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EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

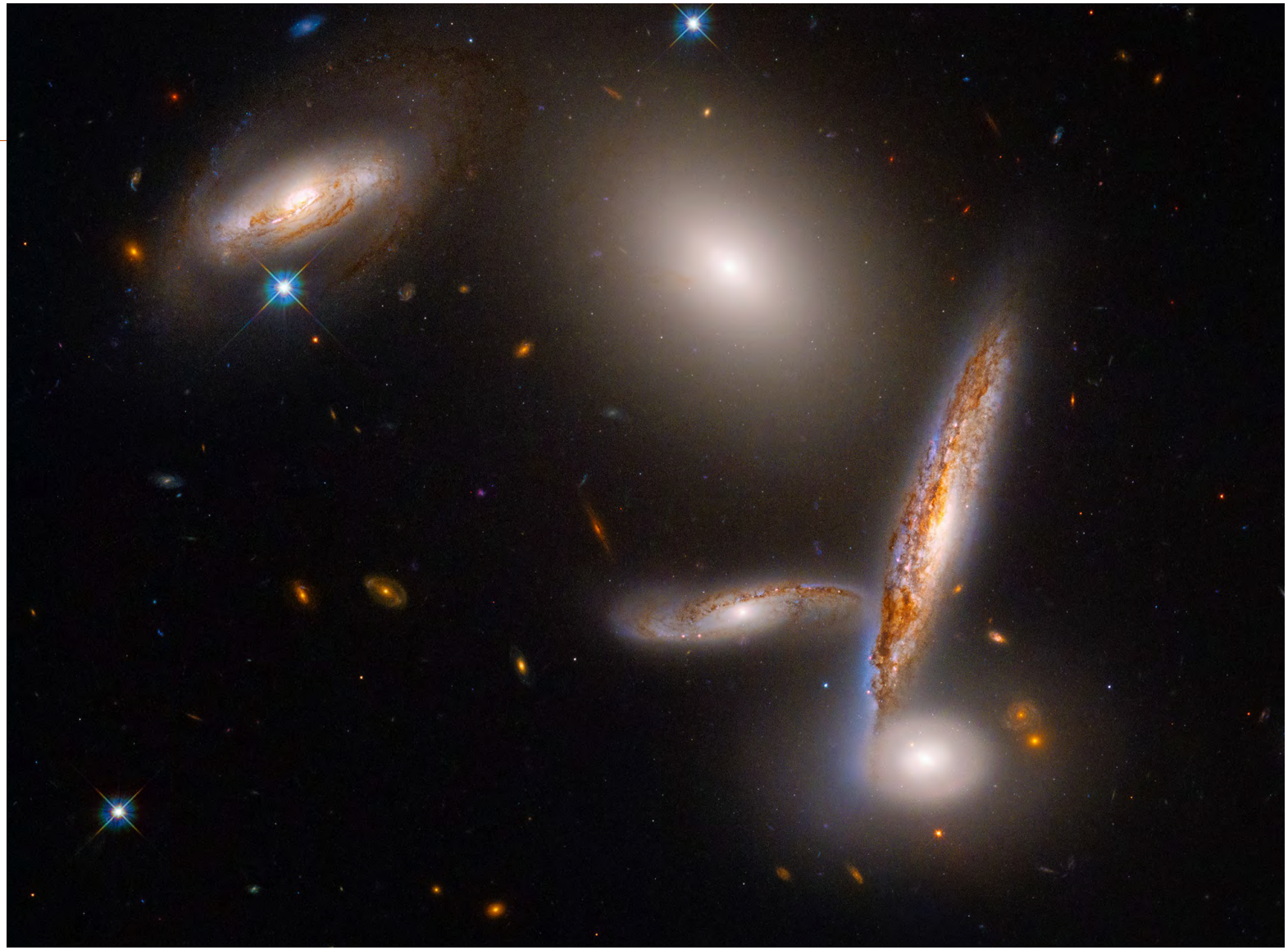
HST Mission Office Report

Tom Brown

STUC – 19 May 2022

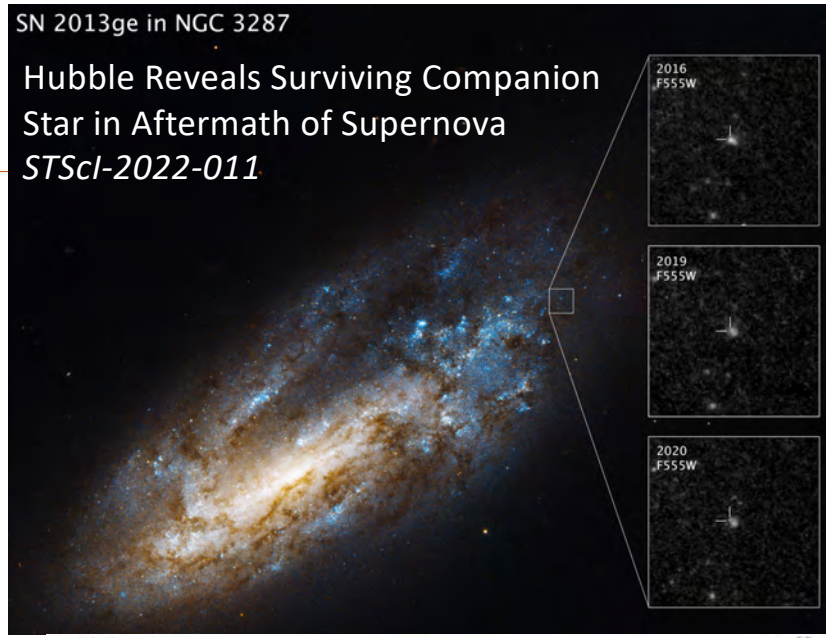
Hubble Celebrates 32nd Anniversary

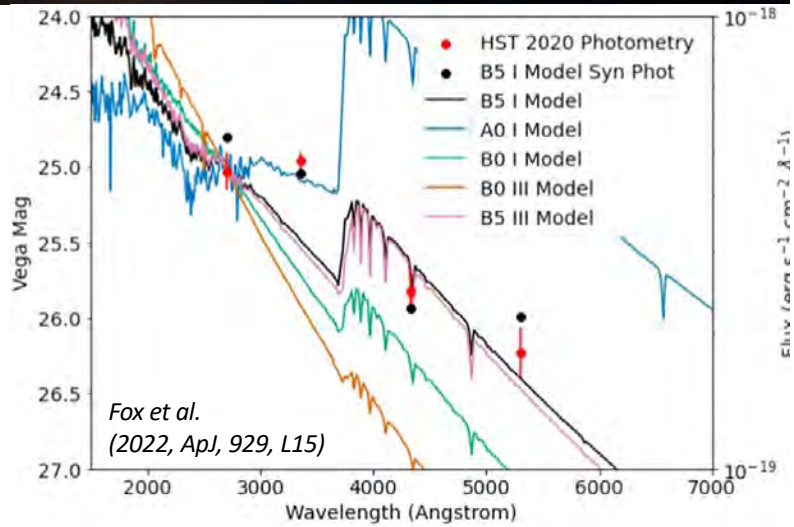
STScI-2022-012



Summary

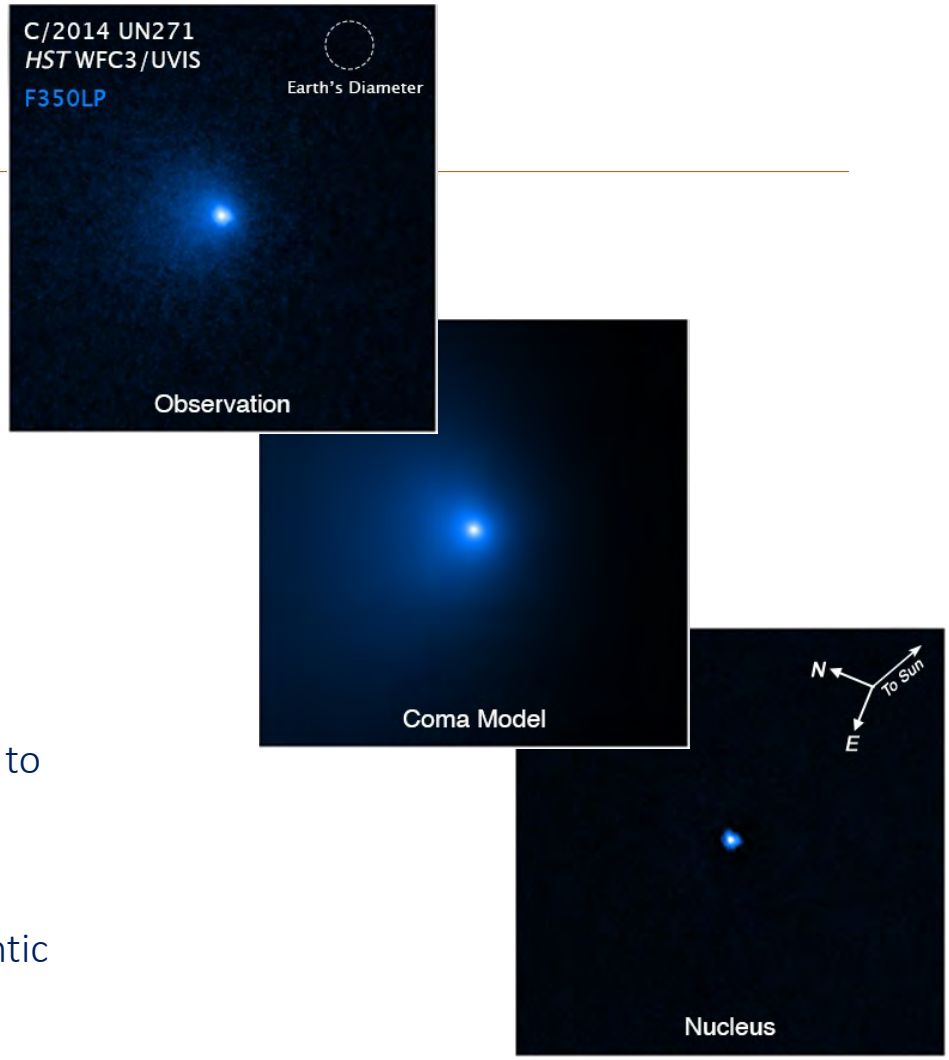
- Progress on recent hardware anomalies
- Hubble Advanced Products
- Long-range plan
- Instrument support
- Cycle 30 extended to 14 months (1 Oct 2022 to 30 Nov 2023) to accommodate Webb Cycle 2 support
  - Pool expanded from ~3000 to ~3500 orbits
  - 1062 proposals submitted
  - Cycle 31 will be 10 months and restore normal schedule
- Hubble science ops contract signed (16 Nov 2021)
- Hubble Senior Review
  - Proposal submitted on 8 Feb 2022
  - Review panel held on 15-17 Mar 2022
  - Expect results this summer





Hubble hardware highlights

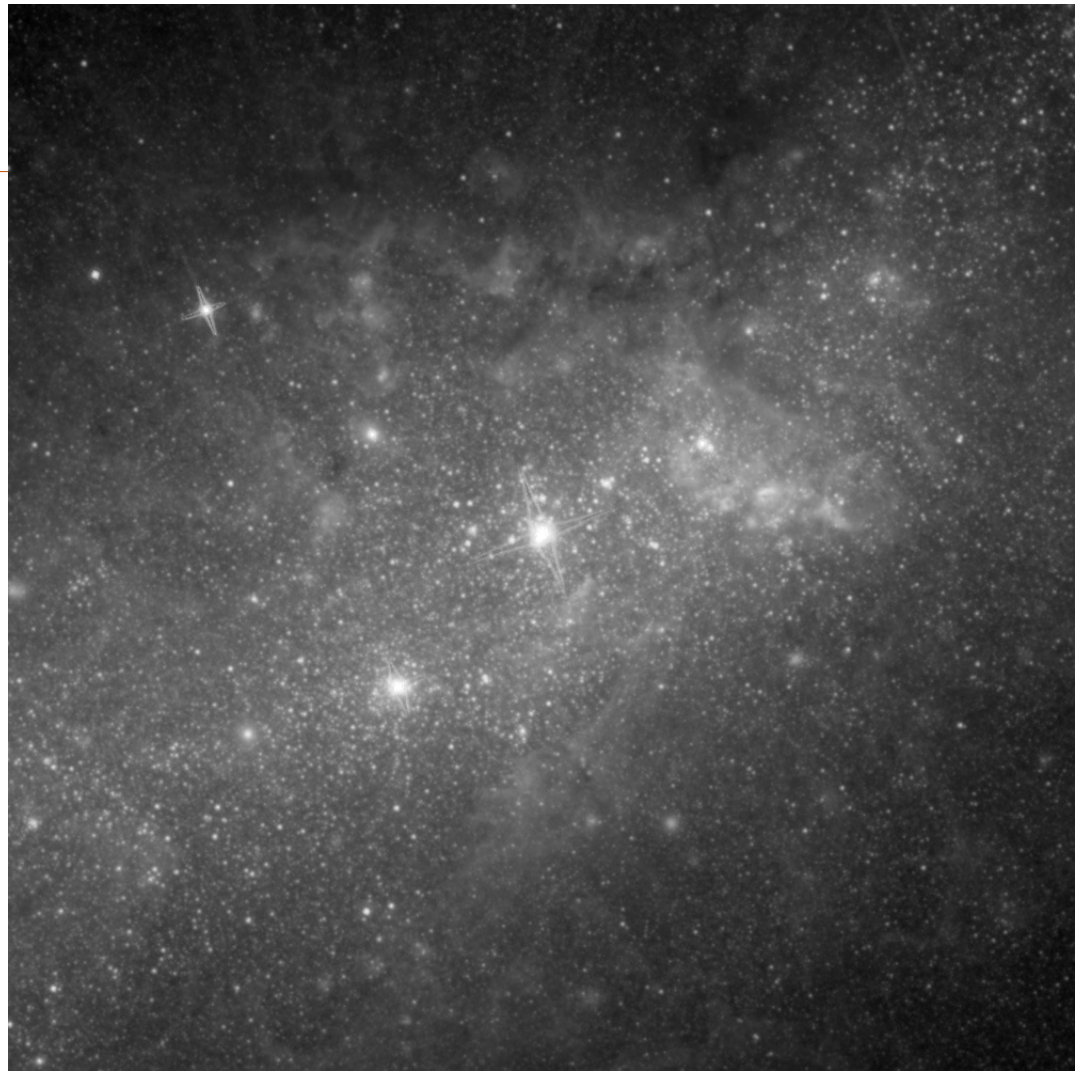
- Lost minor frame sync signal Oct 23 & 25
  - Instruments safed
  - No repeat of anomaly
  - Mitigations implements in flight software patches
    - COS Dec 21, WFC3 Feb 4, STIS Feb 15, ACS Mar 2
  - Longer term, investigating more robust mitigations
- SIC&DH Side B Failure in mid-2021
  - Operations have continued on Side A
  - Staff are working on restoration of Side B operations to provide redundancy
- COS suspended on April 5
  - Single event upset while passing through South Atlantic Anomaly
  - Instrument quickly recovered to science



Hubble Confirms Largest Comet Nucleus Ever Seen
STScI-2022-020

Hubble Advanced Products

- Hubble Data Management System began producing Multi-Visit Mosaics on 28 Apr 2022
  (Single-Visit Mosaics operational Dec 2020)
- Public ACS & WFC3 data drizzled onto grid of pre-defined sky cells
- Separate products for each filter and detector combination, but all on same pixel grid
- Adjacent sky cells can be pieced together using the HAPcut package (https://mast.stsci.edu/hapcut) or directly from MAST using an API



NGC 1569 Hubble Advanced Product

Long Range Plan Status

Prepared by Dave Adler

Long Range Plan: Current Status

Cycle 29 update

- Through the SMS ending May 15, 2022 averaging: **74.8 orbits/week** over 33 weeks
  - Remove four weeks with no/partial observing due to minor frame sync issue: **82.0 orbits/week** over 29 weeks

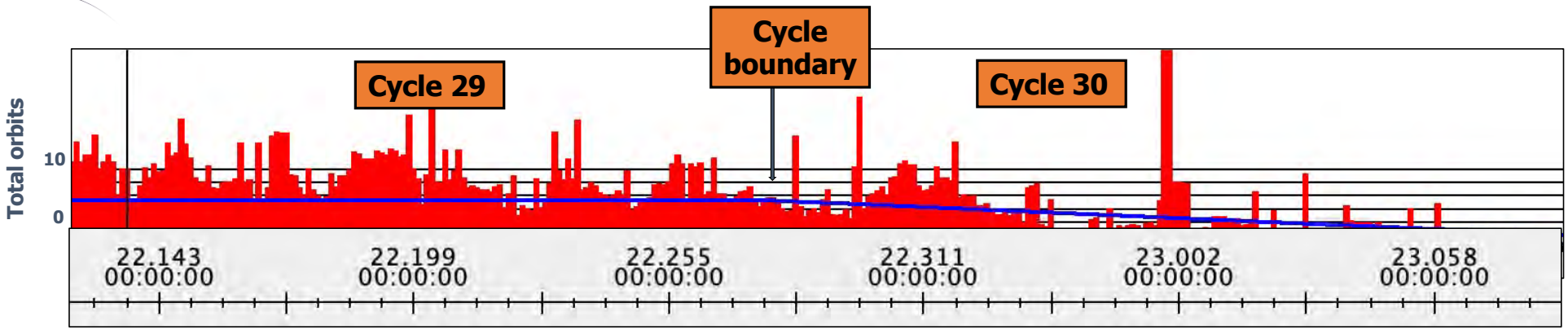
Comparison to previous cycles

- **Cycle 28** averaged 75.1 orbits/week over 52 weeks
  - five-week down-time before the SIC&DH Side B->A switch in July 2021
- **Cycle 27**: 85 orbits/week
- **Cycle 26**: 80 orbits/week
  - Three weeks downtime due to Gyro 2 failure
- **Cycle 17-25**: averaged 84 orbits/week

Previous Cycle Completeness

- **Cycle 25**: one 4-orbits from Trappist exoplanet program **15304** (de Wit)
- **Cycle 26**: complete
- **Cycle 27**: 100 orbits left, some as late as spring 2023
  - Over half from large exoplanet programs waiting for opportunities

LRP: Current Status



Cycle 29 LRP: features

- Cycle 29 is full into mid-July 2022
- Current subscription levels drop off from 12 orbits/day to ~9 orbits/day in mid-July 2022 to save room for:
  - Unschedulables/not ready visits
  - ~100 orbits of not-yet-submitted ULLYSES programs
  - Usual number of ToOs, Director's Discretionary programs, HOPRs, etc.
- If under-subscription still exists in the early summer, programs will be moved up from end of cycle as needed
  - Gives adequate time for Contact Scientist reviews

LRP: Highlights – Exoplanet Programs

Cycle 25-27

- 4 programs (55 orbits) remain
- Highlights:
  - Collecting the Puzzle Pieces: Completing HST's UV+NIR Survey of the TRAPPIST-1 System ahead of JWST (**deWit , Cycle 25, 114-orbits)**
  - Seeing in 3D: Unlocking the dynamical properties of a canonical exoplanet (**Mikal-Evans, Cycle 27, 60 orbits**), with a 29-orbit string and 9-orbit string remaining

Cycle 28

- 20 programs, 279 orbits awarded
- 8 programs, 90 orbits left

Cycle 29

- 21 programs; 403 orbits allocated
- 13 programs/179 orbits contain period/phase constraints, limiting scheduling opportunities
  - 32 orbits have executed to date.
- **Highlights:**
  - Essential Ultraviolet Stellar Characterization for Cycle 1 JWST Transiting Planet Targets (**Youngblood, 110 orbits)**
  - Cloudy mornings and clear afternoons: mapping atmospheric dynamics at the limbs of an exceptional hot Saturn (**Rustamkulov, 23 orbits**)
  - A comparative study of atmospheric escape in the brightest system of super-earths straddling the evaporation valley (**Ehrenreich, 35 orbits**)

LRP: Highlights – Solar System Programs

Cycle 28:

- 2 orbits of moving targets currently in the operational plan

Cycle 29:

- 12 programs, 216 orbits allocated at cycle start
- 10 programs, 171 orbits currently remaining in the plan

- **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, 18 orbits**)
  - Characterization and Temporal Evolution of the Ejecta Created by the DART Impact on Dimorphos (**Li, 19 orbits**)
  - Characterization and Temporal Evolution of the Ejecta Created Are the surfaces of the large moons of Uranus modified by charged particle bombardment? (**Cartwright, 16 orbits**)

Other programs of note

- **Two large M31 programs:**
  - Mapping Andromeda's Inner Circumgalactic Medium **(Lehner, 137 orbits).**
    - 37 executed, 100 left
  - The Panchromatic Hubble Andromeda Southern Treasury (PHAST) **(Williams, 195 orbits)**
    - 72 executed, 123 left
- **Reverberation program:**
  - Shedding light on light echoes: mapping the accretion disk and 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. But as STIS MAMAs, they can only schedule in SAA-free times
  - Might execute in November/December 2022
- **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 December 2022.

ULLYSES

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

- **Cycle 28** programs mostly done
- **Cycle 29** – not all have been submitted; numbers are as of 5/6/22

Program(s)	alloc	progs	Exec/sched by 5/15/22	Planned before 10/1/22	Planned after 10/1/22	comment
C27 Dwarf Galaxy	6	1	4	2	0	complete
C27 LMC	75	8	68	3	0	complete
C27 SMC	69	6	69	0	0	complete
C28 Galactic low-mass stars	106	7	105	0	0	complete
C28 LMC	61	6	53	8	0	
C28 SMC	100	6	87	2	0	11 not in LRP
C28 T-Tauri	107	7	107	0	0	complete
C28 NGC 3109	9	1	9	0	0	complete
C29 LMC	99	16	3	26	0	70 not in LRP
C29 SMC	41	8	0	21	0	20 not in LRP
C29 T-Tauri	274	18	158	114	0	2 not in LRP
C29 Sextans A	20	1	0	20	0	

Large/Treasury programs

Remaining Cycle 25-28 Large Programs

C25-28 Program	alloc	Exec/sched by 5/15/22	Planned before 10/1/22	Planned after 10/1/22	comment
deWit	114	109	4	0	Exoplanet; 1 not planned
Kelly (c27-c28)	192	144	0	32	16 orbit sets; 16 not in LRP
Jones	110	86	22	0	2 not in plan
Momcheva	259	216	29	0	3D-DASH; 14 not in plan
Sabbi	84	67	9	7	GULP; 1 not in plan

Large/Treasury programs

Cycle 29 Large Programs

C29 Program	alloc	Exec/sched by 5/15/22	Planned before 10/1/22	Planned after 10/1/22	comment
Pala	118	19	11	26	22 orbits of ToO; 62 not in LRP
Levan	22	0	0	0	ToO; 22 not in LRP
Youngblood	110	28	65	15	Exoplanets; 2 not in LRP
Trilling	99	0	0	99	TNOs; JWST-coord
Lehner	137	35	100	0	M31; 2 not in LRP
Williams	195	72	78	45	M31-PHAST

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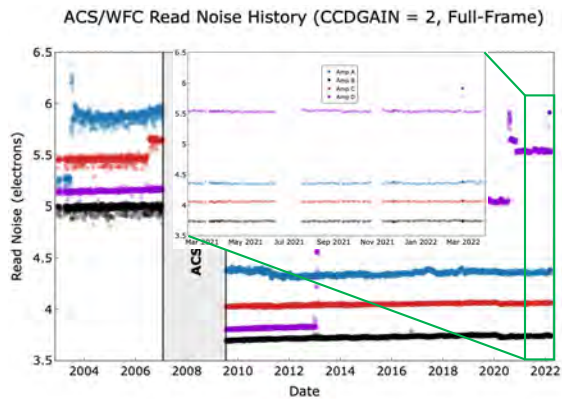
ACS Update

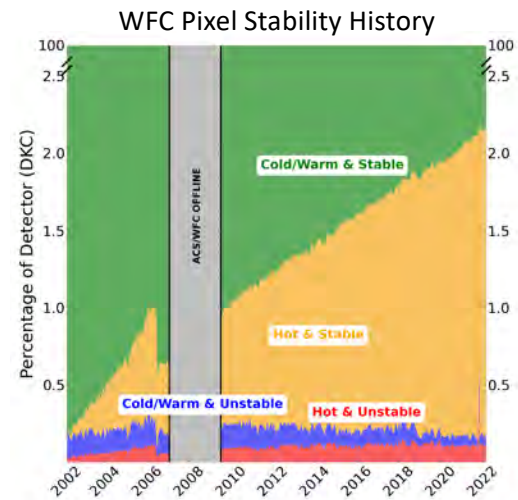
Norman Grogin, Roberto Avila, and ACS Team

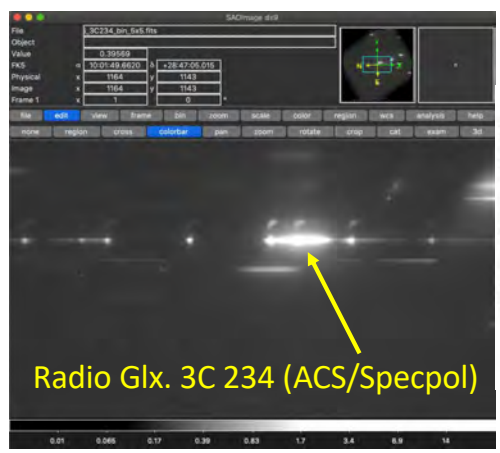
ACS Developments since the October STUC Meeting

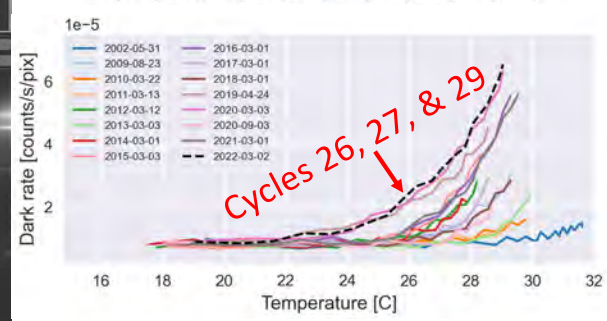
✓ ACS continues to operate nominally. *(Celebrated 20 yrs service in March)*

- Continued stable WFC readnoise since Jul 2020 AmpD glitch (*upper left*); slow trending of WFC dark current & CTE
- WFC pixel stability monitoring (*upper right*) shows steady 99.8% usability
- CAL observations to commission new spectropolarimetry mode (*lower left*)
- Early onset of elevated SBC dark current has returned (*lower right*); schedulers will avoid back-to-back SBC orbits









SBC Dark Current vs. Operating Temperature

ACS Highlights of Recent & Ongoing Work

- Assessment of sky backgrounds in ACS/WFC broadband filters for the ACS ETC
  - ACS/WFC history provides many tens of thousands of sky-background estimates
  - Derived sky-background rates include careful statistical pruning of crowded and/or nebular fields
  - Distribution functions of WFC sky background compared against ETC estimates
  - For the redder WFC broadband filters, *the measured sky background rates increasingly fall below the ETC predictions*, especially severely in the case of F850LP (similarly for WFC3/UVIS)
  - ACS team working with ETC developers to improve sky-background estimates for GOs

- Commissioning nearly complete for new ACS observing mode: WFC spectropolarimetry
  - Crossing the WFC grism filter (G800L) with the polarizer filters (POL0V; POL60V; POL120V)
  - New ACS CAL observations of radio galaxy 3C 234 obtained at multiple position-angles
  - Wavelength calibration excellent; flux calibration shows polarizer efficiency fall-off beyond 0.8μm
  - Goal is to advertise Optical/NIR (0.55-0.85μm) grism spectropolarimetry capability in C31 CfP

New ACS Documentation since the Oct'21 STUC Meeting

- ISR ACS 2021-02 : "Long-term Monitoring of the ACS Tungsten Lamp Brightness" (Cohen & Grogin)
- ISR ACS 2022-01 : "Revisiting ACS/WFC Sky Backgrounds" (Anand et al.)
- ISR ACS 2022-02 : "Fading Hot Pixels in ACS/WFC" (Ryon et al., in prep.)
- ISR ACS 2022-03 : "One-Pass HST Photometry with `hst1pass`" (Anderson et al., in prep.)
- TIR ACS 2022-01 : "Python Build of the IDC Table Generator for ACS/WFC" (Hoffmann et al.)
- ACS Instrument & Data Handbooks for Cycle 30 [both available in HDox format]
- "Advice for Planning ACS Observations – HST Cycle 30" (Lucas et al., in prep.)

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COS Update

Marc Rafelski, Bethan James, and COS team

COS General Updates

- COS is Operating Nominally
  - Time Dependent Sensitivity trends constant; approaching 5% flux calibration spec, update planned this year
  - FUV and NUV dark rate increased by ~10%
  - LP4 FUVB high voltage (HV) will be increased to 175 in the next months (highest approved HV)
- New reference files:
  - Update to FUV FLUXTAB (new CALSPEC models and Vega zeropoint)
  - Update to SPOTTAB to mask transient hotspot in background region of LP4
- Documentation since September 2021: 5 STANS, 5 ISRs, and COS IHB v14
  - IHB: Updates on LP6, choosing G160M lifetime position, and split-wavecals information

Authors	Title	Number
W. Fischer et al.	Cycle 27 COS NUV Spectroscopic Sensitivity Monitor	ISR 2021-09
W. Fischer et al.	Cycle 27 COS FUV Wavelength Scale Monitor	ISR 2021-10
W. Fischer et al.	Cycle 27 COS NUV Wavelength Scale Monitor	ISR 2021-11
C. Johnson et al.	COS FUV Detector Gain Maps Obtained at the Start of LP5 Operations	ISR 2021-12
D. Dashtamirova et al.	Cycle 27 COS FUV Dark Monitor Summary	ISR 2022-01

Reminder: The COS2030 Plan

- Now operating multiple lifetime positions at the same time: LP2, LP3, LP4, & LP5
- LP6 Operations begin with Cycle 30 for G160M exposures

	Grating/Cenwave Lifetime Position					
Date	**Blue Modes**	**G130M-1222**	**G130M-1291 + 1300s**	**G160M-short**	**G160M-long**	**G140L**
In the past	2	4	4	4	4	4
Oct. 2021	2	4	4→5	4	4	4→3
Oct. 2022	2	4	5	4	4→6	3
Late 2024	2	4	5	4	6	3→2
Late 2025	2→?	4	5	4	6	2
Late 2026	?	4	5	4	6	2→?
Late 2028	?	4→6	5	4→6	6	?
Mid-2030	?	6→?	5→?	6→?	6→?	?

LP6 (G160M) timeline with start Cycle 30 October 2022

	LP6 Activity	Programs	Status
Enabling Phase	FSW & commanding	N/A	FSW patched, FSW update in summer
	SIAF	N/A	Complete
	TRANS	N/A	Available restricted, update summer
	APT	N/A	Available restricted, update summer
	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	V1 in hand, V2&V3 data in summer, V4: data taken at start of Cycle 30
Calibration Phase	Profiles and Traces	16906	Observations finish May 14, 2022
	Sensitivities and Flat Fields	16906	Observations finish May 14, 2022
	Spatial Resolution	16906	Observations finish May 14, 2022
	Spectral Resolution	16907	Data in hand
	Dispersion Solutions	16908, 16907, 16909	Data in hand
	Lamp Templates	16909	Data in hand
	Gain Maps	16910	Take data start of Cycle 30
	Code V model LSFs and PSFs	N/A	In progress
	Bad Pixel Table	16829, 16472	In progress

Future Work FY22

- Calibrate LP6
- Update time dependent sensitivity (new slope and/or break point)
- Start work on HV sensitivity correction in pipeline
- Geometric and walk correction effort is now ramping up, large effort in FY23
- Cycle 30 calibration programs and contact scientist support
- Additional python notebook tutorials (co-addition of spectra, exception report)
- Begin Hubble Spectroscopic Legacy Archive (HSLA) revamp including COS & STIS
- Develop, upgrade, & document additional monitors (e.g., new hot spot monitor)
- Support Pandeia ETC development

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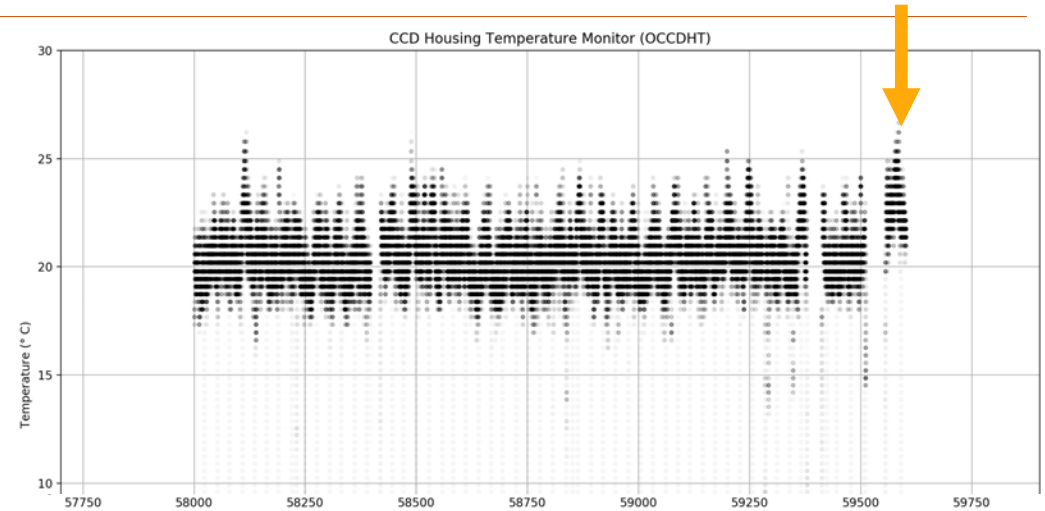
STIS Update

Joleen Carlberg, Tala Monroe, and STIS Team

STIS Status

General Status

- STIS Operating nominally, though at slightly elevated temperature
  - → Slightly higher than nominal dark rate in CCD
  - → Marginal degradation in CCD dark correction

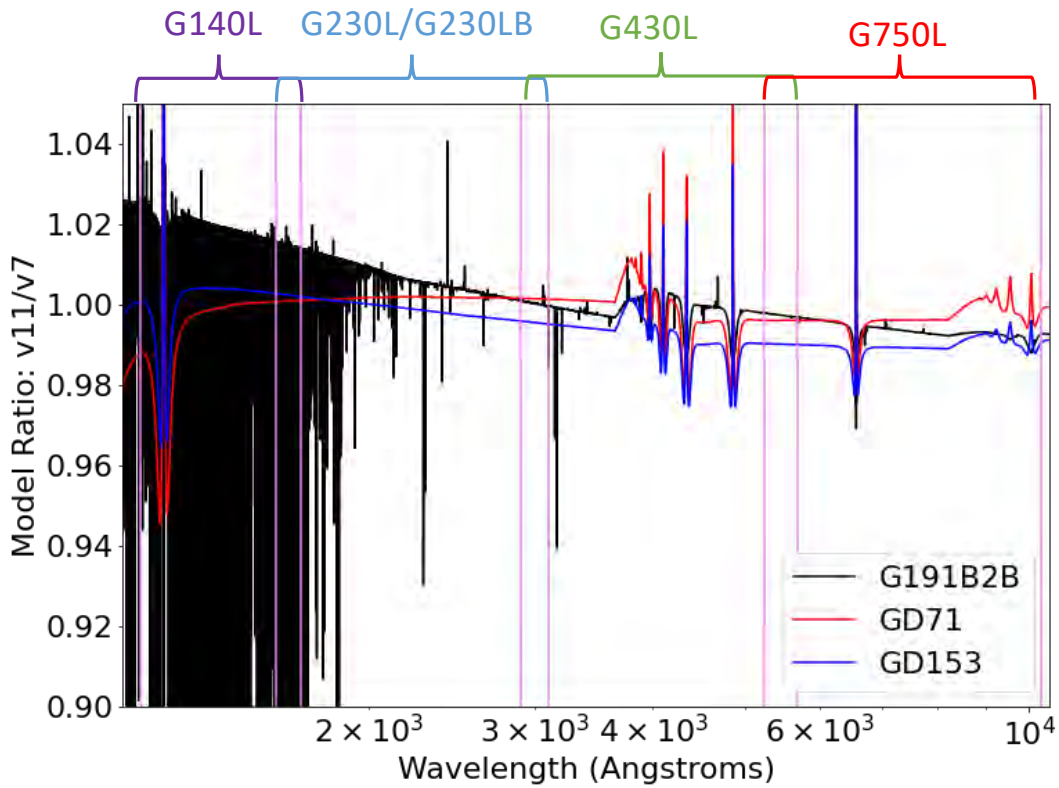


Documentation

- 2 ISRs published; 1 under review will be published soon
  - ISR 2022-01: **Long-Term Rotational Evolution of the STIS CCD Flatfields** (K. Ward-Duong et al.)
  - ISR 2022-02: **STIS CCD & MAMA Full Field Sensitivity & Its Time Dependence** (L. Prichard)
  - ISR 2022-03 (under review): **Comparison of STIS CCD CTI Photometric Calibrations** (L. Prichard)
- 2 STANs published (March, April 2022)
- IHB Updates for Cycle 30

Flux Recalibration – 1st Delivery April 2022

- On-going work to bring sensitivity of all STIS modes onto the CALSPEC v11 standard
- Modes updated in 1st Delivery
  - **FUV**: G140L, E140M
  - **NUV**: G230L
  - **CCD**: G230LB, G430L
  - All above modes have a single cenwave
- 10 modes planned for 2nd Delivery
  - **FUV**: G140M/1222
  - **NUV**: G230M/1933, E230M/1978, 2707, & 2415
  - **CCD**: G750L, G430M/3936 & 4194, G750M/7283 & 8561



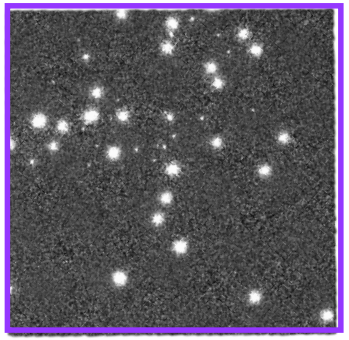
HST Primary standard star model changes between current pipeline calibration (v7) and new (v11)

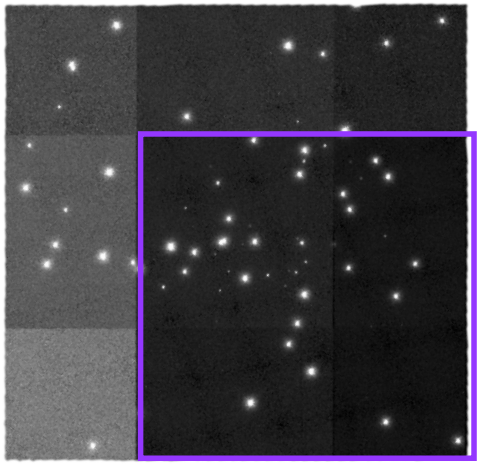
Project status: https://www.stsci.edu/hst/instrumentation/stis/flux-recalibration

New Jupyter Notebook Repository

- STIS has a new GitHub Repository for Jupyter notebooks, with 2 notebooks:
  - Previously released Coronagraphy Visualization notebook moved over
  - A new Jupyter notebook tutorial demonstrates how to use DrizzlePac with STIS data, including
    - CTI correction
    - image alignment
    - drizzling
- A STIS intern will be joining this spring (@50% time for a year) to further populate notebooks
- Repository Link: https://github.com/spacetelescope/STIS-Notebooks

Drizzled CCD images from sensitivity monitoring field





On-Going/Future Work

A deeper look at CCD Anneals

- A new technical team member is working on updating the CCD Anneal Monitor
- An exploratory project tested unsupervised machine learning algorithms to classify CCD pixel behavior during a single anneal → future work will span multiple anneals

Additional Future Work:

- Work recalibration imaging modes will begin later this year
- Plans for a stand-alone tool to inter-combine STIS echelle data

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WFC3 Update

Sylvia Baggett, Annalisa Calamida, and WFC3 Team

WFC3 Highlights

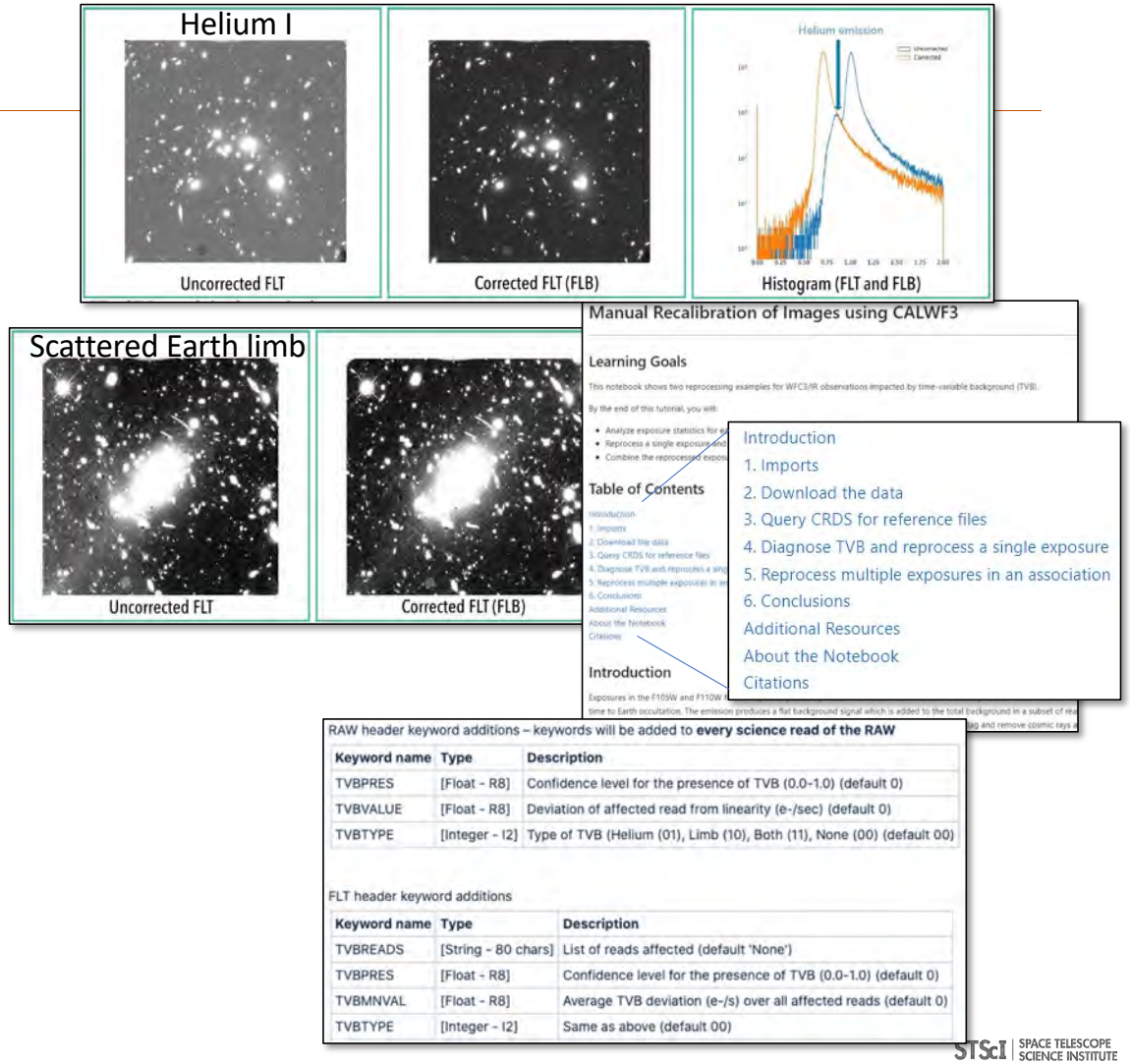
WFC3 operating nominally

- About 309,000 WFC3 images in MAST archive
- Post-Nov 2021 safing recovery data normal

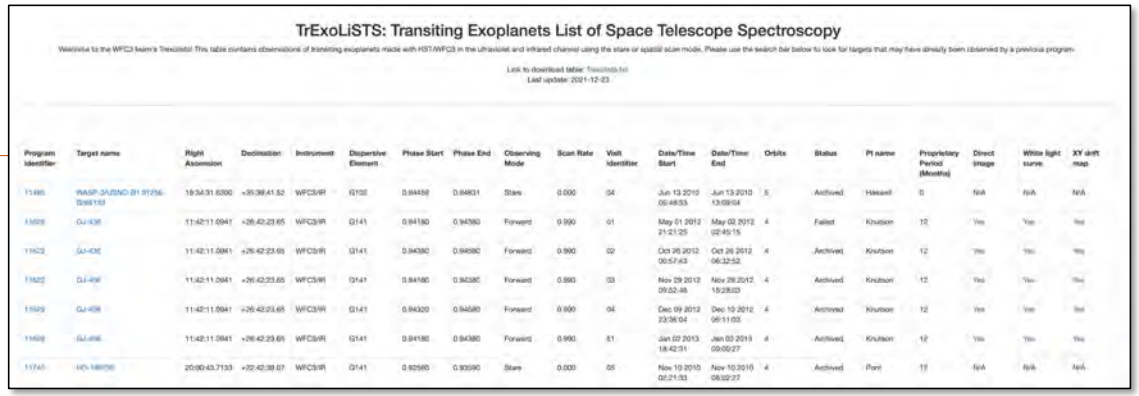
WFC3 Quicklook system improved

Addressing IR time-variable background in calwf3

- ID presence of time-variable background
  - HeI or scattered Earth limb light
- Encode results in image header keywords to alert observers
- Procedures/notebooks to correct affected data
  - ISR 2014-13, ISR 2016-16, DHB, Software Library
- Next: calwf3 automatic correction



WFC3 Highlights



TrExoLiSTS: Transiting Exoplanets List of Space Telescope Spectroscopy

Welcome to the WFC3 team's TrexoLists! This table contains observations of transiting exoplanets made with HST/WFC3 in the ultraviolet and infrared channel using the stare or spatial scan mode. Please use the search bar below to look for targets that may have already been observed by a previous program.

Link to download table: Trexolists.txt
Last update: 2021-12-23

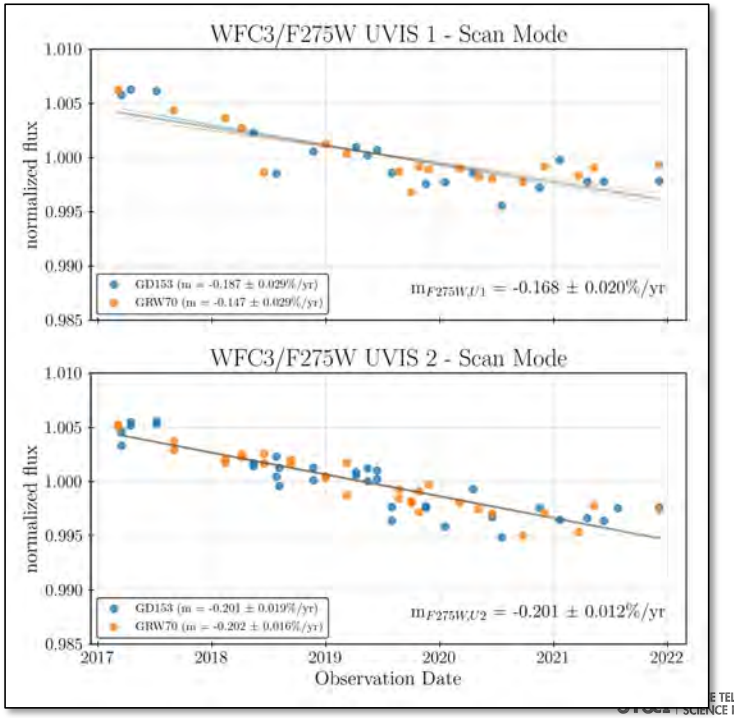
Program identifier	Target name	Right Ascension	Declination	Instrument	Dispersive Element	Phase Start	Phase End	Observing Mode	Scan Rate	Visit identifier	Date/Time Start	Date/Time End	Orbits	Status	PI name	Proprietary Period (Months)	Direct image	White light curve	XY drift map
11485	WASP-34/BND-B1 31256-[illegible]	18:34:31.6300	+35:38:41.52	WFC3/IR	G102	0.94458	0.94831	Stare	0.000	04	Jun 13 2010 05:48:53	Jun 13 2010 13:09:04	5	Archived	Hasswell	0	N/A	N/A	N/A
13828	GJ-436	11:42:11.0941	+26:42:23.65	WFC3/IR	G141	0.94180	0.94380	Forward	0.990	01	May 01 2012 21:21:25	May 02 2012 02:45:15	4	Failed	Knutson	12	Yes	Yes	Yes
13823	GJ-436	11:42:11.0941	+26:42:23.65	WFC3/IR	G141	0.94380	0.94580	Forward	0.990	02	Oct 26 2012 00:57:43	Oct 26 2012 06:32:52	4	Archived	Knutson	12	Yes	Yes	Yes
13822	GJ-436	11:42:11.0941	+26:42:23.65	WFC3/IR	G141	0.94180	0.94380	Forward	0.990	03	Nov 29 2012 09:52:46	Nov 29 2012 15:28:03	4	Archived	Knutson	12	Yes	Yes	Yes
13829	GJ-436	11:42:11.0941	+26:42:23.65	WFC3/IR	G141	0.94320	0.94580	Forward	0.990	04	Dec 09 2012 23:36:04	Dec 10 2012 06:11:03	4	Archived	Knutson	12	Yes	Yes	Yes
13829	GJ-436	11:42:11.0941	+26:42:23.65	WFC3/IR	G141	0.94180	0.94380	Forward	0.990	51	Jan 02 2013 18:42:51	Jan 03 2013 00:00:27	4	Archived	Knutson	12	Yes	Yes	Yes
11741	HD-189733	20:00:43.7133	+22:42:39.07	WFC3/IR	G141	0.92580	0.93590	Stare	0.000	05	Nov 10 2010 05:21:33	Nov 10 2010 08:32:27	4	Archived	Pont	11	N/A	N/A	N/A

Updated TrExoLiSTS

- Landing page for planning observations
- Includes staring and scanning mode data
- Each target connects to exoMAST entry, WFC3 direct Image, white light curve, XY drift map

UVIS scanned standard star data (ISR in prep)

- 5 wide near-UV filters + F606W, F814W
- Scans 2-3x precision over staring mode
- Trend: 0.1-0.2%/yr decline
- Hints of decline slowing, more data will tell



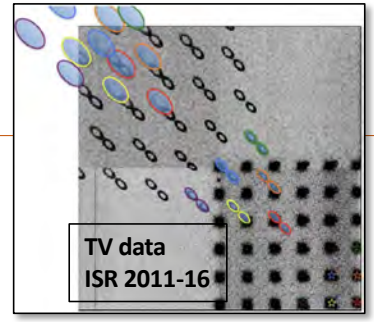
UVIS encircled energy (ISR 2022-02)

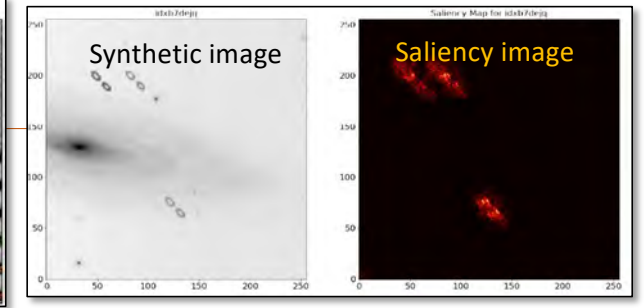
- Five filters added (F336W, F200LP, F350LP, F775W, and F850LP)
  - plus incorporated time-dependent sensitivity
- Improved values for 2 chips: agree to ~0.1%
- UV EE now in better agreement with Hartig 2009 solution

WFC3 Highlights

Application of machine learning to UVIS ghosts (ISR 2022-03)

- Exploratory analysis for anomaly detection
- Five different models: 54-83% accuracy
- Significant work remains
- Includes software repository of ML models + tutorials





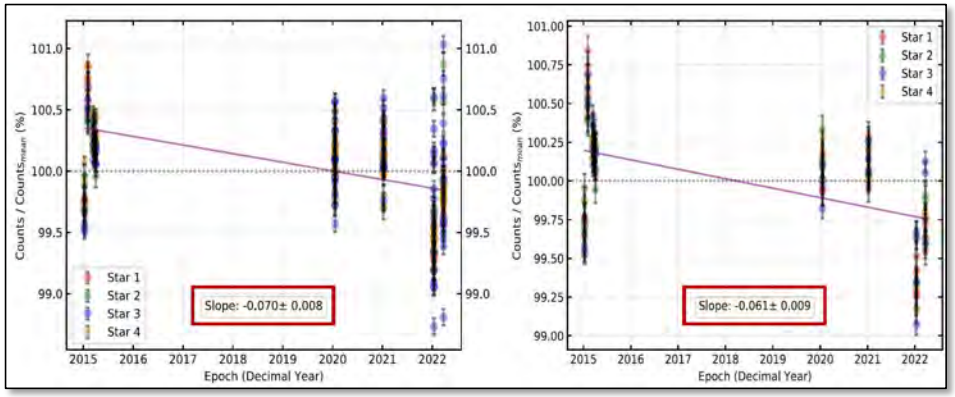
Model	Number of trainable parameters	Training time	TN	FP	FN	TP	Test Accuracy
Synthetic	4.2M	1.5H	0.98	0.02	0.01	0.99	54%
A	2.1M	1.5H	0.93	0.07	0.13	0.87	83%
B	1.07M	1H	0.99	0.01	0.12	0.88	78%
C	160K, 130K(for transfer)	1H, 15m	0.94	0.06	0.25	0.75	79%
D	2.12M, 2.10M(for transfer)	1H, 15m	0.65	0.35	0.09	0.91	62%

WFC3/IR spatial scan data

- High-precision measurements of M35 open cluster
- Through 2021: -0.02 %/year +/- 0.008 (ISR 2021-05)
- New data from 2022: F140W shows ~ -0.07%/yr

  Consistent with G141 grism flux trend

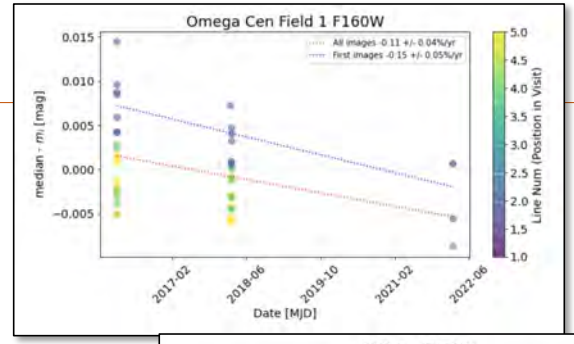
  (-0.06%/yr +/- 0.01, Bohlin)

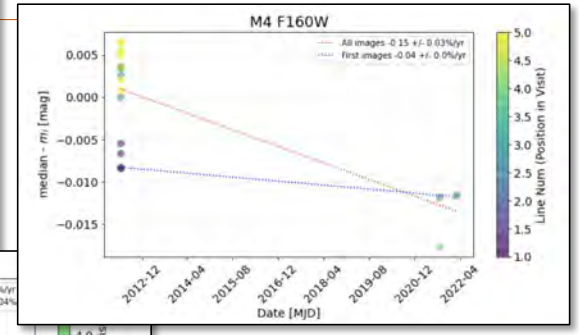


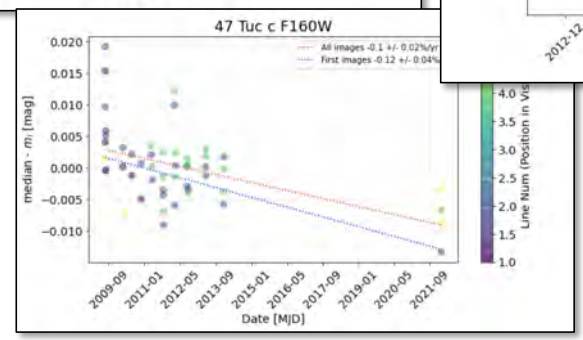
WFC3 Highlights

IR sensitivity

- Staring mode for external clusters
  - F110W, F160W
  - Aperture photometry: -0.1 to -0.2 %/yr
- Grism integrated fluxes through 2021
  - All: -0.136, -0.066 %/yr +/- 0.01 for G102, G141
  - FOV center only: -0.12, -0.06 %/yr +/- 0.01
- Astrometry data – best time coverage
  - Crowded field (Omega Cen core)
  - ePSF analysis: -0.23 %/yr +/- 0.03 (ISR 2020-05)

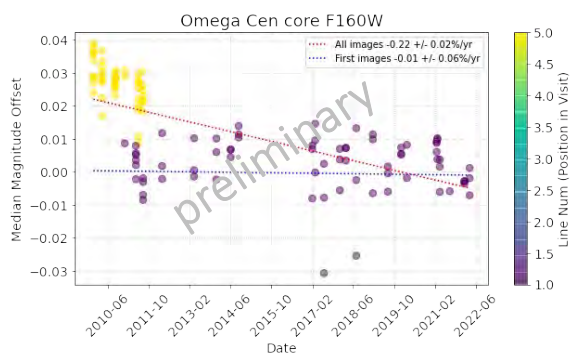






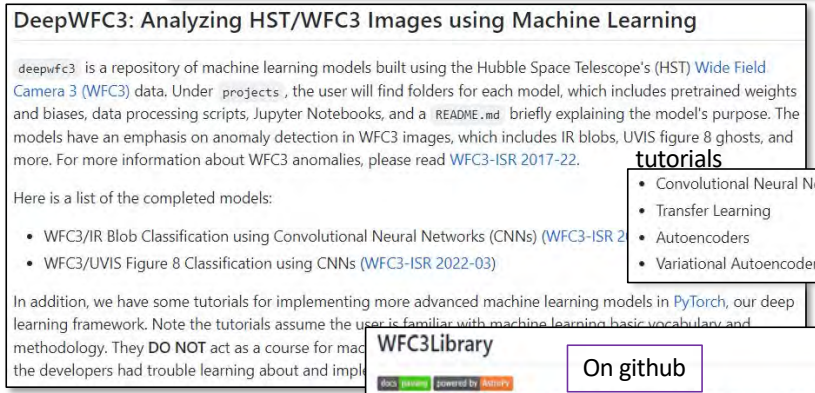
Filter	Target	Time range	Epochs	Slope, % (all images)	Slope, % (first images only)
F110W	M4	2012-2022	3	-0.20 +/- 0.02	-0.15 +/- 0.01
F110W	Omega Cen	2016-2022	3	-0.17 +/- 0.05	-0.13 +/- 0.04
F160W	M4	2012-2022	2	-0.15 +/- 0.03	-0.04 +/- 0.03
F160W	Omega Cen	2016-2022	3	-0.11 +/- 0.04	-0.15 +/- 0.05
F160W	47 Tuc	2009-2022	>10	-0.10 +/- 0.02	-0.12 +/- 0.04

Persistence effects?
Without previous IR:
-0.01%/yr +/- 0.06



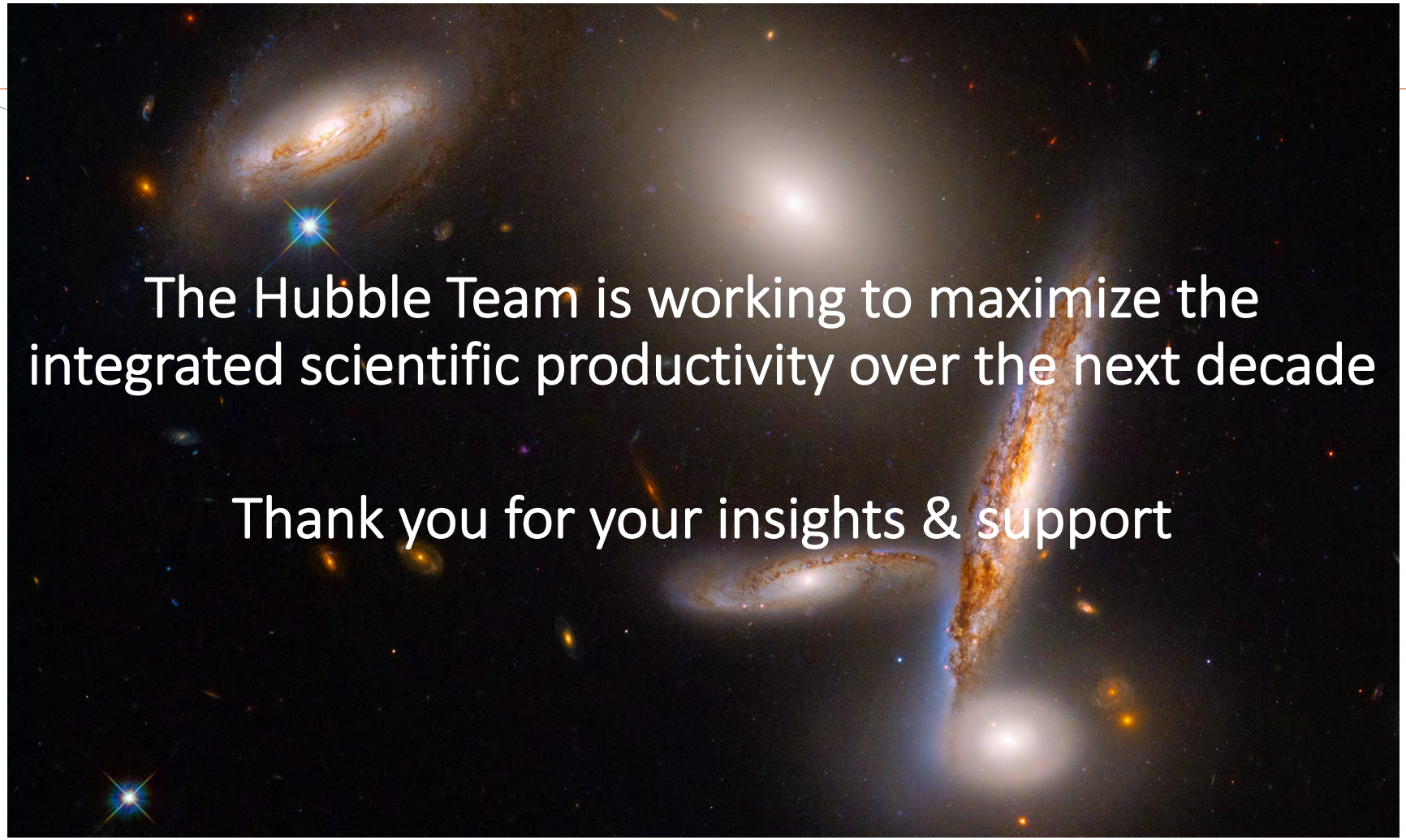
User support/documentation

- Instrument Handbook (Jan 2022)
- STAN (Jan 2022; next one: June 2022)
- 2021 ADASS meeting: virtual talk on WFC3 IR Blob Classification
- Software
  - Additions to Jupyter notebooks
  - New repository for machine learning tests (DeepWFC3)
- Instrument Science Reports
  - 2022-03 UVIS Figure-8 Ghost Classification using CNNs (Dauphin et al.)
  - 2022-02 UVIS Encircled Energy (Medina et al.)
  - 2022-01 Cold and Unstable Pixels in WFC3/IR (Khandrika)
  - 2021-16 UVIS Deuterium Lamp and Filter Performance 2009-2021 (Kuhn et al.)
- Submitted to AJ : Photometric Calibration of the WFC3 Detectors (Calamida et al.)
- Imminent
  - Jupyter notebook to assist observers who receive an Exception Report
  - ISR 2022-0? Monitoring UVIS Photometric Sensitivity with Spatial Scans



tutorials

- Convolutional Neural Network
- Transfer Learning
- Autoencoders
- Variational Autoencoders


The Hubble Team is working to maximize the integrated scientific productivity over the next decade
Thank you for your insights & support