

Status and Calibration of the HST Wide Field Camera 3

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344.01

Summary

• WFC3 continues to perform nominally.

- Photometric zero points (including UV) are stable to <0.5 % since August 2009
- Astrometric calibration is stable and dominated by Telescope “breathing”
- UVIS CCD Detectors CTE decline as expected with radiation damage
- IR Detector shows essentially zero evolution of its performance in flight

• Notes to Observers:

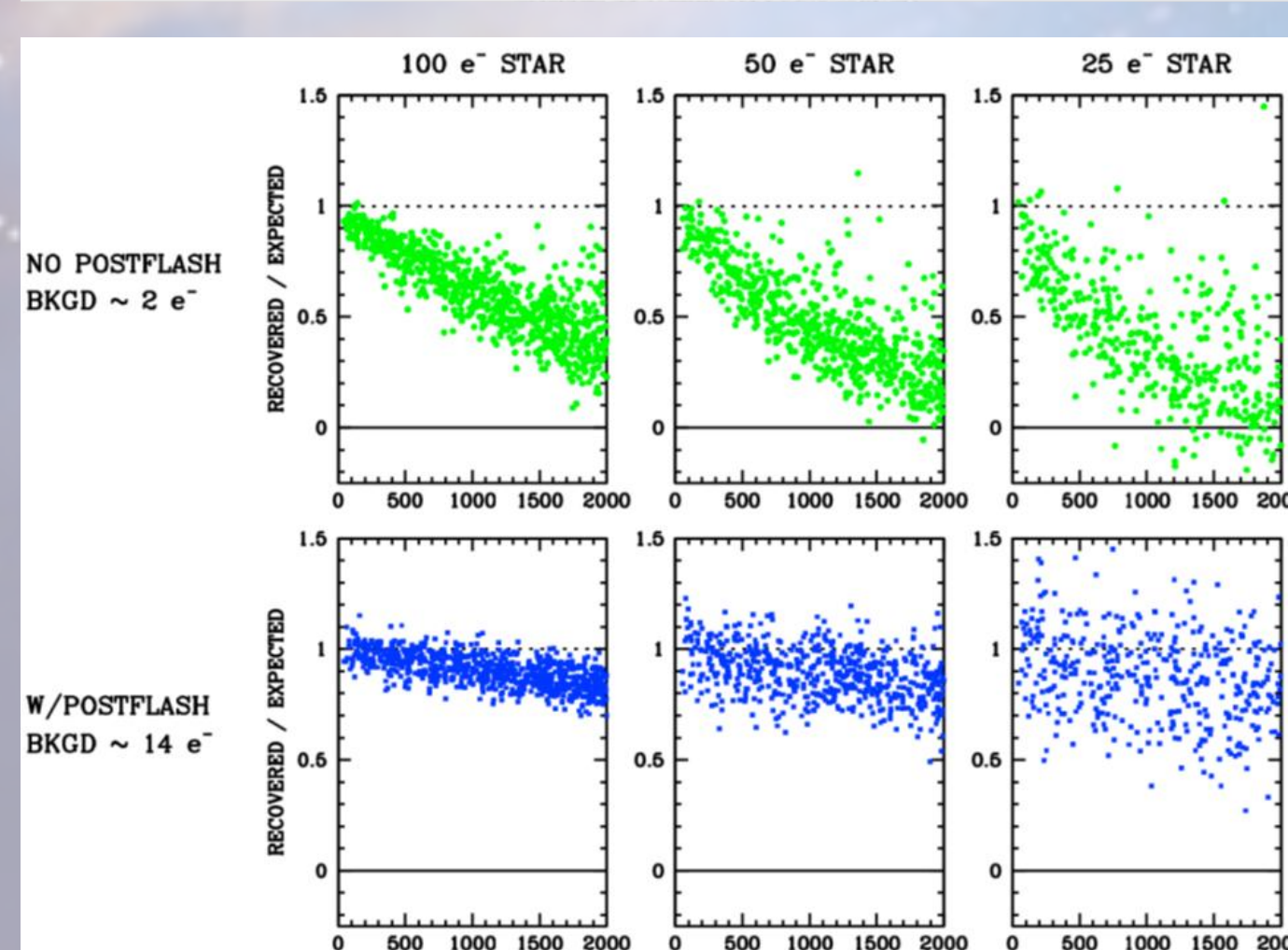
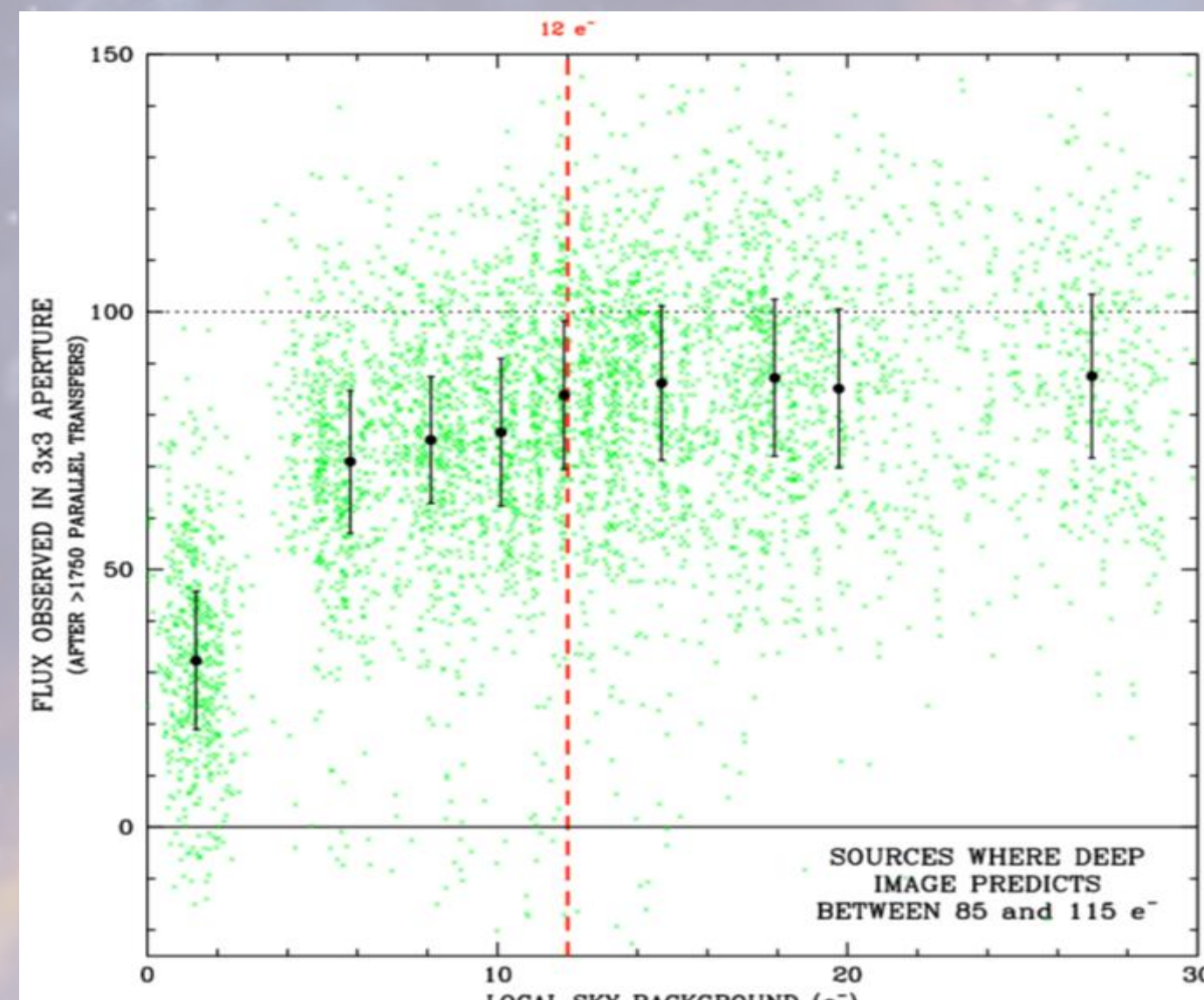
- UVIS CCD Post-Flash became available in Cycle 20 to reduce CTE effects
- Photometric Zero Point and Post-Flash calibrations are available
- IR Detector Persistence tracking is now implemented in MAST
- Spatial Scan Mode supported including FGS control to 4.8 arc sec /second

CCD CTE Mitigation Options → POST-FLASH

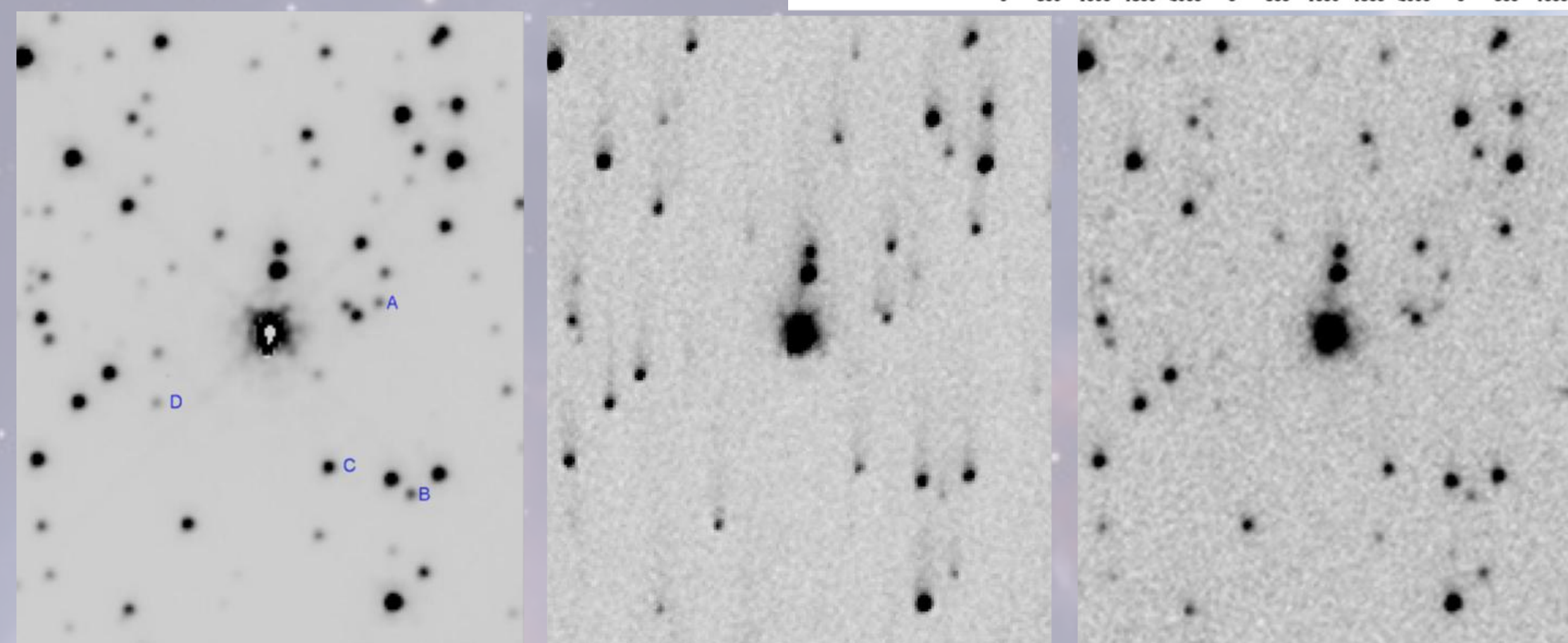
- The WFC3/UVIS CCD detectors experience an inevitable decline in charge transfer efficiency due to proton damage in the space environment.
- Combined with the lower readout noise of the CCDs compared to prior HST instruments this results in a significant (and increasing) loss of S/N for faint sources

Observers have several options to mitigate and correct for this effect:

- 1) Sources placed near the readout amplifiers in the corners are less impacted.
- 2) Post-Observation Corrections
 - Empirical Point Source Flux Model (WFC3 ISR 2012-09 Noeske et al.)
 - Pixel Based Charge Transfer Model (e.g. ACS ISR 2010-03 Anderson&Bedin) is being developed for WFC3 during FY13
- 3) Post-Flash (i.e. Background Enhancement)
 - Recommended **option** for Cycle 20+
 - 10-15 e⁻ per pixel restores most CTE
 - Post-Flash plus background → 12e⁻
 - Cost: increased noise level
 - e.g. zero background UV observation: 3e⁻ readnoise plus 12 e⁻ post-flash is equivalent to 4.6e⁻ readnoise detector
 - Replaces Cy 18-19 Charge-Injection approach (no longer supported).



[See Poster S. Baggett et al 344.06]



Omega Cen Stacked Images:
8x700s (truth image) 9x10s without Post-Flash 9x10s with Post-Flash

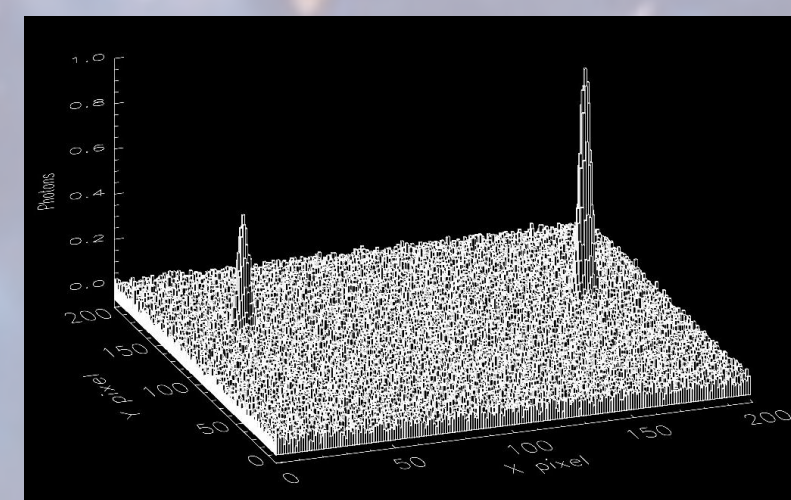
Abstract

We report on the current status and calibration of the Hubble Space Telescope's Wide Field and of Color camera 3. This UV, Visible, near Infrared Camera was installed in 2009 during HST Servicing Mission 4 and has proven to be the most used instrument on the observatory. Recent improvements in its photometric, flat field, dark current, and astrometric calibrations are discussed. As WFC3 approaches the mid-point of its 4th year of operation in space, the impacts of the space environment are presented with particular attention to the consequences of radiation damage on the performance of the CCD detectors. Recent improvements in operational strategies including post-flashing CCD observations are discussed together with recommendations for acquiring optimal observations and methods of improving data analysis. We also highlight recent progress in using observatory level spatial scans to achieve higher dynamic range observations, to obtain higher precision and more efficient photometric measurements of bright sources, to improve our knowledge of the flat fields, and to increase the precision of astrometric measurements.

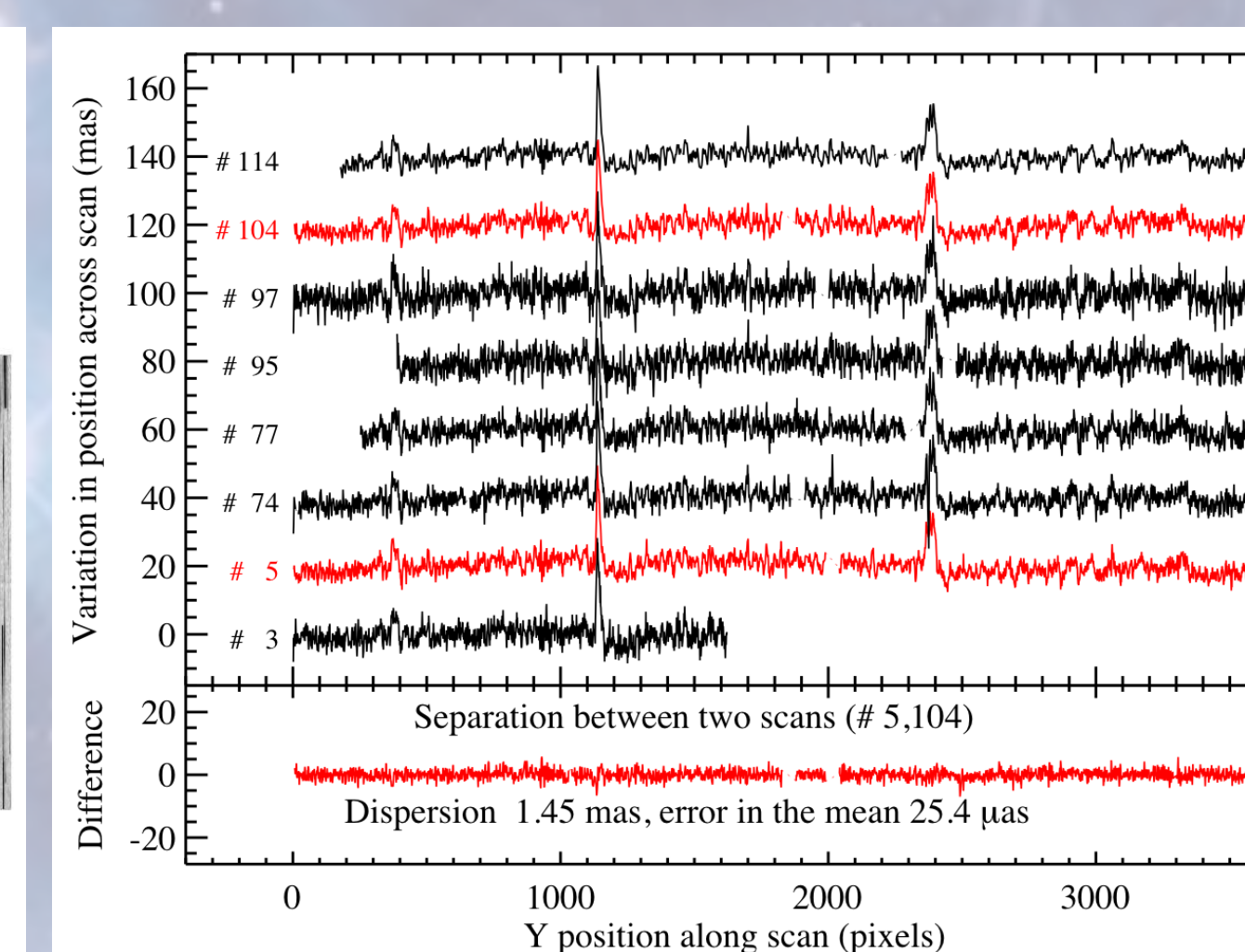
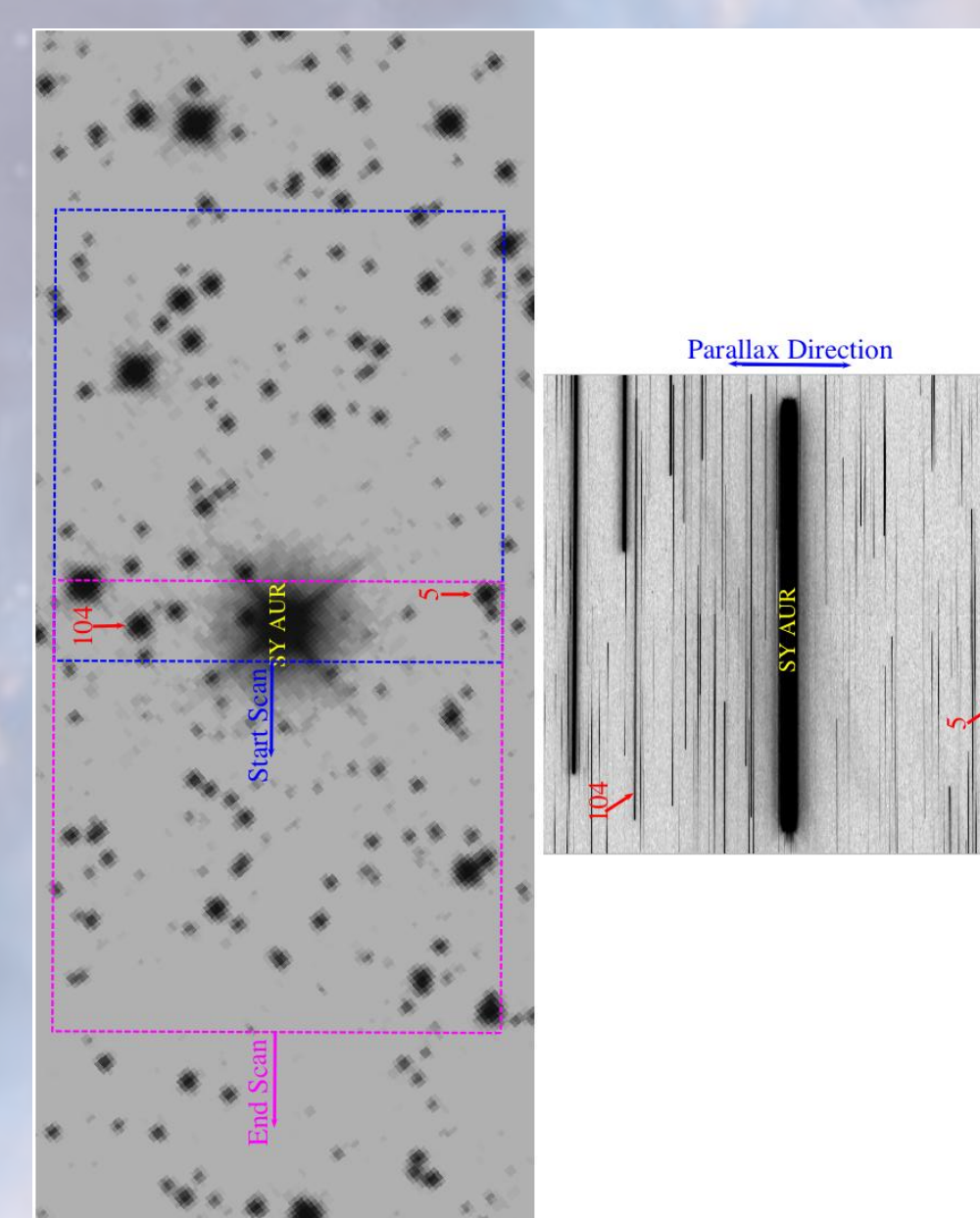
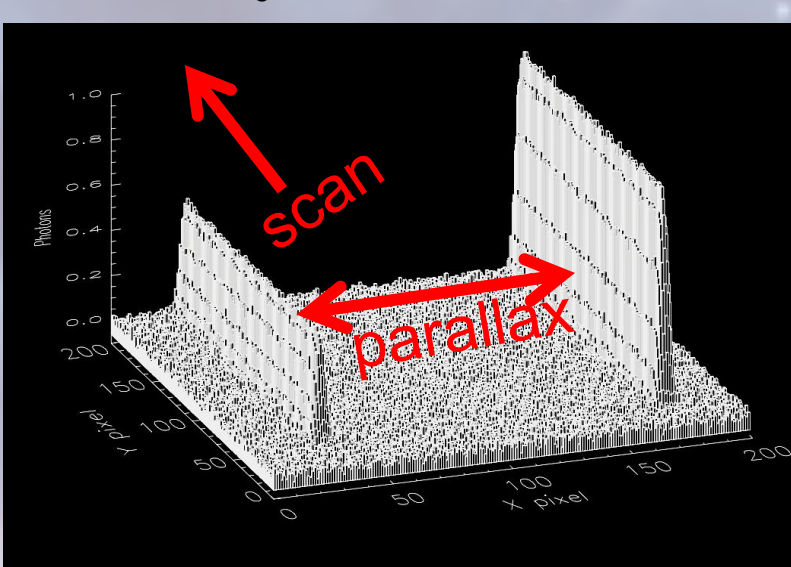
Spatial Scans for High S/N WFC3 Spectroscopy, High Precision Astrometry, and More

- Spatial Scans allow the light from astronomical objects to be trailed across the WFC3 detectors in a predictable and repeatable manner during exposures at rates up to 4.8 arc seconds per second (FGS control) and 7.8 "/s (GYRO control).
- This Enables:
 - Significantly increased S/N observations – especially for infrared spectroscopy of bright sources (e.g. exo-planet transits)
 - Higher precision astrometric measurements orthogonal to the scan direction (measurements to <30 micro-arc seconds)
 - Opportunity to observe brighter sources (especially with the IR detector)
 - Vega has been observed using this technique combined with the IR GRISM -1 order [See Deustua et al Poster 344.12]
 - Multiple scans of a pair of bright stars provides both check on flat fields and a path to improved calibration of mid-spatial freqs

Imaging, PSF $\sigma_0=0.01$ pix

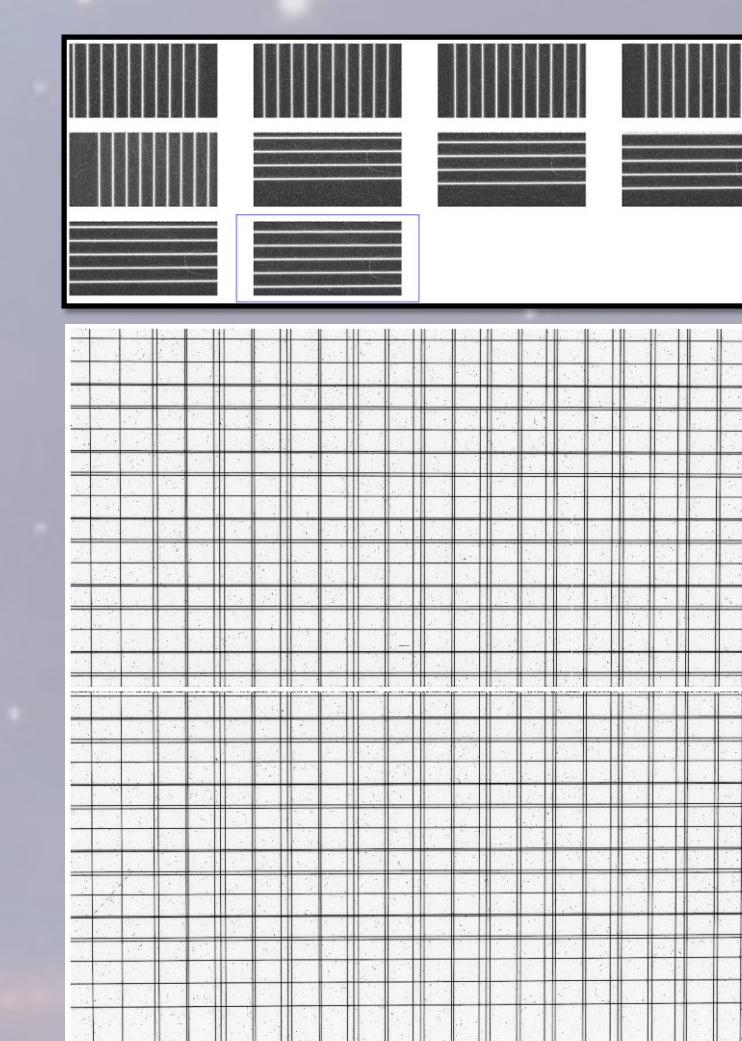


Scanning, $\sigma_0=0.01/\sqrt{N}$ samples pix



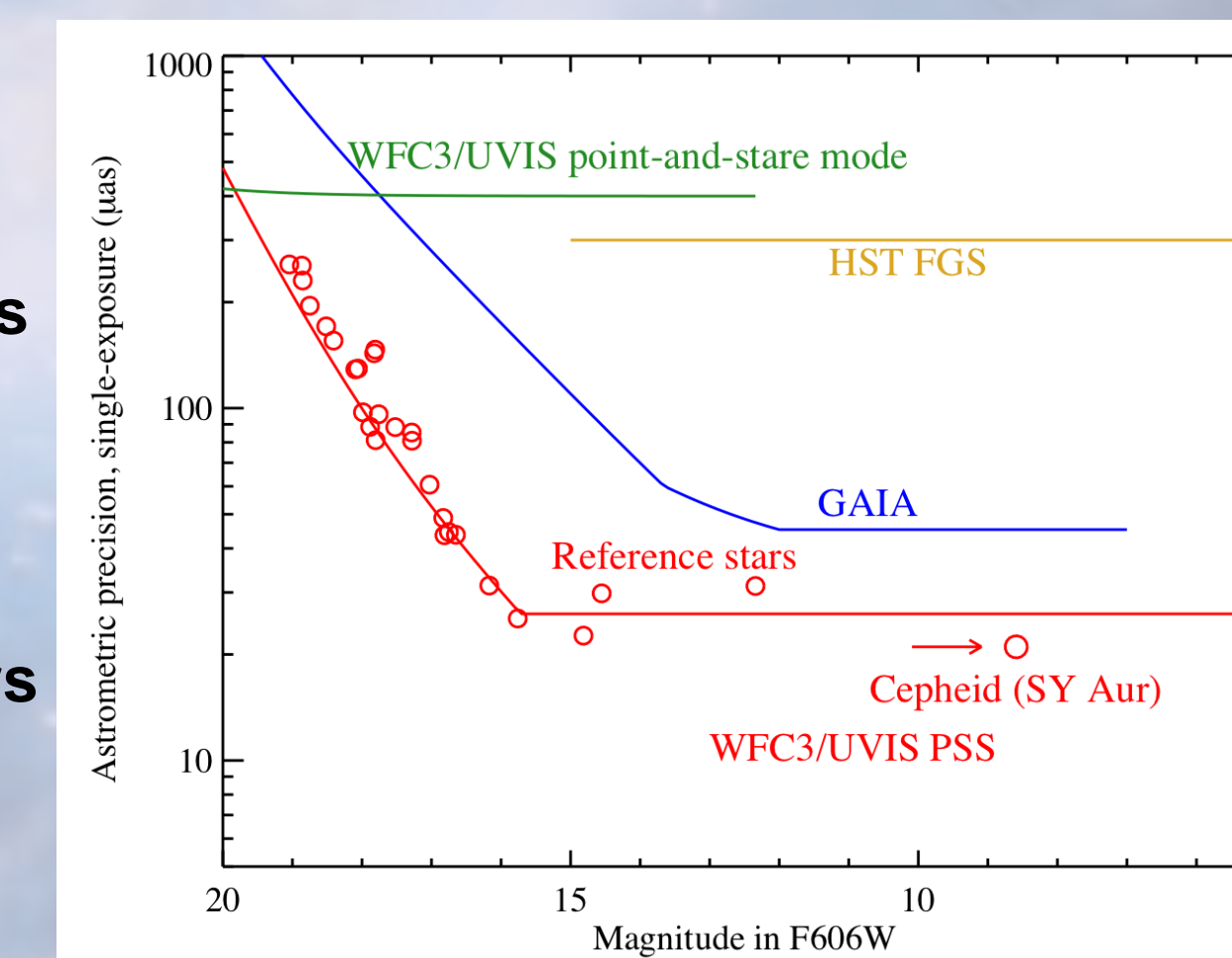
• Above: IR Grism Spectra Image(left) Scan(right)

Below: Star Pair Scans and composite UVIS image



• Example: High Precision Astrometry for Parallax Measurements

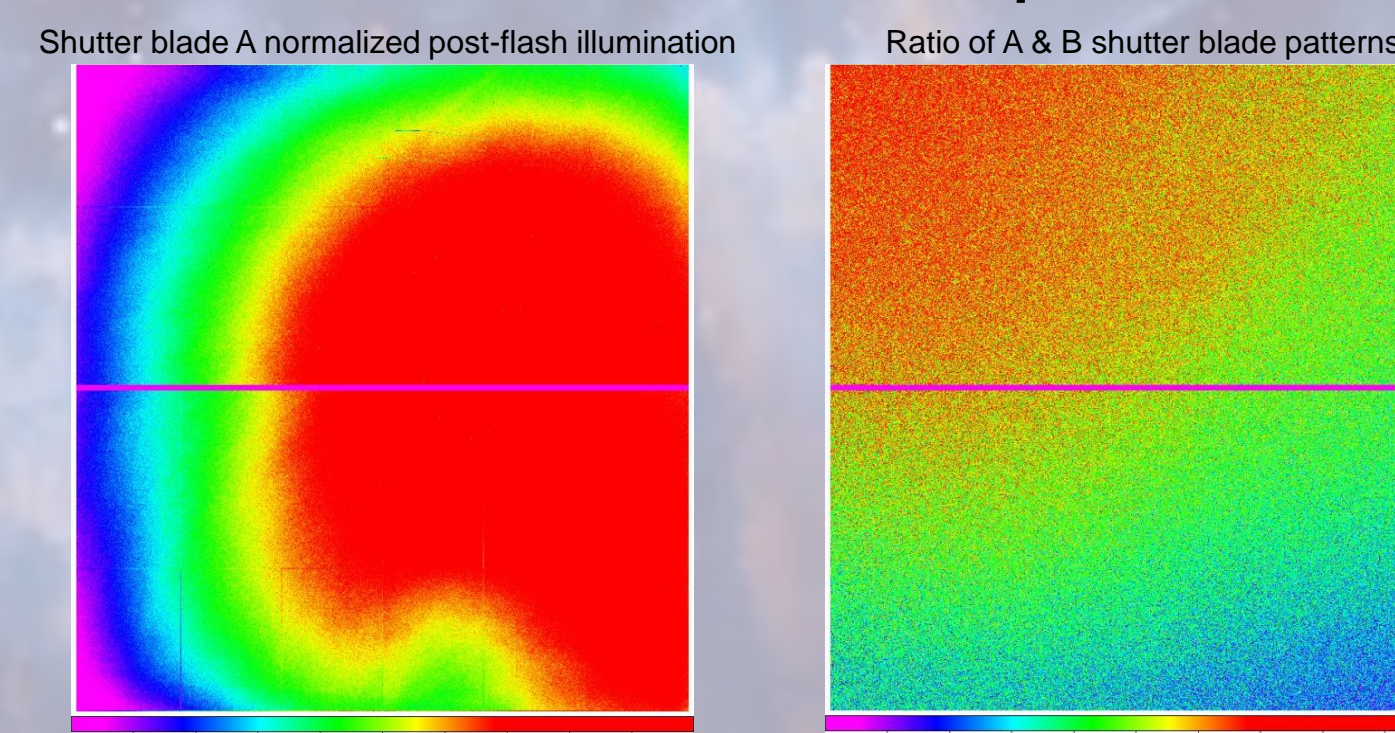
- Precision of centroiding of bright stars is 0.01 pix (400 μ s)
- Scans over several 1000s pixels → factor of >10 better
- Exceeds FGS precision and compares favorably with GAIA
- Spacecraft jitter and astrometric calibration are main factors
 - Differential experiments and multiple reference stars
- Example data available from Proposals 12679 and 12794
- Credit: Riess, Casertano, MacKenty, Anderson



Improved Calibrations

- Photometric Zero Points
 - All UVIS and IR photometric observations re-analyzed with new flats
 - Results at http://www.stsci.edu/hst/wfc3/phot_zp_lbn (March 2012)
 - Most filters have ~1-2% scatter using 4 HST calibrators
 - New: all filters directly measured (removed interpolation to smoothed QE curve)

- Post-Flash Calibration Files became available 5 Dec 2012
 - ~20% variation over UVIS Field of View and +/-3% Shutter Blade difference
 - Pipeline accounts for Blade and Post-Flash exposure time



- Astrometric Calibration
 - Based upon multiple observations of Omega Cen
 - Very stable since SM4
 - UVIS: F225W, F275W, F336W, F390W, F438W, F475W, F555W, F606W, F350LP, F775W, F814W, F850LP, F621M being added for Cycle 21
 - IR: F098M, F105W, F110W, F125W, F139M, F140W, F160W, F153M

- Spectroscopic Mode (GRISM) Calibration [See Poster Pirzkal et al 344.02]
 - www resource → http://www.stsci.edu/hst/wfc3/analysis/grism_obs/wfc3-grism-resources.html#Proposal_Documentation_Information_hdr

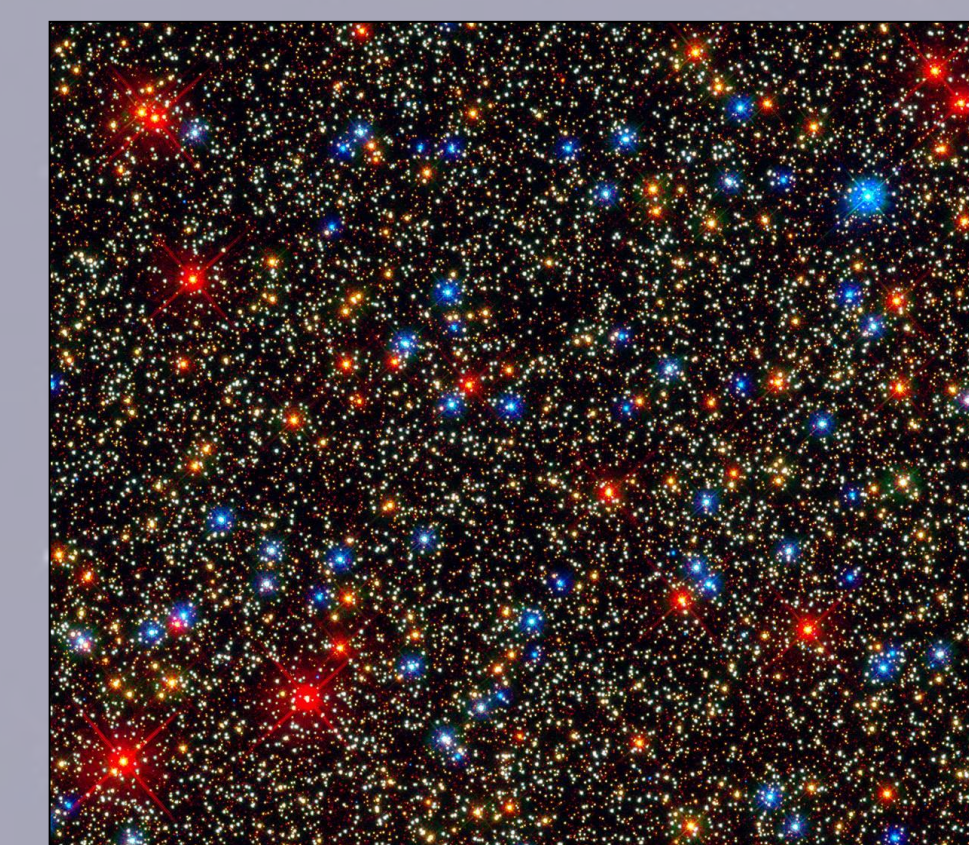
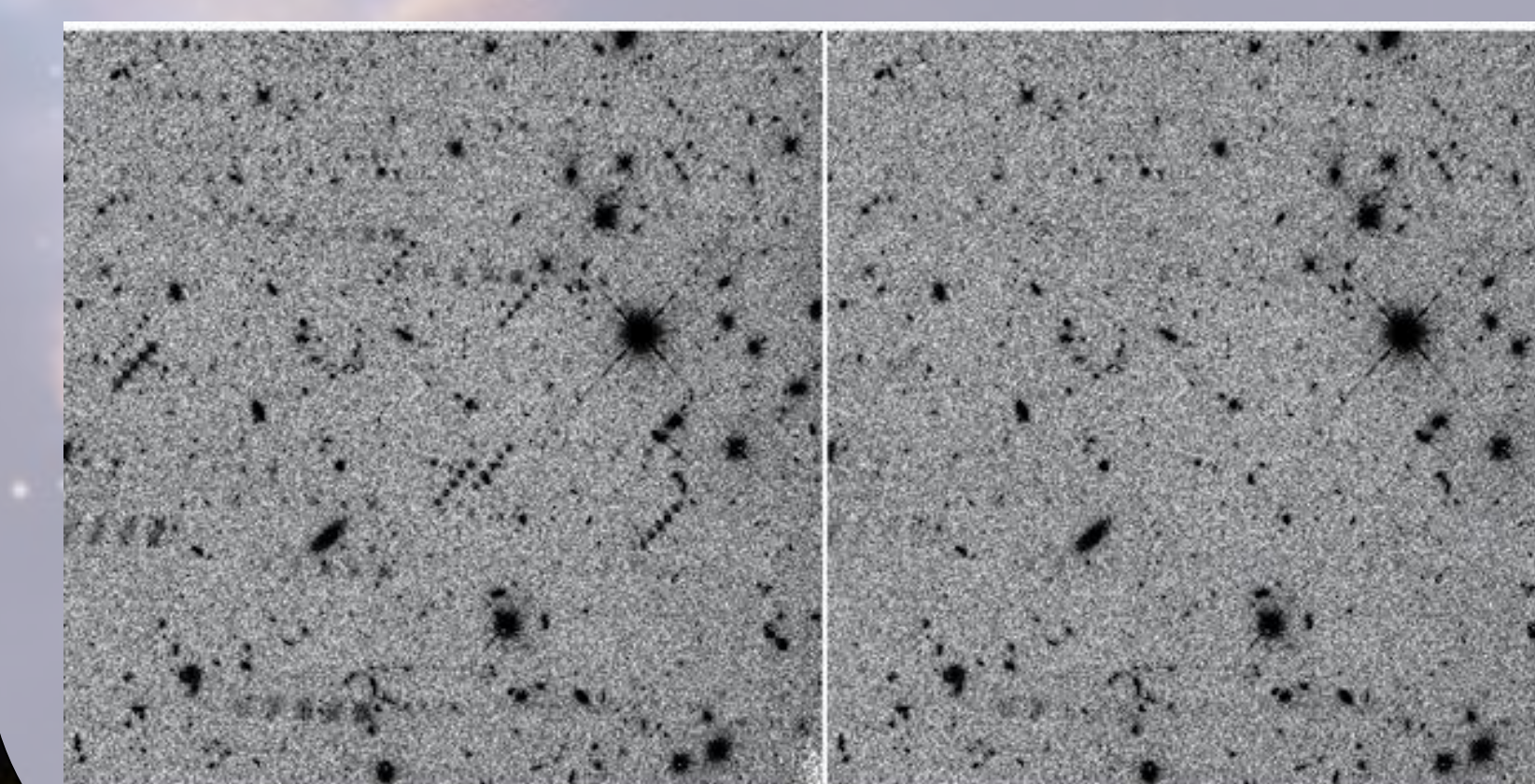
Infrared Image Persistence

- The WFC3/IR detector has excess dark currents for several hours following exposures to ~full well or above producing a typical signal ~0.3 e⁻/s after 1000s

• Mitigation Approaches:

- 1) Users should dither IR images
- 2) STScI manually identifies a subset of the “worst events” in advance and generally precludes other IR observations during several subsequent orbits
- 3) STScI now provides a *predicted* residual image for every WFC3/IR observation

<http://archive.stsci.edu/predps/persist/search.php>



Additional Information:

<http://www.stsci.edu/hst/wfc3>
and
<http://www.stsci.edu/hst/wfc3/documents/ISRs>

Questions and Support: help@stsci.edu