

Workshop Dosimetry, 25.-26.07.2006

Exposure of the general public due to GSM and UMTS base station transmitters

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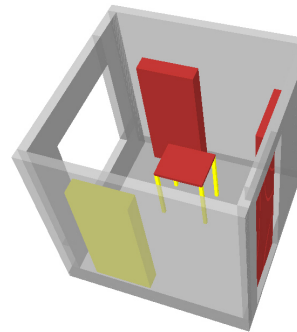
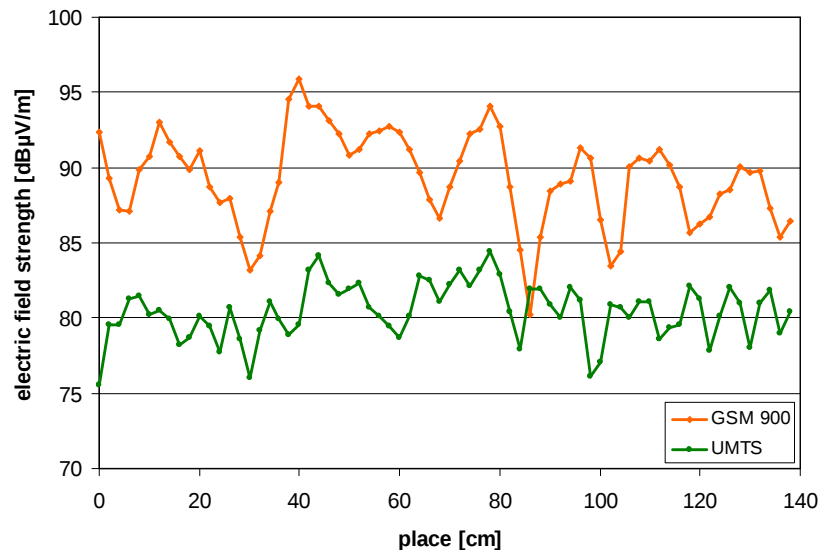
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Project Overview

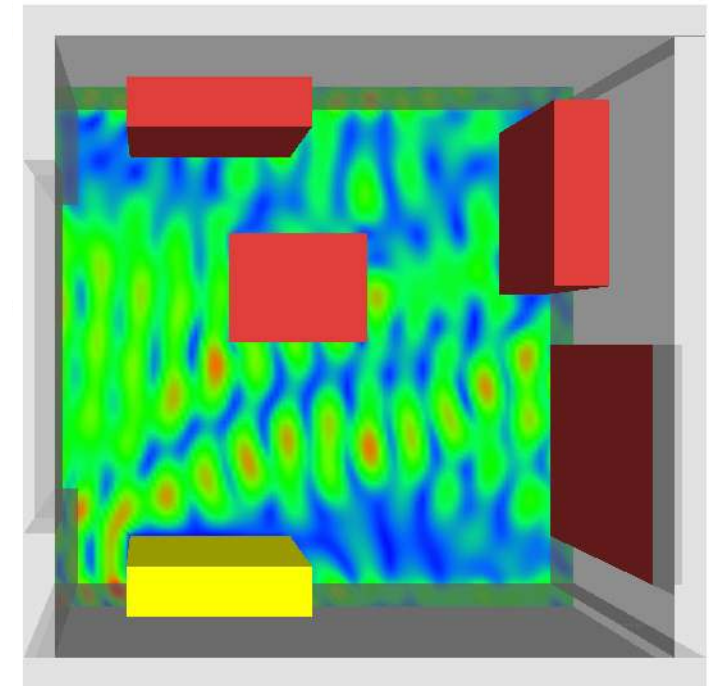
- Literature study on existing projects
- Characterisation of time and space field variations
- Development of measurement and calculation methods
 - Focus: Check of exposure limits
 - In addition: Time and space averaged exposures
- Measurements in different scenarios
- Analysis of field distribution and exposure parameters

Small scale field variation in space

Measurement: GSM 900 and UMTS



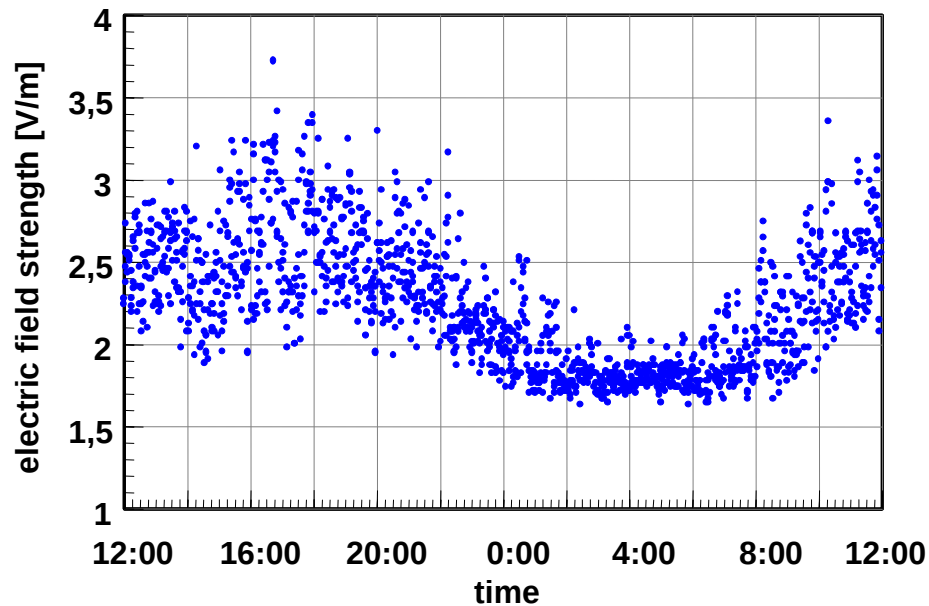
Simulation: GSM 900



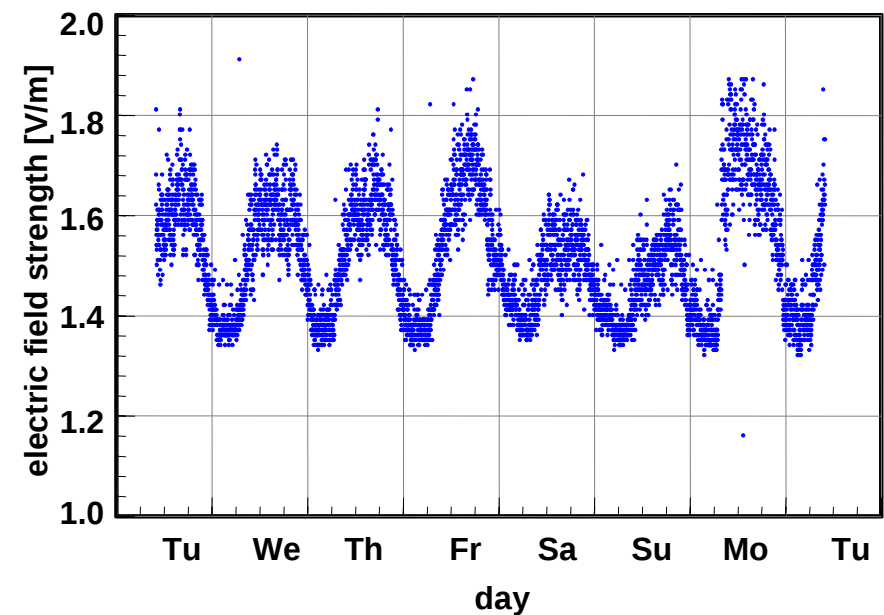
- Small scale variations (fast fading) especially at indoor scenarios due to multipath propagation
- Variations of 10 dB and more

Small and large scale variations in time

Measurement: GSM 24 hours



Measurement: GSM 7 days



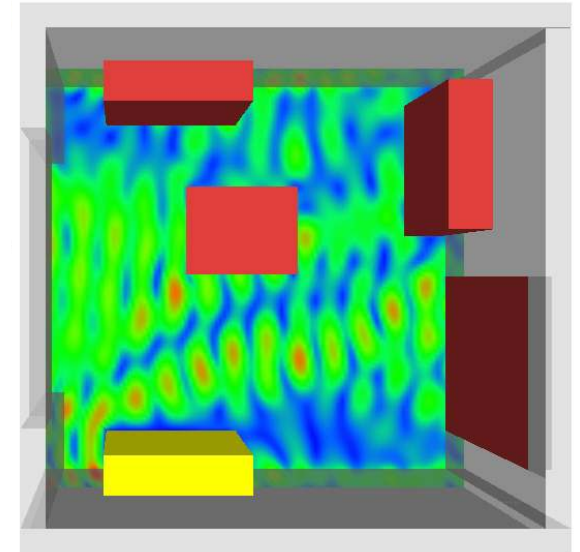
- Small and large scale variations due to traffic load (power control)

German Exposure Ordinance (26. BImSchV) demands ...

- Exposure limits are given as
 - RMS value of
 - electric and magnetic field strength
- Measurements have to be performed at the highest operational state of the station; otherwise they have to be extrapolated accordingly
- Measurements have to be performed at the place with the highest exposure
- Post processing of measurement results on basis of the maximal measured fields strengths or power densities at the measurement place

To account for the space variations

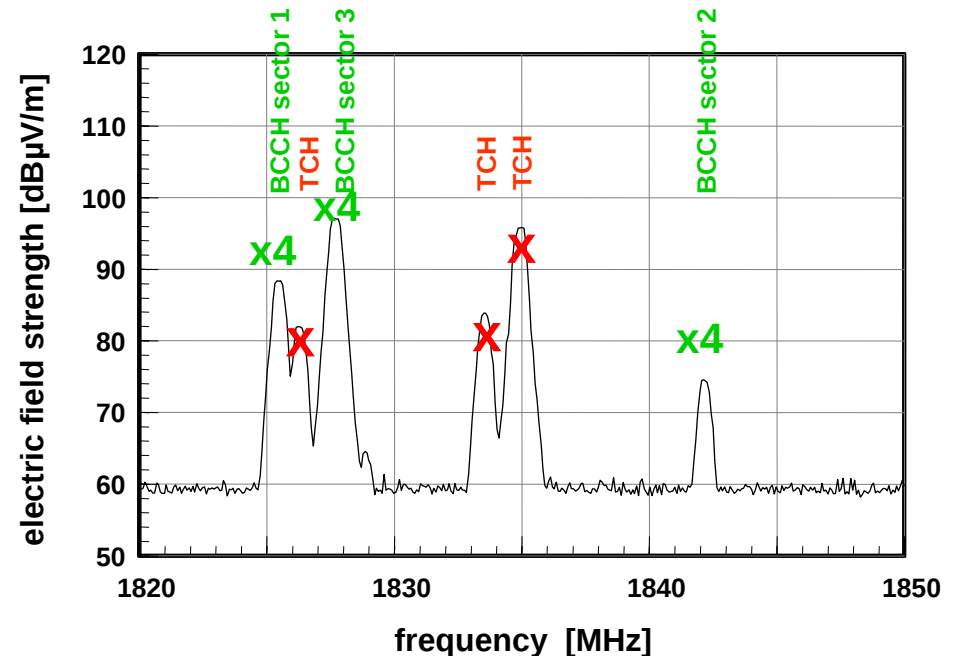
- Measurements on a fix point (e.g. antenna on a tripod) does not make sense
- Maximisation of exposure in a space volume:
 - sweeping method,
 - rotation method,
 - raster method
- Further post processing with the maximal measured value



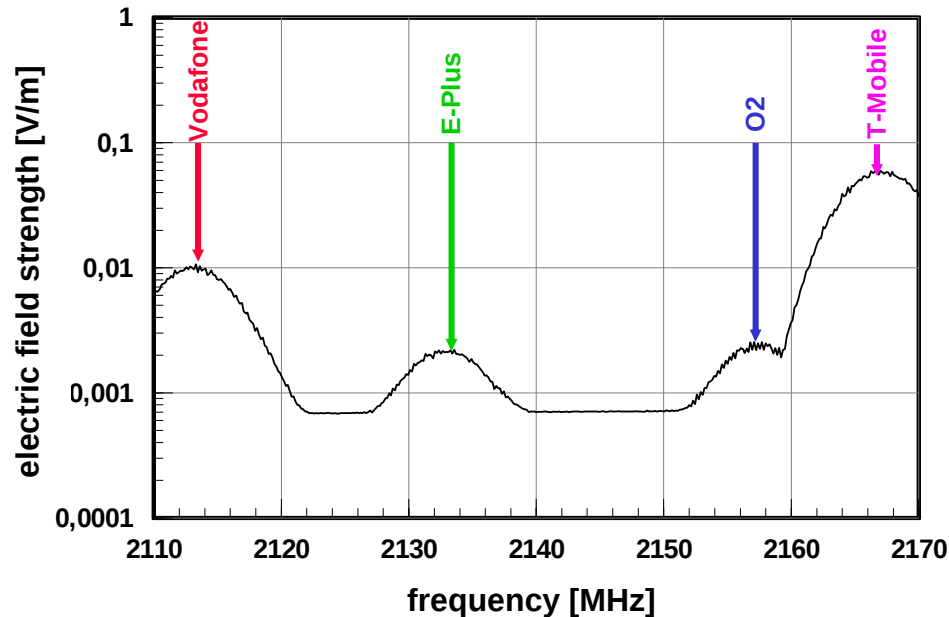
To account for the time variations: GSM

- Frequency selective equipment
- Measure time constant signalling channels (BCCH)
- Extrapolate their exposure to maximal channel number
- Ignore TCH exposure
- Summarise exposures of all sectors

➤ Frequency hopping is automatically accounted for



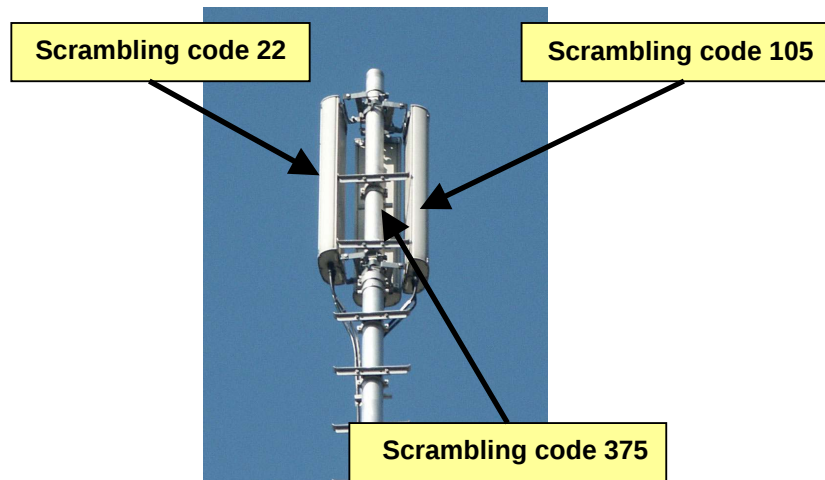
Frequency selective measurements for UMTS?



- Operators can be separated by different frequency
- Different stations cannot be separated (SFN!)
- present traffic load is not known

➤ Extrapolation to maximal operational state only possible under assumption "no traffic load"; this overestimates real exposure

Code selective measurement for UMTS!



Scr. Code	Frequency MHz	Field strength V/m	Power density $\mu\text{W}/\text{cm}^2$
22	2112.8	0.145	5.58E-03
105	2112.8	0.0106	2.98E-05
375	2112.8	0.023	1.40E-04
175	2167.2	0.047	5.86E-04
Sum (RMS):		0.1545	V/m
Max. Value:		0.1450	V/m

- Different stations/sectors are separated by "scrambling codes"
- Physical channels are separated by "spreading codes"
- P-CPICH is a permanent signalling channel with spreading code 0
- P-CPICH transmits with constant power and can be used for extrapolation

Detailed investigations of several code selective devices



Rohde & Schwarz
TSMU



Narda SRM-3000



Rohde & Schwarz
FSP/ESPI with
code-selective option

- Investigations on measurement rate, accuracy, dynamic, linearity, reproducibility, uncertainty, ...

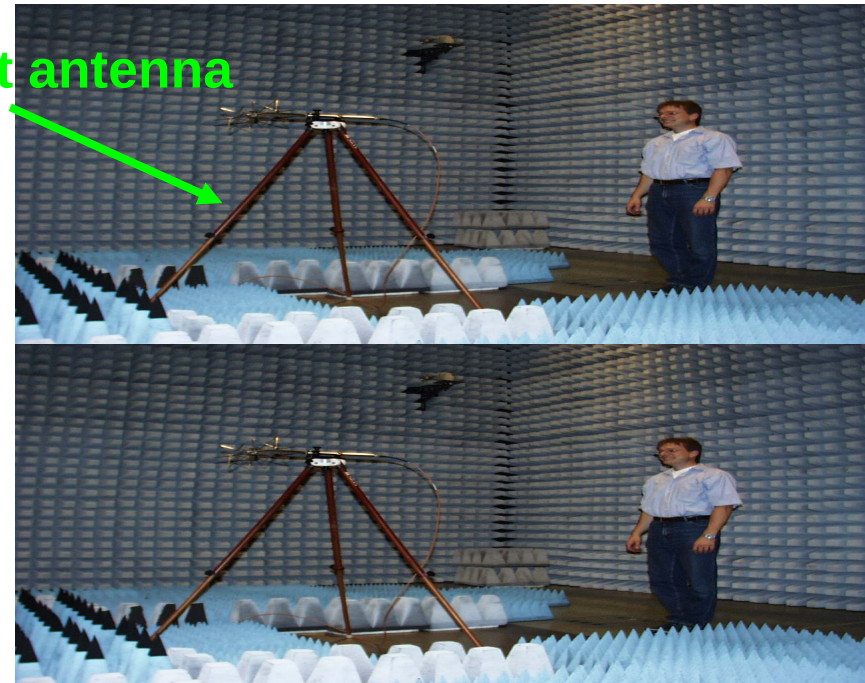
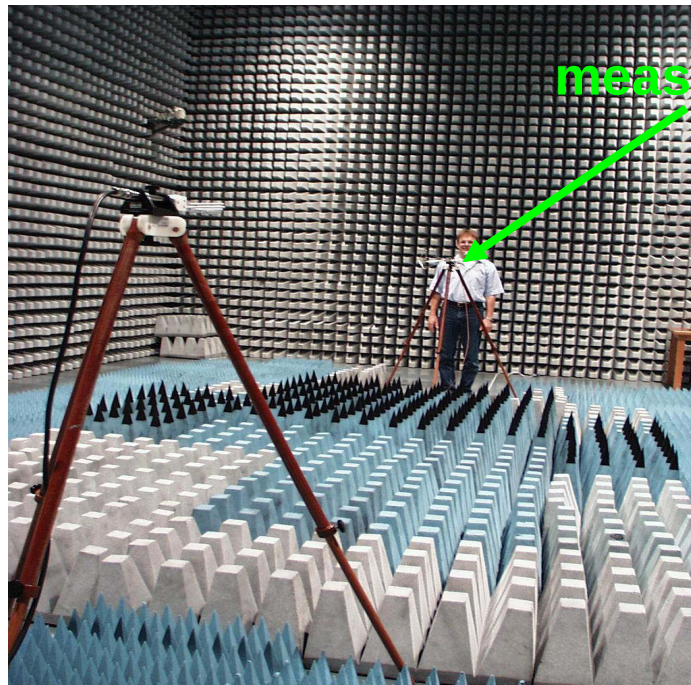
Analyser settings for spectral measurements

Setting	GSM	UMTS
RBW	200 kHz	5 MHz*
VBW	≥ 200 kHz	10 MHz
Detector	Peak or RMS	RMS
Sweep time	Auto (Peak) 100 ms (RMS)	100 ms

*: Alternatives (bandwidth correction, channel power measurement) possible, but lead to overestimations at NLOS conditions

➤ **Wrong settings can lead to wrong results (several dB to several 10 dB)**

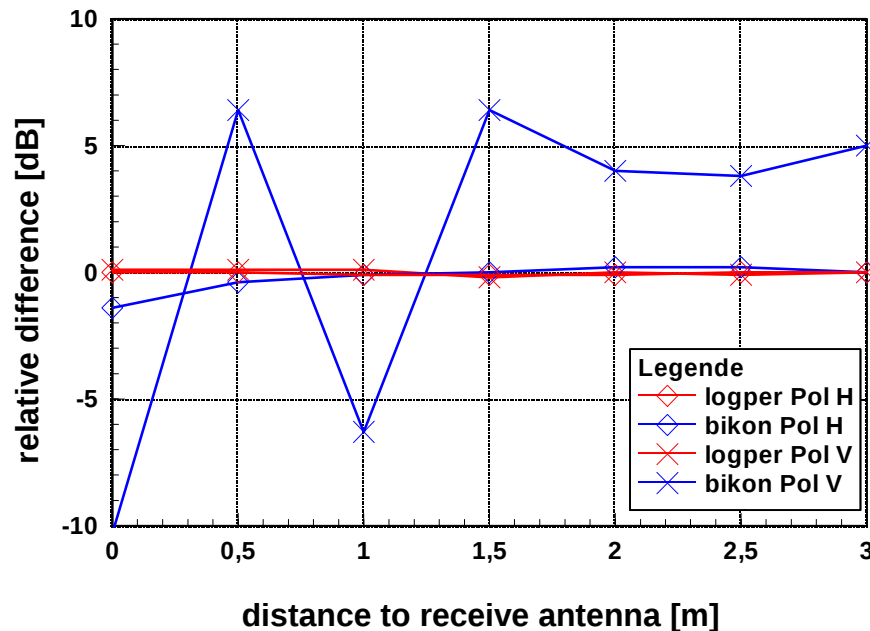
Influence of personnel on measurement antenna



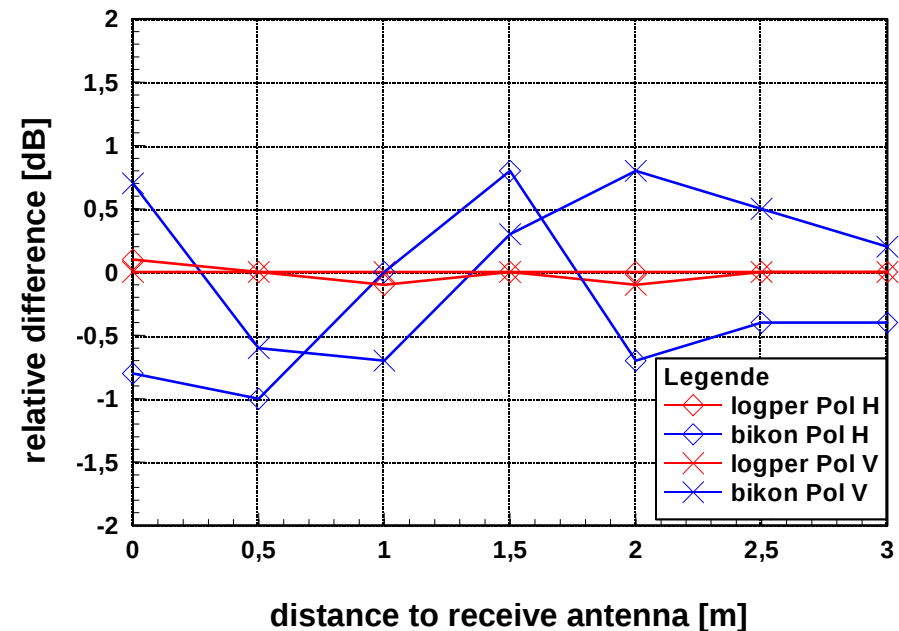
- Tests in anechoic chamber (defined environment)
- Parameters: ground plane lining, frequency, antenna type, distance of the measurement personnel

Results: Example 945 MHz (GSM 900)

w/o ground plane absorbers



with ground plane absorbers



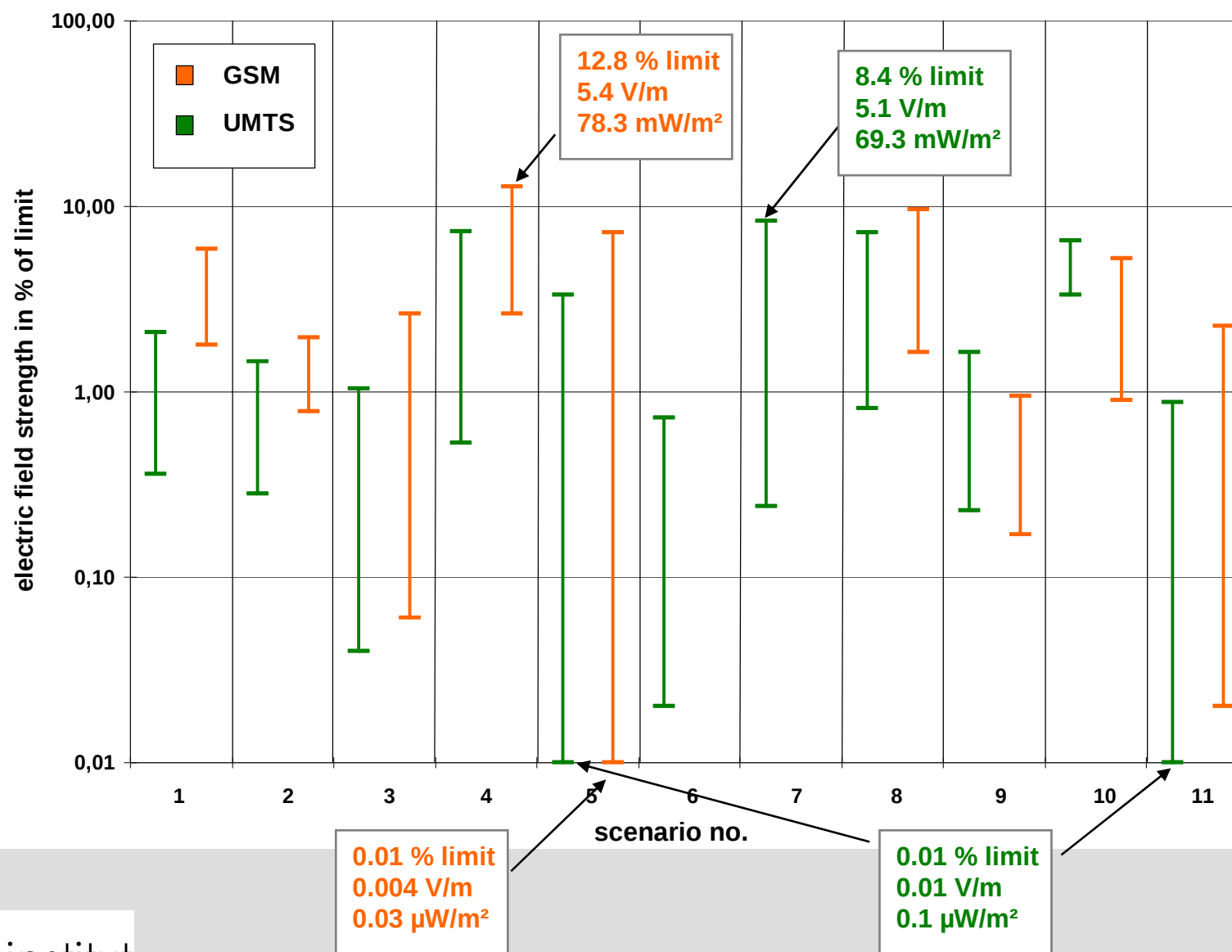
- Partially extreme influence by measurement personnel on low directive antennas
- AT UMTS frequencies: up to 3 dB difference

Measurements in 11 scenarios

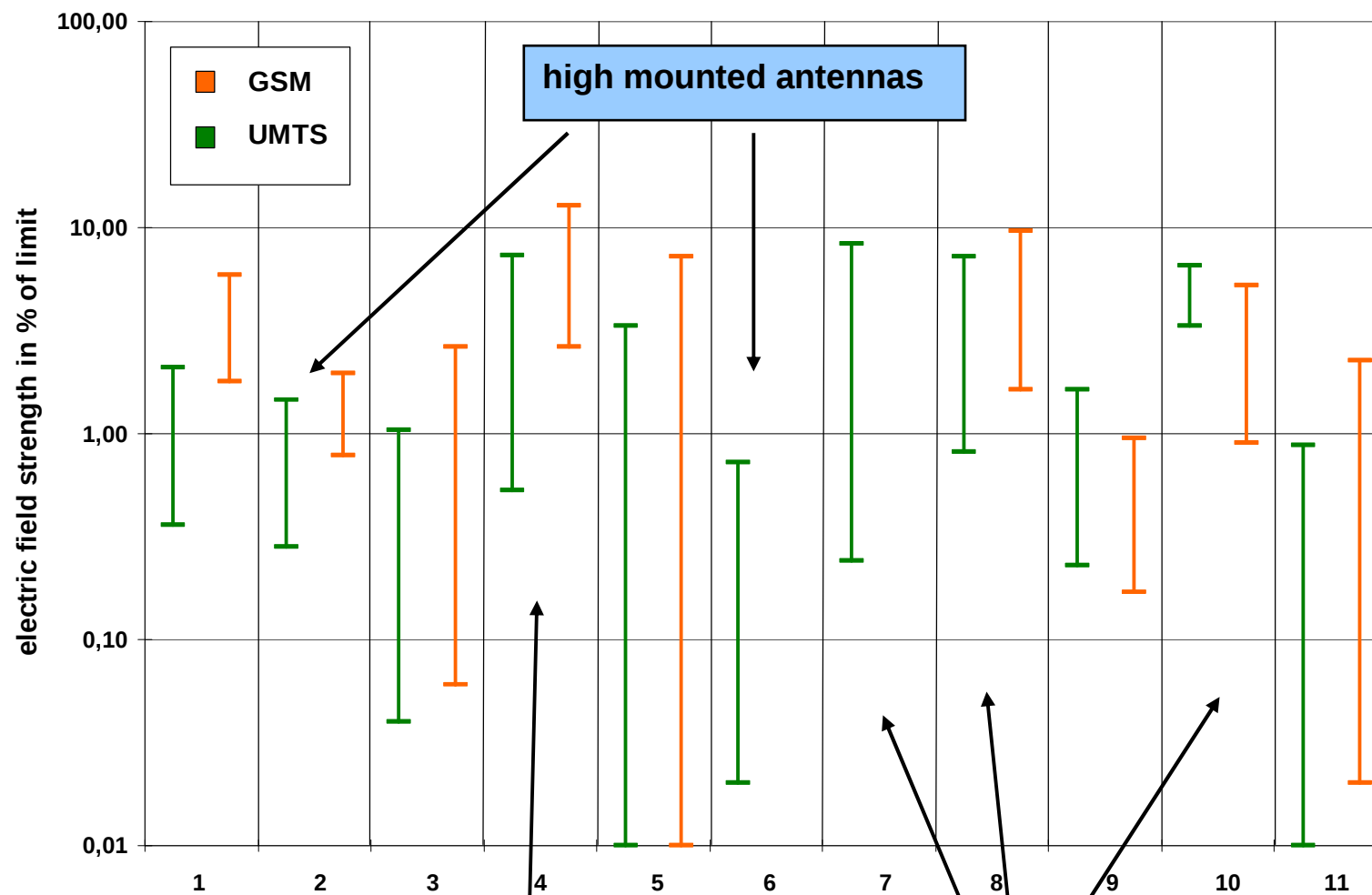
1. Low mounted station in a rural environment
2. High mounted station in a rural environment (mast installation)
3. Base station in a commercial area
4. Low mounted station in an urban environment
5. High mounted station in an urban environment
6. Ultra high site
7. Station for indoor coverage
8. Station for coverage of a football stadium
9. Station for coverage of an exhibition hall
10. Station for coverage of a pico cell
11. Station on a roof and exposure measurements in the building below

➤ **UMTS and GSM base stations are at the same site!**

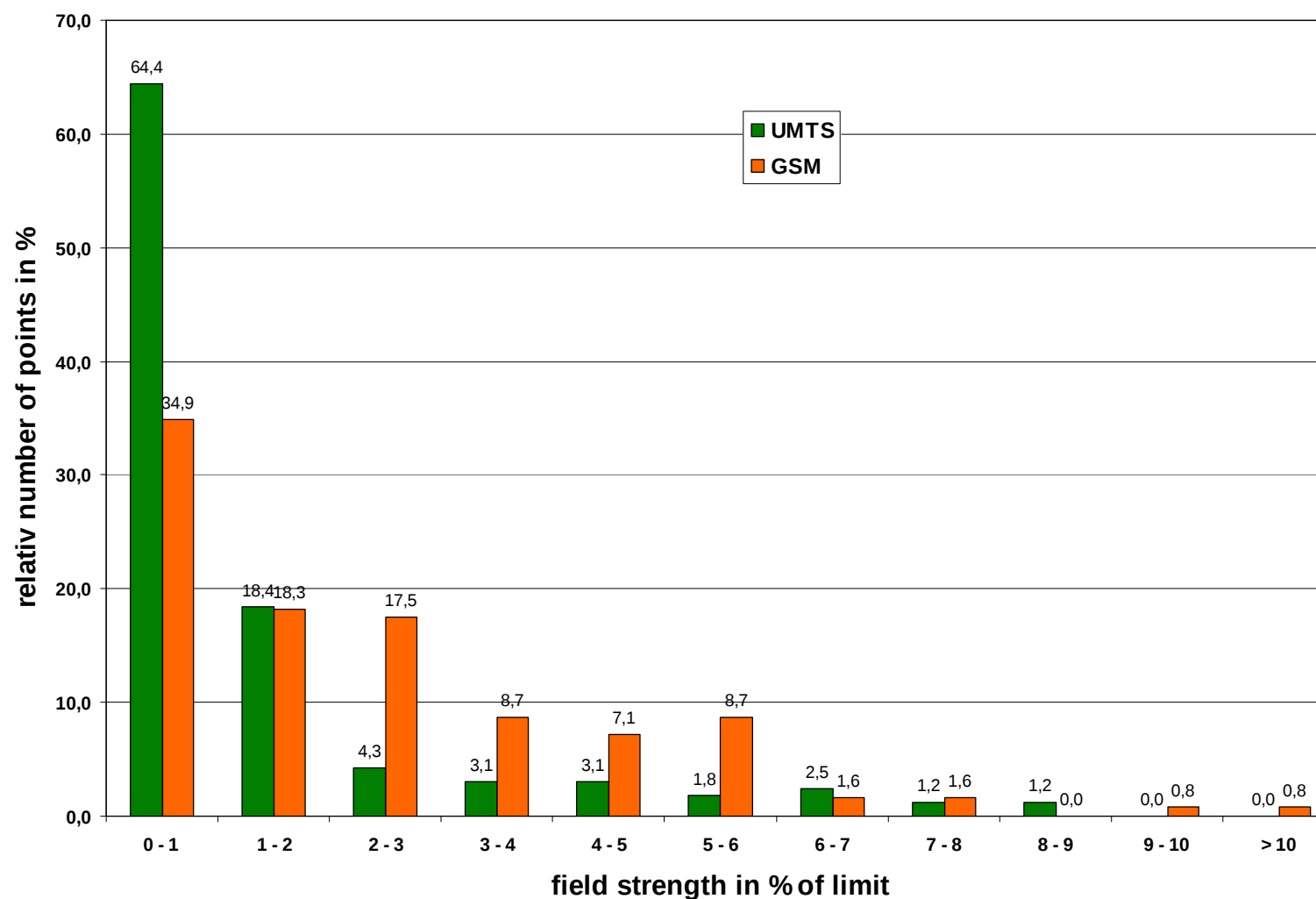
Results: GSM/UMTS Min/Max



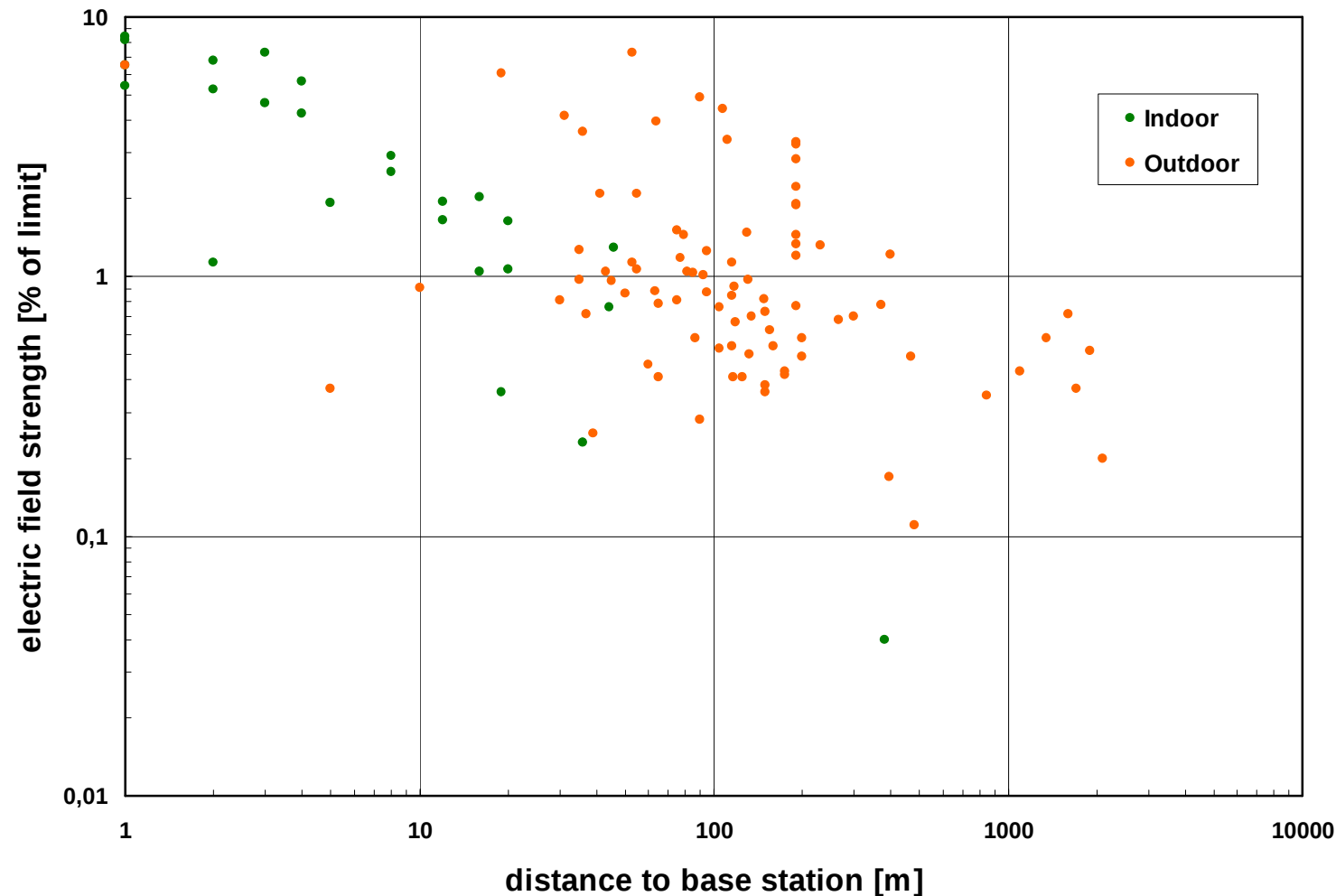
Discussion



Distribution of results

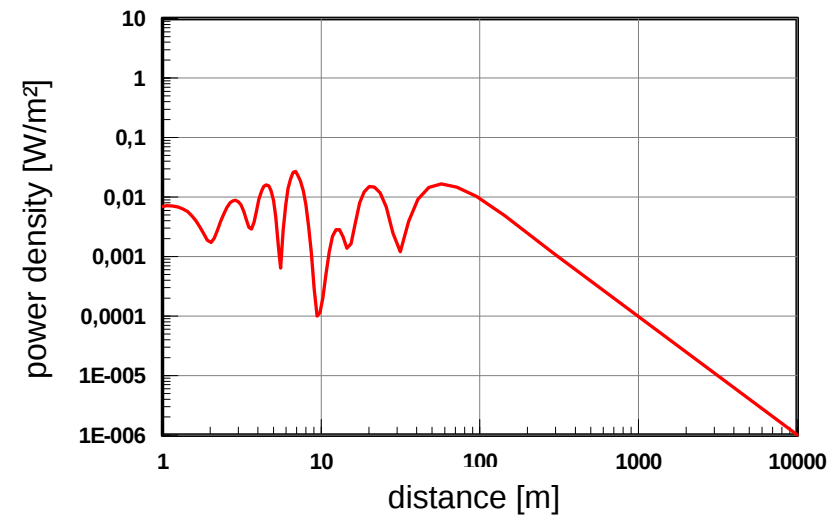
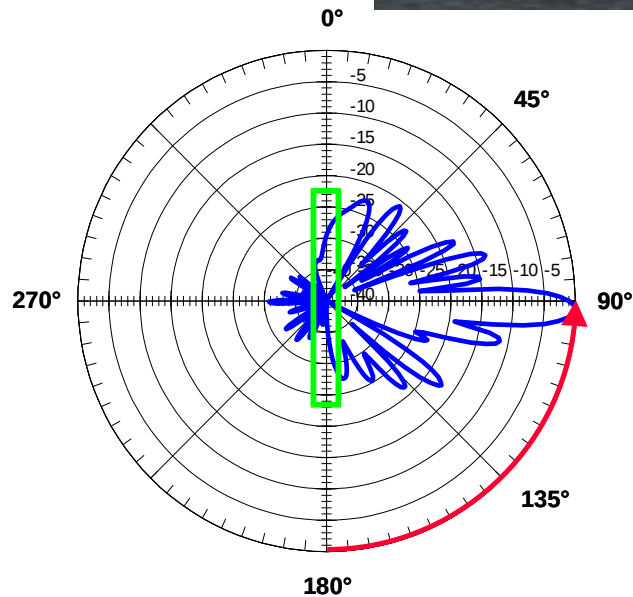
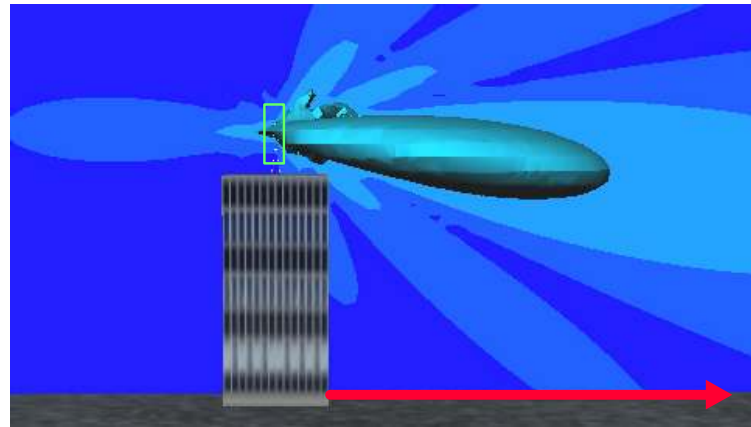


Distance as a main factor for exposure?

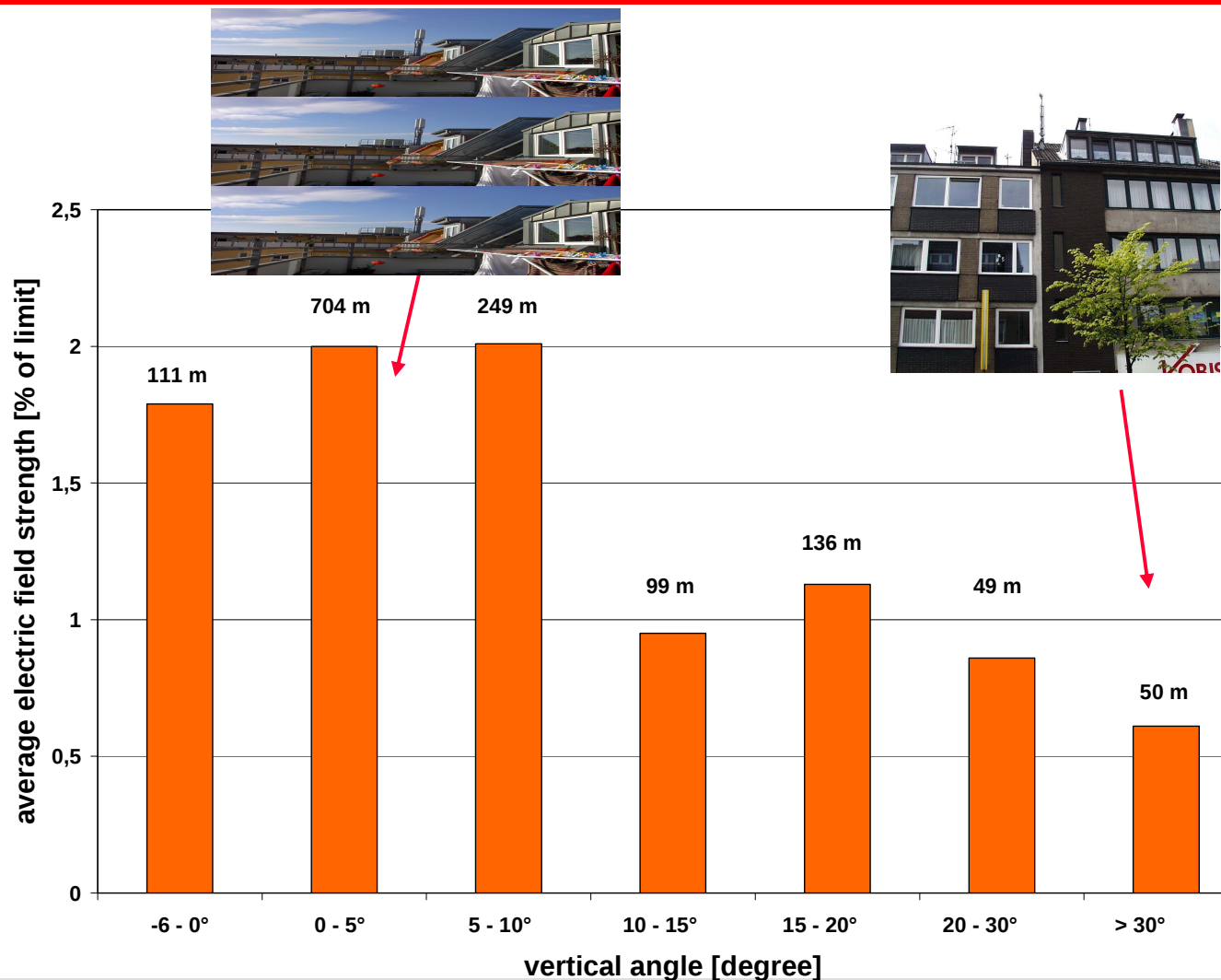


Answer: Outdoor no (up to approx. 200 m)
Indoor yes

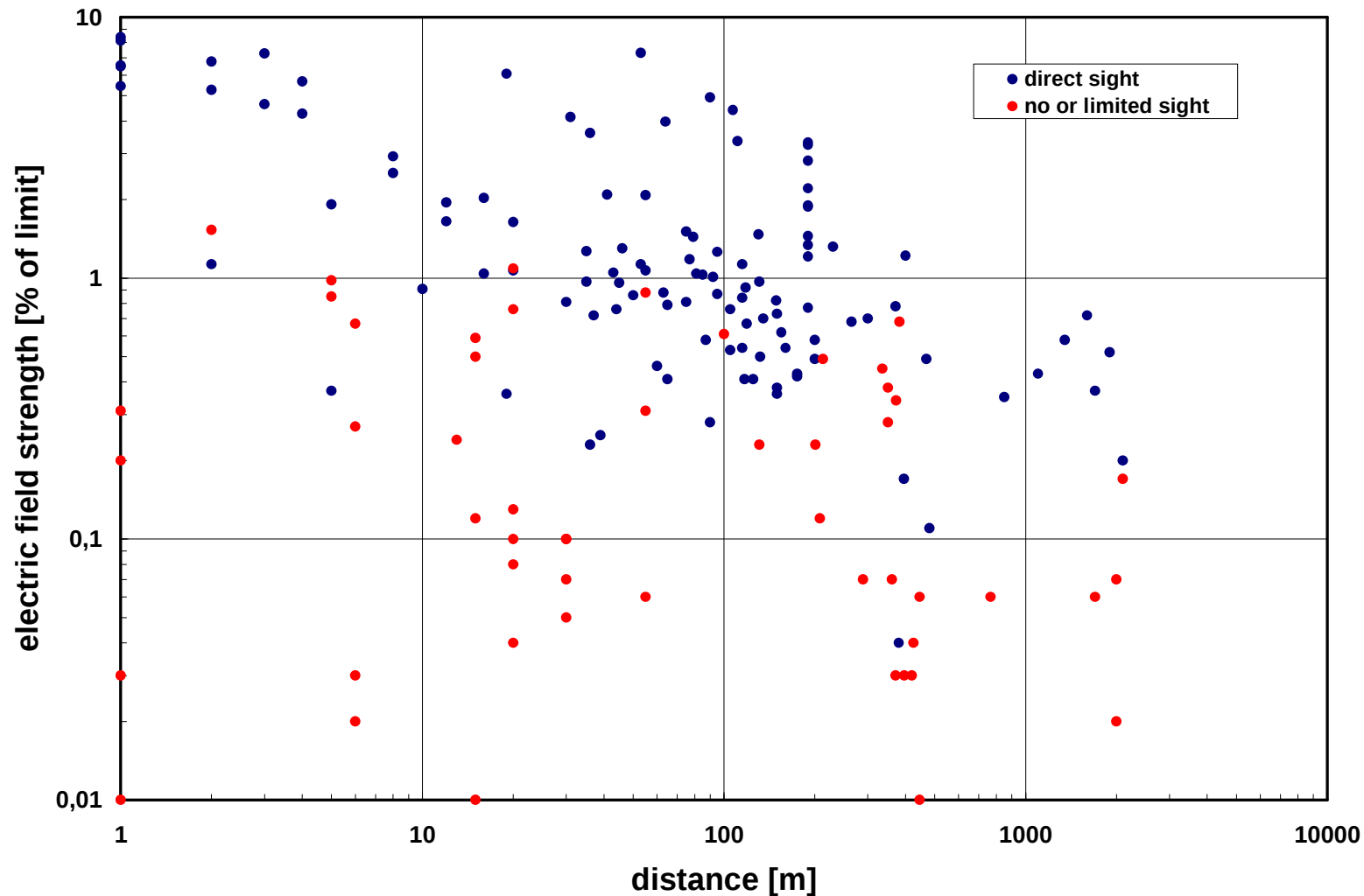
Explanation



Vertical angle as a main factor for exposure?

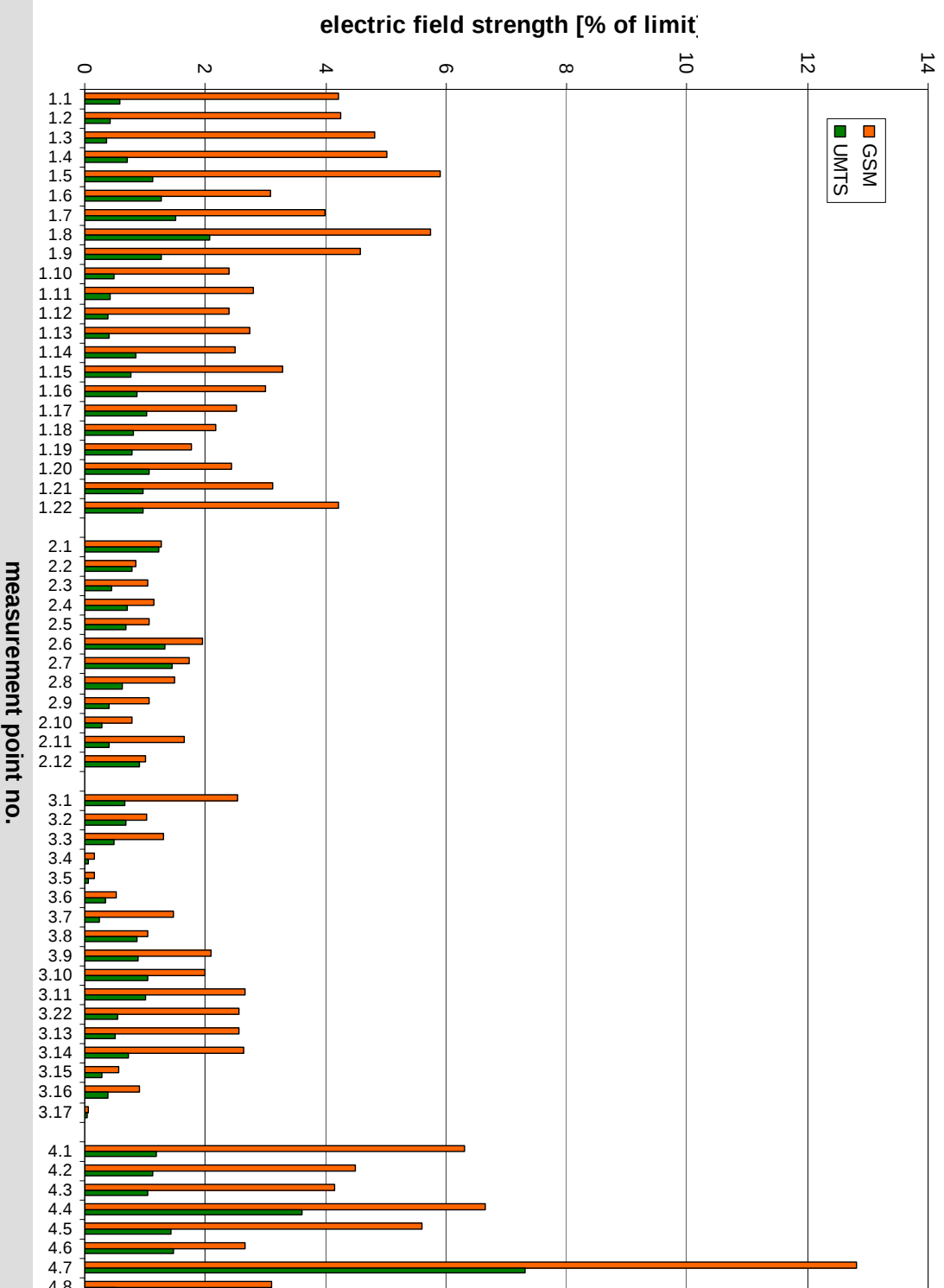


Sight conditions as a main factor for exposure?

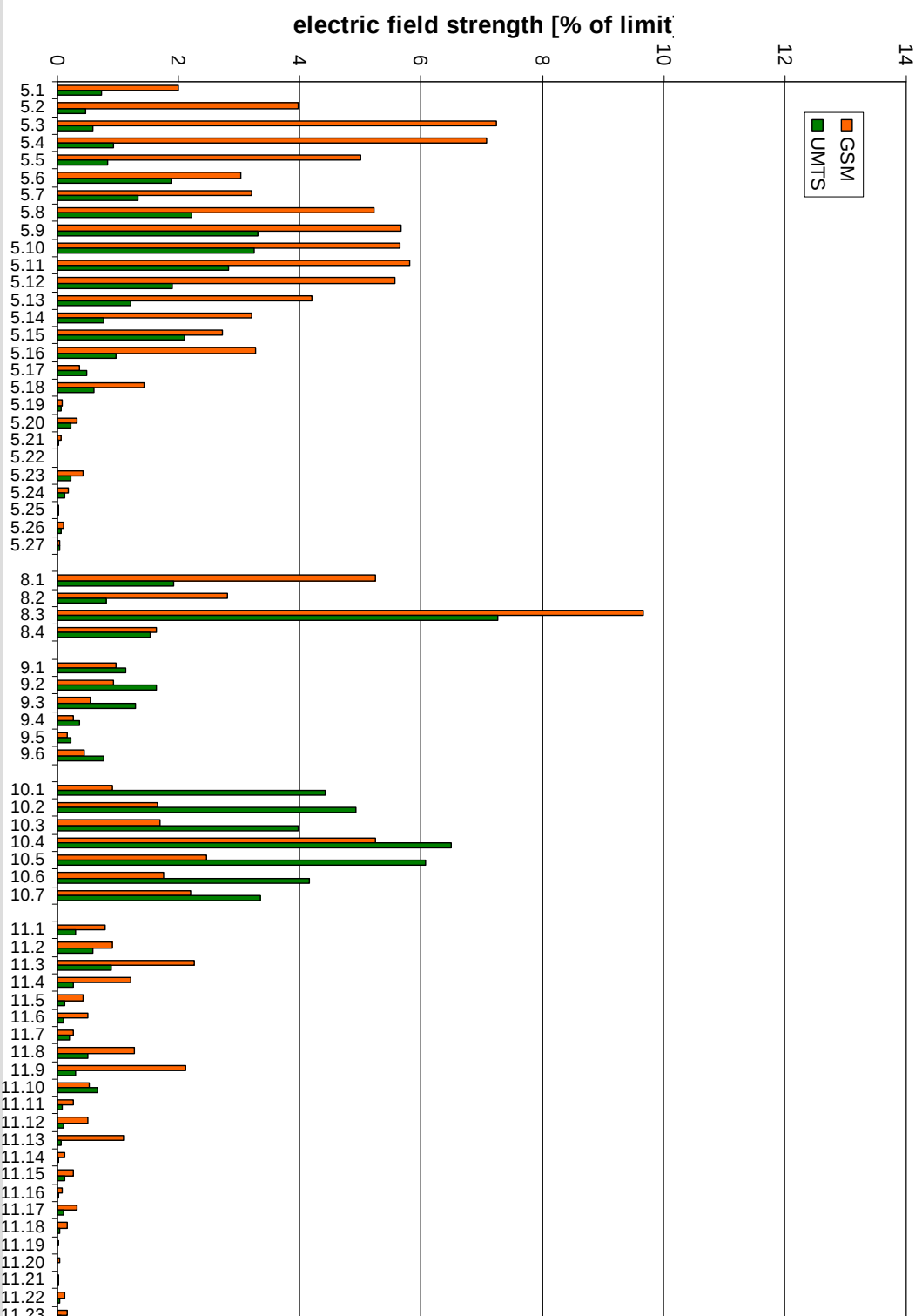


Answer: Yes, but reflections have to be taken into account!

Relation of GSM / UMTS exposure (1)

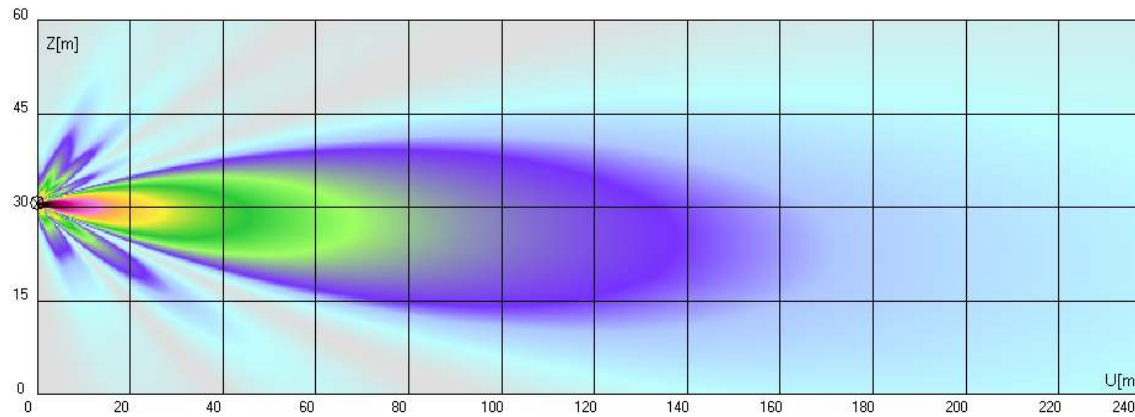


Relation of GSM / UMTS exposure (2)



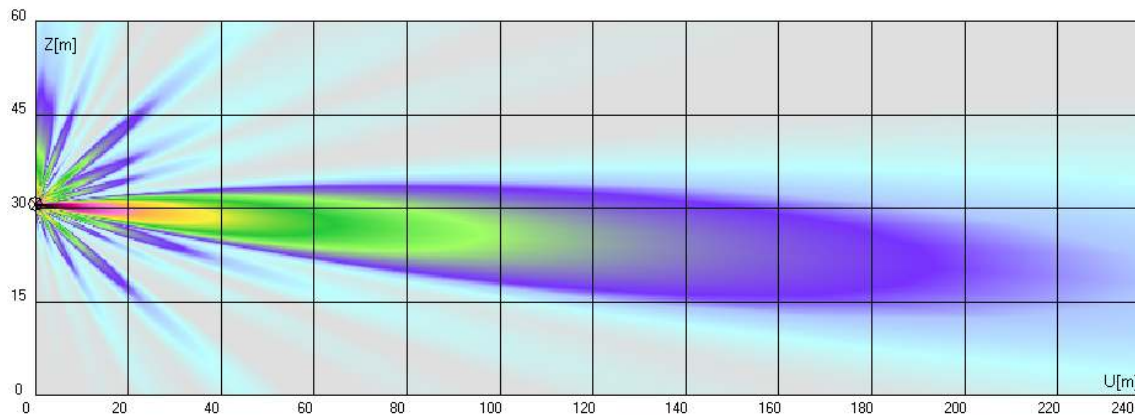
measurement point no.

Broader main lobe of GSM 900 compared to UMTS



GSM900:

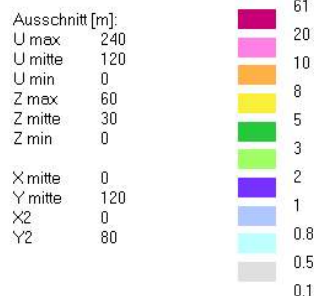
- Mounting height 30 m
- Antenna K 739 681
- Downtilt 3°
- Transmit power 20 W



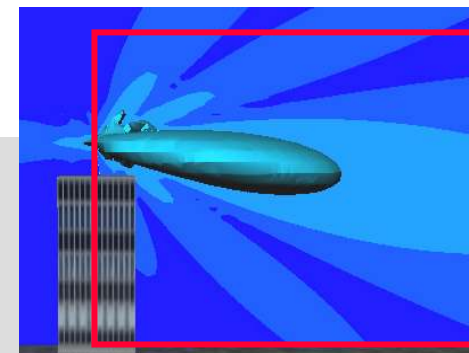
UMTS:

- Mounting height 30 m
- Antenna K 742 212
- Downtilt 3°
- Transmit power 20 W

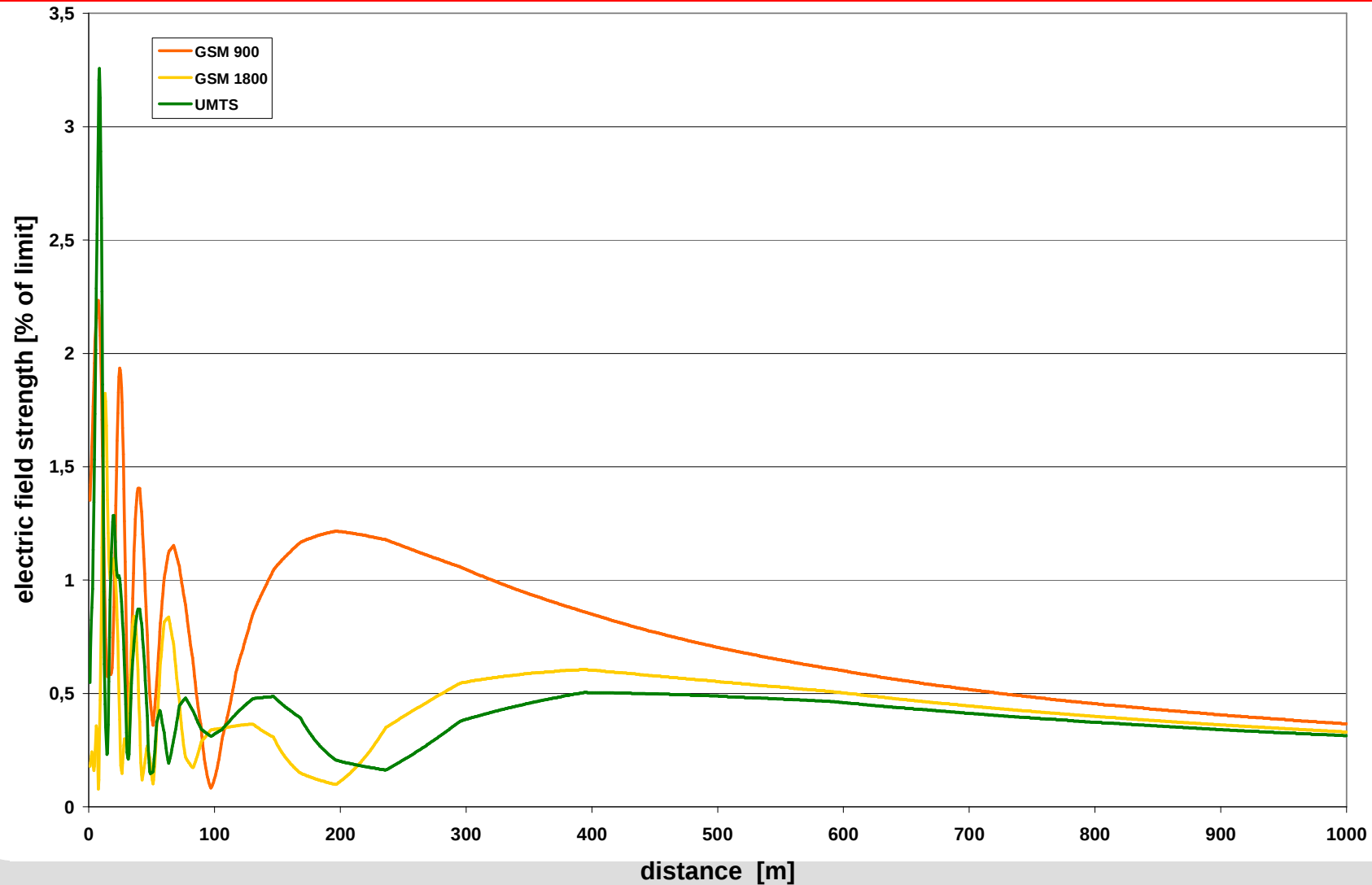
Elektr. Feldstärke E [V/m]



Simulation with FieldView, EM-Institut GmbH



Simulated distance profile



Calculation methods: Commercial software

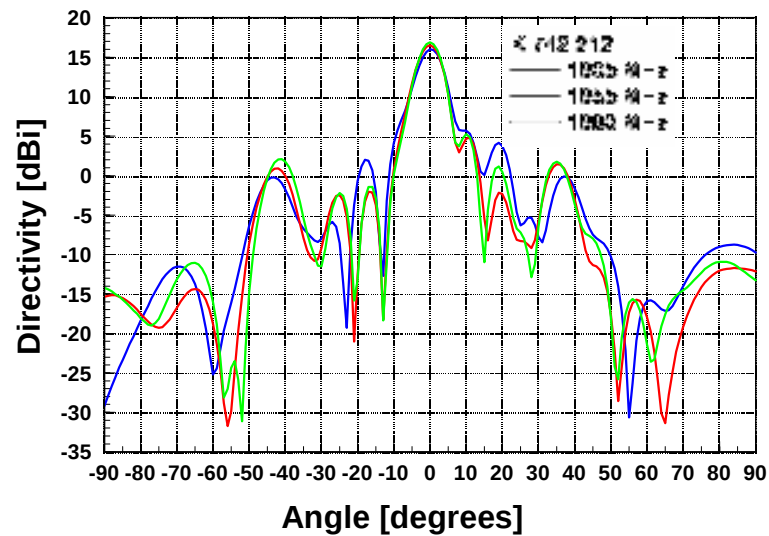
Central question:

Suitability of calculation methods to determine the public exposure due to electromagnetic fields around (outside the regulatory safety distance) cellular GSM and UMTS base station transceivers

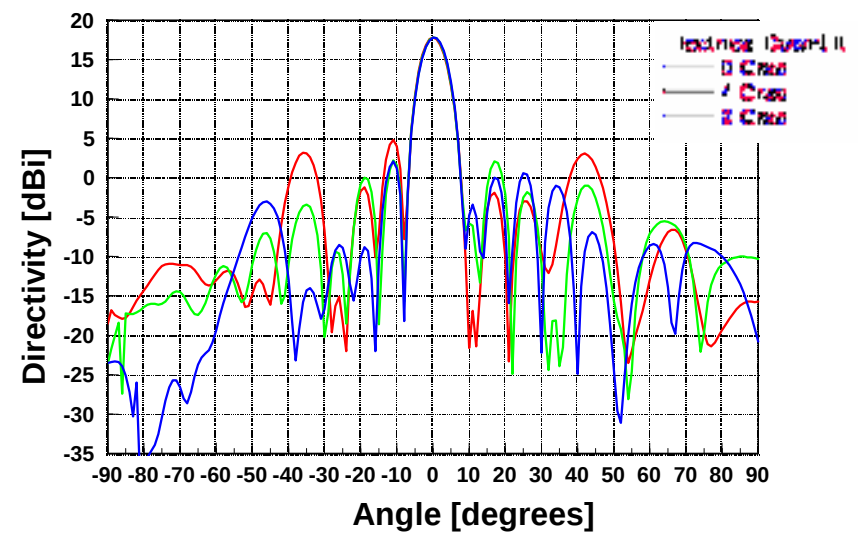
Software	Method	Manufacture	Application
EFC-400	Ray-Optical without phase	FGEU	Exposure (GSM+UMTS)
EMF-Visual	Ray-Optical	Antennessa	Exposure (GSM)
Empire	FDTD	IMST	Installation vicinity + small scale
Feko	Hybrid (e.g. MoM, UTD)	EM Software & Systems	Installation vicinity
FieldView	Free space	EM-Institute	Exposure (GSM+UMTS)
Quickplan	Ray-Optical	TES	Exposure (GSM+UMTS)
Winprop	Ray-optical and empirical	AWE - communications	Exposure (UMTS)
Wireless Insite	Ray-optical with phase	Remcom	Exposure (GSM+UMTS)

Antenna pattern

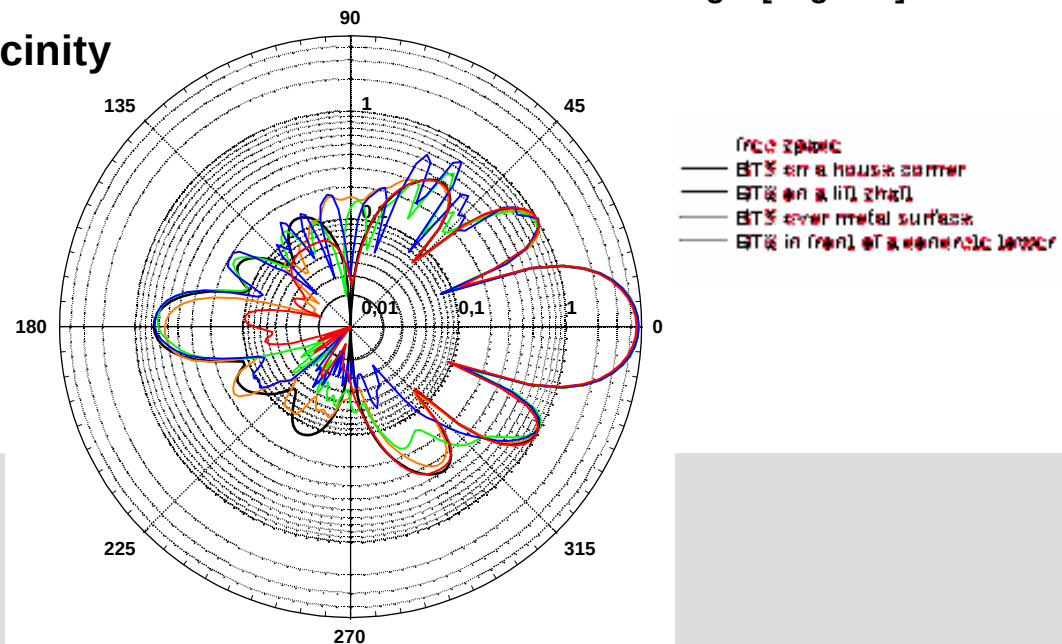
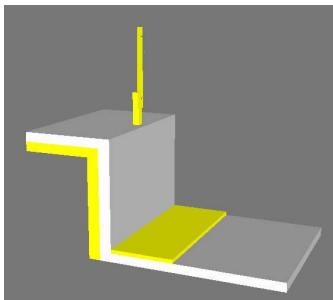
1. Dependency on frequency



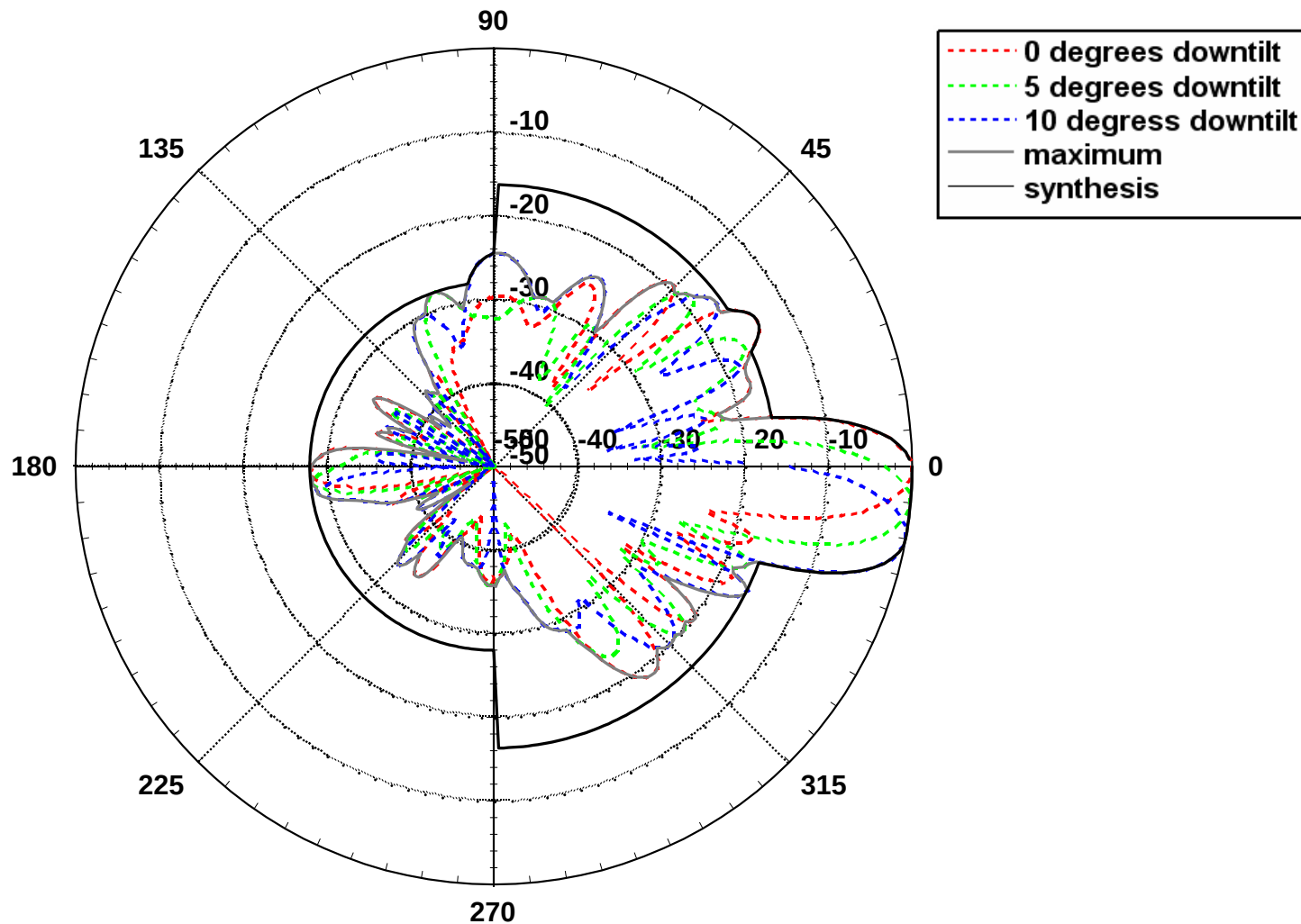
2. Dependency on electr. downtilt



3. Dependency on installation vicinity



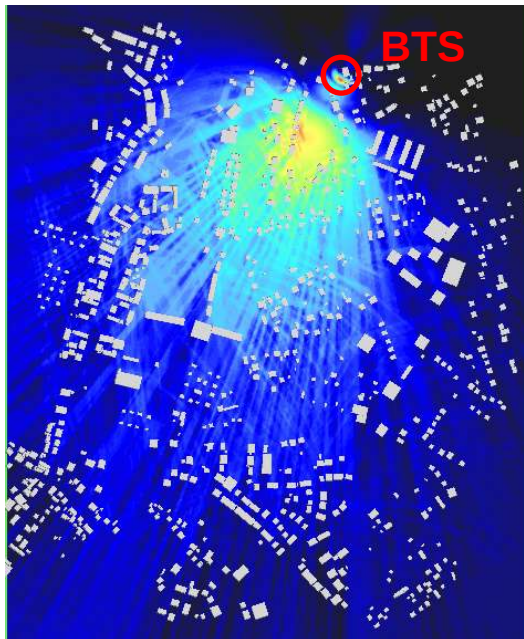
Antenna pattern: Synthesis



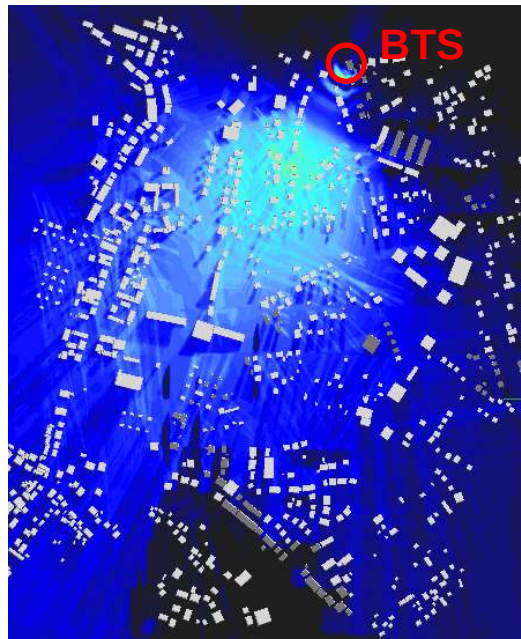
Influence of the terrain profile

Simulation result with EFC-400:

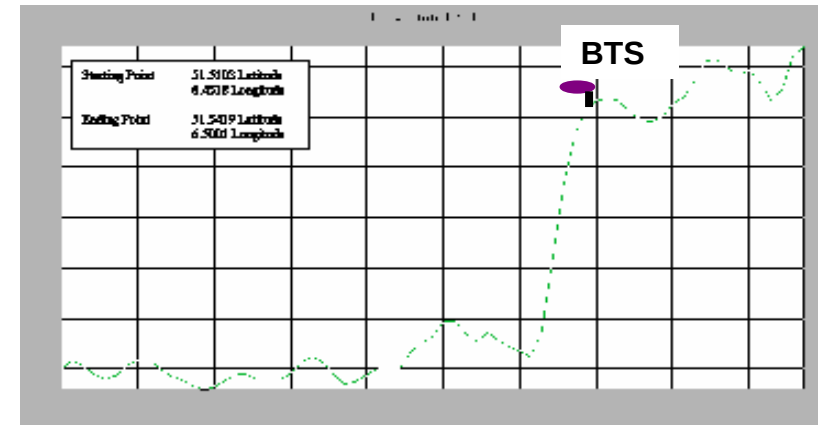
without terrain data



with terrain data



Terrain profile



Building information

Satellite picture



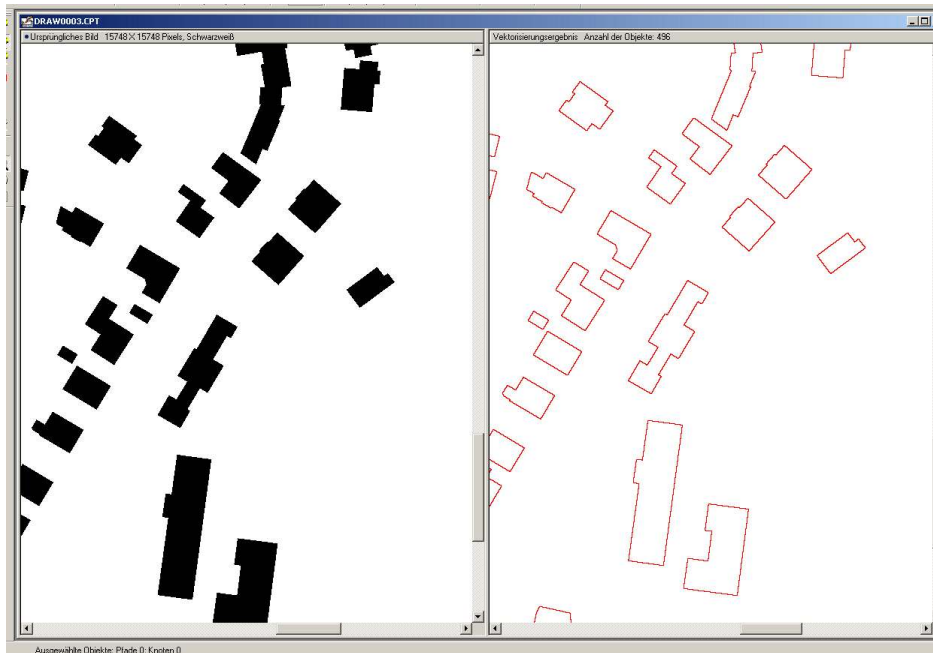
Black-White picture from land register



Import in Winprop and Quickplan

Building information: „Vectorisation“

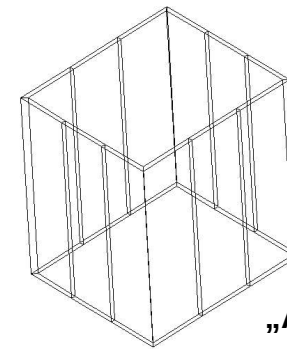
Vectorising the black building shapes



„Corel Draw“

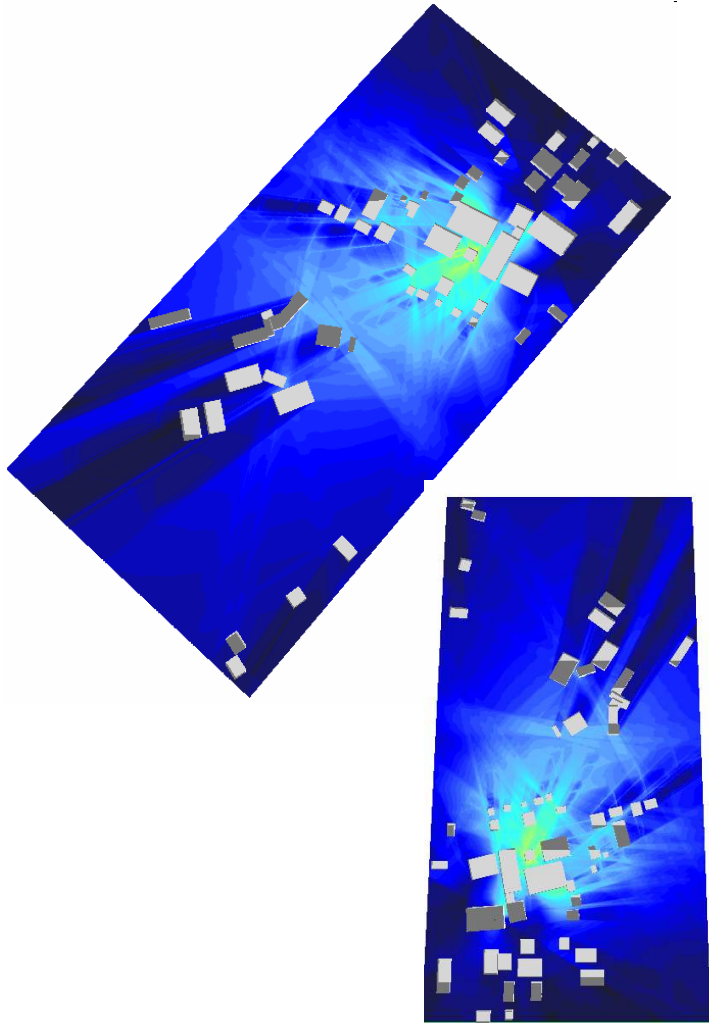
Import in EFC-400

Generate 3rd dimension



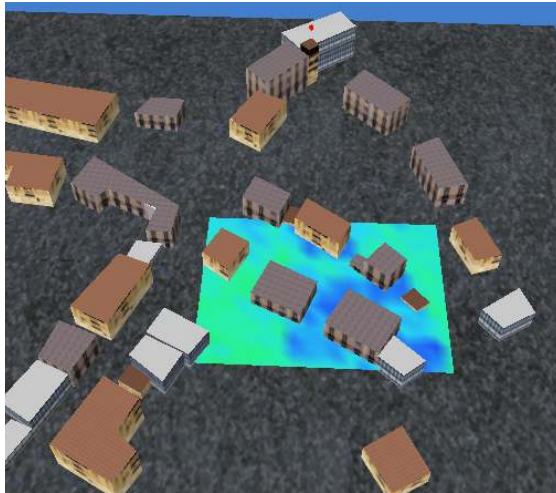
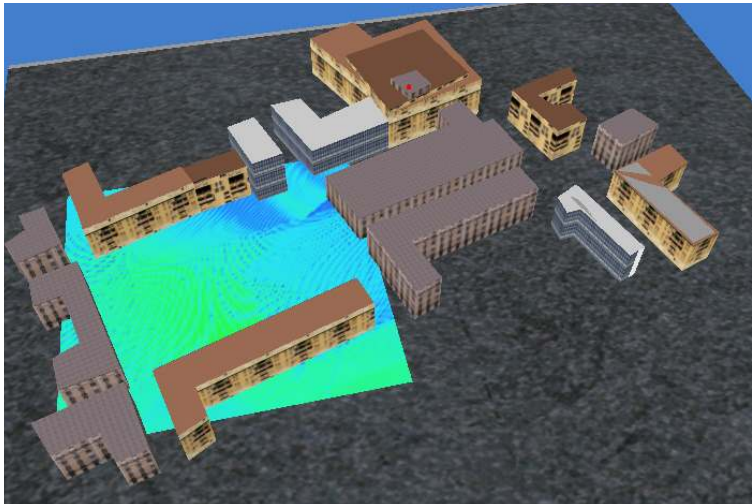
„Autocad“

Import in Wireless Insite



EFC-400 (FGEU)

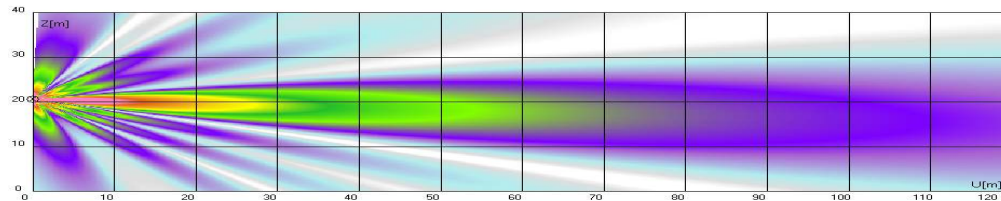
- Ray-optical without phase information
- Consideration of
 - Terrain data: yes
 - Building data: yes
 - Synthesised pattern: yes
- Indoor and outdoor configurations
- Import of a huge number of buildings in vector format possible
- Only rectangular buildings
- 3D plot may be optimised



EMF Visual (Antennessa)

- Ray-optical with phase information
- Consideration of
 - Terrain data: no
 - Building data: yes
 - Synthesised pattern: no
- Indoor and outdoor configurations
- User-friendly method to generate buildings (e.g. on the basis of satellite pictures)
- Buildings only as decoratives, including requires further steps (former version); results in large computation time
- Input data not geo-referenced

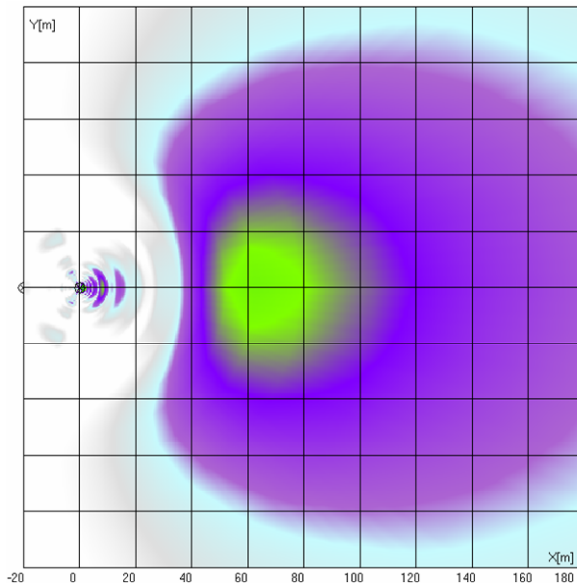
FieldView



Elektr. Feldstärke E [V/m]

Ausschnitt [m]:	10
U max:	120
U mitte:	60
U min:	0
Z max:	40
Z mitte:	20
Z min:	0
X mitte:	0
Y mitte:	60
X2:	0
Y2:	40

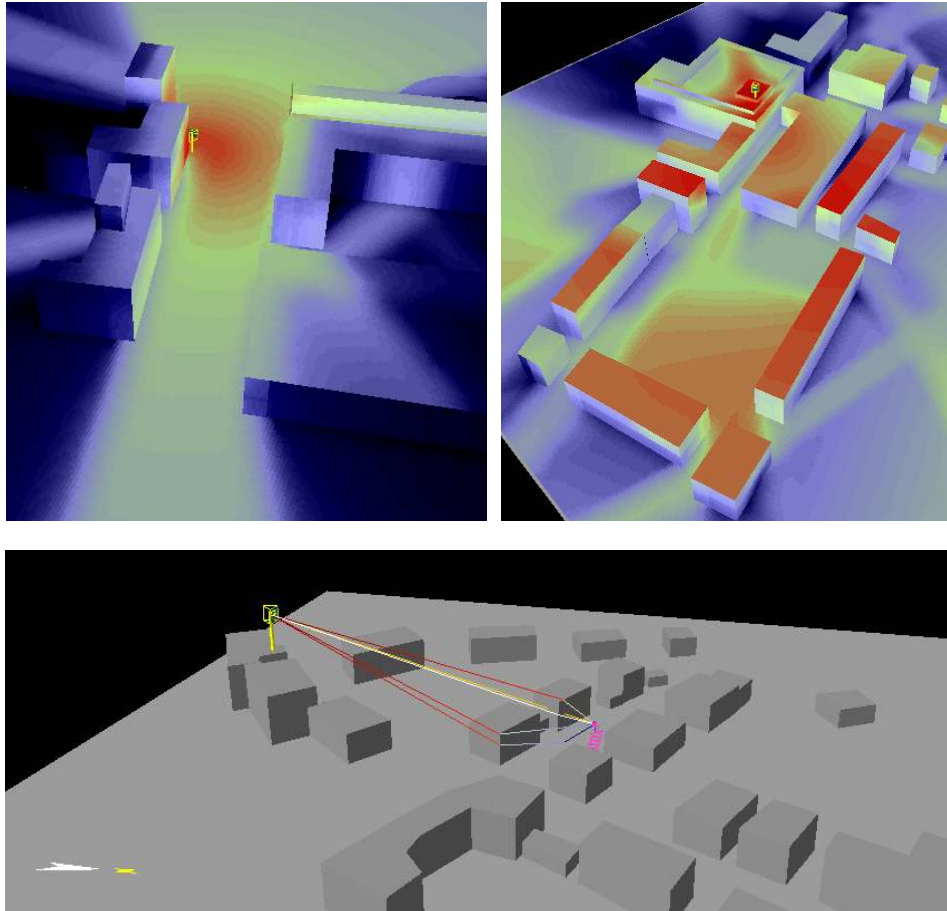
Sendeleistungszuschlag [dB] 0.0



FieldView (EM-Institute)

- Free-space
- Consideration of
 - Terrain data: no
 - Building data: no
 - Synthesised pattern: yes
- Calculations in every vertical and horizontal plane is possible
- Additional factor on the transmitted power possible
- Propagation mechanisms other than free space not taken into account

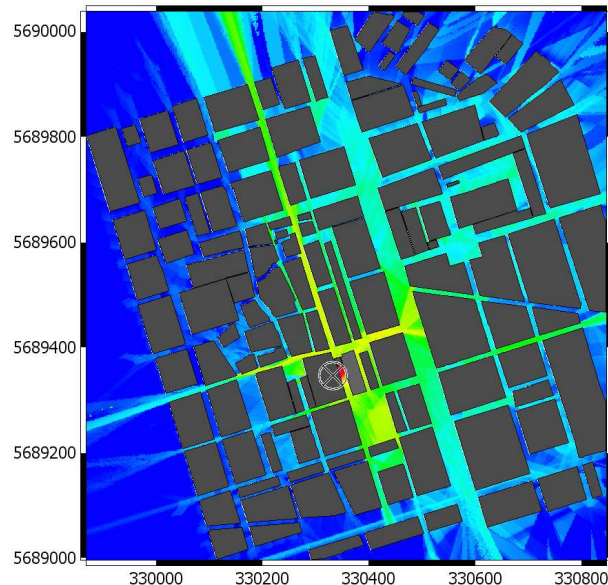
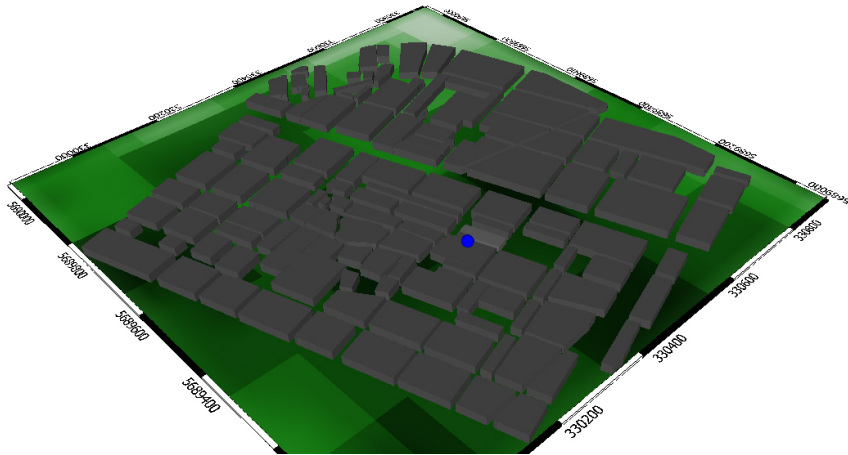
Quickplan



Quickplan (Tes)

- Ray-optical with phase information
- Consideration of
 - Terrain data: yes
 - Building data: yes (automatic generation on the basis of black shapes of the buildings possible)
 - Synthesised pattern: yes
- Different calculation models
 - Surface (left top): dominant path
 - Testpoint (left bottom): „all“ paths
- No indoor configurations
- Simple calculations cumbersome (everything must be geo-referenced!)

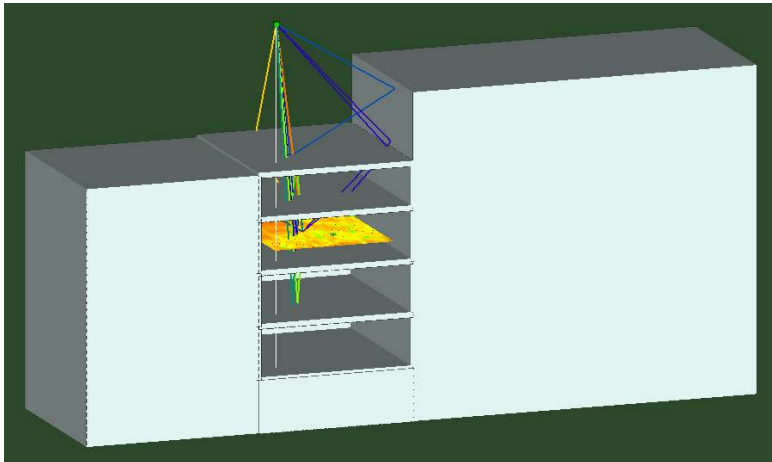
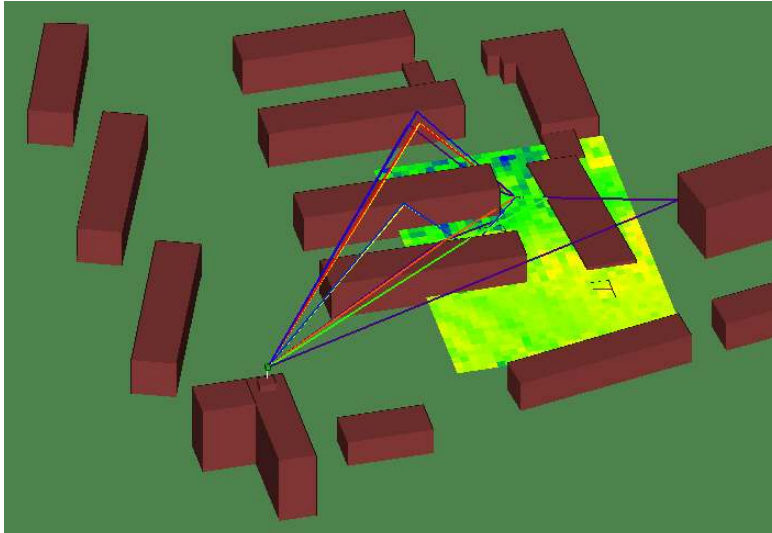
Winprop



Winprop (AWE-Communications)

- Ray-optical with phase information and empirical
- Consideration of
 - Terrain data: yes
 - Building data: yes (automatic generation on the basis of black outlines of the buildings possible)
 - Synthesised pattern: yes
- Indoor and outdoor configurations
- Includes a pre processing step to reduce calculation time
- Only horizontal planes possible
- Possibility of change in calculation parameters requires extended user knowledge

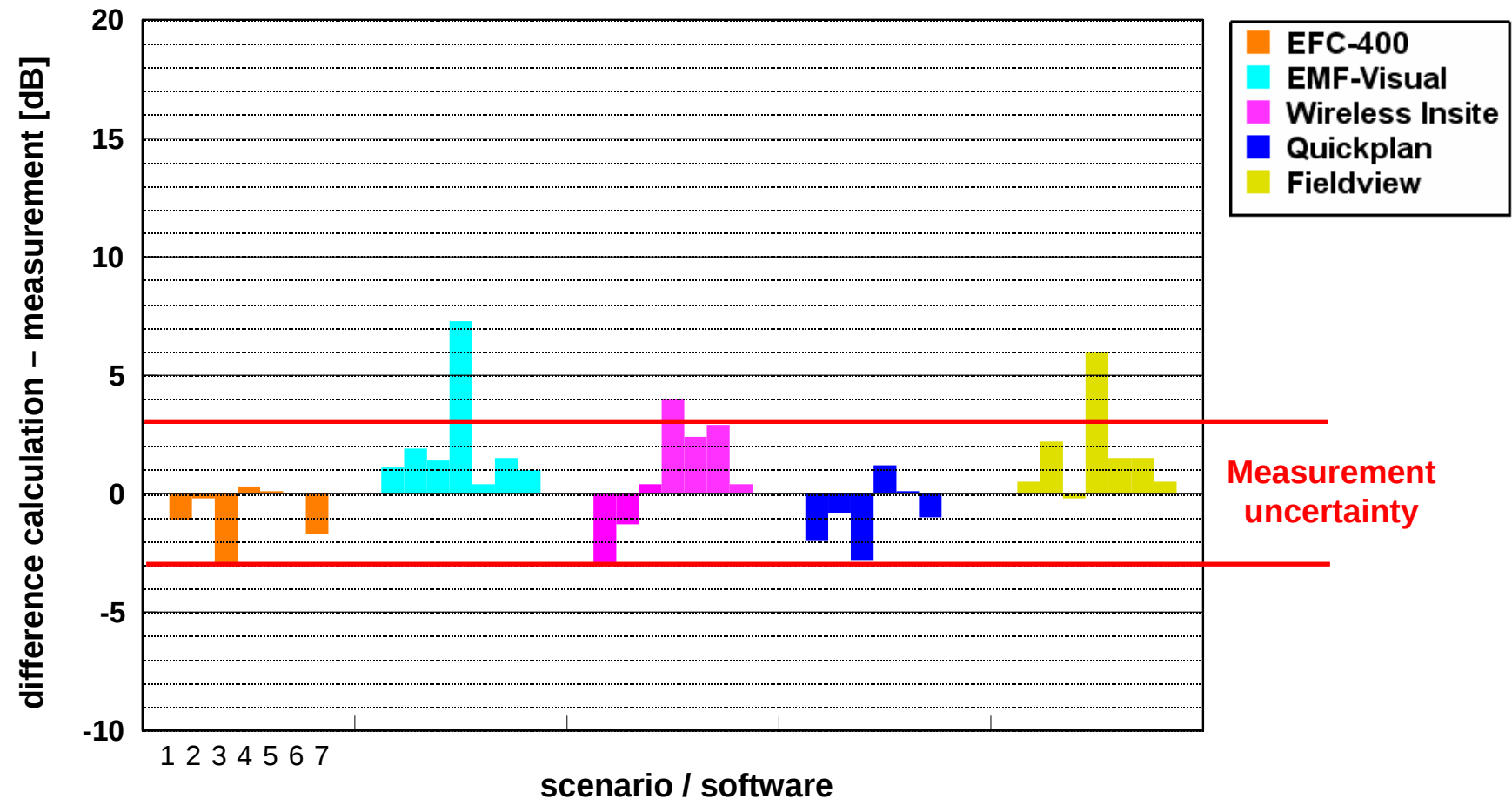
Wireless Insite



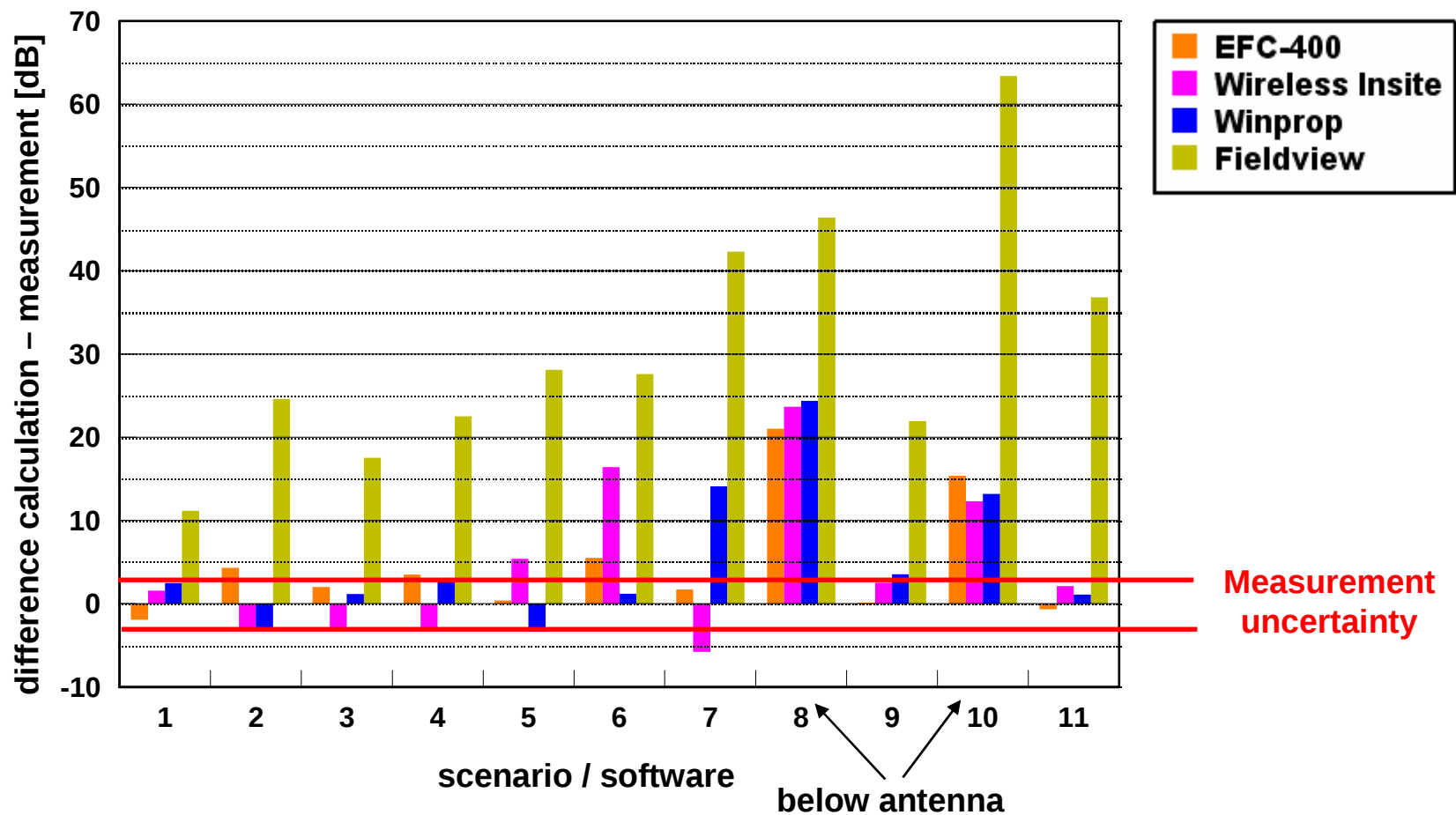
Wireless Insite (Remcom)

- Ray-optical with phase information
- Consideration of
 - Terrain data: yes
 - Building data: yes
 - Synthesised pattern: yes
- Indoor and outdoor configurations
- Import of a huge number of buildings in vector format possible
- Includes a database of different materials
- Not suited for large area computations (computation time!)
- Problems in including msi-files

Results: Line of sight situations (GSM)



Results: Non line of sight situations (UMTS)



Outlook: Application of results

Project: Investigation of sleep quality in persons living near a mobile base station – Experimental study on the evaluation of possible psychological and physiological effects under residential conditions
(Management: Charite – Universitätsmedizin Berlin)

Objective:

- study of diverse sleep parameters in groups near BTS
- double blind study
- artificial mobile phone base station signal
- measurement of exposure: artificial base station, other base stations, other RF exposure
- 60 persons x 6 base station sites