

Exposure of the general public to RF electromagnetic fields

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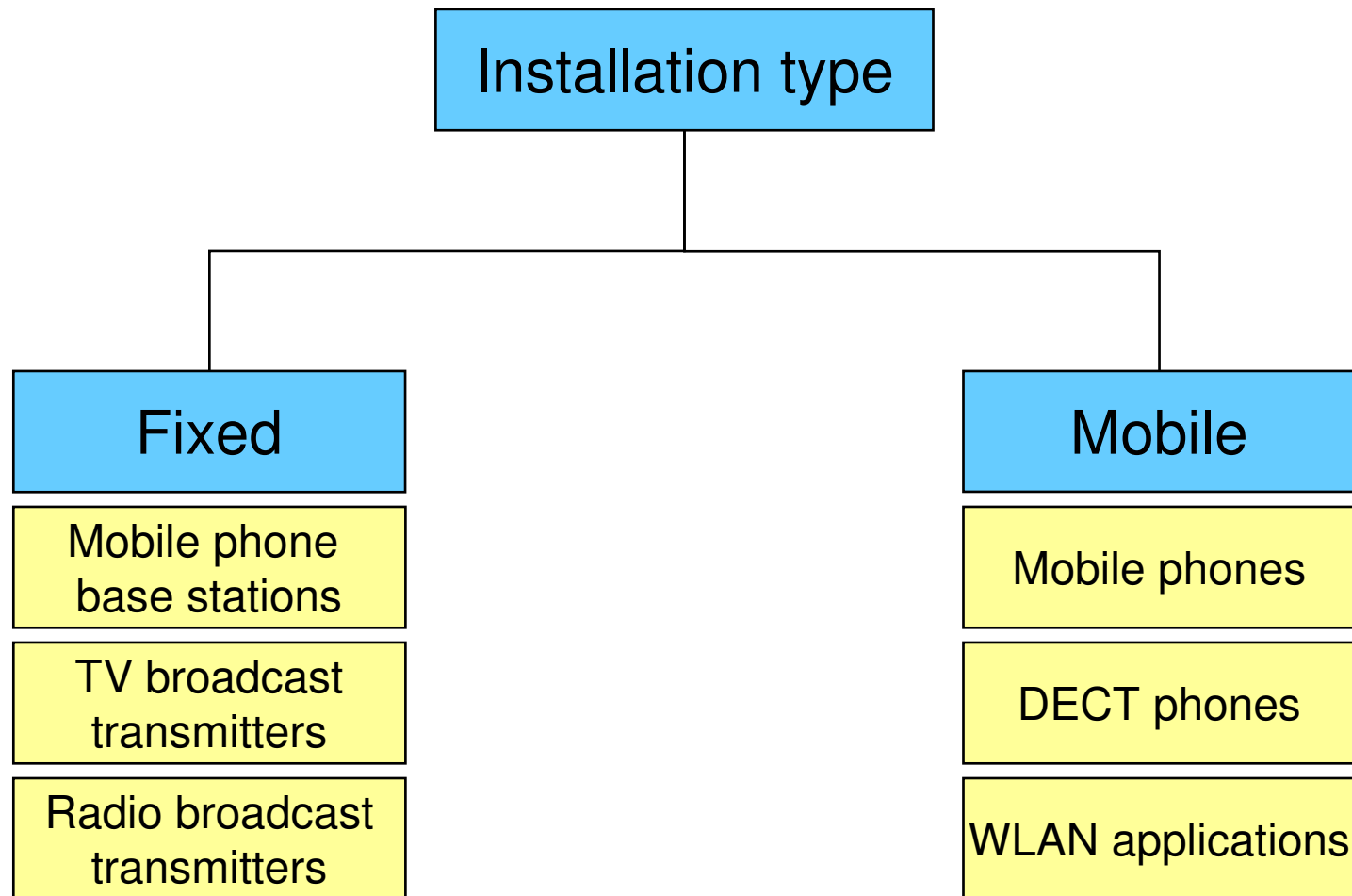
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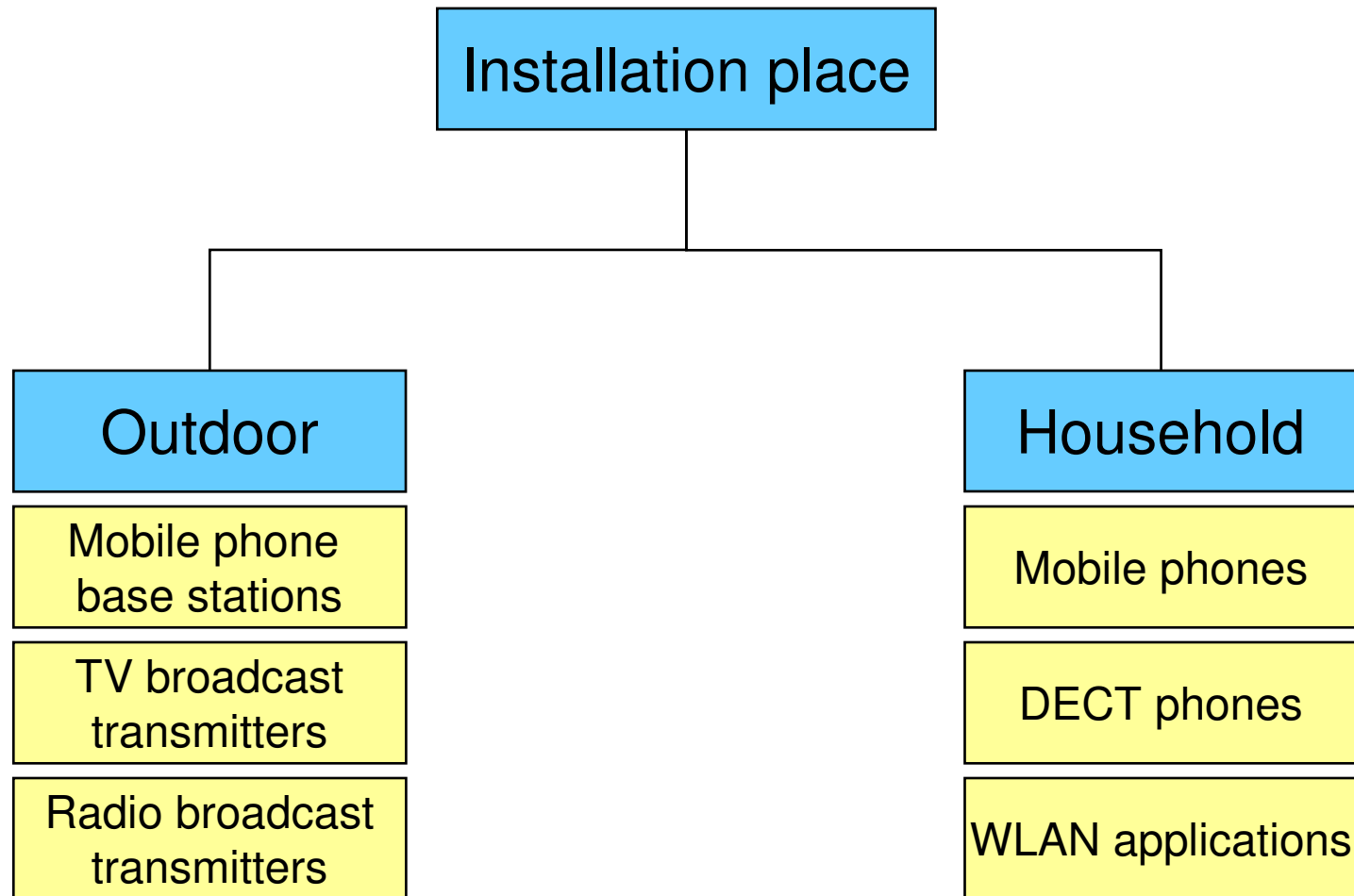
Outline

- RF sources and their exposure
 - relevant exposures in everyday life
 - focus on general public exposure
 - exposure results with special regard to DMF studies
- Personal exposure meters (Dosimeter)
 - available dosimeters
 - typical results

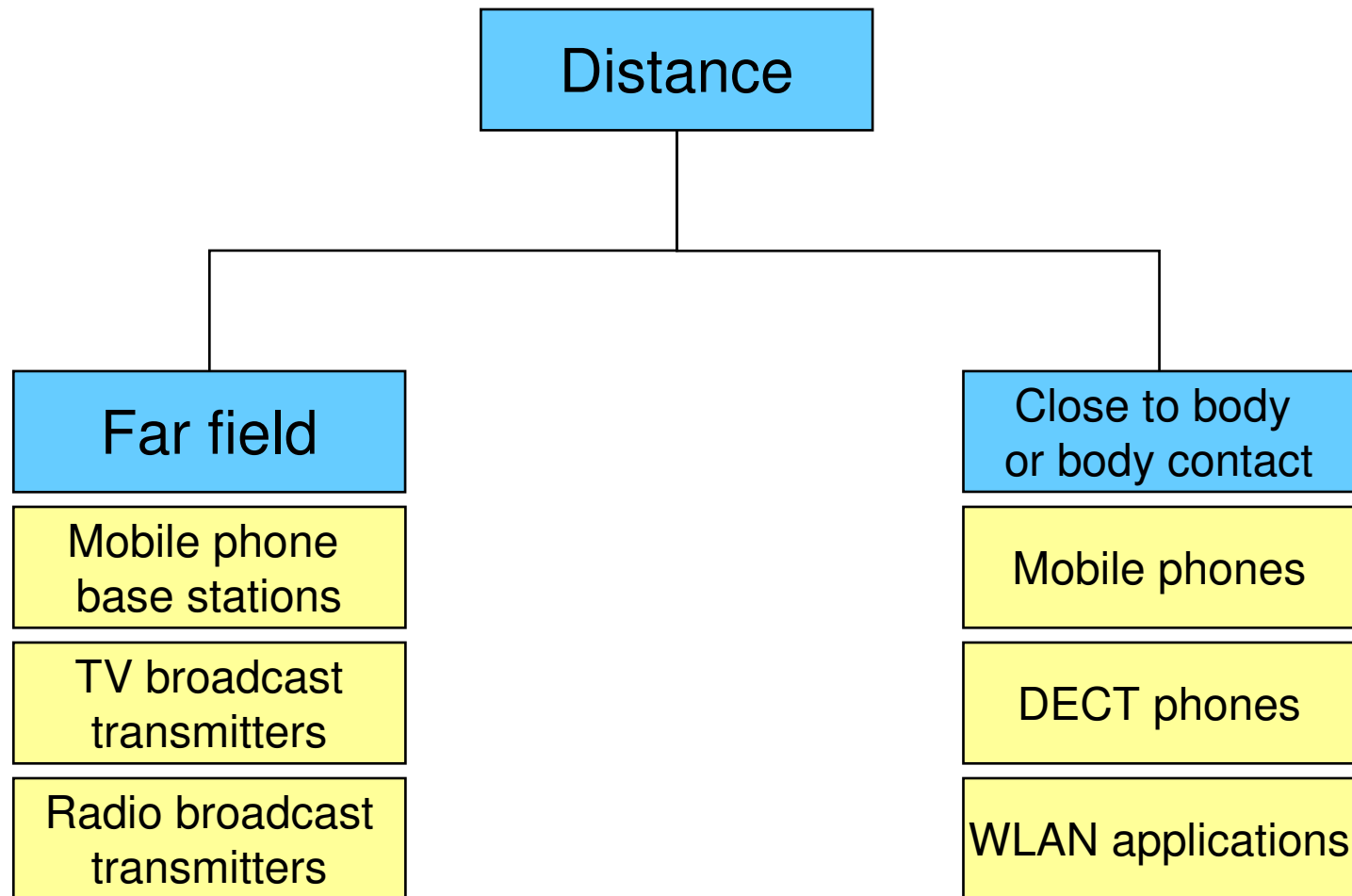
Classification of relevant RF sources



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Classification of relevant RF sources



Mobile phone base stations



Frequency: - 925 – 960 MHz (GSM 900)
- 1820 – 1880 MHz (GSM 1800)
- 2110 – 2170 MHz (UMTS)

Transmit - typ. 5-30 W/channel/sector
Power: - 100-1800 W (EIRP)/channel/sector

Transmitter: - ~85,000 stations in Germany

Coverage: - 500 m – 20 km

Distance to
Persons: - far field

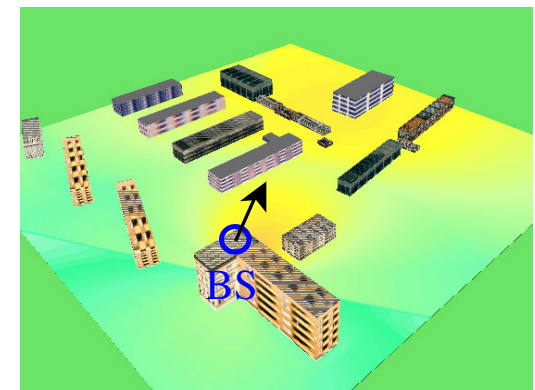
Remarks: - power control

Projects supported within DMF

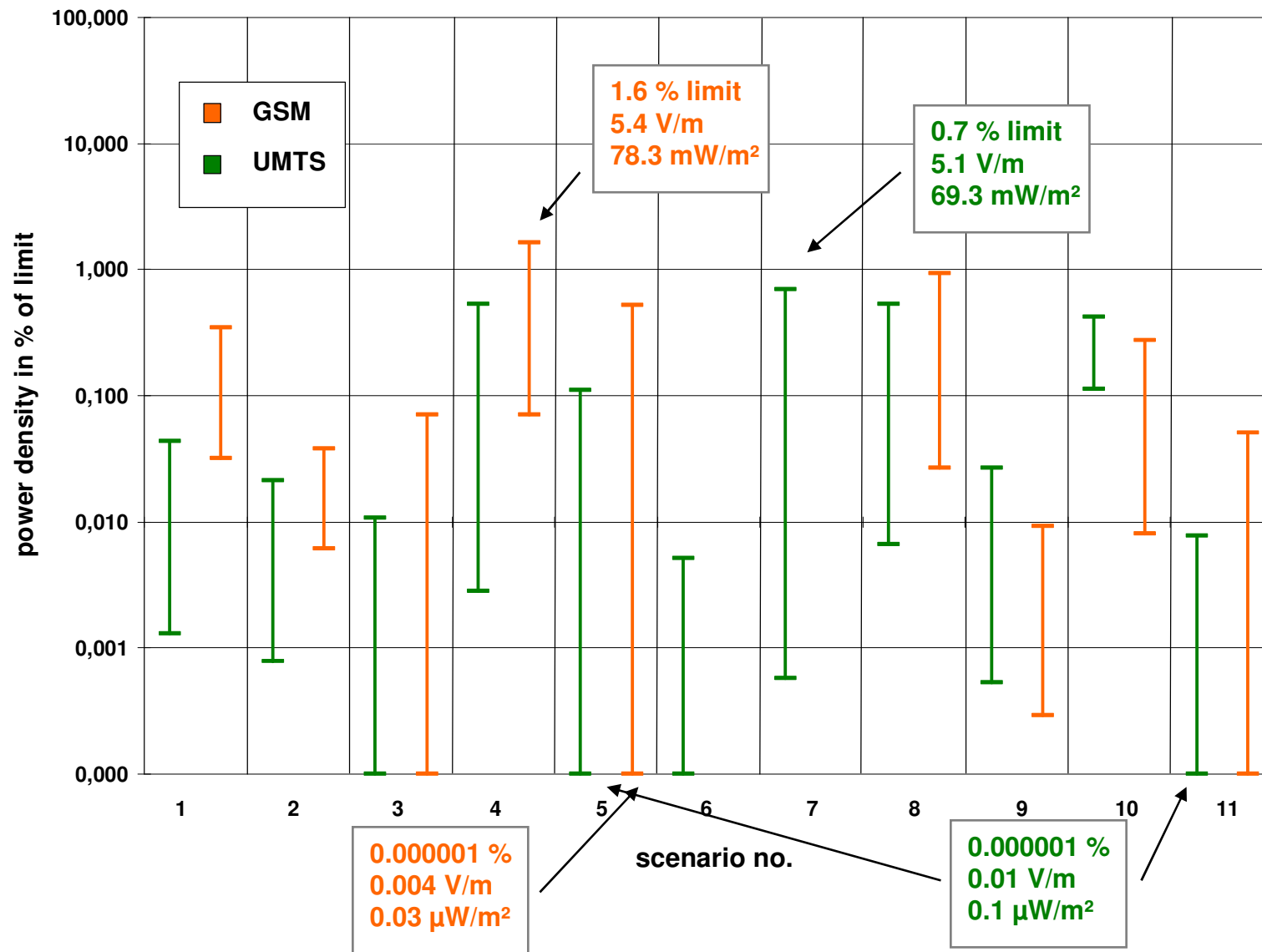
Development of measurement and calculation methods for the determination of the public exposure due to electromagnetic fields in the vicinity of mobile phone base stations (IMST)

Determination of the exposure of groups of people that will be investigated within the scope of the project "Cross sectional study for ascertainment and assessment of possible adverse effects by fields of mobile phone base stations" (ECOLOG)

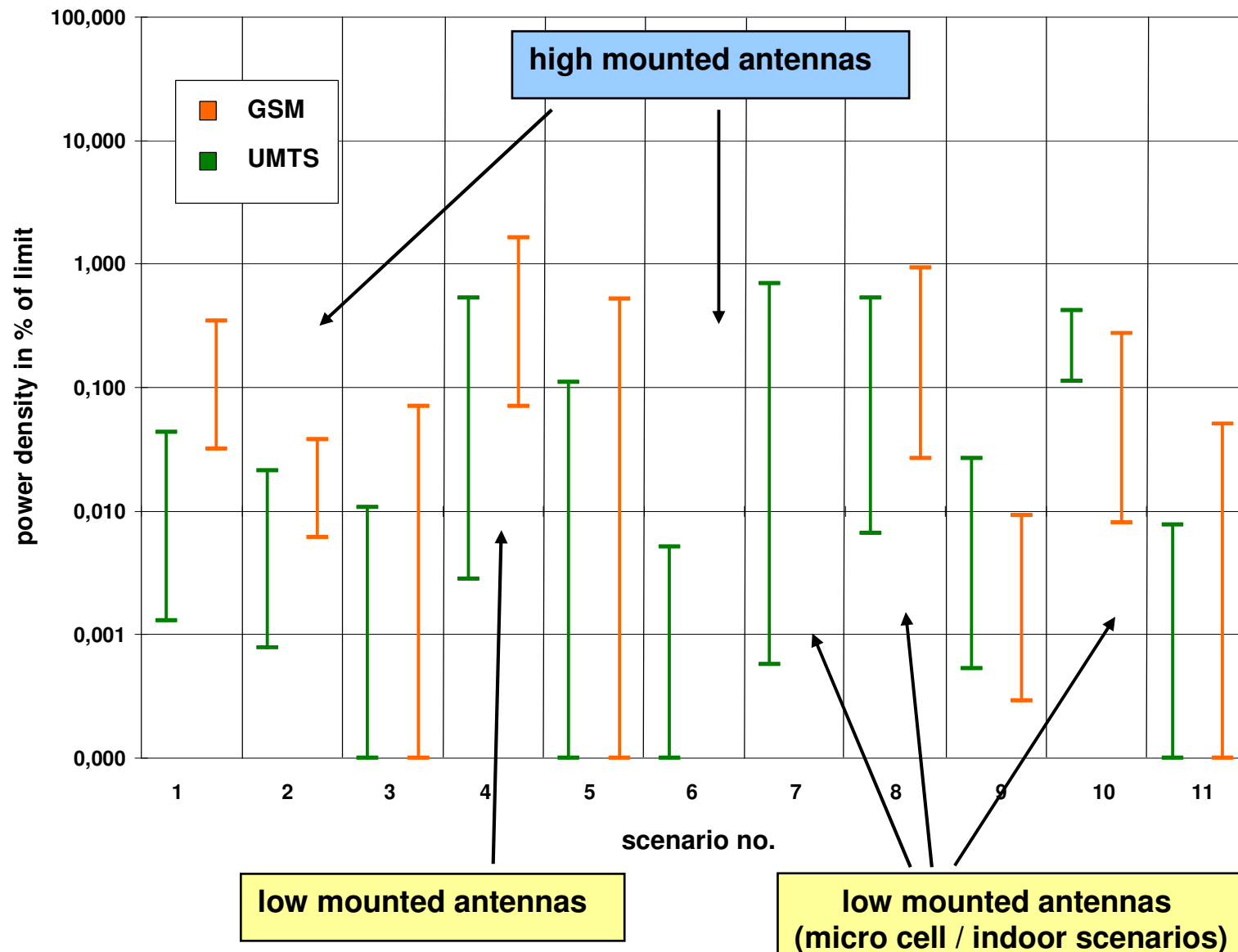
Determination of the real field distribution from high frequency electromagnetic fields near UMTS transmitters (IMST+EM Institute)



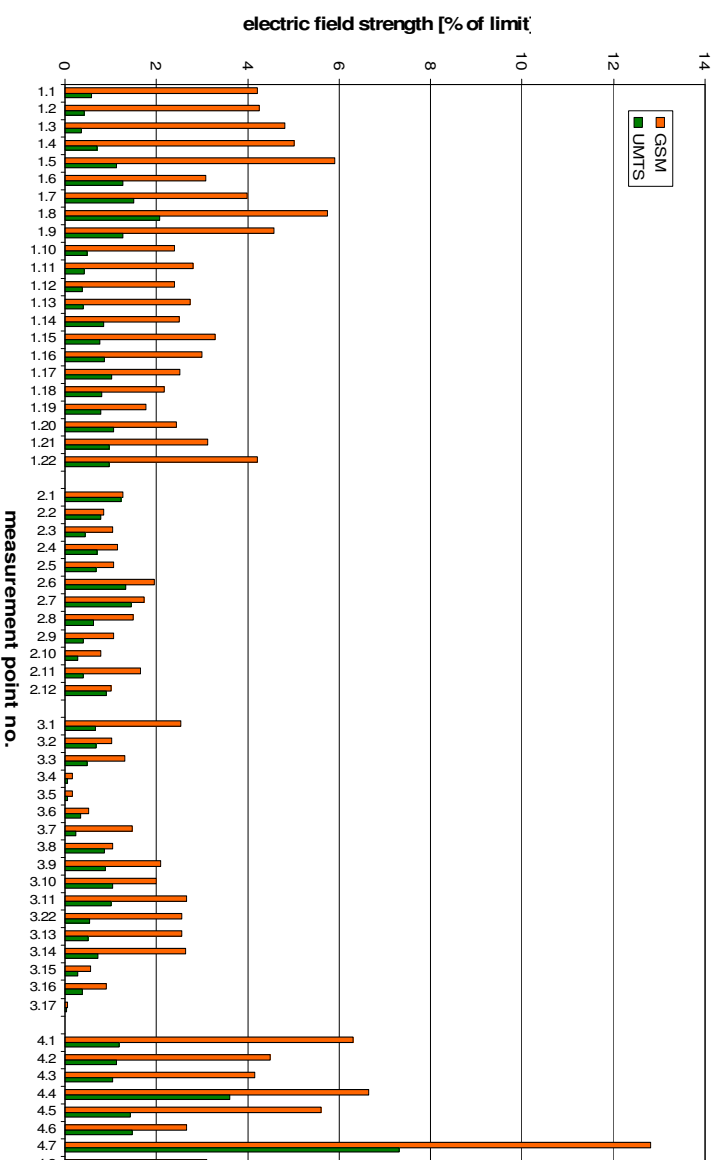
Extrapolated exposure (IMST+EM-Institute)



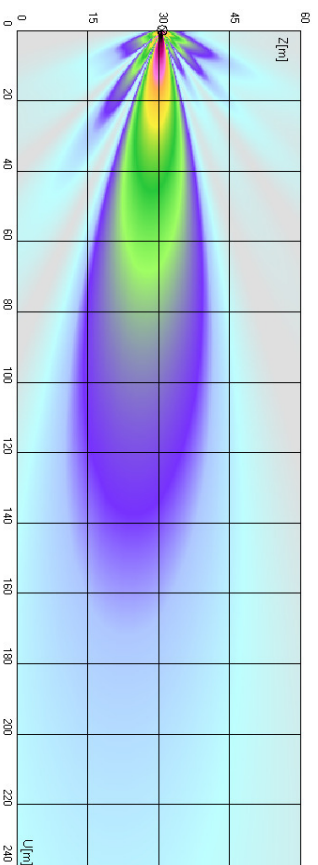
Extrapolated exposure near base stations (2)



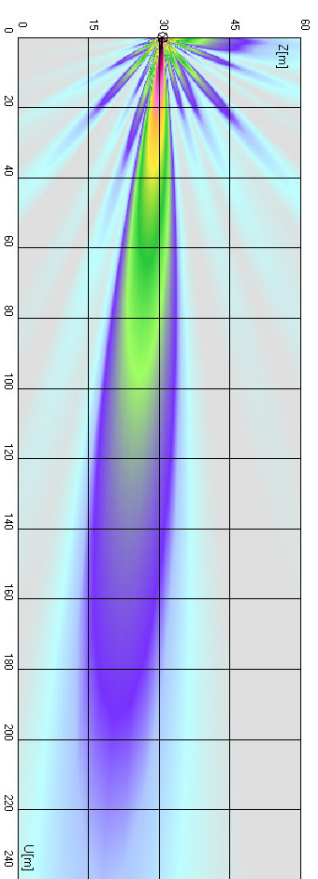
Comparison GSM/UMTS



➤ GSM > UMTS at
85 % of all points
(compared to limit)



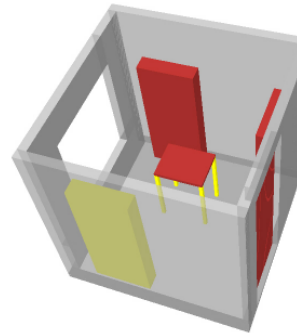
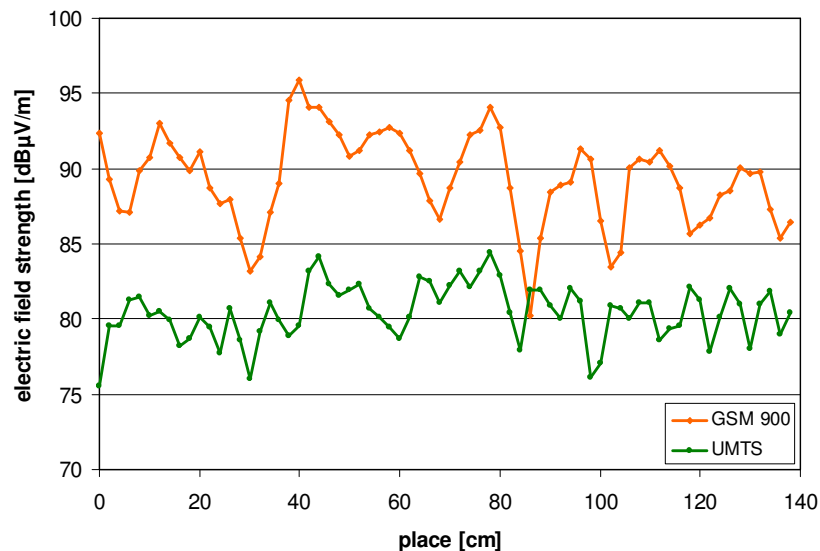
GSM 900 antenna pattern



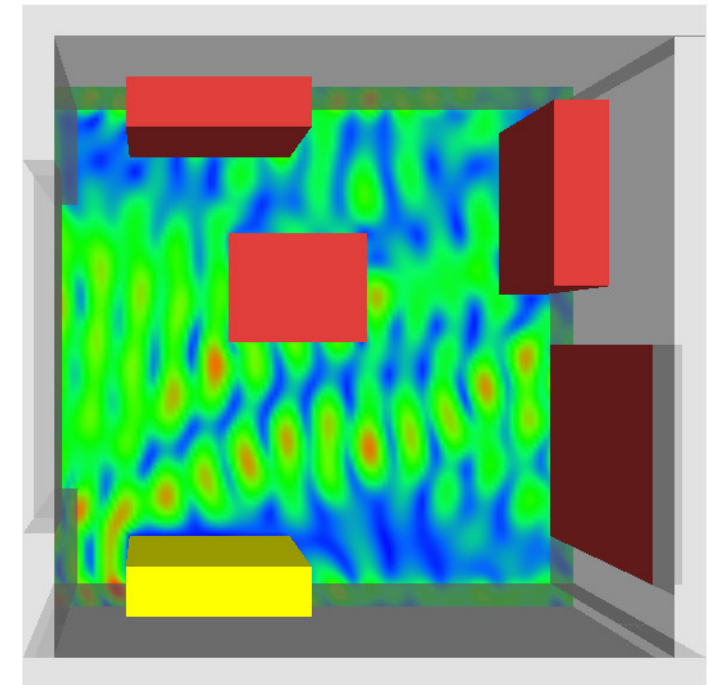
UMTS antenna pattern

Small scale field variation in space

Measurement: GSM 900 and UMTS



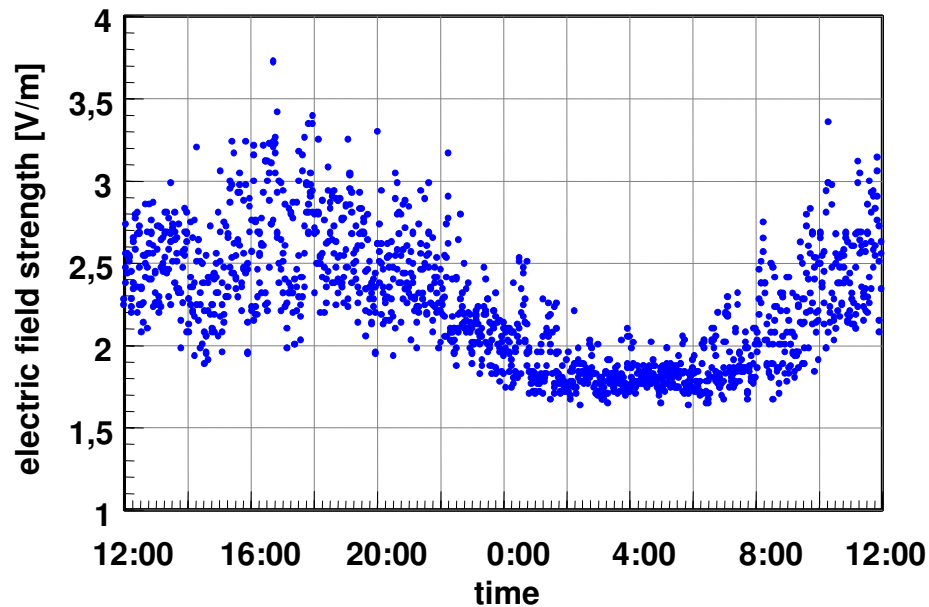
Simulation: GSM 900



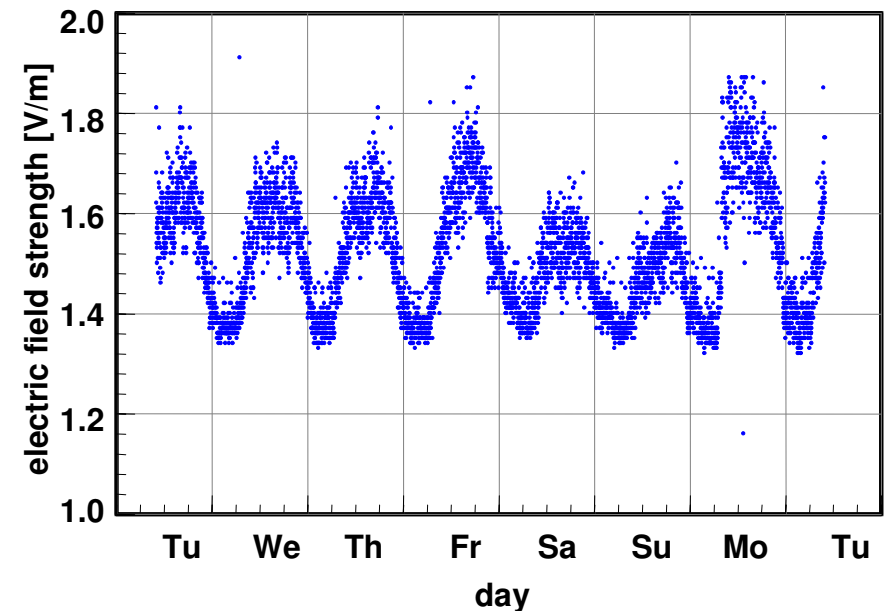
- Small scale variations (fast fading) especially at indoor scenarios due to multipath propagation
- Variations of 10 dB and more

Small and large scale variations in time

Station A: GSM 24 hours



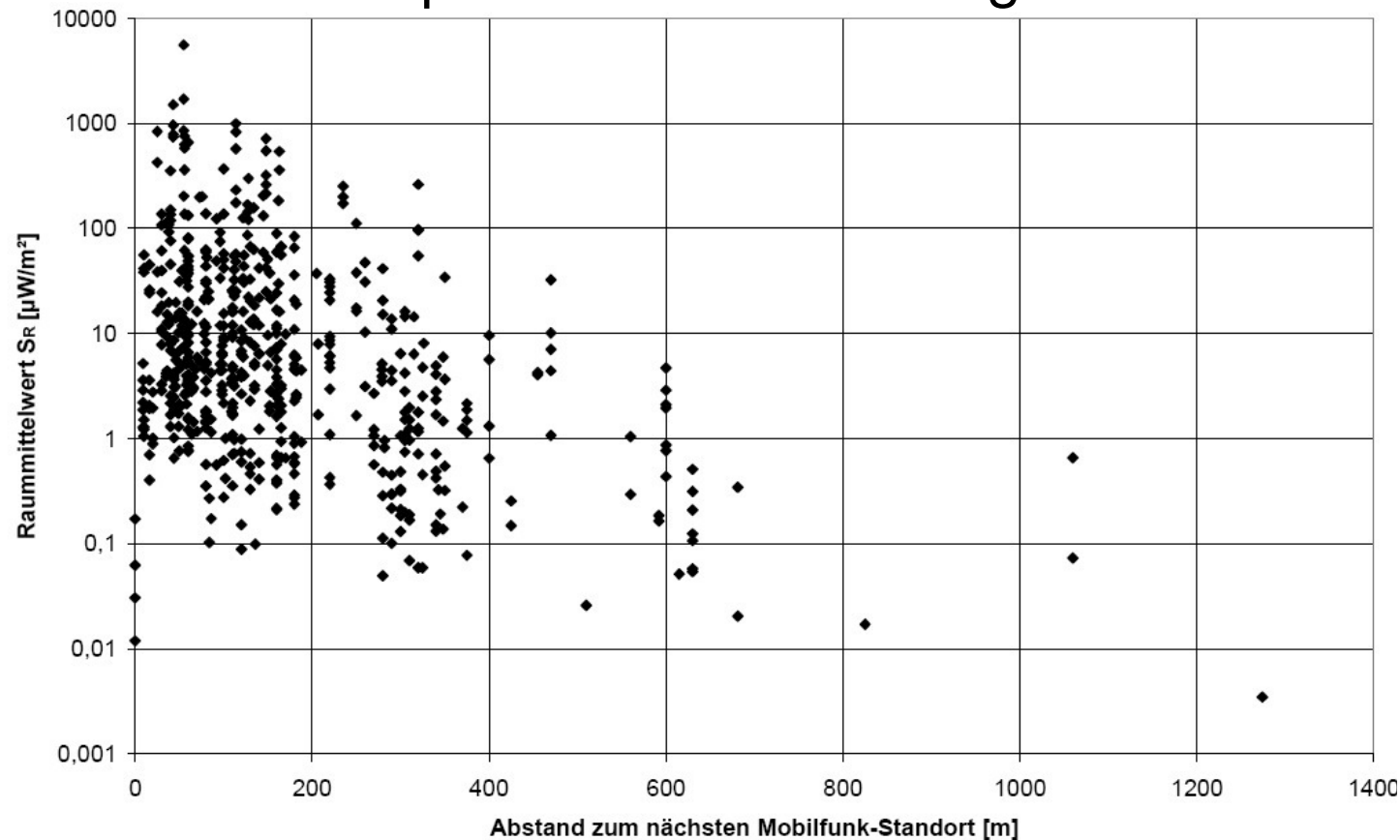
Station B: GSM 7 days



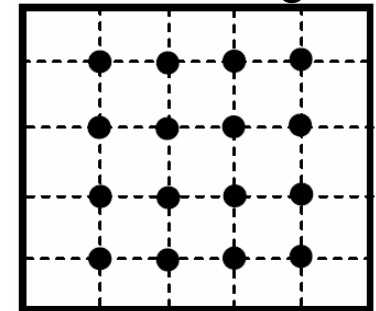
- Small and large scale variations due to traffic load (power control)

Time and space averaged exposure (ECOLOG)

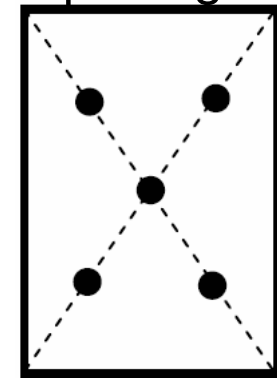
Exposure inside buildings



1 m x 1 m grid



5 point grid



- Time and space averaging, no focus on "maximal exposed areas"
- Exposure 10 - 1,000 times smaller than measured under worst case aspects

Mobile phones



Source:
www.sonyericsson.com

Frequency: - 880 – 915 MHz (GSM 900)
- 1710 – 1785 MHz (GSM 1800)
- 1920 – 1980 MHz (UMTS)

Transmit Power: - up to 250 mW time averaged
- up to 2 W peak

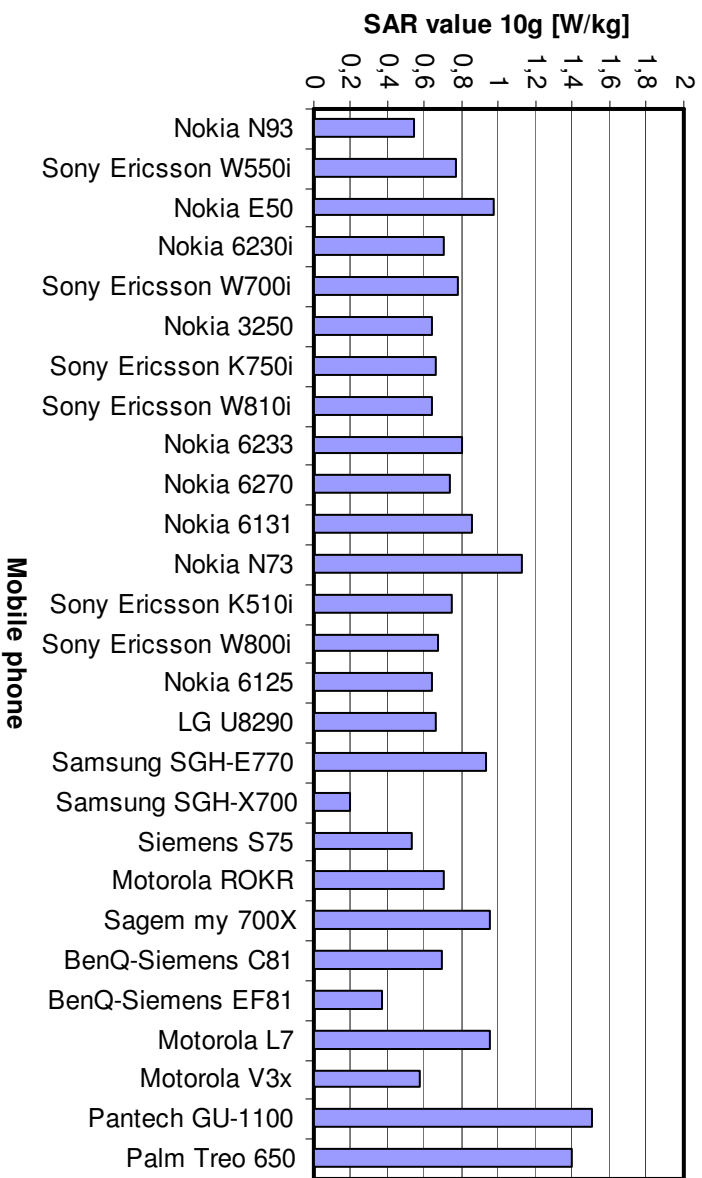
Number: - ~80 million

Coverage: - up to 20 km

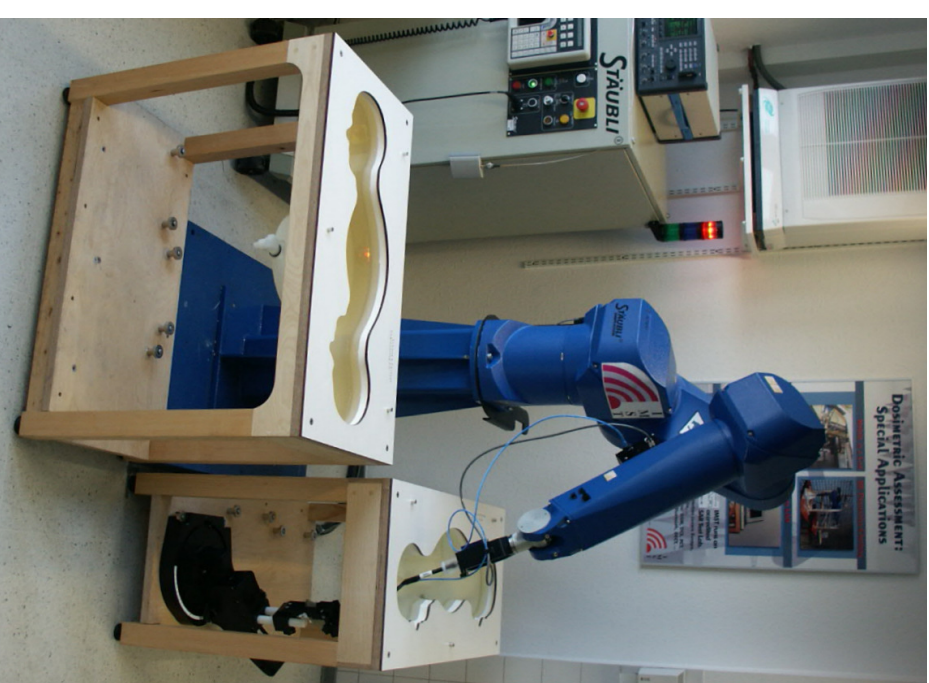
Distance to Persons: - body contact

Remarks: - power control

SAR-Measurements



- SAR is measured under "worst case" conditions (maximal transmit power)
- typ. 10 – 75 % limit consumption



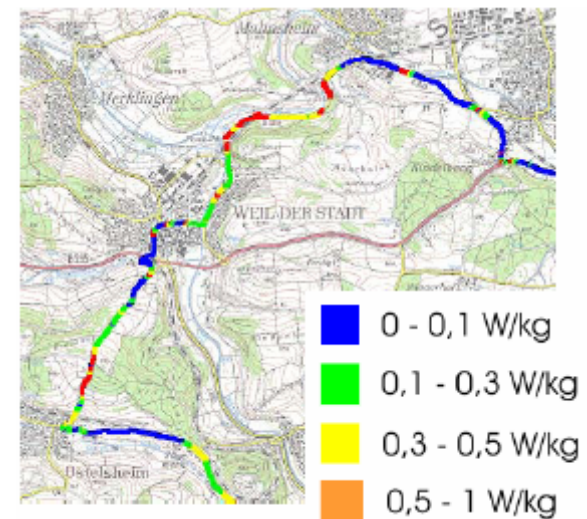
Projects supported within DMF

Determination of the specific absorption rate (SAR values) occurring during day-to-day mobile phone use

(Telecom-Consult)

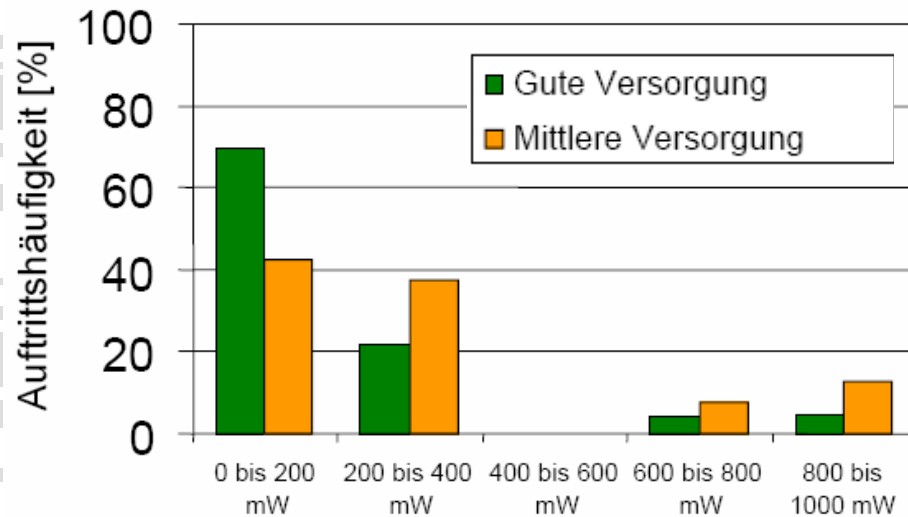
Determination of the real exposure from using mobile phones in partially shielded rooms as compared to exposure under optimal conditions outdoors

(Telecom-Consult)

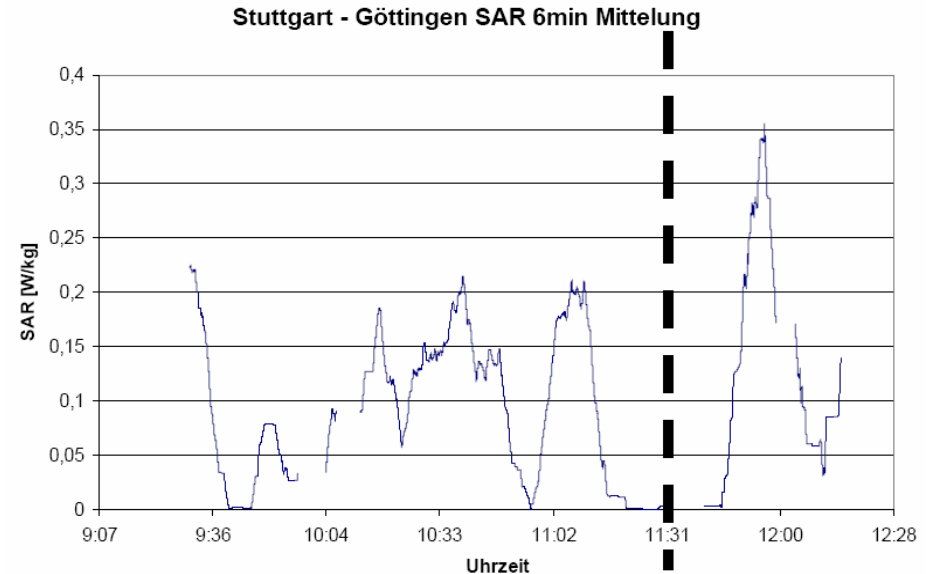


Exposure results: Averaged exposure

Inside a room, Nokia 6150



Inside a train, Nokia 6110/6150



- On average 10 – 50 % of "worst case" SAR, depending on coverage and cell changes
- Further reduction due to DTX

TV Broadcast



Wendelstein

Frequency: - 47 – 68 MHz (analogue)
- 174 – 223 MHz (analogue, digital)
- 470 – 790 MHz (analogue, digital)
- 790 – 862 MHz (digital)

Transmit Power: - up to several 100 kW (ERP)
per site

Transmitter: - typ. 5-15 main transmitters
each federal state (Germany)

Coverage: - up to 60 km

Distance to Persons: - far field

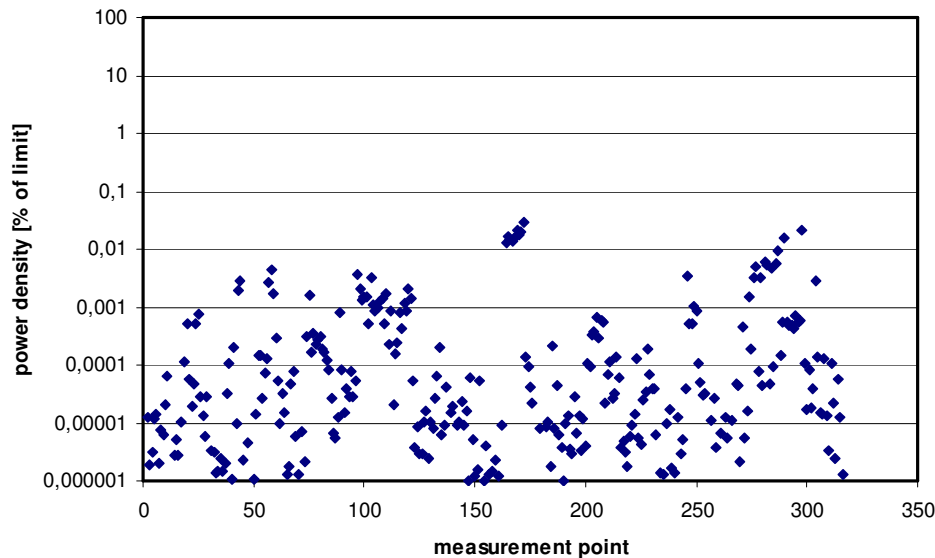
Projects supported within DMF

Determination of exposure
to the population living near
digital radio and television
transmitters
(IMST+EM Institute)

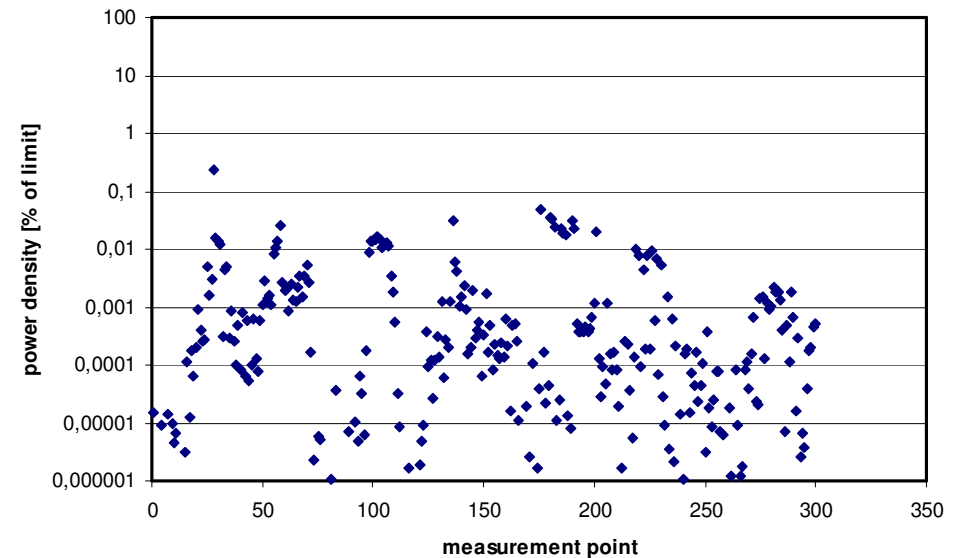


Exposure to Analogue TV and DVB-T (same region)

Analogue TV



DVB-T



- More than 300 measurement points in Nuremberg and Munich region
- Points statistically distributed; proportional to population density
- Measurements before (A-TV) and after (DVB-T) switching to DVB-T
- Exposures mostly below 0.01 – 0.1 % of limit

FM radio and DAB



www.zinsik.de

Frequency: - 88 – 108 MHz (FM radio)
- 174 – 223 MHz (DAB)
- 1452 – 1492 MHz (DAB)

Transmit Power: - FM: typ. several 10 kW (ERP)
DAB: typ. several kW per site

Transmitter: - several 100 (Germany)

Coverage: - up to 60 km

Distance to Persons: - far field

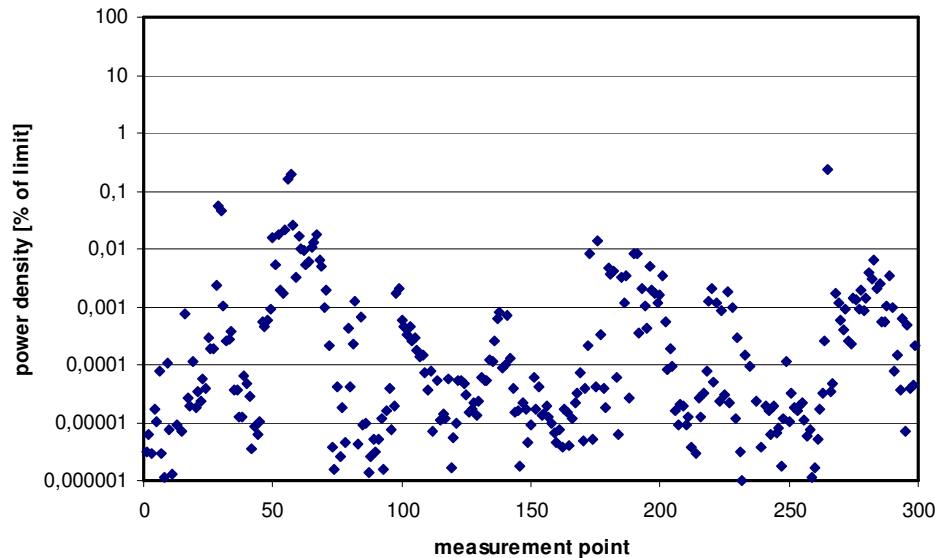
Projects supported within DMF

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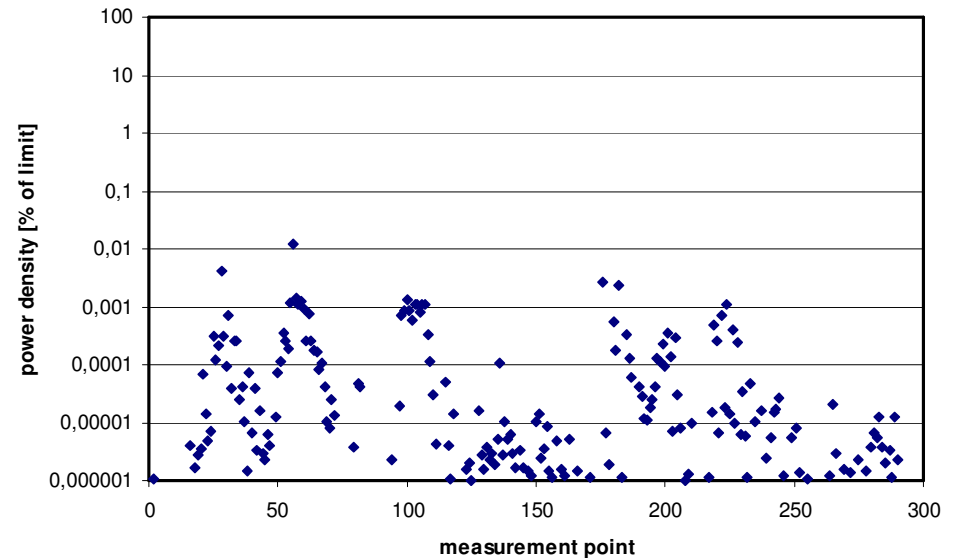


Exposure to FM radio and DAB (same region)

FM radio



DAB



- 300 measurement points in Nuremberg and Munich region
- Points statistically distributed; proportional to population density
- Exposures mostly below 0.01 – 0.1 % of limit
- DAB exhibits ~11 dB lower exposure compared to FM radio (median)

Long/Medium/Shortwave radio services



Frequency: - 148 – 255 kHz (LW)
- 0.526 – 1.6 MHz (MW)
- 3.4 – 26 MHz (SW)

Transmit Power: - several 100 kW per site
(up to 2 MW)

Transmitter: - several 10 (Germany)

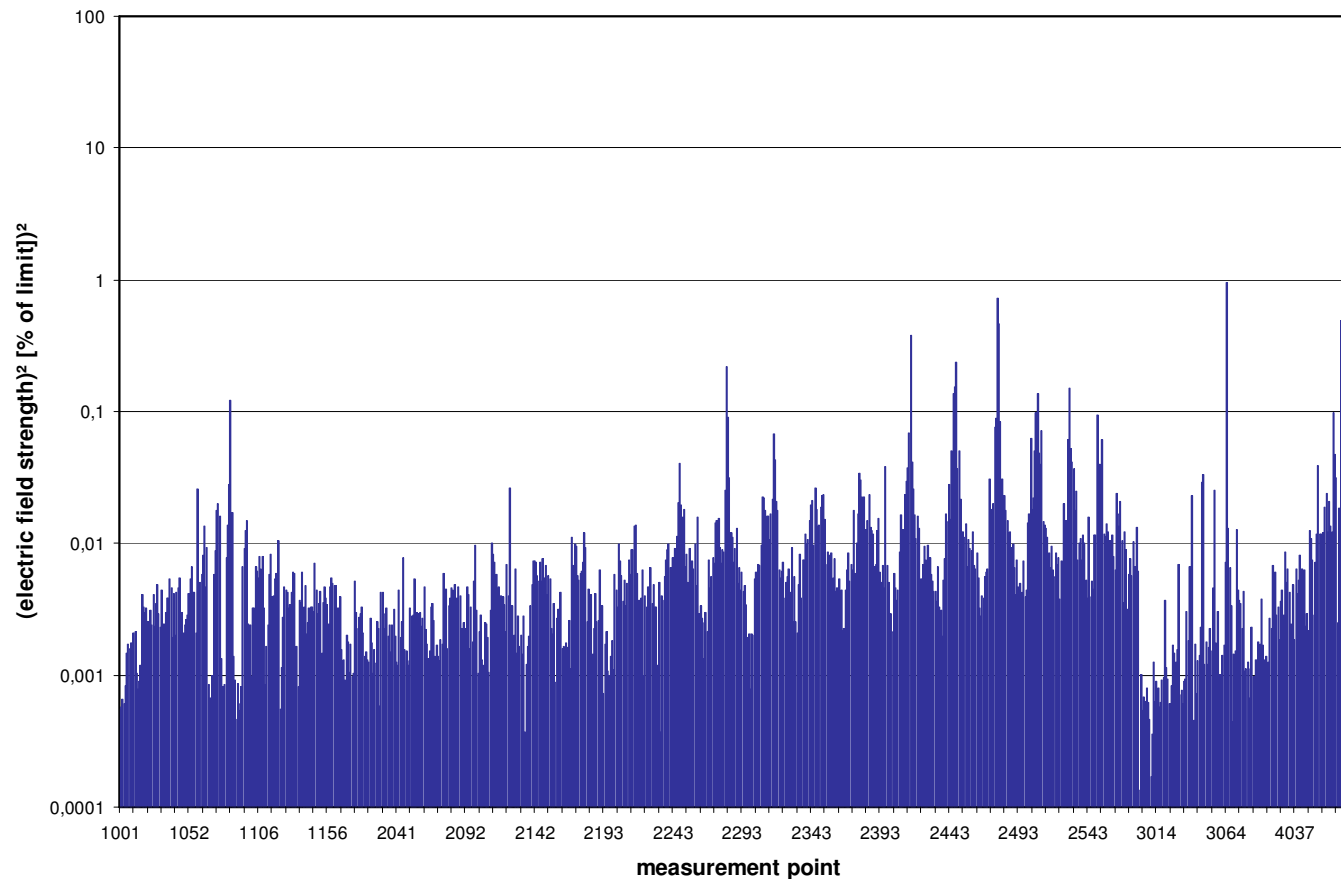
Coverage: - several 100 km

Distance to
Persons: - far field

Exposure results

Study by Wuschek et al., 2003

"Large area measurement of radio waves in Baden-Wurttemberg"



- 895 points, regular 2 x 2 km grid, outdoor
- Exposure may reach or exceed GSM/UMTS exposure near to base stations!

Wireless LAN (IEEE 802.11b)



Frequency: - 2400 – 2483.5 MHz

Transmit
power: - max. 100 mW EIRP

Transmitter: - several 100,000

Coverage: - several 10 meter

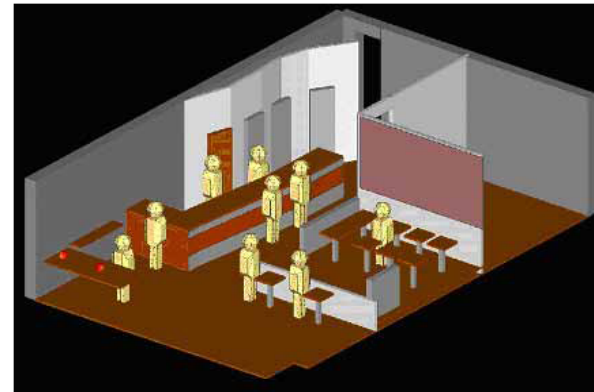
Distance to - access points: far field

Persons: - mobile: close to body
or body contact

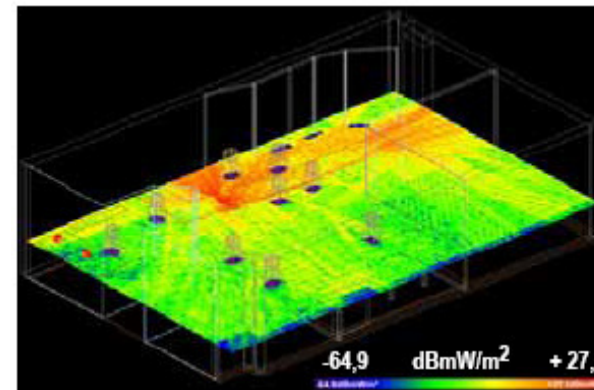
Remarks: - power control by duty cycle

Projects supported within DMF

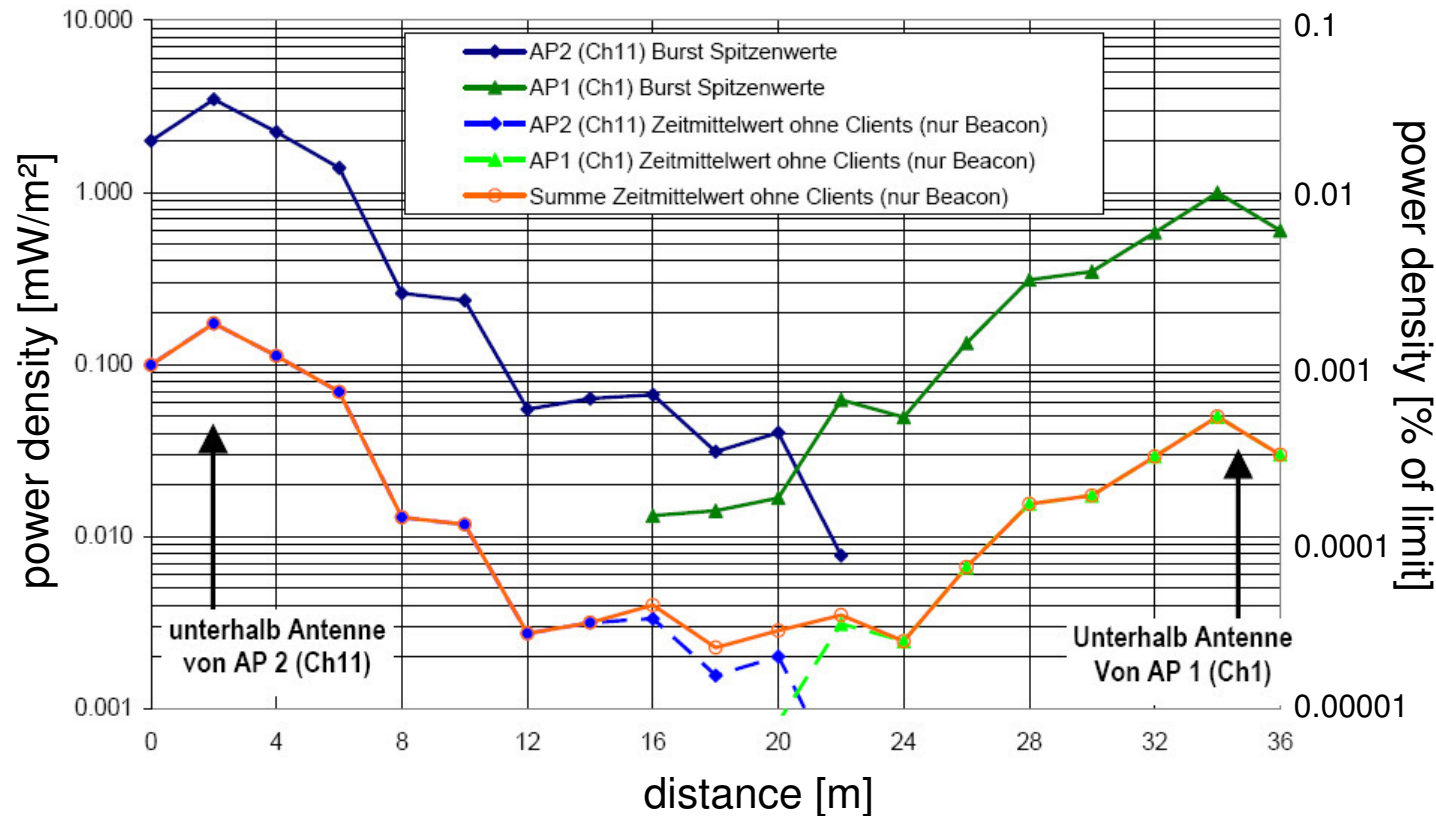
Determination of human exposure caused by indoor wireless communication technologies applied in homes and offices
(ARC Seibersdorf Research)



Determination the real field distribution of high frequency electromagnetic fields near wireless LAN installations (WLAN) in inner cities
(ARC Seibersdorf Research)



Exposure results (time and space averaged)



- outdoor scenarios: typ. 10^{-11} – 0.001 %
- indoor scenarios: up to 0.1 %
- close to body operation: typ. 2 - 3 % of SAR-limit

Digital cordless phones: DECT



Frequency: - 1880 - 1900 MHz

Transmit
power: - max. 250 mW peak power

Transmitter: - several 100,000

Coverage: - several 10 meter

Distance to - base station: far field

Persons: - mobile: body contact

Remarks: - power control by duty cycle

Projects supported within DMF

Determination of human exposure caused by indoor wireless communication technologies applied in homes and offices

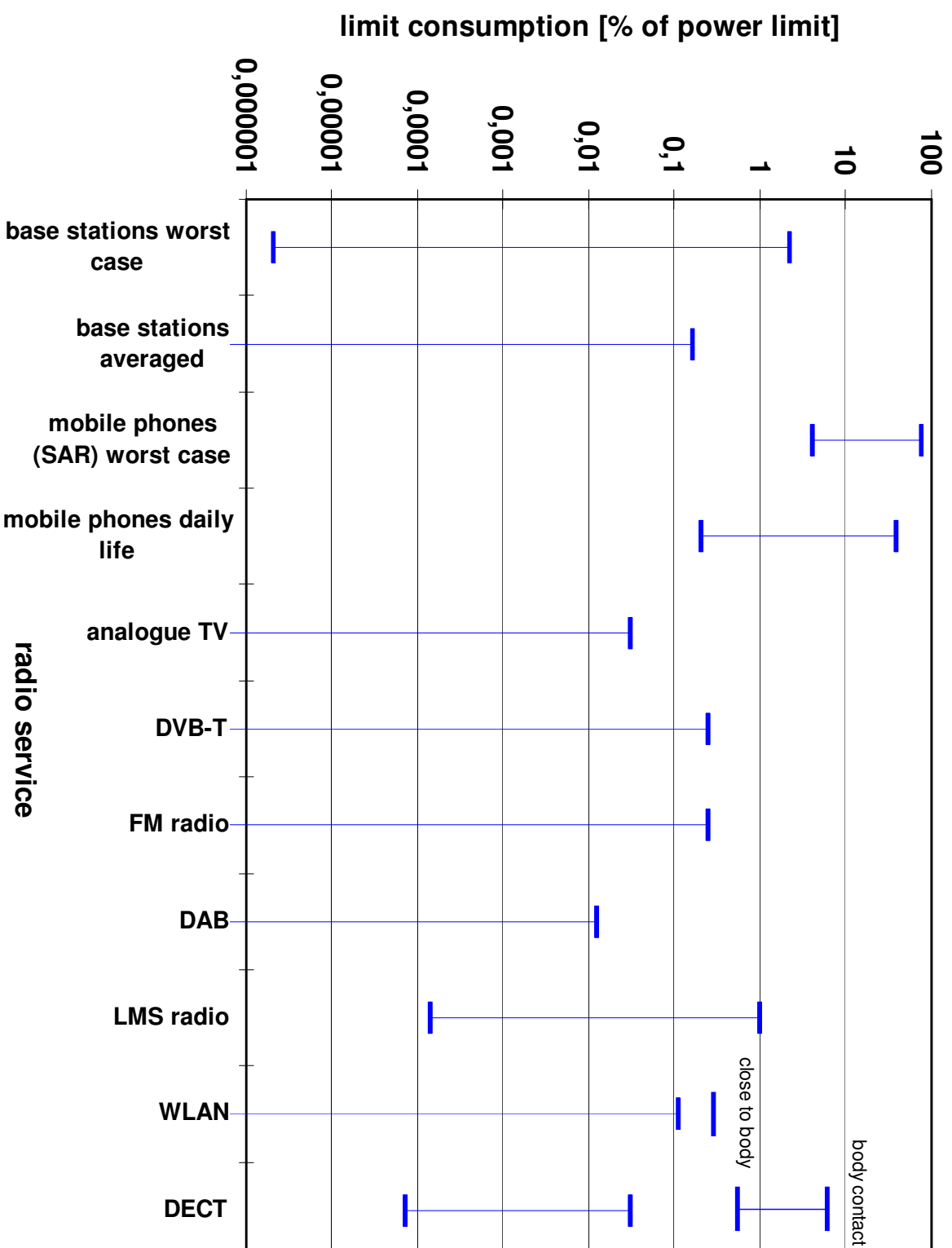
(ARC Seibersdorf Research)

Results: time and space averaged in % of limit

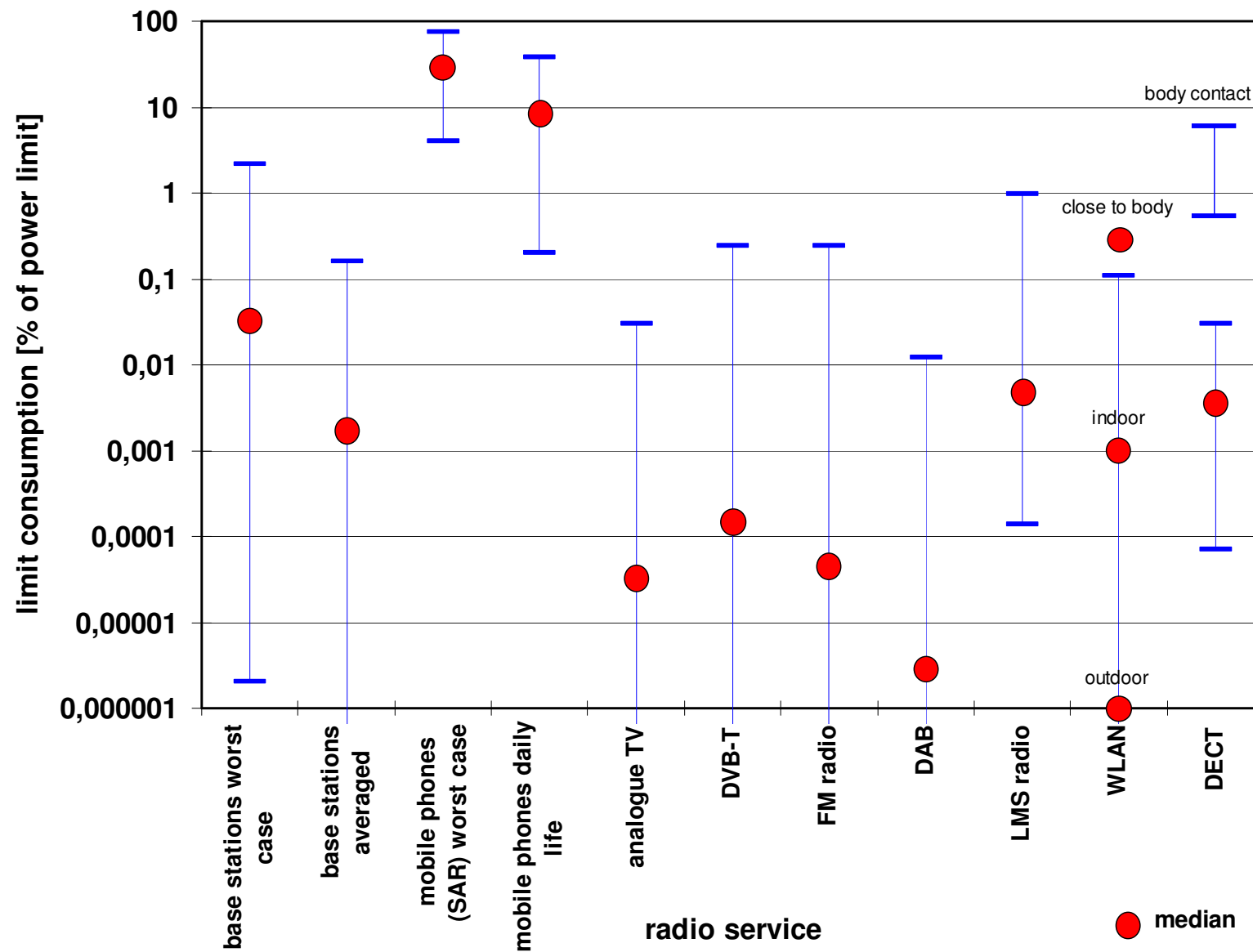
- 2 DECT devices, 1 and 3 m:
BS: 0.004 – 0.03 %,
MS: 0.0002 – 0.004 %
- SAR_{10g}: 0.6 – 8 %
- generic scenarios: 0.00007 – 0.0003 %
- mixed scenarios: 0.00007 – 0.023 %



Putting all results together ...



... the same with median



Personal exposure meters (Dosimeters)

Maschek ESM-140

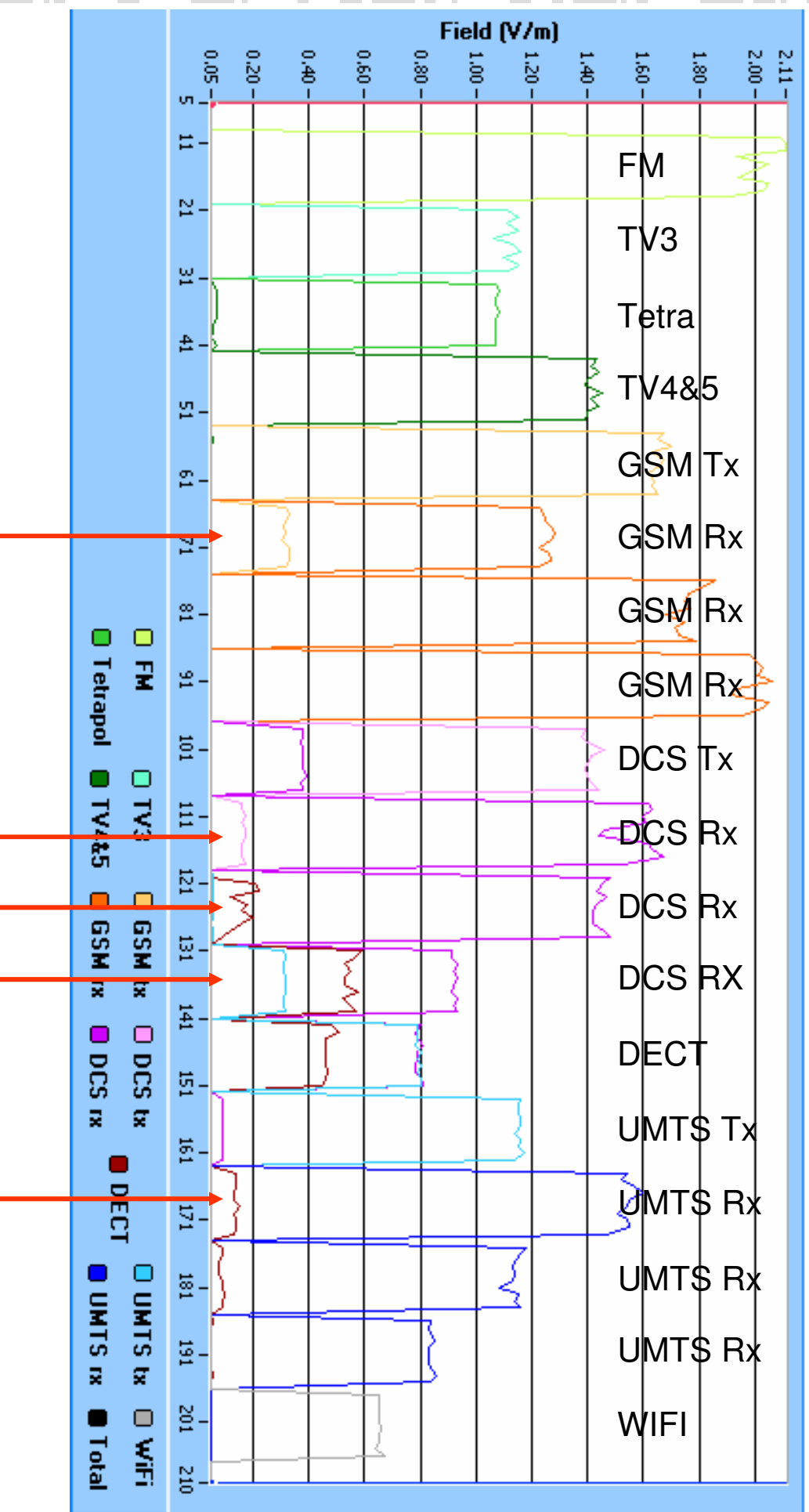


www.maschek.de

Antennessa EME Spy 120

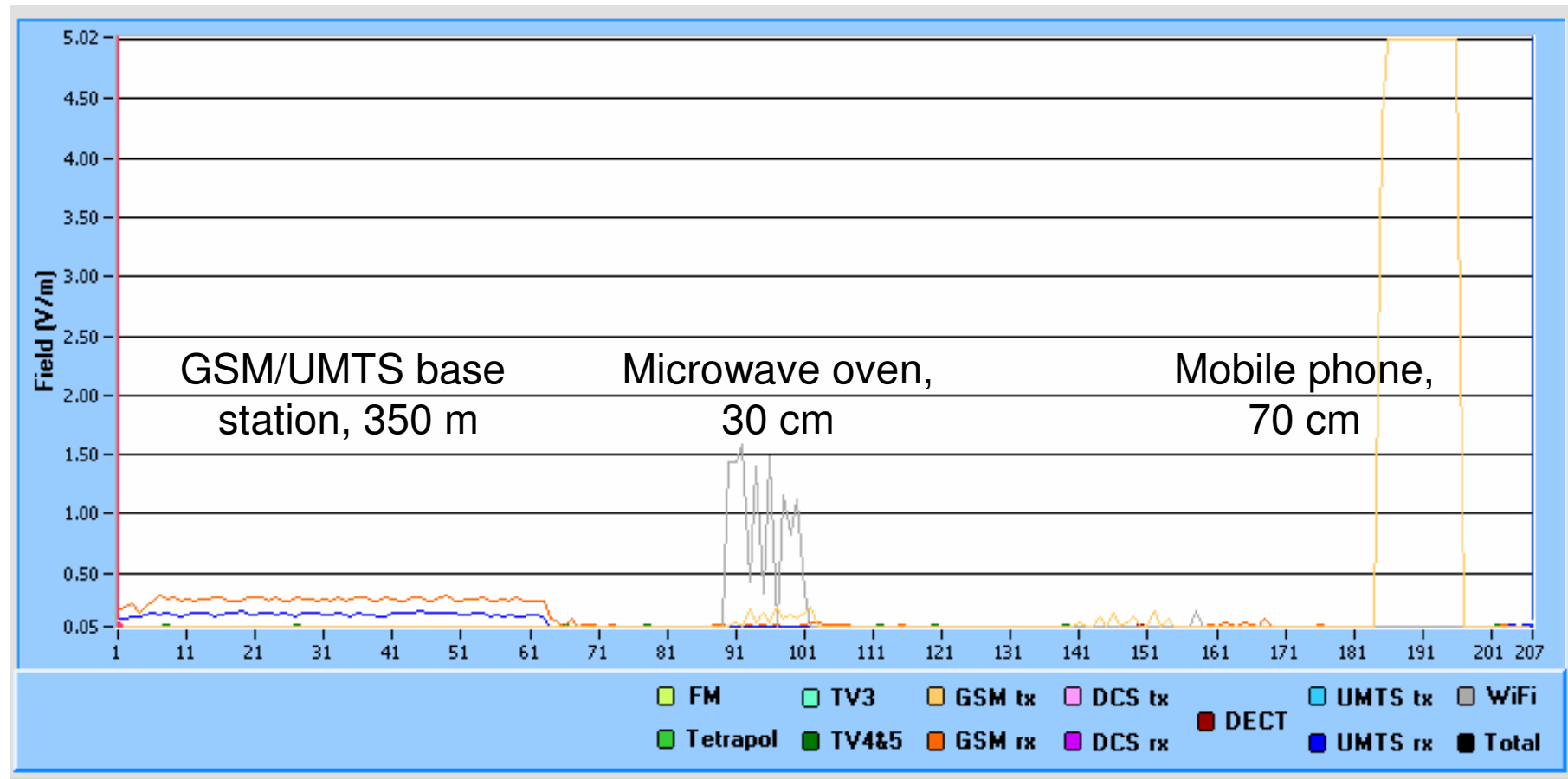


Frequency bands Antennessa

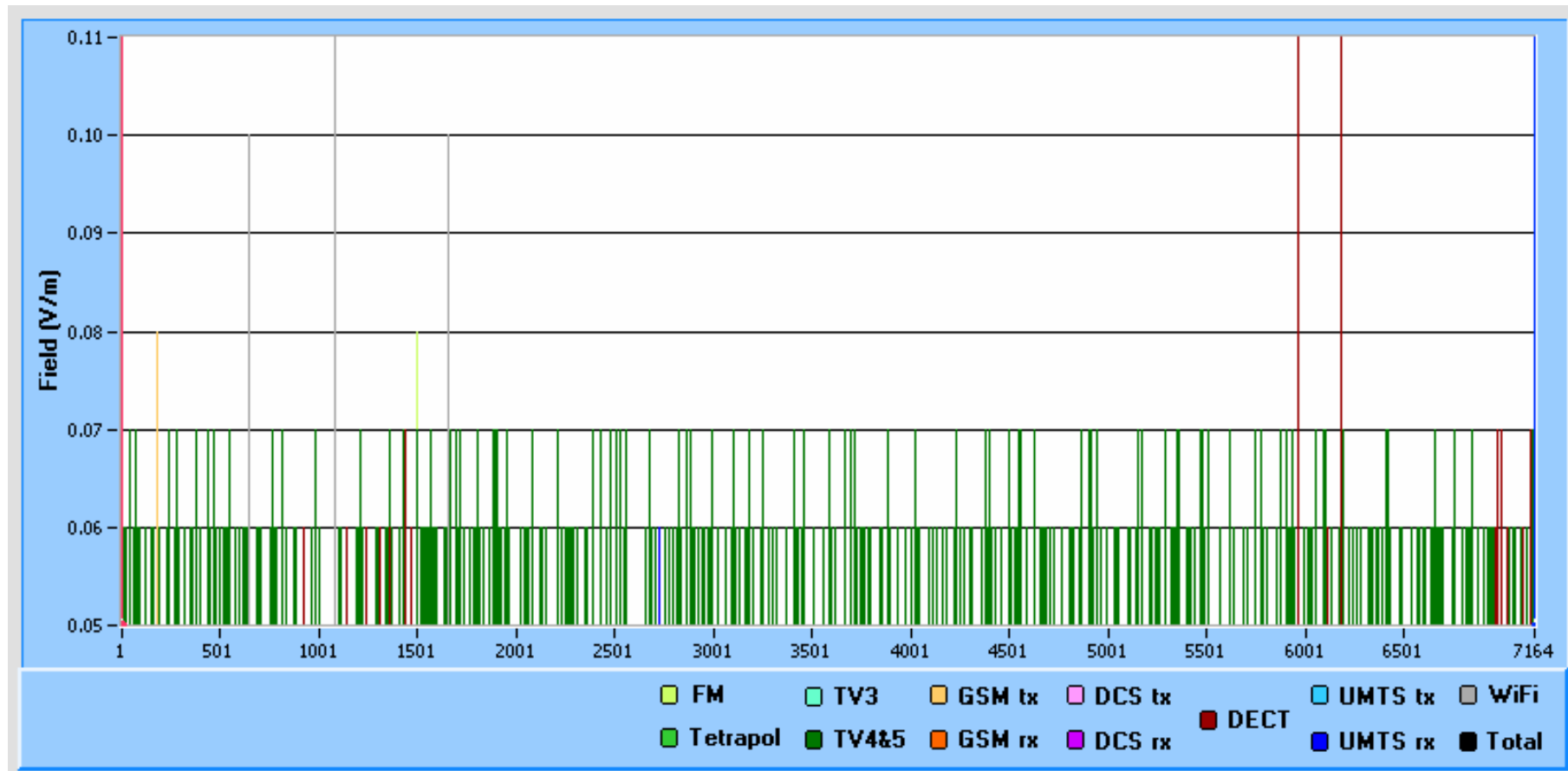


Problems with cross-talk

Measurement with "extra" exposure



"Normal" situation



Dosimeters: Questions to be discussed

- Limited sensitivity
 - Cross talk between different frequency bands
 - Measurement accuracy
 - Isotropy
 - Influence of the user
 - Response to modulated signals
 - Summation of multiple signals in the same band
 - Functional and ergonomic aspects
- **Dosimeters seem to be very helpful for epi-studies, (although their quality need to be investigated in detail)**

Summary and conclusion

- Relevant exposures are:
 - mobile phone base stations (GSM+UMTS) and mobile phones
 - digital and analogue radio and TV broadcast
 - Wireless LAN and DECT cordless phones
- Most services exhibit strong time variations (power control) and space variations (fast fading)
→ worst case exposure differs from averaged exposure
- General comparison of exposures show:
 - Strongest exposure by sources near to body/body contact
 - Long/Medium/Shortwave radio service often underestimated
- Dosimeters seem to be very helpful for epi-studies, (although their quality need to be investigated in detail)