Recent Evaluations of Wireless Exposure within the EU

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Myles Capstick
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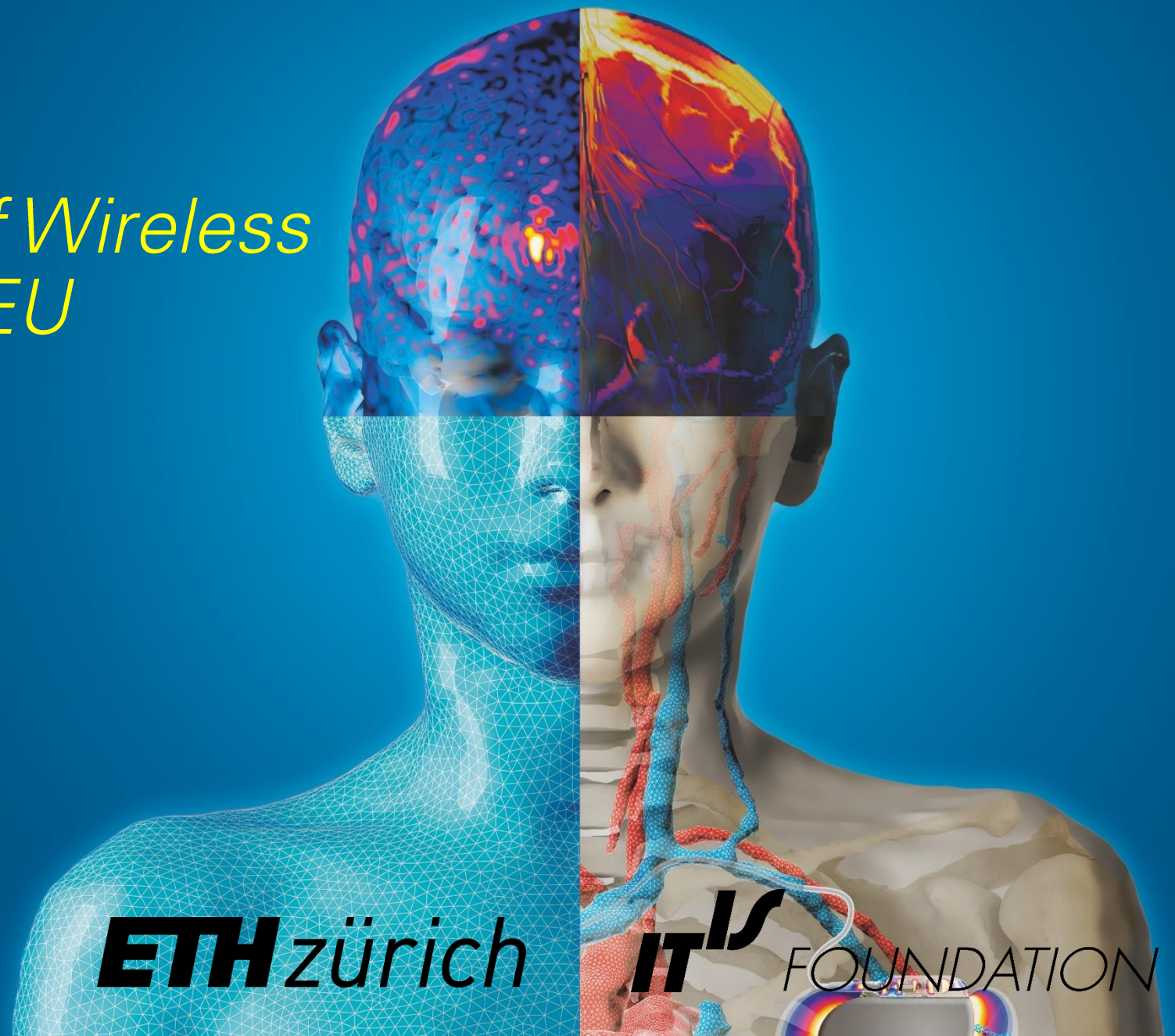
Jerusalem, 25th January 2017



Outline

Introduction
Exposure assessment
Research objectives
Computational and experimental dosimetry
Brain exposure
- mobile phones
- cordless phones
- far field

Mobile phone exposure localisation
Signal characteristics
Estimation of Daily-Life Incident Exposures
Cumulative and Integrative Exposure Estimation

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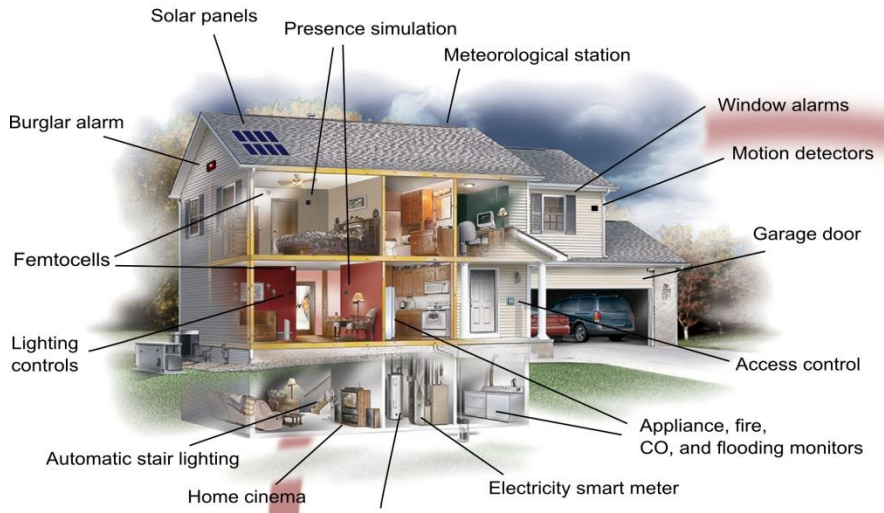
Living in a “smart world”



Domestic environment

Personal environment

Commercial environment

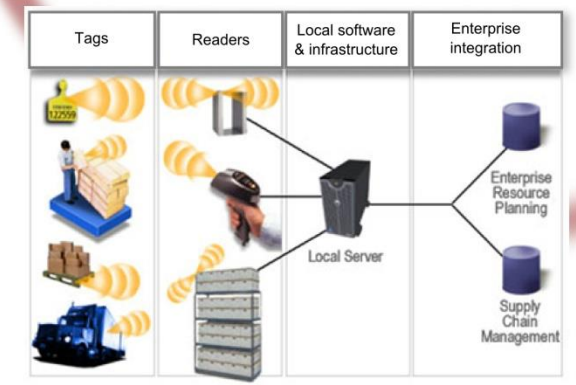


Image adapted from techblog.avira.com

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Objectives

To better understand mechanisms underlying possible health effects of EMF;

To **better characterise current and future population levels of EMF exposure in Europe**;

To further the state of knowledge on EMF and health;

To improve health risk assessment of EMF; and

To underpin policy development and propose **non-technological means to reduce EMF exposure**.

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Introduction

EMF dosimetry:

- device safety (compliance testing);
- public and regulatory information;
- dosimetry for epidemiology, in-vitro, in-vivo, and human studies.

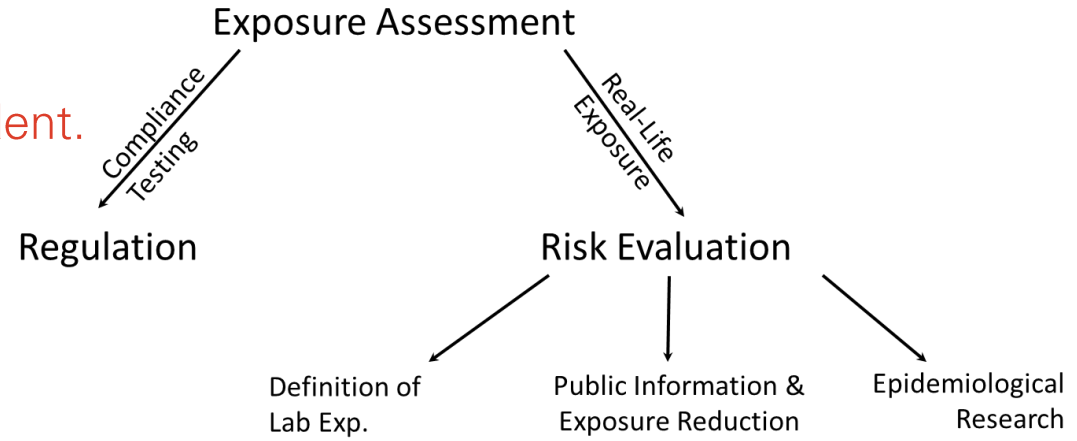
Health risks posed may be thermal or non-thermal nature:

✓ Compliance testing determines safety w.r.t. thermal effects.

o Sound dosimetry with focus on non-thermal effects

■ Hypothesis:

■ non-thermal effects are modulation and tissue dependent.



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Objectives

- To create a meaningful exposure matrix for past and prospective epidemiological studies
- To provide the most relevant exposure parameters for future research projects addressing adverse health effects on the brain
- To provide review committees with sufficient information to appropriately weigh the experimental evidence about brain effects
- To detect potential gaps in current product standards for testing compliance with EMF limits
- To provide the health agencies with the basis for exposure evaluations and also for the development of suitable recommendations and measures for exposure reductions.

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Research Topics

Exposure Assessment

- measurements campaigns (home, offices, school, nurseries)
- development of extrapolation models between different technologies
- development of a model to predict human exposure inside rooms.

Dosimetry

- determination of the induced fields
- development of compliance testing procedures
- determination of worst-case (maximum) exposures
- estimation of typical (average) exposures
- comparison with other sources

Biology & Risk Evaluation

- effect on cells and animals (genotoxicity)
- assessment of safety and risks

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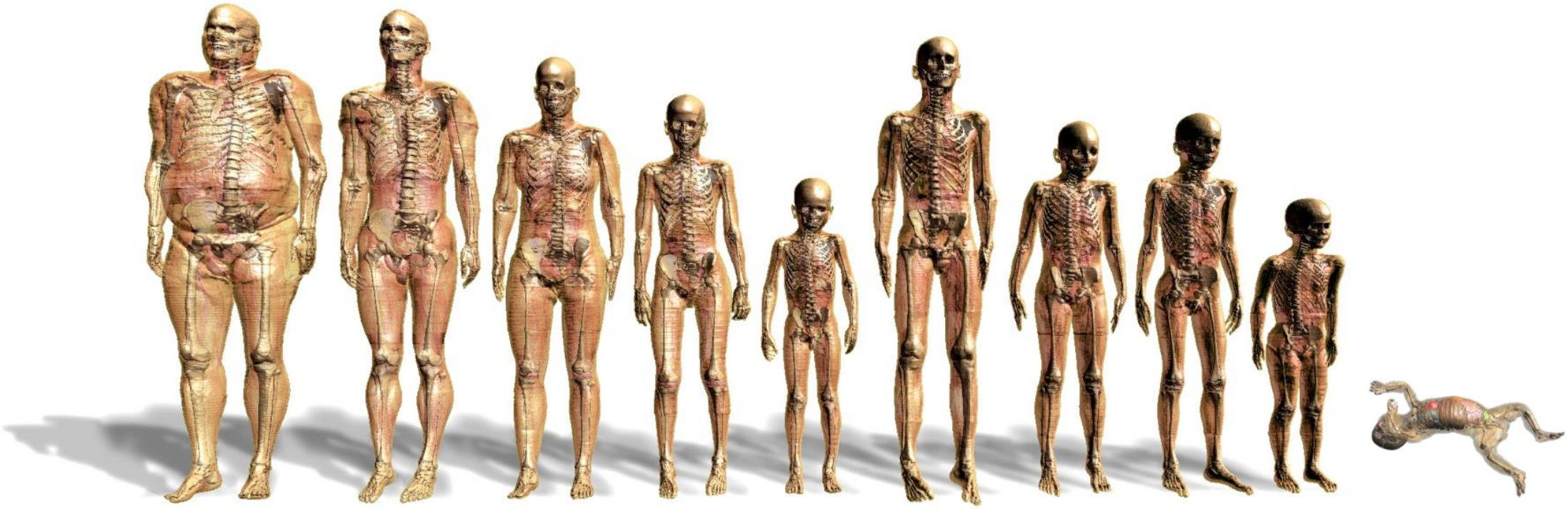
Towards Standard Human Models



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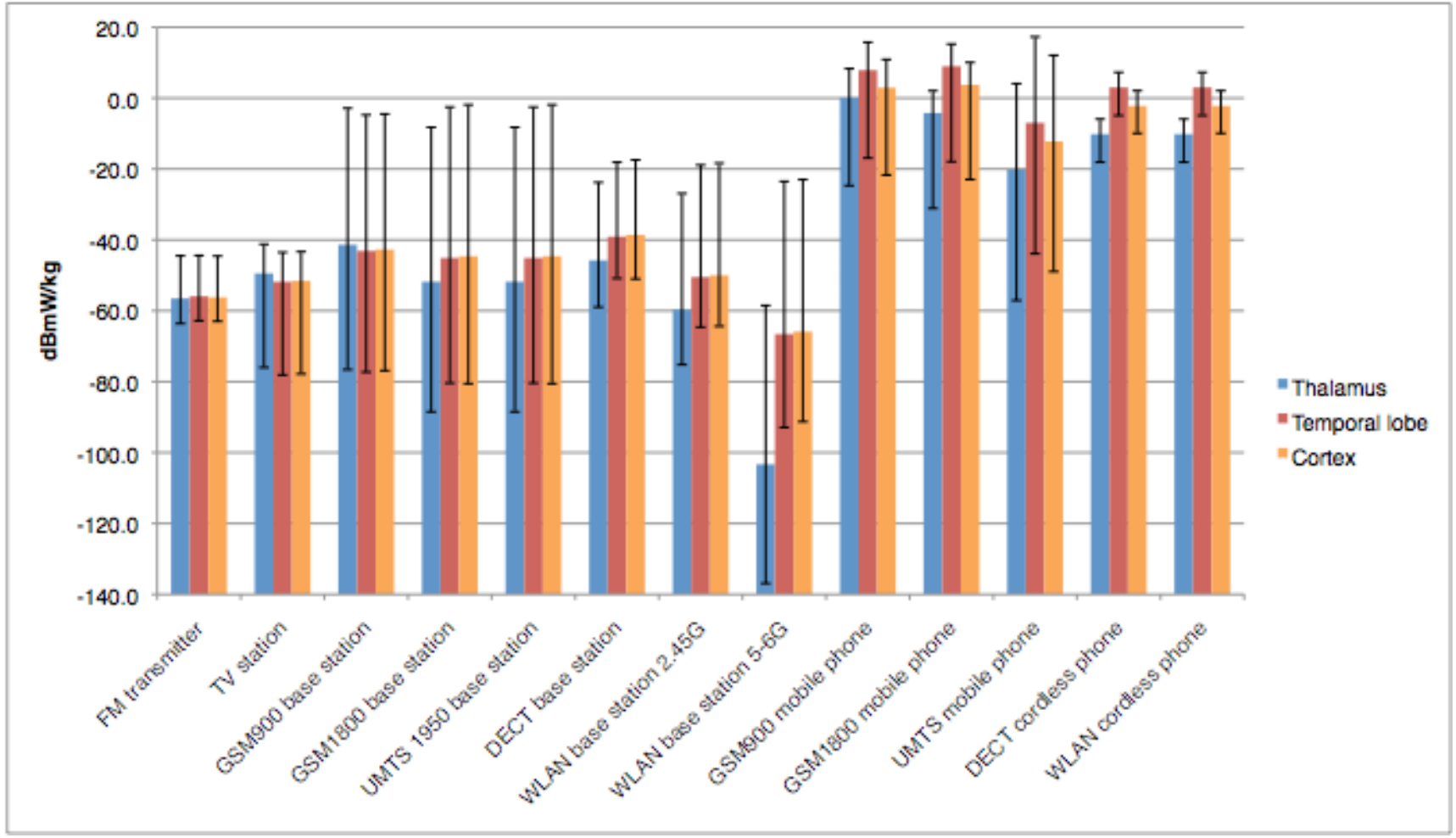
Brain Exposures from Different Sources



Implementation and Experimental Validation of a Brain-Region Specific Exposure Estimation in SAR Measurement Systems, NIR & Children's Health, May 18-20, 2011

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Methods: SAR Measurements

SAR measurements:

- right head side, touch
- GSM900, 1800, UMTS1950
- SAM with low loss holder
- SAM with lossy hand

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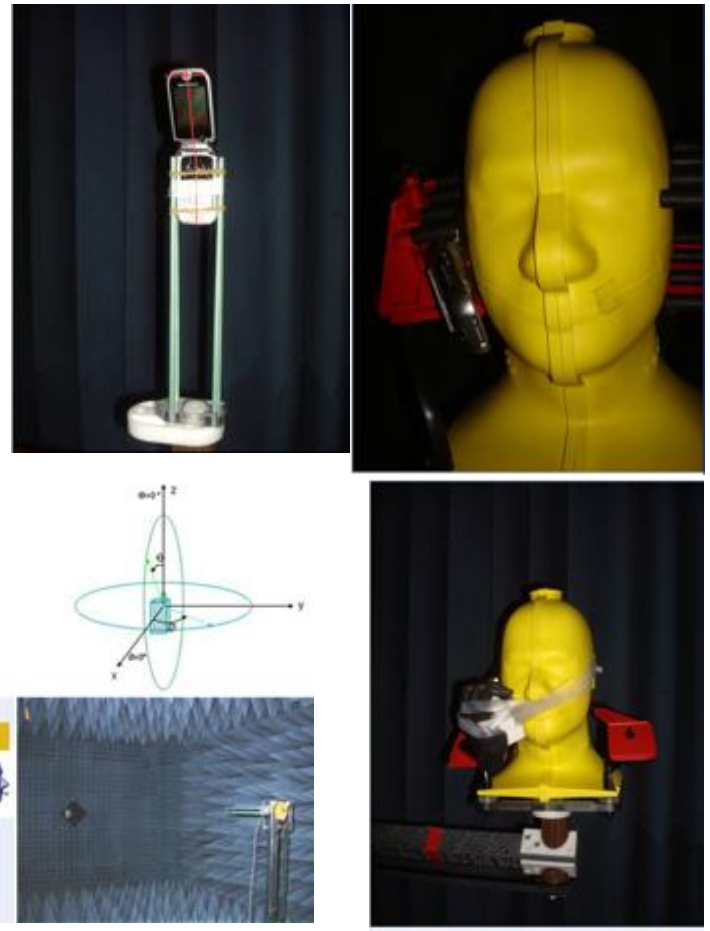
Methods: OTA Measurements

- OTA (TRP, TIS) measurements:
- touch
- GSM900, 1800, UMTS1950
- free-space
- SAM with low loss holder
- SAM with lossy hand



Source: ATL Lab, Taiwans

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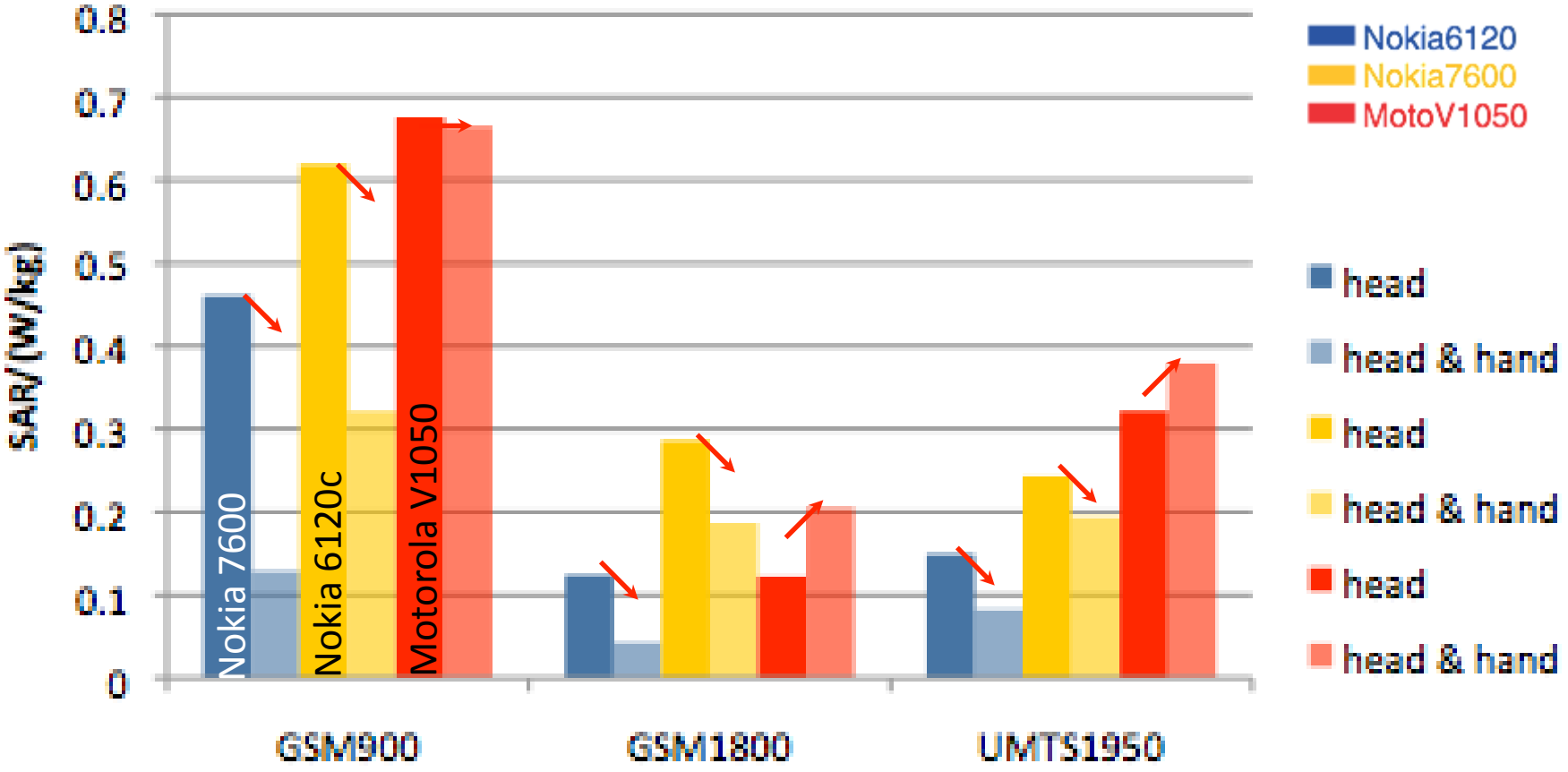
Results: 10g psSAR



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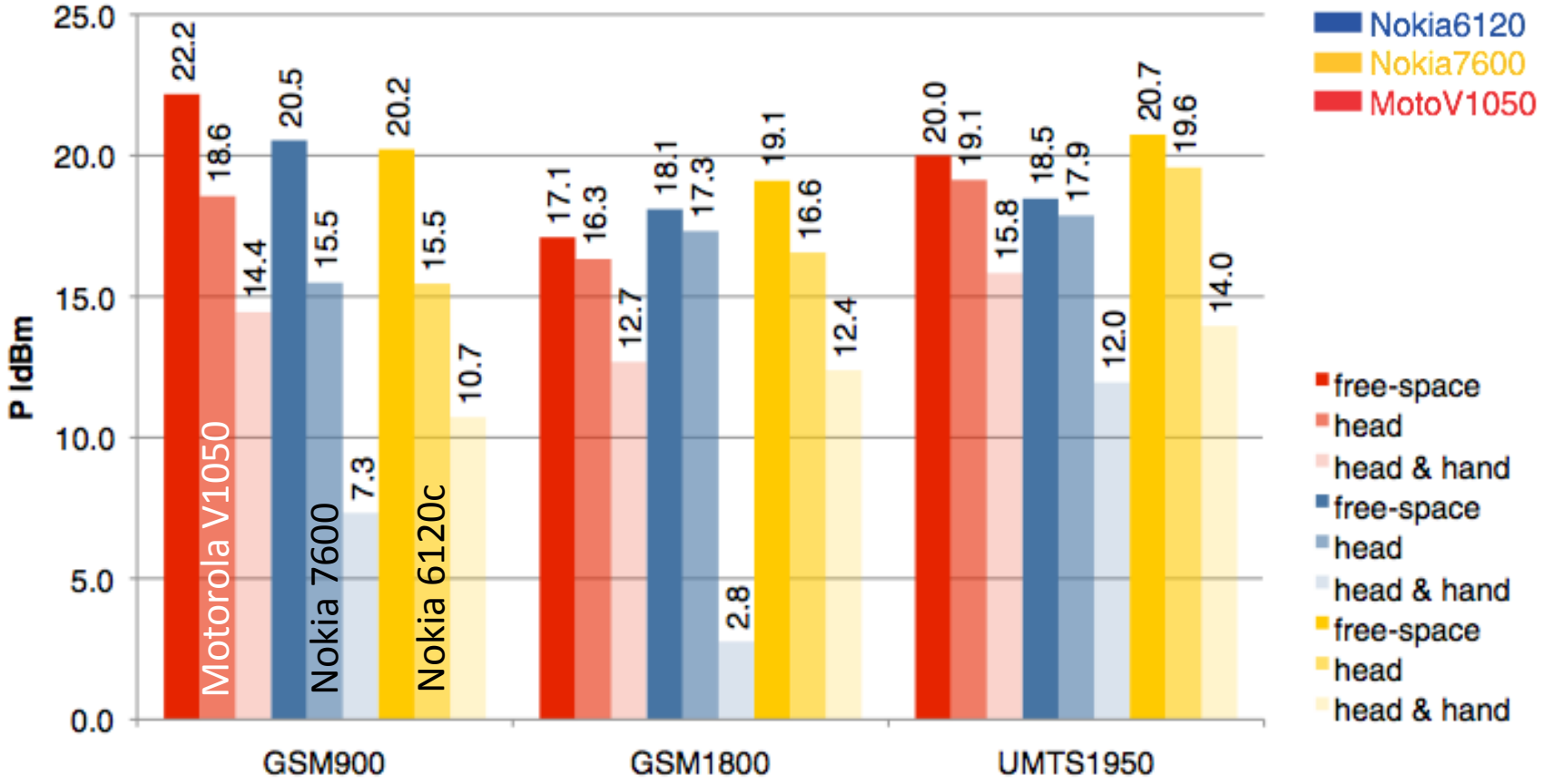
Results: OTA, TRP



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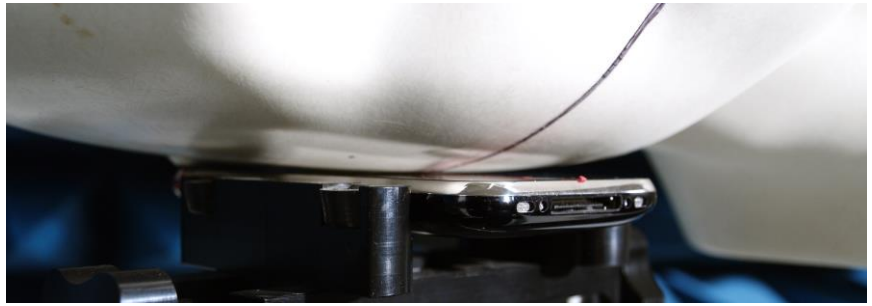
SAR Characterization of Cordless Phones



Methods: SAR measurement of 5 cordless phones (3 DECT, 2 WIFI)

Results:

- DECT, 10g psa SAR: 0.01–0.06 W/kg
- WiFi, 10g psa SAR: 0.011 and 0.017 W/kg
- typically no power control
- no effect on time-average handset output power due to presence of a secondary WiFi transmitter occupying 99%, 80%, 40%, 0% of data bandwidth

[3] Kühn, S., Gosselin, M.-C., Röösli, M., and Kuster, N. (2010). Novel brain and tissue region specific dosimetry for RF EMF epidemiological studies - a mobile user dependent exposure evaluation. Bioelectromagnetics, in preparation.

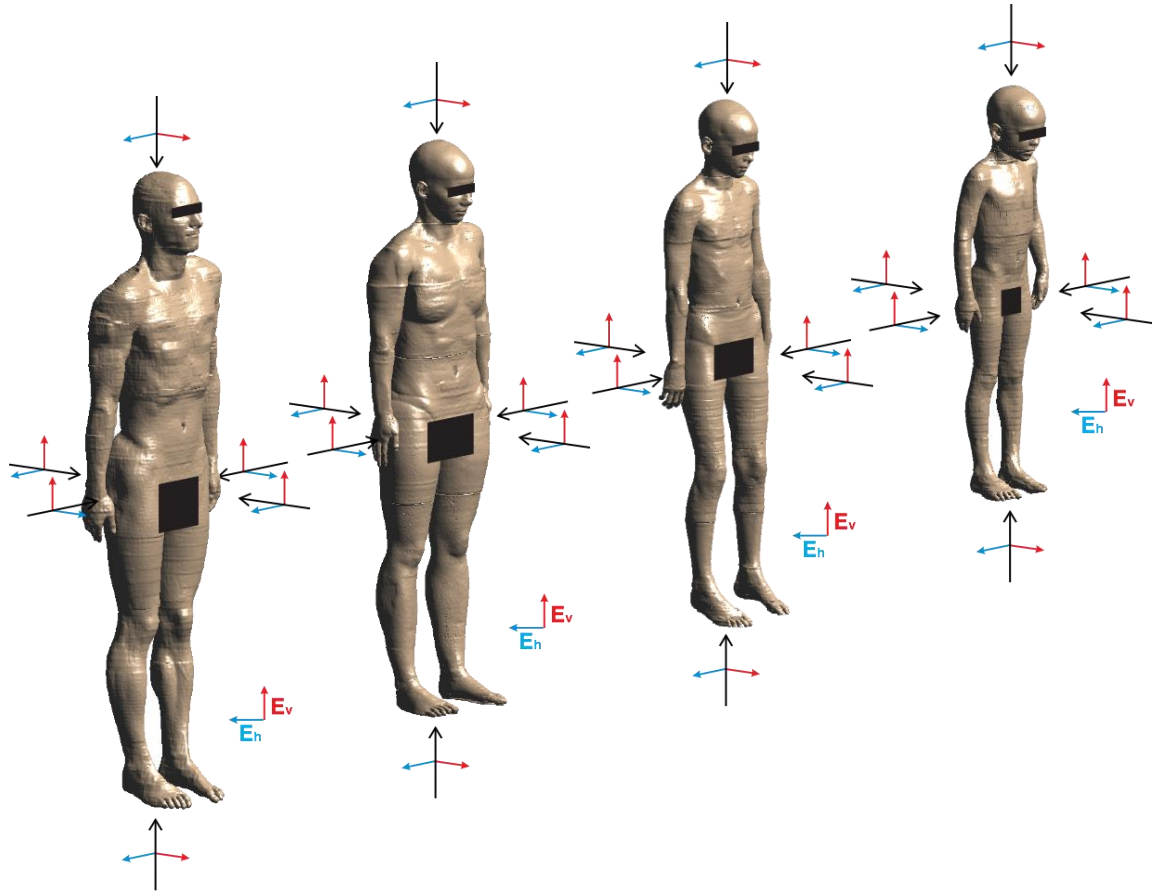
Assessment of Incident and Induced Fields from Quasi Far-Field Transmitters (Transformation)

Exposure from all six sides with 2 orthogonal polarizations each with equal magnitudes

Summation of SAR at each voxel from all incidences

Extraction of tissue and brain-region specific SAR

- Determination of correlation of tissue specific absorption with “time-average” incident field



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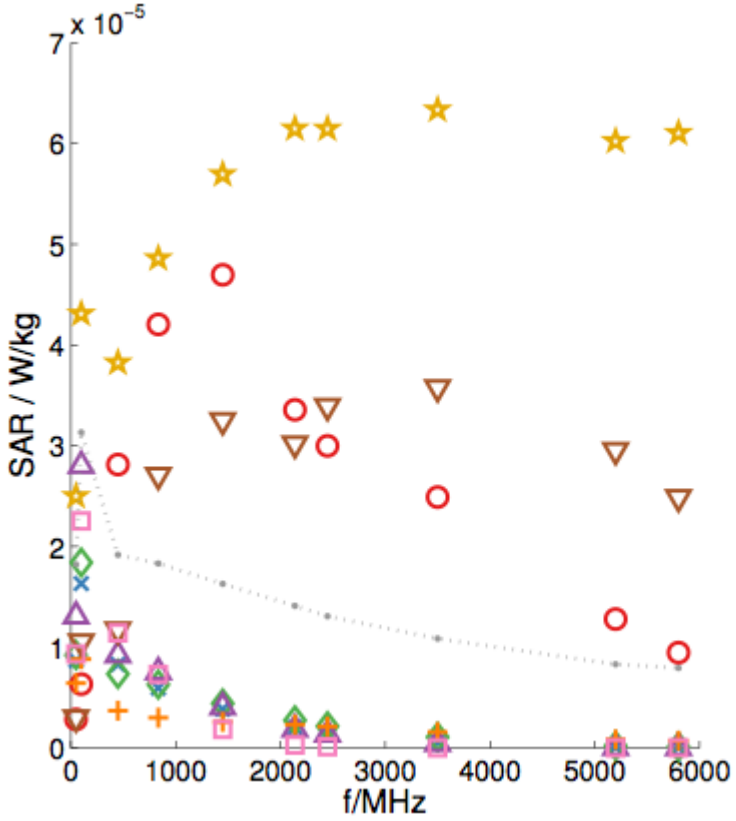
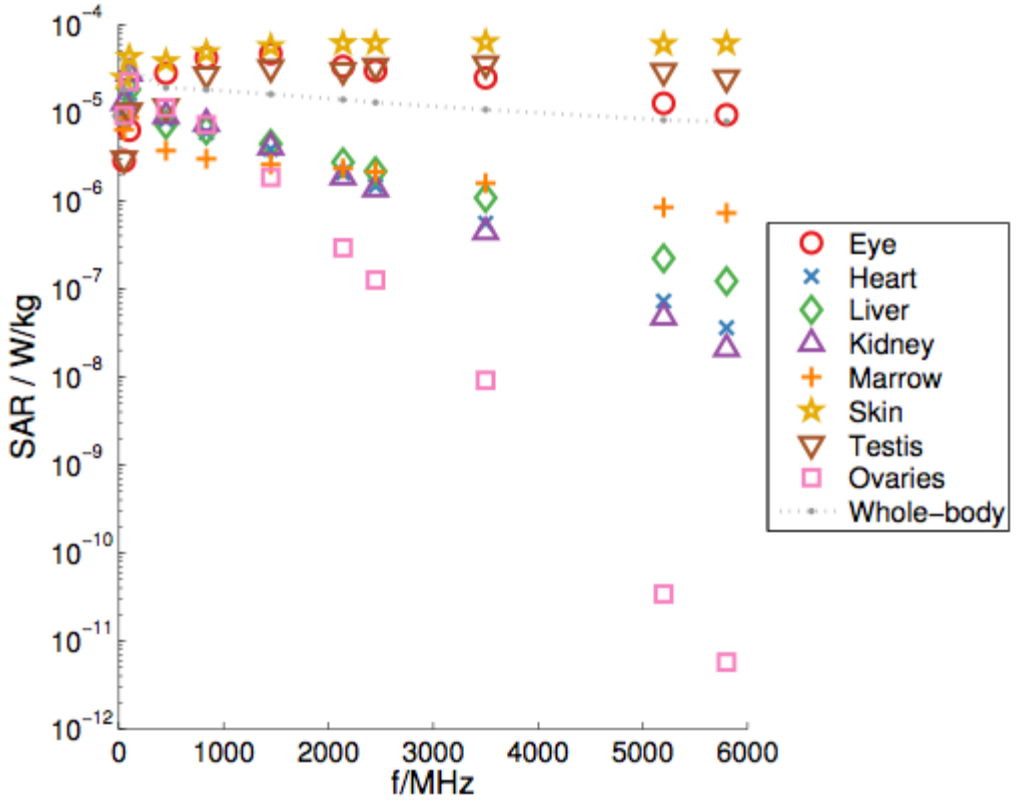
Results: Far-Field Exposure (tissues, avg. over VF)

SAR of various body regions - averaged over the models
Plane-wave incidence - 6 sides, 2 polarizations - E_{rms} = 1V/m





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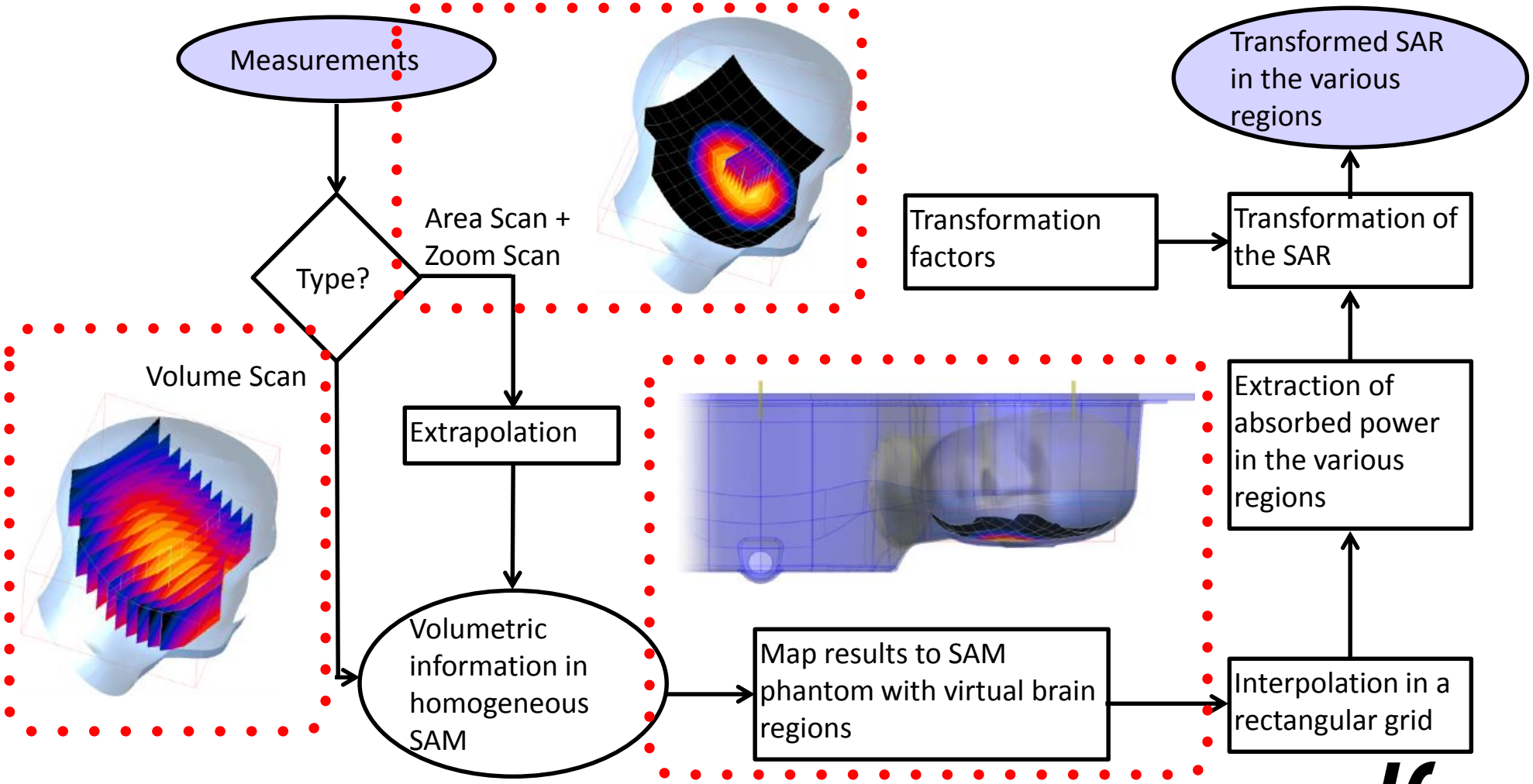
Evaluation of CNS Exposure from Mobile Phones (Transformation Concept)



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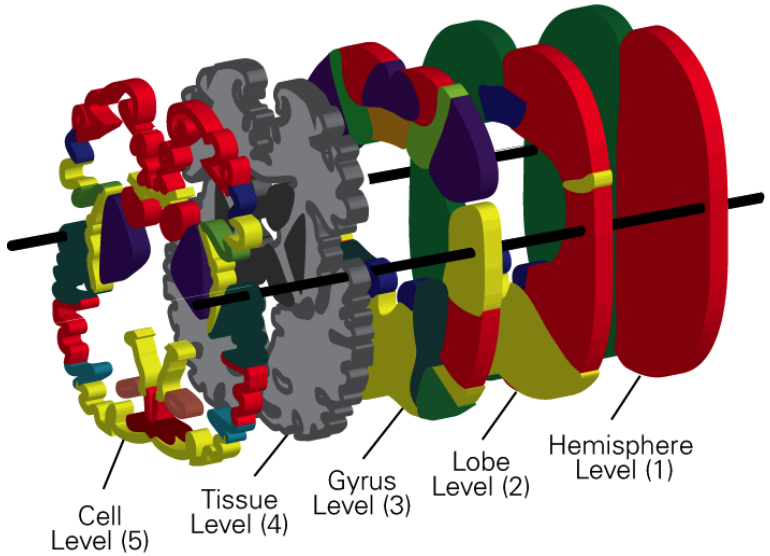
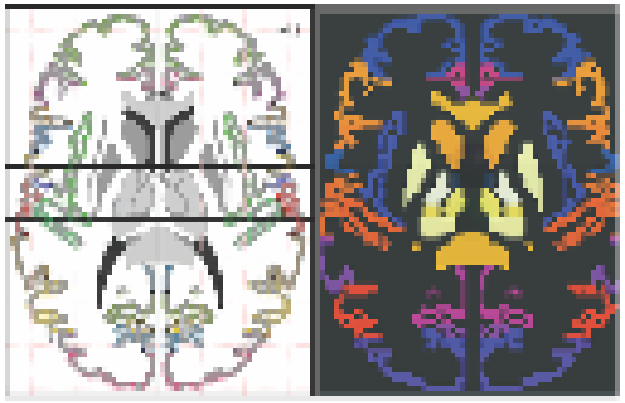
Brain-Region Specific SAR Extraction

VFF brain | hemisphere level | lobe level | gyrus level | tissue level | cell level





reference brain atlas | SEMCAD X

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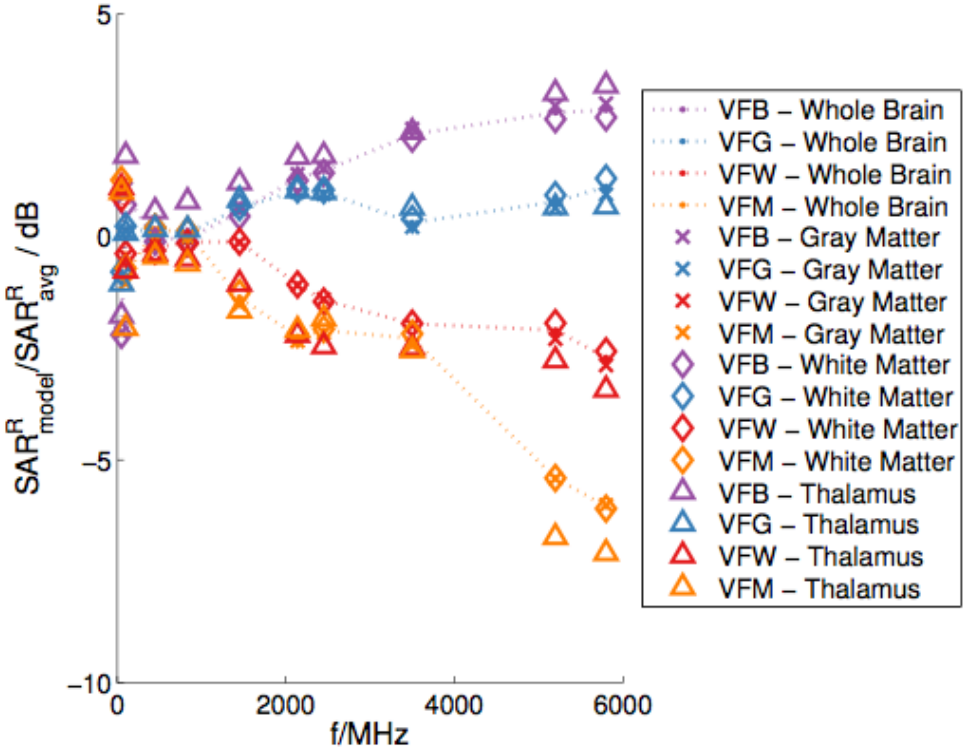
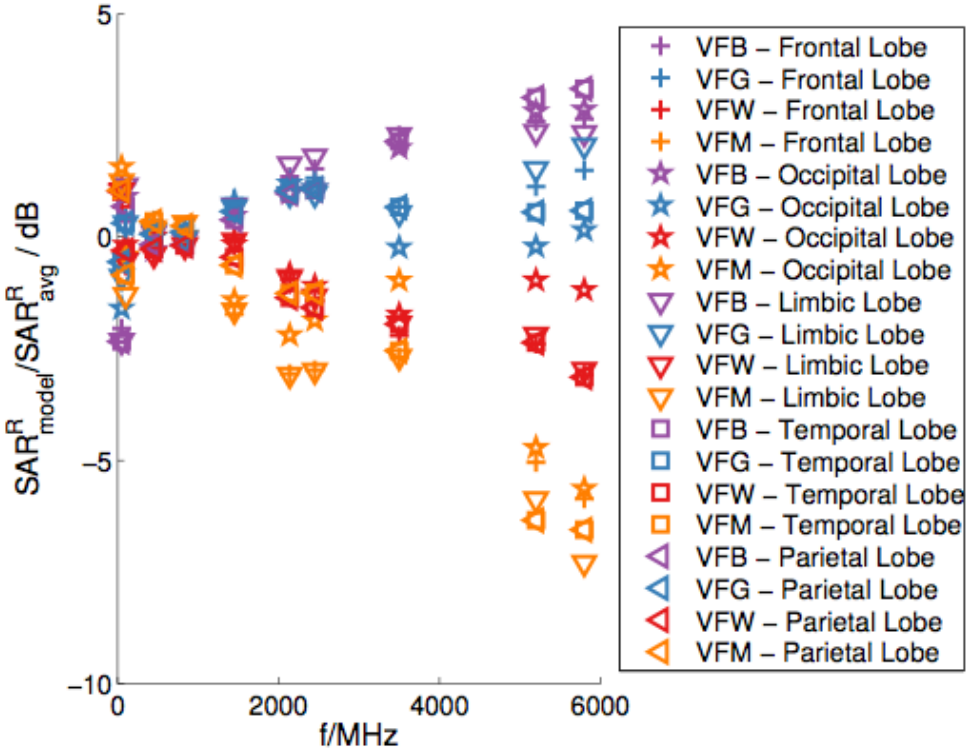
Far-Field Exposure (brain, Δ from avg.)

$SAR^R_{model}/SAR^R_{avg}$ of various brain regions

Plane-wave incidence - 6 sides, 2 polarizations - E_{rms} = 1V/m





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Grid Master – brain exposure localisation

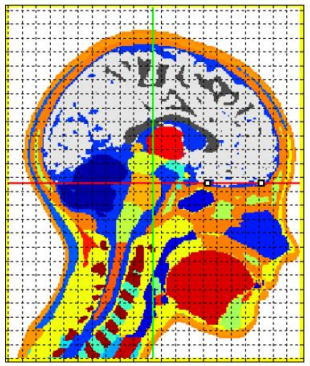
Exposure assessment subcommittee:
Myron Maslany, Joe Wiart, Hans Kromhout, Malcolm Sim, Ae-Kyoung Lee, Masao Taki, Elisabeth Cardis

Exposure assessment- EMF

- Estimation of RF and ELF exposure at different locations of the brain from mobile and DECT phones and other communications technologies
- Estimation of EMF exposure from other residential and occupational sources

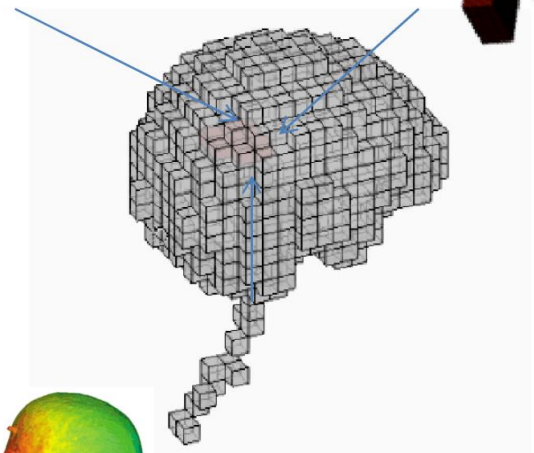
Objective – characterisation of exposure

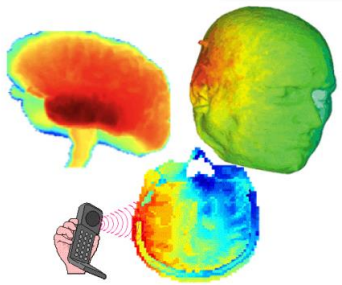
Tumor localisation



SAR

EXPOSURE





highly localized

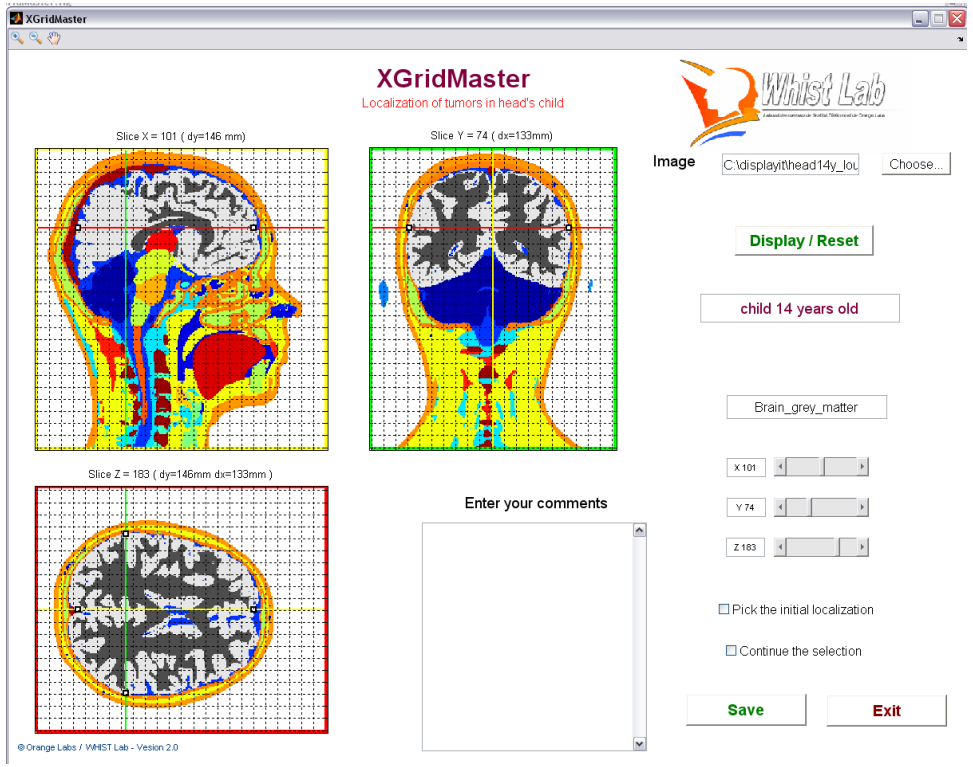
Courtesy: J. Wiart, Whist Labs

mobi-kids
Tecnologías de la comunicación, medioambiente y tumores cerebrales en la gente joven

Tumour diagnosis and localisation

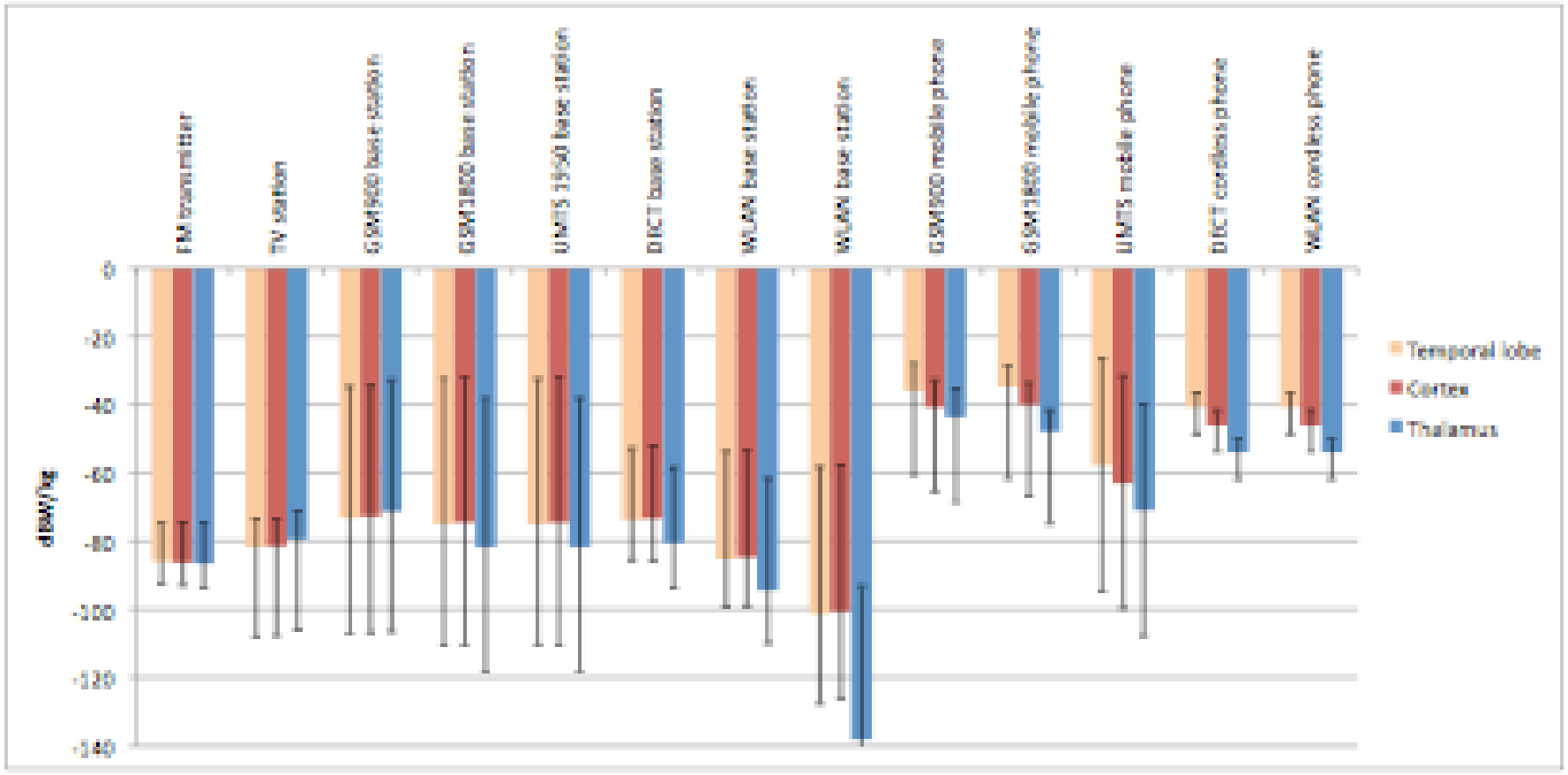
Tumour diagnosis:
central review of sample of histological slides
by international panel of neuropathologists to verify diagnosis

Tumour localisation:
review of MRI/CT scans- mark
precise location of tumour on
specially developed grids



SAR in Various Brain Regions, Weighted for Various Types of Wireless Users

Heavy mobile/cordless phone user



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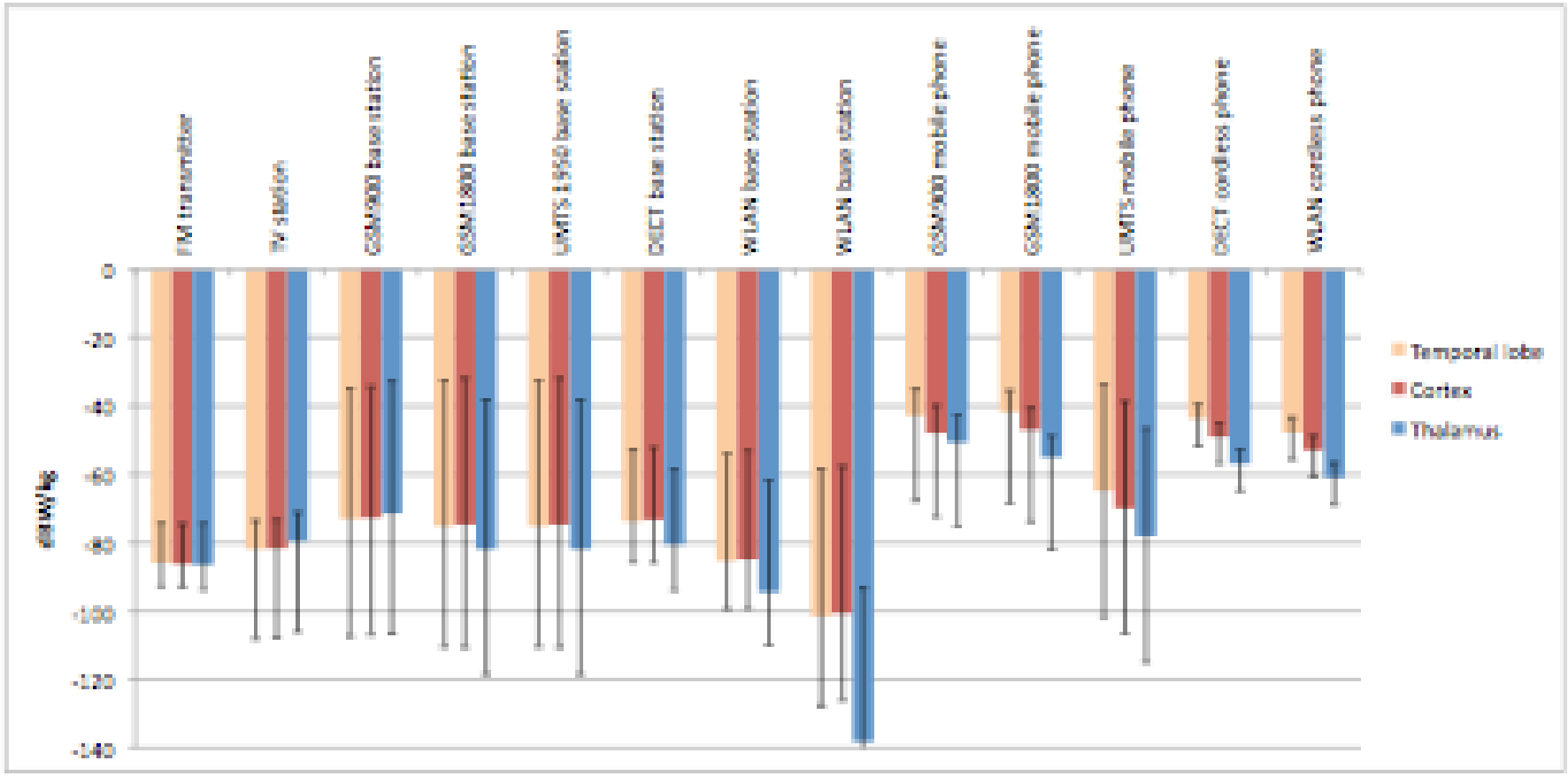
SAR in Various Brain Regions, Weighted for Various Types of Wireless Users

Normal mobile/cordless phone user



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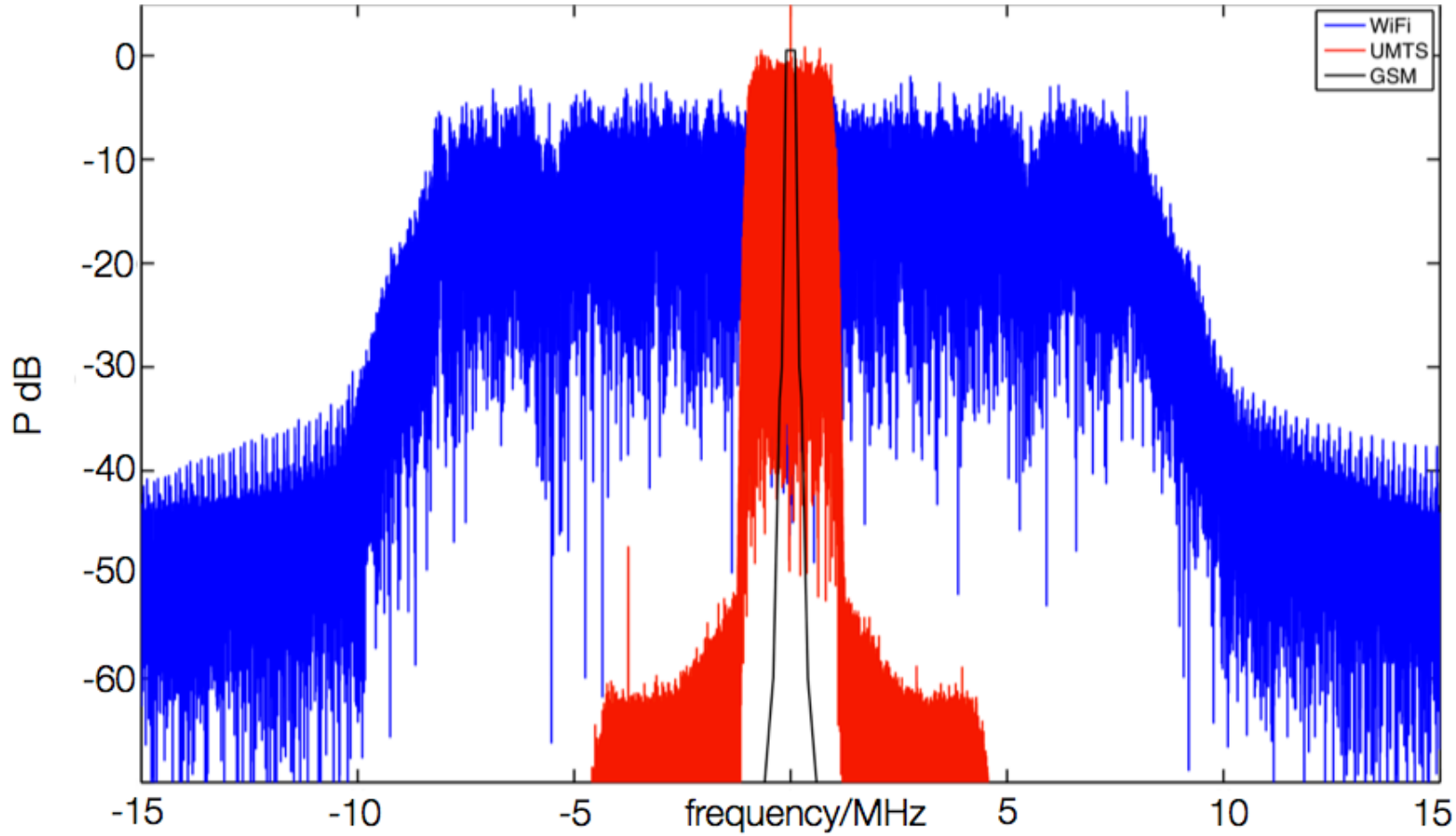
Modulation and signal characteristics

Biologically relevant?

WIFI, 2G, 3G Frequency Domain Signals



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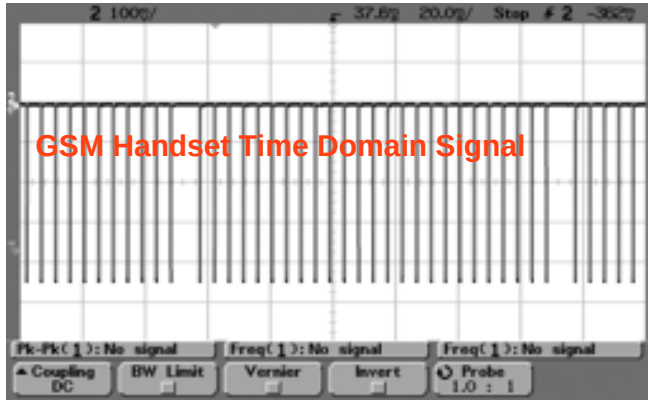
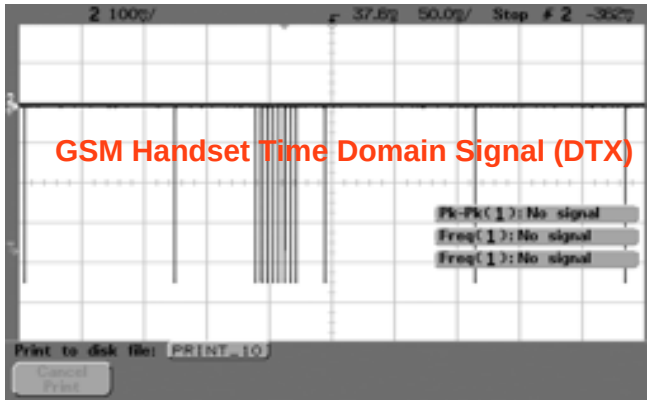
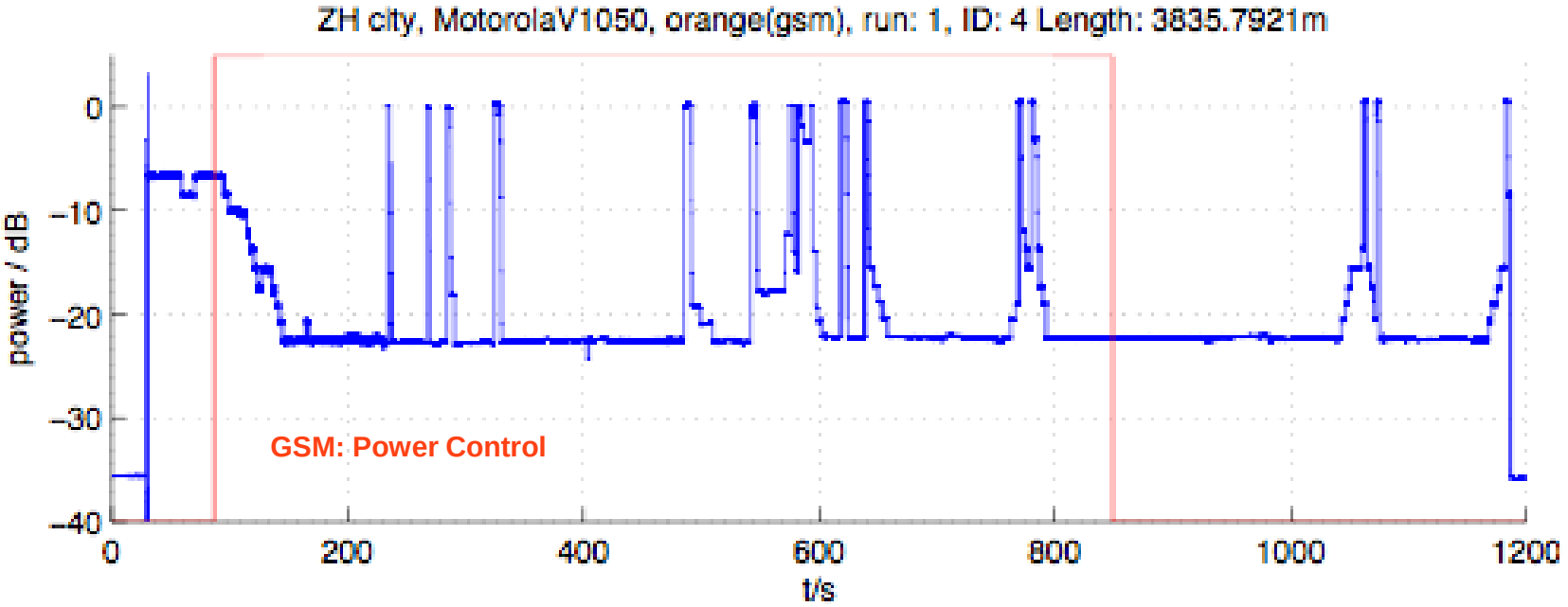
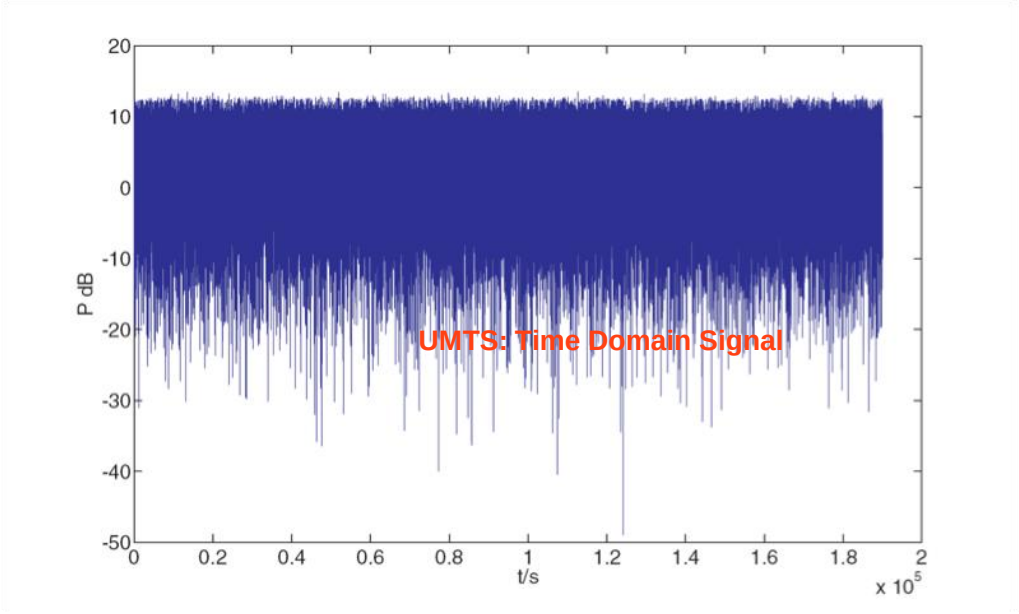
2G Time Domain Signals

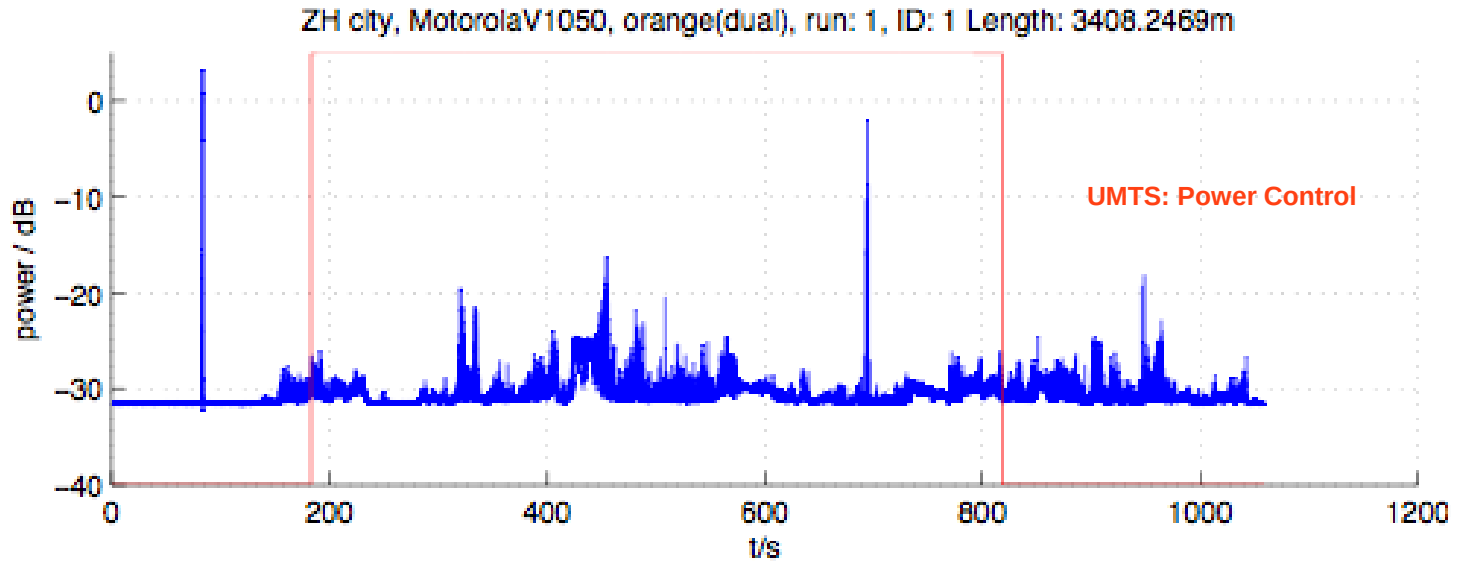






3G Time Domain Signals





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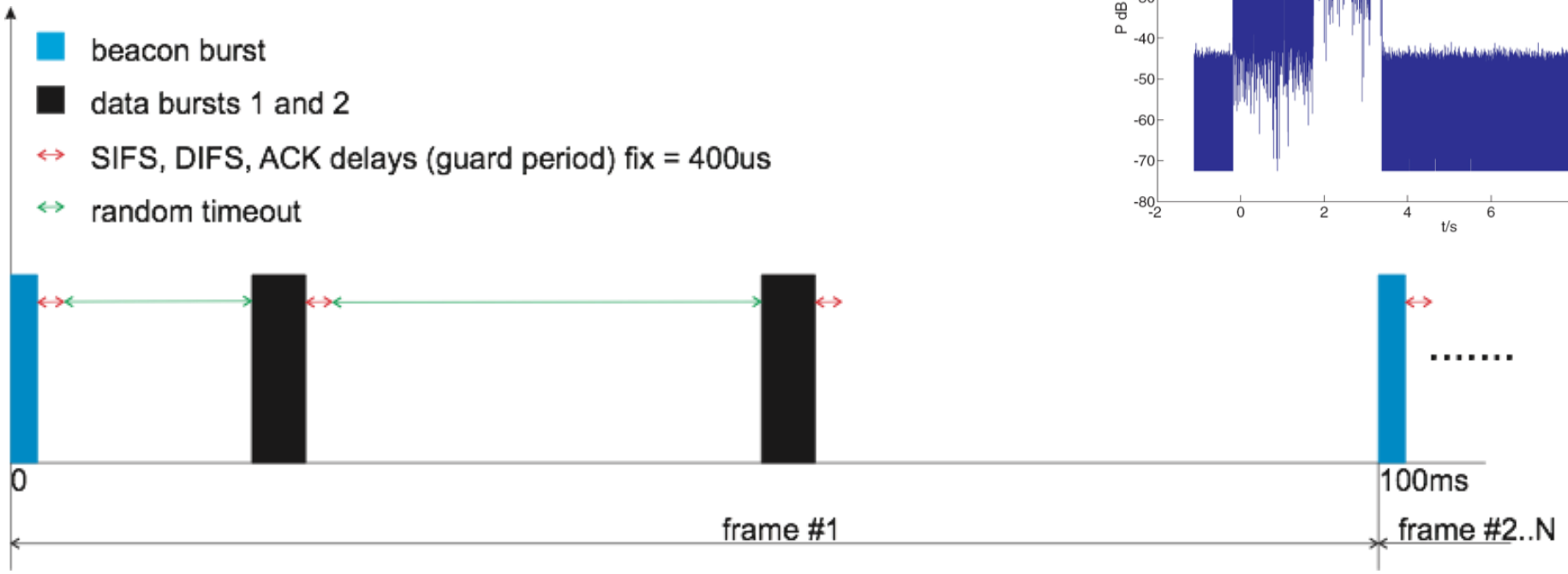
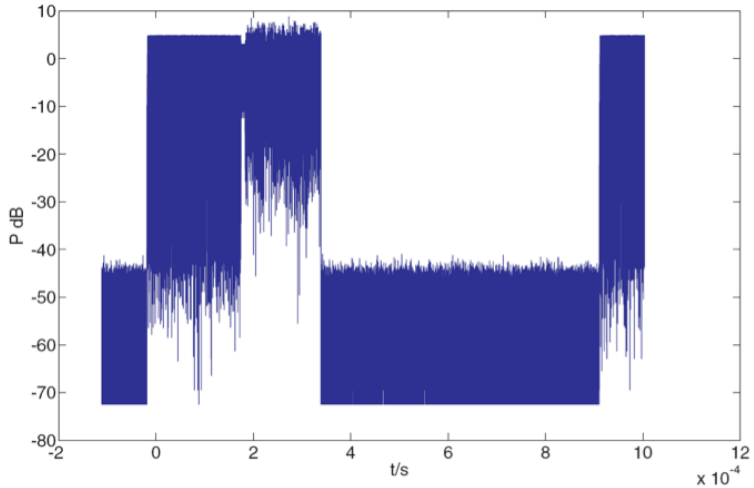
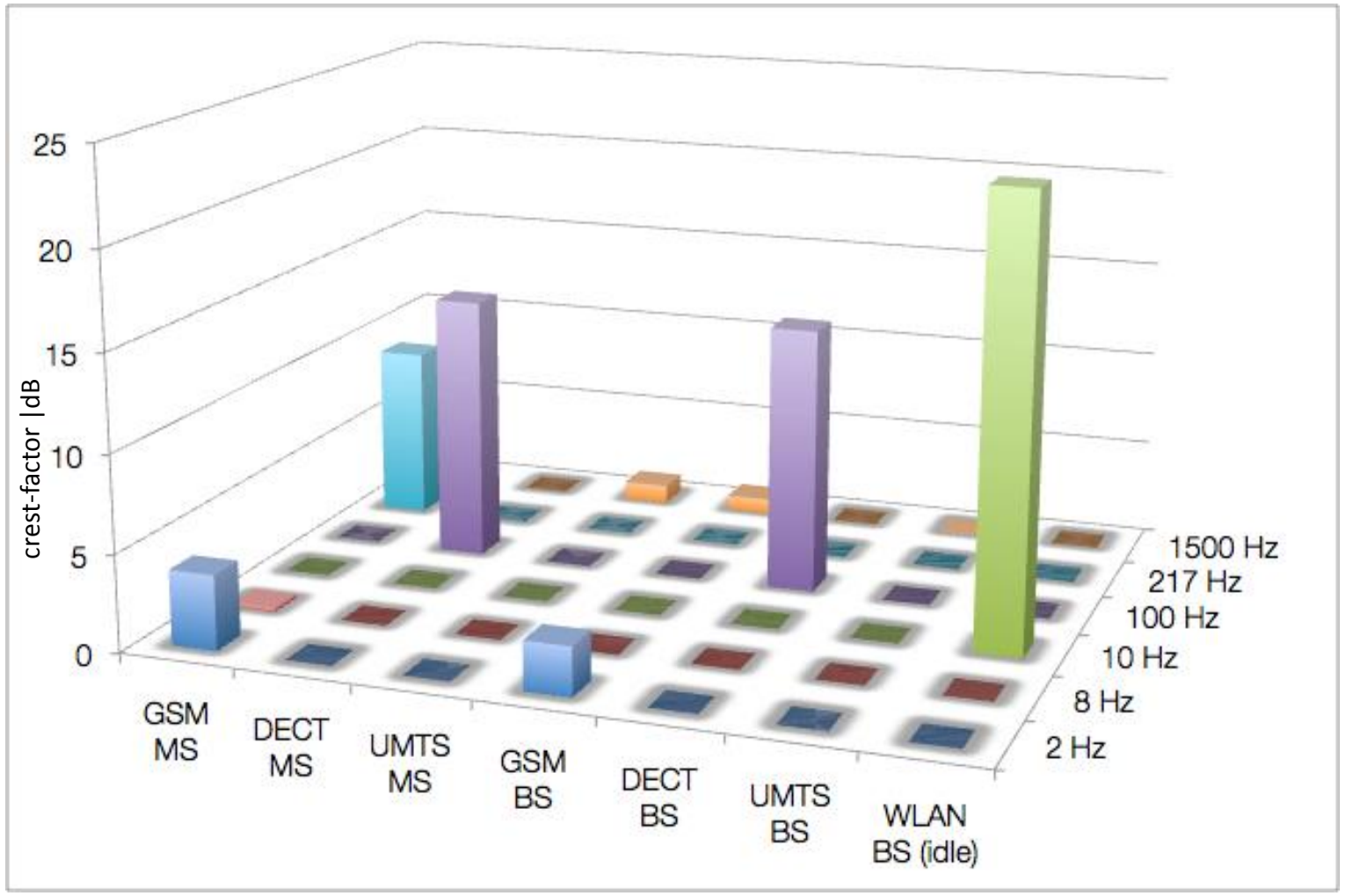
WiFi Signal Concept

Fix beacon burst transmission @ 10Hz = 1frame
Filled with 2 random position data bursts per frame
Fix guard period (always blanked) after every burst





WP7 Results: Modulation Weighting



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Summary: WiFi

WiFi is ubiquitous

WiFi is highly a adaptive (unpredictable) communication system:

- adaptive data rates
- adaptive spreading techniques
- adaptive modulation techniques
- adaptive / unsynchronized data transmission (on demand)

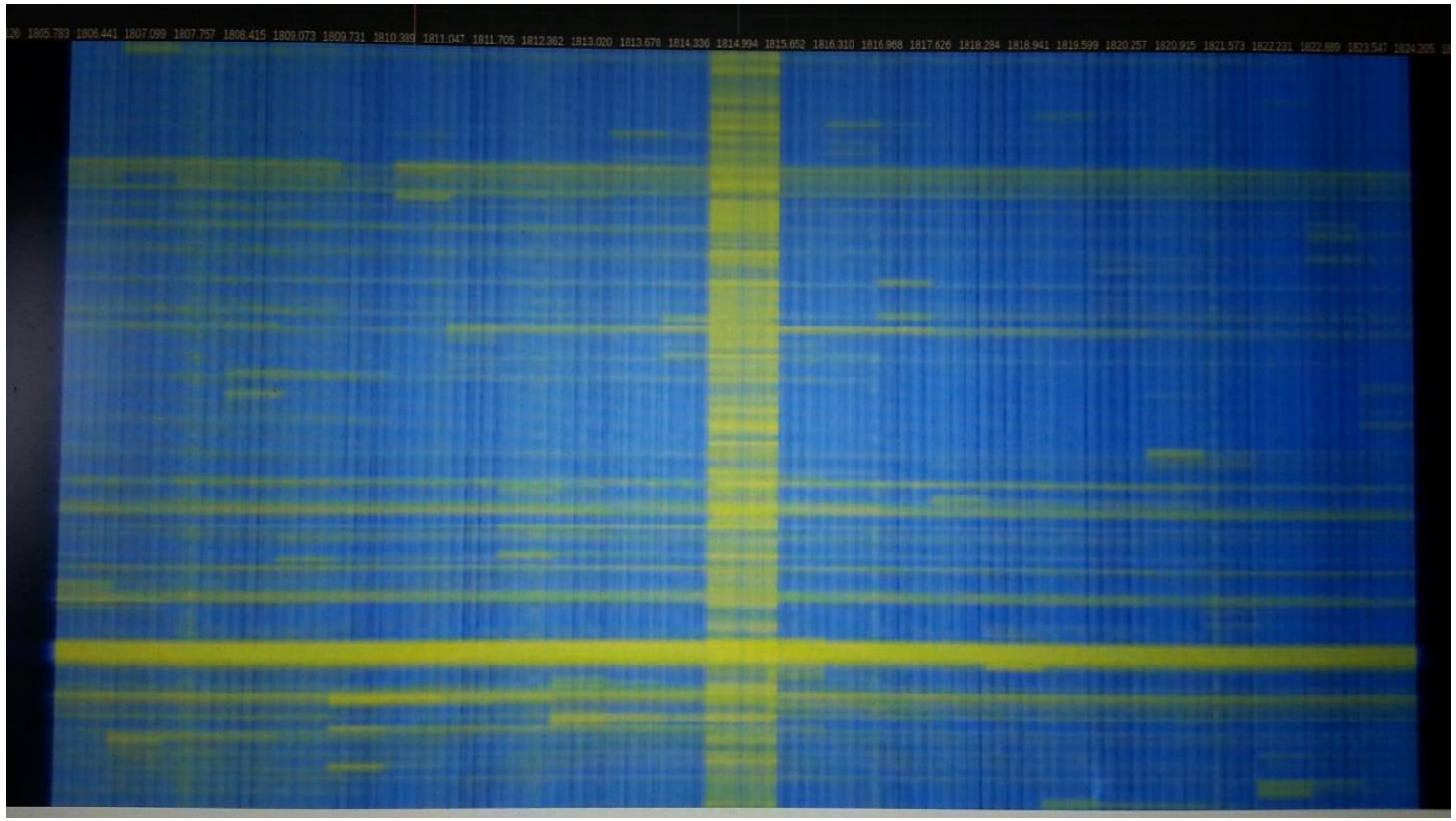
often beacon bearer from access point is the only predictable signal

average output power can be in the range of ~~100mW~~

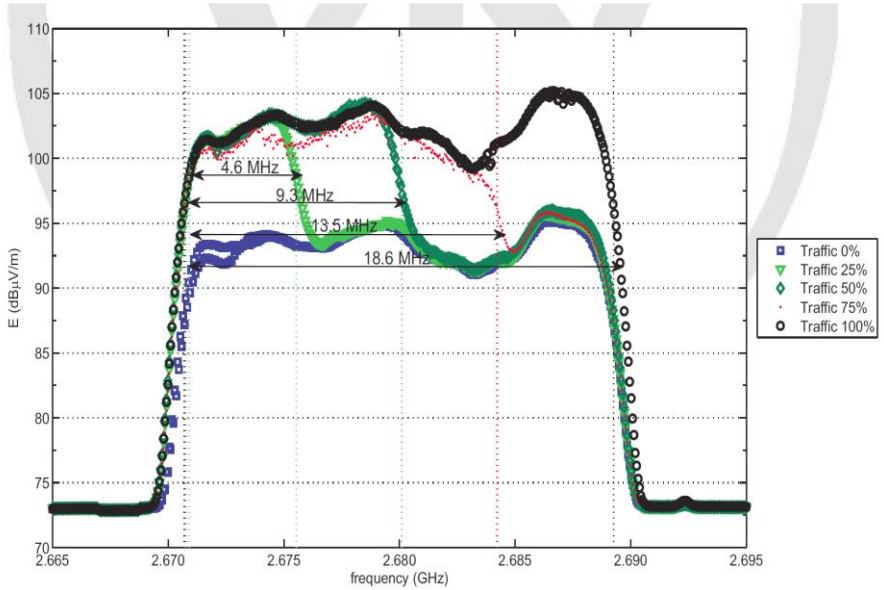
- there is NO typical WiFi
- technology is rapidly developing/changing

LTE

LTE in Europe is predominantly FDD



Waterfall display of an FDD LTE signal



Relative amplitude with and without data in a resource block

In Vitro Exposure Systems - sXc1950

In vitro and in vivo exposure systems are used to expose cell cultures or laboratory animals to various signals to investigate possible biological relevance of modulation

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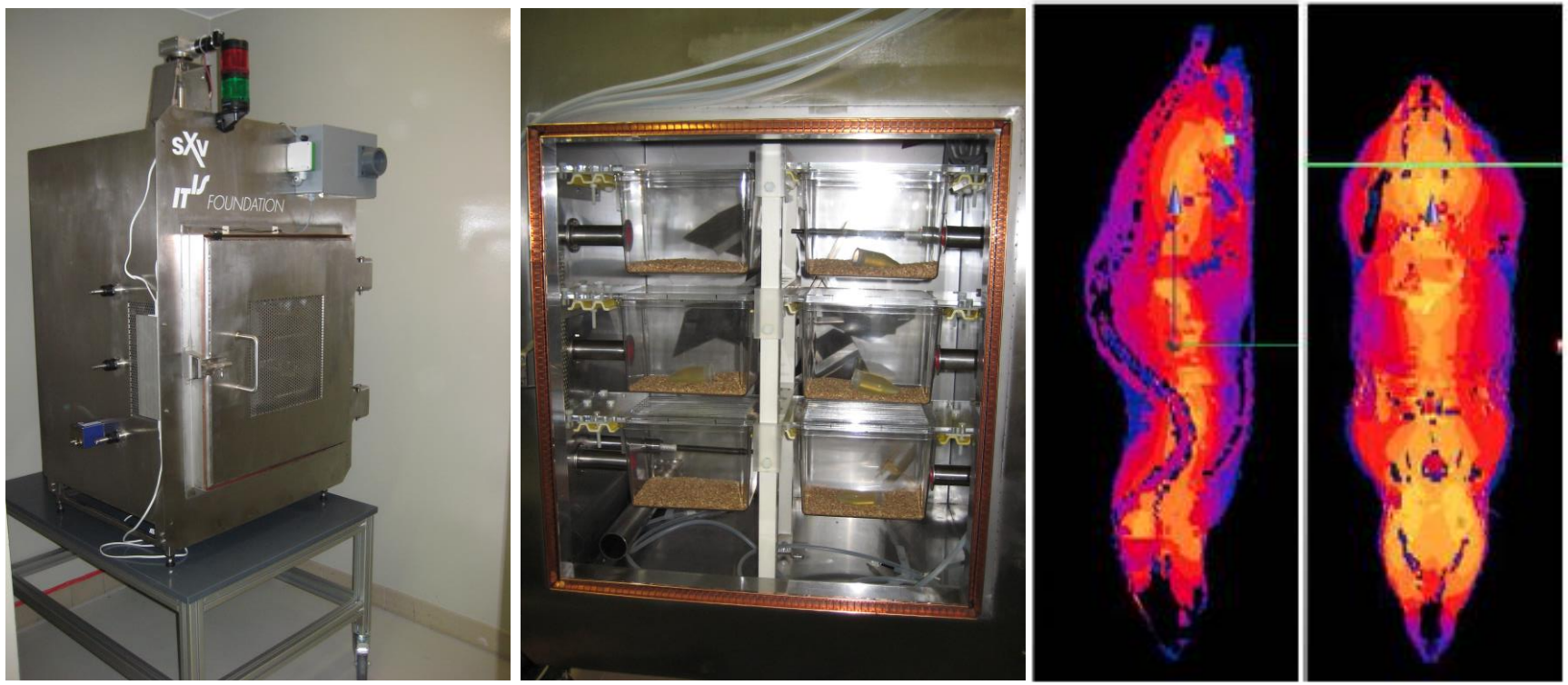
In Vivo Exposure Systems - Mini Reverberation

mini reverberation chamber



Human exposure systems

Used to study various end points

- Cognitive
- EEG
- etc.

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Estimation of Daily-Life Incident Exposures

Specific Issues

Measurement equipment:

- wide band (low spectral power density)-> sensitivity problem
- large peak to average ratios
- largely varying duty cycles

Rapidly changing:

- adaptive technologies: data/modulation rate, data transmission, rapid standards development
- strongly usage dependent: day time dependence of exposure
- adaptive application: even access points are not always fixed but often move in the environment
- large variety of devices: relation of source to body often unknown

Exposure Assessment - Procedure (GR)

1. Scan the location with the sweeping method with a broadband probe.
2. Find the position of maximum.
3. Make a frequency selective measurement at the position of maximum (usually this is close to the base of the DECT phone, which is again close to the WiFi router, because in GR we do not have coaxial cable providers; so all routers are connected to the wall to the same plug where the DECT is connected with an ADSL filter)
4. Leave the exposimeter for 4-7 days at the position of maximum
5. Make a frequency selective measurement at the middle of the same room (at three heights and at four points located on the middle plane)
6. Make a frequency selective measurement in front of the window (at three heights) to take the average

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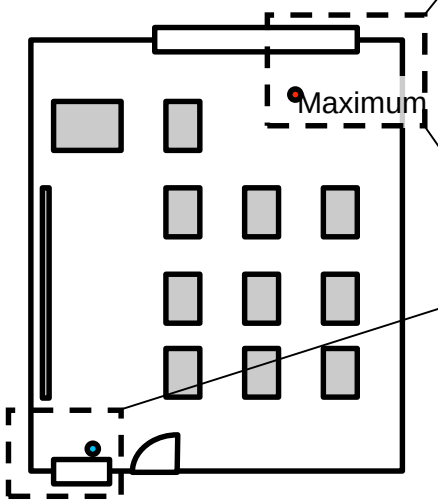
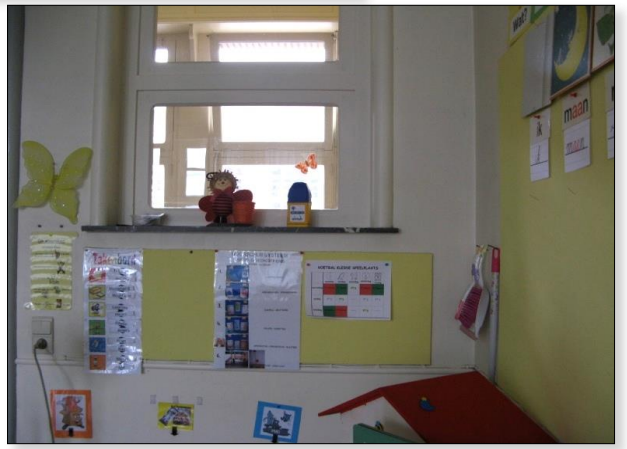
Exposure Assessment - Methodologies

- Typical locations
  - Example: Nursery (BE)





Sint-Antoniuscollege Ronse, Belgium

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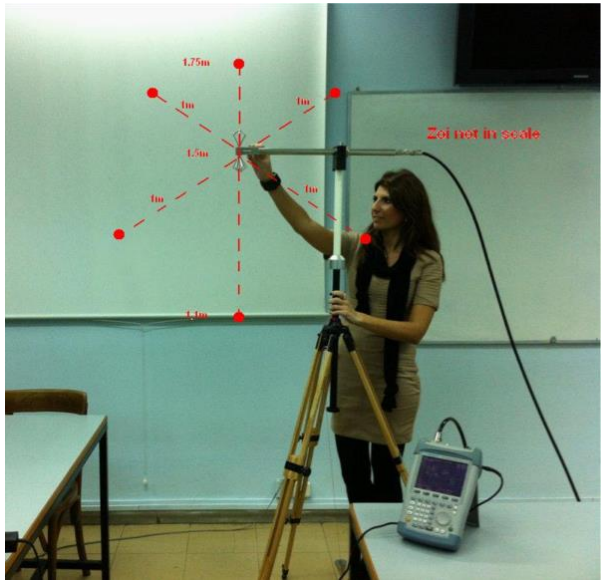
Exposure Assessment - Methodologies

Typical locations

- Example: School (GR)



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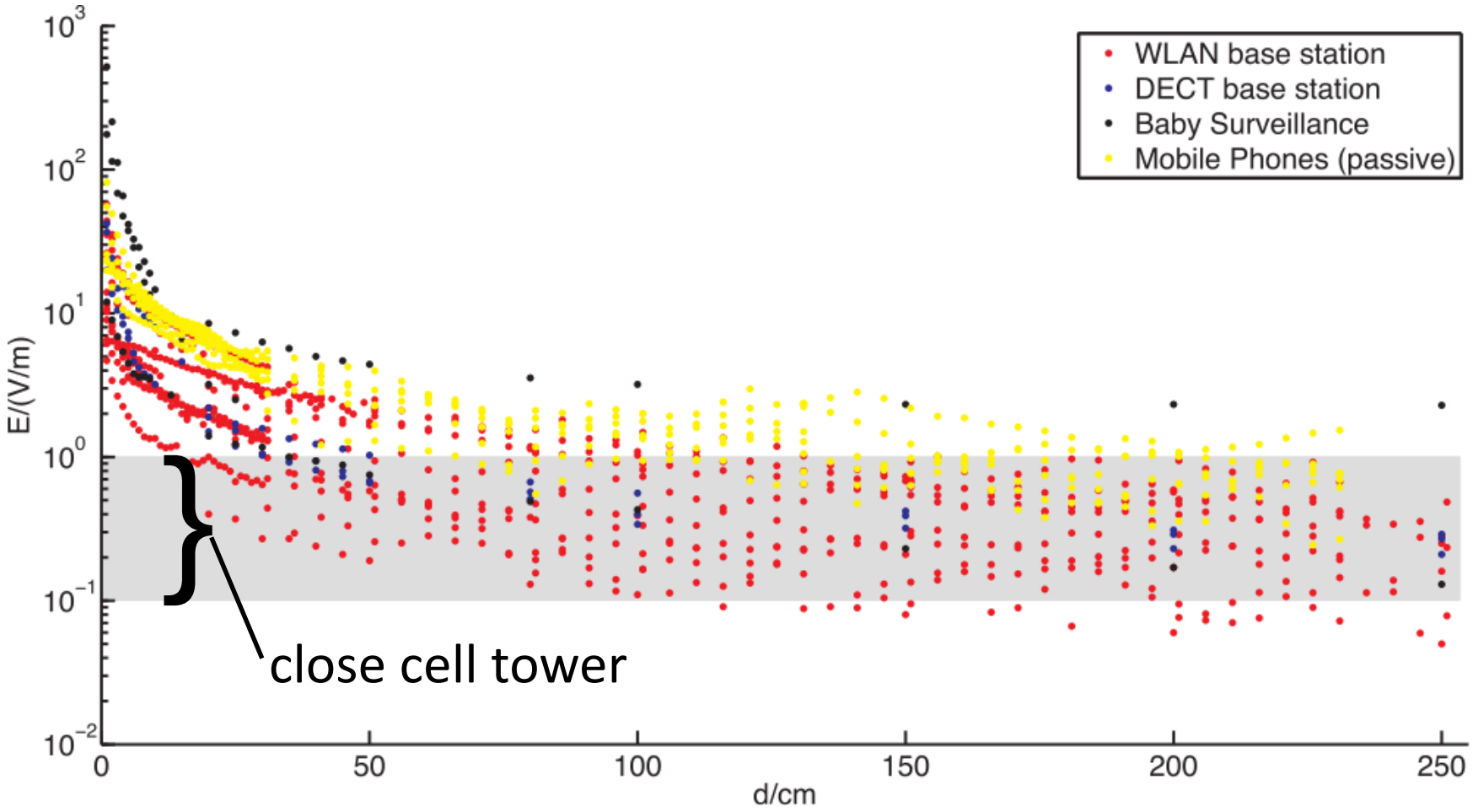
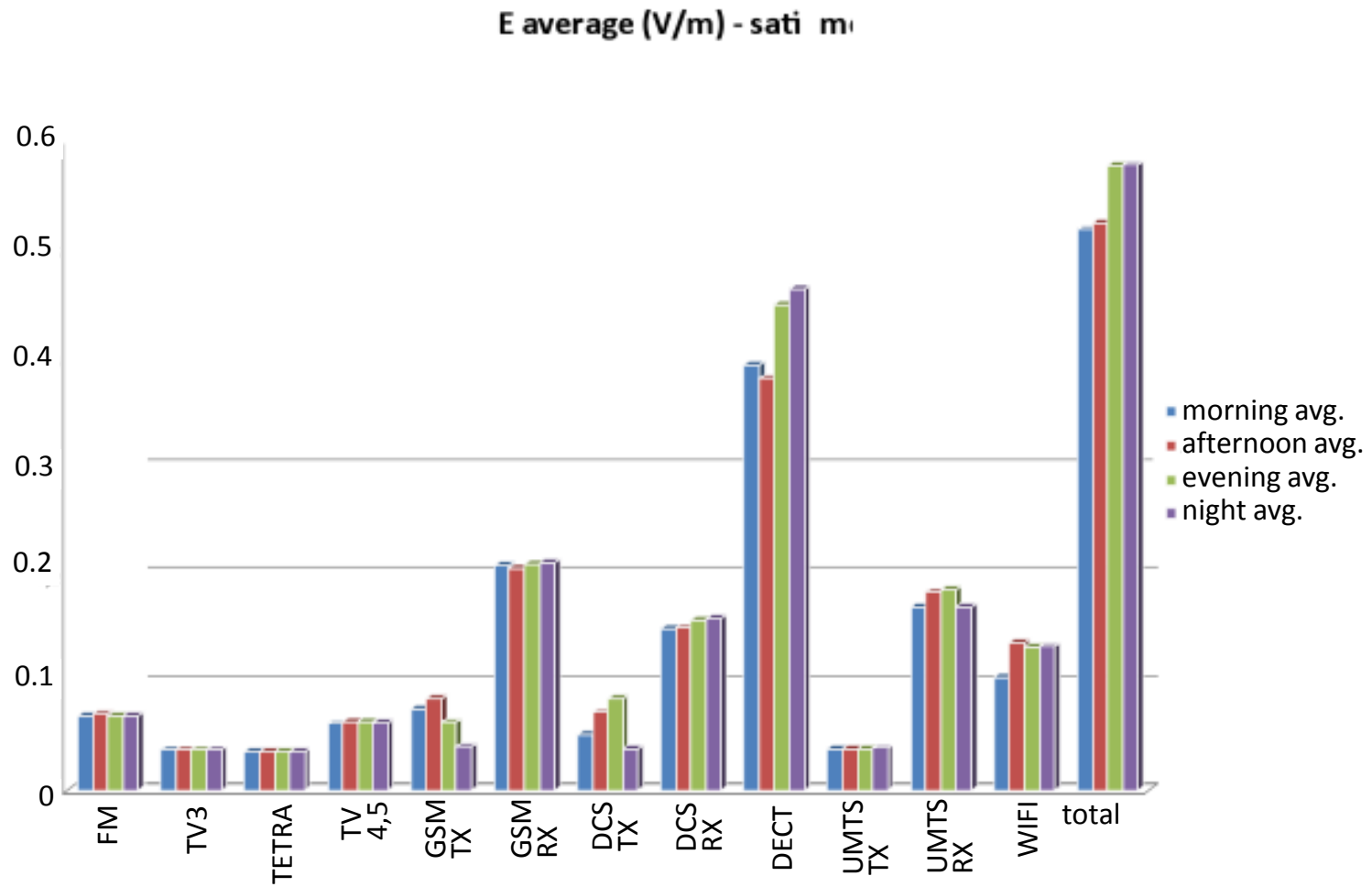
Typical Maximum Values Close to the Source Levels



Exposures Inside Rooms



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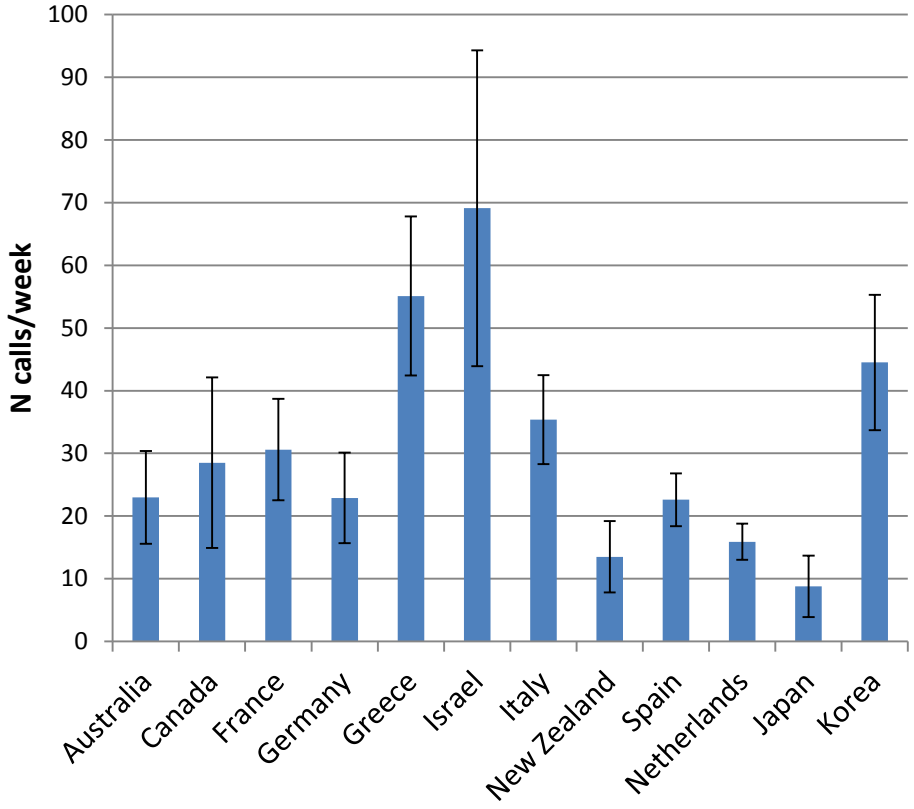
Software Application: XMobiSense

- Developed by Whist Laboratories France
- Android OS

Data recorded by XMobiSense:

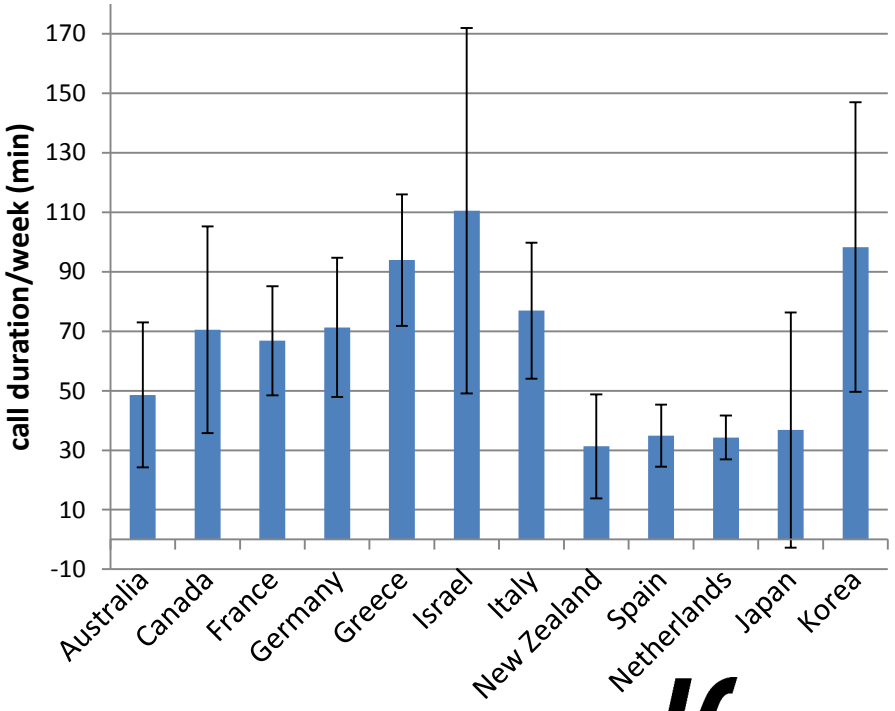
- number of calls
- call duration
- number of SMS in & out
- laterality
- data / WiFi in & out (kB)
- network used (2G/3G/4G/WiFi)
- communication protocol (UMTS, GPRS, HSPDA, EDGE)

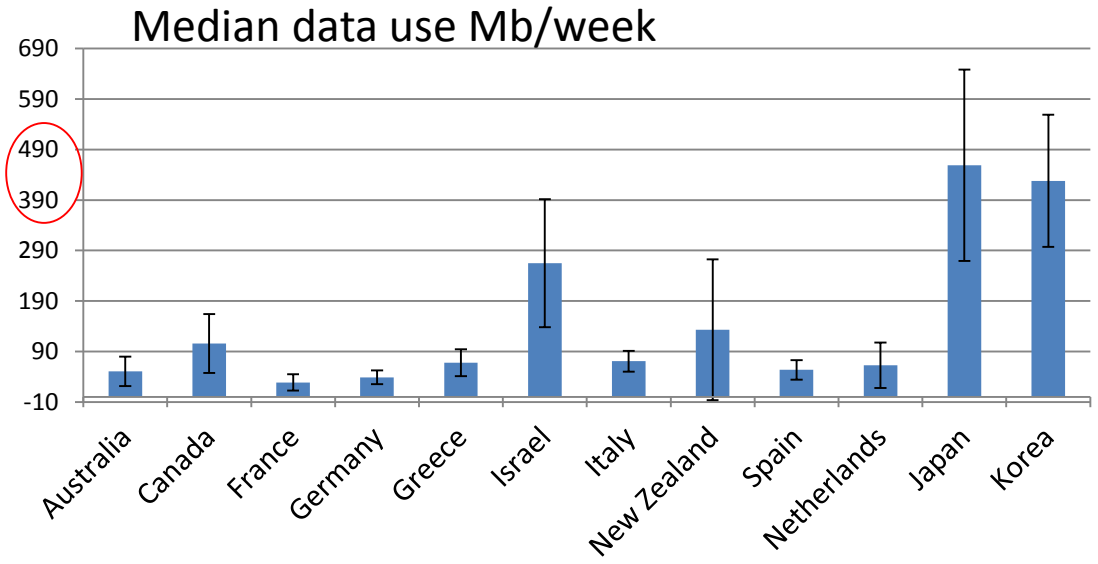


Median number of calls/week

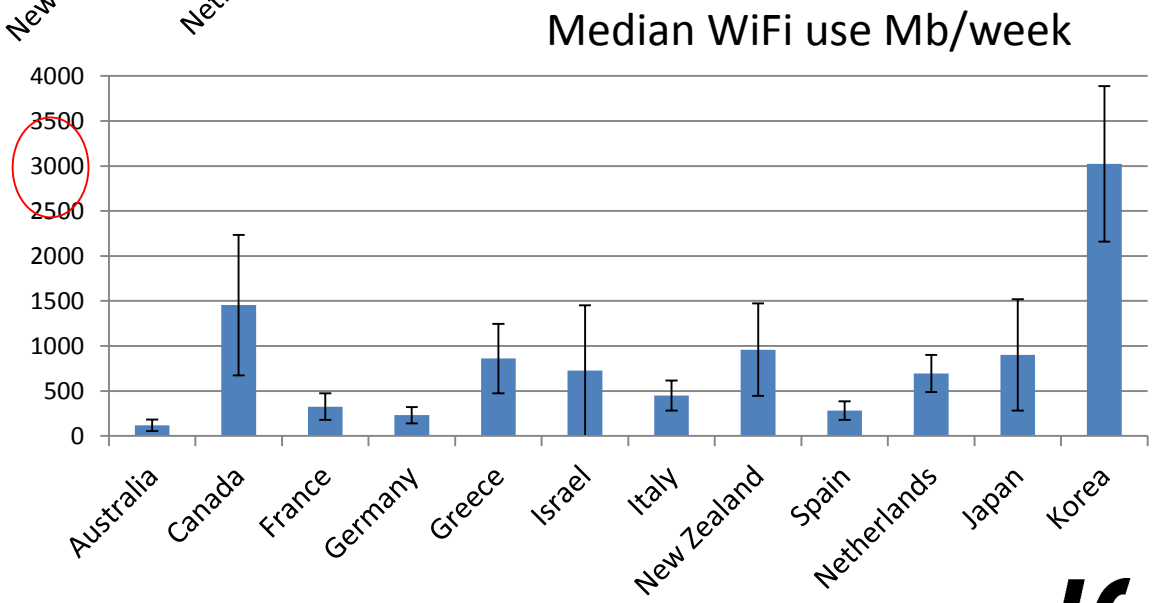
Preliminary results

Average duration of voice use (min/week)





Preliminary results



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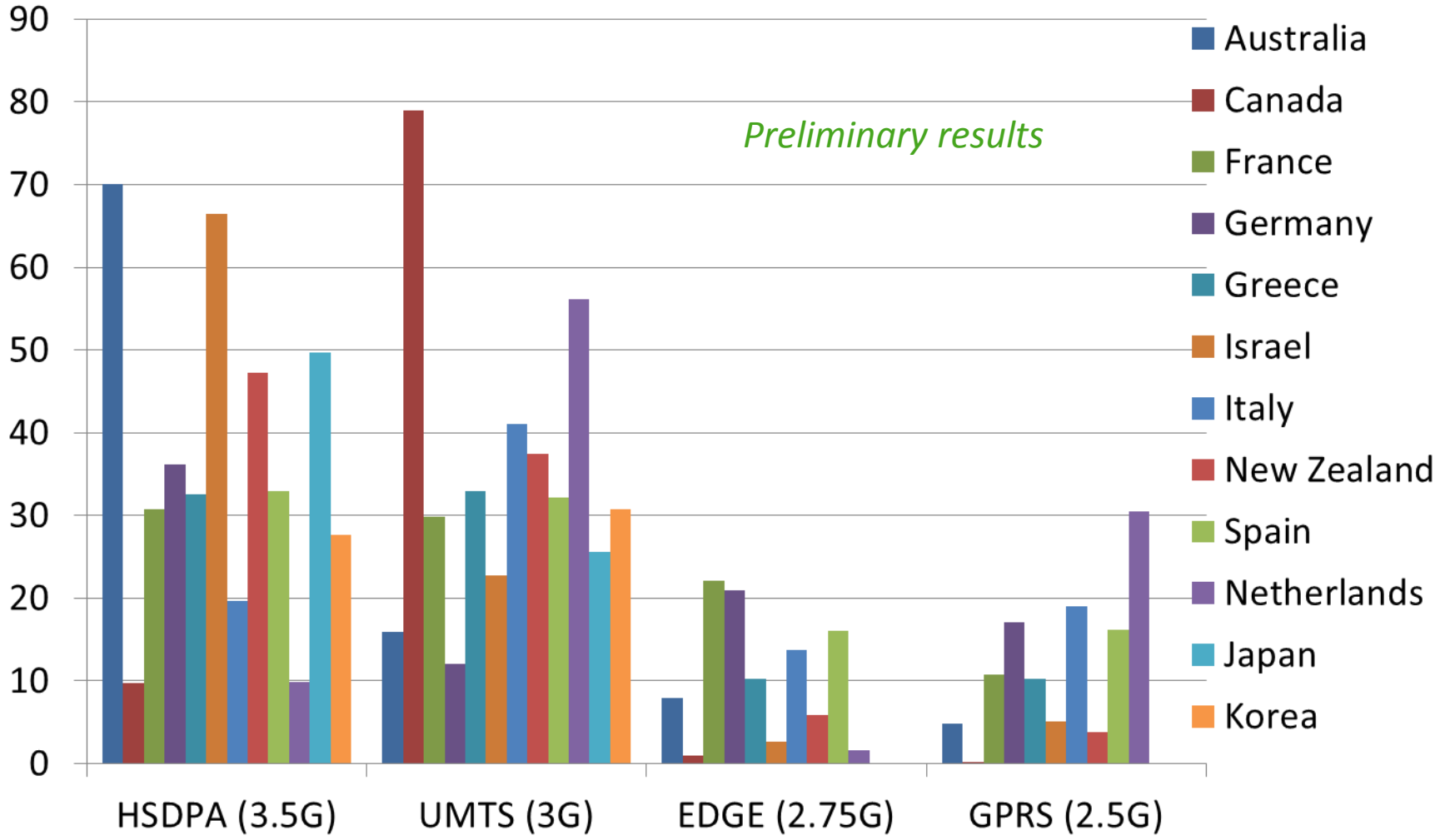
Communication system used for voice calls



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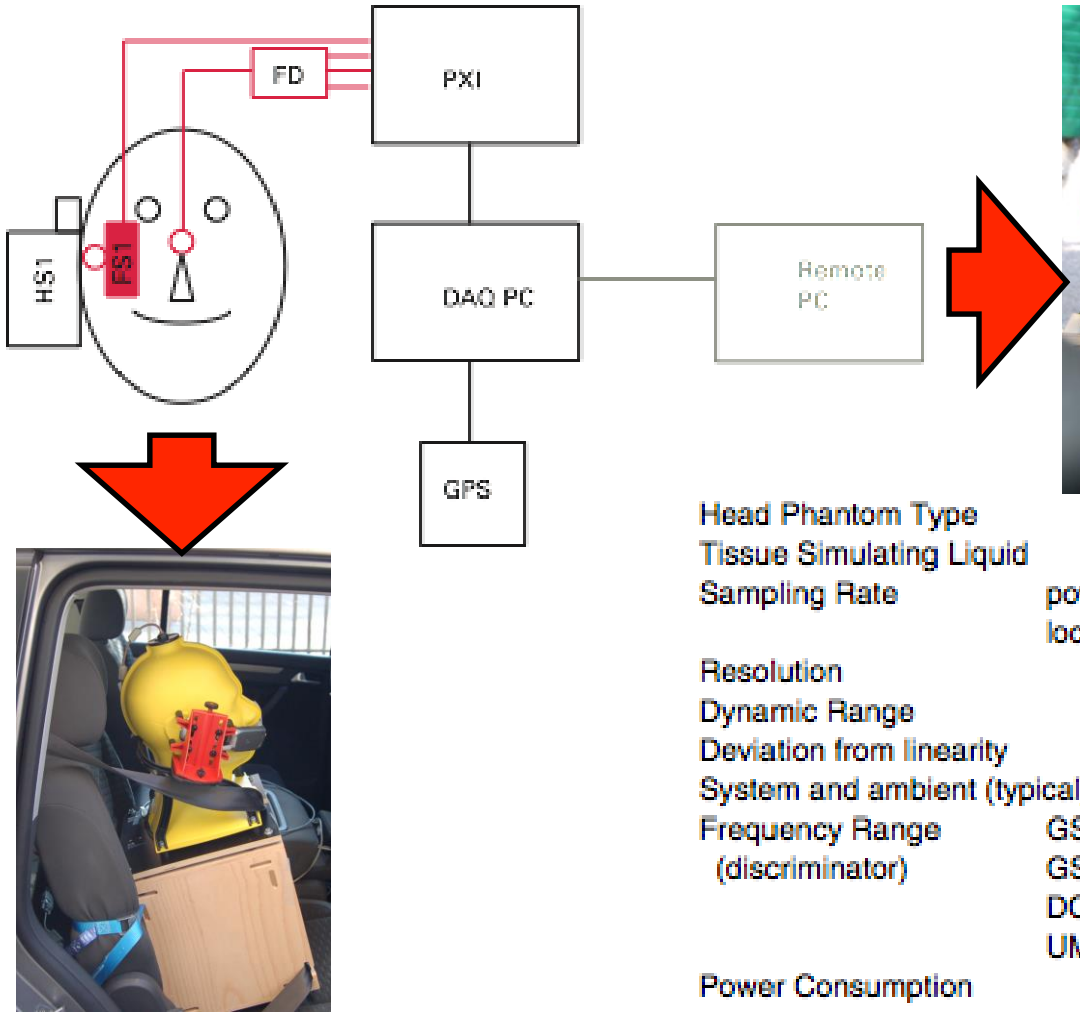
Methods: Mobile Phone Field Test System



Head Phantom Type		Specific Antropomorphic Mannequin
Tissue Simulating Liquid		Head Tissue Simulating Liquid
Sampling Rate	power and band	100 kHz
	location	≈1s
Resolution		<0.04 dB/lsb
Dynamic Range		60 dB
Deviation from linearity		<0.25 dB
System and ambient (typical) noise		<0.3 dB
Frequency Range	GSM900	890-915 MHz
(discriminator)	GSM850	824-849 MHz
	DCS1800/PCS1900	1710-1785 MHz / 1850-1910 MHz
	UMTS1950	1920-1980 MHz
Power Consumption		180 W (typical)

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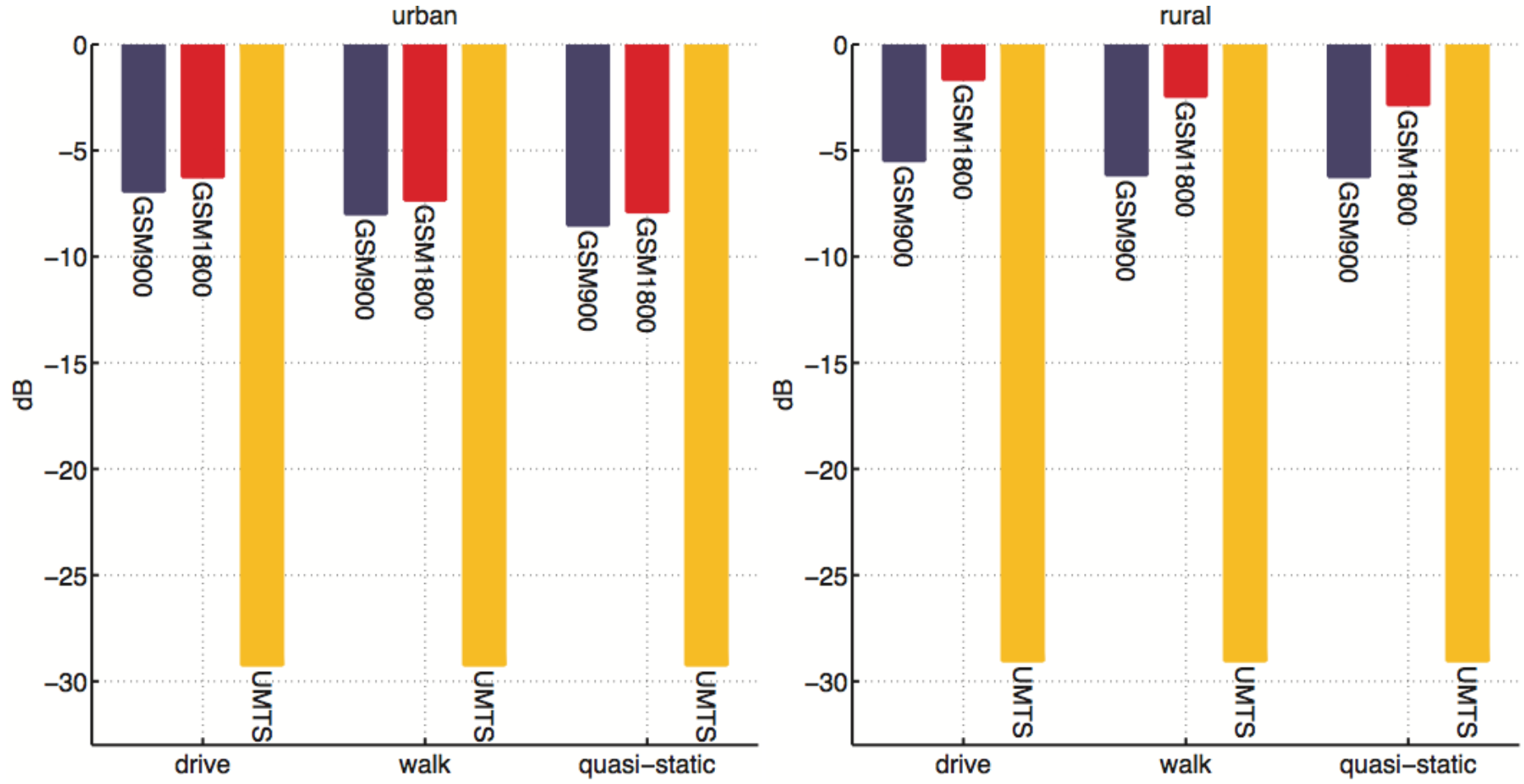
Results: Power Control - Urban vs Rural (no hand)



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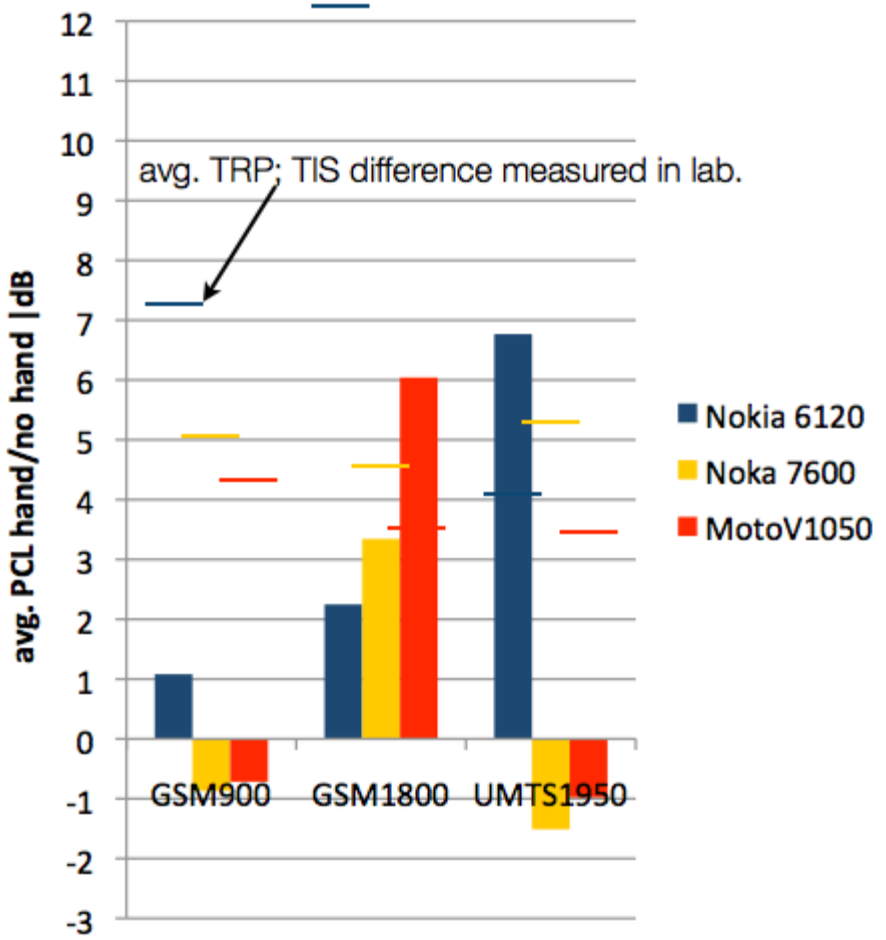
Results: avg. Power control hand vs no hand (urban)

GSM900: effect of hand on avg. PCL <1dB

GSM1800: all phones showed increased avg. PCL (>2dB), due to increased number of handover

UMTS1950: increased avg. PCL between-1.5 and +7dB with hand

Relative effect of hand on cumulative band usage time in avg. <15%



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Conclusions

- presence of lossy hand:
  - increased for 1 out of 3 phones the 10g psa SAR10 during SAR compliance testing
  - decreased the TIS/TRP in all tested cases
  - no change of avg. PCL in GSM900
  - increase of avg. PCL in GSM1800 due to increased hand-overs
  - avg. PCL in UMTS1950, 1 phone: 6dB increase, 2 phones: 1dB decrease
- avg. PCL of UMTS of a factor >100 smaller than in GSM
- effect of movement speed on avg. PWC only <3dB in GSM
- ~6dB higher PCL in rural areas in GSM1800; in urban area
- UMTS1950 used >95% of the time if dual mode was selected

[1] Kühn, S. and Kuster, N. (2009). Field evaluation of the human exposure from multi-band, multi-system mobile phones. IEEE Trans. Electromagn. Compat., submitted.
[2] Kühn, S., Ofli, E., and Kuster, N. (2010). Influence of the human hand on mobile phone SAR, OTA, and power control performance. IEEE Trans. Electromagn. Compat., in preparation.

Cumulative and Integrative Exposure Estimation

Definitions

Integrative

- summation of all sources present in a given environment
- integration across all frequencies IF and RF

Cumulative

- An integration of exposure across time

Basis of calculations

Assumptions

Exposure signals

- Signals are not coherent
- SAR combining

Incident fields

- Far field
  - Frequency
  - Average output power
  - Source location
- Near field
  - Frequency
  - RMS field strength

Considerations - User

Morphology

- Height
- Weight
- Sex
- Age

Posture

User Habits

Transfer matrix – Far field

Far field

- Transfer matrix as a function of frequency
- Decomposing incident waves into 12 plane waves from 6 directions and 2 polariations each

Near far field (Femto cells)

- Spherical wave decomposition

Transfer matrix – Near field

Next to body

- Reactive near field

Close to the body

- Near field hand exposure
- Near far field exposure of body

Set realistic bounds on variation of device position

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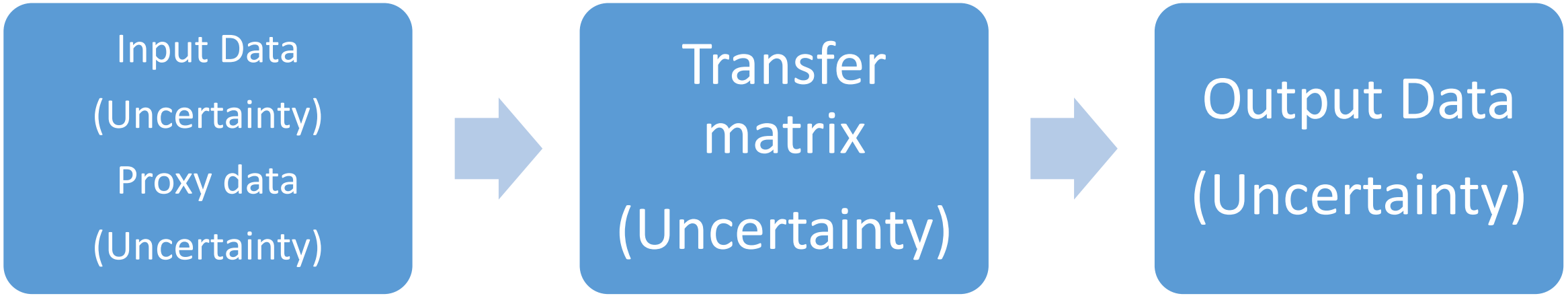
Process



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Three Current European Projects

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mobi-kids

Tecnologías de la comunicación,
medioambiente y tumores cerebrales en la gente joven

Mobi-KIDS

ISGlobal Alliance

Generalitat de Catalunya

Parc de Salut Barcelona MAR

UNIVERSITAT POMPEU FABRA

NDATION

Use of mobile phones during childhood and adolescence

Benefits – non-negligible

- Emergencies
- Communication with family
- Communication with friends

What are the potential risks ?

- Cognitive effects
- Brain and CNS tumours

Health effects of RF not demonstrated at this point

… but if there is a risk, it is likely to be greater for exposures in childhood and adolescence …

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Why would the risk be larger?

Children who start using phones will have much more exposure

- Many more years of use
- Greater quantity of use as much cheaper than before

Children may be more vulnerable

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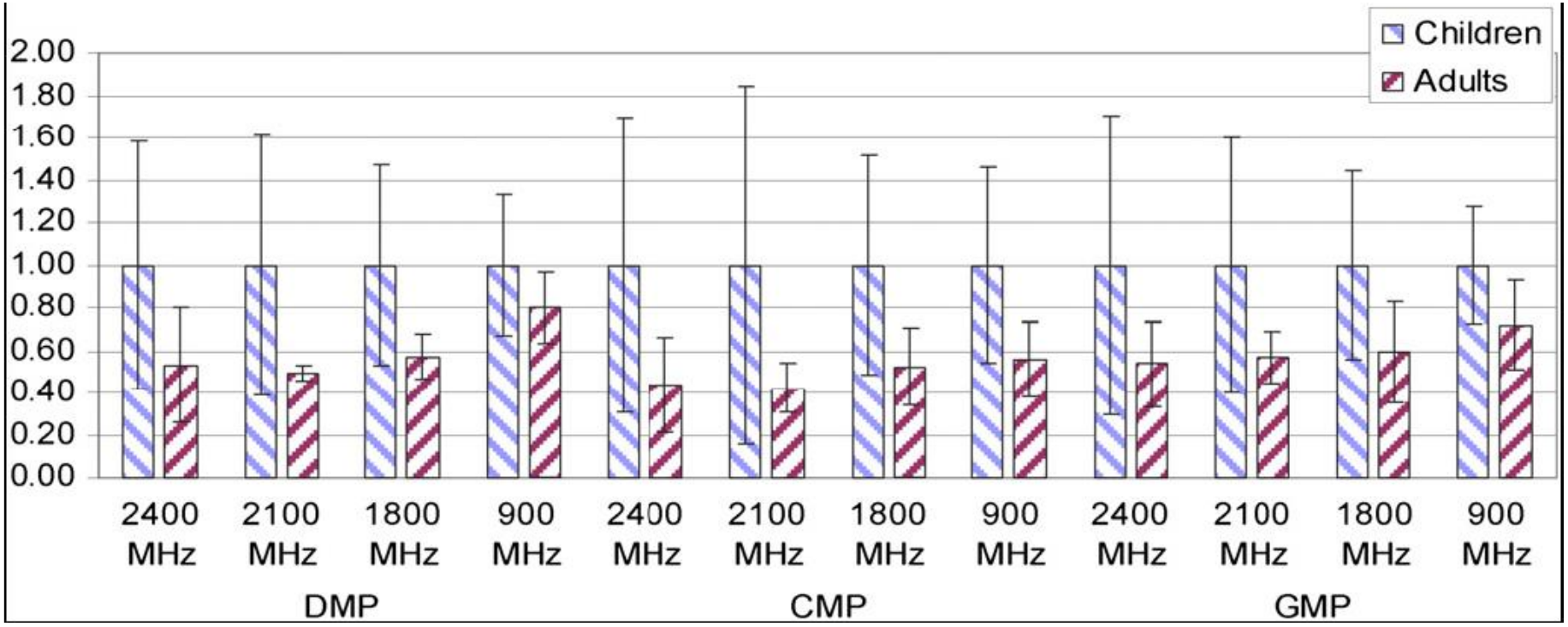
The relative mean MSAR1g tends to be higher in children than in adult brain tissues

(results normalized to children)



Wiart et al, 2008

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GERoNiMO

Generalized EMF research using novel methods
An integrated approach: from research to risk assessment and support to risk management

Generalized EMF research using novel methods.

An integrated approach: from research to risk assessment and support to risk management

Generalitat de Catalunya

Parc de Salut Barcelona MAR

upf. Universitat Pompeu Fabra Barcelona

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Strategy

GERoNiMO builds upon existing European resources to attain its objectives

Through the use of different but complementary populations and approaches, GERoNiMO will, in particular, allow the investigation of

- the potential effects of exposure to
  - radiofrequency (**RF**) and
  - intermediate frequency fields (**IF** – induction cookers, WPT, low energy lightbulbs…)
  - alone and in combination with other environmental agents
- on the risks of
  - cancer,
  - neurodegenerative diseases,
  - behaviour,
  - reproductive outcomes and
  - aging.

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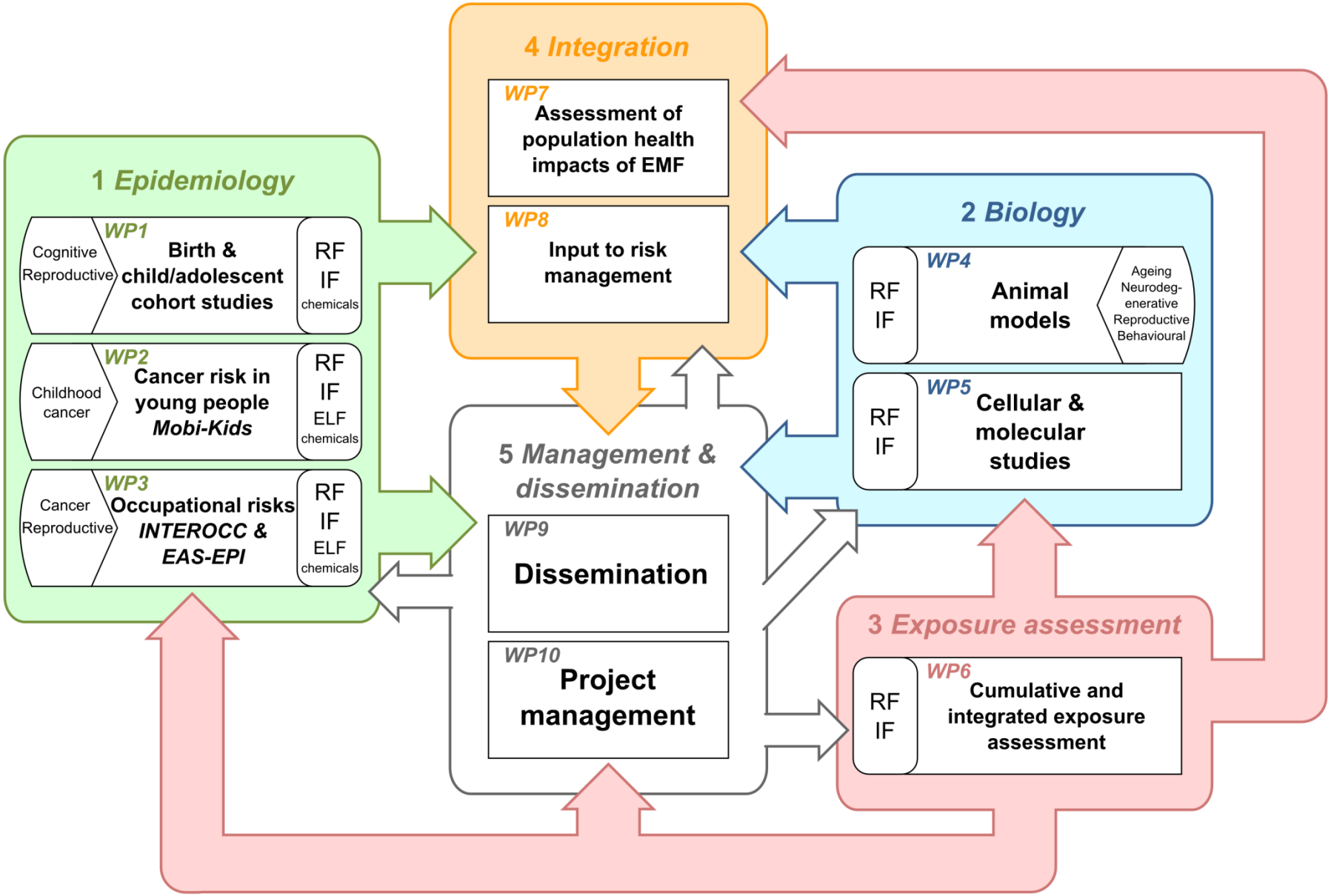

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CREST - Characterisation of RF exposure from new mobile communication systems uses and technologies.

- Objective
  - To **characterize exposure to RF from new mobile sources** (smartphones, tablets, consoles, laptops, …) in the general population as a function of technology and new usages.
- Double aim:
  - Allow estimation of exposure for epidemiological studies
  - Provide information on population exposure in different contexts to allow risk assessment at the level of the general population
- **Complements GERoNiMO**

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CREST - Characterisation of RF exposure from new mobile communication systems uses and technologies.

- 5 complementary WPs
  - WP1. Characterisation and evaluation of use in the general population (smart devices, virtual reality, femto-cells)
  - WP2 . Identification and characterisation of networks and systems, existing and future, supporting uses identified in WP1 (LTE, VoIP…)
  - WP3 : Evaluation of the power emitted by the sources identified in WP2
  - WP4 : Evaluation of exposure from different uses and functions
  - WP5. Development of pertinent indicators to quantify RF exposure from new devices, uses and technologies

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- -- ANSES

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Thank You