Universidade de Aveiro
Departamento de Electrónica,
Telecomunicações e Informática

Using Visualization in the development of Multilayer radiating structures for mm Waves

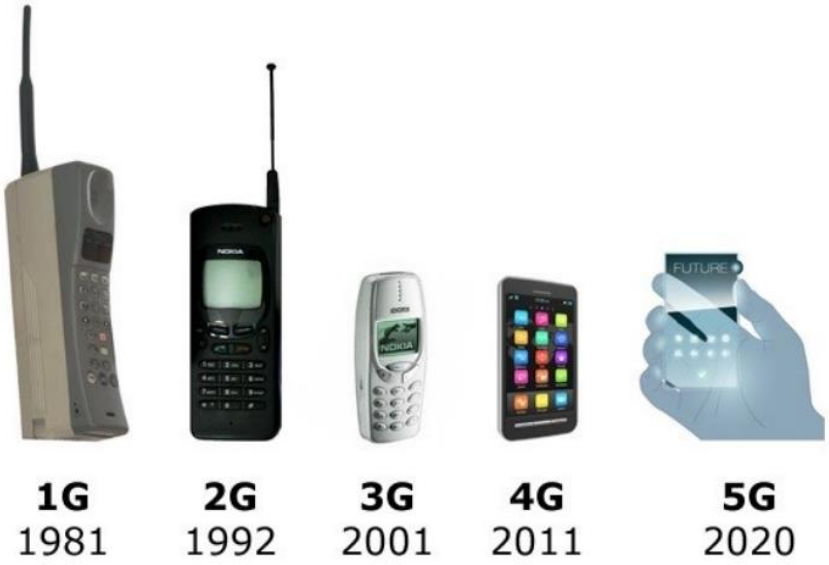
Based on the work by

Amélia Ramos, J. Nuno Matos

DETI/IT

The problem

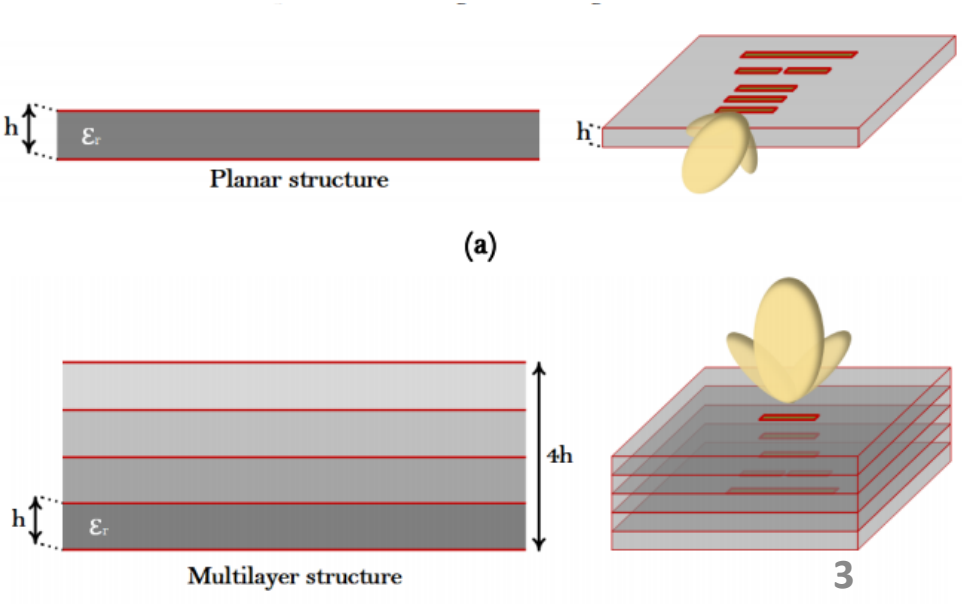
- Millimeter-Waves migration: 5G and IoT demands (higher frequencies, smaller devices and antennas)



Objectives

- Design, implement and test of Yagi-Uda antennas using Computer Simulated Technology (CST):
  - operating at 2.4 GHz and 24 GHz
  - printed Yagi-like prototypes

- Performance comparison:
  - planar
  - multilayer



Users, Context of use, and Goals of using Vis

- Researchers,
- Office and Laboratory using a Laptop/PC
- Visualization was used to guide the design, assess the quality and usefulness of the results and compare both antennas

Electromagnetic systems

Data

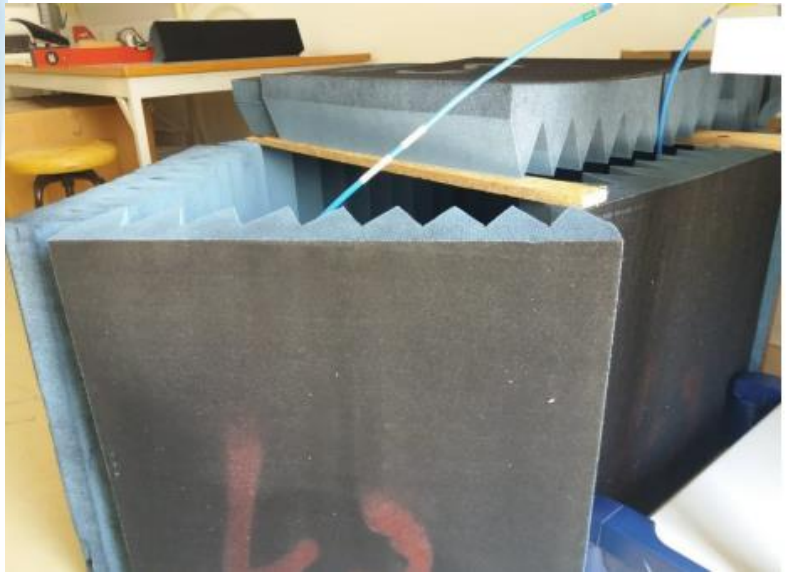
- Simulated data (using commercial S/W)

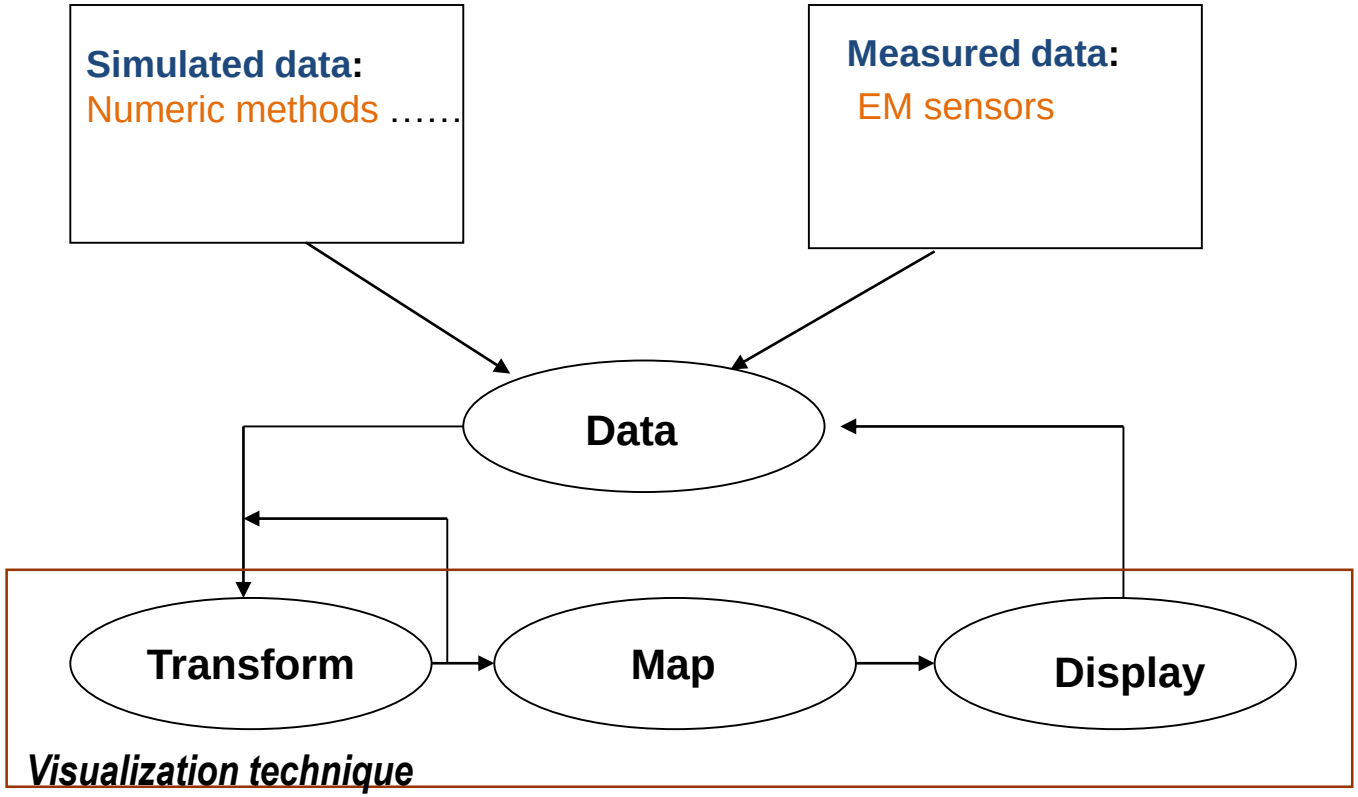
(CST STUDIO SUITE Electromagnetic Field Simulation S/W)

- quantitative value (gain) 2D/3D grid data,
- quantitative value (gain) along frequency

- Measured data

(in a simplified version of an anechoic chamber, built in the laboratory)





(adapted from Schroeder et al., 2006)

The visualizations creator was also user:
a researcher/developer who conducted in all phases

But there were other users:
other researchers

Visualization along the process

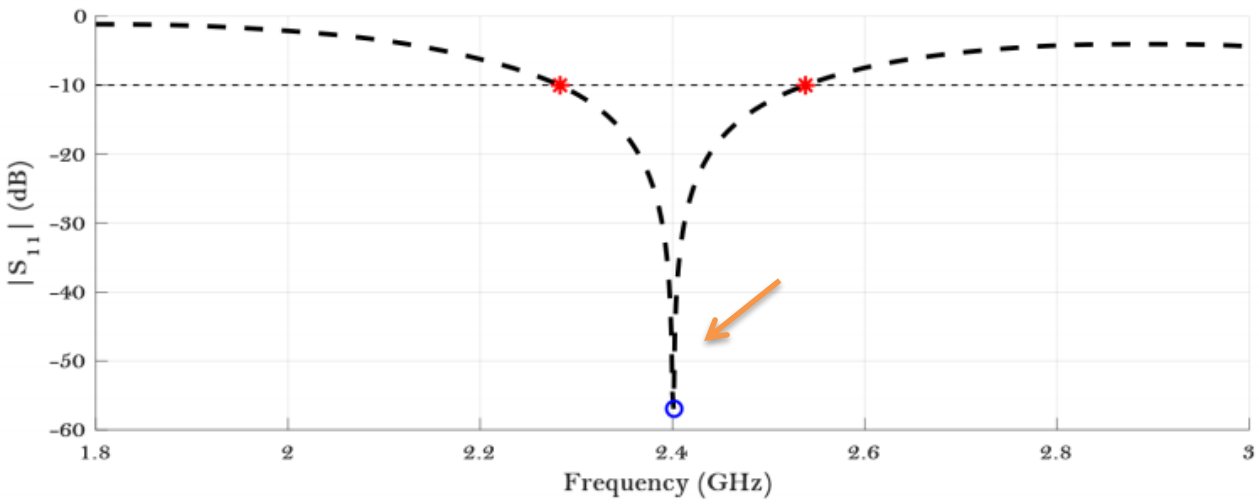
- Simulated data - design phase
- Measured data - test phase

To guide the design, check prototype characteristics, assess quality and usefulness

Visualization of simulated data

- Representing a gain along the frequency
  (continuous quantitative phenomenon, adequate sampling)

- Visualization technique: line chart
  insight: - checking operation frequency

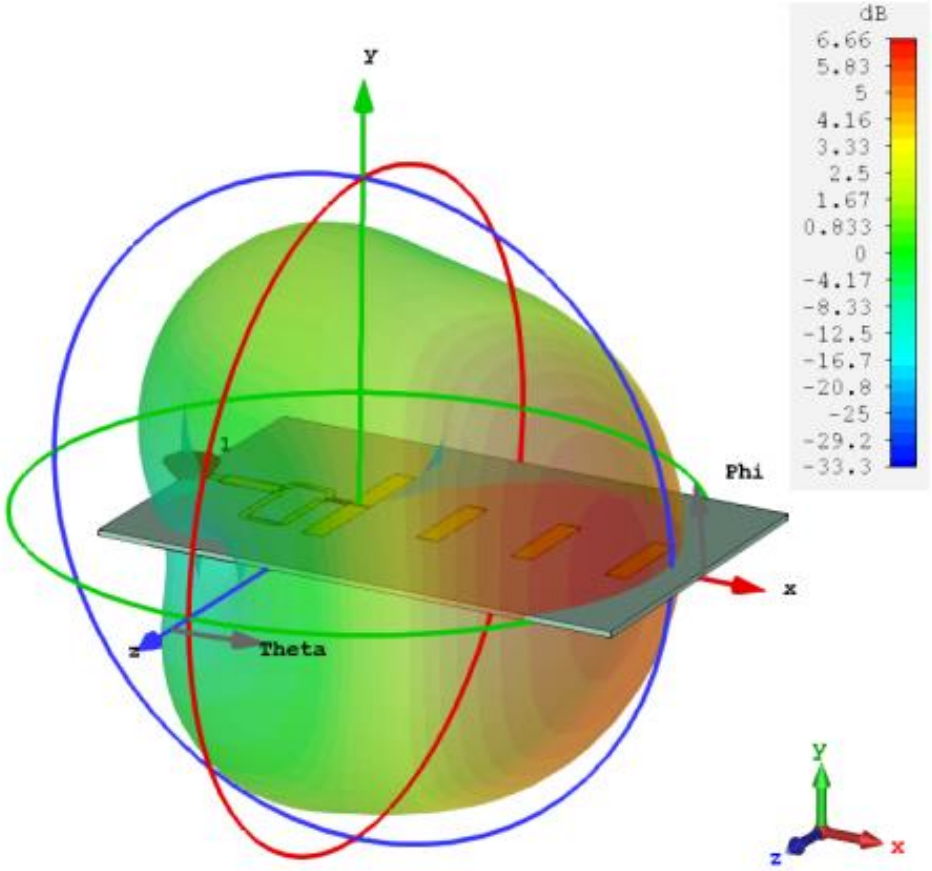


Simulated |S11| of the designed planar Yagi-Uda antenna for 2.4 GHz.

- 3D grid data – continuous quantitative variable in 3D space
  (using adequate sampling)

- Visualization techniques:
  - Isosurface
    (possible to represent
    continuous phenomena)
  - Color coding
    (using a popular, while not
    perceptually effective color scale)

- Main insight:
  - 3D radiation pattern
    shows directional antenna

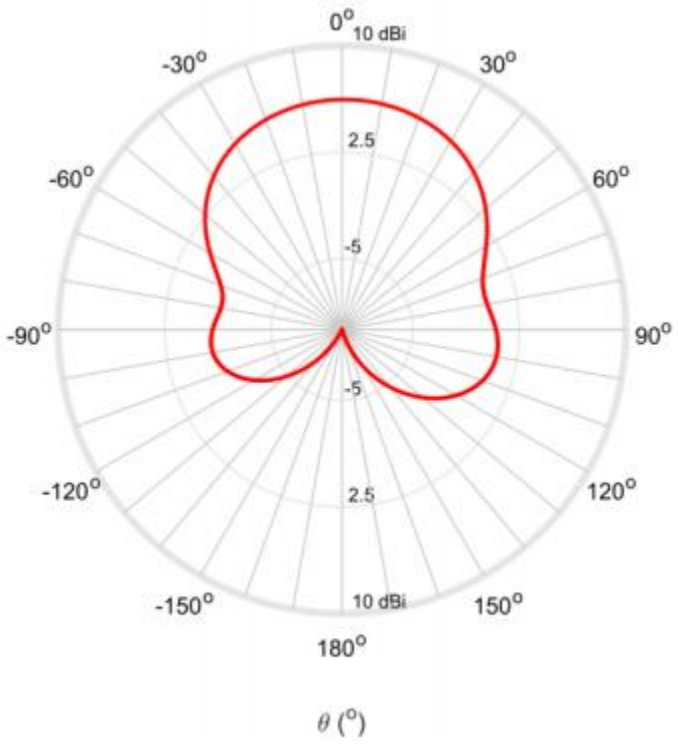


3D view of the radiation diagram of the 2.4 GHz antenna.

- 3D grid data – continuous quantitative variable in 3D space
  (using adequate sampling)

- Visualization techniques:
  - Polar line chart
    (on plane of interest)

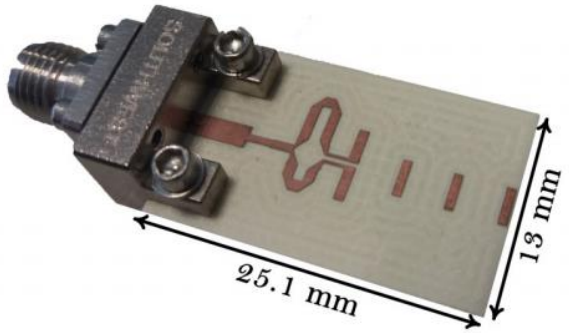
- Insights:
  - Directional antenna
  - Gain *vs* direction
    (w/ greater accuracy)



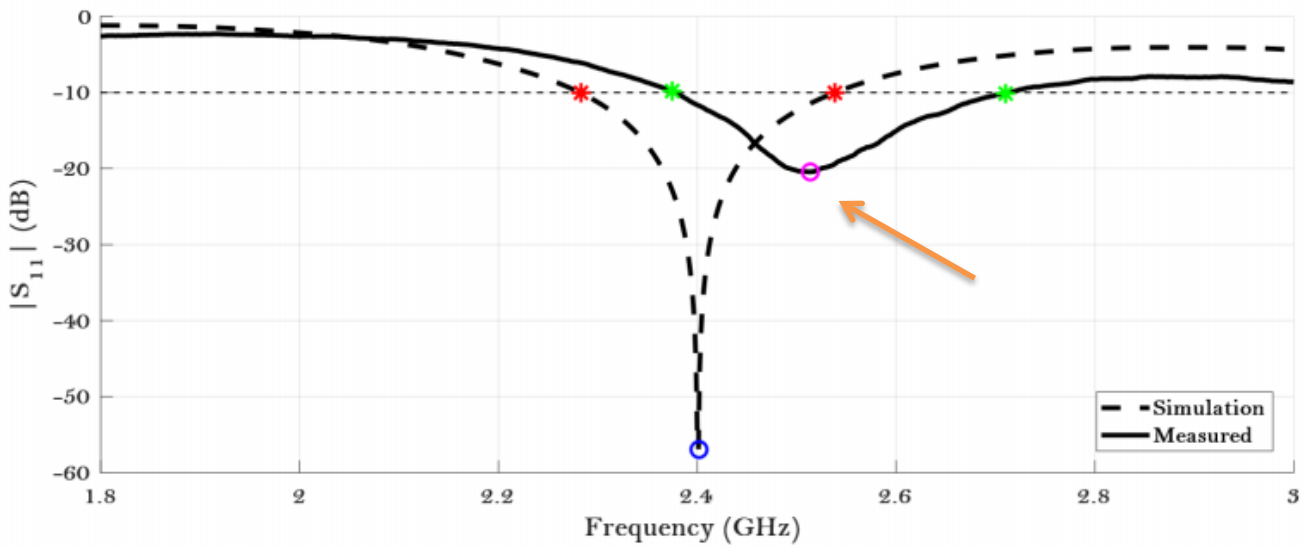
Polar diagram of the radiation pattern of the 2.4 GHz antenna (plane $\varphi = 0°$).

Comparing measured with simulated data

- Same variables as before

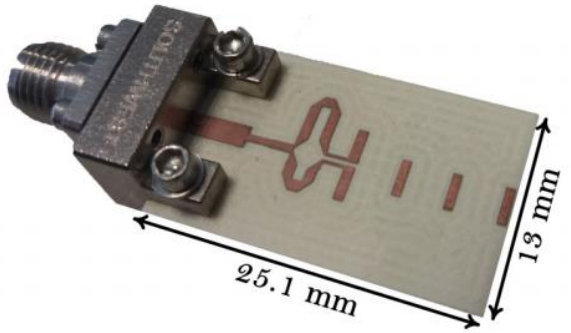


- Visualization technique: Insight:
  - line chart - comparing with the simulation:
    (slightly different frequency)



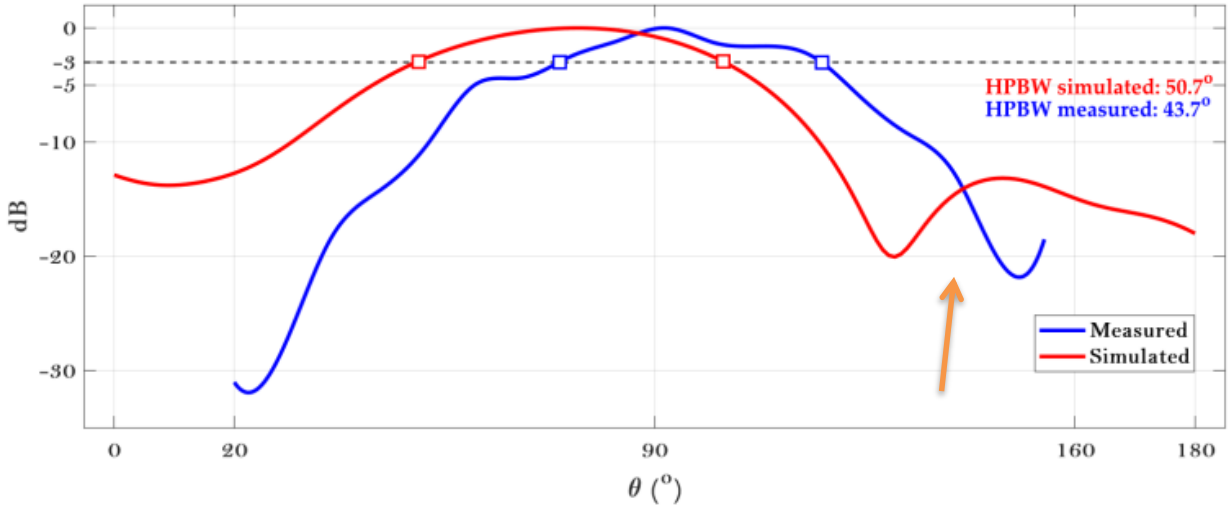
Simulated and measured reflection coefficient (|S11|) of the planar 2.4 GHz antenna.

Visualization of measured data

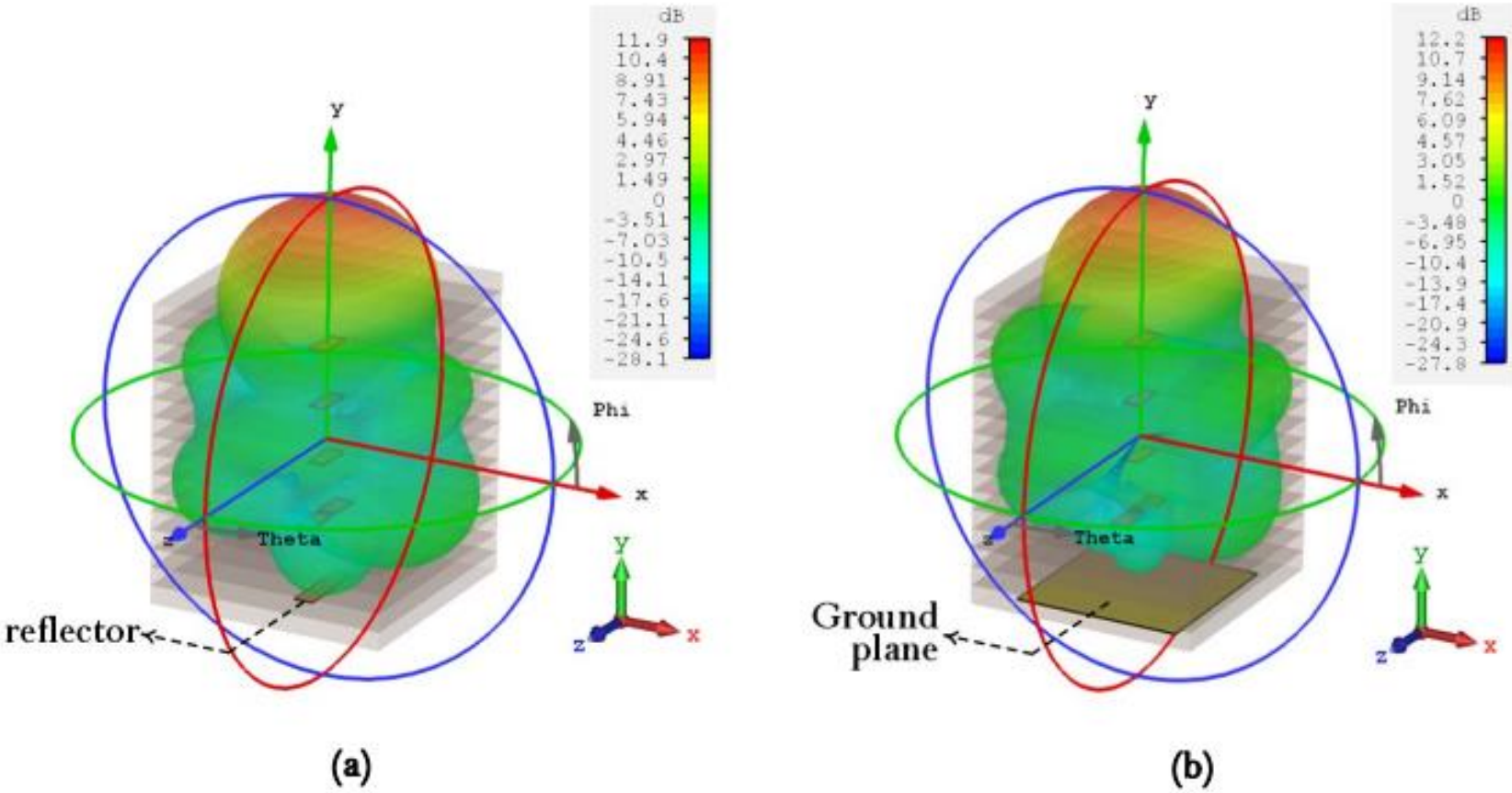


- Same variables as before

- Visualization technique: Insight:
  - line chart (on an interest plane)
  - comparing with the simulation: (different pattern)



Radiation diagram of the 24 GHz planar Yagi antenna (plane $\varphi = 0°$).



(a) (b)

3D view of the antenna's radiation pattern (a) with reflector and (b) with ground plane.

Concluding remarks

- Comparison between planar and multilayer prototypes,
- Slightly different measured and simulation results,
- Multilayer radiating structures seem a promising alternative,
- Good matching of both prototypes regarding simulated and measured radiation pattern
- Visualization was most valuable along the process to guide the design and confirm that goals were met

References

- A. Ramos, *Multilayer radiating structures for mmWaves*, MSc Dissertation, University of Aveiro, 2018.
- A. Ramos, T. Varum, and J. N. Matos, “Compact Multilayer Yagi-Uda Based Antenna for IoT/5G Sensors,” *Sensors*, vol. 18, no. 9, p. 2914, Sep. 2018, doi: 10.3390/s18092914.
- CST Studio Suite, https://www.3ds.com/products-services/simulia/products/cst-studio-suite/ (accessed Feb/2022)