1) Highlights of Recent ACS Team Activities

2) Cycle 24 ACS CAL Plan

3) WFC Long-Term Monitoring Updates

4) Recent ACS Calibration Developments:
   - WFC Subarray Overhaul
   - LED Post-flash Luminance Correction
   - Measurements of SBC PSF Wings (to ≈5”)

5) Additional calibration works-in-progress
Recent ACS Team Activities

- Phase II reviews of *all* Cycle 24 ACS GO/DD/SNAP programs:
  - Reduced Cyc24 usage: WFC = 508 orbits prime + 198 orbits par.; SBC = 48 orbits
  - Current tally, before DD and mid-Cycle additions, is 45 programs using ACS
  - Phase II reviewing is well underway, as of Oct’16

- Revision of ACS Instrument Handbook (for Cycle 25)
  - Revised treatments of WFC geometric distortion, CTE degradation and mitigation
  - Extensive discussion of Cycle 24 changes to WFC subarray modes
  - Incorporating latest developments from last year’s calibration updates [ISR, TIR]

- Support of DD/SNAP legacy programs for the external community
  - Ongoing support of HST Frontier Fields [just finished the last observations!]
    - Phasell preparation & delivery; 4wk base-line superdarks; rapid ReDCaT deliveries after anneals
    - Quality assurance & pipeline “self-calibration” of HFF ACS imagery
  - “Gap-filler” ultra-SNAP program: ~1’ NGC/IC galaxies (for the moment)
## ACS Cycle 24 Calibration Plan

<table>
<thead>
<tr>
<th>PI</th>
<th>Proposal Title</th>
<th>Frequency</th>
<th>Time (orbits)</th>
<th>Scheduling Required</th>
<th>Products</th>
<th>Accuracy Required</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Golimowski</td>
<td>ACD CCD Daily Monitor</td>
<td>3x/week</td>
<td>624</td>
<td>Periodic</td>
<td>Ref flies</td>
<td></td>
<td>Dark, bias creation</td>
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<tr>
<td>Chiaberge</td>
<td>ACS External CTE Monitor</td>
<td>Yearly</td>
<td>8</td>
<td>3Q 2017</td>
<td>correction formula</td>
<td>1% abs</td>
<td>Monitoring of CTE losses to calibrate correction formula</td>
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<tr>
<td>Golimowski</td>
<td>ACS Internal CTE Monitor</td>
<td>2x/cycle</td>
<td>12</td>
<td>Nov 16, May 17</td>
<td>Web, cte ref files</td>
<td></td>
<td>CTE EPER test</td>
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<tr>
<td>Avila</td>
<td>ACS CCD Hot Pixel Annealing</td>
<td>4-weekly</td>
<td>156</td>
<td>Periodic</td>
<td>Ref</td>
<td></td>
<td></td>
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<tr>
<td>Coe</td>
<td>ACS CCD Stability Monitor</td>
<td>Yearly</td>
<td>2</td>
<td>Nov 16, Mar/Jul 17</td>
<td>Ref files</td>
<td>1%</td>
<td>L-flat, Distortion, Photometry</td>
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<tr>
<td>Borncamp</td>
<td>ACS Internal Flat Fields</td>
<td>2x/cycle</td>
<td>16</td>
<td>Nov 16, Aug 17</td>
<td>Ref, IRS</td>
<td>&lt;1%</td>
<td>Track flat field changes, uses lamp</td>
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<tr>
<td>Avila</td>
<td>ACS SBC darks</td>
<td>Yearly</td>
<td>4</td>
<td></td>
<td>Ref, ISR</td>
<td>10%</td>
<td></td>
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<tr>
<td>Bohlin</td>
<td>ACS Photometric Calibration</td>
<td>Yearly</td>
<td>9</td>
<td>Mar 17</td>
<td>ISR, zp, ref files</td>
<td>&lt;1%</td>
<td>Photometric standards; new K-type star added</td>
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<tr>
<td>Wheeler</td>
<td>ACS SBC MAMA Recovery</td>
<td>as needed</td>
<td>4</td>
<td></td>
<td>-</td>
<td>-</td>
<td>After irregular safing</td>
</tr>
<tr>
<td>Bellini</td>
<td>WFC Post-flash Calibration</td>
<td>Yearly</td>
<td>1</td>
<td>Mar 17</td>
<td>Ref, ISR</td>
<td>1%</td>
<td>Post-flash ref file</td>
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<tr>
<td>Anderson</td>
<td>Repinning and reformulation of the ACS/WFC CTE model</td>
<td>as needed</td>
<td>12</td>
<td>Model, ISR</td>
<td></td>
<td></td>
<td>Taken within same anneal pd.</td>
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<tr>
<td></td>
<td>Total requested orbits</td>
<td></td>
<td>23</td>
<td></td>
<td></td>
<td>829</td>
<td></td>
</tr>
</tbody>
</table>

> **Cyc24 CAL orbit-cost is significantly reduced from Cyc23 CAL**
  - 10 fewer external orbits: mostly SBC-related
  - ~230 fewer internal orbits: mostly subarray biases
WFC Read-Noise Monitoring

- All WFC amps’ read noise have been stable since Jan’13 anomaly
- Noise levels remain below pre-SM4 values for all amps
WFC Dark-Current Monitoring

- Global dark-current: slowly and steadily worsening with time
- Improved warm-pixel fidelity from CTE-mitigating post-flash
WFC Absolute Flux Calibrations. I.

• Long-term monitoring of spectrophot. stds:
  – External uncertainty for the absolute flux is ~1%, while the internal consistency of the sensitivities in the broadband ACS filters is ~0.3% among the three primary WD flux stds.
  – For stars as cool as K type, the agreement with the CALSPEC standards is within 1% at the WFC1-1K subarray position, which achieves the 1% precision goal for the first time.
  – Synthetic predictions of WFC & HRC count-rates for the mean of 3 primary WD stds. agree w/ observations to 0.1%.

• (Small) changes made to ACS ETC, ZP webtool
**WFC Absolute Flux Calibrations. II.**

- Revised post-SM4 WFC sensitivity degradation measurements
  - Largely filter-independent value: -0.061%/yr after SM4. [green dashed line]

(from Bohlin 2016, AJ [& ACS-ISR 2016-03])

Post-SM4 WFC
Pre-SM4 WFC
HRC (all pre-SM4)
Dashed: STIS gratings
WFC Subarray Overhaul

- Calibration headaches for post-SM4 ACS/WFC subarrays:
  - De-biasing post-SM4 subarray images
    - Post-SM4 bias structure varies with readout timing pattern (because of new ASIC & DSI)
    - Readout timing patterns, unchanged since pre-SM4, differ b/w subarrays and full-frame
    - Overhead in calibration orbits (~100 orbits/year) to obtain subarray-mode bias frames
    - Overhead in personnel resources to insure subarray biases are contemporaneous
  - Readout-timing Δ makes pixel-based CTE correction inapplicable to non-2K subarrays
  - Readout overheads longer than full-frame; <2K columns prevents bias-shift correction

- Solution: Re-define WFC subarray readouts to match full-frame timing
  - Twelve new subarray modes, all with 2K columns: (512,1K,2K) rows; all 4 quadrants
  - Subarray biases no longer needed (excerpt from full-frame); identical CALACS steps

- Implementation/Validation time-table:
  - GSFC ground-testing (Oct/Nov’15); On-orbit testing (23 Nov’15); OAT (5 Apr’16) recently
  - Successful FSW installation on 2 May’16; validation program executed 9-10 May’16
  - As of OPUS 2016.1 (Aug’16), all new subarray modes are cleanly processed by CALACS
  - Former subarray modes transitioned to “available but unsupported” as of Cycle 24
  - New subarray modes well-documented: ACS IHB for Cycle 24; ACS DHB v8.0; APT
Subarray Validation Program

- Bias-gradient validation
  - Repeat of Nov’15 OOT
  - 5 internal orbits
- CTE validation
  - Same CTE profile?
  - 12 internal orbits
  - FLASH = 0-420e⁻
  - All subarrays & amps
  - Analysis in progress
Curves show the average bias level of 1024 rows in quadrant B for:

- **Blue**: 1K×1K (old, top) and 2K×1K (new, bottom) subarrays
- **Red**: Corresponding regions of full-frame bias
- **Black**: normalized difference of subarray and full-frame
- **Dotted**: ideal fat-zero (min. subarray bias value)

**Take-aways:**

- Bias gradients in the old 1024×1024 subarray and the corresponding region of full frame differ up to ~13 DN (modulo the fat-zero offset and 1/f noise)
- Bias gradients in the new 2048×1024 subarray and the corresponding region of full frame are *identical* (modulo the fat-zero offset and 1/f noise)
- The following two slides show similar results for all new subarrays (512-, 1K-, and 2K-columns) in all four quadrants
**Subarray Validation: Amps A&B**

- Bias gradients for **full-frame vs. subarray** readouts

### 512-subarray

- **Amp A**
- **Amp B**

### 1K-subarray

- **Amp A**
- **Amp B**

### 2K-subarray

- **Amp A**
- **Amp B**

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**STUC – October 2016**
Subarray Validation: Amps C&D

- Bias gradients for full-frame vs. subarray readouts

512-subarray

1K-subarray

2K-subarray

Amp C

Amp D
LED Post-flash Luminance Correction

- Turn-on transient power to LED
- Quadrant-dependent; repeatable
- Deviations ≤10% (from 14 e⁻/sec)
- Asymptotes to steady at >10 sec
- Typical use-case durations:
  - Calibration darks: 4.6 sec
  - GO CTE mitigation: ≈1 sec
  - Reference file: 196 sec
- 3-param fit: good to ~1% (black)
- Correction to CALACS FLASHCORR
- [Year-to-year fading by ~0.1%]
Revised SBC Encircled Energies. I.

- Cyc23 CAL program: isolated WD, $T_{\text{eff}} = 13390$
Revised SBC Encircled Energies. II.

- SOLID: Observed;  DASHED: TinyTim (model)
ACS Works-in-Progress (3–6 mos.)

• Pixel-based CTE correction update
  – All subarrays (new modes should match full-frame CTE)
  – Introduce non-linear time dependence (seen also with UVIS)

• “Save the Pixels”: readout dark (superbiases)
  – “Bad columns” from readout dark are often stable

• Refinement of default WFC AstroDrizzle params.
  – Current ‘MDRIZTAB’ can result in stellar core-clipping for DRZ

• Expanded polarimetry calibrations
  – Several new filters: from F435W to F775W, incl. narrow-band
  – Unique capability for optical: high resolution + precision