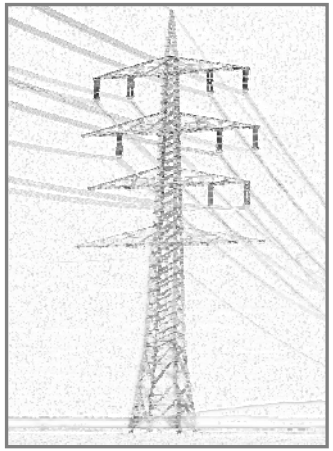


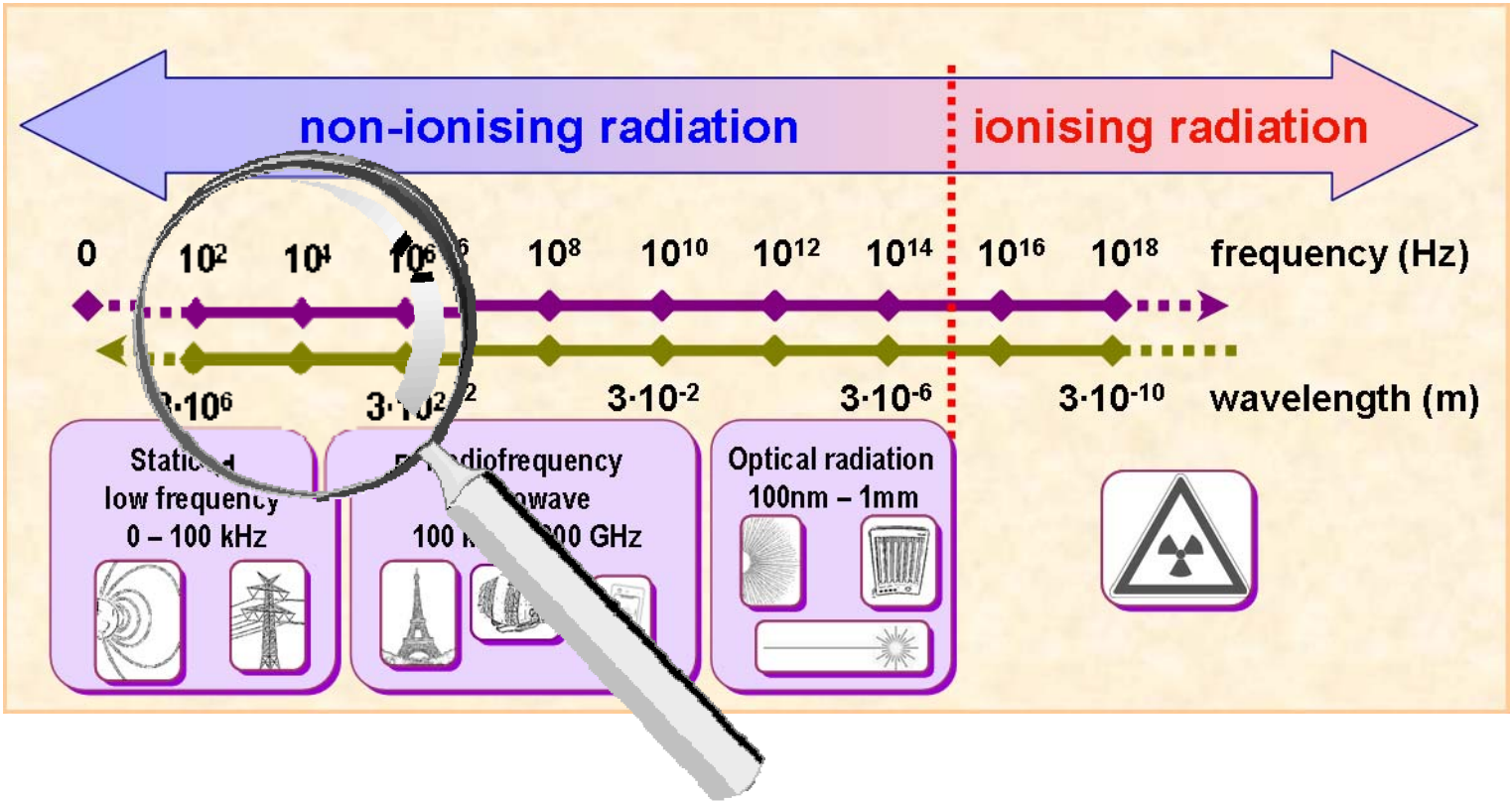
LIMITING EXPOSURE TO ELF ELECTRIC AND MAGNETIC FIELDS (1 Hz TO 100 kHz)

Rüdiger Matthes

ICNIRP VICE CHAIR

Federal Office for Radiation Protection Germany

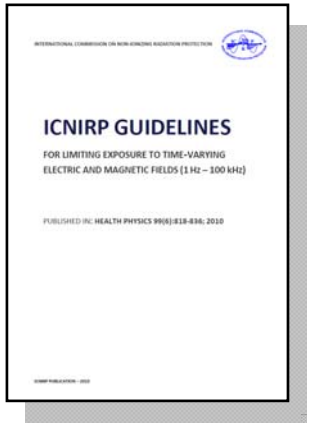
Spectral bands



Relevant documents

www.icnirp.net/documents/..

99(6):818-836, 2010



…LFgdl.pdf

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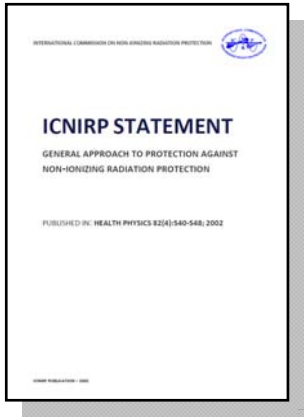
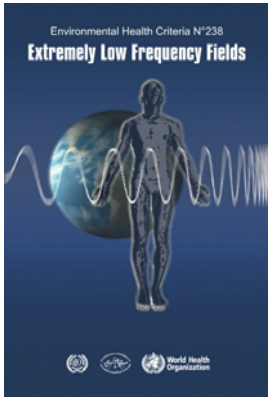
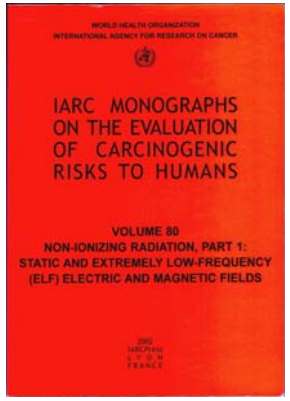


…philosophy.pdf

ISBN 978-3-934994-03-4



www.who.int



monographs.iarc.fr

General concept

Effects result in:
pathological conditions
substantial annoyance
discomfort

ICNIRP philosophy

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

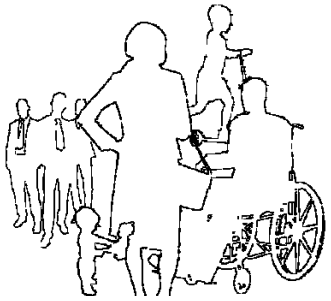
Statuten der WHO, 1946

Health effects

- Definition, identification, quantification

Consideration of uncertainties

- Database, extrapolation

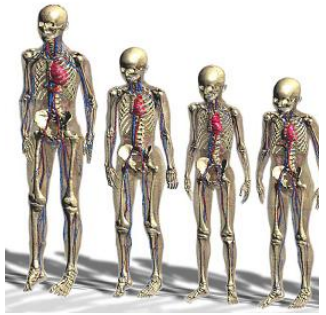


Variability within the population

- Exposure tolerance, concomitant exposure

Exposure limitation

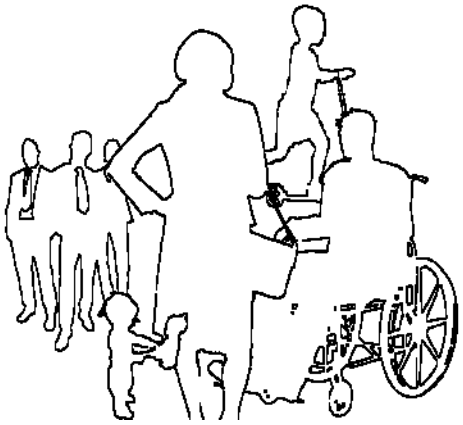
- Effective quantities (related to the effect, inside the body), basic restrictions



Conservative simplification

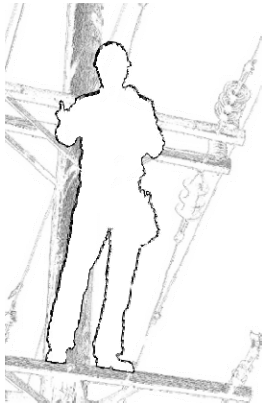
- Practical quantities (dosimetrically related to basic restriction, outside the body), reference levels

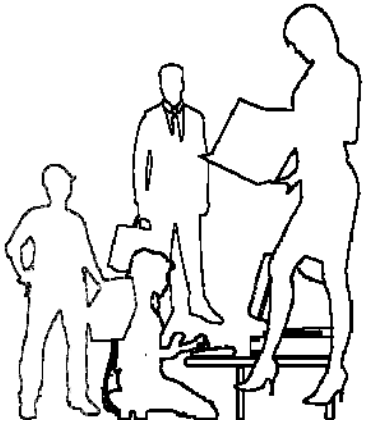
People to be protected



General public
all ages
varying health
unaware of exposure

Workers
adults
known exposure conditions
result of job activities
aware of exposure

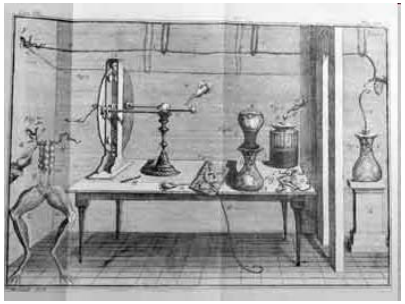




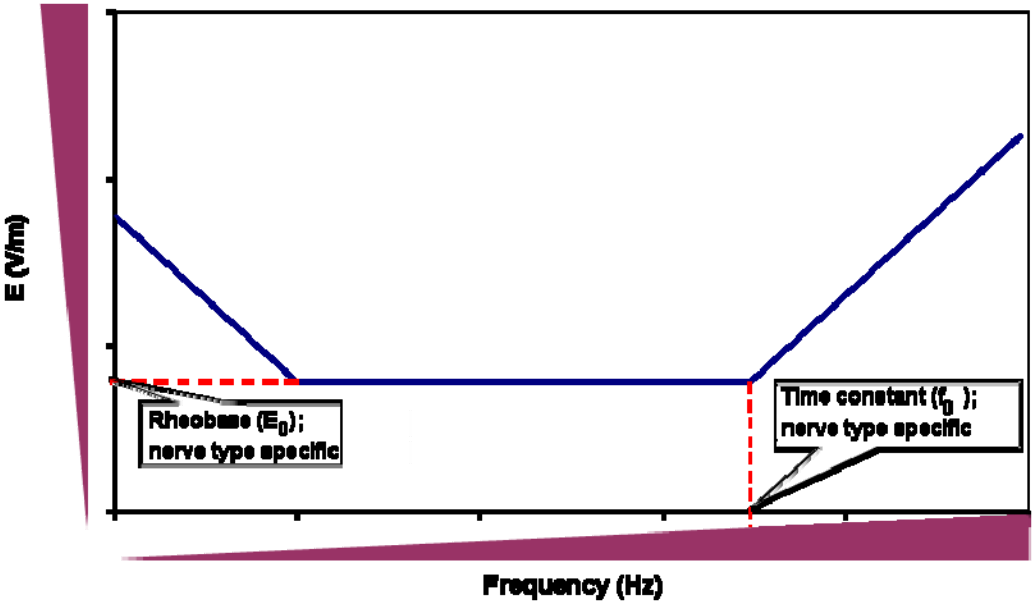
Controlled environment
advice and training
voluntarily and knowingly
transient effects acceptable

Health effects

- Surface charge effects (sensation threshold 2 - 5 kV m^{-1} in 10% of exposed people)
- Spark discharge via grounded conductors (painful in 7% of people exposed to 5 kV m^{-1})
- Discharge of isolated conductors through grounded people
- Neurophysiologic effects of induced electric fields



De Viribus Electricitatis in Motu Musculari, Luigi Galvani, 1791



Nerve / tissue	E_0 (V m^{-1})	f_0 (Hz)
myelinated nerve*	4 - 6	3000
cardiac tissue	12	200
synapses	0,1	20
neural networks	> 0,1 ?	? (kHz)
phosphenes	0,05 – 0,1	20

ELF and cancer

IARC classification 2B "possibly carcinogenic to humans

statistic association with childhood leukemia

no plausible mechanism

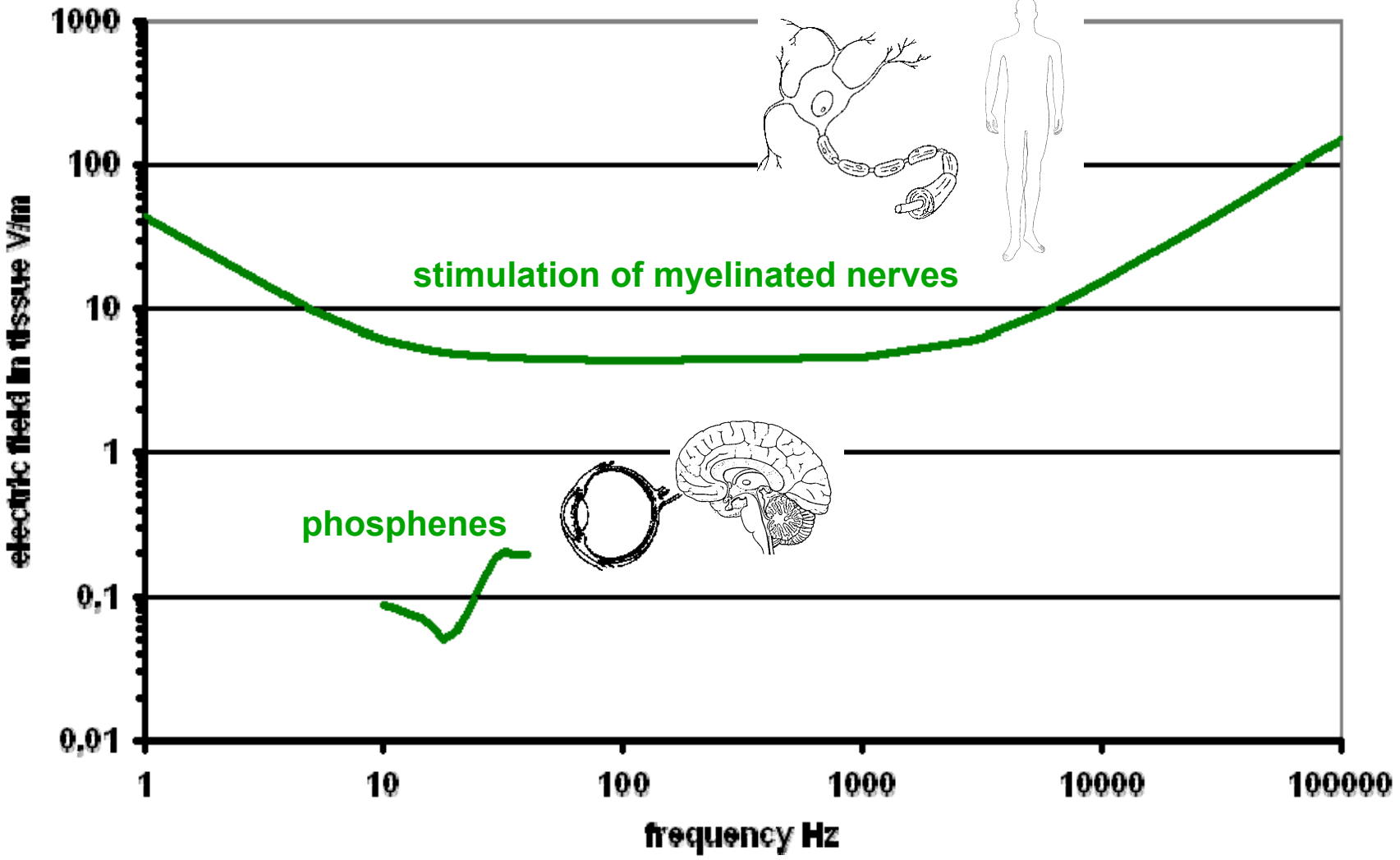
no convincing support from laboratory

no evidence for cancer in adults

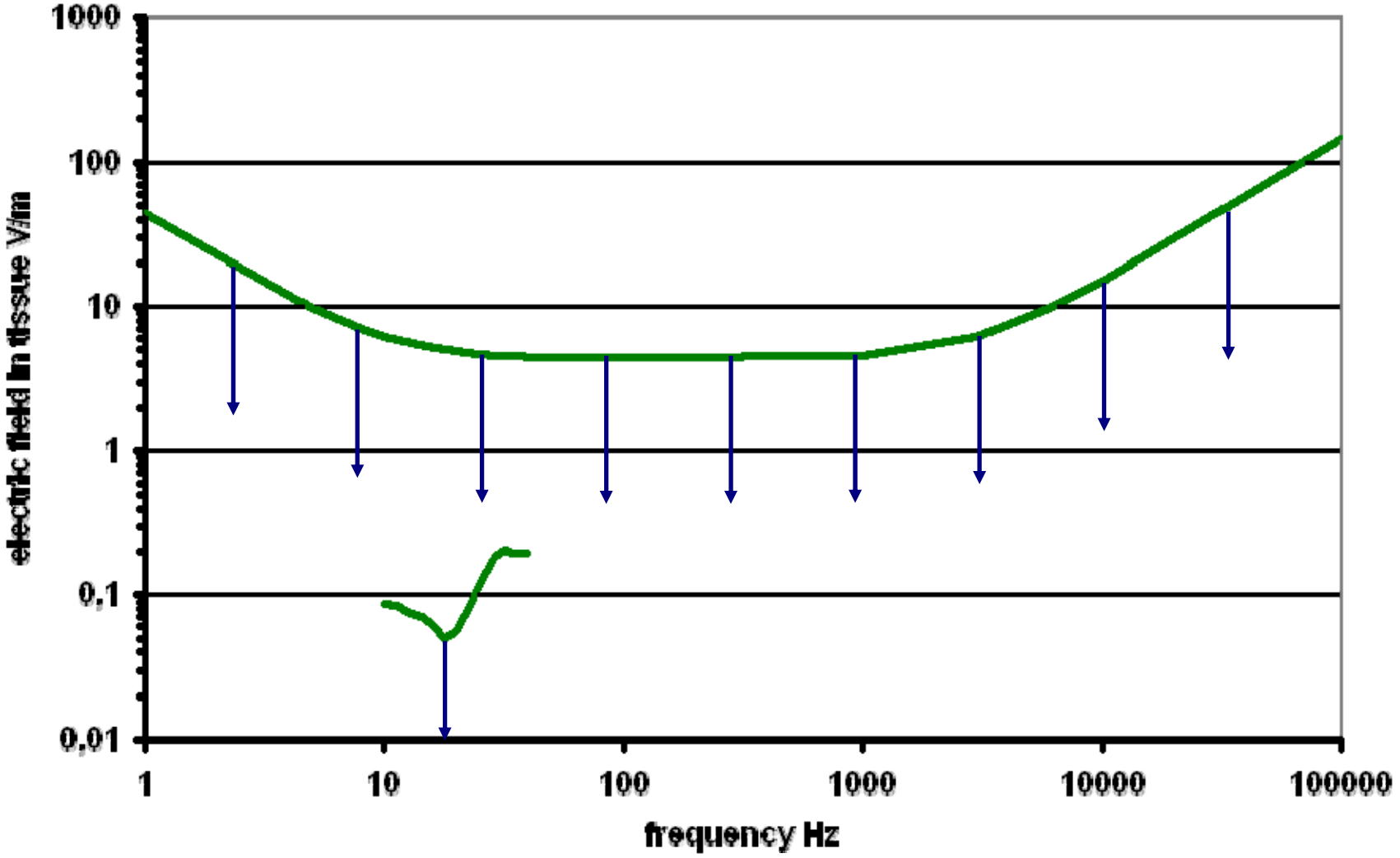
Not considered a basis for quantitatively limiting exposure

May be considered within national risk management

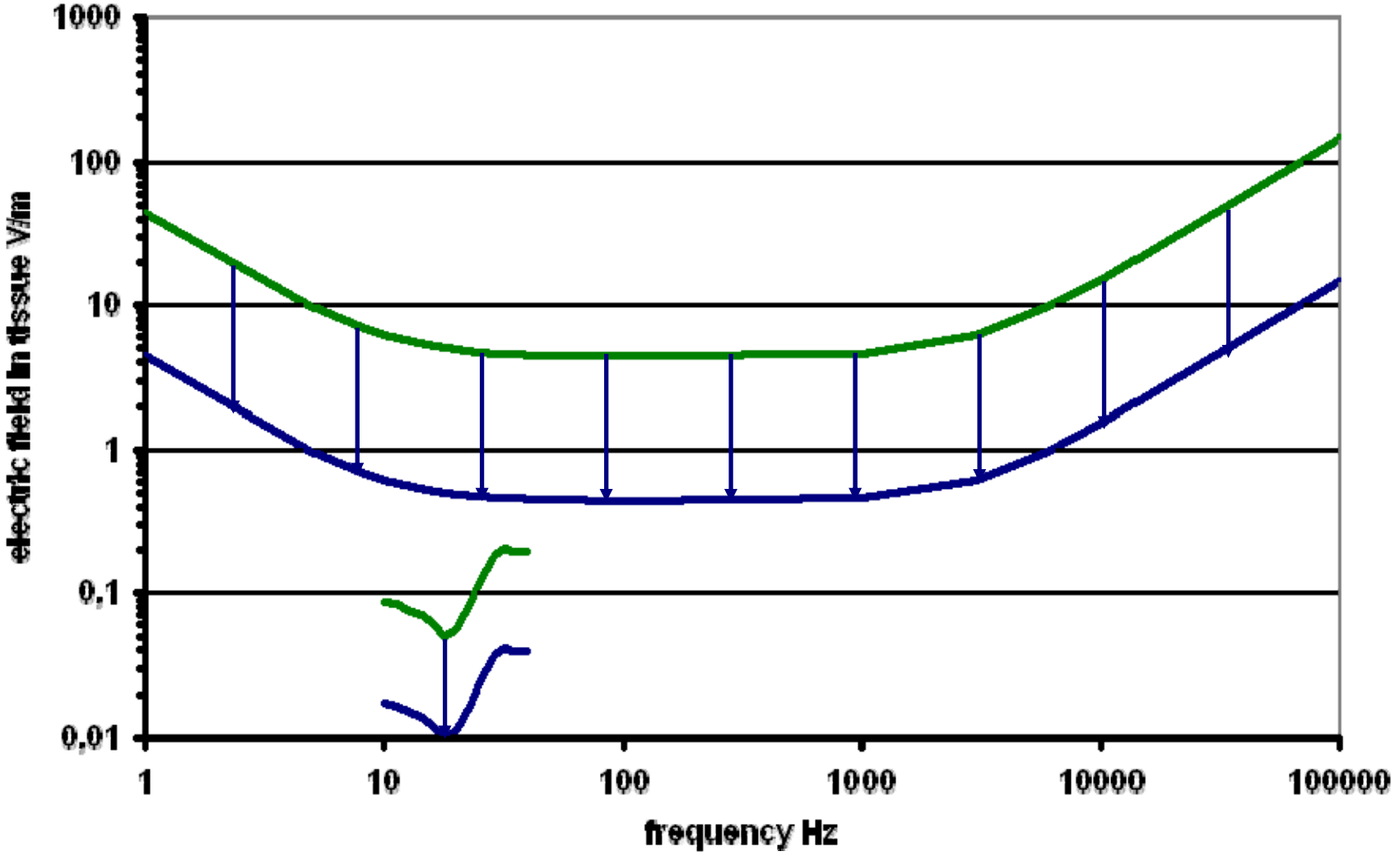
Effect threshold



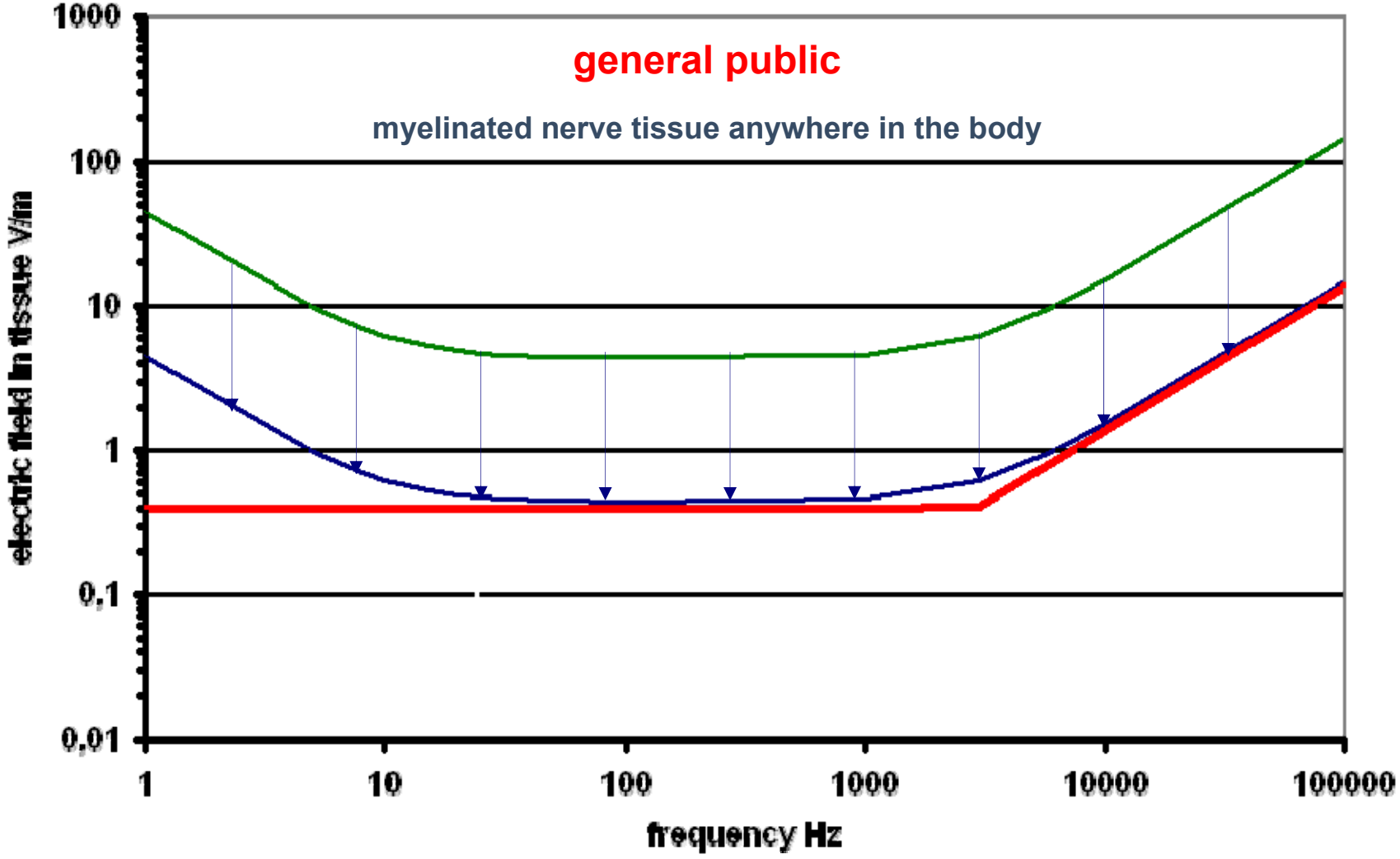
Uncertainties



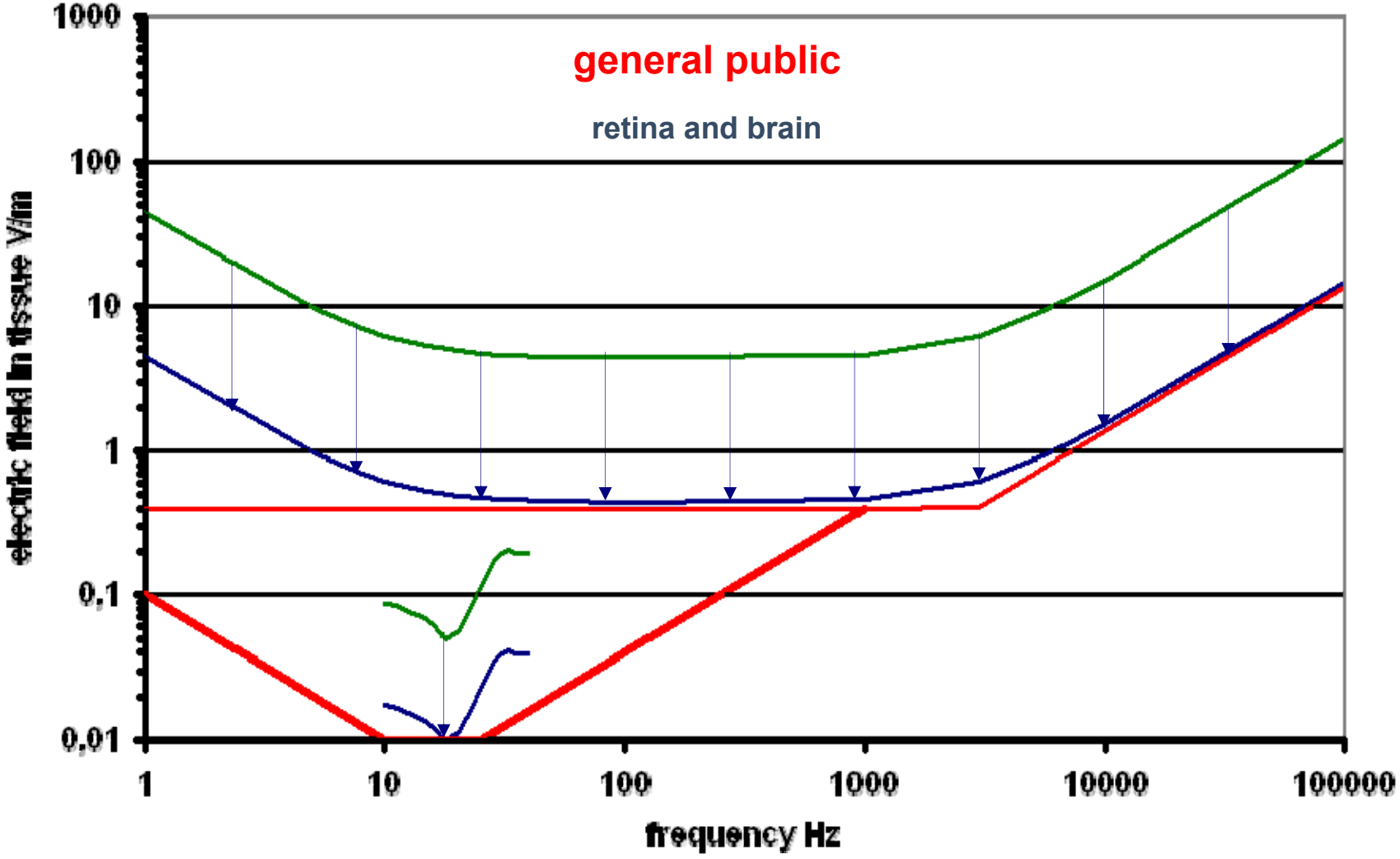
Uncertainties



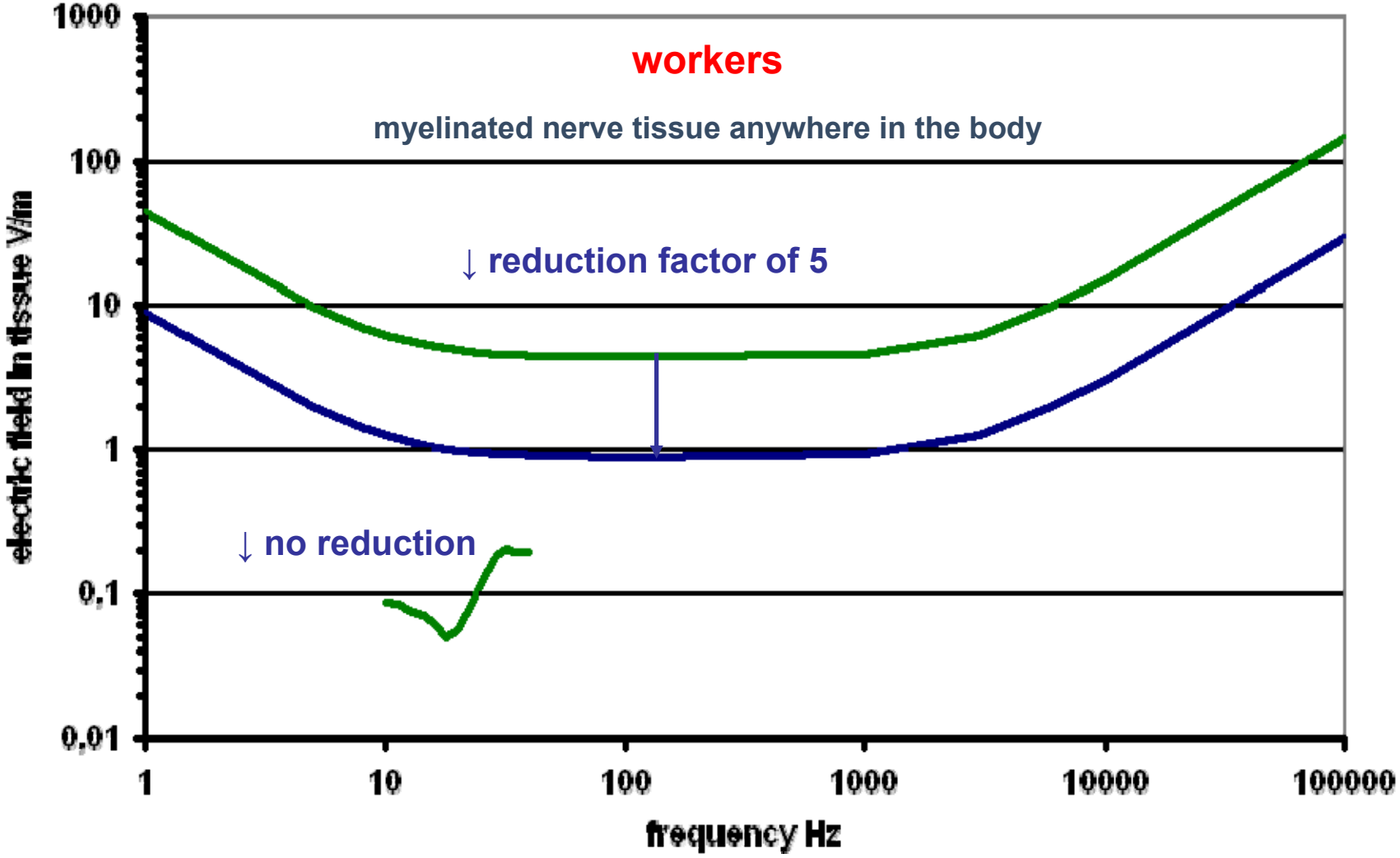
Basic restriction



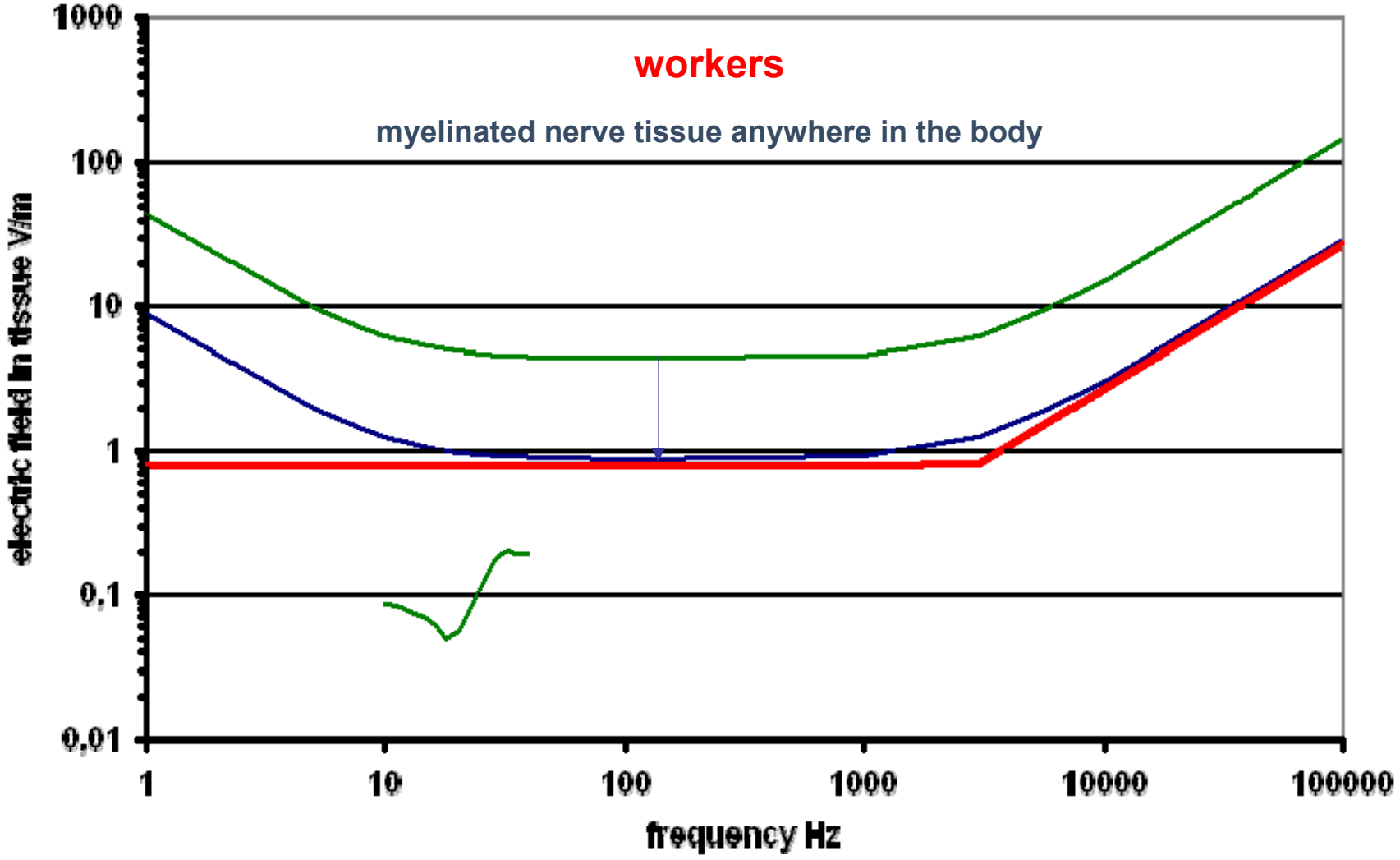
Basic restriction



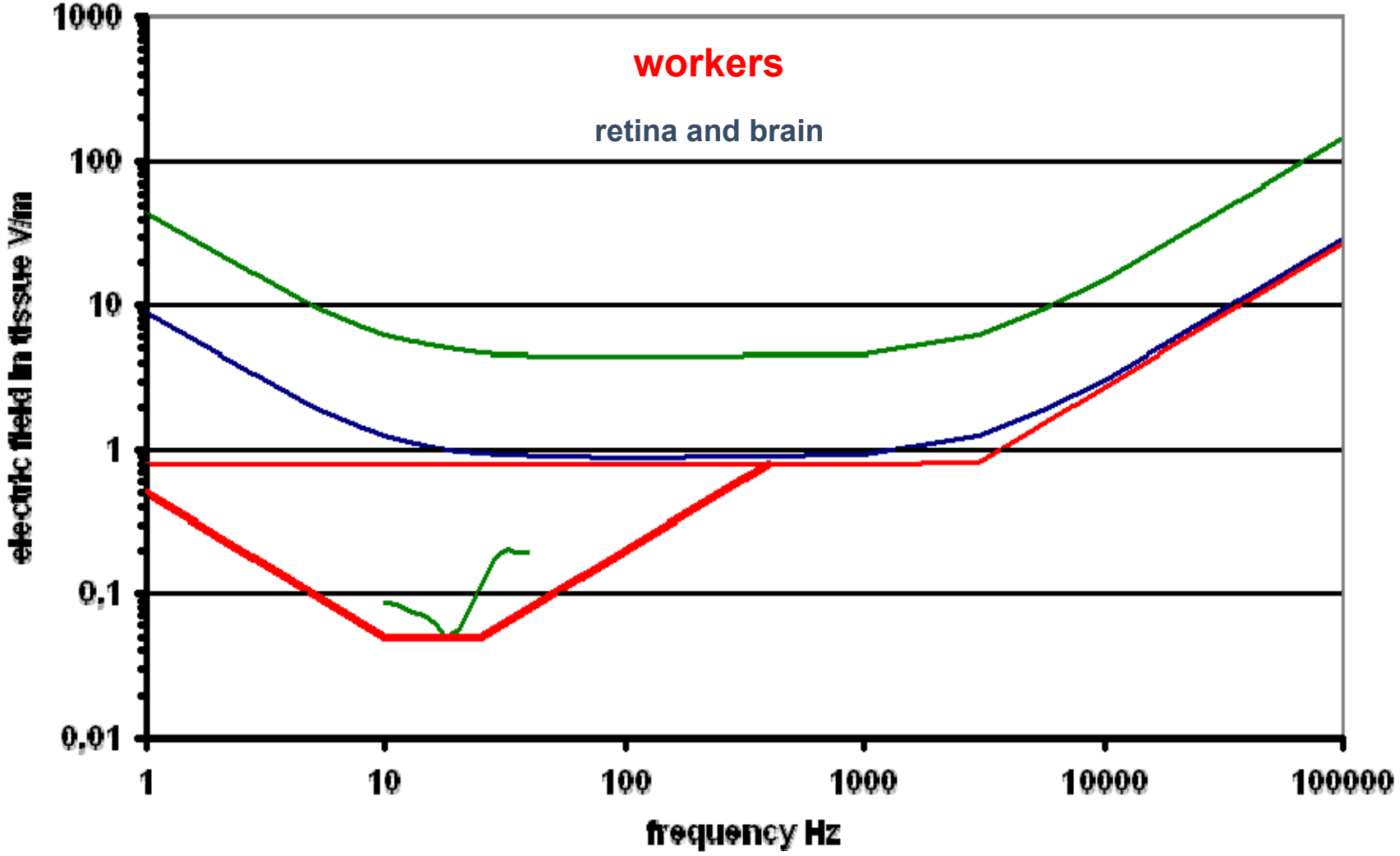
Basic restriction



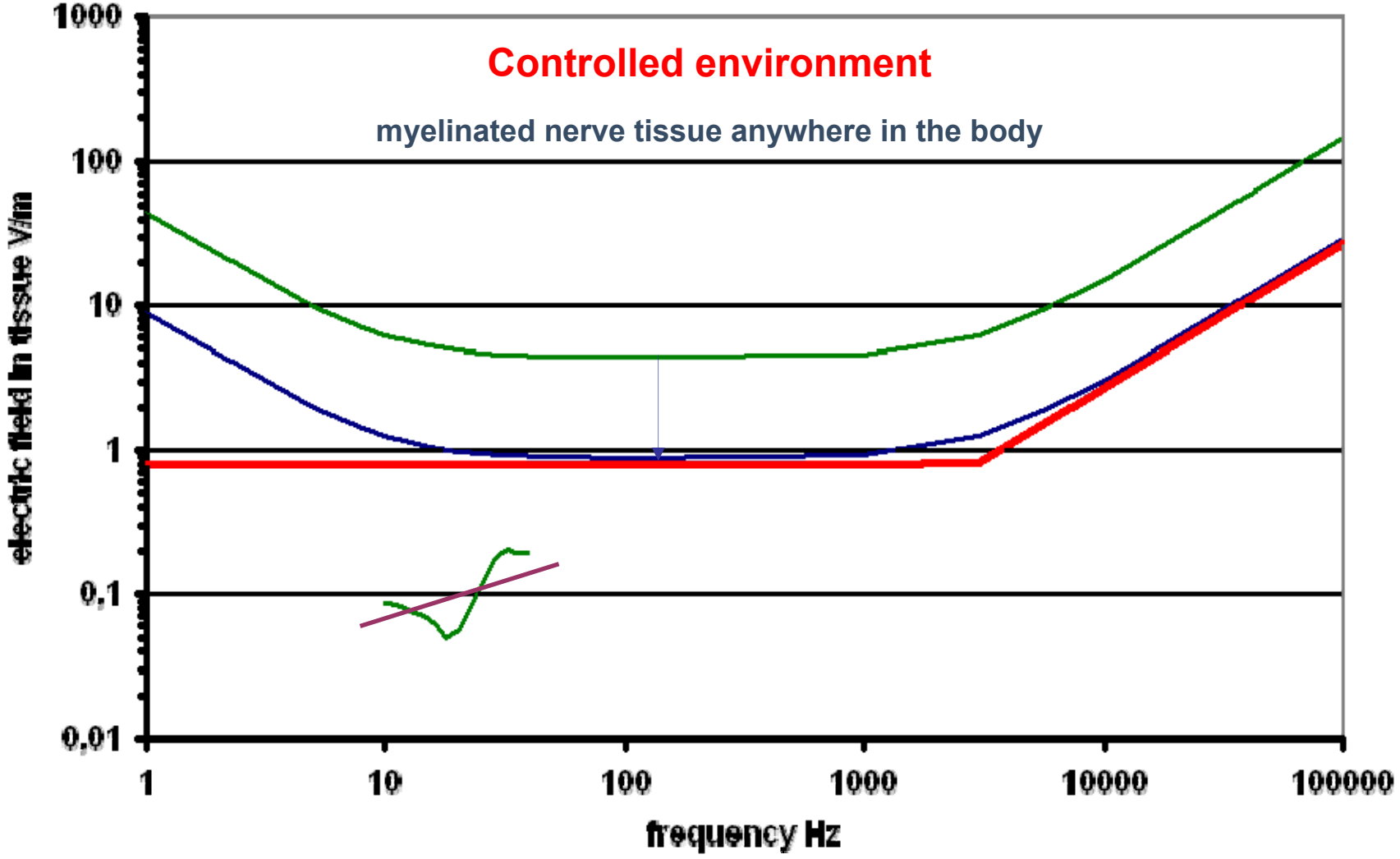
Basic restriction



Basic restriction

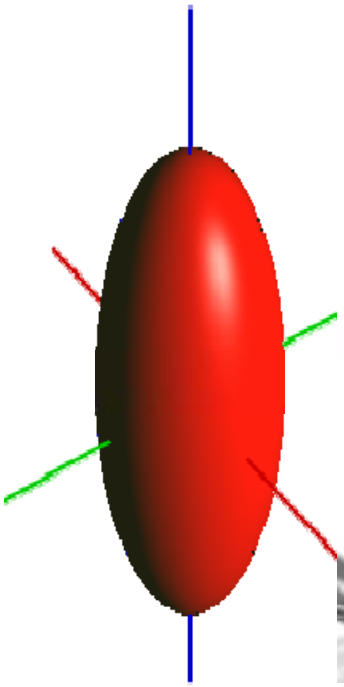


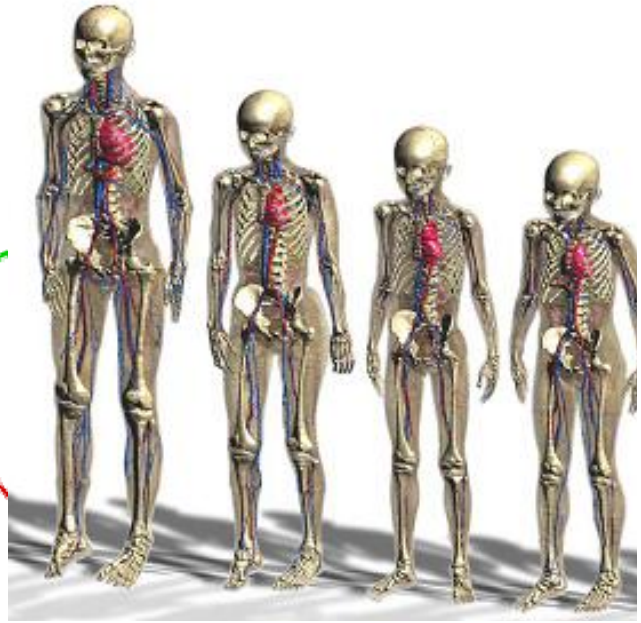
Basic restriction

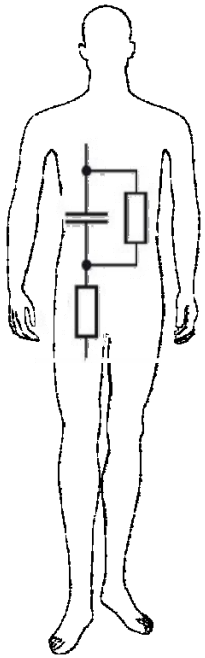


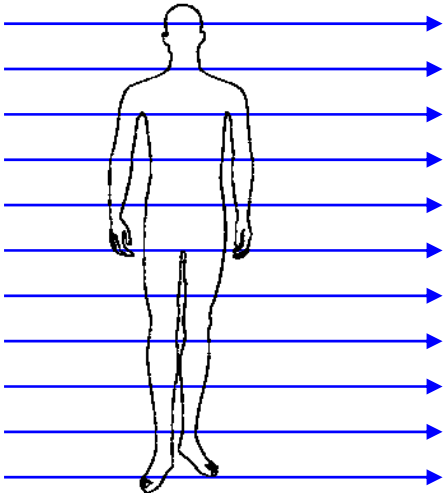
Dosimetric considerations

to derive reference levels







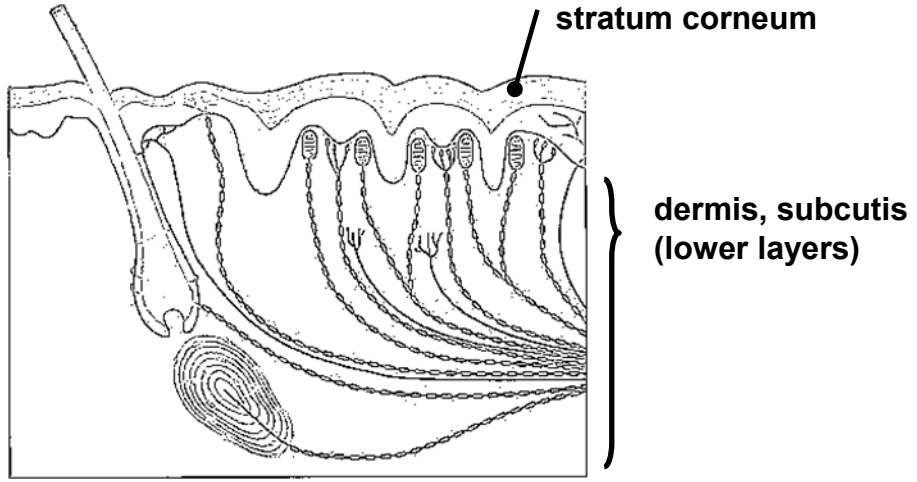


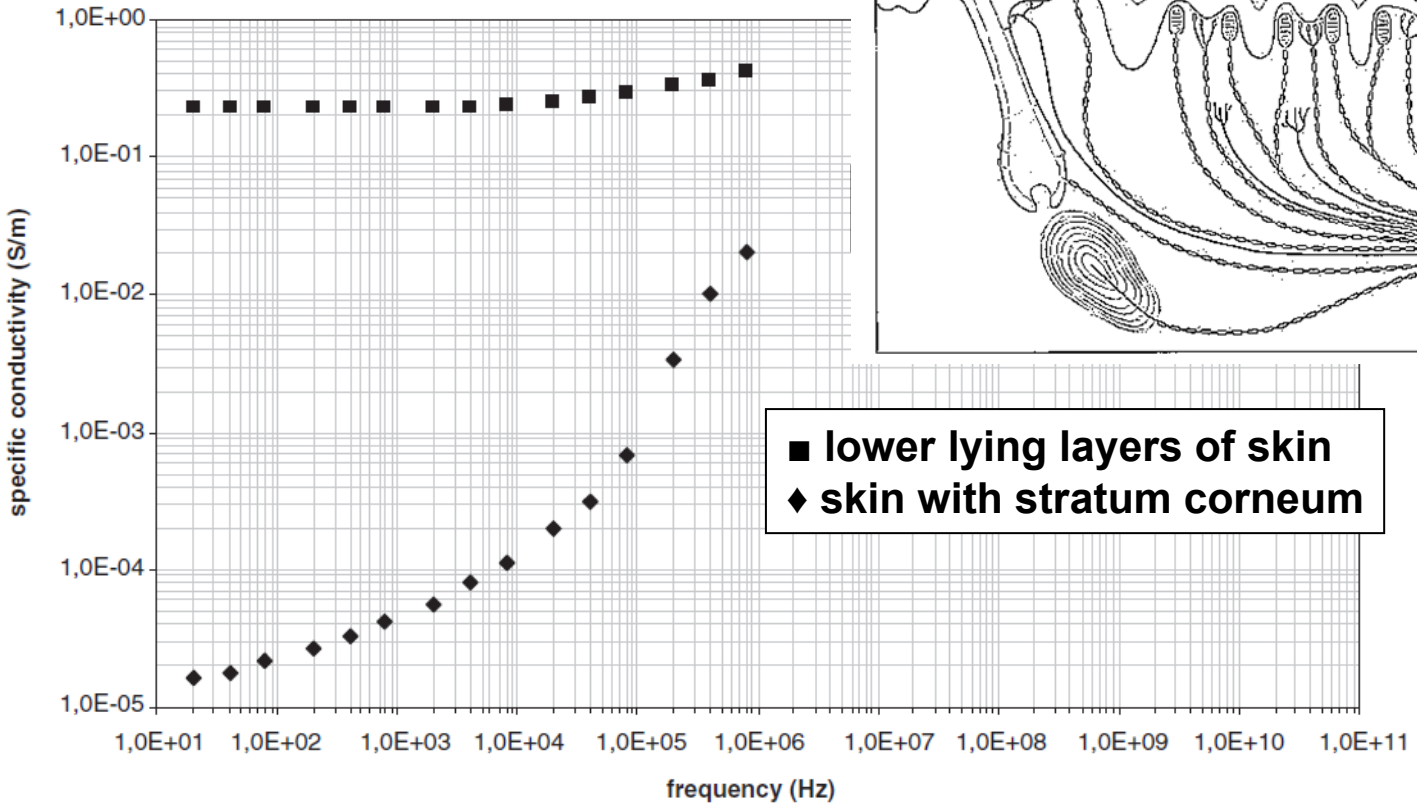
Dielectric properties

* http://niremf.ifac.cnr.it/tissprop/

available for many tissues*

problem skin



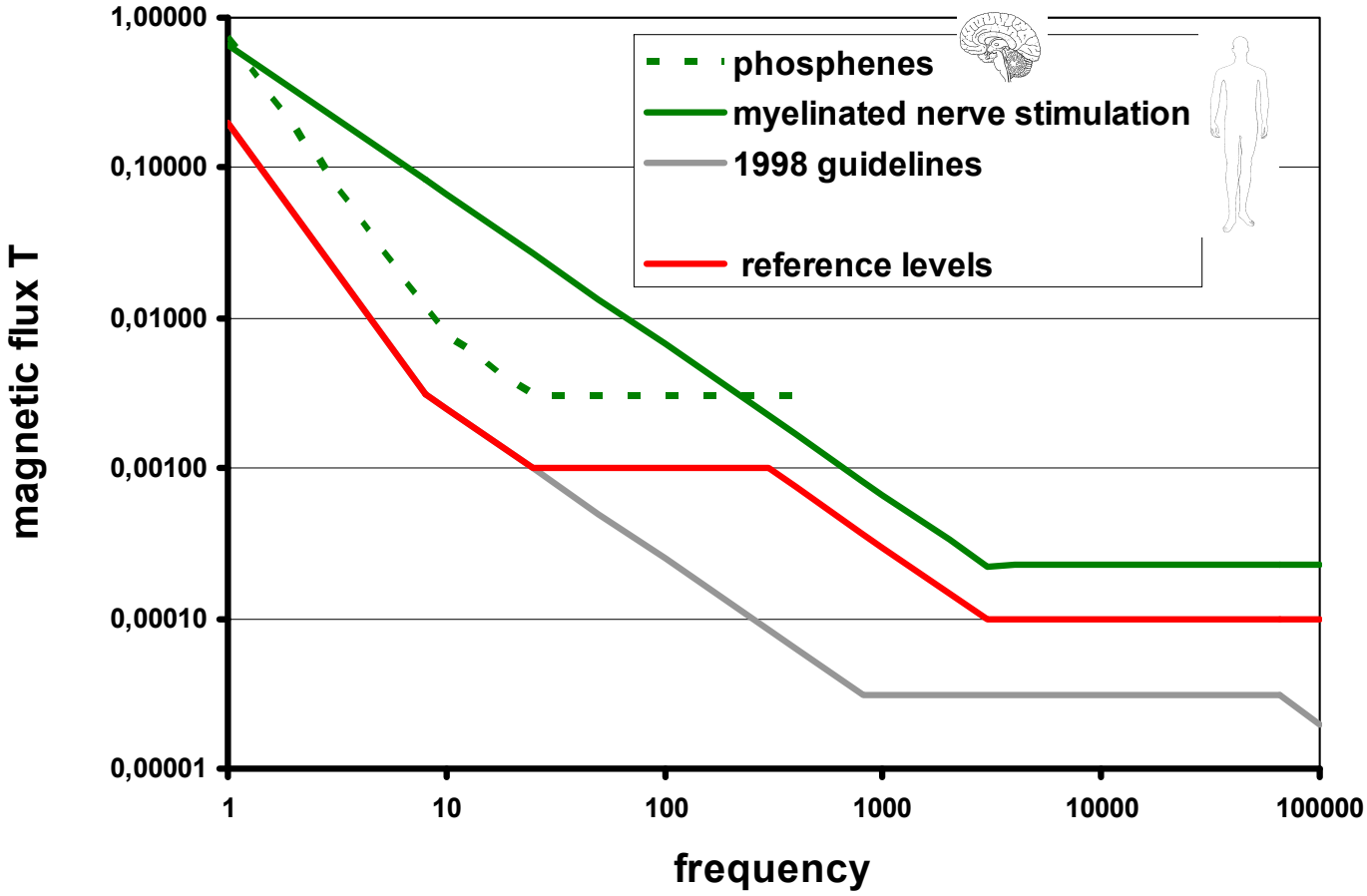


D. MIKLAVCIC, N. PAVSELJ, F. X. HART, ELECTRIC PROPERTIES OF TISSUES, Wiley Encyclopedia of Biomedical Engineering, 2006

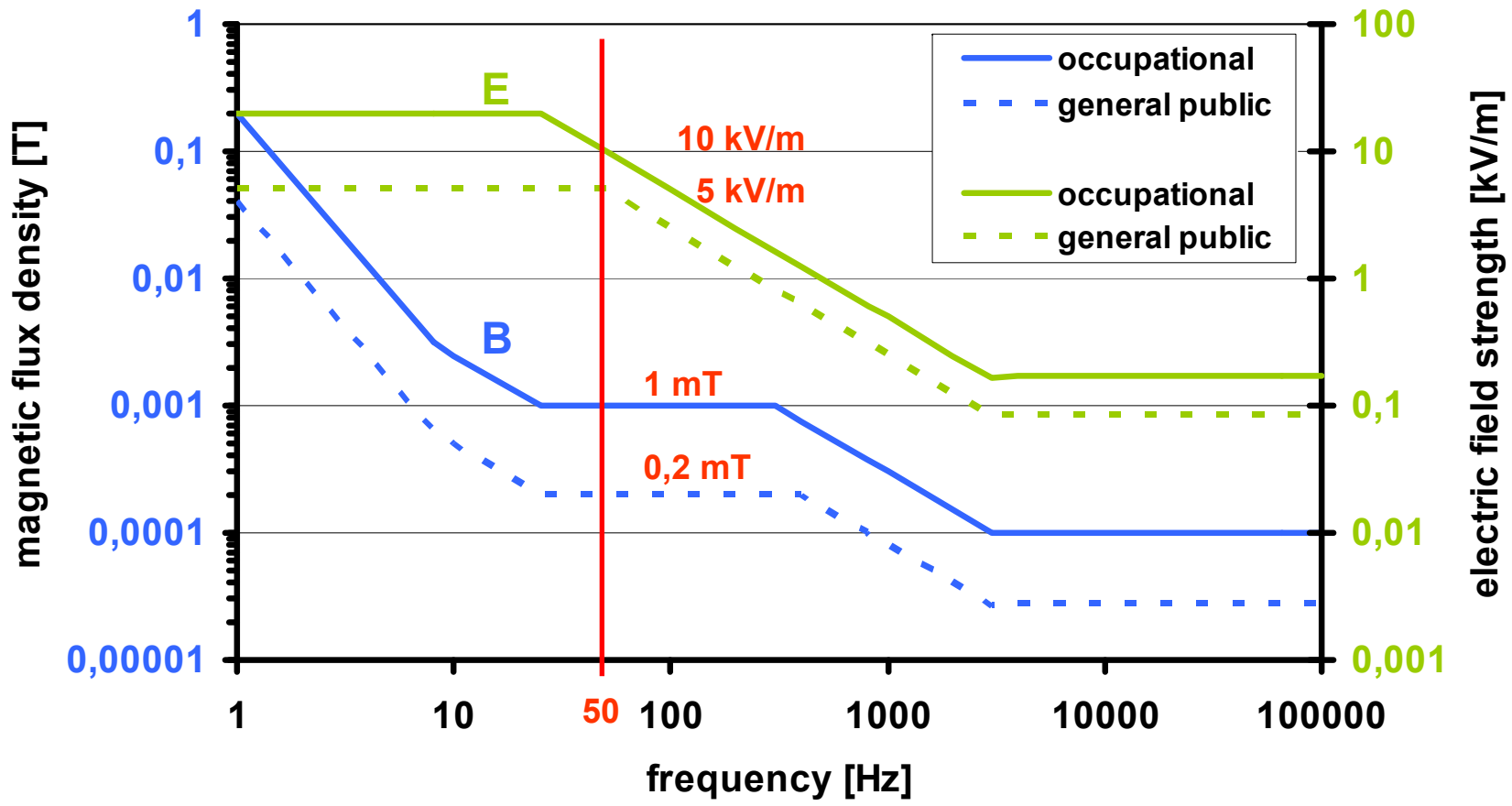
Reference levels

occupational exposure

magnetic field



Reference levels



Additional aspects

Time averaging

basic restrictions are instantaneous values, no time averaging

Spatial averaging of induced electric field

vector average in a contiguous tissue volume of 2 x 2 x 2 mm^3

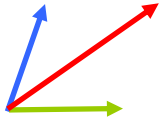
for skin and retina averaging may extend to neighboring tissues

Spatial averaging of external fields

reference levels conservative for localized exposure → basic restriction

spatial averaging appropriate for distant sources (approx. > 20 cm)

Additivity of exposure to electric and magnetic fields



E_i electric

E_i magnetic

E_i total

conservative

very infrequent

Additional aspects

Reference levels for contact currents

to avoid painful shocks →

Exposure characteristics	Frequency range	Maximum contact current (mA)
Occupational exposure	Up to 2.5 kHz	1.0
	2.5–100 kHz	$0.4f$
	100 kHz–10 MHz	40
General public exposure	Up to 2.5 kHz	0.5
	2.5–100 kHz	$0.2f$
	100 kHz–10 MHz	20

Note: f is the frequency in kHz.

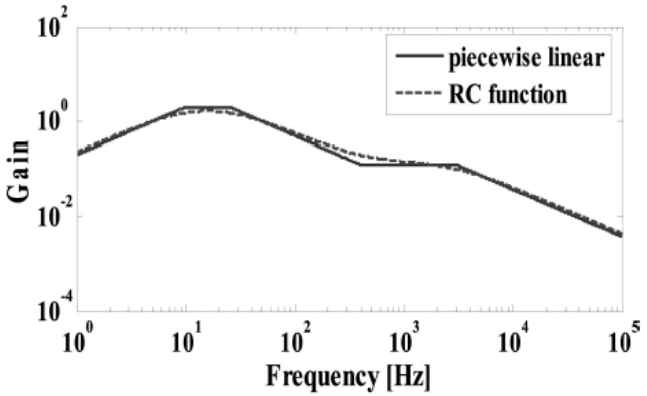
Exposure to multiple frequency fields

$$\sum_{j=1\,Hz}^{10\,MHz} \frac{E_{i,j}}{E_{L,j}} \leq 1 \qquad \sum_{j=1\,Hz}^{10\,MHz} \frac{E_j}{E_{R,j}} \leq 1 \qquad \sum_{j=1\,Hz}^{10\,MHz} \frac{H_j}{H_{R,j}} \leq 1$$

Non sinusoidal exposure

filtering of the waveform in the time domain

refer to peak values



Many thanks for your attention !