NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO
VERY LARGE ARRAY PROJECT

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TEMPERATURE COEFFICIENTS OF A VERTEX ROOM (BEFORE MODIFICATIONS)

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1.0 INTRODUCTION

These results are based on an experiment conducted during the observing session of February 28, 1977. The vertex room temperature of Antenna 3 was varied by 12° C (p-p) while tracking a single calibrator, and the effects on visibilities and certain critical monitor points were noted. The observations were done entirely at 6 cm.

2.0 EQUIPMENT CONFIGURATION AND OBSERVING CONDITIONS

Table I lists the antennas in operation during the experiment, their locations, and the waveguide channels used. Electronics at all antennas, including the test antenna (No. 3), incorporated no major modifications from the original design. The experiment is intended to provide a basis of comparison.

The temperature control of Antenna 3's vertex room had long been the worst in the array, with changes of 5K being observed as a function of elevation. This could be caused by inadequate air flow. For the present experiment, this caused no trouble because large temperature changes were desired; the changes were kept smooth by tracking a single source near the meridian.

The experiment extended over a 6.5 hour period at night (20:00 to 02:30 local standard time). The weather was essentially clear (some high thin clouds during first four hours). The source

4C39.25 ($\delta=39^{o}$) was tracked from -3^{h} to $+3.5^{h}$. Elevation ranged from 49^{o} to 85^{o}. The observations were divided into 10-minute scans, with the transfer switch in all front ends being thrown on alternate scans.

The vertex room temperature was varied by simply changing the thermostat setting, using the extremes of its calibrated range (13 to 30 C). The thermostat operates a proportional-control heater. The refrigerative air conditioner, which is controlled by outside air temperature, should not have been in operation during the experiment (outside temperature range was +1 to -5 C). The vertex room temperature was monitored at two points: in the B-rack just above the L2 module, and in the A-rack inside the F5 module. The two measurements tracked very closely in time, although the A-rack temperature covered a wider range (see Figure 1). There was insufficient time for the vertex room to come completely to thermal equilibrium between thermostat setting changes, and this may affect the validity of the results which follow.

The observing frequency and L.O. frequencies are given in Table II. The 12 MHz bandwidth was used.

3.0 DATA REDUCTION

Temperature coefficients were calculated for various quantities of interest, some of which involved only monitor data and some of which required use of the visibility data. In all cases, only data taken at the times of maximum (38.1 C) and minimum (28.5 C) vertex room temperatures were used. Unless the temperature coefficient was nearly zero, these times also corresponded to extrema of the parameters being studied. In some cases, checks were made at other times to ensure that variations were reasonable; no evidence was found that the parameters are not monotonic in the temperature. The temperature measurements used were those from Rack B. For the visibility data, averages over the 10^{m} scans were used; only scans

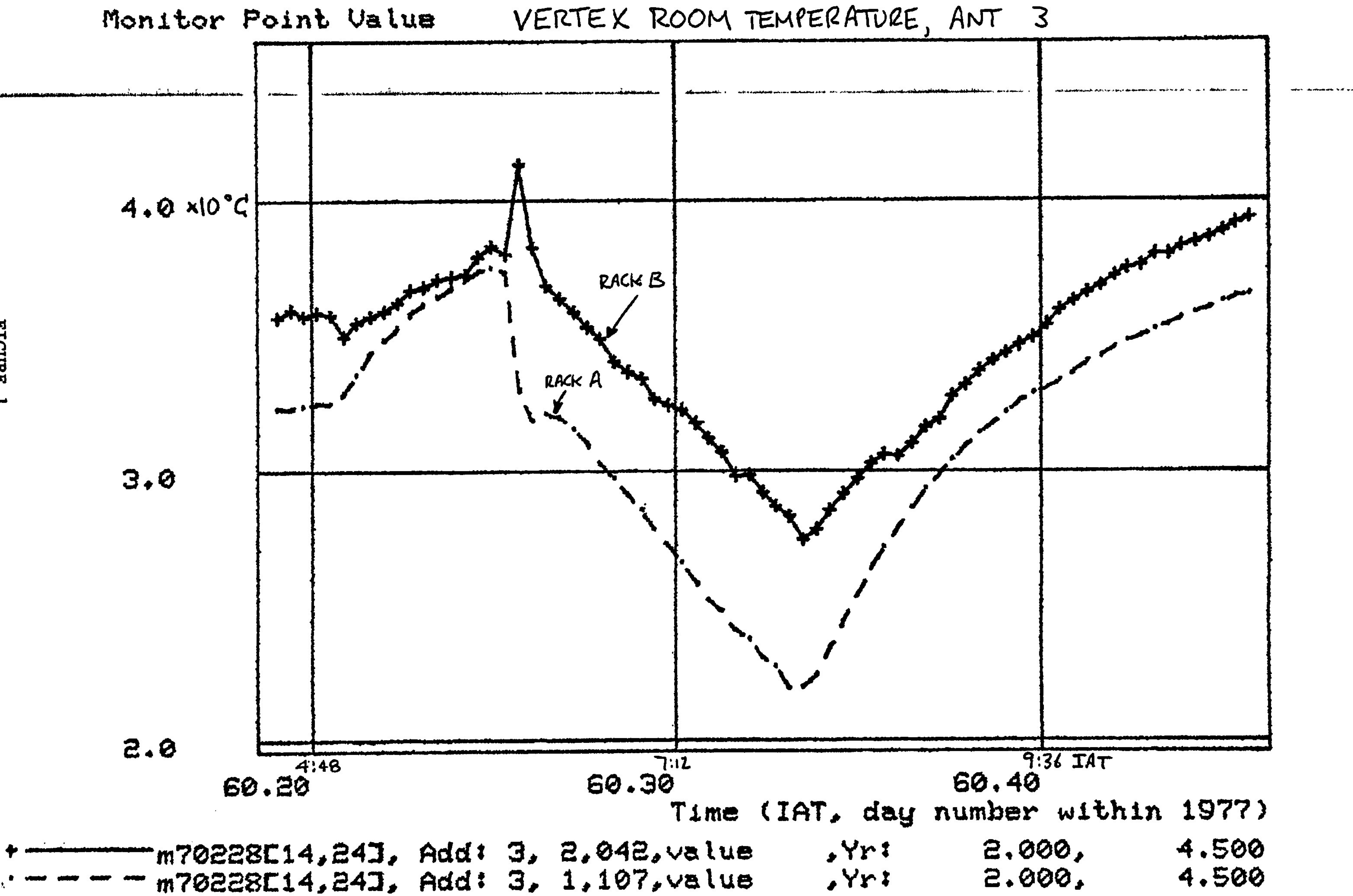

Monitor Point Value
VERTEX ROOM TEMPERATURE, ANT 3
4.0 x10°C
3.0
2.0
RACK B
RACK A
4:48
7:12
9:36 IAT
60.20
60.30
60.40
Time (IAT, day number within 1977)
+ ——— m70228[14,24], Add: 3, 2,042,value ,Yr: 2.000, 4.500
· — — — — m70228[14,24], Add: 3, 1,107,value ,Yr: 2.000, 4.500

FIGURE 1

TABLE I: ANTENNA CONFIGURATION

Antenna	Location	Waveguide Channel
1	DW8 484 m*	6
2	BW8 5223 m	7
3	DW3 90 m	4
4	CW8 1590 m	3
6	CW5 710 m	8

(Antenna 5 was down for retrofitting)

*Distance from array center

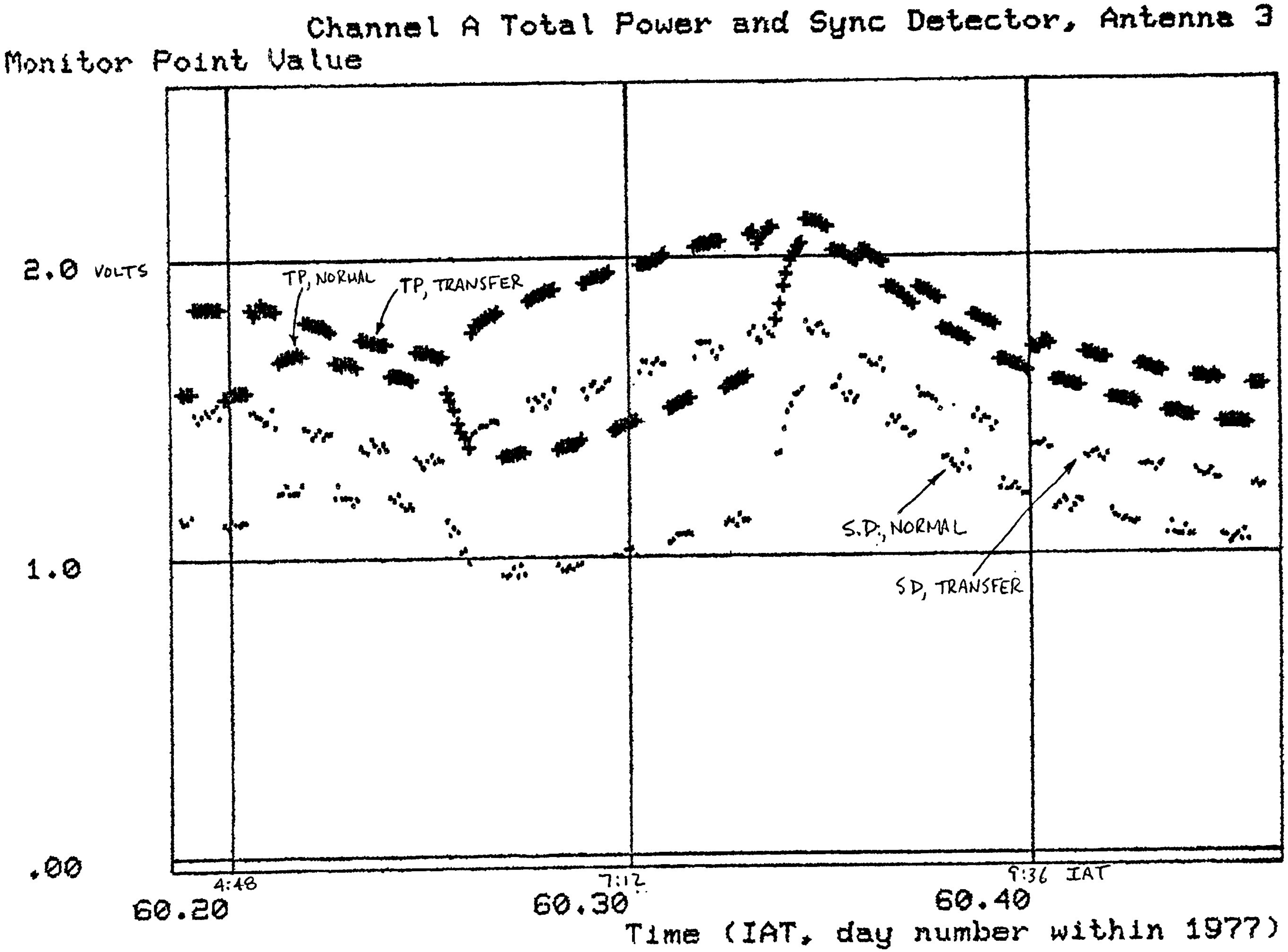
TABLE II: FREQUENCIES

2-4 GHz Synthesizer, Channel A	3260.1 MHz
2-4 GHz Synthesizer, Channel C	3010.1
Final IF center frequency, A=C	40
Center observing frequency, A=C	4600.1
Bandwidth	12

with the transfer switches in "normal" were used, although the "transferred" data closely parallels the "normal" and it is believed that all results would be the same if the former were used.

Reduction of the monitor data was straightforward. Temperature coefficients for the L.O. system's 5 MHz phase detector (in Rack B), the 600 MHz round-trip phase, the front end gains, and the front end system temperatures were derived (Table III). The front end data, being based on the square law detectors in the frequency converters, was first corrected for the d.c. offset of the detectors and data set. Peak errors were estimated from noise in the data samples and from data at temperatures other than the extremes. In the case of the front end gains, the coefficients were calculated several different ways and the errors are based on the consistency of the results. (The raw data is plotted in Figures 2 and 3.)

Reduction of the visibility data was more difficult, since antennas other than No. 3 were involved. Antenna 1 had two of three paramp stages bad on the AB side; Antenna 2 was excluded because of uncertainty about the long baseline; and all antennas were subject to significant phase variations due to waveguide path length changes during the experiment. However, the phase difference between the A and C channels was fairly well determined. To study the two channels separately, it was necessary to correct the phases on all available baselines for measured round-trip L.O. phase, and to apportion the remaining phase variation, seen on all baselines, among the various antennas. It became apparent that Antenna 1 was behaving badly on both channels ($\sim 100^0$ phase variation during the experiment), so it was excluded from further calculations. This left three antennas (3, 4, and 6) and three baselines. By assuming that most of the phase variation was in Antenna 3 (due to the temperature change), consistent results could be obtained for the phase of each IF of each antenna. The



+ m70228[14,24], Add: 3, 1,001,value ,Yr: .0, 2.500

[redacted]m70[redacted]8[[redacted],2[redacted], [redacted]dd: [redacted], [redacted]000[redacted]value ,Yr: .0, 2.500

FIGURE 2

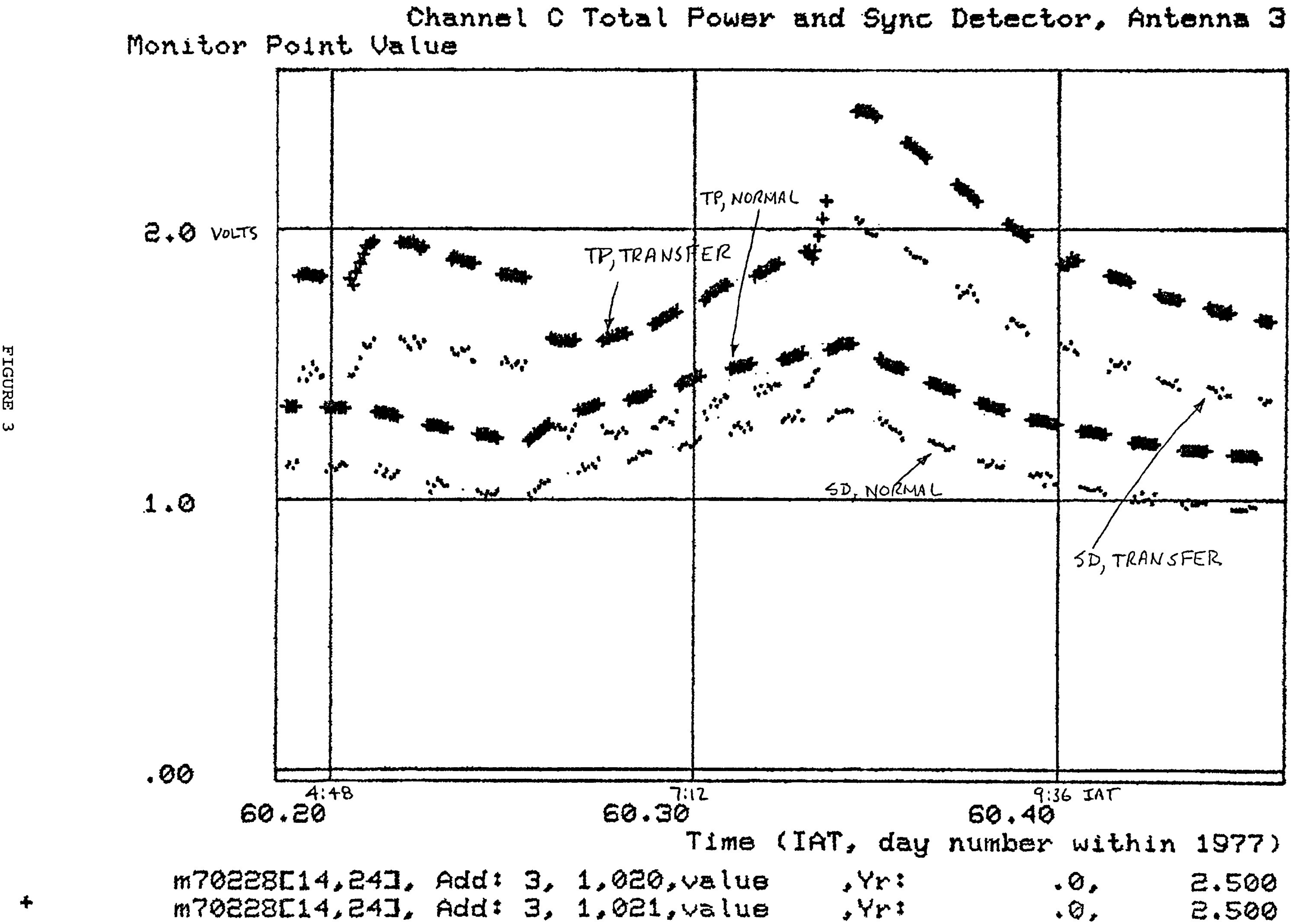

Channel C Total Power and Sync Detector, Antenna 3
Monitor Point Value
2.0 VOLTS
1.0
.00
TP, TRANSFER
TP, NORMAL
SD, NORMAL
SD, TRANSFER
4:48
7:12
9:36 IAT
60.20
60.30
60.40
Time (IAT, day number within 1977)
m70228[14,24], Add: 3, 1,020,value ,Yr: .0, 2.500
+ m70228[14,24], Add: 3, 1,021,value ,Yr: .0, 2.500

FIGURE 3

TABLE III: ANTENNA 3 VERTEX ROOM TEMPERATURE COEFFICIENTS

Measured over temperature range 28.5 to 38.1 C. Errors are estimated peak errors; see text for derivation.

		per °C	
5 MHz phase detector (VR)	$\Delta\phi_5$	0.12 ± .005	deg
600 MHz round-trip phase	$2\phi_{600}$	0.00 ± .25	deg
Visibility phase difference	$\phi_v(A)-\phi_v(C)$	-9.1 ± .1	deg
Visibility phase, A channel	$\phi_v(A)$	-1.25 ± 1.0	deg
Visibility phase, C channel	$\phi_v(C)$	+8.5 ± 1.0	deg
FE gain, AB receiver	$G_1(AB)$	-1.5 ± 1.0	%*
FE gain, CD receiver	$G_1(CD)$	-1.0 ± 1.4	%*
System temperature, AB	$T_{sys}(AB)$	0.0 ± 0.6	%
System temperature, CD	$T_{sys}(CD)$	0.0 ± 0.4	%
System gain, A channel	$g(A)$	0.0 ± 0.2	%*
System gain, C channel	$g(C)$	0.0 ± 0.3	%*

*power, not voltage

temperature coefficients were therefore determined, and errors were estimated from the degree of consistency. It might be noted that closure errors were not significant, being always less than 1°.

Visibility amplitude data was used to look for changes in the overall system gain. Amplitudes from baselines of Antennas 3, 4, and 6 were used to solve for the relative gain of each IF of each antenna. No correction was made for system temperature changes, which were negligible anyway. The gain variation at Antenna 3 was not significantly different from that at the other antennas; this gives an estimate of the peak measurement errors.

4.0 RESULTS AND DISCUSSION

The results are given in Table III.

The L.O. phases have acceptably small coefficients, except that it would be good to put a tighter limit on that of $2\phi_{600}$.

The front end gain and system temperatures are especially stable. The gain coefficient, which is acceptably small, is no doubt mainly due to the 4.5-5.0 GHz room temperature amplifiers, although there could be some contribution from the frequency converters.

The very large temperature coefficient of visibility phase was expected (based on laboratory tests and earlier experience), and has long been thought to be due primarily to the 50 MHz harmonic generators in the 2-4 GHz synthesizers (L6's). However, this should result in a larger coefficient for channel A (synthesizer set to 3260.1 MHz, using 17th harmonic of 50 MHz) than for channel C (3010.1 MHz, 12th harmonic). From Table III it is apparent that this is not the case; furthermore, the signs are different for the two channels. This is difficult to explain. There may be another large coefficient which nearly cancels that of the harmonic generator in the A synthesizer.