

HPA Research on RF Exposures



Simon Mann
Head of Physical Dosimetry Department

19^{ième} Journée Interaction Onde Personne
20 December 2012, Whist Lab, Paris

Centre for Radiation, Chemical and Environmental Hazards
Radiation Protection Division



Set up in 2003 to provide an integrated approach to protecting UK public health from

- Infectious diseases
- Chemical and poisons
- Radiation
- Emergency response

Provides support and advice to the National Health Service, local authorities, emergency services, other arms length bodies, the Department of Health and the devolved administrations (Wales, Scotland and Northern Ireland)

EMF Research at HPA

— Overview



- 1) CRCE: Now and the Future
- 2) Research Drivers and Motivation
- 3) Theoretical Exposure Assessments
- 4) Experimental Exposure Assessments
- 5) Dosimetry for Standards
- 6) Multidisciplinary Studies
- 7) Summary and Future Plans

1) CRCE: Now and the Future



- Functions and Evolution
- Public Health England

Centre for Radiation, Chemical and Environmental Hazards



Evolution and Broadening of CRCE Functions



- 1970 National Radiological Protection Board (NRPB) formed
- 1974 Non-ionising radiation added to NRPB functions
- 2002 Proposal that HPA be formed and include NRPB
- 2004 Ultrasound and infrasound functions added
- 2005 CRCE formed when NRPB merged into HPA and gained chemical functions
- 2011 Climate change and extreme events programme added to the programme on environmental hazards
- 2012 Strategy for noise (audible sound) functions being developed

Advice, research and services to protect the public from hazards resulting from exposure to chemicals and poisons, radiation both ionising and non-ionising and ultrasound and infrasound

- Advance knowledge about protection
- Provide laboratory and technical services
- Run training courses
- Provide expert information
- Advise government and other bodies as appropriate

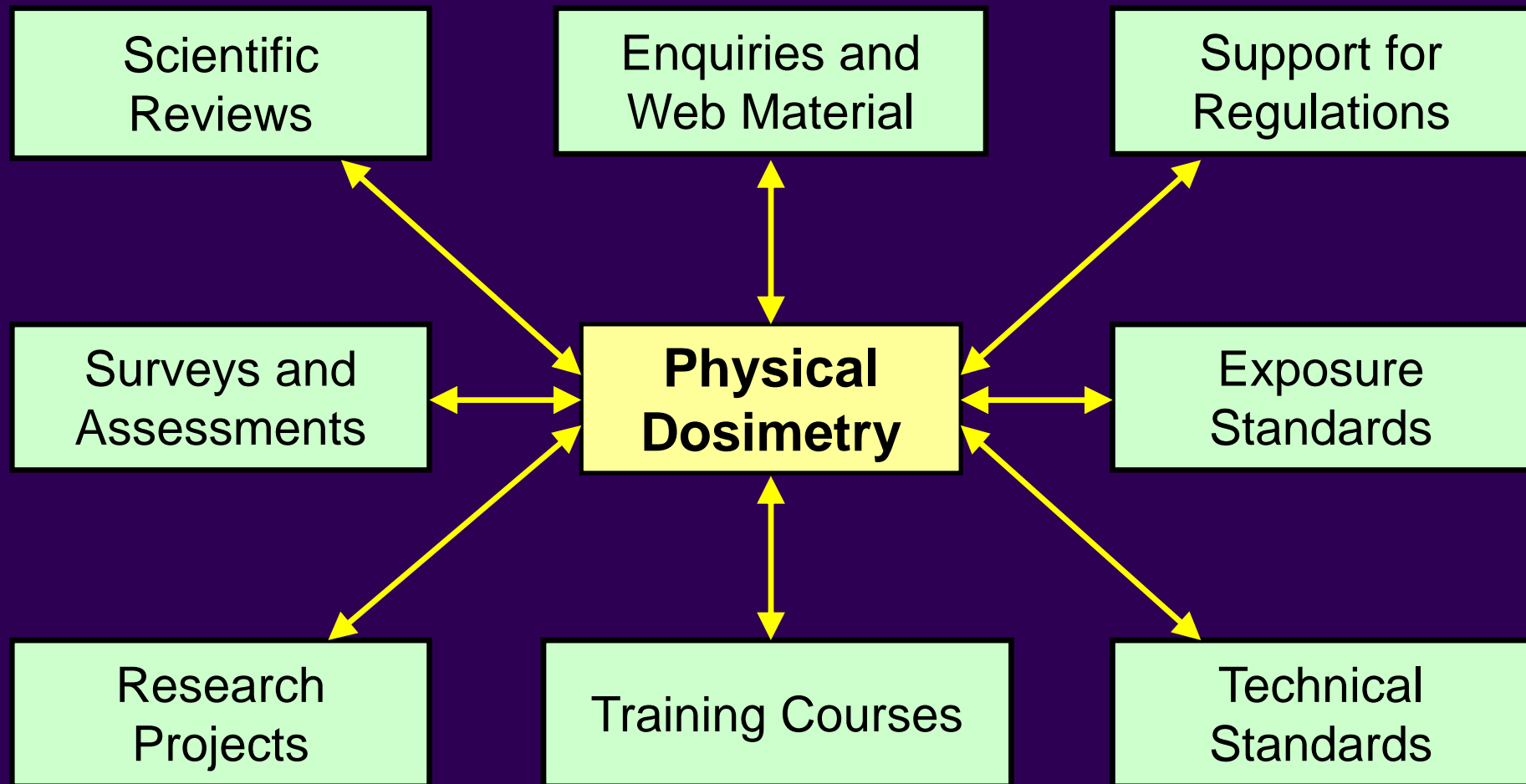
- HPA is to be abolished from April 2013 and a new organisation, Public Health England will be formed
 - Health Protection and Health Improvement roles
- Will be an executive agency of the Department of Health
 - Chief Executive will be accountable to the Secretary of State for Health
- PHE will have an advisory board - publicly appointed chair and majority of non-executive members
- PHE has an eight-member senior leadership team
 - CRCE will report to the Director of Health Protection

2) Research Drivers and Motivation

- Operating Model
- Priorities
- Themes



Physical Dosimetry Department Operating Model



Strategy and Drivers for EMF Research and Development



Research priorities are dictated by advisory needs

- Scientific priorities, e.g. from expert reviews
- Stakeholder needs – public, government
- Co-ordinate and collaborate internationally
- Anticipate needs and respond quickly

Shifting focus of public concerns

- Microwave ovens, VDUs
- Base stations and mobile phones, TETRA
- Wireless networks (Wi-Fi), Smart meters

EMF Research Themes (Exposure Assessment)



Develop and maintain assessment capabilities

- Theoretical
- Experimental

Assess exposure of the public (and workers)

- Sources, scenarios

Dosimetry studies to underpin standards

- Phantoms, material properties, modelling

Assessment support to multidisciplinary studies

- Biology
- Epidemiology

3) Theoretical Exposure Assessments

- Mobile phones
- TETRA handset
- Wi-Fi Laptop



Theoretical Dosimetry Assessment Tools



Suite of numerical phantoms (age, sex etc)

Phantom manipulation tools (change posture)

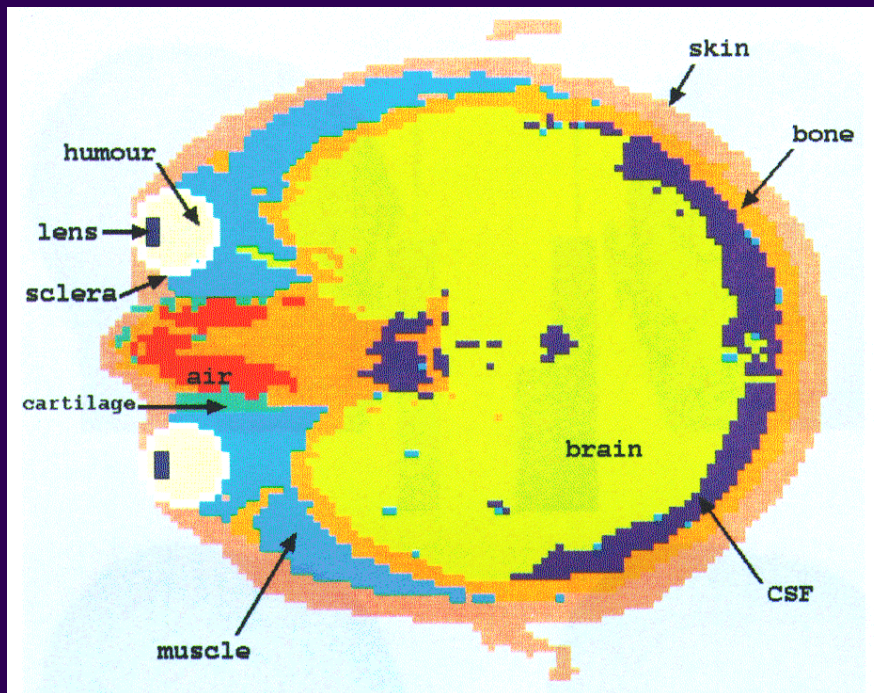
Modelling codes (mainly FDTD for RF)

Computers (powerful)

Validation tools

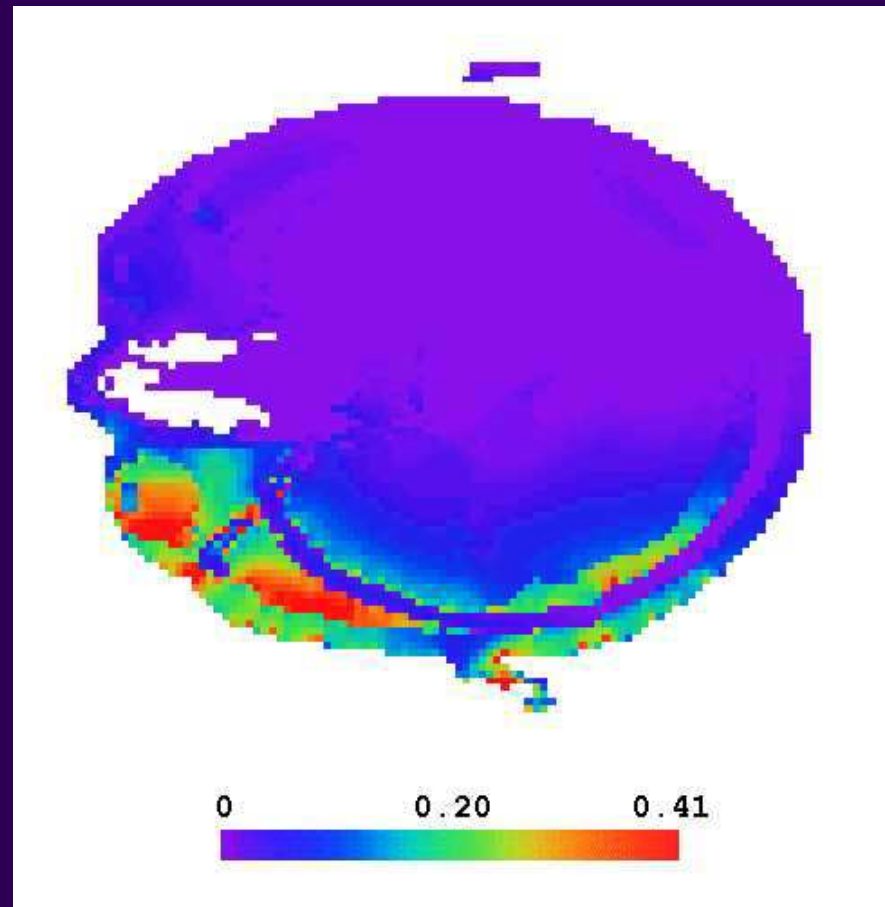
- Compare with measurement
- Canonical problems

1994 Study of SAR from Mobile Phones



New 2 mm resolution head model

Mobile phone horizontal
against side of head



SAR in $W\ kg^{-1}$ per W at 900 MHz

1994 Study of SAR in Head from Mobile Phone



SAR in $W\text{ kg}^{-1}$ for GSM talk mode

- 900 MHz, 2 W output power and $\frac{1}{8}$ duty factor
- 1800 MHz, 1 W output power and $\frac{1}{8}$ duty factor

ICNIRP basic restriction (public) = 2 W kg^{-1}

Position	SAR (10 g), $W\text{ kg}^{-1}$	
	900 MHz	1800 MHz
Front (eye)	0.78	0.48
Horizontal (ear)	0.52	0.38
Vertical (ear)	0.76	0.58

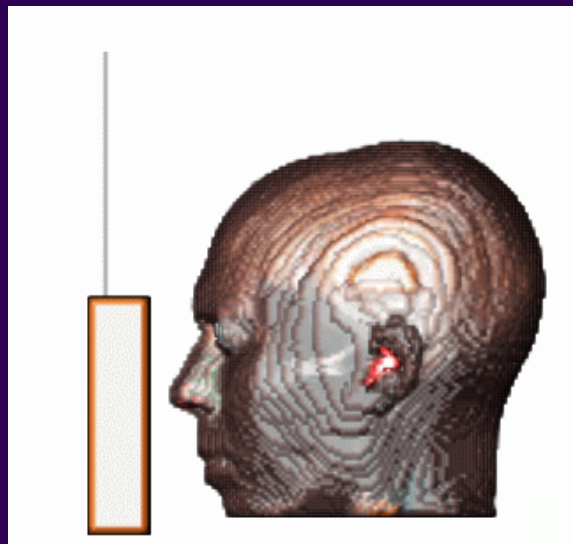
Dimbylow PJ and Mann SM

Phys Med Biol 1994; 39 (23): 1537 - 1553

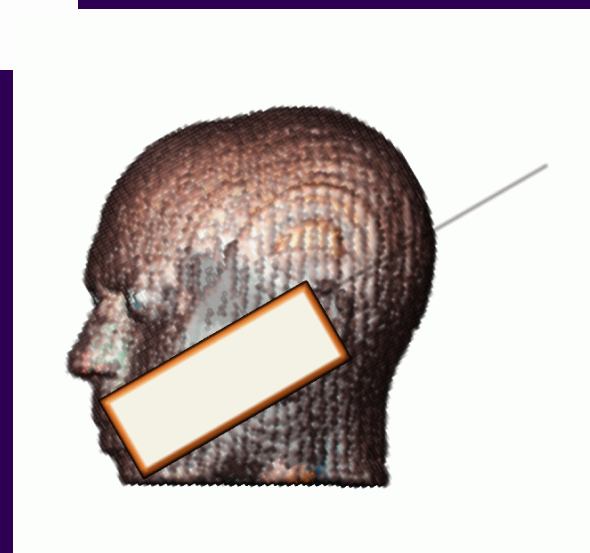
2003 Study of SAR from TETRA Mobile Radio



Modelled Device



Front



Cheek

2003 Study of SAR from TETRA Mobile Radio

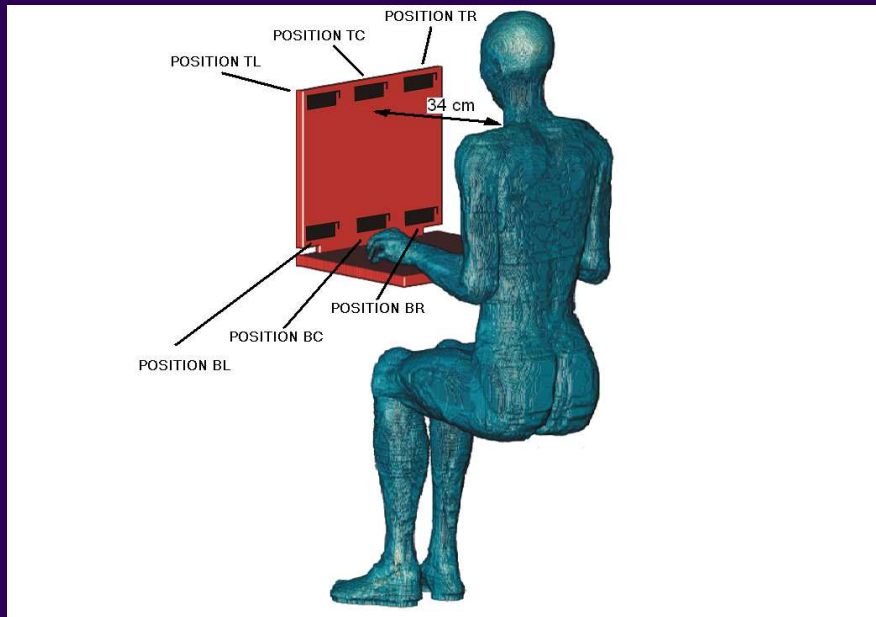


SAR in $W\text{ kg}^{-1}$ for 1 W output power and $\frac{1}{4}$ duty factor
ICNIRP basic restriction (public) = 2 W kg^{-1}

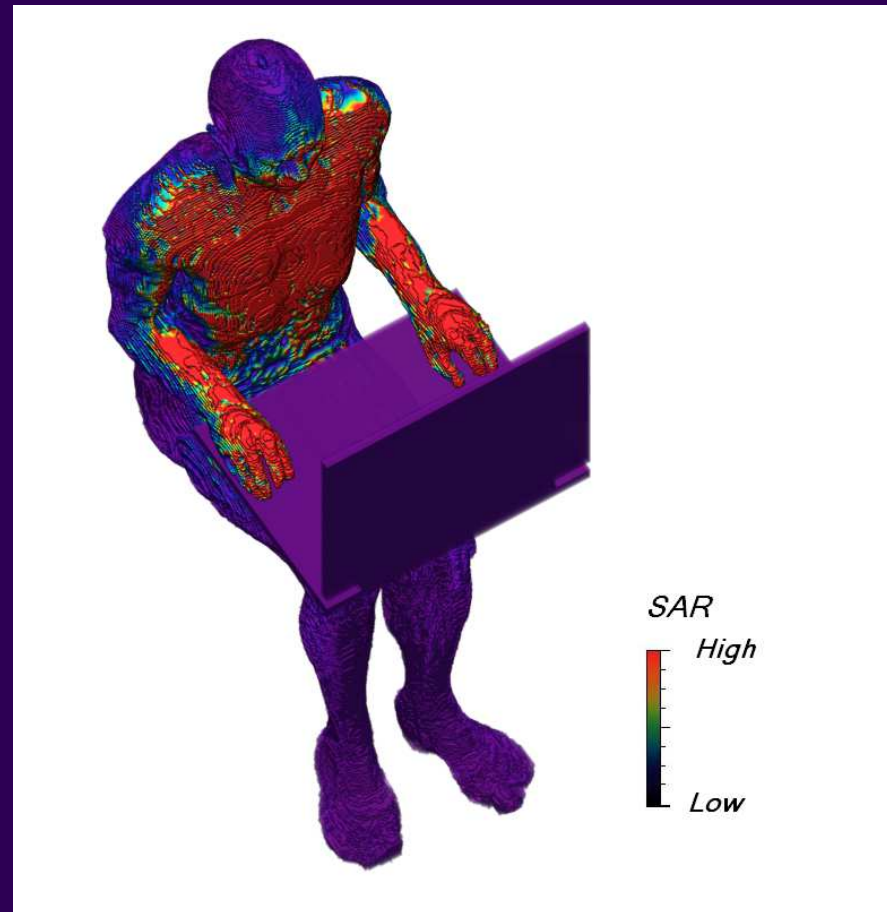
Position	SAR (10 g), $W\text{ kg}^{-1}$	
	Monopole	Helix
Front	0.58	0.77
Cheek	0.52	0.97
Tilt	0.43	0.68

*Dimbylow PJ, Khalid M and Mann S
Phys Med Biol 2003; 48 (23): 3911 - 3926*

2010 Study of SAR in a Child Using a Wi-Fi Laptop



Adult phantom scaled to 10-year old child



Wi-Fi Exposure Scenarios and SAR



ICNIRP basic restriction (public) = 2 W kg^{-1}

Worst case and maximum realistic localised SARs

Scenario Power / Frequency / Duty Cycle	SAR (10 g), mW kg^{-1}	
	Head	Trunk
100 mW, 2.4 GHz, 100%	5.7	14.4
100 mW, 5 GHz, 100%	12.7	39.9
20 mW, 2.4 GHz, 1%	0.011	0.029
20 mW, 5 GHz, 1%	0.025	0.080

*Findlay RP and Dimbylow PJ
Phys Med Biol 2010, 55(15): N405-N411*

4) Experimental Exposure Assessments

- Measurement facilities
- Base stations



Calibration Systems High Frequency



- TEM cells
- GTEM cell
- Anechoic chamber

Equipment for Spot Measurements



Broadband and narrowband probes



Antennas & spectrum analysers



Bespoke Equipment



1986 Personal Current meter



2001 Data logger for Personal exposimeter



2011 Transmit time accumulator

Exposures from Base Stations (Report R321)



Surveyed sites

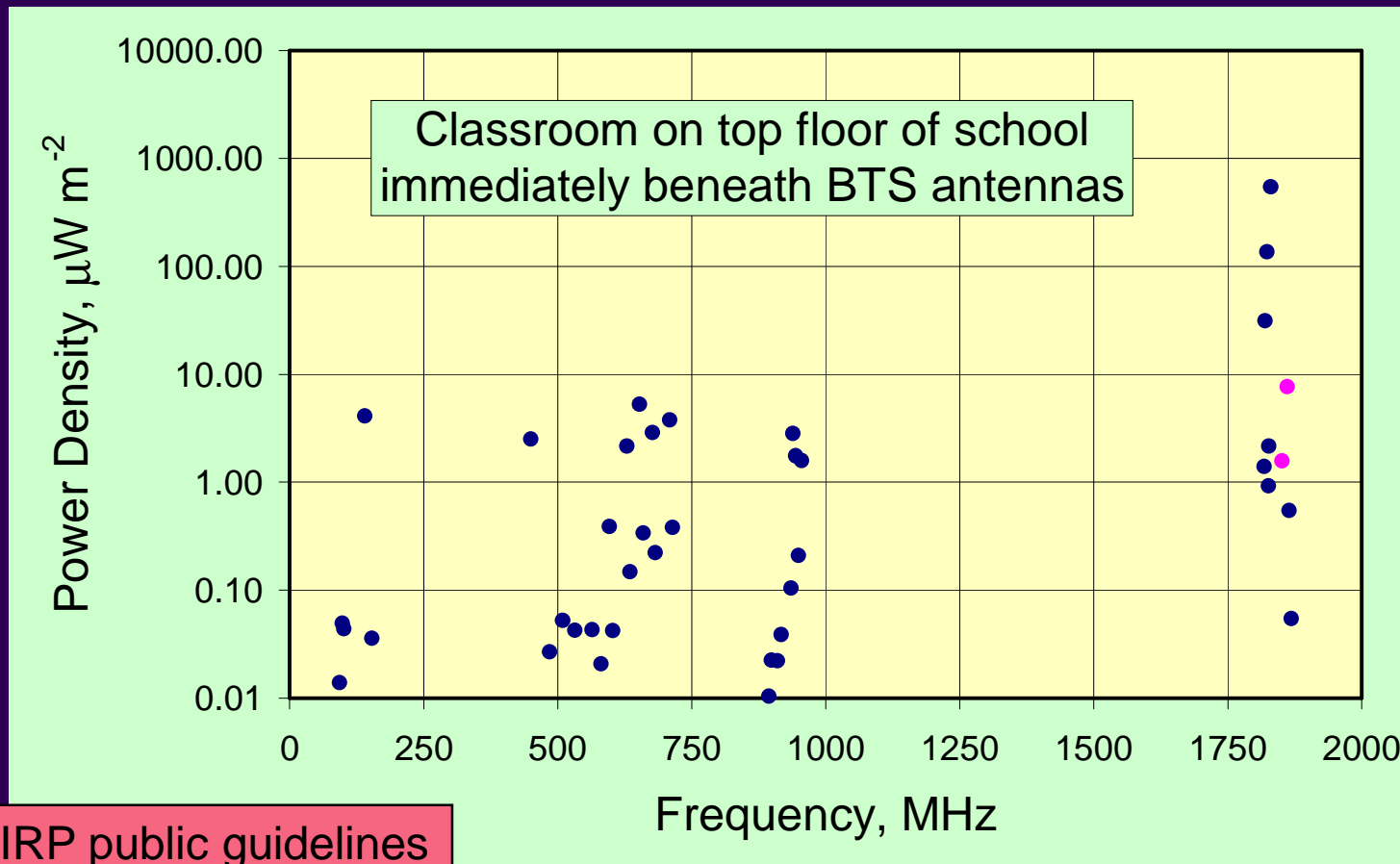
- Schools (8) - Antennas on masts or rooftop
 - Classrooms, playgrounds, corridors
- Tower blocks (local authority and private)
 - Top floor flats, corridors, balconies, car parks
- Private houses
 - Gardens, bedrooms, lofts

Total of 118 locations at 17 sites

73 complete spectra obtained (88 MHz – 2 GHz)

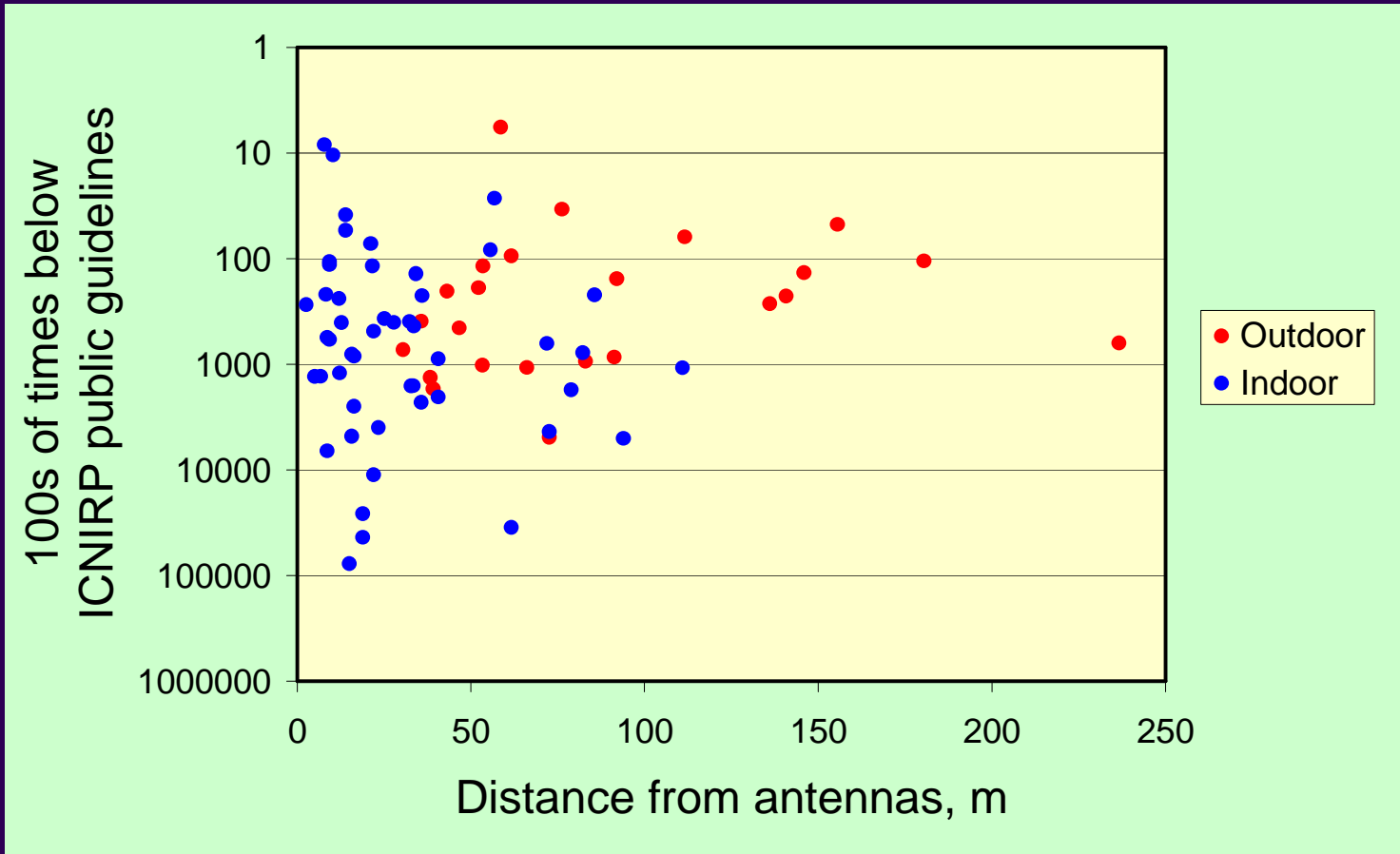


Spectrum in a School



ICNIRP public guidelines
 $\geq 2,000,000 \mu\text{W m}^{-2}$

Exposures from Base Stations

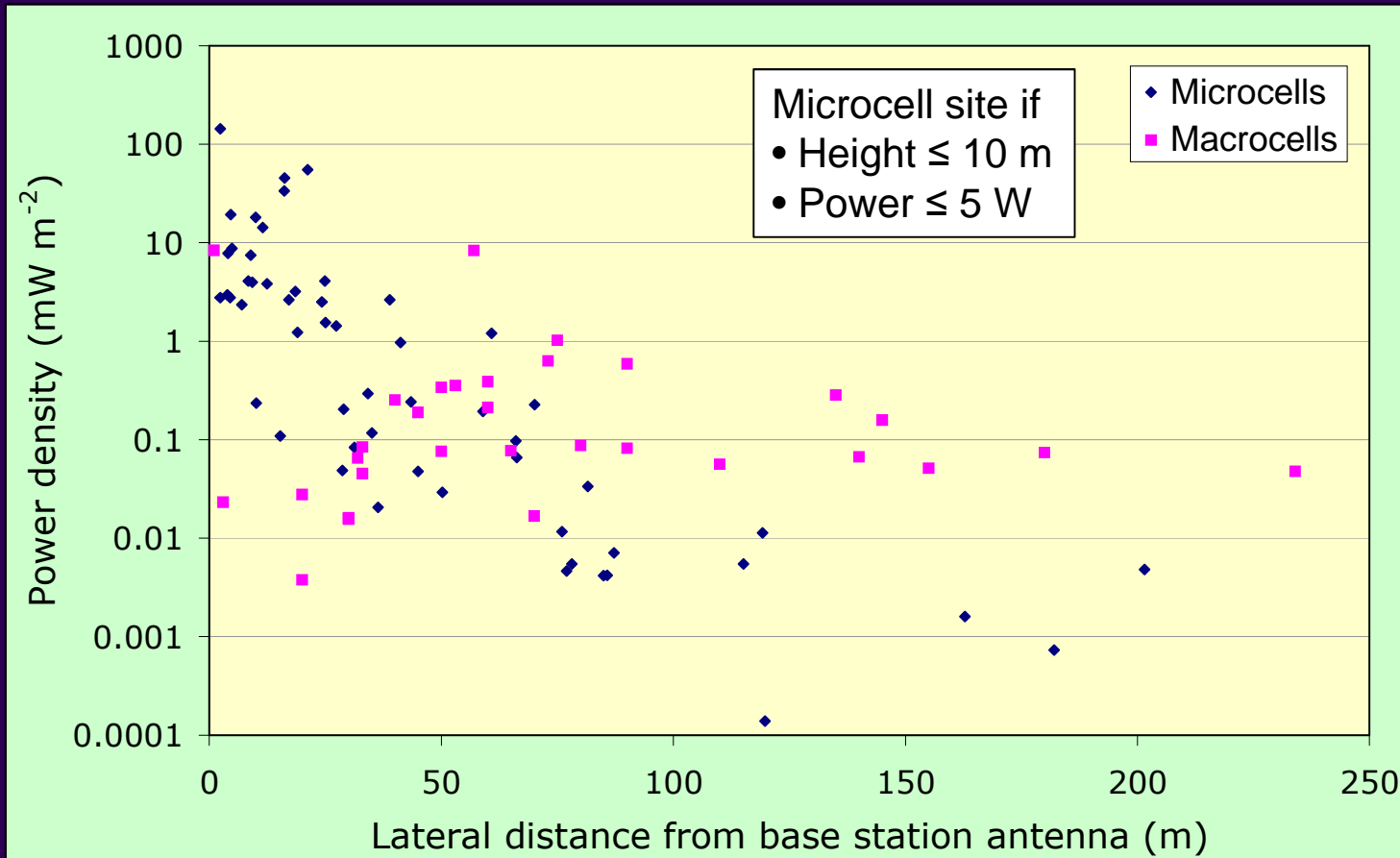


R321 Findings



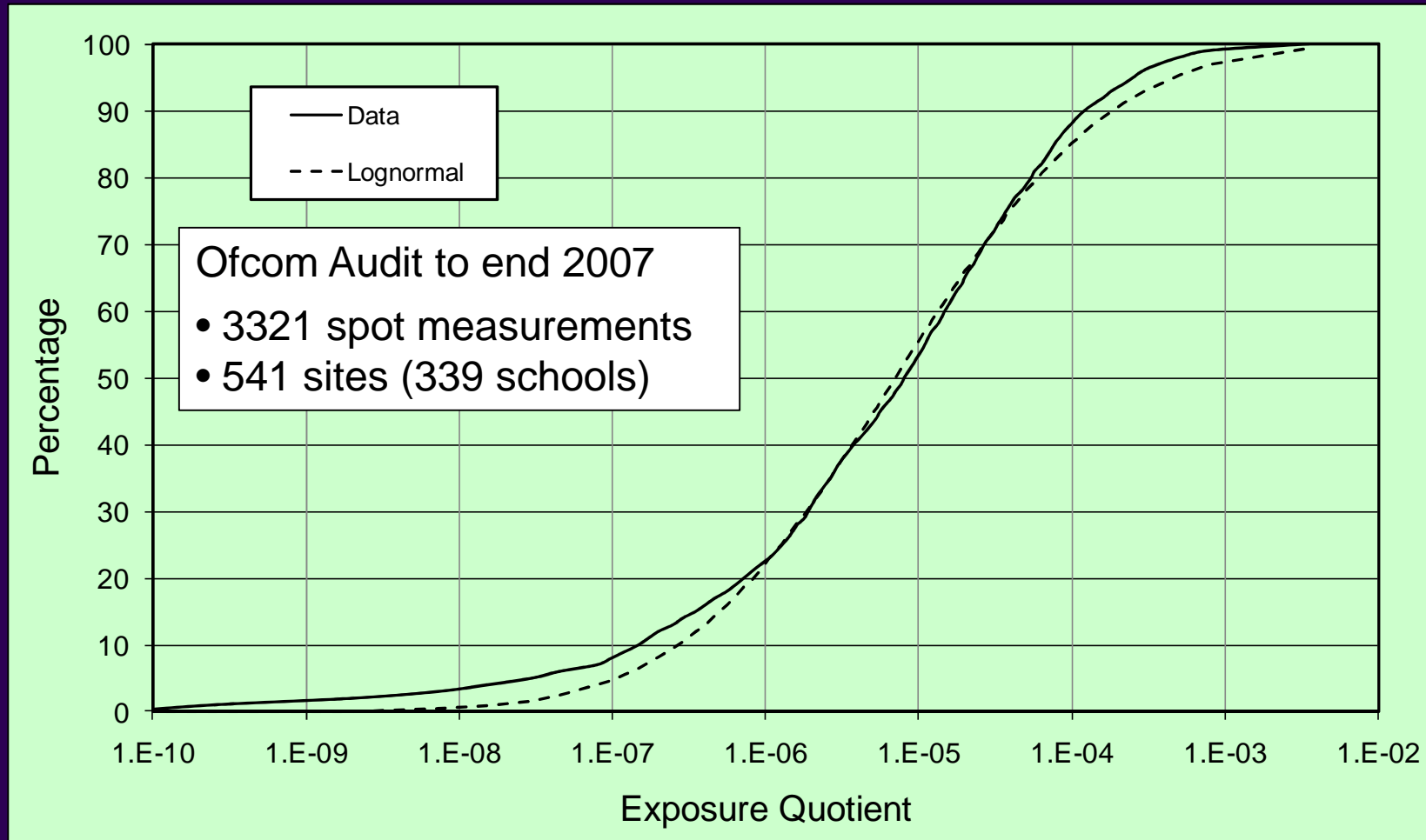
- Exposure <0.2% of ICNIRP reference level
- Exposure shows no clear trend to increase as a base station is approached
 - People at locations of concern are near to the base station, but rarely exposed to its main beam
 - Shielding by buildings weakens the signals from the base station further
 - Exposure to radio waves from sources other than the base station of concern is frequently comparable to that from the base station of concern

Additional work to Consider Microcells



*Cooper TG, Mann SM, Khalid M, Blackwell RP
J Radiol Prot 2006; 26 (2): 199 - 211*

Compilation of Data from UK Audit of Base Stations



5) Dosimetry for Standards



- Phantoms
- Material properties
- Modelling

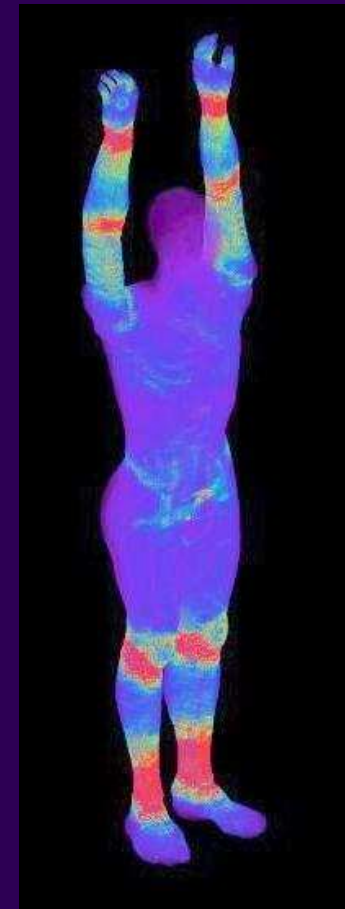
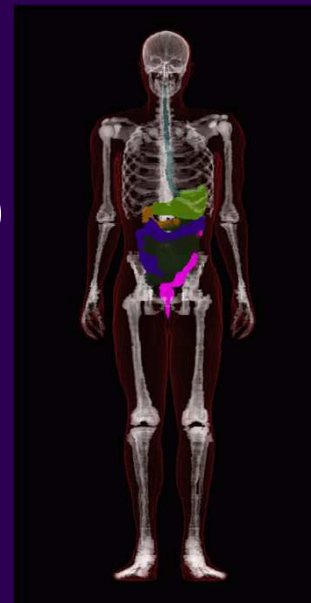
Computer modelling of electromagnetic field interactions with the body

- Energy absorption
- Temperature rise
- Induced currents

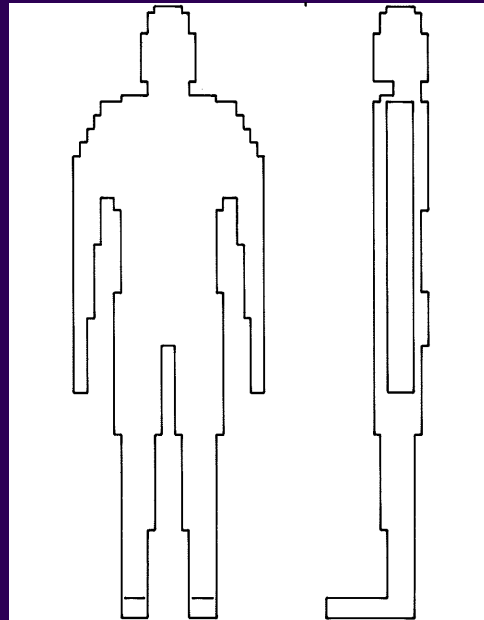
Research topics

- Postural effects (sitting, standing)
- Age-related effects (size, shape)
- Effect of tissue parameters
- Pregnancy

Critical input to standards

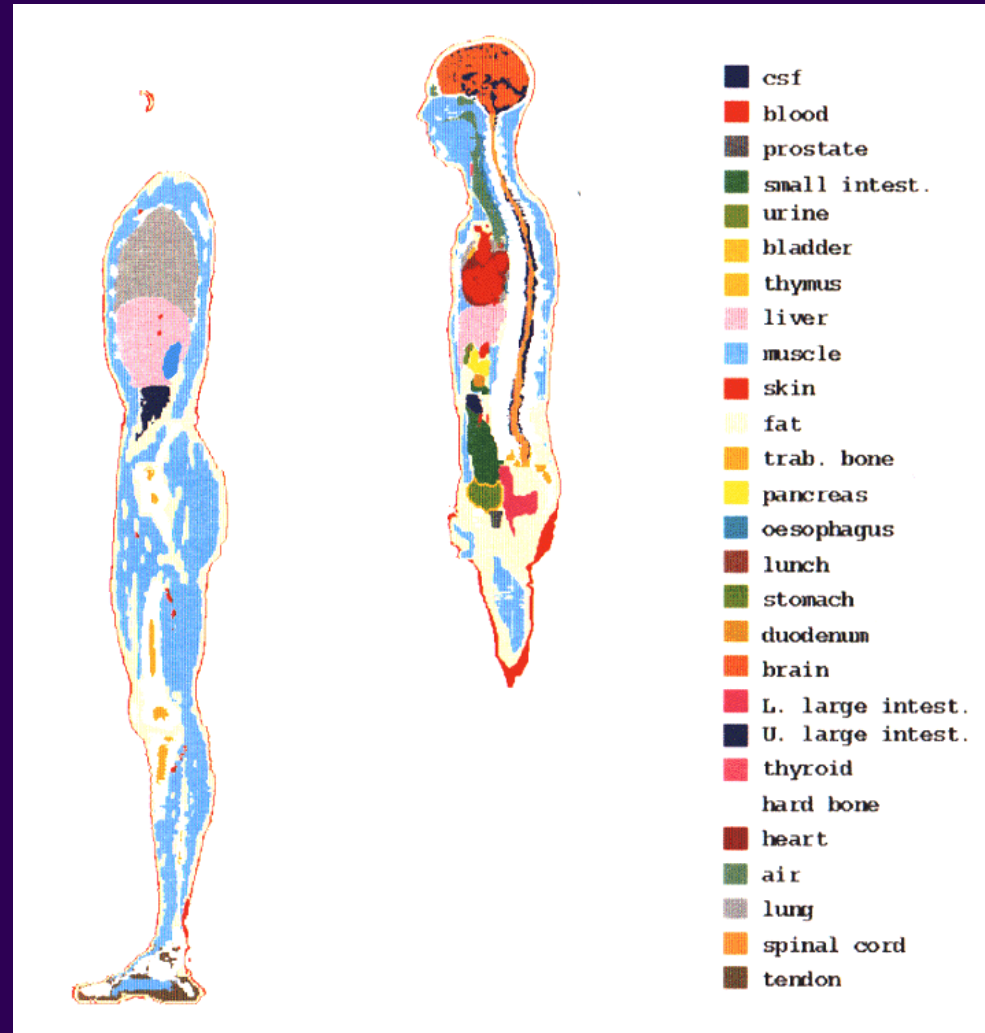


Phantom Development

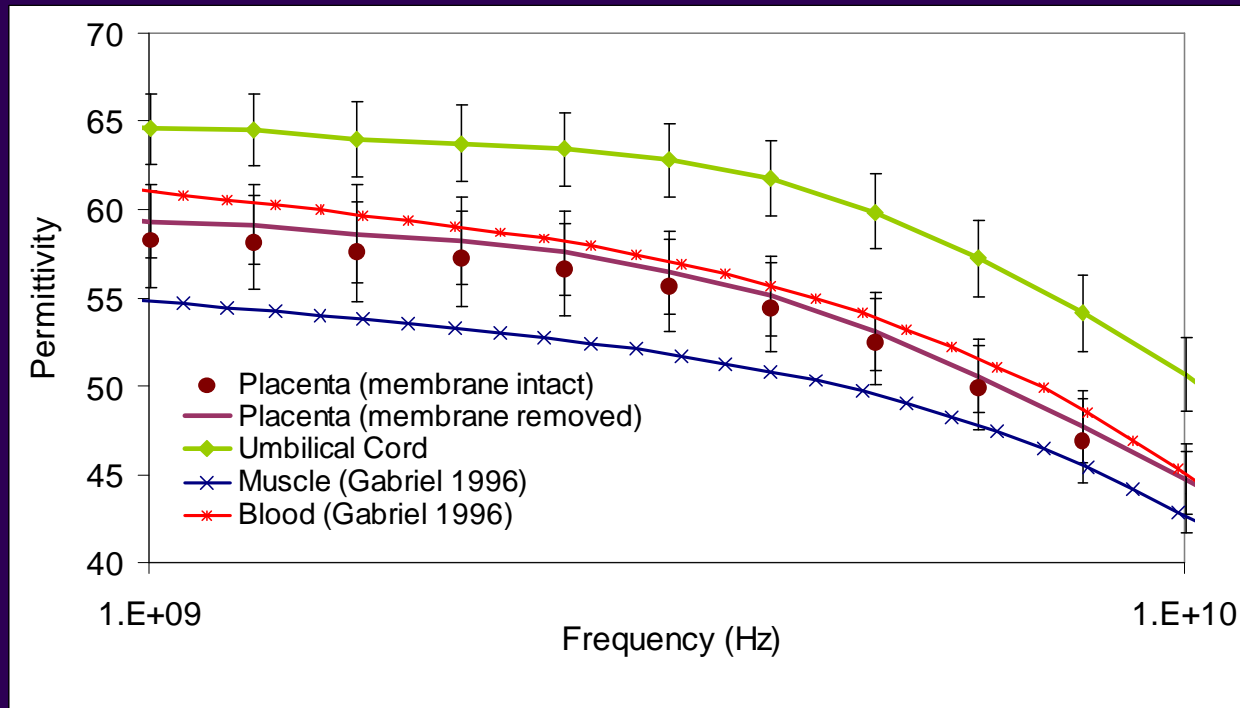


1987

Norman
1997



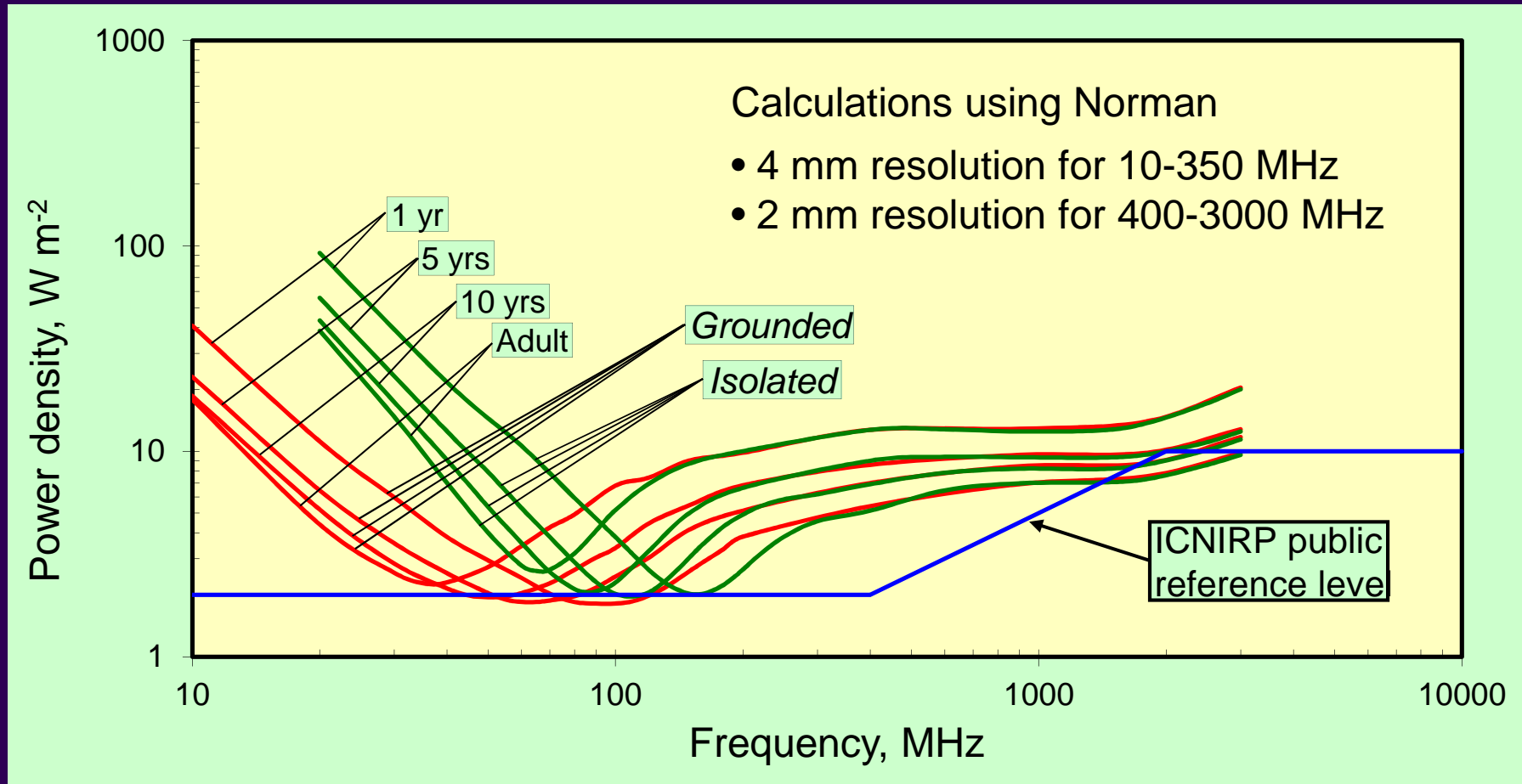
Dielectric Properties of Tissues



- 1996 database (Gabriel et al) “standardised” many tissue electrical parameters that are used for modelling
- Pregnancy-related tissues were a gap in knowledge

*Peyman A, Gabriel C, Benedickter HR, Fröhlich J
Phys Med Biol 2011; 56 (7): N93 - N98*

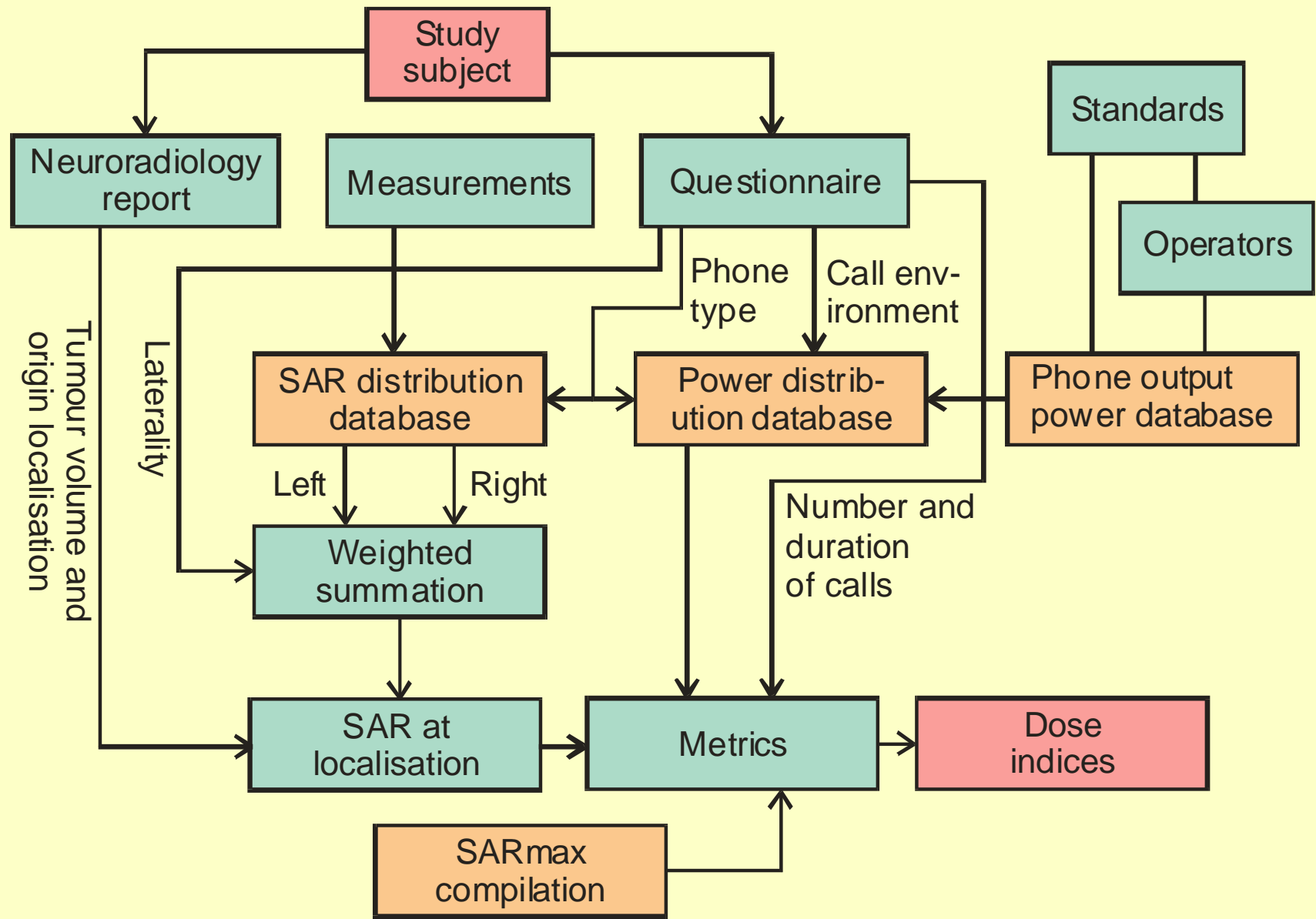
SAR Calculations in Relation to Guideline Levels



6) Assessment Support to Multidisciplinary Studies

- Mobile phone epidemiology
- Personal dosimetry investigations





- Exposure assessment is developed from Interphone
 - Includes low frequency exposures, as well as RF
- HPA is responsible for exposure assessment work package
 - HPA is conducting LF Assessments
 - Induced current distribution in head
 - FT conducting RF assessments
 - SAR distribution in head

Personal Exposure Meters



7) Summary and Future Plans



- Experimental
- Computational
- And staff

Source assessments

- Smart meters, security scanners

Dosimetry for standards

- Thermal dosimetry
- Higher frequencies (>3 GHz to THz)
- Occupational scenarios

Support to multidisciplinary studies

- Continue Mobikids work
- Personal exposures, e.g. workplace