Subject: Laser Safety Program Documentation		
Prepared By: Yuzhen Shen	**Approved By:** Richard Heese	**Approved By:** Richard Heese

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: SDL Drive Laser and Accelerator Enclosure Beams.
Location: Source Development Laboratory, Building 729, Clean room enclosure and accelerator enclosure

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: Yuzhen Shen	*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.

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

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

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

ANALYZE THE LASER SYSTEM HAZARDS

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

LASER SYSTEM CHARACTERISTICS

Laser Type *(Argon, CO2, etc)*	Wavelengths (nm)	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
1 Femtolasers Ti Sapphire	~800	4	13 nJ	80 femtosecond	80 MHz
2 Coherent Nd:YVO_4	532	4	CW, 6 Watts	CW	CW
3 SP* LAB-170 Q-switched YAG	532, 1064	4	400 mJ(532 nm) 1 J (1064 nm)	6 nsec	10 Hz
4 SP GCR-170 Q-switched YAG	532, 1064	4	450 mJ (532 nm) 1.5 J (1064 nm)	6 nsec	10 Hz
5 Ti:Sapph chirped pulse amplification (CPA) system	~800	4	50 mJ	0.1-400 psec	10 Hz
6 Nonlinear frequency synthesis from CPA system	260-800	4	4 mJ	0.1-20 psec	10 Hz
7 Alignment diode laser	780	3B	CW .005 Watts	CW	CW
8 Helium Neon lasers	632 544	3B 3A	CW .030 Watts CW 0.002 Watts	CW CW	CW CW

*SP= Spectra Physics

☐ **Cryogen Use**

Describe type, quantity, and use

None

For all of the above systems the following procedures must be observed:

1) eye protection must be worn when working with open beams
2) laser enclosure must be interlocked

System by system breakdown:

1) SynergyTi:Sapphire laser:
   purpose: oscillator, seeds the regenerative amplifier, also provides light for beam diagnostics (e.g. cross correlator)

output: 0.5-0.75 Watt , 100 fsec pulses at 81.6 MHz, wavelength usually at 800 nm, but tunable from 700-900 nm
beam paths:

- long (~ 8 meters) folded path through pulse stretcher to seed the regenerative amplifier. Most of this is in the amplifier box. Some light will propagate through the amplifier chain even when there is no gain, so care should be taken that the beam is stopped downstream (e.g. at amplifier box exit) when using the oscillator beam alone.
- ~ 1-2 meter in open air on table 1 to Rees Spectrum analyzer
- ~ 1-2 meter in open air on table 1 to Streak Camera Trigger
- ~ 1-2 meter in open air on table 1 to Spectra Physics scanning autocorrelator
- ~ 1-2 meter in open air on table 1 to EOT photodiode for RF clock
- ~ 8-10 meter in open air on tables 1 and 2 to the scanning cross-correlator
- OTHER: remember that this laser is a frequent source of reference beams for experimental diagnostics, as well as a source for alignment when 800 nm or pulsed radiation is required. Operators should be aware of any new applications not listed here, and may inspect for new beam paths by inspecting optics chain from the laser output and looking for beams using an IR card or IR viewer.

goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: 2 control modules located on shelf above the laser, pump laser control is on a stand next to the laser. Shutter control for the pump laser is above the pump laser exit aperture
hazard controls: a beam stop is located near the beam entrance to the amplifier box. This stop should be in place whenever the oscillator is not being used to drive the amplifier. A dedicated power meter is located near the Tsunami exit aperture and may be used to stop the beam going to the diagnostics. The pump laser may be shuttered or powered down when the laser is not needed for an extended time. The pump laser also has a key control.

2) Coherent VerdiNd:YVO_4 laser
purpose: to pump the Tsunami oscillator
output: 0-6 Watts green, continuous wave. Usually operates at 4-5 W output
beam paths: enclosed, to Tsunami pump input port
goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: remote controller on stand next to laser, power supply with located on floor under table 2
hazard controls: laser cover is interlocked, power supply cuts power when room interlock is violated. Key control on power supply (usually left in place, since the laser is connected to the room interlock)

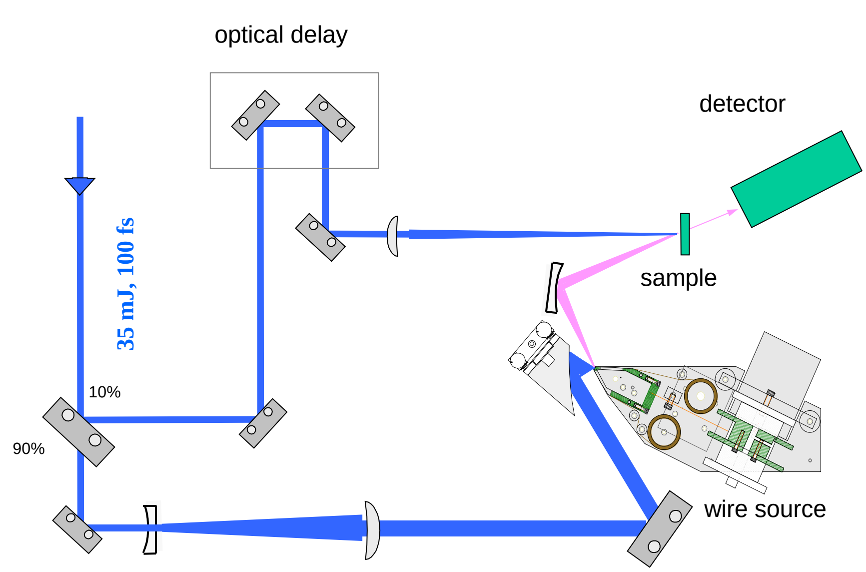
3) Spectra Physics LAB-170
purpose: to pump the regenerative amplifier and the first two-pass amplifier
output: ~400 mJ 532 nm pulsed at 10 Hz. 6-7 nsec pulses when Q-switched
beam paths: closed to amplifier box. Inside the amplifier box, open paths to the regenerative amplifier crystal and the 2-pass amplifier crystal, both approx 1.5-2 meters.
goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: remote located on top of laser head. Gas purge flow control on table 1 next to the laser head. Trigger synchronizaton electronics located on shelf inside table enclosure. Power supply located outside of laser room enclosure
hazard controls: power supply prevents laser firing when room interlock is violated. Key control on power supply (usually left in place, since the laser is connected to the room interlock)

4) Spectra Physics GCR-170
purpose: to pump the second two-pass amplifier
output: 300-340 mJ 532 nm pulsed at 10 Hz. 6-7 nsec pulses when Q-switched
beam paths: enclosed to amplifier box. 1.5-2 meters open path within amplifier box to amplifier crystal

goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: remote located on top of laser head. Gas purge flow control on table 1 next to the laser head. Trigger synchronizaton electronics located on shelf inside table enclosure. Power supply located outside of laser room enclosure
hazard controls: power supply prevents laser firing when room interlock is violated. Key control on power supply (usually left in place, since the laser is connected to the room interlock)

5) Ti:Sapphire CPA system (Spectra Physics TSA 50). Note that this system is essentially the combination of the above systems and the amplifier box.
purpose: provides 800 nm pulses from which photocathode and seed pulses are derived. Also provides light for experimental diagnostics
output: up to 50 mJ at 800 nm. Pulse width from 0.1- 400 picoseconds
beam paths:

- **frequency tripler:** ~4 meters on table 2 through the frequency tripler for the photocathode pulse.
- **Seed Beam generation and transport:** Enclosed and open path to compressor for HGHG seed compressor. Beyond the compressor, this beam has a 10-12 meter path on table 2, followed by an enclosed ~35 meter path to the seed area in the accelerator enclosure
- **Seed area and Diagnostics inside of the accelerator enclosure**. The entire accelerator enclosure is an interlocked Laser Controlled Area. Beams may be introduced into the accelerator beamline and coupled out of it for seeding the FEL or for use in diagnostics such as the electro-optic measurement of the electron bunch length or the measurement of THz fields. A shutter at the gun hutch exit prevents the beam from entering the enclosure when not interlocked.
- **Ultrafast X-ray Source**: On the third optical table in the laser room, against the northwest wall, is a laser driven plasma source that produces ultrafast x-ray pulses at 10 Hz. The compressed output of the amplified 800 nm pulse is transported through an overhead beam tube to this table. A schematic of the beam layout on the table is below:



Note that the beam may be divided into two parts, one to generate the plasma on the moving wire source, and another to excite the sample at a variable delay relative to the x-ray pulse, and both beams are hazardous. THERE ARE ALSO RADIATION HAZARDS ASSOCIATED

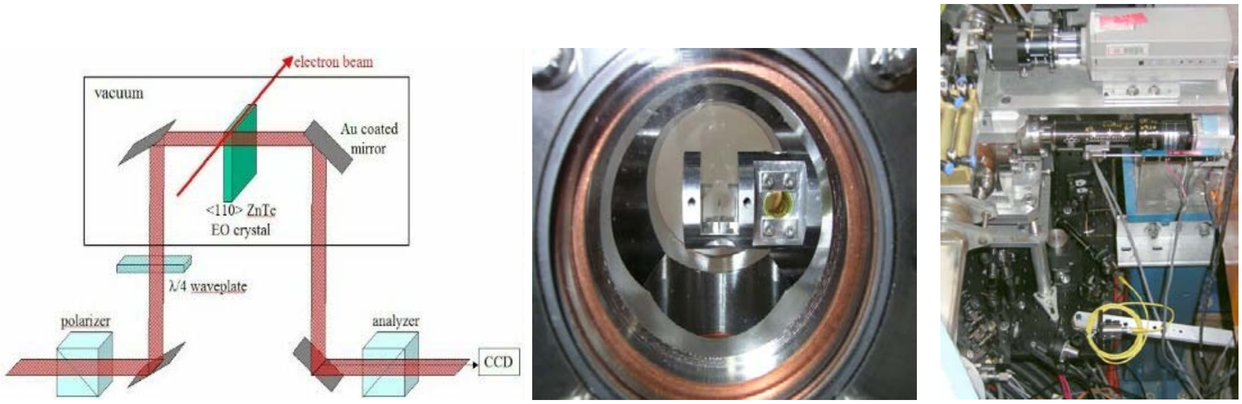
WITH THIS SOURCE WHEN IT IS OPERATING. A lead enclosure surrounds the wire source, and when soft x-rays are being extracted, a steel shield surrounds their path. The source may only be operated by the experimenters approved in a Safety Approval Form.

- The amplified 800 nm beam is also used in experimental applications, and operators should be aware of the current beam configuration.

goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: output contingent on and controlled through lasers 1-4. Also compressor length control is accessible inside of the amplifier box and in the external compressor box. A power attenuator is located in the photocathode pulse leg shortly after the exit from the amplifier box.
hazard controls: output ceases on room interlock violation. Interlocked shutter for output to accelerator area. Hazard zone and postings as described in “beam paths”

6) Nonlinear Frequency Synthesis.
purpose: At present this consist only of 400 nm and 266 nm generation for the photocathode pulse. The 400 nm is dumped immediately after production. 400 nm or 266 nm pulses may also be generated for seeding or diagnostics.
output: 266 nm, 0.1-20 psec, up to 2 mJ
beam paths: The optical configuration on table 2 is fully enclosed through spatial filter to relay input. After spatial filter, part of the beam is picked off and sent ~8 meters to a diagnostic (cross correlator). The relay path is ~13 meters long, enclosed from the room exit on. Beams may also propagate into the accelerator enclosure for seeding or diagnostics.
goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: phase matching control on table 2, spatial filter control on table 2, power attenuator on table 2 in first section of the relay.
hazard controls: output ceases on room interlock violation. Interlocked shutter for output to accelerator area.

7) EO detection of electron beam bunch
purpose: to examine the temporal shape of the electron beam bunch.
brief description: A short 100 fs duration, 100 MeV electron beam passes at the vicinity of an electro-optical crystal (left of Figure) thereby induce a large polarization field on the EO crystal. A 100 fs 800nm NIR probe beam running at <3 Hz rep rate attenuated to the level of 10 microJoule/pulse (CLASS 4) will be send to the experimental setup. An EO detection module is mounted on a motorized retractable vacuum mount (middle of Figure) so that it moves to the beam center during the experiment and completely retracted from the beam center for other SDL experimental runs.
beam paths: All 800 nm NIR beams are enclosed within the optical breadboard shown in the right of Figure. A class 2, 1 mW fiber-coupled alignment diode laser (yellow cable in the right of Figure) is used to check the alignment of the EO measurement apparatus. This alignment laser is part of the equipment attached to the optical breadboard for routine beam alignment
goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: The experimental hall will be interlocked according to the SDL laser safety procedure prior to any class 4 laser work and trained laser personnel shall wear appropriate laser goggle for any laser beam manipulation. During electron beam run, the experimental hall is radiation interlocked, a local computer will collect all data with remote desktop access for experimental monitor and control.



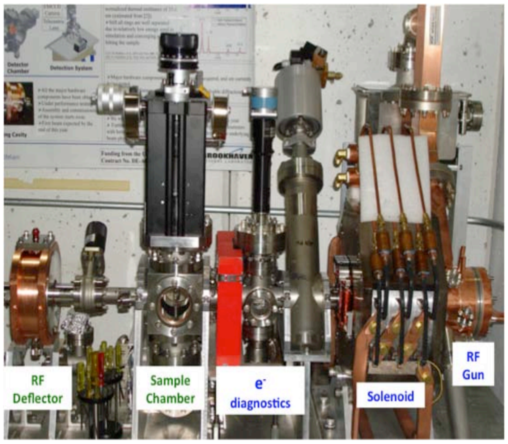
(left) Schemetic of the EO setup, (middle) installed EO detection module, and (right) entire optics on an optical breadboard.

8) Alignment Diode laser
purpose: alignments requiring IR light (e.g. amplifier systems, stretcher, compressors, transport optics)
output: 5 mW CW single frequency in the range 770-820 nm
beam paths: Any amplifier, transport path, or experimental alignment might be done with this laser.
goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: operator must take care to contain beam and limit open path length as much as possible. Look with viewer after each phase of alignment to check for stray beams, leakage or unintended reflections. Always use an opaque backstop at the end of the beam path.
hazard controls: protective eyewear, minimize personnel in use area.

9) Helium Neon Lasers
purpose: experimental alignments
output: up to 30 mW CW at 633 nm, up to 2 mW at 544 nm
beam paths: experimental, also any of the amplifier or transport paths might be aligned with a HeNe
goggles: e.g. Laser Vision L648
controls: operator must take care to contain beam and limit open path length as much as possible. Look with viewer after each phase of alignment to check for stray beams, leakage or unintended reflections. Always use an opaque backstop at the end of the beam path.
hazard controls: protective eyewear, minimize personnel in use area.

Ultrafast electron diffraction (UED) system

purpose: development of a source to generate a MeV electron beam for time-resolved electron diffraction study of condense matter materials
laser output: photocathode drive laser: 266nm, ~100fs, ~1uJ, 10Hz; sample excitation laser: 800nm, ~100fs, ~10uJ, 10Hz.
brief description: The UED system consists of a photocathode RF gun, solenoid magnet, electron beam diagnostics, a sampling chamber, a detector system, and the laser system to drive the photocathode RF gun. It operates at the 10 Hz with 3 MeV beam enrgy, and about 1 pC charge/pulse. The overall dimension of the UED setup is 4.5 m by 0.4m, which is located inside the SDL linac tunnel near the linac beam dump and FEL seed table. The photo of the system setup is below:



(left) UED photocathode, solenoid, sample chamber and beam diagnostics, (right) schematic of UED system including laser enclosure

beam paths: All 800 nm and 266nm beams are enclosed within the optical table shown in the right of Figure. The beam are transported through the beam pipe between different tables.
goggles: use e.g. Kentek GBM 64, KXL-6401, KXP-6401
controls: The experimental areas are interlocked according to the SDL laser safety procedure prior to any class 4 laser work and trained laser personnel shall wear appropriate laser goggle for any laser beam manipulation.
hazard controls: Interlocked and gravitation shutters for laser output to UED area.

☐ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

- Compressed Nitrogen used as a purge gas, ~2 cylinders/week. Compressed gas training is required of operators
- Solvents (methanol, acetone) used for cleaning optics, kept in 1-4 liter quantities . Stored with secondary containment.
- Dessicants (silica gel or calcium carbonate) used for protecting optics in closed containers.

☐ **Electrical Hazards**

There are 3 large power supplies.

The Verdi Nd:YVO_4 power supply is powered by single phase 110VAC 60Hz line and is completely self contained. There should be no reason for the operator to open this. It contains a low voltage, high current (~75 A) supply to drive the diode laser arrays which are contained inside the supply (the diode output is transported to the laser head through fibers in the umbilical cord. No high voltage or large currents are transferred to the laser head.

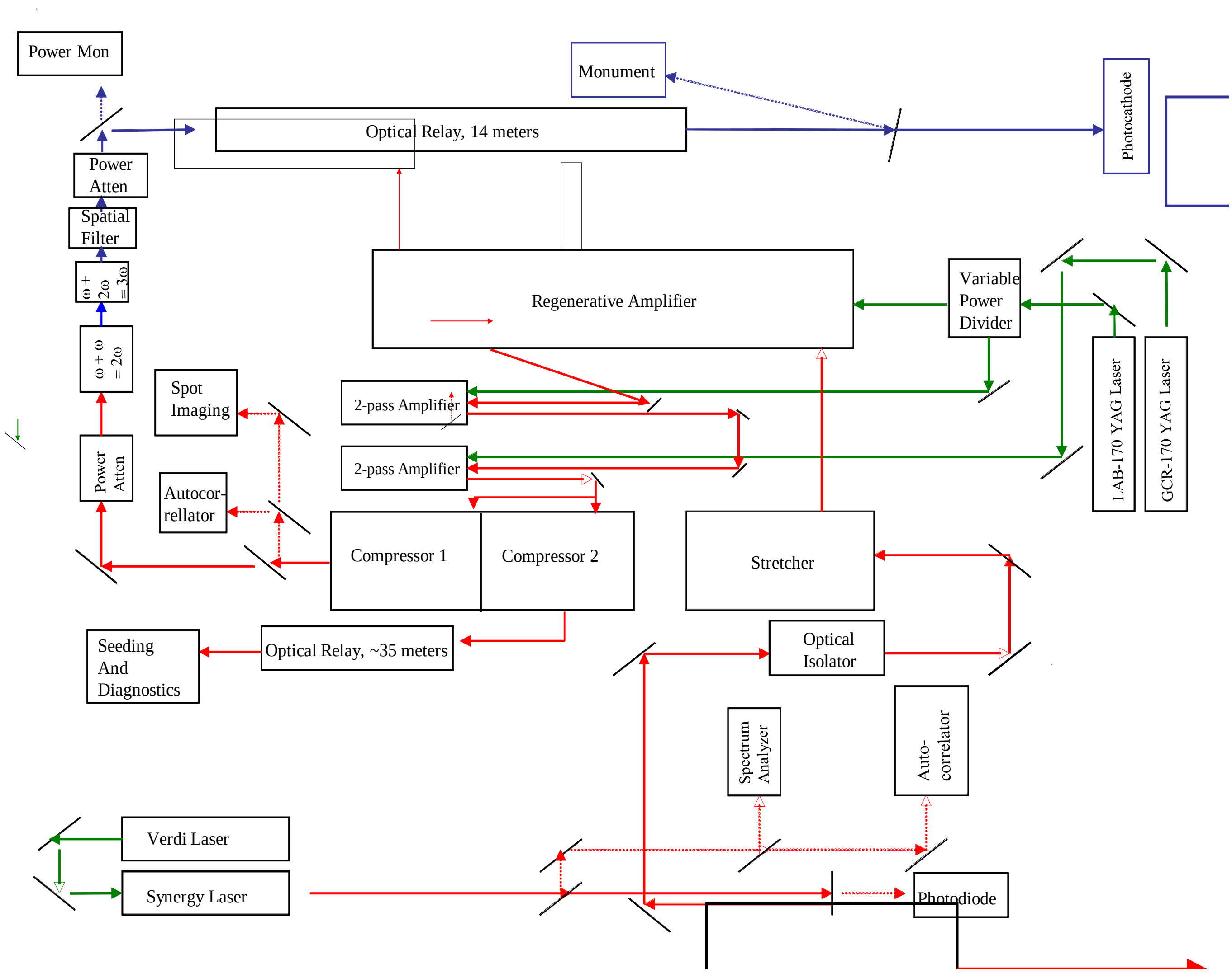
The YAG lasers are each driven by Spectra Physics PS100 power supplies. These are supplied by 3 phase 220 VAC lines. these supply current pulses to the discharge lamps and high voltage to the Q-switches in the laser. When laser head covers are removed, these are an electrical hazard. Lines and contacts where these hazards exist inside the head are clearly labeled. All operators must have Electrical Safety training before working on YAG lasers. When changing filters inside the power supply, power down and unplug the power supply, and wait 5 minutes to be sure that charge on capacitors has leaked off.

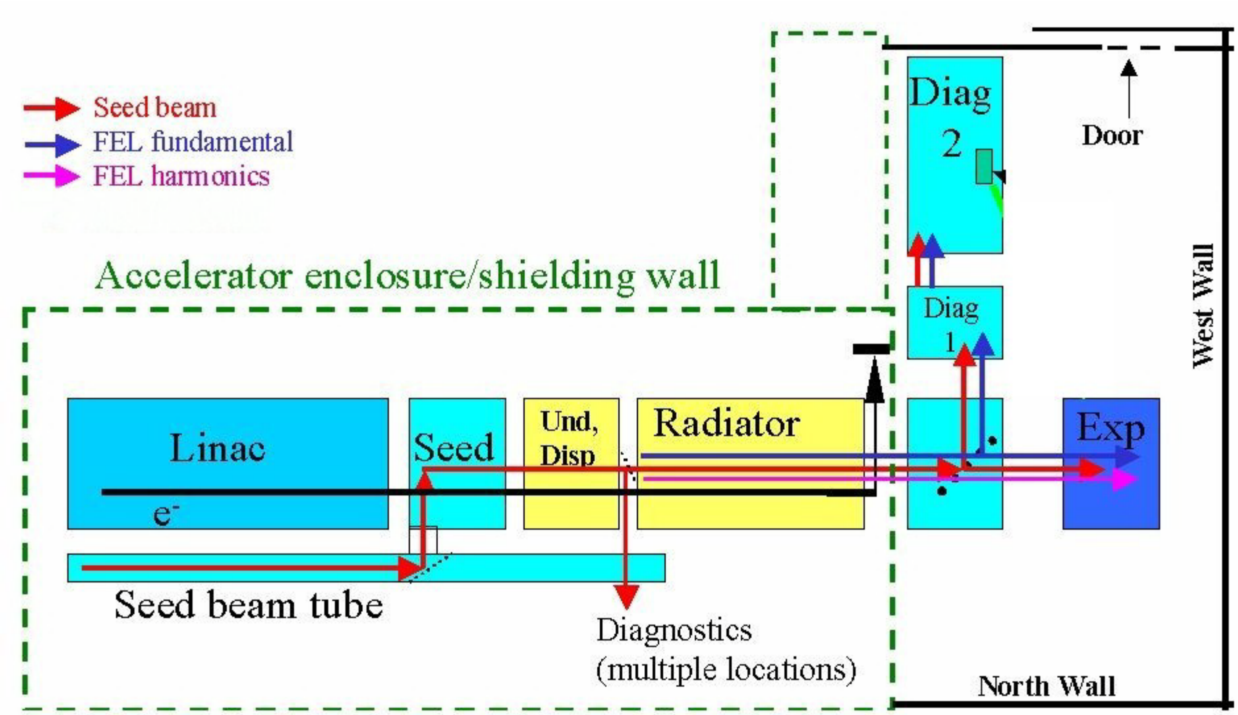
☐ **Other Special Equipment**

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

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)


Power Mon
Monument
Optical Relay, 14 meters
Photocathode
Power Atten
Spatial Filter
ω + 2ω = 3ω
ω + ω = 2ω
Regenerative Amplifier
Variable Power Divider
Spot Imaging
2-pass Amplifier
2-pass Amplifier
LAB-170 YAG Laser
GCR-170 YAG Laser
Power Atten
Autocor-rellator
Compressor 1
Compressor 2
Stretcher
Seeding And Diagnostics
Optical Relay, ~35 meters
Optical Isolator
Spectrum Analyzer
Auto-correlator
Verdi Laser
Synergy Laser
Photodiode



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

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:

The entire Laser system is in an interlocked room which is light-tight to the surrounding environment. The RF gun hutch, where open beams may also occur, is interlocked in the same interlock system. Lasers 2-4 also have key controls (and laser 1 operates only when laser 2 is running). The accelerator enclosure is also an interlocked Laser Controlled Area. The Gun Hutch is interlocked with the Laser Room, so that beams may propagate within the gun hutch while interlocking the laser room, but not the accelerator enclosure. The accelerator enclosure interlock blocks beams from the enclosure with a shutter at the gun hutch exit. If the shutter should fail to close appropriately, the interlock reaches back to the laser power supplies and cuts them off. A laser shutter on the seed table is tied to accelerator enclosure interlock. This shutter together with a gravitation shutter is used to control the laser beam from seed table to ultrafast electron diffraction (UED) setup.

System Breakdown:

Synergy: cover interlock; output tied to laser room interlock; amplifier box encloses the beam for seeding the amplifier; output contingent on Millenia laser output

Verdi Nd:YVO_4: beams enclosed; output tied to laser room interlock; key control on power supply (usually left in place, when security is an issue, the key is to be held by the system owner)

LAB-170 and GCR-170: beams enclosed to amplifier box; low power mode (long pulse) for alignments, IR beams are dumped; green beams dumped when not in use; output tied to laser room interlock; key control on power supplies (usually left in place, when security is an issue, the key is to be held by the system owner)

CPA system: output tied to laser room/gun hutch interlock; power attenuator located just outside of the amplifier box;

Nonlinear Frequency synthesis: output tied to laser room interlock; output shutter to accelerator area is interlocked; power attenuator for photocathode pulse located in the first section of the optical relay to the gun hutch, on table 2;

Diode and HeNe alignment lasers: no engineering controls

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:

The Laser Room and accelerator enclosure are posted with standard signs describing the systems within. They are interlocked, with the standard lighted signs at the entrances when the interlock is active. To gain entry, a person must push a series of buttons and move through doors in a prescribed sequence. All lasers are labeled in accordance with the ANSI standard. Whenever accessing the laser room with the interlock, "pass through" feature, always wear protective eyewear until you can assure that all beams are enclosed. Detailed procedures of entry and exit of SDL laser secured areas as well as SDL laser interlock configurations refer to LS-SDL-0007 (SDL Laser Interlock) and LS-SDL-0033 (Laser Operation for SDL Training Certification Checklist).

Visitors and unauthorized users are not allowed to access laser secured areas unless they obtain permission from SDL Facility Manager and Laser Safety Officer. Visitors and unauthorized users must be accompanied by an operator and must wear the mandated eye protection. The outside contractors who have company laser safety training are permitted to work in laser secured areas under escort of authorized BNL personnel.

A few general principles of alignment safety should be stressed:

1) always wear eye protection when working with open beams.
2) 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.
3) When aligning outside of the laser room with class 2 or 3A lasers, observe all posting requirements (see SBMS laser subject area) and minimize the number of other personnel in the area.
4) when aligning in the laser room, minimize the number of personnel in the area. If other qualified personnel are working in the area, inform them of the alignment, and the location of the beams you will be adjusting.
5) always align with the lowest intensity available for the job.
6) 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.

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.

Safety Configuration Checklist
SDL Laser System

1. Laser Room and accelerator enclosure laser hazard postings in place.
2. Laser Room and accelerator enclosure interlocks and warning lights operational
3. RF Gun Hutch interlock operational
4. YAG Beam Tubes Installed
5. Amplifier enclosure intact
6. Beam dumps in position:
    a. YAG beams, IR (2)
    b. YAG beams, green (4)
    c. Power attenuators for IR light (2)
    d. 400 nm & 800 nm light dump
    e. 266 nm power attenuator
7. Shutter to transport line operational
8. Inspect beam paths on table (eg. tripler and transport of photocathode laser, seed beam paths)
9. With IR viewer, check for unanticipated stray beams (mirror leakage, back surface reflections etc) leaving the table.
10. If not using ultrafast X-ray source, be sure amplified beam is not routed to it

IF USING AMPLIFIED BEAM FOR THE ULTRAFAST X-RAY SOURCE:

- Insure lead shielding is in place as prescribed
- If soft x-rays are extracted out of the lead enclosure, insure that they are enclosed in steel shielding as prescribed

PERSONAL PROTECTIVE EQUIPMENT

☒ Eye Wear ☐ Skin Protection

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.

EYE WEAR REQUIREMENTS

Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
Synergy Ti:sapphire	~800 nm	3.3	0.2	0.26	Kentek GBM 64
Coherent Nd:YVO_4 (Verdi)	532	3.7	2.4	3.1	Kentek GBM 64
Spectra Physics LAB-170 Q-switched YAG	532,1064	6.7, 6.4	4.1, 3.4	22, 9.8	Kentek GBM 64
Spectra Physics GCR-170 Q-switched YAG	532,1064	6.7, 6.4	4.1, 3.4	22, 9.8	Kentek GBM 64
Ti:Sapph CPA system	~800	5.7	2.6	4.2	Kentek GBM 64
Nonlinear frequency synthesis	266,400	2.2, 5.8	0, 2.7	4.2	Kentek GBM 64
Alignment Diode Laser	780-820	2	NA	NA	Kentek GBM 64
Helium Neon Laser	544	1	NA	NA	Kentek GBM 64

Helium Neon Laser	633	2	NA	NA	Laser Vision L648

* 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
Kentek GBM 64	190-520 520-532 750-850 850-1080	9+ 7+ 5+ 7+
Laser Vision L648	633 647-676	2-3 3+
Kentek KXL-6401 Kentek KXP-6401	190-532 750-850 850-1080 5000-11000	7+ 5+ 7+ 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 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.

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. When inserting or removing an optic from the beam path, be certain that the beam is blocked upstream of the optic until the optic is secured.
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. For work with UV wavelengths, if short sleeves are worn, UV skin protection shall be provided by wearing a Laboratory coat or jacket. Skin protection should be worn on the face, hands and arms when aligning at UV wavelengths.
6. 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.
7. Areas where the beam leaves the horizontal plane will be enclosed.
8. Any stray or unused beams are terminated.
9. 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.
10. Pulsed lasers are aligned by firing single pulses when practical.
11. 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.
12. 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.

Training Checklist for this system and area are in NSLS controlled document LS-SDL-0033. Signed Training Certification for each laser operators are stored in the laser document book located at the SDL facility.

Document Review Frequency
1 Year

Review signatures on file with master copy of controlled document

NSLS REVISION LOG

Document Number:	LS-SDL-0032
Subject:	Laser Safety Program Documentation: Drive and Seed Laser System for the Deep Ultraviolet Free Electron Laser (DUVFEL)

Rev	Description	Date
03	Added discussion of procedure for handling optical beams inside of the accelerator vault.	10/01/03
04	Included use of amplified 800 nm beam for the Ultrafast X-ray source.	04/16/04
05	Comply with new SOP format and include accelerator enclosure interlock.	09/30/04
06	Laser owner/operator changed.	04/26/05
07	Laser owner/operator changed.	04/20/06
08	Included EO detection of electron beam bunch. Administrative control description was modified to include access to laser secured areas by visitors, unauthorized users and outside contractors. Laser training is now managed by NSLS training coordinator.	04/05/07
09	Laser eyewear identification and specification are updated.	05/02/08
10	Laser operator changed	04/09/09
11	A new YAG laser (LAB-170) was installed. The GCR-150 was replaced by LAB-170. A laser shutter was installed for UED project. It is integrated with laser interlock system.	04/21/10
12	1. A new laser system was installed. Tsunami was replaced by Synergy, and Millennia was replaced by Verdi. 2. Included the ultrafast electron diffraction (UED) system. 3. Engineering control description was modified to include access to UED areas. 4. New reviewer and approver	03/21/11
13	Laser operator changed	03/21/12