SPACE TELESCOPE SCIENCE INSTITUTE

INSTRUMENT SCIENCE REPORT

TITLE: Results of HSP Throughput Tests During TVTB

AUTHOR: Richard L. White DATE: 20 February 1987

ABSTRACT

Results are reported for the HSP throughput tests carried out during the thermal vacuum/thermal balance test at Lockheed from May–July 1986. The observed count rates are tabulated along with predictions for the HSP count rate based on the HSP component efficiencies and the pre-TVTB calibration of the throughput test lamps. The OTA throughput and the HSP efficiency are substantially what was expected in the UV ($1500 < \lambda < 3000$ Å).

This report will be reissued when the re-calibration of the throughput test lamps is complete.

DISTRIBUTION:

ISB	Instrument Scientists, Cal. Group	Dan Schroeder
CSC		
SDAS		
SOGS		
IDT	HSP IDT	

Results of HSP Throughput Tests During TVTB

Richard L. White, STScI
December 1986

Introduction

During the thermal vacuum/thermal balance (TVTB) test held at Lockheed from May–July 1986, the High Speed Photometer (HSP) made measurements on four occasions which can be used to determine the throughput of the HSP-ST system. The first three tests involved observations of the Throughput Optical Test (TOT) lamps; the last was an observation of the WFPC contamination test lamp. During TOT 1 and 2 there were 4 lamps working (3 Pt-Ne and 1 Pt-Cr-Ne). During TOT 3 one of the Pt-Ne lamps had failed so there were only 3 lamps working.

Description of Measurements

During TOT 1 and TOT 2, measurements were made using the same 4 UV filters (F152M, F184W, F218M, F278N) on both UV IDTs (IDT 2 = UV1, IDT 4 = UV2). During TOT 3, measurements were made with the 4 UV filters on IDT 2 and with 4 filters on IDT 3 = VIS (F184W, F262N, F419N, F551W). During the WFPC test, measurements were made with filter F152M on IDTs 2 and 4. The exposure times and results for all observations are given in Tables 1 and 2.

Measurements of dark count rates at two positions on each detector were taken at the beginning and end of each test. The mean dark rate for the detector was subtracted from the raw count rates to derive the measured count rates reported in Tables 1 and 2.

For the TOT 3 dark count measurements, the lamps were left on. The resulting "dark" count rates were measured at positions on the IDT photocathodes not directly illuminated by an aperture. On IDT 2, the rates with the lamps on were virtually identical to those with the lamps off, indicating that scattered light "leaking" through the various focal plane apertures does not contaminate the results.

On the other hand, on IDT 3 the dark count is quite high and varies by 50% between the 2 points where measurements were taken. Presumably this is a result of the very strong, unfocussed red light from the lamps leaking through the HSP's focal plane filters. This is not a problem on the UV IDTs because they are sensitive only to blue light ($\lambda < 3000$ Å).

The variation of this red scattered light with position on the IDT 3 photocathode was not determined very well by the dark count measurements that were made in TOT 3. Consequently, it is not possible to subtract the dark rate accurately from the measured lamp count rates. This means that the measurements through F184W on IDT 3 cannot be used and that those made through F262M are highly uncertain. The other two filters on IDT 3 (F419N, F551W) have count rates enough above the dark rates that the measurements are reliable.

Predictions

Predicted count rates were calculated by convolving the response of all HSP optics (including filters, relay mirrors, and detector efficiencies) with calibrated lamp spectra. The efficiencies used for all elements are given in the *HSP Instrument Handbook*. For the

TOT lamps, the final lamp calibration from W. Rosenberg was used (November 1986). (For TOT 3, only the 3 working lamps were included.) For the WFPC test, the lamp calibration was taken from measurements by the HRS (see attached memo from K. Carpenter).

The predictions in Table 3 were calculated assuming a perfectly reflecting OTA. Also given in Table 3 is the expected OTA throughput (= actual count rate divided by count rate for OTA=100%) for each filter if the Perkin-Elmer (Facie) measurements of the OTA reflectivity are assumed to be correct.

Results and Discussion

Table 4 gives the measured OTA throughput for all the observations during TVTB. These results are also plotted in Figure 1 along with the Facie PE OTA measurements.

The measurements are generally self-consistent and fall somewhat (~50%) below the PE OTA predictions, especially at short wavelengths. This modest discrepancy has several possible explanations. The HSP component efficiencies (for detectors, filters, etc.) have some uncertainty which could account for the difference. Another possibility is that mis-centering of the IDT beam on the aperture image reduced the measured count rates. The calibration lamps were so faint that it was difficult to determine accurate positions for the apertures during the VAPMAP segments which preceeded each test.

Regardless of the cause of these discrepancies, these tests clearly show that both the OTA throughput and the HSP efficiency are substantially what was expected.

The very high count rate measured for filter F419N is due to strong Cr lines near 4200 Å. The FOS measurements of these lines showed them to be several times brighter than predicted from the lamp calibration. Consequently, the observed count rate for F419N is considerably higher than the predicted rate.

The low efficiency measured for filter F551W is somewhat puzzling. The HSP throughput for this filter was measured at the end of VAP testing in August 1984; that measurement was in good agreement with the predictions based on component efficiencies. The OTA efficiency is certainly much greater than 30% at 5500 Å, however. Possibly the beam mis-centering discussed above is affecting these observations as well. A more likely explanation is that the very red lamp spectrum is sampling the HSP efficiency in only the wings of the F551W filter. Figure 2 shows the filter transmission for F551W and the convolution of the lamp spectrum with the HSP efficiency for that filter. The count rate is determined entirely by lamp emission in the red wing of the filter; consequently, small uncertainties in the filter transmission there could produce relatively large changes in the predicted count rates.

Summary

Tables 1 and 2 give the results of measurements of HSP throughput during the TVTB test. Table 3 gives predicted count rates for the same filters for a perfectly reflecting OTA, and Table 4 gives the measured OTA throughput derived assuming that these predictions are correct. The measured throughput is slightly lower than expected (Figure 1); several possible explanations were offered for this. The tests clearly demonstrate that the OTA throughput and the HSP efficiency are substantially what was expected in the UV ($1500 < \lambda < 3000$ Å).

Table 1: Measurements from HSP Throughput Tests 1, 2, and 3

		TOT 1			*TOT 2*			*TOT 3*		
Filter	*Detector*	*Exposure Time (s)*	*Count Rate (cts/s)*	*σ (cts/s)*	*Exposure Time (s)*	*Count Rate (cts/s)*	*σ (cts/s)*	*Exposure Time (s)*	*Count Rate (cts/s)*	*σ (cts/s)*
Dark	2	400	0.033	0.009	400	0.055	0.012	400	0.060	0.012
Dark	4	400	0.11	0.02	400	0.14	0.02	–	–	–
F152M	2	875	0.21	0.02	875	0.15	0.02	1100	0.097	0.017
	4	875	0.26	0.03	875	0.28	0.03	–	–	–
	mean	1750	0.236	0.016	1750	0.216	0.017	–	–	–
F184W	2	50	3.6	0.3	50	4.1	0.3	50	2.7	0.2
	4	50	3.7	0.3	50	2.8	0.2	–	–	–
	mean	100	3.60	0.19	100	3.46	0.19	–	–	–
F218M	2	50	2.1	0.2	50	2.4	0.2	75	1.63	0.15
	4	50	2.9	0.25	50	2.4	0.2	–	–	–
	mean	100	2.51	0.16	100	2.39	0.16	–	–	–
F278N	2	100	1.41	0.12	100	1.88	0.14	150	1.12	0.09
	4	100	1.25	0.12	100	0.99	0.11	–	–	–
	mean	200	1.33	0.08	200	1.43	0.09	–	–	–
Dark[a]	3	–	–	–	–	–	–	400	6.1	0.1
F184W[b]	3	–	–	–	–	–	–	1100	5.7[b]	0.07
F262M[c]	3	–	–	–	–	–	–	150	4.2	0.3
F419N[c]	3	–	–	–	–	–	–	50	13.8	0.6
F551W[c]	3	–	–	–	–	–	–	75	191.	2.

NOTES: (a) Lamp was left on during dark collection to determine contamination by light coming through red filters. Resulting "dark" count rate varies by at least ±20% (and probably more) with position, making dark subtraction practically impossible.

(b) Raw count rate is given, with dark count rate not subtracted. True count rate through filter cannot be determined from these measurements because of unknown variation in dark rate with position.

(c) Statistical uncertainty is given. True uncertainty is larger (~5 cts/s) because of dark uncertainty.

Table 2: Measurements from HSP Throughput Test with WFPC Lamp

Filter	*Detector*	*Exposure Time (s)*	*Count Rate (cts/s)*	*σ (cts/s)*
Dark	2	3600	0.0031	0.0009
Dark	4	3600	0.070	0.004
F152M	2	14400	0.271	0.004
F152M	4	14400	0.384	0.007
F152M	mean	28800	0.328	0.004

Table 3: Predictions for HSP Throughput Tests

Test[a]	*Detectors*	*Filter*	*λ_{eff}*[b] *(Å)*	*Predicted Rate*[c] *(cts/s, OTA=100%)*	*PE OTA*[c] *Throughput*
TOT 1,2	2,4	F152M	1658	0.774	0.52
TOT 1,2	2,4	F184W	1968	9.90	0.60
TOT 1,2	2,4	F218M	2179	6.54	0.72
TOT 1,2	2,4	F278N	2760	2.63	0.78
TOT 3	2	F152M	1660	0.529	0.52
TOT 3	2	F184W	1970	6.87	0.60
TOT 3	2	F218M	2179	4.58	0.72
TOT 3	2	F278N	2760	1.91	0.78
TOT 3	3	F184W	1971	6.91	0.60
TOT 3	3	F262M	2695	9.47	0.77
TOT 3	3	F419N	4262	7.62	0.82
TOT 3	3	F551W	5972	657.	0.82
WFPC	2,4	F152M	1612	0.797	0.51

NOTES: (a) During TOT 1 and 2 all four A&V lamps were on. During TOT 3 only three lamps were working. During the WFPC test only the WFPC contamination test lamp was on.

(b) The effective wavelength λ_{eff} is the mean wavelength for all detected photons.

(c) The *Predicted Count Rate* is derived assuming a perfectly reflecting OTA. The *PE OTA Throughput* is the ratio of observed to predicted count rates expected if the Facie measurements of the OTA reflectivity are correct.

Table 4: Comparison of Measurements with Predictions for HSP Throughput Tests

		Measured OTA Throughput			
Filter	*Detector*	*TOT 1*	*TOT 2*	*TOT 3*	*WFPC*
F152M	2	0.27±0.02	0.19±0.03	0.18±0.03	0.34±0.01
F152M	4	0.34±0.03	0.36±0.04	–	0.48±0.01
F152M	mean	0.30±0.02	0.28±0.02	–	0.41±0.01
F184W	2	0.36±0.03	0.41±0.03	0.39±0.03	–
F184W	4	0.37±0.03	0.28±0.02	–	–
F184W	mean	0.36±0.02	0.35±0.02	–	–
F218M	2	0.32±0.03	0.37±0.03	0.36±0.03	–
F218M	4	0.44±0.04	0.37±0.04	–	–
F218M	mean	0.38±0.02	0.37±0.02	–	–
F278N	2	0.54±0.05	0.71±0.05	0.59±0.05	–
F278N	4	0.48±0.05	0.38±0.04	–	–
F278N	mean	0.51±0.03	0.54±0.03	–	–
F184W[a]	3			–	
F262M	3			0.44±0.03	
F419N[b]	3			1.8 ±0.1	
F551W[c]	3			0.29±0.01	

NOTES: (a) Dark count problems make deriving ratio for F184W impossible.
(b) Cr lines near 4200 Å were observed by FOS to be much brighter than predicted. That probably explains the high apparent throughput for F419N.
(c) Most counts for F551W come from the red wing of the filter, where the detector sensitivity is dropping at an uncertain rate. Consequently, the prediction is also somewhat uncertain in this case.

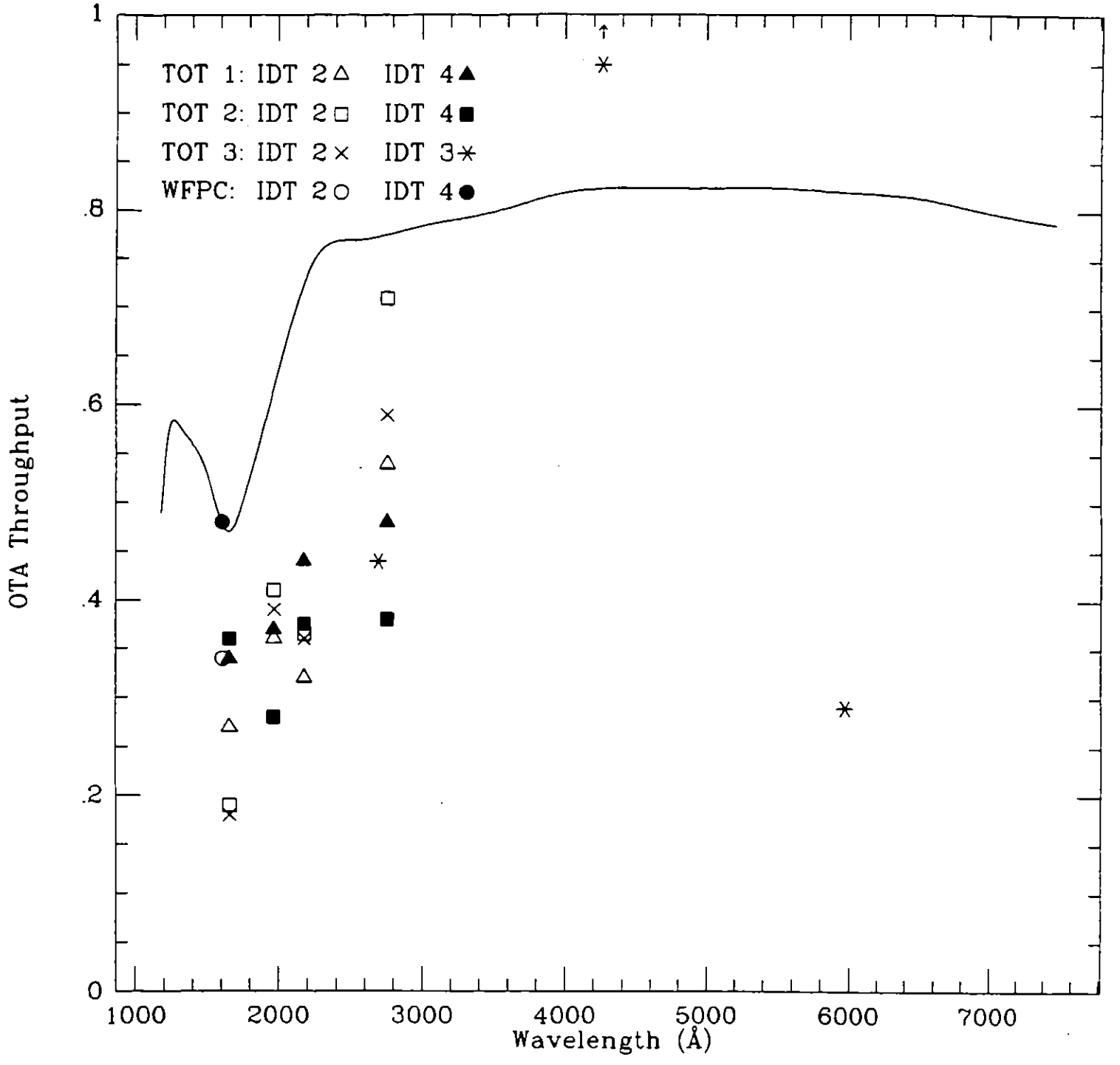

Figure 1: Comparison of OTA throughput calculated from HSP tests with OTA throughput from PE measurements.

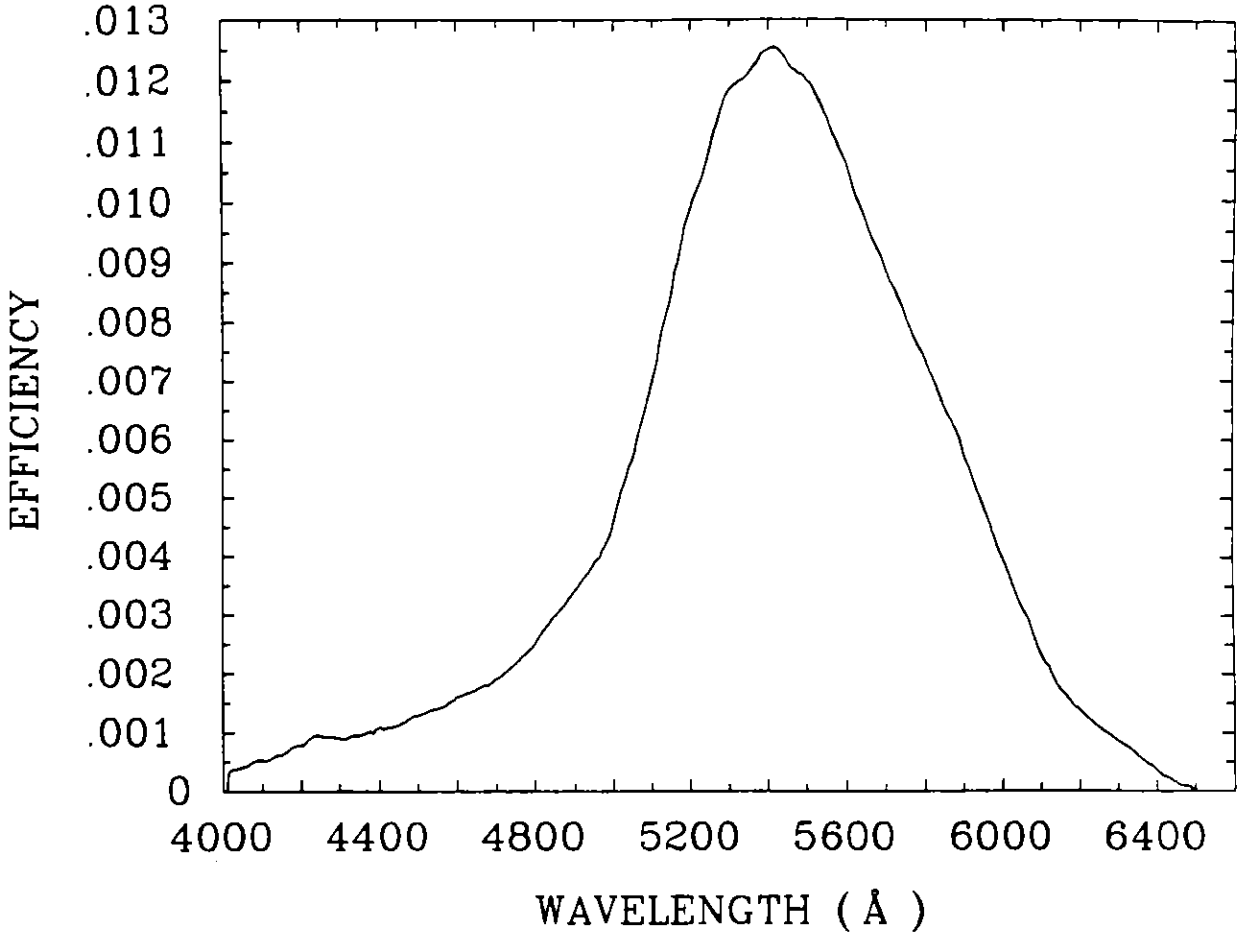

Figure 2(a): HSP efficiency for filter F551W.

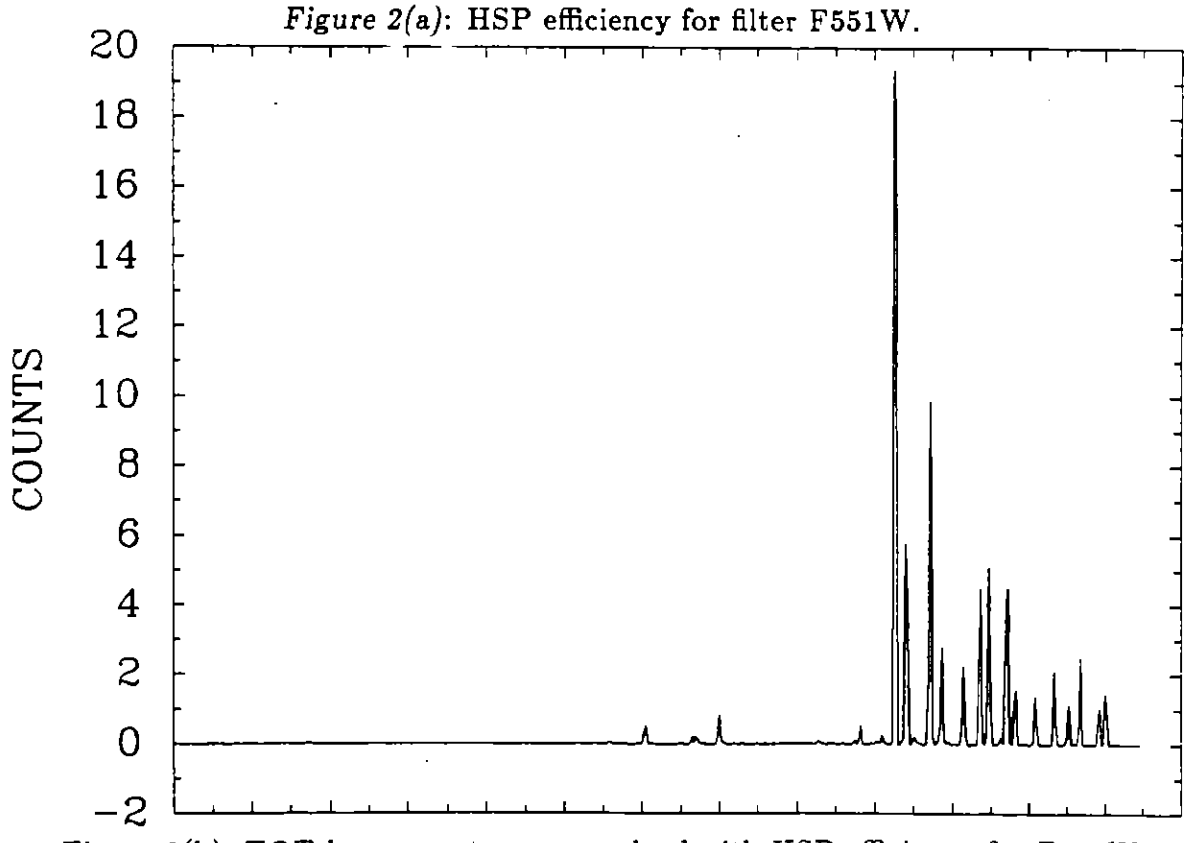

Figure 2(b): TOT lamp spectrum convolved with HSP efficiency for F551W.

MEMO

TO: R. White
HSP IDT
STScI
Baltimore, MD 21218

FROM: K. Carpenter
HRS IDT
Code 680 NASA/GSFC
Greenbelt, MD 20771

286-5781

DATE: 20-October-1986

SUBJECT: The flux of the fifth external calibration lamp during the WF/PC UV thruput test conducted on 6/28/86, based on observations with the HRS.

The HRS only observed the 1387 - 1670 A region during the 6/28/86 WF/PC test. I have therefore created the 1388 - 1924 A "observed HRS spectrum" using a two step process: First, I computed the ratio of the 1387 - 1670 A data taken during the 6/28 test to the same data taken during the first HRS thruput tests (in "hot operate"). The full 1387 - 1924 A spectrum taken during hot operate was then multiplied by this ratio (.77261) to derived a 6/28 "observed spectrum" for the larger spectral region. The HRS obtained no data below 1388A on the fifth lamp.

Figure 1 shows the HRS spectrum, constructed as noted above, in units of counts/Angstrom/sec versus wavelength in Angstroms.

Figure 2 shows the same spectrum expressed in units of photons/cm2/sec/Angstrom versus wavelength. This conversion assumes an HRS aperture size of .0559x.0559 cm and the HRS calibration derived at Ball Aerospace and published in the Oct. 1985 Institute Handbook. The data shown in Figure 2 has already been electronically transferred to you, as previously arranged.

The major "ghost" features in the 1600 - 1650 A region have been removed from the data. However, please note that other, smaller features, not readily separated from true features remain in the HRS spectra shown here.

Although it is not directly relevant to your analysis, you may be interested in the fact that the output of the fifth lamp as seen by HRS appears to have varied significantly during the thermal vac period. The following table shows the total number of counts/sec observed in each HRS observation of the 1388 to 1670 A spectral region.

Observation #	Total counts/sec	and time of test
20981	47.980	hot–operate HRS THRUPUT TEST
21457	37.628	6/24–25/86 WF/PC FAILED UV TEST
21459	37.227	"
21461	36.664	"
21463	36.106	"
21465	37.070	6/28/86 WF/PC UV THRUPUT TEST

All of the exposures were 1 hour in duration except for observation number 20981, which was 10 minutes in duration.

xc: J. Brandt, J. Clarke, D. Ebbets, S. Heap, D. Lindler, R. Melcher

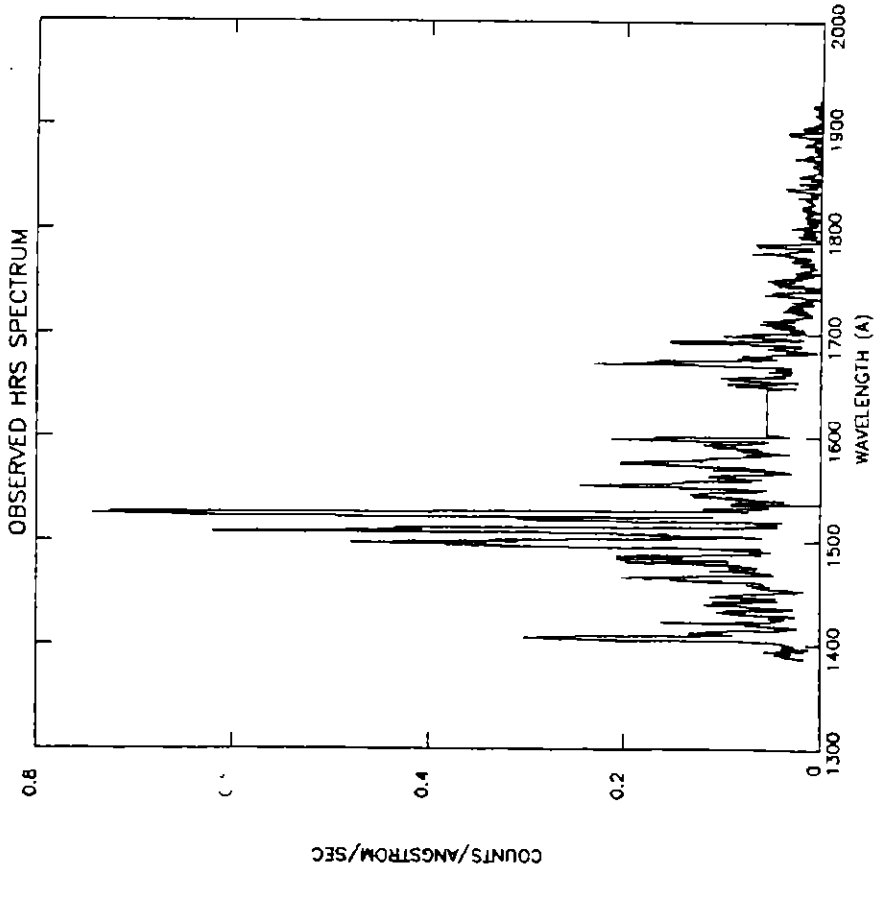
OBSERVED HRS SPECTRUM
COUNTS/ANGSTROM/SEC
WAVELENGTH (A)
0
0.2
0.4
0.8
1300
1400
1500
1600
1700
1800
1900
2000

Fig. 1

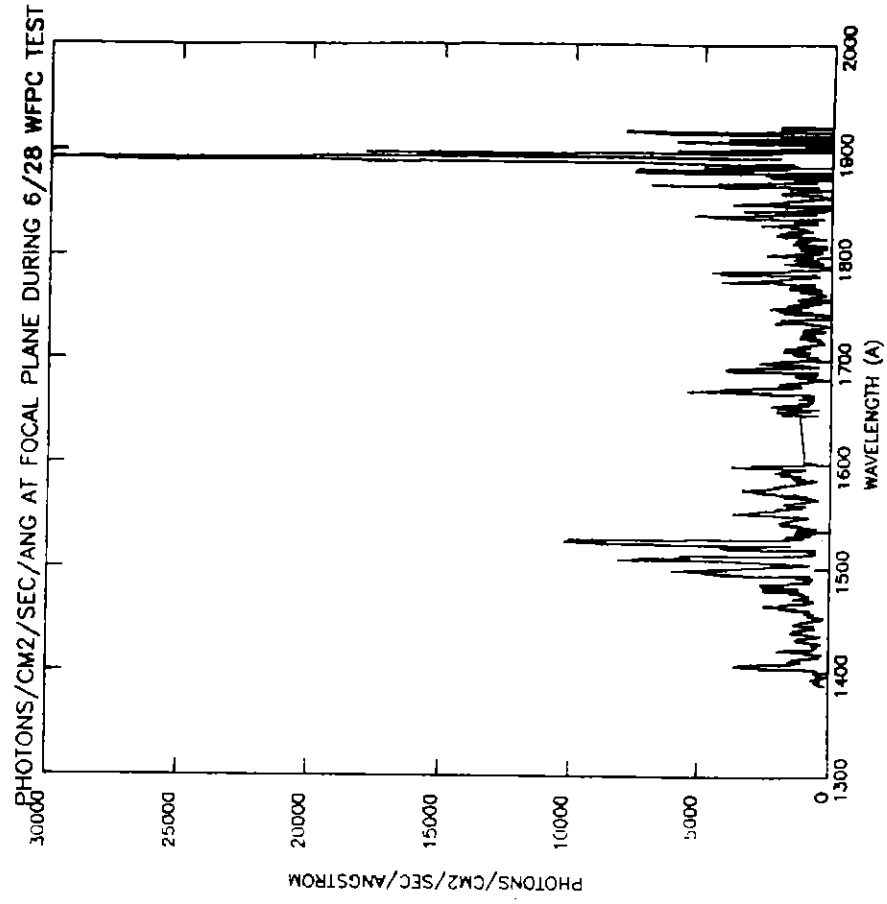
PHOTONS/CM2/SEC/ANG AT FOCAL PLANE DURING 6/28 WFPC TEST
PHOTONS/CM2/SEC/ANGSTROM
WAVELENGTH (A)
0
5000
10000
15000
20000
25000
30000
1300
1400
1500
1600
1700
1800
2000

Fig. 2