Authorization to Operate the E-163 Laser System*
and
Standard Operating Procedure

***(a.k.a.: End Station B Laser System, NLCTA Laser System)**

Request From:	Eric R. Colby, E-163 System Laser Safety Officer
Date of request:	July 25th, 2006
SLAC Laser Safety Officer:	Ted Fieguth
Laser system:	E-163 Laser System in End Station B laser room
Duration of Authorization:	**August 1, 2006 through July 31, 2007**

The E-163 System Laser Safety Officer hereby requests approval of the SOP and authorization to operate the E-163 Laser System.

s/Eric R. Colby/ /July 25, 2006/

Eric R. Colby, E-163 System Laser Safety Officer date

The **Standard Operating Procedure** described herein is approved.

s/Ted H. Fieguth/ /July 25, 2006/

Ted H. Fieguth, SLAC Laser Safety Officer date

Approval to operate the E163 Laser System for the duration above and under the conditions described in this document is granted.

s/Ted H. Fieguth/ /July 25, 2006/

Ted H. Fieguth, SLAC Laser Safety Officer date

1 Scope of Authorization

Operation of the E163 Laser System may include tuning, alignment, and diagnosis of laser beams within any or all of: (1) the End Station B laser room, (2) the NLCTA Accelerator enclosure, or (3) the E163 Experimental Hall enclosure.

2 Hazards and Hazard Controls

2.0 Analysis of Hazards

2.0.0 General Laser System Description

The E-163 laser system is located in a class 10,000 cleanroom in the Northeast corner of End Station B (b. 062). The cleanroom houses three optical tables. Four 6" diameter transport tubes provide the only direct path for light to escape the room, when all the doors are closed. A Laser Safety System (LSS) monitors the entrance doors, Emergency Off buttons, the entrances to the NLCTA and Experimental Hall enclosures and closes shutters (which block laser radiation) and can disable the laser power supplies when emergencies occur. Detailed specifications of the LSS are included in Appendix A. Highlights of the specifications are listed below.

The LSS controls laser radiation through three mechanisms. A table shutter is placed immediately at the output of each laser that emits radiation into an open beam path. (Pump laser pathways are fully enclosed and independently interlocked). The table shutters may be opened and closed by a Qualified Laser Operator (QLO) using the controls on the front panel of the LSS. The table shutters close if the inner doors to the laser room are opened without using the (K1) keyed timed bypass in the entry vestibule. The table shutters will also close if the inner and outer doors are simultaneously opened. QLOs may activate the keyed timed bypass switch using their K1 laser room key, then open the inner door without tripping the table shutters closed.

Emergency Off (E/O) buttons are located on the East, West, and South walls of the laser room, and disable the laser both by closing the table shutters and by turning off the laser power supplies.

Laser transport stoppers control the emission of laser radiation into the adjacent enclosures—the NLCTA and Experimental Hall enclosures.

The LSS also controls personnel access to the NLCTA and Experimental Hall enclosures, monitors the outer door microswitches, E/O buttons, and Emergency Entry/Emergency Exit (E/E) buttons, and controls a stopper that blocks radiation from propagating from the laser room into the NLCTA enclosure (or Experimental Hall, as appropriate). Should an unauthorized entry (including an E/E) into the NLCTA or Experimental Hall occur while the laser stopper is open, the stopper will immediately close. Pushing any E/O button in either the NLCTA or Experimental Hall will likewise close the corresponding laser stopper (but does not disable the laser power supplies).

The LSS controls annunciator signs at the entrances of the Laser Room, NLCTA and Experimental Hall enclosures that display appropriate warning messages. The laser room sign will indicate either “Laser Off” in green, or “Laser On” in red. “Laser Off” means no laser hazard is either imminent or present, and PPEs are not required. “Laser On” means that laser radiation is either present or imminent, and that PPEs are required.

The NLCTA and Experimental Hall enclosure signs will display one of: “Laser Off” in green, “Laser Test” in yellow, or “Laser On” in red, depending on the state of the laser transport stopper for that enclosure and the LSS. “Laser Off” means no laser hazard is present (meaning: the transport stopper for that enclosure is closed), and PPEs are not required. “Laser On” means laser radiation is present (meaning: the transport stopper for that enclosure is open), and PPEs are required. “Laser Test” means Laser Test Mode has been engaged (described below), but that laser radiation is not yet present. “Laser Test” is displayed to help personnel in the area identify why the enclosure doors are locked when the Radiation PPS sign is displaying “Permitted Access”.

The laser system is composed of an oscillator and two amplifiers, each pumped by solid state lasers, along with two diode alignment lasers. For electron generation, the second- and third-harmonic frequencies of the primary laser frequency are generated. The oscillator, both amplifiers, and all three pump lasers are class IV lasers. The second- and third- harmonic products are class IIIb, and the alignment lasers are class IIIa.

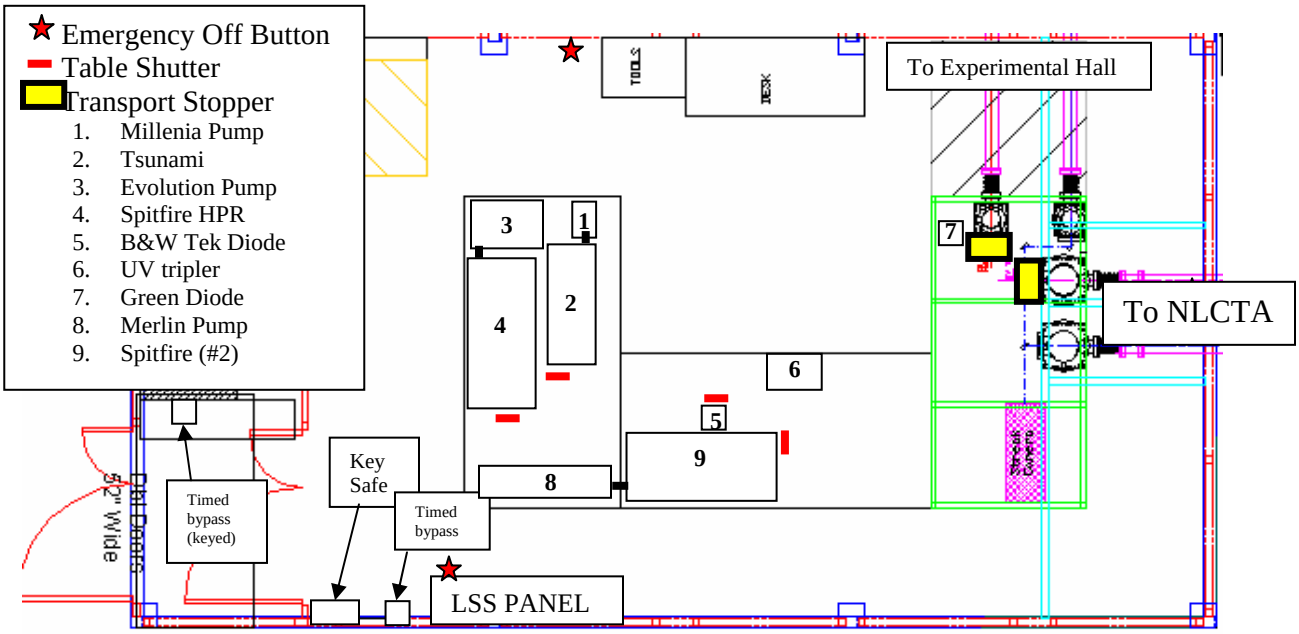

Figure 1. Laser room plan, showing the locations of safety devices. The Nominal Hazard Zone (NHZ) is the entire interior of the laser room.

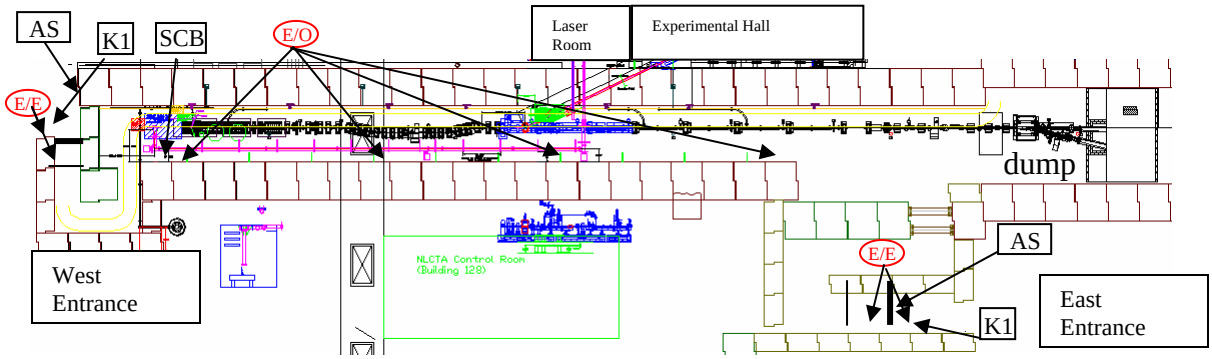

Figure 2. NLCTA plan, showing the location of the Annunciator signs (labeled "AS"), E/O buttons, E/E buttons, timed bypass entry key switch (K1), and Stopper Control Box (SCB). The NHZ is defined to be the entire interior of the NLCTA enclosure.

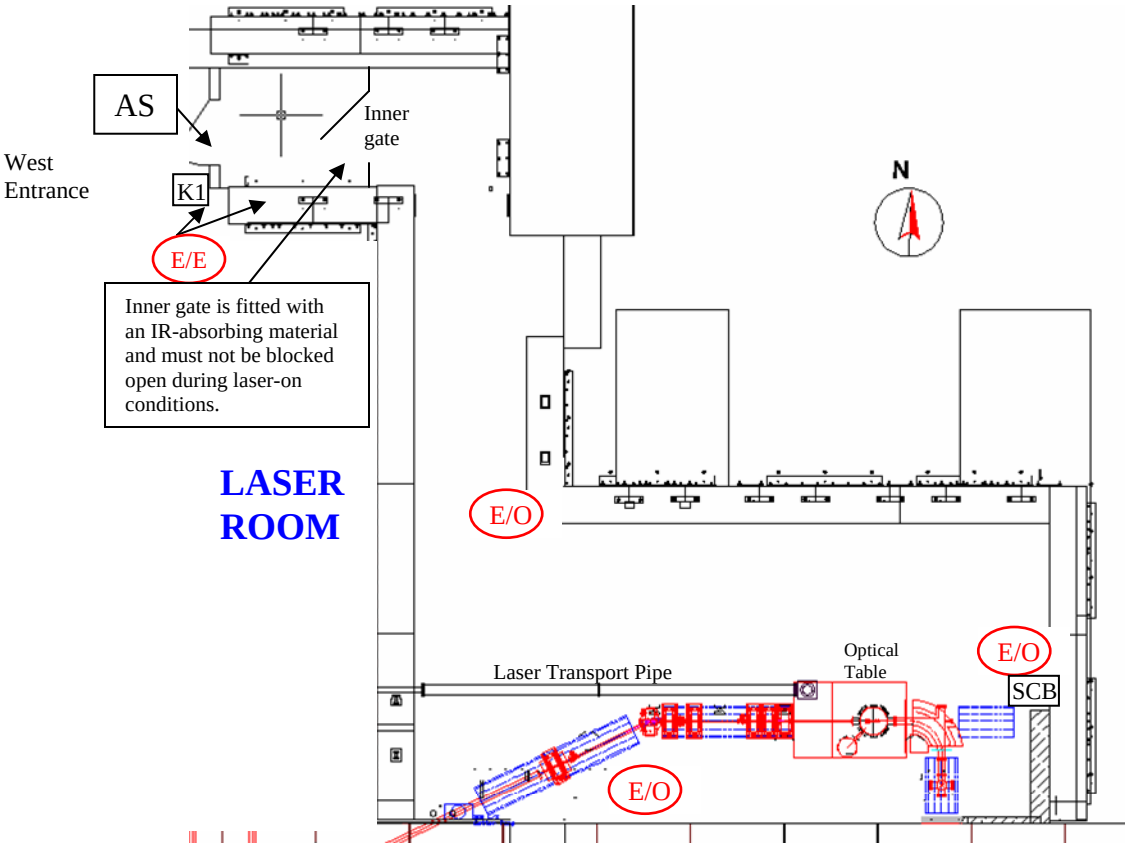

Figure 3. Experimental Hall plan, showing the location of the Annunciator sign (labeled "AS"), E/O buttons, E/E buttons, timed bypass entry key switch (K1), and Stopper Control Box (SCB). The NHZ is defined to be the entire interior of the E163 Experimental Hall enclosure.

These three zones (the Laser Room, the NLCTA Enclosure, and the Experimental Hall Enclosure) will be referred to collectively below as the Nominal Hazard Zones (NHZs).

2.0.1 Hazard 1) The primary hazard is eye or skin damage from exposure to laser radiation for workers within an NHZ. All four primary lasers are ANSI Class-IV. Two additional alignment lasers are used, and are class IIIa. The solid-state oscillator and regenerative amplifiers are externally pumped by either diode-pumped (Evolution) or

flashlamp-pumped (Merlin) solid-state lasers. These lasers and their output characteristics are summarized in Table 1.

Table 1. E-163 Laser System Components

Component	Wavelength (nm)	Average Power	Pulse Length	Pulse Energy	PRF	Beam Size[1]	O.D. Req'd[2,3]	ANSI Class
Millennia (pump)	532 nm	5 W	CW	(CW)	(CW)	2.3 mm	3.7	IV
Tsunami (oscillator)	800 nm	750 mW	80 fs	9.5 nJ	79 1/3 MHz	2 mm	3.1	IV
Evolution (pump)	527 nm	20 W	20 ns	20 mJ	1 kHz	5 mm	5.6	IV
Spitfire HPR (regen amp)	800 nm	2.25 W	1 ps	2.25 mJ	1 kHz	6 mm	5.4	IV
Merlin (pump)	527 nm	10 W	20 ns	10 mJ	1 kHz	5 mm	5.3	IV
Spitfire (#2)	800 nm	1.0 W	1 ps	1.0 mJ	1 kHz	4 mm	5.0	IV
Ti:Sa x 2 Blue	400 nm	239 mW	700 fs	239 μJ	1 kHz	6 mm	4.6	IIIb
Ti:Sa x 3 UV	266 nm	254 mW	580 fs	260 μJ	1 kHz	6 mm	7.4	IIIb
B&W Tek Diode Laser	780 nm	3 mW	CW	(CW)	(CW)	1.0 mm	0.73	IIIa
Green Diode Laser	532 nm	1.7 mW	CW	(CW)	(CW)	1.0 mm	0.24	IIIa

1) Minimum beam diameter at $1/e^2$ points
2) Calculated by LAZAN Quick Calc v.1.1, Rockwell Laser Industries, Cincinnati, OH
3) Exposure bases: <400 nm: 30,000 s, 400-700nm: 0.25 s, >700 nm: 10 s.

2.0.2 Hazard 2) Untrained individuals may try to enter an NHZ while the laser is operating, and might be exposed to hazardous laser radiation. Untrained individuals may be present in the NHZ when laser light is introduced, potentially resulting in injury.

2.0.3 Hazard 3) Untrained individuals may try to operate the laser, resulting in eye or skin damage to himself or others.

No electrical hazard, as defined in ES&H Bulletin 69A "Lock and Tag Program", is present when the Spitfire laser enclosure lids are opened for alignment procedures. A slight startle hazard is presented by the pockels cell driver, which supplies 4.5 kV with a current output capability of less than 400 microAmperes[1].

2.1 Implemented Hazard Controls

2.1.1 Hazard 1: Eye or skin damage from exposure to laser radiation

Hazard Controls:

[1] Per Brent Wheelock, Technical Support, Coherent Inc., April 7, 2005.

1. The NHZ enclosures provide excellent protection against exposure of individuals outside the room. The laser room walls and ceiling are of sheet metal construction, caulked at the joints. There is no line-of-sight view either into the laser room or of a specular surface within the laser room. The NLCTA Enclosure is of concrete block construction, with no line-of-sight view either into the Enclosure, or of a specular surface within the Enclosure. The E163 Experimental Hall Enclosure is also of concrete block construction, with no line-of-sight view either into the enclosure, or of a specular surface within the enclosure.

The NLCTA Safety Officer has conducted an inspection of the laser room and has established that the laser room affords an appropriate level of protection against accidental release of laser radiation. ___<Inspection completed and signed off 4/11/2005>___ R. Keith Jobe, NLCTA Safety Officer

The NLCTA Safety Officer has conducted an inspection of the NLCTA Accelerator Enclosure and has established that the Enclosure affords an appropriate level of protection against accidental release of laser radiation. ___<Inspection completed and signed off 11/7/05> ____ R. Keith Jobe, NLCTA Safety Officer

The NLCTA Safety Officer has conducted an inspection of the E163 Experimental Hall Enclosure and has established that the Enclosure affords an appropriate level of protection against accidental release of laser radiation. _____ R. Keith Jobe, NLCTA Safety Officer

2. It is the responsibility of each Qualified Laser Operator (QLO) to ensure all personnel in the NHZ are wearing the required PPEs when the laser is “imminent” (defined as one or more laser power supplies being “on”, or a transport stopper being open) or when the laser is “on” (defined as one or more laser table shutters being “open”). The laser “on” state is identified by a lit annunciator sign at the entrance(s) of each area. It is also the responsibility of the attending QLO to ensure all individuals in the NHZ have the required training.
3. PPEs (fully enclosed laser goggles) provide protection against eye damage for personnel working within the NHZs. Table 2 below shows how the two different types of goggles address the OD requirements for the two different areas. For the laser room, four pair of Lase-R Shield wrap-around style Flexseal goggles type 31-70111 are provided. These goggles protect against all the lasers listed in Table 1, and may be used in any of the three NHZs. For the NLCTA and Experimental Hall (where green pump laser light is not a hazard) four pair of higher-VLT LS670 wrap-around style goggles are provided. Goggles for the laser room will

be clearly marked: “Use Anywhere”. Goggles for the NLCTA and Experimental Hall enclosures will be clearly marked: “Not for Laser Room Use”.

Table 2. Specifications of laser protective eyewear

	Laser Room “Use Anywhere” Lase-R Shield 31-70111		**NLCTA “Not for Laser Room Use” Lase-R Shield LS670**		**Experimental Hall “Not for Laser Room Use” Laser-R Shield LS670**	
Wave-length	Required OD	Goggles OD	Required OD	Goggles OD	Required OD	Goggles OD
800 nm	5.4	6.42	5.4	7+	5.4	7+
780 nm	0.7	5.57	0.7	7+	0.0	7+
532 nm	3.7	6.98	0.0	0.0	0.0	0.0
527 nm	5.6	8.72	0.0	0.0	0.0	0.0
400 nm	4.6	9.00	0.0	0.0	0.0	0.0
266 nm	7.4	9.00	7.4	9+	0.0	9+
Color, VLT	**brown**	30%	**blue**	50%	**blue**	50%

4. The power density is above the skin MPE for the pump lasers (MPE=0.2 W/cm^2) and oscillator (MPE=0.3 W/cm^2). The pump laser beams (52 and 204 W/cm^2) shall be fully enclosed in metal tubes. The oscillator beam (~8 W/cm^2) will not be enclosed in tubes, but its path is in a difficult-to-access location (making incidental exposure unlikely) and all stray beams will be stopped before they can leave the perimeter of the laser table. The regen beams (~4 W/cm^2) are not enclosed. The UV beam (~1.8 W/cm^2) is well above the skin MPE (0.003 W/cm^2), Skin protection (gloves) should be worn when adjusting optics in the UV beam path. All laser beam heights are between 38-44 inches, well below eye level.

Table 3. Skin exposure limits and protective measures.

Wavelength	**Φ (W/cm^2)**	**MPE (W/cm^2)**	**PPE/Barriers**
800 nm Oscillator	7.8	0.03	Difficult access
800 nm Regen (HPR)	4.0	0.03	None
800 nm Regen (#2)	4.0	0.03	None
532 nm	52	0.02	Full metal tubes
527 nm	204	0.02	Full metal tubes
400 nm	1.7	0.02	Dumped at exit
266 nm	1.8	0.003	Gloves as needed

2.1.2 Hazard 2: Eye or skin damage to an untrained individual entering the room

Hazard Controls:

Laser Room

1. The outer door is locked, the K1 key to release this lock is held only by QLOs. One extra key will be locked in the NLCTA Operations Key safe for emergency entry.
2. An automatic lit sign is mounted above the outer door that will indicate "LASER ON" in red letters whenever the laser is "imminent" or "on" (as defined in 2.1.1 (2) above), and "Laser Off" in green letters only when all power supplies are off and all laser table shutters are closed.
3. Microswitches monitor the inner and outer doors, and will close the laser table shutters if an unauthorized entry is made.
4. Emergency Off buttons are located on three walls of the laser room that will disconnect electrical power to the lasers and close the table shutters in the event of an emergency.
5. The QLO who turns on the power to the lasers is responsible for ensuring no unauthorized personnel are in the laser room, and that all individuals are wearing PPEs. Non-QLO visitors must be escorted by a QLO at all times under "Laser Off" conditions only; the escorting QLO is directly responsible for the safety of the visitor(s). The sole exception is for repair technicians from Spectra Physics, who may service and operate the lasers only when attended by a QLO. The QLO is directly responsible for the safety of the visiting repair technician, and for enforcing compliance with the rules and procedures in this SOP.
6. Non-routine operations plans will be communicated to the area manager and discussed at the NLCTA 7:30am tailgate meeting to alert others in the area.

NLCTA Enclosure

1. The outer doors are monitored by microswitches. The K1 key to bypass the microswitches (thereby preventing the laser stopper from automatically closing) is held only by QLOs. One extra key will be locked in the NLCTA Operations Key safe.
2. An automatic lit sign is mounted above the outer door that will indicate "LASER ON" in red letters whenever the laser transport stopper is open, "Laser Off" in green letters when the laser transport stopper is closed.
3. Microswitches monitor the NLCTA outer doors, and will close the transport line stopper if an unauthorized entry is made.
4. Emergency Off buttons are located along the South wall of the NLCTA Enclosure that will close the transport line stopper in the event of an emergency.
5. The QLO who opens the laser transport stopper must first perform an administrative search of the entire NLCTA. All unauthorized personnel must be expelled; all remaining personnel must be QLOs wearing PPEs.

6. Non-routine operations plans will be communicated to the area manager and discussed at the NLCTA 7:30am tailgate meeting to alert others in the area.

Experimental Hall Enclosure

1. The outer door is monitored by a microswitch. The K1 key to bypass the microswitch (thereby preventing the laser stopper from automatically closing) is held only by QLOs. One extra key will be locked in the NLCTA Operations Key safe.
2. An automatic lit sign is mounted above the outer door that will indicate "LASER ON" in red letters whenever the laser transport stopper is open, "Laser Off" in green letters when the laser transport stopper is closed.
3. A microswitch monitors the Experimental Hall outer door, and will close the transport line stopper if an unauthorized entry is made.
4. Emergency Off buttons are located throughout the Experimental Hall that will close the transport line stopper in the event of an emergency.
5. The QLO who opens the laser transport stopper must first perform an administrative search of the entire Experimental Hall. All unauthorized personnel must be expelled; all remaining personnel must be QLOs wearing PPEs.
6. Non-routine operations plans will be communicated to the area manager and discussed at the NLCTA 7:30am tailgate meeting to alert others in the area.

2.1.3 Hazard 3: An untrained individual may try to operate the laser, resulting in eye or skin damage to himself or others

Hazard Controls:

1. The LSS will close shutters and stoppers in response to an unauthorized entry into the laser room, disabling the laser hazard.
2. The LSS will close the transport stoppers in response to an unauthorized entry into the NLCTA or Experimental Hall enclosures, disabling the laser hazard.
3. The keys to the laser power supplies (K4, K5, K6, K7, and K9) are locked in a key safe (keyed with the K8 key) in the laser room when not in use. The keysafe is mounted within the laser room. Only QLOs hold the K1 key to the laser room, and non-QLO visitors to the laser room must be accompanied by a QLO at all times.

3.0 Work Within Controls/Standard Operating Procedure

PPEs must be worn at all times pursuant to section 2.1.1(2), except:
1) When the warning annunciator sign displays "Laser Off".

Note: should you need to clean the goggles or lift the goggles to rub the eyes, etc., you must first leave the NHZ. In the laser room, this means going out of the room and into the entry vestibule. In the NLCTA or Experimental Hall, this means closing the laser shutter and putting the shutter key in your pocket.

General Rules Regarding Visitors and Visiting Repair Technicians

1) Any individual not meeting all the requirements in section 4.0 is a "visitor". A fully trained Spectra-Physics repair technician is the sole exception to this definition; however, since the technician lacks site-specific training, they must be escorted at all times by a QLO.
2) **Visitors are never allowed in an area under Laser On conditions.**
3) Visitors are allowed only under Laser Off conditions, and may visit the NLCTA and Experimental Hall unescorted. Visitors to the Laser Room, however, must **always** be escorted by a QLO.

(Pursuant to governing sections of ANSI Z136.1-2000, as indicated in parenthesis.)

3.0 Procedures for powering and disabling the lasers, performing alignment, and making entry/exit to the laser room

3.0.1 To energize the lasers, the attending QLO shall:

1. Check that the outer door lock is locked (§4.3.10.2.2)
2. Check that only QLOs are in the laser room, and expel non-QLOs (§4.3.10.1(1))
3. Use a K8 key to unlock the key safe and obtain the laser power supply keys
4. Ensure the K2 and K3 keys are present and are set to "Remote"
5. Visually inspect, then don PPE goggles, and ensure all other personnel are wearing PPEs
6. Verify that the Any Table Shutter Open LED is not lit. Push the ALL TABLE SHUTTERS CLOSED button if it is lit.
7. Verbally warn others in the laser room that the laser is about to be turned on (§4.3.9.4)
8. Insert power supply keys in laser power supplies and turn on supplies
9. Open the laser table shutters by pushing the ALL TABLE SHUTTERS OPEN pushbutton. Alarm will sound (and flash) for 20 seconds, then shutters will open.

3.0.2 At ALL times when laser light is imminent or present ("Laser On"):

1. **PPEs (both eye and skin protection, as defined in section 2.1.1 (2) above) must be worn**
2. Stray laser beams shall be controlled at all times with beam blocks. No laser beam may leave the optical table.
3. Beam attenuators should be used whenever maximum laser power is not needed
4. Appropriate beam stops capable of absorbing the full laser power should be inserted whenever laser radiation is not needed

3.0.3 Alignment Procedure

Alignment of existing beam pathways and the creation of new beam pathways must be performed under the following conditions:

1. PPEs shall be worn. Where skin exposure to UV is possible, gloves should be worn.
2. Beam viewing shall be by indirect means only. Use fluorescent cards, an IR viewer, CCD cameras, or other analytical instruments only.
3. Stray beams (as from surface reflections, back-reflected spots from attenuators etc.) shall be blocked. No stray beams may leave the perimeter of the optical table.
4. No visitors may be present in any NHZ when an alignment procedure is underway. Only QLOs may be present. The sole exception is a qualified Spectra-Physics repair technician, who may work on the laser system only with a QLO present.
5. Remove jewelry, watches, badge, etc. if the objects will be in or near the beam path.
6. The SLSO shall be informed of the creation of new beam pathways.

In addition the following best practices shall be followed to the extent that they are feasible:

1. Low-power alignment diode lasers shall be used as surrogates for the higher power beams whenever practical
2. Where low-power alignment lasers are not practical, the laser shall be attenuated to the lowest usable power for the duration of the alignment procedure
3. Open beams, both stray and deliberate, should be kept strictly in the horizontal plane.
4. Optical table enclosure doors shall be kept closed to the extent possible, to serve as a back-up barrier for stray spots.
5. Avoid bringing the eyes anywhere near the horizontal plane in which the laser propagates.

3.0.4 Maintenance Procedure

Simple maintenance procedures, limited strictly to those procedures that are clearly described in the Spectra Physics manuals for the lasers, may be performed by QLOs, with the prior verbal approval of the SLSO. Such procedures may also be performed by a Spectra-Physics laser technician, provided a QLO is present at all times. The manufacturer-supplied procedures shall be strictly followed.

Examples of maintenance procedures include aligning the Tsunami oscillator cavity, optimizing the doubling crystal temperature, aligning the regenerative amplifier cavity, and replacing consumables (e.g. Drierite cartridges).

3.0.5 Service Procedure
Service procedures shall not be conducted by any QLO or the SLSO. The E163 laser system is under maintenance contract with Spectra Physics. Components covered by the contract are the Tsunami, Millenia, Evolution, and Spitfire lasers, along with their associated electronics. Service procedures shall be conducted only by qualified Spectra Physics personnel under the constant supervision of a QLO. The supervising QLO is responsible for the safety of the visiting service technician and for ensuring that the requirements of this SOP are met.

Service procedures include aligning the pump lasers, replacing laser mirrors, amplifier rods, gratings, and other internal components, and repairing power supplies and control electronics.

3.0.6 To turn off the laser the attending QLO must:
Note: The laser must be secured by locking the power supplies keys in the key safe whenever it is not in use.

1. Close the laser table shutters by pushing the ALL TABLE SHUTTERS CLOSED pushbutton.
2. Turn off the laser power supplies
3. Remove laser power supply keys and secure in the key safe (§4.3.10.1(11))
4. Remove PPEs

3.0.7 To enter the laser room when the laser is on
1. Unlock outer door with a K1 key and enter the vestibule. Close outer door.
2. Don PPEs
3. Insert K1 key in timed bypass and turn
4. Open inner door. Close inner door before 20 second timeout and alarm expires.
5. Do not open inner door until outer door is fully closed.

3.0.8 To exit the laser room when the laser is on
1. Push timed bypass pushbutton
2. Open inner door, exit, and close inner door before timeout expires
3. Remove PPEs and store
4. Exit through outer door. Do not open outer door until inner door is fully closed.

3.1 Procedures to Permit Laser Light Into the NLCTA or Experimental Hall Enclosure, and make entry/exit

Note: Procedures for laser operations in the NLCTA and Experimental Hall Enclosures are analogous, with the exception that the NLCTA has two entrances and the Hall just one entrance. The term "enclosure" used below is understood to mean either the NLCTA Enclosure or the Experimental Hall Enclosure. Where instructions differ, the change in procedure for the Experimental Hall will be noted in parenthesis as "(resp. [changed instruction here])".

3.1.1 Procedure for Admitting Laser Light into an Enclosure in PERMITTED ACCESS

3.1.1.1 For laser light to be present inside the enclosure in Permitted Access a special "Laser Test Mode" (LTM) must be engaged. LTM causes the outer door(s) of the enclosure to be locked, and the E/O and E/E buttons to be activated. With LTM engaged, the outer door(s) are magnalocked, and only QLOs can enter.

1. Go to the NLCTA PPS Control Panel B128-05 (resp. Exp. Hall Control Panel B225-06), check on the video monitors that no one is inside the enclosure, and use a K1 key to set the enclosure to Laser Test Mode. Walk to the laser room. Observe that the enclosure annunciator sign reads "Laser Test".
2. Turn the K2 (resp. K3) key briefly to "Initiate" to engage the search preset, then switch to "Local" and remove the K2 (resp. K3) key.
3. Ensure you have appropriate PPEs with you.
4. Go to the enclosure and make a timed bypass entry using a K1 key.
5. Verify no unauthorized personnel are in the enclosure. To search the NLCTA, start at the East entrance outer door and walk to the NLCTA dump, then walk to the West entrance outer door. Check behind the beamline. (resp. To search the Experimental Hall, start at the dump and walk to the West entrance door.)
6. Don PPEs and ensure any personnel with you also don PPEs.
7. Insert the K2 (resp. K3) key into the Stopper Control Box, push the "set" button, then turn the key to the "Stoppers Open Command" position. Visual and audible alarms should begin and continue for 20 seconds, then the stopper will be open.

3.1.1.2 To close the transport line stopper and terminate Laser Test Mode

1. Rotate the K2 (resp. K3) key to the "Off" position and remove the key.
2. Go to the NLCTA PPS Panel (resp. Exp. Hall Control Panel), and use a K1 key to Cancel the Laser Test Mode.
3. Return the K2 (resp. K3) key to the LSS control panel in the laser room, and leave the key in the "Remote" position.

3.1.2 Procedure for Admitting Laser Light into an Enclosure in CONTROLLED ACCESS

3.1.2.1 For laser light to be present inside the enclosure in Controlled Access the "Laser Test Mode" should NOT be engaged. Note that in this case non-QLOs can enter the enclosure, but will cause the transport stopper to immediately close. The annunciator sign at the entry doors will display "Laser On", but entry is not under K1 key control.

1. Ensure you have appropriate PPEs with you.
2. Go to the enclosure and contact the PPS operator to make a Controlled Access entry. Inform the PPS operator that you will also be making a Laser Entry.
    a. Remove the keybank key when released
    b. Insert the keybank key in the door release box

   c. Insert the K1 key in the laser entry box and start the timed bypass
   d. Use the keybank key to release the outer door, then open the door, making sure you have both the K1 and keybank keys with you
   e. Close the door promptly
3. Verify no unauthorized personnel are in the enclosure. Start at the East entrance outer door and walk to the NLCTA dump, then walk to the West entrance outer door. Check behind the beamline. (resp. To search the Experimental Hall, start at the dump and walk to the West entrance door.)
4. Don PPEs and ensure any personnel with you also don PPEs.
5. Insert the K2 (resp. K3) key into the Stopper Control Box, push the "set" button, then turn the key to the "Stoppers Open Command" position. Visual and audible alarms should begin and continue for 20 seconds, and then the stopper will open.

3.1.2.2 To close the transport line stopper

1. Rotate the K2 (resp. K3) key to the "Off" position and remove the key.
2. Return the K2 (resp. K3) key to the LSS control panel in the laser room, and leave the key in the "Remote" position.

3.1.3 Laser Light in NO ACCESS

1. Rotate the K2 (resp. K3) key to the "Remote" position in the LSS Control Panel.
2. SCP now controls the stopper state. Note that this is a PPS function, and only certain MCC accounts have the required privilege to operate the stopper. (e.g. the console login on the COW in the NLCTA control room has this privilege).

3.1.4 To enter the Experimental Hall or NLCTA when the laser is on

1. Unlock outer door with a K1 key and enter the vestibule. Close outer door.
2. Don PPEs
3. For the Experimental Hall, close the inner gate after entering. (Not needed for NLCTA)
4. Insert K1 key in timed bypass and turn
5. Open inner door. Close inner door before 20 second timeout and alarm expires.
6. Do not open inner door until outer door is fully closed.

3.1.5 To exit the Experimental Hall or NLCTA when the laser is on

1. For the Experimental Hall, close the inner gate behind you (not needed for NLCTA)
2. Push timed bypass pushbutton
3. Open inner door, exit, and close inner door before timeout expires
4. Remove PPEs and store
5. Exit through outer door. Do not open outer door until inner door is fully closed.

3.2 Procedures for Alignment of Diagnostic Light Transport Lines

Diagnostic transport lines are installed which allow light from beam diagnostics in the accelerator tunnel to propagate back to the laser room for diagnosis with cameras. Provisions and requirements are listed below.

1. NO CLASS III OR CLASS IV LASER MAY EVER BE ALIGNED INTO THESE TRANSPORT LINES FOR ANY REASON. Take care to assiduously avoid laser path alignments that might accidentally couple into these transport lines.
2. Diagnostic line alignment can only be performed when all Class III and Class IV lasers are off.
3. Only Class I or Class II lasers may be used in diagnostic line alignment procedures.
4. There are light shrouding pipes and baffles are in place around these transport lines to provide added protection against unintentional laser exposure. If these items must be removed for alignment procedures, they must be restored in place before any Class III or Class IV laser may be used again. Alternatively, a flange must be secured in place over the end of the laser transport tube if the pipes and baffles are not restored.

3.3 Procedures to Recover from Fault Conditions

3.3.1 Access violation (or E/O actuation) in Laser Room

1. Ensure fault condition is corrected
2. If E/O was pressed, press E/O Reset on LSS Control Panel
3. Press “Stopper Open” pushbutton on LSS Control Panel

3.3.2 Access violation (or E/O or E/E actuation) in an enclosure

1. Ensure fault condition is corrected
2. Switch K2 (resp. K3) key in Stopper Control Box to “Off” position and remove.
3. If an E/O or E/E was pushed, contact the NLCTA PPS (resp. Exp. Hall PPS Operator) operator to reset the E/Os or E/Es
4. Walk to the laser room and use the K2 (resp. K3) key to switch to the “Initiate”, then “Local” position to recover the search preset condition.
5. Walk back to the enclosure, make a K1 timed-bypass entry
6. Insert K2 (resp. K3) key in Stopper Control Box
7. Push “Reset” button
8. Switch to “Stopper Out Command” position.

4.0 Required Training

A Qualified Laser Operator (QLO) who may operate the E-163 Laser System is an individual who has:

1. Completed SLAC safety course 253 “Laser Worker Safety”
2. Read Chapter 10 of the SLAC ES&H manual
3. Read ANSI Z136.1-2000 *American National Standard for Safe Use of Lasers*
4. Has a retinal exam on record with the SLAC Medical Department
5. Been interviewed by the SLAC Laser Safety Officer
6. Received E-163 Laser System-specific hands-on training
7. Signed this Standard Operating Procedure on the last page
8. Completed a fully signed-off “Authorization for E-163 Laser System Operator” form.

In addition, since the E-163 Laser System is within End Station B, the individual must have received the End Station B Safety Orientation, which may be administered by any NLCTA OIC.

5.0 Responsibility Assignments

The **System Laser Safety Officer** (SLSO) has the following responsibilities:

1. Maintaining the laser system in safe working order, including arranging for periodic Laser Safety System recertification, and repairs as needed
2. Writing and updating the SOP when necessary
3. Obtaining approval to operate the laser system
4. Providing system-specific training to QLOs
5. Maintaining training records for all QLOs, and lists of keys issued
6. Monitoring and enforcing compliance with the rules and procedures in this SOP.

Every **Qualified Laser Operator** (QLO) has the following responsibilities:

1. Abiding by and enforcing the rules and procedures in this SOP
2. Informing the SLSO of unsafe conditions of any kind, and stopping activity when warranted
3. Informing the SLSO of changes to the system (e.g. new beam paths) that impact the operating safety envelope.

6.0 Required Periodic Inspections

1. The SLSO shall conduct a test of the Laser Safety System, using the *End Station B Laser Safety System Interlock Checklist.* This check shall be documented by the completion of the checklist and shall be completed at least once annually.

7.0 Records

The E163 System Laser Safety Officer shall maintain records as follows:

1. Documents demonstrating completion of the required training for each QLO who works on the E163 Laser System.
2. A list of K1 key holders. The so-called "K1" key unlocks the outer door of the E163 Laser Room, and operates the timed bypass for laser-on entries. K1 keys are serialized (numbered uniquely) for easy identification and tracking.
3. A list of Key Safe key (K8) holders. The Key Safe key allows access to the power supply keys for all the lasers in the E-163 system. K8 keys are serialized (numbered uniquely) for easy identification and tracking.
4. Completed LSS checklists.

These records are kept in a binder in the E163 laser room within End Station B.

Glossary of Terms

Shutter or **Laser Shutter** – an electromechanically actuated metal shutter that completely blocks laser light. Shutters are used as laser Beam Stoppers.

Laser Shutters – shutters SA, SB, SC, and SD (see figure 3), which block light output from the Tsunami oscillator, the Spitfire HPR regenerative amplifier, the low-power diode alignment laser, and the Spitfire regenerative amplifier oscillator, respectively.

- **SA** – laser shutter located at the exit of the Tsunami oscillator.
- **SB** – laser shutter located at the exit of the Spitfire HPR regenerative amplifier.
- **SC** – laser shutter located at the exit of the alignment B&W Tek Inc. Diode Laser.
- **SD** – laser shutter located at the exit of the Spitfire regenerative amplifier.
- **SE, SF** – spares for future use.

Transport Laser Stoppers – shutters S1E, S1N (see figure 2) which block light from entering into the Experimental Area (S1E) or NLCTA Enclosure (S1N).

- **S1E** – laser shutter located within the Laser Room, at the point where laser light would exit the Laser Room and enter the Experimental Hall.

- **S1N** – laser shutter located within the Laser Room, at the point where laser light would exit the Laser Room and enter the NLCTA.

K1 Key (copied, serialized) – held by all Qualified Laser Operators, allows access into the Laser Room, and timed bypassed access to zones with Transport Line Stoppers open

K2 Key (unique) – (also called "NLCTA Transport Line Stopper Key") used to switch between Local and Remote operation of the NLCTA Enclosure Laser Shutter (S1N)

K3 Key (unique) – (also called "Exp. Hall Transport Line Stopper Key") used to switch between Local and Remote operation of the Experimental Hall Laser Shutter (S1E)

K4 Key (unique) – used to turn on/off the power supplies for the Millenia XK5 laser. Once this laser is disabled, the Tsunami Laser is also disabled.

K5 Key (unique) – used to turn on/off the power supplies for the Evolution-30 laser. Once this laser is disabled, the Spitfire HPR Laser is also disabled.

K6 Key (unique) – used to turn on/off the power supply for the B&W Tek diode laser.

K7 Key (copied, serialized) – key safe key, used to open the key safe within the Laser Room, where laser power supply keys are kept when not in use.

K8 Key (unique) – used to turn on/off the power supply for the Merlin pump laser. Once this laser is disabled, the Spitfire Laser is also disabled.

Key Bank Key (copied) – personnel protection system key for entry under the Controlled Access condition.

Experimental Hall – the E163 Radiation shielding enclosure, located North and parallel to the NLCTA enclosure

Laser Room – the E163 Laser Room, located West of and parallel to the entrance labyrinth of the E163 Radiation shielding enclosure

QLO – Qualified Laser Operator—and individual who satisfies all the requirements in section 4.0.

QLO Entry/QLO Exit – A QLO entry or exit through a Laser Safety boundary, accomplished by using a K1 key to activate a timed bypass on entry, or by using the pushbutton bypass to exit.

I agree to abide by and enforce the rules and procedures set out in this document.

	Eric R. Colby, E163 SLSO	
Signature	Printed Name	Date
	Tomas Plettner	
Signature	Printed Name	Date
	Robert H. Siemann	
Signature	Printed Name	Date
	Chris M. Sears	
Signature	Printed Name	Date
	James E. Spencer	
Signature	Printed Name	Date
	Rasmus Ischebeck	
Signature	Printed Name	Date
	Melissa Lincoln	
Signature	Printed Name	Date
	Chris McGuiness	
Signature	Printed Name	Date
Signature	Printed Name	Date
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