Variability in radio-frequency dosimeter readings at 900 MHz when worn by an adult or child

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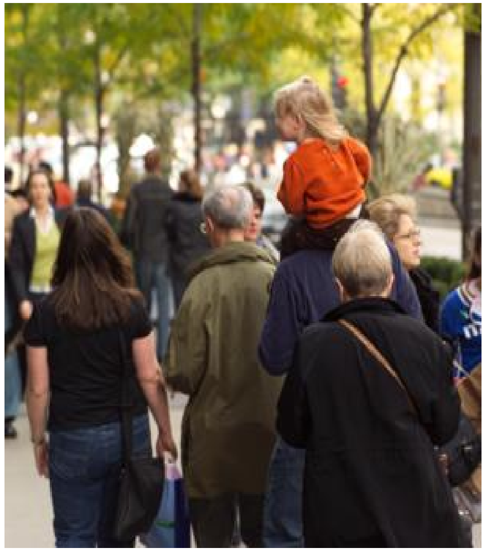
Content

Introduction

- Personal, body worn electric field exposure meters (or dosimeters) have the potential to provide a convenient means of recording real time exposure to RF sources such as mobile telephone base-station antennas.
- Accurate exposure data is essential as input to epidemiological studies into possible links between RF fields and health effects in humans.



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Objective

> Determine the response of a (hypothetical) electric field measuring dosimeter when placed at random locations on the torso region of the adult and child phantoms for a range of incident field conditions.

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Research Approach

- Computational modelling to determine the field, and therefore a reading from a body worn electric field dosimeter, at random locations on the torso region of a heterogeneous human body (adult and child) model.
- Dosimeter readings for different electromagnetic environments:
  - Random: a dominant field varying randomly in incident angle and polarisation (e.g. person is walking randomly with respect to the source)
  - Stationary field: there is a dominant angle of incidence with respect to the body

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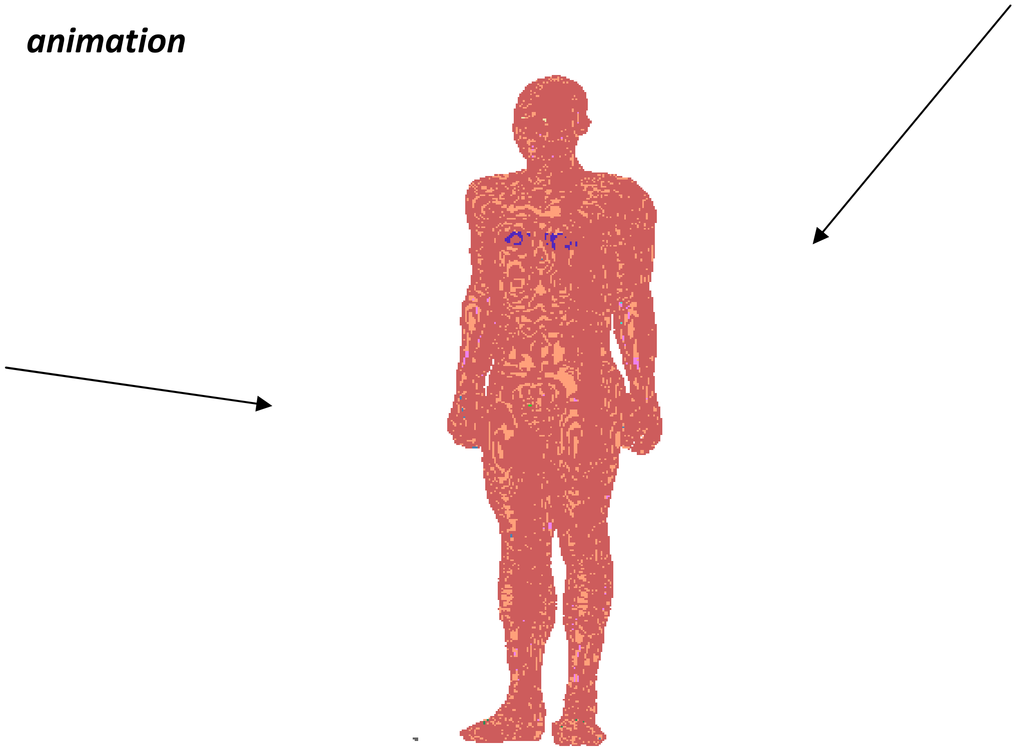
Random field environment

animation

Random: a dominant field varying randomly in incident angle and polarisation (e.g. person is walking randomly with respect to the source)

Direction of incident field varying randomly with time

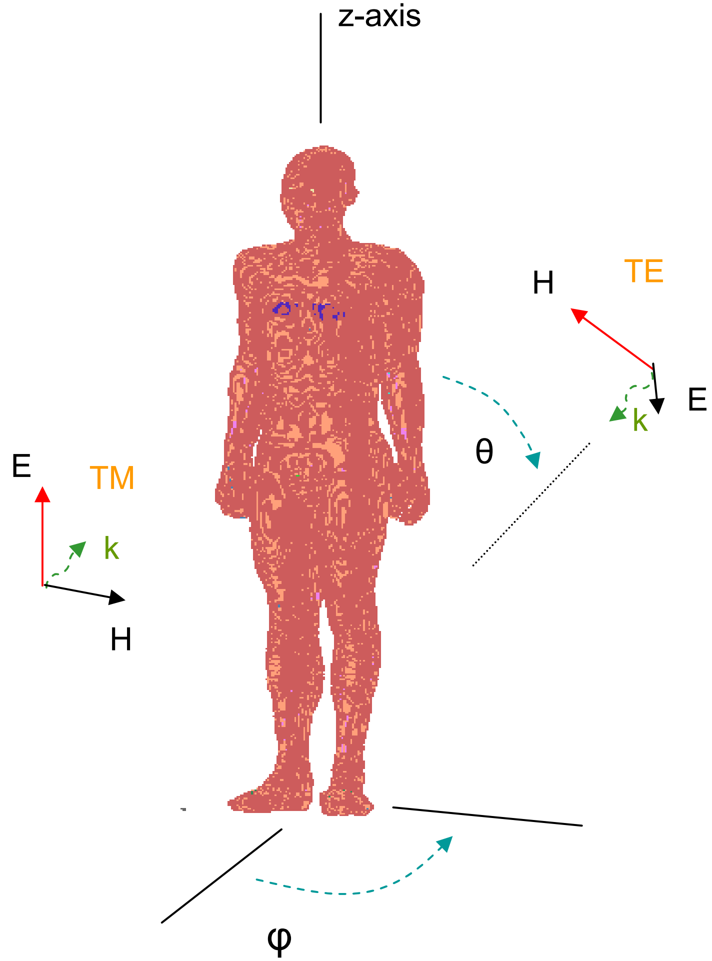
Stationary field environment



<u>Stationary field</u>: there is a dominant, but unknown angle of incidence with respect to the body

Analysis – (a) Field excitation

- Generate set of incident, 900 MHz free space fields using the finite difference time domain (FDTD) method
  - constant power density P_{inc} ($=|E|^2/377$)
- The electric field component (E) is aligned parallel to either the θ (elevation) or φ (azimuth) unit vectors
  - transverse magnetic (TM) and transverse electric (TE) polarization respectively
- Propagation (k) towards the body is varied from $\theta=0^\circ$ to 180° in 30° increments and from $\varphi= 0^\circ$ to 270° in 90° increments.
- A total of 7 (θ) x 4 (φ) x 2 (TM or TE) = 56 FDTD simulations are performed for each human model.



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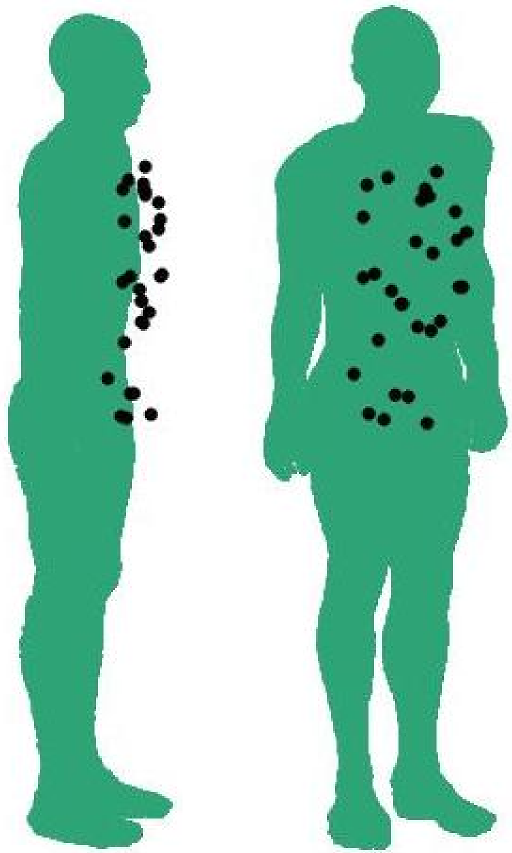
Analysis – (b) Human body models

- **Human body**
  - Adult male, 4 mm cell size with a height of 1.74 m and a mass of 71.2 kg
  - Child based on re-scaled adult with ~3 mm cell resolution, height (1.38 m) and mass (32 kg) of a 10y child.
  - The electrical conductivity, relative permittivity and mass density values of each tissue type at 900 MHz
- **Random locations on torso**
  - The *a priori* location of a dosimeter may be unknown so the magnitude of the total electric field will be determined at random locations on the torso:
  - 30 locations on **front** and on **rear**
  - at separation distances (d) of 50 mm from the surface of the torso



Example of 30 random locations on front of torso

Analysis – (c) dosimeter response

- For a (hypothetical) electric field dosimeter worn on the body, its average response to a set of N simulations can be expressed as:

$$R = \frac{1}{N} \sum_{i=1}^{N} (S_E)_i$$

- N=56 FDTD simulations of equal probability (e.g. ***random*** environment)
- $(S_E)_i$ is the instantaneous dosimeter reading for the i^{th} simulation
- The reading is defined as: $S_E=10Log10((|E_t|^2/377)/P_{inc})$
  - Equivalent power flux density normalised to the incident, free space field P_{inc}

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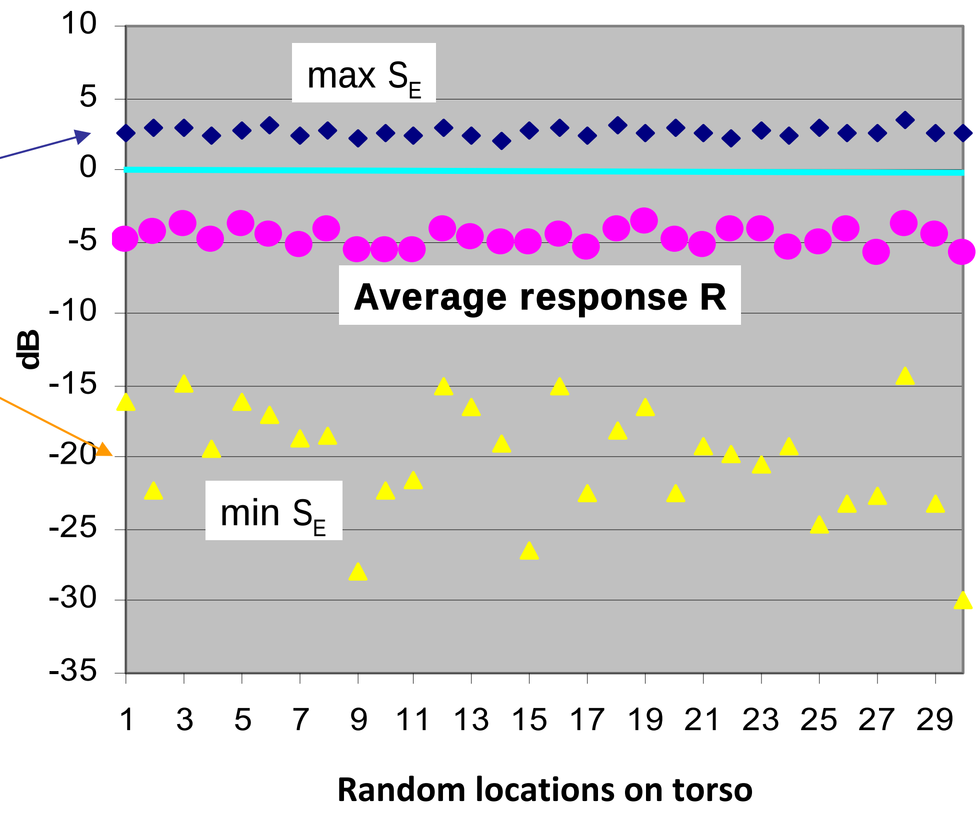
Adult – single dosimeter worn on front of body (torso region)

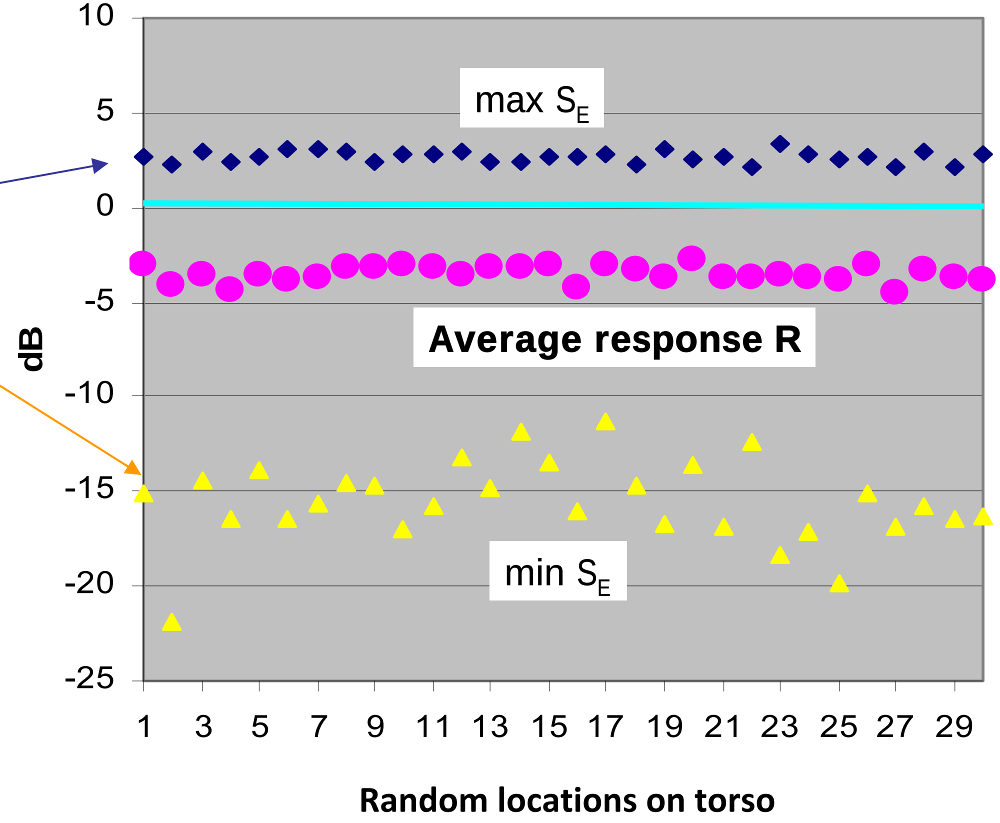
Maximum and minimum dosimeter response S_E over all N simulations (***stationary*** environment)



Incident field level

Child – single dosimeter worn on front of body (torso region)

Maximum and minimum dosimeter response S_E over all N simulations (***stationary*** environment)



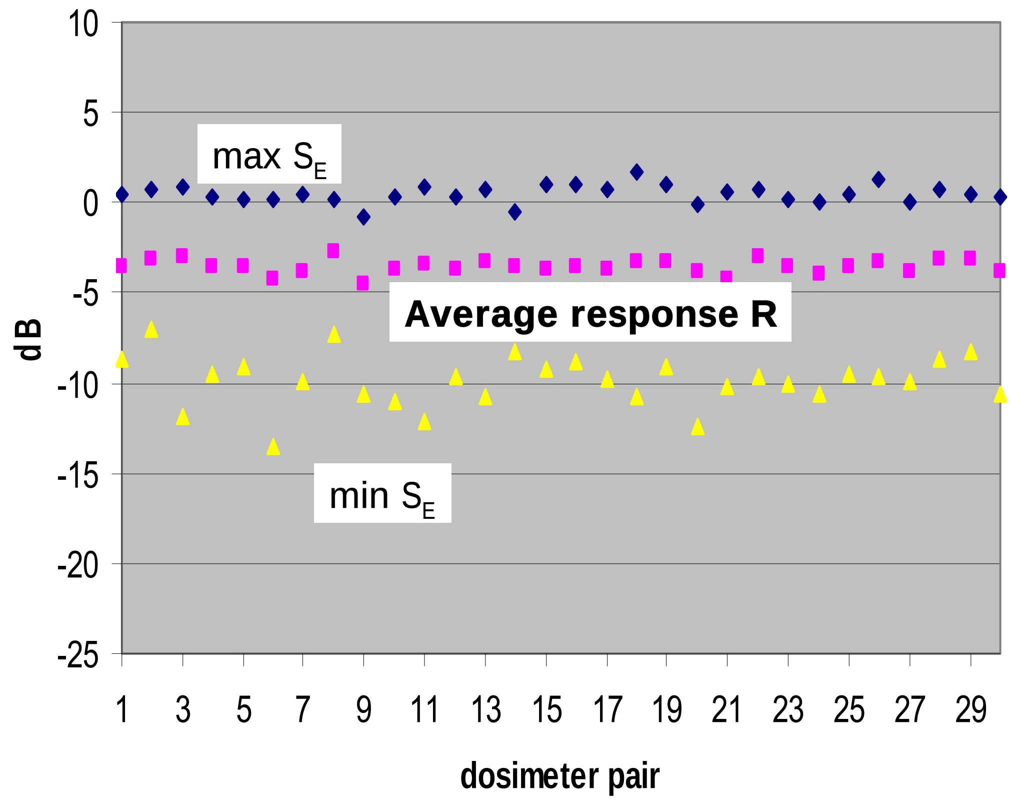
Incident field level

Two dosimeters

- What if the response (R) is based on combining the simultaneous outputs from two dosimeters, one worn on the front and the other on the back of the torso?
  - Pairs based on a random position on front and back of torso
- How would this arrangement impact on:
  - Average response?
  - The difference in level between $maxS_E$ and $minS_E$?

Adult – pair of dosimeters (torso region)

- Average response (R) based on combining simultaneous outputs from pairs of dosimeters
- The average response is similar to single dosimeter result
- Difference between max and min S_E is significantly reduced compared to single dosimeter arrangement
- Similar results for child model



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Conclusions

- Results similar between adult/child models
- Single dosimeter is sufficient for random field environments (and where dosimeter readings are averaged)
  - Little advantage gained by using two dosimeters
- Multiple dosimeters may give lower uncertainty (i.e. spread in max/min readings) in stationary field environments

Future work

- Include other electromagnetic environments (e.g. scattering) by incorporating appropriate statistical models
  - For example, not all angles of incidence are of equal probability in a ‘real’ environment
- Multiple incident fields (scattering from many objects)
- Simulations at other frequencies e.g. 450 and 2100 MHz

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