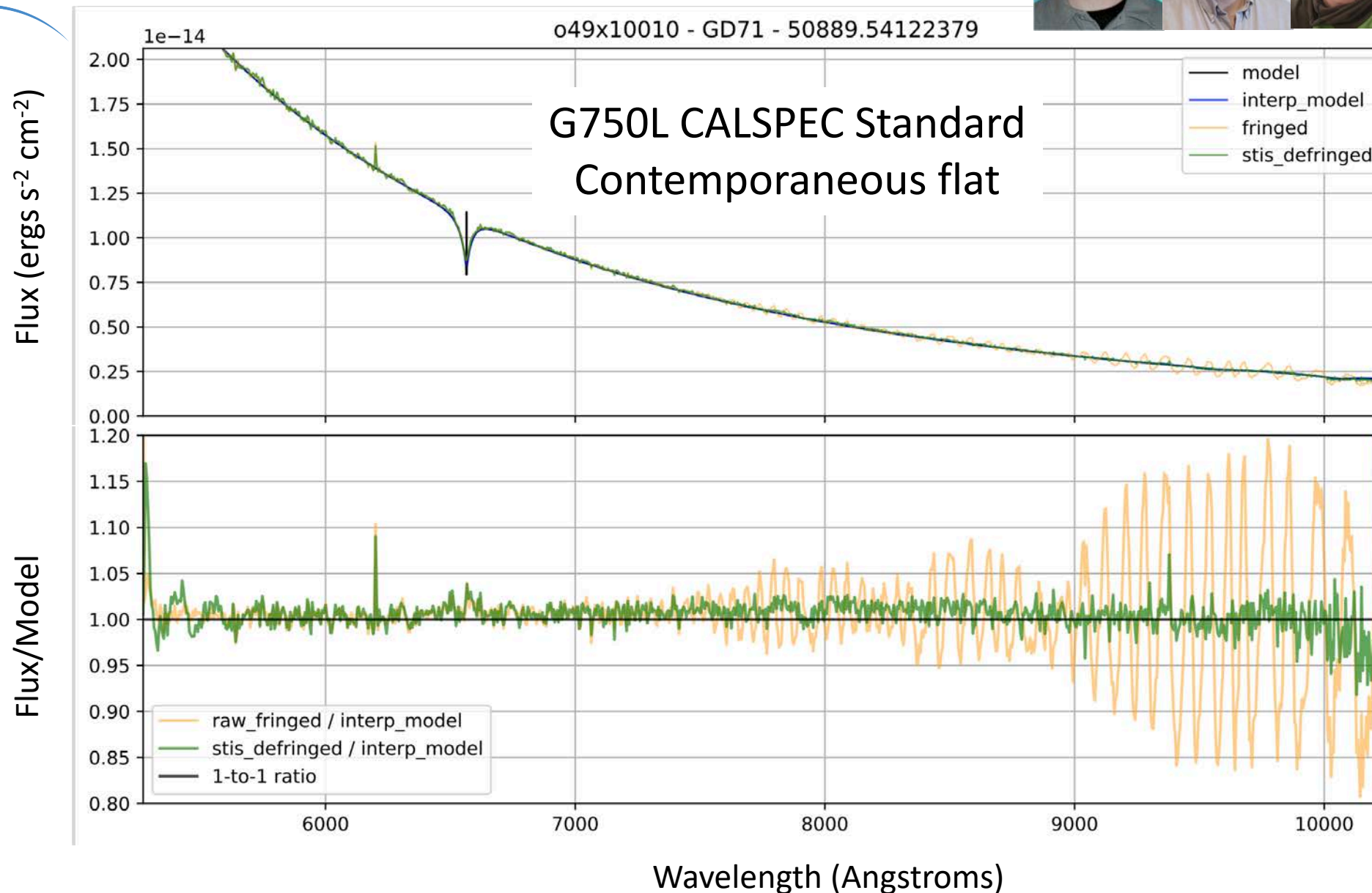


- A new Python-based defringing tool has been developed to defringe STIS CCD G750L and G750M spectral observations in response to IRAF deprecation
- STIS Calibration software is available through AstroConda in *stistools*
stistools.defringe will be released late spring/summer 2020





CCD Defringe Scientific Validation





Instrument Support

Documentation:

- ISR 2019-04: The Impact of Spacecraft Jitter on STIS Coronagraphy (Debes)
- TIR 2020-01: STIS Results: September 2019 HST Gyro High Mode Test (Maclay, Riley)
- AJ Paper: Hubble Space Telescope Flux Calibration I: STIS and CALSPEC (Bohlin, Deustua, DeRosa)
- Updates to IHB, Call for Proposals
- STAN published February 2020
- ISR 2020-01: STIS MAMAs: Checking for Gain Sag (Maclay)--in review

Future Work

- Complete E140M flux recalibration
- Complete investigation of spatial scanning for transiting exoplanet science
- Echelle Dispersion Monitor Revamp—assess need for legacy wavelength dispersion solutions+leverage against external calibration program by PI Ayres (Program 15948--executing)
- Push absolute flux calibration of first order modes towards 1% (initial results obtained)



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WFC3

S. Baggett & WFC3 Team

STUC April 2020



WFC3 status

General

- WFC3 operating nominally
- Approaching 270,000 WFC3 images in MAST archive
- Quicklook: science data & instrument monitoring nominal

Completed

- Quicklook image anomalies database released (ISR 2020-02)
- Guidelines for observers with ultra-rapid ToO published (SMO/WFC3 ISR 2020-01)
- Verification of MAST/SCSB astrometric updates: improved solutions for WCS
a priori (GSC positions based on Gaia) and a posteriori (image sources matched to Gaia)

<http://www.stsci.edu/hst/instrumentation/wfc3/news>

WFC3 Quicklook Project

Unlooked: New unlooked images. [View All] [View From Start]

On Hold: Images placed on hold. [View All] [View From Start]

Log Analysis: Missing files and ingest errors. [Ingest Logs] [Missing File Logs]

Today's Status: Unlooked Images: 161, Images on Hold: 15, Error Folders: 24, Incomplete Folders: 0, Available Disk Space: 113.9899 TB

Automated Outputs
These are the daily outputs of the WFC3 Automation Platform.

UVIS Bowtie Plots [View Plots]
UVIS Contam Monitor Plots [View Plots]
CSMIR Blob Monitor Plots [View Plots]
IR Saturation Prediction [View Proposals]

IR Bias Plots [View Plots]
UVIS EPER CTI Plots [View Plots]
UVIS External CTE Plots [View Plots]
IR Spatial Scan Monitor [View Table]

UVIS Darks Plots [View Plots]
UVIS Gain Plots [View Plots]
IR Background List [View Table]
Jitter Monitor [View Plots]

DISC Data Plots [View Plots]
IR Gain Plots [View Plots]
IR Persistence [View Table]
UVIS Read Noise [View Plots]

Anneal Page
Link to list of current and previous anneal dates. [Anneal Page]

Database
The web interface to the MAST database of all WFC3 images. [Query Database]

Proposal Status
Link to this cycle's proposals. [Proposal Status]

Script Execution Status
Execution status for cron job scripts.

Script	Date Last Executed	Status
cal_ir_check_csm	04-02-2020 08:30	Completed Successfully
cal_ir_make_bad_satur	04/01/2020 18:00	Completed Successfully

Proposal Links
Links to Cal and GO thumbnails by proposal ID. [Cal proposals] [GO proposals]

Anomalies
Links to WFC3 anomaly examples and daily anomaly monitoring. [Examples] [Daily Monitor]

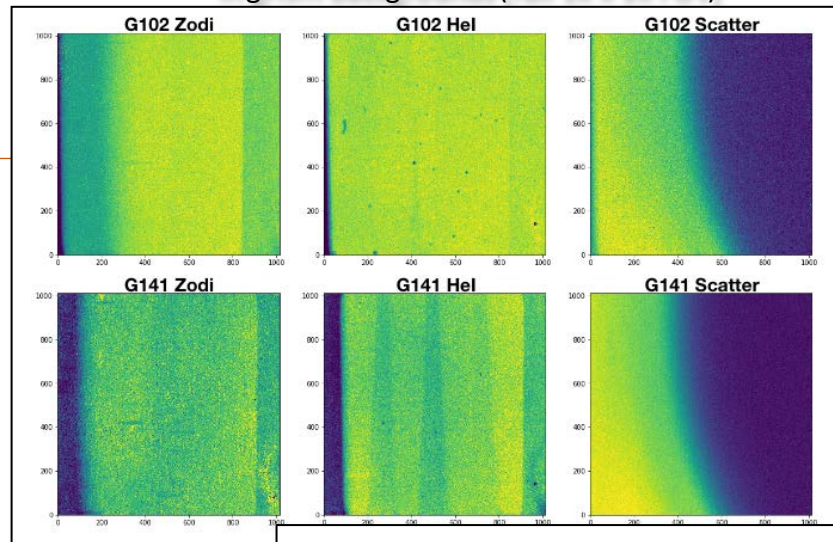


WFC3 status

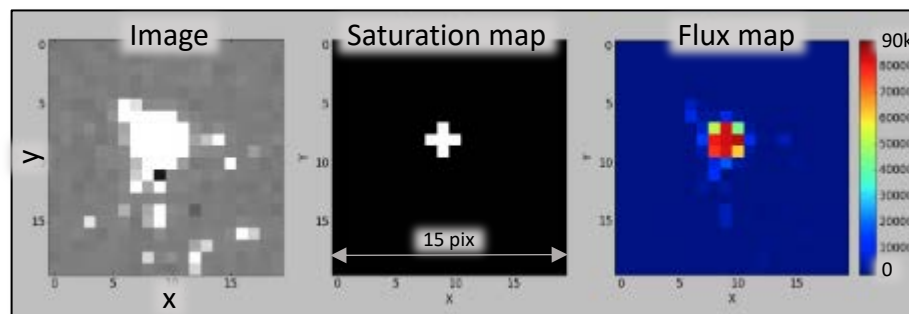
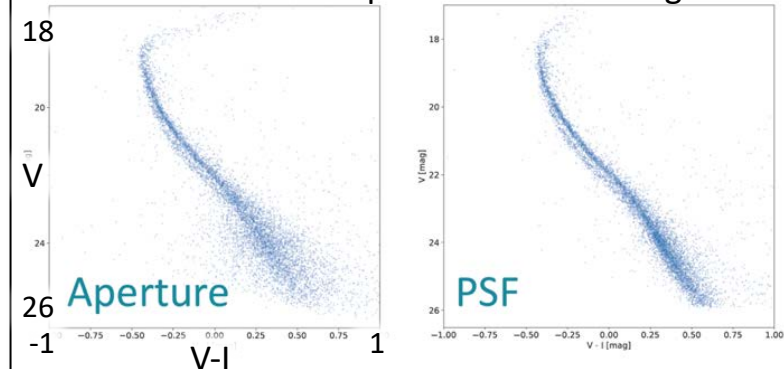
Completed

- New 3-component IR grism backgrounds (ISR under rev.)
Zodi (constant) and time-variable Hel, scattered light
Consistency at multiple PAs, ~3x better than old
- Python workflow for PSF fitting available (ST github)
Based on Anderson's HST1PASS, high precision results
Low false positive detection rate, clean catalogs
- IR snowballs (transients that saturate a few pix, deposit few 100k e-)
Rate constant @1-2/hr from 2009-2019 (ISR 2020-03)
Rules out TH-228 radioactive decay
Could still be U-238 or U234 decays (ISR 2009-44)

IR grism backgrounds (full 1k x 1k FOV)



ω Cen CMD – aperture vs PSF fitting





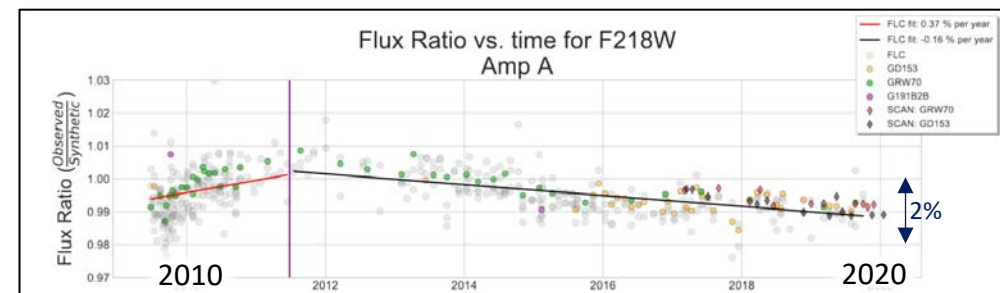
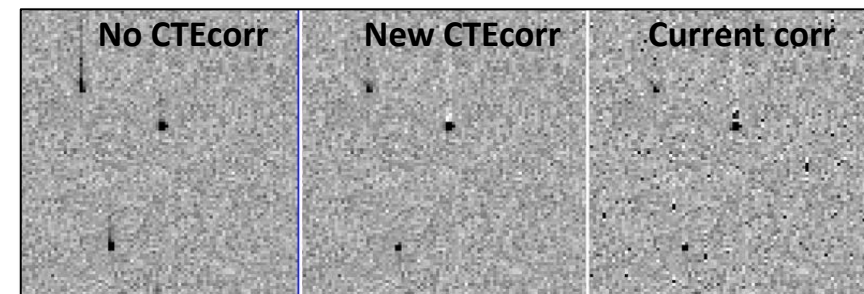
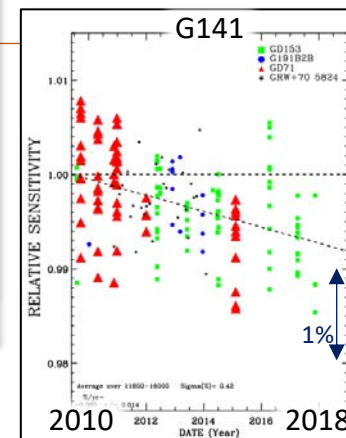
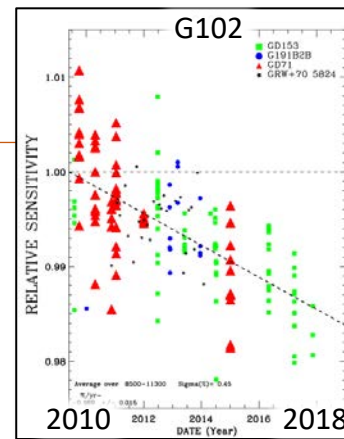
WFC3 status

Completed

- Low-level time-dependent sensitivity in IR
 $\sim 0.17\%/yr$ (G102), $\sim 0.09\%/yr$ (G141; AJ 157, 229)
 $\sim 0.2\%/yr$ (F160W; ISR under review)

In progress

- UVIS CTE correction improvements
 On-the-fly noise sensing sets level for each image
 Mitigates background noise amplification
 Cycle 28 phase II's: optimum background 20 e-/pix
- Updating IR skyflats, including corrections for blobs
- Time-dependent UVIS zeropoints for calibration pipeline





User support, new documentation

- Cycle 28 IHB released Dec 2019
- Mid-cycle 27 Phase II CS reviews completed
- STAN released Jan 2020, next one in ~June
- Helpdesk support
- Jan 2020 AAS presence:
 - PSF Fitting Workflow
 - Python Data Analysis Tools and Jupyter Notebooks
 - DASH Reduction Pipeline Development and Launch
- Reports published:
 - 2020-03: IR 'Snowball' Occurrences in WFC3/IR: 2009-2019, Green & Olszewski
 - 2020-02: WFC3 Quicklook Anomalies Database – Medina et al.
 - 2020-01: Recommendations for Optimizing RapidUltraviolet HST Observations of Gravitational Wave Optical Counterparts – Strolger, Rest, Fox, Calamida et al.
 - CALSPEC: WFC3/IR grism spectrophotometry – Bohlin & Deustua (AJ 157:229)

Under review:

- 2020-tbd WFC3/IR photometric sensitivity in F160W over time – Platais & Baggett
- 2020-tbd The WFC3 Wide-Field Slitless Spectroscopy backgrounds – Pirzkal et al.



Summary

Hubble continues to perform ground-breaking science

Happy to discuss any of the material in this slide package or other topics

Stay tuned for a truly stunning 30th anniversary image

Be safe and stay in touch

HUBBLE SPACE TELESCOPE

30 Years of Discovery

CELEBRATE WITH US