

# Biological impact of optical radiation from curing lights

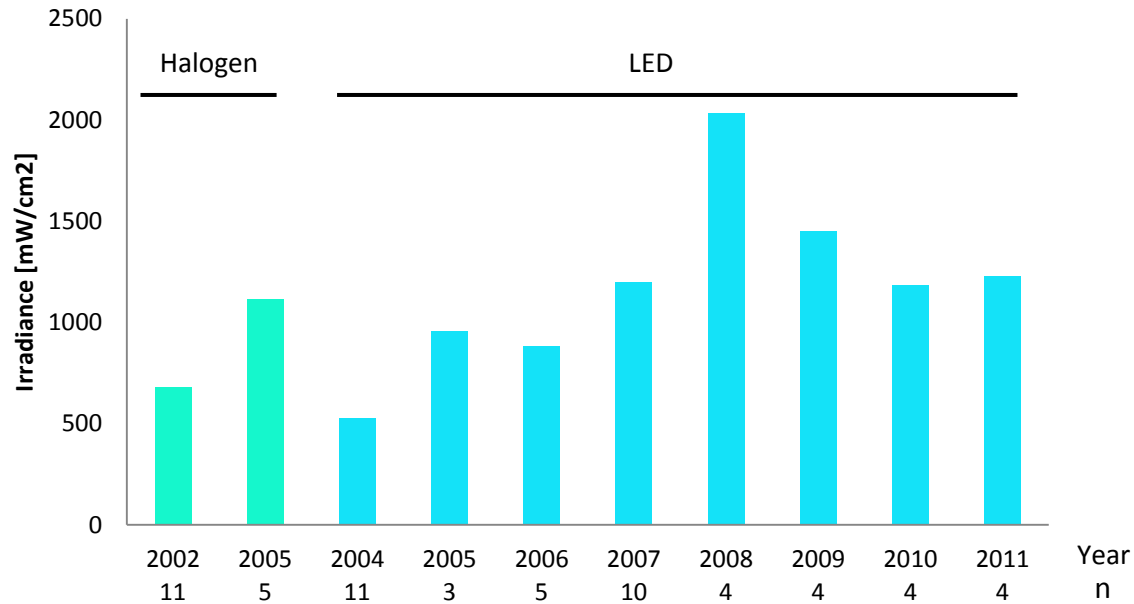
Ellen Bruzell  
Nordic Institute of Dental Materials

Symposium on Light Sources in Dentistry  
Halifax - May 28-30 - 2014

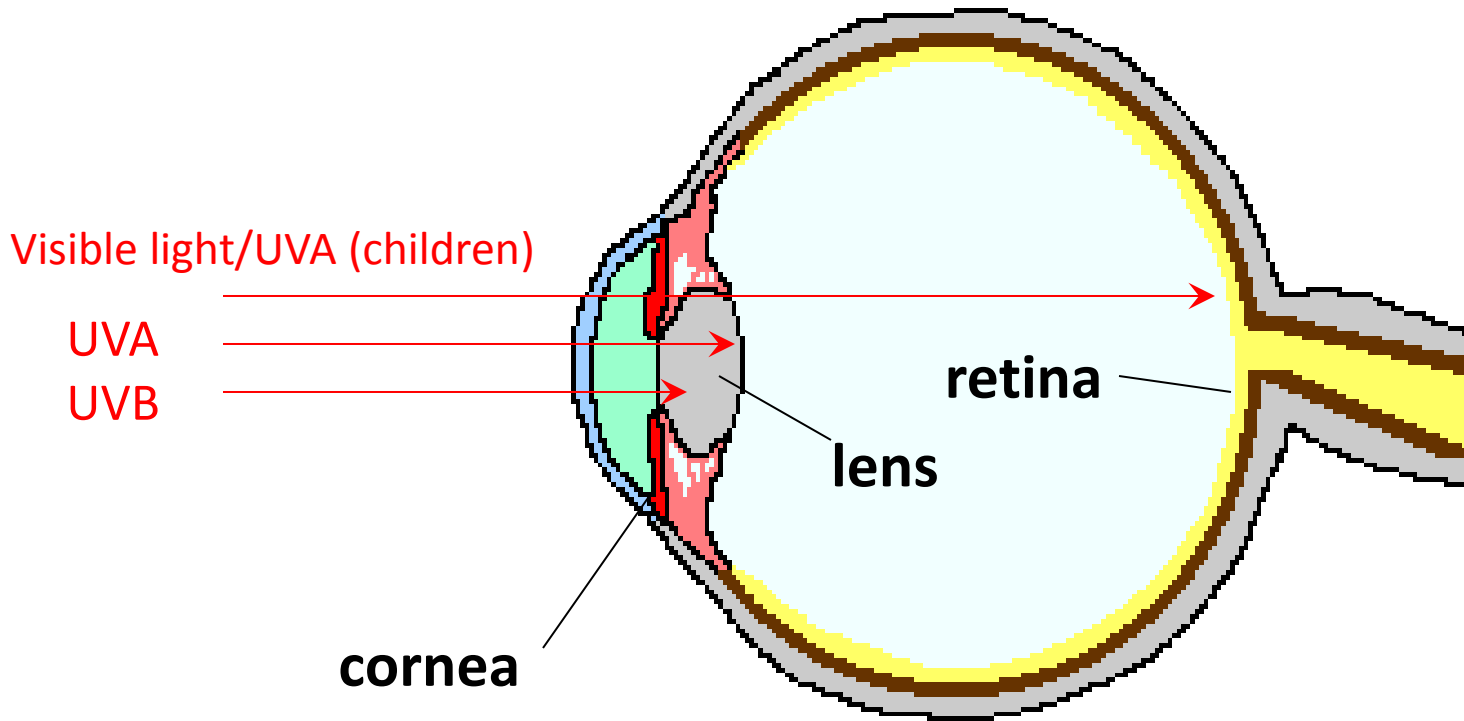
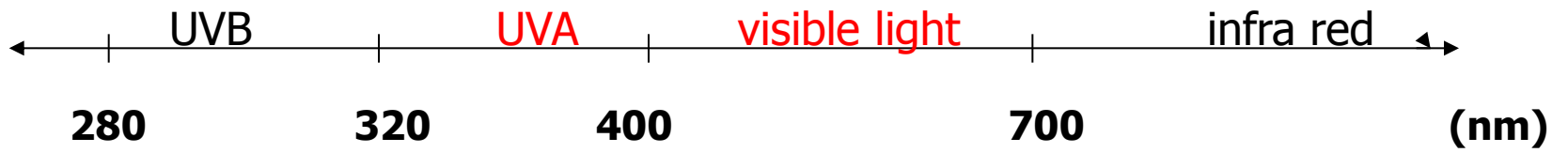
# Optical sources in dentistry (not exhaustive)

Radiation	Wavelengths (nm)	Application in dentistry	Light source
UVC	100-280	Sterilization chamber	Low pressure Hg lamp
UVB	280-315	<i>(Not to my knowledge)</i>	
UVA	315-400	Light curing tooth bleaching	Plasma arc, halogen, LED
Visible light	400-780	light curing <ul style="list-style-type: none"> <li>tooth bleaching</li> <li>operating light</li> <li>diagnostics</li> <li>i-o illumination</li> <li>microscope/loupe</li> </ul>	Plasma arc, halogen, LED, laser
IR-A	780-1400	Various hard/soft tissue interventions, diagnostics	LED, laser (diode, Nd:YAG, Er:YAG, Er,Cr:YSGG CO <sub>2</sub> )
IR-B	1400-3000		
IR-C	3000 nm-1 mm		

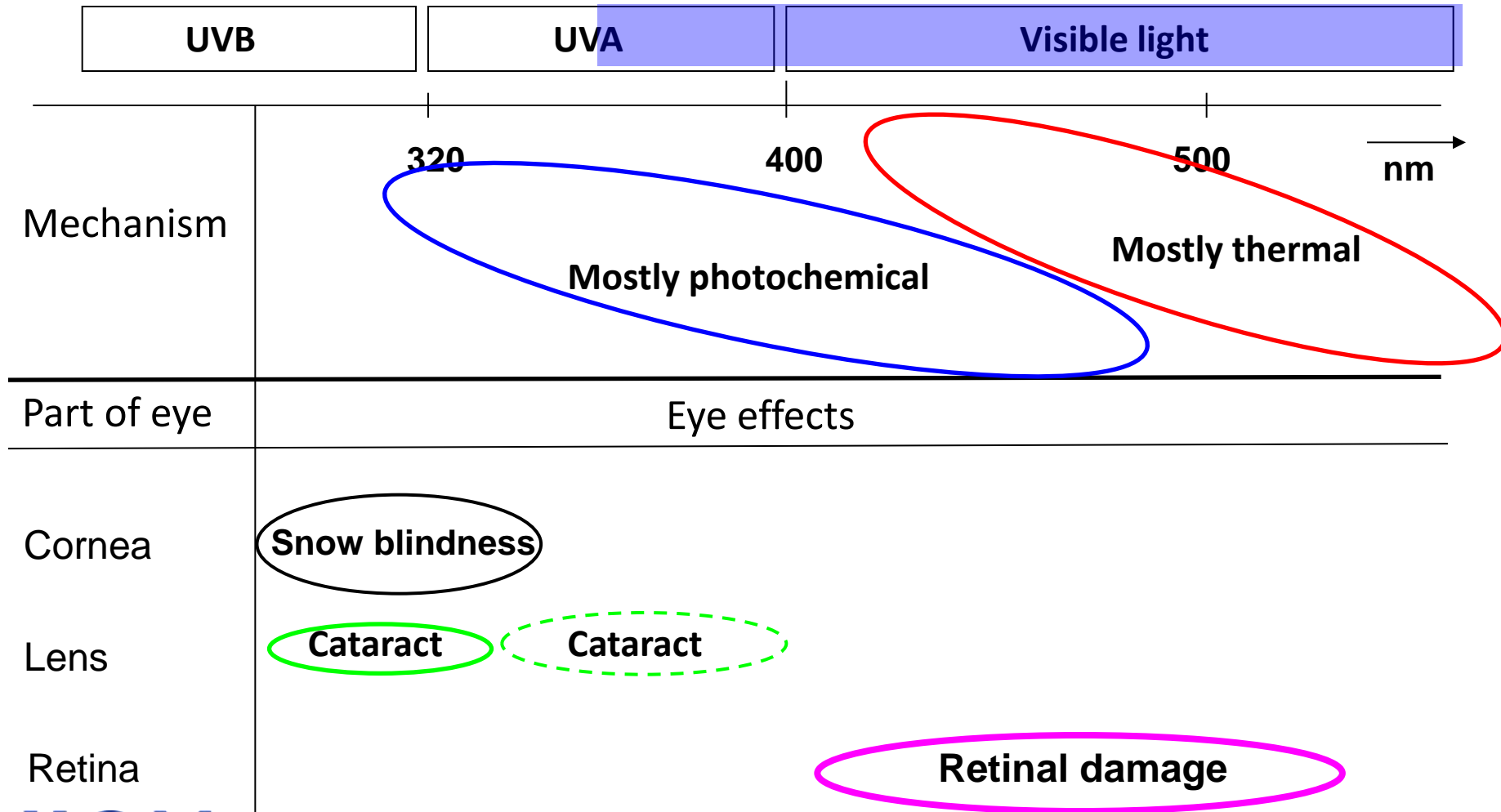
# Curing light irradiance over time



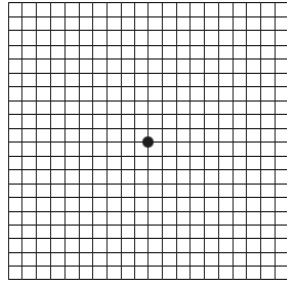
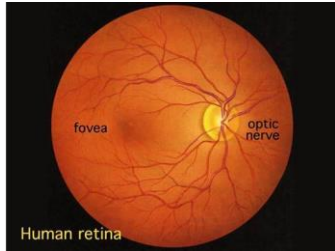
**Note:** LED variations: 95-4600 mW/cm<sup>2</sup> (x 50)



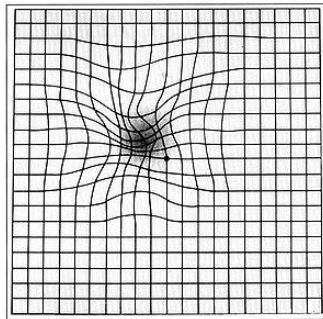
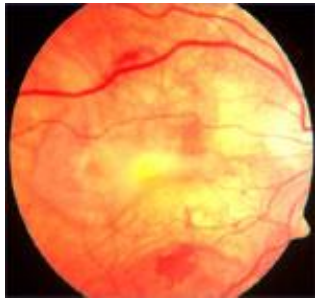
# UV- and light-induced eye damage



# Light-induced retinal damage



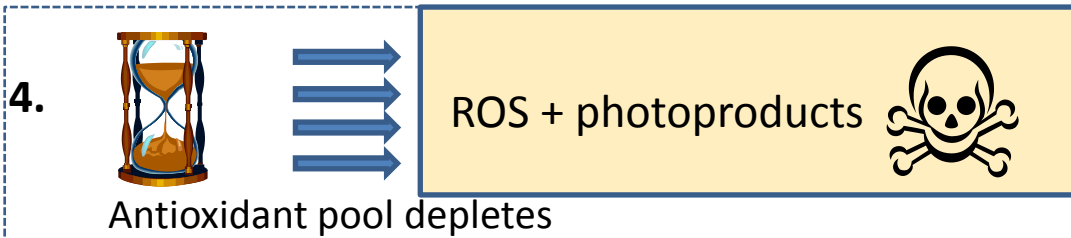
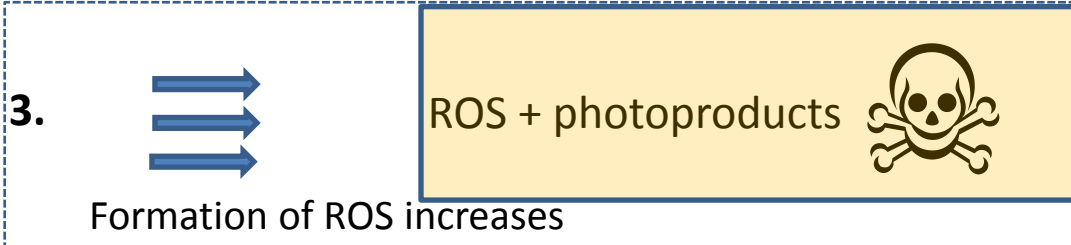
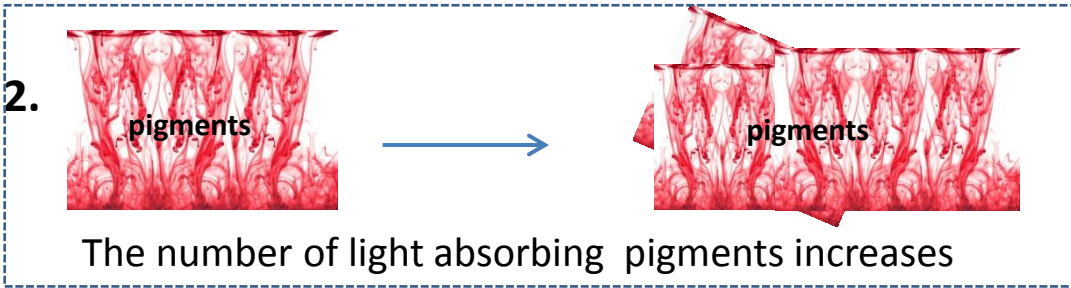
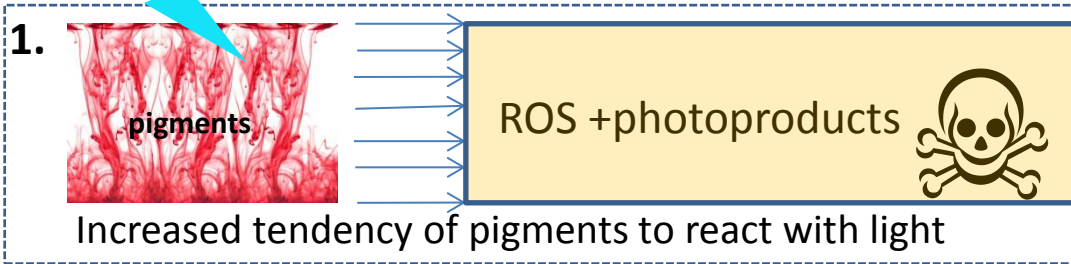
Normal



AMD (uneven pigmentation)

- Acute
  - From sun or strong radiation sources (e.g. laser)
- Chronic
  - Age-related macular degeneration (AMD)? (loss of visual acuity)
    - Light contributes to ageing of the retina
    - AMD develops over 30-40 years

# Chronic blue light retinal damage: risk increases with age



Retinal cell function inhibited or stopped

# Photoactivation of drugs

Mostly toxic (less allergic) reactions , systemic effects

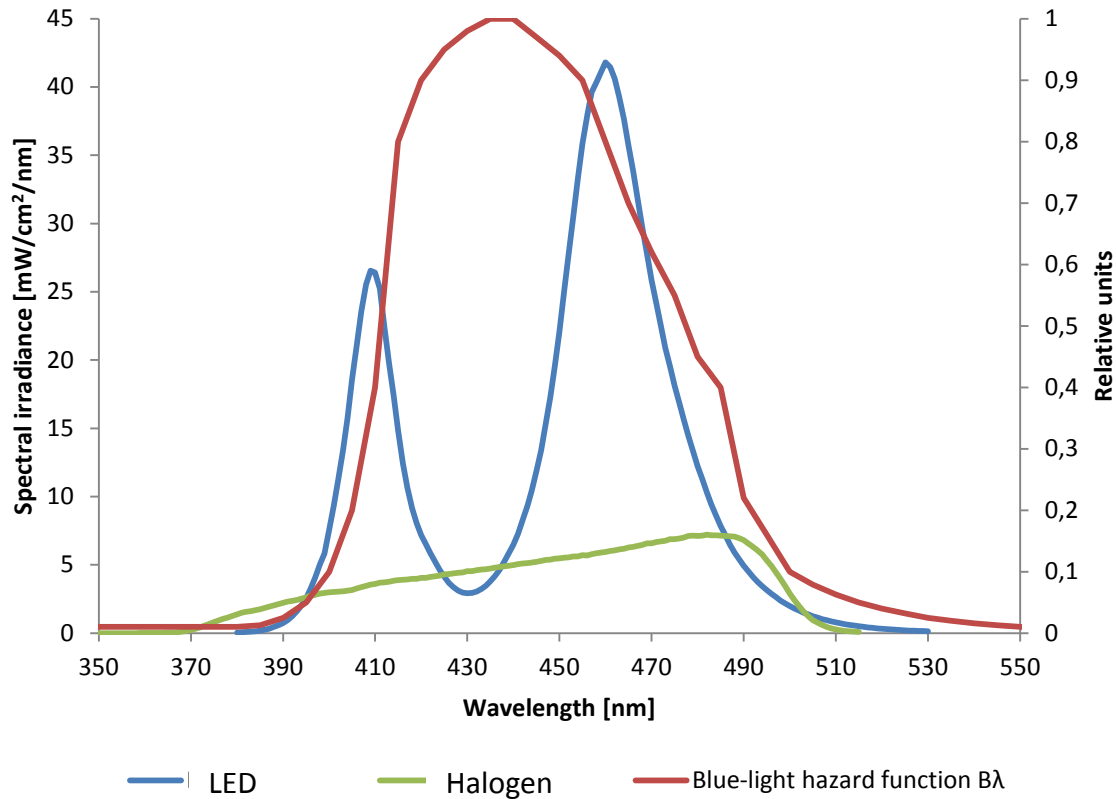
## Drugs that can bind to eye tissue

- Chloroquine (*antimalarial*)
- Allopurinol (*against gout and hyperuricemia*)
- Psoralens (*antipsoriasis*)
- Chlorpromazine/other phenothiazides (*antipsychotics*)
- Griseofulvin (*antifungal*)
- Tetracyclines? (*antibiotics*)





# Lamp emission versus retinal hazard



# Maximum permissible exposure time ( $t_{\max}$ ) for eyes

- LED lamps: 2007-2011<sup>1</sup>
- Mean irradiance: 2009 mW/cm<sup>2</sup> ( $\pm 5\%$ ) (range: 635-4600)
- Exposure limit value according to international guidelines on radiation<sup>2</sup>:

**100 J/cm<sup>2</sup> × sr**

(per day, acute and chronic eye exposure, artificial sources, workers and the public, exposure times < 2.7 h)

**Direct blue light**

Mean  $t_{\max} = 1.9$  min  
(range: 0.5-3.9 min)

**Reflected blue light<sup>3</sup>:**

Mean  $t_{\max} = 23.7$  min  
(range: 5.1-89.9 min)

# Light protection filters

- Worst-case exposure: orthodontics (?):  
**2.5 hr/day** (per operator)
- Six of 13 filters on today's (2013) market were inferior
- Challenge: Filters are not made to protect against emission from one particular lamp
- Lack of standards for filter protection used with light curing (high irradiance sources)

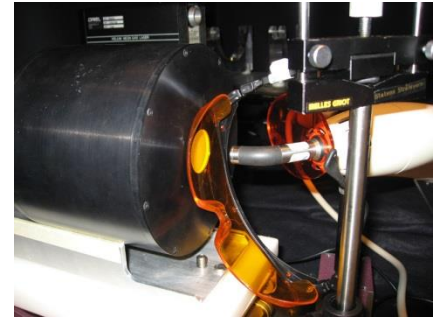
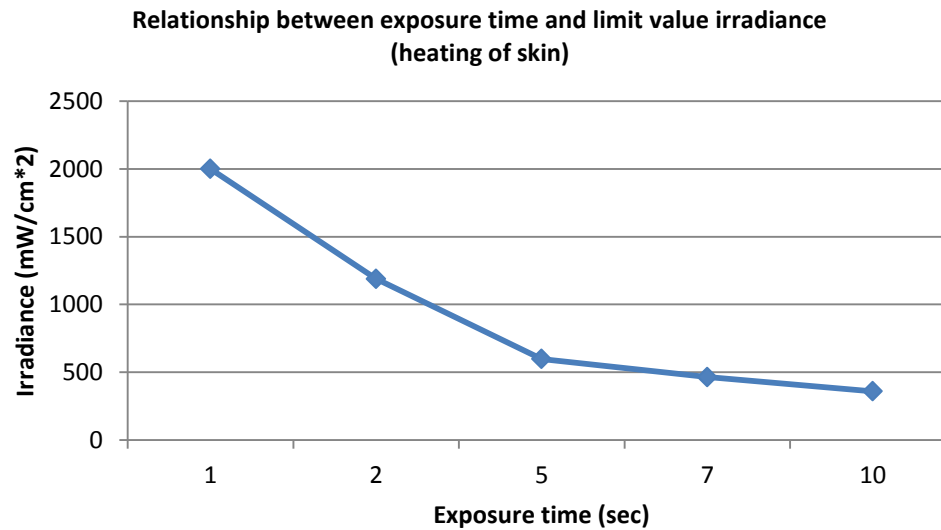


Photo: nrpa.no

# Heating of skin



Radiant exposure (H) (dose)  
within 10 s of exposure:

$$H = 2 \times t^{\frac{1}{4}} \quad [\text{J}/\text{cm}^2]$$

# Regulations, directives, standards

- EU directive 2006/25/EC Artificial Optical Radiation
- ICNIRP (International Commission on Non-Ionizing Radiation Protection): Guidelines on limits of exposure to incoherent visible and infrared radiation, Health Physics 2013; 105 (1): 74-96.
- CIE S009/IEC 62741 Photobiological safety of lamps and lamp systems
- CEN 1455-2: Measurement and assessment of personal exposure to incoherent optical radiation. Part 2: Visible and infrared radiation emitted by artificial sources in the workplace.

