WFPC2 Cycle 5 Calibration Closure Report

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ABSTRACT

This report describes in detail the observations planned to maintain and improve the quality of WFPC2 calibrations during Cycle 5 and the status of their analysis as of December 31, 1996.

1. Overview

The main goals of the WFPC2 Cycle 5 calibration program were: 1) to monitor the stability of the camera to insure the continuing good quality of its basic calibration; 2) to solidify our understanding of the camera properties in those areas where the Cycle 4 calibration was incomplete; and 3) to quantify important instrumental effects that were not well understood. The program was designed to achieve these goals efficiently, and has generally succeeded well.

Monitoring of the basic properties of the camera - flat field, throughput, focus, internal electronics - has continued regularly throughout the cycle, and no major variation has been observed except for those that were expected: the throughput decrease in the UV due to contamination, with the nominal throughput fully restored after each decontamination; the monthly growth in the number of hot pixels, with the normal number restored at each decontamination; and the slow focus drift due to OTA desorption, with focus restored by movements of the secondary mirror. A slight secular increase in throughput - at the 1% level - has been observed in some filter/chip combination, and it is currently a subject of study (see also CALWP2 bug, discussed at the end of this section). One new element has been the degradation of the VISFLAT lamp, which has increased significantly during this cycle, leading to an increased reliance on the INTFLAT channel, which has a separate lamp and light path. The change in emphasis from VISFLAT to INTFLAT is only relevant to the monitoring process, and is not expected to affect users in any way.

Significant improvements have been achieved in the quality of most basic calibration reference files: bias, dark, and flat field. High-quality superbias and superdark frames were produced and installed in the pipeline in connection with the Hubble Deep Field effort. We improved the procedure used to generate weekly darks, which are now based on a high-quality superdark with additional information on hot pixels included each week. New flat fields, with both zonal and pixel-to-pixel errors well below 1%, have been generated using a large number of Earth flats. Detailed tracking information for hot pixels has been made available, and a new STSDAS task introduced to use it effectively.
Progress has also been made in understanding the camera throughput in the UV, where the overall detector sensitivity appears to differ from chip to chip at the few percent level, and therefore individual DQE curves are needed for a proper calibration of the overall system throughput. The camera PSF has been characterized in detail, thanks to both a specific calibration program and a thorough search through all available public data. These PSF have been compiled into a Web-searchable library, and - based on our tests - should enable a much better PSF subtraction for images in commonly-used filters. The two, possibly related, camera anomalies known as CTE and long vs. short have been characterized in significant detail, using both calibration and other public data; however, we cannot yet quantify either anomaly reliably enough to make it possible to correct for their effect or to prevent their occurrence. Additional Cycle 6 calibration data are expected to help in this direction.

The work is not yet complete in some areas of the calibration program. The analysis of the photometric zeropoint data awaits spectrophotometry to be obtained using FOS Cycle 6 data; the refinement of the photometric transformation will likewise benefit from additional data taken in Cycle 6. The quality of the polarization calibration now exceeds our original goal, but most of the work has been based on Cycle 4 data, since Cycle 5 data have not been taken yet. Similarly, Cycle 5 data for the throughput calibration of the linear ramp filters will only be taken after the servicing mission. While basic calibrations are available to users in these areas, the completion of the Cycle 5 program should improve their quality significantly.

A major problem has been the recent discovery of a bug in the pipeline calibration of single-chip data. While very few user data are taken in single-chip readout, a significant fraction of calibration data make use of this mode, mostly to allow better efficiency in the observation of bright calibration targets. As a consequence, most of the images taken for programs 6179, 6184, 6186, and for the Cycle 4 polarization program must be recalibrated, and the throughput tables obtained from these images - including the new UV tables - will probably change. Note that the throughput tables in SYNPHOT have not been affected by the bug, and therefore the values of PHOT-FLAM in the headers of calibrated images are correct. The changes will probably be small, but the impact on personnel resources will be significant. Personnel resources quoted in this document do not include any recalibration or re-analysis.

2. Format of this document

This document collects detailed information about individual programs calibration in a standard format. Table 1 presents the original calibration plan, as approved in April 1995. Table 2 details the current status of the Cycle 5 calibration plan (as of November 30, 1996), including actual orbits used, personnel resources, products, and accuracy actually achieved. Personnel resources include only the WFPC2 group, and not support provided by other groups (OSG, SSG). The figures refer to resources used thus far; estimates of future orbits and personnel resources needed to complete the programs are given in parentheses.

The rest of the document consists of detailed descriptions of each calibration program. For each program, the first page (the “Plan”) contains the original description of the planned observations, their purpose, resources needed, and expected results; the second page (the “Results”) includes
any modifications to the Plan, details on the execution, actual resources used, results achieved, a timeline of activity, and plans for any future continuation of the program. If the program is not complete, an estimate is given of the resources that will be necessary for completion.

3. Other information

The information given in this document is necessarily brief. For more details on individual programs, users can refer to additional documents made available by the WFPC2 group and STScI, through the Web, e-mail, or in printed form.

On the Web, the WFPC2 home page can be found at the URL


From there, users can hyperlink to the WFPC2 documentation page, with links to the Instrument Handbook, the Data Handbook, various Status Reports, all the Instrument Science Reports, and various other memos and documents of interest. Other important links in the WFPC2 home page point to the Frequently Asked Questions page and the Software Tools page, which includes the exposure time calculators, the linear ramp filter calculator, and the PSF library interface. Interim reports on CTE can be found at the URL


while the hot pixel lists can be found at


Of interest to users is also the Tiny Tim page, prepared and maintained by John Krist at


For any additional information, or to request documentation, please contact the STScI help desk by e-mail at

help@stsci.edu.

3.1. List of documents and other publications


The list of frequently asked questions (at http://www.stsci.edu/ftp/instrument_news/WFPC2/wfpc2_top_faq.html)

WFPC2 Instrument Science Reports
(also found at http://www.stsci.edu/ftp/instrument_news/WFPC2/wfpc2_bib.html)

92-02: System Level Contamination Issues for WFPC2 and COSTAR, M. Clampin, 9/92

92-03: WFPC2 Science Observation and Engineering Modes, J.T. Trauger and D.I. Brown, 10/92

92-05: WFPC2 AFM and POMM Actuation Algorithm, J.T. Trauger et al., 7/92
92-06: *WFPC2 CCDs*, Mark Clampin, 12/92
93-01: *Polarizer Quad Nomenclature*, Mark Clampin, 3/93
94-01: *Large Angle Scattering in WFPC2 and Horizontal "Smearing" Correction*, John Krist and Chris Burrows, 10/94
94-03: *WFPC2 Pipeline Calibration*, Chris Burrows, 12/94
95-02: *The Geometric Distortion of the WFPC2 Cameras*, Roberto Gilmozzi, et al., 06/95
95-01: *WFPC2 Polarization Observations: Strategies, Apertures, and Calibration Plans*, Biretta and Sparks, 02/95
95-03: *Charge Transfer Traps in the WFPC2*, Whitmore and Wiggs, 07/95
95-04: *A Demonstration Analysis Script for Performing Aperture Photometry*, Whitmore and Heyer, 07/95
95-06: *A Field Guide to WFPC2 Image Anomalies*, Biretta, Ritchie, and Rudloff, 08/95
95-07: *WFPC2 Cycle 4 Calibration Summary*, Baggett, Casertano, and Biretta, 12/95
96-01: *Internal Flat Field Monitoring*, Stiavelli and Baggett, 01/96
96-02: *Contamination Correction in SYNPHT for WFPC2 and WF/PC-I*, Baggett, et al., 02/96
96-04: *Effects of Contamination on WFPC2 Photometry*, Whitmore, et al., 06/96
96-05: *Wavelength / Aperture Calibration of the WFPC2 Linear Ramp Filters*, Biretta, et al., 05/ 96
96-06: *Photometric Calibration of WFPC2 Linear Ramp Filter Data in SYNPHT*, Biretta, Baggett, and Noll, 07/96
96-07: *WFPC2 Throughput Stability in the Extreme Ultraviolet*, MacKenty and Baggett, 05/96
96-08: *WFPC2 Cycle 6 Calibration Plan*, Casertano, et al., 07/96

Internal memos, reports and useful documents

*Post-day 74 SM Move Focus Checks*, Lallo, 1 April 96
*The Logistics of Acquiring AEDP Temperature Data, and their Application to Focus Monitoring*, Lallo, 13 June 96
*Current Focus Status*, Lallo, 7 August 96
*The Day 304 Mirror Move & Breathing Monitoring of Safing Event*, Lallo, 14 November 96


# Table 1: WFPC2 Cycle 5 Calibration Plan

<table>
<thead>
<tr>
<th>ID</th>
<th>Proposal Title</th>
<th>Frequency</th>
<th>Estimated Time (orbits)</th>
<th>Required Resources (FTE)</th>
<th>Products</th>
<th>Accuracy</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>“External”</td>
<td>“Internal”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6183</td>
<td>Decontamination</td>
<td>1/4 weeks</td>
<td>0</td>
<td>144</td>
<td>0.1</td>
<td>TIPS</td>
<td>n/a</td>
</tr>
<tr>
<td>6184</td>
<td>Photometric Monitoring</td>
<td>2/4 weeks</td>
<td>24</td>
<td>0</td>
<td>0.3</td>
<td>ISR</td>
<td>1% Also focus monitor</td>
</tr>
<tr>
<td>6187</td>
<td>Earth Flats</td>
<td>continuous</td>
<td>155</td>
<td>0.4</td>
<td>CDBS</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>6188</td>
<td>Darks</td>
<td>weekly</td>
<td>260</td>
<td>0.2</td>
<td>CDBS</td>
<td>6% Also hot pixel lists on WWW</td>
<td></td>
</tr>
<tr>
<td>6189</td>
<td>Visflat Monitor</td>
<td>2/4 weeks</td>
<td>66</td>
<td>0.1</td>
<td>ISR</td>
<td>&lt; 1% Also monitor lamp health</td>
<td></td>
</tr>
<tr>
<td>6190</td>
<td>Intflat Monitor</td>
<td>1</td>
<td>18</td>
<td>0.1</td>
<td>CDBS</td>
<td>&lt; 1%</td>
<td></td>
</tr>
<tr>
<td>6191</td>
<td>UV Flat Field Monitor</td>
<td>2</td>
<td>12</td>
<td>0.1</td>
<td>ISR</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>6250</td>
<td>Internal Monitor</td>
<td>weekly</td>
<td>80</td>
<td>0.1</td>
<td>CDBS</td>
<td>0.5 e</td>
<td></td>
</tr>
</tbody>
</table>

**Routine Monitoring Programs**

<table>
<thead>
<tr>
<th>ID</th>
<th>Proposal Title</th>
<th>Frequency</th>
<th>Estimated Time (orbits)</th>
<th>Required Resources (FTE)</th>
<th>Products</th>
<th>Accuracy</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6179</td>
<td>Photometric Zeropoint</td>
<td>1</td>
<td>8</td>
<td>0.4</td>
<td>CDBS</td>
<td>1-2%</td>
<td></td>
</tr>
<tr>
<td>6182</td>
<td>Photometric Transformation</td>
<td>2</td>
<td>6</td>
<td>0.4</td>
<td>CDBS</td>
<td>2-5%</td>
<td></td>
</tr>
<tr>
<td>6186</td>
<td>UV Throughput</td>
<td>1</td>
<td>6</td>
<td>0.2</td>
<td>CDBS</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>6192</td>
<td>CTE Characterization</td>
<td>1</td>
<td>4</td>
<td>0.3</td>
<td>ISR</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>6193</td>
<td>PSF Calibration</td>
<td>1</td>
<td>5+4</td>
<td>0.3</td>
<td>ISR</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>6194</td>
<td>Polarizers and Linear Ramp Filter</td>
<td>1</td>
<td>8</td>
<td>0.3</td>
<td>CDBS</td>
<td>3-5%</td>
<td></td>
</tr>
<tr>
<td>6195</td>
<td>Flat Field Check</td>
<td>1</td>
<td>2</td>
<td>0.2</td>
<td>CDBS</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

**Special Calibration Programs**

<table>
<thead>
<tr>
<th>ID</th>
<th>Proposal Title</th>
<th>Frequency</th>
<th>Estimated Time (orbits)</th>
<th>Required Resources (FTE)</th>
<th>Products</th>
<th>Accuracy</th>
<th>Notes</th>
</tr>
</thead>
</table>

**TOTAL TIME (including all executions)**

|       |                          |          |                         |                          |          |          |                                                 |
|-------|--------------------------|----------|-------------------------|--------------------------|----------|----------|                                                 |
|       |                          | 63+4     | 735                     | 3.5                      |          |          |                                                 |
### Table 2: WFPC2 Cycle 5 Calibration Closure

<table>
<thead>
<tr>
<th>ID</th>
<th>Proposal Title</th>
<th>Time Used (orbits)</th>
<th>Personnel Resources (FTE)</th>
<th>Products</th>
<th>Accuracy Achieved</th>
<th>Status of analysis, notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>“External”</td>
<td>“Internal”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6183</td>
<td>Decontamination</td>
<td>168</td>
<td>0.05</td>
<td>WWW</td>
<td>n/a</td>
<td>Done</td>
</tr>
<tr>
<td>6184</td>
<td>Photometric Monitoring</td>
<td>26</td>
<td>0.40</td>
<td>WWW, interim report</td>
<td>1-2%</td>
<td>Done; reported at TIPS; focus monitor to better than 1 micron rms</td>
</tr>
<tr>
<td>6187</td>
<td>Earth Flats</td>
<td>190</td>
<td>0.20</td>
<td>CDBS (ISR)</td>
<td>0.3%r</td>
<td>Done; high quality flat fields generated</td>
</tr>
<tr>
<td>6188</td>
<td>Darks</td>
<td>263</td>
<td>0.40</td>
<td>CDBS (ISR)</td>
<td>1 e/hr</td>
<td>Done; complete hot pixel lists on WWW</td>
</tr>
<tr>
<td>6189</td>
<td>Visflat Monitor</td>
<td>84</td>
<td>0.10</td>
<td>ISR</td>
<td>0.2-1%</td>
<td>Done; visflat lamp degradation found</td>
</tr>
<tr>
<td>6190</td>
<td>Intflat Monitor</td>
<td>43</td>
<td>0.10</td>
<td>ISR</td>
<td>0.1-1%</td>
<td>Done</td>
</tr>
<tr>
<td>6191</td>
<td>UV Flat Field Monitor</td>
<td>4</td>
<td>0.05</td>
<td>TIPS</td>
<td>2-10%</td>
<td>Done; lower accuracy for F160BW</td>
</tr>
<tr>
<td>6250</td>
<td>Internal Monitor</td>
<td>72</td>
<td>0.25</td>
<td>CDBS (ISR)</td>
<td>0.5 e</td>
<td>Done; high-quality superbias installed</td>
</tr>
<tr>
<td></td>
<td><strong>Routine Monitoring Programs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6179</td>
<td>Photometric Zeropoint</td>
<td>7</td>
<td>0.05 (+0.20)</td>
<td></td>
<td></td>
<td>Analysis awaiting FOS spectra</td>
</tr>
<tr>
<td>6182</td>
<td>Photometric Transformation</td>
<td>6</td>
<td>0.20 (+0.10)</td>
<td>Synphot (ISR)</td>
<td>2-5%</td>
<td>30% done; contamination measurements completed Oct 96, more analysis ongoing</td>
</tr>
<tr>
<td>6186</td>
<td>UV Throughput</td>
<td>9</td>
<td>0.15 (+0.05)</td>
<td>(Synphot) (ISR)</td>
<td>1%</td>
<td>90% done; new throughput tables generated</td>
</tr>
<tr>
<td>6192</td>
<td>CTE Characterization</td>
<td>6</td>
<td>0.40</td>
<td>ISR, WWW, interim report</td>
<td>1-5%</td>
<td>75% done; Cycle 6 data needed for full assessment</td>
</tr>
<tr>
<td>6193</td>
<td>PSF Calibration</td>
<td>5</td>
<td>0.45 (+0.05)</td>
<td>PSF library (WWW)</td>
<td>5-10%</td>
<td>75% done; interface to PSF library ongoing</td>
</tr>
<tr>
<td>6194</td>
<td>Polarizers and Linear Ramp Filter</td>
<td>1 (+23)</td>
<td>0 (+76)</td>
<td>0.35 (+0.35)</td>
<td></td>
<td>Observations to be completed (3 more orbits before SMOV, rest after)</td>
</tr>
<tr>
<td>6195</td>
<td>Flat Field Check</td>
<td>4</td>
<td>0.05 (+0.05)</td>
<td></td>
<td></td>
<td>Analysis ongoing</td>
</tr>
<tr>
<td></td>
<td><strong>Total Time</strong></td>
<td>68 (+23)</td>
<td>824 (+76)</td>
<td>3.20 (+0.80)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Proposal ID 6179: WFPC2 Cycle 5: Photometric Zeropoint

Plan

Purpose: Set synthetic zero points of all WFPC2 filters

Description: GRW+70d5824 is observed through all filters not in the photometric calibration monitors and longward of F336W (inclusive). It is observed in both PC1 and WF3. This dataset is directly comparable to the corresponding results for cycle 4 (program 5572). Because of possible errors in the spectrophotometry for this target, and in order to check synthetic color transformations over a reasonably wide range of colors, the observations are repeated with 3 red standards, and 2 other blue standards in WF3 only. This time most of the 18 broad and medium bandpass filters longward of F336W are included (restricted to 1 orbit/target). If CTE calibration fails, this proposal may need to be run with preflash (and take more time or do fewer targets).

Fraction of GO/GTO Programs Supported: 100% - this proposal is needed by all GO proposals that want to do quantitative photometry at the few percent level

Resources:

- Observation: 8 pointed orbits
- Analysis: 0.4 FTE

Special Requirements: Assumes that the CTE proposal has been run and gives satisfactory results. Therefore it must be run at least 4 months after it

Accuracy: Overall discrepancies between the synthetic photometric products and the results of this test should be reduced to at most 2% rms in the photometric filter set, with a goal of 1% rms. Part of the point of the test is to measure this accuracy, which will largely depend on the accuracy of the spectrophotometric calibration sources

Products: After pipeline processing, each image will be reduced by aperture photometry to measure the throughput of each filter. These numbers can be directly compared to SYNPHOT predictions. Systematic differences will be corrected in the throughput database by tweaking the filter normalizations (already done for the primary target in Cycle 4), overall system response (which is quite uncertain particularly longward of 8000A), and finally bandpass shapes. Residual differences will give an idea of the intrinsic accuracy of the calibration. Expected to run once in the cycle, approximately at the end of 1995
**Results**

**Modifications:** The observations were executed without preflash. The targets chosen were observatory-wide blue standards G191B2B and HZ44, solar-type standards S121-E and P177-D, and the very red standard SA95-330. None of the red stars is a spectrophotometric standard, as none could be identified within the acceptable magnitude range. The two solar-type standards were chosen among the likely NICMOS standards on the basis of information available in Fall 1995, with the plan to obtain FOS spectrophotometry for them. P177-D was in fact chosen for NICMOS, along with two other solar-type standards that will be observed with WFPC2 as part of the corresponding Cycle 6 program 6934.

**Execution:** Nominal.

**Resources Used:**

- **Observation:** 7 pointed orbits
- **Analysis:** 0.05 FTE to define program; analysis TBD pending completion of FOS observations (6925). Will likely take 0.2 FTE

**Accuracy Achieved:** N/A

**Products:** N/A

**Time-line:** Observations executed in February 1996. Analysis to be carried out after completion of FOS observations (program 6925), in spring 1997.

**Continuation Plan:** Two other NICMOS standards to be observed in Cycle 6, along with two selected Landoldt fields containing several standards each (program 6934). Observations of primary WFPC2 standard GRW+70d5824 to be repeated to verify the stability of zero points.
Proposal ID 6182: WFPC2 Cycle 5: Photometric Transformation

Plan

Purpose: Update photometric transformations to Johnson - Cousins system

Description: A photometric standard star field in Omega Cen is observed twice, once at the September 1994 orientation and once rotated by 180 degrees (to correct to first order for residual CTE effects). All broad and medium bandpass filters are used. Based on cycle 4 program 5663, this proposal also gives a check on the long term full field photometric stability of the instrument

Fraction of GO/GTO Programs Supported: 40%

Resources:

   Observation: 6 pointed orbits

   Analysis: 0.4 FTE

Special Requirements: Assumes that the CTE proposal has been run and gives satisfactory results

Accuracy: Independent of the synthetic photometry results this test gives direct transformations to the Johnson-Cousins system for red sources. These transformations should be accurate to 2-5%. The stability of these transformations will be measured to the 1% level. Among other things, the test will allow us to determine how well WFPC2 filters can be used to approximate Johnson-Cousins magnitudes for stars of various spectral types

Products: A comparison with the corresponding cycle 4 monitor (which ran monthly) will verify the photometric stability of the camera. Direct transformations to the Johnson-Cousins photometry system can be derived for all filters. The observations also provide a check of the astrometric and PSF stability of the instrument over its full field of view. Expected to run 9/95 and 3/96
**Results**

**Modifications:** None. No preflash was used

**Execution:** Nominal.

**Resources Used:**

**Observation:** 6 pointed orbits

**Analysis:** 0.2 FTE for contamination study; another 0.1 FTE required for completion

**Accuracy Achieved:** 2-5% in characterization of contamination across field of view, depending on filter

**Products:** Synphot update (to be delivered together with UV throughput from program 6186); ISR on contamination


**Continuation Plan:** Cycle 6 program 6935 continues this program and adds several additional tests: a CTE test using long and short exposures, a test of the spatial dependence of contamination, a direct measurement of the vignetting function of the rotated Woods filter, and checks of gain ratios and zero point differences across chips. The additional information should help make photometric transformations more reliable

<table>
<thead>
<tr>
<th>Filter</th>
<th>PC1</th>
<th>+/-</th>
<th>WF2</th>
<th>+/-</th>
<th>WF3</th>
<th>+/-</th>
<th>WF4</th>
<th>+/-</th>
</tr>
</thead>
<tbody>
<tr>
<td>F160BW</td>
<td>-0.263</td>
<td>0.030</td>
<td>-0.378</td>
<td>0.090</td>
<td>-0.393</td>
<td>0.051</td>
<td>-0.381</td>
<td>0.066</td>
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<tr>
<td>F170W</td>
<td>-0.160</td>
<td>0.011</td>
<td>-0.284</td>
<td>0.005</td>
<td>-0.285</td>
<td>0.006</td>
<td>-0.232</td>
<td>0.006</td>
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<tr>
<td>F218W</td>
<td>-0.138</td>
<td>0.009</td>
<td>-0.226</td>
<td>0.015</td>
<td>-0.255</td>
<td>0.010</td>
<td>-0.213</td>
<td>0.033</td>
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<tr>
<td>F255W</td>
<td>-0.070</td>
<td>0.007</td>
<td>-0.136</td>
<td>0.017</td>
<td>-0.143</td>
<td>0.009</td>
<td>-0.108</td>
<td>0.042</td>
</tr>
<tr>
<td>F336W</td>
<td>-0.016</td>
<td>0.008</td>
<td>(-0.038)</td>
<td>(0.018)</td>
<td>(-0.043)</td>
<td>(0.010)</td>
<td>-0.057</td>
<td>0.011</td>
</tr>
<tr>
<td>F439W</td>
<td>-0.002</td>
<td>0.007</td>
<td>(0.002)</td>
<td>(0.014)</td>
<td>(-0.022)</td>
<td>(0.007)</td>
<td>-0.021</td>
<td>0.010</td>
</tr>
<tr>
<td>F555W</td>
<td>-0.014</td>
<td>0.006</td>
<td>(0.007)</td>
<td>(0.013)</td>
<td>(-0.007)</td>
<td>(0.007)</td>
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<td>(0.020)</td>
<td>(0.020)</td>
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<td>(0.013)</td>
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<td>(0.009)</td>
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**Table 3:** Throughput decrease over 30 days for different chips, based on data taken for Proposal 6182 (from Whitmore et al, ISR WFPC2 96-04). The results are consistent with those derived from the photometric monitoring (see Figure 1).
Proposal ID 6183: WFPC2 Cycle 5: Decontamination

Plan

Purpose: Remove UV blocking contaminants from CCD windows

Description: Based on Cycle 4 program 5568 with bias frames added. A sequence of observations is defined that is run twice - once before and once after a DECON when the CCDs are heated to +20C for 6 hours. The sequence consists of 2 bias frames at each gain setting, 5 1800 second darks, 2 inflats through f555w at each gain, and two K-spot images. The observations are arranged so that the first sequence occurs about 33 hours before the DECON, and the second follows it by 12 hours. The proposal is run every 4 weeks

Fraction of GO/GTO Programs Supported: 100%

Resources:

Observation: 144 occultation periods (internal)

Analysis: 0.1 FTE

Special Requirements: Requires use of WF2 SI DECON QUASISTATE

Accuracy: This proposal is mainly designed to test aliveness, and monitor the instrument to ensure that no untoward effects from the DECON have occurred. It will identify all hot pixels that are annealed by the DECON

Products: The data is examined and checked for anomalies. The dark frames are processed to yield plots showing the growth and annealing of hot pixels
**Results**

**Modifications:** There were 13 Cycle 5 executions, rather than 12, in order to keep to a four-week cycle rather than a monthly cycle. Because of the adverse effect of residual images, darks associated with this program (the last set of darks taken within each decontamination cycle) were protected from intervening WFPC2 science observations. This ensures that a complete list of hot pixels will be available for each decontamination cycle.

**Execution:** Nominal

**Resources Used:**

- **Observation:** 168 occultation periods; no WFPC2 observations allowed for 4 orbits for each execution, while camera warms up and cools down
- **Analysis:** 0.05 FTE specifically associated with decontaminations; other related work on biases, intflats and darks is accounted for in programs 6250, 6190 and 6188, respectively

**Accuracy Achieved:** N/A (see 6250, 6190 and 6188 for biases, intflats and darks)

**Products:** Updates to history files on Web; used in generating hot pixel lists

**Time-line:** N/A

**Continuation Plan:** Decontaminations are continued in Cycle 6 with same structure and frequency
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**Table 4:** Dates and parameters of all WFPC2 decontaminations through December 1996 (from the WFPC2 History Memo, maintained by S. Baggett and M. Wiggs and available on the Web).
Figure 1: Results of the photometric monitoring for the PC through October 1996. Starting with Cycle 5 (July 1995), data were taken in a different camera each month (except for F170W), resulting in the sparser data points - and halving the required number of orbits. The vertical dotted lines correspond to decontaminations (decons); especially in the UV, count rates drop before each decon, to be restored to the “normal” throughput after the decon. Data for the other cameras show similar trends, but are being recalibrated and reduced again after discovery of the CALWP2 bug. Plot generated and maintained on the Web by S. Gonzaga (originally by C. Ritchie).
Proposal ID 6184: WFPC2 Cycle 5: Photometric Monitor

Plan

Purpose: Monthly external check of instrumental stability

Description: GRW+70d5829 is observed through F170W in all four chips. It is then observed in one chip for filters F160W, F185W, F218W, F255W, F300W, F336W, F439W, F555W, F675W, F814W to fill out the orbit. The chip chosen is changed each month, so each chip is used three times during the year. One extra F555W exposure is taken through the PC to allow for focus monitoring. The proposal is run once before and once after (with the same chip selected) each monthly decontamination. Based on cycle 4 programs 5629 + 6143 (5563)+5564

Fraction of GO/GTO Programs Supported: 100%

Resources:

  Observation: 24 pointed orbits

  Analysis: 0.3 FTE

Special Requirements: None

Accuracy: Overall discrepancies between the results of this test should be less than 1% rms. The point of the test is to measure this variation

Products: After pipeline processing, each image will be reduced by aperture photometry to measure the throughput of the filters. These numbers can be directly compared to results for previous months. This will allow the long term performance of the instrument to be checked for changes, and verify that the decontaminations are satisfactory. This proposal will be run every 4 weeks in association with the DECON

Figure 2 (on next page): HST focus history as measured from phase retrieval on PC images (from Matt Lallo’s focus report). The secular decrease in focus position is due to the continuing shrinkage of the OTA metering truss; the discontinuities, roughly every 6 months, correspond to the movements of the secondary mirror. The dashed line is a linear regression to the measurements, corresponding to a shrinkage of about 0.75 micron/month.
Results

Modifications: Cycle 5 included 13 executions (every 4 weeks) instead of 12 (monthly)

Execution: Nominal

Resources Used:

Observation: 26 pointed orbits

Analysis: 0.15 FTE for program definition and routine photometry; 0.05 FTE for focus monitoring plus 0.10 FTE provided by Observatory group; 0.2 FTE for follow-up study of effect of focus on aperture photometry (total of 0.4 FTE spread over the Cycle 4, 5 and 6 data)

Accuracy Achieved: 1-2% in trending routine photometry; 2-5% in assessing UV contamination; 1.5 micron of secondary mirror defocus in focus measurements; 2% in trending aperture corrections vs. focus position

Products: Routine photometry presented in TIPS meetings, plots made available through WFPC2 WWW pages; focus data presented at TIPS and summarized in internal memos; ISR on aperture corrections vs. focus (November 1996)

Time-line: execution, routine photometry and focus measurement throughout cycle, with typical 2 week interval between observation and analysis; for aperture photometry vs. focus, early results in June 1996, ISR completed in November 1996

Continuation Plan: continue monitoring with same frequency and minor changes to ensure that individual executions fit within 1 orbit
Proposal ID 6186: WFPC2 Cycle 5: UV Throughput

Plan

Purpose: Update SYNPHOT database for UV throughput

Description: GRW+70d5824 is observed shortly before and after a DECON through all the UV filters in each chip and through F160BW crossed with F130LP, F185LP and F165LP (where applicable) to determine the wavelength dependence of the throughput across the bandpass (hence color terms). Based on no particular cycle 4 program, this program is designed to better characterize the spectral response curve in the UV, and the spectral shape introduced by the contamination

Fraction of GO/GTO Programs Supported: 20%

Resources:

Observation: 6 pointed orbits

Analysis: 0.2 FTE

Special Requirements: Must be phased with decntamination cycle; one execution just before, one just after decontamination

Accuracy: Overall discrepancies between the updated synthetic photometric products and the results of this test should be 1-2% rms. This does not mean that the UV throughput will be known to this accuracy primarily because of uncertainties in the flux calibration of the standard used (5%), uncertainties in the UV flatfields (maybe 3% near the chip center), and time dependent contamination corrections (3% error), and uncertainties in the CTE correction (2%). The derived UV absolute photometric accuracy at the center of the chips should therefore be about 10%

Products: After pipeline processing, each image will be reduced by aperture photometry. The throughput curves and their normalizations can be updated by trial and error. Expected to run 8/95
Results

**Modifications:** Some pre-decontamination exposures with crossed filters needed to be dropped to limit the length of the program

**Execution:** Nominal

**Resources Used:**

- **Observation:** 9 pointed orbits
- **Analysis:** 0.15 FTE used in initial analysis; an additional 0.05 FTE will be necessary to repeat the analysis after CALWP2 single-chip fix

**Accuracy Achieved:** Based on incorrectly calibrated data, residuals of 5% or smaller could be obtained in matching synthetic and observed counts; the accuracy may improve with the correctly calibrated observations

**Products:** will deliver ISR and new SYNPHOT tables when finished; CALWP2 bug discovered when analysis complete

**Time-line:** data obtained in August 1995, photometry and first check of SYNPHOT in November 1995; full analysis completed in October 1996, will be redone in December

**Continuation Plan:** Repeat subset of the observations in Cycle 6, before and after SMOV; add Lyman alpha test
Proposal ID 6187: WFPC2 Cycle 5: Earth Flats

Plan

Purpose: Generate flat fields for pipeline

Description: 4 sets of 200 earth streak-flats are taken to construct high quality narrow-band flat fields with the filters F160BW, F375N, F502N, F656N and F953N. Of these 200 perhaps 50 will be at a suitable exposure level for destreaking. The resulting earth superflats map the OTA illumination pattern and will be combined with SLTV data (and calibration channel data in case of variation) for the WFPC2 filter set to generate a set of superflats capable of removing both the OTA illumination and pixel-to-pixel variations in flatfield. The Cycle 4 plan is being largely repeated except: 1. UV filters are dropped because measurement is generally only of redleak. 2. F160Bw is retained in order to check for developing pinholes. 3. Crossed filters used as neutral densities are eliminated (illumination pattern is wrong). 4. An attempt will be made to schedule some broad bandpass measurements on the dark earth. Based on cycle 4 programs 5570+5571+6142

Fraction of GO/GTO Programs Supported: 100%

Resources:

Observation: 155 occultation periods (external, non-pointed; no impact on science time)

Analysis: 0.4 FTE

Special Requirements: We would like to schedule some dark earth broadband visible streak flats

Accuracy: Overall accuracy of the flats derived from this test and the corresponding Cycle 4 observations should be below 1% rms. Discrepancies between the results of this test and those from cycle 4 should be 1% rms. Differences between the two datasets analysed separately will measure the flat field variability to this level. These data together with the flat field check proposal should enable similar accuracy in the broad bandpass flats

Products: This proposal provides medium and narrow bandpass streak flats which can be combined with the high frequency information in the TV flats to yield accurate flat fields. The ratio of the TV and derived flats provides a correction that can also be applied to the TV broad bandpass data. We may also get broad band flat fields directly for comparison from the sky or from this proposals exposures on the earth’s shadow
Results

Modifications: Earth flats in F160BW were added to complement the VISFLAT monitoring of pinholes in that filter

Execution: Nominal

Resources Used:

Observation: 190 occultation periods

Analysis: 0.2 FTE for the Cycle 5 proposal (additional 0.2 FTE for Cycle 4)

Accuracy Achieved: Large scale residuals are well below 1%; single-pixel noise should be of order 0.3%

Products: CDBS: a complete new set of flat fields (excludes UV)

Time-line: Observations executed throughout the cycle; analysis complete and flat fields delivered during spring and summer 1996

Continuation Plan: Earth flats will continue to be taken regularly in Cycle 6 to monitor changes in the instrumental response and in the filter uniformity. Dark Earth flats will be taken to test the viability of direct flat-fielding of broad band filters (bright Earth images in broad band filters long-wards of U are saturated even in the shortest exposures, and flat fields are currently obtained by bootstrapping from narrow-band images). From the first tests, it appears that the dark Earth images may not have sufficient signal for this strategy to be viable.

Figure 3: Ratio of single raw F502N cycle 5 Earth flat to cycle 4 calibration flat, both effectively taken 9 days after decontamination. Very little long-term change is seen in the flat field between cycles. Diagonal bars are 0.2% in strength, and are caused by small changes in the optical alignment. By comparison, the monthly decon cycle induces flat field variations between 0.5 to 1%. Display scale runs from -1% (black) to +1% (white). Figure prepared by John Biretta as part of the detailed analysis of WFPC2 flat fields.
Proposal ID 6188: WFPC2 Cycle 5: Darks

Plan

Purpose: Provide dark frames for pipeline reduction, and hot pixel lists

Description: 5 dark frames are taken every week to provide ongoing calibration of the CCD dark current rate and to monitor and characterize the evolution of hot pixels. Over an extended period these data provide a monitor of radiation damage to the CCDs. The dark frames will be obtained with the CLOCKS=OFF. In addition, 4 darks are taken per month with CLOCKS=ON (although there is no effect such as amplifier glow expected from running the serial register for these CCDs)

Fraction of GO/GTO Programs Supported: 80%

Resources:

Observation: 260 occultation periods (internal)

Analysis: 0.2 FTE

Special Requirements: None

Accuracy: The accuracy of the superdark computed from these data depends on the number of frames combined. The present practice is to combine them in groups of 10 frames for pipeline superdarks. This gives a median signal to noise of 16, and higher signal to noise on hotter pixels than the median (with the somewhat shaky assumption that the dark noise is Poisson). This means that the residual systematic error after superdark subtraction on an 1800 second exposure is about 3 electrons - much less than the read noise. This residual can in principle be further reduced to 0.4 electrons if a superdark is generated from all of the dark frames, with suitable masking based on hot pixel lists

Products: The data are grouped into sets of 10 frames every two weeks. These are combined into superdarks for use in the pipeline. In addition, hot pixel lists can be generated with a time resolution of one week
**Results**

**Modifications:** Regular darks in the last week of each decontamination cycle were dropped in favor of protecting the decontamination-attached darks from interspersed WFPC2 science. The rationale for this decision is that five weekly darks are sufficient to identify anomalous pixels, and normal pixels are stable enough that weekly measurements are not required. On the other hand, the last set of darks - just before decontamination - is crucial to the identification of all suspect warm pixels for the decontamination cycle, and as such, they need to be protected from occasional residual images due to well-exposed extended sources (planets are a frequent cause of residual images).

**Execution:** Nominal

**Resources Used:**

**Observation:** 263 occultation periods between July 17, 1995 and August 26, 1996; does not include 48 executions between September 2 and November 8, 1996, and 22 more expected to run through December 4, which are part of the Cycle 6 program even though they were obtained under proposal 6188 to aid PRESTO implementation.

**Analysis:** 0.20 FTE for routine generation of reference files and warm pixel lists; 0.15 FTE to modify the procedure to generate reference files; 0.05 FTE to support implementation of new STSDAS task (does not include actual coding, done in the Software Support group).

**Accuracy Achieved:** About 1 e/hr, or 6%, for “normal” (i.e., non-warm) pixels; warm pixels can be measured to about 10-30 e/hr, but their intrinsic fluctuation can be significantly larger. Notice that the method used to generate darks was changed in summer 1996, resulting in much better quality for normal pixels.

**Products:** CDBS: weekly dark calibration files; STSDAS: new task (warmpix) for the correction of variable and warm pixels; WWW: hot pixel lists for use by themselves and with warmpix task. Comprehensive ISR in preparation.

**Time-line:** Observations taken weekly; new calibration files delivered generally within two weeks, generation procedure modified in August 1996; warm pixel lists made available monthly, typically within 1 month of nominal date; warmpix task completed in November 1995, now part of general STSDAS distribution.

**Continuation Plan:** Continue current policies.
Proposal ID 6189: WFPC2 Cycle 5: Visflats Monitor

Plan

Purpose: Monitor internal flatfields of instrument

Description: All use of the VISFLAT channel is concentrated in this proposal. It is based on Cycle 4 programs 5568 and 5655. The program takes one complete set of exposures using the visible cal-channel lamp (VISFLATS) at the start of the cycle through all visible filters. Monthly, VISFLATS will be obtained with the photometric filter set (F336W, F439W, F555W, F675W and F814W), both before and after the DECON. A monthly VISFLAT exposure with the Woods filter F160BW allows its visible transmission to be monitored. Two monthly VISFLAT exposures obtained through the LRF (FR533N), one at each gain, provide a monitor of the ADC’s performance. The VISFLAT exposures should be packed together to optimize use of each lamp-on cycle.

Fraction of GO/GTO Programs Supported: 100%

Resources:

Observation: 66 occultation periods (internal)

Analysis: 0.1 FTE

Special Requirements: Use of VISFLATS calibration channel

Accuracy: The internal flats, when well exposed are each accurate to 0.6% in terms of the pixel to pixel (high frequency) variations in the CCDs. Thus high frequency flat field stability can be verified to 1%. When the results from several filters are combined it will be possible to check that the CCDs are indeed relatively stable to much better than 1%

Products: The complete filter set sweep will be compared to the corresponding Cycle 4 dataset primarily to verify that none of the filters are developing problems. Ratios of these flats will primarily indicate the stability of the channel itself, unless there are strong variations from filter to filter. Unless time dependence in the filters is seen, it is likely that flatfields for pipeline calibration will continue to be made by combining earthflat, SLTV flats, and eventually skyflats. The bi-monthly photometric filter set observations will be used to monitor WFPC2’s flat field response and to build a high S/N flat field database (primarily useful in tracking any changes in the pixel to pixel response of the instrument, and any possible long term contamination induced changes). Histograms generated from the ramp filter flats will be used to trace the ADC transfer curve. F160BW can be checked monthly for pinholes.
Results

Modifications: Number of observations was significantly reduced in mid-cycle due to the degradation detected in the cal channel lamp. F160BW exposures, used to monitor pinholes, were temporarily suspended, and replaced in Cycle 6 by INTFLATS. Monthly executions were reduced from 5 to 2 occultation periods starting March 1996

Execution: Complete

Resources Used:

Observation: 84 occultation periods

Analysis: 0.1 FTE

Accuracy Achieved: 0.2% in measurement of systematic lamp degradation, 1% in stability of pixel-to-pixel sensitivity variations

Products: ISR; lamp degradation issues discussed at TIPS meetings and in STAN


Continuation Plan: Lamp usage will be further reduced during Cycle 6, with the INTFLAT channel used for monitoring on a monthly basis, complemented by less frequent VISFLAT checks

Figure 4: Output of the VISFLAT lamp in F555W vs. cumulative number of lamp cycles, showing the increasing lamp degradation (from Stiavelli and Baggett, ISR WFPC2 96-01)
Proposal ID 6190: WFPC2 Cycle 5: Internal Flats

Plan

Purpose: Provide backup database of INTFLATS in case VISFLAT channel fails

Description: Based on Cycle 4 program 5568. A complete set of illuminated shutter blade flats (INTFLATS) is taken close to the complete set of VISFLATS. Each filter is exposed on each shutter blade (A or B) at each gain setting (7 or 15). Thus there are 4 exposures per filter which should be sequenced without interruption as A7, A15, B15, B7. There is a possible concern on thermal control for the filter wheel where an out of limit condition was almost reached when 5568 was run. This will be avoided by spacing the exposures suitably. One set of internal flats will be taken with variable exposure lengths to verify the linearity of the lamp and to identify appropriate preflash lengths for the CTE calibration (proposal 6192)

Fraction of GO/GTO Programs Supported: Backup for 6189

Resources:

Observation: 18 occultation periods (internal)

Analysis: 0.1 FTE

Special Requirements: Needs to be scheduled within 2 weeks of the complete filter sweep in the VISFLAT monitor

Accuracy: The signal to noise per pixel is similar to that obtained in the VISFLAT program (0.6%) but there are much larger spatial and wavelength variations in the illumination pattern. As a result, this dataset will not form any part of the pipeline calibration. This baseline is necessary in case the VISFLAT channel fails and there are temporal variations in the camera flatfields at the 1% level. The test does give a good measurement of the gain ratios and their stability, which should be accurate to much better than 1% when all the data are analyzed

Products: INTFLAT/VISFLAT ratios can be generated if there is a failure in the cal channel. Gain ratios and stability will be assessed
Results

Modifications: None

Execution: Nominal

Resources Used:

Observation: 43 occultation periods

Analysis: 0.1 FTE (includes analysis of INTFLATS from program 6250)

Accuracy Achieved: 0.1% stability in gain ratios; 1% stability in pixel-to-pixel sensitivity variations

Products: ISR (together with VISFLATS); also uses INTFLATS acquired for 6250

Time-line: Executed July-August, 1995; ISR issued January 1996

Continuation Plan: Increase INTFLATS monitoring during Cycle 6 as replacement for VISFLATS, in order to protect VISFLATS lamp; execute back-to-back INTFLATS-VISFLATS observations to establish baseline comparison

![Figure 5](image-url)

Figure 5: Value and long-term stability of gain ratios, based on consecutive F555W intflats taken at gain 7 and gain 15. A small correction for the temporal variation of the lamp throughput has been applied (from Stiavelli and Baggett, ISR WFPC2 96-01)
Proposal ID 6191: WFPC2 Cycle 5: UV Flats

Plan

Purpose: Use UV calibration channel to monitor long term internal UV stability

Description: UV flat fields will be obtained with the cal-channels ultraviolet lamp (UVFLAT) using the limited EUV filter set (F122M, F170W, F160BW, F185W and F336W) twice in the cycle immediately after a DECON. The UV lamp is degrading with use, so its use must be minimized. The UV flats will be used to monitor the FUV flat field stability and the stability of the Woods filter F160BW by using F170W as a reference. The VISFLAT/UVFLAT ratio from the F336W filter will provide a diagnostic of the UV flat field stability and tie the UVFLAT and VISFLAT flat field patterns together. This program represents the entire use of the UV lamp in cycle 5. This proposal is based on the Cycle 4 program 5568, but with two extra filters (F122M and F185W)

Fraction of GO/GTO Programs Supported: 20%

Resources:
- Observation: 12 occultation periods (internal)
- Analysis: 0.1 FTE

Special Requirements: Uses the UV lamp. Needs to be run immediately after a DECON

Accuracy: Should verify stability of the UV filters and flatfield to 2%. The overall response is not measured because the lamp output varies

Products: Ratio images with the corresponding dataset from Cycle 4 and future cycles will verify the UV flat field stability
**Results**

**Modifications:** Because the UV lamp was seen to affect the dark current level in subsequent images, visits had to be executed with back-to-back darks, resulting in some impact on pointed (science) time.

**Execution:** Nominal

**Resources Used:**

**Observation:** 4 orbits (internal, but impact on parallel science) + 4 occultation periods. The total length is the same as the 12 occultation periods originally requested, but with different packaging due to the impact of the UV light on dark current.

**Analysis:** 0.05 FTE

**Accuracy Achieved:** 2% on lamp level, 5-10% on pixel-to-pixel sensitivity variation, depending on filter

**Products:** Results described at TIPS meetings

**Time-line:** Two executions in August 1995 and May 1996; analysis within 1 month of each execution

**Continuation Plan:** Maintain current policies

**Figure 6:** Signal variation in UV flats over time in two filters for the four cameras (PC at top). The signal is averaged over the central 300x300 pixels. The lamp degradation in the far UV is apparent from the F170W data. Figure prepared by S. Baggett as part of UV lamp analysis.
Proposal ID 6192: WFPC2 Cycle 5: CTE Calibration

**Plan**

**Purpose:** Calibrate CTE effect for a range of star brightnesses and backgrounds

**Description:** The crowded omega Cen field is observed for 40 sec through F555W with gain 7, one time each with a preflash of 0,5,10,20,40,80 and 160 electrons. As a gain check and calibration, it is observed at the same orientation with gain 15 twice at preflash levels of 0 and 160 electrons. The whole sequence is repeated with filter F814W. Then a whole orbit is filled with 1 second exposures in order to investigate the effect of CTE on low signal level stars (but with high accumulated signal to noise). This last orbit is repeated with a preflash of 40 electrons. Based on cycle 4 programs 5645+5646+5659

**Fraction of GO/GTO Programs Supported:** 25%

**Resources**

**Observation:** 4 pointed orbits

**Analysis:** 0.3 FTE

**Special Requirements:** Requires prior execution of 6190 to verify appropriate preflash lengths

**Accuracy:** As this test is a differential measurement of the CTE slope, it should be very accurate (much better than 1%). As a large number of stars are involved, and the photon noise on each measurement is of order of 1%, the slope derived should be much more accurate. The largest remaining uncertainty will be on the absolute level of the slope, not differential effects caused by varying background

**Products:** After pipeline processing, each image will be reduced by aperture photometry to measure the star brightnesses, and how they depend on preflash level. This is a differential measurement, and gives no direct information about the slope of the CTE effect at high background levels. The absolute CTE can be estimated from 5646 (already run once with a raster in this field). Will be run by 8/95
Results

Modifications: Program was executed as planned, but it has become evident that the CTE is a more complex phenomenon than originally understood; thus, part of the analysis can only be done with the support of additional data to be taken as part of the Cycle 6 program 6937 and other data available from various programs.

Execution: Nominal

Resources Used:

Observation: 6 pointed orbits

Analysis: 0.4 FTE, thus divided: 0.05 FTE for the CTE ramp measurement from this proposal; 0.15 FTE on the analysis of residual images in darks; and 0.2 FTE for the study of the long vs. short anomaly from GO data

Accuracy Achieved: Dependence of CTE ramp on background established to about 1-2%; photometric inaccuracies quantified to about 3-5%, but without good scheme for correction

Products: One ISR, one internal report, and two web pages updated with the current status of our analysis


Continuation Plan: Additional tests planned in Cycle 6 program 6937 and with other GO programs; possibly laboratory tests will be carried out in collaboration with Trauger and the WFPC2 IDT

Figure 7: Effect of preflash on CTE correction as a function of star brightness (from Harry Ferguson’s CTE report, available on the Web)
Proposal ID 6193: WFPC2 Cycle 5: PSF Characterization

Plan

Purpose: Provide a subsampled PSF over the full field to allow PSF fitting photometry

Description: Measure PSF over full field in photometric filters in order to update the TIM and TINYTIM models and to allow accurate empirical PSFs to be derived for PSF fitting photometry. With one orbit per photometric filter, a spatial scan is performed over a 4x4 grid on the CCD. The step size is 0.025 arcseconds. This gives a critically sampled PSF over most of the visible range. The crowded omega Cen field is used; 40 sec images are taken through each of the photometric filters (F336W, F439W, F555W, F675W, F814W). Data volume will be a problem, so special tape recorder management will be called for. Based partially on cycle 4 program 5575, which used the same field. The proposal also allows a check for subpixel phase effects on the integrated photometry.

Fraction of GO/GTO Programs Supported: 50%

Resources:

  - Observation: 5 pointed orbits
  - Analysis: 0.3 FTE

Special Requirements: Requires special tape recorder management

Accuracy: The chosen field will have hundreds of well exposed stars in each chip. Each star will be measured 16 times per filter at different pixel phase. The proposal therefore provides, in principle, a high signal to noise, critically sampled PSF. This would leave PSF fitting photometrists in a much better position than now, where pixel undersampling clearly limits the results. The result will be largely limited by breathing variations in focus. It is hard to judge the PSF accuracy that will result. If breathing is less than 5 microns peak to peak, the resulting PSFs should be good to about 10% in each pixel. PSF fitting results using this calibration would of course be much more accurate. In addition the test gives a direct measurement of sub-pixel phase effects on photometry, which should be measured to much better than 1%

Products: Provides subsampled PSFs for photometry codes. Provides data for comparison with PSF codes. Provides measurement of pixel phase effect on photometry (sub pixel QE variations exist). To be run 10/95
Results

Modifications: Program was extended to 7 orbits to study dependence on breathing, gain

Execution: Two visits were lost due to July 1996 safing event. Since the PSF is known to vary with time, mainly as a consequence of focus drift, it was decided not to request a repeat of the observations lost

Resources Used:

Observation: 5 pointed orbits (7 requested, 2 failed)

Analysis: 0.3 FTE for the proposal proper, and 0.15 FTE to prepare a Web-based interface to a comprehensive PSF library (about 0.05 FTE more to complete)

Accuracy Achieved: Difficult to quantify; probably errors in individual pixels can be kept below 10% rms, at least in the innermost 25 pixels; overall shape and properties of the PSF can be constrained to much better accuracy

Products: PSF library constructed, currently with about 1000 individual PSFs; Web interface near completion

Timeline: Proposal executed June 30-July 4, 1996; PSF extraction completed October 1996 (but PSF library will be continually augmented as more observations become available); Web interface to library under development, expected before end of 1996

Continuation Plan: Repeat observations in Cycle 6 (6938) to test long term stability and impact from servicing mission; continue to populate the PSF library. Plan to develop STSDAS task to take full advantage of the PSF library
Figure 8: A collection of PSFs in the central region of the PC camera, taken with the filter F555W over a two year interval. The primary reason for the differences between PSFs is focus change, due to both secular drift and breathing. Figure prepared by J. Surdej, M. Wiggs, and S. Baggett as part of a study of observed WFPC2 PSFs.
Figure 9: WFPC2 polarimetric images of the reflection nebula surrounding R Mon from calibration proposal 5574. These were generated by John Biretta from three separate images taken through the POLQ filter, and analyzed using the WFPC2 WWW polarization tool. The top panel (A) shows the total intensity (Stokes I) image. The bottom panel (B) shows the derived polarization E-vectors for the same region. Vector lengths are proportional to fractional polarization, with a length of 1 arcsec. indicating 35 percent polarization. Contours indicate total intensity.
Proposal ID 6194: WFPC2 Cycle 5: Polarization and Ramps

Plan

Purpose: Perform residual calibration and check for stability of polarizer and ramp filters

Description: This proposal includes: internal flatfields for the polarizer crossed with several broad-band filters and for all four ramp filters at each rotation, and external flux calibration for the polarizer, using both a polarized and an unpolarized standard, and for the ramp filters, using a spectrophotometric standard at 40 positions in each filter. Flat fields do not exist at this time for some of the polarizer-broad band filter combination and for one of the rotations of the four ramp filters; for the others, flat fields will verify the stability of the setup. No direct flux calibration existed from in-orbit data for the ramp filters

Fraction of GO/GTO Programs Supported: 15%

Resources:

  Observation: 8 pointed orbits
  Analysis: 0.3 FTE

Special Requirements: None

Accuracy: The proposal should support polarimetry at the 3% level, and measure the ramp throughput at the 2% level

Products: To be run after 9/95
Results

Modifications: Scope of polarization part vastly expanded after results of Cycle 4 observations became available, showing significant instrument polarization and thus need for multiple combinations of filter, aperture, and telescope roll. Linear Ramp Filter part slightly expanded to include scanning standard stars along each ramp.

Execution: Except for 4 polarization orbits, all observations will be executed after SMOV. Two of the 4 polarization orbits have executed, but one failed due to the aftermath of a safing event; will be executed after SMOV.

Resources Used:

Observation: 24 pointed orbits (16 polarization, 8 LRF) and 76 occultation periods (24 vis-flats and 52 Earth flats, all for polarization) - only 1 orbit successfully executed as of November 15.

Analysis: 0.35 FTE for proposal development (0.25 FTE for polarization, 0.10 for LRF); no analysis carried out for this proposal, 0.25 FTE dedicated to the analysis of Cycle 4 data. About 0.35 additional FTE will be necessary to analyze Cycle 5 data when available.

Accuracy Achieved: N/A

Products: Improved Web-based LRF tool (used for proposal development); internal report, flat fields for polarization based on Cycle 4 data generated and delivered into CDBS in Fall 1996.

Time-line: Observations will be executed mostly after SMOV.

Continuation Plan: Pending Cycle 5 results.
Proposal ID 6195: WFPC2 Cycle 5: Flat field Check

Plan

Purpose: Check quality of flat fields and estimate errors in them

Description: The crowded Omega Cen field is positioned with a bright star at the center of each CCD in turn. 40 sec images are taken through each of the photometric filters (F336W, F439W, F555W, F675W, F814W) and as many supplementary filters (from F450W, F606W, F702W and F547M) as can fit in the allotted time. If data volume is a problem, single chip readout is acceptable, but should be avoided as much as possible. Based on cycle 4 programs 5659 and 5646

Fraction of GO/GTO Programs Supported: 60%

Resources:

Observation: 2 pointed orbits

Analysis: 0.2 FTE

Special Requirements: Assumes that the CTE proposal has been run and gives satisfactory results. Should be scheduled at least 4 months after it

Accuracy: Overall discrepancies between the synthetic photometric products and the results of this test should be 1-2% rms. Part of the point of the test is to measure this accuracy

Products: After pipeline processing, each image will be reduced by aperture photometry to measure the RMS errors in the flat fields. The RMS error will be determined by the additional noise in the independent measurements over the expected variance of less than 1% from photon statistics. The single bright star at the center of each chip independently estimates the chip to chip normalization error
Results

Modifications: None

Execution: Nominal

Resources Used:

  Observation: 4 pointed orbits

  Analysis: 0.05 FTE thus far; another 0.05 FTE needed for completion

Accuracy Achieved: N/A

Products: N/A

Time-line: Observations executed in June 1996; analysis in progress, to be completed in January 1997

Continuation Plan: None. Images will be used for the PSF library as well (ongoing)
Proposal ID 6250: WFPC2 Cycle 5: Internal Monitor

Plan

Purpose: Check for short term stability of instrument

Description: The routine internal monitor, to be run twice weekly during cycle 5, obtains two bias frames at each gain, two INTFLATS with the F555W filter at each gain, and two Kelsall spot images with exposure times optimized for the WF and PC, respectively. It is identical to the Cycle 4 program 5560

Fraction of GO/GTO Programs Supported: 100%

Resources:

Observation: 80 occultation periods (internal)

Analysis: 0.1 FTE

Special Requirements: None

Accuracy: This monitor is not involved in generating quantitative calibration information

Products: The test provides a biweekly monitor of the integrity of the CCD camera chain electronics both at gain 7 and 14, a test for quantum efficiency hysteresis in the CCDs, and an internal check on the alignment of the WFPC optical chain. The test is not run during decontamination weeks, since similar data are taken before and after the decontamination (proposal 6183)
Results

Modifications: None

Execution: Nominal, except one execution failed on October 6, 1995

Resources Used:

Observation: 72 occultation periods

Analysis: 0.1 FTE to generate superbias; 0.1 FTE to develop software to identify and flag bias jumps; 0.05 FTE for analysis of KSPOTS (see 6190 for INTFLATS)

Accuracy Achieved: 0.5 e in superbias, 0.5 pixels in KSPOT position

Products: CDBS: updated bias reference files

Time-line: Observations executed during the period August 1, 1995-July 20, 1996; superbias delivered in January 1996, new one will be delivered in early December; KSPOTS analysis completed in spring 1996

Continuation Plan: Maintain current policies for INTFLATS and BIAS, but remove weekly KSPOTS (these to be done twice a month, as part of decontamination proposal 6903)