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Possible Overlaps Between Blobs, Grism Apertures, and Dithers

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Abstract

We present a investigation into possible overlaps between the known IR blobs with the grism aperture reference positions and the IR dither patterns. Each aperture was designed to place the science target (e.g. a specific star) on a cosmetically clean area of the IR detector. Similarly, the dither patterns were designed to mitigate cosmetic defects by rarely (or ideally never) placing such targets on known defects. Because blobs accumulate with time, the originally defined apertures and dither patterns may no longer accomplish their goals, it is important to reverify these combinations. We find two potential overlaps between the blob, aperture, and dither combinations, but do not recommend any changes to the current suite of aperture references positions and/or dither patterns for two reasons. First, one of the overlaps occurs with a dither/aperture combination that is seldom used for high-value science operations, but rather more common for wide-field surveys/mosaics. Second, the other overlap is 8.7 pix from a blob that has a fiducial radius of 10 pix, which already represents a very conservative distance. We conclude that a similar analysis should be repeated as new blobs occur, to continue to ensure ideal operations for high-value science targets. The purpose of this report is to document the analysis in order to facilitate its repetition in the future.

Introduction

Shortly after the installation of the Wide-Field Camera 3 (WFC3) small regions of decreased sensitivity ($\sim 10-15\%$) were noticed and detailed by Pirzkal, Viana, & Rajan (2010). These blemishes, referred to as *blobs*, are caused by particulates on the mirror that is supported by the Channel-Select Mechanism (CSM). Durbin & McCullough (2015) show that the photometry of stars near blobs can be largely recovered by a proper flat field. The WFC3 team now marks the appearence of new blobs with the `USEAFTER` keyword in the bad-pixel table (`BPIXTAB`; McCullough et al. 2014). Currently, there are 130 blobs that subtend a total of $\sim 2\%$ (~ 300 arcsec^2) of the IR array (McCullough et al. 2014). In Figure 1, we show the known blobs (as of Oct. 31, 2016), where the size of the symbol refers to the size of the blob (the largest blobs are ~ 12 pix in radius).

The goal of this Instrument Science Report is to briefly describe a method for evaluating whether a blob may overlap with the grism reference positions for the IR apertures and document any such cases. As Users will typically center the detector/aperture on potential high-value science targets, particularly for single-object spectroscopy with the grisms (e.g. exoplanets), we are concerned of low-level photometric losses.

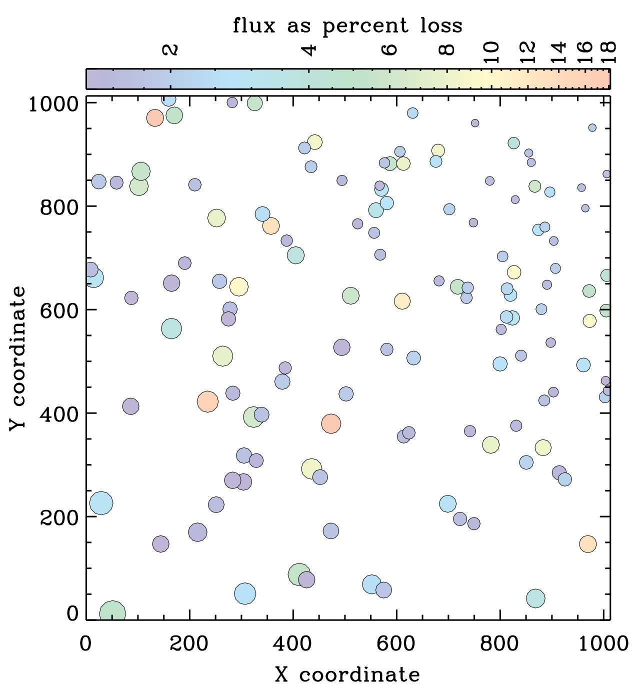

Fig. 1.— Blob positions (left). Here we show the known blobs; the size of the plot symbol indicates the size of the blob (the largest blobs have $r \sim 12$ pix). The correlation with size as a function of position has been discussed by McCullough et al. (2014).

Analysis

We compute the distance between the blobs and every aperture reference position for every dither pattern. For the dither patterns, we assume the default point and line spacing, so the positions of the dithered aperture-reference positions are given by:

$$x' = A_x + \Delta x \quad (1)$$

$$y' = A_y + \Delta y \quad (2)$$

where (A_x, A_y) is the aperture-reference position, and $(\Delta x, \Delta y)$ are the dither positions (see Table 1 and Table 2, respectively). Now the distance between these points and the ith blob is:

$$r_i = \sqrt{(x' - B_{x,i})^2 + (y' - B_{y,i})^2}, \quad (3)$$

where $(B_{x,i}, B_{y,i})$ is the position of the blob taken from McCullough et al. (2014), but see also Figure 1. We flag possible overlaps when this distance (r_i) is less than or equal to the fiducial radius defined by the first equation of McCullough et al. (2014). This represents a fairly conservative upper limit for overlaps, as the McCullough et al. radius extends well beyond the visual size of the blobs. With this we find two possible overlaps, as detailed in Table 3.

Conclusion

Although we find two overlaps between the current set of blobs and the various grism apertures, we do not recommend alterations to the current operations paradigm. The first overlap represents a rarely used configuration for high-value science operations: most Users who are interested in a a small number of sources (typically single source), generally do

Table 1: Grism Aperture Reference Positions

aperture	A_x (pix)	A_y (pix)
`GRISM1024`	497.0	562.0
`GRISM512`	505.0	532.0
`GRISM256`	410.0	532.0
`GRISM128`	376.0	522.0
`GRISM64`	410.0	522.0

http://www.stsci.edu/hst/observatory/apertures/wfc3.html

Table 2: Dither Positions[†]

dither pattern	point spacing (arcsec)	line spacing (arcsec)	Δx (pix)	Δy (pix)
WFC3-IR-DITHER-BLOB	5.183		−14.25	+14.25
			+14.25	+14.25
WFC3-IR-DITHER-BOX-MIN	0.572	0.365	0.0	0.0
			+4.0	+1.5
			+2.5	+4.0
			−1.5	+2.5
WFC3-IR-DITHER-BOX-UVIS	23.020	35.212	−81.7	−146.5
			+88.2	−144.2
			+81.7	+146.5
			−88.2	+144.2
WFC3-IR-DITHER-LINE	0.636		0.0	0.0
			+3.5	+3.5
WFC3-IR-LINE-3PT	0.605		0.00	0.00
			+3.33	+3.33
			+6.66	+6.66

[†]Taken from the WFC3 Instrument Handbook (Dressel 2017).

Table 3: Blob, Aperture, Dither Overlaps

ID	dither pattern	aperture	blob ID[†]	Δx (pix)	Δy (pix)	r_i (pix)
1	WFC3-IR-DITHER-BOX-UVIS	GRISM1024	33	−88.2	+144.2	2.8
2	WFC3-IR-DITHER-BOX-UVIS	GRISM256	9	−81.7	+146.5	8.7

[†]Refer to McCullough et al. (2014) for the blob IDs.

not use the full aperture (`GRISM1024`), but rather opt for a smaller aperture. The second overlap could be more worrisome, except that the distance is 8.7 pix, which is on the edge of the already very conservative radius of blob #9 of McCullough et al. (2014).

We caution these results change change as new blobs develop, and this analysis should be conducted whenever a new blob appears. If more egregious overlaps are found, then we propose the following tactics to compensate:

Warning/Caution flags: This is certainly the simplest solution, but would rely on Contact Scientists to alert Users of this situation.

Offset the aperture-reference position: This would address some human-related concerns, however it may have complex ripple effects through the system. For example, this may have some "backward compatibility" problems of how Users or other components interact with the Archive.

Revisions

None.

Example Python Script

We provide a small Python script to enable further investigations, such as by external Users wishing to examine customized dither strategies or internal staff monitoring this program. The code is called from the command line:

```
linux> python bloboverlaps.py --help
```

The calling sequence will be printed to the screen. There are three files that must be specified, and they are:

blobfile: describes the positions and sizes of the blobs, which is taken from McCullough et al. (2014). *default: blobs.dat*

ditherfile: the set of $(\Delta x, \Delta y)$ offsets, which we take from the Instrument Handbook (see Table 2 here). *default: WFC3-IR-DITHER-BOX-UVIS*

targetfile: a set of names and (x, y)-pairs for positions of interest. For this work, we consider those as the aperture reference positions (`apers.dat` in provide distribution), but in principle could be other positions in the detector (that are completely unrelated to the aperture references). *default: none*

The file format of these files can be displayed with the command:

```
linux> python bloboverlaps.py --fileformats
```

The script and current (as of June 2017) reference files can be downloaded at:

http://www.stsci.edu/hst/wfc3/wfc3_2017_blobsoverlaps.tar.gz

It will unpack in the current-working directory. Please contact rryan@stsci.edu with any issues.

This script is written for Python 3.5 and requires numpy (v 1.11) and argparse (v 1.1).

References

Dressel, L. 2017, "Wide-Field Camera 3 Instrument Handbook, Version 9.0" (Baltimore: STScI)

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