Minimum Exposure Times for Registration of PtNe Wavecals

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1. INTRODUCTION

Initial estimates of the required minimum exposure times to perform a good registration between a PtNe template and a wavecal exposure were calculated in 2006 by Kenneth Sembach and published in the STScI document COS TIR 2006-01. These exposure times were obtained for the NUV detector by adding all three stripes together for each central wavelength. We are presenting in this document the same analysis but keeping each stripe separate. The minimum exposure time for a specific grating and central wavelength is adjusted to the minimum time for the faintest stripe for all FPOFFSET positions.

2. DATA ANALYSIS

The files used to generate the lamp template reference file were used as input files. These are all time-tag files so taking various time slices is very straightforward. The same list of files was used for the analysis reported in document COS TIR 2006-01. For each grating and each central wavelength, time slices of 5, 10, 15, 20, and 30 seconds were extracted. Each time-slice spectrum was shifted randomly between -7.5 and +7.5 pixels, 25 times. The shifted spectra were cross-correlated with the lamp template data and the measured offsets were subtracted from the injected shift. The RMS of these differences is a measure of the ability of the cross-correlation algorithm to match the corresponding low signal-to-noise spectrum. Note that the reference lamp spectra are all from data obtained with FPOFFSET=0.

2.1 NUV DATA

The files used for the analysis are provided in table 2-1 with the total number of counts found in each stripe for the full exposure length. Also listed are the number of spectral lines with more than 100 counts at line center (N100) and the counts at line center of the brightest line for each stripe (PK).

Table 2-1 Total Counts for each Stripe

Filename	Grating	λ_{cen}	T_{exp} (sec.)	Stripe A		Stripe B		Stripe C	
				Counts	N100 / PK	Counts	N100 / PK	Counts	N100 / PK
CSIL03266025117	G185M	1786	120	2723	1 / 115	12741	5 / 736	11051	3 / 394
CSIL03266010953	G185M	1817	120	3251	1 / 178	6114	4 / 211	29342	7 / 1627
CSIL03266030811	G185M	1835	120	4196	2 / 177	7289	4 / 239	18380	5 / 819
CSIL03266012647	G185M	1850	120	4642	3 / 137	6442	2 / 226	8829	2 / 292

CSIL03266032505	G185M	1864	120	11336	5 / 770	6392	3 / 115	5468	3 / 274
CSIL03266014341	G185M	1882	120	12776	6 / 731	8254	3 / 450	7241	3 / 257
CSIL03266034159	G185M	1890	120	12368	5 / 783	9515	3 / 457	6035	3 / 212
CSIL03265222615	G185M	1900	120	12083	4 / 308	19653	5 / 1649	5962	3 / 163
CSIL03266035853	G185M	1913	120	5650	4 / 201	21421	4 / 1770	7224	5 / 386
CSIL03266020035	G185M	1921	120	6228	4 / 213	28448	6 / 1722	11041	7 / 444
CSIL03266041547	G185M	1941	120	7110	3 / 214	18396	5 / 903	13745	7 / 577
CSIL03266021729	G185M	1953	120	6615	3 / 250	13217	3 / 779	10785	7 / 606
CSIL03266043241	G185M	1971	120	7184	2 / 407	6101	3 / 282	10793	7 / 339
CSIL03266023423	G185M	1986	120	8372	3 / 432	7145	4 / 270	14151	6 / 653
CSIL03266044935	G185M	2010	120	15620	3 / 1645	4426	3 / 169	15576	4 / 849
CSIL03266121900	G225M	2186	120	10226	5 / 484	14994	4 / 1747	20321	5 / 996
CSIL03266103736	G225M	2217	120	9934	3 / 795	6259	3 / 299	13411	4 / 807
CSIL03266075357	G225M	2233	120	15381	2 / 1542	16932	7 / 786	8965	4 / 694
CSIL03266105430	G225M	2250	120	12247	2 / 1634	20769	6 / 749	9037	3 / 724
CSIL03266123554	G225M	2268	120	13052	3 / 1644	15257	4 / 792	10175	3 / 759
CSIL03266111124	G225M	2283	120	14603	4 / 1670	21511	6 / 1026	9260	5 / 480
CSIL03266125248	G225M	2306	120	6712	2 / 349	24388	7 / 1077	8427	5 / 501
CSIL03266112818	G225M	2325	120	12312	4 / 602	14557	5 / 865	8716	3 / 442
CSIL03266130942	G225M	2339	120	16802	7 / 732	4814	2 / 242	21218	3 / 2125
CSIL03266114512	G225M	2357	120	22791	7 / 728	9002	4 / 769	22261	3 / 1994
CSIL03266100434	G225M	2373	120	24536	7 / 955	13859	7 / 730	10396	2 / 1313
CSIL03266120206	G225M	2390	120	20499	6 / 992	10365	6 / 478	36727	6 / 3715
CSIL03266132636	G225M	2410	120	13442	5 / 863	7246	4 / 337	18558	4 / 1179
CSIL03266212736	G285M	2617	120	29467	8 / 2866	16972	2 / 2569	37187	5 / 3589
CSIL03266145158	G285M	2637	120	14657	6 / 871	48501	4 / 4857	17152	6 / 1148
CSIL03266214430	G285M	2657	120	5204	3 / 484	76366	5 / 7838	21630	6 / 1199
CSIL03266200306	G285M	2676	120	3897	1 / 444	44715	3 / 7320	16385	5 / 1168
CSIL03266155716	G285M	2695	120	2684	1 / 202	34629	4 / 3043	37224	5 / 4600
CSIL03266202000	G285M	2709	120	4065	2 / 221	39788	4 / 3167	35230	5 / 4691
CSIL03266170234	G285M	2719	120	4393	2 / 231	58857	6 / 3656	31716	4 / 4708
CSIL03266220124	G285M	2739	120	18029	3 / 2771	37556	6 / 3654	7524	1 / -1
CSIL03266221818	G285M	2850	120	36926	5 / 3719	27518	1 / 256	9764	4 / 569
CSIL03266180752	G285M	2952	120	30332	2 / 4811	8776	3 / 613	32694	3 / 4773
CSIL03266203654	G285M	2979	120	8430	1 / 1112	27960	3 / 396	3903	1 / 145
CSIL03266223512	G285M	2996	120	17616	3 / 1241	26940	2 / 4024	3010	1 / 139
CSIL03266205348	G285M	3018	120	14742	4 / 1280	33663	5 / 613	2644	2 / 180
CSIL03266225206	G285M	3035	120	23546	3 / 3357	42466	9 / 5067	2638	1 / 167
CSIL03266211042	G285M	3057	120	26210	3 / 3537	65524	7 / 5321	1210	1 / -1
CSIL03266191310	G285M	3074	120	9599	4 / 586	32550	3 / 5094	2344	1 / 161
CSIL03266230900	G285M	3094	120	30397	3 / 3926	3447	1 / 154	4818	2 / 328
CSIL03267064458	G230L	2635	60	2931	0 / 0	121849	16 / 3506	3455	1 / 104
CSIL03267091836	G230L	2950	60	43191	5 / 815	85195	12 / 2126	3020	1 / -1
CSIL03267074616	G230L	3000	60	54705	7 / 748	75028	10 / 2053	3456	1 / 111
CSIL03267084734	G230L	3360	60	87693	11 / 1260	10913	3 / 243	3047	1 / -1

2.1.1 FPOFFSET 0 (FPPOS 3)

The table 2-2 below summarizes the results of these fits for each grating/central wavelength/stripe/time-slice combination. The RMS values are listed for the 5, 10, 15, 20 and 30 seconds time-slices. The right-most column is the corresponding RMS value for the full exposure. This gives us a measure of the accuracy of the cross-correlation algorithm since it is comparing the same full dataset with the injected offsets. Note that the injected offsets are rounded to the nearest 0.01 pixel before being added to the spectrum.

The IDL `cross_correlate` routine was compared to the calcos python `crosscor` routine for the same datasets. The IDL routine consistently gave slightly better results for the FPOFFSET=0. In the 16 cases where we have TV data available for FPOFFSET=-2, the python routine would sometimes fail or get the wrong offset when a bright line would appear or disappear from the spectrum. The IDL routine is more robust and never miscalculated the offsets even in the cases stated above. The data below reflects the RMS values using the IDL routine.

Table 2-2 RMS of measured to injected offsets (FPOFFSET=0)

Grating	λ_{cen}	Stripe	T_{Exp}	RMS Offset Between Injected Shift and Cross-Correlation Shift (pix)					
				5s	10s	15s	20s	30s	T_{Exp}
G185M	1786	A	120	0.19	0.09	0.07	0.07	0.06	0.04
G185M	1786	B	120	0.15	0.02	0.03	0.02	0.04	0.02
G185M	1786	C	120	0.38	0.15	0.07	0.02	0.02	0.02
G185M	1817	A	120	0.37	0.24	0.11	0.14	0.14	0.03
G185M	1817	B	120	0.14	0.11	0.08	0.06	0.05	0.02
G185M	1817	C	120	0.03	0.03	0.03	0.02	0.02	0.01
G185M	1835	A	120	0.10	0.03	0.03	0.09	0.08	0.02
G185M	1835	B	120	0.43	0.11	0.08	0.06	0.07	0.03
G185M	1835	C	120	0.14	0.12	0.05	0.08	0.02	0.01
G185M	1850	A	120	0.27	0.12	0.29	0.26	0.11	0.03
G185M	1850	B	120	0.05	0.13	0.16	0.13	0.05	0.02
G185M	1850	C	120	0.17	0.11	0.06	0.10	0.05	0.04
G185M	1864	A	120	0.19	0.04	0.08	0.07	0.06	0.03
G185M	1864	B	120	0.32	0.06	0.17	0.08	0.12	0.04
G185M	1864	C	120	0.05	0.11	0.04	0.03	0.03	0.02
G185M	1882	A	120	0.24	0.33	0.18	0.17	0.11	0.02
G185M	1882	B	120	0.12	0.16	0.12	0.08	0.09	0.02
G185M	1882	C	120	0.28	0.23	0.09	0.05	0.04	0.02
G185M	1890	A	120	0.10	0.09	0.06	0.02	0.06	0.02
G185M	1890	B	120	0.02	0.08	0.13	0.05	0.07	0.02
G185M	1890	C	120	0.33	0.16	0.04	0.14	0.15	0.03

G185M	1900	A	120	0.17	0.08	0.05	0.10	0.02	0.02
G185M	1900	B	120	0.13	0.06	0.03	0.03	0.02	0.02
G185M	1900	C	120	0.50	0.18	0.14	0.10	0.02	0.02
G185M	1913	A	120	0.46	0.05	0.13	0.09	0.04	0.02
G185M	1913	B	120	0.07	0.02	0.03	0.04	0.01	0.01
G185M	1913	C	120	0.44	0.36	0.21	0.05	0.04	0.03
G185M	1921	A	120	0.13	0.24	0.14	0.16	0.17	0.02
G185M	1921	B	120	0.10	0.08	0.09	0.11	0.04	0.01
G185M	1921	C	120	0.14	0.07	0.04	0.06	0.08	0.02
G185M	1941	A	120	0.22	0.14	0.04	0.03	0.10	0.03
G185M	1941	B	120	0.08	0.04	0.04	0.06	0.07	0.01
G185M	1941	C	120	0.03	0.19	0.20	0.14	0.12	0.02
G185M	1953	A	120	0.04	0.11	0.12	0.13	0.07	0.03
G185M	1953	B	120	0.26	0.16	0.06	0.03	0.04	0.03
G185M	1953	C	120	0.16	0.16	0.08	0.09	0.03	0.02
G185M	1971	A	120	0.06	0.05	0.08	0.04	0.05	0.04
G185M	1971	B	120	0.32	0.34	0.17	0.07	0.09	0.02
G185M	1971	C	120	0.32	0.23	0.15	0.02	0.05	0.03
G185M	1986	A	120	0.04	0.14	0.09	0.02	0.02	0.02
G185M	1986	B	120	0.14	0.04	0.04	0.03	0.03	0.03
G185M	1986	C	120	0.03	0.02	0.02	0.07	0.03	0.02
G185M	2010	A	120	0.39	0.17	0.14	0.07	0.08	0.01
G185M	2010	B	120	0.17	0.04	0.11	0.10	0.04	0.03
G185M	2010	C	120	0.02	0.05	0.02	0.08	0.10	0.01
G225M	2186	A	120	0.08	0.01	0.07	0.03	0.04	0.02
G225M	2186	B	120	0.25	0.09	0.12	0.12	0.13	0.03
G225M	2186	C	120	0.02	0.11	0.14	0.06	0.05	0.01
G225M	2217	A	120	0.43	0.14	0.18	0.14	0.12	0.01
G225M	2217	B	120	0.06	0.17	0.03	0.04	0.06	0.03
G225M	2217	C	120	0.03	0.09	0.03	0.05	0.03	0.01
G225M	2233	A	120	0.11	0.02	0.07	0.04	0.01	0.01
G225M	2233	B	120	0.03	0.14	0.10	0.10	0.06	0.02
G225M	2233	C	120	0.08	0.18	0.05	0.08	0.06	0.02
G225M	2250	A	120	0.26	0.24	0.09	0.04	0.03	0.01
G225M	2250	B	120	0.03	0.09	0.08	0.06	0.02	0.02
G225M	2250	C	120	0.25	0.04	0.10	0.05	0.02	0.02
G225M	2268	A	120	0.16	0.07	0.08	0.14	0.15	0.01
G225M	2268	B	120	0.02	0.02	0.02	0.03	0.02	0.02
G225M	2268	C	120	0.24	0.08	0.07	0.12	0.11	0.06
G225M	2283	A	120	0.39	0.21	0.15	0.05	0.04	0.03
G225M	2283	B	120	0.09	0.09	0.06	0.03	0.03	0.01
G225M	2283	C	120	0.24	0.07	0.02	0.05	0.03	0.02
G225M	2306	A	120	0.20	0.24	0.27	0.21	0.15	0.06
G225M	2306	B	120	0.14	0.02	0.04	0.05	0.08	0.02
G225M	2306	C	120	0.20	0.15	0.11	0.09	0.03	0.02
G225M	2325	A	120	0.04	0.07	0.13	0.11	0.12	0.03
G225M	2325	B	120	0.51	0.27	0.21	0.20	0.16	0.02
G225M	2325	C	120	0.03	0.06	0.06	0.03	0.03	0.02

G225M	2339	A	120	0.04	0.07	0.01	0.06	0.08	0.01
G225M	2339	B	120	0.44	0.10	0.10	0.11	0.06	0.02
G225M	2339	C	120	0.04	0.03	0.10	0.04	0.01	0.01
G225M	2357	A	120	0.07	0.21	0.16	0.17	0.06	0.02
G225M	2357	B	120	0.03	0.08	0.14	0.12	0.05	0.02
G225M	2357	C	120	0.08	0.23	0.04	0.07	0.15	0.02
G225M	2373	A	120	0.04	0.05	0.09	0.06	0.03	0.02
G225M	2373	B	120	0.53	0.45	0.37	0.26	0.20	0.02
G225M	2373	C	120	0.01	0.02	0.06	0.02	0.03	0.01
G225M	2390	A	120	0.06	0.02	0.07	0.04	0.03	0.01
G225M	2390	B	120	0.05	0.11	0.07	0.06	0.05	0.02
G225M	2390	C	120	0.14	0.08	0.09	0.06	0.04	0.01
G225M	2410	A	120	0.18	0.15	0.08	0.10	0.09	0.02
G225M	2410	B	120	0.04	0.02	0.10	0.02	0.05	0.02
G225M	2410	C	120	0.08	0.06	0.02	0.04	0.12	0.01
G285M	2617	A	120	0.01	0.05	0.04	0.03	0.01	0.01
G285M	2617	B	120	0.06	0.18	0.17	0.13	0.06	0.01
G285M	2617	C	120	0.13	0.07	0.08	0.03	0.08	0.01
G285M	2637	A	120	0.05	0.03	0.03	0.04	0.02	0.02
G285M	2637	B	120	0.07	0.08	0.02	0.02	0.04	0.01
G285M	2637	C	120	0.37	0.23	0.29	0.23	0.07	0.02
G285M	2657	A	120	0.14	0.02	0.06	0.04	0.10	0.02
G285M	2657	B	120	0.09	0.02	0.02	0.02	0.01	0.01
G285M	2657	C	120	0.02	0.02	0.03	0.04	0.05	0.01
G285M	2676	A	120	0.08	0.08	0.15	0.13	0.09	0.05
G285M	2676	B	120	0.20	0.19	0.06	0.06	0.09	0.02
G285M	2676	C	120	0.18	0.03	0.04	0.11	0.09	0.02
G285M	2695	A	120	0.13	0.04	0.06	0.03	0.14	0.02
G285M	2695	B	120	0.04	0.03	0.06	0.05	0.06	0.01
G285M	2695	C	120	0.10	0.10	0.14	0.09	0.07	0.02
G285M	2709	A	120	0.30	0.02	0.04	0.02	0.02	0.02
G285M	2709	B	120	0.03	0.05	0.04	0.03	0.02	0.02
G285M	2709	C	120	0.02	0.02	0.04	0.02	0.02	0.01
G285M	2719	A	120	0.14	0.02	0.05	0.03	0.08	0.02
G285M	2719	B	120	0.08	0.03	0.04	0.04	0.03	0.01
G285M	2719	C	120	0.05	0.03	0.01	0.01	0.03	0.01
G285M	2739	A	120	0.04	0.08	0.09	0.10	0.09	0.02
G285M	2739	B	120	0.01	0.04	0.02	0.02	0.01	0.01
G285M	2739	C	120	0.21	0.18	0.15	0.17	0.08	0.05
G285M	2850	A	120	0.07	0.07	0.04	0.03	0.03	0.01
G285M	2850	B	120	0.41	0.48	0.38	0.32	0.06	0.06
G285M	2850	C	120	0.04	0.04	0.02	0.05	0.03	0.01
G285M	2952	A	120	0.04	0.02	0.01	0.01	0.02	0.01
G285M	2952	B	120	0.03	0.04	0.03	0.04	0.05	0.02
G285M	2952	C	120	0.03	0.02	0.04	0.01	0.05	0.01
G285M	2979	A	120	0.22	0.15	0.11	0.07	0.07	0.02
G285M	2979	B	120	0.48	0.11	0.05	0.02	0.15	0.02
G285M	2979	C	120	0.34	0.04	0.10	0.10	0.03	0.03

G285M	2996	A	120	0.06	0.14	0.06	0.07	0.03	0.02
G285M	2996	B	120	0.03	0.05	0.07	0.03	0.02	0.01
G285M	2996	C	120	0.09	0.24	0.13	0.10	0.04	0.04
G285M	3018	A	120	0.13	0.17	0.18	0.07	0.02	0.02
G285M	3018	B	120	0.08	0.20	0.01	0.08	0.05	0.02
G285M	3018	C	120	0.02	0.11	0.08	0.04	0.02	0.02
G285M	3035	A	120	0.16	0.10	0.02	0.04	0.05	0.01
G285M	3035	B	120	0.06	0.05	0.07	0.03	0.02	0.01
G285M	3035	C	120	0.12	0.12	0.18	0.22	0.18	0.03
G285M	3057	A	120	0.05	0.04	0.02	0.06	0.04	0.02
G285M	3057	B	120	0.04	0.07	0.07	0.11	0.09	0.01
G285M	3057	C	120	0.35	0.31	0.40	0.42	0.41	0.07
G285M	3074	A	120	0.26	0.16	0.13	0.08	0.08	0.01
G285M	3074	B	120	0.03	0.02	0.02	0.04	0.01	0.01
G285M	3074	C	120	0.26	0.23	0.07	0.07	0.14	0.05
G285M	3094	A	120	0.01	0.20	0.21	0.09	0.05	0.04
G285M	3094	B	120	0.35	0.19	0.11	0.03	0.08	0.02
G285M	3094	C	120	0.25	0.05	0.12	0.10	0.05	0.03
G230L	2635	A	60	0.11	0.12	0.21	0.17	0.11	0.10
G230L	2635	B	60	0.05	0.05	0.05	0.04	0.04	0.02
G230L	2635	C	60	0.12	0.05	0.06	0.05	0.04	0.04
G230L	2950	A	60	0.03	0.02	0.02	0.03	0.02	0.02
G230L	2950	B	60	0.06	0.06	0.02	0.03	0.03	0.02
G230L	2950	C	60	0.14	0.15	0.08	0.09	0.08	0.08
G230L	3000	A	60	0.04	0.04	0.07	0.06	0.03	0.02
G230L	3000	B	60	0.06	0.02	0.02	0.02	0.03	0.02
G230L	3000	C	60	0.07	0.16	0.15	0.12	0.09	0.06
G230L	3360	A	60	0.04	0.05	0.05	0.04	0.03	0.02
G230L	3360	B	60	0.28	0.19	0.12	0.05	0.04	0.03
G230L	3360	C	60	0.16	0.11	0.06	0.07	0.06	0.06

2.1.2 FPOFFSET -2 (FPPOS 1)

We also tested the algorithms and exposure times for the two extreme FPOFFSETS, -2 and +1. Thermal-vac data is not available for all of the central wavelength positions and FPOFFSET. Multiple datasets were combined together to simulate the data from the various FPOFFSET positions. The tables below represent the same analysis as above for the FPOFFSET=-2 and +1 positions.

Table 2-3 RMS of measured to injected offsets (FPOFFSET=-2)

Grating	λ_{cen}	Stripe	T_{Exp}	RMS Offset Between Injected Shift and Cross-Correlation Shift (pix)					
				5s	10s	15s	20s	30s	T_{Exp}
G185M	1786	A	120	0.19	0.09	0.07	0.07	0.06	0.04
G185M	1786	B	120	0.15	0.02	0.03	0.02	0.04	0.02
G185M	1786	C	120	0.38	0.15	0.07	0.02	0.02	0.02
G185M	1817	A	120	0.37	0.24	0.11	0.14	0.14	0.03
G185M	1817	B	120	0.14	0.11	0.08	0.06	0.05	0.02
G185M	1817	C	120	0.02	0.03	0.03	0.02	0.03	0.01
G185M	1835	A	120	0.10	0.03	0.03	0.09	0.08	0.02
G185M	1835	B	120	0.43	0.11	0.08	0.06	0.07	0.03
G185M	1835	C	120	0.14	0.12	0.05	0.08	0.02	0.01
G185M	1850	A	120	0.27	0.12	0.29	0.26	0.11	0.03
G185M	1850	B	120	0.05	0.13	0.16	0.13	0.05	0.02
G185M	1850	C	120	0.17	0.11	0.06	0.10	0.05	0.04
G185M	1864	A	120	0.19	0.04	0.08	0.07	0.06	0.03
G185M	1864	B	120	0.32	0.06	0.17	0.08	0.12	0.04
G185M	1864	C	120	0.05	0.11	0.04	0.03	0.03	0.02
G185M	1882	A	120	0.24	0.33	0.18	0.17	0.11	0.02
G185M	1882	B	120	0.12	0.16	0.12	0.08	0.09	0.02
G185M	1882	C	120	0.28	0.23	0.09	0.05	0.04	0.02
G185M	1890	A	120	0.10	0.09	0.06	0.02	0.06	0.02
G185M	1890	B	120	0.02	0.08	0.13	0.05	0.07	0.02
G185M	1890	C	120	0.30	0.14	0.02	0.11	0.12	0.04
G185M	1900	A	120	0.17	0.08	0.05	0.10	0.02	0.02
G185M	1900	B	120	0.13	0.06	0.03	0.03	0.02	0.02
G185M	1900	C	120	0.50	0.18	0.14	0.10	0.02	0.02
G185M	1913	A	120	0.46	0.05	0.13	0.09	0.04	0.02
G185M	1913	B	120	0.07	0.02	0.03	0.04	0.01	0.01
G185M	1913	C	120	0.44	0.36	0.21	0.05	0.04	0.03
G185M	1921	A	120	0.13	0.24	0.14	0.16	0.17	0.02
G185M	1921	B	120	0.10	0.08	0.09	0.11	0.04	0.01
G185M	1921	C	120	0.14	0.07	0.04	0.06	0.08	0.02
G185M	1941	A	120	0.22	0.15	0.04	0.02	0.10	0.03
G185M	1941	B	120	0.08	0.04	0.04	0.06	0.07	0.01
G185M	1941	C	120	0.03	0.19	0.20	0.14	0.12	0.02

G185M	1953	A	120	0.04	0.11	0.12	0.13	0.07	0.03
G185M	1953	B	120	0.26	0.16	0.06	0.03	0.04	0.03
G185M	1953	C	120	0.16	0.16	0.08	0.09	0.03	0.02
G185M	1971	A	120	0.06	0.05	0.08	0.04	0.05	0.04
G185M	1971	B	120	0.33	0.34	0.18	0.07	0.10	0.02
G185M	1971	C	120	0.28	0.19	0.11	0.03	0.09	0.03
G185M	1986	A	120	0.04	0.14	0.09	0.02	0.02	0.02
G185M	1986	B	120	0.14	0.04	0.04	0.03	0.03	0.03
G185M	1986	C	120	0.03	0.02	0.02	0.07	0.03	0.02
G225M	2186	A	120	0.08	0.01	0.07	0.03	0.04	0.02
G225M	2186	B	120	0.25	0.09	0.12	0.12	0.13	0.03
G225M	2186	C	120	0.02	0.11	0.14	0.06	0.05	0.01
G225M	2217	A	120	0.43	0.14	0.18	0.14	0.12	0.01
G225M	2217	B	120	0.06	0.17	0.03	0.04	0.06	0.03
G225M	2217	C	120	0.03	0.09	0.03	0.05	0.03	0.01
G225M	2233	A	120	0.11	0.02	0.07	0.04	0.01	0.01
G225M	2233	B	120	0.03	0.14	0.10	0.10	0.06	0.02
G225M	2233	C	120	0.07	0.18	0.05	0.08	0.06	0.02
G225M	2250	A	120	0.26	0.24	0.09	0.04	0.03	0.01
G225M	2250	B	120	0.03	0.09	0.08	0.06	0.02	0.02
G225M	2250	C	120	0.25	0.04	0.10	0.05	0.02	0.02
G225M	2268	A	120	0.16	0.07	0.08	0.14	0.15	0.01
G225M	2268	B	120	0.02	0.02	0.02	0.03	0.02	0.02
G225M	2268	C	120	0.20	0.10	0.06	0.09	0.07	0.05
G225M	2283	A	120	0.39	0.21	0.15	0.05	0.04	0.03
G225M	2283	B	120	0.09	0.09	0.06	0.03	0.03	0.01
G225M	2283	C	120	0.24	0.07	0.02	0.05	0.03	0.02
G225M	2306	A	120	0.20	0.24	0.27	0.21	0.15	0.06
G225M	2306	B	120	0.14	0.02	0.04	0.05	0.08	0.02
G225M	2306	C	120	0.20	0.15	0.11	0.09	0.03	0.02
G225M	2325	A	120	0.04	0.07	0.13	0.11	0.12	0.03
G225M	2325	B	120	0.51	0.27	0.21	0.20	0.16	0.02
G225M	2325	C	120	0.03	0.06	0.06	0.03	0.03	0.02
G225M	2339	A	120	0.04	0.07	0.01	0.06	0.08	0.01
G225M	2339	B	120	0.43	0.10	0.10	0.11	0.06	0.02
G225M	2339	C	120	0.04	0.03	0.10	0.04	0.01	0.01
G225M	2357	A	120	0.07	0.21	0.16	0.17	0.05	0.02
G225M	2357	B	120	0.03	0.08	0.14	0.12	0.05	0.02
G225M	2357	C	120	0.08	0.23	0.04	0.07	0.15	0.02
G225M	2373	A	120	0.04	0.05	0.09	0.06	0.03	0.02
G225M	2373	B	120	0.53	0.45	0.37	0.27	0.20	0.02
G225M	2373	C	120	0.01	0.02	0.06	0.02	0.03	0.01
G225M	2390	A	120	0.06	0.02	0.07	0.04	0.03	0.01
G225M	2390	B	120	0.05	0.11	0.07	0.06	0.05	0.02
G225M	2390	C	120	0.14	0.08	0.09	0.06	0.04	0.01
G285M	2617	A	120	0.01	0.06	0.05	0.04	0.02	0.02
G285M	2617	B	120	0.06	0.18	0.17	0.13	0.06	0.01
G285M	2617	C	120	0.13	0.07	0.08	0.03	0.08	0.01

G285M	2637	A	120	0.05	0.03	0.03	0.04	0.02	0.02
G285M	2637	B	120	0.07	0.08	0.02	0.02	0.04	0.01
G285M	2637	C	120	0.37	0.23	0.29	0.23	0.07	0.02
G285M	2657	A	120	0.14	0.02	0.06	0.04	0.10	0.02
G285M	2657	B	120	0.09	0.02	0.02	0.02	0.01	0.01
G285M	2657	C	120	0.02	0.02	0.03	0.04	0.05	0.01
G285M	2676	A	120	0.08	0.08	0.15	0.13	0.09	0.05
G285M	2676	B	120	0.20	0.19	0.06	0.06	0.09	0.02
G285M	2676	C	120	0.18	0.03	0.04	0.11	0.09	0.02
G285M	2695	A	120	0.13	0.04	0.06	0.03	0.14	0.02
G285M	2695	B	120	0.04	0.03	0.06	0.05	0.06	0.01
G285M	2695	C	120	0.10	0.10	0.14	0.09	0.07	0.02
G285M	2709	A	120	0.30	0.02	0.04	0.02	0.02	0.02
G285M	2709	B	120	0.03	0.05	0.04	0.03	0.02	0.02
G285M	2709	C	120	0.02	0.02	0.04	0.02	0.02	0.01
G285M	2719	A	120	0.14	0.02	0.05	0.03	0.08	0.02
G285M	2719	B	120	0.08	0.03	0.04	0.04	0.03	0.01
G285M	2719	C	120	0.05	0.03	0.01	0.01	0.03	0.01
G285M	2952	A	120	0.03	0.02	0.02	0.02	0.02	0.01
G285M	2952	B	120	0.03	0.04	0.03	0.04	0.05	0.02
G285M	2952	C	120	0.03	0.02	0.04	0.01	0.05	0.01
G285M	2979	A	120	0.22	0.15	0.11	0.07	0.07	0.02
G285M	2979	B	120	0.48	0.11	0.05	0.02	0.15	0.02
G285M	2979	C	120	0.34	0.04	0.10	0.10	0.03	0.03
G285M	2996	A	120	0.06	0.14	0.06	0.07	0.03	0.02
G285M	2996	B	120	0.03	0.05	0.07	0.03	0.02	0.01
G285M	2996	C	120	0.08	0.25	0.14	0.09	0.04	0.04
G285M	3018	A	120	0.13	0.17	0.18	0.07	0.02	0.02
G285M	3018	B	120	0.08	0.20	0.01	0.08	0.05	0.02
G285M	3018	C	120	0.02	0.11	0.08	0.04	0.02	0.02
G285M	3035	A	120	0.16	0.10	0.02	0.04	0.05	0.01
G285M	3035	B	120	0.06	0.05	0.07	0.03	0.02	0.01
G285M	3035	C	120	0.12	0.12	0.18	0.22	0.18	0.03
G285M	3057	A	120	0.05	0.04	0.02	0.06	0.04	0.02
G285M	3057	B	120	0.04	0.07	0.07	0.11	0.09	0.01
G285M	3057	C	120	0.35	0.31	0.40	0.42	0.41	0.07
G285M	3074	A	120	0.26	0.16	0.14	0.08	0.08	0.01
G285M	3074	B	120	0.03	0.02	0.02	0.03	0.01	0.01
G285M	3074	C	120	0.26	0.23	0.07	0.07	0.14	0.05
G230L	2635	A	60	0.11	0.12	0.21	0.17	0.11	0.10
G230L	2635	B	60	0.05	0.05	0.05	0.04	0.04	0.02
G230L	2635	C	60	0.12	0.05	0.06	0.05	0.05	0.04
G230L	2950	A	60	0.03	0.02	0.02	0.03	0.02	0.02
G230L	2950	B	60	0.06	0.06	0.02	0.03	0.03	0.02
G230L	2950	C	60	0.14	0.15	0.08	0.09	0.08	0.08
G230L	3000	A	60	0.04	0.04	0.07	0.06	0.03	0.02
G230L	3000	B	60	0.06	0.02	0.02	0.02	0.03	0.02
G230L	3000	C	60	0.07	0.15	0.14	0.11	0.08	0.06

2.1.3 FPOFFSET +1 (FPPOS 4)

Table 2-4 RMS of measured to injected offsets (FPOFFSET=+1)

Grating	λ_{cen}	Stripe	T_{Exp}	RMS Offset Between Injected Shift and Cross-Correlation Shift (pix)					
				5s	10s	15s	20s	30s	T_{Exp}
G185M	1786	A	120	0.19	0.09	0.07	0.07	0.06	0.04
G185M	1786	B	120	0.15	0.02	0.03	0.02	0.04	0.02
G185M	1786	C	120	0.38	0.15	0.07	0.02	0.02	0.02
G185M	1817	A	120	0.37	0.24	0.11	0.14	0.13	0.03
G185M	1817	B	120	0.14	0.11	0.09	0.06	0.06	0.02
G185M	1817	C	120	0.03	0.03	0.03	0.02	0.02	0.01
G185M	1835	A	120	0.10	0.03	0.03	0.09	0.08	0.02
G185M	1835	B	120	0.43	0.11	0.08	0.06	0.07	0.03
G185M	1835	C	120	0.14	0.12	0.05	0.08	0.02	0.01
G185M	1850	A	120	0.27	0.12	0.29	0.26	0.11	0.03
G185M	1850	B	120	0.05	0.13	0.16	0.13	0.05	0.02
G185M	1850	C	120	0.17	0.11	0.06	0.10	0.05	0.04
G185M	1864	A	120	0.19	0.04	0.08	0.07	0.06	0.03
G185M	1864	B	120	0.32	0.06	0.17	0.08	0.12	0.04
G185M	1864	C	120	0.05	0.11	0.04	0.03	0.03	0.02
G185M	1882	A	120	0.24	0.33	0.18	0.17	0.11	0.02
G185M	1882	B	120	0.12	0.16	0.12	0.08	0.09	0.02
G185M	1882	C	120	0.28	0.23	0.09	0.05	0.04	0.02
G185M	1890	A	120	0.10	0.09	0.06	0.02	0.06	0.02
G185M	1890	B	120	0.02	0.08	0.13	0.05	0.07	0.02
G185M	1890	C	120	0.33	0.16	0.04	0.14	0.15	0.03
G185M	1900	A	120	0.17	0.08	0.05	0.10	0.02	0.02
G185M	1900	B	120	0.13	0.06	0.03	0.03	0.02	0.02
G185M	1900	C	120	0.50	0.18	0.14	0.10	0.02	0.02
G185M	1913	A	120	0.46	0.05	0.13	0.09	0.04	0.02
G185M	1913	B	120	0.07	0.02	0.03	0.04	0.01	0.01
G185M	1913	C	120	0.44	0.36	0.21	0.05	0.04	0.03
G185M	1921	A	120	0.13	0.24	0.14	0.16	0.17	0.02
G185M	1921	B	120	0.10	0.08	0.09	0.11	0.04	0.01
G185M	1921	C	120	0.14	0.07	0.04	0.06	0.08	0.02
G185M	1941	A	120	0.22	0.15	0.04	0.02	0.10	0.03
G185M	1941	B	120	0.08	0.04	0.04	0.06	0.07	0.01
G185M	1941	C	120	0.03	0.19	0.20	0.14	0.12	0.02
G185M	1953	A	120	0.04	0.11	0.12	0.13	0.07	0.03
G185M	1953	B	120	0.28	0.18	0.04	0.03	0.05	0.03
G185M	1953	C	120	0.16	0.16	0.08	0.09	0.03	0.02
G185M	1971	A	120	0.06	0.05	0.08	0.04	0.05	0.04
G185M	1971	B	120	0.32	0.34	0.17	0.07	0.09	0.02
G185M	1971	C	120	0.28	0.19	0.11	0.03	0.09	0.03

G185M	1986	A	120	0.04	0.14	0.09	0.02	0.02	0.02
G185M	1986	B	120	0.14	0.04	0.04	0.03	0.03	0.03
G185M	1986	C	120	0.03	0.02	0.02	0.07	0.03	0.02
G185M	2010	A	120	0.39	0.17	0.14	0.07	0.08	0.01
G185M	2010	B	120	0.17	0.04	0.11	0.10	0.04	0.03
G185M	2010	C	120	0.02	0.05	0.02	0.08	0.10	0.01
G225M	2186	A	120	0.08	0.01	0.07	0.03	0.04	0.02
G225M	2186	B	120	0.25	0.09	0.12	0.12	0.13	0.03
G225M	2186	C	120	0.02	0.11	0.14	0.06	0.05	0.01
G225M	2217	A	120	0.43	0.14	0.18	0.14	0.12	0.01
G225M	2217	B	120	0.06	0.17	0.03	0.04	0.06	0.02
G225M	2217	C	120	0.03	0.09	0.03	0.05	0.03	0.01
G225M	2233	A	120	0.11	0.02	0.07	0.04	0.01	0.01
G225M	2233	B	120	0.03	0.14	0.10	0.10	0.06	0.02
G225M	2233	C	120	0.08	0.18	0.06	0.09	0.07	0.02
G225M	2250	A	120	0.26	0.24	0.09	0.04	0.03	0.01
G225M	2250	B	120	0.03	0.09	0.08	0.06	0.02	0.02
G225M	2250	C	120	0.25	0.04	0.10	0.05	0.02	0.02
G225M	2268	A	120	0.16	0.07	0.08	0.14	0.15	0.01
G225M	2268	B	120	0.02	0.02	0.02	0.03	0.02	0.02
G225M	2268	C	120	0.20	0.10	0.06	0.09	0.08	0.05
G225M	2283	A	120	0.39	0.21	0.15	0.05	0.04	0.03
G225M	2283	B	120	0.09	0.09	0.06	0.03	0.03	0.01
G225M	2283	C	120	0.24	0.07	0.02	0.05	0.03	0.02
G225M	2306	A	120	0.20	0.24	0.27	0.21	0.15	0.06
G225M	2306	B	120	0.14	0.02	0.04	0.05	0.08	0.02
G225M	2306	C	120	0.20	0.15	0.11	0.09	0.03	0.02
G225M	2325	A	120	0.04	0.07	0.13	0.11	0.12	0.03
G225M	2325	B	120	0.51	0.27	0.21	0.20	0.16	0.02
G225M	2325	C	120	0.03	0.06	0.06	0.03	0.03	0.02
G225M	2339	A	120	0.04	0.07	0.01	0.06	0.08	0.01
G225M	2339	B	120	0.43	0.10	0.10	0.11	0.06	0.02
G225M	2339	C	120	0.04	0.03	0.10	0.04	0.01	0.01
G225M	2357	A	120	0.07	0.22	0.16	0.17	0.06	0.02
G225M	2357	B	120	0.03	0.08	0.14	0.12	0.05	0.02
G225M	2357	C	120	0.08	0.23	0.04	0.07	0.15	0.02
G225M	2373	A	120	0.04	0.05	0.09	0.06	0.03	0.02
G225M	2373	B	120	0.53	0.45	0.38	0.27	0.20	0.03
G225M	2373	C	120	0.01	0.02	0.06	0.02	0.03	0.01
G225M	2390	A	120	0.06	0.02	0.07	0.04	0.03	0.01
G225M	2390	B	120	0.05	0.11	0.07	0.06	0.05	0.02
G225M	2390	C	120	0.14	0.08	0.09	0.06	0.04	0.01
G225M	2410	A	120	0.18	0.15	0.08	0.10	0.09	0.02
G225M	2410	B	120	0.03	0.02	0.11	0.02	0.05	0.02
G225M	2410	C	120	0.08	0.06	0.02	0.04	0.12	0.01
G285M	2617	A	120	0.01	0.05	0.04	0.03	0.01	0.01
G285M	2617	B	120	0.06	0.18	0.17	0.12	0.06	0.01
G285M	2617	C	120	0.13	0.07	0.08	0.03	0.08	0.01

G285M	2637	A	120	0.05	0.03	0.03	0.04	0.02	0.02
G285M	2637	B	120	0.07	0.08	0.02	0.02	0.04	0.01
G285M	2637	C	120	0.37	0.23	0.29	0.23	0.07	0.02
G285M	2657	A	120	0.14	0.02	0.06	0.04	0.10	0.02
G285M	2657	B	120	0.09	0.02	0.02	0.02	0.01	0.01
G285M	2657	C	120	0.02	0.02	0.03	0.04	0.05	0.01
G285M	2676	A	120	0.08	0.08	0.15	0.13	0.09	0.05
G285M	2676	B	120	0.20	0.19	0.06	0.06	0.09	0.02
G285M	2676	C	120	0.18	0.03	0.04	0.11	0.09	0.02
G285M	2695	A	120	0.13	0.04	0.06	0.03	0.14	0.02
G285M	2695	B	120	0.04	0.04	0.07	0.06	0.07	0.02
G285M	2695	C	120	0.10	0.10	0.14	0.09	0.07	0.02
G285M	2709	A	120	0.30	0.02	0.04	0.02	0.02	0.02
G285M	2709	B	120	0.03	0.05	0.04	0.03	0.02	0.02
G285M	2709	C	120	0.02	0.02	0.04	0.02	0.02	0.01
G285M	2719	A	120	0.14	0.02	0.05	0.03	0.08	0.02
G285M	2719	B	120	0.08	0.03	0.04	0.04	0.03	0.01
G285M	2719	C	120	0.05	0.03	0.01	0.01	0.03	0.01
G285M	2739	A	120	0.04	0.08	0.09	0.10	0.09	0.02
G285M	2739	B	120	0.01	0.04	0.02	0.02	0.01	0.01
G285M	2739	C	120	0.21	0.18	0.15	0.17	0.08	0.05
G285M	2850	A	120	0.07	0.07	0.04	0.03	0.03	0.01
G285M	2850	B	120	0.41	0.48	0.38	0.32	0.06	0.06
G285M	2850	C	120	0.04	0.04	0.02	0.05	0.03	0.01
G285M	2952	A	120	0.04	0.02	0.01	0.01	0.02	0.01
G285M	2952	B	120	0.03	0.04	0.03	0.04	0.05	0.02
G285M	2952	C	120	0.03	0.02	0.04	0.01	0.05	0.01
G285M	2979	A	120	0.22	0.15	0.11	0.07	0.07	0.02
G285M	2979	B	120	0.48	0.11	0.05	0.02	0.15	0.02
G285M	2979	C	120	0.33	0.04	0.10	0.10	0.03	0.03
G285M	2996	A	120	0.06	0.14	0.06	0.07	0.03	0.02
G285M	2996	B	120	0.03	0.05	0.07	0.03	0.02	0.01
G285M	2996	C	120	0.09	0.24	0.13	0.10	0.04	0.04
G285M	3018	A	120	0.13	0.17	0.18	0.07	0.02	0.02
G285M	3018	B	120	0.08	0.20	0.01	0.08	0.05	0.02
G285M	3018	C	120	0.03	0.10	0.07	0.05	0.02	0.02
G285M	3035	A	120	0.16	0.10	0.02	0.04	0.05	0.01
G285M	3035	B	120	0.06	0.05	0.07	0.03	0.02	0.01
G285M	3035	C	120	0.12	0.12	0.18	0.22	0.18	0.03
G285M	3057	A	120	0.05	0.04	0.02	0.06	0.04	0.02
G285M	3057	B	120	0.04	0.07	0.07	0.11	0.09	0.01
G285M	3057	C	120	0.36	0.31	0.40	0.41	0.40	0.07
G285M	3074	A	120	0.26	0.16	0.13	0.08	0.08	0.01
G285M	3074	B	120	0.03	0.02	0.02	0.04	0.01	0.01
G285M	3074	C	120	0.26	0.23	0.07	0.07	0.14	0.05
G285M	3094	A	120	0.01	0.20	0.21	0.09	0.05	0.04
G285M	3094	B	120	0.35	0.19	0.11	0.03	0.08	0.02
G285M	3094	C	120	0.25	0.05	0.12	0.10	0.05	0.03

G230L	2635	A	60	0.11	0.12	0.20	0.17	0.11	0.10
G230L	2635	B	60	0.04	0.04	0.04	0.04	0.03	0.02
G230L	2635	C	60	0.12	0.05	0.06	0.05	0.05	0.04
G230L	2950	A	60	0.03	0.02	0.02	0.03	0.02	0.02
G230L	2950	B	60	0.03	0.03	0.02	0.02	0.02	0.03
G230L	2950	C	60	0.14	0.15	0.08	0.09	0.08	0.08
G230L	3000	A	60	0.04	0.04	0.07	0.06	0.03	0.02
G230L	3000	B	60	0.06	0.02	0.02	0.02	0.03	0.02
G230L	3000	C	60	0.07	0.15	0.14	0.11	0.08	0.06
G230L	3360	A	60	0.04	0.05	0.05	0.04	0.03	0.02
G230L	3360	B	60	0.28	0.19	0.12	0.05	0.04	0.03
G230L	3360	C	60	0.16	0.11	0.06	0.07	0.06	0.06

2.1.4 Minimum Exposure Times

The minimum exposure time for a specific central wavelength is determined from the weakest stripe for FPPOS=1, 3 and 4 data sets. In this revision, we added the requirement that at least 3 well identified spectral lines be present in each stripe (≥ 25 integrated counts above background per line). Some of the minimum exposure times had to be revised up from the previous revision. These are indicated in red in the table below. We use the same requirement as described in the document COS TIR 2006-01: the exposure duration must result in an acceptably small offset (3% of a resolution element, <0.09 pixels for the NUV settings). Since this requirement is very conservative and in some cases can't be met when using the full template exposure time, the minimum exposure time with an RMS offset of 10% of a resolution element is also listed in table 2-5. The previously recommended exposure times, when combining the stripes together, are also listed as reference.

Note that if the NUV detector turns out to have a considerable higher background noise ounce in orbit, these minimum exposures will have to be adjusted accordingly.

Table 2-5 Registration Wavecal Exposure Durations

Grating	λ_{cen}	Minimum Exposure Time			Faintest Stripe (counts / N4 / PK)
		Previous	≤0.09 pix	≤0.30 pix	
G185M	1786	10	15	10	A (195 / 4 / 009)
G185M	1817	5	15	10	A (254 / 3 / 015)
G185M	1835	10	15	10	A (337 / 5 / 012)
G185M	1850	20	30	10	A (328 / 3 / 011)
G185M	1864	30	20	10	C (425 / 5 / 019)
G185M	1882	15	30	15	C (603 / 8 / 029)
G185M	1890	10	>30	10	C (445 / 8 / 010)
G185M	1900	20	30	10	C (368 / 5 / 010)
G185M	1913	10	20	15	A (647 / 4 / 029)
G185M	1921	10	>30	10	A (411 / 5 / 020)
G185M	1941	10	>30	10	A (527 / 7 / 014)
G185M	1953	15	30	10	A (519 / 4 / 033)
G185M	1971	15	20	15	B (681 / 7 / 034)
G185M	1986	10	15	5	B (224 / 3 / 012)
G185M	2010	10	30	10	B (302 / 4 / 013)
G225M	2186	5	20	5	A (420 / 4 / 015)
G225M	2217	10	>30	10	B (348 / 5 / 011)
G225M	2233	5	15	10	C (393 / 3 / 020)
G225M	2250	10	20	5	C (333 / 3 / 031)
G225M	2268	10	15	5	C (368 / 4 / 026)
G225M	2283	5	20	10	C (701 / 7 / 046)
G225M	2306	10	30	10	A (479 / 4 / 036)

G225M	2325	10	>30	10	C (679 / 6 / 022)
G225M	2339	5	20	10	B (401 / 6 / 024)
G225M	2357	10	>30	10	B (737 / 5 / 061)
G225M	2373	5	>30	20	C (2641 / 6 / 301)
G225M	2390	5	15	5	B (432 / 5 / 023)
G225M	2410	5	15	5	B (260 / 3 / 008)
G285M	2617	5	30	10	B (1384 / 5 / 210)
G285M	2637	5	30	10	A (739 / 4 / 043)
G285M	2657	5	10	10	A (430 / 3 / 042)
G285M	2676	10	30	15	A (273 / 3 / 026)
G285M	2695	5	20	10	A (210 / 3 / 016)
G285M	2709	5	10	10	A (339 / 4 / 017)
G285M	2719	5	10	10	A (183 / 5 / 017)
G285M	2739	5	30	20	C (1187 / 3 / 010)
G285M	2850	5	30	20	C (1627 / 7 / 094)
G285M	2952	5	5	5	B (366 / 3 / 030)
G285M	2979	15	20	10	C (274 / 4 / 012)
G285M	2996	5	20	15	C (294 / 3 / 012)
G285M	3018	10	20	20	C (444 / 3 / 032)
G285M	3035	5	10	10	C (220 / 3 / 019)
G285M	3057	5	>30	30	C (307 / 3 / 015)
G285M	3074	5	20	30	C (605 / 4 / 046)
G285M	3094	10	30	10	B (269 / 3 / 010)
G230L	2635	5	10	15 *	A (675 / 3 / 014)
G230L	2950	5	15	10	C (653 / 4 / 008)
G230L	3000	5	30	5	C (288 / 3 / 010)
G230L	3360	5	20	10	C (463 / 4 / 009)

* The G30L-2635 case is unique in that stripe A only has signal on less than half of the detector length. There is lots of structure in this region of the spectra and the cross-correlation results indicate a minimum exposure time of 5 seconds. We adopted a minimum exposure time of 15 seconds here corresponding to the new requirement of having 3 well defined spectral lines in the FPPOS=3 dataset.

2.2 FUV DATA

The files used for the analysis are provided in table 2-6 with the total number of counts found in each segment for the full exposure length with a observed background counts. Also listed are the number of spectral lines with more than 50 counts at line center (N50) and the counts at line center of the brightest line for each segment (PK). Note that the segment B is disabled for observations with the G140L.

Table 2-6 Total Counts for each Segment

Filename	Grating	λ_{cen}	T_{exp} (sec.)	FUVA		FUVB	
				Counts (Bkg)	N50 / PK	Counts (Bkg)	N50 / PK
CSIL03286093403	G130M	1291	120	29397 (93)	17 /368	15149 (55)	11 / 423
CSIL03286095158	G130M	1300	120	28649 (101)	18 / 446	16583 (59)	11 / 390
CSIL03286021646	G130M	1309	120	27832 (92)	18 / 394	18720 (64)	12 / 436
CSIL03286100953	G130M	1318	120	29088 (92)	17 / 532	21689 (60)	14 / 402
CSIL03286102748	G130M	1327	120	28846 (99)	16 / 455	24544 (65)	14 / 379
CSIL03286080403	G160M	1577	60	14671 (36)	12 / 158	39903 (101)	23 / 1058
CSIL03286082058	G160M	1589	60	13987 (42)	11 / 175	41810 (95)	22 / 872
CSIL03286034546	G160M	1600	60	13752 (34)	9 / 122	41394 (88)	23 / 1058
CSIL03286083753	G160M	1611	60	17266 (36)	12 / 215	40941 (96)	22 / 798
CSIL03286085448	G160M	1623	60	17063 (38)	7 / 96	41002 (101)	19 / 837
CSIL03286120659	G140L	1105	90	86969 (144)	44 / 703	N/A	N/A
CSIL03286060833	G140L	1230	90	62822 (88)	23 / 486	N/A	N/A

2.2.1 FPOFFSET 0 (FPPOS 3)

Table 2-7 RMS of measured to injected offsets (FPOFFSET=0)

Grating	λ_{cen}	Stripe	T_{Exp}	RMS Offset Between Injected Shift and Cross-Correlation Shift (pix)					
				5s	10s	15s	20s	30s	T_{Exp}
G130M	1291	FUVA	120	0.11	0.11	0.15	0.08	0.08	0.03
G130M	1291	FUVB	120	0.17	0.22	0.20	0.10	0.12	0.02
G130M	1300	FUVA	120	0.06	0.05	0.10	0.12	0.13	0.03
G130M	1300	FUVB	120	0.27	0.04	0.03	0.06	0.05	0.03
G130M	1309	FUVA	120	0.03	0.07	0.11	0.14	0.10	0.02
G130M	1309	FUVB	120	0.09	0.07	0.03	0.04	0.06	0.03
G130M	1318	FUVA	120	0.05	0.07	0.03	0.07	0.05	0.02
G130M	1318	FUVB	120	0.04	0.03	0.04	0.06	0.06	0.03
G130M	1327	FUVA	120	0.06	0.04	0.10	0.06	0.06	0.03
G130M	1327	FUVB	120	0.20	0.09	0.10	0.12	0.07	0.03
G160M	1577	FUVA	60	0.07	0.05	0.07	0.06	0.04	0.04
G160M	1577	FUVB	60	0.14	0.02	0.04	0.05	0.06	0.01
G160M	1589	FUVA	60	0.15	0.04	0.04	0.04	0.04	0.04
G160M	1589	FUVB	60	0.08	0.09	0.08	0.05	0.02	0.02
G160M	1600	FUVA	60	0.05	0.06	0.05	0.06	0.06	0.06
G160M	1600	FUVB	60	0.27	0.14	0.12	0.09	0.05	0.01
G160M	1611	FUVA	60	0.08	0.10	0.12	0.06	0.09	0.04
G160M	1611	FUVB	60	0.04	0.04	0.02	0.02	0.02	0.02
G160M	1623	FUVA	60	0.04	0.06	0.08	0.07	0.07	0.06
G160M	1623	FUVB	60	0.14	0.09	0.10	0.07	0.06	0.02
G140L	1105	FUVA	90	0.08	0.09	0.05	0.04	0.05	0.03
G140L	1230	FUVA	90	0.08	0.05	0.05	0.04	0.04	0.04

2.2.2 FPOFFSET -2 (FPPOS 1)

We also tested the algorithms and exposure times for the two extreme FPOFFSETS, -2 and +1. Thermal-vac data is not available for all of the central wavelength positions and FPOFFSET. Multiple datasets were combined together to simulate the data from the various FPOFFSET positions. The tables below represent the same analysis as above for the FPOFFSET=-2 and +1 positions.

Table 2-7 RMS of measured to injected offsets (FPOFFSET=-2)

Grating	λ_{cen}	Stripe	T_{Exp}	RMS Offset Between Injected Shift and Cross-Correlation Shift (pix)					
				5s	10s	15s	20s	30s	T_{exp}
G130M	1291	FUVA	120	0.11	0.11	0.15	0.08	0.08	0.02
G130M	1291	FUVB	120	0.17	0.22	0.20	0.10	0.12	0.02
G130M	1300	FUVA	120	0.06	0.05	0.10	0.12	0.13	0.02
G130M	1300	FUVB	120	0.27	0.04	0.02	0.06	0.05	0.02
G130M	1309	FUVA	120	0.14	0.07	0.09	0.11	0.12	0.01
G130M	1309	FUVB	120	0.02	0.13	0.15	0.08	0.01	0.00
G130M	1318	FUVA	120	0.04	0.07	0.03	0.06	0.05	0.02
G160M	1577	FUVA	60	0.06	0.07	0.09	0.07	0.04	0.04
G160M	1577	FUVB	60	0.14	0.02	0.04	0.05	0.06	0.01
G160M	1589	FUVA	60	0.15	0.04	0.04	0.04	0.04	0.04
G160M	1589	FUVB	60	0.08	0.09	0.08	0.05	0.01	0.01
G160M	1600	FUVA	60	0.22	0.11	0.12	0.07	0.07	0.00
G160M	1600	FUVB	60	0.10	0.10	0.07	0.06	0.04	0.00
G160M	1600	FUVA	60	0.05	0.05	0.05	0.05	0.05	0.05
G160M	1611	FUVA	60	0.08	0.10	0.12	0.06	0.09	0.04
G140L	1105	FUVA	90	0.08	0.09	0.05	0.04	0.04	0.02
G140L	1230	FUVA	90	0.24	0.05	0.04	0.09	0.08	0.00

2.2.3 FPOFFSET +1 (FPPOS 4)

Table 2-8 RMS of measured to injected offsets (FPOFFSET=+1)

Grating	λ_{cen}	Stripe	T_{Exp}	RMS Offset Between Injected Shift and Cross-Correlation Shift (pix)					
				5s	10s	15s	20s	30s	T_{exp}
G130M	1300	FUVA	120	0.06	0.05	0.10	0.12	0.13	0.02
G130M	1300	FUVB	120	0.27	0.04	0.02	0.06	0.05	0.02
G130M	1309	FUVA	120	0.08	0.02	0.09	0.13	0.12	0.01
G130M	1309	FUVB	120	0.26	0.24	0.02	0.03	0.18	0.00
G130M	1318	FUVA	120	0.04	0.07	0.03	0.06	0.05	0.02
G130M	1318	FUVB	120	0.04	0.03	0.04	0.06	0.06	0.02
G130M	1327	FUVA	120	0.05	0.04	0.11	0.07	0.06	0.03
G160M	1327	FUVB	120	0.20	0.09	0.10	0.12	0.06	0.02
G160M	1589	FUVA	60	0.15	0.04	0.04	0.04	0.04	0.04
G160M	1589	FUVB	60	0.08	0.09	0.08	0.05	0.01	0.01
G160M	1600	FUVA	60	0.20	0.08	0.01	0.02	0.01	0.00
G160M	1600	FUVB	60	0.03	0.01	0.01	0.02	0.03	0.01
G160M	1611	FUVA	60	0.08	0.10	0.12	0.06	0.09	0.04
G160M	1611	FUVB	60	0.04	0.04	0.02	0.02	0.02	0.02
G160M	1623	FUVA	60	0.03	0.06	0.08	0.07	0.06	0.05
G140L	1623	FUVB	60	0.14	0.09	0.10	0.07	0.06	0.02
G140L	1230	FUVA	90	0.02	0.01	0.09	0.06	0.04	0.01

2.2.4 FUV Minimum Exposure Times

The minimum exposure time for a specific central wavelength is determined from the weakest segment for FPPOS=1, 3 and 4 data sets. In this revision, we added the requirement that at least 6 well identified spectral lines be present in each stripe (≥ 25 integrated counts above background per line). One of the minimum exposure time had to be revised up from the previous revision. This entry is indicated in red in the table below. We use the same requirement as described in the document COS TIR 2006-01: the exposure duration must result in an acceptably small offset (3% of a resolution element, <0.18 pixels for the FUV settings). The previously recommended exposure times are also listed as reference. The column to the left represents the minimum exposure time if the requirement is relaxed to 10% of a resolution element. Unlike the NUV detector, the FUV covers a much larger spectral range with many more line so the looser requirement doesn't affect the required minimum exposure times for most of central wavelengths. For the 3 central wavelengths where the looser requirement makes a difference, the difference in exposure times is small enough that the original requirement is kept.

Table 2-9 Registration Wavecal Exposure Durations

Grating	λ_{cen}	Minimum Exposure Time			Faintest Segment (counts / N4 /PK)
		Previous	≤0.18 pix	≤0.60 pix	
G130M	1291	5	5	5	B (0621 / 07 / 16)
G130M	1300	10	10	10	B (1345 / 14 / 23)
G130M	1309	5	5	5	B (0779 / 08 / 24)
G130M	1318	5	5	5	B (0848 / 07 / 20)
G130M	1327	5	10	5	B (0998 / 09 / 19)
G160M	1577	5	5	5	A (1222 / 12 / 16)
G160M	1589	5	5	5	A (1209 / 15 / 15)
G160M	1600	10	10	5	A (1116 / 15 / 11)
G160M	1611	5	5	5	A (1430 / 19 / 24)
G160M	1623	5	5	5	A (1377 / 16 / 29)
G140L	1105	5	5	5	A (4876 / 44 / 45)
G140L	1230	5	5	5	A (4108 / 19 / 23)

2.3 CONCLUSION

The tables 2-5 and 2-9 give a good overview of the results. We added the rquirements that there is at least 3 well defined spectral lines in each NUV stripe and at least 6 lines in each FUV segment. If we keep the same criteria of 3% of a resolution element accuracy (0.09 NUV pixel) for the cross-correlation and we consider each stripe separately, there are some cases for the NUV detector, where the minimum integration time required is longer than 30 seconds and in a few cases, the requirement is not met after 120 seconds. The FUV detector meets the 3% requirement with the same minimum exposure times as previously determined except for the G130M at 1327 Å, where the residual RMS is slightly higher, thus requiring a longer exposure time.

By changing the somewhat arbitrary requirement from 3% to 10% of a resolution element (0.30 NUV pixel), we have shown that we can handle each NUV stripe separately with the appropriate exposure time for each grating and central wavelength.

In the testing process, we have discovered that the cross-correlation algorithm in CALCOS has difficulties in determining a good offset in some cases where the data is from a different FPPOS than the template and when a bright spectral line moves in (or out). A python version of the IDL cross-correlate routine was implemented and showed that it too fails in some, although different, cases. A more robust algorithm needs to be identified.

Note that these minimum exposures were determined with the background noise seen during thermal-vac tests. If the background levels increase considerably in orbit, the minimum exposure times will have to be adjusted accordingly.