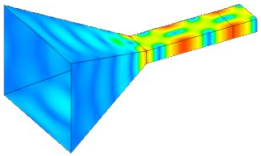
Antennas and electromagnetic simulators for demanding wireless applications in complex environments

Dr. Vladimir V. Petrović

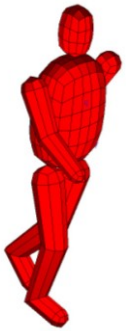
University of Belgrade, School of Electrical Engineering
Group for electromagnetics, antennas and microwaves
http://mtt.etf.bg.ac.rs, vp@etf.rs



Antennas for demanding applications (wireless sensors)

- Antennas need to be extremely versatile:
- small, adaptive, low-cost, mobile, “smart”
- Those demands are almost always opposed to optimal conditions for antenna performance
- Antenna specifications are pushed close to fundamental physical limits

Antennas for WSN operate in unfavorable electromagnetic environments



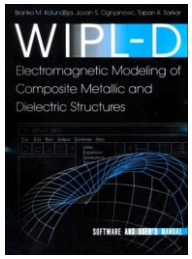
- Inside or close to lossy media (human body, soil, water,...)
- Geometricaly complex and highly inhomogeneous media
- Stohastic (unpredictable) environments:
- movement of the object/body, influence of surrounding bodies, walls, metalic objects..

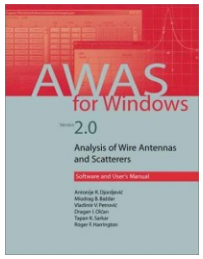
Antenna design

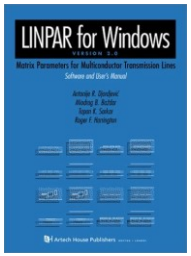
- Modern and future antennas have to be designed by the synergy of
- strong **fundamental knowledge** and
- powerful **software tools**

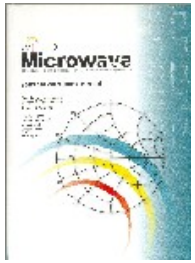
Our software for antenna design

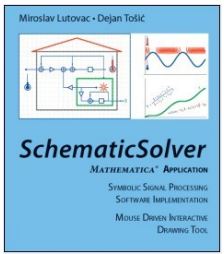
- **Wipl-D Microwave**: MTT simulator
- **Linpar**, **Matpar**, **Linres**, **Multlin**: multiconductor transmission lines (incl. in *Microwave Office*)
- **Wipl-D Pro**: 3D EM simulator and optimizer
- **Awas**: analysis of wire antennas and scatterers
- **E3D**: 3D electrostatic simulator
- ***SchematicSolver***
  symbolic system simulation

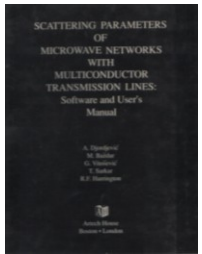


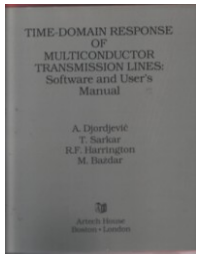


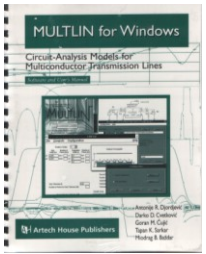






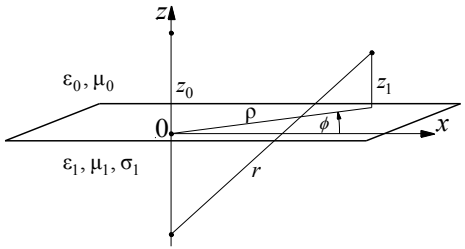


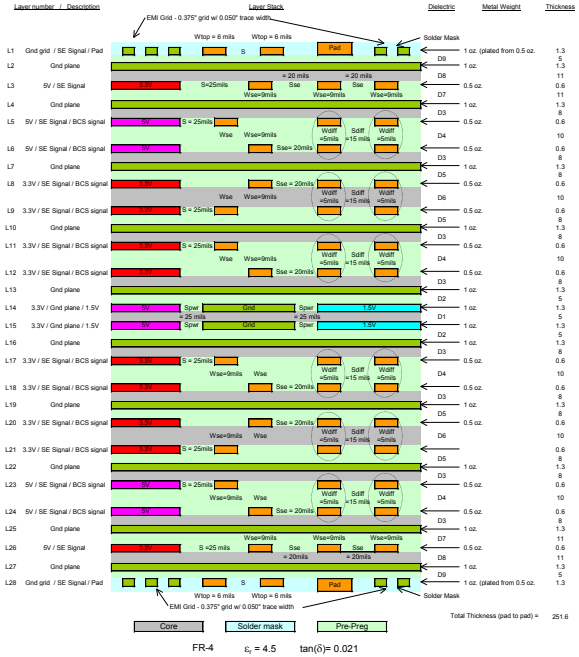




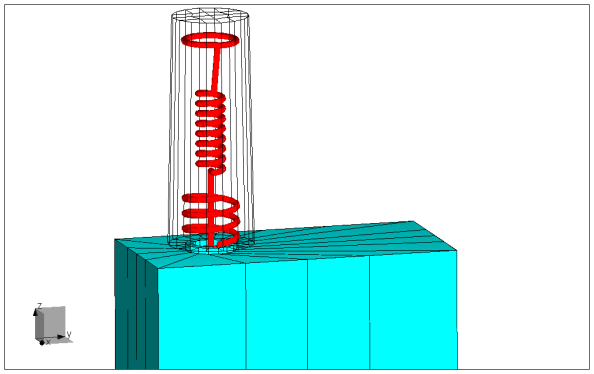
Antennas above and in real ground and layered media

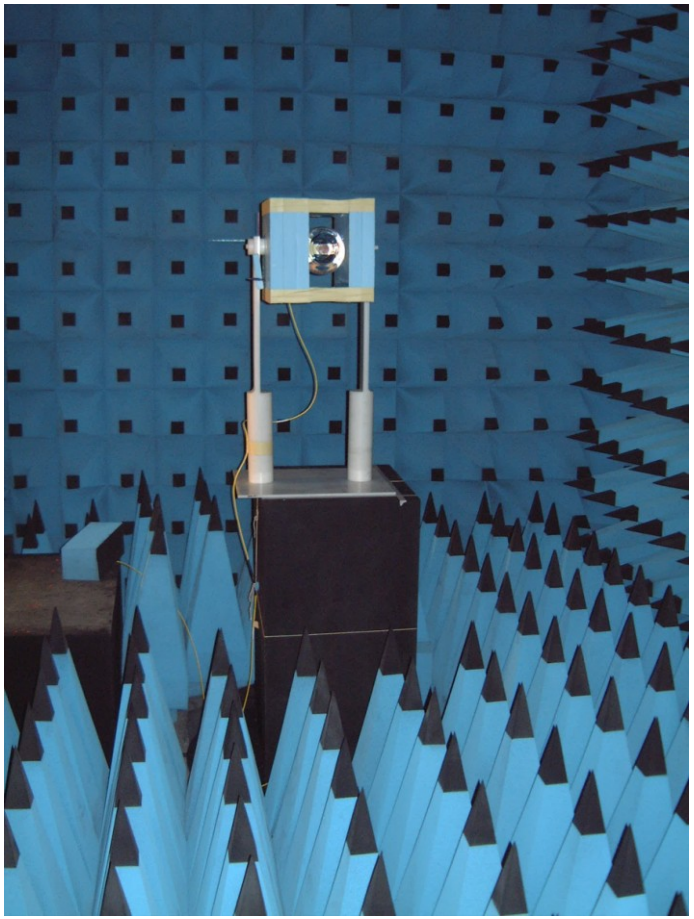
- Accurate method
- Reduces memory demands and computing time more than 10x
- Extension of the method to layered media (in near future)
- Implemented in AWAS and WIPL-D Pro
- Application to WSN: sensors in ground, water, for agriculture, meteorology, geology...
  - GENERAL SINGULARITY EXTRACTION TECHNIQUE FOR REFLECTED SOMMERFELD INTEGRALS, V.V.Petrovic, A.R.Djordjevic, AEU, Vol.61, No.8 pp.504-508, 2007.



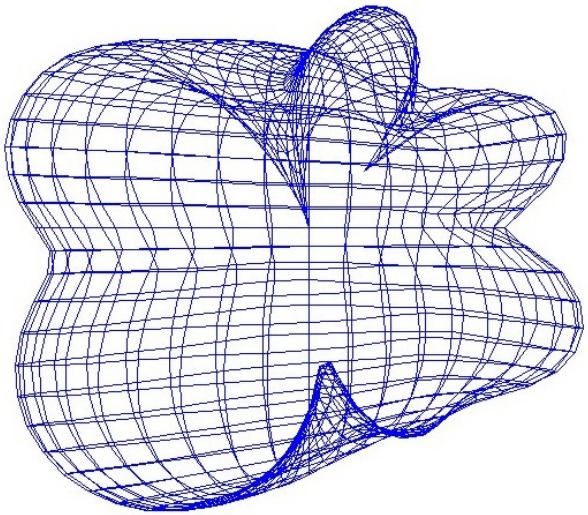


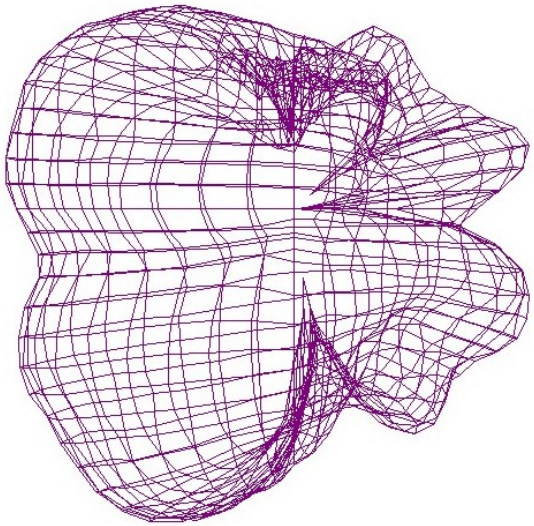
Interaction between mobile handsets and the human head: simulation and measurements



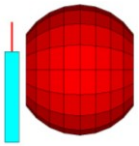


Mobile handset radiation diagram



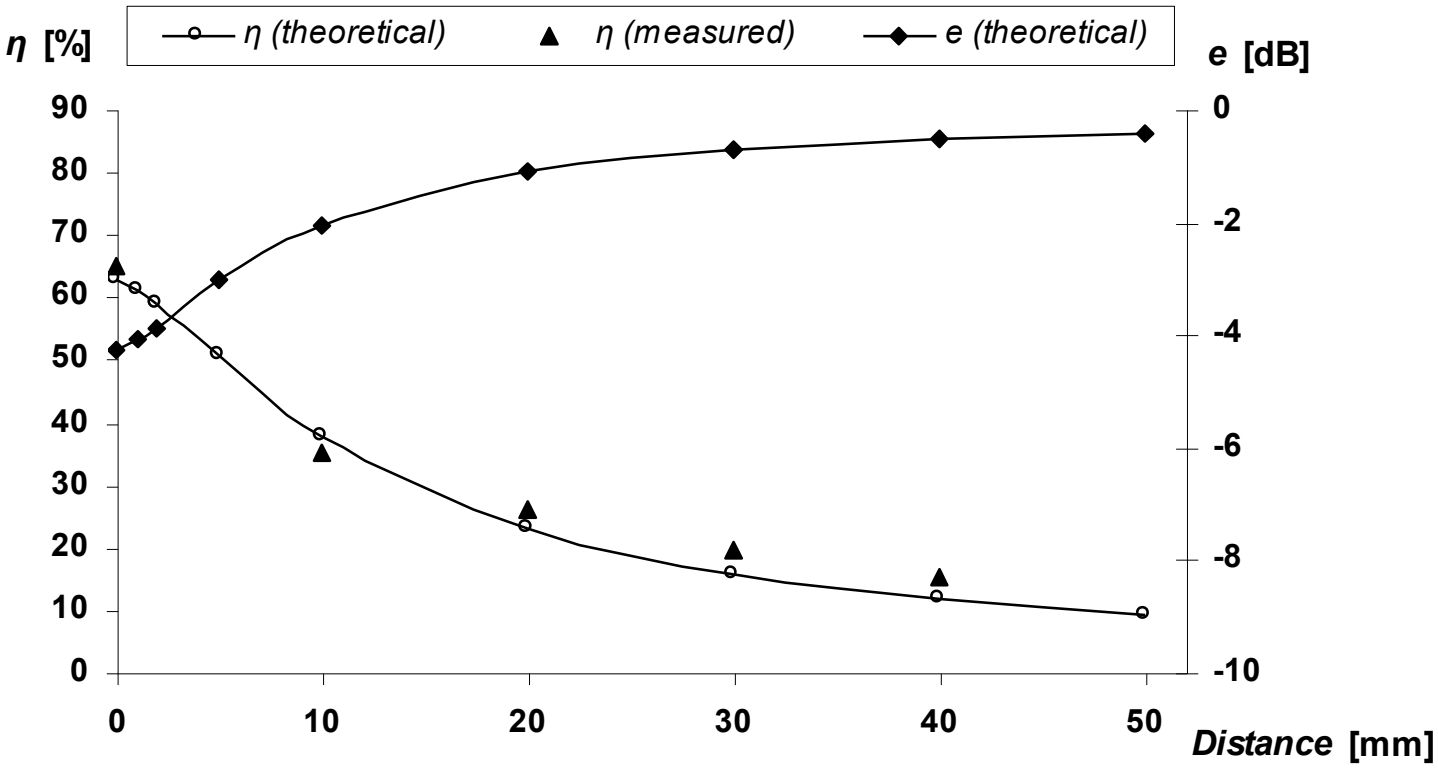


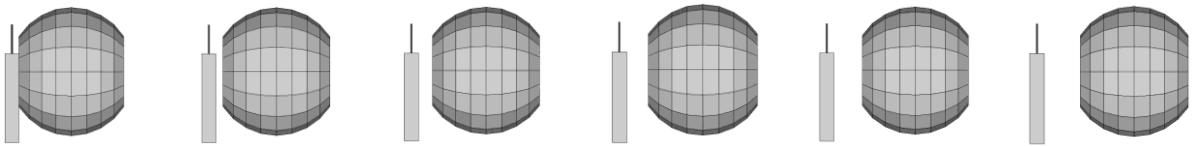
THEORETICAL



MEASURED

Absorbed power and radiation efficiency





Partners:

Mobile communications Lab

NCSR “DEMOKRITOS”
Institute of Informatics &
Telecommunications
www.iit.demokritos.gr

Electromagnetic Group

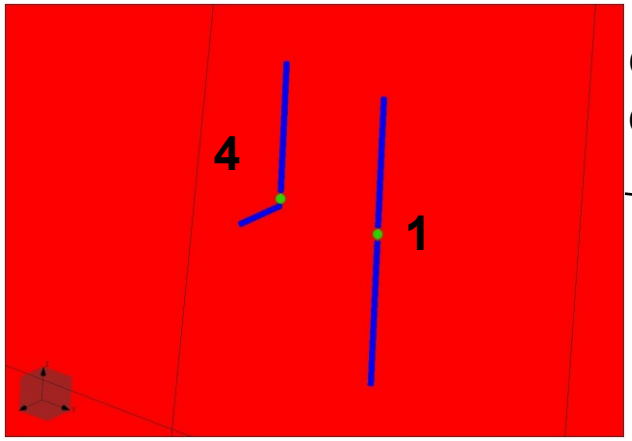
University of Belgrade
Faculty of Electrical Engineering
www.etf.bg.ac.yu

MOBILE PHONE ANTENNA PERFORMANCE AND POWER ABSORPTION IN TERMS OF HANDSET SIZE AND DISTANCE FROM USER'S HEAD, T.Zervos, A.A.Alexandridis, V.V.Petrovic, K.P.Dangakis, B.M.Kolundzija, A.R.Djordjevic, C.F.Soras, Wireless Personal Communications (Springer), Vol.33, No.2, pp.109-120, 2005. April

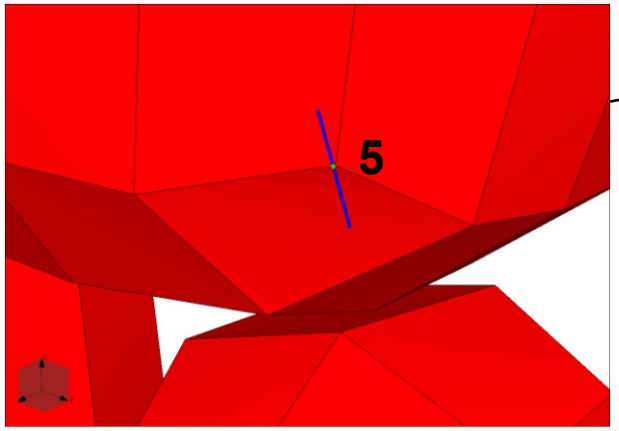
and several conference papers

Antennas on and inside human body for wireless body-area network (WBAN)

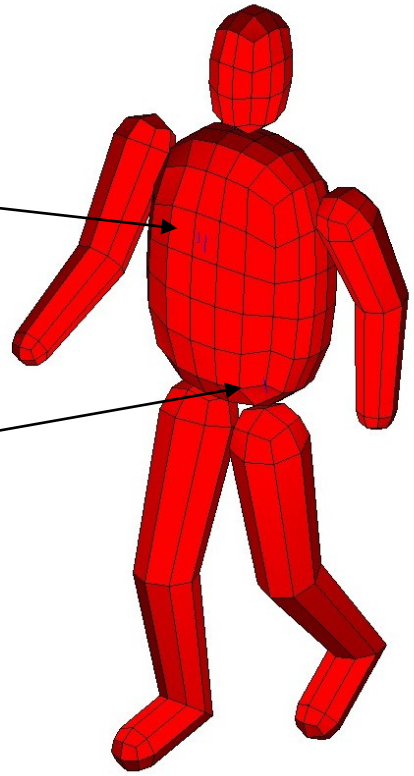
- WIPL-D Pro simulations



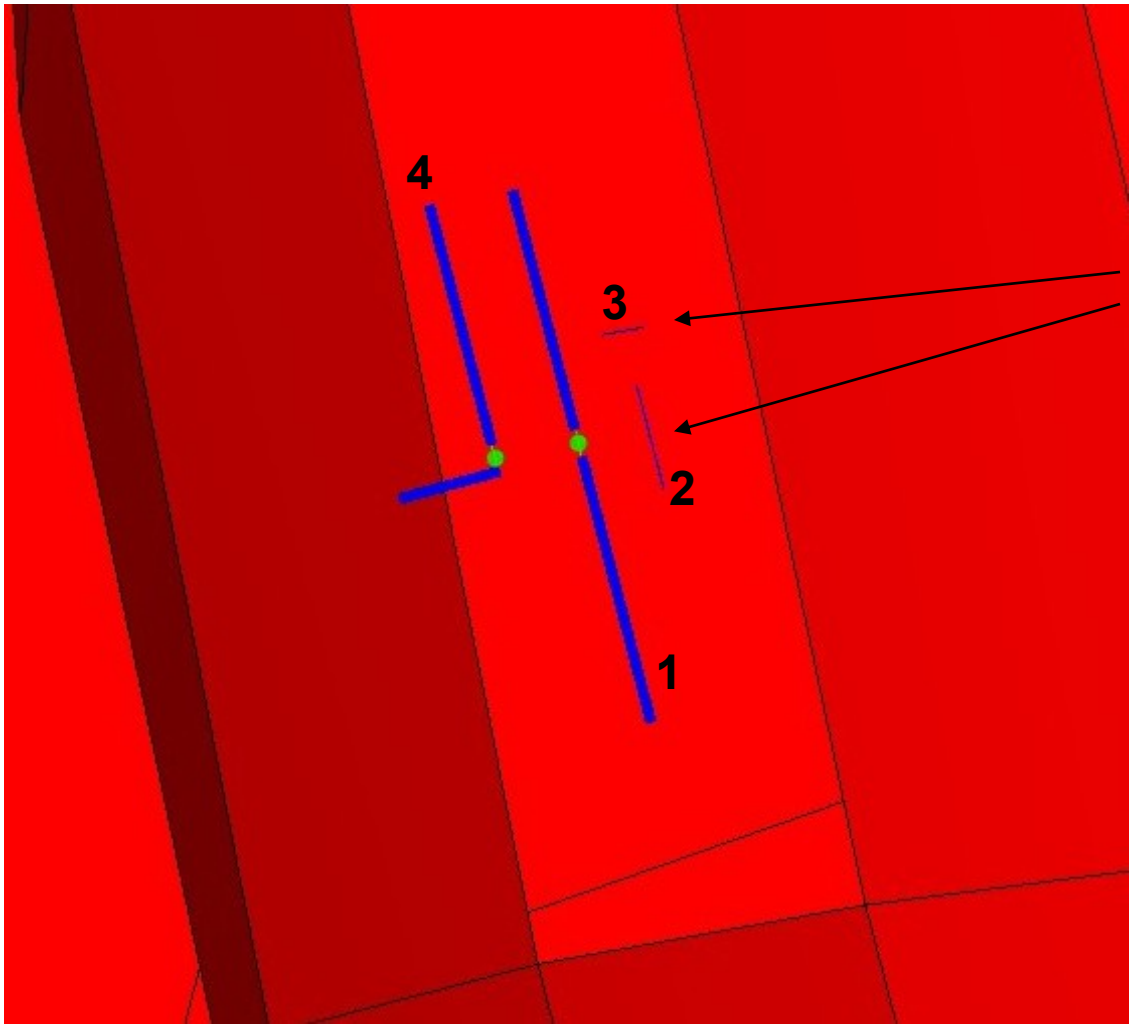
chest: sim. dipole and L-dipole on the skin



belt: simmetrical dipole close to the body



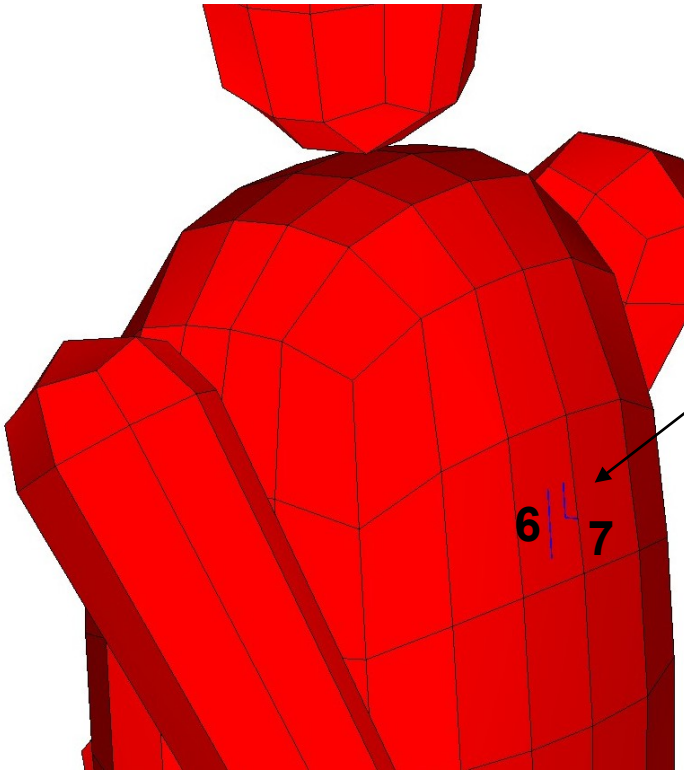
Antennas on and inside human body for wireless body-area network (WBAN)



two chest implanted sim. dipoles (about 0.5 cm deep)

Antennas on and inside human body for wireless body-area network (WBAN)

- WIPL-D Pro simulations



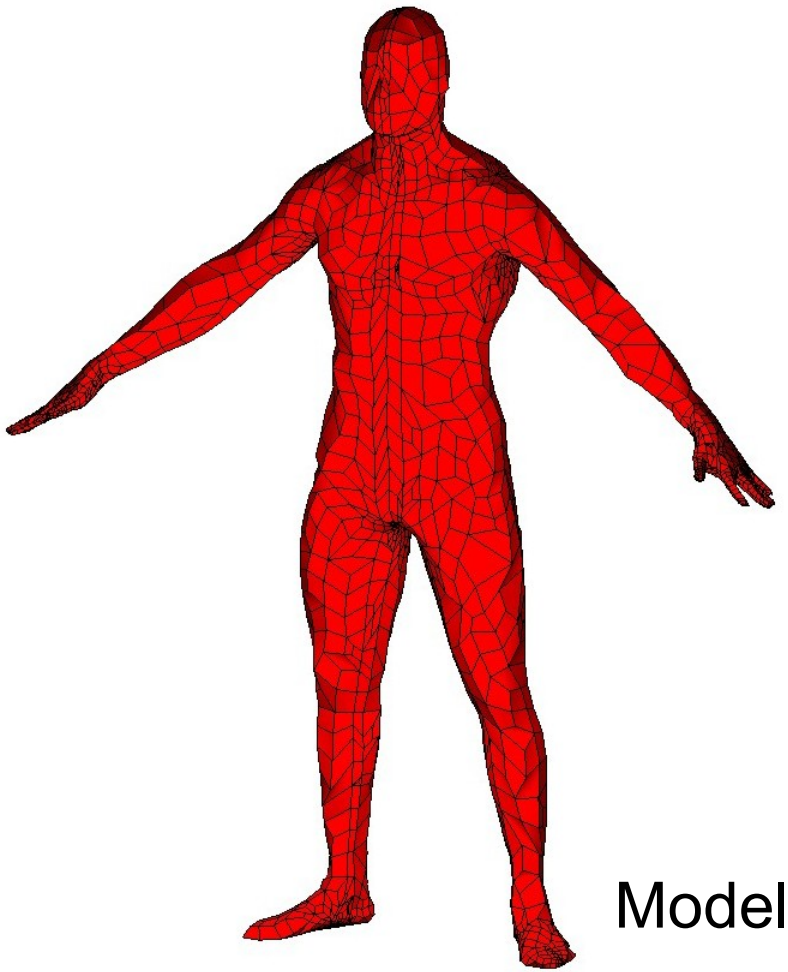
back: sim. dipole and L-dipole on the skin

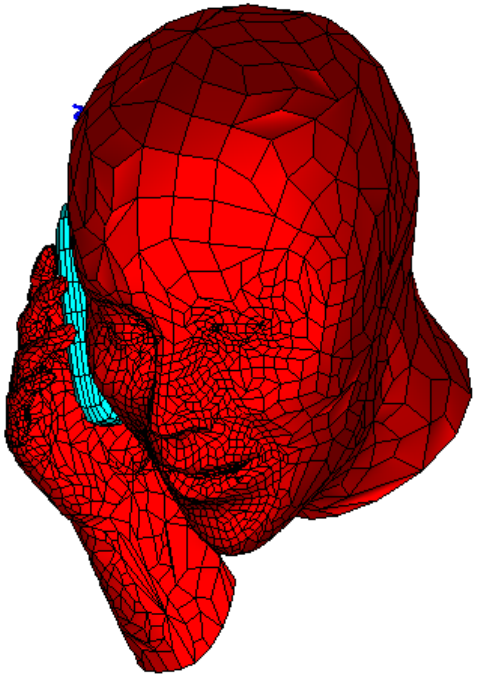
Results for transfer between antennas (Propagation path Gain, *S* parameters)

- frequency *f* = 2.45 GHz, PG [dB] (<10 min, single core PC, 2.6 GHz)

i	j	short L	long L	without body	
1	2	-28	-28	-43	chest dipoles implant - skin, vert.
1	3	-83	-72	-87	chest dipoles implant - skin, horiz.
1	4	-71	-70	-49	chest dipole - belt
1	6	-63	-63	-30	chest dipole - back dipole
1	7	-80	-67	-48	chest dipole - back L
2	4	-73	-73	-87	implanted vert. dipole - belt
2	5	-42	-33	-66	implanted vert. dipole - chest L
2	6	-74	-74	-70	implanted vert. dipole - back dipole
2	7	-92	-93	-88	implanted vert. dipole - back L
3	4	-85	-85	-78	implanted horiz. dipole - belt
3	5	-60	-46	-65	implanted horiz. dipole - chest L
3	6	-116	-110	-118	implanted horiz. dipole - back dipole
3	7	-98	-81	-114	implanted horiz. dipole - back L
4	5	-81	-66	-66	belt - chest L
4	6	-71	-71	-40	belt - back dipole
4	7	-95	-82	-52	belt - back L
5	7	-95	-68	-67	chest L - back L

Simulation models can be much more realistic and detailed





Models in WIPL-D Pro

Conclusion: Possible design procedure for WSN antennas

- Antena design, placement and propagation
- **Extensive numerical simulations and optimization**
- Avoid accurate lab. measurements because:
  - they are complicated, time consuming, expensive, in unrealistic “ideal” environment
- **Test prototipes in real conditions**
- Iterate if necessary
- **Perfect for SME** (WIPL-D company is SME)

Thank you