SWIFT-UVOT-CALDB-##
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SWIFT UVOT CALDB RELEASE NOTE

SWIFT-UVOT-CALDB-##: GRISM CLOCKING

0. Summary:

This document describes how and why the choice of the default grism clocking positions were made for the UV and Visible UVOT grisms.

Zeroth order spectra only appear within the area covered by the grism whereas first order spectra can be dispersed "off the edge" of the grism. The advantage of clocking is twofold:

i. Probably the most important prospect is that of the target first order spectrum being free from zeroth order spectra from other stars.
ii. The second advantage is a reduction in the sky background around the spectrum. This only works for the UV grism, because the photons dispersed off the edge of the grism are UV only. For the Optical grism the sky background in the off-the-edge region is as bright as on the grism because it is the optical photons which are being dispersed.

1. Component Files:

FILE NAME	VALID DATE	RELEASE DATE	VERSION

2. Scope of Document:

This document contains a description of the clocking calibration analysis performed to choose the best clocking positions for taking grism data.

3. Changes:

This is the first released version of the clocking calibration document.

4. Reason For Update:

This is the first released version of the clocking calibration document.

5. Expected Updates:

No further updates are expected.

6. Caveat Emptor:

7. Data Used:

The default filter wheel position for the UV grism is 200; for the V grism 1000.
For the UV grism G63-26 was chosen as a source that would give a good count rate without too many other sources in the field of view to contaminate the spectrum. The V grism source was G108.

Exposures of each of these sources were made at a variety of filter wheel positions. Several different methods were used for the exposures because the filter wheel had to be commanded by hand via TDRSS. Some were image data taken before the build 7, attitude-corrected, image mode. Some were taken in events mode. Some were taken post build 7, using the attitude corrected image mode. The early data were taken binned 2x2.

Tables 1 and 2 lists the sequence numbers with the relevant extensions and filter wheel positions.

Although the later data were taken with "slew and place" so that the target is close to the boresight (within 1′?) the earlier data have offsets of up to 4.5 arcminutes.

Sequence no.	Ext	Clock-ing	RA_PNT	Dec_PNT	Offset (arcmin)	Max thruput	Bkgnd	Dist. Fr. edge	Min dist.	Nom. dist.
55600004	1	200	201.113	20.4717	1.2763	1.1	0.08	1700	1215	1700
55600004	2	170	201.115	20.4705	1.1411	1.3	0.05	1008	514	1001
55600004	3	160	201.114	20.4720	1.2483	1.3	0.03	877	337	807
55600008	2	155	201.180	20.4514	3.1349	0.3	0.003	429	232	722
55600009	2	150	201.184	20.4509	3.3774	0.3	0.003	331	202	570
55605001	0	140	201.1014	20.4305	2.2345	0.3	0.005	554	0	373

Table 1 UVGrism G63-26 (nominal coordinates: 13 24 30.66 +20 27 23.9 or 201.128, 20.4566)

Sequence no.	Ext	Clock-ing	RA_PNT	Dec_PNT	Offset (arcmin)	Max thruput	Bkgnd	Dist. Fr. edge	Min dist.	Nom. dist.
55050017	1	1000	150.1214	-7.5720	4.5468	1.3	0.015	1229	1220	1729
55050019	1	1000b	150.2036	-7.5589	0.4551	1.2	0.015	1377	1220	1730
55050012	2	970	150.1771	-7.5367	1.7385	1.25	0.015	1555	448?	1400
55050013	2	960	150.1736	-7.5381	1.8240	1.3	0.013	1085	692	1162
55050020	2	955	150.1999	-7.5582	0.2365	1.3	0.013	1093	588	1046
55050016	2	950	150.1291	-7.5635	4.0242	0.9	0.010	579	420	905
55050019	2	940	150.2036	-7.5589	0.4551	1.25	0.011	810	354	848

Table 2 V Grism G108 (nominal coordinates: 10 00 47 -7 33 31.2 or 150.196, -7 55867)

8. Description of Analysis:

For each image (or image made from events data using EXTRACTOR) the target was identified by comparison with guide stars in the DSS catalogue. The spectrum was then extracted using IDL. The procedure allows rotatation of the image to make the spectrum vertical then fitting a box around the zeroth and first order. The cross section of the spectrum is fitted by a Gaussian which is used to select the position of the spectrum and fit the background level. This is done in bins 40 rows high. The spectrum is the counts above the background within the chosen width. A nominal (uncalibrated) wavelength scale is added to allow comparison between the extracted spectra. An ascii table is produced in a file with the headings: bins, wavelength, counts/sec/pix, signal to noise ratio. It also records the dimensions of the extraction box and the exposure time (given by the user).

Results

Unfortunately several of the exposures were taken with a large offset in the spacecraft pointing, making the data more complicated to unravel. E.g. the target is actually nearer the edge of the grism in the 150 filter wheel position than the 140 due to it being offset towards the edge. I have therefore measured the distance to the edge of the grism. I have also measured the distance from the edge of where the target *should* have been, and the minimum distance given an offset of 4.5′ in the dispersion direction. These are all in the tables.

Table 1 and 2 list the following parameters:

i) Sequence no.
ii) Extension no.
iii) Clocking i.e. filter wheel position
iv) RA_PNT and Dec_PNT are the pointing position as taken from the header of the file, i.e. where the star tracker thinks we are pointing.
v) Offset is the difference in arcmins between RA_PNT, Dec_PNT and the position of the source.
vi) Max throughput is the maximum of the spectrum in counts/sec/bin
vii) Bkgnd is a measure of the background taken near the middle of the spectrum. (this was not the background used to make the spectra – just a spot check)

viii) Dist. Fr. Edge is the distance (in subpixels) of the zeroth order point to the edge of the grism in the dispersion direction. For the UV grism this was easy to see. For the V grism the dispersion area looks similar to the on-grism area except for the lack of zeroth orders, so the edge is harder to see. For this one (table 2) I have measured from the edge of the dispersal region.

ix) Min dist. is the distance from the edge in the worst case, i.e. if the source were offset 4.5′ from the nominal position in the dispersion direction.

x) Nom. Dist is the distance from the edge if the source had not been offset at all.

The extracted spectra are shown in figures 1 and 2. Signal to noise ratios (normalised by dividing by the square root of the exposure time to make them comparable) are given in figures 3 and 4.

Any change in background level due to e.g. proximity to the earth limb, cannot be taken out of this analysis as all the data were taken in image mode. However, the steady decrease in background with clocking position suggests that there has not been too big an effect from this. Two spectra taken at the same position but at different times (1000 and 1000b) give exactly the same background measurement.

Conclusions

UV Grism

I recommend using **160** as the filter wheel position for single object spectroscopy in the UV.

From Figure 1 it can be seen that the spectrum is similar for positions 200, 170 and 160. For more extreme clocked positions, the throughput seems to fall off dramatically. However, the picture is muddied by the offsets. The best indicator of throughput is actually the distance from the edge of the grism. In all clocked positions, the whole of the 4.5′ offset area would be imaged. At clocked position 140 the target would *not* fall within the area of the grism if it were offset by more than 4.5′ from the nominal position.

At position 160 the throughput is at a maximum and the background is reduced by more than a factor of 2. This position does not clear the spectrum entirely of zeroth order contamination (see the two peaks corresponding to other stars at wavelength 150 and 200), but any further clocking leads to a risk of losing throughput particularly if the target is offset towards the edge of the grism. The benefit of this position will be reduced for offsets in the opposite direction.

The sensitivity calibration will have to take into account the position of the source in the image.

Visible Grism

For the visible grism I recommend a clocked position of **955**.

For this grism it seems as though we could go further towards the edge of the grism before losing throughput (e.g. at 940 we get the same maximum as at 1000), but we still need to allow for the 4.5′ offset. The gains for the visible grism are not as great as the sky background scarcely reduces in the dispersal area. However there is benefit in losing zeroth order contamination.

Figures:

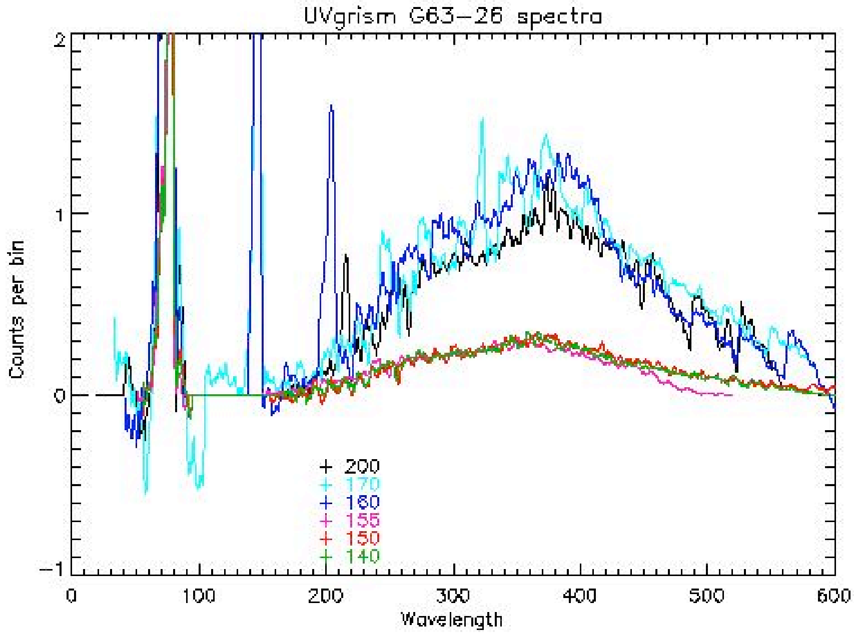
UVgrism G63-26 spectra
Counts per bin
Wavelength
0
100
200
300
400
500
600
2
1
0
−1
+ 200
+ 170
+ 160
+ 155
+ 150
+ 140

Figure 1

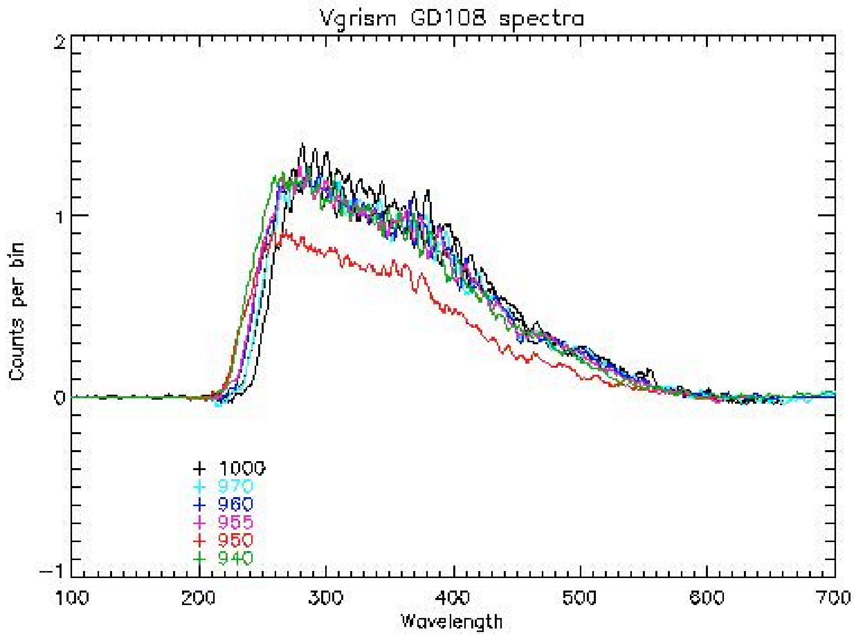
Vgrism GD108 spectra
Counts per bin
Wavelength
2
1
0
−1
100
200
300
400
500
600
700
1000
970
960
955
950
940

Figure 2

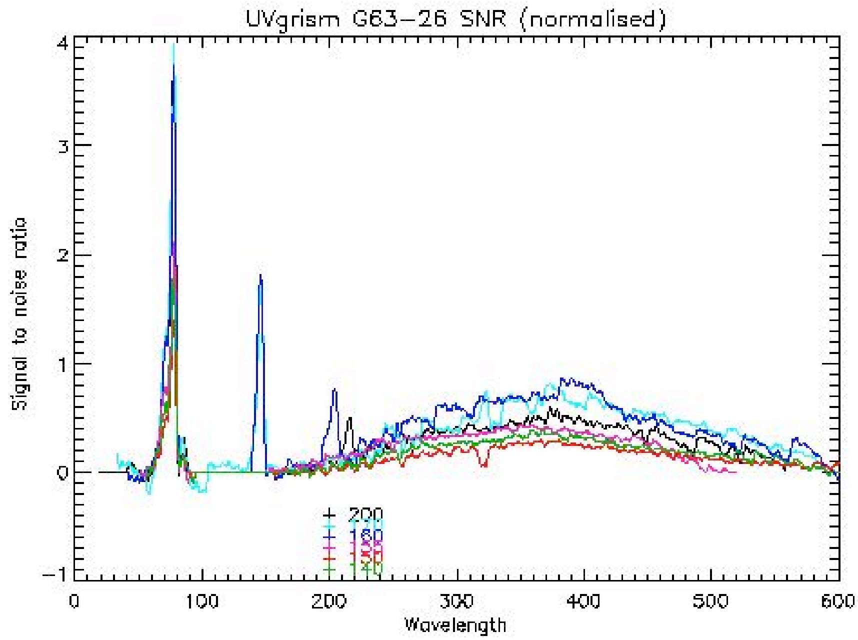
UVgrism G63-26 SNR (normalised)
Signal to noise ratio
Wavelength
0
100
200
300
400
500
600
-1
0
1
2
3
4
200
180

Figure 3

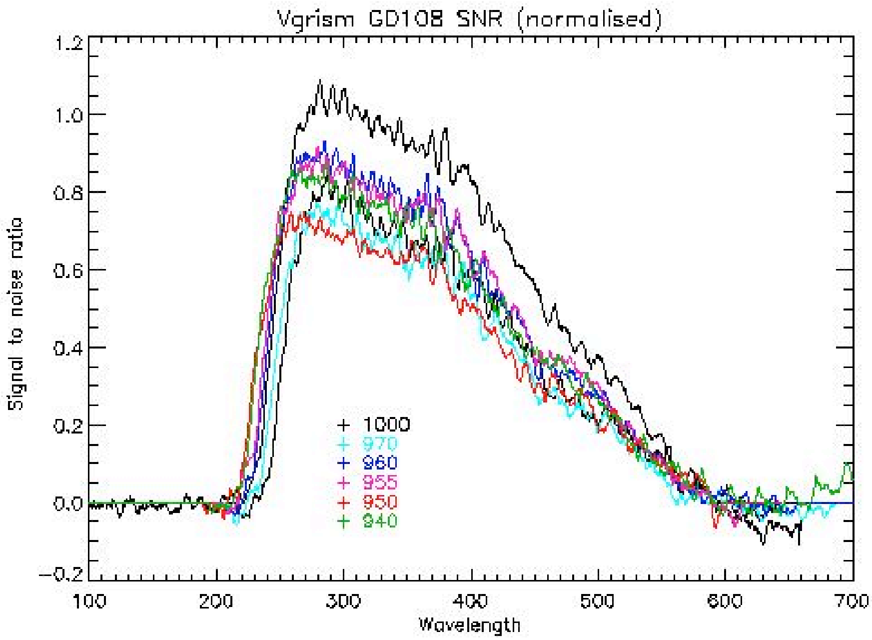
Vgrism GD108 SNR (normalised)
Signal to noise ratio
Wavelength
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
100
200
300
400
500
600
700
+ 1000
+ 970
+ 960
+ 955
+ 950
+ 940

Figure 4