BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system(s) listed below. All American National Standard Institute (ANSI) Hazard Class 3B and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed *annually*. Modify the template for this document to fit your particular circumstance.

System description: **Raman fiber optic system with class 3B laser source**
Location: **Currently in NSLS room 1-127, but will be utilized with beamlines X18A, X18B, and X19A**

LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator(s) for this laser is/are listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

Owner/Operator:		
Name: Anitha Patlolla	*Signature:*	*Date:*

AUTHORIZATION

Work with all ANSI Class 3B and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required. Additional signatures, e.g., the ALSO, are to be added to this signature block when necessary.

BNL LSO (printed name) *Chris Weilandics*	*Signature* *On file*	*Date*
Department ES&H Coordinator (printed name) *Lori Stiegler*	*Signature* *On file*	*Date*
Department Chair/Division Manager (printed name)	*Signature*	*Date*

APPLICABLE LASER OPERATIONS
☒ Operation ☒ Maintenance ☐ Service ☐ Specific Operation (specify)

RELATIONSHIP TO OTHER DOCUMENTS

Specifically name other documents, (such as ESRs, SADs/SARs, other SOPs) that describe hazards present in the Laser Controlled Area outside the scope of this document.

Laser use will be described on Safety Approval Form.

LASER SYSTEM HAZARD ANALYSIS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system. The analysis includes both laser (light) and non-laser hazards. A Nominal Hazard Zone (NHZ) analysis must be completed to aid in the identification of appropriate controls. Laser system characteristics necessary for eyewear calculations and NHZ analysis are described along with the results in the PPE section of this document.

LASER SYSTEM CHARACTERISTICS						
Laser Type *(Argon, CO_2, etc.)*	Wavelength(s) (nm)	ANSI Class	Maximum Power or Energy/Pulse (W or J)	Pulse Length (s)	Repe-tition Rate (Hz)	Beam Diameter (mm)
DPSS	532	3B	23 mW	CW	NA	<7mm

Applicable Laser Operations:
Describe the scope of the work to be done, and how the laser system is used. Provide information regarding unusual circumstances necessary for evaluation of hazards by the LSO not provided elsewhere in this document (e.g., laser beams entering other equipment such as vacuum chambers and microscopes or propagated into unexpected places/directions).

Laser will be focused on a sample (solid or liquid, no sample prep needed) and a Raman spectrum will be collected. Laser will eventually be combined with existing beamlines to obtain simultaneous EXAFS and Raman spectra.

Laser System Configuration:
Describe the laser beam path for fixed components of the system, and provide a functional/block diagram for complicated beam paths. Photographs may be used where they convey sufficient information. Note that Engineering Controls are described in a separate section below.

Identify hazards mitigated or created by the placement, movement, and/or status of components. Examples include any protective housings, beam stops, beam enclosures, and any critical optics (mirrors or lenses that could misdirect the beam and result in personnel hazard).

Laser path: 1. 532nm Laser Source, class 3B (enclosed) >>>> 2. Fiber optic probe (open) >>>> 3. Spectrometer with CCD detector (enclosed)

For specific *laser-related* hazards below, provide details (types, quantities, use) as appropriate. Details of non-laser related hazards should be cross-referenced to the other documents cited above.:

☐ **Cryogen Use**

e.g., laser cooling

☐ **Chemicals & Compressed Gases**

e.g., laser dyes, solvents, excimer laser gases

☐ **Electrical Hazards**

Describe circumstances that could lead to exposure to electrical hazards.

☒ **Other Special Equipment**

Equipment used with the laser[s] that may introduce additional hazards, e.g., beam viewers.

Fiber optic probe

Freely movable probe could be used like a laser pointer to accidently shine beam into another user's eye. However, focal length for probe is 7mm so the beam would be very poorly focused if shined in another user's eye from a distance that is greater than 7mm. Thus, power at the eye would be substantially less than max output power of 23mW.

DESCRIBE CONTROLS

Recognition, evaluation, and control of laser hazards are governed by the following documents:

American National Standards Institute (ANSI) Standard for Safe Use of Lasers (ANSI Z136.1-2007)

BNL SBMS Subject Areas:

Laser Safety Subject Area
Interlock Safety Subject Area

ENGINEERING CONTROLS

☒ Beam Enclosures	☐ Protective Housing Interlocks	☐ Other
☒ Beam Stop or Attenuator	☐ Key Controls	
☐ Activation Warning System	☐ Other Interlocks	
☐ Ventilation	☐ Emission Delay	

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **If any of the controls utilized in this installation requires a design review by the LSO/ALSO and the LESO, a copy of the design review documentation and written testing protocol must be on file. Completed periodic interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

Beam is enclosed at source, but open at fiber optic probe. Laser source has a built in attenuator controlled by rotating the only circular knob on the source enclosure. Attenuator is composed of 33 rounds of a ND step filter.

NOTE: Laser beam can only be turned on and adjusted from the computer software. Beam cannot be turned on from source enclosure, probe, or spectrometer.

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☐ Labels ☐ Operating Limits

Class 3B and 4 lasers are required to be operated in Laser Controlled areas with appropriate warning signs and labels. The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer. All lasers must have a standard label at least indicating the system's wavelength and power. Required labels must remain legible and attached. The manufacturer should label commercial systems.

Describe administrative operational limits (e.g., requirements to operate at reduced power) if appropriate.

Standard Operating Procedures (SOPs) are required for Class 3B and Class 4 laser system operation, maintenance/servicing and laser alignment. The SOPs need only contain the safety information necessary to perform these tasks and identify appropriate control measures including postings (showing required ODs for eyewear and ANSI hazard class) and any additional personal protective equipment required. The BNL Laser Safety Officer must approve SOPs and copies should be available at the laser installation for reference and field verification of stated control measures.

Operation:

Describe controls for routine use and adjustments of laser system(s).

Standard Class 3B signs will be placed on door of room/hutch which will be designated a Laser Controlled Area. Fiber optic probe (open laser path) will always be positioned facing away from door in case of accidental entry by an unqualified user.

Maintenance/Service:

Describe additional controls required to maintain laser operation. May or may not require beam access. Follow manufacturer instructions where appropriate. Routine maintenance: replacing consumables (flashlamps, gases, dyes, etc.). Non-routine service: Less frequent: Replacing damaged components, diagnostics, etc.

N/A. All servicing must be performed by manufacturer at their facility in California.

Outside service personnel:

Indicate how outside service personnel are trained and supervised. Work performed by outside service personnel is planned according to the Work Planning and Control for Experiments and Operations Subject Area and regulated by the Guest and Visitors Subject Area.

No outside service personnel will be allowed to use system. Alignment/use will always be performed by qualified BNL users involved with Prof. Anatoly Frenkel's group.

Alignment:

As most laser accidents occur during alignment, provide a description of routine procedures where appropriate and controls to mitigate the hazards. For non-routine procedures, provide a safety envelope necessary to protect workers. This includes activities such as initial system/ experimental alignment.

Laser focus on sample will always be performed with a laser output of <5mW and always while wearing OD 2+ or greater goggles.

Alignment of the laser will be performed at lowest power possible (<5 mW). Only owner/authorized user will be allowed to perform the alignment. The room door/hutch will be closed during alignment to prevent exposure. Appropriate eyewear will be worn as detailed in the Eyewear section below.

Alignment SOP:

1. **The laser alignment will be performed using the Raman signal of the sample as recorded by the computer outside the hutch, eliminating the need of viewing the beam.**
2. **To reduce accidental reflections, watches, rings, dangling badges, necklaces, reflective jewelry are taken off before any alignment activities begin. Use of non-reflective tools should be considered.**
3. **All equipment and materials needed are to be present prior to beginning the alignment**
4. **All unnecessary equipment, tools, combustible material will be removed to minimize the possibility of stray reflections and non-beam accidents.**
5. **There shall be no intentional intrabeam viewing with the eye!!**
6. **Maintain good housekeeping practices on laser tables; keep the area where you will be working clear of excess objects that might scatter a beam unpredictably, and keep combustible materials away from class 4 hazards or focused 3B lasers.**
7. **During alignment procedures, only persons immediately involved in the procedure are to be in the LCA.**
8. **When it is possible that hazardous beams are not completely contained on the laser tables, the room must be posted with a temporary alignment warning sign on the door warning those that may enter not to until the procedures are completed and the sign removed.**
9. **During all times when the possibility for inadvertent exposure to laser light exists, appropriate laser safety eyewear must be worn. The appropriate ratings are listed in the PPE section, and discussed further below.**
10. **Definite termination of the beam path must be in place before the beam is allowed to propagate. Use moveable beam stops to ensure that uncontrolled propagation does not occur.**
11. **Alignment procedures are always to be performed with the minimum practical laser power levels and repetition rates.**
12. **Routine laser-specific alignment procedures may be simple or complex. In either case, specific procedures are outlined in the operation and alignment manuals supplied by the manufacturers, and they must be followed.**
13. **Pre-position optical components during gross alignment as best as possible and secure them before allowing beams to propagate.**

<u>Laser system configuration changes:</u>

Changes to the laser system can result in new concerns about safety or damage to equipment. Describe how changes are communicated between coworkers (e.g., lab notebooks, logs, whiteboards).

There will be no changes to the laser system.

PERSONAL PROTECTIVE EQUIPMENT

Skin Protection: If the potential exists for damaging skin exposure as determined by the LSO (particularly for UV lasers 295-400 nm or welding/cutting applications), describe the hazard(s) and the method(s) used for mitigation. Skin-covers and/or sunscreen creams are recommended.

N/A

Eyewear: All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Eyewear must be routinely checked for cleanliness and lens surface damage.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the circumstances and the precautions that will be taken to prevent eye injury.

Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

OD 2+ or greater goggles will always be worn when operating this equipment.

Most accidents occur during alignment. Extra care must be taken during alignment. Eyewear must be worn during alignment, but it must be remembered that eyewear is NOT the first level of laser safety. Eyewear protects the wearer only when all other safety procedures and equipment have failed. Better protection is provided by careful consideration of procedures and proper beam management.

LASER SYSTEM CHARACTERISTICS						
Laser Type (Argon, CO_2, etc.)	Wavelength(s) (nm)	ANSI Class	Maximum Power or Energy/Pulse (J or W)	Pulse Length (s)	Repe-tition Rate (Hz)	Beam Diameter (mm)
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EYEWEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
DPSS	532	2	NA	0.06	NoIR LaserShields AG3#38

EYEWEAR SPECIFICATIONS		
Laser System Eyewear Identification***	Wavelengths	Optical Density
NoIR LaserShields AG3#38	532	3+

*Diffuse ODs are calculated assuming a 600 second exposure, a viewing distance of 20 cm, perfect reflectivity, and viewing normal to the surface. The ODs required can decrease for more typical conditions in the laboratory.

**The Nominal Hazard Zone is that zone or distance inside which exists a hazard to the eye from a diffuse reflection (as well as direct or specularly reflected light) for the time specified, in this case, 600 seconds (10 minutes).

***Specified eyewear may not be the only possible option, but represents an approved choice; depending on other laser hazards present in the lab, other eyewear may be acceptable provided the optical densities are equivalent or greater than those required.

Beam divergence: based on measurements, the laser emanating from the fiber optic tip produces a spot size of about one inch at a distance of 2.5 inches. This translates to a full angle of about 22.6 degrees. Based on a measured output of 23 mW*, the irradiance figure of 2.5 mW/cm^2 would occur at a distance of about 8.6 cm. We will use a distance of 10 cm (~4 inches) as the “safe” distance. Maintaining a distance of four inches from the end of the fiber tip will preclude a hazardous exposure.

*Measurements were made with an International Light model IL1400 meter using a SPL024 laser probe (both calibrated in 2012 FEB). The probe is about 75-77% efficient at 532nm so measured levels were divided by 0.75 to obtain a corrected value of the measured output.

The laser current range for the present Raman system is from 0.37-0.97A and the laser power out puts are shown below (the measurements were made by above mentioned method)

Serial No.	*Current (A)*	*Power out put (mw)*
1	***0.4***	***0.05***
2	***0.5***	***0.36***
3	***0.6***	***2.4***
4	***0.7***	***6.6***
5	***0.8***	***13.2***
6	***0.9***	***17.6***
7	***0.97***	***23.2***

TRAINING

LASER SAFETY TRAINING

Laser Operators must complete sufficient training to ensure that they can identify and control the risks presented by the laser systems they use. Owners/Operators must receive a baseline medical surveillance eye examination, documented in the Occupational Medicine Clinic before using lasers. Owners/Operators and Qualified Laser Operators must complete the awareness level BNL online training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training shall be done using the checklist in Appendix 1.**

All Laser Training shall be documented on the On-The-Job Training form found here:

http://www.bnl.gov/ps/nsls/training/Rosters/PS-LASER-OJT.pdf

All laser safety training must be repeated every two years.

APPENDIX 1

Training Topics

General Laser Safety

- Laser classifications
- Laser hazards
- Maximum permissible exposure
- Good practice in the lab

LCA Interlock Instruction

- Configuration
- Operation

Description of Laser Output Characteristics

- Wavelength
- Pulse energy
- Average power

Associated electrical hazards

- Power supply

Normal Operation

- Power on/off
- Shutter operation
- Normal experimental configuration
- Nominal hazard zone
- Alignment using Raman signal