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Radiofrequencies and health:

research in a fast-moving environment

23rd November 2022

Espace Diderot - Paris

#RadiofrequencesRS

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A five-country study of micro-environmental electromagnetic fields using two personal exposimeters and a distributed body-worn sensor

Prof. Dr. Marloes Eeftens
Research Group Leader
Swiss Tropical and Public Health Institute

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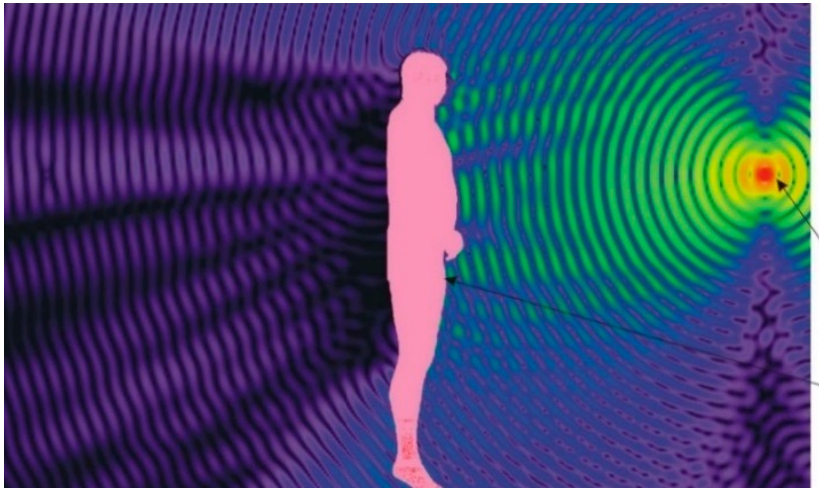
Background

- Exposure characterization for RF-EMF informs studies on environment, epidemiology, risk assessment and risk communication
- Personal exposure monitoring devices underestimate exposure due to body shielding
- Exposimeters are calibrated in free space but often used on-body in studies
- Design a dedicated, on-body calibrated measurement device to avoid body shielding



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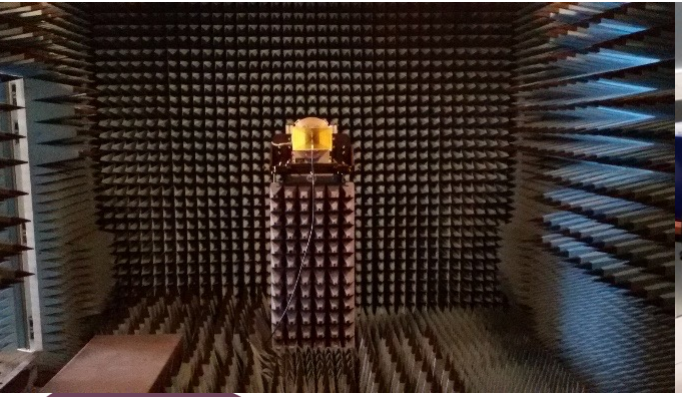
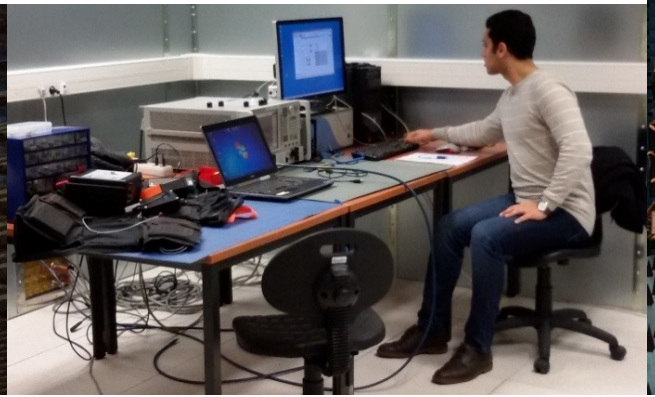
Project Goals

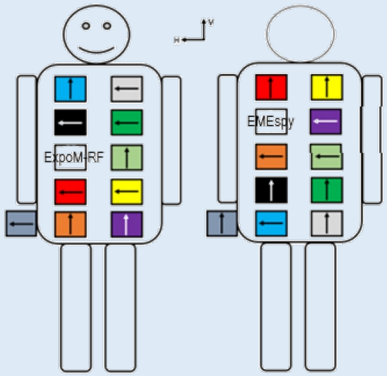
- Characterize RF-EMF exposure levels in different microenvironments in 5 countries
- To use an on-body calibrated measurement device designed to avoid body shielding in real-life conditions: the **BWDM**
- **B**ody-**W**orn **D**istributed exposure **M**eter





Measurement equipment

BWDM
(aka «The Vest»)

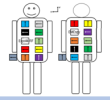


GSM 1800 UL	LTE 2600
LTE 800	GSM 1800 DL
GSM 900 DL	UMS UL
GSM 900 UL	DECT
UMS DL	WiFi 2GHz

ExpoM-RF

EMEspy 200

Frequency bands

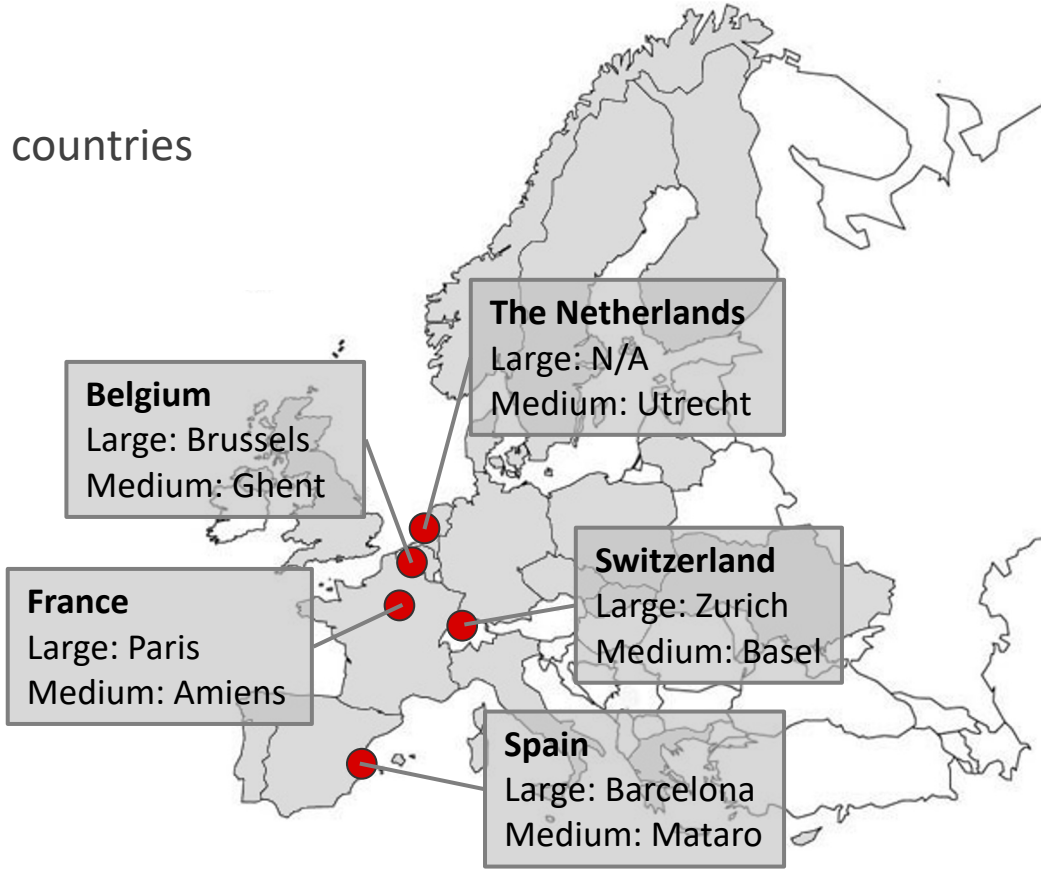


- Devices measure different frequency bands
- Aligned bands are common to all

Frequency band	Frequencies	BWDM Vest (11 bands)	ExpoM-RF (16 bands)	EmeSpy 200 (21 bands)	Included in summary
FM Radio	87-107 MHz		X	X	
TV3	174-223 MHz			X	
TETRA 1	380-400 MHz			X	
TETRA 2	410-430 MHz			X	
TETRA 3	450-470 MHz			X	
TV	470-770 MHz		X	X	
~~Mobile 800 MHz Downlink~~	~~791-821 MHz~~	X	X	X	~~DL, TOTAL~~
~~Mobile 800 MHz Uplink~~	~~832-862 MHz~~		X	X	
~~Mobile 900 MHz Uplink~~	~~880-915 MHz~~	X	X	X	~~UL, TOTAL~~
Mobile 900 MHz Downlink	925-960 MHz	X	X	X	DL, TOTAL
Mobile 1.8 GHz Uplink	1710-1785 MHz	X	X	X	UL, TOTAL
Mobile 1.8 GHz Downlink	1805-1880 MHz	X	X	X	DL, TOTAL
DECT	1880-1900 MHz	X	X	X	DECT, TOTAL
Mobile 2.1 GHz Uplink	1920-1980 MHz	X	X	X	UL, TOTAL
Mobile 2.1 GHz Downlink	2110-2170 MHz	X	X	X	DL, TOTAL
ISM 2.4 GHz (Wi-Fi 2.4 GHz)	2400-2483.5 MHz	X	X	X	WIFI, TOTAL
Mobile 2.6 GHz Uplink	2500-2570 MHz		X	X	UL, TOTAL
Mobile 2.6 GHz Downlink	2620-2690 MHz	X	X	X	DL, TOTAL
Mobile 3.5 GHz	3300-3900 MHz		X	X	
WiFi 5 GHz	5150-5850 MHz	X	X	X	Excluded

Study Areas

- RF-EMF measurements in 5 European countries
- One large city
- One medium-size city
- Several small villages
- …and various microenvironments of public interest in each place



Study Areas – microenvironments

Microenvironment (ME)		Largest city*					Medium city**					Village				
Category	Sub-category	BE	CH	ES	FR	NL	BE	CH	ES	FR	NL	BE	CH	ES	FR	NL
Outdoor areas	Downtown area	2	2	2	4		2	2	2	2	1	2	2	1	2	2
	Business area	2	2	3	2											
	Shopping area	2	2	3	3		2	2	2	2						
	City parks	2	2	3	2		2	2	2	2	2					
	Residential area	11	11	12	12		16	12	14	12	16	1	6	4	6	8
Public indoor places	Railway station		2	2	2		2	3		2	4		2	1	2	1
	Bus station			4					1	2	2				4	1
	Subway station			1	2											
	Shopping centre	2	2	3	2		2	2	1	3	2					
	Children's playground	2	2	2	2		2	2	2	2	3	2	2	2	2	3
	University	2	2	2	3		2	2	1	3	2					
		Full: >80% of seats taken					Medium full (40-80%)					Empty: <40% seats taken				
Transportation modes	Bus	1	7	2	12	12	6	6	2	10	15	3	4		8	19
	Train	1	2		8	1		5		10	2	2	1		11	5
	Tram	1	8		2	2	6	14	2	6	3	5	10	2		2
	Metro			1	9				2	7				1	2	
Total		**28**	**34**	**40**	**65**	**15**	**42**	**53**	**30**	**56**	**30**	**10**	**12**	**8**	**35**	**15**

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* Brussels (BE), Zürich (CH), Barcelona (ES), Paris (FR), Amsterdam (NL)

** Ghent (BE), Basel (CH), Villafranca (ES), Amiens (FR), Utrecht (NL)

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Study Areas – microenvironments

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	City parks	2	2	3	2		2	2	2							
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Public indoor places	Railway station		2	2	2		2	3								
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	Subway station			1	2											
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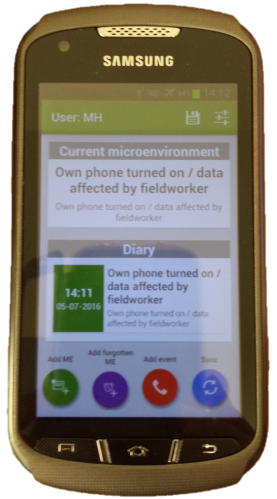
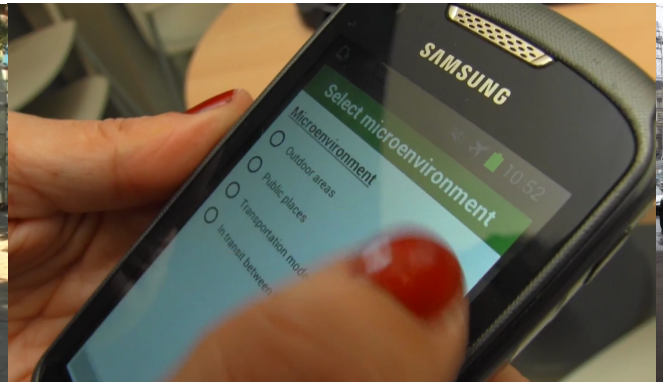
	Train	1	2		8	1		5								
	Tram	1	8		2	2	6	14	2							
	Metro			1	9				2							
Total		**28**	**34**	**40**	**65**	**15**	**42**	**53**	**30**							

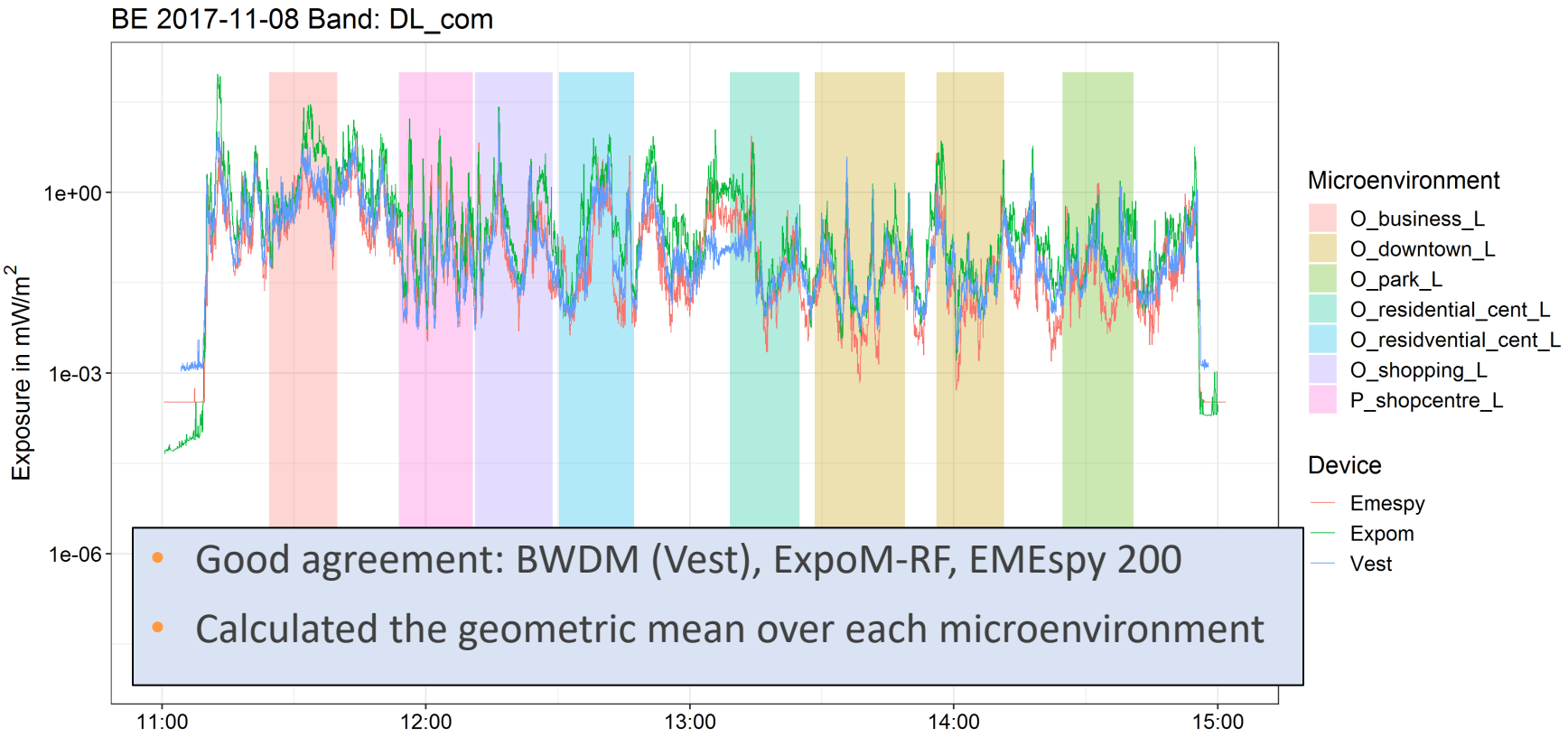
Data collected

- 357 micro-environments measured
- 47522 minutes = 792 hours = 33 days of data captured
- 154 measurement days, aided by “diary app” in flightmode





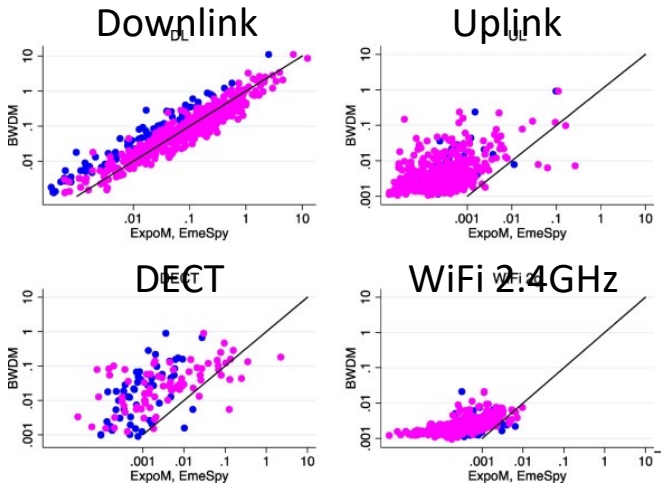
Data collected – time series

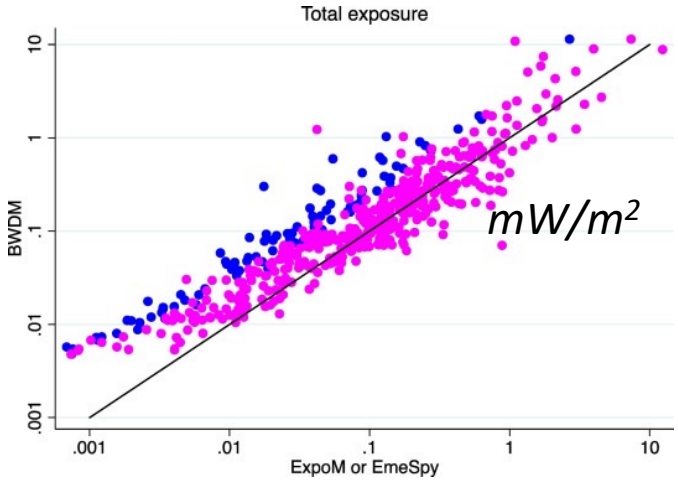


- Good agreement: BWDM (Vest), ExpoM-RF, EMEspy 200
- Calculated the geometric mean over each microenvironment

Results - BWDM versus ExpoM-RF and EMEspy 200

- Highly correlated for total and downlink exposure (73% of total)
- BWDM measured clearly higher UL, DECT and WiFi exposure than the exposimeters
- Difference of total RF-EMF exposure:
- −0.01 mW/m^2 ExpoM-RF versus BWDM
- −0.06 mW/m^{2}m EMEspy 200 versus BWDM

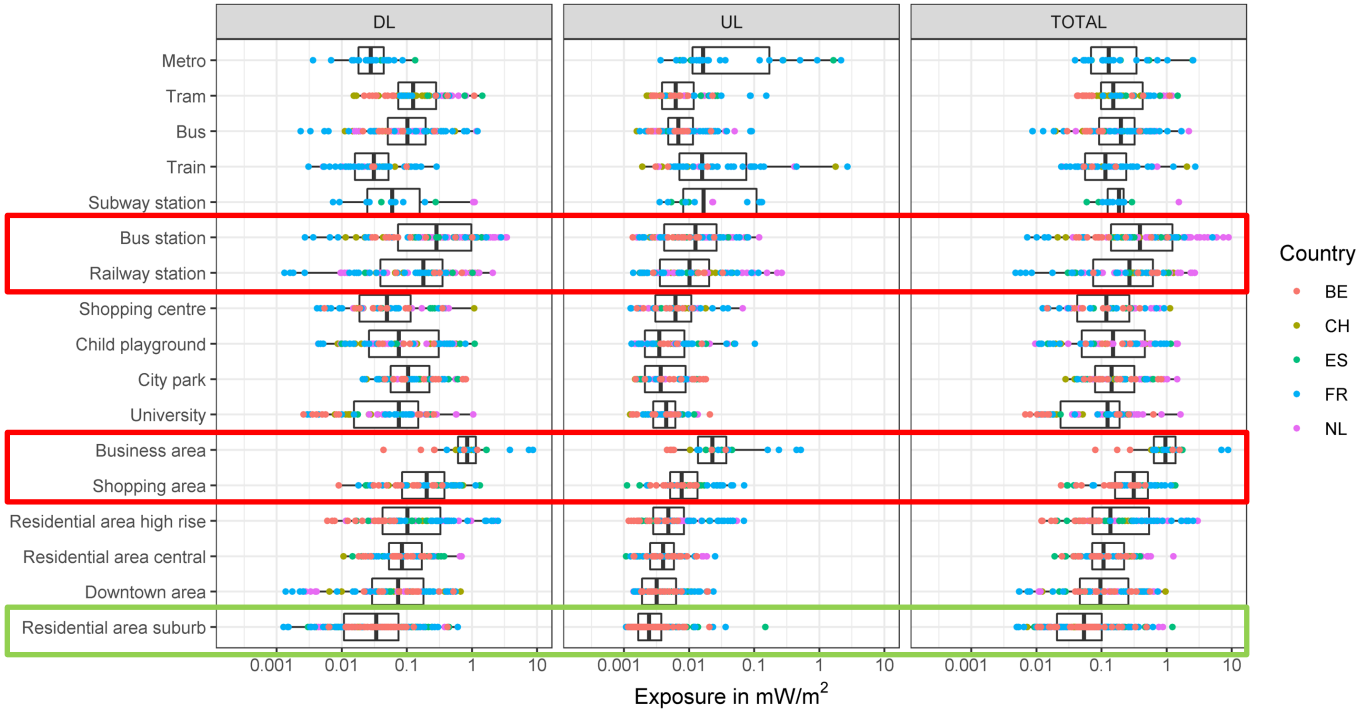




Pink = ExpoM-RF versus BWDM
Blue = EMEspy 200 versus BWDM
From Huss et al., 2021, Env. Int.

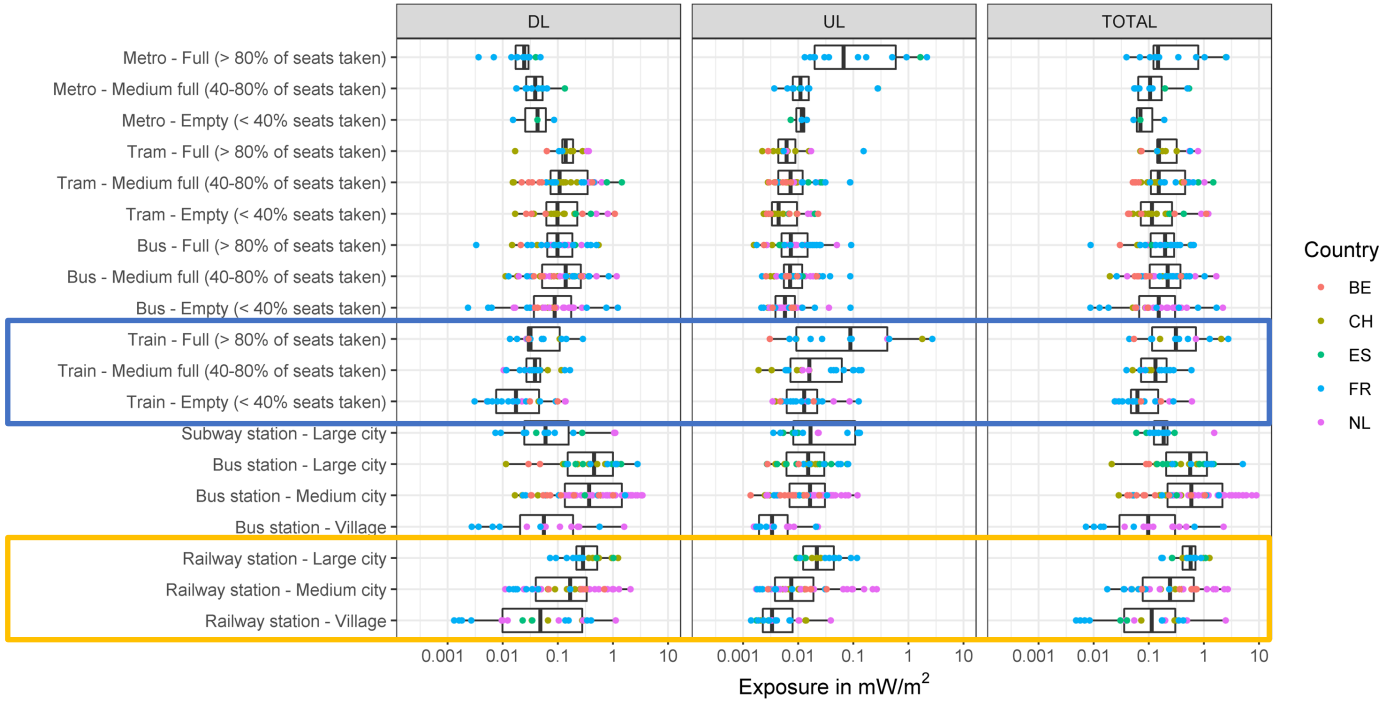
Results – Microenvironments 1

- **Highest exposures:** train and bus stations, business and shopping areas
- **Lowest exposures:** Residential areas, suburbs



Results – Microenvironments 2

- The **busier** that train/metro, the **higher** the uplink exposure
- The **larger** the town, the **higher** the downlink and uplink exposures



Conclusion

- The BWDM measured higher levels than other exposimeters, compatible with body shielding
- Limitation: more effort in calibration (for each wearer), logistics and data post-processing
- BWDM finds similar microenvironmental patterns as have been found in previous studies:
- The busier the higher uplink exposure
- The larger the town the higher downlink

Huss et al., 2021, Env. Int.

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Exposure to radiofrequency electromagnetic fields: Comparison of exposimeters with a novel body-worn distributed meter

Anke Huss [a,*], Stefan Dongus [b,c], Reza Aminzadeh [h], Arno Thielens [h], Matthias van den Bossche [h], Patrick Van Torre [d], René de Seze [e], Elisabeth Cardis [f,i,j], Marloes Eeftens [b,c], Wout Joseph [h], Roel Vermeulen [g], Martin Röösli [b,c]

[a] Institute for Risk Assessment Sciences, Utrecht University, Utrecht, Netherlands
[b] Swiss Tropical and Public Health Institute, Basel, Switzerland
[c] University of Basel, Basel, Switzerland

Aminzadeh et al., 2019, Sensors

A Multi-Band Body-Worn Distributed Exposure Meter for Personal Radio-Frequency Dosimetry in Diffuse Indoor Environments

Reza Aminzadeh, *Student Member, IEEE*, Arno Thielens, Davy Paul Gaillot, Martine Liénard, Lamine Koné, Sam Agneessens, Patrick Van Torre, Matthias Van den Bossche, Leen Verloock, Stefan Dongus, Marloes Eeftens, Anke Huss, Roel Vermeulen, René de Seze, Elisabeth Cardis, Hendrik Rogier, *Senior Member, IEEE*, Martin Röösli, Luc Martens, *Member, IEEE*, and Wout Joseph, *Senior Member, IEEE*

***Abstract*—A multi-band body-worn distributed exposure meter (BWDM) is designed and calibrated for diffuse fields in a reverberation chamber (RC) for personal exposure assessment with a 68% confidence interval on its antenna apertures, in the range 3.4–5.5 dB. A maximum difference of 0.9 dB is obtained for the total exposure in the test areas between the measurements**

Project team:
Reza Aminzadeh, Stefan Dongus, Anke Huss, René de Sèze, Patricia de Llobet, Arno Thielens, Matthias Van den Bossche, Paul Mazet, Sam Agneessens, Patrick Van Torre, Elisabeth Cardis, Roel Vermeulen, Wout Joseph, Martin Röösli

Funding:
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Equipment
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Thank you! Questions?

marloes.eeftens@swisstph.ch

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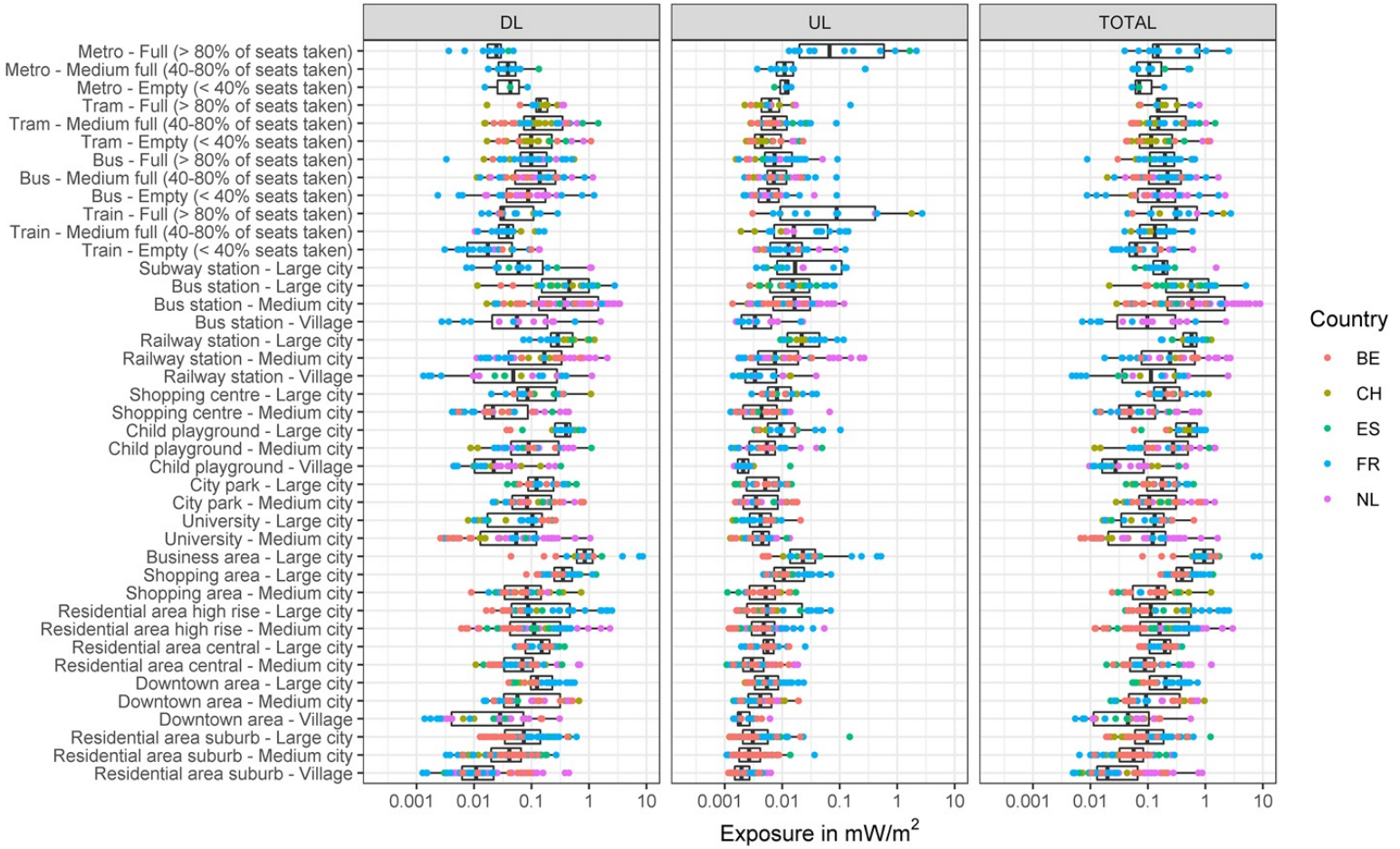

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Data management and statistics

- Software: R version 4.0.3
- Correction for crosstalk from DL1800 -> DECT (Eeftens et al., 2018, Bioelectromagnetics)
- Measurement synchronization, optimizing R between the devices
- BWDM Vest: 1s intervals
- ExpoM-RF: 4s intervals
- EMEspy 200: 4s intervals