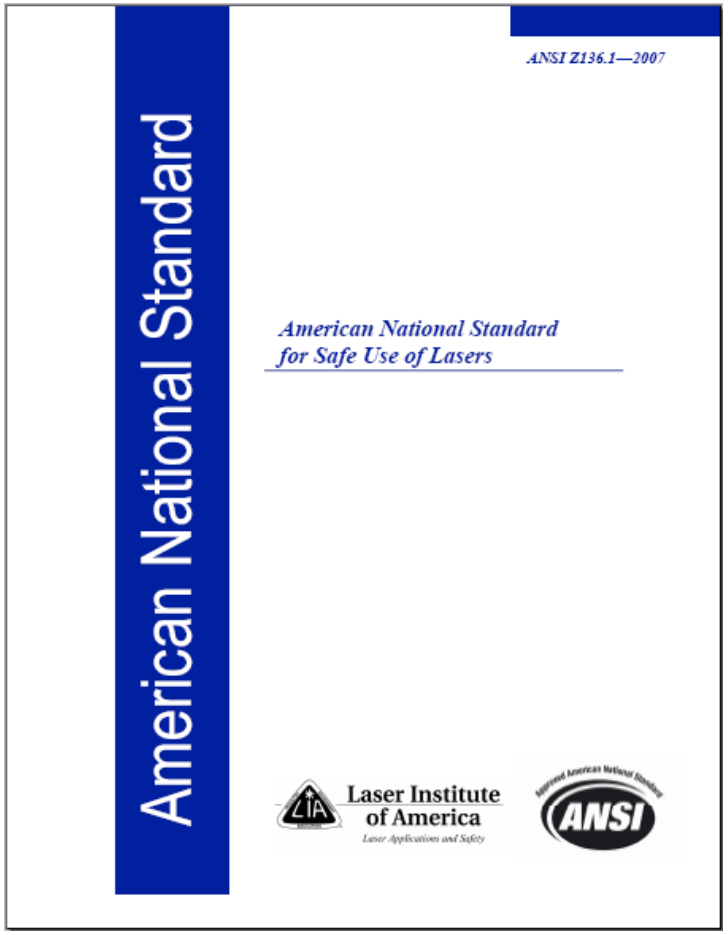
Laser Safety

MS 2014.07.16

- Over the past 15 years there have been no serious laser accidents.
- We want to keep it that way.
- Primary reason: safety of all people involved in research with lasers.
- Secondary reason: a serious accident would likely result in implementation of “standard” safety procedures: interlocks on laser labs, limited access, burdensome procedures.
- These procedures would impact our research but would not guarantee safety.
- The only 100% guarantee of safety is don’t turn the laser on.
- We can find a sensible compromise.

OVERVIEW OF ANSI Z136.1



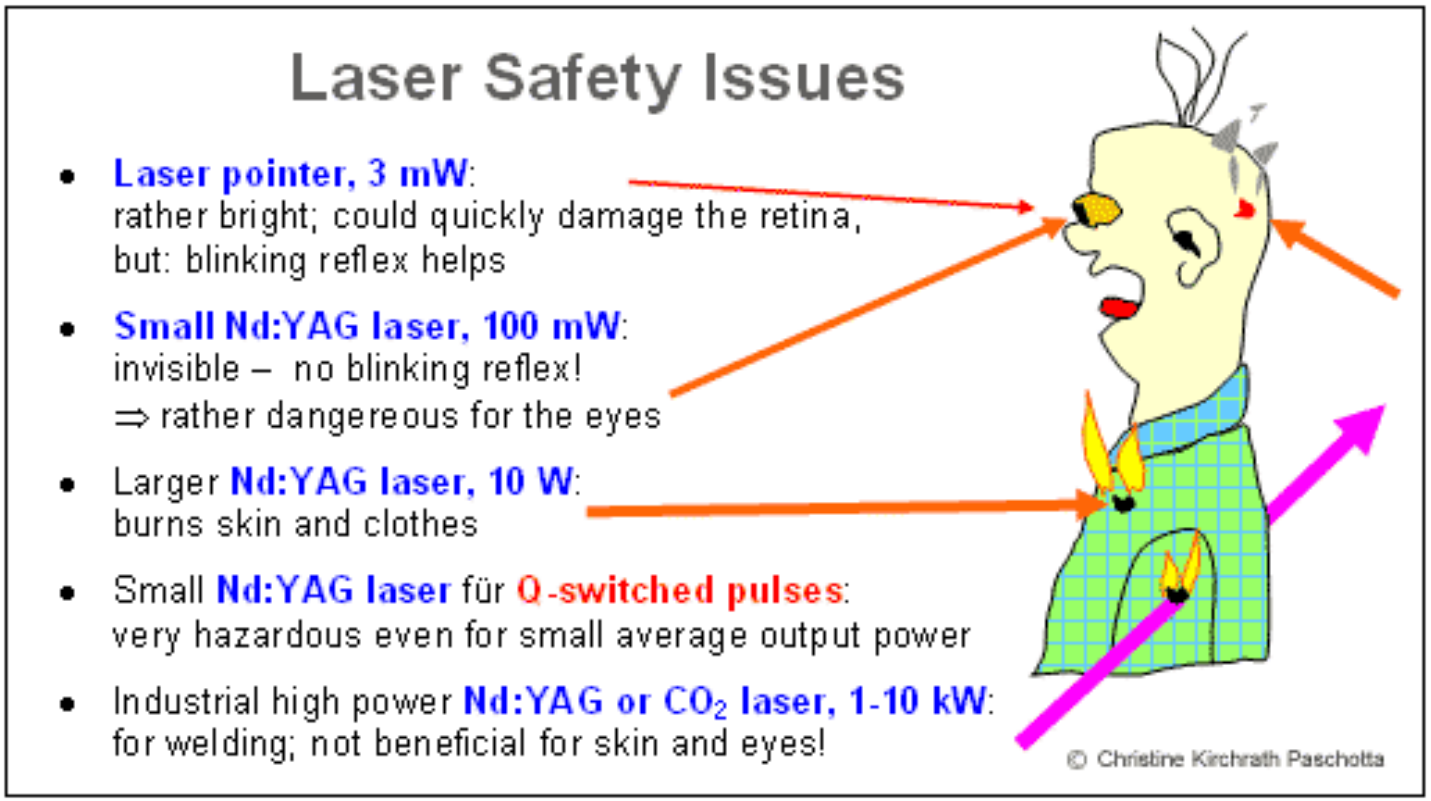
1. MANAGEMENT APPOINTS LASER SAFETY OFFICER
2. LSO VERIFIES LASER CLASSIFICATION
3. LSO EVALUATES HAZARDS BY DETERMINING
   - MPE -- OD -- NHZ
4. LSO SPECIFIES CONTROL MEASURES
   - ENGINEERING CONTROLS
     - ENCLOSURES
     - INTERLOCKS
     - WARNING SYSTEMS
   - ADMINISTRATIVE AND PROCEDURAL CONTROLS
     - AUTHORIZED PERSONNEL
     - SOP (INCLUDING ALIGNMENT)
     - TRAINING
   - PROTECTIVE EQUIPMENT
     - EYEWEAR
     - BARRIERS

Our goal is to stay safe and avoid implementing all of these procedures.

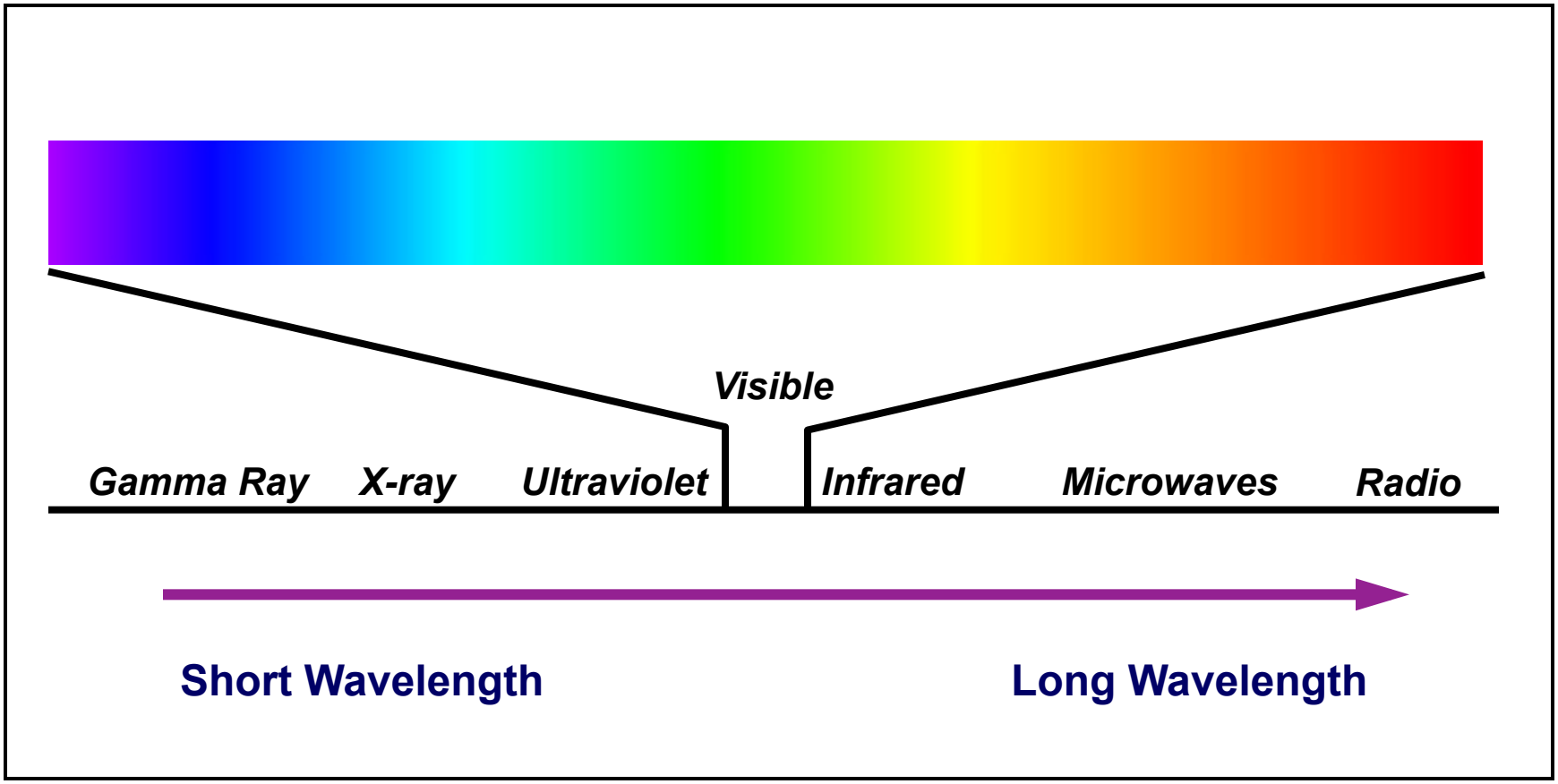
Laser Safety resources

Wikipedia http://en.wikipedia.org/wiki/Laser_safety

OSHA http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_6.html

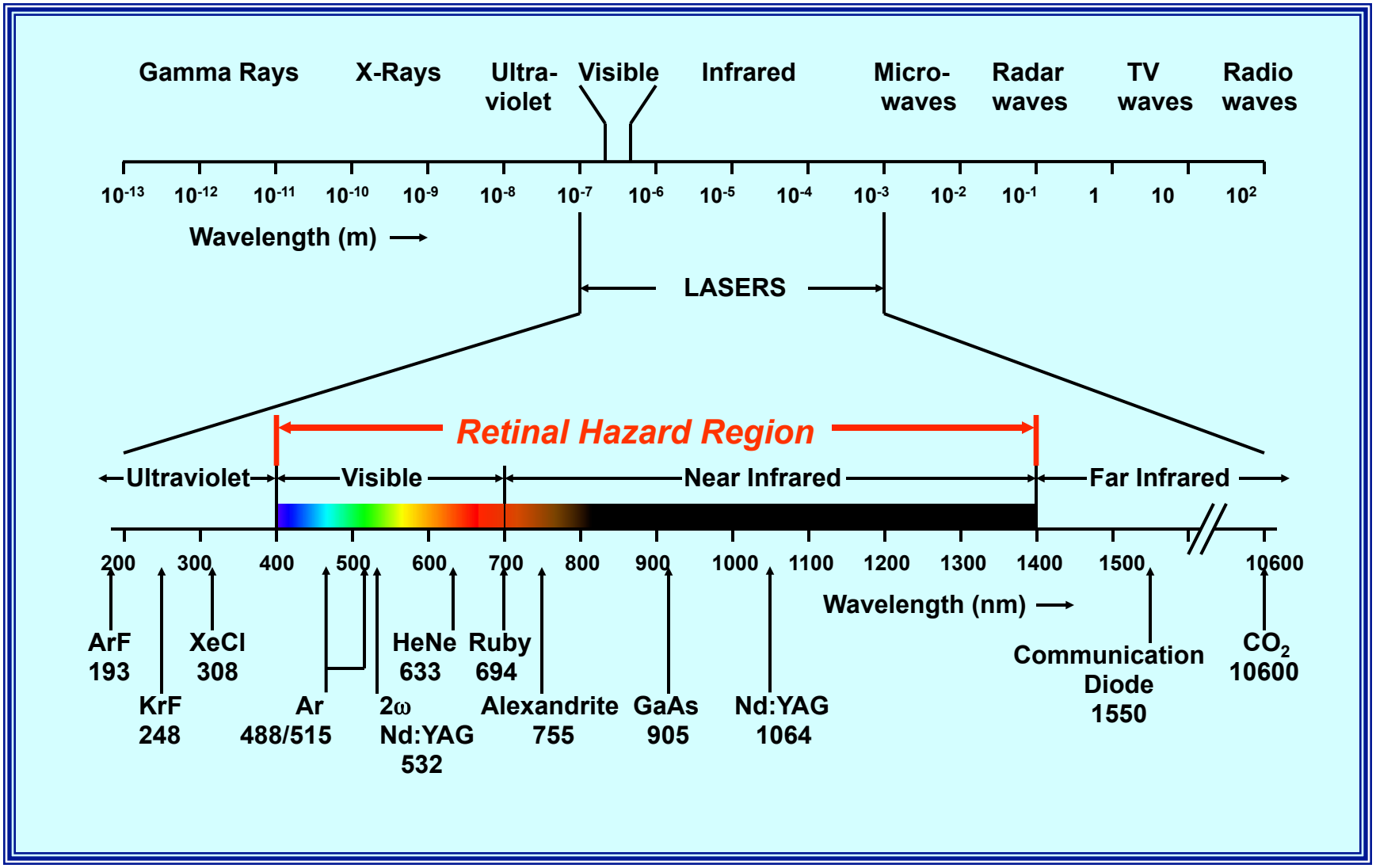


Electromagnetic Spectrum

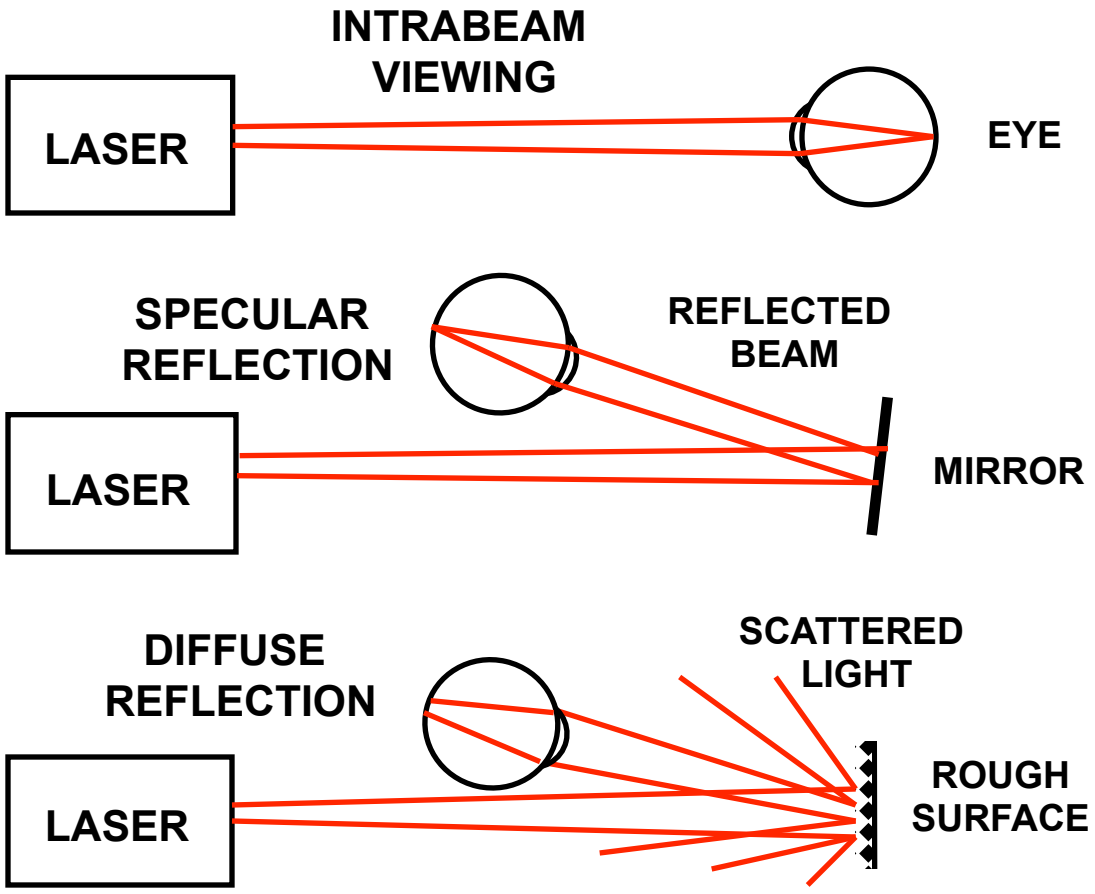


Lasers operate in the ultraviolet, visible, and infrared.

Electromagnetic Spectrum



TYPES OF LASER EYE EXPOSURE



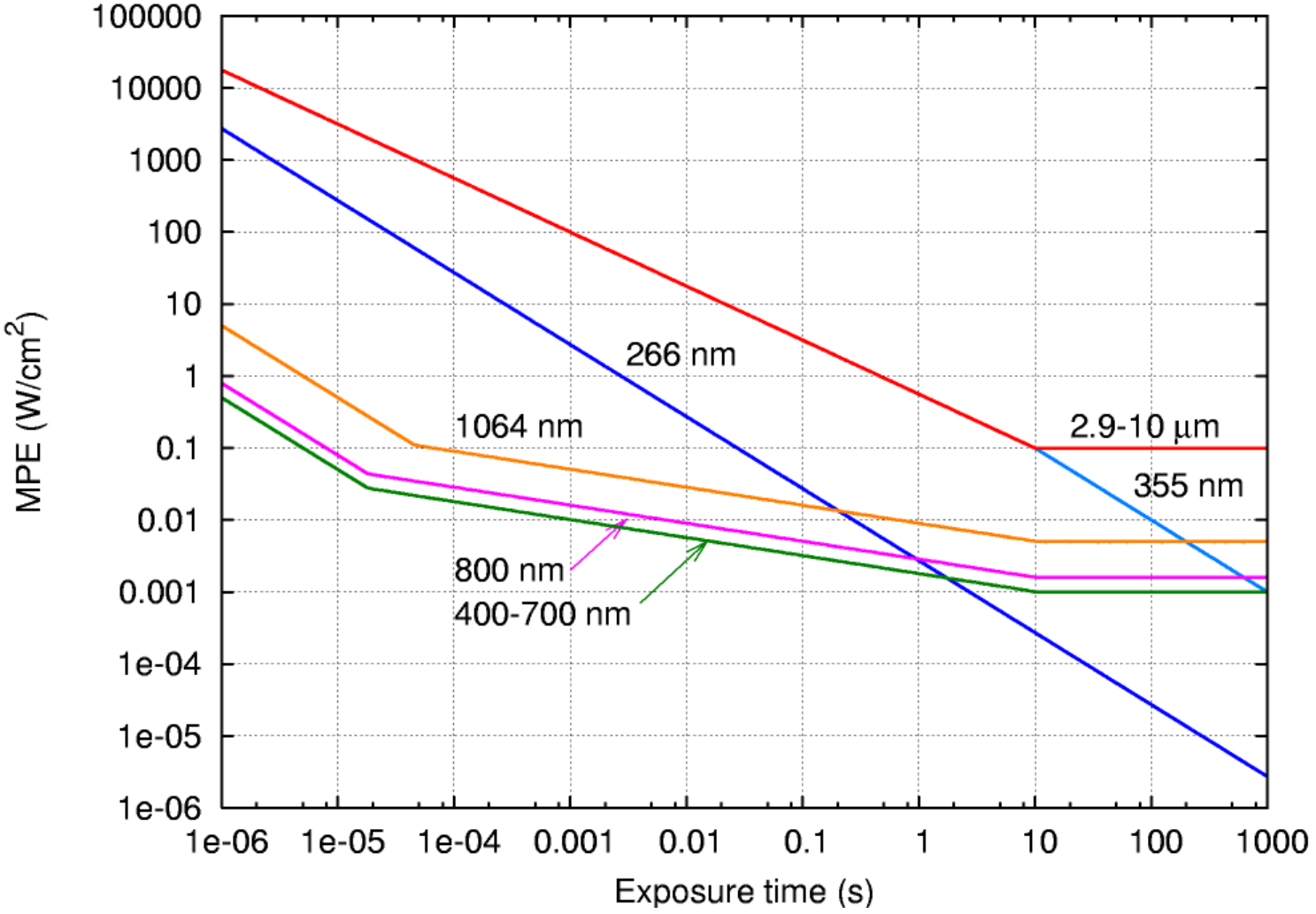
Ocular Damage Mechanisms

Wavelength range	Pathological effect
180–315 nm (UV-B, UV-C)	photokeratitis (inflammation of the cornea, equivalent to sunburn)
315–400 nm (UV-A)	photochemical cataract (clouding of the eye lens)
400–780 nm (visible)	photochemical damage to the retina, retinal burn
780–1400 nm (near-IR)	cataract, retinal burn
1.4–3.0μm (IR)	aqueous flare (protein in the aqueous humour), cataract, corneal burn
3.0 μm–1 mm	corneal burn

Skin damage can be thermal (burns) or sunburn and skin cancer from UV sources

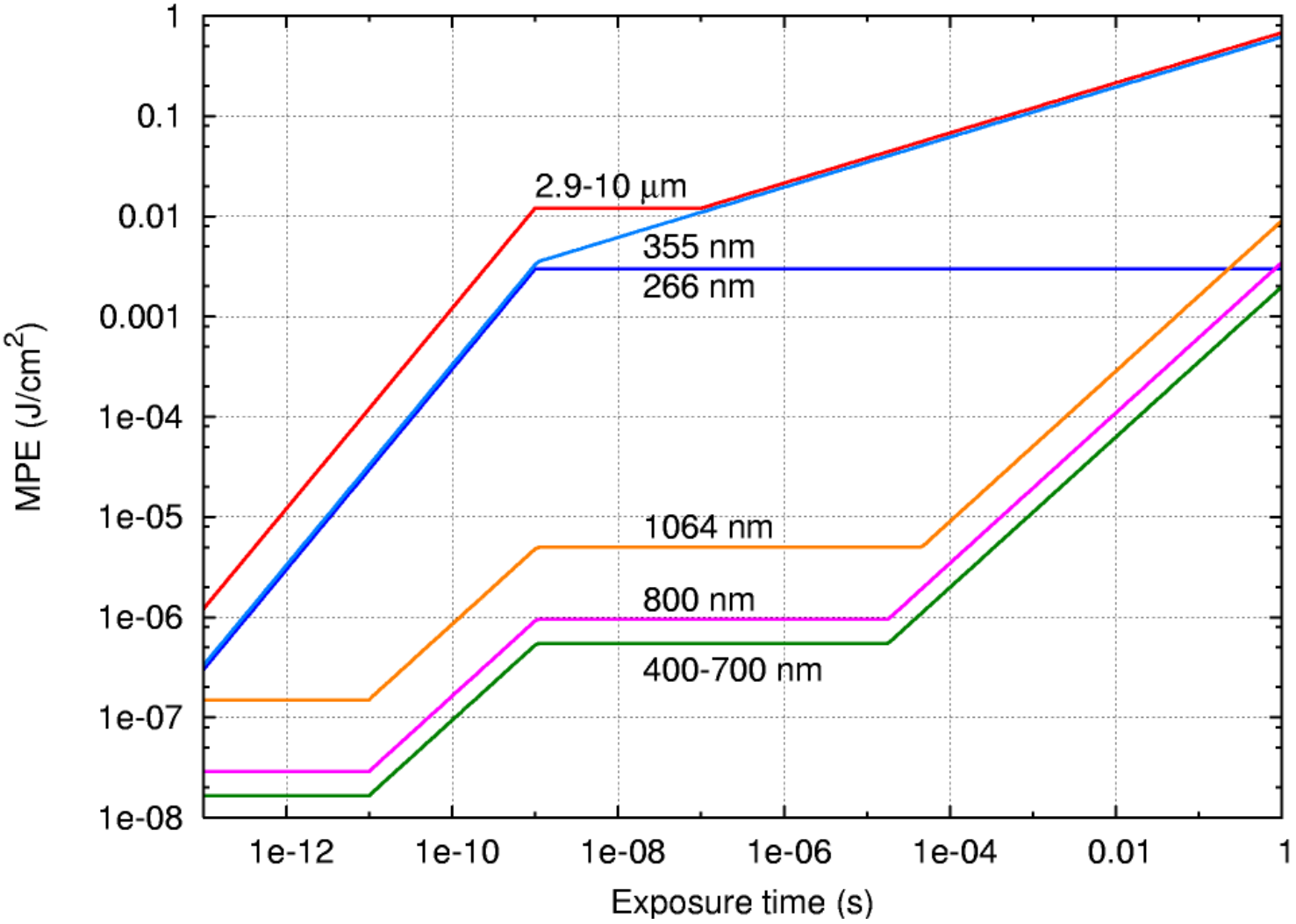
MPE Maximum Permissible Exposure

Continuous lasers



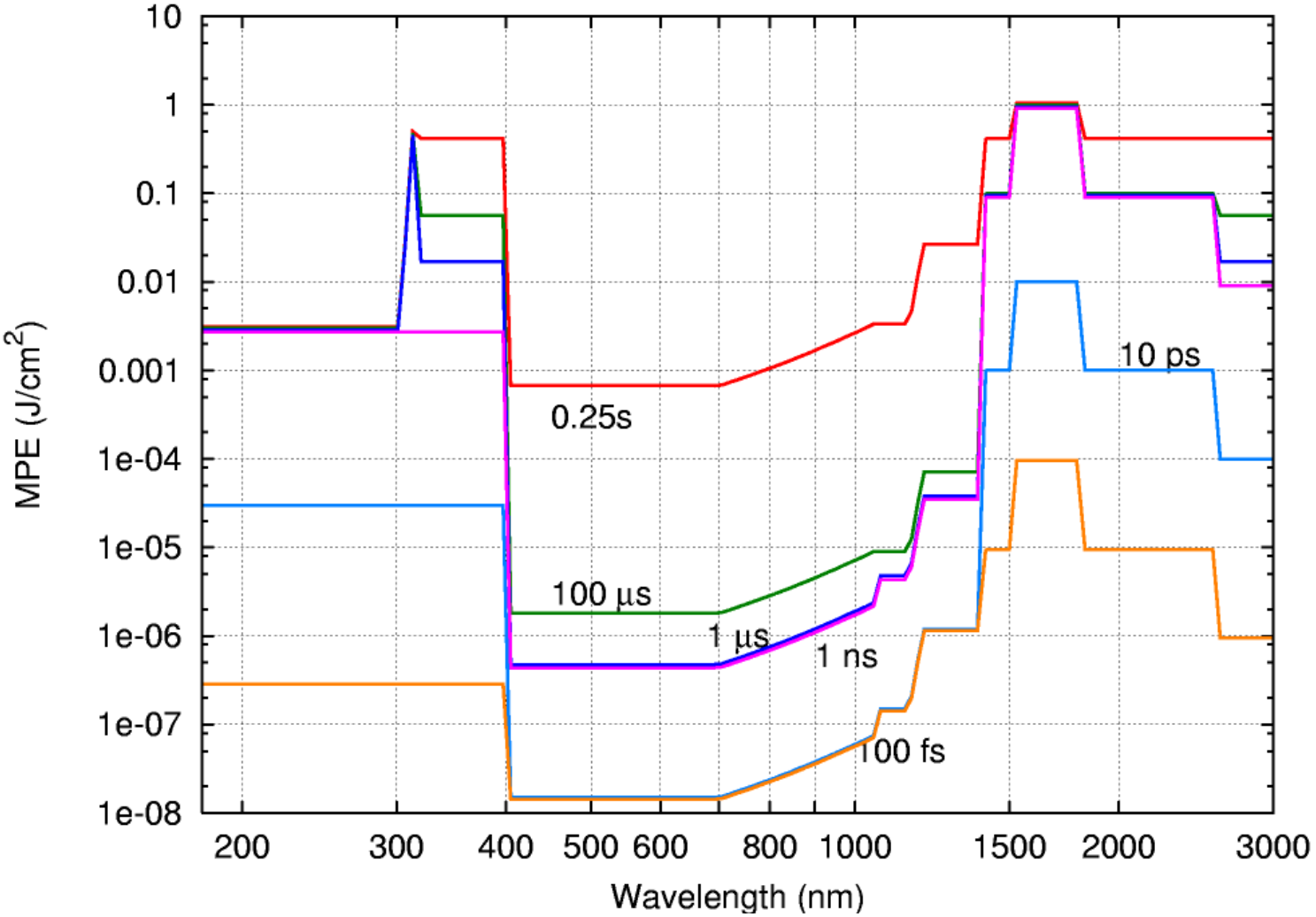
MPE Maximum Permissible Exposure

Pulsed lasers



MPE Maximum Permissible Exposure

Pulsed lasers



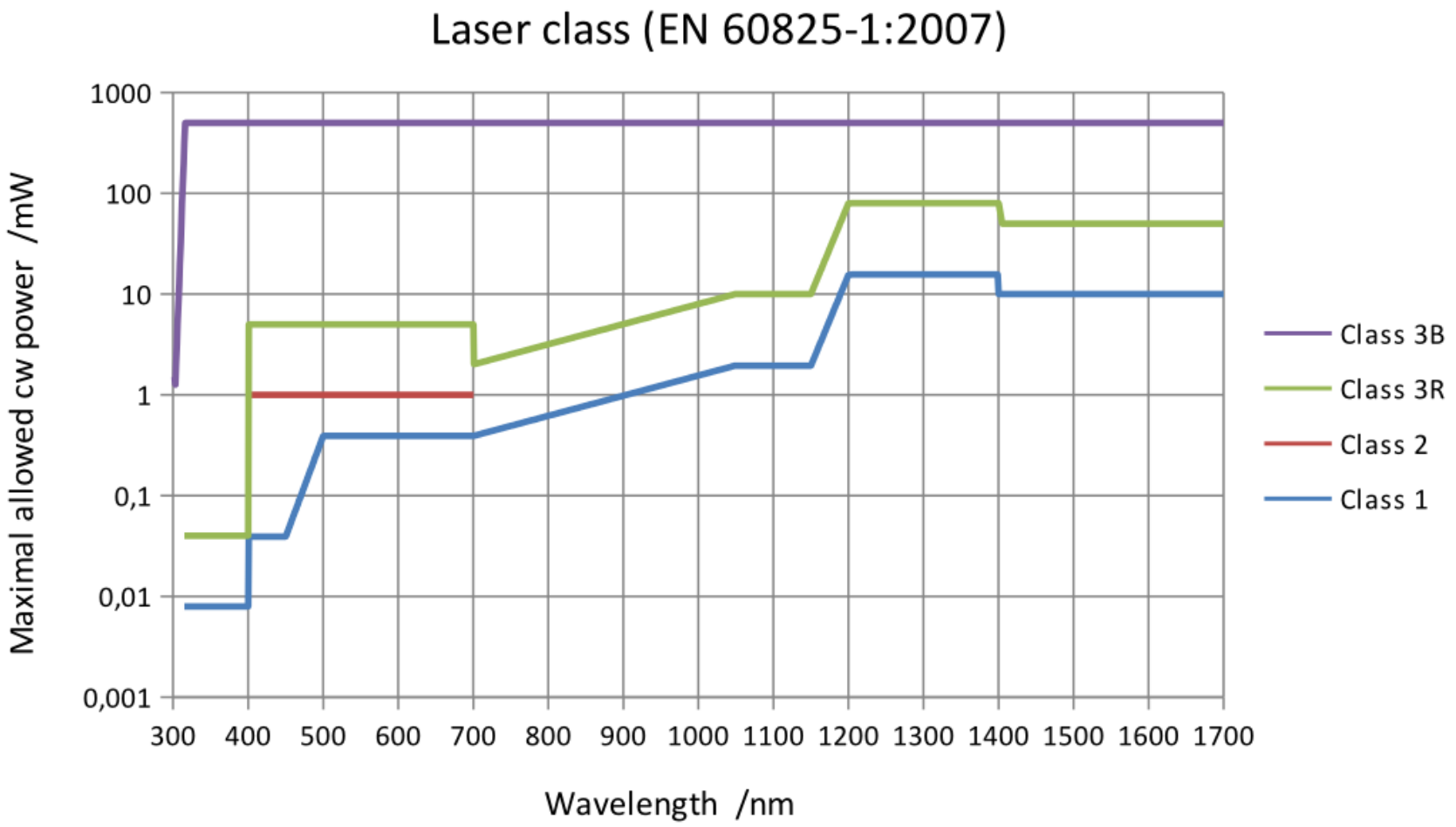
Laser Classification

Class	Characteristic
Class 1	• Eye safe under all operating conditions • Does not emit harmful levels of radiation during normal operation. • Includes higher class lasers completely enclosed and interlocked to prevent beam access, allowing a Class 1 laser system designation; any time the higher class laser is accessible (e.g. during alignment or servicing), the higher laser class controls must be observed. • Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.
Class 2	• Emits accessible laser light in the visible wavelength region. • Chronic exposure can cause eye damage. • In general, the human eye will blink within 0.25 second when exposed to Class 2 laser light; this blink reflex provides adequate protection. • Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.
Class 3a	• Normally not hazardous when viewed momentarily with the unaided eye, but may pose severe eye hazards when viewed through collecting optics (e.g., microscopes and binoculars). Power levels 1-5 milliwatt (mW). • Same controls as Class 1 and Class 2 lasers for normal operations; if viewed through optical instruments (e.g., binoculars, telescopes, or microscopes), contact the LSO for a hazard review.
Class 3b	• Will cause injury upon direct viewing of the beam and specular reflections. • Power output 5-500 mW for CW or less than 0.03 joule (J) for a pulsed system (i.e. pulse width less than 0.25 second). • The radiation can be a hazard to the eye or skin. However, viewing of the diffuse reflection is safe
Class 4	• Includes all laser systems with power levels greater than 500 mW CW or greater than 0.03 J for a pulsed system. • Pose eye hazards, skin hazards, and fire hazards. Viewing the beam or specular reflections or exposure to diffuse reflections can cause eye and skin injuries. • All control measures explained in this document must be implemented.

Laser Classification Summary

Class 1	Incapable of causing injury during normal operation
Class 1M	Incapable of causing injury during normal operation unless collecting optics are used
Class2	Visible lasers incapable of causing injury in 0.25 s. 1 mW max.
Class 2M	Visible lasers incapable of causing injury in 0.25 s unless collecting optics are used
Class 3R	Marginally unsafe for intrabeam viewing; up to 5 times the class 2 limit for visible lasers or 5 times the class 1 limit for invisible lasers 5 mW continuous
Class 3B	Eye hazard for intrabeam viewing, usually not an eye hazard for diffuse viewing 5-500 mW
Class 4	Eye and skin hazard for both direct and scattered exposure > 500 mW.

Laser Classification Power Graph



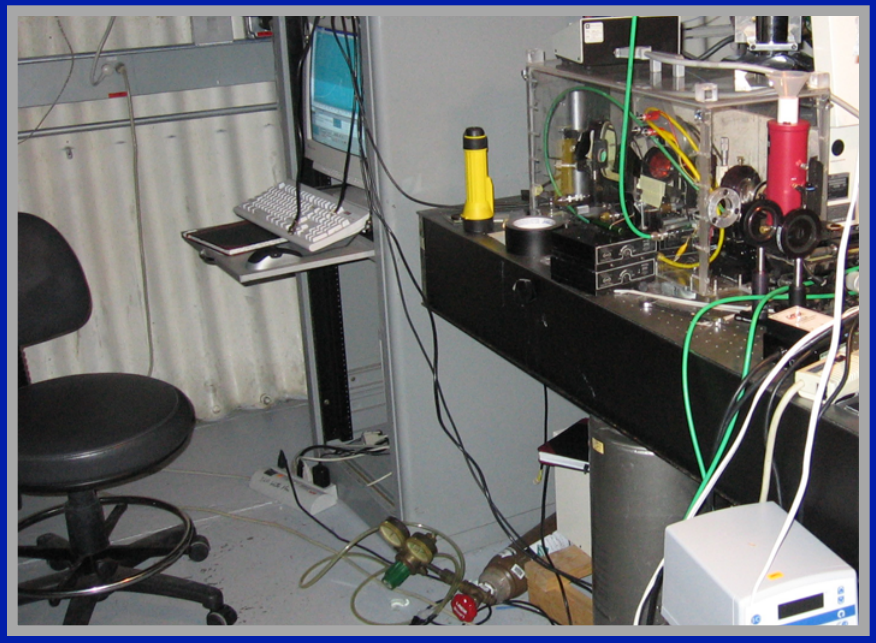
Safety Basics

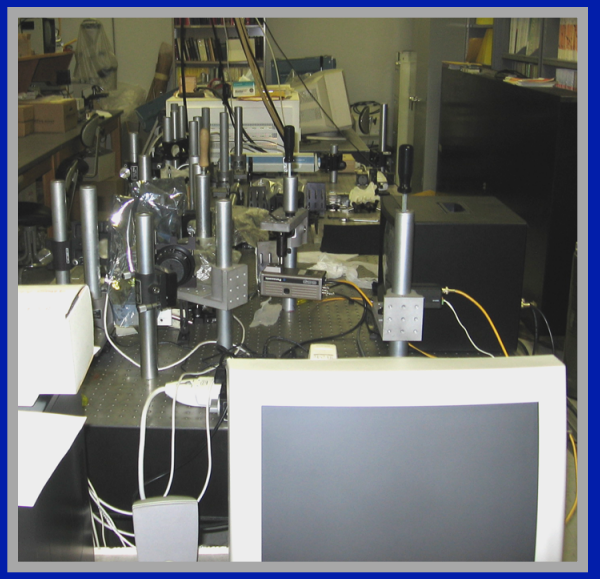
- Despite what your advisor says do not try and work faster than you are comfortable with.
- If you think your research environment is unsafe refuse to continue until a safe solution is implemented.
- Work methodically and always think carefully about where the beam is and where it could go.

Good practices I

- Remove rings and watches from hands when working with lasers.
- Get in the habit of closing your eyes when you pass the level of the laser table when you bend down to pick something up.
- Do not work sitting at a table near the laser table with your eyes level with the laser beams.

COMPUTERS IN RESEARCH LABS





Allowing a direct view from a computer workstation into a laser experimental setup increases the risk of eye exposure to reflected beams.

Good practices II

Most of our research lasers are Class 3 and Class 4. Precautions must be taken to avoid injury.

- Most accidents happen during alignment of optical systems.
- Perform alignment at low power.
- Do not align your optics by staring into the beam.
- Use viewing cards and/or cameras.
- Use laser goggles during alignment procedures.
- Use beam blocks to suppress secondary reflections and scattering.
- Weak reflections can be a danger. For example 1% reflection of a 1W laser = 10 mW which is still dangerous.

Laser Safety resources

Wikipedia http://en.wikipedia.org/wiki/Laser_safety

OSHA http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_6.html