

WFC3: Data Processing and Analysis

H. Bushouse, M. Dulude, B. Hilbert, J. MacKenty, L. Petro, N. Pirzkal,
WFC3 Team (STScI)



Abstract

The Wide-Field Camera 3 (WFC3) on HST has two channels, one in the UV-optical range and one in the near-IR, that are producing excellent imaging results. Here we review some of the features that observers can encounter in their WFC3 data, some due to detector and instrumental artifacts and others due to the space-based environment of HST. We discuss the nature of the near-IR background seen by WFC3, scattered Earth light, optical ghosts, and isolated regions of reduced sensitivity in the IR field of view ("blobs"). We review processes by which some of these can either be avoided to begin with or mitigated in the data reduction and analysis process. This includes the appropriate use of the data quality flags that are included in the calibrated WFC3 imaging products.

Processing Flow and Software

The reduction and calibration of WFC3 data involves the following processing steps.

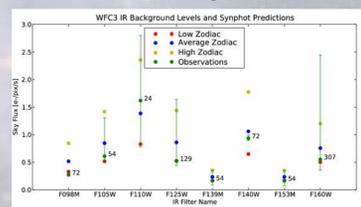
- *Generic Conversion* reformats the raw telemetry from WFC3 into FITS images and populates header keywords with the names of reference files needed to calibrate the data.
- *Calwf3* applies instrumental calibration to each WFC3 image.
- *Multidrizzle* drizzles and combines dithered image sets to remove geometric distortion and Cosmic Ray (CR) hits.
- *Archiving* stores the raw telemetry files in the HST archive and stores metadata gleaned from the calibrated images in the archive catalog.
- *On The Fly Reprocessing* (OTFR) is used to retrieve raw files from the archive and repeat the entire calibration process, delivering up to date results to the requestor.
- *aXe* is an off-line software package for extracting spectra from grism exposures. Originally developed by Space Telescope – European Coordinating Facility (ST-ECF); now supported by STScI.

Re-Processing

- Reprocessing using OTFR is best way to get latest software and calibration reference files applied by calwf3. Retrieval requests to HST archive will deliver reprocessed data.
- Calwf3 can be rerun off-line to apply custom reference files or special parameter settings.
- Multidrizzle processing in OTFR uses "one size fits all" parameter settings and therefore usually needs to be rerun off-line by observers to optimize the results. Typical things to optimize are image offsets for best registration, final image pixel scale, and rejection of pixels based on Data Quality (DQ) settings.
- Observers should check the WFC3 web site "Late Breaking News" and "Pipeline" sections, and Space Telescope Analysis Newsletters (STANs) for info about software and calibration file changes.

IR Background

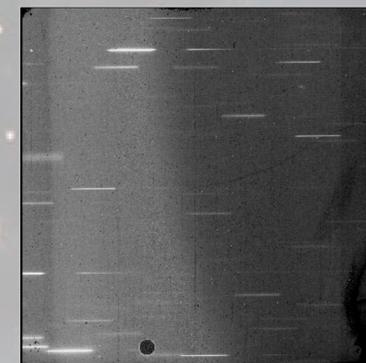
- Near-IR background is dominated by Zodiacal light and Earthshine
- Average WFC3/IR background rates range from 0.2 to 1.5 e⁻/pix/sec for medium to wide filters
- Can go up to ~2.5 e⁻/pix/sec for wide filters with high Zodiacal levels



Predicted IR background for Low, Average, and High Zodiacal light levels, compared to actual Observations. Error bars show the range of values in Observations and dots show the mean.

IR Scattered Earthlight

- Pointings near bright Earth limb can cause unusual pattern of scattered Earth light in IR images
- Targets in Continuous Viewing Zone (CVZ) are particularly susceptible because line of sight can be close to Earth limb for >5 minutes
- For non-CVZ targets, observers can specify LOW-SKY special requirement or larger Bright Earth Avoidance angle.



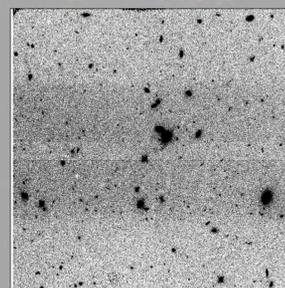
MultiDrizzle and DQ Flags

- When rerunning MultiDrizzle it is advisable to think about which DQ flags to consider as good and bad, relative to the type of target data
- Dead and saturated pixels should always be considered bad (DQ=4 and 256)
- IR pixels with DQ=8 and 32 are probably OK to use if you have bright sources
- With large dither patterns, reject pixels affected by IR blobs (DQ=512)

DQ	UVIS	IR
1	Reed-Solomon error	Reed-Solomon error
2	Missing data packet	Missing data packet
4	Dead/Bad pixel	Dead/Bad pixel
8	(unassigned)	Deviant zero read value
16	Hot pixel	Hot pixel
32	CTE tail	Photometrically unstable
64	Warm pixel	(unassigned)
128	Bad bias	Bad reference pixel
256	Full-well saturation	Full-well saturation
512	Bad flat field value	Bad flat field value
1024	Charge trap	(unassigned)
2048	A-to-D converter saturation	Signal in zero read
4096	CR detected by Multidrizzle	CR detected by Multidrizzle
8192	CR detected by calwf3	CR detected by calwf3
16384	Ghost/Crosstalk	Ghost/Crosstalk

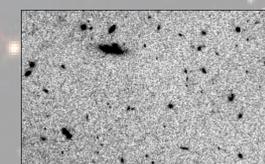
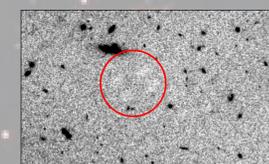
IR Banding

- IR exposures following subarray readouts can show offsets in image background
- Sometimes imprinted during calibration through use of a dark that contains banding
- New banding-free darks are being constructed for all IR readout modes



IR "blobs"

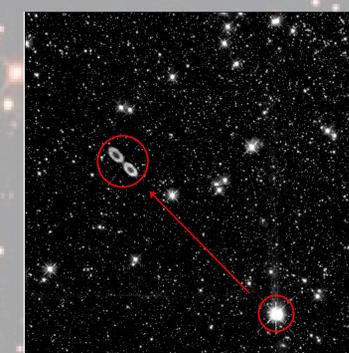
- About 20 spots of reduced sensitivity in IR images, with half-right radii of ~10 pixels and absorb 5-10% of signal
- Dithering exposures by >25 pixels can allow the regions affected by blobs to be filled in during MultiDrizzle processing
- Smaller dither patterns can not fill in the blobs
- MultiDrizzle default settings in OTFR consider blob pixels to be good, thus not rejecting them
- If you have a large dither pattern, rerun MultiDrizzle with blob rejection turned on to fill in those pixels
- See WFC3 ISR 2010-06 and 2010-09



Multidrizzled images of 4-point dither pattern without (left) and with (right) "blob" rejection

UVIS Optical Ghosts

- Reflections between CCD and detector window can produce optical ghosts
- Only occurs for bright sources located in lower-right (amplifier D) quadrant of the UVIS field-of-view
- Reflection appears as a "figure 8" to the upper-left of source, containing ~3% of source flux
- Observers should avoid having bright point sources in quad D if reflection will impact analysis



• See WFC3 ISR 2004-04