AT-39.2/012

Tilt Results (II)

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1 Introduction

Former tests have shown that the P-tilt in the pedestal cabin changed with time as large as 20 arcseconds (peak-to-peak) in 24 hours, although the antenna was stationary. That is what we did not expect because the pedestal room is air-conditioned.

We did an experiment on 26th October after the array reconfiguration. We found that the E-tilt and P-tilt data was almost listed about the standard curve, with a step of about 5 arcseconds; the difference reading between them was a smooth curve. There appeard to be evidence of hysteresis at the 5 arcsec level when slewing in azimuth.

More tests have been done to find out what had happened.

2 The Experimental Tests

We made one azimuth rotation test on 26th October, 27th October, 29th October and 2th November and three on 3th November, two on 4th November respectively. The purpose of the tests (with the exception of 26th October) was to confirm the facts that we had found and to try to find out what had happened with the antenna. Another azimuth scan test was done after reconfiguration on 16th November.

In addition, the data were collected on 26th October while the antenna #2 was stationary for about 10 hours.

3 Data Analysis

3.1 Evidence of Hysteresis?

We did an azimuth scan test on 26th October after the array reconfiguration. The results are plotted in figure 1. It is clear from the graph that the fitting errors of E-tilt and P-tilt scattered about 5 arcseconds along a curve and they did exactly the same way and the difference reading between them was a smooth curve.

To confirm this we did two azimuth scan tests on 27th October and 29th October respectively. We started at a different azimuth and elevation to make determine whether it is related to the starting point and the elevation angle or not. The data were plotted in the figures 2 and 3. They also show the same case.

After the reconfiguration on 2th November, we made a same test. But the antenna #2 has been moved to station #11. We plotted the data in figure 4. The graph shows that the curve was almost the same as that of 29th October, where the antenna was in station #21.

On 3th November we did three azimuth scan tests at different time. The results were plotted in figures 5, 6 and 7. Another test was done on 4th November, when the antenna was driven in the slow slewing speed ($v = 5^{\circ}/Min$). The results are plotted in the figure 8. From the graph it is clear that such case does not exist in the tracking mode.

After the array reconfiguration on 16th November, we did an azimuth scan test where the antenna #2 and #5 were at station #6 and #9 respectively. The graphs, plotted in figures 9 and 10, show that the points which deviate from the curve occur at exact the same azimuth for the two antennas.

What appears to be hysteresis is in fact a data collection problem: there is a time lag between reading the azimuth and reading the tiltmeter— Thus the effect is not present at low slewing rate; nor maximum at the extreme in the azimuth time plots.

3.2 Data Analysis

Because of the data gathering problem, we believe that the plots of the readings of the tiltmeter for the azimuth clockwise and counter-clockwise must be separate curves.

We use the least squares fitting method to fit the data for azimuth clockwise and counter-clockwise respectively. We expect them to have the azimuthal dependance of the form:

$$y_{cw} = a_{cw} + A_{cw} \times sin(az + \phi_{cw})$$

$$y_{ccw} = a_{ccw} + A_{ccw} \times sin(az + \phi_{ccw})$$

From the graphs for the 27th October and 2th November, plotted in figures 11 and 12, we notice that they really show the different curve for azimuth clockwise and counter-clockwise. The plots also indicate that they have a phase difference between the two curves.

Since there exist the different curves for the azimuth clockwise and counter-clockwise, we use the following form to calculate the a_x and a_y in the pointing model:

$$y = a + A \times sin(az + \phi)$$

where

$$a = \frac{a_{cw} + a_{ccw}}{2}$$

$$A = \frac{A_{cw} + A_{ccw}}{2}$$

$$\phi = \phi_{cw} + \Delta\phi$$

$$\Delta\phi = (\phi_{cw} - \phi_{ccw})/2$$

And the relation to the pointing model parameters a_x and a_y are as following:

$$a_x = Asin\phi$$

$$a_y = Acos\phi - arctan(B/R_{\oplus})$$

The results of these tests and astronomical pointing are listed in the Table 1.

date	stn	*Amplitude*		*Phase*		*result*		*obs. pointing*	
		cw	ccw	cw	ccw	a_x	a_y	a_x	a_y
26/10	21	65.8	66.2	-5.5	1.2	-3	26	-16	24
27/10	21	57.9	59.0	-8.1	1.9	-3	17	-16	24
29/10	21	62.2	60.0	-7.3	-8.3	-8	20	-16	24
2/11	11	86.1	85.0	0.9	7.1	6	11	7	19
3/11	11	84.4	83.9	1.2	5.1	5	9	7	19
3/11	11	88.3	69.8	-3.8	13.2	7	4	7	19
3/11	11	81.4	79.7	1.8	5.4	5	6	7	19
4/11	11	88.8	85.9	2.5	5.1	6	12	7	19
16/11	6	98.6	94.9	-5.1	-1.8	-6	4	-6	-2

Table 1. The Least Squares Fitting Results

The table shows that the results of azimuth slewing test are quite in agreement with that of astronomical pointing.

3.3 Tests Results

We have done lots of azimuth scan tests when the antenna # 2 and antenna #5 were at station # 11 and station #34 respectively. The results of E-tilt are listed in the tables 2 and 3.

	2th Nov (5:00pm)	3th Nov (1:00pm)	3th Nov (6:00pm)	3th Nov (7:00pm)	4th Nov (6:30pm)	4th Nov (8:00pm)
a_x	6	5	7	5	6	2
a_y	11	9	4	6	12	8
z0	-19.2	-23.9	-24.0	-26.1	-39.5	-38.8
RMS	3.84	3.03	3.17	2.84	2.61	0.69
T	25.4	24.4	24.4	23.9	18.5	19.5

Table 2. Azimuth Scan Test Results of E-tilt for Antenna #2

	3th Nov (1:00pm)	3th Nov (6:00pm)	3th Nov (7:00pm)	4th Nov (6:30pm)
a_x	-21	-26	-23	-19.7
a_y	-4	-10	-4	-4.6
z0	-32.9	-28.9	-30.5	-28.5
RMS	1.9	2.5	2.1	1.4
T	27.6	26.0	27.0	16.0

Table 3. Azimuth Scan Test Results of E-tilt for Antenna # 5

where a_x and a_y are the two parameters in the pointing model, z0 is the zero-offset of the tiltmeter, RMS the fitting RMS and T the temperature.

From the tables we notice that the a_x, a_y and zero-offset of the tiltmeter change with time, although the antenna was in the same station. It is quite possible that this is caused by the thermal factors.

3.4 Antenna Stationary Results

After reconfiguration on 26th October the antenna was stationary for almost 10 hours. The E-tilt and P-tilt are plotted in the figure 13. The graph shows that E-tilt changed a lot and P-tilt drifted more than 4 arcseconds in that period.

What we expected is P-tilt should not change with time when the antenna is stationary, since the pedestal room is air-conditioned. We believe that part of change of the P-tilt is contributed by the temperature effect on the tiltmeter itself and the other by the temperature impact on the antenna structure as the temperature in the pedestal room is not absolutely constant.

3.5 Hysteresis

In the former note we mentioned about whether or not the hysteresis exists in the azimuth and elevation axis. The plots, which the fitting residual of azimuth clockwise and counter-clockwise are plotted separately, show that the fitting curves of the E-tilt and P-tilt are quite identical and do not have difference.

The above results indicate that the difference between the fitting residual of azimuth clockwise and counter-clockwise in the former analysis did not mean the hysteresis in the azimuth axis. That is caused by the data gathering process.

Therefore no hysteresis have been found in the azimuth and elevation axis.

4 conclusions

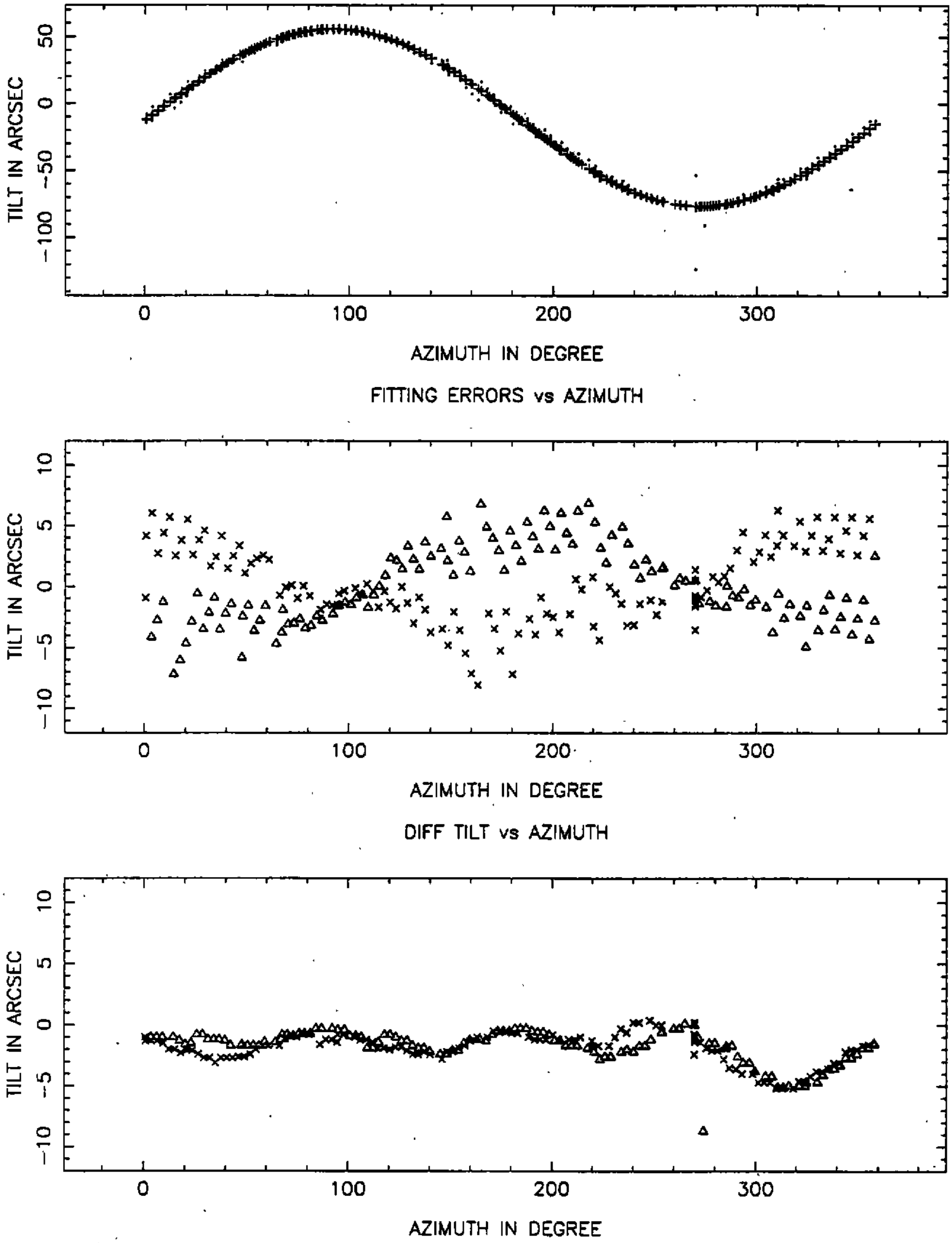
4.1 Hysteresis

- No hystersis is found in both azimuth and elevation axis.

4.2 Temperature

- Temperature causes the change of a_x and a_y in the pointing model and the zero-offset of the tiltmeter.
- P-tilt appears to change with time when the antenna is stationary—presumed temperature affecting the calibration.

Fig 1 E–TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 26oct.cab
THE MODEL FOR E–TILT vs AZIMUTH IS:

$$y = -10.3 \pm 0.19 + (-2.6 \pm 0.28)\cos(AZ) + (65.9 \pm 0.26)\sin(AZ)$$

THE FITTING ERROR RMS: 3.04 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:

$$y = 0.00 + (0.00)EL$$

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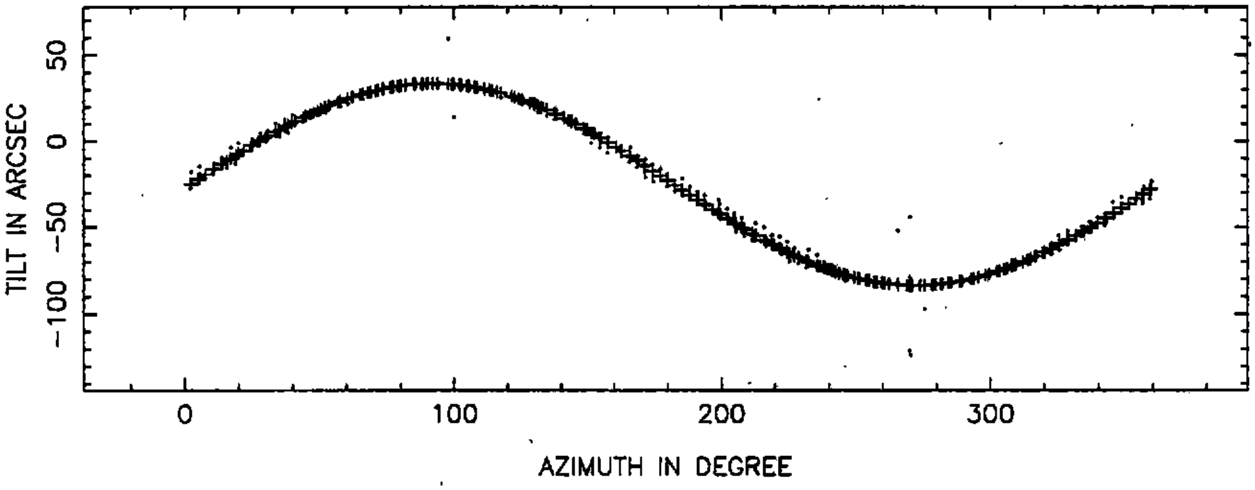
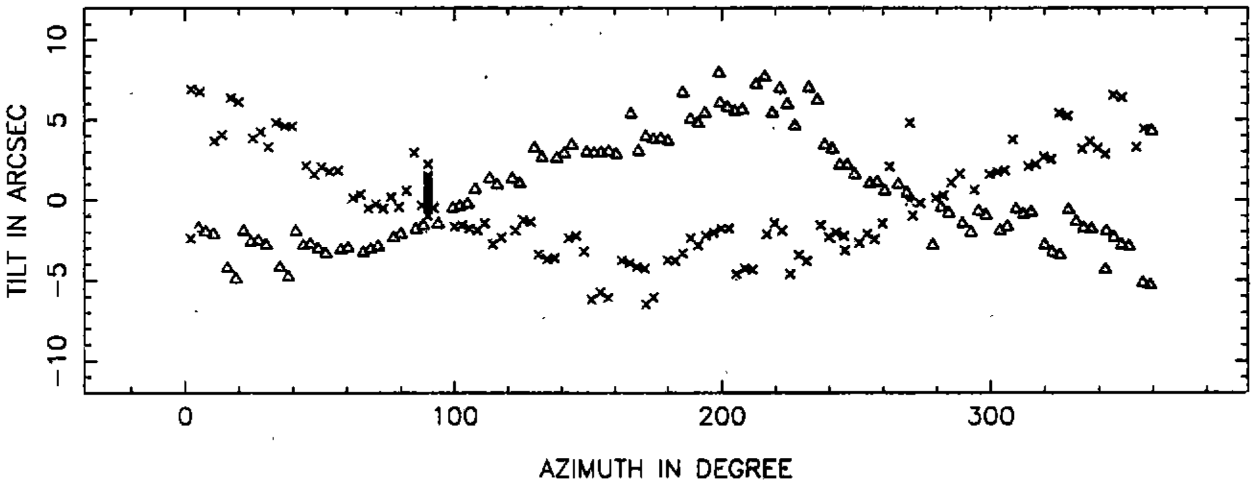
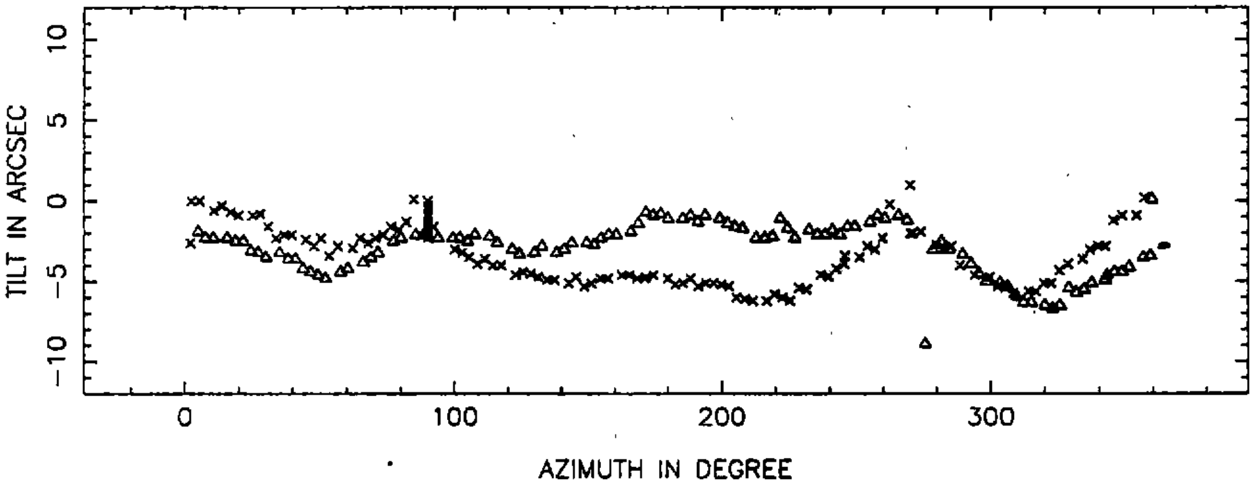
Fig. 2 E–TILT & FITTING CURVE vs AZIMUTH



FITTING ERRORS vs AZIMUTH



DIFF TILT vs AZIMUTH



THE CALIBRATION FILE USED IS: 27oct.cab
THE MODEL FOR E–TILT vs AZIMUTH IS:

$$y = -25.1 \pm 0.21 + (-2.1 \pm 0.31)\cos(AZ) + (58.5 \pm 0.28)\sin(AZ)$$

THE FITTING ERROR RMS: 3.29 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:

$$y = 0.00 + (0.00)EL$$

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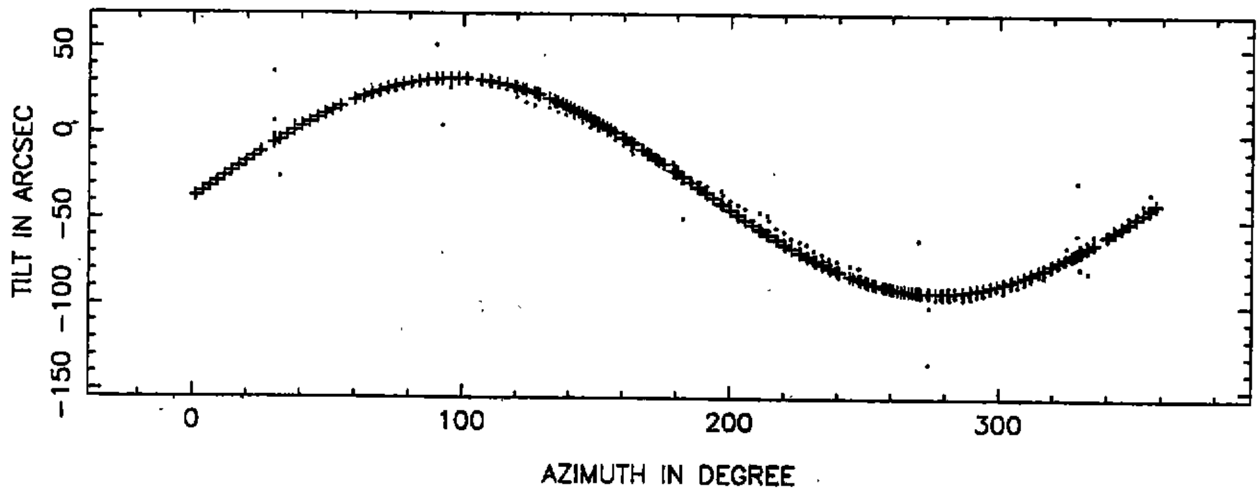
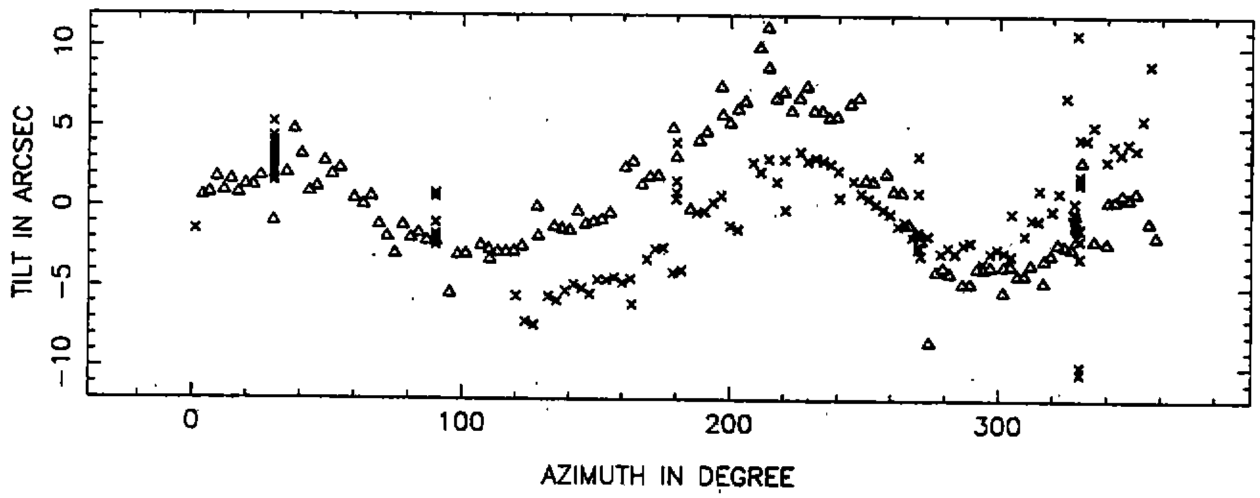
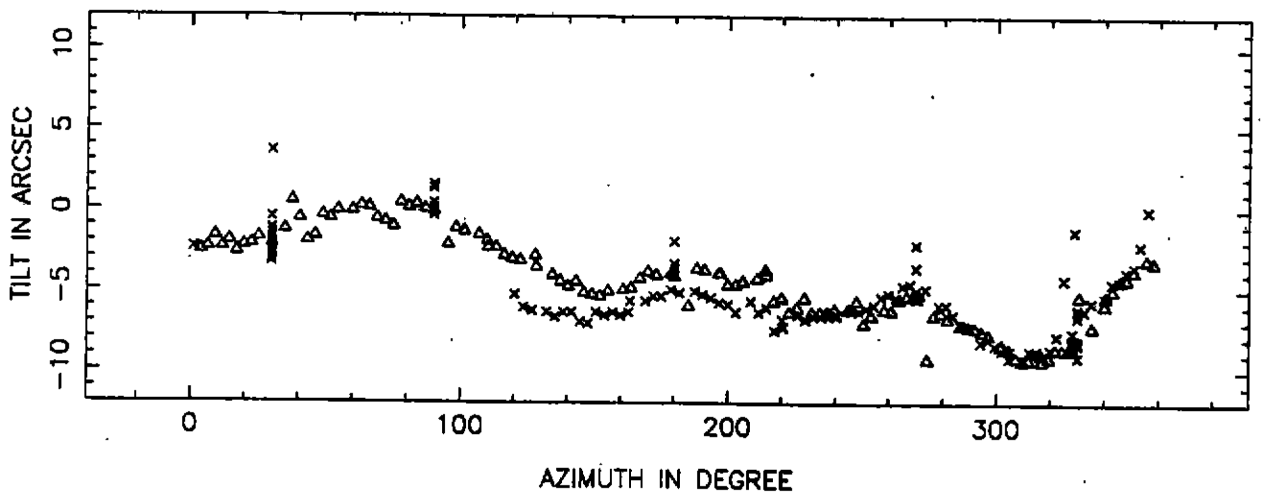
Fig. 3 E–TILT & FITTING CURVE vs AZIMUTH



FITTING ERRORS vs AZIMUTH



DIFF TILT vs AZIMUTH



THE CALIBRATION FILE USED IS: 29oct.cab

THE MODEL FOR E–TILT vs AZIMUTH IS:

$y = -30.6 \pm 0.22 + (-7.6 \pm 0.31)\cos(AZ) + (61.9 \pm 0.32)\sin(AZ)$

THE FITTING ERROR RMS: 3.66 arcsec

THE MODEL OF CALIBRATION ELEVATION EFFECT IS:

$y = 0.00 + (0.00)EL$

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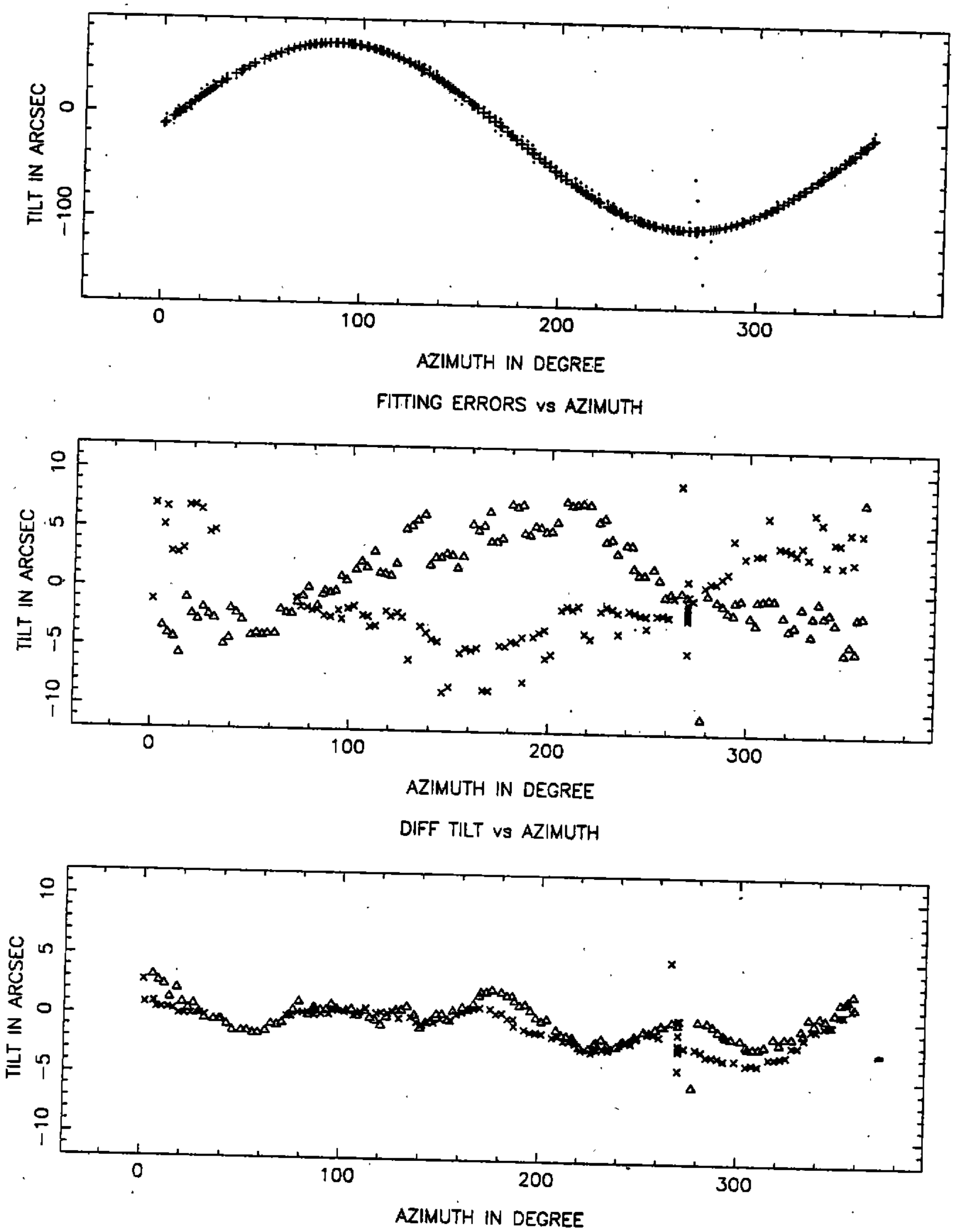
Fig. 4 E-TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 2nov.cab
THE MODEL FOR E-TILT vs AZIMUTH IS:
y = −19.2 +− 0.26 + (5.8 +− 0.36)cos(AZ) + (85.9 +− 0.36)sin(AZ)
THE FITTING ERROR RMS: 3.87 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:
y = 0.00 + (0.00)EL

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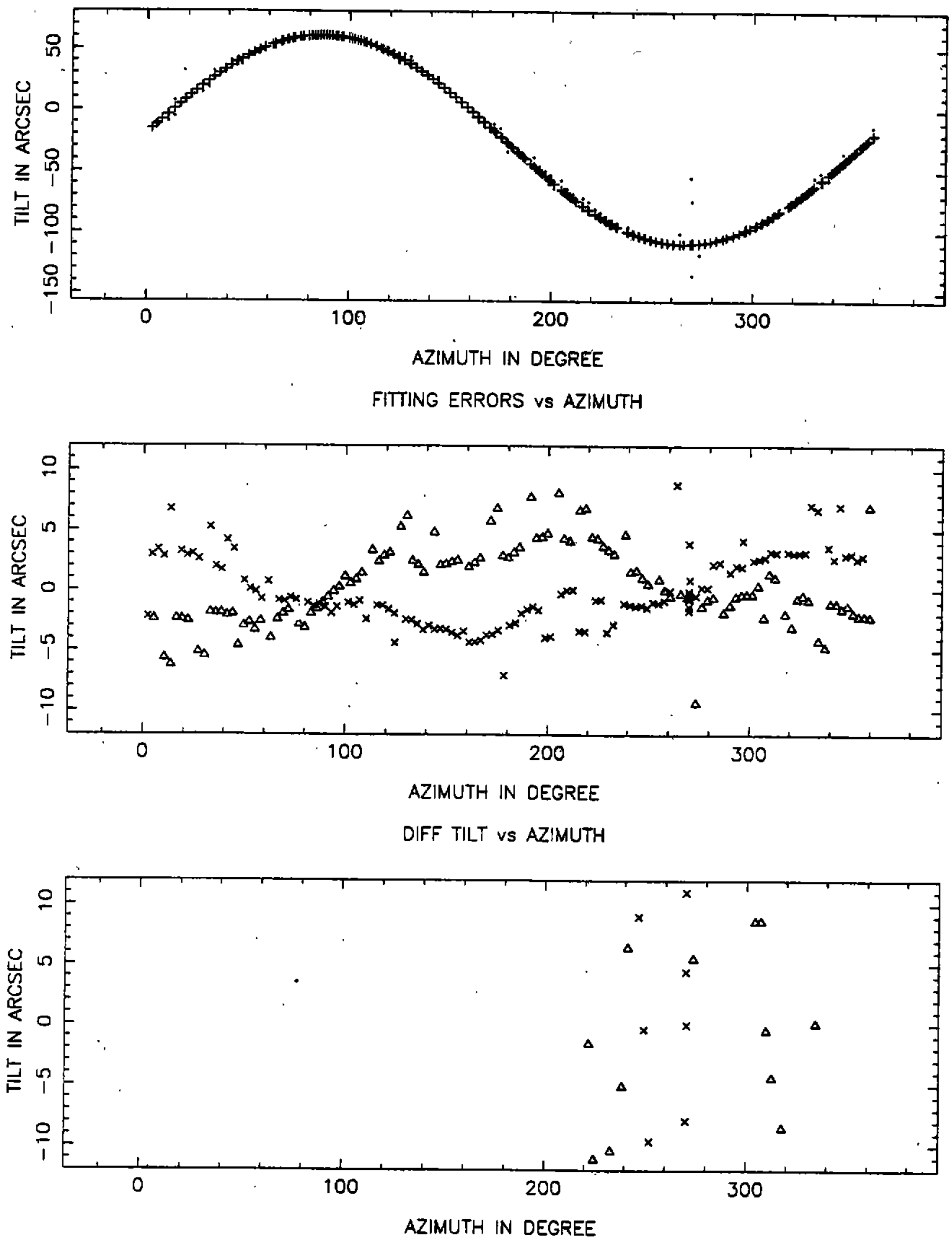
Fig. 5 E–TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 3nov1_2.cab
THE MODEL FOR E–TILT vs AZIMUTH IS:
y = −24.2 +− 0.20 + (5.4 +− 0.29)cos(AZ) + (85.0 +− 0.27)sin(AZ)
THE FITTING ERROR RMS: 3.04 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:
y = 0.00 + (0.00)EL

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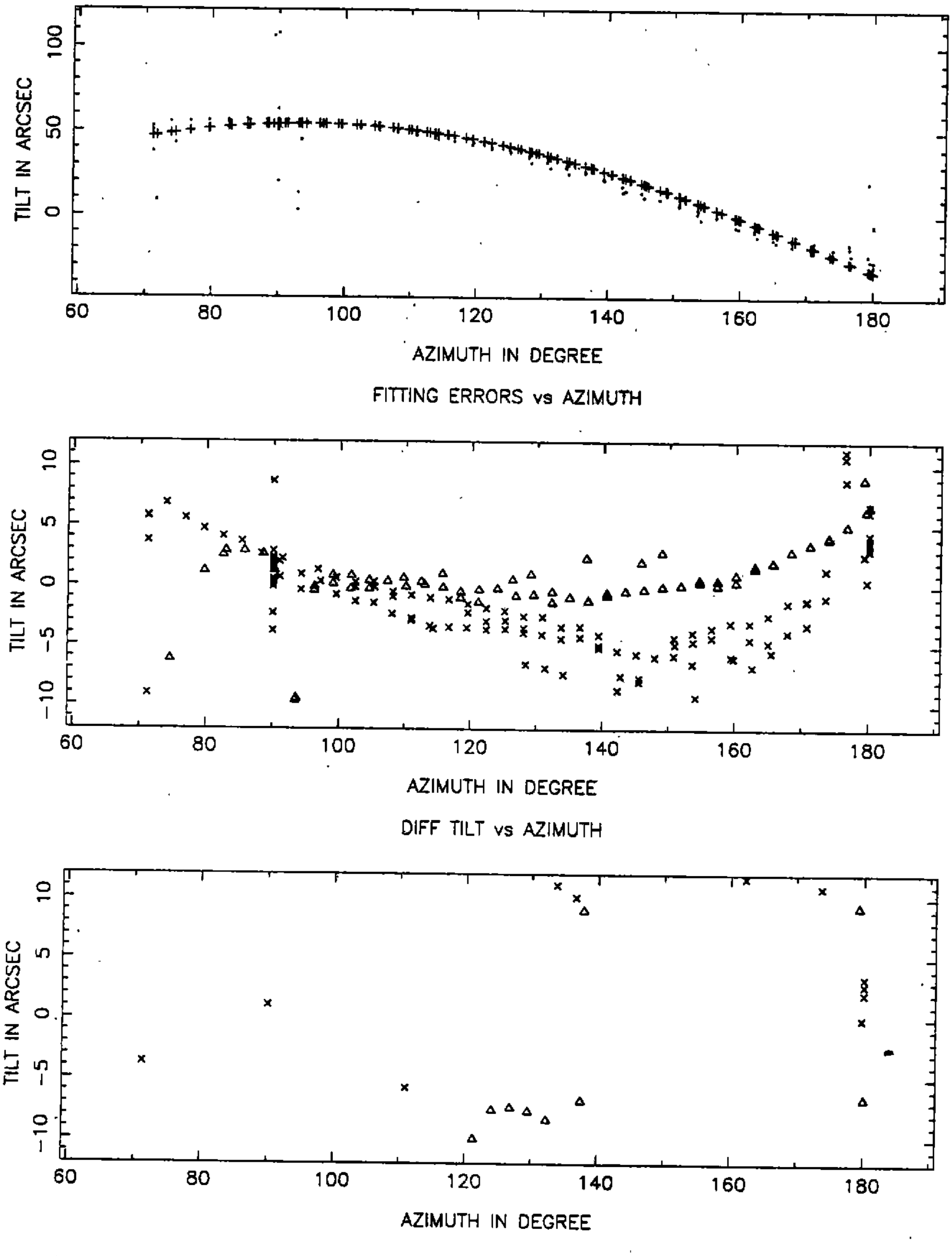
Fig 6 E-TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 3nov2_2.cab
THE MODEL FOR E-TILT vs AZIMUTH IS:
y = -40.2 +- 1.98 + (-7.1 +- 1.58)cos(AZ) + (94.4 +- 1.85)sin(AZ)
THE FITTING ERROR RMS: 4.62 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:
y = 0.00 + (0.00)EL

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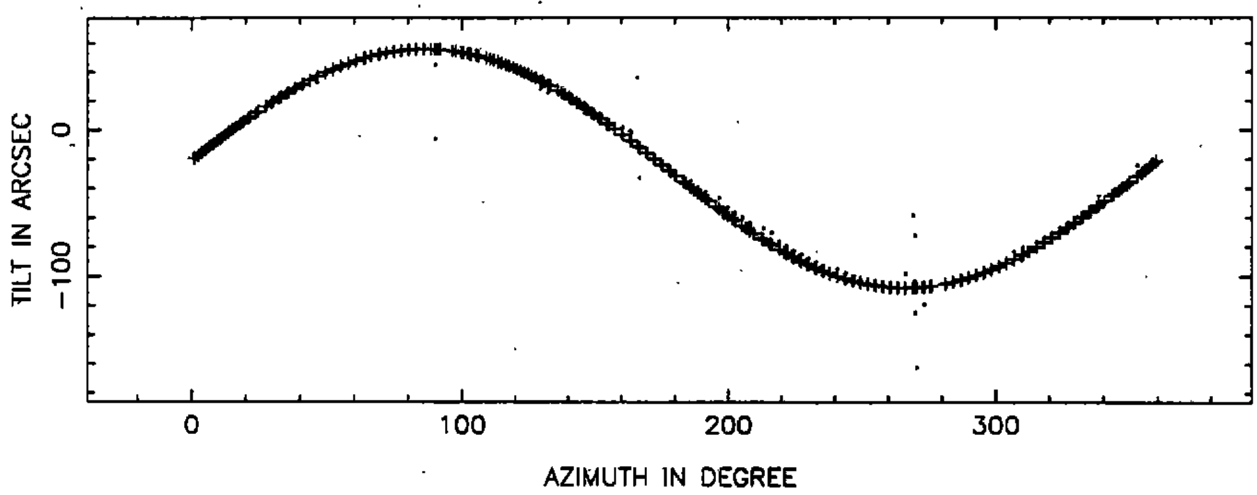
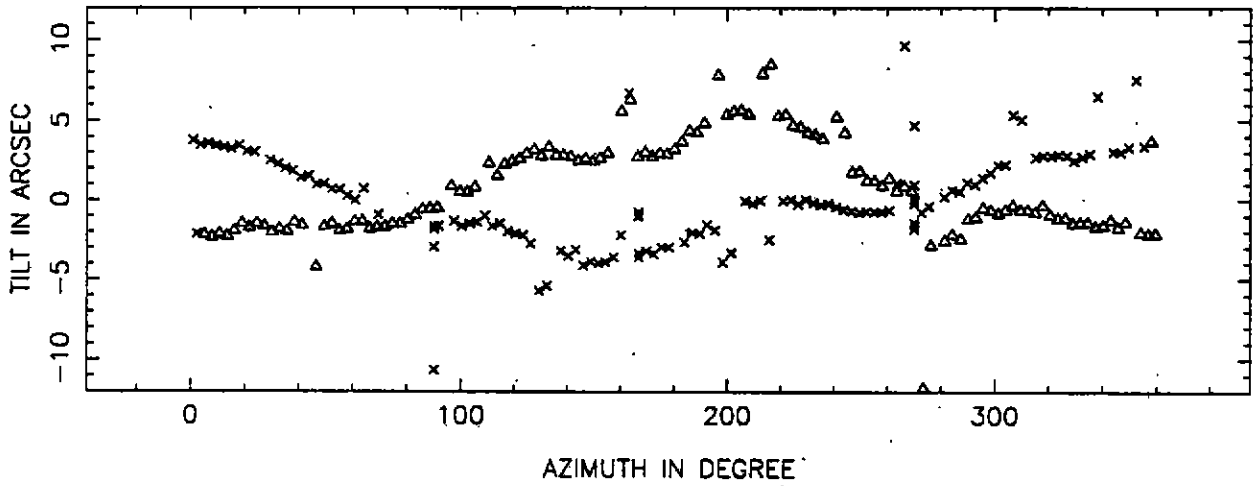
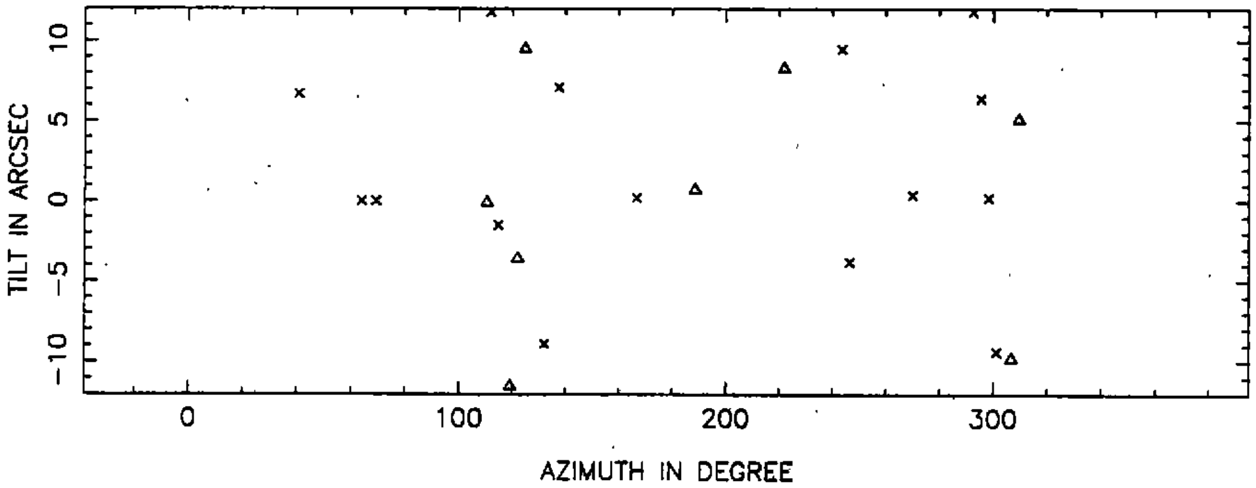
Fig 7 E-TILT & FITTING CURVE vs AZIMUTH



FITTING ERRORS vs AZIMUTH



DIFF TILT vs AZIMUTH



THE CALIBRATION FILE USED IS: 3nov3_2.cab
THE MODEL FOR E-TILT vs AZIMUTH IS:
y = -26.1 +- 0.21 + (5.3 +- 0.31)cos(AZ) + (81.8 +- 0.30)sin(AZ)
THE FITTING ERROR RMS: 3.48 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:
y = 0.00 + (0.00)EL

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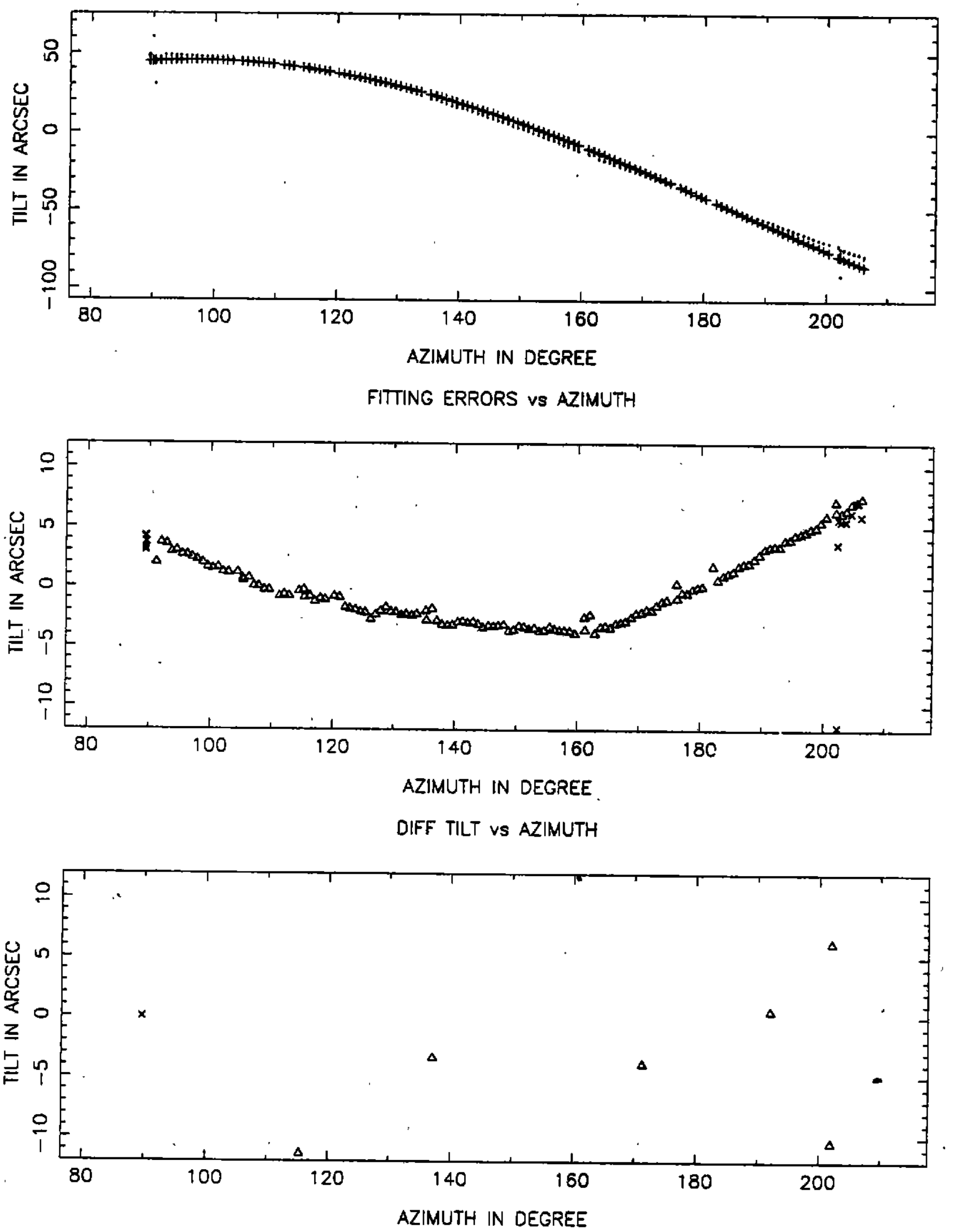
Fig 8 E-TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 4nov2_2.cab
THE MODEL FOR E-TILT vs AZIMUTH IS:

$$y = -52.9 \pm 1.35 + (-11.7 \pm 1.41)\cos(AZ) + (97.8 \pm 0.95)\sin(AZ)$$

THE FITTING ERROR RMS: 3.25 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:

$$y = 0.00 + (0.00)EL$$

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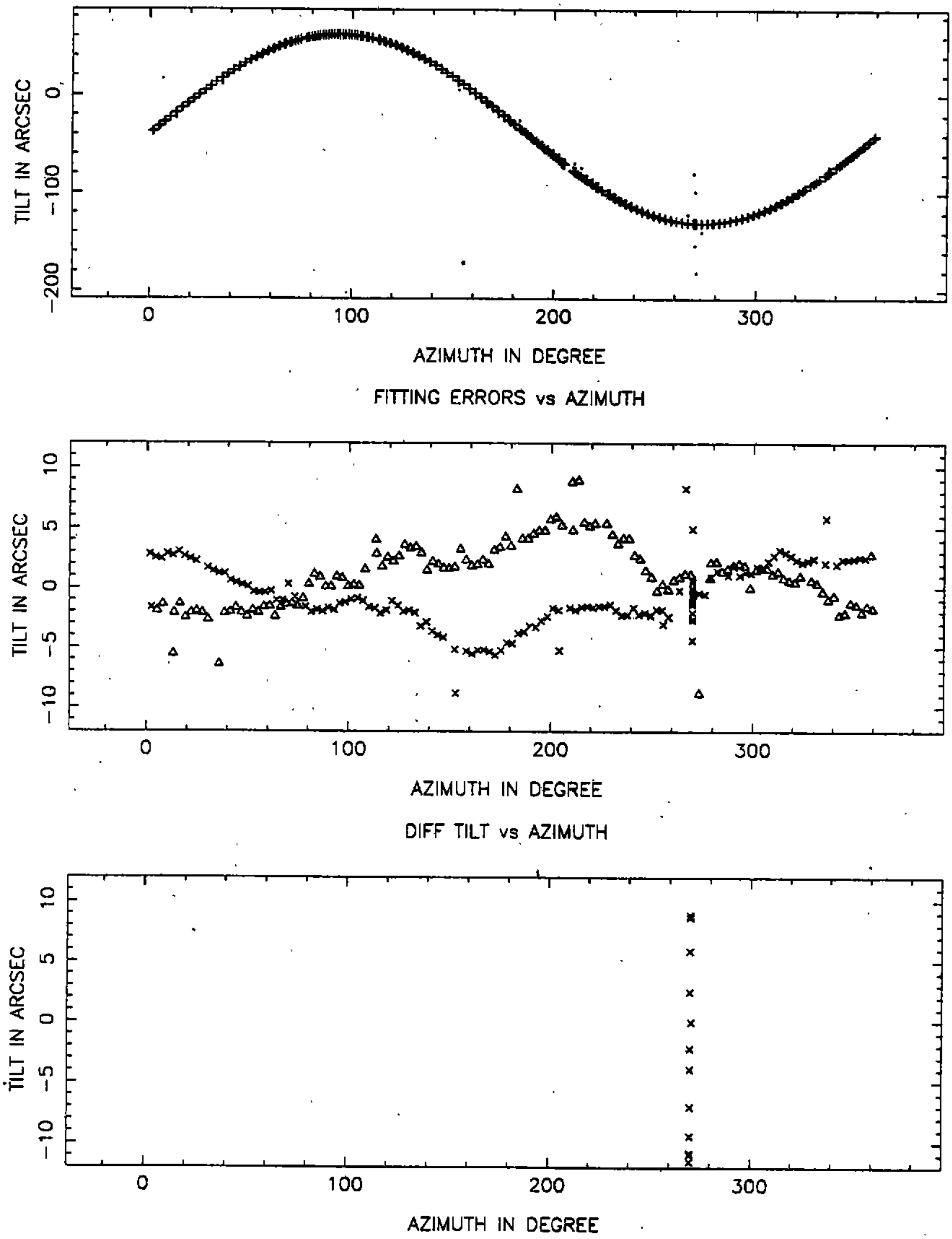
Fig 9 E-TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 16nov1_2.cab
THE MODEL FOR E-TILT vs AZIMUTH IS:
y = −34.2 +− 0.17 + (−5.6 +− 0.25)cos(AZ) + (96.2 +− 0.23)sin(AZ)
THE FITTING ERROR RMS: 2.79 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:
y = 0.00 + (0.00)EL

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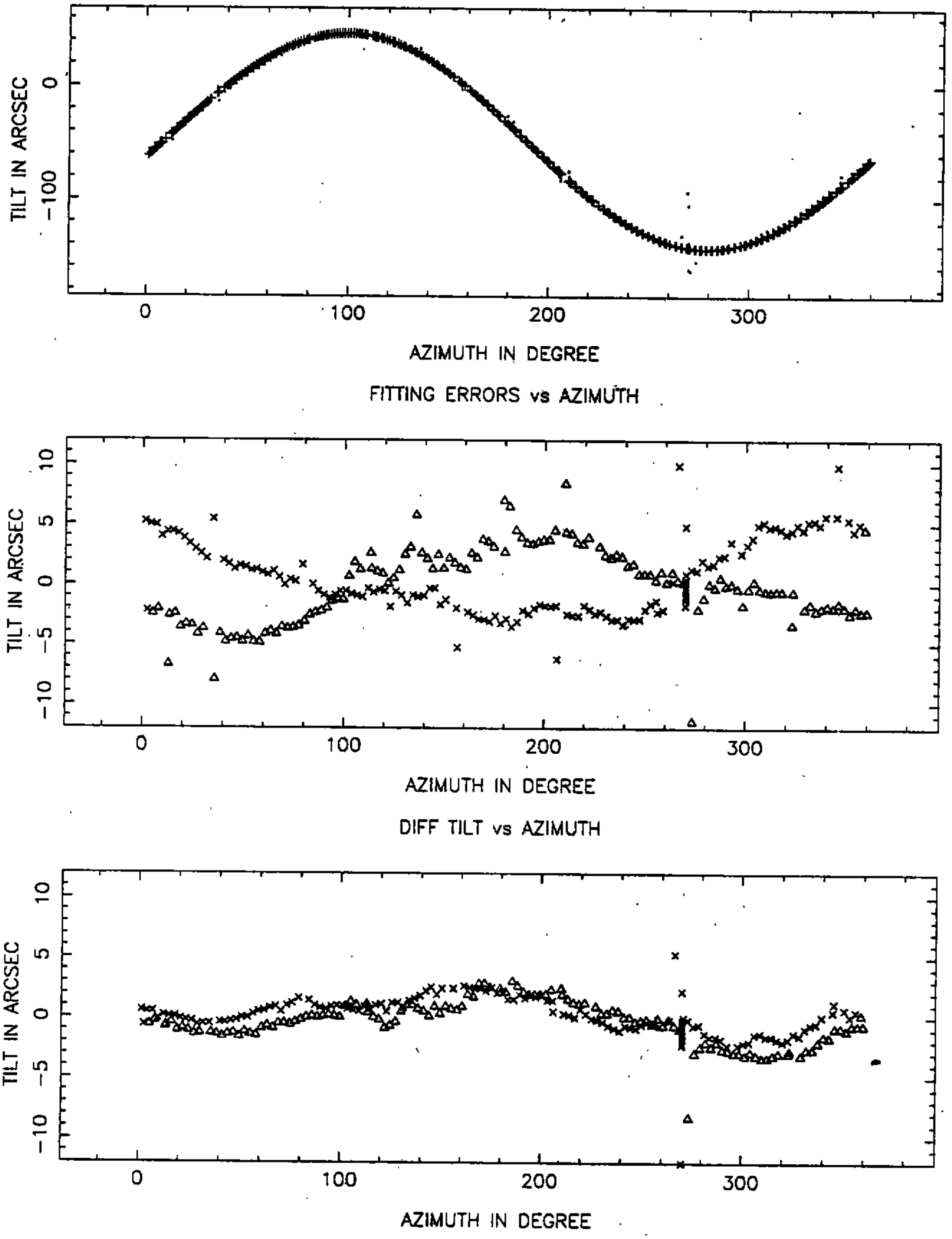
Fig. 10 E–TILT & FITTING CURVE vs AZIMUTH



THE CALIBRATION FILE USED IS: 16nov1_5.cab
THE MODEL FOR E–TILT vs AZIMUTH IS:
y = −48.6 +− 0.18 + (−15.0 +− 0.27)cos(AZ) + (93.7 +− 0.25)sin(AZ)
THE FITTING ERROR RMS: 3.05 arcsec
THE MODEL OF CALIBRATION ELEVATION EFFECT IS:
y = 0.00 + (0.00)EL

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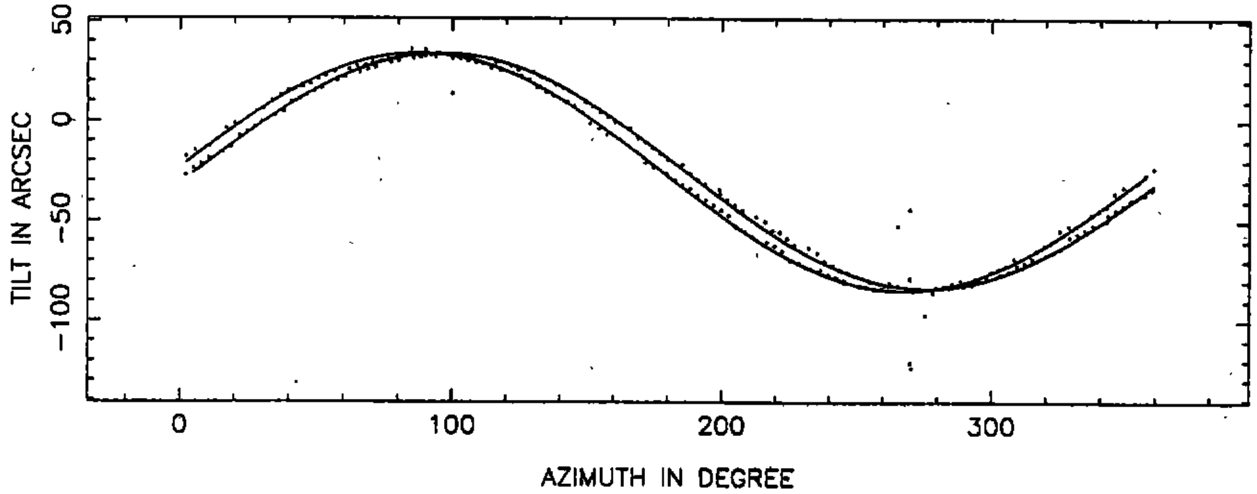
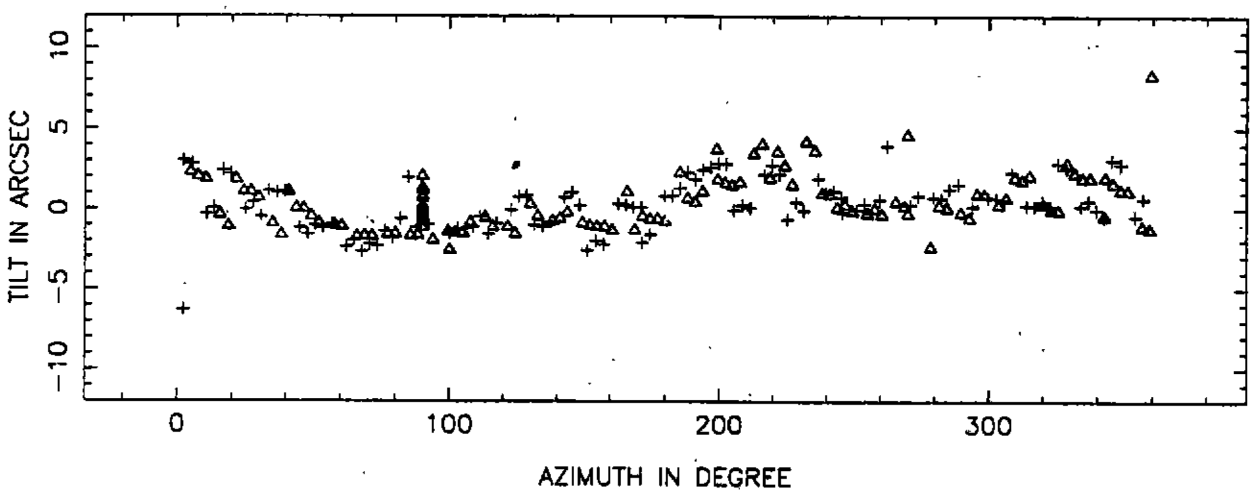
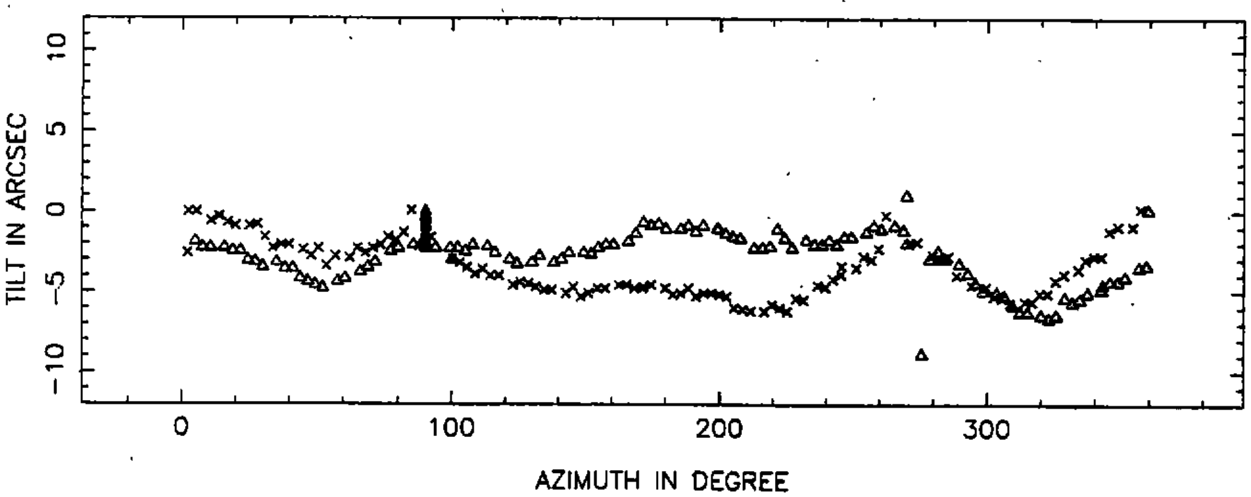
Figure 11. E–TILT & FITTING CURVE vs AZIMUTH



FITTING ERRORS 1 & 2 vs AZIMUTH   Error1= 0.02   Error2= 0.42



DIFF TILT vs AZIMUTH



THE CALIBRATION FILE USED IS: 27oct.cab
THE MODEL(CLOCKWISE) FOR E–TILT vs AZIMUTH IS:
$y = -24.9 + 58.9\sin(AZ - 0.0)$ RMS= 1.97

THE MODEL(C–CLOCKWISE) FOR E–TILT vs AZIMUTH IS:
$y = -25.4 + 59.5\sin(AZ + 2.0)$ RMS= 1.60

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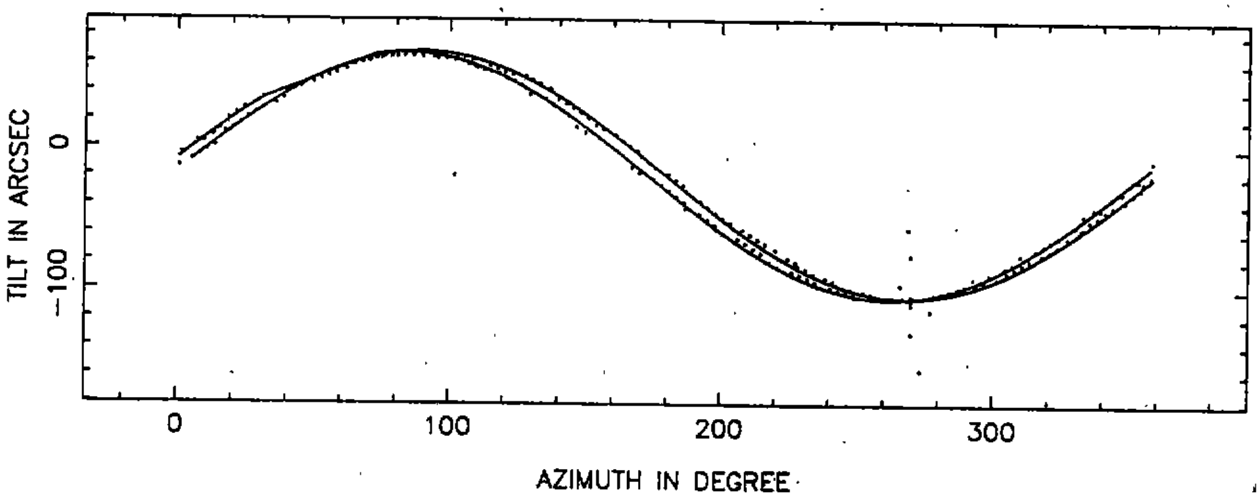
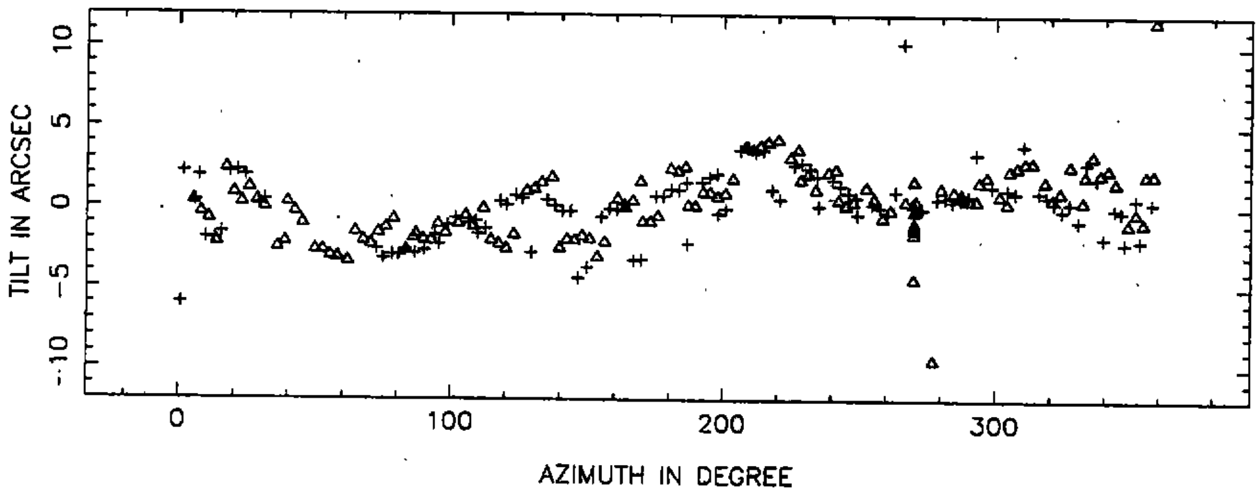
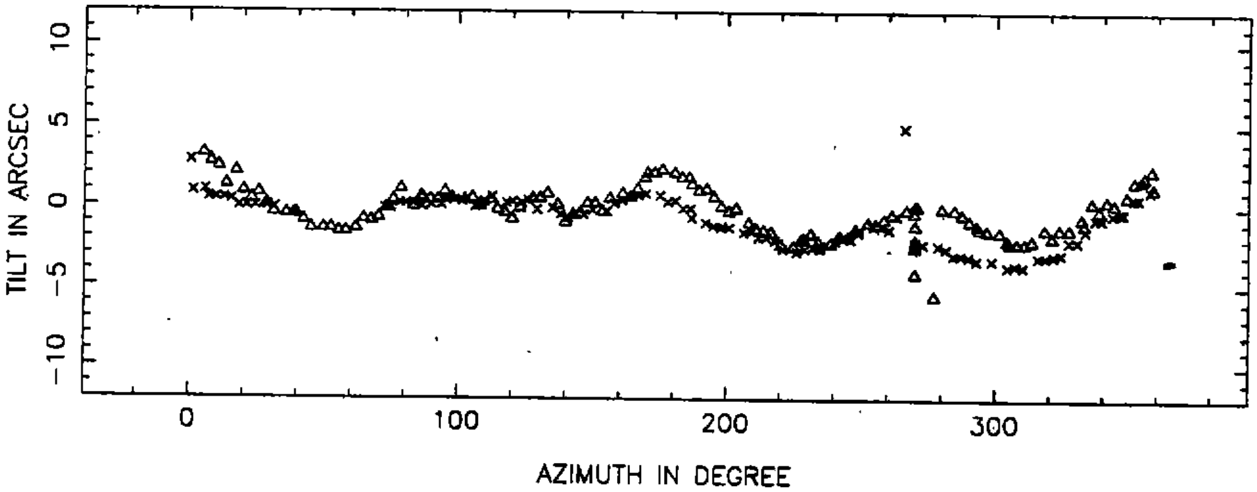
Figure 12. E-TILT & FITTING CURVE vs AZIMUTH



FITTING ERRORS 1 & 2 vs AZIMUTH   Error1=-0.03   Error2= 0.38



DIFF TILT vs AZIMUTH



THE CALIBRATION FILE USED IS: 2nov.cab

THE MODEL(CLOCKWISE) FOR E-TILT vs AZIMUTH IS:

$y = -18.7 + 87.0\sin(AZ + 0.9)$ RMS= 2.26

THE MODEL(C-CLOCKWISE) FOR E-TILT vs AZIMUTH IS:

$y = -19.5 + 87.1\sin(AZ + 7.2)$ RMS= 2.15

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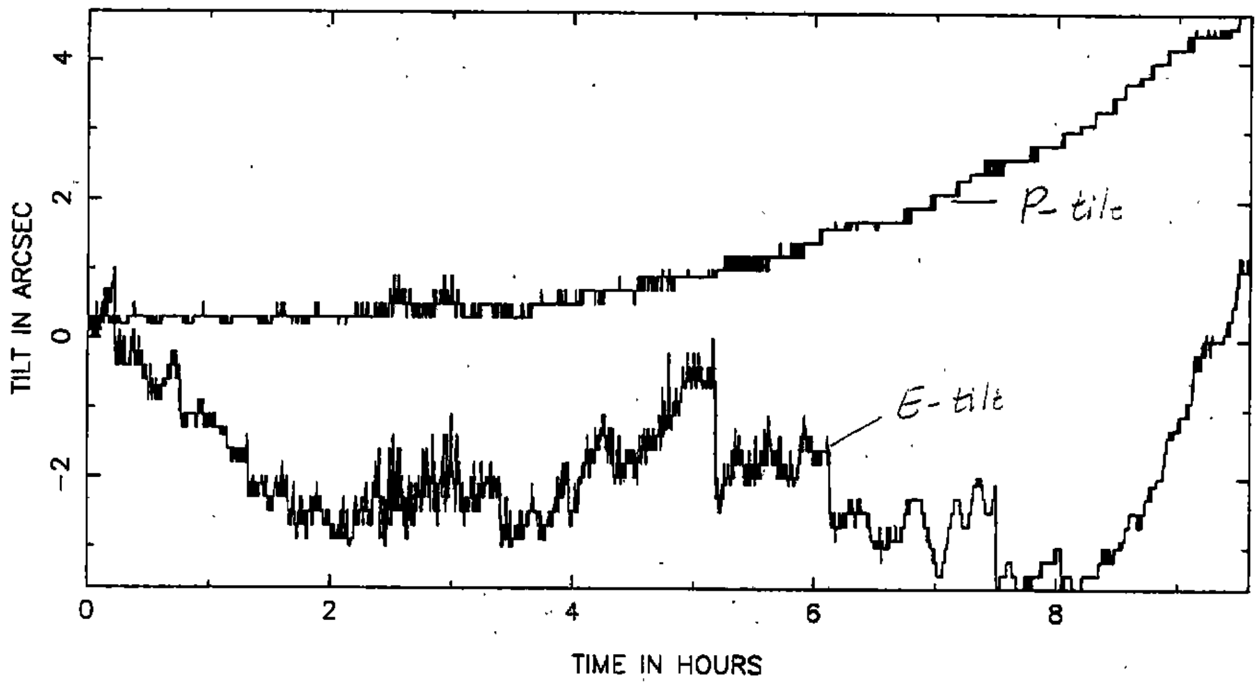
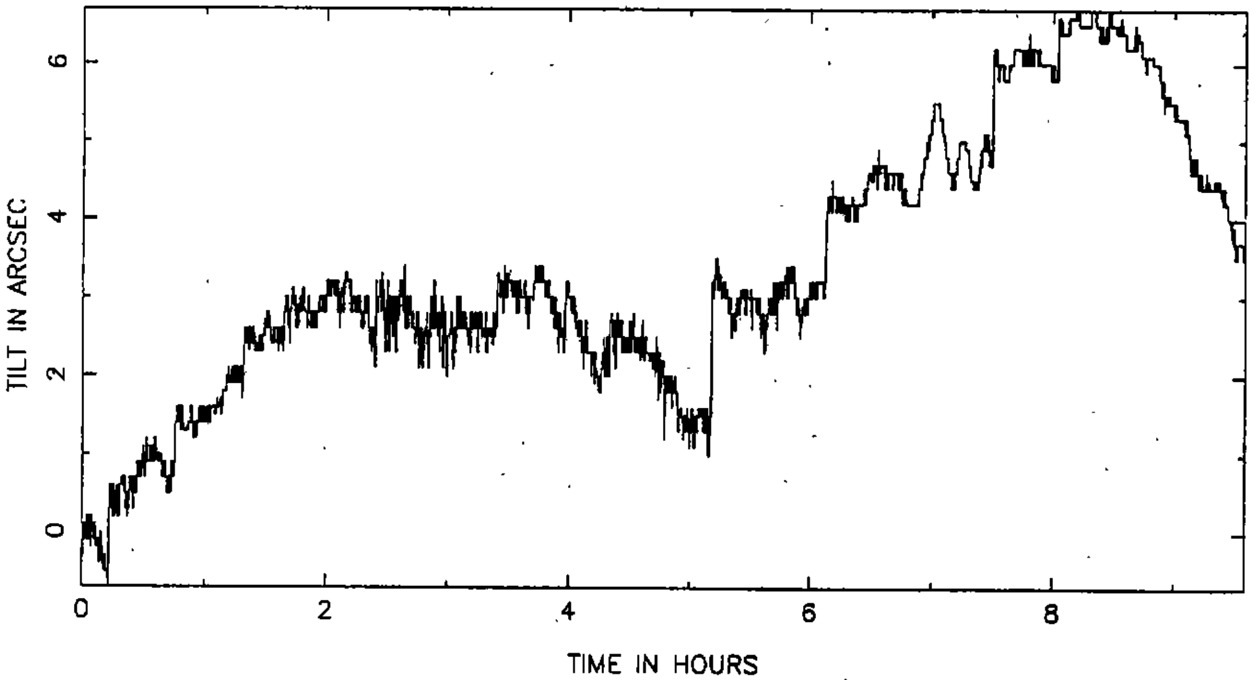
Figure 13. E–TILT P–TILT vs TIME



DIFF TILT vs TIME



THE DATA FILE IS: 26oct.st

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