

Exposure Setups for Laboratory Animals and Volunteer Studies using Body-Mounted Antennas

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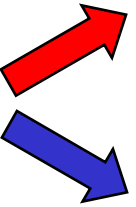
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Outline

- Two Body-Mounted Antenna Systems for localized Exposure

- Exposure Setups for  Volunteer Studies [B6]
Study on Laboratory Animals [B5]

- Motivation and Objectives
- Antenna design
- Used signals for exposure
- Dosimetric evaluation
- Block diagram of the computer controlled exposure setup

- Conclusion

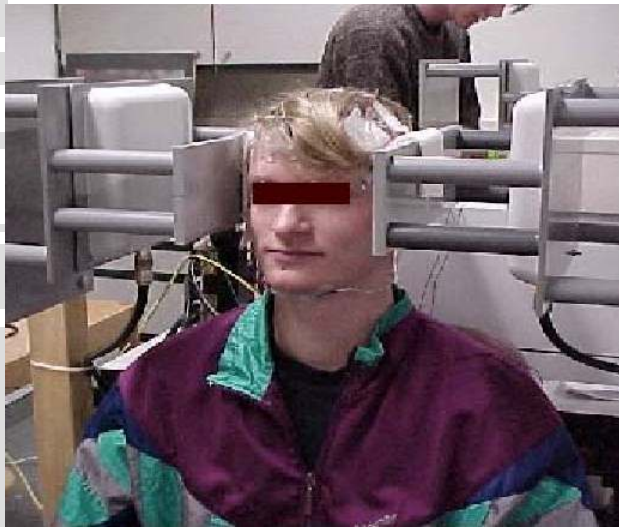
Objectives for Volunteer Study

- **DMF study „Investigation of volunteers exposed to electromagnetic fields of mobile phones“**
- **Analysis of possible effects on brain activity in sleep and waking**
- **Wake outcome variables**
 - Spontaneous EEG
 - Evoked and event related potentials
 - Cognitive functions
- **Sleep outcome variables**
 - Classical sleep parameters
 - Quantitative parameters derived from the raw data

State of the Art Antenna Solutions

Exposure setups simulating mobile phone usage

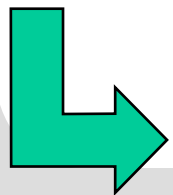
- Commercially available mobile phone [Lee, 2003]
- Patch antennas in a wooden mount [Huber, 2000]
- Quasi-far-Field [Borbély, 1999]
- Body worn antenna [Schmid, 2004]



Antenna Specs and Intended Use Position

Specifications:

- Localized mobile phone like exposure
- GSM and WCDMA coverage
- Exposure times of 8 hours during day and night

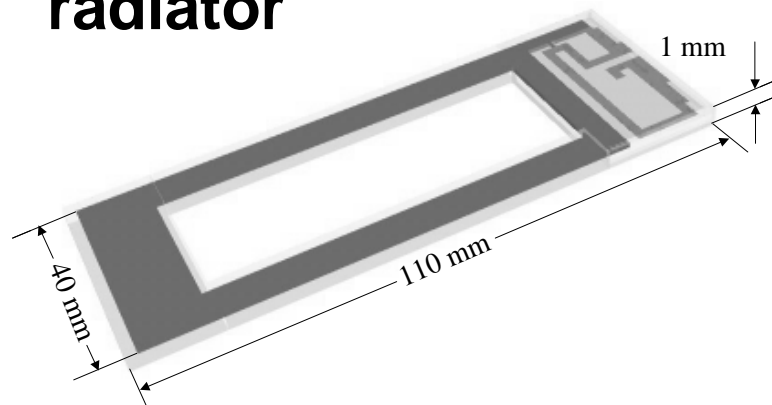


Dual band antenna
surrounding the pinna

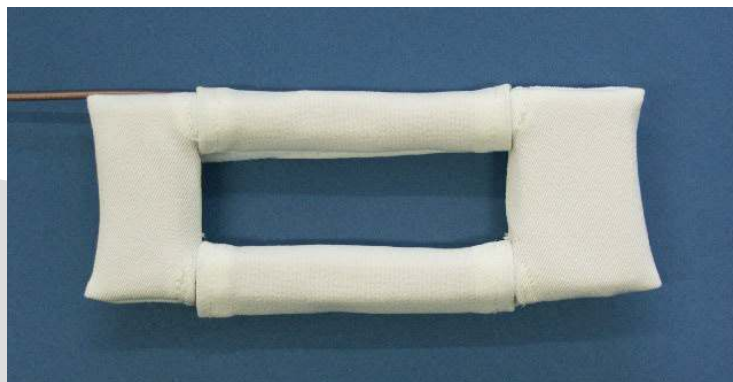


Antenna Details

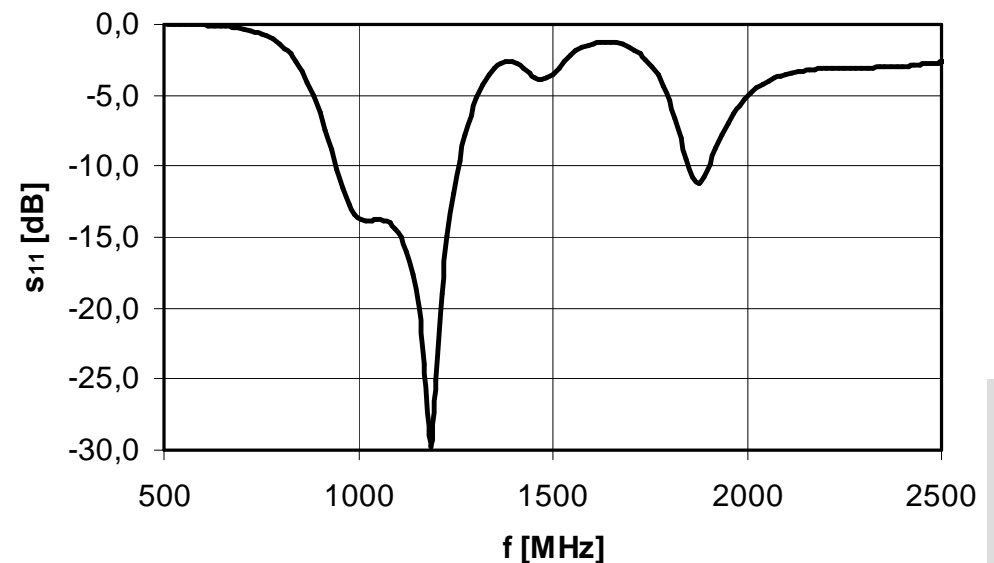
- PCB with a PIFA type radiator



- PCB covered by foam and a washable textile cover



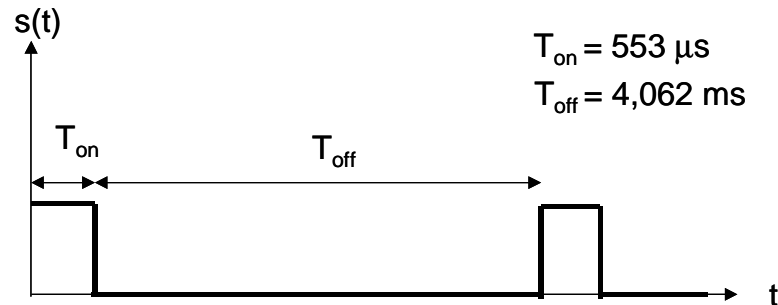
- Weight: 14 g
- Total thickness: 4 mm
- Free space reflection coefficient:



Exposure Signal Characteristics

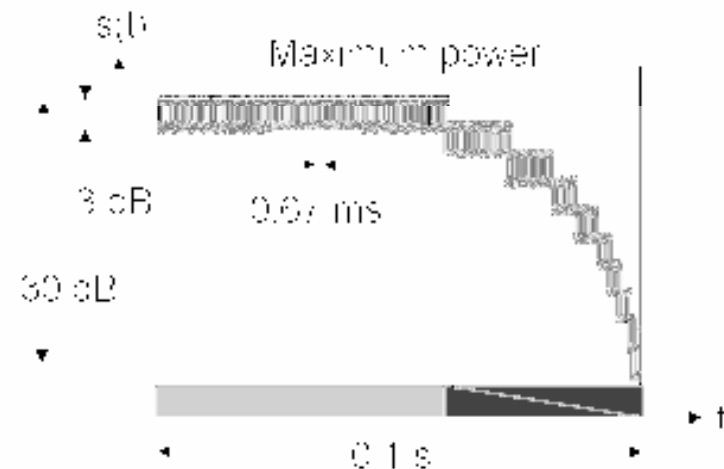
GSM:

- 900 MHz
- Pulse modulated carrier



WCDMA:

- Signal generation according to [Mbonjo, 2004]
- 1966 MHz QPSK signal with fast power control



Measurement Method

- SAR measurement used for verification of FDTD model
- DASY4 system
- Tissue simulating liquids according to FCC requirements

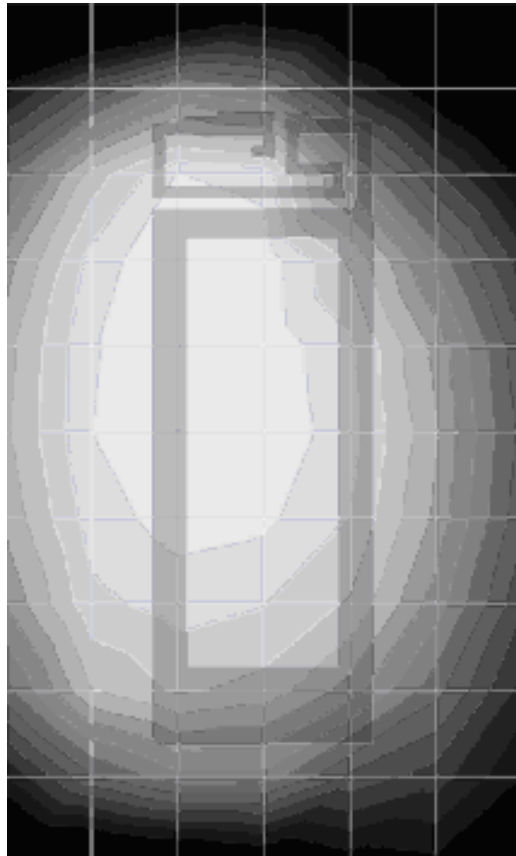


- Measurements in the flat section of SAM phantom

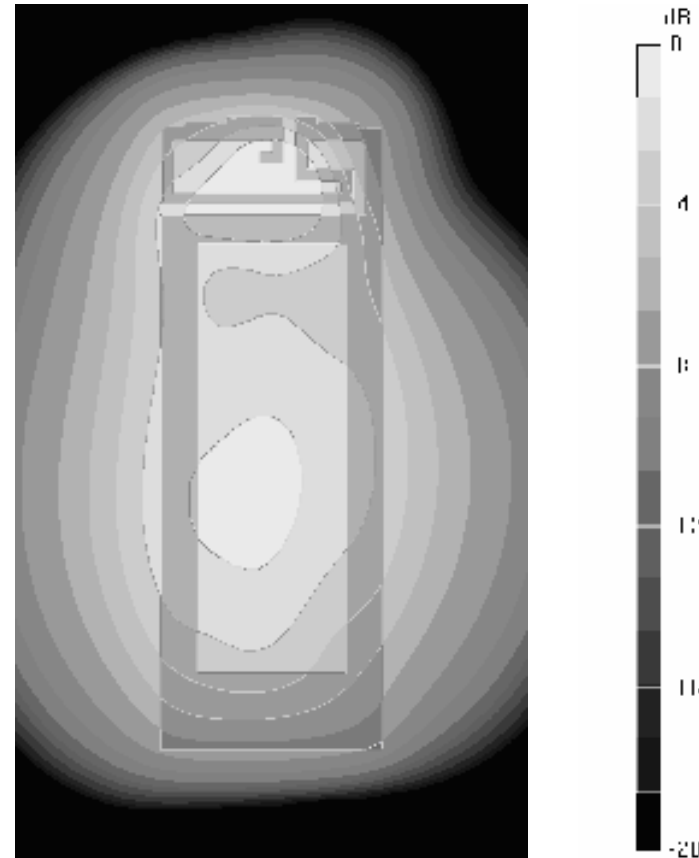


900 MHz Flat Phantom SAR Results

Measurement



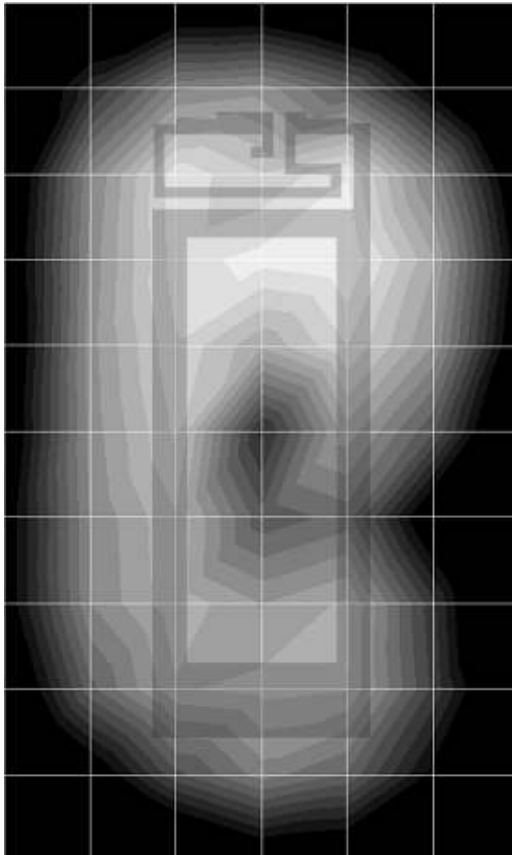
Simulation



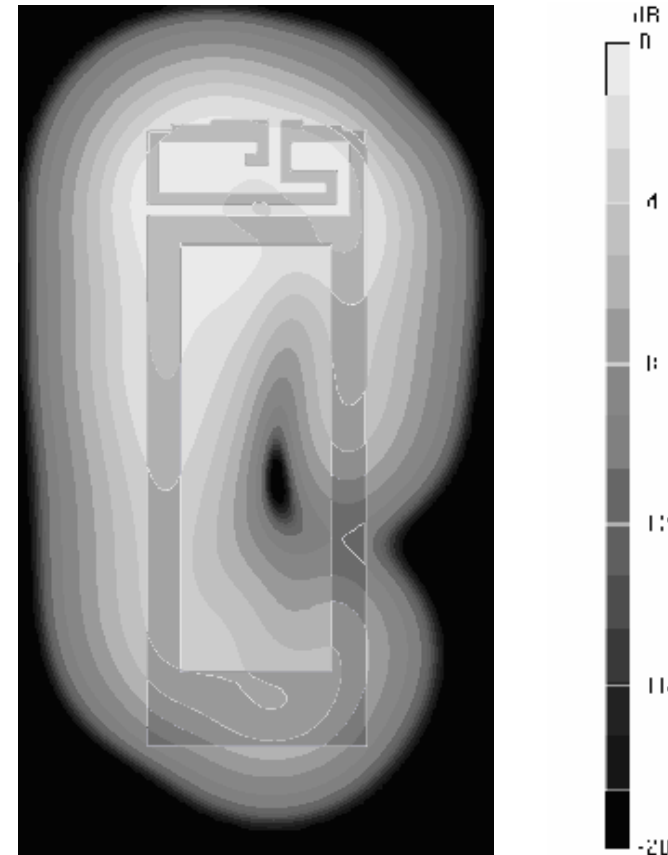
- No experimental artefacts due to antenna feeding cable
- Widespread SAR distribution due to radiation of PCB

1966 MHz Flat Phantom SAR Results

Measurement

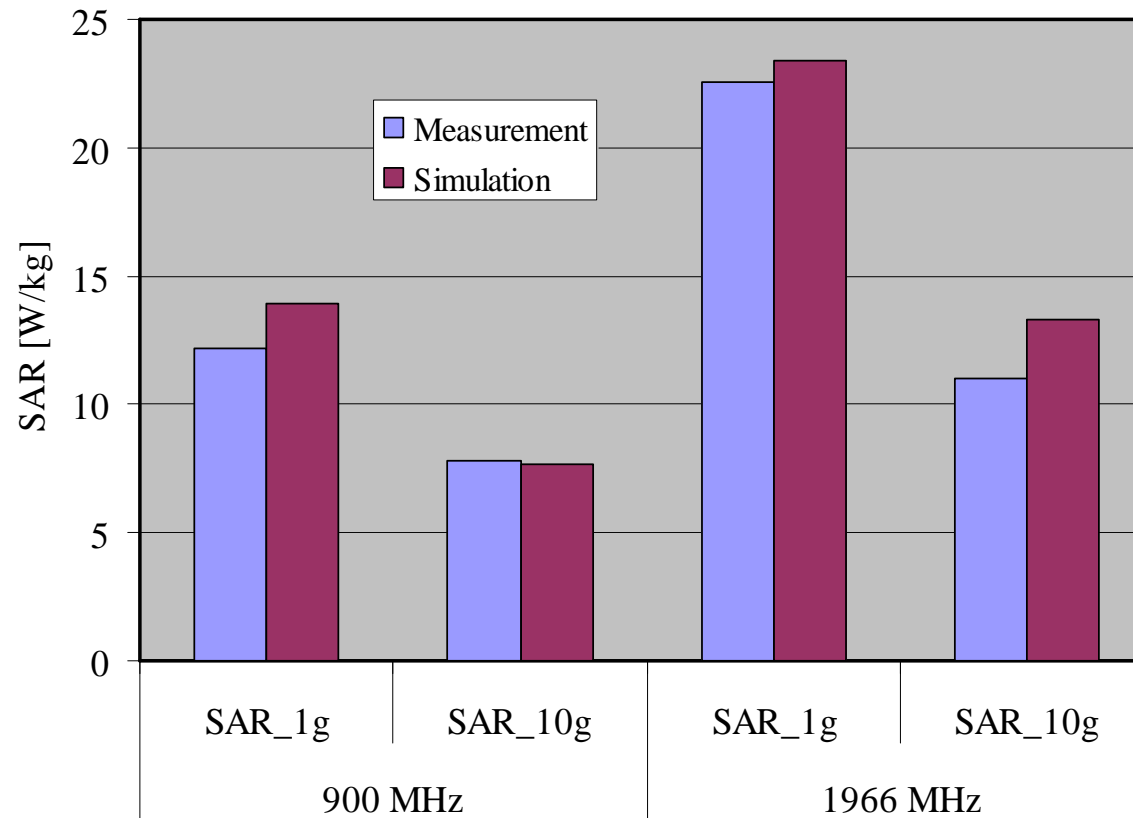


Simulation



- SAR maximum near the radiating element itself

Flat Phantom Localized SAR Values



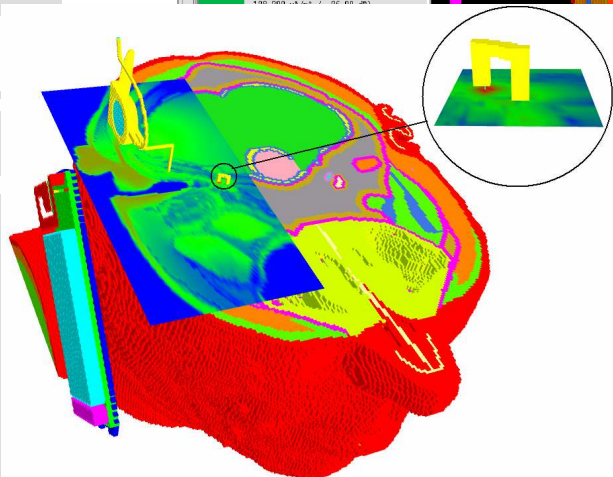
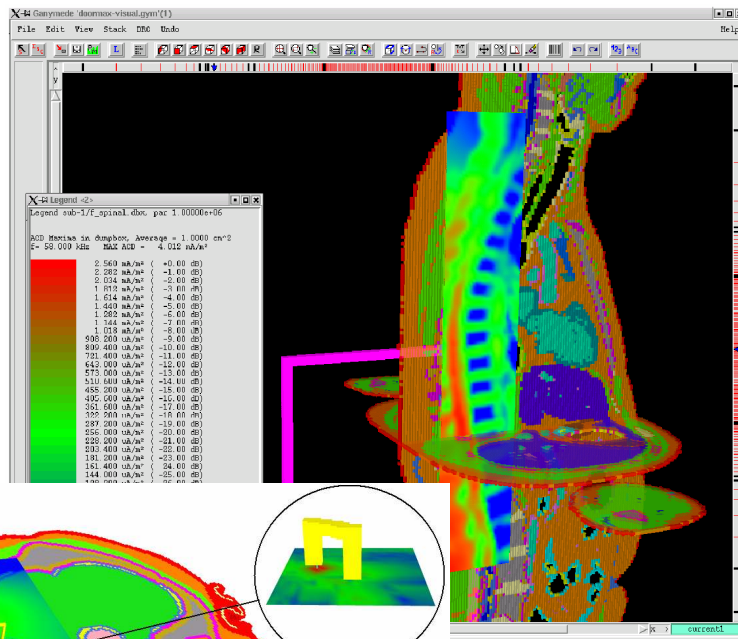
- Simulated SAR > measured one (lossless antenna)

11 • 1 W antenna input power

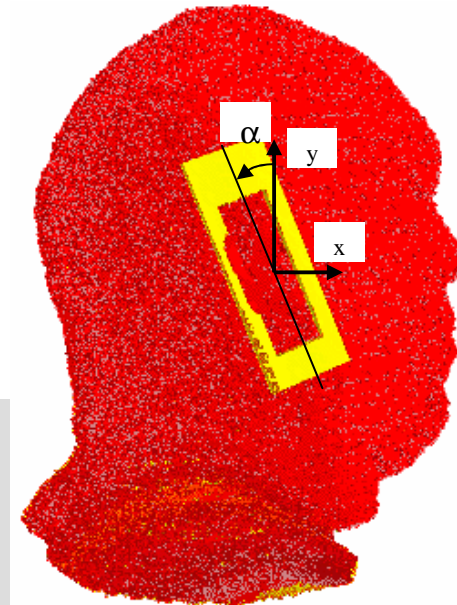


Simulation Method with inhomogeneous Model

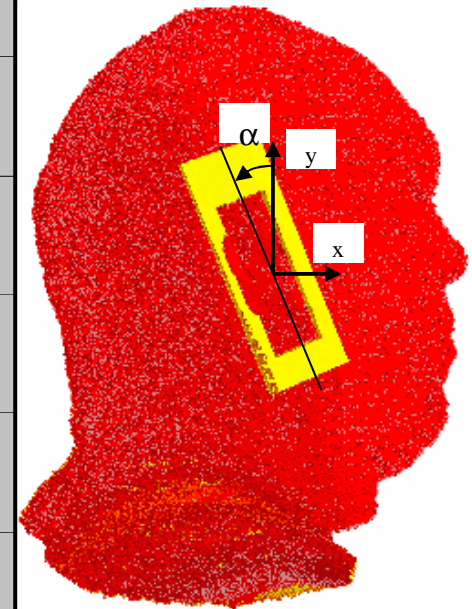
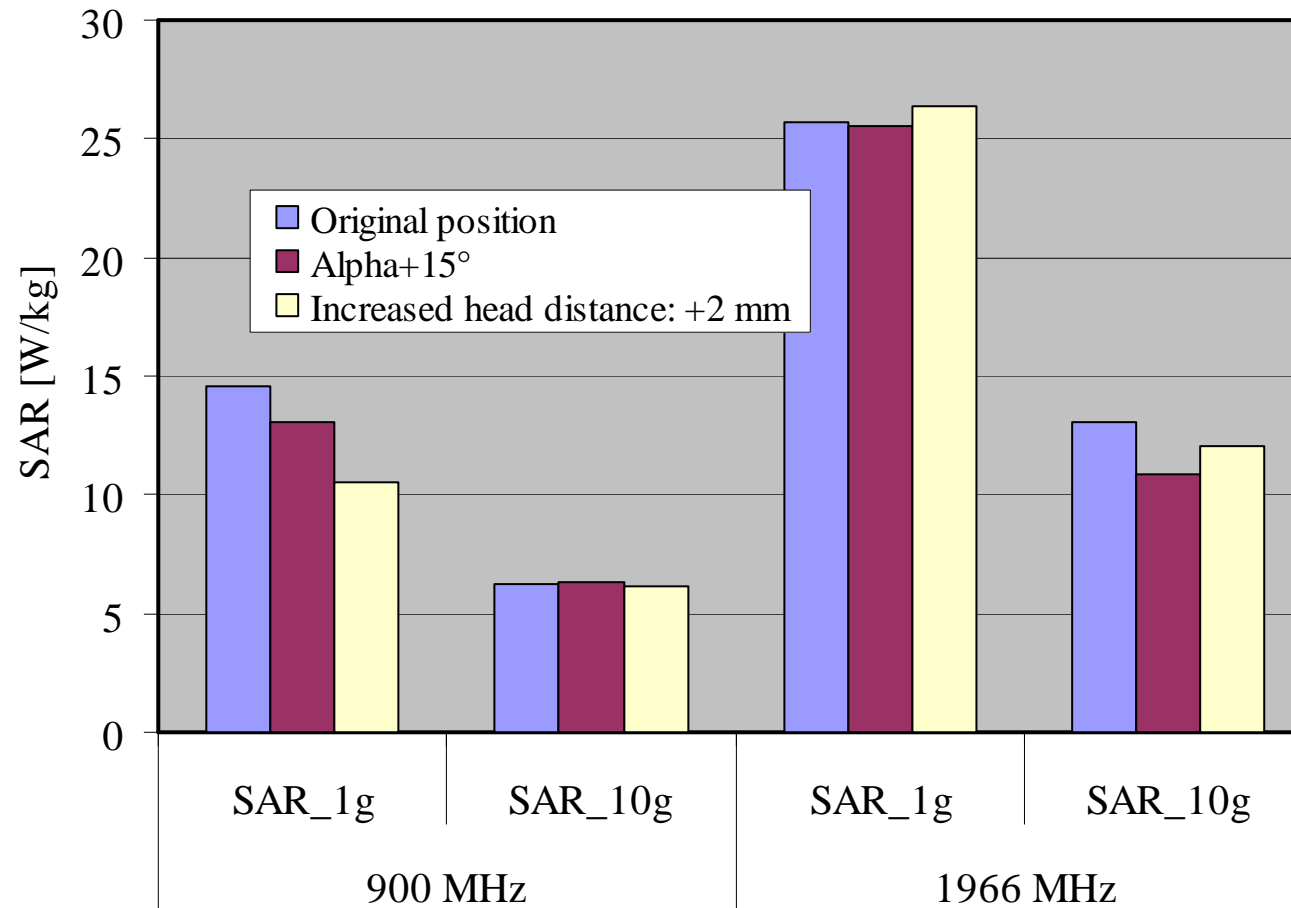
- Empire™ software
- Based on FDTD



- Heterogeneous Visible human head model (AFRL)
- Antenna is directly placed at the head model
- FDTD grid terminated by absorbing boundaries (PML)

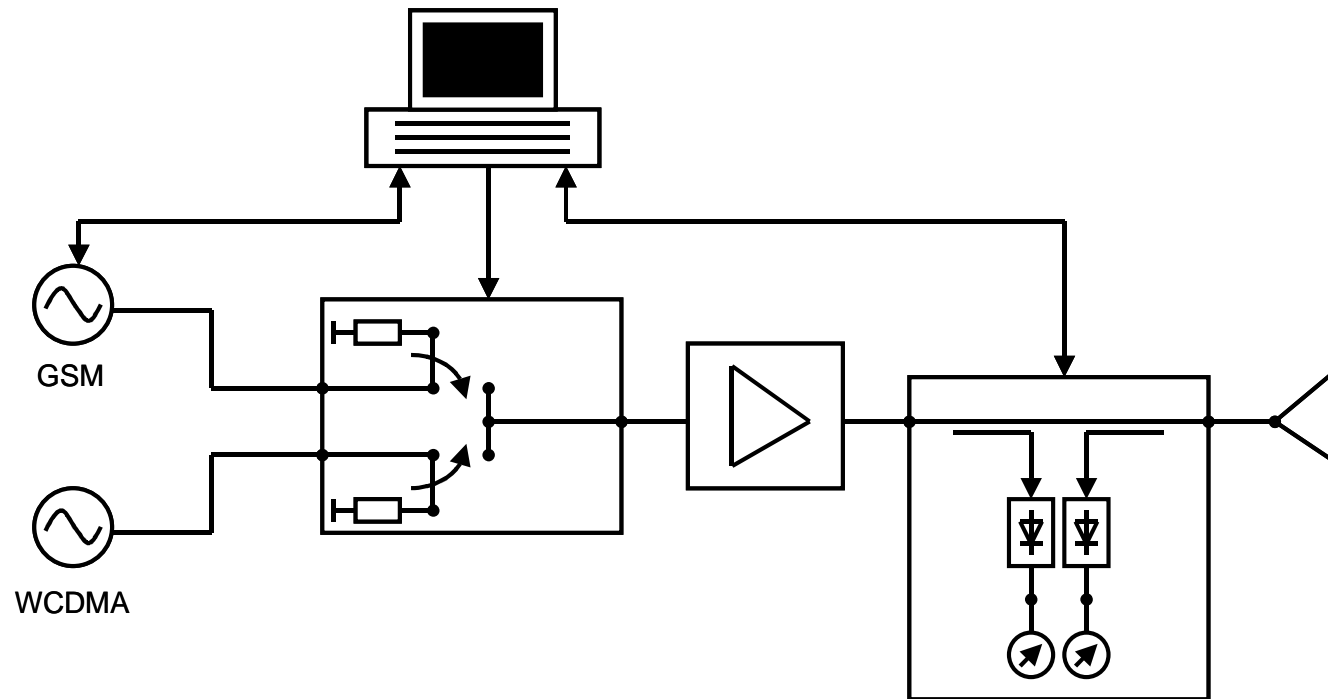


Visible Human Localized SAR Values



- 1 W antenna input power
- 28 % max. positioning dependency

Block Diagram of Complete Exposure Setup



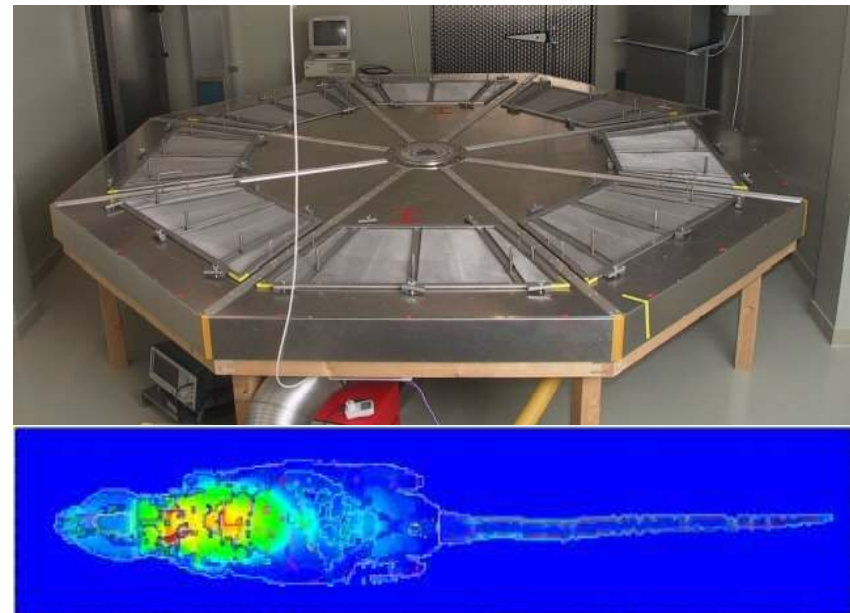
- **Computer controlled double blind protocol**
- **GSM, WCDMA and sham exposure (isolation >80 dB)**
- **Permanent monitoring of power levels**
- **Alarm generation and auto-switch-off in case of malfunctions**

Objectives for Study on Laboratory Animals

- **DMF Study: “Possible influence of RF electromagnetic fields of mobile communication systems on the induction and course of phantom auditory experience (Tinnitus)”**
- **Investigation of influences on the hearing system by using a behavioral animal model (rats) on Tinnitus**
- **Technical objectives:**
A localized, well defined SAR distribution inside the head/neck of the animal at 900 MHz
- **For the behavioral experiments the rats needed to be unrestrained by the exposure system**

State of the Art for “In Vivo” Animal Studies

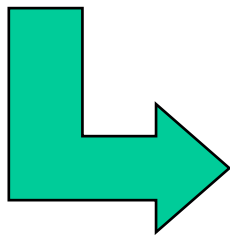
- **Local exposure setup for a rat at 900 MHz – developed during the French “COMOBIO” research project [Leveque, 2004]**
- **Non-local exposition of 24 rats inside a radial waveguide [Bitz, 2003]**



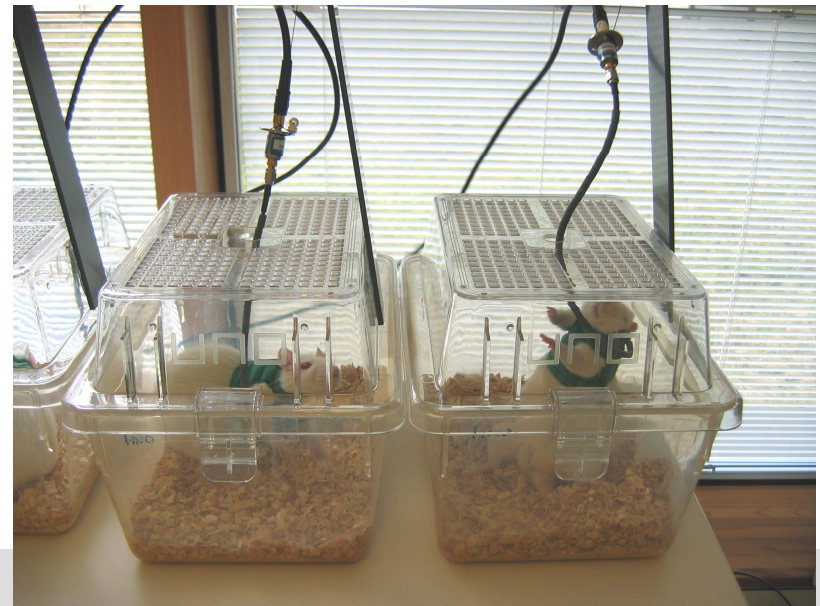
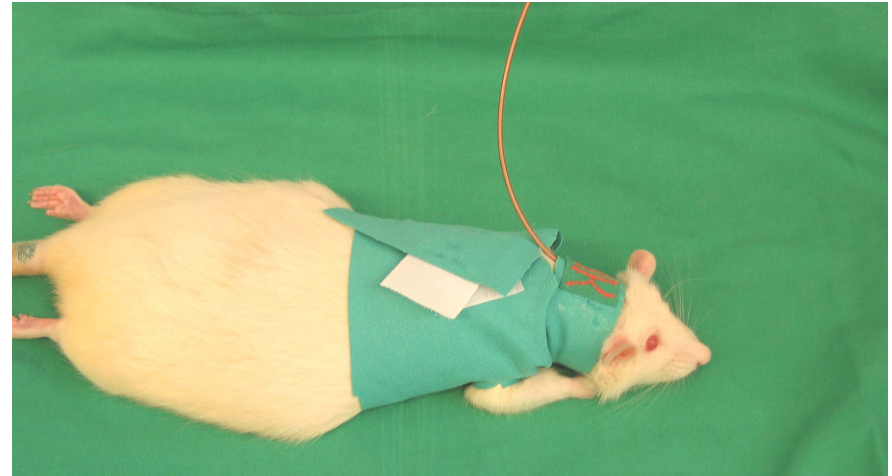
Our Body Mounted Antenna Solution

Specifications:

- Local exposition of the rat's head or neck
- GSM 900
- Rats need to be unrestrained

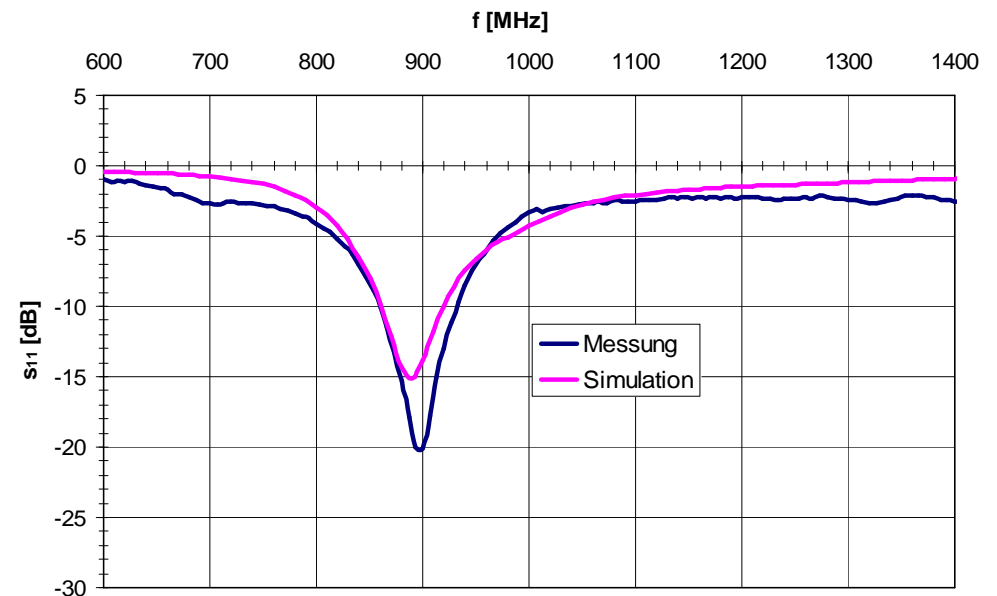
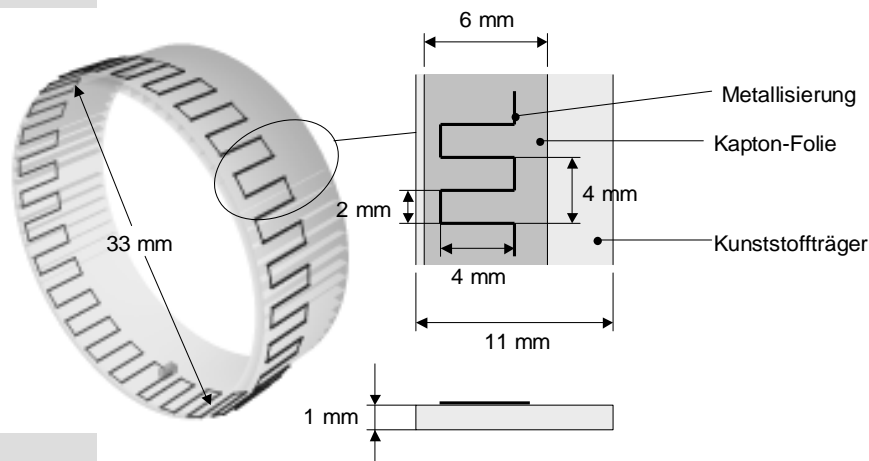


**Loop-Antenna
around the neck
of the animal with a
flexible feeding cable
+ rotary joints**



Loop Antenna Details

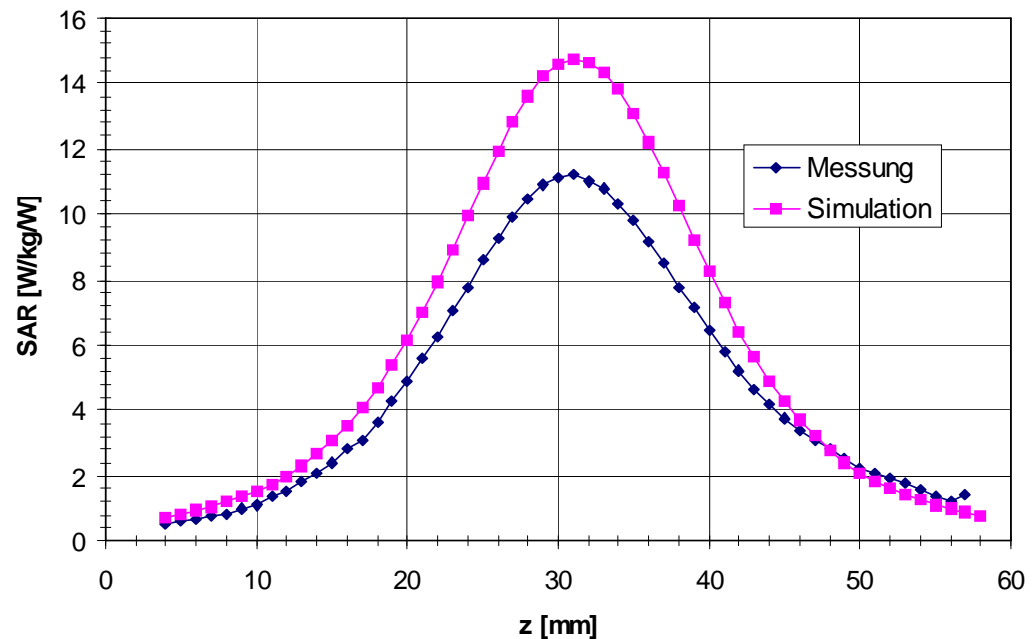
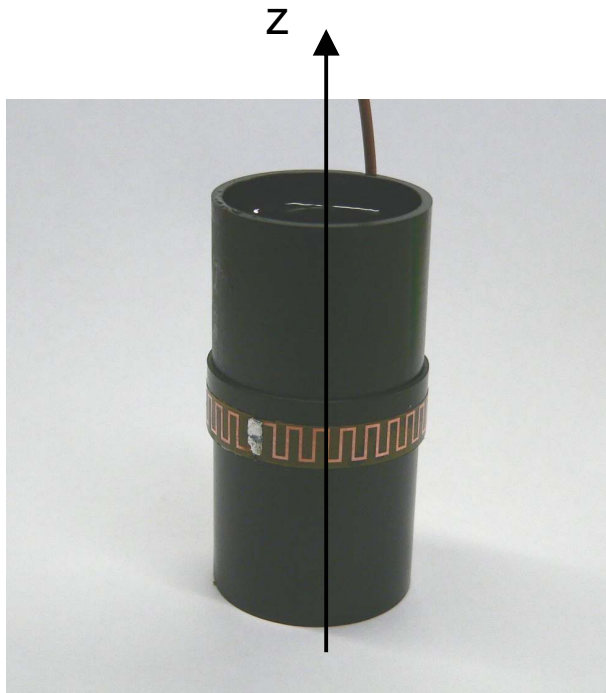
- Metalized Kapton foil
- Meandered line to achieve self resonance at 900 MHz



- Reflection coefficient (with animal inside antenna)

Verification of FDTD Simulation Model

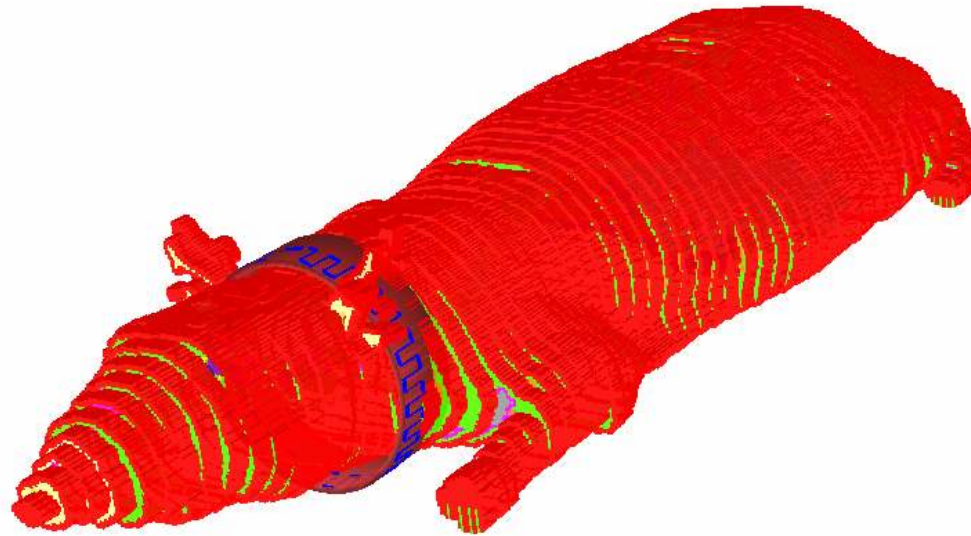
- Comparison of SAR values obtained for measurement and for FDTD simulation by using an homogeneous cylindrical phantom



- FDTD simulation without losses outside phantom
- Acceptable SAR agreement

Inhomogeneous FDTD Model

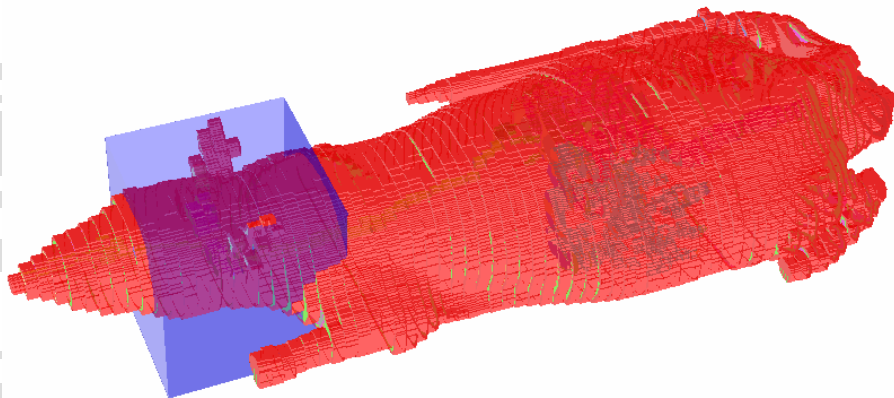
- Inhomogeneous rat model (AFRL)
- Loop antenna is placed around the rat's neck
- FDTD computational domain is truncated by absorbing boundary conditions



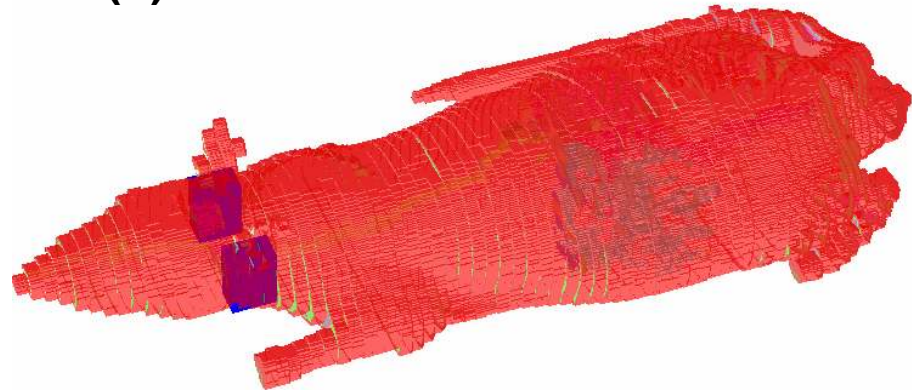
SAR-Results

- Volume used for SAR averaging:

(a) box incl. **head/neck**



(b) volume around **ears**

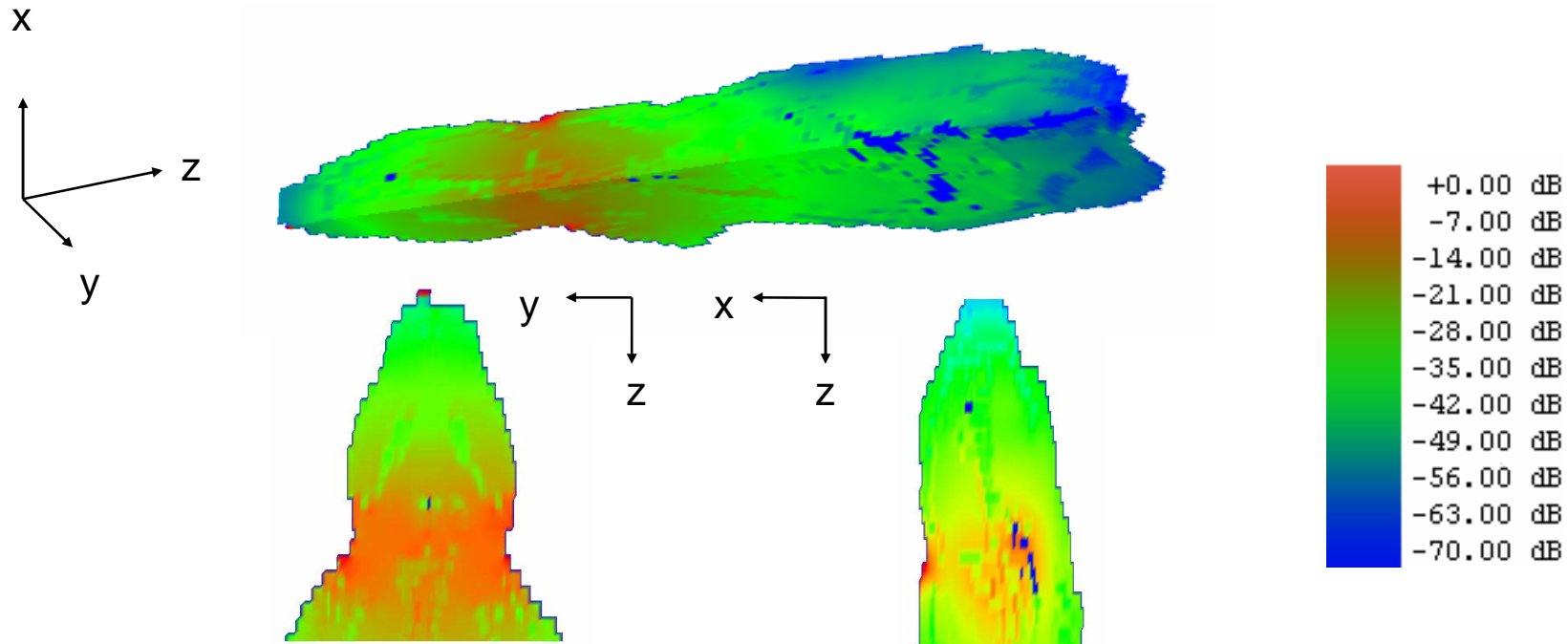


- Averaged SAR values

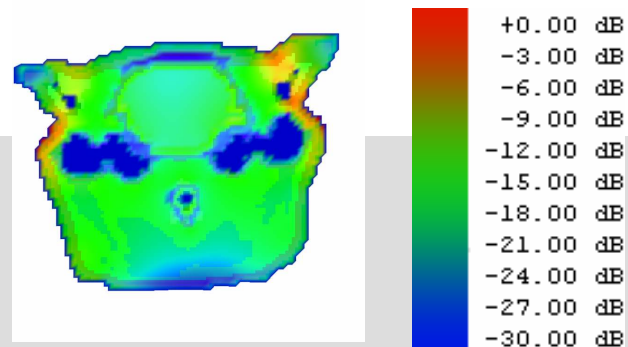
Auswertegebiet	Mittlere SAR [W/kg]	Lokal/Ganzkörper
Kopfbereich (a)	16,18	7,0
Ohrbereich (b)	50,12	21,8
Ganzkörper	2,30	1

Local SAR Distribution

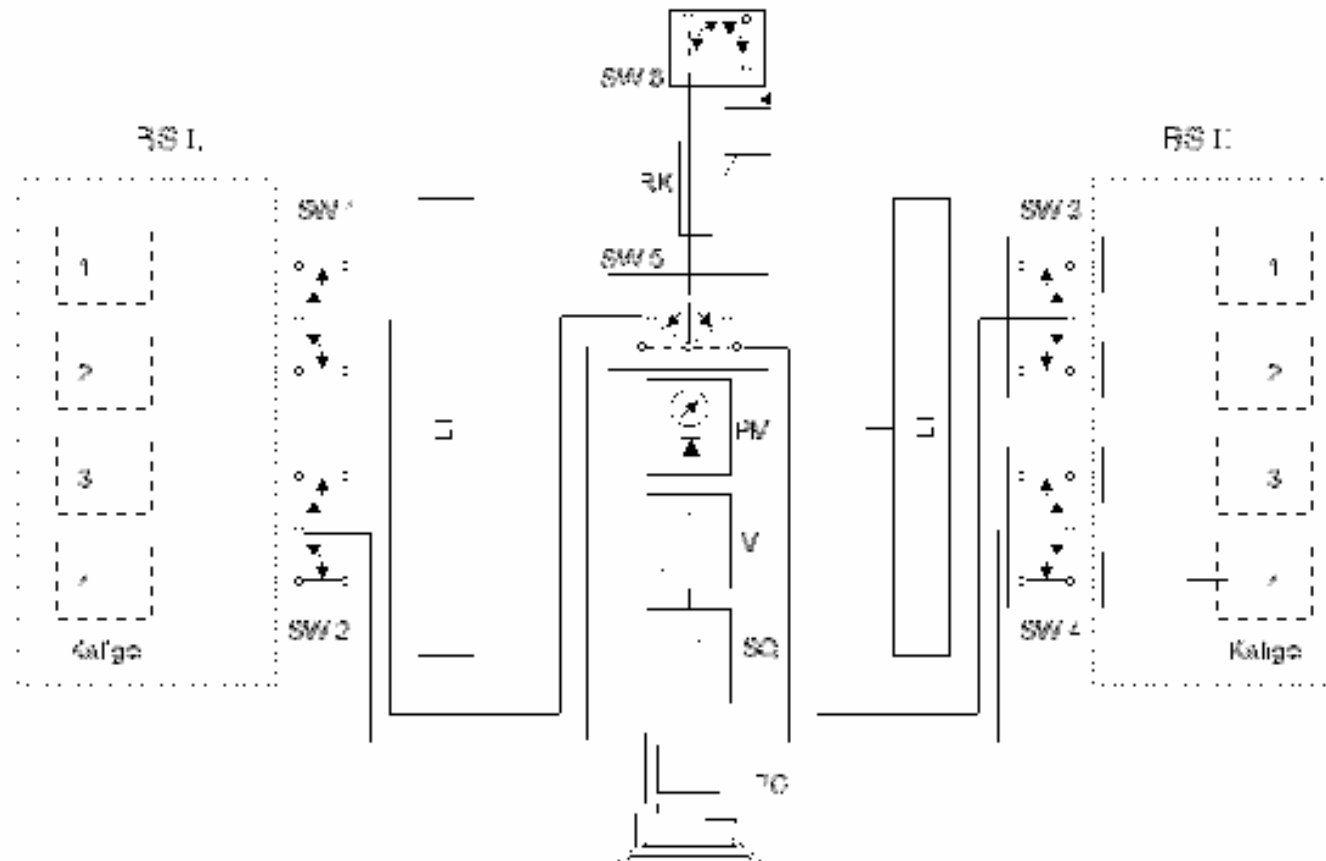
- Longitudinal cut



- Cross section trough ears



Block Diagram of the Exposure Setup



- Simultaneous double-blind expose of two cage systems at GSM 900
- SAR intensities range from 0 W/kg (sham exposure) up to 20 W/kg
- Rats can move in their cages due to rotary joints in the feeding waveguide

Conclusion

- **Development and characterization of body-mounted antennas for volunteer and animal in vivo studies**
- **Volunteers and animals were unrestrained by the exposure system**
- **Computer-controlled double-blind exposure**
- **Permanent power control and “switch off” in error case**
- **High wearing comfort due to low weight and ultra thin antenna used for exposure**
- **Very localized (concentrated) exposure and therefore high SAR efficiency**