

<b>Brookhaven National Laboratory National Synchrotron Light Source</b>	<b>Number:</b> PS-ESH-0025	<b>Revision:</b> 01
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<b>Subject: Laser Safety Program Documentation X17C</b>		

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

**X17C Laser System**

<p><i>System description:</i></p> <p>There is one laser at X17C:</p> <p>Diode-Pumped Solid State Laser (Class 3B) that has two uses:</p> <ul style="list-style-type: none"> <li>- Measurement of diamond anvil pressure from ruby fluorescence</li> <li>- Raman spectrum measurements</li> </ul>
<p><i>Location:</i></p> <p>The DPSS laser system is located in NSLS room 1-134C</p>

**LINE MANAGEMENT RESPONSIBILITIES**

The Owner/Operator for this laser is 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.

<b>Owner/Operator:</b>		
<i>Name:</i> Zhiqiang Chen	<i>Signature:</i> On file	<i>Date:</i>

**AUTHORIZATION**

All 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.

BNL LSO: C. Weilandics	<i>Signature:</i> On file	<i>Date:</i>
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NSLS ESH Review: Lori Stiegler	<i>Signature:</i> On file	<i>Date:</i>

## ANALYZE THE LASER SYSTEM HAZARDS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system.

<b>LASER SYSTEM CHARACTERISTICS</b>					
Laser Type <i>(Argon, CO2, etc)</i>	Wavelengths	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
Diode-Pumped Solid State Laser	532 nm	3B	250 mw	continuous	N/A

**Cryogen Use**

Describe type, quantity, and use.

No cryogenes are used

**Chemicals & Compressed Gasses**

Describe type, quantity, and use.

No hazardous chemicals or compressed gasses, but only for cleaning purpose products, some solvents such as ethyl alcohol, acetone, etc. are used.

**Electrical Hazards**

Description *(Describe the power supply to the system).*

The laser power supply (mpc6000) must be powered by a 12 VDC source (provided), designed specifically to power the Ventus laser head. Do not remove the covers or operate the laser system with the covers removed. There are no-user-servicable parts or controls inside the protective covers of either the laser head or power supply.

**Other Special Equipment**

Description *(Equipment used with the laser(s)).*

Acton SP2356 imaging spectrometer, microscope, optical elements for pressure and Raman signal measuring.

**Laser System Configuration:** Describe the system controls (*keys, switch panels, computer controls*), beam path and optics (*provide a functional/block diagram for complicated beam paths*).

A single laser serves as the source of light for two functions: Diamond Anvil Cell (DAC) pressure measurement through ruby fluorescence and Raman scattering. This results in two distinct optical configurations, each with an open beam path and different beam viewing requirements. For the Raman scattering, the laser beam is viewed with a camera and monitor. For the DAC the laser beam is filtered and then viewed through a microscope. Alignment of the DAC ruby within the correct optical path requires use of a microscope that places the viewer's eyes within the path of the filtered laser beam. The filter is a critical component of the laser safety system and rigid controls are in place to assure its position during system operation and alignment.

## DEVELOP CONTROLS IDENTIFY ES&H STANDARDS

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 Z136.1-2000)

**Laser Safety Subject Area**

**Brookhaven National Laboratory SBMS - INTERLOCK SAFETY**

<b>ENGINEERING CONTROLS</b>
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- |  |  |                                |
|--|--|--------------------------------|
| <input checked="" type="checkbox"/> Beam Enclosures                  | <input checked="" type="checkbox"/> <b>Protective Housing Interlocks</b> | <input type="checkbox"/> Other |
| <input checked="" type="checkbox"/> <b>Beam Stop or Attenuator</b>   | <input checked="" type="checkbox"/> <b>Key Controls</b>                  |                                |
| <input checked="" type="checkbox"/> <b>Activation Warning System</b> | <input type="checkbox"/> Other Interlocks                                |                                |
| <input type="checkbox"/> Ventilation                                 | <input type="checkbox"/> 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. **Attach a copy of the design review documentation and a written testing protocol. Attach or keep elsewhere any completed interlock testing checklists to document the testing history.**

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Engineering Controls Description:

- (1) The key controls: The master key to the power supply controls will remain with the laser owner. Only the qualified users after training can use the key to operate this laser system.
- (2) Protective Housing Interlocks: The unit is sealed and is not meant to be opened except by manufacturer.
- (3) Activation Warning System: A system of controls is associated with the laser operation.
- (4) The DAC pressure measurement optical set up includes a filter. This filter is a critical component for eye safety and must always be in place for use of the microscope. The filter must always be secured and labeled with the following wording:  
  
Laser Filter  
Do Not Remove  
Laser eye hazard
- (5) Beam Enclosures: A Stainless Steel box as a beam enclosure is applied to cover all the major optical components of this laser system except a microscope.

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<b>ADMINISTRATIVE CONTROLS</b>
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**Laser Controlled Area**       **Signs**       **Labels**       **Operating Limits**

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 indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

**Standard Operating Procedures (SOP) are required for laser system operation, alignment, and maintenance. The SOPs need only contain the steps necessary to perform these tasks and identify when and where posting and personal protective equipment is required. SOPs must be approved by the BNL Laser Safety Officer and should be kept with this program documentation.**

Administrative Controls Description:

- (1) Warning Sign: Danger, Class 3B Laser, Power <300mw, Posts on the door of the laser room. This room is controlled as a laser controlled area for DPSS laser system.
- (2) Laser Controlled Area (LCA): Room 1-134C is the LCA. The door of the room is posted as the above and must be closed during any laser operation. There are no personnel protection interlocks for this room. The room is to always be attended during operation.
- (3) Labels: The warning logo labels and the certification label required by Class 3B Laser are attached on the laser by manufacturer, Ventus. Never try to remove them.

\* Procedures have been established for alignment and routine operation. See Appendix 3.

<b>CONFIGURATION CONTROL</b>
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Prepare and attach a checklist to be used for configuration control of any protective housing, beam stops, beam enclosures, and any critical optics (*mirrors or lenses that could misdirect the beam and result in personnel hazard*). Include entries to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.

Prior to operation, the checklist in Appendix 2 must be completed by the user operating the equipment

<b>PERSONAL PROTECTIVE EQUIPMENT</b>
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Eye Wear       Skin Protection

No eye wear or skin protection is required for routine operation of this system since laser filter is applied before microscope eyepieces and major optics components are covered inside a metal box. There is approved eyewear available in the LCA and only these glasses are to be worn for protection from the laser beam as these have been evaluated and we are certain that they have adequate optical density and are protective for this class 3B laser beam. Normal operation for both Raman scattering and DAC pressure measurement requires no eye wear. During gross alignment of the beam, the laser operator is advised to wear the provided eye protection.

**CAUTION ---about eye wear!**

This DPSS laser is a Class 3B device which indicates that is capable of producing eye damage if directly exposed into the laser beam. NEVER look directly into the laser beam, with or without the safety goggles. Permanent blindness or eye damage may result!

**Eye Wear:** 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. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi laser environments. Eyewear must be routinely checked for cleanliness and lens surface damage.

**Skin Protection:** For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE), describe the nature of the hazard and the steps that will be taken to protect against the hazard.

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.

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 precautions that will be taken to prevent eye injury.

<b>EYEWEAR REQUIREMENTS</b>					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
Diode-Pumped Solid State Laser	532	2.4	NA	<20 cm	Laser- GARD

<b>EYE WEAR SPECIFICATIONS</b>		
Laser System Eyewear Identification***	Wavelengths	Optical Density
Laser- GARD	532 nm	OD > 4.5

\*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.

Qualified laser operators will use the attenuation filter to reduce laser intensity to minimum instead of orange filter on the microscope to do system alignment.

## TRAINING

### LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the BNL Internet based training course TQ-LASER Qualified Laser Operators must also complete system-specific orientation with the system owner/operator.

**System-specific training includes:**

- Review of this program documentation
- Review of SOPs

System-specific training is documented on the Laser OJT Form located at:

<http://www.nsls.bnl.gov/training/Courses/Lasers/LS-Laser-OJT-form.pdf>, which requires:

- SOP Number (and revision number, if applicable)
- Trainee name and signature
- Owner/Operator signature
- Date

All laser safety training must be repeated every two years.

### MEDICAL SURVEILLANCE

Operators of ANSI Class 3b and 4 laser systems must complete a baseline medical eye examination prior to laser system operation. Any qualified ophthalmologist may complete this exam. BNL has arranged for this service from the local physicians. Contact the Laser Safety Officer for current listing.

Personnel using physicians other than those listed must have their examination records forwarded to the BNL Occupational Medicine Clinic.

## FEEDBACK AND IMPROVEMENT

Comments and suggestions for improvement should be directed to BNL-Laser Safety Officer, Chris Weilandics (X2593; weil@bnl.gov).



## LASER USER QUALIFICATION

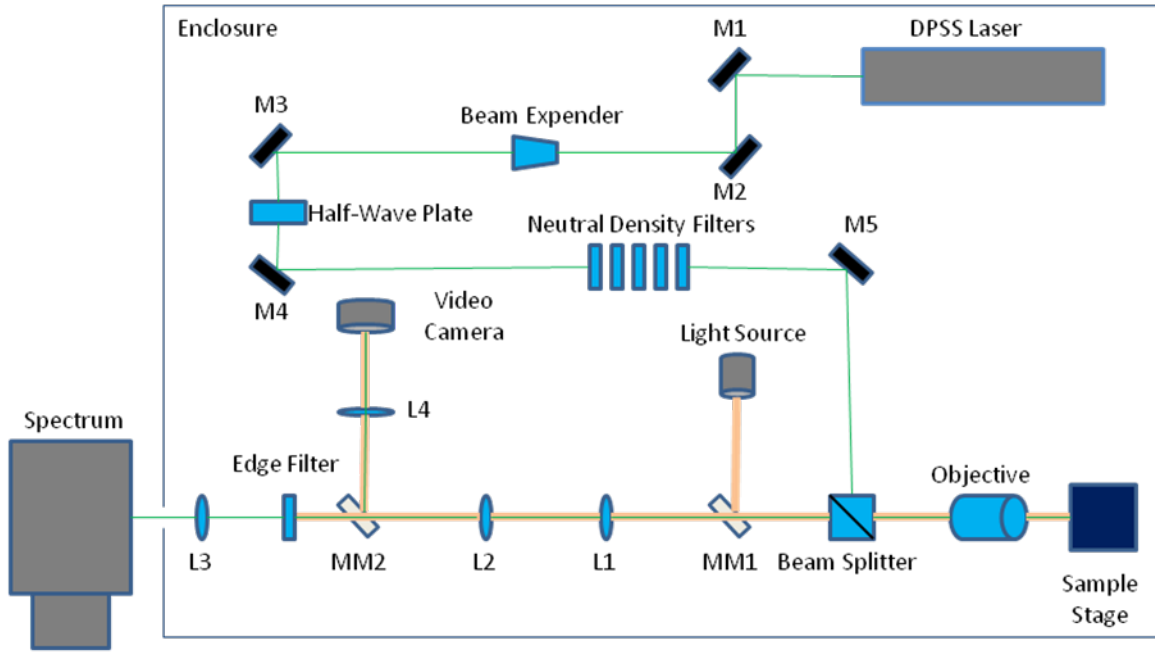
Personnel qualified to work with this laser system are listed below. These Qualified Laser Operators must understand the information and conform to the requirements contained in this document. For training and medical surveillance, enter the date of completion.

### Qualified Laser Operators:

Basic Laser Training	Job-Specific Training	Medical Surveillance	Printed Name	Signature	Owner/Oper. Initial/date
06/23/09	02/01/2011	08/04/2003	Zhiqiang Chen		
07/15/10	02/07/2011	06/16/2010	Xinguo Hong		

**Appendix 1: DPSS Laser system for Raman and pressure measurement schematic diagram**

**Scheme of Ruby/Raman System**



M: reflecting mirror; MM: movable mirror; L: focus lens

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Appendix 2:

## **Configuration Checklist for Operation of X17C DPSS Laser System**

Only authorized personnel are permitted to operate the DPSS laser.

The following checklist will be posted inside of laser room, 1-134C to guide users to use laser system safely.

Before turning on DPSS laser, complete the following review using the schematic shown in Appendix 1:

Assure that the Laser Controlled Area Postings are in place.

- (1) Ensure the laser power is set at the power output as 50% of the maximum power.
- (2) Check the DPSS laser filter is on the video camera position.
- (3) Ensure all sliding doors of the enclosure are closed to avoid any leakage of the reflecting laser.
- (4) Both of movable mirrors (MM1 and MM2) need to be flipped up for video imaging and to be flipped down for spectrum collecting.

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## Appendix 3: SOP

# Standard Operating Procedure (SOP) and Check List for X17C Class 3B DPSS Laser System

## 1. DPSS laser maintenance

The DPSS laser maintenance procedures are only to be done by Ventus Company.

## 2. DPSS laser system alignment procedures.

These alignment procedures are only to be done by the laser owner or the person has approval of the laser owner.

The procedure is as following:

- Close the door to the Laser Controlled Area (Rm. 1-134C)
- Assure proper configuration of the optical path and LCA (checklist).
- **Check the DPSS laser filter is on the camera position**
- Never try to observe laser beam directly even with safety goggles.
- Check the Laser power potential meter is at lowest position.
- Before take orange DPSS laser filter away for alignment, add neutral laser intensity filter 2 to reduce the laser intensity to lower than 2mw for the alignment
- Turn DPSS laser on.
- Very carefully to do the optical alignment coaxially for all mirrors and lens.
- The CCD detector should be Air-cooling more than 5minutes before using it.
- Using WizSpec/32 program to do the signal/noise ratio measurement until the ratio is bigger than the desired one.
- Never leave the system unattended during operation. If need to leave the room 1-134C, push down the shutter on the laser head. And put the note on to show that the laser in on and you will be back in half hour.
- If you need to leave the room for more than half hour, turn off the DPSS laser. Leave the fan on for cooling the laser.

## 3. Operation procedures for sample measurements.

- Close the door to the Laser Controlled Area (Rm. 1-134C)
- The operator has to have BNL laser training, eye examination and X17C DPSS laser SOP training before using DPSS laser.
- Never try to observe laser beam directly even with safety goggles.
- Assure proper configuration of the optical path and LCA (checklist).
- The CCD detector should be Air-cooling more than 5minutes before using it.
- Align DAC to focus sample on the microscope or CCD camera with optical fiber lights.
- Check the Laser power potential meter is at lowest position.

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- Check the DPSS laser orange filter is on the video camera position again.
- Turn laser on. Find ruby with microscope.
- Do measurement with WizSpec/32 program. Use the neutral filter to get reasonable intensity signal.
- Never leave the system unattended during operation. If you are not using laser system within 30 minutes, push the shutter on the head of the laser down to block laser beam and leave the laser on. And put the note on to show that the laser in on and you will be back in half hour.
- If you will not come back to use the system for more than half hour or finish measurement, turn the laser off. Leave the fan on. (The fan will automatically stop when system is cooled down)