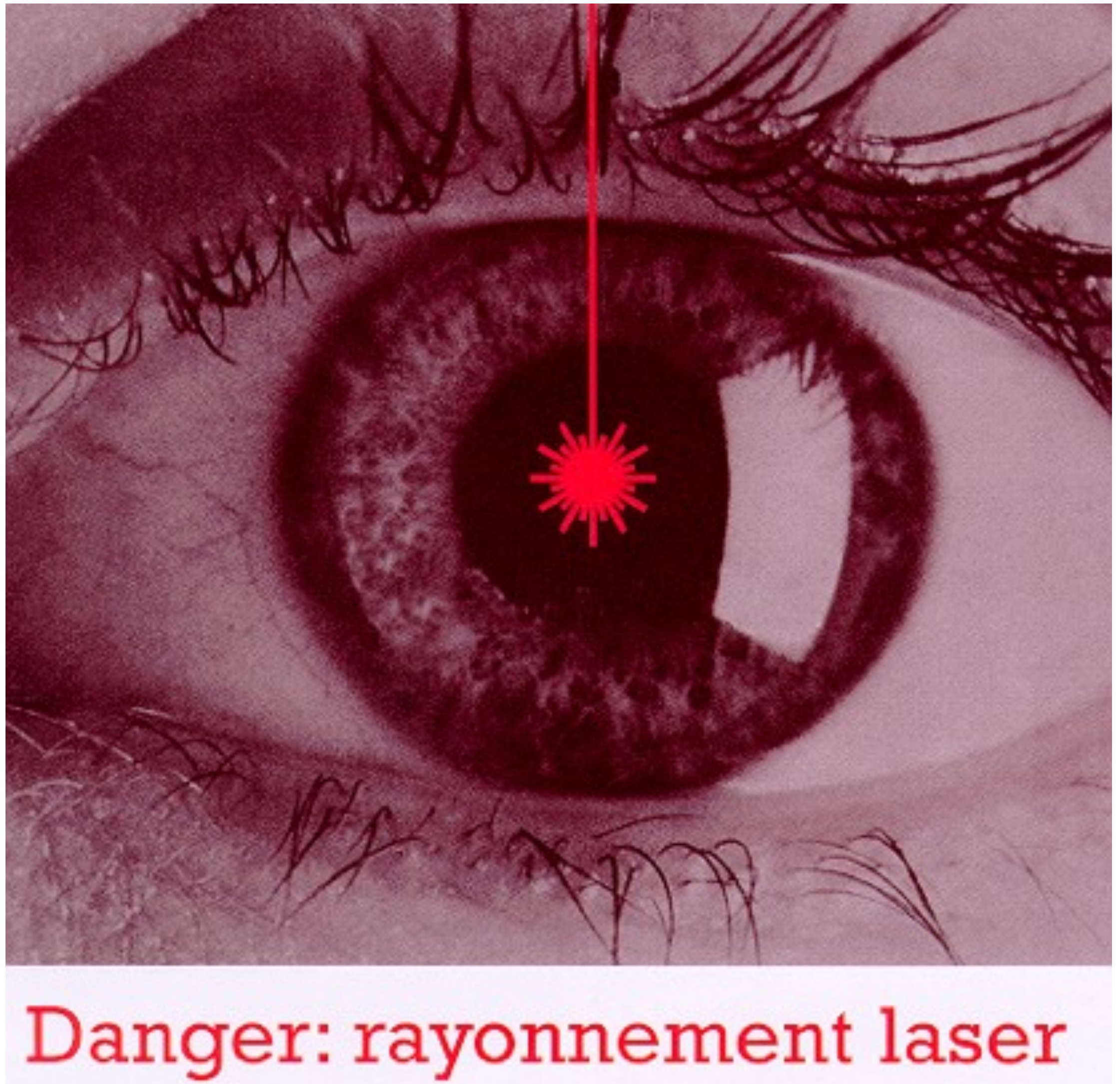
Laser safety in the lab

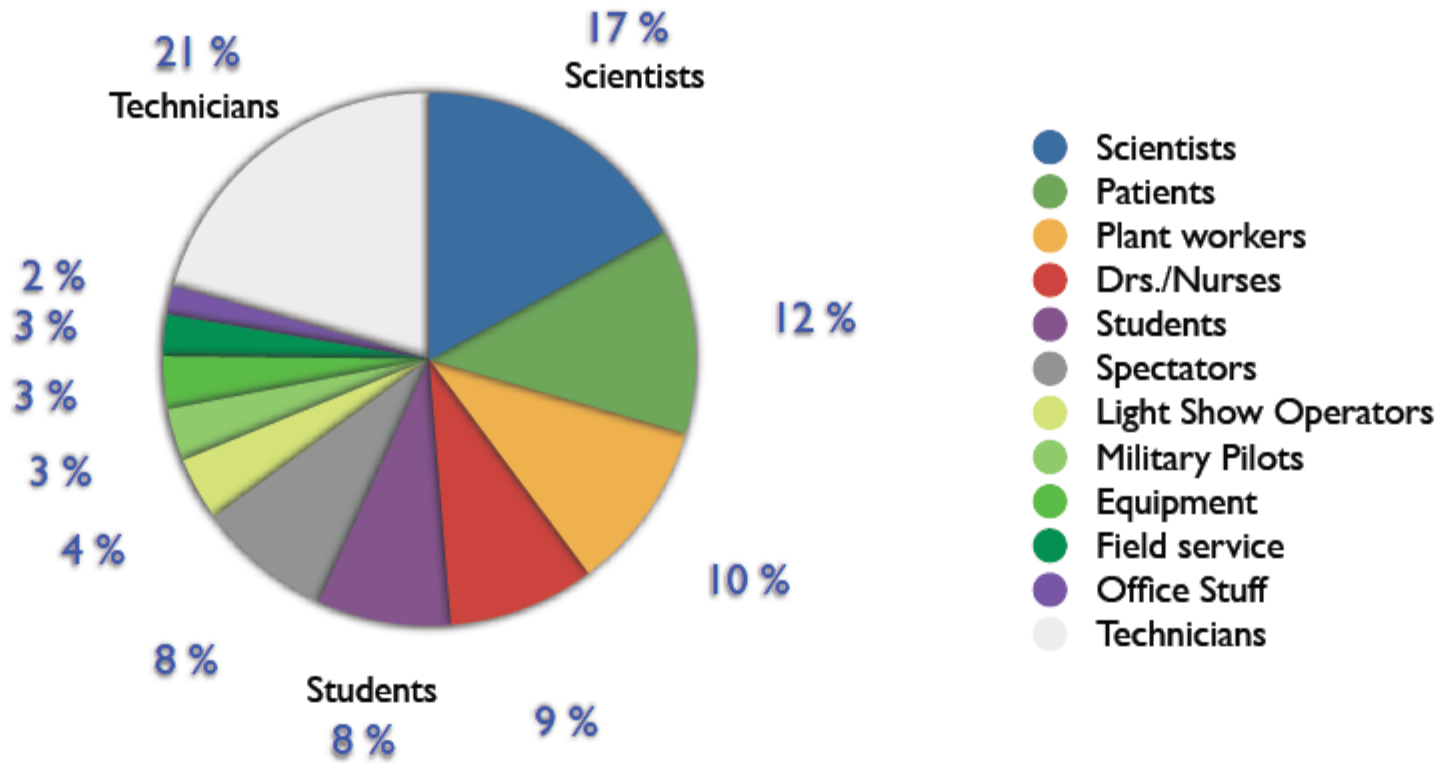


Laser safety

- potential dangers to health
- classification of lasers according to these dangers
- classifications of the lasers in our lab
- how to protect ourselves and our colleagues from these dangers

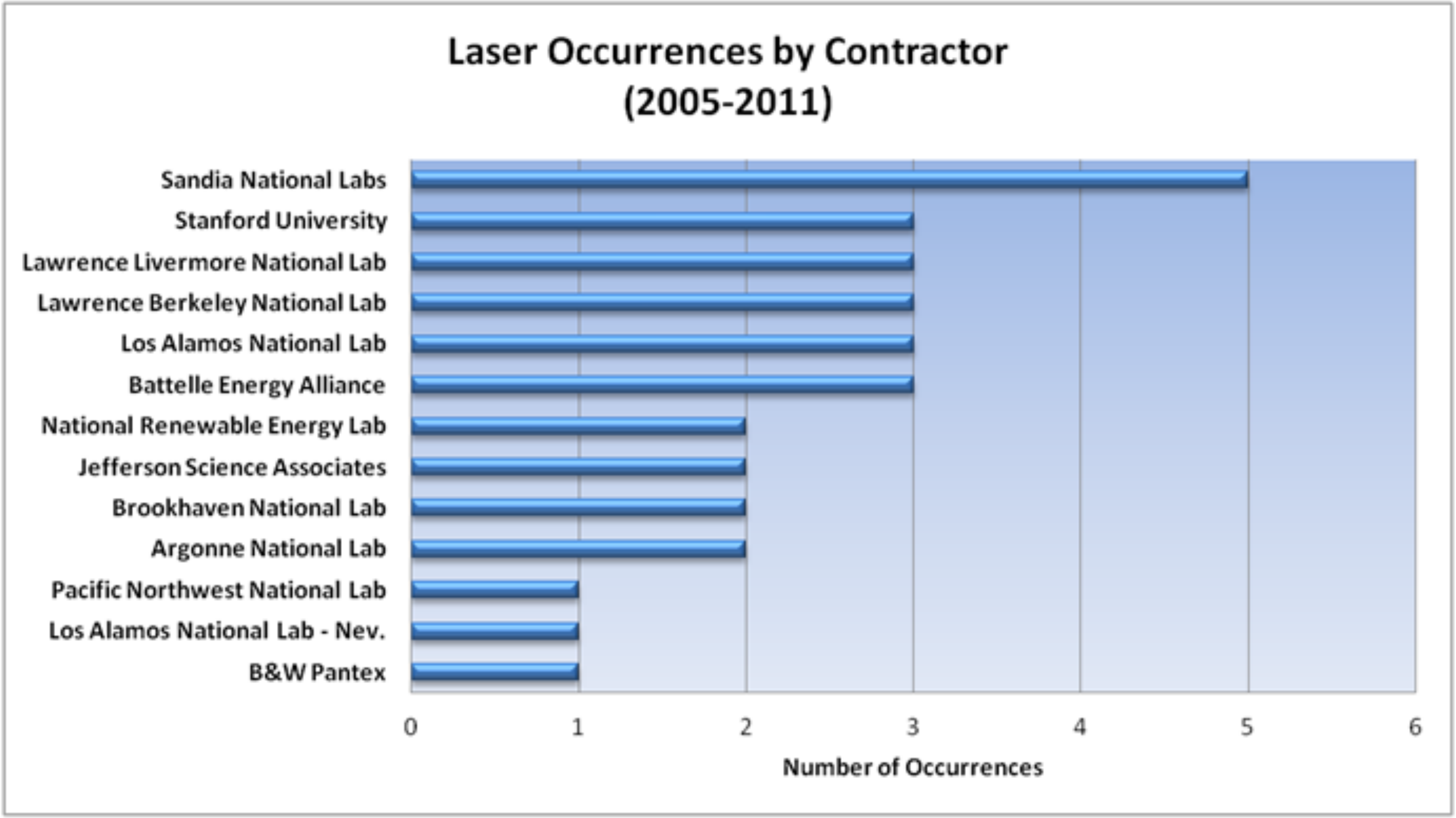
Laser Accidents ...They Do Happen !

Laser accident summary
Breakdown of 272 events by occupation [1964 - 1992]



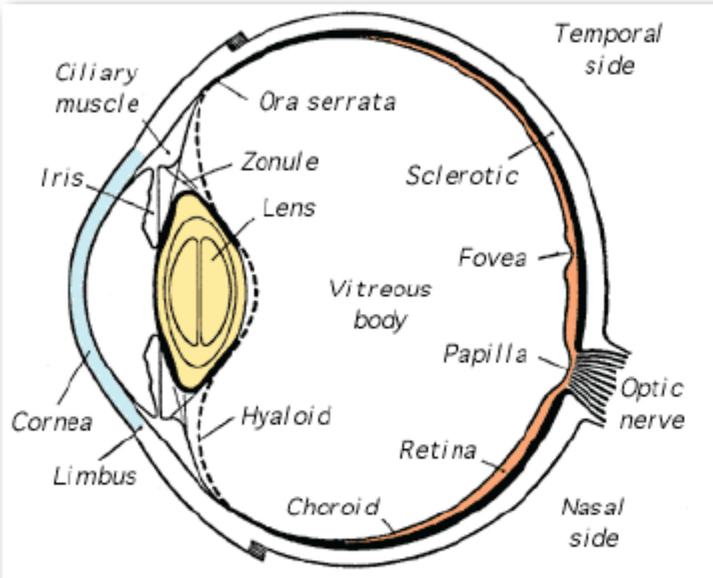
from Rockwell Lasers Industries, Inc. [2004]

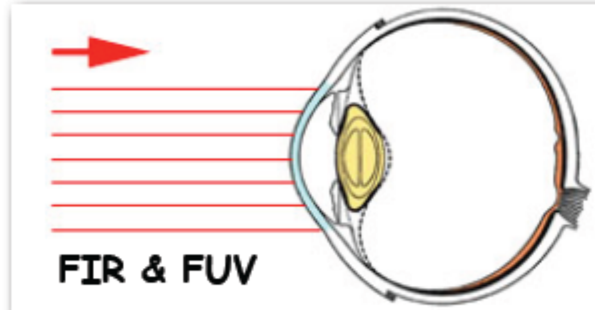
See **J.D. Ganiere, EPFL**,
http://sti.epfl.ch/files/content/sites/sti/files/shared/security/Newsletter/Laser_Safety_Ganiere.pdf

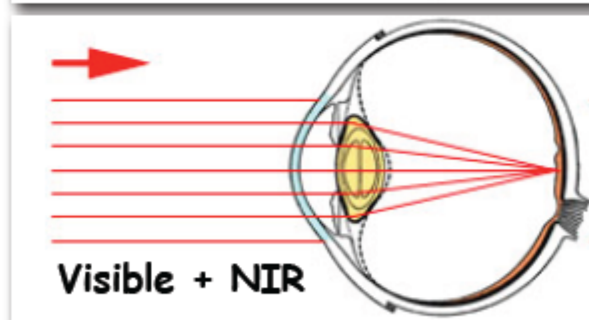


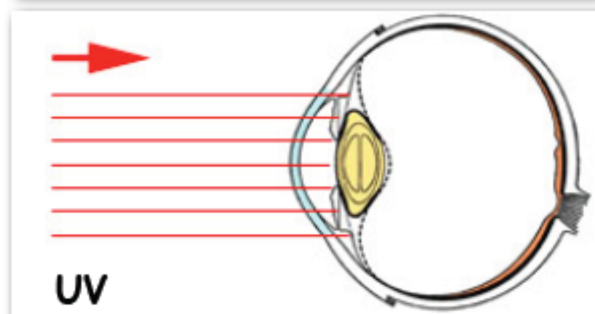
Also: Since November 19, 2004 there have been over 2,800 incidents of lasers directed at aircraft within the United States.

Beam Hazards, Eye Injuries









UV-C [FUV]	0.1 - 0.28 µm
UV-B [FUV]	0.28 - 0.32 µm
UB-A [UV]	0.32 - 0.4 µm
Visible	0.4 - 0.7 µm
IR-A [NIR]	0.7 - 1.4 µm
IR-B [FIR]	1.4 - 3.0 µm
IR-C [FIR]	3.0 - 1000 µm

Potential dangers to health: the eye

- all invisible light: danger is not obvious to our senses
  => no protective reflexes

- UV light: absorption in lens and glass body
  damage through ionisation and photochemistry
  partially curable

- IR light: deeper penetration, absorption and thermal heating, damage by thermal shocks

- visible light: focusing on the retina and total absorption
  damage through photo bleaching of pigments, thermal damage of retina and nerves

Potential dangers to health: the skin

- UV light: “sun burn” of the skin

- vis and IR light: thermal damage at higher intensities

Potential dangers: fire hazard

moderate and high power lasers may burn absorbing substances, causing fire in the lab

Security classification of lasers

Class I: no known biological hazard due to very weak power or effective protection by interlock.

example: laser printers
(used laser is class IIIb but effectively shielded)

Class II: laser power up to 1 milliwatt,
no hazard as closing reflex is fast enough (~1/4s) to protect from radiation.

examples: laser pointers,
laser scanners at checkout in super market

Security classification of lasers

Class IIIa: power output 1 - 5 milliwatt

hazards:

- spot blindness under “right” conditions
- other eye injuries
- no known skin or fire hazard

example: weak He-Ne lasers for adjusting

Class IIIb: power output 5 - 500 milliwatts

hazards:

- definite eye hazard from direct radiation
- particularly at higher power levels.
- skin burn at higher power levels
- fire hazard

Security classification of lasers

Class IV: power output >500 milliwatts.

hazards:

- eye damage
- eye damage even from diffuse radiation.
- skin burn
- fire hazard on materials and clothing
- diffuse radiation has to be considerd as dangerous as primary beam

Security classification of our lasers

He-Ne for adjusting: **Class IIIa**

All other lasers: **Class IIIb and Class IV**

special risk: lasers at 800nm seem to be visible,
what we see is mainly the blue tail of the spectrum

examples:

- moderately focused output of amplifier generates plasma in air
- amplifier output generates second harmonics on a piece of paper without focusing

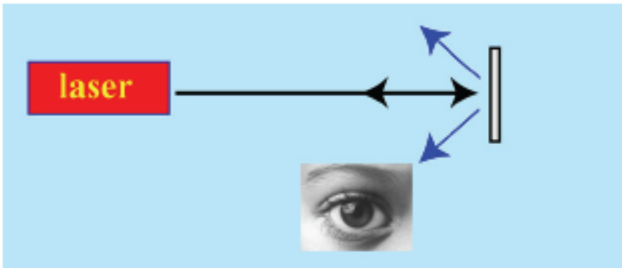
Security classification of our lasers

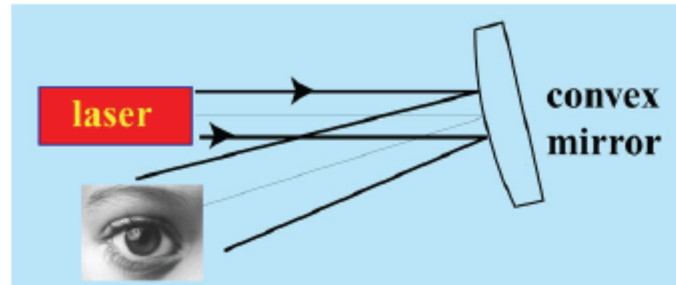
special risks in actual and upcoming projects:

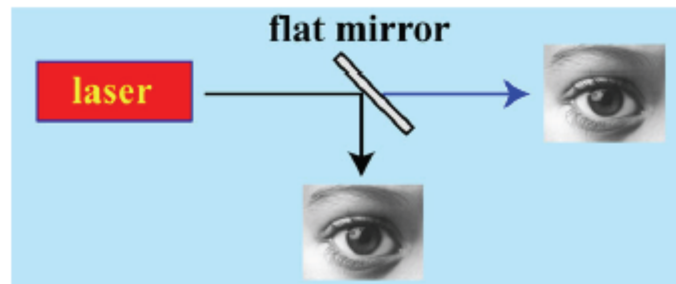
Third Harmonics Generation at 266nm, strong invisible beam

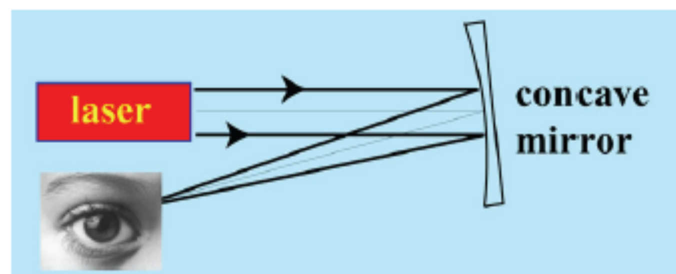
near and mid IR probing: strong beams, even not visible
on piece of paper through luminescence

Specular Reflection

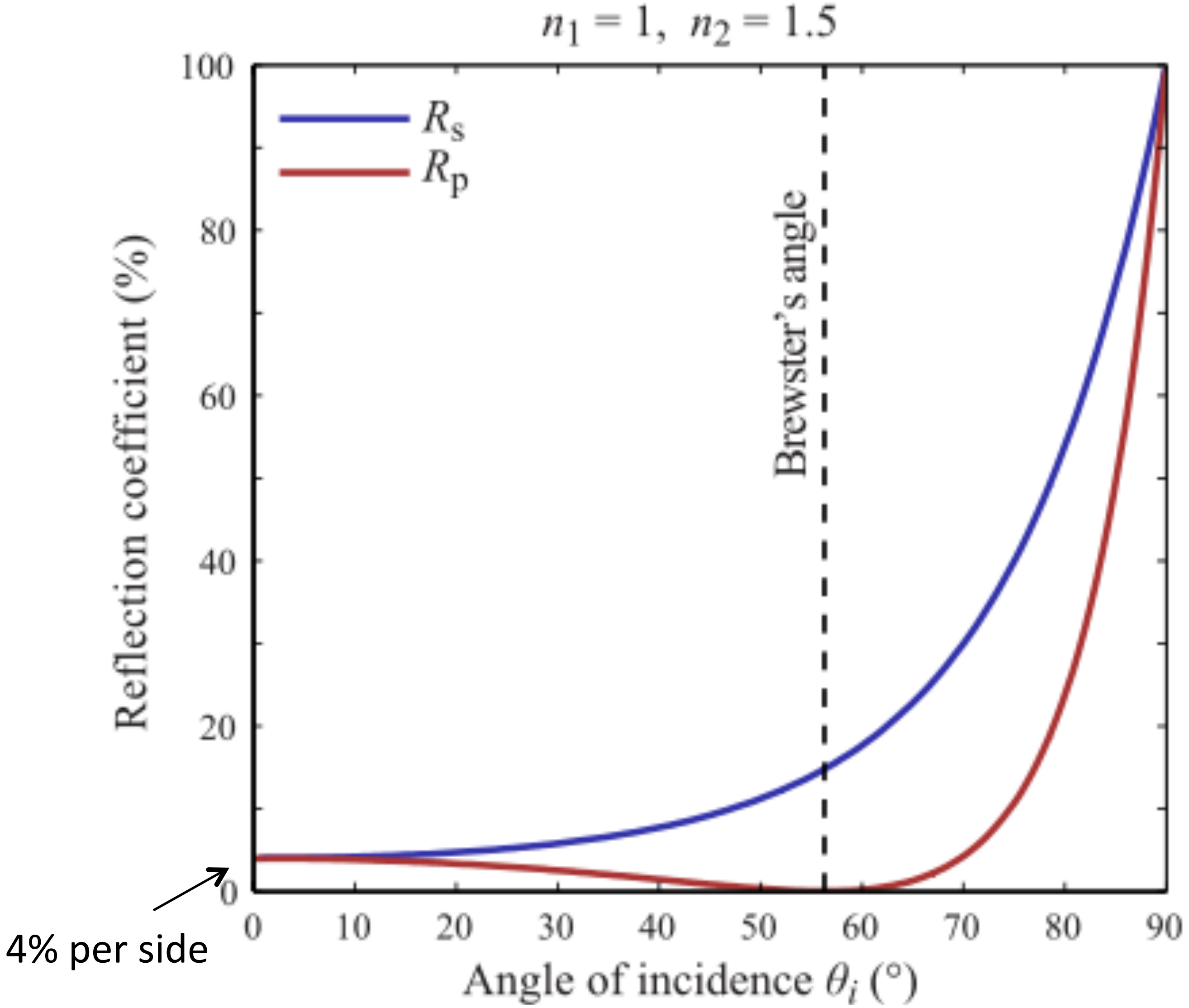






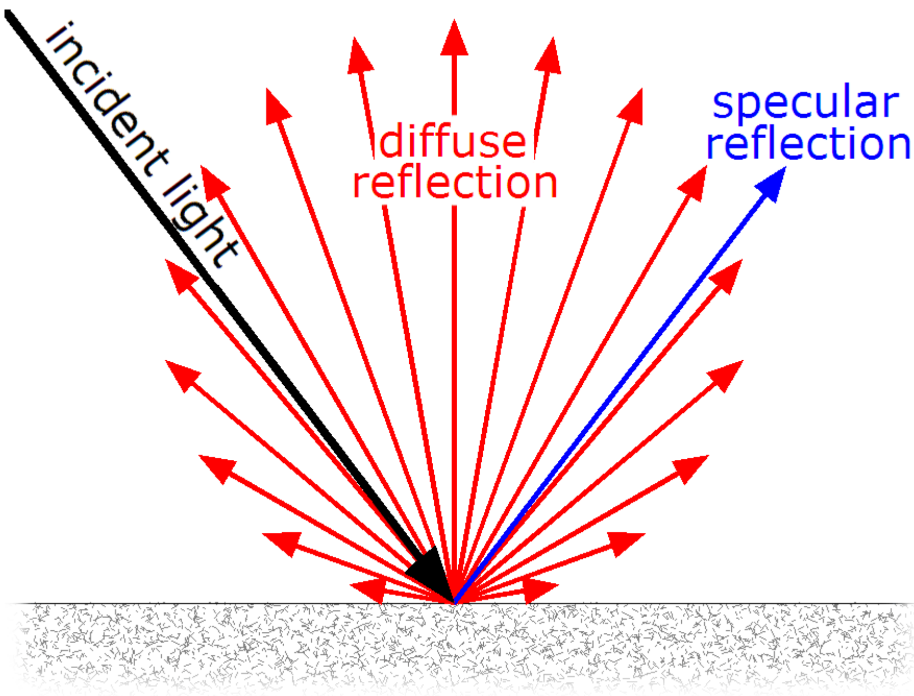


Specular reflection on glass



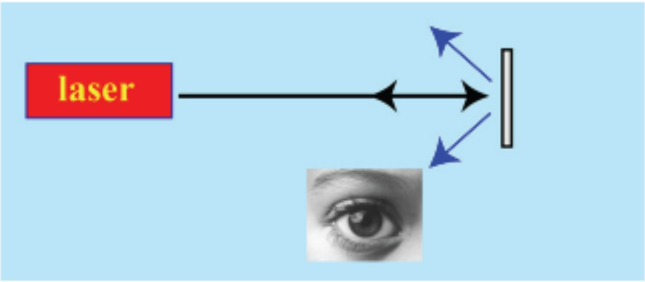
Specular reflection barely decreases with distance

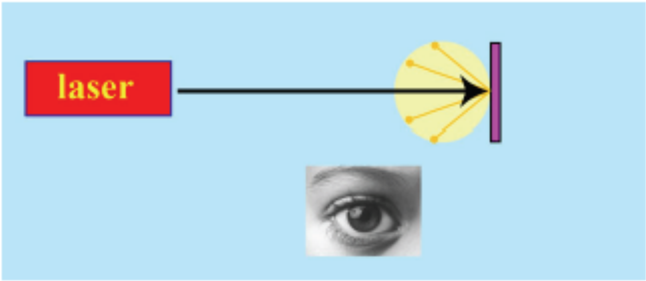
Diffuse reflection decreases with $1/r^2$

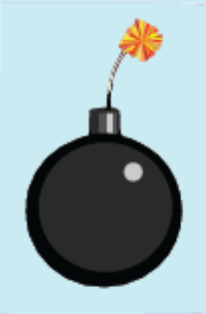


Surface illuminated at r ~ $2\pi r^2$

Specular versus Diffuse Reflection







The specular nature of the a surface is dependent upon the wavelength of incident radiation.
A specular surface is one that has a surface roughness less than the wavelength of the incident light. A very rough surface is not specular to visible light but might be to IR radiation of 10.6 um from a CO_2 laser.

Protection against laser hazards

a) general laser security rules

b) properties and risks of optical compounds

c) appropriate handling

General security rules, what to do / to avoid

general:

- never rush
- think before touching any device or mechanics on the laser table
- keep laser table tidy, fix all mounts on the table
- keep lights on whenever possible:

  smaller iris lets through less light, focus is less tight

- ware goggles when using invisible light or intensities > 100mW
- never do involved alignment in a fatigued state

General security rules, what to do / to avoid

for your colleagues' safety:

- ensure that laser warning light is switched on
- ensure that everybody wears the same type of goggles
- when beams temporally leave your set-up: inform colleagues and put sign at the door
- take off all reflective things (watches, jewelry)
- use "IR cards" with extreme care

General security rules, what to do / to avoid

Protecting yourself:

- protect skin by long sleeves
- attenuate as much as possible for alignment
- locate location of focal point before inserting a lens
- fix cables connected to elements on the table
- remove unused compounds
- bubbled samples: avoid overfilling and bubbles in beam path

General security rules, set-up

- keep beams horizontally ~10cm above table top
- beams out of plane have to be specially protected as possible
- NEVER have eyes at beam level, even when you think that the laser is shut/off
- close eyes when going below beam level
- block beam before handling optical elements or using reflective tools
- block all spots leaving your set-up / not being used
- never use reflective tools
- place computer screens out of beam height or shield them

Unavoidable violation of rules: non-horizontal beams

- pump beam in NOPA
- idler in NOPA
- back reflection from nonlinear crystals
- periscopes
- focusing on liquid surface

Not fixed beams

- Glan-Taylor polarisers
- liquid samples

block unused beams

what:

- reflections from nonlinear crystals
- reflections from prisms
- reflections from filters (fix filters!!)
- transmission through not fully reflective mirrors

how:

- never use loose/scotched material
- never use painted material or coloured paper (danger to burn)
- block as close to source as possible

beams which are not fixed

- Glan-Taylor polariser: block unused beam either directly in mount or by fixed shield around

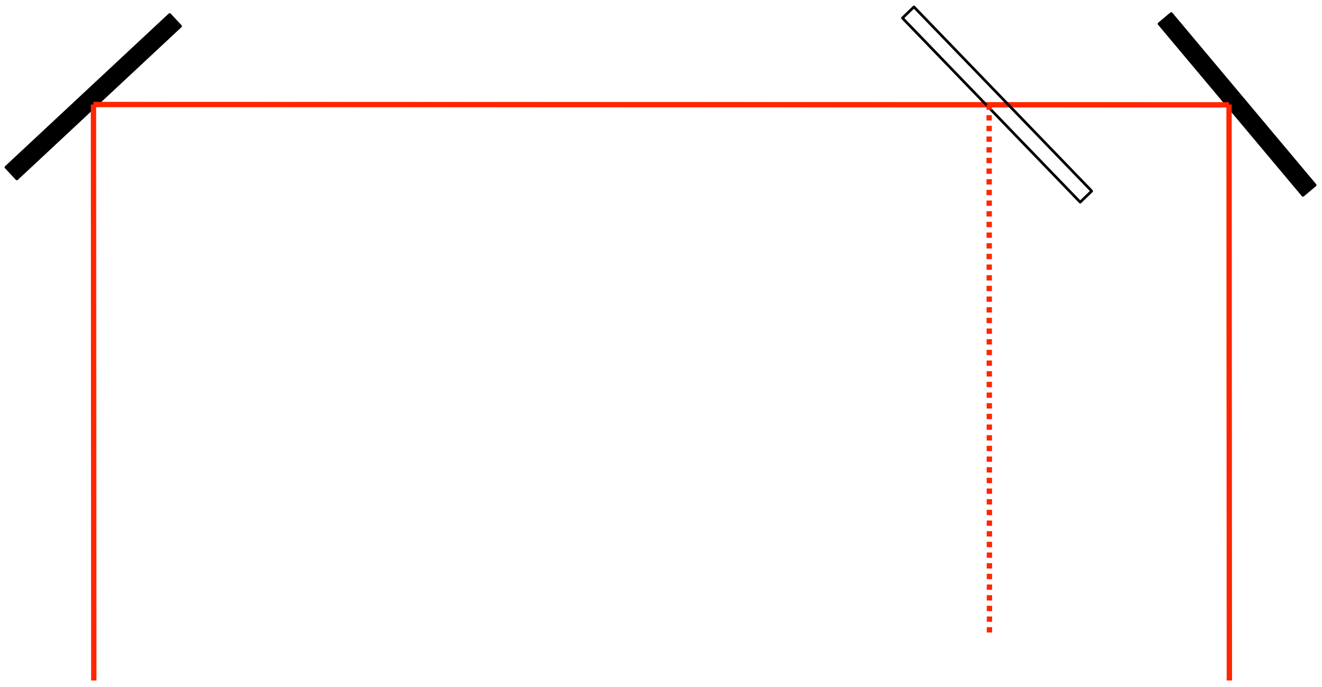
- flipper mirros:
  - only where absolutely necessary
  - reflective coating “downwards”
  - be aware that flippers are less stable than normal mirror mounts

- SHG experiment:
  important for all other people on the lab
  Do not cause laser table to move when SHG people at work

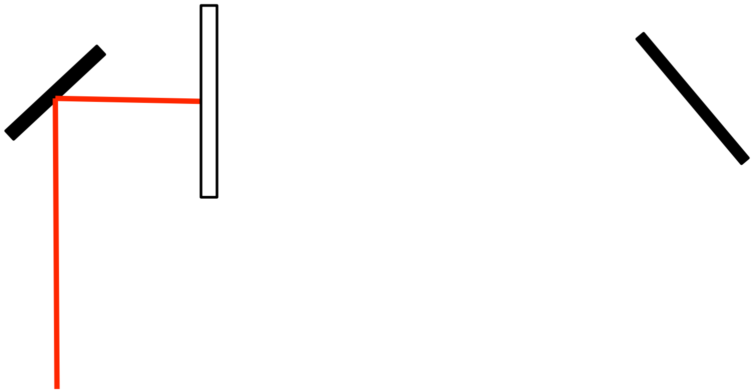
recurrent aligning jobs

recurrent aligning jobs: develop a secure standard procedure to follow

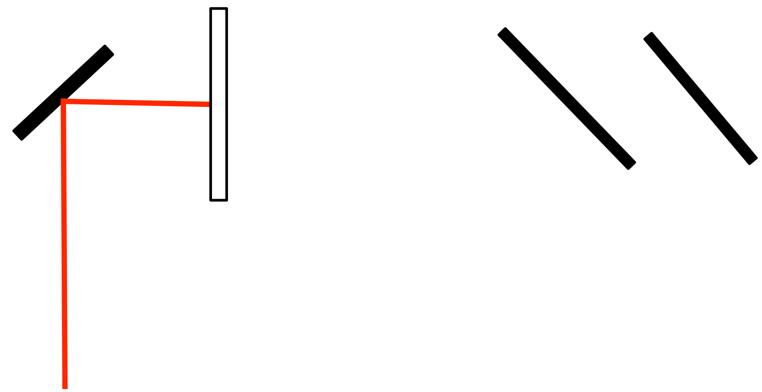
Example: placing a new mirror



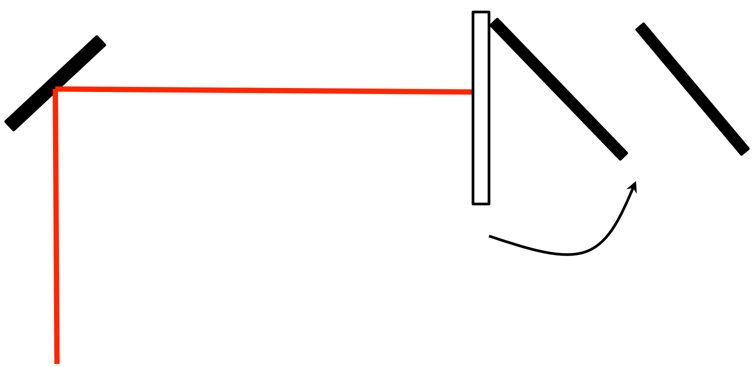
Example: placing a new mirror



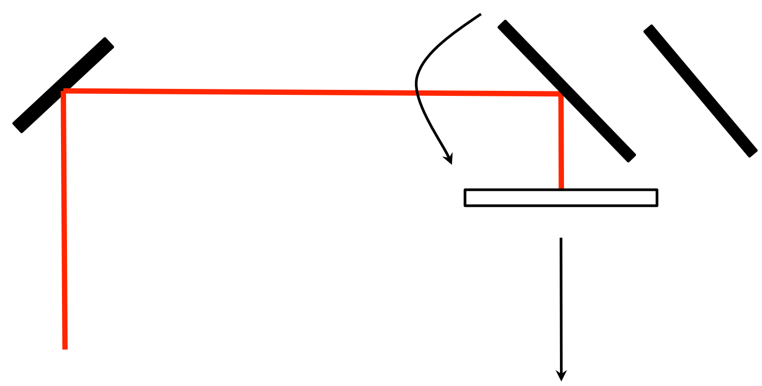
a) block incoming beam



b) fix new mirror while keeping the blocker



c) replace blocker by piece of paper, move towards mirror and turn it



d) follow beam behind mirror, recursion with blocker

Thank you for your attention !