Polarization Stability of the BIMA Array at 1.3mm

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ABSTRACT

We summarize measurements of linear polarization leakage terms made with the BIMA array at 1.3 mm over a 2 year period beginning in 2000. The individual antenna leakage terms show a median rms of 1.5% over this period. If these errors are stochastic, then the error in measured polarization is 0.5%. There is no apparent change in the leakage terms with time. The occurrence of the occasional bad calibration solution argues for the use of a mean set of leakage terms rather than frequent recalibration. There is no apparent reason to calibrate more frequently than once per array. The polarization fraction and position angle measured for 3C 279 agrees with that found at 86 GHz with BIMA and with that found at 22 and 43 GHz with the VLA.

1. Introduction

Polarization calibration requires measurement of leakage terms. These terms give the contamination of one hand of polarization by the other orthogonal hand. This calibration must be performed on a strong source over a wide range of parallactic angle. (If the source is unpolarized or the polarization is known, then parallactic angle coverage is unnecessary). Typically, observations are made of 3C 273 and 3C 279 over a four hour period.

Since 1.3 mm observing conditions are rare at BIMA, it is important that calibration not be performed more frequently than necessary. We investigate the stability of measured leakage terms at 1.3 mm in this memo.

2. Observations and Analysis

We collected past 230 GHz polarization calibration data from 11 May 2000 to 28 February 2002. These data were obtained and reduced in a variety of methods. In all cases, the observations were obtained in a switched polarization mode with LL, RR, RL and LR correlations. Typical reduction methods include a 5 to 20 minute self calibration, a 5 to 20 minute uv average and polarization calibration with gpcal.

We plot the leakage terms in Figures 1-4. The real and imaginary terms are plotted separately for the X→Y and Y→X terms. The plots are given for the lower sideband (227 GHz) and upper sideband (230 GHz). The first epoch is clearly discrepant from the others. An rms is computed for each complex leakage, excluding the first epoch. For all but antennas 1 and 4, the rms is $< 1.7\%$. For the two other antennas, the rms is dominated by an epoch with a deviant solution. There is no apparent trend to the solutions. And there is no apparent tendency for the solutions to agree better on short rather than long timescales. Since these errors in leakage solution are stochastic, then the typical error in polarization will be $\sim 0.5\%$.

The dotted lines in the plots indicate maintenance activity with the receivers and the dewars (see Table 1, R. Plambeck, private communication). This includes removal of the receivers for the Summer shutdown. There is no apparent correlation between maintenance and changes in the solutions with the possible exception of the first to second epoch change.

We tabulate the mean leakage solutions at 227 and 230 GHz, excluding epoch 1 (Tables 2 and 3). We show that these leakage solutions differ only slightly in Figure 5.

We plot in Figure 6 the measured polarization for 3C 279 obtained from the solution for each data set. We also include 86 GHz data obtained with BIMA and 22 and 43 GHz data obtained with the VLA (Taylor & Myers 2000). The polarization fraction appears to agree very well. The 86 and 230 GHz position angle also appear to be in agreement. There is a $\sim$ 10 degree offset between the BIMA and VLA position angles. Whether this is a calibration error or source physics is unknown.

3. References

Taylor, G.B. & Myers, S., 2000, VLBA Sci. Memo #26

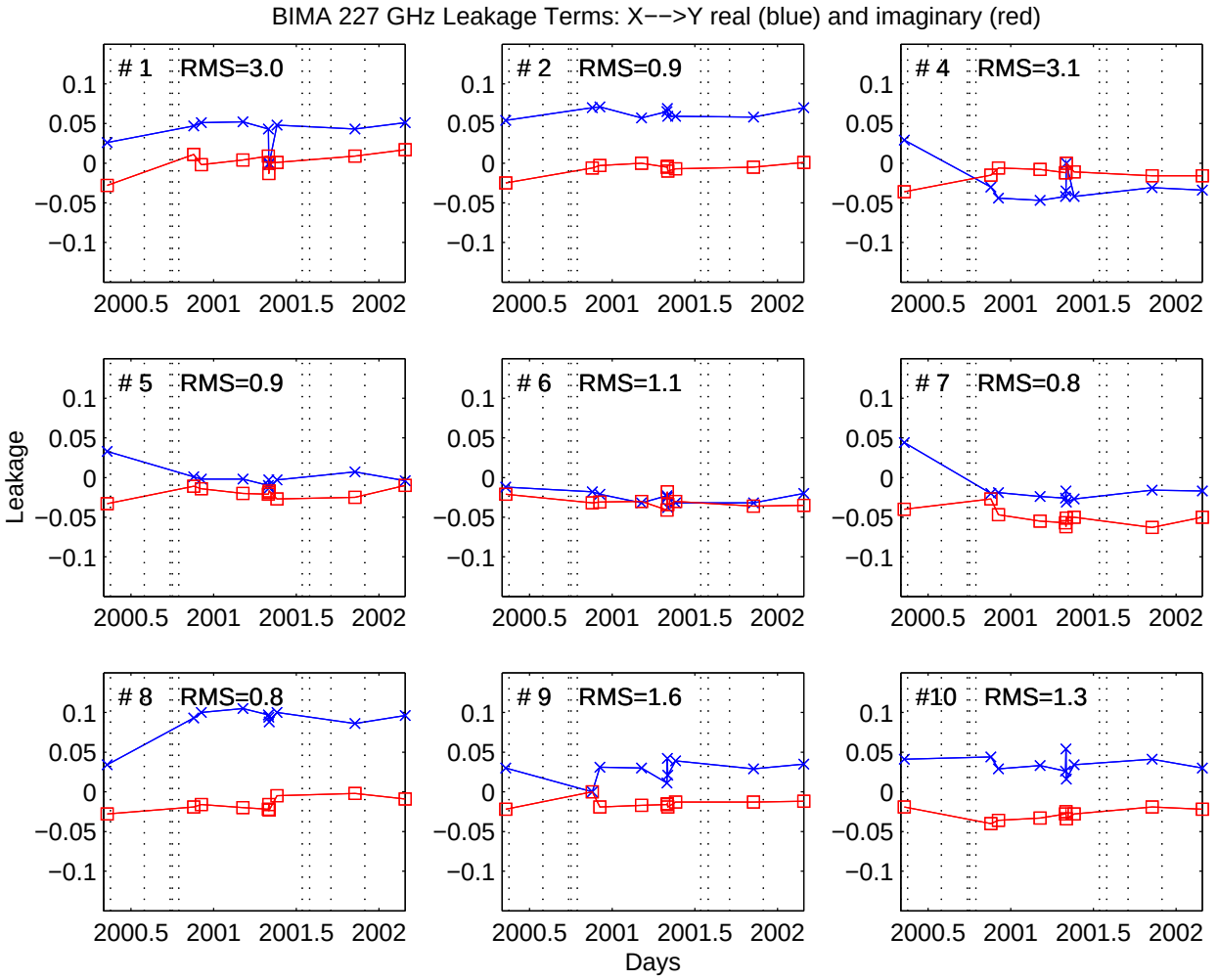

Fig. 1.— Leakage terms determined for BIMA antennas for X→Y at 227 GHz (LSB).

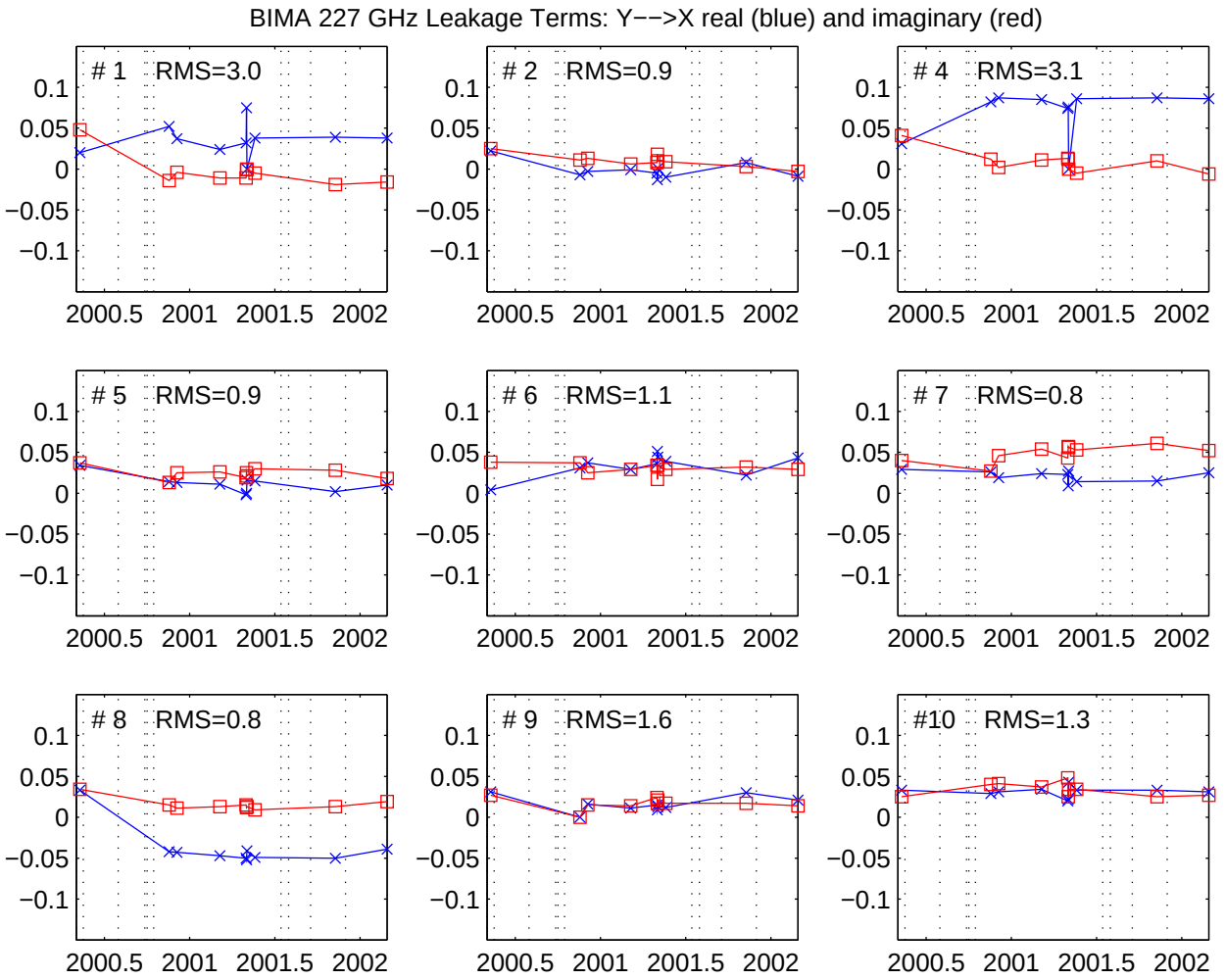

Fig. 2.— Leakage terms determined for BIMA antennas for Y→X at 227 GHz (LSB).

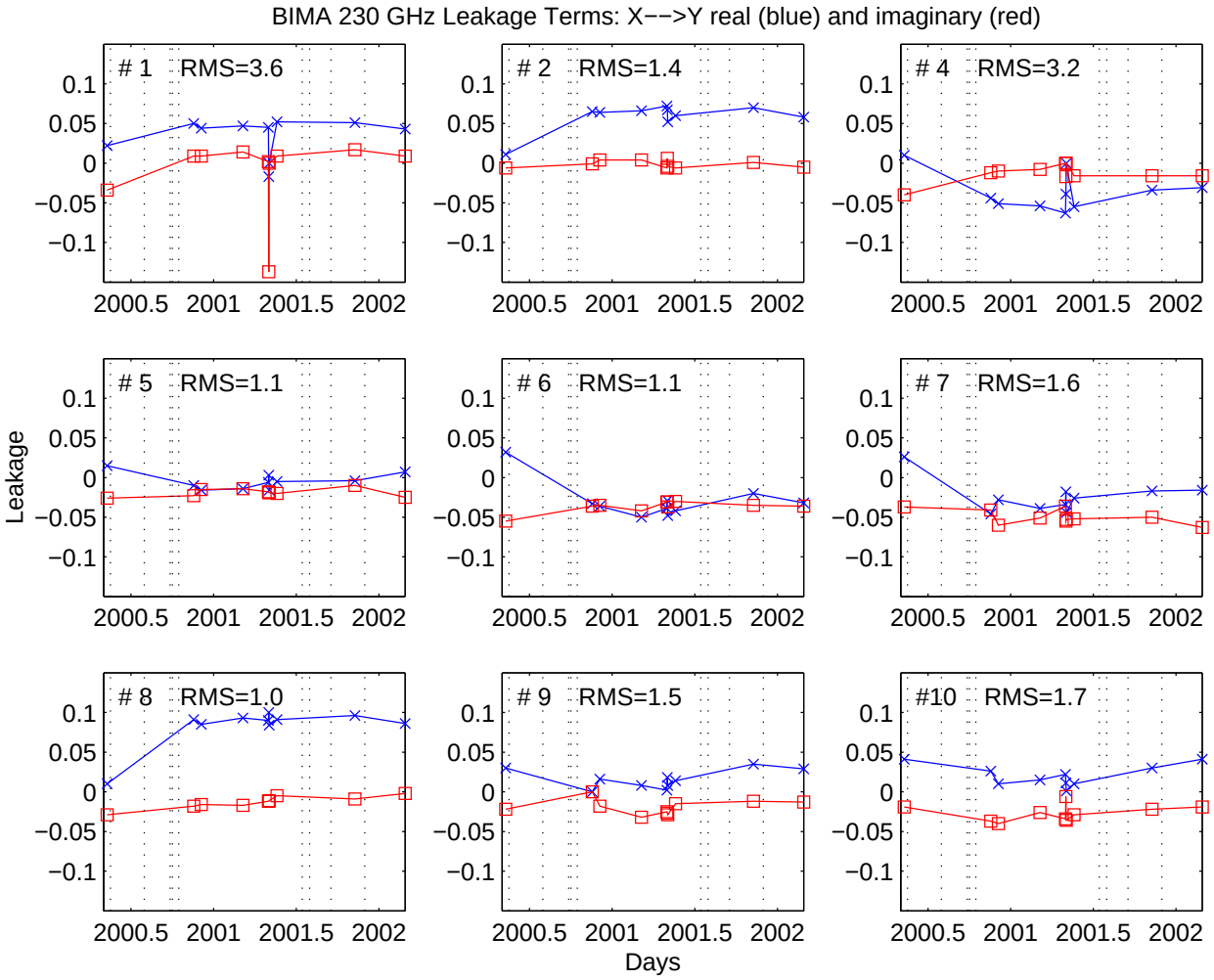

Fig. 3.— Leakage terms determined for BIMA antennas for X→Y at 230 GHz (USB).

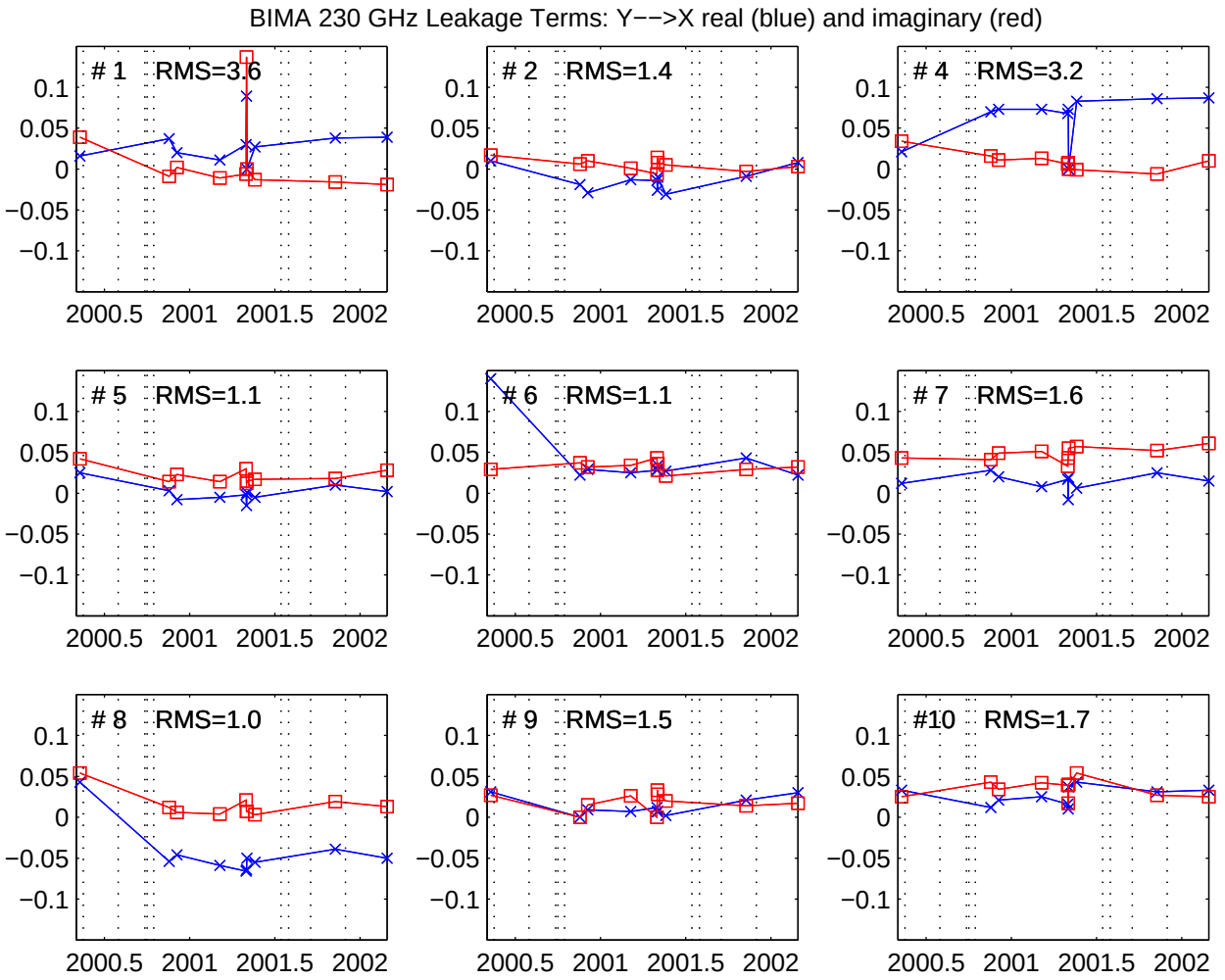

Fig. 4.— Leakage terms determined for BIMA antennas for Y→X at 230 GHz (USB).

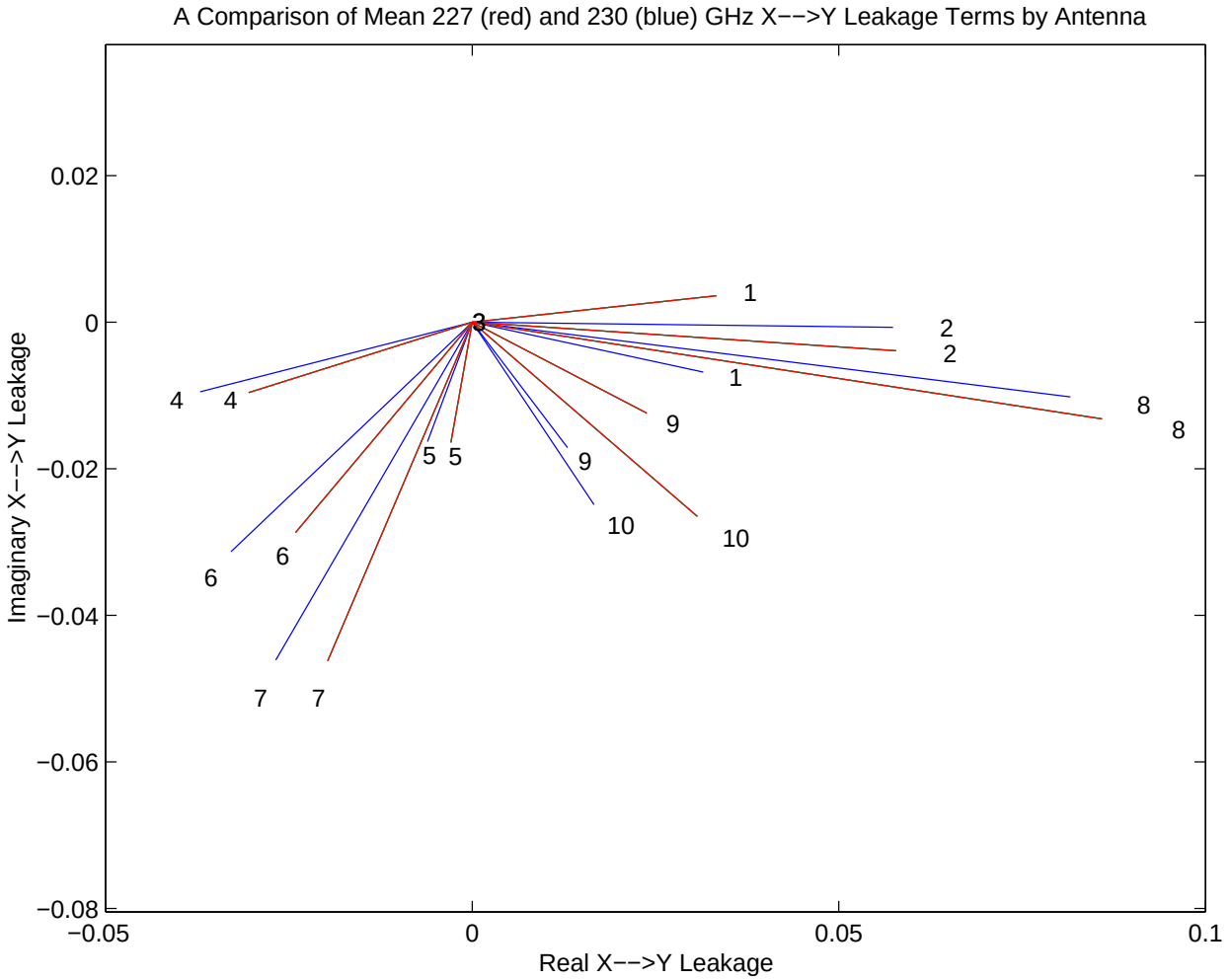

Fig. 5.— A comparison of mean 227 (red) and 230 (blue) GHz X→Y leakage terms by antenna.

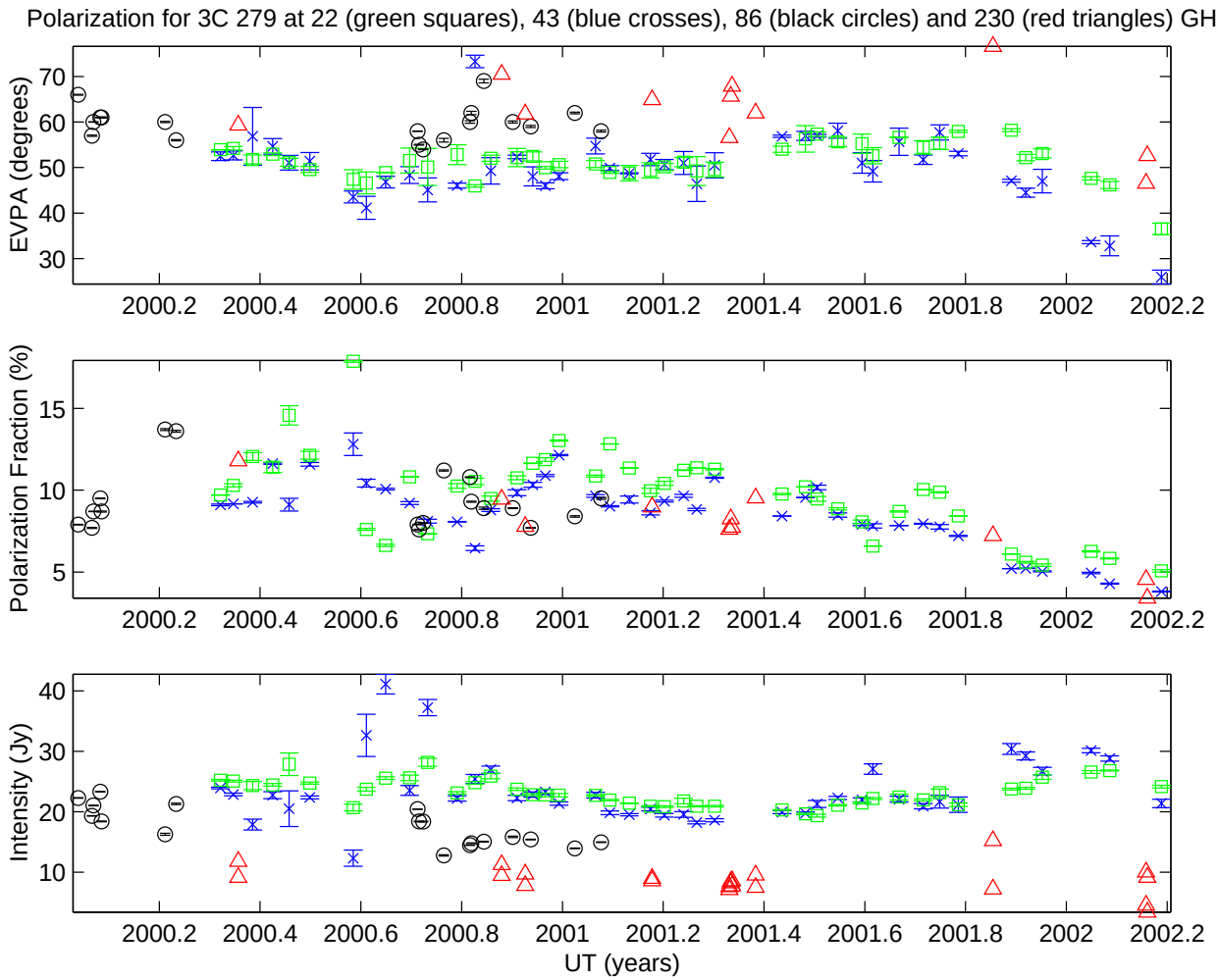

Fig. 6.— Lightcurves of the linear polarization at 86 and 230 GHz (black circles and red triangles, respectively) as measured by BIMA and at 22 and 43 GHz (green squares and blue crosses, respectively) as measured by the VLA. The upper panel shows the electric vector position angle. The middle panel shows the polarization fraction. The lower panel shows the total intensity.

Table 1. Dewar Changes: 2000, 2001, 2002

Date	Antennas	Action
		2000
03 May	6	opened up dewar 12 to replace wiring; probably did not change position of mixer blocks
04 May	5	removed dewar 8 (bad 1mm mixer), installed dewar 14
18 May	3	Mark opened dewar to replace HEMT amplifier
01 Aug	*	installed cm receivers
27 Sep	3	opened dewar to install repaired Schottky mixer
02 Oct	*	reinstall mm receivers
16 Oct	3	opened dewar; removed HEMT #8, installed HEMT #22
01 Dec	1	removed dewar 4 (bad 1mm mixer), installed dewar 8
		2001
16 Jul	*	install cm receivers
Aug	6	opened dewar 4 to install new wiring; probably did change mixer block orientation
17 Sep	*	reinstall mm receivers
		2002
		no dewar changes so far

Table 2. Mean Leakage Term Solutions: 227 GHz

Antenna	X→Y Real	X→Y Imag.	Y→X Real	Y→X Imag.
1	0.037	0.004	0.037	-0.009
2	0.064	-0.004	-0.004	0.008
4	-0.034	-0.011	0.074	0.005
5	-0.003	-0.018	0.009	0.023
6	-0.027	-0.032	0.037	0.030
7	-0.022	-0.051	0.020	0.050
8	0.095	-0.015	-0.046	0.013
9	0.026	-0.014	0.014	0.015
10	0.034	-0.029	0.031	0.035

Table 3. Mean Leakage Term Solutions: 230 GHz

Antenna	X→Y Real	X→Y Imag.	Y→X Real	Y→X Imag.
1	0.035	-0.008	0.032	0.007
2	0.064	-0.001	-0.016	0.004
3	0.000	0.000	0.000	0.000
4	-0.041	-0.011	0.068	0.006
5	-0.007	-0.018	-0.002	0.019
6	-0.037	-0.035	0.029	0.032
7	-0.030	-0.051	0.014	0.049
8	0.091	-0.011	-0.054	0.010
9	0.014	-0.019	0.011	0.017
10	0.018	-0.028	0.025	0.036