1G VS 10G SAR AVERAGE MASS

(*AND OTHER RELATED STUFF*)

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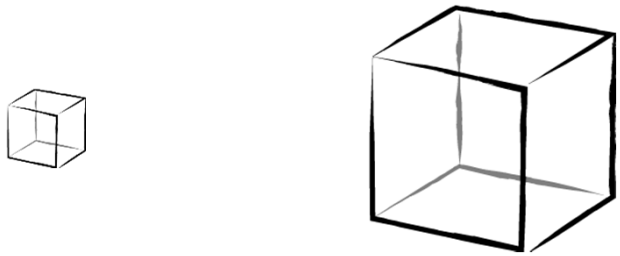
Your EMF safety expert

1g vs 10g SAR



Pennes bioheat equation

Thermal inertia
(temporal smoothing)

Heat inputs

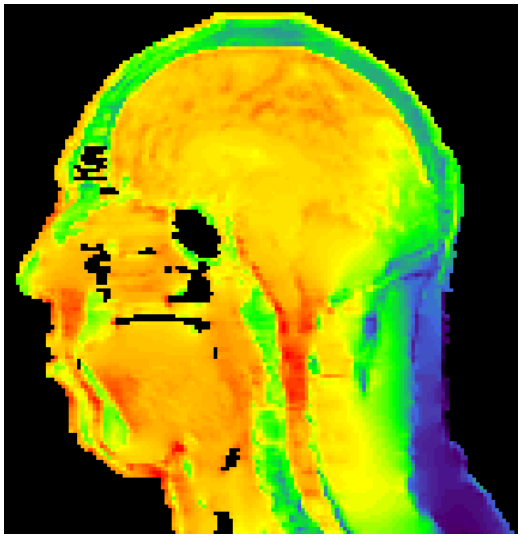
$$\rho c \frac{\partial T}{\partial t} = K\nabla^2 T + \rho SAR + A_0 - b(T - T_b)$$

Thermal diffusion
by heat conduction

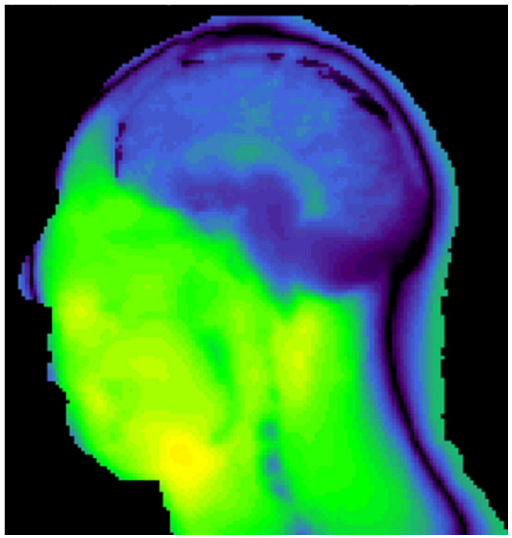
Heat sink from
blood flow

(spatial smoothing)

Point SAR



Temperature rise (ΔT)



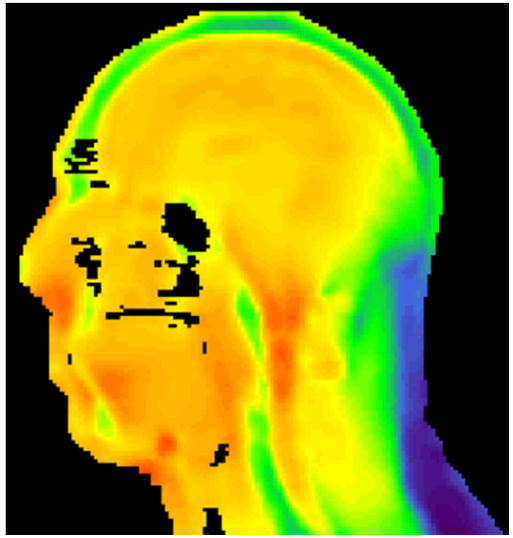
E

S

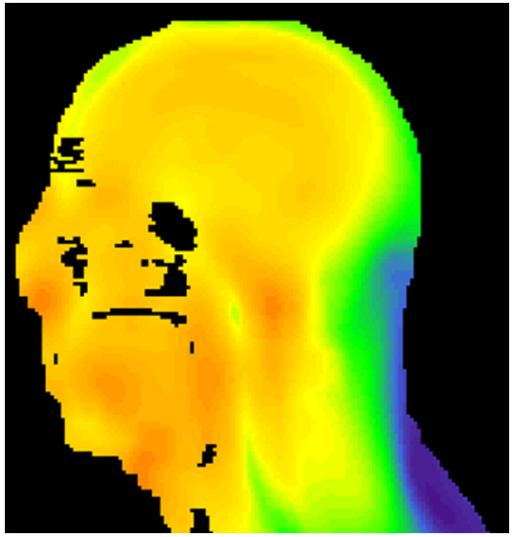
Plane wave
300 MHz
10 W/m^2

HEATING

1g SAR



10g SAR



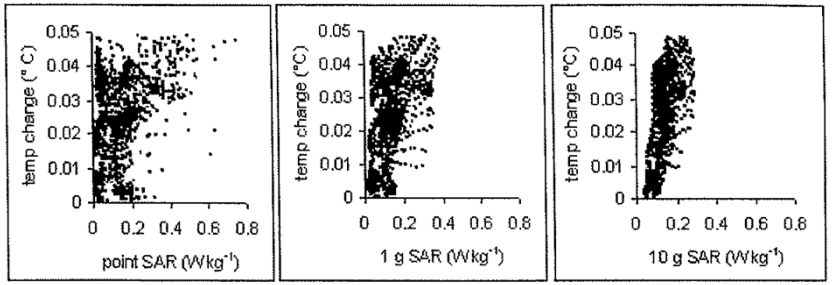
dB scaling

0 dB SAR = 1 W/kg
0 dB temp = 1 ℃

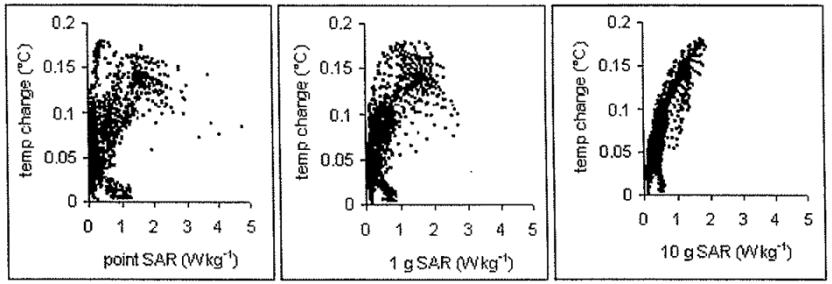
Modelling courtesy of Robert McIntosh

ΔT vs SAR in the head for 10 W/m² plane wave exposure

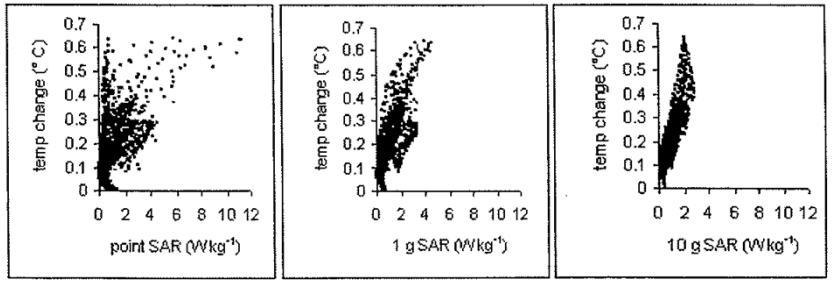
R. L. McIntosh, V. Anderson, and R. J. McKenzie, "The Use of Temperature as a Metric for the Assessment of RF Safety," *Radiation Protection in Australasia*, vol. 25, pp. 9-21, Nov 27-29 2008.



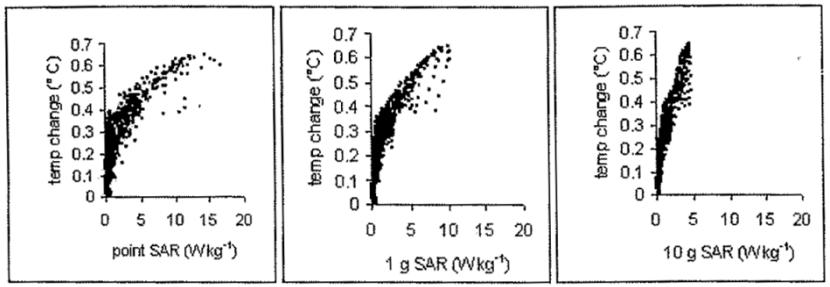
A: 300 MHz



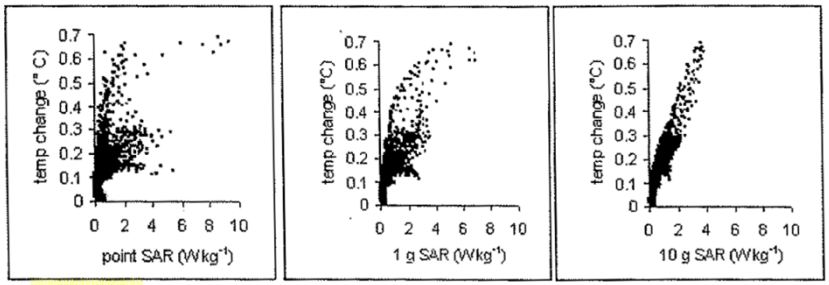
B: 900 MHz



C: 1800 MHz



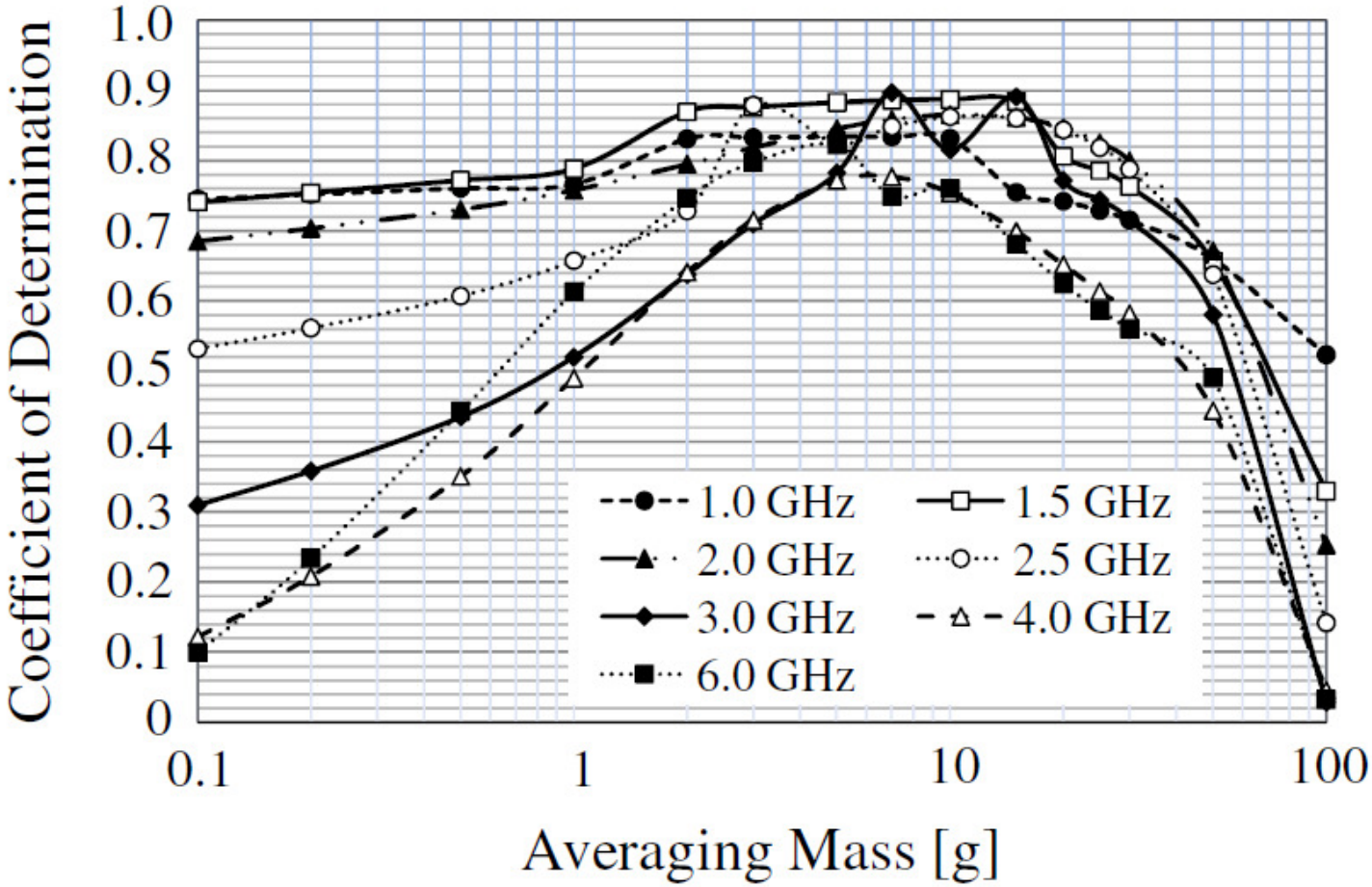
D: 2400 MHz



E: 3000 MHz

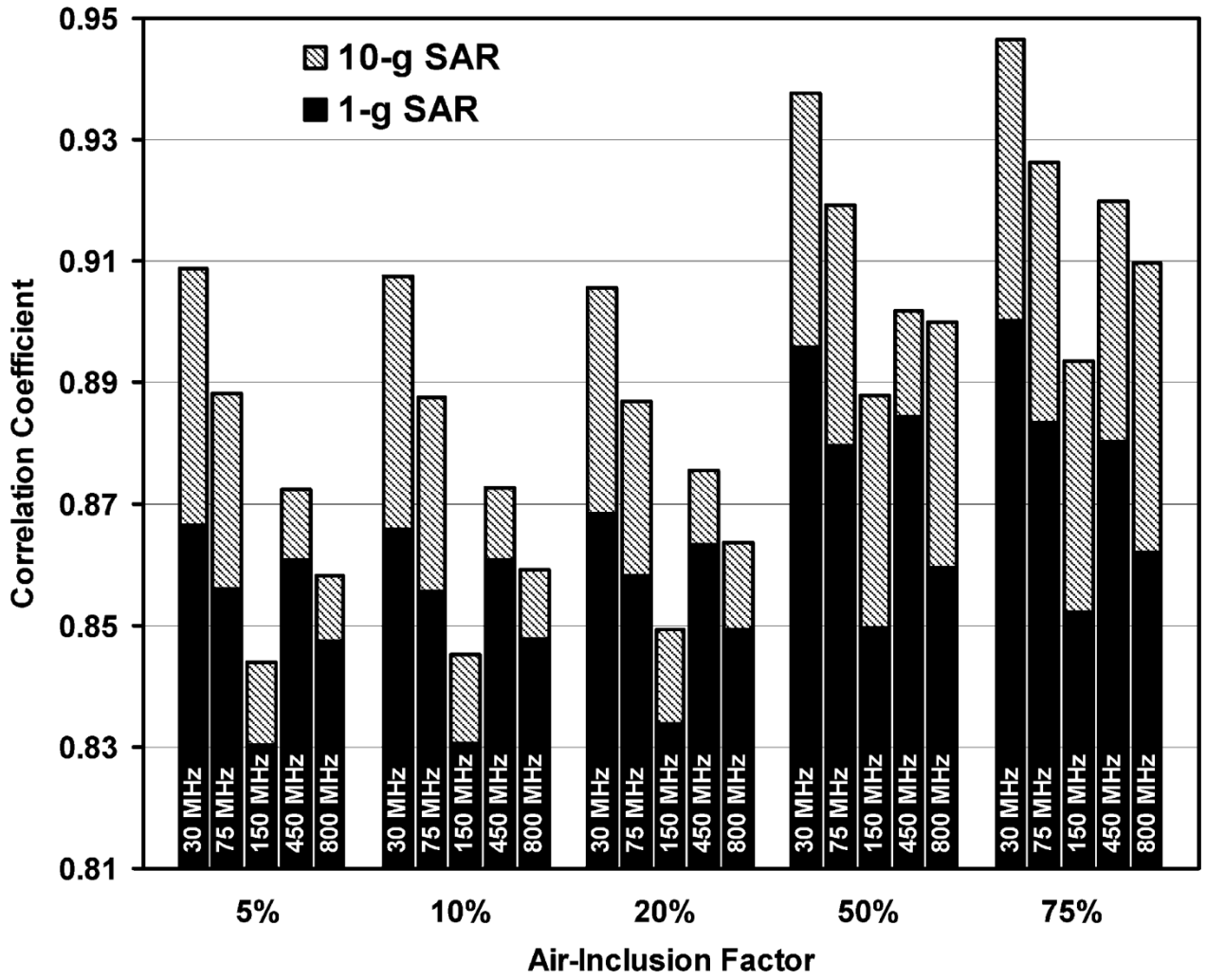
ΔT vs SAR in the head for near-field dipole exposure

A. Hirata and O. Fujiwara, "The correlation between mass-averaged SAR and temperature elevation in the human head model exposed to RF near-fields from 1 to 6 GHz," *Phys Med Biol.*, vol 54, 2009.



ΔT vs SAR in the body of visible human for plane wave exposure

A. Razmadze et al., "Influence of specific absorption rate averaging schemes on correlation between mass-averaged specific absorption rate and temperature rise," *Electromagnetics*, vol 29(1), 2009.



Published data consistently indicates that 10g SAR is better correlated with ΔT than 1 g SAR over a wide range of frequencies and for near and far field exposure

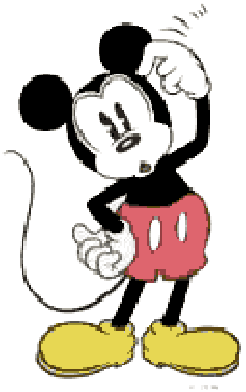
And now the other stuff …

What ICNIRP does well

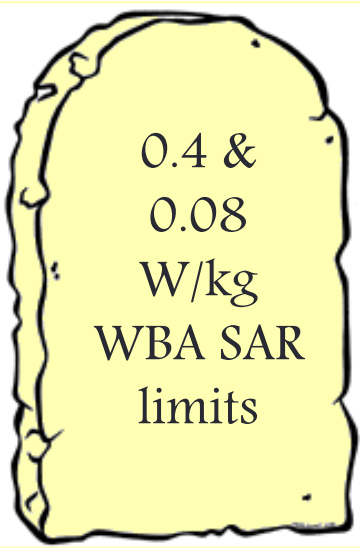
- Identifies credible mechanisms for adverse RF bioeffects
  - Heating
  - Electrostimulation (at low frequencies)
  - High field effects

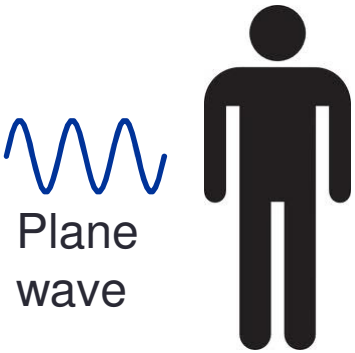
WBA SAR rationale

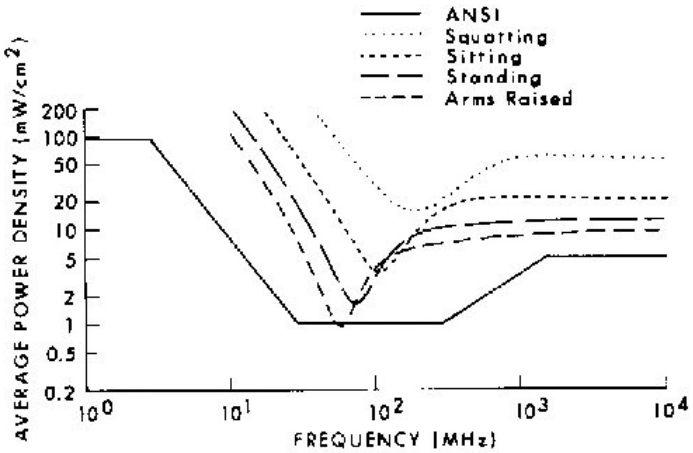
4 W/kg
WBA SAR



1/10, 1/50
safety factors





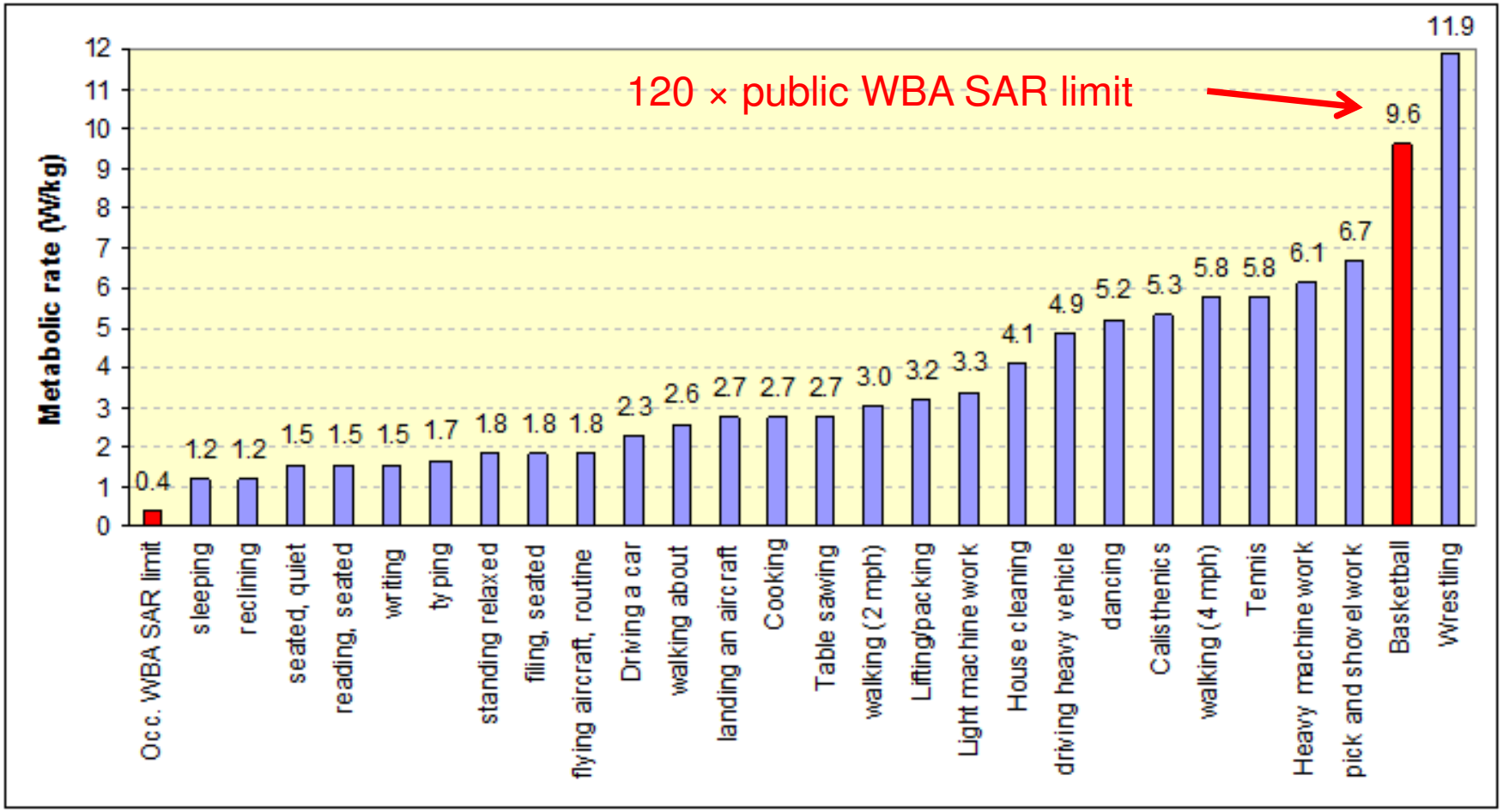


E & H
limits
with extras!
-Spatial avg
-Cumulative
-Near/far field
-Uncertainties
- etc

1st advice

Keep it *REAL* when evaluating risks

WBA SAR compared to metabolic heat loads



Adverse health effects of basketball

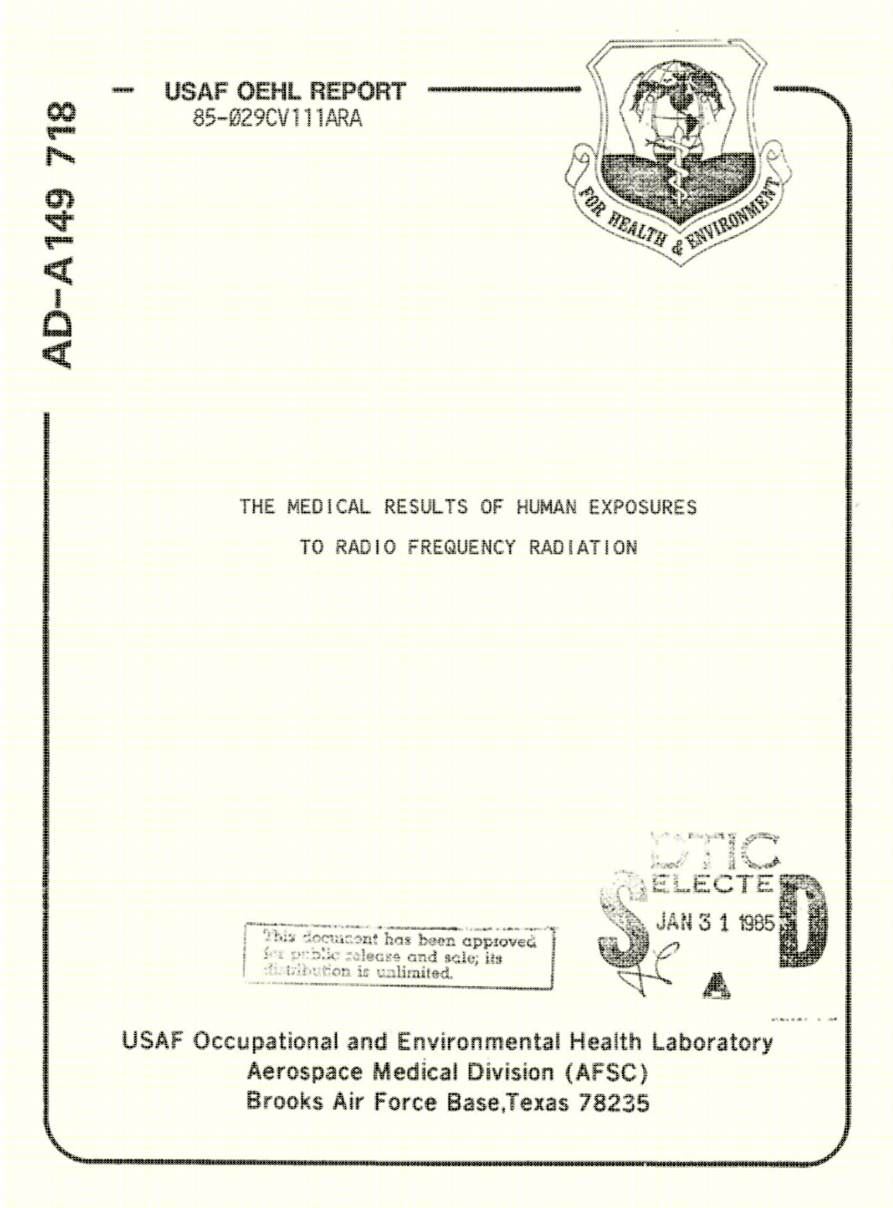
- *Huge* WBA thermal load: **9.9 W/kg** for 50 min !!!!
- Long list of 'adverse effects'
  - Flushed skin
  - Profuse sweating
  - Dehydration
  - Fatigue & lethargy
  - Muscle soreness
  - Headaches
  - Annoying behaviour
- AND IT HAPPENS IN **CHILDREN** !!!

Review RF accident statistics

Work environments offer good opportunities for collating accident statistics

- How many people are seriously injured by RF ???
- What are their injuries ???
- Where do they occur ???

This data is needed for assessing the effectiveness of RF safety regulations and programs



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USAF OEHL REPORT
85-029CV111ARA

FOR HEALTH & ENVIRONMENT

THE MEDICAL RESULTS OF HUMAN EXPOSURES
TO RADIO FREQUENCY RADIATION

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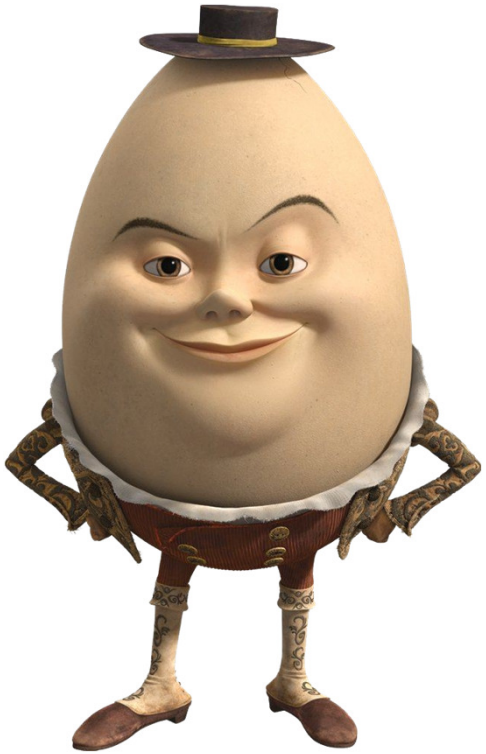
USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

2nd advice

Consider *REAL* exposure scenarios

UNREAL RF exposure

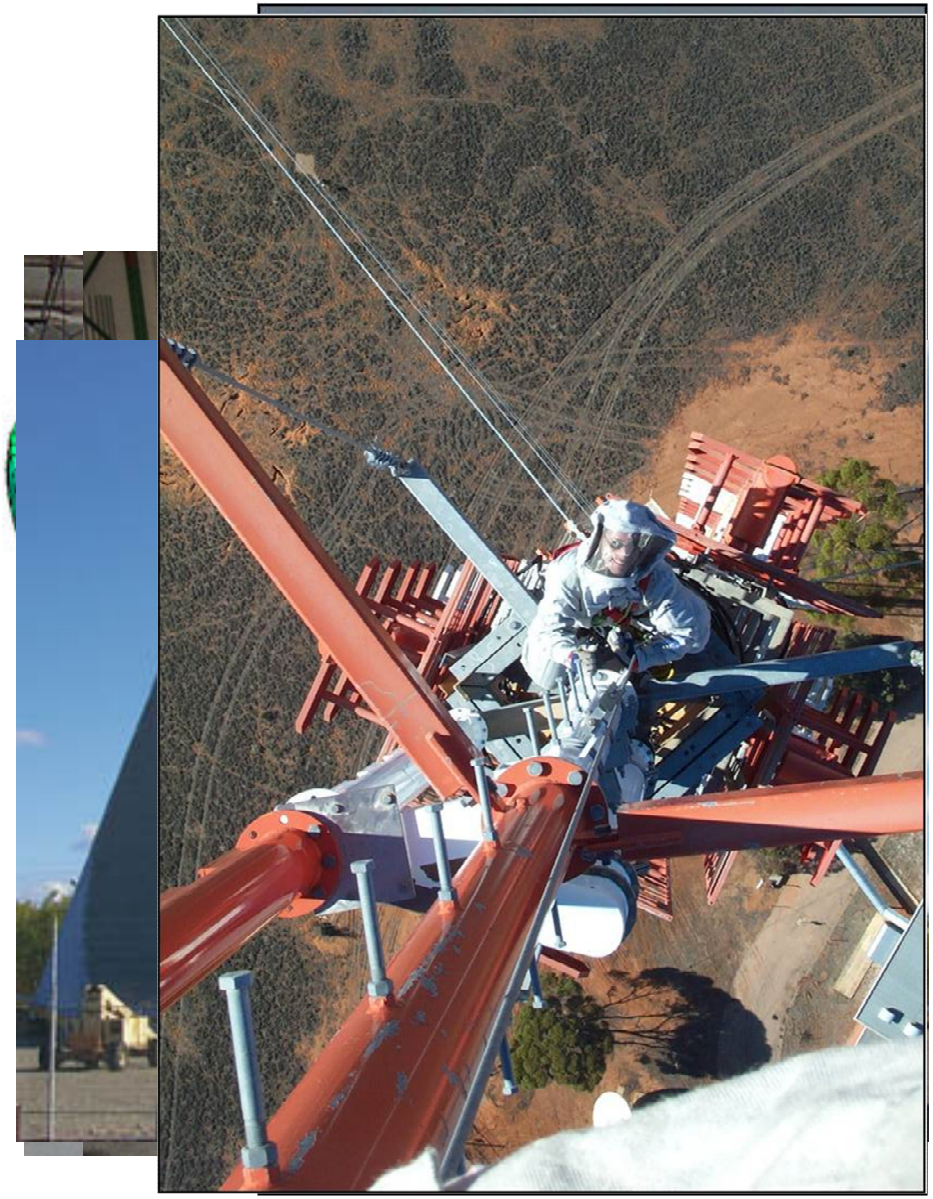
Plane wave



REAL RF exposures

Almost always:

- Near field
- localised



H-field is best for near field assessments

$$SAR = \frac{\sigma}{\rho}\frac{\mu\omega}{\rho\sqrt{\sigma^2 + \varepsilon^2\omega^2}}(1 + c_{corr}\gamma_{pw})^2 H_{t_{inc}}^2$$

N. Kuster and Q. Balzano, "Energy Absorption Mechanism by Biological Bodies in the Near Field of Dipole Antennas Above 300 MHz," *IEEE Transactions on Vehicular Technology*, vol. 41, pp. 17-23, Feb 1992.

3rd advice

Consider whether RF exposure limits are actually the best approach for ensuring safety

How are other heat loads managed?

- Is it possible to suffer injury from RF heating without feeling discomfort or pain first?
- Can we manage excessive RF heating by common sense procedures?

Do different RF exposure scenarios warrant different RF safety measures?

RF exposure type	Potential heating hazard
Telecommunications terminals designed for use close to the body (≤ 1W)	○○○○○
Other telecommunications terminals and base stations	●○○○○
Radar	●○○○○
TV/radio broadcasting antennas and exposures at their sites (MF, HF, TV towers)	●●●○○
Military use of RF	●●●○○
Industrial RF (e.g. RF sealers and welders)	●●●●○
Medical uses of RF (diathermy, MRI, etc)	●●●●●

Good luck!

My ranking of the importance of RF hazards

Decreasing importance

1. *shocks and burns*
   (injurious, painful, no pre-warning)
2. *interference into implanted electronic devices*
   (potentially lethal, no pre-warning, plausible?)
3. *surface heating*
   (painful/unpleasant, some pre-warning)
4. *localized RF heating*
   (painful? injurious? pre-warning available?)
5. *whole-body heating*
   (highly implausible)