IC1301 – WiPE

Towards printed wearable antennas for energy harvesting

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WIPE

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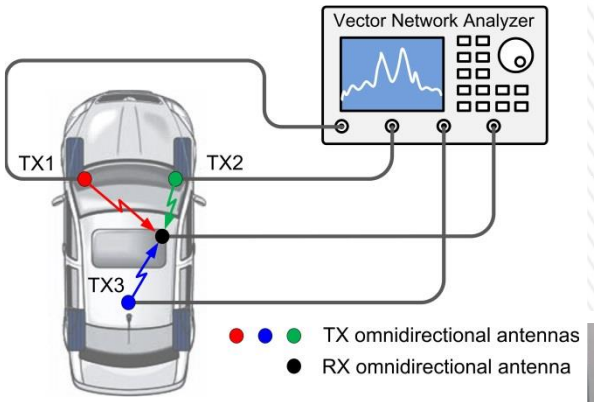
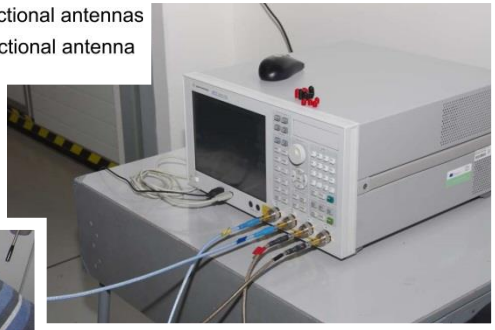
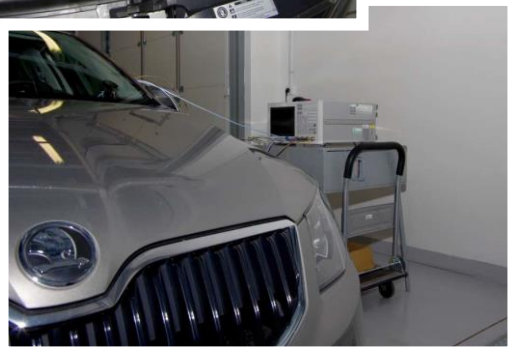
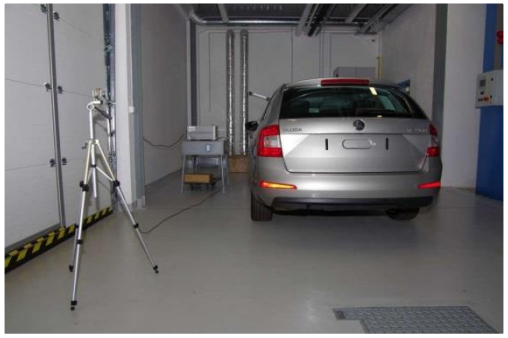
Motivation

- In-car wireless sensor networks

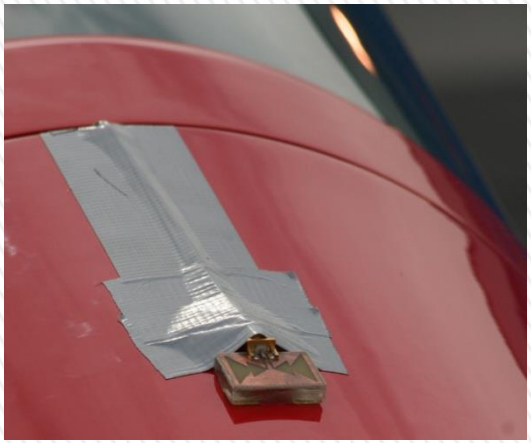


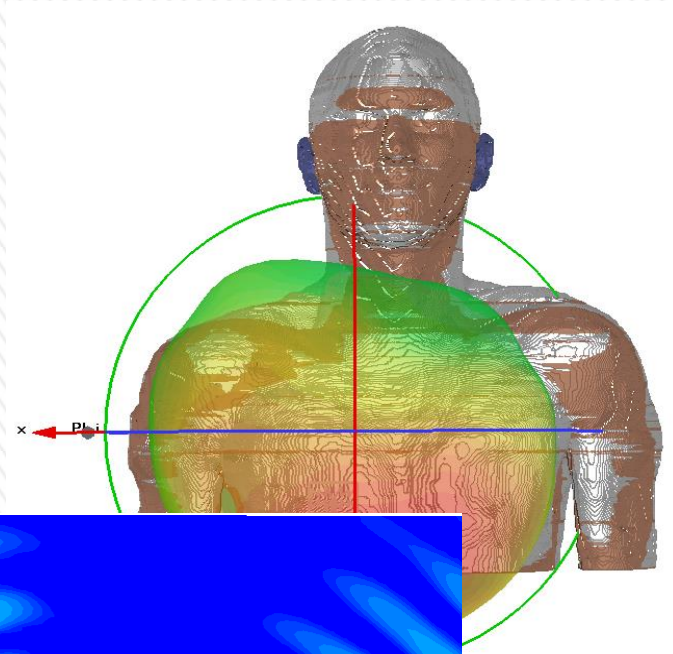


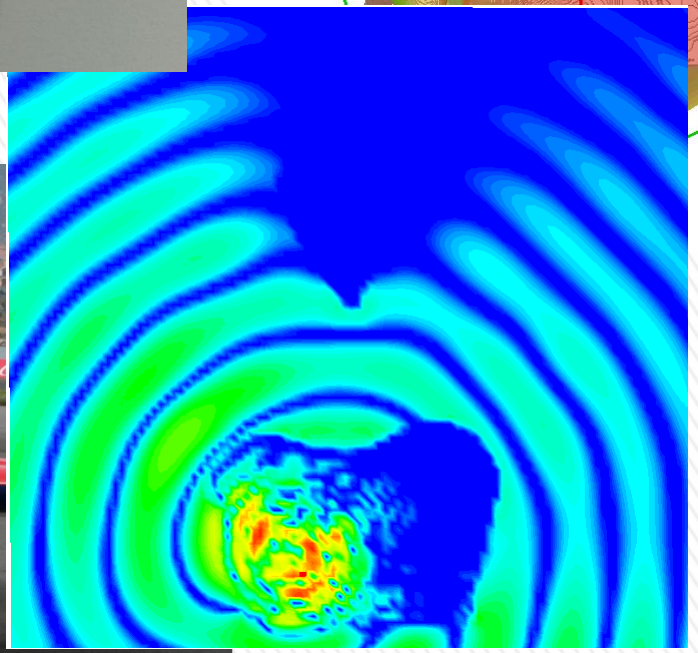




Vehicle → Human body





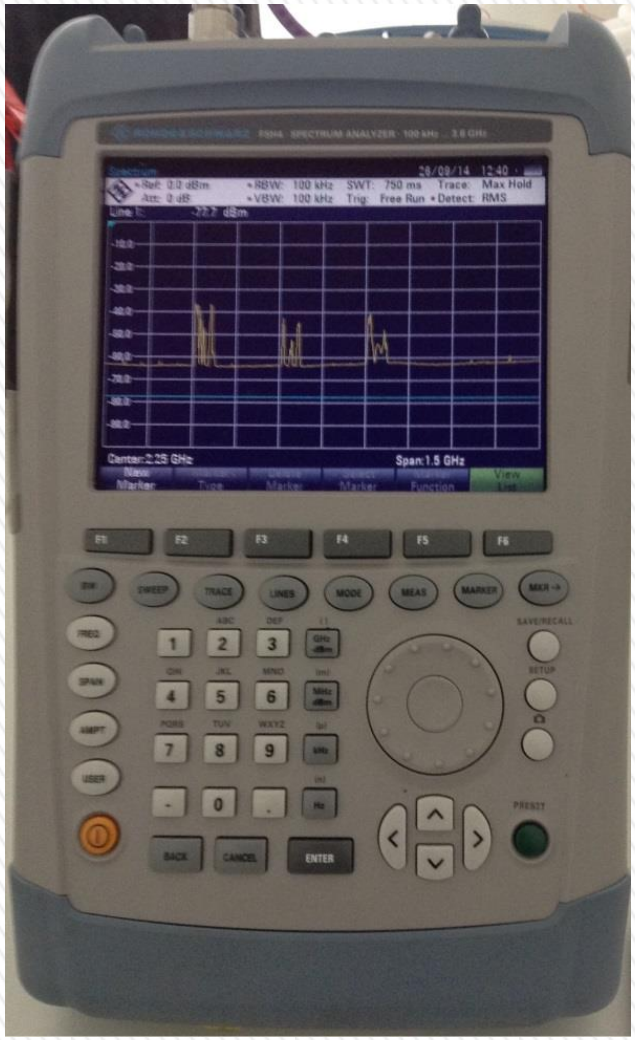


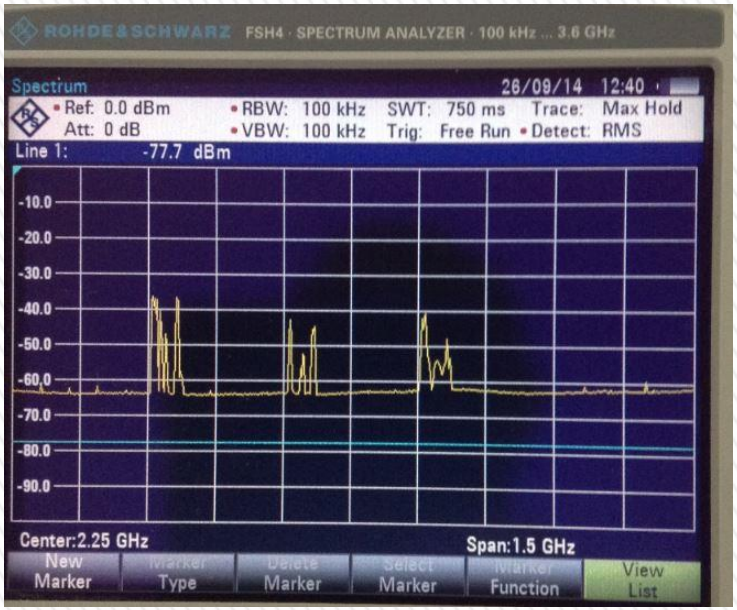
Parameters of human body

	ε_r [-]	ε_r [-]	σ [S/m]	σ [S/m]
Tissue	2.40 GHz	5.80 GHz	2.40 GHz	5.80 GHz
Skin	38.063	35.114	1.441	3.717
Fat	5.285	4.955	0.102	0.293
Muscle	52.791	48.485	1.705	4.962

- Lossy dielectrics → poor efficiency of slot antennas
- What range of frequencies?

Measurement of available energy



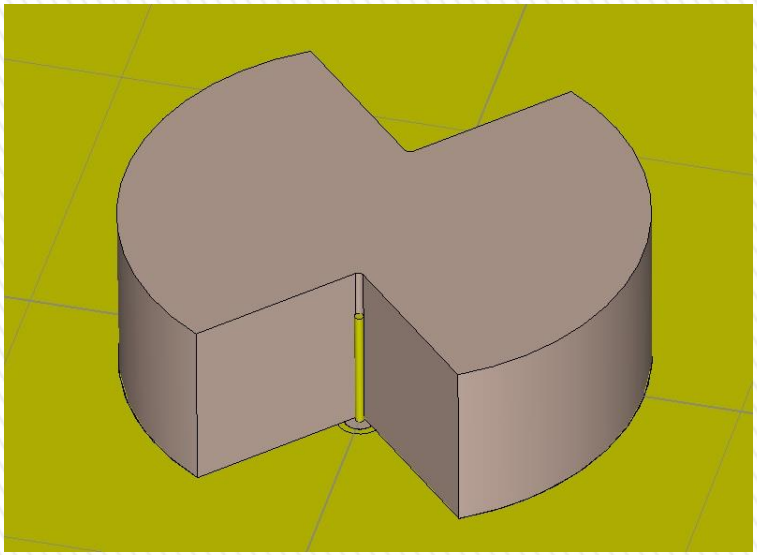


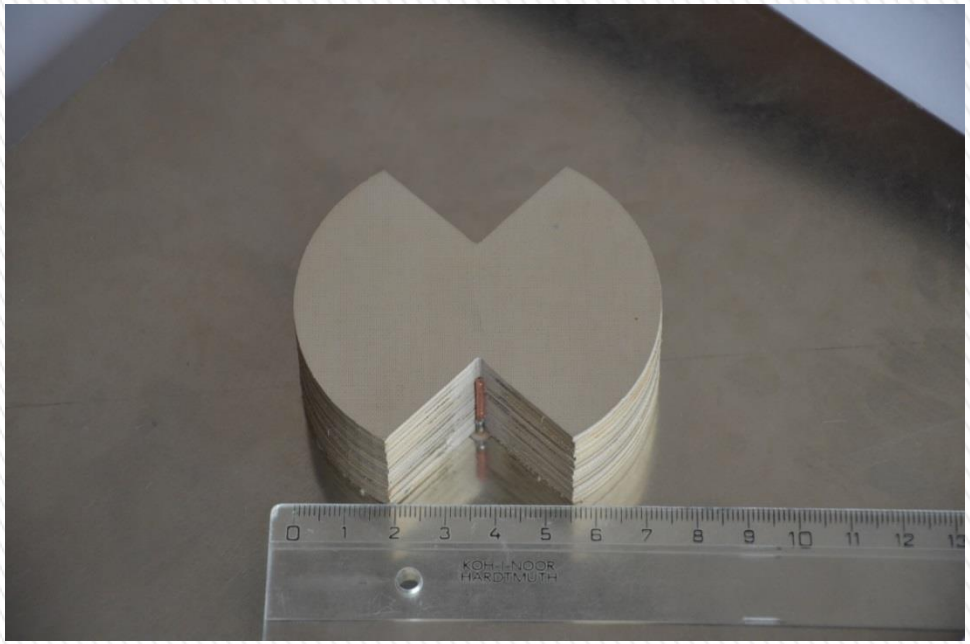
- GSM 1800 – 1.840 GHz
- UMTS 2100 – 2.145 GHz
- WiFi 2400 – 2.445 GHz
- Required bandwidth BW = 28%

Additional requirements

- Energy harvesting conditioned by
  - Omnidirectional radiation patterns
  - Very high radiation efficiency
- Proximity of human body → ground plane preferred to shield the body
- Low profile (small distance) from ground plane → magnetic antenna preferred
- **Dielectric resonator antenna**

Dielectric resonator antenna



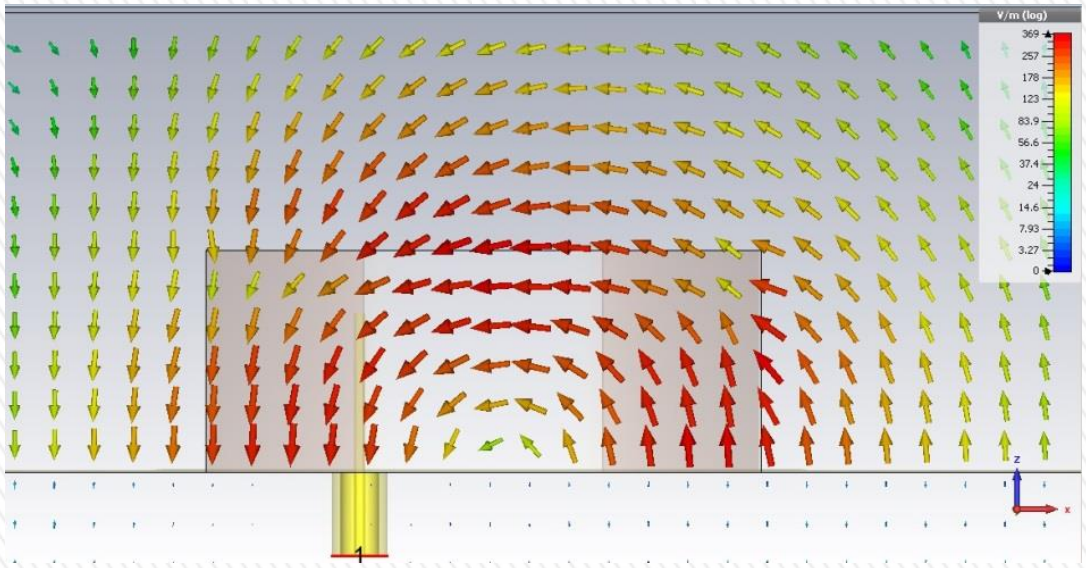


- Arlon AR600
  h = 1.575 mm, ε_r = 6.15, tan δ = 0.003

THAMAE, L. Z., WU, Z. Broadband bowtie dielectric resonator antenna. *IEEE Transactions on Antennas and Propagation*, 2010, vol. 58, no. 11, p. 3707-3710.

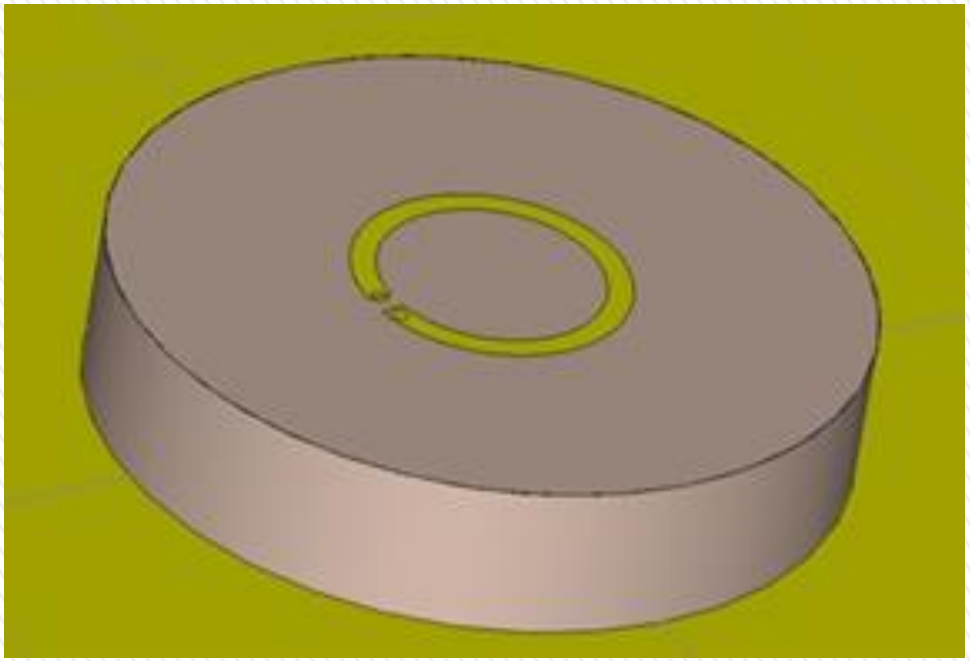
Dielectric resonator antenna

- Optimum notch angle: 90 °
- Fundamental mode: HEM11
- Impedance bandwidth proportional to height of resonator (min. height for required BW: 25.2 mm)

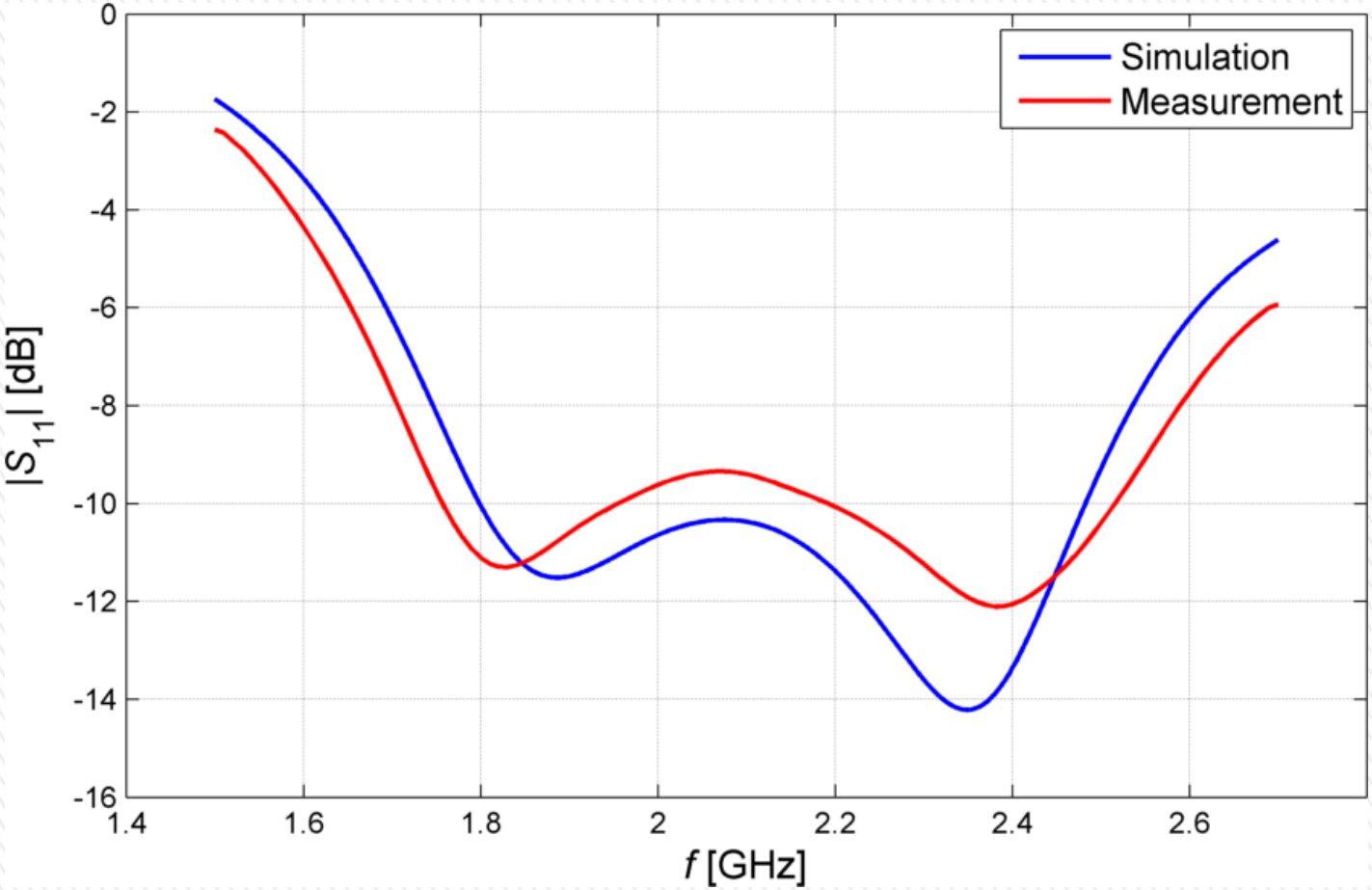


Towards inkjet printing

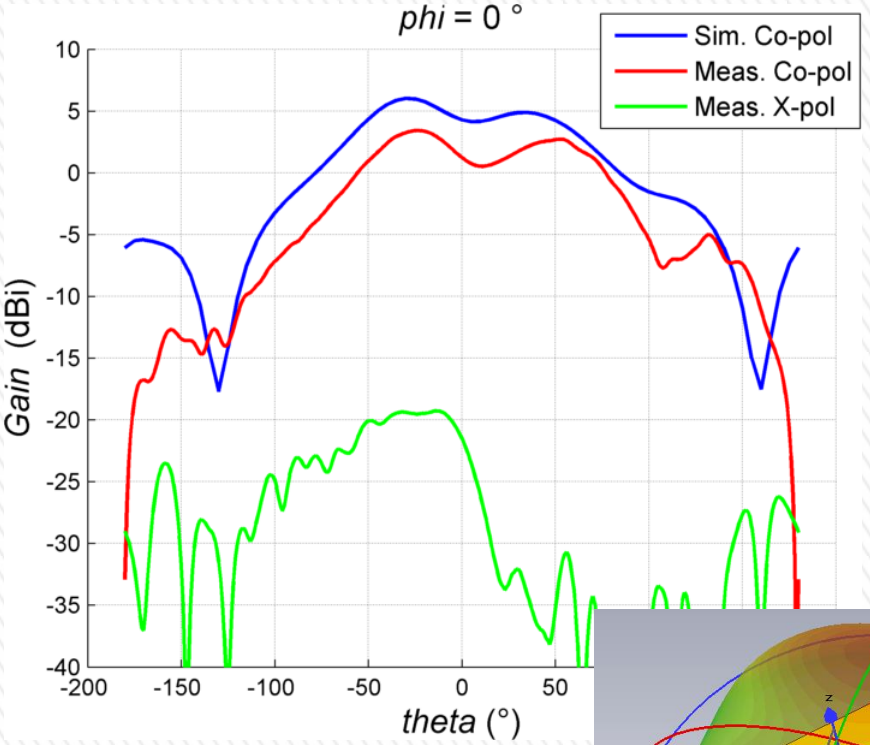
- But, the height of the DRA has to be reduced

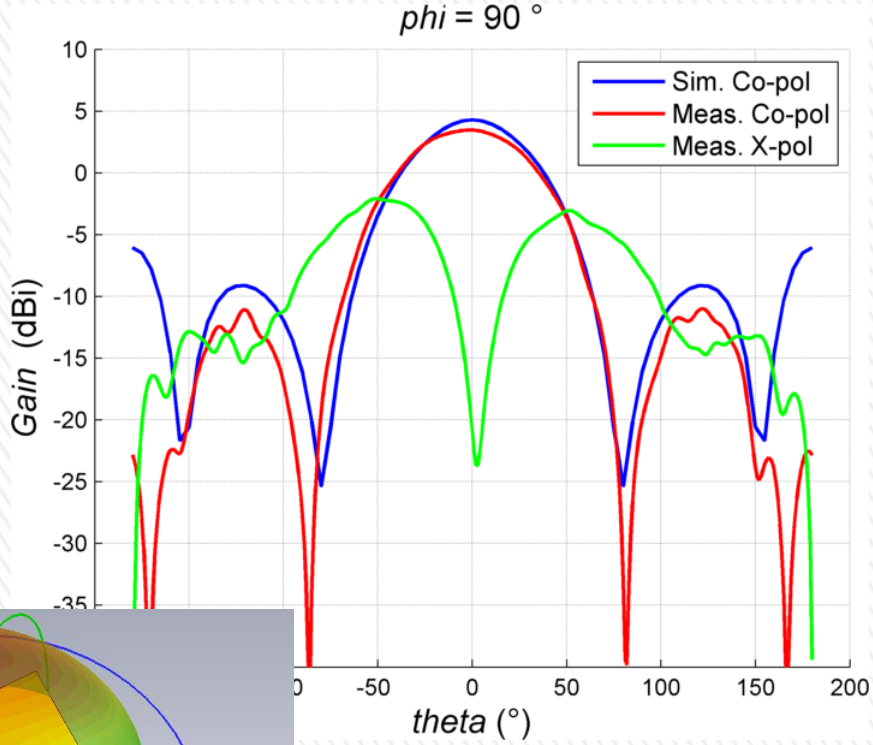


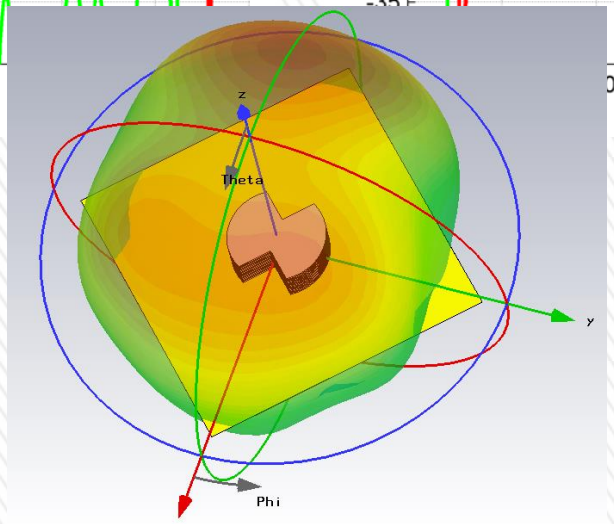
DRA – impedance matching



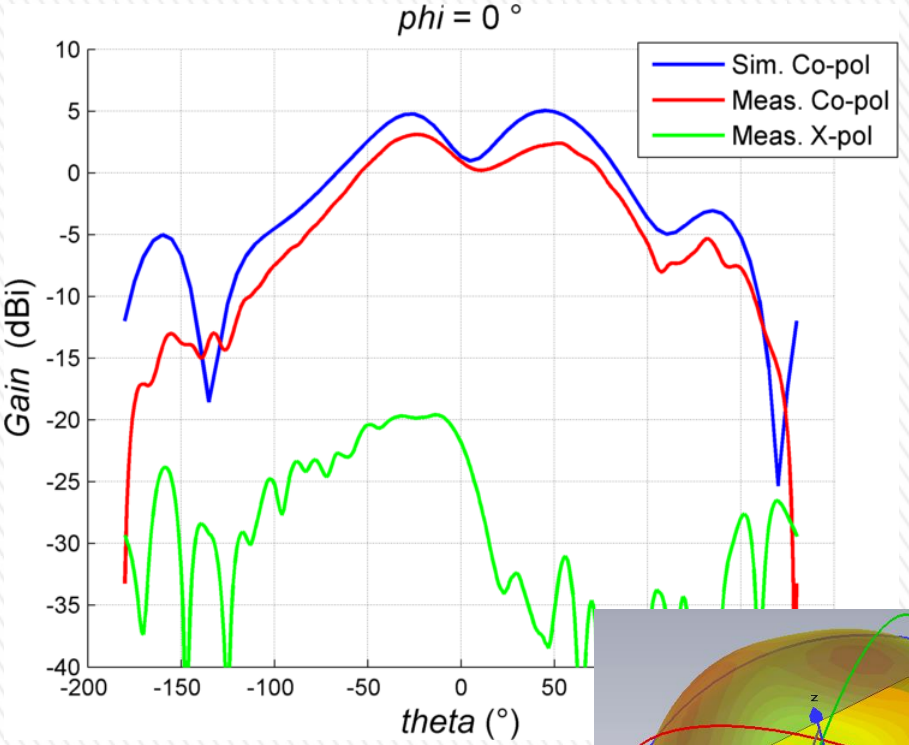
DRA – patterns @ 1.840 GHz

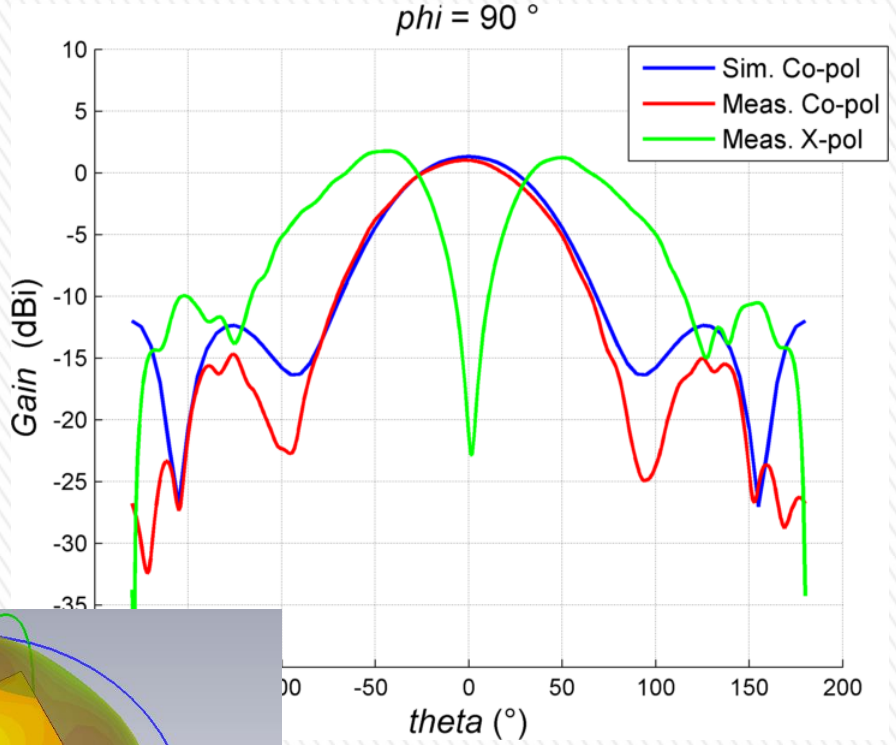


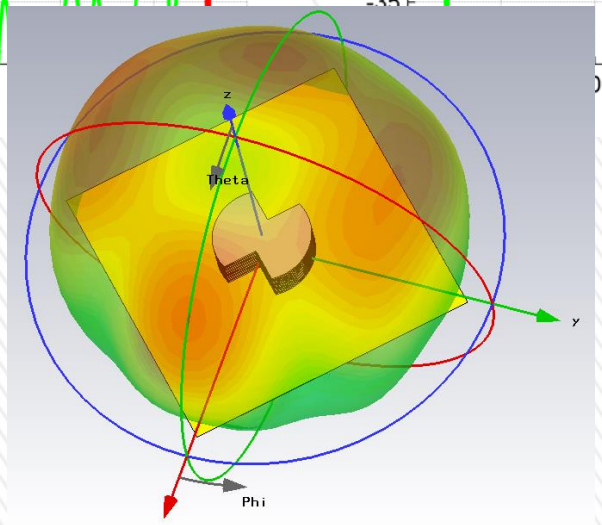




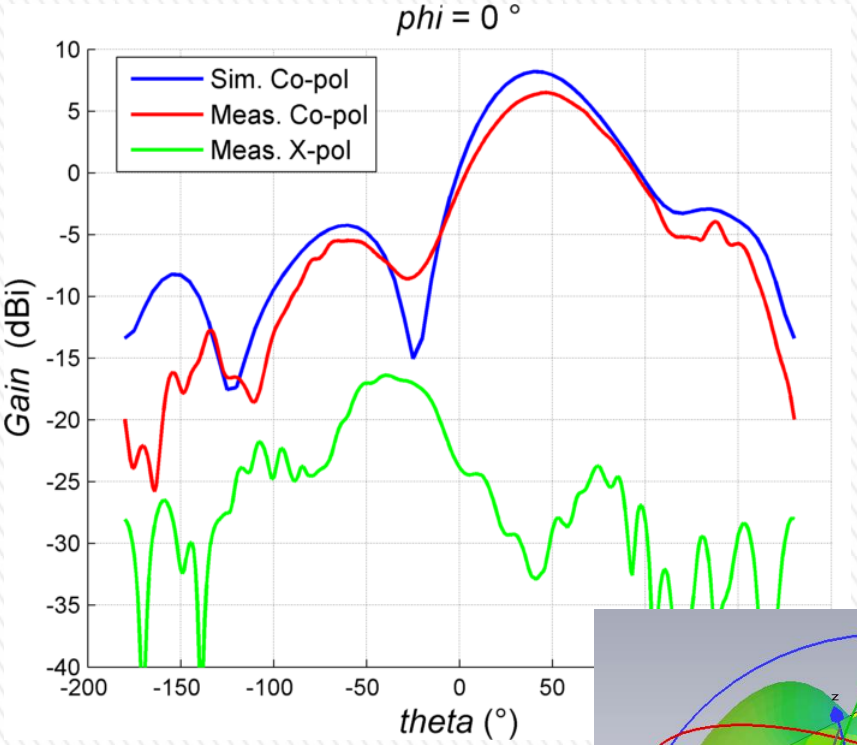
DRA – patterns @ 2.145 GHz

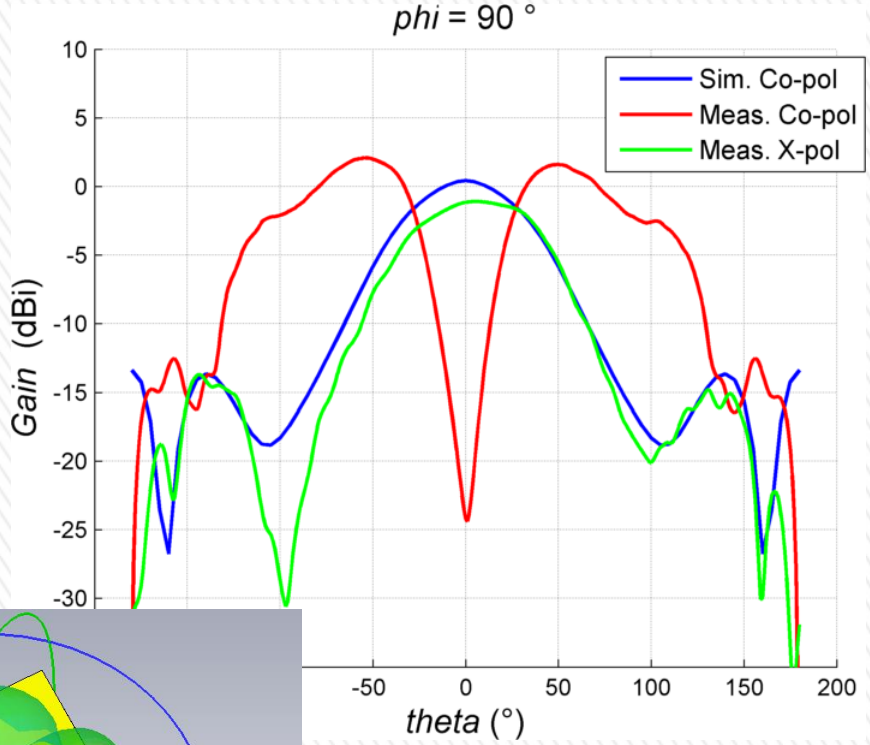


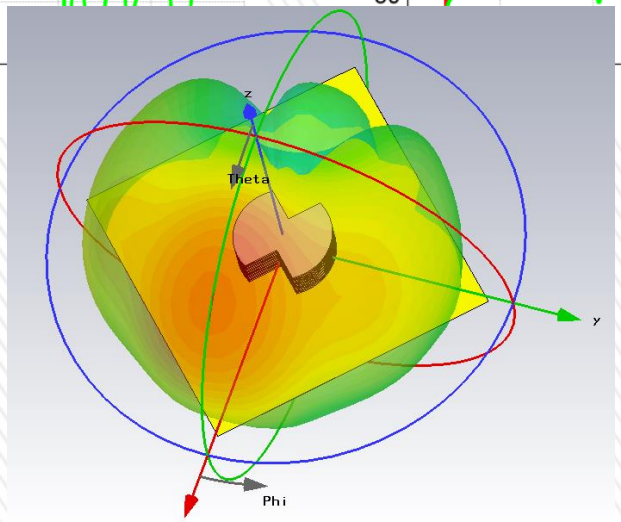




DRA – patterns @ 2.445 GHz







DRA – final parameters

Frequency [GHz]	Radiation eff. [dB]	Total eff. [dB]
1.840	-0.050 (99.4 %)	-0.40 (95.5 %)
2.145	-0.062 (99.3 %)	-0.45 (94.9 %)
2.445	-0.083 (99.0 %)	-0.39 (95.6 %)

- Radiation efficiency:
  dielectric and conduction losses
- Total efficiency:
  Radiation efficiency increased by mismatch loss

Towards inkjet printing

- Available inks Sigma-Aldrich http://www.sigmaaldrich.com
  - Silver nanoparticle inks
  - Photovoltaic inks
  - Dielectrics inks
  - Semiconductor inks
  - …

Conclusions

- Dielectric resonator antennas
  - Acceptable parameters
  - Height of resonator to be reduced
  - Feeding to be redesigned
- Inkjet printing
  - Wide spectrum of inks available
  - The whole harvesting system can be printed
  - Special inks rather expensive
- Prototype of printed harvester under development

Thank you for your attention

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