SPACE TELESCOPE SCIENCE INSTITUTE
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Instrument Science Report WFC3 2008-49

WFC3 TV3 Testing:
Red Leak Checks for the UV Filters

Thomas M. Brown
Dec 11, 2008

ABSTRACT

In the final round of thermal vacuum tests for the WFC3, we performed a check of red leak in the UVIS filters. These checks demonstrate that the filters in general exhibit the excellent blocking of red light expected from the scans of these filters at the component level. For two of the filters (F336W and F343N) we were not able to confirm the expected level of blocking at 450 nm and 600 nm, due to the limitations of the optical stimulus used for testing, but the upper limits obtained at these wavelengths imply that there is no red leak issue.

Background

In the spring of 2008, the Wide Field Camera 3 (WFC3) was subjected to its third and final campaign of thermal vacuum (TV) tests. One of the tests is a check of the red leak in the UV filters. The test is very similar to those used to measure the UVIS throughput (e.g., Brown 2008 ISR WFC3 2008-48), so it is only briefly described here. Images with the UVIS channel are obtained with 800x800 subarrays, with illumination provided by the optical stimulus (CASTLE) using the 200 micron fiber. This fiber produces an extended source on the detector approximately 20 pixels wide. The use of an extended source offers several advantages over a point source, such as allowing the accumulation of a significant signal while avoiding saturation, and providing a measurement of throughput that averages over the response of many pixels instead of a few. We performed tests of eight UV filters (F218W, FQ232N, FQ243N, F225W, F275W, F280N, F336W, and F343N) at four wavelengths (450, 600, 750, and 900 nm). Most of the tests were performed on chip 2, but the FQ243N tests were performed on chip 1 because it is a quad filter that is only visible on that chip.

There is one significant distinction from the usual throughput measurements, and that is the use of a single monochromator mode with a 128 nm bandpass for the checks at most wavelengths, as opposed to the double monochromator mode used in the normal throughput checks, which has a maximum bandwidth of 13 nm. Note that the bandpass of the double monochromator is actually a triangle with a FWHM equal to the selected bandpass width, so the 13 nm bandpass is really a triangle 26 nm wide. When possible, we used the 128 nm wide bandpass in order to provide a higher signal (given the excellent red light blocking in these filters) and to check a wider wavelength range in each exposure. However, in previous TV campaigns, the images obtained through the F336W and F343N filters at 450 and 600 nm were saturated due to scattering of light outside of the nominal CASTLE bandpass at wavelengths that are in-band for these filters. For the current TV campaign, we used the 13 nm double monochromator bandpass for these filter/wavelength combinations, to try to avoid this problem.

Results

The results of the red leak test are shown in Table 1 and Figures 1 through 8. It is clear that the results are within a factor of two of expectations for most of the images, where the expectations come from the product of the relevant WFC3 component throughputs convolved with the spectrum provided by CASTLE. Although this is not the kind of accuracy we expect for traditional throughput measurements, it is acceptable here, for several reasons. First, with the 128 nm bandpass, we are sensitive to the exact shape of the lamp spectrum assumed, compared to the usual throughput measurements performed with a narrow bandpass (5 to 13 nm). Second, the red transmission of these filters ranges from approximately 10^{-5} to 10^{-9}, and it is difficult to measure such transmissions accurately, compared to the in-band transmissions that range from 10% to 100%. Third, the CASTLE target does not provide zero light outside of the selected monochromator bandpass, and the out-of-band light due to scattering is poorly constrained.

This third reason is why the F336W and F343N filters produced saturated images in earlier versions of this test at 450 and 600 nm. Even here, with a *double* monochromator, we see that the measured transmission for these filters at these wavelengths is 10 to 100 times higher than expected. The problem is due to the limitations of the CASTLE configuration. All of these tests employ a CASTLE long-pass filter (LP340) in tandem with the CASTLE monochromators, to try and reduce UV light that would be in-band for the WFC3 filters being checked. The LP340 filter exhibits a gradual decrease in transmission toward shorter wavelengths instead of an abrupt cutoff at 340 nm; its transmission is 80% at 340 nm, 50% at 325 nm, and 1% at 310 nm (R. Telfer, private communication). The WFC3 F336W and F343N filters have significant transmission in the vicinity of 340 nm (see Figures 5 and 6), so this CASTLE long-pass filter is not sufficient to assist the blocking from the monochromators. The WFC3 F336W and F343N filters perform as expected at 750 and 900 nm, and given that the transmission is still very low at 450 and 600 nm, it is very unlikely that these filters have failed in some way. The measured transmission levels at 450 and 600 nm for the F336W and F343N filters are thus upper limits, and the true transmission is likely near the level measured at the component level.

Table 1: Measured red leaks on WFC3 UV filters

filter	wavelength (nm)	bandpass (nm)	observed counts (e^-)	predicted counts (e^-)	measured throughput	ratio observed/ predicted
F218W	450	128	1.12E+06	1.02E+06	2.70E-05	1.10
F218W	600	128	3.61E+05	2.58E+05	5.79E-07	1.40
F218W	750	128	2.26E+05	2.42E+05	1.98E-07	0.94
F218W	900	128	1.83E+05	2.75E+05	2.70E-07	0.67
FQ232N	450	128	6.69E+05	5.05E+05	1.61E-05	1.32
FQ232N	600	128	2.03E+05	3.27E+05	3.25E-06	0.62
FQ232N	750	128	2.21E+05	3.06E+05	2.58E-06	0.72
FQ232N	900	128	9.81E+05	9.75E+05	2.89E-06	1.01
FQ243N	450	128	9.38E+05	5.61E+05	2.25E-05	1.67
FQ243N	600	128	3.05E+05	2.90E+05	3.26E-06	1.05
FQ243N	750	128	3.26E+05	3.16E+05	2.85E-06	1.03
FQ243N	900	128	8.64E+05	6.58E+05	2.55E-06	1.31
F225W	450	128	4.27E+05	3.68E+05	5.13E-06	1.16
F225W	600	128	2.07E+05	2.23E+05	2.21E-06	0.93
F225W	750	128	4.27E+05	3.89E+05	2.48E-06	1.10
F225W	900	128	9.82E+05	1.08E+06	2.90E-06	0.91
F275W	450	128	3.04E+05	3.03E+05	7.31E-06	1.00
F275W	600	128	2.30E+05	1.90E+05	1.48E-06	1.21
F275W	750	128	3.22E+05	3.37E+05	9.38E-07	0.96
F275W	900	128	4.25E+05	3.70E+05	1.25E-06	1.15
F280N	450	128	4.10E+06	3.76E+06	9.84E-05	1.09
F280N	600	128	3.05E+05	2.25E+05	4.89E-06	1.35
F280N	750	128	3.10E+05	2.73E+05	2.17E-06	1.14
F280N	900	128	7.76E+05	8.71E+05	2.29E-06	0.89
F336W	450	13	1.85E+06	2.02E+04	2.69E-06*	91.2*
F336W	600	13	3.51E+05	1.58E+04	5.99E-07*	22.2*
F336W	750	128	2.18E+06	2.49E+06	1.90E-06	0.88
F336W	900	128	2.12E+05	7.61E+05	1.69E-09	0.28
F343N	450	13	1.34E+06	1.52E+04	1.46E-06*	87.6*
F343N	600	13	2.47E+05	1.84E+04	2.64E-07*	13.4*
F343N	750	128	4.87E+05	8.81E+05	2.58E-08	0.55
F343N	900	128	6.46E+03	7.76E+04	3.81E-09	0.08

*Upper limit due to the limitations of the CASTLE. See text for details.

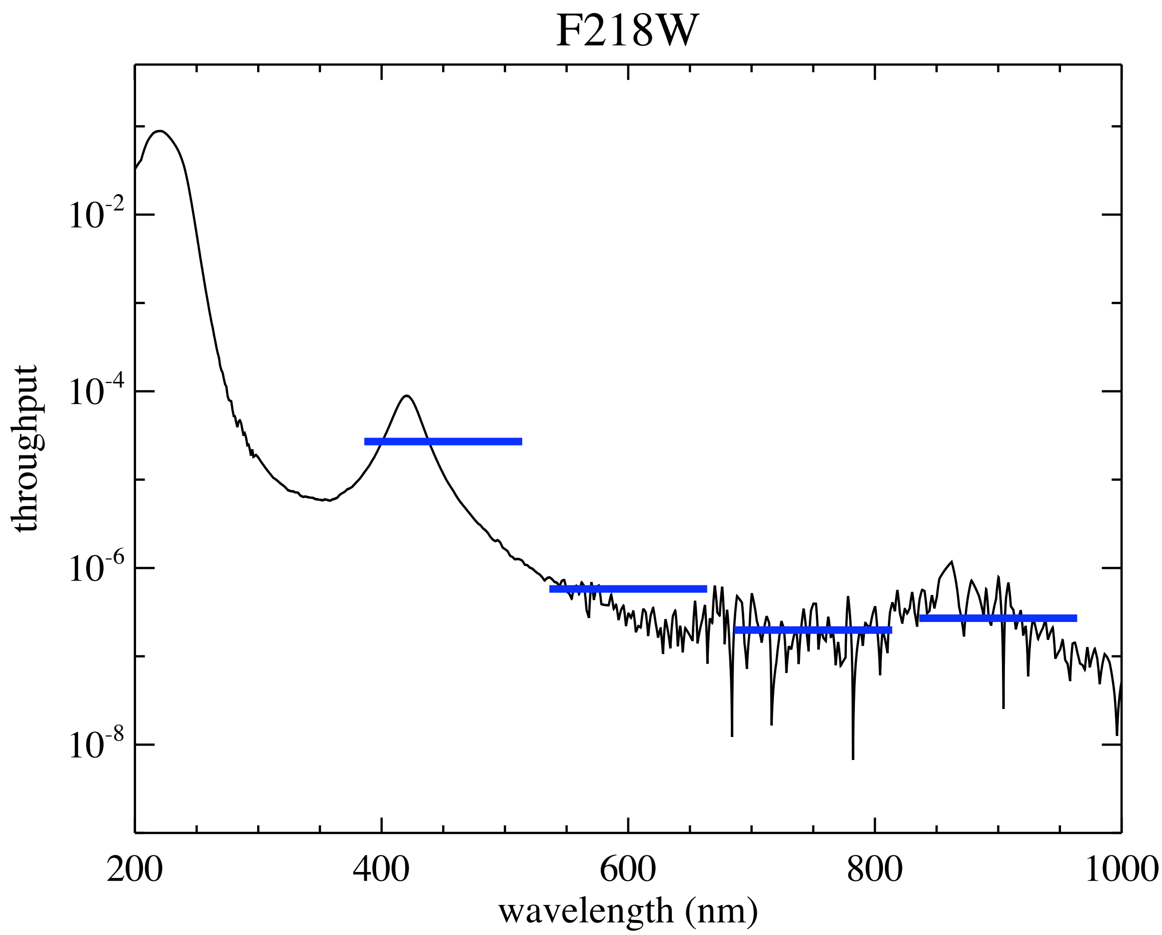

Figure 1: The WFC3 filtered throughput in the F218W bandpass (excluding the HST OTA), with the results of the red leak checks indicated (*blue bars*).

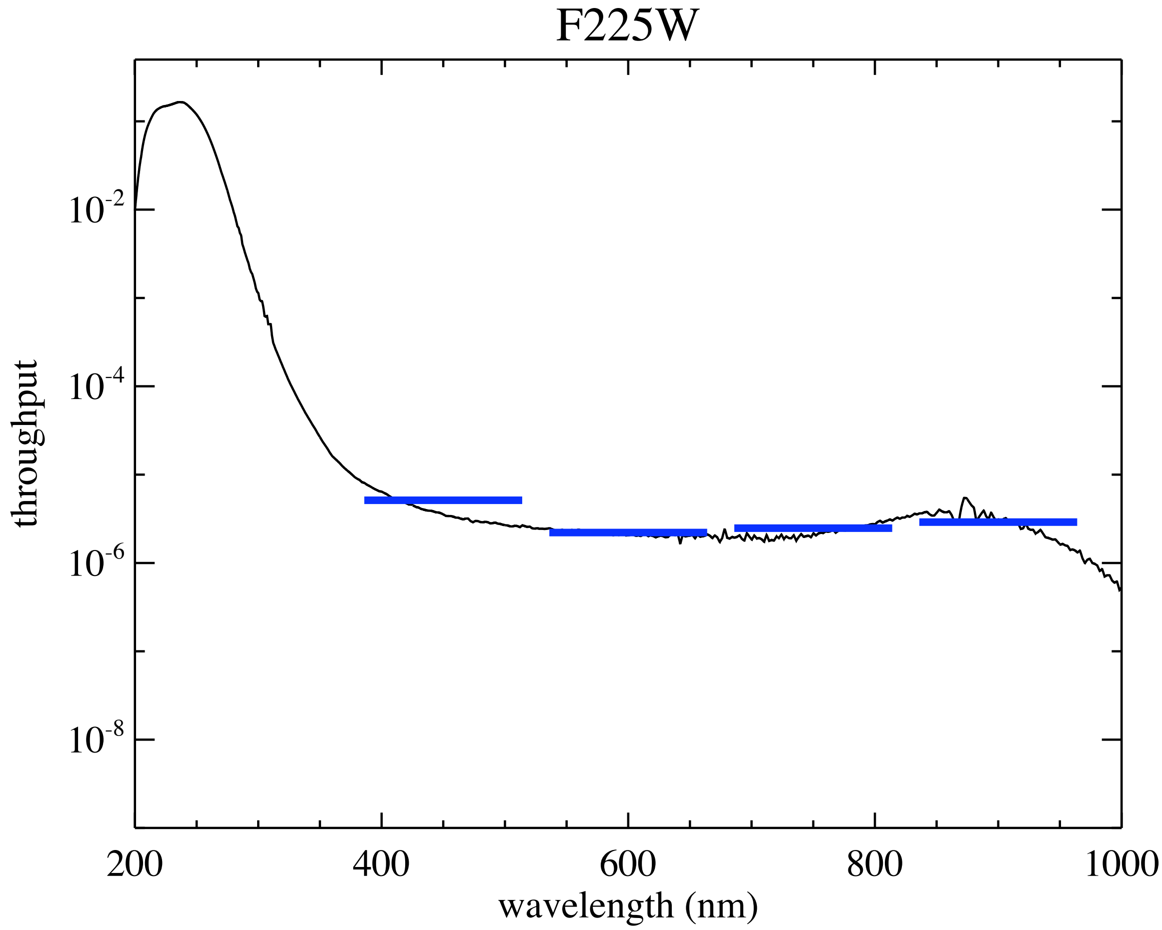

Figure 2: The same as in Figure 1, but for F225W.

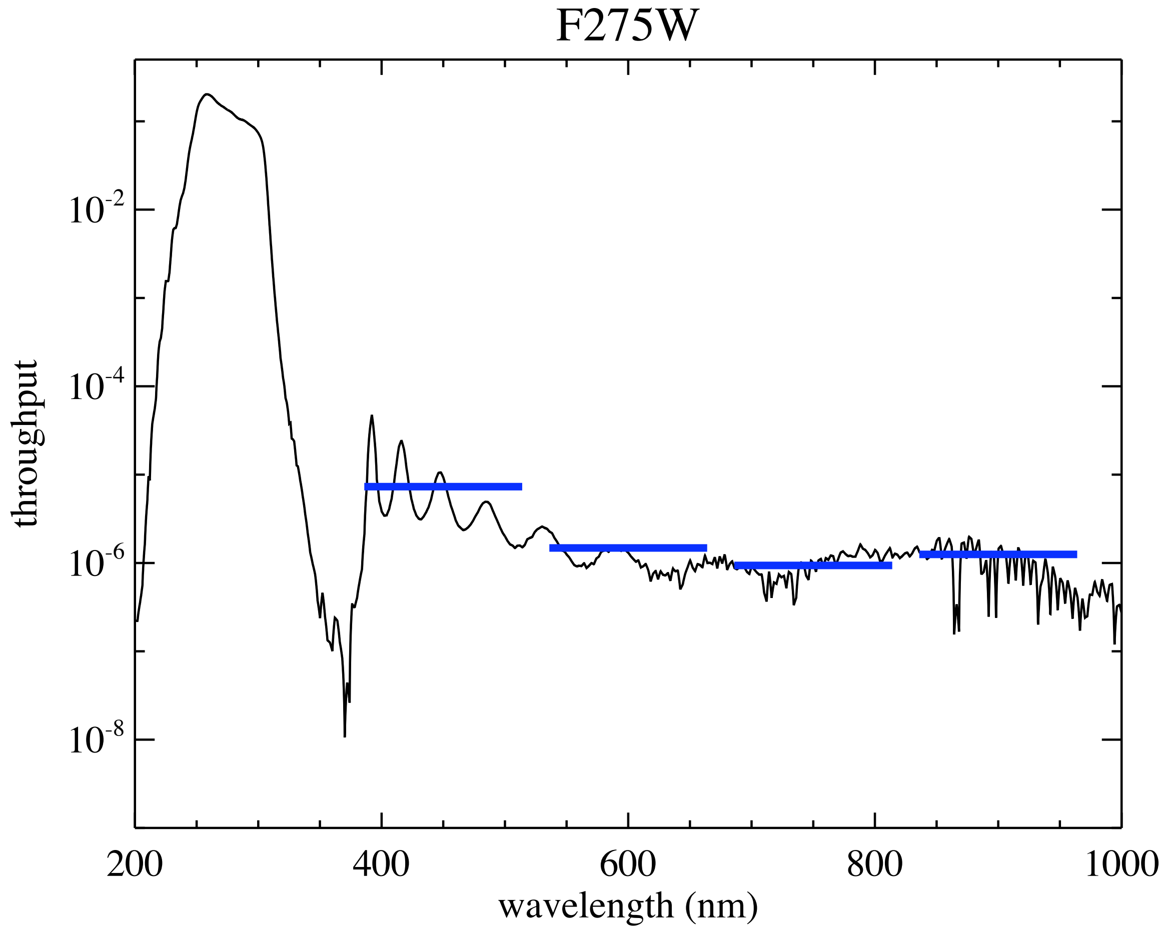

Figure 3: The same as in Figure 1, but for F275W

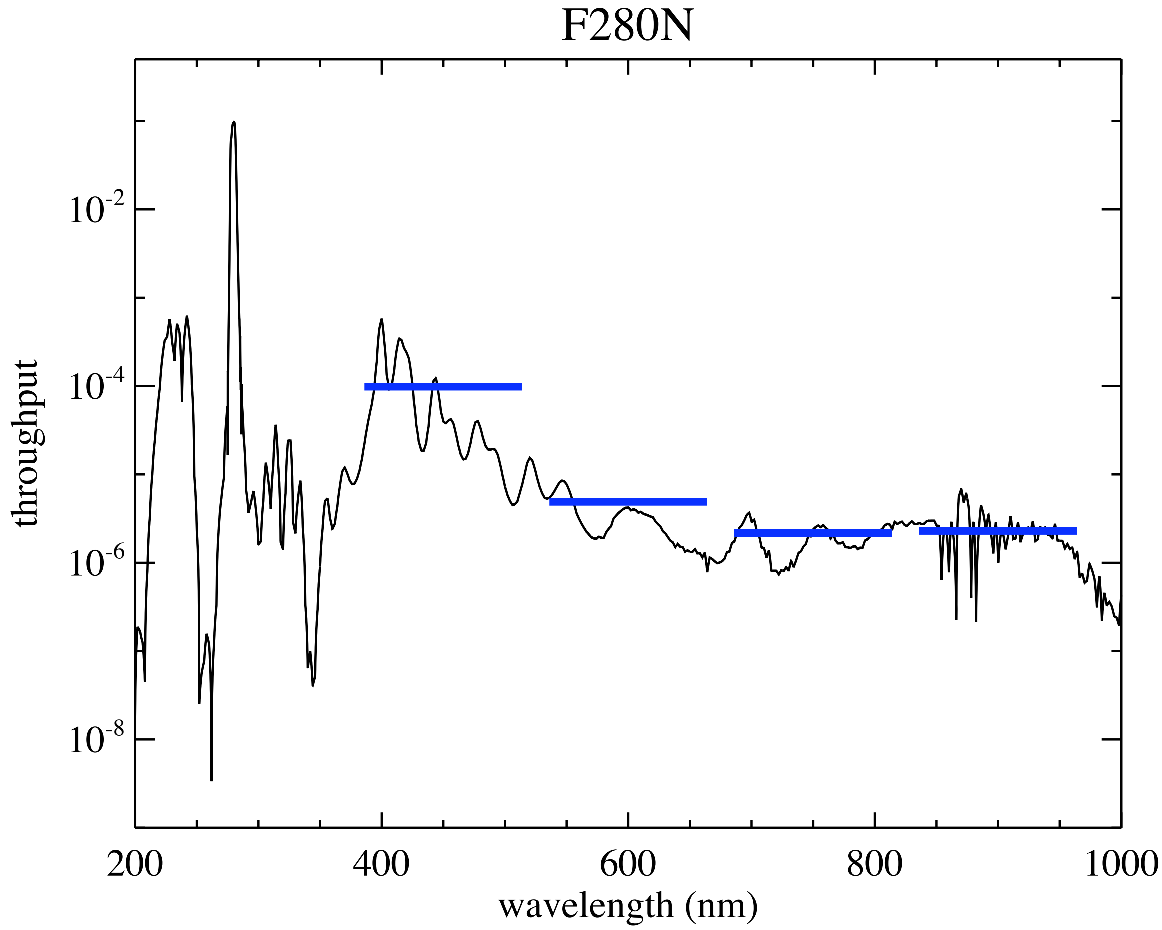

Figure 4: The same as in Figure 1, but for F280N.

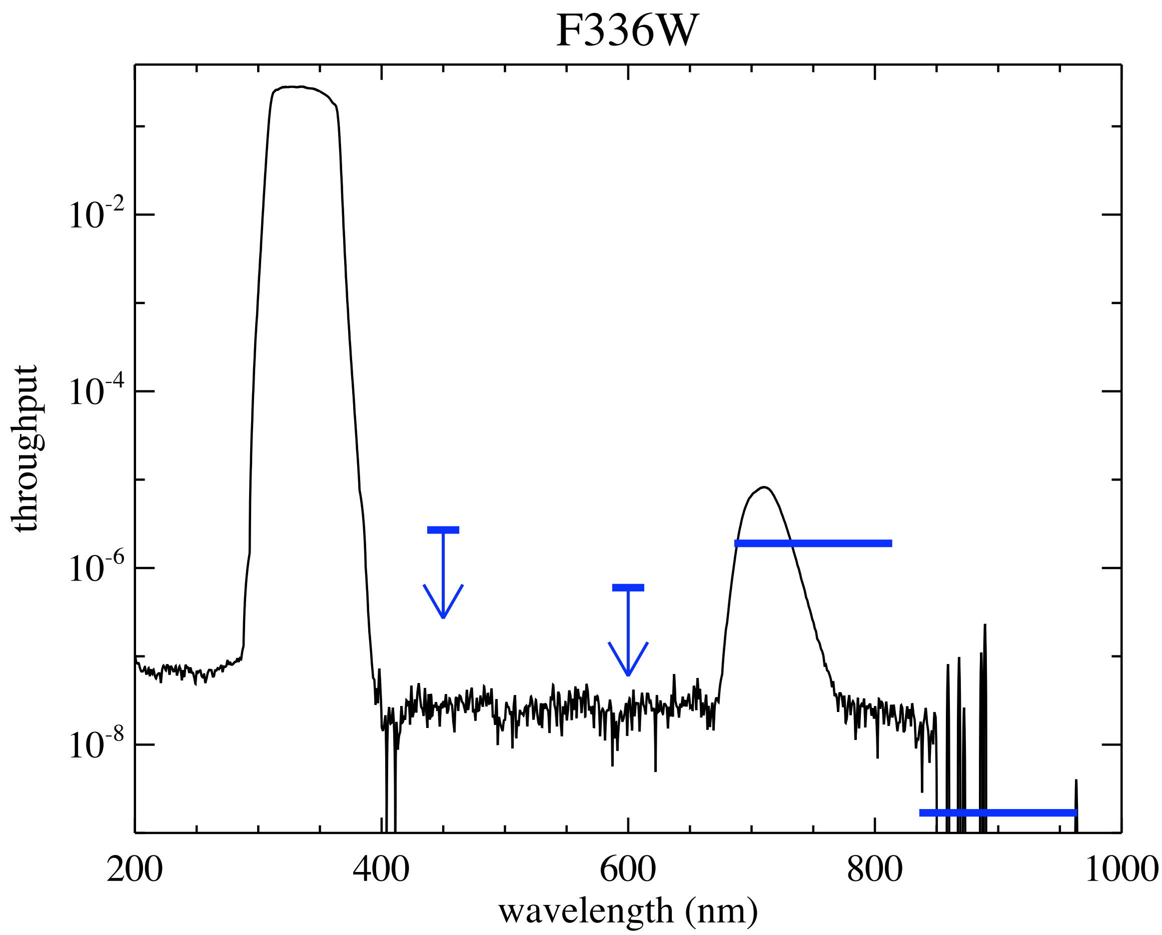

Figure 5: The same as in Figure 1, but for F336W. The measurements are upper limits at 450 and 600 nm.

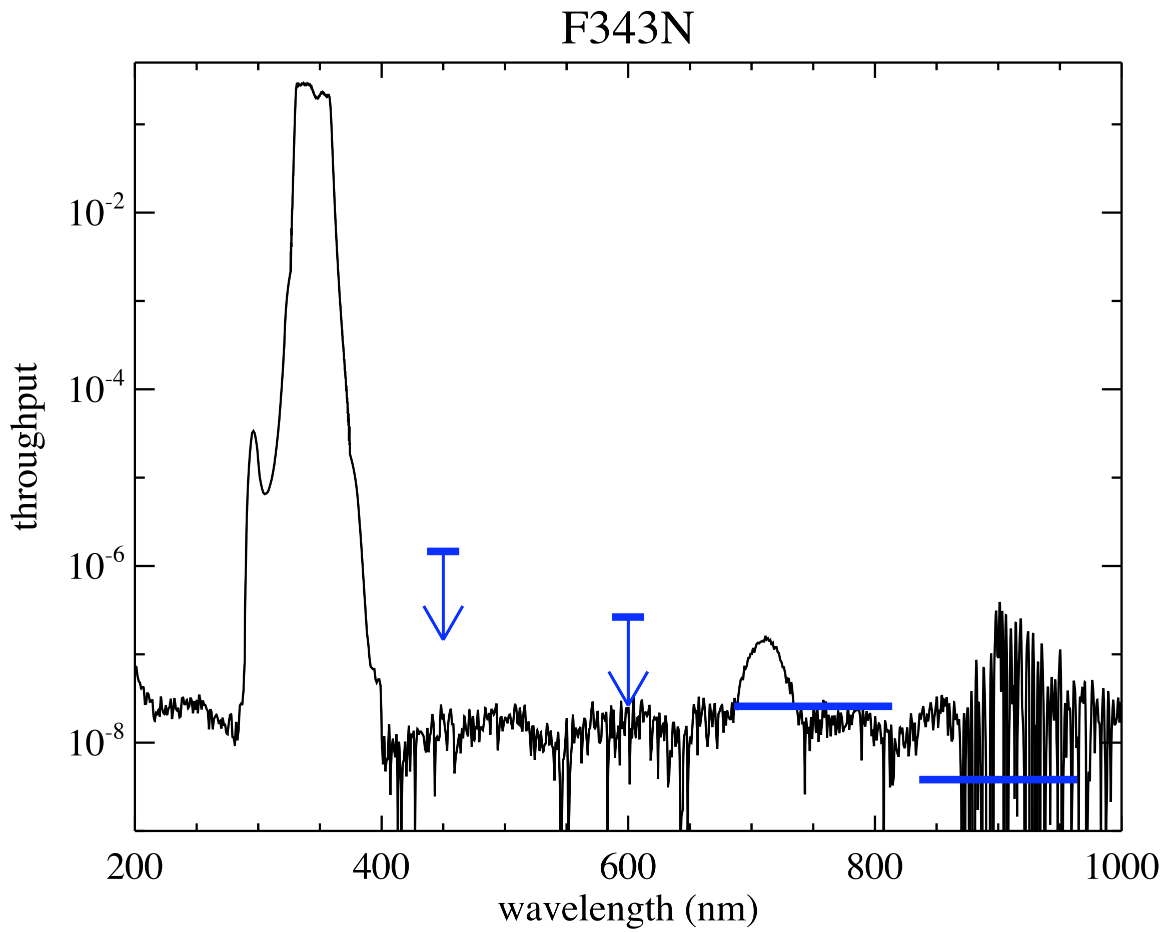

Figure 6: The same as in Figure 1, but for F343N. The measurements are upper limits at 450 and 600 nm.

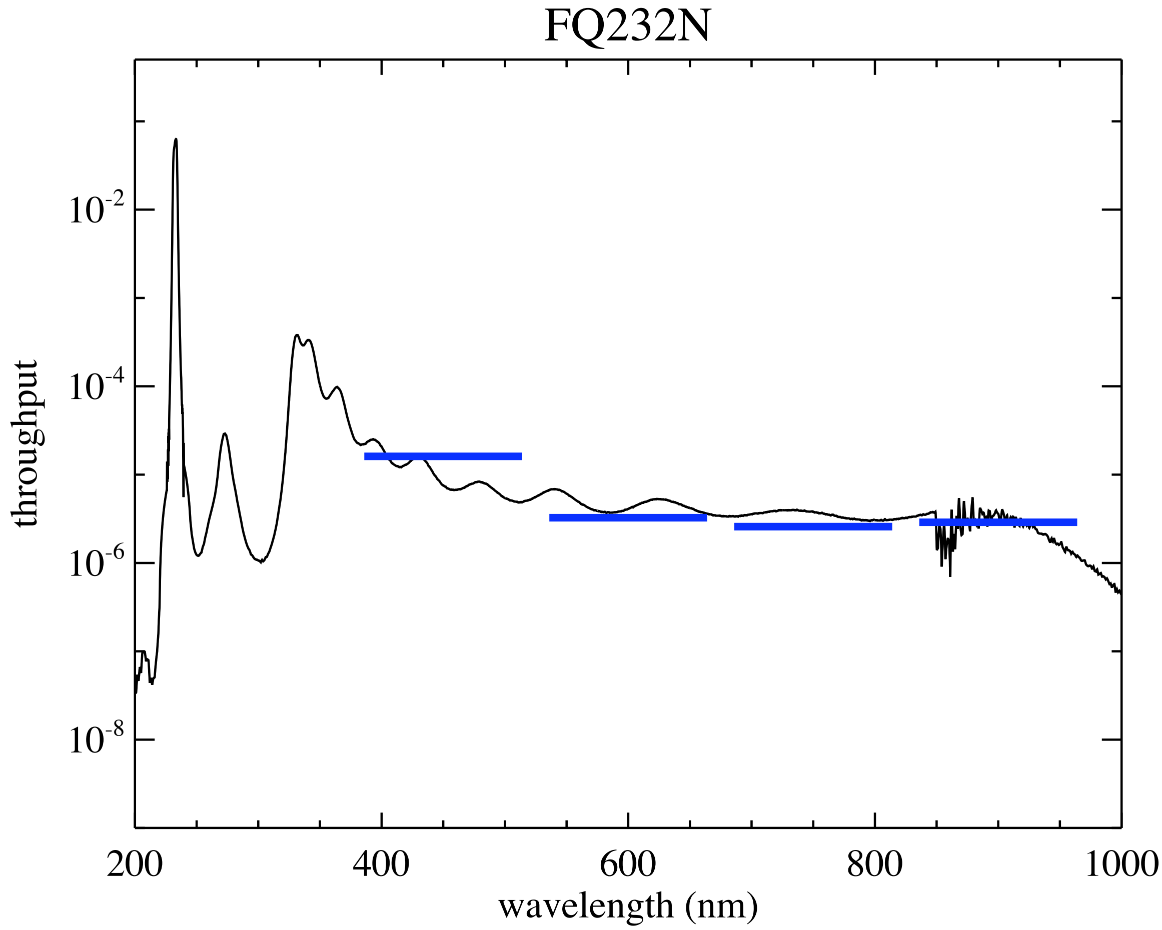

Figure 7: The same as in Figure 1, but for FQ232N.

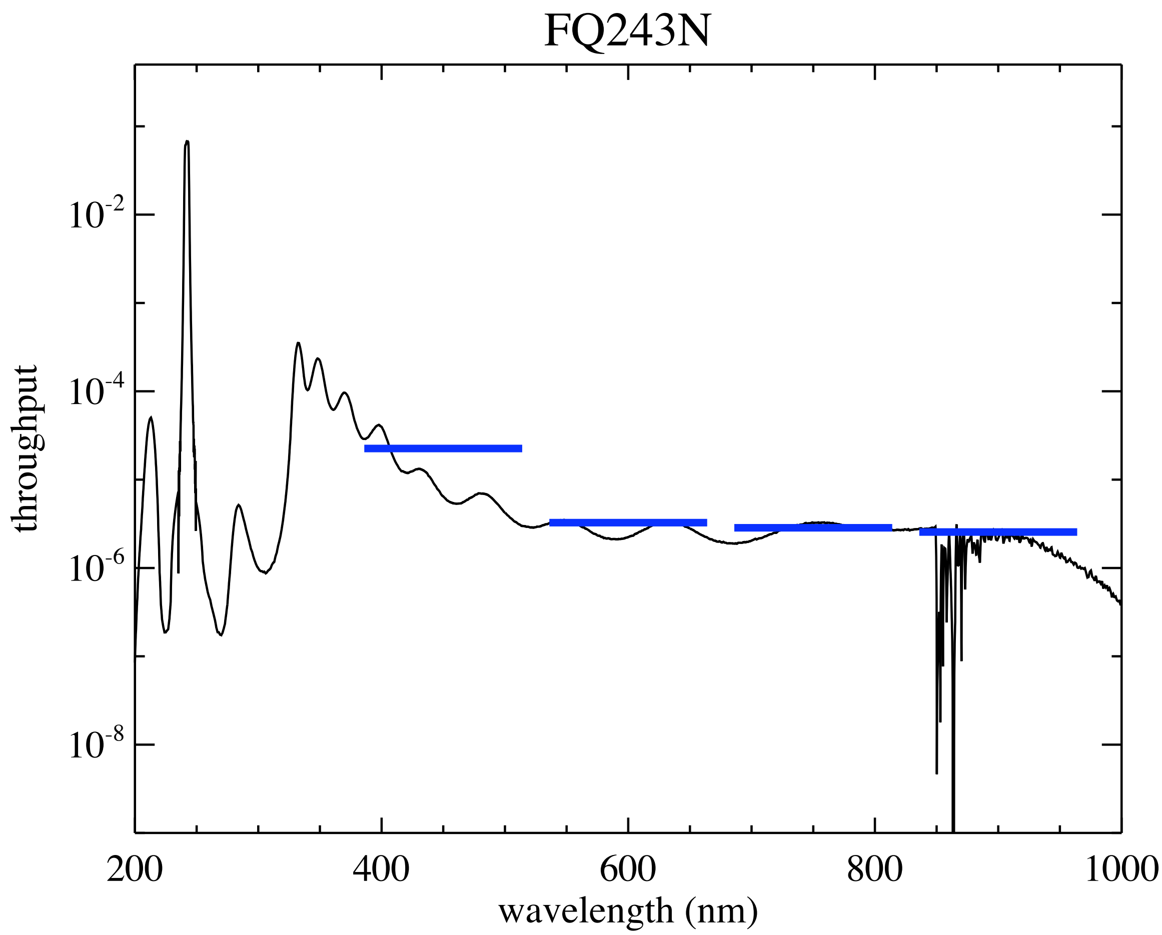

Figure 8: The same as in Figure 1, but for FQ243N.