LABORATOIRE D'ELECTRONIQUE
ANTENNES ET TELECOMMUNICATIONS

Laboratory of Electronics Antennas and Telecommunications

The Challenge of LoRaWan antenna

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Outline

- Why antenna is important ? A practical example
- Antenna key parameters
- Low-cost Antenna Open Source project
- Micro-tracker Antenna Industrial project
- Conclusion and perspectives

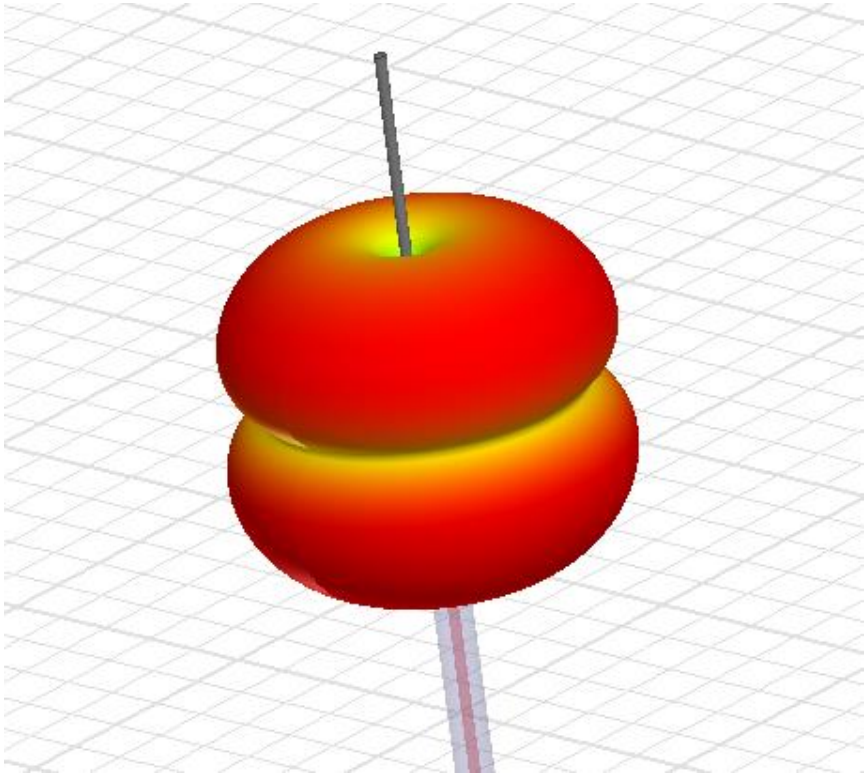
Antenna is important for communication range

- Smart Farming project in Pakistan
- Humidity sensors in a corn field
- Quart-wave antenna placed on a mast
- Communication range limited to 1 km …

project WaterSense UPPA/Nestlé

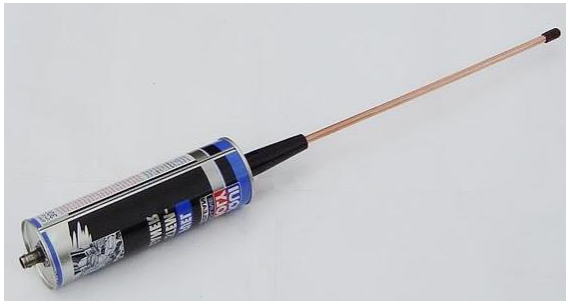
Antenna is important for communication range

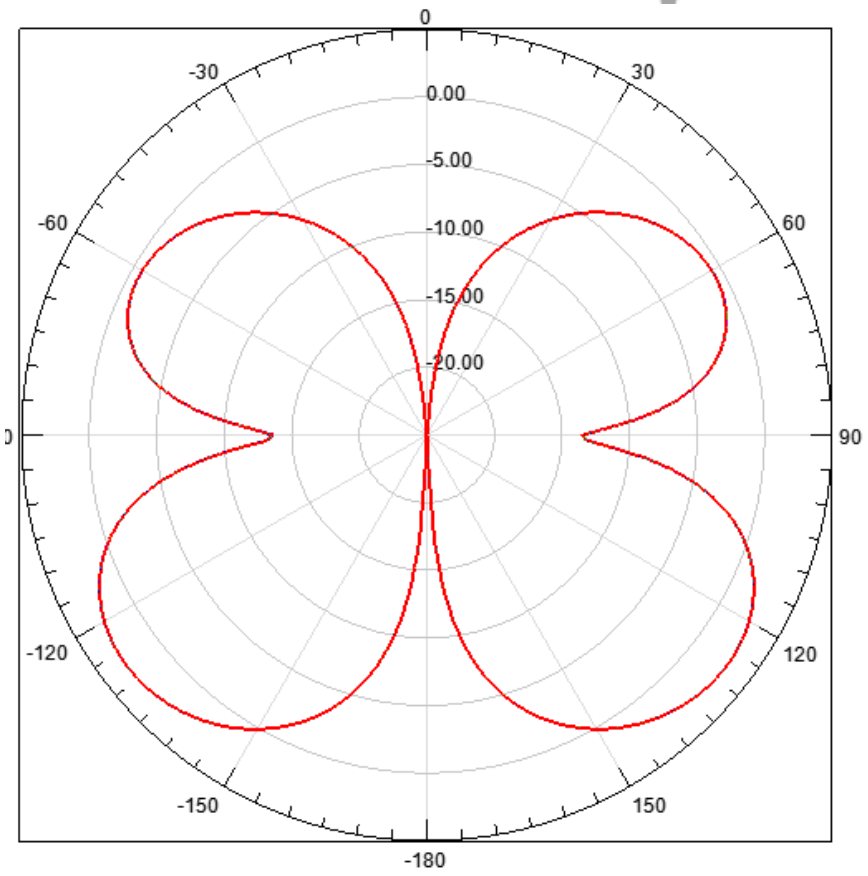
- Quarter-wave antenna need a ground plane
- EM simulation to analyse the radiation pattern



Antenna is important for communication range

- Nulls in the radiation pattern
- Reduced Gain in the direction of the gateway (**-14 dBi**)
- Caused by current flowing on the shield on the coaxial cable
- The cable+antenna form an antenna array with destructive interference toward the horizon.
- Need to use a balanced antenna with a balun like a sleeve dipole





Total Gain Elevation plane

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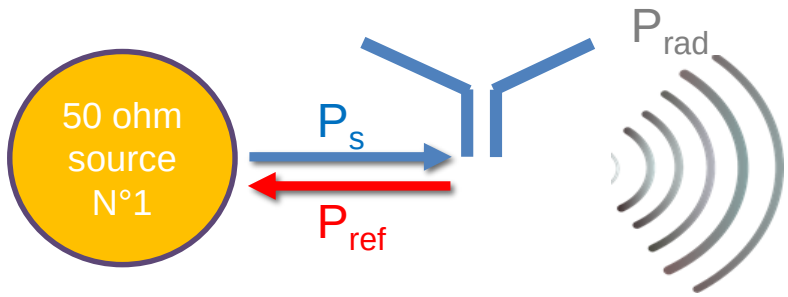
Antenna performance indicator

- 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
    - S_{11} criteria from -10 dB to -6dB (90% to 75% transmitted power)
  - Total Efficiency
    - Include **matching** and **radiation loss**
    - Can be plotted in linear or dB scale
    - 30-70% classically observed
  - Gain
    - Include **matching**, **radiation loss** and **directivity**
    - Plotted in dBi
    - $U(\theta, \varphi)$ is the radiation intensity in a given direction



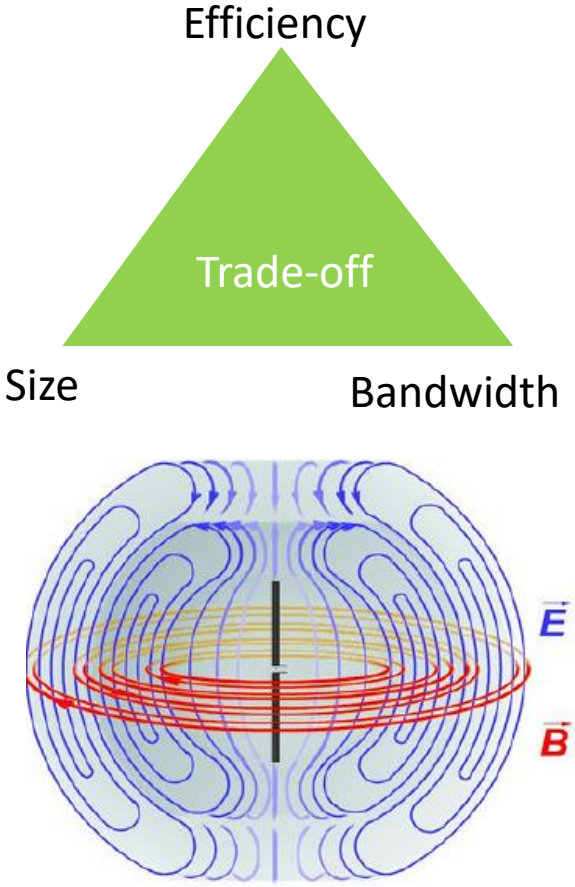
$$|S_{11}|^2 = P_{ref}/P_s$$

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

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

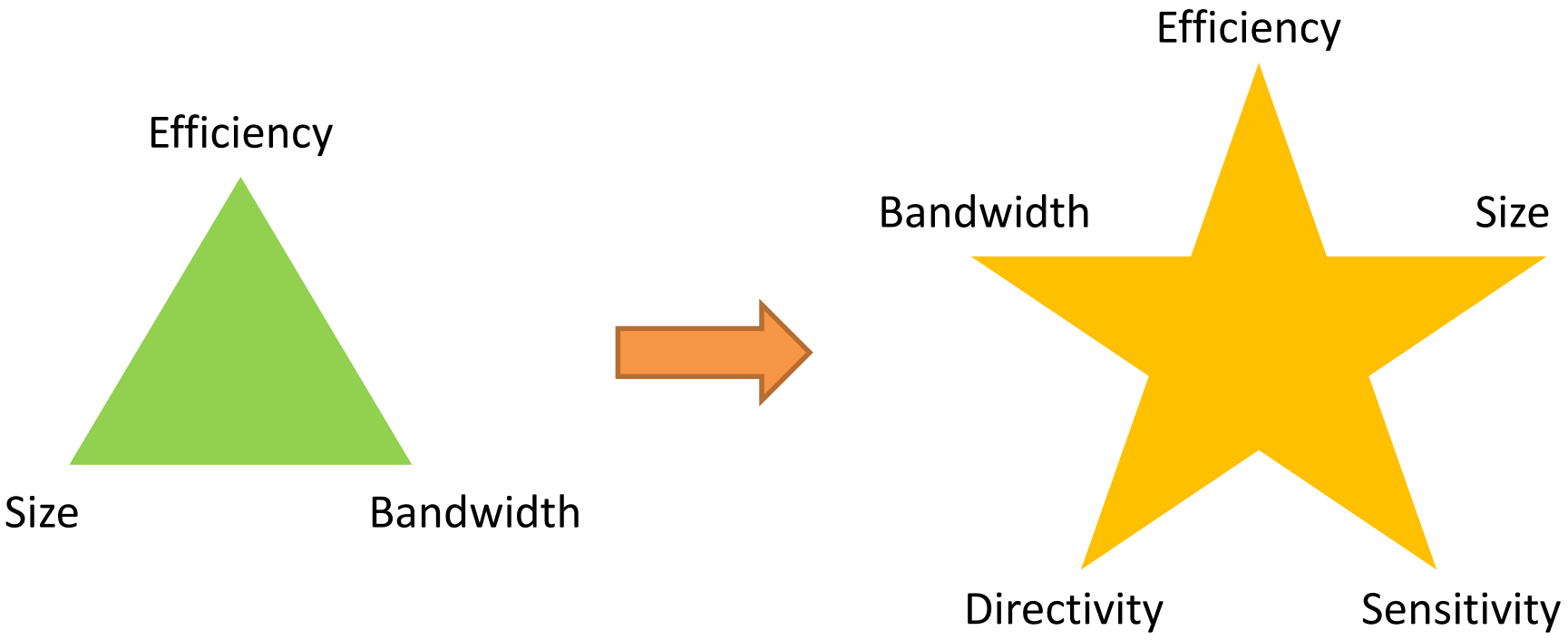
Antenna key parameters

- Antenna is a resonnant structure :
  - Input impedance is changing with frequency
  - 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 antenna **and** by the terminal ground plane
- ➢ Small antenna has to be carefully tuned



Antenna key parameters

Multidimensional Constraints



How much can I radiate ?

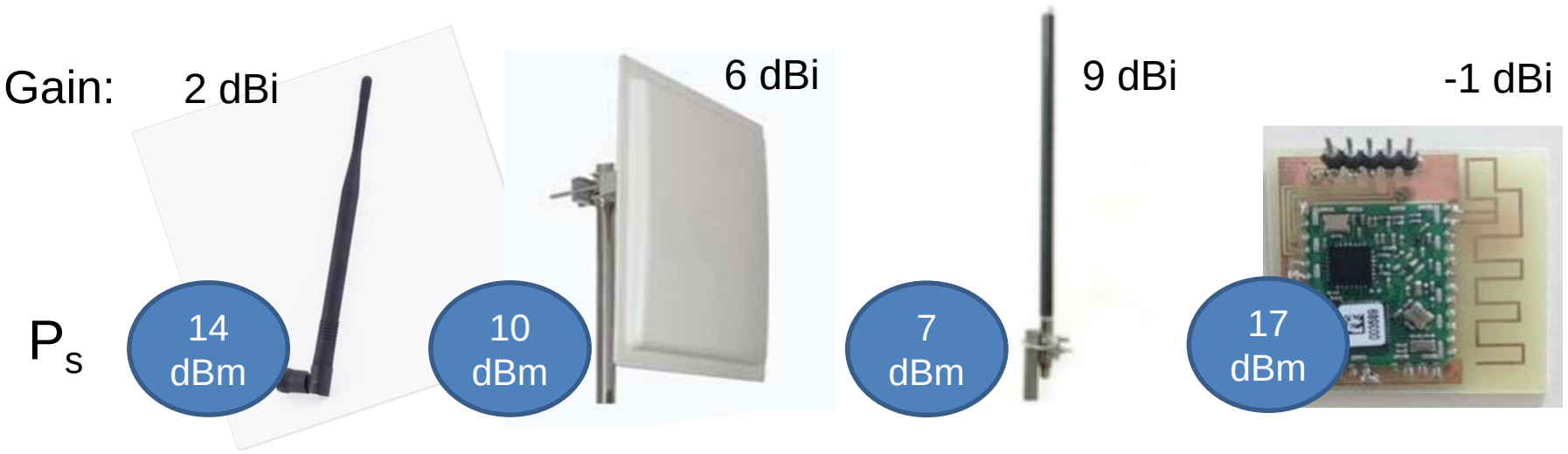
- Regulators defines the maximum radiated power in Equivalent Radiated Power (ERP)

  *In Europe : ERP @868MHz is **14 dBm***

- **E**ffective **R**adiated **P**ower : amount of power applied to a half-wave dipole to give the same power density at a given point

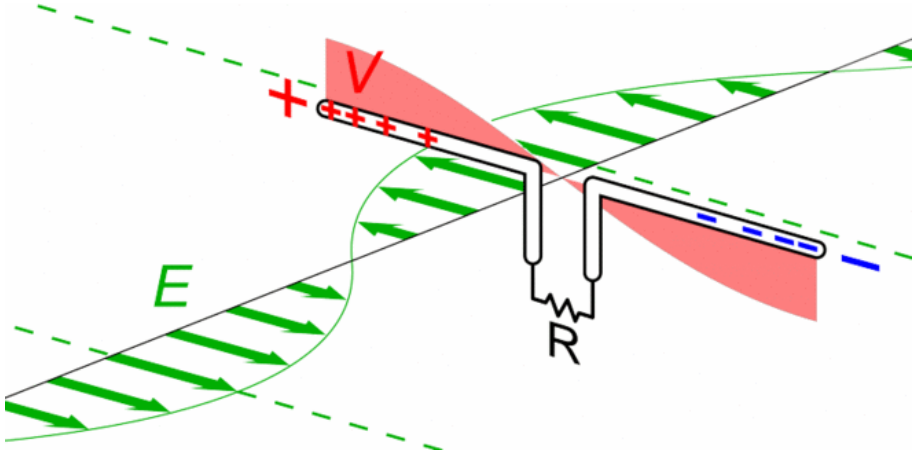
- **E**ffective **I**sotropic **R**adiated **P**ower : the reference is an isotropic radiator

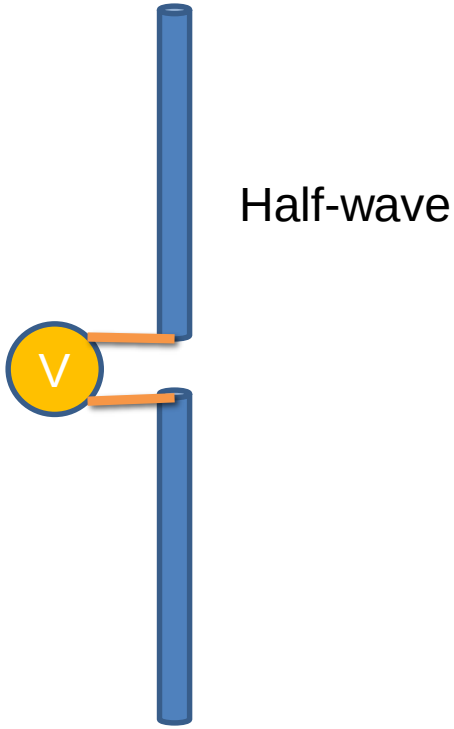
$$EIRP = ERP + 2\ dB$$



Effect of terminal chassis

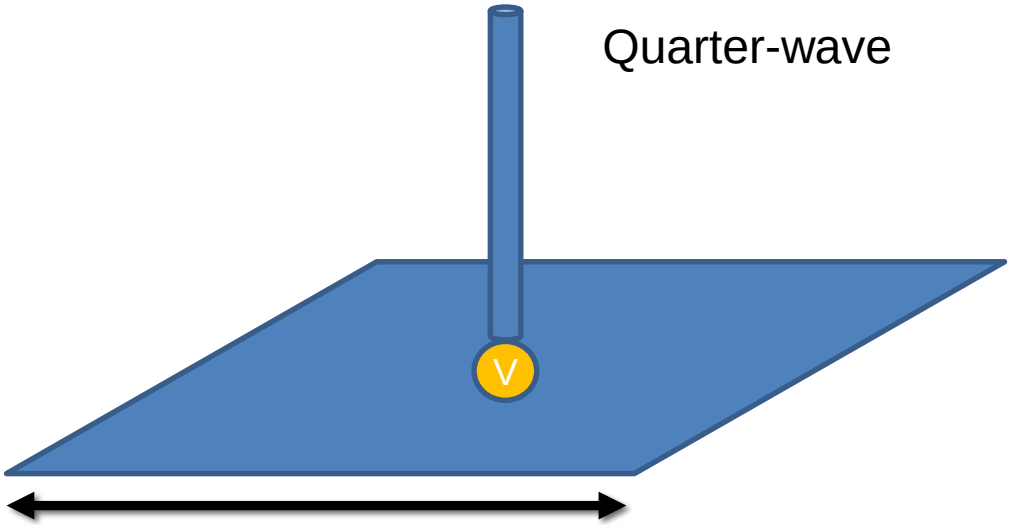
- Antennas can be:
  - Dual-pole : 2 parts will contribute to the radiation
  - Single-pole with a large ground plane





Half-wave

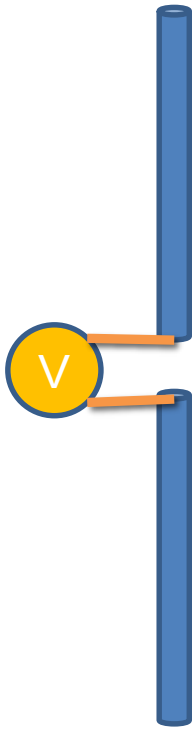
Quarter-wave



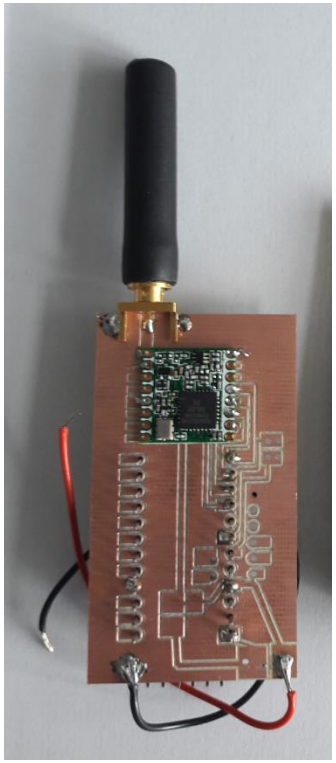
> 2 wavelengths
@868MHz > 70cm

Effect of terminal chassis

- In most of the case, you will have a dual-pole antenna

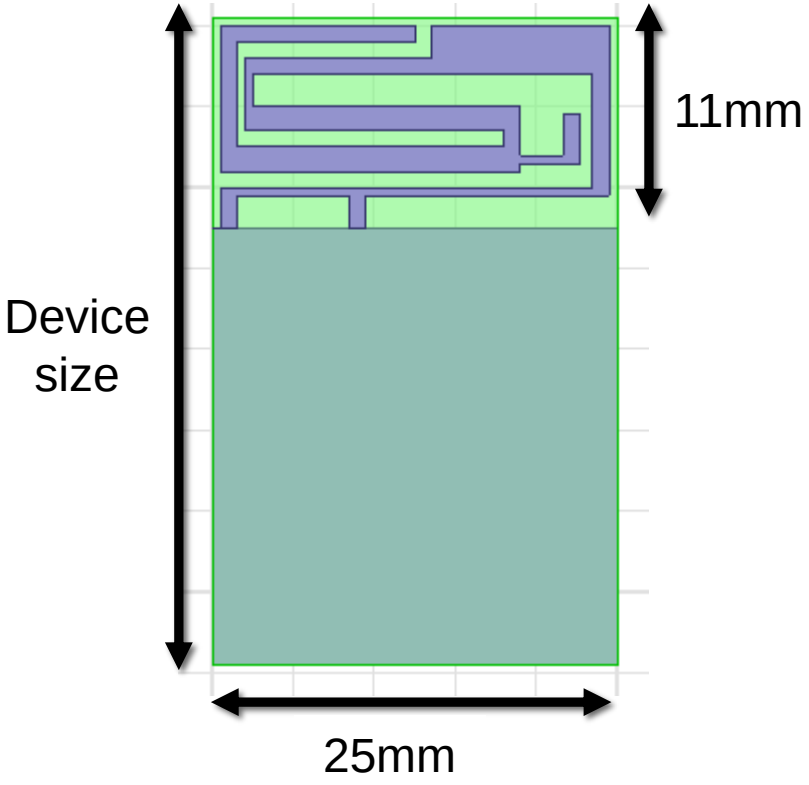


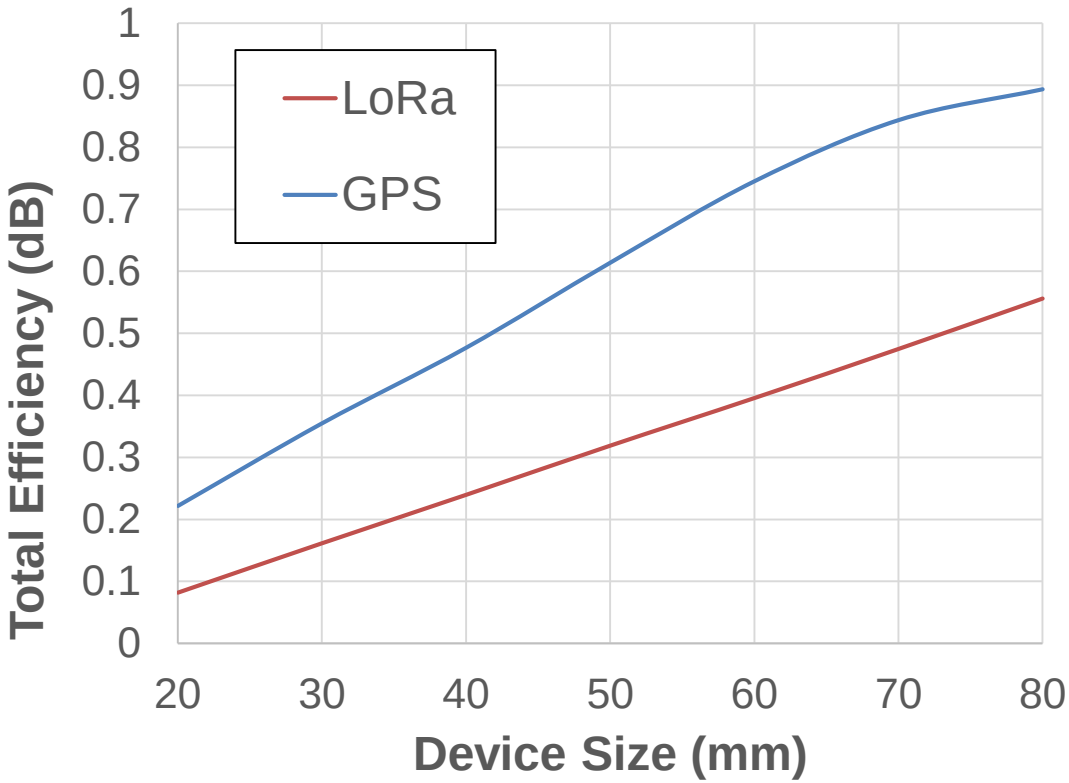
Half-wave



Effect of terminal chassis

- LoRa (868MHz) and GPS (1575MHz) antenna on small terminal





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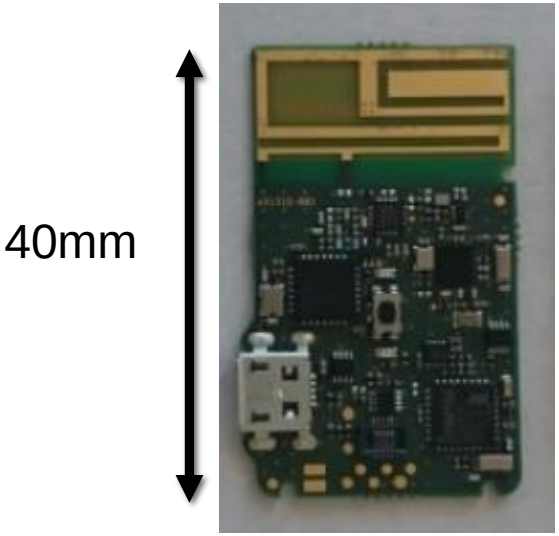
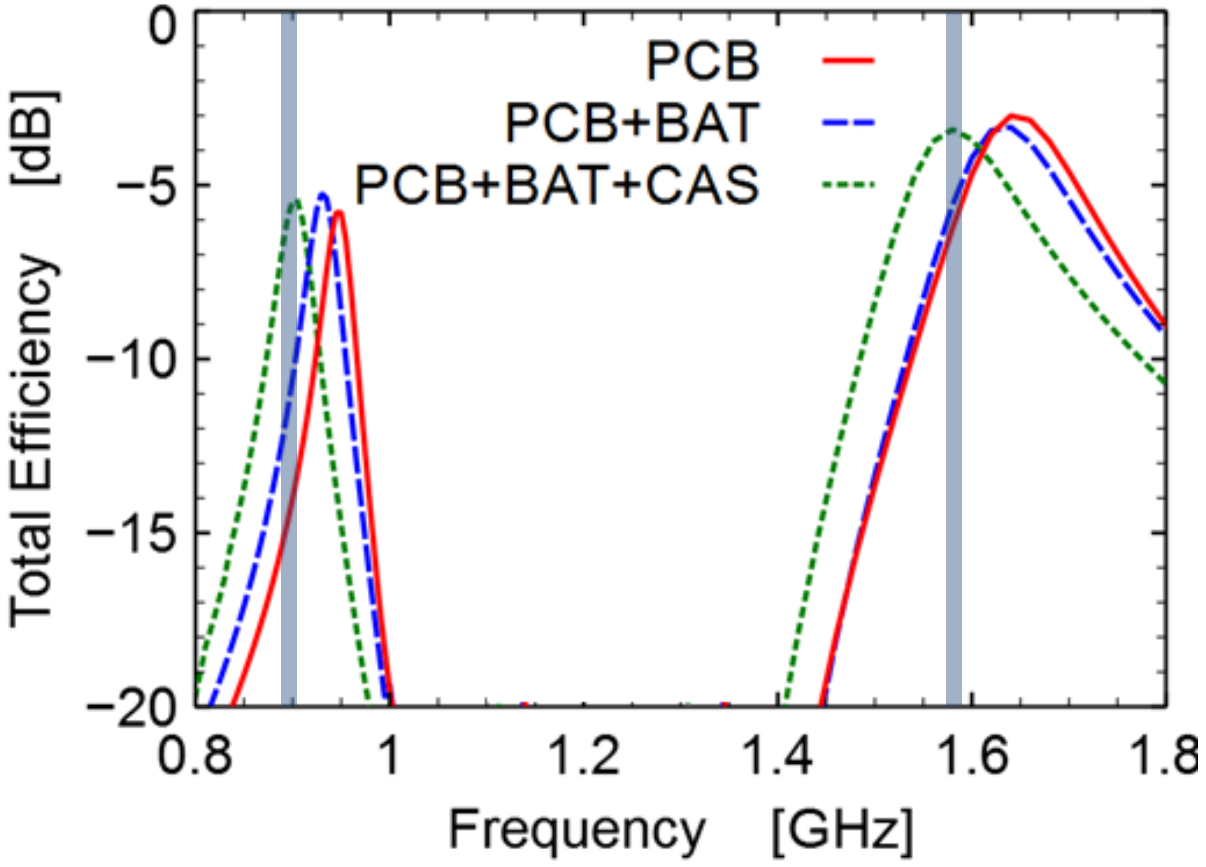
Effect of the environment

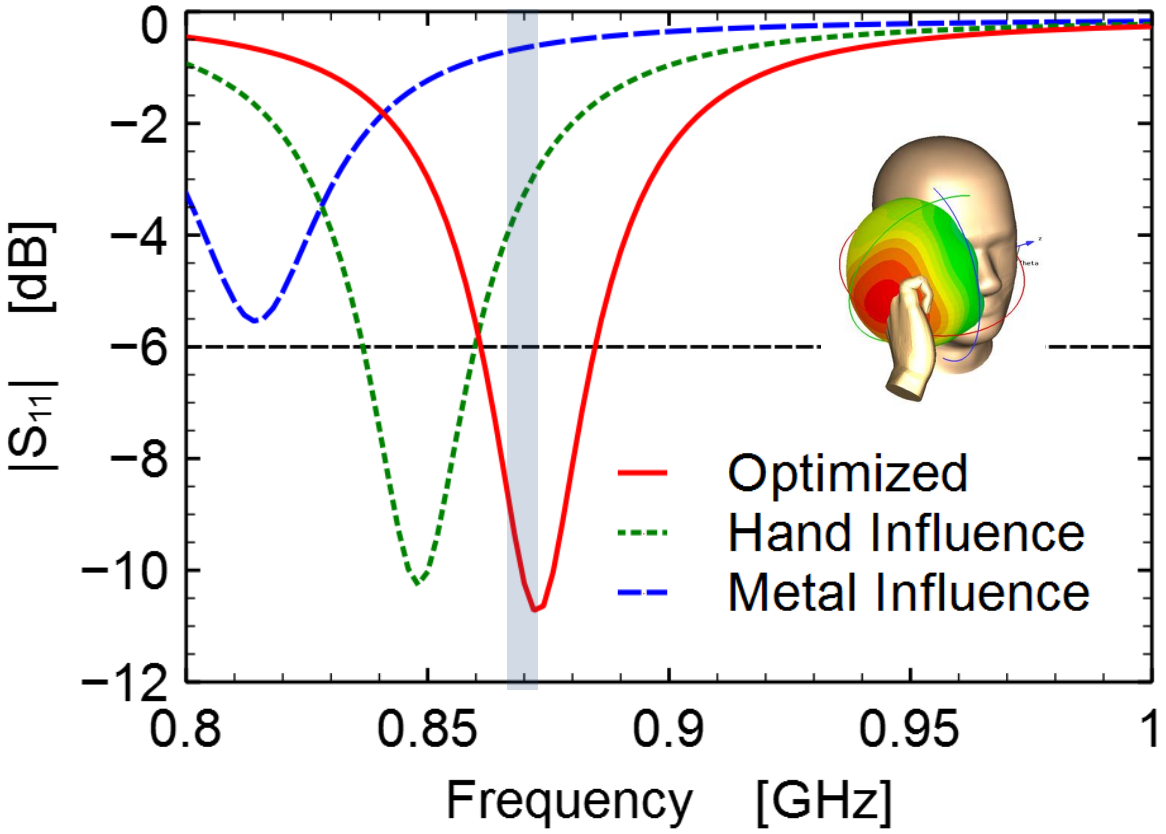
Antenna are strongly influenced by the close environment like the battery or the terminal casing





Effect of the environment

Antenna are also influenced by the surrounding environment



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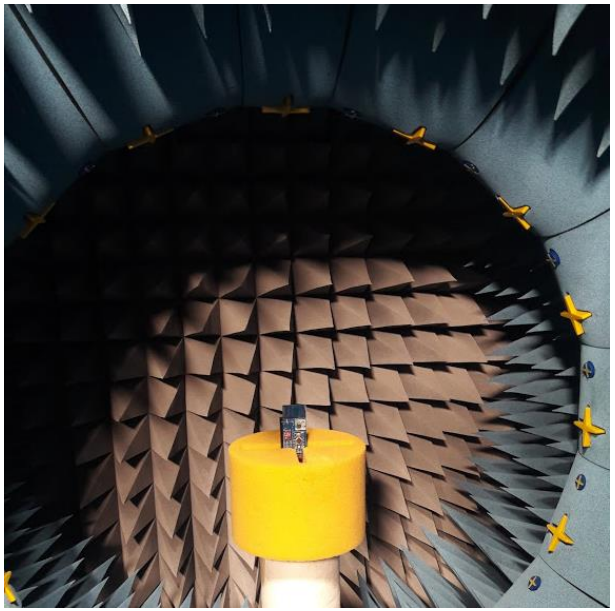
Antenna measurement

- Reliable antenna measurement is not an easy task
- Very hard to test antennas in a non-anechoic environment
- Cables have a large influence on the measurement
- Only Total Radiated Power (TRP) measurement can be trusted



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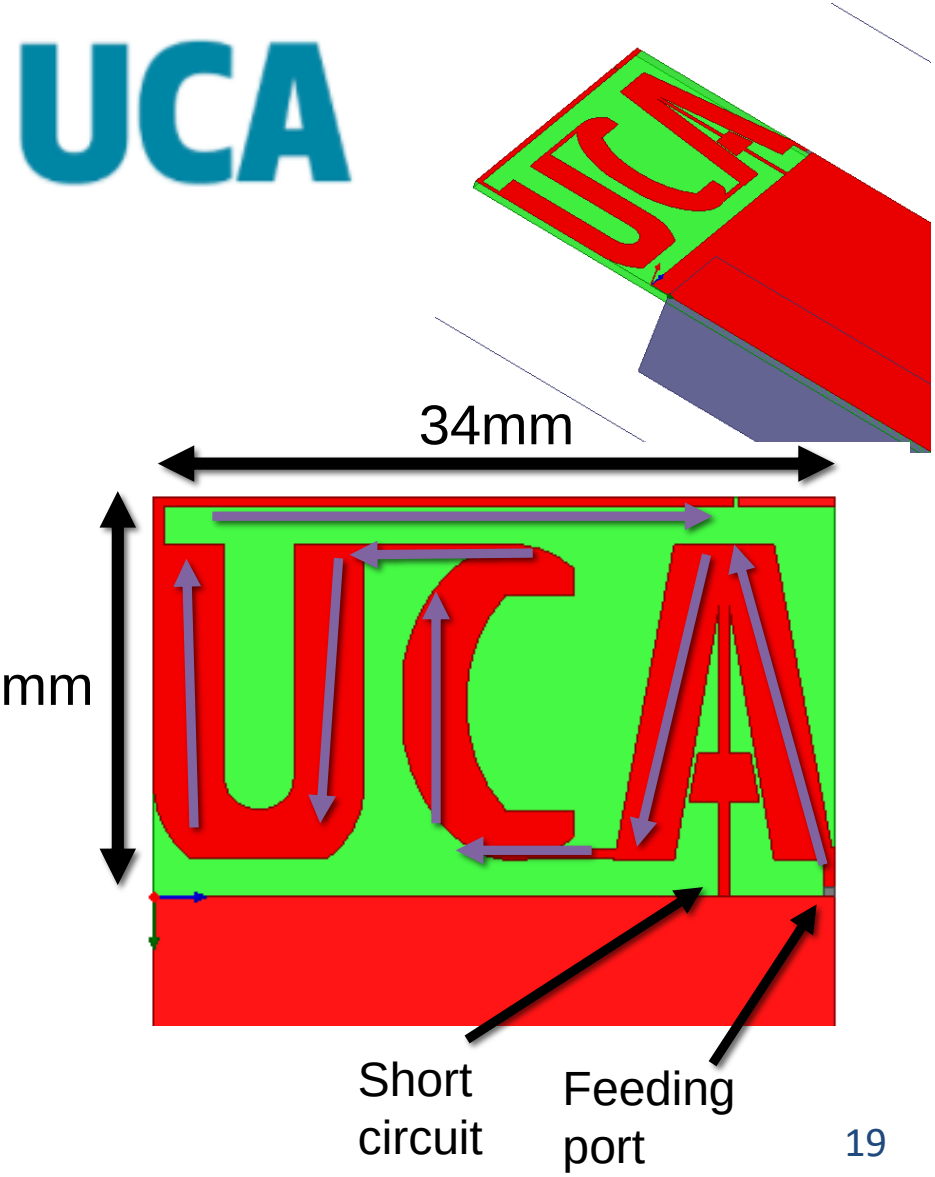
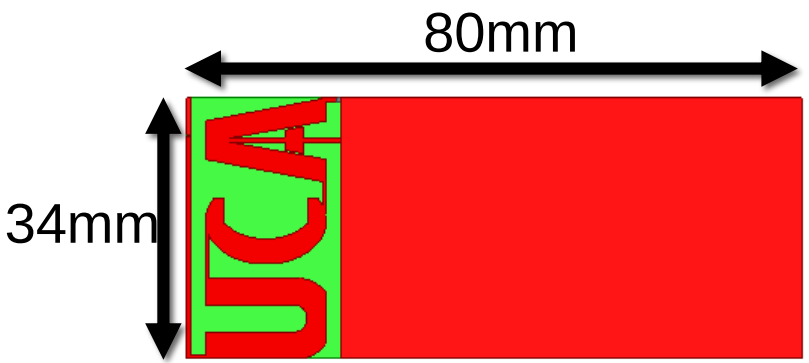
Design of cost efficient antenna @868MHz

- LoRa collar for Cattle Rustling applications
- Cost reduction
  - Remove RF connectors (a SMA connector is 4$)
  - Avoid external antenna (cost between 2 and 8 $)
  - A PCB is needed for component integration
  - The cost for an extension of the PCB is negligible, so PCB integrated antenna is very cost efficient

UCA Antenna layout

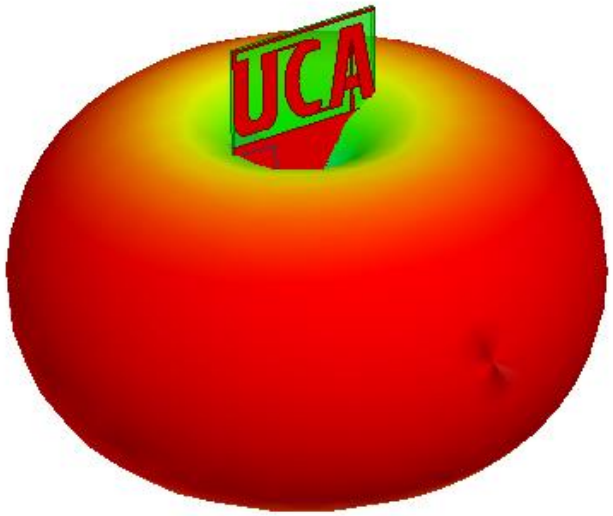
- Miniaturized Printed Antenna(low cost)
- Based on a meandered **I**nverted **F** **A**ntenna (**IFA**) Structure
- Mounted on a 80*34mm 0.8mm-thick FR4 PCB
- Performance equivalent to a classical printed antenna in this area





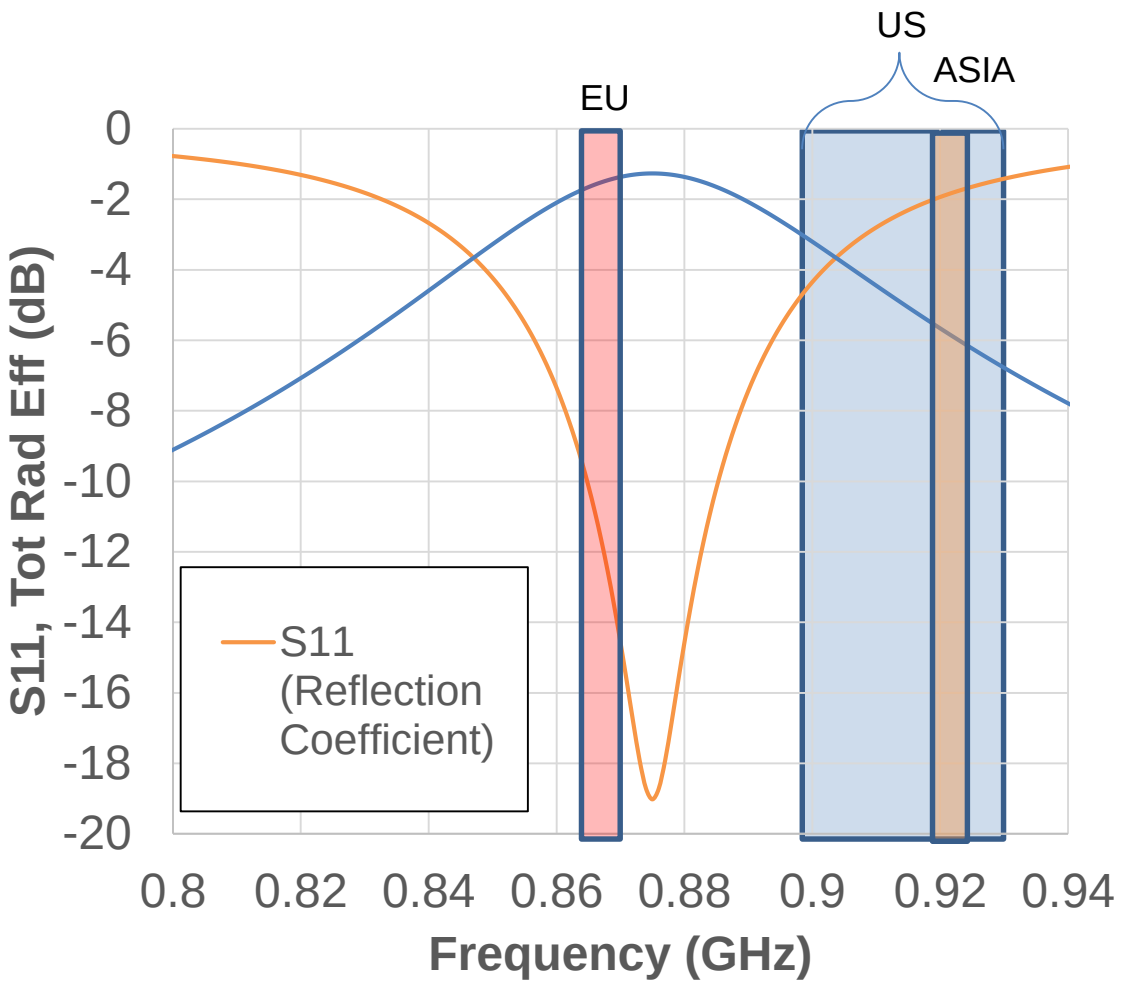
UCA Antenna tuned for EU band

- Antenna simulation
  - Matched to 50 ohm
  - Bw = 30MHz (@-6dB)
  - -1.2 dB radiation efficiency (75%)
  - Dipole radiation pattern
  - 2.1 dBi peak directivity
  - 0.9 dBi peak Gain



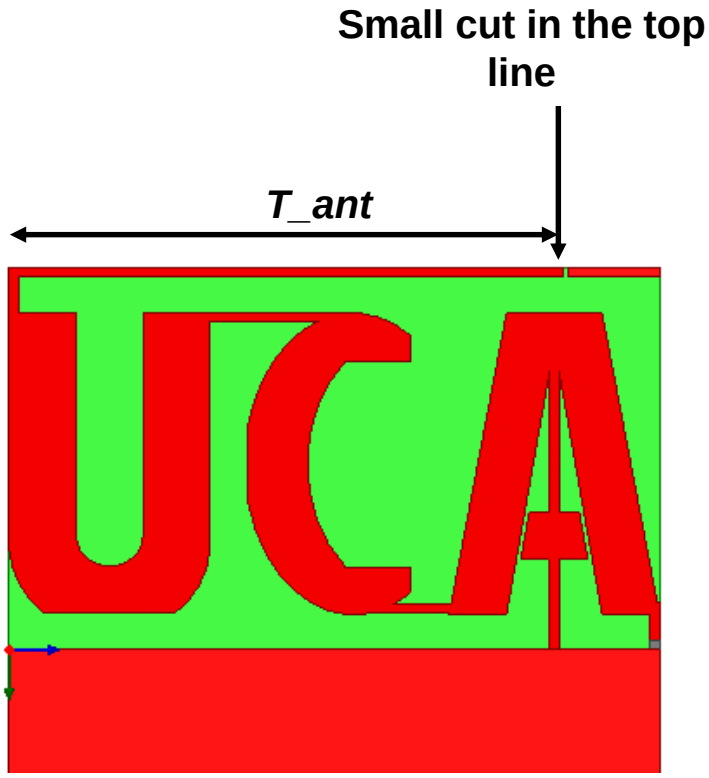
UCA Antenna tuned for EU band

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

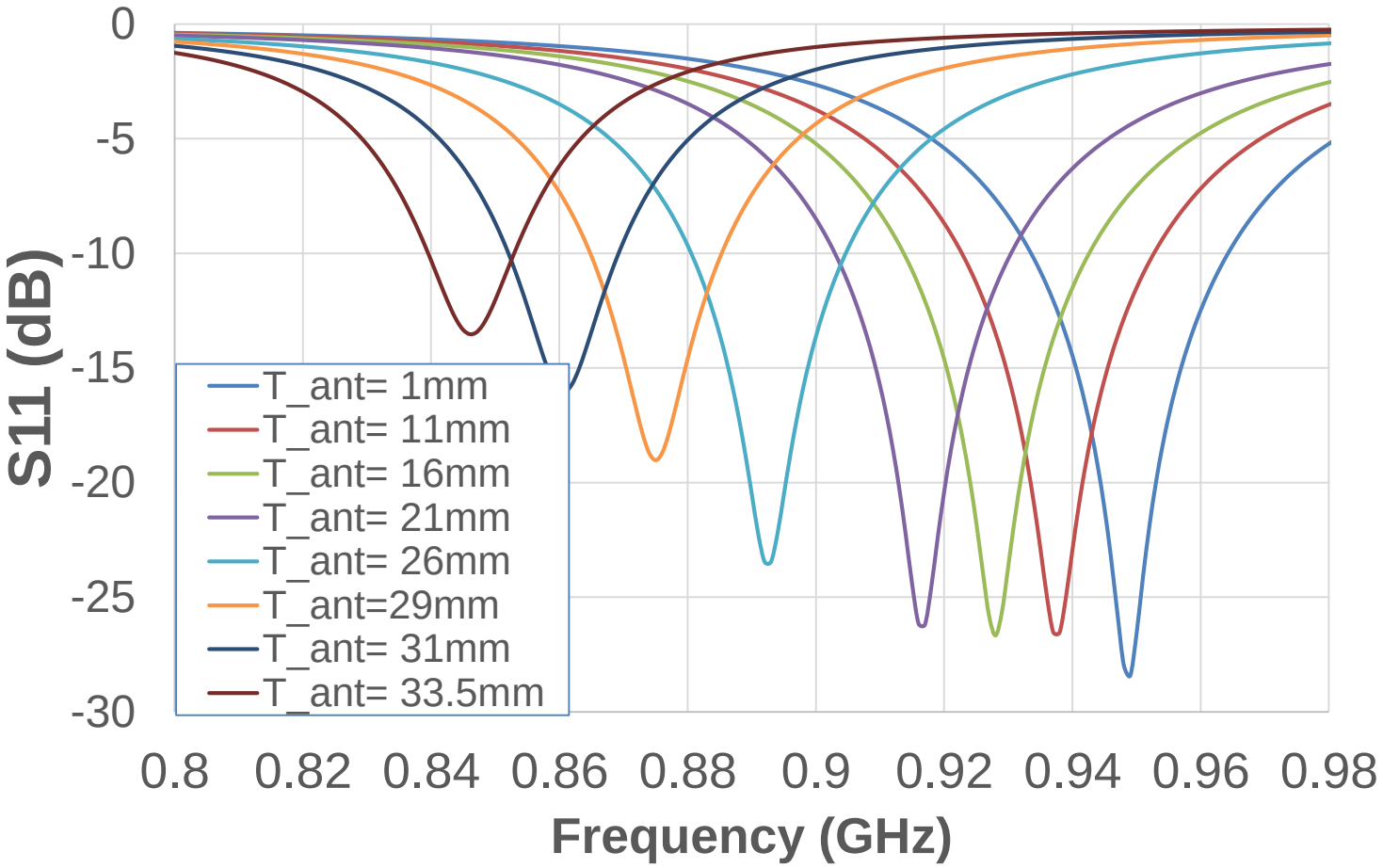


Antenna design

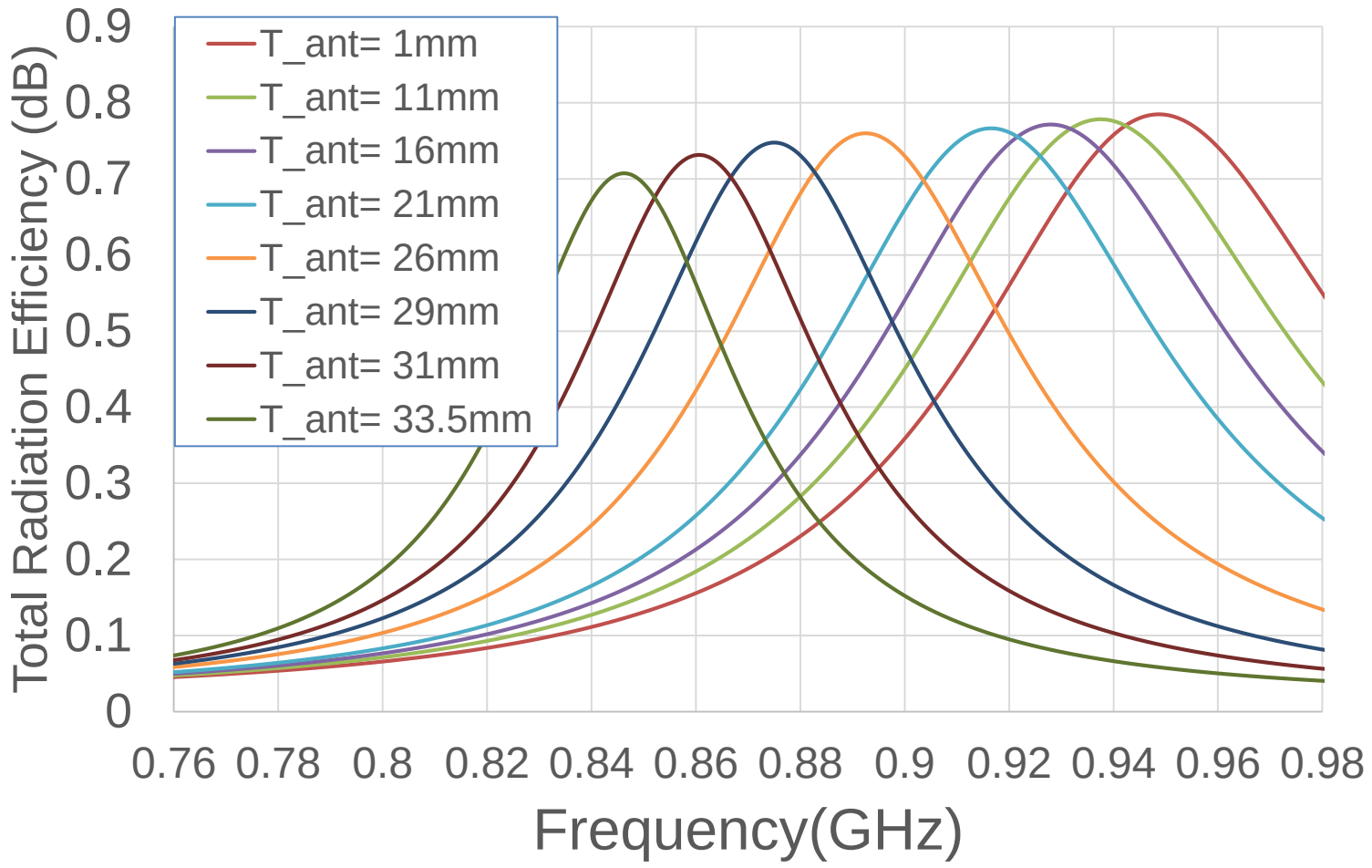
- The antenna shape can be easily tuned to different frequencies
  - The top line can be cut at different position to change the antenna trace length
  - *T_ant* parameter can be tuned from 0 to 34mm
  - Antenna resonance frequency can be tuned from 845 to 950MHz



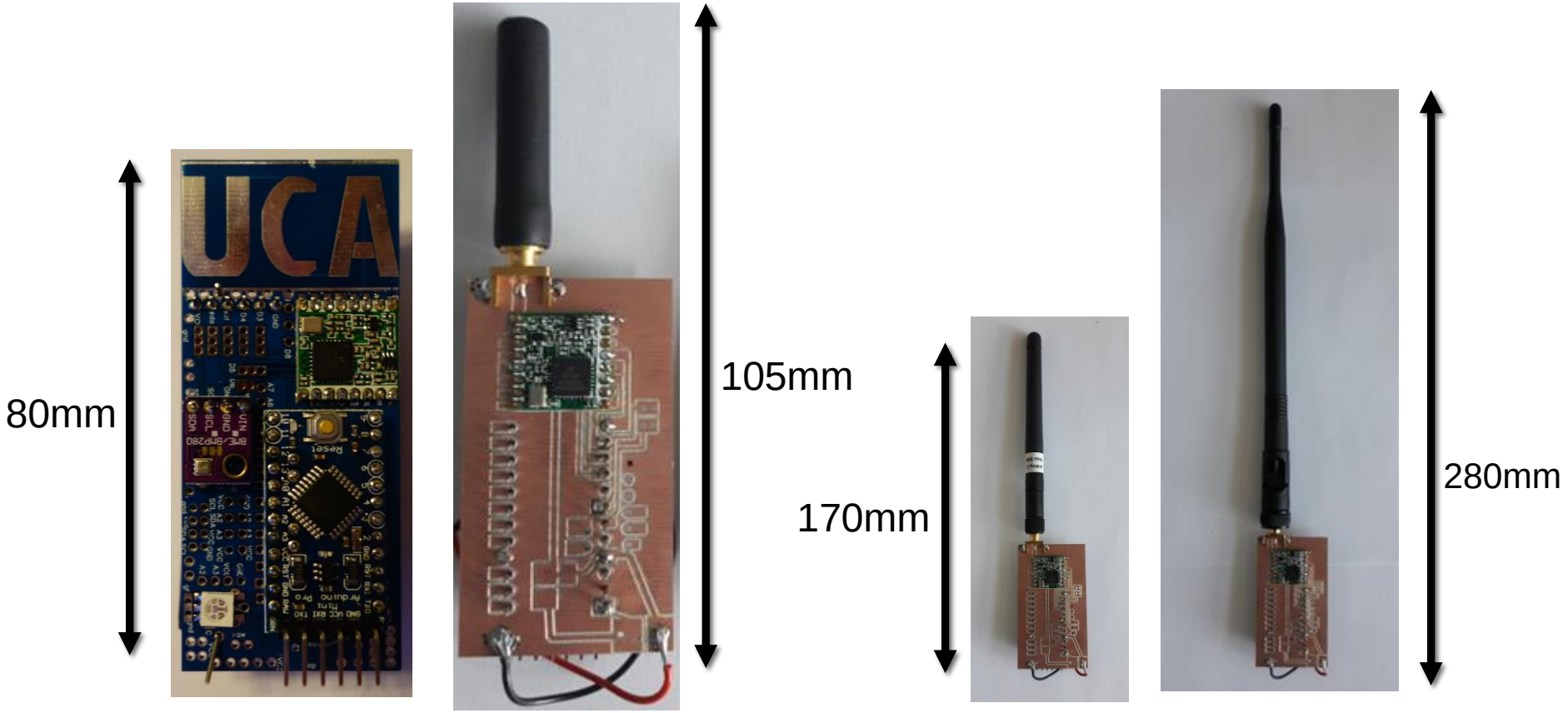
UCA Antenna tuning : Reflection coefficient



UCA Antenna : Linear Total Rad. Efficiency

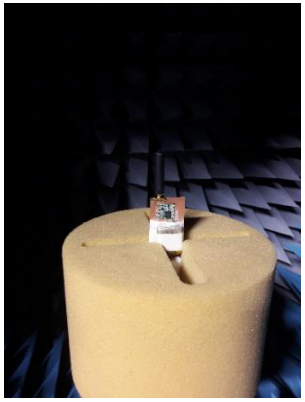


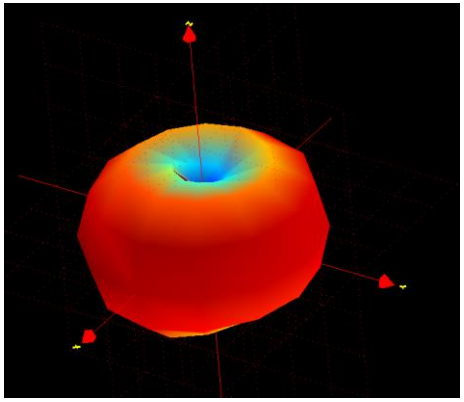
Comparison with on-the-shelf antenna



Comparison with on-the-shelf antenna

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





Antenna structure	TRP (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

https://github.com/FabienFerrero/UCA_Board

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Micro-tracker Antenna Industrial project

- Specs
  - LoRa 868 or 915MHz
  - WiFi/BLE (2.4GHz)
  - GPS L1
  - Terminal size: 50*28mm²
- Proposed solution
  - Dual-band LoRa/GPS
  - SP4T to switch between LoRa Rx/Tx/Txboost and GPS.
  - WiFi/BLE antenna (2.4-2.48 GHz)

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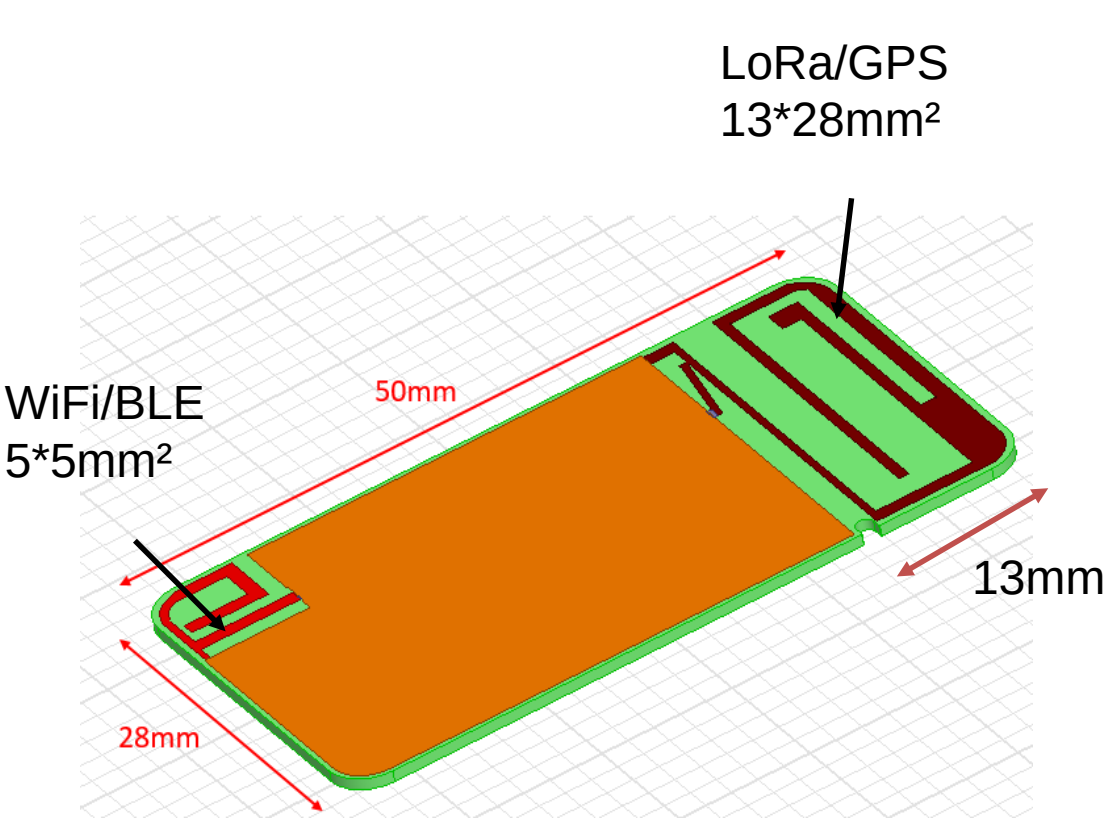
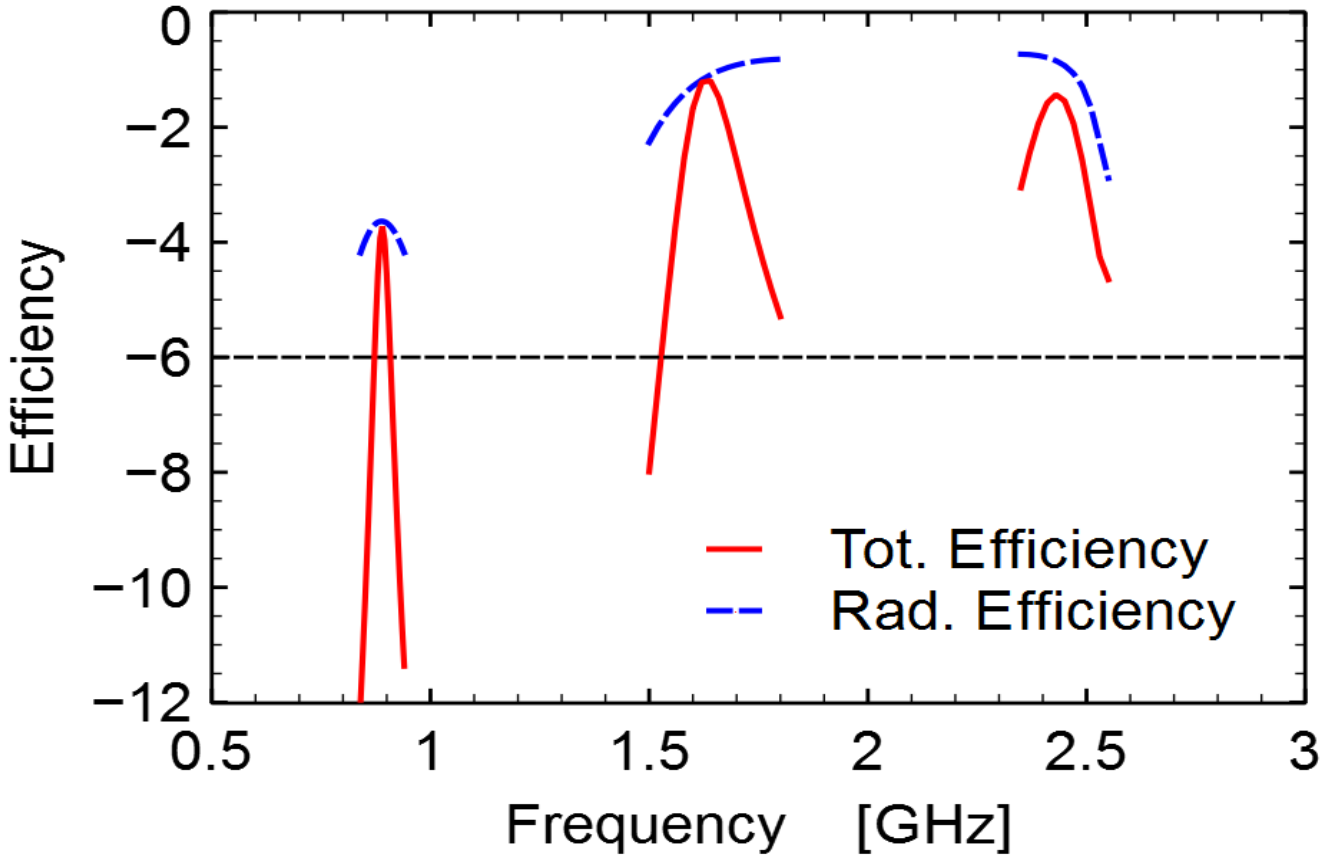
flex LIVE SMARTER

orange

Micro-tracker Antenna Industrial project



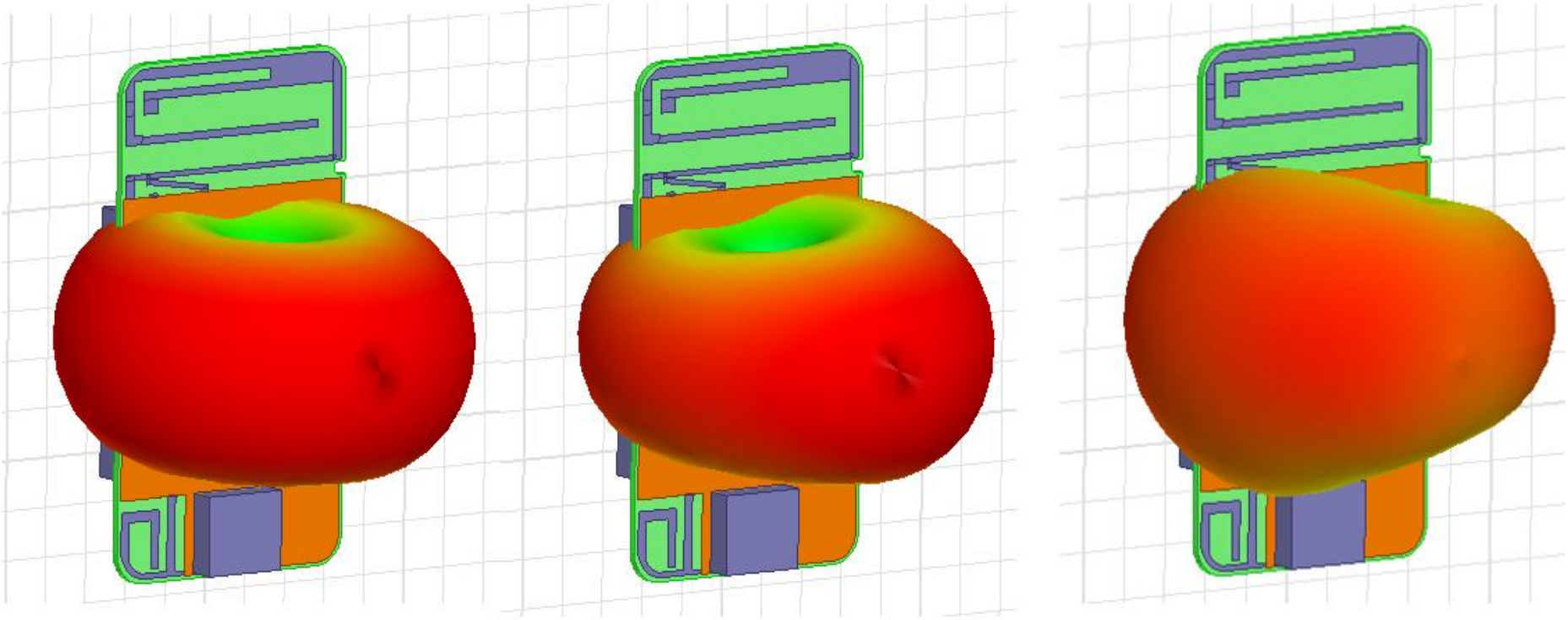
Micro-tracker Antenna Industrial project



- Total Efficiency LoRa -4 dB (40%)
- Total Efficiency GPS -1.5 dB (70%)
- Total Efficiency WiFi/BLE -1.5 dB (70%)

Micro-tracker Antenna Industrial project

Radiation pattern



0.868 GHz

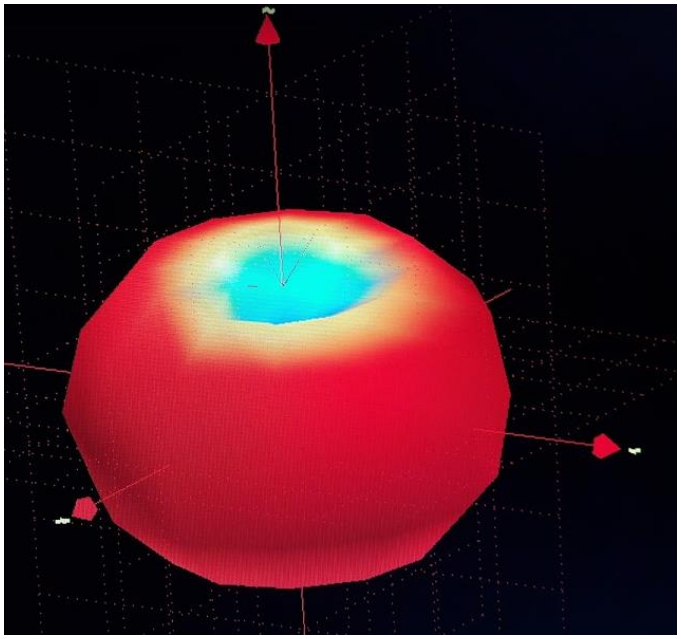
1.575 GHz

2.44 GHz

Micro-tracker Antenna Industrial project

Measurements :

- LoRa : Peak Gain -1.5dBi
- BLE/WiFi : Peak Gain 0.5 dBi
- GPS : Estimated at 0dB from anechoic chamber measurement with GPS protocol tester.



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Conclusion and Perspectives

- Take care of your antenna, else your project might fail
- With a carefull design, antenna can be low-cost **and** good
- Advanced matching network can be used to enlarge bandwidth
- Reconfigurable antenna using RF switch can be a good solution to compensate environment effect or to add antenna diversity

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