SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Laser Safety
Part III Administration

Environmental Health and Research Safety

October 12, 2017

Part III – Overview

- Regulatory Framework
- Laser Safety Program
- Control Measures
- Non-beam Hazard Precautions
- Emergency Plan
- Resources and references

Regulatory Framework

- Laser Safety is provincially regulated by WorkSafeBC
- WorkSafeBC: Enforces workplace health and safety compliance outlined by the Occupational Health and Safety Regulation and the Workers Compensation Act.

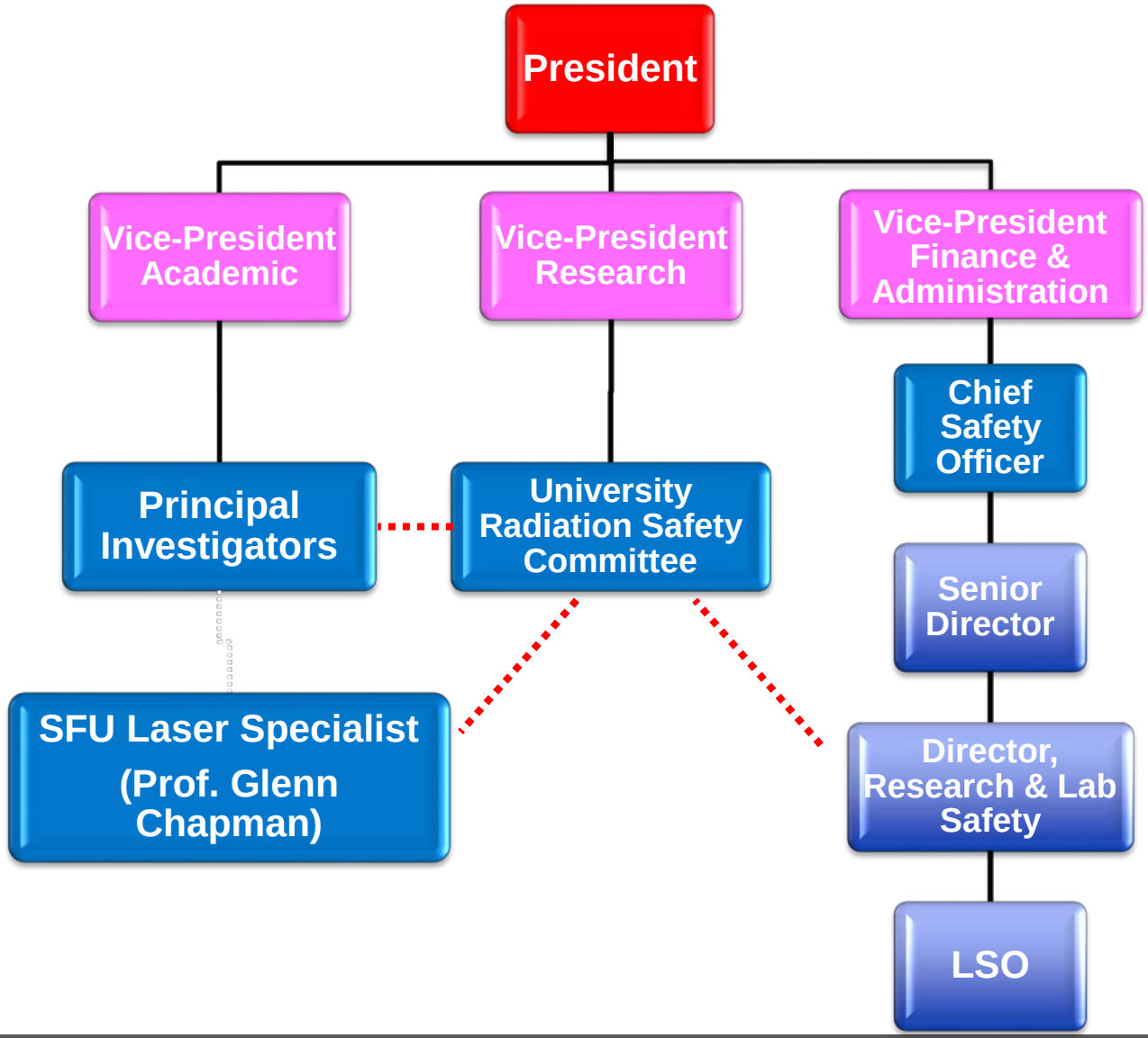
- Regulations:

1. Occupational Health and Safety Regulation:
   Part 7 Division 3 RADIATION EXPOSURE

2. American National Standard for Safe Use of Lasers, 2014 (ANSI Z136.1):
   - Hazard evaluation and classification
   - Control measures
   - Medical examinations
   - Non-beam hazards

3. SFU Non-ionizing Radiation safety policy (R20.05)

Laser Safety Program at SFU



Laser Beam Hazards

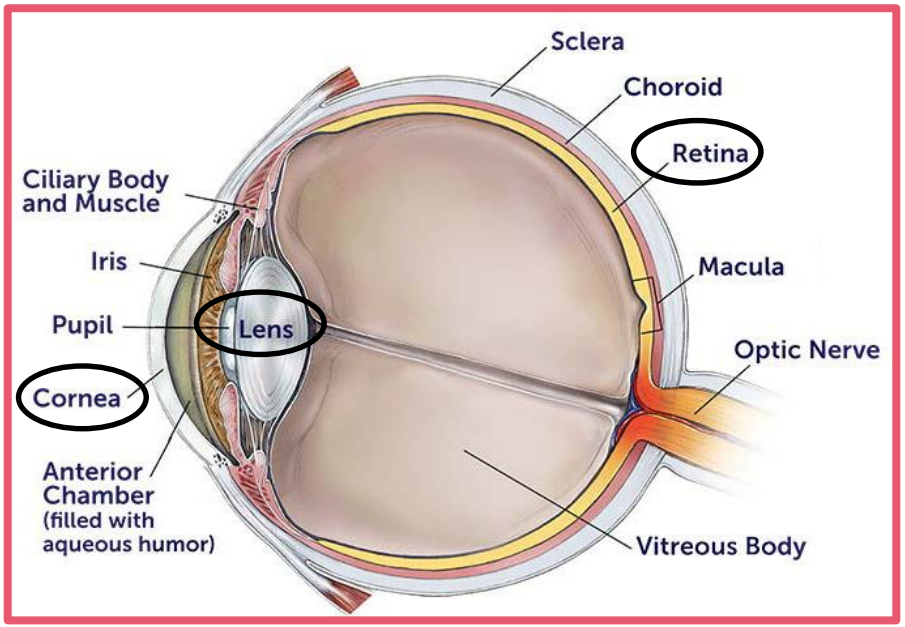
- Severe biological hazards exist from the use of lasers.
- Laser beam hazards:
  - Skin burns
  - Eye damage

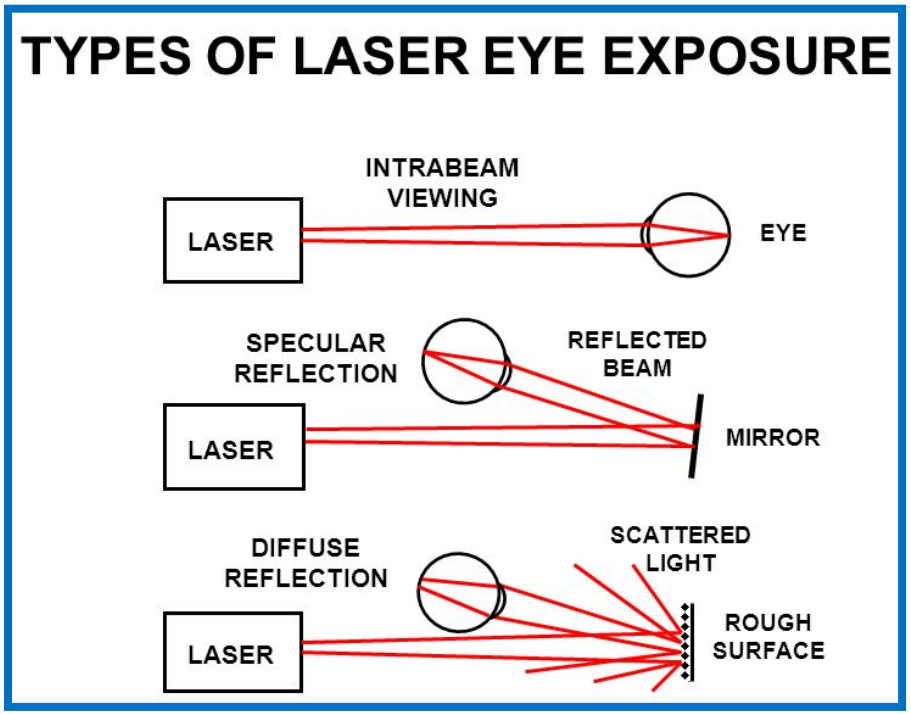
Table 3: Summary of the effects of different wavelengths of light on the eyes and skin

Wavelength Range (nm)	Eye Damage	Skin Damage
UV-C (200 – 280)	Photokeratitis	Erythema & cancer
UV-B (280 – 315)	Photokeratitis	Accelerated skin aging and increased pigmentation
UV-A (315 – 400)	Photochemical reaction	Pigment darkening, photosensitive reaction, and sunburn
Visible (400 – 780)	Photochemical cataract and thermal retinal injury	Photosensitive reaction and skin burn
IR-A (780 – 1400)	Cataract retinal burn	Skin burn
IR-B (1400 – 3000)	Corneal burn, aqueous flare, possible cataract	Skin burn
IR-C (3000 – 1 mm)	Corneal burn	Skin burn

Retinal hazard region

Biological damage to the eye





Laser irradiation of the eye may cause damage to cornea, lens, or retina.

Tissue affected determined by wavelength of the laser and the energy absorption characteristic of the ocular tissue.

Maximum Permissible Exposure (MPE)

- The MPE is defined as "the level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin"

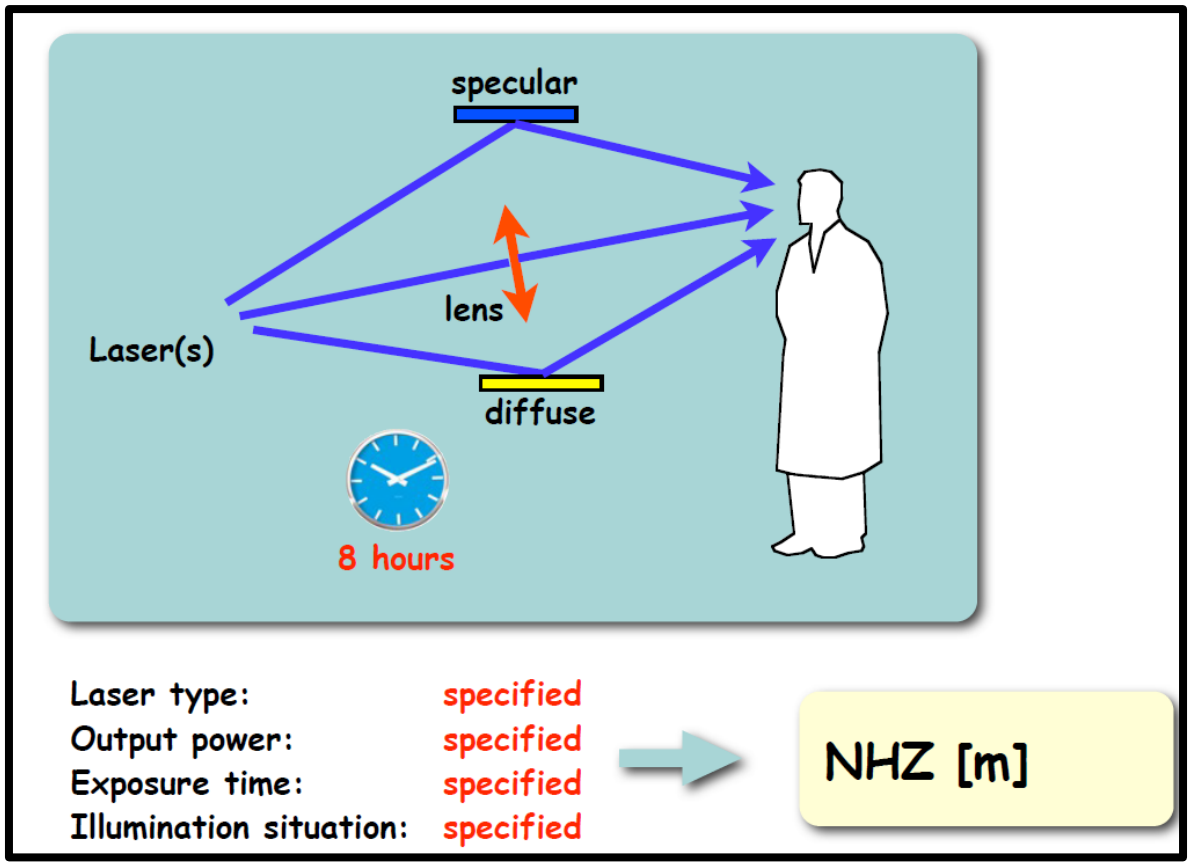
- Highest power or energy density of the light source measured in:

$$\frac{W}{cm^2} \quad \text{or} \quad \frac{J}{cm^2}$$

- MPE has been calculated for nearly all types of laser radiation

- MPE depends on:
  - the wavelength of the laser
  - the duration of the exposure
  - CW or pulsed
  - tissue at risk: eye or skin

Nominal Hazard Zone



Where direct, reflected or scattered radiation during normal operation exceeds MPE.

Control measures must be implemented.

Laser Hazard classes

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

Human aversion response, aka "blink reflex," occurs in less than 0.25s BUT only triggered by visible light!

From "Principles of Laser Safety and the uOttawa Laser Safety Program" by Sean Kirkwood, Ph.D.

Categories of Control Measures

1. Engineering Controls:
   - e.g. protective housing with interlocks
2. Administrative/Procedural Controls:
   - e.g. alignment SOPs
3. Training
4. Personal Protective Equipment (PPE):
   - e.g. eyewear, lab coats
5. Area Warning Signs and Labels
6. Non-beam Hazard Controls

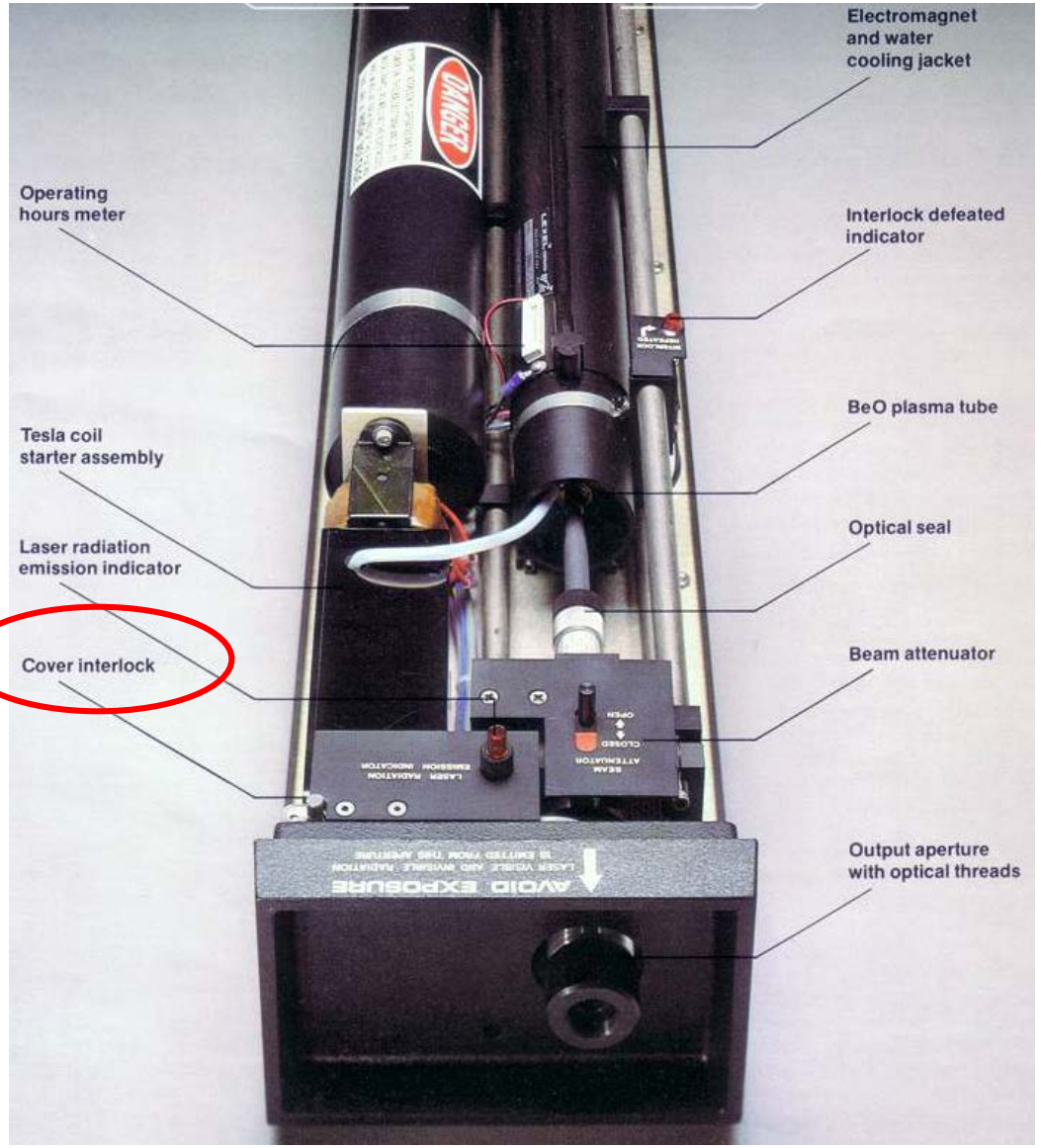
Engineering Controls

Beam stops

Laser barrier

Engineering Controls

- Argon ion laser:
- Core component is argon-filled beryllium oxide ceramic plasma tube.
- Source of Ar^+
- Note the cover interlock



2014 ANSI Standard Z136.1, Table 10a Engineering Controls

Engineering Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing (4.4.2.1)	X	X	X	X	X	X	X
Without Protective Housing (4.4.2.1.1)	LSO shall establish Alternative Controls						
Interlocks on Removable Protective Housings (4.4.2.1.3)	◊	◊	◊	◊	◊	X	X
Service Access Panel (4.4.2.1.4)	◊	◊	◊	◊	◊	X	X
Key Control (4.4.2.2)	--	--	--	--	--	*	*
Viewing Windows, Display Screens and Diffuse Display Screens (4.4.2.3)	Ensure viewing limited < MPE						
Collecting Optics (e.g. lenses, microscopes) (4.4.2.6)	X	X	X	X	X	X	X
Fully Open Beam Path (4.4.2.7.1)	--	--	--	--	--	X NHZ	X NHZ
Limited Open Beam Path (4.4.2.7.2)	--	--	--	--	--	X NHZ	X NHZ
Enclosed Beam Path (4.4.2.7.3)	Further controls not required if 4.4.2.1 & 4.4.2.1.3 fulfilled						
Area Warning Device (4.4.2.8)	--	--	--	--	--	*	X
Laser Radiation Emission Warning (4.4.2.9)	--	--	--	--	--	*	X
Class 4 Laser Control Area (4.4.2.10 & 4.4.3.5)	--	--	--	--	--	--	X
Entryway Controls (4.4.2.10.3)	--	--	--	--	--	--	X
Protective Barriers & Curtains (4.4.2.5)	--	--	--	--	--	*	*

General Engineering Controls Class 3B and 4 Lasers

- Supervision directly by an individual knowledgeable in laser safety
- Restrict entry of non-involved personnel/spectators
- A beam stop to terminate all potentially hazardous beams.
- Appropriate laser protective eye wear must be provided to all personnel within the laser controlled area.
- Beam path of the laser must be located and secured above or below eye level for any standing or seated position in the facility.
- All windows, doorways, open portals, should be covered or restricted to reduce any escaping laser beams below appropriate ocular MPE level.
- Storage or disable lasers when not in use.
- Key control for class 4 lasers, usually restricted to supervisor

Engineering Controls, Class 3b and 4, cont.

- Disable the master switch when the laser is not in use.
- Use protective housing on all lasers and laser systems.
- Interlocks on protective housing
- Remote interlock connectors are required for class 4 lasers and strongly recommended for class 3B lasers.
- Perform alignment of laser optical systems so that the primary beam, specular, or diffuse reflection does not expose the eye above the applicable maximum permissible exposure (MPE) limit.
- Use an alignment laser whenever possible, or use the lowest power setting during alignment.
- An area warning device that is visible prior to entering the area that indicates the laser is operating.
- Quick Check List of Controls: *www.osha.gov/dts/osta/otm/otm_iii/otm_iii_6.html#6*

Access by Janitors, Facilities Services, Campus Security and Outside Contractors

- Service staff may attempt to access your lab during working hours or after hours
- If no entry is acceptable, post appropriate signage

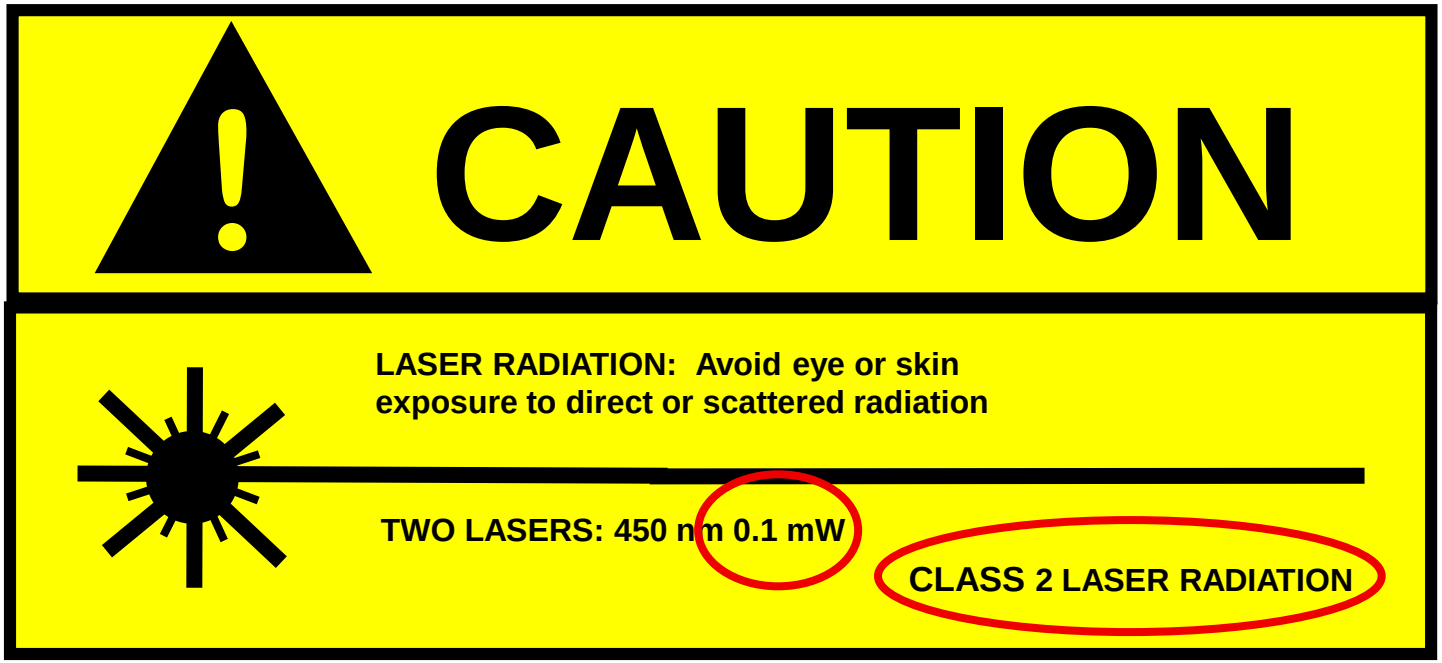
Administrative Controls

- Standard Operating Procedures (SOPs)
- Alignment Procedures
- Signage
- Medical Surveillance
- Laser hazard assessment
- Regular inspections
- Laser safety training
- On-the-job training
- Laboratory Practices
  - No jewelry
  - No spectators
  - No reflective tools

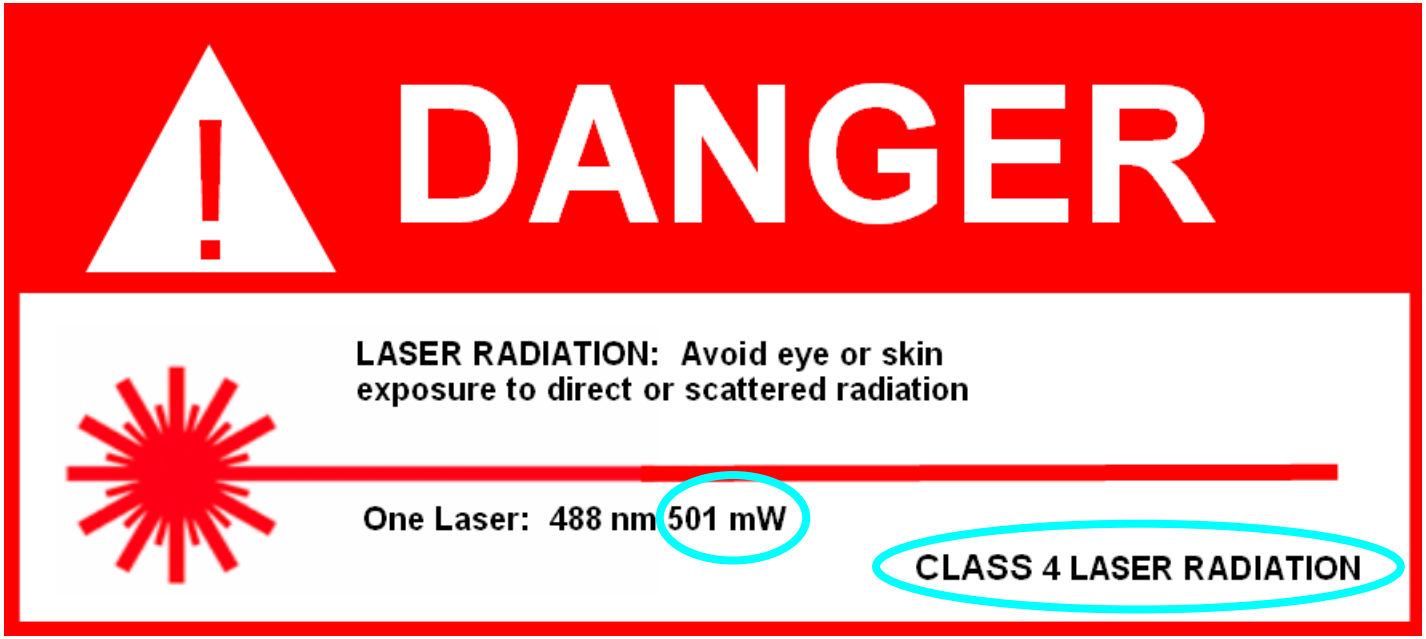
2014 ANSI Standard Z136.1 Table 10b Administrative Controls

Administrative (and Procedural) Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Standard Operation Procedures (4.4.3.1)	--	--	--	--	--	*	X
Output Emission Limitations (4.4.3.2.)	--	--	--	--	LSO Determination		
Education & Training (4.4.3.3)	--	*	*	*	*	X	X
Authorized Personnel (4.4.3.4)	--	--	--	--	--	X	X
Indoor Laser Control Area (4.4.3.5)	--	°	--	°	--	X NHZ	X NHZ
Class 4 Laser Controlled Area (4.4.2.9 & 4.4.3.5)	--	--	--	--	--	--	X
Temporary Laser Control Area (4.4.3.5)	◊ MPE	◊ MPE	◊ MPE	◊ MPE	◊ MPE	--	--
Controlled Operation (4.4.3.5.2.1)	--	--	--	--	--	--	*
Outdoor Control Measures (4.4.3.6)	X	° NHZ	X NHZ	° NHZ	X NHZ	X NHZ	X NHZ
Laser in Navigable Airspace (4.4.3.6.2)	*	*	*	*	*	*	*
Alignment Procedures (4.4.3.8)	◊	X	X	X	X	X	X
Spectators (4.4.3.7)	--	°	--	°	--	*	X
Service Personnel (4.4.3.9)	LSO Determination						

Class 2 and Class 3A Yellow/Black CAUTION



Class 3B, and Class 4 Red/White DANGER



Servicing
Blue NOTICE

Medical surveillance Program – eye examination

Direct exposure on the eye by a beam of laser light should always be avoided with any laser, no matter how low the power.

- Eye examination – application/declination form
- All SFU personnel who work with Class 3B or Class 4 lasers/laser systems are required to either complete the:
- Eye Exam Application Form and undergo eye examination as prescribed by ANSI Z136.1-2014 Safe use of laser or;
- Eye Exam Declination Form (Sign and return to EHRS)
- SFU personnel who work with Class 3B or Class 4 lasers/laser systems are offered cost coverage of qualified eye examinations.

Personal Protective Equipment (PPE)

When is laser protective eyewear required? For class 3B and 4 lasers where exposure may exceed the MPE

How to select laser protective eyewear?

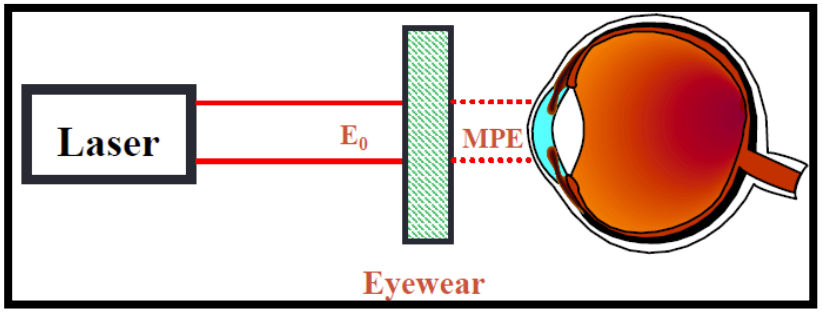
1) Determine laser wavelengths in use

2) Choose OD to remain below exposure limit at each λ

Optical Density (OD) refers to the ability of a material to attenuate optical radiation at specific wavelength to a safe level below the MPE:

$$OD = \log_{10}\left(\frac{Incident\ Beam\ Irradiance, E_0}{Transmitted\ Beam\ Irradiance, MPE}\right)$$

OD = 4.0 ⇒ 1/10,000 of laser light energy will transmit through the eyewear!



Laser protective eyewear must be labeled with the OD and the specific wavelength for which it provides protection

Laser protective eyewear shall be inspected for damage prior to use.

Non Beam Hazards

- Electrical (e.g. high voltage and high current supplies)
- Fire hazards (e.g. laser beam as ignition source and presence of combustible materials). Fire fighting equipment should be present.
- LGAC (laser generated air contaminants): metallic fumes and dust, chemical fumes, and aerosols containing biological contaminants. Created when certain Class 3B and Class 4 lasers interact with matter. Usually occurs when the beam irradiance exceeds 10^7 W/cm2
- Compressed gases: Cl_2 gas corrosive; He, Ar, N_2 asphyxiates; H_2 is flammable. Cylinders must be secured.
- Laser dyes and solvents: may be toxic, carcinogenic, mutagenic, corrosive or flammable. Minimize exposure during solution preparation by handling in a fumehood and by wearing lab coat, safety goggles, gloves. ALWAYS refer to SDS.

Emergency Response

Medical Emergency:

2-4500 or 778-782-4500 SFU Burnaby

2-5252 or 778-782-5252 SFU Vancouver

2-7511 or 778-782-7511 SFU Surrey

Incident Reporting

All incidents, accidents, exposure (including suspected exposures) and near-miss incidents are required to be reported at SFU.

These must be immediately reported to your supervisor and to EHRS so a follow-up investigation can be conducted.

Incident reporting procedure:

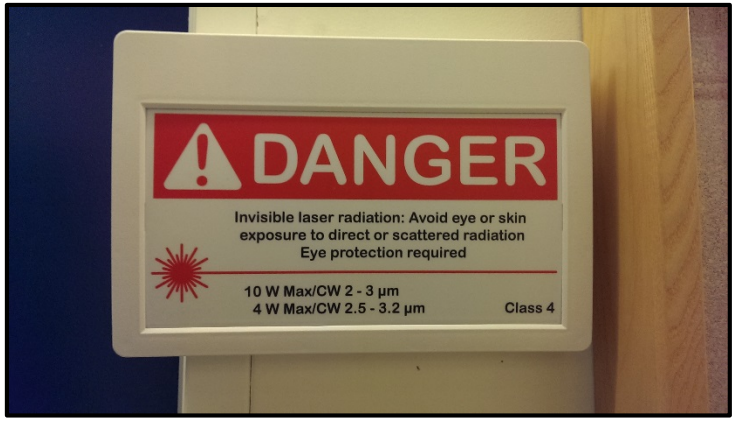
1. Report the incident to EHRS at http://www.sfu.ca/incidentreporting

2. For incidents involving medical aid or time loss for SFU employees, the employee's supervisor is also required to complete a WorkSafeBC Form 7.

3. For more information, please refer to the EHRS website: http://www.sfu.ca/srs/ehs.html

Real (near miss) Incident

- A lab was using a Class 4 laser.
- The main lab door was locked, the exterior laser safety warning sign was lit in the hallway, and the safety curtain was drawn around the doorway.
- Luckily, the laser had just been turned off when a trades person entered the lab through the main lab door.
- A serious near miss: if laser had been on, could have resulted in eye injury to the person.



Caution! Check if warning sign at entrance is lit.

Do not enter if sign is lit.

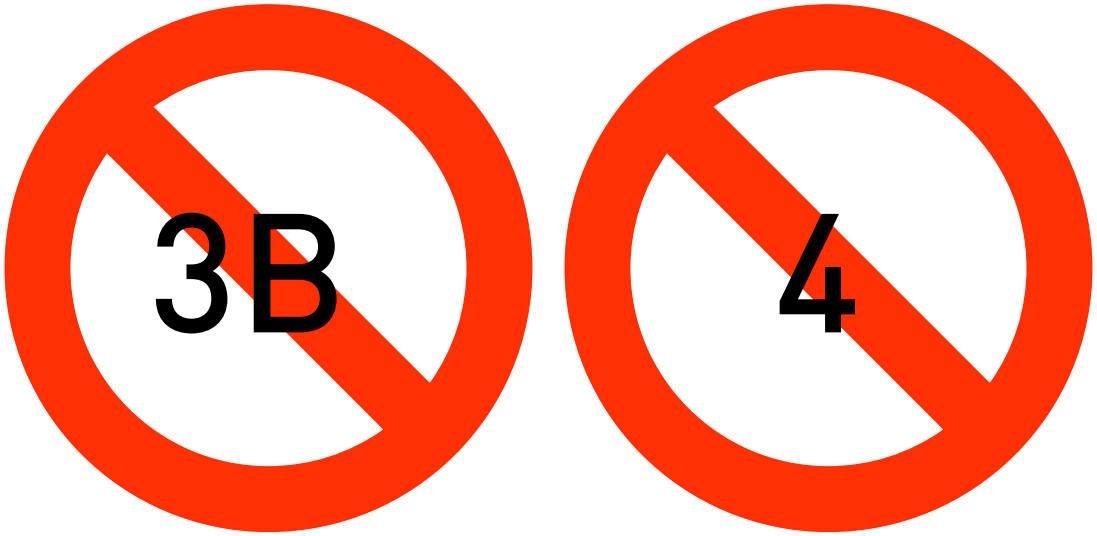
If unsure, knock or phone lab occupants before entering.

Resources

- WorkSafeBC
  www.worksafebc.com
- Laser Institute of America
  www.laserinstitute.org
- ANSI Z136 Standards
  www.laserinstitute.org/store/ANSI%20Z136%20Standards
- SFU EHRS Radiation Safety
  https://www.sfu.ca/srs/ehs/research-safety/rso.html
- SFU EHRS
  www.sfu.ca/srs/ehs.html

SFU Laser Pointer Policy

Classroom teaching – Class 3R or lower

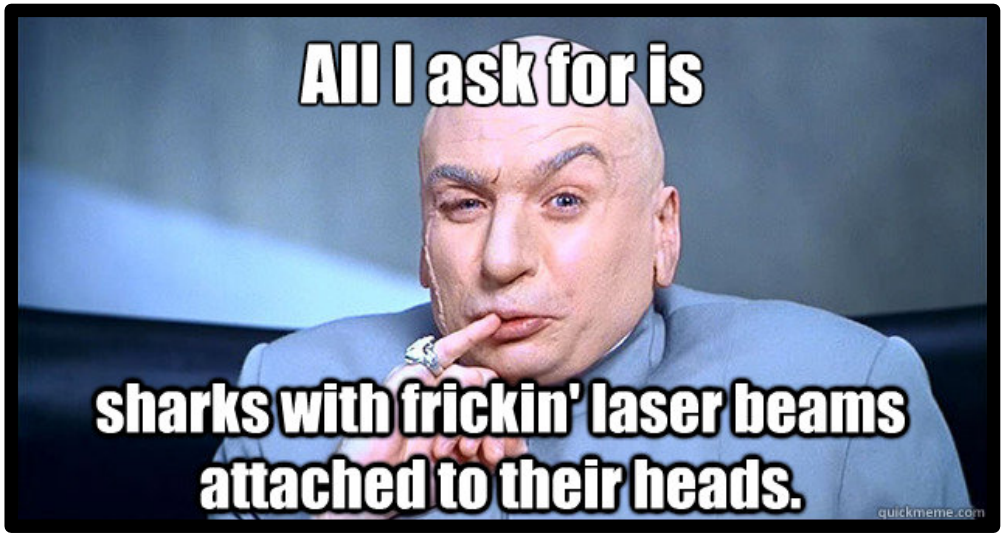


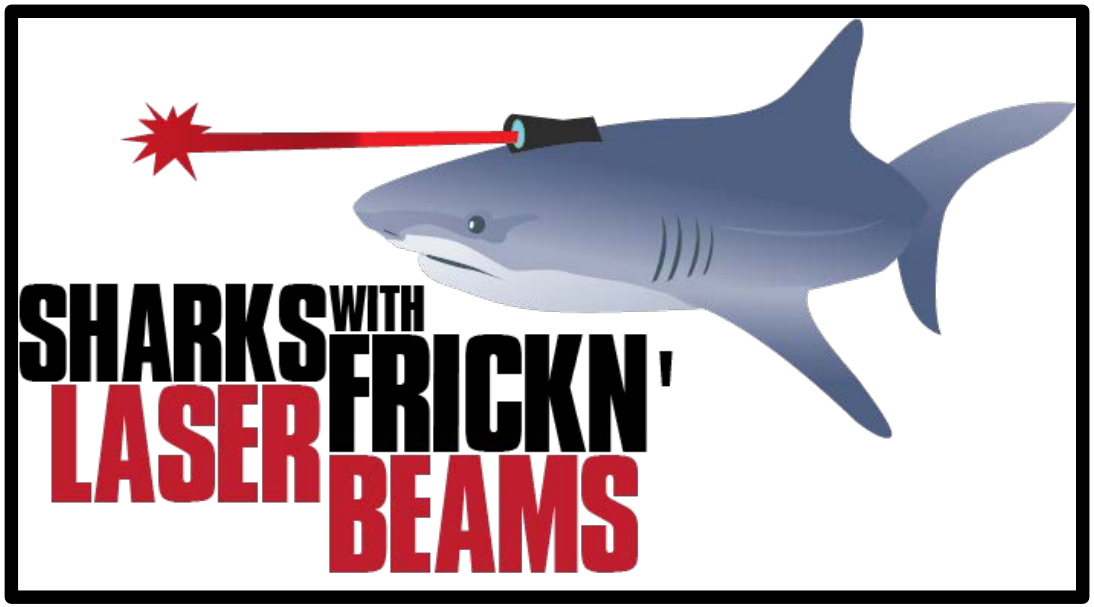
Class 3B or 4 NOT permitted

The Golden Rules of Laser Safety!

1. Wear laser safety eyewear
2. Do not look into the laser beam
3. Keep room lights on brightly, if possible
4. Remove personal jewellery
5. Locate and terminate all stray laser beams
6. Clamp all optical components securely
7. Keep beams horizontal
8. Don't bend down below beam height
9. Remember, optical components reflect, transmit and absorb light
10. Don't forget non-optical hazards


OMG LASERS!
PEW! PEW!


All I ask for is
sharks with frickin' laser beams
attached to their heads.
quickmeme.com


SHARKS WITH FRICKN' LASER BEAMS