LLNL Laser Alignment Training

LAWRENCE LIVERMORE NATIONAL LABORATORY
LASER SAFETY OFFICE

Laser and Non-Ionizing Radiation Safety Office | Safety Engineering
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DOE LSO Workshop

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LASER SAFETY OFFICE
Lawrence Livermore National Laboratory

LLNL's Suite of Laser Safety Training Courses

1. Laser Safety (Online Training)
2 hours

- Covers laser fundamentals, hazards, controls, PPE, regulations and the LLNL Safety Program.
- Required for all Class 3B, Class 4 and Embedded Class 1 laser users.
- Repeated every 3 years

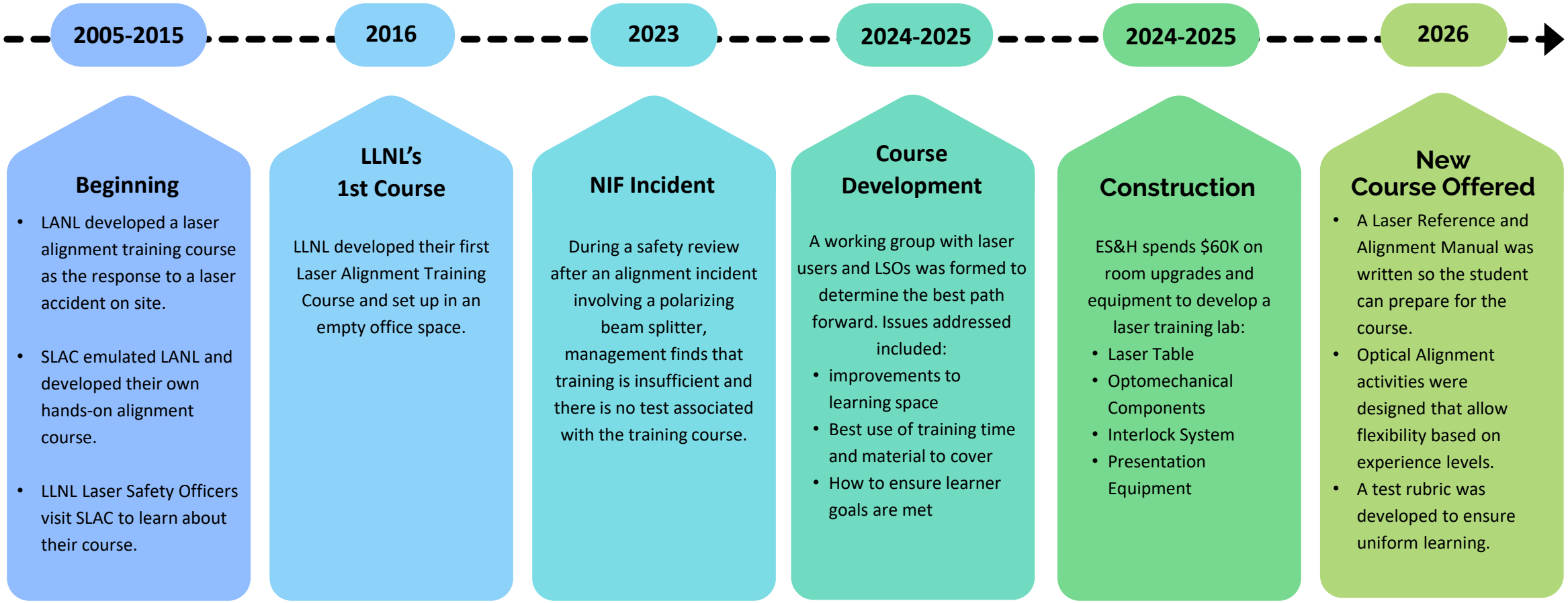
2. Laser Safety Conduct of Operations
1 hour

- In-person course that covers lessons learned scenarios
- Required for all Class 3B Class 4 and Embedded Class 1 laser users

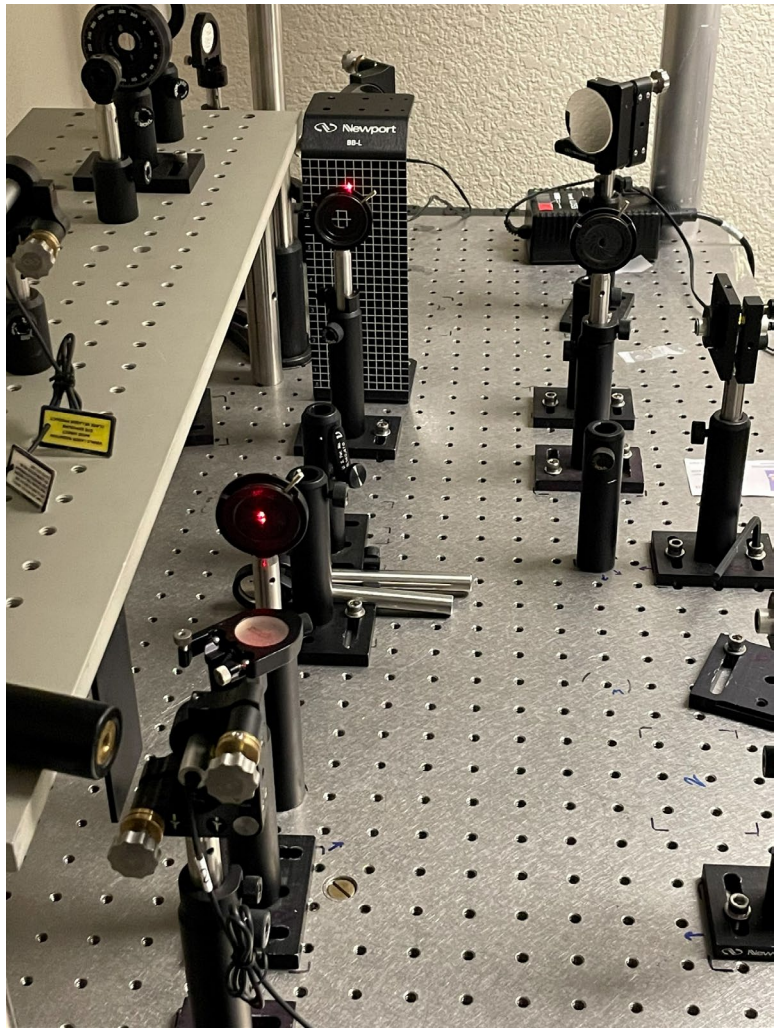
3. Laser Alignment Training
4 hours

- In-person course that covers laser alignment methods and safe practices.
- Required for laser users that will perform alignment tasks involving Class 3B and Class 4 Lasers

Timeline of Events

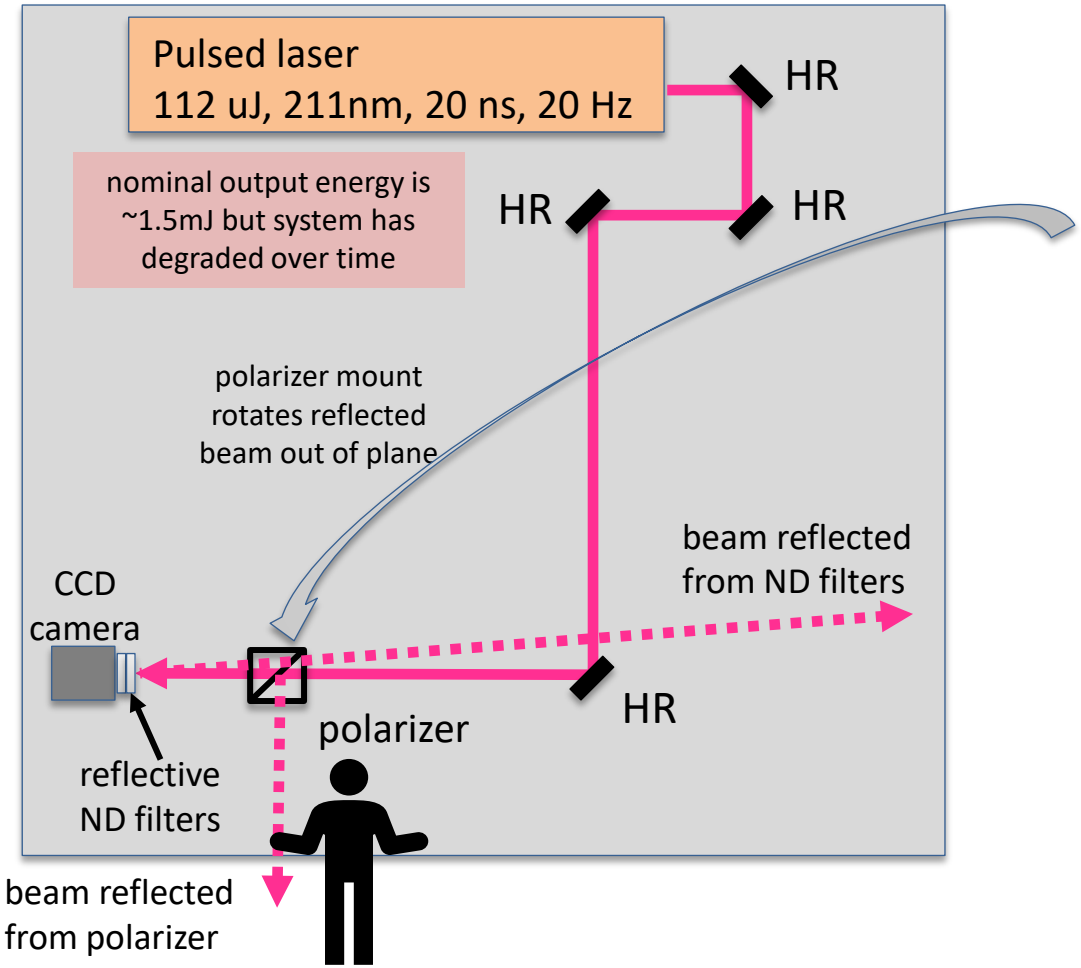


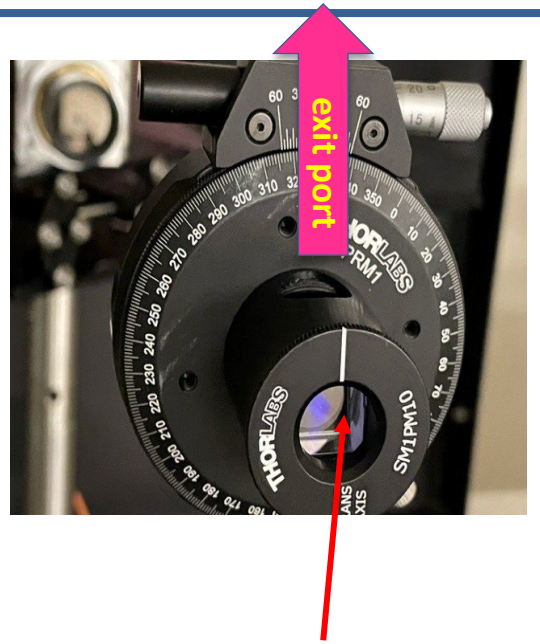
Original course 2016 - 2025



- Lab space consisted of a small table with overhead shelf set up in the corner of an office.
- Space was too small for an instructor and multiple students.
- Optics were difficult to access and beam paths were limited.
- All parts and materials were salvaged.
- Course spent a lot of time focusing on work procedure documents, not hands on training.

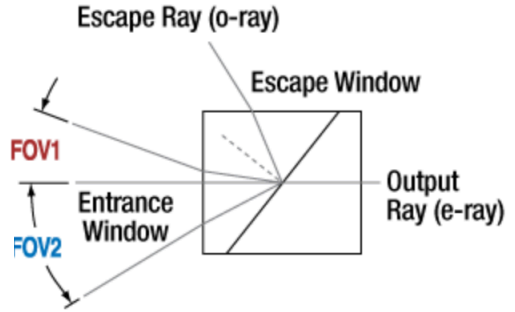
NIF Incident That Triggered Change





Thorlabs GLB10
Glan-Laser alpha-BBO Polarizer

Field of View Angle Orientation



. . significant amount of scattered unpolarized light escapes the polarizers. As a result, the escape ray (o-ray) is not purely polarized and should not be used for polarization dependent applications.

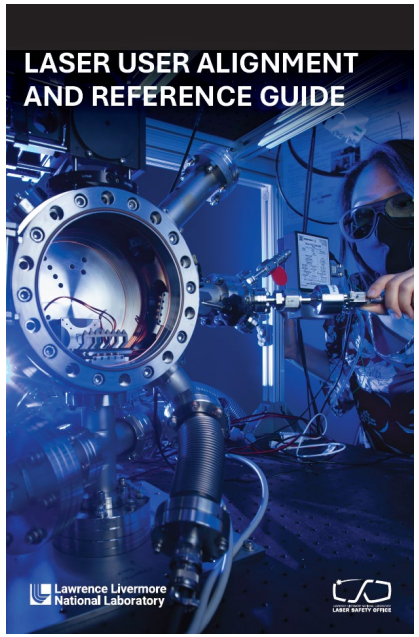
worker was manually rotating the polarizer mount during the test

Recommendations Resulting from Incident Investigation

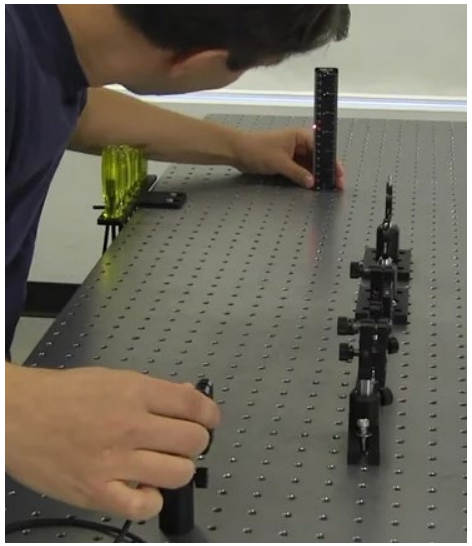
Corrective Actions:

- Upgrade the laser alignment practical course to include more hands-on training of manipulating beam paths and a comprehensive exam. Existing training had a major component of work control document understanding which would be better handled in a separate training.
- Form a team of laser system owners and laser safety officers which is tasked with the generation of an in-depth laser system user signoff process.

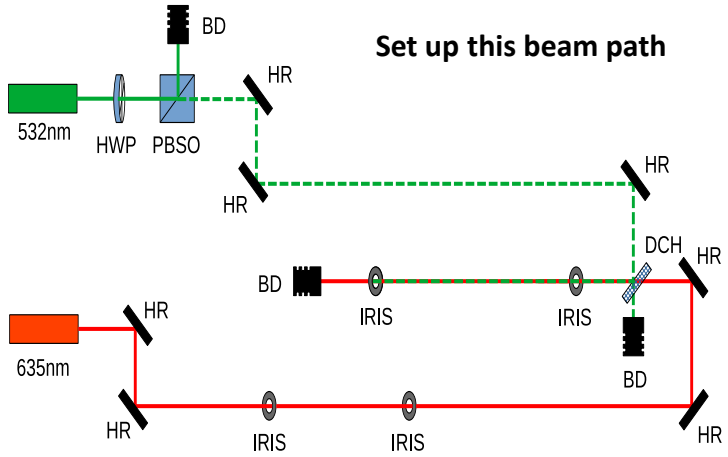
Learn, Practice, Test



Required Reading:
Student reviews our reference guide which covers basic optics knowledge, safety and alignment techniques.

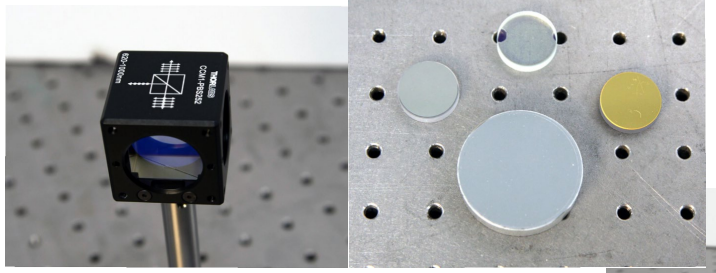


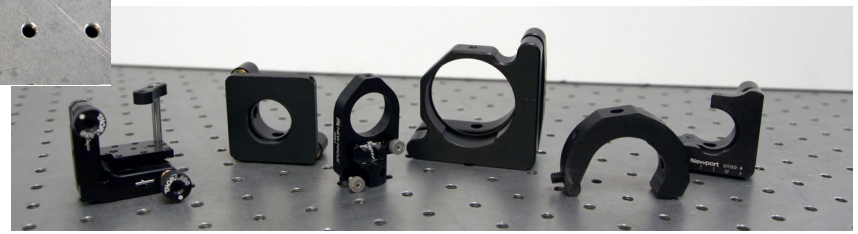
Hands-On Practical:
Students use low power diode lasers to set up and align multiple beam paths under the guidance of a mentor.

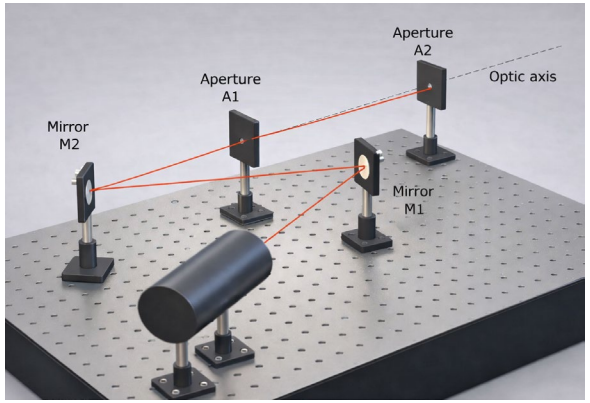


Test:
When the student is ready, they schedule a test session with the mentor to demonstrate what they learned.

Reference Guide: Lab Basics and Safety

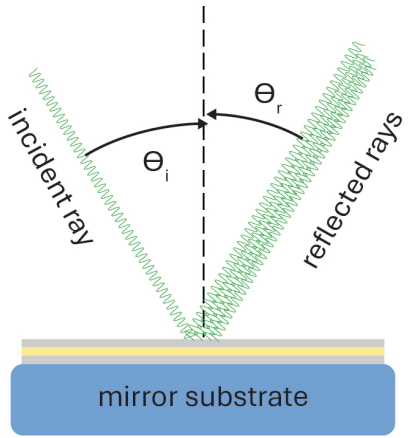




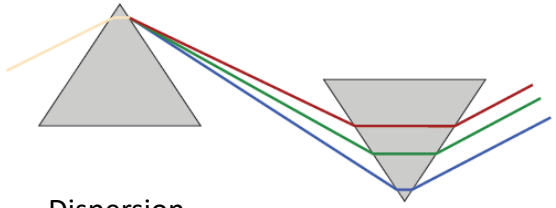


- ANSI Laser Classification, labels and controls
- Basic laser lab safety
- Safety tools for the laser worker including IR viewing, remote camera options, and eyewear
- Introduction to optics, optomechanical components and fiber optics
- Alignment methods

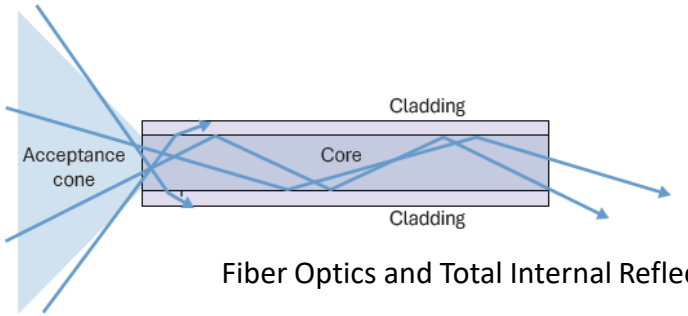
Reference Guide: Intro to Physical and Geometrical Optics and Biological Effects of Lasers



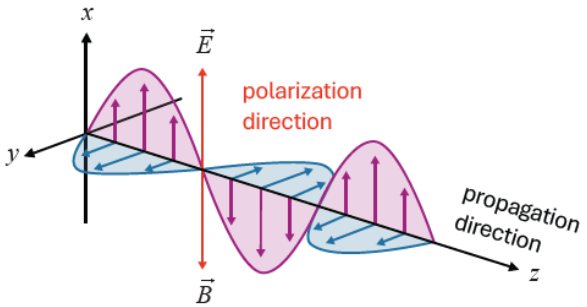
Reflection and Refraction



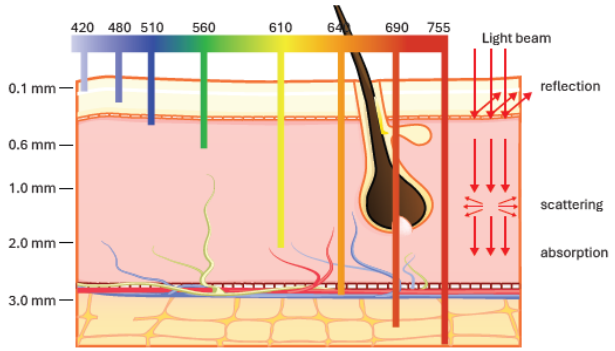
Dispersion



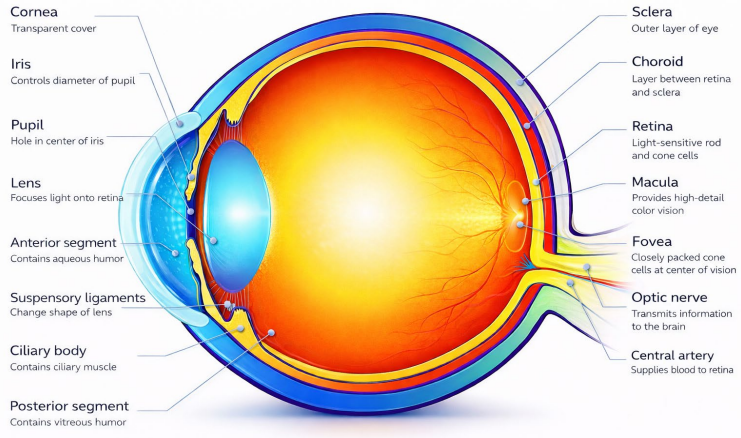
Fiber Optics and Total Internal Reflection



Polarization

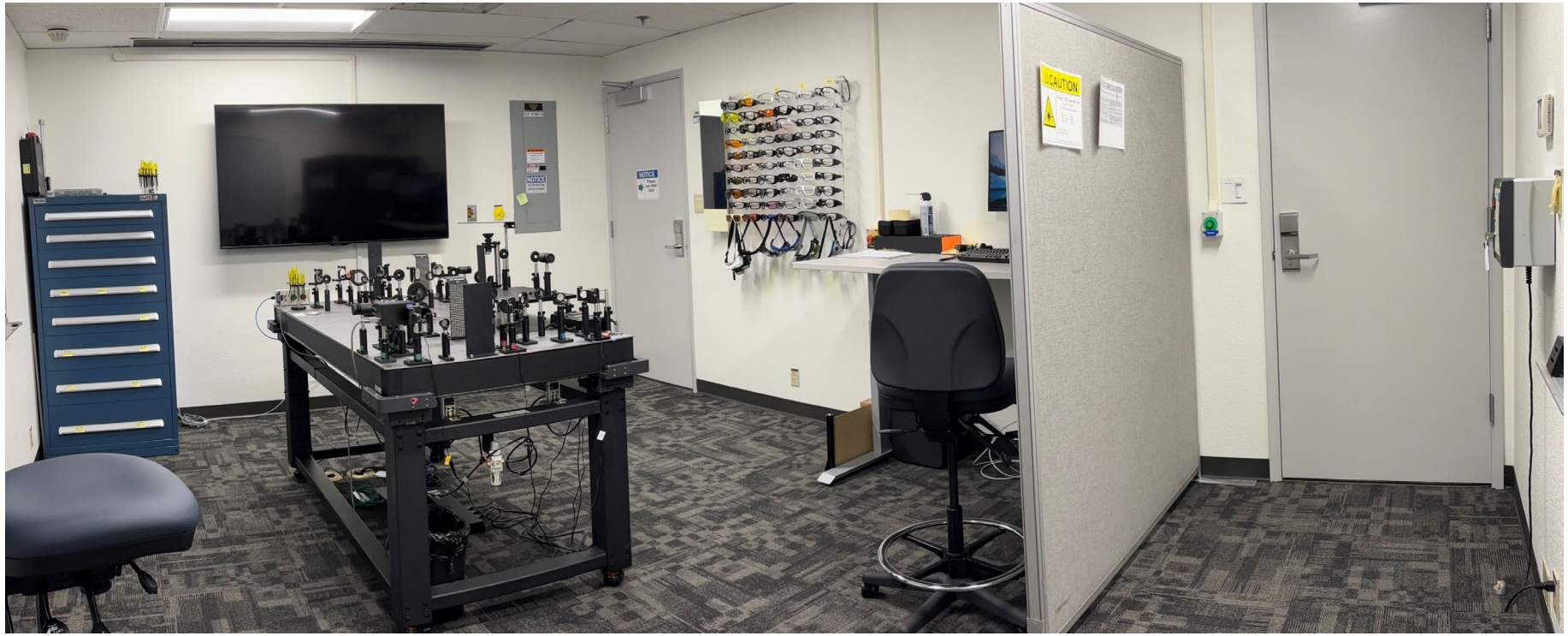


- Introduction to geometrical and physical optics
- Biological effects of laser exposure



Laser Effects on the Eye and Skin

The Practical: Lab Space

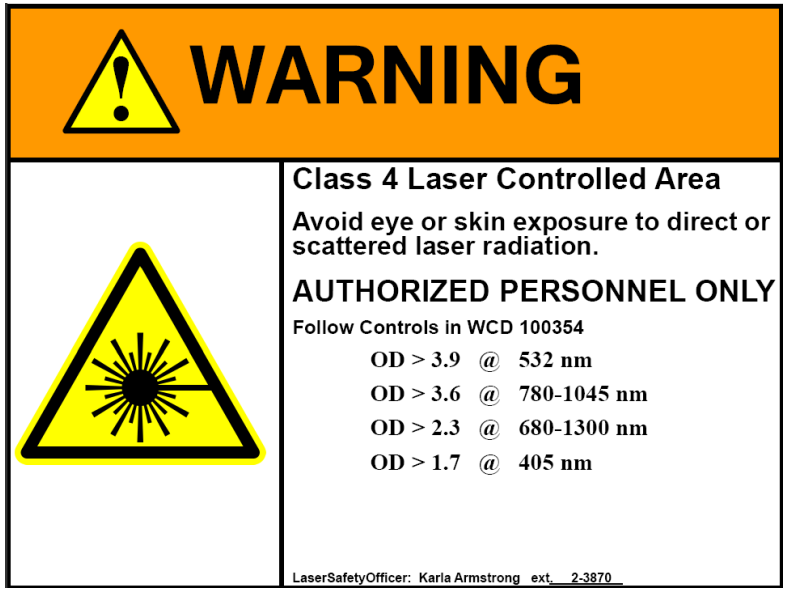


- Larger room with space for students to work.
- Video screens to display instructional material.
- New optical components and storage areas.
- Working interlock system.
- Barrier at bypassed entry and authentic signage.

The Practical: Laser Safety Overview

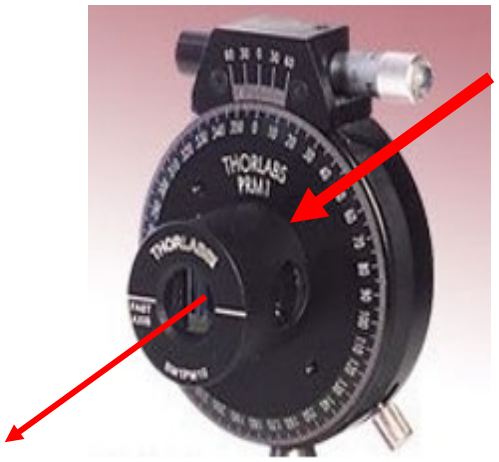
Laser users need to be able to:

- Understand signage and labels
- Determine if their PPE is correct for the work to be done
- Know how to use an interlock system



The Practical: Examples of Risky Optical Components

Glan-Thompson Polarizer



Unpolarized Light Changes Direction w/ Rotation

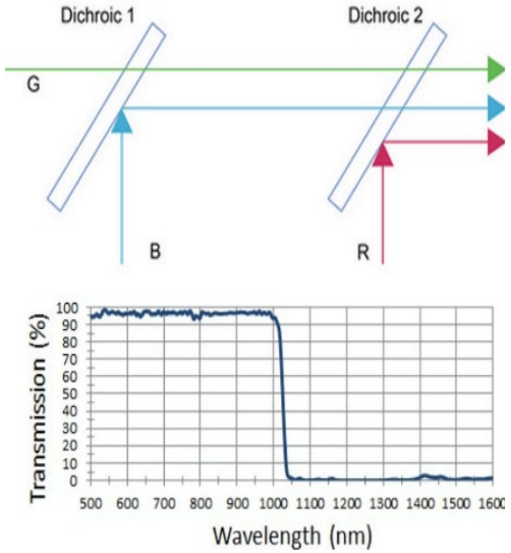
Periscope

Use Extra Caution Whenever the Beam Changes from H to V

Flip Mirror

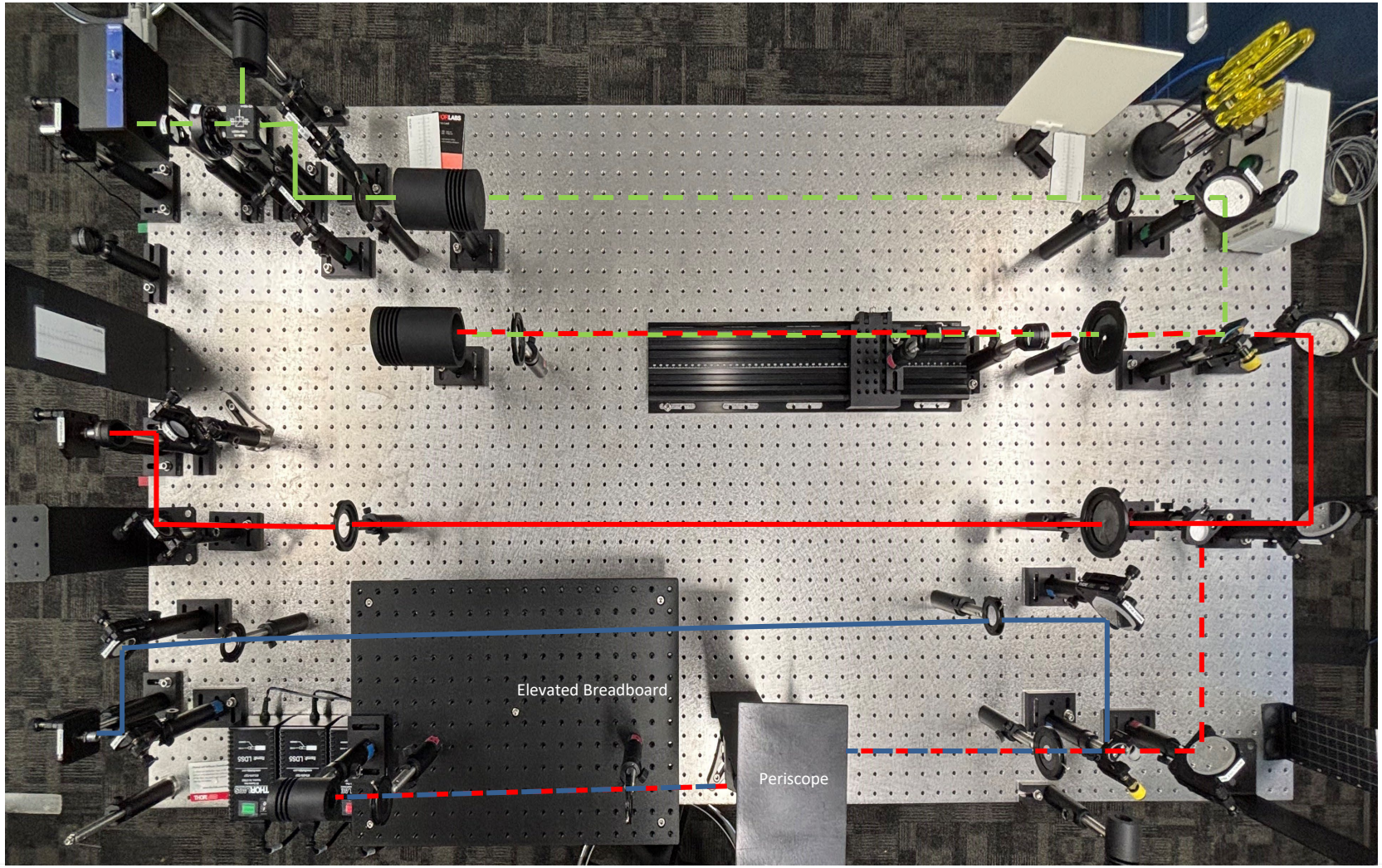
Binary Use of Flip Mirror Only

Dichroic Mirrors



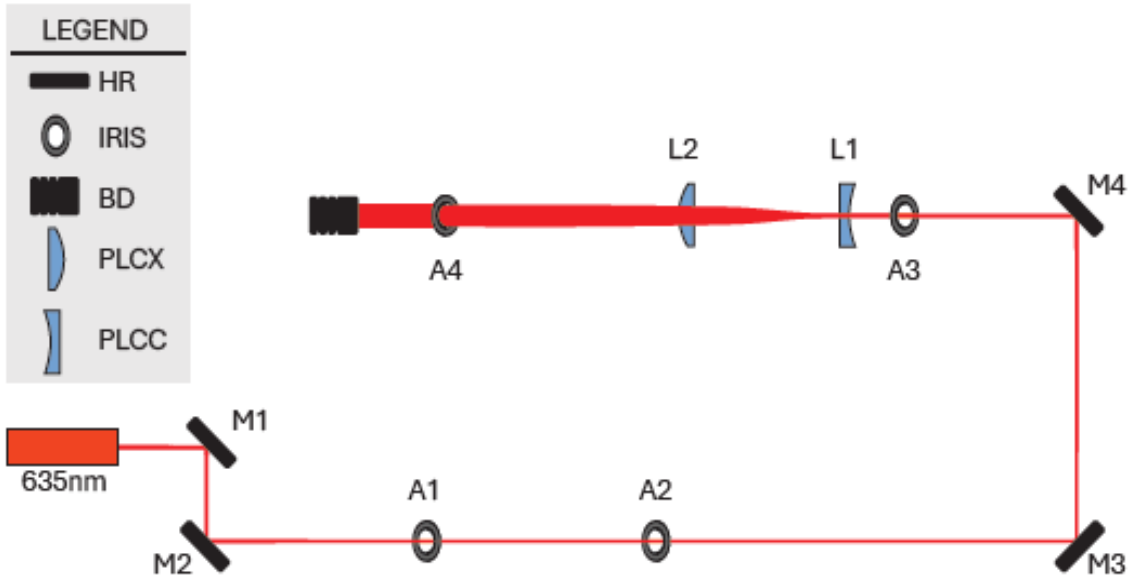
Verify Optical Response Curve

The Practical: Optics Table Layout



- Three beam paths to work with.
- Flexibility to change the difficulty level.
- Practical use of many optical components that tend to be involved in laser incidents

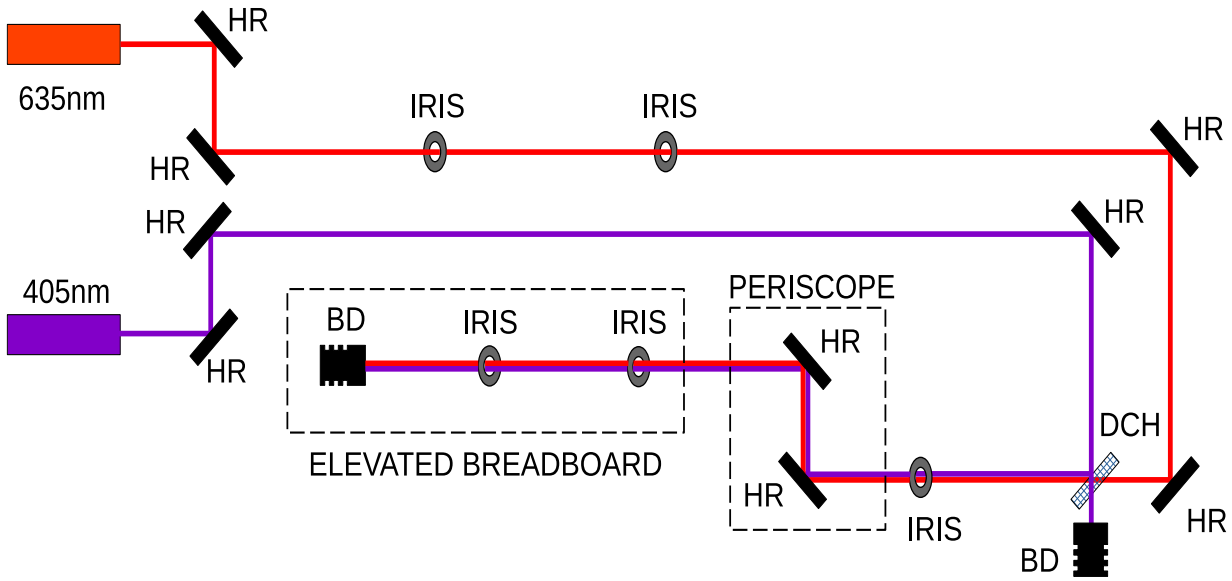
The Practical: Alignment Activities



Skills Taught:

- The importance of setting the beam height and keeping it parallel to the table.
- Pointing and steering a laser beam using alignment apertures and 2 mirrors and maintaining control of the beam.
- Telescopes and Collimation.

The Practical: Alignment Activities

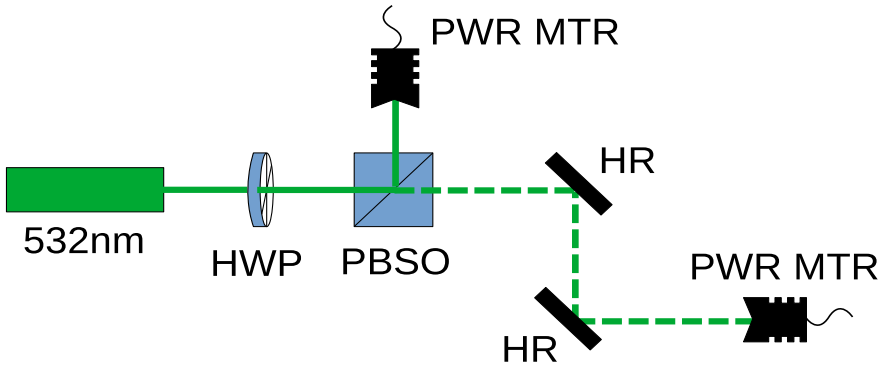


Skills Taught:

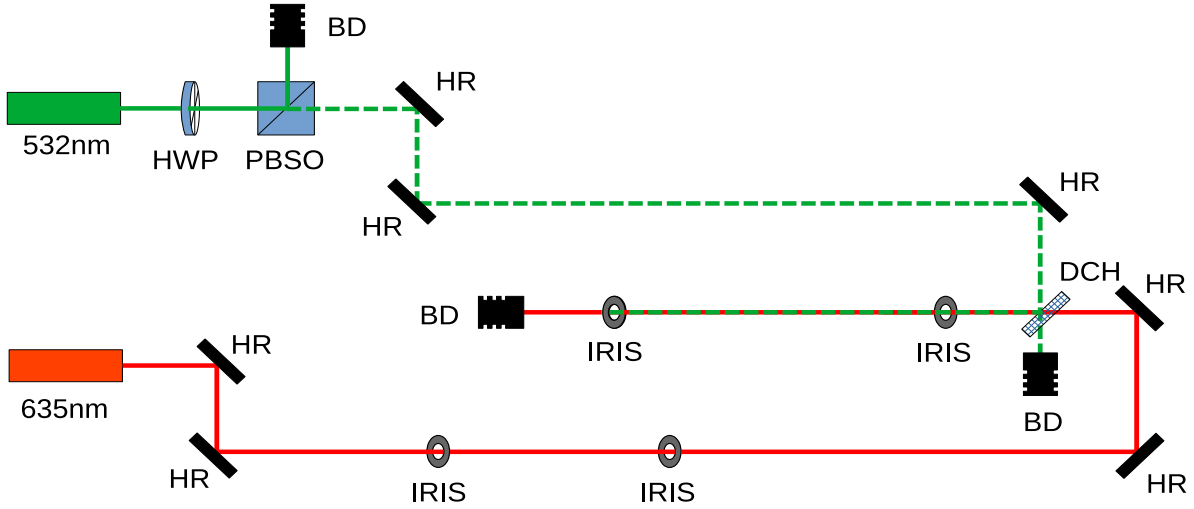
- Using a dichroic mirror to co-align beam paths
- Use of a periscope to change beam height

Skills Taught:

- Using waveplates and polarizers to adjust the power of the beam



The Test: Individual Demonstration of Alignment Skills



- The laser worker will be asked to build a beam line that matches the schematic.
- The entry level laser worker can demonstrate what they learned during the practical with minimum guidance.
- The experienced laser user may skip the practical course and demonstrate mastery and understanding to the instructor during the test.
- Individual testing ensures that standards are being met and workers comprehend how to perform alignment tasks safely.

Skills and Best Practices the Instructor is Looking For

HS5204-P Hands on Laser Alignment Practical

Criteria	Excellent (3)	Good (2)	Poor (1)
Removal of Reflection Hazards	The student removed all jewelry, watches and badges prior to beginning work.	The student remove some of their jewelry, watches and badges prior to beginning work.	The student had to be reminded to remove jewelry, watches and badges by the instructor.
Beam Awareness	The student was aware of the beam location at all times and was able to work without putting themselves in the beam path.	The student was mostly aware of the beam location, but may have accidentally put an arm or hand in the beam when making adjustments, but realized their mistake.	The student was not aware of the beam location and repetitively put an arm or hand in the beam without noticing. (Reaching for optics, placing hands beam path when aligning.)
Beam Control	The student was conscientious of their surroundings, and kept the beam contained to the table at all times by using beam blocks, and turning the laser off while making changes to the beam path. They used a card to trace the beam path and checked for the possibility of back reflections, and stray beams during the alignment process.	The student was aware of their surroundings, but occasionally forgot to use a beam block or positioned the beam block incorrectly so the beam left the table. When the error was realized, they turned the laser off and made corrections. They traced the beam path with a card but may not have considered checking for stray reflections.	The student didn't notice the beam left the table or didn't feel that this was an issue. The student did not trace the beam with an alignment card to determine if it was being directed properly to the next optic. They took optics in and out of the beam path without blocking the beam or turning off the source.
Communication	The student announced to others in the room that the laser was being turned on / off. If working with classmate, they talked through the layout and the next steps to take prior to turning on the laser.	The student occasionally forgot to announce when the laser was being turned on / off but realized their mistake. If working with a classmate, they usually made the others aware of steps being taken.	The student didn't make efforts to communicate their actions to others in the room.
Lab Operations	The student could tell the instructor where to find the requirements for LPE in a lab. (door sign or laser inventory) They knew that LPE is wavelength dependent and the Optical Density describes the level of protection.	The student could tell the instructor where to find the requirements for LPE in the lab. (door sign or laser inventory) They were aware there are different types of LPE, but didn't have a solid definition.	The student could not identify where to find LPE requirements and didn't understand how to confirm they had the correct laser glasses.

HS5204-P Completion ☐ HS5204-T Completion ☐ Score from Rubric above:_____(min. score 10 to pass)

Student Name _____ Student Employee Number _____

Instructor Name _____ Completion Date _____

A two-hour course doesn't make you an expert, but it can raise safety awareness and introduce best practice techniques.

- Removal of reflection hazards prior to start.
- Awareness of the beam location.
- Beam control and alignment techniques.
- Communication with other workers.
- Familiarity with PPE and lab operations.

Parts List to Replicate Alignment Activities from our Course

Item	Qty	Item	Qty
635nm diode laser and power supply	1	Flat metallic mirrors	14
405nm diode laser and power supply	1	Dichroic mirror (reflects 405nm, passes 635nm)	1
532nm diode laser and power supply	1	Dichroic mirror (reflects 532nm, passes 635nm)	1
Periscope mount (post with 2 vertical mirror mounts	1	Plano convex lens	1
Apertures	7	Plano concave lens	1
Mirror mounts	13	Half wave plate for 532nm	1
Flip up mirror mount	1	Polarizing beam splitter for 532nm w/mount	1
Posts	36	Plate Polarizer	1
Post holders	36	Beam dump	5
Post holder bases	36	Power meter	2
Lens mounts	3	Rotating optic mount	1

For Copies of Our Reference Guide or Course Materials

Contact the LLNL Laser Safety Office, or email me directly

Office email: *LaserSafetyOffice@llnl.gov*

Karla Armstrong: *armstrong40@llnl.gov*