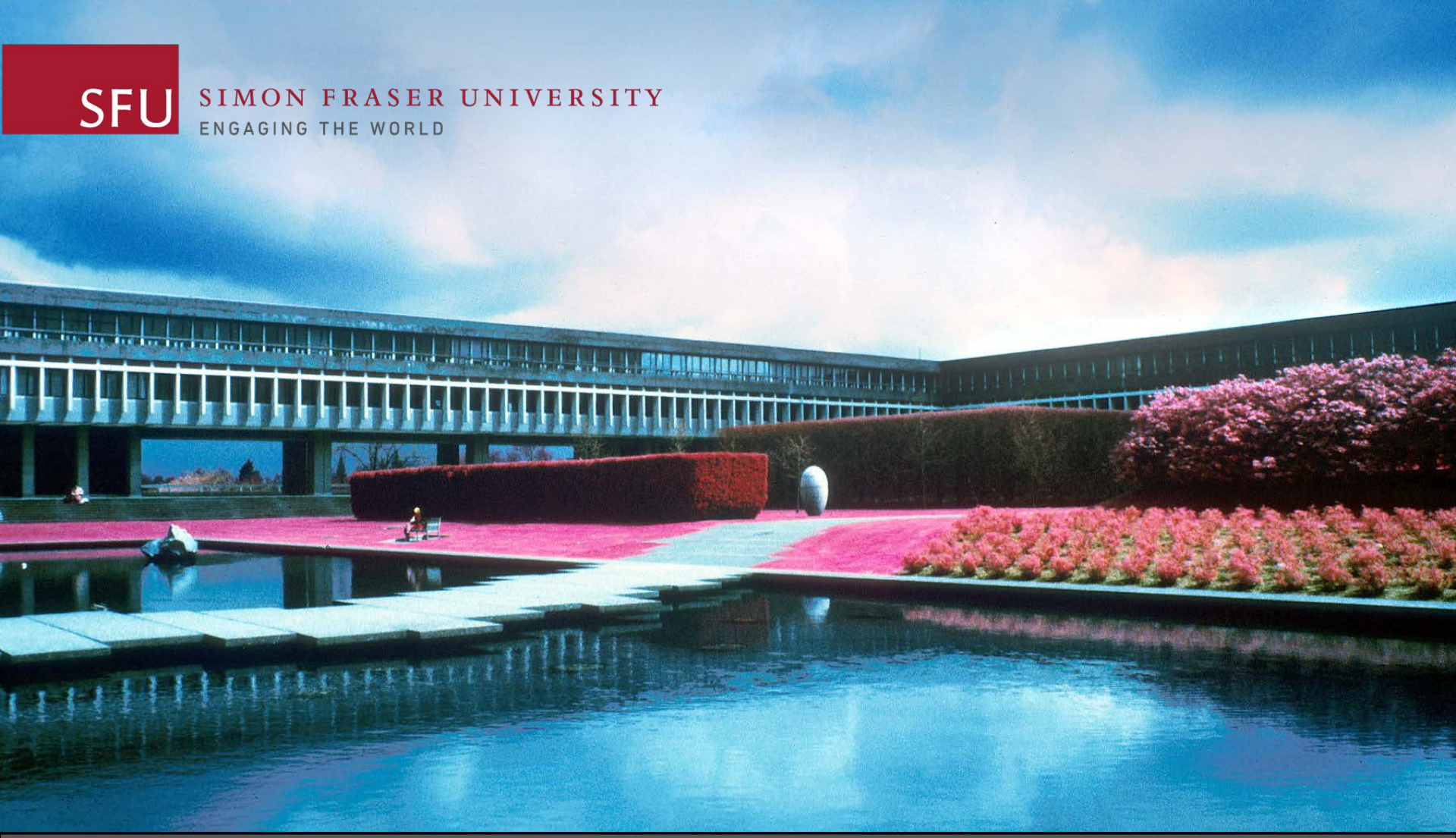


Laser Safety Administration

Environmental Health and Safety

Overview

- Regulatory Framework
- Laser Safety Program
- Laser beam hazards and laser classes
- 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:**

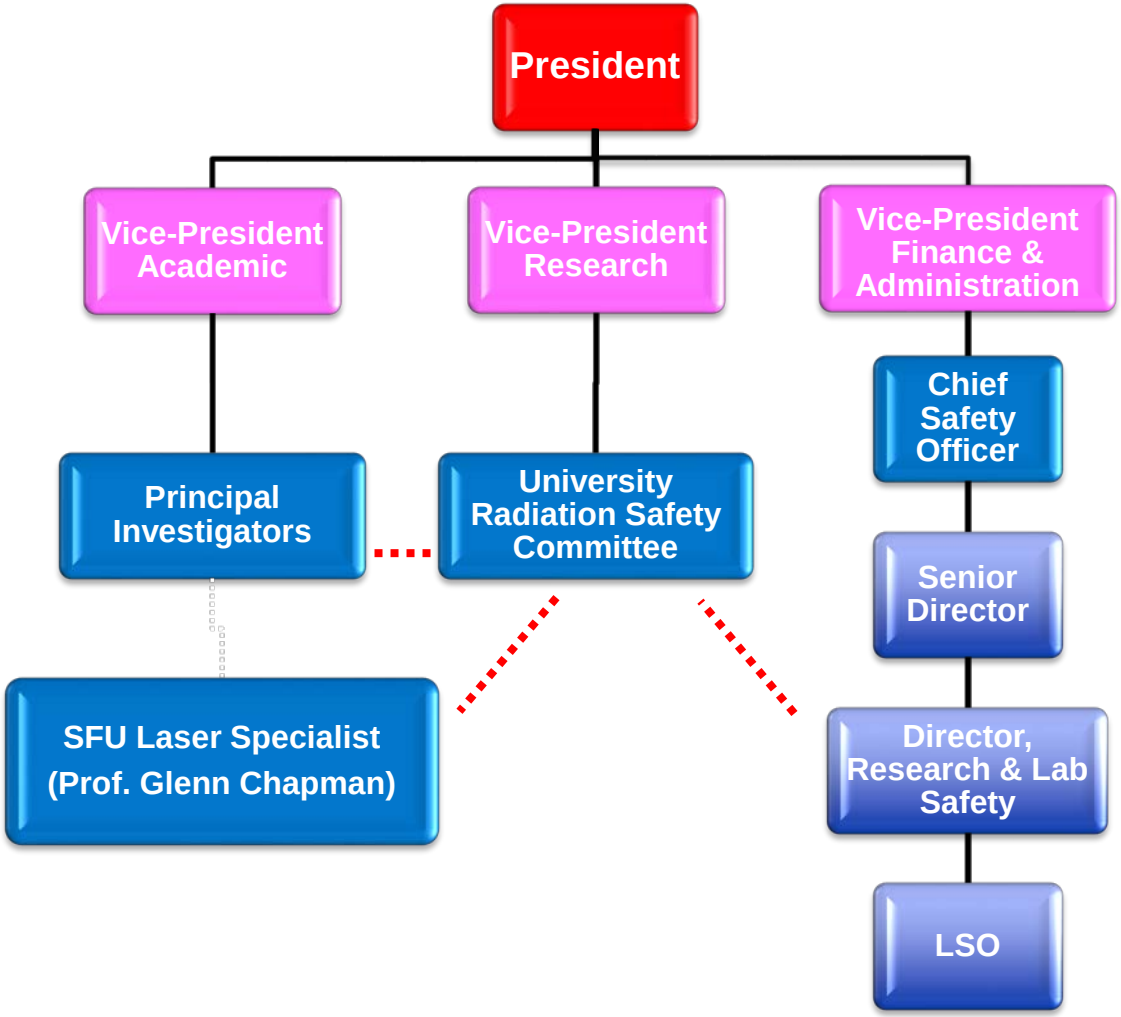
   Part 7 Division 3 RADIATION EXPOSURE

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)**

SFU Laser Safety Program

Ensuring the safety of the SFU community in the effective control of laser hazards.



- registration of all Class 3B and Class 4 laser/laser systems (through SFU's Hazard Inventory System: labhazindex.its.sfu.ca)
- inspections of Class 3B and Class 4 laser/laser systems;
- safety training of laser workers;
- reporting accidents/incidents
- medical surveillance;
- personal protective equipment;
- engineering controls;
- administrative and procedural controls;
- LSO;

Laser Beam Hazards

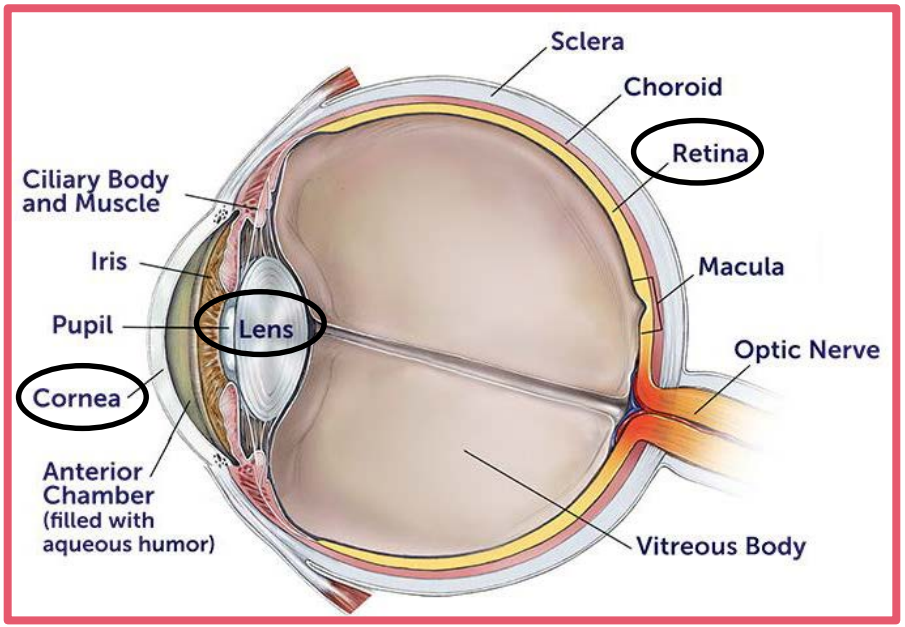
- **Severe biological hazards exist from the use of lasers.**
- **Laser beam hazards:**
  - **Skin burns**
  - **Eye damage**

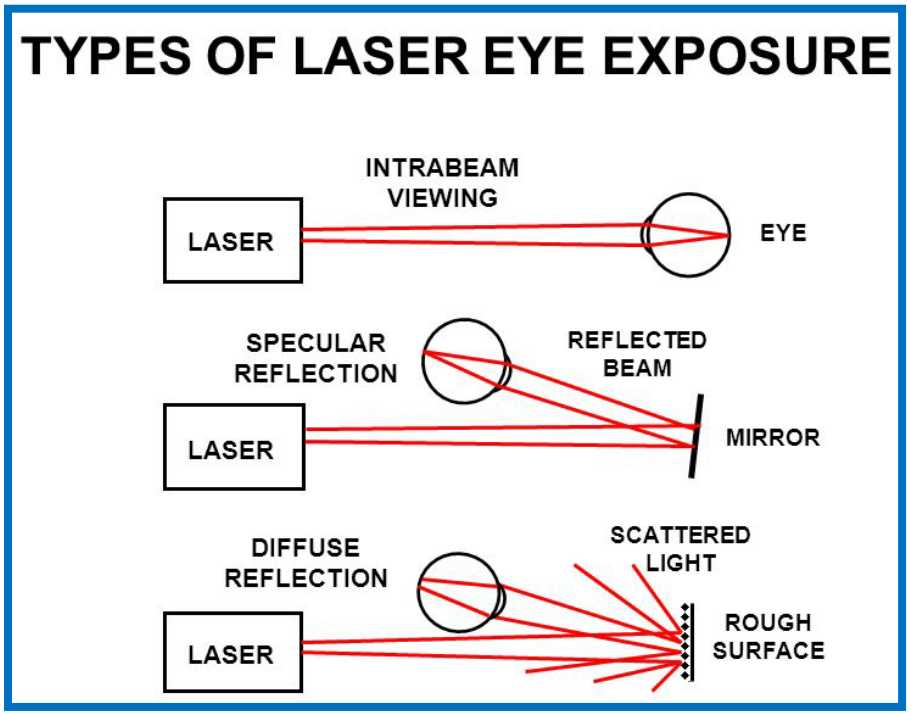
Table 3: Summary of the effects of different wavelengths of light on the eyes and skin

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.

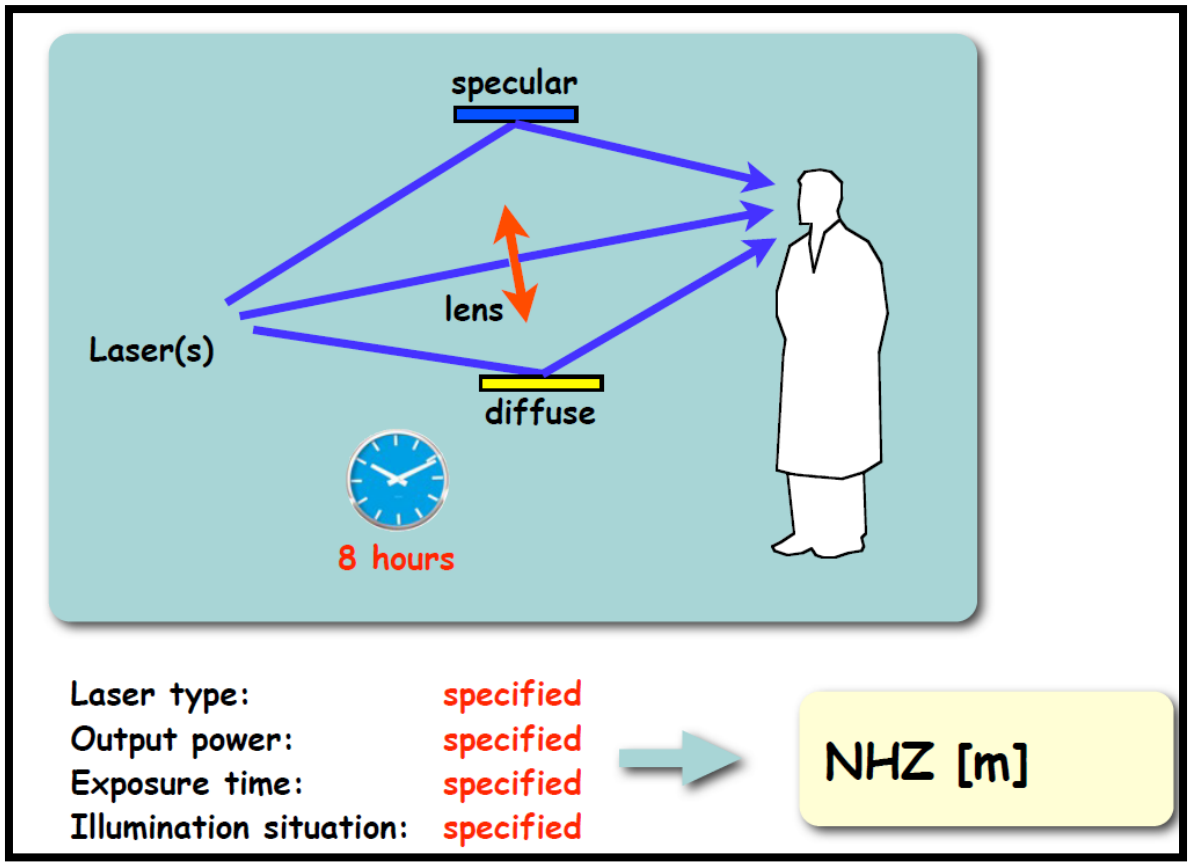
Maximum Permissible Exposure (MPE)

- **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 a light source that is considered safe, (i.e. negligible probability for creating damage);**
- **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

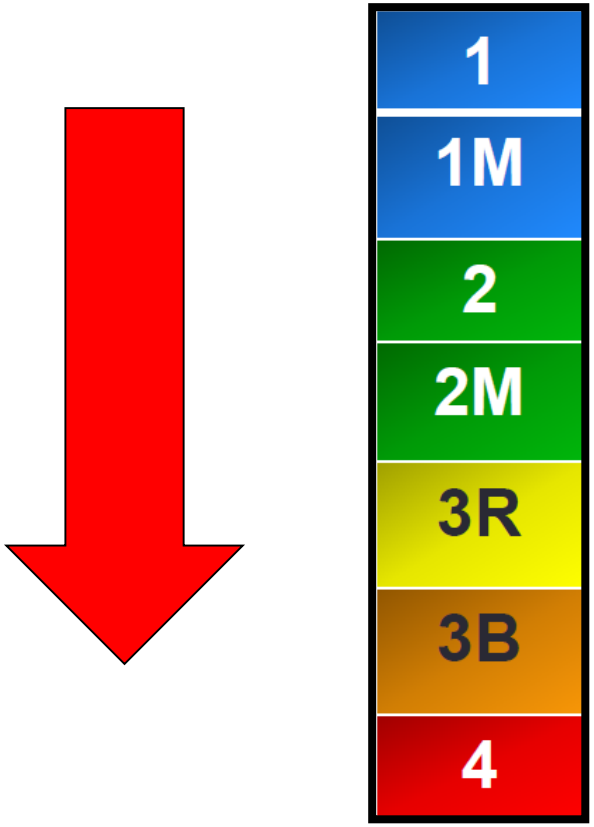


Where direct, reflected or scattered radiation during normal operation exceeds MPE.

Control measures must be implemented.

Laser Hazard classes

- Lasers are classified by wavelength, power and potential for biological damage
- Classification by manufacturer
- Class 1: lowest hazard
- Class 4: highest hazard. Eye and skin hazard for both direct and scattered exposure. 500mW and above



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

Categories of Control Measures

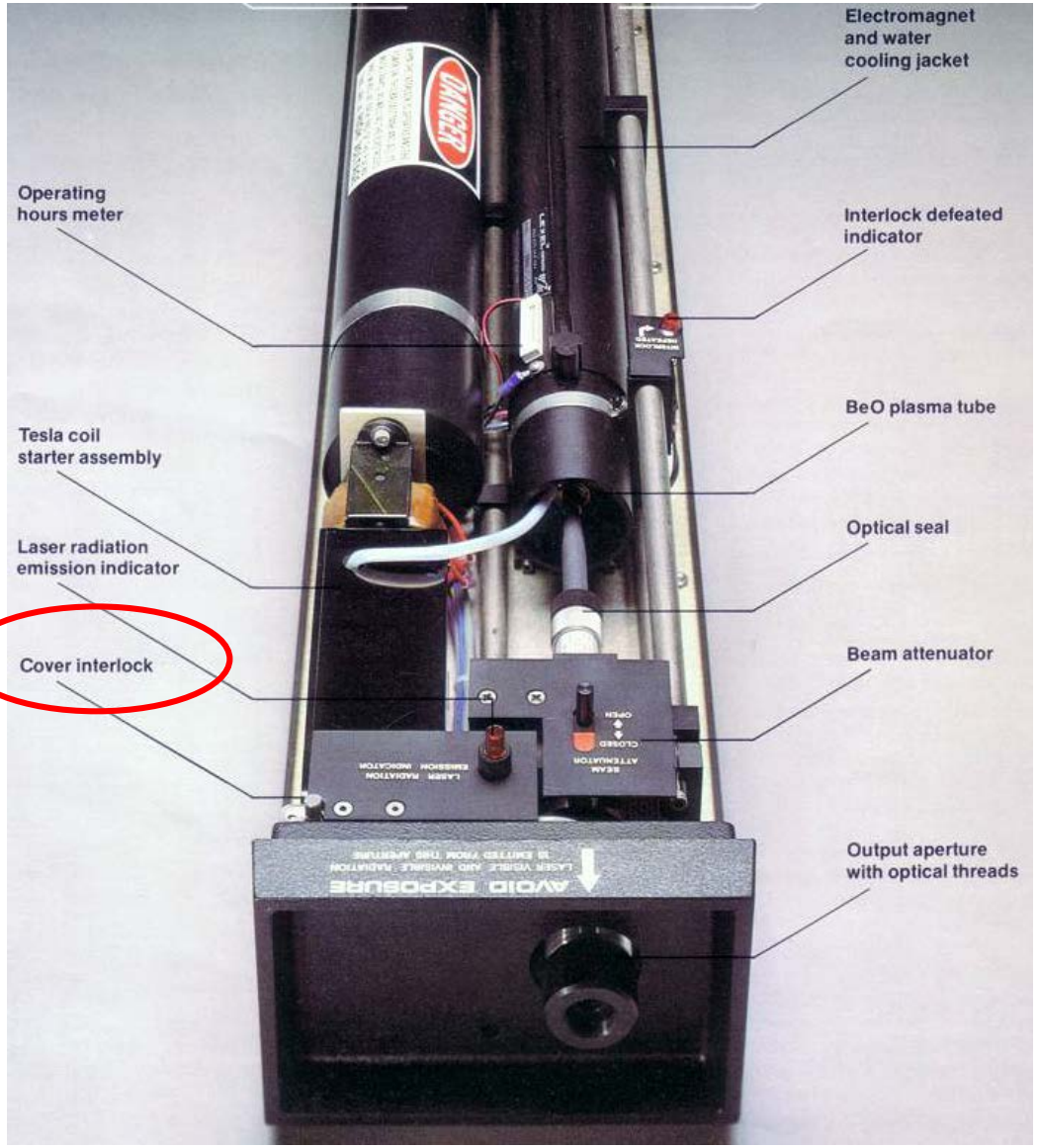
1. **Engineering Controls:**
   - **e.g. protective housing with interlocks**
2. **Administrative/Procedural Controls:**
   - **e.g. alignment SOPs**
3. **Training**
4. **Personal Protective Equipment (PPE):**
   - **e.g. eyewear, lab coats**
5. **Area Warning Signs and Labels**
6. **Non-beam Hazard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

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)	--	--	--	--	--	*	*

Engineering Controls

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



Engineering Controls

Beam stops

Laser barrier

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**

Class 4 entryway controls

- All personnel must be trained and provided with adequate personal protective equipment upon entry (Class 3B as well)
- A door blocking barrier/screen/curtain, etc., must be used to block the laser beam at the entryway to ensure that no one receives laser radiation immediately upon entry.
- An area warning device that is visible prior to entering the area that indicates the laser is operating (e.g. lit warning sign)

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

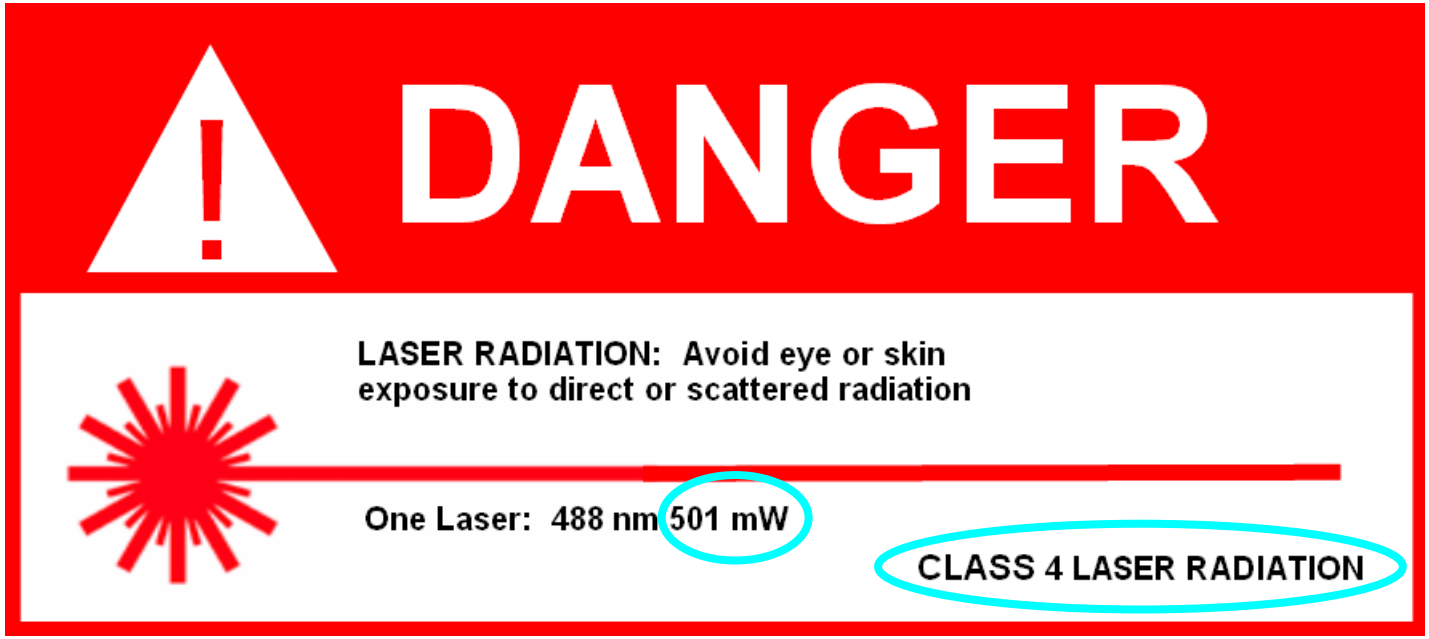
2014 ANSI Standard Z136.1 Table 10b Administrative Controls

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						

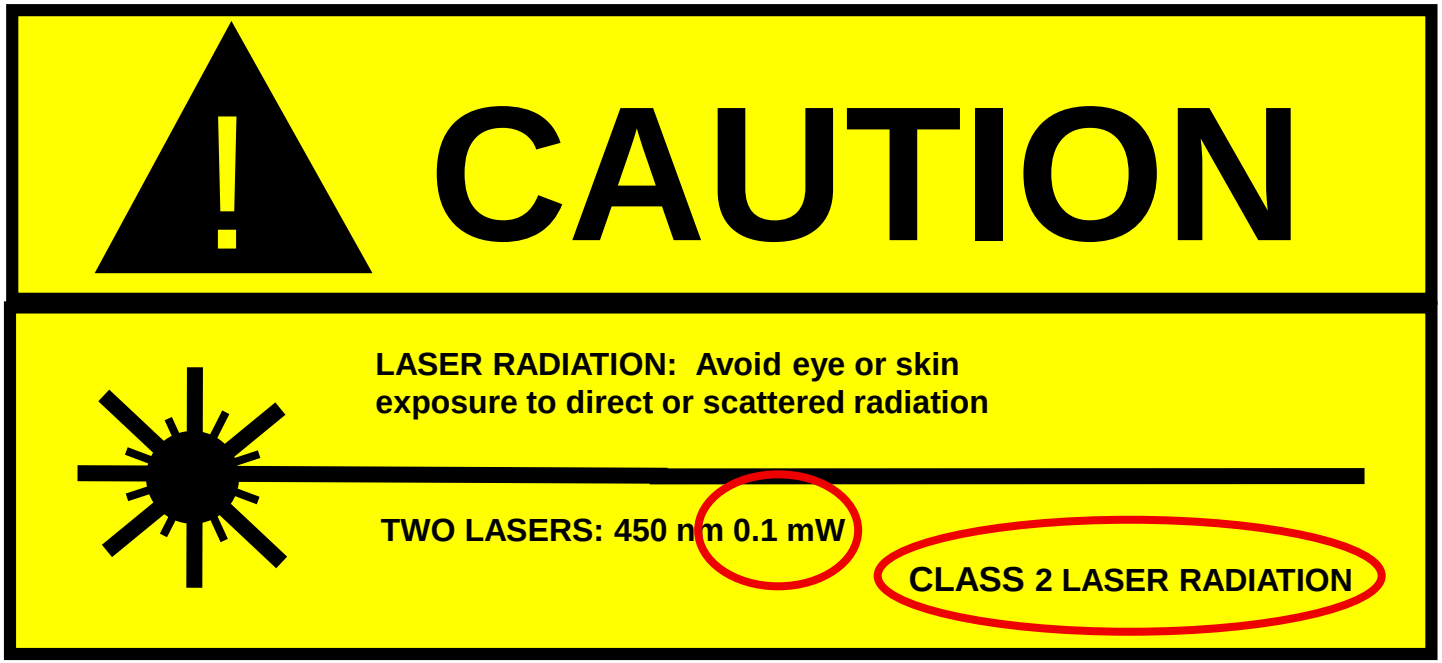
Access by Janitors, Facilities Services, Campus Security and Outside Contractors

- **Service staff may attempt to access your lab during working hours or after hours**
- **Entry may create a hazard to the individual.**
- **Ensure a "Restricted Access Area" sign is used at the entrances to Class 4 laser controlled areas to: a) prevent inadvertent entry and; b) alert service personnel that in order to enter, they must be escorted by individuals responsible for the laser area.**

Warning sign posting required for Class 3B, and Class 4 Red/White DANGER

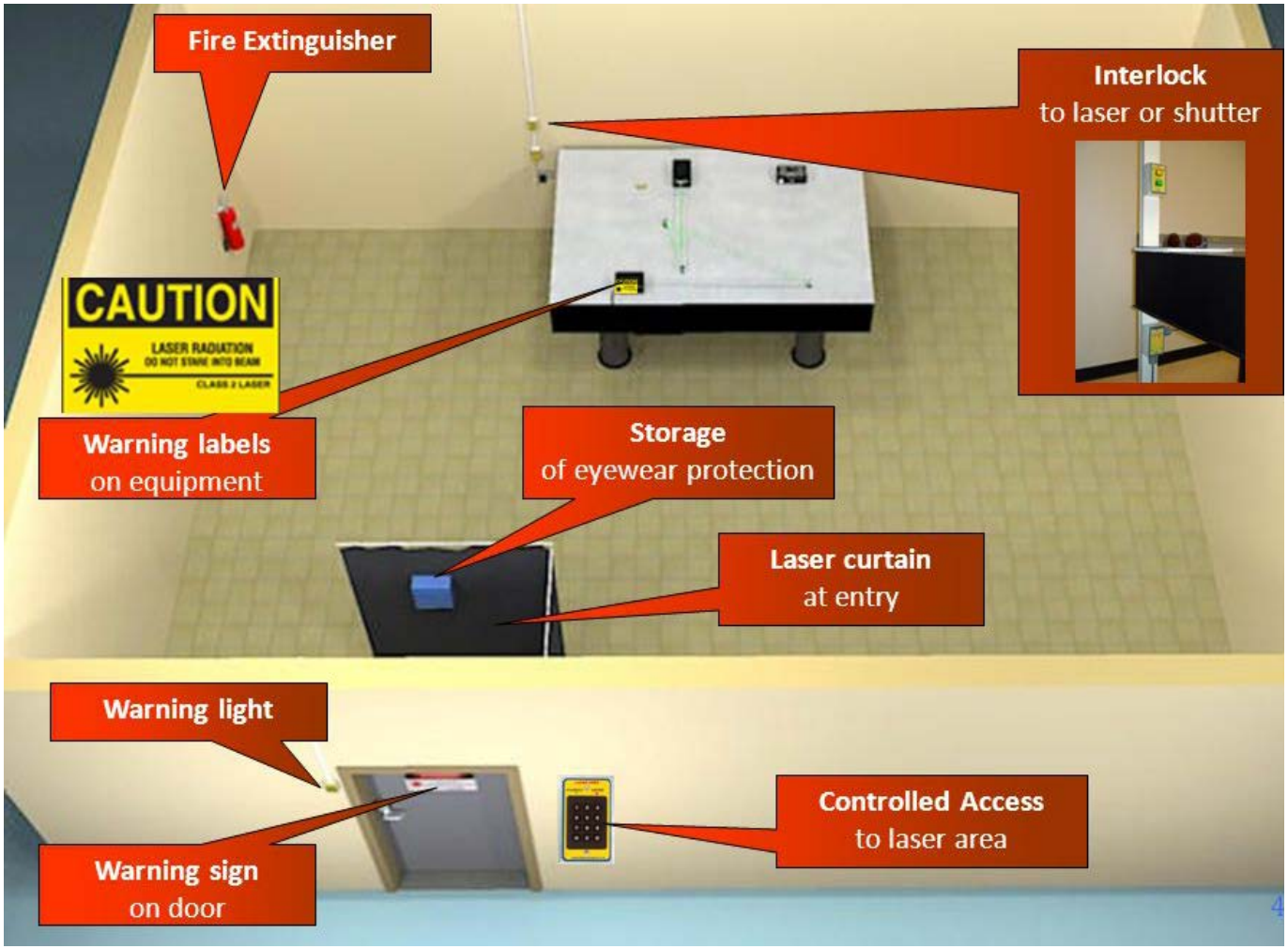


Class 2 and Class 3A Yellow/Black CAUTION



Servicing
Blue NOTICE

Setting up a Class 4 Laser Laboratory



- Adequate personal protective equipment provided upon entry (Class 3B as well)
- Access control
- Barrier/screen/curtain to block the laser beam at the entryway
- Warning light at entryway to indicate the laser is operating
- Door signage

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?

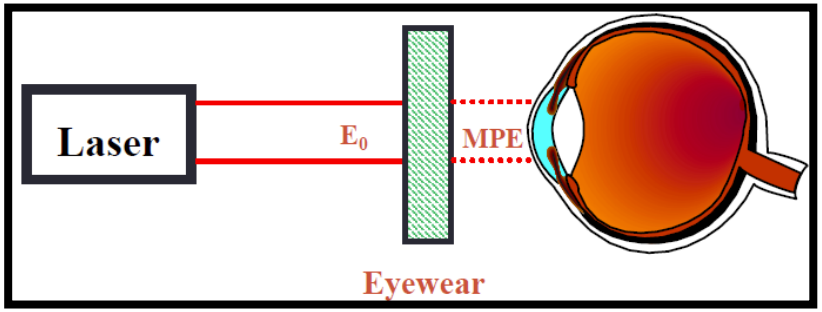
1) Determine laser wavelengths in use

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
  - e.g. laser cutter
- 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

In the event of an emergency, call 911. If possible, call 911 from a campus phone and campus security will be automatically notified of the call location.

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 EHS so a follow-up investigation can be conducted.

<u>Incident reporting procedure:</u>

1. Report the incident to EHS 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 EHS 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.

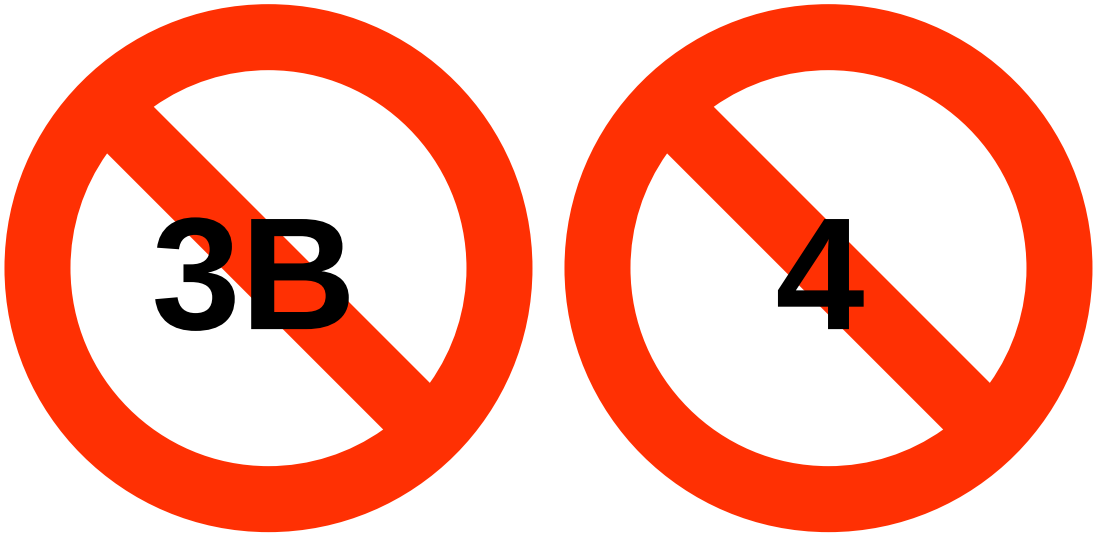
If unsure, knock or phone lab occupants before entering.

Resources

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

SFU Laser Pointer Policy

Classroom teaching – Class 3R or lower

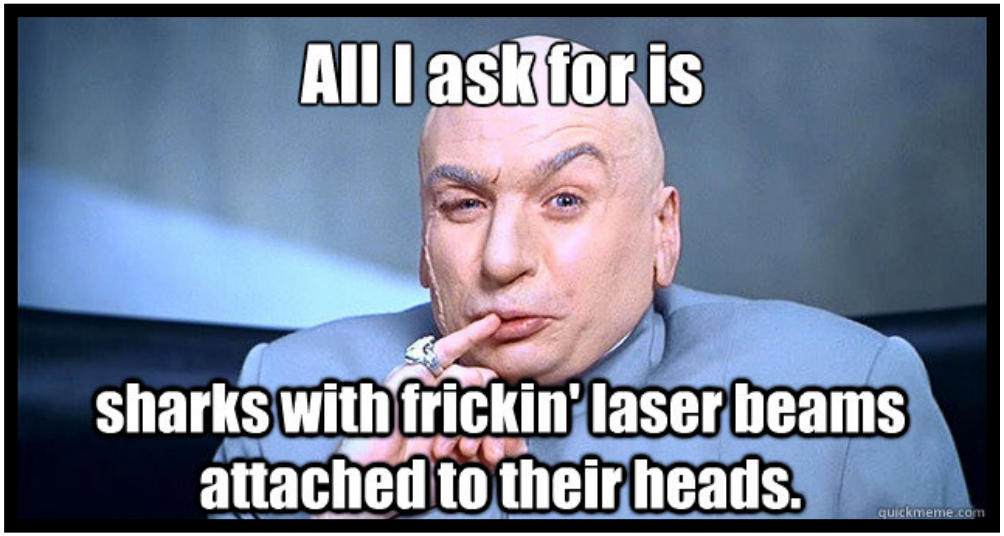


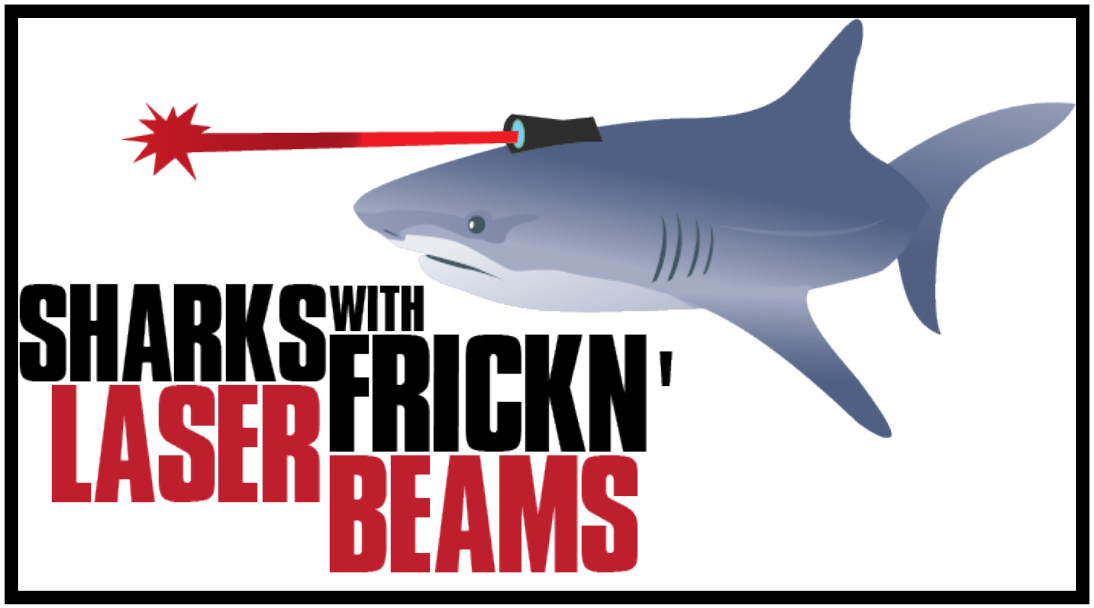
Class 3B or 4 NOT permitted

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