WFC3

4 May 2017

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Instrument Monitoring Programs

WFC3 is operating nominally

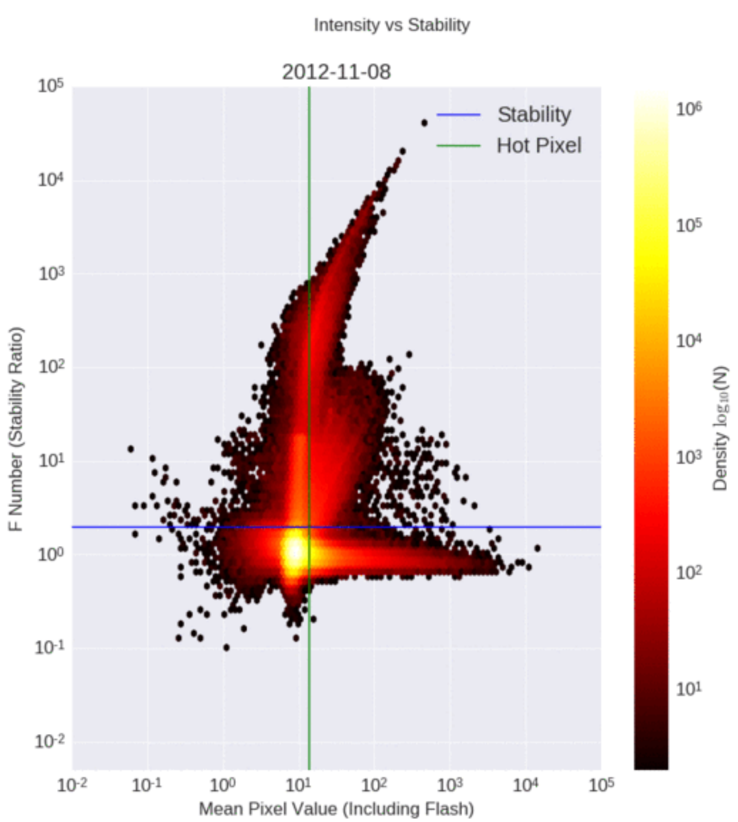
UVIS DARK "PIXEL HISTORY" IMAGE

WORK IN PROGRESS

- Analysis using HDF5 (Hierarchal Data Format) files containing time-ordered arrays of UVIS Dark columns over entire on-orbit history.
- The stability of a pixel over time can be estimated via the 'Stability Ratio' (or 'F ratio')

$$F = \frac{Variance(Science) - Mean(Error^2)}{Mean(Science)} + 1$$

- $F \leq 1$: perfectly stable, $F > 1$: measure of instability ($F >= 2$ considered "unstable")



used in science exposures, but could be flagged

- Ultimate goal is to classify every UVIS pixel into one of four categories:
  - Cold and stable: < hotpix threshold and < F threshold
  - Cold and unstable: < hotpix threshold and > F threshold
  - Hot and stable: > hotpix threshold and < F threshold –
  - Hot and unstable: > hotpix threshold and > F threshold

flagged in science exposures, but could be used

BIAS REFERENCE FILE ANALYSIS

The bias files are used to remove the noise produced by the instrument electronics and can be used to measure the stability of the detector.

We analyzed WFC3 bias in search of significant changes to the data as a function of time while assembling and delivering updated and new reference files to the CRDS.

Statistics of Preliminary Full Frame Bias Reference Files

Chip1 Chip2

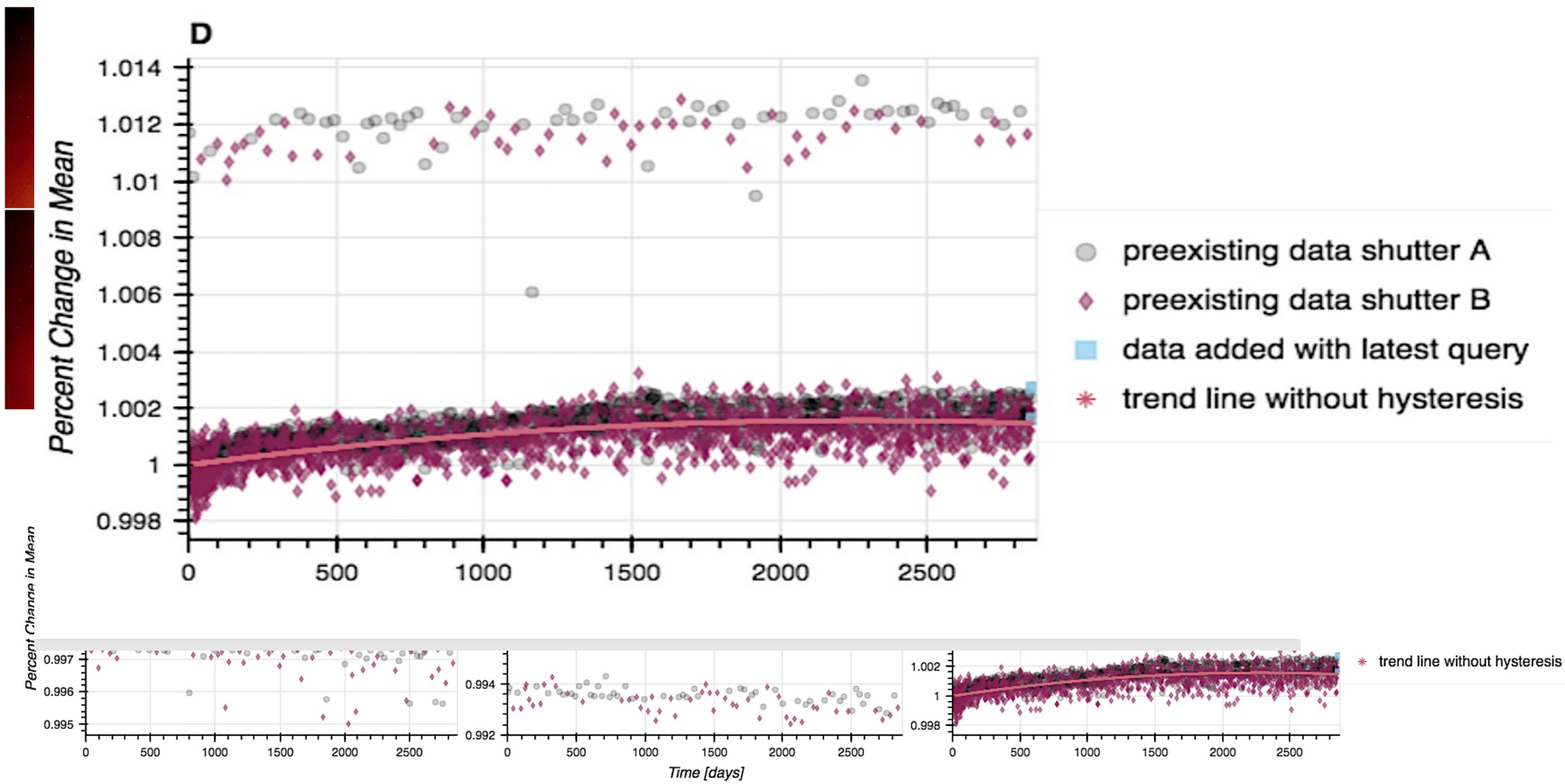
Year	Chip1 Mean	Chip1 Std.Dev	Chip2 Mean	chip2 Std.Dev	Number of Files
2009	0.076	0.11	0.033	0.129	494
2010a	0.08	0.122	0.042	0.137	492
2010b	0.09	0.135	0.046	0.143	524
2011	0.102	0.158	0.061	0.165	347
2012	0.113	0.182	0.083	0.185	246
2013	0.116	0.199	0.108	0.199	219
2014	0.127	0.302	0.137	0.311	52
2015	0.144	0.304	0.163	0.311	52
2016	0.151	0.308	0.193	0.312	53

Mean Values

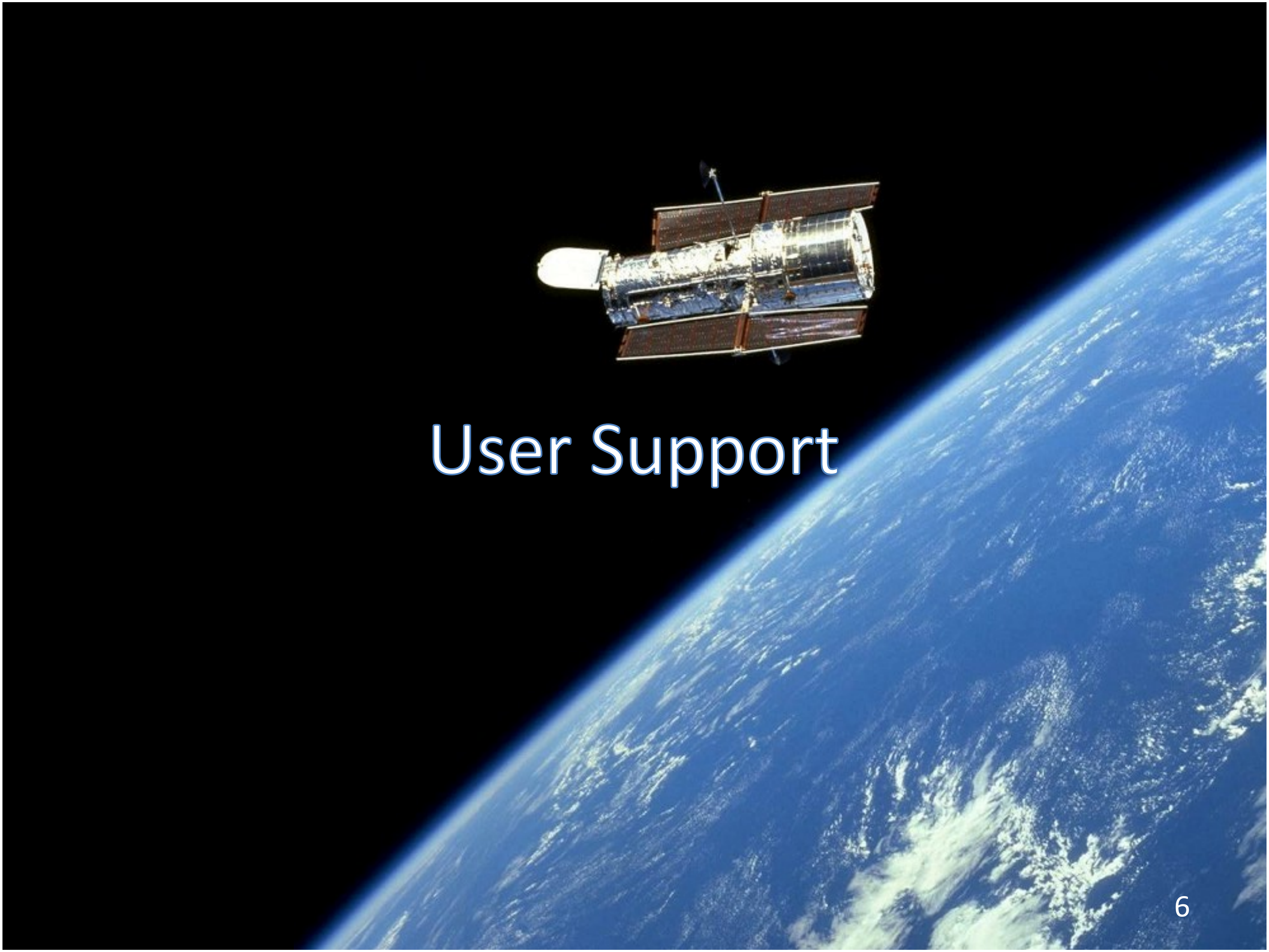
Date-Obs Date-Obs

This will affect all WFC3 UVIS full-frame data! (92,000+ images)

UVIS RELATIVE GAIN MONITOR



WFC3 ISR 2017-08 (Fowler & Baggett)


User Support

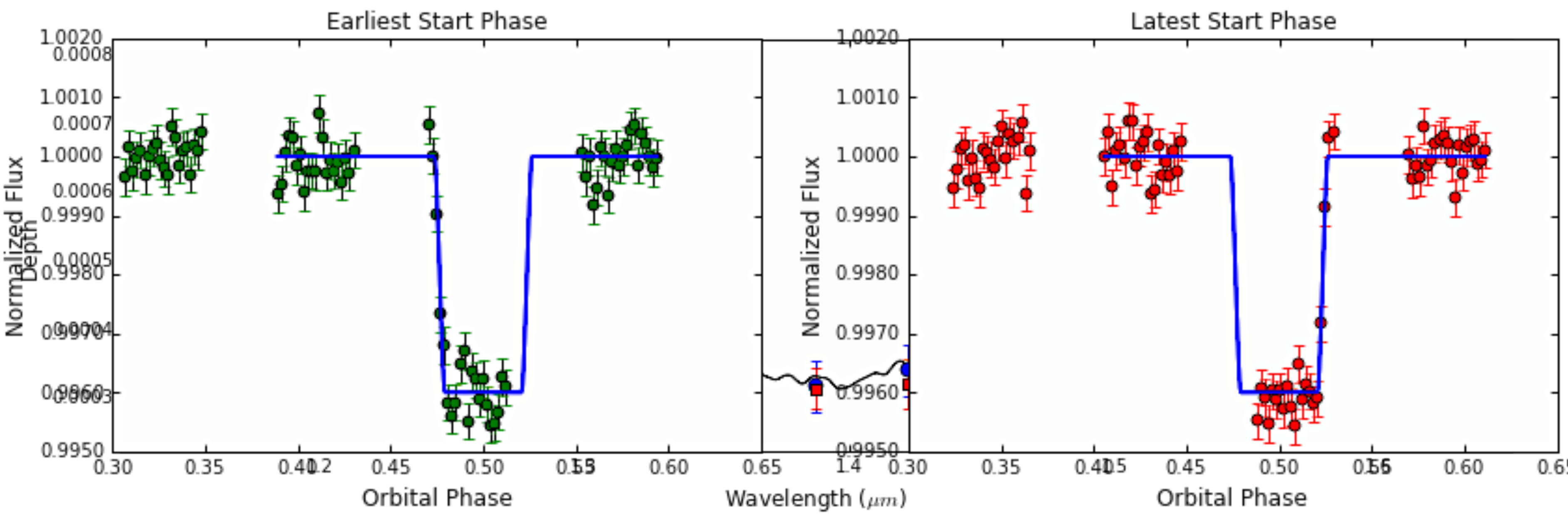
USER SUPPORT

- CS-IS reviews for Mid-Cycle programs;
- Released new version of IHB, 2 STANs & several ISRs;
- Updated ETC to support CY25 call for proposals;
- Updated pysynphot;
- Updating DHB;

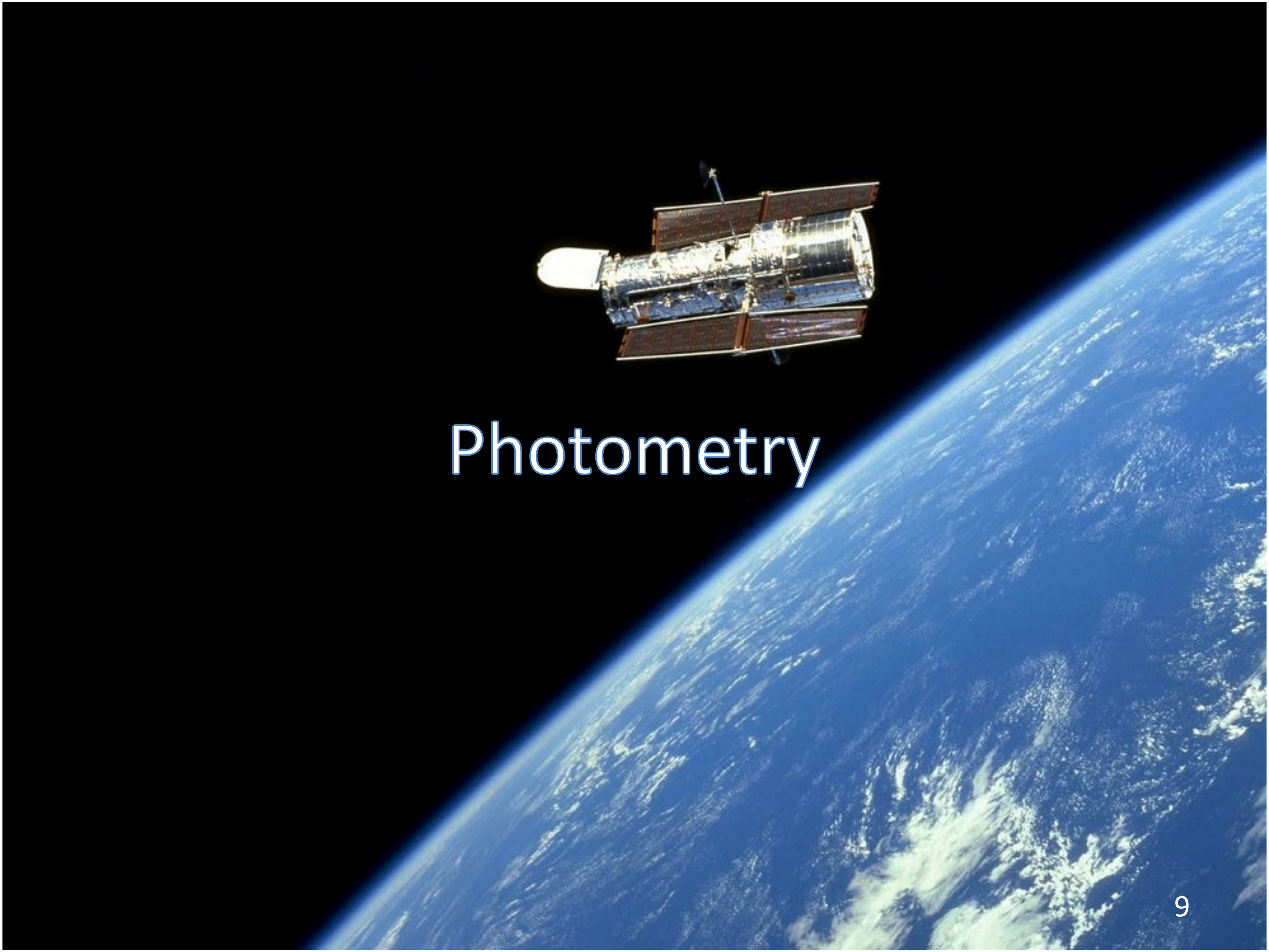
PANDEXO 4 HST

We have released a WFC3 transiting exoplanet noise simulator

- Optimizes WFC3's NSAMP and SAMP-SEQ parameters
- Predicts scan rate, # of orbits per visit, transmission/emission spectrum uncertainties
- Determines the observation start window (for APT)
- Supports G102 & G141, 256x256 & 512x512 subarrays, spatial scanning

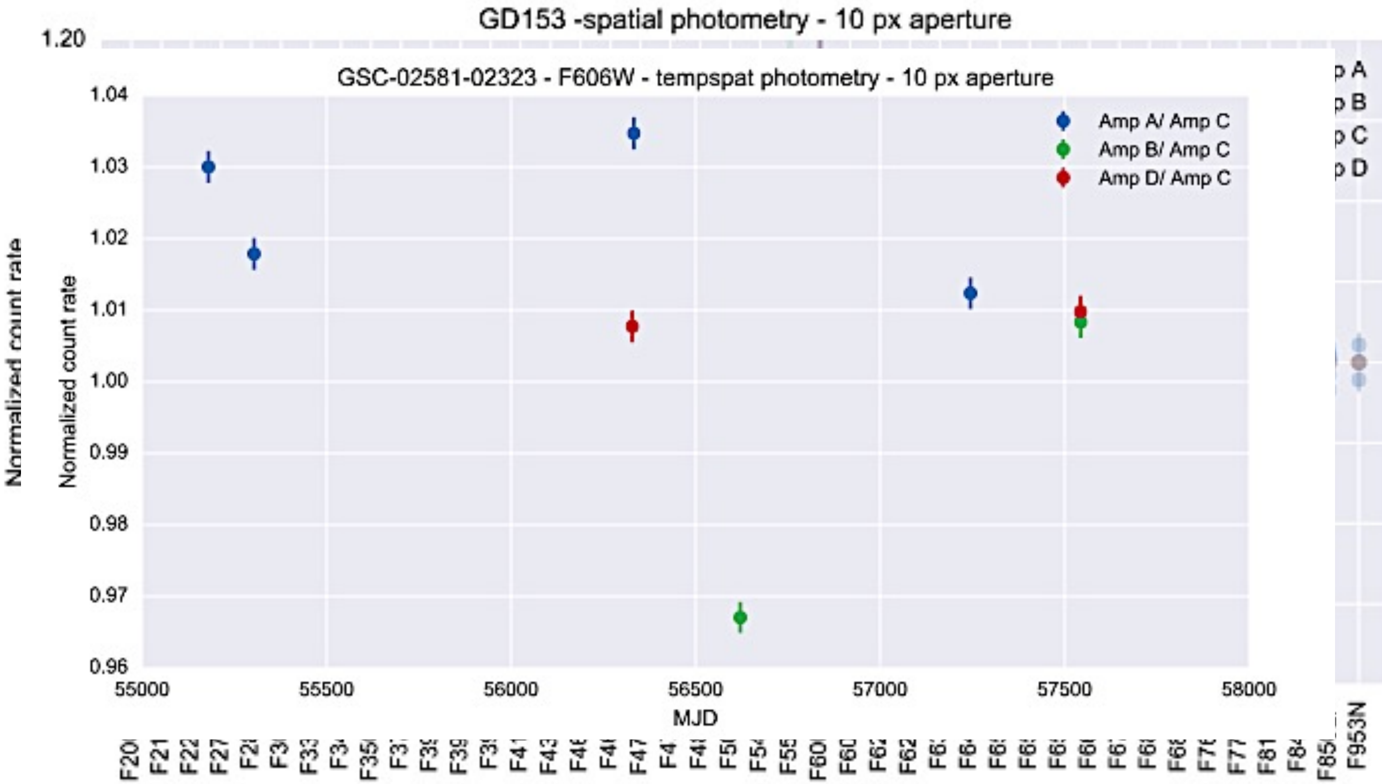


Batalha et al. 2017, PASP
"PandExo: A community tool for transiting exoplanet science with JWST & HST"
https://github.com/spacetelescope/PandExo_HST



Photometry

SPATIAL AND TEMPORAL VARIABILITY OF UVIS ZPS



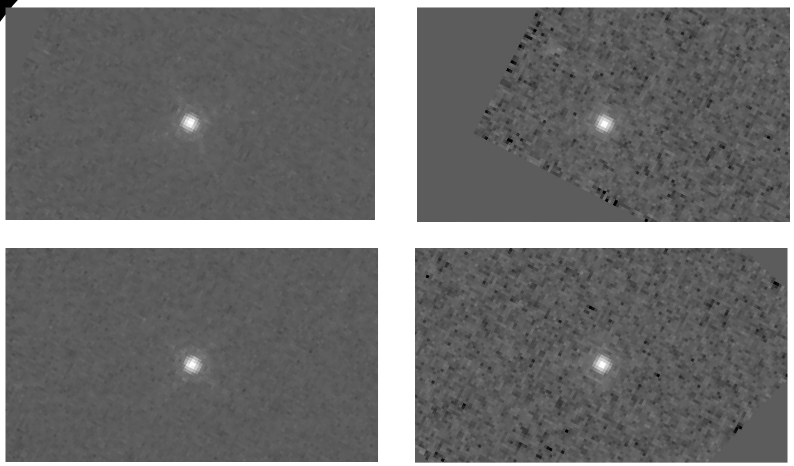
Studied spatial and temporal changes in UVIS photometry using standard star observations (GD153, GD71, P330E, etc) in subarray modes. Used a 10 pixel aperture as it sufficiently samples the PSF flux. Spatial changes were investigated using individual Amp results and also as a ratio with Amp C results.

Aperture photometry at 10 pixels for GD153 through various UVIS filters shows that there is an overall difference of about 2% to 5% for most UVIS filters across all four amps.

The trend is confirmed for example by the aperture photometry of GSC-02581-02323 at 10 pixels. Using AMP C as the fiducial amp to base spatial differences on, we find about a 2-3% variation between Amp A and Amp C.

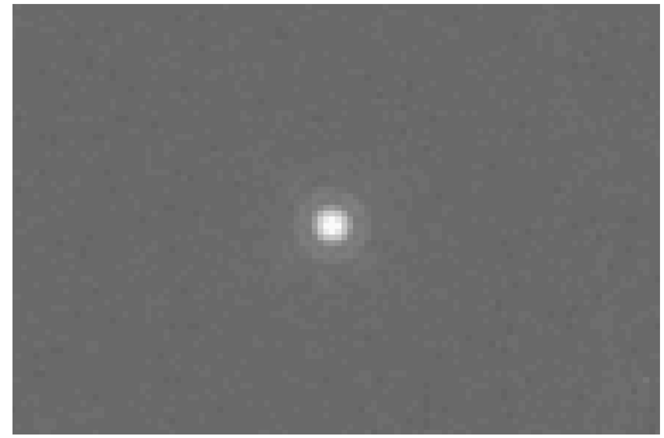
IR ZEROPOINTS & APERTURE CORRECTIONS

WORK IN PROGRESS



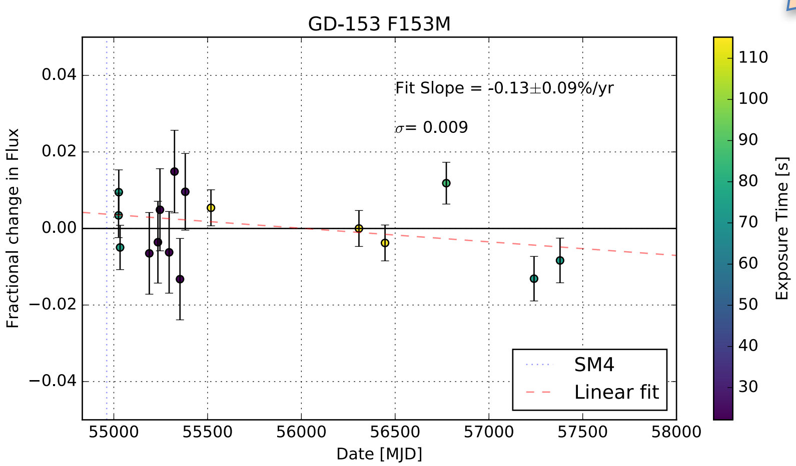
Images from various epochs for four HST photometric standards, in all imaging filters.

Drizzle

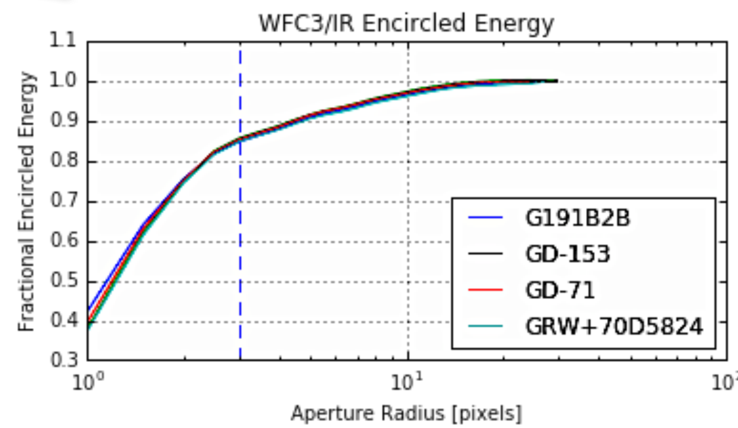


Deep “master” image for each star/filter.

Photometry



Photometry done on input and master images to calculate zeropoint and investigate temporal stability.



Encircled energy curve measured from master image to derive aperture corrections. High S/N in PSF wings allows for accurate measurement.

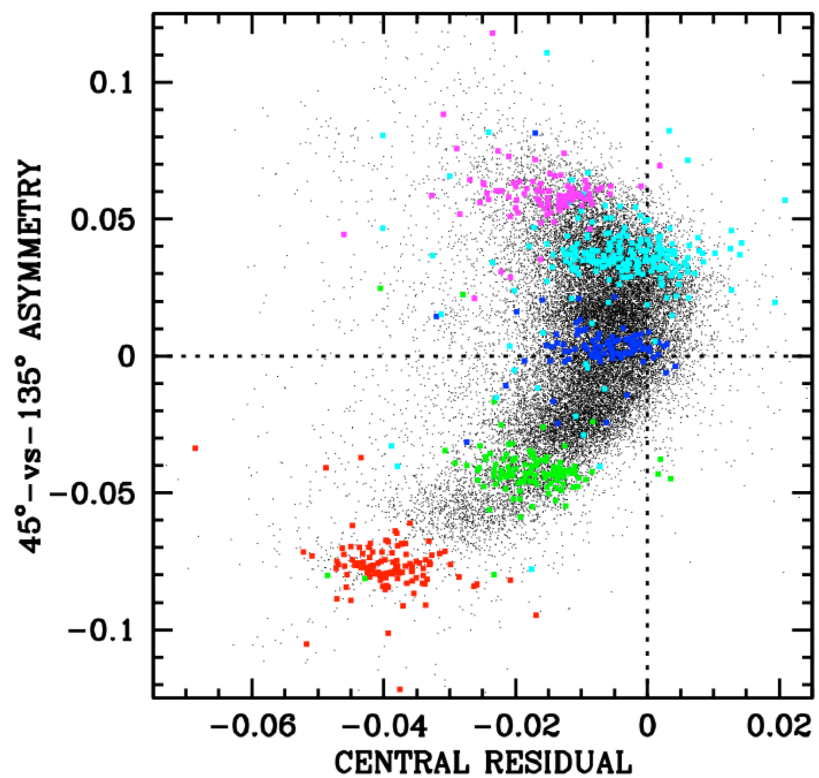
PSF, Focus & Astrometry

WFC3 STAR LIBRARY

WFC3 PSF changes with the Telescope focus.
Observations acquired at different times but with similar focus have similar PSFs

Date	Model Focus Value
03/17/2014	3.75 (magenta)
02/27/2012	1.9 (cyan)
05/24/2013	-2.6 (blue)
06/08/2012	-4.1 (green)
06/06/2012	-7.4 (red)

PSF variation with Focus F606W 2012-2014



We aim to make the entire WFC3 database of high S/N well isolated stars available to the users.

WFC3 STAR LIBRARY

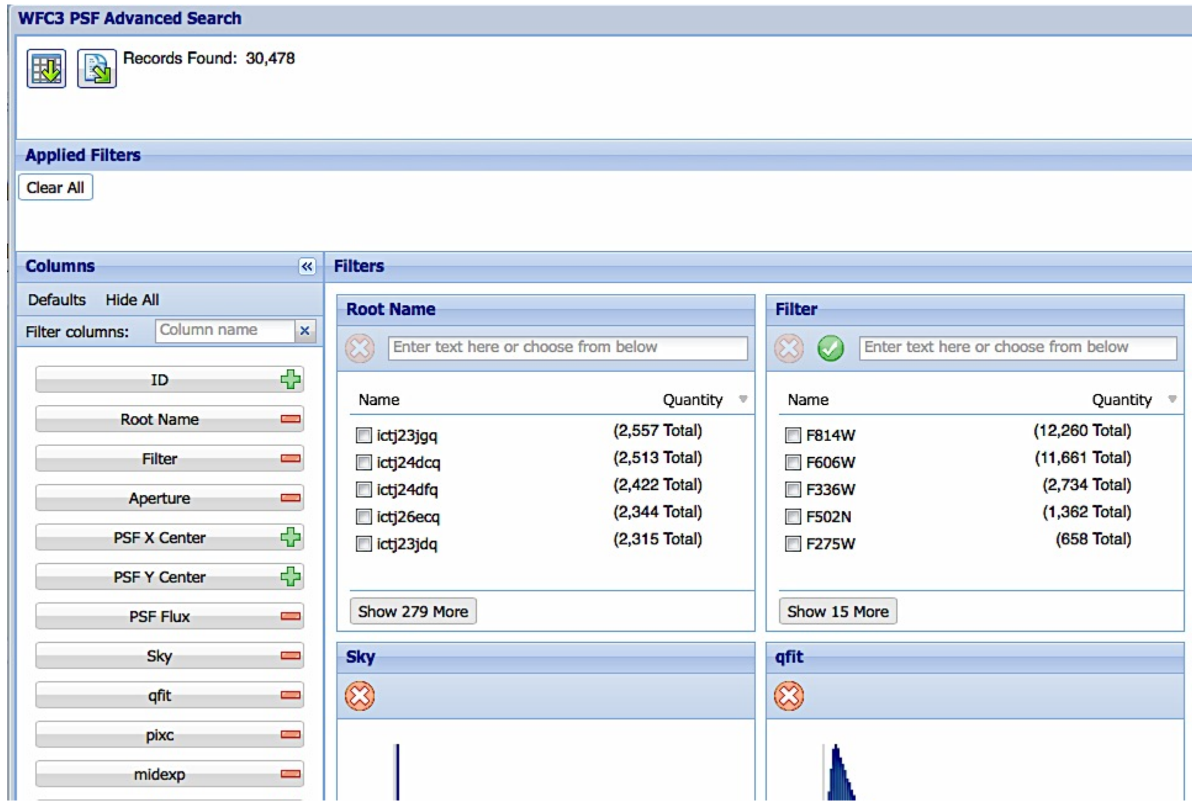
We have extracted high S/N isolated stars for all the filters, from all the WFC3 observations acquired since launch.

Database now >22 million PSFs in all filters

A tool is being developed through MAST to provide the PSFs to users.

Users can search for PSFs through model focus value, time, proposal ID, etc.

PSFs observed at a particular epoch can serve for observations taken at a different epoch at similar focus.



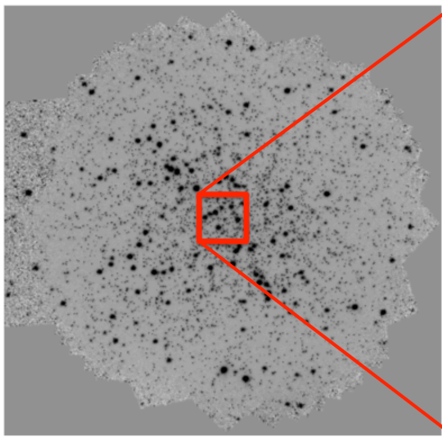
Useful for projects that need accurate PSFs for crowded field photometry/astrometry, image subtraction, etc.

Prototype will be presented at the AAS

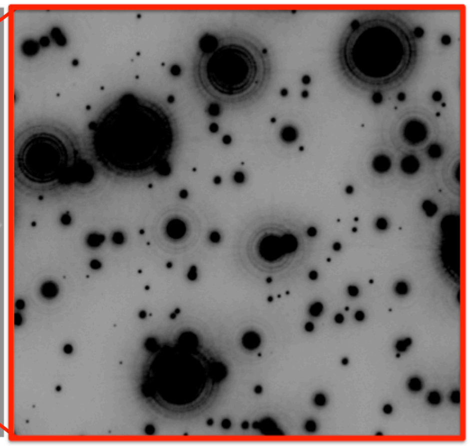
EXTRACTING FOCUS-DIVERSE PSF LIBRARIES

GO-12911 (PI Bedin) observed globular M4 once a month with ~50 exposures in F467M

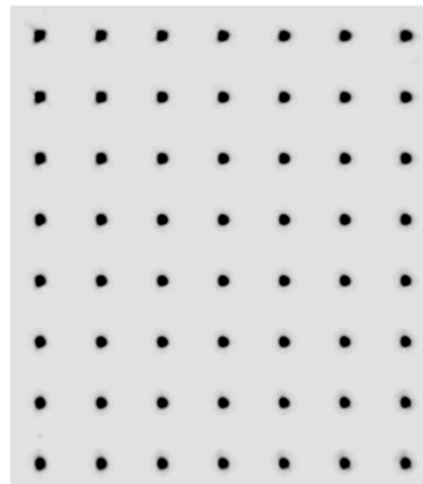
Each image is characterized by its how library PSF



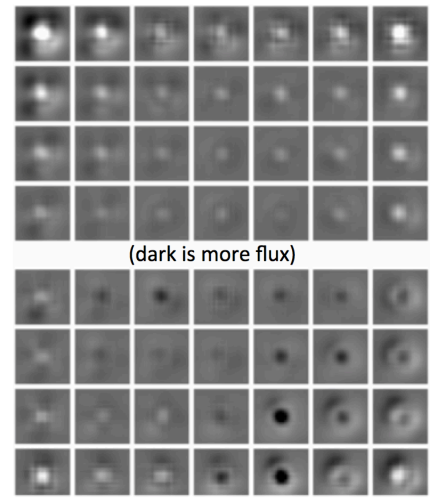
M4 Central Field



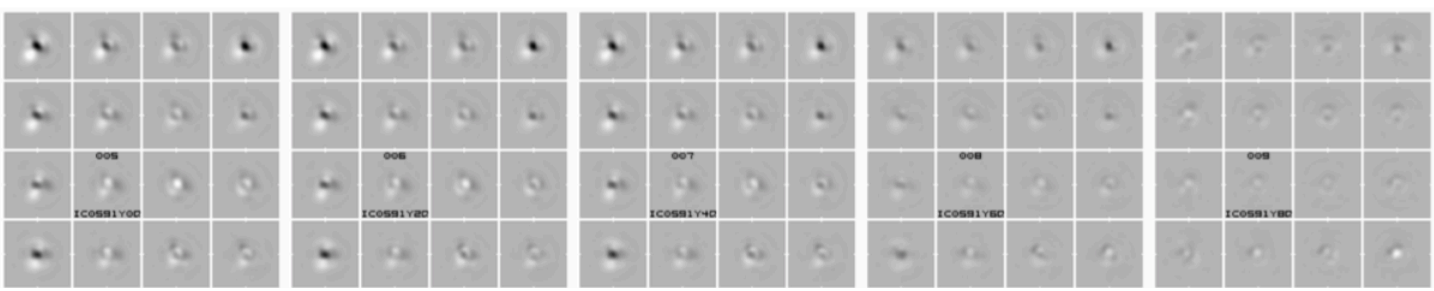
Close-up of Center



Total PSF



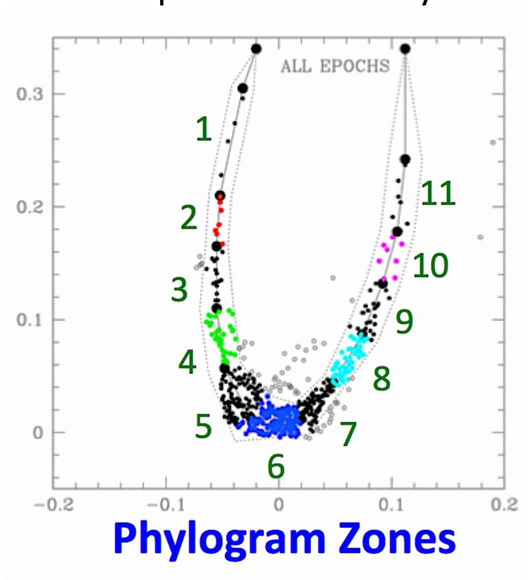
Residual PSF



Correction to the PSF library for five consecutive exposures

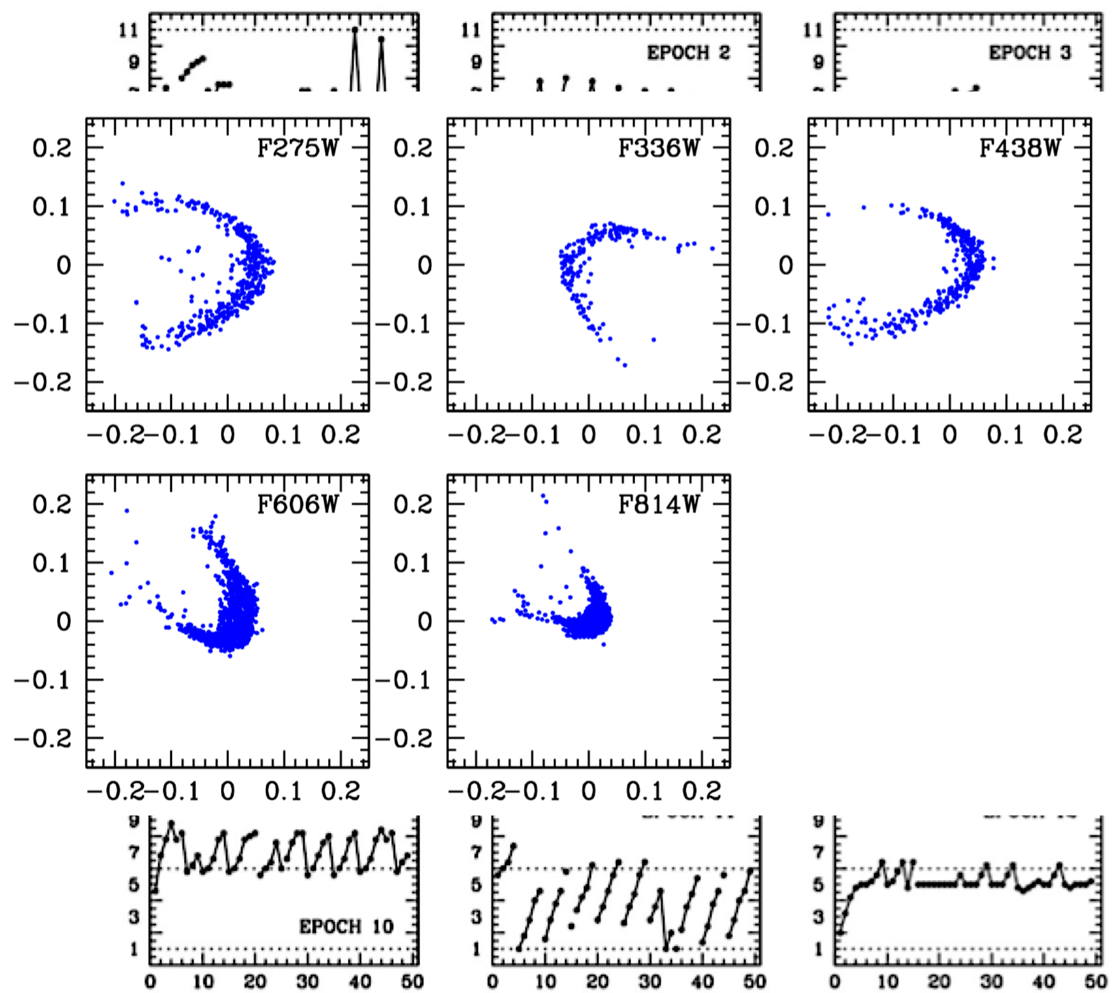
EXTRACTING FOCUS-DIVERSE PSF LIBRARIES

The single-exposure PSFs self-organize into a one-parameter family



5 stars with good S/N are sufficient to determine the focus of an exposure

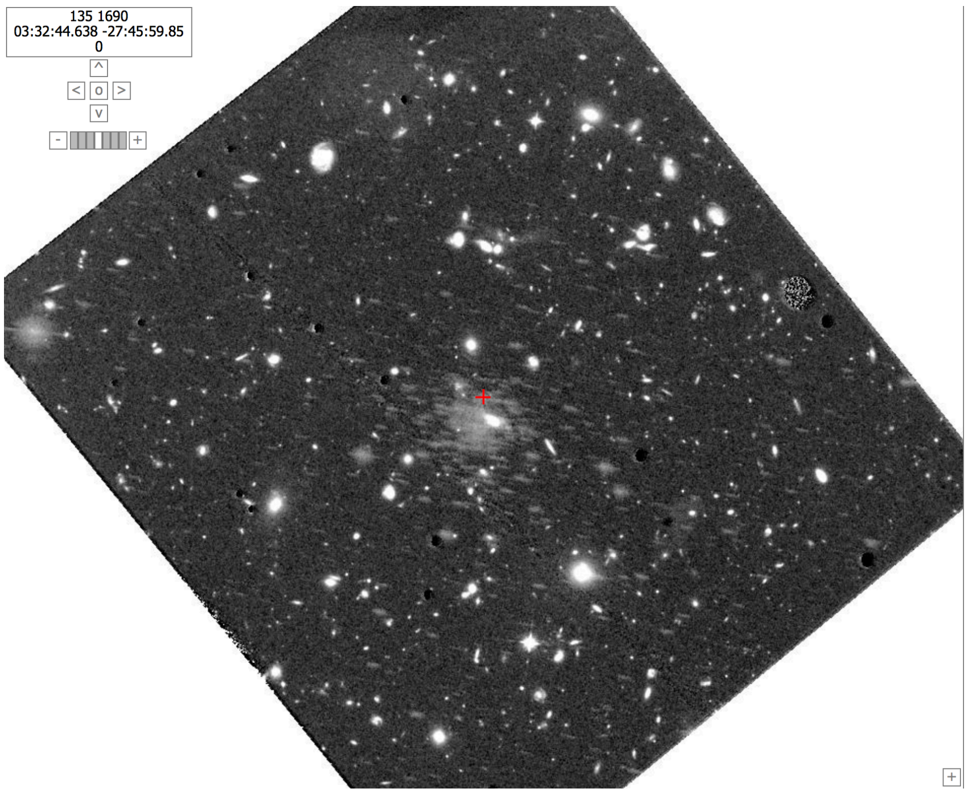
Next:
Compare to phase retrieval;
Extend to the entire archive;
Focus dependent corrections for static library PSF.



Anderson & Bedin 2017, MNRAS (submitted)


Persistence

MODEL FOR PERSISTENCE IN IR



HUDF09, GO-11563, PI Illingworth

Persistence is an afterglow of bright sources observed in previous exposures. Persistence is due to traps in the pixels of an IR detector

The amount of persistence is a function of exposure history of a pixel in the detector.

Our model predicts that persistence goes as $t^{-\gamma}$ ($\boldsymbol{\gamma} > 0$).
It works well for observations acquired few ~100 sec from the "stimulus". It does not work for $t \longrightarrow 0$.

SHORT TERM PERSISTENCE

Persistence on short timescale affects dithered exposures acquired within the same orbit.
It may also be related to the "ramp-up" phenomenon in scanning mode observations.

We are using archival observations of the bright IR cluster Westerlund 1 to study the behavior of persistence on a short time scale. Repeated observations of Westerlund 1 have been acquired within the same orbit. Images are dithered by many PSF FWHM.
We are using the 1^{st} exposure as Stimulus, and measuring how persistence decades on the following exposures.

SHORT TERM PERSISTENCE

Blue: average current between .ima reads

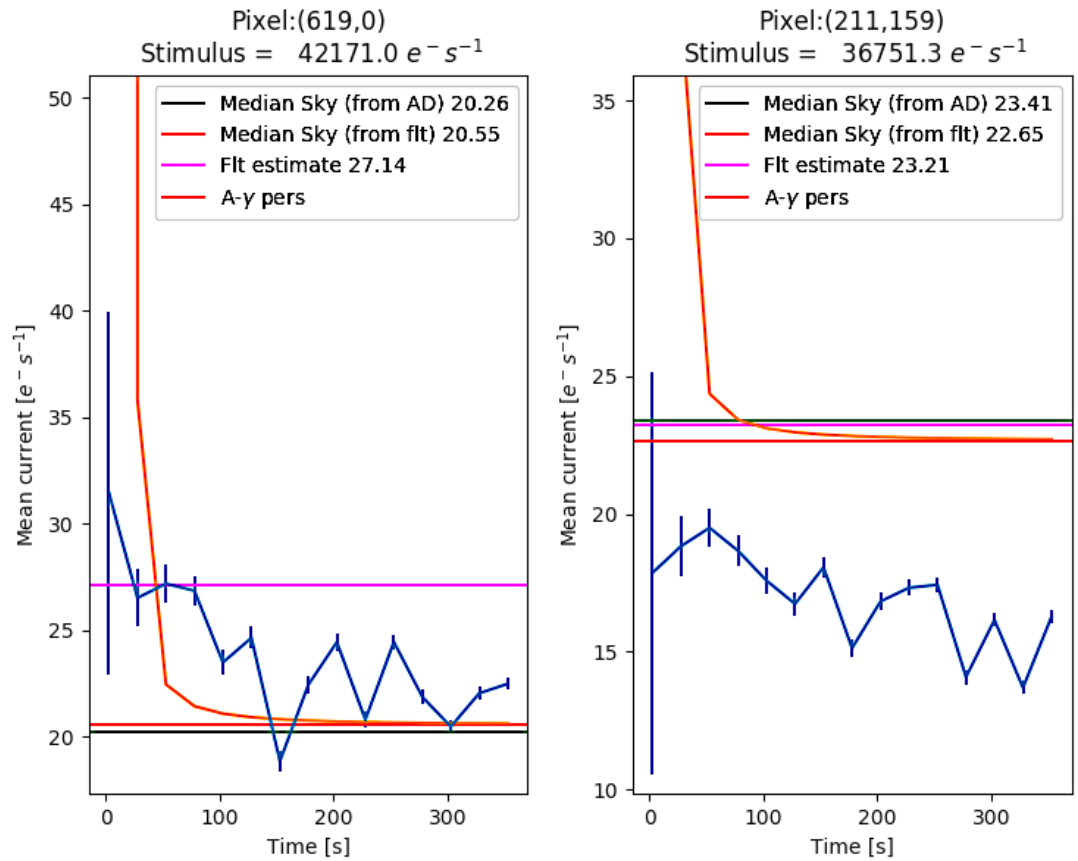
Magenta: corresponding fitted value in the .flt (calwf3 struggles when the assumption of constant signal fails)

Orange: current model prediction of persistence plus the estimated background

Red & green: estimates of the sky background from an annulus of surrounding pixels (presumably not affected by persistence).

<u>Persistence is supposedly the “blue line excess w.r.t the green/red line”</u>

Best fit: double exponential decay model (τ_1 ~ 50 sec, τ_2 ~ 500 sec)



GRISMS

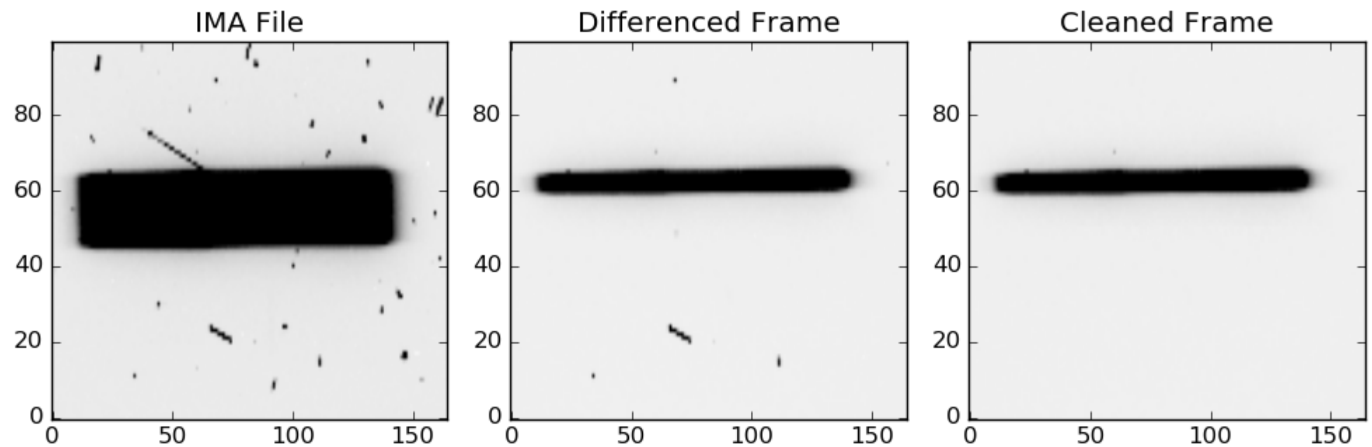
SPATIAL SCAN DURING SAA

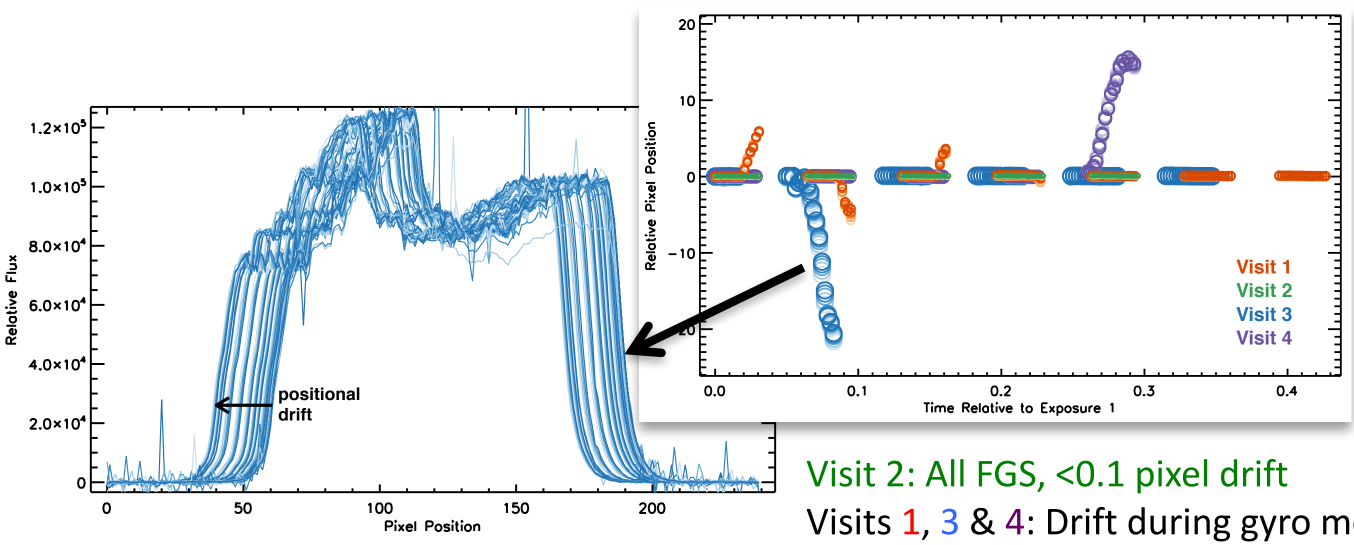
We used archival data to investigate if it is possible to acquire WFC3 time-series observations during South Atlantic Anomaly (SAA) crossing. Known issues are the increase in CR hits and the pointing drift.

Increase in CR hits.

Differencing pairs of non-destructive reads "removes" most of the CRs accumulated during previous reads.

Can identify remaining CRs using time axis.





Visit 2: All FGS, <0.1 pixel drift

Visits 1, 3 & 4: Drift during gyro mode

Pointing drift

No FGS during SAA, only gyro mode

Up to 20 pixels/orbit.

Need to align spectra during post-processing.

Drift impacts light curve precision due to scanning across different pixels.

PIPELINE REPROCESSING IR EXPOSURES WITH VARIABLE BACKGROUND

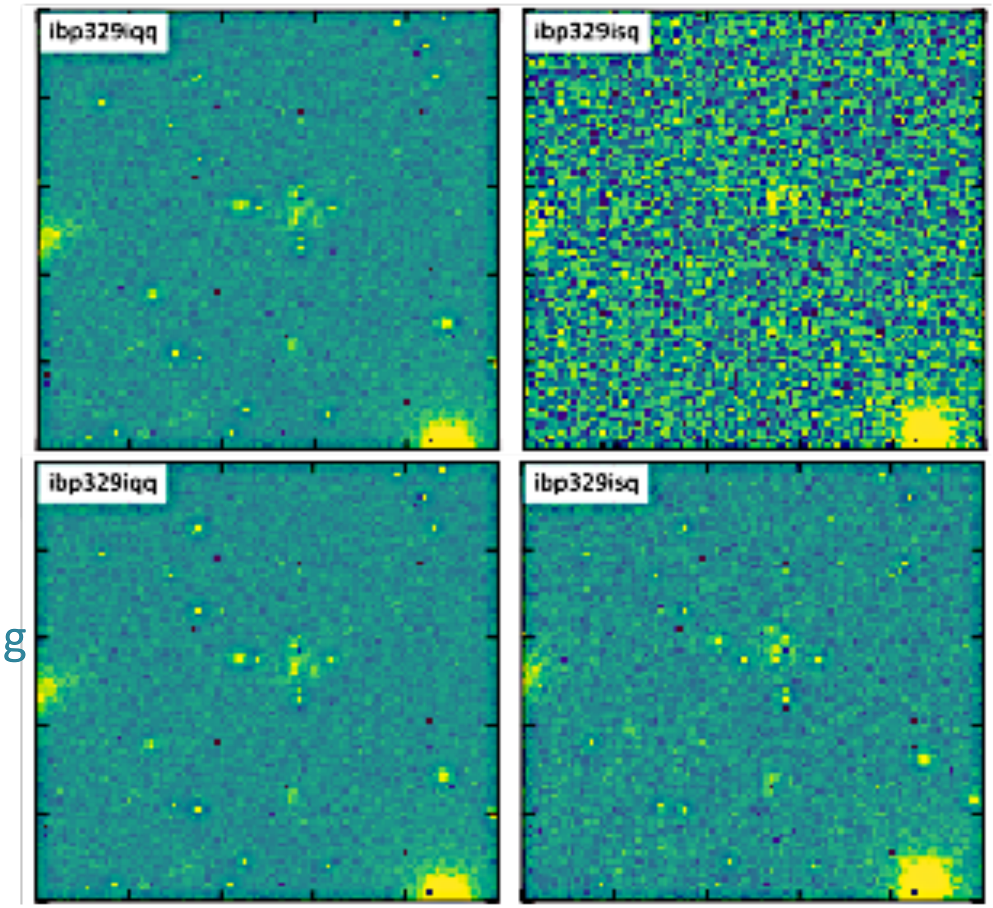
Time-variable backgrounds in the IR channel violate a fundamental assumption of the wf3ir ramp fits and can result in corrupt and unusable FLT data products.

Clean exposure

Affected exposure

Before

After reprocessing



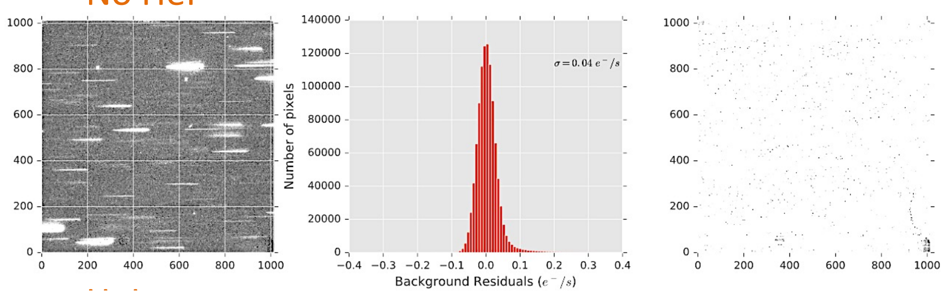
We have now published a *complete* series of ISRs:

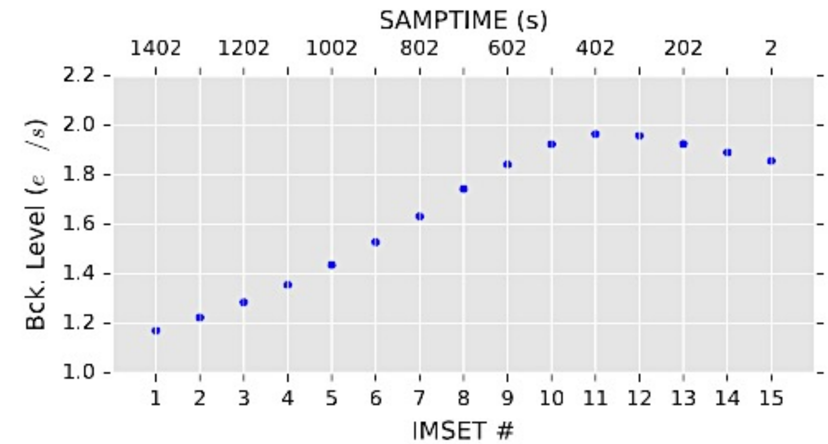
1. Explaining the issues involved (**2014-03, 2015-17**)
2. Presenting prescriptions for reprocessing affected ***imaging*** exposures (**2016-16**)
3. Presenting prescriptions for reprocessing affected ***grism*** exposures (**2017-05**)

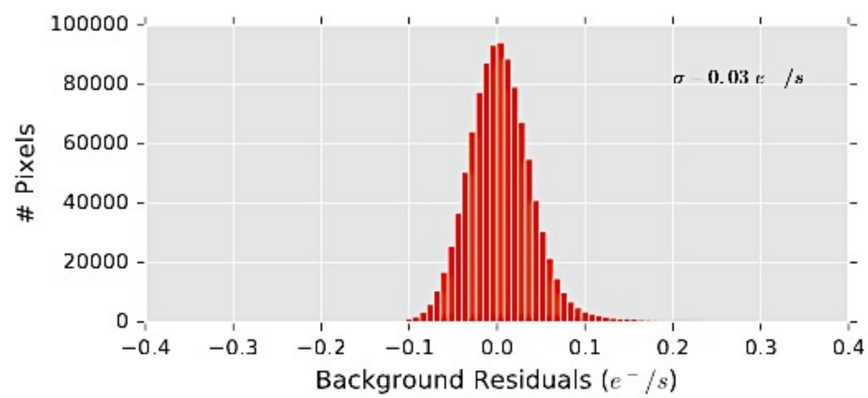
MULTIPLE COMPONENT VARIABLE BACKGROUND SUBTRACTION IN WFC3 IR DATA

Variable HeI **dispersed** background confuses CALWF3

No HeI

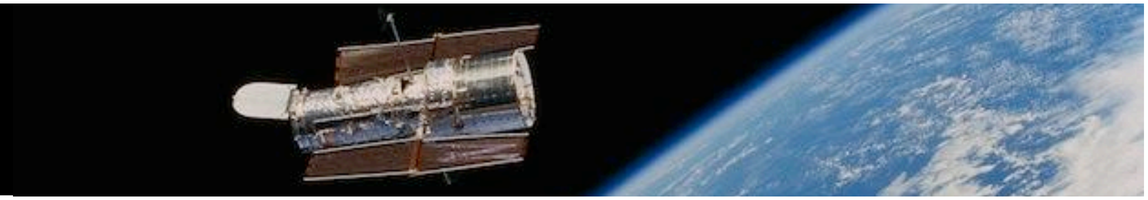






Developed and implemented a new method to quantify the amount of HeI in each IMSET of IMA file, subtract it, and tur file into a “normal” IMA with constant background rate.

Sample code released in ISR WFC3 2017-05 (Pirzkal and Ryan)



RECENTLY PUBLISHED ISRS

- WFC3 ISR 2017-10: *"Comparing Aperture Photometry Software Packages"* Varun Bajaj & Harish Khandrika; 06 Apr 2017
- WFC3 ISR 2017-09: *"WFC3/UVIS External CTE Monitor: 2016 Updates on Coefficient and Analysis Pipeline"* Katie Gosmayer & Sylvia Baggett; 15 Mar 2017
- WFC3 ISR 2017-08: *" Monitoring the WFC3/UVIS Relative Gain with Internal Flatfields"* Jules Fowler & Sylvia Baggett; 15 Mar 2017
- WFC3 ISR 2017-07: *"WFC3 Chip Dependent Photometry with the UV filters"* Susana Deustua, Ralph Bohlin, Jennifer Mack, Varun Bajaj, Harish Khandrika, Elena Sabbi
- WFC3 ISR 2017-06: *"Trajectories of Multi-lines Spatial Scans"* Peter McCullough; 02 Mar 2017
- WFC3 ISR 2017-05: *"Variable He I emission in grism data"* Nor Pirzkal & Russell Ryan 20 Feb 2017
- WFC3 ISR 2017-04: *"An Exploration of WFC3/IR Dark Current Variation"* Ben Sunnquist, Sylvia Baggett, & Knox Long; 15 Feb 2017
- WFC3 ISR 2017-03: *"Long-Term Stability of the Post-Flash LED Lamp"* Catherine Martlin & Sylvia Baggett; 13 Feb 2017
- WFC3 ISR 2017-02: *"Analysis of Dragon's Breath and Scattered Light Detector Anomalies of WFC3/UVIS"* Jules Fowler, Larissa Markwardt, Matthew Bourque, & Jay Anderson, 10 Feb 2017
- WFC3 ISR 2017-01: *"A more Generalized Coordinate Transformation Approach for Grisms"* Nor Pirzkal & Russell Ryan; 05 Jan 2017
- WFC3 ISR 2016-17: *"WFC3/UVIS External CTE Monitor: Single-Chip CTE Measurements"* Katie Gosmeyer & Sylvia Baggett; 14 Dec 2016
- WFC3 TIR 2017-01: "Aladin overlay of a zone of avoidance for Dragon's Breath" P.R. McCullough; 02 March 2017