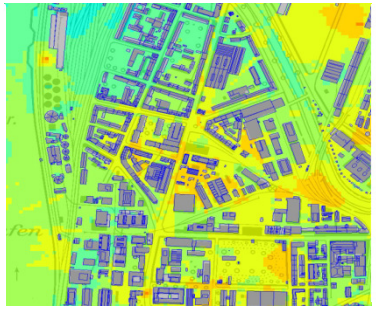
ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Radiofrequency exposure in the general population: sources and exposure levels





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Content

- Exposure assessment approaches
- Measurement surveys
- Personal exposure studies
- From exposure to dose
- Exposure trends in the last 10 years

RF-EMF: Two types of exposure

close to body (near field) ⟷ **environmental (far field)**

mobile phone *(uplink)*
cordless phone

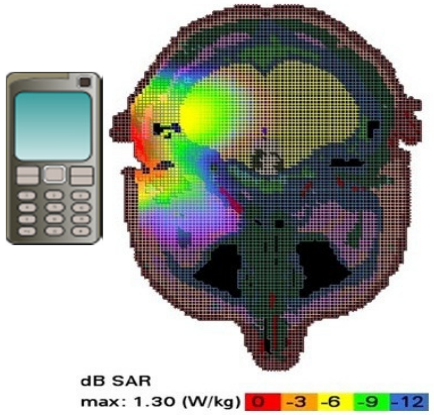
W-LAN

broadcast transmitter
mobile phone base station *(downlink)*

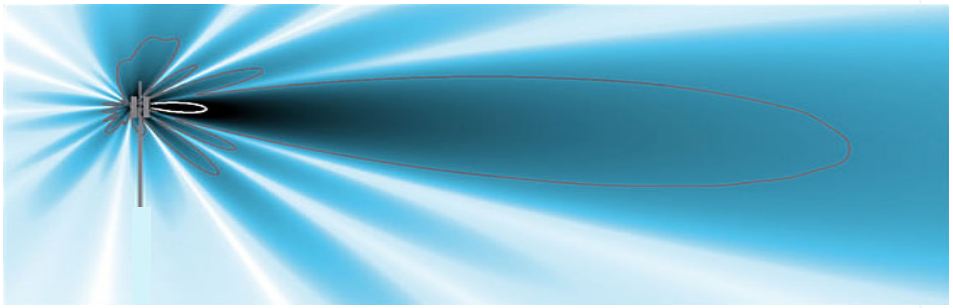
Other people's mobile and cordless phones (uplink)

Radiofrequency exposure measure

- **Near-field exposure**
  SAR in W/kg: Specific absorption rate.
  Regulatory limits for mobile phones: 2 W/kg



- **Far-field exposure**
  Electric field (E) in V/m (sometimes called incident field)
  ICNIRP regulatory limits for mobile phone radiation: <61 V/m



How to combine to one single exposure measure?

- Complex, depends on the relevant exposure metric
  - Spatial average vs. Spatial peak
  - Temporal average vs. Temporal peak
  - Frequency dependence of absorbtion
  - etc.

1. Simplified approach: measured exposure = E-field at the place of a person if the person not were there

2. A cumulative dose approach

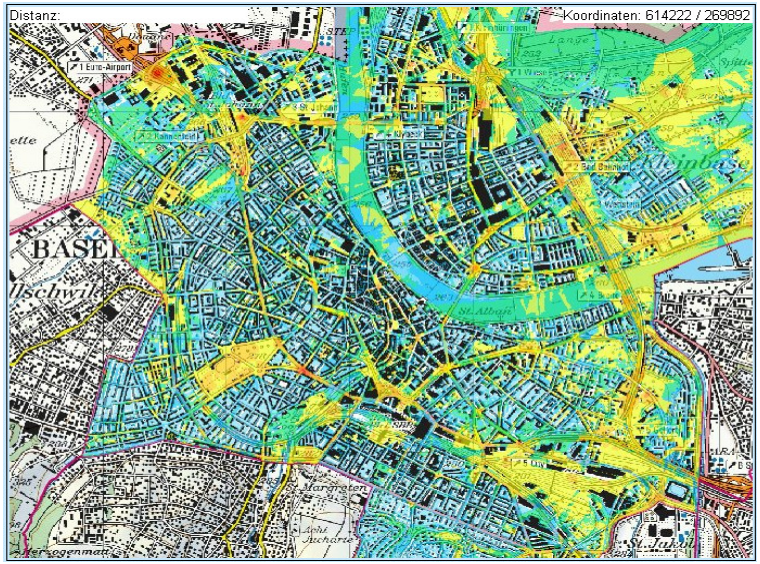
Three approaches for environmental EMF exposure assessment

1. Stationary Measurements

+ accurate temporal resolution

- elaborate
- Low spatial resolution

2. Modeling of fixed site transmitters



+ efficient, illustrative

- no hotspots (W-Lan), femto/nano cells
- No individual behavior

3. Portable measurements

3a. Personal volunteer measurements

+ all sources including behavior

- data quality, manipulation
- selection bias
- No differentiation between own and other people's mobile phone
- body shielding

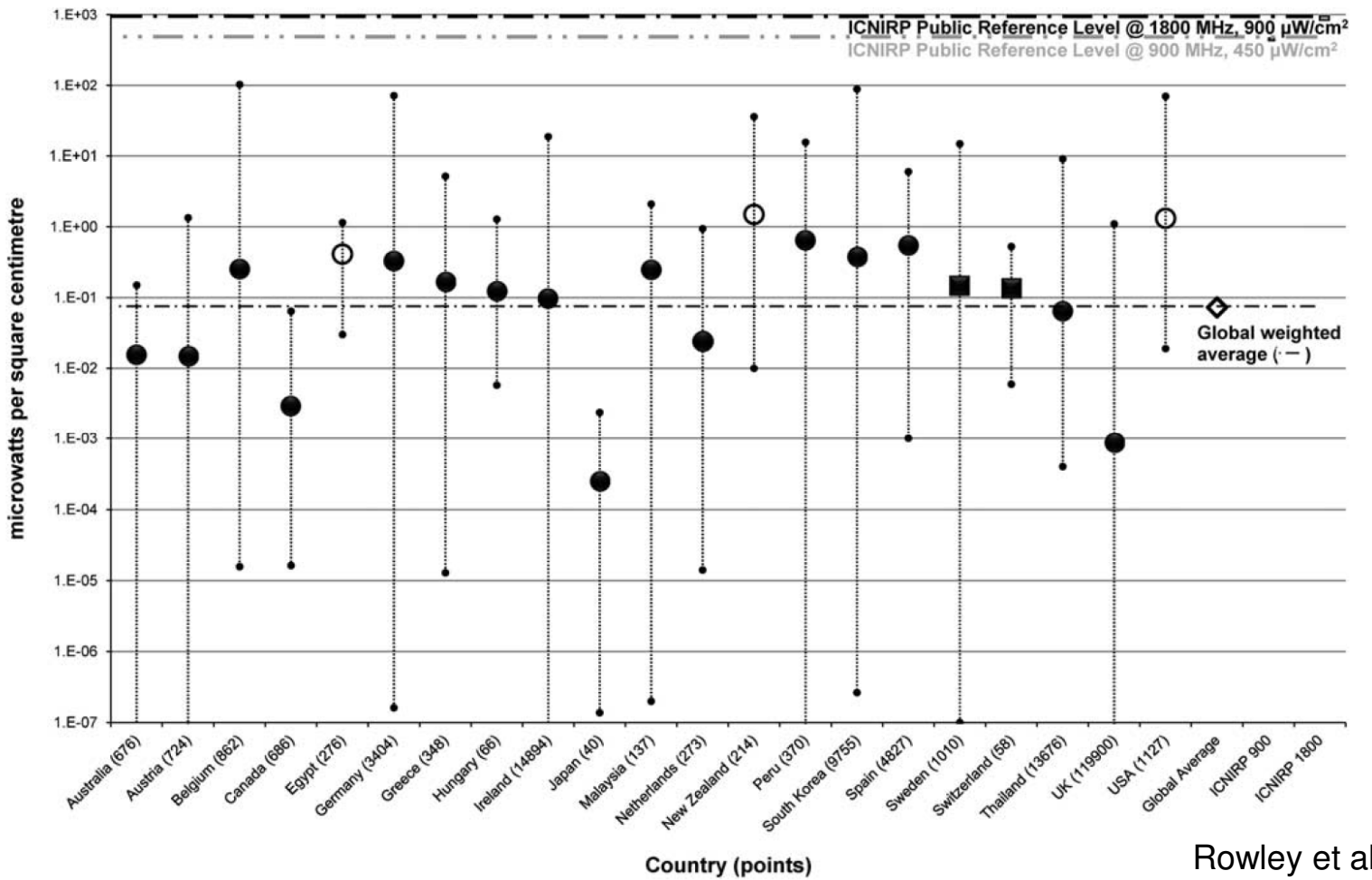
3b. Microenvironmental survey

+ data quality, efficient,
+ minimized body shielding

- No individual behavior
- Private place measurements challenging

Overview measurement survey

Downlink



E-field

60 V/m

6 V/m

0.6 V/m

0.06 V/m

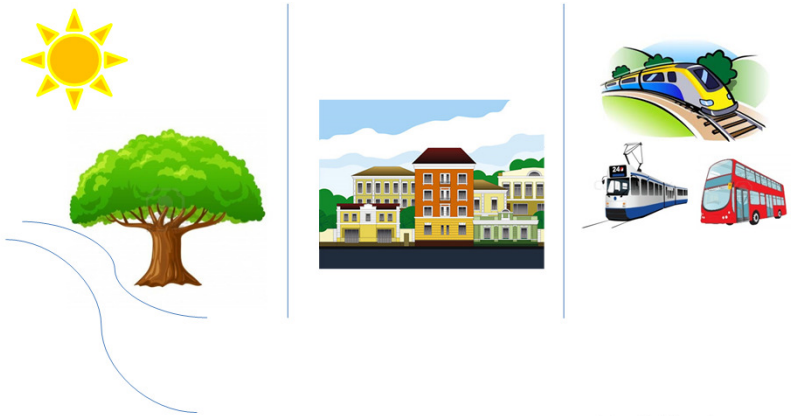
0.006 V/m

Rowley et al., JESEE, *2012*

Microenvironmental survey

Amsterdam Basel Gent and Brussels

- Measurements conducted between 2010 and 2012
- EME SPY 120: 12 frequency bands from 88 to 2500 MHz

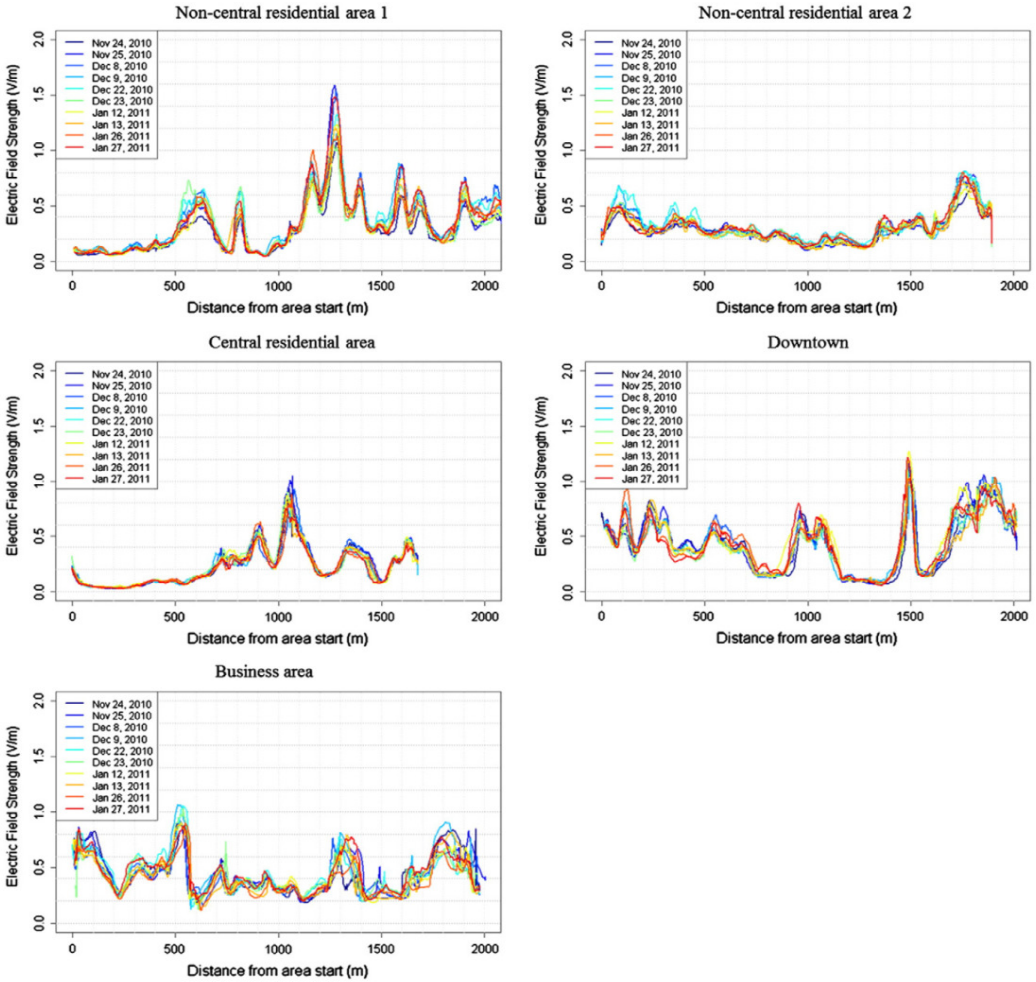


Outdoor:
- Residential areas
- Downtown

Indoor:
- Train station
- Airport
- Shopping centers

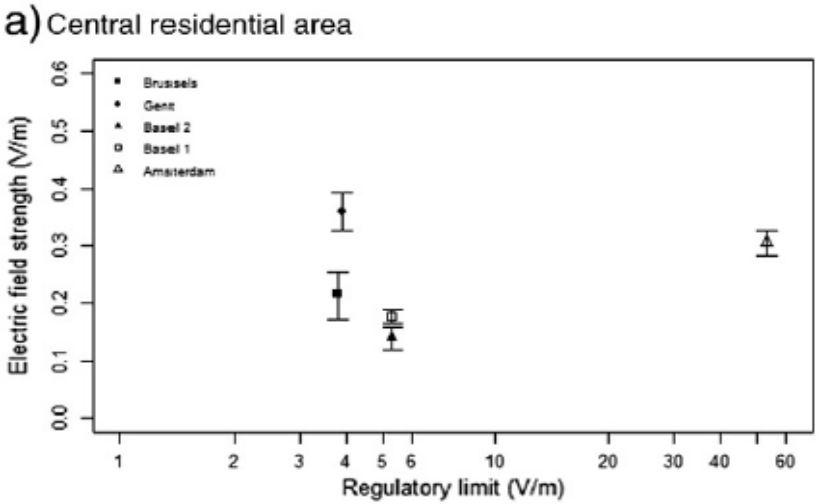
Public transports:
- Trains
- Bus
- Tram/Metro

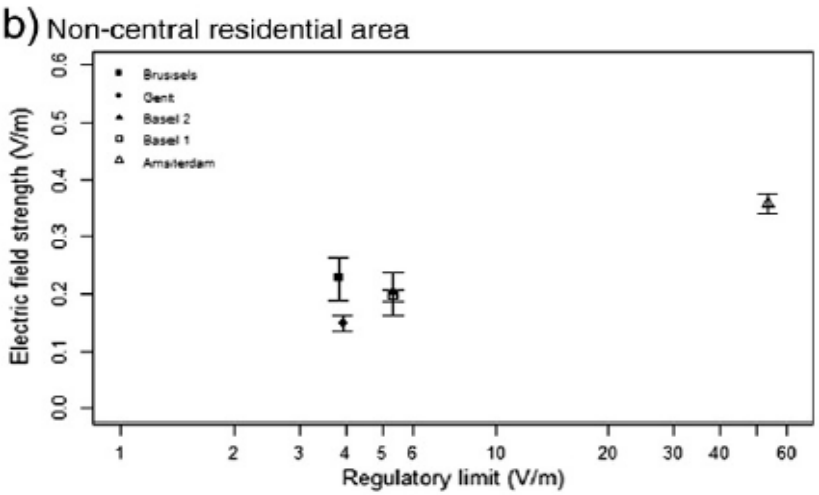
Reproducibility of microenvironmental measurements

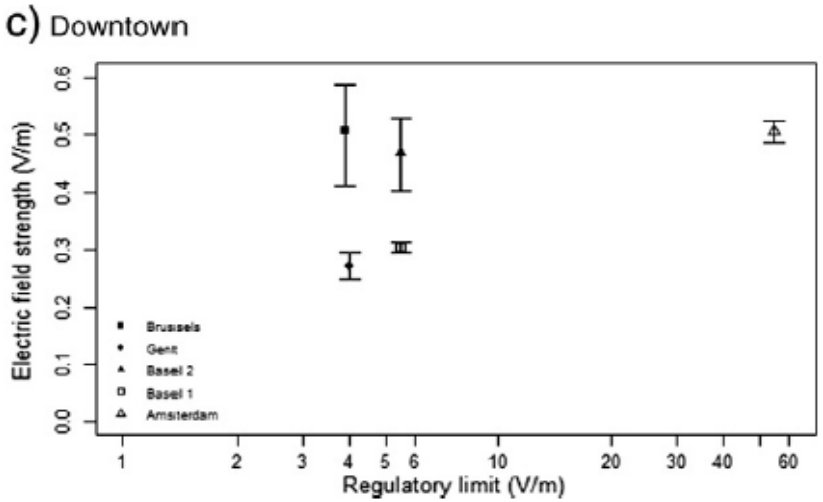


Urbinello et al., *Env Int, 2014*

Exposure vs. Regulatory limits



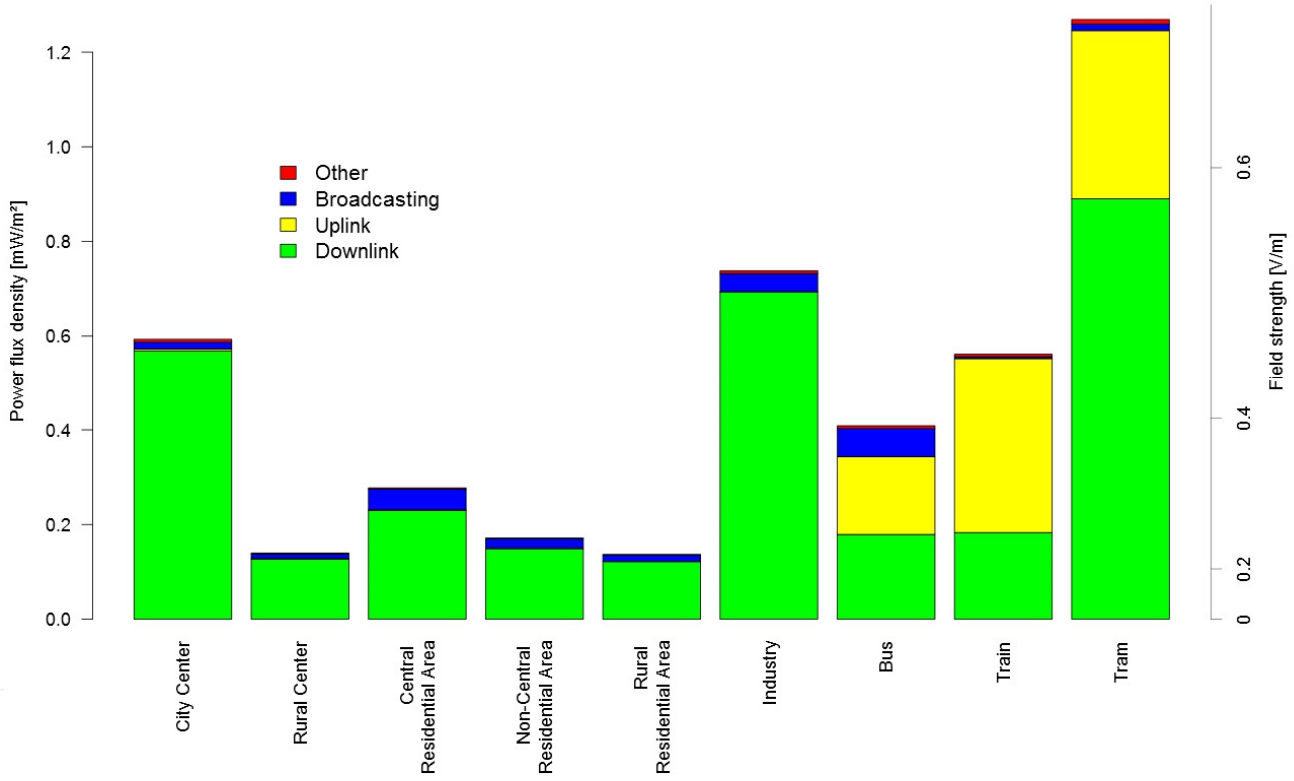




■ Brussels
● Ghent
▲ Basel 2
□ Basel 1
△ Amsterdam

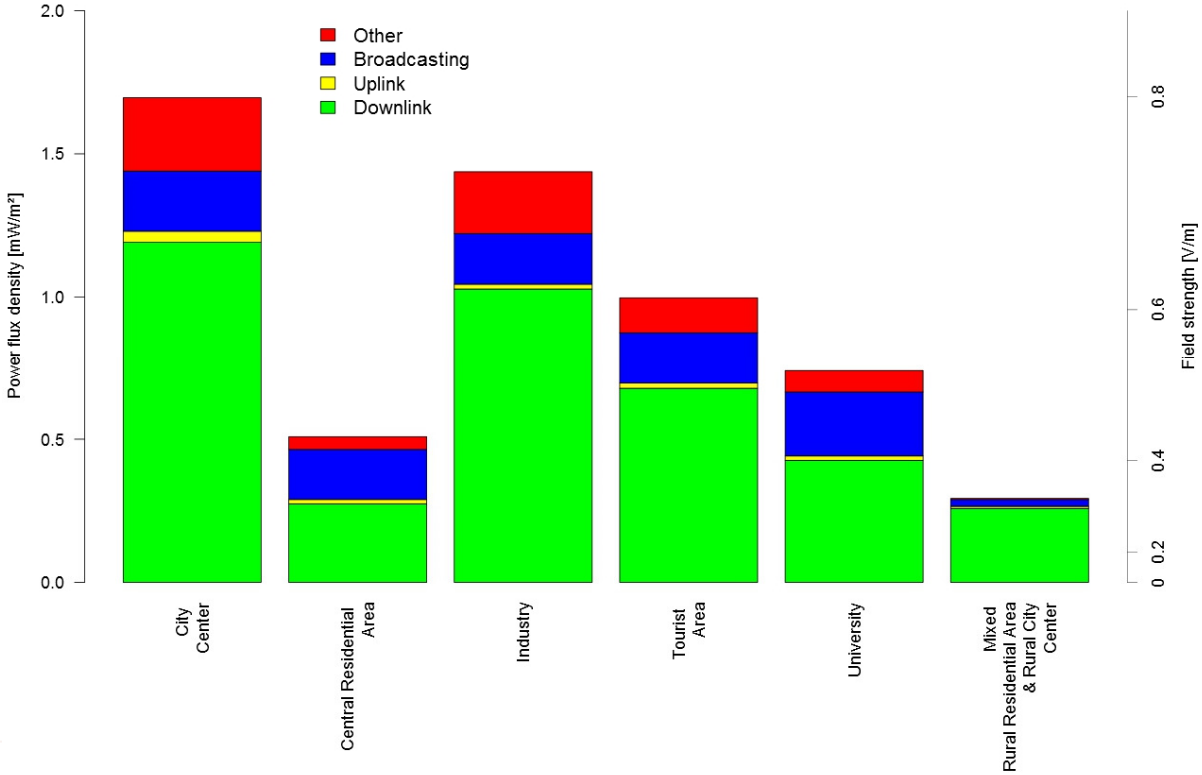
Urbinello et al., *Env Int, 2014*

Summary of 51 outdoor microenvironments in CH (+ public transport) conducted in 2014



Sagar et al., *under review*

Pilot measurements in South Africa from May 2016



See poster of Sagar et al.

Overview personal measurements

Table 3. Summary of the measurement data on the RF EMF exposure of individuals using PEM in Europe in mean total electric field strength in V/m or average exposure in % of the ICNIRP level.

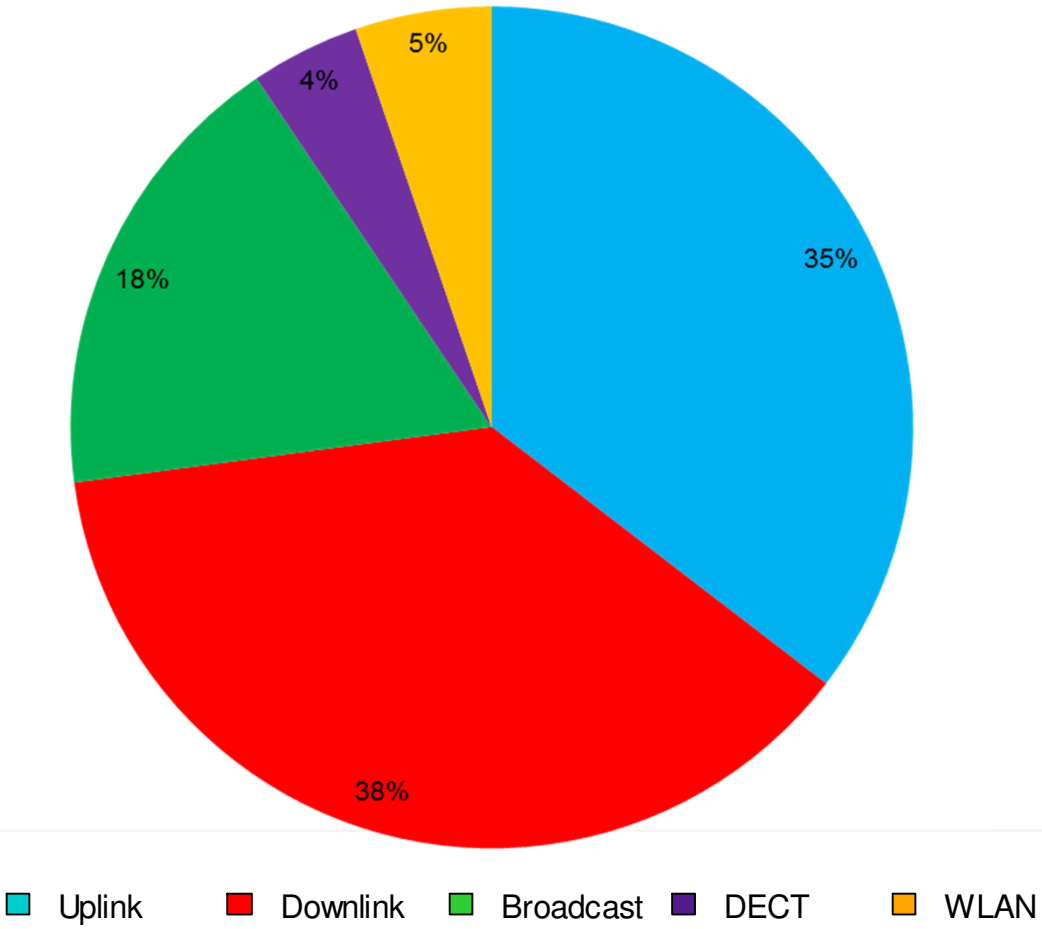
Country	*Mean total electric field strenght (V/m)*	*Authors*
Belgium	0.12	Joseph *et al.*[21]
Switzerland	0.24	Frey *et al.*[22,23]
Slovenia	0.27	Trček *et al.*[24]
Hungary	0.10	Thuróczy *et al.*[26]
Netherlands	0.15	Bolte *et al.*[27]
France	0.21	Viel *et al.*[31]
UK	0.11	Mann[33]
Germany[a]	0.09	Breckenkamp *et al.*[34]
Netherlands	0.26	Bolte and Eikelboom[32]

Gajsek et al. JESEE, 2015

ZüMe: Population based personal radiofrequency electromagnetic field exposure measurements in Zurich

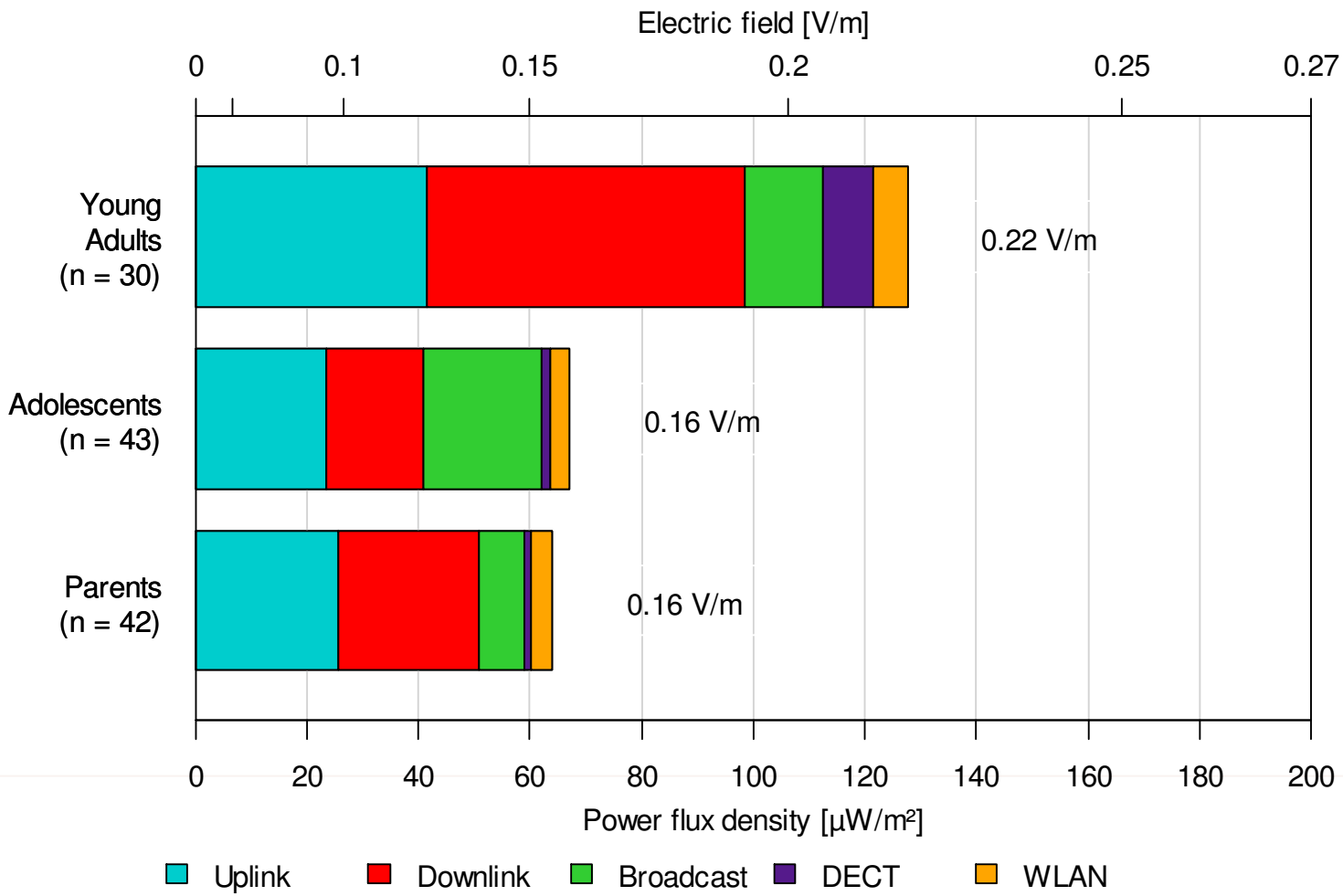
- Random population sample from 12 communities from canton of Zürich (Switzerland) with various degrees of ubanity
- 42 pairs of one parent and adolescent (12-15 years) and 30 young adults (18-30 years)
- Measurements conducted: 21 Feb. – 2. Nov. 2015
- Measurement device ExpoM-RF: 14 frequency bands between 88 MHz – 2690 MHz
- Electronic diary app, GPS recorded by Expom-RF
- Full report (in German): Röösli et al., 2016: http://www.awel.zh.ch/content/dam/baudirektion/awel/luft_asbest_elektrosmog/elektrosmog/dokumente/PersMeas_AWEL_2016.pdf

Average source contributions (mean=0.18 V/m)

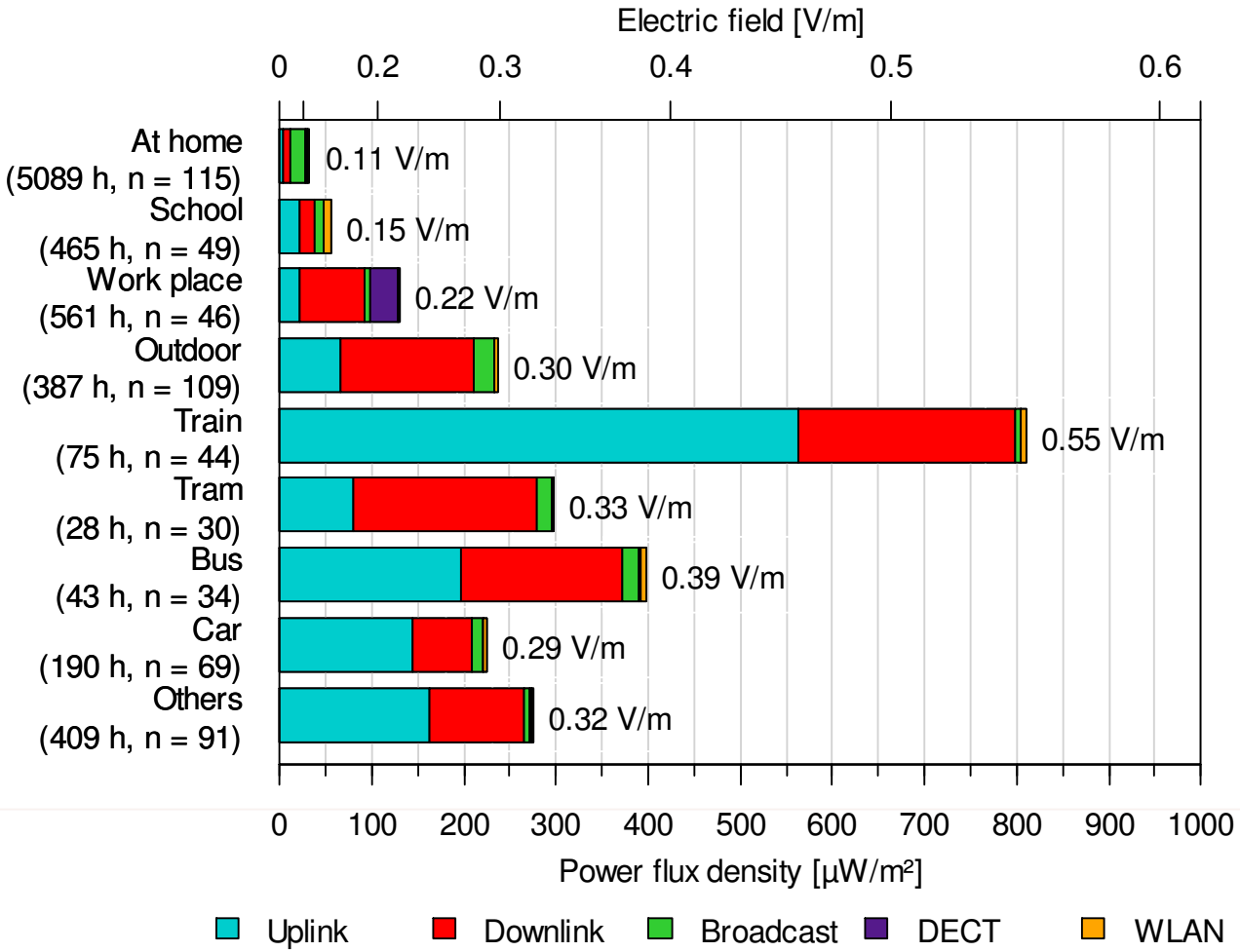


Röösli et al, 2016

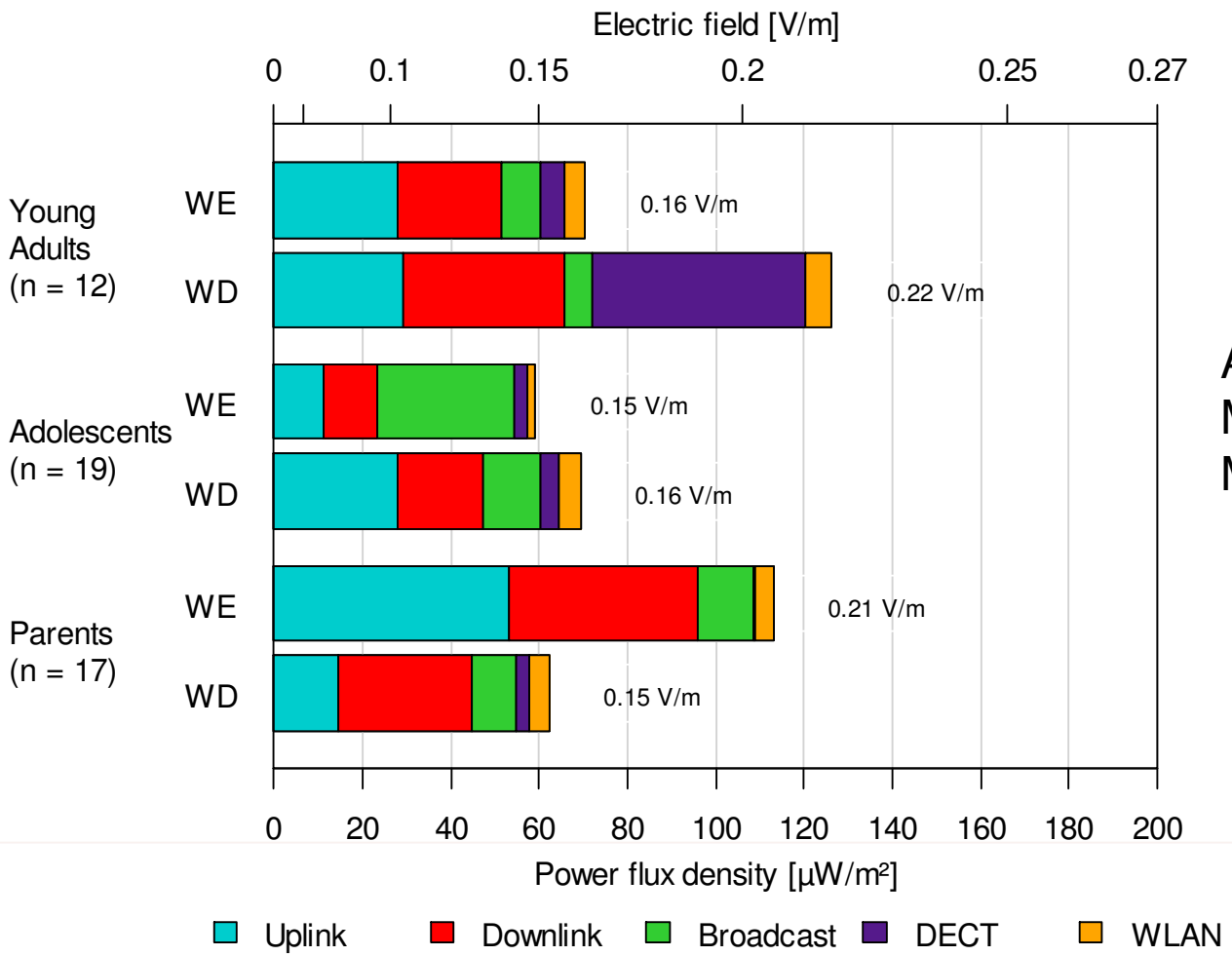
Comparison of the 3 study groups



RF-EMF per activity

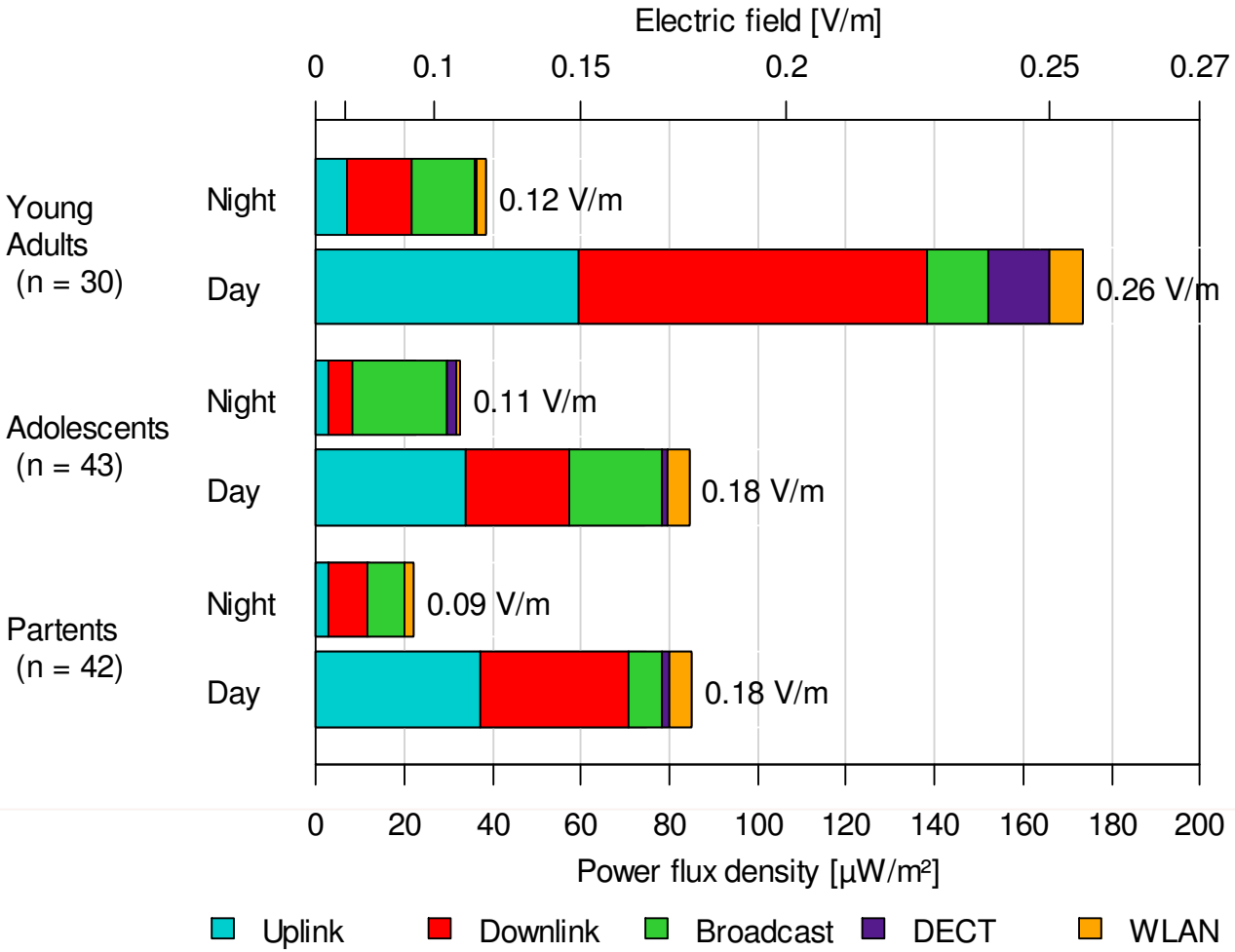


Weekend (WE) vs. workday (WD) exposure



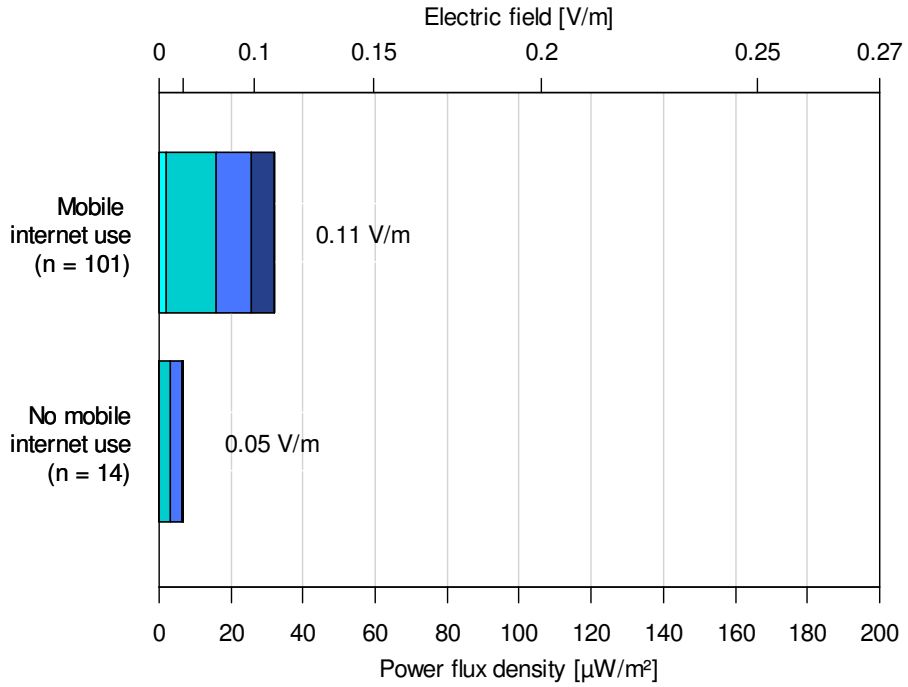
All participants:
Mean weekend: 0.18 V/m
Mean workday:0.18 V/m

Day vs night exposure

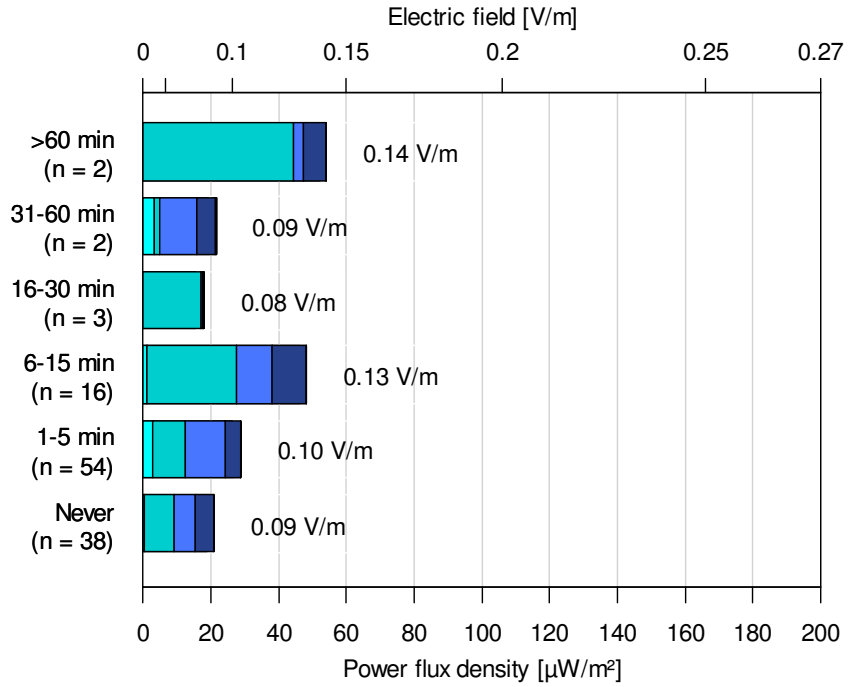


Uplink exposure

Mobile internet use



Call duration (per day)



Combine near and far field by dosimetric approach

RF-EMF dose

Near-field

Far-field

$$\sum \text{dose}$$

$$dose = output\ power * SAR * use\ duration$$

$$dose = incident\ field * SAR * exposure\ duration$$

brain

whole body

SAR = normalized Specific Absorption Rate
RF-EMF = radiofrequency electromagnetic fields

Roser et al., IJERPH, 2015

Average use in Züme

- Calls with mobile phones: 5.2 Min/day (8% with headset/speaker)
- Calls with cordless phones: 4.8 Min/day
- Mobile data traffic on mobile phone: 19.0 Min/day
- WLAN data traffic on mobile phone : 33.3 Min/day
- Mobile phone transmission on the body in stand-by mode: 1.2 Min/day
- WLAN Use on computer: 9.8 Min/day; with Laptop: 50.2 Min/day; withTablet: 15.6 Min/day game console: 2.4 Min/day.
- Mean measured far field exposure as presented before

SAR values from the literature

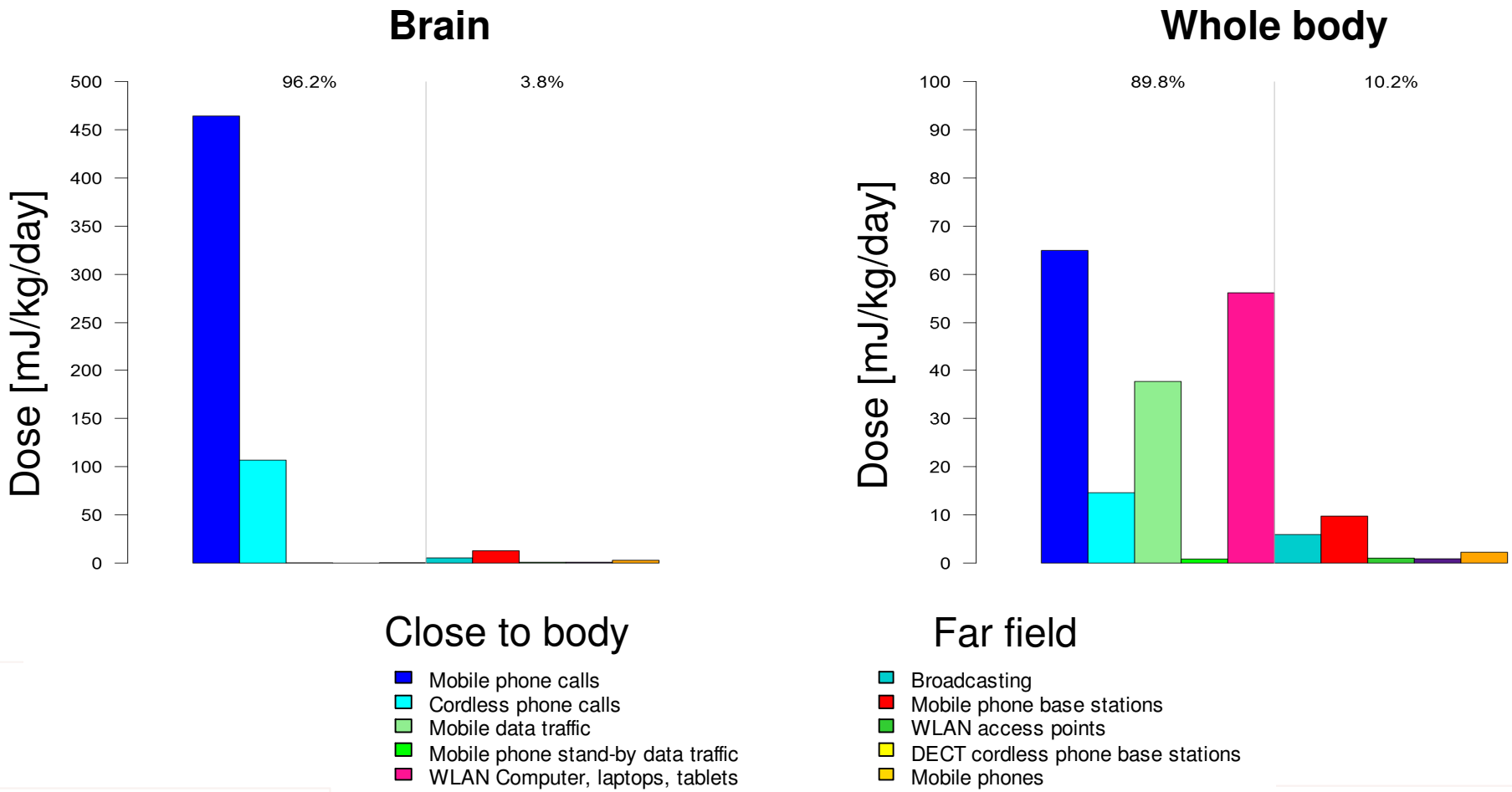
Table 2. Near-field *brain* and *whole-body* SARs, corresponding derivation and references for the near-field predictors.

Near-Field Predictor	Brain SAR		Whole-Body SAR		References
	(mW/kg)	Derivation	(mW/kg)	Derivation	
GSM [1] mobile phone calls without headset	3.198	–	0.411	–	[18]
GSM [1] mobile phone calls with headset	3.198×10^{-3}	3.198×0.001	0.411	0.411×1	[18,20]
UMTS mobile phone calls without headset	0.023	–	0.003	–	[18]
UMTS mobile phone calls with headset	0.023×10^{-3}	0.023×0.001	0.003	0.003×1	[18,20]
DECT phone calls without eco mode	0.373	–	0.051	–	[18]
DECT phone calls with eco mode	0.0373	0.373×0.1	0.0051	0.051×0.1	[18,20]
mobile phone data traffic with mobile internet connection	0.092×10^{-3}	$0.023 \times 4 \times 0.001$	0.012	$0.003 \times 4 \times 1$	[18,20–24]
mobile phone close to body (passive mobile phone data traffic)	0.092×10^{-3}	$0.023 \times 4 \times 0.001$	0.012	$0.003 \times 4 \times 1$	[18,20–24]
mobile phone data traffic with WLAN	0.092×10^{-3}	$0.023 \times 4 \times 0.001$	0.012	$0.003 \times 4 \times 1$	[18,20–24]
computer, laptop and tablet use with WLAN	0.092×10^{-3}	$0.023 \times 4 \times 0.001$	0.012	$0.003 \times 4 \times 1$	[18,20–24]

[1] For calls with the mobile phone on the GSM network the mean of the SARs for the GSM900 and the GSM1800 network was used because there was no differentiation between GSM900 and GSM1800 network in the mobile phone operator data.

Roser et al., IJERPH, 2015

Average cumulative dose



Uncertainties

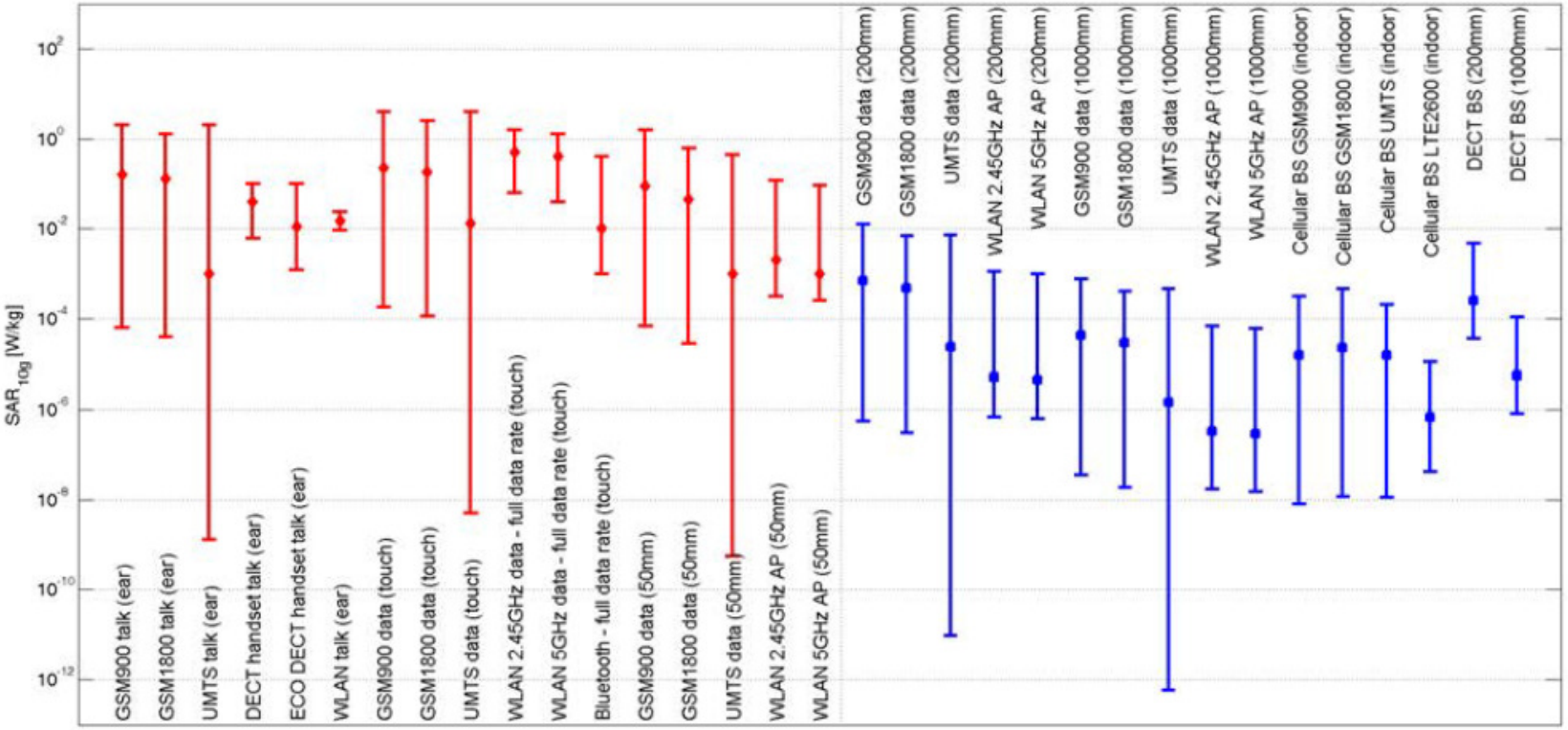


Figure 1: Estimated mean and maximum and minimal exposures of wireless network devices compared to other wireless sources (red: near-field sources; blue: far-field sources). These were compiled for the purpose of comparison at the end of the project and are subject to technology, usage, and implementation changes.

Seawind, Final Report, FP7-ENV-2009-1

UMTS phones emit 100-500 times less than GSM phones!

GSM:

Adapted from Vreiheid, OEM, 2009

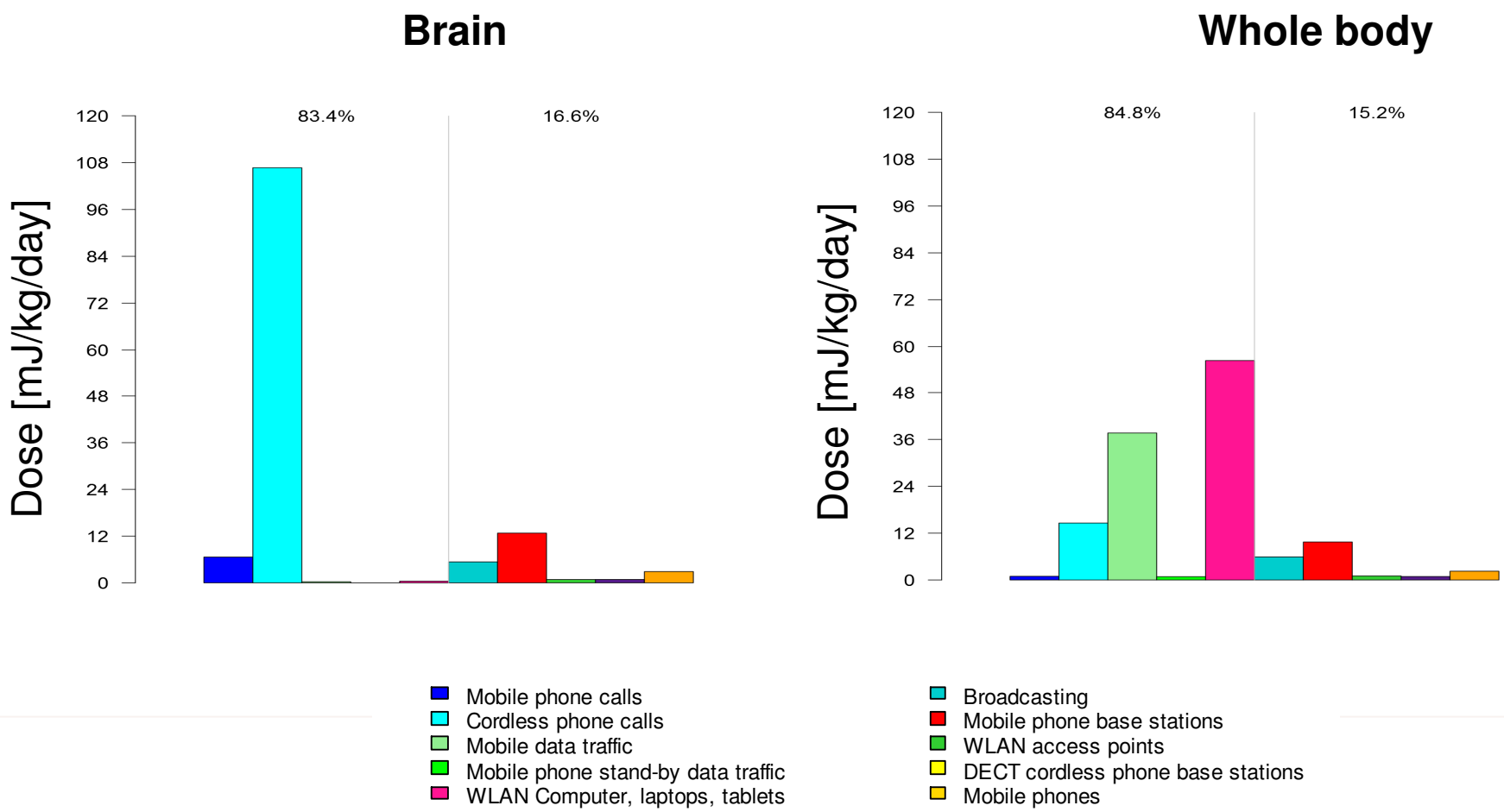
	900 MHz				1800 MHz			
		Output power per call (mW)				Output power per call (mW)		
Study centre	No of calls	Mean (SD)	Median	Interoperator range§	No of calls	Mean (SD)	Median	Interoperator range
Sweden	4185	118.2 (95.2)	101.6	67.6–146.5†	2366	52.1 (47.4)	36.2	45.5–68.7
Total	46994	133.3 (91.7)	127.2	67.6–204.0‡	29505	64.2 (45.5)	57.8	44.7–99.0‡

UMTS:

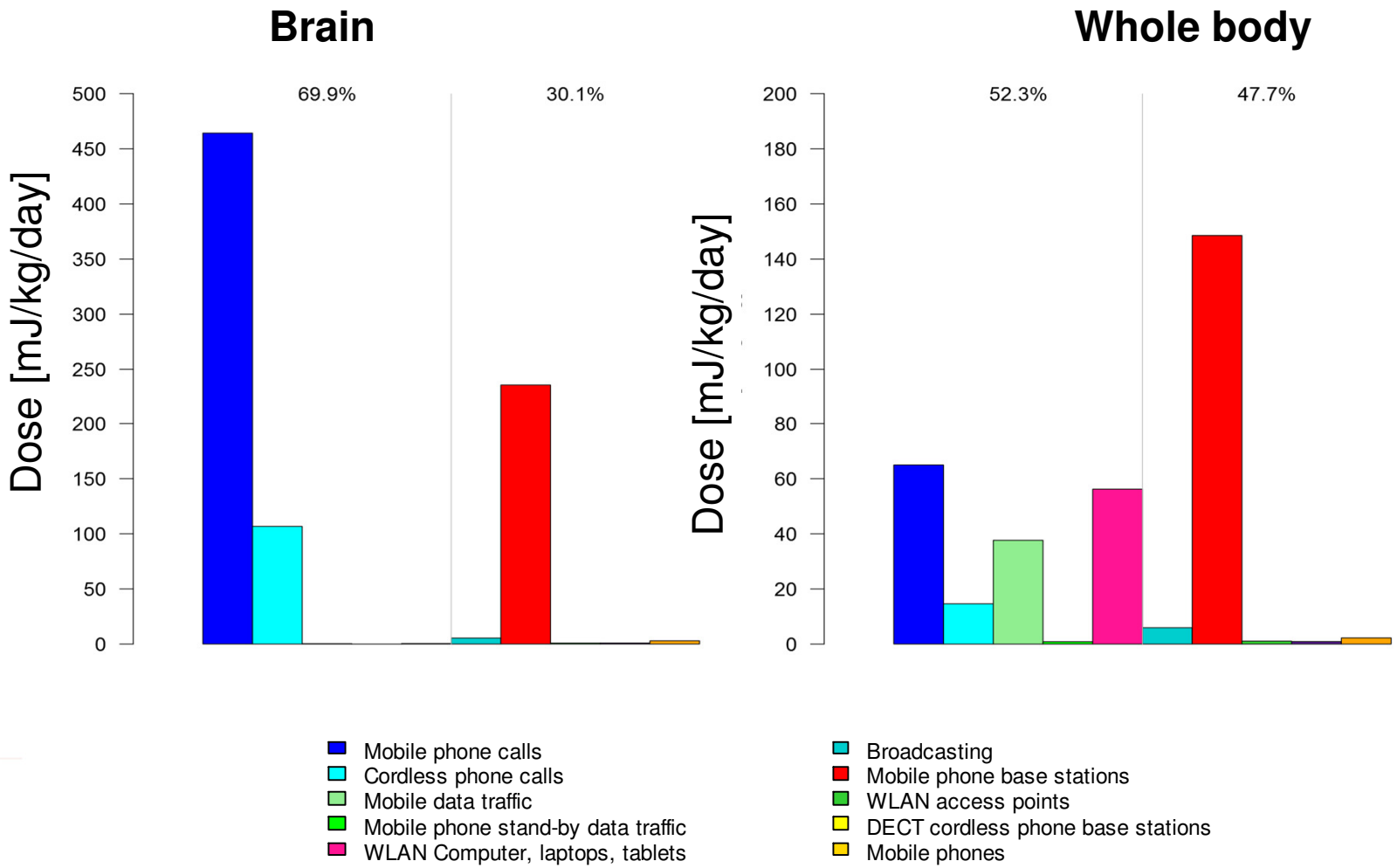
Location	Median	Mean	90th percentile
Rural	0.04	0.5	0.7
Suburban	0.02	0.4	0.4
Urban	0.02	0.4	0.4
Dense urban	0.008	0.3	0.3
Indoor net	<0.008	0.2	0.1

Persson et al., BioEM, 2012

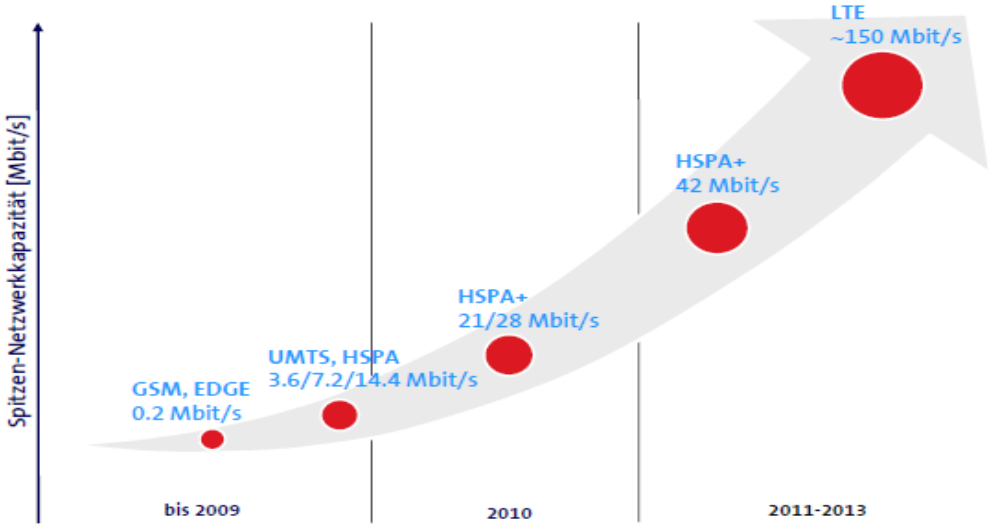
Dose Züme: assuming UMTS call only



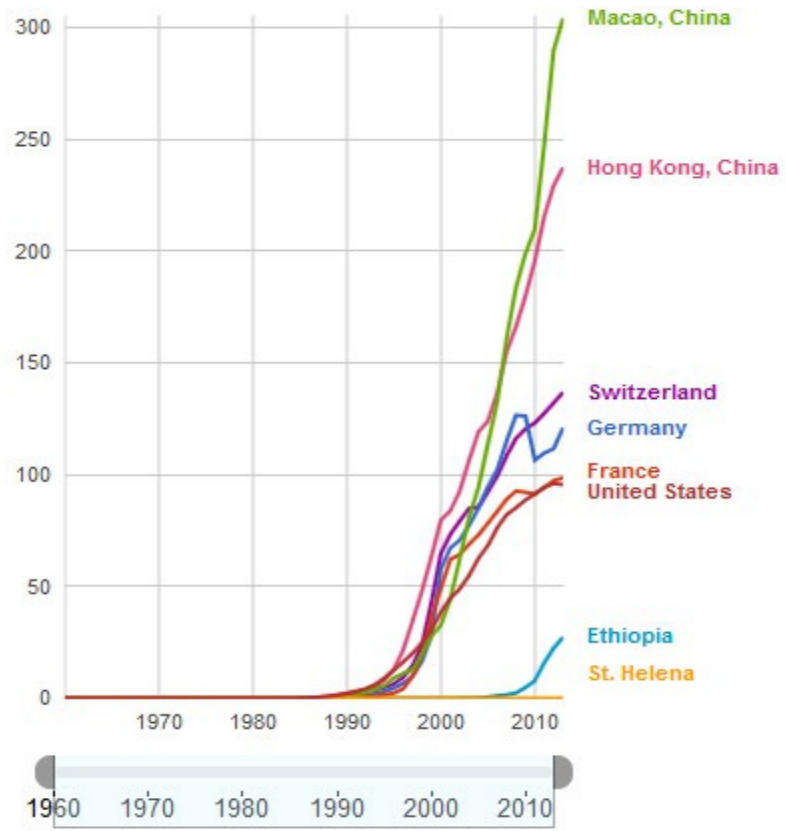
Dose Züme: assuming max. downlink (0.51 V/m)



Exposure change over time



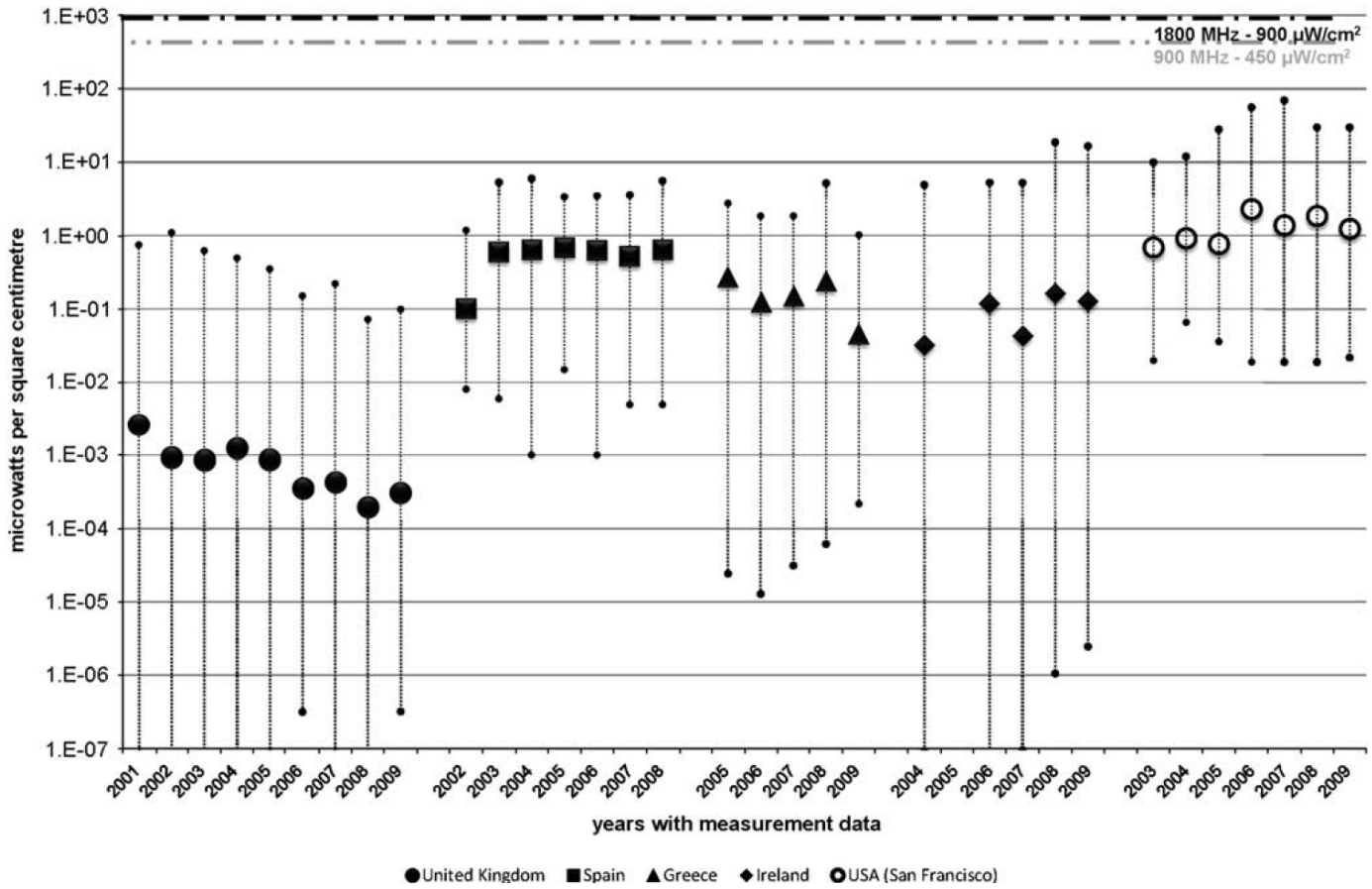
Mobile phone subscribers per 100 inhabitants (ITU, 2015)



Temporal trends in measurement surveys

E-field

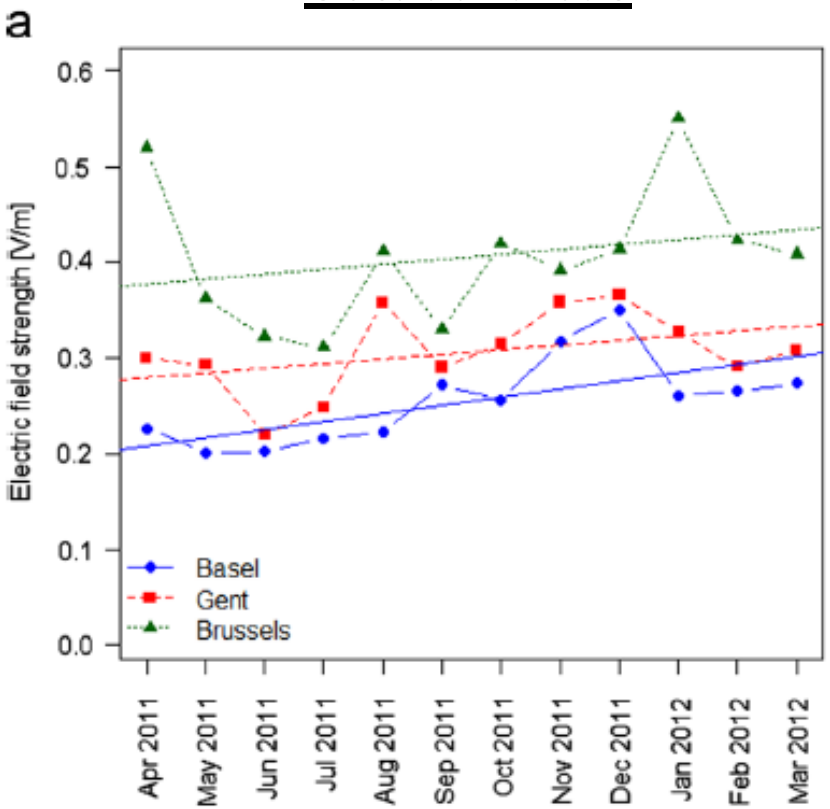
Downlink



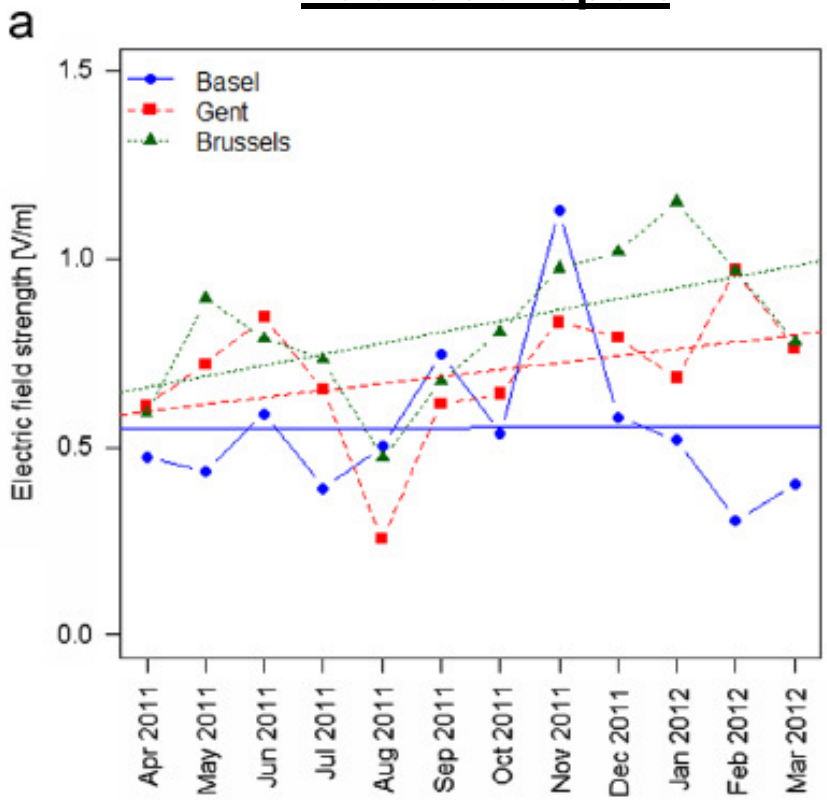
Rowley et al., JESEE, *2012*

Temporal Variability in microenvironmental surveys (Total RF-EMF)

Outdoor areas



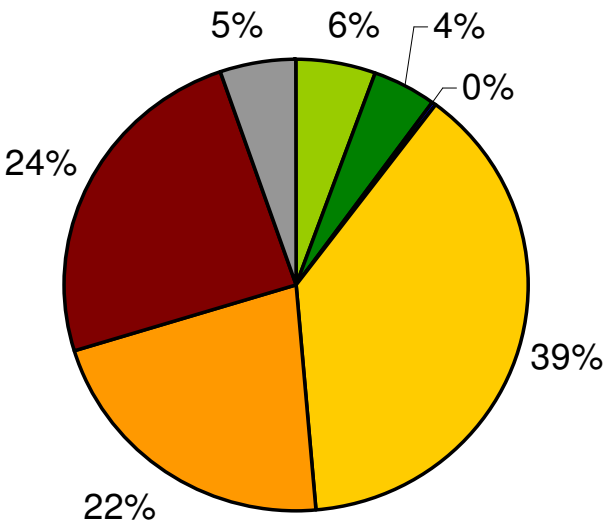
Public transport



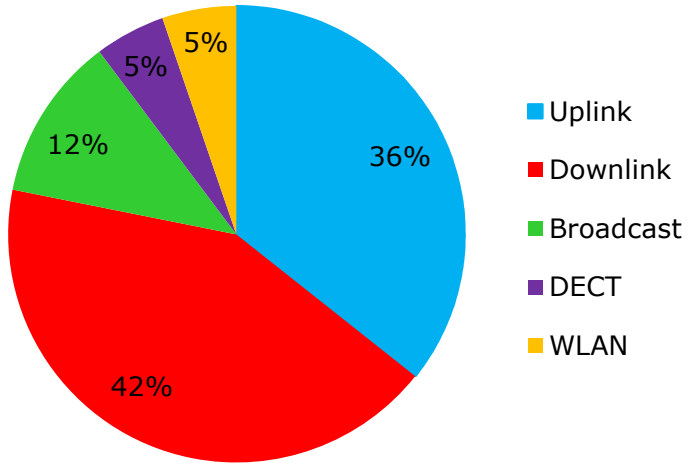
Urbinello et al., *Env Res, 2014*

Comparison of adult exposure in Qualifex and Zürich study

Qualifex (Basel), 2007/2008 (n=131)



Zürich 2014/2015 (n=72)



FM | TV | Tetrapol | Uplink* | Downlink | DECT | W-LAN

* without own phone use

Mean HF-EMF: 117 µW/m² (0.21 V/m)

Mean Downlink: 26 µW/m² (0.10 V/m)

Mean Uplink: 46 µW/m² (0.16 V/m)

Mean HF-EMF: 90 µW/m² (0.18 V/m)

Mean Downlink: 32 µW/m² (0.11 V/m)

Mean Uplink: 38 µW/m² (0.12 V/m)

Conlusions

- Far field exposure levels considerably below ICNIRP guidelines.
- Environmental exposure levels remarkably constant in the last 10 years.
- Own use of devices close to body most relevant for cumulative dose.
- For head dose: mobile phone use most relevant, but highly dependent on technology and connection quality.
- For whole body dose: data transmission very relevant.
- Several aspects of exposure not well understood: stand-by, different data transmission technology, etc.
- A better understanding of the link between technology and exposure would allow efficient exposure reduction.