Calibration of the LWR at Reduced UVC Voltage

1. Introduction

The LWR flare anomaly has now developed to the stage at which only images of very short exposure times (~ a few minutes) are completely free of the bright patch which on long exposures contaminates 30% or more of the image area (see ESA IUE Newsletter no. 22, p. 19). Fortunately the flare can be "turned off" by reducing the operating voltage of the LWR ultraviolet-to-visible converter (UVC) from the normal value of 5kV to 4.5 kV. In this way it should be possible to obtain flare-free images for a further 18 months or more, after which time it may be necessary to make a further reduction in the UVC voltage. Current project policy is to allow guest observers to use the LWR (at the lower UVC voltage) if they provide sufficient scientific justification. However, they must be prepared to lose the time required to switch the camera on and off during their shift (about 30 minutes).

Unfortunately, reducing the UVC voltage also reduces the camera sensitivity. It is therefore necessary to investigate the recalibration requirements at the lower operating voltage. An earlier study (ref. 1 had indicated that the 5/4.5 kV gain ratio was about 1.36. In this report a detailed analysis is presented in which an order-by-order comparison of the 5/4.5 kV gain ratio has been made using 11 high dispersion spectra (the 5/4.5 kV gain ratio is the factor by which the 5 kV exposure time must be increased to obtain the same DN level at 4.5 kV). The results of a similar comparison of low dispersion spectra are also given.

2. Procedure

Corresponding IUESIPS extracted orders in 2 high dispersion spectra of Zeta Cas, taken with the UVC voltage reduced to 4.5 kV and the standard exposure time increased by a factor of 1.36, were averaged and binned at 3 A intervals. Mean, binned orders were also derived from 2 spectra of the same star taken with the normal 5 kV UVC setting and standard exposure time. Each resultant 4.5 kV order was then ratioed to the corresponding 5 kV order. Similar order ratios were also derived from averaged 4.5 and 5 kV spectra obtained with double the 100% exposure times in order to increase the signal/noise in the outer orders.

3. Results and Discussion

I. High Dispersion

Examples of the order ratios are given in Figures 1 and 2. In Figure 1 (100% exposure) every 5th order is plotted from 73 to 118 inclusive (wavelength decreases with increasing order number), while in Fig. 2 (200% exposure) every order is plotted in the range 72-81 inclusive. The faint lines superimposed on the order ratios show the unity levels. The separation between consecutive lines corresponds to a deviation of 30% from unity.

No significant non-uniformity in the gain ratio is evident in these plots, either along the orders or from one order to another. Deviations of the 3 A bins from unity are generally only a few % except for the extreme high and low orders, or at the ends of the orders, where signal/noise is reduced.

The mean of the 3 A bin ratios in each 4.5/5 kV order ratio was derived for 3 pairs of averaged 4.5 and 5 kV spectra. The procedure was repeated on a control set in which all 4 spectra were obtained at 4.5 kV. The results for the full range of high-dispersion orders are plotted against order number in Figs. 3, 4, 5, and 6. Apart from the high orders (> 115), which have relatively low signal/noise, the deviation from unity is generally very small. However, there is a clear non-random component in the distribution of points in the sense that the 4.5/5 kV gain ratio is slightly lower in the outer orders. This is a reproducible result apparent in all cases except that of the control spectra (Fig. 6) and must be considered real. If the gain ratio is normalised to 100% over the order range 86-105 then it falls gradually to 96% at order 72, the longest wavelength order. At the high order end there is a similar, but possibly somewhat larger effect, although the magnitude of the trend is less clear due to the reduced signal/noise.

In order to check whether the gain ratio exhibits similar behaviour parallel to the orders, 14 order ratios (77-90) from the set of spectra used for Fig. 3 were averaged. The result (Fig. 7) shows that a similar variation in gain ratio may also occur along the orders, but the magnitude is less than 4% at maximum. However, a similar check made on the set of spectra used for Fig. 5 did not reproduce this result (Fig. 8).

The means of the order ratios plotted in Figs. 3 and 5 are 0.988 and 0.979 respectively. The exposure times used were 28.5 secs (4.5 kV) and 21 secs (5 kV). Correcting for OBC quantisation and camera dead-time the ratio of the actual exposure times is 1.355. Hence the mean 5/4.5 kV gain ratio from these data is 1.378±0.01. If this mean value were adopted as an invariant calibration factor, then ignoring the slight gain ratio variation across a spectrum would incur only a very small error (<2%) over most of the spectral range, with the exception of the high orders, 115-125, where the error might be ~ 5%.

II. Low Dispersion

An order ratio for low dispersion, in 50 A bins, was derived in the same way as for high dispersion orders (Fig. 9). The two 5 kV spectra used for Fig. 9 were themselves ratioed to produce a comparison control plot (Fig. 10). The deviation of the 50 A bin ratios from unity in Fig. 9 is no greater than that seen in the control plot and there is no evidence of any wavelength dependence of the gain ratio. After correction for OBC quantisation and camera dead-time the ratio of the 4.5/5 kV exposure times is 1.371. In the good signal/noise range 1860 - 3200 A the mean of the 50 A bins in Fig. 9 is 1.004. Therefore the gain ratio from the low dispersion data is 1.366, which agrees to within 1% with that derived from high dispersion data.

4. Conclusions

1. In high dispersion the 4.5/5 kV gain ratio appears to vary slightly from order to order in the sense that it decreases from the middle orders towards the edge of the image. The maximum deviation is around 5%. There is some evidence that a similar variation occurs along the orders.

2. The mean gain ratio derived from the optimally exposed high dispersion spectra used in this study is 1.378± 0.01. Use of this value as an invariant calibration factor would introduce a small error (<2% over most of the spectral range) due to the slight non-uniformity in the gain ratio. The error for the highest orders (115-125) would be somewhat larger (~ 5%).

3. The gain ratio derived from low dispersion data agrees to within 1% with that derived for high resolution. There is no evidence of any variation of the gain ratio along the low dispersion order.

REFERENCE

1. Harris, A. W., 1984, Report to the IUE 3-Agency Meeting, ESOC, May 1984.

Alan Harris

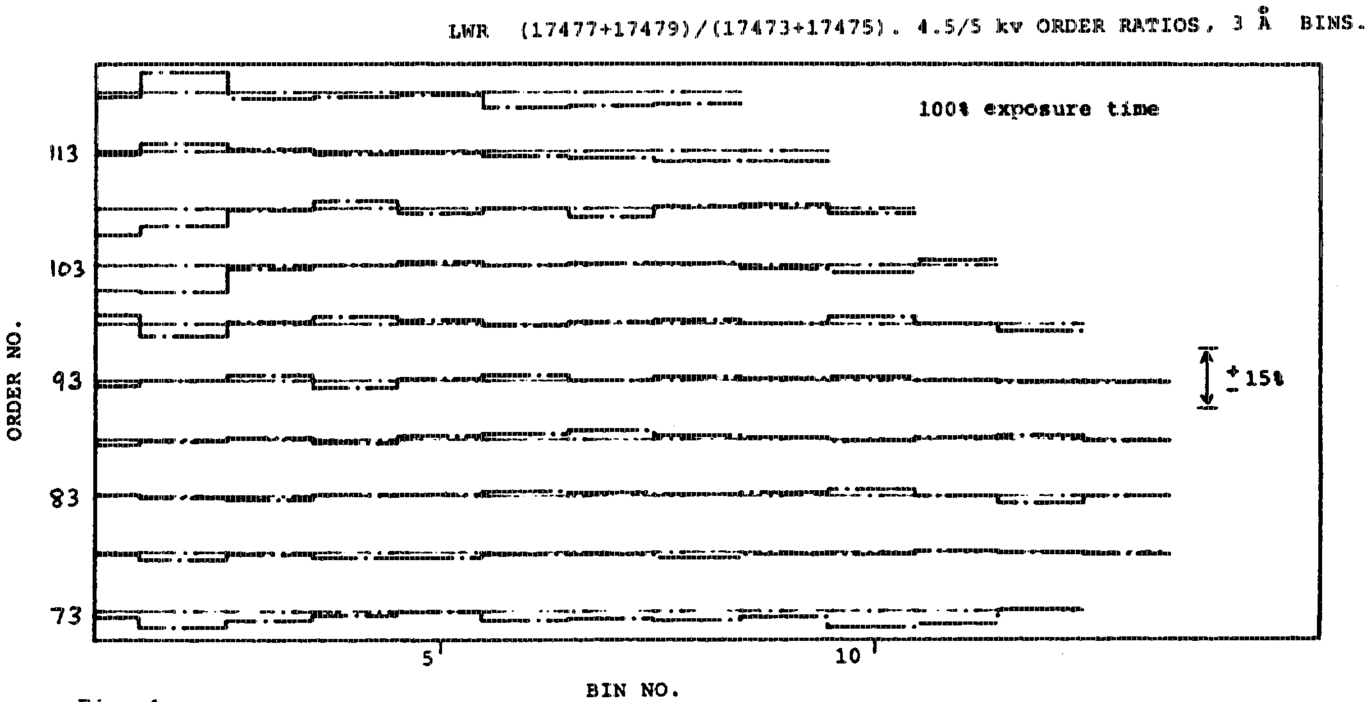

LWR (17477+17479)/(17473+17475). 4.5/5 kv ORDER RATIOS, 3 Å BINS.
100% exposure time
113
103
93
83
73
ORDER NO.
± 15%
5
10
BIN NO.

Fig. 1

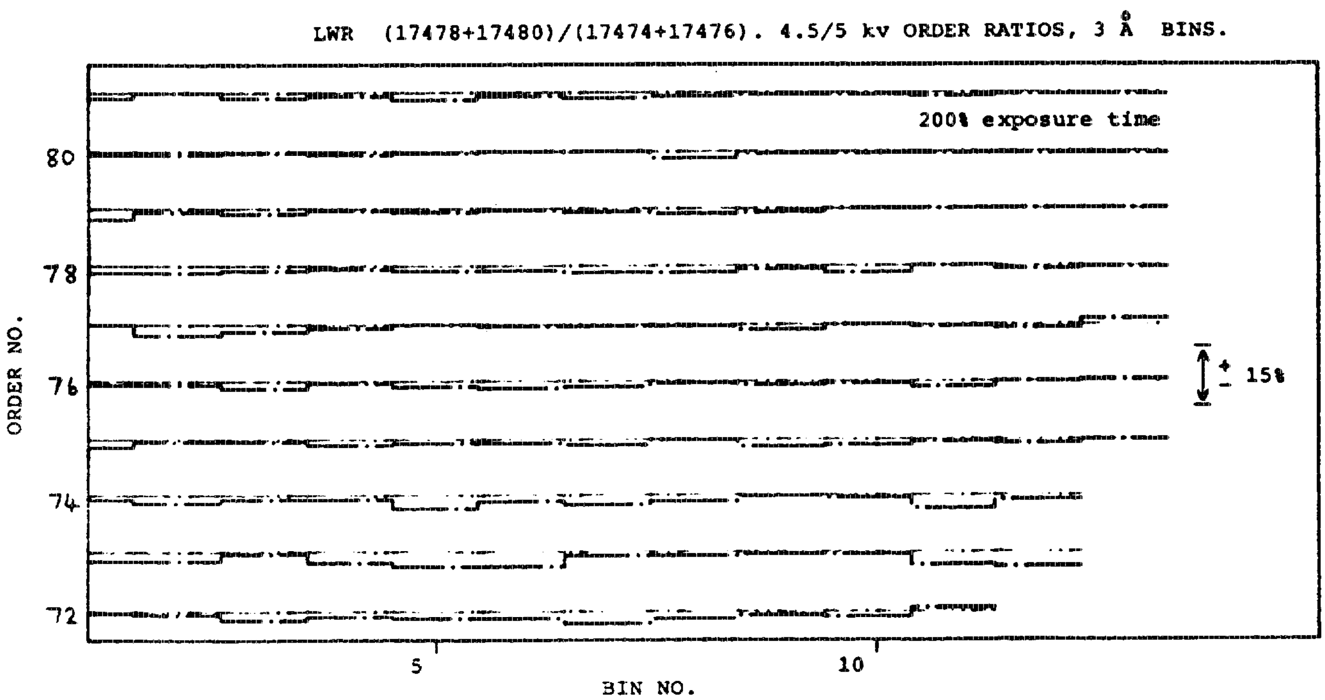
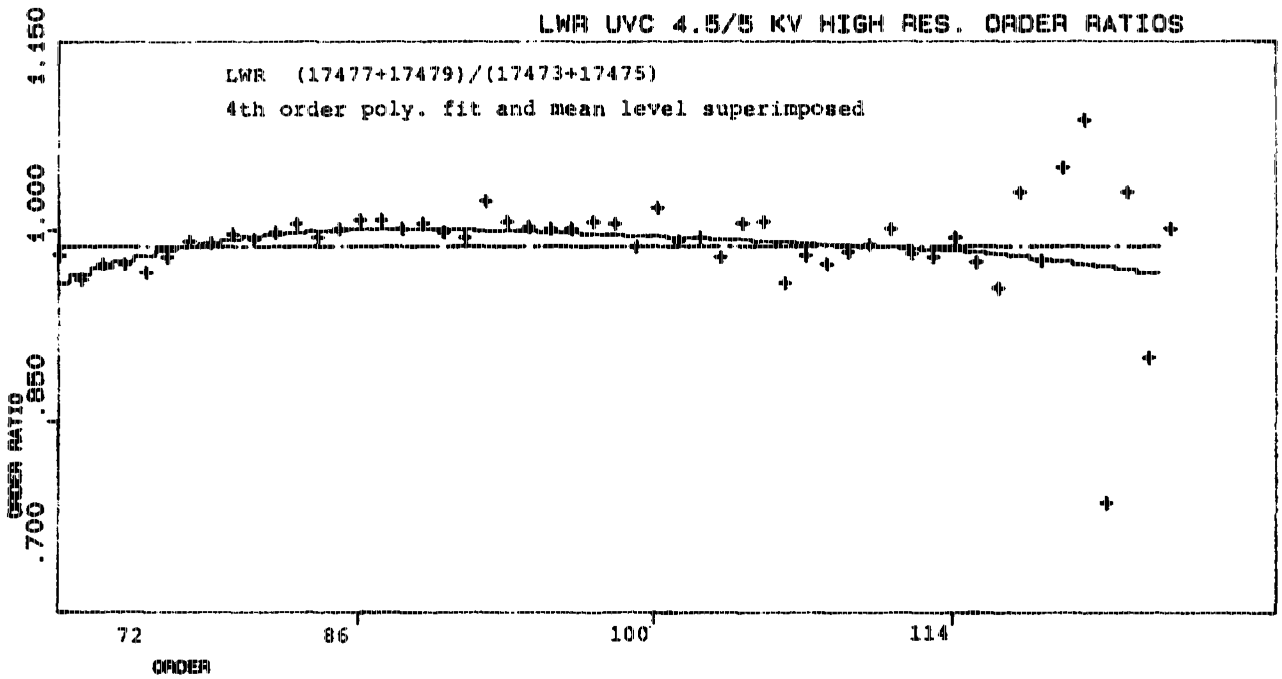
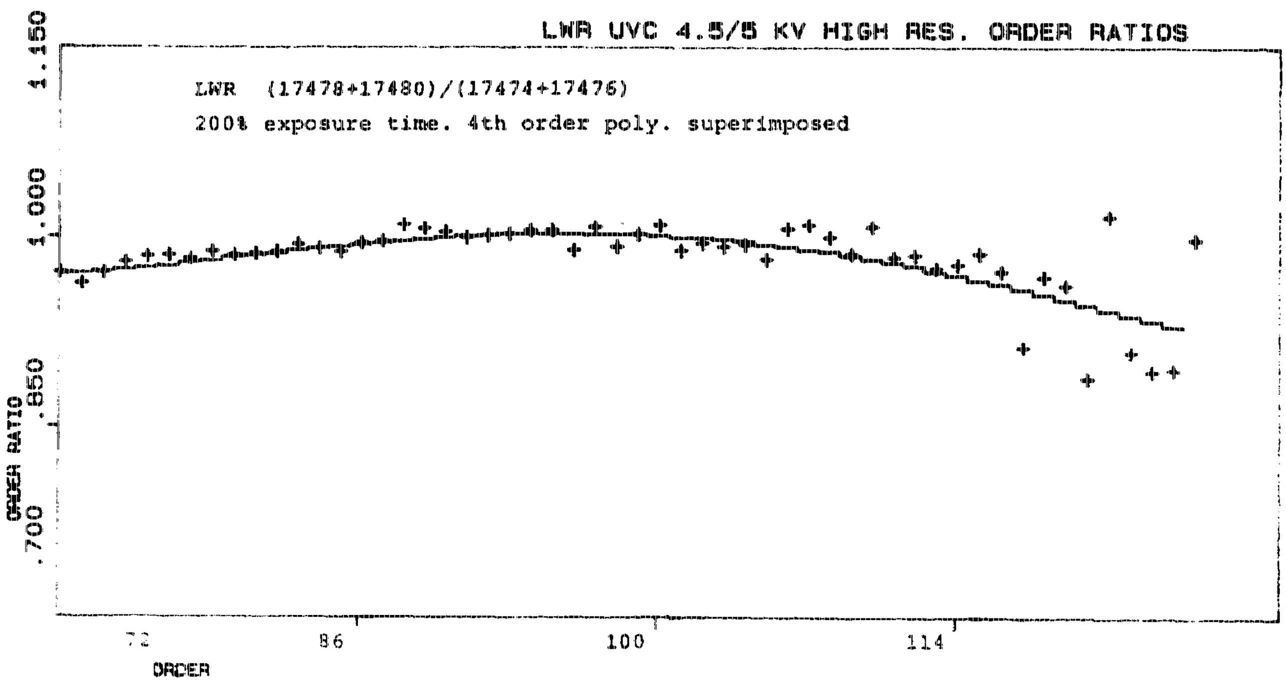

LWR (17478+17480)/(17474+17476). 4.5/5 kv ORDER RATIOS, 3 Å BINS.
200% exposure time
80
78
76
74
72
ORDER NO.
± 15%
5
10
BIN NO.

Fig. 2



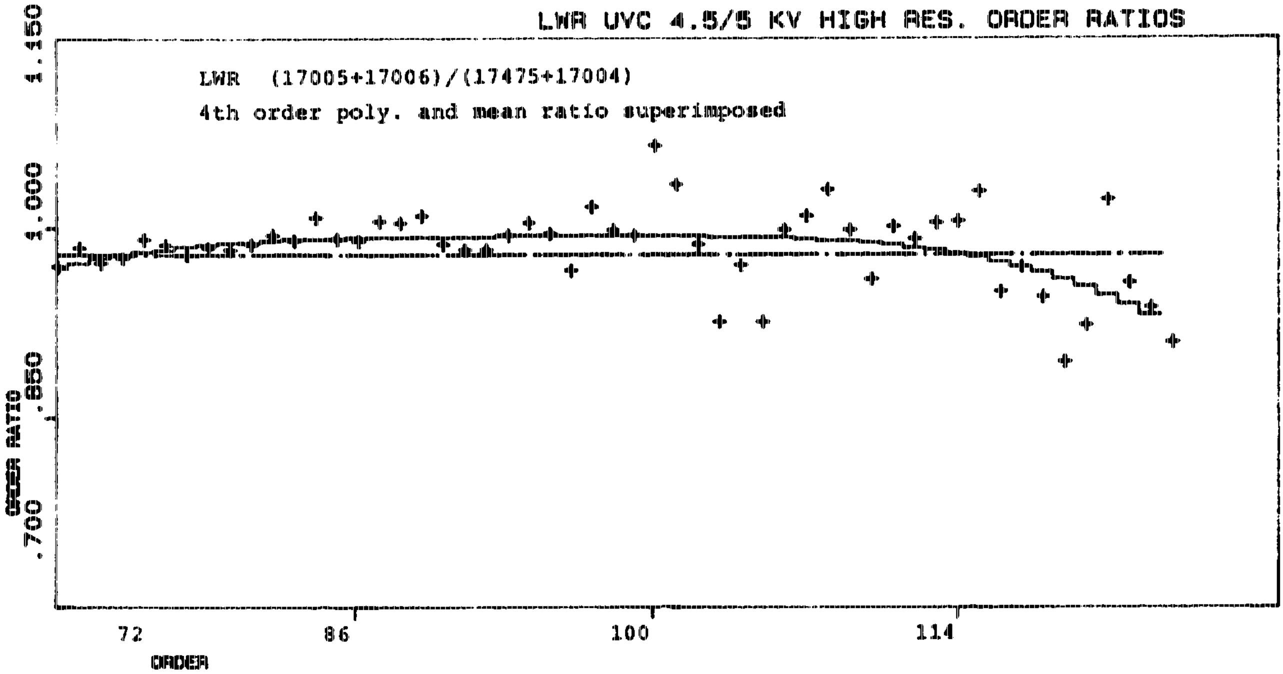
LWR UVC 4.5/5 KV HIGH RES. ORDER RATIOS
LWR (17477+17479)/(17473+17475)
4th order poly. fit and mean level superimposed
ORDER RATIO
1.150
1.000
.850
.700
72
86
100
114
ORDER

Fig. 3



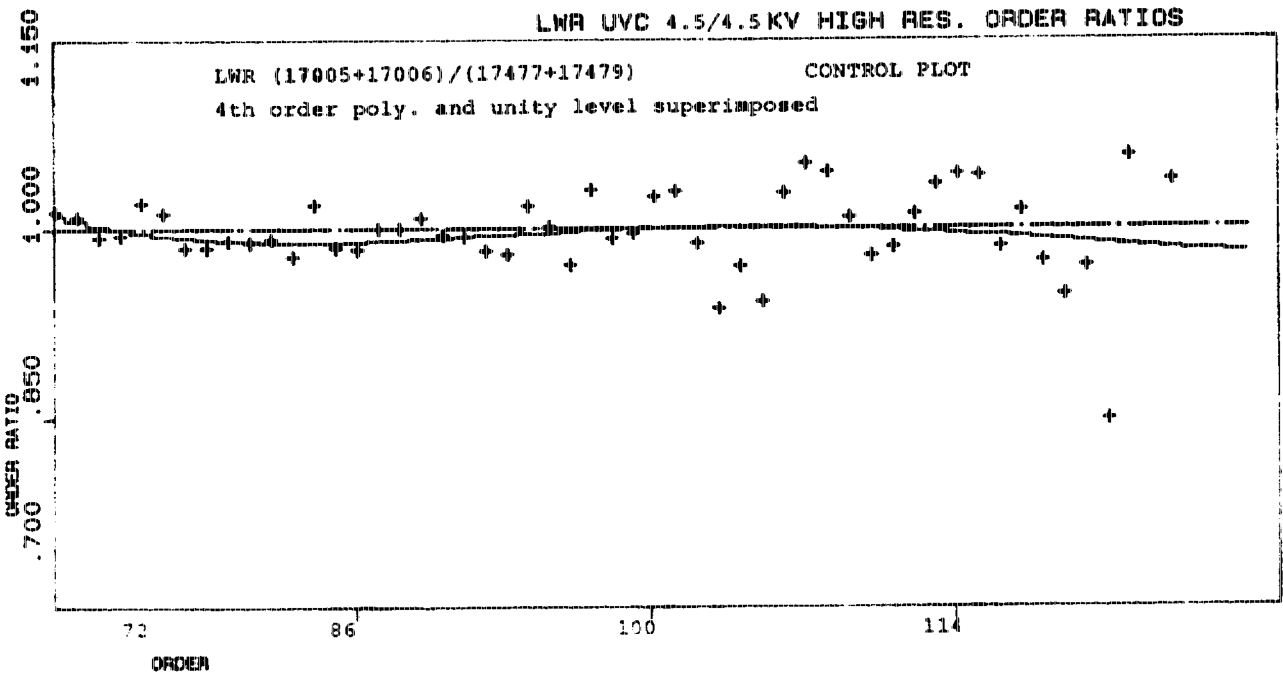
LWR UVC 4.5/5 KV HIGH RES. ORDER RATIOS
LWR (17478+17480)/(17474+17476)
200% exposure time. 4th order poly. superimposed
ORDER RATIO
1.150
1.000
.850
.700
72
86
100
114
ORDER

Fig. 4



LWR UVC 4.5/5 KV HIGH RES. ORDER RATIOS
LWR (17005+17006)/(17475+17004)
4th order poly. and mean ratio superimposed
ORDER RATIO
1.150
1.000
.850
.700
72
86
100
114
ORDER

Fig. 5



LWR UVC 4.5/4.5 KV HIGH RES. ORDER RATIOS
LWR (17005+17006)/(17477+17479)
CONTROL PLOT
4th order poly. and unity level superimposed
ORDER RATIO
1.150
1.000
.850
.700
72
86
100
114
ORDER

Fig. 6

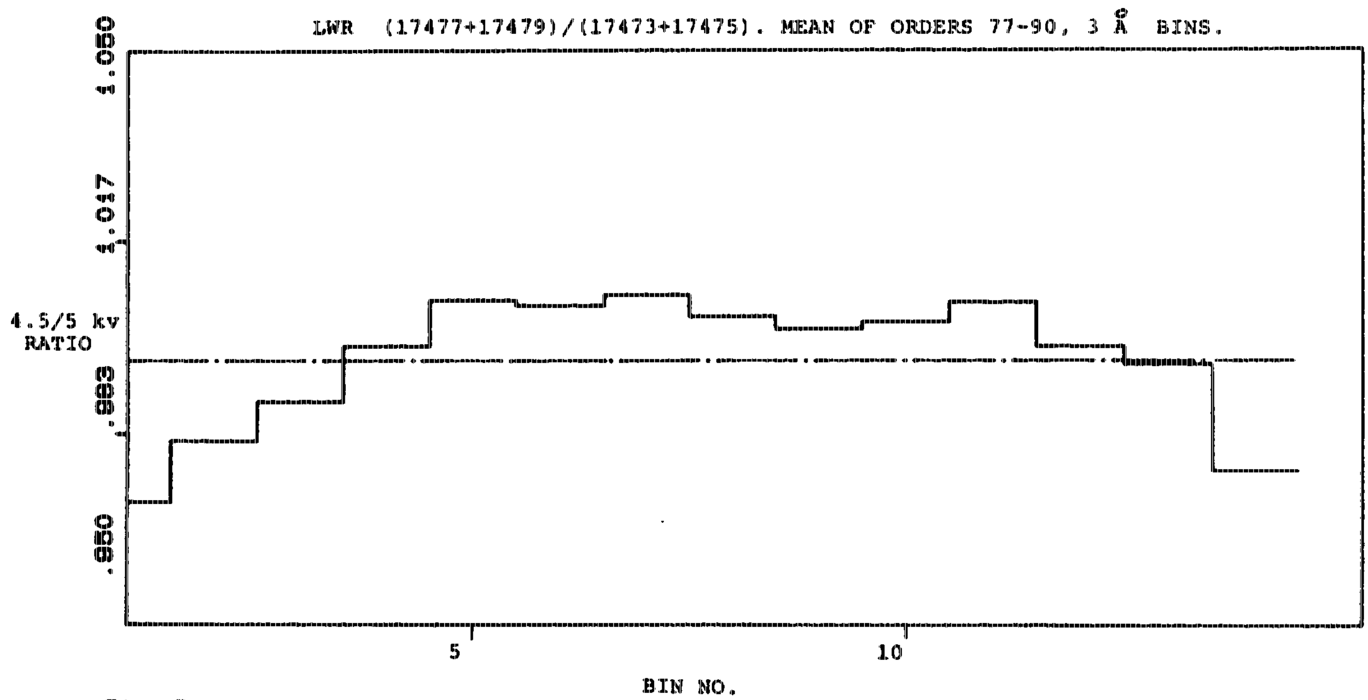

LWR (17477+17479)/(17473+17475). MEAN OF ORDERS 77-90, 3 Å BINS.
1.050
1.017
.983
.950
4.5/5 kv
RATIO
5
10
BIN NO.

Fig. 7

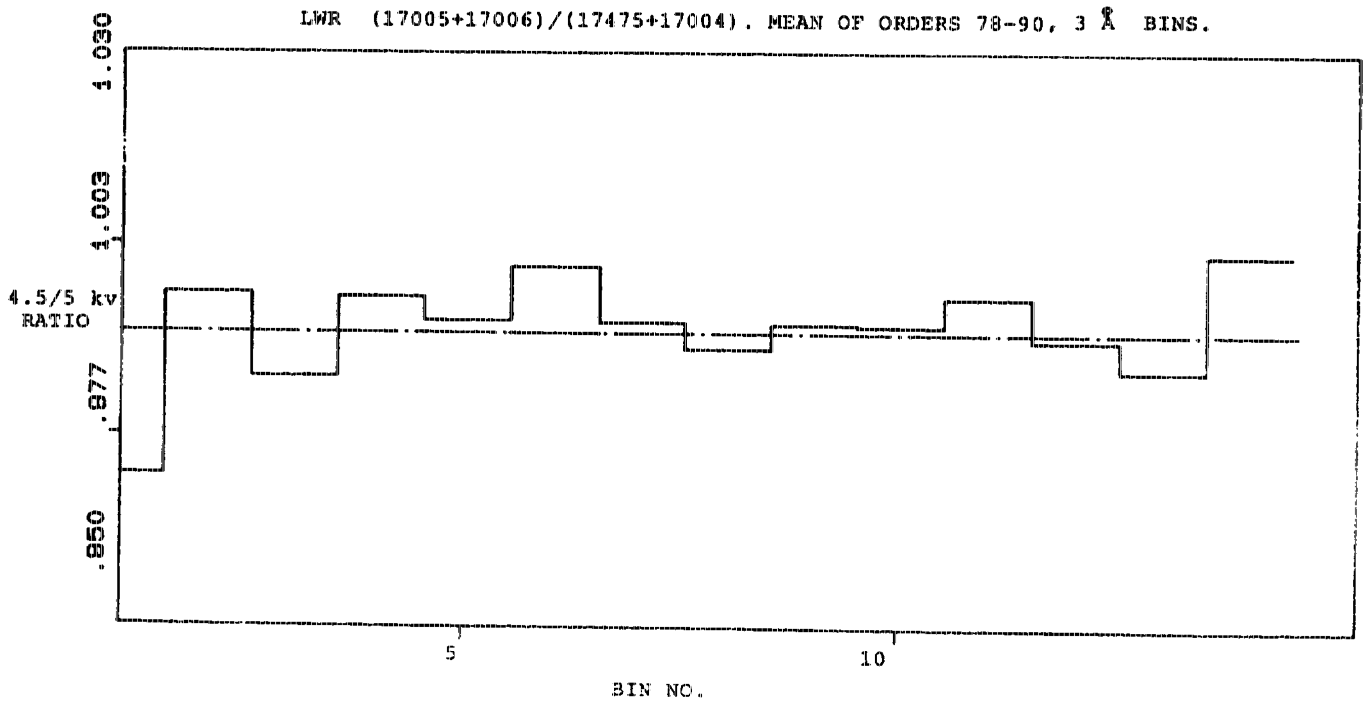

LWR (17005+17006)/(17475+17004). MEAN OF ORDERS 78-90, 3 Å BINS.
1.030
1.003
.977
.950
4.5/5 kv
RATIO
5
10
BIN NO.

Fig. 8

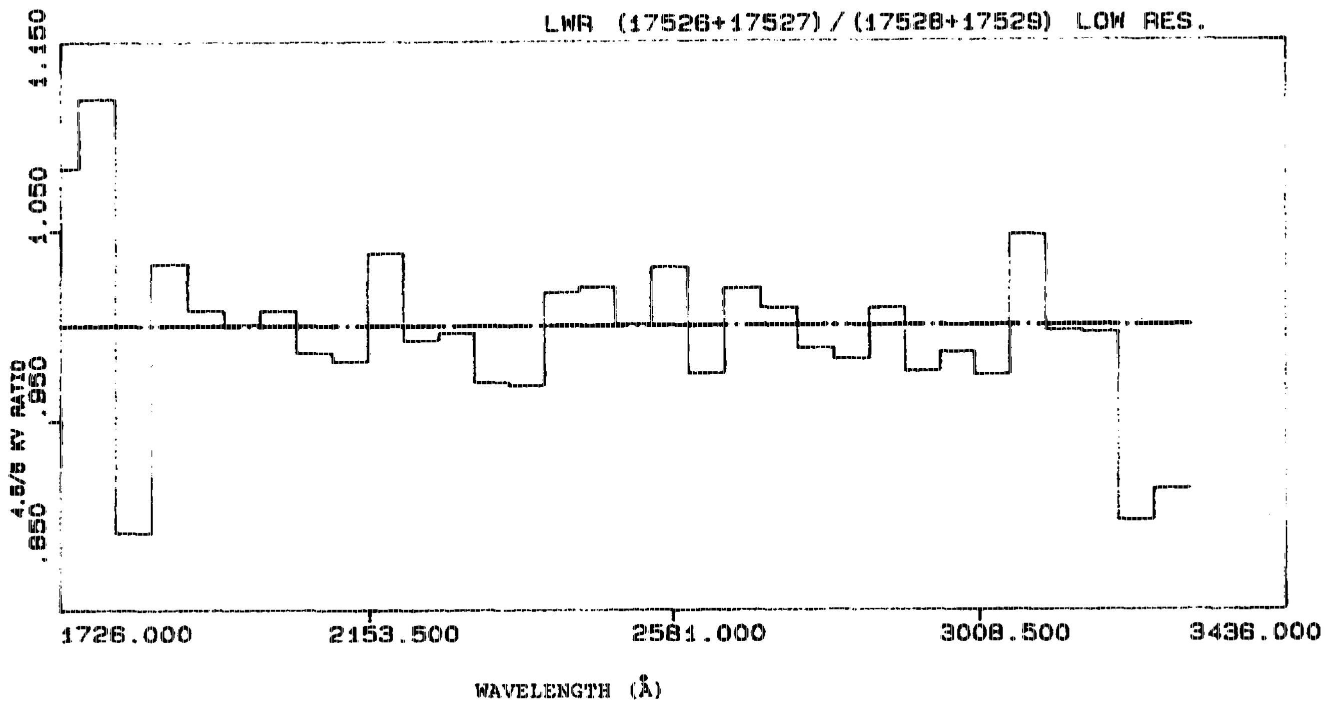

LWR (17526+17527)/(17528+17529) LOW RES.
1.150
1.050
.950
.850
4.5/5 KV RATIO
1726.000
2153.500
2581.000
3008.500
3436.000
WAVELENGTH (Å)

Fig. 9

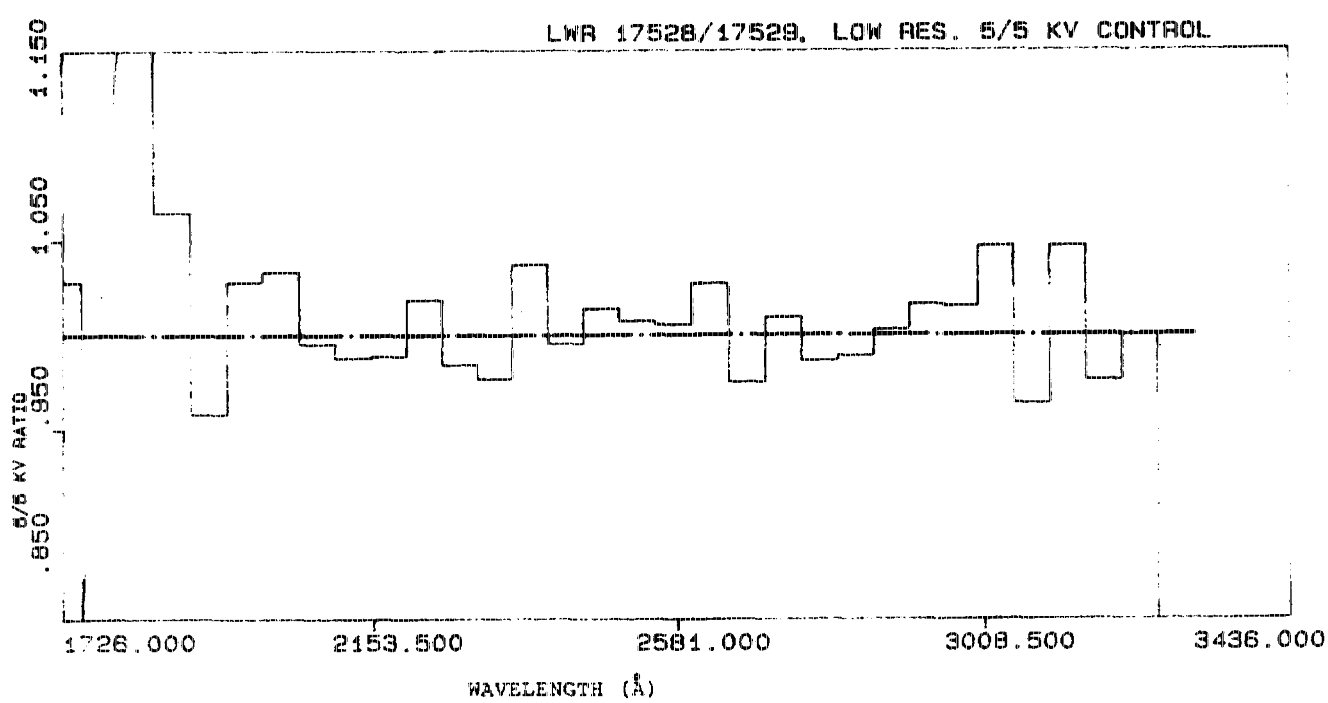

LWR 17528/17529, LOW RES. 5/5 KV CONTROL
1.150
1.050
.950
.850
5/5 KV RATIO
1726.000
2153.500
2581.000
3008.500
3436.000
WAVELENGTH (Å)

Fig. 10