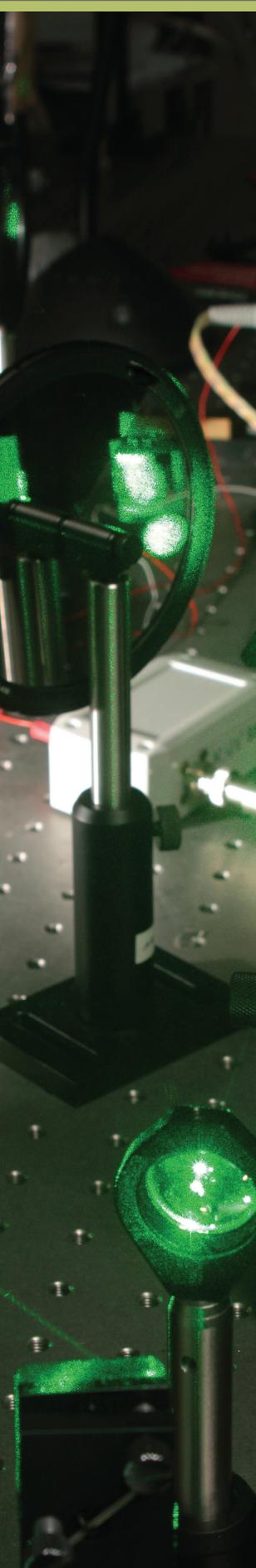


A close-up photograph of a microscope's objective lens and surrounding mechanical components. The lens is a prominent blue-tinted circle on the right side, reflecting light. The rest of the image shows dark, metallic parts of the microscope with various screws and adjustment knobs, creating a technical and scientific atmosphere.

# Laser Safety Manual



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## Introduction

The University of California Berkeley Laser Safety Program is intended to provide staff, researchers, students, and visitors with a safe laser use environment. This manual was written to outline UC Berkeley's laser safety policy and guidance and to serve as a reference source for laser users.

## Program Authority

The UC Berkeley Laser Safety Program was developed in accordance with a charge from the Research Compliance Advisory Committee (RCAC). The RCAC directed that a faculty committee be formed to provide a Laser Safety Program based on the American National Standards Institute (ANSI) Z136.1 Standard for the Safe Use of Lasers. The UC Berkeley Non-Ionizing Radiation Safety Committee's (NIRSC) charge is to take the actions necessary to provide a safe laser use environment. The policies set forth in this manual were developed and approved by the NIRSC under their bylaws. See [Appendix A](#) for the NIRSC bylaws. The laser safety officer (LSO) and the Office of Environment, Health & Safety (EH&S) provide support to the NIRSC and are tasked by the NIRSC to implement the Laser Safety Program.

## Regulatory Requirements

Regulation of laser hazards fall under the California Code of Regulations (CCR), Title 8, Subchapter 7 General Industry Safety Orders, Section 3203 (Injury and Illness Prevention Program). Section 3203 requires that every employer "...include a system for ensuring that employees comply with safe and healthy work practices..." Enforcement of the regulations falls to the California Occupational Safety and Health Administration (CAL-OSHA). At this time, CAL-OSHA has not developed specific laser safety regulations, but they train their inspectors in the ANSI Z136.1 Standard for the Safe Use of Lasers as the accepted "...safe and healthy work practice..." to use in inspecting laser facilities.

The UC Berkeley Laser Safety Program is based on the ANSI Z136.1 "Standard for the Safe Use of Lasers" and Z136.8 "Standard for Safe Use of Lasers in Research, Development, or Testing. In addition, standards for lasers used in a medical setting are based on ANSI Z136.3 "Standard for the Safe Use of Lasers in Health Care Facilities." A copy of the standards is available at EH&S.

## Applicability / Scope

The UC Berkeley Laser Safety Program covers Class 3B and 4 lasers and laser systems on the campus and at UC Berkeley managed off-site locations. The Laser Safety Program applies to all persons: faculty, staff, students, and visitors operating with or

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working in close proximity to a Class 3B or Class 4 laser.

## Roles / Responsibilities

### Research Compliance Advisory Committee

The Research Compliance Advisory Committee (RCAC) advises the Vice Chancellor for Research (VCR) on issues related to regulatory compliance and risk management in all research activities conducted on UC Berkeley property or by UC Berkeley personnel. The committee also informs the Vice Chancellor for Research of current and upcoming issues and concerns in research compliance and risk management and helps establish priorities for campus research compliance efforts.

### Non-Ionizing Radiation Safety Committee

The Non-Ionizing Radiation Safety Committee (NIRSC) advises on all matters related to coherent and non-coherent sources of non-ionizing radiation, reviews and approves uses of lasers and laser systems and advises EH&S staff in carrying out the campus Laser Safety Program in accordance with applicable state and federal requirements.

### Laser Safety Officer

The laser safety officer (LSO) reports to the radiation safety officer (RSO) of EH&S and is responsible for Laser Safety Program development, implementation and compliance. The LSO is the technical advisor to the NIRSC regarding laser safety and regulatory affairs. Responsibilities include but are not limited to:

- Investigate, prepare and approve all Laser Use Authorizations (LUAs)
- Prescribe and/or provide laser safety training
- Review and approve laser Standard Operating Procedures (SOPs)
- Inform NIRSC of any safety concerns associated with the use of lasers
- Perform hazard evaluations of laser use areas
- Verify laser classifications
- Specify control measures
- Perform and document audits, surveys and inspections
- Recommend and approve protective equipment
- Investigate laser incidents
- Maintain records associated with the Laser Safety Program

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- Provide laser hazard signs and labels
- Provide annual report to UC Berkeley Non-Ionizing Radiation Safety Committee (NIRSC) summarizing all program activities from the year

### Office of Environment, Health, & Safety

The Office of Environment, Health & Safety (EH&S) administers this program for NIRSC. EH&S is responsible for providing personnel and other resources to assist the LSO in this mission. No Class 3B or 4 lasers may be used on campus without a LUA. The LUA is used to assure the NIRSC that the laser use has been examined and found to be safe. The LUA is also used to track the location and ownership of each UC Berkeley laser.

### Department Chairpersons

Department chairpersons are responsible for assuring that Principal Investigators (PIs) utilizing lasers within their department respond to and comply with all requests from the LSO and NIRSC implementing the Laser Safety Program.

### Principal Investigators

PIs are directly responsible for implementing the Laser Safety Program. This includes the implementation of specified hazard controls, oversight and management of non-laser hazards, and informing the LSO of any changes that affect the laser users. It is also the responsibility of the PI to assure that all laser users operating under their LUA have met the training requirements set forth by the NIRSC. Responsibilities include, but are not limited to:

- Providing a safe workplace.
- Taking the laser safety training and refreshers as needed.
- Identifying all laser users to the LSO.
- Ensuring that all laser users under their direction comply with all aspects of the Laser Safety Program.
- Ensuring that identified users meet the campus laser safety training requirement.
- Creating detailed Standard Operating Procedures (SOPs) that thoroughly document all aspects of laser use from set-up and alignment through service, repairs, and incident reporting procedures.
- Providing and documenting that all laser users operating under their LUA have taken the laser safety training online, received specific hands-on instruction in the use of the laser system, are aware of safety precautions associated with the laser, have read the SOPs relating to the laser, and have agreed to the proper use of laser

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protective eyewear.

- Ensuring that laser users comply with other campus or departmental safety procedures, requirements, or policies.
- Signing off on the approved SOP(s).
- Ensuring that appropriate Personal Protective Equipment (PPE) is available.
- Ensuring that appropriate PPE is worn.
- Reporting any laser eye exposure incidents to the LSO within 24 hours.
- Notifying the LSO of any laser acquisitions, transfers, or disposals.
- Ensuring that the designated laser use area is posted with the appropriate laser hazard warning signs.
- Notifying the LSO with any experimental or facility changes that may impact safety.

## Laser Users

All users must meet the laser safety training requirement prior to operating any Class 3B or Class 4 laser. All laser users are responsible for following the LUA specific hazard controls and notification requirements. Responsibilities include but are not limited to:

- Attend the campus laser safety training class or Lawrence Berkeley National Laboratory (LBNL) equivalent prior to using any Class 3B and 4 laser unsupervised.
- Receive appropriate hands-on/on-the-job training.
- Read, understand, sign and follow lab specific laser standard operating procedures (SOPs).
- Wear appropriate Personal Protective Equipment (PPE) in accordance with the campus Laser Safety Program requirements.
- Immediately report any suspected eye exposures to PI or Authorized User, LSO, or Health Services.
- Follow any other campus or lab specific safety procedures, requirements, or policies.
- Report any safety concerns to the PI (or designated Lab Contact) or LSO.

## Lab/Group Laser Safety Contact

A laboratory/group laser safety officer is designated by the PI or Authorized User to

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serve as the liaison to the EH&S Laser Safety Program. This individual can be a staff member, postdoctoral scholar, or a graduate student but cannot be an undergraduate student. This designated Lab/Group Contact is given the authority by the PI or Authorized User to implement and maintain the Laser Safety Program for the lab/group.

Responsibilities include, but not limited to:

- Contact person for EH&S inspection of laser use lab/facility
- Inform PI/Authorized User of any laser safety deficiencies, laser incidents
- Identify lab members who will be operating a laser(s)
- Ensure laser user completes campus laser safety training (initial or refresher)
- Inform LSO of any personnel changes
- Ensure laser user receives hands-on training
- Inform Laser Safety Officer of any newly obtained laser/laser system by submitting a Laser use authorization (LUA) application.
- Maintain LUA inventory current
- Create or assist with the creation of laser standard operating procedure (SOP)
- Spot check safety practices within research group

### Visitors and Short-Term Researchers

A visitor is any person who is present in the laboratory as an invited guest of any UC Berkeley employee or student researcher for a time period of 1-30 days for the purpose of doing research or visiting a laboratory environment. They are considered to be a short-term researcher. If the short-term researcher stays longer than 30 days, they are considered a campus laser user.

It is the policy of the UC Berkeley NIRSC to require the same level of laser laboratory safety for all visitors and short-term researchers as is required for laser users. All visitors and short-term researchers are to be escorted by a person whose name appears on the Laser Use Authorization (LUA) as a laser user. If it is necessary for a short-term researcher to work alone in the laser laboratory, the individual must be added to the LUA as a laser user. It is the responsibility of the Principal Investigator to assure that the laser users in their facilities are informed of, understand, and follow this visitor policy. It is the responsibility of the visitor's laser user escort to provide the visitor with an appropriate safety orientation covering the hazards in the laser laboratory. The escort shall also provide appropriate safety equipment and require the visitor to use the safety equipment.

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Short-term researchers must meet the same laser safety training requirement as campus laser users (but do not need to be added to the LUA). Laser users must be immediately added to the LUA. See [Appendix B](#) for further details on the Laser Visitor Policy.

### Minors

Regardless if they are UC Berkeley students or not, minors must comply with the UC Office of the President (UCOP) policies which include parental sign-off on waivers of liability. PIs must be made aware of requirements on minors in research labs.

### Other Visitors

A visitor such as friends, family members, lab tour, or sales person must be accompanied by a trained laser user.

### Department Safety Coordinators

Department Safety Coordinators (DSCs) play a vital role in the safety network supporting campus operations. DSCs are the principal liaison between the employees/staff/students in their department and campus service providers such as EH&S. DSCs are informed of any corrective actions found in facility audits.

## Laser Classifications

The hazard class of a laser is very important to determine what appropriate controls are needed to make the laser safe. The LSO must assure that all UC Berkeley lasers are properly designated as to their appropriate hazard class. All commercially-manufactured lasers come marked with the hazard class as required under the FDA Center for Devices and Radiological Health regulations. Lasers modified at UC Berkeley must be evaluated by the LSO and appropriately classed. It is the responsibility of the PI to assist the LSO by supplying the appropriate radiometric parameters of the laser system. The campus Laser Safety Program is designed for the oversight of Class 3B and Class 4 lasers only.

The most common classes of lasers are as follows:

### Class 1 - exempt

- Output a few microwatts; and
- Beam fully enclosed; incapable of causing eye or skin injury due to enclosure. They may contain a higher class laser embedded within the unit that cannot be accessed in normal operations; and
- Exempt from additional control measures



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- Example: Laser printers

### Class 1M

- Large diameter or divergent beams
- Same as Class 1 except they may be hazardous to view with the aid of optical instruments
- Examples: LEDs and bare laser diodes

### Class 2 – low power visible

- Output < 1 mW in the visible portion of the spectrum (400-700 nm), and
- Eye protection is normally afforded by the aversion response
- Example: Supermarket style bar-code scanner.



### Class 2M- medium power visible

- Same as Class 2 but may be hazardous if viewed with the aid of optical instruments

### Class 3R- medium power visible (used to be called Class 3A)

- Output 1- 5mW visible and invisible range
- Only a hazard if viewed through optics or for long duration
- This laser will not pose either a fire hazard or diffuse-reflection hazard
- Examples: Laser pointers See [Appendix C](#) for Laser Pointer Safety Guidelines



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## Class 3B- intermediate power continuous wave or pulsed- requires Laser

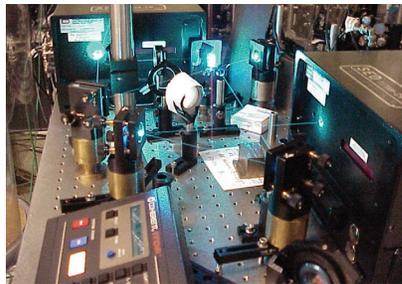
### Use Authorization (LUA)

- Output 5-500 mW visible and invisible range; pulsed or continuous wave
- May be hazardous under direct and specular reflection viewing conditions, but normally not a diffuse reflection or fire hazard; and
- It is a hazard to the eye or skin from the direct beam and eye protection is required, as well as barriers
- Example: Diode pump solid state lasers used for spectroscopy



## Class 4 – high power laser- requires LUA

- Output > 500 mW; visible and invisible range; pulsed or continuous wave
- A hazard to the eye or skin from the direct beam; it may also pose a diffuse reflection and fire hazard. Eye protection is required, as well as other barriers
- It may also produce laser generated air contaminants and hazardous plasma radiation
- Example: Nd:YAG laser used to pump a Ti-Sapphire laser



## Program Requirements/Procedures

### Acquisition, Modification, Sale or Transfer of Lasers

The campus LSO must be informed by the PI within 14 days of the acquisition, modification, sale, or transfer of any Class 3B or 4 lasers. Other classes of lasers are not controlled in this manner.

- Acquisitions - complete and submit an LUA application form. New LUA is assigned.
- Transfers from the jurisdiction of one PI to another PI on or off campus. LUA# is

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maintained, but ownerships and laser users lists are updated.

- Disposals or selling of the equipment. LUA# is terminated and archived.

### Laser Use Authorization (LUA)

The LUA is initiated by the PI or PI designate for Class 3B or 4 lasers by completing a LUA application form (see [Appendix D](#)). The completed form is sent to the LSO who contacts the PI to discuss the laser system and application. After the LSO has evaluated the proposed LUA, the LSO may choose to approve the LUA application or request the chair or full NIRSC to review the application depending on the complexity of the proposed setup. A list of all LSO approved LUA applications may be presented at the next NIRSC meeting. After review and approval, a copy of the LUA is sent to the PI. LUAs are reviewed by an EH&S Lab Safety Specialist each year during the annual Lab Safety Program audit for accuracy. Modification, transfer or termination of a LUA is done at the request of the PI or under special circumstances; the NIRSC may also modify or terminate a LUA. The LUA may be temporarily suspended by order of the LSO or the NIRSC if they feel that the health or safety of a laser user or the public is in immediate danger. The LSO or their designee maintains documentation of all changes to a LUA.

Any laser/laser system that is intended to be used in a human subject's experiment/protocol is required to undergo additional review and approval by NIRSC and the UC Berkeley Committee for the Protection of Human Subjects prior to any use.

### Laser Safety Training Requirements

#### Initial Training

All people seeking to use a Class 3B or 4 laser are designated as a "laser user" (including PIs) and are required to complete the campus laser safety initial training e-course requirement, EHS 301. Completion of the EHS 301 e-course is required prior to operating any laser/laser system. Laser users can enroll in the laser safety class by going to the [UC Learning Center](#) website and searching for the course title: EHS 301 Laser Safety Initial.

Once the laser safety initial training requirement is completed, users will be added to the PI/Authorized User personnel list.

The PI/Authorized User shall also provide and document that all new laser users operating under their LUA have received specific hands-on instruction in use of the laser system, safety precautions associated with the laser, any standard operating procedures (SOPs) relating to the laser, and proper use of laser protective eyewear.

Laser users who have met the LBNL initial laser safety requirements (LBNL EHS 302) will be granted exemption from meeting the campus laser safety training class. The LBNL EHS 302 (Initial) and EHS 303 (refresher) are considered equivalent to the campus training class.

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## Refresher Training

All laser users, including PIs, are required to refresh their knowledge of laser safety every three years (from initial training). Laser users can fulfill this requirement by completing an online laser safety refresher training course. The laser safety refresher course is available through the campus [UC Learning Center](#). Search for course title: “EHS 302 Laser Safety Refresher.”

## Other Training

Supplementary laser safety training is available from the EH&S upon request. The NIRSC may direct a PI to obtain a supplementary laser safety training presentation for their users. The LSO maintains documentation on all training presentations.

## Suspected Laser Incidents

Laser users must inform the PI and LSO of any suspected (or sustained) laser incidents/exposures within 24 hours. The LSO is responsible for investigating laser incidents, providing a report to the PI and the NIRSC, and maintaining records on incidents. Please refer to [Appendix D](#), of the Standard Operating Procedures template for the Emergency Procedure for Laser Accidents. Eye examinations will be performed on all UC Berkeley personnel whenever a laser eye exposure is suspected.

Following the incident, the PI is responsible for filing all appropriate campus or departmental documentation related to the incident. After an incident, the laser/laser system must not be used until the LSO and the NIRSC reviews the incident, reviews and approves corrective actions/recommendation, and approves a restart.

## Laser Safety Inspections

Annually, all laser facilities are inspected by the LSO or their designee to ensure that the lasers are being operated in a safe manner. The LSO every other year may offer the PI the option of performing a self-assessment in place of an LSO inspection. If the PI agrees to a self-assessment, they must complete the Laser Safety Inspection form and return the completed form to the LSO for review within 30 days of the request. See [Appendix D](#) for a copy of the Laser Safety Inspection form. Copies of all inspection reports are provided to the PI for their review. The LSO maintains records of all inspections performed.

If there is an imminent hazard, the LSO is authorized to stop the operation and will advise the PI and the chair of the NIRSC of this action. The PI is responsible for correcting unsafe conditions in a timely manner. The LSO or their designee will re-inspect the laser

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facility to verify the correction of the unsafe condition. The LSO will inform the NIRSC of uncorrected unsafe conditions and the PI may be asked to attend a NIRSC meeting to brief the NIRSC on the issue.

The LSO will provide the NIRSC an annual report summarizing key findings from annual laser safety inspections. These data will be used to further revise and refine the UCB Laser Safety Program to improve user safety.

### Consequences of Non-Compliance

When problems are identified during an inspection of a laser and its operation, the LSO or EH&S designate will prepare a report detailing the issues(s) and corrective action(s) required. Identified non-compliance items reported shall be corrected within 30 days or as communicated in the report. The LSO or EH&S designate may either perform a follow-up inspection or request confirmation of compliance.

In the event of any serious violation or discovery of unsafe conditions, the LSO will bring the matter to the attention of the PI. The LSO may take action to prevent any imminent danger by stopping work. The LSO will inform the NIRSC chair after taking such action. The LSO may also refer the matter to the NIRSC Chair or committee to address.

Serious or chronic non-compliance issues can result in review by the NIRSC and may lead to restrictions, more frequent EH&S surveys, additional training, or in severe cases, suspension or termination of the LUA.

The following step(s) may be taken by EH&S and/or by NIRSC to resolve non-compliance items:

- EH&S (LSO or designee) performs a follow-up inspection with PI or lab contact 30 days after receipt of the initial report. Note: correction of non-compliance items is at the discretion of the LSO and/or NIRSC Chair.
- NIRSC Chair or NIRSC department representative contacts the PI and/or lab safety contact with a formal request to the PI with copies to the Department Chair.
- During the two-week interval, the PI may work with the LSO to resolve the non-compliance issue or make an appeal to the NIRSC committee for an extension.
- NIRSC Chair formally informs Vice-Chancellor for Research (VCR) of the suspension or termination of an LUA or LUA user. The Dean of the College and Department Chair are notified of the impending suspension or termination of laser use activity.

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If at any time the LSO is not satisfied with the user's safety and health practices, the project may be halted (with NIRSC/chair approval) until corrections have been made. The LSO's action(s), other than stop work orders, may be appealed to NIRSC.

## Standard Operating Procedures

For lasers, standard operating procedures (SOPs) are required for all active Class 3B and 4 lasers. These SOPs must:

- Describe hazards and controls associated with the use of the laser
- List laser protective eyewear requirements
- Describe procedures for: start up, shut-down, alignments, service, and maintenance
- Describe safety precautions (stray beam/unwanted reflection checks, beam blocks, avoidance of the beam on a horizontal plane with the user's eyes, beam enclosures, eyewear, hands-on training, etc.) to be followed
- Describe how to respond in an emergency situation
- Include procedures/instructions for non-laser user personnel such as trades staff, custodial services, visitors, etc. entering laser use facility
- Include an Authorized Laser User signature page for users to sign that they have read the document

SOPs are to be reviewed and approved by the PI and then the LSO. A copy of the SOP should be available for review at all times. PIs and laser users should review their specific SOP annually or more often, if conditions change.

An SOP template is available for campus users through the EH&S Laser Safety Program website and is referenced in [Appendix D](#) - Laser Safety Forms.

## Personal Protective Equipment (PPE)

The PI shall provide their laser users with the appropriate laser eye protection and is

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responsible for ensuring that the eye protection is used when needed. See [Appendix E](#) for an eyewear selection guide. Appropriate laser eye protection must be used for beam alignments or anytime an open beam exceeds the ANSI Z136.1 maximum permissible exposure (MPE) value. The LUA document will detail the MPE and the required minimum optical density (OD) for laser protective eyewear. The LSO should be consulted prior to purchasing any laser protective eyewear.

Some ultraviolet (UV) laser uses may require the use of skin protection. Any need for skin protection will be identified by the LSO and communicated to the PI through the LUA.

Additional PPE such as respirators, face shields, gloves, lab coats and hearing protection, etc. may be required whenever engineering controls cannot provide protection from harmful ancillary hazards and is warranted by the campus PPE criteria or policy.

### Beam Management

Laser beam(s) must be restricted to the immediate location of use. Beams paths should be enclosed whenever practical. Beam stops/barriers must be used to terminate beams. The use of shutters, curtains, beam tubes, and other beam control devices are strongly encouraged. If the beam path cannot be enclosed, appropriate beam control measures (engineering and administrative) must be employed and detailed in the laser standard operating procedure. It is the responsibility of the PI and their laser users to verify through survey that appropriate beam management is being practiced.

### Posting and Labeling

All access points to the laser facility must be marked with ANSI standard laser hazard warning signs. Laser enclosures must be labeled to alert users to laser hazards as per the ANSI standard. Labels, laser hazard signs, and advice on their use are available from EH&S. See [Appendix F](#) for the approved ANSI laser warning signs.

New or renovated campus laser facilities will be required to meet the campus laser safety design requirements. Design requirements for a Class 4 shall include illuminated laser hazard warning sign(s), laser rated curtain or barrier, emergency power off (EPO) switch(s). Please note that any deviation from the laser safety program design requirements is at the discretion of the LSO.

### Access Control

Whenever the laser is in operation, access to laser facilities is restricted to laser users or persons being escorted by laser users. Access control must be maintained by a positive means such as locked or interlocked doors. Laser warning signs alone are not considered sufficient to control access.

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For the entryway to a Class 3B Class 4 laser facilities, a door, blocking barrier, screen, curtain, etc. shall be used to block, screen, or attenuate the laser radiation at the entryway. The level of laser radiation at the exterior of these devices shall not exceed the applicable MPE, nor shall personnel experience any exposure above the MPE immediately upon entry.

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## Substitution of Alternate Control Measures (Class 3B or 4)

The ANSI Z136.1 Laser Standard (4.2) provides the LSO authority to substitute control measures specified in the standard for Class 3B and Class 4 laser or laser systems with other procedural, administrative, or alternate engineering control measures which provide equivalent protection.

## Administrative Control Measures for Class 3B and Class 4 lasers

The following administrative controls are used for Class 3B and 4 lasers:

Laser Class	Control Measures
Class 3B & 4	<ul style="list-style-type: none"><li>• Access limited to authorized laser users</li><li>• Access for non-authorized laser users must follow the Laser Laboratory Visitor Policy (<a href="#">Appendix B</a>)</li><li>• Current laser safety training for all users</li><li>• Standard Operating Procedure</li><li>• Perform and document stray beam/unwanted reflection checks</li><li>• Establish a Nominal Hazard Zone (NHZ) - See <a href="#">Glossary</a></li><li>• Post appropriate laser hazard warning sign at all entrances(s)</li><li>• Appropriate laser eye protection is required</li><li>• LSO may require additional control measures as needed*</li></ul> <p>* LSO has the authority to assign additional safety control measures (engineering/administrative/PPE) if needed</p>

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## Engineering Control Measures for Class 3B and Class 4 lasers

The following engineered controls are used for Class 3B and 4 lasers:

Laser Class	Control Measures
Class 3B & 4	<ul style="list-style-type: none"><li>• Use of appropriate beam stop or attenuators and beam enclosures</li><li>• A door, blocking barrier, screen, curtain, etc. shall be used to block, screen, or attenuate the laser radiation at the entryway</li><li>• All windows, doorways, open portals, etc., from an indoor facility either covered or restricted</li><li>• LSO may require additional control measures as needed*</li></ul> <p>* LSO has the authority to assign additional safety control measures (engineering/administrative/PPE) if needed</p>

## Record Keeping Requirements

EH&S maintains all records/documents (paper and electronic) pertaining to the campus Laser Safety Program. Baseline eye exam records are considered medical records and maintained by the UC Berkeley Meredith W. Morgan University Eye Center.

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## Non-Beam / Ancillary Hazards

It is important to address other hazards associated with the use of lasers beyond eye or skin hazards. Non-beam hazards include physical and chemical hazards. The LSO and/or EH&S should be contacted to evaluate any potential non-beam/ancillary hazard conditions. The most prominent non-beam hazards are:

**Electrical Hazards** - Laser systems and power supplies may require thousands of volts and tens of amperes to operate. The electrical needs associated with laser use present inherent electrical safety hazards.

These hazards are normally mitigated by the engineering controls (enclosures, interlocks, grounding, etc.) built into the laser systems. However, if these engineering controls are defeated during tuning or maintenance, live contacts can be directly accessed. Contact with these may cause any number of adverse bio-effects, up to and including death by electrocution.

Work on electrical equipment can only be performed by “qualified” personnel (Cal-OSHA requirement). These personnel must be properly trained in electrical safety practices and procedures and must be approved by their department to work on electrical equipment. It is essential that you do not work on electrical equipment if you are unfamiliar with electrical devices or if you are untrained in electrical safety.

### Electrical Safety at UC Berkeley

The [UC Berkeley Electrical Safety Program](#) provides information about electrical hazards, guides University safe-work policy, electrical safety procedures, equipment design, development and installation for all electrical work, equipment and systems at UC Berkeley. All faculty, staff, students, visitors and contractors must comply with the requirements of this program as it ensures their safety by:

- Defining safe work practices and use requirements for all people who work with electrically energized equipment as part of their normal job / research duties.
- Establishing training requirements for “qualifying” and “authorizing” persons who work on or near energized electrical circuits and components, and establishing “qualification” requirements for UCB-hired electrical contractors.
- **TRAINING:** The [EHS 804 Electrical Safety Awareness](#) training is available for employees who are around electrical hazards and who are unqualified electricians.
- Establishing a process for evaluating the hazards of every potentially energized electrical work task and for determining appropriate hazard controls.
- **HAZARD EVALUATION:** To evaluate laboratory equipment for potential electrical

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hazards, use the [Electrical Safety Laboratory Equipment Hazards and Controls Checklist](#).

- Establishing a formal process for controlling energized electrical work through an assessment and documented “energized work” or “[Energized Work Permit](#)” process.

The [UC Berkeley Electrical Safety Program](#) must be applied to every individual piece of equipment, research/experimental apparatus or facility that has electrical energy as a source of power and/or utility distribution in compliance with Cal/OSHA code, California Electrical Code, California Building/Construction Code and NFPA Life Safety Code.

For basic information about Electricity and Electrical Safety, please review the [Fact Sheet](#) to become familiar with electrical hazards and controls.

Contact your department safety coordinator for specific information on your department’s electrical safety policies and resources. EH&S (510-642-3073) is available to provide electrical safety training and electrical inspection services upon request.

For more information on the campus Electrical Safety Program, please visit the [EH&S website](#).

### Collateral Radiation Hazards

Laser excitation systems and power supplies may produce hazardous collateral radiation of various types. These hazards are normally controlled by the equipment housings, and are usually a problem only if the protective housings are removed.

The laser excitation device may produce very intense UV/Visible/IR radiation that can be hazardous. Collateral ultraviolet radiation may injure both the eye and the skin if the exposure duration is long enough. Blue light presents a special hazard because of its ease of absorption in the retina. This “Blue Light Hazard” is thought to create photochemical injury in the retina. Exposure to any very intense visible light source can seriously degrade color vision and night vision capabilities. Exposure to these intense light sources should be carefully controlled or eliminated by leaving the housings in place.

Laser power supplies capable of creating energies greater than 15 kVp may be a source of x-rays if they contain high voltage vacuum tubes. Electric discharge excitation sources in lasers may also be a source of x-rays. Generally, these x-rays are low energy and are shielded by the equipment housings.

**Toxic Lasing Media Hazards** - Some laser dyes are considered mutagenic and carcinogenic. Halogen gases used in excimer lasers are powerful oxidizers and are toxic if inhaled.

The solvents used for mixing the dyes may be flammable, toxic, or present other health

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hazards. Material Safety Data Sheets (MSDS) on dyes or solvents are available from your department or by contacting the LSO.

Appropriate PPE (lab coat, disposable gloves, safety glasses or splash goggles, etc.), and a properly functioning chemical fume hood must be used when handling or mixing the dyes.

**Compressed Gas and Cryogen Hazards** - There is a kinetic energy hazard associated with all compressed gas cylinders. Cryogenics can cause burns and eye injuries from contact. Leaking cylinders may present an asphyxiation hazard if ventilation is insufficient.

The use of compressed gases is common in the laser laboratory. Some lasers use either pure gases or gas mixtures as the lasing media. The high pressure of the gas translates into substantial potential energy stored in the cylinder. If this pressure is released in an uncontrolled manner (such as broken nozzle) the cylinder can become an unguided missile. Compressed gas cylinders must be properly restrained to prevent damage to the nozzle or regulator.

The gases themselves may present a variety of hazards if they leak from the cylinder. Depending on the gas, it may be toxic, corrosive, flammable, etc. Refer to the MSDS for detailed information on the gas in question. If the hazards are sufficient, it may be necessary to provide a gas cabinet under negative pressure to control the hazard in the case of a leak. Inform your department safety contact if compressed gases are to be used in the laser facility.

**NOTE:** Any gas mixture that falls under criteria of the campus “Toxic, Corrosive and Pyrophoric Gas Program” is required to receive pre-approval prior to ordering. For Information on the campus Toxic, Corrosive and Pyrophoric Gas Program, please see the [EH&S website](#).

**Laser Generated Air Contaminate Hazards** - The interaction of the laser beam with target materials may produce toxic dusts, vapors or gasses. This is particularly true during material processing (welding, cutting, vapor deposition, etc.). Toxic products resulting from laser processing must be properly controlled through the use of adequate ventilation and filtration.

**Noise Hazards** - Some laser systems create significant levels of noise in the laser laboratory. If the noise level seems unpleasant or painful, contact your department safety contact to have a noise survey done.

**Fire and Explosion Hazards** - Class 4 lasers can present fire hazards. Lasers being operated in a CW mode with a beam power that exceeds 0.5 Watt can ignite or cause off gassing in combustible materials left in the beam path. Beam stops, barriers, and curtains used with Class 4 lasers must be made of compatible, non-combustible materials.

Explosion hazards in the laser lab include: the storage and use of flammable solvents and gases (both compressed and cryogenic) and the implosion potential from Dewar’s and

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excitation flash lamps. Proper storage and control of these sources should reduce the potential hazard.

## Laser Applications Outside the Laboratory

The use of a laser outside of a controlled area can present special hazards to the campus community and to the general public. These applications may include; lasers used for telecommunications, laser research being performed outdoors, and lasers used for entertainment or public viewing.

See [Appendix G](#) for details on the controls required for use outside the normal research laboratory environment of a Class 3R, 3B, or 4 laser.

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# Appendix A:

## Bylaws of the Non-Ionizing Radiation Safety Committee

**Authority and Responsibility-**The Non-Ionizing Radiation Safety Committee (NIRSC or also referred to as “the Committee”) is appointed by and reports to the Vice-Chancellor for Research. This Committee was formerly known as the Laser Safety Committee.

The Committee is delegated the authority and responsibility for setting campus policy for lasers and other forms of non-ionizing radiation, within the scope of the campus Laser Safety Program and Non-Ionizing Radiation (NIR) Safety Program; for reviewing laser and other NIR source uses, and, where appropriate, authorizing such uses; for reviewing the operations and procedures of the Office of Environment Health & Safety (EH&S) with respect to lasers and other NIR safety issues and offering comments to the laser safety officer (LSO) and radiation safety officer (RSO) regarding EH&S laser and other NIR safety operations and procedures.

**NOTE:** Non-ionizing radiation shall be defined as all electromagnetic radiation with either a wavelength  $\geq 100$  nm or a photon energy  $< 12.4$  eV.

The Committee has the first responsibility to act in the best interests of safety. The Committee has the authority to terminate a laser or other NIR source use, should termination be warranted. Committee decisions to revoke or suspend the use of a laser or other NIR source may be appealed to the Vice-Chancellor for Research. The Vice-Chancellor for Research will meet with the petitioner, EH&S staff, and members of, or the full, Non-Ionizing Radiation Safety Committee, as necessary, to make a determination as to revocation or suspension. Decisions to modify actions of the Non-Ionizing Radiation Safety Committee will be transmitted to the Committee in writing and included in their files.

**Composition** - The Committee consists of not more than 10 or less than 5 members exclusive of ex-officio members. Membership of the Committee shall meet appropriate federal and state guidelines (if any) for composition of the Committee.

**Experience** - Members are appointed on the basis of knowledge of the principles and practices of the control of hazards resulting from or associated with the use of lasers and other NIR sources. The membership is to reflect the diversity of scientific disciplines using lasers and other NIR sources on campus.

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Ex-officio members - The campus LSO and RSO shall serve as ex-officio members. Other ex-officio members may be appointed by the Committee.

Length of Service - Members will normally serve for a three-year term but may be re-appointed for additional terms.

Appointment Process - On behalf of the Chancellor, the Vice-Chancellor for Research shall receive nominations from the current Chair and may solicit nominations from the Associated Students of the University of California (ASUC) Committees and other academic administrative officers as appropriate. The VCR approves all appointments to NIRSC.

Chair of the Committee - The Chair is selected from among continuing members of the Committee, and will normally have at least two years prior service as a member. Re-appointment of the Chair beyond a one-year term will be at the recommendation of the Vice-Chancellor for Research.

## Functions

### (a) General

The Committee is responsible for setting campus policy in laser and NIR safety, within the scope of the campus Laser Safety Program and NIR Safety Program; for reviewing uses of laser and other NIR sources, authorizing laser and other NIR source use where appropriate; and reviewing and approving procedures of EH&S with respect to laser and other NIR safety. The Committee can also delegate actions to the LSO/LSO designate as needed to ensure compliance with the campus laser and NIR safety programs.

### (b) Use of NIR Sources.

The Committee authorizes the use of laser or other NIR sources where appropriate as recommended by the LSO. Any authorizations granted are to be supported by documentation including the following:

1. Adequate experience and training of the Authorized User;
2. Sufficient and appropriate equipment and facilities;
3. Adequate plans and procedures for the use of a laser or other NIR sources; and
4. Establishment of procedures to reduce the potential for a laser or other NIR related incident and accident.

### (c) Review of Authorized Uses

The Committee is to verify that each authorized laser or other NIR use is periodically reviewed by the EH&S.

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The Committee will review safety issues regarding lasers or other NIR uses referred by the LSO and will determine whether to modify, restrict, or terminate the use of a laser or other NIR source.

#### **(d) Review of the EH&S Laser and NIR Safety Activities**

The EH&S staff is responsible for the day-to-day implementation of the campus Laser Safety Program and NIR Safety Program and for assuring that laser and other NIR sources are used in conformity with policies set by the Committee. EH&S brings to the attention of the Committee matters affecting campus laser and other NIR safety, changes needed in campus laser or NIR safety policy, and changes in standards or regulations related to laser or other NIR source use and safety. EH&S provides such reports, summaries, and statistics as the Committee may require. The Committee reviews the operations and procedures of the EH&S with respect to laser and other NIR safety and offers comments to the LSO regarding laser and other NIR safety operations and procedures. Problems discovered during these reviews that cannot be resolved or are of concern, are referred to the Committee for review and resolution.

#### **(e) Meetings**

1. The Committee meets triennially for the purpose of reviewing campus laser and other NIR safety issues, operations and procedures of EH&S with respect to laser and other NIR safety, and to consider other materials needing its attention.
2. At the discretion of the Committee Chair, or the LSO, special meetings may be called to review and approve laser or other NIR source use, review and act on laser or other NIR incidents, review and make changes in campus laser or NIR safety policy, or members of the Committee.
3. A quorum, consisting of a simple majority of the membership, shall be present at all meetings and will include the LSO and the radiation safety officer, or designated alternates.
4. Committee members are required to attend two of the three meetings. A member may choose to send a substitute in their place should a scheduling conflict arise.
5. The LSO or a designated alternate keeps minutes of the meetings. Copies of the minutes are sent to members of the Committee. EH&S maintains a file of the Committee meeting minutes and associated Committee files.

#### **(f) Annual Report**

The LSO prepares an annual report detailing the activities of the Committee. This report shall be reviewed and approved by the Committee Chair prior to being submitted to the Vice-Chancellor for Research.

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# Appendix B:

## Laser Laboratory Visitor Policy

### Definitions:

- A laboratory visitor is any person who is present in the laboratory as an invited guest of any UC Berkeley employee (Principal Investigator [PI], staff, post-doc) or student researcher and who is identified as a non-laser user. The following example individuals can be identified as a “visitor”:
  - **Campus/Department staff**
  - **Facility service staff or service contractor/trades staff**
  - **Sales person**
  - **Family members or friends**
  - **High school students (tours)**
- Visitors who are to be in the laboratory for a period of more than one day but less than 30 days are considered short term researchers and must comply with the Laser Safety Program requirements for a “new” laser user.
- Persons who will be in the laboratory for a period of more than 30 days are considered to be campus laser users and must comply with the Laser Safety Program requirements for a “new” laser user.

### Visitor Policy and Requirements:

It is the policy of the UC Berkeley Non-Ionizing Radiation Safety Committee (NIRSC) to require the same level of laser laboratory safety for all visitors as is required for laser users. All visitors are to be escorted by a person whose name appears on the Laser Use Authorization (LUA) as a laser user. It is the responsibility of the Principal Investigator and designated lab/group laser safety contact to assure that the laser users in their facilities are informed of, understand, and follow this visitor policy.

It is the responsibility of the visitor’s laser user escort to provide the visitor with an appropriate safety orientation covering the hazards in the laser laboratory. The escort shall also provide appropriate safety equipment and require the visitor to use the safety equipment.

Short-term researchers must be escorted by an approved laser user and they are not authorized to work independently with lasers. Under these arrangements, they do not

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need to be added to an LUA. If they wish to work independently with a laser, they must become an approved laser user by attending UC Berkeley's laser safety training and be added to an active status LUA.

As a reminder, no unregistered use of lasers is allowed under any circumstances. The LUA indicates the registered use(s) of the laser system. All LUA and UC Berkeley Laser Safety Policy requirements must be followed at all times

It is the responsibility of the Principal Investigator to ensure that persons who are not invited into the laser laboratory or who fail to follow directions regarding safety policy or the use of safety equipment are immediately escorted out of the laser use areas.

### Coordination with EH&S:

Normally, it is not necessary to inform EH&S of the presence of visitors. It is necessary to inform EH&S of the presence of short-term researchers, although it is not necessary to add them to the LUA. EH&S must be immediately informed of new laser users as specified in the Laser Safety Manual.

### Special / Unique Visitors (Scheduled):

In the case where there is a request or need to perform service or maintenance of the facility or equipment within the laser facility by a campus facility/trades staff member, or non-campus service personnel the PI and lab laser safety officer shall ensure that all laser/laser systems are turned off.

### Visitor Requirements:

Although it is primarily the responsibility of the escort to provide a safe environment for laboratory visitors, consideration should be given to the following:

- Unless it is absolutely necessary to have the laser energized during the visit, it is required that all lasers and laser power supplies be turned off during the visit. Laser/laser systems can be placed in idle mode (power supply on but no beam produced). Authorized users shall verify that beam shutter is engaged and there is no laser beam present.
- Minors are not allowed in laboratories that contain hazards unless they are registered University of California students or are registered participants in a University-sanctioned project, program, or tour. In all cases, the PI is required to follow the [campus and UC system policy for minors entering a research lab](#). Minors must be properly supervised while in laboratories.
- Any laser demonstration be conducted so that the laser beam is directed away from any visitor, regardless of the laser eye protection being used.

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## Patients and Visitors Exposed to Medical Lasers:

- Except as required for medical treatment or the instruction of medical staff, every effort should be made to limit the presence of visitors in the laser treatment room.
- Except as required for medical treatment of the eye, appropriate beam management shall be practiced to prevent eye exposure from any medical laser.
- Persons not receiving laser eye treatment who are present in the laser treatment room shall be provided, instructed in the use, and required to use appropriate laser eye protection.

If you need more information, please contact the laser safety officer, at (510)643-9243 or [lso@berkeley.edu](mailto:lso@berkeley.edu).

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## Appendix C:

# Laser Pointer Safety Guidelines

**Applicability:** All Class 2 or 3R laser pointers used for class room instruction or presentations shall be operated under the guidelines established in this document. Class 3B and Class 4 laser devices are not addressed in these guidelines, and shall not be used in instruction or presentations. A Class 3R laser can cause eye injury, but the intended use of laser pointers carries a very low probability of injury. For this reason, the Non-Ionizing Radiation Safety Committee has approved the use of Class 3R pointers for their intended use as instruction and presentation aids.

**Labeling of Pointers:** The manufacturer is required by the FDA Center for Devices and Radiological Health to provide correct labeling for their laser pointers. This includes the laser hazard symbol, laser classification, and maximum power output and laser wavelength. This information should be clearly visible on the laser pointer. The manufacturer should also provide operating and safety instructions.

### Operating Safety Guidelines

- No person should ever intentionally stare into the laser beam.
- The laser beam should never be intentionally directed toward oneself or directed toward another person. The beam should be directed towards the screen and directed away from the audience.
- Mirror-like surfaces (such as glass, metal and other highly reflective materials) should be avoided when directing the laser beam.
- Use of Class 3R laser pointers should be limited to the intended purpose. Indiscriminate use may present an eye hazard.
- Class 3R laser pointer use is prohibited when optically aided viewing of the beam is probable. Optical aids include telescopes, binoculars, viewing optics, and similar devices.

**Exceptions:** Exceptions to the above guidelines should be coordinated with the laser safety officer.

**Legal Implications of Laser Pointer Misuse:** The California Penal Code has several sections that indicate the willful misuse of a laser pointer can be considered either a misdemeanor or a felony. In particular, directing any laser beam at another person may constitute assault (suggesting the use of a laser gunshot) and directing any laser beam at an aircraft may constitute malicious mischief.

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Emergencies: Although the potential for injury from a laser pointer is very slight, notify your immediate supervisor and get medical attention if an eye injury from laser use is suspected. Also notify the laser safety officer at (510) 642-3073 as soon as possible. Go to the Tang Center Urgent Care Unit for emergency medical assistance if open. If Tang Center is not open, go to Alta Bates Hospital.

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## Appendix D: Laser Safety Forms

UC Berkeley Laser Use Authorization (LUA) Application Form:

<https://ehs.berkeley.edu/sites/default/files/laseruseauthorizationform.pdf>

Standard Operating Procedures Template:

<http://ehs.berkeley.edu/sites/default/files/lines-of-services/laser-safety/lasersoptemplate2014.pdf>

Laser Safety Inspection Form:

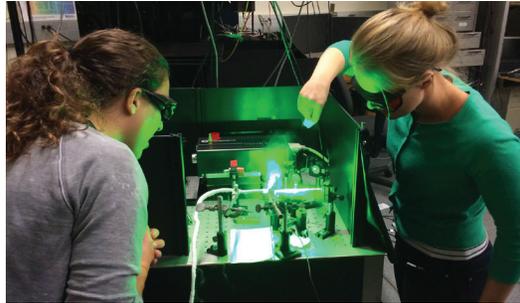
[http://ehs.berkeley.edu/sites/default/files/lines-of-services/laser-safety/  
LaserSafetyInspectionForm.pdf](http://ehs.berkeley.edu/sites/default/files/lines-of-services/laser-safety/LaserSafetyInspectionForm.pdf)

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## Appendix E:

# Selection of Laser Safety Eyewear

Appropriate laser protective eyewear must be used for beam alignments or anytime an open beam exceeds if the viewed beam exceeds the ANSI Z136.1 MPE (maximum permissible exposure) value. All eyewear must be labeled with the optical density and wavelength.



Laser protective eyewear is usually not required for Class 2 or 3R laser or laser systems unless viewed by certain optical aids.

Factors in selecting eyewear:

- Laser power and/or pulse energy
- Wavelength(s) of power output
- Potential for multi-wavelength operations
- Radiant exposure or irradiance levels for which protection (worst case) is required
- Exposure time criteria
- Maximum permissible exposure (MPE)
- Optical Density requirement of eyewear filters at laser output wavelengths
- Angular dependence of protection afforded
- Visible light transmission requirement and assessment of the effect of the eyewear on the ability to perform task while wearing the eyewear
- Need for side-shield protection and maximum peripheral vision requirement; side shields shall be considered and should be incorporated where appropriate
- Radiant exposure or irradiance and the corresponding time factors at which laser

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safety filter characteristics change occurs, including transient bleaching especially for ultra-short pulse lengths

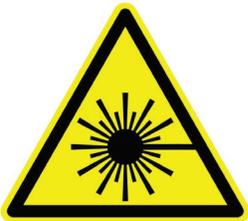
- Need for prescription glasses
- Comfort and fit
- Degradation of filter media, such as photo-bleaching
- Strength of materials (resistance to mechanical trauma and shock)
- Capability of the front surface to produce a hazardous specular reflection
- Requirement for anti-fogging design and coatings

Laser protective eyewear should be inspected before each use for damage, and or cleanliness, and replaced if necessary. Contact the LSO for assistance in selecting eyewear at [lso@berkeley.edu](mailto:lso@berkeley.edu).

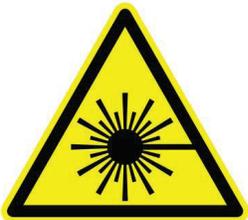
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## Appendix F: Laser Hazard Warning, Danger and Notice Signs

Laser hazard signs must be conspicuously posted to warn onlookers of the potential hazard. The appropriate warning or danger sign shall be posted at the entryway(s) and, if deemed necessary by the LSO, should also be posted within the laser-controlled area. Laser hazard warning, danger or notice signs and labels (except lighted hazards warning signs) are provided by the LSO or are available on the [EH&S website](#).

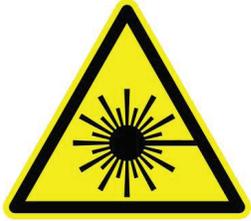
 <span style="font-size: 2em; font-weight: bold; margin-left: 10px;">WARNING</span>	
	<p style="text-align: center; margin: 0;"><b>CLASS 3B LASER CONTROLLED AREA</b></p> <p style="text-align: center; margin: 0;"><b>LASER RADIATION</b></p> <p style="text-align: center; margin: 0;"><b>AVOID DIRECT EYE EXPOSURE TO BEAM</b></p> <p style="text-align: center; margin: 0;"><b>LASER EYE PROTECTION REQUIRED</b></p> <p style="margin-top: 10px;">Laser Type/Max Power: _____</p> <p style="font-size: 0.8em; margin-top: 10px;">Laser Safety Officer : Eddie Ciprazo EXT. 3-9243</p>

[Standard laser WARNING sign for a Class 3B laser.](#)  
Complete the blanks on the sign and post as directed by the LSO.

 <span style="font-size: 2em; font-weight: bold; margin-left: 10px;">WARNING</span>	
	<p style="text-align: center; margin: 0;"><b>CLASS 4 LASER CONTROLLED AREA</b></p> <p style="text-align: center; margin: 0;"><b>AVOID DIRECT EYE EXPOSURE TO DIRECT AND SCATTERED RADIATION</b></p> <p style="text-align: center; margin: 0;"><b>DO NOT ENTER WHEN LIGHT IS ILLUMINATED</b></p> <p style="text-align: center; margin: 0;"><b>LASER EYE PROTECTION REQUIRED</b></p> <p style="margin-top: 10px;">OD @ nm</p> <p style="margin-top: 5px;">Laser Type: _____</p> <p style="margin-top: 5px;">Max Power: _____</p> <p style="font-size: 0.8em; margin-top: 10px;">Laser Safety Officer: _____ Ext. _____</p>

[Standard laser WARNING sign for a Class 4 laser.](#)  
Complete the blanks on the sign and post as directed by the LSO.

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 <h1 style="margin: 0;">DANGER</h1>	
	<p><b>CLASS 4 LASER CONTROLLED AREA</b></p> <p><b>AVOID DIRECT EYE EXPOSURE TO DIRECT AND SCATTERED RADIATION</b></p> <p><b>DO NOT ENTER WHEN LIGHT IS ILLUMINATED</b></p> <p><b>LASER EYE PROTECTION REQUIRED</b></p> <p><b>AUTHORIZED PERSONNEL ONLY</b></p> <p>Laser Type: _____ Max Power: _____</p> <p>Laser Safety Officer: _____ EXT. _____</p>

[Standard laser DANGER sign for a Class 4 laser.](#)  
 Use of this sign requires LSO authorization. Receive approval and complete the blanks on the sign and post as directed.

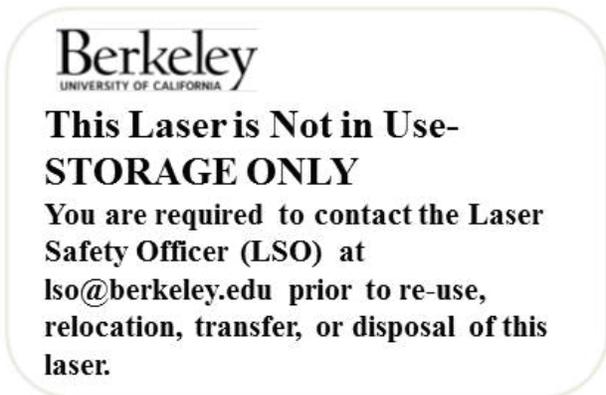
<h1 style="margin: 0;">NOTICE</h1>	
	<p><b>UNATTENDED LASER IN OPERATION</b></p> <p><b>AUTHORIZED PERSONNEL ONLY</b></p> <p><b>Emergency Contact</b>        Name: _____        Phone: _____</p> <p>Laser Safety Officer: Eddie Ciprazo EXT. 3-9243</p>

[Standard NOTICE Unattended Laser sign](#)  
 is required when lasers are being operated and not attended. Complete the blanks on the sign and post as directed.

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[Standard NOTICE Alignment in Process laser sign](#) is required when beam alignment is in-process. Complete the blanks on the sign and post as directed.



[Standard sticker for lasers in STORAGE ONLY](#) status. The LSO shall post lasers in storage only status with this label.

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## Appendix G:

# Laser Applications Outside the Laboratory

Introduction: The use of a laser(s) outside of a controlled area can present special hazards to the campus community and to the general public. This appendix addresses the control of any laser (Class 3R, 3B, or 4) used outside the normal research laboratory environment. These applications may include; lasers used for telecommunications, laser research being performed outdoors, and lasers used for entertainment or public viewing.

Applicability: Any laser system (Class 3B or 4) used outdoors for research projects (i.e. telecommunication, 3D scanning, astronomy) shall be registered with the EH&S as per the requirements of the Laser Use Authorization (LUA) Program. All Class 3R, 3B, or 4 laser systems being used on UC Berkeley property must be used in accordance with the UC Berkeley Laser Safety Program. The campus Non-Ionizing Radiation Safety Committee must approve any variation from the Laser Safety Program.

The Principal Investigator (PI) shall inform the LSO of any lasers used outdoors for research projects. Such laser uses will need to be covered under a LUA. The Department Safety Coordinator will be responsible for informing the LSO of any indoor or outdoor applications being pursued by that department. In both cases, the application and operation of the laser system(s) shall be evaluated by the LSO to ensure that appropriate safety measures are in place prior to operation.

### Laser Safety Requirements - Other Outdoor Uses of Lasers

**(Note: A LUA is required for the use of a Class 3R, 3B, or 4 laser.)**

Meet the specified LUA safety requirements:

- The LSO will establish a Nominal Hazard Zone (NHZ) - defined as any area where the maximum permissible exposure (MPE) is exceeded.
- The NHZ must be posted and/or restricted as directed by the LSO.
- The PI must ensure that only trained personnel enter the NHZ, and that appropriate personal protective equipment is issued and used.
- The PI must ensure users are properly trained and meet the campus laser safety training requirements.
- The PI must ensure only authorized personnel are allowed to operate the laser.
- The PI must ensure the use of any required administrative/engineering controls.
- Laser beams shall not be directed toward structures, automobiles, aircraft, or other

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vehicles within the NHZ unless adequate training and protective equipment is provided and used by all personnel within these structures/vehicles.

- The laser beam path shall not be maintained at eye level without LSO approval.
- Federal departments/agencies such as Federal Aviation Administration or Department of Defense notification is required (for Class 3R, 3B or 4 lasers) if the laser is being used in navigable airspace.
- Additional State or Federal safety requirements such as a Food and Drug Administration (FDA) / Center for Devices and Radiological Health (CDRH) laser operator variance may be needed as specified by the LSO.



### Lasers Used for Public Displays/Entertainment (Non-Research)

Applicability: Any Class 3B or 4 laser used for entertainment, displays, demonstrations, or any related use intended for public viewing (indoors or outdoors) on UC Berkeley property shall be operated in accordance with federal, state, local, and campus regulations/requirements.

The operators of laser systems used for entertainment are required by law to file a “Report on Laser Light Show Display” (or a variance document), with the Food and Drug Administration’s Center for Devices and Radiological Health (FDA/CDRH). If the venue is outdoors and the beam(s) may terminate in navigable airspace, then the operators are also required to file a report with the Western Regional Federal Aviation Administration office (FAA).

Procedures: Cal Performances, campus departments, or campus-affiliated groups (student or otherwise) shall notify the LSO of any laser light show (indoor or outdoor) to be performed on UC Berkeley property. The LSO will request from the light show operators a copy of the CDRH required “Report on Laser Light Show Display” (or variance document) prior to the show. Upon receipt, the LSO shall review the description of the show and the operator’s safety procedures. The LSO may require additional safety measures to assure the safety of the operators, performers, or audience.

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## Laser Safety Requirements - Laser Light Shows

(Note: A LUA is not normally required for laser light shows.)

- The CDRH and ANSI requirements specified by the LSO must be met.
- Any audience exposure to laser radiation must not exceed the ANSI Class 1 limit.
- Operators, performers, and employees must be able to perform their duties without having to directly view laser radiation exceeding the ANSI Class 1 limit, and without being exposed to laser radiation exceeding the ANSI Class 2 limit.
- All laser scanners (including mirror balls) must incorporate proper scanning safeguards.
- If the laser is not under continuous operator control, any Class 3R, 3B, or 4 level of laser radiation cannot be closer than 6 m vertically or 2.5 m horizontally from any standing surface or standing position where the audience may be located.
- If the laser is under continuous operator control, any Class 3R, 3B, or 4 level of laser radiation cannot be closer than 3 m vertically or 2.5 m horizontally from any standing surface or standing position where the audience may be located.
- An operator with an accessible control to terminate the beam must be available if conditions become unsafe.
- FAA notification is required (for Class 3R, 3B, and 4 lasers) if the display is being used in navigable airspace.
- Additional safety requirements may be required as specified by the LSO.
- The CDRH “Report on Laser Light Show Display” forms are available from the LSO.

### Policy Exceptions

The campus Non-Ionizing Radiation Safety Committee must approve any exceptions to this policy. Contact the campus LSO at (510) 642-3073 or [lso@berkeley.edu](mailto:lso@berkeley.edu).

### Emergencies

The potential for injuries from a laser light show/display is minimal if the operators observe the CDRH requirements. In the event that an individual suspects an eye injury, the operators of the laser system shall be notified immediately so that the laser beam(s) can be terminated. The event staff shall also be notified and medical attention shall be provided to the injured individual if needed. The LSO shall be informed as soon as possible should any laser injury be suspected. The LSO or their alternate can be contacted

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by calling (510) 642-3073 or off hours (510) 642-6760.

### Regulatory References

- Food and Drug Administration's Center for Devices and Radiological Health (FDA/CDRH)
- Federal Aviation Administration (FAA)
- American National Standards Institute (ANSI) Z136.1 - Safe Use of Lasers
- ANSI Z136.6 (2005) for safe use of laser outdoors

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# Glossary

**American National Standards Institute (ANSI)** - The technical body which releases the Z136.1 Standard for the Safe Use of Lasers and Z136.3 Standard for Safe Use of Lasers in Health Care Facilities. The secretariat for the Z136.X standard series is the Laser Institute of America.

**Average Power** - The average power of a pulsed laser is the product of the energy per pulse (J/pulse) and the pulse repetition frequency (Hz or pulses/sec). The average power is expressed in Watts (J/sec).

**Aversion Response** - Closure of the eyelid, eye movement, pupillary constriction, or movement of the head to avoid an exposure to noxious or bright light stimulant. The aversion response to an exposure from a bright, visible, laser source is assumed to limit the exposure of a specific retinal area to 0.25 s or less.

**Blink Reflex** - The blink reflex is the involuntary closure of the eyes as the result of stimulation by an external event such as an irritation of the cornea or conjunctiva, a bright flash, the rapid approach of an object, an auditory stimulus or with facial movements. The ocular aversion response for a bright flash of light is assumed to limit the exposure of a specific retinal area to 0.25 s or less.

**Coherent Radiation** - Radiation whose waves are in-phase. Laser radiation is coherent and therefore very intense.

**Continuous Wave (CW)** - A term describing a laser that produces a continuous laser beam while it is operating (verses a pulsed laser beam).

**Diffuse Reflection** - When an incident radiation beam is scattered in many directions, reducing its intensity. A diffusely reflecting surface will have irregularities larger than the wavelength of the incident radiation beam.

**Embedded Laser** - An enclosed laser that has a higher classification than the laser system in which it is incorporated, where the system's lower classification is appropriate due to the engineering features limiting accessible emission.

**Incoherent Radiation** - Radiation whose waves are not in-phase.

**Intrabeam Viewing** - The viewing condition whereby the eye is exposed to all or part of a laser beam.

**Irradiance** - The power being delivered over the area of the laser beam. Also called power density, irradiance applies to CW lasers and is expressed in W/cm<sup>2</sup>.

**Laser** - Light Amplification by Stimulated Emission of Radiation. A monochromatic, coherent beam of radiation not normally believed to exist in nature.

**Laser Controlled Area (LCA)** - An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from laser radiation.

**Laser User** - Any person who uses a laser for any purpose on the UC Berkeley campus or off-campus property.

**Laser Safety Manual** - A document defining the UC Berkeley Laser Safety Program available on the EH&S website.

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**Laser Use Authorization (LUA)** - The mechanism used by the EH&S to track lasers on campus. The LUA details the safety requirements for each Class 3B and 4 laser.

**Laser Safety Officer (LSO)** - A member of the EH&S staff, the laser safety officer (LSO) is responsible for implementation of the Laser Safety Program.

**Maximum Permissible Exposure (MPE)** - The level of laser radiation to which an unprotected person may be exposed without adverse biological changes in the eye or skin.

**Nominal Hazard Zone (NHZ)** - The space within which the level of the direct, reflected, or scattered radiation may exceed the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE.

**Optical Density (OD)** - Also called transmission density, the optical density is the base ten logarithm of the reciprocal of the transmittance (an OD of 2 = 1% transmittance).

**Peak Power** - The highest instantaneous power level in a pulse. The peak power is a function of the pulse duration. The shorter the pulse, the greater the peak power.

**Radiant Exposure** - The energy being delivered over the area of the laser beam. Also called energy density, radiant exposure applies to pulsed lasers and is expressed in J/cm<sup>2</sup>.

**Retinal Hazard Region** - Optical radiation with wavelengths between 0.4 and 1.4 μm, where the principal hazard is usually to the retina.

**Safety Data Sheet (SDS)** - A document, required by law, which is supplied by the manufacturer of a chemical. The SDS details the hazards and protective practices required for protection from those hazards, as well as other information.

**Specular Reflection** - Results when an incident radiation beam is reflected off a surface whose irregularities are smaller than the radiation wavelength. Specular reflections generally retain most of the power present in the incident beam. Exposure to specular reflections of laser beams is similar to intrabeam exposure.

**Standard Operating Procedure (SOP)** - Formal written description of the safety and administrative procedures to be followed in performing a specific task. For lasers, SOPs are required for all active Class 3B and 4 lasers. These procedures must include all safety precautions (beam blocks, eyewear, hands-on training, etc.) to be followed.

**Ultraviolet (UV) Radiation** - Invisible radiation with a wavelength between 10 nm and 400 nm. The near ultraviolet (UV-A) is the 315 to 400 nm band, the mid ultraviolet (UV-B) is the 280 to 315 nm band, the far ultraviolet (UV-C) is the 100 nm to 280 nm band, and the extreme ultraviolet is the 10 to 100 nm band. Note: Wavelengths below 200 nm are absorbed in the atmosphere and are known as the vacuum ultraviolet.

**Visible Light** - Radiation that can be detected by the human eye. These wavelengths are between 400 and 780 nm.

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