NUV GRATINGS RELATIVE EFFICIENCIES MONITORING REPORT

Date:	May 11, 2006
Document Number:	COS-11-0045
Revision:	Rev-A
Contract No.:	NAS5-98043
CDRL No.:	

Prepared By: ______________________________ ____________

Dr. Steven Penton, COS Software Scientist, CU   Date

Reviewed By: ______________________________ ____________

Mr. Stephane Beland, COS Software Engineer, CU   Date

Reviewed By: ______________________________ ____________

Dr. Steven Osterman, COS Instrument Scientist, CU   Date

Approved By: ______________________________ ____________

Dr. James Green, COS Principal Investigator, CU   Date

Center for Astrophysics & Space Astronomy
University of Colorado
Campus Box 593
Boulder, Colorado 80309

REVISIONS

Letter	ECO No.	Description	Check	Approved	Date
-		Initial Release			
A	COS-88?	Updated to include results from the 08/30/2005 and 1/30/2006 functional test at GSFC.			

Original Release Name	Date
Drawn: S. Beland	8/22/05
Reviewed:	
Approved:	

THE UNIVERSITY OF COLORADO
At Boulder
The Center for Astrophysics and Space Astronomy

NUV Grating Relative Efficiencies Monitoring Report

Size	Code Indent No.	Document No.	Rev
A		COS-11-0045	A
Scale: N/A			

Table of Contents

Table of Tables

Table of Figures

1. INTRODUCTION

This document reports on the NUV gratings' relative efficiencies as described in the related document "Procedure for Monitoring Relative Efficiencies of the NUV Gratings During Extended Storage," COS-05-0004. We are reporting the results from the baseline measurements taken in September and October 2003, as well as measurements taken on April 5, April 22, and December 3, 2004; August 30, 2005; and January 6, 2006. The main concern of this monitoring program is to ensure that there is no loss of reflectivity from the gratings coated with bare aluminum (G225M, G285M) compared to the gratings with an added MgF_2 coating (G185M, G230L).

In general, a new NUV monitoring campaign will be undertaken every six months until launch. The two tests in April 2004 were pre-ship (at Ball in Boulder, Colorado) and post-ship to the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The 2003 datasets were taken in vacuum, while all other datasets were obtained in a nitrogen purge environment.

In the Appendix we recommend updated exposure times for future monitoring campaigns. The reduced exposure times are inspired by concerns over the lifetime of COS's internal Pt-Ne lamps. We find that a 40% reduction in exposure time will have a negligible effect on the results of future NUV grating efficiency monitoring campaigns.

2. MONITORING TEST PLAN

2.1 UPDATED BASELINE

The document COS-05-0004 describes the test plan, the data acquisition method, and the results from a series of images that defined the baseline measurements of the relative efficiencies. Unfortunately, differences were inadvertently introduced between the baseline dataset and the other datasets. In 2003, the Pt-Ne lamp #1 was used, while the Pt-Ne lamp #2 was used for all the data taken in 2004-2006. Additionally, the lookup table used to determine the OSM2 mechanism step position for a specific central wavelength and grating was updated after the 2003 data was taken, and is different for each electronics side. These new step positions are a result of the tests performed during the September/October 2003 thermal-vacuum (TV) testing and represent a better centering of the requested wavelength. One side effect of these new step positions is a slight shift in the spectral regions covered in 2004–2006 compared to the baseline data.

2.2 NEW WAVELENGTH REGIONS

Although nothing can be done about the different lamps used, we have redefined the various spectral regions in COS-05-0004 to allow for consistent wavelength coverage for all datasets. We have recalculated a new relative efficiency baseline from the data taken in 2003. In addition, we now cross-correlate all observations against a common wavelength template to obtain accurate and consistent spectral extractions.

Table 2-1 shows the grating, spectral stripe, central wavelength (λ_C), and the new spectral bandpasses used to monitor the relative NUV efficiencies. These regions are also displayed in Figure 1, using the baseline dataset.

Table 2-1: Spectral Information for Monitoring Relative Efficiencies

Grating	Stripe	λ_C (Å)	Test Bandpass (Å)
G185M	C	1986	2093 – 2105
G185M	C	2010	2126 – 2130
G225M	A	2186	2093 – 2105
G225M	A	2217	2126 – 2130
G225M	C	2390	2485 – 2500
G225M	C	2410	2503 – 2519
G285M	A	2617	2485 – 2500
G285M	A	2637	2503 – 2519
G230L	B	2635	2478 – 2533
G230L	A	3360	2120 – 2140

Figure 1 illustrates the different spectral regions used for the efficiency analysis. The caption of each figure indicates the grating and bandpass.

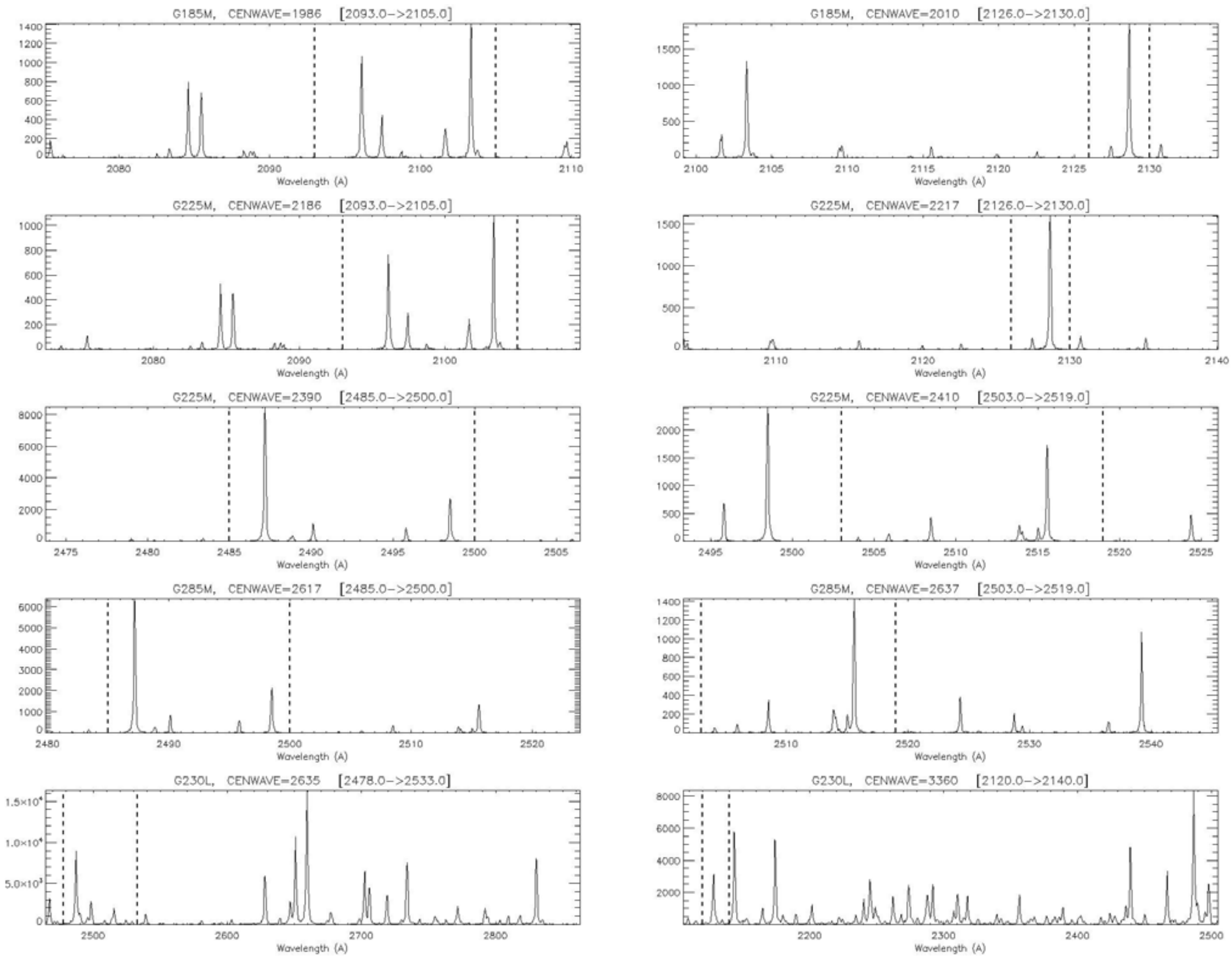

Figure 1: Spectral regions monitored during the NUV efficiency analysis. The displayed spectra are that of the baseline observation.

2.3 DATAFILES, COUNT RATES AND EXTRACTION REGIONS

Table 2-2 through Table 2-7 identify the COS calibration files used for the data analysis, grouped by the date the data was taken. The tables also indicate the spectral stripe, grating, central wavelength (λ_C), exposure time (T), counts ($\mathbf{C}_\lambda$), count rates ($\mathbf{R}_\lambda$), and the detector coordinates of the extraction boxes. The coordinate pairs, (X_L,Y_L) and (X_U,Y_U), define the extraction boxes used for each spectral region. The edges of the extraction boxes were considered to be part of the extraction region.

The extraction boxes, counts and count rates were determined with the following algorithm:

1) Locate the cross-dispersion centroid of spectral stripe.
2) Extract the spectral stripe using a pre-determined width (which varies by grating/stripe) into a one-dimensional spectra (defining X_L and X_U).
3) Cross-correlate the extracted spectra against a reference spectra to determine the wavelengths of the extracted spectra.
4) Determine the dispersion-direction coordinates of the desired spectral region (Table 2-1, defining Y_L and Y_U).
5) Determine the counts ($\mathbf{C}_\lambda$) in the desired extraction region.
6) Divide by the exposure time to determine the count rate ($\mathbf{R}_\lambda$).

Figure 2, located after Table 2-7, displays the observed counts, as a function of time, for all the NUV monitoring spectral regions, as defined in Table 2-1. The 2003 dataset contains thermal-vacuum test exposures and are in-vacuum observations. All other datasets were taken in a nitrogen purge environment.

It should be pointed out that the quality of the nitrogen purge cannot be precisely monitored and controlled, particularly campaign to campaign. Therefore, some variation in count rates should be expected that are the result of the environment, and not due to losses relating to the gratings. Additionally, it is known that the internal Pt-Ne calibration lamps fade with usage. It is suspected that this fading is wavelength dependent on both large (shorter wavelengths fading faster) and small scales (individual Pt lines will fade, Ne lines may fade or brighten).

Table 2-2: NUV Data From 09/2003 and 10/2003

Filename	Stripe	Grating	λ_C (Å)	T (sec)	$\mathbf{C}_\lambda$	$\mathbf{R}_\lambda$	X_L	Y_L	X_U	Y_U
Trial A										
CSIL03266023423	C	G185M	1986	120	8,749	72.9	228	63	262	408
CSIL03266044935	C	G185M	2010	120	5,176	43.1	227	38	261	153
CSIL03266103736	A	G225M	2217	120	4,430	36.9	471	185	505	296
CSIL03266120206	C	G225M	2390	120	33,761	281.3	215	87	249	555
CSIL03266121900	A	G225M	2186	120	6,240	52.0	473	15	507	348
CSIL03266132636	C	G225M	2410	120	7,550	62.9	213	110	247	609
CSIL03266194612	A	G285M	2637	120	5,232	43.6	438	520	472	875
CSIL03266212736	A	G285M	2617	120	23,072	192.3	437	456	471	802
CSIL03267064458	B	G230L	2635	60	19,444	324.1	367	759	401	899
CSIL03267084734	A	G230L	3360	60	4,850	80.8	466	867	500	918
Trial B										
CSIL03291125625	C	G185M	1986	360	26,326	73.1	227	90	261	435
CSIL03291130525	C	G185M	2010	360	15,038	41.8	227	63	261	177
CSIL03291131453	A	G225M	2186	360	18,017	50.0	472	41	506	374
CSIL03291132354	A	G225M	2217	360	12,508	34.7	470	208	504	318
CSIL03291133254	C	G225M	2410	360	21,250	59.0	212	137	246	637
CSIL03291134154	A	G285M	2637	360	15,145	42.1	439	533	473	888

Table 2-3: NUV Data From 04/05/2004

Filename	Stripe	Grating	λ_C (Å)	T (sec)	C_λ	R_λ	X_L	Y_L	X_U	Y_U
Trial A										
CSIL04096200831	C	G185M	1986	300	17,586	58.6	267	166	301	511
CSIL04096201702	C	G185M	2010	300	9,937	33.1	267	133	301	248
CSIL04096202603	A	G225M	2186	300	11,394	38.0	512	123	546	456
CSIL04096203432	A	G225M	2217	300	8,267	27.6	509	289	543	400
CSIL04096204302	C	G225M	2390	300	70,411	234.7	253	202	287	671
CSIL04096205132	C	G225M	2410	300	15,484	51.6	251	220	285	720
CSIL04096210001	A	G285M	2617	300	46,328	154.4	475	557	509	903
CSIL04096210833	A	G285M	2637	300	10,888	36.3	476	618	510	989
CSIL04096211802	B	G230L	2635	300	78,699	262.3	405	855	439	995
CSIL04096212631	A	G230L	3360	300	18,468	61.6	503	947	537	997
Trial B										
CSIL04096213630	C	G185M	1986	300	17,268	57.6	266	165	300	510
CSIL04096214502	C	G185M	2010	300	9,977	33.3	266	132	300	247
CSIL04096215402	A	G225M	2186	300	11,323	37.7	511	121	545	455
CSIL04096220231	A	G225M	2217	300	7,988	26.6	509	286	543	397
CSIL04096221101	C	G225M	2390	300	70,134	233.8	253	200	287	669
CSIL04096221931	C	G225M	2410	300	14,996	50.0	251	216	285	716
CSIL04096222802	A	G285M	2617	300	46,616	155.4	475	556	509	902
CSIL04096223631	A	G285M	2637	300	10,867	36.2	476	616	510	988
CSIL04096224602	B	G230L	2635	300	78,896	263.0	405	853	439	993
CSIL04096225430	A	G230L	3360	300	18,351	61.2	503	945	537	996

Table 2-4: NUV Data From 04/22/2004

Filename	Stripe	Grating	λ_C (Å)	T (sec)	$\mathbf{C}_\lambda$	$\mathbf{R}_\lambda$	X_L	Y_L	X_U	Y_U
Trial A										
CSIL04113133501	C	G185M	1986	300	17,819	59.4	216	194	250	539
CSIL04113134331	C	G185M	2010	300	10,284	34.3	216	163	250	277
CSIL04113135230	A	G225M	2186	300	12,242	40.8	462	147	496	480
CSIL04113140100	A	G225M	2217	300	8,796	29.3	460	310	494	422
CSIL04113140931	C	G225M	2390	300	66,515	221.7	203	231	237	699
CSIL04113141801	C	G225M	2410	300	14,964	49.9	201	248	235	748
CSIL04113142631	A	G285M	2617	300	49,610	165.4	427	580	461	926
CSIL04113143500	A	G285M	2637	300	11,738	39.1	427	641	461	1012
CSIL04113144430	B	G230L	2635	300	83,883	279.6	358	869	392	1009
CSIL04113145231	A	G230L	3360	300	19,085	63.6	455	960	489	1010
Trial B										
CSIL04113150230	C	G185M	1986	300	17,597	58.7	216	188	250	533
CSIL04113151101	C	G185M	2010	300	10,391	34.6	216	155	250	270
CSIL04113152001	A	G225M	2186	300	11,819	39.4	463	142	497	475
CSIL04113152830	A	G225M	2217	300	8,587	28.6	461	306	495	417
CSIL04113153700	C	G225M	2390	300	66,611	222.0	204	225	238	693
CSIL04113154531	C	G225M	2410	300	14,954	49.8	202	242	236	742
CSIL04113155400	A	G285M	2617	300	49,120	163.7	428	576	462	922
CSIL04113160230	A	G285M	2637	300	11,624	38.7	429	637	463	1008
CSIL04113161201	B	G230L	2635	300	83,882	279.6	358	864	392	1004
CSIL04113162030	A	G230L	3360	300	19,215	64.1	456	957	490	1007

Table 2-5: NUV Data From 12/03/2004

Filename	Stripe	Grating	λ_C (Å)	T (sec)	$\mathbf{C}_\lambda$	$\mathbf{R}_\lambda$	X_L	Y_L	X_U	Y_U
Trial A										
CSIL04337140001	C	G185M	1986	300	18,319	61.1	223	162	257	507
CSIL04337140832	C	G185M	2010	300	10,596	35.3	222	131	256	245
CSIL04337141731	A	G225M	2186	300	11,843	39.5	469	120	503	453
CSIL04337142600	A	G225M	2217	300	8,609	28.7	466	283	500	394
CSIL04337143430	C	G225M	2390	300	69,271	230.9	209	202	243	671
CSIL04337144300	C	G225M	2410	300	15,522	51.7	207	220	241	720
CSIL04337145131	A	G285M	2617	300	47,959	159.9	433	556	467	902
CSIL04337150000	A	G285M	2637	300	11,360	37.9	434	617	468	989
CSIL04337150930	B	G230L	2635	300	83,935	279.8	363	848	397	988
CSIL04337151800	A	G230L	3360	300	19,315	64.4	460	935	494	985
Trial B										
CSIL04337152801	C	G185M	1986	300	17,748	59.2	222	162	256	507
CSIL04337153630	C	G185M	2010	300	10,609	35.4	222	130	256	245
CSIL04337154531	A	G225M	2186	300	11,839	39.5	468	120	502	453
CSIL04337155400	A	G225M	2217	300	8,463	28.2	466	283	500	394
CSIL04337160230	C	G225M	2390	300	69,177	230.6	209	200	243	669
CSIL04337161101	C	G225M	2410	300	15,397	51.3	208	216	242	716
CSIL04337161929	A	G285M	2617	300	48,092	160.3	433	555	467	901
CSIL04337162801	A	G285M	2637	300	11,267	37.6	434	615	468	987
CSIL04337163730	B	G230L	2635	300	83,144	277.1	363	846	397	986
CSIL04337164601	A	G230L	3360	300	19,412	64.7	461	933	495	984

Table 2-6: NUV Data From 08/30/2005

Filename	Stripe	Grating	λ_C (Å)	T (sec)	$\mathbf{C}_\lambda$	$\mathbf{R}_\lambda$	X_L	Y_L	X_U	Y_U
Trial A										
CSIL05243123756	C	G185M	1986	300	18,488	61.7	220	184	254	529
CSIL05243124556	C	G185M	2010	300	10,872	36.2	220	152	254	267
CSIL05243125424	A	G225M	2186	300	12,167	40.6	466	138	500	471
CSIL05243130225	A	G225M	2217	300	8,642	28.8	464	302	498	413
CSIL05243131028	C	G225M	2390	300	67,292	224.3	207	218	241	687
CSIL05243131825	C	G225M	2410	300	14,847	49.5	205	236	239	736
CSIL05243132624	A	G285M	2617	300	46,269	154.2	430	569	464	916
CSIL05243133425	A	G285M	2637	300	10,676	35.6	431	630	465	1001
CSIL05243134328	B	G230L	2635	300	84,291	281.0	361	860	395	1000
CSIL05243135126	A	G230L	3360	300	19,026	63.4	458	950	492	1000
Trial B										
CSIL05243140126	C	G185M	1986	300	18,055	60.2	220	180	254	525
CSIL05243140930	C	G185M	2010	300	10,608	35.4	220	147	254	261
CSIL05243141830	A	G225M	2186	300	11,952	39.8	466	132	500	465
CSIL05243142700	A	G225M	2217	300	8,638	28.8	464	297	498	409
CSIL05243143530	C	G225M	2390	300	67,100	223.7	207	213	241	681
CSIL05243144400	C	G225M	2410	300	15,097	50.3	206	228	240	729
CSIL05243145229	A	G285M	2617	300	45,919	153.1	431	564	465	910
CSIL05243150100	A	G285M	2637	300	10,842	36.1	432	625	466	997
CSIL05243151031	B	G230L	2635	300	83,874	279.6	362	854	396	994
CSIL05243151900	A	G230L	3360	300	19,600	65.3	459	946	493	997

Table 2-7: NUV Data From 01/30/2006

Filename	Stripe	Grating	λ_C (Å)	T (sec)	$\mathbf{C}_\lambda$	$\mathbf{R}_\lambda$	X_L	Y_L	X_U	Y_U
Trial A										
CSIL06030132453	C	G185M	1986	300	17,952	59.8	216	220	250	565
CSIL06030133253	C	G185M	2010	300	10,586	35.3	216	187	250	301
CSIL06030134122	A	G225M	2186	300	11,913	39.7	462	165	496	498
CSIL06030134928	A	G225M	2217	300	8,681	28.9	460	331	494	442
CSIL06030135728	C	G225M	2390	300	64,378	214.6	203	250	237	718
CSIL06030140525	C	G225M	2410	300	14,217	47.4	202	265	236	765
CSIL06030141324	A	G285M	2617	300	44,375	147.9	427	596	461	943
CSIL06030142128	A	G285M	2637	300	10,477	34.9	427	656	461	1022
CSIL06030143026	B	G230L	2635	300	83,352	277.8	359	886	393	1022
CSIL06030143826	A	G230L	3360	300	18,999	63.3	455	977	489	1022
Trial B										
CSIL06030144824	C	G185M	1986	300	17,579	58.6	216	207	250	552
CSIL06030145629	C	G185M	2010	300	10,538	35.1	217	173	251	287
CSIL06030150530	A	G225M	2186	300	12,023	40.1	463	154	497	487
CSIL06030151359	A	G225M	2217	300	8,573	28.6	461	321	495	432
CSIL06030152230	C	G225M	2390	300	64,978	216.6	205	238	239	706
CSIL06030153059	C	G225M	2410	300	14,534	48.4	203	252	237	752
CSIL06030153930	A	G285M	2617	300	44,690	149.0	429	587	463	934
CSIL06030154800	A	G285M	2637	300	10,326	34.4	430	648	464	1019
CSIL06030155729	B	G230L	2635	300	83,462	278.2	361	878	395	1018
CSIL06030160600	A	G230L	3360	300	19,540	65.1	457	969	491	1019

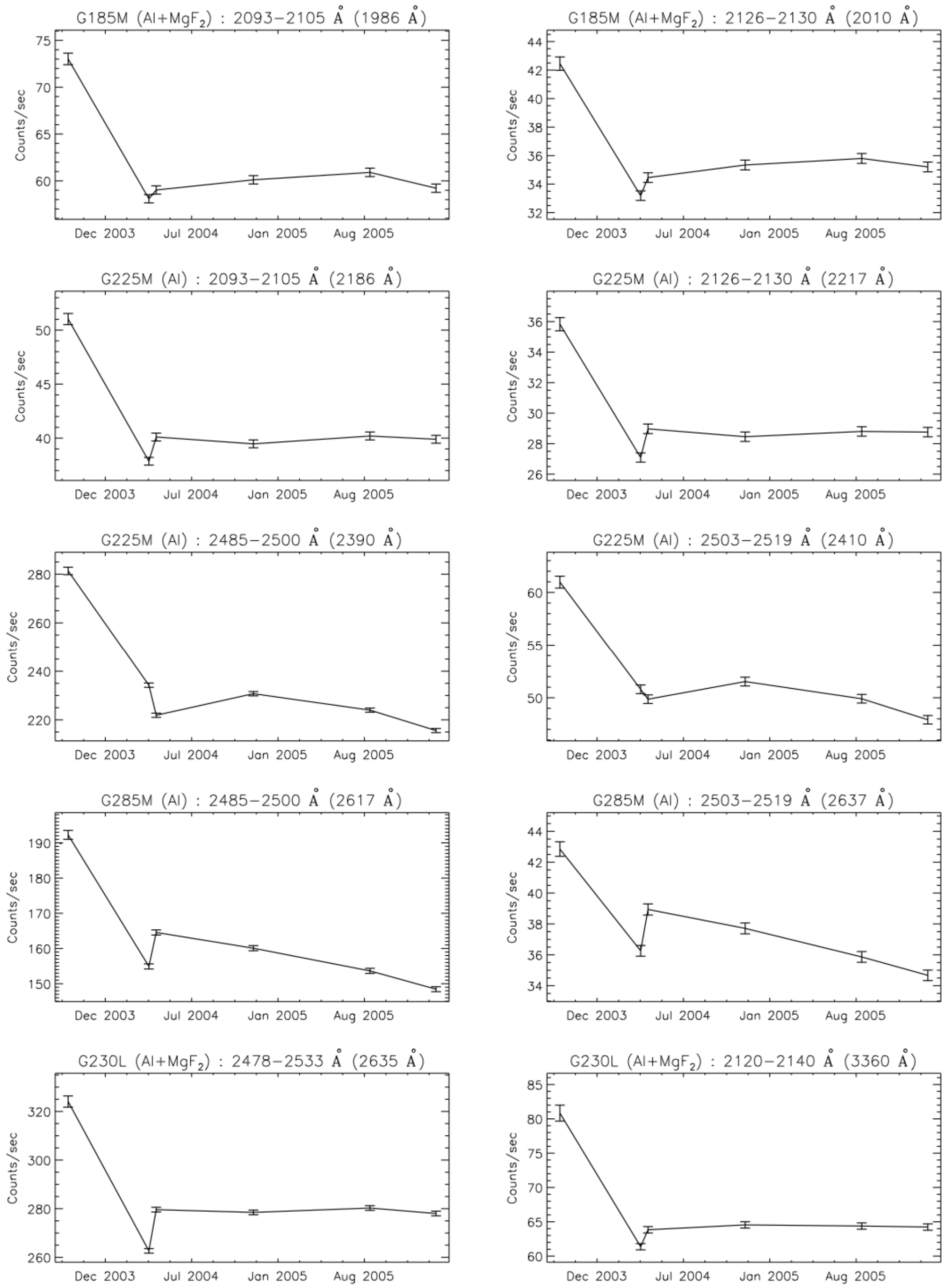

Figure 2: Observed count rates for the NUV monitoring spectral regions. The 2003 dataset was taken in vacuum, while all other datasets were taken in nitrogen purge.

3. RELATIVE EFFICIENCIES

3.1 DEFINITIONS

The relative efficiencies (ε) and the associated statistical (σ) errors are computed as:

$$\varepsilon_\lambda = \frac{R_{grating1,\lambda}}{R_{grating2,\lambda}} = \frac{C_{grating1,\lambda}/T_1}{C_{grating2,\lambda}/T_2}$$
$$\sigma_\varepsilon = \varepsilon_\lambda \sqrt{1/C_{grating1,\lambda} + 1/C_{grating2,\lambda}}$$

Where $\mathbf{R}_{grating1,\lambda}$ and $\mathbf{R}_{grating2,\lambda}$ correspond to the count rates within a fixed bandpass as measured with grating 1 and grating 2 respectively. $\mathbf{T_1}$ and $\mathbf{T_2}$ are the exposure times and $\mathbf{C}_{grating1,\lambda}$ and $\mathbf{C}_{grating2,\lambda}$ are the total counts observed in each grating/bandpass.

In each data campaign, two sets of observations (Trial A and Trial B) were obtained for each grating and bandpass combination[1]. The total counts and exposure times are summed for the two independent measurements as shown below:

$$C_{grating(1or2),\lambda} = C_{grating(1or2),\lambda,A} + C_{grating(1or2),\lambda,B}$$
$$T_{(1or2)} = T_{(1or2),A} + T_{(1or2),B}$$

Seven relative efficiencies of interest were previously defined and are reproduced below. These efficiencies were designed to compare all COS NUV gratings (and their respective coatings) at a variety of central wavelengths. For each grating, the subscript indicates the spectral stripe containing the spectral regions of interest. An eighth relative efficiency (ε_8) is added in this revision to track large-scale intensity variations of the internal lamps.

ε_1 = $G185M_C$ (1986 Å) ÷ $G225M_A$ (2186 Å) = Al+MgF_2 ÷ Al
ε_2 = $G185M_C$ (2010 Å) ÷ $G225M_A$ (2217 Å) = Al+MgF_2 ÷ Al
ε_3 = $G225M_C$ (2390 Å) ÷ $G285M_A$ (2617 Å) = Al ÷ Al
ε_4 = $G225M_C$ (2410 Å) ÷ $G285M_A$ (2637 Å) = Al ÷ Al
ε_5 = $G185M_C$ (2010 Å) ÷ $G230L_A$ (3360 Å) = Al+MgF_2 ÷ Al+MgF_2
ε_6 = $G225M_A$ (2217 Å) ÷ $G230L_A$ (3360 Å) = Al ÷ Al+MgF_2
ε_7 = $G285M_A$ (2637 Å) ÷ $G230L_B$ (2635 Å) = Al ÷ Al+MgF_2
ε_8 = $G230L_B$ (2635 Å) ÷ $G230L_B$ (3360 Å) = Al+MgF_2 ÷ Al+MgF_2

[1]In the initial data campaign of 2003, some second measurements using the G225M, G285M and G230L gratings were not obtained. Therefore, some efficiencies in this dataset use only a single observation.

3.2 RESULTS

Table 3-1 shows the resulting relative efficiencies for all of the data measured in 2003 and 2004. Table 3-2 and Table 3-3 give expanded results from the 2005 and 2006 data campaigns and list the measured efficiencies for each observation, as well as the combined measurement.

Figure 3 shows the trends of the efficiencies over time. Figure 4 shows the trends normalized to the long-term efficiency average.

Table 3-1: Relative Efficiencies 2003/2004

Ratio	10.2003		04.05.2004		04.22.2004		12.03.2004	
	ε	σ_ε	ε	σ_ε	ε	σ_ε	ε	σ_ε
ε_1	**1.446**	0.012	**1.534**	0.013	**1.472**	0.012	**1.523**	0.013
ε_2	**1.193**	0.012	**1.225**	0.013	**1.189**	0.012	**1.242**	0.013
ε_3	**1.463**	0.012	**1.512**	0.006	**1.348**	0.006	**1.441**	0.006
ε_4	**1.413**	0.013	**1.401**	0.012	**1.281**	0.011	**1.366**	0.012
ε_5	**0.521**	0.008	**0.541**	0.005	**0.540**	0.005	**0.548**	0.005
ε_6	**0.437**	0.007	**0.441**	0.004	**0.454**	0.004	**0.441**	0.004
ε_7	**0.131**	0.001	**0.138**	0.001	**0.139**	0.001	**0.135**	0.001
ε_8	**4.009**	0.064	**4.280**	0.025	**4.380**	0.025	**4.314**	0.024

Table 3-2: Relative Efficiencies 08/30/2005

Ratio	Grating1$_{stripe}$ (λ_C in Å) / Grating2$_{stripe}$ (λ_C in Å) [Grating Coatings]	08/30/05 (A)		08/30/05 (B)		08/30/05 (A+B)	
		ε	σ_ε	ε	σ_ε	ε	σ_ε
ε_1	G185M$_C$ (1986) / G225M$_A$ (2186) [**Al+MgF$_2$ / Al**]	**1.520**	0.018	**1.511**	0.018	**1.515**	0.013
ε_2	G185M$_C$ (2010) / G225M$_A$ (2217) [**Al+MgF$_2$ ÷ Al**]	**1.258**	0.018	**1.228**	0.018	**1.243**	0.013
ε_3	G225M$_A$ (2390) / G285M$_C$ (2617) [**Al / Al**]	**1.454**	0.009	**1.461**	0.009	**1.458**	0.006
ε_4	G225M$_A$ (2410) / G285M$_C$ (2637) [**Al / Al**]	**1.391**	0.018	**1.392**	0.018	**1.392**	0.012
ε_5	G185M$_C$ (2010) / G230L$_A$ (3360) [**Al+MgF$_2$ / Al+MgF$_2$**]	**0.571**	0.007	**0.541**	0.007	**0.556**	0.005
ε_6	G225M$_A$ (2217) / G230L$_A$ (3360) [**Al / Al+MgF$_2$**]	**0.454**	0.006	**0.441**	0.006	**0.447**	0.004
ε_7	G285M$_A$ (2637) / G230L$_B$ (2635) [**Al / Al+MgF$_2$**]	**0.127**	0.001	**0.129**	0.001	**0.128**	0.001
ε_8	G1230L$_B$ (2635) / G230L$_A$ (3360) [**Al+MgF$_2$ / Al+MgF$_2$**]	**4.430**	0.036	**4.279**	0.034	**4.354**	0.025

Table 3-3: Relative Efficiencies 01/30/2006

Ratio	Grating1$_{stripe}$ (λ_C in Å) / Grating2 $_{stripe}$ (λ_C in Å) [Grating Coatings]	01/30/06 (A)		01/30/06 (B)		01/30/06 (A+B)	
		ε	σ_ε	ε	σ_ε	ε	σ_ε
ε_1	G185M$_C$ (1986) / G225M$_A$ (2186) [**Al+MgF$_2$ / Al**]	**1.507**	0.018	**1.462**	0.017	**1.484**	0.012
ε_2	G185M$_C$ (2010) / G225M$_A$ (2217) [**Al+MgF$_2$ ÷ Al**]	**1.219**	0.018	**1.229**	0.018	**1.224**	0.013
ε_3	G225M$_A$ (2390) / G285M$_C$ (2617) [**Al / Al**]	**1.451**	0.009	**1.454**	0.009	**1.452**	0.006
ε_4	G225M$_A$ (2410) / G285M$_C$ (2637) [**Al / Al**]	**1.357**	0.017	**1.408**	0.018	**1.382**	0.013
ε_5	G185M$_C$ (2010) / G230L$_A$ (3360) [**Al+MgF$_2$ / Al+MgF$_2$**]	**0.557**	0.007	**0.539**	0.007	**0.548**	0.005
ε_6	G225M$_A$ (2217) / G230L$_A$ (3360) [**Al / Al+MgF$_2$**]	**0.457**	0.006	**0.439**	0.006	**0.448**	0.004
ε_7	G285M$_A$ (2637) / G230L$_B$ (2635) [**Al / Al+MgF$_2$**]	**0.126**	0.001	**0.124**	0.001	**0.125**	0.001
ε_8	G1230L$_B$ (2635) / G230L$_A$ (3360) [**Al+MgF$_2$ / Al+MgF$_2$**]	**4.387**	0.035	**4.271**	0.034	**4.328**	0.024

3.3 SAMPLE RELATIVE EFFICIENCY CALCULATION

As an example, we review the calculations associated with ε_7 in the 1/30/2006 data campaign. As indicated in Table 2-7, the G285M$_A$ count rates were 10,477 and 10,326 counts over 300 second exposures, while the G230L$_B$ count rates were 83,352 and 83,462 counts over 300 second exposures, for the A and B exposures respectively.

The 01/30/06 trial A and B efficiencies and uncertainties are given by:

$$\varepsilon_{\lambda(A)} = \frac{10,477/300}{83,352/300} = 0.1257 \qquad \varepsilon_{\lambda(B)} = \frac{10,326/300}{83,462/300} = 0.1237$$

$$\sigma_{\varepsilon(A)} = \varepsilon_{\lambda(A)}\sqrt{1/10,477 + 1/83,352} = 0.0013 \qquad \sigma_{\varepsilon(B)} = \varepsilon_{\lambda(B)}\sqrt{1/10,326 + 1/83,462} = 0.0013,$$

whereas, the combined A+B efficiencies and uncertainties are calculated as:

$$\varepsilon_{\lambda(A+B)} = \frac{(10,477 + 10,326)/600}{(83,352 + 83,462)/600} = 0.1245$$

$$\sigma_{\varepsilon(A+B)} = \varepsilon_{\lambda(A+B)}\sqrt{1/(10,477 + 10,326) + 1/(83,352 + 83,462)} = 0.0009.$$

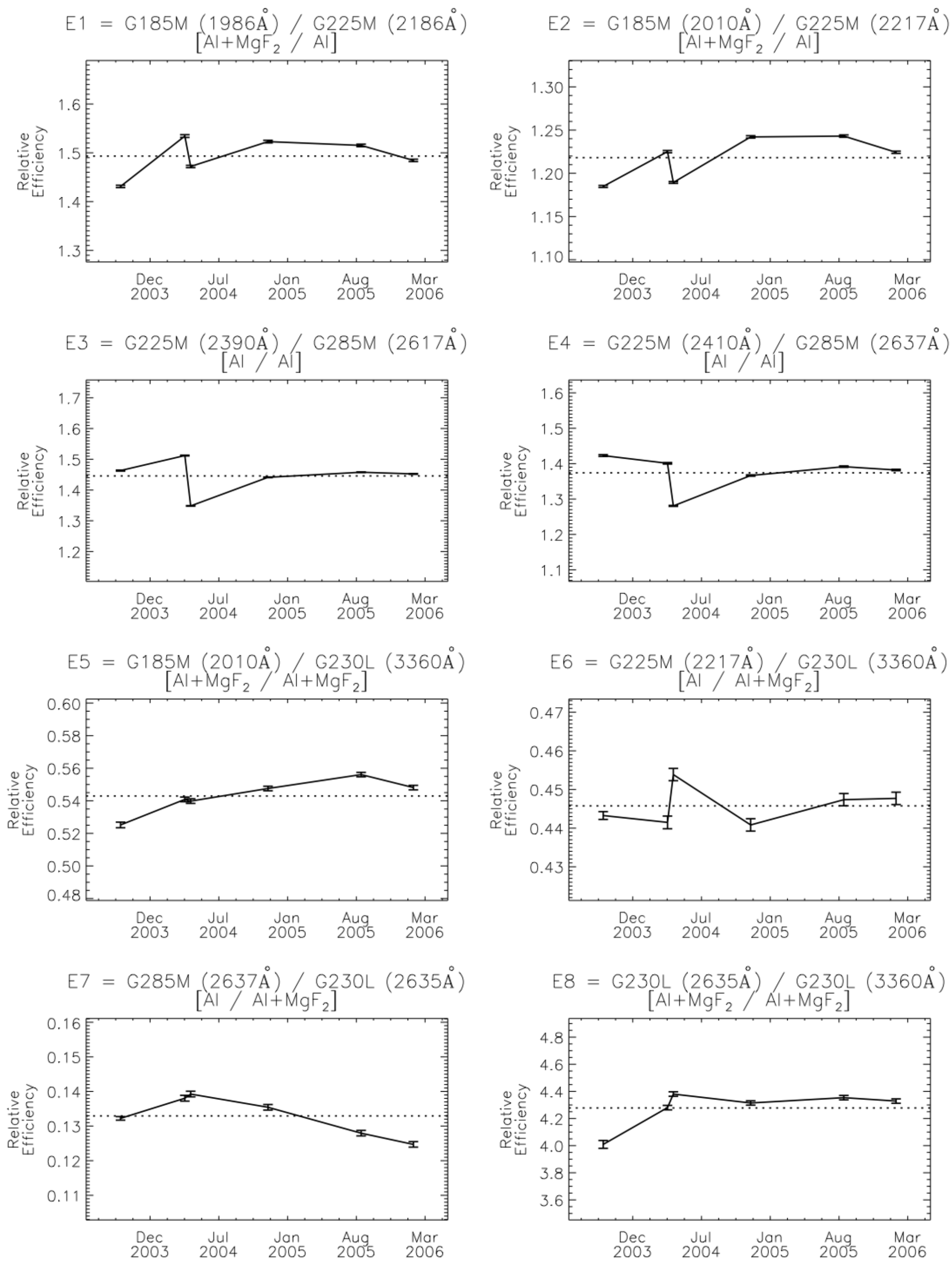

Figure 3: Relative efficiencies as a function of time.

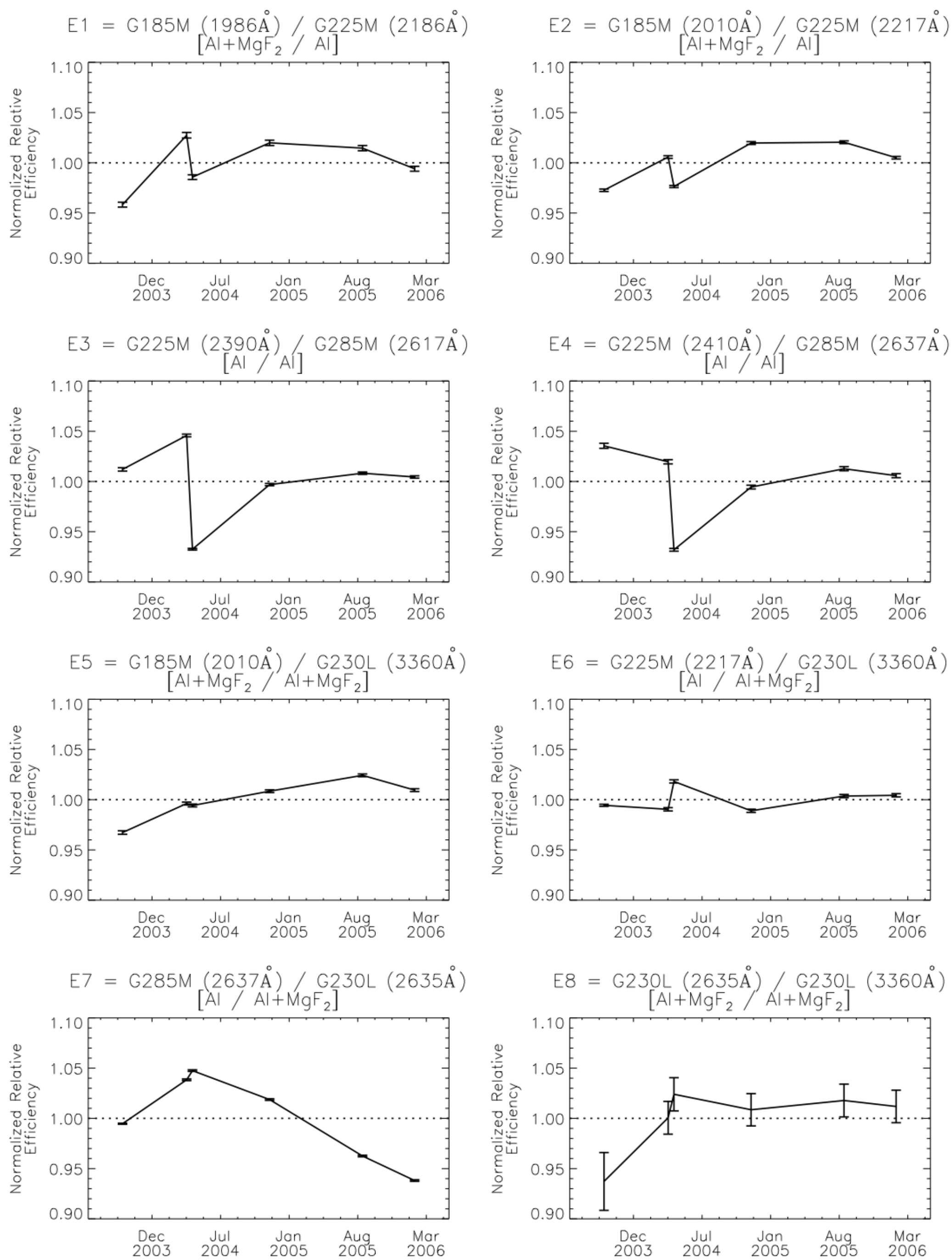

Figure 4: Normalized relative efficiencies. This figure is identical to Figure 3, except that all efficiencies have been normalized and are on the same scale.

4. CONCLUSION

From the results shown in Figure 2 and Figure 4, there is no significant degradation in the reflectivity of the G225M and G285M gratings coated with bare aluminum compared to the gratings with an added MgF_2 coating.

However, there is some evidence (the middle four panels of Figure 2, and ε_7 in Figure 4) that the bare aluminum gratings may have degraded as much as 5–10% over the last 21 months (April 2004 to January 2006). For example, on April 22, 2004, the ε_7 ratio (Figure 3) was measured as 0.139, whereas the January 2006 measurement was 0.125, or a drop of ~10%.

APPENDIX A. EXPOSURE-TIME ADJUSTMENTS FOR THE NUV MONITORING EXPOSURES

Due to concerns over lamp lifetime of the onboard Pt-Ne wavelength calibration lamps, we recommend reducing the lamp exposure times for future NUV monitoring campaigns. Currently, the ten grating and central wavelength settings are each observed twice at the medium current settings, 10 mA, with a duration of 300 seconds each. Not including the 30-second per exposure overhead associated with safety and rate count checks, this equates to a total exposure time of 6,000 seconds, or 0.0167 Amp-Hrs. As we have now undertaken five monitoring campaigns, a total of ~0.1 Amp-Hrs have been devoted to this test. Assuming a lifetime of 5–10 Amp-Hrs, this equates to 1–2% of the lamp lifetime.

There are two complementary figures of merit that can guide us in determining proper reduced exposure times for the NUV monitoring tests. One merit, relating to the ability to achieve a reliable cross-correlation, is the number of counts per resolution element across the spectrum. The second figure of merit is the number of counts in the bandpass, which sets the limit on statistical photon noise.

For the first figure of merit,we propose that all future datasets should have an average of at least 100 counts per resolution element across the spectral region of interest. We identify this as the T100 exposure time. For the second figure of merit, we propose that all bandpasses contain at least 6,400 counts, or equivalently that the count rates are known to 1.25% or a statistical signal-to-noise ratio of 80. We identify the second exposure time as T6400.

Table 4-1 lists the ten grating and central wavelength NUV spectral monitoring bandpasses (see Table 2-1) along the combined counts, exposure times (T), and count rates (CR) of the January 2006 NUV monitoring campaign. Also listed in the table are the actual bandpasses ($\Delta\lambda$) of the monitoring regions along with per Angstrom (**Å**) and per resolution element (RE) count rates for the January 2006 campaign. The T100 column indicates the exposure time (in seconds) required to obtain an average of 100 counts per RE (our first criteria). The T6400 column indicates the time required to obtain 6400 counts across the bandpass. The T100 and T6400 columns are both rounded up to the nearest 15-second increment, and are not allowed to be less than 30 seconds, nor greater than the current exposure time of 300 seconds. The final column (T') lists our new recommended exposure, and is defined as the greater of T100 and T6400. Totals for all exposure-time columns are given below the table and reflect two equal duration exposures per spectral monitoring setting.

It is clear from this analysis that we can significantly reduce the total exposure time of the NUV spectral monitoring campaign without any significant loss in our ability to monitor the grating efficiencies. Currently, 6,000 seconds of exposure time is used per spectral monitoring campaign, we recommend this be reduced to 3,660 seconds as outlined by the T' column of Table 4-1.

Table 4-1: Reduced NUV monitoring exposure times. The counts and exposure times listed here are those of the January 2006 NUV spectral monitoring campaign.

Grating	λ_c (Å)	Counts	T (sec)	CR cts/sec	$\Delta\lambda$ (Å)	CR/Å	CR/RE	T100 (sec)	T6400 (sec)	T' (sec)
G185M	1986	35,531	600	59.2	12	4.9	0.51	210	120	210
G185M	2010	21,124	600	35.2	4	8.8	0.90	120	195	195
G225M	2186	23,936	600	39.9	12	3.3	0.34	300	165	300
G225M	2217	17,254	600	28.8	4	7.2	0.74	150	225	225
G225M	2390	129,356	600	215.6	15	14.4	1.47	75	30	75
G225M	2410	28,751	600	47.9	16	3.0	0.31	300	135	300
G285M	2617	89,065	600	148.4	15	9.9	1.19	90	45	90
G285M	2637	20,803	600	34.7	16	2.2	0.26	300	195	300
G230L	2635	166,814	600	278.0	55	5.1	5.89	30	30	30
G230L	3360	38,539	600	64.2	20	3.2	3.75	30	105	105
Total Exposure Time (sec) =			**6000**					**3210**	**2490**	**3660**