NAS8-35921

SP93-NASA-3405

Final Report

Solar Maximum Mission/Ultraviolet Spectrometer and Polarimeter Studies

February 1993

(NASA-CR-192463) SOLAR MAXIMUM MISSION/ULTRAVIOLET SPECTROMETER AND POLARIMETER STUDIES Final Report (Teledyne Brown Engineering) 45 p

N93-23011

Unclas

G3/92 0157556

TELEDYNE BROWN ENGINEERING

Common sense ... uncommon innovation

Cummings Research Park • Huntsville, Alabama 35807

FINAL REPORT
SP93-NASA-3405

SOLAR MAXIMUM MISSION/ULTRAVIOLET SPECTROMETER AND POLARIMETER STUDIES

February 1993

Prepared By:

William Henze, Jr.

William Henze, Jr.
Principal Investigator

Approved By:

A. Sharpe
Project Manager

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA

Contract No. NAS8-35921

Prepared By

SPACE PROGRAMS
TELEDYNE BROWN ENGINEERING
HUNTSVILLE, ALABAMA

SOLAR MAXIMUM MISSION/ ULTRAVIOLET SPECTROMETER AND POLARIMETER STUDIES

Abstract

This final report for NASA Contract No. NAS8-35921 describes various studies performed for the Ultraviolet Spectrometer and Polarimeter (UVSP) experiment, one of several instruments on the Solar Maximum Mission (SMM) satellite which was launched on 14 February 1980. The UVSP consisted primarily of a Gregorian telescope and an Ebert-Fastie spectrometer with a polarimeter that could be inserted into the light path. The spacecraft and most of the instruments, including the UVSP, operated successfully until 23 November 1980, when part of the SMM attitude control system (fine pointing control) failed. The UVSP was then unable to observe the Sun until 18 April 1984, when the SMM was visited by the space shuttle and the attitude control module was replaced by astronauts. The SMM mission ended when the spacecraft reentered the atmosphere of the Earth and was thereby destroyed on 2 December 1989. The topics covered in this report include the following: (1) Ultraviolet stellar polarimetry (probably the first such attempted measurement); no polarization was detected and the upper limits, based on the sensitivity as determined by the observed count rate, are rather high. (2) An investigation into the possible position of the UVSP wavelength drive after it became stuck on 26 April 1985. (3) Fast timing tests for sit-and-stare observations involving one or two detectors. (4) Development of computer subroutines to allow the calculation of the component of the SMM spacecraft orbital velocity along the line of sight to the Sun at any desired time during the 1984/1985 period when the UVSP wavelength drive was operating properly. (5) Listing of published research papers. (6) Description of the UVSP catalog of observations. (7) Description of UVSP calibration report and data users guide.

This work was done in collaboration with many colleagues from other organizations. The efforts and support of E. Tandberg-Hanssen and E. J. Reichmann of the Marshall Space Flight Center are especially acknowledged.

Table of Contents

List of Tables

List of Figures

SOLAR MAXIMUM MISSION/ ULTRAVIOLET SPECTROMETER AND POLARIMETER STUDIES

1. Ultraviolet Stellar Polarimetry

Summary

In August 1980, the Ultraviolet Spectrometer and Polarimeter experiment on the Solar Maximum Mission satellite attempted to measure polarization in the ultraviolet at 1559 Å (3 Å bandpass) on two B stars, chosen because they are bright in the ultraviolet and because their positions in the sky were conveniently close to the Sun at that time. This was probably the first attempt to do ultraviolet stellar polarimetry. The two stars were Alpha Leonis (Regulus), spectral type B7V, for which little or no visible polarization has apparently been observed and little would be expected, and Rho Leonis, spectral type B1Ib, for which polarization equal to 0.16 per cent in the visible has been observed.

The measurement technique involved analyzing the effect of a rotating quarter-wave plate on the observed signal. No evidence for ultraviolet polarization in the two stars was obtained; the upper limits were set by the observed count rates and are fairly high compared to commonly observed levels in visible stellar polarimetry. The 3-sigma upper limits are 3 per cent for Alpha Leonis and 7 per cent for Rho Leonis.

1.1 Introduction

In August 1980, the Ultraviolet Spectrometer and Polarimeter (UVSP) experiment on the Solar Maximum Mission (SMM) satellite observed two stars whose positions are close to the ecliptic and thus could be conveniently observed by offpointing the SMM from the sun by a relatively small angle. The stellar observations were made primarily to aid in calibrating the sensitivity of the UVSP against the International Ultraviolet Explorer. However, it was decided to take advantage of the opportunity by also attempting to measure polarization in the ultraviolet portion of the spectrum of the two stars. The two stars, Alpha Leonis (Regulus) and Rho Leonis, were chosen because they are B stars and, therefore, are bright in the ultraviolet.

The UVSP consisted primarily of a telescope and spectrometer (Woodgate *et al.* 1980, Henze 1979). Polarimetry was accomplished by inserting a waveplate into the light path and measuring the variation of the signal as the waveplate is rotated.

Some of the stellar polarimetry data were examined briefly in 1980; no obvious polarization signal was detected and nothing further was done with the data until the analysis reported here. Because this was probably the first attempt to measure polarization in the ultraviolet spectrum of stars, the fact that the observations were performed and analyzed is documented here even though no evidence for polarization was actually obtained. The remainder of this section describes the polarimetry observations and their analysis. A summary of the results has been presented at a scientific meeting (Henze and Woodgate 1987).

1.2 Description of Data

The observing sequences were designed by Bruce Woodgate of the NASA Goddard Space Flight Center. In the orbits devoted to stellar polarimetry, several I-Max experiments of decreasing size (24×24 pixels at 10 arc sec spacing, 10×10 pixels at 3 arc sec spacing, and 5×5 pixels at 3 arc sec spacing) were first performed to find the star, beginning in the area of the sky where the star was expected to be. Figure 1-1 illustrates such a sequence for Alpha Leonis. Slit 18 (N) was used; its entrance slit aperture was 10×10 arc sec. The individual polargram experiments consisted of 6 repetitions, each containing measurements at 16 positions of the rotating waveplate; the gate time for an individual measurement was 0.992 seconds. After each polargram, which required 100 seconds for execution, the smallest I-Max experiment was repeated to be sure that the star had not drifted out of the entrance slit. Another polargram was then executed and so on for the entire SMM orbit. Detectors 4 and 3 were used; the exit slit for detector 4 was 3.0 Å wide while the exit slit width for detector 3 was 0.5 Å. Although the data from both detectors have been analyzed and the results presented here, it is detector 4, bcause of its wider exit slit and, therefore, higher count rate, which provides the more meaningful results.

The wavelength positions of the exit slits were determined from the wavelength drive step number for these observations (80376), the wavelength drive step number (mean at approximately 85830) at a known spectral line (1548.19 Å) during spectral scans (experiment numbers 9449, 9451, 9453, 9931, 9943) with a different slit (slit 12, detector 3) close in time to the stellar observations, the offsets for the step numbers relating the various exit slits (4340 for slit 12, detector 3; 4259 for slit 18, detector 3; 921 for slit 18, detector 4), and the dispersion relating changes in wavelength to changes in step number (193.3 Å per step at 1550 Å). The results are that the exit slit for detector 4 was centered at 1558.7 Å and the exit slit for detector 3 was at 1576.0 Å.

Alpha Leonis passed above the north pole of the sun on 22 August 1980 with the closest approach being approximately 0.73 solar radii above the pole. Two SMM orbits were used for polarimetry. The polargrams were the odd-numbered experiments in the ranges 9703 to 9745 and 9749 to 9791. The experiments which were not used in the analysis and the corresponding reasons are the following:

9725 shows increasing count rate
9735 shows decreasing count rate
9741 shows starset
9743, 9745 occurred after starset
9749 shows decreasing count rate at end
9753 shows increasing count rate
9759 shows increasing count rate at beginning
9765, 9775 shows slightly increasing count rate
9781 shows decreasing count rate
9787 shows starset
9789, 9791 occurred after starset.

Rho Leonis was actually occulted by the sun on 29 August 1980. Polarimetry was attempted on two SMM orbits before occultation and one orbit after occultation. The orbit immediately before occultation was useless because the limb of the sun was in the field of view of the I-Max experiments and therefore a point on the sun was found as the brightest point. The polargrams in the two good orbits were the even-numbered experiments in the range 10526 to 10566 and the odd-nunbered experiments in the range 10671 to 10711. The experiments which were not used in the analysis were the following:

10526 shows increasing count rate
10546 has missing points
10558 shows increasing count rate at beginning
10560, 10562, 10564, 10566 occurred during South Atlantic Anomaly
10677 shows slightly decreasing count rate at end
10705 contains glitch
10707 contains glitches and shows starset
10709, 10711 occurred after starset.

1.3 Analysis Procedure

The analysis procedure for UVSP polargrams has been described by Henze (1984). It is the same as that used by Henze and Stenflo (1987) and is similar to that used by Henoux *et al.* (1983). First, however, the six repetitions in each polargram were coadded, and then all the usable polargrams for each star as specified in the previous section were coadded. The basic data set for each star thus consisted of the signal measured at 16 equally spaced values of the waveplate position angle (22.5° apart). A Fourier analysis of the 16 data points was performed and the Stokes parameters were determined from the Fourier coefficients (Berry *et al.* 1977) using laboratory-measured values of the retardance of the waveplate (270°) and the polarization of the spectrometer grating (0.65) which was used as the analyzer.

1.4 Results and Discussion

The observations and their power spectra are shown in the figures. Figures 1-2 and 1-3 show Alpha Leonis while Figures 1-4 and 1-5 show Rho Leonis. Figures 1-2 and 1-4 show detector 4 while Figures 3 and 1-5 show detector 3. The upper plot in each figure shows the summed counts minus the mean value wuith the Fourier components superimposed for frequency index values equal to 2 and 4. The component with index 4 corresponds to linear polarization while index 2 corresponds to circular polarization. The lower plots show the power spectrum as a function of frequency index where the upper and lower lines indicate the statistical uncertainties at the 1-sigma level.

No significant peaks can be seen in the power spectra at the frequency index values of 4 and 2, especially if one multiplies the uncertainties by 3 to test at the commonly used 3-sigma level.

If one does assume that the Fourier components at 4 and 2 are due to polarization, one obtains the numerical results shown in Table 1.1. The statistical uncertainties here are 3 sigma. Again, the uncertainties are larger than the inferred values of the polarization, leading to the conclusion that we have not detected any polarization. The 3-sigma uncertainties provide upper limits.

Table 1.1 Stellar Polarimetry Results

	Alpha Leo		Rho Leo	
	Det. 4	Det. 3	Det. 4	Det. 3
Mean Intensity (counts)	8508	857	2301	226
Linear Polarization (%)	2.3 ± 3.4	8.6 ± 11.4	2.1 ± 6.8	1.9 ± 21.6
Circular Polarization (%)	0.7 ± 1.7	1.6 ± 5.7	0.5 ± 3.4	1.9 ± 10.8

Alpha Leonis or Regulus, H087901, is of spectral type B7V. Kemp *et al.* (1987) have looked for variable polarization in the visible spectrum from Regulus (among other bright stars). If they have really measured any polarization at all, it is at the level of 0.001 per cent. Other than that possibility, no polarization in the visible has apparently been observed and little would be expected (A. Code, private communication). Rho Leonis, HD91316, is of spectral type B1Ib; polarization in the visible spectrum of 0.16 per cent has been observed (listing by Mathewson and Ford 1970). The rather high upper limits for the ultraviolet polarization given above are therefore probably too high to be astrophysically interesting.

1.5 References

Berry, R. G., Gabrielse, G., and Livingston, A. E.: 1977, *Applied Optics* **16**, 3200.

Henoux, J. C., Chambe, G., Semel, M., Sahal, S., Woodgate, B., Shine, R., Beckers, J., and Machado, M.: 1983, *Astrophys. J.* **265**, 1066.

Henze, W.: 1979, "The Ultraviolet Spectrometer and Polarimeter Experiment on the Solar Maximum Mission: A General Description", Teledyne Brown Engineering, Huntsville, Alabama, Interim Contract Report No. PI79-MSFC-2323.

Henze, W.: 1984, "Research in Solar Physics: Some Techniques for Analyzing Data from the Ultraviolet Spectrometer and Polarimeter", Teledyne Brown Engineering, Huntsville, Alabama, Final Report No. SPB4-MSFC-2726.

Henze, W., and Stenflo, J. O.: 1987, *Solar Physics* **111**, 243.

Henze, W., and Woodgate, B. E.: 1987, presentation at Joint Meeting of the American Astronomical Society and the Canadian Astronomical Society, Vancouver, British Columbia, June 1987; abstract in *Bull. American Astron. Soc.* **19**, 724.

Kemp, J. C., Henson, G. D., Kraus, D. J., and Dunaway, M. H.: 1987, presentation at Joint Meeting of the American Astronomical Society and the Canadian Astronomical Society, Vancouver, British Columbia, June 1987; abstract in *Bull. Anerican Astron. Soc.* **19**, 752.

Mathewson, D. S., and Ford, V. L.: 1970, *Mem. Royal Astron. Soc.* **74**, 139.

Woodgate, B. E., Tandberg-Hanssen, E. A., Bruner, E. C., Beckers, J. M., Brandt, J. C., Henze, W., Hyder, C. L., Kalet, M. W., Kenny, P. J., Knox, E. D., Michalitsianos, A. G., Rehse, R., Shine, R. A., and Tinsley, H. D.: 1980, *Solar Physics* **65**, 73.

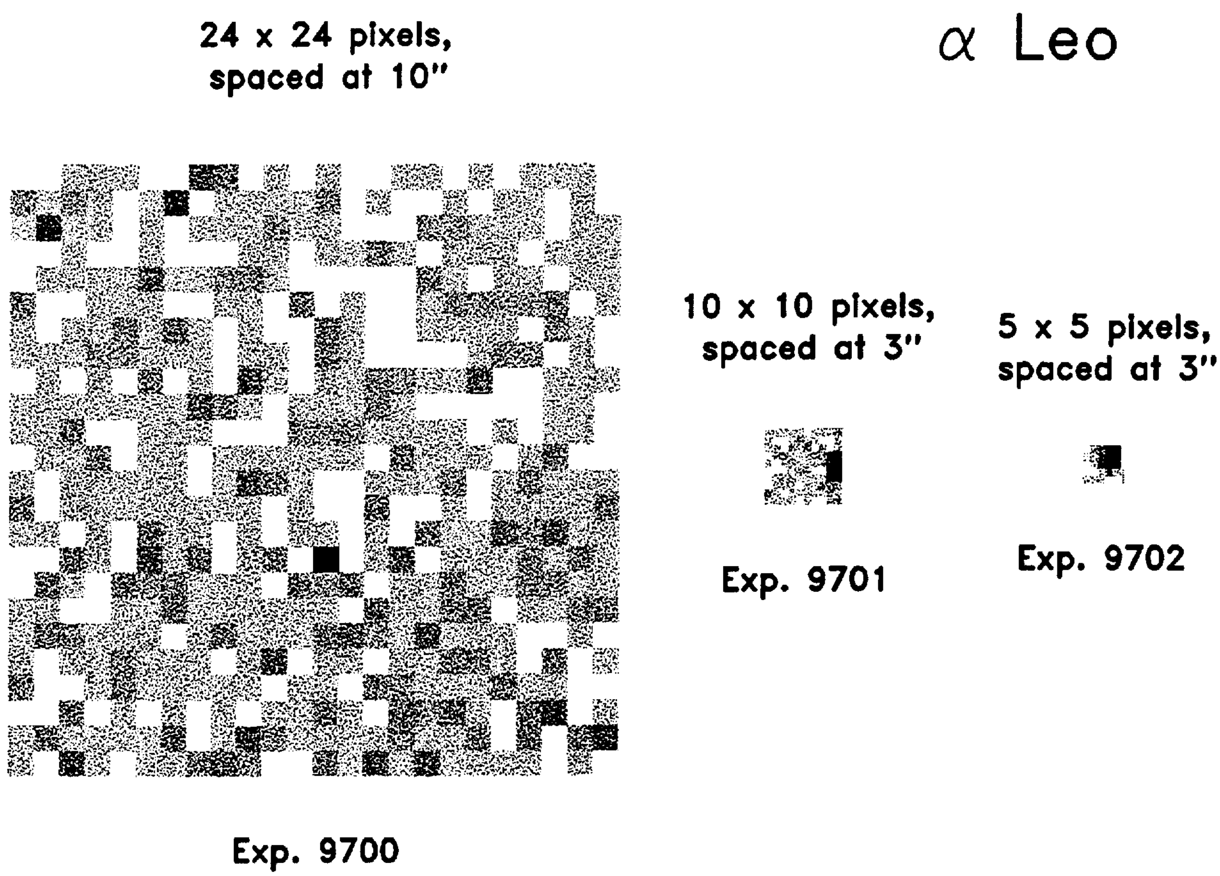


Figure 1-1. Star-finding rasters.
Gray-scale images of rasters of decreasing size used by the UVSP to find Alpha Leonis. The UVSP experiment numbers are given below each image.

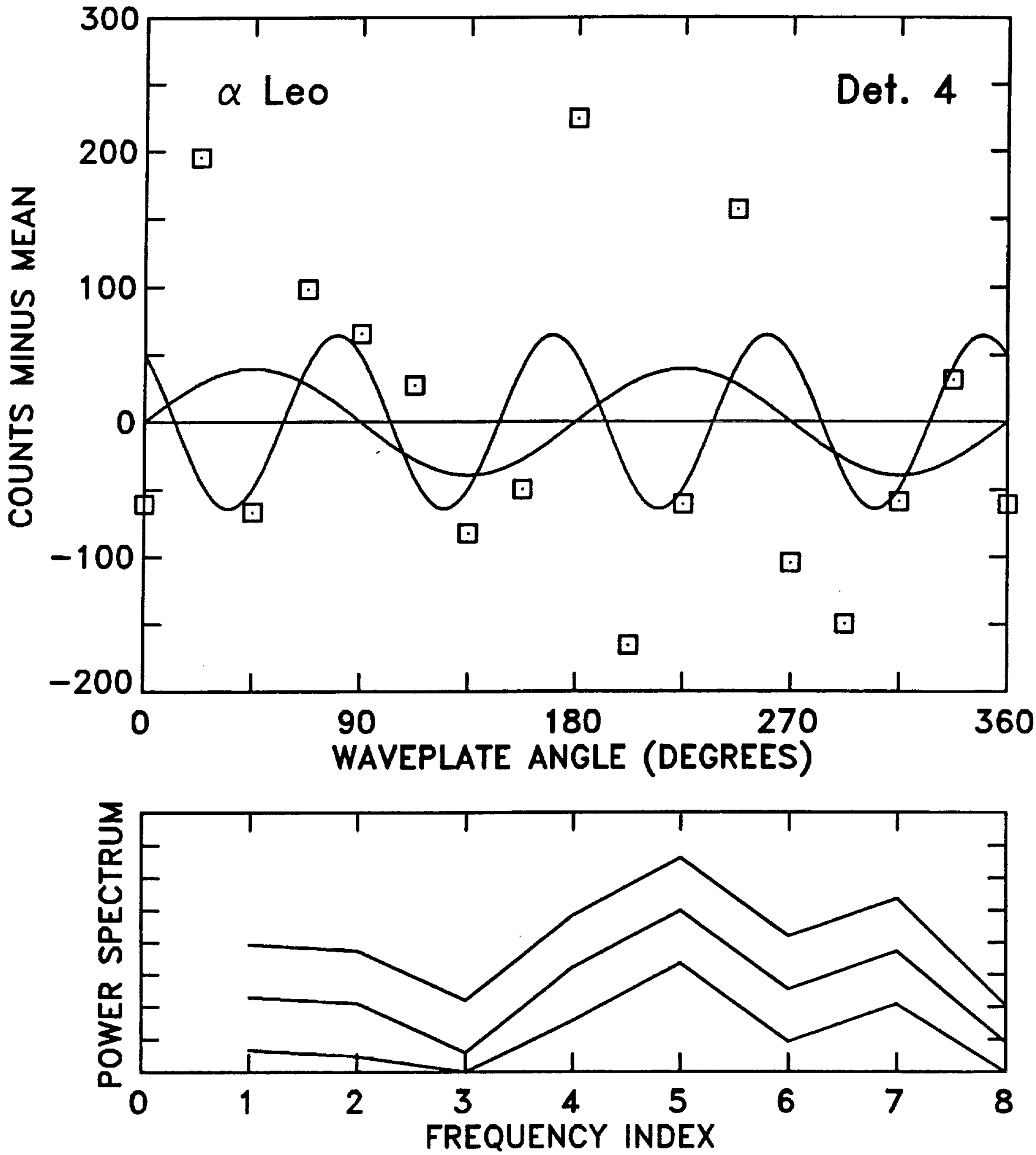


Figure 1-2. Polarimetry for Alpha Leonis, Detector 4.
Top: Squares – Observed counts minus mean versus waveplate angle. Curve with 4 cycles – Fourier component with frequency index = 4, supposedly corresponding to linear polarization. Curve with 2 cycles – Fourier component with frequency index = 2, supposedly corresponding to circular polarization. Bottom: Power spectrum of observed counts with respect to waveplate angle ± 1 sigma statistical uncertainties. Frequency index values of 2 and 4 should correspond to circular and linear polarization respectively.

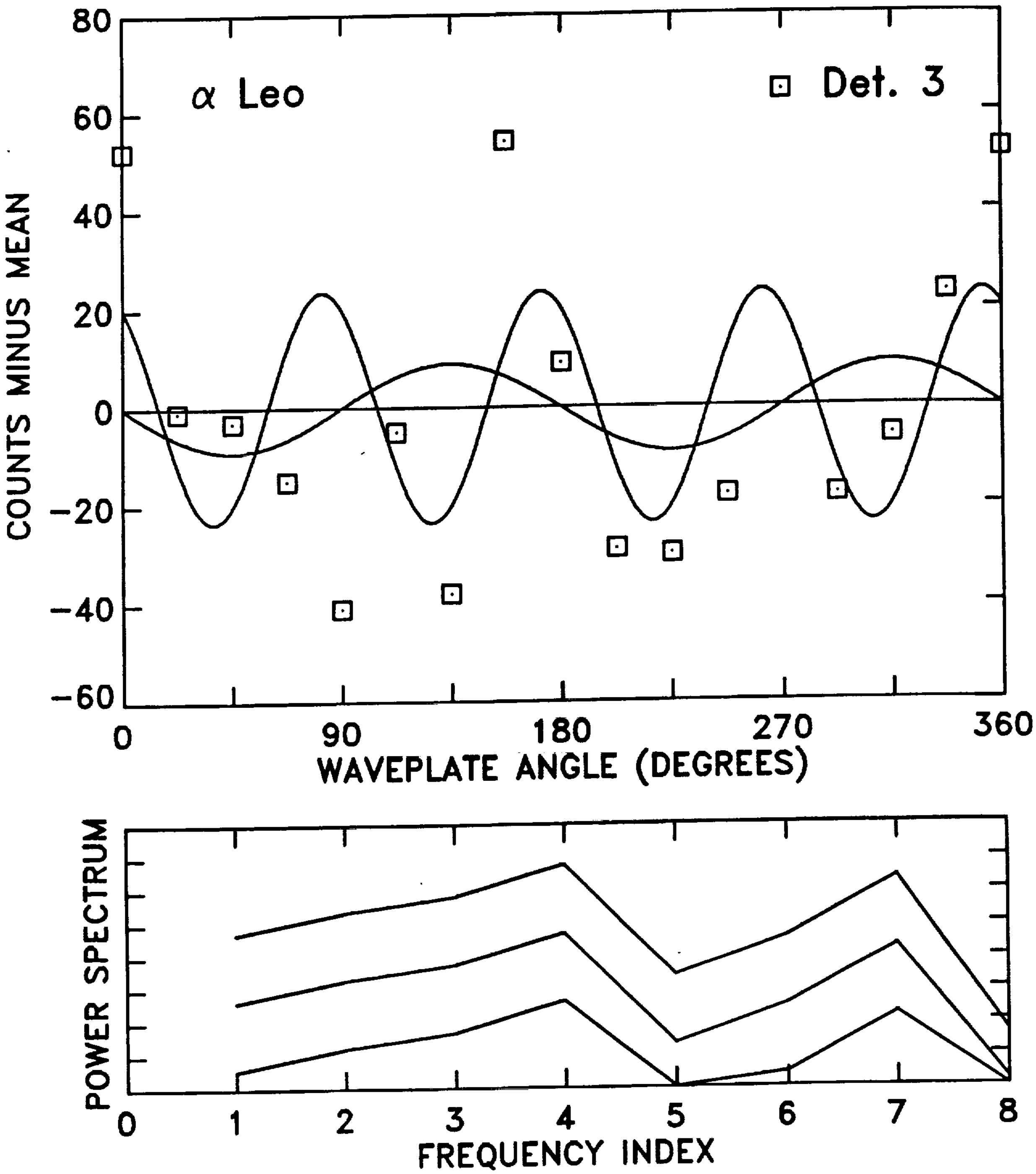


Figure 1-3. Polarimetry for Alpha Leonis, Detector 3.
Top: Squares – Observed counts minus mean versus waveplate angle. Curve with 4 cycles – Fourier component with frequency index = 4, supposedly corresponding to linear polarization. Curve with 2 cycles – Fourier component with frequency index = 2, supposedly corresponding to circular polarization. Bottom: Power spectrum of observed counts with respect to waveplate angle ± 1 sigma statistical uncertainties. Frequency index values of 2 and 4 should correspond to circular and linear polarization respectively.

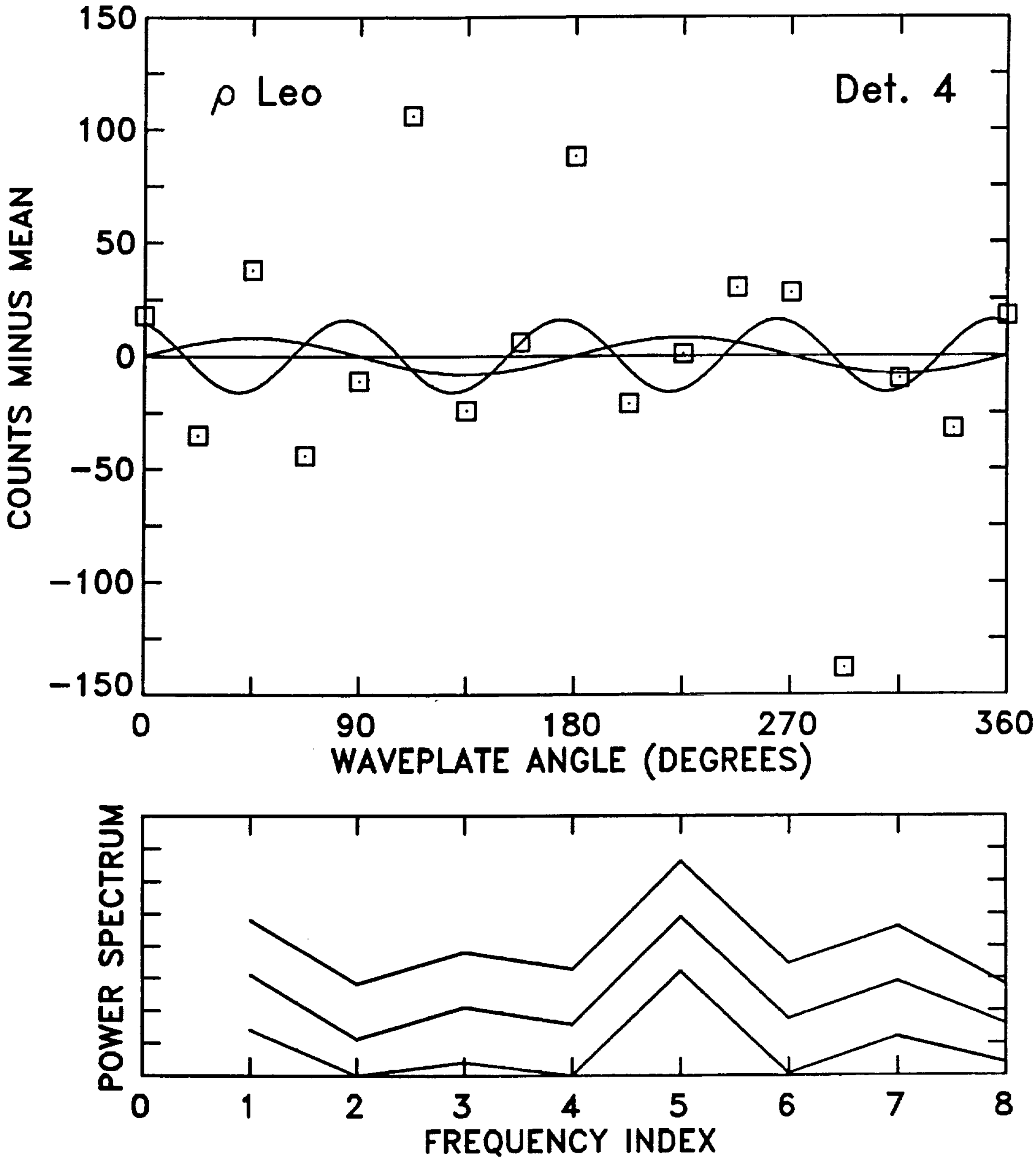
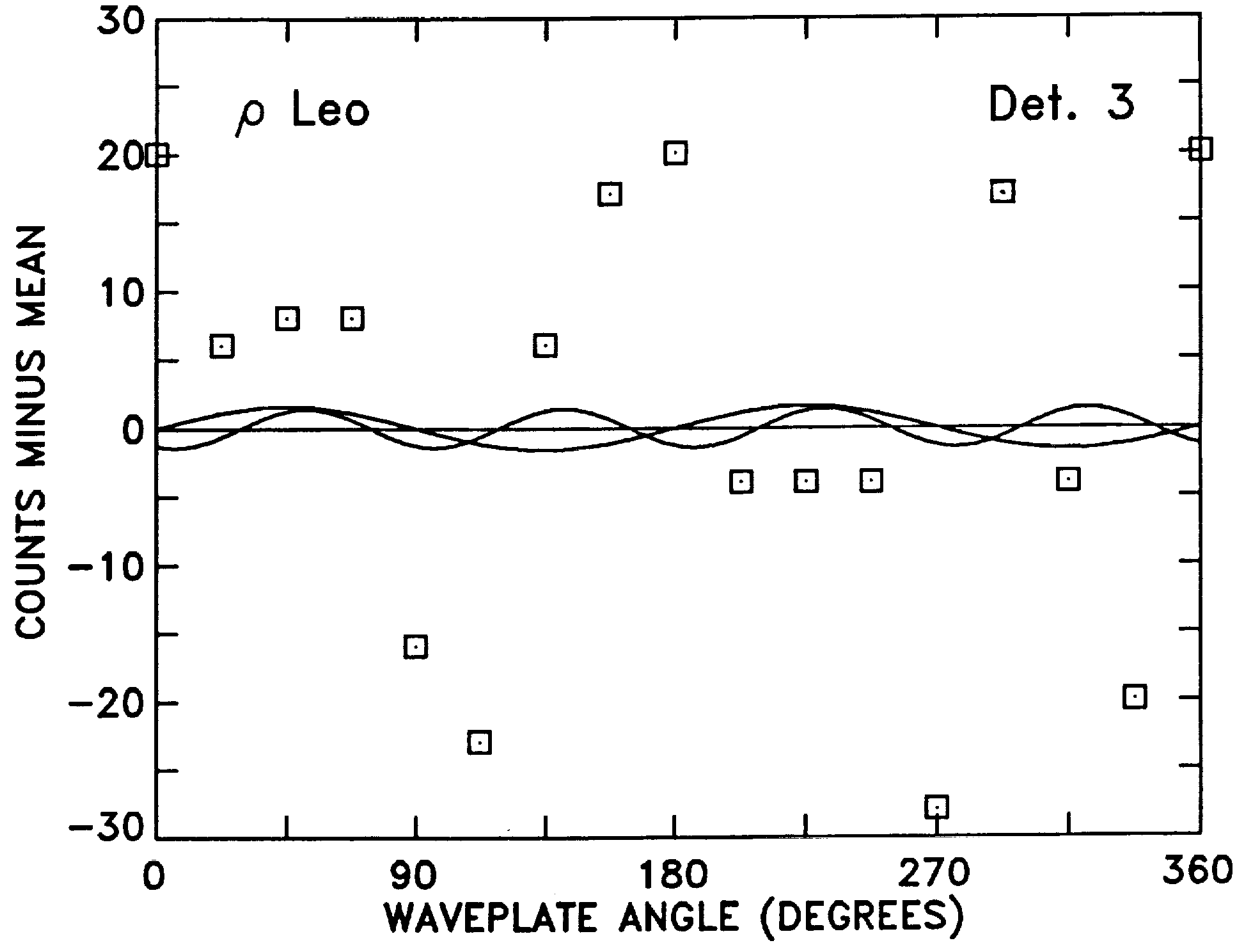


Figure 1-4. Polarimetry for Rho Leonis, Detector 4.
Top: Squares – Observed counts minus mean versus waveplate angle. Curve with 4 cycles – Fourier component with frequency index = 4, supposedly corresponding to linear polarization. Curve with 2 cycles – Fourier component with frequency index = 2, supposedly corresponding to circular polarization. Bottom: Power spectrum of observed counts with respect to waveplate angle ± 1 sigma statistical uncertainties. Frequency index values of 2 and 4 should correspond to circular and linear polarization respectively.



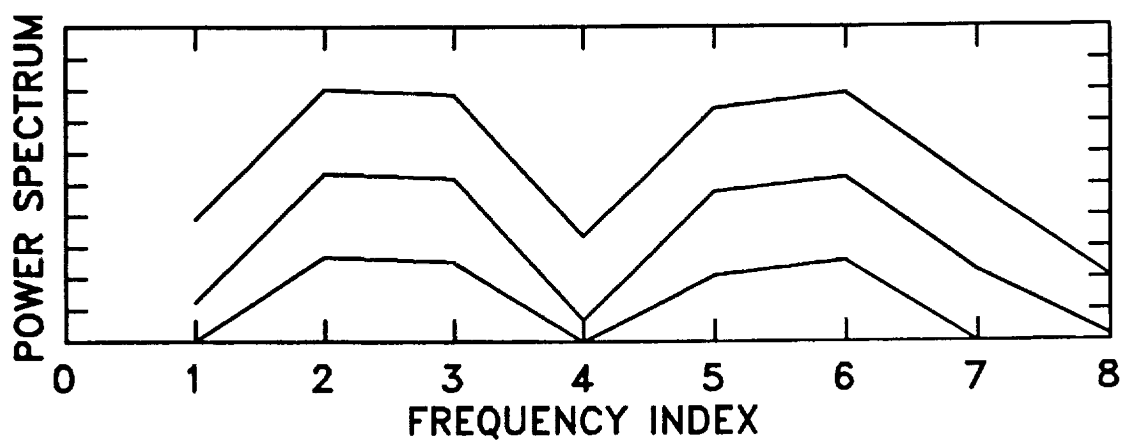


Figure 1-5. Polarimetry for Rho Leonis, Detector 3.
Top: Squares – Observed counts minus mean versus waveplate angle. Curve with 4 cycles – Fourier component with frequency index = 4, supposedly corresponding to linear polarization. Curve with 2 cycles – Fourier component with frequency index = 2, supposedly corresponding to circular polarization. Bottom: Power spectrum of observed counts with respect to waveplate angle ± 1 sigma statistical uncertainties. Frequency index values of 2 and 4 should correspond to circular and linear polarization respectively.

2. Final Stuck Position of the UVSP Wavelength Drive

An analysis was performed to attempt to determine the final position of the UVSP wavelength drive (WLD) after it became stuck on 26 April 1985. The investigation was inspired in part by work originally done by Joseph Gurman of the Goddard Space Flight Center. The conclusion, based on this analysis, is that the most probable position of the UVSP wavelength drive is at step number 115380 which corresponds to a wavelength in air of 2787.83 Å for slit 20, detector 5. This section contains a description of how this conclusion was reached.

The basic method involves finding wavelengths in the vicinity of 2760 to 2810 Å which satisfy certain conditions. These conditions are the count rate in slit 20, detector 5, and the ratio of the count rates for detector 5, slits 20 and 12. Also considered later will be the variation of the count rates during an orbit for detector 5, slits 20 and 12. The result will then be used to compute the positions of the exit slits for the second-order detectors which were still functional, detectors 1 and 3, which will be compared to earlier conclusions reached from the observed count rates in those detectors.

2.1 Count Rates in Detector 5

The observed count rate for detector 5 at disk center after the wavelength drive became stuck on 26 April 1985, is taken from experiments 43348–43351 for slit 20 and 43344–43347 for slit 12. These experiments were run on 9 September 1986. They consisted of sit-and-stare observations over one entire orbit for each slit (4 experiments per orbit); the experiment definition name was AEROTEST.V01. The observations and the ratio of the datasets are shown in Figures 2-1 through 2-3. The observed counts in slit 20 and the point-by-point ratio of slit 20 to slit 12 were smoothed with a running mean and the minimum and maximum were determined to provide the basis for the limits used in the search program. Those limits were 300 and 500 for the counts per 0.056 s in slit 20, detector 5, and 3.3 and 5.6 for the ratio of the counts in slit 20 to slit 12.

Only a few UVSP spectra at disk center were available for comparison with the observed count rates. The ideal situation would be to have spectra of the entire spectral region, i.e., from about 2760 to 2810 Å, in both slit 20 and slit 12. No such spectra for the entire spectral range exist; however, a pair of spectra does exist for a more limited spectral range. They are shown in Figure 2-4. Experiment 26425 in slit 20 covered the range from 2794.5 to 2809 Å (air) while the corresponding experiment in slit 12 was 26428 which had exactly the same definition and, therefore, covered exactly the same range of WLD steps. No positions were found which satisfied both conditions, i.e., on the count rate in slit 20 (corrected for different gate times) and on the ratio of slit 20 to slit 12.

Although no satisfactory positions were found using experiments 26425 and 26428, they are useful for verifying that the difference in WLD steps for detector 5 between slits 20 and 12 is close to the value of 186 steps (almost 2 Å) which is computed at 2800 Å. The computations include conversions between WLD step number and wavelength, either vacuum or air, for any desired slit and detector; they are based on the grating equation and use the spatial positions of the entrance and exit slits as given in Table 3.2–2 on page 3–24 of the report by Knox *et al.* (1980). The actual difference between the maxima at the Mg II k2 blue peak in the two spectra was 184 steps; I decided to use the value of 186 after a test comparing the two values did not show any significant difference between the results.

Because no spectra for both slits 20 and 12 existed covering the entire spectral region of interest, the approach taken was to use experiment 21578, a long spectral scan at disk center in slit 20, detector 5, and then to generate an artificial spectrum for slit 12. The nominal exit slit width for slit 12 was 3 times that for slit 20 and the sample spacing in experiment 21578 was 2 WLD steps or one exit slit width for slit 20. Therefore, the artificial spectrum for slit 12 was generated by smoothing experiment 21578 by a 3-point running mean, shifting it by 186 WLD steps ($186/2 = 93$ points), and dividing by a sensitivity correction factor of 7.98. The factor 7.98 was determined by taking the observed ratio of the sum of the counts between the Mg II h and k lines (not including the h2 and k2 emission features) for experiments 26425 and 26428; the factor is very close to the ratio of the entrance slit areas (180/9) times the ratio of the nominal exit slit widths (1/3) which equals 6.67. The result is shown in Figure 2-5.

Computer programs generated the artificial spectrum just described, plotted the spectra and their ratio, and then searched for WLD positions satisfying the conditions discussed earlier. One additional constraint imposed was that a satisfactory WLD position or range actually had to consist of more than one wavelength point. This last constraint was actually expanded subjectively when examining the results from the programs. The reason for this is that the variation of the component of the orbital velocity along the line of sight toward the Sun is large enough during an orbit (up to $\pm$ 7.5 km s^{-1} or approximately 0.14 Å but perhaps more typically 0.10 Å) that a contiguous range of at least 0.10 Å must satisfy the conditions. This means that the total of 27 ranges with at least two contiguous wavelength points found by program S21578A in the spectral region from 2760 to 2810 Å can be reduced to 3 ranges with at least 6 contiguous points. These are centered at 2787.85, 2888.25, and 2789.40 Å and are shown in more detail on the expanded plots in Figures 2-6 and 2-7.

2.2 Orbital Variation of Count Rates

To further constrain the possible solutions, we note that the time variations of the sit-and-stare observations for slit 20 during an entire orbit (experiments 43348–43351) are what would be expected if the exit slit were scanning (due to the orbital velocity of the SMM spacecraft) through a narrow, relatively weak absorption line. On the other hand, the time variations of the sit-and-stare observations for slit 12 (experiments 43344–43347) are small and are consistent with a relatively flat part of the spectrum. All three of the possible ranges have slit 12, detector 5, in flat spectral regions and therefore, cannot be excluded on that basis. With regard to the variations expected for slit 20, the range at 2788.25 Å is clearly excluded because it is entirely in one wing of a relatively deep line. The range at 2789.40 Å is not so obviously excluded but the long-wavelength side of the absorption feature at 2789.37 Å (corresponding to the beginning of the orbit) does not seem to be high enough compared to the bottom of the line. Still, the wavelength of 2789.37 Å (air) corresponding to a WLD step number of 115230 is a possibility. Finally, the range at 2787.85 Å seems to best satisfy the requirements with the absorption feature at 2787.83 Å (air) for slit 20, detector 5, corresponding to a WLD step number of 115380, being chosen as the most probable position of the wavelength drive.

2.3 Count Rates in Other Detectors

As a final test, the positions of the exit slits for detectors 1 and 3 in all of the slit sets were plotted for the WLD step numbers 115380 and 115230 in Figures 2-8 and 2-9. The slit positions are shown against the UVSP second-order "Atlas" spectrum made at disk center (courtesy of Richard Shine). No strong lines, such as the O V line at 1371.29 Å or the Si IV line at 1393.76 Å in the "Atlas" spectrum, fall in any of the exit slits, which is consistent with the results of the count rate tests done separately. (Those count rate tests were made primarily in quiet regions near the limb. The count rates for detectors 1 and 3, when corrected for entrance slit area and nominal exit slit width, all agreed to within a factor of approximately 2, indicating that no strong line is evident in any of those exit slits.) Rasters in many (or all?) of the exit slits show plage structure and transient brightenings, but this would be expected even from the continuum which is probably representative of the low chromosphere in this part of the spectrum. For this reason, even if a weak line (at least in the quiet Sun) were to fall within an exit slit, its expected brightening during activity would be difficult to distinguish from continuum brightening and could not be used as proof that such a line were being observed. With this in mind, there does appear to be a weak line at 1375.8 Å in experiment 21126 (not plotted but which consisted of a spectrum made in or near an active region near the east limb but with a relatively short gate time and a very coarse wavelength sampling of 0.1 Å) which would be seen by detector 1 of slits 1 and 2, definitely if the WLD step number were 115230 and possibly if it were 115380. This feature might be a group of three lines within approximately 0.1 Å of that wavelength, including an Fe II line, in the line list published by Sandlin *et al.* (1986). Unfortunately, there are several other equally strong lines in the list by Sandlin *et al.* which possibly do or do not appear in the spectrum of experiment 21126, some of which should fall within at least one exit slit, so that the feature at 1375.8 Å does not appear to be useful. It has also been observed that detector 3 of slit 7 or 8 is enhanced to a greater extent than detector 1 during a flare. This observation might potentially be more useful, but, again, examination of the list by Sandlin *et al.*does not allow a conclusive choice between the two possible WLD positions under consideration. In experiment 28485 (not plotted but which was made off the limb with the very large slit 21), there is a line at 1392 Å which may be an Ar XI line at 1392.12 Å and which should fall in detector 3 of slits 13 and 14 if the WLD step number were 115230. However, this line has not been observed on the disk and would probably be very difficult to detect by the UVSP; therefore, it too does not seem to provide a useful test for the WLD position.

2.4 References

Knox, E. D., Sterk, A., Bethke, G., Franklin, R., and Buzinski, R. 1980: "High Resolution Ultraviolet Spectrometer and Polarimeter for the Solar Maximum Mission", SD Document No. 80SDS4233, General Electric Company (Space Division), Philadelphia, Pennsylvania.

Sandlin, G. D., Bartoe, J.-D. F., Brueckner, G. E., Tousey, R., and VanHoosier, M. E.: 1986, *Astrophys. J. Supp.* **61**, 801.

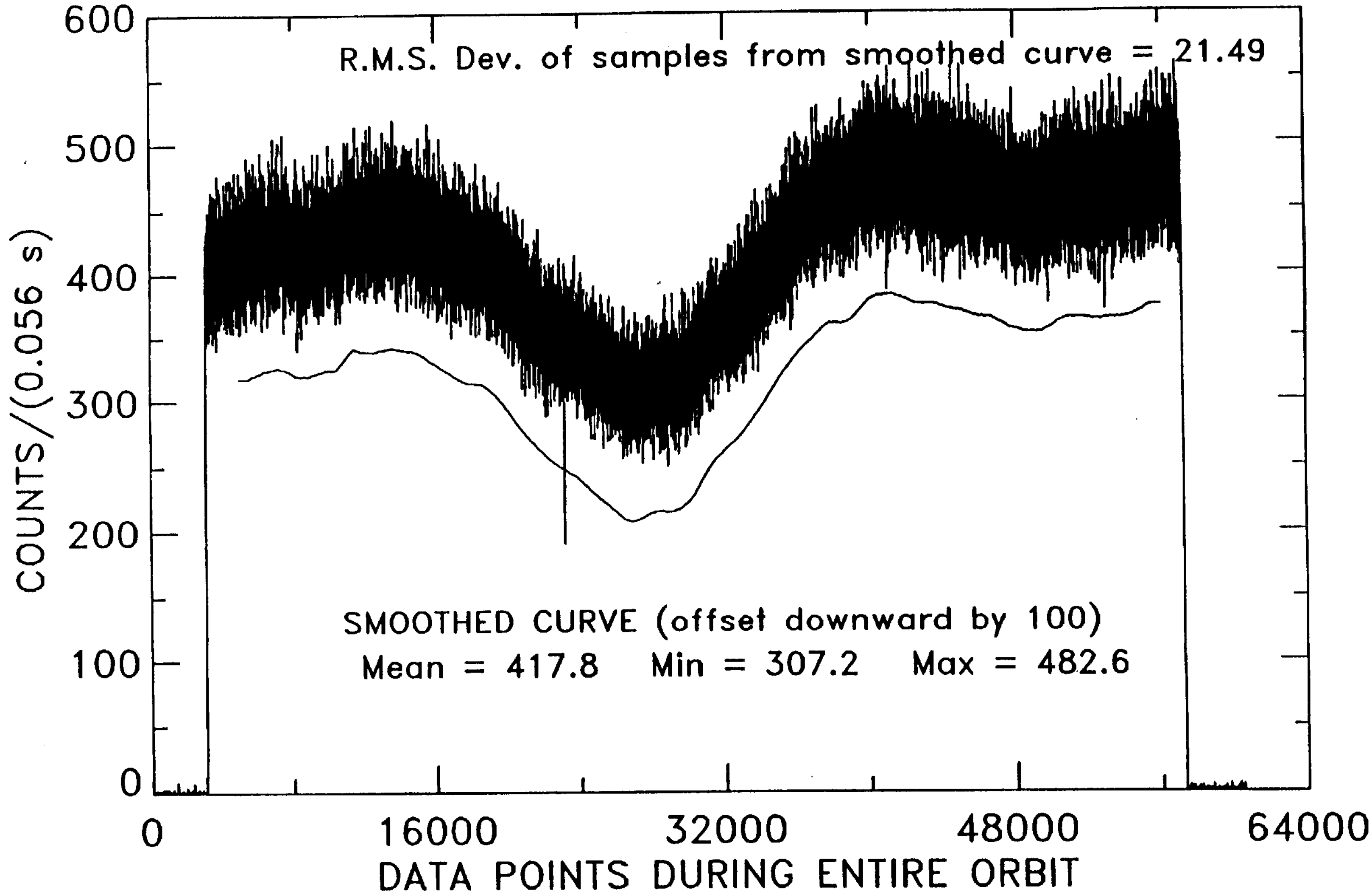


Figure 2-1. Orbital variation of count rate, Slit 20, Det. 5.
The count rate in slit 20, det. 5, is plotted for the complete daylight portion of an SMM orbit on 9 September 1986. Experiments 43348–43351 have been combined. The wavelength drive was at its final stuck position. Also shown (offset downward by 100 counts) is a smoothed curve obtained by forming a running mean.

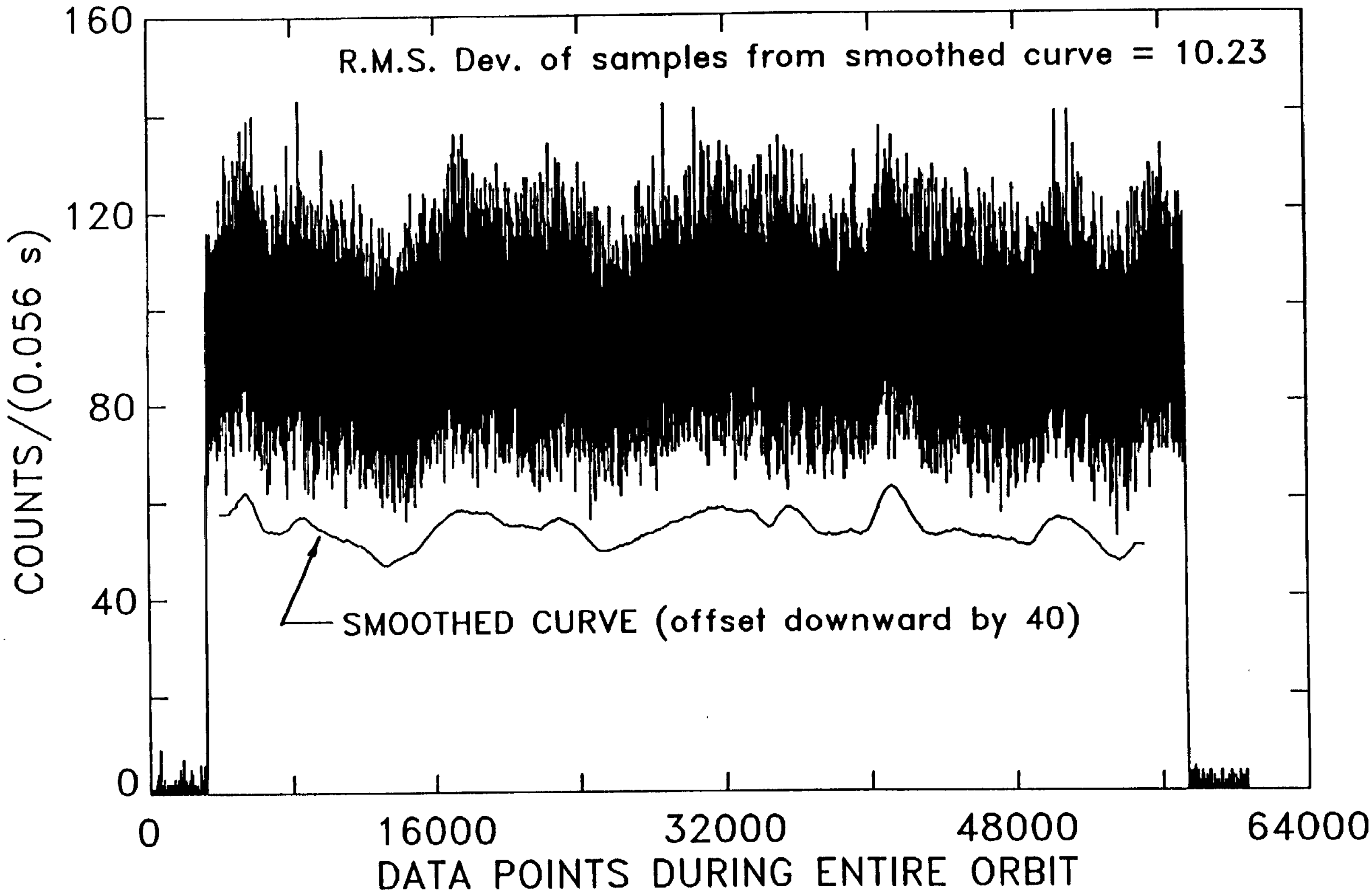


Figure 2-2. Orbital variation of count rate, Slit 12, Det. 5.

The count rate in slit 12, det. 5, is plotted for the complete daylight portion of an SMM orbit on 9 September 1986. Experiments 43344–43347 have been combined. The wavelength drive was at its final stuck position. Also shown (offset downward by 40 counts) is a smoothed curve obtained by forming a running mean.

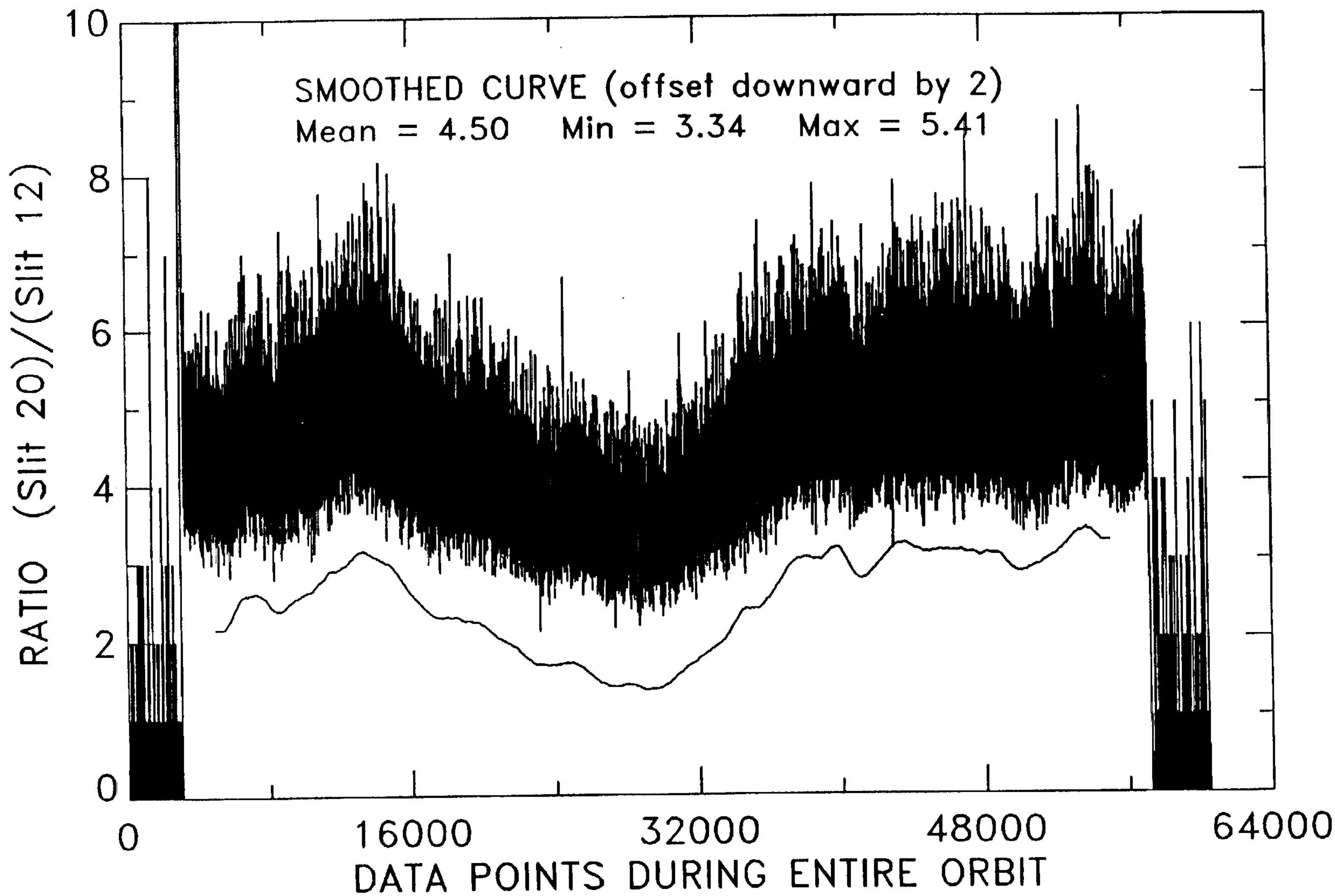


Figure 2-3. Orbital variation of ratio of count rates, Slit 20 to Slit 12.
The ratio of count rates in det. 5 for slit 20 to slit 12 is plotted for the daylight portion of the SMM orbit. The observations for the two slits were made in adjacent orbits and are the same data plotted in Figures 2-1 and 2-2. The wavelength drive was at its final stuck position. Also shown (offset downward by 2 in the ratio) is a smoothed curve obtained by forming a running mean.

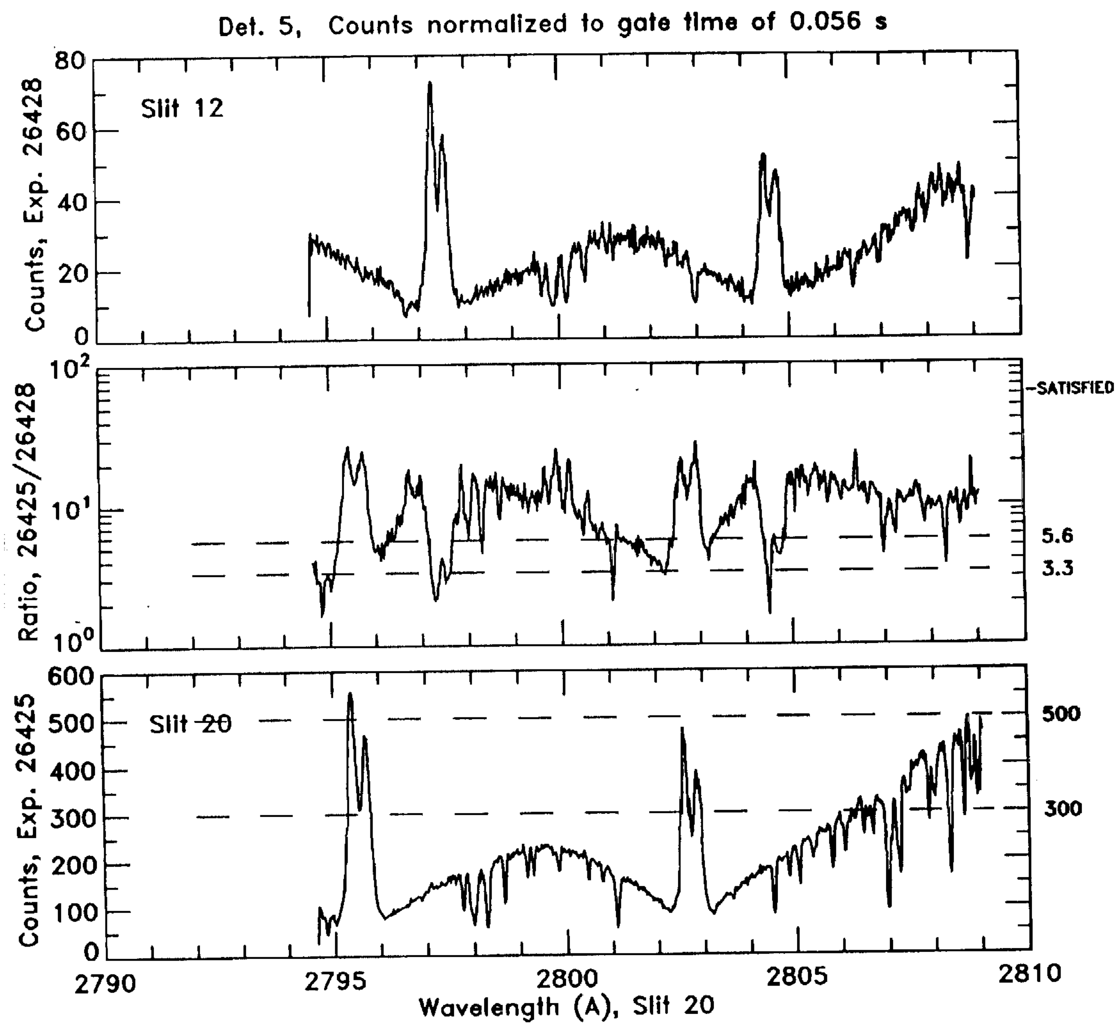


Figure 2-4. Spectra, Slit 20 and Slit 12, 2794–2809 Å.
The count rates in the plots have been corrected to correspond to the gate time in the sit-and-stare experiments in Figures 2-1 and 2-2. Bottom: spectrum in slit 20, det. 5, from UVSP experiment 26425. Dashed lines indicate expected or allowed range of counts. Top: spectrum in slit 12, det. 5, from UVSP experiment 26428. Center: ratio of spectra in det. 5, slit 20 to slit 12, at the same wavelength drive positions. Dashed lines indicate expected or allowed range of ratios. No positions were found which satisfied both conditions.

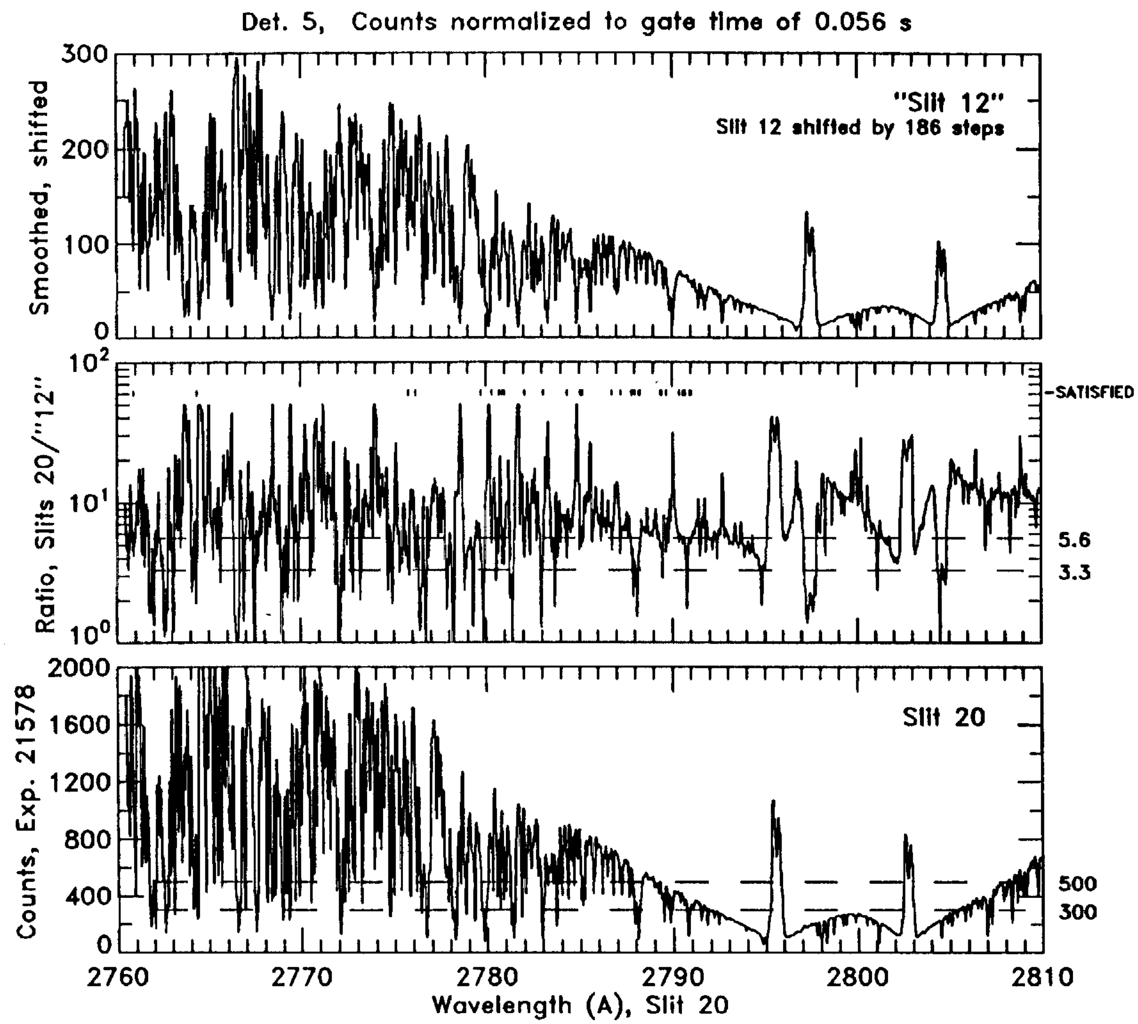


Figure 2-5. Spectra, Slit 20 and artificial Slit 12, 2760–2810 Å.

The count rates in the plots have been corrected to correspond to the gate time in the sit-and-stare experiments in Figures 2-1 and 2-2. Bottom: spectrum in slit 20, det. 5, from UVSP experiment 21578. Dashed lines indicate expected or allowed range of counts. Top: artificial spectrum in "slit 12", det. 5, generated by smoothing and shifting the slit 20 spectrum. Center: ratio of spectra in det. 5, slit 20 to "slit 12", at the same wavelength drive positions. Dashed lines indicate expected or allowed range of ratios. The small bars, with label "SATISFIED" at right, indicate the positions which satisfied both conditions.

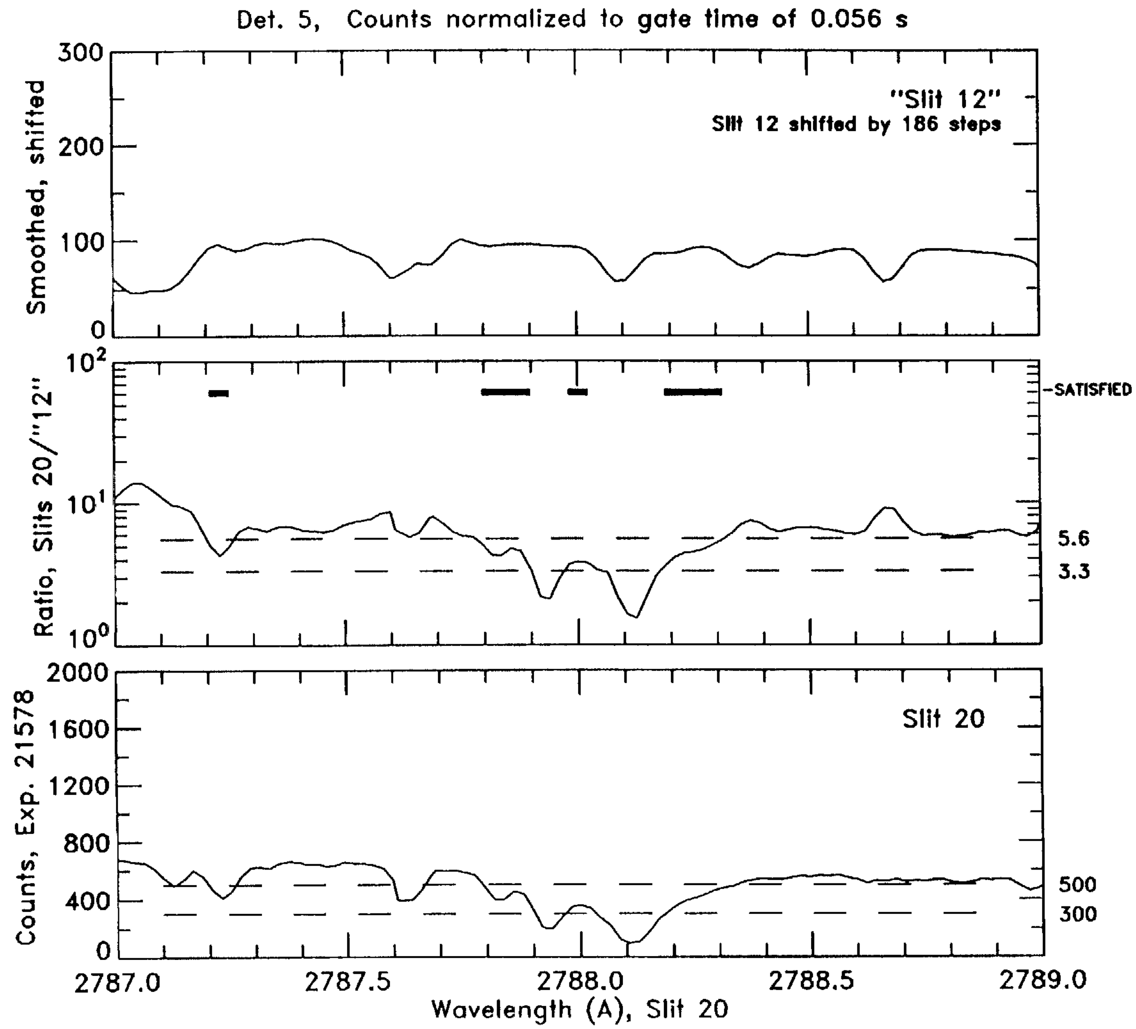


Figure 2-6. Spectra, Slit 20 and artificial Slit 12, 2787–2789 Å.
Expansion of a portion of Figure 2-5. The small bars in the center plot, with label "SATISFIED" at right, indicate the wavelength drive positions which satisfied both conditions.

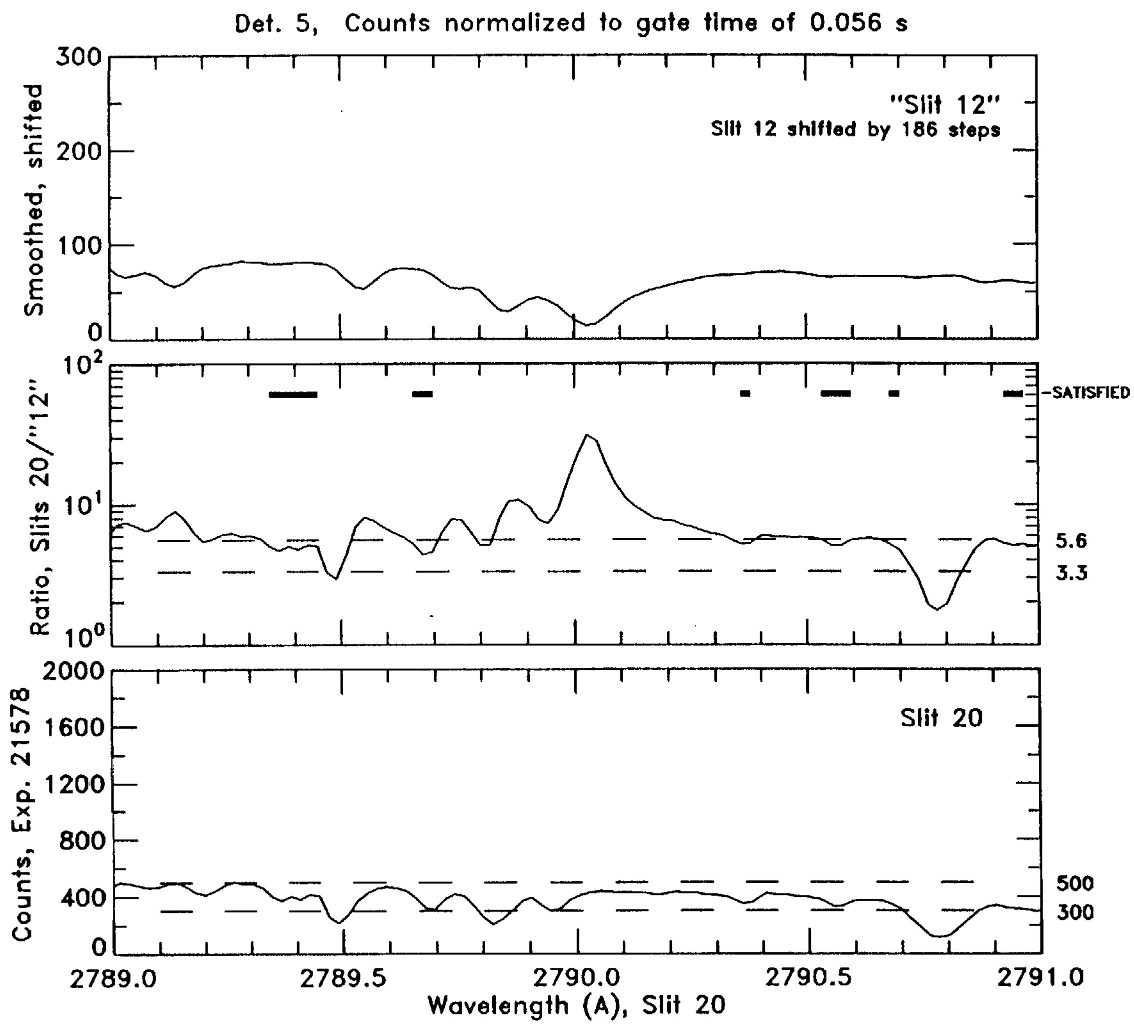


Figure 2-7. Spectra, Slit 20 and artificial Slit 12, 2789–2791 Å.
Expansion of a portion of Figure 2-5. The small bars in the center plot, with label "SATISFIED" at right, indicate the wavelength drive positions which satisfied both conditions.

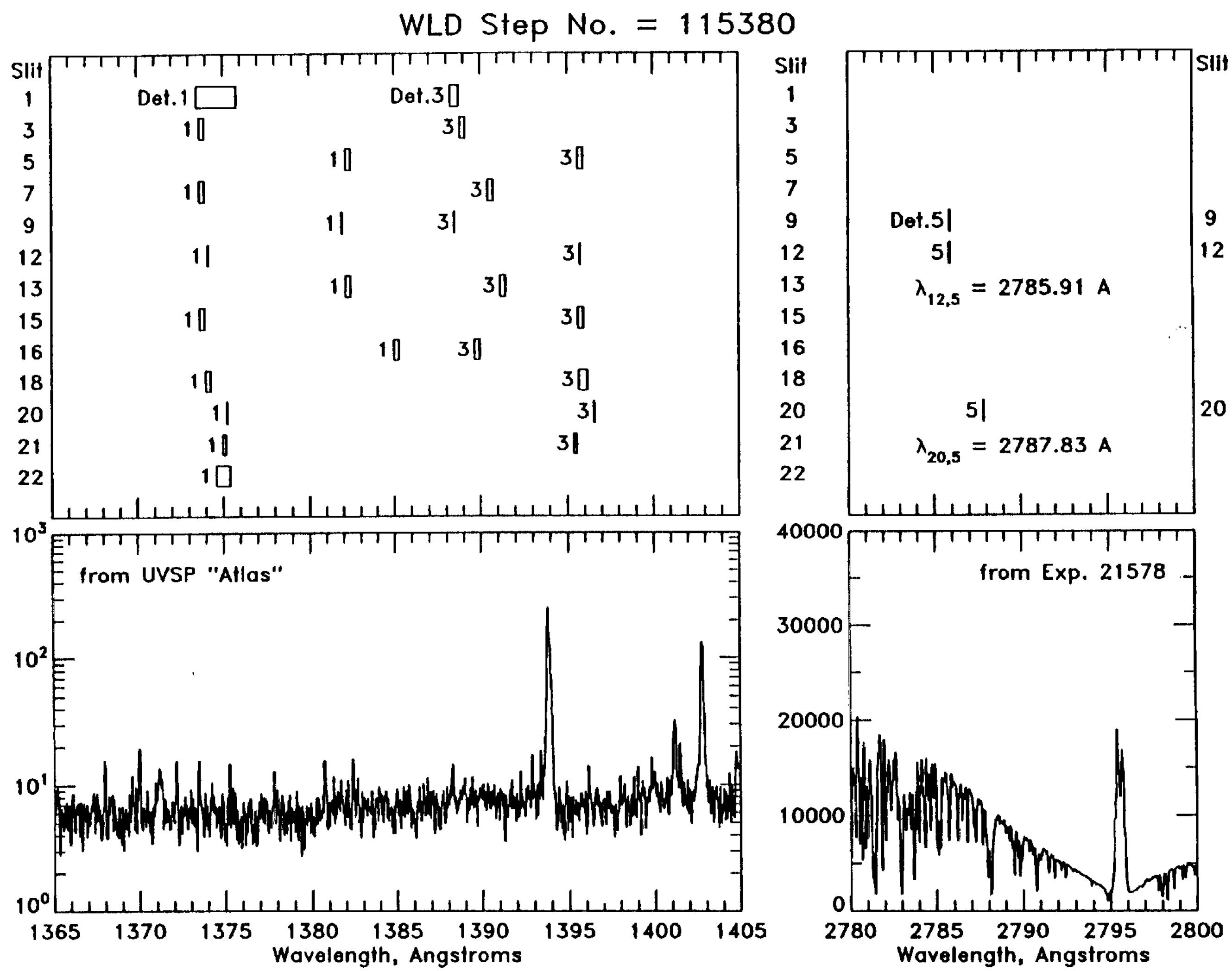


Figure 2-8. Exit slit positions assuming WLD step number = 115380.
The exit slit positions for detectors 1 and 3 are plotted against the UVSP second-order "Atlas" spectrum, assuming that the wavelength drive step number is 115380. The corresponding exit slit positions for detector 5 are plotted against the spectrum from UVSP experiment 21578.

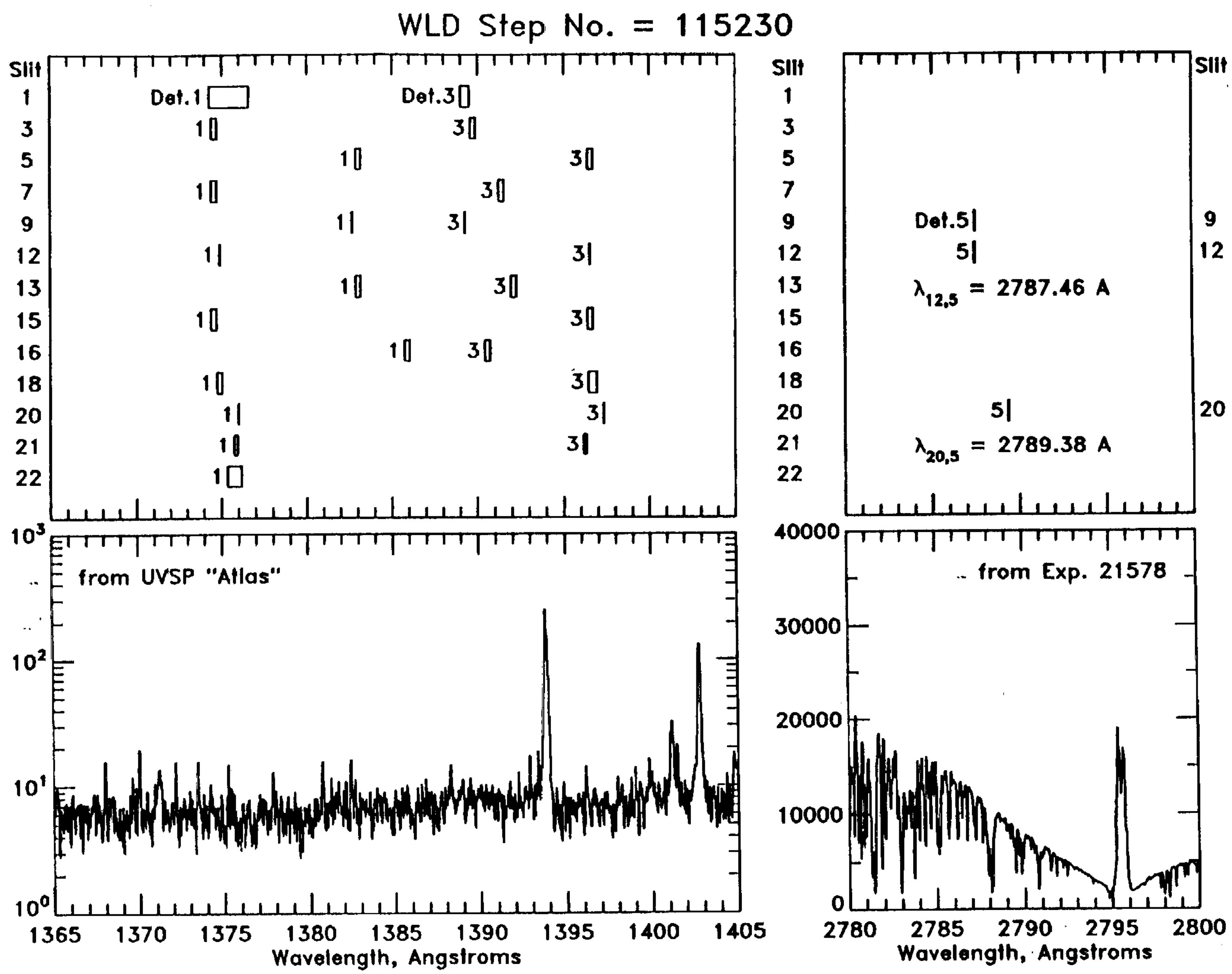


Figure 2-9. Exit slit positions assuming WLD step number = 115230.
The exit slit positions for detectors 1 and 3 are plotted against the UVSP second-order "Atlas" spectrum, assuming that the wavelength drive step number is 115230. The corresponding exit slit positions for detector 5 are plotted against the spectrum from UVSP experiment 21578.

3. Fast Timing for UVSP Observations

During 1985, tests were run to determine what gate times would be necessary to allow measurements to be made (i.e., to be put into the telemetry) exactly every 32, 64, or 128 milliseconds in the sit-and-stare mode. The spacing of 32 milliseconds is the interval between successive appearances in the telemetry of the output of each of the two UVSP data buses. It had long been known that the UVSP computer, Junior, required some overhead when making observations so that the mean spacing between data points would be longer than the gate time.

All of the test experiments were done in the sit-and-stare mode (no raster, wavelength drive, or polarimeter motions), contained 1024 repetitions, and used either only one detector (Det. 1) or two detectors (Dets. 1 and 3) with one in each UVSP data gathering interval. The results are shown in Table 3.1 and in Figure 3-1.

The conclusions are as follows:

(a) For one detector, a gate time of 26 ms yielded a uniform spacing of 32 ms. A gate time of 27 ms was too long.

(b) For one detector, a gate time of 58 ms yielded a uniform spacing of 64 ms. A gate time of 59 ms was too long.

(c) For two detectors, a gate time of 27 ms yielded a uniform spacing of 64 ms. A gate time of 28 ms was too long.

(d) For two detectors, a gate time of 59 ms yielded a uniform spacing of 128 ms. A gate time of 60 ms was too long. (Two experiments with gate times of 53 and 57 ms had mean spacings greater than 128 ms. These were probably due to unusual or random Junior activities which could actually have affected any experiment at any time. Other experiments with two detectors and the same gate times did have mean spacings at the expected 128 ms.)

Table 3.1 Results of Timing Tests

One Detector			Two Detectors (one in each interval)		
Exp. No.	Gate Time (ms)	Mean Time Per Point (ms)	Exp. No.	Gate Time (ms)	Mean Time Per Point (ms)
29474	20	32.0	31512	21	64.0
31095	20	32.0	31513	22	64.0
29475	22	32.0	31514	23	64.0
31096	22	32.0	31515	24	64.0
29476	24	32.0	31516	25	64.0
31097	24	32.0	31517	26	64.0
31098	26	32.0	31518	27	64.0
31522	27	33.5	31519	28	66.4
29478	28	34.9	31520	29	69.9
31099	28	35.0	31521	30	72.0
25663	40	48.0	31101	48	112.0
25664	44	53.3	31102	50	112.0
25665	48	64.0	31103	52	118.1
25666	52	64.0	30731	53	128.0
25667	56	64.0	31104	53	132.8
29469	56	64.0	31479	53	128.0
31090	56	64.0	31491	53	128.0
29470	57	64.0	31105	54	128.0
31091	57	64.0	31106	55	128.0
29471	58	64.0	31107	56	128.0
31092	58	64.0	30735	57	128.0
29472	59	65.3	31108	57	132.9
31093	59	65.3	31483	57	128.0
25668	60	67.0	31495	57	128.0
29473	60	67.0	31109	58	128.0
31094	60	67.0	31110	59	128.0
25669	127	135.8	31111	60	130.3
29477	256	272.0			

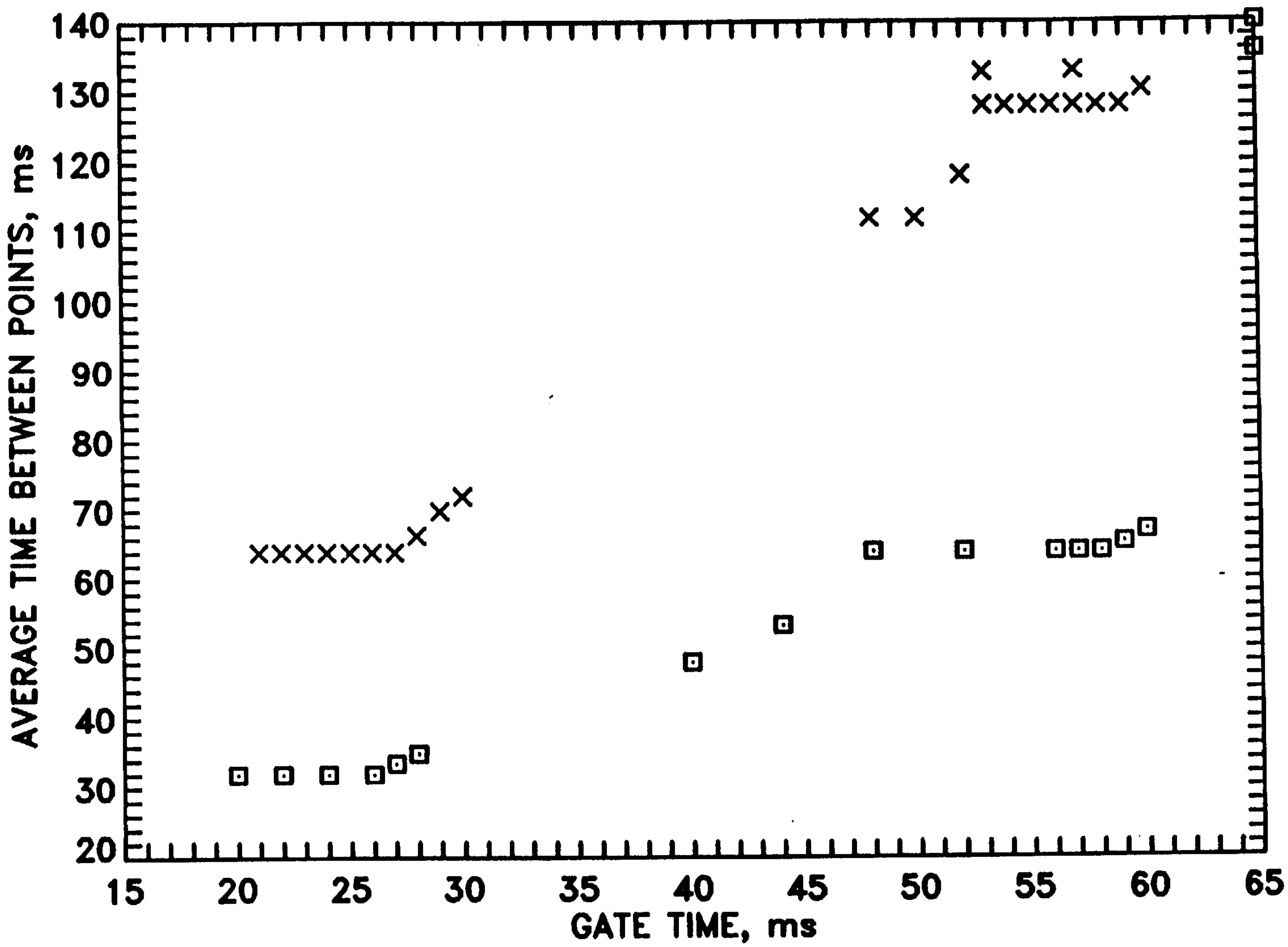


Figure 3-1. UVSP Fast Timing Test Results.
The mean time interval between individual data points for sit-and-stare experiments is plotted versus gate time. Squares indicate experiments with only one detector. ×'s indicate experiments with two detectors (one in each UVSP data gathering interval).

4. SMM Velocity Along Line of Sight to Sun in 1984

This section describes and lists subroutines in several computer languages which calculate the component of the SMM spacecraft orbital velocity along the line of sight to the Sun at any desired time during the 1984/1985 period when the UVSP wavelength drive was operating properly. The routines are similar to but are not identical to the routines which were written for the 1980 period and which have different names. The 1980 routines are described in an earlier report by Henze (1984).

4.1 Method

The routines which calculate the component of the SMM orbital velocity along the line of sight to the Sun use as a database an ASCII file containing circular velocity amplitudes and velocity offsets from zero as a function of time. The times also provide the phases or reference times for the orbit, usually two per day. The file is named ORBVEL84.DAT and is expected to be in the logical directory UVSP$DATA. The information in the file was generated from least-squares fits of sine functions to velocities determined for individual orbits from orbital data provided in the telemetry. The orbits are assumed to be circular with an offset due to the eccentric orbital motion of the Earth about the Sun. This is different from the approach used for the 1980 period. The file ORBVEL84.DAT contains information for only the limited period from 6 September 1984 to 1 May 1985.

4.2 File Listings

There are versions for the subroutines in three languages, all of which are normally run on a Vax computer:

VSMM84B.FOR in Fortran,

VSMM84A.PRO in IDL, and

VSMM84A.ANA in ANA.

Listings of the routines are presented here.

The input required for all of the routines is the time expressed as two variables. The first is the day of year relative to the beginning of 1984 expressed as a scalar integer.

(For 1984, use the actual day of year; for 1985, add 366 to the 1985 day of year.) The second is the seconds from the beginning of the day expressed as a real, i.e., floating point, number. For the Fortran version, the seconds of day must be a scalar. For the IDL and ANA versions, the seconds of day may be either a scalar or an array; however, all of the times in the array should be in the same orbit of the spacecraft.

The output is the component of the SMM spacecraft orbital velocity along the line of sight to the Sun (negative, i.e., toward the Sun, during the first half of the daylight portion of an orbit and positive during the second half). The output is real and has the same structure, scalar or array, as the input seconds of day.

4.3 Reference

Henze, W.: 1984, "Research in Solar Physics: Some Techniques for Analyzing Data from the Ultraviolet Spectrometer and Polarimeter", Teledyne Brown Engineering, Huntsville, Alabama, Final Report No. SPB4-MSFC-2726, chapter 2.

```
C       FILE VSMM84B.FOR   FORTRAN SUBROUTINE.  LATEST REVISION APRIL 4, 1986
C       Based on VELSC2.FTN (APRIL 5, 1982 PDP 11/34 version for 1980 data).
C       Calculates component of SMM spacecraft orbital velocity along
C       line of sight to the Sun for desired time(s) during late 1984 and
C       early 1985 (when the UVSP wavelength drive was working).
C       INPUT:  IDOY84  = Day-Of-Year (scalar) relative to beginning of 1984
C                         (If year is 1985, add 366 to 1985 DOY to get IDOY84.)
C               SEC     = Time in seconds from beginning of day (scalar).
C       OUTPUT: VLOS    = Line-Of-Sight component of SMM orbital velocity
C                         relative to the Sun, in km/s (scalar).  The
C                         velocity is negative (toward the Sun) during the
C                         first half of the daylight portion of an orbit
C                         and positive during the second half.
C       This subroutine reads in the file ORBVEL84.DAT only once, the first
C       time it is called.  It then searches the table for each call.
C***********************************************************************
      SUBROUTINE VSMM84(IDOY84,SEC,VLOS)
C     IF ORBVEL84.DAT CONTAINS MORE THAN 1000 ENTRIES, THEN THE DIMENSIONS
C      IN THE FOLLOWING STATEMENT MUST BE INCREASED.
        DIMENSION ITD(1000),TSEC(1000),TVAMP(1000),TBIAS(1000)
        DATA IOPEN/0/
C
        LUN=4   ! LOGICAL UNIT FOR DATA FILE CONTAINING TIMES (DOY84 AND
C               SECONDS OF DAY) OF ORBITAL NOON AND CORRESPONDING
C               AMPLITUDE AND BIAS (KM/S) OF SINE FUNCTION.
        IF(IOPEN.NE.0)GOTO 10    ! SKIP OPEN AND READ IF DONE PREVIOUSLY
        OPEN(UNIT=LUN,NAME='UVSP$DATA:ORBVEL84.DAT',TYPE='OLD',READONLY)
        IOPEN=99
        NTAB=1
15      READ(LUN,110,END=20)ITD(NTAB),TSEC(NTAB),TVAMP(NTAB),TBIAS(NTAB)
110     FORMAT(I10,F10.3,2F10.4)
        NTAB=NTAB+1
        GOTO 15
20      CLOSE(UNIT=LUN)
        NTAB=NTAB-1
10      CONTINUE
C                               ! TEST FOR OUT OF RANGE
        IF(IDOY84.LT.ITD(1))GOTO 600
        IF(IDOY84.EQ.ITD(1) .AND. SEC.LT.TSEC(1))GOTO 600
        IF(IDOY84.GT.ITD(NTAB))GOTO 600
        IF(IDOY84.EQ.ITD(NTAB) .AND. SEC.GT.TSEC(NTAB))GOTO 600
C
200     CONTINUE                ! BEGIN LOOP TO TEST ENTRY FROM TABLE
        DO 400 ITAB=2,NTAB
        IF(IDOY84.LT.ITD(ITAB))GOTO 300
        IF(IDOY84.EQ.ITD(ITAB) .AND. SEC.LE.TSEC(ITAB))GOTO 300
400     CONTINUE
C
300     CONTINUE                ! FOUND POSITION, NOW INTERPOLATE
        BIGDT=(ITD(ITAB)-ITD(ITAB-1))+(TSEC(ITAB)-TSEC(ITAB-1))/86400.
        NDORB=BIGDT/(5740./86400.)+0.5
        P=BIGDT/NDORB
        DT=(IDOY84-ITD(ITAB-1))+(SEC-TSEC(ITAB-1))/86400.
        IORB=DT/P+0.5
        TORB=DT-P*IORB
        VAMP=TVAMP(ITAB-1)+(DT/BIGDT)*(TVAMP(ITAB)-TVAMP(ITAB-1))
        BIAS=TBIAS(ITAB-1)+(DT/BIGDT)*(TBIAS(ITAB)-TBIAS(ITAB-1))
        VLOS=BIAS+VAMP*SIN(2.*3.141593*(TORB/P))
        RETURN
C
600     TYPE *,'  DOY(',IDOY84,'),  TIME(',SEC,' SEC)  OUT OF RANGE'
        TYPE *,' TABLE: FIRST: D=',ITD(1),',   T(SEC)=',TSEC(1)
        TYPE *,'        LAST:  D=',ITD(NTAB),',  T(SEC)=',TSEC(NTAB)
        STOP
        END
```

```
;       FILE VSMM84A.PRO    IDL PROCEDURE.  LATEST REVISION MAY 13, 1986
;               Based on VELSC1.PRO (MAY 14, 1982 PDP 11/34 version for 1980)
;       Calculates component of SMM spacecraft orbital velocity along
;       line of sight to the Sun for desired time(s) during late 1984 and
;       early 1985 (when the UVSP wavelength drive was working).
;       INPUT:  IDOY84  = Day-Of-Year (scalar) relative to beginning of 1984
;                         (If year is 1985, add 366 to 1985 DOY to get IDOY84.)
;               SEC     = Time in seconds from beginning of day (scalar
;                         or array).
;       OUTPUT: VLOS    = Line-Of-Sight component of SMM orbital velocity
;                         relative to the Sun, in km/s.  VLOS has same
;                         structure - i.e., scalar or array - as SEC.  The
;                         velocity is negative (toward the Sun) during the
;                         first half of the daylight portion of an orbit
;                         and positive during the second half.
;       This procedure reads in the file ORBVEL84.DAT each time it is called,
;       using READF until it finds the right records.  However, SEC and VLOS
;       can be arrays (all within the same orbit), thus avoiding the reading
;       in of the file for each element of the array.
;*************************************************************************
PRO VSMM84,IDOY84,SEC,VLOS
        LUN=4   ; LOGICAL UNIT FOR DATA FILE CONTAINING TIMES (DOY84 AND
;               SECONDS OF DAY) OF ORBITAL NOON AND CORRESPONDING
;               AMPLITUDE AND BIAS (KM/S) OF SINE FUNCTION.
        OPENR,LUN,'UVSP$DATA:ORBVEL84.DAT'
        VECSEC=SIZE(SEC)
        IF VECSEC(0) EQ 0 THEN SEC1=SEC
        IF VECSEC(0) GE 1 THEN SEC1=SEC(0)
        IOLTD=0 & ITD=0
        READF,LUN,IOLTD,OLTSEC,OLVAMP,OLBIAS
;                       TEST FOR OUT OF RANGE
        IF IDOY84 LT IOLTD THEN GOTO,S600
        IF IDOY84 EQ IOLTD THEN BEGIN
                IF SEC1 LT OLTSEC THEN GOTO,S600
         END
        ON_IOERROR,S700
S200:                   ; BEGIN LOOP TO READ AND TEST ENTRY FROM TABLE
        READF,LUN,ITD,TSEC,TVAMP,TBIAS
        IF IDOY84 GT ITD THEN GOTO,S400
        IF IDOY84 LT ITD THEN GOTO,S300
        IF SEC1 LE TSEC THEN GOTO,S300
S400:                   ; UPDATE OLD VALUES BEFORE NEW READ
        IOLTD=ITD & OLTSEC=TSEC & OLVAMP=TVAMP & OLBIAS=TBIAS
        GOTO,S200       ; LOOP BACK FOR NEW READ

S300:                   ; FOUND POSITION, NOW INTERPOLATE
        BIGDT=(ITD-IOLTD)+(TSEC-OLTSEC)/86400.
        NDORB=FIX(BIGDT/(5740./86400.)+0.5)
        P=BIGDT/NDORB
        DT1=(IDOY84-IOLTD)+(SEC1-OLTSEC)/86400.
        IORB=FIX(DT1/P+0.5)
        DT=(IDOY84-IOLTD)+(SEC-OLTSEC)/86400.
        TORB=DT-P*IORB
        VAMP=OLVAMP+(DT/BIGDT)*(TVAMP-OLVAMP)
        BIAS=OLBIAS+(DT/BIGDT)*(TBIAS-OLBIAS)
        VLOS=BIAS+VAMP*SIN(2.*3.141593*(TORB/P))
        CLOSE,LUN & ON_IOERROR,NULL
        RETURN
S600:   PRINT,'  DOY(',IDOY84,'),  TIME(',SEC,')  OUT OF RANGE'
        PRINT,' TABLE: FIRST: D=',IOLTD,',  T=',OLTSEC
        CLOSE,LUN & STOP
S700:   PRINT,'  DOY(',IDOY84,'),  TIME(',SEC,')  OUT OF RANGE'
        PRINT,' TABLE: LAST:  D=',IOLTD,',  T=',OLTSEC
        CLOSE,LUN & STOP
        END
```

```
;       FILE VSMM84A.ANA    ANA SUBROUTINE.  LATEST REVISION MAY 13, 1986
;               BASED ON VSMM84A.PRO  (IDL PROCEDURE)
;       Calculates component of SMM spacecraft orbital velocity along
;       line of sight to the Sun for desired time(s) during late 1984 and
;       early 1985 (when the UVSP wavelength drive was working).
;       INPUT:  IDOY84  = Day-Of-Year (scalar) relative to beginning of 1984
;                         (If year is 1985, add 366 to 1985 DOY to get IDOY84.)
;               SEC     = Time in seconds from beginning of day (scalar
;                         or array).  These are the times provided by the
;                         ANA subroutine:  UVSP,'Vnnnnn',XI,SEC.  All times
;                         in SEC should be in the same orbit.
;
;       OUTPUT: VLOS    = Line-Of-Sight component of SMM orbital velocity
;                         relative to the Sun, in km/s.  VLOS has same
;                         structure - i.e., scalar or array - as SEC.  The
;                         velocity is negative (toward the Sun) during the
;                         first half of the daylight portion of an orbit
;                         and positive during the second half.
;
;       This subroutine reads in the file ORBVEL84.DAT each time it is called,
;       using READF until it finds the right records.  However, SEC and VLOS
;       can be arrays (all within the same orbit), thus avoiding the reading
;       in of the file for each element of the array.
;************************************************************************
SUBR VSMM84,IDOY84,SEC,VLOS
VLOS=999.       ; RETURNS THIS ABSURD VALUE IN CASE OF ERROR
LUN=4           ; LOGICAL UNIT FOR DATA FILE CONTAINING TIMES (DOY84 AND
;                 SECONDS OF DAY) OF ORBITAL NOON AND CORRESPONDING
;                 AMPLITUDE AND BIAS (KM/S) OF SINE FUNCTION.
OPENR,LUN,'UVSP$DATA:ORBVEL84.DAT'
IF NUM_DIM(SEC) EQ 0 THEN SEC1=SEC
IF NUM_DIM(SEC) GE 1 THEN SEC1=SEC(0)
IOLTD=0 & ITD=0 & TSEC=0.0 & TVAMP=0.0 & TBIAS=0.0
READF,LUN,IOLTD,OLTSEC,OLVAMP,OLBIAS
;                         TEST FOR OUT OF RANGE
IF IDOY84 LT IOLTD OR (IDOY84 EQ IOLTD AND SEC1 LT OLTSEC) THEN BEGIN
        PRINT,'  DOY(',IDOY84,'),  TIME(',SEC,')  OUT OF RANGE'
        PRINT,' TABLE: FIRST: D=',IOLTD,',  T=',OLTSEC
        CLOSE,LUN
        RETALL   ; WAS STOP IN IDL
 END
REPEAT BEGIN    ;       START LOOP TO READ AND TEST ENTRY FROM TABLE
        KBARF=READF(LUN,ITD,TSEC,TVAMP,TBIAS)
        IF KBARF NE 1 THEN BEGIN
                PRINT,'  DOY(',IDOY84,'),  TIME(',SEC,')  OUT OF RANGE'
                PRINT,' TABLE: LAST:  D=',IOLTD,',  T=',OLTSEC
                CLOSE,LUN
                RETALL   ; WAS STOP IN IDL
         END
;                         UPDATE OLD VALUES BEFORE NEW READ
        IF IDOY84 GT ITD OR (IDOY84 EQ ITD AND SEC1 GT TSEC) THEN BEGIN
                IOLTD=ITD & OLTSEC=TSEC & OLVAMP=TVAMP & OLBIAS=TBIAS
         END
 END UNTIL IDOY84 LT ITD OR (IDOY84 EQ ITD AND SEC1 LT TSEC)
;                         FOUND POSITION, NOW INTERPOLATE
BIGDT=(ITD-IOLTD)+(TSEC-OLTSEC)/86400.
NDORB=FIX(BIGDT/(5740./86400.)+0.5)
P=BIGDT/NDORB
DT1=(IDOY84-IOLTD)+(SEC1-OLTSEC)/86400.
IORB=FIX(DT1/P+0.5)
DT=(IDOY84-IOLTD)+(SEC-OLTSEC)/86400.
TORB=DT-P*IORB
VAMP=OLVAMP+(DT/BIGDT)*(TVAMP-OLVAMP)
BIAS=OLBIAS+(DT/BIGDT)*(TBIAS-OLBIAS)
VLOS=BIAS+VAMP*SIN(2.*3.141593*(TORB/P))
CLOSE,LUN & RETURN
ENDSUBR
```

5. Published Scientific Research

Various research papers have been published in scientific journals and in proceedings of conferences. Some of these papers are listed here.

"Discussion of a Possible Magnetic Transient in UVSP Observations" by W. Henze, *Solar Physics* **104**, 359–362 (1986). Showed that earlier report of a possible magnetic transient observed in July 1980 was probably spurious.

"Polarimetry in the Mg II h and k Lines" by W. Henze and J. O. Stenflo, *Solar Physics* **111**, 243–254 (1987). Attempt to measure polarization across the Mg II h and k lines at the solar limb. Weak polarization was measured (although significance was not high) consistent with expected variation across part of line profiles (due to quantum mechanical interactions between atomic energy levels); however, the observed signal was weker than expected.

"Variations of Mesospheric Equatorial Ozone As Observed by the Solar Maximum Mission" by A. C. Aikin, W. Henze, D. J. Kendig, R. Nakatsuka, and H. J. P. Smith, *Geophysical Research Letters* **17**, 299–302 (1990). Ozone concentrations in the mesosphere of the Earth (at altitudes above the ozone peak) were measured using the occultation of monochromatic solar ultraviolet light by the atmosphere. Changes with time (seasonal and secular, 1985–1989) and latitude ($\pm 20°$) were observed with different time variations at northern and southern latitudes.

"Ultraviolet Polarimetry with the UVSP" by W. Henze, in *Solar Polarimetry* (L. J. November, ed.), National Solar Observatory/Sacramento Peak, pp. 16–24 (1991). Review of previous UVSP polarimetry analyses plus new analysis of UVSP magnetograms observed in a sunspot in March 1985.

"Absolute Redshifts in the C IV 1548 Å Line in the Transition Region of the Quiet Sun" by W. Henze and O. Engvold, *Solar Physics* **141**, 51–63 (1992). More detailed report on mean redshifts (downflows) observed in lines emitted in the solar transition region. The mean redshifts at disk center are in the range 4–8 km s^{-1} based on a comparison with the line position at the limb. There appears to be a correlation between mean downflow and mean brightness for observations made at different times.

6. UVSP Catalog of Observations

It is expected that a printout of the UVSP catalog of observations (experiments) will soon be published separately as a NASA Contractor Report. It will be split into three volumes: volume 1 will contain experiments 1–30719 (February 1980 – April 1985); volume 2 will contain experiments 30720–63057 (April 1985 – February 1988); and volume 3 will contain experiments 63058–99771 (February 1988 – November 1989). The information for each experiment will include the time of each observation, the observed position on the Sun, the target of the observation (such as active region number), the spacecraft roll angle, the slit and detectors used, and instrument parameters such as raster size, pixel spacing, wavelength, polarimeter usage, gate time, number of repetitions planned, etc., which come from the experiment definition file whose name is also listed.

6.1 Electronic Version of the Catalog

The electronic version of the UVSP catalog is a computer file (usually named CATALOG.CAT) containing selected information about each UVSP experiment identified by its experiment number. The entry for each experiment number in the catalog file is a record containing 128 bytes. The record number in the file is the same as the experiment number.

Missing experiment numbers, for which no reformatted data files exist, can occur as result of several causes. Occasionally, telemetry gaps occurred for which the data can never be recovered. It was also decided not to reformat and save the data for certain test experiments such as those run during the period from 1981 through 1983 (experiment numbers near 16800) when SMM was unable to point in a stable manner at the Sun and when the UVSP door remained closed. Another reason for missing experiments was the decision not to save files for experiments used only to slew the wavelength drive over long spectral ranges.

The information in the catalog is mostly from the experiment header blocks of the data files for a given experiment. Some additional items have been included which are not in the experiment header; these include the experiment definition file name, the active region number or pointing code, and the initial and final wavelengths in Å. Many errors have been found which were caused by telemetry problems, onboard computer problems, slit counter errors, etc. Also, some values of pitch and yaw were incorrect due to a poor calibration of the Fine Pointing Sun Sensors in the spacecraft during 1980 and to other problems with the Fine Pointing Sun Sensors. These errors, if known, have been corrected in the UVSP catalog although it is impossible to correct them in the data files themselves. *Therefore, whenever there is a conflict between information in the catalog and in the header blocks of the reformatted data files, the catalog should normally be considered the more reliable source.*

The active region number in the catalog is the number assigned by the U.S. National Oceanic and Atmospheric Administration (NOAA) Solar Environmental Laboratory. If the target or purpose of the pointing was not an active region, a code was inserted to describe the pointing as sun center, a coalignment exercise with the spacecraft or with other instruments, a stellar observation, the solar limb (usually east or west), a coronal hole, etc., or whether the observation occurred during orbital night, i.e., when the sun was occulted by the Earth, or occurred when the UVSP instrument door was closed.

The wavelengths in the electronic version of the catalog were normally calculated from the WLD step number using a crude approximation. They are usually accurate to within 5 Å; the uncertainties are due in part to the approximation used to correct for various exit slit positions and in part to occasional shifts in the wavelength drive zero point. The wavelengths are incorrect for most experiments in the range 16801–19436 (early SMM-2) when the wavelength drive was not operating normally but was not stuck at a known position and for experiments following 30719 when the wavelength drive became permanently stuck. For experiments 19437–21122 (summer 1984) when the wavelength drive was temporarily stuck and 21123–21127 when the wavelength drive was first successfully moved again, the wavelengths are not based on the recorded WLD step numbers but are based on what was later determined to be the true WLD position.

6.2 Printed Version of the Catalog

The printed version of the catalog was generated by a computer program known as CATSEARCH (source language is Fortran). The printout is *not* identical with the contents of the electronic version. The printout contains selected information, some of which comes directly from the electronic catalog and some of which is calculated using information in the catalog.

If one has access to the electronic version of the catalog and to the CATSEARCH program, the program can be used to search the catalog and print out only those experiments satisfying whatever criteria are desired. The possible search criteria can include such parameters as the experiment number, the definition name, the detector number, the wavelength range, the experiment type, the pointing target, etc.

In the catalog printout, a blank line normally separates an experiment which was not contiguous in time with an adjacent experiment. This means that blank lines usually separate a group of experiments performed in one orbit from those in the preceding or following orbit. A blank line at the top of the page (following the column headers) means that a new group of experiments has started; the absence of a blank line at the top means that the first experiment (and possibly more) belongs to the group which started on the preceding page.

For some experiments, the value of a parameter is so large that there is no blank space between the parameter and whatever is in the preceding column. Such cases should be obvious and not cause any significant confusion.

The wavelength in the printout is the approximate initial wavelength in Ångstroms (integer), accurate to perhaps 5 Å, for the first detector listed. If the first detector is in the range 1–4, the wavelength is the second-order value corresponding to the wavelength drive position at the beginning of the experiment; if the first detector is 5, the wavelength is the corresponding first-order value. For experiments higher than 30719, i.e., after the wavelength drive became stuck in April 1985, the wavelength is not taken from the catalog but is calculated based on what is thought to be the possible position of the wavelength drive; the symbol "?" following the wavelength indicates its uncertainty. Also, the wavelength is incorrect for most experiments in the range 16801–19436 (early

SMM-2).

The position of the center of the UVSP raster for any experiment is shown as the radius vector from the center of the Sun and the position angle measured from solar north. These values are calculated for the printout based on the UVSP coordinates of the center of the raster, the spacecraft pitch and yaw, and the calibration of the spacecraft boresight relative to the UVSP coordinate system.

7. UVSP Calibration and Data Users Guide

It is expected that a UVSP calibration report and data users guide will be published in the near future, probably as a NASA publication in collaboration with other coauthors. The expected contents of that publication are briefly listed and described here.

7.1 Introduction

A brief instrument description and history will be given. The UVSP reformatted data files will be described, including their file structure and the contents of the experiment and record header blocks. A brief description of the UVSP catalog will also be given.

7.2 Sensitivity Calibration

Definitions of various calibration parameters will be presented along with the relationships among them. The relative sensitivity measurements will be discussed, including detector sensitivity ratios for Dopplergram slits and interslit sensitivity comparisons. Time variations of the sensitivity will be presented. A description will be given of various absolute sensitivity measurements, including pre-launch calibration, comparison with stars, and comparison with other solar observations.

7.3 Polarimeter

Definitions and the method of analysis for polarimetry will be discussed. Measurements of waveplate retardance, grating and polarizer polarization, and waveplate and polarizer transmission will be presented.

7.4 Wavelength Drive and Slits

The relationship between wavelength drive step number and wavelength will be given for Slit 20, Detector 1. Modifications for different slits and detectors will then be described along with a discussion of the history of changes in the zero point of the conversion between step number and wavelength.

7.5 Pointing and Spatial Alignment

The definition of UVSP and SMM coordinates will be given along with the exact meaning of the coordinates of the center of a UVSP observation and the spatial offsets of the entrance slits for UVSP Slits 20, 21, and 22. The history of the changes in the SMM boresight in the UVSP coordinate system will be described. Finally, the position of the Hard X-ray Imaging Spectrometer (HXIS) boresight in the UVSP coordinate system will be shown.