General public exposure to electromagnetic fields generated by mobile phone base stations: A simple model

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Agenda:

- Motivation
- Model properties
- Results:
  - field distributions
  - probability density distributions
  - medians / parts of populations exposed over 1 V/m
- Extrapolation to different average powers per cell
- Conclusions

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Motivation:

- Assessment of electromagnetic fields (EMF) generated by mobile phone networks: by measurements?
  - huge spatial variations (interference)
  - temporal changes (traffic, uncontrolled parameters) of the signal strength
  - quite important uncertainty
  - results depend on the chosen measurement procedure / equipment

➢ measurements give only extremely restricted information on the average exposure

- Time demanding > high costs

➢ It is almost impossible to get the necessary data for exposure classification for epidemiological studies solely by measurements

- Personal dosimeters have yet to prove validity and liability

➢ exposure assessment by calculations

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Simple free space propagation model:

I $$S = \frac{EIRP}{4\pi \cdot d^2}$$

II $$S = E \cdot H = \frac{E^2}{c\mu_0}$$

I equals II

$$E = \frac{7}{d}\sqrt{\frac{ERP}{\delta \cdot \gamma}}$$ III

Average E-field strength

- Attenuation factors δ and γ :
  - δ: attenuation of the construction materials: set to 1
  - γ: attenuation characteristics of the antenna as provided by the antenna manufacturer
- Eq. III is used in Swiss regulation for the estimation of the electrical fields generated by a BS before its construction

Region of interest (i), Bern north, suburban area:

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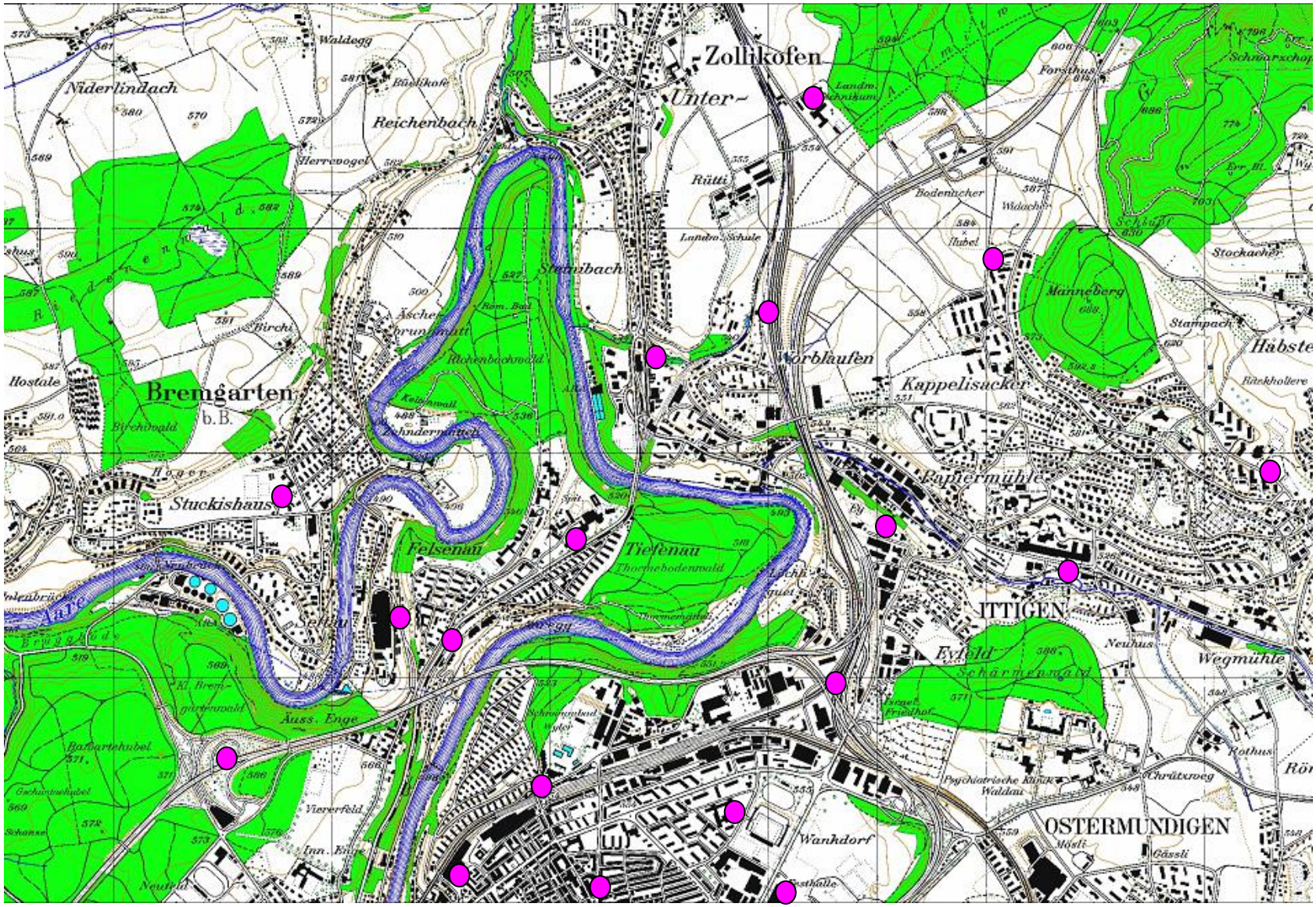

Further assumptions of the model/restrictions:

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- Only base stations of the Swisscom mobile network have been included in the calculations
- Neglecting topographical data, a flat surface was adopted.
- Geometrical properties: relative distance of antennas, height and main beam directions have been taken into account
- No absorption due to construction materials and no shadowing effect have been considered
- Calculation of the electrical field at 1.5 m over ground
- The contributions of the different base stations have been summed up according to (n=# of base stations):

$$E = \sqrt{\sum_{i=1}^{n} E_i^2}$$

Region of interest (ii), Zurich City, urban aera:

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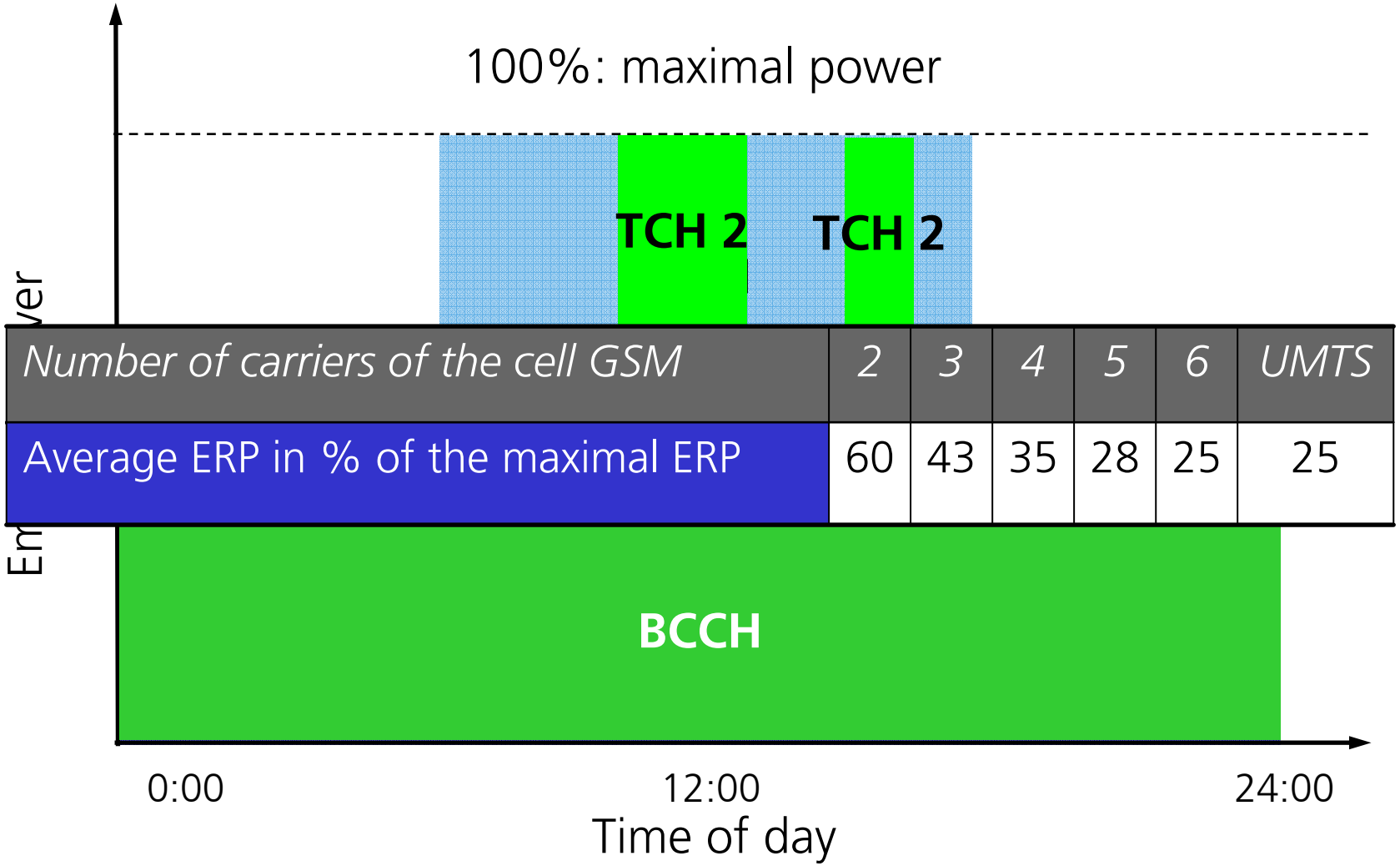
Properties of the chosen areas:

Region of interest	*Bern North*	*Zurich City*
area	*24 km²*	*0.805 km²*
Inhabitants	*41'615*	*4450*
Population density	*1734 persons/km²*	*5528 persons/km²*
Demographical type	*suburban*	*urban*
Status of network	*GSM: summer 03* *UMTS: march 04*	*GSM & UMTS:* *march 04*
# of base stations	*18*	*12*

Time averaged emitted power:



Results (i): field distributions, Bern north

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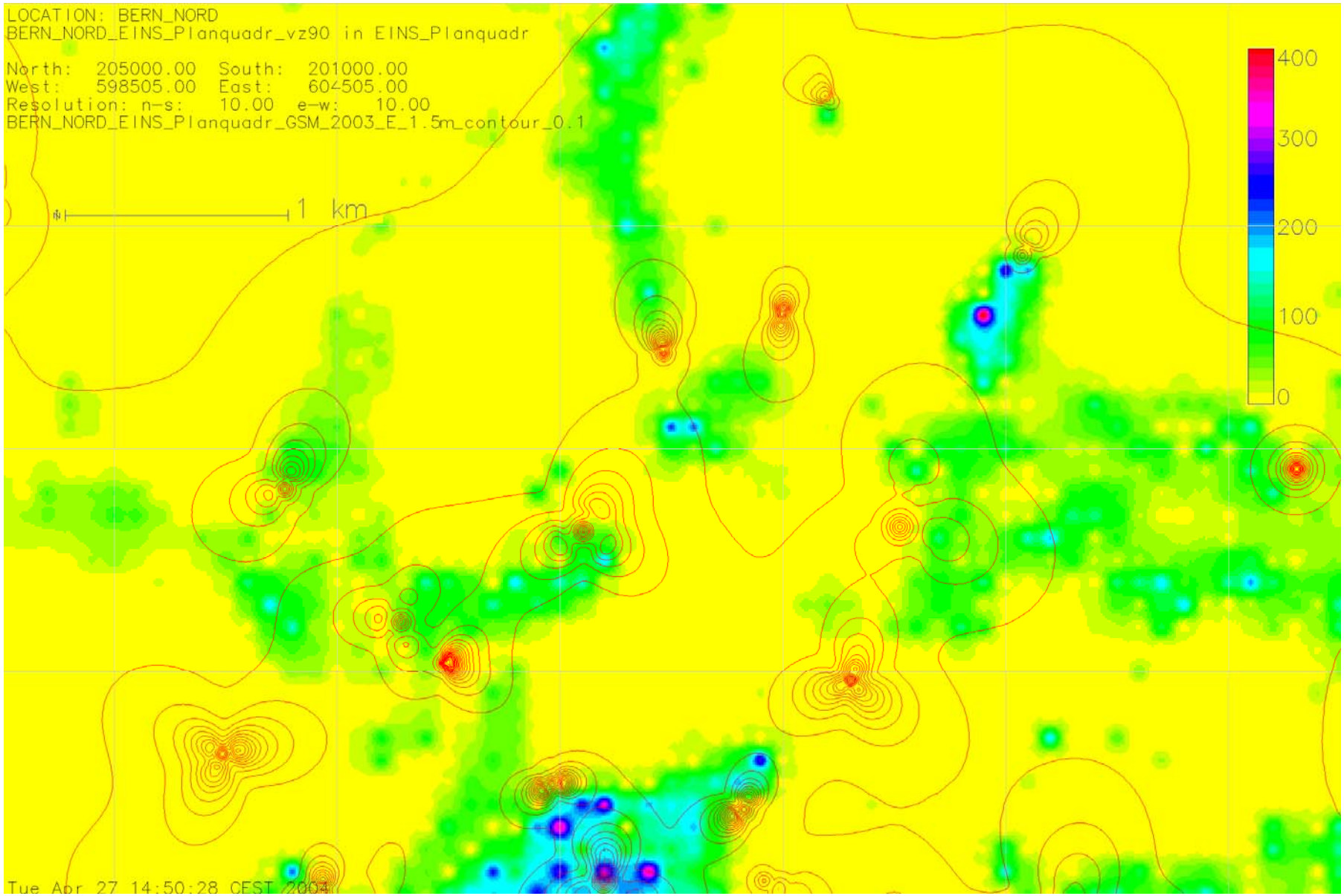

Region of interest (i), Bern north, suburban area:

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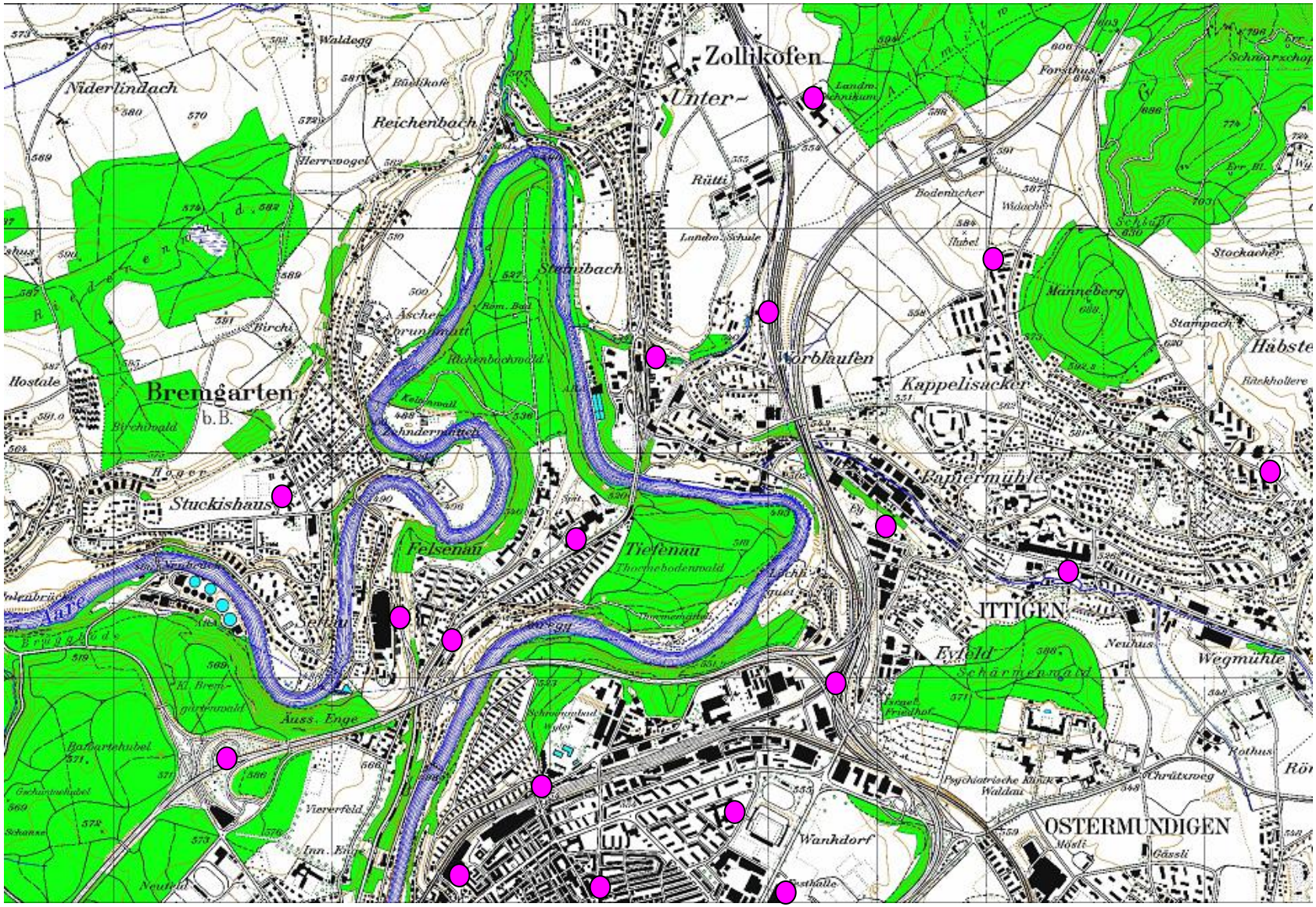

Results (i): field distributions, Zurich City

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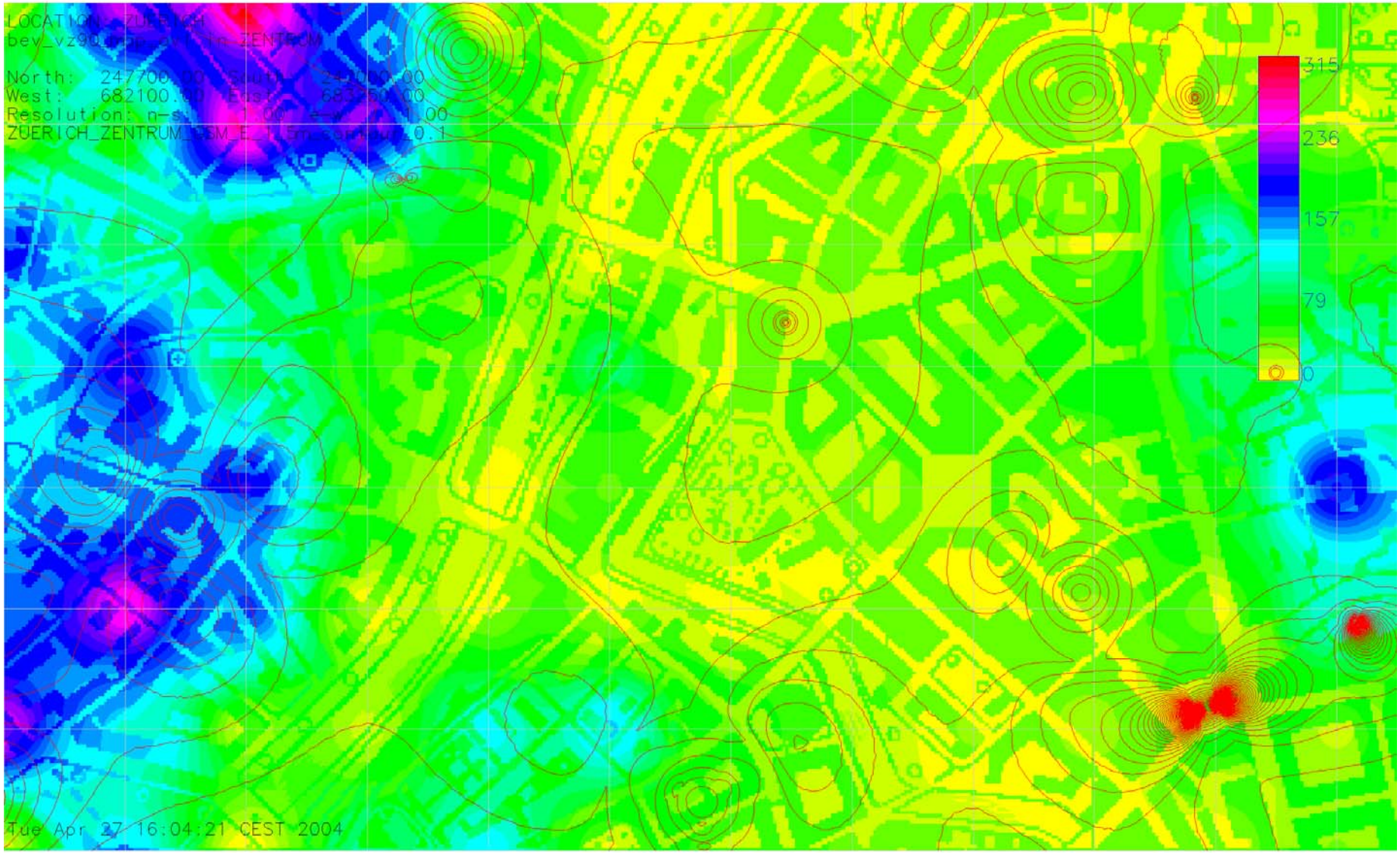
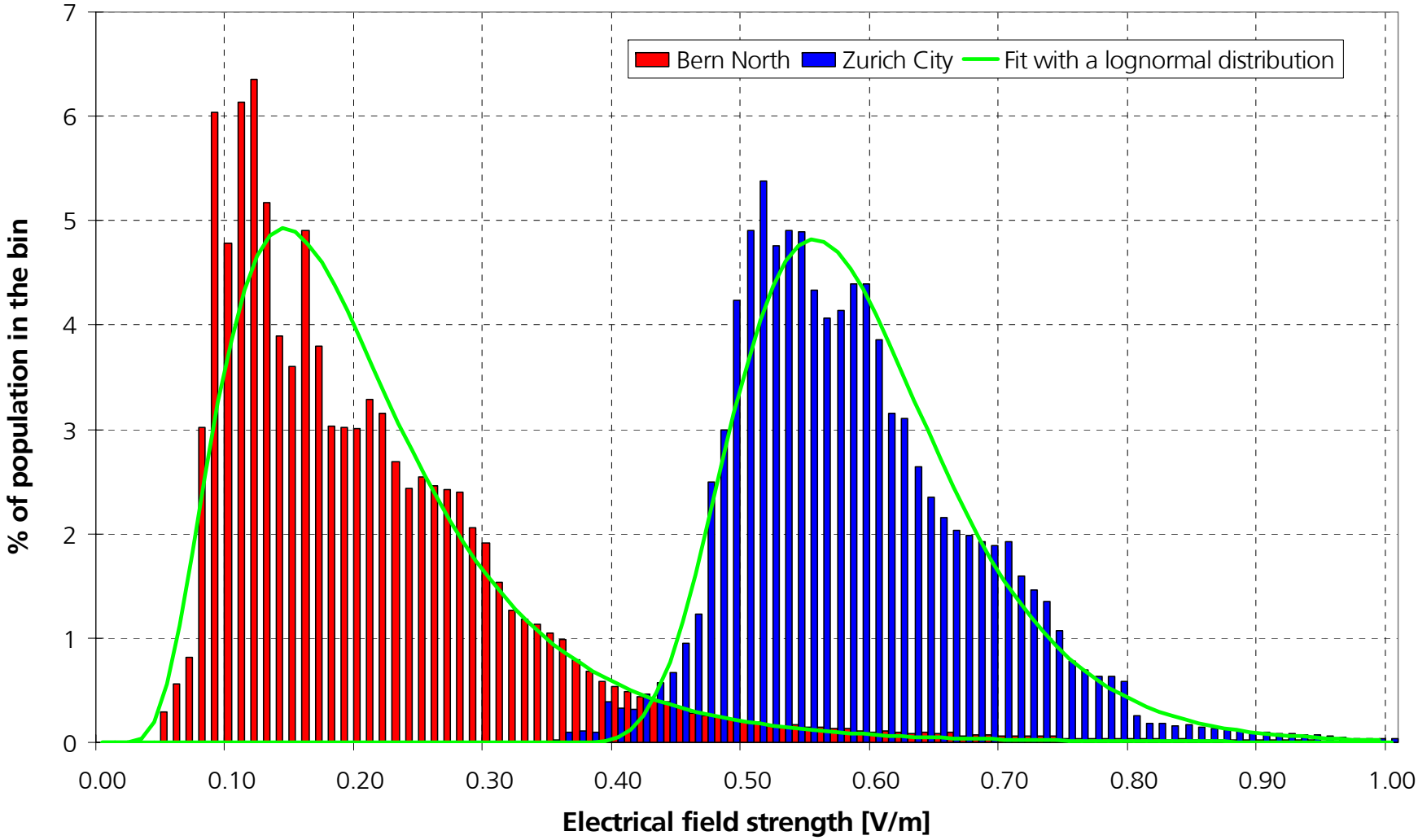


Results (ii): probability density distributions: GSM



Results (ii): probability density distributions: UMTS

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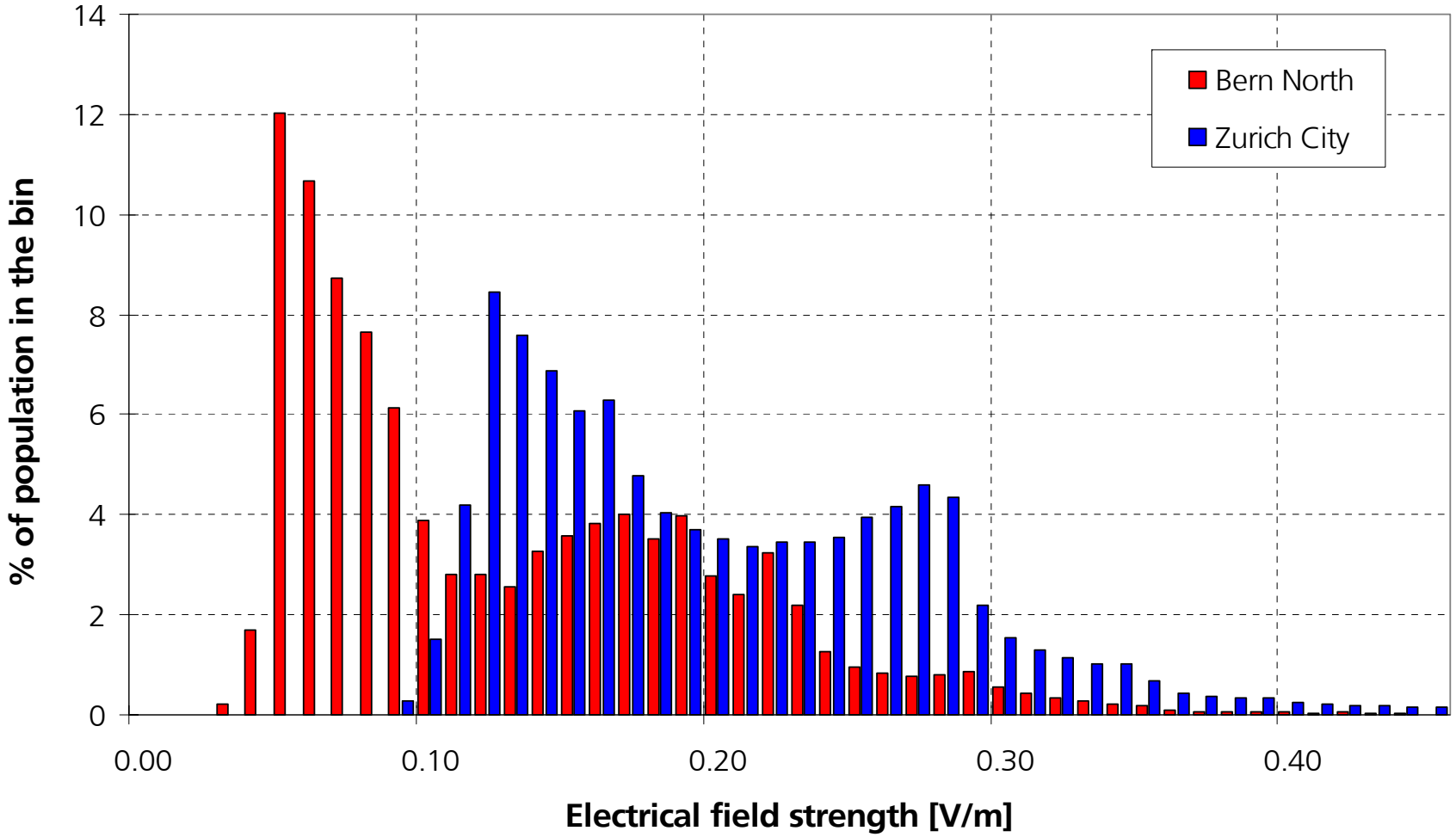

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Results (iii): characteristic numbers

	Suburban Bern North		*Urban Zurich City*	
Network	*GSM*	*UMTS*	*GSM*	*UMTS*
Proportion of the population exposed to more than 1 V/m [%]	*0.12*	*0*	*0.80*	*0*
Median exposure [V/m]	*0.18*	*0.10*	*0.58*	*0.18*

- How does the system behave for different average powers of the cells?

➢ Assuming that the population density over the field strength shows a lognormal behaviour (as for the GSM-system), an extrapolation to higher average powers per cell was done.

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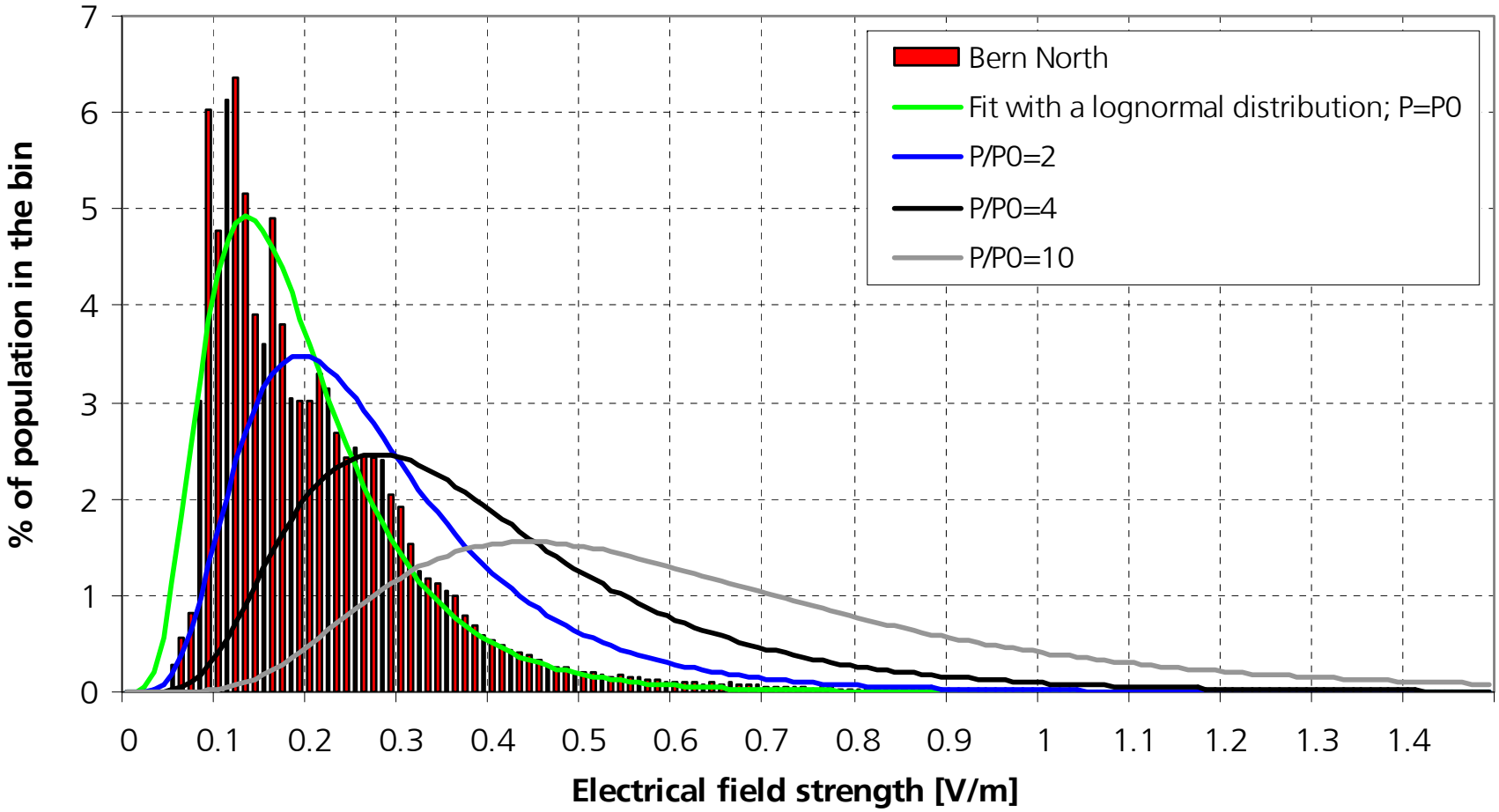
Extrapolation to different average powers per cell (i): probability distributions



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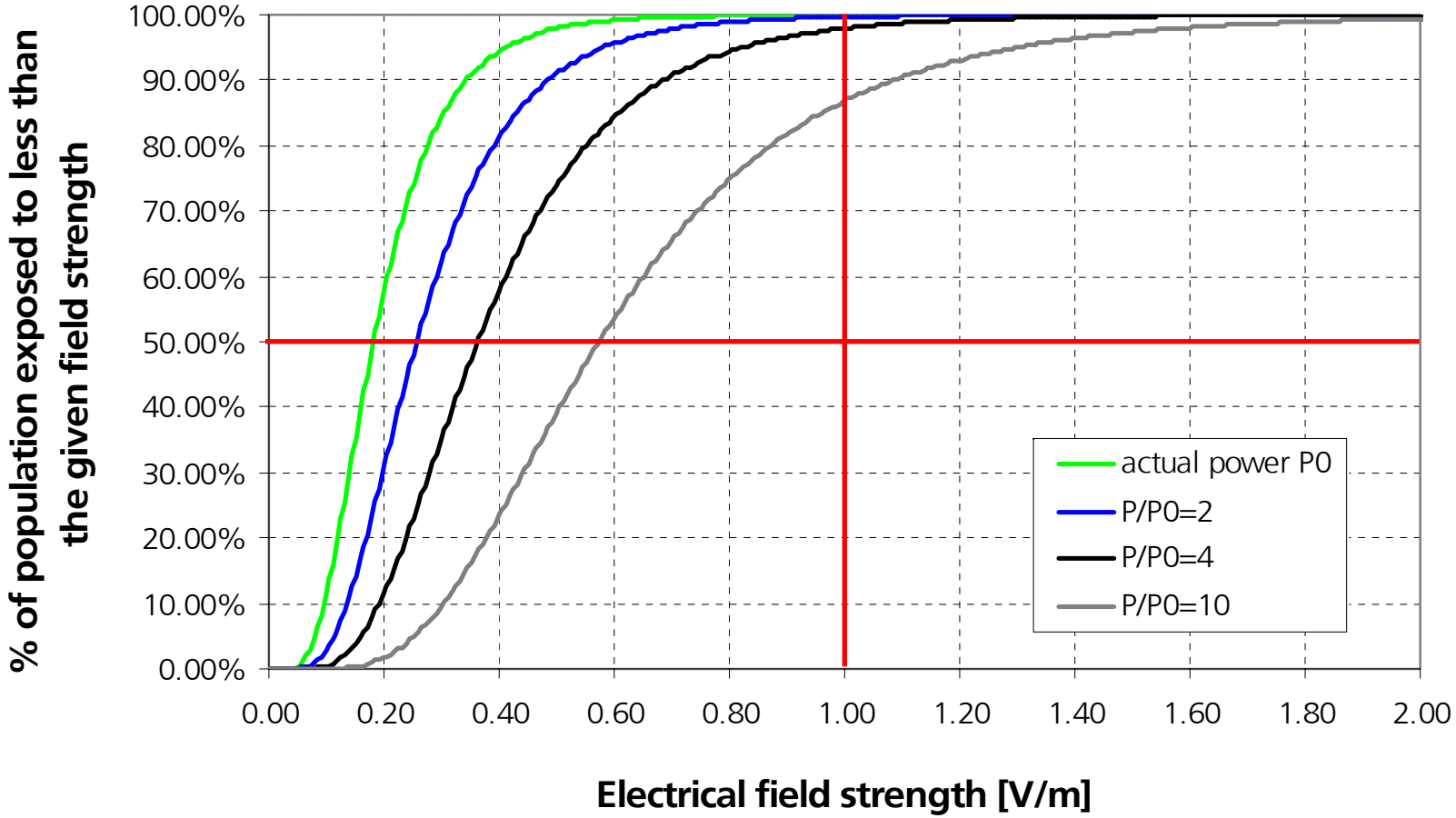
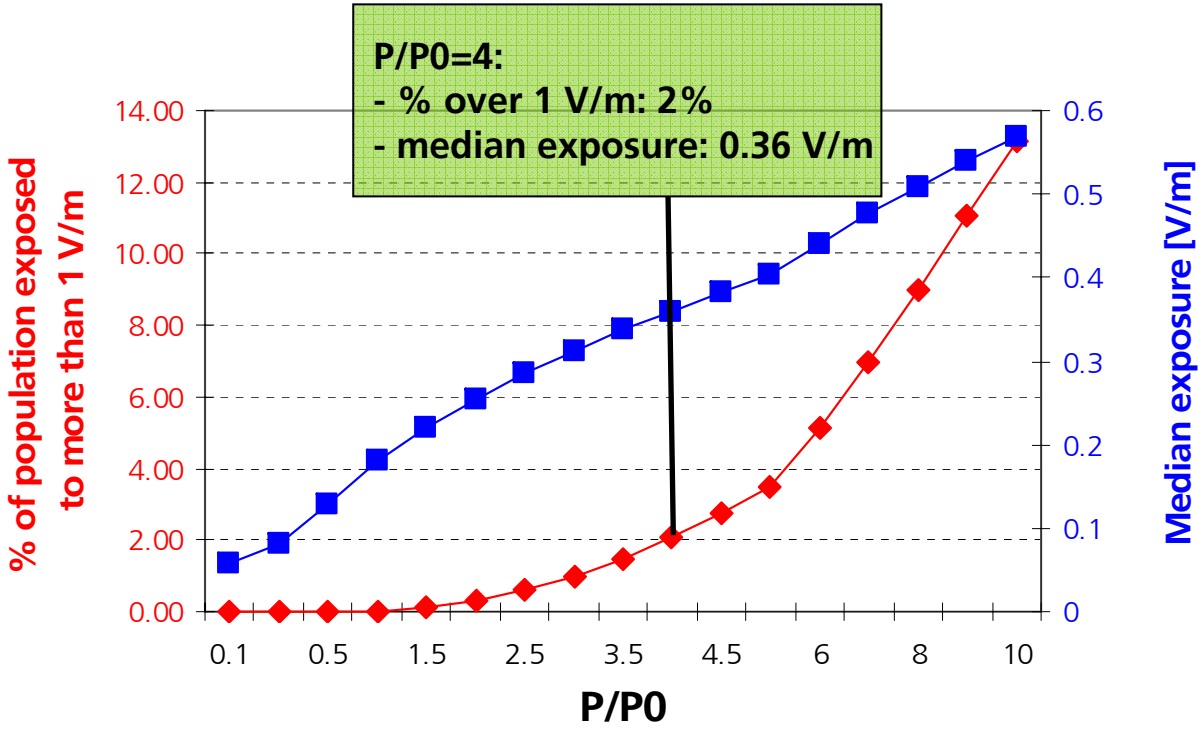
Extrapolation to different average powers per cell (ii): cumulated distributions



Extrapolation to different average powers per cell (iii) : Results



- Characteristic numbers change rapidly with changing power of the cells
- The extrapolation is only valid if the network structure remains identical.

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Conclusions:

- The proposed model based on data used for regulation purposes allows for an estimation of the general public exposure to EMF generated by mobile phone networks.
- Time averaged exposition is generally much lower than 1 V/m.
- Characteristic numbers can easily be calculated:
  - median field strength
  - proportions of the population exposed to a given field strength
- These characteristic numbers change rapidly with changing radiated power per cell.
- Improvements by integration of the topographical information and the average attenuation of construction materials