Wide Field Planetary Camera II Status Update

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Abstract

We review the status of the Wide Field and Planetary Camera II (WFPC2) onboard the Hubble Space Telescope, as well as recent enhancements to calibration and user support. The photometric, flat field, and PSF stabilities continue to be excellent, and they do not appear to have been affected by the recent servicing mission. Charge Transfer Efficiency (CTE) in the CCDs remains a concern; we discuss the latest results from on-going monitor programs, as well as the latest correction procedures. We also discuss a reanalysis of the "long-vs-short" anomaly, which suggests that the effect is primarily relevant for very crowded fields (several thousand stars per CCD). The entire set of flat fields for the standard filters redward of F300W has been updated. Plans are under way for Cycle 11 calibration programs, and some of the highlights are discussed. A new edition of the WFPC2 Data Analysis Tutorial is available. The WFPC2 Instrument Handbook has been updated for Cycle 12, and a new edition of the HST Data Handbook is also available. Efforts have begun to update the WFPC2 website to make it easier for people to find desired documents. The Servicing Mission SM3b occurred in March 2002, and we summarize the WFPC2 SMOV3B results. These and other issues will be discussed.

Cycle 11 News.

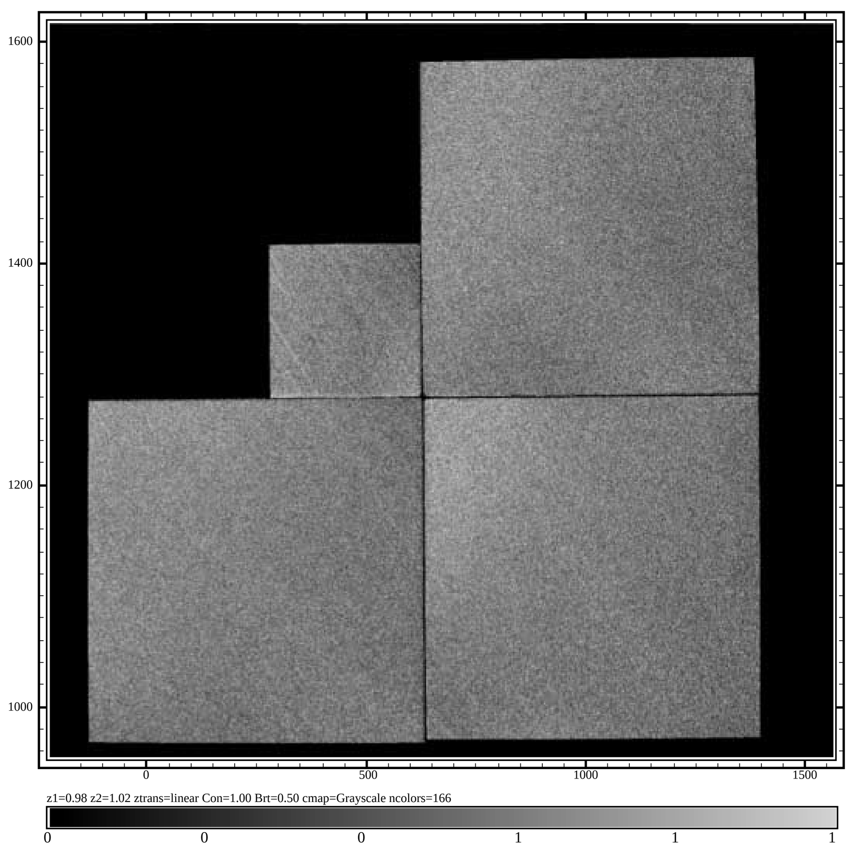
Due to the availability of ACS, the usage of WFPC2 in Cycle 11 will be significantly reduced. 5% of the total GO primary orbits have been allocated to WFPC2. Many of these programs exploit the specialized narrow-band and quad filters of the instrument. WFPC2 will still see substantial usage from coordinated parallel and pure parallel programs. There are over 200 orbits allocated to coordinated parallels with WFPC2, with considerably more being used for pure parallel programs. The Cycle 11 calibration plan for WFPC2 includes standard monitoring programs to maintain accurate calibration of the instrument. In addition, we will be performing several special programs which include astrometric monitoring to measure any shifts of chip position; Charge Transfer Efficiency (CTE) characterization to continue to monitor the CTE degradation; photometric characterization to verify stability and update the photometric zeropoints; and a WFPC2-ACS photometric cross-calibration of the heavily used ACS filters.

WFPC2 SMOV3B Flat Field Verification.

As part of our post-servicing check-out of WFPC2 after SM3B we observed a series of exposures of the bright Earth ("earthflats") to test the flat field stability over a wide range of narrow-band filter including F375N, F502N, F656N, and F953N. The goal of these observations is to test for any unexpected OTA obscuration or contamination in WFPC2 that may have occurred as a result of the servicing mission. The flats are also capable of revealing changes in the OTA/ WFPC2 geometry, as well as any QE changes localized to one CCD camera or to a small region of the field-of-view.

For the pre-SMOV observations we started with a total of 124 Earthflats in F502N taken between June 2001 and February 2002 as part of proposals 8815 and 8940. We discarded images with mean counts in the PC1 below 500 DN and mean counts in the three WFC chips above 3200 DN (to avoid saturation), and furthermore selected only those that had been obtained within 7 days after a decontamination (to minimize effects from contamination). These images were then examined for streaks (produced by features on the Earth moving across the detector), after multiplying with the current F502N flat field reference file, and images with excessive r.m.s. were further rejected. Similar criteria were applied to earthflats obtained during SMOV3B as part of proposal 8952.

We then divided the SMOV flat by the pre-SMOV image, and normalized so that the central 400x400 pixels of WF3 had a mean of unity. The resulting post-SMOV/pre-SMOV ratio image is shown in Figure 1. No change in chip-to-chip sensitivity is seen on any levels above ~0.3% in the average ratio of post-SMOV / pre-SMOV counts over the central 400x400 pixels of each CCD. There is also no significant evidence of obscuration or other changes in the OTA. While there are some lower-level changes (less than 0.1-0.2%) on large scales, these effects are well characterized in terms of gradual long-term trends of the camera. Thus we conclude that the WFPC2 flat field characteristics have not changed as a result of SMOV3B.



The figure shows the ratio of SMOV / pre-SMOV flats taken in F502N. The display greyscale ranges from 0.98 (black) to 1.02 (white). The large-scale changes are of the order of 0.1-0.2%, and are entirely consistent with well-known long-term changes in the camera geometry.

WFPC2 Instrument Science Reports.

New ISRs since the last AAS Meeting:

- 2002-01 *"WFPC2 Clocks-ON Close Out"*, Schultz et al.
- 2002-02 *"Updated WFPC2 Flatfield Reference Files for 1995 - 2001"*, Koekemoer et al.
- 2002-03 *" Charge Transfer Efficiency for Very Faint Objects and a Reexamination of the Long-vs-Short Problem for the WFPC2"*, Whitmore and Heyer.

The ISRs can be accessed on the web at http://www.stsci.edu/instruments/wfpc2/wfpc2_doc.html#Inst

Other WFPC2 Documents.

Other new documents since the last AAS Meeting

- The WFPC2 Instrument Handbook has been updated for Cycle 12. (http://www.stsci.edu/instruments/wfpc2/Wfpc2_hand/wfpc2_handbook.html)
- A new edition of the HST Data Handbook is available. (http://www.stsci.edu/instruments/wfpc2/Wfpc2_dhb/WFPC2_longdhbcover.html)
- A new edition of the WFPC2 Data Analysis Tutorial is available. (http://www.stsci.edu/instruments/wfpc2/wfpc2_doc.html#Hand)

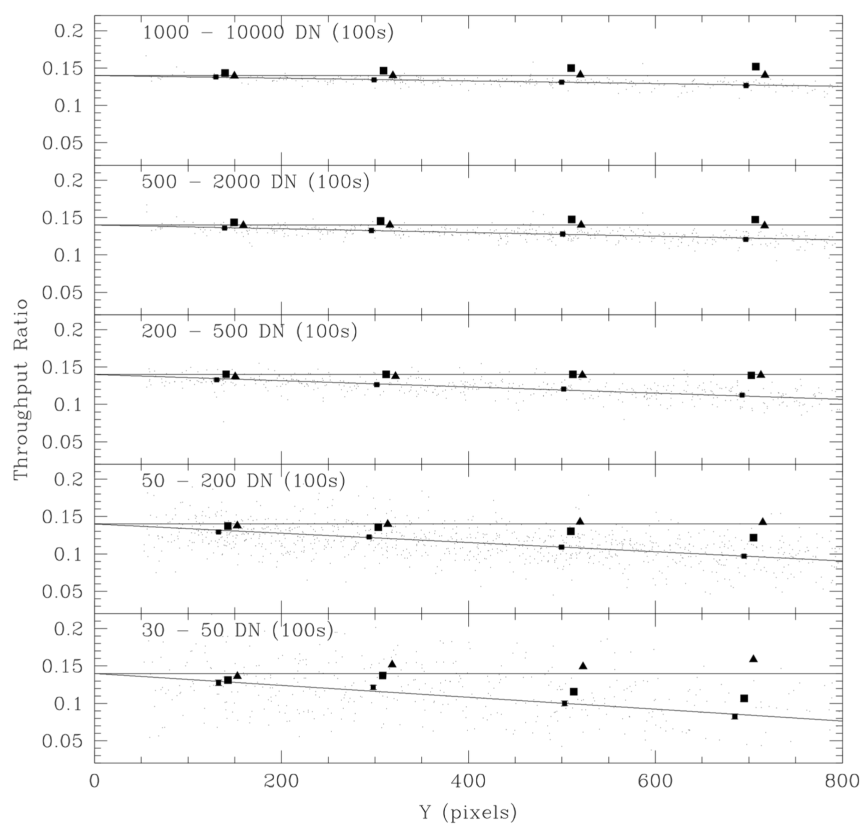
References to published results of the data discussed in this poster are available in a handout. We have limited copies of several of the latest ISRs underneath this poster. If you don't find what you need please either check our website, or leave your name, address, and list the document(s) you'd like mailed.

Charge Transfer Efficiency for Very Faint Objects and a Reexamination of the Long-vs-Short Problem for the WFPC2.

An analysis of WFPC2 observations of Omega Cen and NGC 2419 leads to the following results.

1. The correction formula developed by Whitmore, Heyer, and Casertano (1999; hereafter WHC99) does a reasonable job of correcting for CTE loss down to extremely low count levels (i.e., so faint you cannot actually see the object but only know of its existence from longer exposures). There is no sharp cutoff to the detection threshold for very faint stars.
2. A comparison of the WHC99 formula with the Dolphin (2000b; hereafter D00) formula shows reasonable agreement for bright and moderately bright stars, with the D00 formula giving better results. However, at very faint levels, the D00 formula overestimates, and the WHC99 formula underestimates, the correction by tens of percent. Our current recommendation is to use the D00 formula for CTE loss correction.
3. A reexamination of the long-vs-short nonlinearity shows that the effect is very small (a few percent) or nonexistent for uncrowded fields, with less than ~ 1000 stars per chip. However, for crowded fields, with ~ 10,000 stars per chip, apparent nonlinearities of tens of percent are possible. A possible explanation is that this is due to an overestimate of the sky measurement in the short exposure, which is probably due to the presence of scattered light around bright stars and the subsequent improvement in CTE loss in these regions. No correction formula has been derived since the effect is dependent on the analysis parameters (aperture size) and probably also on the photometry package (psf-fitting, aperture photometry, ...).
4. Preflashing may be a useful method of reducing the effects of CTE loss for certain observations (moderately bright objects on very faint backgrounds), but the effects of added noise and longer overheads limit its effectiveness.
5. The detection thresholds for typical broad band observations have been reduced by ~ 0.1 - 0.2 mag in the ~7 years since WFPC2 was launched. For worst-case observations (F336W) the effect is currently ~ 0.4 magnitudes.

The figure below shows the ratio of counts between a 14 sec and 100 sec exposure for stars in Omega Cen vs. the Y position for stars on all three WF chips. The raw values (filled circles) fall below a ratio of 0.14 due to CTE loss. The different panels are for different target brightness, as selected on the 100 sec exposure and described by the labels. The filled squares show the values corrected using the Whitmore, Heyer & Casertano (1998) formula while the filled triangles show the values corrected using the Dolphin (2001) formula. Note that neither of the two correction formulae is very good for the faintest stars (~5 DN on the short exposure). Also note that the extrapolation of the raw data to Y=0 (the sloped line) is consistent with the predicted value of the throughput ratio based on the exposure times, hence the long-vs-short anomaly is not a problem for this data set (from Dolphin 2002).



WFPC2 SMOV3B UV Contamination Monitoring and Throughput Check.

A critical aspect of the initial cool-down and activation of WFPC2 after SM3B involved a period of intensive monitoring and verification of the throughput of the instrument at UV wavelengths, in order to ensure that the camera throughput was not permanently degraded by contamination deposited on the cold (-88 C) CCD windows. In particular, the throughput in the F170W filter needed to be monitored to verify that the decrease in flux due to contamination never exceeded the safe limit of a 30% drop in total throughput, which corresponds to the maximum level that is known to be removed by the regular decontamination procedures.

The UV contamination monitoring plan for WFPC2 was based on observations of the WFPC2 primary standard star GRW+70d5824 through the F170W filter, in all 4 cameras of the instrument. The first, intensive phase began with a set of observations immediately after cool-down, and repeated at 3, 6, 12, 18, 24, 36 hours, and 2, 3, 4, 5, 6 days after cooldown. At each epoch, the two observations for each chip consisted of a dither-pair where the second exposure was offset by 0.25" along both the x and y axes in a simple DITHER-LINE pattern. All exposures were 40s in length and obtained using GAIN=15. Subsequent monitoring observations were obtained before and after each of the decontamination procedures at 7, 14 and 28 days after cooldown.

The data were calibrated using the normal WFPC2 pipeline, after which cosmic rays were removed from the images and photometry was carried out using standard photometry procedures. Only about 10% of the images had cosmic rays sufficiently close to the star, and of sufficient intensity, that editing was necessary.

From our photometry, we have verified the following:

At no point did the contamination on any of the CCD windows exceed a 15% drop in throughput, which is well above the safety limit of a 30% drop in throughput.

While the contamination rate was measured to be slightly higher than our normal rate in each of the cameras (up to a factor of 2), the rates were still well below those observed during the previous servicing mission. This is likely due to a combination of factors, including not cooling down the camera until 12 days after release (allowing extra time for contaminants to escape), as well as possibly a reduced level of contaminants from the new instruments compared to previous servicing missions.

The decontamination procedures carried out during SMOV3B demonstrated that the UV throughput in the F170W filter was successfully recovered to its nominal value (within our measurement errors and systematic uncertainties of 1-2%). Moreover, the contamination rates for each camera now appear to have returned to their nominal values.

Thus we conclude that our program of delayed cooldown, pro-active UV monitoring, and frequent decontaminations during SMOV3B were successful in fully retaining the UV throughput capabilities of WFPC2 as measured in the F170W filter.

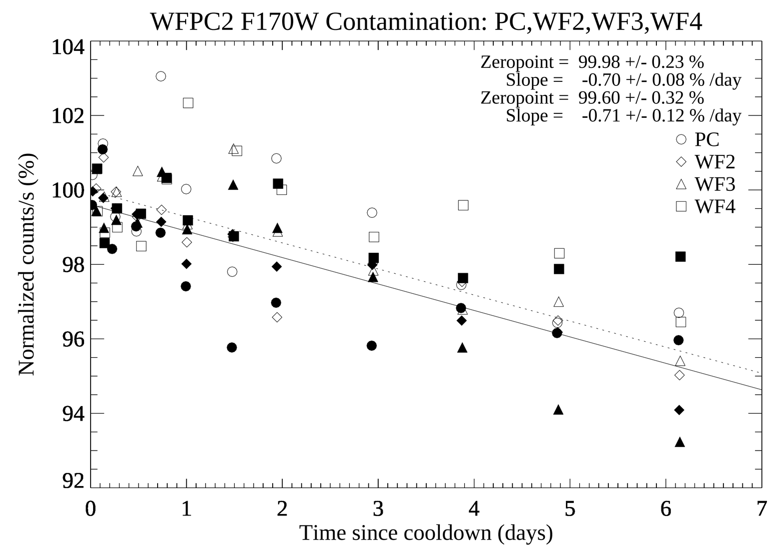


Figure: Measured decrease in throughput of GRW+70d5824 during the first week after cooldown, for each of the chips, plotted on the same set of axes and normalized to the count-rate of the first data-points after cooldown. At each epoch there are two split observations per chip; we use solid symbols to denote the first exposure in each pair and open symbols to denote the second exposure. The second exposure is often systematically brighter than the first by about a percent, which is likely attributable to mild "pre-flashing" of the pixels by the first exposure. The two lines correspond to fits with and without the second exposure in each pair, showing a slight offset but consistent contamination growth rates.

SMOV3B WFPC2 Photometry Check.

A check of the photometric throughput of the WFPC2 following SMOV3B was performed March 31, 2002 (program ID: 8953). The standard star GRW+70d5824 was observed with a selection of filters and the standard star was centered in each of the four CCDs. The data indicate that any changes in the photometric throughputs due to SM3B are less than 1% in most of the visible wavelength filters, and less than a few percent in the UV filters. The distribution shows a mean value of 0.34 +/- 0.26 sigma (where sigma is defined separately for each filter-chip combination) for all the observations, essentially consistent with an unchanged photometric throughput. This corresponds to about 0.4% on an absolute scale. The long-term throughput decline is consistent with the expected CTE loss. The response of the WFPC2 has essentially not changed following SMOV3B.

The figure on the left shows the statistical distribution of the post-SM3b photometry data points (number of data points vs. sigma).

The figure on the right shows the actual throughput (solid lines) vs. expected decline from Dolphin's CTE equations (dashed lines) for F336W, F555W, and F814W for the PC1 chip. This shows that the long-term trends are due to CTE loss, within the measurement uncertainty. The discontinuity for the early data points for F814W is due to a change in the exposure times.