PART VI:

WFPC2

■ WFPC2

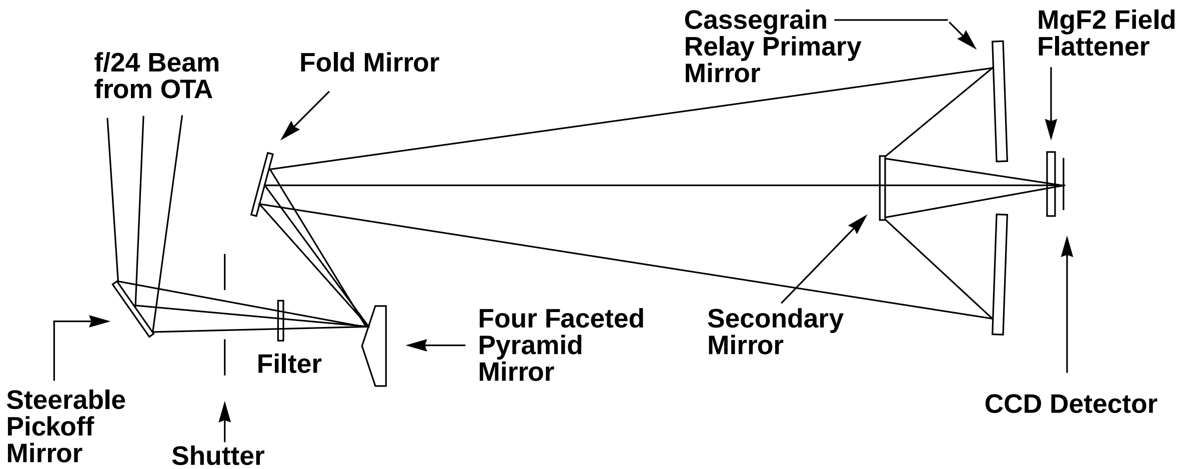
Chapter 24
WFPC2 Instrument Overview

The Wide Field and Planetary Camera 2 (WFPC2) is a two-dimensional imaging device covering a wavelength range from Lyman-α to about 1 μm. It was built at the Jet Propulsion Laboratory by an Investigation Definition Team (IDT) headed by John Trauger, as a replacement for the first Wide Field and Planetary Camera (WF/PC). WFPC2 includes built-in correction for the spherical aberration of the HST Optical Telescope Assembly (OTA). The WFPC2 was installed in HST during the First Servicing Mission in December 1993. An early IDT report of the WFPC2 on-orbit performance can be found in Trauger et al. (1994, *ApJ*, 435, L3), and a more detailed assessment of its capabilities in Holtzman et al. (1995, *PASP*, 107, page 156 and page 1065).

The WFPC2 field of view is located at the center of the HST focal plane; Figure 24.1 shows a schematic of its optical arrangement. The central portion of the *f*/24 beam coming from the OTA is intercepted by a steerable pick-off mirror attached to the WFPC2 and is diverted through an open port entry into the WFPC2. The beam then passes through a shutter and interposable filters. A total of 48 spectral elements and polarizers are contained in an assembly of 12 filter wheels. The light then falls onto a shallow-angle, four-faceted pyramid located at the aberrated OTA focus. Each face of the pyramid is a concave spherical surface. The pyramid divides the OTA image of the sky into four parts. After leaving the pyramid, each quarter of the full field of view is relayed by an optical flat to a Cassegrain relay that forms a second field image on a charge-coupled device (CCD) of 800 x 800 pixels. Each of these four detectors is housed in a cell sealed by a MgF_2 window. This window is figured to serve as a field flattener.

The aberrated HST wavefront is corrected by introducing an equal but opposite error in each of the four Cassegrain relays. An image of the HST primary mirror is formed on the secondary mirrors in the Cassegrain relays. The spherical aberration from the telescope's primary mirror is corrected on these secondary mirrors, which are extremely aspheric; the resulting point spread function is quite close to that originally expected for WF/PC-1.

Figure 24.1: WFPC2 Optical Configuration



The optics of three of the four cameras are essentially identical and produce a final focal ratio of *f*/12.9. These are the Wide Field Cameras (WF2, WF3, WF4). The fourth camera, known as the Planetary Camera (PC or PC1), has a focal ratio of *f*/28.3.

Figure 24.2 shows the field of view of WFPC2 projected on the sky. The readout direction is marked with arrows near the start of the first row in each CCD. The *x,y* coordinate directions are for POS-TARG commands. The position angle of V3 on the sky varies with pointing direction and observation epoch and is given in the calibrated science header by the keyword PA_V3.

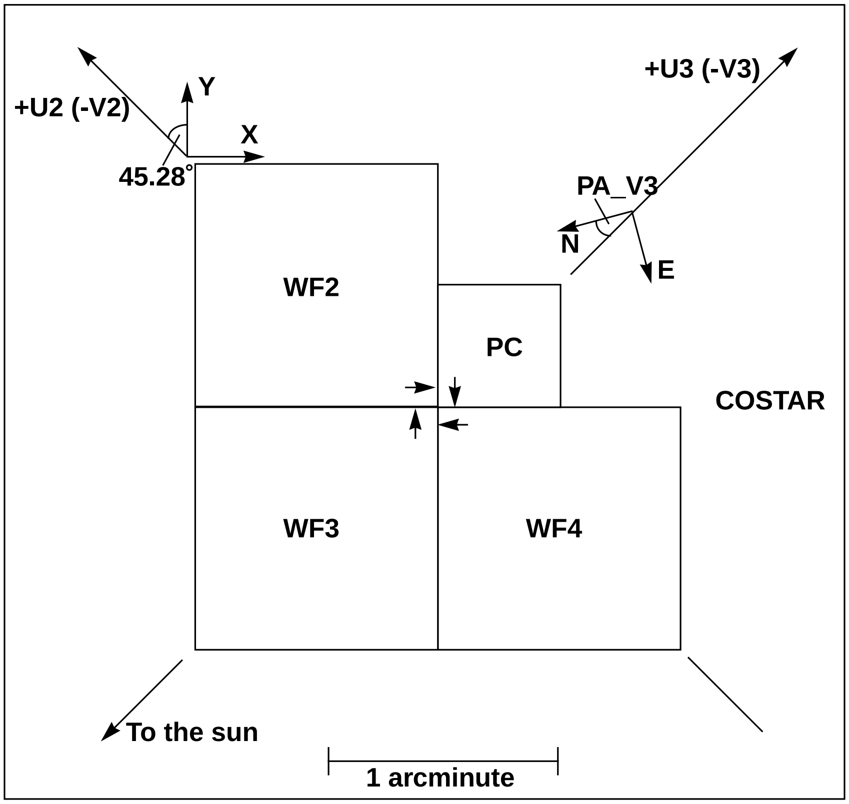
Table 24.1: Camera Configurations

Camera	Pixels	Field of View	Scale	f/ratio
PC	800 x 800	36" x 36"	0.0455" per pixel	28.3
WF2, 3, 4	800 x 800	80" x 80"	0.0996" per pixel	12.9

The Planetary Camera (PC) provides a field of view sufficient to obtain full disk images of all planets except for Jupiter. However, even with this high resolution camera, the pixels undersample the point spread function of the telescope and camera optics by a factor of two at 5800 Å. The WF pixels are over a factor of two larger, and thus undersample the image by a factor of four at visual wavelengths. It is possible to recover some of the sampling lost to these large pixels by image dithering, i.e., taking observations at different sub-pixel offsets. A short discussion of dithering is provided in “Dithering” on page 28-19.

Two readout modes are available on the WFPC2: FULL and AREA (the mode used for a given observation is shown in the MODE keyword in the image header). In FULL mode each pixel is read out individually. In AREA mode pixels

Figure 24.2: WFPC2 Field of View Projected on the Sky



are summed in 2 x 2 boxes before readout. The advantage of the AREA mode is that readout noise for the larger pixels is nearly the same as for the unsummed pixels: $6e^{-}$ vs. $5e^{-}$ per pixel. Thus, AREA mode can be useful in observations of extended sources when readout is the primary source of noise (often the case in the far UV).

The readout direction of the four CCDs is defined such that in IRAF pixel numbering (origin at lower left corner), the origin of the CCD lies at the corner of the chip pointing towards the center of the WFPC2 pyramid (see Figure 24.2). As a result of the aberration of the primary beam, the light from sources near the pyramid edges is divided between adjacent chips, and consequently the lower columns and rows of the PC and WF chips are strongly vignetted, as shown in Table 24.2. The CCD *x,y* (column,row) numbers given in this table vary at the 1–2 pixel level because of bending and tilting of the field edge in detector coordinates due to geometric distortion in the camera. The orientation of each camera on the sky is provided by the ORIENTAT group keyword in the image headers. The geometry of the cameras and the related keywords are explained in greater detail in Chapter 25.

Table 24.2: Inner Field Edges of Field Projected Onto CCDs

Camera	Start Vignetted Field	Contiguous Field	Start Unvignetted Field
PC1	x>0 and y>8	x> 44 and y>52	x>88 and y>96
WF2	x>26 and y>6	x>46 and y>26	x>66 and y>46
WF3	x>10 and y>27	x>30 and y>47	x>50 and y>67
WF4	x>23 and y>24	x>43 and y>44	x>63 and y>64

A quick way of putting an image together from its four chips is provided by the STSDAS task **wmosaic**, which can also be used for WF/PC-1 images. This task, in its default mode, will combine the four chips in a large, 1600 x 1600 pixel image at the resolution of the Wide Field cameras, resampling the pixels in order to correct for the chip overlap, rotations, and distortions. Of course, resolution will be lost in the PC, whose pixels are rebinned to the resolution of the Wide Field Cameras (a factor 2.3 coarser). The images produced by **wmosaic** are usually quite adequate for presentations and the identification of interesting features, but are not recommended for science uses because of the loss of resolution and photometric accuracy associated with data resampling, especially in the PC.