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: November 7, 2005
SLAC Laser Safety Officer: Ted Fieguth
Laser system: E-163 Laser System in End Station B laser room
Duration of Authorization: November 7, 2005 through April 30, 2006

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/ 07-NOV-05
Eric R. Colby, E-163 System Laser Safety Officer date

The Standard Operating Procedure described herein is approved.

s/Ted Fieguth/ 07-NOV-05
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 Fieguth/ 07-NOV-05
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 the End Station B laser room and the NLCTA Accelerator enclosures only. The laser transport tubes connecting the laser room to the Experimental Hall shall be physically blocked with a light-tight obstruction that is either locked-out or tagged-out by the NLCTA Safety Officer.

Approval to remove the transport tube barriers and propagate laser light in the E163 Experimental Hall shall be contingent on (1) the successful demonstration of a Laser Safety System governing the subject enclosure, and (2) a new operation authorization and revised SOP, to be completed when condition (1) is met.

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, and NLCTA Enclosure and closes shutters (which block laser radiation) and can disable the laser power supplies when emergencies occur. The LSS will be expanded in the future to govern the Experimental Hall as well. 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 also will 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 Enclosure and the Experimental Hall. Laser emission into the Experimental Hall is forbidden for the time being, and the transport lines have been blocked and tagged out.

The LSS also controls personnel access to the NLCTA Enclosure, 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. Should an unauthorized entry (including an E/E) into the NLCTA occur while the laser stopper is open, the stopper will immediately close. Pushing any E/O button will likewise close the laser stopper.

The LSS illuminates Annunciator signs at the entrances of the Laser Room and the NLCTA Enclosure (and in the future, at the entrance of the Experimental Hall as well) that display an appropriate warning message. The laser room sign will indicate either “Laser Off” in green, or “Laser On” in red. “Laser Off” means no laser hazard is imminent or present, and PPEs are not required. “Laser On” means either that laser radiation is present or imminent, and the PPEs are required.

The NLCTA Enclosure sign will display one of: “Laser Off” in green, “Laser Test” in yellow, or “Laser On” in red. “Laser Off” means no laser hazard is present, and PPEs are not required. “Laser On” means laser radiation is present, and PPEs are required. “Laser Test” means Laser Test Mode has been engaged (described below), PPEs are required, but that laser radiation is not yet present.

The laser system is composed of an oscillator/amplifier, each pumped by solid state lasers, along with two diode alignment lasers. For electron generation, the second- and third-harmonic frequency multiplication of the primary laser output. The oscillator, amplifier, and both 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.
2.0.1 Hazard 1) The primary hazard is eye or skin damage from exposure to laser radiation for workers within the Nominal Hazard Zones (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 amplifier are externally pumped by diode-pumped solid-state lasers. These lasers and their output characteristics are summarized in Table 1.

Table 1. E-163 Laser System Components

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

1) Minimum beam diameter at 1/e² 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 the laser room or NLCTA Enclosure while the laser is operating, and might be exposed to hazardous laser radiation. Untrained individuals may be present in the laser room or NLCTA Enclosure 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 enclosure lid is open 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. The laser room and NLCTA 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 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.

___s/R. Keith Jobe/ 07-NOV-05_____________________

R. Keith Jobe, NLCTA Safety Officer

2. It is the responsibility of each Qualified Laser Operator (QLO) to ensure all personnel in the laser room or NLCTA are wearing the required PPEs when the laser is “imminent” (defined as one or more laser power supplies being “on”) 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 laser room (or NLCTA) have the required training.

3. PPEs (fully enclosed laser goggles) provide protection against eye damage for personnel working within the laser room and the NLCTA. 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

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\(^1\) Per Brent Wheelock, Technical Support, Coherent Inc., April 7, 2005.
the lasers listed in Table 1, and may be used in the laser room or the NLCTA. For the NLCTA (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 will be clearly marked: “Not for Laser Room Use”.

Table 2. Specifications of laser protective eyewear

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Laser Room “Use Anywhere”</th>
<th>NLCTA “Not for Laser Room Use”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lase-R Shield 31-70111</td>
<td></td>
<td>Lase-R Shield LS670</td>
</tr>
<tr>
<td>Wavelength</td>
<td>Required OD</td>
<td>Goggles OD</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>800 nm</td>
<td>5.4</td>
<td>6.42</td>
</tr>
<tr>
<td>780 nm</td>
<td>0.7</td>
<td>5.57</td>
</tr>
<tr>
<td>532 nm</td>
<td>3.7</td>
<td>6.98</td>
</tr>
<tr>
<td>527 nm</td>
<td>5.6</td>
<td>8.72</td>
</tr>
<tr>
<td>400 nm</td>
<td>4.6</td>
<td>9.00</td>
</tr>
<tr>
<td>266 nm</td>
<td>7.4</td>
<td>9.00</td>
</tr>
<tr>
<td>Color/VLT</td>
<td>brown</td>
<td>30%</td>
</tr>
</tbody>
</table>

4. The power density is above the skin MPE for the pump lasers (MPE=0.2 W/cm²) and oscillator (MPE=0.3 W/cm²). The pump laser beams (52 and 204 W/cm²) shall be fully enclosed in metal tubes. The oscillator beam (~8 W/cm²) 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 beam (~4 W/cm²) is not enclosed. The UV beam (~1.8 W/cm²) is well above the skin MPE (0.003 W/cm²). 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.

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Φ (W/cm²)</th>
<th>MPE (W/cm²)</th>
<th>PPE/Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 nm Oscillator</td>
<td>7.8</td>
<td>0.03</td>
<td>Difficult access</td>
</tr>
<tr>
<td>800 nm Regen</td>
<td>4.0</td>
<td>0.03</td>
<td>None</td>
</tr>
<tr>
<td>532 nm</td>
<td>52</td>
<td>0.02</td>
<td>Full metal tubes</td>
</tr>
<tr>
<td>527 nm</td>
<td>204</td>
<td>0.02</td>
<td>Full metal tubes</td>
</tr>
<tr>
<td>400 nm</td>
<td>1.7</td>
<td>0.02</td>
<td>Dumped at exit</td>
</tr>
<tr>
<td>266 nm</td>
<td>1.8</td>
<td>0.003</td>
<td>Gloves as needed</td>
</tr>
</tbody>
</table>
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 (4) 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 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 (4) above), “Laser Off” in green letters only when all power supplies are off and all laser table shutters are 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 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 to the laser room, disabling the laser hazard.
2. The keys to the lasers are locked in a key safe (keyed with the K8 key) in the laser room when not in use, and are locked in 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”.

(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. Don PPE goggles, 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 the 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, shall 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 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 serviceman 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:

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 Enclosure

3.1.1 Laser Light in PERMITTED ACCESS

3.1.1.1 For laser light to be present inside the NLCTA in Permitted Access a special “Laser Test Mode” (LTM) must be engaged. LTM causes the outer doors of the NLCTA to be locked, and the E/O and E/E buttons to be activated. With LTM engaged, the outer doors are magmalocked, and only QLOs can enter.
1. Go to the NLCTA PPS Control Panel, check on the video monitors that no one is inside the NLCTA, and use a K1 key to set the enclosure to Laser Test Mode. Walk to the laser room. Observe that the NLCTA annunciator sign reads “Laser Test”.
2. Turn the K2 key briefly to “Initiate” to engage the search preset, then switch to “Local” and remove the K2 key.
3. Ensure you have appropriate PPEs with you.
4. Go to the NLCTA Enclosure and make a timed bypass entry using a K1 key.
5. 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.
6. Don PPEs and ensure any personnel with you also don PPEs.
7. Insert the K2 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 key to the “Off” position and remove the key.
2. Go to the NLCTA PPS Panel, and use a K1 key to Cancel the Laser Test Mode.
3. Return the K2 key to the LSS control panel in the laser room, and leave the key in the “Remote” position.

3.1.2 Laser Light in CONTROLLED ACCESS

3.1.2.1 For laser light to be present inside the NLCTA in Controlled Access the “Laser Test Mode” should NOT be engaged. Note that in this case non-QLOs can enter the enclosure, causing the transport stopper to close.

1. Check the PPS video cameras to see that no one is inside the NLCTA enclosure.
2. Ensure you have appropriate PPEs with you.
3. Go to the NLCTA 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
4. 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.
5. Don PPEs and ensure any personnel with you also don PPEs.
6. Insert the K2 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 open.
3.1.2.2 To close the transport line stopper

1. Rotate the K2 key to the “Off” position and remove the key.
2. Return the K2 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 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 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).

3.2 Procedures to Permit Laser Light Into the Experimental Hall

Laser light is not permitted in the Experimental Hall at this time.

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 actuation) in NLCTA Enclosure

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

3.3.3 Access violation (or E/O actuation) in Experimental Hall

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

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
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

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.

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 regenerative amplifier, the low-power diode alignment laser, and the Cheetah-X Nd:YAG oscillator, respectively.

- **SA** – laser shutter located at the exit of the Tsunami oscillator.
- **SB** – laser shutter located at the exit of the Spitfire 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 Cheetah-X laser. (to be installed in 2006).
- **SE, SF** – spares for future use.

**Transport Laser Stoppers** – shutters S1E, S2E, S1N, S2N (see figure 2) which block light from entering into the Experimental Area (S1E, S2E) or NLCTA Enclosure (S1N, S2N).
• S1E – laser shutter located within the Laser Room, at the point where laser light would exit the Laser Room and enter the Experimental Hall.

• S2E – laser shutter located within the Laser Room, at the point where diagnostic light would enter the Laser Room from 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.

• S2N – laser shutter located within the Laser Room, at the point where diagnostic light would enter the Laser Room from 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 Shutters (S1N, S2N)

K3 Key (unique) – (also called “Exp. Hall Transport Line Stopper Key”) used to switch between Local and Remote operation of the Experimental Hall Laser Shutters (S1E, S2E)

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 Laser is also disabled.

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

K7 Key (unique) – used to turn on/off the power supplies for the Cheetah-X laser. The laser will be installed sometime in 2006.

K8 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.

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
QLD – Qualified Laser Operator—and individual who has had the Laser Safety Training Course (CBT Core Course 253), a Laser Eye Examination, and E163-specific training.

QLD Entry/QLD Exit – A QLD 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.

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E163
Laser Acceleration at the NLCTA

October 21, 2005


Authors: Eric Colby and Robert Noble

The design specifications for the E-163 Laser Safety System described herein have been reviewed and are approved.

________________________________________ date:______________________________
Eric R. Colby, E-163 Spokesman

________________________________________ date:______________________________
Robert J. Noble, E-163 Project Manager

________________________________________ date:______________________________
Robert H. Siemann, E-163 Principal Investigator

________________________________________ date:______________________________
Ted H. Fieguth, SLAC Laser Safety Officer

________________________________________ date:______________________________
R. Keith Jobe, NLCTA Safety Officer
The purpose of this document is to describe the E163 Laser Safety System (LSS). Although the Access Control System also includes ionizing radiation hazards, a completely separate, stand alone Personnel Protection System (PPS) will be used to ensure personnel protection from ionizing radiation, and details of this function are not addressed in this document. All E163 electrical hazards shall be covered, and therefore not interlocked to the LSS or PPS. The description of the PPS is found in the document “Proposed Personnel Protection System (PPS) Access Control System for the E163 Enclosure”, January 5, 2004.

Although ionizing radiation hazards are not discussed in detail here, it is noted that the LSS will make use of the outer doors of the NLCTA and E163 access modules. The outer door will have a magnalock that may be controlled by the LSS and an additional annunciator sign indicating Laser On whenever laser light is enabled in the Experimental Hall or NLCTA enclosures. A light-absorbing curtain inside the inner gate will be drawn (if needed) to ensure no laser light leaves the enclosure. Shelves containing laser personal protective equipment will be located between the outer door and inner gate. The LSS is not part of the radiation PPS. However, the LSS will use state information from the PPS system to enable the Laser On state under certain conditions, described below.

The E163 experiment will use electron bunches of maximum energy 70 MeV extracted from the Next Linear Collider Test Accelerator (NLCTA) and transported via a beamline into a separate shielded enclosure (referred to as the enclosure or hall in the following) built alongside the NLCTA (Figure 1). For the purposes of laser safety, the NLCTA (labeled Zone 1 in the figure) and the Experimental Hall (Zone 2) are separate enclosures where laser light may be enabled independently. The only source of laser light will be light originating from the Laser Room (Zone 3), which has light pipes connecting it to the NLCTA and E163 hall with shutters to prevent light propagation when activated by the LSS.
Simply stated, laser light will be permitted to leave the Laser Room and enter either one of the Experimental Hall or NLCTA enclosures under either of the following conditions: (1) the enclosure is in the No Access state, or (2) a Qualified Laser Operator (QLO) has searched the enclosure and has opened the shutters manually from within the enclosure using a unique key.

No Access State of the PPS

The E163 PPS Access Control System will be a three-state access system:

- PERMITTED ACCESS (P/A)
- CONTROLLED ACCESS (C/A)
- NO ACCESS (N/A)

Transport Line Stoppers allowing light into an enclosure can be opened remotely only in the No Access state. They can be opened locally with a unique, captured key in a key box during either Controlled or Permitted Access/Laser On states according to the procedures below.

The NLCTA PPS system shall provide an NLCTA Ready for Laser Beam status signal to the Laser Safety System that will be used to permit remote enabling of Transport Line Stoppers that protect personnel in the NLCTA enclosure. This status shall be logically equal to:

\[((\text{NLCTA enclosure Search-Reset}=\text{Set}) \text{ AND } \text{(NLCTA enclosure access state} = \text{No Access}) \text{ AND} \]
The Experimental Hall PPS system shall provide an Experimental Hall Ready for Laser Beam status signal to the Laser Safety System that will be used to permit remote enabling of Transport Line Stoppers that protect personnel in the Experimental Hall. This status shall be logically equal to:

\(((\text{Experimental Hall Search-Reset} = \text{Set}) \text{ AND } \text{Experimental Hall access state} = \text{No Access}) \text{ AND } (\text{Radiation warning announcement} = \text{Complete}))\)

The NLCTA PPS system shall provide an Emergency Off Button Reset status signal to the E163 Laser Safety System. The loss of this status will result in the closure of all Transport Line Stoppers (S1E, S2E, S1N, S2N) leading out of the Laser Room, thus stopping any laser light from reaching either the Experimental Hall or the NLCTA enclosure.

The E163 PPS system shall likewise provide an Emergency Off Button Reset status signal to the E163 Laser Safety System. The loss of this status will result in the closure of all Transport Line Stoppers (S1E, S2E, S1N, S2N) leading out of the Laser Room, thus stopping any laser light from reaching either the Experimental Hall or the NLCTA enclosure.

### Laser Room Safety System

The laser room outer door is always locked for property and personnel control, and may be opened with a K1 laser key. The main LSS panel resides in the laser room, as does a keybox, which is used to store the unique copies of K2 (=Laser to NLCTA), K3 (=Laser to Experimental Hall), K4 (=Power On for Millenia XK5 Laser), K5 (=Power On for Evolution 30 Laser), K6 (=Power On for B&W Tek Diode Laser), and K7 (=Power On for Time-Bandwidth Cheetah-X laser) when not in use.

#### a. Laser Off Entry

- Laser Shutters SA, SB, SC, SD, SE, and SF are closed
- Outer door can be unlocked with K1 key, and entry into laser room does not require timed interlock bypass

#### b. Laser On Entry

- One or more of Laser Shutters SA, SB, SC, SD, SE, or SF is/are open
**E163 Laser Safety System Design Document**

- Micro-switch on both the inner and outer doors are interlocked to insure that if both inner and outer doors open simultaneously, then Laser Shutters close
- Micro-switch on inner door closes Laser Shutters unless QLO uses laser entry key (K1) to enter. Key K1 starts a 20 second (or less) timed interlock bypass to permit entry without closing the Laser Shutters.
- Laser Shutters can be opened locally by push button on main LSS panel (see figure 2). Shutters will open after a warning light illuminates and an audible alarm sounds for 20 seconds.
- Annunciator sign at outer door indicates Laser On, requiring PPE to be worn upon entry
- Push-button inside laser room initiates a 20-second or less timed interlock bypass to exit room without closing Laser Shutters (20 second or less bypass of micro-switch)
- Emergency exit (without depressing bypass button) closes Laser Shutters
- Emergency entry (opening door without using the K1 entry bypass) will close Laser Shutters
- Enclosure Laser Shutters S1E, S2E, S1N, S2N do not change state when entry/exit is made to/from the Laser Room under any circumstance.

c. Laser Imminent Entry

- Laser Shutters SA, SB, SC, SD, SE, and SF are closed
- At least one laser power supply is electrically On
- Annunciator sign at outer door indicates Laser On, requiring PPE to be worn upon entry
- Use of timed interlock bypass is NOT required

**Normal Entry & Exit Procedures under the PERMITTED ACCESS Condition into the NLCTA or Experimental Hall**

The following factual statements and procedures apply to entering the enclosure under PERMITTED ACCESS:

a. Laser Off Entry

   a. Defining condition: Transport Line Stoppers S1E and S2E or S1N and S2N are closed
   b. Outer PPS door is open, the magnalock is not engaged.
   c. Procedure:
      i. Enter under conventional P/A rules.

b. Initiating the Laser Test Mode in Permitted Access

   a. Result: outer door magnalocks on the NLCTA (or Experimental Hall) will engage, locking the doors shut. The Laser On annunciator sign will be illuminated. The Emergency Off buttons will become activated, and will
E163 Laser Safety System Design Document

close Transport Line Stoppers if any E/O is pressed. Bailing from P/A to C/A will be disabled.

b. Procedure:
   i. Ensure no one is inside the enclosure
   ii. Close the outer door(s) to the enclosure (inner gate is neither controlled nor monitored in Laser Test Mode under P/A, and may be braced open or left closed).
   iii. Use key K1 to switch the Laser Test Mode switch on the NLCTA PPS console to SET
   iv. Press the Laser Test Mode Reset button
   v. Record the initiation of Laser Test Mode in the PPS log

c. Cancelling the Laser Test Mode in Permitted Access
   a. Result: Outer door magnalocks will release. Laser On annuciator will be extinguished. E/O buttons will become inactive. Transport Line Stoppers will close if open.
   b. Procedure
      i. Remove the Transport Line Stopper key
      ii. Use K1 key to switch the Laser Test Mode switch on the NLCTA PPS console to CANCEL.
      iii. Brace open the outer door, if desired.
      iv. Return Transport Line Stopper key to Laser Room LSS panel, and set position to REMOTE.
      v. Record the cancellation of Laser Test Mode in the PPS log.

d. Laser On Entry
   a. Result: Transport Line Stoppers will not change state.
   b. Defining condition: Laser Test Mode has been SET.
   c. PPS system is not powering the magnalock on outer door
   d. LSS powers outer door magnalock, locking it
   e. A separate micro-switch (specific to the LSS, not used by the PPS) on the outer door will close Transport Line Stoppers for that enclosure if the door is opened without a Laser Entry Key (designated K1).
   f. Transport Line Stoppers can only be opened locally from within the respective enclosure.
   g. The QLO is responsible for laser safety of all persons inside enclosure.
   h. Procedure
      i. Proceed to the East entrance of the NLCTA (or entrance of the Experimental Hall).
      ii. Use K1 key for timed entry
      iii. Close door within 20 seconds

e. Laser On Exit
   a. Result: Transport Line Stoppers will not change state
   b. Procedure
      i. Proceed to East exit of the NLCTA (or Experimental Hall)
ii. Push timed bypass exit button
iii. Close door within 20 seconds

f. Emergency Entry or Exit
   a. Result: Transport Line Stoppers S1E, S2E, S1N, and S2N will close.
   b. Procedure
      i. Push E/E button at any entrance to make an emergency entry
      ii. Push E/E button at any exit to make an emergency exit

g. Opening Transport Line Stoppers
   a. Result: Transport Line Stoppers will open for the specific enclosure.
   b. Procedure
      i. Set enclosure to Laser Test Mode as described above.
      ii. Enter the Laser Room and set the appropriate Transport Line Stopper keyswitch on the main LSS panel momentarily to INIT, then to LOCAL.
      iii. Remove the Transport Line Stopper key.
      iv. Make a QLO entry (with the K1 key) into the enclosure.
      v. Insert the Transport Line Stopper key in the local Stopper Control Box (NLCTA: South wall near the gun, Exp. Hall: North wall near the experiment) and switch to ENABLE. The key will be captured in this state.

h. Closing Transport Line Stoppers
   a. Result: Transport Line Stoppers will close for the specific enclosure.
   b. Procedure
      i. Switch the Transport Line Stopper key to the OFF position and withdraw the key.
      ii. Restore the key to the main LSS panel in the Laser Room, and set the Transport Line Stopper keyswitch to REMOTE.

i. Recovering from an LSS Boundary Violation in P/A
   a. Result: LSS will be reset following a boundary violation
   b. Procedure
      i. Enter the enclosure (Transport Line Stoppers will automatically close and magnalock will release following a boundary violation in P/A)
      ii. Set Transport Line Stopper keyswitch in Stopper Control Box to OFF and withdraw the key
      iii. Make a QLO entry into the Laser Room
      iv. Insert Transport Line Stopper key in the Transport Line Stopper keyswitch and momentarily set the position to INIT, then back to LOCAL, withdrawing the key
      v. Make a QLO entry into the enclosure
      vi. Re-open the shutter by switching the Transport Line Stopper keyswitch to ENABLE.
Normal Entry & Exit Procedure under CONTROLLED ACCESS Conditions to the Experimental Hall or NLCTA

The following procedural steps will be followed to enter the enclosure under CONTROLLED ACCESS with the Laser On. Under Controlled Access, there is no Laser Test Mode, the outer door magnalock is under PPS control alone. The LSS monitors a microswitch on the outer door, and closes shutters if a non-QLO access is made. The PPS console will not respond to attempts to enable Laser Test Mode under C/A.

j. Laser Off Entry under C/A
   a. Defining condition: Transport Line Stoppers S1E and S2E or S1N and S2N are closed
   b. Outer PPS door is locked and monitored by the PPS system.
   c. Procedure:
      i. Enter under conventional C/A rules.

k. Laser On Entry under C/A
   a. Result: Transport Line Stoppers will not change state.
   b. A separate micro-switch (specific to the LSS, not used by the PPS) on the outer door will close Transport Line Stoppers for that enclosure if the door is opened without a Laser Entry Key (designated K1). Transport Line Stoppers can only be opened locally from within the respective enclosure.
   c. QLO is responsible for laser safety of all persons inside enclosure.
   d. Procedure
      i. Proceed to the East entrance of the NLCTA (or entrance of the Experimental Hall).
      ii. Press intercom button to contact the PPS operator; notify the operator this will be a Laser On entry
      iii. Obtain a Key Bank Key when the key bank is released
      iv. Wait for door release light to flash
      v. Start 20 second (or less) timed bypass with K1 key
      vi. Release door in concert with PPS operator using Key Bank Key
      vii. Close door within 20 seconds

l. Laser On Exit under C/A
   a. Result: Transport Line Stoppers will not change state
   b. Procedure
      i. Proceed to East exit of the NLCTA (or Experimental Hall)
      ii. Press intercom button to contact the PPS operator
      iii. Wait for door release light to flash
      iv. Push timed bypass exit button
      v. Exit and close door within 20 seconds

m. Emergency Entry or Exit under C/A
   a. Result: Transport Line Stoppers S1E, S2E, S1N, and S2N will close.
   b. Procedure
E163 Laser Safety System Design Document

- Push E/E button at any entrance to make an emergency entry
- Push E/E button at any exit to make an emergency exit

n. Opening Transport Line Stoppers under C/A
   a. Result: Transport Line Stoppers will open for the specific enclosure.
   b. Procedure
      i. Enter the Laser Room and set the appropriate Transport Line Stopper keyswitch on the main LSS panel momentarily to INIT, then to LOCAL.
      ii. Remove the Transport Line Stopper key.
      iii. Make a QLO entry (with the K1 key) into the enclosure.
      iv. Insert the Transport Line Stopper key in the local Stopper Control Box (NLCTA: South wall near the gun, Exp. Hall: North wall near the experiment) and switch to ENABLE. The key will be captured in this state.

o. Closing Transport Line Stoppers
   a. Result: Transport Line Stoppers will close for the specific enclosure.
   b. Procedure
      i. Switch the Transport Line Stopper key to the OFF position and withdraw the key.
      ii. Restore the key to the main LSS panel in the Laser Room, and set the Transport Line Stopper keyswitch to REMOTE.

p. Recovering from an LSS Boundary Violation in C/A
   a. Result: LSS will be reset following a boundary violation, permitting Transport Line Stoppers to be re-opened.
   b. Procedure
      i. Make a standard C/A entry.
      ii. Set Transport Line Stopper keyswitch in Stopper Control Box to OFF and withdraw the key.
      iii. Make a standard C/A exit
      iv. Make a QLO entry into the Laser Room
      v. Insert Transport Line Stopper key in the Transport Line Stopper keyswitch and momentarily set the position to INIT, then back to LOCAL, withdrawing the key.
      vi. Make a Laser On under C/A entry as described in section (k) above
      vii. Re-open the shutter by switching the Transport Line Stopper keyswitch to ENABLE.
      viii. Learn from your mistake.

The NO ACCESS state

Under the NO ACCESS state:
Enclosure Laser Shutters (S1E, S2E, and/or S1N, S2N) can be opened remotely for each enclosure that is in the No Access state. Note that the No Access state is the only state under which the Enclosure Laser Shutters may be remotely opened and closed.

Leaving the No Access state for either enclosure automatically closes the corresponding Enclosure Laser Shutters (S1N and S2N if the NLCTA drops out of No Access, S1E and S2E is the Experimental Hall drops out of No Access).
Caption for Figure 2: Sketch of Laser Room showing location of important LSS components, the main LSS control panel, and the Emergency Off buttons.
Caption for Figure 3: Sketch of Experimental Hall showing locations of important LSS components, and the remote Enclosure Laser Shutter control panel. The number, type, and configuration of LSS components for the NLCTA enclosure is essentially identical.
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 regenerative amplifier, the low-power diode alignment laser, and the Cheetah-X Nd:YAG oscillator, respectively.

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- **SE, SF** – spares for future use.

Transport Laser Stoppers – shutters S1E, S2E, S1N, S2N (see figure 2) which block light from entering into the Experimental Area (S1E, S2E) or NLCTA Enclosure (S1N, S2N).

- **S1E** – laser shutter located within the Laser Room, at the point where laser light would exit the Laser Room and enter the Experimental Hall.
- **S2E** – laser shutter located within the Laser Room, at the point where diagnostic light would enter the Laser Room from 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.
- **S2N** – laser shutter located within the Laser Room, at the point where diagnostic light would enter the Laser Room from the NLCTA.

K1 Key (copied) – 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 Shutters (S1N, S2N)
**E163 Laser Safety System Design Document**

**K3 Key** (unique) – (also called “Exp. Hall Transport Line Stopper Key”) used to switch between Local and Remote operation of the Experimental Hall Laser Shutters (S1E, S2E)

**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 Laser is also disabled.

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

**K7 Key** (unique) – used to turn on/off the power supplies for the Cheetah-X laser. The laser will be installed sometime in 2006.

**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 has had the Laser Safety Training Course (CBT Core Course 253), a Laser Eye Examination, and E163-specific training.

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