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WCAM PROTOTYPE FEED HORN DESIGN (WCAM-PROT01)

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Abstract

This Technical note reports the electromagnetic design of the a W-band feed horn prototype with the aim to investigate the manufacturing technologies for building a large number of feeds.

1. INTRODUCTION

Future CMB polarization experiments require a large amount of feeds to obtain a measurement sensitivity at sub-microK level. The manufacturing technology is one of the limiting factor for building a very large number (~ 1000) of corrugated feed horns. Electroformation and direct machining are the best way to manufacture corrugated feeds but such technologies are quite expensive. Other solutions must be identified with the aim to produces a large number of feeds at the same time at limited costs, as for example the possibility to manufacture platelet corrugated horns (R. J. Haas, 1993; M.M. Kangas, 2005). The horn has been designed in W-band, considering the possibility to manufacture it by electro-formation, direct machining and as a sandwich of plates.

2. ELECTROMAGNETIC DESIGN

The electromagnetic design starts form an existing design (F. Villa, 1997). Firstly, the design has been scaled form the existing one. Secondly the corrugation step has been adjusted to 1 mm in order to eventually use standard aluminum plates. Lastly, the radius of the circular waveguide at the throat region has been adapted in three steps form 1.87mm to 1.49mm in order to use an existing circular- rectangular transition.

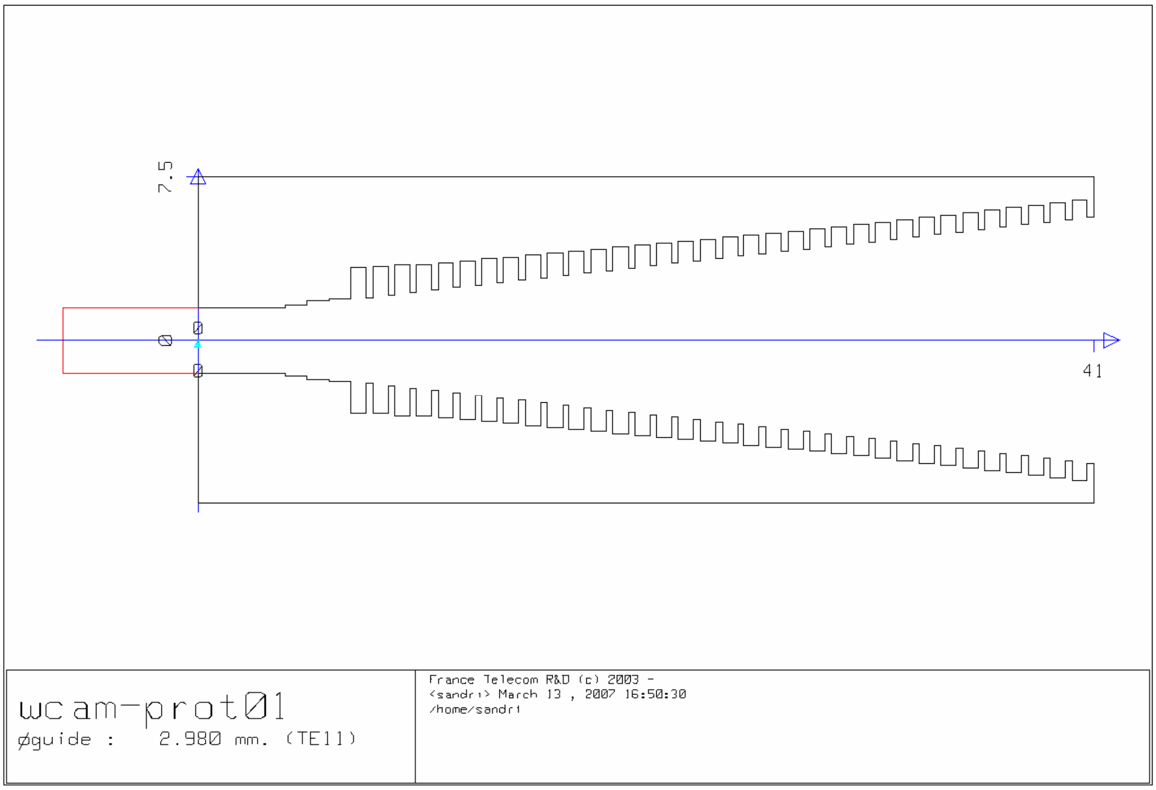

***Figure 1** – Horn Design as obtained graphically using SRSR-D software.*

In addition a straight section 4mm long has been added to purify the TE11 mode at the throat. No further optimizations have been performed form electromagnetic point of view, since this is for manufacturing investigation only. Each teeth and groove are 0.3mm and 0.7mm wide respectively.

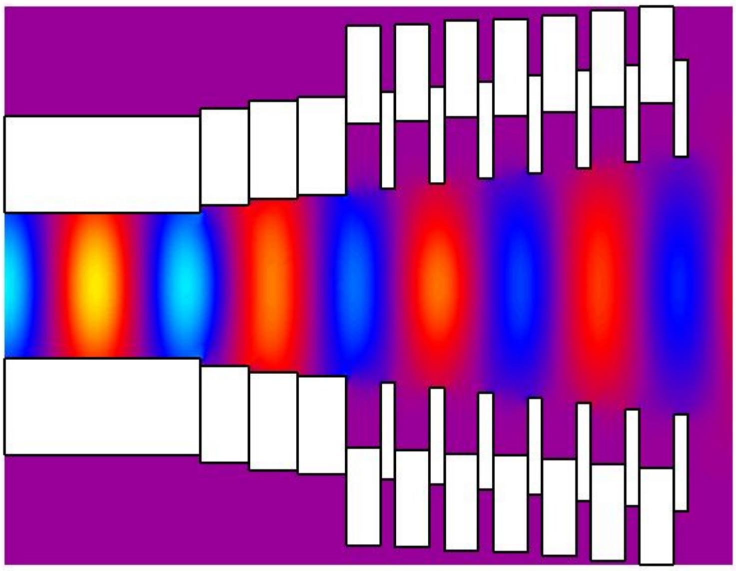

Figure 2 – *Electric field at 100GHz as propagates in the first 7 corrugations. Simulation performed with © CST microwave studio*

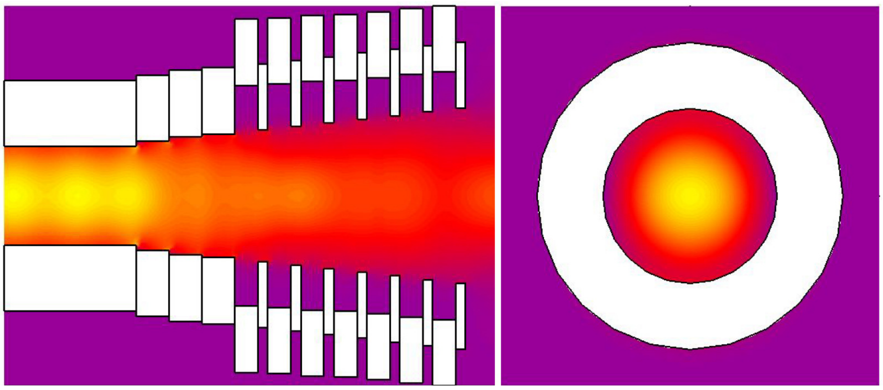

Figure 3 – *Amplitude of the electric fieldat 100GHz in the first 7 corrugation. It is recognized that the field is well formed and confined as expected. Simulations performed with © CST microwave studio*

In table above the corrugation geometry is reported. Radii and thickness are reported in mm.

N	R [mm]	L [mm]	N	R [mm]	L [mm]	N	R [mm]	L [mm]
1	1.49	4.0	**25**	4.11	0.7	**49**	5.20	0.7
2	1.64	1.0	**26**	3.09	0.3	**50**	4.41	0.3
3	1.79	1.0	**27**	4.19	0.7	**51**	5.31	0.7
4	1.87	1.0	**28**	3.20	0.3	**52**	4.52	0.3
5	3.34	0.7	**29**	4.29	0.7	**53**	5.42	0.7
6	1.98	0.3	**30**	3.31	0.3	**54**	4.63	0.3
7	3.38	0.7	**31**	4.38	0.7	**55**	5.53	0.7
8	2.09	0.3	**32**	3.42	0.3	**56**	4.74	0.3
9	3.46	0.7	**33**	4.47	0.7	**57**	5.64	0.7
10	2.20	0.3	**34**	3.53	0.3	**58**	4.85	0.3

N	R [mm]	L [mm]	N	R [mm]	L [mm]	N	R [mm]	L [mm]
11	3.48	0.7	35	4.55	0.7	59	5.75	0.7
12	2.31	0.3	36	3.64	0.3	60	4.96	0.3
13	3.56	0.7	37	4.64	0.7	61	5.86	0.7
14	2.42	0.3	38	3.75	0.3	62	5.07	0.3
15	3.66	0.7	39	4.73	0.7	63	5.97	0.7
16	2.53	0.3	40	3.86	0.3	64	5.19	0.3
17	3.74	0.7	41	4.82	0.7	65	6.08	0.7
18	2.64	0.3	42	3.97	0.3	66	5.30	0.3
19	3.83	0.7	43	4.91	0.7	67	6.19	0.7
20	2.75	0.3	44	4.08	0.3	68	5.41	0.3
21	3.93	0.7	45	5.00	0.7	69	6.31	0.7
22	2.86	0.3	46	4.19	0.3	70	5.52	0.3
23	4.01	0.7	47	5.09	0.7	71	6.42	0.7
24	2.98	0.3	48	4.3	0.3	72	5.63	0.3

3. Electromagnetic Performances

The VSWR and radiation patterns have been calculated at 90 GHz, at 92.5 GHz, from 95.0GHz to 105GHz with a step of 0.25GHz, then at 107.5GHz and at 110GHz with SRSR-D FranceTelecom software. The return loss can be derived form VSWR using

$$RL = 20 \cdot \log\left(\frac{VSWR-1}{VSWR+1}\right)$$

As a reference a VSWR of 1.04 corresponds to a return loss of about –34 dB. The return loss of this horn peaks at –32.8 dB (see Figure 11).

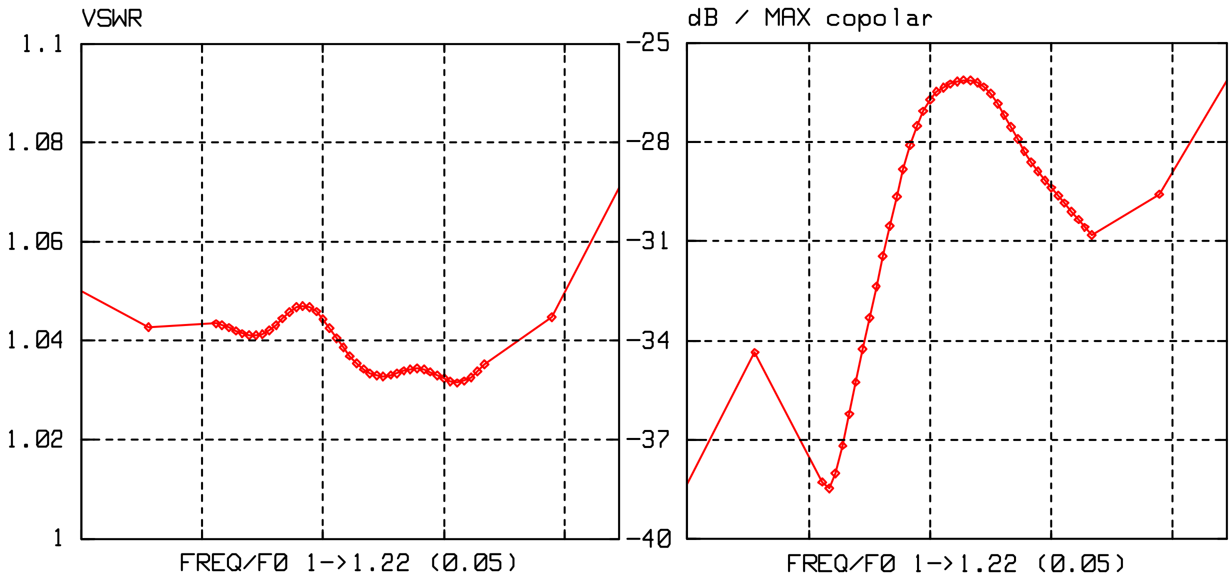

***Figure 4** – Left figure is shown the VSWR as function of frequency from F0 (90GHz) to 1.22*F0 (110 GHz). Right figure shown the cross-polar peak as function of frequency in the same units.*

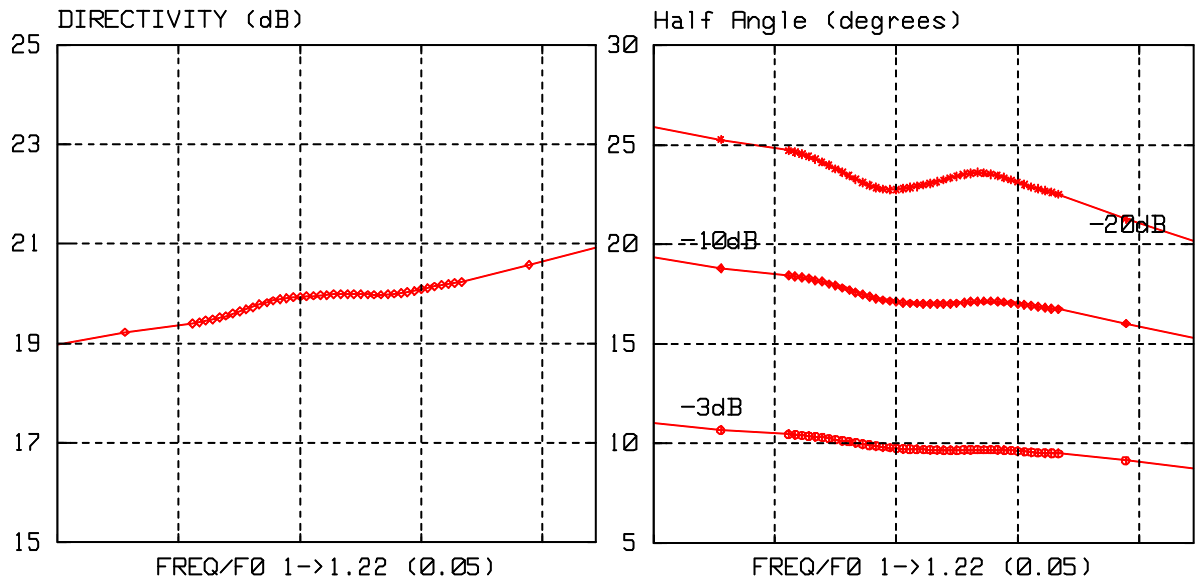

Figure 5 – *Left figure is shown the Directivity as function of frequency from F0 (90GHz) to 1.22*F0 (110 GHz). Right figure shown the half beamwidth at -3dB, -10dB, and -30dB as function of frequency in the same units.*

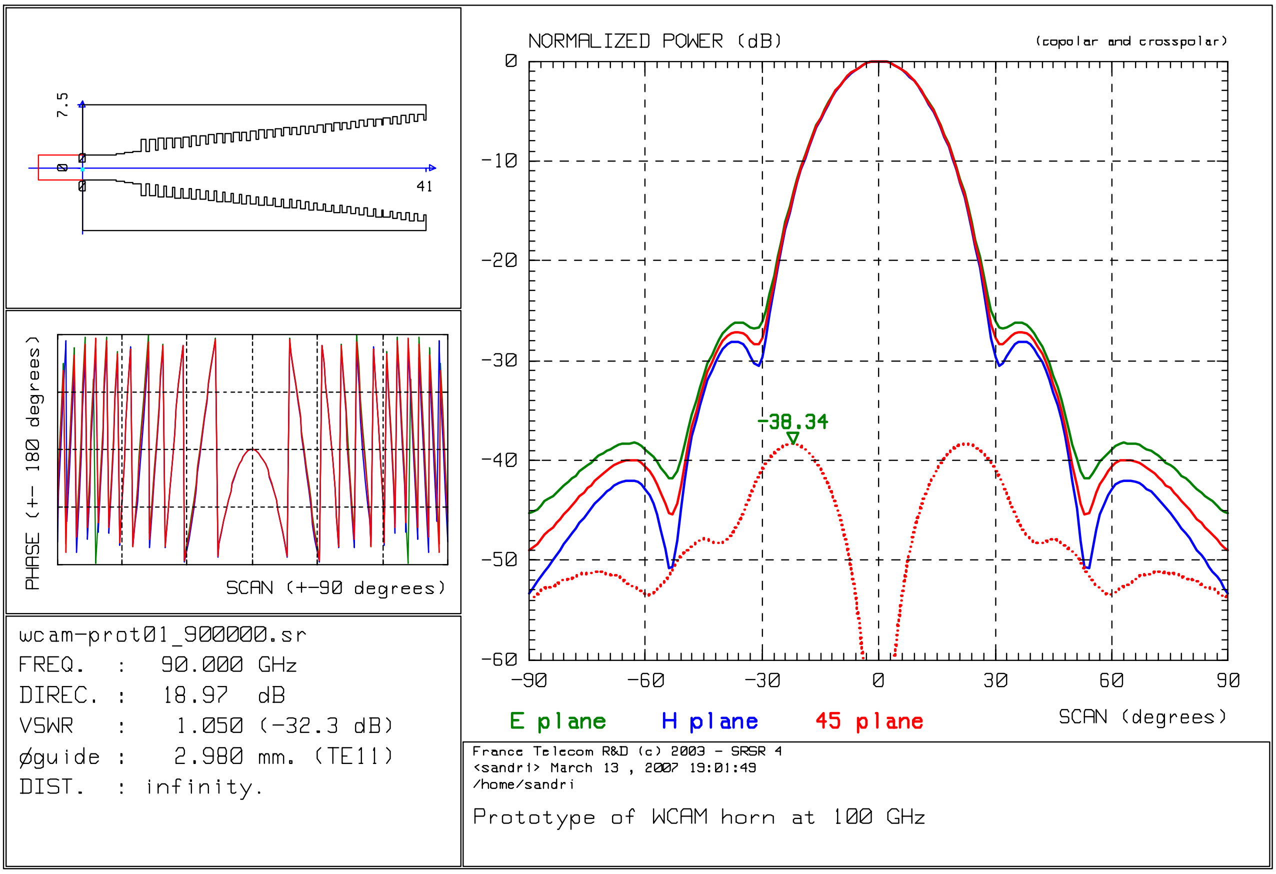

Figure 6 *– Radiation Pattern at 90GHz.*

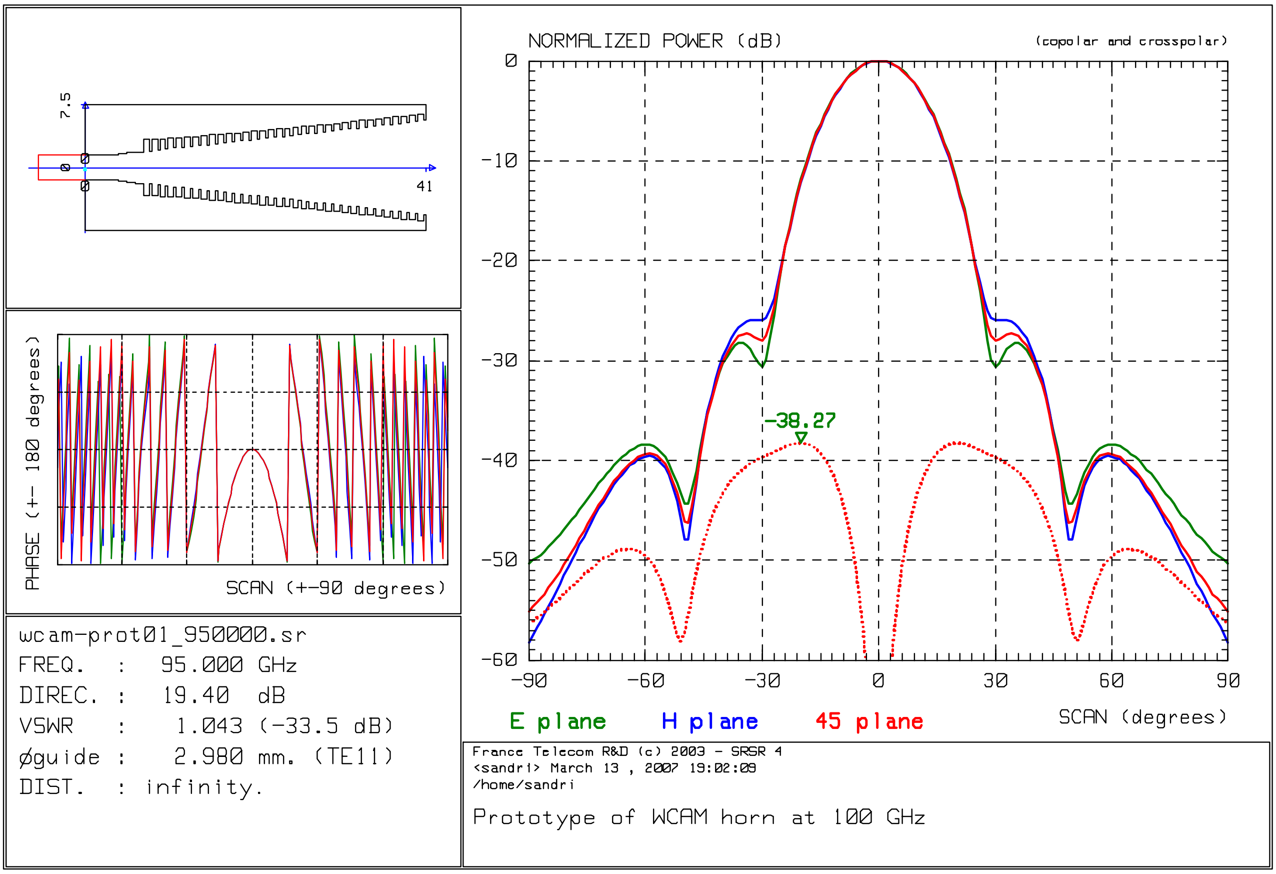

***Figure 7** – Radiation Pattern at 95GHz.*

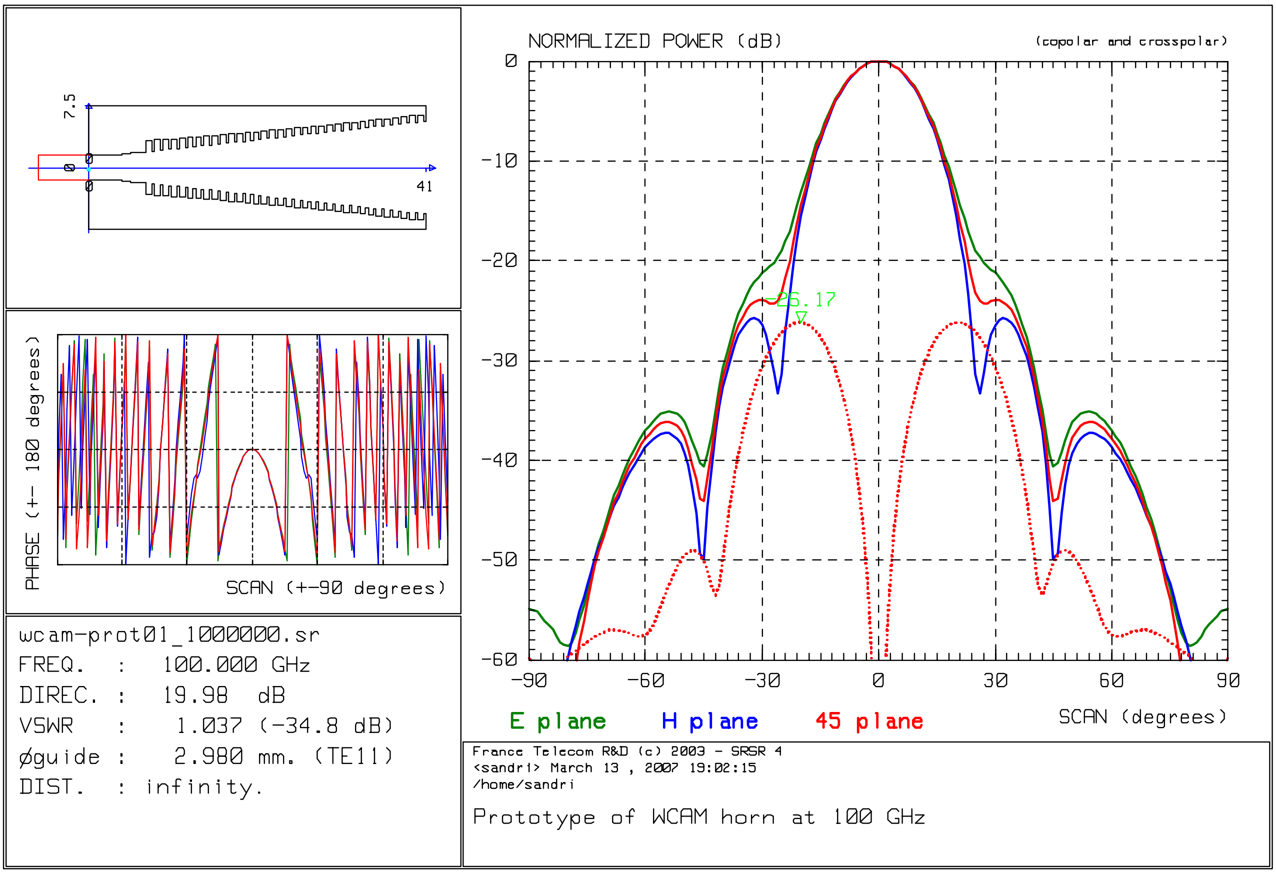

***Figure 8 –** Radiation Pattern at 100GHz.*

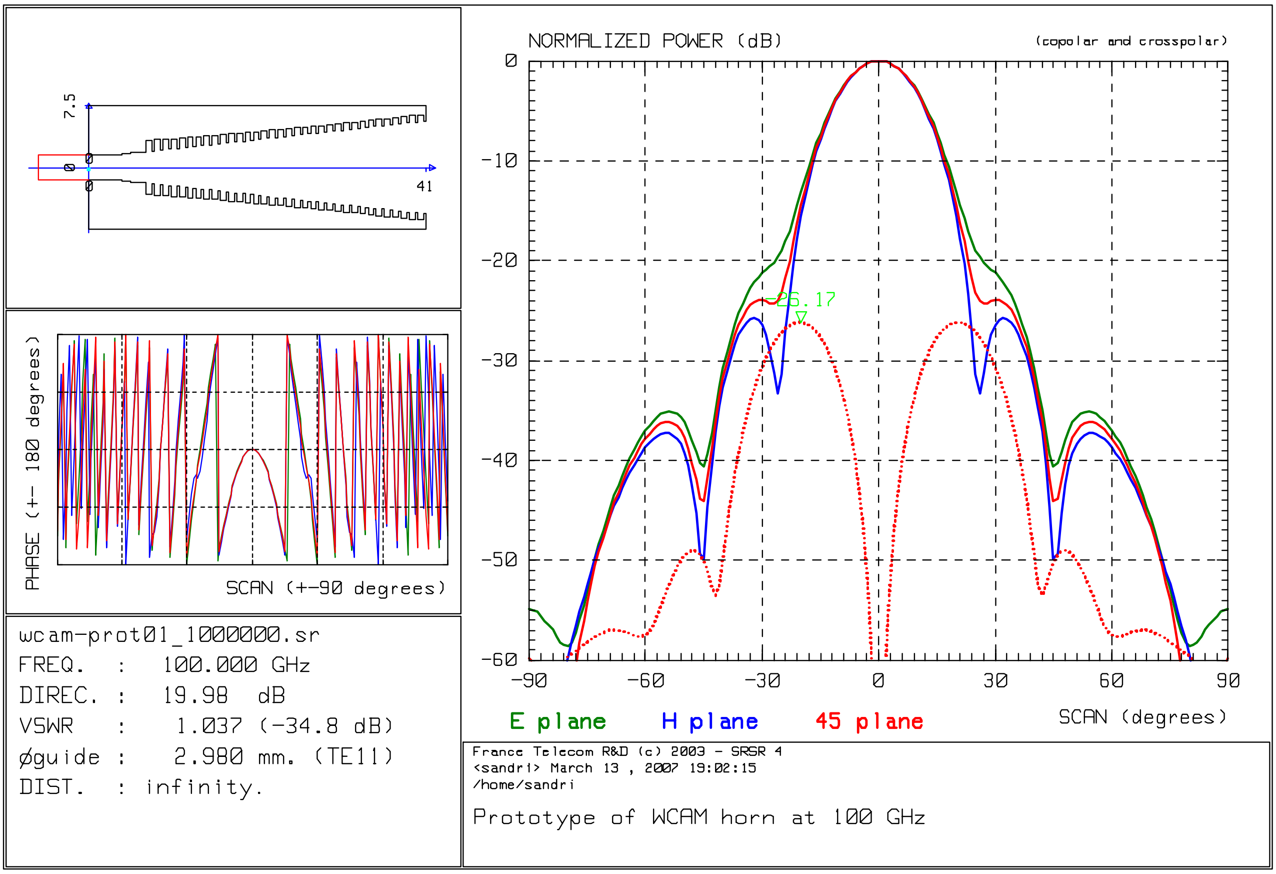

***Figure 9** – Radiation Pattern at 105GHz.*

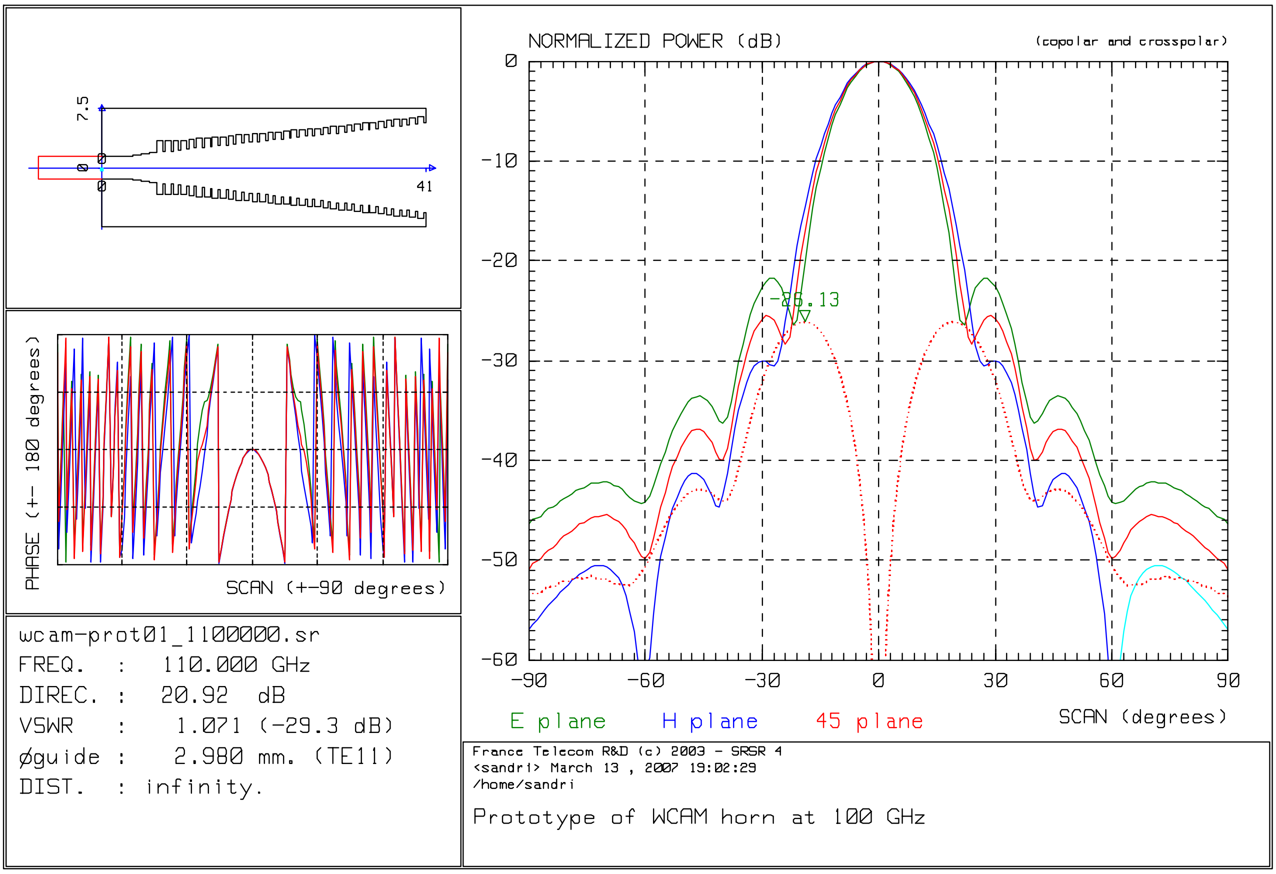

***Figure 10** – Radiation Pattern at 110GHz.*

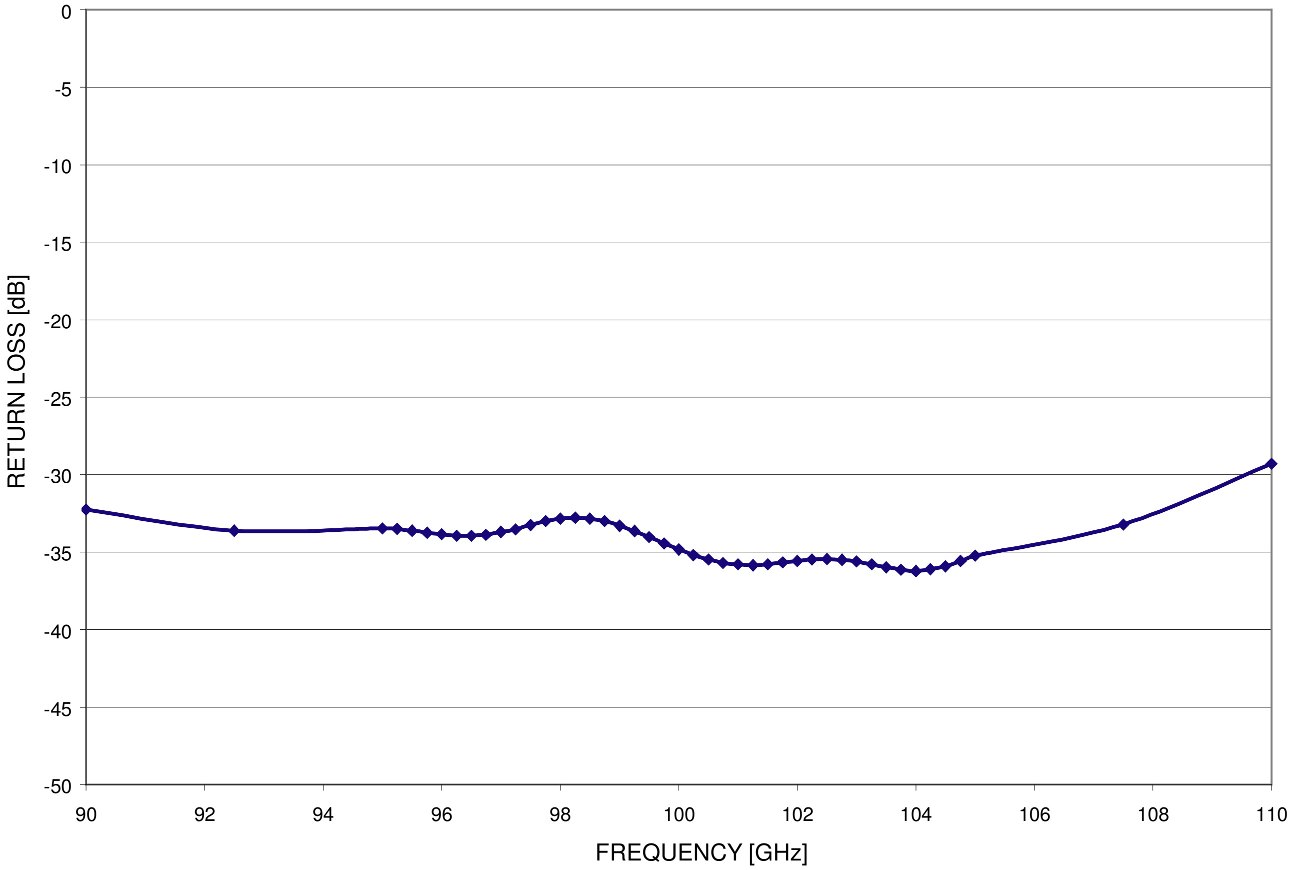

Figure 11– *Return Loss in dB as function of frequency*

4. REFERENCES

[1] Robert W. Haas, Dennis Brest, Harry Mueggenburg, Lee Lang and Dave Heimlich, *Fabrication and performance of MMW and SMMW platelet horn arrays,* International Journal of Infrared and Millimeter Waves, Issue Volume 14, Number 11 / November, pp. 2289-2294, (2003)

[2] Miikka M. Kangas, Markus Ansmann, Keith Copsey, Briony Horgan, Rodrigo Leonardi, Philip Lubin, and Thyrso Villela , *a 100-GHz High-Gain Tilted Corrugated Nonbonded Platelet Antenna*, IEEE antennas and wireless propagation letters, VOL. 4 (2005)

[3] F.Villa, M.Bersanelli, N.Mandolesi, *Design of Ka and Q Band Corrugated feed Horns for CMB Observations,* Internal Report ITESRE 188/1997 (1997)