ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

Update on the ICNIRP Guidelines

Akimasa Hirata, PhD

Chair, International Commission on Non-Ionizing Radiation Protection (ICNIRP)

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

What is ICNIRP?

- Independet, non-for-profit, non-governmental organisation
- Provide advice relating to the protection of people and the environment from exposure to non-ionizing radiation.
- Originally developed as a commitee within IRPA, Independet Commission since 1992.
- Officially Collaborating with WHO, ILO etc

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

Relevant current EMF guidelines

- Electromagnetic fields
  - Static magnetic field (2009)
  - Low frequency (1 Hz – 100 kHz) (2010)
  - High frequency (100 kHz – 300 GHz) (2020)
- Optical radiation
  - Visible and infrared radiation (up to 3000 µm) (2013)
  - Laser radiation (180 nm – 1000 µm) (2013)

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

WorkPlan (2024-2028)

Project Groups (PG) (2020-2024)

- Chronic UV Exposure
- Environment and EMFs
- RF Knowledge Gaps (Published in 2025)
- LF guidelines (< 10 MHz)
- LF dosimetry review

Newly established PG and Standing Committee for 2024-2028

- Standing Committee on Communication
- Sub-THz Gap (Difference of optical radiation and EMF guidelines)
- Protection System
- Acute UV Exposure

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

Published in *Health Physics Journal* (2025)
Project was led by C. Marino

RF Data Gap (1) -from abstract-

- During the development of ICNIRP's 2020 radiofrequency EMF guidelines (ICNIRP 2020a) some gaps in the available data were identified.
- To encourage further research into knowledge gaps in research that would, if addressed, assist ICNIRP in further developing guidelines and setting revised recommendations on limiting exposure, data gaps that were identified during the development of the 2020 radiofrequency EMF guidelines,
- This process and resultant recommendations were not intended to duplicate more traditional research agendas, whose focus is on extending knowledge in this area more generally but was tightly focused on identifying the highest data gap priorities for guidelines development more specifically.
- The present data gap recommendations do not include some gaps in the literature that *in principle* could be relevant to radiofrequency EMF health, but which were excluded because either the link between exposure and endpoint, or the link between endpoint and health, was not supported sufficiently by the literature.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

RF Data Gap (2)

- **Pain threshold for radiofrequency EMF heating**

….. further studies with radiofrequency EMF exposure are warranted, including those designed to determine the impact of rate of radiofrequency EMF-induced temperature rise on pain, and the effect of spatial extent and duration of exposure on pain.

- **Core temperature rise and health effects**

… we here recommend further research to better characterize the radiofrequency EMF-whole body heating relation from 100 kHz to 300 GHz, including consideration of exposure duration and multi-frequency exposures. This would ideally utilize measurements, but as the number of exposure scenarios that can be experimentally tested is limited, computational studies are needed to extrapolate across the range of scenarios/frequencies. The computational models for thermoregulation are mainly derived for healthy adults (Stolwijk, 1971, Fiala et al., 2001, Moore et al., 2015), and thus additional investigations with models of children and elderly are also needed, which may be useful to set or confirm reduction factors.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

RF Data Gap (3)

- **Ocular injury and function**

….. Human data would be most useful, but experiments at high exposure levels are likely not feasible given ethical considerations. So, animal models analogous to humans with respect to morphology are here recommended. Computational dosimetric studies of temperature rise in the human eye are also recommended.

- **Pain from contact current**

Further clarifications are needed regarding the effect of grounding condition, contact area and location on the body in terms of pain thresholds; computational and experimental dosimetry studies to clarify the influence of amplitude of contact current, contact area, exposure time, internal electric field, SAR, and temperature rise, as a function of field strength, are therefore recommended.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

RF Data Gap (4)

-Comments on topical issues for which data gaps are not identified-

- **Oxidative stress**
- **Symptoms, well-being, and IEI-EMF**
- **Blood Brain Barrier (BBB) integrity and Brain physiology and function**
- **Neurodegenerative disorders**
- **Brain physiology and function**
- **Vestibular function**
- **Auditory function**
- **Male fertility, reproduction and embryo/fetus development**
- **Cancer**

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

RF Data Gap (5) -Comments on Dosimetry-

Primary changes in 2020 guidelines

1) The absorbed power density averaged over 4 cm^2 has been introduced as a basic restriction above 6 GHz for local exposures….

2) A reference level for local exposure has been introduced (in addition to that for whole-body exposures, which was already set in the 1998 ICNIRP guidelines).

3) The frequency range of the limb current restriction has been extended to be from 100 kHz to 110 MHz (which was 10 MHz to 110 MHz in the 1998 ICNIRP guidelines).

4) A limit for brief exposure was introduced.

Related to all the dosimetry items listed above, present models and techniques mostly focus on healthy adults, although some dosimetry on children and pregnant women has been reported. Further exploration of the effects of age, gender and other morphological differences on these models and their outcomes, would be of great benefit for the derivation of reduction factors in future guidelines.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

RF Data Gap (6) -From Summary of the document-

For biological outcomes where effects have not been substantiated, we did not find sufficient plausible evidence that radiofrequency EMF might cause harm below currently established thresholds. This does not imply that there are no open scientific questions.

For instance, studies on oxidative balance and brain physiology repeatedly observed effects (although not consistently). Without knowledge of the underlying mechanism this is unlikely to influence guidelines development.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

Update of LF Guidelines

- Currently, four reviews are on-going for guidelines development

1. Epidemiology
2. In-vitro and in-vivo
3. Human study
4. Dosimetry (to be submitted to Health Physics in 2026)

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

Table of Content in LF Dosimetry Review

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

The rational for Sections 2 and 3

From ICNIRP 2010

relevant for CNS effects, and the induced electric fields in non-CNS tissues anywhere in the body, relevant for PNS effects (i.e., at 50 Hz, the factor used to convert the basic restriction for CNS effects to an external magnetic field exposure is 33 V m^{-1} per T, and for PNS effect 60 V m^{-1} per T. An additional reduction factor of 3 was applied to these calculated values to allow for dosimetric uncertainty).

Spatial averaging of induced electric field

When restricting adverse effects of induced electric fields to nerve cells and networks, it is important to define the distance or volume over which the local induced electric field must be averaged. As a practical compromise, satisfying requirements for a sound biological basis and computational constraints, ICNIRP recommends determining the induced electric field as a vector average of the electric field in a small contiguous tissue volume of $2 \times 2 \times 2$ mm^3. For a specific tissue, the 99^{th} percentile value of the electric field is the relevant value to be compared with the basic restriction.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

2. Dielectric Properties of Tissues

- The variation reported in different reports would be attributable to the difference between in vitro and in vivo measurement, room temperature, time after excision, tissue surface condition. **The standard deviation of conductivity** measurements for biological tissues at lower frequencies was generally 10 % or higher.
- **Brain:** One potential reason was suggested to be the surface condition of the brain in the measurement.
- **Skin:** There exists a significant variation in conductivity among the individual layer.
- **Muscle**: The anisotropy is the most variable factor. A few studies reported **more than twice higher** conductivities for longitudinal direction than that for transverse direction.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

3. Computational Artifact in LF dosimetry

- The absence of post-processing can lead to overestimation of in situ electric fields when using peak values, particularly due to computational artifacts.
- Although several mitigation methods such as percentile filtering and spatial averaging have been proposed, none offer a universal solution, especially under non-uniform exposure conditions.
- Case-specific approaches may therefore be required. These challenges also reflect the inherent limitations of human models with finite size and resolution, including inaccuracies in tissue conductivity assignment and modeling of skin contact, which collectively contribute to the uncertainty in low-frequency dosimetry.

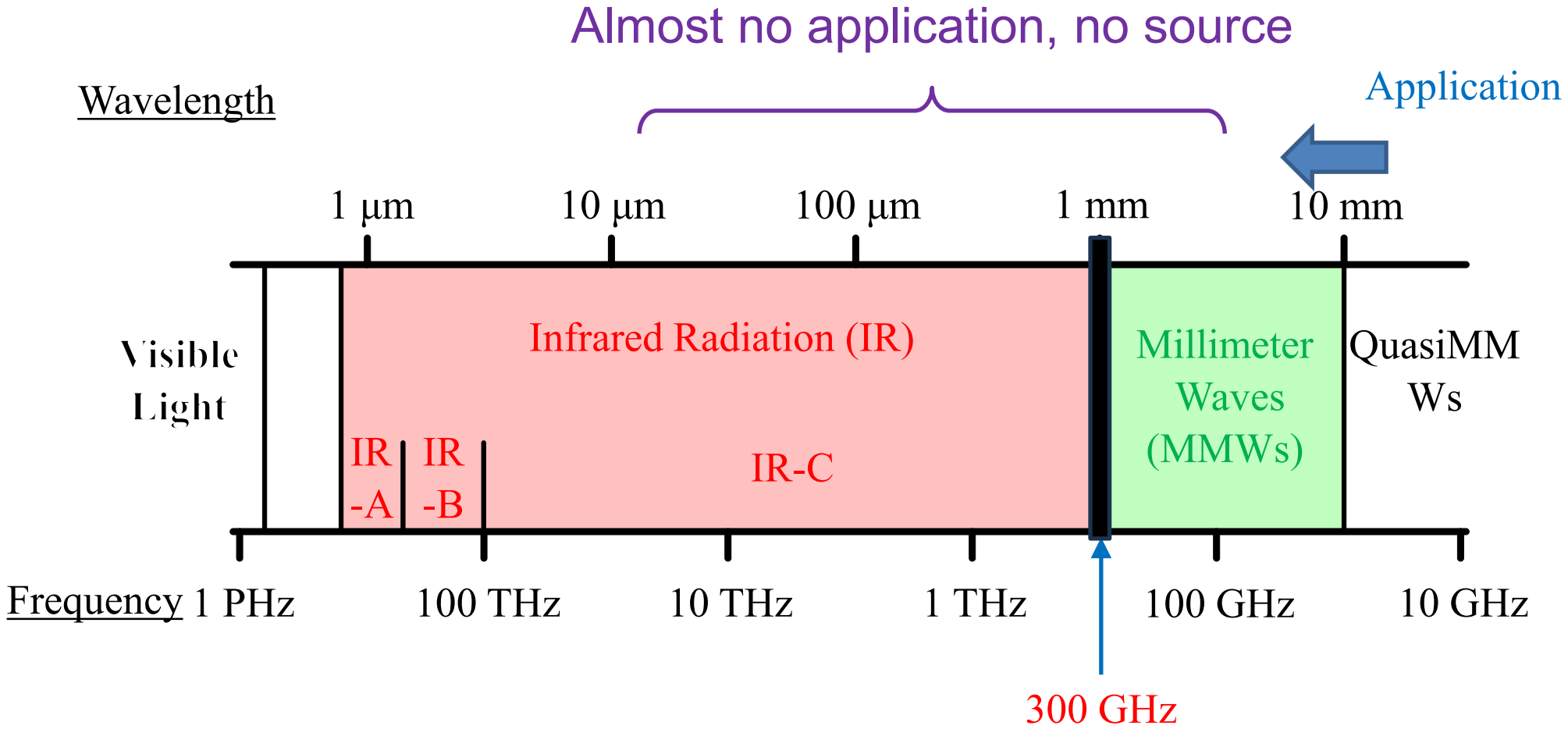
ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

The rationale for Sections 4 and 5

- Most studies assume **ideal exposure conditions** (human standing in free space)
- To quantify the relationship between external field strength and internal (induced) field strength.
- This directly corresponds to the derivation of reference level from the basic restriction.
- Additional effort is needed for derivation of threshold of pain or sensation, corresponding to induced electric field, which is directly associated with pain or sensory effect.

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

Sub-THz Gap (Gap at 300 GHz)



ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

Objective

To summarize the difference between the IR and MMW guidelines

Contents

- Guidelines for IR and RF
- Comparison between the IR and RF guidelines
- Issues to be considered when potentially harmonizing the IR and MMW guidelines

Statement

- To be published in 2027 or 2028.