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Updated Contamination Rates for WFPC2 UV Filters

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Abstract. Photometric monitoring observations of a white dwarf standard have been used to update the contamination rates for WFPC2 UV filters. Observations from April 1994 through May 2002 were used in the analysis. In general, the contamination rates have declined by roughly 50 fits have been made to the data to allow observers to remove the effects of contamination in their WFPC2 observations.

1. Introduction

Contaminants within the WFPC2 instrument gradually build up on the cold CCD faceplate which results in a decrease of the UV throughput. Approximately once per month, these contaminants are melted off of the faceplate by means of a decontamination procedure (decon) which restores the UV throughput to its nominal value.

This study extends earlier analyses and provides least-squares fits to the yearly contamination rates. The resulting formulae provide both more accurate and more easily used corrections for the effects of contamination on WFPC2 UV data.

For a more detailed version of this paper, please see McMaster and Whitmore (2002).

2. Data

The data used in this study were taken from the F160BW, F170W, F218W, F255W, F336W, and F439W photometric monitoring observations of the DA3 white dwarf, GRW+70D5824 and can be found at:
http://www.stsci.edu/instruments/wfpc2/Wfpc2_memos/wfpc2_stdstar_phot3.html. The data cover the time period from April 1994 (after the cool down from −76°C to −88°C) to May 2002.

3. Analysis

The first step in the analysis was determining the contamination rate as a function of the number of days since decontamination (DSD) for each year. The resulting least-square fits for the period 4/97–4/98 and 4/01–4/02 are shown below for the F170W and F336W filters. As a matter of clarity, only the 97–98 data are compared with the 01–02; for similar plots of earlier data, please consult earlier work done on this subject.

As seen on the left hand side of Figure 1, the count rates (DN/sec) for F170W in the PC at or near 0 DSD for 2001–2002 are generally higher than those for 1997–1998. The opposite is true for the F336W data (right hand side of Figure 1) where the difference in count rates for the PC near 0 DSD is lower by 3–7 percent. The F160BW data behave similarly to the F170W data, while the data for the F218W, F255W, and F439W filters (not shown) follow the trend of F336W. Since the NUV filters studied (F218W, F255W, F336W, and F439W) are less affected by contamination than the FUV filters (F160BW and F170W), this may suggest that some of the long-lived contaminants (i.e., those that

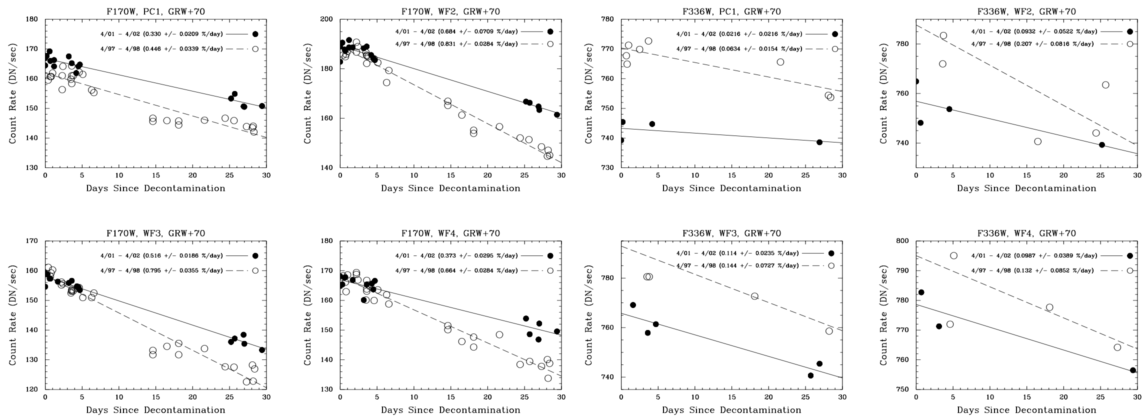

Figure 1. Contamination rates for 1997–1998 (open circles) and 2001–2002 (filled circles) for F170W (left) and F336W (right).

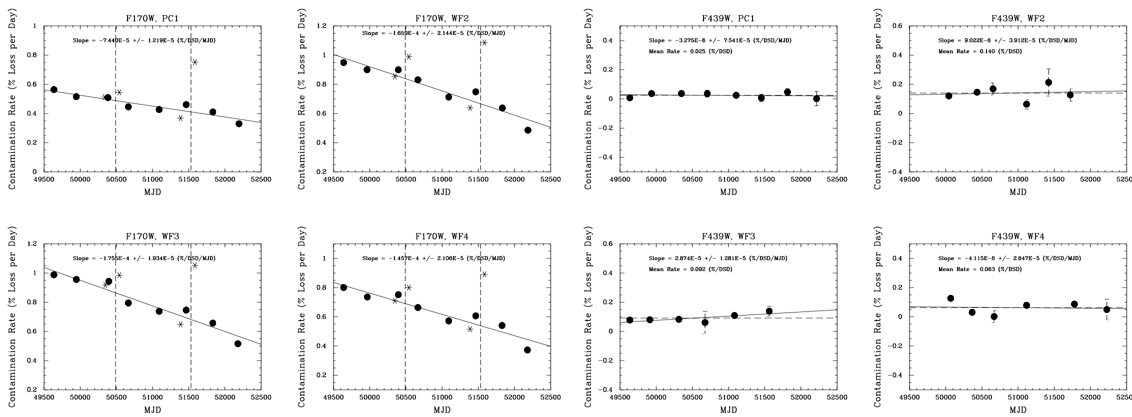

Figure 2. Fits to the contamination rates for F170W (left) and F439W (right). See McMaster & Whitmore (2002).

are not removed by the monthly decons) have outgassed from the PC over time. Also, it is now known that throughput loss due to CTE has been increasing linearly with time and it is probably this increase which has caused the count rates to decline in the NUV data. Since a decrease in count rates is not seen for F160BW and F170W, it can be concluded that these filters are more affected by the loss of long-lived contaminants than they are by the increase in CTE loss.

4. Phase II

The second part of the analysis consisted of plotting the yearly contamination rates as a function of time and making a least-squares fit to the data. These fits can be used as correction formulae, and are made possible due to the longer temporal baseline. The subsequent smoothing and averaging of the data provide an improvement of our past technique of listing the yearly rates, where occasional increases were inferred due to observational scatter. The plots below are a representative sample of the fits.

Note the step-like structure for F170W (Figure 2, left); this is probably an indication of an effect after Servicing Missions 2 and 3A, MJD = 50490.03 and 51531.16 respectively (dashed lines in the plots). The asterisks to the left of the dashed lines are the contamination rates before the servicing missions (from several months to a few days before), and those to the right are the contamination rates after the servicing missions (from a few days to a few months). Note that all of the asterisks to the right of the dashed lines are higher than those to the left, indicating an increase in the contamination rate just after a servicing mission. This would explain the step-like structure seen in the plots. Note also that while the contamination rates immediately after a servicing mission can be quite high (almost twice as high after SM3A), they return to the general trend soon afterward. Only the solid points were used in determining the fits. Despite an increase in the contamination rates shortly after a servicing mission, a simple linear fit appears to represent the data quite well.

An exception to this is the F439W data (Figure 2, right), where due to observational scatter, it appears that the rates for WF2 and WF3 are increasing. Since this is not thought to be true, a mean rate (the dashed lines in the plot and the numbers in parentheses in Tables 1 and 2) is also provided for each of the chips; we recommend using this mean rate.

Table 1. Fits to Yearly Contamination Rates for PC and WF2

	PC			WF2		
Filter	Const[a]	Slope	Error	Const	Slope	Error
F160BW	0.857	−1.348E-4	3.042E-5	1.499	−2.985E-4	4.821E-5
F170W	0.562	−7.440E-5	1.219E-5	1.004	−1.659E-4	2.144E-5
F218W[b]	0.478	−5.185E-5	6.497E-6	0.829	−1.519E-4	
F255W	0.246	−4.240E-5	6.803E-6	0.462	−8.050E-5	1.926E-5
F336W	0.081	−1.084E-5	1.569E-5	0.276	−6.245E-5	2.212E-5
F439W[c,d]	0.029	−3.275E-6	7.541E-5	0.128	+9.022E-6	3.912E-5
		(0.025)	(0.017)		(0.140)	(0.050)

Table 2. Fits to Yearly Contamination Rates for WF3 and WF4

	WF3			WF4		
Filter	Const[a]	Slope	Error	Const	Slope	Error
F160BW	1.344	−2.401E-4	2.210E-5	1.285	−2.443E-4	4.474E-5
F170W	1.038	−1.755E-4	1.934E-5	0.835	−1.457E-4	2.106E-5
F218W	0.863	−1.387E-4	3.091E-5	0.795	−1.651E-4	1.673E-5
F255W	0.459	−6.093E-5	3.958E-5	0.387	−7.822E-5	1.750E-5
F336W	0.234	−5.005E-5	1.862E-5	0.214	−6.210E-5	2.597E-5
F439W[c,d]	0.062	+2.874E-5	1.281E-5	0.069	−4.115E-6	2.647E-5
		(0.092)	(0.028)		(0.063)	(0.044)

[a]The value of the percentage throughput loss at MJD = 49500 (May 28, 1994)

[b]Due to a lack of sufficient data, the values for WF2 are an average of those for WF3 and WF4 and are recommended when determining the contamination correction for this filter/chip combination.

[c]A plus (+) sign indicates where the rate appears to be increasing, though this is probably due to observational scatter rather than a larger number of contaminants falling on the chips.

[d]The numbers in parentheses are the mean values of the yearly contamination rates (in percent throughput loss per days since decontamination) and should be used when correcting for contamination effects in this filter (i.e., with Equation 2).

5. Correction Formulae

The following formula can be used in correcting data taken in the F160BW, F170W, F218W, F255W, and F336W filters

$$COUNTS_{\mathrm{corr}} = \frac{COUNTS_{\mathrm{obs}}}{1.0 - (Slope(MJD - 49500) + Constant)\,(DSD/100)} \tag{1}$$

where $COUNTS_{\mathrm{obs}}$ is the count rate, in DN/second, measured from the image; *Slope* is the percentage throughput loss per day per MJD; *MJD* is the Modified Julian Date which can be determined from the header parameter EXPSTART; *Constant* is the value of the throughput loss per day at MJD = 49500; and *DSD* is the number of Days Since Decontamination which can be found on the WFPC2 Decontamination Date web page: http://www.stsci.edu/instruments/wfpc2/Wfpc2_memos/wfpc2_decon_dates. html.

For an object observed in the F439 filter, the correction formula would be:

$$COUNTS_{\mathrm{corr}} = \frac{COUNTS_{\mathrm{obs}}}{1.0 - (Mean\,(DSD/100))} \tag{2}$$

where $COUNTS_{\mathrm{obs}}$ is the count rate, in DN/second, measured from the image; *Mean* is the average value of the yearly contamination rate in percentage throughput loss per days since decontamination (the number in parentheses in Tables 1 and 2); and *DSD* is the number of days since decontamination.

6. Red Leaks

Some of these UV filters have substantial red leaks which have not been accounted for in the photometric monitoring data. In fact, red leaks can account for a significant percentage in the overall count rate for an observation in the FUV filters and strictly speaking, the corrections presented here are valid only for an object with the same spectral distribution as GRW+70D5824 (a white dwarf). The red leak is minimal for this case since the star is a very blue DA3 star. Table 3.13 in the *WFPC2 Instrument Handbook* indicates that roughly 6% of the light comes from the red leak. We caution users about using the contamination rates presented here for very red sources. SYNPHOT (the Space Telescope Science Institute's SYNthetic PHOTometry package) can be used to determine more realistic corrections for these objects.

7. Conclusions and Recommendations

Photometric monitoring observations from April 1994 to May 2002 have shown a decrease in the rate of contamination in the UV filters, with F160BW and F170W showing the steepest drop off. While it appears that the data show a correlation with the Servicing Missions, especially in the F170W filter, a least squares fit seems to be adequate. These fits, listed in Tables 1 and 2, along with the equations given above, can be used to correct for the effects of contamination in WFPC2 UV photometric data.

The corrections presented here supersede those given in previous work and when using SYNPHOT to account for contamination in the obsmode parameter
(e.g., wfpc2,2,a2d7,f170w,cont#MJD).

References

McMaster, M. & Whitmore, B. C. 2002, *Instrument Science Report* WFPC2 02-07 (Baltimore: STScI)