The University of Texas at Austin
Laser Safety Program

Laser Safety Standard Operating Procedure

Forward:

This procedure shall be reviewed annually by all persons who use Class 3B & 4 lasers or laser systems listed in this SOP. This procedure shall also be reviewed every two years by the Permittee or Laboratory Laser Safety Supervisor (LSS) to ensure it reflects the most current conditions. Changes in the operating procedure shall be forwarded to EHS – Laser Safety for review and approval.

Laboratory Information:

Laboratory PI Name:	John Snow	Date:	03/25/2024
Department:	EHS – Laser Safety	Revision #:	001
Building & Room #:	ECG 1.220	Author:	John Snow

Contact Information:

Laboratory LSS:	John Snow	Phone #:	512-471-2042
University LSO:	DeWayne Holcomb	Phone #:	512-471-2038
Maintenance/Repair:	Facilities Services	Phone #:	512-471-2020
Medical Emergencies	1. Call 911 for medical emergencies and shut down all laser operations. 2. Notify the Laboratory LSS and University LSO of all laser-related injuries and near misses as soon as possible.		

Laser Description: Describe the laser(s) setup and how it is used including general beam parameters, optics, and equipment. Include a diagram or picture with the beam path depicted. This may be included as an attachment if necessary.

The NIR spectroscopy setup utilizes two 532nm CW pump lasers, a Ti:Sapphire OPA, and Ti:Sapphire OPO for tunable wavelengths from 800-980 nm. The table utilizes several polarizers and filters to tune the probe and signal before recombining at the microscope stage for analyzing. The signal stage utilizes a retro reflector on a translational stage to adjust to the Rayleigh length for the wavelength being used. The system operates at roughly 1W average power in the open beam portion and is reduced to 1 uW before entering the microscope stage. There are known reflections at each filter and polarizer which have been demarcated with a yellow post-it sticker to ensure it' location is known and unchanged. The lab utilizes a laser curtain to block the entrance which must remain closed, along with the lab door, while lasers are in use. Laser eyewear is available inside the lab, but outside the curtain to allow users to don the eyewear before entering the hazard zone. Eyewear must be worn at all times while the laser is in operation.

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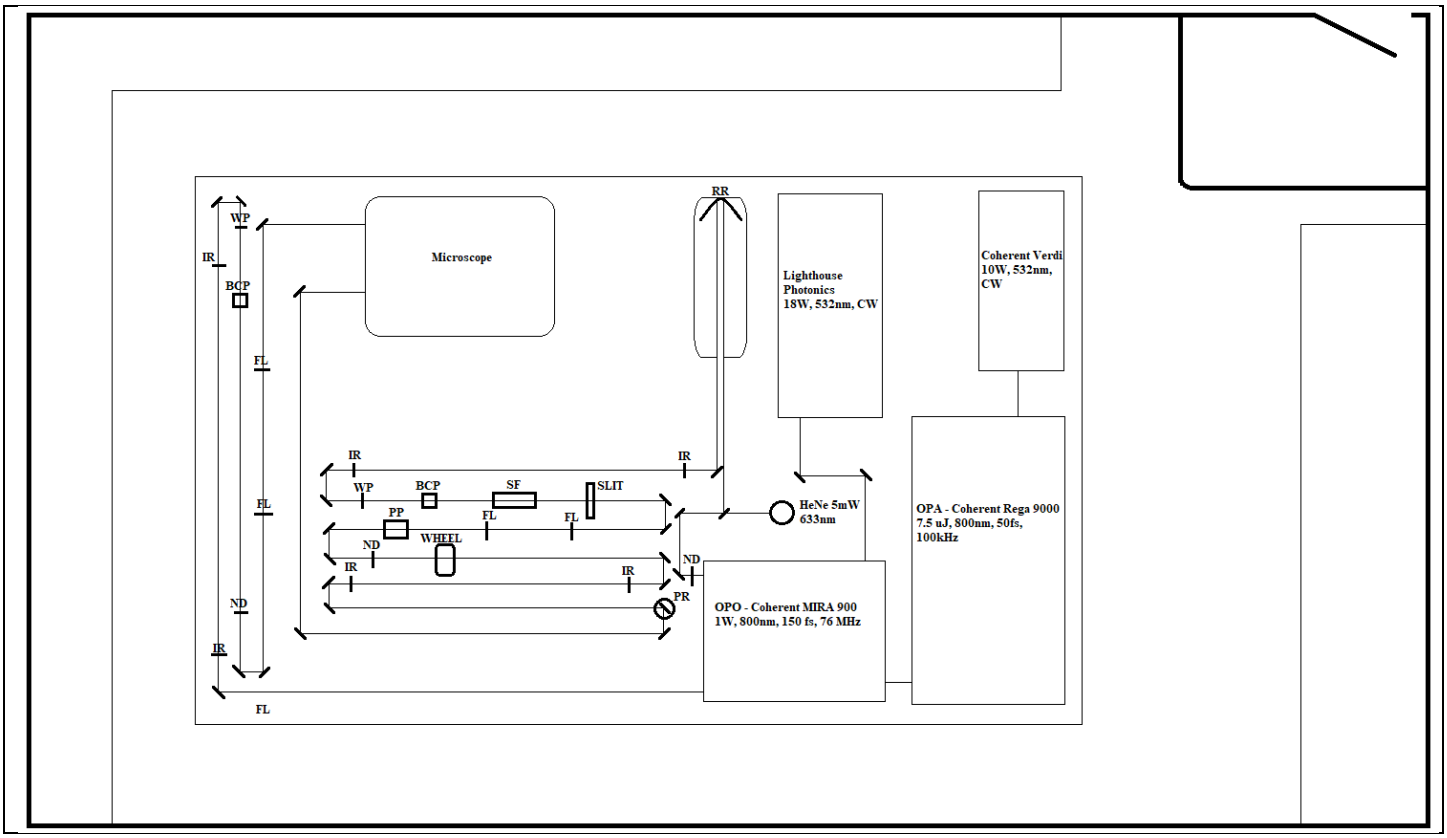

Laser Parameters: Complete the table below using the operating conditions (power output, pulse energy, duration, etc.) of the laser. If more than one laser is used, copy and paste this table to complete the laser parameters for the other lasers. Laser eyewear is to be inspected by the user for lens applicability and integrity prior to each use.

Make:	Coherent	Wavelength (nm):	532
Model:	Verdi-10W	Output Power (W) or Energy (J):	10W
Serial Number:	EHS-JS-LAS1	Beam Diameter (mm):	2.5 mm
Class:	4	Beam Divergence ($1/e^2$) (mrad):	<1 mRad
Cont. or Pulsed:	CW	Duration (ns) & Rate (Hz):	N/A
Eyewear Make:	Kentek	Eyewear Wavelength:	190 – 532 nm
Eyewear Model:	KXL-5401	Eyewear Optical Density:	7+

Make:	Coherent	Wavelength (nm):	800
Model:	Rega 9000	Output Power (W) or Energy (J):	7.5 uJ
Serial Number:	EHS-JS-LAS2	Beam Diameter (mm):	2.5 mm
Class:	4	Beam Divergence ($1/e^2$) (mrad):	<1 mRad
Cont. or Pulsed:	Pulsed	Duration (ns) & Rate (Hz):	7.5 uJ, 100 kHz

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Eyewear Make:	Kentek	Eyewear Wavelength:	678 - 1350 nm
Eyewear Model:	KXL-40C	Eyewear Optical Density:	7+

Make:	Lighthouse Photonics	Wavelength (nm):	532 nm
Model:	Sprout 18W	Power Output (W):	18 W
Serial Number:	EHS-JS-LAS3	Beam Diameter (mm):	2.3 mm
Class:	4	Beam Divergence ($1/e^2$) (mrad):	<0.5 mRad
Cont. or Pulsed:	Continuous	Duration (ns) & Rate (Hz):	N/A
Eyewear Make:	Kentek	Eyewear Wavelength:	190 – 532 nm
Eyewear Model:	KXL-5401	Eyewear Optical Density:	7+

Make:	Coherent	Wavelength (nm):	800-980
Model:	Mira 900	Output Power (W) or Energy (J):	1 W
Serial Number:	EHS-JS-LAS4	Beam Diameter (mm):	2.5 mm
Class:	4	Beam Divergence ($1/e^2$) (mrad):	<1 mRad
Cont. or Pulsed:	Pulsed	Duration (ns) & Rate (Hz):	150 fs; 76MHz
Eyewear Make:	Kentek	Eyewear Wavelength:	678 – 1350 nm
Eyewear Model:	KXL-40C	Eyewear Optical Density:	7+

Make:	Melles Griot	Wavelength (nm):	633 nm
Model:	25-LHP-991-249	Power Output (W):	5 mW
Serial Number:	EHS-JS-LAS3	Beam Diameter (mm):	2
Class:	3B	Beam Divergence ($1/e^2$) (mrad):	1
Cont. or Pulsed:	Continuous	Duration (ns) & Rate (Hz):	N/A
Eyewear Make:	Kentek	Eyewear Wavelength:	620 - 647 nm
Eyewear Model:	KXL-40C	Eyewear Optical Density:	2+

Laser Safety Program Resources:

EHS has several resources on their website at: https://ehs.utexas.edu/programs/lasers/ including information regarding laser safety training and program requirements. The Laser Safety Program Manual can also be found here and should be referred to for:

- Lab PI roles and responsibilities
- Laser User roles and responsibilities
- Laser permits and registration
- Program requirements (SOP, Training, etc.)
- PPE requirements (eyewear and inspections)
- Signs and Labeling
- Non-Radiation Hazards
- Procurement and Disposal Requirements

Operating Procedures:

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All Class 3B and 4 lasers and laser systems shall have a documented operating procedure that provides the end user the necessary instruction for completing their experiment safely. The operating procedure shall include instructions for all times it is necessary for the laser to be powered on including normal operation, alignments, service, and repairs as applicable. The procedure shall incorporate all safety measures including when to don/doff eyewear, room securement, signs and warning labels, housekeeping, and other control measures identified in the hazard section above. This procedure shall be updated to reflect current operations prior to commencing the experiment.

A. Initial preparation of lab environment for normal operation (lab security, warning light on, keys, interlocks and guards, identification of personnel, etc.)
    1. Begin by asking all unneeded personnel to leave the lab space.
    2. Ensure the lab entrance laser warning light is On and operating.
    3. Ensure the lab door is closed and locked to prevent unauthorized entry, and that the window covering is in place.
    4. Ensure the laser curtain is closed completely. The optic table should not be visible from the entrance, and the curtain should not be propped open.
    5. Inspect the optic table and remove all excess equipment and objects.
    6. Warn others in the lab that the laser will be powered On, and to don eyewear.
    7. Inspect and don the appropriate laser eyewear for the wavelength and power levels to be operated.
    8. Ensure all others have donned eyewear.
    9. Obtain keys for HeNe and Pump Lasers.

B. Laser Startup Procedure
    1. Ensure the alignment iris at each stage of the table have been closed to the minimum 1.5mm diameter.
    2. Power on, and unshutter the HeNe laser to verify alignment of the optic table. Do **Not** power on the Ti:Sapphire laser until the alignment has been verified.
    3. Ensure the HeNe beam is centered within the Iris at each stage. The HeNe laser should form a halo around each iris opening, and it' image centered on the sample stage camera.
       NOTE: If the HeNe laser shows the optical setup to be out of alignment, the optics must be brought back into alignment before using the Ti:Sapphire laser. Do **Not** power on the Ti:Sapphire laser until alignment has been verified.
    4. Verify the known reflections from the filters, polarizers, lenses and beamsplitter are in their expected location designated by arrow demarcation on the table enclosure or optic. (i.e. they have not moved).
    5. Once the system alignment has been verified, you are now cleared to power on the pump, Ti:Sapphire laser and amplifier using the following steps.
    6. Turn on the chiller for the Ti:Sapphire and amplifier/oscillator.
    7. Ensure the chillers are operating as intended by viewing the control station for error codes.
    8. Turn on the power supplies for the Ti:Sapphire and amplifier/oscillator.
    9. Ensure the approved Thorlabs LB-2 beam block is placed at the emitting aperture of the Ti:Sapphire laser. Do **NOT** use unapproved materials as beam block. This could result in unintended beam emission, fire, or damage to the laser.

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10. Notify other personnel the laser will be powered On and ensure users are wearing laser eyewear.
11. Power on the Ti:Sapphire and set the pump laser to 2W using the computer control station.
12. Ensure the Ti:Sapphire laser properly modelocks and record the following data in the lab notebook: Time, Pump power, pump current, chiller temperature, Ti:Sapphire output power.
13. Reset the Pockel cells by pressing the 'Reset' button on the side of the SDG housing. A feint hum will resonate from the Pockel cell high voltage power supply when it is in operation.
14. Power On the amplifier using the control software. The amplifier will power on over the course of 3-5 minutes by slowly ramping up the power automatically, at which time emission will occur.
15. After approximately 15-20 minutes, thermal and power stability of the system should be reached and the computer should show the ECU and LBO are within their target margins.
16. Record the amplifier power, efficiency, and current, as well as the LBO crystal temperature and Pockel cell delay settings within the lab logbook.
17. Before removing the LB-2 beam block, ensure any path that will not be used is blocked using an approved beam dump.
18. Ensure the iris located directly before the dichroic mirror (IR^1) has been closed fully.
19. Remove the LB-2 beam block and verify the beam is centered on IR^1. If the beam is centered on the iris, the beam should be aligned with the entire optical train.
20. Open IR^1 to allow transmission of the beam.
21. Note any unusual or unexpected laser behavior within the lab logbook.

C. Operation procedures are as follows:
    1. Following completion of the start up procedure, the laser is ready to be taken to it' operational state.
    2. Within the Ti:Sapphire control panel, enter 12W within the power level settings. The power will be increased automatically by the system. **NOTE**: No coarse adjustments to alignment may be made to the optic train while at operational power. If adjustments using mount knobs are not sufficient to restore alignment, power must be reduced before changes are made. See alignment procedure.
    3. To place a sample at the microscope sample stage, engage the shutter on the pump control panel by pressing the 'Shutter' button. An audible sound should be heard from it closing.
    4. Place the slide sample on the microscope tray and secure with the slide holders. Close the microscope cabinet behind you.
    5. Disengage the shutter at the pump control panel.

D. Shutdown procedures for this laser are as follows:
    1. Block the output of the amplifier using the approved LB-2 beam block.
    2. Turn off the Ti:Sapphire by pressing the Off button within the laser control software.
    3. Turn off the Ti:Sapphire power supply by pressing the Power button on the control panel. Turn the key to the Off position and place in the key box.
    4. Turn off the oscillator by turning the key to the Off position, then uncheck the emission switch within the oscillator software.
    5. Switch the oscillator chiller to standby mode by pressing the Power button on the control panel.

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6. Turn down the pump power supply to 0 using the dial wheel on the control panel. Once power has fully reduced, turn off the pump by pressing the Power button on the control panel.
7. Wait for each ECU to warm to 15ºC before switching them off. Failure to do this will result in moisture freezing within the crystal housing potentially damaging the laser.
8. Turn off the Ti:Sapphire chiller and note the laser off time in the lab logbook.

E. Alignment procedures (describe the specific steps and settings needed to reduce power before interacting directly with the beam path. For example, shuttering the pump laser, using ND filters, etc.)

NOTE: Alignment must be performed by an authorized person who has completed the requisite OJT and has received written authorization to perform alignments. If you are not authorized, but require help with aligning the system, contact the laser safety supervisor for assistance.

1. Before performing an alignment, ensure the goals of the alignment have been planned out and communicated to the lab manager prior to the work being performed. This may require additional resources such as beam blocks, optomechanics, viewing methods, etc.
2. Always communicate your plans to other personnel in the room. Remove any and all non-essential personnel during the alignment.
3. Always perform the coarse alignment of a new optic using the HeNe laser. Never align a new optic using the Ti:Sapphire beam or other high power (>5mW) laser. The Ti:Sapphire alignment will be verified once the coarse alignment is performed, and reflections have been traced and verified to be terminated properly.
4. Always block the new beam path beyond the new optic to ensure the laser does not scatter to an unintended area. Ideally the block is placed close to the new optic to ensure the beam lands on the block, then the block is extended to the desired location while the beam remains terminated on the block.
5. Always trace the beam to the center of the new optic using an alignment card prior to releasing the beam onto the optic. Do not guess where the beam will impact, be precise and aim for the middle 1/3 of the optic. A backlight (headlamp) can be used to illuminate the shadow of the optic mount to the backside of the alignment card, showing the user exactly where the beam will impact the optic.
6. Ensure all joints and connections are secured prior to moving on from a new optic.
7. Thoroughly examine each new optic for reflections by using the alignment card to cover the areas of the optic directly next to where the beam impacts the optic, and checking for back reflections.
8. Examine the table, surrounding optics, and room for stray reflections. Be thorough and methodical in review while the risk level is low compared to operating at full power.
9. Once the new optic has been coarsely aligned, and new reflections have been accounted for, alignment of the operational (Ti:Sapphire) laser can occur. The Ti:Sapphire alignment must be performed at lower power (saturation threshold) of the Ti:Sapphire crystal. This equates to a pump setting of 2W for our system.
10. Adjustment of the Ti:Sapphire beam must only be performed using motion restricted by the mount or optomechanical device that houses the optic (i.e. kinematic mount knobs, translation stage micrometer). Do NOT move an optic freely by hand while the Ti:Sapphire is in use. You cannot control the motion finely enough to ensure the beam does not move unexpectedly.

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11. After alignment of the Ti:Sapphire check for reflections again using the alignment card and IR viewer for both the table and the rest of the lab space. Do **NOT** assume reflections stay contained to the table.

Physical Controls: Describe the physical controls of the laser setup in the condition which the setup is intended to be operated. Edit the comment section as necessary to depict the lab specific controls implemented. EHS will review and approve the described control measures.

Check If Applicable:	Control:	Comments:
☒	Entryway (door) Interlocks or Controls	Entry to the lab is restricted to authorized and properly trained lab personnel only with an active lock. The lab door is to remain closed at all times unless the laser is shutdown and under the direct supervision of an authorized person. Illuminated laser signs/placards are provided at the entrance to the laser control area/nominal hazard zone. A laser curtain is provided at the nominal hazard zone perimeter.
☐	Laser Enclosure Interlocks	Any laser enclosure interlocks will be engineered to fail safe and require manual re-activation if defeated.
☐	Laser Housing Interlocks	Fail-safe or redundant interlocks shall be provided if they can be removed or displaced during operation and still allow access to Class 3B or 4 laser radiation. Warning labels shall be provided near the interlock if it can be defeated or by-passed.
☒	Emergency Stop	An emergency E-stop button shall be provided or the master key/power switch shall be designated at the emergency stop as applicable and clearly labeled as such.
☒	Beam Stops	The beam terminates in an aluminum beam block capable of withstanding the heat from the laser setup without degradation.
☐	Master Switch	The laser is only operable via a switch key. When the key is in standby mode, the laser is inactive.

Hazards & Controls:

Check If Applicable:	Hazard:	Controls:
☒	Housekeeping	The beam path and surrounding areas will be kept free of clutter and obstructions. Hand clearing of clutter from the optical table and beam area will be performed prior to each laser operation.
☐	High Voltage	The building manager and facilities electrical shop shall be consulted prior to operation/maintenance involving high voltage exposure including any adjustments needed.
☐	Capacitors	Any capacitors will be enclosed within a protective panel during operation and fully discharged prior to maintenance.

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☐	Open Beam	The beam is contained within a curtained area. The outside door will also be closed as a secondary protection. Appropriate laser eyewear protection shall be worn in all areas with open, accessible laser radiation.
☐	Fumes/Vapors	Any fumes/vapors generated during operation will be exhausted through a fume hood or local ventilation apparatus.
☐	Ultraviolet Radiation or Blue Light	Appropriate barriers and PPE to protect skin and eyes from UV and eyes from blue light will be in place upon consultation with EHS if needed. This may include lab coats, eyewear, gloves, fade shields or topical sunblock applications.
☒	Compressed Gases	Compressed gases will be properly secured and labeled. Safety caps will be in place for unused cylinders. Flammable and oxidizing cylinders shall be stored at least 20 feet apart unless specifically required for an experiment upon consultation with EHS. OH 204 compressed gas cylinder training from EHS should be taken and is available in UT Learn.
☐	Hazardous Chemicals/Waste	No hazardous waste is expected to be made during ordinary operation. If hazardous waste is generated, training course OH 202 should be taken (available in UT Learn) and all waste properly handled, labeled and stored per EHS guidelines.
☐	Reflective Material in Beam Path	The open beam paths will be kept free of clutter to prevent inadvertent ignition of materials, specular and diffuse reflections, and laser generated airborne contaminants.
☒	Fire	A fire extinguisher is located within a few steps of the table. Laser operators will ensure familiarity with its location and complete FF 205 hands on fire extinguisher training from Fire Prevention Services. Beam blocks will be used to absorb laser energy capable of generating hazardous levels of heat.
☐	Laser at eye level of person sitting or standing	The laser is mounted below the eye level of a person sitting normally. Beam blocks and additional barriers will be used to prevent the cohesive beam from travelling beyond the limits of the optical table.
☐	Infrared Lasers	Invisible lasers will be properly blocked and attenuated. Adequate viewing equipment such as IR viewers, cards, cameras, etc. must be available to the end user to ensure reflections are minimized.
☒	Correct Eyewear	Appropriate EHS approved laser eyewear protection with labelling of wavelength and optical density will be present and worn by all lab personnel working in rooms with accessible laser radiation. The eyewear will be made readily available prior to entering a nominal hazard zone at the door or curtain entrance, properly maintained, cleaned, and stored per manufacturers recommendations.
☒	Secured Laser	Lasers shall be secured to the operating surface during operation to prevent movement of the beam while the laser is on. The method of securing should be robust enough that if the laser is incidentally bumped or contacted, the beam does not lose contact with the target surface.

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Operator Review:

By signing this form, I agree that I have read and understand the contents of this SOP and will adhere to it' instructions. Furthermore, I agree that I have successfully complete the University's Laser Safety Training and I am aware that it is my responsibility to operate in a safe manner.

Name:	EID:	Signature:	Date: