

# E163

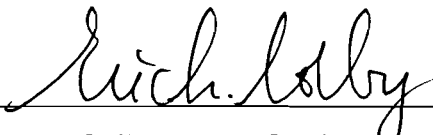
*Laser Acceleration  
at the NLCTA*

May 13, 2005

**Subject:** Laser Safety System (LSS) Design  
Specification for E-163

**Authors:** Eric Colby and Robert Noble

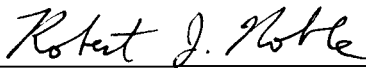
The design specifications for the E-163 Laser Safety System described herein have been reviewed and are approved.



Eric R. Colby, E-163 Spokesman

date:

5/13/05



Robert J. Noble, E-163 Project Manager

date:

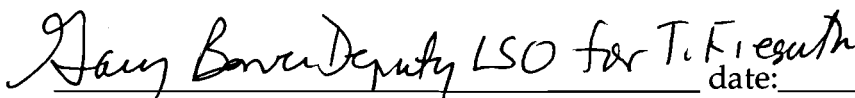
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Robert H. Siemann, E-163 Principal Investigator

date:

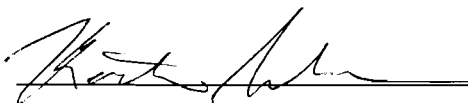
5/13/05

 Deputy LSO for T. Fieguth

Ted H. Fieguth, SLAC Laser Safety Officer

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date:

5/13/2005

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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.

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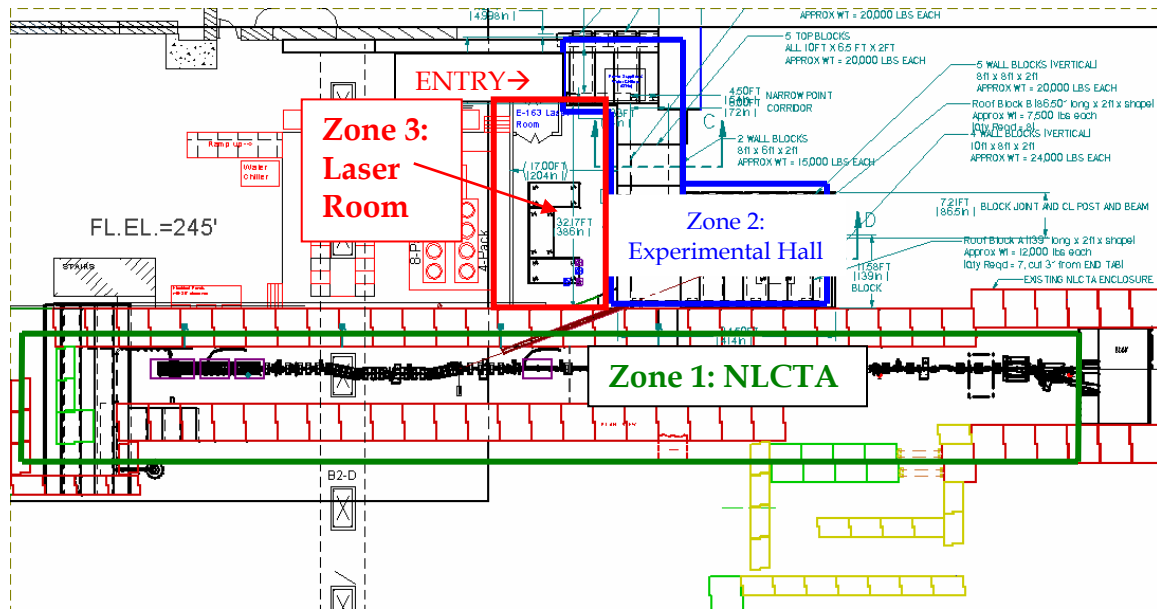


FIGURE 1. PPS zone designations for the NLCTA, Laser Room, and Experimental Hall.

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:

<b>PERMITTED ACCESS</b>	<b>(P/A)</b>
<b>CONTROLLED ACCESS</b>	<b>(C/A)</b>
<b>NO ACCESS</b>	<b>(N/A)</b>

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:

((NLCTA enclosure Search-Reset=Set) AND  
(NLCTA enclosure access state = No Access) AND

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(Radiation warning announcement = Complete))

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:

((Experimental Hall Search-Reset=Set) AND

(Experimental Hall access state = No Access) AND

(Radiation warning announcement = 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

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- 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

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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 annunciator 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)

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- 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 Stoppper 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.

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### 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

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- 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
- 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:

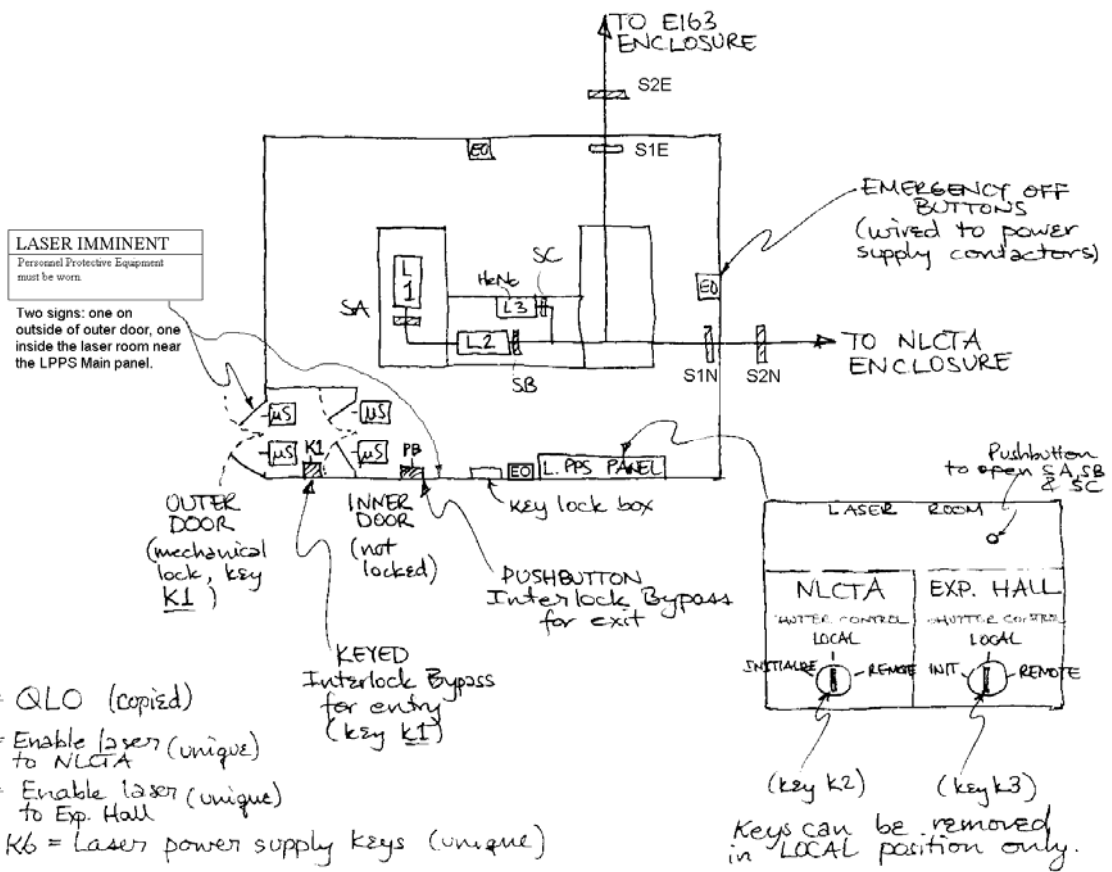
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- Enclosure Laser Shutters (S1E, S2E, and/or S1N, S2N) can be opened remotely for each enclosure that is in the No Access state. Note that the No Access state is the only state under which the Enclosure Laser Shutters may be remotely opened and closed.
- 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 if the Experimental Hall drops out of No Access).

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E. Gilby 1.

E163 LASER ROOM PPS 10/14/03



Caption for Figure 2: Sketch of Laser Room showing location of important LSS components, the main LSS control panel, and the Emergency Off buttons.



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### 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) – 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)

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**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.

**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.