GBT Memo No. 19

MORE ON THE SPILLOVER NOISE TEMPERATURE COMPARISONS FOR THE GREEN BANK TELESCOPE

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In GBT Memo No. 16, spillover noise temperature calculations are given for various optics configurations at 1.42 GHz. From the results presented in the memo, the cassegrain geometry with arm at the bottom and the gregorian geometry with arm at the top seem to be acceptable. However, the former has lower spillover of almost 2 K at 45° elevation and 3.5 K at 10° elevation compared to the latter. In this memo, following the same methodology as in the above memo, calculations have been done at 5.0 GHz for the two acceptable optics. Also a symmetric cassegrain antenna results are compared with that of the clear aperture cases at 1.42 GHz. Results are tabulated in Tables 1 and 2.

Figure 1 shows the geometry for the clear aperture antenna, which is the same as in GBT Memo No. 16. The illumination taper at the edge of the subreflector is -12 dB, same as at 1.42 GHz. Hence, the forward spillover (T_f) at 5.0 GHz is the same as at 1.42 GHz. The temperature used for the sky is 6 K at all elevation angles and for the ground 270 K. In Figure 2 one of the many subreflector scattered patterns used in the rear spillover (T_r) calculations is shown. The taper at the edge of the main reflector is indicated. Figure 3 shows the total (T_{sp}) as well as the components of the spillover noise temperatures at 5.0 GHz. The rear spillover at 5.0 GHz is lower than at 1.42 GHz for both cases at all elevations. This is due to the sharper falloff of the subreflector scattered pattern at 5.0 GHz as seen in Figure 2. The difference in spillover between the two cases is still significant, 1.3 K and 3 K at 45° and 10° elevations, respectively, the cassegrain optics being the better one.

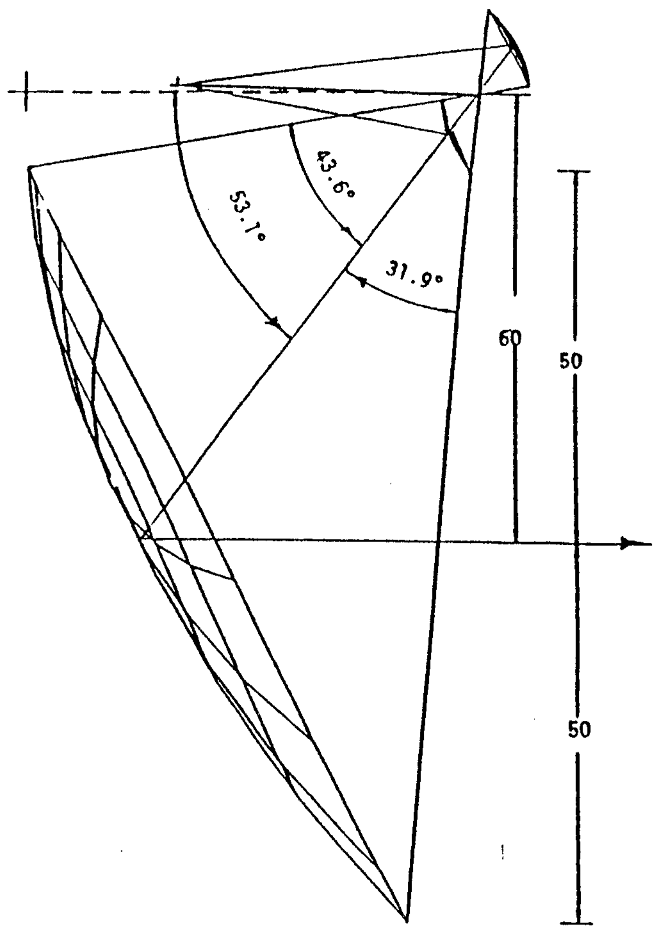
Computations of spillover for a symmetric cassegrain antenna at 1.42 GHz have also been done for comparison with the clear aperture antenna. The focal length to diameter ratio for the symmetric antenna is 0.4. The half-cone angle to the edge of the subreflector is 13.89°. The subreflector is illuminated with a -12 dB taper, identical to the clear aperture cases. Figure 4 shows the subreflector scattered pattern at 1.42 and 5.0 GHz. The taper at the edge of the main reflector is -14.6 and -15.0 dB, respectively. In Figure 5, T_r for the symmetric antenna at different elevations is shown along with the unblocked cases. For most of the elevation angles, T_r of the symmetric antenna is between that of the arm at the bottom and arm at the top. Figure 6 shows T_f for the same cases. In case of the symmetric antenna for elevations lower than 40°, T_f increases rapidly and reaches 11 K at 10°, where about 35% of the spillover hits the ground. Figure 7 compares the total spillover temperature for the three cases. It is interesting to note that the gregorian geometry with arm at the top has spillover more than the symmetric antenna at most elevation angles. The cassegrain geometry is consistently better than the symmetric antenna at all elevation angles. However, with the addition of the contribution to system temperature from scattering (T_{sc}) by aperture blockage, the symmetric antenna gets worse than the clear aperture cases at all elevation angles as seen in Figure 8. The scattering component used is not calculated but obtained from measurements (at JPL), which is about the typical in a symmetric antenna. For the unblocked antenna, T_{sc} in the range of 0.2 to 0.5 K is used on the assumption that its sidelobes are lower than that of the symmetric antenna by -20 db.

TABLE 1. SPILLOVER NOISE TEMPERATURE AT 5.0 GHZ

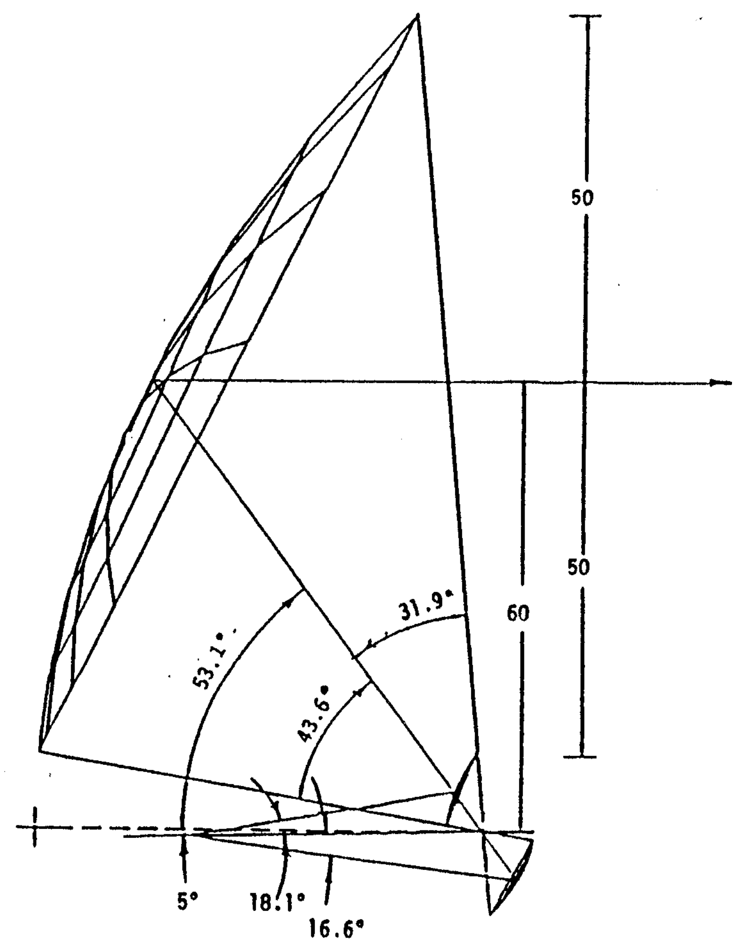
ELEVATION	REAR T_r (K)		FORWARD T_f (K)		TOTAL T_{sp} (K)	
(Degrees)	Cass. Bottom	Greg. Top	Cass. Bottom	Greg. Top	Cass. Bottom	Greg. Top
90	2.357	2.357	0.650	0.650	3.007	3.007
75	1.763	2.445	0.595	0.607	2.358	3.052
60	1.423	2.488	0.586	0.672	2.009	3.160
45	1.307	2.522	0.641	0.721	1.948	3.243
30	1.109	2.557	0.679	0.744	1.788	3.301
20	0.860	2.571	0.754	0.940	1.614	3.511
10	0.582	2.584	0.860	1.843	1.442	4.427

TABLE 2. SPILLOVER + SCATTERED NOISE TEMPERATURE AT 1.42 GHZ

ELEVATION	REAR T_r (K)	FORWARD T_f (K)	TOTAL SPILLOVER T_{sp} (K)	SCATTERED T_{sc} (K)	TOTAL $T = T_{sp} + T_{sc}$ (K)		
(Degrees)	Symmetric	Symmetric	Symmetric	Symmetric	Symmetric	Cass. Bottom	Greg. Top
90	3.140	0.547	3.687	2.30	5.987	3.716	3.716
75	3.037	0.615	3.652	2.55	6.202	2.790	3.910
60	2.354	0.670	3.024	2.75	5.774	2.529	4.139
45	2.038	0.687	2.725	3.70	6.425	2.444	4.225
30	1.927	1.002	2.929	4.80	7.729	2.379	4.389
20	1.852	2.504	4.356	5.20	9.556	2.261	4.590
10	1.853	11.158	13.011	5.20	18.211	2.151	5.620

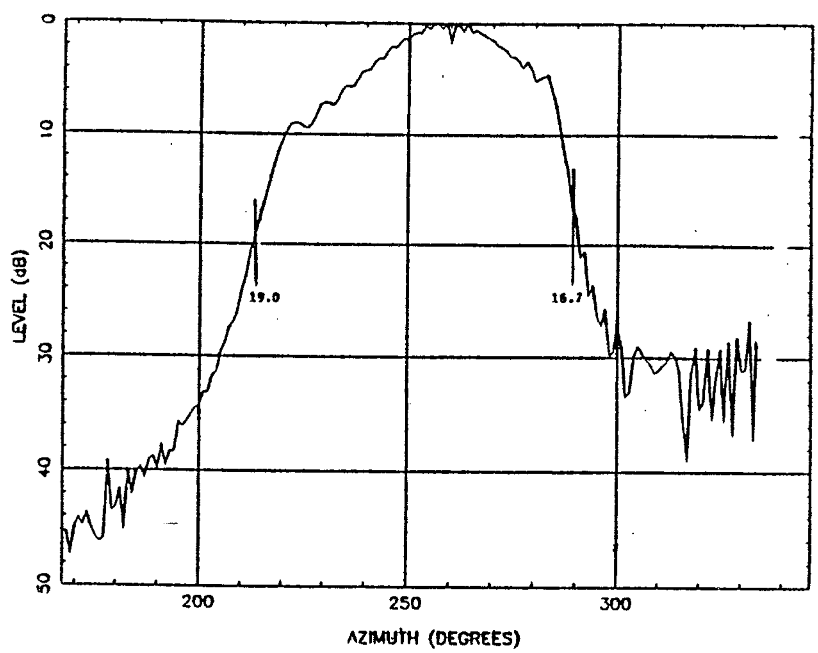


(a) Arm at the Top.

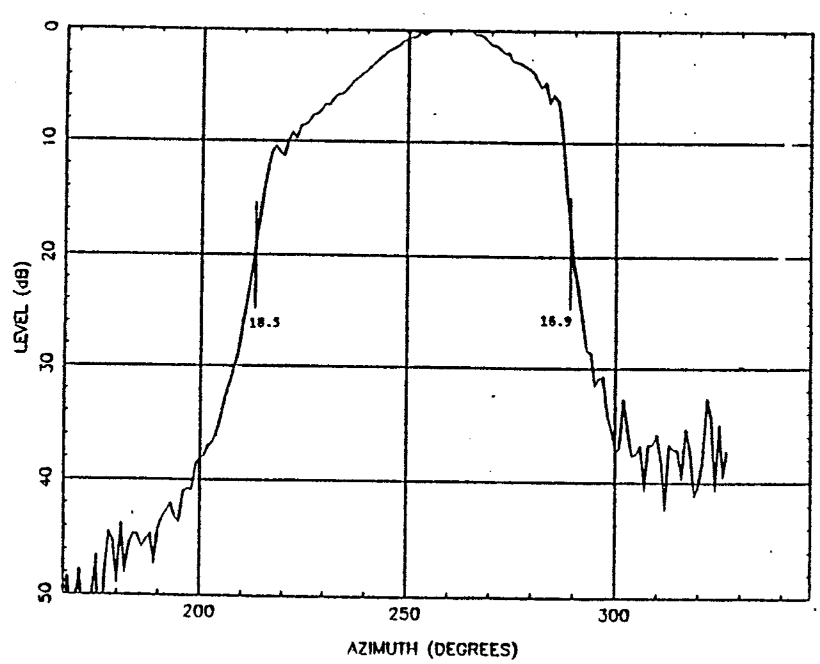


(b) Arm at the Bottom.

Fig. 1. Cassegrain, Gregorian Geometry (Clear Aperture Antenna).



(a) 1.42 GHz



(b) 5.0 GHz

Fig. 2. Subreflector Scattered Pattern in the Plane of Symmetry (Clear Aperture Antenna).

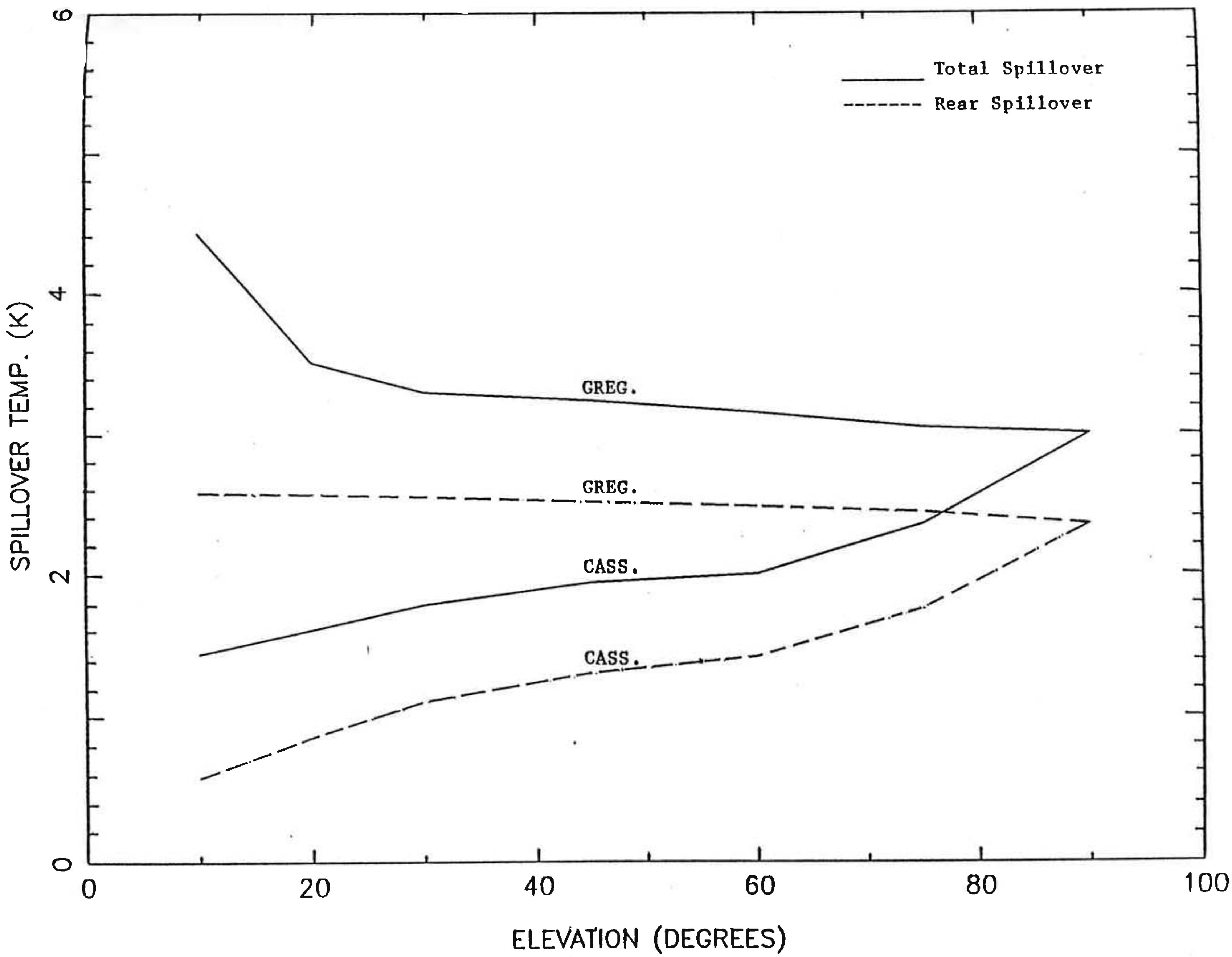
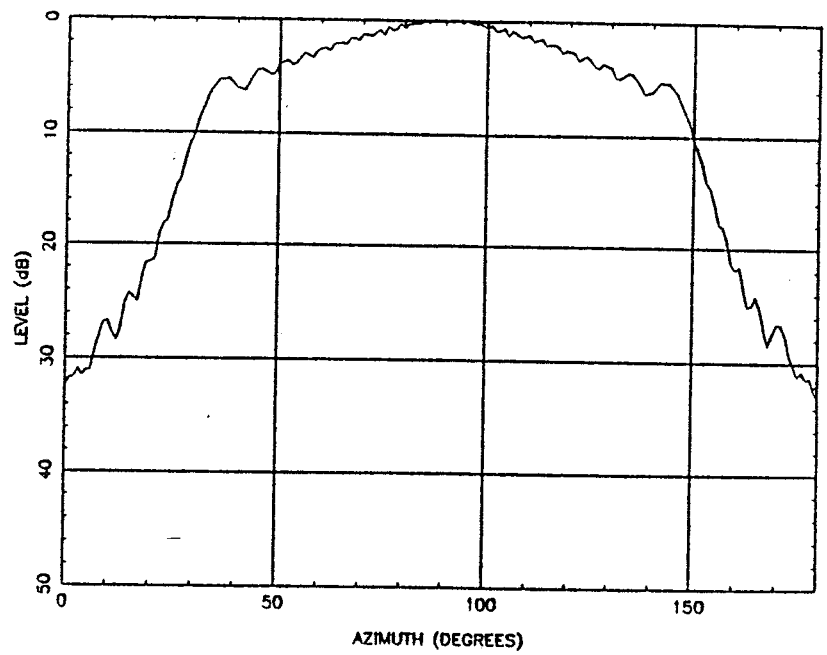
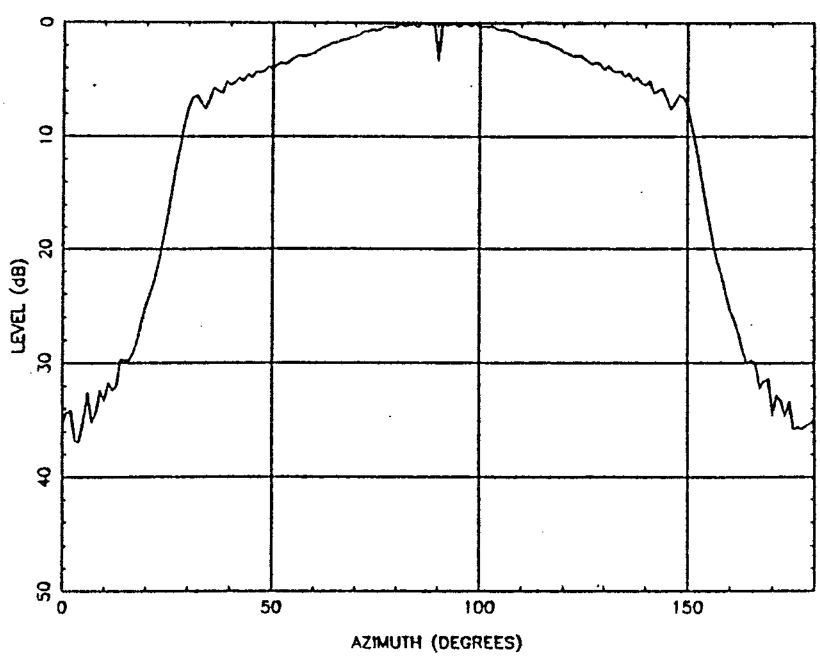


Fig. 3. Spillover Noise Temperature at 5.0 GHz. Cassegrain at the Bottom (Cass.) vs. Gregorian at the Top (Greg.)



(a) 1.42 GHz



(b) 5.0 GHz

Fig. 4. Subreflector Scattered Pattern (Symmetric Antenna).

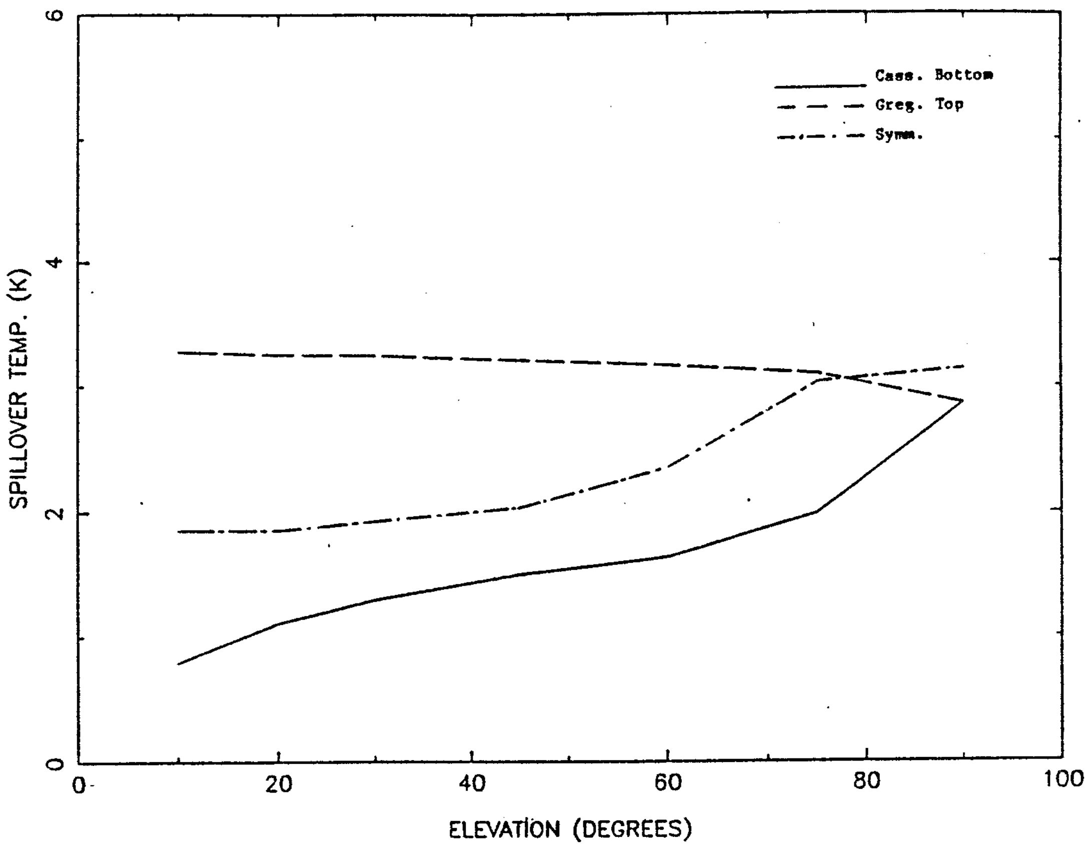


Fig. 5. Rear Spillover Noise Temperature (T_r) at 1.42 GHz.

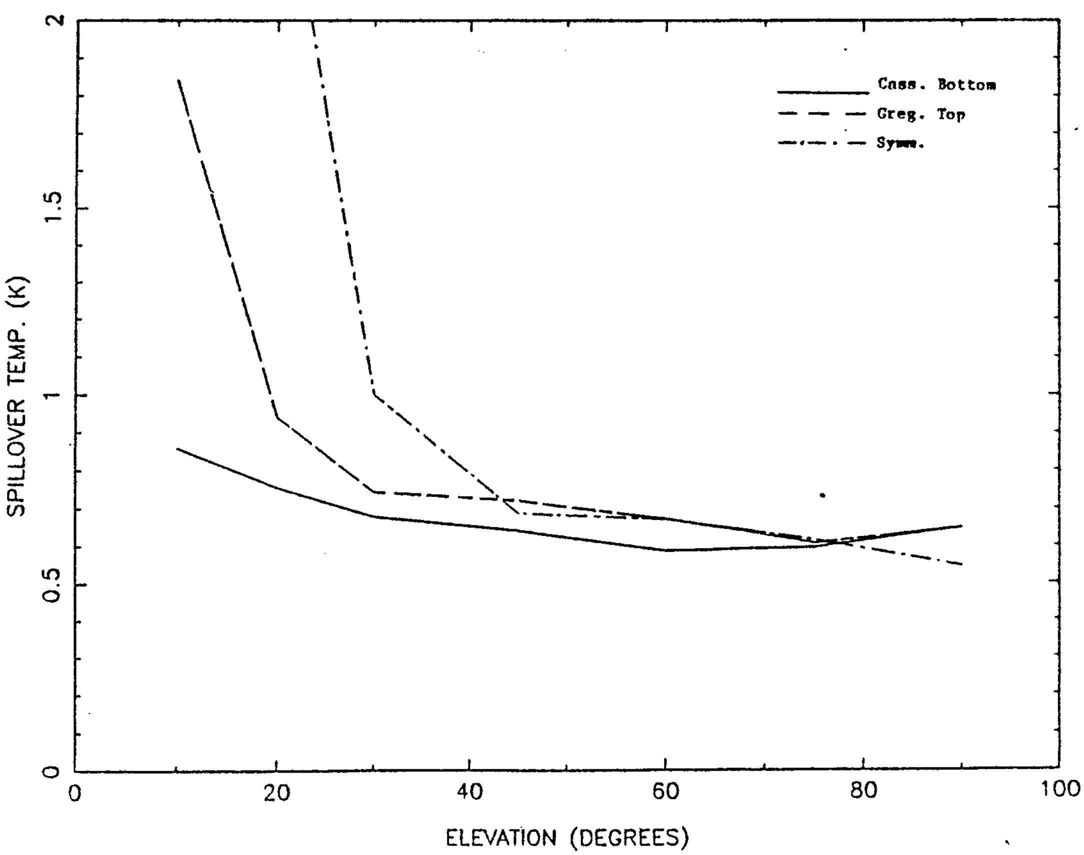


Fig. 6. Forward Spillover Noise Temperature (T_f) at 1.42 GHz.

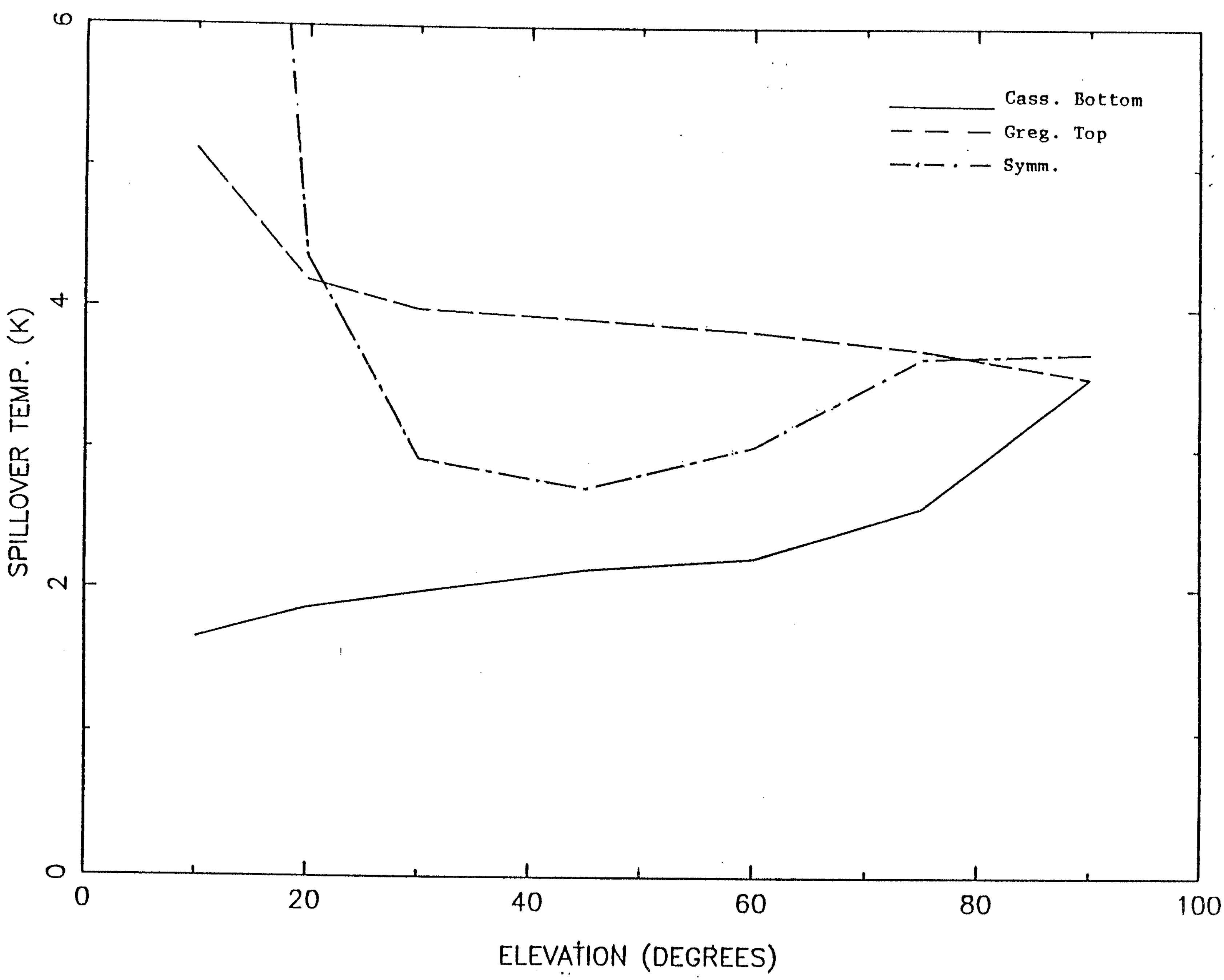


Fig. 7. Total Spillover Noise Temperature (T_{sp}) at 1.42 GHz.

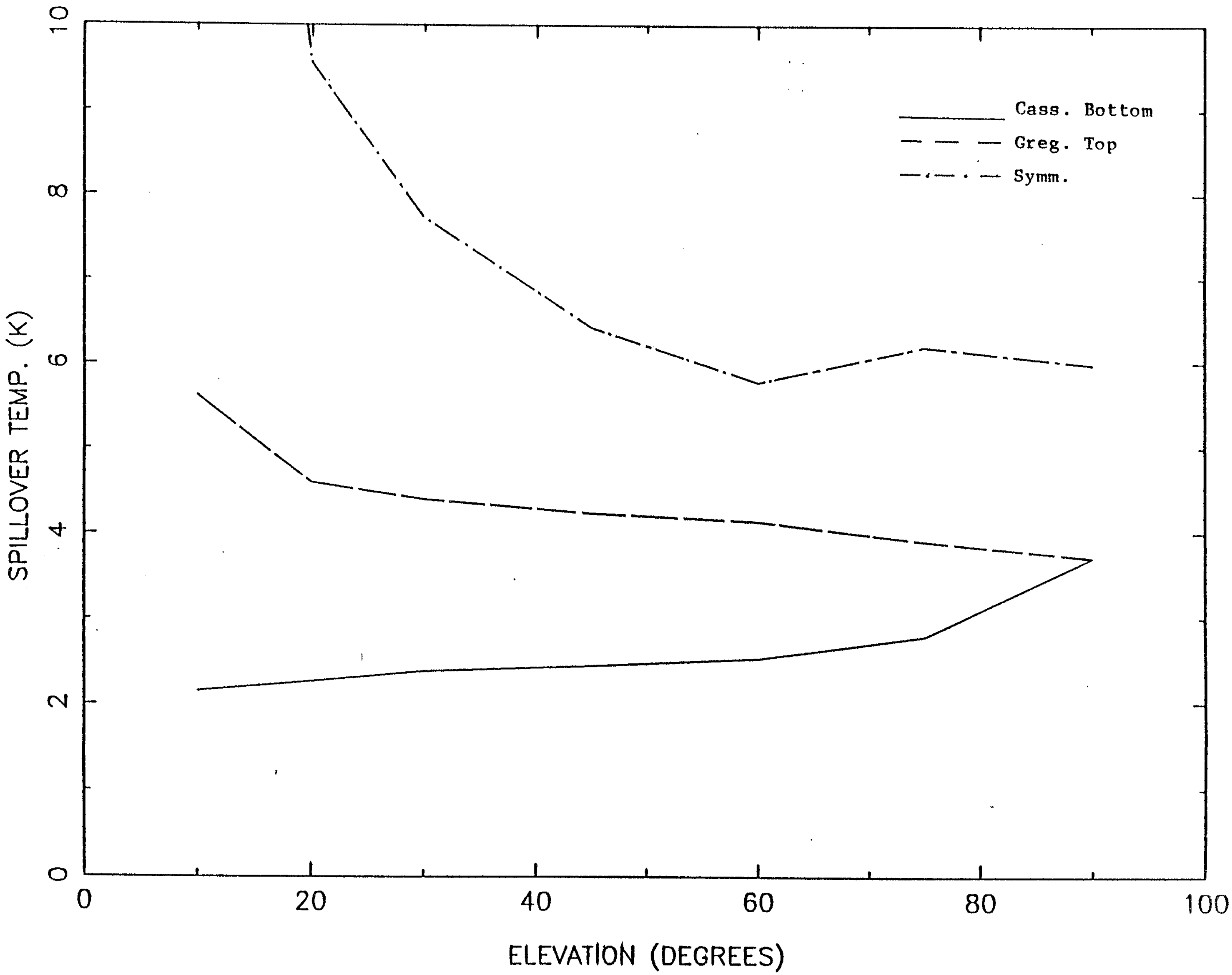


Fig. 8. Scattered + Spillover Noise Temperature (T) at 1.42 GHz.