12 METER MILLIMETER WAVE TELESCOPE
MEMO No. 239

National Radio Astronomy Observatory

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MEMORANDUM

TO: 12-M Memo Series

FROM: J. M. Payne, P. J. Rhodes, C. J. Salter, E. B. Stobie

SUBJECT: 12-m Telescope Calibration

We report the results of a 48 hour observing session made with the 12-m telescope between 26 and 28, February, 1984. The session was divided equally between observations made at 89.6 and 223 GHz using the standard λ3.3 and 1.3 mm two-channel mixer receivers. The planets and other discrete radio sources were observed. The data has been used to revise the telescope pointing constants, determine flux densities for a number of the sources and to study the telescope characteristics as a function of elevation.

a) Pointing

A set of seventy λ3.3 mm measurement, covering all azimuths and the observable range of elevations, were used to determine the pointing constants. The r.m.s. deviations of the observed positions using the revised pointing constants were,

σ (azimuth) = 3".5 ; σ (elevation) = 2".6

The revised constants were entered into the 12-m control computer on 13 March 1984. A check of the resultant pointing was made that same day via observations of strong sources at elevations between 14° and 81°. No change of thumbwheel offset was found to be necessary in either azimuth or elevation. The r.m.s. deviations of the measured positions were,

σ (azimuth) = 4".5 ; σ (elevation) = 3".2

It is concluded that the pointing of the antenna appears to have been stable over this two week period.

Independent pointing constants were derived using a set of thirty eight λ1.3 mm observations. These constants agreed well with the values derived at λ3.3 mm, the biggest difference being a small azimuth encoder offset of 16" between the two receivers.

At λ3.3 mm a small pointing offset was found between the two channels of the receiver. This collimation offset was such that at the horizon,

Δ Azimuth (Ch1-Ch2) = -4".8 ± 0".2
Δ Elevation (Ch1-Ch2) = +2".0 ± 0".2

The equivalent quantities at λ1.3 mm were,

Δ Azimuth (Ch1-Ch2) = 0".9 ± 0".1
Δ Elevation (Ch1-Ch2) = 1".5 ± 0".2

While the short term stability of the antenna seems good, 12-m observers are recommended to check the pointing of the antenna at the beginning of a run. This is probably best achieved in the continuum mode, measuring a few strong sources at as wide a range of elevations as possible.

It would be greatly appreciated if observers could produce an extra hard-copy of all their pointing "five-point" outputs and leave these with the telescope operator before quitting the mountain. These records will assist the 12-m staff greatly in monitoring the long-term pointing performance of the antenna.

b) <u>Elevation Dependent Effects</u>

The observations made between 26 and 28 February, 1984 have been used to study variations of system gain and half-power beamwidth with elevation.

The measured λ3.3 mm deflections for five strong sources (corrected for atmospheric extinction) were normalized to their deflections at elevation 30° to obtain the gain-elevation curve shown in Fig. 1. There is a small, but measurable, effect with maximum gain near elevation 30°. The gain-elevation curve at λ1.3 mm is shown in Fig 2. Here a much more pronounced effect is seen, again having maximum gain at about 30° elevation. The λ1.3 mm azimuth beamwidth did not vary by more than ±3" for 19° $\lesssim$ elevation $\lesssim$ 58°. In contrast, there seems to be a significant variation of elevation beamwidth with elevation (Fig. 3). We note that as both the gain and beamwidth are functions of elevation at λ1.3 mm, measurements of unresolved and extended sources will be affected differently.

The causes of the strong elevation-dependent effects at λ1.3 mm are not completely clear at present. A number of candidates present themselves (i.e., positioning of the north-south translation stage of the subreflector, gravitational deformation of the telescope surface, inadequate corrections for radial focus movement, etc.) and these will be investigated with the highest priority. It is intended to implement computer control of the N-S translation stage in the coming months. However, the stage was fixed at a reading of +1 mm during the present measurements. Should observers wish to move the stage, suggested values for different elevation ranges (derived by Rick Howard) are given in Table 1. When the stage is moved, a suitable correction (see

Table 1) must be added to the elevation "thumbwheel" offset. Observers moving the translation stage should calibrate carefully using a strong source near the elevation of interest.

C) Flux Densities of Calibration Sources

While observations of the planets are recommended for primary calibration of the flux scale, many observers have requested values for the flux densities of the strong sources regularly used for calibration.

We have computed the flux densities of sources observed on 26 to 28 February, 1984, using the planets to calibrate flux scales at the two frequencies. The following brightness temperatures were assumed for the planets, (Cardarella, 12-m memos; Ulich, B.L., A.J., 87, 1619).

	Tb (λ3.3 mm)	Tb (λ1.3 mm)
Venus	--	290K
Mars	200K	215K
Jupiter	179K	160K
Saturn	149K	140K
Uranus	134K	100K

The internal consistency of the ratio of predicted peak flux density to mean measured deflection for the four planets at λ3.3 mm was good, with an r.m.s. of 2.3% and a total spread of 6%. At λ1.3 mm the internal consistency for the five planets is less satisfactory with an r.m.s. of 8.2% and a total spread of 18%. More accurate values of planetary temperatures would appear to be needed at this wavelength.

The computed flux densities for the observed sources are given in Table 2. It is to be noted that a few sources occasionally observed for pointing at λ3.3 mm (i.e., 0224 + 671) are currently too weak to be used comfortably for this purpose.

d) Observing through the Dome

The planet, Saturn, was observed through the side of the dome at both frequencies. The telescope was not refocused for either measurement. The azimuths and elevations of the measurements were (155°, 40°) at λ3.3 mm and (190°, 43°) at λ1.3 mm. Comparison of observations of the planet through the dome, with those made immediately before and after, yielded dome power transmission coefficients of 0.41 ± 0.01 at λ3.3 mm and 0.44 ± 0.01 at λ1.3 mm. Note that Ulich (Tucson Operations Internal Report No. 1, 1976) found the telescope to need refocusing when observing through the dome side, and then derived a power transmission coefficient of 0.51 ±0.02 at λ3.3 mm.

No large pointing change was found when observing through the dome ($\lesssim$ 4"). At both frequencies the beamshape remained essentially circular and did not change significantly in size.

e) The λ1.2 mm Bolometer

A short calibration run was made with the bolometer on 13 March, 1984, using the λ1.2 mm filter (Center frequency $\sim$ 240 GHz; Bandwidth $\sim$ 65 GHz). It was found that the new λ3.3 mm pointing constants are not good approximations to those needed for the bolometer. A systematic change of azimuth pointing by $\sim$ 70" was measured between elevations 16° and 72°. The elevation pointing changed by only a far smaller amount ($\lesssim$ 20"). The latest bolometer pointing curves are left with the telescope operator.

Table 1

Suggested settings for the subreflector, N-S translation stage

(Rick Howard, 1/19/84)

Elevation	Setting	Elevation Thumbwheel Correction
15° - 25°	+1.5 mm	+18"
25° - 45°	+1.0 mm	0"
45° - 60°	+0.5 mm	-18"
60° - 80°	-0.5 mm	-54"

Table 2

Flux Densities at epoch 26-28, February, 1984

Source	S (89.6 GHz)	S (223 GHz)
3C84	44.2 ± 1.2 Jy	18.2 ± 2.0 Jy
3C273	41.1 ± 1.1 Jy	28.1 ± 2.0 Jy
2C279	5.6 ± 0.4 Jy	--
3C345	8.3 ± 0.4 Jy	5.1 ± 1.2 Jy
NRAO150	4.9 ± 0.3 Jy	--
DR21	14.5 ± 0.7 Jy	--
W3(OH)	3.8 ± 0.3 Jy	--
Cen. A	8.6 ± 0.4 Jy	11.3 ± 1.3 Jy
Virgo A	6.5 ± 0.3 Jy	--
0224 + 671	0.8 ± 0.3 Jy	--
0402 - 362	2.3 ± 0.4 Jy	--
0420 - 014	4.5 ± 0.3 Jy	--
0458 - 020	1.4 ± 0.5 Jy	--
0642 + 449	1.1 ± 0.3 Jy	--
0851 + 202 (OJ287)	7.9 ± 0.3 Jy	--
0923 + 392	0.9 ± 0.5 Jy	--
1124 - 186	0.9 ± 0.4 Jy	--
1334 - 127	4.2 ± 0.4 Jy	4.8 ± 1.6 Jy
1741 - 038	2.0 ± 0.4 Jy	--
1749 - 096	1.9 ± 0.3 Jy	--

Fig 1.

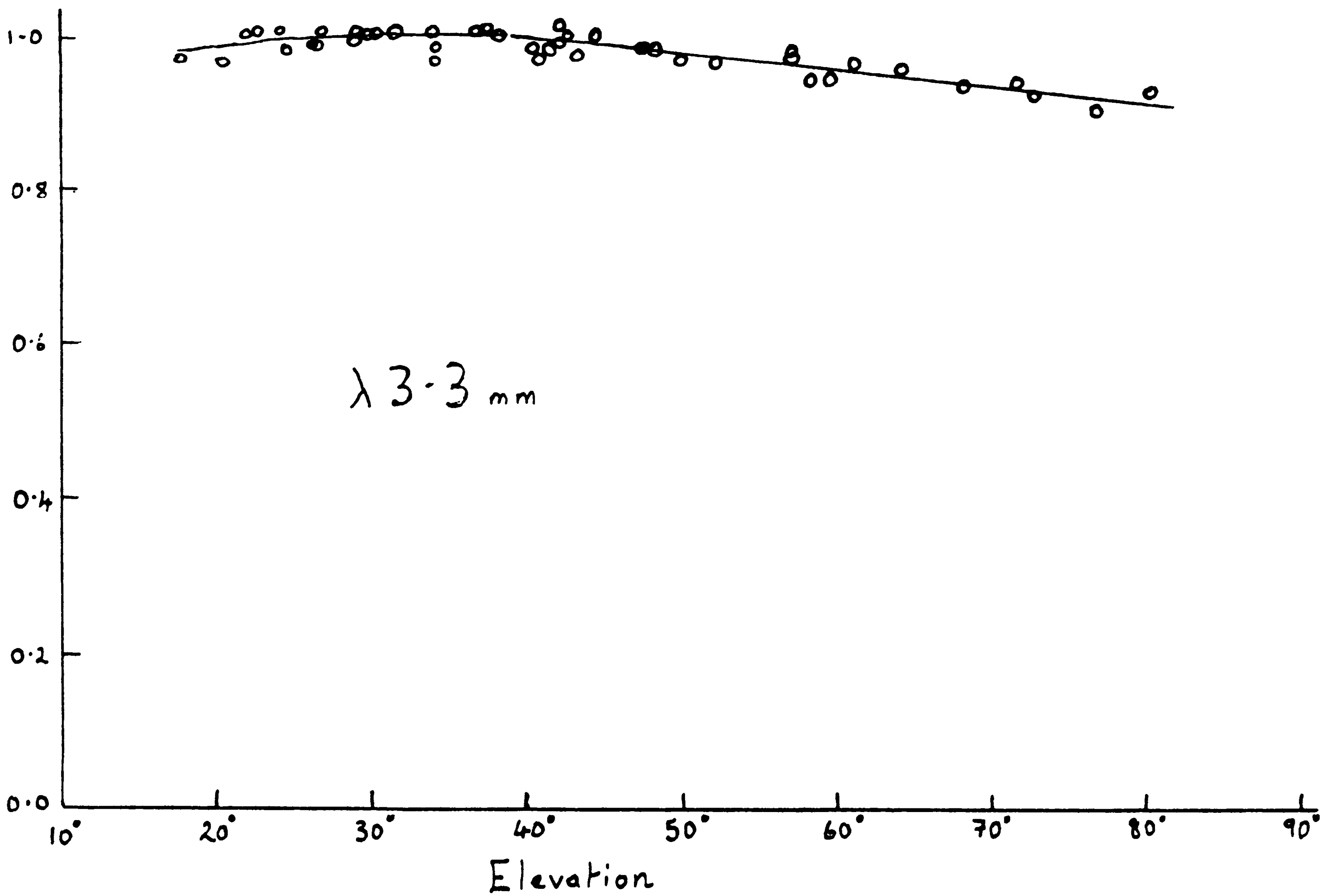

Fig 2.

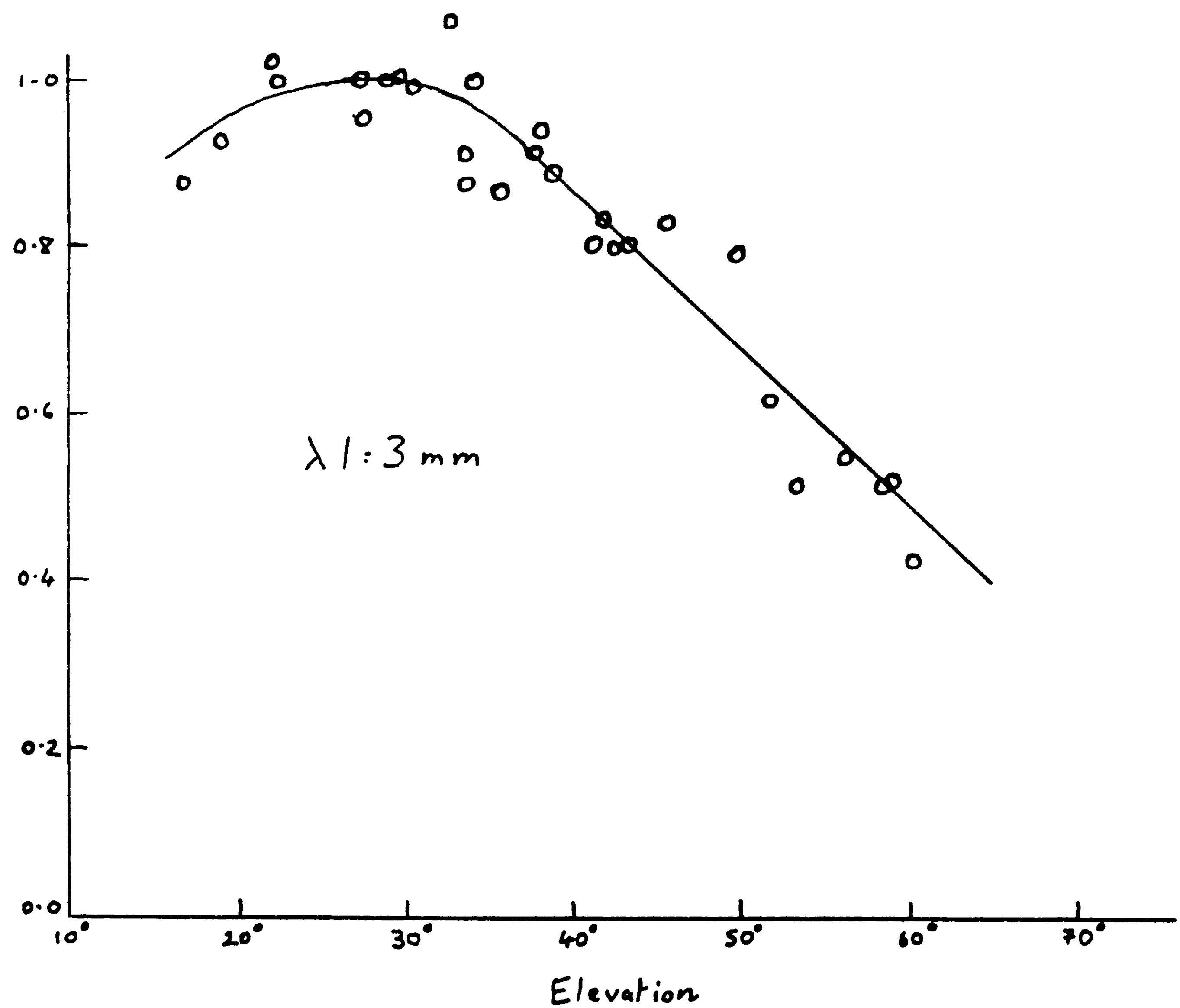

Fig 3.