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The cross dispersion profiles of the WFC3 grisms

H. Kuntschner, H. Bushouse, M. Kümmel, J. R. Walsh
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ABSTRACT

This document summarizes the analysis of the cross-dispersion profile width for the three grisms of the WFC3. For the IR grisms, the cross dispersion profile width derived from white light images and monochromator steps obtained in TV3 provide consistent results also in agreement with estimates derived from direct images. The width increases from about 1.3 to 1.6 pixel (FWHM) for wavelengths 800 to 1600 nm. For the UVIS G280 grism we find a cross-dispersion profile width of ~2.1 pixel for wavelengths smaller than 270 nm consistent with estimates from the direct imaging. For longer wavelengths, the cross-dispersion profile width increases to ~3 pixels at 450 nm and remains roughly constant thereafter. This marked increase is not reflected in the direct imaging PSF measurements.

1. Introduction

The Wide Field Camera 3 (WFC3) is fitted with three grisms for slitless spectroscopy. In the UVIS channel there is one grism, G280, for the near-UV to visible range (200 - 400nm). The NIR channel has two grisms (G102 and G141) for the shorter (800 - 1150nm) and longer NIR wavelengths (1100-1700nm). The results from ground calibration efforts, including trace, wavelength, throughput and aperture correction calibrations are summarized in Kuntschner et al. (2008) and

Kuntschner et al. (2009). This report focuses on the analysis of the cross-dispersion profile width of the grisms, which can be compared with the direct image point-spread-function (PSF) and also serves as a guideline for the minimum expected spectral resolution (line spread function).

All analysis in this report is based on calibrations obtained during the TV3 campaign. Throughout this report we use a Gaussian function approximation for the cross-dispersion PSF core and report sizes in units of detector pixels.

2. WFC3 IR G102 and G141 grism cross-dispersion profiles

For each IR grism there is one set of monochromator steps and at least one white light ("continuum") exposure available from which one can determine the cross-dispersion profile. Since the camera is undersampled it is important to properly treat the integration of flux over a given pixel correctly when estimating the FWHM at a given wavelength. For this purpose we used the IDL implementation of the DAOPHOT package where GETPSF fits a Gaussian profile to the core of selected observations.

For each available monochromator step a 2-dimensional Gaussian was fitted and the resulting FWHM in detector y-direction (i.e. cross-dispersion) recorded. These results were compared with estimates obtained from the white light exposures where 5-10 pixel were summed up along the trace before a cross-dispersion PSF was measured.

The resulting measurements are summarized in Figure 1. There is excellent agreement between the profile width estimates derived from white light images and monochromator steps. However, we detect a strong wave-like pattern for our cross-dispersion PSF width estimates, which is caused by the finite detector pixel sampling. The derived width is maximal when the PSF centre falls in between two pixels and is minimal when the PSF centre is in the middle of a given pixel. For the G102 grism one can see two cycles through a maximum whereas for G141 only one maximum is visible. We regard the minima as the useful cross-dispersion PSF width estimates. Overall there is a trend with wavelength such that at 800 nm the FWHM is about 1.3 pixel, degrading to a FWHM of 1.6 pixel at 1600 nm.

The PSF along the dispersion direction is dominated by the wavelength width of the monochromator beam and therefore not useful for the analysis of the line-spread function.

Hartig (2008b) carried out an extensive analysis of the direct image PSFs as function of position and wavelength. We compare here Hartig's measurements (shown as triangles connected by a solid line in Figure 1) for position "IR03" with our cross-dispersion estimates. The direct image PSFs show the same trend in wavelength albeit with a slightly smaller (0.1-0.2 pixel) PSF width.

Overall we find good agreement between the cross-dispersion profile of the grisms and the direct image PSF where the extra optical element (i.e. grism) only adds a minor addition to the PSF width (+0.1-0.2 pixel).

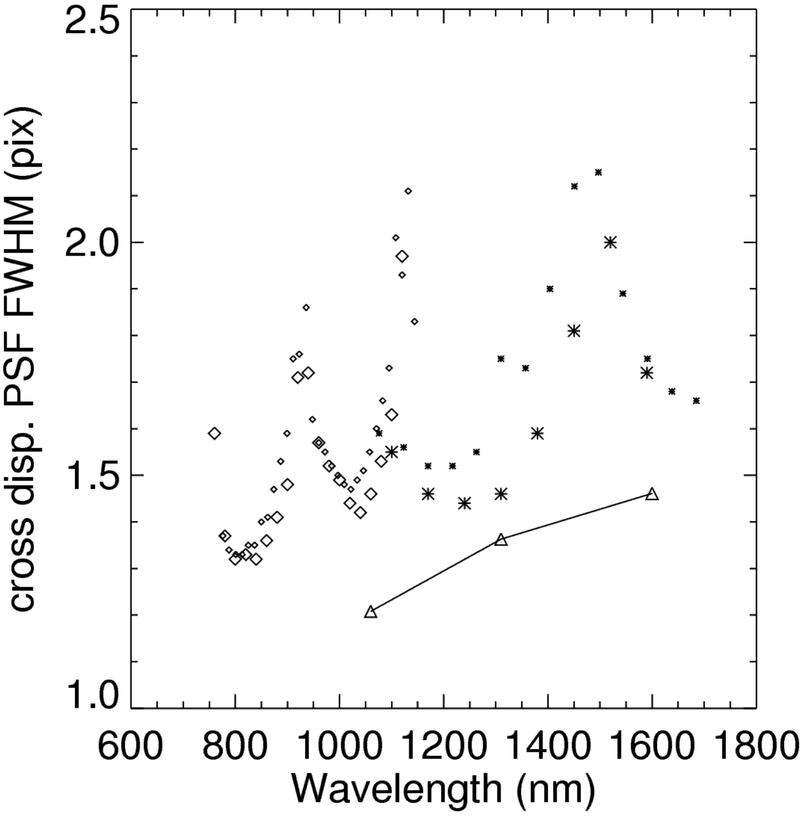

Figure 1: Cross-dispersion profile width as measured in FWHM (pixel) in a Gaussian approximation. Diamonds represent data for grism G102 and stars represent data for grism G141. Large and small symbols show estimates derived from the monochromator steps and white light observations, respectively. The triangles connected with a solid line show for comparison measurements from the direct light images as tabulated by Hartig (2008b).

3. WFC3 UVIS G280 grism cross-dispersion profile

For the UVIS G280 grism it is difficult to use the white light exposures for an analysis of the cross-dispersion profile width due to the overlap with higher orders and the significant bending of the trace. Therefore we restrict our analysis here only to the monochromator steps where we fit a 1-dimensional Gaussian in cross dispersion direction[1]. Two independent sets of calibrations for chip 1 and chip 2 are available. We find good agreement between the two sets. For wavelengths below 270 nm the cross dispersion profile width amounts to approximately 2.1 pixels, and increases to values of up to 3 pixels for longer wavelengths (see Figure 2). The cross-dispersion profile shows a significant non-Gaussian halo but what we measure and plot is the width of the Gaussian core. Exact numbers depend on the fitting procedure and error weighting; however, the significant increase of profile width starting at approximately 270 nm is consistently seen in all analysis and weighting schemes.

For comparison we show in Figure 2 also the width of the direct imaging PSF (triangles connected by solid line) tabulated in Hartig (2008a). For wavelengths below 270 nm the numbers are in good agreement, whereas there is no equivalent strong increase in profile width beyond 270 nm seen in the direct imaging.

[1] Fitting 2-dimensional Gaussian to the monochromator steps did not yield satisfactory results since the individual steps are very elongated along the dispersion direction.

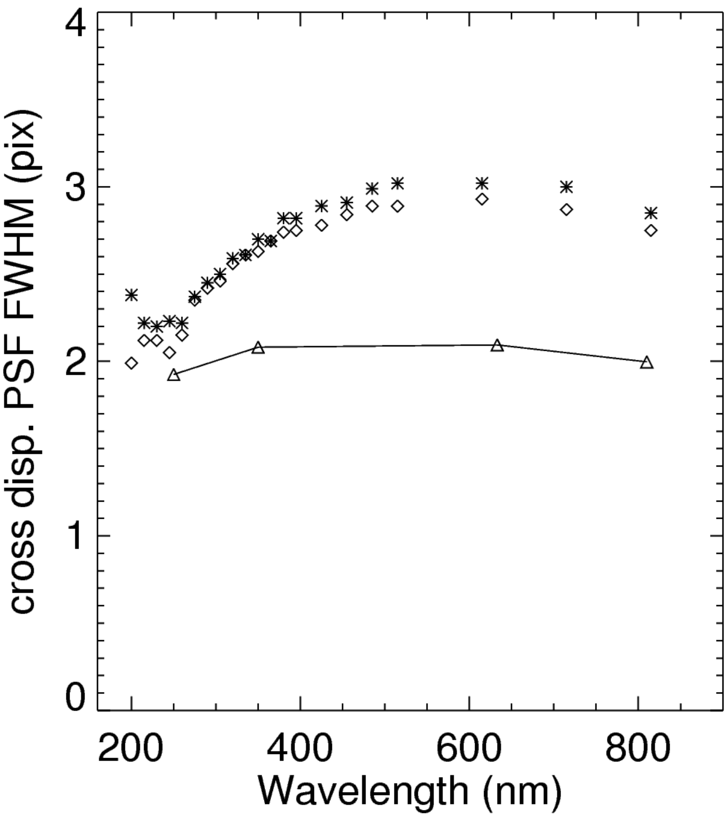

Figure 2: Cross-dispersion profile width as measured in FWHM (pixel) in a Gaussian approximation. Diamonds and stars represent data for G280 on chip 1 and 2, respectively. The triangles connected with a solid line show for comparison measurements from the direct light images as tabulated by Hartig (2008a).

4. Conclusions

This document summarizes the analysis of the cross-dispersion profile width for the three grisms used in WFC3. The analysis is performed in a Gaussian approximation where essentially the PSF core is fit by a Gaussian neglecting the PSF halo. For the IR grisms we find a PSF width (FWHM) increasing from about 1.3 pixel at 800 nm to 1.6 pixel at 1600 nm. This is about 10% larger than the estimates derived from the direct imaging, thus confirming the very good imaging quality of the IR grisms. We note, however, that due to the undersampling of the IR camera PSF, width estimates are dominated by detector pixel sampling effects.

For the UVIS G280 grism we find a cross-dispersion PSF width (FWHM) of about

2.1 pixel for wavelengths smaller than 270 nm, which is consistent with the measurements from the direct imaging (~1.9 pixel). For wavelengths larger than 270 nm we detect a significant increase for the cross-dispersion PSF width rising to 3 pixels for wavelengths larger than ~450 nm. This marked increase is not seen in the direct imaging.

References

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