



Mark J. Prandolini  
UKP-Laserlabors in CFEL

## General laser safety instructions

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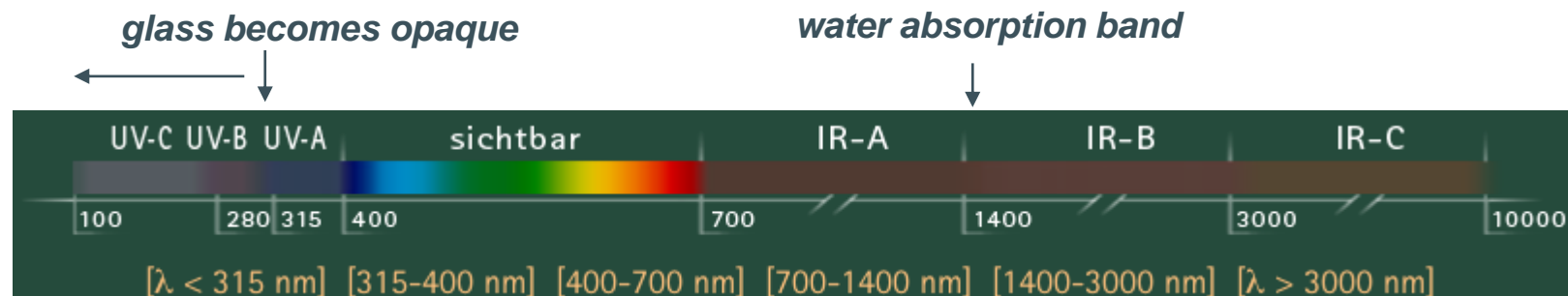
Institut für Experimentalphysik  
Universität Hamburg

## Overview

1. Laser radiation basics
2. Danger from laser radiation to the eye and skin, and behaviour in case of an emergence
3. Classification of lasers
4. Laser laboratory responsibilities and your personal laser safety and some basic tips to avoid laser accidents.

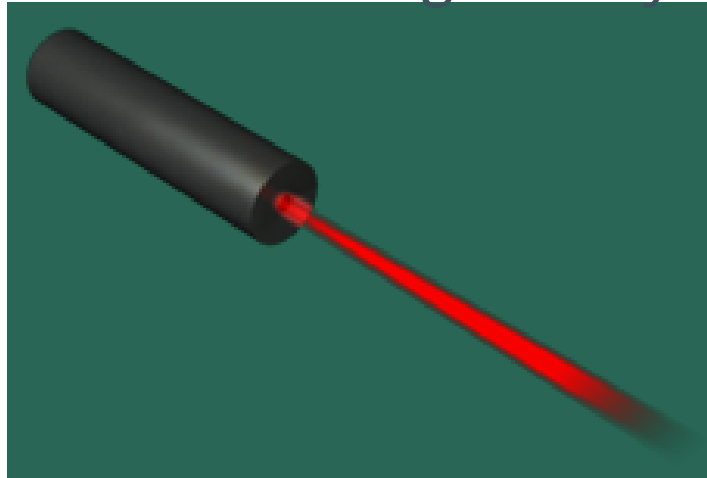
# Laser Radiation Basics

- Light spreads as an electromagnetic wave through space
- Natural light sources always consist of multiple wavelengths.
- A part of the EM spectrum can be observed by the human eye as different colors.



*Spectral range from UV to far-infrared*

- Laser radiation is a ***coherent light source***. ***Spatial coherence*** allows a laser to be focused into a tight spot, and ***temporal coherence*** can be used to produce ultrashort pulses.
- Laser radiation generally spreads as a ***collimated*** beam !

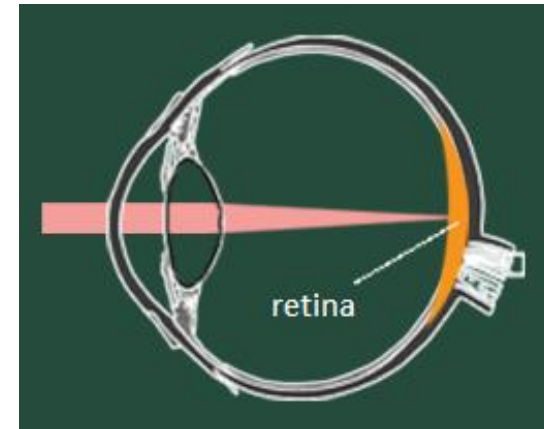
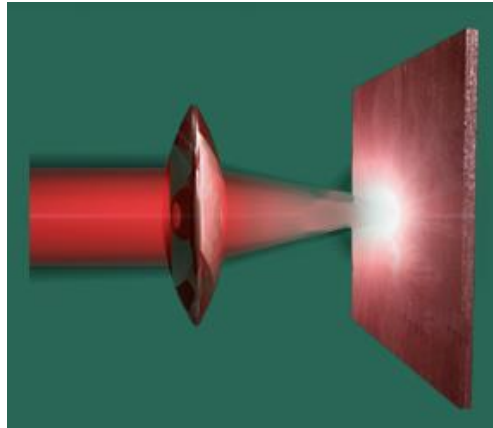


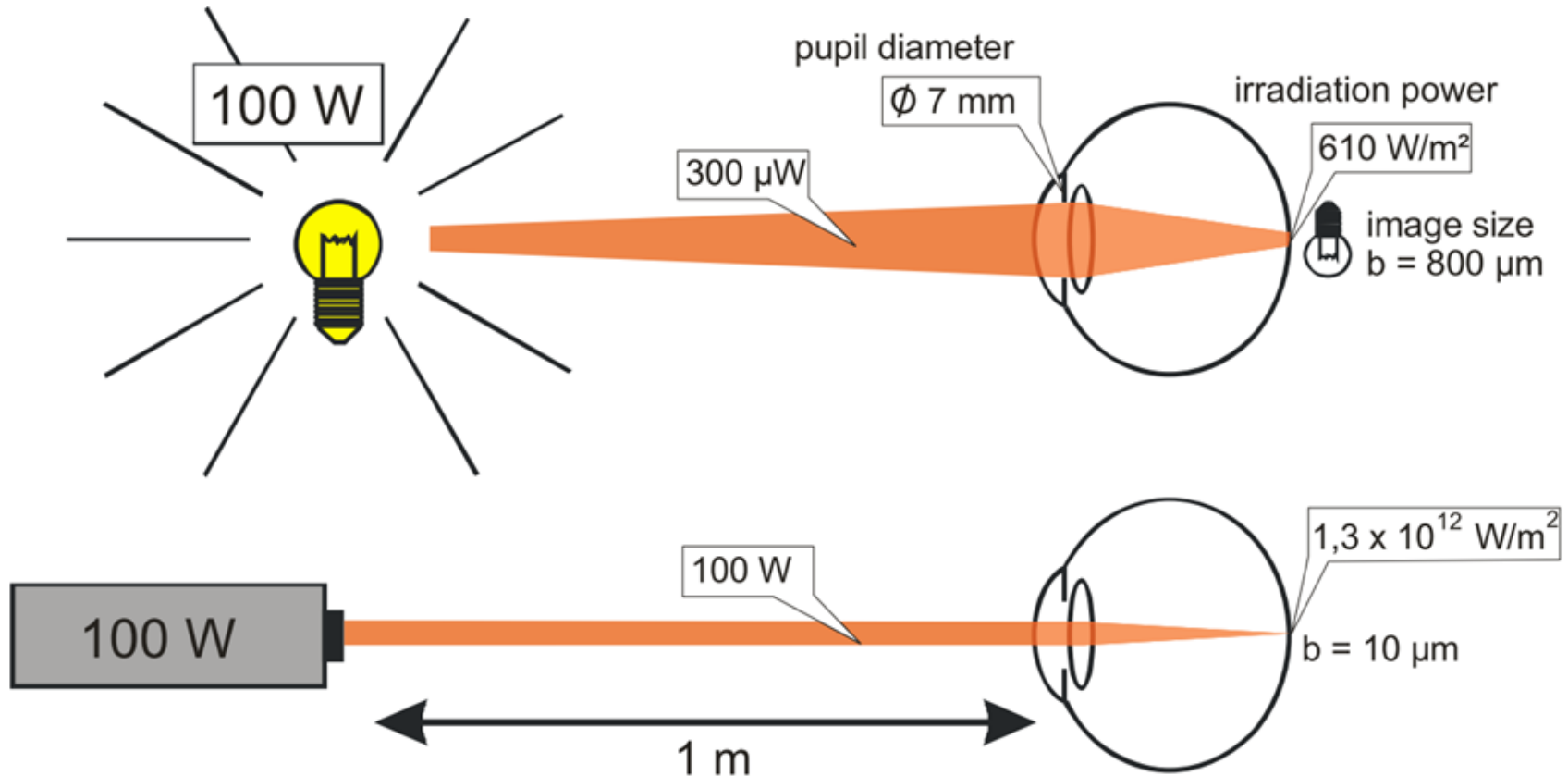
collimated beam



$4\pi$ -emitter,  
uncollimated

- Collimated radiation is dangerous to the human eye, because it can be strongly focused by the natural lens within the eye and could be focused onto the visual nerve of the retina.





ratio of irradiation powers:

$$\frac{I(\text{Laser, 100 W})}{I(\text{light bulb, 100 W})} = 2,1 \times 10^9$$

# Laser Damage to Personal

a. eye

b. skin

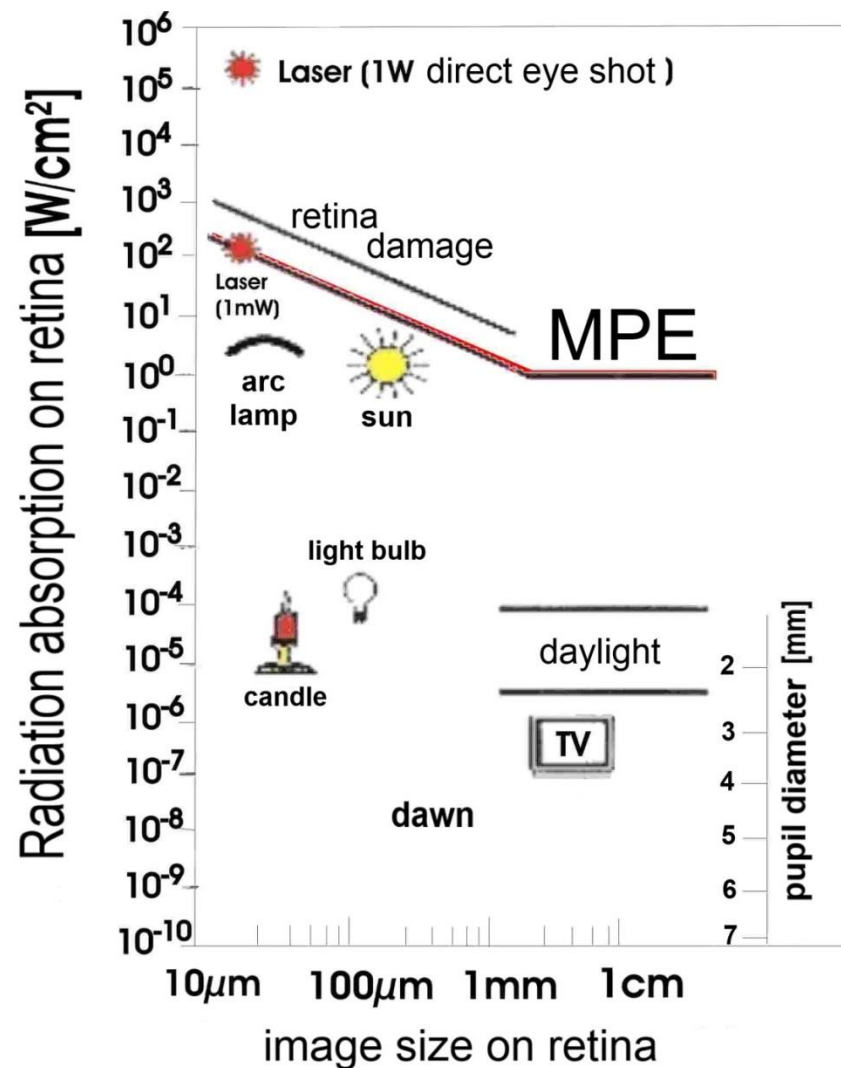
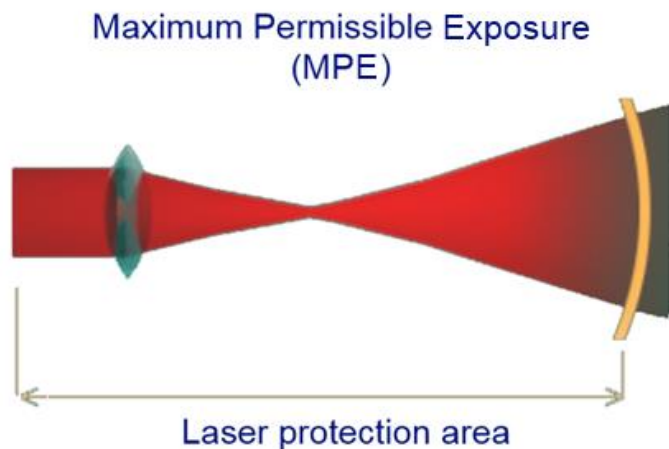
# What to do in case of a laser emergence

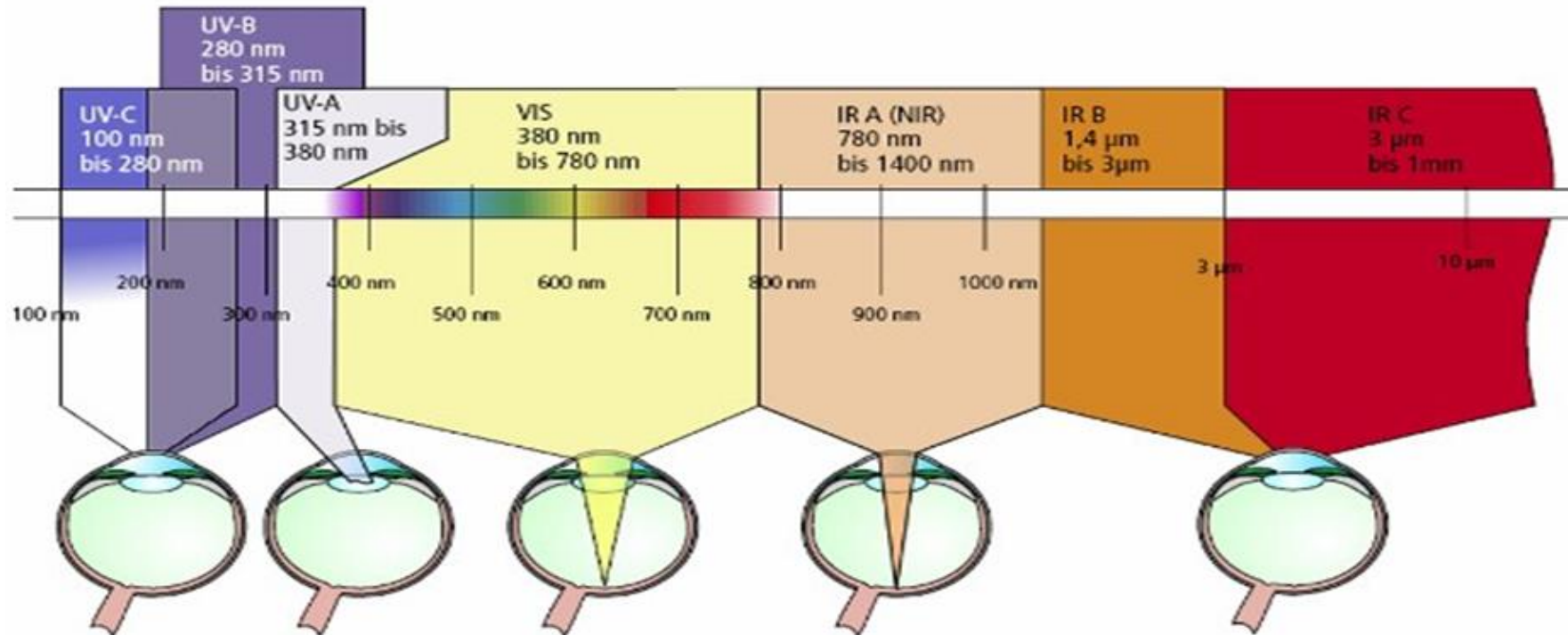
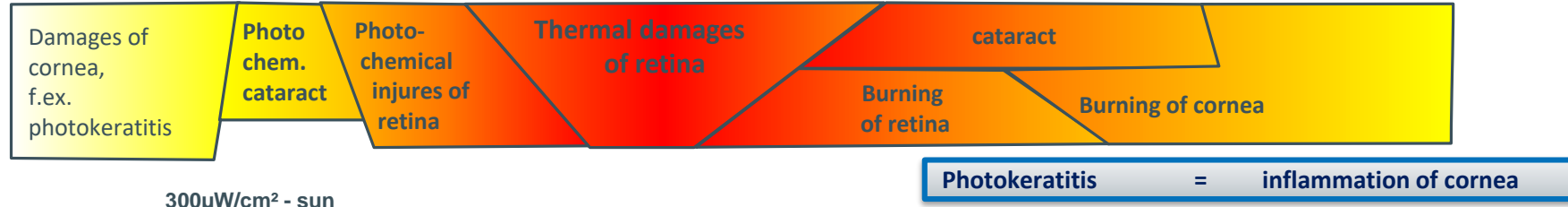


Damage of the eye appears after exceeding a certain irradiation intensity level [ $\text{W}/\text{cm}^2$ ].

⇒ Threshold definition for tissue damage: **MPE** (German [MZB](#)) (**M**aximum **P**ermissible **E**xposure)

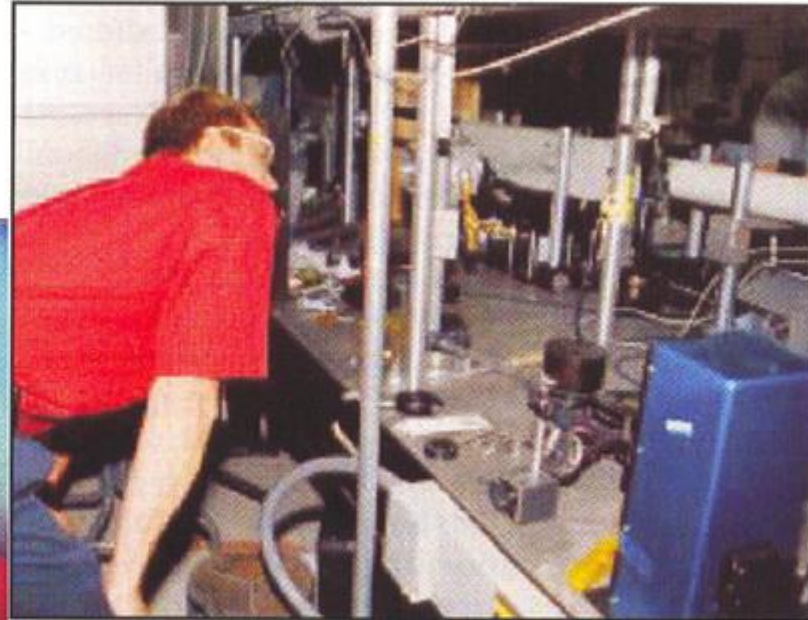
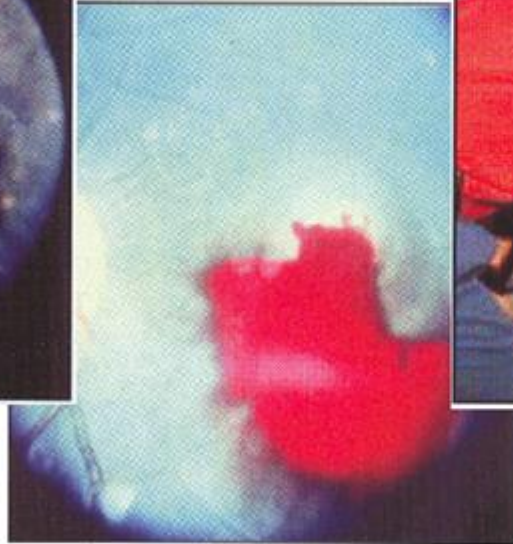
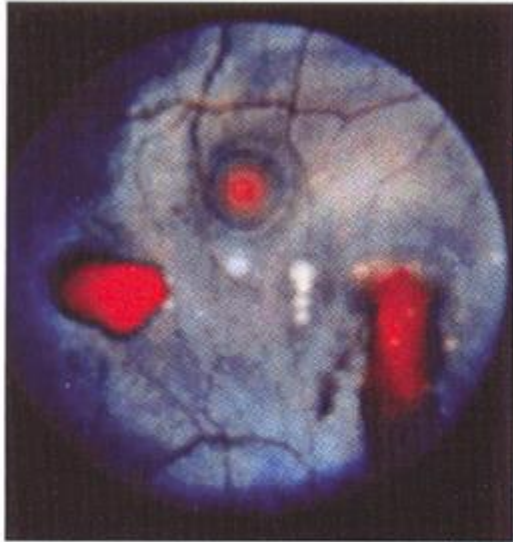
In combination with these thresholds for accessible radiation, laser classes and laser protection areas are defined in DIN-EN 60825.





Eye penetration depth of spectral ranges

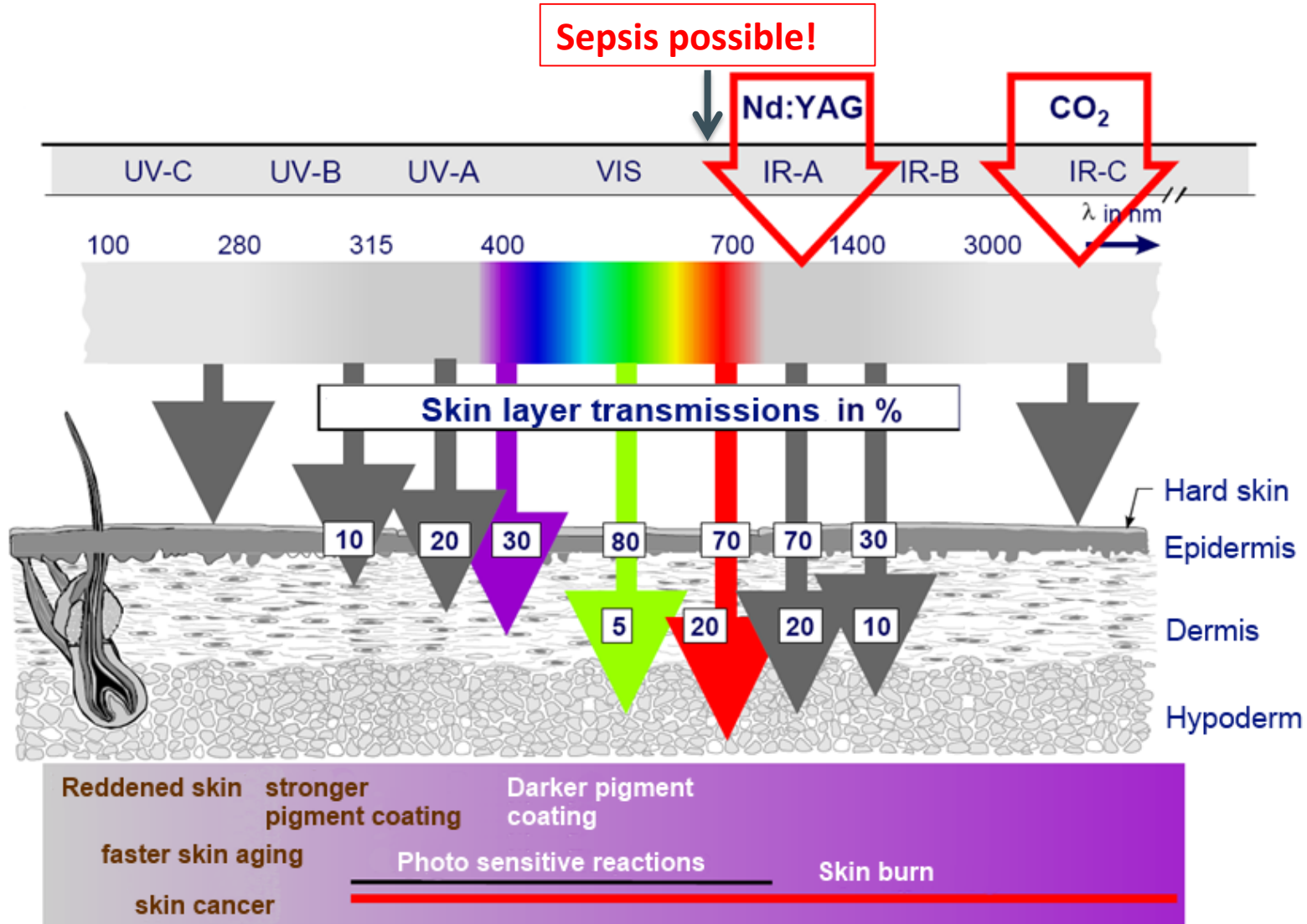
## ▪ Laser accident by observation of a process chamber



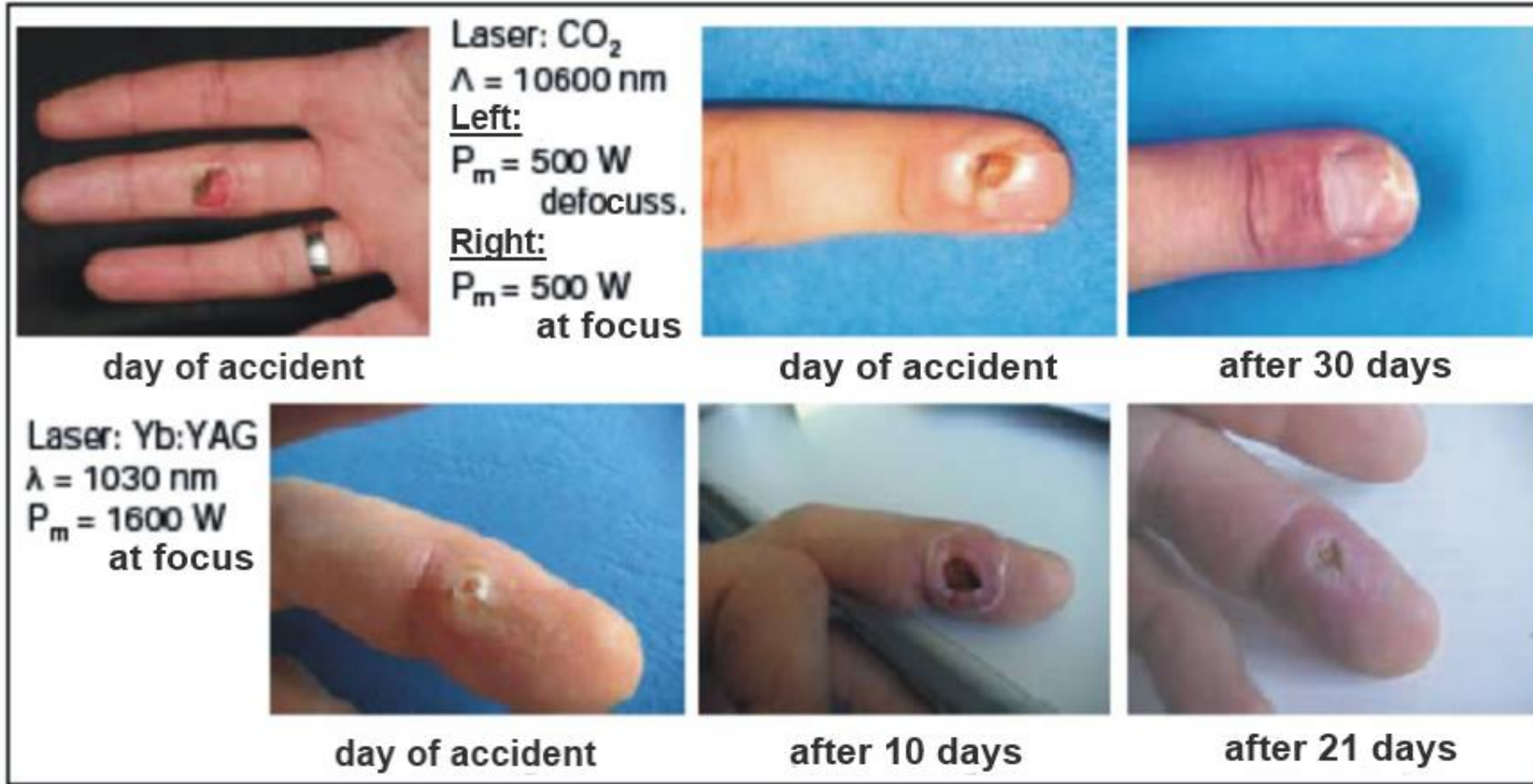
- Damage size of retina , ca. 0,4 x 0,25 mm<sup>2</sup>

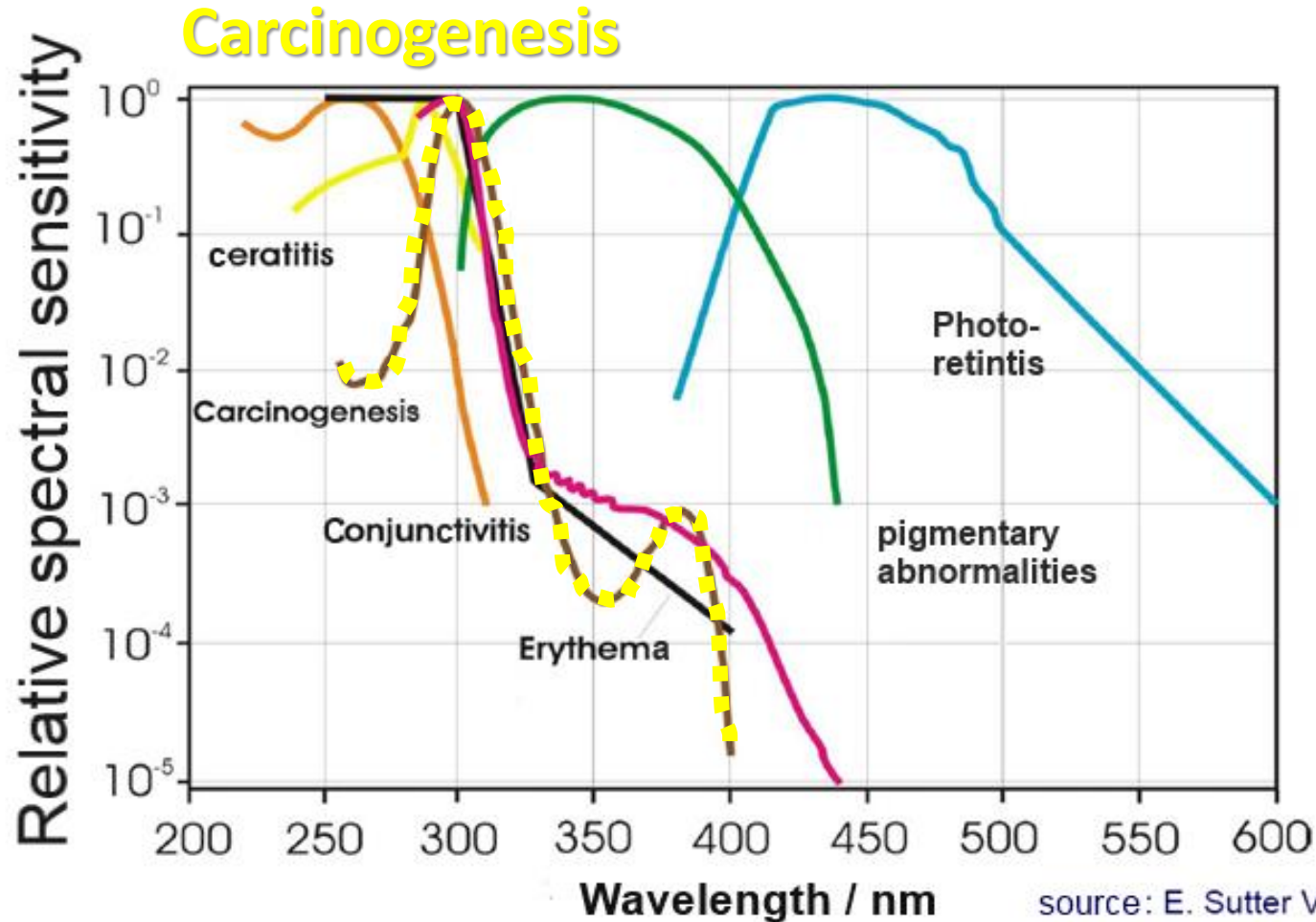
- Q-Switch Nd:YAG Laser
- $\lambda = 1064 \text{ nm}$











Wear gloves  
for wavelengths  
smaller than  
400nm !

- In case of an accident **CALL 2500** and inform them that an eye specialist is required and wait for rescue service

**Tel.:2500**

- If there exists the suspicion, that an eye damage has occurred, quickly head for an eye doctor:

**UKE Eppendorf  
Klinik für Augenheilkunde  
Martinistraße 52  
20246 Hamburg  
Tel.: +49(0) 40 7410 - 52350**

**Notfallpraxis Altona  
Stresemannstraße 54  
22769 Hamburg22763  
Hamburg**

**Due to scarring, a local retina damage can spread further. A doctor is able to stop the scarring and inhibit further nerve damage! The treatment should be done during the first days after incidence!**

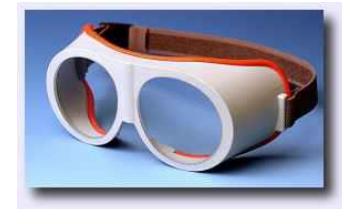
- Strong IR radiation can deeply penetrate the skin and may lead to an inner injury, which can lead to a sepsis!

# Classification of Lasers



Since 2007 the **following laser classification** is active

- Class 1      **harmless** for the human eye
  - Class 1M     **harmless** because of large divergence.  
Becomes harmful, if observed with **optical instruments**
  - Class 2      **actually harmless** for the human eye for **exposure times < 0,25s**  
only defined for **visible light 400-700 nm**, with working eye lid  
closing reflex,  **$P < 1\text{mW}$  (CW)**
  - Class 2M     because of divergence **actually harmless** as class 2.  
Becomes harmful, if observed with **optical instruments**
- 
- Class 3R      **direct beam harmful**, but not for the skin,  
» (may exceed up to **5 times** the thresholds of class 2 in visible range  
and of class 1 in the non-visible range)
  - Class 3B      **direct beam harmful** for skin and eye
  - Class 4      **direct beam and diffuse reflexes** are very harmful for  
**eye and skin**, in addition to causing a fire on exposed material



**Laser class 1**

acc. to DIN EN 60825-1:2001-11

**Laser radiation**

Don't look into the beam

**Laser class 2**

acc. to DIN EN 60825-1:2001-11

**Laser radiation**

Don't look into the beam with  
optical instruments

**Laser class 1M**

acc. to DIN EN 60825-1:2001-11

**Laserstrahlung**

Don't look into the beam neither  
directly nor with optical instruments

**Laser Klasse 2M**

acc. to DIN EN 60825-1:2001-11

**No laser safety precautions are necessary !**

**Laser radiation**

avoid direct irradiation

**Laser class 3R**

acc. to DIN EN 60825-1:2001-11

**Laser radiation**

don't expose yourself to the beam

**Laser class 3B**

acc. to DIN EN 60825-1:2001-11

**Laser radiation**

avoid irradiation of eye or skin by direct  
beam or reflexes

**Laser class 4**

acc. to DIN EN 60825-1:2001-11

**Laser protection measures are required !**

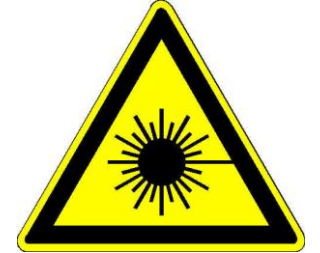
# **Laser laboratory responsibilities and your personal laser safety and responsibilities and some tips to avoid laser accidents.**

- All **research group leaders** who operate laser safety-relevant systems **are** automatically nominated as **laser safety officers** in their area.
- In addition, the group leaders can appoint technical representatives to support laser safety within their group.

Before you work in a laser laboratory at the University of Hamburg you must be aware of the following:

1. You must have completed this General Laser Safety Instruction, as well as other specific training for a particular laboratory or building.
2. Gefährdungsbeurteilung (Risk Assessment)
3. Betriebsanweisung (Operational Instructions)
4. Respect the laser safety infrastructure: signs, laser interlocks, laser curtains and laser blocks and shutters on the laser table
5. For Class 3 and 4, you must wear the correct personal protection and you must plan and observe best laser practice.

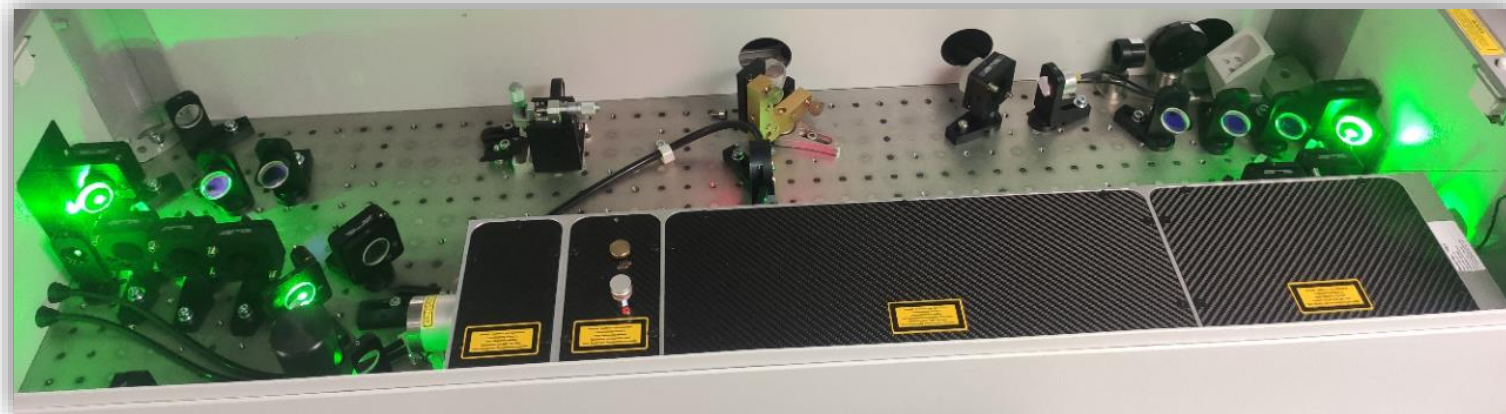
1. We have completed our training.
2. We understand the risks and the laser equipment.
3. We will respect the laser safety infrastructure.
4. We are now ready to work with Class 3R, 3B, and 4 lasers; the most important is the correct **laser class** →
5. In addition, if you work with wavelengths below 400 nm, you might want to wear laser gloves and face





## Laser amplifier and oscillators can be dangerous

Because of the large laser power, which a laser amplifier or oscillator provides, even scattering on optics or walls are very dangerous for the eyes  
→ possible retina damage !!



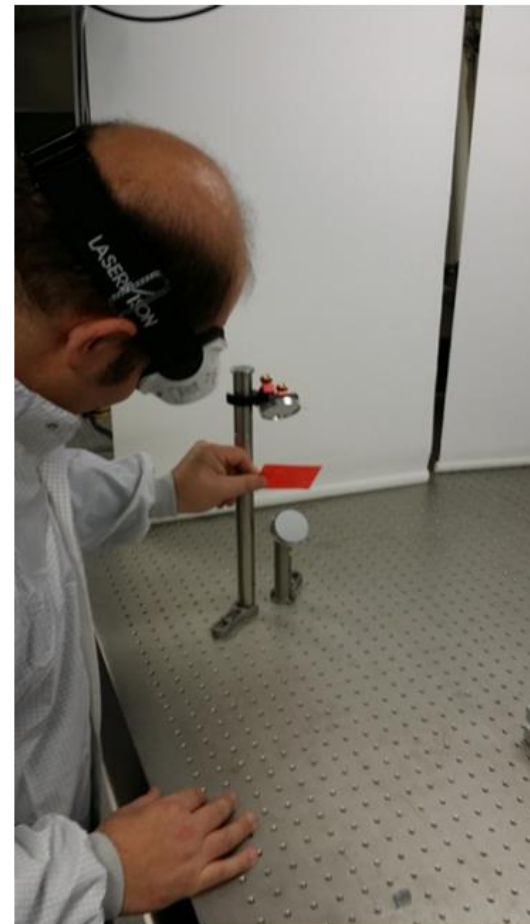


## Periscopes can be dangerous

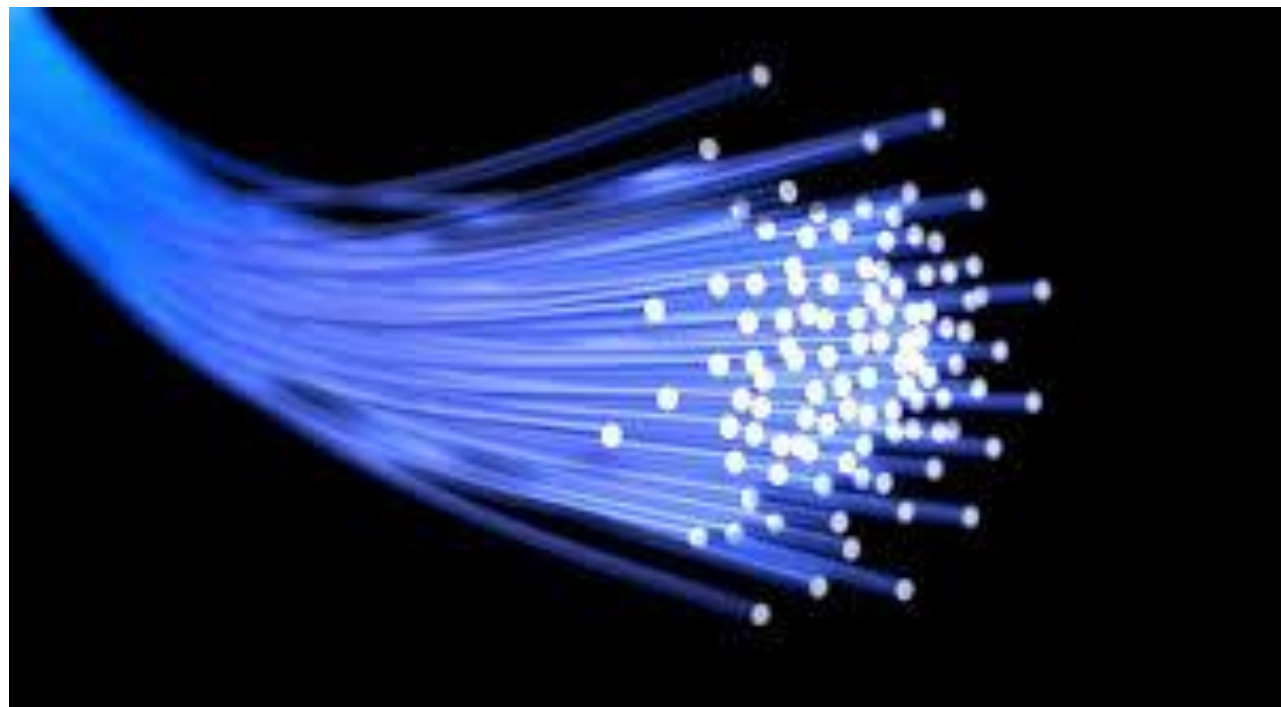
wrong



right



## Loose optics on optical tables and loose end optical fibers can be dangerous.



# Final Comments

1. In case of an emergence call **2500**.
2. For Class 3 & 4 lasers, you need to wear laser goggles and take special precautions.
3. Follow all laser safety instructions for your laboratory and plan your experiment carefully.
4. Laser light directed away from the laser table plane is a major source of laser accidents; this can be caused by diffuse scattering, loose optics and/or periscopes.
5. UV radiation  $<400$  nm is particularly dangerous to the eyes and skin; wear the additional appropriate clothing.

Thank you for your attention!

