

WF/PC-1 Instrument Overview

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43.1 Historical Overview

The development and construction of the Wide Field and Planetary Camera (WF/PC-1) was led by Prof. J.A. Westphal, Principal Investigator, of the California Institute of Technology. The Investigation Definition Team (IDT) also included J.E. Gunn (deputy P. I.), W.A. Baum, A.D. Code, D.G. Currie, G.E. Danielson, T.F. Kelsall, J.A. Kristian, C.R. Lynds, P.K. Seidelmann, and B.A. Smith. The instrument was built at the Jet Propulsion Laboratory, California Institute of Technology. A general overview of the instrument is given by Westphal et al., 1982, "The Wide Field/Planetary Camera," in *The Space Telescope Observatory*, ed. by D.N.B. Hall, page 28, NASA CP-2244.

The WF/PC-1 was a dual two-dimensional spectrophotometer with rudimentary polarimetric and transmission-grating capabilities. The instrument was designed to operate from 1150 Å to 11,000 Å, with a resolution of 0.1 arcsec per pixel (Wide Field Camera, $f/12.9$) or 0.043 arcsec per pixel (Planetary Camera, $f/30$) using an array of CCD detectors.

Launched aboard the HST in April of 1990, the WF/PC-1 underwent an initial checkout period, obtained the HST's first light images, and was central to the discovery and characterization of the OTA spherical aberration. In December 1990, the WF/PC-1 detectors were conditioned (UV flood procedure) in preparation for the scientific observing program. During 1991, Science Verification (SV) tests and calibration data were obtained by the IDT concurrent with the Cycle 0 GTO science observations. Starting in mid-1991, GO science

observations became a significant part of the WF/PC-1 observing program. The engineering handover of the WF/PC-1 from JPL to STScI was completed in November 1991. Observations for the IDT's SV program were completed in January 1992 and the formal SV Report (Faber et al., 1991) delivered in February 1992. The GO science programs and the STScI calibration programs began during the fall of 1991 and continued successfully until December 1993, when WF/PC-1 was replaced by WFPC2 during the first maintenance and servicing mission.

43.2 WF/PC-1 Documentation

In this section we list important STScI sources of documentation for WF/PC-1.

43.2.1 Instrument Handbook

The final version of the *WF/PC-1 Instrument Handbook* (version 3.0) is a useful description of the technical capabilities of the instrument and practical information for its use. Earlier versions contain little useful information not included in the final version. Version 3.0 is not available in electronic format.

43.2.2 Instrument Science Reports

Instrument Science Reports (ISRs) are technical reports issued by STScI that describe calibrations, anomalies, and operational capabilities of the instrument. ISRs are generally written for a technical audience, so we have tried to incorporate their results into this handbook as necessary. When an ISR may be particularly helpful, as in treatment of a topic beyond the scope of this volume, we provide the appropriate reference. For completeness we have included a listing of WF/PC-1 ISRs in the bibliography section at the end of this chapter. Paper copies of all ISRs are available from the STScI Help Desk; send E-mail to help@stsci.edu.

43.2.3 Previous Data Handbooks

This version of the *HST Data Handbook* replaces all previous data handbooks as we have tried to improve upon and slightly expand the treatments in the previous handbooks. Any updates to this handbook will be posted on the STScI WWW site.

43.2.4 WF/PC-1 WWW Resources

The top WF/PC-1 WWW page can be found among the STScI World Wide Web resources, in the Instruments section.¹ The STScI home page is at:

<http://www.stsci.edu/>

The WF/PC-1 pages are grouped into three major categories: memos, general documentation (more formal reports), and calibration products. We provide below a short summary of the items on these pages that may be of particular interest to an archival user, grouped by page, not in order of importance.

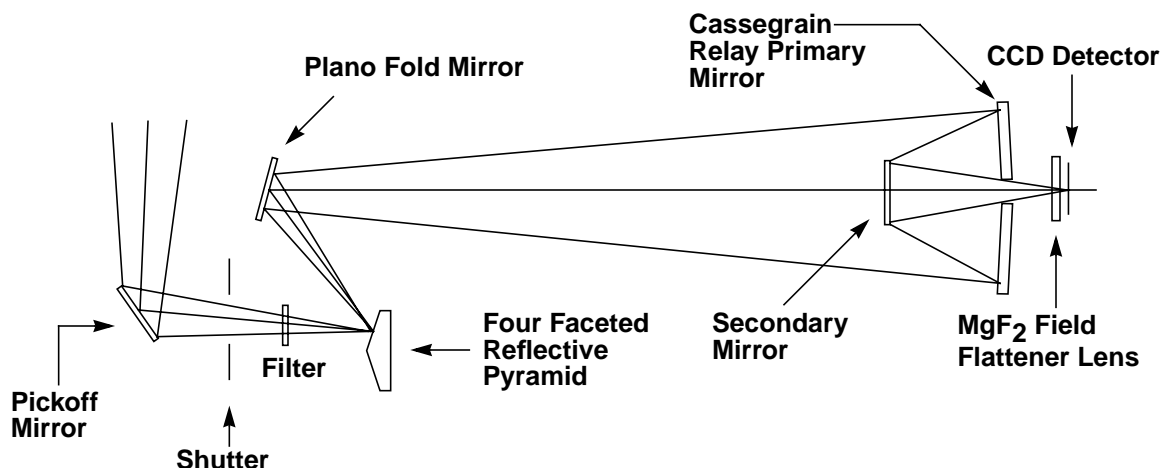
- WF/PC-1 Memos Page
 - Closure Flatfields
 - Reference File Memo
 - Super-sky Flatfields
 - Lick Group Flatfield Correction Frames
 - Deltaflat Corrections
 - Measles Contamination and Compensation
 - Hot Pixel List
 - Photometric Monitoring Results
 - PSF Library
- General WF/PC-1 Documentation Page
 - Online Data Handbook
 - WF/PC-1 Instrument Science Reports (see Bibliography below)
 - Calibration Workshop Proceedings
- Calibration Products page
 - WF/PC-1 Filter Scans, measured in the lab after the mission
 - Photometric Monitoring Results

Additionally, notices concerning any updates to WF/PC-1 documentation will be posted here, though none are presently planned.

43.3 WF/PC-1 Instrument Basics

Figure 43.1 shows a schematic of the optical arrangement of the WF/PC-1. The central portion of the optical telescope assembly (OTA) $f/24$ beam was intercepted by a steerable pick-off mirror attached to the WF/PC-1 and diverted through an open port entry into the WF/PC-1. The beam then passed through a shutter and interposable filters. A total of 48 spectral elements and polarizers were contained in an assembly of 12 filter wheels. The light then fell onto a shallow-angle, four-faceted pyramid located at the aberrated OTA focus. Each face of the pyramid was a concave spherical surface. The pyramid divided the OTA image of the sky into four parts. After leaving the pyramid, each quarter of the full field-of-view was relayed by an optical flat to a Cassegrain relay that formed a second field image on a charge-coupled device (CCD) of 800 x 800 pixels. Each of these detectors was housed in a cell filled with 0.1 atmosphere of argon sealed by a MgF_2 field flattener.

1. A list of URLs is also provided in Appendix E.

Figure 43.1: WF/PC-1 Optical Configuration

In total, the WF/PC-1 contained eight relay mirror-repeater-CCD trains, four for the wide-field camera and four for the planetary camera. To place the desired camera into operation, the pyramid was commanded to rotate into one of two fixed orientations separated by 45 degrees. The Wide Field cameras (WF) produced a final focal ratio of $f/12.9$ while the Planetary Cameras (PC) produced $f/30$.

Table 43.1 summarizes the configuration of the two cameras (also see the *OV/SV Report*, 1992 and the *WF/PC-1 Instrument Handbook*, 1992). The Wide Field chips are numbered 1 through 4, the Planetary Camera chips 5 through 8.

Table 43.1: Camera Configurations

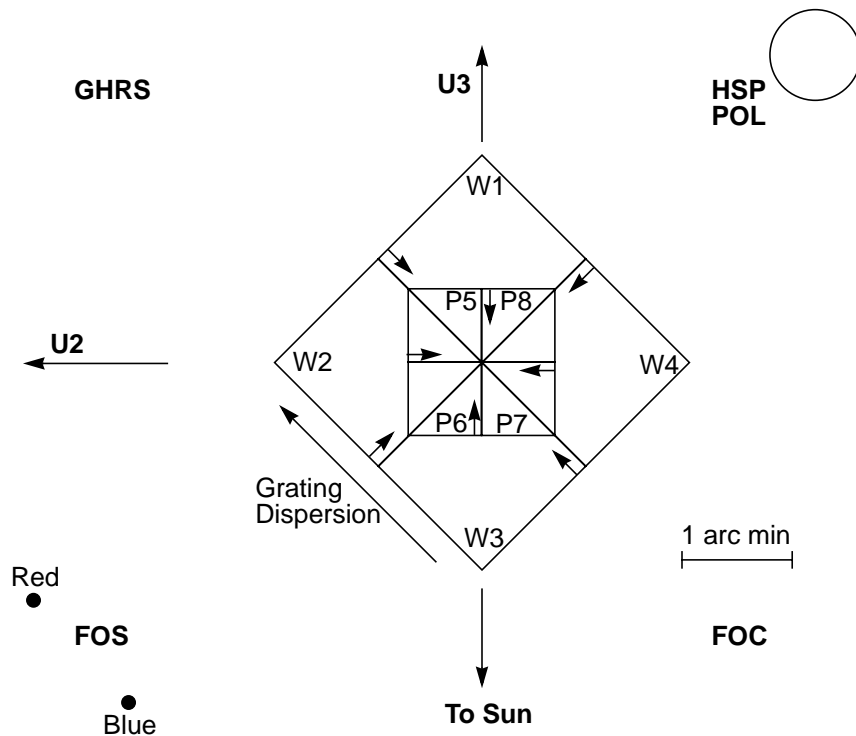
Camera	Pixels	Field of View	Scale	f/ratio
WFC	800 x 800 x 4 chips	2.6' x 2.6'	0.102"	12.9
PC	800 x 800 x 4 chips	66" x 66"	0.043"	30

Two readouts for each camera were available: FULL and AREA mode (given in the MODE header keyword). FULL mode was the default, with full single-pixel resolution. In full mode, each line of science data contained two 16-bit words of engineering data followed by 799 16-bit numbers as read from the chip, followed by 12 overclocked pixels which were used to determine the bias level (BLEV) correction (see "Calibration Details" on page 45-7. During the initial steps of the routine pipeline processing, the science data was reformatted and separated into the raw (.d0h/.d0d) science data (800 x 800 pixels) and the engineering data along with the 12 bias columns (.x0h/.x0d).

AREA mode—which was not used often (only 50 images, 35 of them externals, out of 15,746 total WF/PC-1 images)—was a 2 x 2 pixel summation. In this case, the two words of engineering data were followed by only 400 16-bit numbers read out from the chips; no overclocking was done. In this mode, the BLEV correction was determined from the second column of engineering data. The least significant bit (from odd rows only, even rows contained engineering data) was averaged, then multiplied by two.

The field of view of the WF/PC-1 charge-coupled devices (CCDs) on the sky is illustrated in Figure 43.2; some features of the chips are summarized below.

Figure 43.2: WF/PC-1 Field of View on Sky



- Each chip was read out from the corner nearest the central point where all chip corners meet; the arrows indicate the readout direction. The column and row (line) numbers increased from the center outwards; the direction of blooming (along columns) was parallel to the arrows.
- An optically inactive edge (about 25 pixels wide) bordered the two sides of each chip that were adjacent to another chip. The resultant area on the sky covered by all four chips was approximately 1543 x 1543 pixels for the wide field camera (WFC) (154.5" x 154.5") and 1531 x 1531 pixels for the planetary camera (PC) (65.8" x 65.8").

- A region of low reflectance on the pyramid (called the *Baum spot*) with 0.1% reflectance of the rest of the pyramid can be found in PC 8 ($x=416$, $y=417$) and in WF 4 ($x=195$, $y=197$), about 1.2" (~28 pixels) in diameter.
- The *Kelsall spots*, a series of eleven pinholes along each of the common pyramid edges used for image registration, were illuminated only during special calibration observations.
- *Read noise* was around 13 rms electrons per pixel; gain was approximately 7.5 electrons per digital number (DN) (see the *WF/PC-1 Instrument Handbook*, Version 3.0 page 34).

The images from each chip are oriented such that north shifts by roughly 90 degrees from chip to chip. The orientation of each chip (i.e., the direction of north) is stored in the ORIENTAT group keyword; the **north** task can be used to obtain the position angle of the image. Calibrated WF/PC-1 images retain a residual geometric distortion (about 1 pixel, corner to corner). The **wmosaic** task can be used to geometrically correct and align the four chip images (see Chapter 3 for more details). Figure 43.3 shows the image produced after **wmosaic** has been used to properly align and geometrically correct the four sub-images and produce a single mosaic image.

Figure 43.3: Aligned WF/PC-1 Mosaic Image

43.4 WF/PC-1 Bibliography

43.4.1 WF/PC-1 Instrument Handbook

- MacKenty, J., R. Griffiths, W. Sparks, K. Horne, R. Gilmozzi, S. Ewald, C. Ritchie, S. Baggett, L. Walter, and G. Schneider, *WF/PC-1 Instrument Handbook*, version 3.0, 1992.

43.4.2 Calibration References

- Ratnatunga, K.U., et al., “Calibration of HST Wide Field Camera for Quantitative Analysis of Faint Galaxy Images,” , 1994, *AJ* **108**, 2362.
- Phillips, A.C., et al., “Flatfielding and Photometric Accuracy of the First Hubble Space Telescope Wide Field Camera,” 1994, *AJ* **107**, 1904.
- *Calibrating Hubble Space Telescope*, 1994 workshop proceedings, edited by J.C. Blades and S.J. Osmer.
- Lauer, T., “The Reduction of Wide Field/Planetary Camera Images,” 1989, *PASP*, **101**, 445.
- Faber, S. M., and the WF/PC-1 Investigation Definition Team, “Final Orbital/Science Verification Report,” 1991.

43.4.3 WF/PC-1 Instrument Science Reports²

- Contramination Correction in SYNPHOT for WFPC2 and WF/PC-1 (WFPC2 ISR 96-02), S. Baggett, W. Sparks, and J. MacKenty
- WF/PC Observed PSF Library (93-03), S. Baggett and J. MacKenty
- WF/PC Photometric Monitoring Results (93-02), C. Ritchie and J. MacKenty
- The Evolution and Treatment of Hot Pixels in the WF/PC (93-01), J. Biretta and C. Ritchie
- PSF Calibration Plan (92-13), S. Baggett and J. MacKenty
- Currently Available Non-SV Flatfield Calibrations (92-12), C. Ritchie and J. MacKenty
- The Stability of Measles Features: an Autocorrelation Analysis (92-11), W. Sparks, C. Ritchie and J. MacKenty
- Deltaflat Corrections (92-10), S. Baggett and J. MacKenty
- Absolute Efficiency of the WF/PC (92-09), W.B. Sparks, C. Ritchie, J. MacKenty
- Numbers and Characteristics of PC “Measles” Features from February through April 1992 (92-08), S. Baggett and J. MacKenty
- WF/PC UV Calibration Following Decontamination (92-07), C. Ritchie and J. MacKenty
- A Library of Observed WF/PC Point Spread Functions (92-05), S. Baggett and J. MacKenty

2. Paper copies of these reports are available from help@stsci.edu; only the titles and abstracts are on the WF/PC-1 WWW pages.

- WF/PC Measles Contamination and Compensation with Delta Flats (92-04), J. MacKenty and S. Baggett
- WF/PC Reference Files Currently in the Calibration Data Base (92-03), S. Baggett and J. MacKenty
- Estimation of the Current Status of the WF/PC UV Flood (92-02), J. MacKenty and C. Ritchie
- Determination of the Position Dependent Zero Point Magnitude Correction for the Core Aperture Photometry with WF/PC (not WFPC ISR but TS #92-02), Ellyne Kinney and Roberto Gilmozzi
- Position Changes for Standard Star Observations (92-01), C. Ritchie
- Exposure Times for G200L Images of AGK+81D266 during UV Flood (91-08), K. Horne and J. MacKenty
- Analysis of Stellar Monitor Proposal #3173 (91-07), C. Ritchie
- July 6 Decontamination Affected QE Slightly (91-05), S. Ewald
- WF/PC Photometric Calibration during Jan-May 1991 (91-04), K. Horne, L. Walter, C. Ritchie
- WF/PC II Contamination Control (91-03), J. Barengoltz, J. Millard, T. Jenkins, D. Taylor
- Spacecraft Jitter: Its Effect on the HST PSF and on the `Breathing`?) (91-02), R. Gilmozzi
- 91-01 Post-Flood PC quantum Efficiency (91-01), K. Horne and C. Ritchie
- Technical Report on Wide Field Camera Observations of 2237+0305 (SV 3068) (90-10), D. Schneider & J. Bahcall
- WF/PC Internal Molecular Contamination During System T-V Test (90-08), R. Griffith
- "Core" Aperture Photometry with WF/PC (90-07), R. Gilmozzi
- A Pre-Flood Checkup on WF/PC Quantum Efficiency Using the STSDAS SYNPHOT
- Software Package (90-06), K. Horne, E. Wyckoff, and D. Bazell
- A Pre-Flood Study of WF/PC Photometric Stability Using Aperture Photometry on NGC 188 Data Taken in August and September (90-05), E. Wyckoff, R. Gilmozzi, K. Horne
- Sensitivity at 9000A, (90-04), P. Seitzer
- The Take Data Flag (90-03), S. Ewald
- Filter F656N Anomaly I (90-02), S. Ewald
- Bias Change During TV6 (90-01), C. Ritchie and S. Ewald

