

Laboratory & Volunteer Trials of an RF Personal Dosimeter



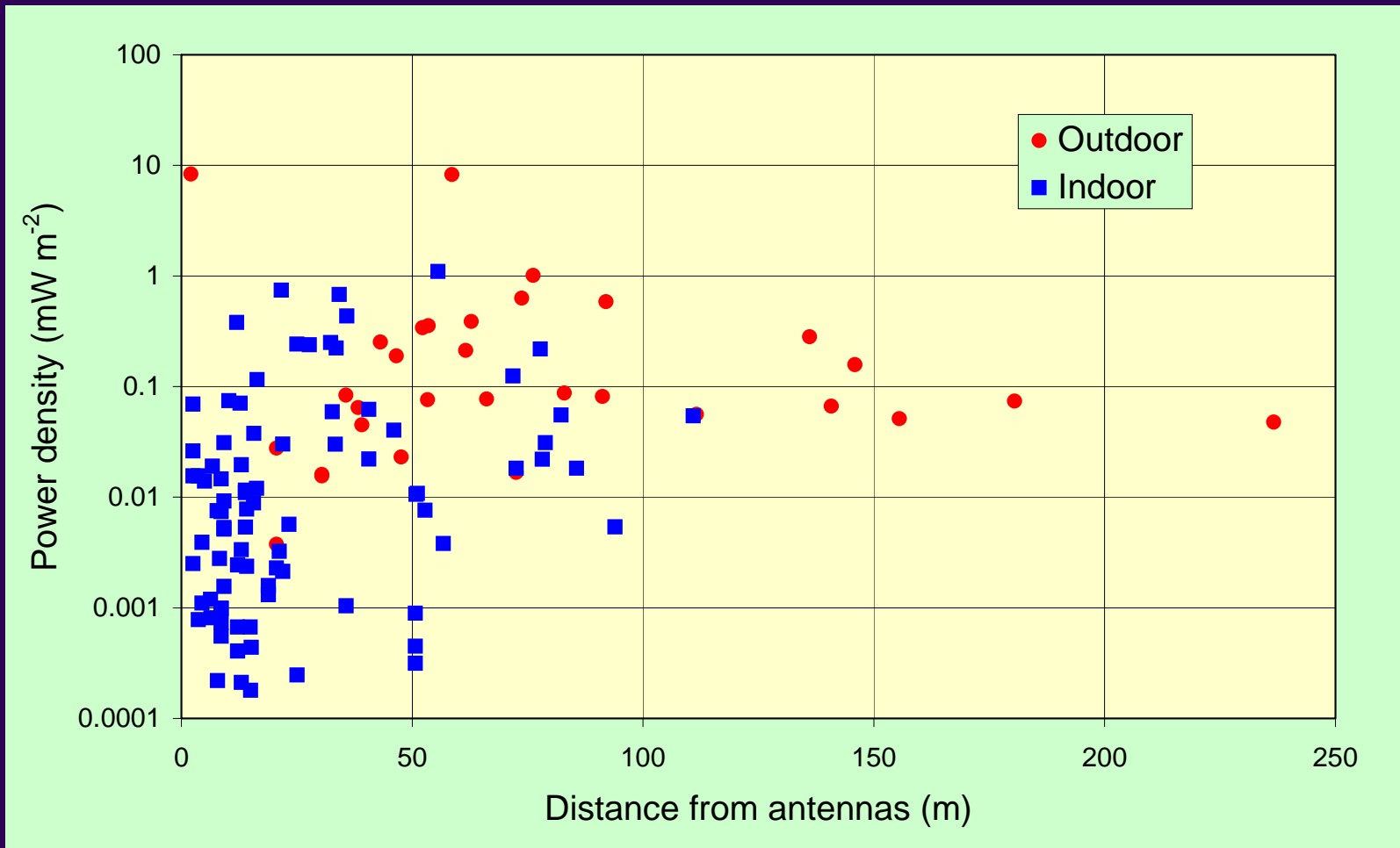
An MTHR Project

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- Concern about exposures from base stations
 - Need to respond scientifically
 - Develop robust studies
- Difficulties with studying people's exposure to RF in the environment
 - RF propagation issues
 - Multiple sources
 - Personal use of mobile phones
 - People move around
- What is feasible?

Base Station Spot Measurements



Spot Measurements & Personal Exposures



Spot measurements

- Made at a fixed point
- Made at a fixed time

Interpretation

- No clear relationship between exposure and distance
- Confounding effect of other sources
- Difficult to design studies of people's health

Personal Measurements

- Made where a person is
- Made as they move
- Made over time

Requirement

- Need a body-worn instrument to sample and store a person's exposure over time
- This might open new research possibilities

Capabilities of the Personal Exposure Meter (PEM)



- Contains filters to separate exposures by frequency band (MHz)

FM	88-108	DCS Tx	1710-1785
TV3	174-223	DCS Rx	1805-1880
TV4&5	470-830	UMTS Tx	1920-1980
GSM Tx	876-915	UMTS Rx	2110-2170
GSM Rx	935-960		

- Records electric field strength in each band at set intervals and for a set duration
- Dynamic range: 50 mV m^{-1} to 5 V m^{-1}

Scope of this Project



- To evaluate a new personal exposure meter developed by France Telecom and Antennessa
 - Laboratory investigations
 - Volunteer trials
- Funding of £44k has been provided
 - An adjunct to the MTHR Programme
- Work carried out by the EMF Dosimetry Group at HPA's Radiation Protection Division
- Draft report delivered on 31 May 2005

- **Laboratory testing**
 - Radiofrequency behaviour
 - Battery and memory
 - Software
- **Performance in use - 10 volunteers to each use the PEM for one week while keeping a location diary**
 - Sensitivity
 - Volunteer perceptions
 - Comparison with spot measurements

Key performance parameters

- Battery capacity / memory capacity
- Frequency bands - suitability for UK
- Response to modulated signals
- Response to multiple signals
- Isotropy
- Dynamic range
- Vulnerability to interference
- Spread of values between instruments

Results - Battery Capacity and Data Retention



Serial no.	1	2	3	4	5	6	7
Data collection days	5	5	6	6	7	7	7
Download after day	5	7	6	7	7	8	10
Final battery voltage	3.82	3.88	3.87	3.83	3.81	3.84	??
Data retained	Yes	Yes	Yes	Yes	yes	Yes	No
No. of events	1	7	None	~200	6	None	??
Event bands	TV4&5	TV4&5		TV4&5, UMTSrx	TV4&5		??

- Recording interval = 2 minutes in all cases
- 7-day run possible
- Data must be downloaded promptly to avoid loss

Results - Multiple Signals in Different Bands



Signals applied separately				Signals applied together				Change > 10%?
Signal 1		Signal 2		Signal 1		Signal 2		
Band	E, V m ⁻¹	Band	E, V m ⁻¹	Band	E, V m ⁻¹	Band	E, V m ⁻¹	
FM	1.76	TV3	1.00	FM	1.70	TV3	0.97	No
FM	1.09	GSMrx	1.65	FM	1.10	GSMrx	1.66	No
FM	1.13	TV4&5	1.04	FM	1.11	TV4&5	1.02	No
TV4&5	1.52	GSMtx	1.43	TV4&5	1.47	GSMtx	1.41	No
TV4&5*	0.97	GSMrx	1.56	TV4&5	0.64	GSMrx	1.55	Yes, TV4&5: - 34%
TV4&5†	1.43	GSMrx	1.59	TV4&5	0.96	GSMrx	1.57	Yes, TV4&5: - 33%
GSMrx	1.59	DCSrx	1.28	GSMrx	1.62	DCSrx	1.28	No

* modulated ATV † unmodulated ATV

- Presence of a GSMrx band signal affects the response to a TV4&5 band signal

Results - Multiple Signals in the Same Band



PEM band	Individual signal E-fields, $V m^{-1}$			E-field of signals together, $V m^{-1}$		
	Signal 1	Signal 2	Signal 3	Recorded	Predicted	Error %
FM	1.66	1.98		1.77	2.65	-34%
FM	0.71	0.66		0.65	0.97	-33%
FM	0.71	0.86	0.91	1.03	1.44	-31%
FM	1.66	0.66		1.59	1.78	-11%
GSMrx	1.92	1.83		1.75	2.65	-34%
DCSrx	1.47	1.34		1.31	1.99	-45%
UMTSrx	1.63	1.65		1.73	2.32	-34%

- Response is less than the RMS sum of the signal fields
- Signals are not summed correctly

Summary - Filter Selectivity and Signal Discrimination



- Filters have significant responses (to CW signals) outside their specified bandwidths
 - Performance relies heavily on the discrimination of pulsed (TDMA) and continuous signals by the PEM
- The PEM does not sum the field strengths of multiple in-band signals together properly
 - Probably a consequence of the detector design
 - Possible to improve?
- Need to improve the filter responses and make the detector respond properly to multiple signals

Volunteer Trials - Spot Measurements



Field testing in people's homes and workplaces

- Recruit ten volunteers - each to use the PEM for a week
- Identify several locations where each volunteer spends significant time (e.g. office, bedroom, kitchen, lounge)
- Compare precision spot measurements made at the locations on deployment and collection of the PEM
 - a) with readings from the PEM at the same spot measurement locations
 - b) with readings from the PEM when the volunteer wore it while present at the locations

Precision Spot Measurement Equipment



Summary - Results of Spot Measurements



- TETRA, DECT and WLAN signals found to give significant contributions to exposure
- Band field strengths on deployment and collection differ by no more than 3.4 dB (95% confidence)
- Erroneous summation of multiple in-band signals confirmed to cause under-reading of exposures
- Many locations found where band field strengths were below the PEM detection threshold of 50 mV m^{-1}

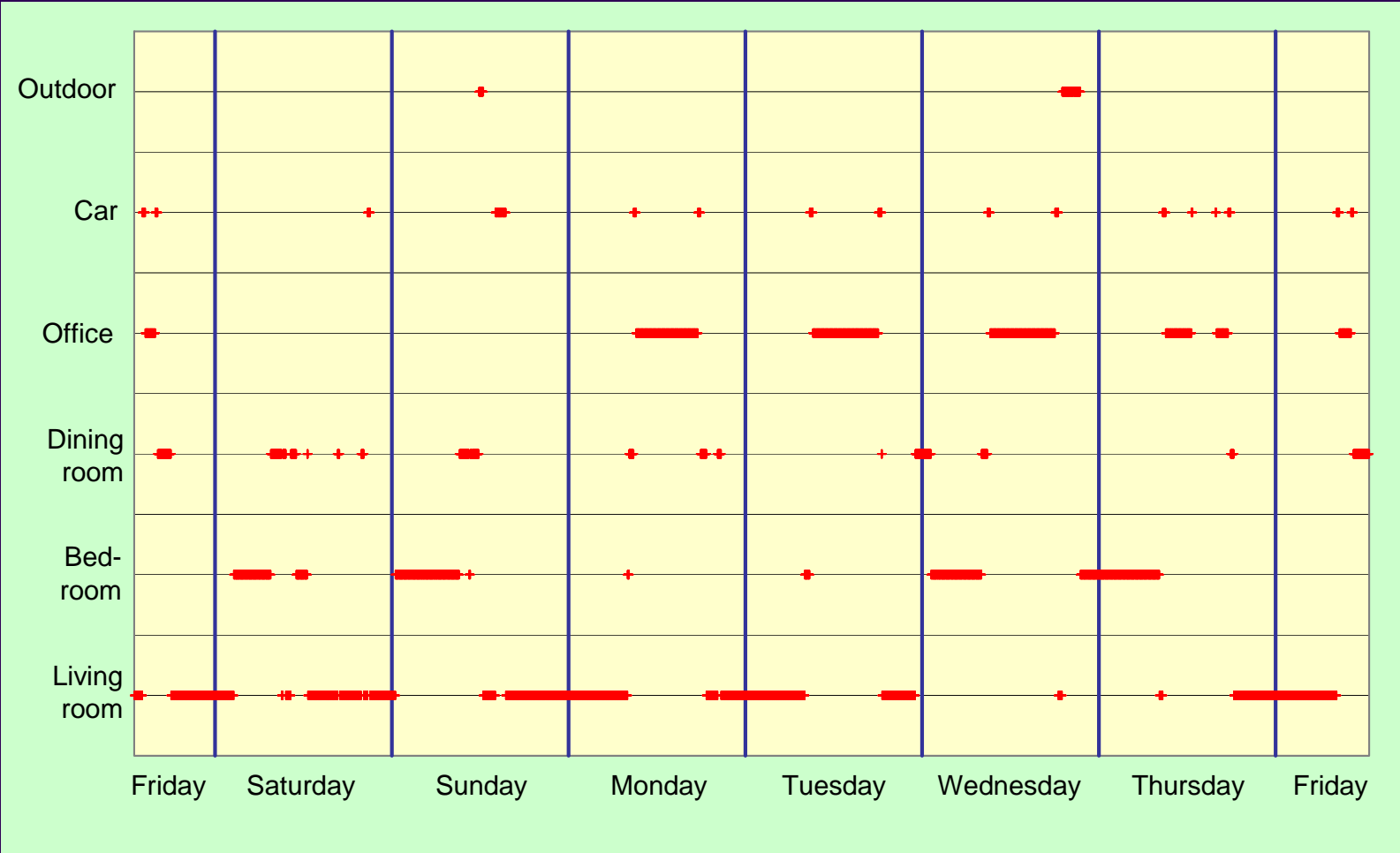
Volunteer Trials - Personal Exposures



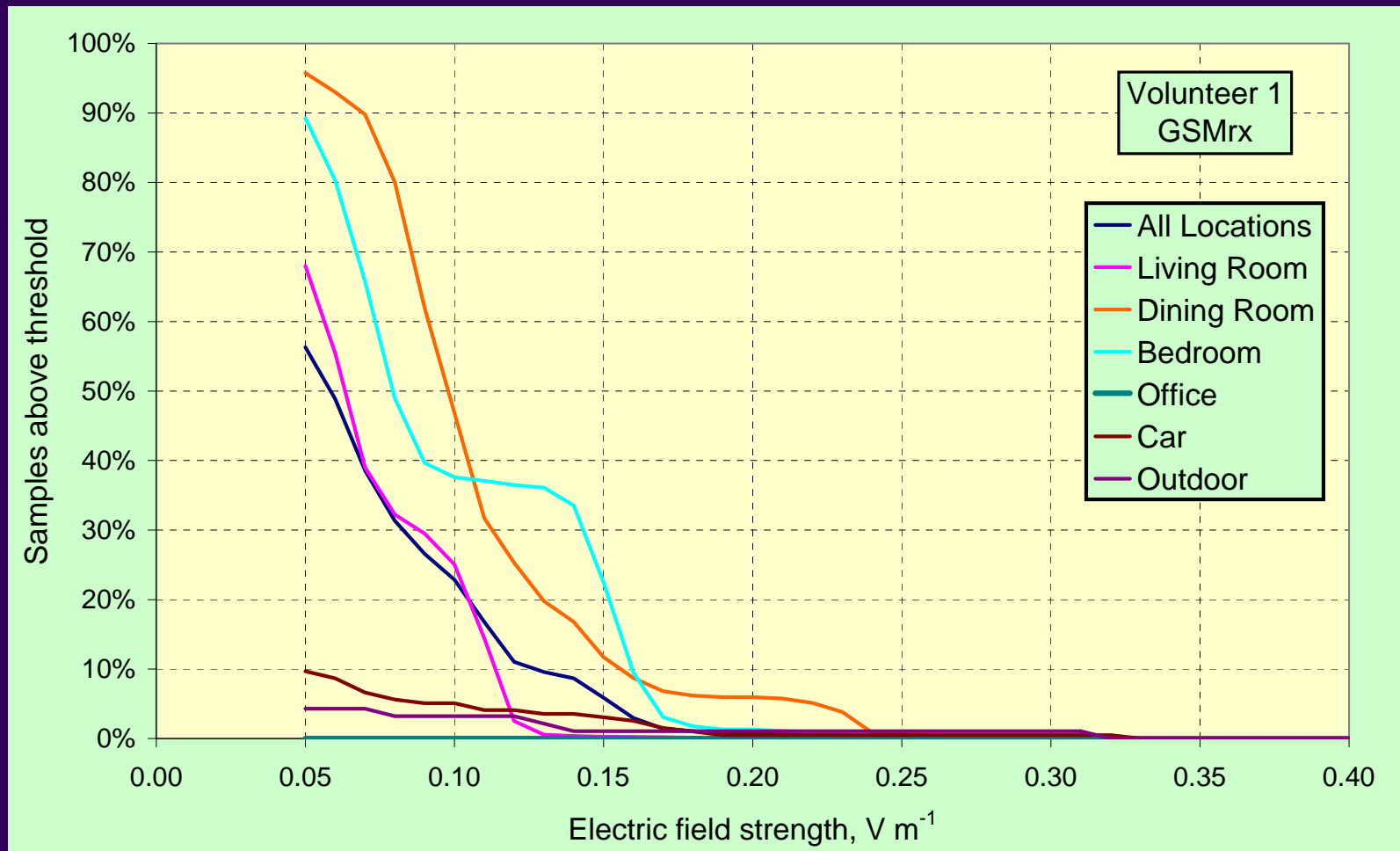
Gathering logged personal exposure data

- Each volunteer to use a PEM for a week, as if they were involved in a health study (2 minutes sampling interval)
- Volunteers to keep a diary showing where they were at a given time (e.g. the spot measurement locations)
- Examine the logged data
 - a) in the context of the dynamic range of the instrument
 - b) to identify exposure trends with location
- Compare the logged data for each location with the corresponding spot measurements

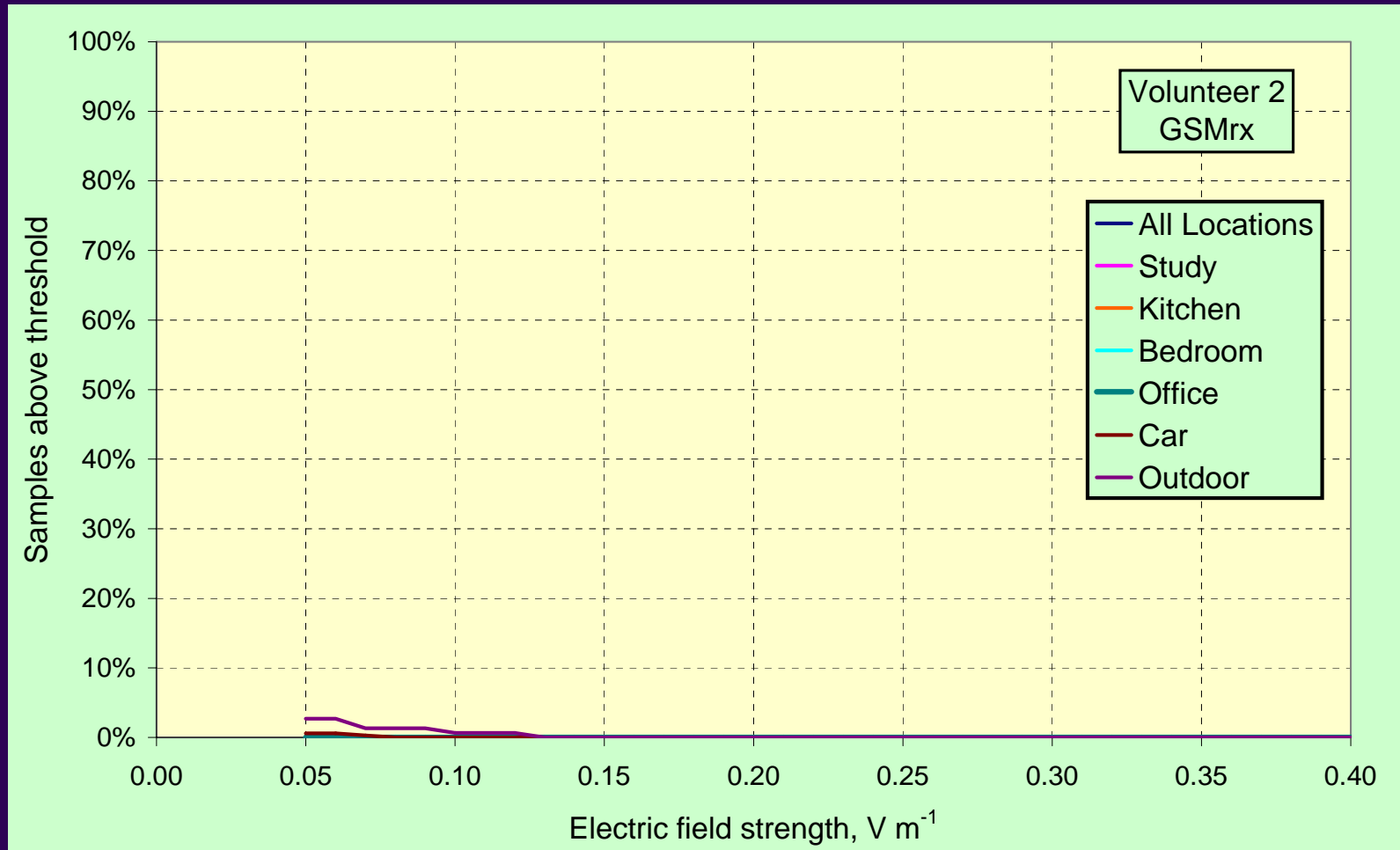
Results - Personal Exposures



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Results - Personal Exposures



Summary - Results of Personal Exposures



- Much of the time the recorded data were below the 50 mV m⁻¹ detection threshold of the PEM
- PEM does seem able to discriminate the relatively high exposures of people who live near to mobile phone base stations and television broadcast transmitters
- Generally higher exposures found in all bands when volunteers were outdoors, e.g. on foot, in a car, on a train
- In a small number of cases where comparison was possible, spot measurements agreed well with the time-averaged personal exposure data at a given location
- Need to provide placement guidelines for the PEM when not worn

User feedback on the instrument

- Safety issues
- Structured framework for reporting
- Modification of behaviour
- Practicality of wearing
- Issues of appearance - public acceptability

Results - User Feedback



- Important to establish a comfortable way for volunteers to wear/carry a PEM
 - Belt clip unlikely to be acceptable for majority
 - Some form of shoulder bag would be better
- Strong consensus that the PEM needs to be smaller
 - Maybe less of a problem if used in a carrying bag
- Weight less of a problem than size
- Problems with volunteers forgetting to pick up a PEM placed by their side, e.g. when going to bed.

The PEM has overall performance broadly in line with that required for its intended purpose, however there are a number of issues requiring attention.

Significant issues

- Battery charging reliability
- Absence of TETRA, DECT and WLAN bands
- How to “wear” the PEM and place it when not worn

Important issues

- Storage integrity on battery discharge
- Summation of multiple signals
- Measurement of GSM secondary carriers