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Mutlimode Horns for VSOP-2 Satellite

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1. Introduction

Angular resolution of a radio telescopes improves with larger aperture diameter. VLBI(Very Long Baseline Interferometer) has greater resolution than a single-dish telescopes because the distances of telescopes are several hundreds km. VSOP(VLBI Space Observatory Programme) uses radio telescopes on a satellite to extend the baseline over the diameter of the earth. The first VSOP satellite in the world, "HALCA" terminated its mission life in the end of 2005, and the next, VSOP-2 satellite is planned in NAOJ and JAXA, which has higher observational bands and sensitivity than the first.

Antenna optics of VSOP-2 is offset Cassegrain optics to lower cross polar and avoid the blocking of the sub-reflector. Main reflector is composed of 7 hexagonal metal meshed mirrors to fit the paraboloid and deployed after reached the orbit. 3 horns, for X,K,Q-band, are closely placed on the focus, and they have own two individual amplifiers for each left/right circular polarizations to be able to observe Polarization in a selected band, show in table 1. For switching the bands, the starlit changes its direction. Their dimensions of the horns are shown in fig 1 for examples.

2. Multimode Horn

Previously, corrugated horns were planed for low cross-polar optics, however they have narrow edges in the inner walls which are difficult in fabrication with GFRP. Straight conical horns are simple but their beam width are quit different in E-plane and H-plane. The horns for the satellite also should have short axial length as possible, however conical horns and corrugated horns has difficulty in shorten the length, because of the excitations of higher modes at the edge of the different flare angles.

However, controlled higher mode excitations in multimode horns enable us to reduce the axial length with low cross polarization and simple horn structure. Thus, the Author proposed multimode horns for VSOP-2 in the end of 2005. Rational bandwidth of VSOP-2 are around 10% typically. When polarizer bandwidth are successfully extended to cover 6.7GHz for methanol maser observation, the bandwidth of X-band horn should be extended.

They have simple shapes as shown in figs, however they have more design parameters such as diameters, length, mode-amplitudes in each sections than the conical and corrugated horns. Therefore numerical simulations are necessary to design and evaluate the characteristics of horns.

3. Numerical Simulations

There are several methods to calculated the horn characteristics. "Generalized Telegraphist's Equation" [1] uses to expand the field in the horn with the basis of linear waveguide everywhere included tapered sections. This method is simple, however the field in the equation described as voltage and current lead amplified solutions under cutoff frequency which degrade the accuracy of the solutions in smaller radius. DEGUCHI, et.al [1] avoid the difficulty by limiting the calculated modes with real wave-numbers. However they mentioned arbitrary field can be expanded everywhere in the horn with linear waveguide modes, they neglected the modes with large imaginary wave-numbers without physical reasons.

Expansions with tapered waveguide modes are simple which describes mode transfer at the edge of the tapered sections with difference of flare angles. However, they depend on numerical tables for mode transitions of various angles.

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Table 1: Observational Bands for VSOP-2

	Specifications	
	Frequency[GHz]	notes
X-Band	8.0-8.8	nominal
	6.5-7.0	additional
K-Band	20.6-22.6	
Q-Band	41.0-45.0	cutoff for 37GHz down-link

Thus, CAHMP is used for the simulations, which uses mode-matching at the interfaces of very short modules divided in the horn for mode transitions. This software is made by TICRA, and shipped with GRASP-8w for antenna optics simulations. The Author added wrapper programs to provide input files and evaluate the beam patterns for feed-back in numerical optimizations.

The horns have restricted aperture size and positions by cooled receiver dewar size and aberrations of the antenna optics.

Optimizations of multimode horns are complex. Thus, to simplify the optimization process, the horn structure is divided in two sections, which are mode and beam width converter. At first step, mode converter sections is designed by the conditions to minimize cross polarization. The next, the beam width converter is followed to the mode-converter is shaped with gradually changing its radius to fit the beam width with optics and to avoid extra higher mode excitation.

The axial length of horns are reduced to under 70% of conical and corrugated horns previousely planed. Q-band horn in this examples, has a filter section to reject the down link signals in 37GHz band by the cutoff of reduced radius.

Beam patterns and characteristics of horns are shown in figs. 2, 3, 4. They have sufficiently lower cross polarization than conical horns and shorter length than corrugated horns. In addition, the depth of the corrugation in corrugated horn needs excess outer radius. In the case of multimode horns, rooms for the corrugations may be used for adding higher modes to improve the illumination.

4. Developing Plans

In these examples, TE11 and TM11 are controlled and their measurement are planed in this year. After the measurement, TE12 and TM12 may be added to improve the illumination on the reflectors for the next step. These results will be shown at this conference.

References

[1] Hiroyuki DEGUCHI,et.al, “An Analysis of Multimode Conical Horn Antennas with Flare-Angle Changes by using Generalized Telegraphist’s Equation” IEICE Journal, Vol. J79-B-II, No. 1 pp.33-41,1996

[2] Takashi EBISUI, TakashiKATAGI, “High Efficiency Dual-Mode Horn Antenna” IEICE Journal, Vol. J65-B-II, No. 5, pp.664-665,1982

[3] Takashi EBISUI and Osam ISHIDA, “12/14GHz Bands Double Flare Type Triple-Mode Horn” IEICE Journal, Vol. J73-B-II, No. 10, pp.546-553,1990

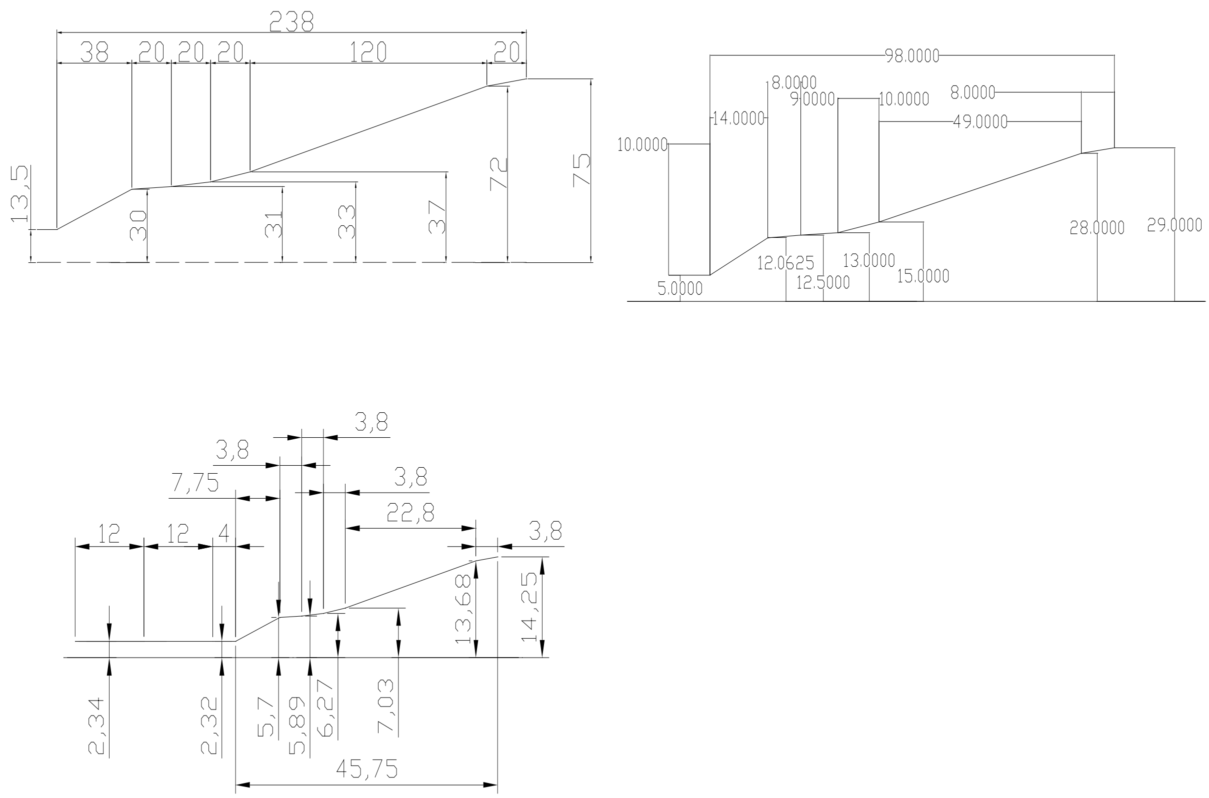

Figure 1: Dimensions of the horns for X-Band, K-Band,Q-Band

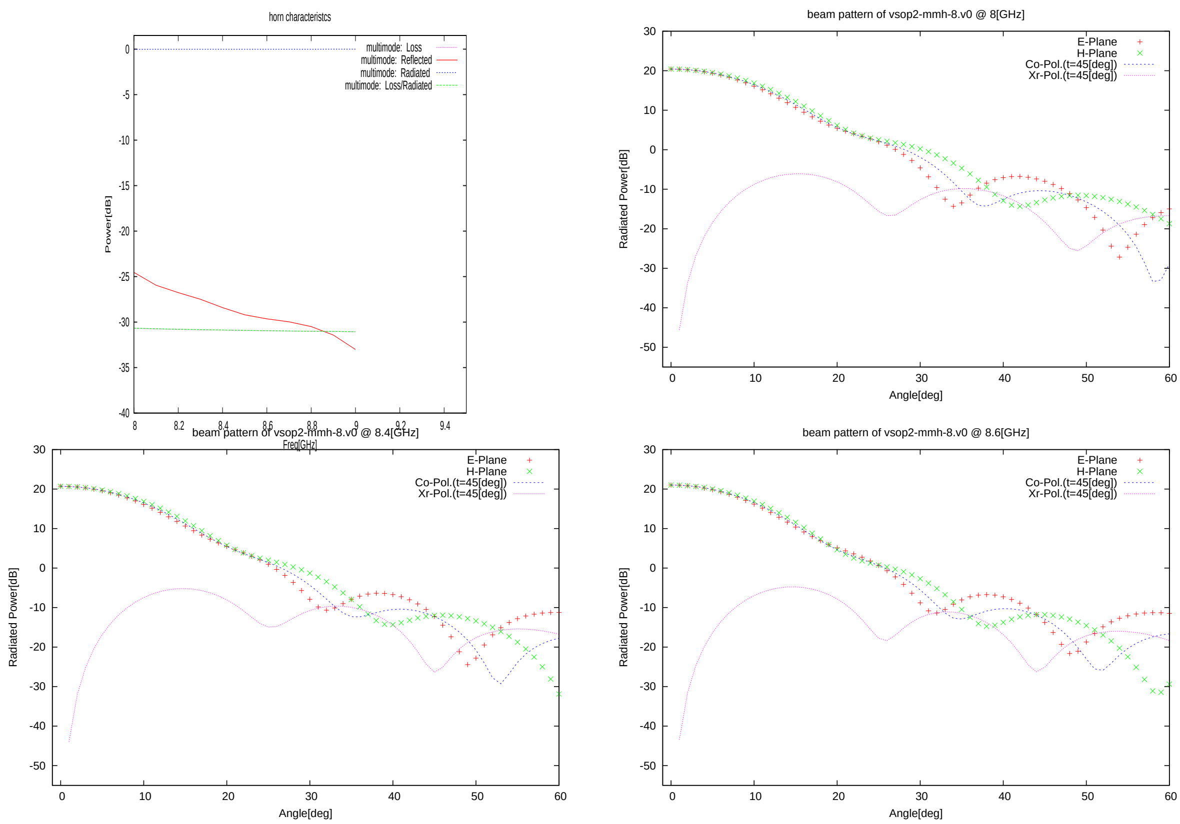

Figure 2: Characteristics and Beam Patterns of X-Band Horn at 8.0GHz,8.4GHz,8.8GHz

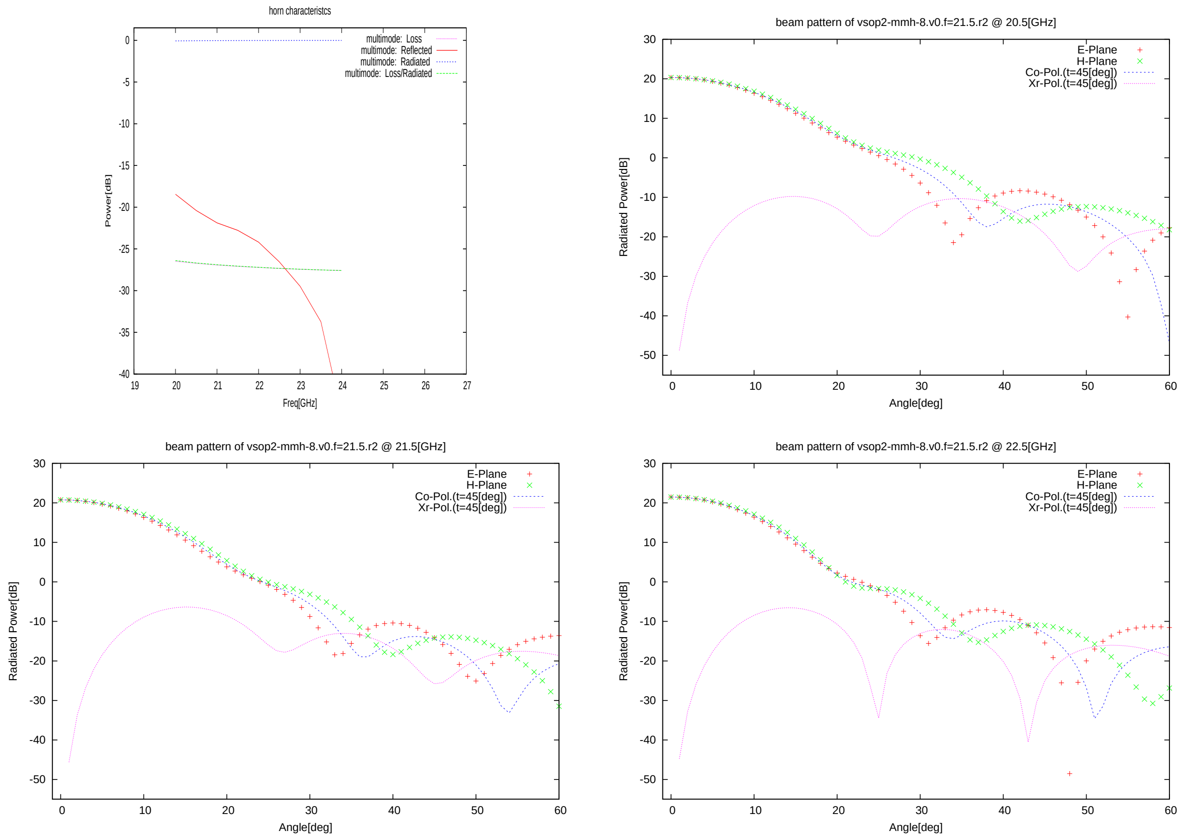

Figure 3: Characteristics and Beam Patterns of K-Band Horn at 20.5GHz,21.5GHz,22.5GHz,

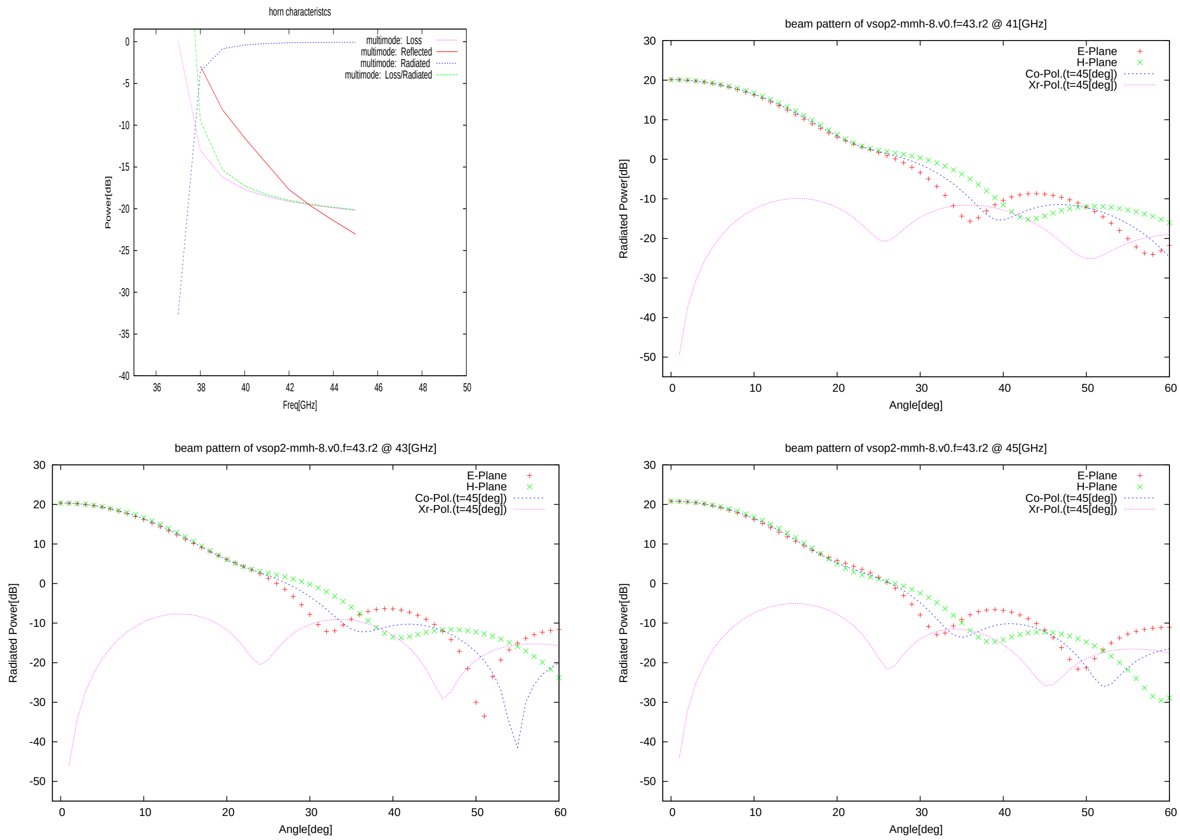

Figure 4: Characteristics and Beam Patterns of Q-Band Horn at 41.0GHz,43.0GHz,45.0GHz,