

# DOLPHOT/WFIRST User's Guide

version 2.0

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# 1 Introduction

This manual describes installation and use of the WFIRST module for DOLPHOT. The WFIRST module replaces the analytic PSF model with a lookup table computed using Tiny Tim PSFs.

If you have any problems installing or using DOLPHOT or the provided utilities, please let me know.

Note that the current release of the WFIRST module supports photometry of STIPS generated (simulated) images only. Due to limitations of the PSF generation process used by STIPS (at the time of this writing, 26 Aug 2017), supersampling of the simulated images at 4x or higher is mandatory in order to create realistic images. Additionally, supersampling of exactly 5x (or possibly 10x) may result in overly optimistic predictions of the photometry performance, given that the WFIRST module's PSF library is generated at 10x supersampling and stored at 5x.

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## 2 Installation

Installation of the WFIRST module is done in addition to the regular DOLPHOT installation. See the DOLPHOT manual for installation instructions for DOLPHOT.

The WFIRST module requires less than 1Mb for the sources and binaries, plus less than 1Mb per set of PSFs. Note that the PSFs are distributed separately, as you only need PSFs for the filters that you will actually be using.

The .tar.gz file for the WFIRST module (as well as the PAMs and PSFs) should be expanded from the same directory from which the DOLPHOT distribution was expanded.

### 2.1 Makefile

The Makefile is the same as the regular DOLPHOT installation, but includes several options used by the WFIRST module. To enable the WFIRST module, the three lines beginning with the WFIRST definition should be uncommented.

No customization of the Makefile within the “wfirst” subdirectory is needed.

After editing the makefile, you should be able to type “make” to compile DOLPHOT without any error or warning messages. Should you need to later recompile the programs, typing “make clean” will remove the original compilations to ensure that all programs get recompiled.

### 2.2 PSFs

You can either make your own PSFs or use the precomputed ones. Generally there is no need to generate your own, as precomputed PSFs are available for all filters. Instructions for computing PSFs are not currently available.

### 3 Preprocessing Steps

For the WFIRST module to run correctly, data must be in the default format created by the image simulation tool STIPS. This is a single chip of data (stored in an extension), with 4096 x 4096 pixels.

This section takes you through the necessary steps (in order) for obtaining the best possible photometry from DOLPHOT.

#### 3.1 *wfirstmask*: Convert to DOLPHOT Usable Format

```
wfirstmask -exptime=<exptime> -rdnoise=<readout noise> <fits files>
```

*WFIRSTmask* takes as input FITS files in the format created by STIPS. (one-extension files with a 4096x4096 image.

Before running *wfirstmask*, make sure you have backed up the original images, since *wfirstmask* will alter them!

#### 3.2 *calcsky*: Calculate Sky for Image

```
calcsky <fits base> < $r_{in}$ > < $r_{out}$ > <step> < $\sigma_{low}$ > < $\sigma_{high}$ >
```

*Calcsky* is described in the DOLPHOT manual. Recommended parameters are as follows:

$$r_{in} = 10$$

$$r_{out} = 25$$

*step* = 2 for an accurate sky map, or *step* = -64 for a quick one.

$$\sigma_{low} = 2.25$$

$$\sigma_{high} = 2.00$$

Since I always use FitSky=1 or FitSky=3 in my photometry, the negative values of *step* are sufficient.

Note that running *calcsky* is currently mandatory, even if using FitSky settings of 3 or 4.

## 4 Running DOLPHOT

### 4.1 DOLPHOT Parameters

The WFIRST module of DOLPHOT will be invoked whenever processing images that have been run through wfirstrmask. When using the WFIRST module, several parameters are disabled or have restricted ranges.

img\_aprad is set to 0.5 arcsec

img\_RPSF and img\_RAper cannot exceed 41 pixels (UVIS) or 19 pixels (IR)

Zero disabled (set to ABMAG zero points)

FPSF, SubPixel, img\_psfa, img\_psfb, img\_psfrc disabled

EPSF, PSFsol, PSFStep disabled

MinS, MaxS, MaxE disabled

Recommended values for other parameters are as follows:

img\_apsky = 15 25

img\_RAper = 3

img\_RChi = 1.5

img\_RSky = 8 20

SkipSky = 1

SkySig = 2.25

SecondPass = 5

SigFindMult = 0.85

MaxIT = 25

NoiseMult = 0.10

FSat = 0.999

ApCor = 1

RCentroid = 2

PosStep = 0.25

RCombine = 1.5

`img_RPSF = 10`

`SigPSF = 5.0`

`PSFres = 1`

The best overall combination of solution parameters are `PSFPhot = 1`, `FitSky = 1`, and `Force1 = 0`. Generally, `Align = 2` and `Rotate = 1` provide the best alignment. If using `FitSky = 3`, the parameters are largely the same except that suggested `img_RAper` values are 8 pixels for UVIS and 5 pixels for IR.

In some cases, blends or extended objects can hamper photometry of nearby stars. Setting `Force1 = 1` will solve this, but of course will also result in false detections of hot pixels and extended objects as single stars. So one may have to choose between a very clean but slightly incomplete CMD and a complete but contaminated one.

Finally, there are two new parameters that can be used:

`FlagMask = 4`

`CombineChi = 0`

`FlagMask` is a bitwise mask that determines what error flags will not be accepted when producing the combined photometry blocks for each filter. Note that error flag values of eight or more (when the “extreme case”) always cause the photometry to be ignored. A value of zero allows photometry with an error flag less than eight to be used. Adding one eliminates stars close to the chip edge, adding two eliminates stars with too many bad pixels, and adding four eliminates stars with saturated cores.

`CombineChi` also affects the combined photometry blocks. If set to zero (default), photometry will be combined weighted by  $1/\sigma^2$  to maximize signal to noise. If set to one, weights will be  $1/\sigma^2 \max(1, \chi^2)$  to reduce the impact of epochs with bad photometry. Note that using `CombineChi` of one will require tuning `NoiseMult` so that well measured stars have  $\chi = 1$  at all magnitudes (plots of chi vs. magnitude should show this). Note also that this will result in larger uncertainties for combined (but not individual image) magnitudes and normalized count rates, as the individual image uncertainties are effectively multiplied by  $\chi$  when calculating combined magnitudes.

## 4.2 DOLPHOT Output

The DOLPHOT/WFIRST output is virtually identical to the regular DOLPHOT output, with a few exceptions. First, if multiple images exist per filter, it will insert extra sets of photometry for each such filter (in order of wavelength) prior to the individual-image photometry. For example, if your data consist (in order) of J129, Z087, F184, J129, and Z087 images, the output photometry will have the combined Z087 photometry first, combined J129 photometry second, and last, the five sets of single-image photometry.

Within the photometry blocks, there are also some differences. First is that calibrated instrumental magnitudes and transformed magnitudes are provided. Note that transformations are not yet supported, so the second magnitude is always 99.999 in the current

DOLPHOT release. Also, a calibrated count rate and uncertainty is provided (effectively the instrumental magnitude and uncertainty expressed as a count rate).

As with all photometry, you will need to trim your detection list to eliminate objects classified as non-stellar, low signal-to-noise, or bad photometry quality. See the DOLPHOT manual for further discussion.



## 5 PSF Utility Reference

The following programs are utilities included with the WFIRST module. Since there is little need for computing custom PSFs, no documentation is provided – use at your own risk!

### 5.1 *wfirstmakepsf*: Compute PSF for Filter

```
wfirstmakepsf <filter>
```

### 5.2 *wfirstshowpsf*: Display PSF for Filter

```
wfirstshowpsf <filter> <chip> <X/4096> <Y/4096> <dX> <dY> <<flags>>
```

## 6 Recipe for WFIRST Photometry

Assuming that an appropriate reference image exists, the recipe for generating photometry is reasonably simple.

1. Run `wfirstmask` on all WFIRST images.
2. Run `calsky` on each image to generate `*.sky.fits` files.
3. Run `dolphot`.
4. If artificial star tests are to be run, use `wfirstfakelist` to generate the star list and re-run `dolphot` with the `FakeStar` parameter used to trigger artificial star mode.

## 7 Changes to DOLPHOT/WFIRST

August 26, 2017 release

1. Initial release

February 3, 2018 release

1. Changed zero points from ABmag to VEGAMAG
2. Improved calculation of combined magnitudes and uncertainties