



# Laser Safety

Group Prof. Jing Wang

Guangyu Qiu

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**Caution: laser beam!**

Improper handling of lasers can cause permanent damage to your health, in particular to the eyes and skin.

This safety training provides information on the dangers and the necessary protective measures when operating laser devices.

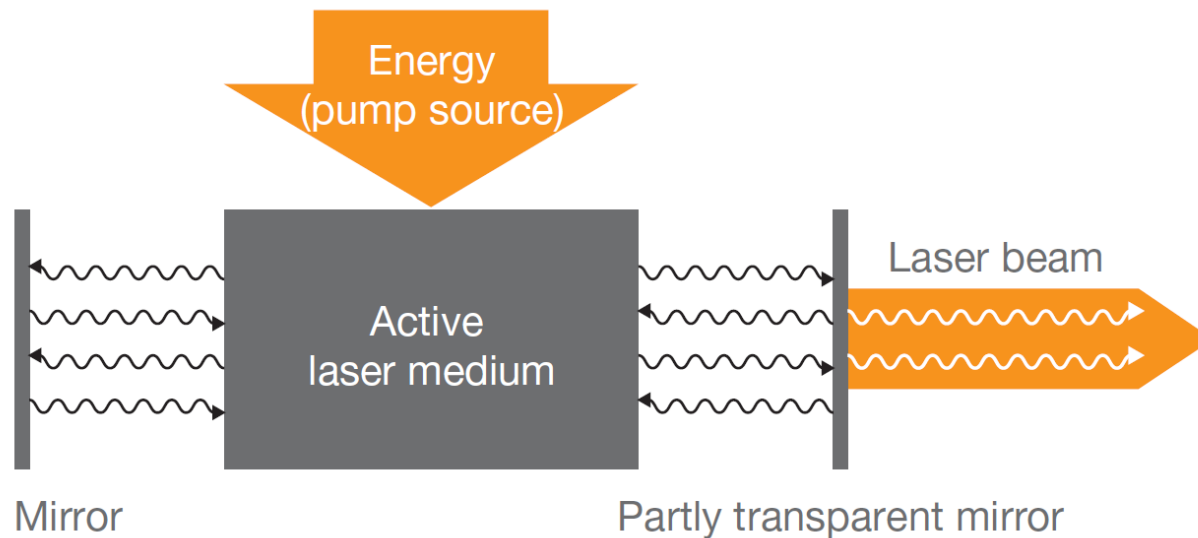
It is primarily intended for group members who use our laser products, but it also addresses individuals who might exposure to the laser. It will help you to handle lasers safely and lawfully.

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2. Why is laser radiation dangerous
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# What is a laser?

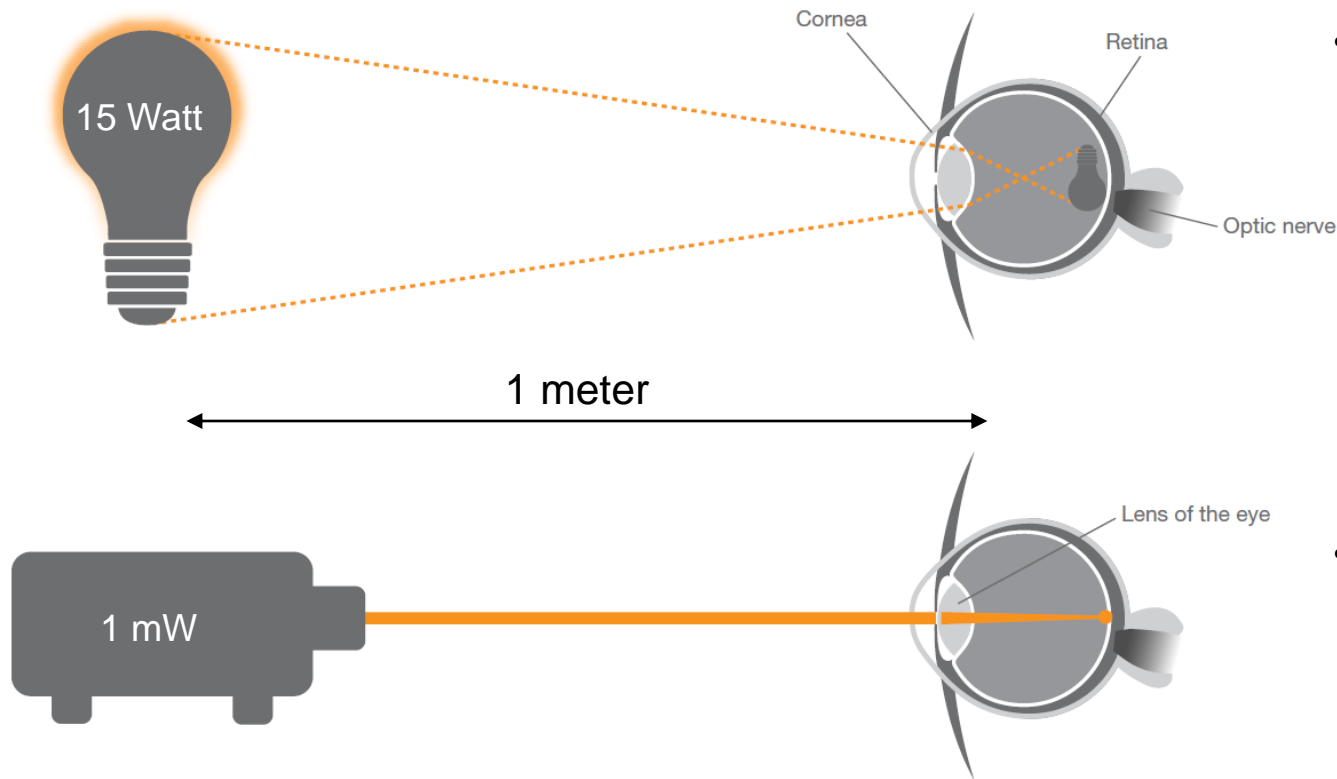
The word **laser** is an acronym for «**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation».



How a laser works

- A laser medium is excited (pumped) by an external energy source.
- Depending on the material of the laser medium, this begins to emit the characteristic radiation due to the excitation
- This radiation is reflected by mirrors (resonator), amplified, and finally directed to the outside through a partially transparent mirror.

# Different between laser light and normal light source (e.g. LED)

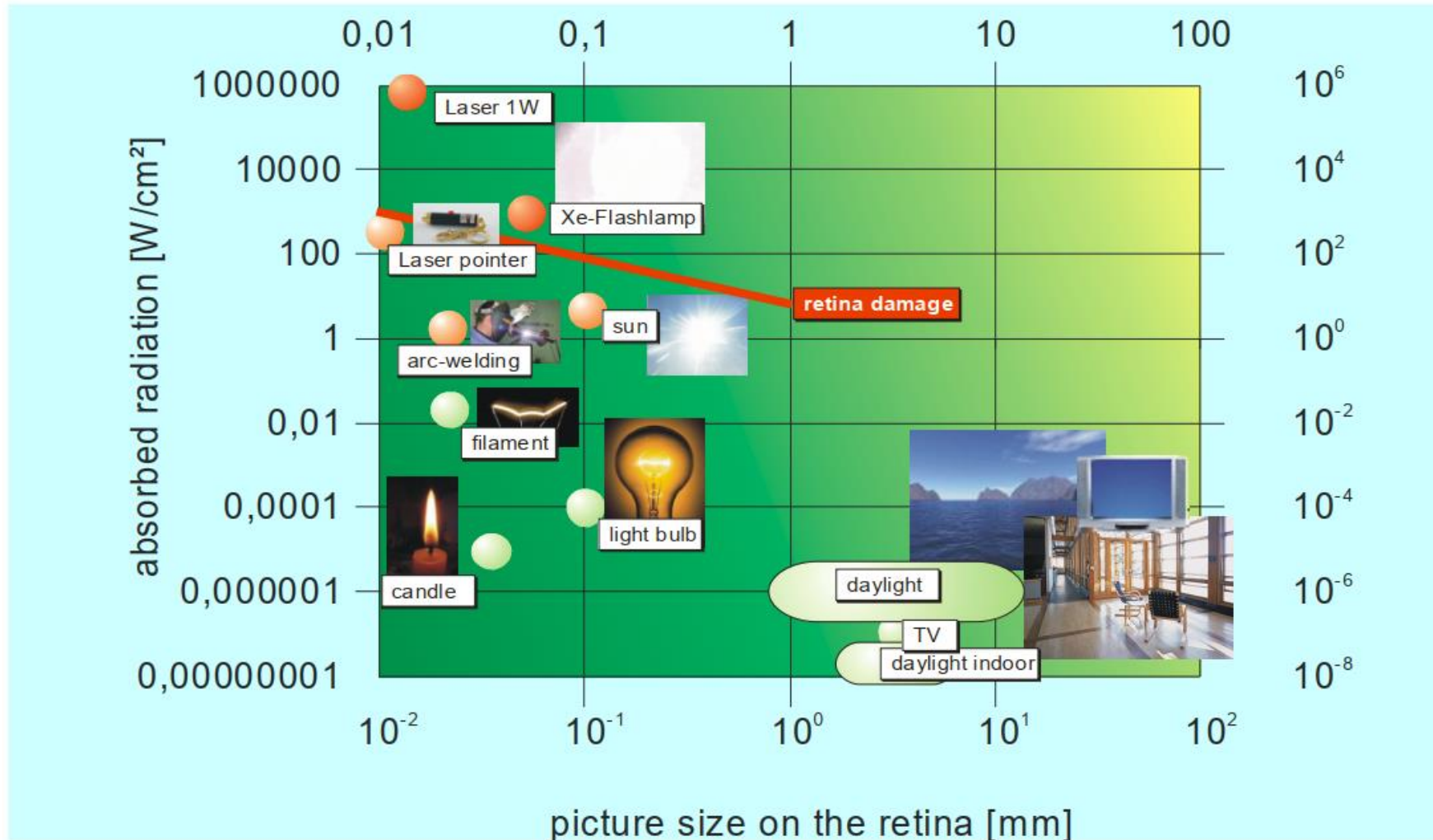


- Most light sources (e.g. light bulbs, energy saving bulbs or LEDs) generate white light and emit it in all directions. The radiant intensity thereby rapidly decreases with increasing distance from the light source.
- Laser light, in contrast, is directed and travels mostly parallel. This causes the laser beam itself to expand or contract only slightly over long distances.

Laser power density on the retina is roughly 35,000 times greater than the common light source

# Size on Retina

Radiation power of different light sources





# Laser classes and safety measurements

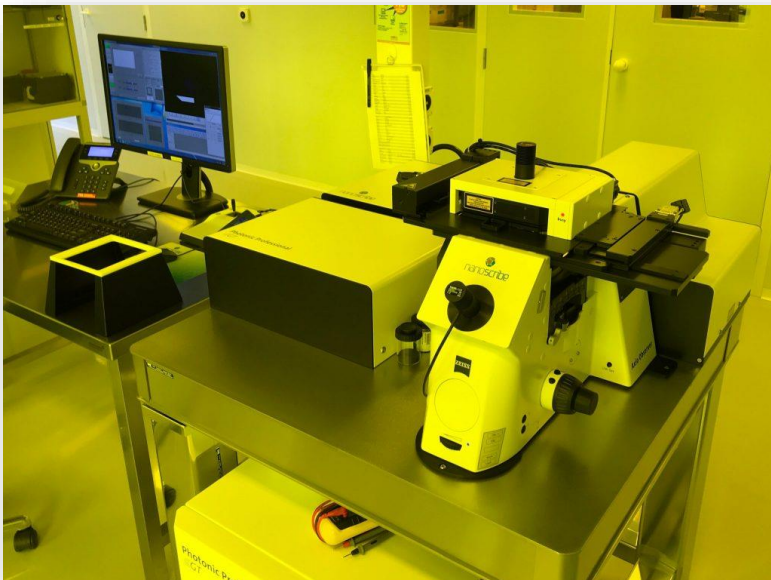
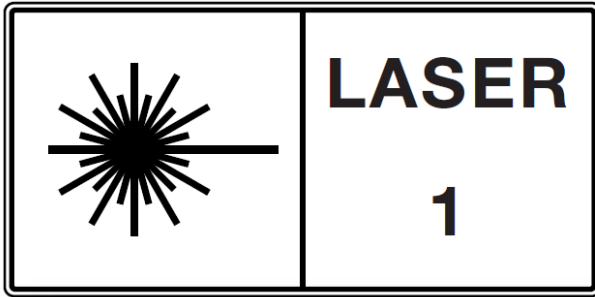
# Laser classes

<b>Class 1</b> Eye safe, complete range of wave lengths	<b>Class 1M</b> Eye safe without optical instruments	<b>Class 2</b> Eye safe if blink reflex ( $t=0,25s$ ) works, 400- 700nm	<b>Class 2M</b> Eyesafe without optical instruments blink reflex ( $t=0,25s$ )	<b>Class 3R</b> 5 x Class 1 or 5 x Class 2	<b>Class 3B</b> The view into the laser is dangerous at all wavelengths	<b>Class 4</b> Even scattered radiation of eye and skin can be dangerous
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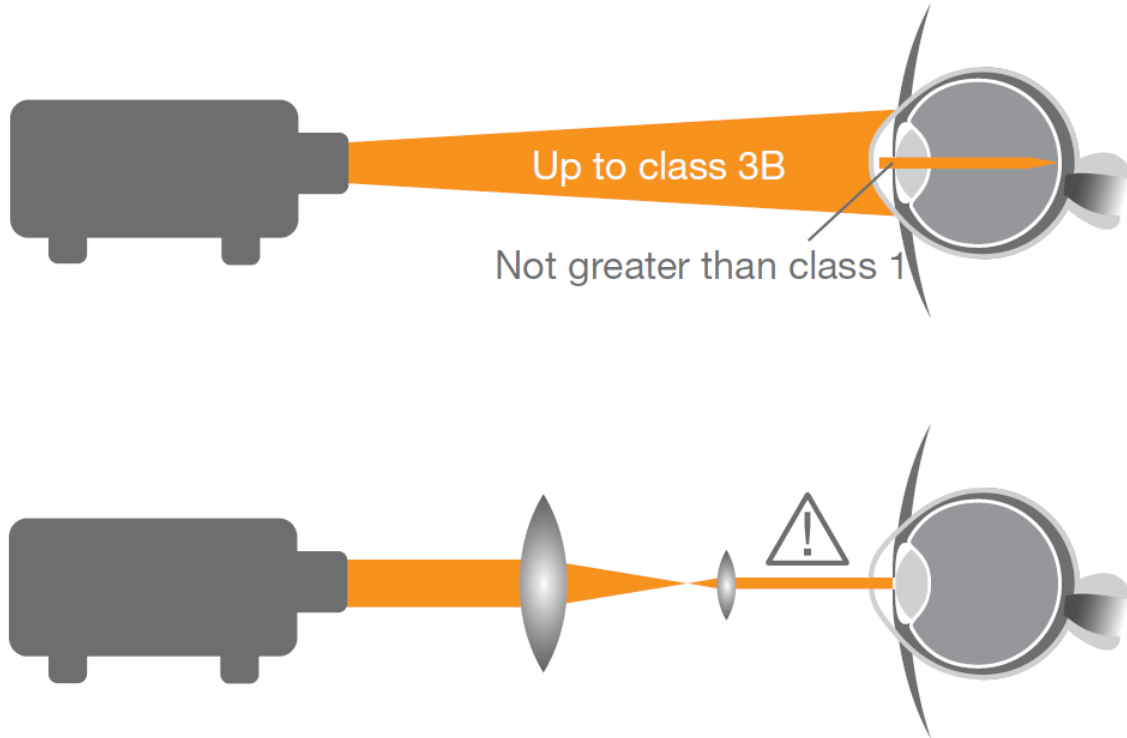
M = Magnification

# Class 1, 1M, 1B LASER

**Safety measures:** No measures are required. Class 1 lasers must be safe to handle in normal operation without instruction.



- Class 1 – Exempt lasers or laser systems that cannot, under normal operation conditions, produce a hazard. Or, Class 1 lasers also includes high-power lasers that are completely enclosed by shielding so that no dangerous radiation is emitted outside.
- Example: Nanoscribe GT

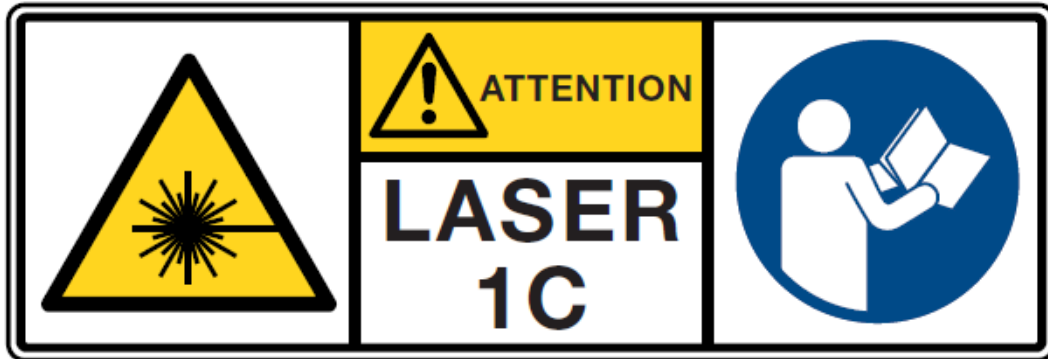


**Safety measures:** Do not direct the beam at other persons. Specifically warn persons who might use optical instruments (telescopes, microscopes).



- Class **1M** laser--has a larger diameter than the pupil of the eye so that only part of the radiation can reach the retina. Class 1M lasers are harmless to the naked eye, even after long-term exposure.
- However, damage to the eye is possible if the beam is focused through additional optical instruments such as binoculars or microscopes (eyeglasses excluded). This way, a larger proportion of the radiation can pass through the pupil. The wavelength is limited to the 302.5 nm to 4000 nm range in this class.

**Safety measures:** Check safety equipment periodically and follow the manufacturer's safety instructions.

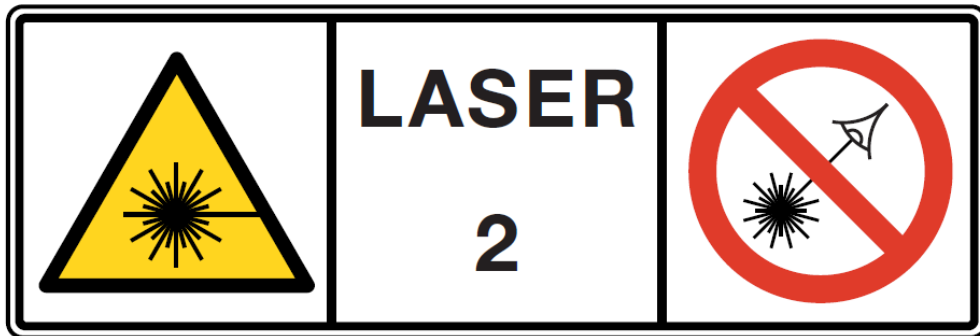


- Class **1C** lasers are used to directly treat skin or tissue during medical, therapeutic or cosmetic procedures.
- The emitted laser radiation can correspond to Class 3R, 3B or 4. It must be guided to the part of the body to be treated and monitored by at least one safety mechanism of the device so that the accessible radiation complies with the Class 1 requirements.

## Class 2, 2M LASER



**Safety measures:** Do not stare into the beam. Do not direct the beam at other persons. Should you still be struck by a beam, deliberately close your eyes and turn away from the light source immediately.



- Class 2 – Low power visible (400-700 nm ) lasers or lasers systems which, because of normal human aversion responses, do not normally present a hazard, but may present some potential for hazard if viewed directly for **extended periods** of time (0.25s).
- CW: <1mW
- Example – most alignment lasers should be Class 2; laser pointer;

# Class 2, 2M LASER

**Safety measures:** Do not stare into the beam. Do not direct the beam at other persons. If you are hit by a laser beam, close your eyes and turn away. Specifically warn persons who might use optical instruments (telescopes, microscopes).



- **Class 2M laser** -- has a larger diameter than the pupil of the eye so that only part of the radiation can reach the retina.
- Class 2M lasers only emit radiation in the visible range of the spectrum (400 nm to 700 nm). Short-term exposures (< 0.25 s), without the use of optical instruments such as binoculars or microscopes (eyeglasses excluded), are safe.
- As with Class 2, radiation may cause afterimages or glare effects. This can lead to temporary visual impairment, which may have serious consequences, for example, during safety-critical work on machinery, when working at heights, when driving a vehicle or for pilots.

# Class 3R LASER

**Safety measures:** Only use qualified and trained personnel. The open beam must not pass at eye level (either when sitting or standing), otherwise the application range must be shut off. The laser must be protected against unauthorized access.

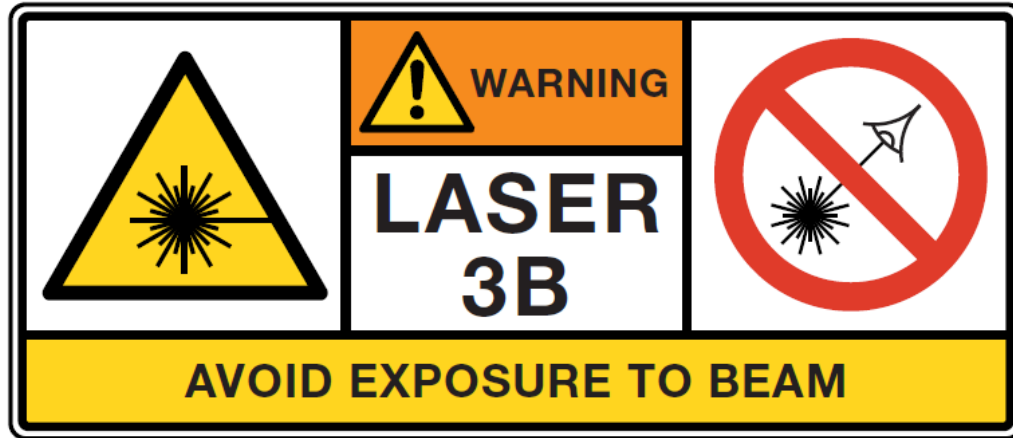


- Class 3R laser -- is considered safe if handled carefully, with restricted beam viewing. With a class 3R laser, the Maximum Permissible Exposure (MPE) can be exceeded, but with a low risk of injury. Visible continuous lasers in Class 3R are limited to **5 mW**.
- Example – HeNe up to 5 mW total power





# Class 3B LASER



- Class 3B – Lasers or laser systems that can produce a hazard if viewed directly.
- Staring into Class 3B lasers is dangerous and may cause eye damage (even from brief, accidental exposure). Gazing at diffuse reflections is normally not harmful to the eye. Direct exposure to the laser can also damage the skin or inflame combustible materials. Class 3B lasers emit at most **0.5 watts** in continuous wave mode.
- Example – HeNe from 5 mW up to 500 mW total power

# Class 4 LASER



- Class 4 – Lasers that can produce a hazard not only from direct reflection, but also from **diffuse** reflection. In addition, such lasers may produce **fire** hazards and **skin** hazards
- Example – High power Argon Ion lasers

# Class 3R, 3B and 4 lasers: only operated by qualified and trained personnel

- **Safety measures for Class 3B and 4 lasers:**
  - Class 3B and 4 lasers may only be operated (completely enclosed as a Class 1 laser) or, if not possible otherwise, in a defined and monitored laser area.
  - The operator must ensure that no one can be unduly irradiated. In this regard, he is obliged to take the necessary safety precautions and train or instruct the employees accordingly.

# **Safety regulations in our group**

## System in ETH

- 80 mW **red** light laser, class 3B
- 1.5 W **green** light laser, class 4
- the laser beam can damage the eyes
- Laser power density is too low to cause significant skin damage
- Class 3B laser system (microscopic) is covered by laser protection curtain capturing stray light;
- Class 4 laser system (photothermal) is homogenized and the power density is reduced; the laser is aligned in the plasmonic system;



class 4



class 3B



# !! General Safety Practices While Working

- Wear appropriate protective **eyewear**
- Use **minimum** power/energy required for project
- Enclose beam as much as possible
- Reduce laser output with shutters/attenuators
- Terminate laser beam with **beam trap**
- Use diffuse reflective screens, remote viewing systems, etc., during alignment if possible
- Remove unnecessary objects from vicinity of laser
- Locate beam at waist level or below. Keep beam path away from eye level (sitting or standing)
- Don't put your body parts (particularly your eyes) in the beam path!



## Protection in our cases:

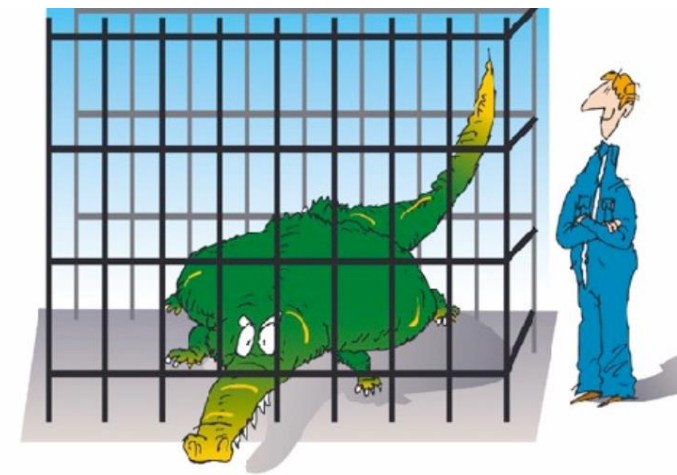
- Laser safety glasses for the operator
- Use **minimum** power/energy required for project
- Laser safety curtain protects the rest of the lab members from stray light
- Organization:
  - If laser light is on, knock the door and wait for operator to let you in
    - This is necessary in case that the laser safety curtain is opened for alignment
  - The operator has to inform the lab members if laser is used or safety curtain is used
  - New users must be trained
  - All lab members must get a anual training and sign it

# BE SAFE + BE SMART

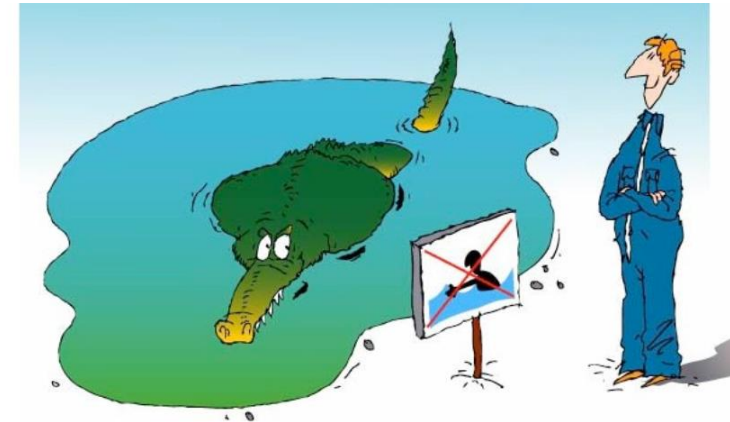
- Technical
- Organizational
- Personal

THANKS FOR  
YOUR  
ATTENTIONS

**T**echnical:



**O**rganizational:



**P**ersonal

