ELECTROHYPERSENSITIVITY: INPUT OF MECHANISTIC STUDIES WITH LOW-INTENSITY RADIOFREQUENCY AND EXTREMELY LOW FREQUENCY ELCTROMAGNETIC FIELDS

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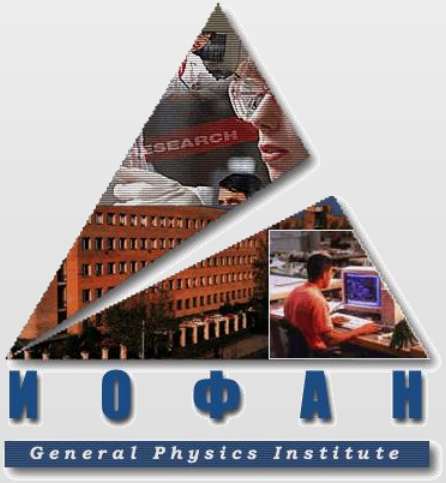

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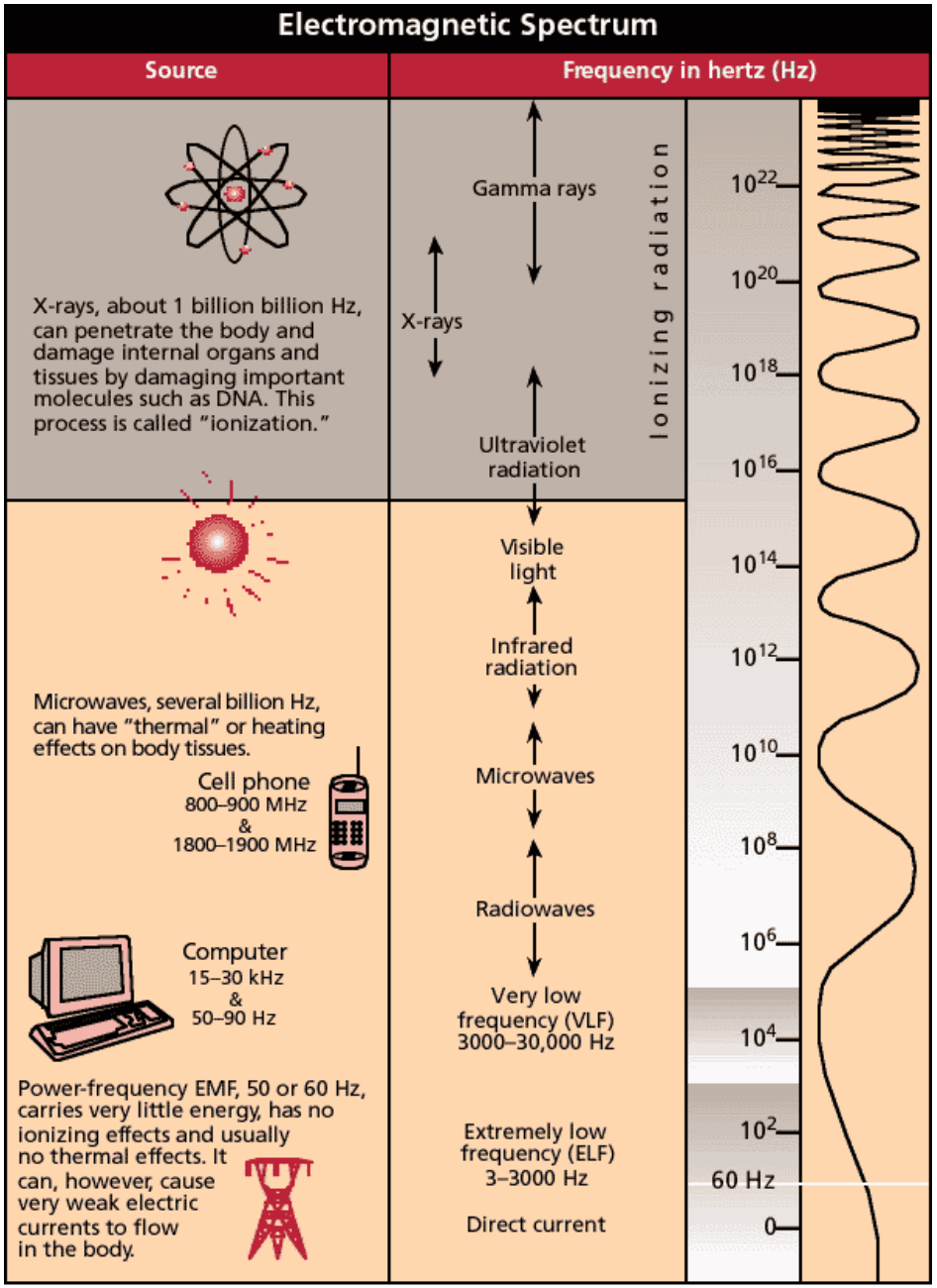
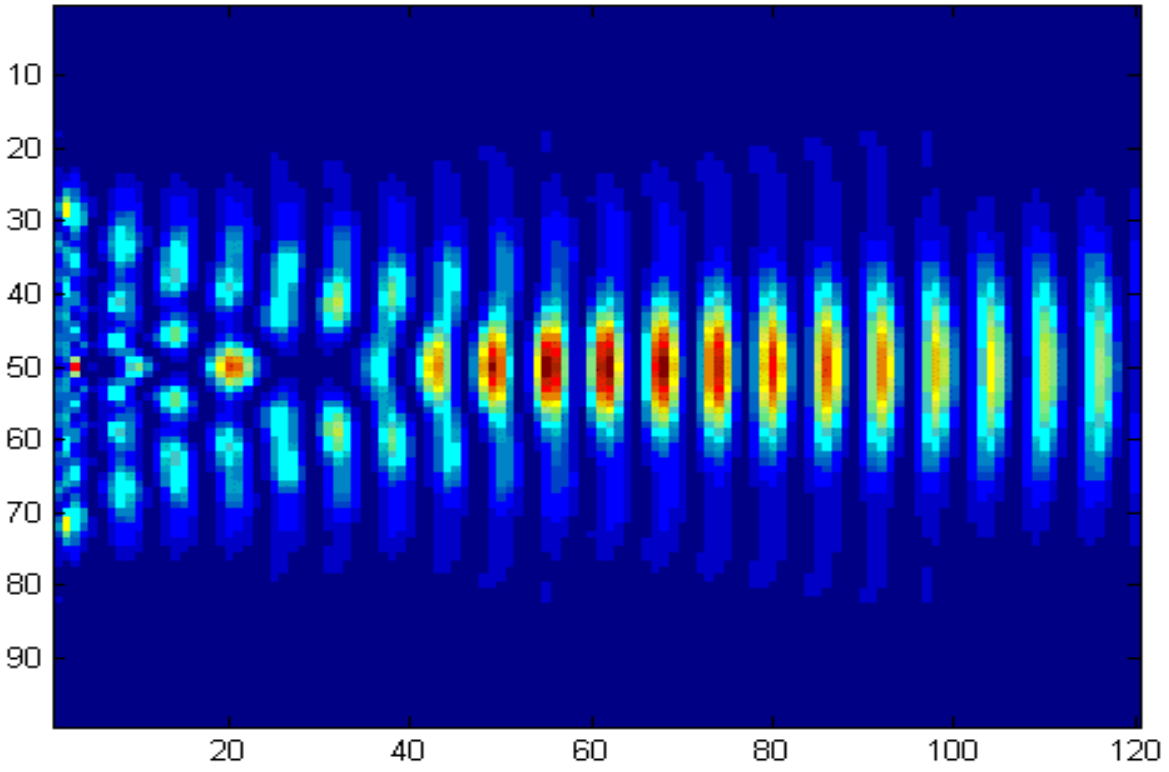
Electromagnetic spectrum

The wavy line at the right illustrates the concept that the higher the frequency, the more rapidly the field varies. The fields do not vary at 0 Hz (direct current) and vary trillions of times per second near the top of the spectrum.



MOBILE PHONES EMIT BOTH ELF AND MICROWAVES :



EMF of extremely low frequency (ELF) (up to 20 µT)

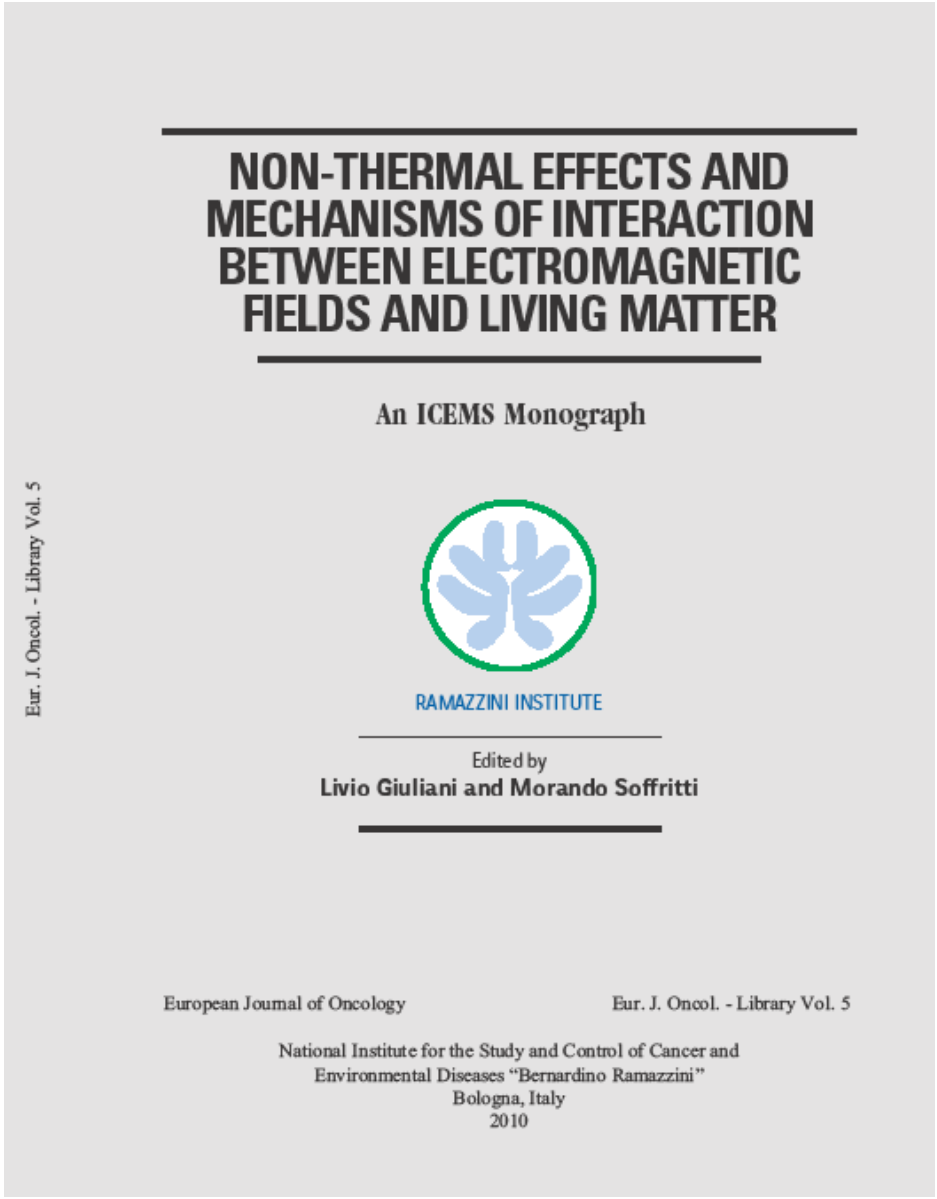
Microwaves (MW) (SAR up to 2 W/kg)

International Commission for Electromagnetic Safety (ICEMS) 2010

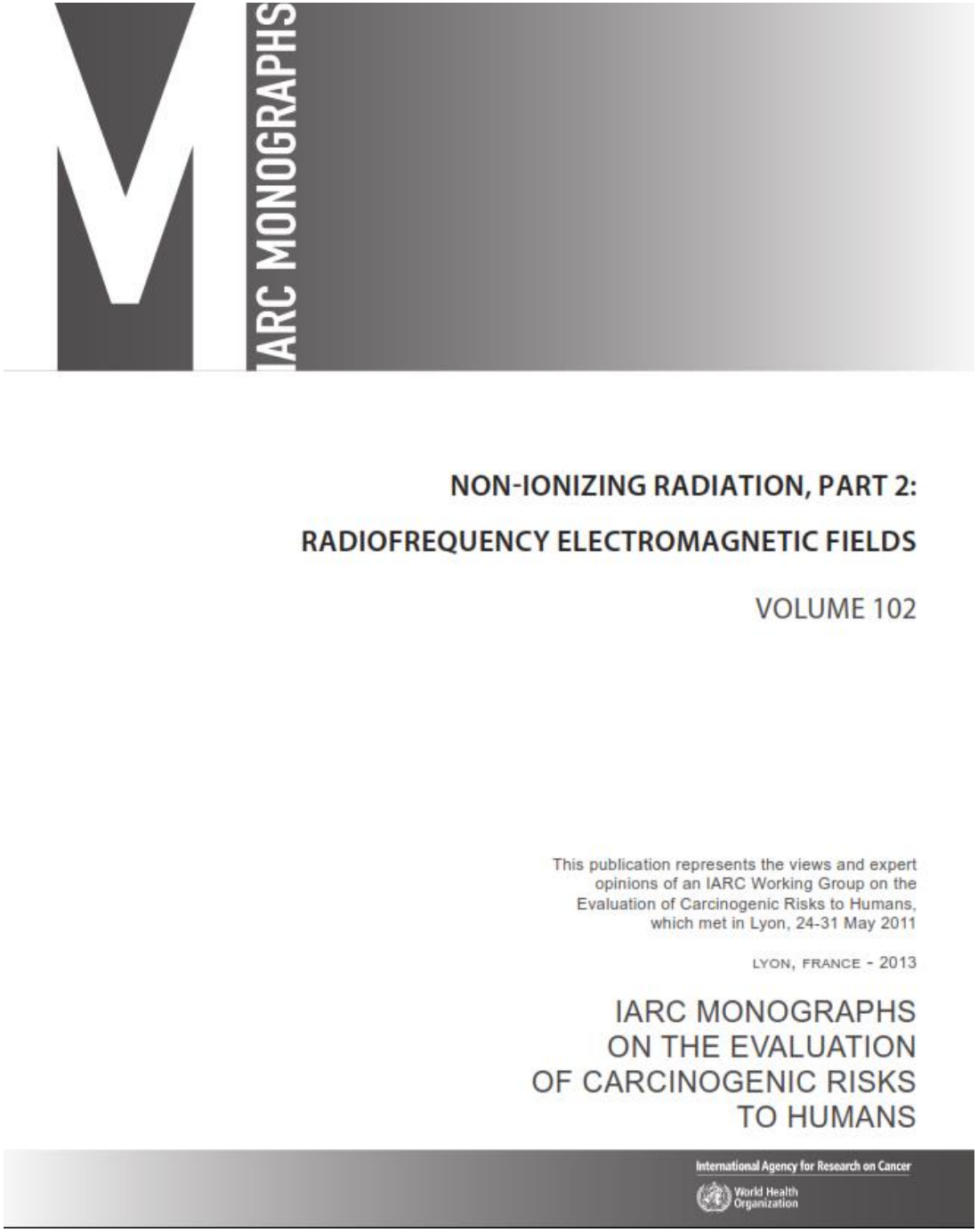
Many groups over the world described various biological responses to weak ELF and non-thermal microwaves (MW) at intensities below ICNIRP safety limits

Bioinitiative Group 2012

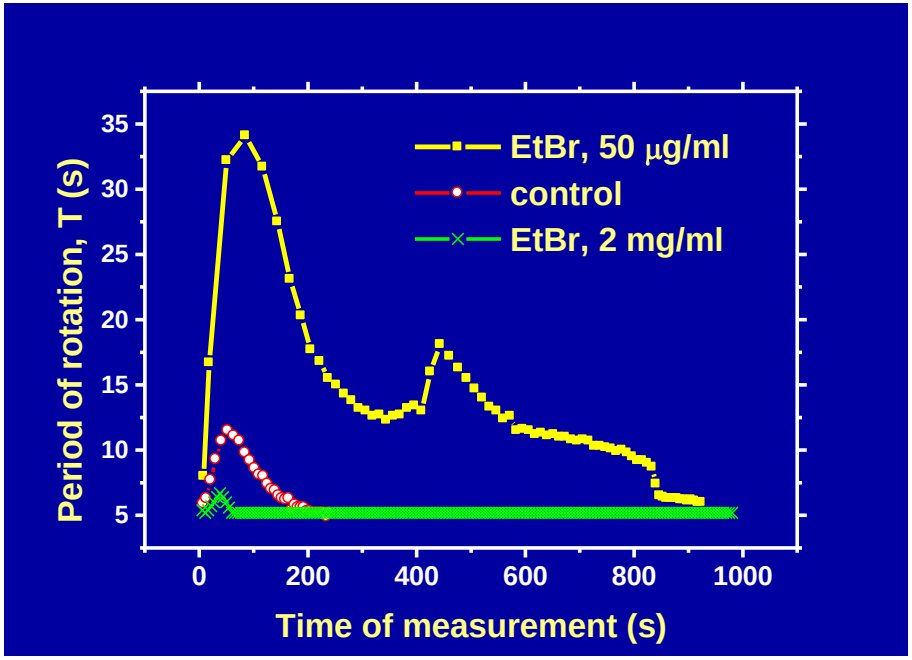
www.bioinitiative.org

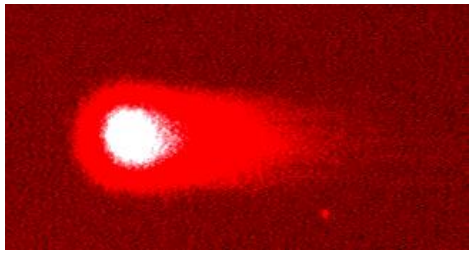


The aim of this presentation is to provide an overview of the complex dependence of the ELF/MW effects on various physical and biological parameters. The role of these parameters was acknowledged by the recent monograph of the International Agency for Research on Cancer (IARC) on carcinogenicity of radiofrequency EMF (possible carcinogen, group 2B).

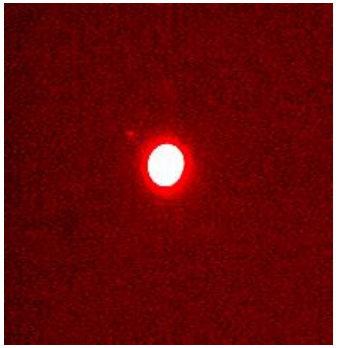


Anomalous viscosity time dependence (AVTD) similar to Neutral comet assay measures relaxation and condensation of DNA loops

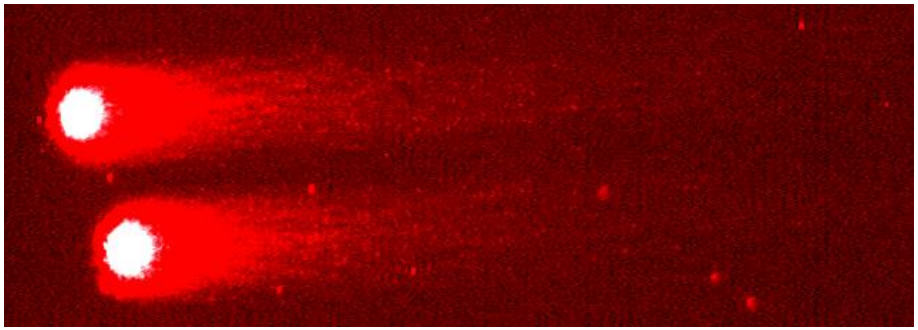




Control



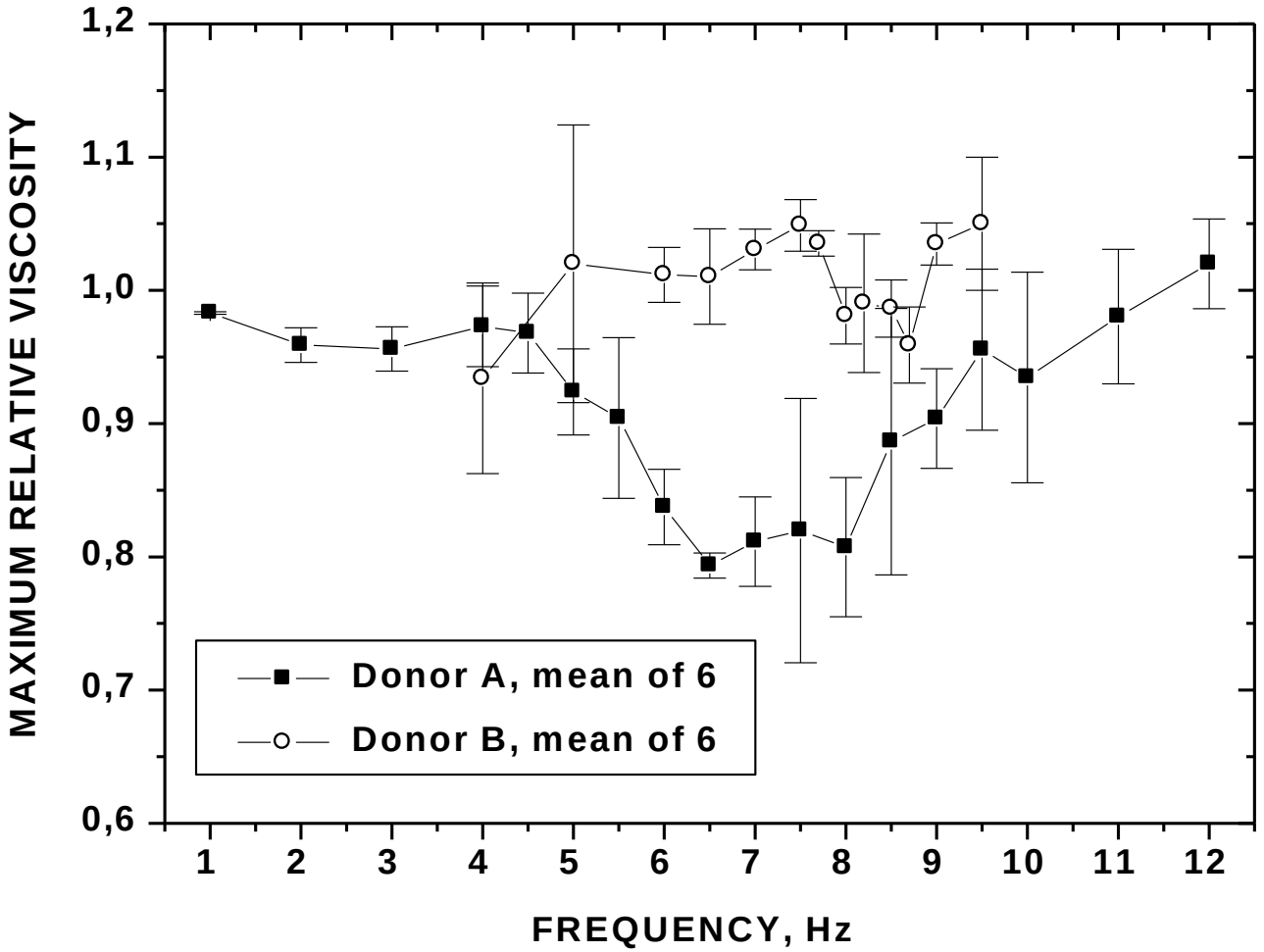
EtBr, 2 mg/ml, condensation



EtBr, 50 μg/ml relaxation

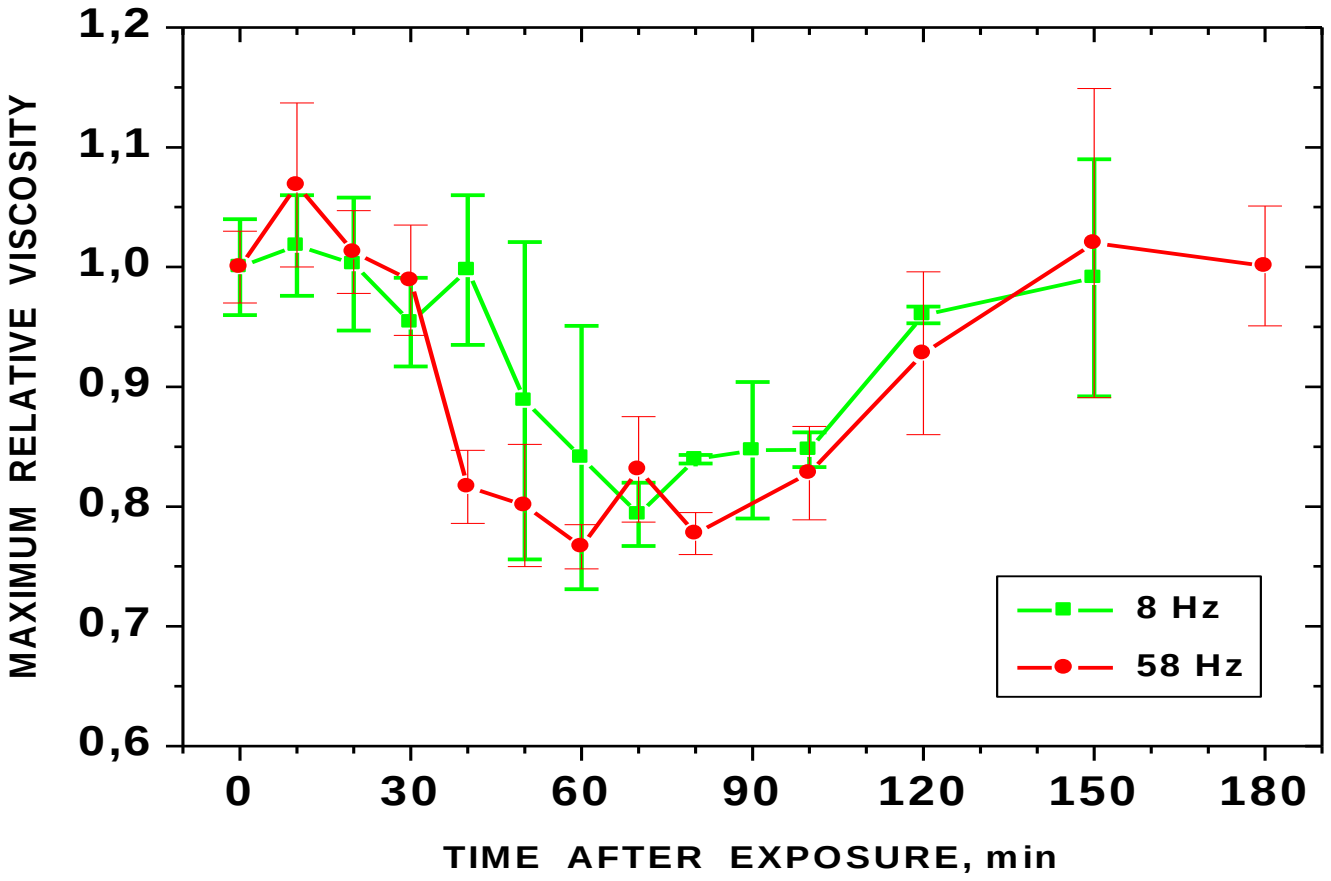
I. Y. Belyaev, S. Eriksson, J. Nygren, J. Torudd, and M. Harms-Ringdahl, *Biochim Biophys Acta*, vol. 1428, pp. 348-356, 1999

Frequency window in the ELF effect on chromatin conformation. Individual response of lymphocytes from healthy subjects to ELF (21 μT rms) (AVTD)



Belyaev and Alipov, *Biochim Biophys Acta*, vol. 1526, pp. 269-276, 2001

ELF effects on chromatin conformation were transient and disappeared with time after exposure. Human lymphocytes exposed to 21 μT rms, 20 min



50 Hz magnetic fields individually affect chromatin conformation in human lymphocytes: dependence on amplitude, temperature, and initial chromatin state

Sarimov, Alipov, Belyaev, Bioelectromagnetics, 2011

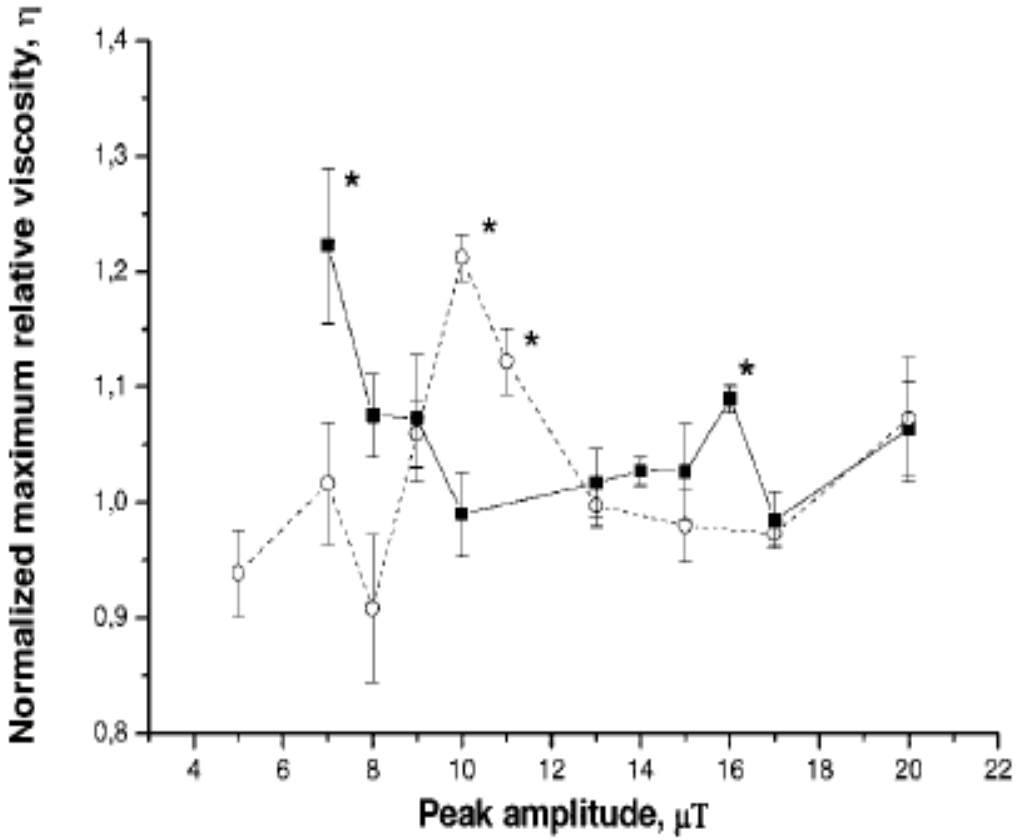
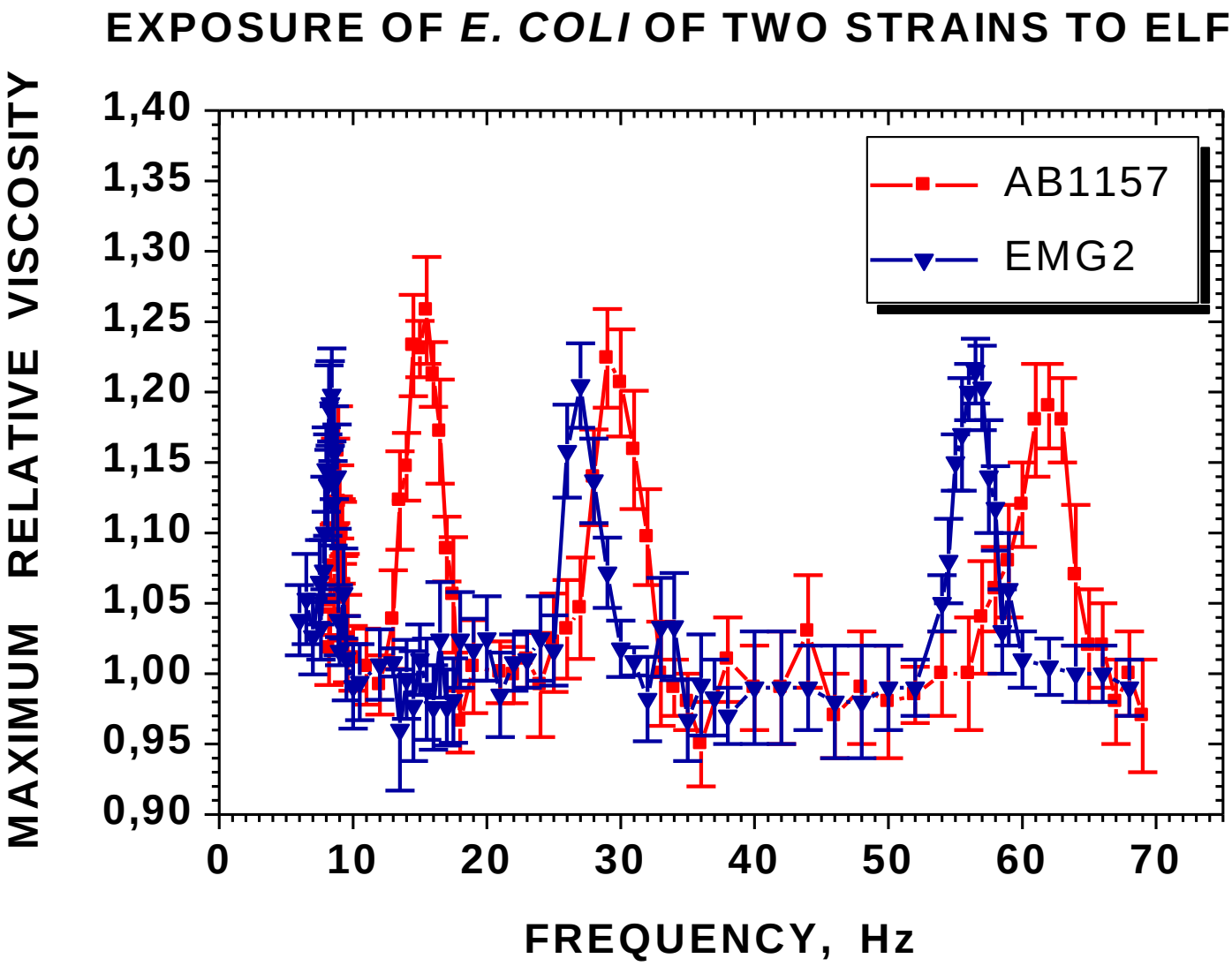


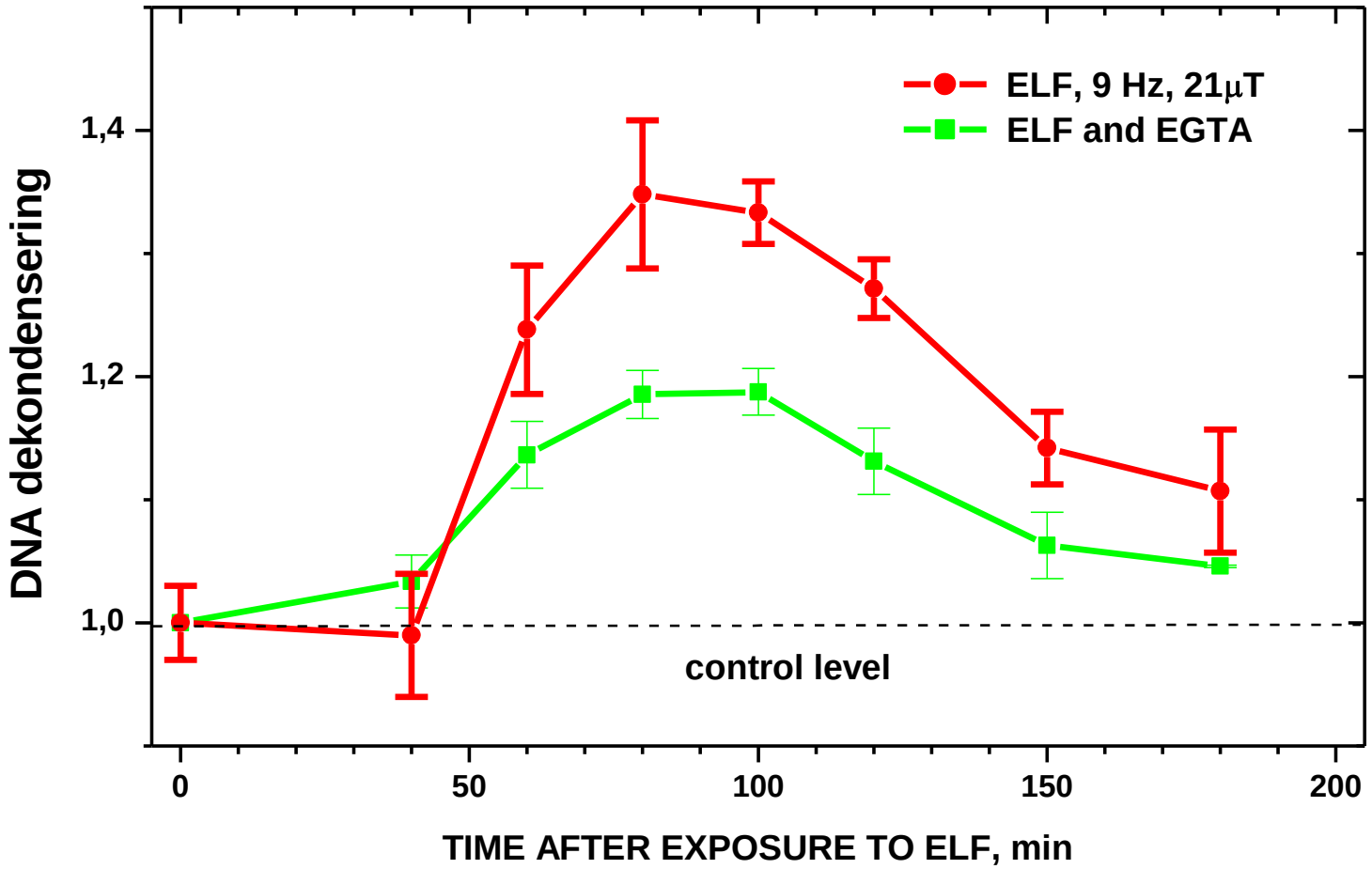
Fig. 3. Dependence of the normalized maximum relative viscosity η on the peak amplitude of 50 Hz MF. Lymphocytes from Don A (—■—) and Don B (--○--) were exposed to sinusoidal AC MF at the frequency of 50 Hz for 1 h. Data for two donors, which were obtained in 21 independent experiments, are given separately. Statistically significant effects are designated by * ($P < 0.003$).

Genomic differences influenced response to ELF

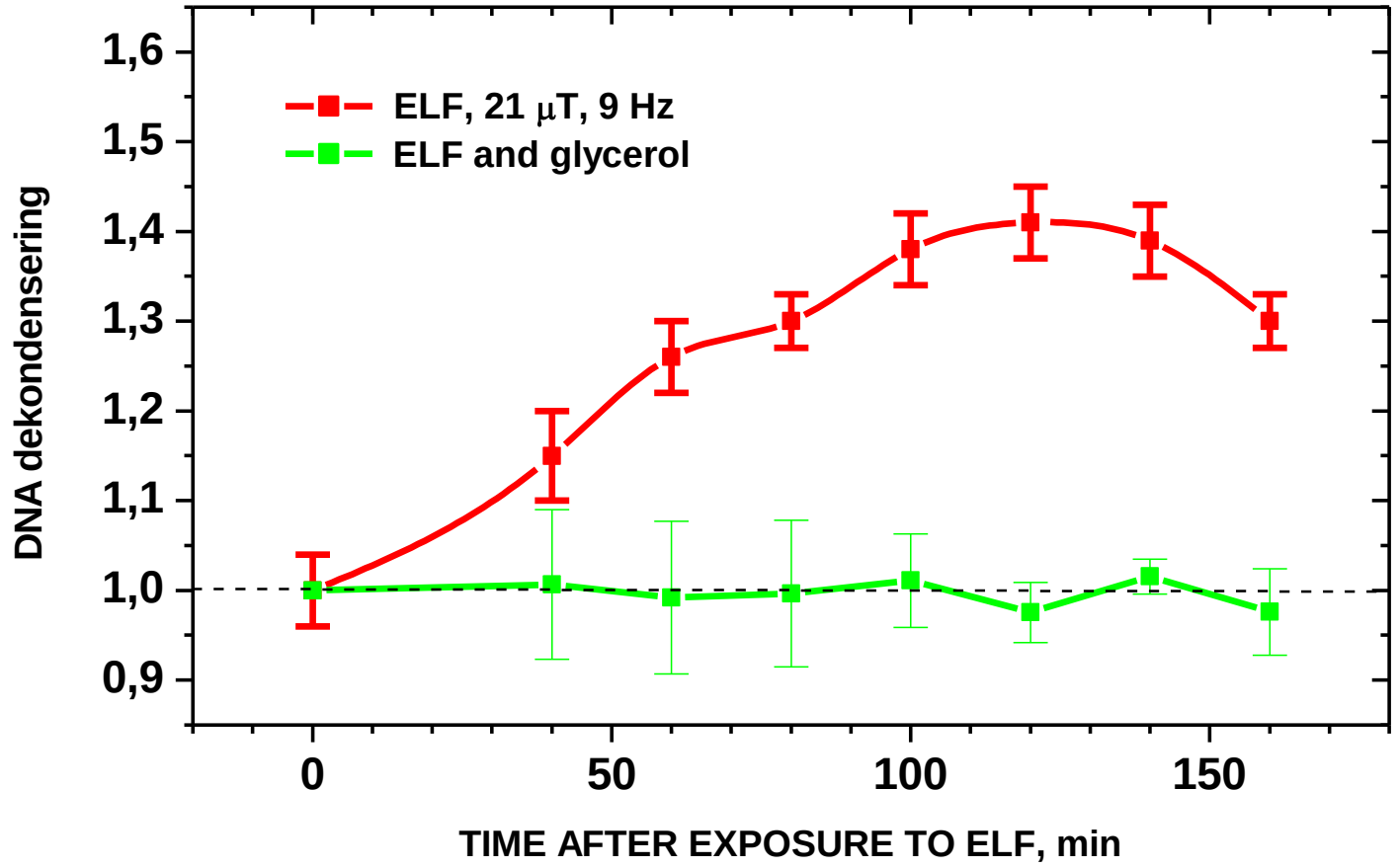


Alipov and Belyaev, *Bioelectromagnetics*, vol. 17, pp. 384-387, 1996

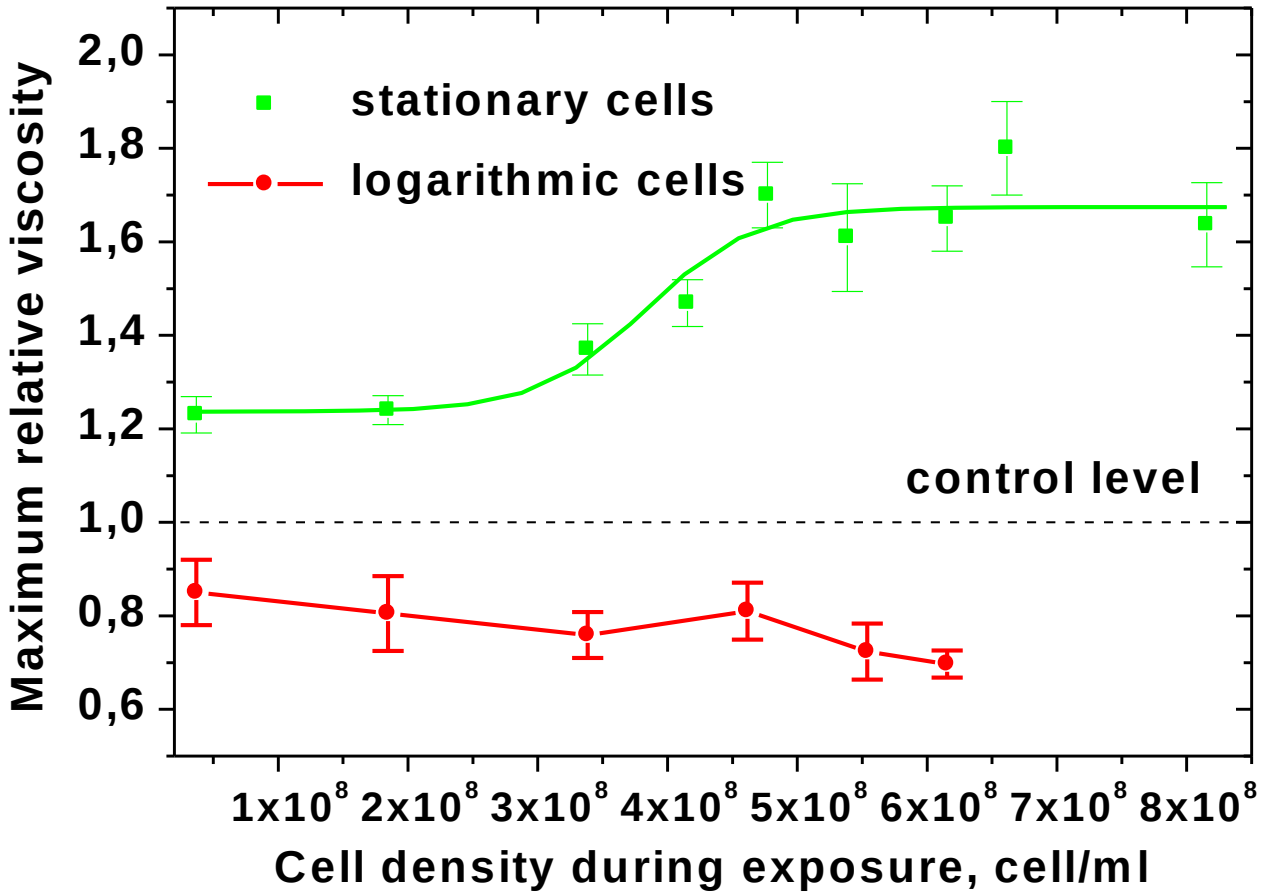
EGTA binds divalent ions and minimize the ELF effects on E. coli cells



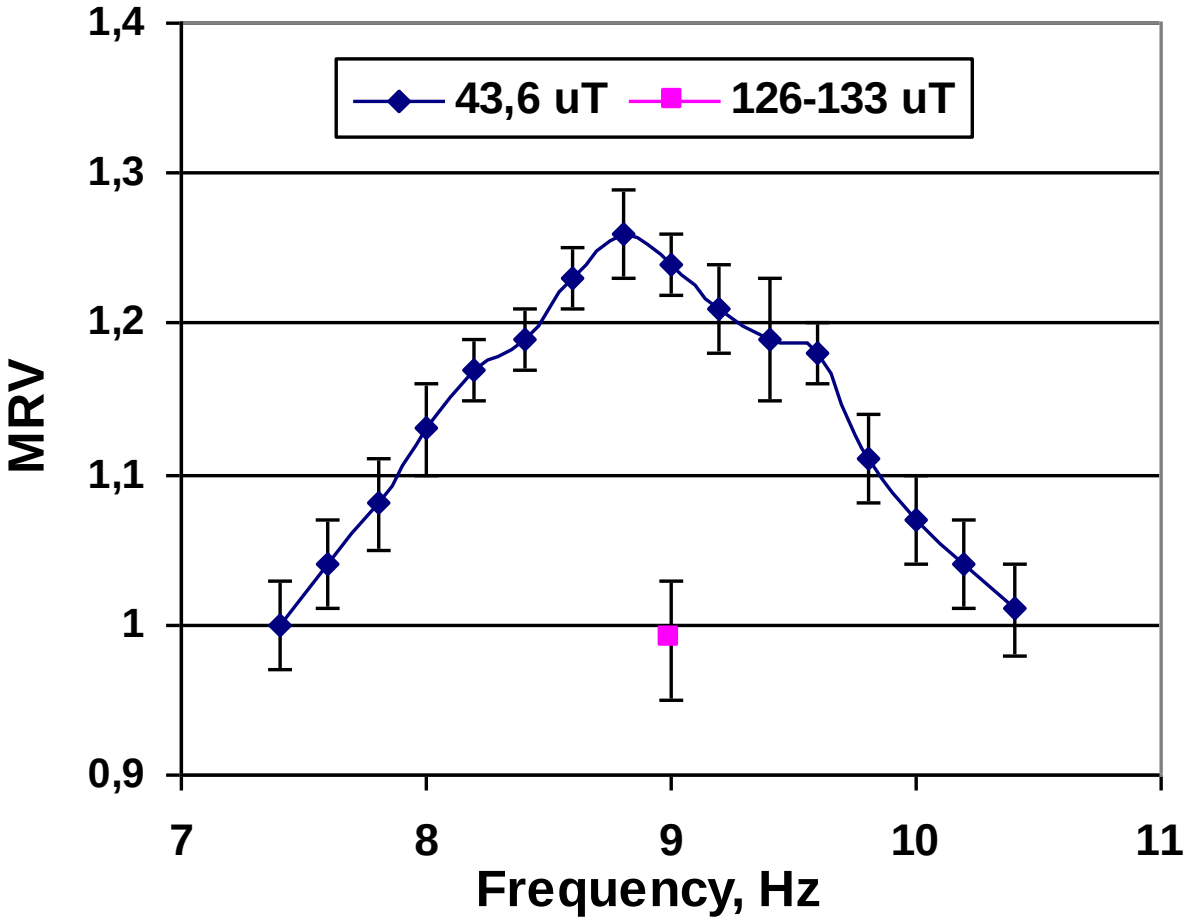
Glycerol scavenges radicals and abolishes ELF effects on E. coli cells



Dependence of the ELF effect on cell density, stage of cell growth



ELF effects on *E. coli* AB1157 were dependent on static collinear magnetic field



ELF effects depend on Biological and Physical Variables

- Individual traits
- Genetic background
- Frequency, intensity, static magnetic field
- Temperature, initial state, presence of radicals/radical scavengers/antioxidants and ions,…….

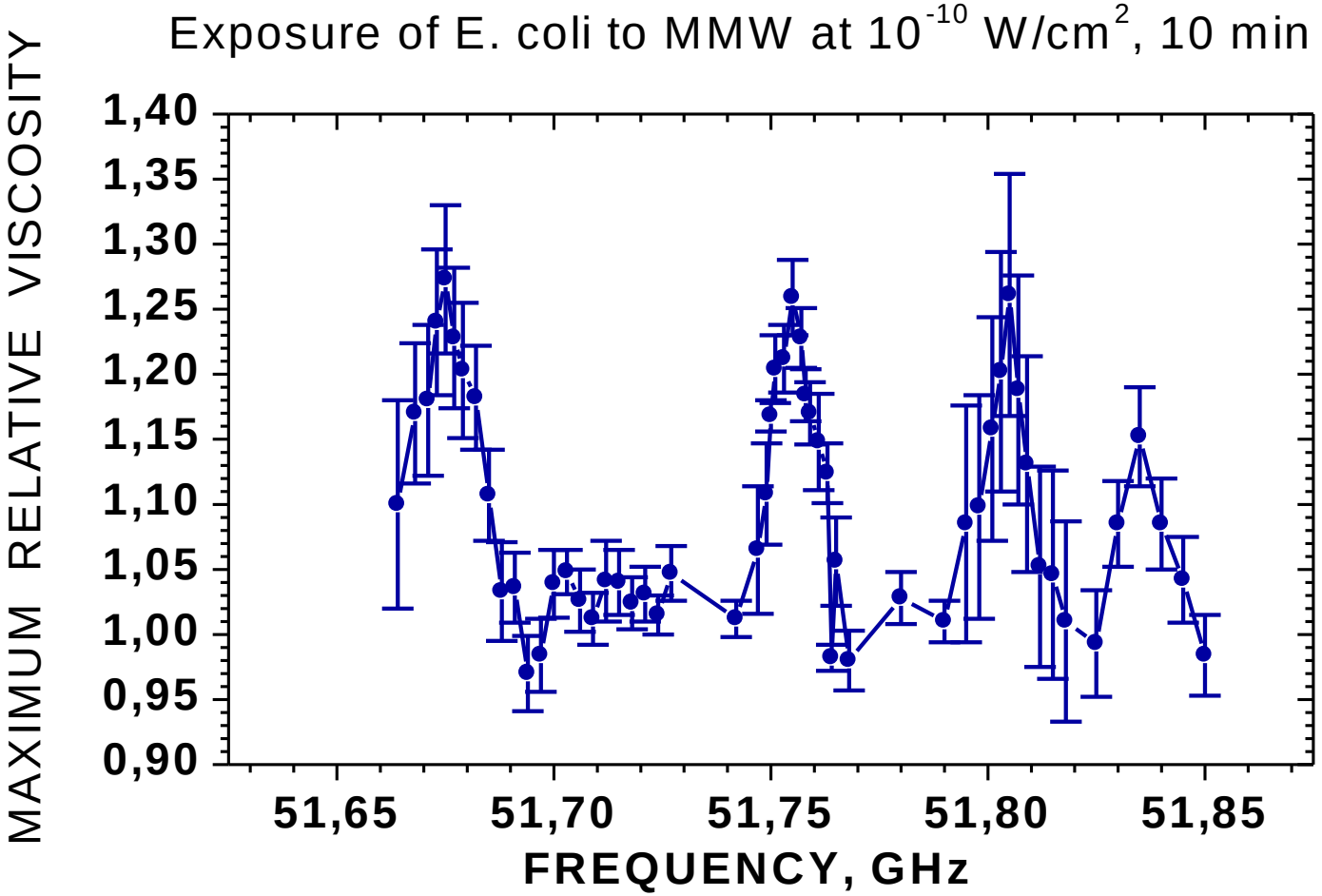
Microwaves (MW)

SAR – specific absorbed energy, W/kg
(analogues to dose rate in Radiobiology)

- Thermal effects - heating

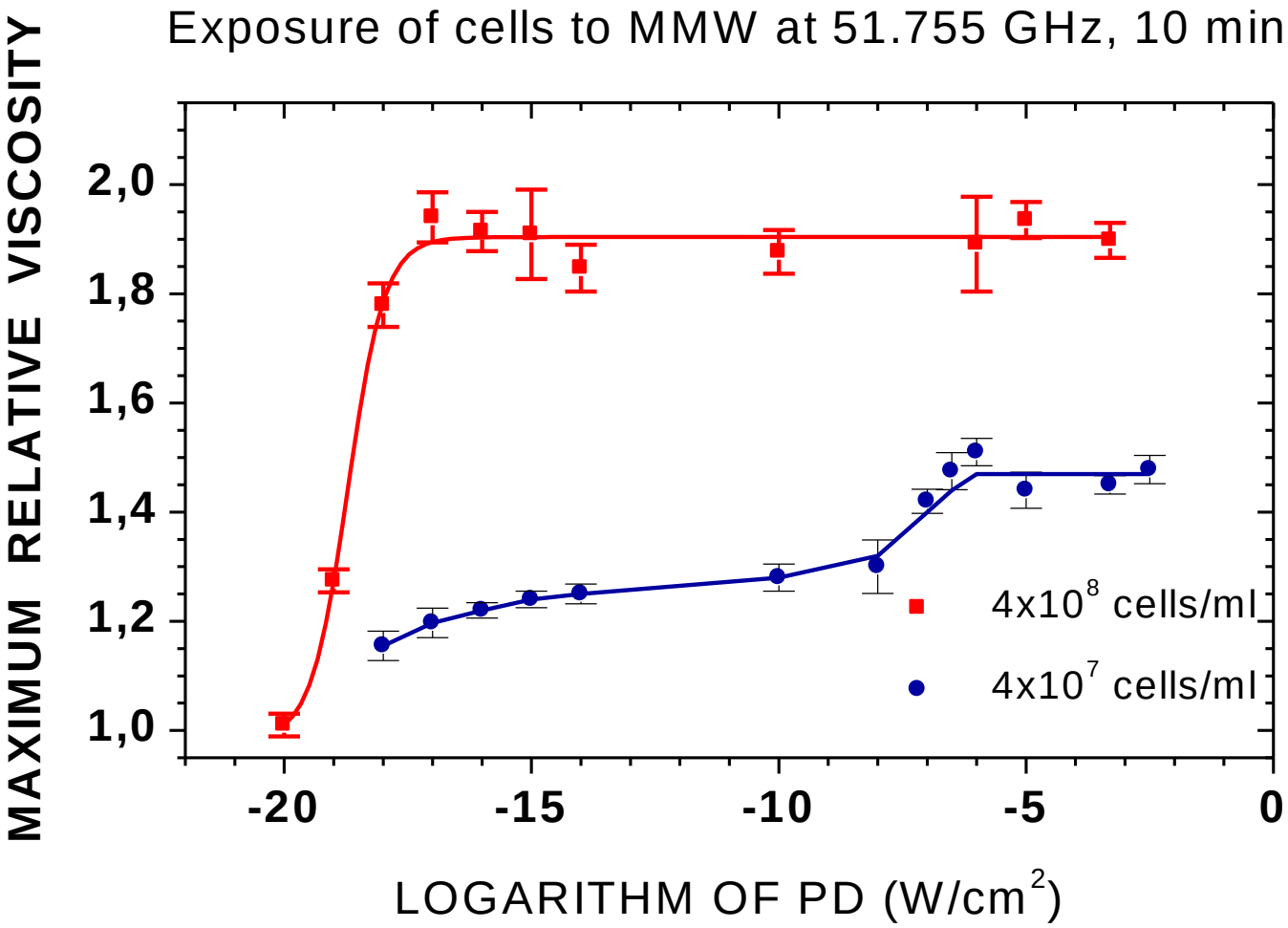
- Nonthermal effects – no heating

Frequency dependent effects of MW at low intensities comparable with intensities produced by base stations

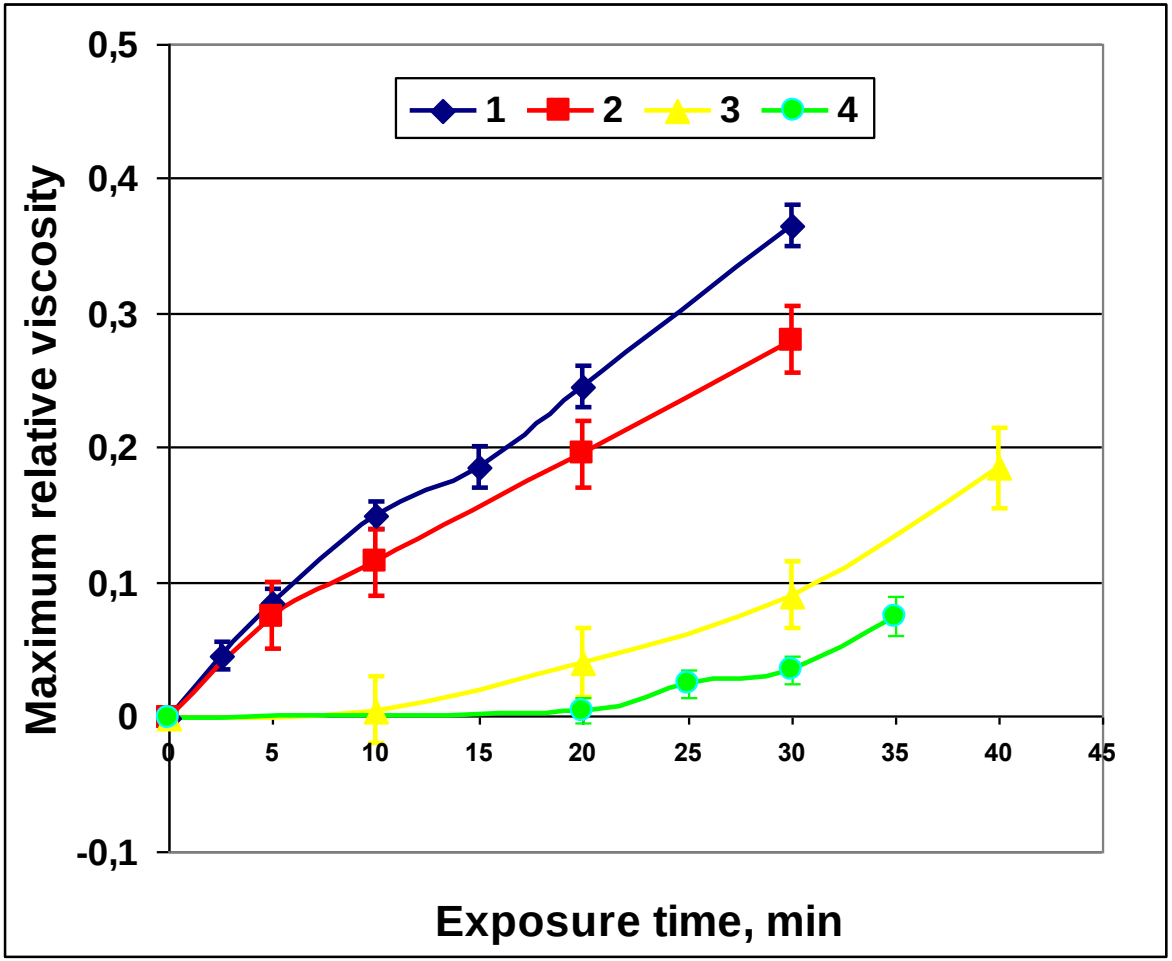


I. Y. Belyaev, V. S. Shcheglov, Y. D. Alipov, and V. A. Polunin, Bioelectromagnetics, vol. 17, pp. 312-321, 1996

MW resonance effect depend on cell density suggesting cell-to-cell interaction during response



Decreasing of intensity by orders of magnitude could be compensated by increasing of exposure time



(1) 10^{-14} W/cm^2;

(2) 10^{-16} W/cm^2;

(3) 10^{-17} W/cm^2;

(4) 10^{-18} W/cm^2;

I. Y. Belyaev, Y. D. Alipov, V. S. Shcheglov, V. A. Polunin, and O. A. Aizenberg, Electro- and Magnetobiology, vol. 13, pp. 53-66, 1994.

- **Changing of static magnetic field by 20 μT abolished resonance effect of MW on *E. coli* cells**

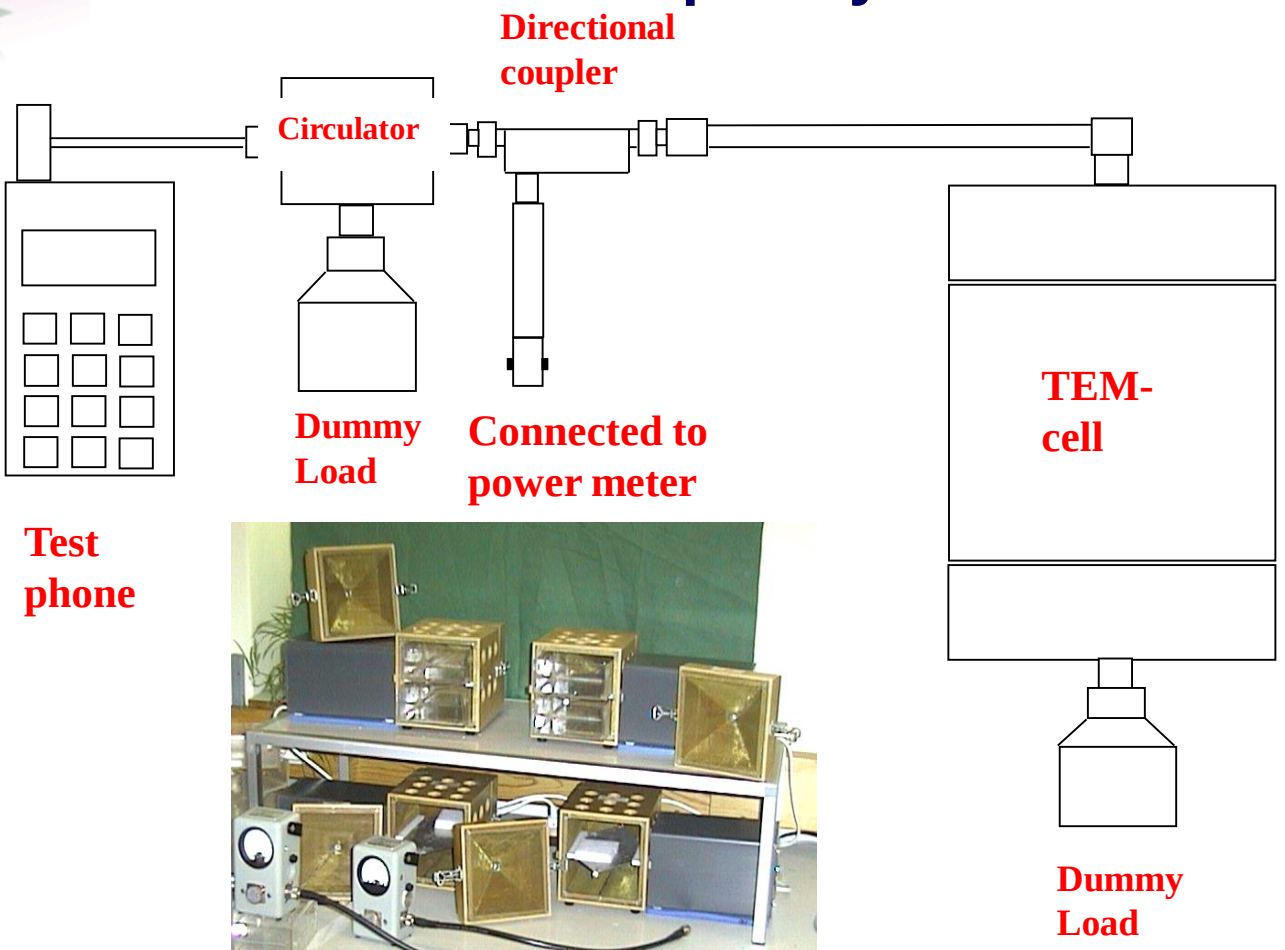
During a single call, GSM users are exposed to microwaves at different frequencies

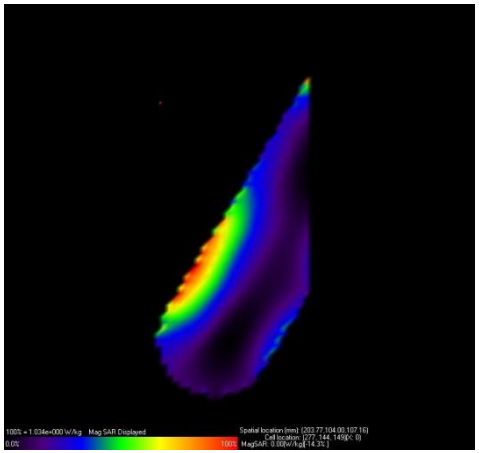
•There are 124 different channels/frequencies, which are used in GSM900 (Global System for Mobile Communication). They differ by 0.2 MHz in the frequency range between 890 MHz and 915 MHz. Frequency is supplied by base station to a mobile phone user depending on the number of connected users. The frequency can be changed by base station during the same call.

How various mobile phone channels affect human lymphocytes from hyperelectrosensitive and healthy subjects?

Non-thermal microwave exposure of human differentiated and stem cells in different frequency channels

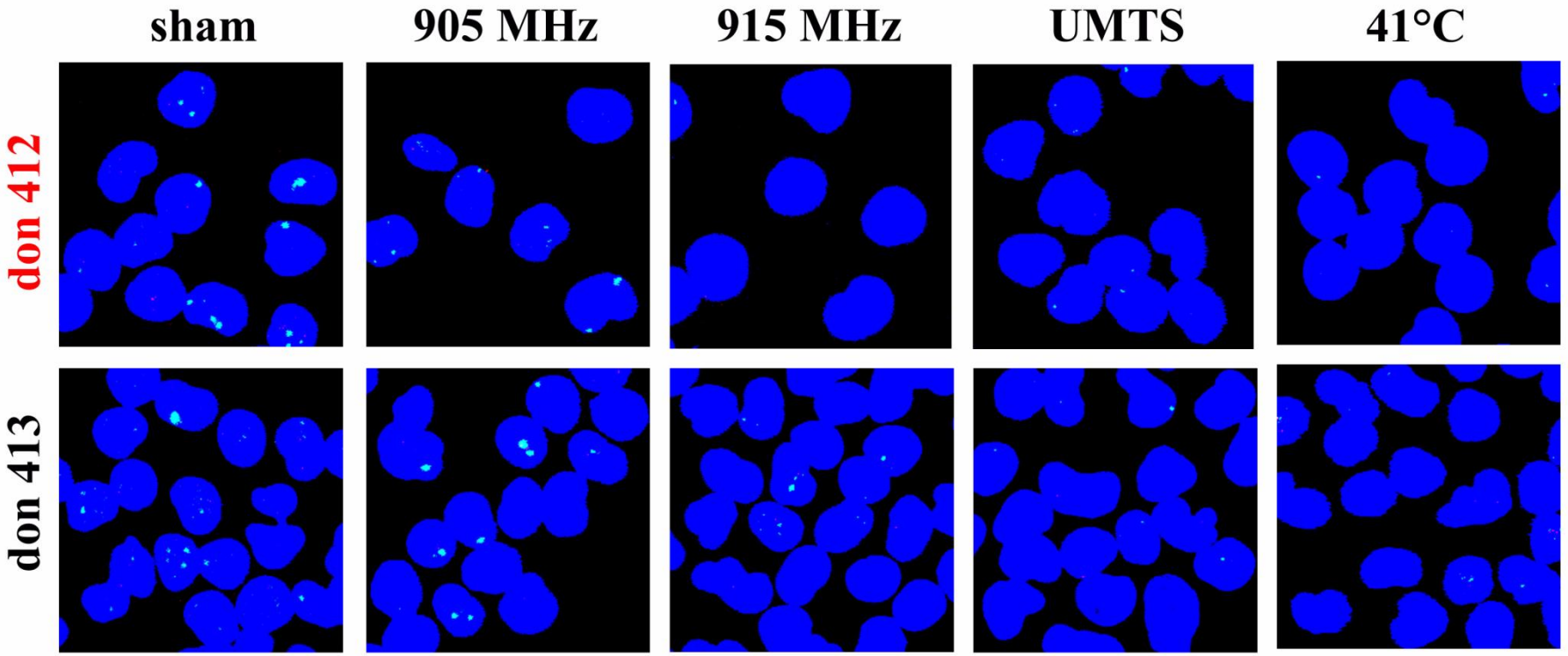
The test-mobile phone is programmed to select a GSM/UMTS frequency channel, and 0.25 W output power.





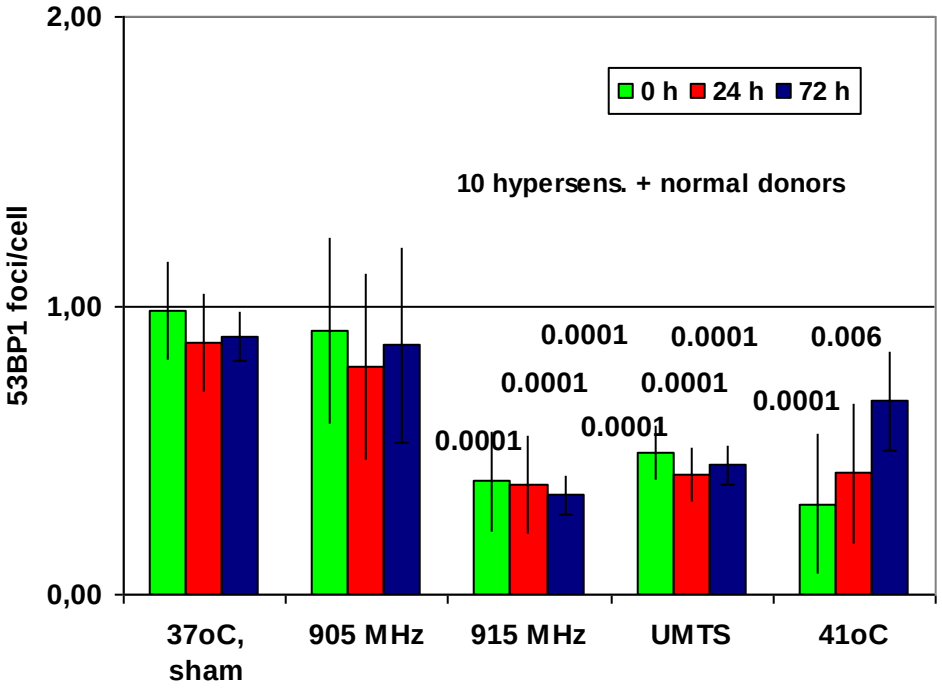
Distribution of specific absorption rate (FDTD-METHOD)

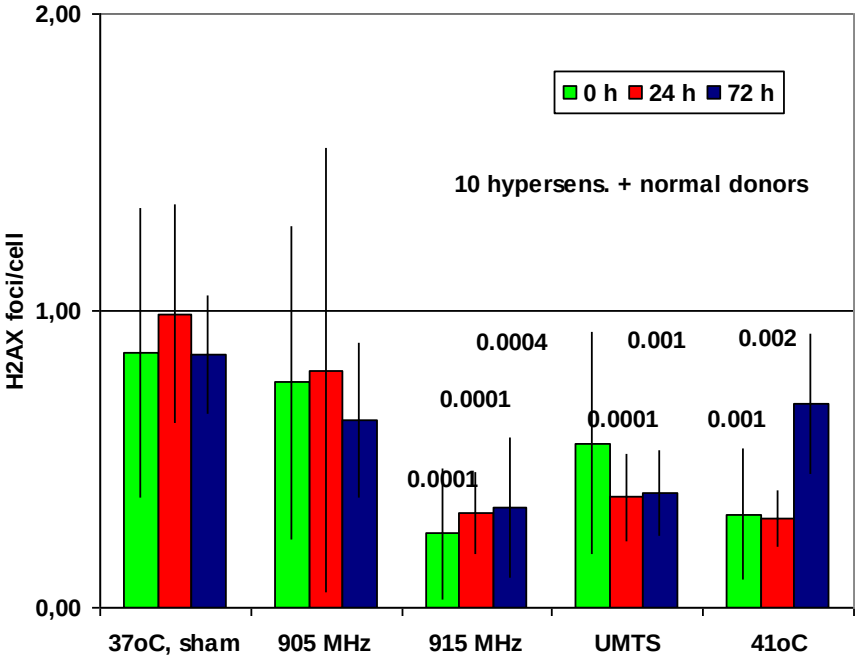
Exposure to 3G/1947 MHz and GSM/915 MHz MW inhibit formation of 53BP1 foci in human lymphocytes from healthy and hyperelectrosensitive persons similar to heat shock



53BP1 foci (stained in green) after 1-h exposure of human lymphocytes (counterstained in blue) with MW and heat shock

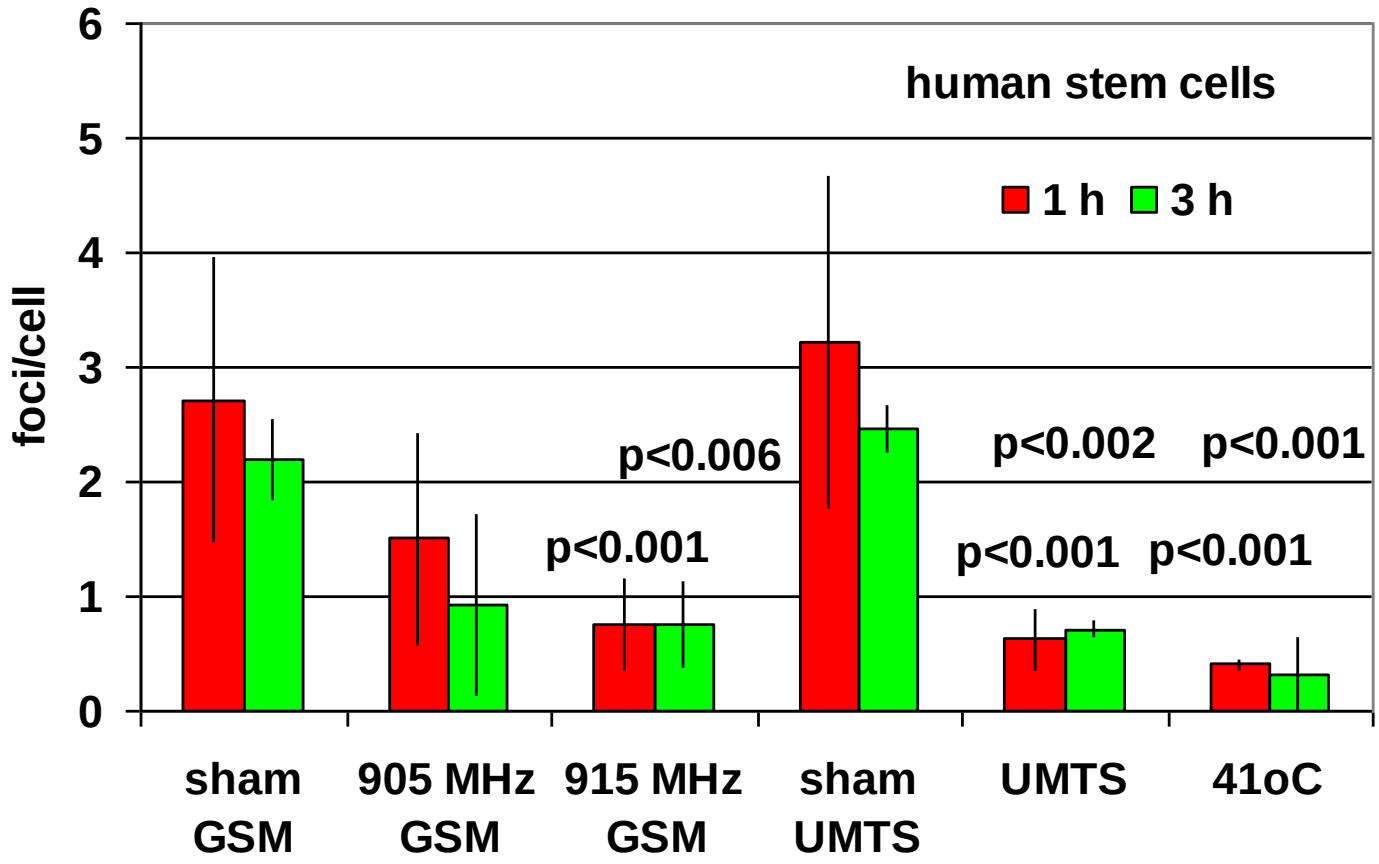
Persistent inhibition of DNA repair foci in human lymphocytes following 1 h exposure to 3G/UMTS and 915 MHz GSM (similar to heat shock). No effect at 905 MHz.





From Belyaev et al., Biolectromagnetics, 2009

Human mesenchymal stem cells were most sensitive to 915 MHz GSM and 1947 MHz UMTS MW-exposure



Mesenchymal stem cells are multipotent cells capable of giving rise to cells of mesodermal origin, including bone, cartilage, fat, tendon, and muscle

From Markova et al., Env Health Perspectives, 2010

Conclusions

Our results and analysis of available data suggest that different EMF signals (bandwidth, frequency, modulation, polarization) should be considered separately when studying EMF biological effects including electromagnetic hypersensitivity.

The data also indicate that durations of exposure and post-exposure are important parameters for setting up the EMF effects.

Taken into account the EMF response time kinetics, individual sensitivity, variation in physiology, and dependence on physical parameters it follows that more conditions of exposure should be validated in studies of electrohypersensitivity. In view of complex dependence of the EMF effects on physiological state of the object, individual sensitivity, physical parameters of exposure, duration and time after exposure the provocation studies should not be considered informative regarding exposure to all real exposures including cell phones because only minor part of these parameters (frequency, modulation, duration of exposure et cetera) have been analyzed.

Significant body of studies show that ELF/MW effects depend on concentration of divalent metals, ROS and antioxidants. These studies provide a mechanistic background for the treatment of electrohypersensitivity based on chelating divalent metals, reducing ROS, and balancing vitamins.