

OPTICAL POINTING ON ANTENNA NUMBER FOUR
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SUMMARY

We obtained optical pointing data for antenna No. 4 on 9-11 Aug 1991. The data from the three nights is consistent with an rms residual of 2.5 arcsec in azimuth and 7.1 arcsec in elevation. Some time dependence is observed in the elevation pointing. This may be due to thermal drifts since the antenna is not currently temperature regulated. Plots of pointing residuals are attached.

INTRODUCTION

This is the first set of pointing data obtained for antenna No. 4. At present there are two rings of panels and the template is attached to the antenna. The antenna is roughly balanced and levelled, and the optical pointing is probably representative of what can be achieved with the finished antenna. The pointing equations contain parameters to describe the collimation axis, angles between the azimuth and elevation axes, and antenna tilt. In addition we include parameters to represent encoder errors, and a refraction parameter. The following three functions were tried:

$$\begin{aligned} \text{daz} = & v(1)*\text{cosel} + v(2) + v(3)*\text{sinel} + \text{sinel}*(v(4)*\sin(\text{az})) \\ * & + v(5)*\cos(\text{az})) + \text{cosel}*(v(6)*\sin(2.*\text{az}) + v(7)*\cos(2.*\text{az})) \end{aligned}$$

The parameters v(4) and v(5) were originally used to describe the antenna tilt, but were changed to fit a large encoder error term on antennas 1-3.

$$\begin{aligned} \text{daz} = & v(1)*\text{cosel} + v(2) + v(3)*\text{sinel} + \text{cosel}*(v(4)*\sin(\text{az})) \\ * & + v(5)*\cos(\text{az})) + \text{cosel}*(v(6)*\sin(2*\text{az}) + v(7)*\cos(2*\text{az})) \end{aligned}$$

The best fit was obtained with parameters for tilt and encoder runout:

$$\begin{aligned} \text{daz} = & v(1)*\text{cosel} + v(2) + v(3)*\text{sinel} + \text{sinel}*(v(4)*\sin(\text{az})) \\ * & + v(5)*\cos(\text{az})) + \text{cosel}*(v(6)*\sin(\text{az}) + v(7)*\cos(\text{az})) \end{aligned}$$

where the pointing constants represent the following:

- v(1) - Azimuth encoder + antenna mount offset from the meridian
- v(2) - Collimation error of optical or radio axis from the mechanical axis (orthogonal to the elevation axis). Note that the optical and radio pointing will differ in this term.
- v(3) - Misalignment of elevation axis relative to azimuth axis.
- v(4) to v(7) - Tilt and azimuth encoder errors.

The elevation pointing was fit to:

$$\begin{aligned} \text{del} = & v(1) + v(2)*\sin(\text{el}) + v(3)*\cos(\text{el}) + v(4)*\sin(\text{az}) \\ & + v(5)*\cos(\text{az}) + v(6)*\sin(2.*\text{az}) + v(7)*\tan(1.5708-\text{el}) \end{aligned}$$

where:

- v(1) - Elevation encoder offset.
- v(2) and v(3) - Elevation axis errors. The radio pointing contains an additional contribution due to subreflector sag.
- v(4) and v(5) - tilt of azimuth axis.
- v(6) - Fourier analysis residual.
- v(7) - Refraction term. Differs for radio and optical pointing.

Although the functions in the above equations are not orthogonal, additional corrections may be added to the pointing constants already in use provided that sufficient pointing data are taken to separate the terms. A correlation matrix printed for each fit, indicates the degree of independence of the parameters fitted.

POINTING FITS

A total of 653 points were obtained between 04-10 UT on 9-11 Aug 1991. FIGURE 1 shows the distribution of the data versus AZ and EL. Sources north of the latitude (~ 40 degrees) were observed, as usual, with $90 < EL < 180$. The data cover the full range of AZ-EL in this mode of pointing. A more extended AZ range could be obtained by observing northern sources with $0 < EL < 90$ as is sometimes done to minimize the slew time between source and calibrator. Two bad points were deleted.

FIGURE 2 shows the histogram of azimuth residuals for all data. A small residual $\sin(2*az)$ and $\cos(2*az)$ can be seen in FIGURE 3. We could improve the fit by including these additional terms. The pointing parameters are consistent over the 3 nights as shown by independent fits to the data for the 3 nights in FIGURES 4,5,6. Future data will show us whether the pointing parameters are stable, or the additional terms significant.

The elevation pointing has more scatter (FIGURE 7). Much of this is due to a time variation of the elevation pointing, as shown for the 3 nights in FIGURES 8,9,10. This may be due to thermal drifts since the antenna is not currently temperature regulated. The azimuth residuals do not show a time dependence. The elevation encoder is mounted in the insulated cabin which might take longer to come into equilibrium with the outside temperature. The dependence might also be due individual components in the electronics. Some component swapping between azimuth and elevation might isolate a temperature dependence. There are presently no thermistors available to monitor temperatures on antenna 4. The time dependence is very similar for the nights of 10-11 aug with a 20 minute time shift. If we eliminate the rapid variation in the 1st hour on both nights we obtain an rms= 4.4 arcsec as shown by the histogram in FIGURE 11.

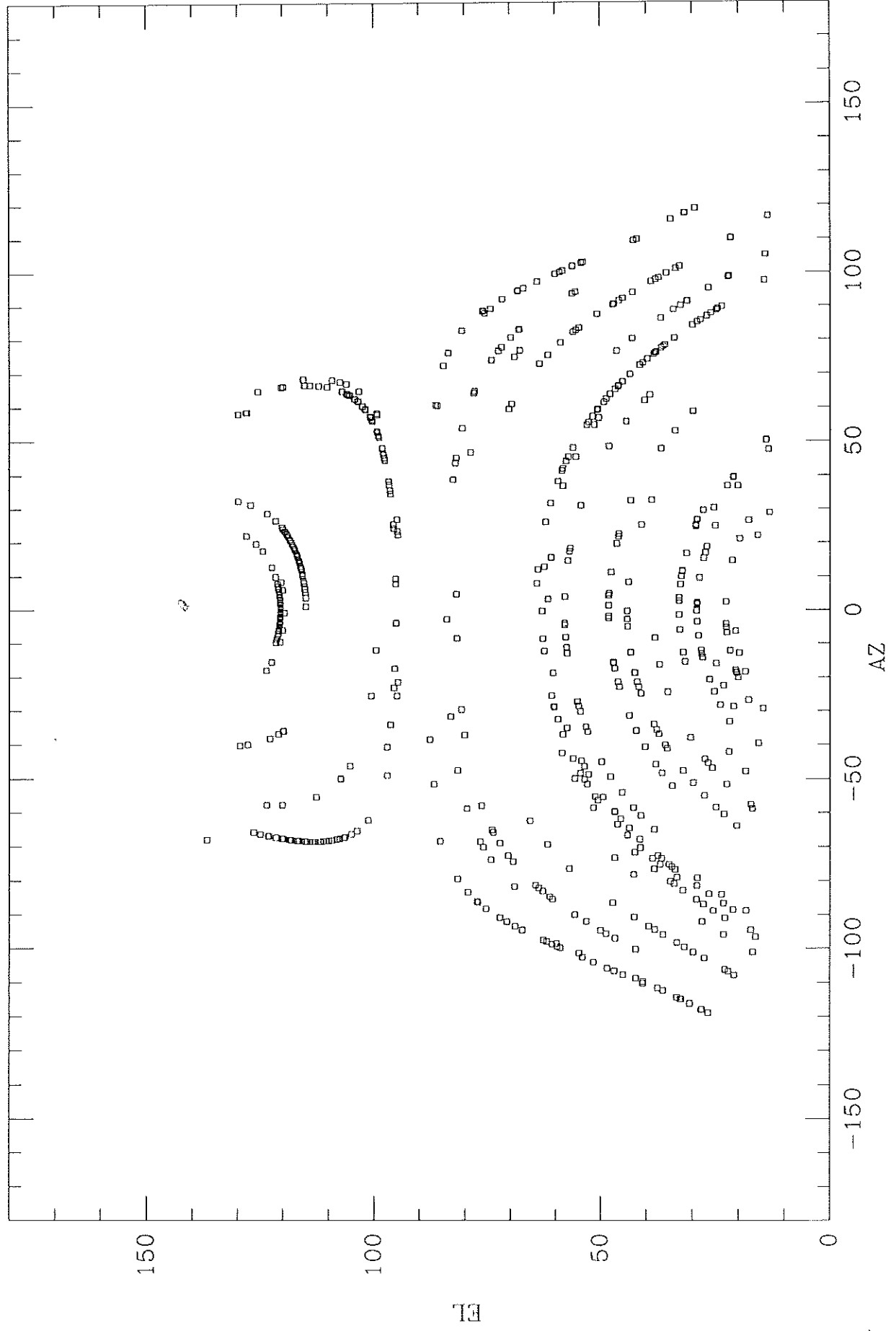
CONCLUSION

The azimuth pointing residual is as good as can be expected from the typical optical seeing at Hat creek. Also note that data were acquired as soon as the star position repeated within 4". Additional parameters can be added if future data indicate that the pattern of pointing residuals is reproducible. The time dependence observed in the elevation pointing may be due to thermal drifts since the antenna is not currently temperature regulated. This can be improved.

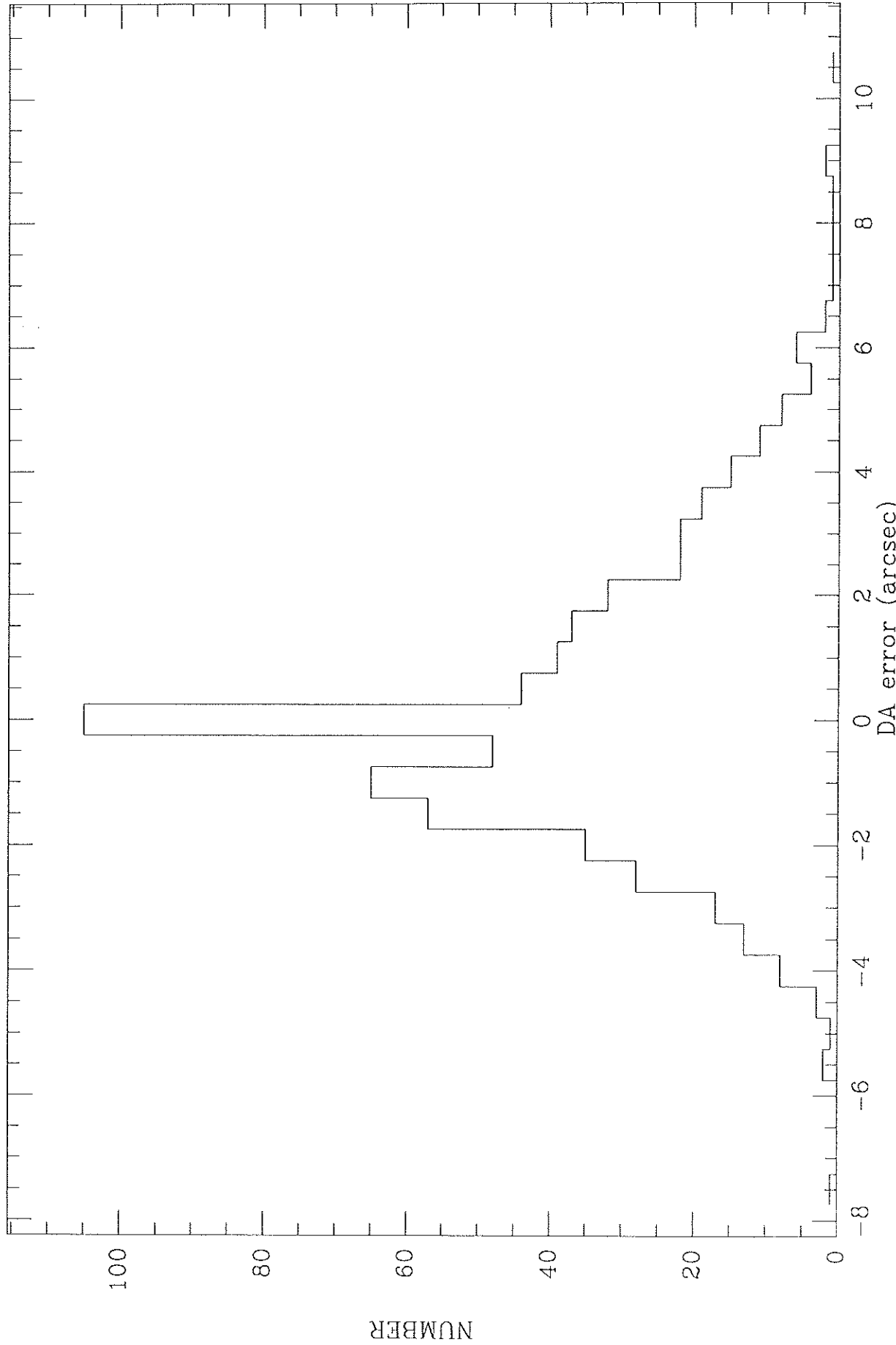
Antenna 0. 14-AUG-91 tvcop.11aug rms=2176.8 arcsecs

Pointing coverage

APC	27.84	11.46	-0.05	-0.07	0.06	-0.02	0.00
EPC	80.13	0.83	0.38	-0.15	0.02	0.03	0.50



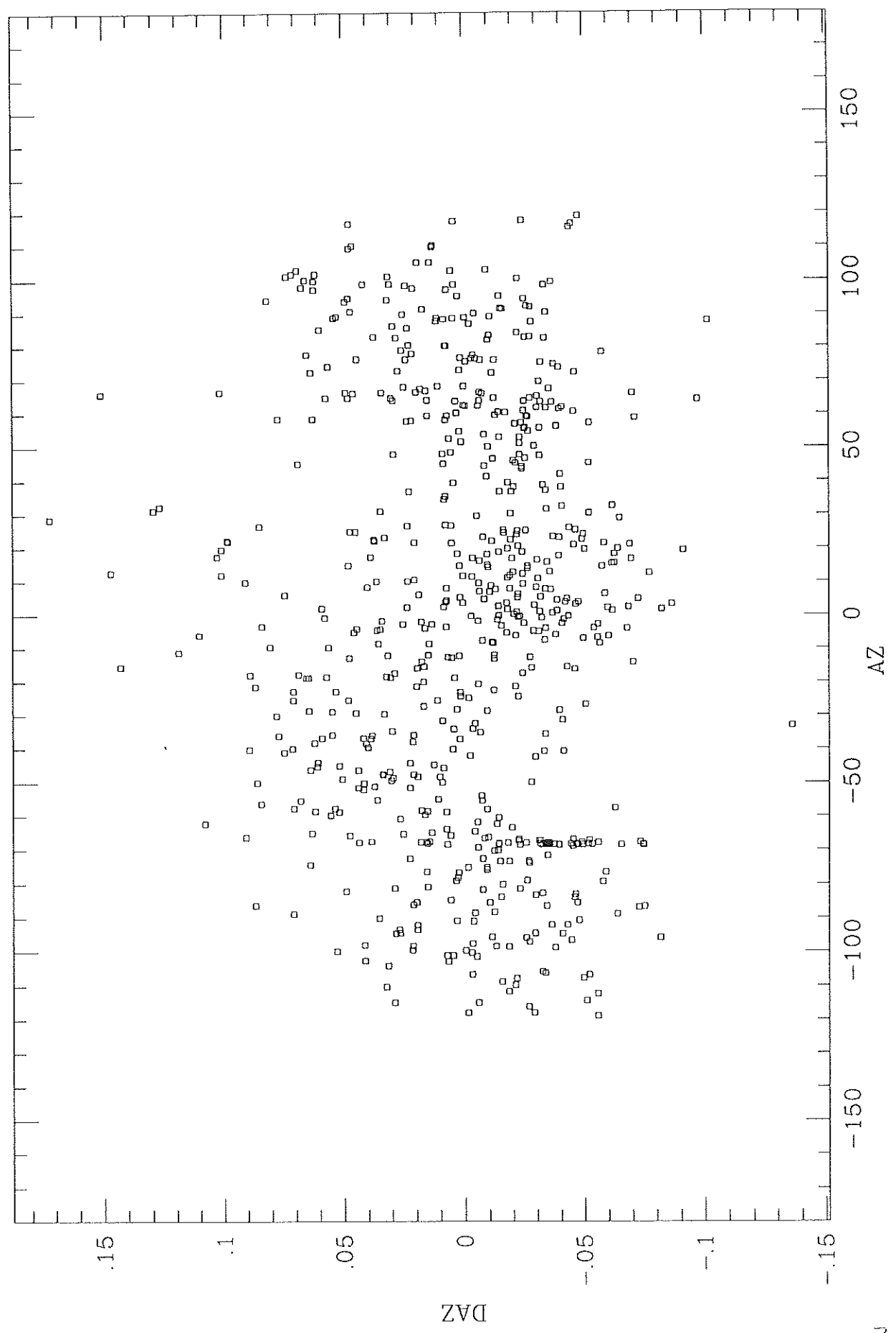
Antenna 1. 14-AUG-91 tvcop.11aug rms= 2.5 arcsecs
 7-parameter fit with Tilt and sin/cos(az)encoder errors
 APC 33.12 7.13 -0.29 -0.03 0.26 -0.09 0.00 Pointing Equation No. 3.
 EPC 0.00 0.00 0.00 0.00 0.00 0.00 Units are arcmin



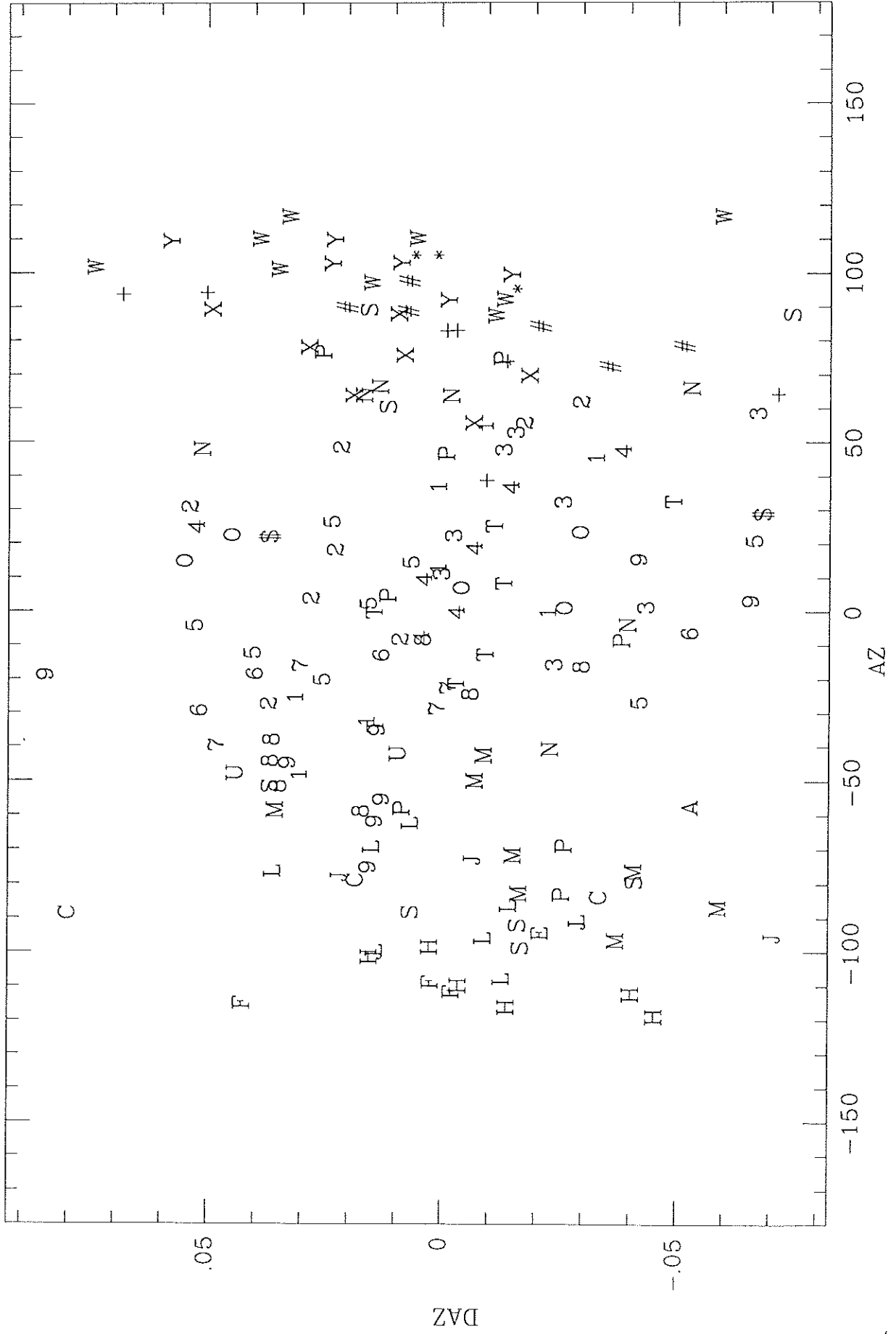
Antenna 1. 14-AUG-91 tvcop.11aug rms= 2.5 arcsecs

7-parameter fit with Tilt and sin/cos(az) encoder errors

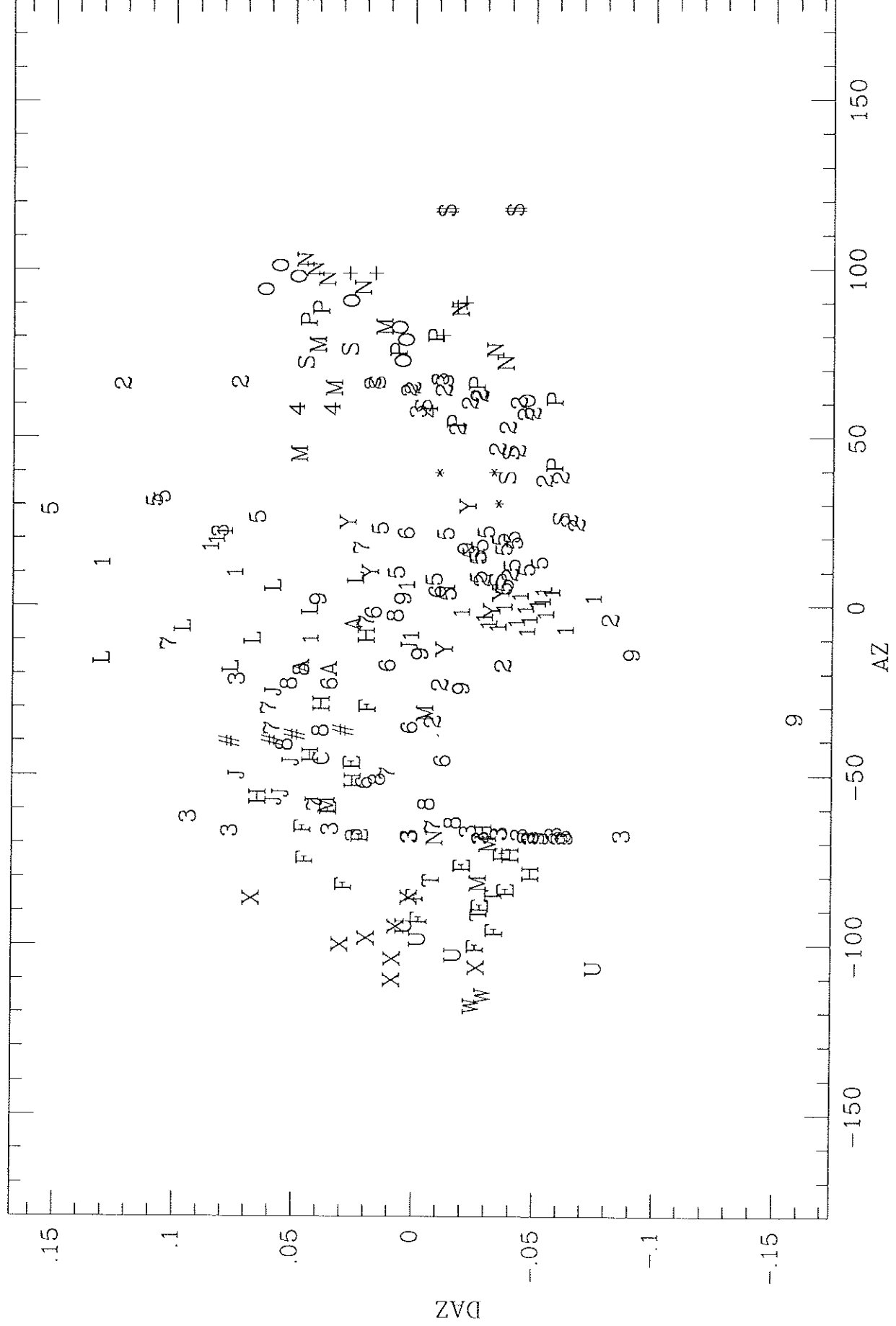
APC	33.12	7.13	-0.29	-0.03	0.26	-0.09	0.00
EPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00



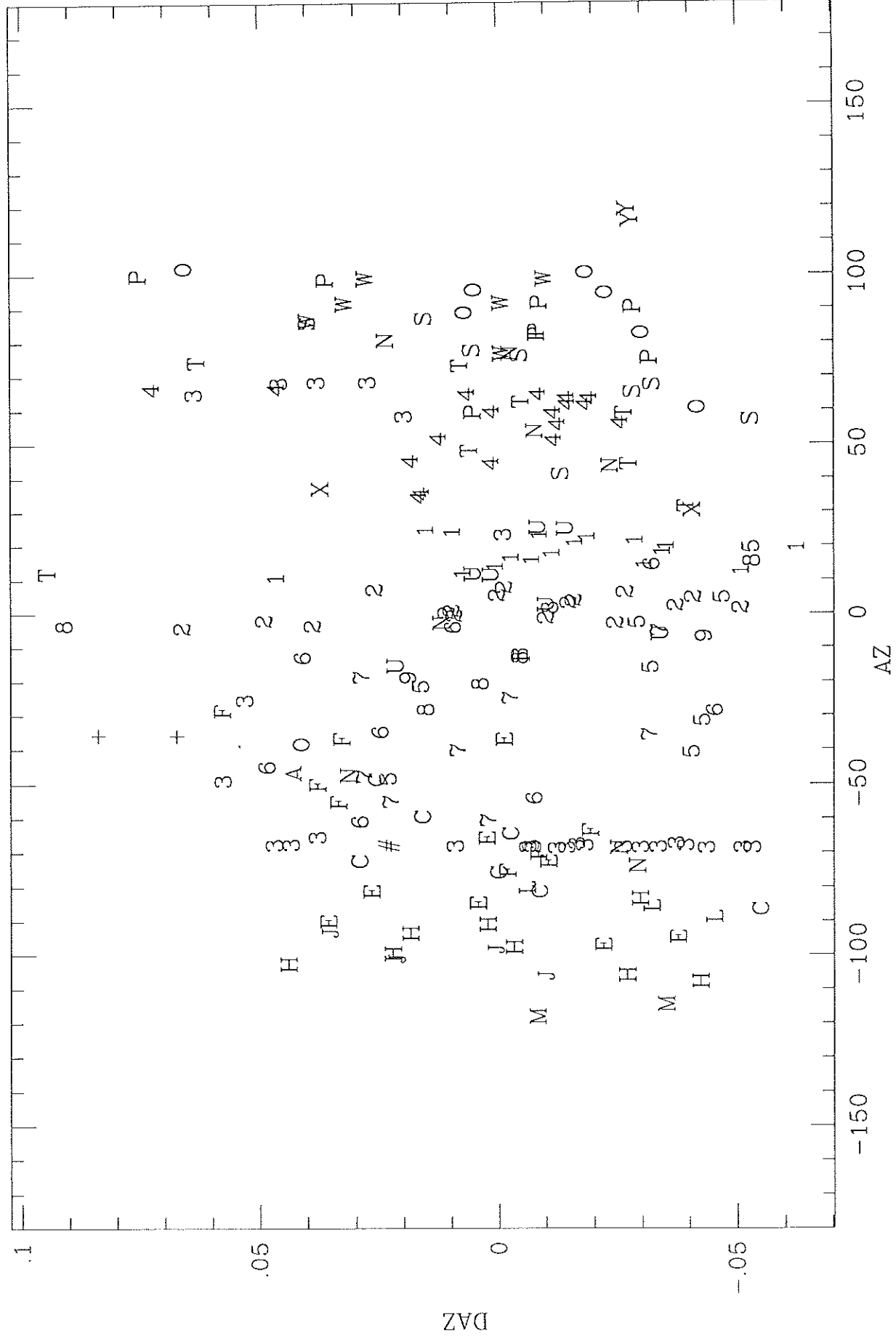
Antenna 1. 15-AUG-91 tvcop.09aug rms= 1.9 arcsecs
 7-parameter fit for 09aug91 only
 APC 33.11 7.16 -0.34 -0.03 0.27 -0.08 -0.01 Pointing Equation No. 3.
 EPC 78.86 0.47 0.66 -0.28 0.03 0.02 0.84 Units are arcmin



Antenna 1. 15-AUG-91 tvcop.10aug rms= 2.8 arcsecs
 7-parameter fit for 10aug91 only
 APC 33.12 7.15 -0.28 -0.02 0.25 -0.10 0.01 Pointing Equation No. 3.
 EPC 79.48 -0.07 0.72 -0.33 0.03 0.05 0.73 Units are arcmin



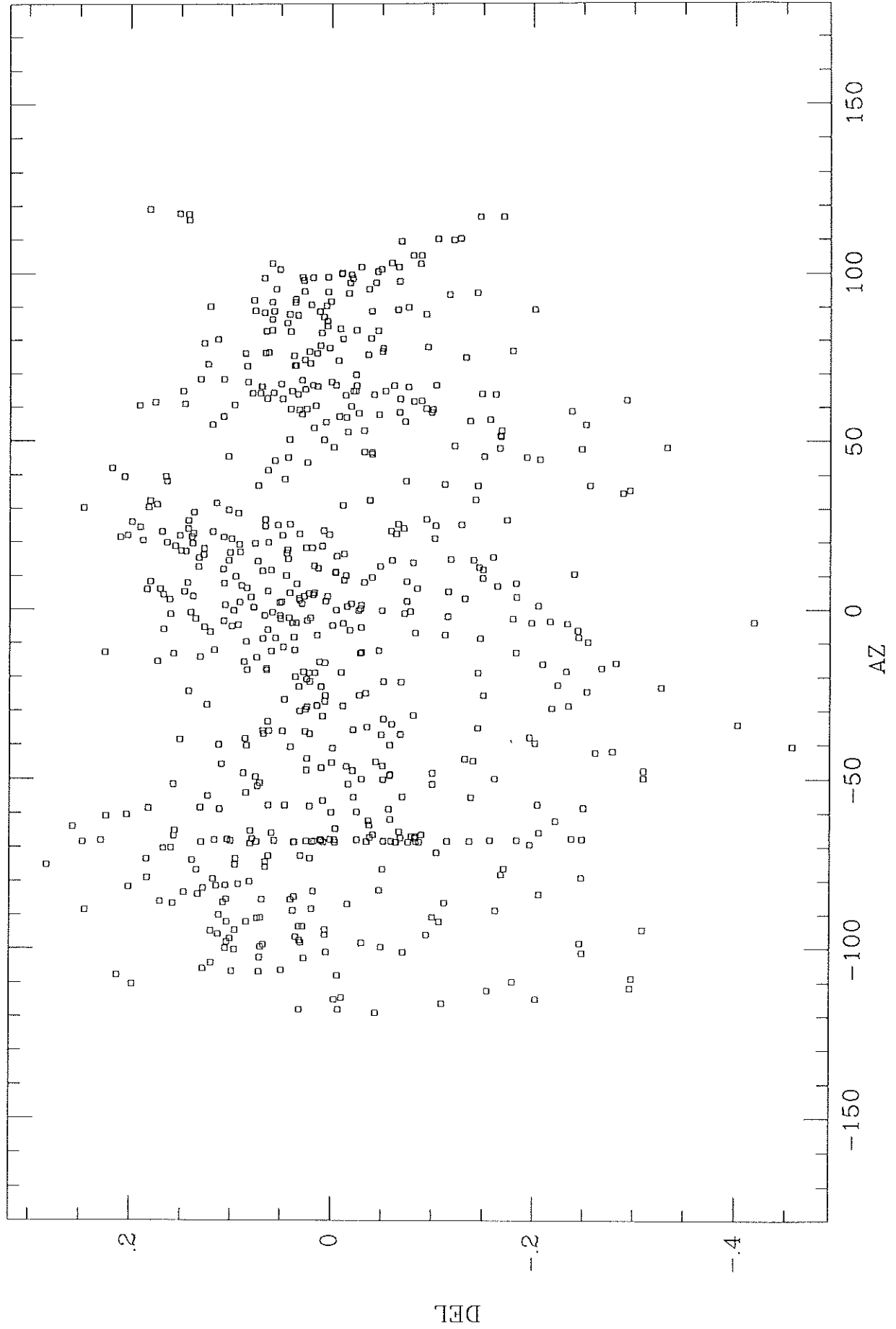
Antenna 1. 15-AUG-91 tvcop.11aug rms= 1.9 arcsecs
 7-parameter fit for 11aug only
 APC 33.15 7.06 -0.22 -0.03 0.27 -0.09 0.01 Pointing Equation No. 3.
 EPC 79.46 -0.11 0.75 -0.32 0.03 0.03 0.72 Units are arcmin



Antenna 1. 14-AUG-91 tvcop.11aug rms= 7.1 arcsecs

5-parameter fit with fixed refraction term

APC	33.12	7.13	-0.29	-0.03	0.26	-0.09	0.00
EPC	79.19	0.21	0.61	-0.30	0.03	0.00	0.81

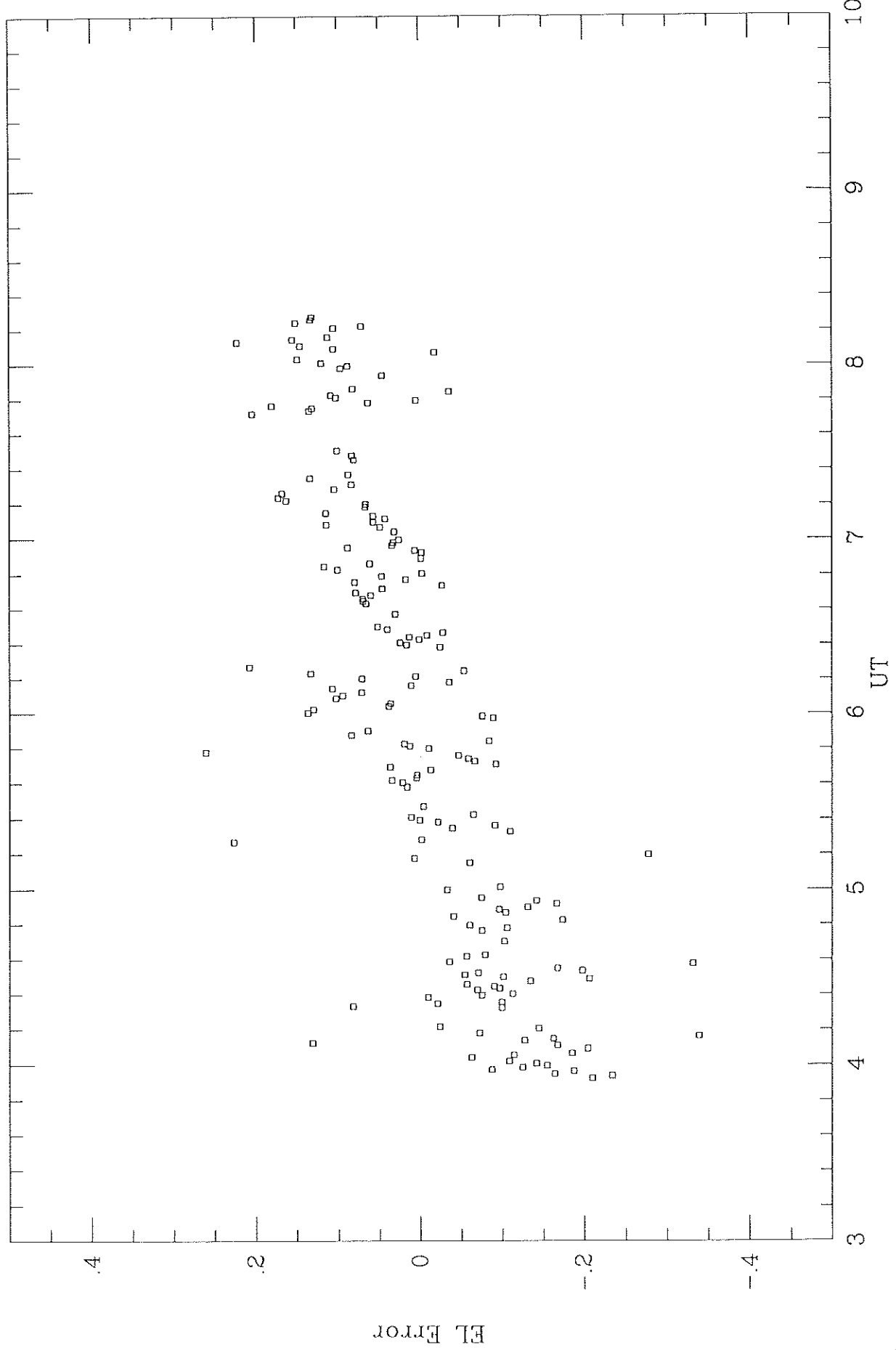


Antenna 0. 13-AUG-91 tvcop.09aug rms= 7. arcsecs

09aug91

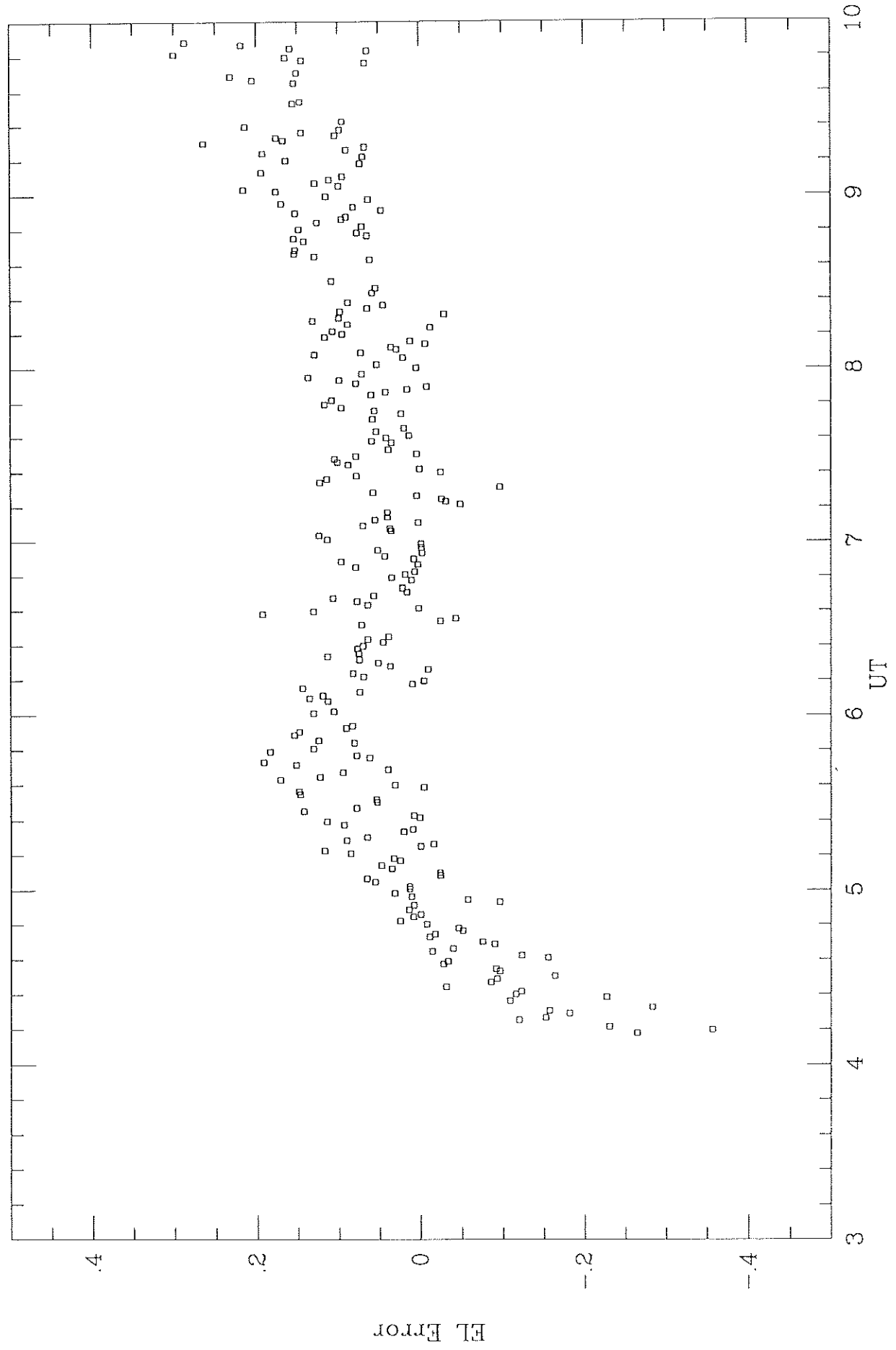
APC	33.08	7.35	-0.41	-0.17	-0.26	-0.15	0.29
EPC	78.86	0.47	0.66	-0.28	0.03	0.02	0.84

} Fits to 09 Aug only



Antenna 0. 13-AUG-91 tvcop.10aug
 10aug91 rms= 6. arcsecs

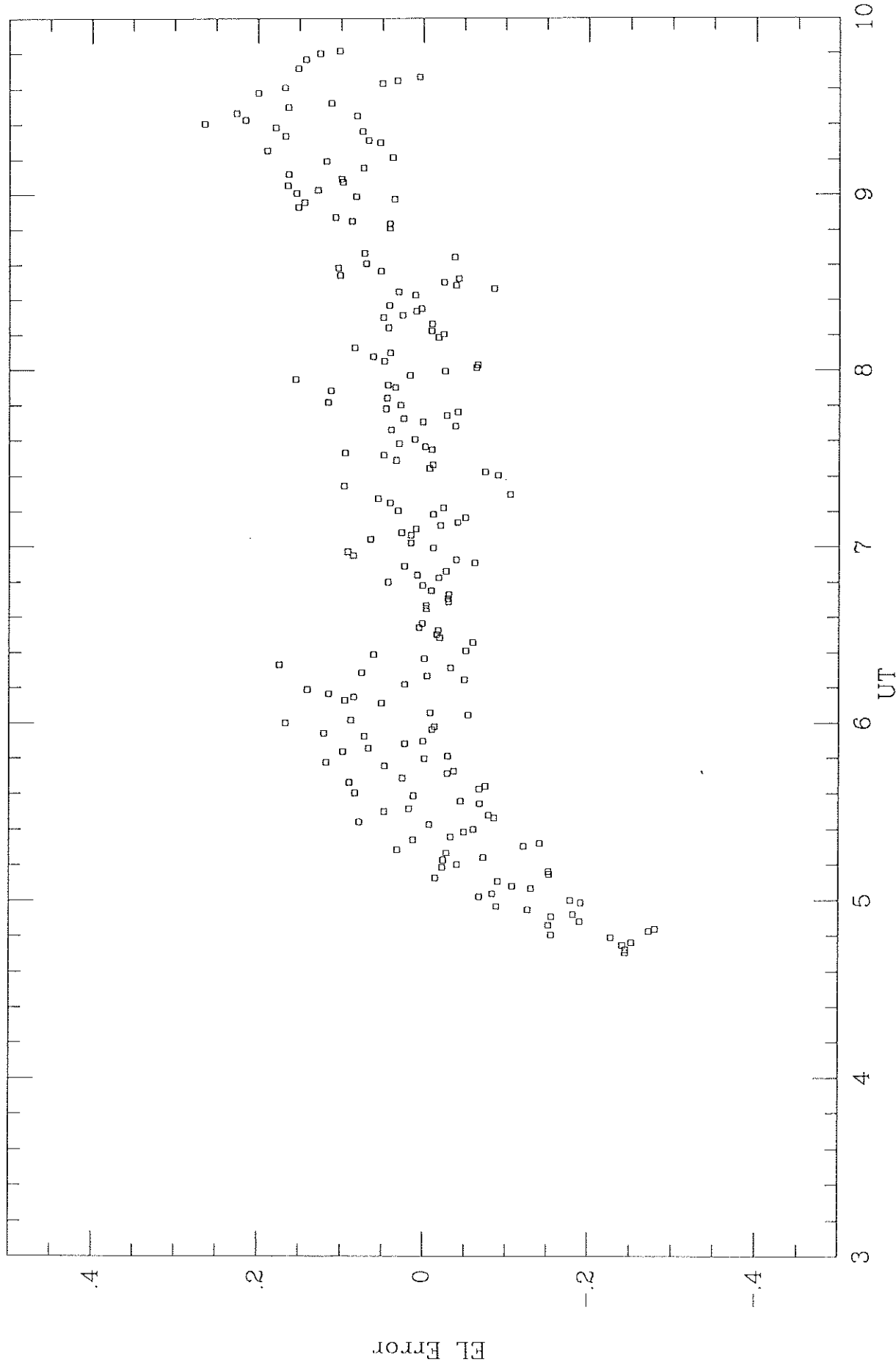
APC	32.98	7.29	-0.31	-0.13	0.05	-0.09	0.06
EPC	79.43	-0.06	0.71	-0.31	0.03	0.02	0.71



Antenna 0. 13-AUG-91 tvcop.11aug rms= 6. arcsecs

11aug91

APC	32.94	7.32	-0.33	-0.09	0.13	-0.02	0.03
EPC	79.43	-0.06	0.71	-0.31	0.03	0.02	0.71



Antenna 1. 14-AUG-91 tvcop.11aug rms= 4.4 arcsecs
7-parameter fit for UT=5-10, 10-11 aug
APC 0.00 0.00 0.00 0.00 0.00 0.00 0.00 Pointing Equation No. 3.
EPC 79.51 -0.11 0.68 -0.33 0.05 0.03 0.73 Units are arcmin

