VLBA TEST MEMO NO. 22

POINTING, GAINS, AND SYSTEM TEMPERATURES - I

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Pointing equations have been determined for Pie Town, Kitt Peak and Los Alamos at 6cm. Collimation offsets, appropriate for use with these equations, have been determined for most frequencies at Pie Town and all frequencies at Kitt Peak and Los Alamos. For some frequencies, enough data was obtained to determine the pointing equations independently for comparison with 6cm. In most cases, the 6cm equations are good enough for use at all frequencies, at least until we have a deeper understanding of time variability etc. However, at Kitt Peak, the most recent determination at 4cm suggests that a significant change in the azimuth collimation offset has occured. The pointing results for all 3 antennas and plots of the residuals are given in this memo.

The pointing results are analyzed in such a way that gain information is obtained. These results are also presented in this memo. Unless otherwise noted, the results are based on the lab measurements of the cal temperatures. These are also the values used to derive the system temperatures given to users for calibration so the efficiencies etc. are appropriate for the users. However, it is clear from unreasonable efficiencies in some cases, that some of the cals need to be measured on the telescope. Indeed, a few have been already.

The VLBA antennas currently use the same 6 parameter pointing equation as is used on the VLA. The parameters are: 1) the North Tilt, 2) the West Tilt, 3) the Azimuth Collimation Offset, 4) the Azimuth Encoder Offset, 5) the Sag, and 6) the Elevation Collimation Offset. The parameters now in use are given in Table 1, which is a copy of the file UVAX1:[OPERATOR.SETUPS]OFFSETS.DAT. Parameters 1, 2, 4, and 5 are instelled by entering them into the program STA.C. Parameters 3 and 6, the collimation offsets which change with frequency band, are included in observing schedules. A proceedure for updating collimation offsets in SETUP files for the scheduling program SCHED has been established based on the OFFSETS.DAT file.

The figures attached to this memo show the data used to determine the pointing parameters in OFFSETS.DAT. There are two pages of plots for each antenna/frequency, with 8 plots per page. The plots are:

1. The measured azimuth offset from the pointing equation in use at the time of the observations plotted against azimuth. For bands other than 6cm, this plot, with an average removed, should show the quality of future pointing.

2. The azimuth offset from the best fit pointing equation. For 6cm, this should indicate the quality of future pointing. For other bands, any differences between this plot and the previous one, other than a shift in the average, show possible changes in the pointing equation in time and/or frequency and are cause for concern.

3. The measured azimuth offset plotted against elevation.

4. The azimuth offset from the best fit pointing equation.

5. The measured elevation offset plotted against elevation.

6. The elevation offset from the best fit pointing equation.

7. The measured elevation offset plotted against elevation.

8. The elevation offset from the best fit pointing equation.

9. The distribution of measured points in azimuth and elevation. This gives a good impression of the quality of the data set for pointing determination. There should be a good spread in both azimuth and elevation.

10. The measured azimuth offset as a function of time. This is shown to help find any temporal effects. So far, I haven't seen any. This plot is not always shown.

11. The system temperature as a function of sec(z). In the analysis program, a fit is made for the opacity using the data over a restricted range, usually sec(z) less than 2 (30 deg elevation). Lower elevations are not used because of confusion with spillover. The system temperatures are based on the measurements of the low cal temperature made in the lab before the receiver is installed except for the Pie Town 1.3 cm case where a value measured by Durga Bagri on the antenna with hot loads was used.

12. The system temperature plotted against elevation.

13. The pointing offset plotted against antenna temperature. The antenna temperature is also based on the lab cal measurement and is a byproduct of the measurement of the pointing offset. This plot should help identify any serious problem with measurements on weaker sources.

14. The measured elevation offset plotted against time to look for temporal effects.

15. The sensitivity plotted against elevation for the flux calibrators. The flux calibrators are any sources in Baars or any other source for which a flux density was provided. At 1.3 cm, Bagri measured a flux density of 35.3 Jy for 3C84 at the VLA and the sensitivity results are mainly based on that value, although a few 3C274 points are also available. At other frequencies, Baars sources are available in all cases. No corrections for opacity have been made.

16. The sensitivity plotted against elevation for all sources. A mean sensitivity is determined from the calibrator measurements and used to derive a flux density for each source, using only measurements made above some limiting elevation (usually 30 deg - it is the same limit as used for the opacity fit). This plot shows the ratio, for each observation, between the antenna temperature and the measured flux density. Again, no opacity correction.

In addition to the above plots, the analysis program provides 8 more that I have chosen not to show here but have available if anyone wants to see them. They are:

1. The measured azimuth offset plotted against time of day to look for diurnal effects. I haven't seen any yet but expect to someday.

2. The azimuth offset from the best fit pointing equation plotted against time of day.

3. The measured elevation offset plotted against time of day to look for diurnal effects.

4. The elevation offset from the best fit pointing equation plotted against time of day.

5. The system temperature plotted against time.

6. The antenna temperature plotted against time. These last two may be particularly interesting for observations of a single source for an extended period.

7. The sensitivity for all sources plotted against elevation. For this plot, the flux density is reduced by the measured opacity. There is a tendency to flatten the curves at low elevations, but it is at the low elevations where the sec(z) law breaks down and I have not put in a more sophisticated model yet. The pronounced droop of the sensitivity at 1.3cm at Pie Town is flattened somewhat, but by no means completely.

8. The sensitivity for all sources, not corrected for opacity, plotted against time to look for temporal effects.

Some of the numerical results, other than the actual pointing values, are tabulated in Tables 2 through 7.

Table 2 is a summary of the observations in this memo.

Table 3 is gives the squint (offset between RCP and LCP beams) for each antenna/frequency.

Table 4 gives the beam size (FWHM of a gaussian approximation) for each antenna/frequency/polarization.

Table 5 gives the rms pointing offsets from the prefit average and from the postfit pointing equation. The second value if of greatest interest for 6 cm where the equations in use were determined. The first is of more interest for other frequencies where only the averages (collimation offsets) are to be removed. For frequencies other than 6 cm, the difference between the two shows what might be gained from an improved pointing equation.

Table 6 gives the pointing coefficients of the best fit model for those data sets with enough points to provide a good solution. The 6cm results are those currently in use.

Table 7 gives the sensitivity, efficiency, zenith system temperature and system temperature in Jy for each antenna/frequency/polarization. All of these numbers, except the last, depend on the assumed low cal temperature. For all but one case, the low cal values used are those measured in the lab. For Pie Town at 1.3 cm, values measured with hot load tests on the antenna were also used. System temperatures sent to users are based on the lab cal temperatures, so the sensitivities measured here are correct for calibration. However, as the impossibly high efficiencies in a few cases make clear, the cal values are not always correct.

NOTES:

1. The 6 cm Pie Town data show an abnormally large number of points of high pointing residual. There are also a lot of points of low sensitivity, most of which are RCP.

2. At 1.3 cm at Pie Town below about 40 deg. elevation, the gain drops much more than it does at the other antennas and more than can be accounted for by atmosphere.

3. The 4 cm Kitt Peak data suggests that there has been a large change in the azimuth encoder offset since the 6 cm and 1 cm data were taken. New 1 cm data will be taken shortly.

Table 1.
OFFSETS.DAT

```
 STA.C  Version 2.4
!  File version 1.0  RCWalker  Initial file, Sep 18, 1989.
!  Some versions not recorded.
!  File version 1.1  RCWalker  Los Alamos pointing updated Nov. 8, 1989.
!  File version 1.2  RCWalker  Los Alamos K band col offsets. Nov. 9, 1989
!  File version 1.3  RCWalker  PT 4cm, PT 1cm, KP 1cm, LA 18cm, LA 1cm updated.
!                        Nov. 15, 1989.
!  File version 1.4  RCWalker  PT 4cm/13cm updated.  13cm set to same value.
!  File version 1.5  RCWalker  KP 4cm  - warnings about bad pointing.
!
!  Pointing equations - values from STA.C
!
!  Pie Town  well determined at 6 cm Sept. 11-12, 1989.
!       Later reanalysis (Nov 14) suggests small changes, but STA.C not updated.
!            Ntilt  = -0.02
!            Wtilt  =  0.37         (add 0.45 to long)
!            Az Enc =  180d40'15"
!            Sag    = -1.77
!
!   Better collimation offsets needed at 90cm, 13cm, 4cm/13cm, and 2cm.
PT  90cm       azcolim = 0.0   elcolim = 0.0   ! Not determined - large beam.
PT  20cm       azcolim = -0.3  elcolim = -0.6  ! Measured Oct 13-24, 1989
PT  13cm       azcolim = 1.7   elcolim = -1.0  ! Set same as 4cm/13cm.
PT  6cm        azcolim = 0.28  elcolim = -1.22 ! Measured Sep 11-12, 1989.
PT  4cm        azcolim = 0.54  elcolim = -0.61 ! Measured Nov. 14, 1989
PT  4cm/13cm   azcolim = 1.71  elcolim = -1.0  ! Poor measurement Oct 6, 1989.
PT  3cm        azcolim = 0.75  elcolim = -0.71 ! Measured Sep. 13-14, 1989.
PT  2cm        azcolim = 0.75  elcolim = 0.18  ! Shifted from old eqn.
PT  1.3cm      azcolim = 0.64  elcolim = -0.86 ! Measured Sep 13-18, 1989.
!
!  Kitt Peak  well determined at 6cm Sept. 11-12, 1989.
!   Nov 14 reanalysis with editing suggests small changes but not installed.
!            Ntilt  =  0.24
!            Wtilt  =  0.23         (add 0.27 to long)
!            Az Enc =  179d59'25"
!            Sag    = -1.31
!
!   4cm collimation offsets poor - clocks ok.  Pointing equation has changed
!   between Sept runs and Nov 4 cm runs.  Something is wrong!
KP  20cm       azcolim = -2.0  elcolim = 2.5   ! Measured Oct. 24, 1989.
KP  6cm        azcolim = 0.42  elcolim = 1.64  ! Measured Sep. 11-12, 1989.
KP  4cm        azcolim = 0.5   elcolim = 2.1   ! Measured Nov. 18, 1989.
KP  1.3cm      azcolim = 0.58  elcolim = 1.96  ! Measured Sep. 13-18, 1989.
!
!  Decent determination at 6 cm on Nov. 7-8, 1989 - Paul Johnson operating.
!            Ntilt  =  0.20
!            Wtilt  =  0.03         (add 0.04 to long)
!            Az Enc =  179d42'53"
!            Sag    =  -1.49
!
LA  20cm       azcolim =-0.02  elcolim = -6.15 ! Measured Nov 14-15, 1989
LA  6cm        azcolim = 1.03  elcolim = -3.96 ! Measured Nov. 7-8, 1989.
LA  1.3cm      azcolim = 0.52  elcolim = -3.86 ! Measured Nov. 14, 1989.
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Table 2.
OBSERVATION SUMMARY

Antenna	Freq. Band	Freq. MHz	Dates 1989	Number of points. total	high el.	Comments
Pie Town	18cm	1655	Oct. 13–24	533	419	Good
	6cm	4998	Sep. 11–12	467	311	Good
	4cm	8418	Nov. 14	148	144	No Dichroic
	4cm	8418	Oct. 6	17	12	With Dichroic (Poor)
	3cm	10658	Sep. 13–14	24	24	Ok
	1cm	22235	Sep. 13–18	347	248	Good
Kitt Peak	18cm	1655	Oct. 25	35	33	Fair – should improve.
	6cm	4998	Sep. 11–12	436	298	Good
	4cm	8418	Oct30–Nov19	644	465	Good but pointing changed!
	1cm	22235	Sep. 13–18	361	306	Good
Los Alamos	18cm	1655	Nov. 14–15	109	84	Gains ok (mainly Cyg A) Pointing not so good.
	6cm	4998	Nov. 7–8	131	90	Good
	1cm	22235	Nov. 14	145	66	Good

Table 3.
SQUINT (RCP–LCP)

Antenna	Frequency Band	El Squint (arcmin)	Az Squint (arcmin)	Notes
Pie Town	18cm	–0.52	1.50	
	6cm	–0.14	0.46	
	4cm	0.20	–0.18	No Dichroic
	4cm	0.07	–0.31	With Dichroic
	3cm	0.21	–0.08	
	1cm	0.02	0.10	
Kitt Peak	18cm	0.20	–1.15	
	6cm	–0.08	0.45	
	4cm	0.21	–0.16	
	1cm	0.04	0.08	
Los Alamos	18cm	–0.57	–1.58	
	6cm	–0.13	0.44	
	1cm	0.02	0.10	

What is going on at L band?

Table 4.
BEAM SIZE (FWHM)

Antenna	Frequency Band	El (RCP) (arcmin)	El (LCP) (arcmin)	Az (RCP) (arcmin)	EL (LCP) (arcmin)	Notes
Pie Town	18cm	25.8	25.8	25.9	25.9	
	6cm	8.7	8.7	8.6	8.6	
	4cm	5.0	4.9	5.0	5.0	No Dichroic
	4cm	5.1	5.1	5.1	5.4	With Dichroic
	3cm	4.0	4.0	4.1	4.1	
	1cm	1.90	1.89	1.88	1.87	
Kitt Peak	18cm	25.2	25.4	25.1	25.1	
	6cm	8.7	8.6	8.6	8.6	
	4cm	5.0	5.0	5.0	5.0	
	1cm	1.90	1.89	1.92	1.91	
Los Alamos	18cm	25.4	25.5	25.0	25.3	
	6cm	8.5	8.6	8.5	8.5	
	1cm	1.84	1.83	1.86	1.84	

Table 5.
RMS POINTING OFFSETS

Antenna	Frequency Band	Prefit El (")	Prefit Az (")	Postfit El (")	Postfit Az (")	Notes
Pie Town	18cm	19.8	19.4	18.2	12.6	
	6cm	14.9	15.1	12.8	14.0	
	4cm	6.9	5.6	5.3	3.6	No Dichroic (Why so good?)
	4cm	20.6	7.6	15.0	6.3	With Dichroic (little data)
	3cm	9.0	11.4	9.2	7.9	
	1cm	10.1	8.1	9.1	7.5	
Kitt Peak	18cm	41.1	44.0	40.3	44.2	Mostly a weak source.
	6cm	12.9	16.4	9.9	13.0	
	4cm	9.4	21.2	9.3	9.6	Pointing changed!?
	1cm	11.6	9.1	7.6	8.5	
Los Alamos	18cm	24.4	23.9	21.9	23.9	
	6cm	33.2	62.8	13.8	10.2	Bad apriori equation.
	1cm	10.5	13.0	8.4	11.5	

Note: Pointing equations were determined at 6cm - apriori at 6cm was not too good so deviation from average could be large. The postfit RMS is the best indicator of future pointing.
At other frequencies, only collimation offsets, which equal the average offets, were determined so the prefit RMS is the best indicator of future pointing.

Table 6.
POINTING COEFFICIENTS

Antenna	Freq. Band	W Tilt (')	N Tilt (')	Az Col. (')	Az Enc.	Sag (')	El Col. (')	Comment
Pie Town	6cm	0.38	-0.02	0.26	180d40'17"	-1.74	-1.24	
	4cm	0.35	-0.10	0.67	180d39'59"	-1.65	-0.66	No Dichroic
	1cm	0.31	-0.05	0.69	180d40'10"	-1.56	-0.99	
	18cm	0.20	-0.33	-0.50	180d40'30"	-1.26	-0.68	Big Beam
Kitt Peak	6cm	0.23	0.22	0.45	179d59'23"	-1.35	1.68	
	1cm	0.24	0.08	0.55	179d59'29"	-1.11	1.92	
	4cm	0.14	0.14	1.12	179d58'08"	-1.50	2.25	Later date
Los Alamos	6cm	0.03	0.20	1.03	179d42'53"	-1.49	-3.96	
	1cm	-0.10	0.03	0.54	179d42'50"	-1.64	-3.86	

The collimation offsets are expected to be different between frequencies.

There are high correlations between the az collimation offset and the az encoder offset and between the el collimation offset and the sag.

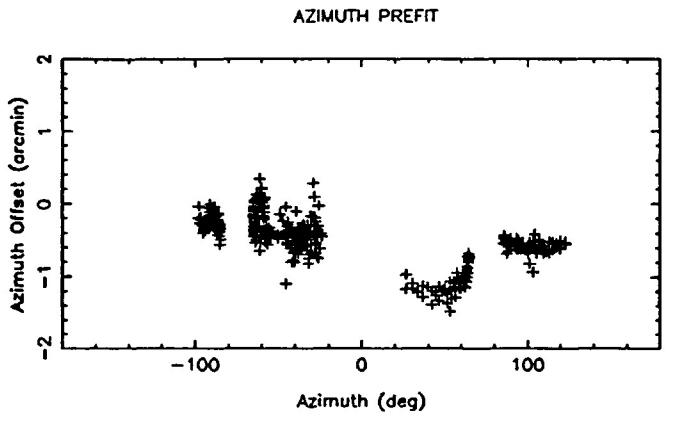
Table 7.
ZENITH SENSITIVITY, SYSTEM TEMPERATURE

Antenna	Freq. Band	Pol	Tsys (K)	Tatm (K)	Sens. (K/Jy)	Eff. (%)	Tsys (Jy)	Notes
Pie Town	90cm	New data needed.						
	50cm	ditto						
Pie Town	18cm	RCP	30	1.1–2.5	0.104	58	288	
		LCP	28	0.8–2.6	0.099	56	283	
Pie Town	13cm	RCP	31		0.102	58	301	With Dichroic Old data (Jul 7 89)
Pie Town	6cm	RCP	39	2.6	0.123	69	317	
		LCP	43	2.8	0.132	74	325	
Pie Town	4cm	RCP	40	2.4	0.129	73	310	No Dichroic
		LCP	36	2.2	0.122	69	295	
Pie Town	4cm	RCP	43		0.117	66	370	Old data (Jul 7 89) With Dichroic
Pie Town	3cm	RCP	60	5.7	0.123	69	488	FET
		LCP	57	5.2	0.122	68	467	
Pie Town	2cm	No data						
Pie Town	1cm	RCP	69–82	23–25	0.116	65	590–710	Bagri Cals
		LCP	68–81	23–26	0.117	66	580–690	(see note)
Kitt Peak	18cm	RCP	31	3.9	0.103	58	301	Tatm high.
		LCP	34	4.0	0.104	59	327	
Kitt Peak	6cm	RCP	42	2.7	0.133	75	316	
		LCP	45	2.8	0.133	75	338	
Kitt Peak	4cm	RCP	32	1.7–2.8	0.121	68	264	
		LCP	34	2.1–3.0	0.122	69	279	
Kitt Peak	1cm	RCP	98–104	10–15	0.107	60	920–970	
		LCP	97–103	11–16	0.114	64	850–900	
Los Alamos	18cm	RCP	27	0.9	0.079	44	341	Cal wrong?
		LCP	31	1.7	0.103	58	301	
Los Alamos	6cm	RCP	42	3.1	0.147	83	286	Cal wrong.
		LCP	38	2.9	0.142	80	268	
Los Alamos	1cm	RCP	138	11	0.132	74	1045	Cal wrong.
		LCP	150	12	0.141	79	1063	

Only data at higher elevations used (usually above 30 degrees). Opacity corrections have been made.

A range of value indicates that the atmosphere was different on different days and seperate determinations were made.

For Pie Town 1cm, the Bagri Tcal's are RCP 13.90, LCP 15.75. The lab measurements (used for user Tsys's) are RCP 16.3, LCP 17.0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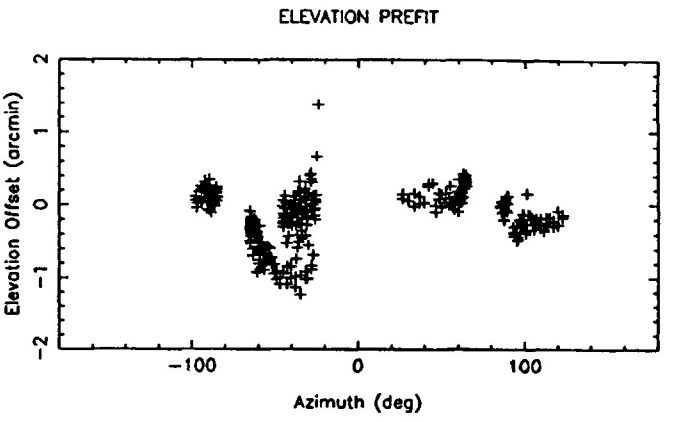
Azimuth (deg)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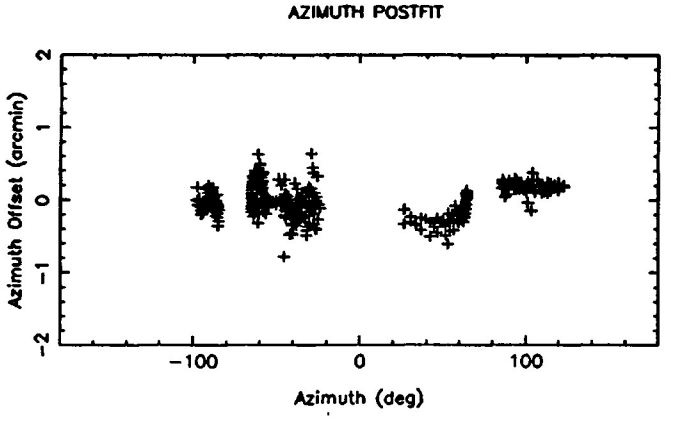
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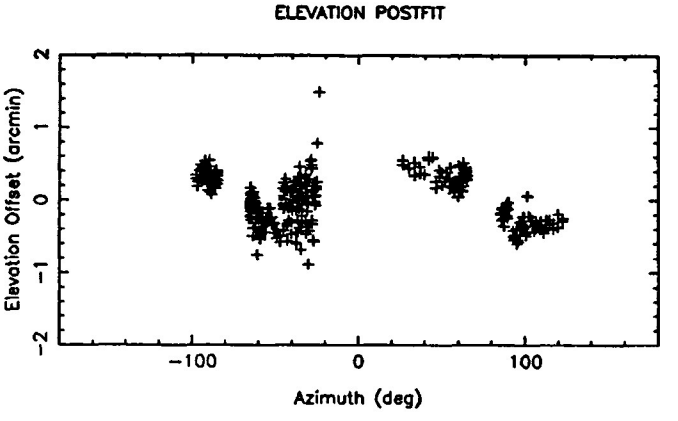
Azimuth (deg)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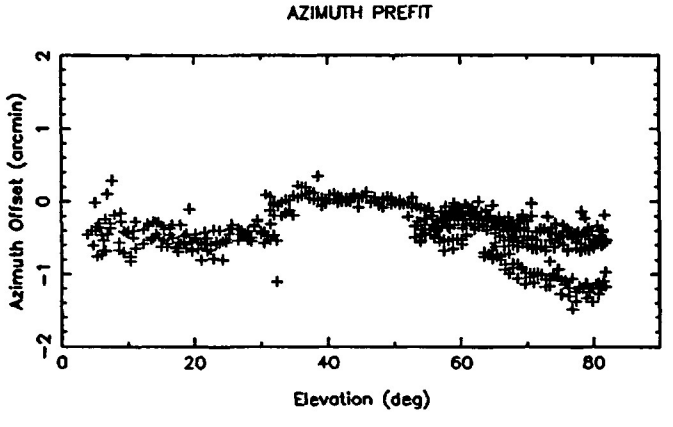
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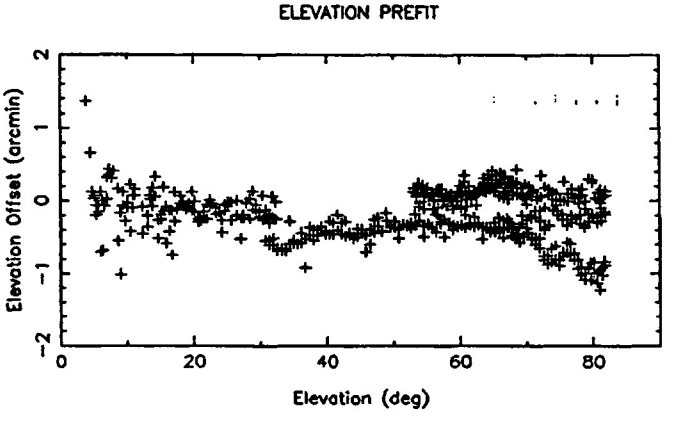
Elevation (deg)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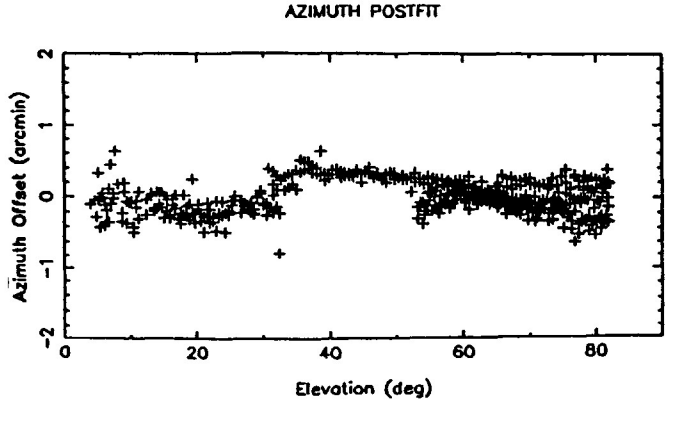
Elevation (deg)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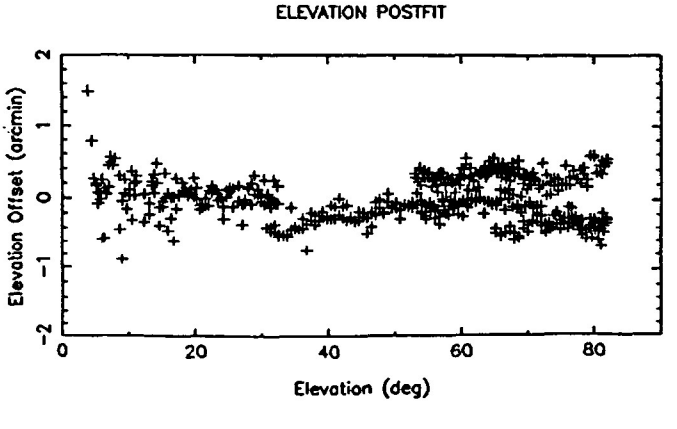
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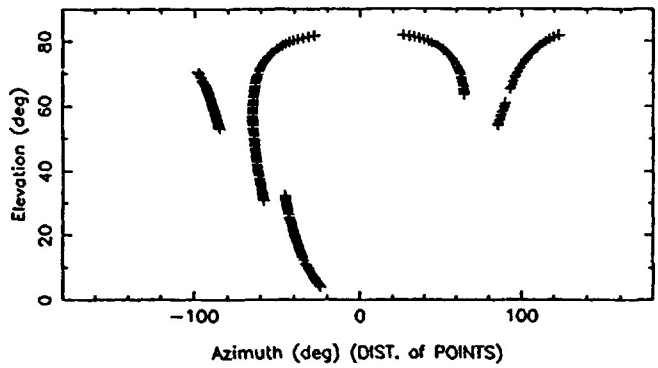
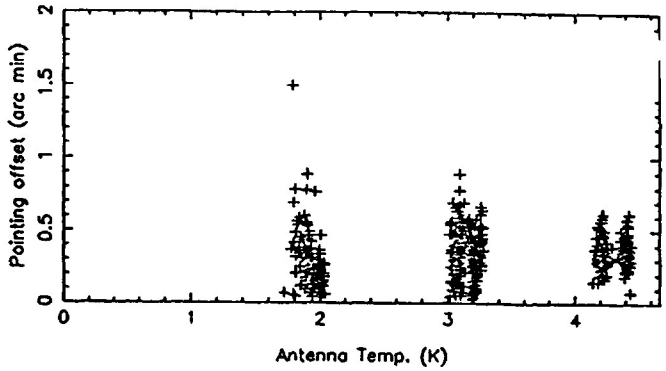
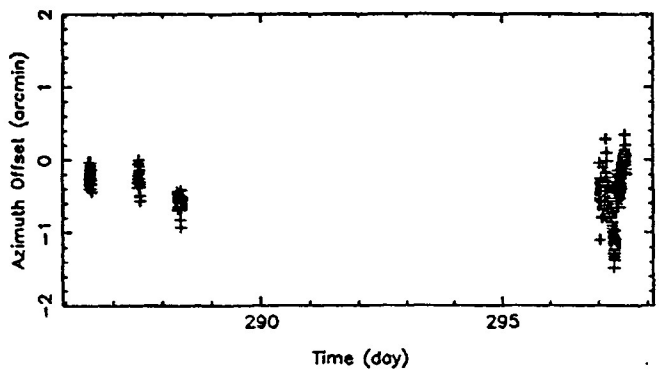


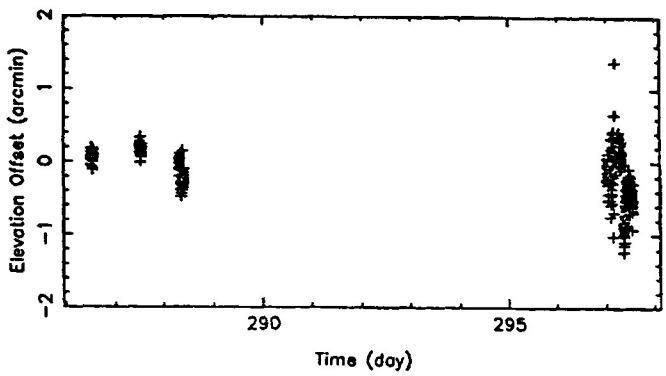
POINTING OFFSET vs ANTENNA TEMP



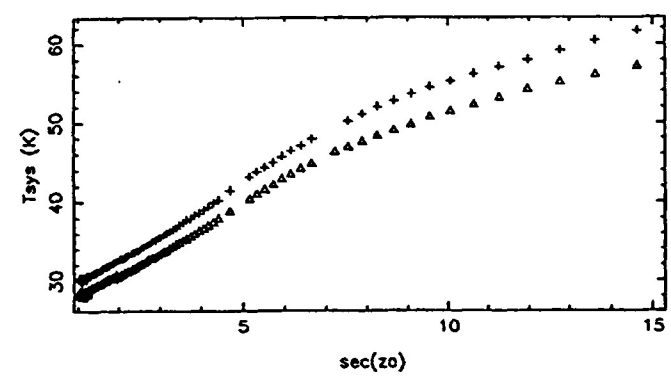
AZIMUTH PREFIT vs TIME



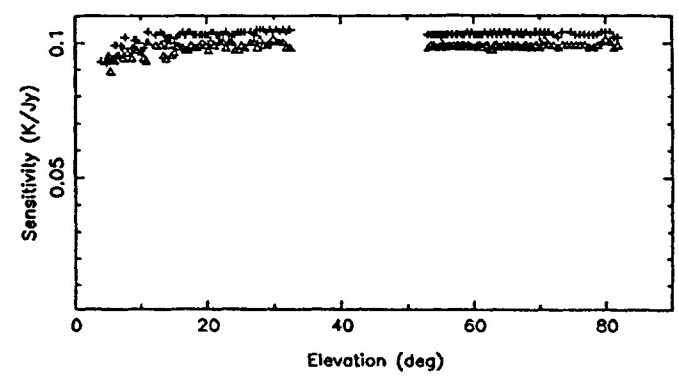
ELEVATION PREFIT vs TIME



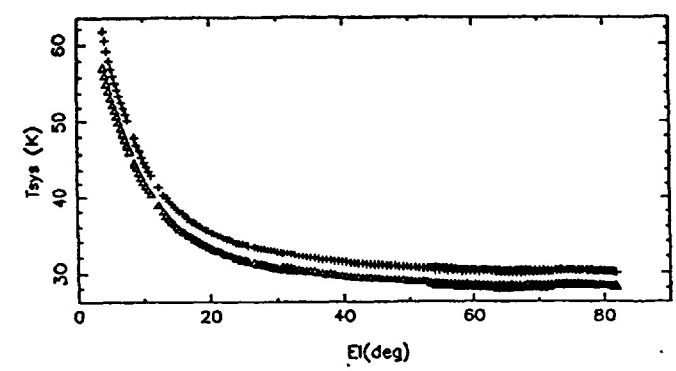
SYSTEM TEMP vs SEC(Z)



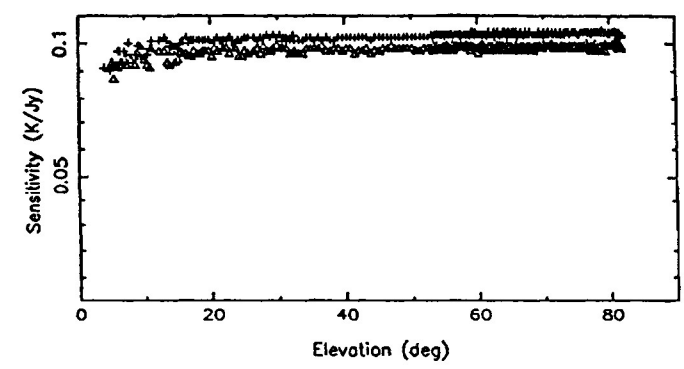
Tant / Assumed Flux (Calibrators)

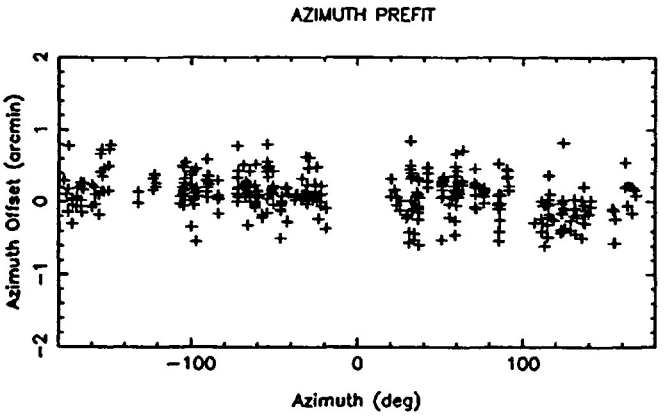


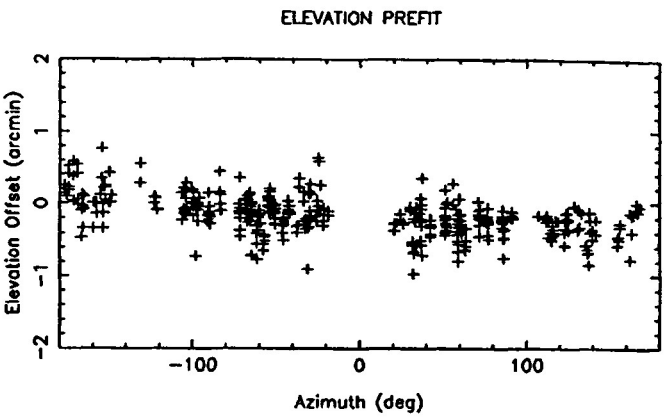
SYSTEM TEMP vs ELEVATION

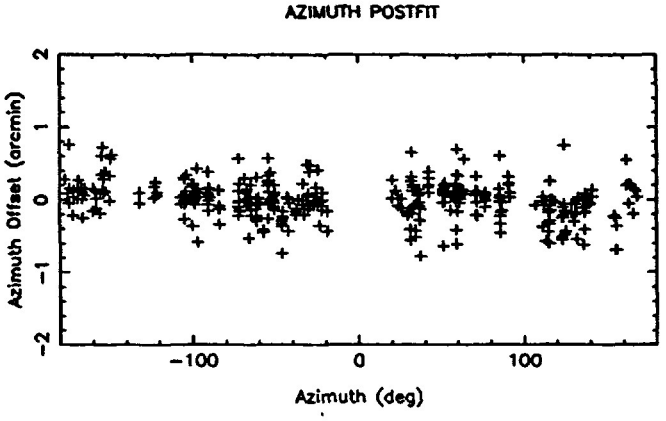


Tant / Measured Flux (All Sources)




AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)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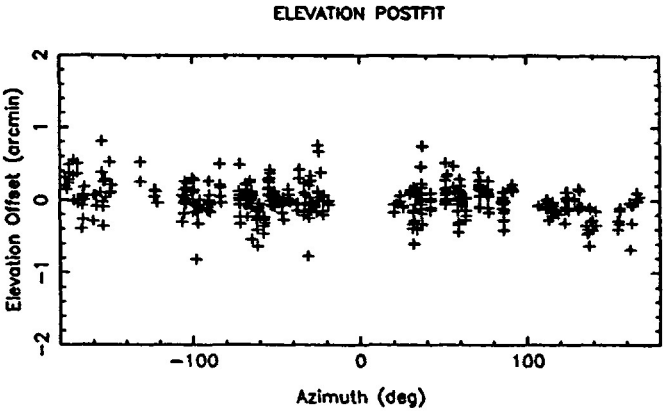
Azimuth (deg)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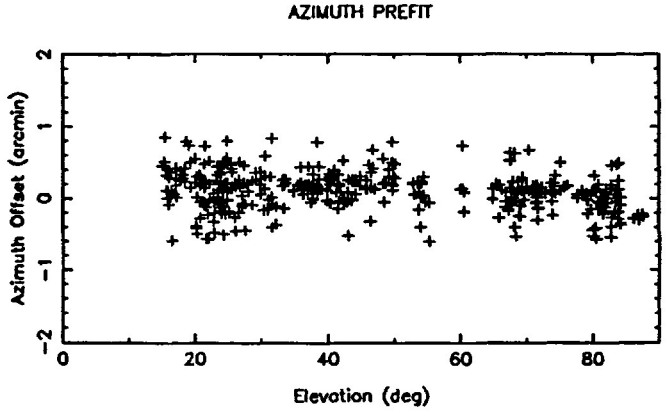
Azimuth (deg)


AZIMUTH PREFIT
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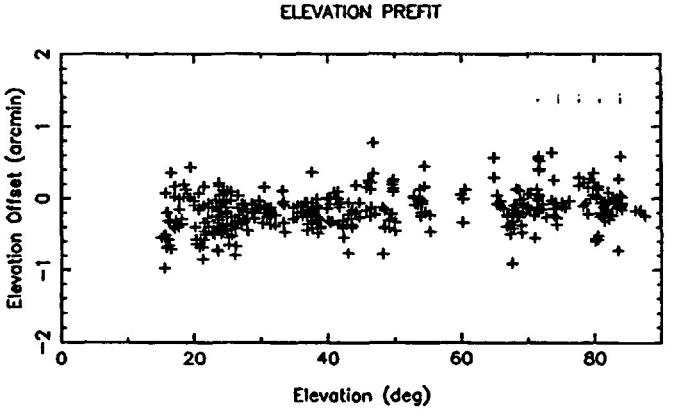
Elevation (deg)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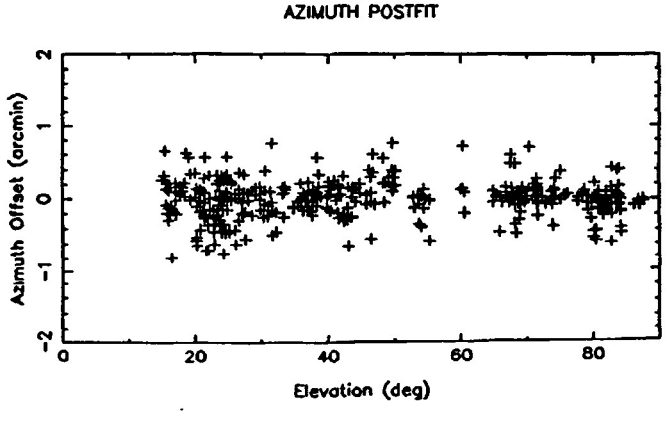
Elevation (deg)


AZIMUTH POSTFIT
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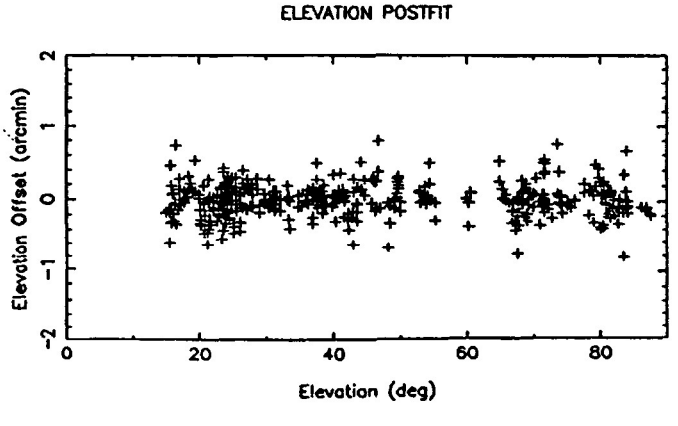
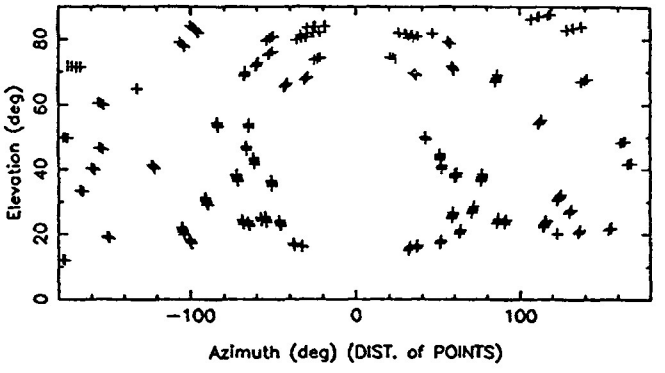
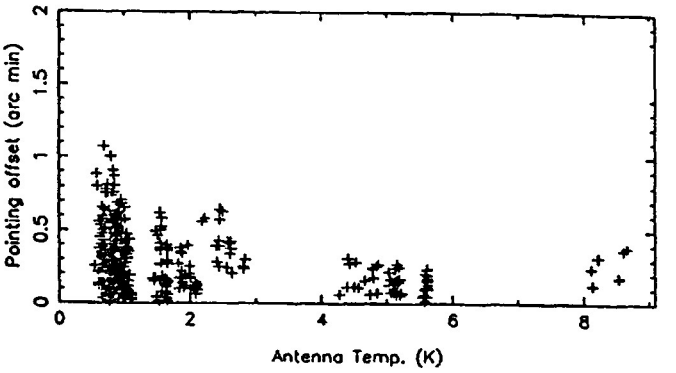
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

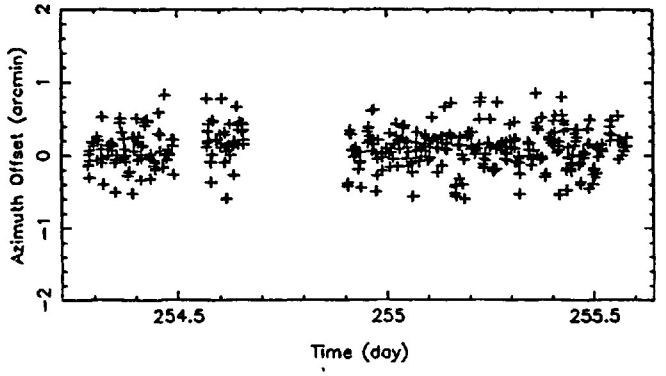
DISTRIBUTION OF POINTS



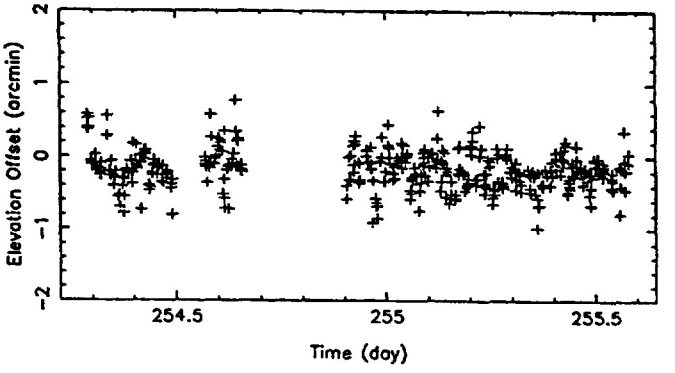
POINTING OFFSET vs ANTENNA TEMP



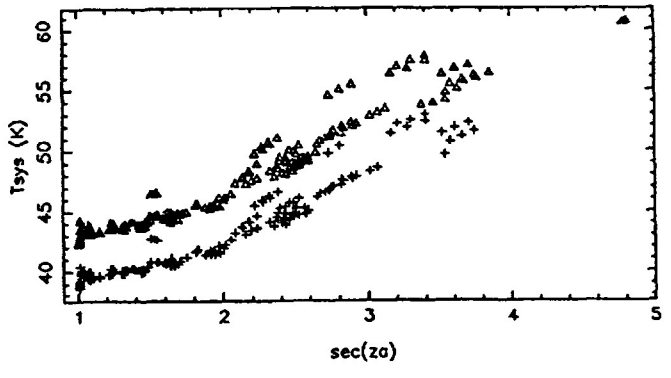
AZIMUTH PREFIT vs TIME



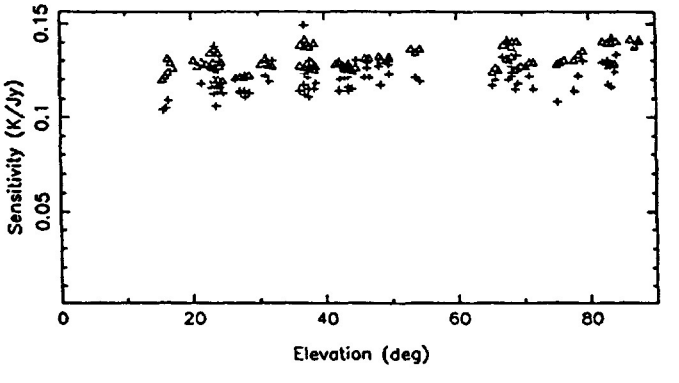
ELEVATION PREFIT vs TIME



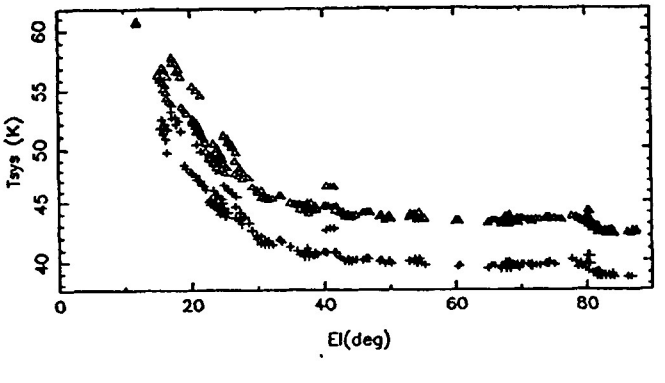
SYSTEM TEMP vs SEC(Z)



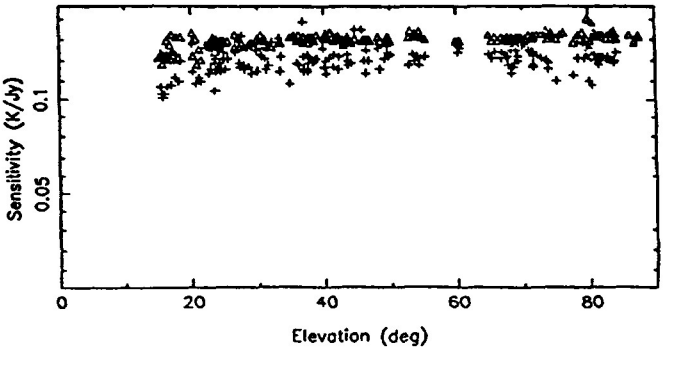
Tant / Assumed Flux (Calibrators)

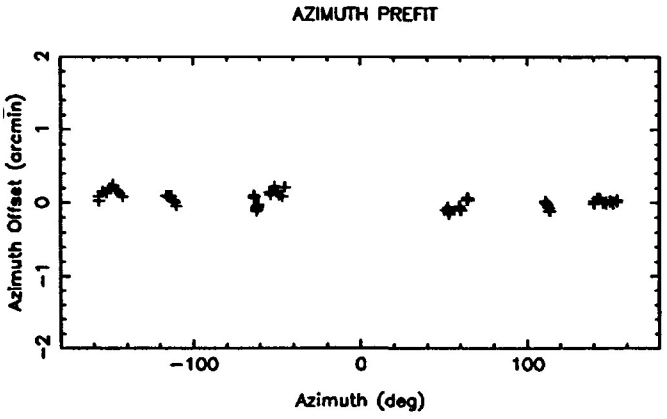


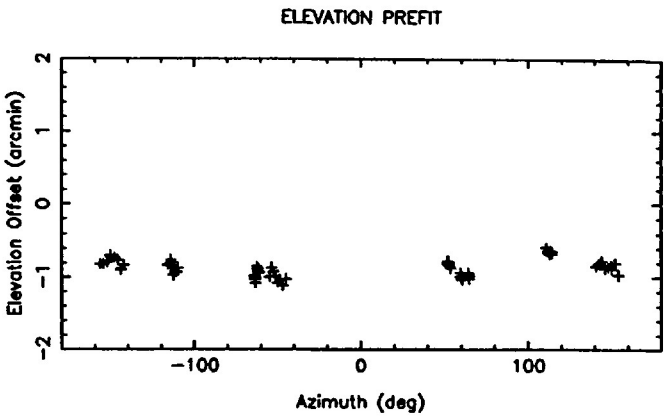
SYSTEM TEMP vs ELEVATION

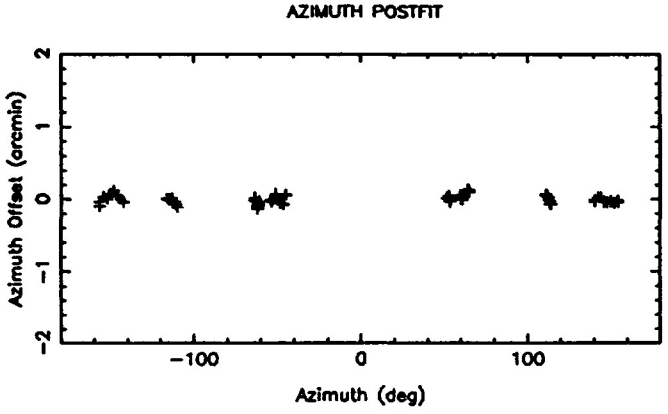


Tant / Measured Flux (All Sources)




AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)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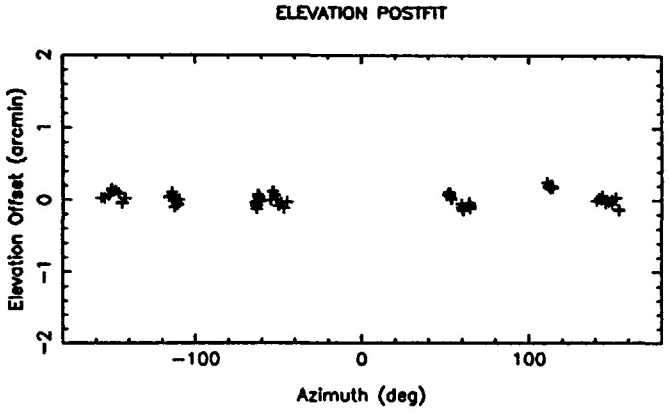
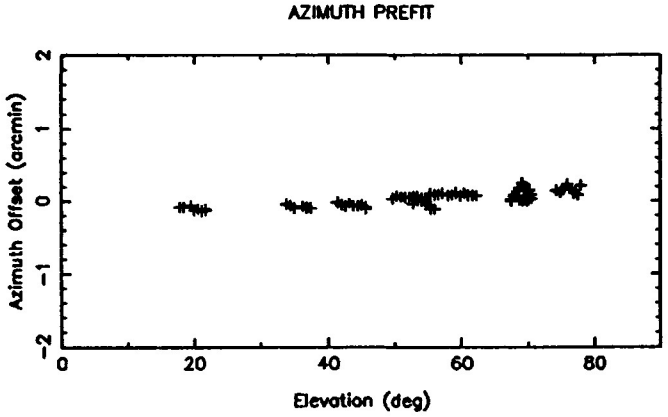
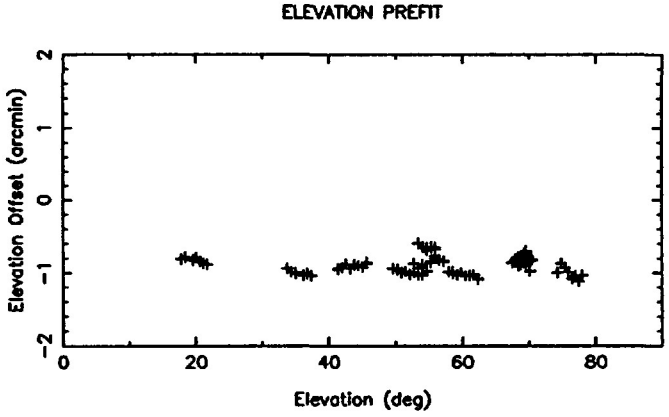
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)


AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)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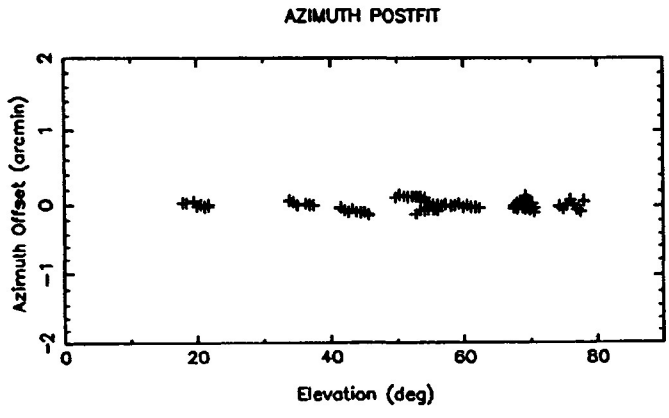
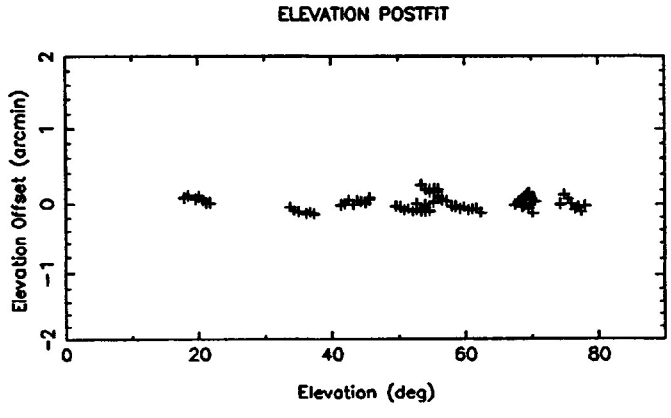
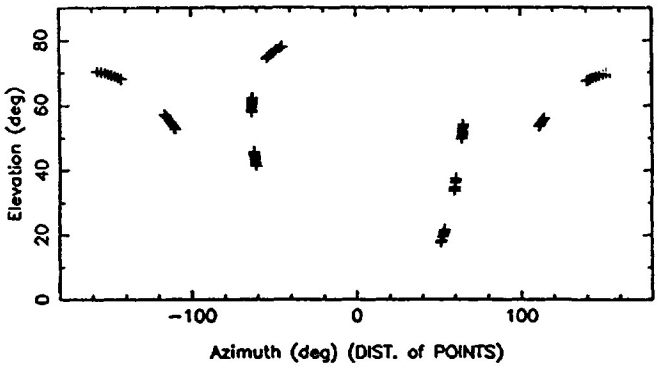
Elevation Offset (arcmin)
Elevation (deg)

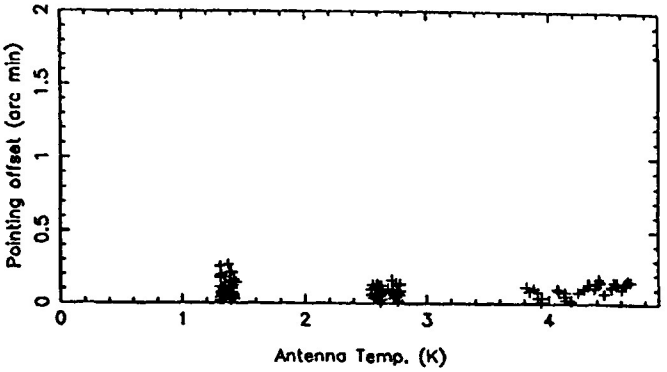

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

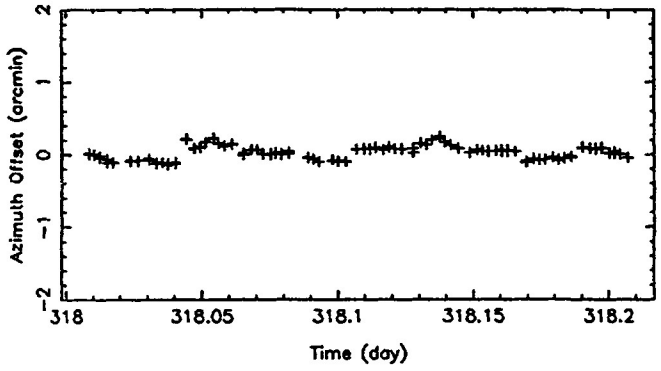
DISTRIBUTION OF POINTS



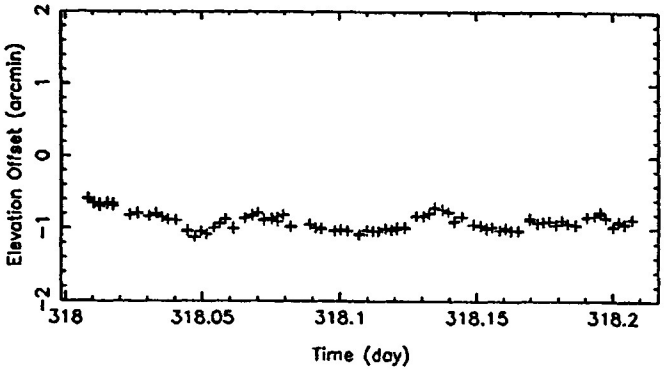
POINTING OFFSET vs ANTENNA TEMP



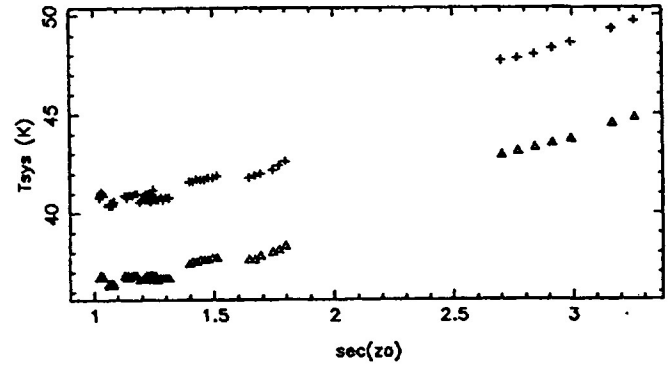
AZIMUTH PREFIT vs TIME



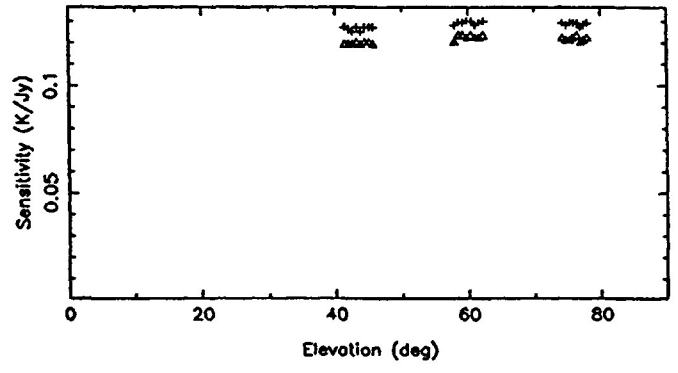
ELEVATION PREFIT vs TIME



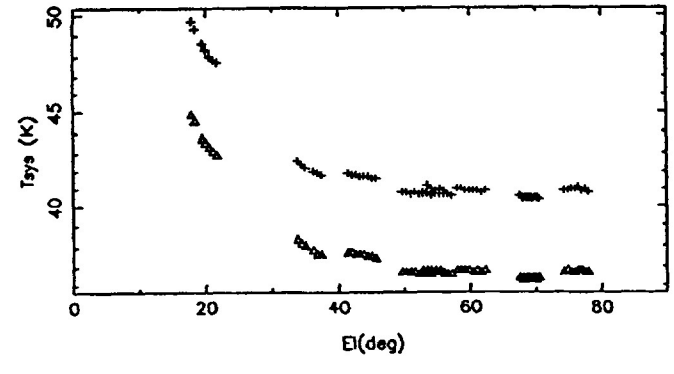
SYSTEM TEMP vs SEC(Z)



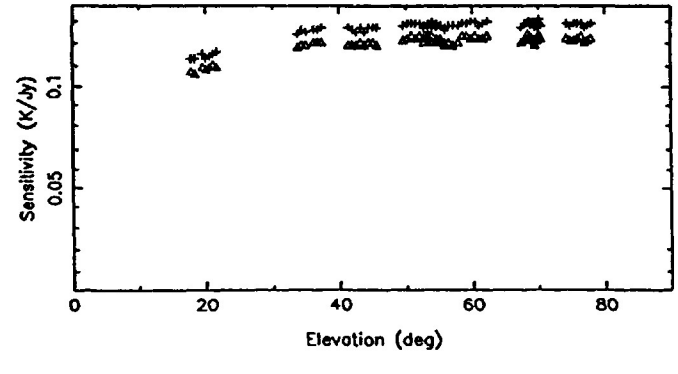
Tant / Assumed Flux (Calibrators)

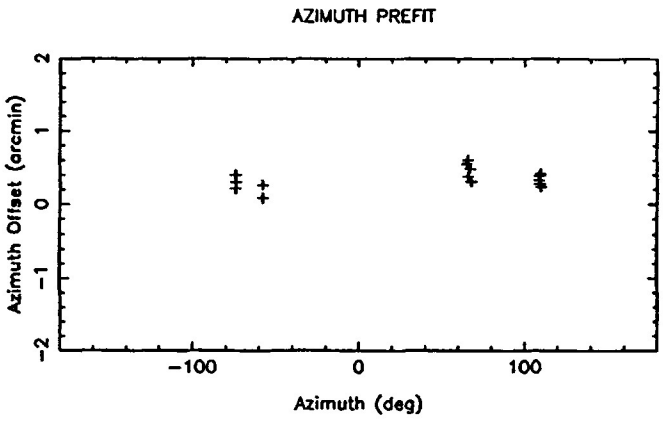


SYSTEM TEMP vs ELEVATION



Tant / Measured Flux (All Sources)

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Azimuth (deg)
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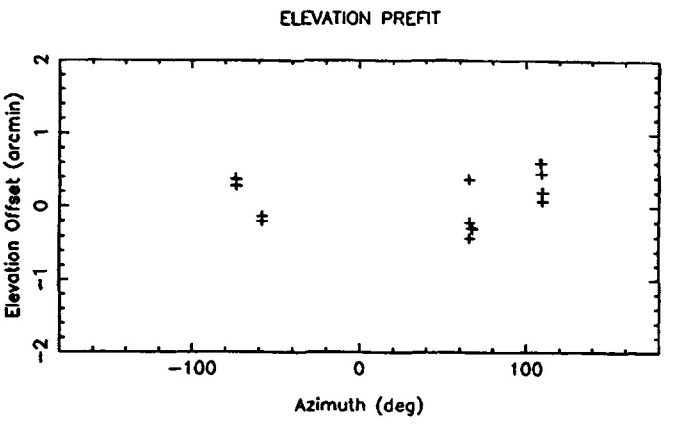
ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)
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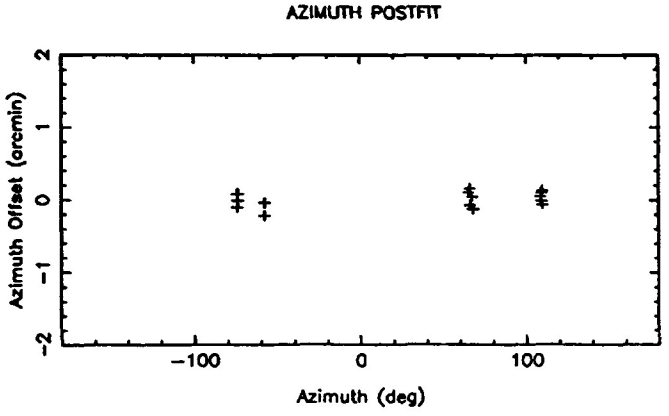
AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)
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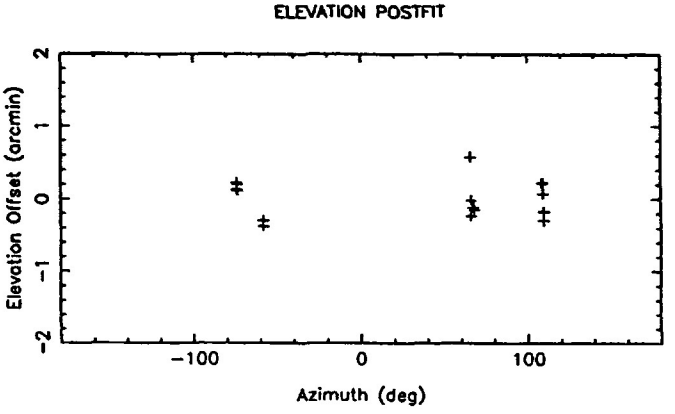
ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)
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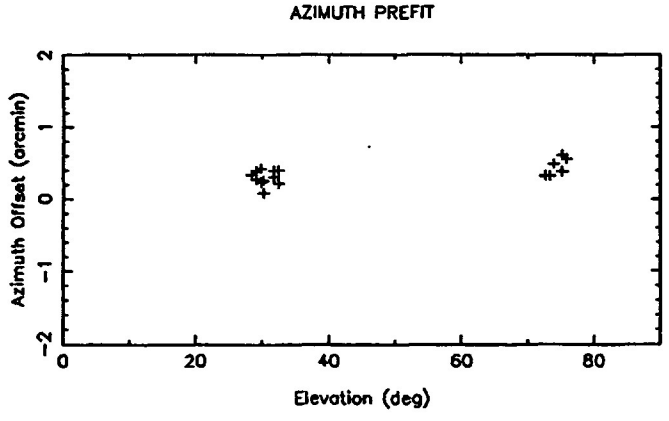
AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)
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−1
−2
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20
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60
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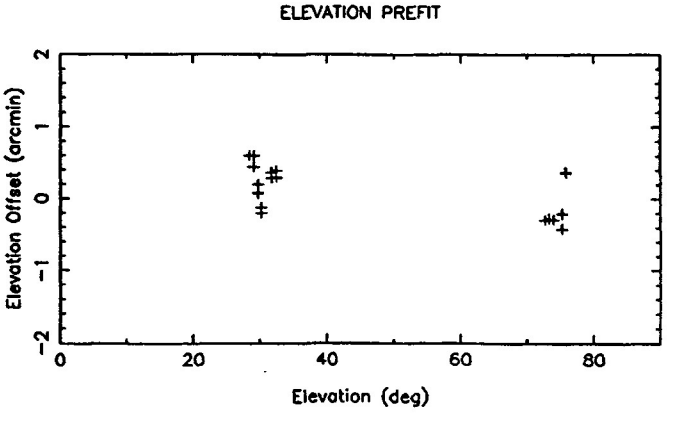
ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)
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−2
0
20
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60
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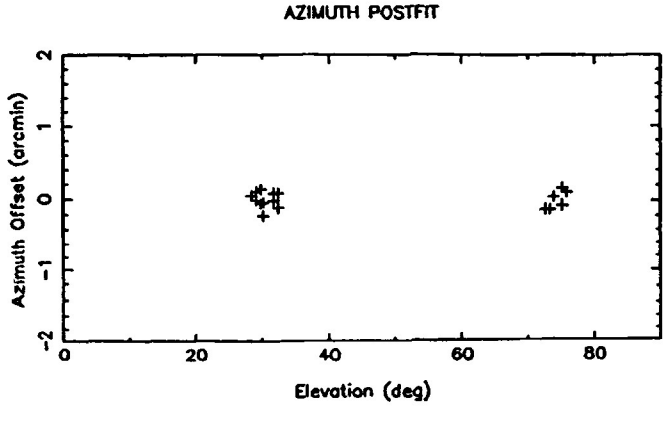
AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)
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20
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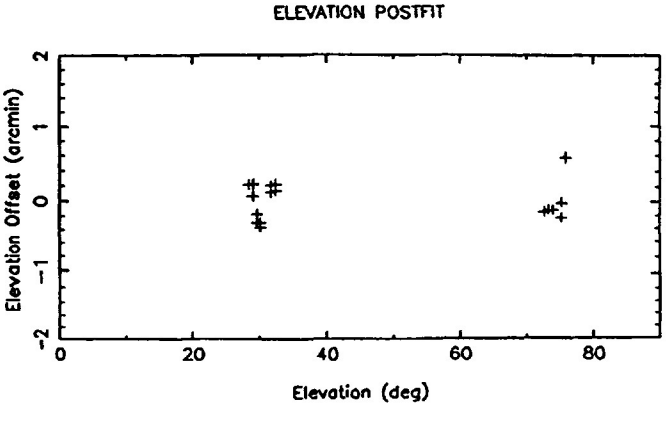
ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)
2
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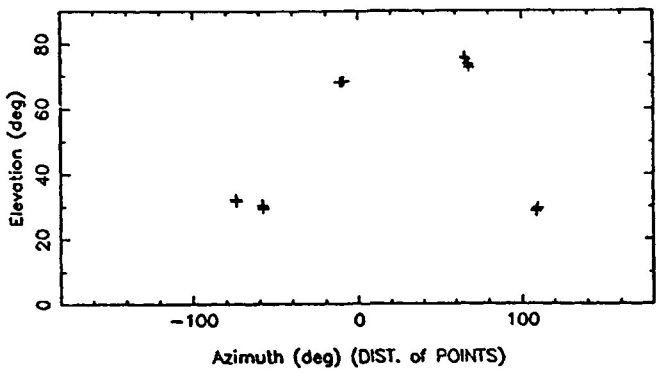
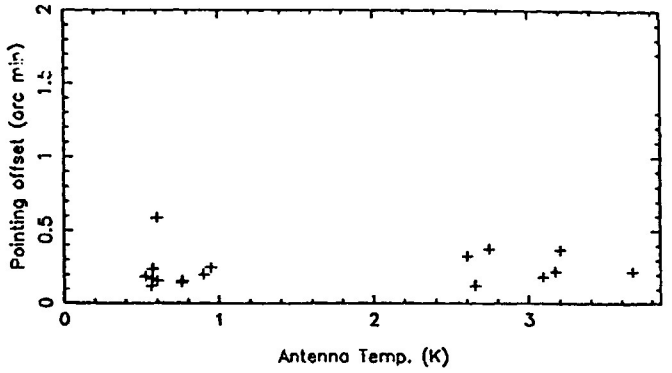
−2
0
20
40
60
80

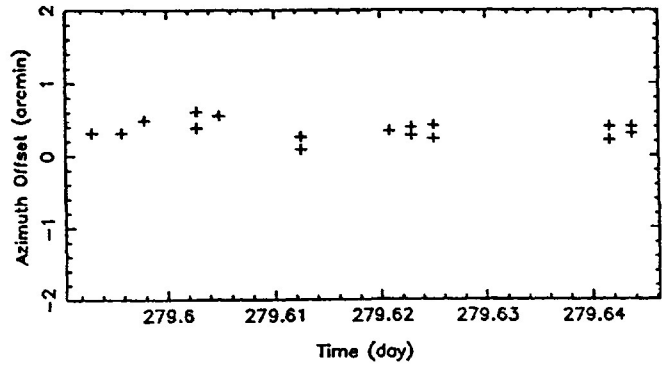
DISTRIBUTION OF POINTS



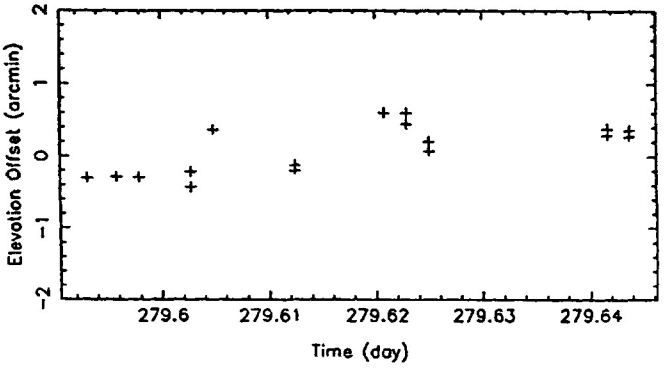
POINTING OFFSET vs ANTENNA TEMP



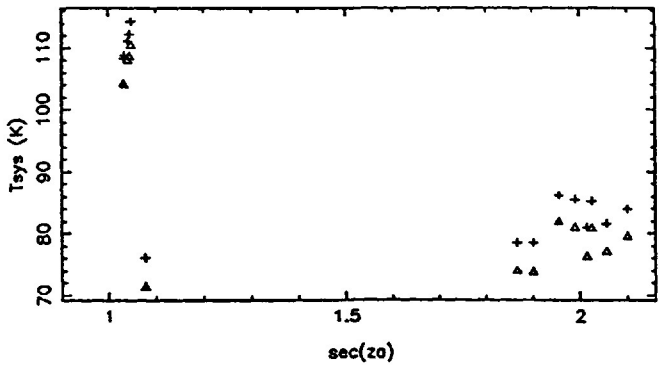
AZIMUTH PREFIT vs TIME



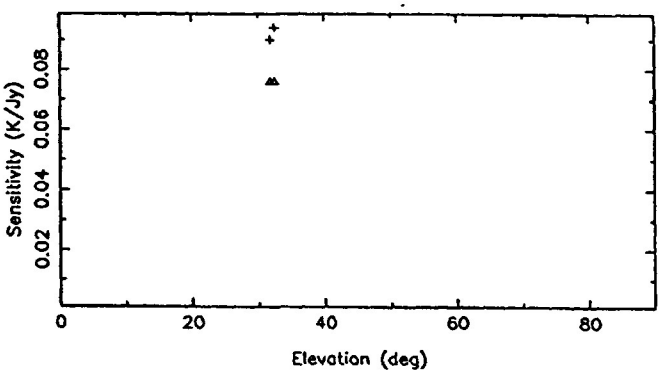
ELEVATION PREFIT vs TIME



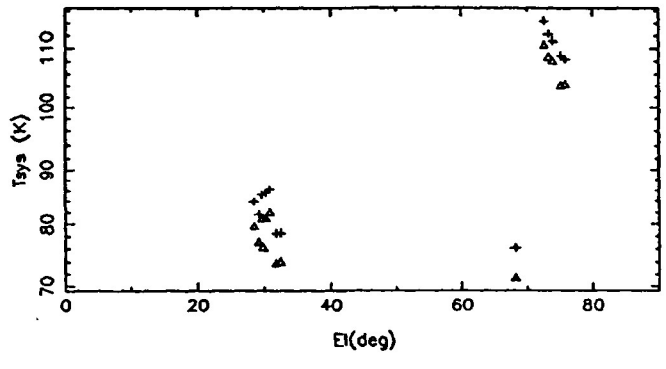
SYSTEM TEMP vs SEC(Z)



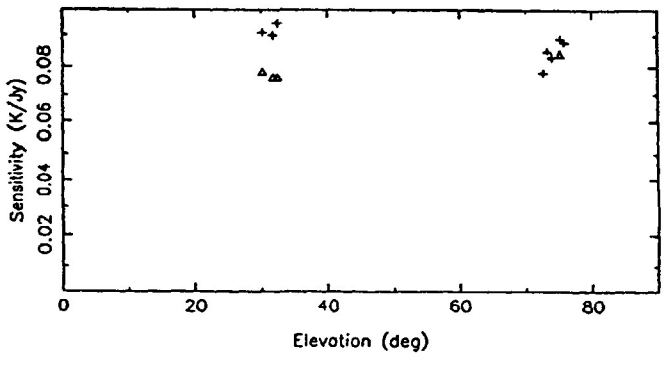
Tant / Assumed Flux (Calibrators)

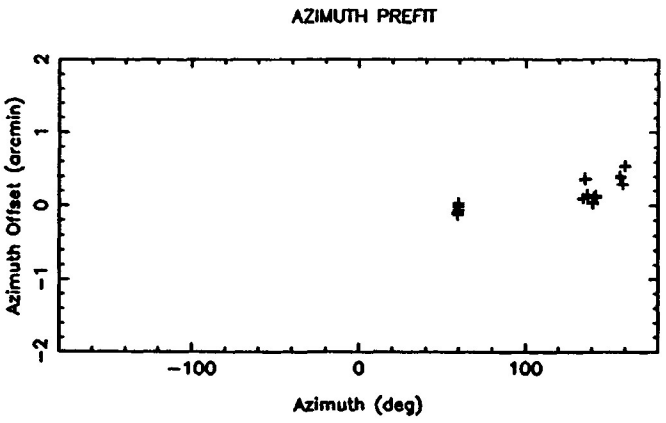


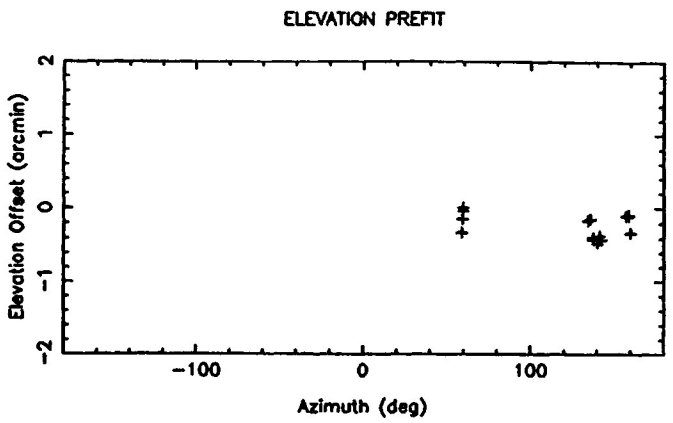
SYSTEM TEMP vs ELEVATION

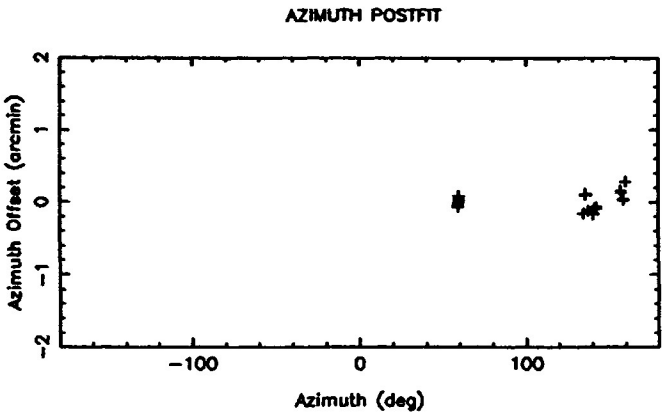


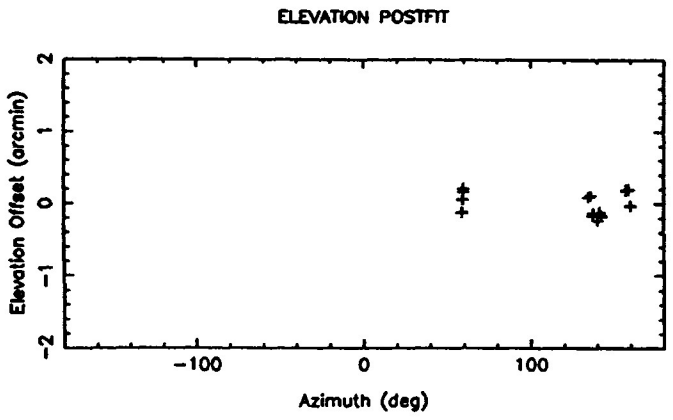
Tant / Measured Flux (All Sources)

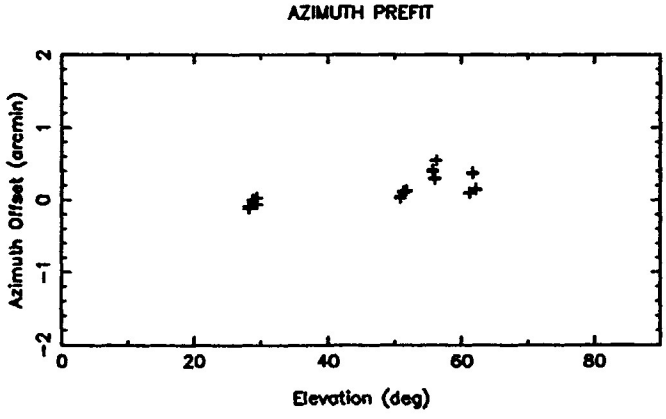


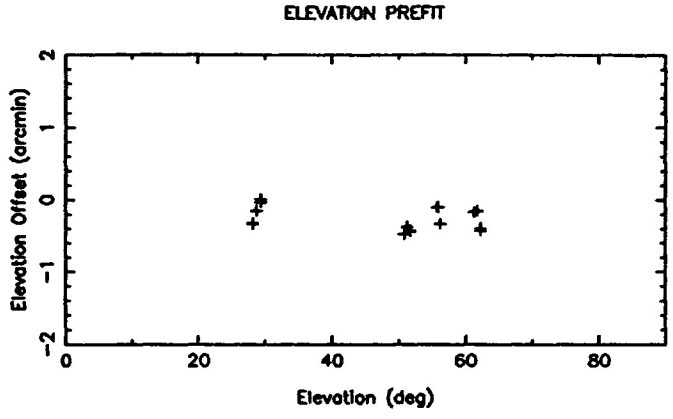

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

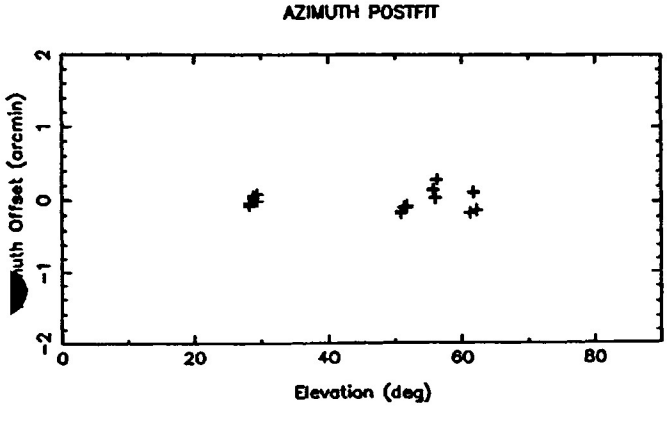

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)

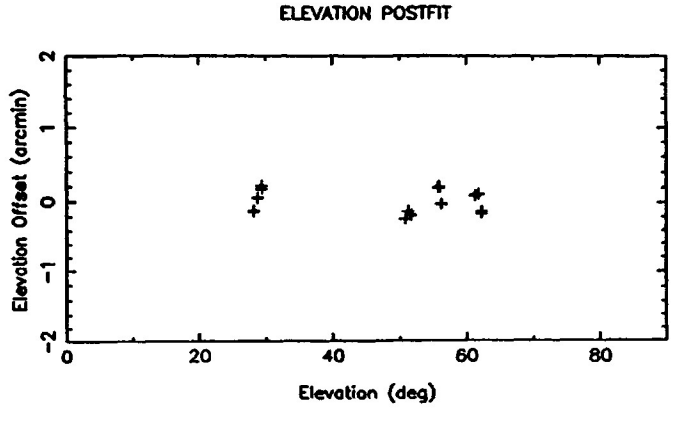

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)

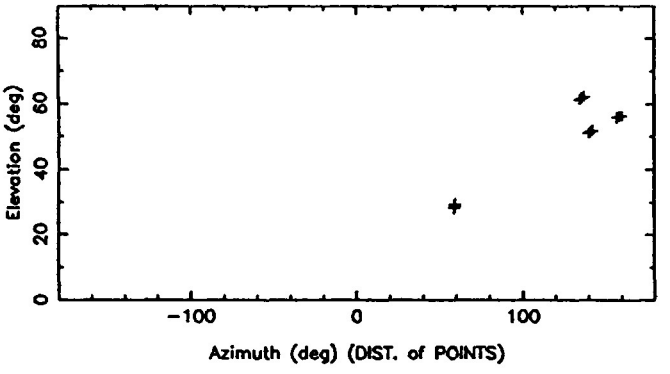

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)

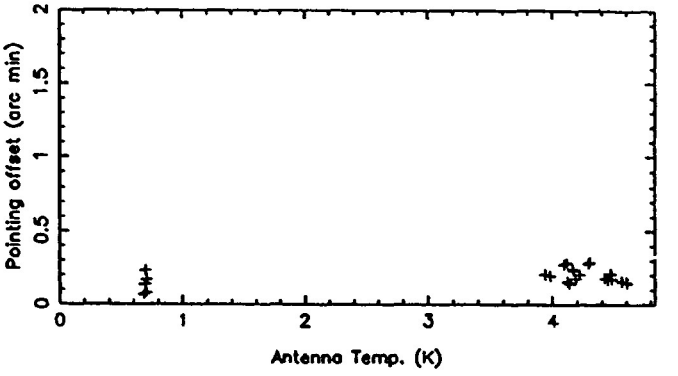

AZIMUTH POSTFIT
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

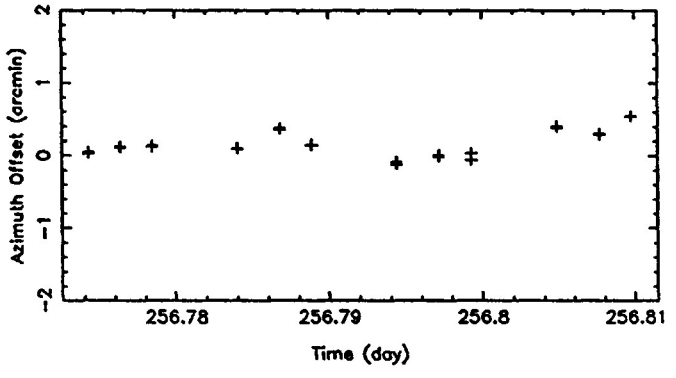
DISTRIBUTION OF POINTS



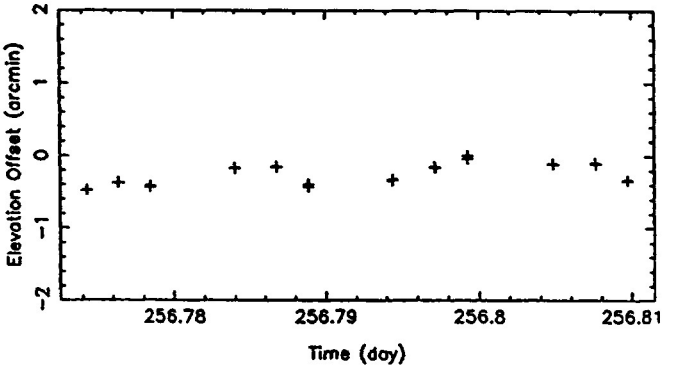
POINTING OFFSET vs ANTENNA TEMP



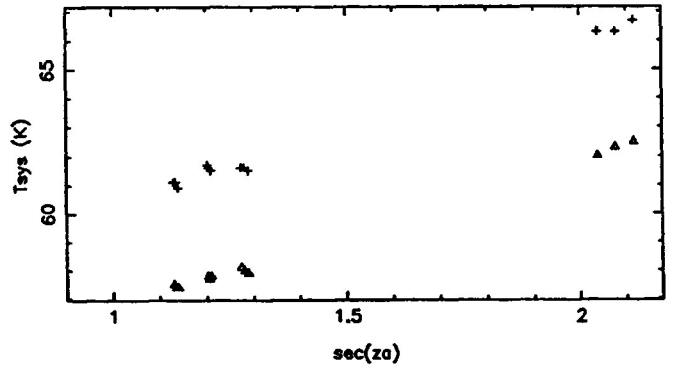
AZIMUTH PREFIT vs TIME



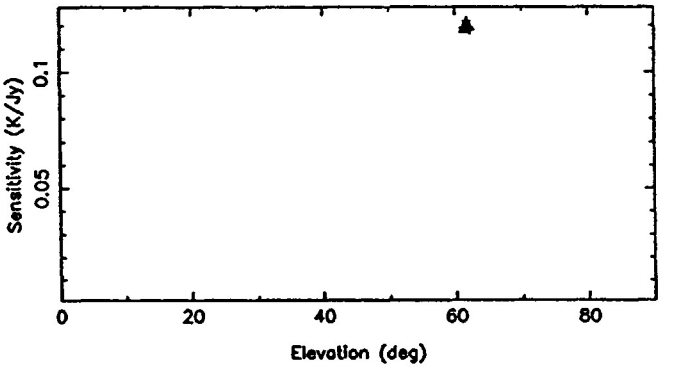
ELEVATION PREFIT vs TIME



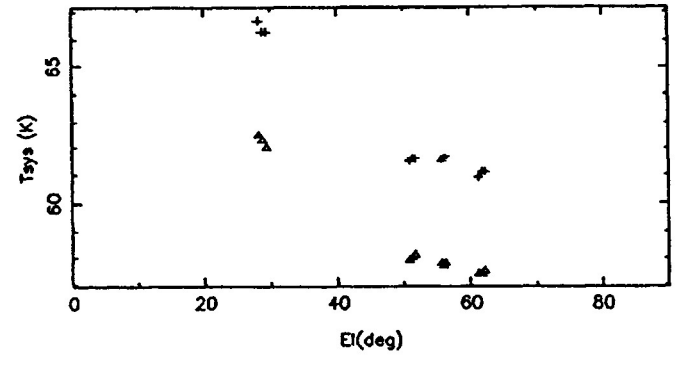
SYSTEM TEMP vs SEC(Z)



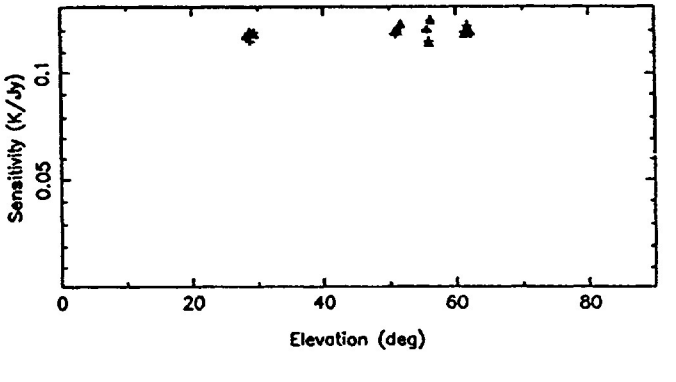
Tant / Assumed Flux (Calibrators)

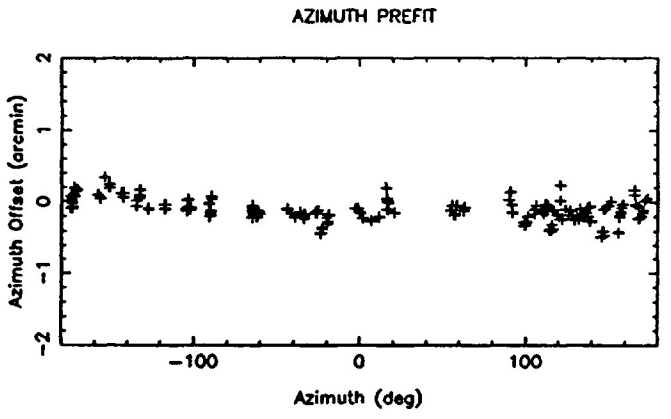


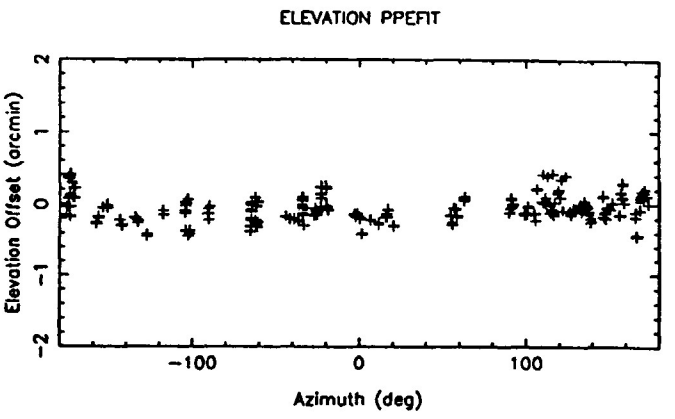
SYSTEM TEMP vs ELEVATION

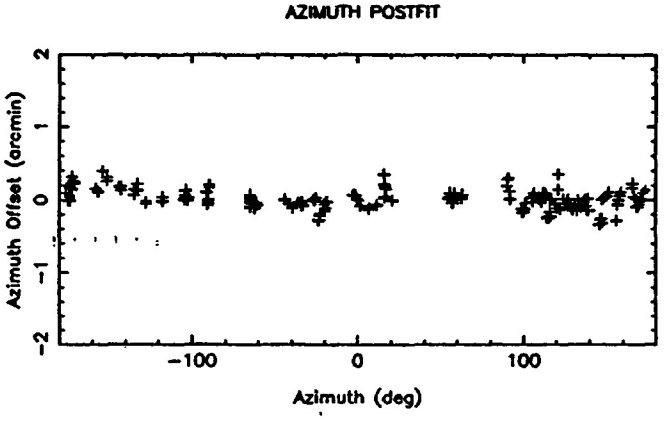


Tant / Measured Flux (All Sources)




AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION PPEFIT
Elevation Offset (arcmin)
Azimuth (deg)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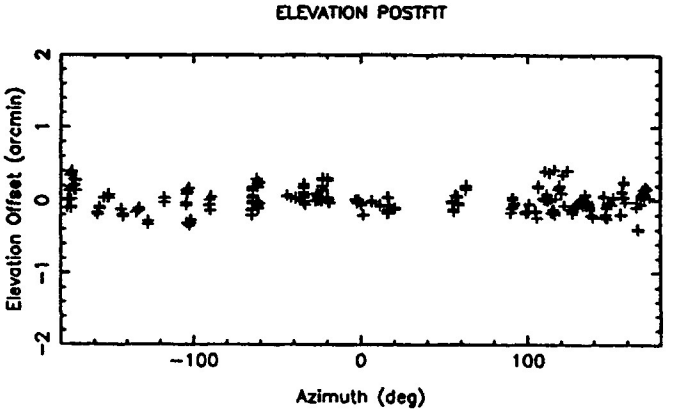
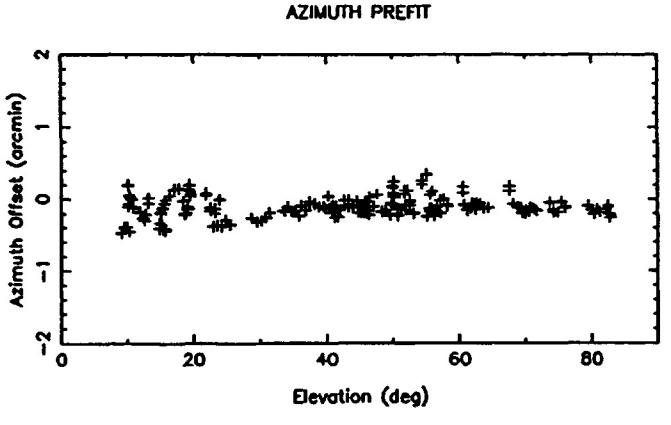
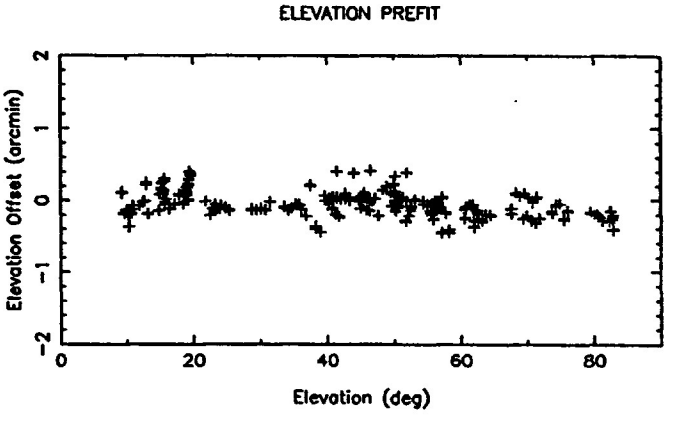
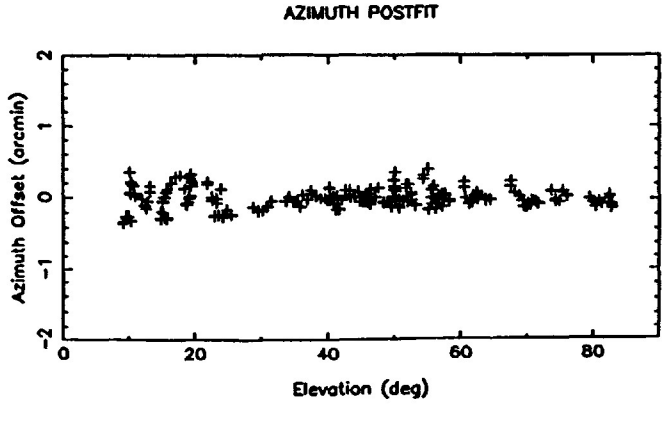
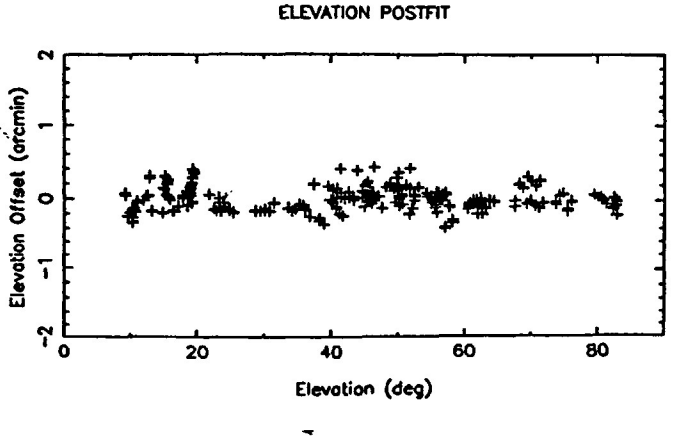
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)

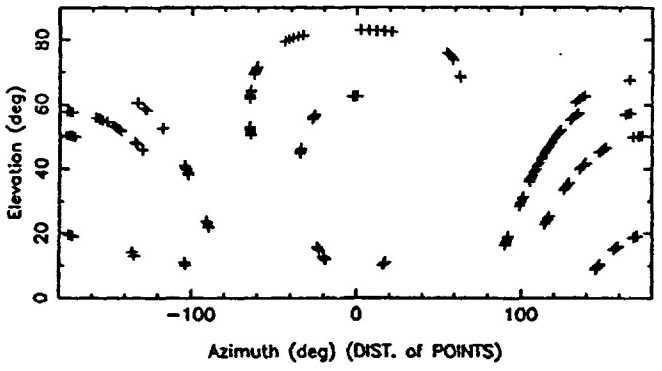

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)

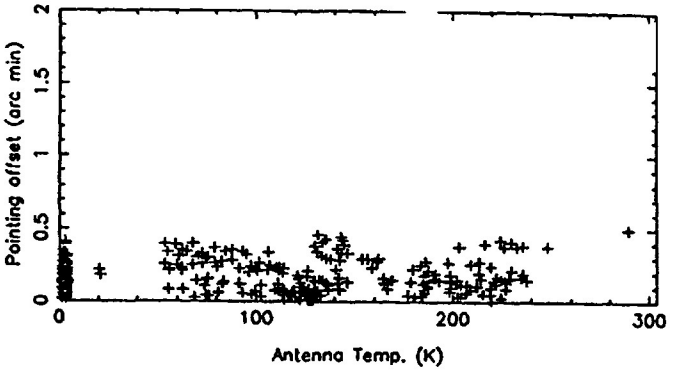

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

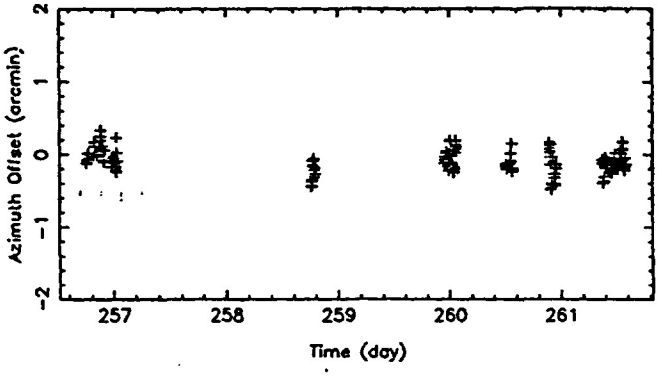
DISTRIBUTION OF POINTS



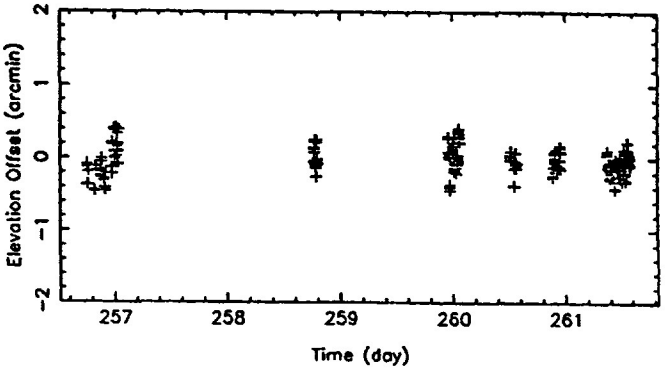
POINTING OFFSET vs ANTENNA TEMP



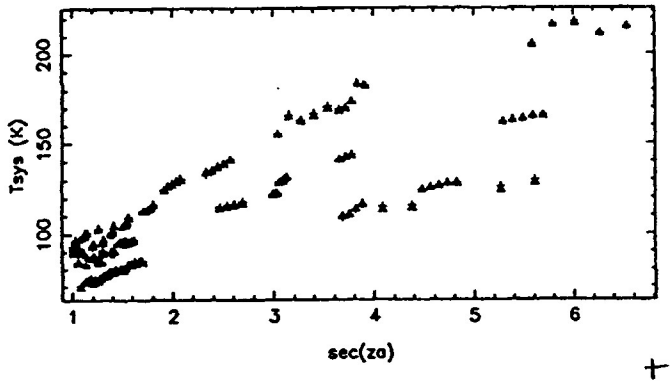
AZIMUTH PREFIT vs TIME



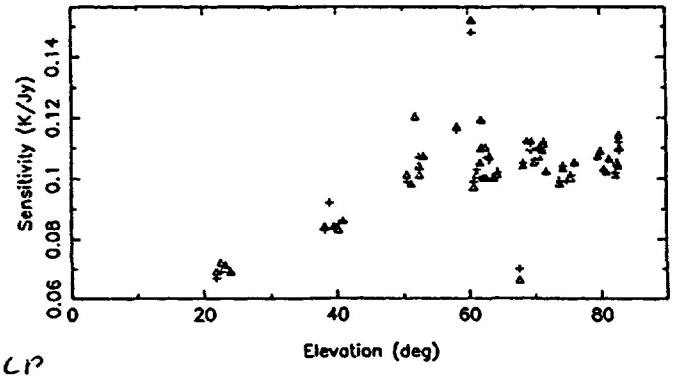
ELEVATION PREFIT vs TIME



SYSTEM TEMP vs SEC(Z)



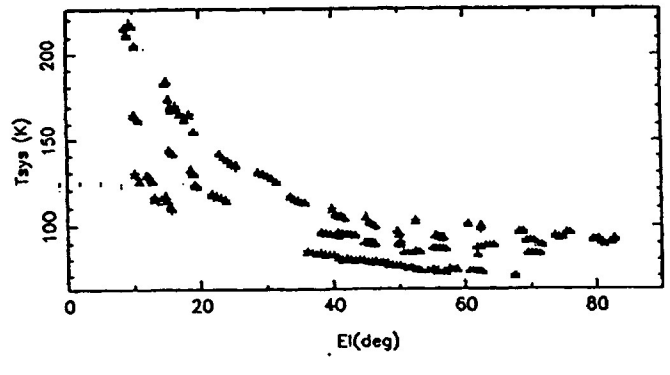
Tant / Assumed Flux (Calibrators)



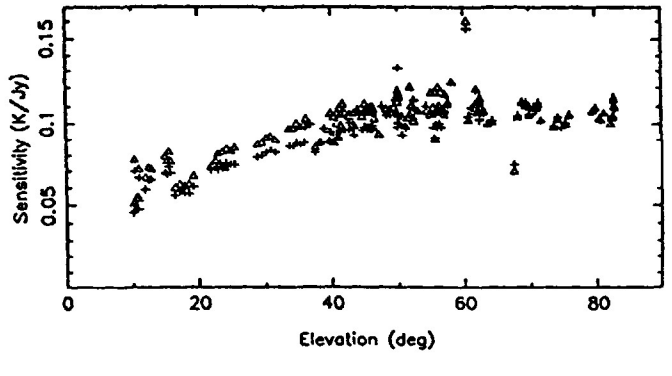
+ RCP

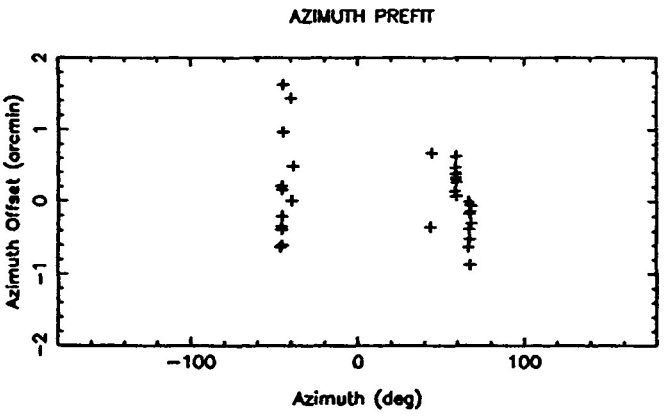
− LCP

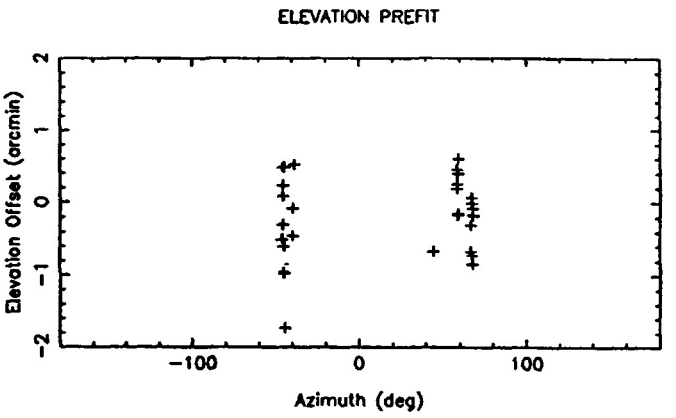
SYSTEM TEMP vs ELEVATION

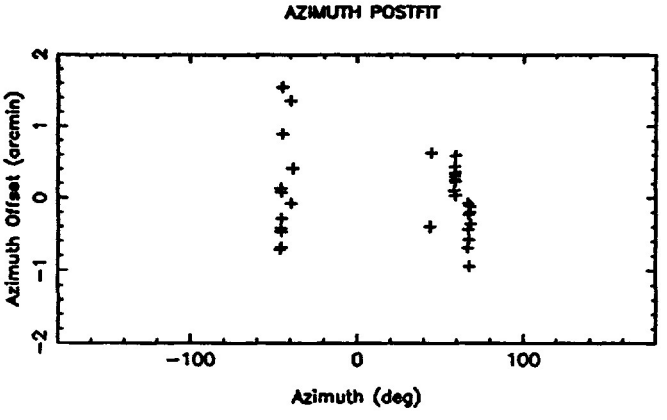


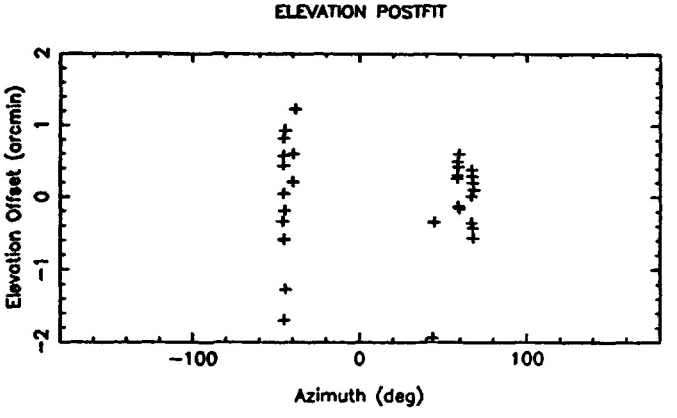
Tant / Measured Flux (All Sources)

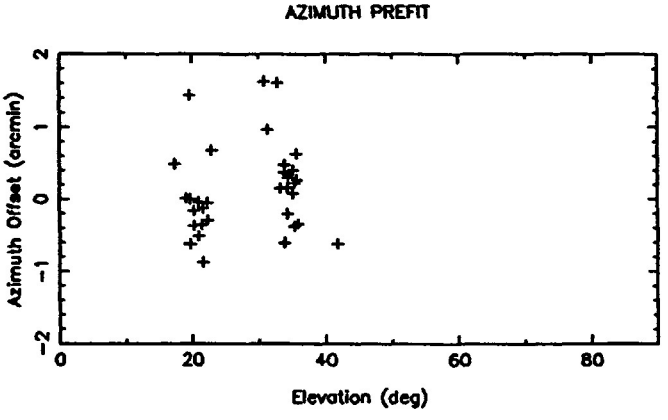


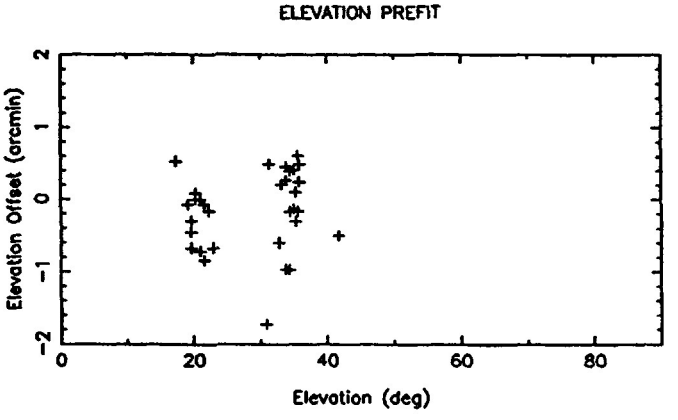

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

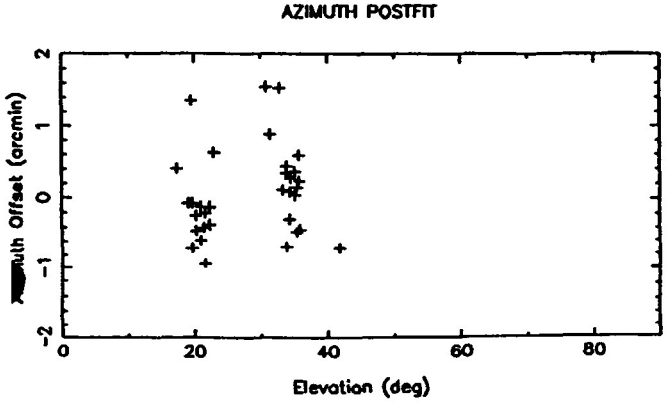

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)

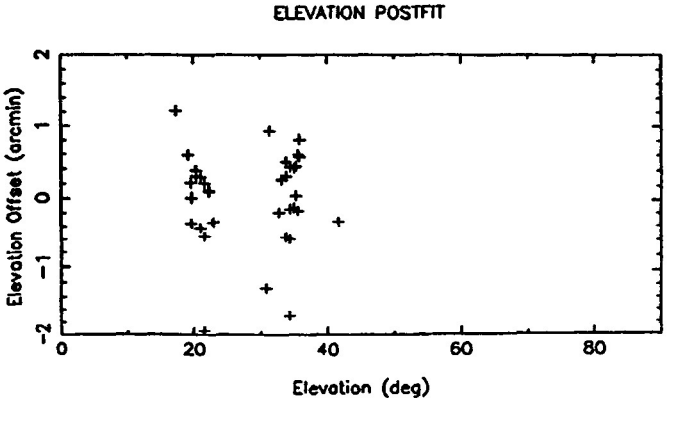

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)

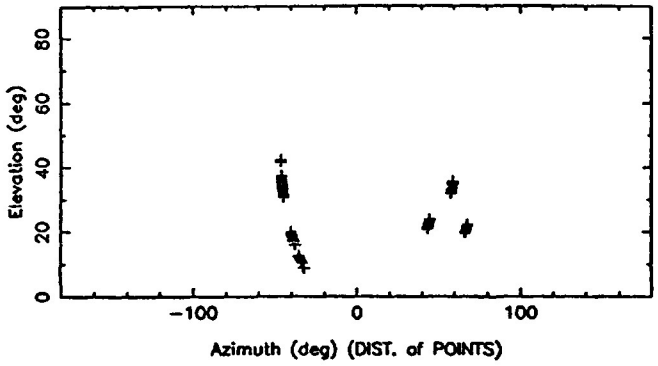

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)

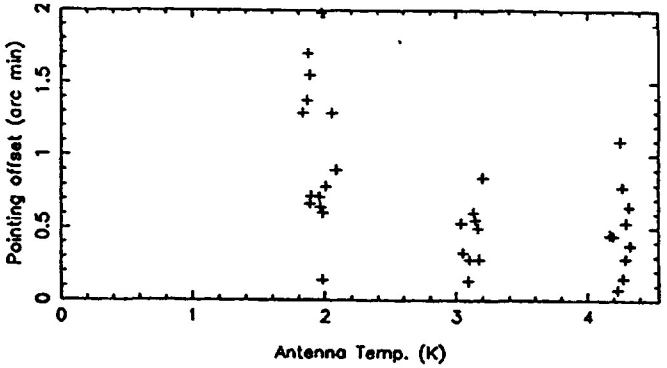

AZIMUTH POSTFIT
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

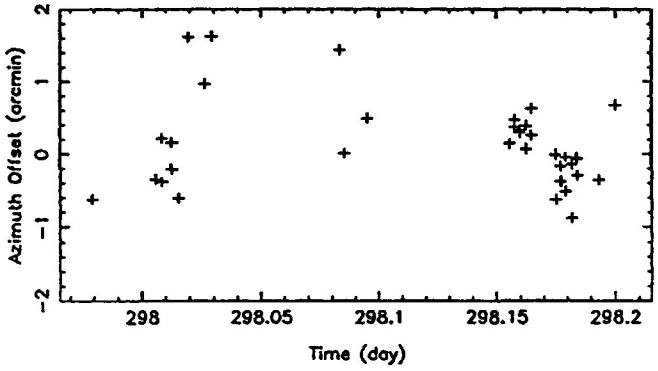
DISTRIBUTION OF POINTS



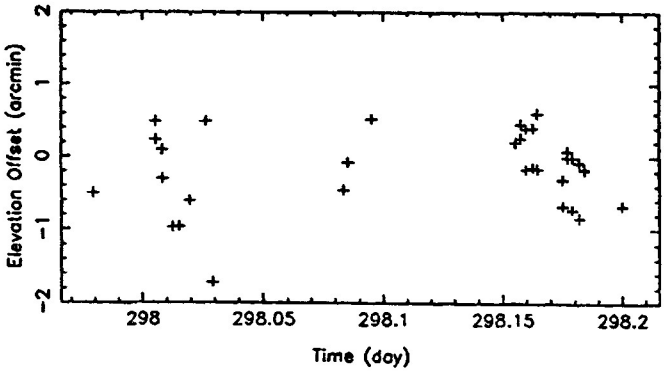
POINTING OFFSET vs ANTENNA TEMP



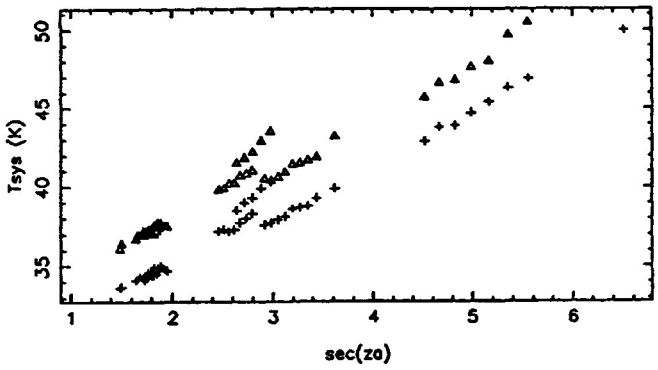
AZIMUTH PREFIT vs TIME



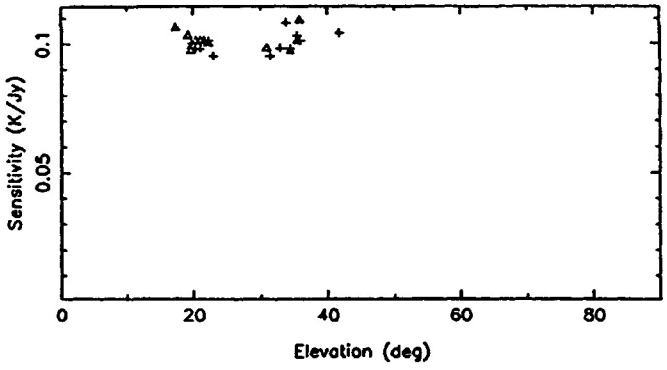
ELEVATION PREFIT vs TIME



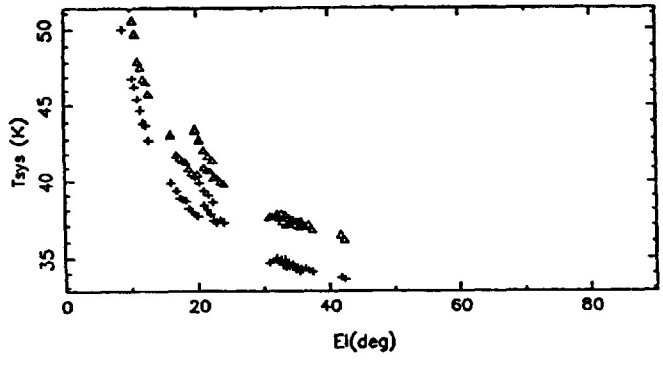
SYSTEM TEMP vs SEC(Z)



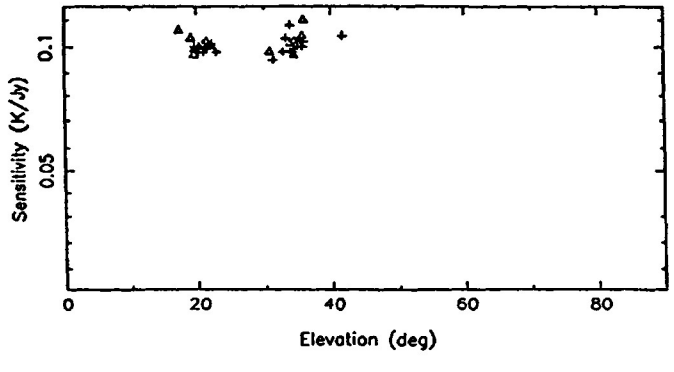
Tant / Assumed Flux (Calibrators)

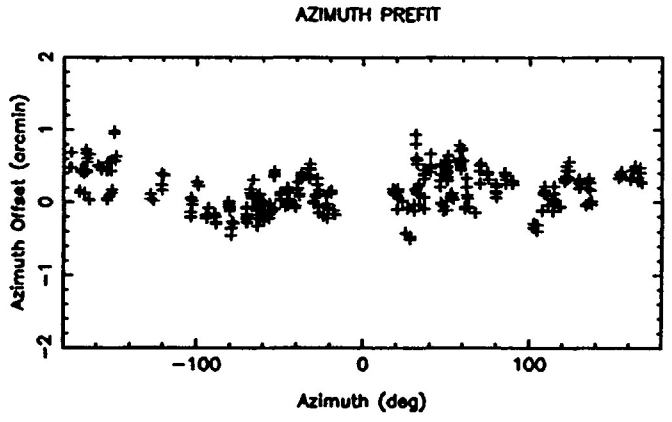


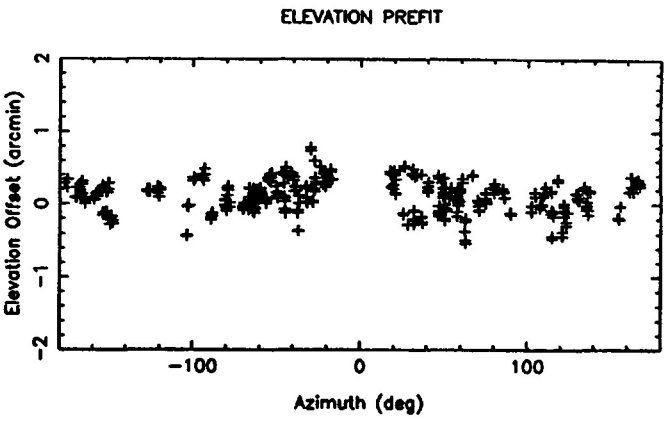
SYSTEM TEMP vs ELEVATION

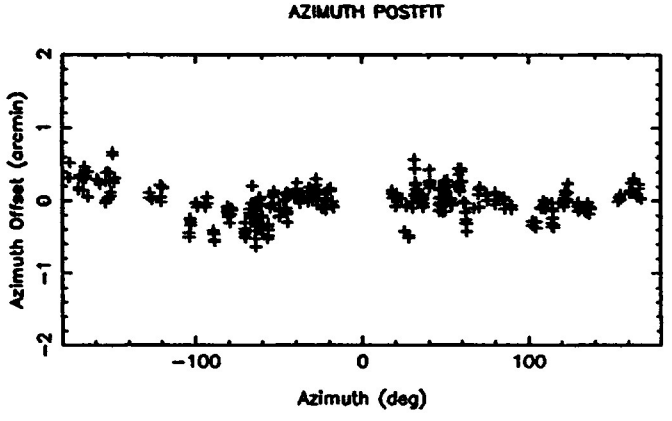


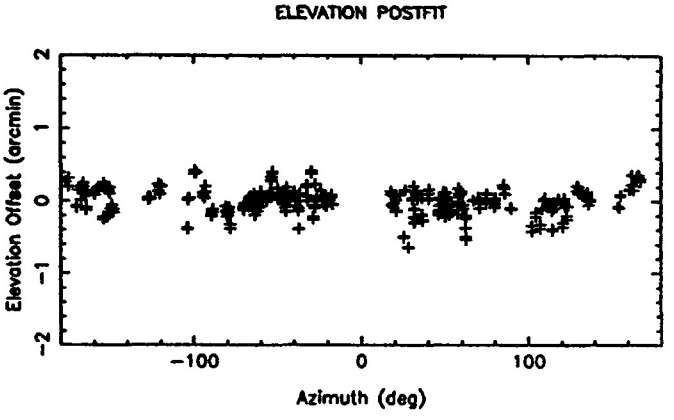
Tant / Measured Flux (All Sources)

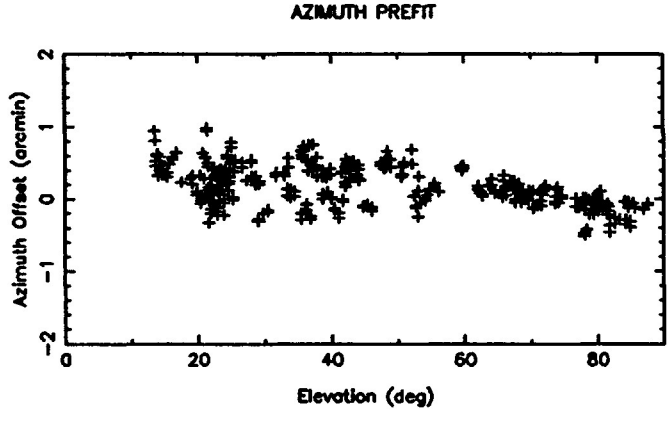


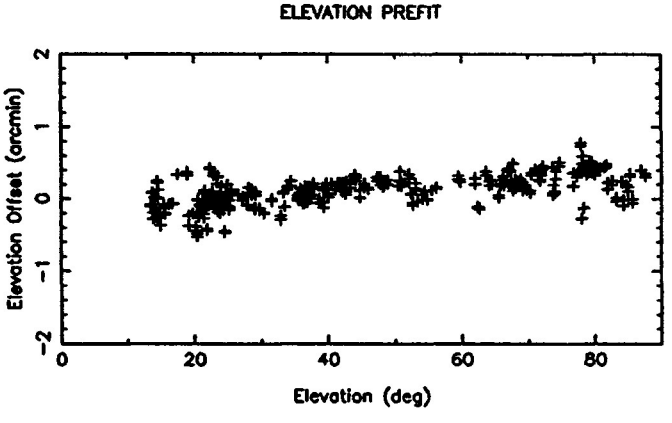

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

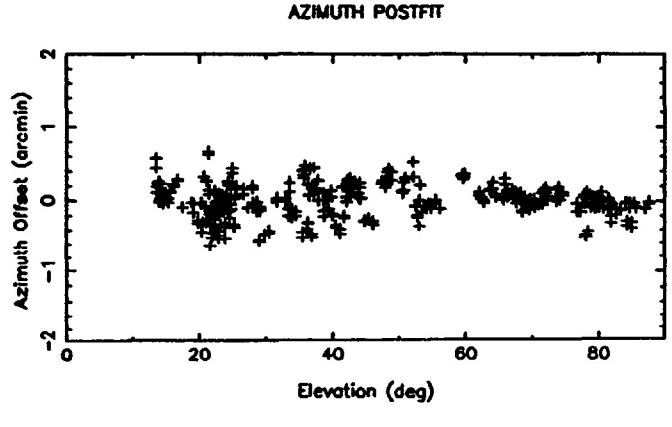

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)

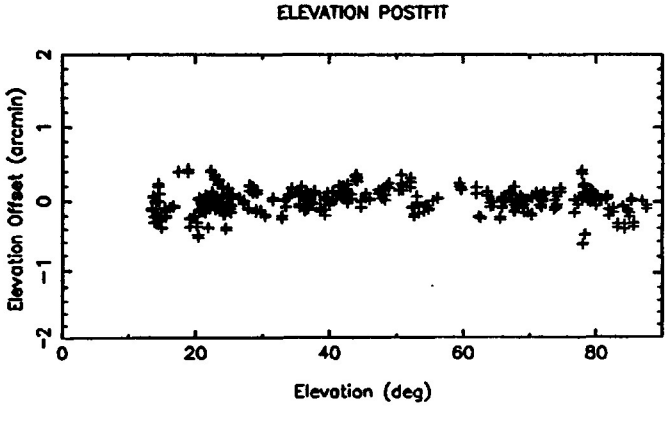

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)

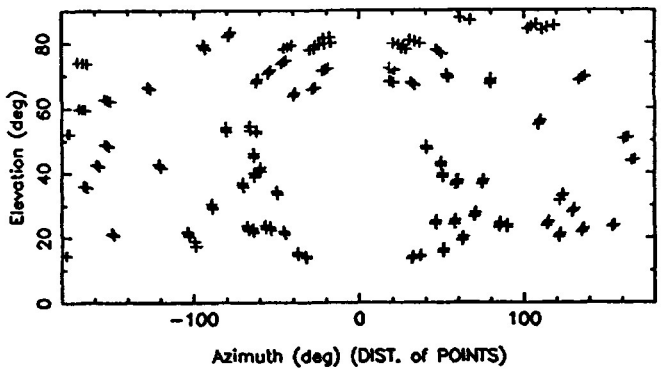

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)

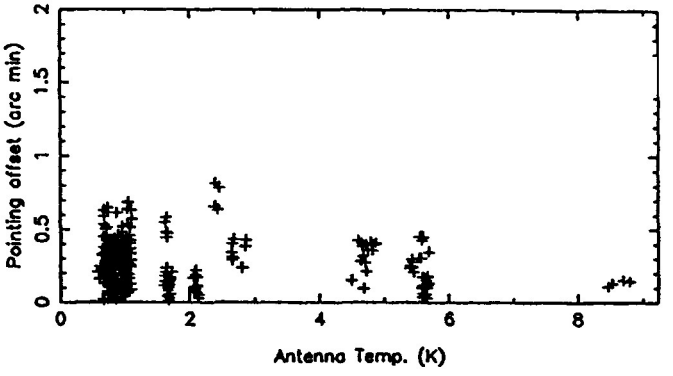

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

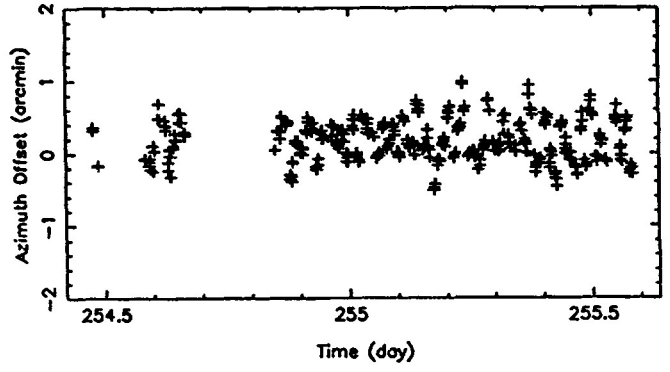
DISTRIBUTION OF POINTS



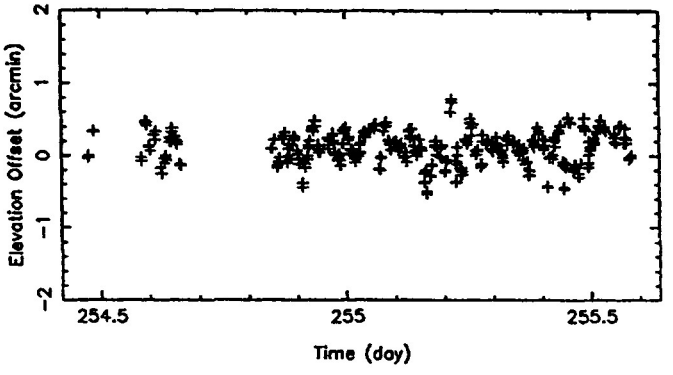
POINTING OFFSET vs ANTENNA TEMP



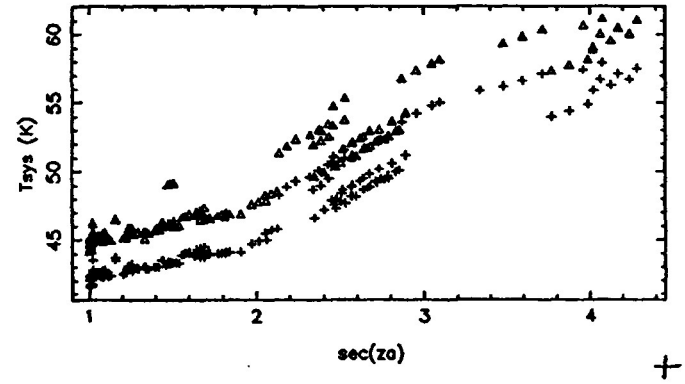
AZIMUTH PREFIT vs TIME



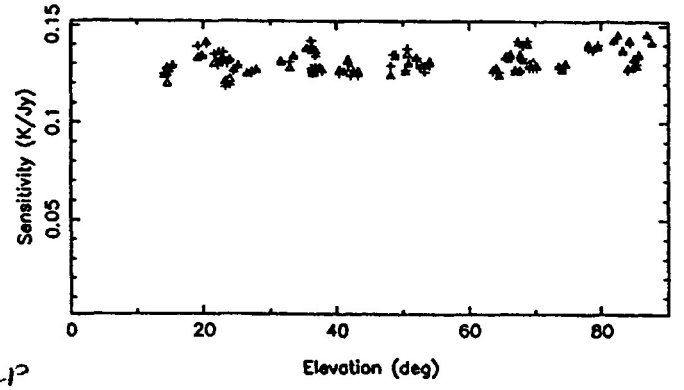
ELEVATION PREFIT vs TIME



SYSTEM TEMP vs SEC(Z)



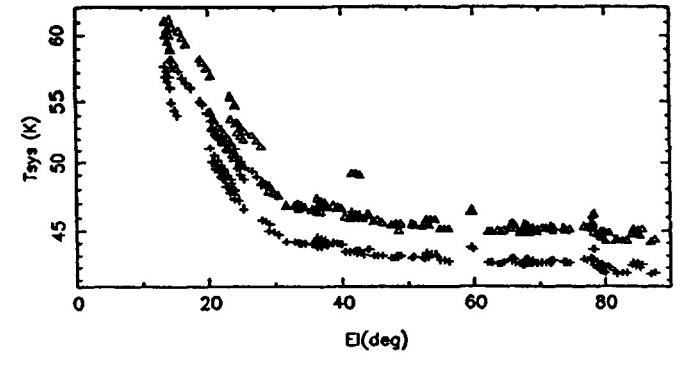
Tant / Assumed Flux (Calibrators)



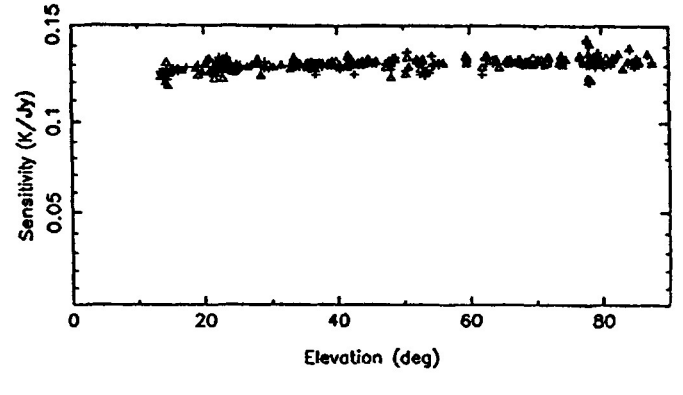
+ RCP

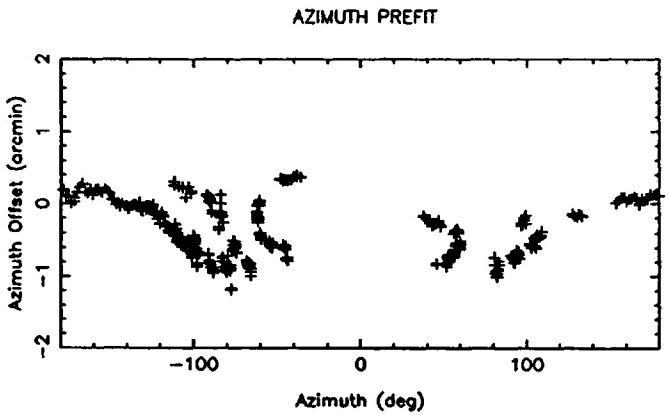
Δ LCP

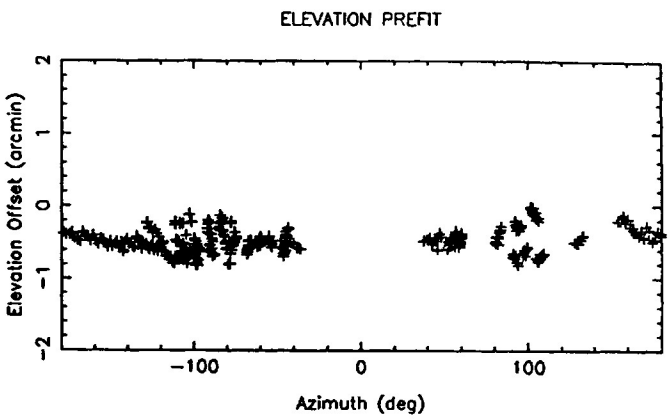
SYSTEM TEMP vs ELEVATION

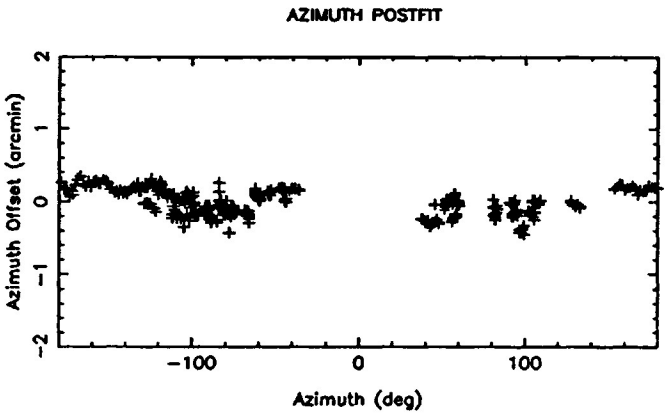


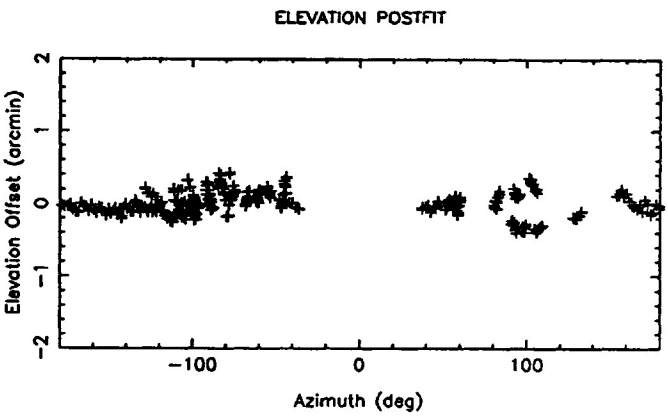
Tant / Measured Flux (All Sources)

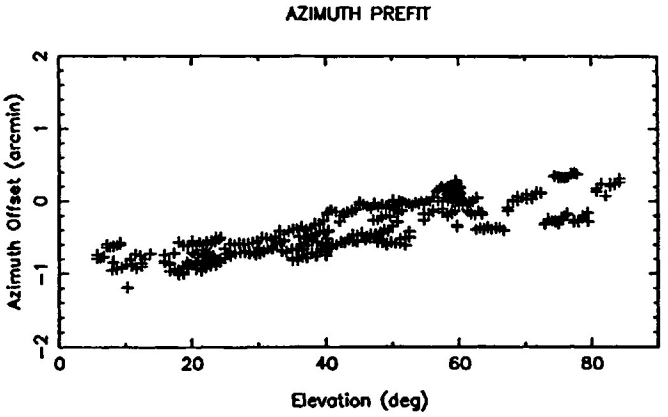



AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)


AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)


AZIMUTH PREFIT
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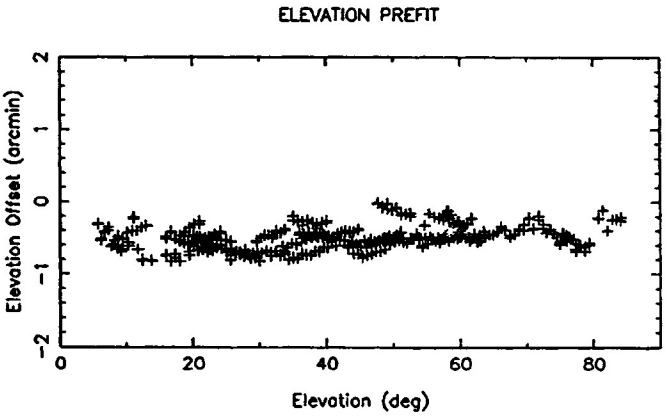
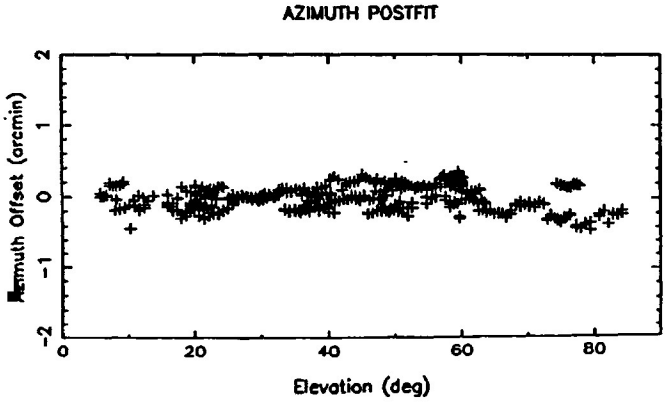
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)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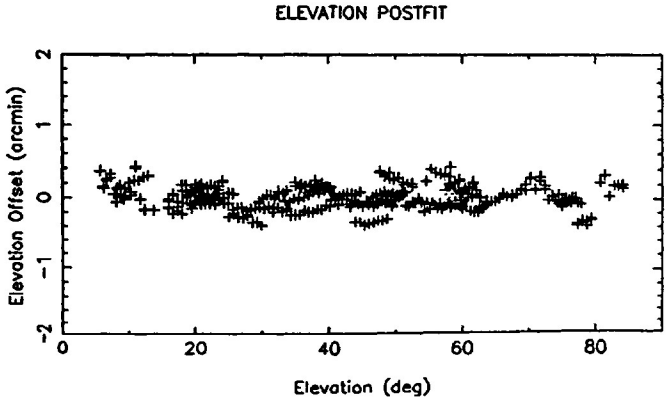
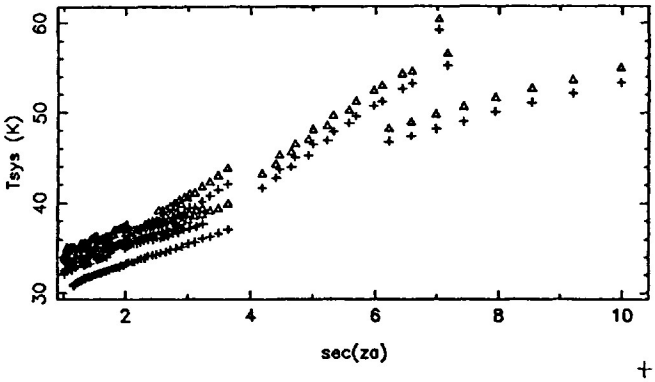
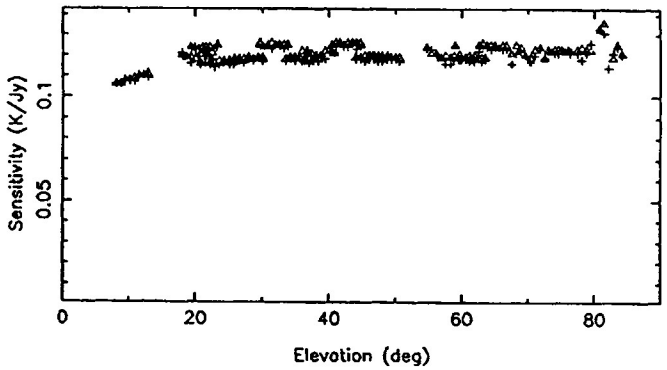
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

SYSTEM TEMP vs SEC(Z)

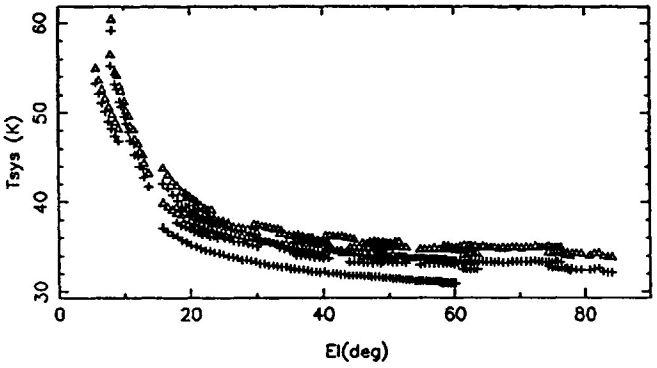


Tant / Assumed Flux (Calibrators)

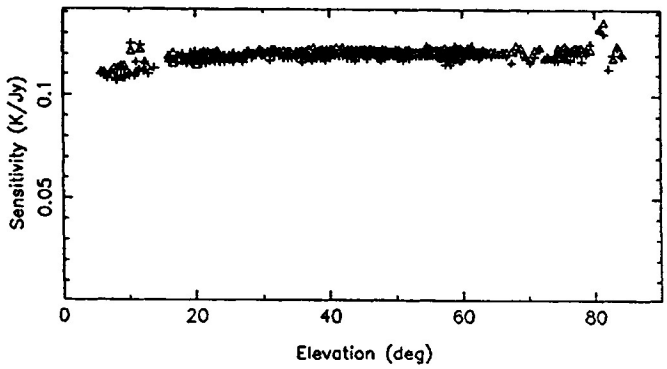


+ RCP
- LCP

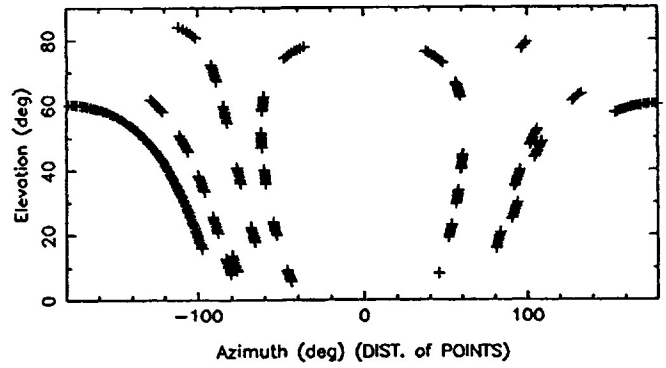
SYSTEM TEMP vs ELEVATION



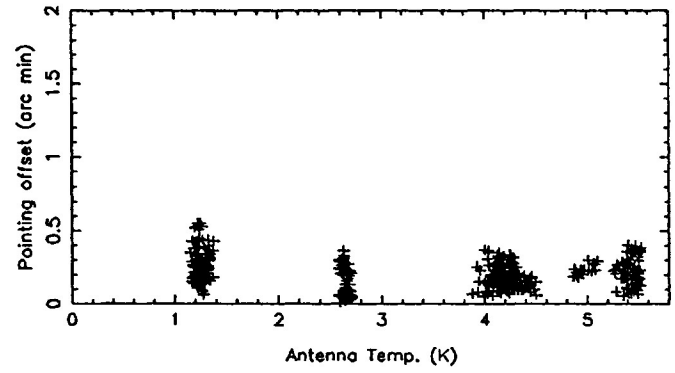
Tant / Measured Flux (All Sources)



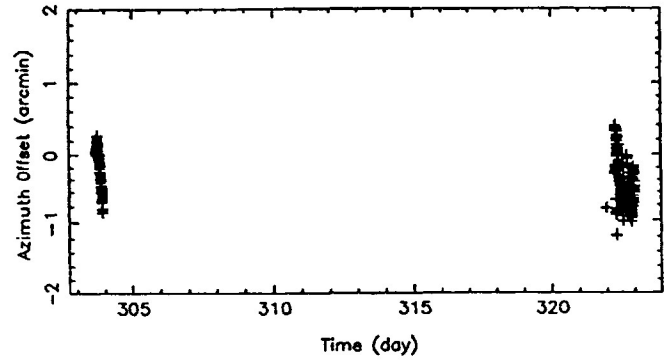
DISTRIBUTION OF POINTS



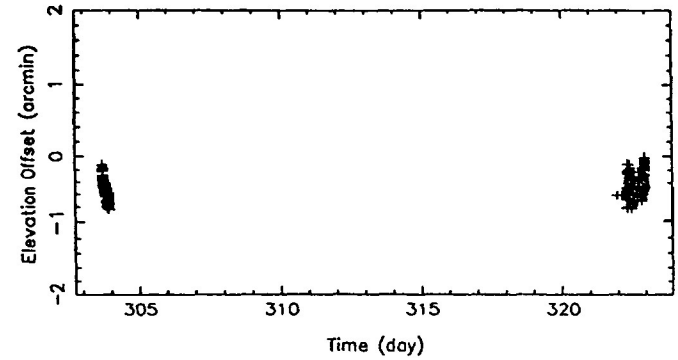
POINTING OFFSET vs ANTENNA TEMP

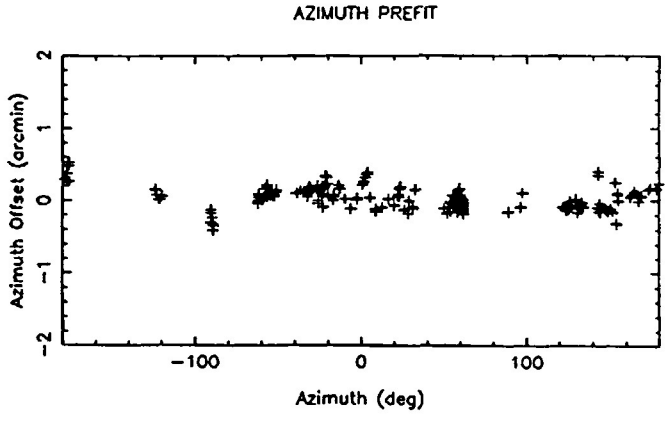


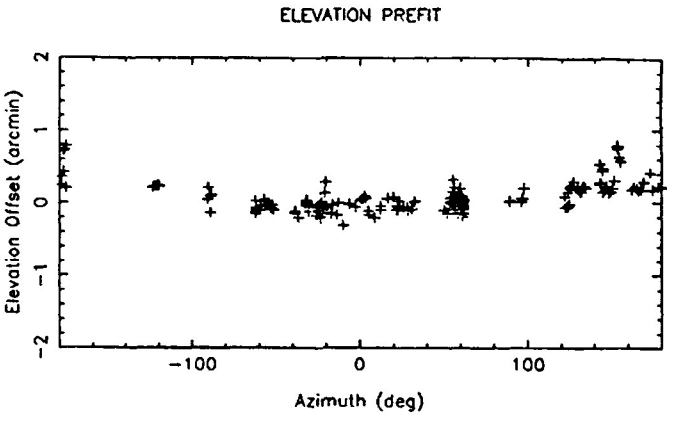
AZIMUTH PREFIT vs TIME

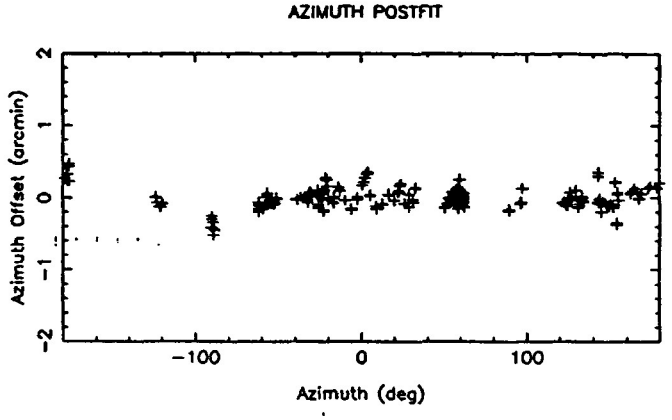


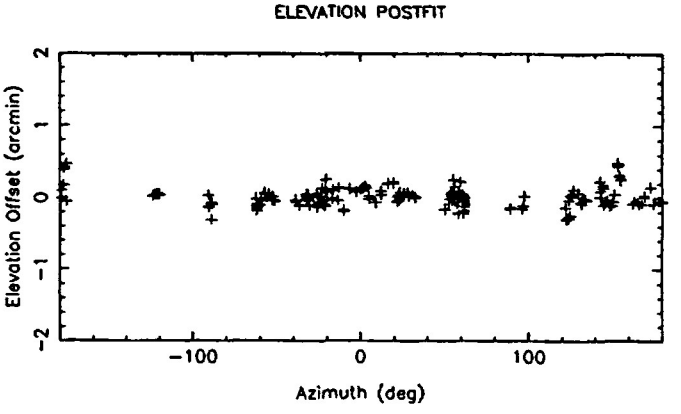
ELEVATION PREFIT vs TIME

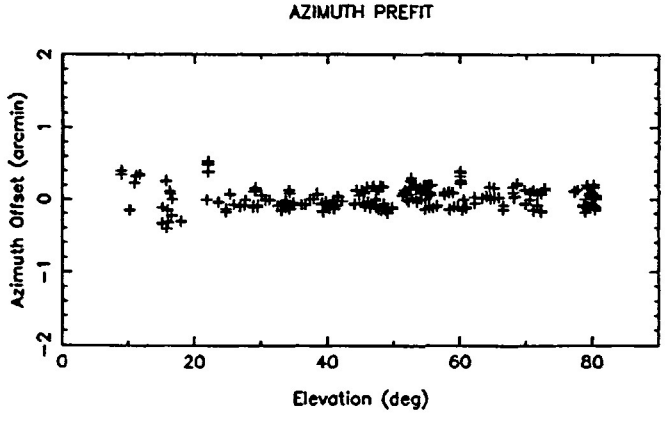


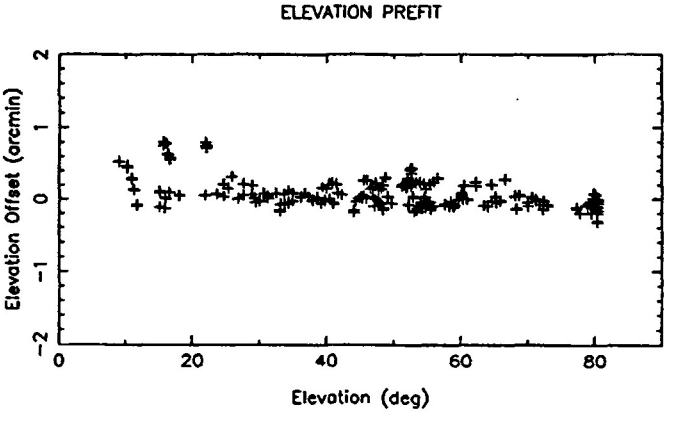

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

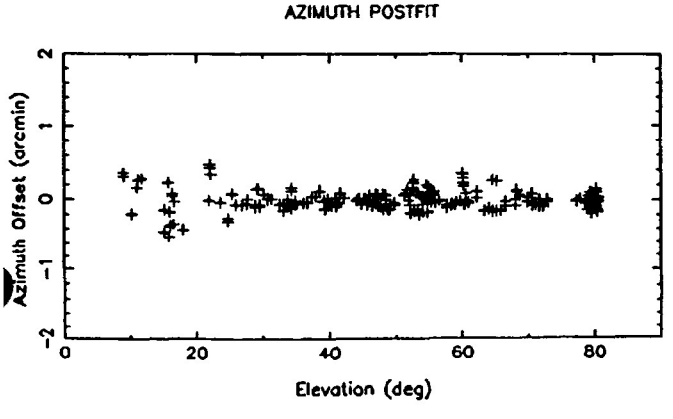

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)

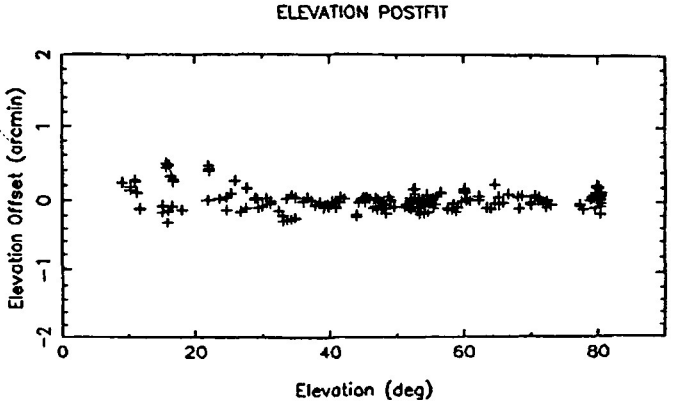

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)

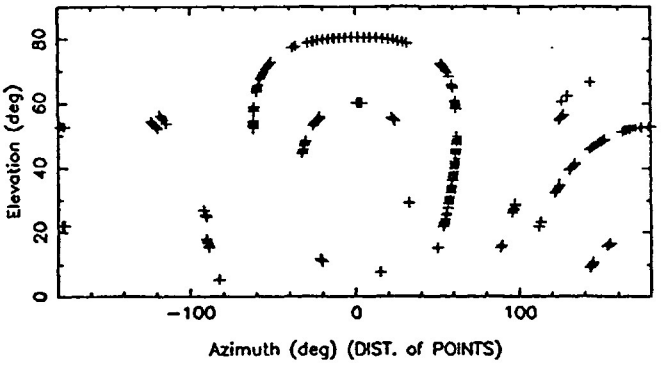

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)

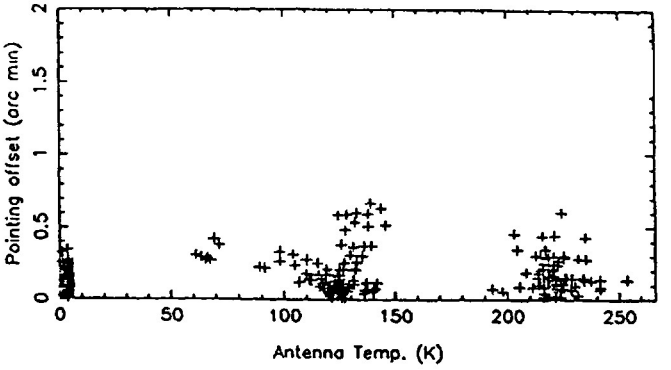

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

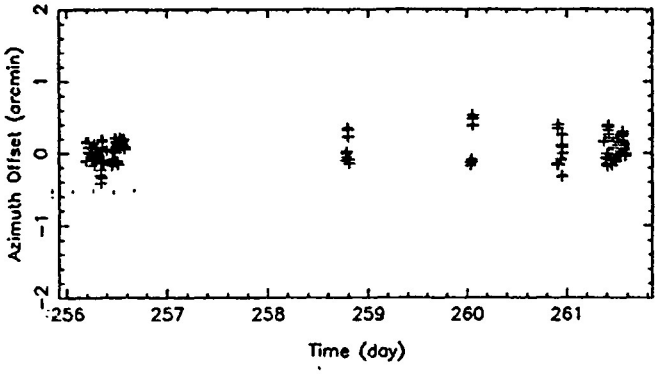
DISTRIBUTION OF POINTS



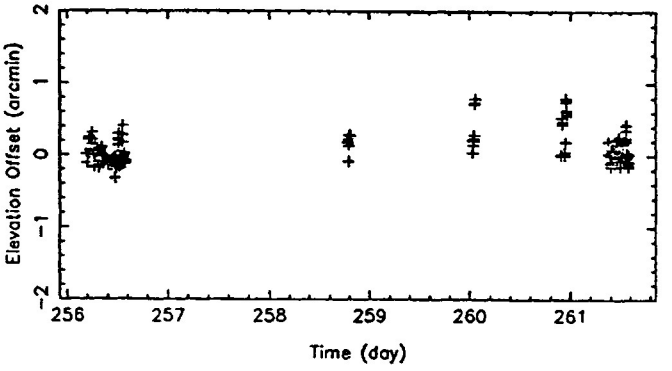
POINTING OFFSET vs ANTENNA TEMP



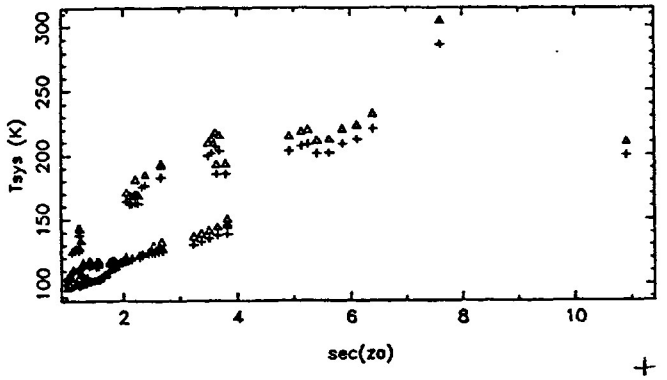
AZIMUTH PREFIT vs TIME



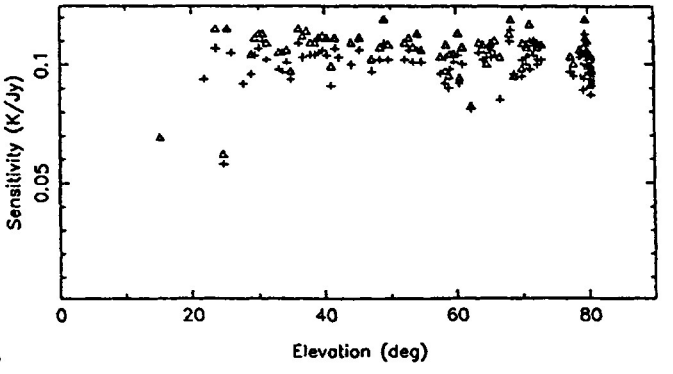
ELEVATION PREFIT vs TIME



SYSTEM TEMP vs SEC(Z)

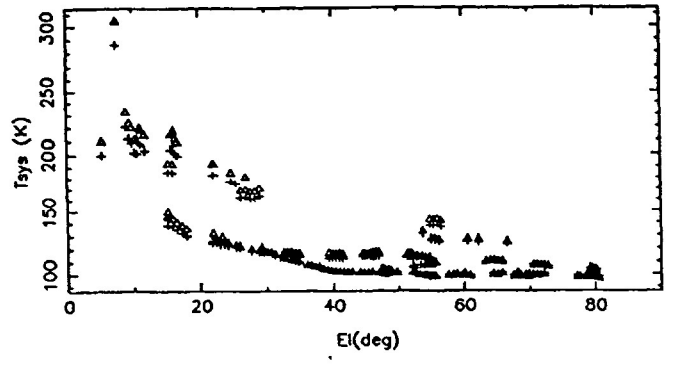


Tant / Assumed Flux (Calibrators)

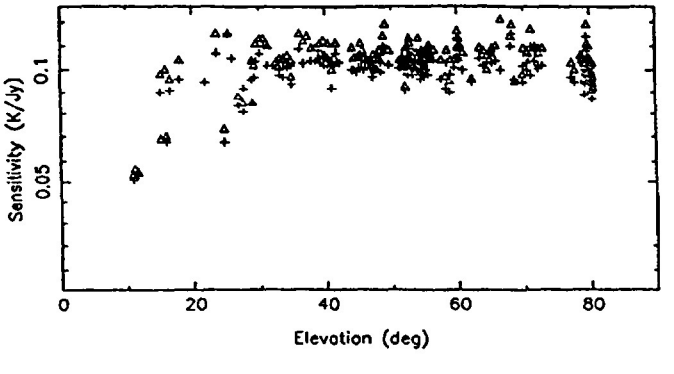


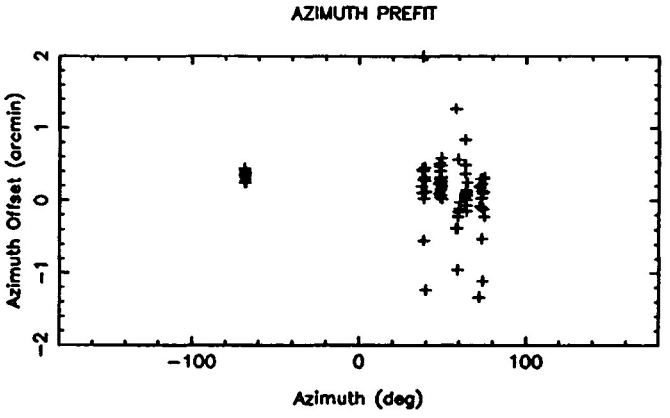
+ RCP
△ LCP

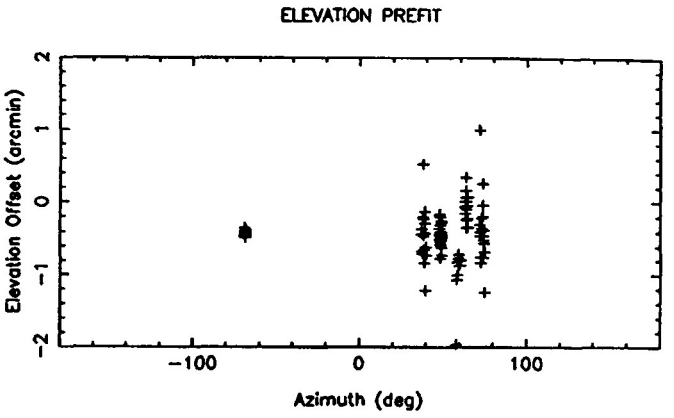
SYSTEM TEMP vs ELEVATION

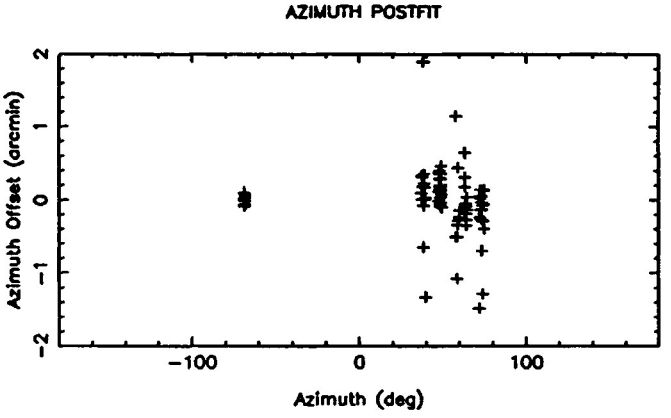


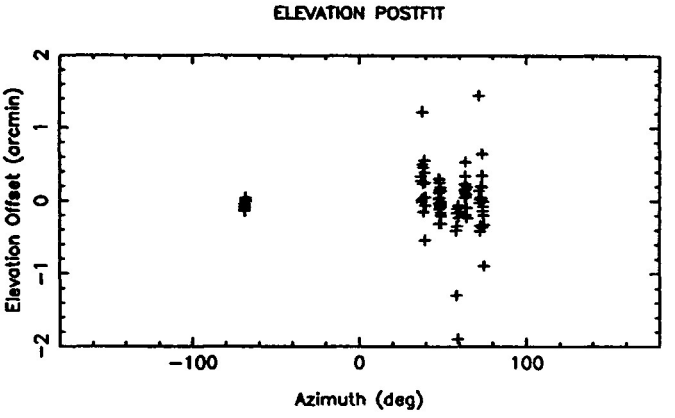
Tant / Measured Flux (All Sources)

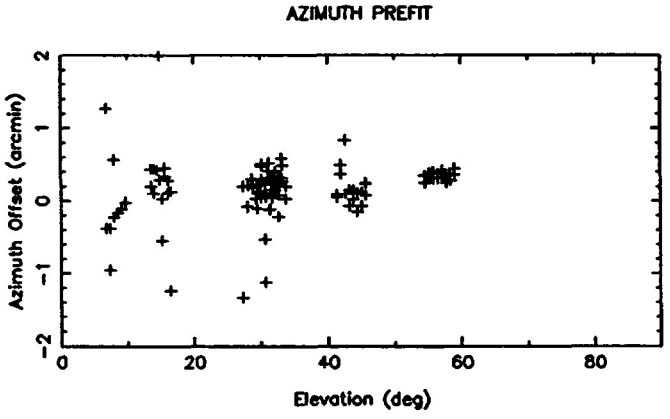


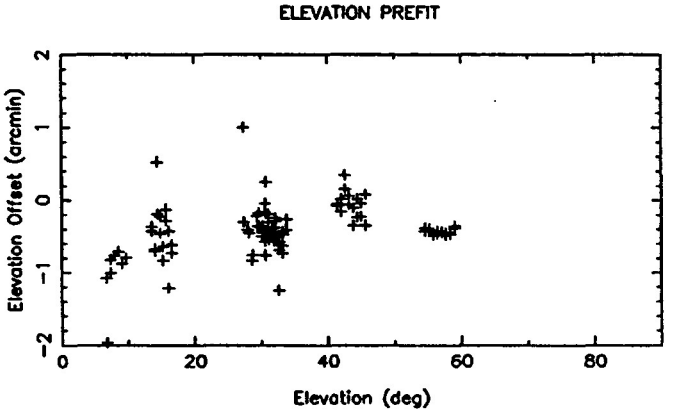

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

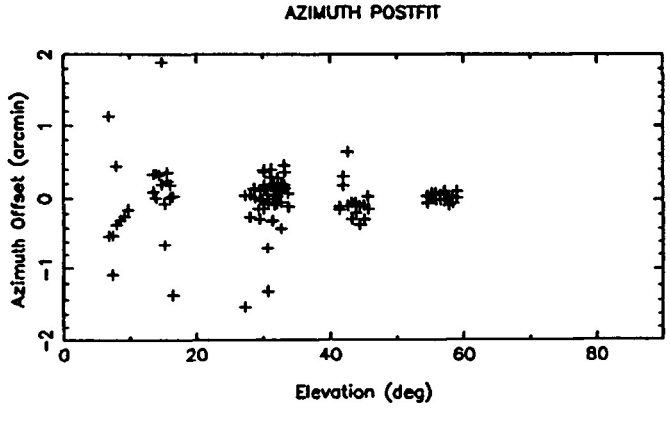

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)

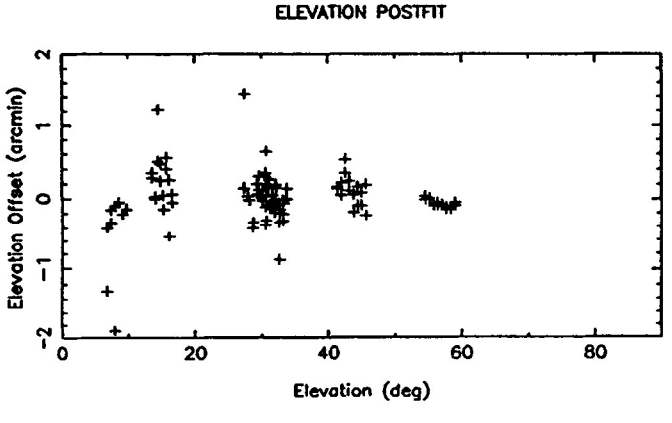

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)

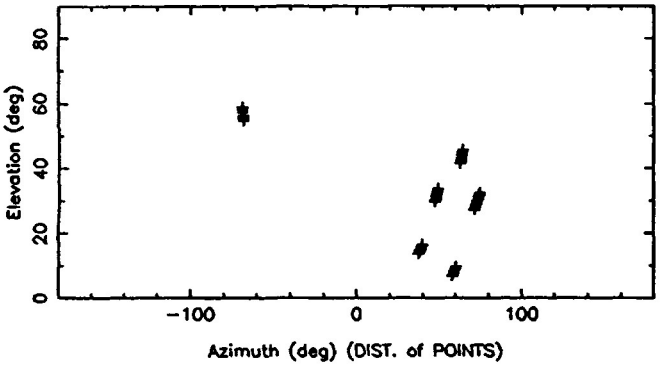

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)

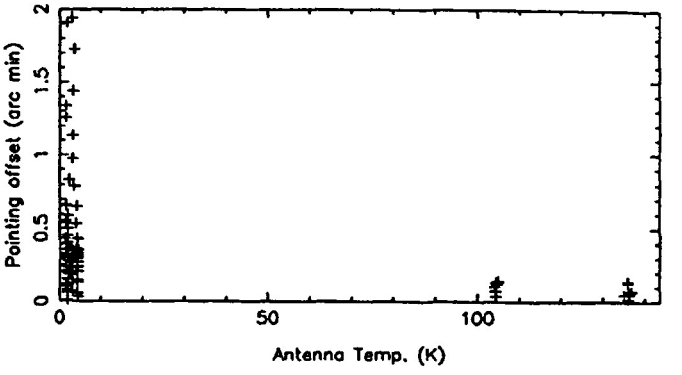

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

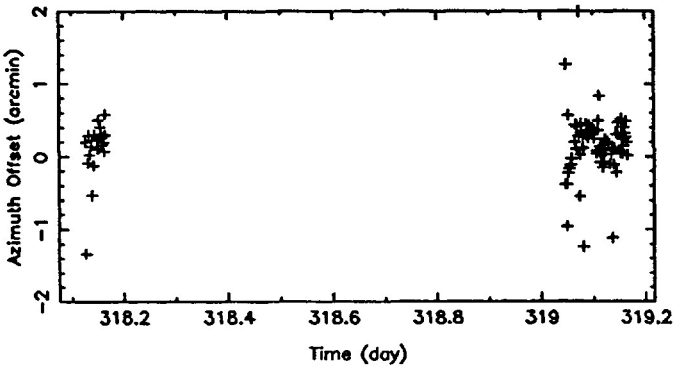
DISTRIBUTION OF POINTS



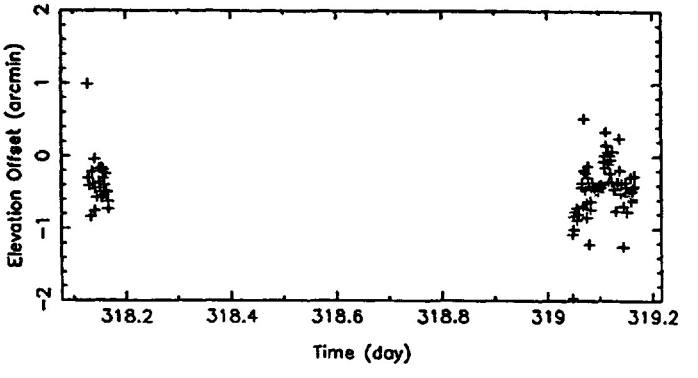
POINTING OFFSET vs ANTENNA TEMP



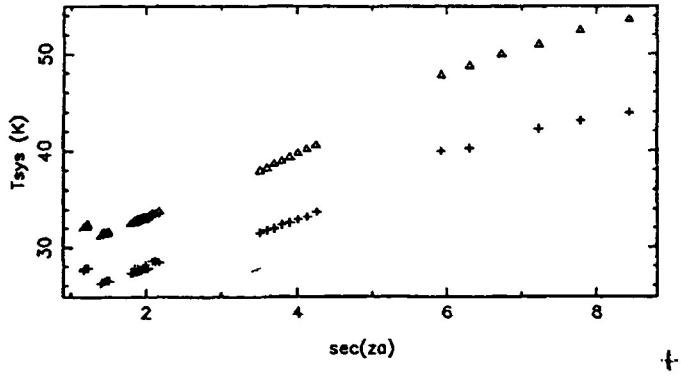
AZIMUTH PREFIT vs TIME



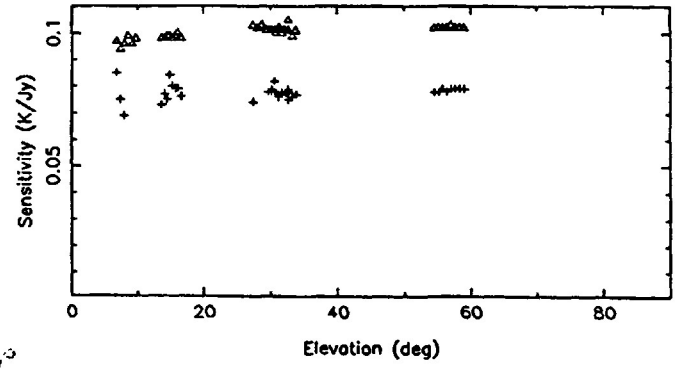
ELEVATION PREFIT vs TIME



SYSTEM TEMP vs SEC(Z)

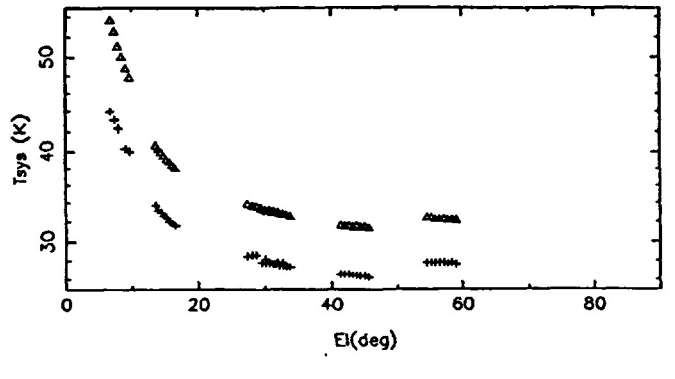


Tant / Assumed Flux (Calibrators)

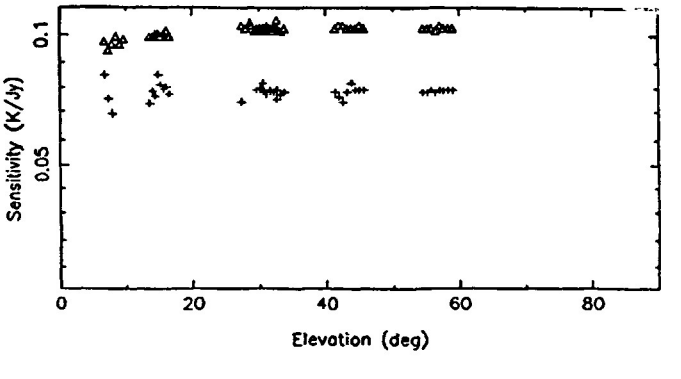


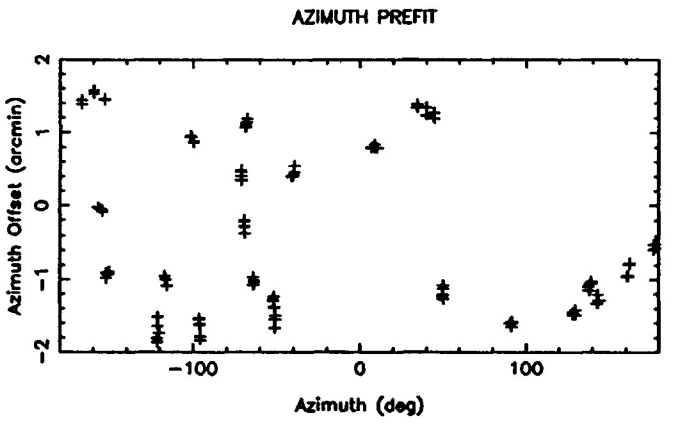
+ RCP
△ LCP

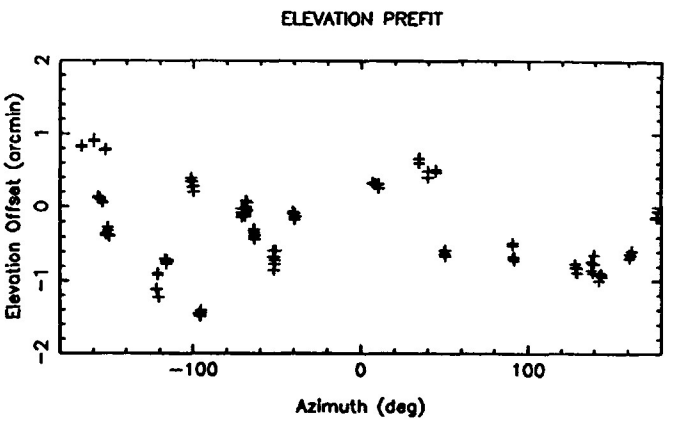
SYSTEM TEMP vs ELEVATION

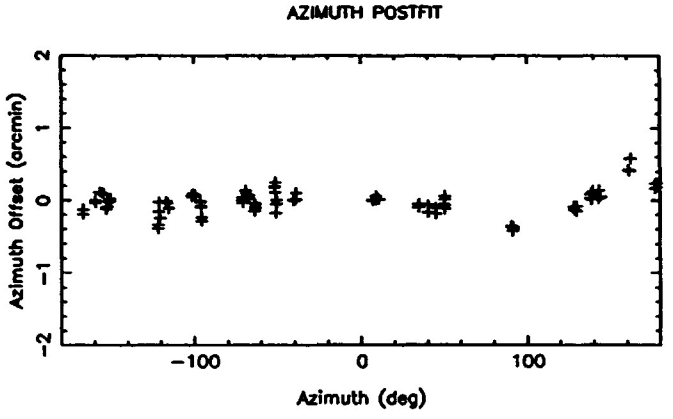


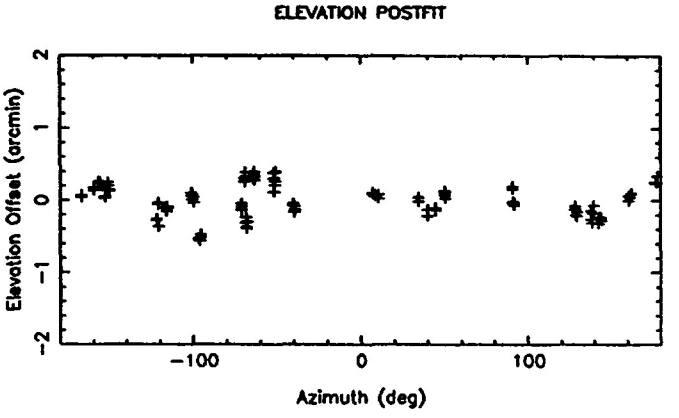
Tant / Measured Flux (All Sources)

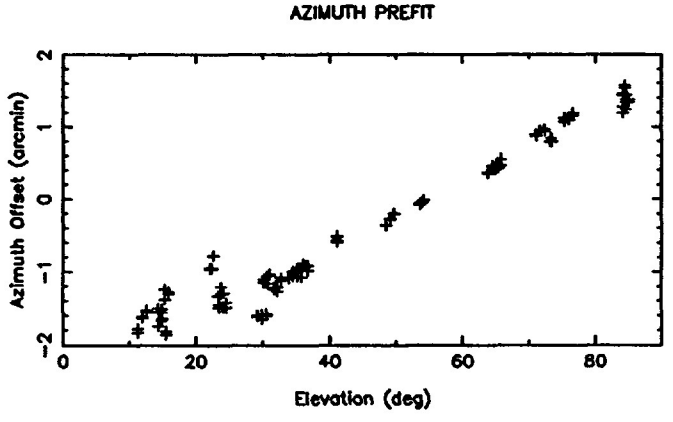


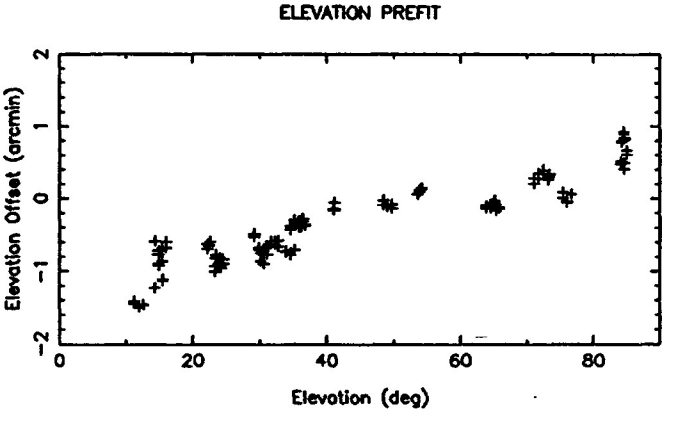

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

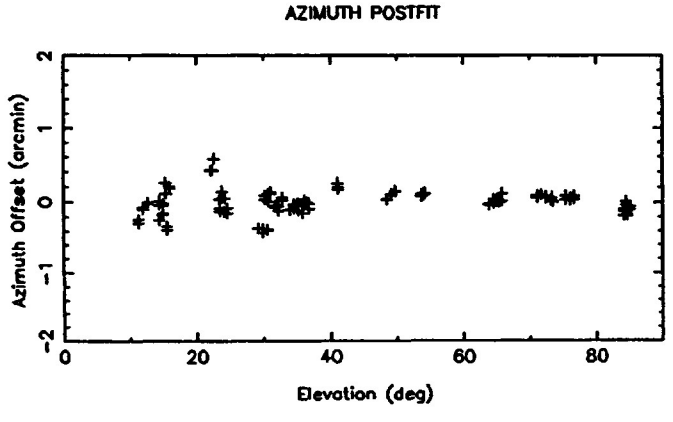

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)


AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)


AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)


ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)


AZIMUTH POSTFIT
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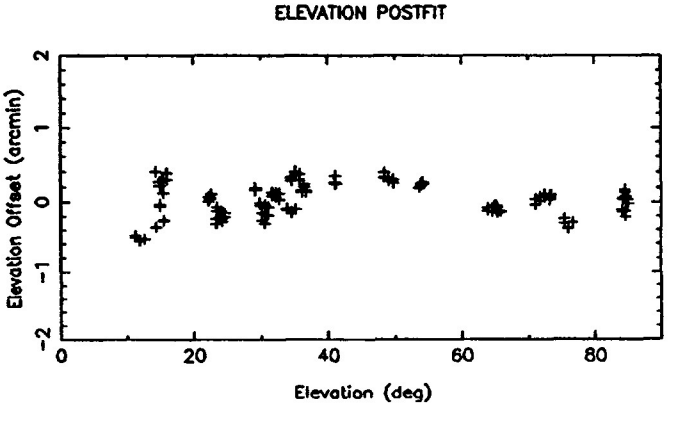
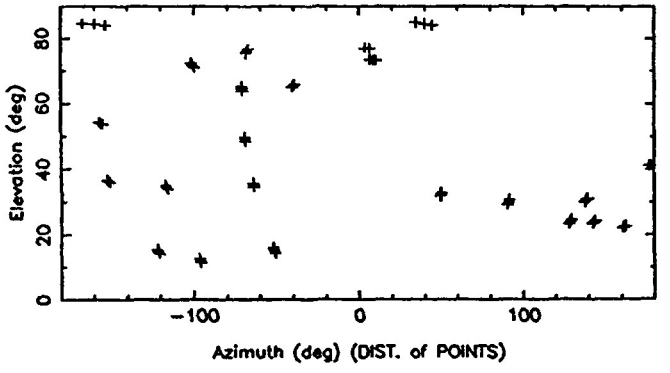
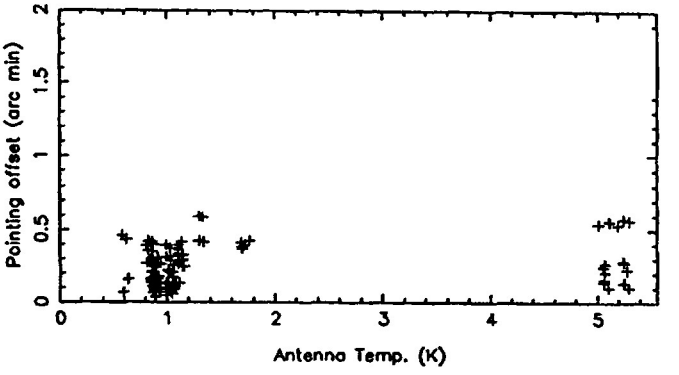
Elevation (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

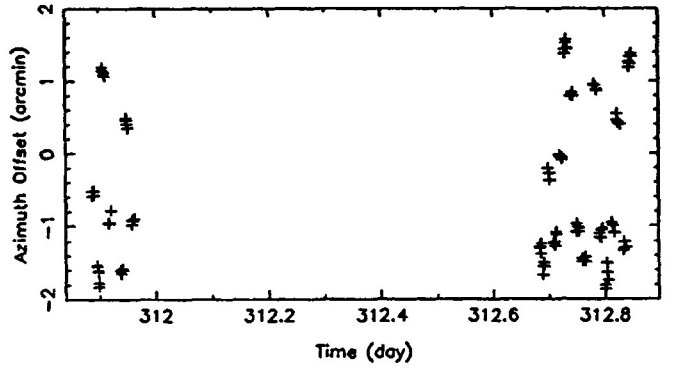
DISTRIBUTION OF POINTS



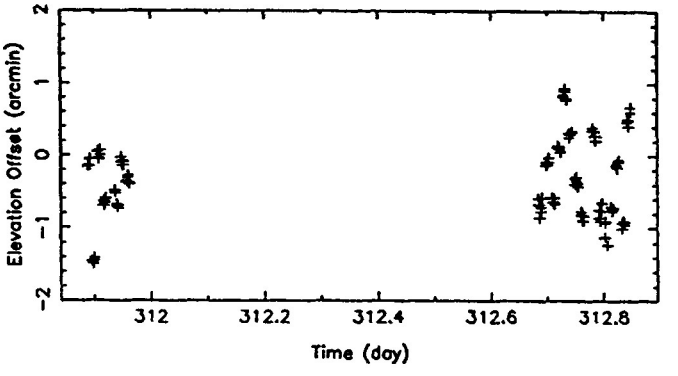
POINTING OFFSET vs ANTENNA TEMP



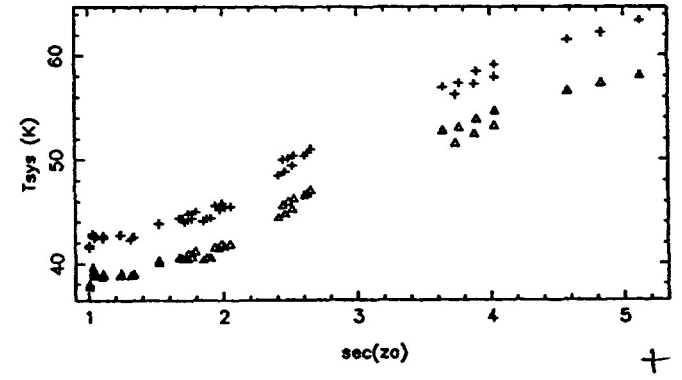
AZIMUTH PREFIT vs TIME



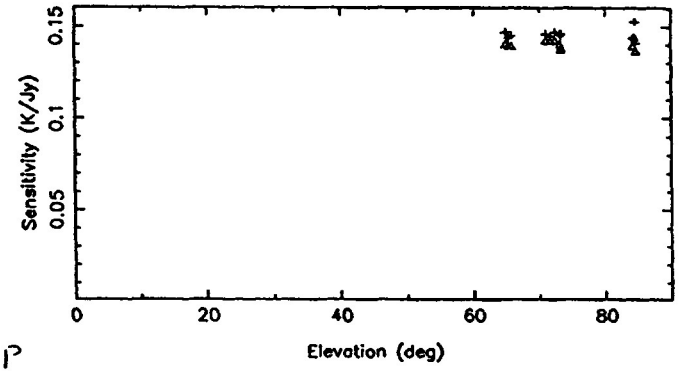
ELEVATION PREFIT vs TIME



SYSTEM TEMP vs SEC(Z)

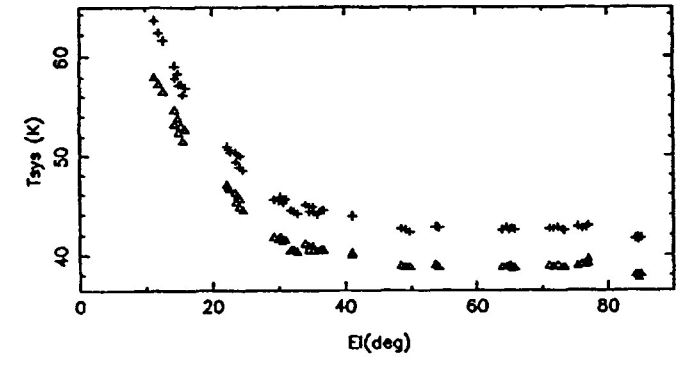


Tant / Assumed Flux (Calibrators)

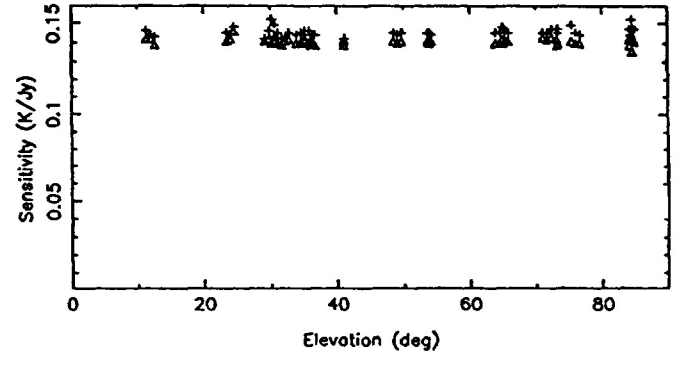


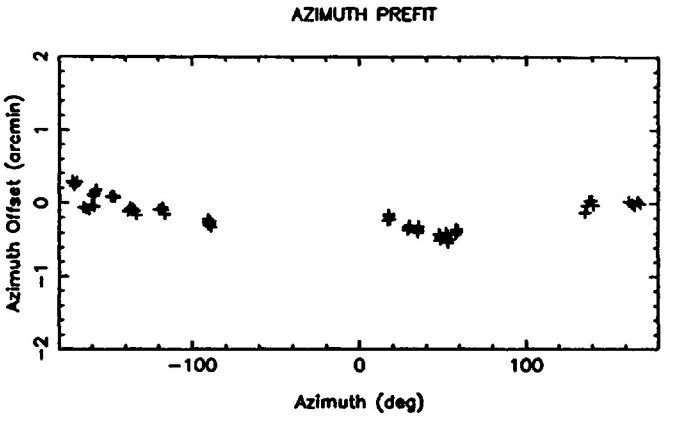
+ RCP
Δ LCP

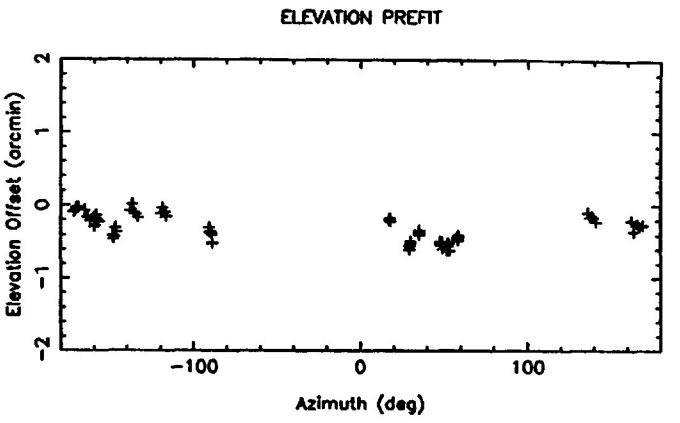
SYSTEM TEMP vs ELEVATION

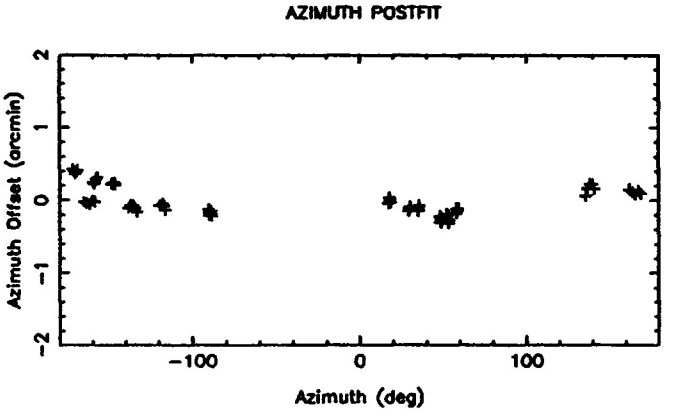


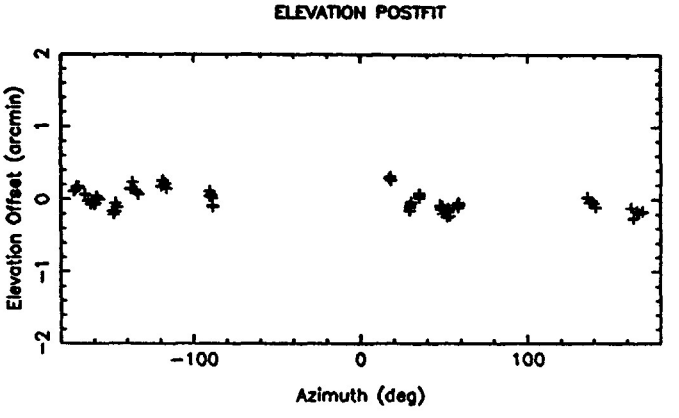
Tant / Measured Flux (All Sources)

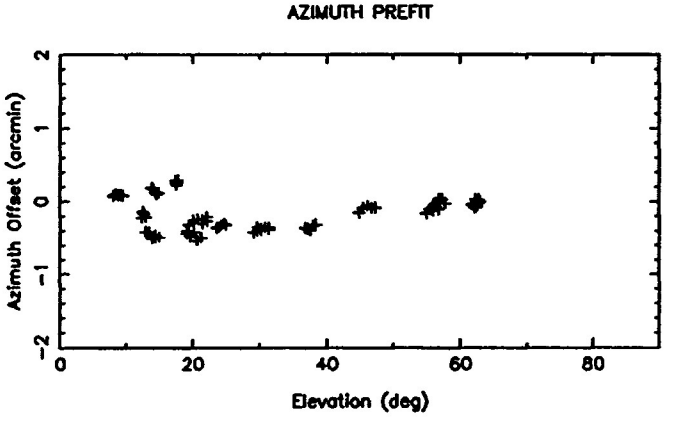


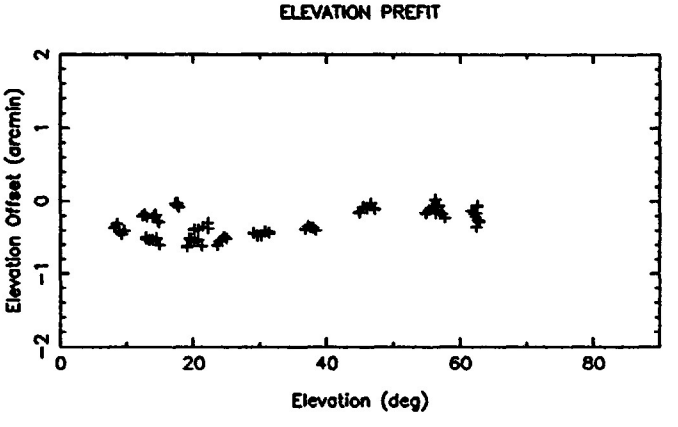

AZIMUTH PREFIT
Azimuth Offset (arcmin)
Azimuth (deg)

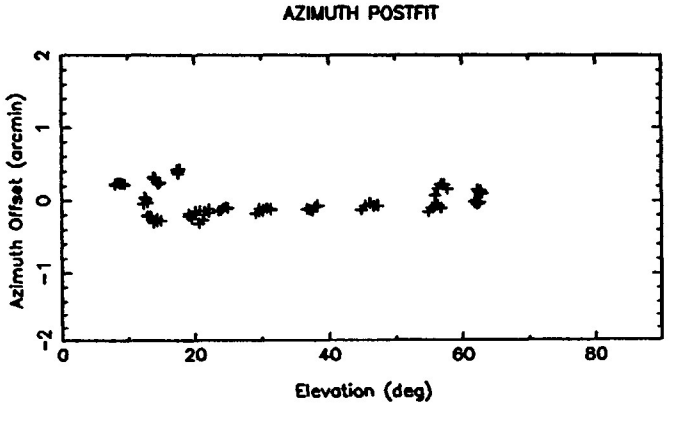

ELEVATION PREFIT
Elevation Offset (arcmin)
Azimuth (deg)

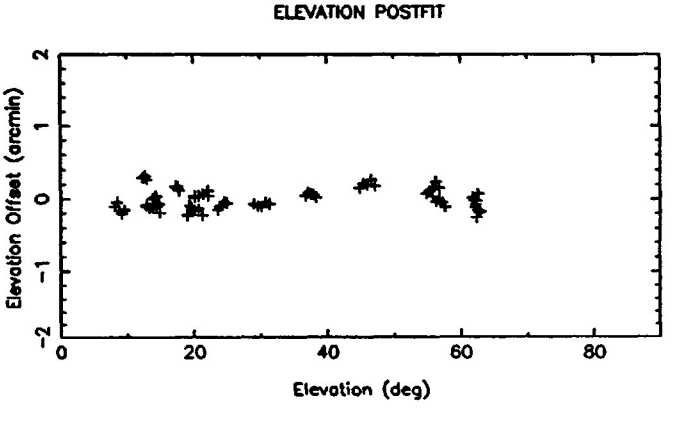

AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Azimuth (deg)


ELEVATION POSTFIT
Elevation Offset (arcmin)
Azimuth (deg)


AZIMUTH PREFIT
Azimuth Offset (arcmin)
Elevation (deg)

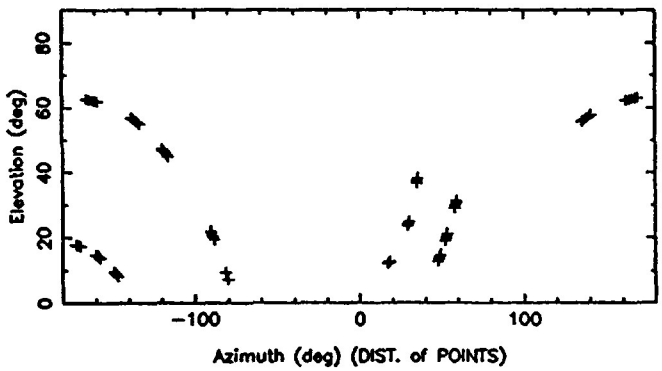

ELEVATION PREFIT
Elevation Offset (arcmin)
Elevation (deg)


AZIMUTH POSTFIT
Azimuth Offset (arcmin)
Elevation (deg)

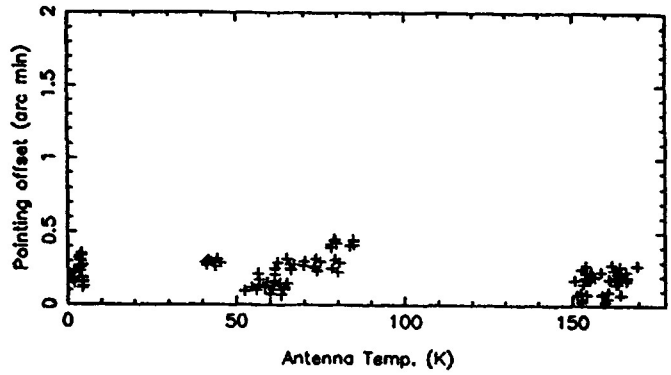

ELEVATION POSTFIT
Elevation Offset (arcmin)
Elevation (deg)

+ RCP
Δ LCP

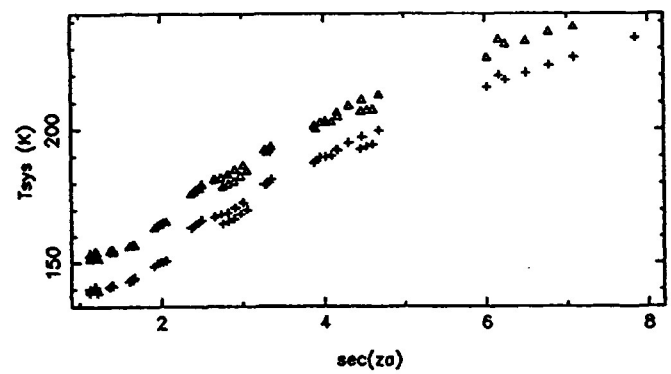
DISTRIBUTION OF POINTS



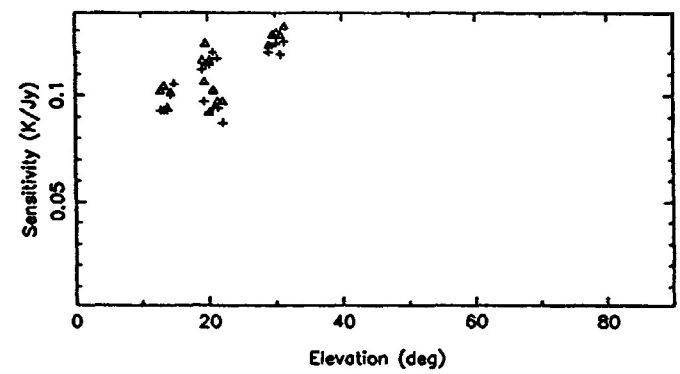
POINTING OFFSET vs ANTENNA TEMP



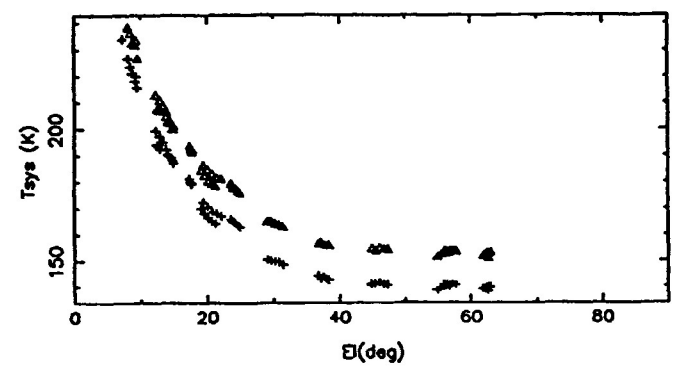
SYSTEM TEMP vs SEC(Z)



Tant / Assumed Flux (Calibrators)



SYSTEM TEMP vs ELEVATION



Tant / Measured Flux (All Sources)