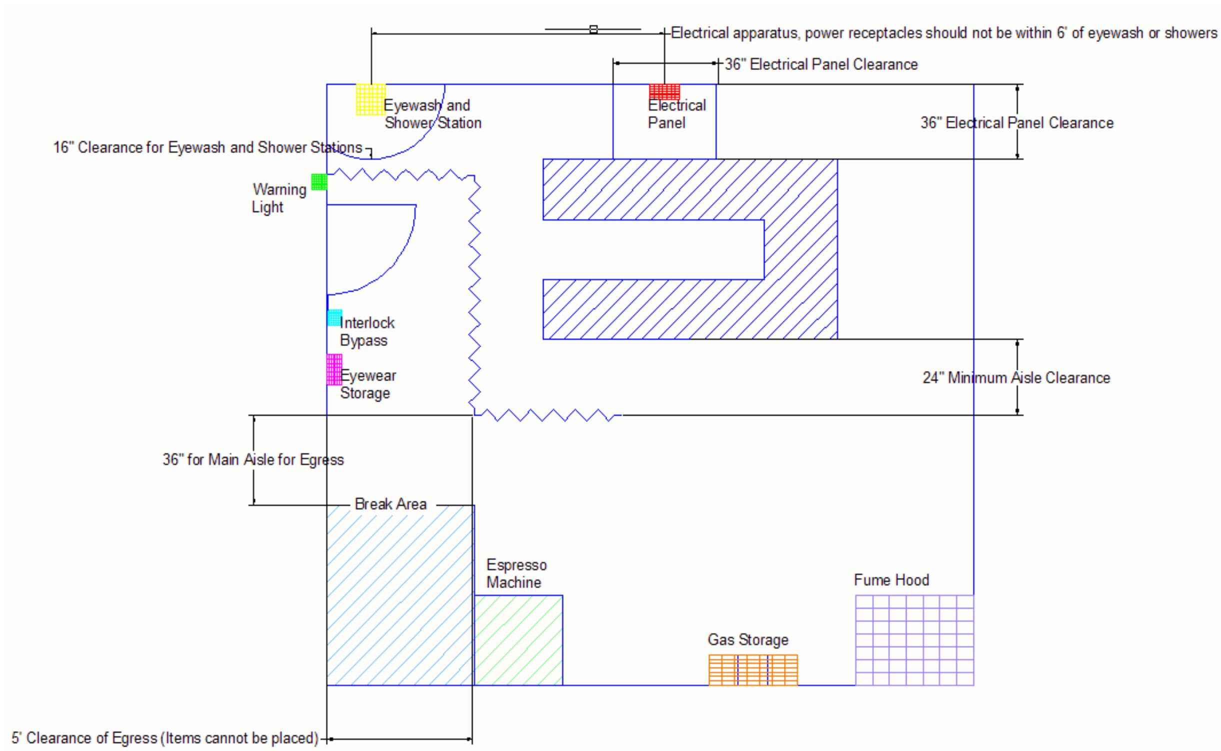
Laser Laboratory Design Guide

LBNL Laser Safety Program- V1-2012

Things to consider & avoid



Introduction:

The opportunity to set up one's lab is always a great occasion. In doing so, there are items one can easily overlook. The purpose of this guide is to provide guidance, reminders and explanations of items for you to consider in establishing or retrofitting your lab. Some items will be repeated from different vantage points within the guide.

Please send any comments or suggestion for the guide to the laser safety officer (LSO). A major tenet of the Laser Safety Program is to keep looking for ways to improve service to you the laser user.

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Section 1 Exterior Design

This section details items to consider, when setting up your lab, that are on or related to the exterior of your lab. Remembering your lab is not just the inside.

Access Control/Controlled Entry:

Class 3B & Class 4 laser labs require access control. The laser chapter of Pub 3000 and the laser ANSI standard (Z136.1 & Z136.8), allow for a wide range of access controls. The three most common are: door interlock systems; an electronic lock; and/or posting. The system that should be chosen depends on how well the laser beams are contained. The LBNL LSO needs to be consulted to help make this determination. If a laser interlock system is required, it must be such that the interlock must be armed first to allow the laser to be turned on. An interlocked system is not always the best solution. Most importantly it does not protect the users, only those who should not be entering. Interlock systems must only cause the laser beam to become safe when tripped. This is often achieved by dropping a shutter or causing the laser to lose power (least favored approach).

Door Interlock System

- The interlock must be armed to allow the laser to be turned on
- An interlock system is not always the best solution
- Non-defeatable door interlock is not a viable option. This type of system is designed to block the beam or drop power every time the door is opened.
- Defeatable door interlock is set with an access device on the outside (i.e. key pad or card key reader) that allows authorized staff to enter. Triggering the device sets a pre-determined (15-30 second) bypass where the door can be open and the laser will stay on. Exiting is best controlled by a crash bar which triggers a pre-timed bypass.

Electronic Lock

- Cipher lock with key override: this approach provides secure access but has no effect on laser operation. The key override is for first responders only, not housekeeping.

Posting Only-Administrative Access Control

Can be allowed if the Class3B & or Class 4 laser system is in normal operation operating in a Class 1 or near Class 1 system configuration

Door Notes

- **Standard door safety requirements**
  - Self-closing device on door a must for laser labs
  - Standard keyed lock, should not be used, too many people have "master keys"
  - Doors to lab should not be fire-rated unless necessary
  - Fire resistant doors should have magnetic hold-open features
  - Door will close in event of an alarm
- **Egress doors**
  - Crash-bar for easy egress
  - 36" or 42" wide doors
  - Doors opening onto exit corridors must swing with exit egress
  - Minimum clearance if 32" when door is open 90 degrees
  - Lab benches, equipment, furniture, etc. cannot be placed within 5' of egress
  - Doors within interior partitions must be self-latching

Illuminated Warning Sign

It is preferred that laser labs that contain a Class 3B or Class 4 laser have a visual indicator that the laser is in use. Once again, a review of beam containment during normal operation may void this requirement. The illuminated warning sign can be of several variations. The sign can solely indicate the laser is powered up or multi-modes such as safe, laser on, and beam accessible.

Figure 1: Laser Warning Sign Too High and Not Informative

Sign Conditions

- Posted at eye level (60" or 152 cm above the floor) to the side of the entryway, not above the door frame
- Low voltage rather than 110 Volts
- LED light source rather than standard bulbs
- A red light or non-descriptive sign is not sufficient
- The illuminated sign is required for each doorway that is accessible
- Illuminated whenever the laser is energized and capable of producing a beam
- Automatic light, light turn off/on based on when the laser is on/off
- If light manually controlled, light switch shall be located in a convenient position near the laser control

Eyewear Storage

A critical element of laser safety is laser protective eyewear; hence, the storage and protection of that eyewear is very important. Laser eyewear can be stored inside or outside of the laser use area or at both locations. The storage device must protect the physical integrity of the eyewear and be easily accessible to the users.

Figure 2: Eyewear Being Stored on Interior of Door

Storage Considerations

- The storage device must protect the physical integrity of the eyewear, protect from scratches and stored in clean and sanitary "Ready for use" condition, keeping away from dust, dirt or other contaminants.
- Prolonged exposure to ultraviolet radiation can degrade laser protective eyewear, in particular laser eyewear with high optical densities.
- Remove damaged eyewear from storage holder i.e. broken temples, scratches that would render it unsafe to use, burn marks, etc.
- Eyewear with worn off labeling is not allowed to be used; it is advisable to replace manufacturer labeling with one's own or post image of eyewear and labeling at storage location.
- Store in a way to avoid confusing different types of eyewear that may be used
- A good practice is to store alignment eyewear separately from other eyewear at the lab
- Store separately standard non laser safety glasses to ensure they are not confused with laser protective eyewear,
- Wall pouch holder, can be obtained from LSO as well as vendor list of commercial eyewear holders.

Windows

As a rule, windows into the typical laser lab are not a good idea and doors should not be equipped with such. If doors are equipped with windows, the following needs to be considered:

- Window panels in doors should be covered with an permanent opaque material

- If windows are required for non-laser use periods, then shades or removable covers for laser operation need to be available
- Electronic shutter windows can be used in some circumstances
- Windows can be covered with optical density acrylics to provide protection and viewing. Such acrylics must be labeled with wavelength and optical density.
- Portals/viewing windows must be designed to prevent any exposure above the maximum permissible exposure value.
- Wall windows should be treated the same as door windows.

Door Postings

Any laboratory using a Class 3B and or Class 4 laser is required to have a hazard communication posting. This can be a sole ANSI laser warning sign or the ANSI warning sign in combination with the standard chemical hazard communication sign. Each can be obtained from the LSO or appropriate Division Safety Coordinator.

- The ANSI required warning information must be on the posted sign:
  - Highest class laser in use
  - Signal word (Warning or Danger)
  - Wavelengths in use
  - Optical Density for wavelengths
- The door posting should also contain the following:
  - Alert of hazards
  - List of authorized users and emergency contact numbers
  - Instruction on entry

Emergency Crash-Off Switch

LBNL policy does not require a button (commonly seen as red mushroom button) for a Class 3B or Class 4 lab. It is suggested by the ANSI standard; equivalent devices are acceptable, such as posting the location of the circuit breaker box that controls the lasers or the location of the laser power supplies in the room. Most commercial interlock systems include this crash off device. Some labs locate this switch inside the lab or both inside & outside.

Figure 3: Labeled Emergency Stop

Section 2 Interior Layout

This section details interior items to consider when setting up your lab. There is more to consider than where the wine rack or cappuccino machine goes.Remember it is best to have all room construction completed before the optical table is put into place.

Optical Table

The optical table is the place where your experimental action will take place and how it is laid out is of extreme importance to you because it directly affects your success. While your mind is spinning experimentally, there are additional items to consider.

Before the Tables Arrive

- Scanning the floor: get scanned for wires and cables under and within the floor (remember floor scanning results are only good for so long before they expire).
- Penetration permit will be required to install table legs
  - Contact Riggers to schedule installation
- Consider seismic system for the table:
  - Can this be provided by the vendor or will it have to be LBNL engineered?
- Determine how much power you will need for experimental equipment
  - **See Section 3 Environmental Factors:**
- How tables will fit into the room, when you consider institutional clearance from electrical panels, etc **See Section 3A & 3B for details**
- Will shelves be required above the optical table?
  - If yes, make sure equipment fits under the shelves. Determine height of equipment including addition of cameras, and then determine height of shelves over table.
- Laser Exclusion zone (laser free area)
  - Some users set up a curtained or blocked off area right inside the entry point of the lab. This establishes a laser-free zone. LBNL laser safety program protocol is no optics can be seen from open doorway.

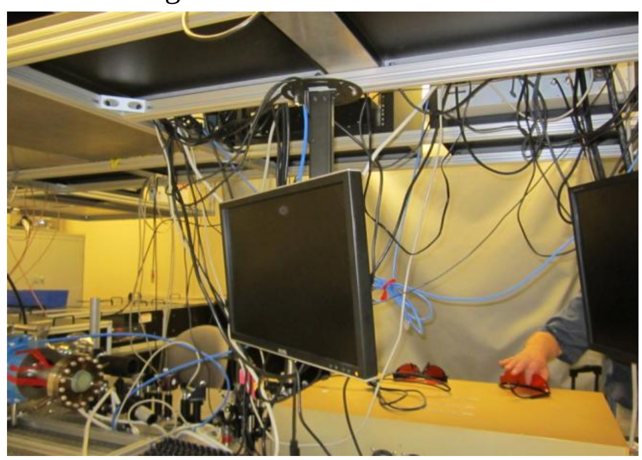


Figure 4: Flat Screen Hanging from Over Table Shelf

The Optical Table is in Place

OK, the table(s) has arrived and has been put into place, now you have to consider

- Seismic Bracing – anchor, support, brace to building structure: will it be obtained from the vendor or lab designed, built and installed?
- The tables will need to be grounded
- Laser exclusion zone
  - Some users set up a curtained or blocked off area right inside the entry point of the lab; this establishes a laser-free zone
- LBNL laser safety program protocol states no optics shall be seen from open doorway.

Which Way are the Beams Pointing?

A good practice in laser safety is to not have the beam path pointing towards doorways.
This can be implemented with the use of barriers around the optical table or at the end facing the entry way.

Can the laser set up be positioned towards the back of the room, rather than right near the entry way?

The LBNL standard approach is for one not to be able to see optics from outside the doorway. Many types of enclosures can provide compliance with this approach. Types of enclosures close to beam or optical path that provides the best protection are listed below.

Enclosures/Barriers

Depending on the experimental set up, several means of beam containment are open to the user. One is walls around the set up. The enclosure needs to be at least several inches higher than intended beam path:

Figure 5: Cover Optics and Beam Tubes

Perimeter Guard

Plastic Laser Enclosures

- These should be rated for your wavelengths and required optical density Have a diffuse interior surface to promote diffuse reflections from any stray beams.
- Available from a number of vendors as kits
- Can be self-tested, using spectrometer/power meter
- **Plastic laser enclosure covers**
  - Covers will provide a cleaner work area
  - Contain reflections
  - Negative impact: can quickly become a shelf and maybe be difficult to remove

Metal Laser Enclosures- Wavelength & optical density determination not a concern

- Should have an diffuse pattern on the inside surface
- Beware of the intensity of your beams, metal coatings can be ablated off, yielding a specular surface.
  - Commercial units generally come in 12" and 18 " heights
  - Homemade enclosures have no such limitation, but often need to be anodized (which LBNL can do for you)
- **Metal laser enclosure covers**
  - Covers will provide a cleaner work area
  - Contain reflections
  - Negative impact: can quickly become a shelf and maybe be difficult to remove

Complete Table Barriers

These units are 80/20 frames or uni-strut that stand a few inches off from the optical table and have a track for panels (most commonly sliding panels). Frame can be equipped with HEPA Filters, lights or no roof at all.

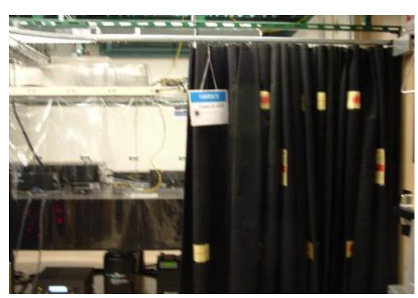


Figure 6: Complete Table Barrier

❖ Around entire table or portion of it
❖ Can be open or closed on top
❖ May need task lighting
❖ Items stored on top must be seismically braced

Local Blocks- Beam Blocks

Even with the use of perimeter guards and other barriers, the use of beam blocks is recommended. It is an absolute must when the table is an all open beam path. Their function is to block stray reflections/beams.

Beam Path Management

❖ Enclosures should be compatible with laser wavelength and beam power.
❖ Laser enclosures, beam stops, beam barriers and other exposed surfaces shall be diffusedly reflective at laser wavelength used
  ➢ Surfaces that create specular reflection cannot be used
  ➢ Materials used for beam stops or beam barriers shall not off-gas or be combustible at the beam power used

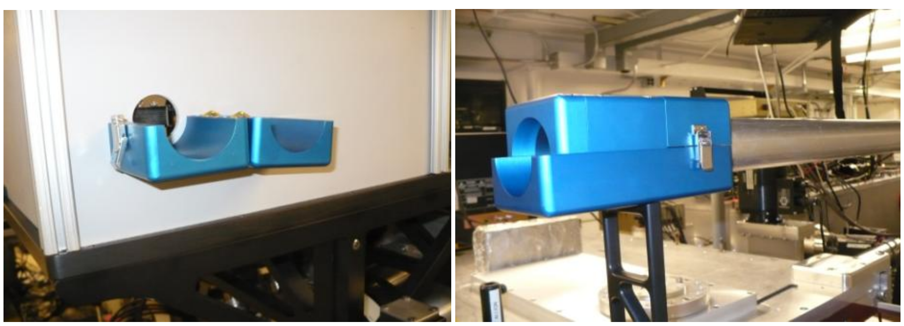


Figure 7: Device to Hold Beam Tube in Place

Shelves Over Tables

For experimental and space reasons, many times shelves will be suspended over the optical table. In these situations, the following needs to be considered:

❖ Head clearance room
❖ Putting cushion guards (pipe foam) around the corners and straight sections of the shelves, to prevent injury

Figure 8: Shelves Over Tables

❖ Seismic Bracing of shelves and equipment placed on shelves
❖ Means to reach equipment on shelves (step stools or platforms)
❖ Bracing to building structure
❖ Need to be grounded electrically

Work Station

❖ When a computer workstation exists within the lab, laser protective eyewear needs to be removed to see the screen

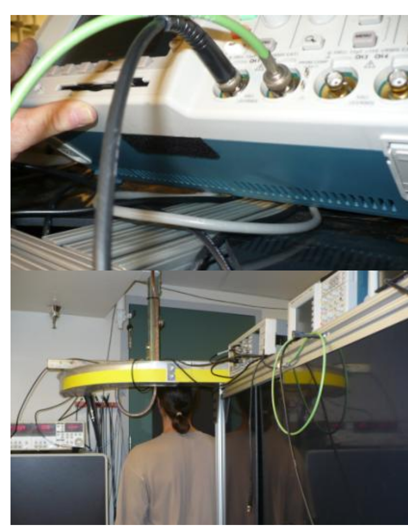


Figure 10: Cable Tray too Low

- Take steps to make sure working there is protected
    - Partitions and, perimeter guards are all good approaches

Rack Unit

At times, laboratory equipment will be placed in instrument racks. When using these, one needs to make sure they are:

- Seismically braced
- Grounded
- Special note: equipment made to be rack mounted, used outside of the rack, needs to be grounded

Curtain Area

- Purpose: protect doorway from stray beams that might be reflected out the door
- At entrance
  - No line of sight between room entrance and optics on optical table
- Hang from track with rollers
- Fabric should be fire resistant
  - Prevent combustion when hit by enclosed laser beam
  - Shall not off-gas
  - Shall be flame-retardant/flameproof/laser rated
- Curtain Types
  - Thermal curtains
  - Laser certified curtains
  - Opaque welding curtains
  - Metal curtains
- Curtain overlap should be 12” for vertical curtain pieces
- Allow enough room for people entering to put on eye protection
- Do not hang from floor to ceiling unless required for lighting conditions
  - Do not allow it to interfere with fire suppression sprinklers

Laser Protective Eyewear Storage

- Within curtained area

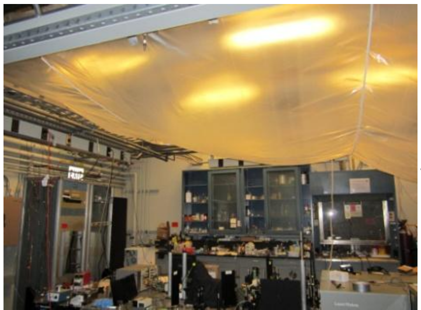
Emergency Off

- Emergency cut off switch installed near entrance of lab to turn off laser remotely
- Emergency Beam off – activate beam shutter
  - Located within curtained enclosure
- Emergency Power off – cuts off electrical service to high power equipment in case of electrical emergency
  - Located within lab

Section 3A Environmental Factors:

Utilities

These items are critical to the performance on your laser system and cannot be overlooked or taken for granted.



❖ Utilities shut-off controls should be located outside the lab

Temperature Control/Chillers

❖ If needed for cooling investigate chilled water loops and how available.
  - ➢ Loops help to avoid excessive wastewater
  - ➢ Chillers can generate heat;, think about where they will be located

Figure 11: Plastic Hanging from Ceiling to Trap Particulates from Air Handling System

Ventilation

There are three components to consider regarding ventilation in a laser lab.
First is airflow in the room.

- Not only can excessive air currents be a trouble to your experimental set up, but it can be a source of particulates from the air handling system. Make sure you notice the position of air vents as they relate to the position of your experimental set up.

The second is that appropriate ventilation to remove laser generated airborne contaminates must be provided.

Figure 12: Homemade Airflow Shield

The third is the need for local ventilation due to hazards in the room, brought in or generated. The following are standard building and institutional codes that relate to ventilation:

❖ Provisions should be made for local exhaust of instruments, gas cabinets, vented storage cabinets or other operations requiring local ventilation.

❖ Laboratories must be designed to pull air into laboratory from the corridor (negative pressure in relation to rest of the building).

❖ Placement of "supply air" and "exhaust air" vents must be located to avoid short-circuited air movement patterns. Further, in laboratories requiring tremendous volumes of supply air, such as laboratories with multiple fume hoods, low velocity air diffusers will be required to avoid turbulence and noise.

❖ Fume hoods
  - ➢ Bypass style fume hoods should be used
    - ▪ Auxiliary hoods should not be used
  - ➢ Each hood must contain a monitoring device
    - ▪ Ex: Magnehelic gauge
    - ▪ Device should display either air velocity or static pressure
      - Not just audible alarm
  - ➢ Canopy hoods are not acceptable for contaminant exhaust
  - ➢ Should have recessed work surfaces to control spills
  - ➢ Location of fume hoods, supply air vents, operable windows, laboratory furniture, and pedestrian traffic should encourage horizontal, laminar flow of air into the face of the hood, perpendicular to the hood opening
    - ▪ Hoods should be placed away from doors and not where they can face each other across a narrow aisle

    - Located to minimize cross-drafts and turbulence
  - Unless otherwise specified, air pressure in lab should be negative with respect to outer hallways and non-lab areas
  - May have a face velocity of 100-125 linear feet per minute with the sash fully open or at its standard configuration (at the stopper height)
  - Noise from fume hood should not exceed 65 dBA at the face of the hood
  - Using hard ducting for the positive side of exhaust ducting for all internal fans to prevent contaminant leakage into work areas
  - Exhaust ducts must not contain fire dampers
  - Single vertical sliding sashes are preferred over horizontal or split sashes
  - No chemicals or equipment within 6” of sash during experiments
  - Debris screens should be placed in the ductwork leading from the hood.
  - For perchloric acid, stainless steel construction and a wash-down system and a dedicated, isolated fan is required
  - Radioisotopes or biological materials may require hoods with filters
    - Design and located such that filter may be accessed and changed easily
- For excimer lasers
  - Ventilation system capable of maintaining an average face velocity of 200 fpm at the cabinet’s window opening when the window is fully opened
  - Alarming airflow meter should be used to monitor and indicate low-flow conditions

Vacuum Pumps

Many laser related experiments require the use of vacuum pumps. These pumps can be the source of noise, heat and contamination. One needs to consider their location which might lead to the pumps going into an auxiliary room.

Central vacuum systems should not be used

  - Vulnerable to contamination
- All vacuum lines should have cold traps or filters to prevent contamination
- Auxiliary valves for gas/vacuum lines should be located outside the lab

Lighting

You need to consider room lighting requirements and experimental lighting requirements. If work is light sensitive, task lighting may be needed just for vision in the lab during experimental runs.

- Windowless labs need to have emergency lighting

Fire Safety & Controls

Fire safety cannot be overlooked in your design process. Consider the following:

- Coaxial cable near the beam path can melt and gives off noxious fumes
- Dangling wires can be a combustion source. They can also block your beam path. If you have wires hanging from shelves above the optical table, make sure they are clear of the beam.
- Floor to ceiling curtains can block fire sprinkler patterns.

For fire safety, check for placement of:

- Smoke Detectors
- Sprinkler heads
  - Additional ones if there is gas use

- Fire extinguishers
  - Should be conspicuously labeled, particularly if recessed
  - Appropriate for chemicals/equipment in use should be placed near the entrance of each lab, mechanical, electrical room
  - Carbon Dioxide fire extinguishers rather than dry chemical extinguishers
- Fire Alarm Annunciators
- Some chemical operations may benefit from hood fire suppression systems
  - Ex: Distillation hoods
- Flammable/combustible construction materials shall be avoided in spaces with a Class 4 laser

Electrical Power

- **Determine how much power you will need for experimental equipment**
  - Where the outlets for such power will go
  - Number and location of standard 110 V outlets for scopes, etc
- Wires/equipment present electrical hazards
  - If wires are disconnected or damaged, electrical pulsers for Pockels cells can be a hazard
- Labs should have an abundant amount of electrical supply outlets to eliminate the need for extension cords and multi-plug adapters
  - Outlets can accommodate electrical current requirements with additional 20-40% capacity
- Electrical systems shall be marked to show voltage, frequency, and power output
  - All high voltage sources need to be marked properly and secured to prevent accidental access
- Electrical receptacles:
  - Provide GFI protection to electrical receptacles above counter tops and within 6' of sinks, safety showers, and other sources of water
  - For those that aren't readily accessible or those for appliances occupying dedicated space, which are cord-and-plug connected, are exempt
- Electrical outlets need to be positioned such that leakage of water coolant will not lead to risk of electrocution
  - Away from cooling water pumps, lines, filters, etc.
- Grounding:
  - Ground fault circuit interrupters should be installed near sinks, wet areas, near water-cooling systems
    - Consider using chilled water loop
  - Appropriate grounding connections for laser power supplies/electrical components
  - Ground all optical tables, all tables with energized equipment, racks that contain energized equipment
  - Mark all grounding connections
- Circuit breakers – located outside the lab, not in rated corridors
- Protection against electric shock
  - Barrier system for energized conductors
  - Unplug before working with equipment
- Working with or near live circuits should be avoided

Eyewash/Shower Station

Figure 13: Eyewash Shower in Lab, Good Location

Must be installed in labs with fume hoods. Also consider, laboratories using hazardous materials must have an eyewash and safety shower within 55 feet or 10 seconds travel time from the chemical use areas

- Items that cannot be close to them:
  - No obstructions, protrusions, or sharp objects shall be located within sixteen inches of the center of the spray pattern of the emergency shower facility (i.e., a thirty-two clearance zone shall be provided).
  - No electrical apparatus, telephones, thermostats, or power receptacles should be located within six feet of either side of the emergency shower or emergency eyewash facility. If receptacles are necessary within six feet, they should be equipped with GFI.
  - Emergency eyewash facilities and safety showers shall be in unobstructed and accessible locations that require no more than ten seconds for the injured person to reach along an unobstructed pathway. If both eyewash and shower are needed, they shall be located so that both can be used at the same time by one person
- Flooring under safety showers should be slip-resistant.

Section 3B Interior-Institutional Items:

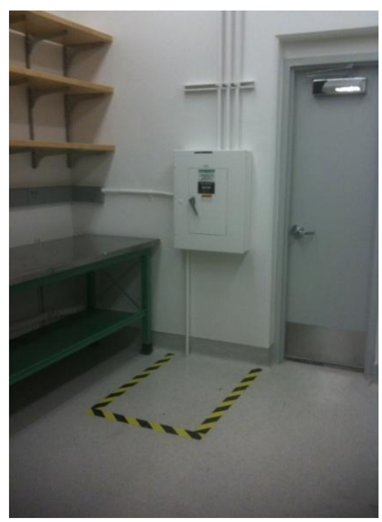


Figure 14: Clear Space Around Electrical Panel

Space around Electrical Panel

- Place in an accessible area not likely to be obstructed
- Those with a circuit breaker or switch needs 36" clearance

Seismic Bracing

- See under specific sections

Flooring

- Scan floor before planning for electrical wiring, etc.
- Solvent resistant flooring
- Non-pervious, one piece, with covings to the wall/cabinets
- Spills cannot penetrate under floors/cabinets
- Floors in storage areas for corrosive liquids shall be liquid- and air tight

Storage (Chemicals, Flammable Liquids, Gases)

- Must be built of non-porous material, secured to wall
- Shelves
  - Seismic Bracing
    - All shelves must have passive restraining systems

        - Ex: seismic shelf lip (3/4 in or greater)
        - Shelves must be fixed so cannot vibrate out of place and allow shelf content to fall
    - For bookshelves – friction matting may be suitable
- Storage Racks and Cylinder Restraints
  - Seismic Bracing
    - Approved storage racks (e.g., Unistrut, pipe racks) shall be provided that adequately secure gas cylinders by chains, metal straps, or other approved materials, to prevent cylinders from falling or being knocked over. Chains are preferable to straps. Straps shall be non-combustible.

Figure 15: Gas Cylinder Holder

        - Cylinder restraints shall be sufficient to prevent cylinders from tipping over. In seismically active areas, more than one chain/strap should be used (double chains/straps should be located at one-third and two-thirds the height of the cylinder.
        - Gas-cylinder securing systems should be anchored to a permanent building member or fixture. This connection is needed to prevent movement during a seismic event.

Storage Space for Supplies

We all know one cannot have enough storage space. This covers space of optical components, chemicals, tools scopes and a large list of assorted items. In addition, a number of hazards need to be stored per LBNL requirements:

Chemical storage

- Cabinets should be solid, sturdy construction
  - Hardwood/metal shelving preferred
  - May require ventilation
    - For chemicals with low odor thresholds
- Separate storage area
  - Separate storage for acids and solvents
- Do not place above sinks
- Solvents should not be stored under lab fume hood, unless in a specifically designed flammable cabinet or corrosive cabinet constructed under the fume hood
- Incompatible chemicals must be physically separated and stored
- Safe storage for laser dye solutions, solvents, other flammable materials

Gas Storage

- Ensure that the cylinder is properly and prominently labeled as to its contents.
- Gas cabinets with adequate exhaust
  - Gas cabinets shall have self-closing doors and may require internal sprinklers; they shall also be constructed of at least 0.097-inch (12-gauge) steel; and seismically anchored.

    - Gas cabinets shall be fitted with sensors connected to alarms that give warning in the event of a leak, or exhaust system failure, as appropriate.
- Exhaust monitoring device
- Gas detection system wired for fail-safe shutdown
- Required systems
    - For highly toxic gases: alarmed vapor sensors, automatic shutdown system.
- All cylinders must be secured to a wall, bench or fixed support using a chain or strap placed 2/3 of the way up. Cylinder stands are an alternative to straps.
    - Cylinders should be strapped individually.
- Cylinders should not be stored with a regulator attached. Secure the proper gas cap to the threaded portion on the top of the cylinder to protect the valve.
- Keep the number of cylinders in a laboratory to a minimum to reduce the fire and toxicity hazards.
- Lecture bottles should always be returned to the distributor or manufacturer promptly when no longer needed or discarded if at atmospheric pressure.
- Do not store full and empty cylinders together.
- Cylinders should not be stored near radiators or other heat sources.
- No part of a cylinder should be subjected to a temperature higher than 125^{o}F.
- Do not place cylinders where they may become part of an electric circuit.
- Incompatible gases must be physically separated and stored.
- For compressed gases:
    - Recessed areas for cylinder storage
    - Equipped with devices to secure cylinders in place
    - A flame should never be permitted to come in contact with any part of a compressed gas cylinder.
- Oxidizers and flammable gases should be stored in areas separated by at least 20 feet or by a noncombustible wall.
- NEVER place acetylene cylinders on their side.
- Used in Excimer lasers
    - Halogen gas mixtures – stored in gas storage cabinet
        - All transfer lines and components in contact with halogens shall be of compatible (non-reactive) materials.
        - Connect to appropriate exhaust ventilation system (see Ventilation).

Flammable Liquid Storage

- Labs have space for suitable number of flammable storage cabinets.
- Uniform Fire Code: quantities greater than 10 gal of flammable gas should be stored in a flammable liquid storage cabinet
    - Unless safety cans are used
- No more than 25 gal of flammable liquid in safety cans may be stored outside a flammable liquid storage cabinet.
- Storage not allowed below grade or near a means of egress
- Flammable liquids should be stored separately from strong oxidizers, shielded from direct sunlight, and away from heat sources.
- Flammable liquid storage cabinets shall not be located near exit doorways, stairways, or in locations that would impede leaving the area.
- Flammable liquid storage cabinets shall not be wall-mounted

    - Flammable liquid storage cabinets shall not be located near an open flame or other ignition source.
- Cabinets should not be vented unless there is a significant odor or vapor control concern or it is required by code.
    - It may compromise the cabinet's fire-resistance performance during a fire
    - If a flammable liquid storage cabinet is ventilated, then it shall be connected through the lower bung opening to an exterior exhaust in such a manner that the specified performance or UL listing of the cabinet is not compromised.
        - Polypropylene is not appropriate vent duct material, since it is combustible
    - Flammable cabinets built into laboratory casework are not to be vented into the fume hood except for new cabinets that are installed under fume hoods and are vented into the exhaust system but upstream from the hood.

Biological Storage

- Locate the biological safety cabinets (BSC) away from doors, operable windows, high-traffic, ventilation diffusers and other possible airflow disruptions; use a guideline of six feet of separation.
- Provide a minimum of six feet of clearance between BSCs installed directly opposite another
- Provide at least four inches of clearance behind and on the non-utility side, and six inches clearance on the utility side of the cabinet.
- Do NOT plumb the BSCs with natural gas
- Class II, Type A2 BSC
    - Shall be connected to the general exhaust system via a thimble connection unless approved by EH&S to recirculate into the room. The thimble will be provided by the BSC manufacturer and installed per manufacturer's instructions
    - Provide at least ten inches of clearance above a recirculating Class II A2 BSC; this is to facilitate decontamination of the exhaust HEPA filter.
- Class II Type B2 BSC
    - Shall be directly (hard) connected to a dedicated exhaust system.
- Class II Type B BSCs
    - Shall be interlocked with the exhaust fan so they shut down and alarm in the event of an exhaust fan/system failure.
    - Exhaust shall be provided with a gas-tight valve that is accessible from the front or side of the cabinet; the purpose of this valve is to facilitate decontamination of the BSC.
    - Provide each with a bypass system for exhausting the room when the BCS fan is turned off; turning the BSC fan off saves filter life and the bypass facilitates decontamination of the BSC.
- Thimble connection exhaust airflow shall be 120-125% of the BSC manufacturer's exhaust specification.
- Provide a NEMA 5-20 (20-amp) receptacle located high so that unit may be easily unplugged for servicing.
- Specify BSC to be seismically anchored per manufacturer recommendations and include seismic braces and other necessary components in the purchase.

Radioactive Waste

- To reduce unnecessary exposure, radioactive waste should be stored in areas separate from work places. However, it is recommended that the transfer route of radionuclide to waste areas be over as short a distance as possible.

Cryogen Use

- Cryogen liquid tanks should be placed such that their controls cannot accidentally be manipulated.
  - Secure to prevent unauthorized access
- Cryogenic use creates potential hazards and requires the proper Personal Protective Equipment (PPE) such as gloves, face shield and clothing.
- Cryogen
  - Tanks should be placed away from below grade areas, glass door and windows

Superconducting Magnet

- Do you need to provide space for liquid nitrogen storage?

Section 4 Human Factors:

Walkway Spacing

There is never enough space in one's lab, but efforts need to be taken to give you and your staff sufficient walkway space around the lab and equipment.

- Minimum aisle clearance of 24"
- Main aisles used for emergency egress must have clearance of 36"
- Pathway clearance of 36" must be maintained at face of access/exit door

Reach Issues

As optical tables and lab shelves fill up remember one needs to be able to reach these items. Can you reach optics that need to be moved? Does the work flow smoothly? Can you see monitors? Consider the use of step stools, platforms and viewing angles. Today you should consider remote viewing options and automated items as real world solutions.

Figure 16: Low Profile Step Stool

Workstation Locations

Lab space should be physically separate from personal desk space, meeting area, and eating areas; that sounds nice but at times can be near impossible to obtain. At the very least workstations should not put one at risk. Make sure when at a workstation one is protected from any direct or stray beams.

- You shouldn't have to go through lab space where hazardous materials are used in order to exit from non-lab areas.

Storage Space

As said a few times prior, there is never sufficient space for all you have or will acquire. But pre-thought on storage will save you much grief. There are several equipment and parts storage options and traps.

Shelving hanging above optical table

Figure 17: Padding Over Shelf Edges

- Padding is needed shelves that hang from the ceiling to protect one's head.
- Consider height as an obstacle when there are microscopes/other tall objects in use.
- Need to be at a height that does not restrict the placement of equipment on the optical table.

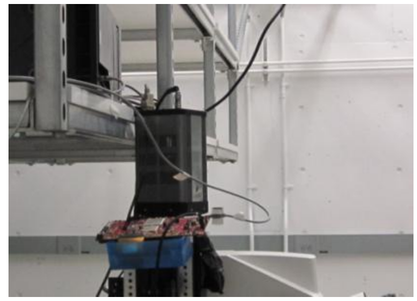


Figure 18: Shelf too Low

Wall units

A number of commercial units exist for storage that will either hang on your walls or can be put against them

- Shelving:
  - Do not install at height/distance which required workers to reach 30 cm above shoulder height and extend arms greater than 30 cm while holding objects 16 kg or less when standing on the floor or on a 12" step stool.

Instrument Location

- Tripping Hazards
  - Equipment and wires create tripping hazards. Heavy duty bridges are available to cover wires and hoses. Plastic ones are better than metal bridges, which might have to be grounded.

Figure 19: Wire Floor Bridge

Last Step

Before placing laser and optics in the room; have it cleaned; this will pay off in the long run.

Section 5 Abbreviated Checklist

This checklist is a reminder of general topics to be considered before and during laser lab set up. The laser lab design guide needs to be consulted for detailed information concerning setting up a laser laboratory. This checklist is not a summary of this guide.

LASER SAFETY [consult LSO]	YES	NO	NA
Access control	[ ]	[ ]	[ ]
Illuminated sign	[ ]	[ ]	[ ]
Posting	[[	[ ]	[ ]
Beam control	[ ]	[ ]	[ ]
Eyewear requirements	[ ]	[ ]	[ ]
PERMITS			
Floor scanning	[ ]	[ ]	[ ]
Penetration	[ ]	[ ]	[ ]
Biohazards	[ ]	[ ]	[ ]
Authorizations (i.e. AHD)	[ ]	[ ]	[ ]
STORAGE			
Satellite accumulation area	[ ]	[ ]	[ ]
Chemicals	[ ]	[ ]	[ ]
Gas cylinders	[ ]	[ ]	[ ]
Cryogens	[ ]	[ ]	[ ]
Lab supplies	[ ]	[ ]	[ ]
Eyewear-PPE	[ ]	[ ]	[ ]
Radioactive Materials	[ ]	[ ]	[ ]
Refrigerator	[ ]	[ ]	[ ]
INSITUTIONAL SAFETY EQUIPMENT			
Eyewash	[ ]	[ ]	[ ]
Fume Hood	[ ]	[ ]	[ ]
Gas Cabinet	[ ]	[ ]	[ ]
Emergency Lighting	[ ]	[ ]	[ ]
Sprinklers	[ ]	[ ]	[ ]
ELECTRICAL ITEMS			
Panel Clearance	[ ]	[ ]	[ ]
Power needs	[ ]	[ ]	[ ]
Outlet locations	[ ]	[ ]	[ ]
HV outlets	[ ]	[ ]	[ ]
OPTICAL TABLE			
Grounding	[ ]	[ ]	[ ]
Seismic bracing	[ ]	[ ]	[ ]

Shelving	[ ]	[ ]	[ ]
Enclosures	[ ]	[ ]	[ ]
Rigid or floating?	[ ]	[ ]	[ ]

VENTILATION

Room air pressure (+ or -)	[ ]	[ ]	[ ]
Temperature control	[ ]	[ ]	[ ]
Oxygen deficiency	[ ]	[ ]	[ ]
Pump venting	[ ]	[ ]	[ ]
Chiller- heat	[ ]	[ ]	[ ]
Local ventilation	[ ]	[ ]	[ ]

MISCELLANEOUS

Windows	[ ]	[ ]	[ ]
Lighting	[ ]	[ ]	[ ]

Appendix A: Laboratory Lessons

The following pages are examples good and poor planning. Each is explained as either a good solution or one to avoid.

Topics Covered

A.1 Removing Laser Hazard at Doorway

A.2Think about Institutional Clearances

A.3 Emergency Crash Buttons that Will Never Work

A.4 Table Placement

A.5 Equipment at the Edge of the Optical Table

A.6 Poor Placement of Equipment

A.7 Homemade Shelves that Hang Over Optical Table

A.8 Monitor Placement Suggestions

A.9 Storage Planning

A.10 Non-Laser Storage

A.11 Cable Trays & Cable Management

A.12 Solutions to Help Reach Problems

A.13 Airflow/Ventilation Problems

A.14 3D Area Planning Needed

Appendix A.1 Removing Laser Hazard at Doorway. This can be accomplished three ways

1. **Enclosures and or perimeter guards around optical set up**
2. **A room in a room approach, curtain around optical table**
3. **A laser free zone upon entry, by the use of curtains, below are three examples of this**

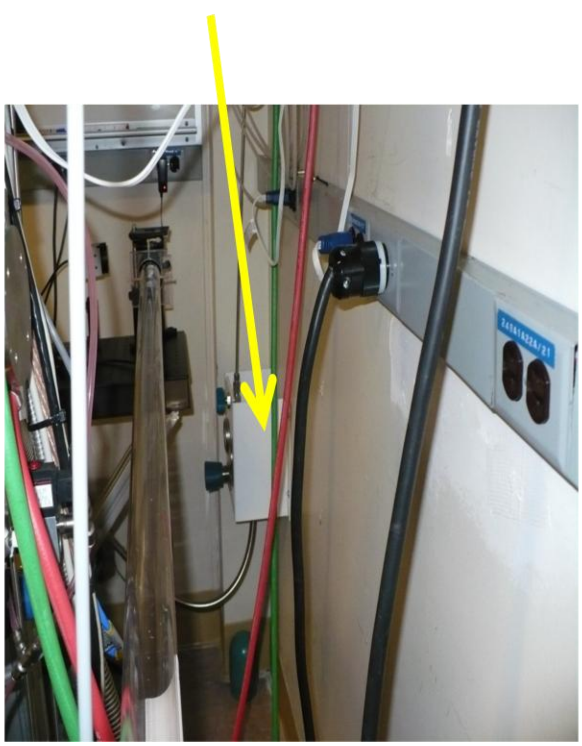
Figure: Interior View, Curtain Forming Laser Free Entry Zone, Half-Curtain Blocks View from Door, Sets Laser Free Zone

A.2 Think about Institutional Clearances

A.3 Emergency Crash Buttons that Will Never Work

One is unreachable behind optical table; the other has a plastic cover screwed over it

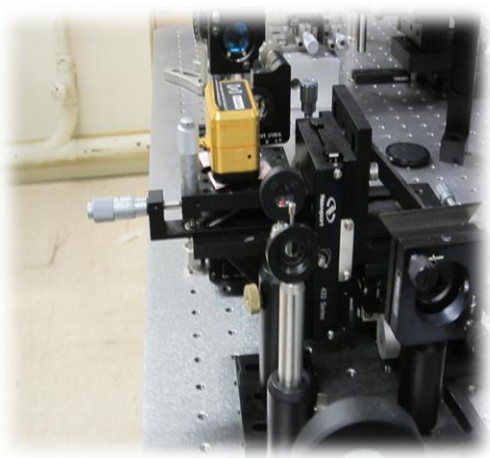
Emergency stop blocked in

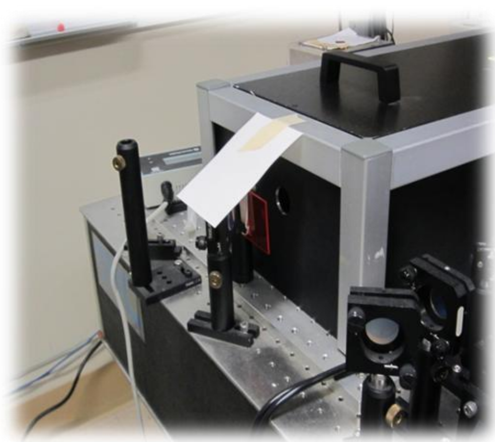


A.4 Table Placement: Table placement in room, is there space to work around the table?

A.5 Equipment at the Edge of the Optical Table

No room for perimeter guards, or beam blocks





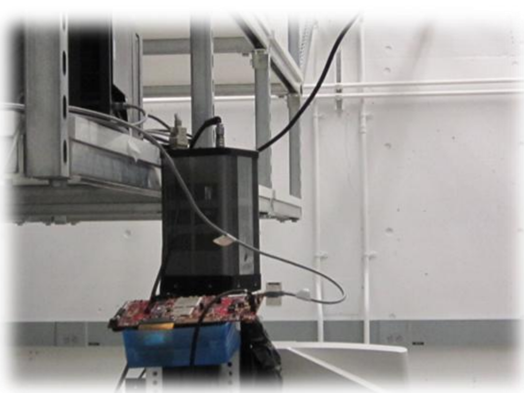
A.6 Poor Placement of Equipment, sometimes for lack of having the right tool




Laptop is cover cooling vents on this equipment, indented for rack mounting
Keyboard and mouse barely fit on table
Laptop holder and table extenders might be viable solution

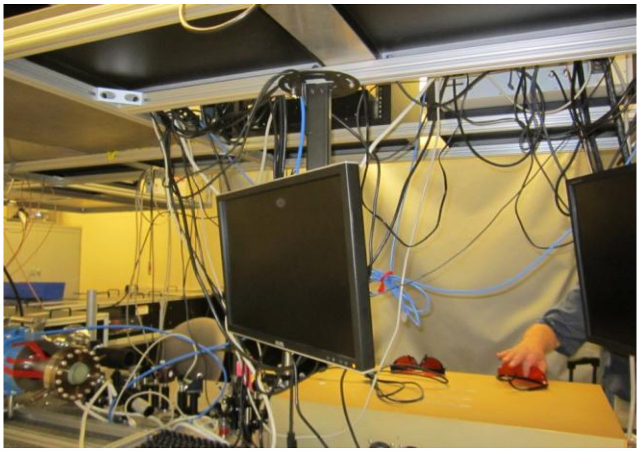
A.7 Homemade Shelves that Hang Down Over Optical Table, while useful can be a source of problems if not planned correctly.

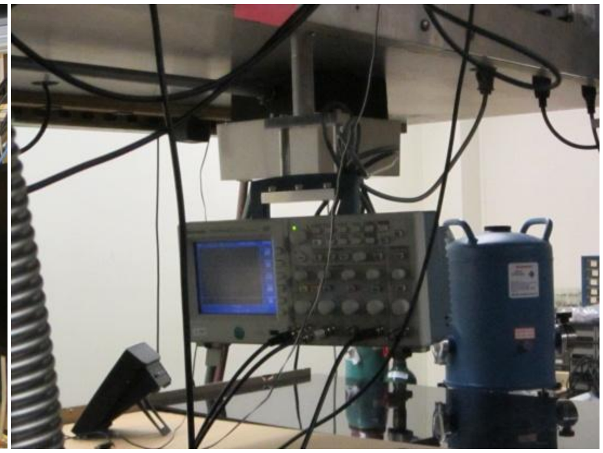
Adequate padding on the shelves is needed. A quick fix for this is to use Foam Pipe Insulation (found at hardware stores).

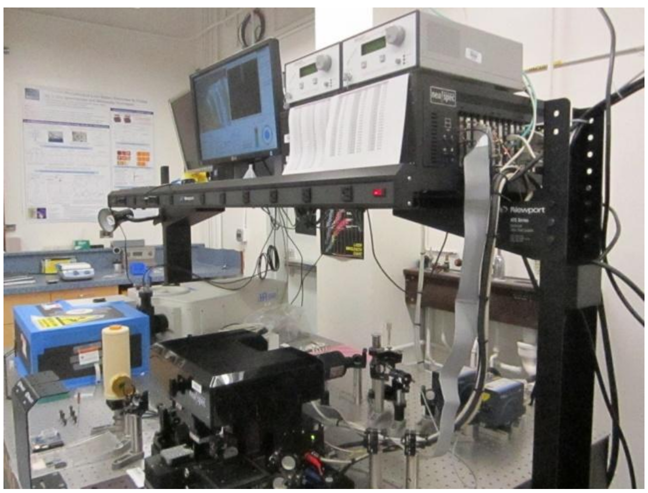


Shelve too low or equipment too tall, you decide

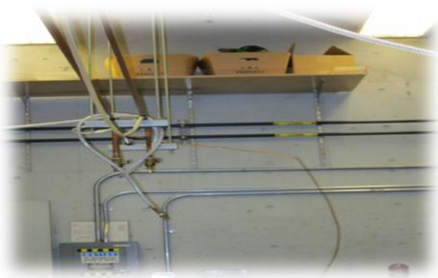
A.8 Monitor Placement Suggestions







A.9 Storage Planning: Storage can be planned or just shove it anywhere



A.10 Non-Laser Storage




Gas cabinet, Liquid N Dewar, Gas cylinder rack

A.11 Cable Trays & Cable Management

Poor Cable Management is a hazard because the wires can come into contact with the laser beam. Tie-wrap your cables or place them into wire ways.

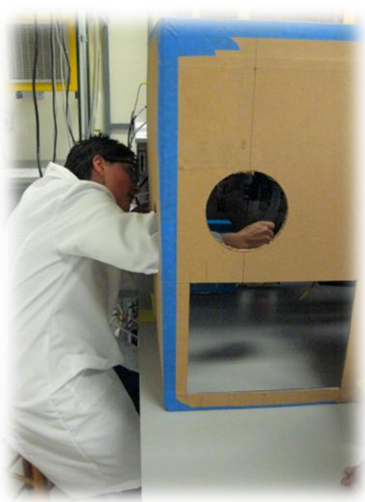
A.12 Solutions to Help Reach Problems

Below a device that can be used to lean over optical tables, comes in several different models, some with steps some fold up

A.13 Airflow/Ventilation Problems

Cardboard being place to advert airflow, plastic sheet hung to stop rain of particulates


A.14 3D Area Planning Needed



Items in the lab need to be planned accordingly so that they will fit in a practical manner. When planning where the optical table goes, consider also the items that will have to surround it, such as chairs, stools, and equipment. To prevent equipment from being too low for persons to pass under or for equipment to fit on the optical table and also under the shelves, analyze how much space is needed for headroom and plan accordingly. For items on the optical table, a mock-up can be created.

Miscellaneous Errors

Optical table with microscope system set up too close to electrical panel.