Laboratory of Electronics
Antennas and Telecommunications

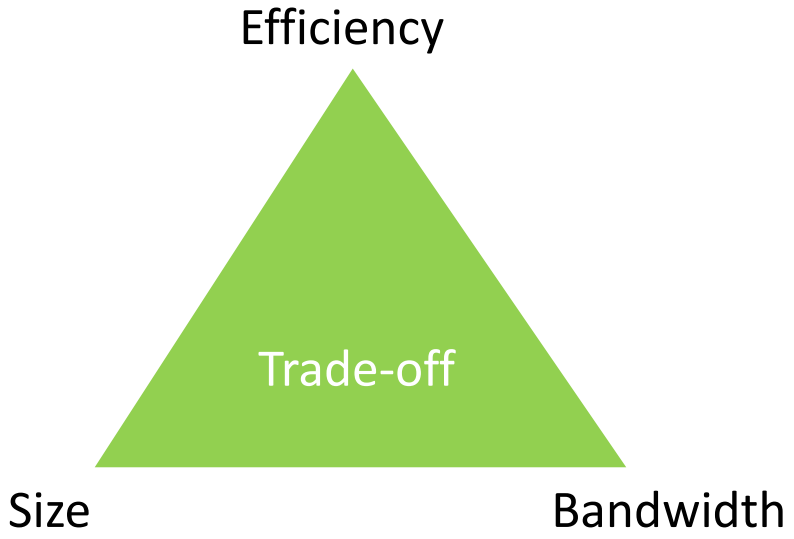
UCA Antenna tutorial

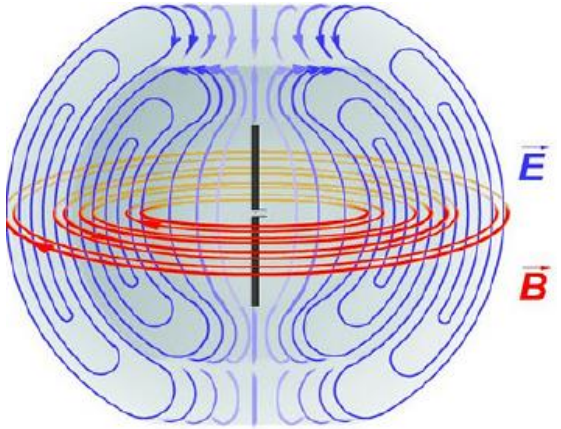
Fabien Ferrero, Université Côte d'Azur

Antenna key parameters

- Antenna is a resonnant structure :
  - antenna input impedance is changing with frequency
  - antenna have a limited frequency bandwidth
  - Miniature antenna can have a low efficiency due to metallic or dielectric losses
- Antenna is an open structure
  - Compare to electronic components, antenna is strongly influenced by its surrounding environment
  - For integrated antenna, the electromagnetic wave is generated by the antena **and** by the terminal ground plane

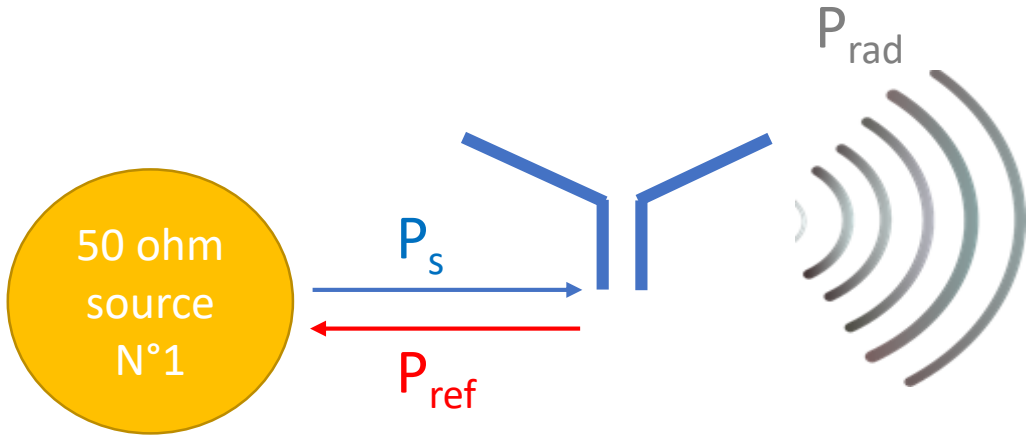
➢ **Small antenna has to be carefully tuned**





Antenna key parameters

- Definition :
  - P_s : Power from the source
  - P_{ref} : Power reflected by the antenna
  - P_{rad} power radiated by the antenna



- Antenna Performance Indicator
  - Reflection coefficient
    - S_{11} is usually plotted in dB scale
    - Classical S_{11} criteria is -10 dB (90% transmitted power)
    - For miniature antenna, -6dB is commonly used (75% transmitted power)

$$|S_{11}|^2 = P_{ref}/P_s$$

  - Total Efficiency
    - Include matching loss (from S_11) and radiation loss caused by metallic and dielectric losses
    - Can be plotted in linear or dB scale
    - No specific criteria, 30-70% classically observed

$$\eta_t = P_{rad}/P_s$$

Antenna key parameters

- Antenna Performance Indicator
  - Directivity
    - Directional properties of the antenna as compared with those of an isotropic source.
    - For an isotropic source, power is equally radiated in all directions.
    - $\overline{U}$ is the mean radiation intensity over a sphere
    - $U(\theta, \varphi)$ is the radiation intensity in a given direction
    - Plotted in dBi

$$\overline{U} = \frac{Prad}{4\pi}$$

$$D(\theta, \varphi) = \frac{U(\theta, \varphi)}{\overline{U}}$$

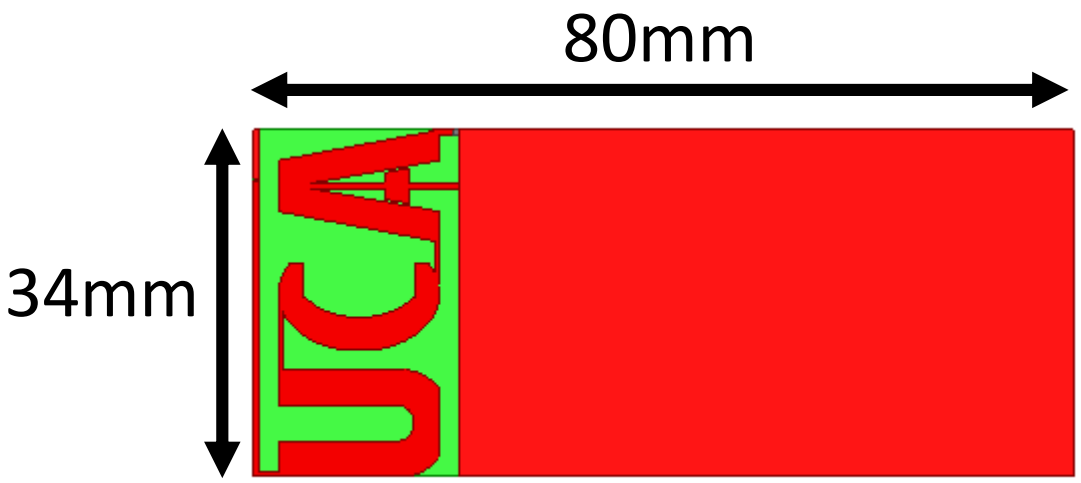
  - Gain
    - Include **matching**, **radiation loss** and **directivity**
    - Radiation intensity of your antenna referenced to a **loss-less isotropic** source
    - Plotted in dBi

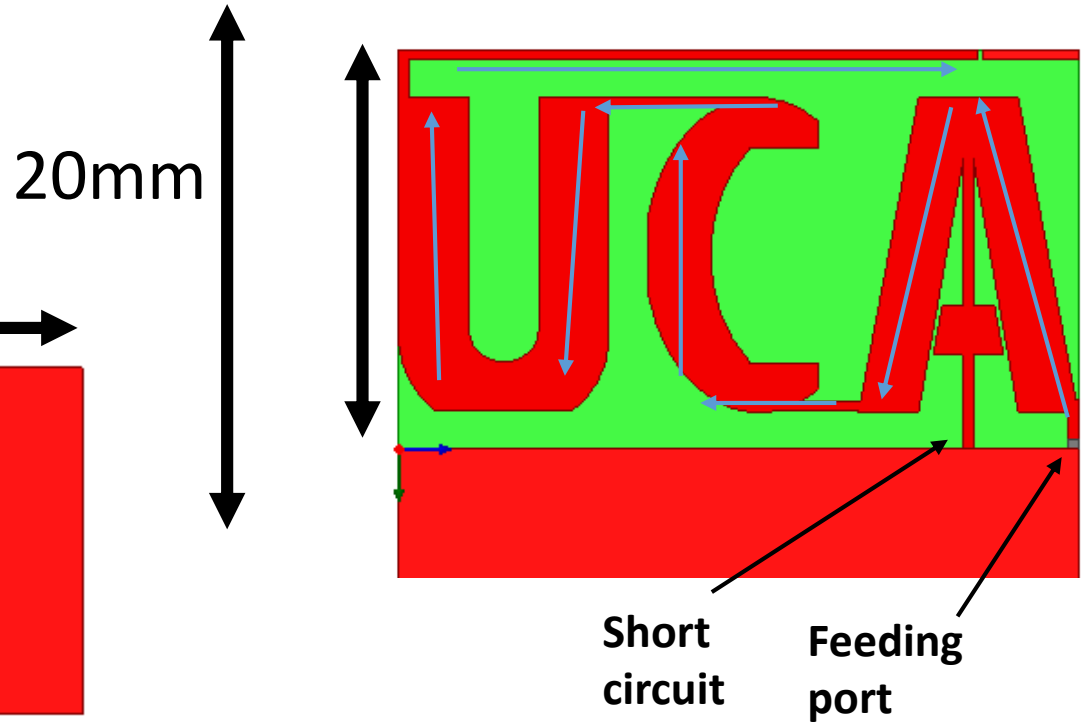
$$G(\theta, \varphi) = \frac{U(\theta, \varphi)}{P_s/4\pi}$$

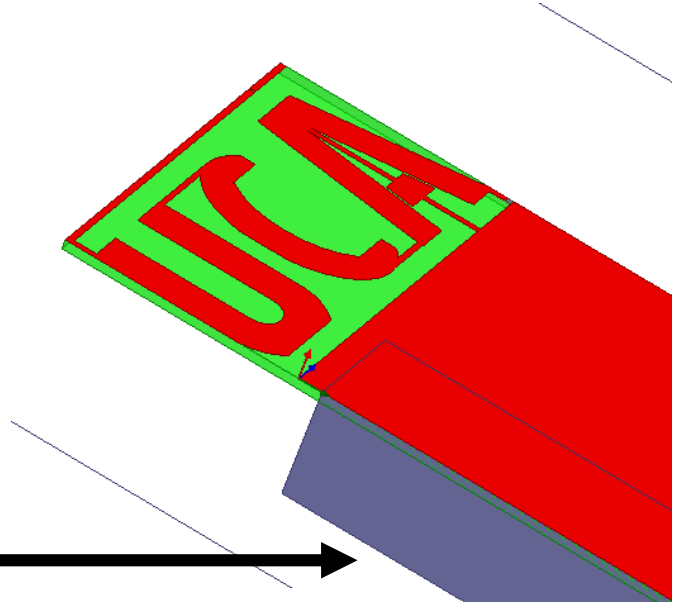
UCA Antenna layout

- Miniaturized Printed Antenna (low cost)
- Based on a meandered **I**nverted **F** **A**ntenna (**IFA**) Structure
- Mounted on a 80*34mm

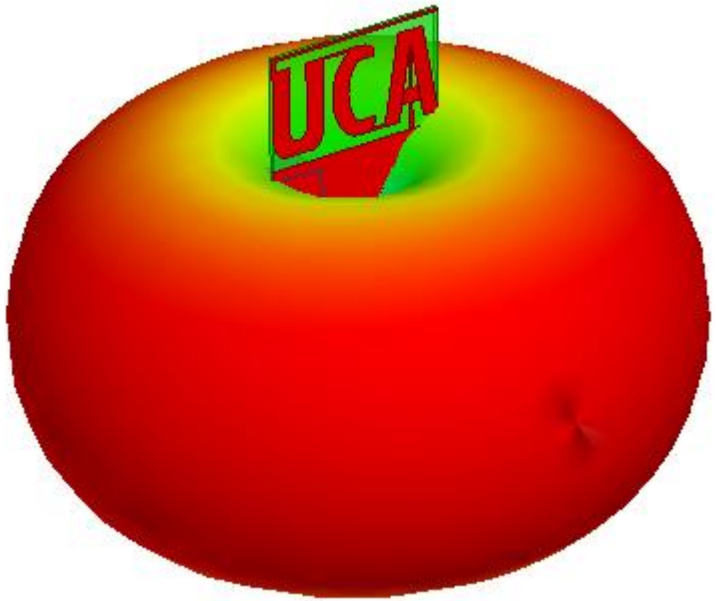
0.8mm-thick FR4 PCB



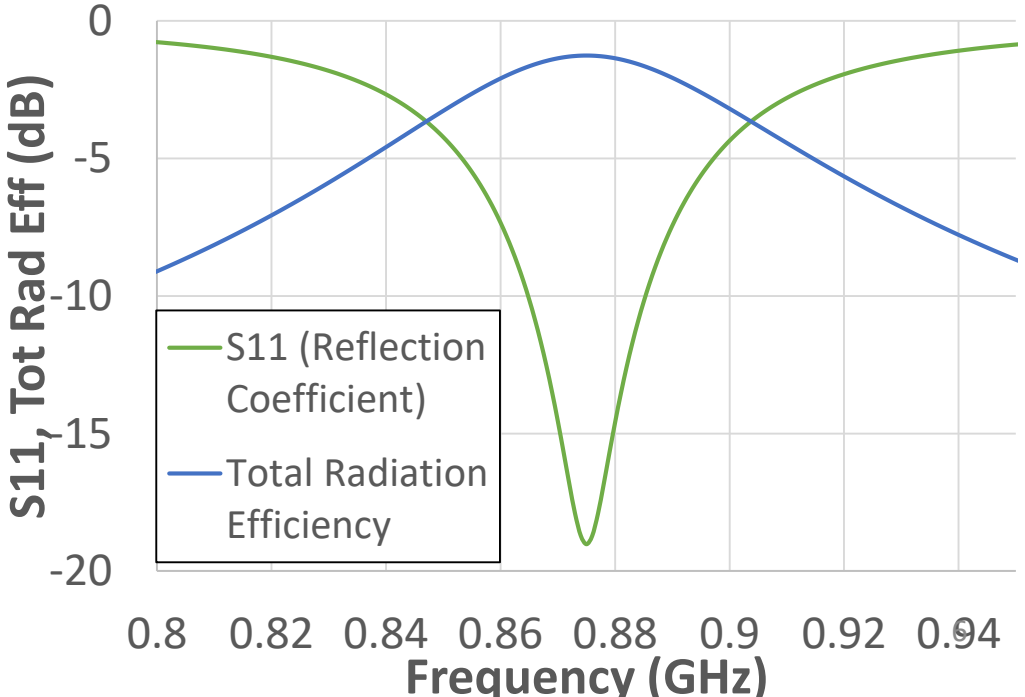




UCA Antenna tuned for EU band

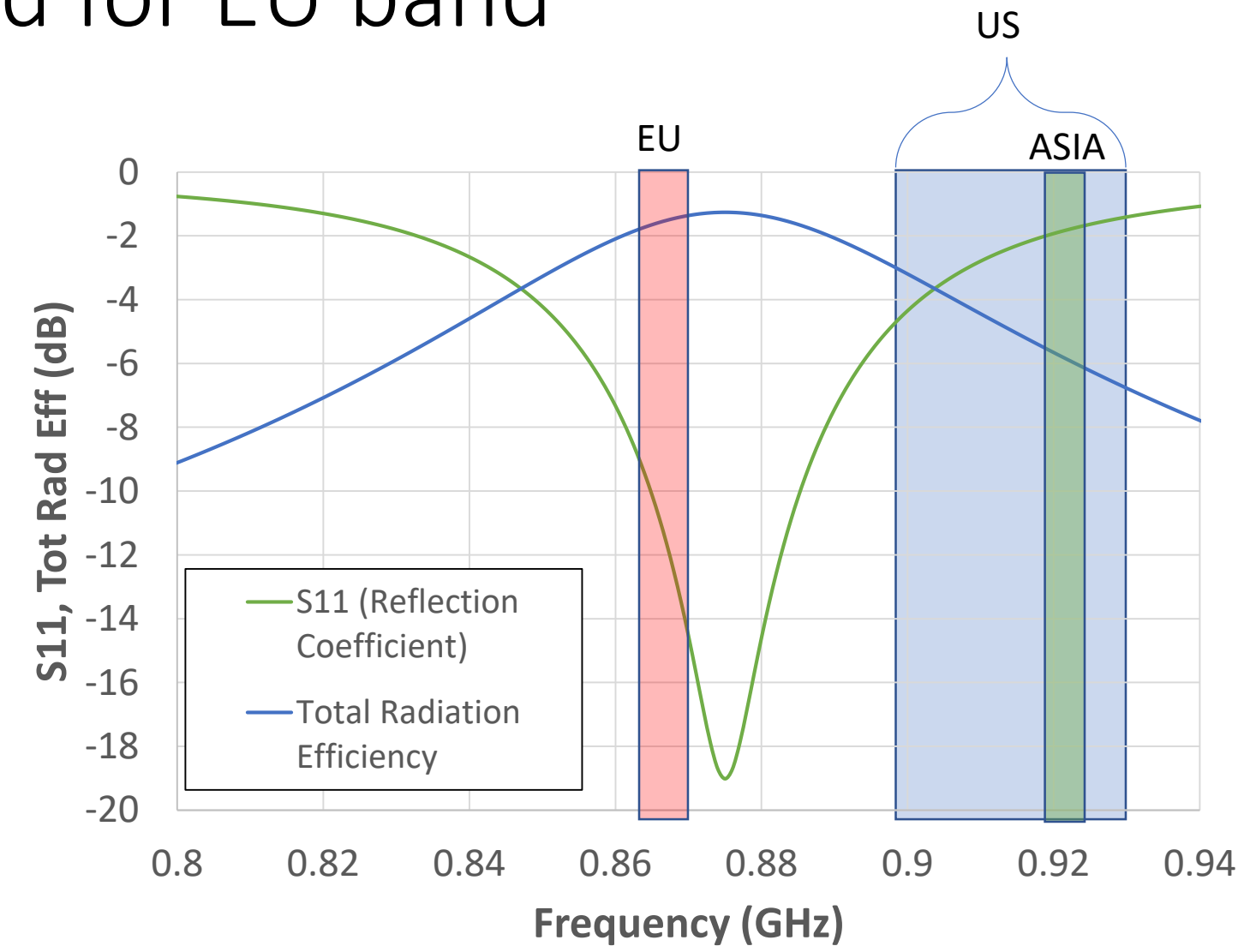


- Antenna simulation
  - Matched to 50 ohm
  - -6dB reflection coefficient between 857 and 888MHz
  - -10 dB reflection coefficient between 863 and 882 MHz
  - -1.2 dB radiation efficiency (75%)
  - Dipole radiation pattern
  - 2.1 dBi peak directivity
  - 0.9 dBi peak Gain



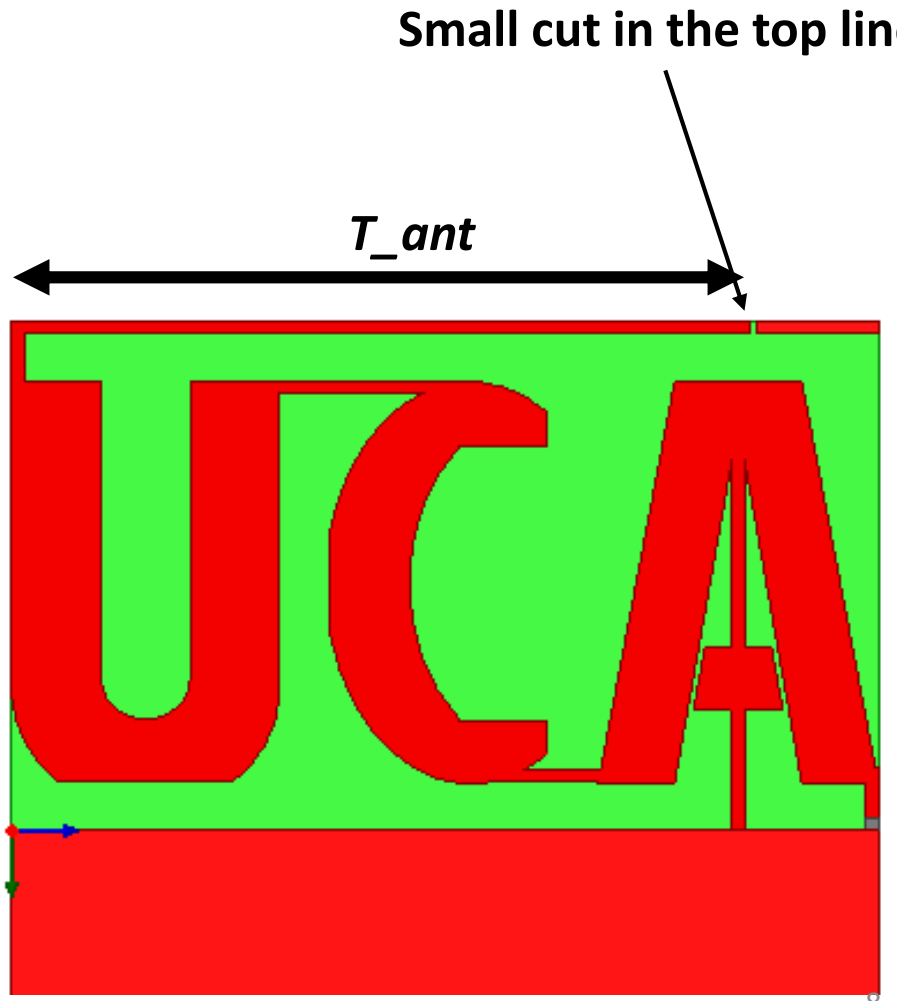
UCA Antenna tuned for EU band

- Miniature antenna
  - Limited frequency bandwidth
  - If the antenna is matched for European band, the antenna has poor radiation performance in US and ASIA bands

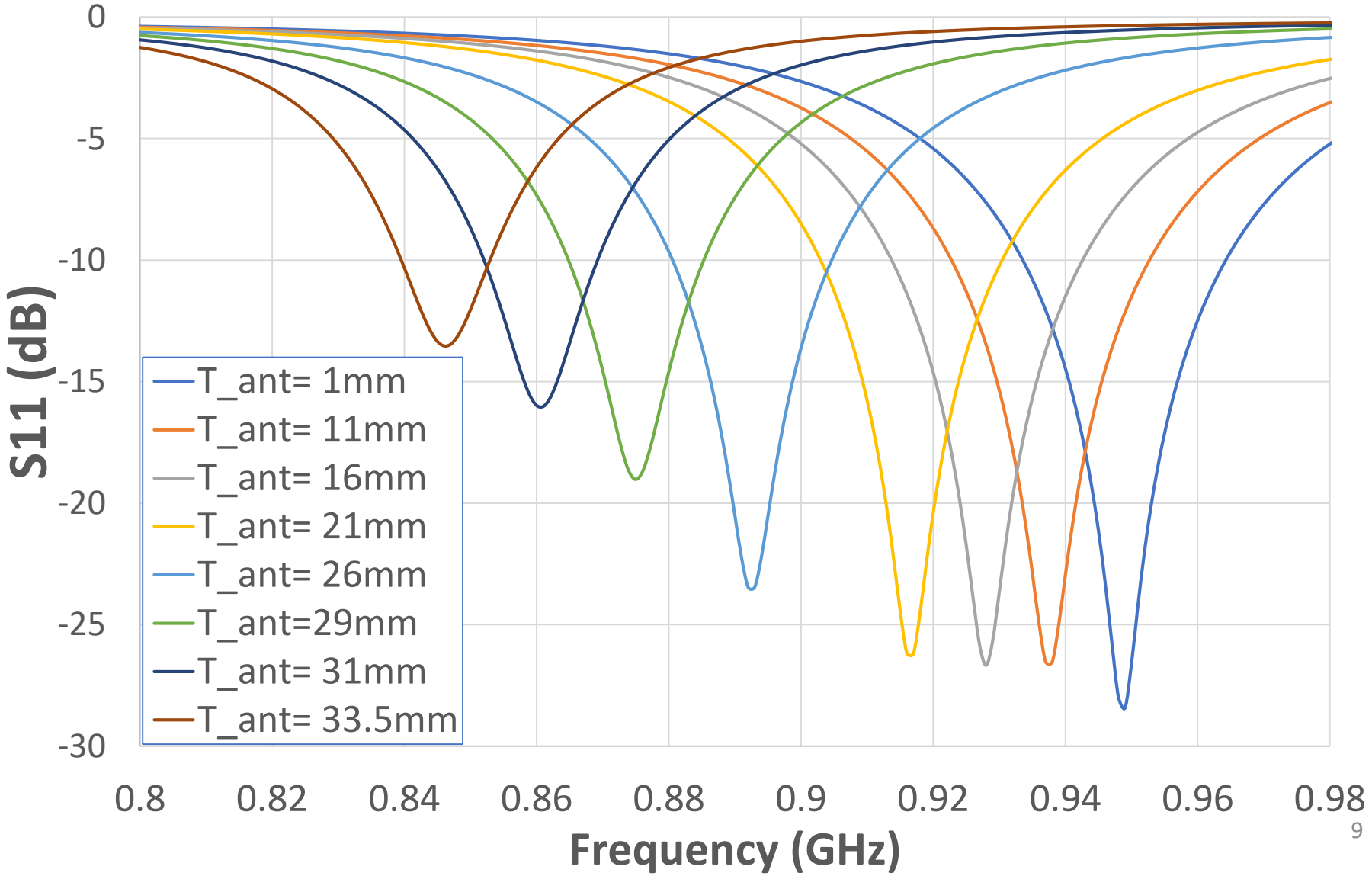


UCA Antenna tuning

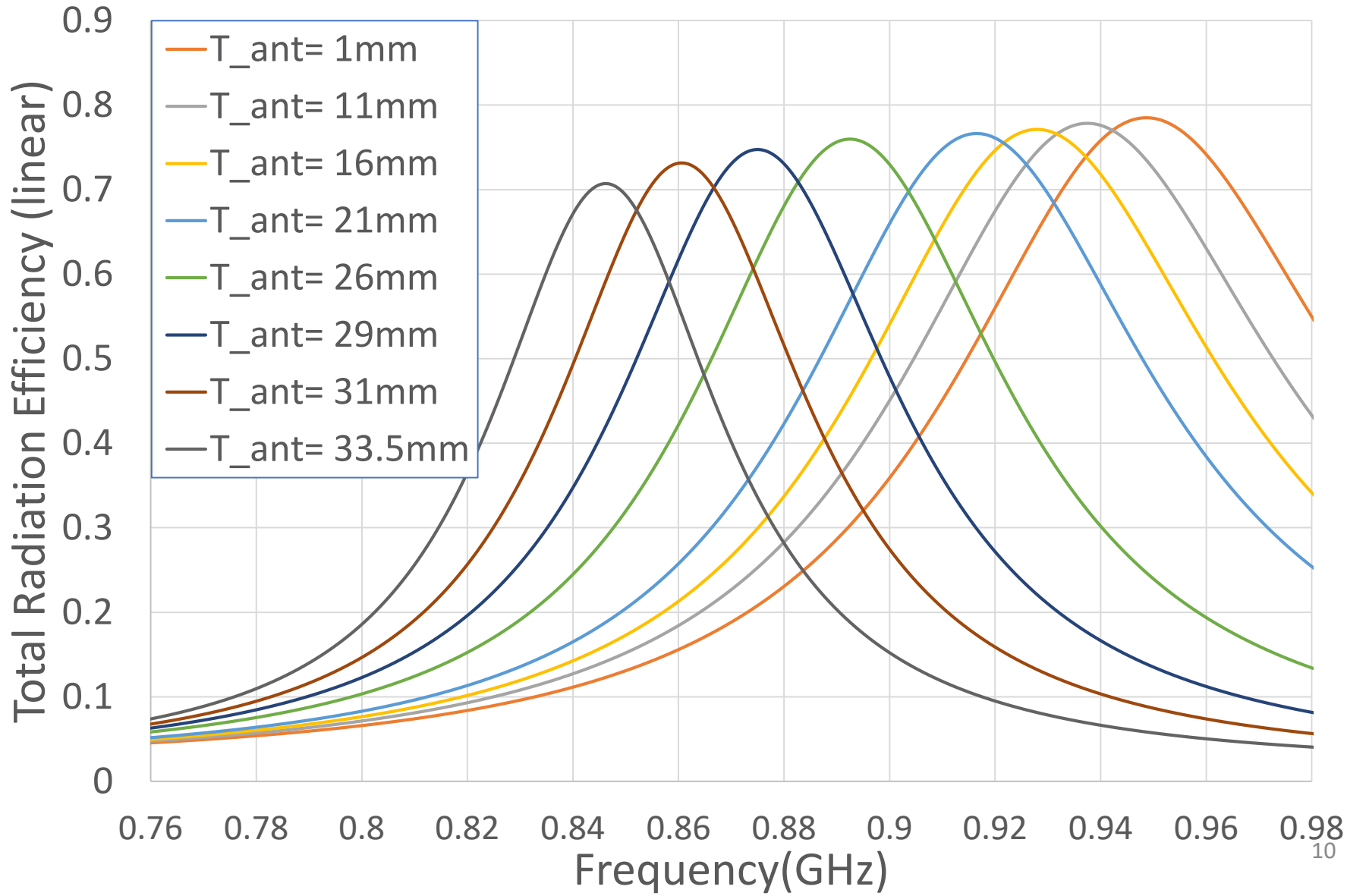
- The antenna shape can be easily tuned to different frequencies
  - The top line can be cut at different position to change the antenna trace length
  - *T_ant* parameter can be tuned from 0 to 34mm
  - Antenna resonance frequency can be tuned from 845 to 950MHz



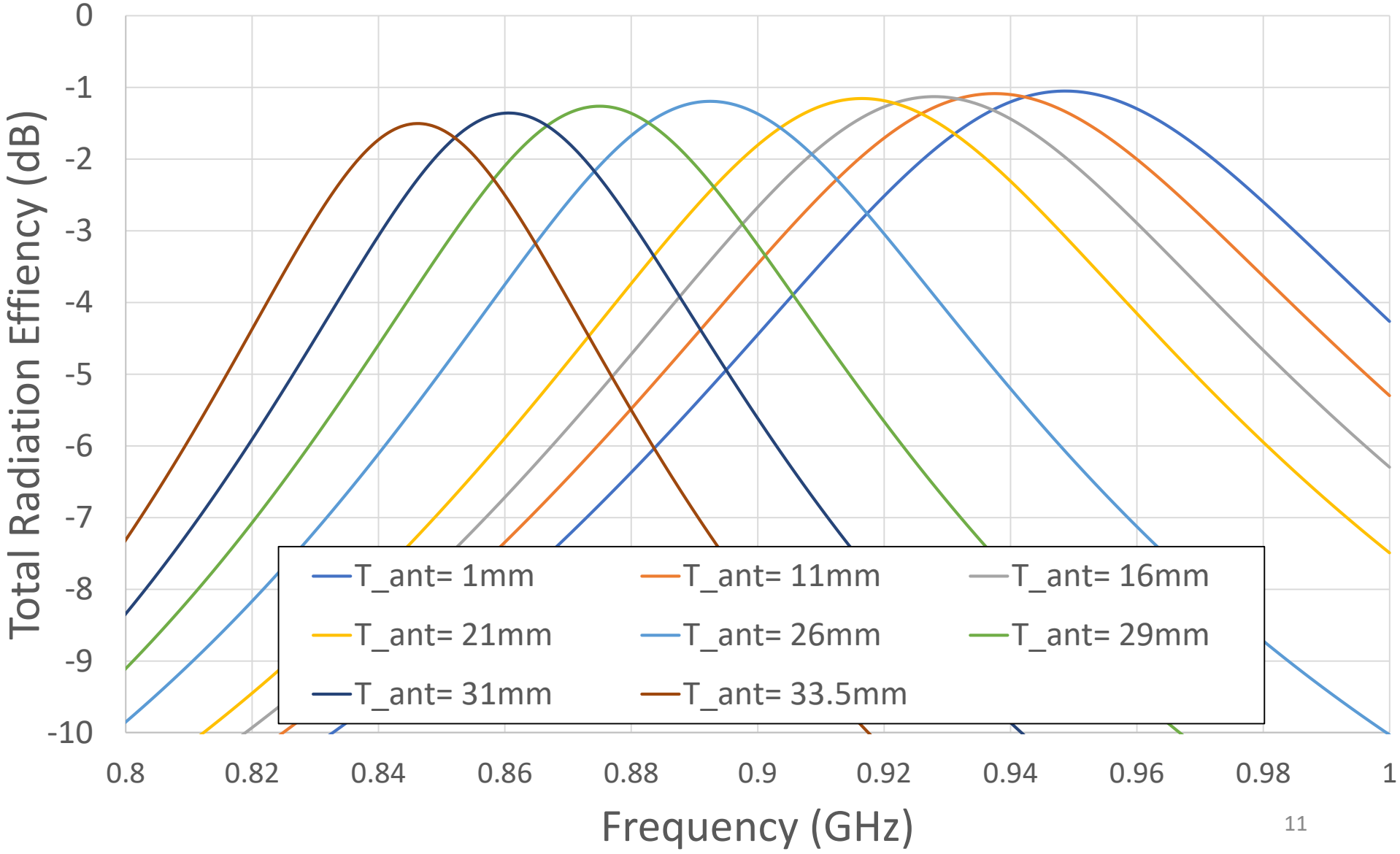
UCA Antenna tuning : Reflection coefficient



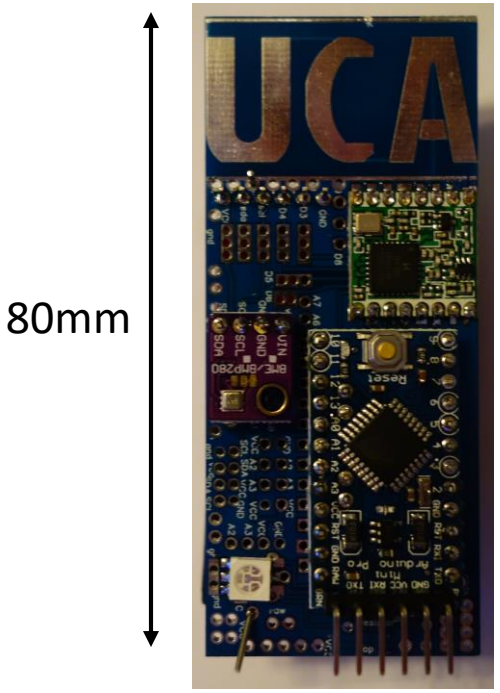
UCA Antenna :Linear Total Radiation Efficiency



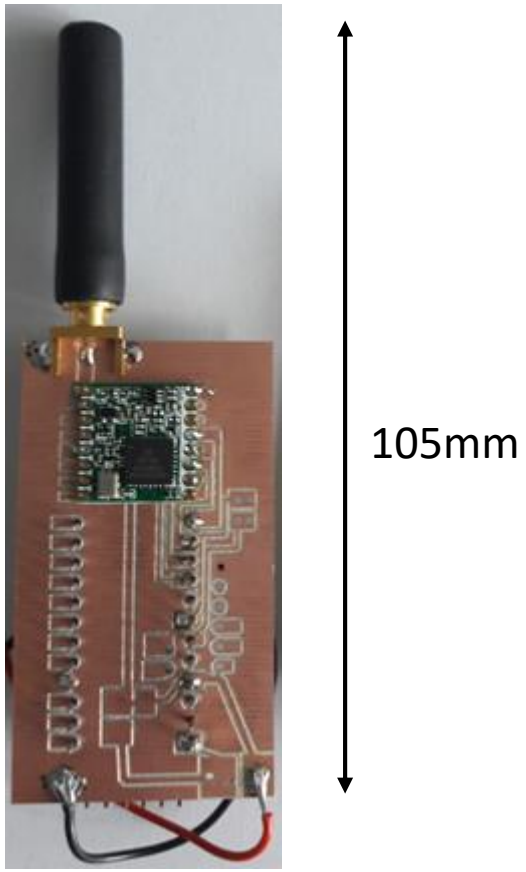
UCA Antenna :Total Radiation Efficiency in dB



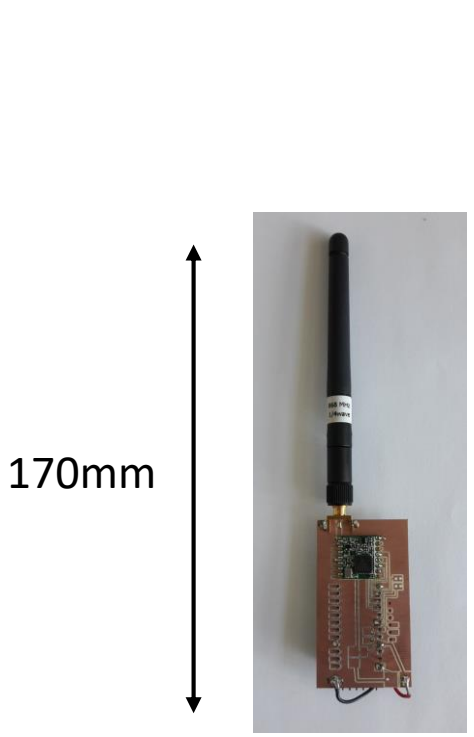
UCA Antenna : Comparison with on-the-shelf antenna



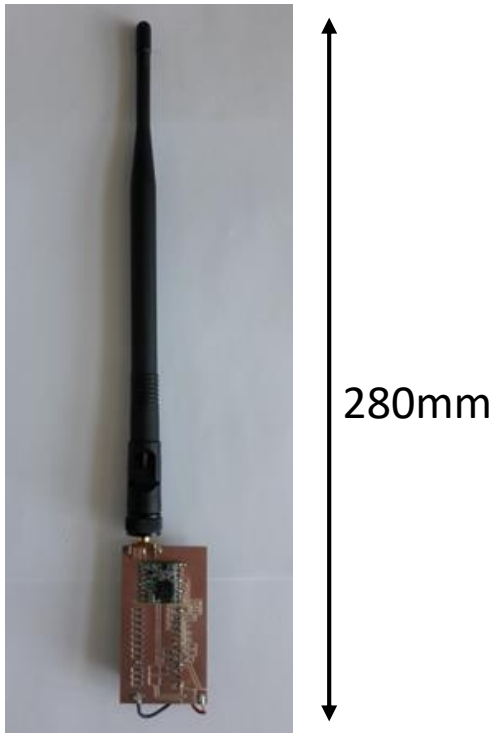
UCA antenna



Short monopole



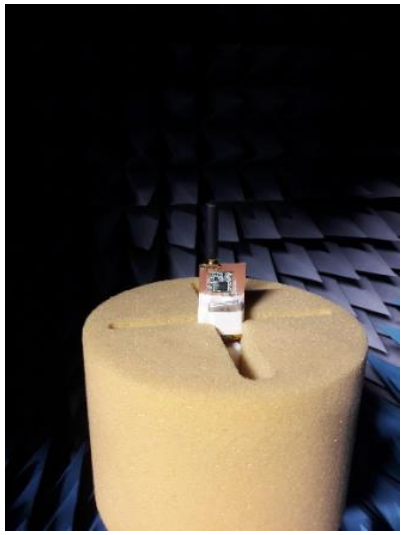
Quarter-wave monopole

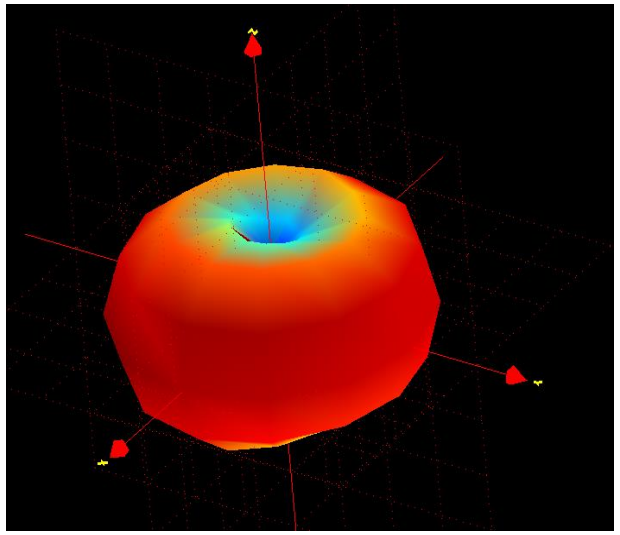


half-wave dipole

UCA Antenna : Measurements

- Measurement on Satimo Starlab station
  - Continuous wave with 14 dBm power from RFM95W module
  - Efficiency calculated from the 3D antenna measurement





Antenna structure	EIRP (dBm)	Total efficiency	Max Dimension
Small monopole	14.7	74%	105 mm
Quarter-wave monop.	15.7	94%	170 mm
Half-wave dipole.	13.9	61%	280 mm
UCA untuned	13.8	60%	80mm
UCA after tuning	14.8	76%	80mm