IC1004

Statistical Modeling of Antennas Applied to Realistic Use Cases in Wireless Networks

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Scientific context and objectives (1/3)

Connected man, connected things

- a huge number of scenarios/environment types
- a huge number of wireless device types
- a large number of physical layer schemes
- a strong impact of the performance/characteristics of devices on the radio link quality, especially in wide band, with multiple antennas…

How to model this complexity ?

➔A mixture of deterministic and stochastic modeling

Scientific context and objectives (2/3)

Benefits/objectives

- performance evaluation for algorithms, physical layer schemes, terminal/antenna configurations etc, with more realistic models !
- incorporation of models into wireless standards

Methodology (1/2)

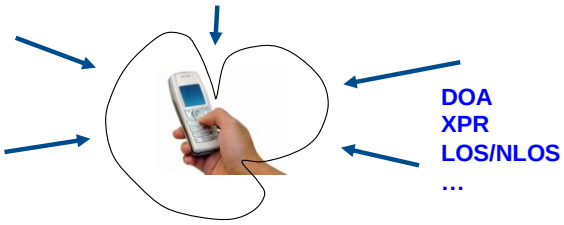
- propagation channel modeling: ongoing since COST 207 !
- antenna statistical behavioural modeling: new !
- joint antenna/channel statistical modeling: new !

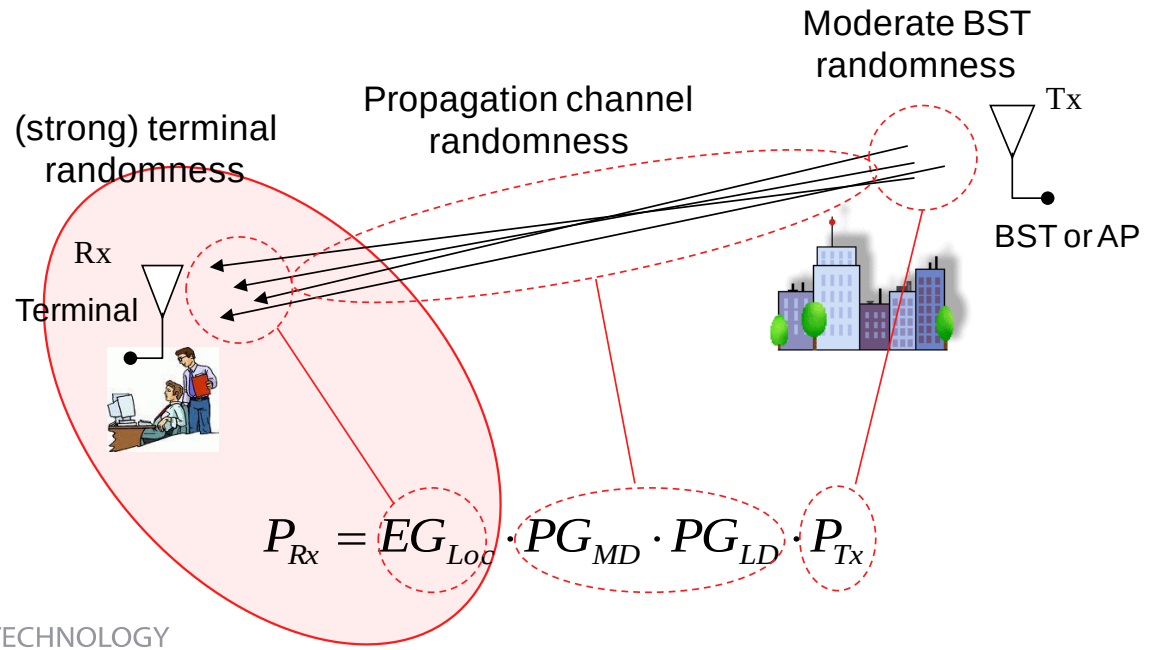
(started in COST 2100)

Scientific context and objectives (3/3)

Methodology (2/2)

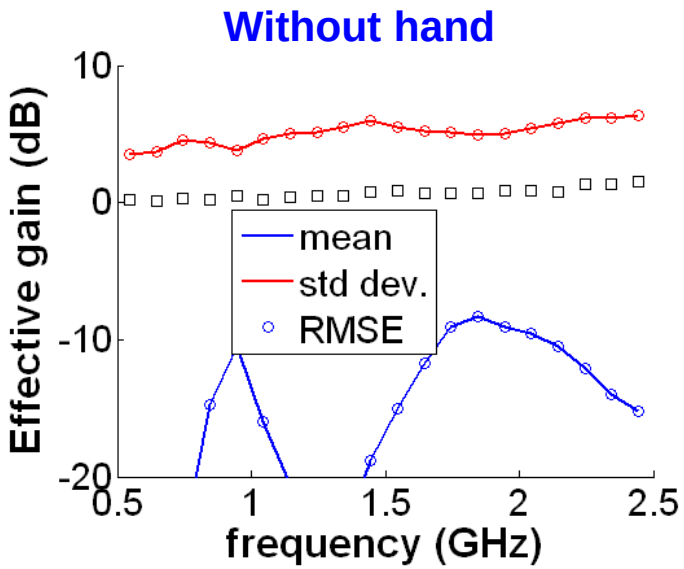
- consider antenna level variability
  - variability of antenna design
  - impact of integration into device
  - impact of immediate environment
- hybridize with propagation models (deterministic, statistical)

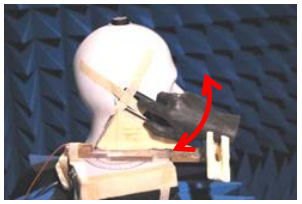


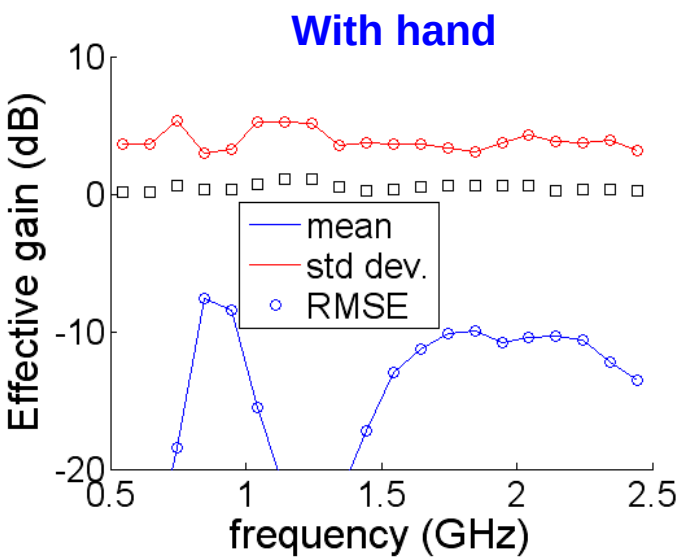


Examples (1/4)

Cellular systems



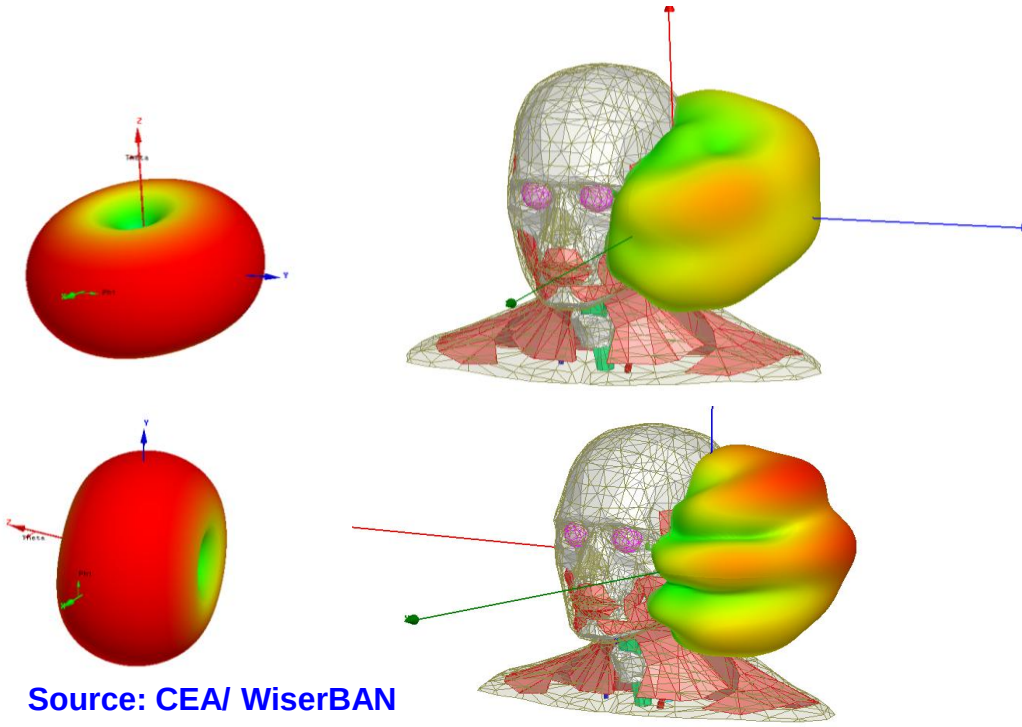




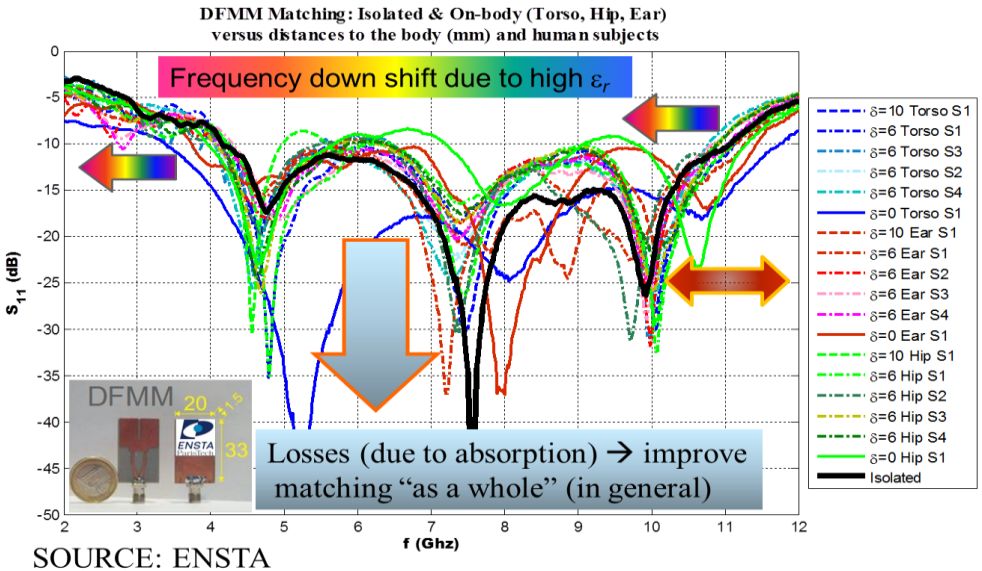
•A. Sibille, "Statistical Modeling of the Radio-Electric Properties of Wireless Terminals in their Environment," IEEE Antennas and Propagation Magazine, Vol. 54 , 6, 2012

Examples (1/4)

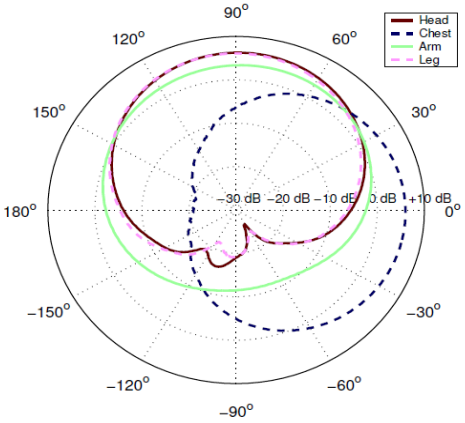
- Antenna characteristics depend on
  - On-body position
  - Antenna-body separation
  - Antenna type
- Randomness

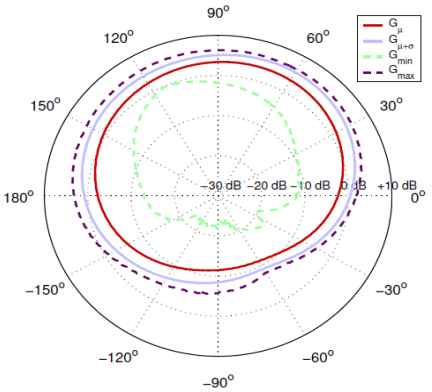


Source: CEA/ WiserBAN



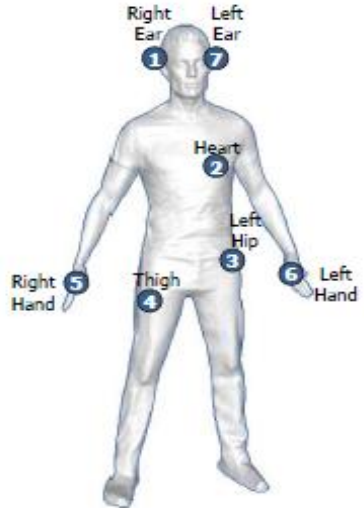
SOURCE: ENSTA

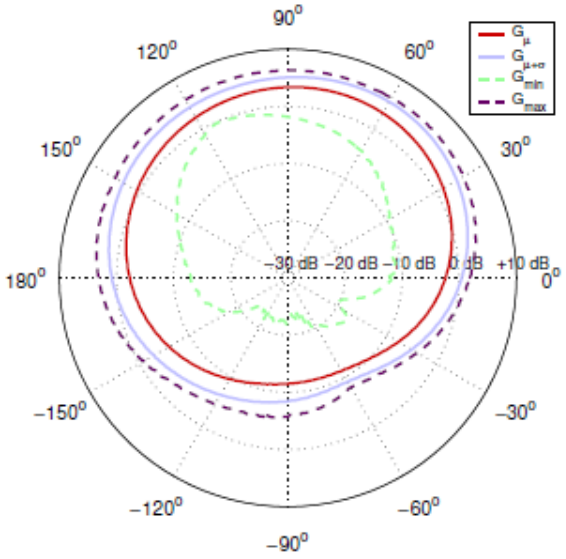


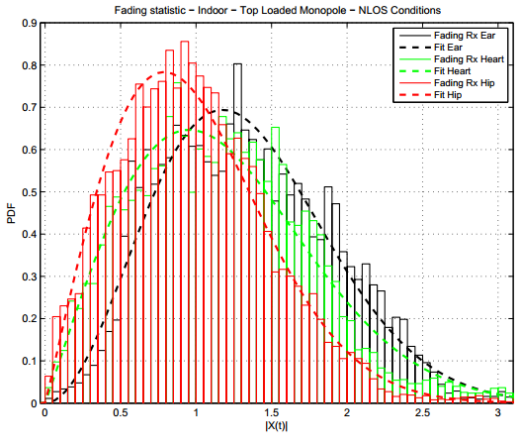


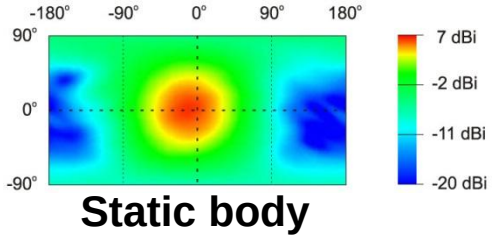
Examples (2/4)

Body area networks

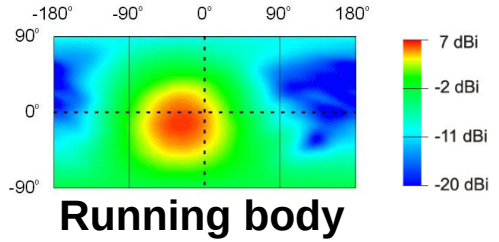




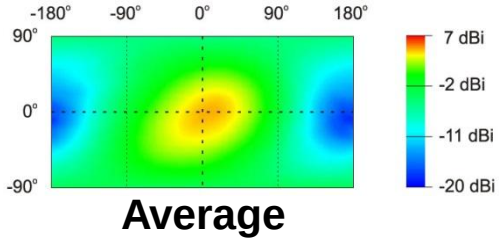




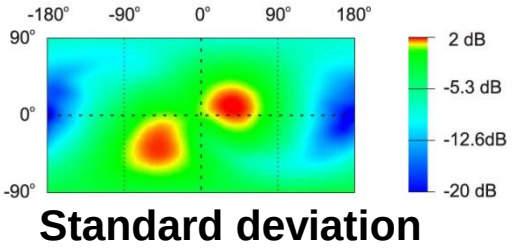
Static body



Running body



Average



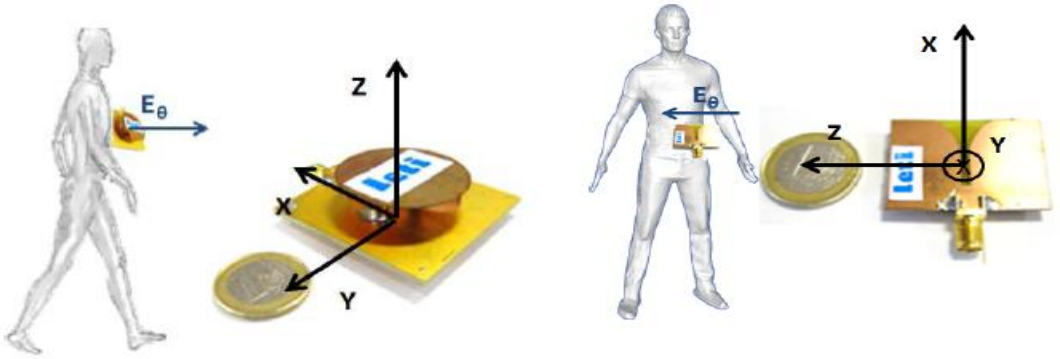
Standard deviation

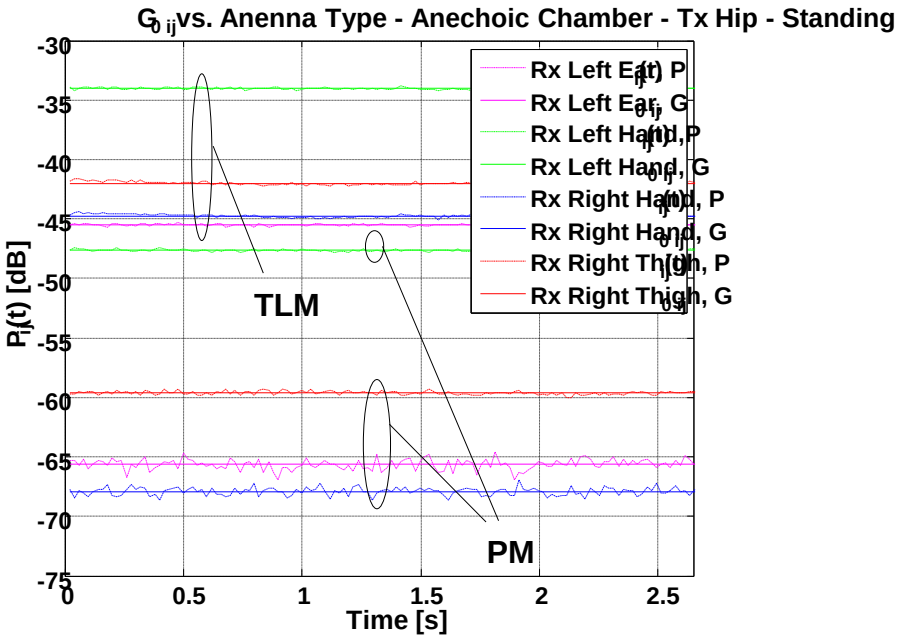
M. Mackowiak, C.Oliveira L. Correia, "Statistical Model of the Influence ofBody Dynamics on the Radiation Pattern of Wearable Antennasin Off-Body Radio Channels," in *IC1004*, no. TD(11) 02017.

Examples (2/4)

- Normal polarization helps creeping wave propagation
  - Higher gain
  - Smaller shadowing (high K Rice factor)

Antenna-channel joint effects➔ still a lot to do !!

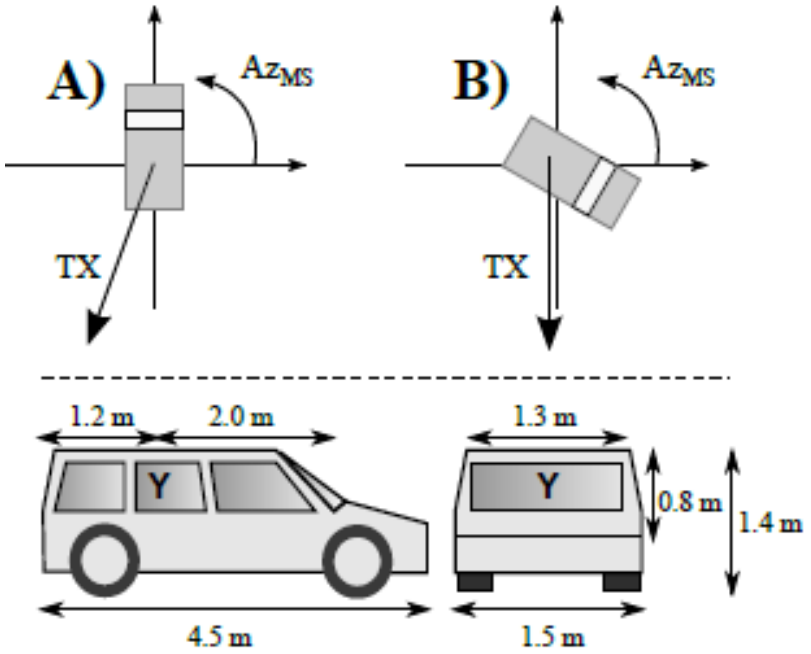


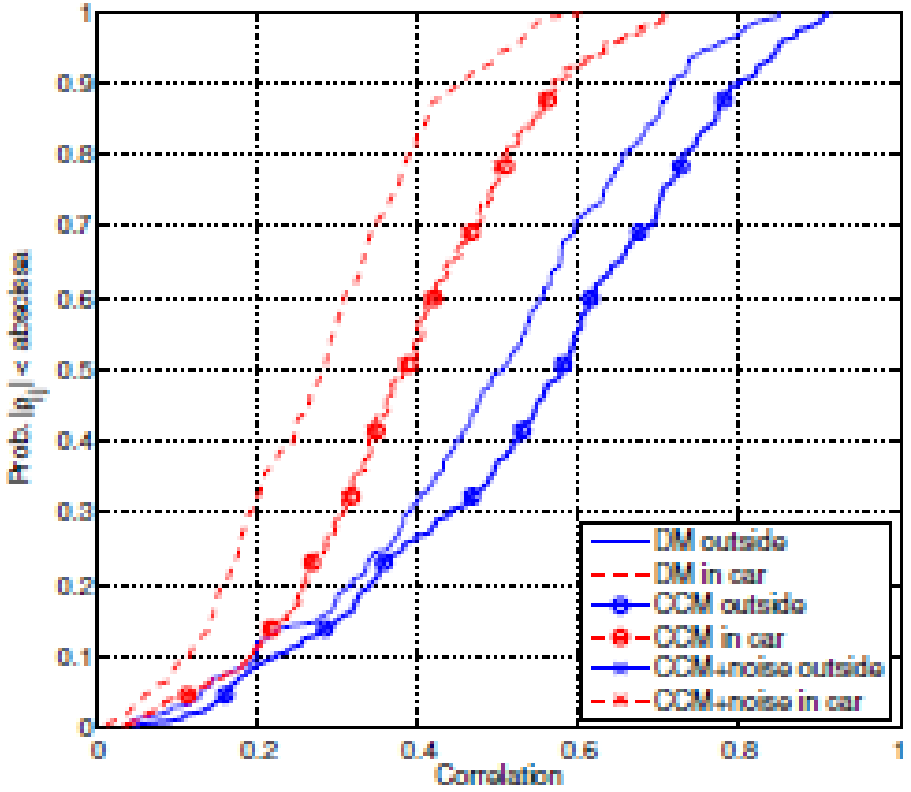


R. Rosini, R. D'Errico, "Comparing On-Body Dynamic Channels for Two Antenna Designs", LAPC 12 Loughborough UK, November 2012 (BEST STUDENT PAPER)

Examples (3/4)

In-vehicle communications

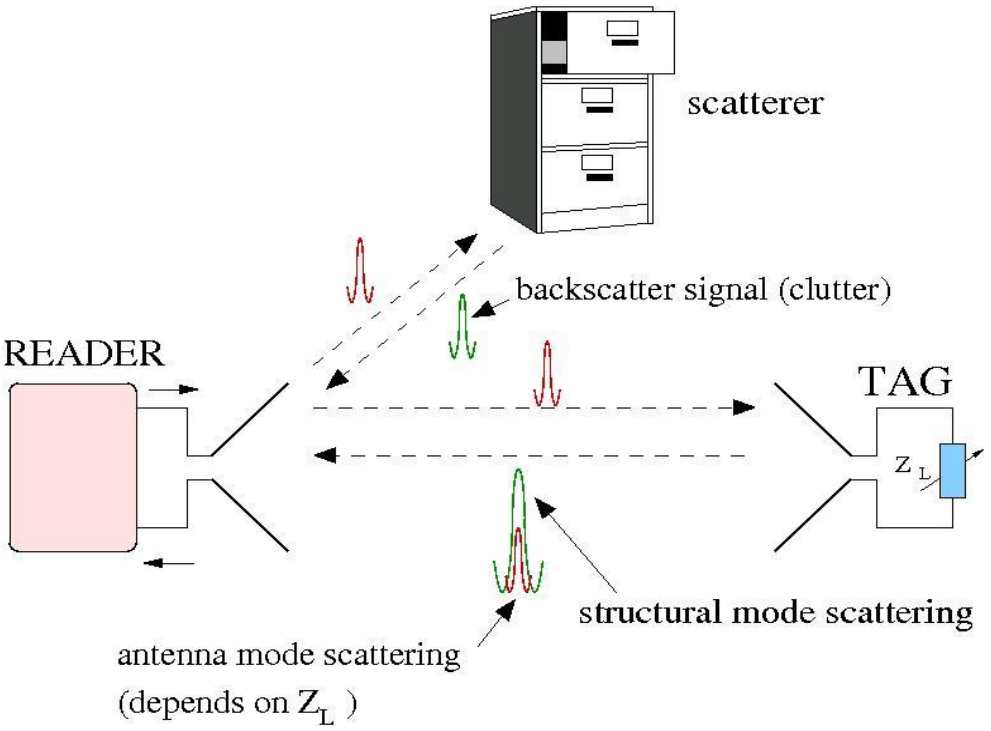


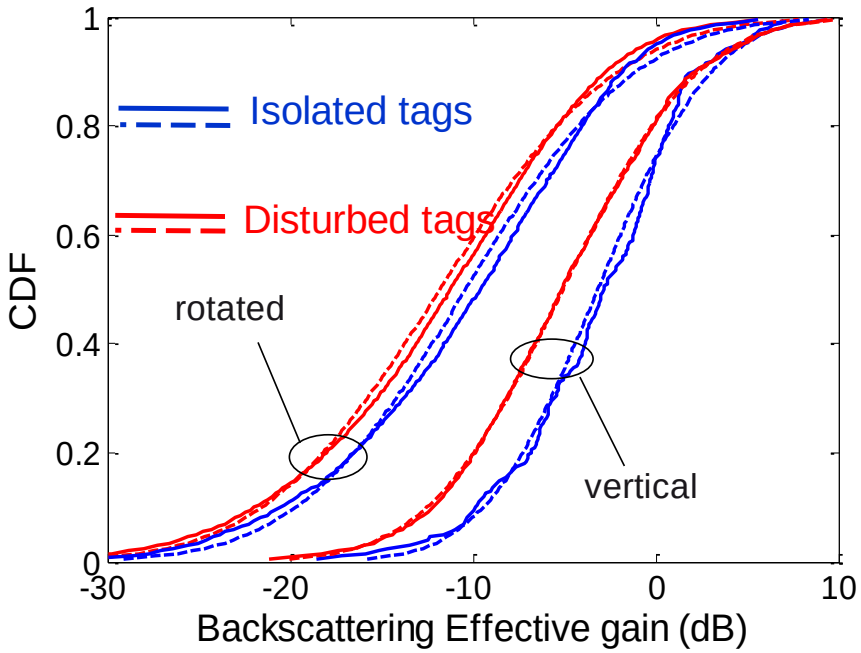


•F. Harrysson, T. Hult and F. Tufvesson, "Evaluation of an Outdoor-to-In-Car Radio Channel with a Four-Antenna Handset and a User Phantom," IEEE Vehicular Technology Conference, VTC 2011-Fall, San Francisco, CA, Sept. 2011

Examples (4/4)

Backscattering based UWB RFID system





A. Sibille, M. Sacko, Z. Mhanna, F. Guidi, and C. Roblin, "Joint antenna-channel statistical modelling of UWB backscattering RFID." ICUWB, Bologna, Italy, 14-16 Sept. 2011

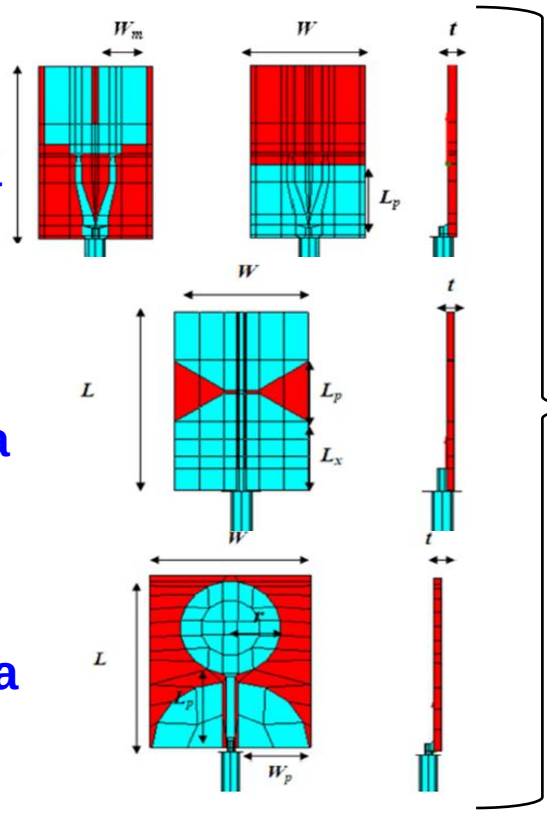
Example of class of antennas

- Aim: Identify scattering properties for a class of antennas for UWB MIMO
  - 3x100 “random” antennas
  - Similar scattering characteristics: poles decomposition, Spherical Wave Expansion
  - Unique statistical model for UWB monopoles

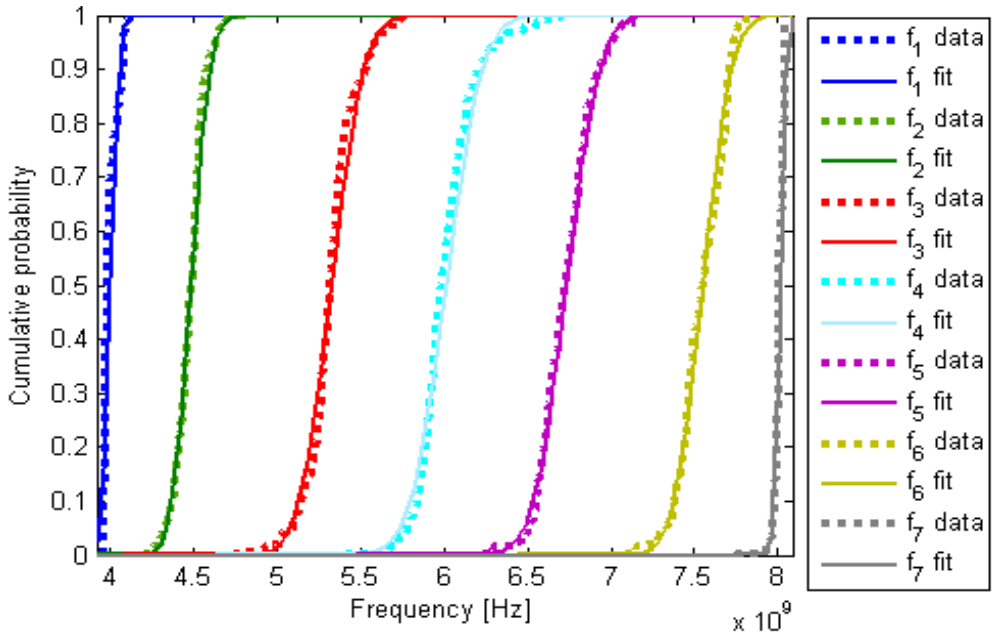
100 DFMM-like Random Antenna

100 CPWFP-like Random Antenna

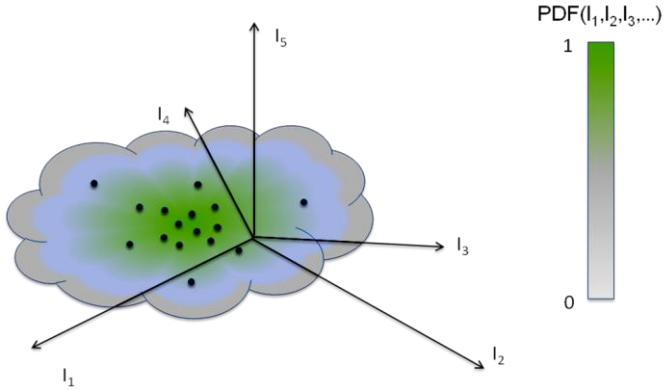
100 PDM-like Random Antenna



Natural Frequencies



Issues



Difficulties

- the dimensionality curse
- identify the major parameters to model
- find the suitable multi-variate distributions

Methods

- brute force Monte-Carlo
- “Small signal” case
- clever “design of experiments”
- chaos polynomials
- …

Conclusion

Impact

- add-on to COST IC1004 channel model
- dissemination towards the scientific community
- connection with OTA test methods for MIMO terminals
- …

➔ **Still very much to do !**

A.Sibille, "Statistical modeling of antennas in the radio channel context: a new impetus ?", IC1004 TD(13) 06083, Malaga, Spain, 6-8 February, 2013
and references herein (available on request)