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FIELD OF VIEW OF GBT - UNSHAPED

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Scanning the secondary beam off axis by translating the feed is an important characteristic of a dual reflector antenna for a number of reasons. For the Green Bank Telescope, providing multiple beams in the sky is the prime reason for studying the scanning properties. The maximum possible scan at a particular frequency is limited by the space available to translate the feed off the secondary focus, loss of gain and the increase in coma sidelobe level. The phase aberrations in the aperture field cause gain loss and increase the sidelobes. Gain loss is also caused by an increase in spillover. In this memo results are presented for beam scan in the plane of symmetry (elevation plane) as well as in the plane of asymmetry (azimuth plane) of the GBT. Scan performance in other planes would lie between the two extremities presented here. The results are presented for the subreflector M1 (7.55m x 7.95m) at 5 GHz and 1.42 GHz.

When the beam is scanned, the focal surface on which to locate the feed in order to get the best radiation pattern must be found. To find this focal surface, the caustics of the reflector must be examined. For an incident plane wave inclined with respect to the reflector axis, the focal surface has two sheets, one corresponding to rays focusing in the plane of incidence and the other corresponding to rays focusing in the orthogonal plane. Traces of the caustic on the principal coordinate planes are helpful in finding the best feed locations. For the GBT, the feed locations were determined by R. Norrod using the above technique described in [1]. After locating the feed, the gain and radiation pattern are calculated by using an analysis program. The orientation of the translated feed axis with respect to the untranslated feed (nominal case) axis is determined by a trial and error method for the best performance.

At 5 GHz, the performance is assessed for scans of 2.8, 6 and 10 half-power beamwidths (HPBW's), while at 1.42 GHz, scans of 2.8 and 6 HPBW's are treated. At the latter frequency, the feed translation for scans greater than 6 HPBW's gets too large, causing blockage of the main reflector and, hence, is not considered in this memo. Figure 1 gives the coordinate system used for the feed translation. Table 1 lists the feed translations (off the secondary focus) used for various beam scanning angles. Also given are the orientation angles θ_f of the feed axis from the untranslated position. In the plane of symmetry for feed translation in the $+Y_f$ direction, the beam scan is in the $\phi = 90°$ plane, while in the asymmetric plane for feed translation in the $+X_f$ direction, the beam scan is in the $\phi = 0°$ plane.

Performance results for scanning in elevation are tabulated in Table 2. These include the peak gain, gain loss and HPBW with respect to the nominal case, the levels of cross-polarization and first sidelobe. Table 3 lists the results for scanning in azimuth. At both frequencies, the scan losses and beam broadening are higher for the case of scanning in the plane of symmetry. In this plane, if the feed is translated in the $-Y_f$ direction, the resulting gain loss would be lower than for $+Y_f$ translation.

The peak cross-polarization levels shown in Tables 2 and 3 occur in the plane of scanning. It is to be noted that the cross-polarization performance has deteriorated to a large extent. A possible reason is the optimum tilt angle condition for low cross-polarization as described by Mizugutch *et al.* [2] is no longer satisfied when the feed is translated and tilted. Further, the cross-polarization levels in the asymmetric plane scans are higher than those in the symmetric plane scans.

The far-field patterns for different scan angles are shown in Figures 2, 3, 4 and 5. The patterns have been shifted vertically and the gain and scan angle values are noted for each pattern.

References:

[1] C. J. Sletten, *Reflector and Lens Antenna - Analysis and Design Using Personal Computers*, Artech House, Inc. 1988.

[2] Y. Mizugutch, M. Akagawa, and H. Yokoi, "Offset Dual Reflector Antenna," *IEEE AP-S Int. Symp. Digest*, Oct. 1976, pp. 1-5.

TABLE 1. Feed Translations and Orientations.

Freq. (GHz)	Beam Scan Angle θ_s		Translation (Meters) and Orientation (Degrees)							
	(arcmin)	$(\theta_s/HPBW_o)$	Symmetric Plane				Asymmetric Plane			
			ΔX_f	ΔY_f	ΔZ_f	θ_f	ΔX_f	ΔY_f	ΔZ_f	θ_f
5.00	6.8	2.7	0	0.379	-0.083	1.8	0.382	-0.005	-0.021	1.8
	14.6	5.9	0	0.806	-0.176	3.5	0.818	-0.022	-0.028	4.0
	24.4	9.8	0	1.343	-0.293	5.8	1.368	-0.061	-0.030	6.5
1.42	24.4	2.8	0	1.343	-0.293	6.0	1.368	-0.061	-0.030	6.5
	52.0	6.0	0	2.948	-0.902	12.5	3.021	-0.282	-0.196	13.8

NOTE:

Nominal case: $HPBW_o$ (arcmin) = 2.5 (5GHz); 8.7 (1.42 GHz).

TABLE 2.   Scanned Performance - Symmetric Plane

Freq. (GHz)	Scan Angle/ HPBW$_o$	Peak Gain G (dB)	Loss in Gain G$_o$ - G (dB)	$\dfrac{\text{HPBW}}{\text{HPBW}_o}$	Peak Cross- Polarization Below G (dB)	First Sidelobe Below G (dB)
5.00	2.7	72.840	0.140	1.01	-36.0	-26.62
	5.9	72.513	0.467	1.06	-29.5	-25.68
	9.8	72.191	0.789	1.13	-25.2	-23.70
1.42	2.8	61.705	0.308	1.07	-25.0	-28.12
	6.0	60.888	1.125	1.21	-19.0	-24.42

NOTE:

Nominal case: peak gain G$_o$ (dB) = 72.980 (5 GHz); 62.013 (1.42 GHz)
   HPBW$_o$ (arcmin) = 2.5 (5 GHz); 8.7 (1.42 GHz)

TABLE 3. Scanned Performance - Asymmetric Plane

Freq. (GHz)	Scan Angle/ $HPBW_o$	Peak Gain G (dB)	Loss in Gain $G_o - G$ (dB)	$\dfrac{HPBW}{HPBW_o}$	Peak Cross-Polarization Below G (dB)	First Sidelobe Below G (dB)
5.00	2.7	72.962	0.018	1.00	-29.0	-26.82
	5.9	72.900	0.080	1.02	-22.5	-26.52
	9.8	72.752	0.228	1.04	-19.0	-26.07
1.42	2.8	61.878	0.135	1.02	-18.5	-23.36
	6.0	61.091	0.922	1.10	-13.0	-20.45

NOTE:

Nominal case: peak gain G_o (dB) = 72.980 (5 GHz); 62.013 (1.42 GHz)
$HPBW_o$ (arcmin) = 2.5 (5 GHz); 8.7 (1.42 GHz)
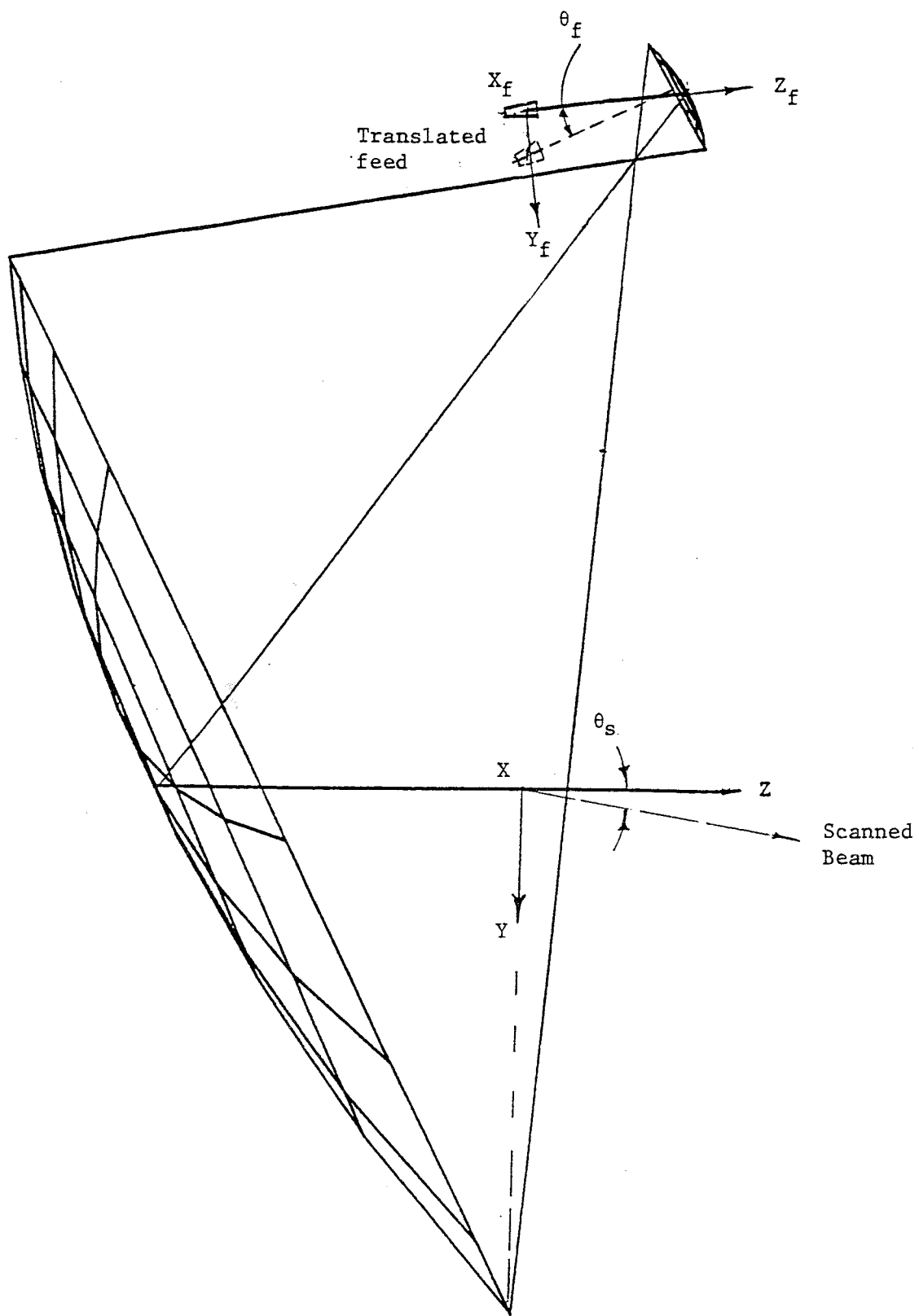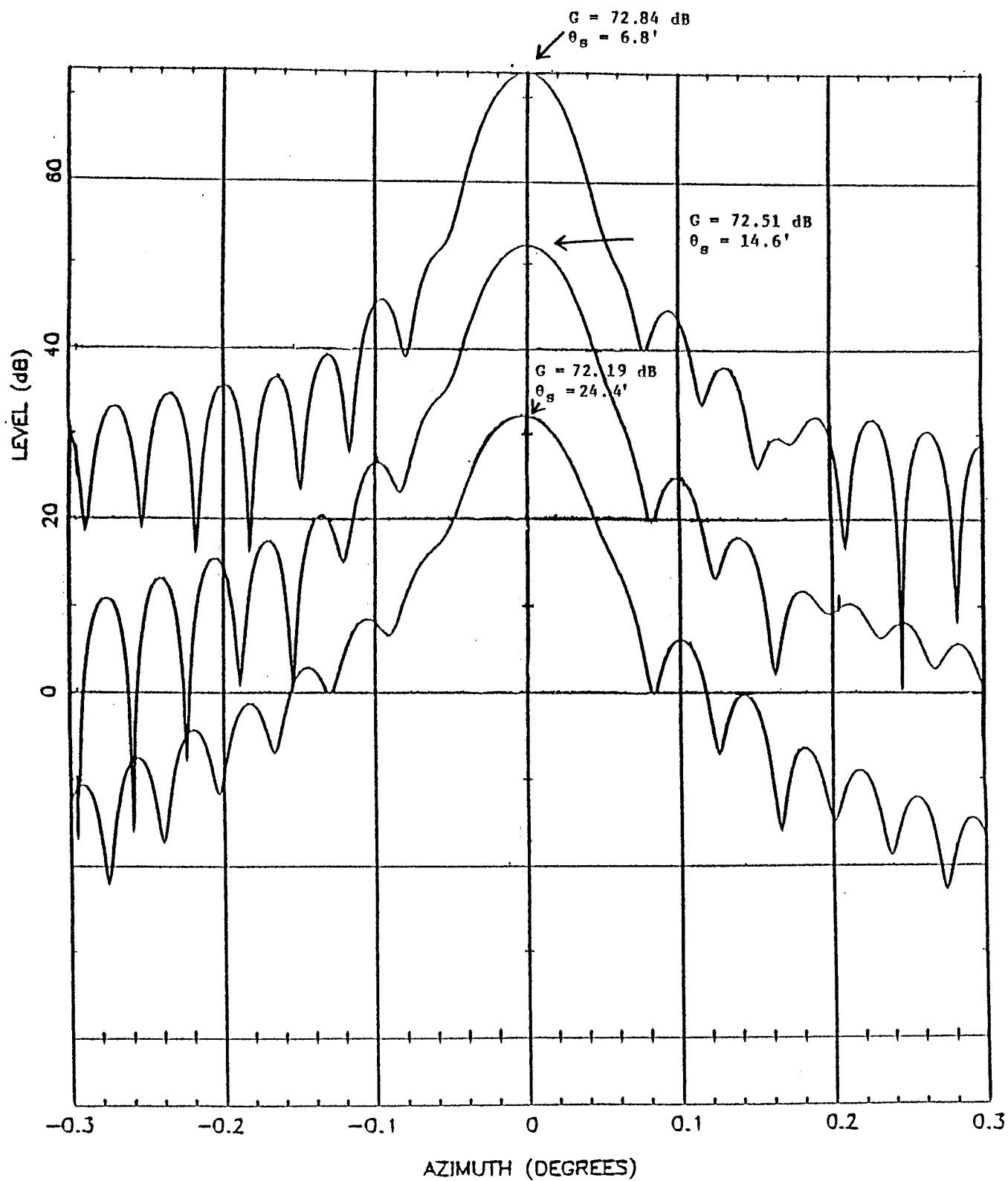
Fig. 1.   Geometry of feed translation.

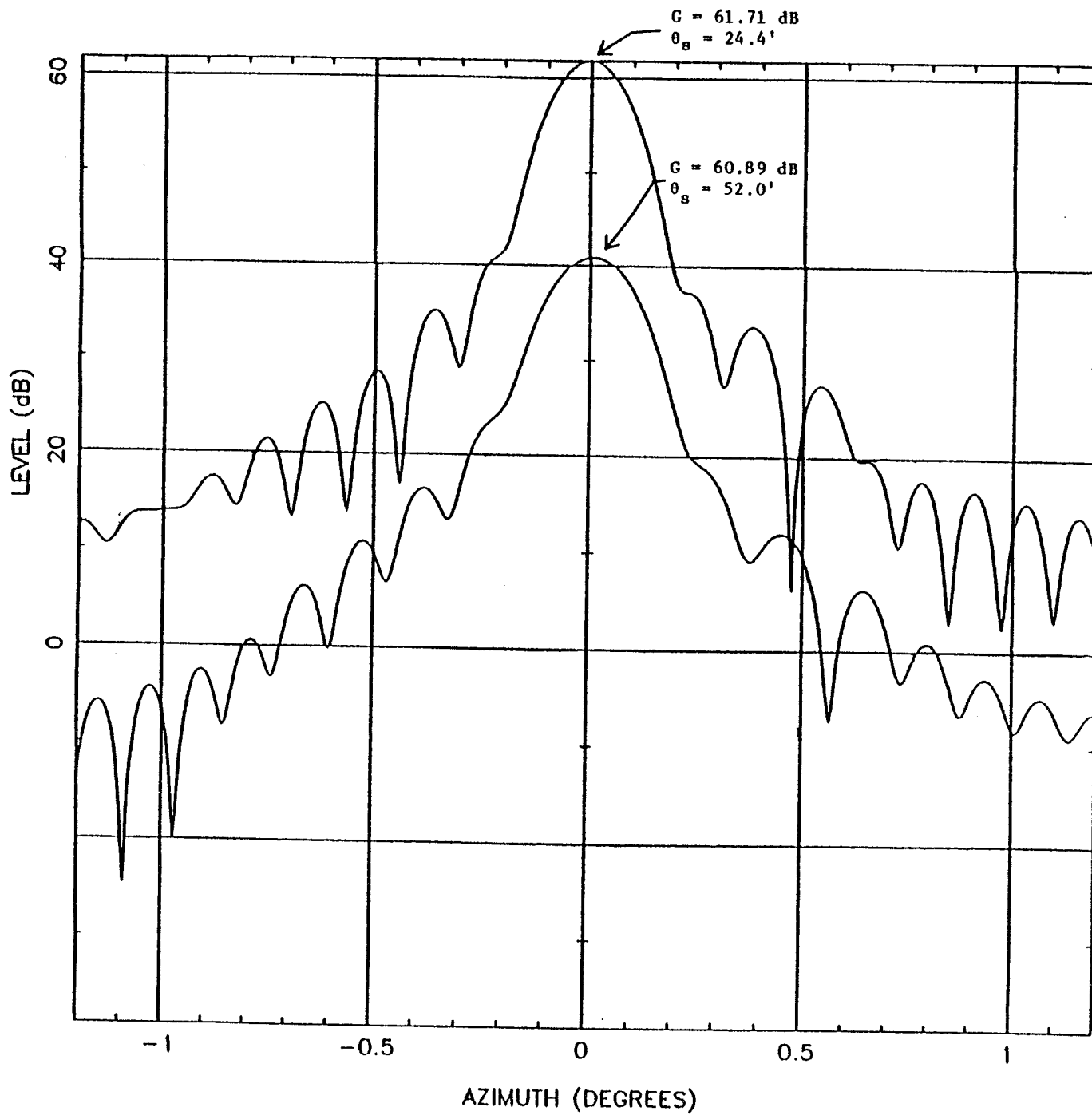Fig. 2. Scanned far-field patterns at 5 GHz.

(Plane of Symmetry)

Fig. 3. Scanned far-field patterns at 1.42 GHz.
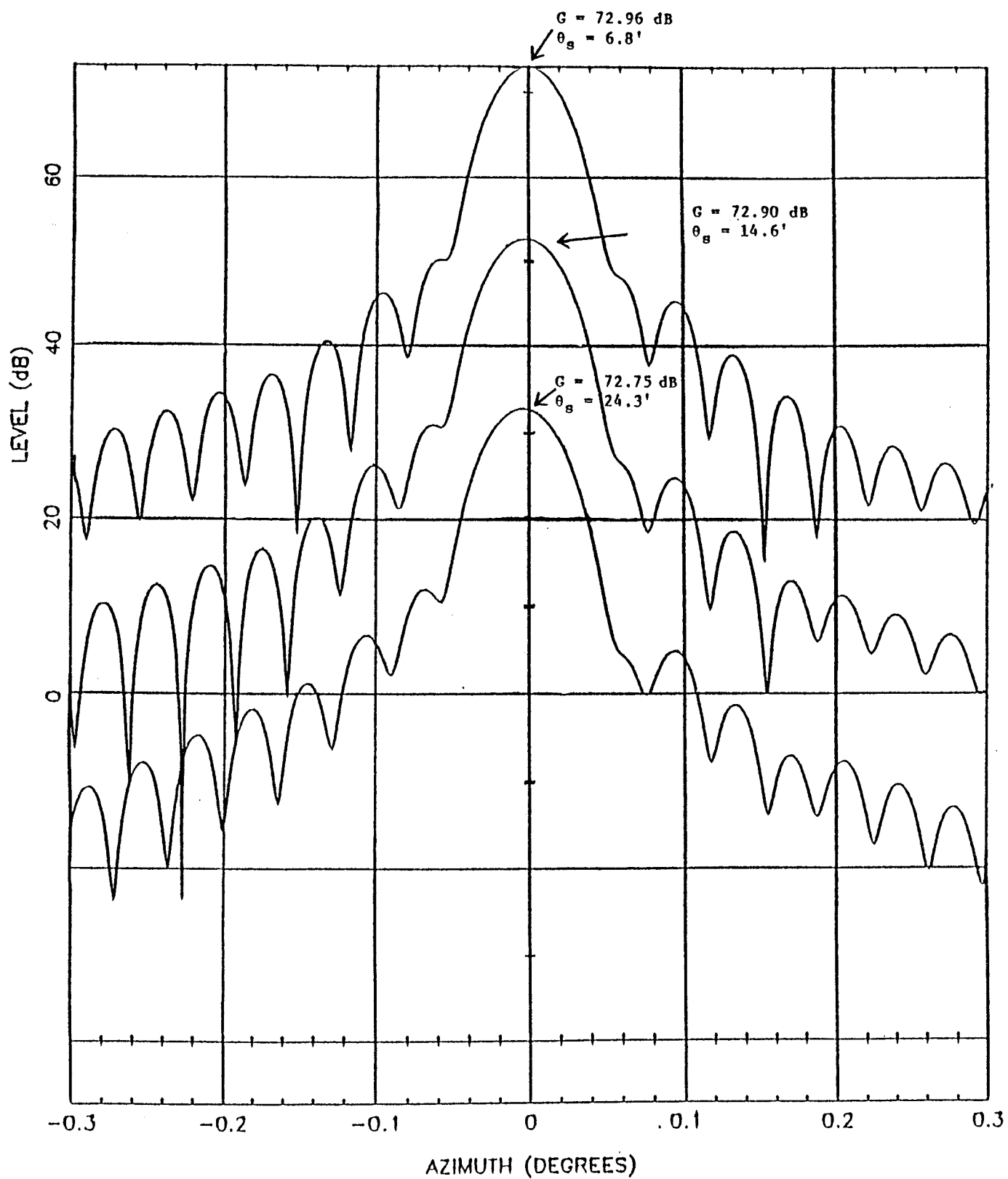
(Plane of Symmetry)

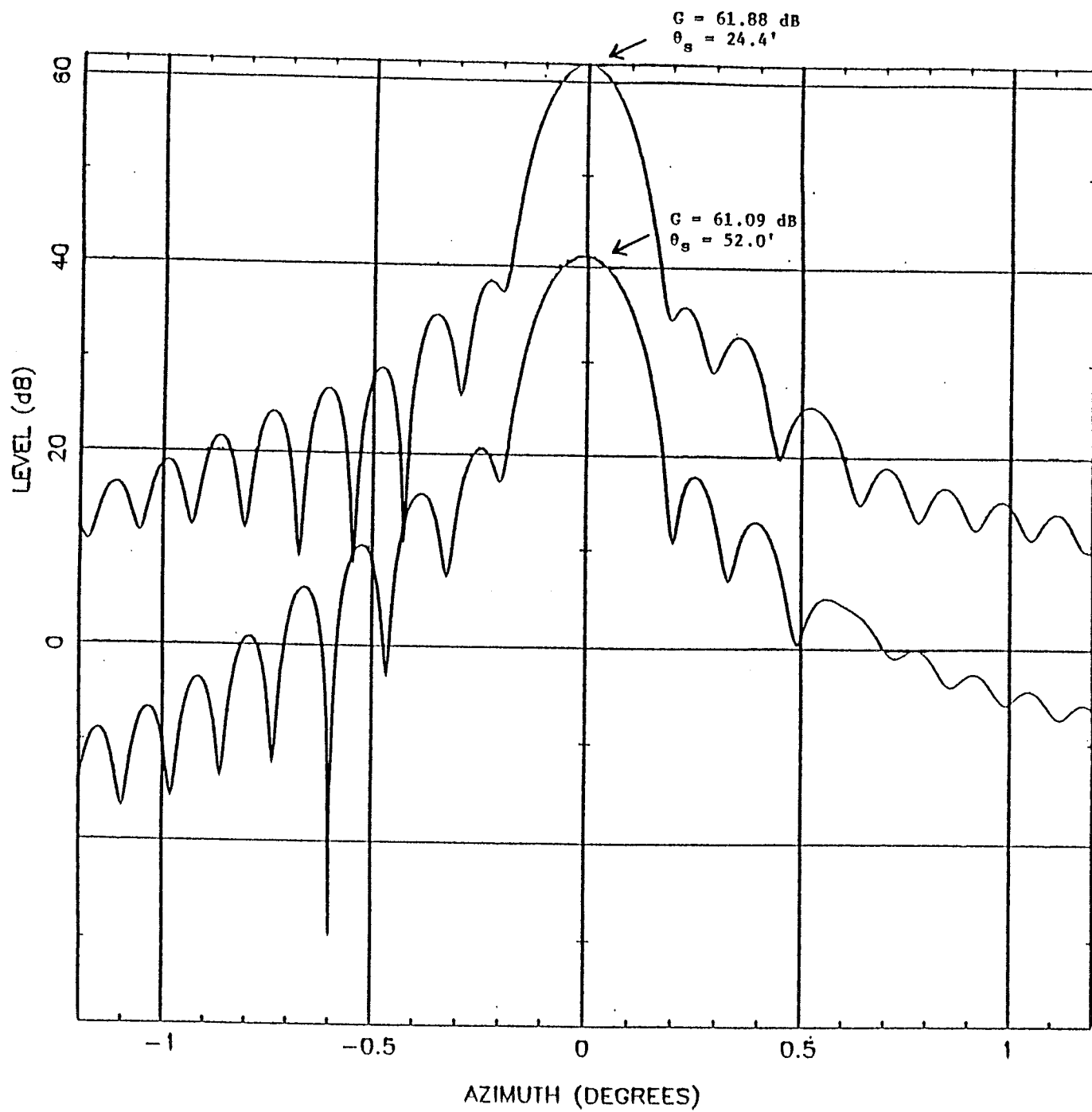Fig. 4.   Scanned far-field patterns at 5 GHz.

(Plane of Asymmetry)

Fig. 5. Scanned far-field patterns at 1.42 GHz.

(Plane of Asymmetry)