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: Time-resolved light scattering
Location: X20C Hutch

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: Jean L. Jordan-Sweet	*Signature: on file*	*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) *C. Weilandics*	*Signature* *On file*	*Date*
Department ES&H Coordinator (printed name) *L. 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.

Use of the laser is described in specific Safety Approval Forms associated with this beamline.

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)
HeNe	632.8	3B	35mW	CW	NA	

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 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).

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**

N/A

☒ **Chemicals & Compressed Gases**

N2, He, Ar, N2(5%H2), or He(5%H2) is used as ambient in chamber through which laser light is passed. 5% H2 mixtures are non-flammable.

☐ **Electrical Hazards**

Describe circumstances that could lead to exposure to electrical hazards.
No hazards. Power supply is enclosed, supplied by laser manufacturer, and not serviced locally.

☒ **Other Special Equipment**

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

Stainless steel chamber containing sample holder, boron nitride heater, gas and vacuum lines, and Be window for entry and exit of synchrotron x-rays. Chamber is mounted on phi circle of Huber diffractometer inside X20C hutch. Light from laser is brought into chamber via fiber optic, passes through a lens, scatters off of sample, and exits chamber through two fiber optics. Chamber is opened for changing samples. Laser light inside chamber is reduced to <0.5 mW through attenuation of fiber optic and feed-throughs.

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
Electrical Safety Subject Area (section Interlock Safety for Protection of Personnel)

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 enclosures: Aluminum box encloses beam within 1mm of exiting the laser. Beam exits enclosure via 50 micron-ID fiber optic. Beam is enclosed in fiber optic up to sample chamber and exiting sample chamber. Beam inside sample chamber is <0.5 mW due to attenuation by fiber optics and path length.

Beam stop or attenuator: A shutter is integral with laser.

Key control: Laser power supply is operated by a key and is provided with laser from manufacturer. The key is removed from the power supply when the laser is not in use.

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.

Sign: An ANSI-standard sign for Class 3B lasers is posted on outside of hutch during setup and alignment. It is then posted on aluminum enclosure during normal operations and ANSI-standard sign for Class 2 lasers is posted on outside of hutch.

Label: Laser has a manufacturer-supplied, ANSI-standard label on it.

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).

Operation: Performed by Users of the beam line. Flange that holds sample mount and feedthroughs and entrance fiber optic is removed from chamber for sample changes. Flange is mounted on a support, old sample is removed by pressing on two spring-loaded clamps, and new sample is inserted. During this procedure the only exposed laser light is <0.5mW and the direction of beam is away from the line of sight of the operator. Lock-in amplifier signal is checked and flange is then replaced on chamber. Other than during sample changes, the entire path of the laser light is enclosed. During operation (sample changes) we are working with an ANSI Hazard Class 2 laser beam. A Class 2 laser sign is posted on the outside wall of the hutch

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.

NA

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.

NA

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.

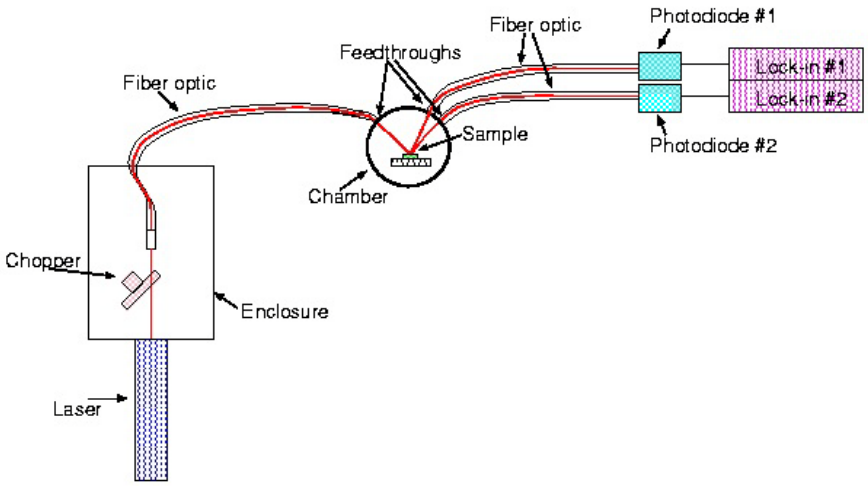
Setup and alignment: Only performed by those trained as, "Qualified Laser Operators". Laser Class 3B sign is posted on outside wall of hutch. Laser, chopper, and fiber optics are assembled. Laser is aligned by hand by maximizing light exiting the 50 micron-ID fiber optic and illuminating a white paper diffuser at a distance of ~ 1ft from the exit of the fiber optic. (Beam exiting fiber optic is very divergent and illuminates a ~ 6 in. diameter circle on the paper.) Optical-bench laser-mounting clamp is then tightened down. After alignment, aluminum enclosure is put in place and fastened to the table with screws. Sign is then transferred from hutch wall to enclosure. During setup and alignment we are working with an ANSI Hazard Class 3B laser beam. Laser eyewear specified in Eyewear Requirements is worn when aligning the laser into the 50 micron fiber inside the aluminum box.

Laser system configuration changes:

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).

Laser is clamped to Huber table and controlled by keyed power supply. Light enters aluminum enclosure at 1mm from front of laser, passes through a chopper and exits enclosure through 50 micron-ID fiber optic. Enclosure is locked in place by screws into Huber table. Fiber optic enters chamber through vacuum feedthrough, at which point laser light is attenuated to class 2 power (<0.5 mW). Laser light passes through lens, and scatters off of sample surface. Two angles of scattered light are collected by two 600micron-ID fiber optics which exit the chamber via vacuum feedthroughs and enter 1mm-ID fibers. Light is passed through filters to block blackbody light emitted by hot sample, and sent into photodiodes. Lock-in amplifiers are used to reject red light emitted by hot sample.

Configuration



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.

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.

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.

Light is viewed only after passing through fiber optic and lens, when it is below 0.5mW. It is oriented so that light is traveling away from operator and is viewed when scattered off of a piece of white paper. Small adjustments are made by maximizing intensity of spot on paper. Laser glasses do not allow for accurate viewing of spot intensity.

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)
HeNe	632.8	3B	35mW	CW	NA	

EYEWEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
HeNe	632.8	1.54	NA	<10 cm	LASER-GARD HeNe

EYEWEAR SPECIFICATIONS		
Laser System Eyewear Identification***	Wavelengths	Optical Density
LASER GARD HeNe	632.8	6

*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.

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.

All laser safety training must be repeated every two years.

BNL Basic Laser Training (web course TQ-LASER) is only required for staff who align and set up the system. Users who only operate the device and change samples are not required to complete the BNL Basic Laser Training. Users who only operate and change samples must be oriented with the checklist included here as Appendix #2.

Personnel who align and set up are working with a class 3B beam and must complete TQ-LASER, the checklists in Appendices #1 and #2, and the medical examination.

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

http://www.nsls.bnl.gov/training/Courses/Lasers/

Appendix #1

Time-resolved Light Scattering Laser Checklist

(For setup or alignment)

- Post Laser Class 3B sign on outside of hutch door.
- Clamp laser to upstream end of diffractometer table, within 1mm of Al enclosure perimeter line (enclosure not yet in place).
- Set up chopper and fibers for entry into chamber (laser is off).
- Close hutch door before turning on laser
- Don appropriate eyewear (See SOP)
- Align laser and fiber for maximum output by looking at beam scatter from white paper ~ 1ft from end of fiber. Beam size ~6 in. dia. and highly divergent.
- Put Al enclosure in place and bolt down to table. Eyewear may be removed when cover is secured
- Post Laser Class 3B sign to top of enclosure box.
- Make sure entrance fiber optic is securely attached to feedthrough on chamber. (Light from fiber is Class 2 in power).
- Install exit fibers and photodiodes.
- Post Laser Class 2 sign on outside of hutch door.

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

http://www.nsls.bnl.gov/training/Courses/Lasers/

Appendix #2

Time-resolved Light Scattering Laser User Training Checklist

(For standard operation only—*not* setup or alignment)

- Review of laser setup and beampath
- Review of Laser SOP documentation
- Review of standard operating procedure
- Do not tamper with enclosure or laser
- Make sure laser Class 3B sign is posted on enclosure box
- Make sure laser Class 2 sign is posted on outside of hutch door
- Make sure entrance fiber optic is securely attached to chamber feedthrough.

Bring any questions/problems to the attention of any persons listed as Qualified Laser Operators in the X20C laser SOP.

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

http://www.nsls.bnl.gov/training/Courses/Lasers/