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Low Cost Antenna for IoT Deployment in Developing Country

*Fabien Ferrero*¹ & *CongDuc Pham*²

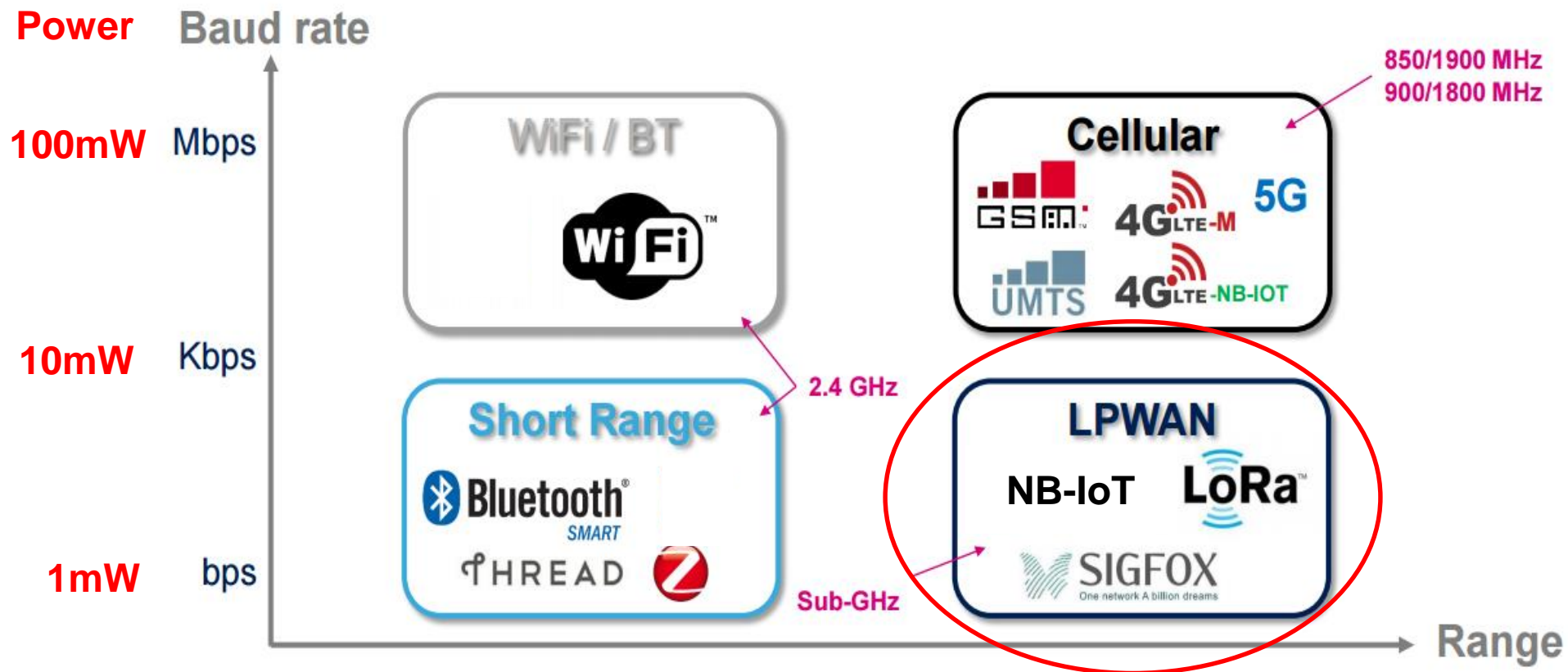
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Outline

- IoT for Developing country : Opportunity and Challenge
- Low-cost Antenna for end-node
- Low-cost Antenna for gateway
- Conclusion and perspectives

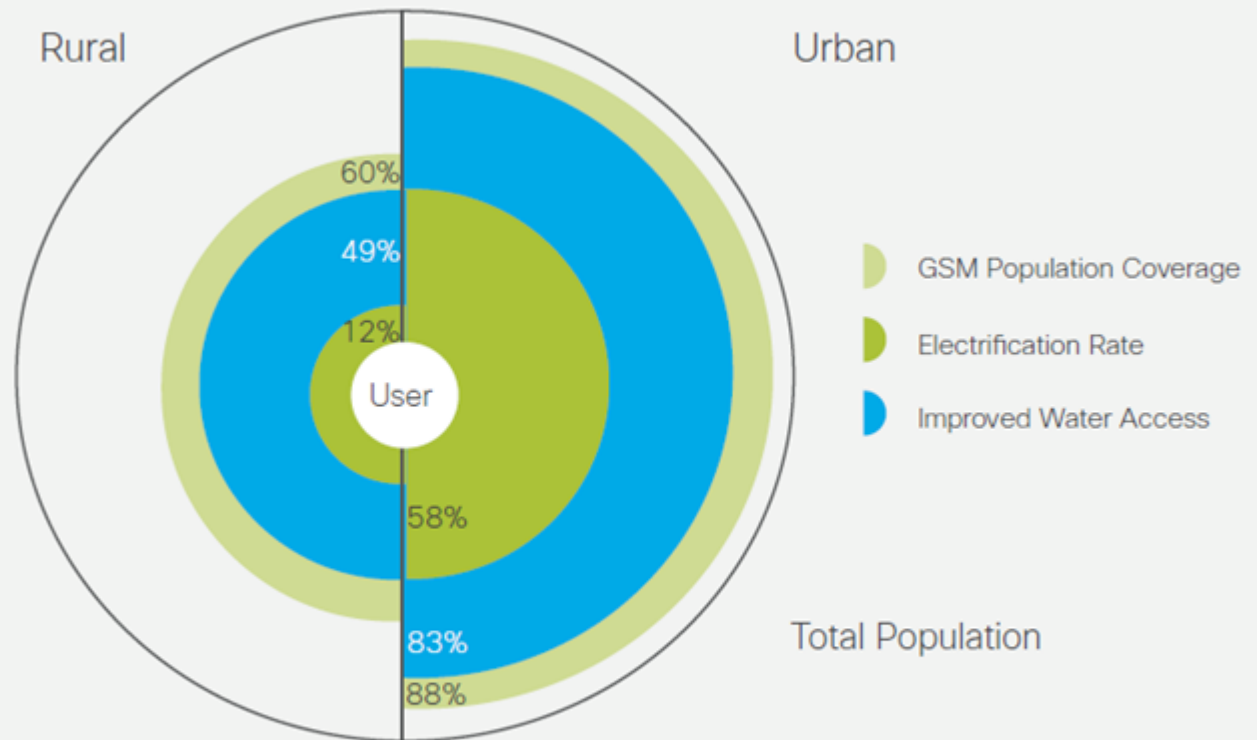
LP-WAN technologies opportunities



LP-WAN to improve energy and water access



Access to Energy, Water & GSM Population Coverage in Sub-Saharan Africa



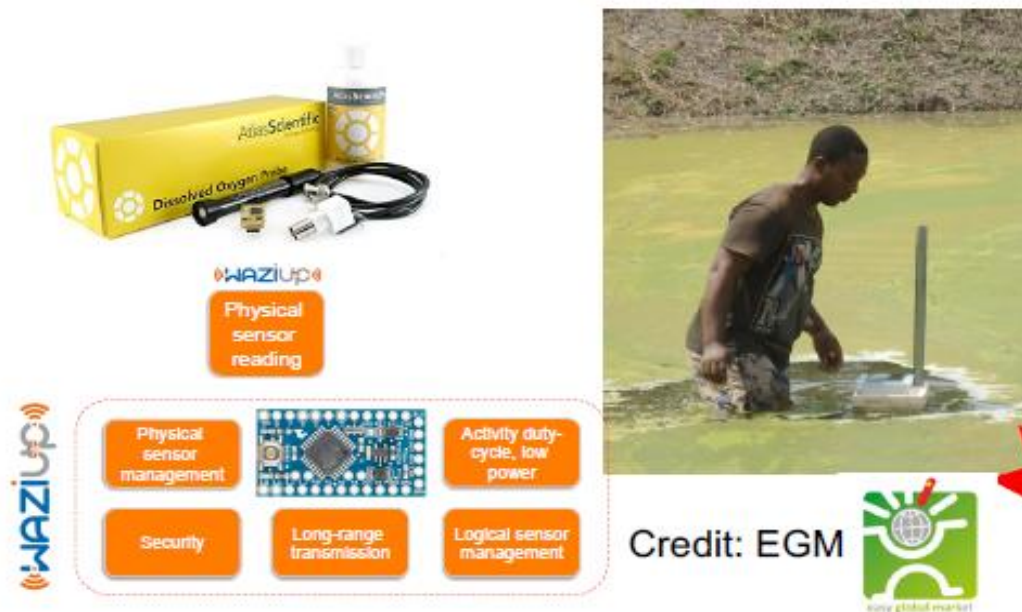
Source: GSMA, "Sustainable Energy & Water Access through M2M Connectivity. <http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2013/01/Sustainable-Energy-and-Water-Access-through-M2M-Connectivity.pdf>.

LP-WAN to improve energy and water access



*“Give a man a **fish** and you feed **him** for a day; **teach a man to fish** and you feed **him** for a lifetime”*

Chinese Proverb



Do It Yourself IoT technologies

Widespread implementation of IoT solutions in developing countries are helped by **technological and social trends**:

- **Prices** for IoT component have declined by 80-90 per cent over the past 5 years
- **Internet** penetration is increasing : 35 per cent of people now have access
- Falling cost of **smartphones** is driving rapid uptake in Internet access in the developing world.

To foster this trends, we can :

- Provide simple and robust **building blocks** for DIY IoT project
- Develop simple **tutorial** to help for project implementation
- Initiate **Open-source** project to prime the pump

What antenna is needed ?

- **Low cost**, robust and easy to assemble
- Good documentation and tutorial
- Simple and low-cost method to measure and to optimize antenna

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- IoT for Developing country : Opportunity and Challenge
- Antenna for end-node : LoRa collar
- Antenna for gateway
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Design of cost efficient antenna @868MHz

- LoRa collar for Cattle Rustling applications
 - Localization using GPS
 - Data transmission using LoRa (868MHz)
- Initial solution based on-the-shelf antenna
- New Custom Antenna for LoRa
 - 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



Design of cost efficient antenna @868MHz

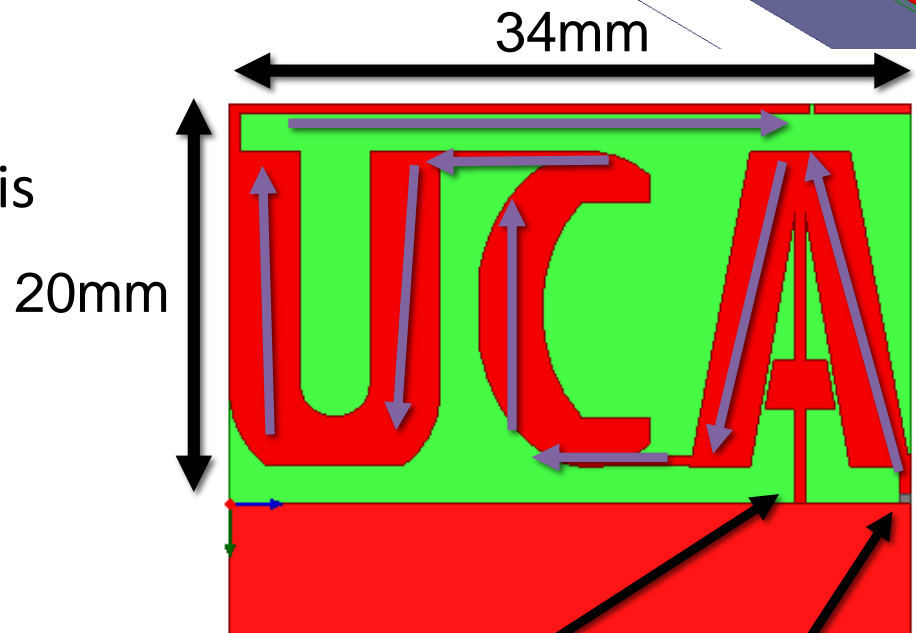
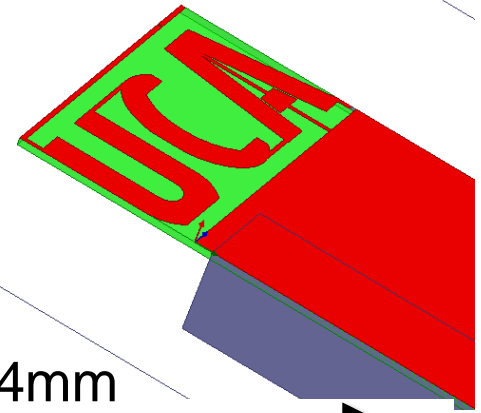
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UCA Antenna layout @868MHz

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

UCA

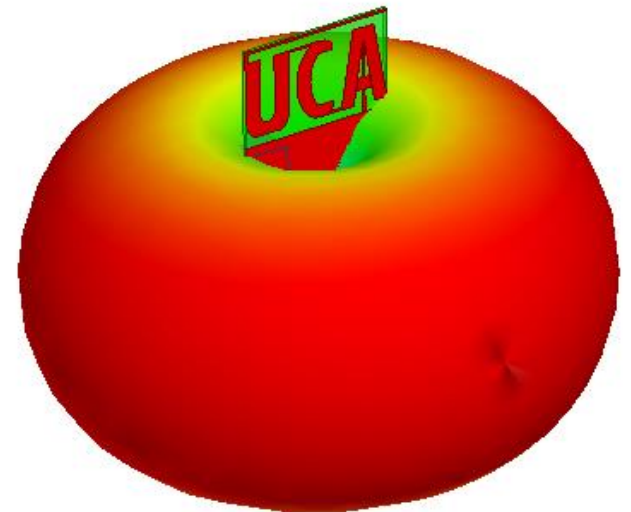


Short
circuit

Feeding
port

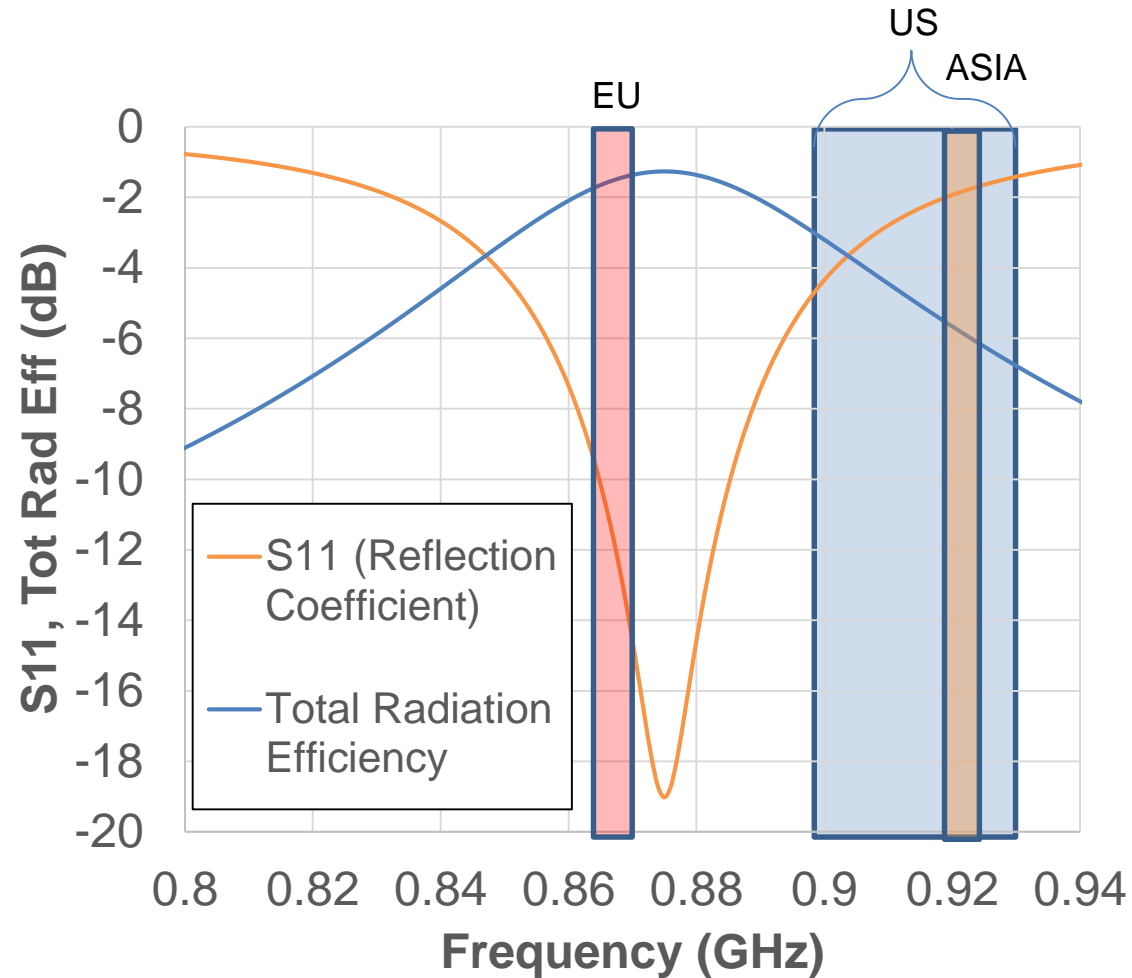
UCA Antenna tuned for EU band

- 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



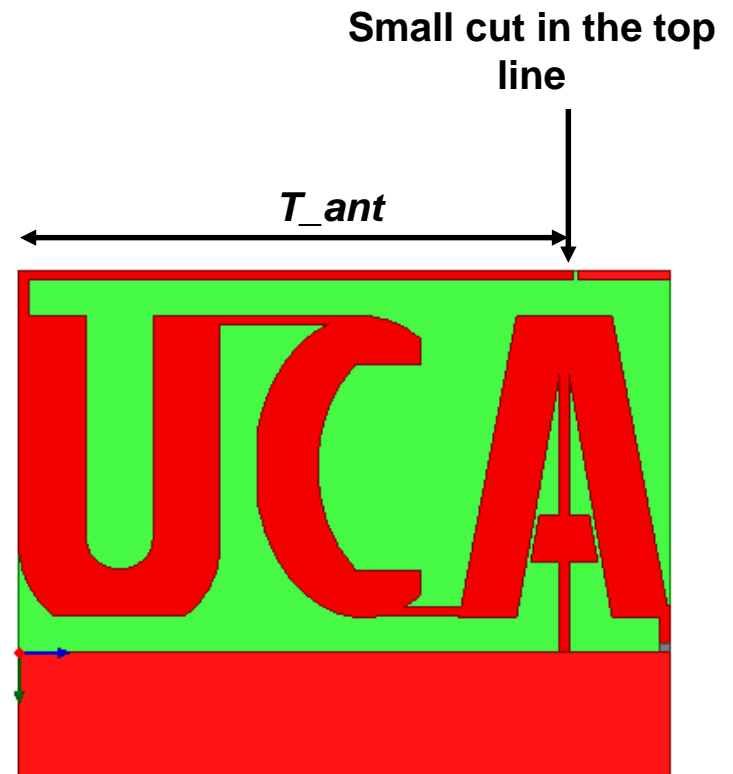
UCA Antenna tuned for EU band

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

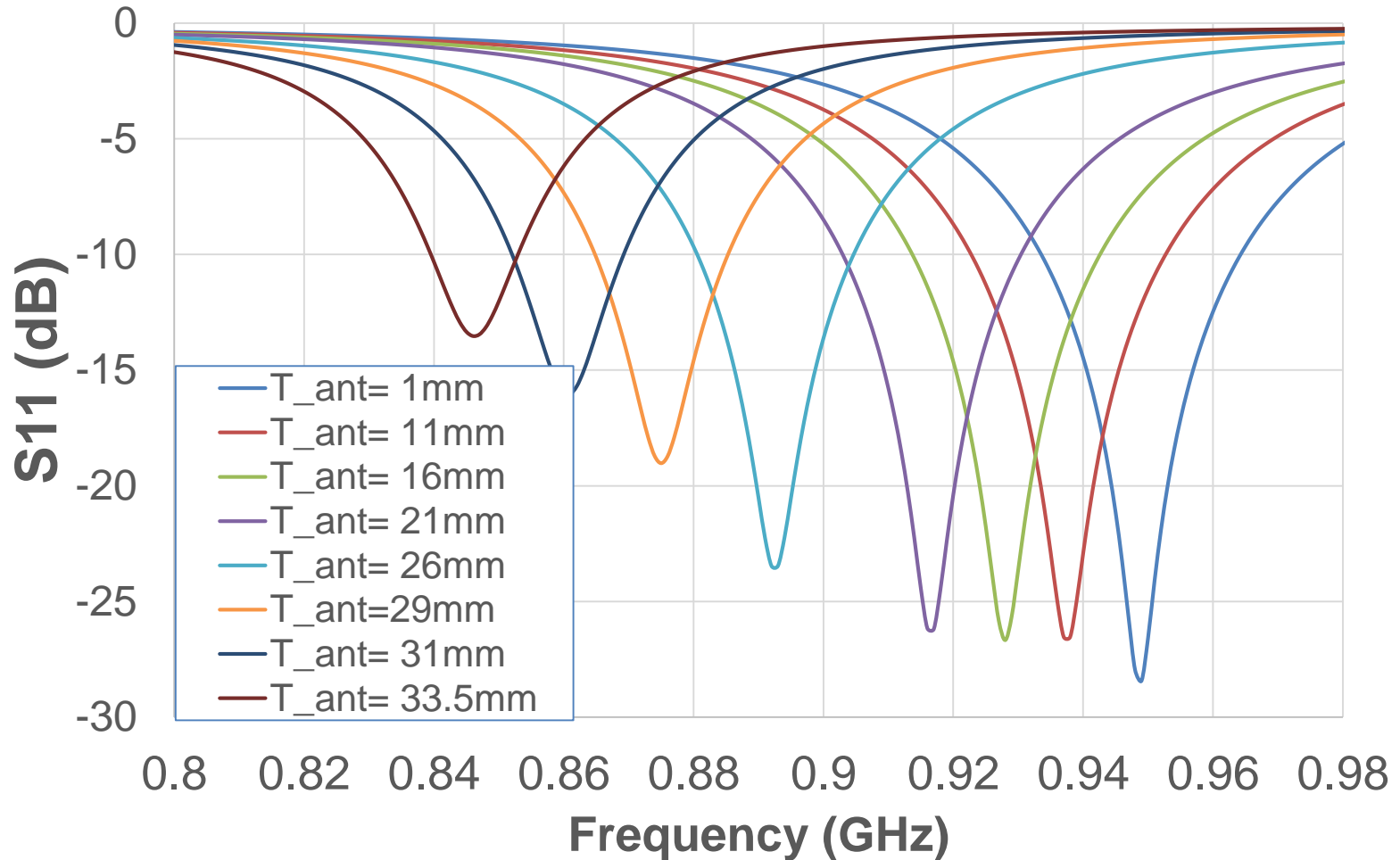


Antenna design frequency tuning

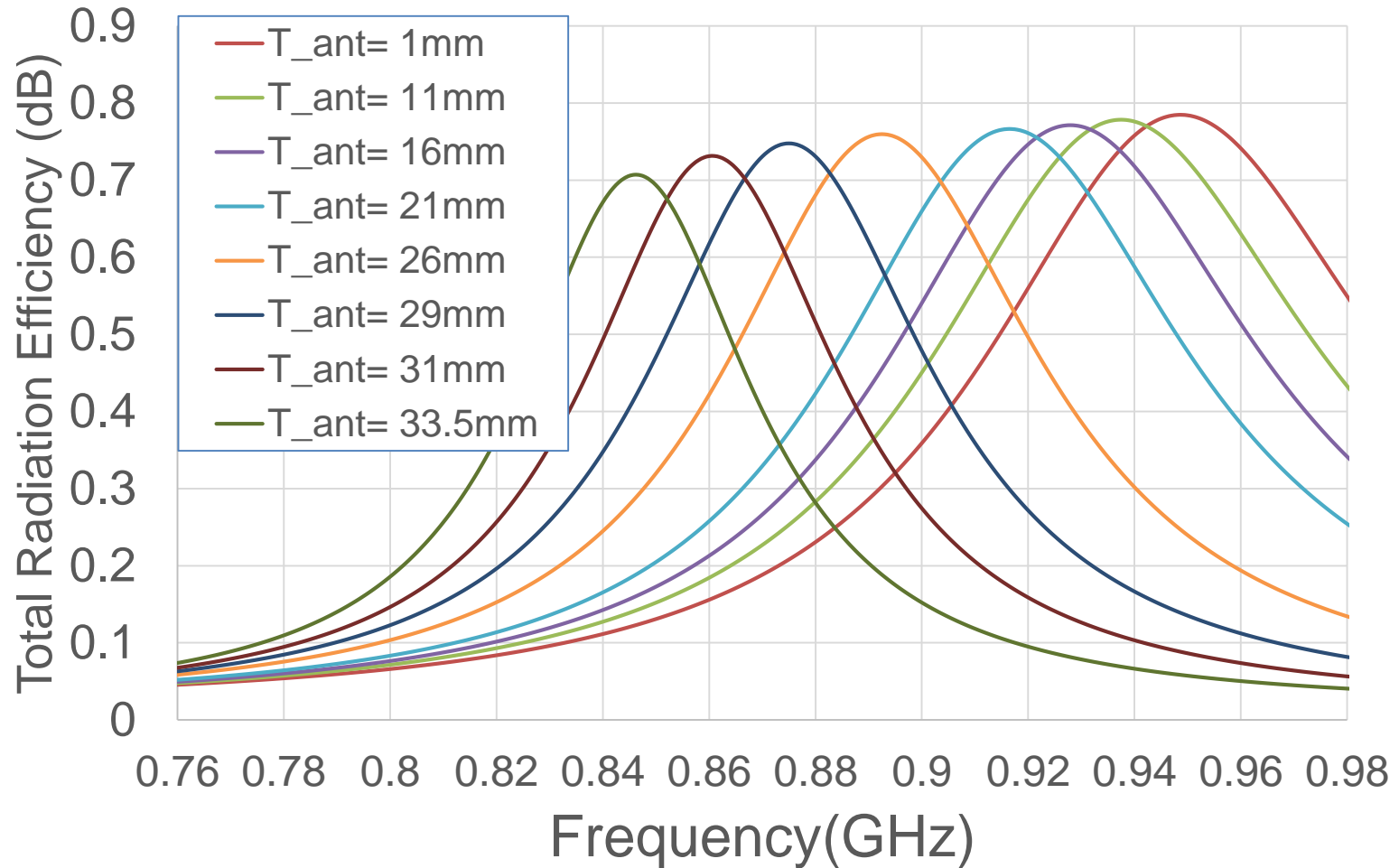
- The antenna shape can be easily tuned to different frequencies
 - The top line can be cut at different position to change the antenna trace length
 - T_{ant} parameter can be tuned from 0 to 34mm
 - Antenna resonance frequency can be tuned from 845 to 950MHz



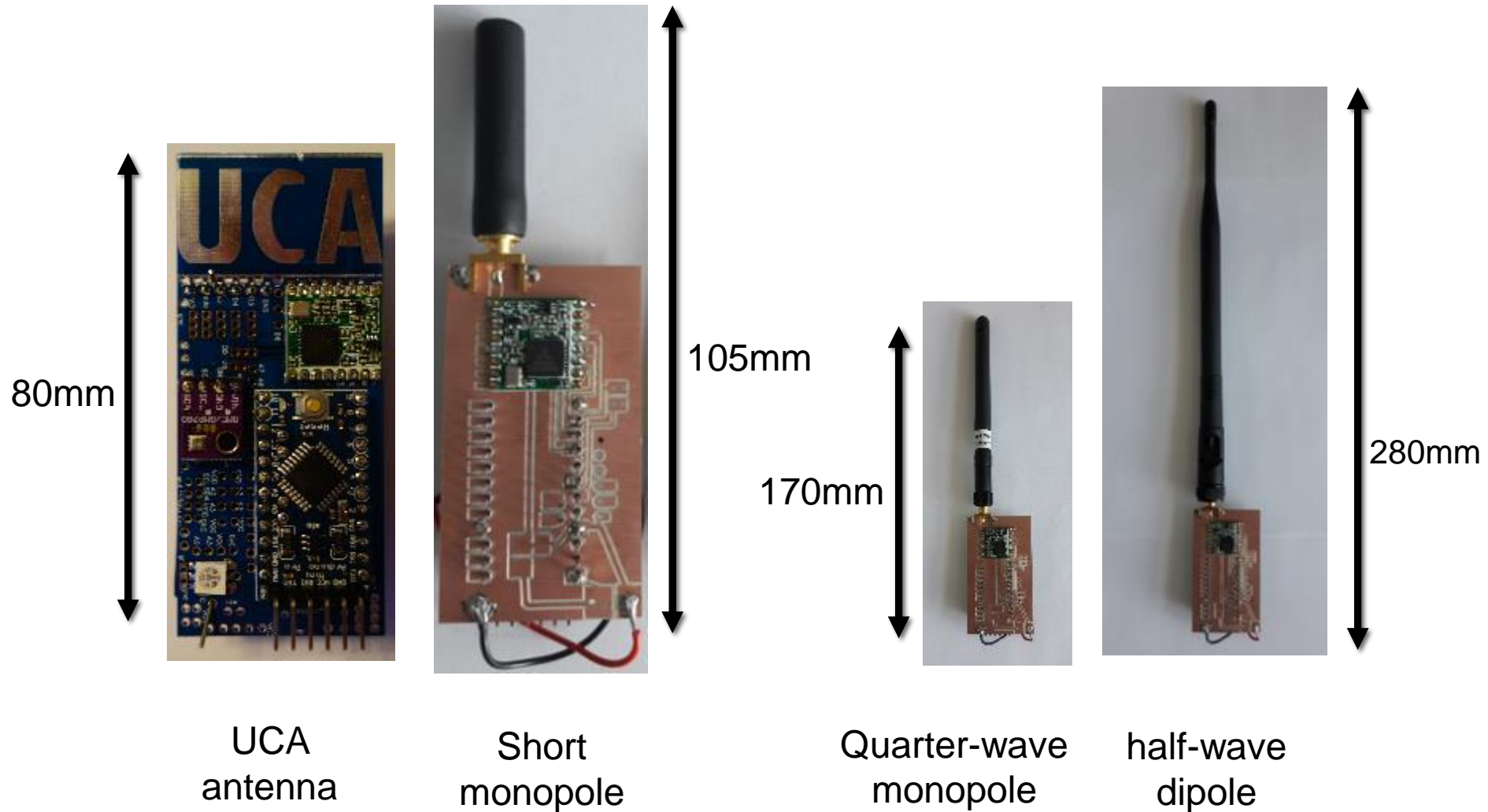
UCA Antenna tuning : Reflection coefficient



UCA Antenna : Linear Total Rad. Efficiency

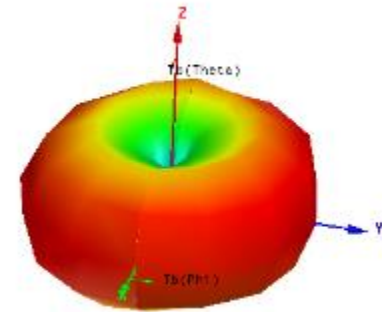
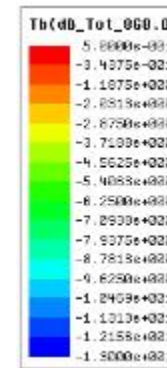


Comparison with on-the-shelf antenna



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



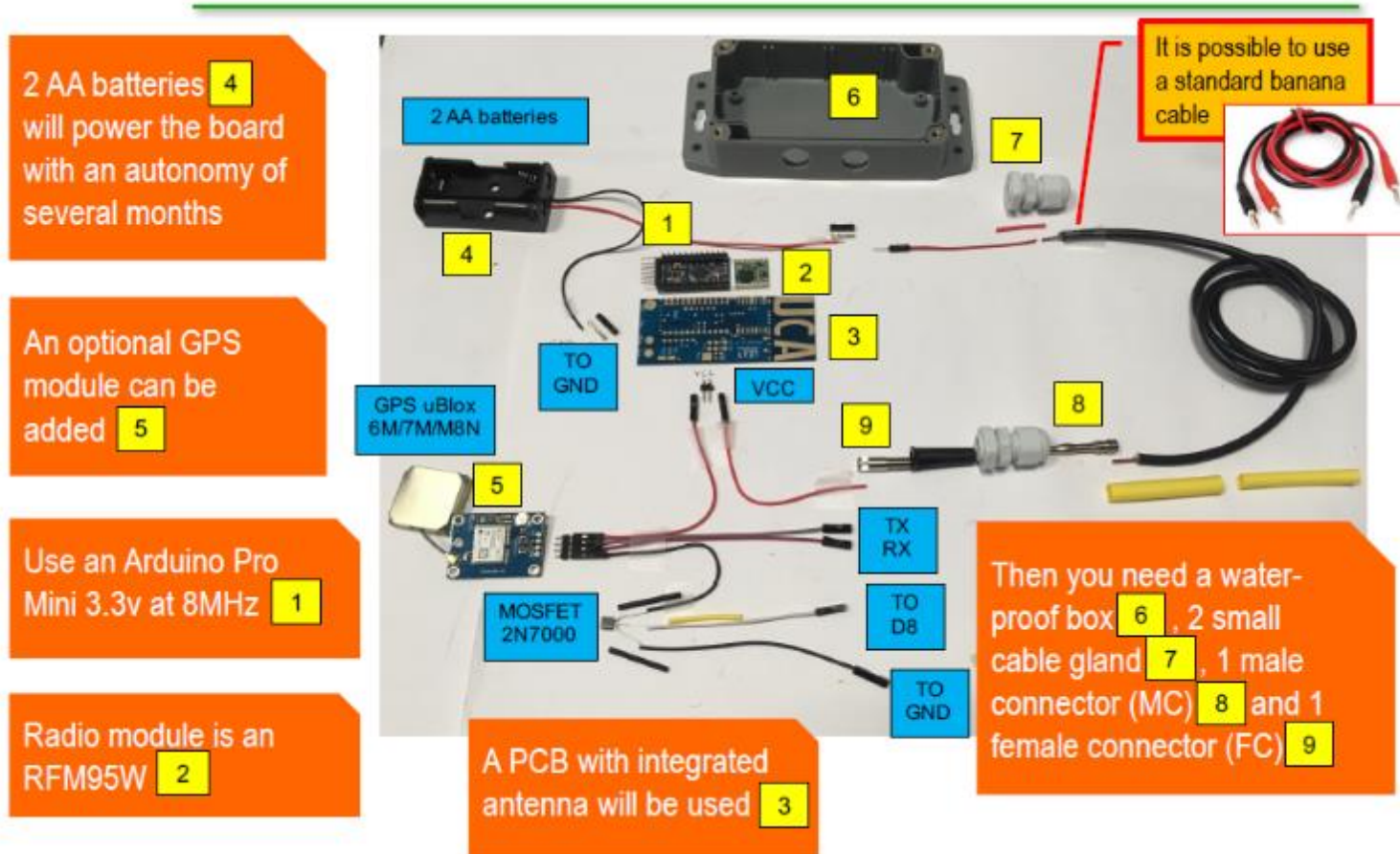
Antenna structure	EIRP (dBm)	Total efficiency	Max Dimension
Small monopole	14.7	74%	105 mm
Quarter-wave monop.	15.7	94%	170 mm
Half-wave dipole	13.9	61%	280 mm
UCA untuned	13.8	60%	80mm
UCA after tuning	14.8	76%	80mm

https://github.com/FabienFerrero/UCA_Board

DIY Integration : Tutorial to fabricate the collar

Complete tutorial to fabricate this collar :

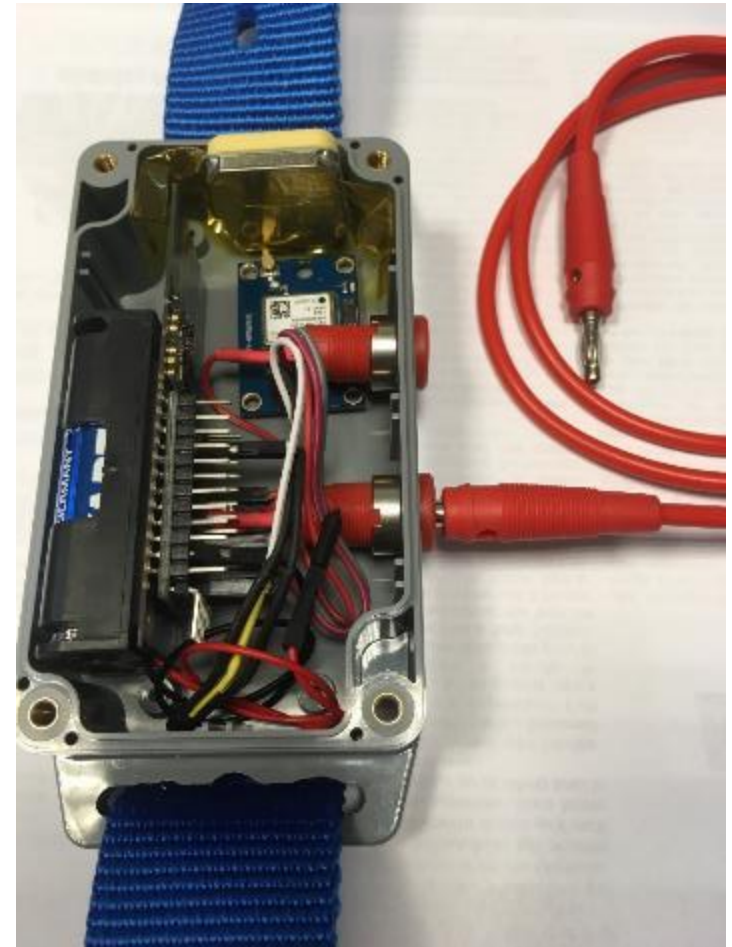
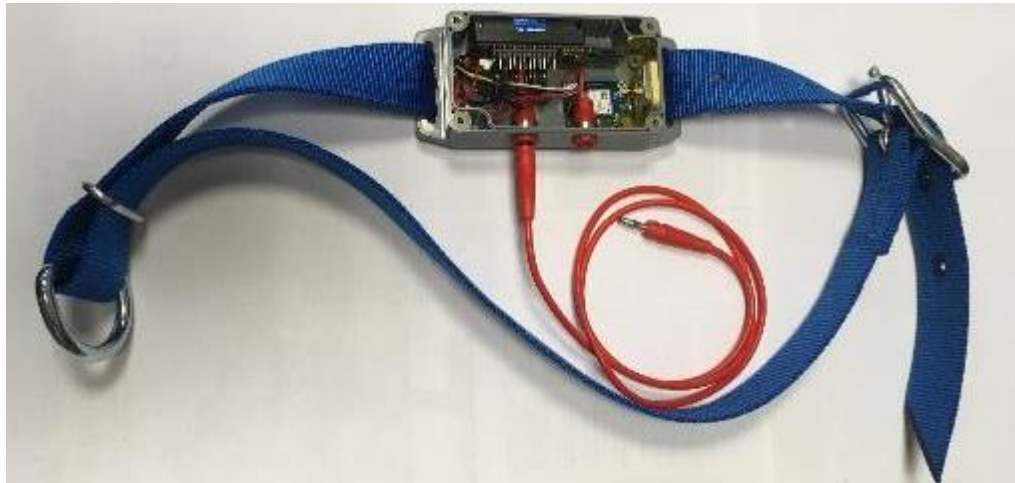
- <https://github.com/CongducPham/tutorials/blob/master/Low-cost-LoRa-Collar.pdf>



DIY Integration : Tutorial to fabricate the collar

Additional components:

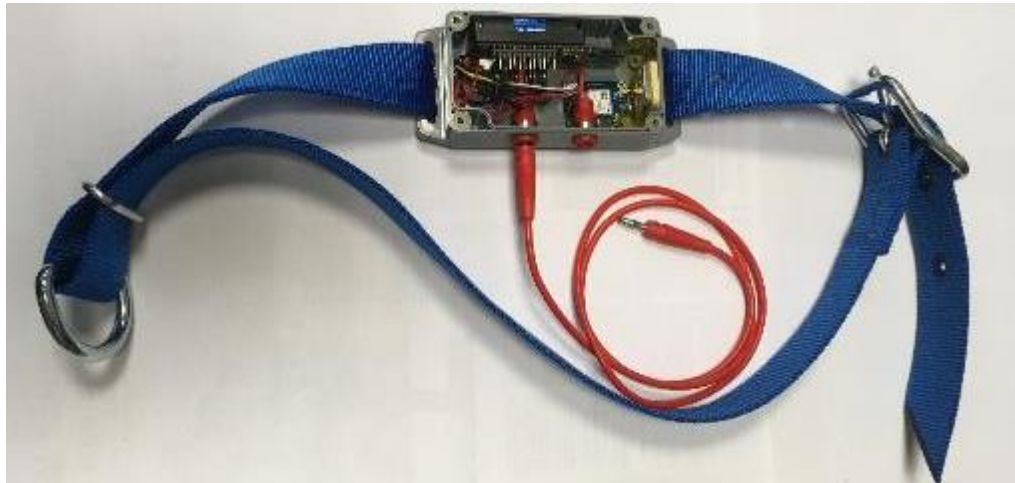
- Waterproof
- 2 AA batteries
- GPS receiver



DIY Integration : Tutorial to fabricate the collar

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- Waterproof
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Antenna with cable

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

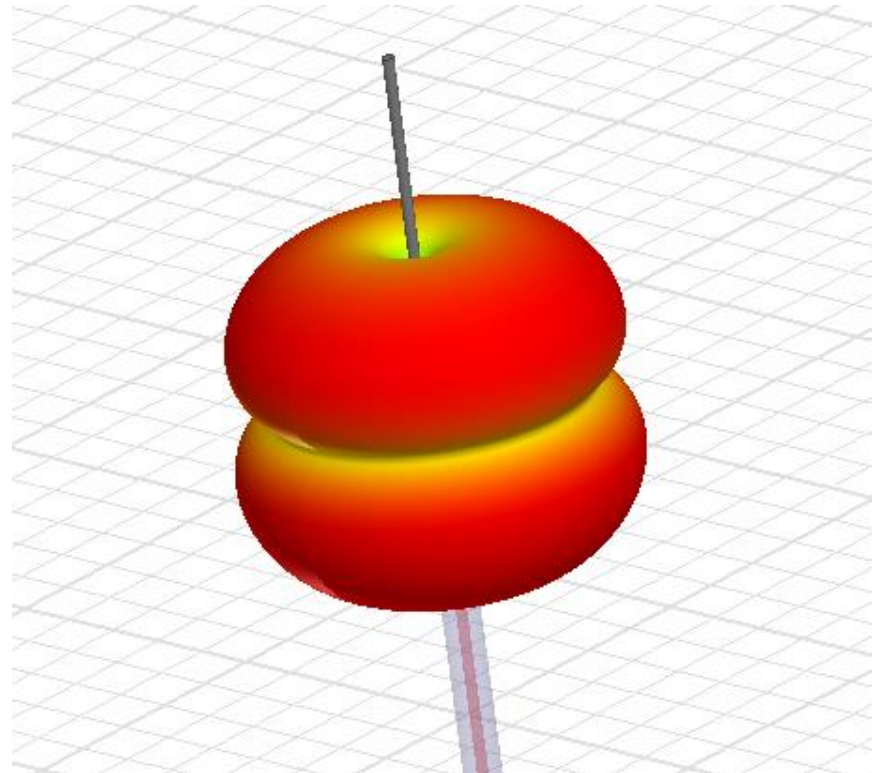


project WaterSense UPPA/Nestlé



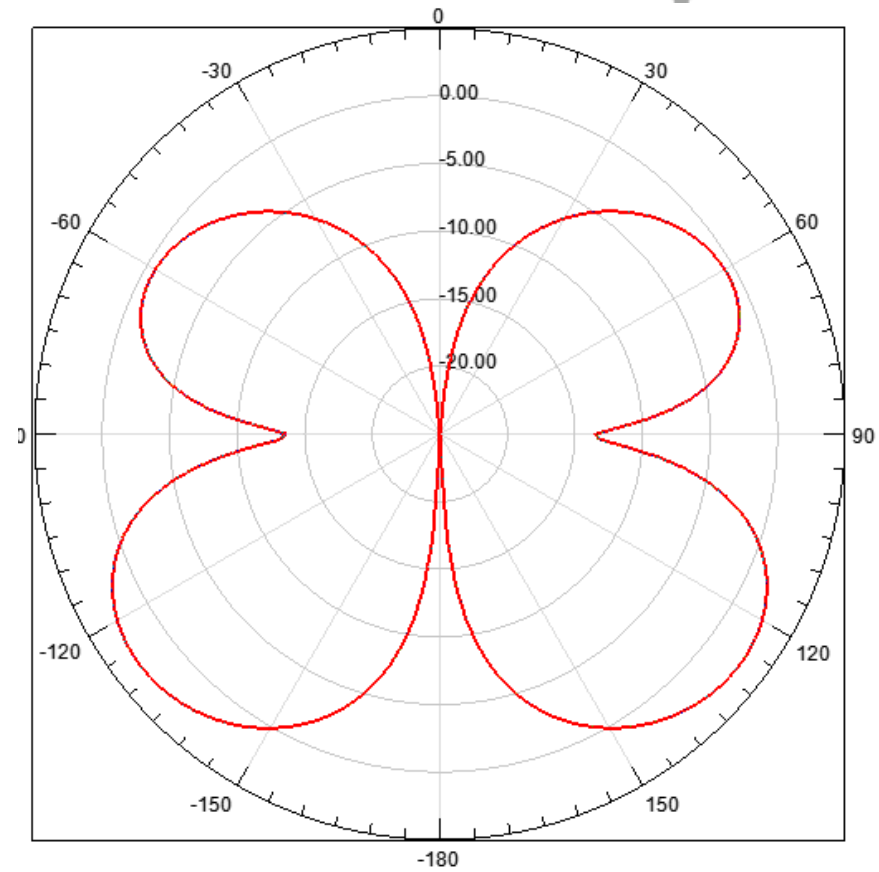
Antenna with cable

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



Antenna with cable

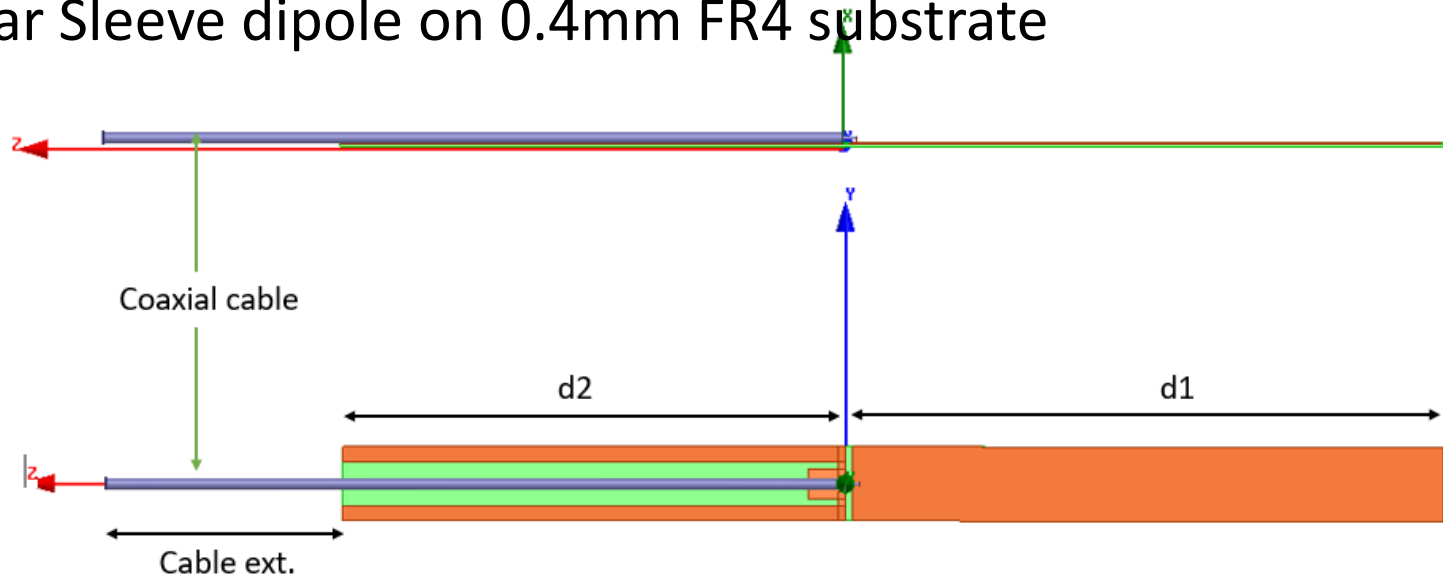
- Nulls in the radiation pattern
- Reduced Gain in the direction of the gateway (**-14 dBi**)
- Caused by current flowing on the shield on the coaxial cable
- Need to use a balanced antenna with a balun like a sleeve dipole



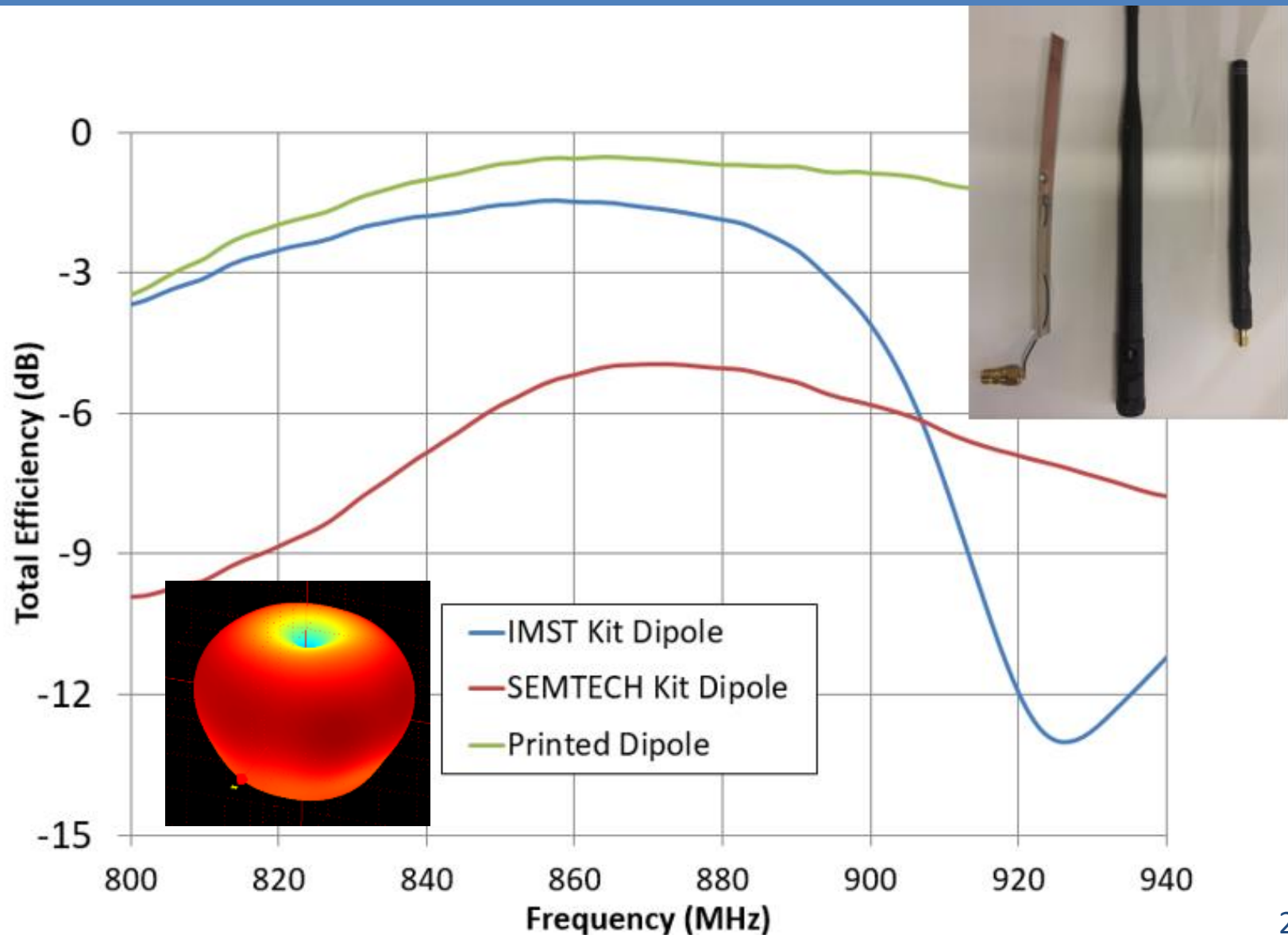
Total Gain Elevation plane

Half-wave dipole Antenna

- Planar Sleeve dipole on 0.4mm FR4 substrate



Comparison with on-the-shelf antenna



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Conclusion and Perspectives

- DIY project need low-cost and simple antenna
- Great opportunity for education



- Dual-band antenna for 433 and 868MHz
- Low-cost localization based on LoRa signal
- Need simple measurement method to tune the antenna



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Do It Yourself IoT technologies

IoT create substantial changes for populations in emerging and developing countries.

The prospects for widespread implementation of IoT solutions in development contexts are helped by broader technological and social trends:

- Prices for sensors, an integral component of IoT applications, have declined by about 80-90 per cent over the past five years.
- Internet penetration in developing countries is increasing. 35 per cent of people in developing countries now have access to the Internet.
- falling cost of smartphones is driving rapid uptake in Internet access in the developing world. Across emerging and developing countries, a median average of 24 per cent of the population now owns such a device.

Do It Yourself IOT technologies

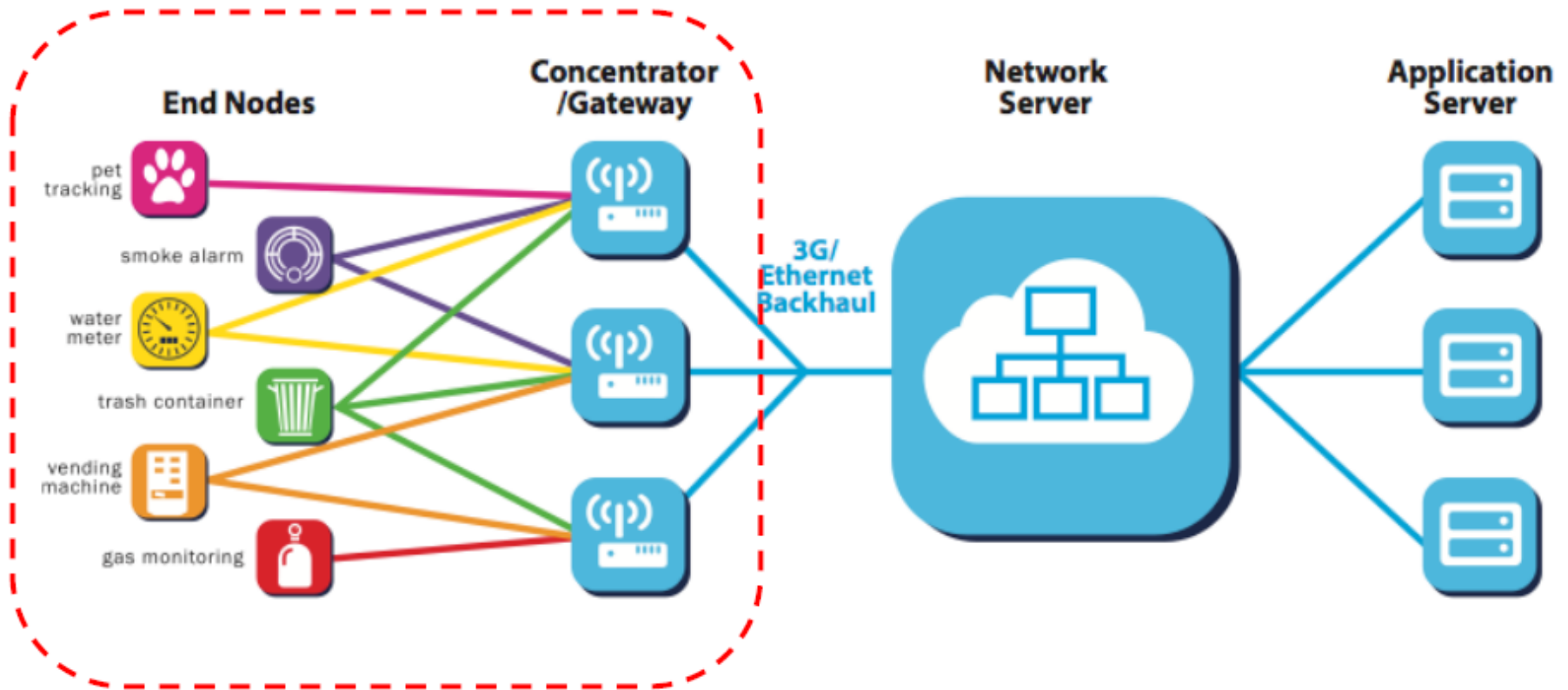


Figure from Semtech