NATIONAL RADIO ASTRONOMY OBSERVATORY

Engineering Memo No. 144

POINTING CALIBRATION OF THE NEW TRAVELING FEED ON THE 300-FOOT TELESCOPE

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I. Introduction

In October 1980 a new traveling feed was installed on the 300-foot telescope. The new feed and track are stronger and heavier than the old, and are designed to carry heavier receivers. In addition, cryogenically cooled receivers can be used over the center 40 percent of its tracking range.

Observations by Greenhalgh (1972) with the old traveling feed showed that the beam deflection factor was constant out to a critical beam displacement angle, at which point its value increased. A more recent measurement by Guiffrida and Haschick (1974) indicated that the critical angle scales inversely with frequency.

I am reporting in this memo on a series of observations I made between November 1980 and July 1981 of the pointing properties of the new traveling feed, at several frequencies between 300 and 1000 MHz. The extensive new measurements confirm the earlier results of Greenhalgh and of Guiffrida and Haschick.

II. Background

The basic parameter determining the right ascension pointing of the traveling feed is the beam deflection factor or BDF. The BDF relates the angular displacement of the beam to the angular offset of the feed:

$$\mathrm{BDF} = \frac{\Delta\gamma_B}{\Delta\gamma_F} \quad . \tag{1}$$

γ_B is the geometrical angle of the beam and γ_F is the geometrical angle of the feed given by

$$\gamma_F = \tan^{-1}\left(\frac{X}{F}\right), \tag{2}$$

for a linear feed offset X and flocal length F (1525.0 inches for the 300-foot telescope).

Because the track of the traveling feed is parallel to a circle of latitude only at the celestial equator, it is necessary to know γ_B as a function of hour angle and declination. For an apparent declination δ_{app} and geometrical angle of the beam γ_B, the meridian declination of the traveling feed is

$$\Delta = \sin^{-1} (\cos \gamma_B \sin \delta_{app}). \tag{3}$$

The corresponding hour angle is

$$h = \sin^{-1}\left(\frac{\sin \gamma_B}{\cos \Delta}\right) . \tag{4}$$

These relations can be inverted to determine γ_B as a function of h and δ_{app}:

$$\gamma_B = \sin^{-1}\left(\frac{\sin h \cos \delta_{app}}{\sqrt{1 - \sin^2 \delta_{app} \sin^2 h}}\right) . \tag{5}$$

III. Right Ascension Pointing Curves

To determine the right ascension pointing curves, I used the following procedure to obtain feed offsets and hour angles: With the telescope in manual control, the operator and I moved the traveling feed to the desired linear offset with the telescope at the declination of the source of interest. We would then lock the traveling feed in position and manually start a continuum scan. Once the source had moved through the offset beam, we would stop the scan, move the traveling feed ahead of the source, and repeat the procedure. We obtained up to nine measurements for most sources.

For each observation, I later determined the local sidereal time of the peak response, precessed the source coordinates, applied the right ascension pointing correction reported in Engineering Memo No. 143, and calculated the hour angle corresponding to each lateral offset.

I then used equations (2) and (5) to calculate the geometrical angles of the feed and beam. With the data for each receiver I calculated the linear offset necessary to center the receiver, the BDF near the meridian, the critical angle where the slope changes, and the BDF beyond the critical angle. The results for the six receivers I checked are tabulated in Table 1. The 950 MHz observations with a slope of 0.865 removed are shown in Figure 1.

The principal results of these observations are:

1. Apparently the traveling feed is not aligned with the Sterling mount since all the receivers have observed offsets approximately 1 inch less than expected (none for the 740-1000 MHz receiver and $\pm$34 inches for the 300-1000 MHz receiver). Use of the new right ascension pointing curve has reduced the magnitude of this offset by 0.1 inch. This is not a problem because the appropriate offset can be applied using a box card.

2. The observations with the 740-1000 MHz receiver covered the range $\pm$250 inches. Limited observations in the range 250 to 302 inches suggest that the slope increases again around 250 inches, but this is well beyond the useful range of the traveling feed.

3. The values for the inner and outer BDF's are in good agreement (except that the outer BDF at 320 MHz is poorly determined and will be ignored). The observations confirm that the critical angle does scale inverse with frequency. The weighted averages of the BDF's are given in Table 2 along with the result of fitting the critical angles with a function of the form a/ν. The critical angle is approximately equal to six half-power beamwidths.

IV. Declination Pointing Curve

I was also able to check the declination pointing curve of the traveling feed at 950 MHz (32 cm), with the results summarized in Table 3. The corrected pointing curve was determined using the April 1980-May 1981 level curve. The corrected curve is compared in Figure 2 to the July 1981 6-cm curve for pa = 0° determined at the same time. The traveling feed is apparently offset from the Sterling mount in declination as well as in right ascension.

V. Summary

1. The present, extensive observations of the pointing of the traveling feed confirm and quantify the earlier observations of Greenhalgh and of Guiffrida and Haschick. The pointing program at the 300-foot telescope should be updated to include the frequency dependence of the critical angle.

2. The declination pointing curve reported here, while determined from a small number of measurements (only 3 above $\delta = 55°$), is similar to those reported at other wavelengths in Engineering Memos No. 142 and 143.

References

Guiffrida, T., and Haschick, A. 1974, "870 MHz Traveling Feed Measurements".

Greenhalgh, J. P. 1972, "300-Ft. Pointing."

Table 1. Pointing Parameters of Receivers on the Traveling Feed

Frequency	Date	Receiver	# Points	RMS/Point	Offset	Inner BDF	Critical Angle	Outer BDF
320 MHz	July 1981	300-1000 MHz	130	$8^{s}.25$	-36.061±0.099 in.	0.8465±0.0013	$3^{\circ}.745 \pm 1^{\circ}.425$	0.9102±0.0153
610	February 1981	"	74	$8^{s}.11$	-35.020±0.095	0.8515±0.0021	2.120±0.233	0.9793±0.0068
750	November 1980	740-1000 MHz	41	$6^{s}.38$	- 0.831±0.107	0.8504±0.0029	1.952±0.133	0.9842±0.0032
750	July 1981	300-1000 MHz	114	$4^{s}.26$	+33.365±0.047	0.8552±0.0013	1.657±0.091	0.9564±0.0026
950	July 1981	"	113	$3^{s}.69$	+33.414±0.042	0.8615±0.0014	1.430±0.060	0.9621±0.0016
990	November 1980	740-1000 MHz	39	$7^{s}.52$	- 0.804±0.112	0.8875±0.0034	1.739±0.214	0.9856±0.0040

Table 2. Weighted Least-Squares Parameters of Pointing Curve

Inner BDF	0.8549 0.0039	
Critical Angle	$(1344\overset{\circ}{.}0 \pm 45\overset{\circ}{.}1)/\nu$	(ν in MHz)
Outer BDF	0.9665±0.0053	

Table 3. Parameters of Declination Pointing Curves at 950 MHz

	Corrected	Uncorrected
Number of Points	50	50
RMS/Point(")	17.21	15.38
C_0(")	-93.61±3.02	-102.53±2.70
C_1("/°)	4.33±0.10	4.20±0.09

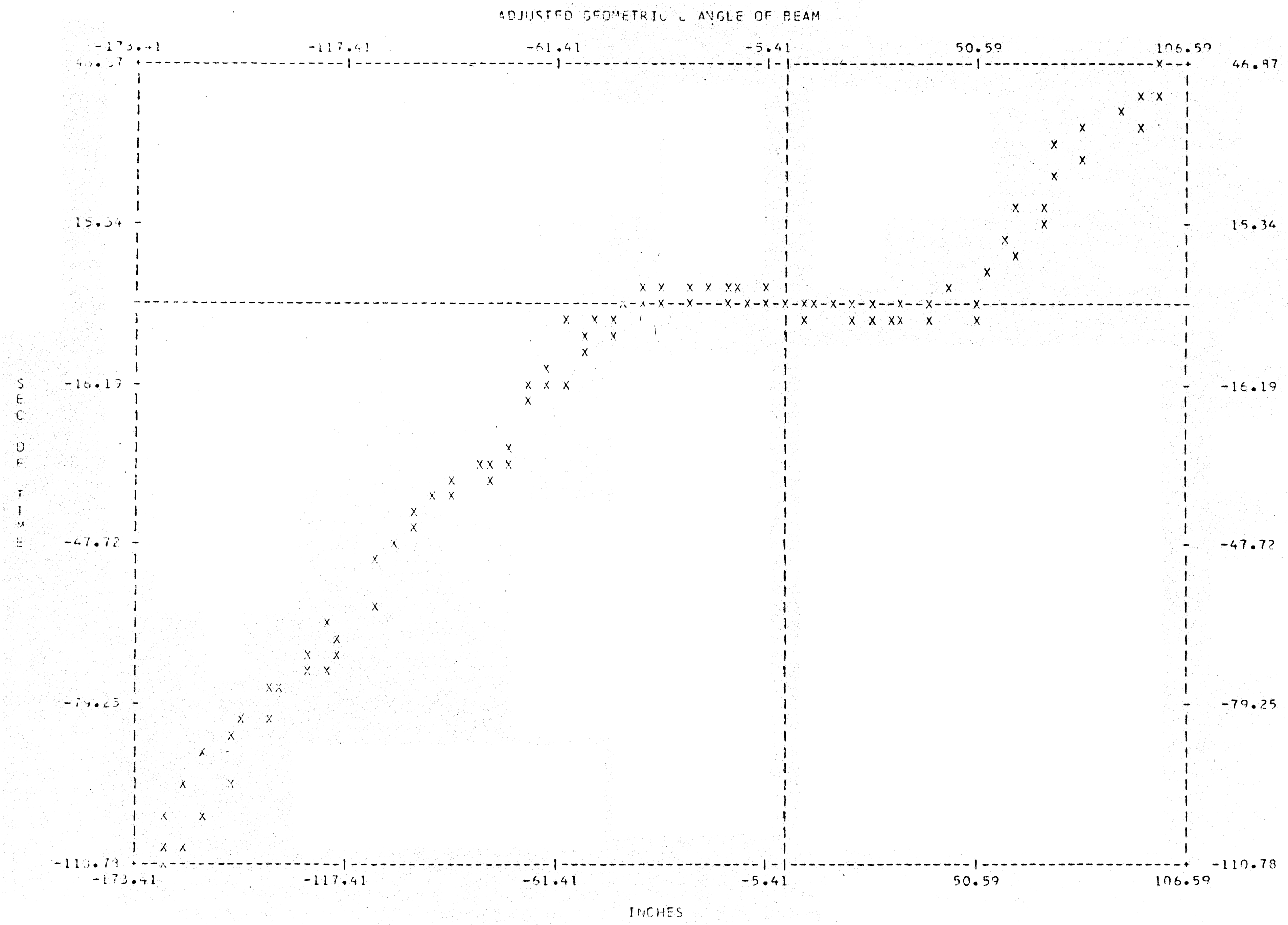

Figure 1. 950-MHz observations with a slope of 0.865 removed.

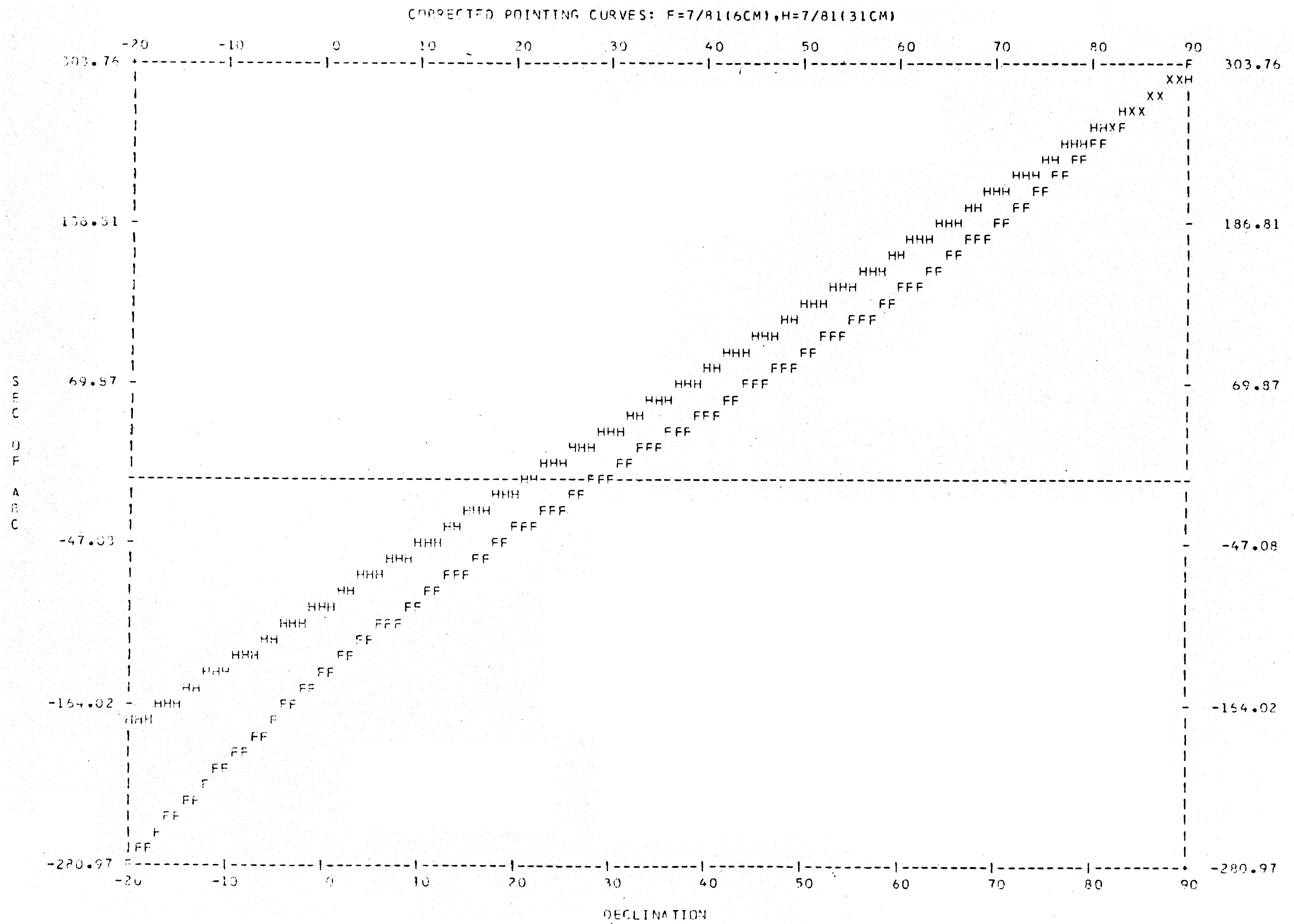
CORRECTED POINTING CURVES: F=7/81(6CM),H=7/81(31CM)
SEC OF ARC
303.76
186.81
69.87
-47.08
-164.02
-280.97
-20
-10
0
10
20
30
40
50
60
70
80
90
DECLINATION

Figure 2.