Studies of the effects of exposure to electromagnetic fields emitted from mobile phones on volunteers

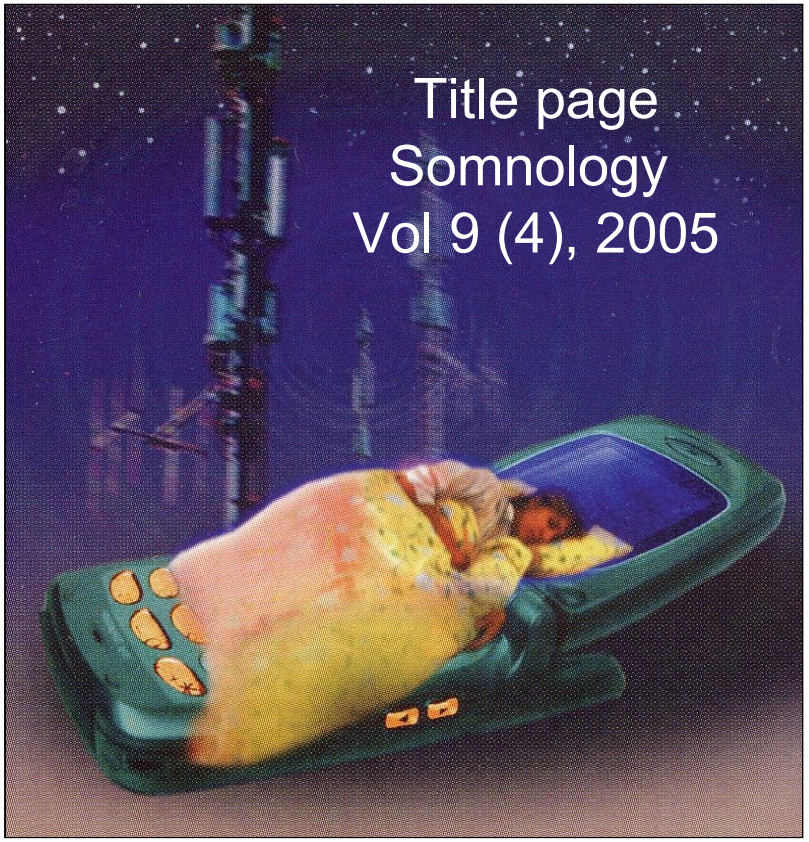
Investigation of sleep quality in subjects living near a mobile base station – Experimental study on the evaluation of possible psycho-logical and physiological effects under residential conditions

Heidi Danker-Hopfe and **Hans Dorn**

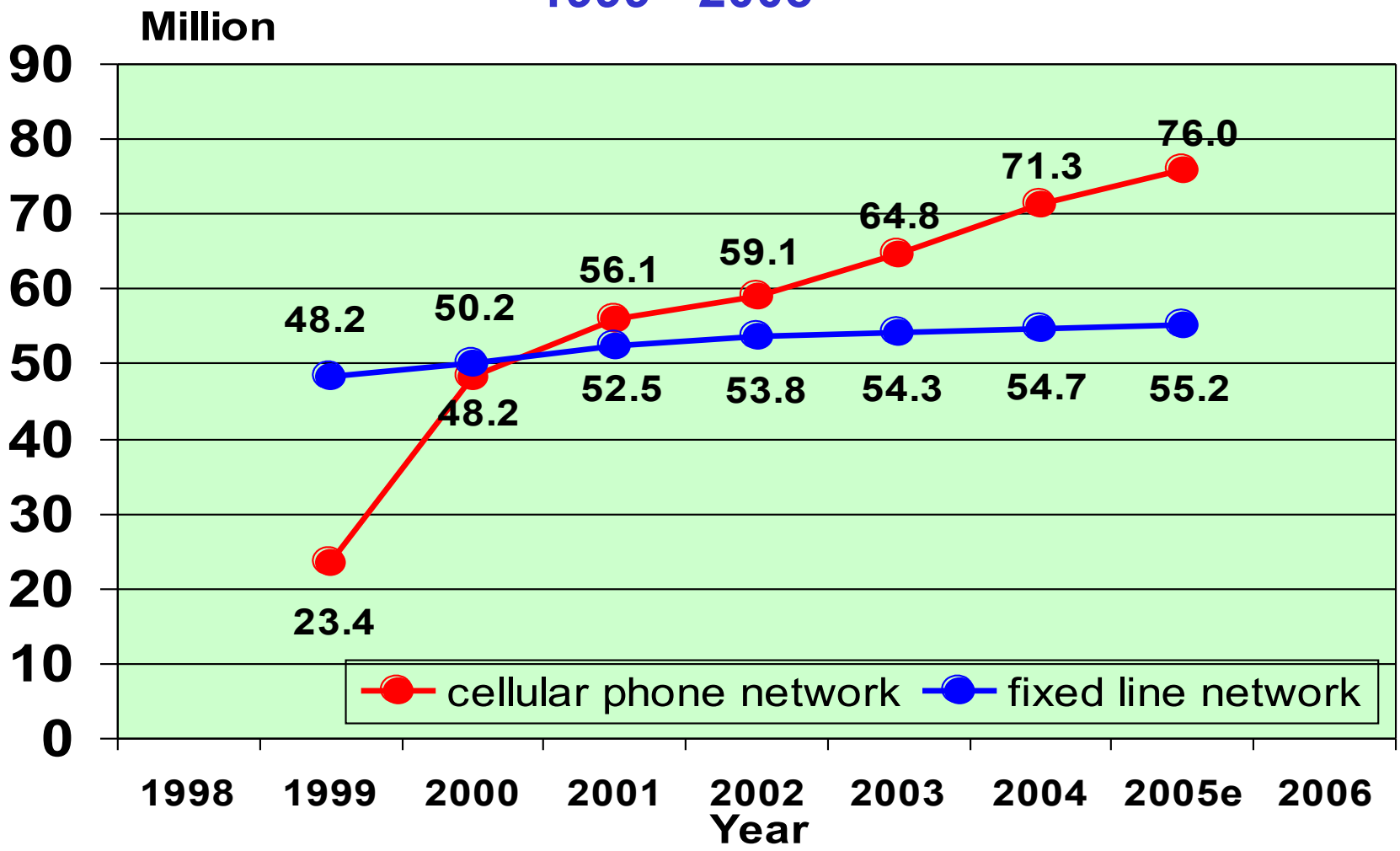
German Mobile Telecommunication Research Programme
Munich, 12./13. December 2006

Overview

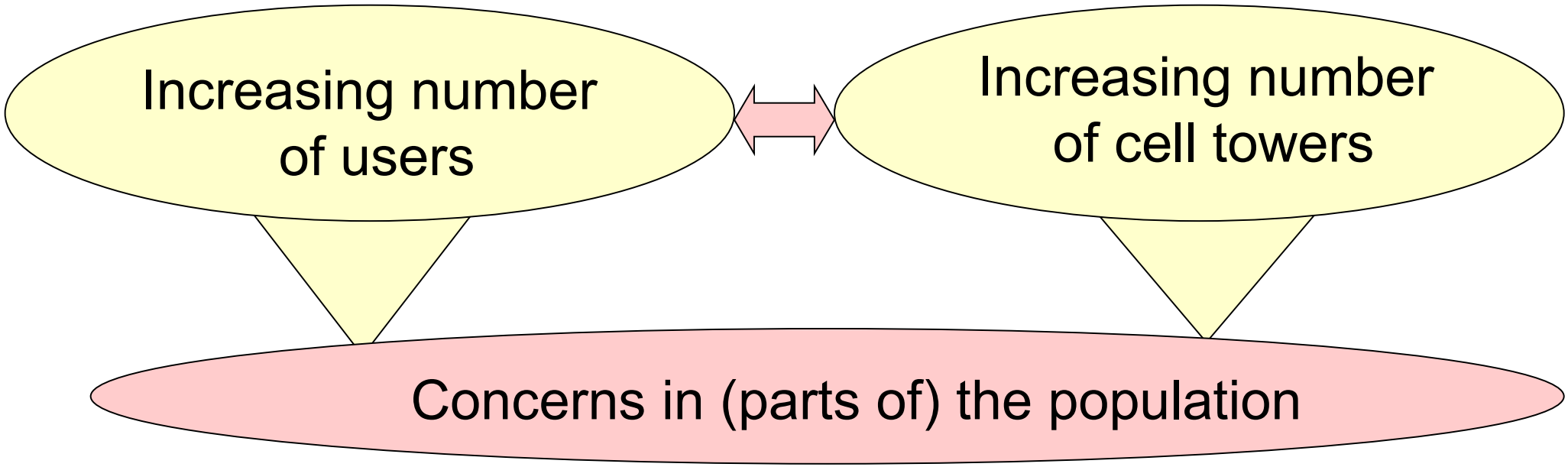
- Sleep – basics
- **Motivation to study sleep in the context of electro-magnetic fields**
- *Laboratory study:* mobile phones and sleep
- *Field study:* base stations and sleep



Development of users of the cellular phone network in Germany: 1999 - 2005



Report of the German Federal Network Agency 2005

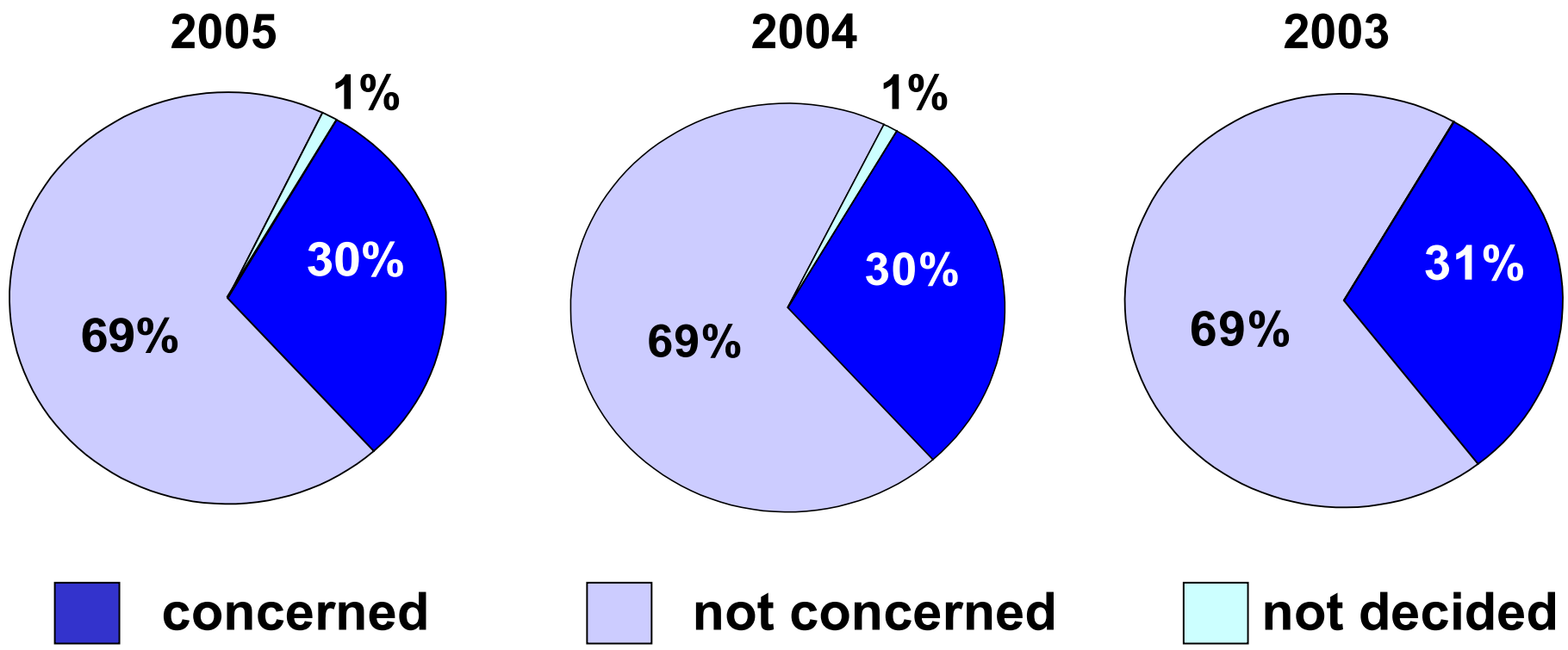


in Germany doctumented by annually telephone surveys
2500 subjects age > 13 years

infas – Institute for Applied Social Sciences

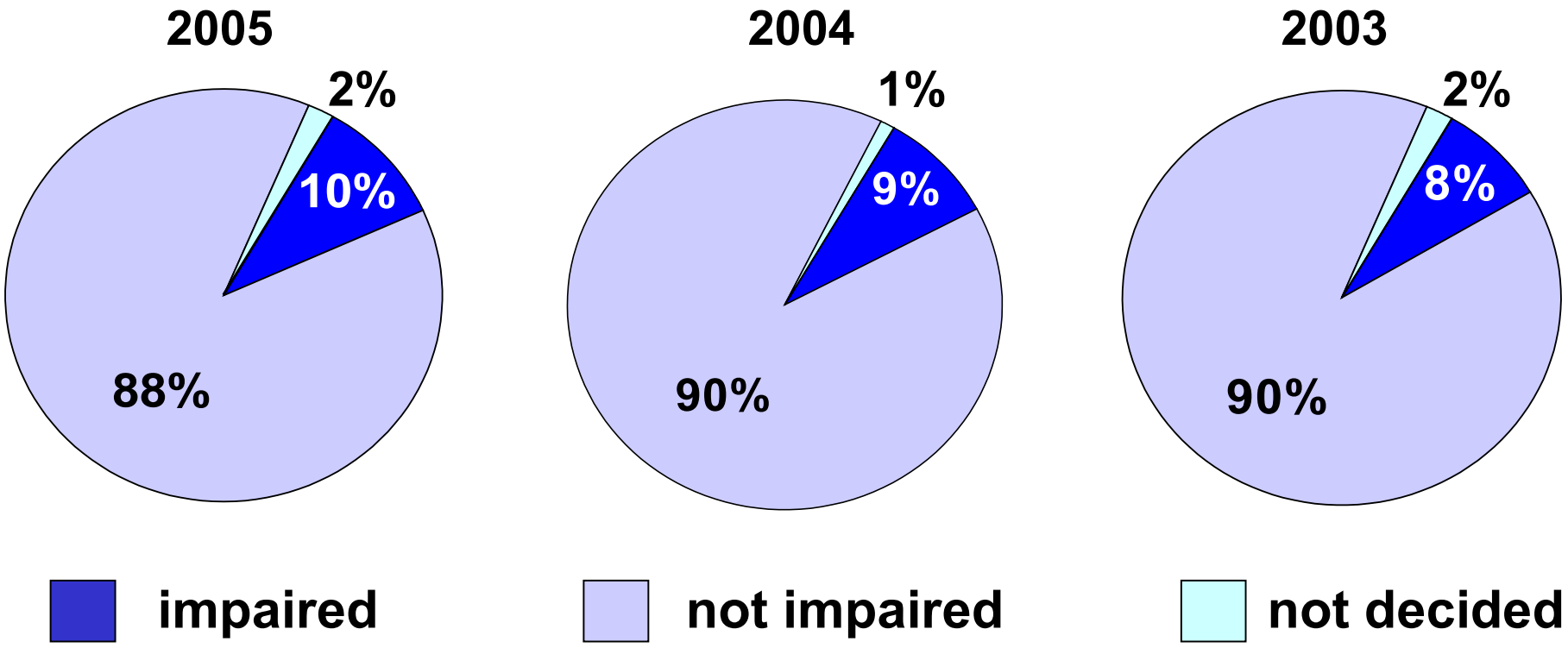
funded by the German Federal Office of Radiation Protection (BfS)

Health related concerns due to cell phones, cell phone towers, or wireless phones



Results of surveys 2003 - 2005

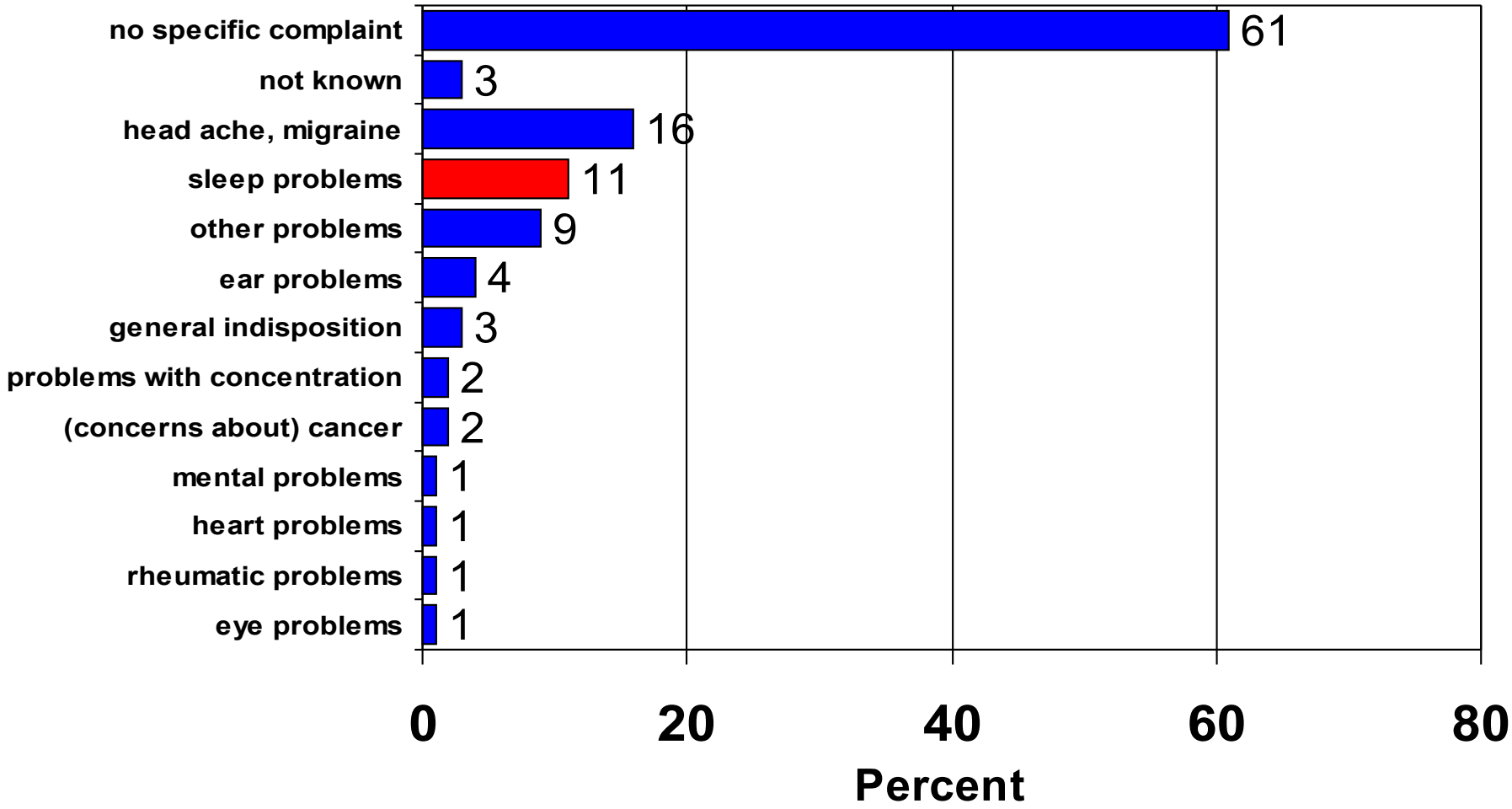
Adverse health effects attributed to cell phones, cell phone towers, and/or wireless phones



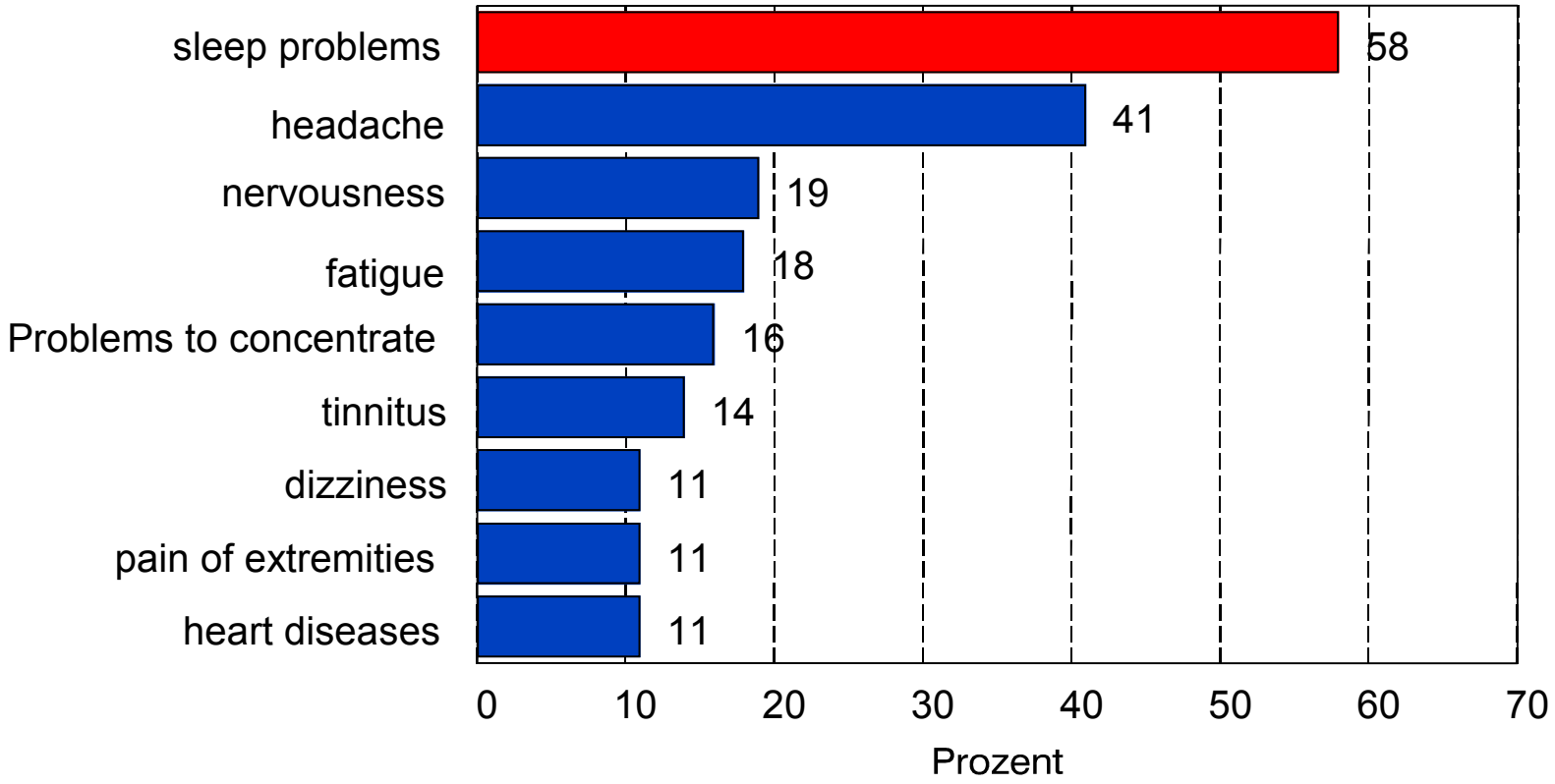
Results of surveys 2003 - 2005

Adverse health effects: Basis: Subjects who felt impaired and subjects who had more or less strong concerns

(n = 1,063, 42% of the sample)



Results of a study in 394 subjects, who feel that an impairment of their health is due to EMF exposition



Röösli et al. 2004: Symptoms of ill health ascribed to electromagnetic field exposure – a questionnaire survey. – Int J Hyg Environ Health, 207: 141 - 150

Sleep as primary endpoint in EMF research

Cell phones

Risks due to self-determined individual use

High exposition during calls

Cell towers

Evaluation of risks with regard to residents

Continuous, much lower exposition

Sleep as primary endpoint: study designs

Effects on sleep

Epidemiological approaches

- natural setting
- long term effects

Experimental approaches

- laboratory setting
- short term effects

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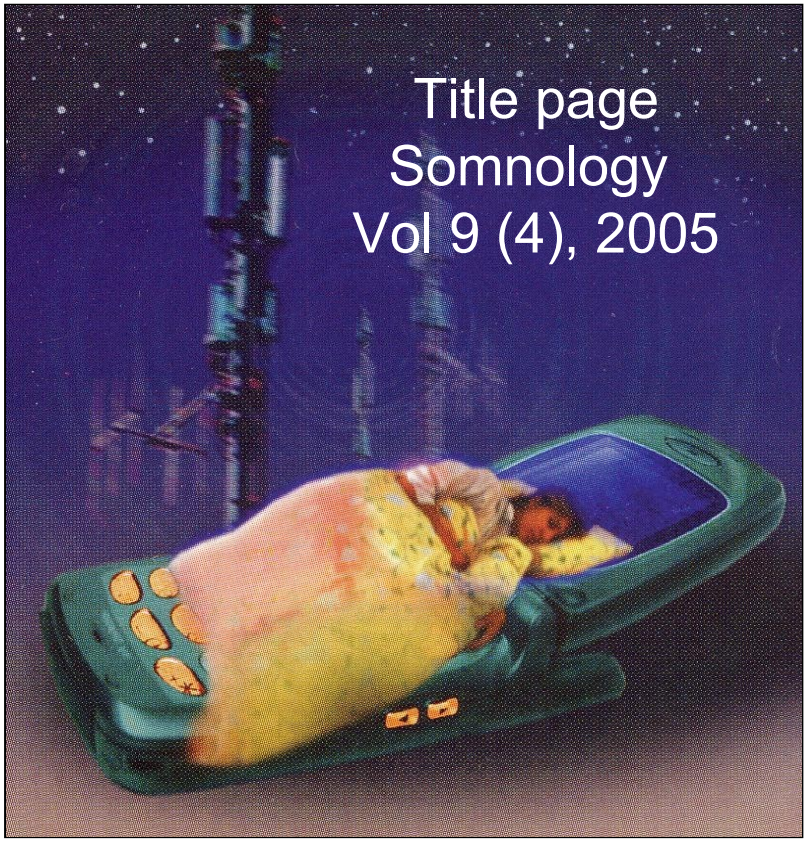
- ***Laboratory study:*** **mobile phones and sleep**
- *Field study:* base stations and sleep



Laboratory study: mobile phones and sleep

- Background
- Sample: inclusion/ exclusion criteria
- Exposure
- Study protocol
- Methods
- Results
- Discussion

BfS Federal Office of Radiation Protection

Charité – CBF

project funded within the *German Mobile Telecommunication Research Programme (DMF)*

Title: ***Studies of the effects of exposure to electro-magnetic fields from cell phones on volunteers***

Duration: **October 1st, 2003 – March 31st, 2007**

Background

Dept. of Psychiatry University of Mainz
Mann / Röschke / Wagner et al.

1996	1998	2000
Subjects		
12 men 21-34 y	24 men 18-37 y	20 men 19-33 y
Design		
single-blind, cross-over, exposition (8h) randomly assigned		
1 adaptation night and 2 PSG-study nights		2 sessions with 1 adapt. night and 2 study nights each
power flux density at the subjects' head		
0.5 W/m^2	0.2 W/m^2	50 W/m^2
cell phone	circular polarized antenna	

Background

No replication of the significant results in later studies

Dept. of Psychiatry
University of Mainz
Mann / Röschke / Wagner et al.

1996	1998	2000
Results		
Sleep latency ↓ (p<0.01)	Sleep latency ↓ (p=0.404)	Sleep latency ↓ (p=0.46)
REM-sleep ↓ (p<0.05)	REM-sleep ↓ (p=0.081)	REM-sleep — (p=0.71)
REM-sleep latency ↑ ns	REM-sleep latency ↑ (p=0.072	REM-sleep latency ↓ (p=0.69)
mean EEG-amplitude REM-sleep ↑ (p<0.05)	no effect on quantitative EEG-parameters	no effect on quantitative EEG-parameters

Background

Institute of Pharmacology and Toxicology,
University of Zürich
Achermann / Borbély / Huber et al.

1999, 2003	2000, 2003	2002
Subjects		
24 men 20-25 y	16 men 20-25 y	16 men 20-25 y
Design		
double-blind, cross-over, randomized assignment of exposition		
1 screening night, 2 PSG-nights with sep. adapt. Night	sleep restriction 4 h 3 h sleep at daytime	3 PSG-nights with separate adaptation nights
Exposition		
whole night; alternating 15 min on/off	duration 30 min, end: 10 min prior to bed time	

Background

Consistent results showing an effect on the power of the NREM-EEG in the spindle frequency range

Institute of Pharmacology and Toxicology, University of Zürich
Achermann / Borbély / Huber et al.

1999,2003	2000,2003	2002
Results		
Wake after sleep onset (p<0.01) ↓	quantitative sleep parameters no effect	quantitative sleep parameters no significant effect, tendencies cw-EMF: SOL ↑ pm-EMF: SWS ↑ cw- & pm-EMF: REM ↓ cw- & pm-EMF: WASO ↑
NREM: EEG-amplitude ↑ spindle frequency range	NREM: EEG-amplitude 9.75 - 11.25 Hz ↑ 12.75 - 13.25 Hz ↑	NREM2: EEG-amplitude 12.25 - 13.5 Hz ↑ increase only for pm not for-Ex.

Background

Dept. of Neurology University of Magdeburg *Hinrichs et al. 2005*	Brain Science Institute Swinburne University *Loughran et al. 2005*
Subjects	
13 subjects, mainly women, 20-28 y	55 subjects (25 females) 18-60 y
Design	
double-blind, cross-over randomized	double-blind, cross-over randomized
5 consecutive nights, 1 adaptations night two paired nights with exposition	two paired nights, 1 adaptation and one with exposition
Exposition	
approx. base station signal (1736 MHz)	mobile phone (894,6 MHz), 30 min prior to max SAR 0.11 W/kg (10g)
SAR	
max. SAR: 0.072 W/kg (10g)	lights off, max SAR 0.11 W/kg (10g)

Background

Dept. of Neurology University of Magdeburg *Hinrichs et al. 2005*	Brain Science Institute Swinburne University *Loughran et al. 2005*
Results	
no significant effects for visually scored sleep stages no effect on EEG amplitude	significant reduction of REM sleep latency ↓ significant increase in EEG-amplitude for 11.5 to 12.25 Hz ↑

Laboratory study: mobile phones and sleep

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Study sample: **30 healthy young men, age range 18 - 30 years**

Inclusion criteria

- able to understand the *subject information sheet* and to sign an *informed consent form*
- right handedness
- alpha-EEG during relaxed wakefulness
- physically and psychologically healthy
- no use of a medication which has an effect on sleep
- no history of sleep disturbances
- normal sleep-wake schedule
- no history of drug or alcohol abuse
- non-smoker

Exclusion criteria

- Impairment of concentration, attention, memory, speech, hearing and/or motor function
- History of head trauma
- History or presence of seizures or risk factors for seizure
- Zung Depression Scale: score > 40
- Zung Anxiety Scale: score > 35
- Adaptation night: AHI > 5 and/or PLMAI > 20, sleep onset latency > 30 min, wake after sleep onset > 45 min

Exclusion criteria - *continued*

- Epworth Sleepines Scale score > 10
- extreme morning type or evening type (score < 32 or score > 69)
- more than 5 caffeine beverages per day
- more than 2 glas of wine and/or 3 glas of beer per day
- collodium allergy
- electronic or conductive implants

Subject selection procedure *- continued*

Contact by phone:
293

Study completed
31

Subjects who completed the study received 1800 €

Laboratory study: mobile phones and sleep

- Background
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Exposure

Signal:
Simulated GSM (900 MHz, 217 Hz) and UMTS uplink signals and sham (placebo).

Design: 8h exposition during TIB, simulation of a cell phone use at maximum RF output power. Transmitted power is adjusted in order to approach but not to exceed the SAR limits of the law (SAR_{10g} = 2.0 W/kg).

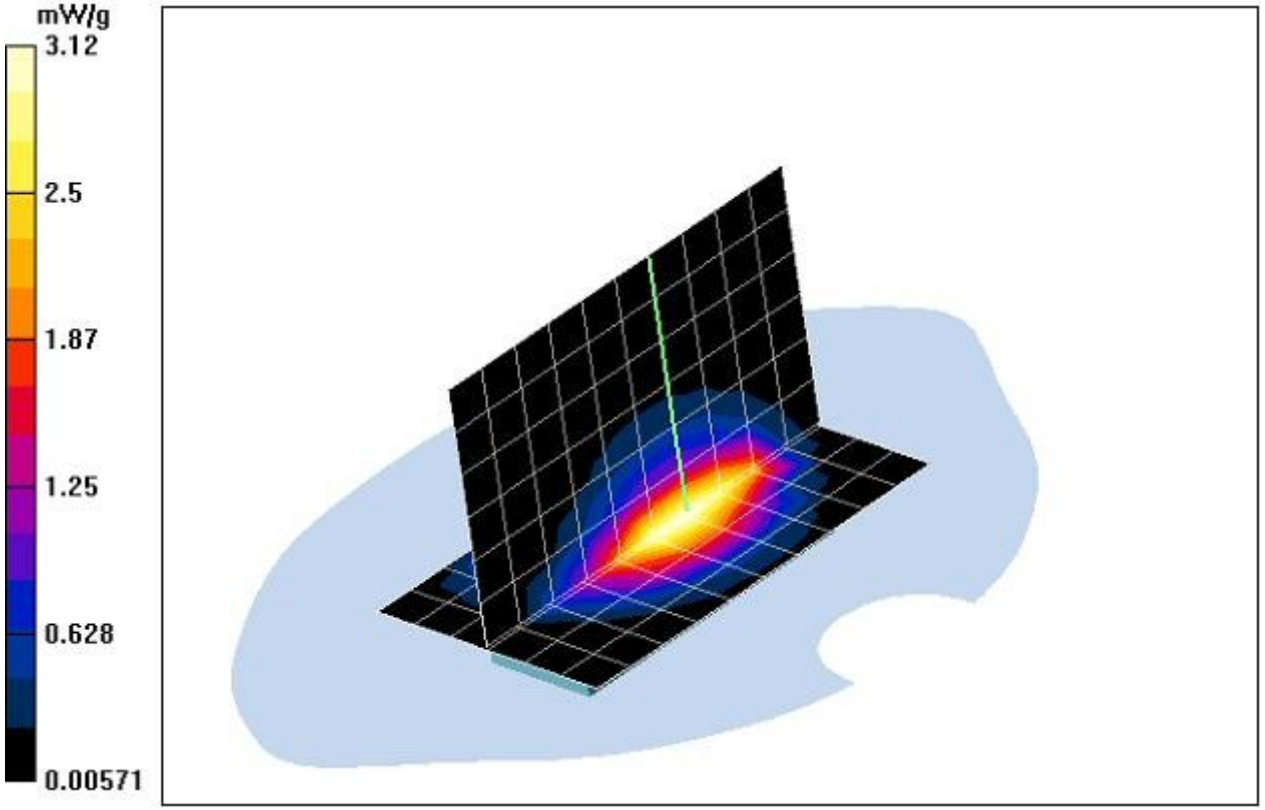
Exposure

Realisation

A head worn antenna especially designed for the present study approximates the spatial field distribution of a common dual band cell phone.

The development, production and surveillance of the exposition system was realised by **IMST GmbH, Kamp Lintfort.**

For more details see
www.emf-forschungsprogramm.de/forschung/biologie/biologie_verg/bio_080.html



Source:

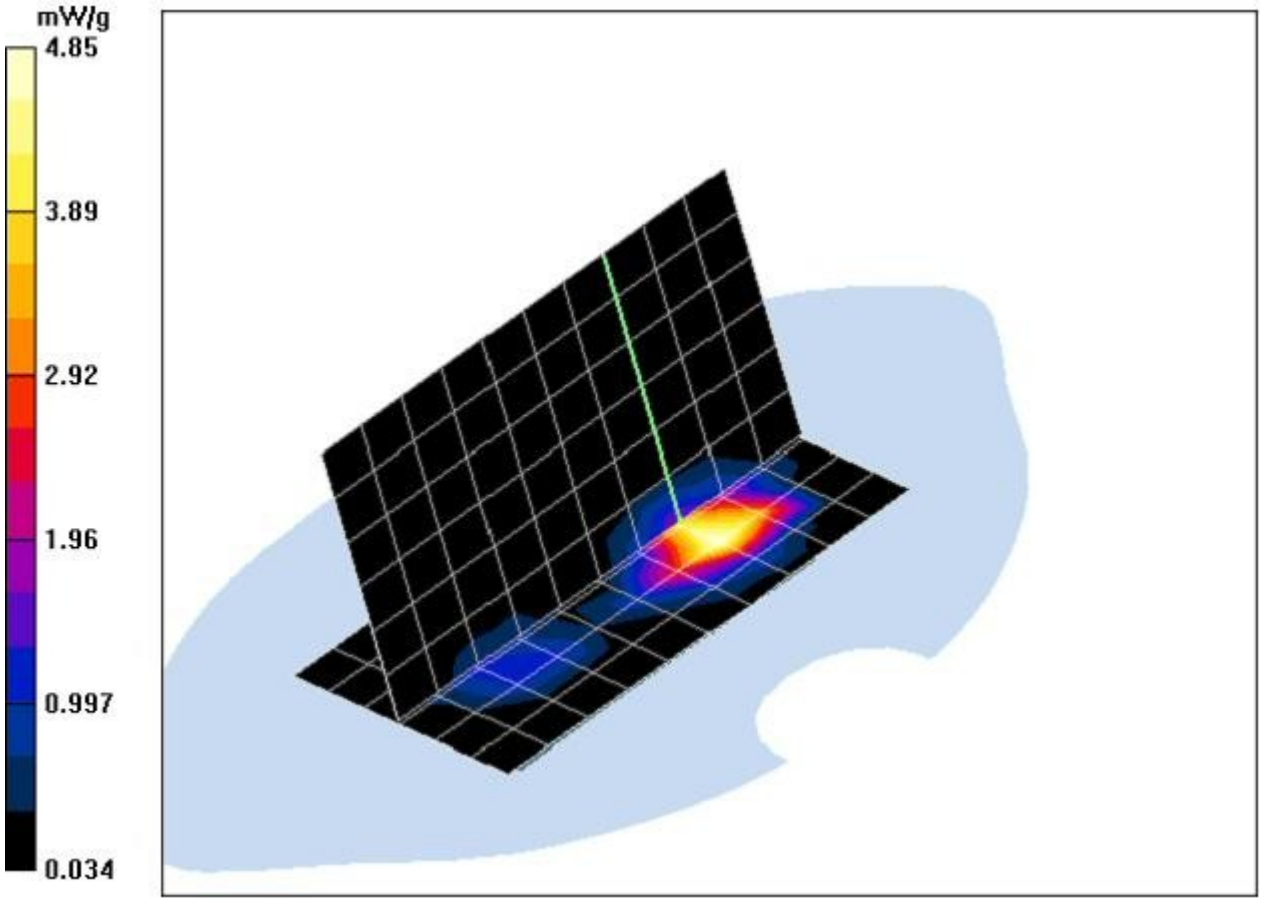
Zwischenbericht zum Projekt StSch4376
,,Aufbau einer Expositionsein-richtung"

IMST GmbH Carl-Friedrich-Gauß-Str. 2 D-47475 Kamp-Lintfort Dr.-Ing. Achim Bahr Dipl.-Ing. Thomas Bolz

2. April 2004

Local SAR distribution at 900 MHz of the cloth covered dual band antenna mounted on a flat surface of the SAM phantom.

SAM: Standard Anthropomorphic Model



Source:

Zwischenbericht zum Projekt StSch4376
,,Aufbau einer Expositionsein-richtung"

IMST GmbH Carl-Friedrich-Gauß-Str. 2 D-47475 Kamp-Lintfort Dr.-Ing. Achim Bahr Dipl.-Ing. Thomas Bolz

2. April 2004

Local SAR distribution at 1966.5 MHz of the cloth covered dual band antenna mounted on a flat surface of the SAM phantom.

SAM: Standard Anthropomorphic Model

Measuring EEG under exposure – problems

- EEG preamplifiers produce artifacts by demodulating RF signal.

- RF field distribution is disturbed by EEG cables:
  There are two effects:
  1) EEG cables lower RF field strengths parallel to the head surface due to their conductive property
  2) EEG electrodes inject additional RF currents into the head surface

Laboratory study: mobile phones and sleep

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	Night	Day
Week 1	Adaptation	
Week 2		Adaptation
Week 3	N1	
Week 4		D1
Week 5	N2	
Week 6		D2
Week 7	N3	
Week 8		D3
Week 9	N4	
Week 10		D4
Week 11	N5	
Week 12		D5
Week 13	N6	
Week 14		D6
Week 15	N7	
Week 16		D7
Week 17	N8	
Week 18		D8
Week 19	N9	
Week 20		D9

Study protocol

Duration: 20 weeks
Interval between visits: 1 week
(72 hours – 3 weeks)

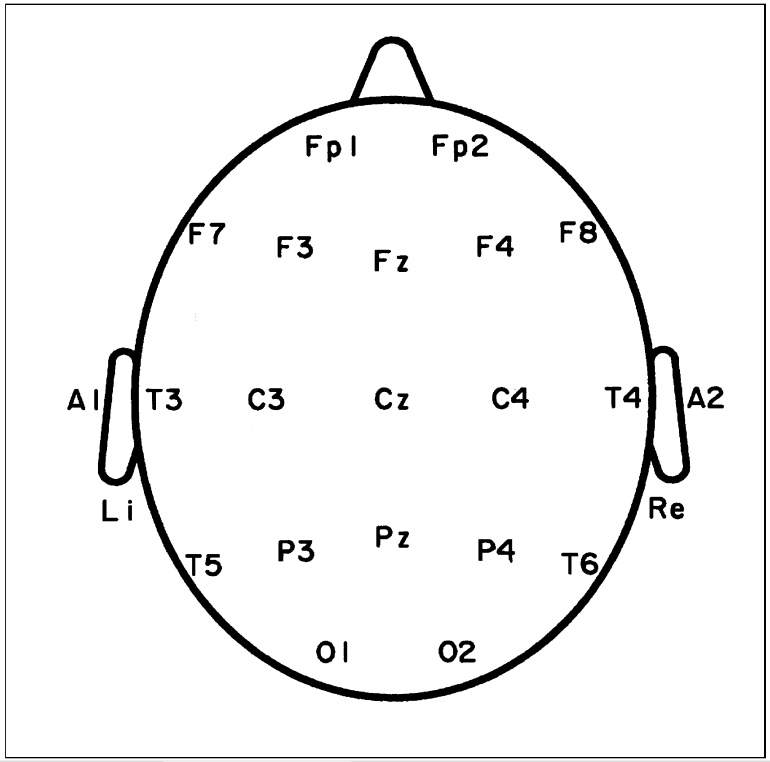
Conditions:
GSM 900, UMTS, and Sham
three visits each, randomly assigned conditions - separately for days and nights

- **double-blind**
- **randomized**
- **placebo-controlled**
- **crossover**

Time in bed: 8 hours

Study design

EEG recording with 19 EEG-electrodes



Tests on possible effects of EMF on brain functioning during wake

Arrival at the clinic: 8:00 h

Testsession 1: **11:00 h**

standardized meal

Testsession 2: **16:00 h**

Pupillography	Alpha-attenuation-test
Acoustic choice reaction time test	Visual monitoring task (VMT)
Contingent negative variation (CNV)	Working memory task
Oddball paradigm	Devided attention
Sustained attention	Vigilance test

Departure from the clinic: 19:00 h

Laboratory study: mobile phones and sleep

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Statistical analysis

Design:	**pairwise test of GSM and UMTS against sham condition**
Structure of the data:	**dependend**
Normal distribution:	**Shapiro-Wilk test** (n<50) and **Kolmogorov-Smirnov test** (n>50) to test the nullhypothesis that the data are a random sample from a normal distribution
Test of the nullhypothesis: sample mean of differences = 0:	**Student's t-test** (if ND-test was not sign.) **Signed Rank test** (if ND-test was significant)

Laboratory study: mobile phones and sleep

- Background
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Results - descriptive

Group level - descriptive
Global measures
Sleep period time (min)
Total sleep time (min)
Sleep efficiency index (%)
Sleep latency (min)
REM-sleep latency (min)
REM sleep (min)
Stage shifts
Sleep architecture *(% SPT)*
NREM1
NREM2
Slow wave sleep
REM sleep
Wake

Number of variables (derived from visual scoring) tested per comparison (*Sham-GSM und Sham UMTS*): **124**.

⇒ At a significance level of 5% **6 results are expected to be statistically significant just by chance.**

Laboratory study: mobile phones and sleep

- Background
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- **Discussion**

Discussion

Results from other studies related to the macrostructure of sleep:

Deviating results:

- ***Mann and Röschke 1996*** **(exploratory study, GSM 900 cell phone): decrease in sleep latency, increase in REM sleep latency and decrease of REM** (% TST)
- ***Loughran et al. 2005*** **(894,6 MHz): decrease in REM sleep latency**

Similar results (no effect):

- ***Hinrichs et al. 2005*** **(GSM 1800 farfield):**
- **Various studies from Zurich (*Achermann*)**

Discussion

Comparing our study with other studies

- **Highest exposition of all studies**
- **Whole night exposition**
- **Constant exposition since device was fixed to the ear, no change of exposition with movement of the subject**

Conclusion

So far only parameters based on visual expert scorings related to the macrostructure of sleep have been analysed.

⇒⇒ ⇒ ⇒ ⇒

No conclusions on the effect of RF-EMF on sleep should be drawn from this study at the present state of analysis

(data evaluation in progress).

Discussion

Limitation:

- Only young healthy men were included

  There is no or little information

  - for females
  - for elderly subjects and/or
  - for subjects with pre-existing sleep complaints

Outlook: Further steps to be taken

- Analysis of spectral power
- Analysis of microstructures of sleep, e.g. REM density and spindles
- Analysis of regional differences in effects of brain activity during sleep
- Analysis of possible effects of EMF on daytime functioning of the brain

Network providers

T-Mobile
Vodafone
E-Plus
O2

FGF

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IMST GmbH, Kamp Lintfort

Achim Bahr, PhD
Thomas Bolz, Dipl.-Ing
Christian Bornkessel, Dr.-Ing. and his team

Fachhochschule Deggendorf

Matthias Wuschek, Prof. Dr.-Ing. and his team

Federal Agency of Radiation Protection

Blanka Pophof, PhD

Thank you for your attention

Charité - CBF

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