# Updated WFC3/UVIS Chip Dependent SYNPHOT/PYSYNPHOT Files

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May 02, 2016

**ABSTRACT**

*The purpose of this ISR is to document the changes to WFC3/UVIS component files that are used with SYNPHOT and PYSYNPHOT as a result of the implementation of the detector dependent photometric calibration in February 2016.*

## Introduction

The inflight characterization of the WFC3/UVIS performance relies on the initial, prelaunch measurements of the optical elements in the light path (from the 'entrance aperture of the telescope' to the detectors, through filters, mirrors, and various lenses and windows), as well as measurments made during on-orbit operations. Brown (2007) provides a description of the components as they originally were developed. This ISR identifies nomenclature and value changes in the tables which were made to conform to the chip dependent photometric calibration for the UVIS instrument implemented on 23 February 2016 (Deustua et al 2016).

Because the chip dependent photometry departs from the approach implemented at the time WFC3 was installed in 2009, changes to the synthetic photometry were made. All correction factor files are removed, effectively reverting to the pre-launch throughputs, but the encircled energy (aperture correction) and gain are updated with their in-flight measured values. After determining the new photometric calibrations, the filter transmission, aperture correction and wavelength dependent corrections were recomputed, and the corresponding SYNPHOT/PYSYNPHOT files updated and renamed.

### SYNPHOT/PYSYNPHOT Files

Synthetic photometry with SYNPHOT-and PSYNPHOT rely on FITS binary tables to compute photometric quantities such as throughputs and signal to noise estimates, and can be divided into four groups: Optics, Detectors, Photometry, and Filters.

#### Changes to SYNPHOT Files

These changes affect both the values and names of the filter transmission files for the 42 full frame WFC3/UVIS filters. No changes were made to the values or the names of the quad filter transmission files. Neither the names or the values for the UV grism files were changed. A description of the current (as of 2016) synphot files follows.

### Optics.

The optics component files remain the same as in 2009, and contain the measured or calculated throughput, transmission or reflectivity values for the HST optical telescope assembly (OTA), pick off mirror reflectivity (POM), the two UVIS mirrors, (mir1, mir2), and the outer and inner dewar windows (owin, iwin). They are listed in Table 1.

Table 1.  Synphot Optics files.

| Component Name | Filename | comment |
|---|---|---|
| hst_ota | hst_ota_007_syn.fits | HST OTA throughput |
| wfc3_pom | wfc3_pom_001_syn.fits | Pick Off Mirror (POM) reflectivity |
| wfc3_uvis_iwin | wfc3_uvis_iwin_002_syn.fits | UVIS inner dewar window |
| wfc3_uvis_mir1 | wfc3_uvis_mir1_002_syn.fits | UVIS mirror 1 |
| wfc3_uvis_mir2 | wfc3_uvis_mir2_002_syn.fits | UVIS mirror 2 |
| wfc3_uvis_owin | wfc3_uvis_owin_002_syn.fits | UVIS outer dewar window |

### Detectors

Characterisics of the detectors, quantum efficiency, quantum yield and gain are initially measured on the ground. Of these, only the gain values were updated inflight. These files are also listed in Table 2.

### Photometry

#### Aperture Correction

Chip dependent aperture corrections are determined for each full frame filter and CCD, resulting in two aperture correction files. This is a change from 2009 when only one apercture correction file was provided for the entire WFC3/UVIS detector array.

*Wavelength Dependent Correction.*

At the same time, a wavelength dependent correction, unattributable to any single component, to the throughput is computed for each detector; they replace the previous 2012 version, wfc3_uvis_cor_003_syn.fits.

*Flat Field Normalization*

For the 'single detector' photometric calibration, the flat fields were normalized to the chip midpoints using 'fudge' files, and which are denoted wfc3_uvis_FFFfn_xxx_syn.fits. FFF is the filter name, f is for flat, n is the CCD number (chip 1 or chip 2), and xxx the file version. In the chip dependent implementation the values in these files are set to 1, and the version number updated to 004, for example, wfc3_uvis_f606wf1_003_syn.fits and wfc3_uvis_f606wf2_003_syn.fits.

The detector and photometry synphot files are listed in Table 2, and the filter transmissions are listed in Tables 3,4,5 and 6.

Table 2. Synphot Detector and Photometry files.

| Component Name | Filename | Comment |
|---|---|---|
| wfc3_uvis_ccd1 | wfc3_uvis_ccd1_003_syn.fits | Pre-launch QE measurements for UVIS1 |
| wfc3_uvis_ccd2 | wfc3_uvis_ccd2_003_syn.fits | Pre-launch QE measurements for UVIS2 |
| wfc3_uvis_qyc | wfc3_uvis_qyc_001_syn.fits | quantum yield correction (UV) |
| wfc3_uvis_dn | wfc3_uvis_dn_002_syn.fits | inflight gain correction |
| wfc3uvis1_aper | wfc3uvis1_aper_005_syn.fits | inflight aperture correction for UVIS1 |
| wfc3uvis2_aper | wfc3uvis2_aper_005_syn.fits | inflight aperture correction for UVIS2 |
| wfc3uvis1_cor | wfc3uvis1_cor_004_syn.fits | UVIS1 inflight wavelength dependent correction |
| wfc3uvis2_cor | wfc3uvis2_cor_004_syn.fits | UVIS2 inflight wavelength dependent correction |
| wfc3_uvis_FFFf1 | wfc3_uvis_f606wf1_003_syn.fits | UVIS1 flat field normalization, values set to 1 in 2016 |
| wfc3_uvis_FFFf2 | wfc3_uvis_f606wf2_003_syn.fits | UVIS2 flat field normalization, values set to 1 in 2016 |

**Filter Transmission Files.**

Transmission of all the UVIS filters was measured in the lab, at air wavelengths, prior to 2009. Changes made to the transmission before WFC3 was installed on HST were: conversion from air to vacuum wavelengths, and for several filters, the transmission was changed based on measurements made during the final Thermal-Vacuum ground test in 2008. The SYNPHOT

files corresponding to the pre-launch values are given in Table 3, and the updated, 2016 files for UVIS1 and UVIS2  in Table 4.

### *Graph and Component Tables*

The graph table, ending in the suffix tmg.fits, specifies the light paths through the telescope and instruments, effectively the order in which components are used for an observing mode.  Due to the chip dependency, the graph table was modified to include the new component names, e.g. wfc3uvis*  instead of wfc3_uvis_*.  New names have a slightly different format from previous names in order to comply with the character limit on component names.  The graph table for WFC3/UVIS was also modified to include the proper components for UVIS1 and UVIS2.

The component table, ending in the suffix tmc.fits,  specifies the files associated with each component name.  Filenames were updated, as were the component names.

## Retrieving SYNPHOT/PYSYNPHOT files.

Instructions for retrieving synphot files are available at
http://www.stsci.edu/hst/observatory/crds/throughput.html

The current component table (*tmc.fits) and graph table (*tmg.fits) files can be retrieved from
http://www.stsci.edu/hst/observatory/crds/SIfileInfo/pysynphottables/current_tmc_html

## Using  SYNPHOT files

The 2005 Synphot User's Guide   (Laidler et al 2005) contains a good description of how SYNPHOT and PYSYNPHOT work, whereas the 2008 Synphot Data User's Guide (Laidler et al 2008) provides information on keywords and observing modes, including how to use synphot for non-HST instruments.

### *Acknowledgements*

Thanks to Rosa Diaz and Matt McMaster for their invaluable help in getting the new synphot files properly constructed, and in editing the graph and component files, and, to Megan Sosey for reviewing this ISR.

## References

Brown, T., 2007, *WFC3 SYNPHOT Data*, Instrument Science Report WFC3 2007-06
Deustua, S.,  et al, 2016, UVIS 2.0 Chip Dependent Values for the Inverse Sensitivity
        (Zeropoints), Instrument Science Report,  WFC3 2016-03
Laidler V., et al, 2005, *Synphot User's Guide*, Version 5.0 (Baltimore:STScI,
        http://www.stsci.edu/institute/software_hardware/stsdas/synphot/SynphotManual.pdf
Laidler et al, 2008, *Synphot Data User's Guide* (Baltimore, STScI),
        http://www.stsci.edu/hst/HST_overview/documents/synphot/hst_synphot_cover.html

Table 3. Pre-launch Filter Transmission Files. Nineteen filters had transmissions updated in 2008 as a result of measurements made during TV3. These are indicated in the Comment column.

| Component Name | File Name | Comment |
|---|---|---|
| wfc3_uvis_f200lp | wfc3_uvis_f200lp_002_syn.fits | |
| wfc3_uvis_f218w | wfc3_uvis_f218w_002_syn.fits | |
| wfc3_uvis_f225w | wfc3_uvis_f225w_002_syn.fits | |
| wfc3_uvis_f275w | wfc3_uvis_f275w_002_syn.fits | |
| wfc3_uvis_f280n | wfc3_uvis_f280n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f300x | wfc3_uvis_f300x_002_syn.fits | |
| wfc3_uvis_f336w | wfc3_uvis_f336w_002_syn.fits | |
| wfc3_uvis_f343n | wfc3_uvis_f343n_002_syn.fits | |
| wfc3_uvis_f350lp | wfc3_uvis_f350lp_002_syn.fits | |
| wfc3_uvis_f373n | wfc3_uvis_f373n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f390m | wfc3_uvis_f390m_002_syn.fits | |
| wfc3_uvis_f390w | wfc3_uvis_f390w_002_syn.fits | |
| wfc3_uvis_f395n | wfc3_uvis_f395n_002_syn.fits | |
| wfc3_uvis_f410m | wfc3_uvis_f410m_002_syn.fits | |
| wfc3_uvis_f438w | wfc3_uvis_f438w_002_syn.fits | |
| wfc3_uvis_f467m | wfc3_uvis_f467m_002_syn.fits | |
| wfc3_uvis_f469n | wfc3_uvis_f469n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f475w | wfc3_uvis_f475w_002_syn.fits | |
| wfc3_uvis_f475x | wfc3_uvis_f475x_002_syn.fits | |
| wfc3_uvis_f487n | wfc3_uvis_f487n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f502n | wfc3_uvis_f502n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f547m | wfc3_uvis_f547m_002_syn.fits | |
| wfc3_uvis_f555w | wfc3_uvis_f555w_002_syn.fits | |
| wfc3_uvis_f600lp | wfc3_uvis_f600lp_002_syn.fits | |
| wfc3_uvis_f606w | wfc3_uvis_f606w_002_syn.fits | |
| wfc3_uvis_f621m | wfc3_uvis_f621m_002_syn.fits | |
| wfc3_uvis_f625w | wfc3_uvis_f625w_002_syn.fits | |
| wfc3_uvis_f631n | wfc3_uvis_f631n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f645n | wfc3_uvis_f645n_002_syn.fits | |
| wfc3_uvis_f656n | wfc3_uvis_f656n_003_syn.fits | Updated TV3 |

| Component Name | File Name | Comment |
| --- | --- | --- |
| wfc3_uvis_f657n | wfc3_uvis_f657n_002_syn.fits | |
| wfc3_uvis_f658n | wfc3_uvis_f658n_003_syn.fits | Updated TV3 |
| wfc3_uvis_f665n | wfc3_uvis_f665n_002_syn.fits | |
| wfc3_uvis_f673n | wfc3_uvis_f673n_002_syn.fits | |
| wfc3_uvis_f680n | wfc3_uvis_f680n_002_syn.fits | |
| wfc3_uvis_f689m | wfc3_uvis_f689m_002_syn.fits | |
| wfc3_uvis_f763m | wfc3_uvis_f763m_002_syn.fits | |
| wfc3_uvis_f775w | wfc3_uvis_f775w_003_syn.fits | Updated TV3 |
| wfc3_uvis_f814w | wfc3_uvis_f814w_002_syn.fits | |
| wfc3_uvis_f845m | wfc3_uvis_f845m_002_syn.fits | |
| wfc3_uvis_f850lp | wfc3_uvis_f850lp_002_syn.fits | |
| wfc3_uvis_f953n | wfc3_uvis_f953n_002_syn.fits | |
| wfc3_uvis_fq232n | wfc3_uvis_fq232n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq243n | wfc3_uvis_fq243n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq378n | wfc3_uvis_fq378n_002_syn.fits | |
| wfc3_uvis_fq387n | wfc3_uvis_fq387n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq422m | wfc3_uvis_fq422m_002_syn.fits | |
| wfc3_uvis_fq436n | wfc3_uvis_fq436n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq437n | wfc3_uvis_fq437n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq492n | wfc3_uvis_fq492n_002_syn.fits | |
| wfc3_uvis_fq508n | wfc3_uvis_fq508n_002_syn.fits | |
| wfc3_uvis_fq575n | wfc3_uvis_fq575n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq619n | wfc3_uvis_fq619n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq634n | wfc3_uvis_fq634n_002_syn.fits | |
| wfc3_uvis_fq672n | wfc3_uvis_fq672n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq674n | wfc3_uvis_fq674n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq727n | wfc3_uvis_fq727n_003_syn.fits | Updated TV3 |
| wfc3_uvis_fq750n | wfc3_uvis_fq750n_002_syn.fits | |
| wfc3_uvis_fq889n | wfc3_uvis_fq889n_002_syn.fits | |
| wfc3_uvis_fq906n | wfc3_uvis_fq906n_002_syn.fits | |
| wfc3_uvis_fq924n | wfc3_uvis_fq924n_002_syn.fits | |
| wfc3_uvis_fq937n | wfc3_uvis_fq937n_002_syn.fits | |

Table 4.  2016 Filter Transmission files for UVIS1 and UVIS2

| UVIS1 | | UVIS2 | |
|---|---|---|---|
| **Component Name** | **Filename** | **Component Name** | **Filename** |
| *Full Frame Filters* | | *Full Frame Filters* | |
| wfc3uvis1_f200lp | wfc3uvis1_f200lp_006_syn.fits | wfc3uvis2_f200lp | wfc3uvis2_f200lp_006_syn.fits |
| wfc3uvis1_f218w | wfc3uvis1_f218w_006_syn.fits | wfc3uvis2_f218w | wfc3uvis2_f218w_006_syn.fits |
| wfc3uvis1_f225w | wfc3uvis1_f225w_006_syn.fits | wfc3uvis2_f225w | wfc3uvis2_f225w_006_syn.fits |
| wfc3uvis1_f275w | wfc3uvis1_f275w_006_syn.fits | wfc3uvis2_f275w | wfc3uvis2_f275w_006_syn.fits |
| wfc3uvis1_f280n | wfc3uvis1_f280n_006_syn.fits | wfc3uvis2_f280n | wfc3uvis2_f280n_006_syn.fits |
| wfc3uvis1_f300x | wfc3uvis1_f300x_006_syn.fits | wfc3uvis2_f300x | wfc3uvis2_f300x_006_syn.fits |
| wfc3uvis1_f336w | wfc3uvis1_f336w_006_syn.fits | wfc3uvis2_f336w | wfc3uvis2_f336w_006_syn.fits |
| wfc3uvis1_f343n | wfc3uvis1_f343n_006_syn.fits | wfc3uvis2_f343n | wfc3uvis2_f343n_006_syn.fits |
| wfc3uvis1_f350lp | wfc3uvis1_f350lp_006_syn.fits | wfc3uvis2_f350lp | wfc3uvis2_f350lp_006_syn.fits |
| wfc3uvis1_f373n | wfc3uvis1_f373n_006_syn.fits | wfc3uvis2_f373n | wfc3uvis2_f373n_006_syn.fits |
| wfc3uvis1_f390m | wfc3uvis1_f390m_006_syn.fits | wfc3uvis2_f390m | wfc3uvis2_f390m_006_syn.fits |
| wfc3uvis1_f390w | wfc3uvis1_f390w_006_syn.fits | wfc3uvis2_f390w | wfc3uvis2_f390w_006_syn.fits |
| wfc3uvis1_f395n | wfc3uvis1_f395n_006_syn.fits | wfc3uvis2_f395n | wfc3uvis2_f395n_006_syn.fits |
| wfc3uvis1_f410m | wfc3uvis1_f410m_006_syn.fits | wfc3uvis2_f410m | wfc3uvis2_f410m_006_syn.fits |
| wfc3uvis1_f438w | wfc3uvis1_f438w_006_syn.fits | wfc3uvis2_f438w | wfc3uvis2_f438w_006_syn.fits |
| wfc3uvis1_f467m | wfc3uvis1_f467m_006_syn.fits | wfc3uvis2_f467m | wfc3uvis2_f467m_006_syn.fits |
| wfc3uvis1_f469n | wfc3uvis1_f469n_006_syn.fits | wfc3uvis2_f469n | wfc3uvis2_f469n_006_syn.fits |
| wfc3uvis1_f475w | wfc3uvis1_f475w_006_syn.fits | wfc3uvis2_f475w | wfc3uvis2_f475w_006_syn.fits |
| wfc3uvis1_f475x | wfc3uvis1_f475x_006_syn.fits | wfc3uvis2_f475x | wfc3uvis2_f475x_006_syn.fits |
| wfc3uvis1_f487n | wfc3uvis1_f487n_006_syn.fits | wfc3uvis2_f487n | wfc3uvis2_f487n_006_syn.fits |
| wfc3uvis1_f502n | wfc3uvis1_f502n_006_syn.fits | wfc3uvis2_f502n | wfc3uvis2_f502n_006_syn.fits |
| wfc3uvis1_f547m | wfc3uvis1_f547m_006_syn.fits | wfc3uvis2_f547m | wfc3uvis2_f547m_006_syn.fits |
| wfc3uvis1_f555w | wfc3uvis1_f555w_006_syn.fits | wfc3uvis2_f555w | wfc3uvis2_f555w_006_syn.fits |
| wfc3uvis1_f600lp | wfc3uvis1_f600lp_006_syn.fits | wfc3uvis2_f600lp | wfc3uvis2_f600lp_006_syn.fits |
| wfc3uvis1_f606w | wfc3uvis1_f606w_006_syn.fits | wfc3uvis2_f606w | wfc3uvis2_f606w_006_syn.fits |
| wfc3uvis1_f621m | wfc3uvis1_f621m_006_syn.fits | wfc3uvis2_f621m | wfc3uvis2_f621m_006_syn.fits |
| wfc3uvis1_f625w | wfc3uvis1_f625w_006_syn.fits | wfc3uvis2_f625w | wfc3uvis2_f625w_006_syn.fits |
| wfc3uvis1_f631n | wfc3uvis1_f631n_006_syn.fits | wfc3uvis2_f631n | wfc3uvis2_f631n_006_syn.fits |
| wfc3uvis1_f645n | wfc3uvis1_f645n_006_syn.fits | wfc3uvis2_f645n | wfc3uvis2_f645n_006_syn.fits |

| UVIS1 | | UVIS2 | |
|---|---|---|---|
| **Component Name** | **Filename** | **Component Name** | **Filename** |
| *Full Frame Filters* | | *Full Frame Filters* | |
| wfc3uvis1_f656n | wfc3uvis1_f656n_006_syn.fits | wfc3uvis2_f656n | wfc3uvis2_f656n_006_syn.fits |
| wfc3uvis1_f657n | wfc3uvis1_f657n_006_syn.fits | wfc3uvis2_f657n | wfc3uvis2_f657n_006_syn.fits |
| wfc3uvis1_f658n | wfc3uvis1_f658n_006_syn.fits | wfc3uvis2_f658n | wfc3uvis2_f658n_006_syn.fits |
| wfc3uvis1_f665n | wfc3uvis1_f665n_006_syn.fits | wfc3uvis2_f665n | wfc3uvis2_f665n_006_syn.fits |
| wfc3uvis1_f673n | wfc3uvis1_f673n_006_syn.fits | wfc3uvis2_f673n | wfc3uvis2_f673n_006_syn.fits |
| wfc3uvis1_f680n | wfc3uvis1_f680n_006_syn.fits | wfc3uvis2_f680n | wfc3uvis2_f680n_006_syn.fits |
| wfc3uvis1_f689m | wfc3uvis1_f689m_006_syn.fits | wfc3uvis2_f689m | wfc3uvis2_f689m_006_syn.fits |
| wfc3uvis1_f763m | wfc3uvis1_f763m_006_syn.fits | wfc3uvis2_f763m | wfc3uvis2_f763m_006_syn.fits |
| wfc3uvis1_f775w | wfc3uvis1_f775w_006_syn.fits | wfc3uvis2_f775w | wfc3uvis2_f775w_006_syn.fits |
| wfc3uvis1_f814w | wfc3uvis1_f814w_006_syn.fits | wfc3uvis2_f814w | wfc3uvis2_f814w_006_syn.fits |
| wfc3uvis1_f845m | wfc3uvis1_f845m_006_syn.fits | wfc3uvis2_f845m | wfc3uvis2_f845m_006_syn.fits |
| wfc3uvis1_f850lp | wfc3uvis1_f850lp_006_syn.fits | wfc3uvis2_f850lp | wfc3uvis2_f850lp_006_syn.fits |
| wfc3uvis1_f953n | wfc3uvis1_f953n_006_syn.fits | wfc3uvis2_f953n | wfc3uvis2_f953n_006_syn.fits |
| *Quad Filters* | | *Quad Filters* | |
| wfc3_uvis_fq378n | wfc3_uvis_fq378n_004_syn.fits | wfc3_uvis_fq232n | wfc3_uvis_fq232n_005_syn.fits |
| wfc3_uvis_fq387n | wfc3_uvis_fq387n_005_syn.fits | wfc3_uvis_fq243n | wfc3_uvis_fq243n_005_syn.fits |
| wfc3_uvis_fq437n | wfc3_uvis_fq437n_005_syn.fits | wfc3_uvis_fq422m | wfc3_uvis_fq422m_004_syn.fits |
| wfc3_uvis_fq492n | wfc3_uvis_fq492n_004_syn.fits | wfc3_uvis_fq436n | wfc3_uvis_fq436n_005_syn.fits |
| wfc3_uvis_fq508n | wfc3_uvis_fq508n_004_syn.fits | wfc3_uvis_fq575n | wfc3_uvis_fq575n_005_syn.fits |
| wfc3_uvis_fq619n | wfc3_uvis_fq619n_005_syn.fits | wfc3_uvis_fq634n | wfc3_uvis_fq634n_004_syn.fits |
| wfc3_uvis_fq674n | wfc3_uvis_fq674n_005_syn.fits | wfc3_uvis_fq672n | wfc3_uvis_fq672n_005_syn.fits |
| wfc3_uvis_fq750n | wfc3_uvis_fq750n_004_syn.fits | wfc3_uvis_fq727n | wfc3_uvis_fq727n_005_syn.fits |
| wfc3_uvis_fq889n | wfc3_uvis_fq889n_004_syn.fits | wfc3_uvis_fq906n | wfc3_uvis_fq906n_004_syn.fits |
| wfc3_uvis_fq937n | wfc3_uvis_fq937n_004_syn.fits | wfc3_uvis_fq924n | wfc3_uvis_fq924n_004_syn.fits |