Contents: Laser Safety

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

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2. Developing the Laser Controlled Area Documentation	• Identify controls to be documented. • Register Class 3b and 4 lasers. • Revise the existing Laser Controlled Area SOP or develop a new one. • Annually review Laser Controlled Area SOP.
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Equipment
Definitions

Exhibits

Alignment Guidelines
Bibliography of Laser-related Resources
Biology Alignment Practice
Collider-Accelerator Department (CAD) EEMC Laser Alignment
Engineered and Administrative Controls Matrix
Examples of Standard Operating Procedures (SOPs) from Working Laboratories
General Guidance for Laser Protective Eyewear
Guidance on Interlock Systems for Lasers
Guidelines for Laser Pointer Safety
Instrumentation Ti:Sapp Operation
Instrumentation YAG Operation
Laser Commissioning Process Flowchart
Laser-Electron Accelerator Facility (LEAF) Working Procedures
Laser Safety Inspection (BNL Chemistry Example)
Outline for ANSI Z136.1-2000 Topics
Source Development Laboratory Reference Document: Laser Eyewear Requirements
YAG Laser Operations at Accelerator Test Facility (ATF)

Forms

BNL General Laser Registration Form
BNL General Class 2/3A Laser Use Permit
Laser Controlled Area Standard Operating Procedure (SOP)
Laser System-Specific Training Checklist
Laser User Medical History and Examination Form with Instructions
Laser User Qualification Form
System Training Log

Training Requirements and Reporting Obligations

This subject area contains training requirements. See the Training and Qualifications Web Site.

This subject area does not contain reporting obligations.

References

American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers. ANSI Z136.1-2000, Laser Institute of America, Orlando, FL.

BNL Training and Qualifications Web Site

ES&H Standard 1.5.0, Electrical Safety

ES&H Standard 1.5.1, Lockout/Tagout Requirements

ES&H Standard 1.5.2, Design Criteria for Electrical Equipment

ES&H Standard 1.5.3, Interlock Safety for Protection of Personnel

Work Planning and Control for Experiments and Operations Subject Area

Standards of Performance

Management systems, standards, implementing procedures, and guidelines shall be developed with appropriate input from staff enabling them to effectively work in compliance with applicable requirements.

All staff and guests shall ensure that personnel radiation exposure is maintained As Low As Reasonably Achievable (ALARA).

All staff and guests shall comply with applicable Laboratory policies, standards, and procedures, unless a formal variance is obtained.

All staff and users shall identify, evaluate, and control hazards in order to ensure that work is conducted safely and in a manner that protects the environment and the public.

Management System

This subject area belongs to the **Worker Safety and Health** management system.

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Introduction: Laser Safety

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The subject area provides procedures and guidelines for working with lasers at Brookhaven National Laboratory (BNL) that conform to ANSI Z136.1-2000, American National Standard for the Safe Use of Lasers. The subject area is not a restatement of the standard, although the exhibit Outline for ANSI Z136.1-2000 Topics is provided and copies of the full standard are available from the research library.

The potentially more hazardous Class 3b and 4 laser systems are emphasized, but requirements for all lasers used at BNL are covered in this subject area. Exhibits that illustrate the implementation of the Laser Safety Program for different types of installations at BNL are included. The exhibit Bibliography of Laser-related Resources is also provided for reference.

The Laser Commissioning Process Flowchart shows the path for commissioning and operating lasers at BNL. It is highly recommended that laser owners/operators seek assistance from the Laser Safety Officer (LSO) early in the planning process for a laser installation.

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Subject Area: ***Laser Safety***

1. Conducting the Safety Hazard Analysis

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Applicability

This information applies to all staff who design and/or set up workplaces where lasers are to be used.

Required Procedure

Staff planning an operation involving the use of a laser must provide for a workspace with appropriate engineered and administrative controls. Refer to the Work Planning and Control for Experiments and Operations Subject Area when planning experimental work, as well as ES&H Standard 1.5.2, Design Criteria for Electrical Equipment.

Step 1	Notify Line Managers or Building Managers, where applicable, of the workspace during the preparation of all safety hazard analyses. The Line Manager or Building Manager may allow or deny the planned use of selected workplaces for specific applications and systems. **Note:** Appeals may be made to Line Managers.
Step 2	Characterize the laser output and determine the classification of the laser or laser system.
Step 3	Register the lasers to be used by completing the BNL General Laser Registration Form. Operations for Class 2/3A lasers only outside of a normal Laser Controlled Area can be addressed through the use of the BNL General Class 2/3A Laser Use Permit. Send both forms to the Laser Safety Officer.
Step 4	Identify associated nonlaser hazards. See the exhibit Hazards Associated with Using Lasers.
Step 5	Evaluate the risk posed by the laser hazards. For Class 3b and 4 lasers, complete the Laser Controlled Area Standard Operating Procedure, in consultation with the Laser Safety Officer

	consultation with the Laser Safety Officer.
Step 6	Using the exhibit Engineering and Administrative Controls, determine engineered and administrative controls that would mitigate unacceptable risk. Evaluate the costs and benefits. **Note:** If you use interlocks, follow ES&H Standard 1.5.3, Interlock Safety for Protection of Personnel. For more information on interlocks, see the exhibit Guidance on Interlock Systems for Lasers.

Guidelines

When selecting a workplace where lasers will be used, staff may first want to identify available workspace with existing engineered controls in place to minimize modification investment. When selecting space, consider the following factors:

- Spaces already set up for lasers containing
  - a laser interlock system;
  - ANSI-approved signs;
  - light enclosure to control laser light to the working area;
- Accommodation of area to bench layout requirements of laser;
- Risks to others present.

The following exhibits may be useful:

Engineered and Administrative Controls Matrix

Guidance on Interlock Systems for Lasers

References

ES&H Standard 1.5.2, Design Criteria for Electrical Equipment

ES&H Standard 1.5.3, Interlock Safety for Protection of Personnel

Work Planning and Control for Experiments and Operations Subject Area

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Subject Area: ***Laser Safety***

2. Developing the Laser Controlled Area Documentation

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Applicability

This information applies to staff who are involved in operations utilizing Class 3b or 4 lasers.

Required Procedure

A BNL Laser Controlled Area Standard Operating Procedure (SOP) must be developed. It is a key safety document that must be consistent with the guidance provided in the subject area. The SOP must include appropriately detailed information on configuration, administrative controls, engineering controls, personal protective equipment, and staff training requirements. Revisions to existing documentation must follow the format of the SOP. The exhibit Examples of Standard Operating Procedures (SOPs) from Working Laboratories provides representative examples from laser installations at BNL.

Step 1	Using hazards analysis information and consequent engineering and administrative controls identified from the hazards analysis (see the section Conducting the Safety Hazard Analysis), identify those controls that need to be documented in a laser controlled area standard operating procedure (SOP).
Step 2	For Class 3b and 4 lasers, register the lasers on the BNL General Laser Registration Form.
Step 3	Revise the existing Laser Controlled Area SOP, if appropriate, or develop a new Laser Controlled Area SOP, making sure to include the following • The safe operating envelope for anticipated configurations and operating modes (routine operation, maintenance including alignments, and service), where appropriate; • Requirements for worker qualification (see the section on Ensuring Worker Qualification);

	Qualification); • Approval signatures of the Line Manager, Environmental Safety and Health Coordinator, and Laser Safety Officer.
Step 4	Annually review the Laser Controlled Area SOP to ensure that it accurately reflects current activities.

Guidelines

The use of working procedure documents separate from the Laser Controlled Area SOP is encouraged as long as they do not modify the safety envelope of the installation. Documents of this type provide a useful reminder of working practices as well as an important training aid. Some examples of laboratory working procedures are provided by the following exhibits:

Alignment Guidelines

Biology Alignment Practice

Collider-Accelerator Department (CAD) EEMC Laser Alignment

Instrumentation Ti:Sapp Operation

Instrumentation YAG Operation

Laser-Electron Accelerator Facility (LEAF) Working Procedures

Laser Safety Inspection (BNL Chemistry Example)

YAG Laser Operations at Accelerator Test Facility (ATF)

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Subject Area: ***Laser Safety***

3. Using Class 2 and 3a Lasers

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Applicability

This information applies to all staff who operate Class 2 or 3a lasers.

Required Procedure

Although laser pointers are exempt from any registration requirements, staff are required to utilize them safely and responsibly. See the exhibit Guidelines for Laser Pointer Safety for guidelines on use.

Step 1	Register Class 2 and 3a lasers using the BNL General Laser Registration Form. If the laser is to be used outside a laser controlled area approved for Class 3b or 4 lasers, continue to steps 2 and 3.
Step 2	Complete the BNL General Class 2/3A Laser Use Permit and review it with the Laser Safety Officer. The Laser Owner/Operator retains the original form. The Laser Safety Officer retains the copy.
Step 3	Obtain the appropriate signs for the area from the Laser Safety Officer, and post the area.

Guidelines

Where practical, Class 2 laser devices should be used. These may be available from the Laser Safety Officer.

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4. Installing Laser Equipment

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Applicability

This information applies to staff who set up and/or install Class 3b or 4 lasers.

Required Procedure

Staff must ensure that the laser, laser hardware, and laser safety engineered controls are consistent with the guidelines in the exhibit Engineered and Administrative Controls Matrix.

Step 1	Determine if a facility modification permit or engineered design is required.
Step 2	Notify the Building Manager of the intent to install the laser system.
Step 3	Install the laser to operate in conformance to the engineered and administrative controls identified for this laser operation (see the section Conducting the Safety Hazard Analysis), and in accordance with ANSI-Z136.1-2000, American National Standard for the Safe Use of Lasers.
Step 4	Where appropriate, install laser such that laser radiation above the maximum permissible exposure is limited to the laser table. Otherwise, ensure that laser radiation is controlled within the established Nominal Hazard Zone (NHZ) control area.
Step 5	Ensure that all administrative and engineering controls are in place.
Step 6	The Laser Safety Officer reviews and approves the laser configuration and installation.

References

American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers. ANSI Z136.1-2000. Laser Institute of America. Orlando, FL.

of Laser. ANSI Z136.2 2000, Laser Institute of America, Orlando, FL.

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Subject Area: ***Laser Safety***

5. Ensuring Worker Qualification

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Applicability

This information applies to BNL staff and non-BNL staff who operate Class 3b and 4 lasers. It also applies to staff who supervise users of lasers or laser systems.

Required Procedure

Ensuring Worker Qualification contains two subsections:

5.1 Medical Evaluations
5.2 Laser Safety Training

Staff using or supervising users of lasers or laser systems must meet medical and training qualification requirements consistent with ANSI Z136.1- 2000, American National Standard for the Safe Use of Lasers.

5.1 Medical Evaluations

Baseline medical eye examinations are required and provided for individuals working with or in an area of Class 3b or 4 lasers. When an examination is required, a user must receive the examination before participating in laser work. Pertinent examinations are repeated following any suspected laser injury.

Step 1	The Line Manager identifies staff requiring laser medical examinations based on potential exposure to Class 3b or 4 laser radiation.
Step 2	The line manager provides each user requiring a laser eye exam with a Laser User Medical History and Examination Form with Instructions.
Step 3	The user completes Part A of the Laser User Medical History and Examination Form with Instructions and contacts one of the contracted local ophthalmologists

	Form with Instructions and contacts one of the contracted local ophthalmologists listed on the form instructions to schedule a baseline laser eye examination. The ophthalmologist records the eye exam on Part B of the form and forwards both parts of the completed form to the BNL Occupational Medicine Clinic (OMC). Staff, off-site personnel, guests, and students, who are resident laser users, may obtain laser eye examinations through opthalmologists other than those listed. The ophthalmologist's exam should be recorded on Part B of the Laser User Medical History and Examination Form with Instructions. Users who have had a recent laser eye exam can fax or mail a copy of this exam to OMC, accompanied by a completed part A of the Laser User Medical History and Examination Form with Instructions, in lieu of a new exam. OMC reserves the right to reject forms that are too old or do not meet the minimal requirements of ANSI Z136.1- 2000. In general, an acceptable substitute exam must be no more than 3 years old and have substantially the same content as Part B of the Laser User Medical History and Examination Form with Instructions.
Step 4	OMC reviews the information it receives and contacts the user if any additional information or examinations are needed. When all requirements are met, OMC notifies the Training and Qualifications Program Office that the protocol has been completed.
Step 5	The Line Manager ensures that requirements for laser medical examinations are met before the user begins laser operations.
Step 6	The user must report any injury/exposure involving lasers to their Line Manager and report to the OMC.

5.2 Laser Safety Training

Both basic and job-specific laser safety training are required and provided for laser users and temporary visitors, or guest laser users working in a Class 3b and Class 4 laser controlled area. Basic laser safety training must be retaken every 2 years.

Step 1	The Line Manager must ensure that staff have met requirements for basic laser safety training, as described in step 2, before they participate in laser work.
Step 2	**Basic Laser Safety Training** Ensure each resident laser user, temporary visitor, or guest completes the awareness level web-based training course TQ-LASER before beginning work (see the BNL Training and Qualifications Web Site).
Step 3	**Job-Specific Training** The Laser Owner/Operator ensures that adequate training has been provided to laser users for operating the lasers for which they are responsible. The Laser Owner/Operator conducts an orientation for the trainee of the laser operation and its controlled area requirements. Completion of training is documented using a System Training Log maintained by the Laser

	Owner/Operator.

Guidelines

The following exhibits are examples of tools for tracking the training of laser users and can be used to assist in developing a training program for new installations:

Laser System-Specific Training Checklist

Laser User Qualification Form

References

American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers. ANSI Z136.1-2000, Laser Institute of America, Orlando, FL.

BNL Training and Qualifications Web Site

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Subject Area: ***Laser Safety***

6. Wearing Personal Protective Equipment

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Applicability

This information applies to all staff who operate Class 3b or 4 lasers.

Required Procedure

Step 1	Each staff member identifies specification and usage requirements for laser safety eyewear as described in the exhibit Laser Controlled Area Standard Operating Procedure (SOP).
Step 2	The Line Manager ensures that the laser safety eyewear identified is of the appropriate optical density and covers the appropriate wavelength produced by the laser. Staff must wear laser safety eyewear, where appropriate, to reduce risk of eye injury. See the exhibit Source Development Laboratory Reference Document: Laser Eyewear Requirements, which contains an example of a format for a user aid. For information on protective eyewear, refer to the exhibit General Guidance for Laser Protective Eyewear.
Step 3	The Line Manager ensures that skin protection in the form of clothing or screening lotion is provided for staff, where appropriate. Staff must wear skin protection to reduce exposure to laser radiation to skin where applicable.

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Definitions: Laser Safety

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Term	Definition
Class 1 laser	A type of laser that is incapable of emitting damaging radiation levels, except for embedded Class 3b or Class 4 lasers.
Class 2 laser	A laser system that has a low hazard potential because of the expected aversion response. There is some possibility of injury if stared at longer than the 1/4-second aversion response.
Class 3a laser	A laser or laser system that normally cannot produce a hazard if viewed for only momentary periods with the unaided eye. Class 3a lasers can present a more serious hazard if viewed through collecting optics such as a microscope or telescope.
Class 3b laser	A laser that has a moderate hazard category. Class 3b lasers may cause retinal damage if the energy is collected and focused into the eye or if viewed directly. Mirror-like (specular) reflection of the beam is also considered hazardous. Class 3b lasers also may present a minor skin hazard. They do not produce hazardous diffuse reflections except at very close viewing distances.
Class 4 laser	Those systems that emit radiation, either directly or by diffuse reflection, that may be hazardous to personnel or constitute a fire hazard. These systems require the use of controls that prevent exposure of the eye and skin or other unwanted targets to specular or diffuse reflections of the beam. These lasers have a high hazard category.
controlled area	An area where the presence and activities of personnel are subject to control and/or supervision to protect them from the laser beam and its associated hazards.
laser owner/operator	The individual responsible for the laser or laser system and who controls the use, repair, and alignment of the laser. The individual is the custodian of the laser.
Laser Safety Officer	The individual who has authority to monitor and enforce measures to control laser hazards and effect the knowledgeable evaluation

	and control of laser hazards.
laser user	The individual conducting hands-on work with the laser equipment. This may be an individual using the laser under the guidance of the laser operator.
maximum permissible exposure (MPE)	The level of laser radiation to which a person may be exposed without experiencing hazardous effects or adverse biological changes in the eye or skin. (The MPE is determined by the criteria specified in Section 8 of ANSI Z136.1 - 2000).
nominal hazard zone (NHZ)	The space within which the level of the direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE.
resident laser users	Resident staff that are full- or part-time BNL employees or resident visitors, such as post-doctorate and visiting alumni, who are resident at the BNL campus for periods of 6 weeks or longer per year.
temporary guest users	Temporary visitors/guests who are not BNL employees, or BNL employees who are resident at the BNL campus for less than 6 weeks per year.

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Subject Area: ***Laser Safety***

Alignment Guidelines

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Alignment Guidelines is provided as a Word file.

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ALIGNMENT GUIDELINES

Appendix A
Laser Alignment Procedure
David Taylor, CLSO,
LSO Lawrence Livermore National Laboratory

(Note: the RI/DLSOs are free to edit verbiage and choose which points to include and tailor to their setup in the "*Procedural Considerations"* and the "*Alignment Methods to be used for this laser"* sections only. Leave the intro line and paragraph below. It is intended that this wording below be either 1) included into the body of an OSP, 2) as an appendix, 3) attached to the IWS, 4) or as a stand-alone document. In all cases, it must be reviewed by the Responsible Individual (and possibly signed off by the LSO/DLSO) periodically, at a minimum annually or as operations change). **Delete this paragraph before you finalize the procedure. Don't forget to edit the header above.**

Procedural Considerations

1. 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.
2. Access to the room/area is limited to authorized personnel only.
3. Consider having someone present to help with the alignment.
4. All equipment and materials needed are present prior to beginning the alignment
5. All unnecessary equipment, tools, combustible material (if fire is a possibility) have been removed to minimize the possibility of stray reflections and non-beam accidents.
6. Persons conducting the alignment have been authorized by the RI
7. A NOTICE sign is posted at entrances when temporary laser control areas are setup or unusual conditions warrant additional hazard information be available to personnel wishing to enter the area.

Alignment Methods to be used for this laser

1. There shall be no intentional intrabeam viewing with the eye. (This statement must remain. Do not delete.)
2. Co-axial low power lasers should be used when practical for alignment of the primary beam.
3. Reduce the beam power through the use of ND filters, beam splitters and dumps, or reducing power at the power supply. Avoid the use of high-power settings during alignment as much as is practical.
4. Laser Protective Eyewear shall be worn at all times during the alignment, within the parameters and notes established on the accompanying laser table.
5. (this paragraph must be accepted or deleted in it's entirety) The LSO has authorized reduced optical density eyewear to allow the beam spot to be seen. Measures shall be taken and documented to ensure that no stray hazardous specular reflections are present before the lower OD eyewear is worn. A return to the Maximum OD eyewear as listed in the laser table will be made when the alignment is complete. The eyewear is labeled as alignment eyewear and is stored in a different location than the standard laser eyewear for this operation.
6. Skin protection should be worn on the face, hands and arms when aligning at UV wavelengths.
7. Beam Control- the beam is enclosed as much as practical, the shutter is closed as much as practical during course adjustments, optics/optics mounts are secured to the table as much as practical, beam stops are secured to the table or optics mounts.
8. Areas where the beam leaves the horizontal plane shall be labeled.
9. Any stray or unused beams are terminated.
10. Invisible beams are viewed with IR/UV cards, business cards or card stock, craft paper, viewers, 3x5 cards, thermal fax paper, Polaroid film or similar technique. Operators are aware that specular reflections off some of these devices is possible, and that they may smoke or burn.

11. Pulsed lasers are aligned by firing single pulses when practical.
12. No intra-beam viewing is allowed unless specifically evaluated and approved by the LSO/DLSO. Intrabeam viewing is to be avoided by using cameras or fluorescent devices.
13. Normal laser hazard controls shall be restored when the alignment is completed. This includes enclosures, covers, beam blocks/barriers have been replaced, and affected interlocks checked for proper operation.

This document is to be reviewed in one year from the date of the OSP/IWS, or as conditions warrant, which ever is the shorter time period

Reviewed by:

_____

LSO/DLSO Date

Approved/Reviewed/Revised by

_____

Responsible Individual Date

Beam alignment requires work with an open beam and involves directing the beam toward a series of reflective or partially reflective surfaces, such as mirrors or lenses, so that the beam follows some predetermined path. With respect to the laser, alignments may be internal or external.

Internal alignments are those occurring within the laser cavity or head and often place the worker at increased risk of electrical accidents as well as beam exposure. The need for internal alignments arises most often because of problems associated with beam mode or power.

External alignments are those that occur from the laser's end window to some terminal target. In between these two locations may be a number of optical components (optics) arrayed in more or less complex configurations. The need for external alignments occurs because of reconfiguration of the optical setup or replacement of components either within the laser head or in the open beam path. External alignments may be optical table (benchtop), laser-to-fiberport, fiberport-to-fiberport, free-space transmission, beam-to-sensor (receiver), and laser therapy. The following practices are most applicable to external alignments on the optical table.

General Considerations

1. **Co-Workers**: Consider performing alignments with a colleague or "buddy." Review alignment operating procedures with that person

2. **Prepare**: In advance, identify and obtain equipment and materials necessary to perform alignment.
    a. View beams indirectly: remote viewing, thermal paper, ceramic discs, IR/UV viewing scopes, paper business 3x5 inch cards, phosphor-viewing cards.
        i. Make sure viewing cards have diffusing surfaces.
        ii. Cover the face of cards with specular surfaces with clear, matte-finish tape.
        iii. If fluorescent viewing cards need optical charging, have a UV lamp on hand.
        iv. Make sure conversion wavelengths are visible through protective eyewear.
    b. Tools, targets, beam stops/blocks, power meter/detector, beam profiling system, curtain, signage, caution tape.
    c. Make sure tools or items used in an around the beam path have non-reflective, diffusing surfaces at the wavelength(s) to be aligned.
    d. Be aware of the Maximum Permissible Exposure levels for the type of laser you'll be working with.
    e. Personal protective equipment (PPE): alignment eyewear, operational power eyewear, face shields for scattered UV, skin protection as necessary.

3. **Housekeeping**: Pay attention to housekeeping; make sure the immediate work area/benchtop/optical table is free from opportunistic specular reflectors that are not needed for alignment (glass bottles, razor blades, forceps, screw drivers, optical posts, photographic paper, plastic, dye cells, etc.)

4. **Sources of Reflection**: Remove jewelry from hands, wrist, ankles, ears, and neck that may be reflectors and are electrically conductive; if jewelry (e.g., wedding bands) is not easily removed, cover with multiple layers of electrical tape; remove tie tacks/clasps and neckties and materials in shirt pocket that may fall into the beam path.

5. **Posting**: A NOTICE sign is posted at entrances when temporary laser control areas are setup or unusual conditions warrant additional hazard information be available to personnel wishing to enter the area.

Alignment Methods to be used for this laser

1. Make sure that the beam shutter is closed or a beam block is in front of the end window. Make sure beam block is securely mounted.

2. Isolate and demarcate the area to avoid distractions and minimize the hazard to others.
    a. If Class-IV, open-beam system, make sure exterior warning signs/indicators are functioning, or posted if interlocks are not active.
    b. If embedded high-power laser, establish temporary laser controlled area.
        i. Restricted to authorized and trained individuals.
        ii. Use beam blocking barrier or laser curtain to contain beam
        iii. Cover windows or viewing ports that are within the controlled area.
        iv. Use “Notice” and “Danger” signs per ANSI Z136.1.
3. Confine the beam to the optical table or benchtop.

4. If the primary laser is optically pumped by another laser and alignment of the pump beam is necessary, block the primary beam to limit potential multi-wavelength exposure/eyewear concerns, align the pump beam then replace beam enclosure in the pump-to-laser beam path.

5. Prepare the beam delivery system: remove beam tubes or other parts of the protective housing as necessary, including extended sections that may be covered by beam tubes or bellows; check all optics (mirrors, lenses, filters, polarizers, expanders, etc.) and optomechanical components (base plates, post holders and fasteners, mirror mounts, etc.) ensuring they are currently aligned (for changes/additions to an existing alignment) and securely mounted.

6. If the beam path to be aligned is located in different rooms, locate a beam block in the beam path between the rooms, and align one room, then the other. If line of sight with buddies in other rooms is blocked, use two-way, real-time communications. Be patient at each step.

7. Use the minimum beam power/energy for as many alignment steps as possible or use a low-power, coaxial laser for path simulation.
    a. For CW lasers with adjustable power, adjust the power to a minimum stable level.
    b. For pulsed lasers, use single pulses and/or reduce pump power, where practical.
    c. For Q-switched lasers, turn off the Q-switch and use in the low-power, CW mode
    d. In some cases, power-reducing (e.g., neutral density) filters may be used during alignment.
    e. Ensure that you have protective eyewear with the appropriate value of optical density for the beam power; using high OD eyewear that is suitable for normal operation with low-power, alignment beams is a formula for failure as is wearing low OD, alignment eyewear for high-power beams.

8. Proceed with system alignment:
    a. Wear laser protective eyewear to view diffuse reflections from viewing devices.
    b. Never view laser beams directly unless the scenario has been specifically approved by a knowledgeable laser safety officer (LSO).
    c. Perform the “rough” or coarse” alignment with the beam blocked.
    d. As you progress down the optical path, place beam blocks behind optics to be adjusted to stop errant (stray) beams.
    e. When using viewing aids to visualize the beam, reach into the beam path slowly and deliberately with the card slightly angled so you can see the diffuse reflection. Adjust the optic so that the beam strikes the card just in front of the surface of the component.
    f. If the beam path changes elevation (+Z), be aware of the increased potential for vertical reflections.

g. Close the shutter or insert the beam block during adjustments; re-secure optics making sure components are properly located/adjusted.
h. Be aware of the potential for errant reflections (stray beams) from components such as polarizers and dielectric mirrors. Check for stray beams at each step and again after completing all alignment steps.
i. If the alignment has been performed at lower power or with a low-power collinear beam but final steps will be performed at operational power levels, be sure and change to the appropriate eyewear for the high-power beam.
j. Communicate with your co-worker at all times (e.g., during change of process step or before removal of protective eyewear.

9. Restore the system to normal operational mode (pay attention to the protective housing, interlock switches, and shutters) and verify normal operation.

Subject Area: ***Laser Safety***

Bibliography of Laser-related Resources

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

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Subject Area: ***Laser Safety***

Biology Alignment Practice

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Biology Alignment Practice is provided as a Word file.

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BIOLOGY ALIGNMENT PRACTICES

Laser Alignment Fundamentals
-Class IIIb and IV Lasers-

Prealignment Procedures:

-Remove all jewelry/watches from hands and wrists
-Consider having limited access to the laser area before starting
    *Post signs, lock doors, erect barriers…
-Alignment may be easier and safer with two qualified operators
-Locate the proper safety goggles for the wavelength(s) of the laser(s)
-If the power output of the laser can be adjusted, set it to the lowest
    *Otherwise, install an attenuator directly in front of the output
    *A coaxial low power (visible) laser may fit into the optical layout
-Remove clutter from in and around the alignment area
-Have everything you need on hand before beginning
    *Fluorescing cards, screens, tools, etc.
-Check to see that all optics and translators are secure

During Alignment:

-Wear the specified safety goggles.
-Never look directly into the beam, no matter what power!
    *A mirror or reflective surface can direct the beam inadvertently into someone's eye.
-Observe the beam indirectly using a card, screen, paper, fluorescent material, etc. (many items fluoresce at wavelengths which the laser goggles will transmit).
    *Class IV lasers may ignite certain alignment aids!
    *Class IIIb lasers may also ignite certain materials when focused.
    *Skin (hands, arms, etc.) should not be placed into the beam.
-UV lasers present a "sunburn" hazard from scattered light.
    *Cover exposed skin.
    *Wear specified safety goggles, even low power scattered UV light will burn the eyes!
-With visible lasers, when the power is attenuated to below a Class IIIb, safety glasses may be removed to view scattered light directly.

Subject Area: ***Laser Safety***

Collider-Accelerator Department (CAD) EEMC Laser Alignment

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Collider-Accelerator Department (CAD) EEMC Laser Alignment is provided as a Word file.

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Collider-Accelerator Department (CAD) EEMC Laser Alignment

Appendix 2: Procedure checklist

for alignment and maintenance of the EEMC Laser

(Only authorized and properly trained laser operators[*] listed in the SBMS Laser Controlled Area SOP may perform these steps. The lid of the primary box may be open.)

- Sign out the laser power supply key from the cabinet in the STAR trailer.
- Check that the removable access ladder is in place and available.
- Inspect primary, 1st-, and 2nd-level splitter boxes to ensure that no interconnecting fibers have been disconnected or removed.
- Verify the integrity of the enclosure curtain.
- Ensure that only authorized operator are within the curtained enclosure.
- Verify that operation of the primary box lid interlock: follow procedures and complete appropriate section of the "Laser Interlock Checklist."
- Set up laser warning sign at top of ladder and lighted sign at the access point.

[*] These individuals are listed in the EEMC Laser SBMS SOP as "Qualified Laser Operators"

- Check that the infra-red beam sensor is installed, and verify its operation: follow procedures and complete the "Laser Interlock Checklist."
- Check that all operators inside laser enclosure are wearing authorized eye protection.
- Turn on AC power, use key to enable power supply.
- Use local control to energize laser to needed intensity

Additional safety steps for all lid-open operations

- Enable Infra-Red Interlock Mode.
- Ensure there are no mirrors or sharply reflective surfaces anywhere inside the primary box, other than those rigidly attached to the optical bench.
- Ensure that any temporary beam stops to be employed are diffusely reflective or absorptive.
- Set and keep the laser output intensity as low as possible during all alignment procedures.
- Do not leave the curtained area at any time while the lid is open.
- Disable Infra-Red Interlock Mode upon completion of alignment and maintenance operation.

Operator's name (print): _____ Date: _____

Signature: _____

Appendix 3:

Procedure checklist to verify the operation of the EEMC Laser Interlock System

(These procedures may be performed only by authorized and properly trained laser operators.[*]
The lid of the primary box will be open during some steps.)

- Sign out the laser power supply key from the cabinet in the STAR trailer.
- Check that the removable access ladder is in place and available.
- Close the manual shutter on the laser head.
- Close the lid to the primary laser box.
- Turn on AC power, use key to enable the power supply.
- Set flashlamp voltage to zero.
- Put on authorized eye protection.
- Close the manual shutter on the laser head.

<u>Testing the primary box interlock:</u>

- Disable Infra-Red Interlock Mode.
- Close the lid to the primary laser box.

[*] These individuals are listed in the EEMC Laser SBMS SOP as "Qualified Laser Operators"

- Push the “stand-by” button; verify that laser is ready to fire (stand-by light remains on after 7-second warning beep).
- Open the box lid; verify that laser control reverts to “stop” mode.
- Verify that laser cannot be returned to “stand-by” mode with lid open.
- Close box lid; verify that laser can now be returned to “stand-by” mode.

Testing the infra-red beam sensor interlock:

- Enable Infra-Red Interlock Mode.
- Check that sensor system is installed and receiving AC power.
- Remove any interruptions to the IR beam (red light should go off).
- Push the “stand-by” button; verify that laser is ready to fire (stand-by light remains on after 7-second warning beep).
- Interrupt the IR beam; verify that laser control reverts to “stop” mode.
- Remove interruption; verify that laser can now be returned to “stand-by” mode.
- Disable Infra-Red Interlock Mode.

Operator’s name (print): _____ Date: _____

Signature: _____

[*] These individuals are listed in the EEMC Laser SBMS SOP as “Qualified Laser Operators”

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Subject Area: ***Laser Safety***

Engineered and Administrative Control Matrix

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The table summarizes the hazard controls described by ANSI Z136.1-2000. The applicable sections are referenced in parentheses. The engineering control measures recommended in the table may be replaced by alternatives that are approved by the Laser Safety Officer and provide equivalent protection.

Control Measures	**Classification**				
Engineering Controls	1	2	3a	3b	4
Protective housing requirements (4.3.1)	R	R	R	R	R
Without protective housing (4.3.1.1)	Laser Safety Officer establishes Alternate Controls.				
Interlocks on protective housing (4.3.2)	E	E	E	R	R
Service access panel (4.3.3)	E	E	E	R	R
Key control (4.3.4)	--	--	--	S	R
Viewing portals (4.3.5.1)	--	MPE	MPE	MPE	MPE
Collecting optics (4.3.5.2)	MPE	MPE	MPE	MPE	MPE
Totally open beam path (4.3.6.1)	--	--	--	R NHZ	R NHZ
Limited open beam path (4.3.6.2)	--	--	--	R NHZ	R NHZ
Enclosed beam path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 are fulfilled.				

Remote interlock connector (4.3.7)	--	--	--	X	R
Beam stop or attenuator (4.3.8)	--	--	--	X	R
Activation warning systems (4.3.9.4)	--	--	--	S	R
Emission delay (4.3.9.1)	--	--	--	--	R
Indoor laser controlled area (4.3.10)	--	--	--	R NHZ	R NHZ
Class 3b laser controlled area (4.3.10.1)	--	--	--	R	--
Class 4 laser controlled area (4.3.10.2)	--	--	--	--	R
Laser outdoor controls (4.3.11)	--	--	--	R NHZ	R NHZ
Temporary laser controlled area (4.3.12)	E MPE	E MPE	E MPE	--	--
Labels (4.3.14 and 4.7)	R	R	R	R	R
Area posting (4.3.9)	--	--	S	R NHZ	R NHZ
Administrative & Procedural Controls	1	2	3a	3b	4
Laser in navigable airspace (4.3.11.2)	--	--	S	S	S
Remote firing and monitoring (4.3.13)	--	--	--	--	S
Standard Operating Procedures (4.4.1)	--	--	--	R	R
Output emission limitations (4.4.2)	--	--	Laser Safety Officer determination		
Education and training (4.4.3)	--	--	--	R	R
Authorized personnel (4.4.4)	--	--	--	R	R
Alignment/Procedures (4.4.5)	--	S	S	R	R
Protective equipment (4.6)	--	--	--	S	R
Spectator (4.4.6)	--	--	--	R	R

Service personnel (4.4.7)	E MPE	E MPE	E MPE	R	R
Demonstration with general public (4.5.1)	UI MPE	R	R	R	R
Laser optical fiber systems (4.5.2)	MPE	MPE	MPE	R	R
Laser robotic installations (4.5.3)	--	--	--	R NHZ	R NHZ
Eye protection (4.6.2)	--	--	--	S MPE	R MPE
Protective windows (4.6.3)	--	--	--	R NHZ	R NHZ
Protective barriers and curtains (4.6.4)	--	--	--	S	S
Skin protection (4.6.6)	--	--	--	R MPE	R MPE
Other protective equipment (4.6.7)	Use may be required.				
Warning signs and labels (4.7) (design requirements)	--	R	R	R NHZ	R NHZ
Service and repairs (4.4.7)	Laser Safety Officer determination				
Modification and laser systems (4.1.2)	Laser Safety Officer determination				

Legend				
R	Required		**E**	Required if enclosed Class 3b or Class 4
S	Suggested		**MPE**	Required if MPE is exceeded
--	No requirement		**NHZ**	Nominal Hazard Zone analysis required
UI	Applicable only ultraviolet and infrared lasers (4.5.1.2)		**X**	Suggested if < 15 milliwatts and between 400 to 700 nm wavelength. Required if < 15 milliwatts and < 400 nm or > 700 nm in wavelength. The requirement can be evaluated on a case-by-case basis by the Laser Safety Officer.

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Subject Area: ***Laser Safety***

Examples of Standard Operating Procedures (SOPs) from Working Laboratories

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser Controlled Area (LCA) Standard Operating Procedure (SOP) must be written for the installation it covers. The exhibit Examples of Standard Operating Procedures (SOPs) from Working Laboratories is provided to illustrate the implementation of the LCA-SOP for several installations at BNL. These documents are for guidance only.

Laboratory Document	Type of Installation
Accelerator Test Facility (ATF) SOP	Facility laser installation
Biology (Single molecule imaging) SOP	Laboratory installation
CAD (RHIC, STAR EEMC) SOP	Integrated Instrumentation
NSLS (DUV-FEL) SOP	Facility laser installation

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BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
Accelerator Test Facility (ATF)
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system 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.

System description: ATF Nd:YAG System
Location: YAG room; transport to gun hutch, laser lab, CO2 Amp (C3), CO2 main (C2), FEL rooms

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.

Owner/Operator:		
Name: Marcus Babzien	*Signature:*	*Date:* 4/30/2004

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.

BNL Laser Safety Officer printed name	*Signature*	*Date*
ES&H Coordinator printed name	*Signature*	*Date*

APPLICABLE LASER OPERATIONS				
x Operation	x Maintenance	x Service	x Specific Operation	x Fiber Optics

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					
Laser Type *(Argon, CO2, etc)*	Wavelengths	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
Nd:YAG	1064, 532, 266 nm	IV	1064 nm 1W	7 ps ML @ 81.6 MHz	CW
		IV	1064 nm 500 mJ	14 ps	1.5-6 Hz
		IV	532 nm 200 mJ	3-10 ps	1.5-6 Hz
	1040-1060 nm	IV	266 nm 50 mJ	8 ps	1.5-6 Hz
Yb:glass		IV	250 mW	100 fs ML @ 81.6 MHz	CW

☒ **Cryogen Use**

After certain maintenance periods, clean, high vacuum conditions must be restored in spatial filter and transport tubes in the laser system. This is partly achieved with a cryosorption pump located in the front-end vestibule. The liquid nitrogen reservoir that maintains the temperature of the pump is filled by a hand carried dewar. Total volume of the reservoir is less than 3 liters when full, and requires frequent manual refill. All personnel using the cryosorption pump must complete the web-based BNL cryogenic safety awareness training course HP-OSH-025 at http://training.bnl.gov/cbt/cryogenics. Protective gloves and face shield are available at ATF for use with the liquid nitrogen.

☒ **Chemicals & Compressed Gasses**

Compressed nitrogen gas is used to actuate shutters, purge optical assemblies, and periodically clean optics throughout ATF. The gas is supplied from boil-off in a portable liquid nitrogen dewar near the front-end laser area in the high-bay of Building 820. The gas pressure is regulated to 100 psi, and maximum flow is limited by the 0.25-inch distribution lines.

☒ **Electrical Hazards**

Several high voltage power supplies are used to provide transient pulses to Pockels Cells throughout the laser system. Maximum voltages are less than 10 kV, and currents limited to 1 mA or less DC. All power supplies and pulse generators are commercial devices and are enclosed and labeled by the manufacturers. Pockels Cell terminals are enclosed with tool-removable enclosures and labeled.

☐ **Other Special Equipment**

Laser System Configuration:

Refer to Drawing ATF SK-1181-5 Laser Path Layout for facility beam path details.

Refer to drawing below for YAG laser beam path:

DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

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

American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers. ANSI Z136.1-2000, Laser Institute of America, Orlando, FL.

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard, 1.5.3 Interlock Safety for Protection of Personnel

ENGINEERING CONTROLS

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

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.**

Engineering Controls Description:

Refer to ATF Laser Interlock System Operating Procedures ATF-LAS-025 for interlock description.
Refer to ATF Laser Interlock System Search Procedures ATF-LAS-026 for search and secure description.
Refer to ATF Laser Interlock System Test Procedures ATF-LAS-027 for interlock recertification process.

Class IV light from this system is only accessible in controlled areas. Rooms are secured before the light is accessible in the area (see above procedures). Transport paths from laser sources to beam blocks or between rooms are inaccessible inside light-tight enclosures that require tool-aided removal and are administratively controlled. Additional enclosures are used in controlled areas where beam placement may increase the likelihood of inadvertent exposure to authorized users, e.g., beam crosses eye-level.

Different transport paths that share a common dichroic (two collinear beams of different wavelengths) segment are designed such that the failure of optical splitters/combiners by laser irradiation or other environmental mechanism would result in reduced transport efficiency and minimum cross-talk. Unintended delivery of one beam into the opposite transport path shall therefore not be possible above the MPE.

ADMINISTRATIVE CONTROLS

☒ 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 (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. SOPs must be approved by the BNL Laser Safety Officer and copies should be available at the laser installation for reference and field verification of stated control measures.

Administrative Controls Description:

The official copies of the following documents are available online:
ATF-LAS-005 Nd:YAG Operating Procedures.
ATF-LAS-004 Nd:YAG Maintenance Procedures.
ATF-LAS-006 Nd:YAG Alignment Procedures.

CONFIGURATION CONTROL

The ATF laser interlock system is designed and maintained only by qualified members of the CAD Interlock Group. Configuration control is governed by this group. Bypassing, defeating, or otherwise modifying the functioning of the interlock system by any other personnel is prohibited.

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☒ Eye Wear

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.

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.

Documentation regarding optical density of available eyewear and manufacturer certification is kept in the ATF control room.

EYE WEAR REQUIREMENTS

Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density *	NHZ** meters	Appropriate Eye Wear***
Nd:YAG 1ω	1064	6 (10s)	3	5.8 m	KG5
Nd:YAG 2ω	532	6 (0.25s)	6.5	8.3 m	OG570
Nd:YAG 4ω	266	3.4 (10s)	NA	NA	LOTG-CO2

*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.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density
KG5	1040-1064 nm	6+
OG570	532 nm	6+
LOTG-CO2	190-380 nm	7

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 World Wide Web based training course (TQ-LASER).

In addition, all ATF laser users must complete a one-time site-specific laser training of the facility conducted by a senior staff member. The training will cover the general aspects of the ATF laser safety program including installed laser systems and hazards, facility layout and beam transport, postings and administrative controls, laser controlled areas and facility interlock operation.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.,
  - Review of SOPs
  - Review of working procedures, and other program specific documentation

Except for the site-specific training, all laser safety training must be repeated every two years.

BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
Biology (Single molecule imaging)
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system 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.

System description: **Ultraviolet Biophysics Group, Single Molecule Imaging System**
Location: **Biology Dept., Bldg. #463, Room B-239**

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.

Owner/Operator:		
Name: **John C. Sutherland**	*Signature:* **John C. Sutherland**	*Date:* **2004-05-06**

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.

BNL LSO printed name	*Signature*	*Date*
ES&H Coordinator printed name	*Signature*	*Date*

APPLICABLE LASER OPERATIONS				
x Operation	x Maintenance	Service	Specific Operation	Fiber Optics

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					
Laser Type *(Argon, CO2, etc)*	Wavelengths	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
Argon-Ion	**488 & 512nm**	**IIIb**	**120 mW cw**	**NA**	**NA**
Solid State Pumped Diode	**532 nm**	**IIIb**	**80 mW cw**	**NA**	**NA**

☐ **Cryogen Use**

Describe type, quantity, and use.

_____

x Chemicals and Compressed Gasses

Describe type, quantity, and use.

Chemical use is covered under the Experimental Safety Review BO03-JCS1. Briefly, DNA from organisms that are not pathogens to mammals will be suspended in dilute ionic, non-toxic buffers. Non-toxic fluorophores will be used in small quantities in accord with existing experimental protocols. Users are trained in chemical hygiene (Laboratory Standard) and have Material Safety Data Sheets for fluorophores used. No compressed gasses will be used.

_____

x Electrical Hazards

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

The laser covers are interlocked so that the high-voltage is interrupted when the cover is removed. High voltage supplied to power the detectors shall use approved connectors, and circuits shall not be disconnected if the power supply is energized.

_____

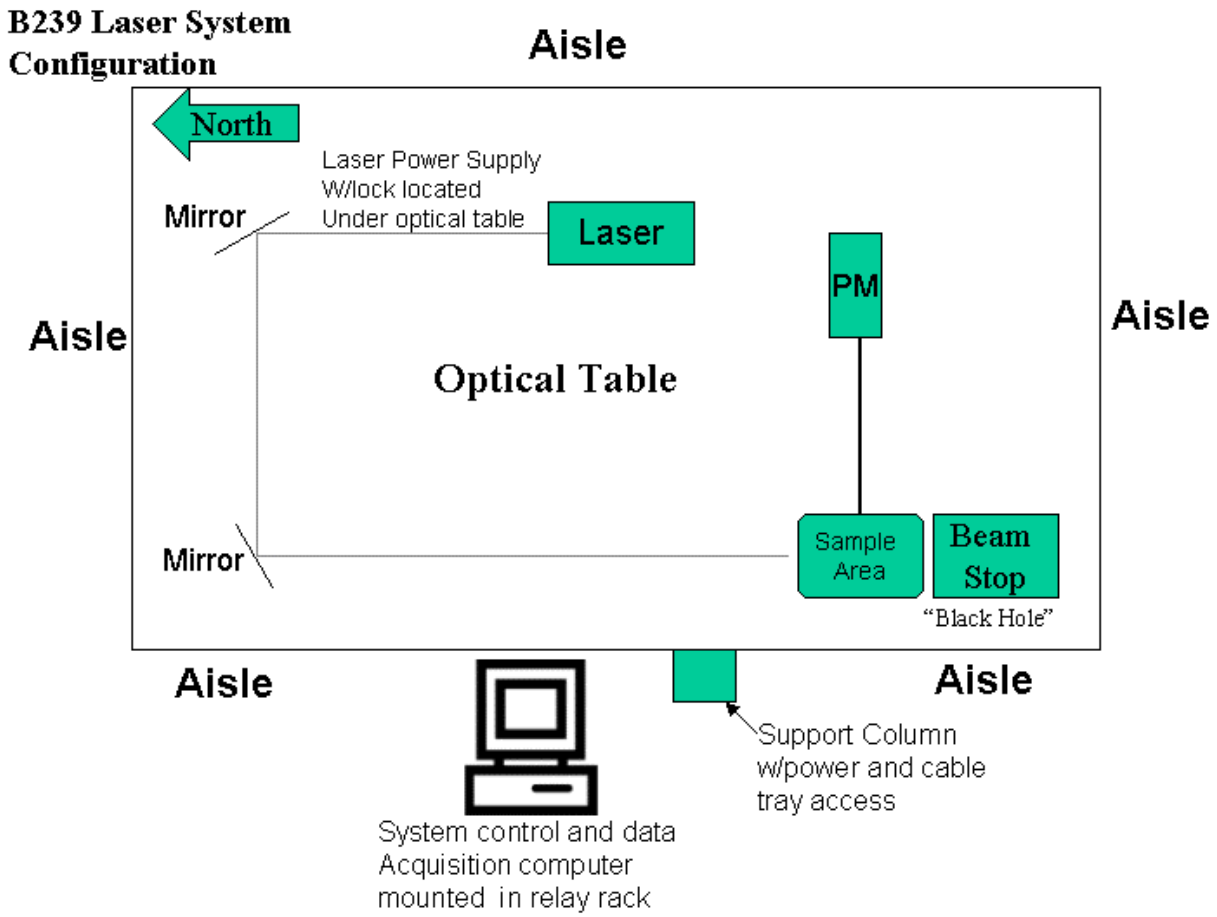
x Other Special Equipment

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

High Voltage Power Supplies that feed photomultiplier tubes.

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 functional diagram is shown below. There are no switch panels or computer controls associated with the lasers.



DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

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

American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers. ANSI Z136.1-2000, Laser Institute of America, Orlando, FL.

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard, 1.5.3 Interlock Safety for Protection of Personnel

ENGINEERING CONTROLS

X Beam Enclosures

X Beam Stop or Attenuator

X Activation Warning System

☐ Ventilation

X Protective Housing Interlocks

X Key Controls

☐ Other Interlocks

X Emission Delay

☐ Other

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, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

* **Beam Enclosures……..……..The entire optical table has been enclosed with black optical cloth**
* **Beam Stop**
* **Key Controls……Laser power supply**
* **Activation Warning System…….Located at laboratory entrance**
* **Protective Housing Interlocks…On the Argon-Ion laser head, others have no access covers**
* **Emission Delay……..Once enabled, there is an approx. 20 sec. delay before beam appears**

ADMINISTRATIVE CONTROLS

X Laser Controlled Area **X** Signs **X** Labels **X** 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 (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. SOPs must be approved by the BNL Laser Safety Officer and copies should be available at the laser installation for reference and field verification of stated control measures.

Administrative Controls Description:

*** Laser Controlled Area……all of room B-239**

*** Signs……..doors of room B-239**

*** Labels……laser heads (provided by manufacturer)**

*** Operating Limits……laser beams and target must remain on table**

CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. Examples include any protective housing, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Entries should also be included 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.

Standard Operating Procedures

-Normal Operations-

- **Laboratory doors shall be locked and warning sign illuminated before starting the laser.**
- **Laboratory windows shall be secured during operation of the laser.**
- **Laboratory exterior windows shall be covered with opaque shades during operation of the laser.**
- **Check to see that all bending mirrors and other optics are in place.**
- **Laser shall be operated only by a listed operator.**
- **Only listed operators and attending scientists may enter the laboratory when laser is in use.**
- **Photomultipliers shall not be exposed to room light or the laser beam while energized.**
- **Aisles surrounding the optical table shall not be blocked at any time.**
- **The laser beam shall be actively terminated with a "black hole" at the end of its normal path and any possible alternate path(s).**
- **The laser beam should never be routed at normal eye level, typically heights between 1.3 and 2.0 m above the floor.**
- **Objects capable of specular reflections should be avoided on the optical table and scientific staff, *e.g.*, jewelry.**
- **Turn on laser only after all steps above have been completed.**

-Maintenance (Alignment)-

- **Attenuate beam so power is a Class IIIA (5 mW) or below.**
- **All normal operating procedures shall be followed during alignment of the laser and the optical system.**
- **Any changes in optical configuration required for alignment but not for normal operations shall revert to the normal configuration when alignment operations are completed.**

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection **X** Eye Wear

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.

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.

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.

_____

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.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density *	NHZ** (meters)	Appropriate Eye Wear***
Argon-Ion 120mW	**488 & 512nm**	**2.1 (0.25sec.)**	**NA**	**NA**	**"Laser-Guard" Argon**
Solid-State Pumped Diode 80mW	**532nm**	**1.7 (0.25sec.)**	**NA**	**NA**	**"UVEX" Orange**

* 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.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density
"Laser Guard" Argon	**190 nm-520 nm** **520 nm-532 nm**	**> 9** **> 4.5**
"UVEX" Orange	**Wavelength < 532 nm**	**4.0**

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 awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.,
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

All laser safety training must be repeated every two years.

BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
CAD (RHIC, STAR EEMC)
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system 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.

System description: Class IV Nd:YAG laser, operated at 3rd harmonic (λ=355 nm) Max pulse energy = 11 mJ, max repetition rate = 10 Hz
Location: West end of Bldg 1006 (STAR Wide Angle Hall), south of DX magnet in RHIC tunnel

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.

Owner/Operator:		
Name: Scott W. Wissink	*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.

C. Weilandics

BNL Laser Safety Officer printed name *Signature* *Date*

Asher Etkin

ES&H Coordinator printed name *Signature* *Date*

APPLICABLE LASER OPERATIONS
X Operation X Maintenance X Service X Specific Operation X Fiber Optics

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					
Laser Type *(Argon, CO2, etc)*	Wavelengths	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
Nd:YAG	355 nm (1064 and 532 nm internal to laser head)	IV	11 mJ/pulse @ 355 nm	4-6 ns	10 Hz max

☐ **Cryogen Use**

Describe type, quantity, and use.

none

☐ **Chemicals and Compressed Gasses**

Describe type, quantity, and use.

none

☒ **Electrical Hazards**

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

The power supply (external to the lasing head) is supplied by the manufacturer and is rated at 120 VAC, 60 Hz, 250 watts. Potentially lethal voltage levels exist inside the power supply.

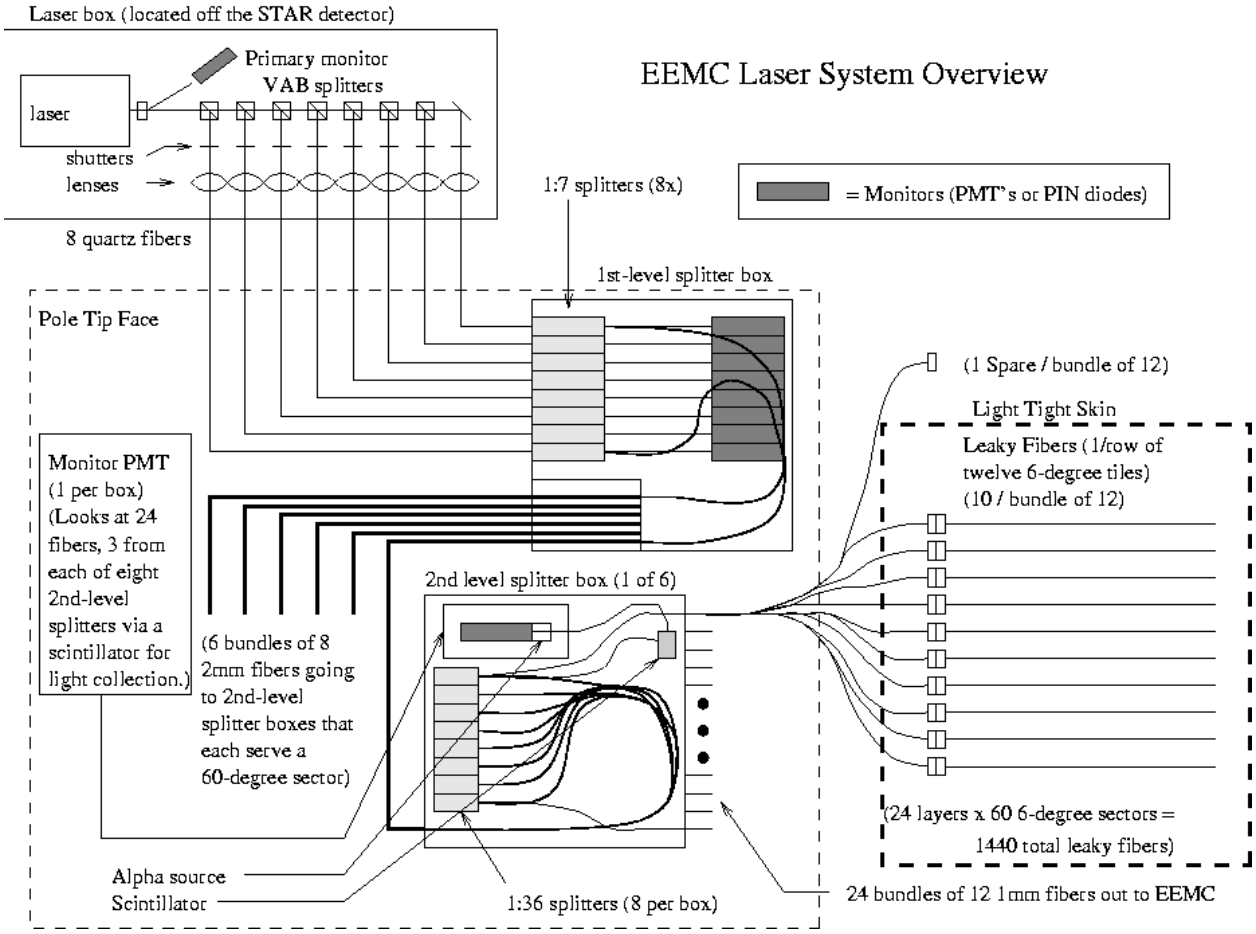
☒ **Other Special Equipment**

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

The laser head itself contains the actual Nd:YAG lasing rod, a remotely controlled optical attenuator (1/2-wave plate followed by a cubic beam splitter), the 2nd and 3rd harmonic

generators, and two 90° totally reflecting mirrors. The laser head is mounted on a 2′ x 5′ commercial optical bench inside an interlocked aluminum box. This box also contains a single 90° mirror, a diffraction grating, a PMT and resistive base, seven partially reflecting mirrors, eight focusing lenses, eight neutral density filters, and eight 2-m lengths of high-damage threshold quartz optical fiber. Light exits the box via eight SMA bulkhead connectors, then passes through eight 21-m lengths of quartz fiber to the 1st-level splitter box. This box contains a single block of Spectralon and eight PIN diodes and preamplifier electronics, plus connectors for the six bundles of 2-mm plastic fiber that pass light to the six 2nd-level splitter boxes. Each of these boxes contains a block of Spectralon for the splitting cavities, a single PMT and base, and many connectors for the 1-mm fibers that carry light to the individual EEMC megatiles.

A schematic overview of the system configuration illustrating the role of much of this equipment is provided below. This is explained in more detail in the following section of this document.



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)*.

Laser operation is keyed (key is removable from power supply). All controls are provided via an RS-232 cable from either the manufacturer-supplied control panel or a local PC with ethernet connection. The setting of the optical attenuator, the flashlamp high voltage, and the laser firing repetition rate are controlled over this cable, as well as starting and stopping (or pausing) the laser from firing. The only 'beam path' is within the primary aluminum box; outside of this box, the laser light is always fully contained within either splitting cavities or optical fibers. The schematic on the previous page may be useful while reading the following description of the configuration for the STAR EEMC (**E**ndcap **E**lectro**M**agnetic **C**alorimeter) laser system.

The laser system includes components located in the RHIC tunnel just west of the STAR WAH, on the back of the west poletip of the STAR magnet, and within the EEMC itself (which is mounted on the front of the same poletip). The UV laser resides inside an interlocked (and lockable) aluminum box, on a table in the RHIC tunnel, just south of the DX magnet. A series of seven partially reflecting mirrors, mounted on an optical table within this box, are used to form eight beams of roughly comparable intensity (I_{max} = 1.3 mJ[1]), each of which is focused down into 600-μm diameter single strand silica core optical fibers. These 8 fibers transport the UV light to the back of the poletip and into a single "1st-level splitter box," located near the top of the magnet. Within this light-tight box, the light from each fiber emerges into a diffuse reflective cavity, and a fraction of the light (~5%[1]) is captured by seven 2-mm diameter plastic optical fibers, chosen for their excellent transmission (low attenuation) in the UV. Bundles of eight 2-mm fibers then carry the light to six "2nd-level splitter boxes," distributed around the outer edges of the back of the west poletip. Inside these boxes, the light from each fiber is distributed among a large number (36) of high-transmission 1-mm fibers, using a second type of diffuse reflective cavity. Each of the resulting 1440 1-mm fibers then transports a very small fraction (~1:10^6) of the initial UV light around to the front of the poletip and into a special `leaky' fiber that is embedded within every EEMC megatile. As the laser light propagates through this fiber, a set of precision scribes made along the fiber surface injects a small pulse of UV light into each of the 12 individual tiles. The laser energy, level of splitting, and 'leak' sizes have been chosen so that each EEMC tower PMT can "see" a light pulse comparable in intensity to that produced by the shower of a 150 GeV electron, while an attenuator internal to the laser head (and remotely adjustable) will allow us to simulate the light response of a minimum-ionizing particle as well.

Associated with each of the three levels of splitting are different types of monitoring. Inside the primary box, a single PMT views ~1% of the laser output light (through a neutral density filter), which is deflected from the main beam using a special diffraction grating. After the first splitting on the poletip, one of the seven 2-mm fibers from each cavity injects its light onto the face of a photodiode. Information from the PMT and the PIN diodes will be used to monitor the actual output intensity and the relative intensities of the 8 beams from the primary box. Finally, each of the six 2nd-level splitter boxes contains a single PMT, which provides event-by-event normalizations for each laser pulse seen by the towers within that 60° sector.

[1] All values based on detailed attenuation and splitting efficiencies calculations, verified by measurements at IUCF.

DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

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

American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers. ANSI Z136.1-2000, Laser Institute of America, Orlando, FL.

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard, 1.5.3 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, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

1. _ Beam enclosures: the laser beam is always fully contained within Spectralon splitting cavities or inside optical fiber, except for the initial splitting inside the primary box. This box is light-tight and interlocked to kill laser power if opened.

2. Beam stop or attenuator: The laser head contains a manual shutter at the exit aperture that can stop the beam. The beam(s) to individual quartz fibers can be temporarily blocked with thin pieces of Spectralon. The only attenuation of the beam occurs in the commercial optical attenuator located inside the lasing head, or in a few high-damage threshold neutral density filters located in front of several of the monitor detectors.

3. Activation warning system: When the laser is operating with the lid to the primary box open, a warning light indicating that UV light is present will be posted at the access to the area enclosure (at the top of the ladder needed to reach the laser area).

4. Protective housing interlocks: The actual laser head is enclosed in a protective housing (provided by the vendor) that prevents access to radiation in excess of Class I limits, except for the output beam. This housing is light-tight and interlocked to kill laser power if opened (see item 6. below). Laser operation is interrupted if the laser head cover is removed. The laser power supply, which contains high voltages, is also powered down if its cover plate is removed.

5. Key controls: The power supply cannot be energized unless a removable key is in place and turned. During extended periods of access to the STAR Wide Angle Hall, this key will be locked in a cabinet in the STAR trailer.

6. Other vendor-supplied interlocks: The manufacturer has installed interlocks such that laser operation will be interrupted if:

   - The laser head cover is removed (item 4. above)
   - The control cable (RS-232) is detached from the power supply
   - The laser head umbilical cable is detached
   - Cooling water temperature is too high or too low
   - Remote interlock is not satisfied (see immediately below)

7. User-supplied interlocks: The IUCF group has installed interlocks to ensure that laser operation will be interrupted if:

   - The primary box lid is opened
   - Anyone attempts to enter the laser area. This is implemented using an infra-red sensor which has been mounted directly outside the enclosure curtain.

8. Emission delay: When the laser system is first turned on, or after it has been interrupted by an interlock not being satisfied, a restart involves two steps – pressing a START/STANDBY button, which sounds an audible alarm (beep) for seven seconds, followed by pressing the FIRE LASER button. Thus, after an interrupt, the laser can not be re-fired for at least seven seconds. The actual delay is somewhat longer, because the START/STANDBY button can only be energized if the flashlamp voltage has been run to zero. Thus, to restart laser firing:

   - Run flashlamp voltage to zero
   - Push START/STANDBY button
   - Wait 7 seconds
   - Push FIRE LASER button
   - Set flashlamp voltage to desired value

   If a PC is used, rather than the control panel, a series of RS-232 commands are issued instead of pushing buttons, but the above sequence (including the delay) must still be followed.

9. Other: an enclosure curtain, made of material opaque in the near UV, optically isolates the primary box area from the STAR WAH. Access to the enclosure is physically limited to a single entrance.

ADMINISTRATIVE CONTROLS

☒ 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, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. SOPs must be approved by the BNL Laser Safety Officer and copies should be available at the laser installation for reference and field verification of stated control measures.

Administrative Controls Description:

Laser Controlled Area: The laser is normally operated fully enclosed (Class 1). If it becomes necessary to perform maintenance or service on the laser and associated optics, a temporary laser controlled area will be established in the laser enclosure.

Signs: Appropriate laser signs are posted at the entrance to the laser area.

Labels: Appropriate warning labels are posted on the cover of the laser and splitters. Additional labels have been attached to the quartz fibers that extend from the primary box to the 1st-level splitter box.

Sets of operating procedures and associated checklists have been developed for routine operation and special operations for the EEMC UV laser system, as well as for verification of the laser interlock system. The distinction is that routine operation does **not** involve firing the laser with the lid of the primary box open, in which case the laser beam is fully enclosed along its entire path. For alignment and certain maintenance tasks (special operations), the lid needs to be open. During these tasks, additional precautions and procedures must be in place, as outlined below. Prior to performing any special operations, the Laser Interlock System checklist must also be complete.

Current copies of the SOP, checklists, and Operator's Manual are to be kept in the drawer of the table on which the primary laser box is mounted. The log of completed checklists is also kept in this drawer.

Reference to procedures to be established

CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. 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)*. Entries should also be included 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.

Reference to checklist to be established

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☒ Eye Wear

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.

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.

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.

_____

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.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density *	NHZ** meters	Appropriate Eye Wear***
Nd:YAG(laser head)	355 nm	4.5 OD(10 sec.) 2.5(1% pwr.)	1 OD (600 sec.) NA(1% pwr)	0.7 meters NA	Elvex LG-0601/18
Laser box(fiber)	355 nm	3.6 OD(10sec.) 1.6(1% pwr.)	0.15 OD (600 sec.) NA	0.24 meters NA	Elvex LG-0601/18
1st level splitter(bundle) output	355 nm	3.6 OD(10sec.) 1.6(1% pwr.)	0.2 OD (600 sec.) NA	0.25 meters	Elvex LG-0601/18

* 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.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density
Elvex LG-0601/18	180 – 380 nm 10,600 nm	6 5

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 awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered eg.
  - Review of SOP's
  - Review of working procedures, and other program specific documentation

All laser safety training must be repeated every two years.

Subject: Laser Safety Program Documentation		
Prepared By: Brian Sheehy	Approved By: Xijie Wang	Approved By: James B. Murphy

BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
NSLS (DUV-FEL) STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system 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.

System description: Deep Ultraviolet Free Electron Laser
Location: Source Development Laboratory, Building 729

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.

Owner/Operator:			
Name: Brian Sheehy	*Signature:*	*Date:*	Sep 15, 2003

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.

Chris Weilandics
BNL LSO printed name *Signature* *Date*

Andrew Ackerman
ES&H Coordinator printed name *Signature* *Date*

APPLICABLE LASER OPERATIONS
x General Operation x Alignment x Service/Repair x Specific Operation ☐ Fiber Optics

ANALYZE THE LASER SYSTEM HAZARDS

LASER SYSTEM CHARACTERISTICS					
Laser Type *(Argon, CO2, etc)*	Wavelengths (nm)	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
1) Seed Laser	800 nm	*IIIb*	5 mJ	0.1-100 psec	10 Hz
2) FEL output (fundamental)	266 nm	*IIIb*	100 uJ	0.1-2 psec	2.5 Hz
3) FEL output (harmonics)	89 and 133 nm	*I*	1 uJ	0.1-2psec	2.5 Hz

NOTE: **For all of the above systems eye protection must be worn when working with open beams**

System by system breakdown:

1) Seed Laser
purpose: seed the FEL process. This can be done by overlapping the seed pulse with the electron bunch in the radiator (direct seeding) or in an undulator prior to the radiator, the modulator (in High Gain Harmonic Generation)
output: Typically 1 mJ pulses are injected into the accelerator; only a portion of this makes it through the apparatus to the FEL output window: the 2 silicon carbide mirrors constituting the periscope after the radiator each have a reflectivity of ~ 40% at the seed wavelength, and the output coupling mirror to the diagnostics is currently a dielectric mirror for 266 nm, so its reflectivity at the seed wavelength is 2 x 4% (reflections from both surfaces). The current energy is thus 2 spots of ~ 6 microjoules each. Operators should be aware however, that changes in the output optics or coupling more energy into the seed will raise that number. The current output parameters are: 1-10 psec pulses at 10 Hz, wavelength ~ 800 nm
beam paths:
- from laser room, ~35 meters enclosed (via the RF gun hutch) to seeding table in the accelerator enclosure. From there, into the accelerator and ~ 21 meters enclosed to the output port.
- Diagnostics inside of the accelerator enclosure. The seed beam may be diverted outside of the beamline for various diagnostics (e.g. electro-optic electron beam profiler, THz output profiler). These applications are covered in the “SDL Drive and Seed Laser System” SOP.

goggles: use e.g. Kentek GBM 64
controls: neutral density filters located on seed table may be inserted in and retracted from the beam through the control system. Power attenuator located in laser room. Beam shutter (located

in the laser room) may be controlled from the control area, the laser room, or the gun hutch. A 633 nm cw alignment beam is permanently set up to be co-aligned with this beam.
hazard controls: beam enclosure. beam in the experimental area is enclosed and terminated, except for rare alignments. The beam in the 2 diagnostic enclosures is also enclosed. Procedures and posting requirements for access to the enclosures described below (an interlocked enclosure for the diagnostic beams will be in place by January 2004)

2) FEL output (fundamental)
purpose: supplied to user experiments and diagnostics
output: 200 μJ max, 266 +-10 nm, 0.2-1psec pulse width, 2.5 Hz
beam paths: beam enclosure. beam in the experimental area is enclosed and terminated, except for rare alignments. The beam in the 2 diagnostic enclosures is also enclosed. Procedures and posting requirements for access to the enclosures described below (an interlocked enclosure for the diagnostic beams will be in place by January 2004)
goggles: use e.g. Kentek GBM 64
controls: controlled through electron beam and seed beam parameters.
hazard controls: beam enclosure. beam in the experimental area is enclosed and terminated. The beam in the 2 diagnostic enclosures is also enclosed, with procedures and posting requirements for access to the enclosures described below (an interlocked enclosure will be in place by January 2003)

3) FEL output (harmonics)
purpose: supplied to user experiments
output: 89 and 133 nm, 0.2-1psec, 1 μJ, 2.5 Hz
beam paths: originates in the radiator (see diagram) and propagates to the experimental chamber (enclosed path)
goggles: N.A (absorbed in air, and no exposure possible).
controls: controlled through electron beam and seed beam parameters.
hazard controls: enclosed beam in vacuum.

☐ **Cryogen Use: None**

☐ **Chemicals & Compressed Gasses**

- Solvents (methanol, acetone) used for cleaning optics, kept in 1-4 liter quantities . Stored with secondary containment.

☐ **Electrical Hazards**

There are no electrical hazards associated directly with the DUVFEL output. Users and operators should of course be aware that this is located in an accelerator laboratory however, and there are electrical hazards associated with that, which are documented in the accelerator standard operating procedures. A user at the end station will not encounter these, but should be aware that hazards exist elsewhere in the building.

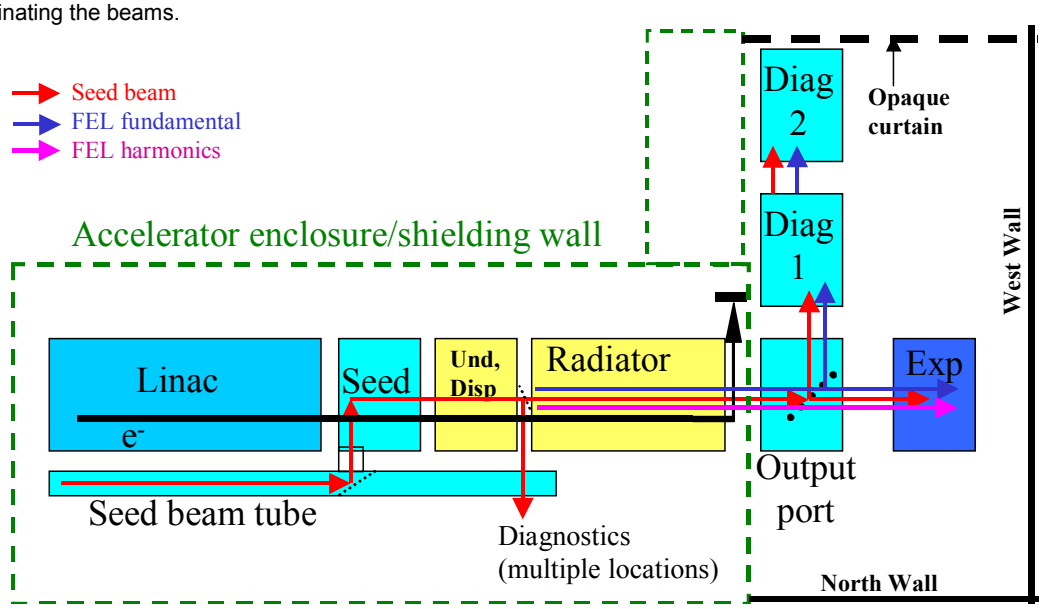
☐ **Other Special Equipment**

Standard Diagnostic equipment: oscilloscopes, photodetectors, power meters, autocorrelators, spectrum analyzers, monochromators, streak camera, PC-based data acquisition system, cameras, monitors.

With all optical diagnostics, the operator must exercise special care when working with the optical beams inside the device, as the beams may pose a hazard when misaligned or even during normal operation

(e.g. the moving reflection inside a scanning autocorrelator). Read the safety section of the device's manual and wear protective eyewear.(see charts below for proper eyewear for given wavelengths)

Laser System Configuration:
As shown in the diagram below, the seed beam (source #1) propagates in an enclosed pipe parallel to the accelerator on the latter's north side. West of the linac, the beam is deflected into an optical enclosure (box labeled Seed in diagram), where several optics are positioned to couple the beam into the accelerator. In FEL operation, the seed beam interacts with the electron beam in a short undulator (Und, Disp box) and then propagates to the end of the vacuum line. The electron bunch propagates on through the dispersive section and radiator, and then is deflected by a dipole magnet. The electorn bunch produces the FEL output fundamental and harmonics (sources #2 and #3) inside the radiator section All three sources: seed, fundamental, and harmonics are coupled out of the accelerator enclosure via a periscope comprising 2 mirrors, normally of Silicon Carbide. These steer the beams into the experimental chamber, where they terminate. An insertable mirror located in the output port can divert all or part of the seed and fundamental to the diagnostic enclosures (Diag1 and Diag2), via enclosed beam tubes. Instrumentation inside these enclosures is used to analyze the output before terminating the beams.



DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

ENGINEERING CONTROLS

☒ Beam Enclosures ☐ Protective Housing Interlocks ☒ Other

☐ Beam Stop or Attenuator ☐ Key Controls

☐ Activation Warning System ☐ Other Interlocks

☐ Ventilation ☐ Emission Delay

Engineering Controls Description:

At present, all beam paths are enclosed. Inadvertent access to the experimental chamber would vent the accelerator and terminate the beam before personnel exposure would be possible. At present access to the enclosures Diag 1 & 2 will not terminate the beam. The area containing these enclosures is to be blocked off by an opaque curtain, with access to be governed by the administrative procedures below on a temporary basis. Those enclosures will be replaced by January 2004 with an interlocked enclosure.

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☒ Labels ☐ Operating Limits

Administrative Controls Description:

- The area around the experimental enclosures and the diagnostic enclosures 1 and 2 will be posted with the "Danger" laser warning sign as follows:
  - sign on shielding wall above output port
  - signs on top panel and front panel of enclosures Diag 1 and Diag 2
  - sign on transport tubes between enclosures
- Diag1 and Diag2 enclosures are to remain closed and may only be accessed by a Qualified Laser Operator.

When laser radiation is reaching the DUVFEL output port and entering enclosures Diag1 or Diag2, or if it is entering the experimental area and not being terminated (as for a rare alignment), the following procedures will be followed

- The opaque curtain south of the diagnostic enclosures is to be drawn from the shielding wall to the west wall of the building. The area bounded by the curtain and the north, west, and shielding walls will optically enclose the endstation area on four sides, and constitute a Temporary Laser Controlled Area (TLCA). The LSO must approve any change in the TLCA, and designate the nominal hazard zone (NHZ)
- Access to the TLCA is permitted only to qualified operators and users who have completed Laser Safety Training. Of those, only persons who have received the laser medical surveillance and

have completed the system specific training may work within the diagnostic enclosures manipulating beams. The others may remain in the area provided they are wearing protective eyewear.

- Access is for servicing the seed beams and output beams of the DUVFEL. This may be done when measurements need to be done or the output configuration altered in the normal course of daily operations.
- The entrance to the NHZ will be posted with the "Danger" laser warning sign.

Users accessing the enclosures Diag 1 or Diag 2 are reminded that, under safe operating procedures, there is no reason that any beam should leave the confines of the enclosures. Only the top covers need to be removed when the beam is on under normal operations, the optics are prealigned with a HeNe laser such that all paths are confined, and no user adjustment should alter that fact. It is worth reiterating here, however, a few common sense principles of working with exposed beams:

- always wear eye protection, and make sure that others in the hazard zone are wearing them.
- make sure that reflective jewelry/badges/clothing that might intercept the beam is removed. For example, watches, rings, bracelets, pendulous necklaces. Note that ID badges should not be worn around the neck: they can drop into the beam when you lean over.
- always make all adjustments at the lowest possible intensity
- never insert reflective surfaces into the beam. When inserting an optic, block the beam upstream of the intended insertion, then secure the optic stably in the desired location and orientation, then unblock the beam. When removing an optic, block the beam upstream of the optic before removing it, and be certain of where the new beam path will be with the optic removed..
- always minimize the number of personnel within the hazard zone, and be sure that those who do remain in the area are aware of what you are doing

Comment: Here is where we need to define the, "service operation" for which we will use the "Temporary Laser Controlled Area" . We need statements to describe:

-What specific operations require work with open beams?
- How often these operations are required?

CONFIGURATION CONTROL

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.

See DUV FEL SOP Attachment #2

PERSONAL PROTECTIVE EQUIPMENT

☒ Eye Wear ☐ Skin Protection

No.	System Name						
1	**Seed Beam**						
2	**DUVFEL output (fundamental)**						
3	**DUVFEL output (harmonics)**						
Laser & Eyewear Parameters							
	ANSI Z136.1 Class				I	IIIb	IIIb
	Wavelength [nm]				~89, 133	~266	~800
	Intra-Beam OD Required						
	single shot				NA	1	5
	0.25 s				NA	1(single shot)	1
	10 s				NA	2	2

Comment: We need to define here which glasses to use for these lasers. I deleted the larger chart that you had as it pertained to other laser systems. Here we need to tell the laser operator which glasses to use for these three systems.

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 World Wide Web based training course (BNL course #TQ-LASER).

See attached training checklist (SDL SOP Attachment #1)

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 following local physicians:

Dr. Charles Rothberg 331 East Main St. Patchogue, NY 11772	The Ophthalmic Center Dr. Basilice 3400 Nesconset Highway East Setauket, NY 11733	East End Eye Associates Dr. Sherin 669 Whiskey Road Ridge, NY 11961
631 758-5300 $65 per exam	631 751-2020 $60 per exam	631 369-0777 $125 per exam

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.

Each Qualified Laser Operator must sign below to confirm the he/she has completed the training and surveillance indicated in each column and that the dates indicated for the, “Basic Laser Training” and the, “Medical Surveillance” are accurate and may be found in the BNL BTMS database.

Qualified Laser Operators:

Basic Laser Training	Job-Specific Training	Medical Surveillance	Printed Name	Signature	Owner/Oper. Initial/date
9/12/03	10/27/03	4/9/02	Zilu Wu		
5/21/03	10/27/03	5/25/01	Henrik Loos		
10/08/02	10/27/03	11/13/02	Yuzhen Shen		
9/24/03	10/27/03	9/24/93	Brian Sheehy		
7/31/03	10/27/03	2/25/97	Adnan Doyuran		
7/25/02	10/27/03	5/15/00	Timur Shaftan		
5/3/02	10/27/03	8/14/98	Li Hua Yu		
10/2/03	10/27/03	7/16/96	Xijie Wang		
	10/27/03		James Murphy		

Comment: All the dates in the “Basic Laser Training” and “Medical Surveillance” columns must be in the BTMS database. When the Qualified Laser Operator signs this, he/she affirms that the dates are accurate and in the database.

	10/27/03		James Rose		
	10/27/03		Jonathan Neumann		
7/9/02	10/27/03		Wen Li		
	10/27/03		Arthur Suits		
	10/27/03		Pooran Singh		
	10/27/03		Joe Greco		

DUV FEL SOP Attachment #1

Laser Operator for the DUVFEL Output Training Certification Checklist

Completion of the items on this checklist and the signature of an authorized trainer will constitute the record of certification for an individual to be a qualified operator of the Laser System.

Safety Requirements:

- ☐ 1. Read appropriate safety documentation. This includes the material in the SBMS Laser subject area, and the SDL SBMS Laser Standard Operating Procedures (SOP). It also includes any information specific to a device the operator is working on (e.g safety sections of manuals to lasers, test, and diagnostic equipment). It is the operators responsibility to learn the published safety procedures for any equipment he undertakes to use.
- ☐ 2. Take required BNL eye examination
- ☐ 3. Complete Laser Safety Awareness Training Course, Compressed Gas Course, and Basic Electrical Safety course.
- ☐ 4. Eye protection required.
- ☐ 5. Insure that Controlled area is properly posted and light curtain is closed.

Minimum Systems Knowledge requirements for qualified operators (both levels). A detailed description of the current system start-up and alignment procedures for basic operation is given in the SOP. Since the SDL is an experimental facility, the details of the SOP procedure may change. . The procedures listed there are effectively the present implementation of the tasks/skills listed below and required of a laser operator

☐ 2. Understand procedures for starting/stopping beam
- o seed laser shutter control at control desk or in laser room
- o retractable mirror in the FEL output port that steers the beam to the diagnostics

☐ 3. Understand that there are two beams coming out of the FEL: residual seed beam also reaches the diagnostic table. This is an invisible IR beam, which may be seen with an IR detector card or the IR viewer. USERS SHOULD BE AWARE THAT THIS BEAM MAY BE PRESENT EVEN WHEN FEL OUTPUT IS NOT. It may be blocked with the laser shutter.

☐ 4. Understand the principles of safe alignment (in the Standard Operating Procedure). In particular, users should note the proper use of flip-up mirrors, which are used on the diagnostic table. Before flipping a mirror in or out of the beam, block the beam upstream of the flipper first.

☐ 5. Understand the basic beam path layout to monochromator and energy detector, and how this prealigned with the Helium Neon laser on the diagnostic table.

Operator Duties:

☐ 1. Perform beam alignments into diagnostics and make measurements

☐ 2. Insure that light is properly terminated.

☐ 3. Shut down any part of the facility within their area of control which may present a safety hazard until that hazard has been removed.

Trainer: _____
(print name) (signature)

Trainee: _____
(print name) (signature)

Date: _____

SDL FEL SOP Attachment #2

DUV FEL Configuration Control Checklist

- Beam terminated in Experimental Chamber
- Beam Tubes from output port to Diag1 in place
- Beam tube from Diag1 to Diag2 in place, or beam terminated in Diag1
- Diag1 and Diag2 enclosures intact
- Opaque curtain blocks beams below 8 feet at and beyond the boundary of the nominal hazard zone.

A completed checklist must be posted at the laser location.

This checklist must be exercised whenever there has been a system modification, extended shutdown, or change of operations.

Completed by:

(Printed Name) (Signature) (Date)

Revision Review Log

Subject Area: ***Laser Safety***

General Guidance for Laser Protective Eyewear

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

General Guidance for Laser Protective Eyewear is provided as a Word file.

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2.0-062004/standard/2g/2g04e011.htm

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GENERAL GUIDANCE FOR LASER PROTECTIVE EYEWEAR

Experience has shown that laser eye accidents more frequently occur during alignment procedures. In many of these instances, a problem has been that AVAILABLE EYE PROTECTION HAS NOT BEEN WORN. There have been numerous accidents reported involving individuals who had eye protection within reach but did not wear it. The reason stated was that during "alignment" they need to see the beam and could not.

Often, eyewear designed for full protection often greatly reduces the possibility of seeing the beam. Thus a diffuse reflection cannot be seen during an alignment process. As a result, the eyewear is removed to accomplish the alignment task. So-called "alignment" eyewear is designed to allow a safe level of laser light to be transmitted through the filter. This requires viewing only diffuse (scattered light) reflections of the beam and never the direct beam. Usually the alignment eyewear does afford some limited-time protection for accidental direct beam exposure but it is never intended for such viewing.

Visibility of normal ambient light (luminous transmission, or LT) through the filter can sometimes be improved if the laser eyewear filters are designed for the task. For example, optical alignment with a modestly powerful continuous wave (cw) laser can be done using a filter type that reduces the laser power transmitted through the filter from a diffuse reflection to not only a "safe" level but also a level that is "comfortable" to view. This might be required during alignment of an optical system by a technician using a diffusely reflecting target "to see the beam" during the task. In these cases, the MPE used in the optical density determinations can be based upon an exposure time of 600 seconds. Often the design allows an optical density significantly lower than would be required using an 8-hour MPE criterion. This usually results in a filter of greater overall luminous transmission, hence superior visibility while wearing the eyewear. It is important to account for sources of direct or specular (mirror-like) reflections.

Since the option during alignment processes is to "cheat" and not wear protective eyewear, in essence, alignment eyewear provides an alternative to no eyewear at all.

THE BASIC REQUIREMENTS UNDER ANSI Z136.1

- Protective eyewear shall be worn whenever operational conditions may result in potential eye hazard.
- All laser protective eyewear shall be **clearly labeled** with the **optical density** value and **wavelength** for which protection is afforded.
- Protective eyewear should be **comfortable**, provide **adequate visibility** (luminous transmission) and prevent hazardous peripheral radiation.
- **Periodic frequent inspection** shall be made of protective eye wear to insure the maintenance of satisfactory filtration ability especially following exposure to hazardous Class 4 laser radiation. See “Care and Maintenance” section below.

FACTORS IN CHOOSING LASER PROTECTIVE EYEWEAR

- **Optical density (OD) of eyewear at laser output**: These will be based on the output of the lasers and the wavelength(s) involved. Optical densities stamped on older eyewear may be misleading in that damage may occur to the eyewear and power densities or irradiances implied by the OD. Optical densities in excess of 6 on many types will also have rather low figures for luminous transmission, or the amount of visible light they let through.
- **Visible light (luminous) transmission requirements**: This figure should be as high as practical. Laser protective eyewear with luminous transmissions of around 20% and less should be avoided.

- **Damage thresholds**: Different goggle materials have different damage thresholds. The manufacturer should be consulted for these specifications on resistance to damage from high average power or peak irradiances.
- **Need for prescription glasses**: Some protective eyewear types (i.e., spectacles) can have prescriptions built right into the eyewear. Other types (i.e., goggles and wrap-arounds) may able to fit over normal prescription eyewear, and be less expensive but may be bulkier and/or heavier and less comfortable. This will affect **comfort and fit**, as well as **peripheral vision** of the eyewear, which can discourage its use.
- **Degradation of absorbing media**: Plastic filter materials often offer greater impact resistance, lighter weight, and convenience of molding the eye protection into comfortable shapes. The disadvantages are that they are more readily scratched and the filters often "age" poorly in that the organic dyes used as absorbers are more readily affected by heat and/or ultraviolet radiation, which cause the filter to significantly darken. Plastic materials generally display a lower threshold for laser beam penetration. This may be offset somewhat by the fact that the absorbing media is contained throughout the matrix and is not subject to scratching or wearing off.
- **Strength of materials (resistance to shock)**: Not all-absorbing glass filters used for laser protection can be easily hardened and, consequently, may not provide adequate impact resistance. In some goggle designs, however, impact resistant plastic filters (polycarbonate) can be used together with non-hardened glass filters in a goggle design where the plastic is placed in front and behind of the non-hardened laser filter glass.

TYPES

Goggles: This type of eyewear fits closely on the face and can usually be worn over prescription eyeglasses. They are usually constructed with frame vents to minimize lens fogging and are generally larger and heavier than spectacles or wraps

Wraps: This design is composed of a frame with a single lens that covers both eyes usually lighter than spectacles/goggles. This design, similar to goggles, can usually accommodate prescription glasses worn underneath.

Spectacles: A frame that usually has two separate lenses with side shields can be made with vision-correcting prescription eyeglasses.

SOME HELPFUL HINTS

- Even if you are wearing laser protective eyewear, **never look directly into any laser beam.** Contact the Laser Safety Officer (LSO) if you feel that aligning your laser requires intrabeam viewing.
- If laser protective eyewear is required, the Standard Operating Procedure specifies the OD (optical density) at the laser wavelength(s) being used. The OD specified is the minimum OD sufficient to protect the user against a momentary intrabeam or specular reflection exposure. Contact the LSO for any questions you may have regarding laser protective eyewear.
- For **visible lasers**, the minimum OD required to protect the user against intrabeam viewing should allow the viewing of a diffuse spot on a light colored surface. If the laser protective eyewear has an OD much larger than the specified minimum OD, it may be impossible to properly view a diffuse beam spot (or even see properly in the laser facility).
- In some instances (visible lasers from 400 - 450 nm and 650 - 700 nm), it may be preferable to reduce the OD below the specified intrabeam minimum OD to better view a diffuse spot. Reducing the OD by 1 or 2 should substantially improve viewing while still offering adequate eye protection (the intrabeam OD has a X10 safety margin calculated into the value, which includes the human aversion (blink) response). Reducing the specified OD by a number greater than 2 may reduce the protection factor enough to allow eye injury should a specular reflection be viewed accidentally.

- For **invisible lasers**, the minimum OD for intrabeam viewing should not be reduced, as OD reduction will not aid in viewing the beam. Instead, the laser protective eyewear should be chosen to allow the wavelength produced by the viewing aid to be transmitted while absorbing the invisible beam. Luminous transmission for protective eyewear that is designed specifically for UV and IR wavelengths is often good. For example, a Nd:YAG beam at 1064 nm is being aligned with the use of an IR sensing card, which absorbs some of the 1064 nm radiation and emits radiation at 550 nm. The calculated intrabeam OD for the Nd:YAG is 6.0. A good choice for laser protective eyewear would be a goggle with a UVEX type 06 filter (an OD of 8+ at 1064 nm and an OD of less than 1 at 400 to 700 nm). This goggle has a visible light transmission of 70% and should allow the diffuse spot to be easily viewed while giving excellent protection from the invisible Nd:YAG beam. **NOTE**: This eyewear would obviously not be a good choice if the Nd:YAG beam frequency was doubled to 532 nm.
- All laser protective eyewear should have a luminous transmission sufficient to allow safe operation in the laser facility. The luminous transmission should be about 35%. Laser protective eyewear with a low luminous transmission will generally not be worn by users and so cannot provide any protection. A proposed European Standard CEN sets full protection VLT eyewear level at 20%, and 40% for alignment eyewear. One way to accommodate this would be to increase illumination in the workplace.

CARE AND MAINTENANCE

The proper care and maintenance is essential to ensure that the equipment remains in good condition and is serviceable. Eyewear can represent a significant investment. It will last longer and give better service if it is kept clean and properly stored. Poorly maintained eyewear will not only need to be replaced more often but can be a liability to the wearer.

Storage: Eyewear should be stored in clean and sanitary “ready for use” condition in an area away from dust and dirt and other contaminants. The eyewear should also be kept in an area away from exposure to chemicals and vapors, which could degrade or affect the material over time. This may be especially true in some of the plastic lenses in that the organic dyes used as absorbers are more readily affected by heat and/or ultraviolet radiation, which cause the filter to significantly darken. In addition to affecting the eyewear, contaminants in the work area may also be introduced into or around the eye when the contaminated eyewear is worn.

Cleaning: If the eyewear needs to be cleaned, follow the recommendations of the manufacturer. Generally, a mild soap solution is fine for polycarbonate eyewear. Special care may need to be taken for coated or laminated eyewear.

Inspection: This shall include inspection of the filter material **for pitting, crazing, cracking,** and inspection of the goggle frame for mechanical integrity and light leaks. Straps should be inspected as well and replaced if they have been stretched or are frayed.

Subject Area: ***Laser Safety***

Guidance on Interlock Systems for Lasers

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser Safety Subject Area requires that Class 4 lasers have their controlled areas interlocked. ES&H Standard 1.5.3, Interlock Safety for Protection of Personnel details the requirements for technical design, hardware, testing, and documentation for these systems. As guidance from ES&H for design basis requirements, the level of protection category for Class 4 laser systems is for "critical" hazards and the design probability for their failure is considered "remote."

ES&H Standard 1.5.3, Interlock Safety for Protection of Personnel provides the minimum requirements for noncommercial interlock systems, which were installed for personnel protection at the Laboratory after January 1995. In addition, any modifications to a preexisting system must be designed to maximize compliance with this Standard. For those systems predating January 1995, the new documentation and testing requirements apply. The required documentation will give a reviewer a brief summary of what systems are in place and how they are tested. For your guidance, the following are required:

1. A written functional description of the interlock system, which includes

    a. Hazards that are to be controlled by interlock protection;
    b. Means by which the interlock provides protection;
    c. Entry and search protocols if applicable, including announcements, alarms and emergency responses;
    d. Response of the system in normal operation, and to fault conditions and foreseeable personnel error, as well as to equipment failure.

2. Documentation of the physical and electrical configuration of the system, including circuit diagrams, wiring diagrams, and component specifications.

3. Written test procedures that specify test frequency (at least every six months) and completeness, including prepared checklists to ensure complete functional and auditable records of tests of the system.

4. A description of configuration management for controlling design, modifications, replacements, and maintaining complete and accurate documentation.

The following exhibits are provided to illustrate the implementation of interlocks in laser systems at Brookhaven National Laboratory (BNL). The exhibit Laser Lab Interlock Instrumentation Test Procedure is an interlock inspection checklist that illustrates the level of detail required, even for a comparatively simple interlock system. Interlock systems serve an important protection function and the exhibit List of Security Components contains parts used in the construction of a laser interlock in the Collider-Accelerator Department.

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2.0-062004/standard/2g/2g07e011.htm

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Laser Lab Interlock Instrumentation Test Procedure

Scope: The following procedure is for checking the operation of the laser interlock system. The interlock system is located in Building 535, Room B-102A.

The interlock system is to be tested bi-annually as per ES&H Standard, 1.5.3 Interlock Safety for Protection of Personnel**.**

Procedure:

A. Setting up the interlock system in preparation for testing.

1. Ensure that all laser systems are off.
2. Close all doors to the laser lab.
3. Ensure that all of the laser enable switches on the interlock panel are in the off position.
4. Move the warm-up/operate switch to the "warm-up" position.
5. Check that all laser shutters are closed.
6. Check that the "LASER ON" warning light, located above the door at the main entrance of the laser lab, is off.
7. Check that the two yellow "SHUTTER OPEN" warning lights, located on both sides of the main entrance door, are off.

B. Testing each laser system. **Note:** Do not use the door pass-through system. It will be tested separately in section C of this procedure.

1. Choose one laser system and attempt to start it. It should *not* start.
   - Note: The term "start" means that the electronics for the laser system will turn on but there is an external interlock fault condition.
2. At the interlock system panel flip the switch that enables that laser.
3. Check that the "LASER ON" warning light is *on*.
4. Check that the yellow "SHUTTER OPEN" warning lights are still *off*.
5. Reattempt to start the same laser. It *should* start.
   - The laser system's external interlock clears.
6. Move the warm-up/operate switch to the "operate" position. The shutter for the laser under test should open. If not, press the reset button. The "SHUTTER OPEN" warning light should turn *on*.
7. Open any door. The shutter should close and the "SHUTTER OPEN" warning light should turn *off*.
8. Open and close the door several times. The shutter should remain closed and the "SHUTTER OPEN" warning light should remain *off*.
9. Repeat steps 6 through 8 for the other two doors.
10. Repeat steps 1 through 9 for all laser systems. Check off each laser system on the Interlock Check Log after testing.
11. Turn off electrical power to all lasers.

C. Testing the door pass through systems. **Note:** This section does not require any laser system to be energized.

1. Enable any one of the laser systems and open it's shutter. The "SHUTTER OPEN" warning light should turn *on.*
2. Press the door pass through button. The yellow light on the pass-through enclosure should turn *on*. The buzzer should sound.
3. Open the door. The shutter should remain open and the "SHUTTER OPEN" warning light should remain *on*.
4. Close the door and press the pass-through button again.
    - The yellow light on the pass-through enclosure should turn *off.*
    - The buzzer should stop sounding.
    - The shutter should remain open.
    - The "SHUTTER OPEN" warning light should remain *on.*
5. Press the pass-through button and exit the laser lab through the doorway. Close the door behind you. Press the pass-through button.
    - The yellow light on the pass-through enclosure should turn *off.*
    - The buzzer should stop sounding.
    - The "SHUTTER OPEN" warning light should remain *on.*
6. Press the pass-through button. The yellow light on the pass-through enclosure should turn *on.*
    - Enter the laser lab through the doorway. Close the door behind you. Press the pass-through button. The yellow light on the pass-through enclosure should turn *off.*
    - The buzzer should stop sounding.
    - The shutter should remain open.
    - The "SHUTTER OPEN" warning light should remain *on.*
7. Press the pass through button. Time how long the pass-through system takes to reset itself. It should be less than 30 seconds.

D. Returning the interlock system to service.

1. Flip the warm-up/operate switch to the "warm-up" position.
    - The laser shutter should close.
    - The "SHUTTER OPEN" warning light should turn *off.*
2. Flip all laser enable switches to the off position.
    - The "LASER ON" warning light should turn *off.*
3. Ensure that all laser systems are off.
4. Open any door.

E. Test complete.

Be sure to initial and date the Interlock Check Log.

List of Security Components

(Security Parts List for E-Cooler Stand-Alone System)

1. Siemens Potter&Brumfield programmable time delay relay. Mod.3594, Pn. CNS-35-96.
2. Moeller Relay, 24 Vdc, Pn. DIL ER 40-G, with no. 4 contacts.
3. Omron Switch, Pn.WL-CA2-TS, with roller arm.
4. Ledtronics lamp sockets, Pn. HLDR BS850S
5. Ledtronics lamp covers, Green cover Pn. LCF850-CGF, Amber cover, Pn. LCF850-CAF, Red cover, Pn. LCF850-CRF.
6. Incandescent Lamp, 24 Vdc, ANSI Lamp # 313
7. Acopian power supply, 24 Vdc, Pn.W24M16, 10A
8. PanelView Plus, 6.5” with DH+, Pn. 2711P-T7C6D1
9. Key Switch, Tschudin & Heid, Style #544042 with KABA type keys.

Subject Area: ***Laser Safety***

Guidelines for Laser Pointer Safety

Effective Date: **July 2001**
Point of Contact: Laser Safety Officer

The Guidelines for Laser Pointer Safety is provided as a Word file.

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1.2-072001-/standard/2g/2g12e011.htm

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Guidelines for Laser Pointer Safety

Applicability:
These guidelines cover the use of all Class 2 or Class 3a laser pointers used for seminar or classroom presentations. The use of any other class laser pointer will need the prior approval of the Laser Safety Officer.

Rationale:
The use of laser pointers as an instructional aid has been gaining increased popularity. Laser pointers fall into two laser hazard classifications. One is Class 2, for which the human blink reflex is sufficient to provide protection; power output is less than 1 mW. The other is Class 3a, which can be safe for momentary viewing, but a recognized eye hazard, if viewed through optics. The Class 3a power output is between 1-5 mW. Most of the laser pointers available are Class 3a, in the 630-680 nm range.

Labeling of Pointers:
Potential users should be aware that some of these devices might also lack the appropriate warning labels. Federal law, 21CFR part 1040 requires the laser pointer manufacturer, to have a laser-warning label on the pointer. ***The label needs to show the laser hazard symbol, laser classification, laser wavelength, and maximum power output.*** The laser pointer should not be used if it is missing this label.

Green Pointers:
A new group of laser pointers is on the market, frequency doubled Nd:YAG lasers, whose output may be either continuous or pulsed. The output beam is 532 nm, with a blocked infrared beam at 1064 nm. These pointers are exceptionally bright to the human eye, and for safety, it is critical that the invisible 1064-nm beam-blocking filter be in place.

Laser Pointer Safety Guidelines

When used as intended, these devices do not present a hazard to the user or members of the audience. The following guidelines are provided to maximize safety:

- Use only those pointers labeled as Class 2 or 3a.
- Never intentionally stare into the laser beam.
- Never intentionally aim the pointer beam at oneself or another person, particularly in the facial area.
- The beam should always be directed away from the audience.
- The beam should be turned off when not in use.
- Mirror-like surfaces should be avoided when directing the laser beam. A reflected beam can act like a direct beam on the eye.

Emergencies:
Although the potential for injury from a laser pointer is very slight, notify your supervisor and get medical attention, if an eye injury from laser use is suspected. Call the Laboratory's emergency extension 2222, or 911.

Subject Area: ***Laser Safety***

Instrumentation Ti:Sapp Operation

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Instrumentation Ti:Sapp Operation is provided as a Word file.

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Instrumentation Ti:Sapp Operation

Standard Operating Procedures
Laser system: Ti:sapphire laser oscillator and amplifier.

A. Laser Oscillator

Laser specification - oscillator

Pump laser: Class IV, diode-pumped solid-state laser, 7 Watt, cw, 532 nm.
Output: Class IV, mode-locked Ti:sapphire solid-state laser, 400 mW, 100 MHz, 800 nm, 100 fs.

Laser system configuration - oscillator

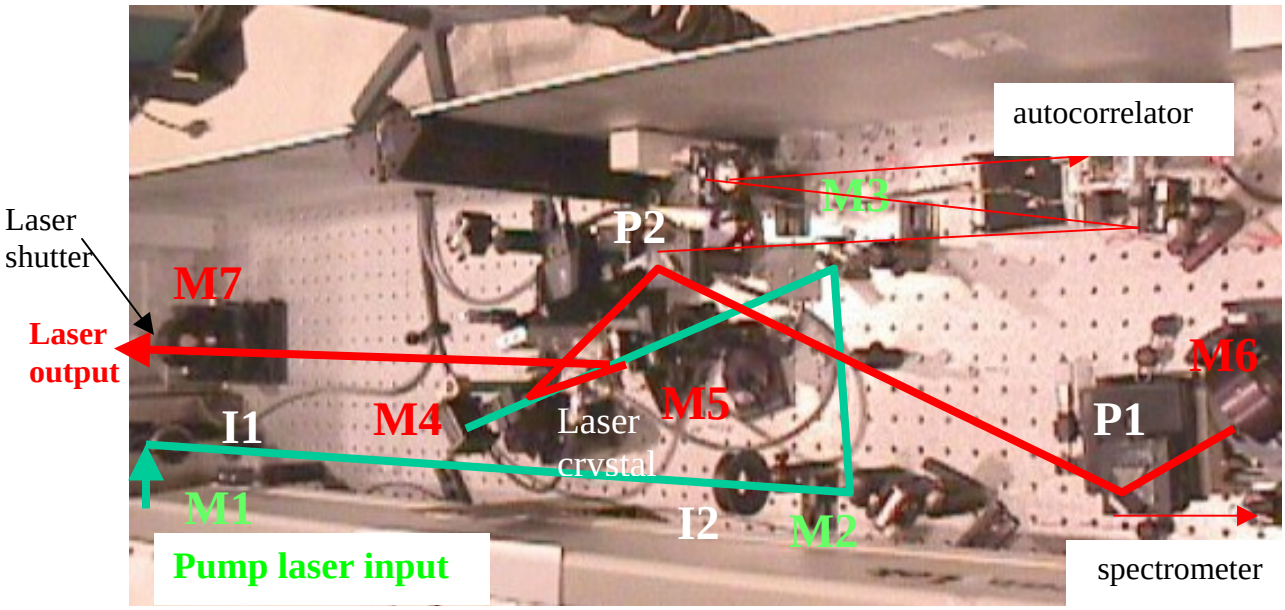

Figure 1. Ti:sapphire laser oscillator

Laser operation - oscillator

The system consisting of the Argon ion pump laser and the Ti:sapphire laser oscillator, is fully enclosed in a metal case. The oscillator consists of an argon ion pump laser and a passive Ti:sapphire laser cavity. A manual flip panel from the top of the enclosure is available for alignment and routine laser start up of the laser oscillator. A laser shutter indicated in Figure 1 normally blocks the laser output. Laser shutter is in fail-safe mode - in the close position on power fail condition. Upon uncontrolled entrance to the laser controlled area, interlock will break and the laser shutter will close to block the output.

The laser oscillator operation procedures are:

1. Wear correct laser safety goggle.
2. Ensure the flip panel of the laser enclosure is completely closed.
3. Enable the Ti:sapphire oscillator on the laser selection switch box, laser controlled area is interlocked.

4. Turn Argon laser on – enable main power supply of the argon ion laser, turn the water circulation on, and enable the argon ion laser from the control panel of the power supply.
5. After laser warm-up (~45 minutes), mode-lock the Ti:sapphire laser by manually flipping open the top laser enclosure, and translating the prism, P1 in Figure 1.
6. Close the top flip panel.
7. The mode-locked operation is monitored by the spectrometer and/or the autocorrelator outputs displayed on the computer monitor.

The laser oscillator is ready for experiments.

Laser alignment – oscillator

Laser oscillator beam alignment is *not* a routine operation. It should only be done by qualified and trained laser operators.

The procedures for the normal laser alignment are:

1. Wear correct laser safety laser goggle. No beam should be viewed directly.
2. Ensure the laser-controlled area is secured and interlocked.
3. Place an optical power meter at the output aperture
4. Lower the power of the argon ion pump laser to below 10 mW
5. Flip open the top panel of the laser enclosure.
6. Send the pump beam through the iris I1 and I2 by manipulating mirror M1.
7. Send the pump beam through mirror M5 to the laser crystal by manipulating mirrors M2 and M3. The pump beam path can be observed with the laser safety goggle using a green fluorescence card.
8. Increase the pump power to the normal operating power of 4 Watt.
9. With the aid of an IR fluorescence card, send the laser fluorescence from mirror M4 to prisms P2 and P1. Using mirror M6 to retroreflect the dispersed fluorescence light back to the laser crystal.
10. With the aid of an IR fluorescence card, send the laser fluorescence from mirror M5 to the output coupler M7. Then retroreflect the fluorescence light from M7 back to the laser crystal.
11. The oscillator cavity should be lasing and NIR optical power should be registered on the power meter.

The laser oscillator cavity alignment is done.

Laser service – oscillator

The only service on the oscillator is the argon ion pump laser. Servicing and replacing the argon ion tube are done by the manufacturer. Optics in the argon ion laser cavity is occasionally cleaned. Follow the cleaning procedures detailed in the manual of the argon ion laser.

B. Laser Amplifier

Laser specification - amplifier

Pump laser: Class IV, diode-pumped solid-state Nd:YLF laser, 6 mJ/pulse, max PRF 1 kHz, 532 nm.
Output: Class IV, 1 mJ/pulse, 1 kHz, 800 nm, 200 fs.

Laser system configuration - amplifier

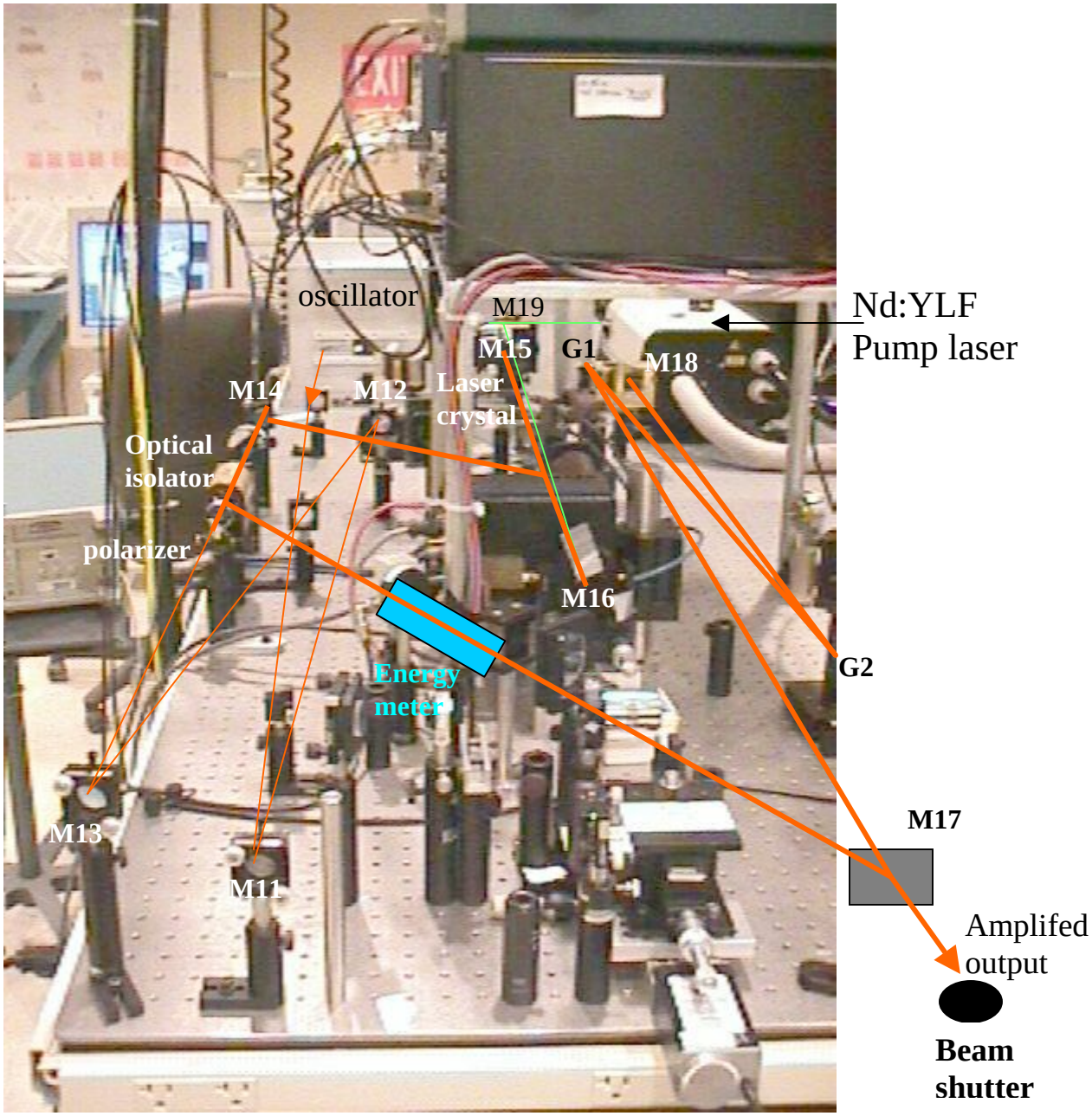

Figure 2 – Ti:sapphire laser amplifier

Laser operation - amplifier

The complete amplifier system, Nd:YLF pump laser and the Ti:sapphire regen amplifier, pulse stretcher, and pulse compressor, are (will be) completely enclosed in a metal enclosure. A manually flip panel from the top of the enclosure is available for alignment and routine laser start up of the laser amplifier. A laser shutter, indicated in Figure 2, normally blocks the light output. Laser shutter is in power fail-safe mode--in the close position on power fail condition. Upon uncontrolled entrance to the laser controlled area, interlock will break, the pump laser power will be deactivated by an intra-cavity shutter internal to the Nd:YLF laser, simultaneously, the beam shutter to the amplified Ti:sapphire laser is also closed.

The laser amplifier operation procedures are:

1. Wear correct laser safety goggle.
2. Ensure the flip panel of the laser enclosure is completely closed.
3. Enable Ti:sapphire amplifier on the laser selection switch box, laser controlled area is interlocked.
4. Flip open the top panel and place a calibrated energy meter at the output of the amplifier to monitor the optical power.
5. Open the manual aperture on the oscillator enclosure to allow the propagation of the stretched seed beam to the regen amplifier.
6. Turn Nd:YLF pump laser on – enable the close-cycle chiller unit and then enable the Nd:YLF laser when the temperature readout of the chiller dropped below 20 degrees C.
7. After laser warm-up (~45 minutes), turn on the Pockels cell to switch out the amplified pulse.
8. Remove the energy meter and close the top panel.

The laser amplifier is ready for experiments.

Laser alignment – amplifier

Laser amplifier beam alignment is *not* a routine operation. It should only be done by qualified and trained laser operators.

The procedures for the normal laser alignment are:

1. Wear correct laser safety laser goggle. No beam should be viewed directly.
2. Ensure the laser-controlled area is secured and interlocked.
3. Flip open the top panel of the laser enclosure.
4. Lower the energy of the Nd:YLF pump laser to below 0.1 mJ/pulse at 100 Hz repetition rate.
5. Redirect the pump beam to the laser crystal through mirror M15 by manipulating mirror M19.
9. Remove the quarter-wave plate in the amplifier beam cavity.
10. Increase the energy of pump beam to about 4 mJ/pulse.
11. With the aid of an IR fluorescence card and an infrared viewfinder, locate the florescence of the laser crystal and send the fluorescence light from mirrors M15 and M16 back to the laser crystal.
12. A self-lasing beam will be emitted from the regen amplifier to mirror M14, through the optical isolator and the polarizer to the output beam aperture.
6. Place an optical energy meter at the desired position to monitor the amplified output energy.
13. Open the manual aperture of the oscillator enclosure to allow the propagation of the stretched seed beam to the regen amplifier.
7. Insert the quarter-wave plate in the amplifier beam cavity.

8. Enable the Pockels cell to switch out the amplified pulse. The energy meter should read the correct amplified pulse energy.

The laser amplifier alignment is done.

Laser service – amplifier

The only service on the amplifier is the Nd:YLF pump laser. The manufacturer does servicing and replacing the pump laser diode. Optics of the amplifier are routinely cleaned using optical cleaning solutions when no lasers are energized.

C. Optical Beam Transport

The safety goggles provide primary protection to the user in the vicinity of the laser, and hence appropriate goggles should be worn at all times. Never view a laser beam directly. The alignment procedures applied to all classes of lasers, including Class IV.

1. Prior to transport an optical beam to an experimental setup, plan a lay out of the transport and the procedure to be followed to implement the transport.
2. Identify locations that could cause stray reflections or scattering from elements such as lens, windows or any other reflective surface.
3. A Class II/IIIa alignment laser shall be used to establish the desired optical beam transport path and to locate the position of the desired optics. The beam path should be established by placing two or more iris along the beam path.
4. Block any scattered beams. Set up equipment, such as fluorescent card, camera, and energy/power meter to view the target indirectly.
5. Reduce the power/energy of the desired optical beam to be transported to below the maximum permissible optical power/energy of the goggles recommended for that laser.
6. Align the desired optical beam to the alignment beam path using the already positioned alignment iris. Align the optical beam to be collinear with the alignment laser.
7. View the alignment to the target indirectly to confirm the alignment.
8. The beam transport is done. Confirm the scattered beams are blocked at various locations.

The beam transport line is ready to transport the full beam intensity of the desired optical beam to the target.

Subject Area: ***Laser Safety***

Instrumentation YAG Operation

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Instrumentation YAG Operation is provided as a Word file.

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INSTRUMENTATION YAG OPERATION

Nd: YAG Q Switching Dye Maintenance Procedure

Avoid contact with the skin at all times. Wear Neoprene or latex gloves whenever handling laser dyes. Work under the exhaust hood whenever handling this solvent.

I. Daily maintenance

1) The stability of the oscillator should be checked each day. If stability decreases, the most likely cause is the dye.

a) see start-up procedure for dye maintenance indications;
b) close shutter before adding dye;
c) add small amount of dye.

NOTE: Dye is kept in a dry box in the lab refrigerator. The dye should receive minimum light. The dye reservoir should be kept about ~ full. When adding concentrated dye to the reservoir, the dye should be brought to room temperature before removing the stopper from the bottle to avoid contamination due to water condensation.

d) allow the dye to circulate at least 1 minute;
e) open shutter and recheck the stability.

II. Bi-weekly maintenance: complete dye change

1) Turn pump off.
2) Drain tubes into small beaker; drain and clean the dye reservoir completely. Circulate
3) Dichloroethane through system for 1 minute.
4) Discard.this solvent, drain the tubes, clean the reservoir again.
5) Repeat steps 1-4 until the solvent runs completely clear.
6) Turn on the laser; it should lase with solvent only.
7) Allow the laser to run for 1 ~ hours with clear solvent.
8) Empty this solvent from the system and replace with new.
9) Add about 6 cc of dye concentrate to the dye cell. (The method for preparing this concentrate is given in part III of this document.)
10) While viewing the individual train of pulses on the scope, continue to add small (1 cc) amounts of dye concentrate until 9-10 pulses per train are obtained.
11) Allow the dye to circulate overnight in this condition.
12) In the morning, adjust the dye concentration to obtain 7 pulses and adjust the optics to produce stable operation.

III. Making dye concentrate

1) Use whole bottle of dye (l00 mg Exciton Q Switching 5)

NOTE: Exposed dye powder degrades quickly.

NOTE: Solvent reacts unfavorably with plastic. When working with solvent, make sure not to use bottles with plastic covers.

2) In a clean bottle, mix dye with 150 m1 of 1, 2 Dichloroethane. Shake dye and solvent until completely mixed. Use the magnetic stirrer.
3) Using tweezers, get one circular filter from blue filter box (10 micron filter).
4) Place the filter into its holder and place holder into large flask with pump. The holder is constructed in such a way that the filter fits between a reservoir at the top and a funnel at the bottom.
5) Place dye concentrate into reservoir before the filter so that the dye flows through the filter. Turn on the pump. The pump should be run for only 1-2 seconds, or until the concentrate is completely pulled through the filter.
6) Repeat this process several times.
7) Place filtered dye into clean flask and place this flask into the refrigerator dry box. After about 15 minutes, close the bottle with a stopper.

Subject Area: ***Laser Safety***

Laser Commissioning Process Flowchart

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser Commissioning Process Flowchart is provided as a PDF file.

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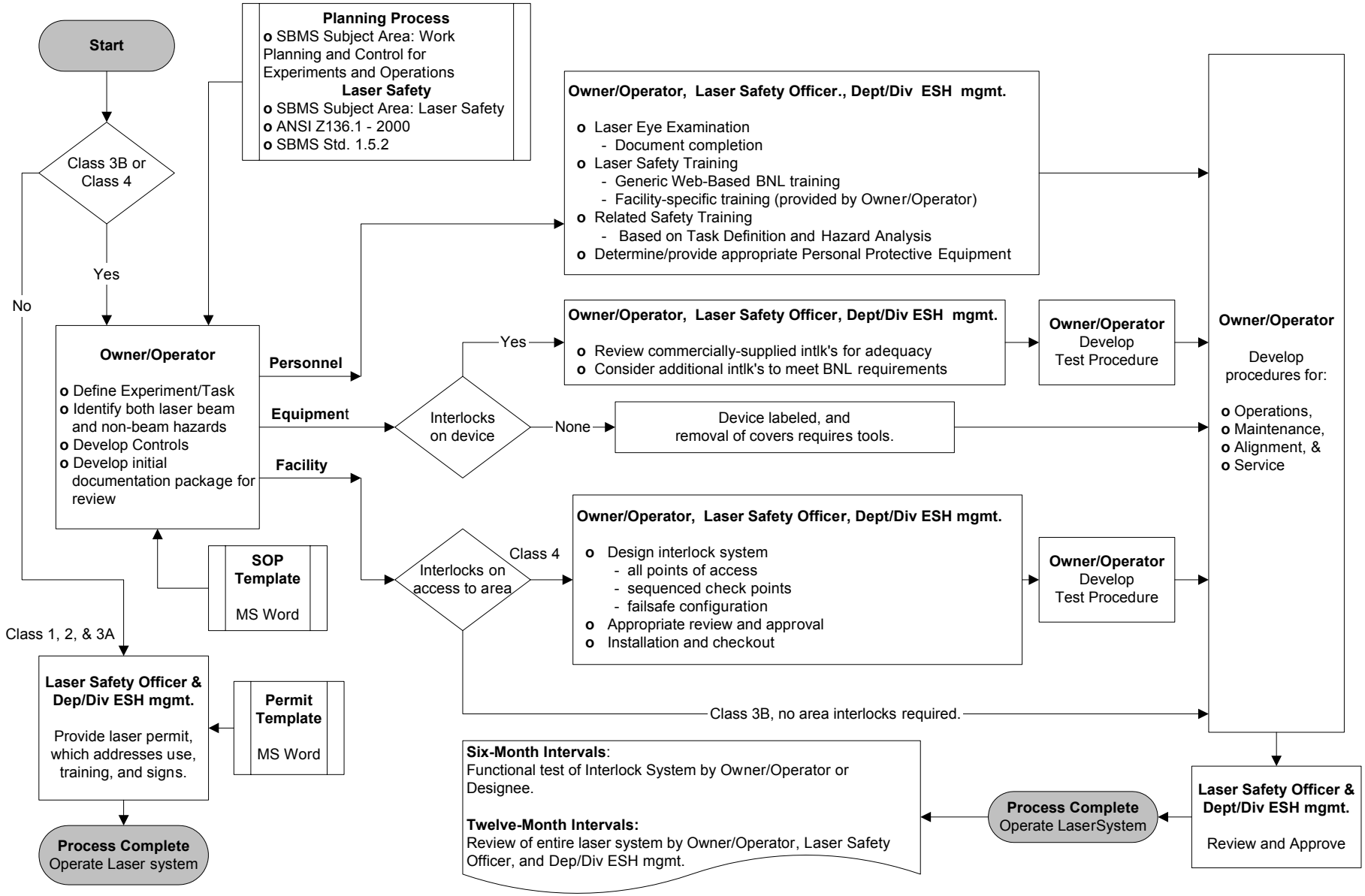
Laser Commissioning Process Flowchart



Subject Area: ***Laser Safety***

Laser-Electron Accelerator Facility (LEAF) Working Procedures

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Laser-Electron Accelerator Facility (LEAF) Working Procedures is provided as a Word file.

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Laser-Electron Accelerator Facility (LEAF)
Working Procedures

Administrative Controls Description:

General comments for all work in Laser-Electron Accelerator Facility (LEAF) Laser Controlled Areas (LCAs).

1. All lasers under this Standard Operating Procedure (SOP) are operated in the LCAs at LEAF described above. Appropriate warning signs are posted at each entrance. All lasers have mandated labels. Flashing warning signs, activated whenever the interlock system is live, are mounted outside the main laser room entrances. Yellow warning lights are lit at the doors to the vault when its interlock system is active.

2. Remember that Class 4 laser beams are dangerous to view even in diffuse reflection. Class 4 limits and maximum permissible exposures (MPEs) for all wavelengths emitted by lasers covered by this SOP are listed in the section "Analyze the Laser System Hazards" above, and eyewear requirements are listed in the eyewear table below. Requirements for when/what eyewear is required are discussed below.

3. Before working within the laser nominal hazard zones at LEAF, users must remove personal objects that might intercept a beam accidentally during work. This is especially true for shiny BNL badges attached to ropes around your neck or even clipped to shirts, and things like rings and watches when making laser adjustments. Such objects make very good reflectors that could cause specularly reflected beams to leave the NHZ in an uncontrolled fashion.

4. Users must use good sense in avoiding actions that place themselves or co-workers at risk of laser-related injuries. Users must be aware of others in the LCA, especially those who enter the area while work is in progress.

5. If at any time a user is unsure of the correct procedure to follow, the user shall **STOP** and seek the advice of the responsible Principal Investigator (PI).

6. Definitions:
    a. Operation – use of laser systems; will involve energy adjustments via waveplate/polarizer pairs already in place.
    b. Gross alignment – any procedure where beams are not already on optical components, or those that may lead to beams leaving established paths and optical surfaces.
    c. Simple/normal alignment – procedures where beams do not leave established beam paths/optical surfaces/beam stops.

Operation SOP:

1. Except during alignment procedures, all primary and specular beams, as well as diffuse reflections from Class 3b and 4 beams must be contained on the laser tables using non-combustible diffusely reflecting or absorbing laser beam stops that do not create hazardous vapors. Class 3b and 4 beams between tables across open floor space must be enclosed in protective tubes. All optics must be solidly attached to laser tables so that accidental "bumps" cannot send beams in unknown directions. Physical protection must be provided from vertical beams or any other situation where unexpected exposure might occur. Under these conditions, the nominal hazard zone is confined to the areas above the laser tables, and eye protection as specified below is required for work within the nominal hazard zone. *Any light outside the NHZ must be at levels at or below the maximum permissible exposure (MPE).*

2. Lasers should be operated at the minimum intensity consistent with experimental requirements.

3. Nd:YAG lasers must be used with enclosed termination of all unused harmonics.

4. Users must know and follow the routine operation instructions for all lasers as described in the manuals provided by the laser vendors.

5. A common operation procedure is the adjustment of the amplifier pump energy, by rotating wave plates in the amplifier box. While this does not involve moving any beams, users must:
    a. Wear eye protection for 800 nm (532 nm is optional; if worn, users must know ahead of time where the beams are to avoid skin burns).
    b. Do not put any objects (fingers, watches, cards) in any beams.
    c. Only open the amplifier cover as much as necessary, and close the covers when done.

6. Another common procedure is measuring the output energy of the amplifier and it's third harmonic:
    a. Wear eye protection for invisible beams including both 800 nm and 266 nm.
    b. Do not put any objects (fingers, watches, cards) in any beams.

Alignment SOP:

1. There must be no intentional intrabeam viewing with the eye!!

2. 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.

3. Consider the use of low power Class 1 to 3a coaxial CW alignment lasers when convenient.

4. During alignment procedures, only persons immediately involved in the procedure are to be in the LCA. These individuals must have appropriate training and be listed in this document as authorized laser users.

5. 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.

6. During all times 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.

7. 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.

8. Alignment procedures are always to be performed with the minimum practical laser power levels and repetition rates. This is especially true for the output of the primary pump lasers. In the case of the Quanta-Ray Nd:YAG lasers this can be achieved by the use of long pulse mode that dramatically reduces the high-energy 532 nm output, and produces a much longer pulse width. Since you must be able to see this beam in order to align it, refer to the comments in #14 below. The beam energy can be further reduced if necessary by tweaking the harmonic generator off the maximum, though you should be aware that this will also move the beam some. Inside the TSA amplifier, use the wave plates to minimize the 532 nm energy to the point (nearly minimum) where a good quality beam is just visible before doing alignments.

9. Following a new laser beam set-up or change in alignment, a survey of the (ANSI) Limited Open Beam Path will be conducted to verify that all unwanted beams and reflections have been properly terminated. Opaque barriers will be used to confine low intensity stray reflections and scattered light to the optical tables. Any unwanted primary or specular beams in excess of Class 4 thresholds will be terminated in a beam stop within the NHZ that does not produce hazardous diffuse reflections.

10. Gross alignment of beams from Class 4 lasers into experiments or tunable lasers should be done with beams attenuated as far below Class 4 thresholds as possible, with eye protection adequate for the beam in use.

11. 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.

12. Pre-position optical components during gross alignment as best as possible and bolt them down before allowing beams to propagate.

13. Be aware of the potential for errant reflections (stray beams) from and leaked beams transmitted through components such as polarizers and dielectric mirrors. For example, do not use or rotate calcite polarizers with escape windows without first being sure that all exit beams will be blocked. Check for stray beams at each step and again after completing all alignment steps.

14. In some circumstances, unobstructed viewing of diffuse reflections from Class 3b beams is non-hazardous as long as reasonable care is taken. In cases where it is necessary to view diffuse reflections from Class 3b laser beams in order to align them, the following apply:
    a. Heightened awareness of beam hazards is necessary during such procedures. Special care and planning is needed to insure that unexpected specular reflections do not occur, and that hazards from other beam sources are controlled.
    b. Consider other ways first that do not require direct viewing of diffuse reflections (viewers, emissive cards).
    c. Use the minimum possible energy consistent with the task at hand.
    d. Discuss new procedures with a colleague in order to identify safe methods.
    e. Use only cards without shiny surfaces to produce only diffuse reflections.
    f. Minimize viewing time of the beam on a card; often only a second or two is necessary to align a beam.
    g. Do not put your face close to the source of diffuse reflections; use cards at arm's length away when possible.
    h. Consult the eyewear PPE table below for ODs need for diffuse reflections of the primary laser sources, and the discussion below it on how to limit the hazard to below the MPE by using primarily lower power, distance from the source, and viewing time.

i. If you are not absolutely sure about the safety of the procedure you are doing, stop and seek assistance from the appropriate PI and/or other reference person such as the department LSC or BNL LSO.

Maintenance SOP:

1. Laser users will conduct some routine maintenance. This includes procedures such as replacement of the flash lamps and cooling water in the Nd:YAG lasers, optics cleaning and/or replacements in all lasers. All of these procedures are to be conducted in strict accordance with the methods described in the laser manuals provided by the manufacturers, and only by individuals with appropriate training who are listed in this document. Any maintenance on BNL constructed equipment will only be performed under the direction of the appropriate PI.

2. Non-routine maintenance and troubleshooting is a serious matter, as injury or damage to equipment could result from actions taken in unfamiliar circumstances. When an uncharacterized fault condition exists, some actions that would be safe under ordinary conditions may have unsuspected hazards. Diagnostic work on optics or electronics will thus only be undertaken strictly following specific instructions in the manufacturer's laser manual, or in consultation with the manufacturer's service engineering staff. When there is any uncertainty about the safety of a diagnostic procedure, don't do it, and seek additional expert guidance. The laser manufacturer's field service engineers may be required to perform specialized maintenance tasks for which lab employees lack specific expertise and training.

Subject Area: ***Laser Safety***

Laser Safety Inspection (BNL Chemistry Example)

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

Laser Safety Inspection (BNL Chemistry Example) is provided as a PDF file.

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LASER SAFETY INSPECTION (BNL) CHEMISTRY EXAMPLE
Chemistry Department Semiannual Laser Safety Inspection Protocol

1. Chemistry Department LSIs shall be carried out two times per calendar year. The first shall be performed in the month of January, the second in the month of July.
2. LSIs shall be performed by the Chemistry Department LSC or delegate as approved by the Chemistry Department Chair.
3. LSIs shall be made of all laser laboratories located in the Chemistry Department (Building 555). A laser laboratory shall be defined as any laboratory for which a BNL SOP has been authorized.
4. At least one owner/operator named in the SOP must be present during the inspection.
5. During December and June, reminders shall be sent to each owner/operator stating that LSIs will be scheduled and that laser safety door interlock system tests be performed and documented prior to the LSI.
6. The LSI shall consist of: (1) confirmation that all laser-specific documentation, including SOPs, laser registrations, interlock tests, and laser-specific training forms, are current, (2) inspection of the lab and (3) discussion of any changes made in documentation, operations, personnel, and equipment since the preceding LSI. A *Semiannual Laser Safety Inspection and Action Item Checklist* specifying all required inspection items shall be developed and maintained by the LSC.
7. During and immediately following the LSI, a *Semiannual Laser Safety Inspection and Action Item Checklist* shall be completed for each laser laboratory. The checklist shall document where the laboratory documentation, experimental configuration, or operations are found to be noncompliant, and shall indicate corrective actions. Completed checklists shall be kept on file by the LSC.
8. In cases where a corrective or other action is required, a copy of the inspection checklist shall be given to the owner/operator. It shall be the responsibility of the owner/operator to: (1) confirm that the specified action(s) is(are) completed, (2) sign and date the checklist and (3) return the checklist to the LSC within two weeks of the inspection date. Failure of the owner/operator to return the completed checklist may result in the issue of a Stop Work order.
9. Upon completion of the LSIs, the LSC shall file a report with the Chemistry Department Chair and Chemistry Department ES&H Coordinator. This report shall consist of a completed *Semiannual Chemistry Department Laser Safety Inspections Report* form and shall document that the inspections have been performed. In the event that non-compliance has been noted, a memo documenting any comments and concerns to the Chair and ES&H Coordinator shall also be included. The semiannual reports must be filed on or before the 15th day of February and August.
10. Following completion of the July LSI report, SOPs shall be reviewed. The LSC shall initiate the review process by sending the current electronic copy of each SOP to the responsible owner/operator. An updated version of the SOP shall be returned to the LSC within three weeks. The LSC will forward the updated SOPs to the LSO for review. Subsequently, the LSC shall convene meetings, attended by the LSO, the owner/operator, and the LSC, for the purpose of finalizing and authorizing the SOPs.

Acronyms:

BNL	Brookhaven National Laboratory	LSO	Laser Safety Officer
ES&H	Environmental Safety and Health	LSI	Laser Safety Inspection
LCA	Laser Controlled Area	SOP	Standard Operating Procedure
LSC	Laser Safety Coordinator		

Semiannual Laser Safety Inspection and Action Item Checklist

Room No.:		**SOP Control No.:**		
Owner/Operator:	*Print Name*	*Signature*	**Date:**	
Inspector:	*Print Name*	*Signature*	**Date:**	

A	***P***	***Item***	***Required corrective or other action(s)***
Administrative Controls			
		SOP authorizations current	
		Correct door signage in place	
Laser Inventory			
		SOP consistent with active inventory	
		New laser arrived or expected	
Personnel Authorizations			
		Web laser training current for all	
		Laser specific training current for all	
		SOP personnel list current	
		New users arrived or expected	
Door Interlock System			
		All active lasers interlocked	
		Logbook current	
Engineering Controls			
		Enclosures & barriers adequate	
		All beams properly terminated	
		Recent changes in NHZ / beam path	
		Recent changes in experimental geometry	
Personal Protection Equipment			
		Eyewear adequate and accessible	
		PPE for New lasers available	
Other			
		Power supply cabinets closed	
		Excimer laser ventilation	

A *= Action required,* ***P*** *= Passed (No action required); If corrective or other action is required, owner/operator shall confirm that specified action is completed, sign and date below, and return this form within two weeks to the Chemistry Department Laser Safety Coordinator.*

This space reserved for additional comments from the inspector and/or feedback from the owner/operator

I certify that the above specified actions have been completed.

Print Name	*Signature*	Date

Semiannual Chemistry Department Laser Safety Inspections Report

Assessment Description: Building 555 Semiannual Laser Safety Inspection Report	
Scope of Assessment: Interlock logs (six-month interlock checks carried out – system in compliance for next 3 months) Laser SOPs (annual updates, signatures of all personnel, verification against active lasers in room) Laser Registration Records (all lasers in room properly registered).	
Conducted by: Laser Safety Coordinator N. Camillone (or delegate as approved by Chemistry Chair)	**Date:**
Persons contacted: At least one laser user/owner in each laser room to verify documentation/laser use for room.	
Procedures or documents reviewed: Interlock Logs, Laser SOPs, Laser Registration Records, Lab inspected	

Room Number	Document	Comments	Date
22 Wishart/Cook	Interlock Test SOP Registration	._____. ._____.	
115 Creutz	No Interlock No SOP Registration (2 class 2 lasers)	._____. ._____.	
121 DiMauro	Interlock Test SOP Registration	._____. ._____.	
127 White/Beuhler	Interlock Test SOP Registration	._____. ._____.	
221 Hahn	No interlock (3A rules apply) SOP Registration	._____. ._____.	
261 Fujita	Interlock Test SOP Registration	._____. ._____.	
306 Hall/Suits	Interlock Test SOP Registration	._____. ._____.	
321 Preses	Interlock Test SOP Registration	._____. ._____.	
323 Fockenberg	Interlock Test SOP Registration	._____. ._____.	
325/327 Hall/Sears	Interlock Test SOP Registration	._____. ._____.	
329 Suits	Interlock Test SOP Registration	._____. ._____.	
353 Camillone	Interlock Test SOP Registration	._____. ._____.	

Subject Area: ***Laser Safety***

Outline for ANSI Z136.1-2000 Topics

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The exhibit Outline for ANSI Z136.1-2000 Topics is provided as a PDF file.

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2.0-062004/standard/2g/2g18e011.htm

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Outline for ANSI Z136.1-2000 Topics

Section	Title	Notes
1	General	Overview
1.1	Scope	Standard for lasers between 180 nm and 1 mm
1.2	Application	Reasonable and adequate guidance for safe use of lasers
		1 Determine class of laser
		2 Comply with measures for control of hazards
1.3	Laser Safety Officer	
1.3.1	General	LSO designated w/ authority and knowledge to monitor and enforce laser standards
		LSO may do, or cause to be done the required things
1.3.2	LSO Specific Responsibilities	
2	Definitions	Exhaustive list running some 6 pages
3	Hazard evaluation and classification	
3.1	General	Three aspects of importance in classification
3.2	Laser Considerations	LSO ensure laser output data are valid, mfg or measurements (Section 9)
3.3	Laser and Laser System Hazard Definitions	Ref Tables 1, 2 and appendix A
3.4	Environment in which laser is used	Wide latitude for LSO regarding environment and additional controls esp. for Class 3b and 4 systems
3.5	Personnel	People who may be in vicinity of laser when in operations
4	Control Measures	
5	Laser Safety Programs and Employee Training	
5.1	General	Management has responsibility for assurance of safe use of lasers owned and operated by them
5.2	Laser Safety Program	What has to be in it; Guidance in appendix D
5.3	Education	Consider guidance in appendix D; also consider periodic training
6	Medical Surveillance	See also Appendix E
6.1	General	Rational for surveillance
6.2	Personnel Categories	Who's who determined by LSO
6.3	General Procedures	
6.4	Frequency of Exams	Baseline before work, after an accident if it happens. No periodic exam requirement

Outline for ANSI Z136.1-2000 Topics

7	Non-Beam Hazards
8	Criteria for Exposures of Eye and Skin
9	Measurements
10	Revision of Standards referenced in ANSI Z136.1-2000
Appendices	
A	Examples of Typical Lasers or Laser System Classification and MPE Values for Selected Lasers
B	Calculations for Hazard Evaluation and Classification
C	Hazard Evaluation, Classification and Control Measures
D	Guide for Organization and Implementation of Laser Safety Programs and Employee Training
E	Medical Surveillance
F	Non-Beam Hazards
G	Biological Effects of the Eye and Skin
H	Harmonization with international standards

Subject Area: ***Laser Safety***

Source Development Laboratory Reference Document: Laser Eyewear Requirements

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Source Development Laboratory Reference Document: Laser Eyewear Requirements is provided as an Excel file.

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		Kentek GBM 64 (Orange)		SDL	Potential Sources in SDL Laser System
	Glendale GPT 2233 LRQ07 (Orange)			Lasers	
	Laser Vision L648 (Green)				
Wavelength [nm]	OD	OD	OD		
190-490		9+			Freq. Tripled Ti:Sapp (266 nm for Gun)
514.4		7+			
190-520			9+		Freq. Tripled Ti:Sapp (266 nm for Gun)
500-520		6+			
520-532		4+	7+	1,2,3	Green Second Harmonic from YAG, Millenium Output
633	2-3			6	He:Ne Alignment laser 632
647-676	3+				
710-750			3+		
750-780			5+		
750-850			5+		
840-920		3+			
920-1070		4+		1,2	YAG Fundamental (1064 nm)
850-1080			7+		
694-1320	7+			1,2,4,5,7	Ti:Sapp Fundamental (~800nm), Alignment Diode
10600	5+				
5000-11000		7+	7+		
			For YAG 532 line protection (*nb* GPT 2222 or 3932 equivalent)		
		Nominally for use with YAG systems			
	Nominally for use with Ti:Sapp laser system				
Laser Vision L648 are goggles with dark green lenses					
Glendale Protective technologies GPT 2233 are more like glasses with sideshields with orange lenses					

Laser Vision Goggles:	Glendale Goggles:	Kentek Goggles
UVEX Safety	Glendale Protective Technologies	KENTEK Corporation
10 Thurber Blvd	5300 Region Court	19 Depot Street
Smithfield RI 02917	Lakeland FL 33815	Pittsfield, New Hampshire 03263
800/343-4311	941/687-7266	800/432-2323

Make sure the eye protection you use is adequate for the sources of light!!!

Subject Area: ***Laser Safety***

YAG Laser Operations at Accelerator Test Facility (ATF)

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

YAG Laser Operations at Accelerator Test Facility (ATF) is provided as a Word file.

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YAG Laser Operations at Accelerator Test Facility (ATF)

YAG operations: turning the system on

1. Prepare interlock system.

1a. Verify that the YAG room, and for photocathode operation, the Gun Hutch are secure by checking the status indicators on the MCR laser interlock panel. If not secured, follow the search and secure procedures for the room(s) as specified in the ATF handbook section 1.3.4.2.

1b. Obtain the YAG LASER SHUTTER KEY (#1) from the key box in the control room. For photocathode operation, also obtain the YAG TO GUN KEY (#2).

1c. Sign out the key(s) in the key log.

1d. Insert the key(s) into the appropriate lock on the MCR laser interlock panel and open the YAG LASER SHUTTER.

1e. For photocathode operation, open the YAG TO GUN SHUTTER.

1f. Close the UV shutter (yellow LED OFF).

2. Prepare equipment.

2a. Turn OFF the STANDBY power (circuit B) and turn ON the RUN power (circuit A) with the switches next to the YAG room door.

3. Check the oscillator.

3a. Look at the oscilloscope on the SE corner of the table roof and verify proper autocorrelation shape and timing stabilizer phase lock.

3b. If no signal is seen, verify that the oscillator controller is not in standby mode.

YAG operations: turning the system on (continued)

4. Activate the amplifiers.

4a. Return to the vestibule.

4b. Verify that the preamplifier pump voltage is set to its minimum, fully counterclockwise.

4c. Turn on the preamplifier key switch.

4d. Push the preamplifier HV ON switch.

4e. Verify that the amplifier triggering section key switch is on.

4f. Verify that the amplifier HV section power is on.

4g. Switch the amplifier trigger mode to EXT. Verify that the power supply begins to pulse.

4h. Return to the preamplifier and slowly raise the pump voltage to the posted value.

5. Check the protection system status.

5a. Return to the YAG room.

5b. If pulsing stops, or if the red indicators on the protection system panel in the corner rack go on, stop and notify a laser operator.

6. Record data in the logbook.

6a. Enter pump levels from the amplifier and preamplifier power supplies in the vestibule.

6b. Enter energy levels from the joulemeter readouts on the SW corner of the table roof. Remember to return the readouts to normal operation and display channel A.

7. Return to MCR.

7a. Inform the physicist in charge of the laser status.

YAG operations: turning the system off

1. Close shutters.

1a. Close the UV shutter (yellow LED OFF).

1b. Close the YAG LASER SHUTTER and, after photocathode operations, the YAG TO GUN SHUTTER on the MCR laser interlock panel.

1c. Return the key(s) to the key box and sign back in.

2. Turn off the amplifiers.

2a. Enter the vestibule following the pass through procedure.

2b. Lower the HV pump level (counterclockwise) on the preamplifier power supply to its minimum.

2c. Turn off the preamplifier key switch.

2d. Set the amplifier power supply to MAN trigger mode.

2e. Turn off the power switch for the amplifier HV section, wait 5 seconds, and then turn it on again.

3. Turn off remaining equipment.

3a. Turn OFF the RUN power (circuit A) and turn ON the STANDBY power (circuit B) with the switches next to the YAG room door.

YAG operations: restart following power outage

1. Oscillator.

1a. Turn OFF the RUN power (circuit A) and turn ON the STANDBY power (circuit B) with the switches next to the YAG room door. This will allow the oscillator to run in the absence of an interlock permit signal by closing an additional shutter.

1b. For outages of only a few minutes, the oscillator, timing stabilizer, and RF amplifier will operate on an uninterruptible power supply. For longer outages, the oscillator will shut down, and return to STANDBY mode when power is restored. Switch the oscillator controller from STANDBY to RUN mode to begin warm up. Thermal equilibrium is reached after many hours after a cold start.

1c. The small chiller in the vestibule must be running to establish the proper temperature around the oscillator. Verify that it is running and has adequate water level.

2. Interlock system.

2a. The interlock system powers up in a failsafe mode that disables all lasers power supplies. Use the Safety Officer Reset (SOR) key to re-enable the system. Every control panel must be enabled independently.

3. Amplifiers and cooling.

3a. The amplifier power supplies are tied into the interlock system, and power switches must be cycled to start the cooling loops. Check that both the preamp and amplifier power supplies in the vestibule show proper temperature regulation on the heater controllers.

3b. The power supplies are cooled by the chiller in the high bay. It will not restart after power is restored. Use the START button to restore normal cooling operation.

4. Pulsers

4a. Verify that the SRS DG-535 delay generators have returned to normal operation or restore saved memory settings as required.

4b. The DEI high voltage pulser on the YAG table roof must be manually reset after a power outage. Press the OUTPUT ENABLE button to return to normal operation.

Subject Area: ***Laser Safety***

BNL General Laser Registration Form

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The BNL General Laser Registration Form is provided as a Word file. It is used to notify the Laser Safety Officer of any changes in disposition of lasers at the Laboratory including

1. Registration of new lasers.
2. Change in location of lasers.
3. Transfer of ownership of lasers.

Multiple lasers may be listed on a single form, however, please use a separate form for each type of disposition change. Some types of lasers are exempted from registration requirements at BNL including laser pointers and lasers built into equipment such as CD writers or laser printers. Guidelines for safe laser pointer use are provided in the exhibit Guidelines for Laser Pointer Safety. If you are in doubt about the need for registration of a laser system, contact the Laser Safety Officer.

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2.0-062004/standard/2g/2g02e011.htm

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BNL GENERAL LASER REGISTRATION FORM

Instructions: Fill out form and submit to the Laser Safety Officer (LSO). The LSO sends back the signed form and the owner/operator retains the original.

This form may be used to change the disposition of any laser requiring registration at Brookhaven National Laboratory (BNL). The form can be used for multiple lasers, but should only represent one type of change of disposition. Please indicate the type of change (check one option):

1. **Register new laser(s)** ☐
2. **Document the movement of lasers to new locations** ☐
3. **Document the transfer of ownership of laser(s)** ☐

LASER INFORMATION

Laser Type (lasing medium)		Manufacturer/Model/Serial # BNL Bar Code (if applicable)	Class	Wavelength(s)	Maximum power/PRF*	Beam Diameter (cm)
1						
2						
3						
4						
5						
6						

***PRF:** Pulse Repetition Frequency

PRIMARY LOCATIONS OF LASERS

Building	Room #

LASER OWNER/OPERATOR:_____ **DEPT**: _____

(For transfer only) ☐
(FROM) LASER OWNER/OPERATOR: _____ **DEPT**: _____
(TO) LASER OWNER/OPERATOR: _____ **DEPT**: _____

Project:

Comments:

Record Number (Assigned by LSO) LR_____

Subject Area: ***Laser Safety***

BNL General Class 2/3A Laser Use Permit

Effective Date: **May 2004**
Point of Contact: Laser Safety Officer

The BNL Class 2/3a Laser Use Permit is provided as a Word file. When completed, it documents the controls for utilization of a Class 2 or Class 3a laser outside of a laser controlled area in a specific location where lasers are not normally used. The form may not be used for operation of higher class lasers (3b and 4), which require the development and approval of a Laser Controlled Area Standard Operating Procedure. Some types of lasers are exempted from permit requirements at BNL including laser pointers and lasers built into equipment such as CD writers or laser printers. Guidelines for safe laser pointer use are provided in the exhibit Guidelines for Laser Pointer Safety. If you are in doubt about requirements for use permits for a laser system, contact the Laser Safety Officer.

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BNL GENERAL CLASS 2/3A LASER
USE PERMIT

This permit is to be filled out to document controls for the utilization of Class 2/3a lasers outside of Laser Controlled Areas in a specific location(s) where lasers are not normally used.

Instructions: Fill out the form and submit it to the Laser Safety Officer (LSO) for approval and signature. The LSO sends back the signed form and the owner/operator retains the original.

PERIOD OF OPERATION: **FROM** _____ **TO** _____
(Period not to exceed one year)

PURPOSE and USE LOCATION(s):

LASER OWNER/OPERATOR: _____ **DEPT**: _____

SAFE USE GUIDANCE (Laser Safety Officer):

1. NEVER point or aim a laser of any power at anybody.
2. Operate lasers with beam horizontal, above, or below eye level.
3. Remove unnecessary reflectant surfaces from near the beam path.
4. Use a beam stop at the end of its useful path.
5. NEVER view a laser beam using an optical instrument (such as binoculars, microscope) unless the Laser Safety Officer has technically approved the procedure.
6. Always use LOWEST power rating practical. The Laser Safety Officer may have a Class 2 laser available for use on loan, which may satisfy the purpose.
7. The area of use is required to be POSTED with an appropriate sign to be supplied by the Laser Safety Officer.
8. Lasers of identical or lower power may be substituted for use.

Required Controls and Comments:

APPROVAL (LSO): _____ **DATE**: _____

Record Number (Assigned by LSO) LP_____

Subject Area: ***Laser Safety***

Laser Controlled Area Standard Operating Procedure (SOP)

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser Controlled Area Standard Operating Procedure (SOP) Template, Laser Controlled Area SOP Template with Annotations, and Commentary on the Laser Controlled Area SOP have been provided as Word files.

Commentary on the Laser Controlled Area SOP

Laser Controlled Area SOP Template

Laser Controlled Area SOP Template with Annotations

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2.0-062004/standard/2g/2g03e011.htm

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Commentary on the Laser Controlled Area Standard Operating Procedure (SOP)
Brookhaven National Laboratory (BNL) Laser Safety Committee

What's in a name?

The term Standard Operating Procedure or SOP is a reserved descriptor included in the ANSI standard on Safe Use of Lasers (ANSI Z136.1-2000 Sec 4.4 'Administrative and Procedural Controls [Class 3b and Class 4] *et seq.*). The standard defines an SOP as a "Formal written description of the safety and administrative procedures to be followed in performing a specific task." The use of the word 'Procedures' in this context is unfortunate, because it has lead to confusion in the implementation of SOPs at the Laboratory where procedures have their own cultural and contextual meaning.

The functions described for SOPs in the ANSI standard are more akin to Operational Safety Envelopes in the DOE oversight environment. Within the Laboratory, procedures for actually conducting work are developed through work planning or experimental review processes. BNL has chosen to adopt the ANSI standard for its implementation of a laser safety program and has retained the term SOP in the Laser Safety Program Subject Area as a way to help in facilitating implementation of the standard.

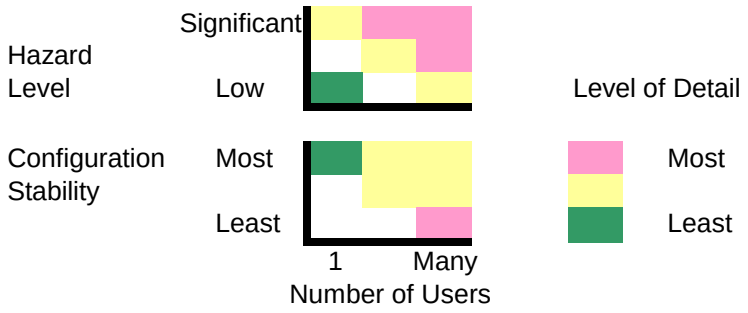
What is in a Laser Controlled Area SOP document at BNL?

In implementing the standard, as with other activities at BNL a graded approach is adopted. This allows the document to be tailored to the hazard levels and control measures that are suitable for a particular installation. At a minimum, the SOP must contain the information that allows for the identification of the hazard envelope for a particular laser installation and the control measures required to maintain a particular type of operation within the defined safety envelope. Additional information may be included as deemed necessary or convenient by either the installation owner or the Laser Safety Officer.

The SOP stands on a thorough analysis of the hazards and controls; hence it is a revision-controlled document where changes in the document should reflect real changes in the operational safety envelope. For this reason, information relating to details of particular set-ups that have no role in determining the safety envelope, but which might be subject to frequent changes, are best included in working procedures maintained through work planning or experimental safety reviews at the Department/Division level. The BNL Laser Controlled Area Standard Operating Procedure (SOP) Template is a useful guide to the types of information typically included in an SOP. It is important to note that SOPs must be reviewed *annually*.

The level of detail actually provided will be influenced by many factors including complexity, stability, and number of users of a system. This is illustrated qualitatively in the following figure:

Qualitative Guide for Graded approach to SOP Content



The level of detail included should be sufficient to allow a knowledgeable individual to verify that the laser controlled area is configured as described, and that the required control measures are in place.

The ANSI standard outlines three modes of operation for laser controlled areas; Operation, Maintenance, and Service. They each describe expected types of operations, which must be anticipated in the hazard analysis. Operation envisions the 'normal use' of a laser installation. In the standard, Maintenance is more narrowly defined than the usual meaning and describes activities meant to be performed by the trained user to ensure optimal operation of the laser for its intended function (including alignments). Service is a broader term that encompasses any kind of work on the laser system, which can include major repairs as well as adjustments necessary to keep the laser functional. In commercial systems, a service representative from the vendor would often perform this service.

The Art in Writing the SOP

SOPs must cover all three modes of operation (where applicable). Practice at BNL allows for separate documents describing one or more of these modes where the separation provides better clarity in understanding the safety envelope.

In the conduct of research, the Principal Investigator needs to ensure that all aspects of safety are understood by, and communicated to, the users of systems under their charge. Safety procedures can and should be a vital part of this process.

Establishing the Envelope

In describing the working boundaries for operation/maintenance/service, the writer should mentally walk through the steps of the task to be accomplished, stopping and noting where specific steps/precautions need to be taken to conduct the work safety. Any of these steps or precautions, which are important for safety, needs to appear in the SOP. These steps needn't necessarily be listed chronologically or step-wise, as they would be encountered in a checklist format. The writer may choose to list them in terms of the magnitude of the hazard they represent. This latter approach may work well especially

for relatively simple systems. Whatever form they take, the SOP should highlight and outline what is necessary.

Laser manuals

Laser manuals supplied by the manufacturer can be useful and should be consulted in composing procedures for operation, and maintenance including internal alignment, of the laser itself. Of course, because the manuals typically refer to laser specific issues, they cannot be relied upon to address beam hazards once the beam exits the aperture. What happens after the beam leaves the laser proper also needs to be addressed.

SOPs as training tools

Specific training is required to be given to all laser users by the person responsible for the laser system they will be using. In constructing the SOP, the information they provide should be viewed as complementing the operations specific training and should also serve as a summary of safety highlights for each system. Some basic level of knowledge needs to be assumed, however; they should be written for those individuals who are least familiar with the system. Writing them at this level also prompts the writer to analyze and think about how the work should be done. Writing them at a higher level may cause people to omit information that may be obvious to the author, but could be of vital safety consequence to the uninitiated user. Writing the SOP at the introductory level will also facilitate the addition of less experienced users to the laboratory.

The SOPs are also a useful tool for reinforcing safety expectations, especially to new or non-BNL employees. It is also important to maintain frequent contact between the worker and the supervisor and a clear definition of the expectations of conduct for both. Both scientific staff supervisors and the people under their charge can benefit from sharing work experiences through regular discussions with their staff. In some settings this may be best accomplished through regularly scheduled meetings, even if they are informal.

Revisions to SOP's

The question inevitably arises; what will trigger a revision of an SOP? The broad answer is anything that changes the safety envelope of the laser controlled area. This in turn depends on examining the proposed changes in activity. For example, if an SOP specified a laser of a specific model from a particular vendor, a change in the laser would trigger a revision. If in the same situation, the laser was specified in the SOP with all of the parameters required to perform a hazard analysis, perhaps even giving the envisioned laser model information as a reference, substitution of a laser of substantially the same or reduced hazard characteristics need not trigger a revision. In such cases advice should be sought from the Laser Safety Officer.

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

This document defines the safety management program for the laser system 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.

System description:
Location:

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.

Owner/Operator:		
Name:	*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.

BNL LSO printed name	*Signature*	*Date*
Department ES&H Approval printed name	*Signature*	*Date*

APPLICABLE LASER OPERATIONS				
Operation	Maintenance	Service	Specific Operation	Fiber Optics

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					
Laser Type *(Argon, CO_2, etc.)*	Wavelengths	ANSI Class	Maximum Power or Energy/Pulse	Pulse Length	Repetition Rate

☐ **Cryogen Use**

Describe type, quantity, and use.

_____

☐ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

_____

☐ **Electrical Hazards**

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

_____

☐ **Other Special Equipment**

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

_____

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)*.

_____

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 Environment Safety and Health Standard: 1.5.3 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, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

_____

ADMINISTRATIVE CONTROLS

☐ 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 (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. 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.

Administrative Controls Description:

_____

CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. 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)*. Entries should also be included 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.

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☐ Eye Wear

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.

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.

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.

_____

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.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***

* 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.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density

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 awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

All laser safety training must be repeated every two years.

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

This document defines the safety management program for the laser system 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.

System description:
Location:

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.

Owner/Operator:		
Name:	*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.

BNL LSO printed name	*Signature*	*Date*
Department ES&H Approval printed name	*Signature*	*Date*

About this Form:
The template was created to help in the development of a Laser Controlled Area Standard Operating Procedure (LCA-SOP or SOP). As explained elsewhere, at BNL the SOP is treated as a safety envelope and information document. The template is a form that provides 'blanks' for the information most typically required in creating an SOP document.

Using the Form:
The explanatory text in each field can either be left on the completed form or removed. It is really meant to be a narrative to help explain what kind of information is required. This annotated form is meant to provide elaboration beyond what is included in the word template.

System Description and Location: Couples the SOP to a particular installation.

Line Management Responsibilities: Assigns responsibility for the system to a single accountable person. The owner/operator helps to develop the SOP, and has responsibility for assuring that the conditions it describes are met when the laser installation is in operation in any of the described modes.

Authorization: Demonstrates that the Laser Safety Officer (LSO) and cognizant Department/Division ESH officer has reviewed the LCA-SOP.

APPLICABLE LASER OPERATIONS				
Operation	Maintenance	Service	Specific Operation	Fiber Optics

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					
Laser Type *(Argon, CO_2, etc.)*	Wavelengths	ANSI Class	Maximum Power or Energy/Pulse	Pulse Length	Repetition Rate

☐ **Cryogen Use** Describe type, quantity, and use. _____

☐ **Chemicals & Compressed Gasses Describe** type, quantity, and use. _____

☐ **Electrical Hazards** Description *(Describe the power supply to the system).* _____

☐ **Other Special Equipment** Description *(Equipment used with the laser[s]).* _____

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)*.

_____

Applicable Laser Operations:
Can be used as a checkbox to show what kinds of operations this particular SOP describes. ANSI defines three, Operations, Maintenance (in which alignment is included) and Service, which is most often major repairs or installations often by the vendor. At BNL, other types of operation might be envisioned hence the ‘ Specific Operation’ check box. In some cases sub-groups of uses or users may be applicable for a large facility laser. The purpose of the Fiber Optics checkbox is meant as a flag to cover operations that occur in several locations at BNL where the light from a laser is conveyed some considerable distance from the laser and its controls. For these unusual circumstances check the box and enter the operation name or characteristics in the line below the boxes.

Laser System Hazard Analysis: The heart of the SOP. It lays out both the laser and non-laser hazards that one expects to encounter in the installation. It is important to enumerate all potentially hazardous coherent sources (including e.g., frequency mixing or parametric sources) and their parameters so that a full hazard analysis can be completed and the Nominal Hazard Zone, protective equipment needs, and required controls can be determined. The ANSI Standard has detailed procedures for determining laser class and NHZ, so these are best determined with the help of the LSO when there is any ambiguity.

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 Environment Safety and Health Standard: 1.5.3 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, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

_____

Laser System Hazard Analysis cont'd
Examples of typical non-beam hazards are given by the checkboxes. The laser system configuration helps both in identifying the hazards and later in the use of the SOP as an aid for field verification of the laser configuration it describes.

Develop Controls: Having identified the hazards and the NHZ in the previous section, we now turn to dealing with the hazards through the application of appropriate controls. A brief list of ES&H standards that most often apply to laser installations is given at left.

To the extent possible Engineered controls are usually favored over administrative controls. A checkbox list to outline the engineered controls that apply is provided followed by space for information describing the control measures. Again the objective is the identification of the controls that are employed so they can be verified at the laser installation. Interlocks are often employed as a control measure. As noted at left, ESH Standard 1.5.3 Interlock Safety for Protection of Personnel provides guidance on the requirements for design and testing of interlock systems.

The description provided should be sufficiently complete that a knowledgeable person can readily identify the control measures.

ADMINISTRATIVE CONTROLS

☐ 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 (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. 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.

Administrative Controls Description:

_____

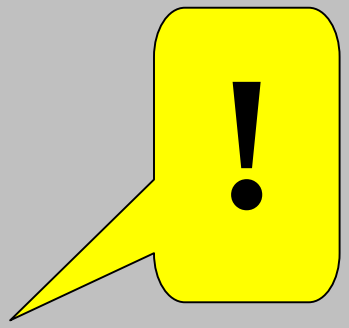
CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. Examples include any protective housing, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Entries should also be included 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.

(Controls cont'd)

Administrative controls are usually used to provide identification of hazards, hazard boundaries, and operating limits. The LSO will assist in the identification of proper wording and content for signs that must be posted for laser controlled areas.

The Configuration Control section provides information that can be field verified. Importantly it identifies critical systems (optics and enclosures for example) that can readily contribute to a hazardous condition if they are improperly configured.



Many of the accidents resulting in eye exposure occur during alignment activities. This type of work often requires a non-standard configuration of a relatively small number of components. It is important to identify these components and make sure that the hazards are well understood and appreciated by the system users.

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☐ Eye Wear

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.

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.

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.

_____

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.

Personal Protective Equipment:

This section identifies the equipment that is used to protect against inadvertent exposure when neither engineered nor administrative controls are deemed to be fully adequate protection. Usually this amounts to judicious selection of eyewear. One must be careful to identify the hazards, and select eyewear that provides adequate protection but does not unduly interfere with the planned work. Really dark shades with more than adequate OD that spend all their time on the table (instead of on your nose) because they are too dark to see through, are of absolutely no value. The annotation in the form provides further information regarding the proper use of laser eyewear.

If you need to operate the laser without wearing eye protection you must describe the precautions that will be implemented to prevent eye injury.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density *	NHZ** (meters)	Appropriate Eye Wear***

*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.

Personal Protective Equipment cont'd

To aid in the selection of eyewear, the SOP template provides a table to help identify the requirements for the eyewear, and a second table to list the specifications of eyewear actually selected for use.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density

TRAINING

LASER SAFETY TRAINING

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Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

All laser safety training must be repeated every two years.

Training:
This section outlines the training that all users (including owner/operators) must complete prior to operation of the laser systems identified in the SOP.

Documentation of qualified operators and their training status is no longer a part of the SOP. However, an up to date list of operators and the training they have received must be on file, and should be available at the laser installation. If an applicable SOP or other required training document is revised, the user training list becomes the resource for assuring that all qualified users are notified of the changes. It is also the vehicle for recording that they have received any updated training that is required.

Note that all laser safety training must be repeated every two years (at minimum).

Subject Area: ***Laser Safety***

Laser System-Specific Training Checklist

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser System-Specific Training Checklist is provided as a Word file.

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LASER SYSTEM-SPECIFIC TRAINING CHECKLIST

Laser User:	
Laser Owner:	
Laser System:	

Topic	User Signature / Date	Owner Signature / Date
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 • PMT detectors		
Normal Operation • Power on/off • Shutter operation • Normal experimental configuration • Nominal hazard zone		
Non-Normal Operation* • Gross alignment • Troubleshooting		

** Only those users who have completed the Non-Normal Operation portion of the laser-specific training may perform gross alignment procedures as defined in the Standard Operating Procedure.*

Subject Area: ***Laser Safety***

Laser User Medical History and Examination Form with Instructions

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser User Medical History and Examination Form with Instructions is provided as a Word file.

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BROOKHAVEN NATIONAL LABORATORY (BNL)
OCCUPATIONAL MEDICINE CLINIC (BNL-OMC)

LASER USER MEDICAL HISTORY AND EXAMINATION FORM WITH INSTRUCTIONS

Purpose of the attached Form

The purpose of the attached two-part form is to provide BNL-OMC with information necessary to determine that an individual to be cleared as a laser user at BNL has met the medical requirements of ANSI Standard Z136.1-2000 (Appendix E) governing the safe use of lasers.

This standard requires each Class 3b and 4 laser user to have a preassignment eye examination by an ophthalmologist, which is recorded on Part B of the attached form. Based upon medical history and type of laser, a preassignment skin examination performed by a BNL-OMC physician may also be required.

Instructions to BNL Host/Supervisor

Please give this form to the prospective laser user, as soon as possible. It may be necessary to forward this file since the SBMS links are generally not accessible offsite.

Instructions to Laser User

As soon as possible:

1. Contact one of the contracted local ophthalmologists from the list on the next page and request an appointment for a "laser eye exam for Brookhaven Lab." (Note: You may also obtain this exam from a Board Certified ophthalmologist other than those listed, but BNL cannot guarantee payment—consult with your BNL supervisor or host to discuss payment issues. Note also that no matter which ophthalmologist performs the exam, it must be recorded on Part B of the attached form—see step #4 below.)
2. Complete Part A of the form. This provides BNL-OMC with needed contact and medical information.
3. Give the completed form to your ophthalmologist, including this instruction page, the completed Part A, and the blank Part B.
4. Your ophthalmologist should record his/her examination on Part B of the form and forward the form to BNL-OMC as instructed below.
5. After receipt of the form, BNL-OMC will contact you if additional information or a skin examination is required.

Instructions to Laser User who wishes to submit a recent laser eye exam in lieu of having a new eye exam

A laser user who has already had a laser eye exam can submit this exam to BNL-OMC in lieu of a new laser eye exam. BNL-OMC will then consider whether the submitted exam is acceptable, or whether a new exam will still be required. Generally, to be acceptable, the submitted exam must

- be performed by a Board Certified ophthalmologist;
- provide substantially the same information that is requested in Part B of the attached form;
- have been performed within the last 3 years, with no laser eye accidents or changes in vision subsequent to the exam.

BROOKHAVEN NATIONAL LABORATORY (BNL)
OCCUPATIONAL MEDICINE CLINIC (BNL-OMC)

Instructions

The laser user who wishes to submit a recent laser eye exam for consideration by BNL-OMC must do the following

1. Fill in Part A of the form.
2. Fax Part A of the form to BNL-OMC at **631-344-7366**, along with the written record of the laser eye exam. (If unable to fax, mail as soon as possible to BNL-OMC at the address below.)
3. BNL-OMC will contact you if additional information or examinations are required.

Instructions to ophthalmologist

1. Please record your laser user eye examination on Part B of the attached form.
2. As soon as possible, please fax completed Parts A and B to BNL-OMC at **631-344-7366**. This is a secure, clinic fax that can receive confidential medical information. BNL-OMC's voice number for problems or questions is 631-344-3670.
3. If you cannot fax the completed form, please mail it to

Occupational Medicine Clinic
Brookhaven National Laboratory
Bldg. 490
Upton, NY 11973-5000

Thank you.

Contracted Local Ophthalmologists

Dr. Charles Rothberg
331 East Main
Patchogue, NY 11772
631-758-5300

The Ophthalmic Center
Dr. Vincent Basilice
3400 Nesconset Highway
East Setauket, NY 11733
631-751-2020

East End Eye Associates
Dr. Scott Sheren
669 Whiskey Road
Ridge, NY 11961
631-744-8020

BROOKHAVEN NATIONAL LABORATORY (BNL)
OCCUPATIONAL MEDICINE CLINIC (BNL-OMC)

Part A: Laser user contact information and brief medical history—to be completed by laser user

Name _____Life/Guest# _____ Date _____

Usual/permanent address_____

Usual/permanent phone # _____ e-mail _____

BNL address_____ BNL extension _____

Name of BNL supervisor, sponsor, or host_____ BNL extension _____

If at BNL on a temporary basis Expected arrival date_____ Expected departure date_____

What types of lasers will you be working with or near? ____UV ____Visible _____IR ____Other (Specify)_____

Brief medical history

Please list current medications: _____

_____

Do you have either of the following conditions?

_____ Aphakia (absence of a lens in one or both eyes)

_____ Photosensitivity - unusual sensitivity of the skin or eyes to sunlight or other light.

Please describe if you checked either of the above:

Laser user signature: _____

Instructions to laser user: After completing Part A, give the entire form, including instructions, Part A and Part B, to the examining ophthalmologist. Exception: If you are submitting a prior laser eye exam to BNL-OMC in lieu of having a new exam, submit this page (Part A) along with the record of that exam (see the instruction page for details).

BROOKHAVEN NATIONAL LABORATORY (BNL)
OCCUPATIONAL MEDICINE CLINIC (BNL-OMC)

Part B: To be completed by ophthalmologist

Examinee name _____ Date of exam_____

Current complaints: _____

Ocular history: _____

Pertinent family history: _____

Ocular Examination

Visual acuity

Far Point

	Uncorrected	Corrected
OD		
OS		

Near Point

	Uncorrected	Corrected
OD		
OS		

Refraction: _____

_____

Macular function (by Amsler grid or other pattern): _____

Visual fields: _____

Color vision: _____

Intraocular pressure (if over age 40 or otherwise indicated): OS _____ OD _____

Pupils and motility: _____

Anterior segment: _____

Fundus: _____

Impression: _____

_____

Examiner Information

Ophthalmologist name and title (printed): _____

Signature_____

Medical License # and state_____ Phone #_____

Office address_____

- Ophthalmologist: Forward completed Parts A and B to BNL-OMC, Bldg 490, Upton, NY 11973-5000.
- If any questions or problems, call 631-344-3670.

Subject Area: ***Laser Safety***

Laser User Qualification Form

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The Laser User Qualification Form is provided as a Word file.

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LASER USER QUALIFICATION FORM

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. Laser-Electron Accelerator Facility (LEAF) specific laser training and the types of work users are qualified for is documented using the separate training certification form below.

Qualified Laser Operators (see individual training certificates for level of qualification):

Basic Laser Training*	Medical Surveillance	Printed Name	Life Number	Signature	Owner/ Operator Initial/date

* Re-qualification every two years, dates are available in the training database

Training certification for laser users in Building 555, Rooms 23 and 25 (LEAF)

Training for Laser User:	
On laser system:	All lasers at LEAF

Topic	Signature of user/date (Initial of laser owner)
Instruction in interlock configuration for laser access restricted area (room or enclosure)	
Description of laser output characteristics (wavelength, pulse energy, length of pulse and/or average power)	
Checklist of major hazards (including laser light, compressed gases, cryogens, electrical): • Wear eye protection for invisible beams at all times when laser emission is possible. This includes both the laser room and the vault. • Never intentionally direct a beam towards your face, or put your face in line with any laser beam: **do not depend on eyewear to protect you**. • Be aware of what your co-workers are doing, and alert them to any potentially hazardous conditions or actions. • Use minimum laser power possible during alignment. • Use plain or fluorescent sensor cards or IR viewers when possible to aid in locating laser beams. • Locate all surface reflections and terminate with appropriate beam dumps. • Use *COMMON SENSE* and *CARE* in performing all alignments. Think about the consequences of your actions, as it pertains to the safety of yourself, others and equipment. • If unsure about what you are doing, STOP! Ask a knowledgeable person what to do before proceeding. • Don't grossly align lasers at high power. • Don't place optical elements into the laser beam without first blocking the beam with an appropriate dump. • Don't wear any reflective materials (such as rings, watches, BNL badge) on your hands or arms, or around your neck during the arraignment. • No *unauthorized* personnel are allowed in the laboratory during laser operation. • When adjusting the amplifier pump energies, take care not to put objects and/or fingers in the pump beam.	
Operation: Power on/off, shutter operation, normal experimental configuration, nominal hazard zone where class IV intra-beam beam protection is required, adjustment of bema energies via waveplate/polarizers.	
Normal maintenance: Changing laser lamps, filters, minor experimental alignment.	
Non-normal operation: Cases where additional advice/training is required. Examples: replacing damaged components, gross configuration/alignment changes.	
For students/postdocs: one-on-one training with PI: Trainer:	

Subject Area: ***Laser Safety***

System Training Log

Effective Date: **June 2004**
Point of Contact: Laser Safety Officer

The System Training Log is provided as a Word file.

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System Training Log

System Description:
Location:
System Owner/Operator:

This sheet provides a local record of training for working within a specified Laser Controlled Area (LCA). It should provide information regarding users, required training, date of completed training, and verification by the installation owner/operator that the training has been completed and understood at a satisfactory level by the user. As the system expert, the owner/operator should 'self-train' and log the training on the first line of the form. When new or revised training requirements arise, they can be handwritten into a blank column. The date and initials of both the user and owner signify completed training. This record should be updated to reflect current training requirements during the annual review of the LCA-Standard Operating Procedure (LCA-SOP).

Name/Life No.	Eye Exam	Laser Safety Awareness Training	SOP (#) Rev n	Job Specific Training Rev x			
Owner/Operator (Self Training)							
User							
Owner							
User							
Owner							
User							
Owner							
User							
Owner							
User							
Owner							

Revision History: Laser Safety

Point of Contact: Laser Safety Officer

Revision History of this Subject Area

Date	Description	Management System
June 2004	This revision includes updated procedures and guidelines to ensure the subject area is in compliance with requirements in DOE Order 440.1A, Worker Protection Management for DOE Federal and Contractor Employees and the DOE-referenced ANSI Z136.1-2000, American National Standard for the Safe Use of Lasers. The previous program requirement for termination (exit) eye examinations was deleted to conform with the recommendations of ANSI Z136.1-2000. The exhibits Local Ophthalmologists and Requirements for Laser Eye Examinations were removed and incorporated into the new Laser User Medical History and Examination Form with Instructions. The BNL General Laser Registration Form & Class 2/3A Use Permit form was revised and renamed the BNL General Laser Registration Form. The new BNL General Class 2/3A Laser Use Permit was added. Guidelines were added to the section Developing the Laser Controlled Documentation and the following new exhibits were added to the subject area as guidance to assist personnel in the implementation of the Laser Safety Program:	Worker Safety and Health

	implementation of the Laser Safety Program. • Alignment Guidelines; • Biology Alignment Practice; • Collider-Accelerator Department (CAD) EEMC Laser Alignment; • Examples of Standard Operating Procedures (SOPs) from Working Laboratories; • Instrumentation Ti:Sapp Operation; • Instrumentation YAG Operation; • Laser-Electron Accelerator Facility (LEAF) Working Procedures; • Laser Safety Inspection (BNL Chemistry Example); • Outline for ANSI Z136.1-2000 Topics • YAG Laser Operations at Accelerator Test Facility (ATF). In the section Ensuring Worker Qualification, completion of training is documented using the new System Training Log. Guidelines were added to the section and the following new exhibits Laser System-Specific Training Checklist and Laser User Qualification Form were added as examples of tools for tracking the training of laser users and developing a training program for new installations. The following exhibits were updated: Bibliography of Laser-related Resources, Engineered and Administrative Controls Matrix, Guidance on Interlock Systems for Lasers, and the Laser Commissioning Process Flowchart. The Laser Controlled Area Standard Operating Procedure (SOP) template was updated and includes commentary and a template with annotations as an example.	
November 2000	This subject area describes the procedures and guidelines for working with lasers at Brookhaven National Laboratory (BNL), according to the requirements established in the American National Standards Institute (ANSI), American National Standard for the Safe Use of Lasers, ANSI Z136.1-2000. It contains procedures on conducting the safety hazard analysis, developing documentation on laser controlled areas, using class 2 and 3a lasers, and installing laser equipment. This subject area replaces	Worker Safety and Health

	laser equipment. This subject area replaces ES&H Standard 2.3.1, Lasers.	

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