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THE ANALYSIS OF AN INPUT TRANSITION FOR THE CEDUNA HORN NEAR 12GHz

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1. Introduction

The 30m antenna at Ceduna, operated by the University of Tasmania, was originally owned by Telstra and operated as a satellite earth-station in the 4 and 6GHz bands. The University has requested the CSIRO ATNF to carry out research into extending the frequency range of the antenna through the use of feed-horn input sections to cover radio-astronomy bands outside the original design range, and microwave holographic measurements to evaluate the deformations in the reflector profiles.

The feed horn, which is situated at the tertiary focus is nominally 4.21m long with an aperture of 1.29m and a semi-angle of about 8.7°. The current modification requires a new input corrugated horn section which will operate over the nominal frequency range of 10.5 to 12.8GHz. Of particular importance is the band 12.25 to 12.75GHz for holography measurements using the Optus satellite as a source.

Since the existing fixed section of horn extending beyond an internal diameter of 121.1mm cannot be removed, the overall performance of the horn within any desired band will be determined by both the input section of horn (as designed) and the existing large output section.

For the nominal band of 10.5 to 12.8GHz, the slots in the output section are greater than one wavelength deep (so that slow waves, if excited, can propagate), and greater than one-half wavelength wide in the upper part of the band. Consequently to ensure that the required input section of horn operates with normal slot reactances, and at the same time to minimise the discontinuity (in reactance) between the two sections of horn, the nominal slot depth was made less than one-wavelength, and the slot width less than one-half wavelength, at 12.8GHz.

Finally, two input radii were used at the throat: 13.40mm to match (via a transition) to standard 8.2 to 12.4GHz rectangular waveguide, and 11.16mm to match 10.0 to 15.0GHz rectangular waveguide.

The dimensions of the two sections of horn were provided to Christophe Granet who calculated the return loss and radiation patterns for the input section of horn alone, and for the output section added, firstly by incremental lengths, and finally by calculating the patterns of the complete horn.

2. Analyses

The following horns were analysed:

- Option 0: Input horn only:
  13.40mm input radius with smooth taper to 14.60mm radius; slot-depth transition (over 10 slots), then constant depth slots extending to a radius of 121.10mm over 60 slots (see Fig. 1).

- Option 1: As for Option 0 but with an input radius of 11.16mm.

- Options 2, 3 and 4: With sections of the output horn added as follows (not shown):
  - Option 2: 10 slots added
  - Option 3: 20 slots added
  - Option 4: 40 slots added

- Options 5 and 6: Complete horn with input sections as for Option 0 and Option 1 above.

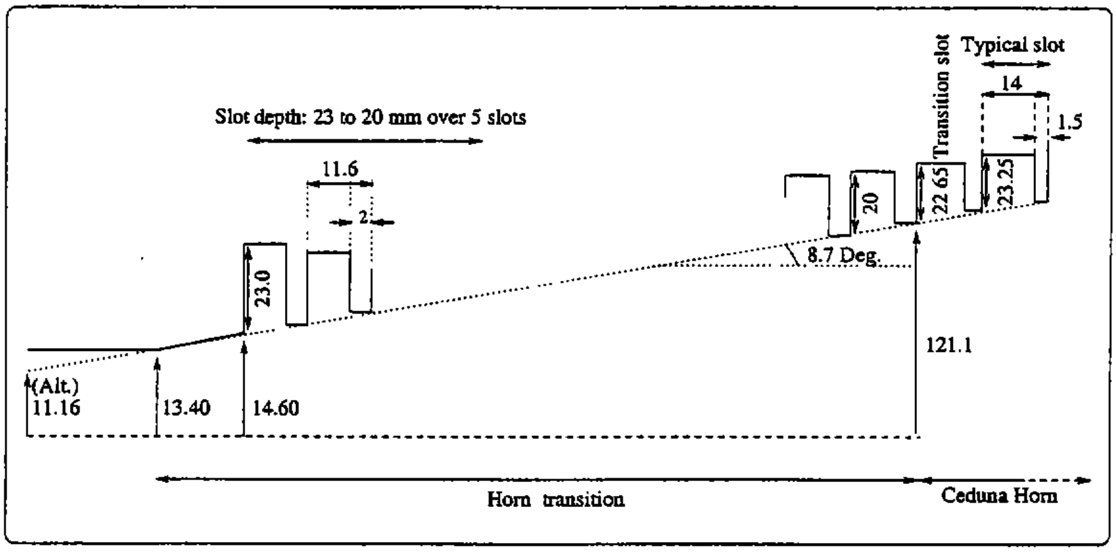


Figure 1: Geometry parameters.

3. Summary of Results

- Input horn: The results show that Option 0 (input radius 13.4mm) gives superior return loss and cross-polar performance than Option 1 (input radius 11.16mm).

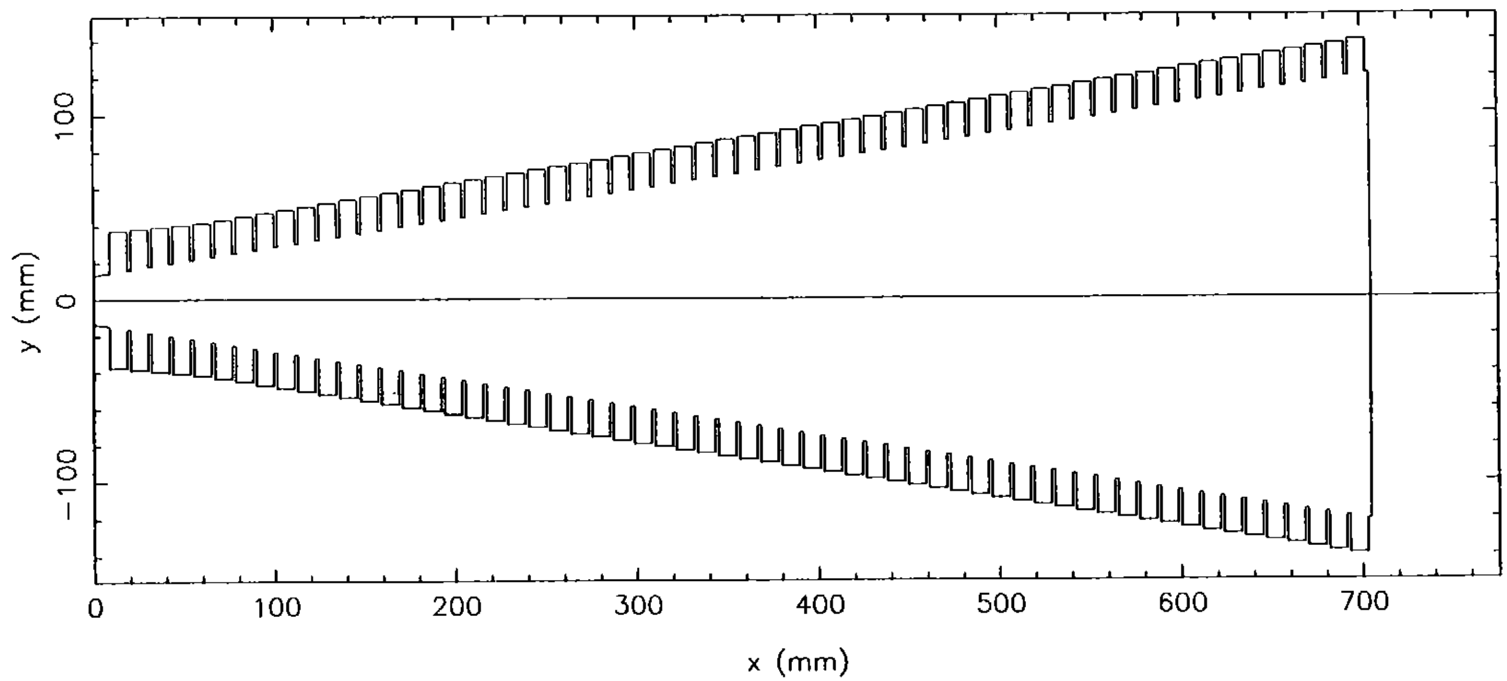
  For Option 0, the return loss is greater than 20dB for frequencies above 11.5GHz. The worst-case cross-polar sidelobe levels are –33dB at 12.8GHz.

- Adding sections of the output horn: The table below shows the effect on the off-axis cross-polar levels in the 45° plane of adding additional sections of the non-optimum output horn for the case where the input horn corresponds to Option 0.

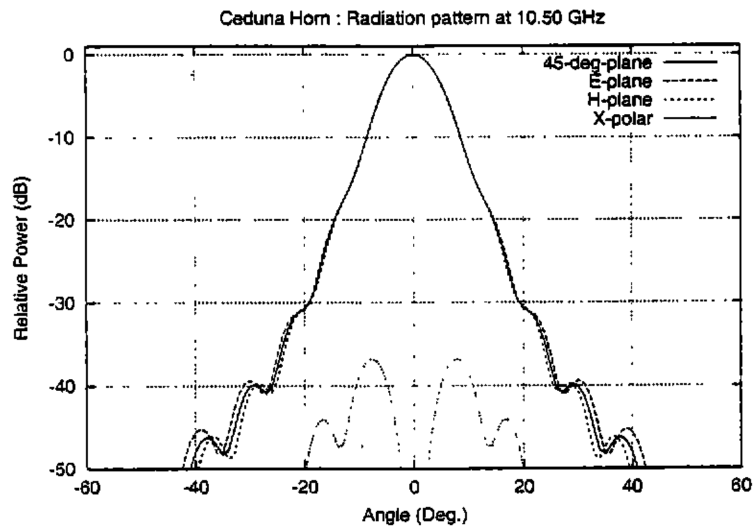
Cross-polar(dB) as a function of frequency(GHz) and output horn length

No. slots (output horn)	*10.5*	*11.5*	*12.2*	*12.5*	*12.8*
0	-37	-47	-45	-34	-33
20	-33	-41	-36	-31	-32
40	-37	-41	-30	-29	-27
245	-21	-25	-20	-19	-21

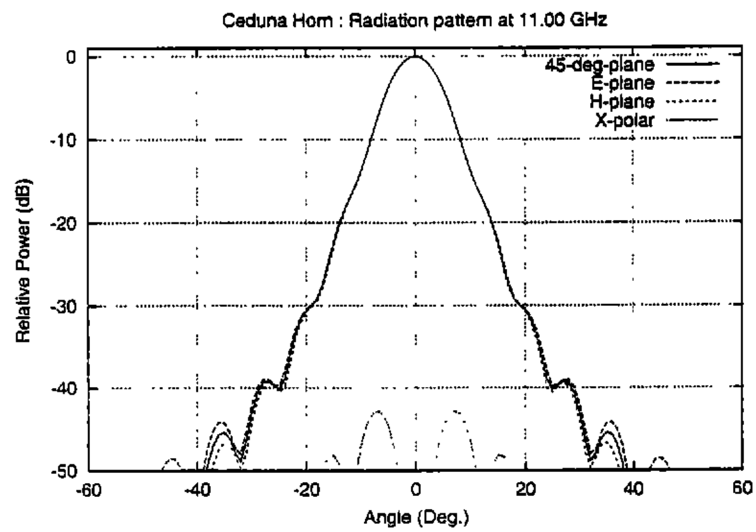
The results show that the cross-polar levels deteriorate with increased length of the output horn. For the full length of the horn, the beam width and symmetry are acceptable. The peak cross-polar levels are typically –20 to –23dB across the 10.5 to 12.8GHz band. The diameter of the circular waveguide at the input to the horn should be maintained at 26.8mm.



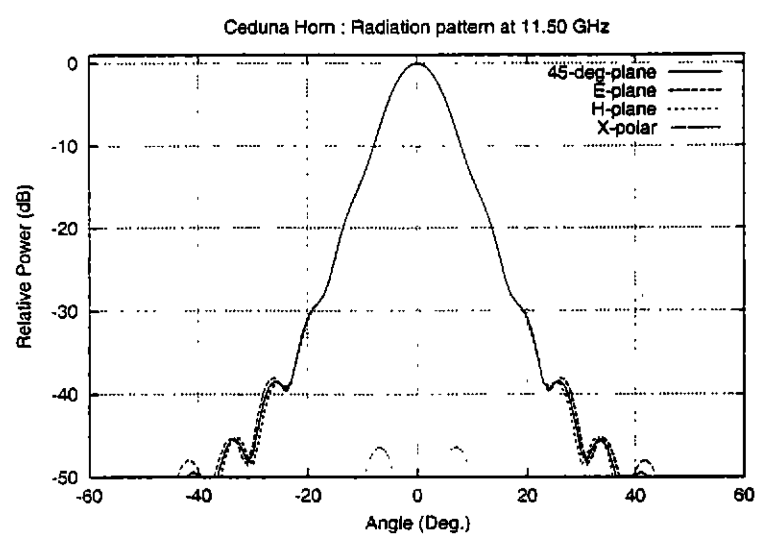
OPTION - O



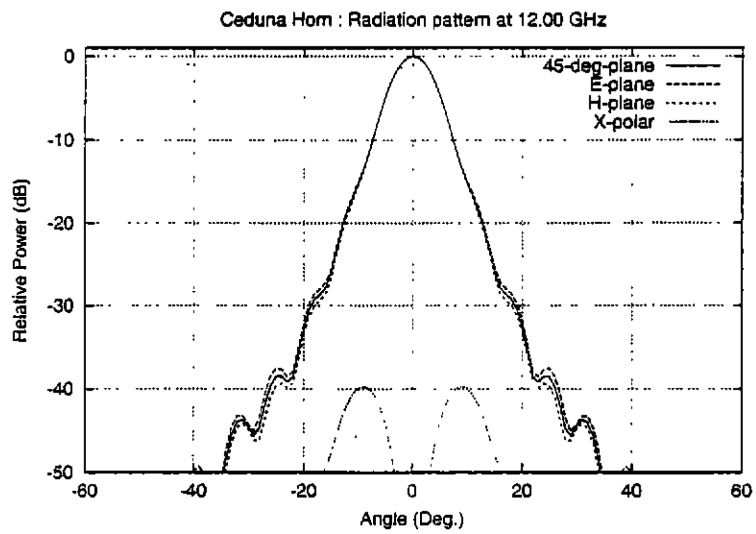
Ceduna Horn : Radiation pattern at 10.50 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)



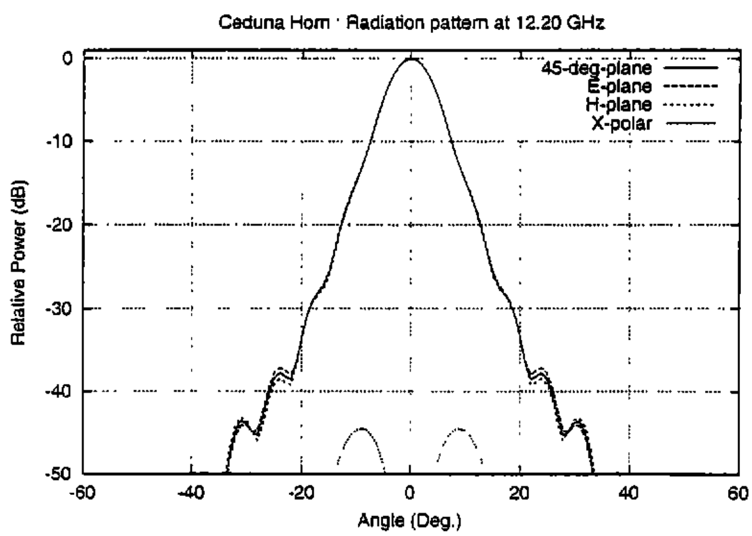
Ceduna Horn : Radiation pattern at 11.00 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)



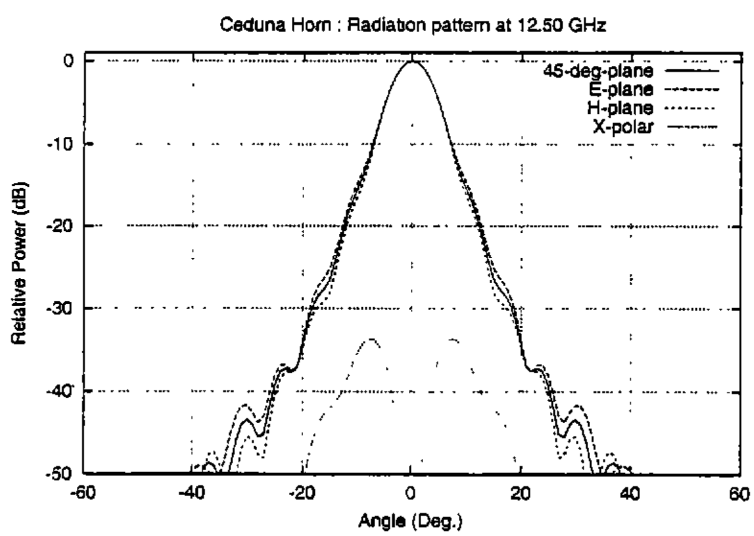
Ceduna Horn : Radiation pattern at 11.50 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)



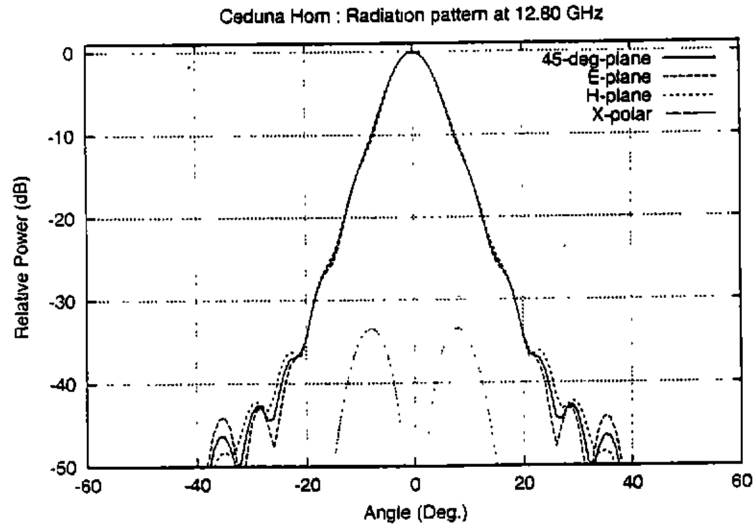
Ceduna Horn : Radiation pattern at 12.00 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)



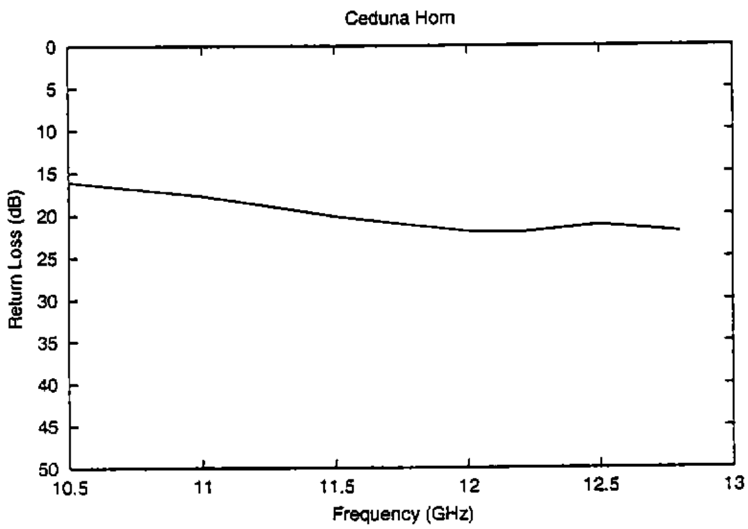
Ceduna Horn · Radiation pattern at 12.20 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)



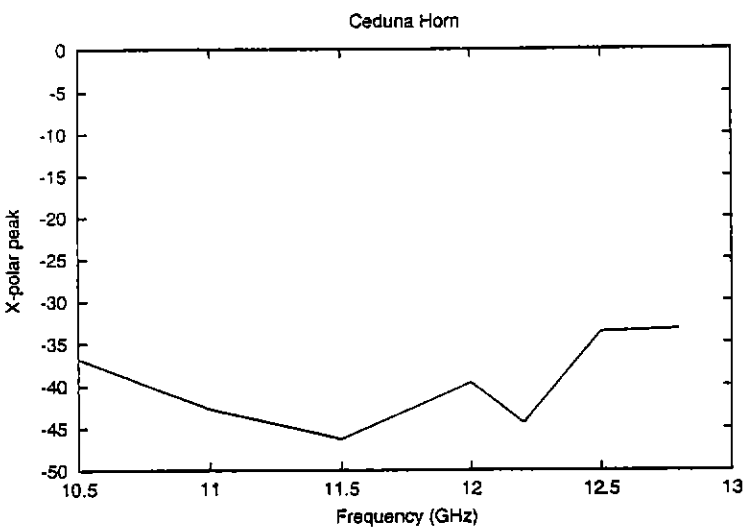
Ceduna Horn : Radiation pattern at 12.50 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)



Ceduna Horn : Radiation pattern at 12.60 GHz
45-deg-plane
E-plane
H-plane
X-polar
Relative Power (dB)
Angle (Deg.)
0
-10
-20
-30
-40
-50
-60
-40
-20
0
20
40
60



Ceduna Horn
Return Loss (dB)
Frequency (GHz)
0
5
10
15
20
25
30
35
40
45
50
10.5
11
11.5
12
12.5
13



Ceduna Horn
X-polar peak
Frequency (GHz)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
10.5
11
11.5
12
12.5
13

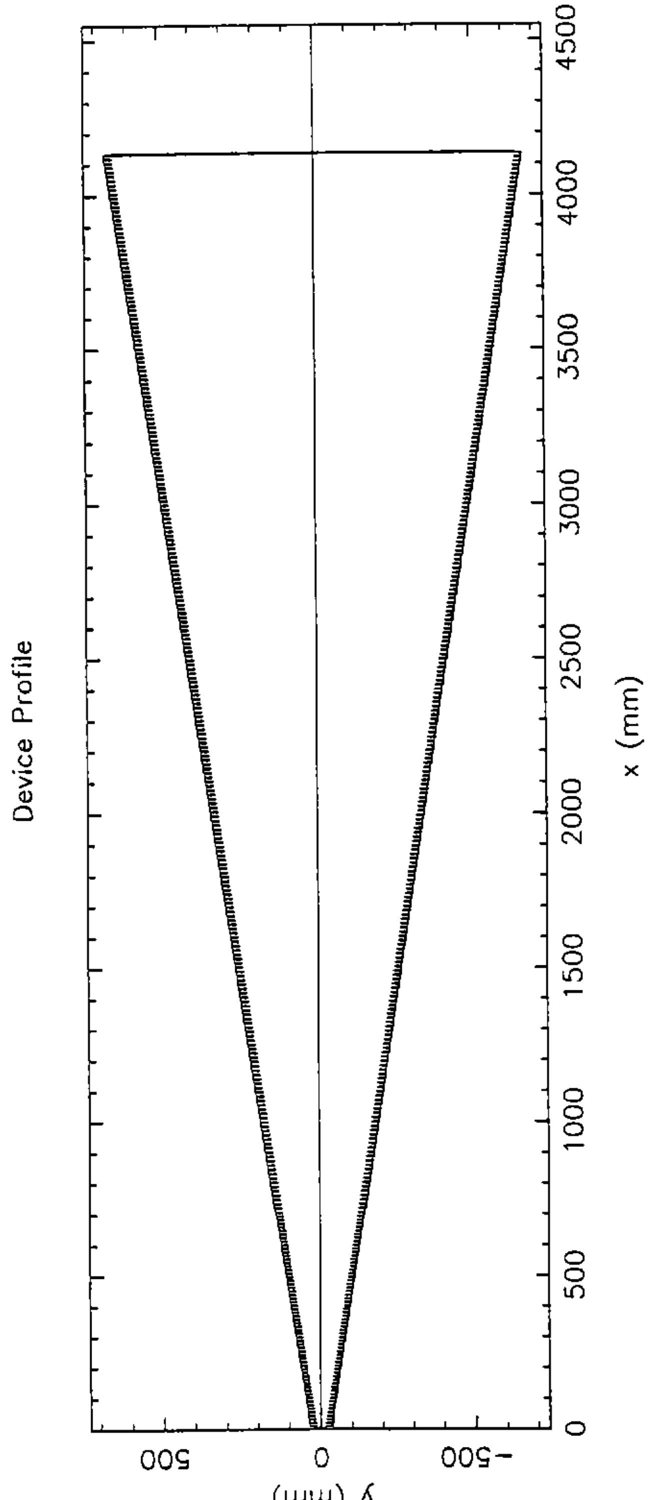


Figure 2: geometry of Option 5.

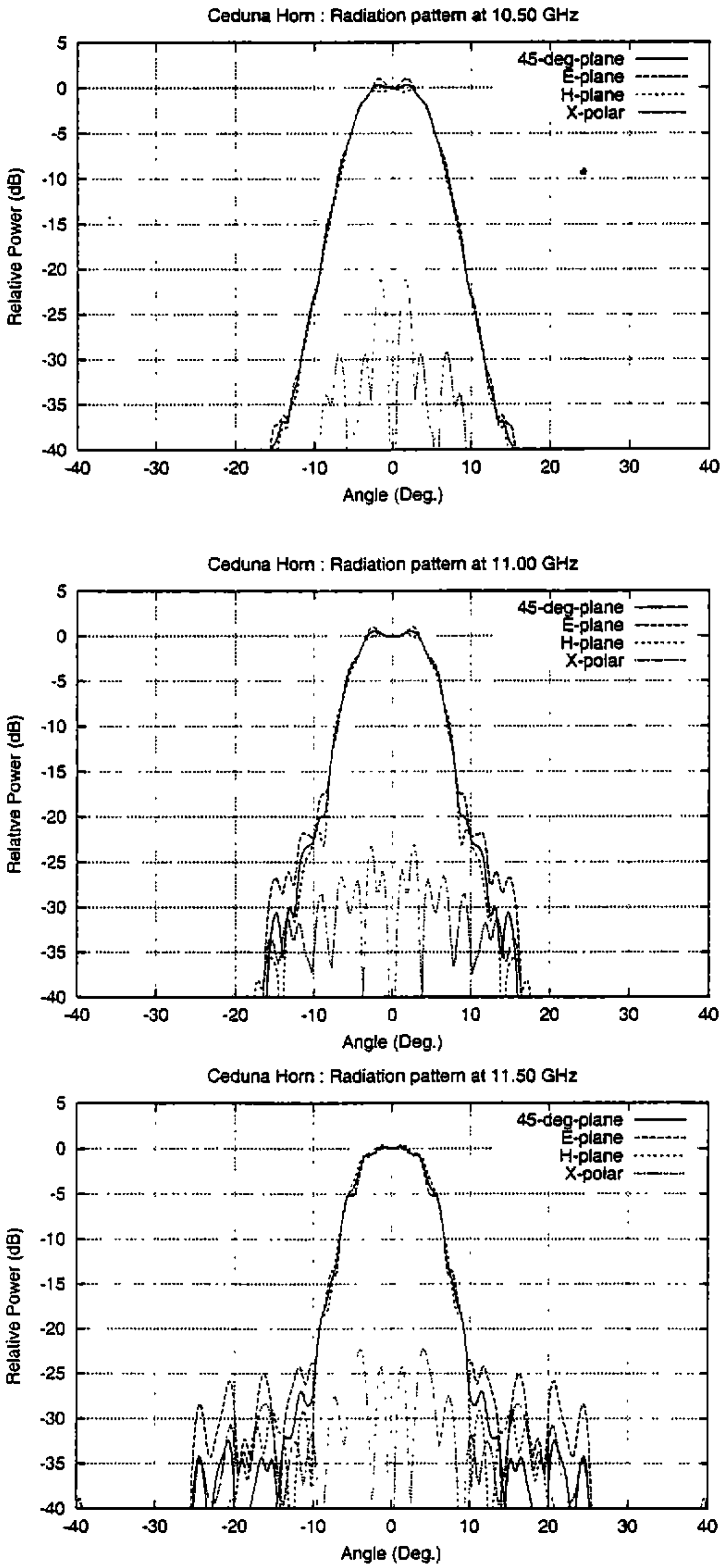


Figure 3: option 5: radiation pattern at 10.5, 11.0 and 11.5 GHz.

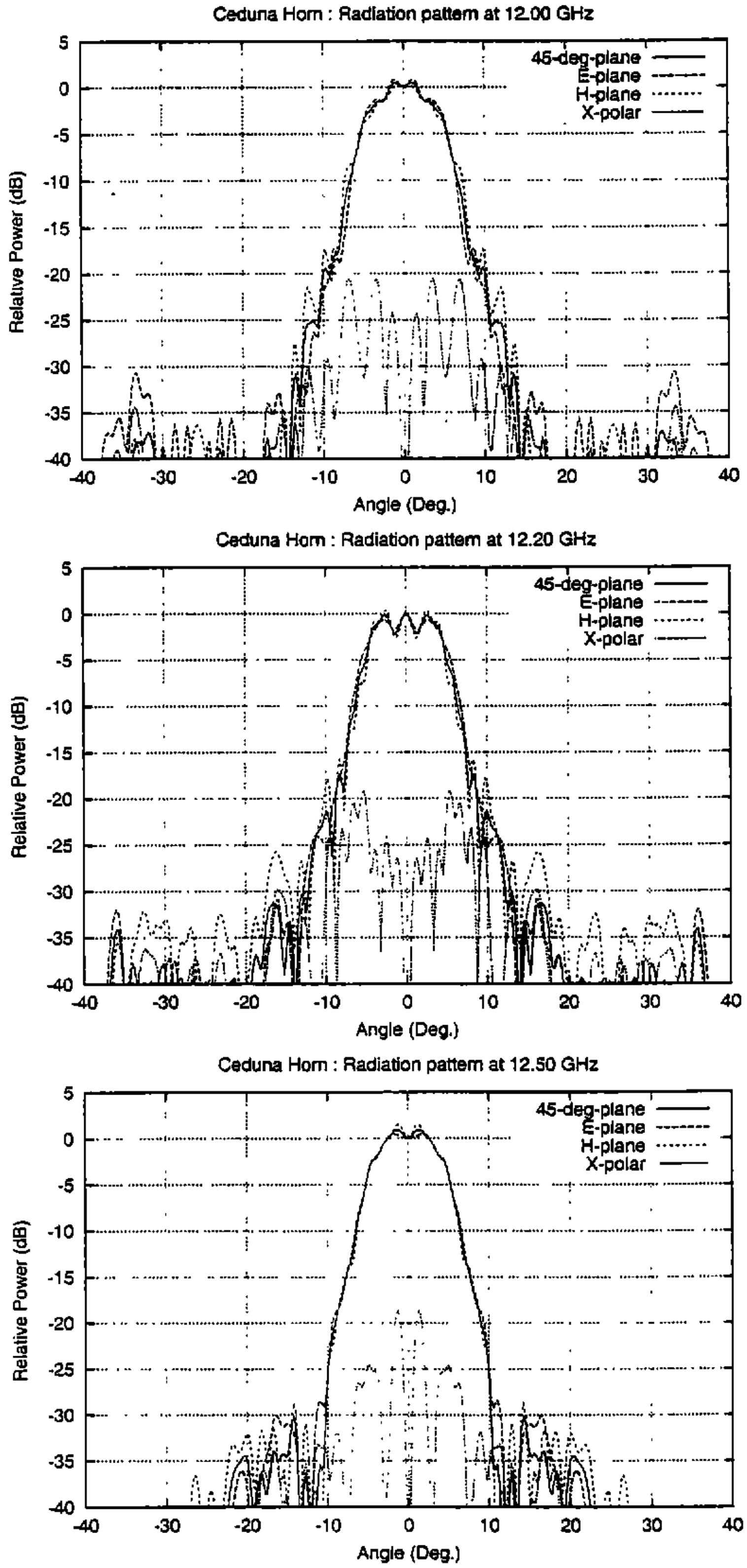


Figure 4: option 5: radiation pattern at 12.0, 12.2 and 12.5 GHz.

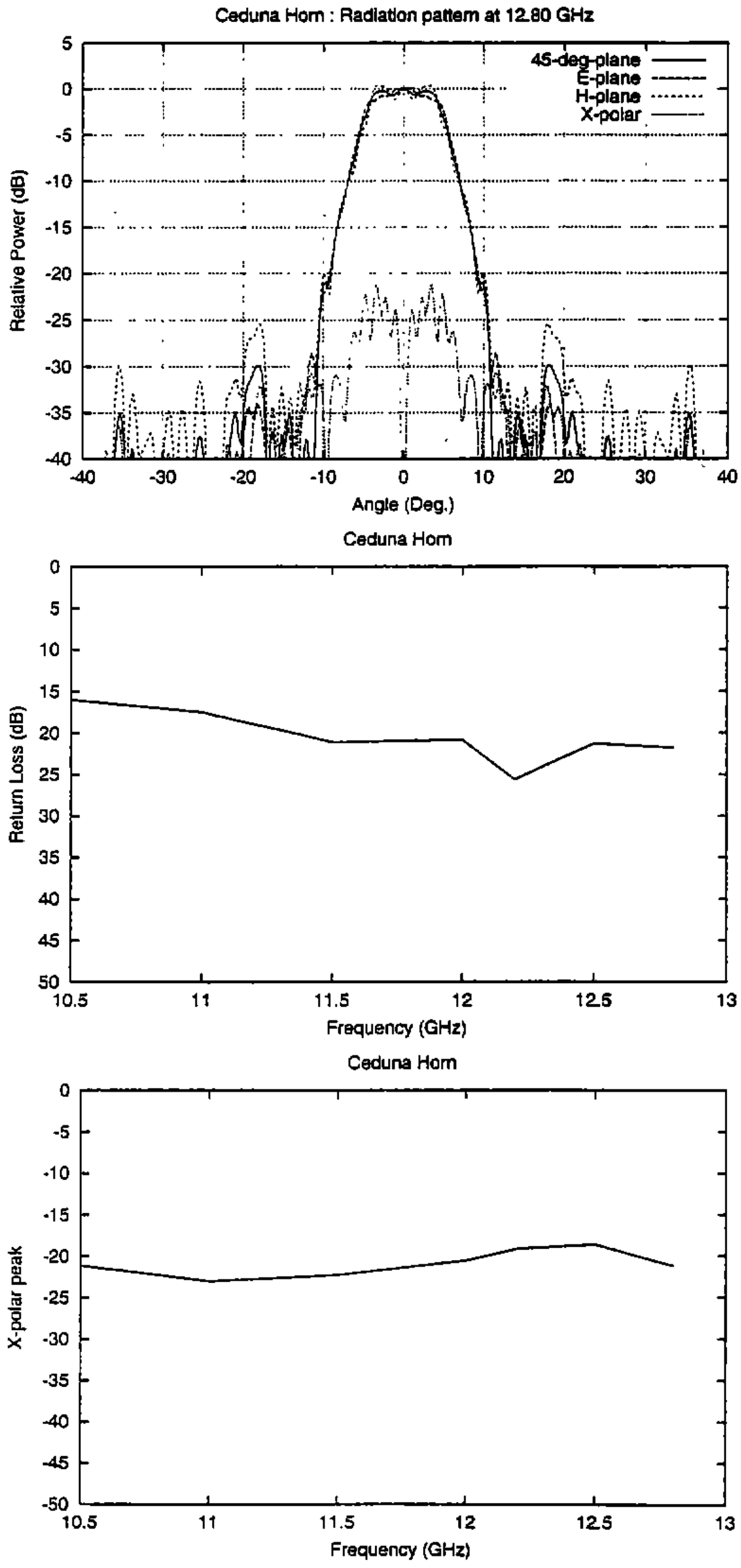


Figure 5: option 5: radiation pattern at 12.8 GHz, return loss and cross-polarization peak over the 10.5-12.8 GHz frequency band.

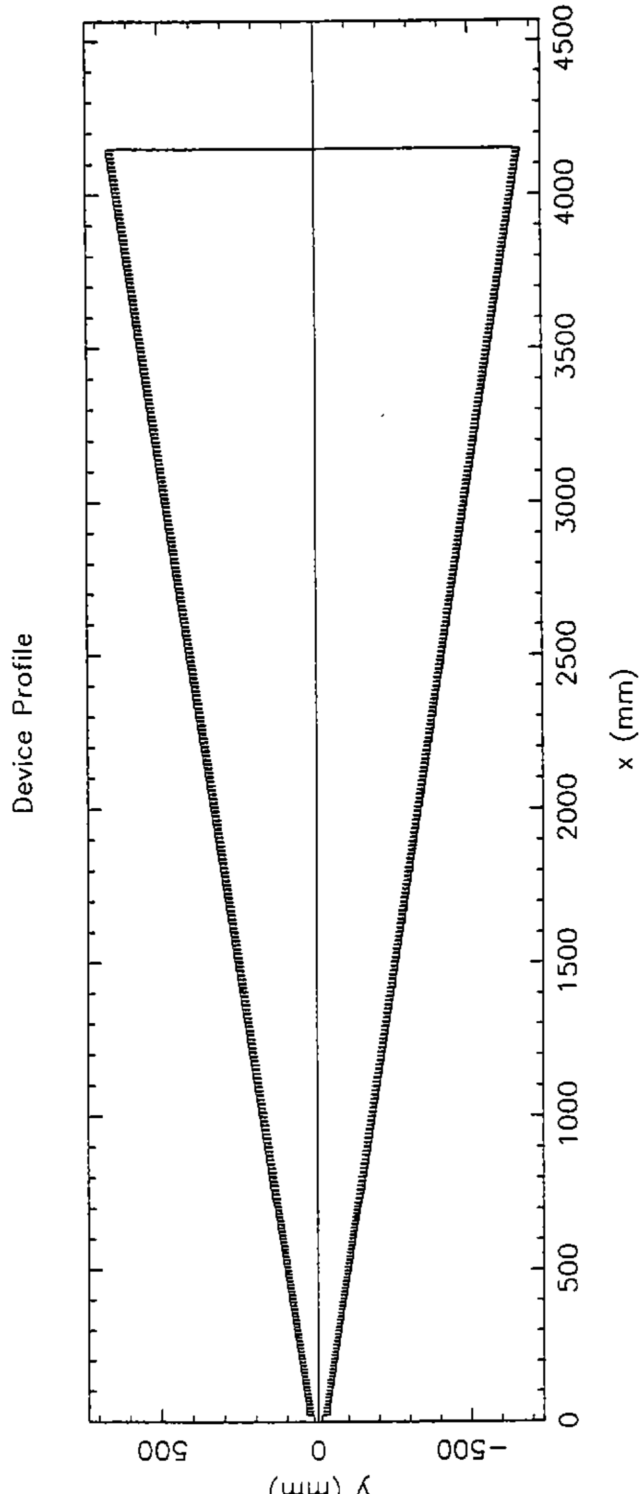


Figure 6: Geometry of Option 6.

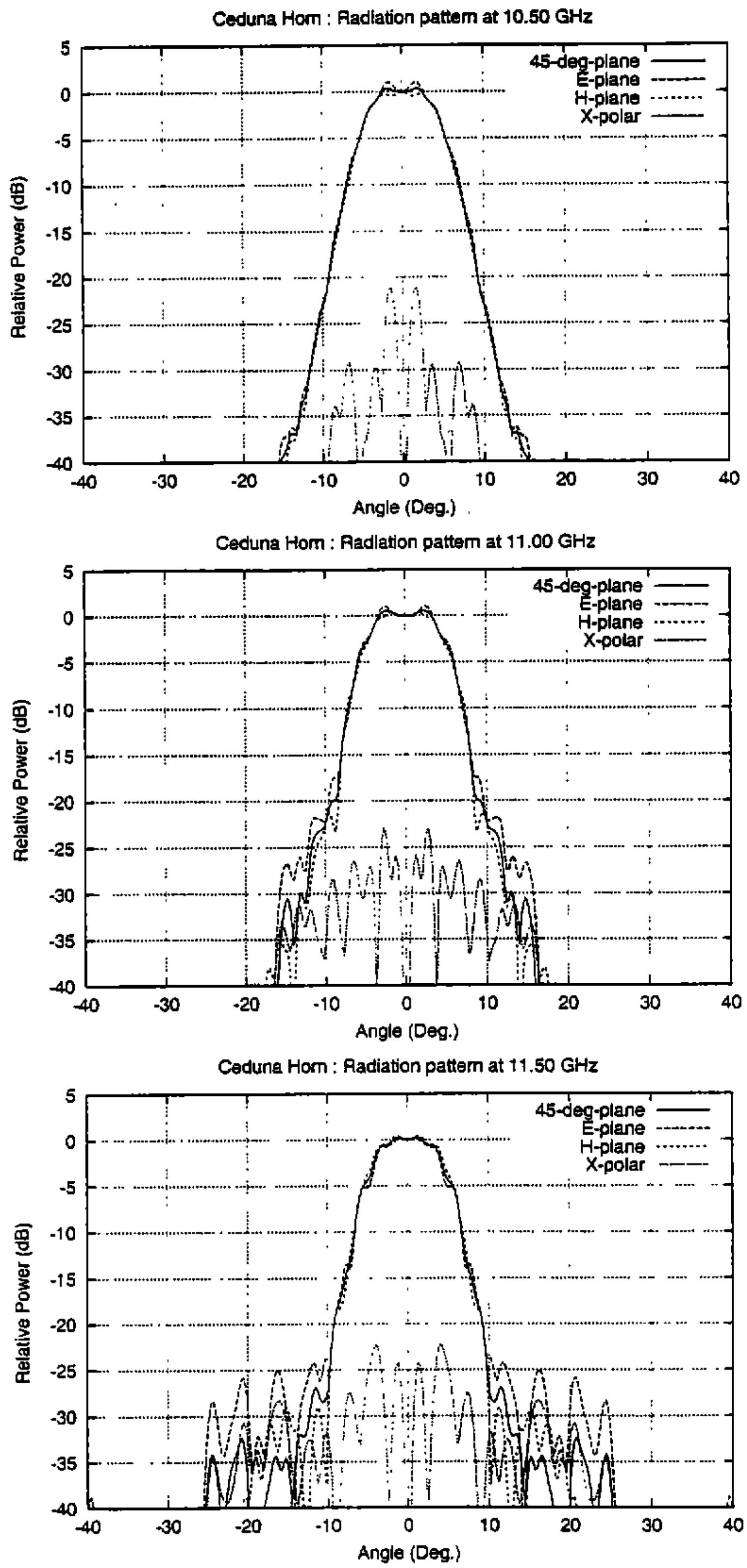


Figure 7: option 6: radiation pattern at 10.5, 11.0 and 11.5 GHz.

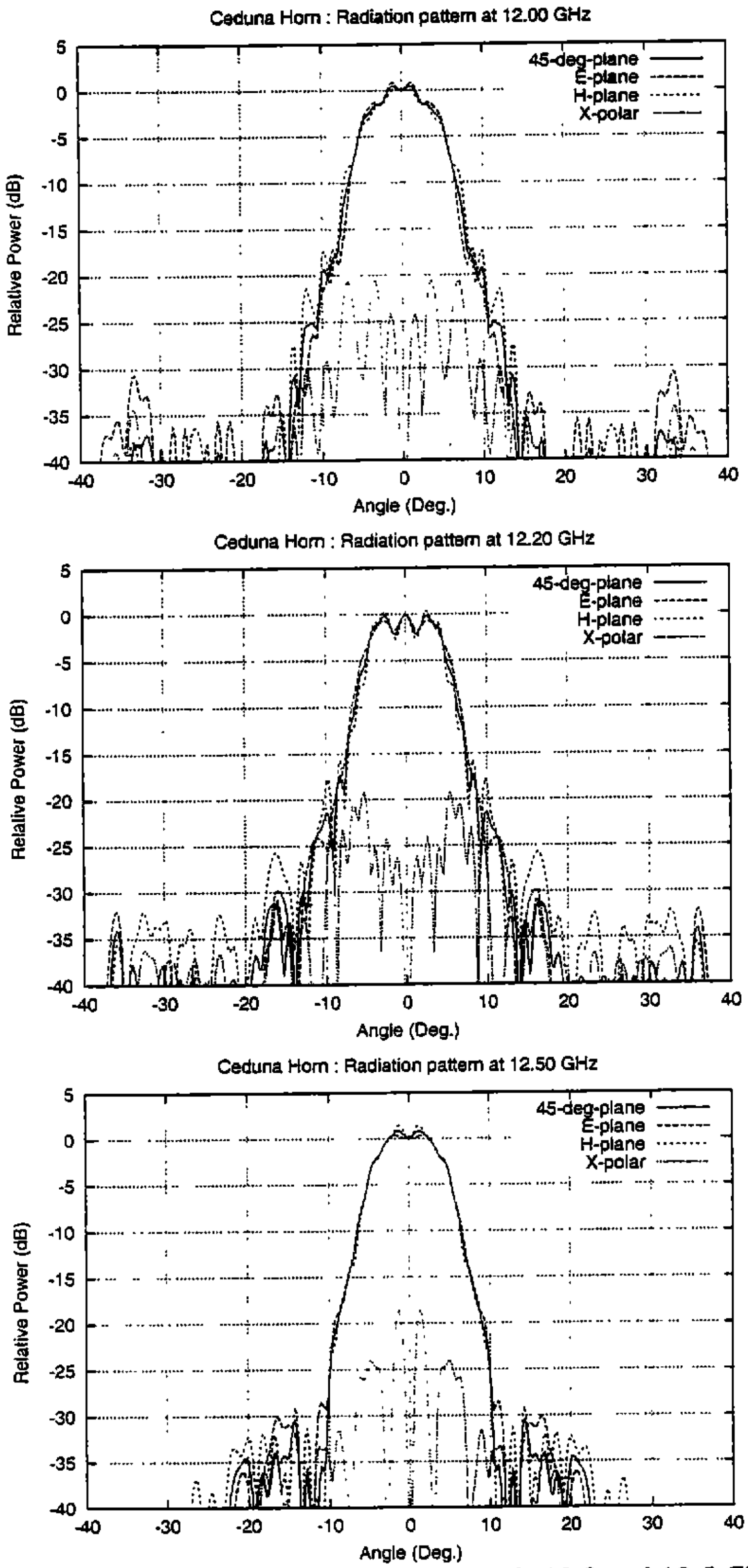


Figure 8: option 6: radiation pattern at 12.0, 12.2 and 12.5 GHz.

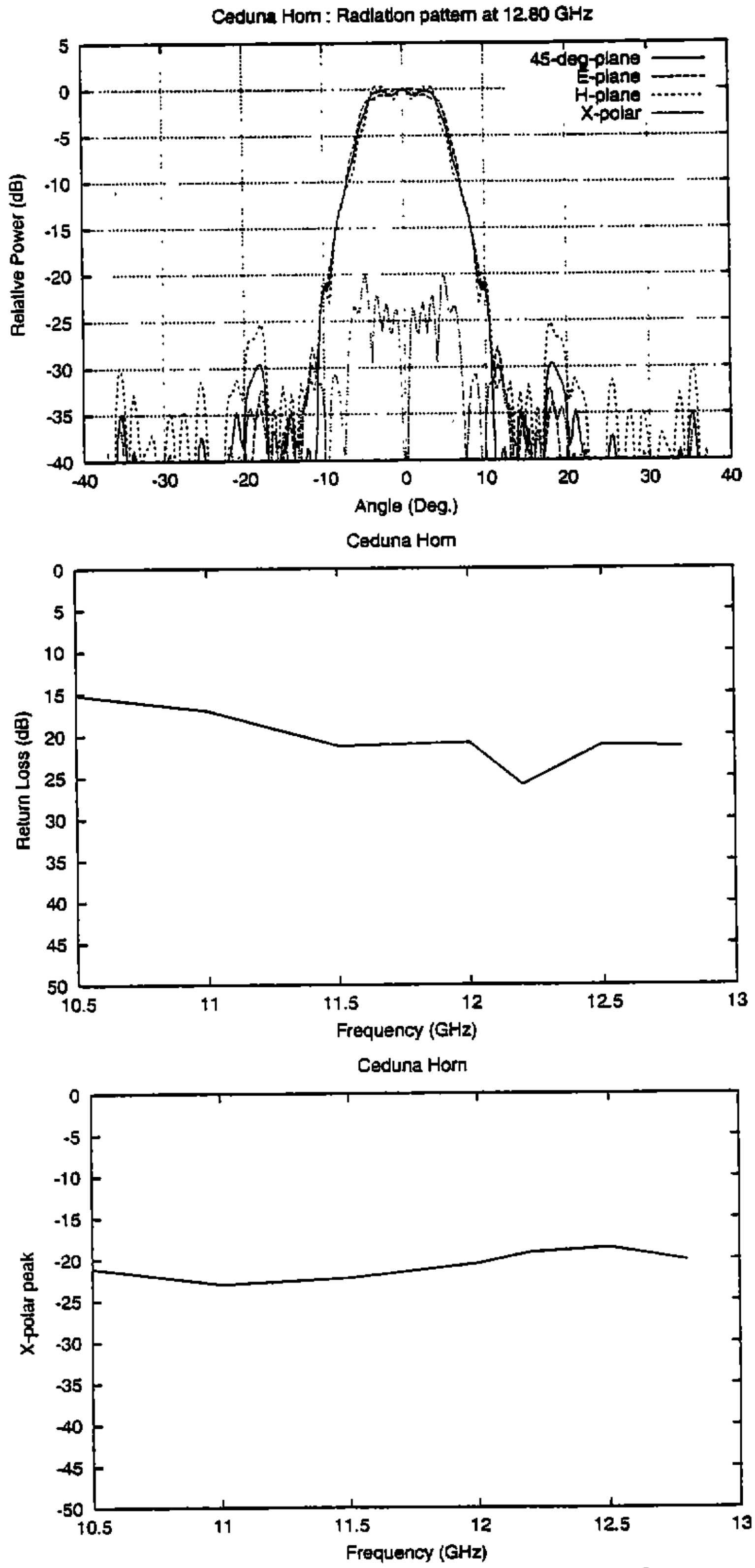


Figure 9: option 6: radiation pattern at 12.8 GHz, return loss and cross-polarization peak over the 10.5-12.8 GHz frequency band.