Half Width Leaky Wave Antenna

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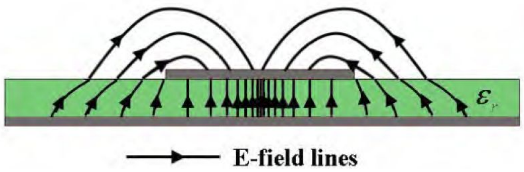
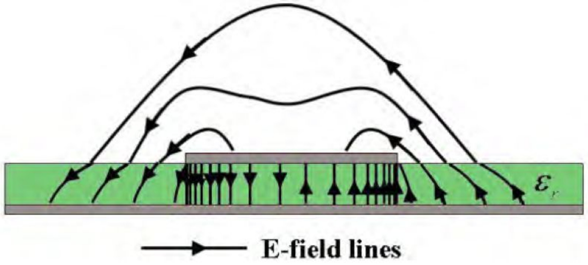
Introduction - Propagating Modes in Microstrip Line

Fundamental Mode



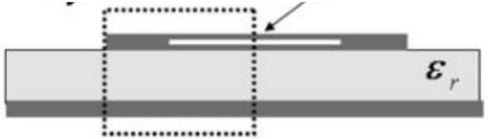
Higher Order Mode



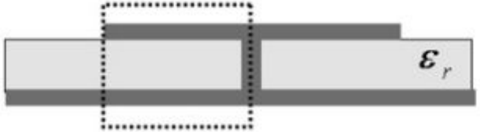
Menzel's Original Antenna

Losito, Onofrio & Dimiccoli, Vincenzo. (2012). Travelling Planar Wave Antenna for Wireless Communications. 10.5772/35914.

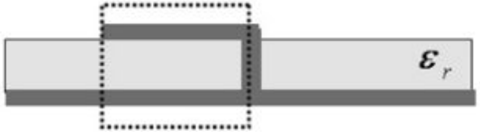
Transverse Slot



Midline Metal Bifurcation (FWA)



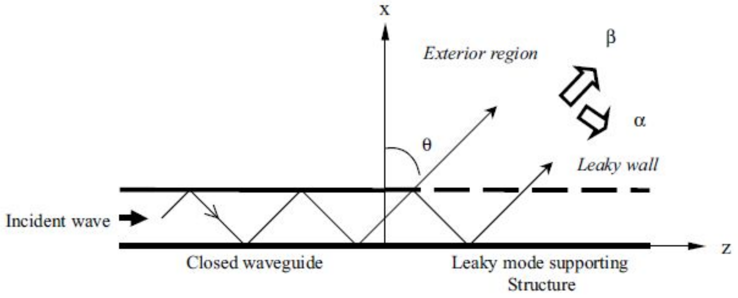
Edge Metal Wall (HWA)



Zelinksil, G. M., Thiele, G. A., Hastriter, M. L., Havrilla, M. J., & Terzuoli, A. J. (2007). Half width leaky wave antennas. *IET Microwaves, Antennas & Propagation*, *1*(2), 341–348. https://doi.org/10.1049/iet-map:20060011

Introduction - Propagation Analysis

What is Leaky Wave Antenna (LWA)?



Mahmoud, S. F., & Antar, Y. M. M. (2010). Printed Leaky Wave Antennas. In *Microstrip and Printed Antennas* (1st ed., pp. 435–462). Chichester, UK: Wiley. https://doi.org/10.1002/9780470973370.ch13

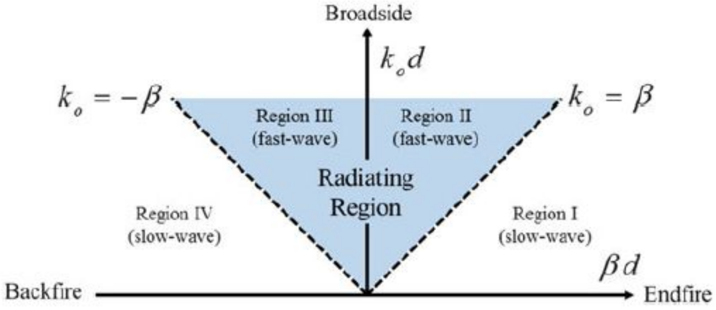
- Complex propagation wave number.
- Operated in fast wave region (β/k_0 < 1).
- Uniform and progressive LWA.

Direction of Propagation

$$\cos(\gamma_0) = \frac{\beta_1}{\beta_2}$$

Beam width -

$$\Delta\gamma = \frac{1}{(L/\lambda_0)\cos\gamma_0}$$

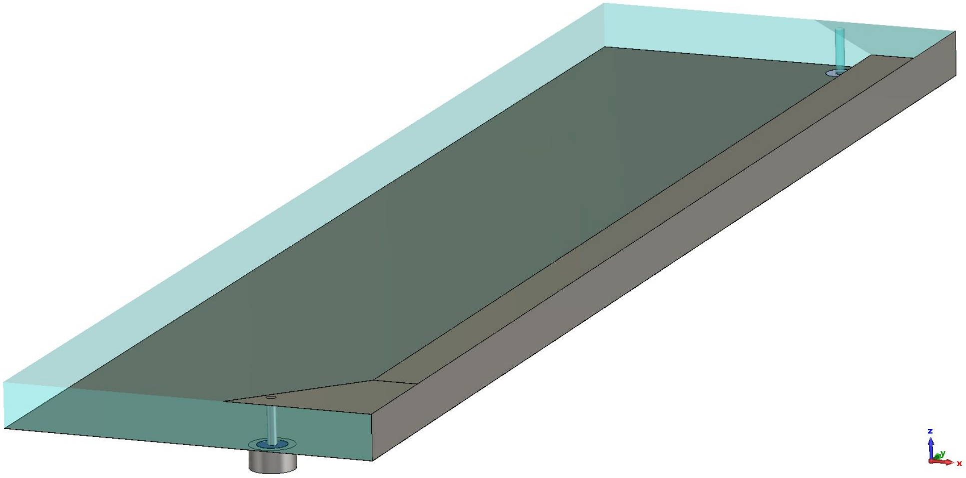


Choi, Jun & Itoh, Tatsuo. (2016). Beam-Scanning Leaky-Wave Antennas. DOI : 10.1007/978-981-4560-44-3_60.

LWA Simulation - Goals

To design a ***Half Width Leaky Wave Antenna*** with the following specifications.

- Operating frequency - 5 GHz.
- Bandwidth - 1 GHz.
- Directivity - 45°.
- Side lobe levels < -10 dB.

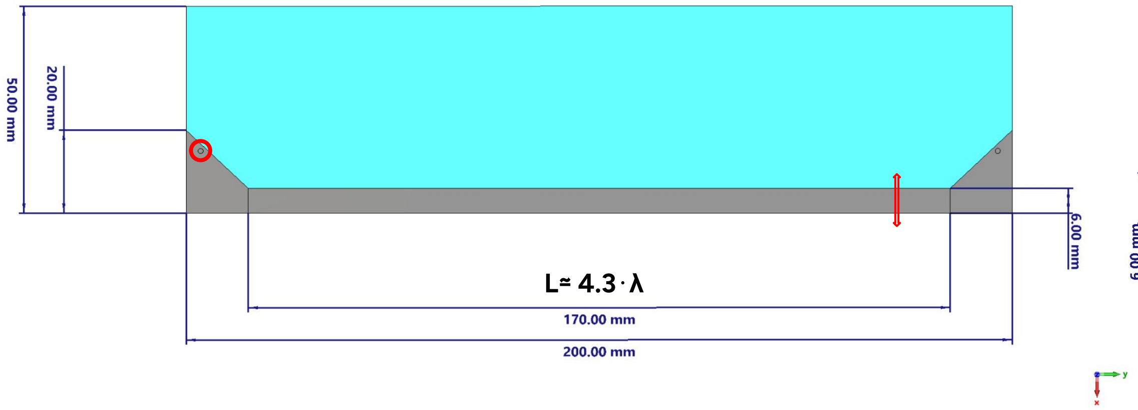


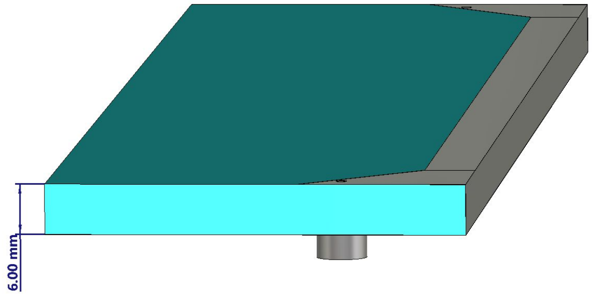
Final design of the leaky wave antenna.

LWA Simulation - Model and Dimensions

- Dimensions of the antenna define the radiation pattern and the coupling between the leaky part and the ground plane.
  → The longer the antenna, the smaller the beamwidth: $\Delta\gamma = \frac{1}{(L/\lambda_0)cos\gamma_0}$
- Design on CST oriented at fixing as many geometrical degrees of freedom to then optimize as few as possible.

1. Position of the feed **2. Width of the leaky part (W)**

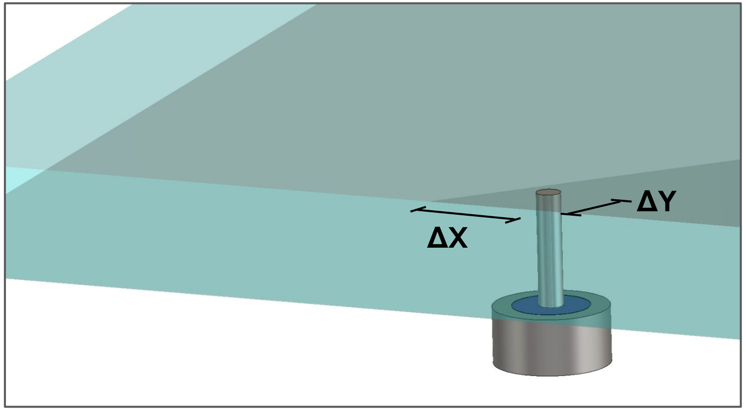




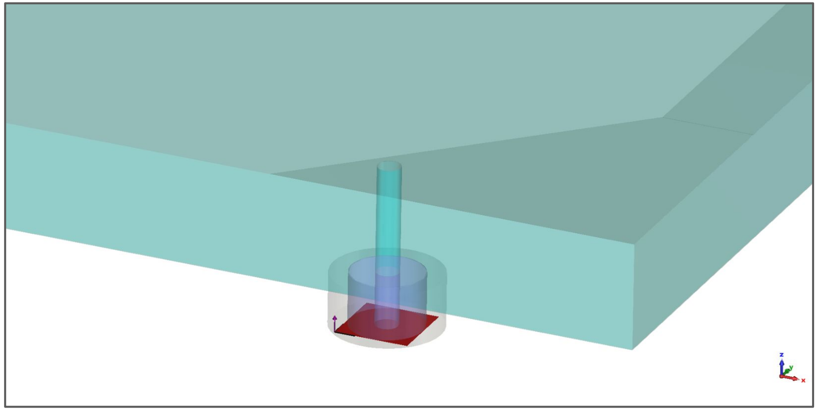
Height of the dielectric set at the start (ε_R=2.3).

LWA Simulation - Feeding and Matching

- Coaxial cable ($\varepsilon_{coaxial}$=2.1).
- 2 ports to have a symmetric antenna.
- Tapering to match the impedance (dimension from microstrip calculator).
  → Position of the feed fundamental to get the proper matching in the desired BW.



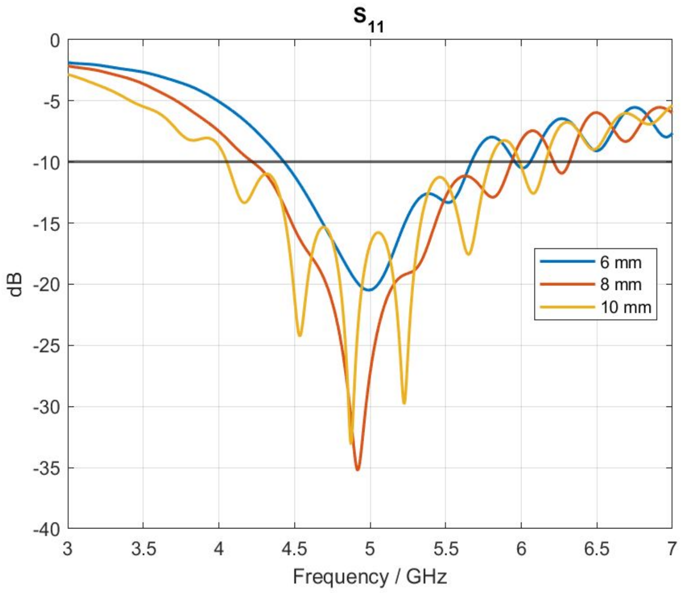
Coaxial cable model (ΔX=5 mm, ΔY=3.5 mm).

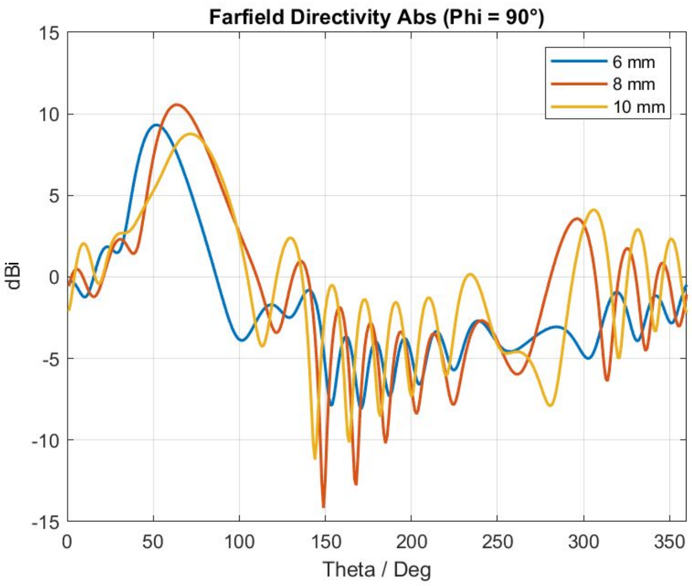


Waveguide port.

LWA Simulation - S_{11} and Radiation Pattern

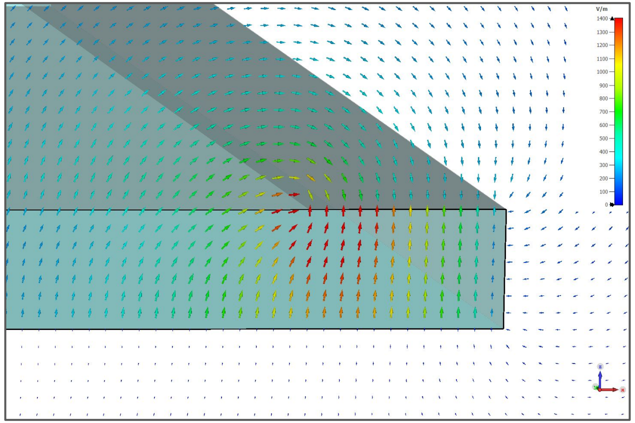
- W has to be comparable to $\lambda_{diel}/4$ = 9.89 mm.
- Comparison between W = [6, 8, 10] mm.
- Results for the S11 parameter: acceptable BW (4.5 - 5.5 GHz).



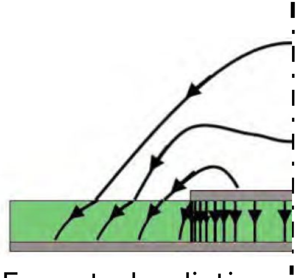


LWA Simulation - Field Distribution

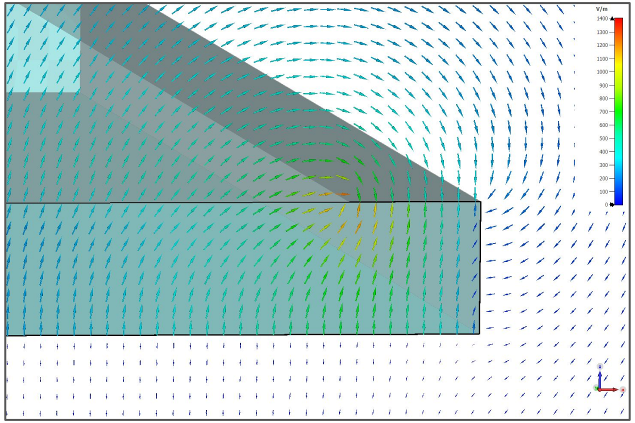
- In the first case the electric field is radiated at its maximum ($\lambda_{diel}/4$ = 9.89 mm ≃ 10 mm).
- In the second case the electric field not radiated at the maximum.
- If the wave is leaked rapidly the beamwidth will be large.
  → 6 mm leads to smaller angular width.



1) W = 10 mm



Expected radiation for W = $\lambda_{diel}/4$

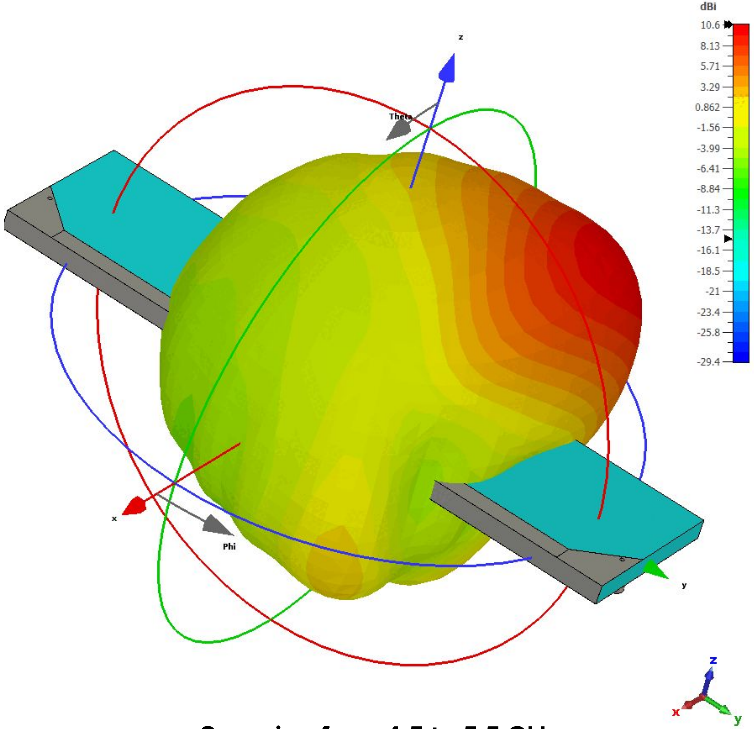


2) W = 6 mm

LWA Simulation - Radiation pattern

- W = 6 mm is the best compromise in terms of:
  - Main lobe magnitude.
  - SLL (-7.5 dB at 5 GHz).
  - Angle of propagation.
- The radiation is slightly tilted for the effect of the electric wall.
- BW: 4.4-5.8 GHz.

→ **Ready to be manufactured!**



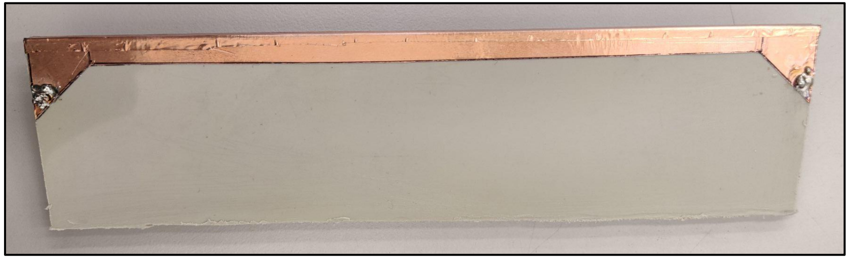
Scanning from 4.5 to 5.5 GHz.

Manufacturing

- Material used:
  - Substrate - Polypropylene sheet with ϵ_R= 2.3 and thickness of 6 mm.
  - Ground plane - Copper tape with thickness = 0.036 mm.
- Coaxial connector placement.
- Make sure of the contact between the dielectric of the antenna and coaxial connector.

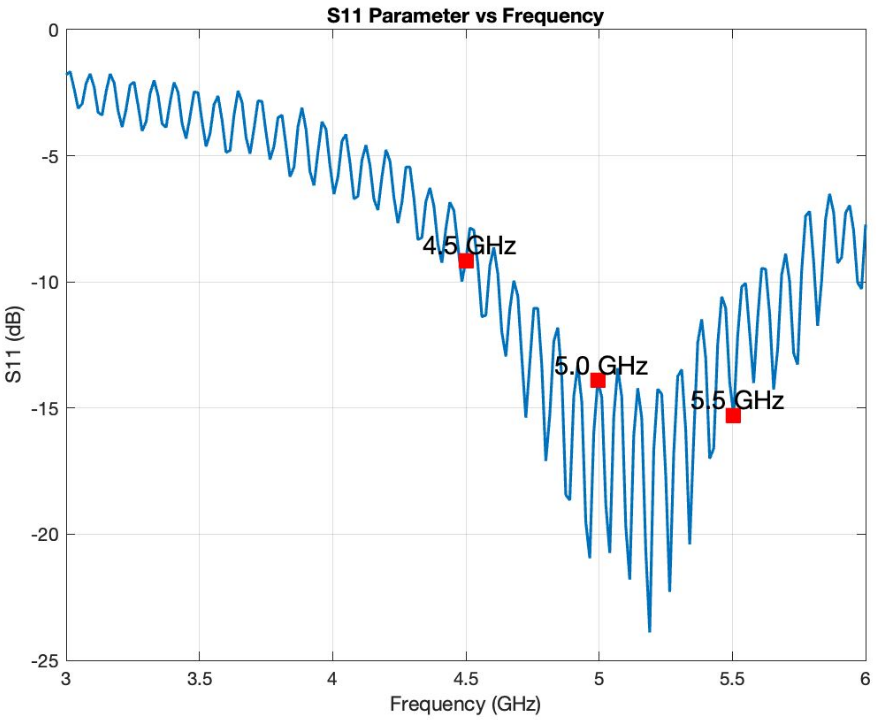
→ Measure with VNA and near field scanner.

Ground plane.



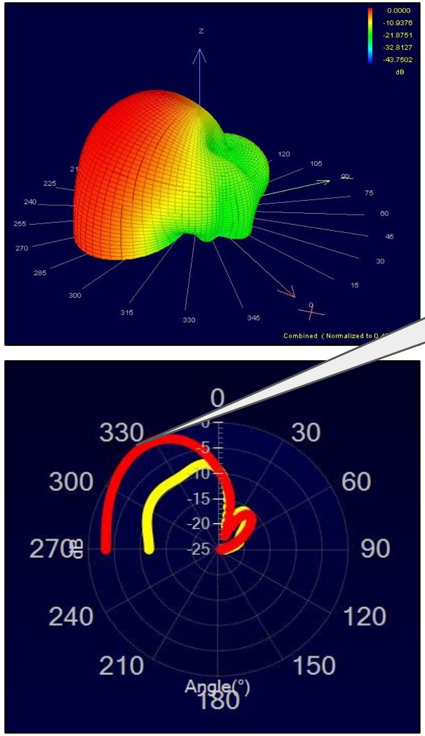
Leaky part.

Manufactured LWA - S_{11} Results



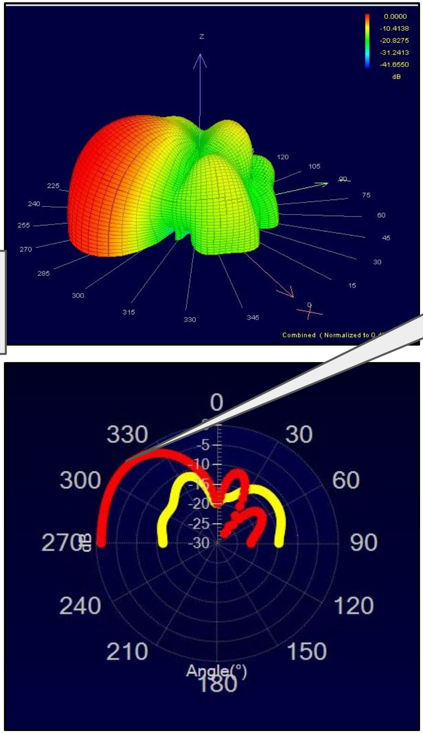
- Resonance pattern observed.
- BW from around 4.5 to 5.5 GHz.
- Electrical discontinuity at the end of the antenna.

Manufactured LWA - Radiation Pattern Results



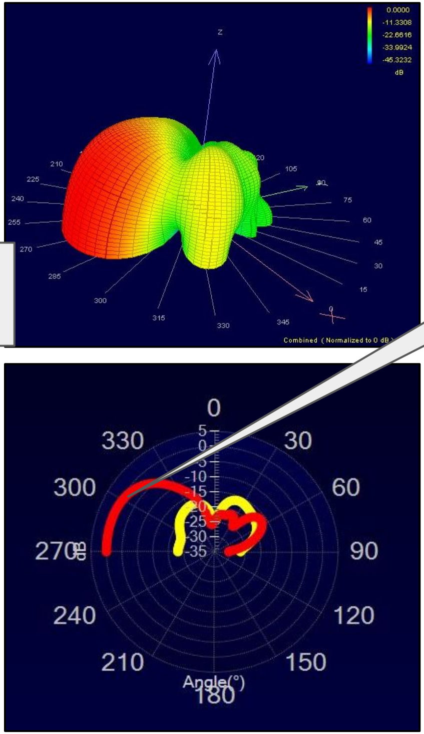
ɣ=330°
(30°)

4.5 GHz



ɣ=315°
(45°)

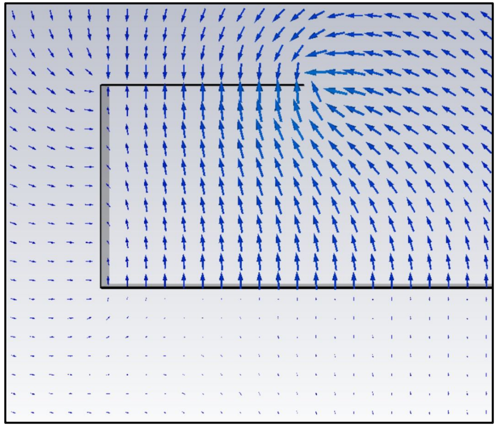
5 GHz

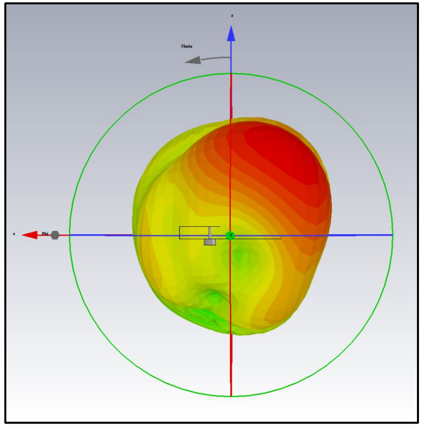


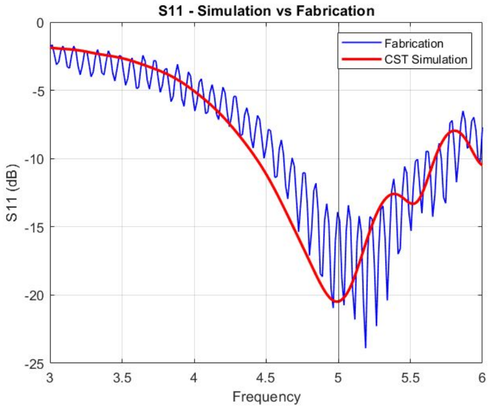
ɣ=300°
(60°)

5.5 GHz

Manufactured and Simulated LWA Comparison







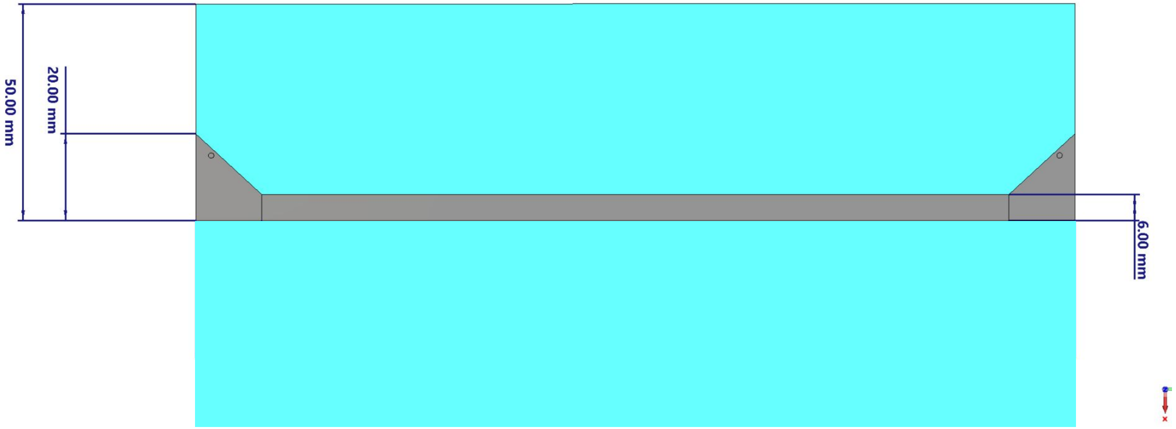
- Deflection in the radiation pattern.
- Effect of the edge wall.

- Shift in the peak.
- Due to fabrication tolerance of different materials.

A Different Approach!

An alternative to our design with full dielectric substrate:

- More material
- Less ripples in S_{11}



Thank you for your attention!

Any questions?