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SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

HST Mission Office Report

Tom Brown

STUC – 27 Apr 2021



Hubble Operations Proceeding Normally

Science operations continue to work well in remote posture

- Recent string of challenges met by diligence of GSFC & STScI staff
 - Hardware Sunpoint Safemode (March 7)
 - Due to hybrid mode flight software bug
 - Aperture door failed to close on primary path (March 7)
 - Now configured for redundant path
 - Wide Field Camera 3 suspend (March 11)
 - Slightly lower voltage due to cold state after observatory safing
 - Possible conjunction event (March 15)
 - Ultimately required no action beyond monitoring
 - Space Telescope Imaging Spectrograph suspend (March 18)
 - Low-probability timing conflict between shutter and delayed acquisition
- HST contract extension for July 2021 – June 2026
 - Proposal submitted in January, negotiations expected in May
- HST Senior Review efforts expected to begin this summer



Hubble 31st Anniversary Image
AG Carinae



Archive efforts underway

- Hubble Advanced Products
 - Single-visit mosaics went into operations December 2020
 - Multi-visit mosaics expected later in 2021
 - Allows eventual retirement of Hubble Legacy Archive system for coadded images
 - Better automation and more frequent releases
- Hubble in the Cloud reprocessing
 - Using Amazon Web Services for pipeline reprocessing of Hubble data
 - Reduces reprocessing time from weeks to days
 - Users still retrieve data via MAST as before
 - Expected to go operational in May
 - Next steps will migrate Hubble Advanced Products to cloud processing
- New archive interface planned for release this summer
 - See presentation by Scott Fleming
- ULLYSES Data Release 2 - March 17
 - See presentation by Julia Roman-Duval
- Exploring High Level Science Product pages for gap programs
 - Gap programs approximately 40% done – may revisit in upcoming STUC meeting



Hubble 31st Anniversary Image
AG Carinae

The background of the slide is a deep space image featuring a dense field of stars and a prominent nebula with blue and purple hues. A thin orange horizontal line is positioned below the title text.

Long Range Plan Status

Prepared by Dave Adler



Long range plan status

Cycle 28 execution rate consistent with previous cycles

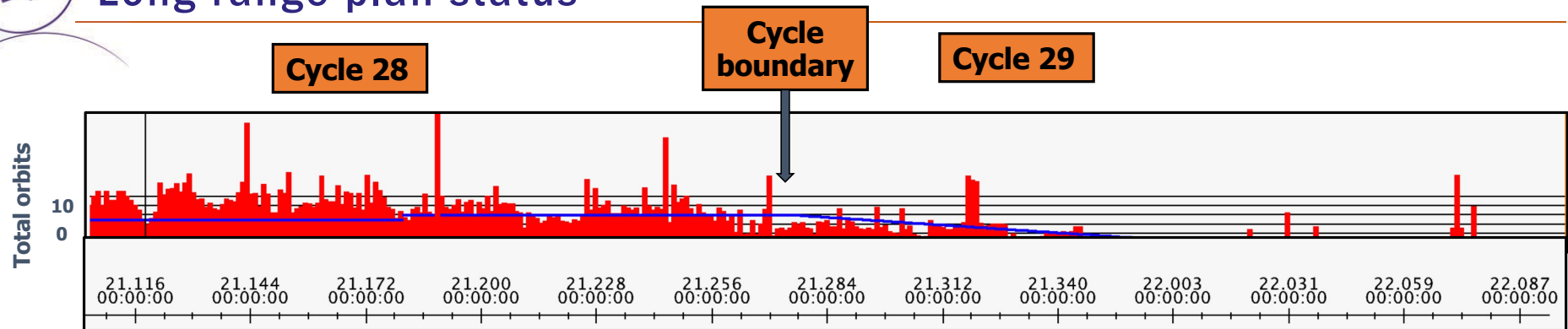
- Averaging 84.6 orbits scheduled per week through first 30 weeks
- Current acquisition failure rate near 5%
- Cycle 17-25: 84 orbits/week scheduled
- Cycle 26: 80 orbits/week (85 orbits/week without 3-week hiatus due to Gyro 2 failure)
- Cycle 27: 85 orbits/week scheduled

Previous Cycle Completeness

- Cycle 25 (22 orbits)
 - 12 orbits from TRAPPIST program 15304 (de Wit)
 - 10 orbits of ToO followups from SUSHI program 15363 (Suzuki)
- Cycle 26 (47 orbits)
 - 40 from astrometry program 15491 (Bedin)
- Cycle 27 (225 orbits through spring 2022)
 - 97 orbits in 4 to 5-orbit visits that cannot schedule due to SAA impacts and pushed later



Long range plan status



- **Scheduling challenges**

- **19 occurrences of long blocks with 10 – 31 consecutive orbits on a single target**
 - Usually (but not always) exoplanets
 - Requires coordination with other science programs that have timing links
- **Moving targets**
 - No longer limited to 2 consecutive orbits if visibility shortened by 6 minutes to allow gyro bias update
 - Phase II instructions updated for Cycle 29
 - Planning & scheduling team spreads out moving target scheduling to the extent possible
 - Reduces stress on Flight Operations Team



Long range plan status

Exoplanet Programs

- For exoplanets with tight period/phase constraints, planning windows outside the definitive ephemeris (10 weeks) are not reliable

Cycle 25

- 1 program out of 12 still active
 - **15304 de Wit** (Cycle 25 Large)
 - 102 of 114 orbits complete. 3 visits (12 orbits) planned summer 2021

Cycle 27

- 11 programs; 240 orbits allocated, 168 completed, 72 remain

Cycle 28

- 19 programs; 262 orbits allocated, 86 completed, 176 remain



Long range plan status

Solar System Programs

- 79 moving target orbits remaining to execute in the Cycle 28 plan

Highlights

- **OPAL: Outer Planet Atmospheres Legacy (Simon)**
 - **Cycles 22-24:** 29 total orbits per cycle on Jupiter, Uranus, & Neptune
 - **Cycle 25-27:** 41 total orbits per cycle, adding Saturn after Cassini mission ended
 - **Cycle 28**
 - **Uranus:** October 2020
 - **Jupiter & Saturn:** planned in July 2021
 - **Neptune:** planned in August 2021
- **New Horizons: Potential KBO targets (Porter)**
 - 58 orbits allocated; 18 done, 40 not yet submitted, but anticipated May 2021 and beyond



Long range plan status

Other programs of note

- **Individual Stars as probes of Dark Matter (Kelly)**
 - 96 orbits in each of Cycles 27 and 28
 - Six sets of 16 consecutive orbits each cycle
 - Precise timing required to get all visits scheduled around SAA efficiently
 - Cycle 27 - 80 done, 16 remain
 - Cycle 28 - 16 done, 80 remain
- **Reverberation in AGNs (Peterson)**
 - 198 total orbits
 - Most sequenced to go every other day for a year
 - Each visit has a small tolerance (+/- 12 hours) to allow scheduling around other programs
 - 83 orbits done, 115 remain
- **3D-DASH: WFC3/IR Survey of COSMOS (Momcheva)**
 - 259 total orbits total, 79 orbits done, 180 remain (spread over Cycles 28 and 29)
 - Using “drift and shift” (DASH) observing technique
 - Cannot schedule consecutively due to gyro-3 risk issues (would not get bias update if GSACQ runs long)



Long range plan status

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

- **Cycle 27** material mostly done
- **Cycle 28** material executing, with many visits planned this spring

Program(s)	alloc	progs	Exec/sched by 5/2/21	Planned before 10/1/21	Planned after 10/1/21	comment
C27 Dwarf Galaxy	6	1	4	0	2	
C27 LMC	75	8	68	0	3	4 not in plan*
C27 SMC	69	6	69	0	0	complete
C28 Galactic low-mass stars	106	7	71	24	0	11 not in plan*
C28 LMC	64	6	10	27	0	27 not in plan*
C28 SMC	100	6	0	30	0	70 not in plan*
C28 T-Tauri	106	7	23	75	0	8 not in plan*

*Phase II implementation underway



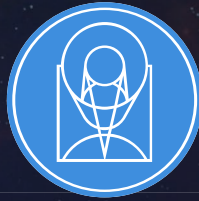
Long range plan status

Remaining Cycle 25-27 Large Programs

C25-27 Program	alloc	Exec/sched by 5/2/21	Planned before 10/1/21	Planned after 10/1/21	comment
deWit	114	101	12	0	Exoplanet; 1 not planned
Lee	122	119	0	0	3 not planned
Weiss	244	227	16	0	HOPRs; 1 not planned
Kelly	96	80	16	0	

Cycle 28 Large Programs

C28 Program	alloc	Exec/sched by 5/2/21	Planned before 10/1/21	Planned after 10/1/21	comment
Jones	110	48	60	0	2 not planned
Kelly	96	16	48	32	6 sets of 16-consecutive orbits
Momcheva	259	106	118	23	3D-DASH; 12 not planned
Peterson	198	87	76	20	Reverberation; 15 not planned
Sabbi	84	32	39	12	GULP; 1 not planned



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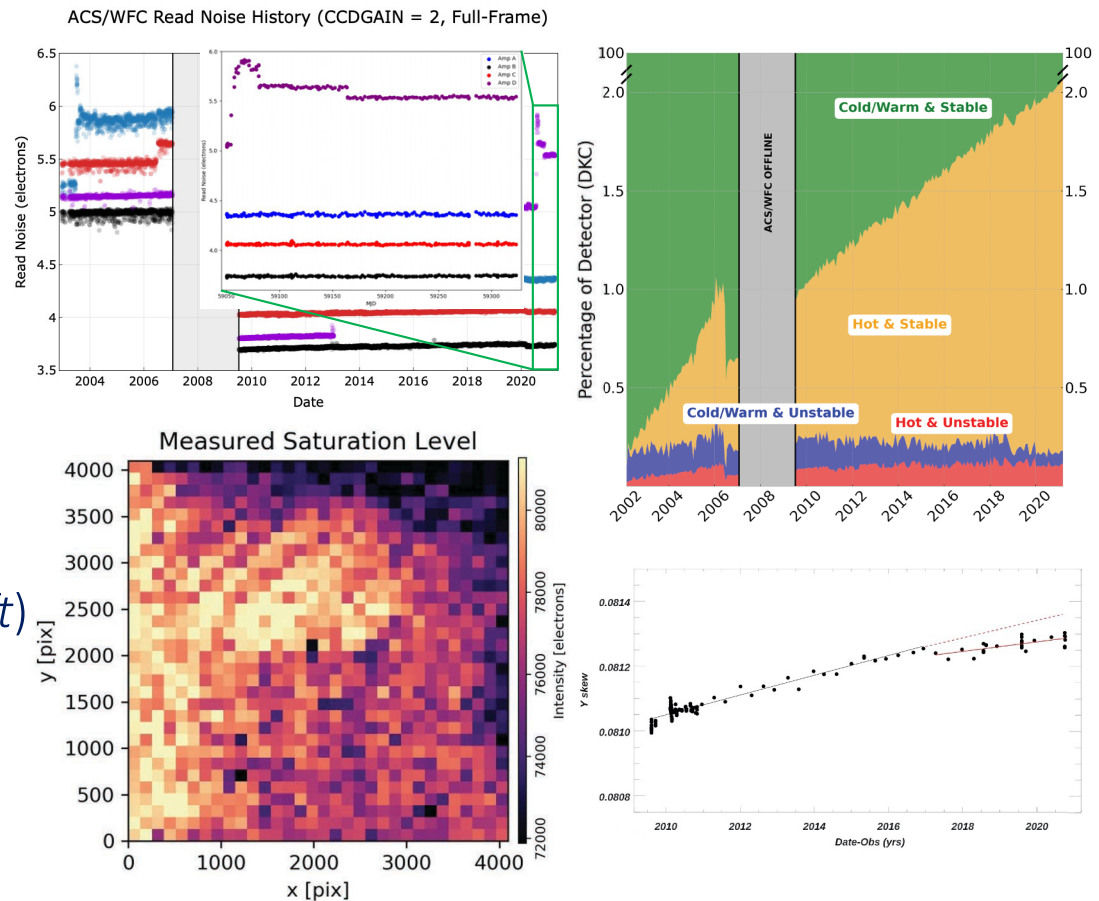
ACS Update

Norman Grogin, Roberto Avila, and ACS Team



ACS Developments since the Oct'20 STUC Meeting

- ✓ ACS continues to operate nominally.
- Continued stable WFC readnoise after Jul'20 AmpD glitch (*upper left*); slow trending of WFC dark current & CTE
- WFC pixel stability monitoring (*upper right*) shows steady 99.8% usability
- CALACS updated to DQ-flag spatially variable WFC CCD saturation (*lower left*)
- 47 Tuc astrometric reference catalog newly validated with Gaia eDR3; indications of slower trending in WFC geom. dist. since ~2017 (*lower right*)





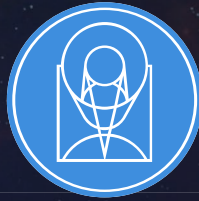
Highlights of ACS Ongoing & Planned Work

- Spatially-dependent saturation flagging in CALACS
 - ACS/WFC shows $\pm 10\%$ variation; CALACS implementation in 1Q21
 - Extension to ACS/HRC (legacy) imagery planned for 3Q21, with 4Q21 implementation
- Seeking improvements to DARKCORR in CALACS
 - Traditional 1000sec DARKs suffer from saturated hotpix; $65e^-$ FLASH possibly excessive
 - Cyc27/Cyc28 testing of superdarks using $2\times$ more, $2\times$ shorter DARKs (& $3\times$ shorter FLASH)
 - Status quo is narrowly preferred, but also a serendipitous discovery of ‘fading hot pixels’
 - Later 2021: DARKCORR update for fading hotpix; improved DARKTIME overheads estimate
- Further support for WFC polarimetric observing
 - Recent validation of pixel-based CTE correction for (filter-vignetted) WFC imaging polarimetry
 - Observations taken to commission new WFC mode: grism spectropolarimetry (6000-9500Å)



New ACS Documentation since the Oct'20 STUC Meeting

- Delivery of ACS Instrument & Data Handbooks for HST Cycle 29 (in HDox format)
- “Advice for Planning ACS Observations - HST Cycle 29” (HDox; Lucas, Hathi, & Grogin)
- ACS STAN, December 2020: Describes updates to the ACS/WFC flux calibration, geometric distortion, read noise, and detector documentation.
- ISR ACS 2020-08 : “Update of the Photometric Calibration of the ACS CCD Camera” (Bohlin, Ryon, & Anderson)
- ISR ACS 2020-09 : “Validation of New ACS/WFC Geometric Distortion Reference Files Calibrated with Gaia Data Release 2” (Hoffmann & Kozhurina-Platais)
- ISR ACS 2021-01 : “Effects of Pixel-based CTE Correction on the Accuracy of ACS/WFC Point Source Polarimetry” (Desjardins et al., in press)
- TIR ACS 2021-01 : “An Exploration of Reduced Exposure Time and Post-Flash Duration of ACS/WFC Calibration Darks” (Ryon, Grogin, & McDonald, in press)



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COS Update

Marc Rafelski, Bethan James, and COS team



COS General Updates

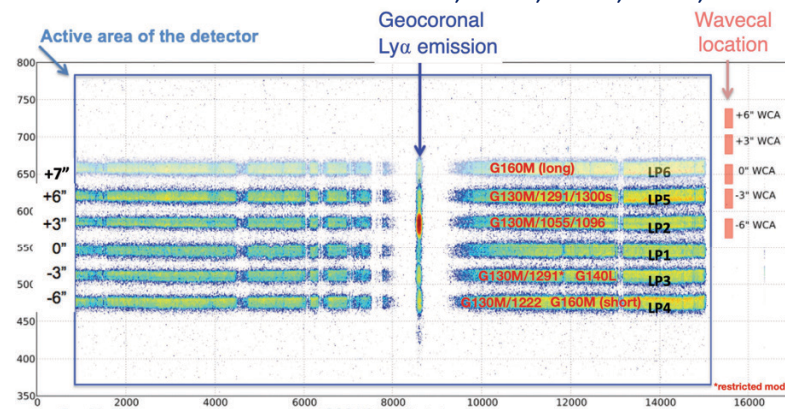
- COS is Operating Nominally
 - Time Dependent Sensitivity trends remain constant
 - Slight increase in FUV dark rate in last month, NUV dark rate remains constant
- Work continues on lifetime positions 5 & 6 (subsequent slides)
- Time-dependent sensitivity reference file updated (March 2021)
- Gain sag reference file updated (April 2021)
- Updating walk and geometric distortion corrections
- Implementing new flux calibration based upon updated CALSPEC and special C28 cal program
- New COS python notebook tutorials for June 2021 AAS
- Documentation: 2 STANS, 5 ISRs, and Cycle 29 COS IHB

Authors	Title	ISR Number
N. Kumari et al.	Wavelength Calibration of the COS/FUV Cenwaves G130M/1055 and G130M/1096	2020-09
D. Sahnou et al.	Summary of COS Cycle 24 Calibration Plan	2020-10
C. Magness et al.	The Lamp Template for the New COS/FUV Cenwave G140L/800	2021-01
R. Sankrit et al.	Cycle 27 COS/FUV Spectroscopic Sensitivity Monitor	2021-02
C. Johnson et al.	Updated Flux Error Calculations for CalCOS	2021-03



COS Lifetime Positions (LP): The road to 2030 and beyond

- LP4 has longer lifetime due to COS2025 rules, but already halfway to end of life
- LP5 has to be close to LP2 to avoid light leak, resulting in a short lifetime due to G160M
- New ideas / methods now enable us to use area above LP5; currently exploring LP6 +
 - Increased overheads due to split-wavecals that avoid light leak
- New hybrid-LP mode of operating, along with LP6, will enable COS operations to 2030
 - Move G130M 1291+1300s to LP5 and G140L to LP3 start of Cycle 29
 - Move G160M long exposures to LP6 start of Cycle 30
 - Operate multiple LP's at the same time at LP2, LP3, LP4, LP5, and LP6 simultaneously





LP5 / LP3 Update: Operations start Cycle 29

- G130M settings (1291, 1300, 1309, 1318, 1327) at LP5 using COS2025 rules
- G140L settings (800, 1105, 1280) at LP3 since mostly fall on segment A. Calibrate cenwave 800 only.
- Enabling LP5 and Calibrating LP5/LP3
- No BOA operations at LP5

		LP5/LP3 Activity	Status
Enabling Phase		Focus	Analysis complete
		Target Placement	Analysis complete
		Target ACQ Parameter (FUV spectroscopic ACQs)	V1&2: Analysis Ongoing V3&4: Take data start of Cycle 29
		TRANS/APT Parameters	Testing
		SIAF & FSW parameters	Complete
Calibration Phase		Profiles and Traces	Data in hand
		Sensitivities and Flat Fields	Data in hand
		Spatial Resolution	Data in hand
		Spectral Resolution	Data in hand
		Dispersion Solutions	Data in hand
		Lamp Templates	Data in hand
		Gain Maps	Take data start of Cycle 29
		Bad Pixel Table	Analysis Complete



LP6 Update: Operations start Cycle 30

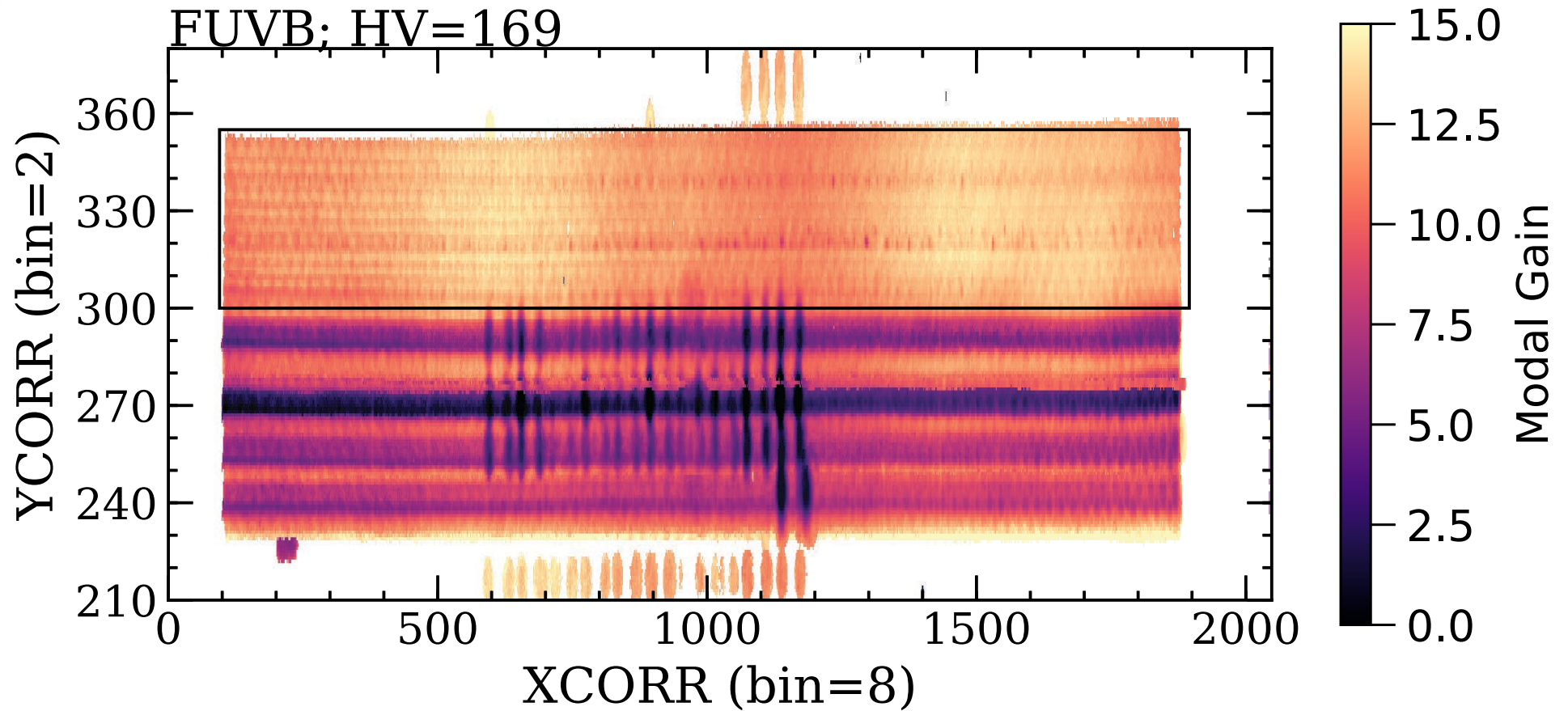
- Exploring new area of detector to determine placement of LP6
- Cycle 30: G160M (1533, 1577, 1589, 1600, 1611, 1623)
- Initially long exposures only; eventually long and short exposures in 2028
- Gain predictions suggest in ~2025: G130M (1055, 1096), ~2027: G130M (1222)
- No BOA operations, no FCA, use split-wavecal for calibration lamps

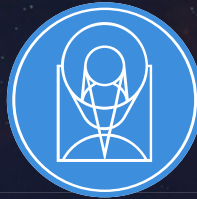
Exploratory Phase

LP6 Activity	Status
FSW, TRANS, & commanding Instructions	In progress, testing Summer 2021
APT Rules + implementation	In progress
Gain Map over new area: +6" to +14"	Complete
Aperture Placement LP6	Data in hand, In progress
Exploratory Focus Sweep (7, 9, 11")	Data in progress, analysis in progress
Exploratory Resolution Sweep (7, 9, 11")	In scheduling -> Awaiting Focus Sweep Results
WCA Placement	Complete
Split-Wavecal Rules	In progress
CalCOS Pipeline	In progress



LP6 Exploration: Gain Map, highlighting +6.2" to +14"





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STIS Update

Joleen Carlberg, Tala Monroe, and STIS Team



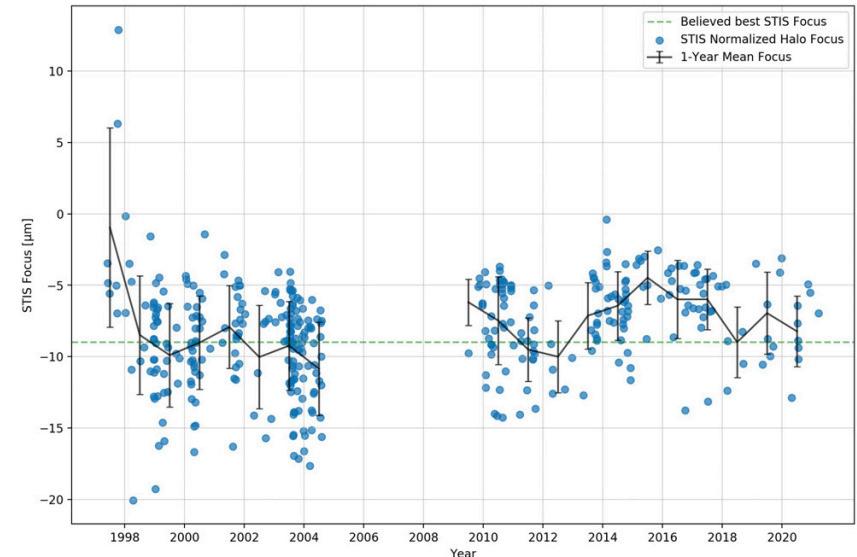
STIS Status

General

- STIS operating nominally
- Routine monitors nominal
 - **Focus (example shown)**
 - Darks (all detectors)
 - Lamp brightness
 - General CCD (bias, readnoise, spurious charge, charge transfer efficiency)

Documentation

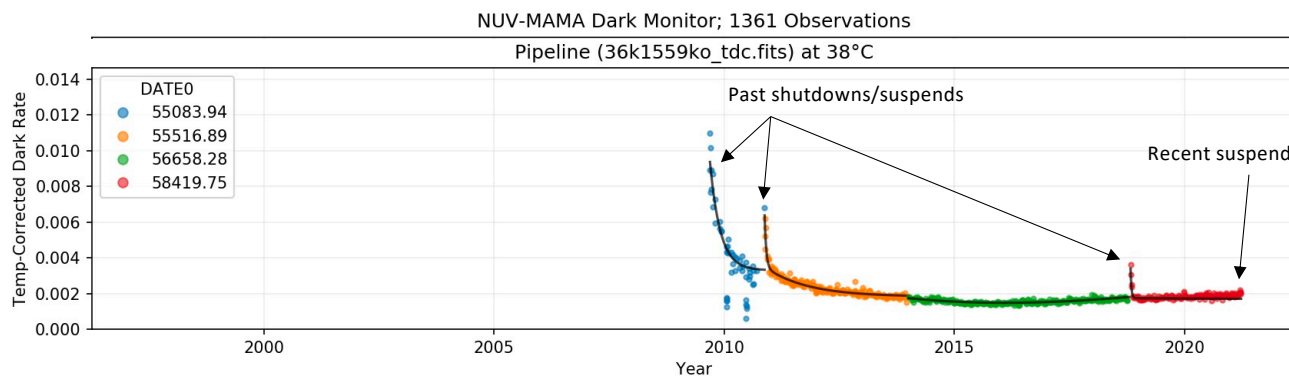
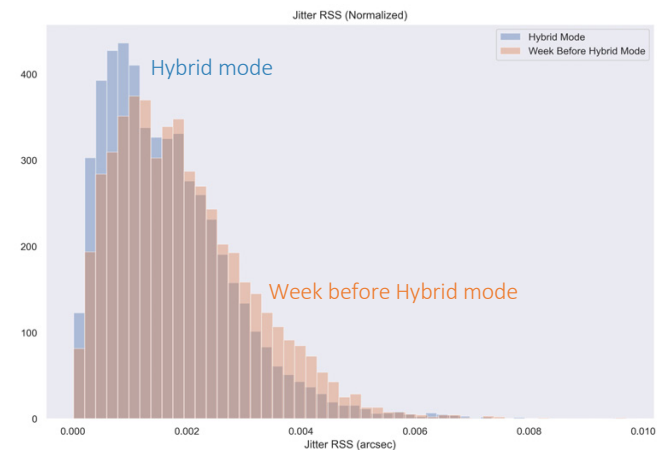
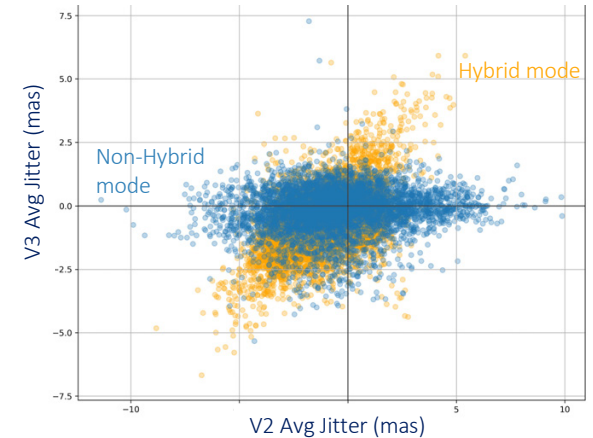
- **ISR 2021-01: Testing the Defracting Tool Suite on the Time Dependent Sensitivity Data** (S. Hernandez)
- 1 STAN published (Mar 2021)
- Updates to IHB for Cycle 29, Support for call for proposals





Front end support – hybrid mode, HST safing, STIS suspend

- STIS team supported investigations of hybrid mode
 - New behavior of jitter in V2/V3 axes means jitter is now perpendicular to STIS slit (along dispersion direction)
 - Hybrid mode has overall lower total jitter
- Support for HST safing and STIS suspend
 - Short duration of NUV-MAMA time-off meant no increase in dark rate
 - Marginal temporary increase of CCD dark rate/readnoise, but still within family of rates seen pre-suspend





Flux recalibration to CALSPEC version 11 timeline

- Unexpected departures of 2 STIS team members has slowed progress
- STAN will be distributed to alert community of new timeline, and STIS will provide a website to track completion/plans on a rolling basis.

Imaging modes:

- Original timeline: Winter 2020-2021
- Current timeline: Deferred (no earlier than Fall 2021)
- Status: Running/verifying outputs of old scripts
- (Will update IMPHTTAB photometric zeropoints for out-of-date TDS corrections this Spring)

Spectroscopic modes:

- Original timeline: Summer 2021
- Current timeline:
 - High priority modes*: Summer 2021
 - Low priority modes: Beginning Fall 2021 and rolling based on mode priority
- Status: Modes prioritized; old scripts identified and have started running

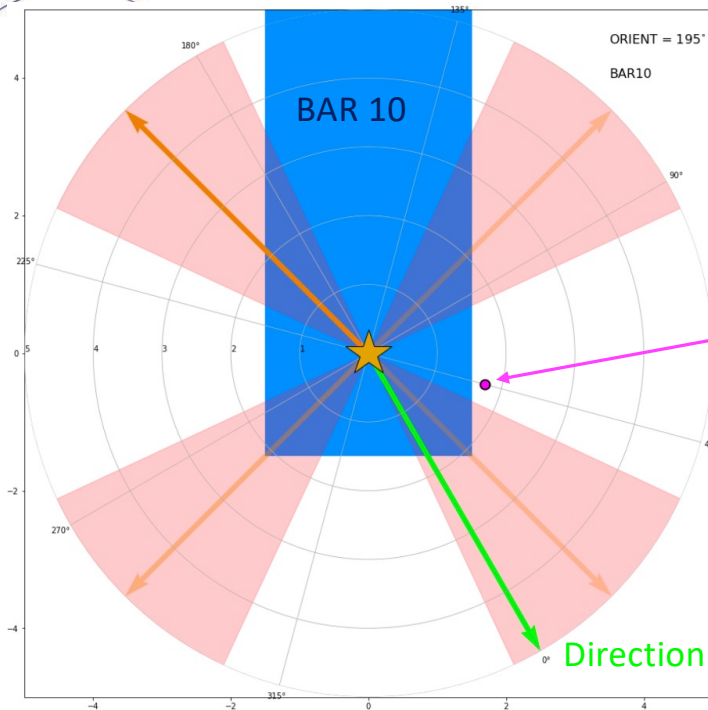
* All 5 L-modes, E140M, E230M/2707 & 1978 – these are favored by the community and ULLYSES



Jupyter Notebook for Coronagraphy planning

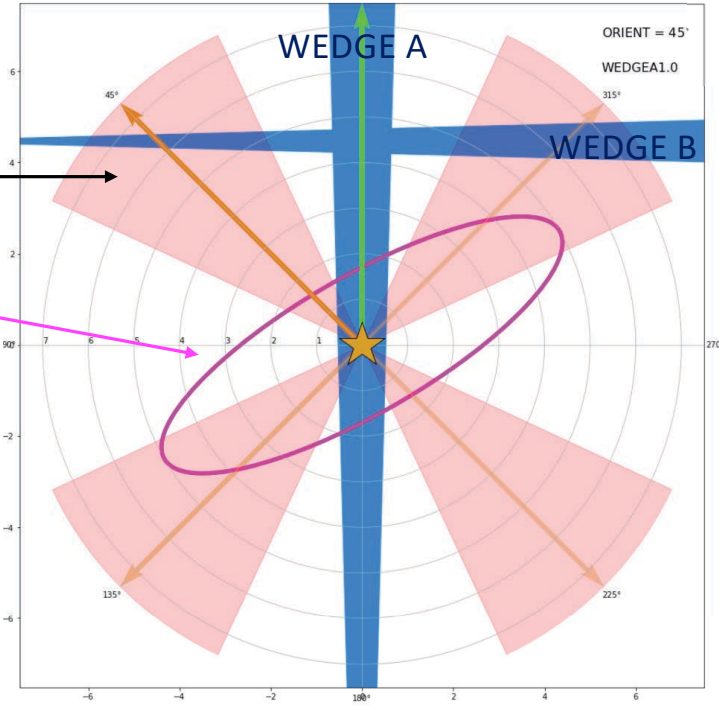


Kimberly Ward Duong



Diffraction spikes and zone of avoidance (default 20°)

Feature (companion or disk)



Jupyter notebook tool for visualizing coronagraphic mask/sky orientation (see [March 2021 STAN](#))

- Feature choices: companions or disks; custom separations/sizes, shapes
- Custom zone of avoidance angle around diffraction spikes and FOV zoom



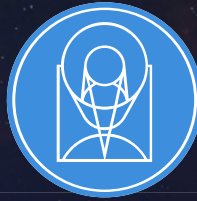
Future/On-going work

Cycle 28 Special Calibration Program:

- Spatial scanning follow-up: **Assessing Flux Reproducibility in STIS Spatial Scans**
 - Testing flux repeatability over one 5-orbit spatial planning visit
 - Includes transit of 55 Cnc e to ensure these data can reproduce known transit parameters
 - Advertising to exoplanet community (AAS, STAN, STScI Symposium) as a test dataset for proposal planning
 - Observations scheduled (at time of writing) for April 25th

Other on-going projects:

- Splice replacement – investigating SpecUtils and ULLYSES tool expansion as solutions
- CCD rotation investigation
- Historic Coronagraphic performance



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WFC3 Update

Sylvia Baggett, Annalisa Calamida, and WFC3 Team



WFC3 status

General

- WFC3 operating nominally
- HST March 2020 safe: post-recovery data normal
- Currently ~292k WFC3 images in MAST archive

Completed

- New zeropoints/IR flats documented/publicized
ISRs 2021-04, 2021-01, 2020-10
Jupyter notebook; STAN; STScI Newsletter, WWW, AAS
- Testing of hstaxe (python aXe) + Jupyter notebook
https://github.com/npirzkal/aXe_WFC3_Cookbook/blob/main/aXe_WFC3_Cookbook.ipynb
- DASH mode software package + tutorial (ISR 2021-02)
https://github.com/spacetelescope/wfc3_dash
- UVIS G280 recalibration with all on-orbit data (ISR 2020-09)
 - Traces, wavelength and flux calibration across full FOV
 - Eight orders (+/- 1,2,3,4) plus 0th

Calculating WFC3 zeropoints with STSynphot

This notebook briefly shows how to calculate zeropoints and other photometric system quantities using the python package (stsynphot). zeropoints are not time dependent). To install stsynphot, activate your conda environment in a bash shell and enter the command:

Using stsynphot requires downloading the throughput curves for the HST instruments and optical path. One method of doing this is to use the following command:

```
import os
cmd_input = 'curl -O ftp://archive.stsci.edu/pub/hst/pysynphot/synphot1.tar.gz'
os.system(cmd_input)
```

Once the files are downloaded, unpack the files and set the environment variable PYSYN_CDBS to the path of the unpacked files:

```
os.environ['PYSYN_CDBS'] = '/YOUR/PATH/HERE/'
```

```
# os.environ['PYSYN_CDBS'] = '/YOUR/PATH/HERE/'
```

```
import numpy as np
```

```
import stsynphot as stsyn
```

```
from astropy.table import Table
```

```
from astropy.time import Time
```

```
from synphot import Obsrvr
```

1. Set a few inputs

Parameters to set include observation date, filter, and aperture.

calculated for an infinite aperture.

These inputs can be changed:

```
#Date
```

```
mjd = '55000'
```

```
# mjd = str(Time.now().mjd)
```

HSTaXe Installation

- conda create --name hstaxe python=3
- conda activate hstaxe
- git clone <https://github.com/spacetelescope/hstaxe.git>
- conda install numpy astropy gsl cfitsio wcsutils stwcs stsci.imagestats drizzle drizzlepac jupyter
- cd hstaxe
- python setup.py install

Load a few Python modules

```
In [ ]: from astropy.io import fits
import numpy as np
import os, shutil
import matplotlib.pyplot as plt
import matplotlib inline
from drizzlepac import drizzle
from hstaxe import axetasks
```

We save the current working directory

```
In [ ]: cwd = os.getcwd()
print("We are in %s" % (cwd))
```

Preparing the G141 data

We will create a G141 subdirectory to copy all of the G141 files into.

Creating the directory, removing any existing one

```
In [ ]: os.chdir(cwd)
if os.path.isdir("G141"):
```

UVIS Time-dependent photometry

Description

This Jupyter notebook demonstrates how to apply the new time-dependent inverse sensitivities (zeropoints) to sample data.

The notebook comes with example standard star (GD153) flat-fielded CTE-corrected (FLC) files for three separate subarray modes. It also comes with a CSV file that contains a list of FLCs, and the coordinates of the star for each FLC.

Table of Contents

1. Import all modules

data, set up pandas dataframe, load pixel array map images

structure photometry on the FLCs

magnitudes, applying the new time-dependent PHOTFLAM (inverse sensitivity) keywords

is and magnitudes

count rate values in the science array of all FLC frames (optional step to prepare for drizzling)

structure photometry and plot new count rates

level drizzled DRC data products

structure photometry on the DRC files

prepare all results

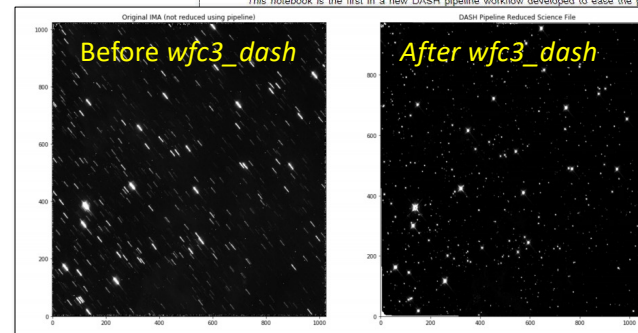
How to Use wfc3_dash on DASH data:

Table of Contents:

1. Introduction
2. Imports
3. Downloading Relevant Data
4. Running DASH
 - a) Creating DashData object
 - b) Create diff files from Reads
 - c) Create association table
 - d) Subtract background from new FLT's
 - e) Fix cosmic rays
 - f) Align reads to each other
 - g) Plotting Original IMA vs. Post-Processing Science Result

Introduction

This notebook is the first in a new DASH pipeline workflow developed to ease the process of reducing DASH data to a finished product.





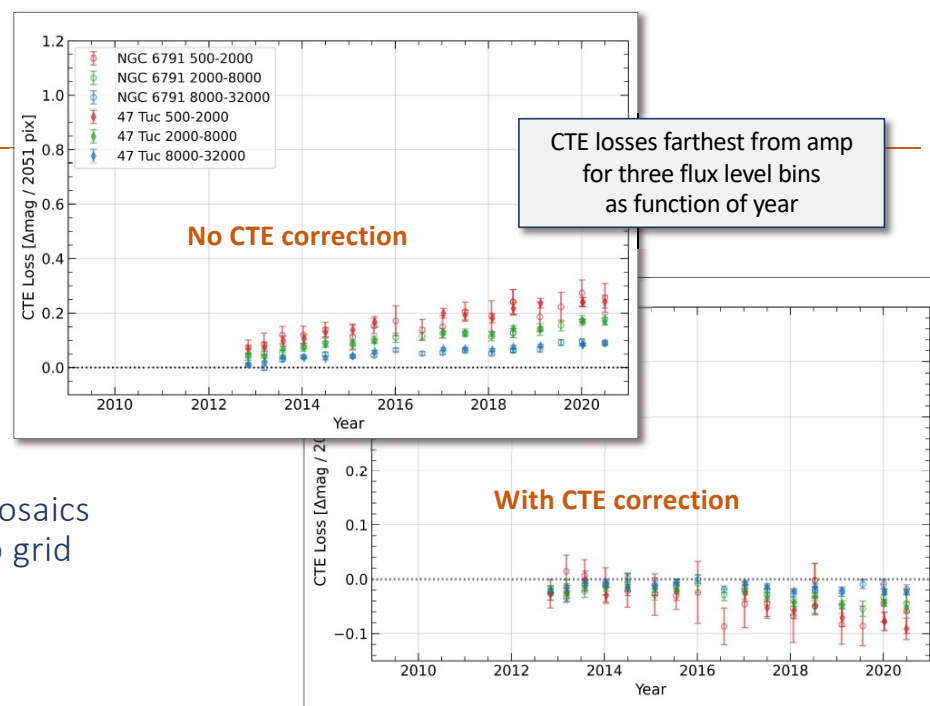
WFC3 status

Completed

- External CTE monitor analysis (ISR 2021-03)
 - Omega Cen aperture photometry
 - Faintest sources (<2000 e-), farthest from amp, with >12e-/pix background, now showing ~25% loss
 - Currently recommending 20e-/pix pre-flash
- Verification of Hubble Advanced Products Single Visit Mosaics
 - Images in single visit now drizzled onto same north-up grid

<https://drizzlepac.readthedocs.io/en/latest/singlevisit.html>

<https://archive.stsci.edu/contents/newsletters/december-2020>



In progress

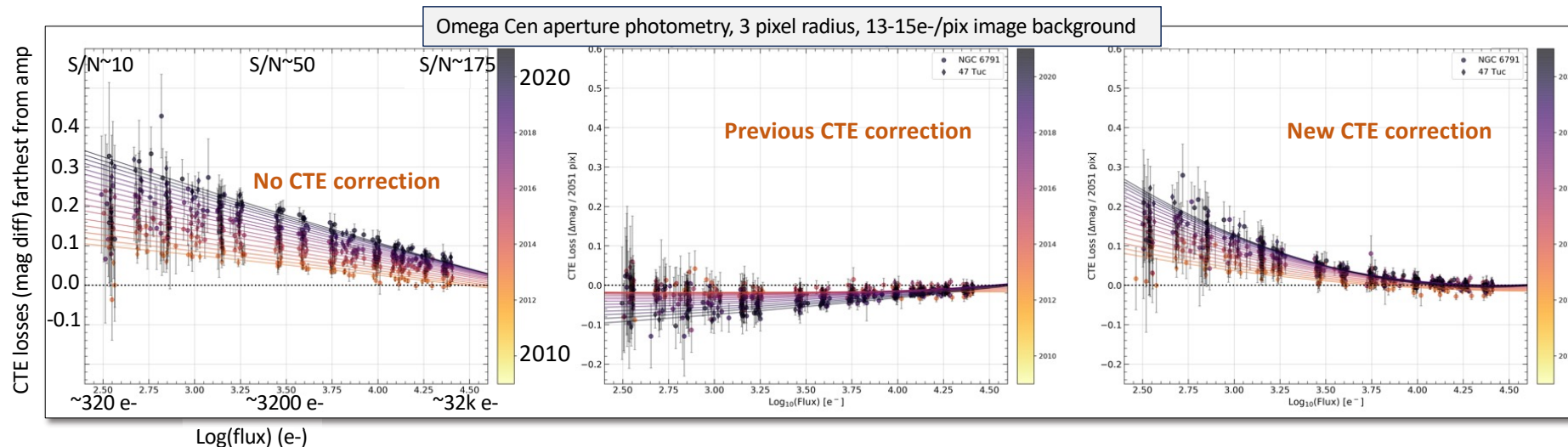
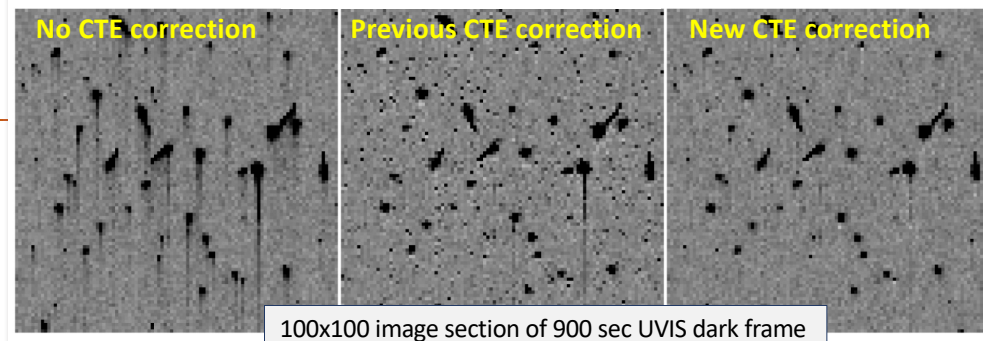
- Exoplanet Catalog of transiting WFC3/IR observations (ExoCat)
 - Beta version: target, phase start/end, scan parameters, spectral element, etc.
 - Next: scan quality <https://www.stsci.edu/~WFC3/exocat/exocat/exocat.html>
- Continuing investigation into possible low-level IR time-dependent sensitivity



WFC3 status

New CTE correction

- Released CTE correction 2021 into calibration pipeline
 - Includes new daily darks 2009-2020
- Radiation damage: CTE corr no longer working well
- New correction: background/bright sources better
 - In order to 'do no harm' (prevent background noise amplification), algorithm leaves faintest sources ~uncorrected
 - Earlier calwf3 version (with prior CTE corr) will be available
- Extensive publicizing planned (STAN, ISRs, webpages, STScI Newsletter article, DHB, AAS, suggestions welcome)





User support/documentation

- Cycle 29 Instrument Handbook (Jan 2021)
- WFC3 team members co-editors of 2021 DrizzlePac Handbook
- STANs (Oct 2020, Jan 2021)
- Jan 2021 AAS
 - Hubble's WFC3 in 2021
 - Updated HST/WFC3 Photometric Calibration
 - Machine Learning Anomaly Detection with PyTorch in WFC3/IR images
- Reports
 - 2021-04 – New time-dependent WFC3 UVIS inverse sensitivities
 - 2021-03 – WFC3/UVIS: External CTE Monitoring 2009-2020
 - 2021-02 – Reducing DASH Data using *dash* Script and Accompanying Notebook Workflow
 - 2021-01 – WFC3/IR Filter-Dependent Sky Flats
 - 2020-09 – Updated Calibration of the UVIS G280 Grism
- In preparation
 - Data Handbook updates
 - AJ article on zero point updates

Version 13.0 – January 2021
PDF version

Wide Field Camera 3 Instrument Handbook for Cycle 29

Expand all Collapse all

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PDF version

DrizzlePac Handbook

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Summary

Hubble continues to perform ground-breaking science on its own and in tandem with other facilities

We continue to maximize the scientific return on the observatory for the next decade

