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The Updated Calibration Pipeline for WFC3/UVIS: A Cookbook to Calwf3 3.3

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Abstract

The new version of the WFC3 calibration pipeline calwf3 *(version 3.3, also called UVIS 2.0) incorporates two major changes for the calibration of WFC3/UVIS images. The first new feature is charge transfer efficiency (CTE) correction for full frame WFC3/UVIS data. The second is an updated, chip-dependent solution for photometric calibration of WFC3/UVIS data with new zeropoints and flatfields. (The previous chip-independent solution/flatfield/zeropoint calibration is still supported). We will refer to the updated, chip-dependent solution/files as the 2016 solution/files in this document , though the solution should be understood to be valid for all epochs of WFC3/UVIS imaging data. Running the new version of the pipeline with these new corrections requires new header keywords as well as new reference files. The usual* *flt.fits *products will feature chip-dependent photometrically corrected data. New,* *flc.fits, products will feature CTE and chip-dependent photometrically corrected data. We describe the process for processing and recalibrating UVIS data with calwf3 v3.3 in the sections below. A companion ISR, Ryan et al. (2016) gives more information on the effects of the new calibrations.*

NOTE: CTE correction is currently only supported for the full-frame images (`*flc.fits` products are only produced for full-frame data). Subarray support may be added at a later date.

NOTE: Re-retrieving `*raw.fits` products from MAST ensures that all the relevant keywords are properly set for running `calwf3` with the new corrections on the uncalibrated

data. Re-retrieving `*flt.fits` or `*flc.fits` files from MAST returns calibrated products already using the new corrections. **Use the following steps ONLY if you already have the *raw.fits products and wish to manually reprocess offline.**

1 New Reference Files and Software

Calibration software (calwf3) can only be ran on `*raw.fits` files. Updated calwf3 software, version 3.3, and new reference files are required for the new corrections. Calwf3 software can be obtained by updating or installing the SSBX development build of Ureka. Information on using Ureka is available at ssb.stsci.edu/ureka. Check to ensure that the new version of calwf3 is installed. Enter your Ureka environment by typing `"calwf3.e -r"`. **Make sure that the current version is listed as 3.3 or later**; previous versions do not support the new corrections. The new reference files can be retrieved from the CRDS Page under the `wfc3` section or from the WFC3 reference file FTP. These new files are:

- zcv2057ni_bic.fits
- zcv2057mi_cte.fits
- zcv2057oi_snk.fits
- *_dkc.fits (use the appropriate file based on `"USEAFTER"` date)
- zcv2057li_imp.fits
- *_pfl.fits (use the appropriate file based on filter and binning level, see Table 3)
- *_drk.fits (use the appropriate file based on `"USEAFTER"` date)

NOTE: calwf3 processing using the `drk` files is unchanged, but dark current files (`DARKFILE`) created with a new algorithm are being released coincident with the release of the new calwf3 software.

The `bic` and `snk` files are current as of February 2016, and will likely be updated in the future. New `dkc` files are created each day, the correct file is selected by date. The `"DATE-OBS"` and `"TIME-OBS"` keyword values in the primary header of the `*raw.fits` files must be compared to the `"USEAFTER"` keyword value in the `dkc` file's primary header. Select the `dkc` file with the `"USEAFTER"` date closest to (**but not after!**) the `"DATE-OBS"` and `"TIME-OBS"` values. Consult the WFC3 CRDS page for updated reference files.

2 New Header Keywords

In addition to retrieving new reference files, new header keywords must be added to the `*raw.fits` files to properly run the new pipeline. The new keywords and their values are shown in Table 1. CTE correction is computationally intensive, and is therefore time-

Keyword	Value	function
PCTETAB	'iref$zcv2057mi_cte.fits'	CTE Parameter Table
BIACFILE	'iref$zcv2057ni_bic.fits'	CTE Bias Image
DRKCFILE	'iref$*_dkc.fits'	CTE Dark
SNKCFILE	'iref$zcv2057oi_snk.fits'	Sink Pixel Table
DARKFILE	'iref$*_drk.fits'	Regular Dark
CTE_NAME	'pixelCTE 2012'	CTE Keyword
CTE_VER	'1.0'	CTE Keyword
CTEDATE0	54962.0	CTE Keyword
CTEDATE1	56173.0	CTE Keyword
PCTERNOI	3.25	CTE Keyword
PCTENFOR	5	CTE Keyword
PCTENPAR	7	CTE Keyword
PCTENSMD	0	CTE Keyword
PCTETRSH	-10.	CTE Keyword
FIXROCR	1	CTE Keyword
PCTETLEN	60	CTE Keyword
PCTECORR	'PERFORM'	CTE Correction Switch
PFLTFILE	'iref$*_pfl.fits'	Flatfield Image
IMPHTTAB	'iref$zcv2057li_imp.fits'	Image Photometry Table
FLUXCORR	'PERFORM'	Chip Flux Scaling Switch

Table 1: New header keywords and their corresponding values. These keywords should be added to the header of the 0^{th} extension. The keywords highlighted in **red** are relevant to the CTE correction. The keywords highlighted in **blue** are relevant to the new photometric calibration see Table 3 to choose the correct PFLTFILE.

consuming compared to the other calibration steps. If you do not wish to perform the CTE correction set `"PCTECORR"` to `"OMIT"` to only create the `*flt.fits` images. **The other CTE keywords must still be added to the header.**

NOTE: CTE correction is not supported for subarray data. Set `"PCTECORR"` to `"OMIT"` for subarray images.
NOTE: The photometric calibration for quad filter data (`FILTER = FQ___N`) and the UVIS grism (`FILTER = G280`) is unchanged. `"FLUXCORR"` **should be set to** `"OMIT"` **for data taken with these filters**. When FLUXCORR is set to `"PERFORM"` calwf3 will compute and apply PHTRATIO so that Chip2 is normalized to Chip1. CTE correction is still supported for full-frame data using these filters. CTE correction for subarrays may be carried out using the FORTRAN code developed by J. Anderson, and, which is available at the WFC3 CTE Tools Page.

3 Adding the Keywords and Running calwf3

We include an example for updating the header keywords and running the pipeline here. These examples require the user to be in one of the Ureka development (SSBX or SSBDEV) environments.
NOTE: CTE correction is not supported for subarray data. Set `"PCTECORR"` to `"OMIT"` for subarray images.
In Python:

```
>>> from astropy.io import fits
>>> from wfc3tools import calwf3
>>> with fits.open('ib6w62toq_raw.fits', mode='update') as image: # open file
...     image[0].header['PCTETAB'] = 'iref$zcv2057mi_cte.fits'  # set or add  keyword
...     image[0].header['BIACFILE'] = 'iref$zcv2057ni_bic.fits'
...     image[0].header['DRKCFILE'] = 'iref$zcv1924di_dkc.fits'
...     image[0].header['DARKFILE'] = 'iref$zcv15218i_drk.fits'
...     image[0].header['SNKCFILE'] = 'iref$zcv2057oi_snk.fits'
...     image[0].header['CTE_NAME'] = 'pixelCTE 2012'
...     image[0].header['CTE_VER'] = '1.0'
...     image[0].header['CTEDATE0'] = 54962.0
...     image[0].header['CTEDATE1'] = 56173.0
...     image[0].header['PCTERNOI'] = 3.25
...     image[0].header['PCTENFOR'] = 5
...     image[0].header['PCTENPAR'] = 7
...     image[0].header['PCTENSMD'] = 0
...     image[0].header['PCTETRSH'] = -10.
...     image[0].header['FIXROCR'] = 1
...     image[0].header['PCTETLEN'] = 60
...     image[0].header['PCTECORR'] = 'PERFORM'
...     image[0].header['PFLTFILE'] = 'iref$zcv2054mi_pfl.fits'
...     image[0].header['IMPHTTAB'] = 'iref$zcv2057li_imp.fits'
...     image[0].header['FLUXCORR'] = 'PERFORM'
>>> calwf3.calwf3('ib6w62toq_raw.fits')
```

In IRAF:

```
iraf> hedit ib6w62toq_raw.fits PCTECORR "PERFORM" verify- update+ add+  # use add+
iraf> hedit ib6w62toq_raw.fits PCTERSH "10." verify- update+ add+    # for new keywords
<etc>
iraf> stsdas.hst_calib
iraf> wfc3
iraf> calwf3 ib6w62toq_raw.fits
```

If the headers are already updated with the correct keywords/reference files, calwf3 can be run from the command line:

```
$ calwf3 ib6w62toq_raw.fits
```

The output files from running calwf3 include the calibrated `*flt.fits` and `*flc.fits` files.

4 Using the Previous Photometric Solution

In some cases the use of the old photometric solution is desired (to have consistent photometry with previously analyzed data, for example). The corresponding older reference files are required to use this solution, and can be downloaded from the WFC3 reference file FTP. The photometric keywords, highlighted in blue in Table 1, require different values to be set (the CTE keywords should still be set appropriately):

Keyword	Value
PFLTFILE	'iref$*_pfl.fits'
IMPHTTAB	'iref$x5h1320fi_imp.fits'
FLUXCORR	'OMIT'

Table 2: Photometric keywords and values for the old photometric solution. See Table 3 to choose the correct PFLTFILE.

5 References

Ryan, R., et al. *The Updated Calibration Pipeline for WFC3/UVIS: A Reference Guide to calwf3 (version 3.3)*, WFC3 ISR 2016-01

A APPENDIX: Filters and corresponding flatfields

Each flatfield file is unique to each filter. To use the new 2016 solution set the keyword "PFLTFILE" to the entry for the corresponding filter listed under the "2016 Flat" column in Table 3. To use the old method set the keyword "PFLTFILE" to the entry in the "Old Flat" column of Table 3. To determine which filter was used for a particular image, print the "FILTER" keyword located in the header.

Note: The UVIS Quad filters (FQ___N) and Grism (G280) are not included in the following table as the flatfield files have remained the same. You do not need to update the "PFLTFILE" keyword for images using these filters.
Note: In the (very rare) case that your images are binned either in 2x2 or 3x3 pixel bins, separate, binned flatfields must be used for successful calibration. These binned flatfields are available at the WFC3 CRDS page or WFC3 reference file FTP. To determine if data is binned, check the keyword "BINAXIS1" in the header of the 1^{st} extension.

Filter	2016 Flat	Old Flat	Filter	2016 Flat	Old Flat
F200LP	zcv2053ei_pfl.fits	vcd2017oi_pfl.fits	F547M	zcv20545i_pfl.fits	vcd2018ci_pfl.fits
F218W	zcv2053fi_pfl.fits	vcd2017pi_pfl.fits	F555W	zcv20546i_pfl.fits	v8816168i_pfl.fits
F225W	zcv2053gi_pfl.fits	vcd2017qi_pfl.fits	F600LP	zcv20547i_pfl.fits	vcd2018di_pfl.fits
F275W	zcv2053hi_pfl.fits	vcd2017ri_pfl.fits	F606W	zcv20548i_pfl.fits	v8816169i_pfl.fits
F280N	zcv2053ii_pfl.fits	vcd2017si_pfl.fits	F621M	zcv20549i_pfl.fits	vcd2018ei_pfl.fits
F300X	zcv2053ji_pfl.fits	vcd2017ti_pfl.fits	F625W	zcv2054ai_pfl.fits	vcd2018fi_pfl.fits
F336W	zcv2053ki_pfl.fits	v8816165i_pfl.fits	F631N	zcv2054bi_pfl.fits	vcd2018gi_pfl.fits
F343N	zcv2053li_pfl.fits	vcd20180i_pfl.fits	F645N	zcv2054ci_pfl.fits	vcd2018hi_pfl.fits
F350LP	zcv2053mi_pfl.fits	vcd20181i_pfl.fits	F656N	zcv2054di_pfl.fits	vcd2018ii_pfl.fits
F373N	zcv2053ni_pfl.fits	vcd20182i_pfl.fits	F657N	zcv2054ei_pfl.fits	vcd2018ji_pfl.fits
F390M	zcv2053oi_pfl.fits	vcd20183i_pfl.fits	F658N	zcv2054fi_pfl.fits	vcd2018ki_pfl.fits
F390W	zcv2053pi_pfl.fits	v8816166i_pfl.fits	F665N	zcv2054gi_pfl.fits	vcd2018li_pfl.fits
F395N	zcv2053qi_pfl.fits	vcd20184i_pfl.fits	F673N	zcv2054hi_pfl.fits	vcd2018mi_pfl.fits
F410M	zcv2053ri_pfl.fits	vcd20185i_pfl.fits	F680N	zcv2054ii_pfl.fits	vcd2018ni_pfl.fits
F438W	zcv2053si_pfl.fits	v8816167i_pfl.fits	F689M	zcv2054ji_pfl.fits	vcd2018oi_pfl.fits
F467M	zcv2053ti_pfl.fits	vcd20186i_pfl.fits	F763M	zcv2054ki_pfl.fits	vcd2018pi_pfl.fits
F469N	zcv20540i_pfl.fits	vcd20187i_pfl.fits	F775W	zcv2054li_pfl.fits	v881616ai_pfl.fits
F475W	zcv20541i_pfl.fits	vcd20188i_pfl.fits	F814W	zcv2054mi_pfl.fits	v881616bi_pfl.fits
F475X	zcv20542i_pfl.fits	vcd20189i_pfl.fits	F845M	zcv2054ni_pfl.fits	vcd2018qi_pfl.fits
F487N	zcv20543i_pfl.fits	vcd2018ai_pfl.fits	F850LP	zcv2054oi_pfl.fits	vcd2018ri_pfl.fits
F502N	zcv20544i_pfl.fits	vcd2018bi_pfl.fits	F953N	zcv2054pi_pfl.fits	vcd2018si_pfl.fits

Table 3: UVIS filters and the corresponding PFLTFILE for the 2016 solution and previous years' solution.