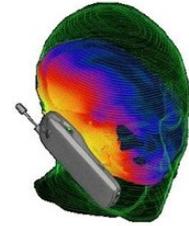




# Microwave Radiation, Guidelines and Debate during the Last 50 Years

PhD Mikko Ahonen

# Table of Contents



- Intro: Natural microwave radiation and its importance
- Historical reasons for IEEE, FCC & ICNIRP RF-guidelines
- Guidelines for near-field and far-field exposure. Thermal dogma and limitations of the SAR-concept
- Russian approach + a need for new, biology-based guidelines
- Conclusions



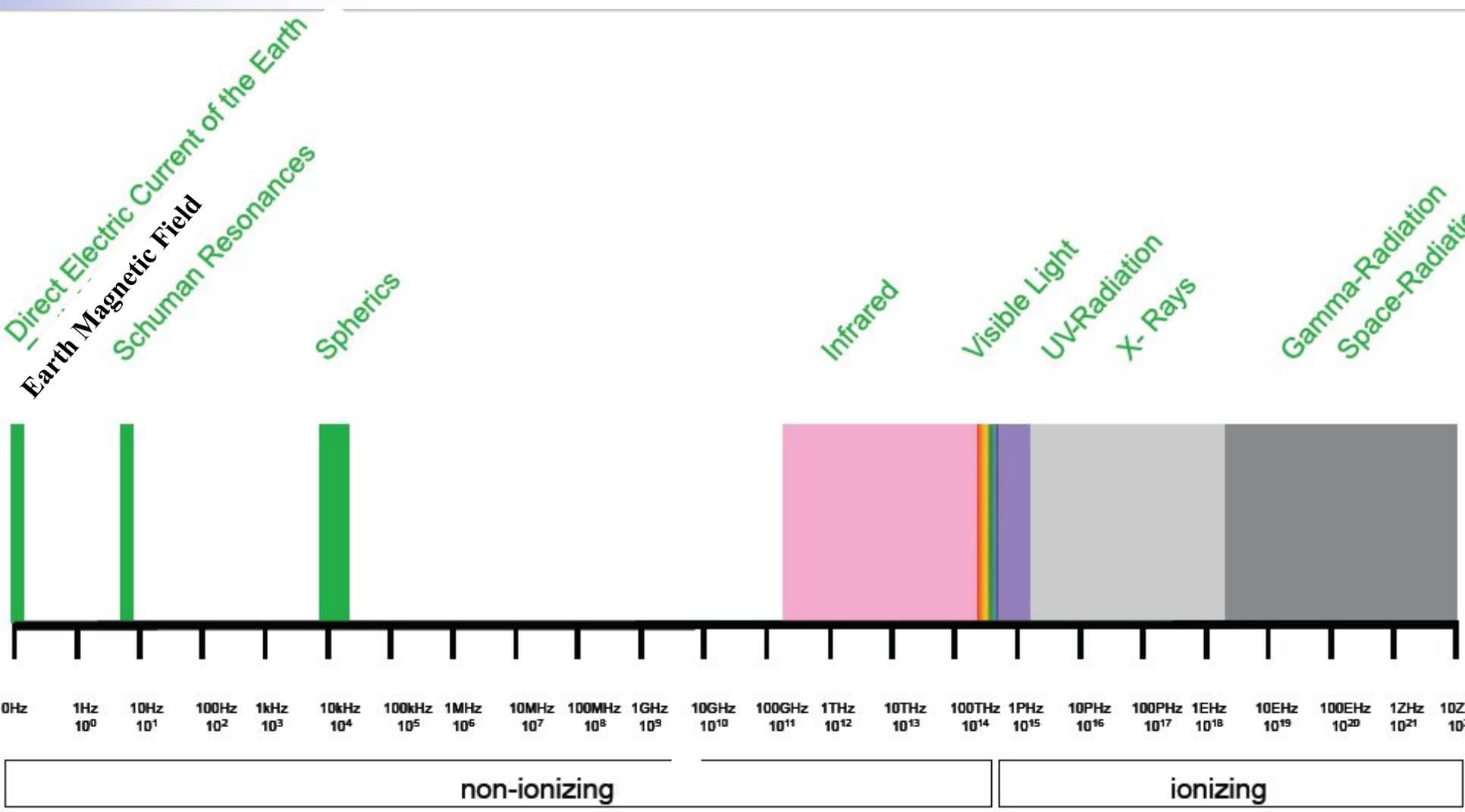
## Background - Mikko Ahonen:

- Researcher, including bioelectromagnetics research (worked 20 years at the University of Tampere, Finland)
- PhD in computer science
- Co-operation:
  - Researcher Tarmo Koppel, Tallinn Technical University
  - FinnMedi Ltd
  - Центр электромагнитной безопасности , RNCNIRP
- Worked earlier in IT&Telecom
- Partner, Sustainable Mobile Ltd, RF-measurements

## Introduction:

Natural (microwave) radiation  
and  
it's importance

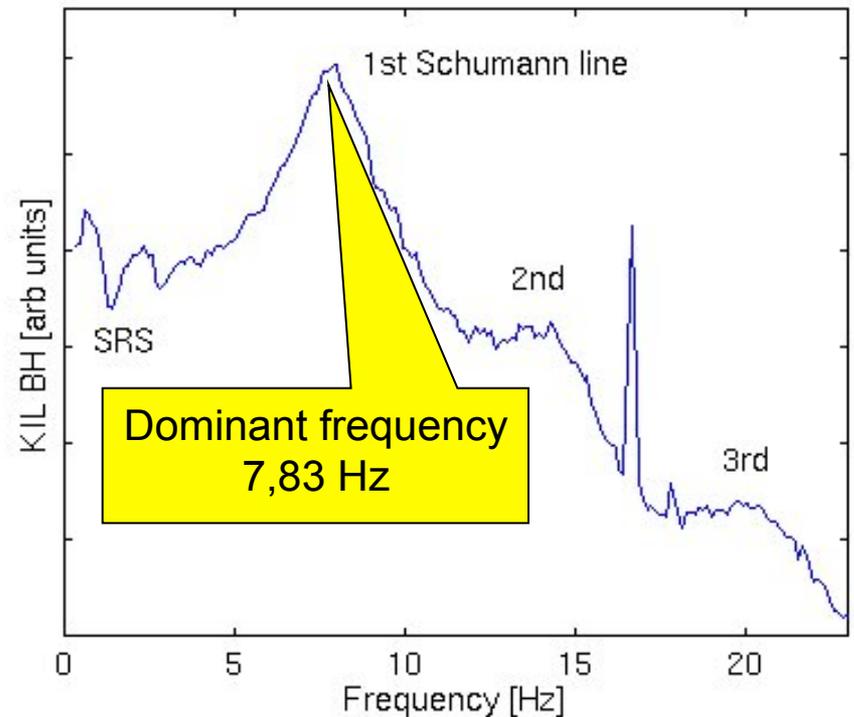
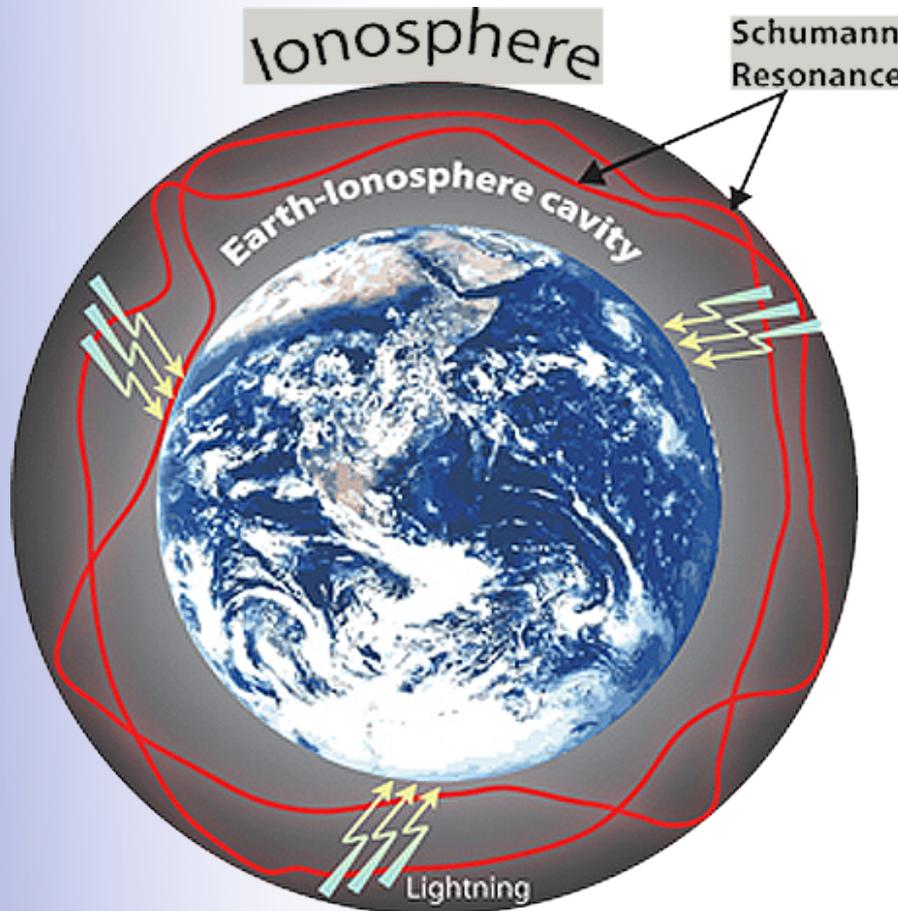
# Natural radiation, special focus on the non-ionising part



# Schumann Resonance, Professor W. O. Schumann (1952)

<http://magbase.rssi.ru/REFMAN/SPPHTEXT/schumann.html>

Kilpisjärvi 17 Nov 1993, 18–19 UT



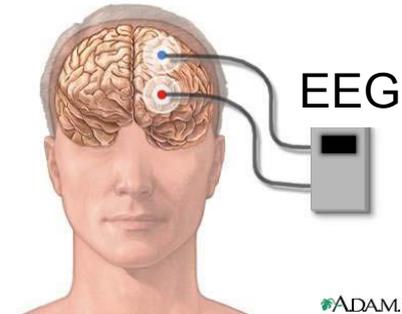
7.83 Hz , 14.3 Hz, 20.8 Hz, 27.3 Hz

Very weak level: 1-10 nT, 0,3  $\mu\text{W}/\text{m}^2$

**Overview:** <http://www.sciencedirect.com/science/article/pii/002191699400075Y>

<http://www.scribd.com/doc/228596266>

# Natural Schumann Resonance missing in space / in higher altitudes



- A Schumann-generator needed, designed for space travel
- For health reasons (to synchronise brain, EEG for circadian rhythm)
- Both for the Sojuz & Apollo -programs
- Professor Yuri Grigoriev, RNCNIRP (Russian National Committee on Non-Ionising Radiation Protection)



<http://www.scirp.org/journal/PaperInformation.aspx?PaperID=20022>  
<http://link.springer.com/article/10.1023%2FA%3A1015637127504>

# What happens when natural EMFs are removed?

- Research done in the Max Planck Institute in the 1960's
- In a bunker (Faraday cage) both humans and animals observed.



- Lighting changes did not much affect circadian rhythm. BUT when natural EMFs (including Schumann resonance) were removed, the rhythm changed to 33 hour. Caused several stress-related symptoms.



# What happens when natural electromagnetic fields are returned?

- By producing an artificial Schumann resonance in the bunker (10 Hz:n frequency,  $8,3 \mu\text{W}/\text{m}^2$  power density \* ), the 24 hour rhythm returned.
  - (Natural) EMFs has a Zeitgeberfunktion / effect on Circadian Rhythm
- \* Comment:  $8,3 \mu\text{W}/\text{m}^2$  is about 1/1.000.000-part of official ICNIRP guideline for EMFs.

# Resonance - Beings of Frequency

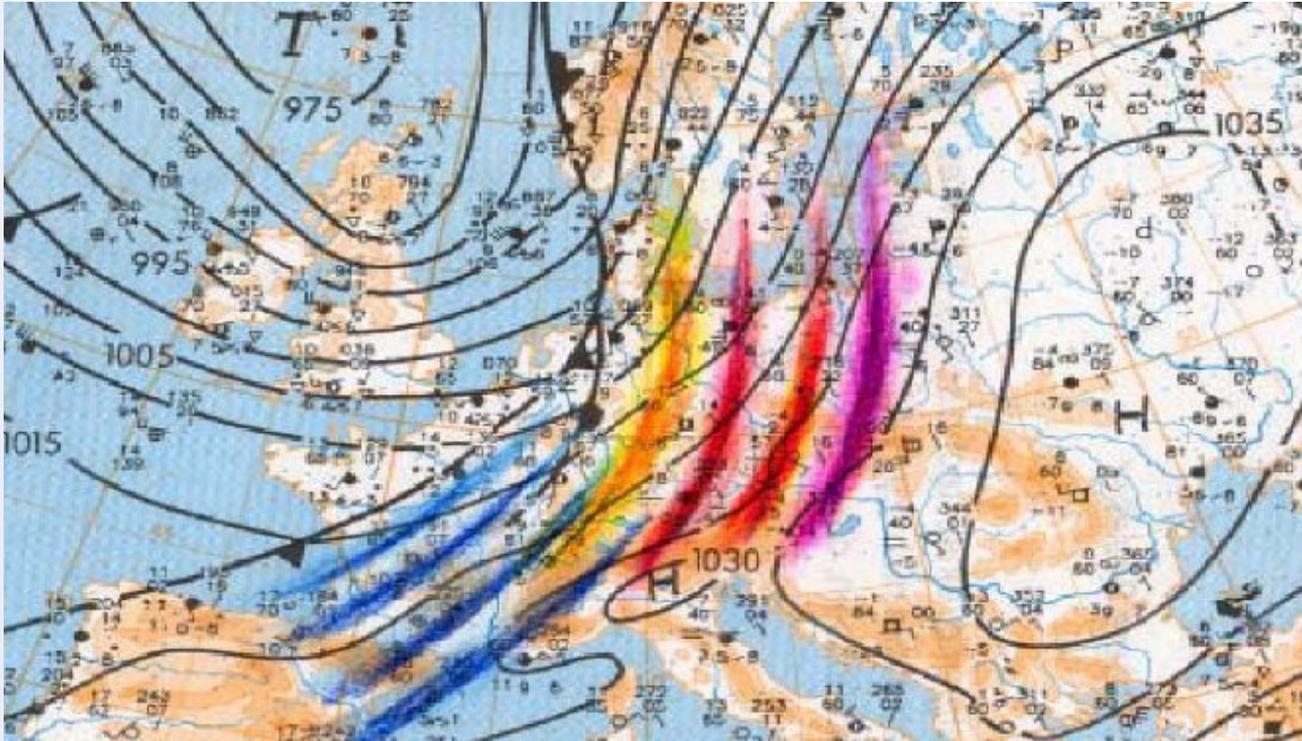
## - A document about Schumann Resonance

- [https://www.youtube.com/watch?v=QV9dhGv\\_tTs](https://www.youtube.com/watch?v=QV9dhGv_tTs)



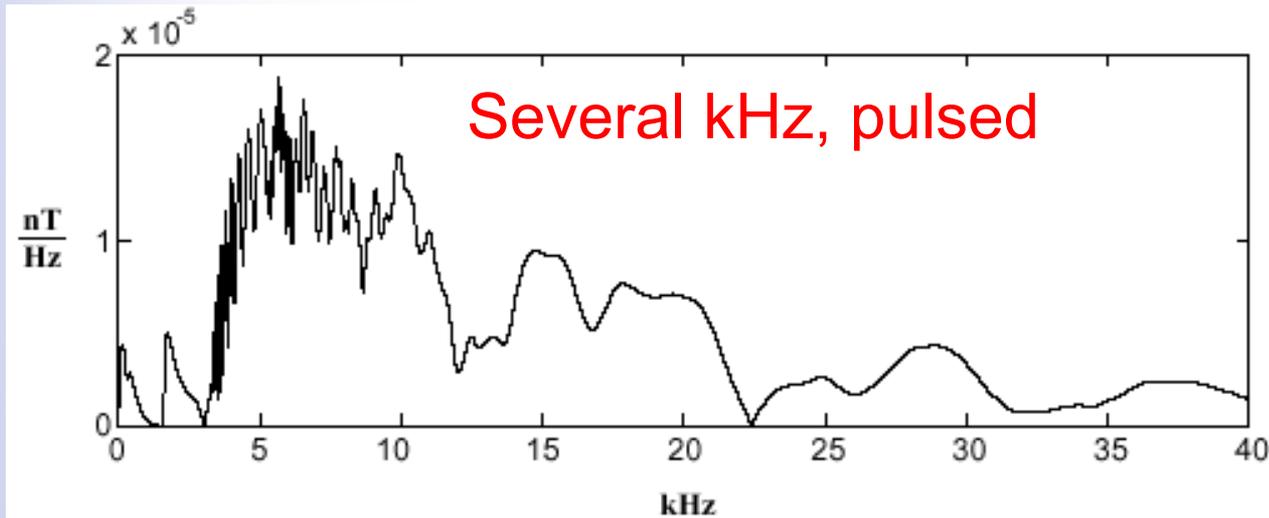
Natural microwave radiation – Schumann Resonance – 7.83 Hz –EEG-synch  
- required by human beings – $< 0,3 \mu\text{W}/\text{m}^2$  (a very tiny value)

# Sferics, cold and warm -front, Föhn-wind, “Wetterfühligkeit” , in kHz-range



Before the front:  $0,27 \mu\text{W}/\text{m}^2$  ,  
During Sferics:  $27 \mu\text{W}/\text{m}^2$   
(causes headache, tiredness, depression for some people,  
also pain in amputated limbs)  
(Lotmar *et al.*, 1969; Reiter, 1960; König, 1974)

# Typical frequencies - During Atmospherics (Sferics)

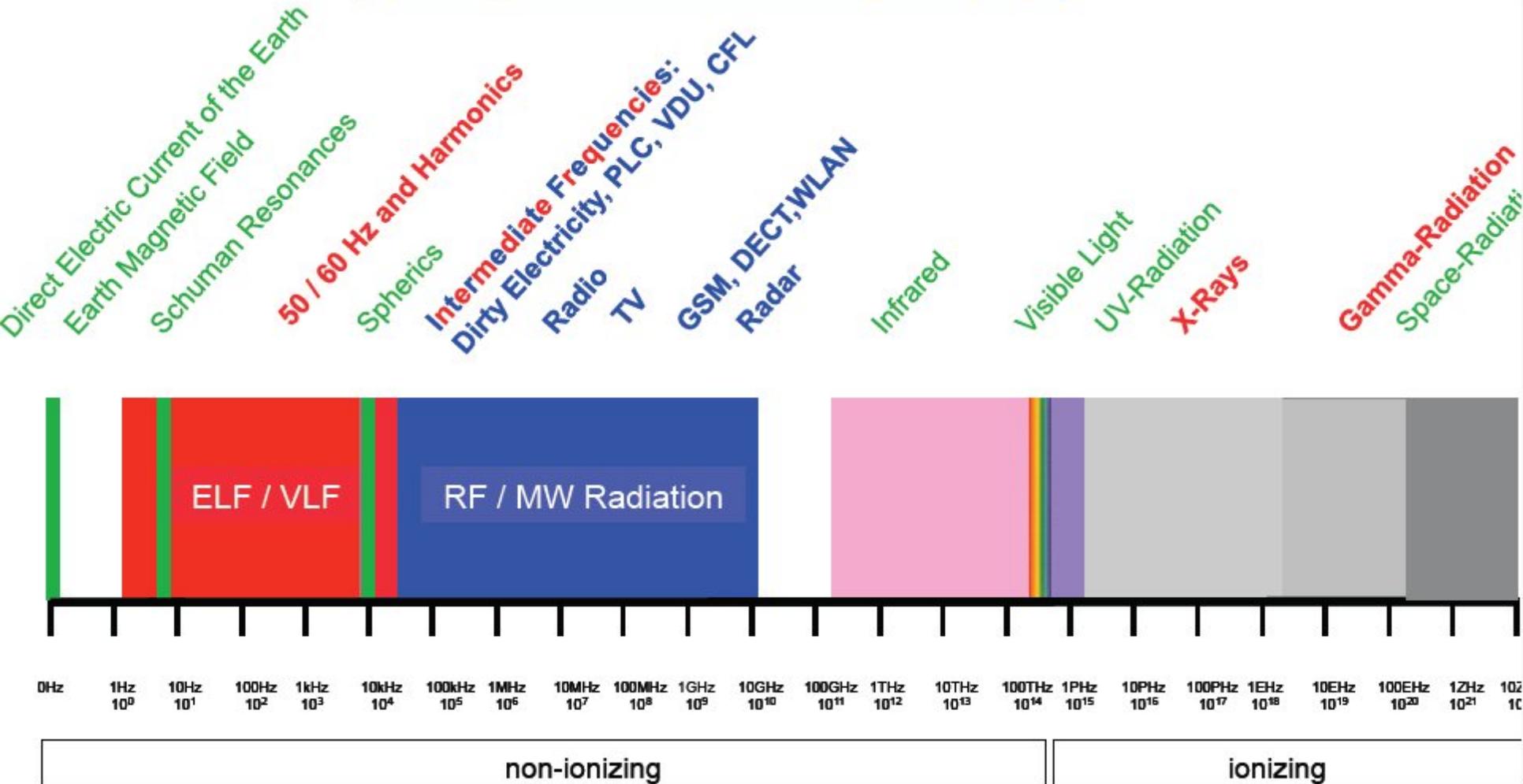


Simulated Sferics in a laboratory: Decrease in EEG alpha power

Schienle *et al.* (1998): [http://www.scientificexploration.org/journal/jse\\_12\\_3\\_schienle.pdf](http://www.scientificexploration.org/journal/jse_12_3_schienle.pdf)

# Man-made electromagnetic fields - overlapping natural radiation

# Man-made electromagnetic fields



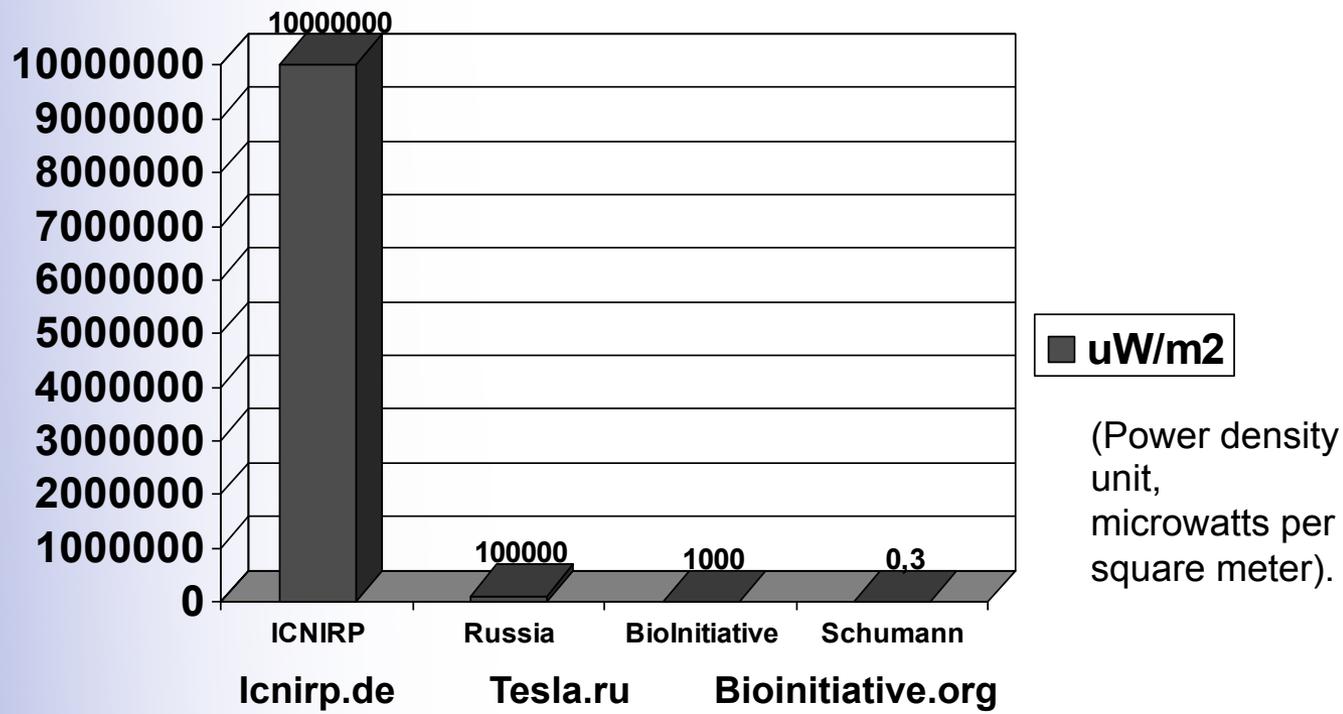
Picture: G. Oberfeld

# (Radiofrequency (RF) radiation <=> Microwave radiation)

## Thermal-only ICNIRP-guidelines (for 3G/UMTS)

vs.

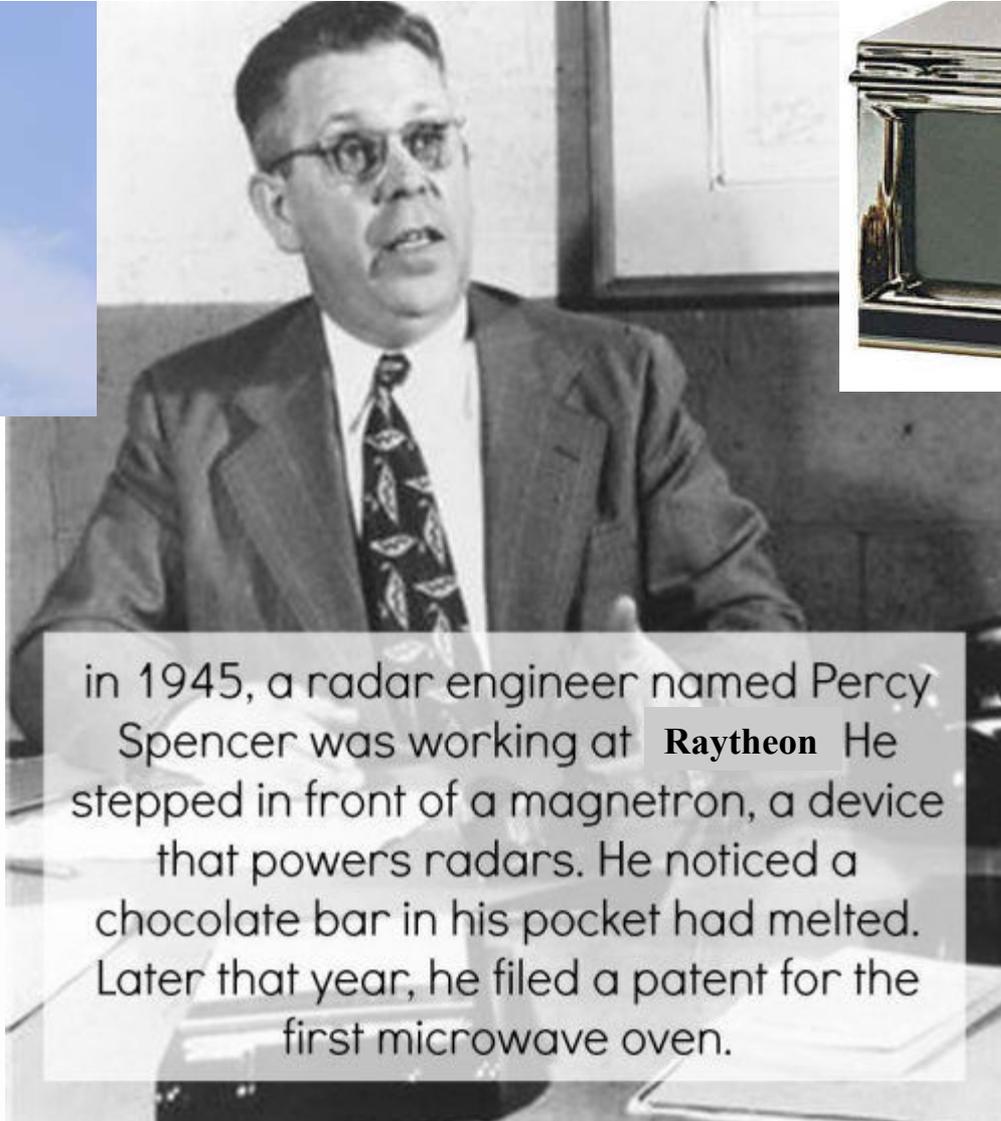
## Chronic-exposure non-thermal guidelines (Russia etc.) + BioInitiative recommendations+ RF levels in the nature



A note: ICNIRP/FCC-RF-guideline in many Western countries is million times higher than natural RF-level.

# Historical reasons for microwave / RF -guidelines

# Military radars and microwave ovens - same guidelines in the USA



in 1945, a radar engineer named Percy Spencer was working at **Raytheon**. He stepped in front of a magnetron, a device that powers radars. He noticed a chocolate bar in his pocket had melted. Later that year, he filed a patent for the first microwave oven.

# Thermal standard document from 1966

C95.1 - 1966 (later ANSI/IEEE C95.1)

USA  
standard

USAB  
C95.1-1966

Safety Level of  
Electromagnetic  
Radiation  
With  
Respect to  
Personnel

To limit an immediate, excessive and harmful rise in body temperature as a consequence of exposure to high-level RF/MW emissions (radar).

## Sponsors

U.S. Department of the Navy  
Institute of Electrical and Electronics Engineers

Approved November 9, 1966  
United States of America Standards Institute

**10 MHz - 100GHz**

**10 mW/cm<sup>2</sup>**

**0.1-hour (6 minute)  
averaging time introduced**

**1.2 pages long**

# EMC-view - thermal standards

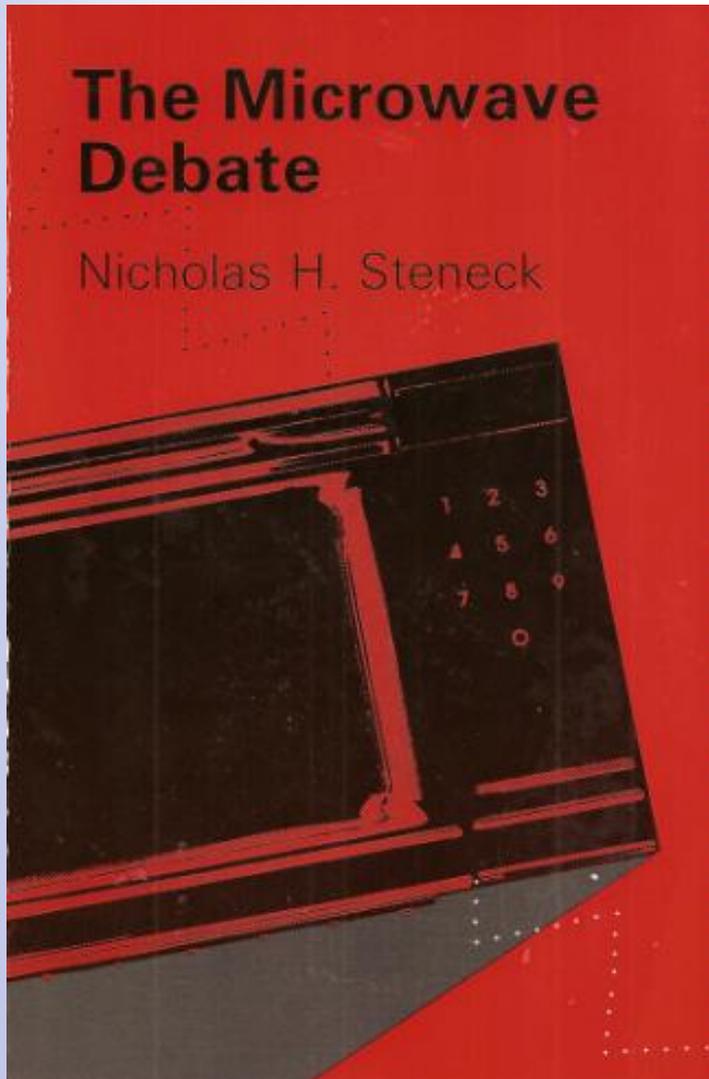
Institute of Electrical and Electronics Engineers (IEEE)

- Goal is to ensure that **marketed devices do not interfere with EMC (Electromagnetic Compatibility)**.
- To prevent **Electromagnetic Interference (EMI) with other devices**
- Exposure limits for electric and magnetic fields are all based on the same concepts of **body heating and electrostimulation (shocks and burns)**.

<http://standards.ieee.org/develop/project/C95.7.html>

- → Critic: <http://www.scribd.com/doc/172703028>

# Classics – a book & a thesis



## **THE PROCRUSTEAN APPROACH**

Setting Exposure Standards for Telecommunications  
Frequency Electromagnetic Radiation



An examination of the manipulation of telecommunications standards by political, military, and industrial vested interests at the expense of public health protection

<http://ro.uow.edu.au/theses/3148/>

**Don Maisch PhD**

# Video: A Radiant Day

NRK documentary - microwave guidelines and their origin



<http://www.youtube.com/watch?v=X9j4WwI49GE>

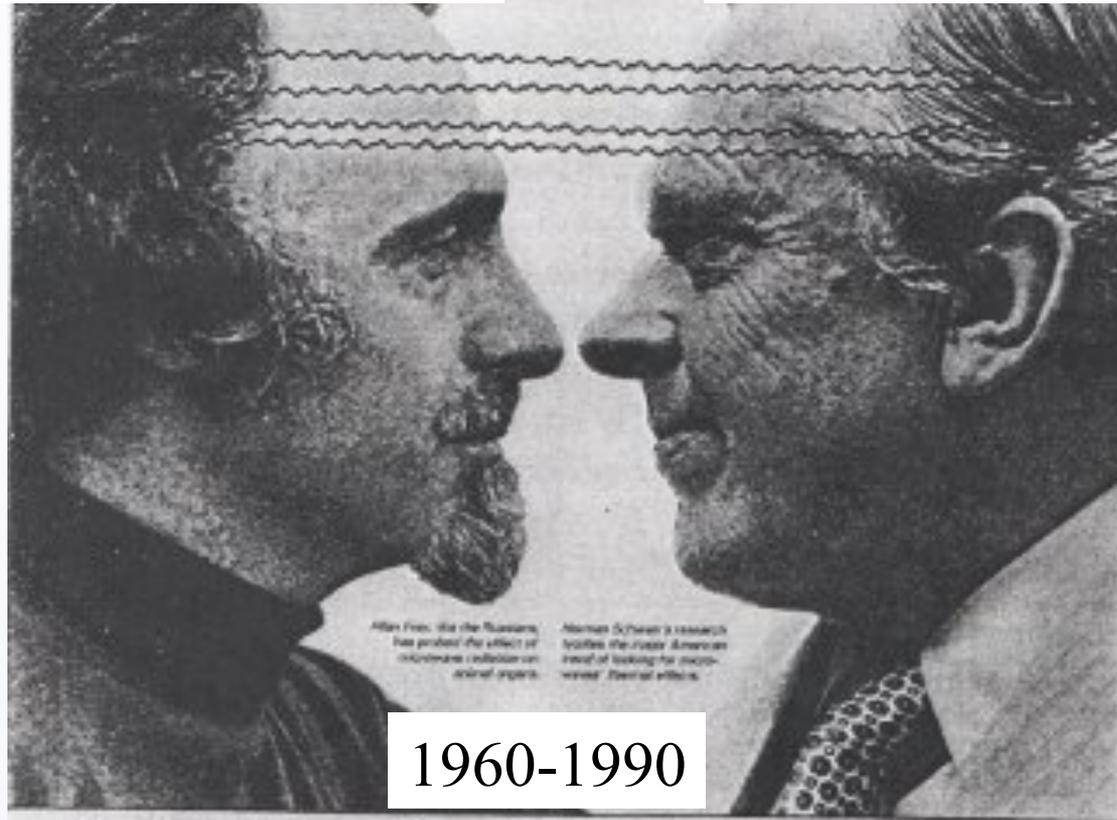
<http://www.nrk.no/programmer/tv/brennpunkt/1.6292981>

## Biologist Allan Frey

- Microwave hearing
- Blood-brain barrier leakage
- Chronic 24/7 exposure in focus
- Biology-based guidelines

## Biophysicist Herman Schwan

- Heating experiments
- Field-force calculations
- Short, max 30 min exposure
- Physics-Thermal guidelines



### Debating the Microwave Danger

Some scientists believe the threat is small; others, including the Russians, believe it may be grave. Do they know something we don't?

# Thermal-standard, assumptions

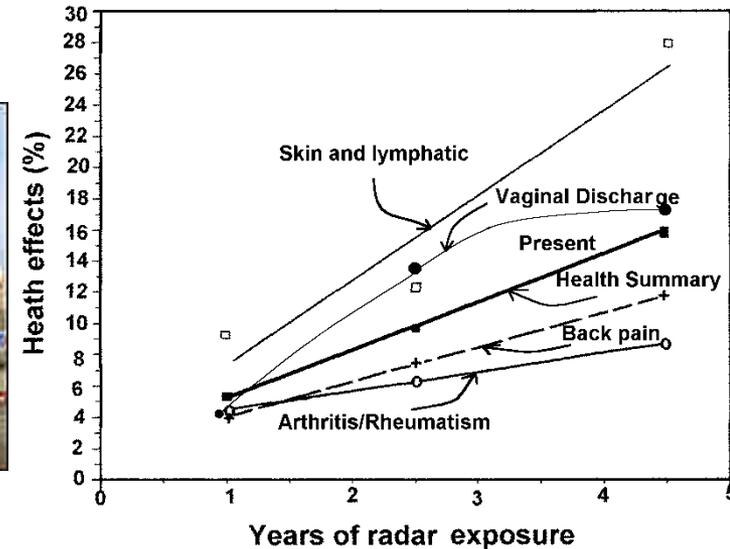
- In contrast, the nonthermal interaction is still controversial, although, to date, **there is only one mechanism of demonstrated validity - field-induced force effects**. A field-induced force effect is any movement or rearrangement, on a size scale from molecular to macroscopic, which is the **direct result** of the presence of an AC or DC electric and/or magnetic field.

---

Sher, L. D., Kresch, E., & Schwan, H. P. (1970). On the Possibility of Nonthermal Biological Effects of Pulsed Electromagnetic Radiation. *Biophysical Journal*, 10(10), 970–979.

# Case: US Embassy in Moscow 1962-1988, chronic microwave exposure by Soviets. The first real test for (US) thermal guidelines?

Radiation  
50.000-280.000  $\mu\text{W}/\text{m}^2$   
1-3 antennas,  
between 8-17 (daily)  
→ 1/1000-part of  
US guideline



- 2 ambassadors had leukemia
- chromosome changes (tested)
- several different skin diseases (eczema etc.)
- Memory problems, depression
- Microwave Illness

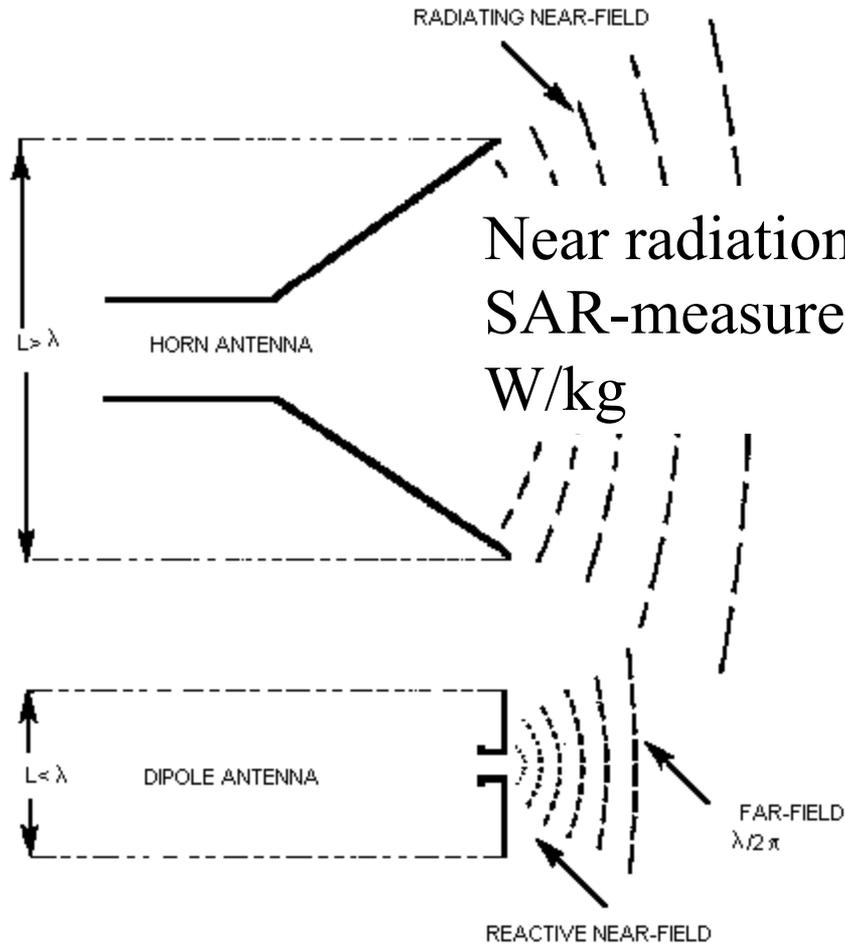
?

The conclusions were  
that no adverse health effects  
of the radiation were shown.  
Elwood (2012)

Source: Lilienfield *et al.* (1978), Pollack (1979), Johnson-Liakouris (1998), Goldsmith (1997) ja Lai & Levitt (2010)

- “Many subjective judgements, based on vested interests and limited knowledge melded together by Cold War political and military concerns lie at the very foundations of the thermal paradigm.” (Maisch, 2008, 14)

# Near Field vs. Far Field



Far away from radiation source:  
Power density measurements,  
 $(\mu)W/m^2$

## Is temperature rise needed for certain effects? Heavy debate.

- Moriyama, E., Salcman, M., & Broadwell, R. D. (1991). **Blood-brain barrier (BBB) alteration after microwave-induced hyperthermia is purely a thermal effect**: I. Temperature and power measurements. *Surgical Neurology*, 35(3), 177–182.

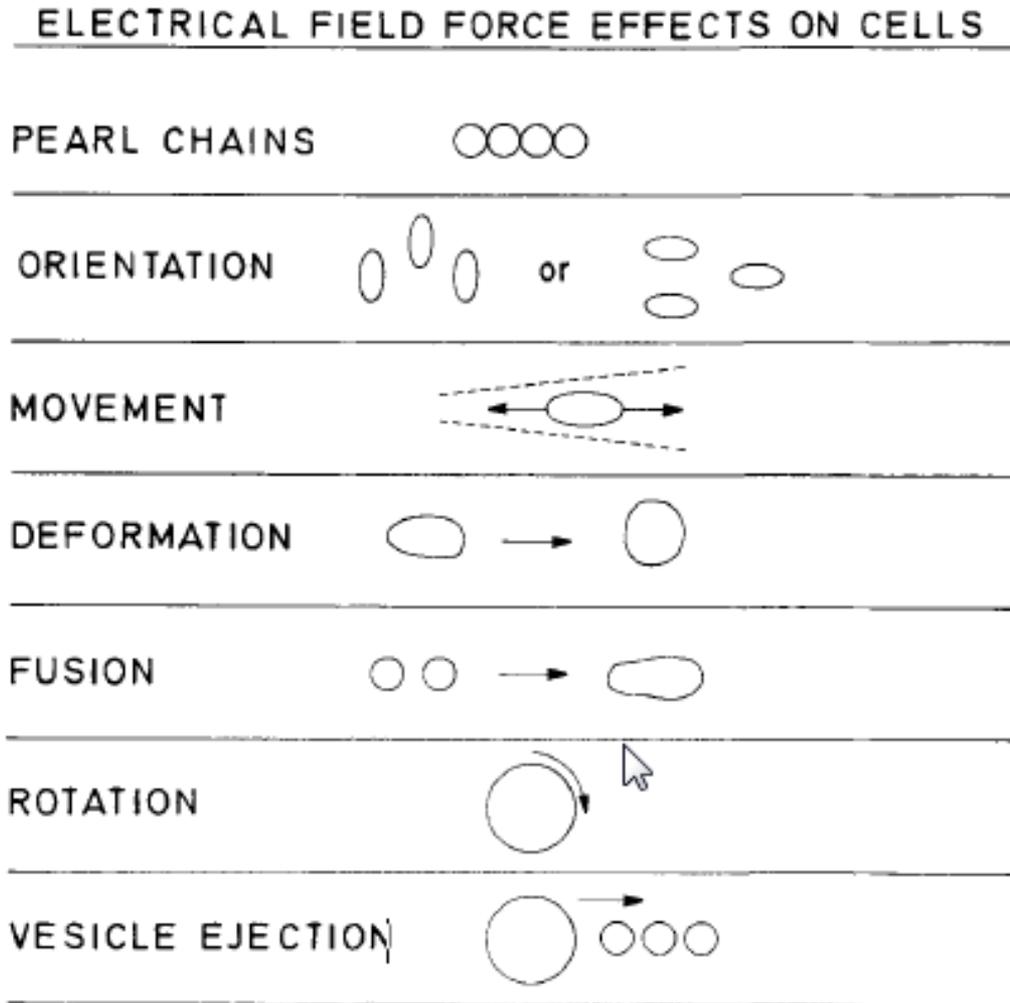
**Alternative views, non-thermal BBB leakage:**

Frey *et al.* (1975), Oscar & Hawkins (1977), Salford *et al.* (1993).

Herman Schwan was behind those thermal guidelines.

In his later writings he described athermal, field force effects on cells

<http://www.ncbi.nlm.nih.gov/pubmed/3400907>



Schwan (1988)

FIGURE 2. Several athermal (field-force) effects can be induced in cells and biologically simulating particles by time-varying electric fields. These effects are summarized pictorially.

# Near-field exposure and SAR-value

# SAR

## – Specific Absorption Rate

- SAR is a calculated energy absorption in an assumed homogenous mass of tissue.



SAR for electromagnetic energy can be calculated from the electric field within the tissue as:

$$\text{SAR} = \int_{\text{sample}} \frac{\sigma(\mathbf{r})|\mathbf{E}(\mathbf{r})|^2}{\rho(\mathbf{r})} d\mathbf{r}$$

where

$\sigma$  is the sample electrical conductivity

$E$  is the RMS electric field

$\rho$  is the sample density

ICNIRP maintains SAR thermal dogma

→ While admitting only acute thermal effects

International Commission of Non-Ionizing Radiation Protection

<http://www.icnirp.org/documents/emfgdl.pdf>

# Problems with ICNIRP Guidelines: Simultaneous exposure of agents

“Some guidelines may still not provide adequate protection for certain sensitive individuals nor for normal individuals exposed concomitantly to other agents....”

<http://www.icnirp.de/documents/philosophy.pdf> , page 546

→ **If simultaneously exposed chemicals and RF, guideline does not protect.**

See for example Lerchl *et al.* (2015) and Tillman *et al.* (2010)

<http://www.ncbi.nlm.nih.gov/pubmed/25749340,20545575>

# Problems with ICNIRP Guidelines: Special groups

“Different groups in a population may have differences in their ability to tolerate a particular NIR exposure. For example, children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population.” (NIR = Non Ionising Radiation)

page 546, <http://www.icnirp.de/documents/philosophy.pdf>

→ **Guideline does not protect children, elderly or chronically ill.**

(See for example: Gandhi et al. (2012) → SAR-values are based on (adult) military recruit head model, not children's.

<http://www.ncbi.nlm.nih.gov/pubmed/21999884>

# WHO International EMF Project + ICNIRP - Bias?



**World Health Organization**

International EMF Project  
in the WHO.

Previous leader: Michael Repacholi  
Current leader: Emilie van Deventer



**ICNIRP**

International Commission  
on Non-Ionizing  
Radiation Protection  
(a German private foundation)

Founder, Honorary chair:  
Michael Repacholi

<http://www.icnirp.de>

**EU**

**SCENIHR** (ICNIRP) + **COST 281** (ICNIRP)

Critic:  
<http://www.chronicexposure.org/limitsICNIRP.html>

# One animal study behind the whole SAR-system

It was determined that trained rats stopped working for food at a whole body average SAR exposure of 4 W/kg (D'Andrea *et al.*, 1975).

This level of exposure increased core body temperatures measured with rectal thermometers.

10 x “safety factor” -> 0,4 W/kg  
= population guideline for the FCC.

So simple!



D'Andrea, J. A., Gandhi, O. P., Kesner, R. P. (1975). Behavioral effects of resonant electromagnetic power deposition in rats. Biological Effects of Electromagnetic Waves HEW Publication (FDA) 778011, I:257-273 (selected papers of the 1975 USNC/URSI Meeting, Boulder, CO).

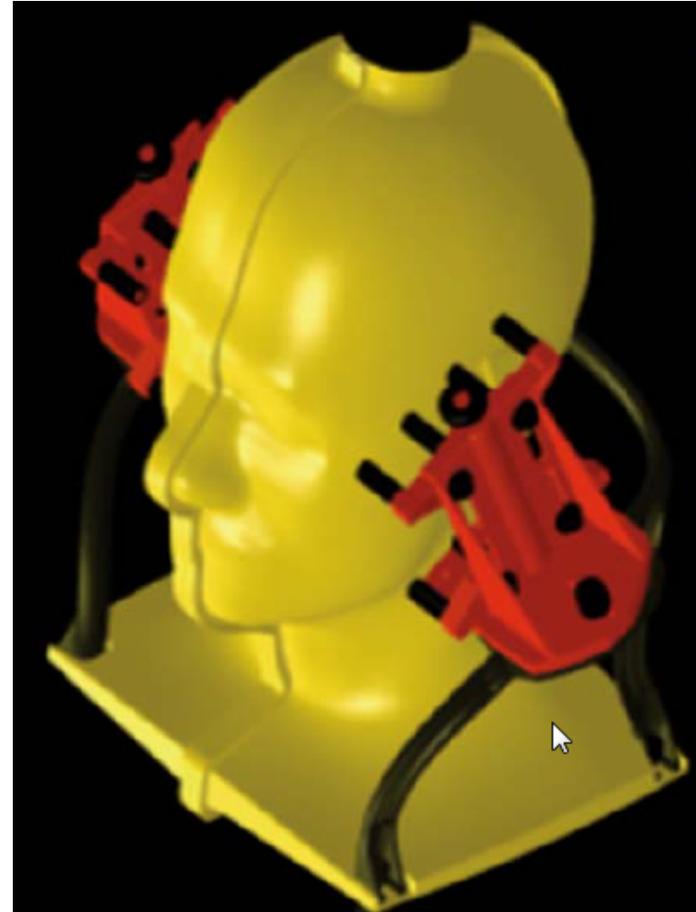
# Mobile phone related SAR: Higher exposures allowed in Europe than in U.S -> 1 g versus 10 g

<b>Region / Country</b>	<b>-- Reference to -- SAR measurement protocol</b>	<b>Reference to SAR limit</b>	<b>Limit</b>
<b>Europe</b>	<b>European Specification ES 59005 (1998)</b>	<b>ICNIRP Guidelines 1998 (ICNIRP 1998)</b>	<b>2.0 W/Kg in 10g of tissue</b>
<b>Australia/Canada</b>	<b>Various Communications Authority (ACA) Standard (ACA RS 1999)</b>	<b>Australian Standard AS/NZS 2772.1</b>	<b>1.6 W/Kg in 1g of tissue</b>
<b>US</b>	<b>Federal Communications Commission (FCC) Guidelines (FCC 1997)</b>	<b>American Standard ANSI C95.1 (ANSI 1992)</b>	<b>1.6 W/Kg in 1g of tissue</b>

## Specific Anthropomorphic Mannequin (SAM)

is a plastic head mannequin (Beard and Kainz, 2004),

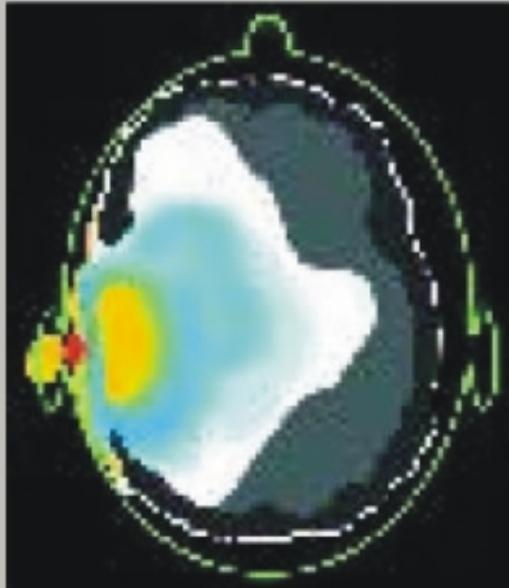
based on the 90th percentile of 1989 United States military recruits (Gordon *et al.*, 1989).



# Comparison: adults and children

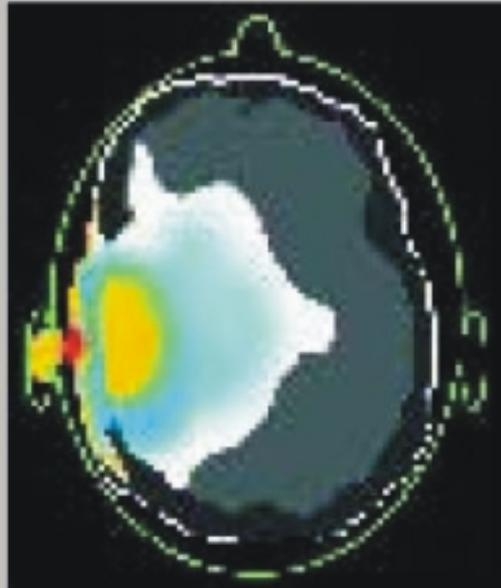
Gandhi O.P., Lazzi G., Furse C.M. (1996 vol.44, p1884-1897) :  
Electromagnetic Absorption in the human Head and Neck for  
Mobile Telephones at 835MHz and 1900MHz

## How mobil phone radiation penetrates the brain



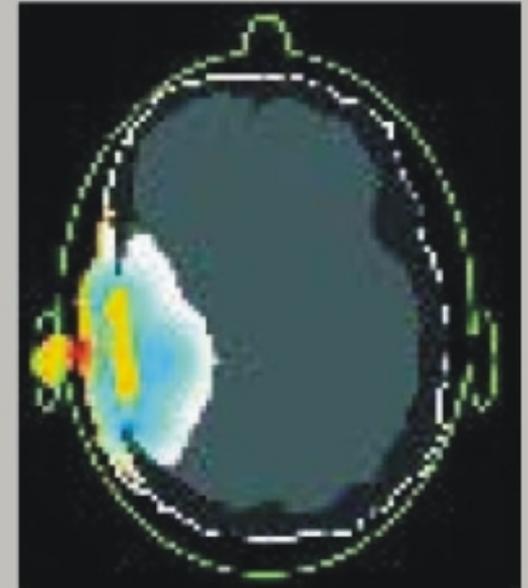
5 year old

Absorption rate : 4,49W/kg



10 year old

Absorption rate: 3,21W/kg



Adult

Absorption rate: 2,93W/kg

For a absorption rate of 2,93 W/kg of power absorptive by an adult : This same power will produce a absorption rate of 3,21 W/kg for a 10 year old child and absorption rate of 4,49 W/Kg for a 5 year old child.

Gandhi *et al*, IEEE T-MTT, vol. 44, N. 10, October 1996, 1884-1897.

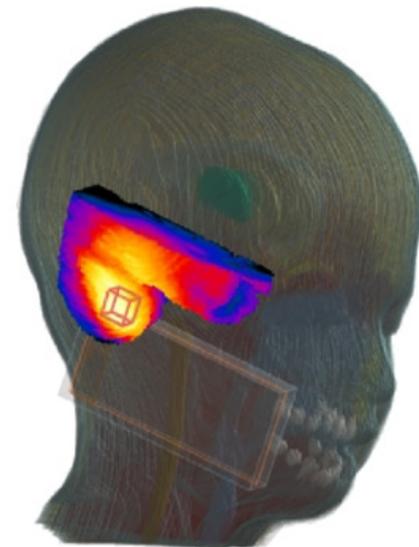
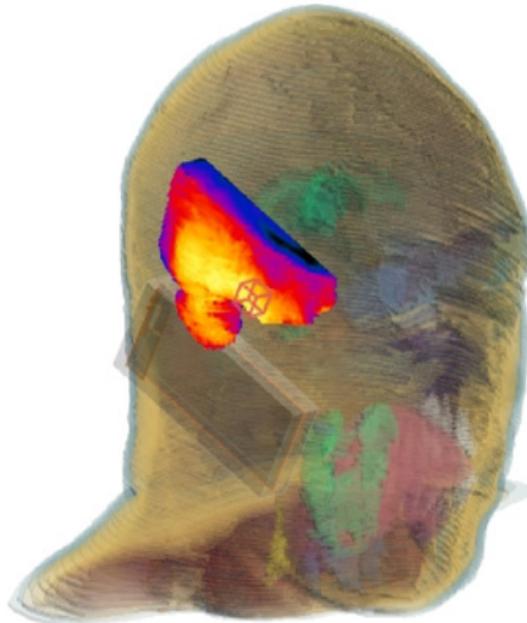
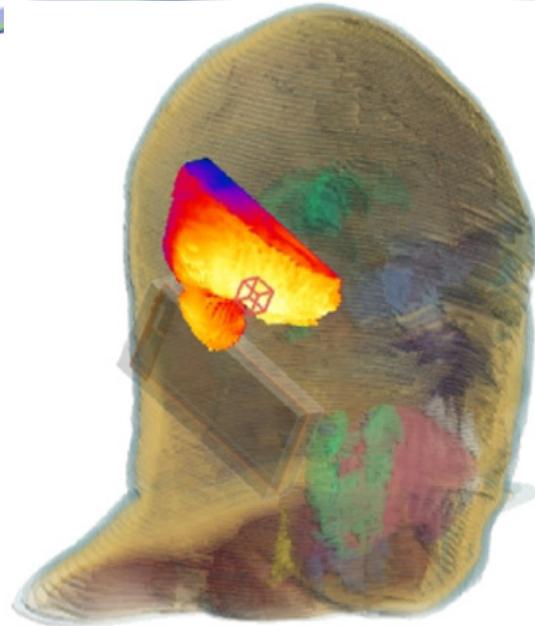
Cell phone standards are based on a heavy-set 6 foot tall man NOT a young child

900 MHz the SAR maximum occurs in the center of the case

(w 15 mm spacer for 10 gm)

1800 MHz SAR max occurs at edge of case,

Christ et al, 2010



How SAR-testing  
could be improved?

# Head models for people of different ages are NOT used to set standards today

However, “Virtual Family” MRI&CT-scan based models do exist



SAM

Duke

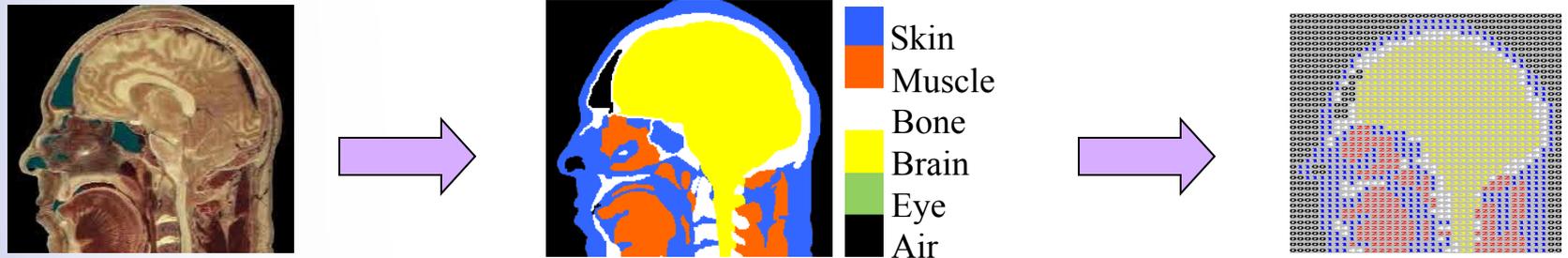
Billie/female 7 y o

Thelonus 3 y o

Christ et al, 2010

Gandhi, O. P., Morgan, L. L., de Salles, A. A., Han, Y.-Y., Herberman, R. B., & Davis, D. L. (2012). Exposure limits: the underestimation of absorbed cell phone radiation, especially in children. *Electromagnetic biology and medicine*, 31(1), 34–51. <http://www.ncbi.nlm.nih.gov/pubmed/21999884>

# FDTD (Finite-Difference Time-Domain) Algorithm based Simulation



- It is based on medical images (MRI + CT-scans). This results the numerical domain where the field is calculated.
  - Each cell in this domain matrix is associated with a spatial place and tissue in each place.
  - The permittivity, the electrical conductivity and the mass density are associated to each kind of tissue, as functions of the frequency of operation.
  - Existing FDTD-models can be used for standard setting!
- (De Salles, 2009; Gandhi *et al.*, 2012)

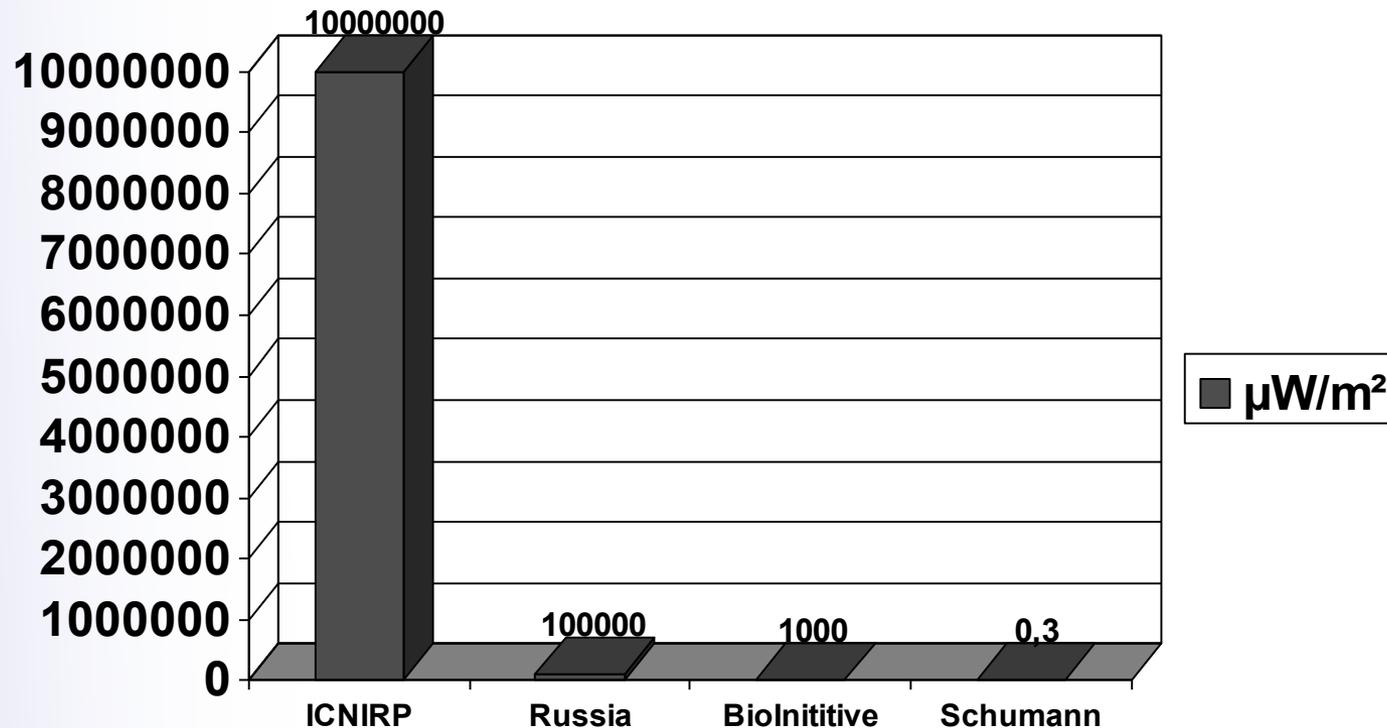
# SAM Process versus FDTD Process

Attribute	SAM Process	FDTD Process	Comments
Children's exposure	No	Yes	Multiple ages
Pregnant women's exposure	No	Yes	1,3 & 9 months
Female exposure	No	Yes	
Specific tissue parameters	No	Yes	
3-D resolution	~ 1 cm <sup>3</sup>	<1 mm <sup>3</sup>	
Relative cost	Higher	Lower	
Medical implant exposure	No	Yes	
Testicle exposure	No	Yes	
Female breast exposure	No	Yes	With & without wire frame bra
Eye exposure	No	Yes	With & without wire frame eyeglasses
Thyroid gland exposure	No	Yes	With & without metal necklace
Parotid gland exposure	No	Yes	With and without dental braces

# Chronic, far-field exposure

- challenges for standard setting

# Guidance Levels for 3G vs. natural radiation



Radiofrequency radiation levels measured in  $\mu\text{W}/\text{m}^2$ .

Compare: Thermal 10.000.000  $\mu\text{W}/\text{m}^2$  vs. nature  $<0,3 \mu\text{W}/\text{m}^2$ .

# EPIDEMIOLOGICAL STUDIES NOT CONSIDERED IN ICNIRP STANDARD SETTING



## Radio and TV transmitters:

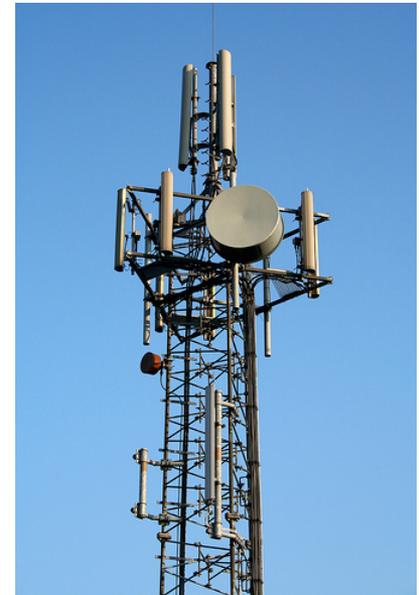
**Effect:** Dolk *et al.* (1997a), Hocking & Gordon (2003), Ha *et al.* (2007), Mascarinec *et al.* (1994), Michelozzi *et al.* (2002), Morton & Phillips (1983), Park *et al.* (2004)  
[More leukemia and lymphoma]

**No effect:** Dolk *et al.* (1997b), Mersenich *et al.* (2008)

## Mobile phone base stations:

**Effect:** Abdel-Rassoul *et al.* (2007), Eger *et al.* (2004), Hutter *et al.* (2006), Gadzicka *et al.* (2004), Navarro *et al.* (2003), Santini *et al.* (2003), Wolf & Wolf (2004), Blettner *et al.* (2008), Eger & Jahn (2010), Dode *et al.* (2011), Shahbazi-Gahrouei (2013) [great variety: from headaches to breast cancer]

**No effect:** Meyer *et al.* (2006), Berg-Beckhoff *et al.* (2009)



Review: Khurana *et al.* (2010)

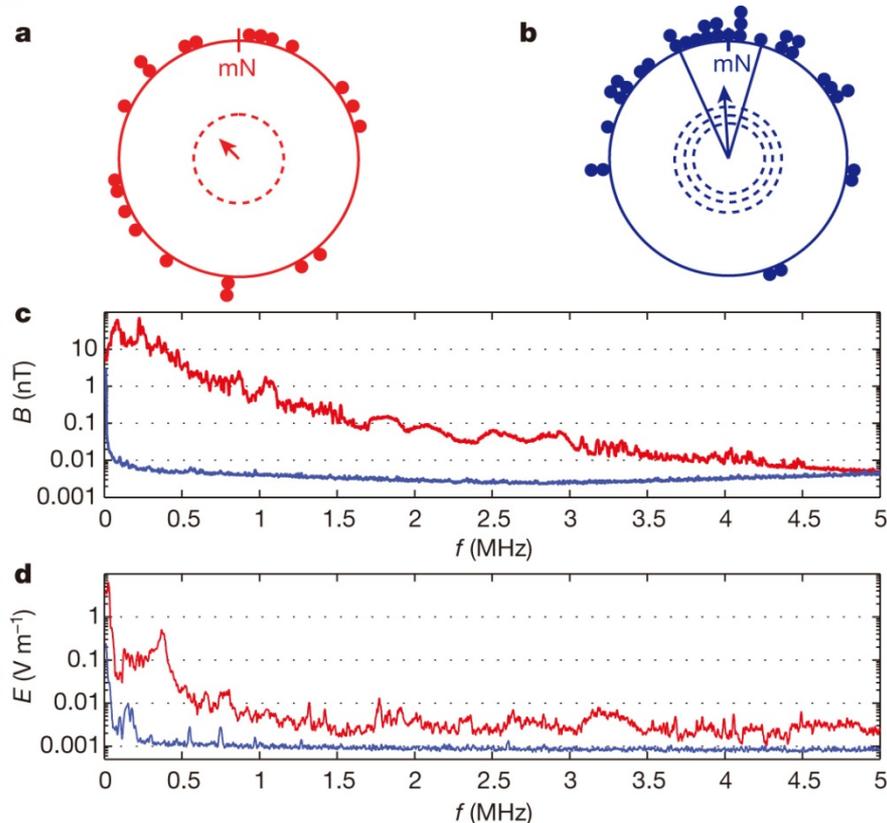
<http://www.ncbi.nlm.nih.gov/pubmed/19328536>

<http://www.chronicexposure.org>



# 1/1000-part of ICNIRP guidelines

causes disorientation for birds (Engels *et al.*, 2014) → A real problem close to mobile phone base stations and radars.



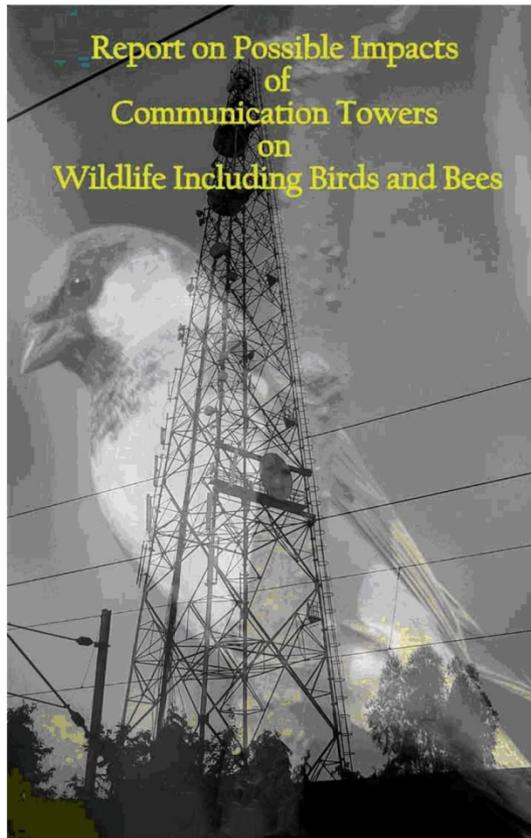
nature

Picture: Anthropogenic electromagnetic noise in the huts before (red) and after (blue) installation of shielding  
→ Shielding corrected the magnetic compass functioning of birds.

Engels, S., Schneider, N.-L., Lefeldt, N., Hein, C. M., Zapka, M., Michalik, A., ... Mouritsen, H. (2014). Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird. *Nature*, 509(7500), 353–356. <http://www.nature.com/nature/journal/v509/n7500/full/nature13290.html>

Wiltchko *et al.* (2015): <http://www.ncbi.nlm.nih.gov/pubmed/25540238> , Kavokin *et al.* (2014): <http://www.ncbi.nlm.nih.gov/pubmed/24942848>

# Effects on bees, birds and plants - Radiofrequency radiation



Already 3 reviews indicate harmful effects:

Cucurachi *et al.* (2013).

<http://www.ncbi.nlm.nih.gov/pubmed/23261519>

Balmori (2009):

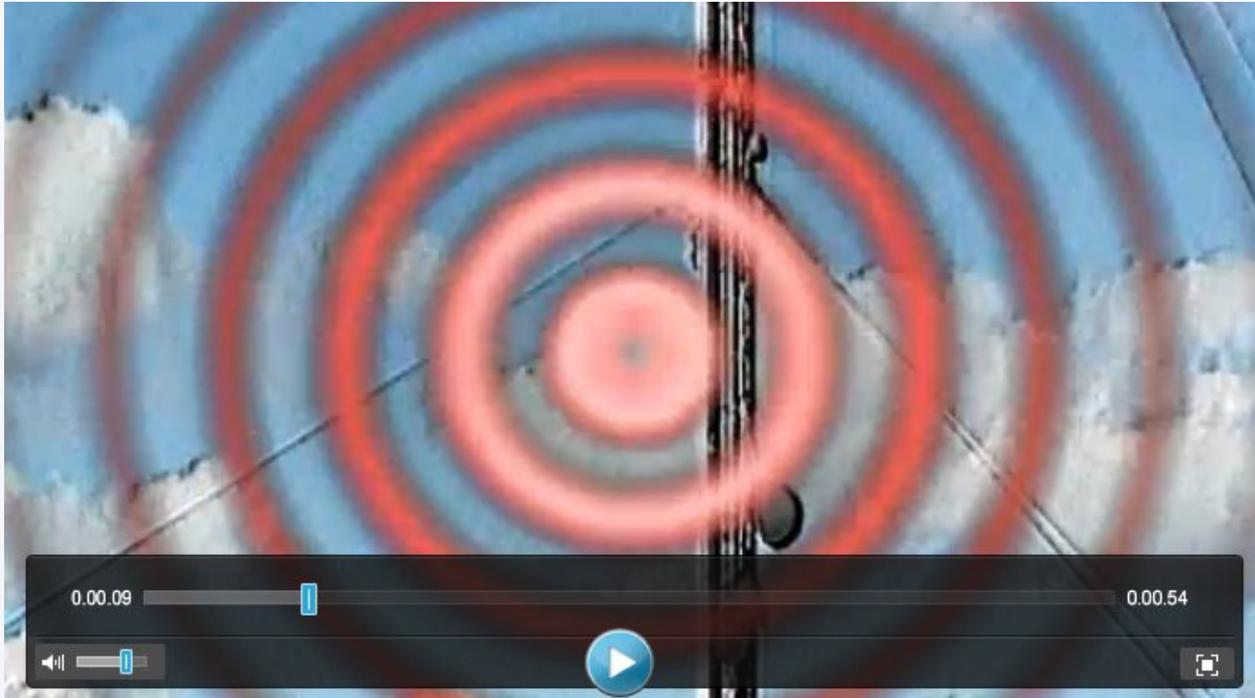
<http://www.ncbi.nlm.nih.gov/pubmed/19264463>

Sivani & Sudarsanam (2012).

[http://www.biolmedonline.com/Articles/  
Vol4\\_4\\_2012/Vol4\\_4\\_202-216\\_BM-8.pdf](http://www.biolmedonline.com/Articles/Vol4_4_2012/Vol4_4_202-216_BM-8.pdf)

+ [http://www.indiaenvironmentportal.org.in/files/file/final\\_mobile\\_towers\\_report.pdf](http://www.indiaenvironmentportal.org.in/files/file/final_mobile_towers_report.pdf)  
<http://www.ncbi.nlm.nih.gov/pubmed/23915130>

# A documentary about mast-worker's illness and guidelines



Video:, SAR-measurements (6:30-)

[http://www.youtube.com/watch?v=bXe\\_VWzWaxM](http://www.youtube.com/watch?v=bXe_VWzWaxM)

[A government representative talks about microwave ovens and says that ICNIRP-guideline protect from similar kind of heating...]

Heavy critic  
focusing on  
the ICNIRP  
and the thermal  
paradigm by  
German  
academics.



<http://kompetenzinitiative.net/KIT/KIT/broschuerenreihe/>  
<http://www.bzur.de/Radar/GUS-Studie.pdf>



## Analogy: ELF&RF vs. Lead

“The policy would “keep **attention focused on old, leaded paint** [as the source of pollution] and **make clear that other sources of lead are not significantly involved.**”

David Michaels – Doubt is their product (2008, 43)

Evolving: Radar → Powerlines →  
Mobile phones → Base stations  
→ Wi-Fi ??



# Late lessons from early warnings?

<http://www.eea.europa.eu/publications/late-lessons-2>

“The vilification of any research that might threaten corporate interests as “junk science” and the sanctification of its own bought-and-paid-for research as “sound science” is indeed Orwellian- and nothing less than standard operating procedure today.”

Michaels (2008, 43)

# Paradigm shift?

## FDA approves a new device for treating liver cancer (comment: no heat is produced)

"Treated with very low levels of an electromagnetic field emitting from a spoon-like device placed in the patients' mouths. ... After six months, the tumors in 14 patients had stabilized after each received three one-hour treatments per day each day; the therapy created no significant side effects."

Clinical trials / 3 publications in the British Journal of Cancer :

Zimmerman *et al.* (2012)

Costa *et al.* (2011)

<http://www.ncbi.nlm.nih.gov/pubmed/22134506>

Barbault *et al.* (2009).



Operating at  
27.12 MHz,  
Pulses between  
100 Hz–21 kHz

Overview of PEMF (Pulsed ElectroMagnetic Fields) -area:

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3261673/>

## Latest IARC/WHO classification:

- The WHO/International Agency for Research on Cancer (IARC) has classified in 2011 radiofrequency (RF) electromagnetic fields (=microwave radiation) as **possibly carcinogenic to humans (Group 2B)**.
- So far, no effect on standard setting.

[http://www.iarc.fr/en/mediacentre/pr/2011/pdfs/pr208\\_E.pdf](http://www.iarc.fr/en/mediacentre/pr/2011/pdfs/pr208_E.pdf)

<http://monographs.iarc.fr/ENG/Monographs/vol80/volume80.pdf>

[http://ec.europa.eu/research/quality-of-life/ka4/pdf/report\\_reflex\\_en.pdf](http://ec.europa.eu/research/quality-of-life/ka4/pdf/report_reflex_en.pdf)

[http://www.law.harvard.edu/news/2011/11/18\\_safra-center-cellphone-radiation-corruption.html](http://www.law.harvard.edu/news/2011/11/18_safra-center-cellphone-radiation-corruption.html)



# Precedents, insurance policies and class actions suits



**USA 2014:  
Class actions ready for court:**

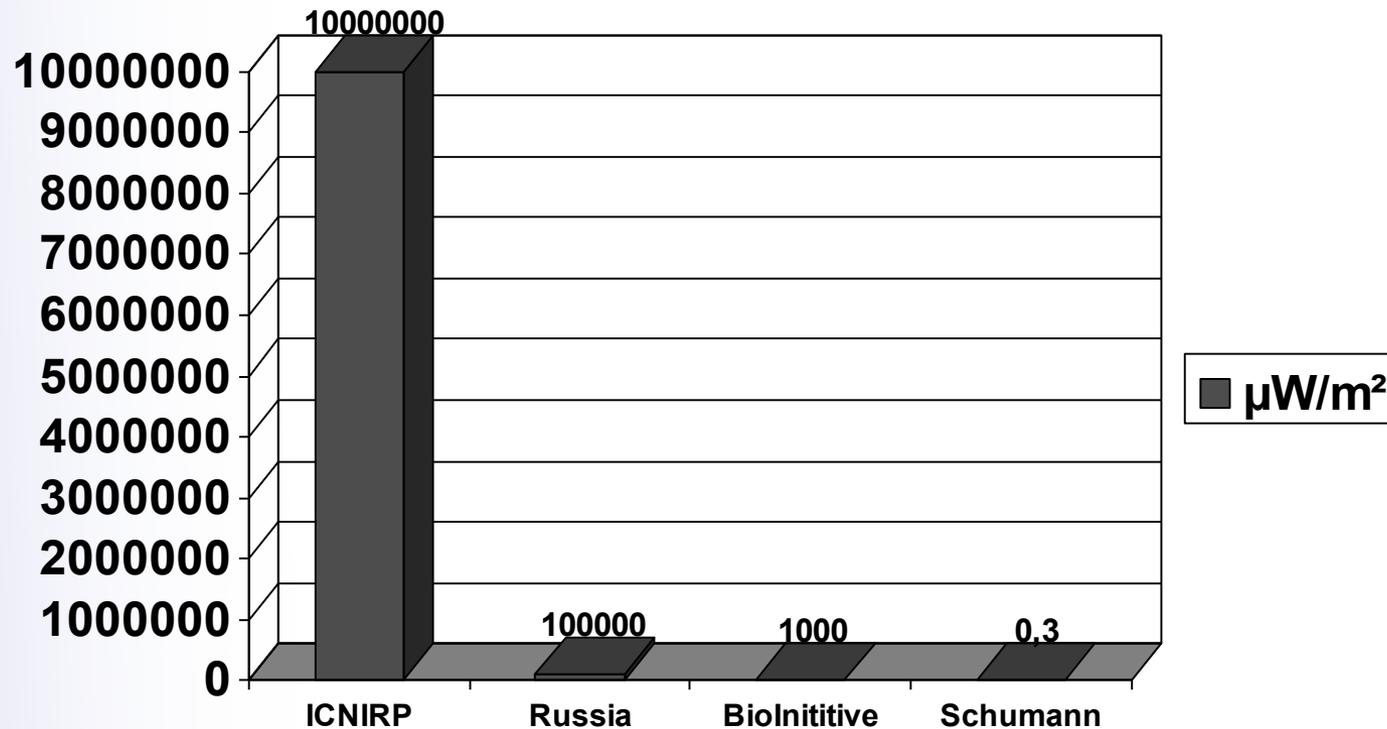
<http://tinyurl.com/class-action-ready>

EU- Precedent: Italy 2012:  
**Salesman Innocente Marcollini.**  
Had used several years  
a mobile phone and a DECT-  
phone at his workplace,  
got a tumor to his head, was fully  
compensated for the work-  
based injury

<http://microwavenews.com/news-center/italian-supreme-court-affirms-tumor-risk>

**In 2013 the insurance giant Swiss Re classified RF+ELF to be included in the highest (observed) risk class. Lloyds of London followed 2015** <http://tinyurl.com/vakuutusriski> , <https://www.scribd.com/doc/261610831> )  
→ Pressure from insurance companies may affect standard setting

# Far-field exposure guideline for 3G



Radiofrequency power density levels measured in  $\mu\text{W}/\text{m}^2$ .

Compare: Thermal, acute (ICNIRP) 10.000.000  $\mu\text{W}/\text{m}^2$  vs. Russia 100.000  $\mu\text{W}/\text{m}^2$ .

# Eastern European standards for microwaves, depend on exposure time

Dauer der Mikrowellen-Exposition pro Tag (Einwirkungszeit)	Maximal zulässige mittlere Leistungsdichte in mW/cm <sup>2</sup>			Betriebsweise
	UdSSR, Polen	ehemalige CSSR	ehemalige DDR	
Ganztägig, 8 Stunden maximal	0,01	0,025	0,1	Dauerstrich
		0,01	0,05	Impuls
Bis 3 Stunden (UdSSR: bis 2 Stunden)	0,1	0,065	0,5	Dauerstrich
		0,025	0,25	Impuls
Bis zu 20 Minuten	1,0	0,2	1,0	Dauerstrich
		0,08	0,5	Impuls

Difference:  
Continuous wave  
Vs  
Pulsed (Impuls)  
signal

Hecht *et al.* (2009)

Compare: Eastern (**0,01 mW/cm<sup>2</sup>**) vs. Western/US guidelines (**10 mW/cm<sup>2</sup>**).

# Russia: Guidelines based on immunological studies and chronic exposure – $100.000 \mu\text{W}/\text{m}^2$

- Earlier research: Shandala et al. [1983], Vinogradov and Naumenko [1986] and Vinogradov et al. [1991]: chronic exposure results a weakened immune system.
- Wistar rats were exposed in the far field to 2450MHz continuous wave RF fields with an incident power density in the cages of  $5\text{W}/\text{m}^2$  for 7 h/day, 5 days/week for a total of 30 days, resulting in a whole-body SAR of  $0.16 \text{ W}/\text{kg}$  → Immune system effect [again]. (Grigoriev *et al.*, 2010)

<http://www.ncbi.nlm.nih.gov/pubmed/21452364>

# Reason for the biological-effects –focused guideline in Russia

- The exposure limits for EMF established in the USSR in the 1970s were based on restricting to levels that did not result in a “status of permanent compensation” (the body having to permanently compensate for the effects of EMF), since this may lead to a reduction in protective capabilities and result in possible development of pathological processes several years later. (RNCNIRP, 2003)

<http://www.who.int/peh-emf/publications/reports/en/russia.pdf>

# A prerequisite for non-thermal effects?

Experimental findings have also demonstrated that **low-frequency pulse modulation of radio frequency EMF is necessary to induce changes in the waking and sleep EEG**, and that pulse modulation is crucial for radio frequency EMF-induced alterations in brain physiology

(Huber *et al.* 2002, Huber *et al.* 2005, Hinrikus *et al.* 2008 ).

## **Important biological and biomedical question:**

- What are those tissue mechanisms in detection of amplitude- and pulse-modulation of RF/microwave fields?

(Adey, 1999)

→ Not yet (fully) answered!

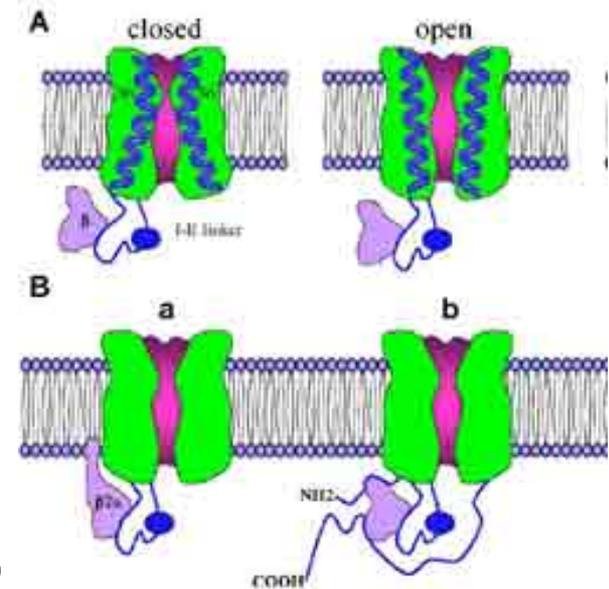
# One paper challenges the whole thermal guideline system?

- Pall, M. L. (2013). Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects.

*Journal of Cellular and Molecular Medicine*, 17(8):958-65

<http://www.ncbi.nlm.nih.gov/pubmed/23802593>

(Hold your horses: Only a literature review, not showing the actual RF-induced mechanism)



Picture:

<http://www.landesbioscience.com/books/iu/id/854>

# No heating or ionisation needed to cause DNA damage?

Results from review of Yakymenko *et al.* (2015):

It indicates that among 100 currently available peer-reviewed studies dealing with oxidative effects of low-intensity RFR, in general, 93 confirmed that RFR induces oxidative effects in biological systems. A wide pathogenic potential of the induced ROS and their involvement in cell signaling pathways explains a range of biological/health effects of low-intensity RFR, which include both cancer and non-cancer pathologies.

- Yakymenko, I., Tsybulin, O., Sidorik, E., Henshel, D., Kyrylenko, O., Kyrylenko, S., 2015. Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation. *Electromagn Biol Med* 1–16.

<http://www.ncbi.nlm.nih.gov/pubmed/26151230>

“

It's perfectly reasonable to think that humans have a magnetosensing response. Maybe we've been looking at it in a way that's not been fruitful in the past.

- University of Massachusetts neuroscientist Steven Reppert

- Cryptochrome

# Magnetosense



**Human Eye May Have Magnetic '6th Sense'**

Jun 22, 2011 9:50 AM CDT

<http://www.nature.com/ncomms/journal/v2/n6/full/ncomms1364.html>

<http://www.andrewamarino.com/PDFs/158-IntJRadiatBiol2009.pdf>

<http://tinyurl.com/eilampo>

Professor Andrew Marino: Non-linear signal analysis is needed !!



# Conclusions

# A Need for new, biology-based standards

## Electromagnetic fields and health: DNA-based dosimetry <http://www.ncbi.nlm.nih.gov/pubmed/22676645>

Martin Blank<sup>1</sup> & Reba M. Goodman<sup>2</sup>

<sup>1</sup>*Physiology and Cellular Biophysics, Columbia University, 630 W 168 St, New York, NY 10032, USA, and* <sup>2</sup>*Cell Biology & Pathology, Columbia University, 630 W 168 St, New York, 10032, USA*

We propose a biologically based measure of EMF radiation to replace the energy-based “specific absorption rate” (SAR). A wide range of EMF frequencies has been linked to an increased risk of cancer. The SAR value used to measure the EMF dose and set the safety standard in the radiofrequency (RF) range fails as a standard for predicting cancer risk in the ELF power frequency range. Because cancers are believed to arise from mutations in DNA, changes in DNA induced by interaction with EMF could be a better measure of the biologically effective dose in both frequency ranges. The changes can be measured by transcriptional alterations and/or translational changes in specific proteins. Because ionizing radiation also causes DNA damage, a



Work of professor Dariusz Leszczynski: <http://www.ncbi.nlm.nih.gov/pubmed/18267023>  
+ Bio-indicator studies of insects ( like Margaritis *et al.* 2013)

**"Observation of these modulation frequency - dependent bioeffects would appear to raise significant questions concerning the validity of continued use of thermally based Specific Absorbption Rate (SAR) as a universally valid predictor of bioeffects attributable to RF field exposure."**

W. Ross Adey (Review of Radio Science, 1996-1999. Oxford Univ.Press, 1999, pp 845-872)

“Given the sheer number of people exposed to RF/MW from telecommunications devices, **there is an urgent need to reform the standard setting process and to conduct an international re-assessment of the biological limits placed on current RF/MW standards.**”

Maisch (2009)

# Questions and comments welcome!



PhD Mikko Ahonen

Publications: <http://tinyurl.com/MAhonenCV>

E-mail: mikko [ät] sustainablemobile . com

Telephone: +358-(0)50-3451528

Skype: AhosMikko

LinkedIn: <https://fi.linkedin.com/in/mikkoahonen>

Twitter: <http://www.twitter.com/ahosmikko>

Blog 1: <http://beyondradiation.blogs.com>

Blog 2: <http://mikkoahonen.puheenvuoro.uusisuomi.fi>