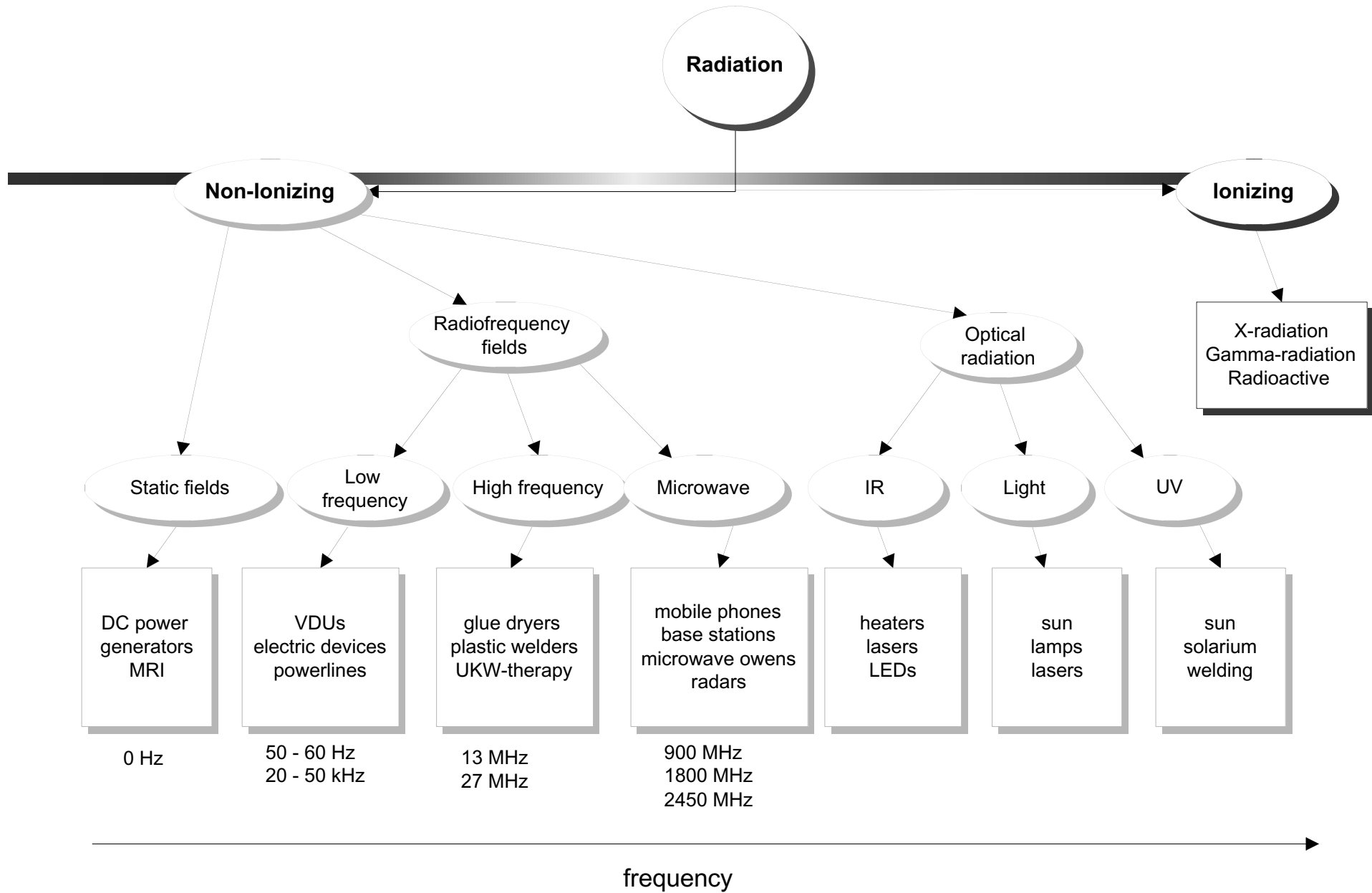

Overview of Effects and Protection of Non-Ionizing Radiation

Maila Hietanen, Professor
Finnish Institute of Occupational Health
Helsinki, Finland



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ICNIRP



- ◆ International Commission on Non-Ionizing Radiation Protection
- ◆ Independent scientific organization
- ◆ Provides guidance and advice on the prevention of health hazards of non-ionizing radiation
- ◆ 13 invited members
- ◆ 4 Standing Committees covering:
 - Epidemiology - Biology
 - Physics - Optical radiation
- ◆ <http://www.icnirp.de>

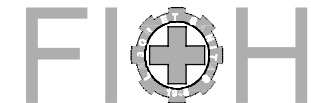
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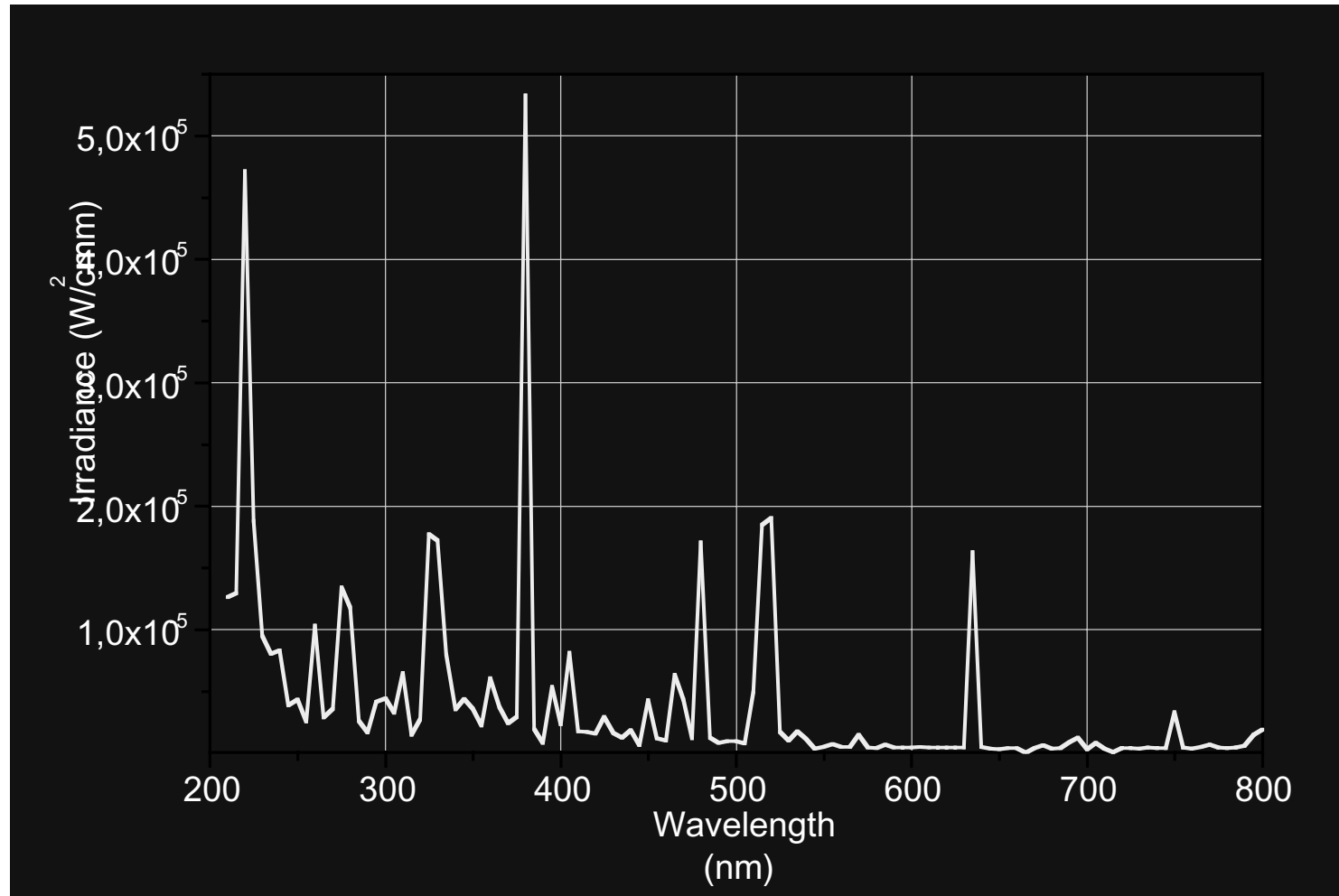
Spectral ranges and health effects of optical radiation

Spectral range	Wavelength range	Ocular effects	Skin effects
UV-C	100 - 280 nm	Photokeratitis	Erythema
UV-B	280 -315 nm	Photokeratitis	Erythema Skin cancers
UV-A	315 - 400 nm	Photochemical cataract	Skin cancers
Visible	400 - 770 nm	Retinal injury	
IR-A	770 nm - 1.4 m	Retinal injury Thermal cataract	Skin burn
IR-B	1.4 - 3 m	Corneal burn	Skin burn
IR-C	3 m - 1 mm	Corneal burn	Skin burn

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Spectral irradiance of arc-jointing process (zinc coated steel)



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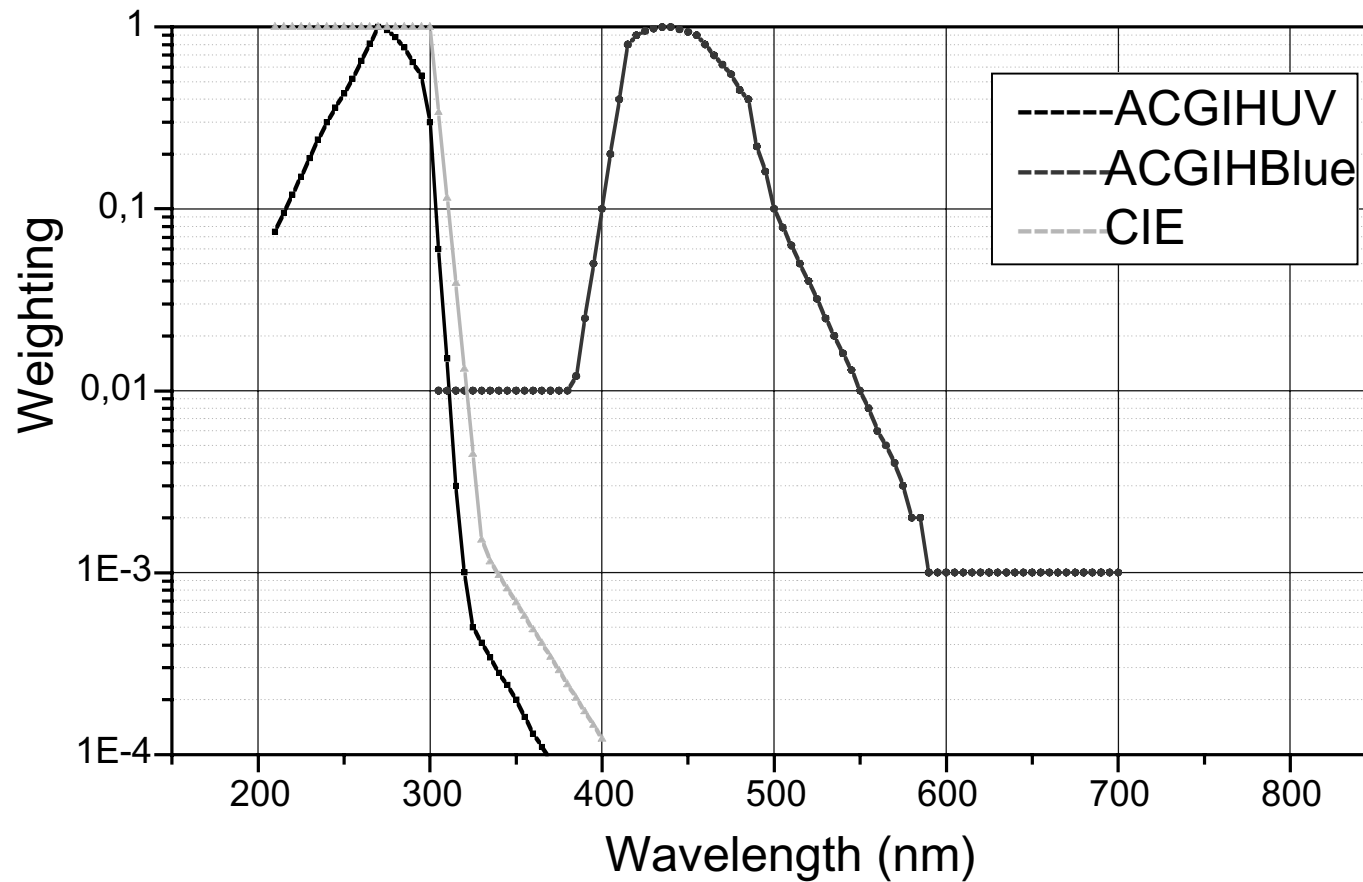
Exposure guidelines for optical radiation

- ◆ ACGIH TLVs for visible light, IR and UV radiation (occupational)
- ◆ ICNIRP guidelines for
 - UV radiation (180 - 400 nm)
 - laser radiation (180 nm - 1000 nm; 400 nm - 1.4 μm)
 - broad-band optical radiation (0.38 to 3 μm)

Visible radiation (light)

- ◆ Detailed data on spectral radiance or spectral irradiance required if the luminance of the source $> 1 \text{ cd/cm}^2$
- ◆ Photochemical and thermal hazards shall be considered separately
- ◆ Weighting functions: B_λ for "blue-light" and R_λ for "burn hazard"

Spectral weighting curves



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SED for UV

- ◆ Standard Erythemal Dose (SED)
- ◆ Equivalent to 100 Jm^{-2} of any source, efficiency normalised at 297 nm
- ◆ Examples:
 - 3 SED correspond to non-painful erythema
 - 6 SED is painful
 - 10 SED is lethal for many epidermal cells or corneal epithelium

UV Index (UVI)

- ◆ Measure of the solar UV radiation levels relevant to health effects
- ◆ Used for public information
- ◆ Dimensionless number
 - maximum at Equator 15
 - in Australia up to 11
 - in Finland up to 7

Effects on the retina

- ◆ Thermal injury to the retina (400 - 1400 nm)
 - scotoma (blind spot)
 - lasers or intense xenon-arc sources
- ◆ Blue-light photochemical injury to the retina (400 - 550 nm)
 - photoretinitis ("eclipse blindness")
 - welding arcs
 - sun
 - photofloods

Effects on the lens and cornea

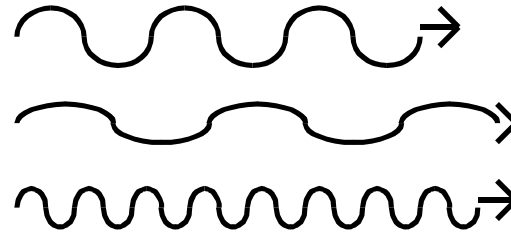
- ◆ Near-infrared thermal hazards to the lens (800 - 3000 nm)
 - average corneal exposure in sunlight 10 W/m²
 - exposure of glass and steel workers 0.8 - 4 kW/m²

- ◆ Thermal injury of the cornea and conjunctiva (1400 nm - 1 mm)
 - laser radiation exposure

Laser radiation



Lamp



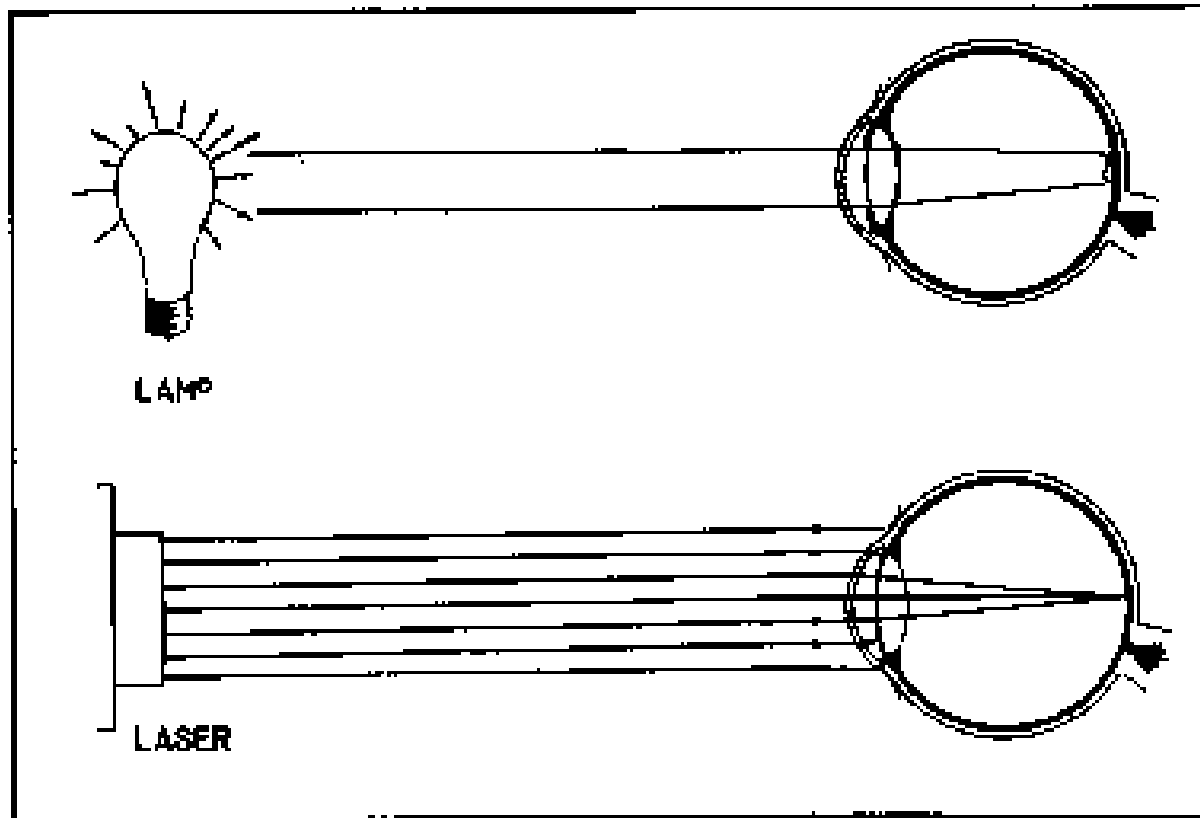
Incoherent



Laser

Coherent, monochromatic

Image formation on the retina



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Laser applications

- ◆ Construction
 - alignment laser (tunnels, pipes)
 - distance measurement
- ◆ Manufacturing
 - material processing (mirowelding, surface treating)
 - printing plates
- ◆ Medical facilities
- ◆ Consumer and office products
 - laser displays (sound and light shows)
 - laser point-of-sale terminals
 - office machines (printers, data recording)
- ◆ Military
- ◆ Research

Characteristics and applications of various types of laser

Active medium	Examples	Wavelengths (nm)	Applications
Gas	He-Ne	543.5, 632.8, 1152.6	Alignment, barcode scanning, printing, measurement
	CO ₂	10 600	Cutting, welding, surgery
	Argon-ion	488, 514.5	Entertainment, surgery, printing, measurement
Liquid	Dye lasers	310-1200 dye dependent	Entertainment, medical diagnosis, measurement
Solid	Neodymium: YAG	1064, 532	Cutting, welding, entertainment, surgery
	Ruby	694.3	Holography, surgery
Semiconductor	Various	600-29 000	Communicatins, pointers, compact disc palyers

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NORME
INTERNATIONALE
INTERNATIONAL
STANDARD

CEI
IEC
825-1

Première édition
First edition
1993-11

PUBLICATION GROUPEE DE SÉCURITÉ
GROUP SAFETY PUBLICATION

Sécurité des appareils à laser –

Partie 1:
Classification des matériels, prescriptions
et guide de l'utilisateur

Safety of laser products –

Part 1:
Equipment classification, requirements
and user's guide



Numéro de référence
Reference number
CEI/IEC 825-1: 1993

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Typical values of electric and magnetic fields

Source	Distance	Electric field strength	Magnetic flux density
400 kV power lines	25 m from midline	1 - 10 kVm ⁻¹	8 - 40 T
Electrical appliances	30 cm	10 - 250 Vm ⁻¹	0.01 - 30 T
Background fields at home and in offices	Ambient levels	1 - 10 Vm ⁻¹	0.01 - 1 T
TVs and VDUs	30 cm	1 - 10 Vm ⁻¹	up to 0.2 T

Sources of RF exposure

Source	Frequency	Distance	Exposure	Power
LF radio	130-285 kHz	300 m	90 V/m	1.8 MW
MF radio	415-1606.5 kHz	50 m	450 V/m	1.8 MW
HF radio	3.95-26.1 MHz	50 m 220 m	121 V/m 27.5 V/m	750 kW
Walkie-Talkie	27 MHz	5cm	< 1000 V/m < 0.2 A/m	several Watts
UHF TV	470-890 MHz	1.5 km	< 5 mW/m ²	< 5 MW
VHF TV	47-68 MHz 174-230 MHz	1.5 km	< 20 mW/m ²	100 - 300 kW

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Sources of RF exposure (continued)

Source	Frequency	Distance	Exposure	Power
FM stations	87.5-108 MHz	1.5 km	< 50 mW/m ²	< 100 kW
Microwave oven	2.45 GHz	5 cm 1 m	< 10 W/m ² < 0.25 mW/m ²	
Security systems	0.9-10 GHz	within system	< 2 mW/m ²	
Radar stations	1-10 GHz	0.1-1 km < 1 km	0.1-10 W/m ² < 0.5 W/m ²	0.2-20 kW
Traffic radar	9-35 GHz	3 m 10 m	< 250 mW/m ² < 10 mW/m ²	0.5 - 100 mW

ICNIRP

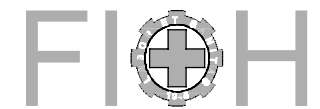
- ◆ Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)
- ◆ Statement on Health issues related to the use of hand-held radiotelephones and base transmitters

ICNIRP - Basic restrictions

Frequency	Parameter	Effect
1 Hz - 10 MHz	Current density, Am^{-2}	Effects on nervous system
100 kHz - 10 GHz	SAR, Wkg^{-1}	Whole-body heat stress and localized tissue heating
10 - 300 GHz	Power density, Wm^{-2}	Heating in tissue at or near the body surface



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Basic restrictions for general public exposure (10 MHz - 10 GHz)

	Whole-body average SAR (W/kg)	Localized SAR (head and trunk) (W/kg)	Localized SAR (limbs) (W/kg)	Averaging time (min)	Averaging mass (g)
ICNIRP	0.08	2	4	6	10
EC Council	0.08	2	4	6	10
ANSI/ IEEE	0.08	1.6	1.6	30	1
TTC/MPT (Japan)	0.08	2	4	6	10

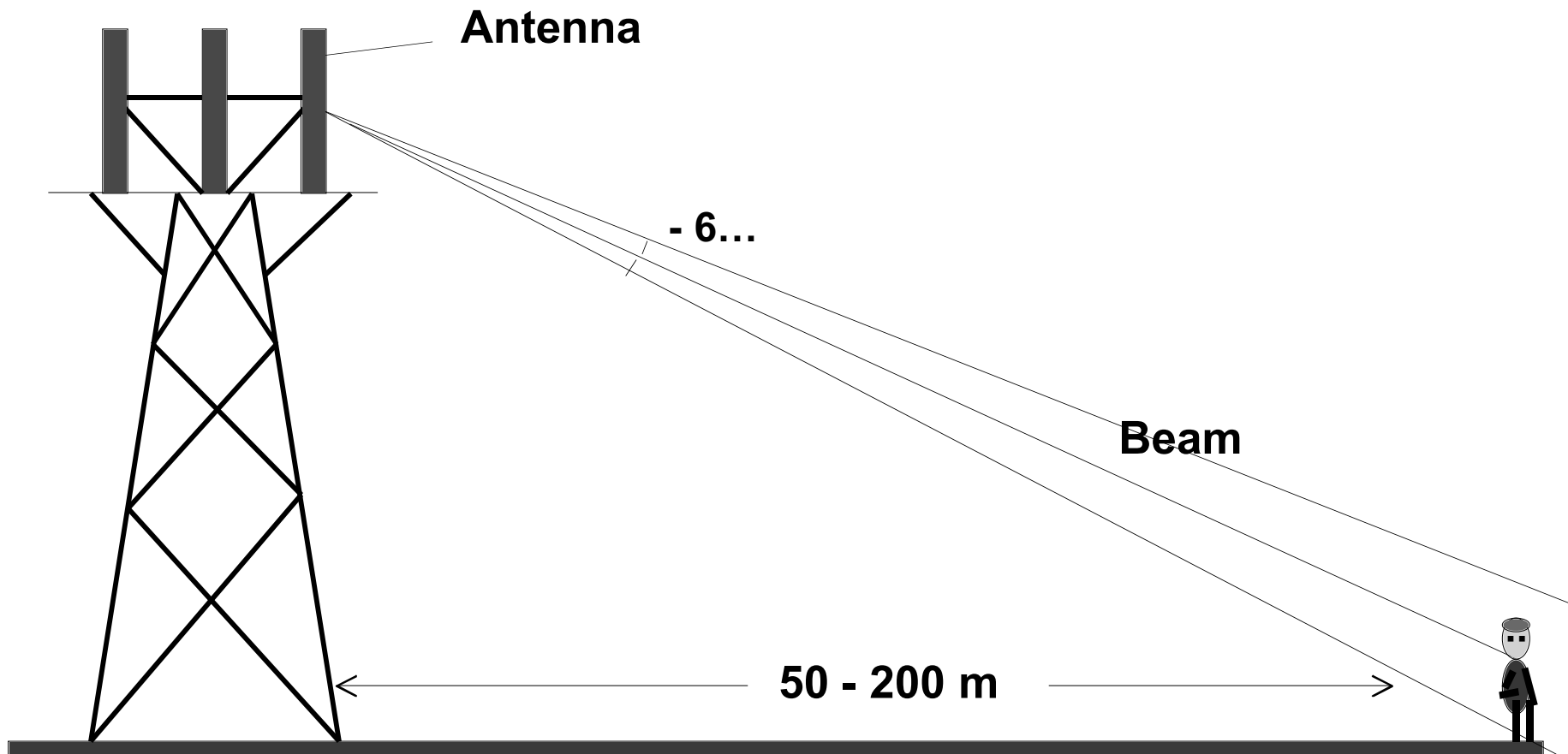
Reference Levels for general public exposure at various RF-frequencies

	Power density (W/m ²)			Averaging time (min)
	450 MHz	900 MHz	1800 MHz	
ICNIRP	2.3	4.5	9	6
EC Council	2.3	4.5	9	6
ANSI/ IEEE	3	6	12	30
TTC/MPT (Japan)	0.3	0.6	1	6



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Main beam from an antenna mounted on a tower



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Measurements of Public Exposure at 26 Sites in Sweden (Y Hamnerius and T Uddmar 1999)

Location	Max (mW/m ²)	Mean (mW/m ²)	Median (mW/m ²)
City	3.01	0.8	0.5
Town	0.049	0.034	0.033
Rural	0.006	0.0016	0.0006
Indoors	0.0115	0.0055	0.005
Office (1.6 m from DECT base station)	3.7	0.154	-

Research on biological effects of EMF

- ◆ Nervous system
- ◆ Cardiovascular systems
- ◆ Endocrine and immune systems
- ◆ Reproduction and development
- ◆ Genetics
- ◆ Cancer
- ◆ Auditory perception
- ◆ Ocular effects

COST 244 and COST 244bis

- ◆ European Co-operation in the Field of Scientific and Technical Research (COST)
- ◆ Biomedical Effects of Electromagnetic Fields
 - COST 244: 1992-1996
 - COST 244bis: 1996-2000
- ◆ 200 national research groups,
> 600 scientists, > 140 research institutes
- ◆ <http://www.radio.fer.hr/COST244>

COST - Specific Topics

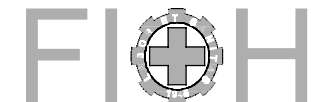
- ◆ Human epidemiology
- ◆ Occupational medicine
- ◆ Hypersensitivity to electricity
- ◆ Design performance and evaluation of experiments
- ◆ Interaction mechanisms leading to biological effects
- ◆ Experimental and numerical dosimetry

WHO - International EMF project



- ◆ Duration 1996-2005
- ◆ In collaboration with international agencies and organizations
- ◆ Aims:
 - pooling resources and knowledge concerning effects of exposure to EMF
 - identify gaps in knowledge
 - critical reviews of the scientific literature
 - international consensus and resolution on the health concerns
- ◆ <http://www.who.int/peh-emf>

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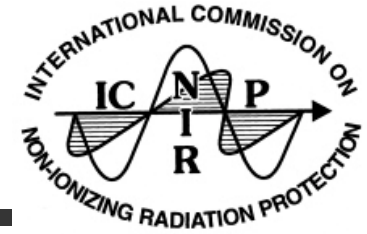


Guidelines on limiting exposure to non-ionizing radiation - ICNIRP 7/99



- ◆ Collection of the guidelines on limiting exposure to non-ionizing radiation and statements on special applications
- ◆ ICNIRP Guidelines for:
 - airborne ultrasound
 - static magnetic fields
 - electromagnetic fields (up to 300 GHz)
 - UV radiation
 - laser radiation
 - broad-band optical radiation

Guidelines on limiting exposure to non-ionizing radiation - ICNIRP 7/99



◆ ICNIRP Statements on:

- radiation risks from visual display units
- fluorescent lighting and malignant melanoma
- UV sunbeds
- light emitting diodes
- laser pointers
- health issues related to mobile telephones and base stations
- safety aspects of magnetic resonance imaging

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