INSTRUMENT SCIENCE REPORT
FOC-024

TITLE: Format-Dependent Nonuniformity of Response of the FOC

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ABSTRACT

We test the hypothesis that the spatial detective efficiency of the FOC is independent of video format. We find that the hypothesis is clearly false and that there are 40% peak-to-peak variations as result of this format-dependent nonuniformity. This finding has important implications for the generation of calibration files for RSDP, the pipeline calibration process, which assumes no video-format dependent detective efficiency effects. There is evidence to support the hypothesis that this format-dependent effect is independent of wavelength and that it can be corrected for using the ITF correction in RSDP, albeit in a way not originally intended for that correction.

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1 Introduction

One of the key assumptions the Routine Science Data Processing (RSDP) system makes is that one 1024×1024 relative detective efficiency image for a given wavelength will suffice for all smaller video formats. This image would cover the usable photocathode area. A subsection of that relative detective efficiency image corresponding to the format of the incoming science image will be extracted to be used for that science image. For example, a science image taken in the centered 512×512 format would use the center 512×512 of the 1024×1024 relative detective efficiency image for relative detective efficiency correction. The validity of this approach requires that there be no difference in relative detective efficiency between two different video formats greater than a few percent. This report describes the results of comparisons of FOC calibration images taken in different video formats to prove or disprove this assumption. The results indicate that this assumption is flawed and that there is a very clear format-dependent sensitivity of the FOC on the level of 40% variation of response across the image. Now, the details.

2 The Details

The assumption was tested by comparing two different sets of images, all taken from the 1984 (summer) Goddard vacuum calibrations using PFM2 in f/96. One set was a pair of UV external exposures (both 2500 angstroms)—one in a 1024×512 zoomed format (image 3634), and one in a 512×512 normal pixel format (image 3734). The other set was a pair of yellow LED exposures matching the formats of the external exposures (images 3510 and 3535 respectively). First the large format images were “unzoomed”—i.e. all pixels were split into two pixels with each having half the value of the original. The central 512×512 region was extracted from the resulting 1024×1024 image. All the images were geometrically corrected using the FOC calibration programs available in CDBS (see the CDBS-FOC help files for detailed descriptions). In particular, the geometric correction aligned the 9×9 grid of reseau marks so that the outer reseau marks fell exactly on the image’s edges and were evenly spaced. The resulting spacing of reseaux is close (in pixels) to those of the input image. Flux was conserved. Areas where all four surrounding reseaux were not found by the reseau finding program (because they were too close to the input image’s edge or lay outside the image) were not used in any analysis since this would involve extrapolation by the geometric correction program.

The geometrically corrected small format image was divided by the geometrically corrected
center of the large format image for both wavelengths. The resulting images were scaled so that the center 100×100 square had a mean of one. Contour plots of these images are shown in Figures 1 and 2 (some smoothing was used to produce the contour plots). The odd boundaries result from reseau squares where all four reseaux were not found. They should be disregarded.

If there were no format-dependent effect, the ratio of the geometrically corrected images should be exactly uniform except for the presence of photon noise. It is evident that this is not the case. There is a clear enhancement of sensitivity of the smaller format relative to the larger format on the left side (smaller sample numbers). A better idea of the variation can be gotten by plotting an average of several rows of both images. The average of rows 390 through 445 is shown plotted in Figures 3 and 4. The plots go only to pixel 450 because the rest of the row lies in an "extrapolated" area. One can see that there is an approximately 40 to 50% variation across the image with the variation being worse in the case of The L.E.D. exposures. Although there is the possibility that the 2500 angstrom images did not have the same spatial illumination, this is very unlikely in the case for the L.E.D.s. Not only is this format dependency much larger than expected, it extends over at least half of the image—not just at the first 50 or so pixels as previously thought.

The question arises: how large is the format dependency compared to the wavelength dependency? We checked this in two ways. One way compared the relative DE files generated at different wavelengths for PFM2 to examine the variations in response between different wavelengths. Since they all were generated using the same video format, any variation in spatial response—aside from noise and uncertainty of spatial illumination—will be due to wavelength dependence. The variations seen by doing this comparison (carried out by dividing one relative DE image at one wavelength by that at another wavelength) are generally less than 10% over most of the image; much of this variation may be due to errors in our assumptions about spatial illumination so the wavelength dependence may be even smaller (see FOC Instrument Science Reports FOC-022 and FOC-023).

The other way we checked this was to take the ratio of the two geometrically corrected small format images. No smoothing was used here except in averaging the rows. The average of the same rows used in Figures 3 and 4 is shown in Figure 5. The variation seen, aside from photon noise, is small (approximately 5%) and well represented by a slope which may arise from differences in spatial illumination or wavelength response. These two checks suggest that this format-dependent effect is not dependent on wavelength since the nonuniformity was greatly reduced.
3 Implications

This result has serious implications for RSDP processing. The approach now implemented in RSDP will work correctly for only one video format. Otherwise significant errors will result. Fortunately, it appears that it may be possible to fool RSDP into using the correction intended for correcting the ITF instead for correcting for video format dependencies since they are both selected on the basis of video format (see Giaretta, FOC Instrument Science Report FOC-019)

4 Further Work

More work is needed to determine the consistency of this format-dependent nonuniformity and its shape (the analysis in this report has not isolated the component of nonuniformity due to the format; it has just shown that it exists). Several exposures are planned in Calibration III to settle these questions.
FIGURE 1

Ratio of geometrically corrected 250x250 images (512x512 by 1024x512)
Figure 2

Ratio of geometrically corrected LED images (512x512 by 1024x512x2)
Figure 3
Figure 4

nglratio: rows 390 to 445
Figure 5
sum of rows 390 to 445