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# Gain and Phase Stabilities of Some Components Used in the BIMA Array.

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# Gain and phase stabilities of some components used in the BIMA array. These data may be helpful in system considerations for the MMA.

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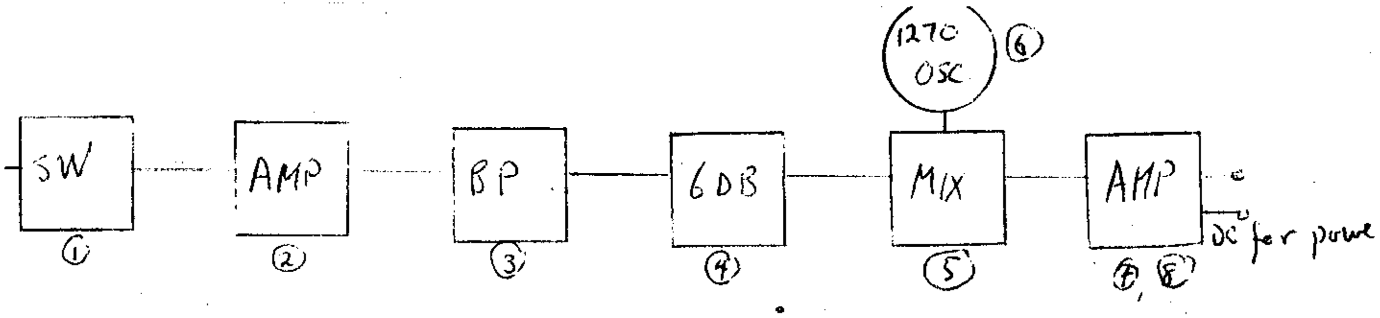
The following sections summarize various stability measurements on BIMA components and subsystems. The first section describes gain stability measurements of individual components of the IF system and then summarizes the overall IF stability. The second section discusses phase/temperature stability of some components. The third section discusses measurements on optical fiber. The fourth secion describes some overall receiver gain/temperature measurements.

I. First, a summary of the temperature sensitivity of the gains of the IF components on the IF plate between the dewar and the total power dectector. Below is a block diagram of the layout. The temperature/gain sensitivity was measured using an environmental chamber. The test of each component consisted of measuring its gain throughout the cycle: (1) increase of temperature from 25.0 to 35.0 C in 10 minutes (2) steady temperature at 35.0 C for 10 minutes, then (3) decrease temperature from 35.0 to 25.0 C in 10 minutes, (4) steady temperature at 25.0 C for 5 - 10 minutes. Temperature changes occurred at a constant rate. The 10 minutes spent at each temperature seemed to be adequate for the temperature of each device to stabilize.

Gain measurements were made at a fixed frequency, either 600 MHz or 1900 MHz, with an HP 8753A Network analyzer. Power detector output was measured with a Fluke voltmeter. The power detector is installed in the second IF amplifier box.



1. **Minicircuits switch (ZSDR-425): (dG/G)/dT < .0003 db/deg C**

2. 1.3 - 2.2 GHz first amplifier. This contains 2 NEC UTC27xx amplifiers: (dG/G)dT = -.0091 db/deg C

3. Bandpass Filter (KWM FSCM 56216): (dG/G)dT = -.005 db/deg

4. 6 db pad: dG/G = 0

5. Anzac MDC-169 mixer: (dG/G)dT = -.0015 db/deg

6. 1270 Oscillator: Output power: (dP/P)dT = -.019 db/deg. The MDC-169 mixer is saturated, reducing this effect by a factor of about ten at the mixer to: -.0014 db/deg

7. Second IF Amp. This contains 3 NEC UTC27xx and one MSA 0420 (Avantec) amplifiers, a 9 pole 70 MHz Hi-pass filter, and a 9-pole 900 MHz low pass filter. The circuit board is low loss ceramic, as it is for the above amplifier. (dG/G)dT = -.010 db/deg

8. Power detector in the final amp: (dDC/DC)dT = -.7%/deg. No DC drift with temperature, only the multiplicative factor changes with temperature.

The overall drift with temperature is: -.027 db/deg or -.62%/deg.

All of the coefficients are negative, and they simply add. Adding the effect of the power detector, -.7%/deg, gives a total of -1.32%/deg for the overall total power sensitivity.

The IF components are located on a plate within an enclosure which has its temperature regulated. The best regulated front-end IF plate maintains a peak to peak temperature variation of .02K over 24 hours. It's about half that over an hour, .01K. This leaves us with an overall gain stability of -.013% p-p for times of the order of an hour.

Here is a break-down showing the various contributions to the gain/temperature sensitivity of the 1.3 - 2.2 GHz amplifier, item 2 above. Each active unit in the system has its own voltage regulator, in this case a Motorola MC78L05AC, to increase stability. The overall power supply is, of course, also stable. The two amplifiers are from NEC:UTC2711 and UTC2712. Their gain sensitivities are -.002 and -.003 db/degK, respectively. Their power supply sensitivities are both .0015 db/mV. The regulator drifts by -1.0mV/degK, which tanslates to -.003db/degK for the two amplifiers. The ceramic circuit board for this length of trace has a sensitivity of -.001 db/degK at 1.7 GHz. ( Note that this is an order of magnitude less than what one gets with normal fiberglass boards). The total is just -.009 db/degK, as measured. This component is typical.

II. Here are measurements of the phase stability of some components with respect to temperature.

1. A 10 MHz distribution amplifier: 0.1 deg phase/degK at each port. This ultimately is multiplied up to be the reference of the second LO at 1270 MHz on each antenna, where the phase is therefore 12.7 deg/degK.

2. A multiple doubler which produces 20, 40, and 80 MHz from the 10 MHz. The 20 and 80 are phase lock offsets. The 20 MHz is 0.75 deg/degK. It is the offset for the 10 GHz intermediate lock loop, and so is multiplied by 25 at 250 GHz, giving a sensitivity of 19 deg/degK. The 40 MHz has a sensitivity of -.25 deg/degK. It is multiplied up to produce the reference for the 1270 MHz LO, giving a sensitivity of -8deg/degK.

3. An Anzac model DS 4-4 four way power splitter at 730 MHz: less than .01deg/degK. (This is a freebe. We don't use it anymore, but we had the measurements.)

The array uses a system of filters to put all the signals onto one coax cable for the connection between the lab and each antenna. These filters have the following phase/temperature sensitivities.

4. The input port to the 1100-1260 MHz high frequency reference port: .16deg/deg at 1180 Mhz, 34 deg/degK at 250 GHz.

5. The input port to the 10 MHz port: .025deg/degK, 3 deg/degK at 1270 MHz.

6. The input port to the 70-900MHz IF port, at 600 MHz: less than .013deg/degK

7. The bandpass filter, item 3 from the first list: 0.1 deg/degK @ 1.75 GHz

8. The second IF amplifier, item 7 from the first list: less than .03deg/degK, at 600 MHz.

9. The L-band amplifier, item 2 from the first list: less than 0.1 deg/deg, at 1.9 GHz.

Items 1,2,4,5,6,7,8, and 9 are located on the front-end IF plate, and so their variations are reduced by a factor of 100 to small values. There are also filter units in the lab, with the properies of 4 and 5, which are not so well regulated. However, they drift slowly, changing by less than 0.2K in a half hour, and are tolerable.

III. For our more distant stations, we are using optical fiber for the connections of all the signals between the lab and the antenna. The phase reference, at 1100 - 1260 MHz, and the IF, 70 - 900 MHz, use single mode fiber, and the low frequency signals, 10 MHz reference, telemetry at 1 MHz, and TV and communication in a 20-70MHz band, use multimode.

A harmonic of the 10 MHz is the phase reference for the 1270 MHz second LO, and so we tested the phase stability of the multimode fiber. The phase sensitivity of the fiber, referred to 1270 GHz, is 4deg/degK for a 100 foot length of the fiber. This is the length of the run from a pit up to the receiver on one antenna, and it is the length whose temperature changes. The remainder of the cable is burried at a depth of about 18 inches and is relatively stable. The variation of 4 deg/degK will be corrected using delay measurements on the single mode fiber used for the reference. These fibers are packaged together, and so this should work, although we haven't tried it yet.

We also made temperature/phase tests on the single mode fiber. It is the tightly jacketed version, with several fibers in the bundle. We found that the sensitivity is about 10 deg/degK per meter length at 100 GHz. This is worse than coax and requires regulation of some kind. The attached panel of figures, 2a, 2b ,2c ,and 2d, shows measurements of the one way phase on the fiber, in turns at 1.2 GHz. These are for the runs to antennas 6 and 7 which were connected to the fiber. These measurements are made with our line length measuring system. THe short term measurement noise has an RMS of about 1 degree at 100 Ghz. The abcissa is time, 200 measurements, each of which is 1.5 sec in duration. Figures 2a and 2b show the temperature drift effects with the two antennas stationary. Figures 2c, and 2d show the mechanical effect of beginnig a slew at full speed.

Although the tightly jacketed fiber has a poor temperature stability, it is often recommended because it is sturdy. For the underground burial, the gel filled version, which is more stable, is probably a good choice. Vertical runs of this style are not recommended because all the weight may fall on just one fiber. The highly stabilized fiber made by Sumitomo is too rigid for our bicycle chain azimuth cable wrap.

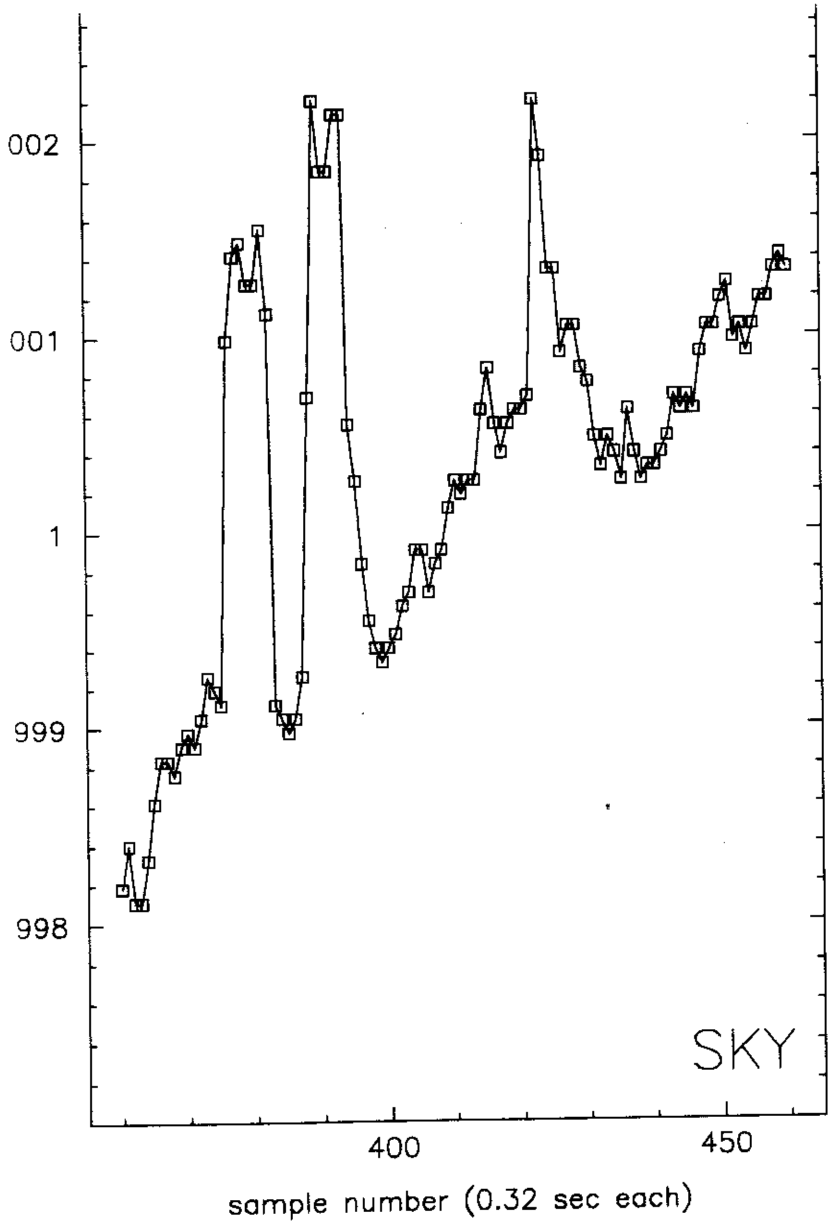
IV. An overall gain stability measurement has been made on one of the receiver front-ends at 100 GHz. It includes everything from a load at the receiver input through to the total power detector on the IF plate. The input load is an absorber whose physical temperature is recorded. Figure 3 shows the total output power as a function of time. The input load is mounted on a thermo-electric cooler/heater, whose temperature can be changed. Near the beginning of the run, there is a 0.5K pulse to calibrate the system. Load temperature is on the right, output total power on the left. The measured load temperature is shown by the dotted line. After the pulse is turned off, the load temperature drifts in time and appears on the total power. The magnitude of a deflection of 1/1000 is shown in the lower lefthand corner.

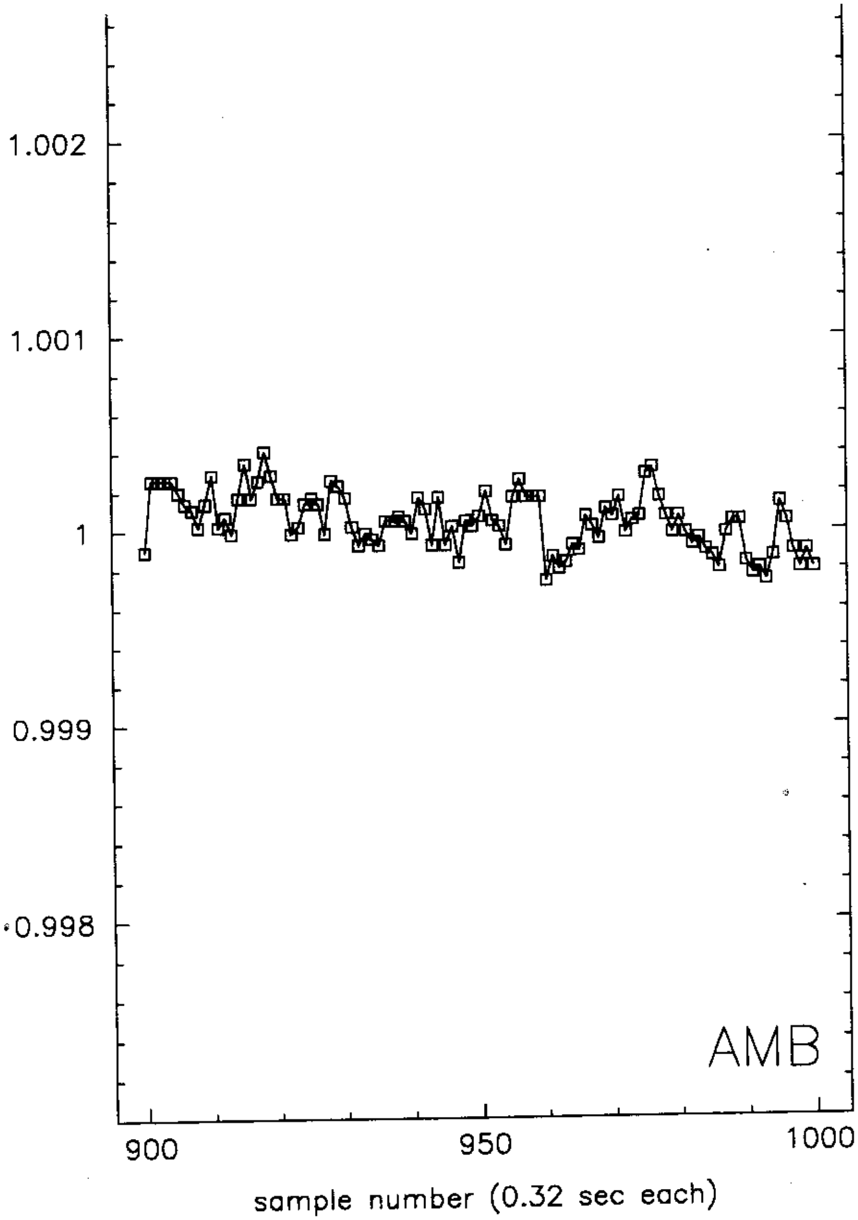
The temperature regulation of components in the dewar is as follows. The SIS mixer block temperature is 3.6K with an RMS fluctuation of 4mK. We find that the lower the operating temperature, the smaller is the gain fluctuation for a given temperature fluctuation. The HEMT first IF stage is thermally connected to the second refrigerator stage. It's average temperature here is 13.6K, and its RMS fluctuation is 2mK. Active regulation is necessary to achieve this stability, because the temperature of the

Gifford-McMahon refrigerator swings up and down with the motion of the displacer. The local oscillator power is regulated with a Hughes ferrite modulator.

The sample time for the output in Figure 3 is 0.3 seconds, and the bandwidth is 830 MHz, predicting a minimum RMS thermal fluctuation of 6 x 10**-5. The actual RMS fluctuations are about 2 x 10**-4, 3-4 times larger. They also have a strong low frequency component, probably 1/f, although we did not calculate it. These are evidently the residual gain fluctuations.

From these results, one can estimate the atmospheric phase vs total power sensitivity. The theoretical prediction is that at 100 Ghz 1 degK of atmospheric brightness temperature fluctuation will result in about 200 degrees of phase fluctuation. In addition, whereas this experiment was done with a 296K load, the expected atmospheric brightness is more like 45k. (Tau=.12 and secz=1.4, sort of average). With a receiver T(DSB)=70K, the system temperature on the sky will be about one third its value during the experiment. With this correction, the deflection on the right side of Figure 3 is therefore the equivalent of a 13 degree phase change. Evidently, this deflection represents something like the peak phase fluctuation to be expected.





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noticed spiky signals from the "sky" on antenna 6. upper figure is
ed :: fluctuation on the ambient load. Bottom picture is output on the sky.

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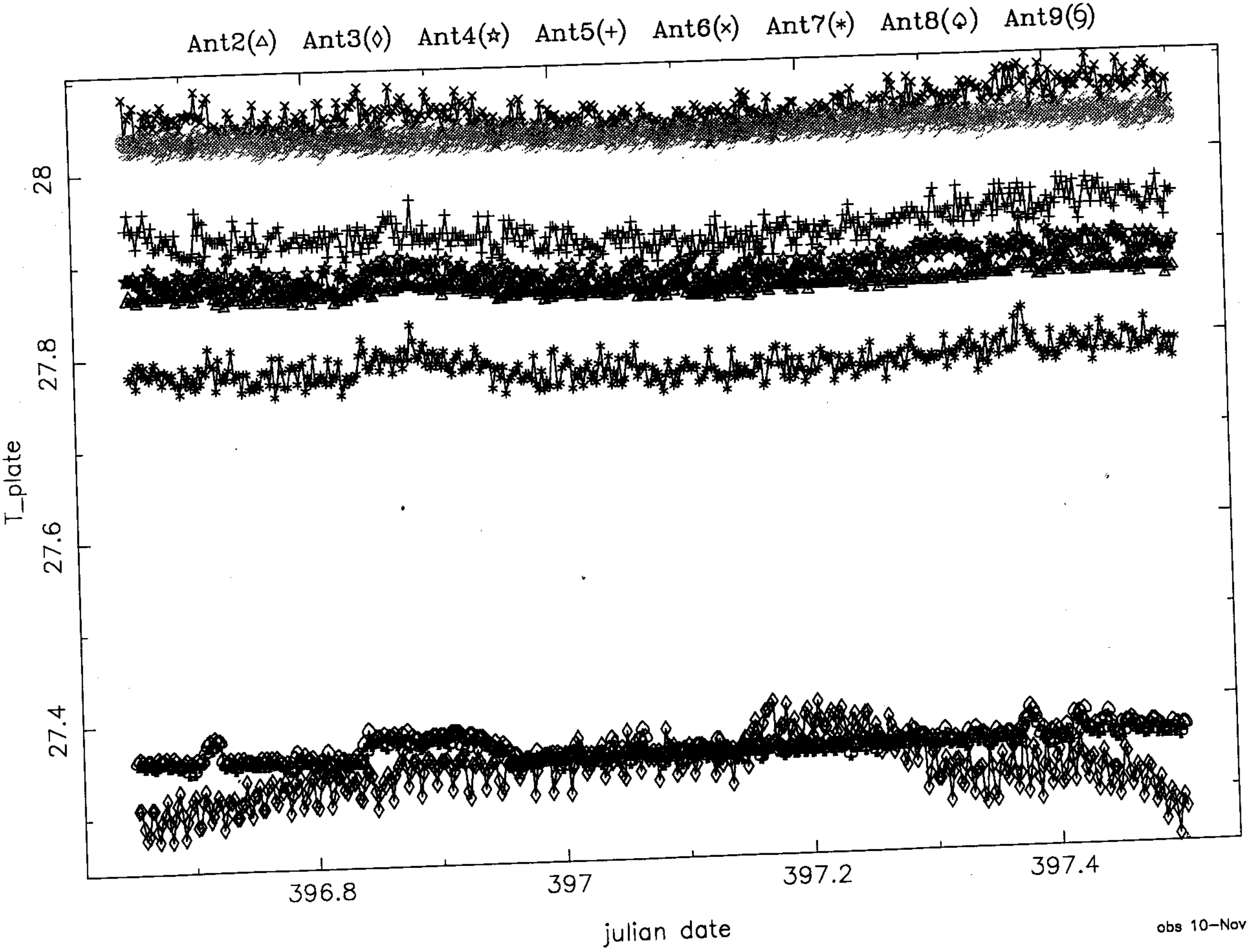

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