IUE DATA REDUCTION

XXX. Implementation of New Dispersion Constants

Introduction

On September 21, 1982, (GMT 264:17:20) updated dispersion constants were implemented in production processing at GSFC for the LWR, SWP, and LWP cameras. These calibration files replace those originally implemented for the LWR and SWP cameras on March 3, 1981 in low dispersion and on April 30, 1981 in high dispersion. These original files, and their time/temperature corrections which were implemented on March 3, 1981 for low dispersion and on May 19, 1981, for high dispersion, were described in IUE Data Reduction Memo XXI (NASA IUE Newsletter No. 15). The previously implemented LWP dispersion constant files first used on August 17, 1981 were generated using only a single wavelength calibration image and were not documented in a NASA IUE Newsletter report. An evaluation of the new calibration files is described below.

Long Wavelength Prime Camera (LWP)

As shown in Table 1 the updated LWP dispersion constants represent the mean of dispersion constants generated from 14 wavelength calibration images obtained between June 17, 1980 and August 17, 1982. The actual coefficients are shown in Table 3 in the same format used in IUE Data Reduction Memo XXI. These terms define the sample (S) and line (L) position of a given wavelength (λ, in $\mathring{A}$) and order (m) using the following formulae for the high dispersion case:

$$S = a_1 + a_2 m\lambda + a_3 (m\lambda)^2 + a_4 m + a_5 \lambda + a_6 m^2 \lambda + a_7 m\lambda^2 \qquad (1)$$

$$L = b_1 + b_2 m\lambda + b_3 (m\lambda)^2 + b_4 m + b_5 \lambda + b_6 m^2 \lambda + b_7 m\lambda^2 \qquad (2)$$

In low dispersion (m = 1), only the first two terms are used. The differences in the predicted positions of the low and high dispersion Pt-Ne emission lines using the old and new dispersion relations are shown in Figures 1.1 and 1.2 respectively. In these figures the diamond symbols represent the positions predicted using the old dispersion constants. The scaled vectors represent the displacements to the positions predicted using the new dispersion constants. The large (2-pixel) displacement presumably

reflects the large difference in time and mean temperature between the two dispersion relations. (The old dispersion constants file represents the earliest dispersion constants used in generating the new means and was obtained at the lowest recorded temperature).

An analysis of the 14 LWP dispersion constant files was made to determine whether shifts in the spectral format (with respect to the grid of reseaux) were correlated with time and/or variations in the LWP head amplifier temperature (THDA). Although the data in Table 2 show that a correction for time and THDA could result in a reduction in the scatter of the predicted emission-line positions, it was decided that there were insufficient data available to warrant its implementation. This decision was also influenced by the large temperature variations observed during the acquisition of the LWP calibration images which would tend to make the temperature correlations less reliable. Therefore, until more images are available for analysis, the implemented LWP mean dispersion constants will not be corrected for time and temperature.

In addition to the studies described above, tests were made to verify that the new dispersion files were appropriate (i.e., improved the wavelength assignments) for recently obtained images. The evaluation was based on running the wavelength calibration processing schemes on recent Pt-Ne calibration images using both old and new dispersion constant files for the "preliminary dispersion relation". As described in the IUE Image Processing Information Manual (CSC/TM-79/6301 and CSC/TM-81/6268), the preliminary dispersion relation is used to initiate the cross-correlation search used for locating each of the Pt-Ne lines listed in the current IUE line library. The results showed that for every emission line the new dispersion constants resulted in initial search locations closer to the actually found line positions than those determined using the old dispersion constants. It was concluded that the new LWP dispersion relation more accurately describes the location of the LWP spectral format for recently obtained IUE images.

Long Wavelength Redundant Camera (LWR)

Tables 1-3 and Figures 2.1 and 2.2 show the same data for the LWR camera as described above for LWP. In addition, Table 3 contains the updated temperature and time correlation coefficients. As explained in Memo XXI, the corrected dispersion constants are the means plus a value

W where W(S) and W(L) are the corrections to equations 1 and 2 respectively, such that

$$W = W_1 + W_2T + W_3t \qquad (3)$$

where

T = head amplifier temperature (THDA, in C°) and
t = number of days since January 1, 1978.

A comparison of the correlation coefficients in Table 3 with those in Table 6 of Memo XXI shows that although the temperature dependence remains nearly unchanged, the time dependence has decreased. This can also be seen in Figures 2.3-2.4 which show the low and high dispersion LWR spectral format shifts along and perpendicular to the dispersion after correction for temperature, as a function of time. The straight lines shown are the result of a least squares fit to the points marked with a "+" symbol and represent the updated time dependence. Note that if the earlier points were used rather than the later ones, the time dependence would be described by a different line. The reason for this change is unknown; however, it is the main justification for updating the dispersion constants and the temperature and time correlations. It should also be pointed out that the feature evident between days 1300 and 1450 is considered an anomaly and cannot be explained. Images taken during this period were found consistently to contain larger-than-expected (i.e., 3 σ) errors in their wavelength assignments.

The wavelength calibration tests described above for the LWP camera were also performed for the LWR and (see below) SWP camera with the additional step that the temperature and time corrections appropriate for the wavelength calibration image were applied prior to determining the initial search positions. The results for LWR showed that not only were the temperature and time corrections (that were applied to the means) smaller using the new dispersion constants and correlation coefficients but, as for LWP, the initial search positions were closer to the actually found Pt-Ne line positions. The smaller temperature and time corrections using the new means were to be expected since the mean time for these dispersion constants was closer to the time of acquisition of the calibration images. The improved starting search positions signify that the variation in the time dependence warranted updating the dispersion relation.

Short Wavelength Prime Camera (SWP)

As for LWR, Tables 1-3 and Figures 3.1-3.4 describe the new SWP mean dispersion constants and correlation coefficients. A comparison of the correlation coefficients in Table 3 with those given in Table 6 of Memo XXI suggest small changes have occurred in the time and temperature dependence although the significance of these changes is not clear. The reason for this is that although Figures 3.3-3.4 would suggest that the new means and correlation coefficients better describe the location of the spectral format for recent images, the wavelength calibration tests performed as described for LWR showed little difference between the old and new dispersion relations (the temperature and time corrections, however, were smaller, as expected, using the new means). We conclude that, except for the mean time, the new SWP dispersion constants are basically equivalent to the old.

Header Label Information

The time period of images used to define the mean dispersion constants, the number of images used in the evaluation, and the residual 1 σ scatter in the line and sample direction (all of which are contained in the label line beginning "MEAN DC") have been modified to describe the newly implemented dispersion relations. It should be noted that the sigmas in the header label describe the residual scatter after time and temperature regardless of whether a correction was applied to the particular image. Therefore, if the phrase "MEAN DC USED" appears in the line describing the THDA for spectrum motion, the sigmas pertinent to the dispersion constants used would be those listed in Table 2 under the heading "no correction".

Conclusion

As described above, the new dispersion constant files implemented on September 21, 1982 show definite improvements in describing the location of the spectral format for the LWP and LWR cameras. Although the tests for the SWP camera were less conclusive, the new relations are at least as good as the previously implemented dispersion relations in describing the spectral format. Guest Observers can determine that their images were processed with the new dispersion relations from the processing date or the dispersion constant information added to the image header label as described in Memo XXI.

R.W. Thompson
B.E. Turnrose

Table 1

Dispersion Constant Statistics

	LWP		LWR		SWP	
	low	high	low	high	low	high
# Disp. Cnsts.	14	14	46	47	44	45
mean time	3/4/82	3/4/82	4/1/81	3/26/81	4/2/81	3/27/81
start	6/17/80	6/17/80	1/1/80	1/1/80	1/1/80	1/1/80
end	8/17/82	8/17/82	8/10/82	8/10/82	8/10/82	8/10/82
mean THDA(C°)	8.3	9.0	13.45	13.50	8.78	8.82
lowest	6.2	6.8	9.2	9.5	5.1	5.1
highest	10.5	11.2	18.3	18.3	13.2	12.8
slope ($^{DL}/_{DS}$)	-.8603	1.20*	.7464	-1.38*	-.8066	1.28*

*m=100

Table 2

Error (1σ in Pixels) for Corrections to the Mean Dispersion Constants

Dispersion Direction	No Correction	THDA and Time
SWP high		
parallel	.69	.25
perpendicular	.35	.15
SWP low		
parallel	.45	.20
perpendicular	.61	.32
LWR high		
parallel	1.39	.37
perpendicular	.29	.20
LWR low		
parallel	.34	.23
perpendicular	1.37	.36
LWP high		
parallel	.90	.51
perpendicular	.43	.18
LWP low		
parallel	.50	.31
perpendicular	.85	.53

Table 3

Updated Coefficients Defining the Dispersion Relations for the Small Aperture

	SWP High	SWP Low	LWR High	LWR Low	LWP High	LWP Low
a_1	621.889	983.125	4877.918	-299.088	7092.434	1045.484
b_1	-7263.345	-263.382	15409.031	-264.404	-102.733	-272.238
a_2	-17231.887(-5)	-466.493(-3)	14727.910(-5)	302.228(-3)	-18332.296(-5)	-286.471(-3)
b_2	-11679.486(-5)	376.252(-3)	-27745.744(-5)	225.597(-3)	-13694.831(-5)	246.469(-3)
a_3	12730.463(-10)		5522.146(-10)		6804.252(-10)	
b_3	12173.485(-10)		9077.724(-10)		5902.048(-10)	
a_4	2.769(-2)		Ø.745(-2)		1675.931(-2)	
b_4	-.0867(-2)		5.926(-2)		Ø	
a_5	-465.440(-3)		276.735(-3)		374.701(-3)	
b_5	398.810(-3)		226.099(-3)		330.485(-3)	
a_6	-1.991(-7)		Ø.0292(-7)		-721.526(-7)	
b_6	.2124(-7)		-Ø.0802(-7)		180.210(-7)	
a_7	-1.312(-8)		11.105(-8)		-284.761(-8)	
b_7	-17.260(-8)		Ø.4017(-8)		-36.529(-8)	
W_1(S)	-2.243	-2.239	5.279	5.348		
W_1(L)	-2.586	-1.633	-8.648	-8.601		
W_2(S)	.02709	.001985	-.2945	-.2516		
W_2(L)	.2170	.1546	.5826	.5316		
W_3(S)	1.696(-3)	1.870(-3)	-1.102(-3)	-1.652(-3)		
W_3(L)	.569(-3)	Ø.233(-3)	.6621(-3)	1.222(-3)		
Plate Scale (per pixel)	7.697 kms^{-1}	1.669Å	7.236 kms^{-1}	2.652Å	7.223 kms^{-1}	2.646Å

The values listed should be multiplied by the power of 10 given in parentheses. The values are to an accuracy such that the contribution of each term can be computed to ~0.001 pixel in the range of interest.

Figure Captions

Fig. 1.1 - Predicted positions of the low dispersion LWP Pt-Ne emission lines using the old and new dispersion relations. The diamond symbols represent the mean positions predicted using the old dispersion constants. The scaled vectors represent the displacements to the mean positions predicted using the new dispersion constants.

Fig. 1.2 - Same as Fig. 1.1 for high dispersion.

Fig. 2.1 - Same as Fig. 1.1 for LWR

Fig. 2.2 - Same as Fig. 1.2 for LWR

Fig. 2.3 - Relative spectral format shifts along and perpendicular to the dispersion for a particular LWR low dispersion wavelength after correction for temperature, as a function of time. The straight lines shown are the result of a least squares fit to the points marked with a '+' symbol and represent the updated time dependence.

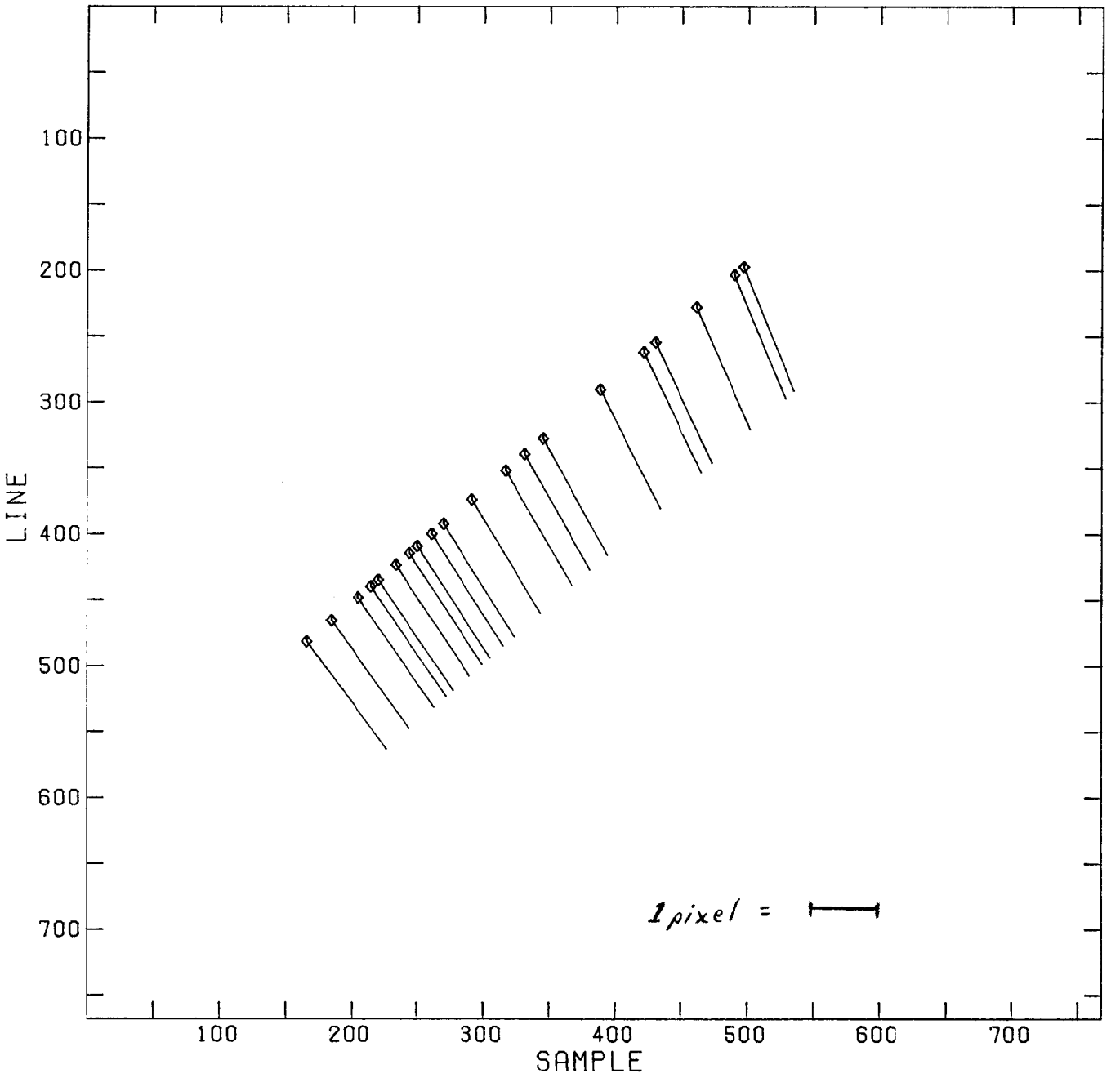
Fig. 2.4 - Same as Fig. 2.3 for high dispersion with the addition of some more recently obtained data points.

Fig. 3.1 - Same as Fig. 1.1 for SWP

Fig. 3.2 - Same as Fig. 1.2 for SWP

Fig. 3.3 - Same as Fig. 2.3 for SWP

Fig. 3.4 - Same as Fig. 2.4 for SWP



18:00 AUG 24,'82

Figure 1.1

LWP CAMERA

MAGNIFICATION = 50.00

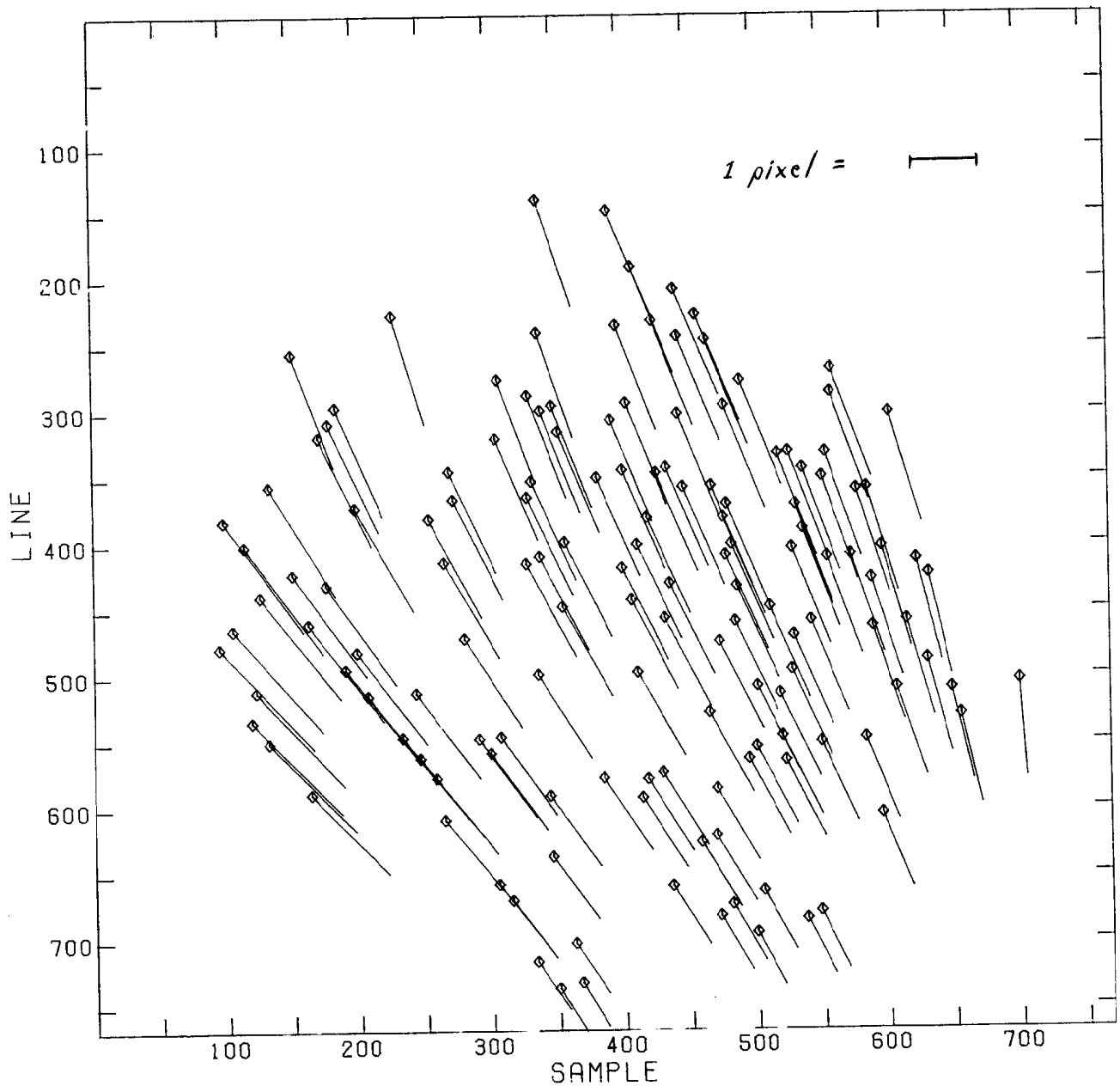
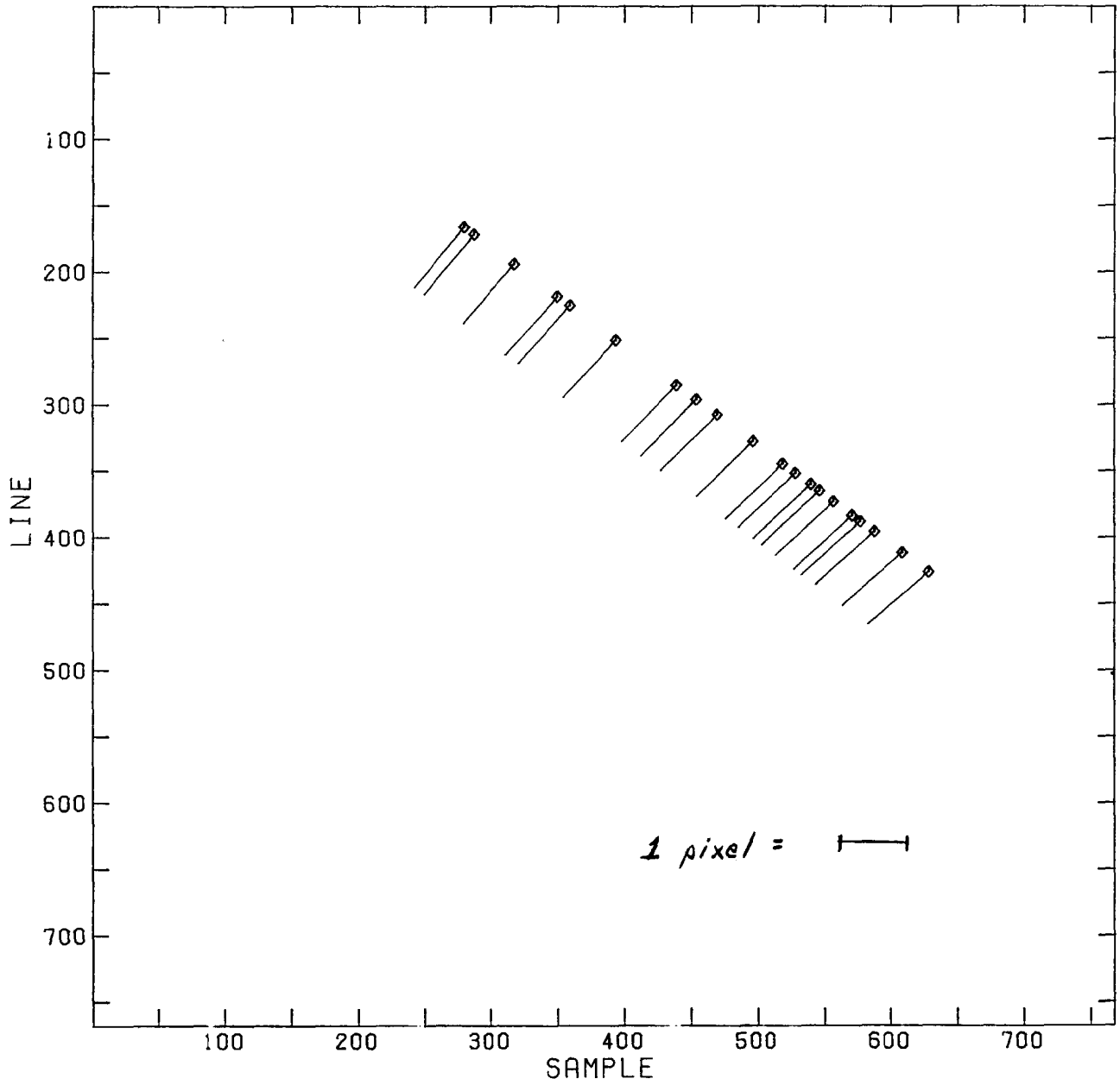


Figure 1.2

LWP CAMERA

MAGNIFICATION = 50.00

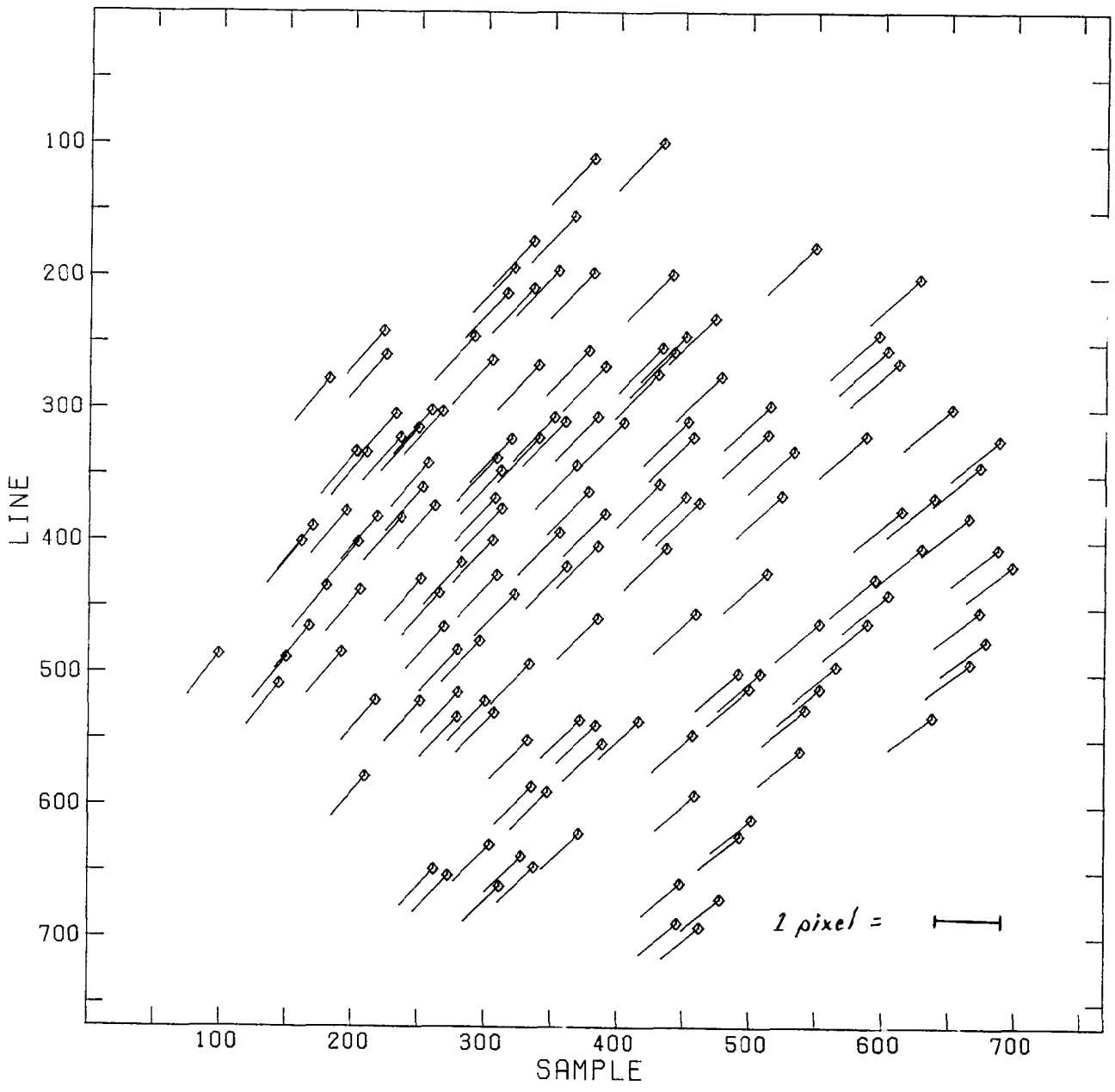


18:08 AUG 24,'82

Figure 2.1

LWR CAMERA

MAGNIFICATION = 50.00



17:39 AUG 26,'82

Figure 2.2

LWR CAMERA

MAGNIFICATION = 50.00

Low Dispersion

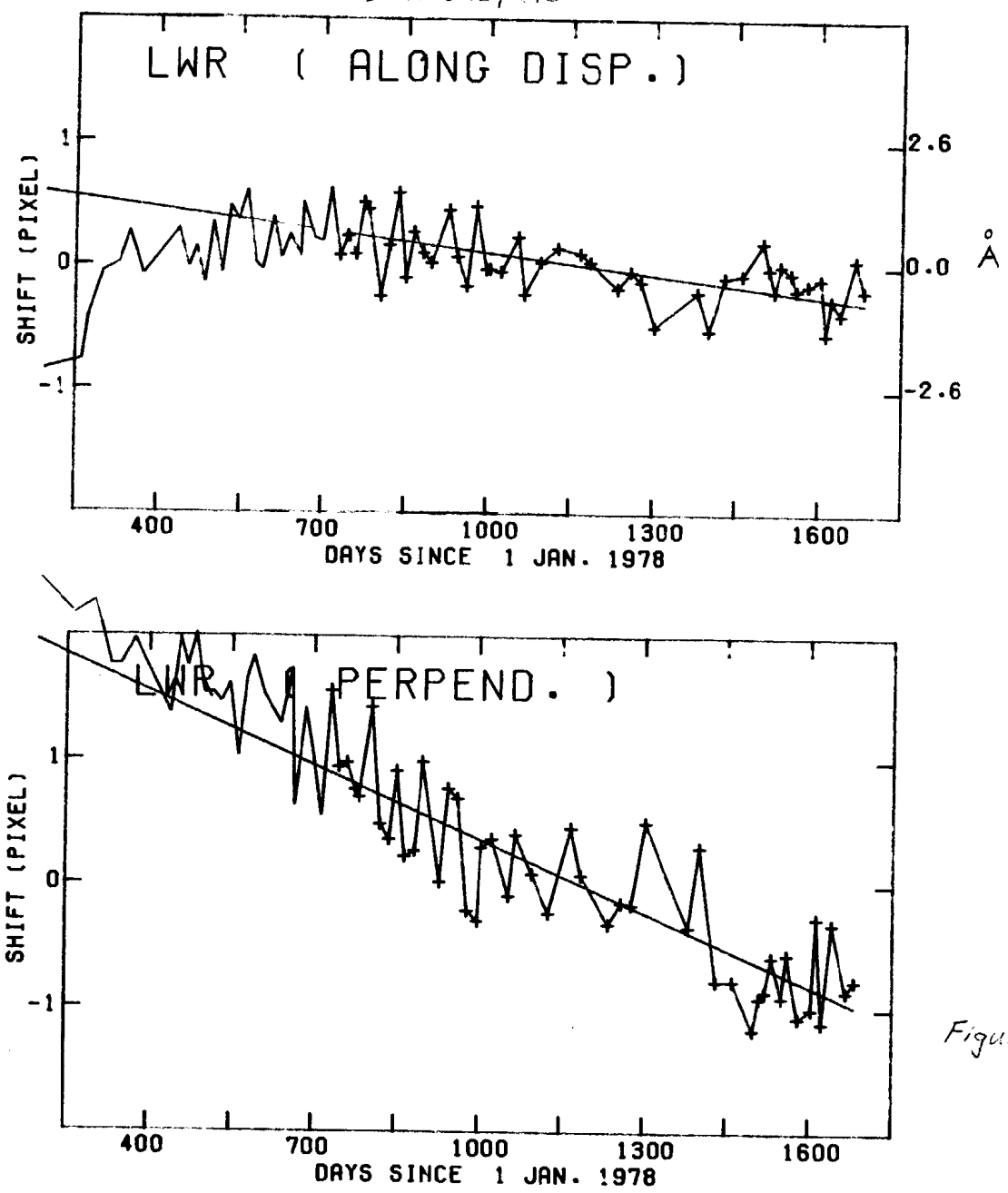


Figure 23

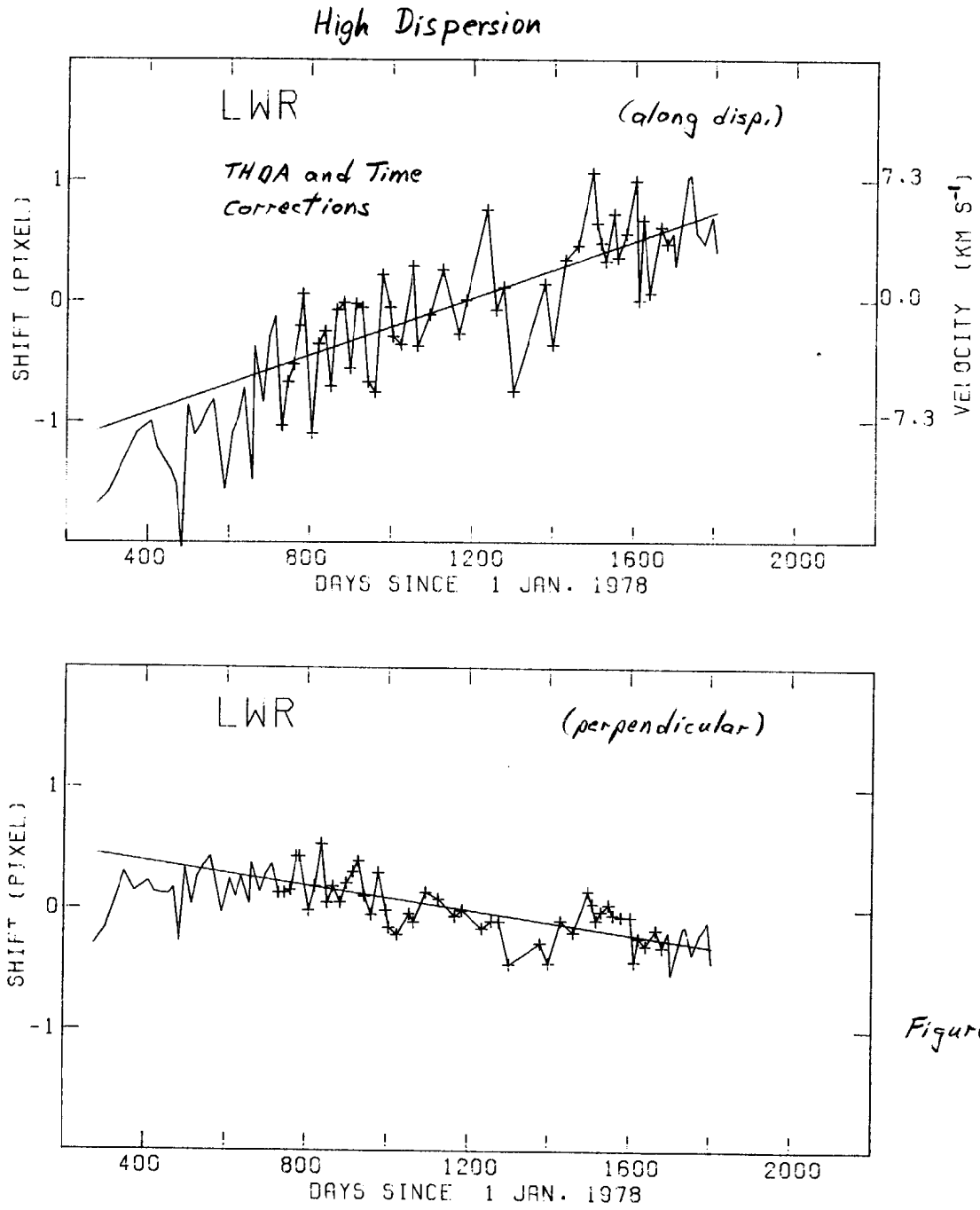
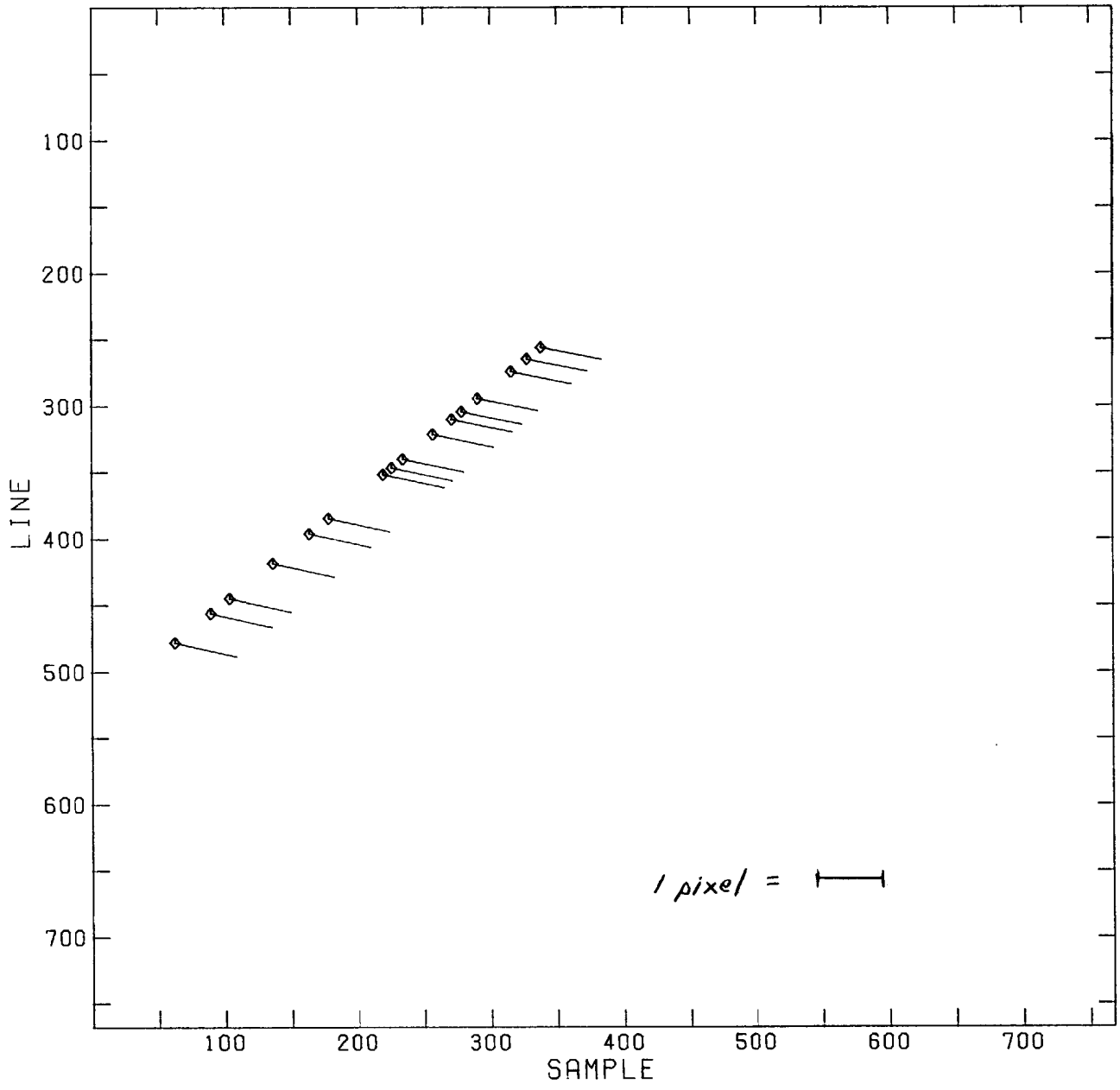

High Dispersion
LWR
(along disp.)
THOA and Time Corrections
SHIFT (PIXEL)
1
0
-1
7.3
0.0
-7.3
VELOCITY (KM S-1)
400
800
1200
1600
2000
DAYS SINCE 1 JAN. 1978
LWR
(perpendicular)
SHIFT (PIXEL)
1
0
-1
400
800
1200
1600
2000
DAYS SINCE 1 JAN. 1978

Figure 2.4

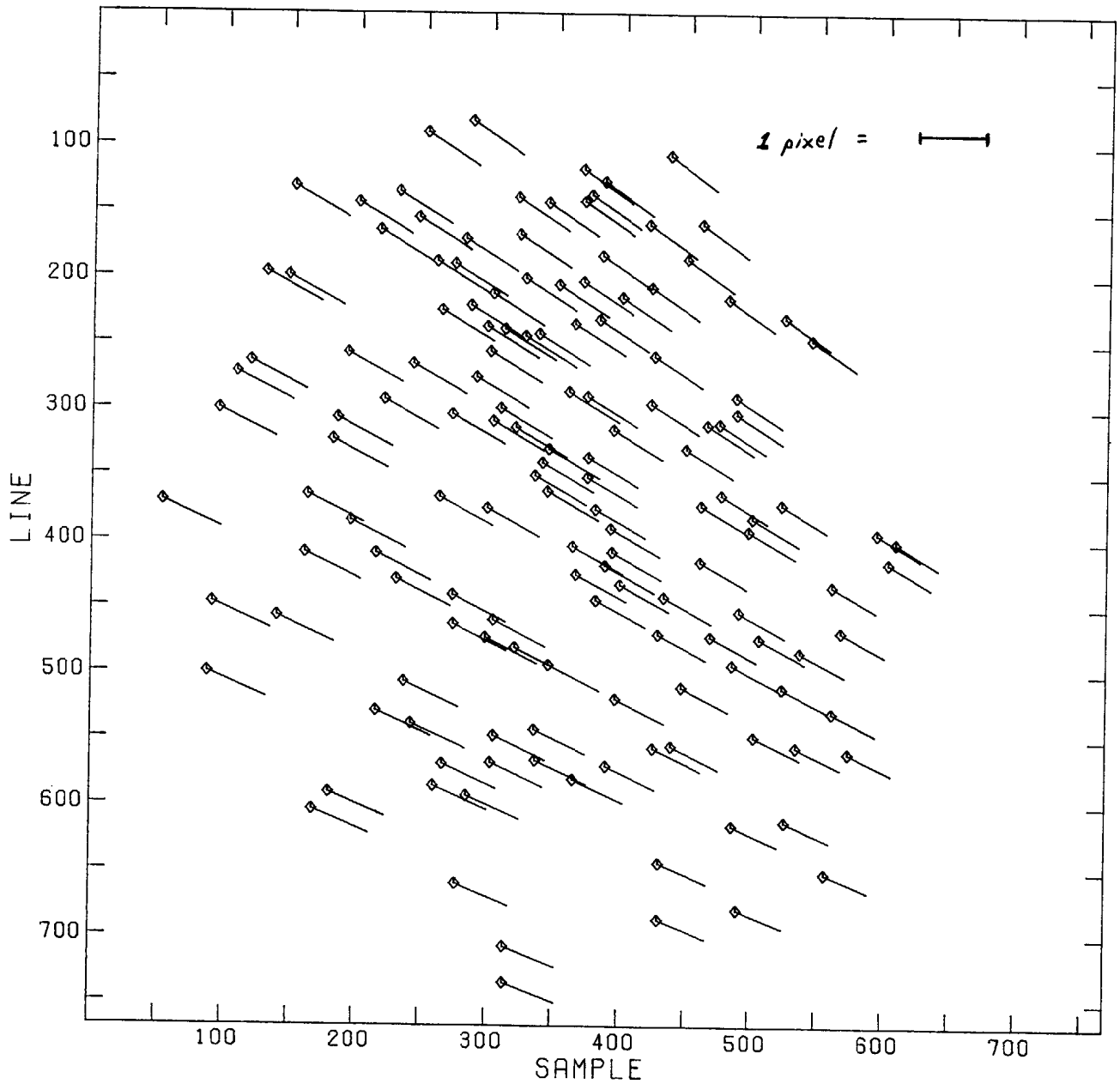


18:11 AUG 24,'82

Figure 3.1

SWP CAMERA

MAGNIFICATION = 50.00

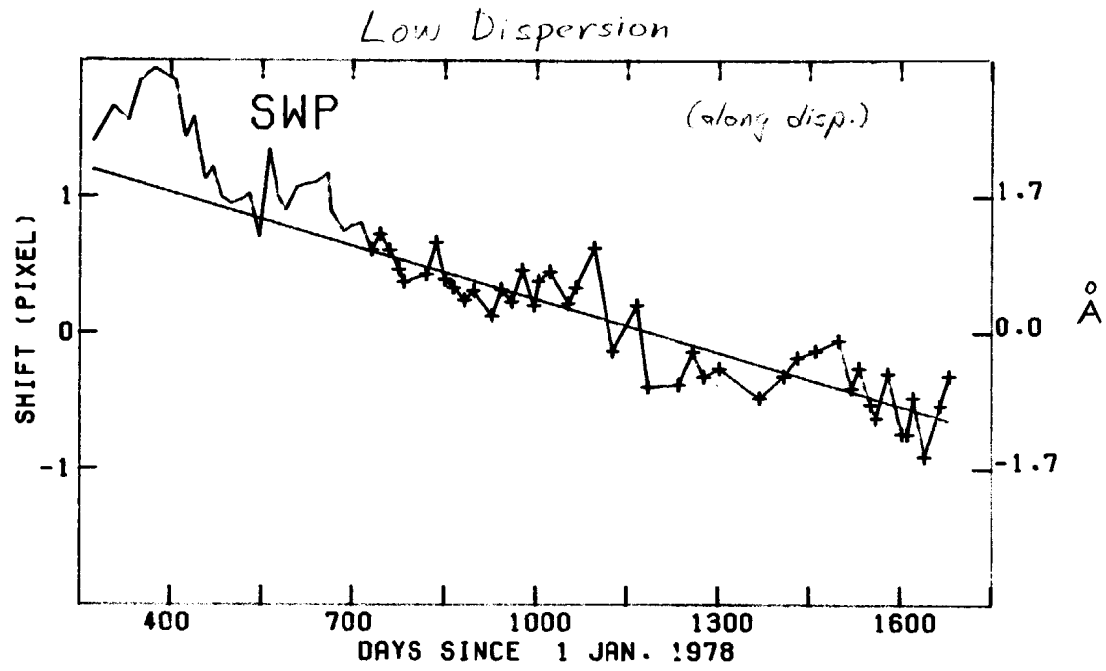


17:13 AUG 26, '82

Figure 3.2

SWP CAMERA

MAGNIFICATION = 50.00


Low Dispersion
SWP
(along disp.)
SHIFT (PIXEL)
1
0
-1
1.7
0.0
-1.7
Å
400
700
1000
1300
1600
DAYS SINCE 1 JAN. 1978

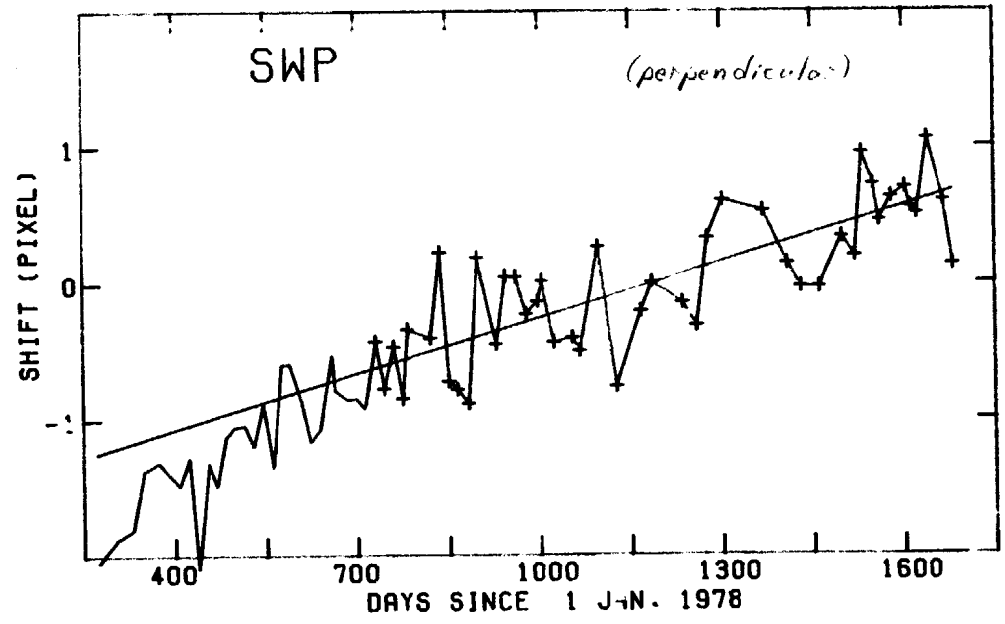

SWP
(perpendicular)
SHIFT (PIXEL)
1
0
400
700
1000
1300
1600
DAYS SINCE 1 JAN. 1978

Figure 3.3

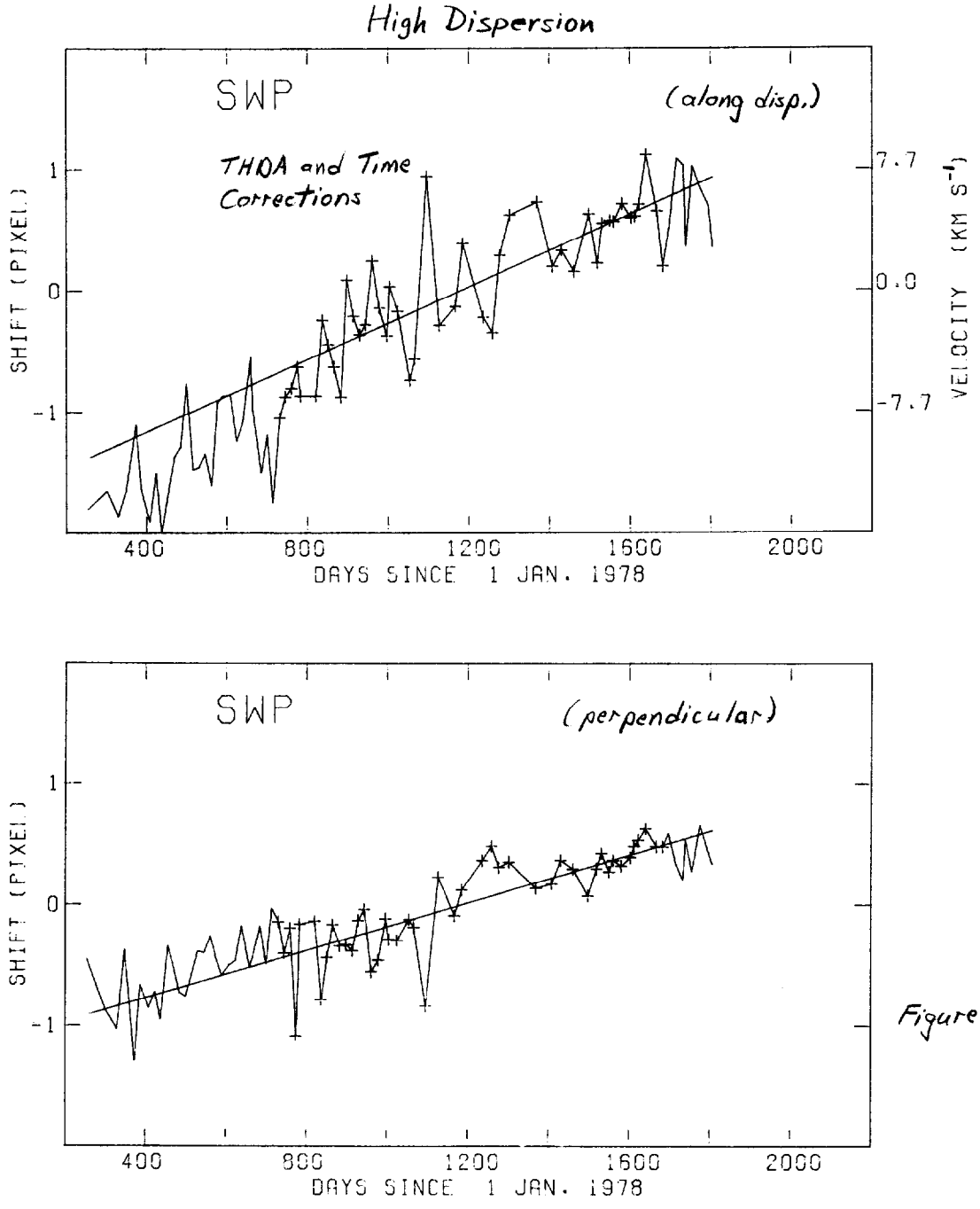

High Dispersion
SWP
(along disp.)
THOA and Time Corrections
SHIFT (PIXEL)
VELOCITY (KM S⁻¹)
7.7
0.0
-7.7
1
0
-1
400
800
1200
1600
2000
DAYS SINCE 1 JAN. 1978
SWP
(perpendicular)
SHIFT (PIXEL)
1
0
-1
400
800
1200
1600
2000
DAYS SINCE 1 JAN. 1978

Figure 3.4