LSOP for CLAS Inner Calorimeter Laser System

1 Environment

The highest level of the space frame in Hall B at Jefferson Lab already contains class IIIb lasers used for calibrating equipment for the CLAS detector. The lasers are used to provide light sources for photomultiplier tubes of the CLAS Time-of-Flight (TOF). The calibration laser box for the Inner Calorimeter will be located in the same area.

The locations of the lasers are shown schematically in Figure 1. This Laser Standard Operating Procedure (LSOP) gives a description of the laser, the hazards present, requirements for personnel and procedures for operation. The schematic of the optical system for the inner calorimeter is shown in Figure 2.

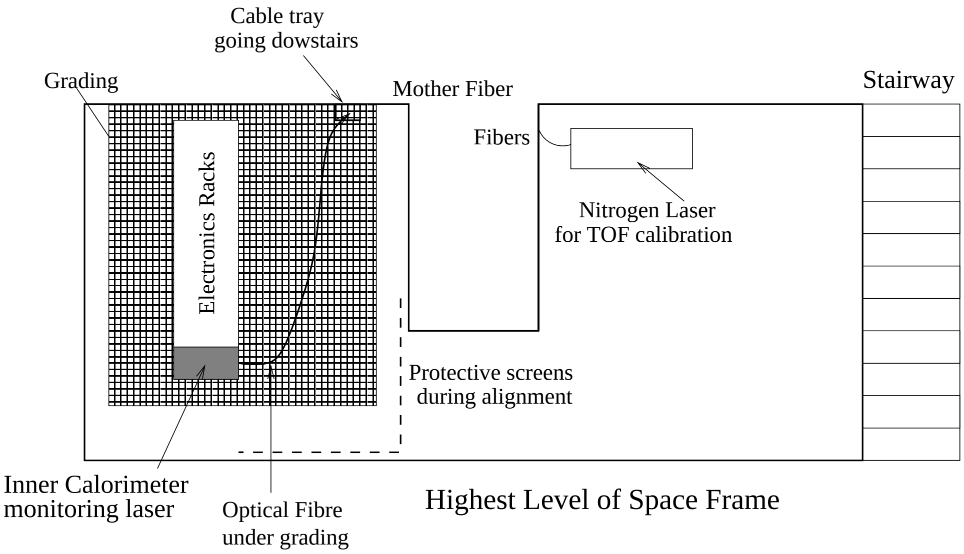

Figure 1: Locations of the inner calorimeter laser in Hall B.

2 Personnel

The laser may only be operated by personnel which have

- Completed a laser safety course administered by the safety officers at JLAB.
- Read the Laser Safety section of the EH&S Manual (6410).
- Read this document.

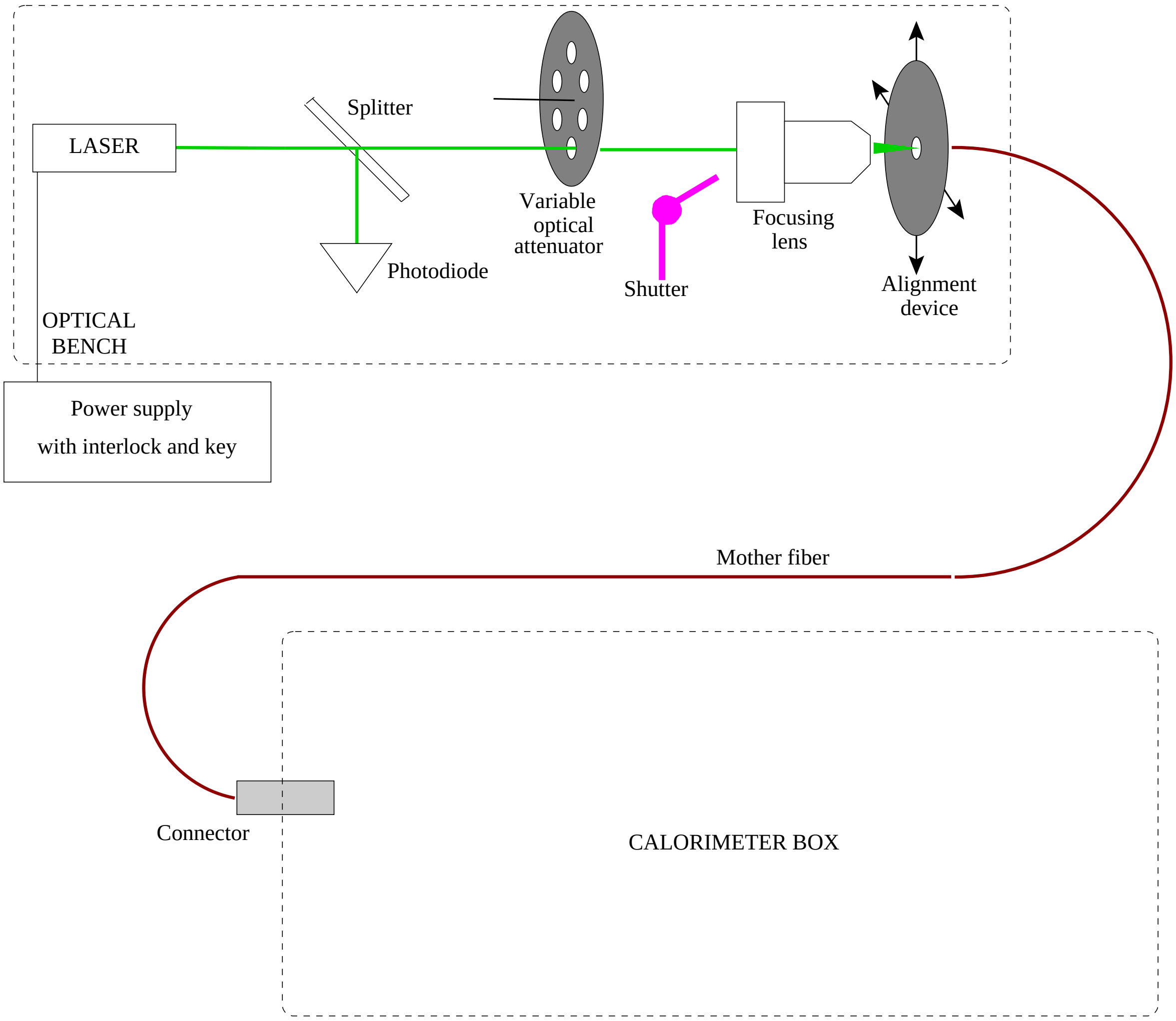

Figure 2: Schematic of optical bench for the inner calorimeter laser system. The whole laser area is enclosed in a metal box. The calorimeter itself sits inside of CLAS.

- Completed and passed an ophthalmological exam which has been reviewed and approved by the JLAB occupational health physician.
- Signed list of authorized operators

JLAB personnel or outside visitors, who have not completed the required training, may only enter the laser control area with permission of the Laser System Supervisor (Elton Smith) or if the laser is setup for calibration in class 1 condition.

3 Laser

The laser itself is not CDRH compliant by itself. However, all requirements for CDRH compliance are met for the laser system. Table 1 lists the characteristics of the Laser used for the monitoring of the Inner Calorimeter.

Table 1: Specifications for NanoGreen laser from Nanolase/JDS Uniphase

Specification	**MGL-MIII406026**
Spectral Output	532 nm
Pulse width (FWHM)	600 ps
Maximum Energy/pulse	2 μJ
Energy Stability	3%
Maximum Average Power	4.0 mW
Maximum Repetition Rate	100 Hz
Beam Profile	TEM_{00}
Beam Divergence (hor x ver, half angle)	2×2 mrad^2
Output Beam Diameter	0.2 mm
Numerical aperture of fiber	0.22
Dimensions	$100 \times 23 \times 31$ mm^3
Weight	250 g

4 Hazards

4.1 Laser Beam Hazards

Class 1 eyesafe laser conditions exist except during alignment procedures. During alignment procedures, the primary beam hazard associated with class IIIb lasers consists of eye injury caused by viewing the beam either directly or by specular reflection. Doubled Nd:Yag lasers at 532 nm have typical risks associated with visible light lasers: retinal burns. Most direct and specular viewing will cause macular burns and can lead to blindness. To minimize the laser beam hazard associated with alignment procedures,

- supplied laser safety goggles must be worn,
- the nominal hazard zone will be controlled with a light barrier. A welding curtain will be used to keep incidental personnel from gaining access to this zone. The welding curtain will be opaque and tested to ensure that the laser light cannot penetrate it.

4.2 Non-beam hazards

The following non-beam hazards exist:

- trip: access to the laser area is through a stairway. Usual caution associated with stairways should be used to avoid trips.
- electric shock: If interlocks are bypassed and voltage is exposed, there is potential for electric shock. No interlocks are to be bypassed, except by qualified service representatives.
- Fire: a portable fire extinguisher is located in the work area.

5 Laser Environment

During normal operation, the laser beam is extracted via a mother optical fiber. These measures prevent unintentional interception of the beam, either directly or by specular reflection. Under special circumstances, detailed below, the laser beam is exposed, and precautionary measures must be taken. The laser light is confined to the shielding box except during alignment. During alignment, the light is confined by using welding curtains around the work area. A danger sign and a cone with a yellow beacon will be posted at the entrance of the nominal hazard zone. Before work begins, personnel should make sure that they have a clear path to an exit.

6 Remote Control and Operation

The laser can be remotely controlled during routine operation by using specifically designed circuits for the laser. The remote function only includes power supply on/off, and can be used to automatically shut down operations in case of emergency. An emission time delay is built into the remote control: the yellow beacon energizes when the laser power is turned on, and lasing is delayed by 10 secondes. Once the laser yellow beacon is energized, goggles must be worn.

7 Procedures

In this section we review the various procedures that are required to operate the laser. Hazards are least likely to occur during normal operation. During maintenance and alignment, the laser box is open and beam and non-beam hazards are present.

When working with the lasers, the personnel must not wear jewelry or clothing which presents a specular reflection hazard. Protective eye wear must be worn with a minimum optical density OD = 1.69 at 532 nm (see Section 8 for details about OD calculations).

7.1 Maintenance and Initial Alignment (Class 3B Conditions)

The techniques for laser alignment listed below will be used to help prevent accidents during alignment of this laser system.

Procedural Considerations

1. To reduce accidental reflections, watches, rings, dangling badges, necklaces, reflective jewelry are taken off before any alignment activities begin. Use of non-reflective tools should be considered.

2. Access to the room/area is limited to authorized personnels. A danger sign as well as a cone with a yellow beacon will be posted at the entrance of the nominal hazard zone. Before work begins, personnel should make sure that they have a clear path to an exit.

3. All equipment and materials needed are present prior to the beginning the alignment.

4. All unnecessary equipment, tools have been removed to minimize the possibility of stray reflections and non-beam accidents.

5. Persons conducting the alignment have completed all necessary trainings, have read this document, passed an eye exam and signed the authorized operators list.

Alignment Methods

1. There shall be no intentional intrabeam viewing with the eye.

2. Choose the filter position giving the minimum output power.

3. Laser Protective Eyewear shall be worn at all times during the alignment, within the parameters detailed in Section 8.

4. Beam Controls- the beam is enclosed as much as practical, the shutter is closed as much as practical during the course of the alignment, optics/optics mount are secured to the table as much as practical, beam stops are secured to the table.

5. Any stray or unused beams are terminated.

6. No intrabeam viewing is allowed unless specifically evaluated and approved by the LSO/DLSO. Intrabeam viewing is to be avoided by using cameras or fluorescent devices.

7. Normal laser hazard controls shall be restored when the alignment is completed. This includes the laser cover, and the mother fiber should be connected back to the calorimeter system so beam part is exposed.

In this case the shielding box is open, the on/off switch is activated. To prevent optical hazards the beam stop should remain closed for this operation except during the initial alignment period. Standard electrical hazard prevention procedures should be followed. To minimize optical hazards, no one will be allowed in the laser control area except trained and qualified personnel who are wearing appropriate safety glasses (see Section 8).

7.2 Inner Calorimeter Calibration (Class 1 Conditions)

The laser beam is focused to a multimode optical fiber, which exits the shielding box. The fiber is directly connected to the Inner Calorimeter which itself sits in the center of CLAS. The laser shall be considered to pose a Class 1 hazard, as no portion of the beam is exposed.

7.3 Controls

- The laser control area will be posted with a danger sign describing the tests being conducted. Figure 1 will also be posted to indicate the laser control area.
- The key which turns the laser on shall be kept separate when the laser is not in use, to avoid unintentionally enabling operation.
- Eyewear is provided and shall be used during maintenance, alignment and any activity which allows viewing of the laser beam.
- No high voltage is present near the laser itself as it only uses 24V DC power.
- Removal of the top access panel is required for servicing and will automatically break the interlock. Any interlock interruption will require the voltage enable switch to be re-engaged to resume operation.
- All controls must and will be checked every 6 months by the LSS using the Laser Safety Chapter Checklist.

8 MPE, OD and nominal hazard zone calculations

The print-out of the computer calculations is included in this LSOP. The following subsections give the important information.

8.1 Maximum Permissible Exposure limit

The maximum permissible exposure limit for this repetitively pulsed laser at 532 nm is 2.11E-04 W/cm^2.

8.2 Minimum required optical density

The optical density requirement for a 100 Hz, 2E-06 J/pulse, 600 ps pulse length 532nm is 1.69. Eyewear with an OD greater than 2 for this laser is available. It exceeds the requirements.

8.3 Nominal Hazard Zone

For direct beam conditions, the nominal hazard zone (NHZ) is 24.5 meters.

When an optical fiber is connected, the NHZ is reduced to 19 cm.

Conditions of use: The fiber will always be connected to the laser during laser operation. The laser will be turned off before removing the fiber. This effectively reduces the NHZ to 8 inches from the fiber output. Therefore, the use of the welding curtain should be more than adequate control of the NHZ. They need to be placed only where accessroutes are available.

9 Authorized Personnel

Table 2 lists personnel who are trained and qualified to operate the lasers in Hall B. No other personnel shall be added to the list without authorization by Elton Smith.

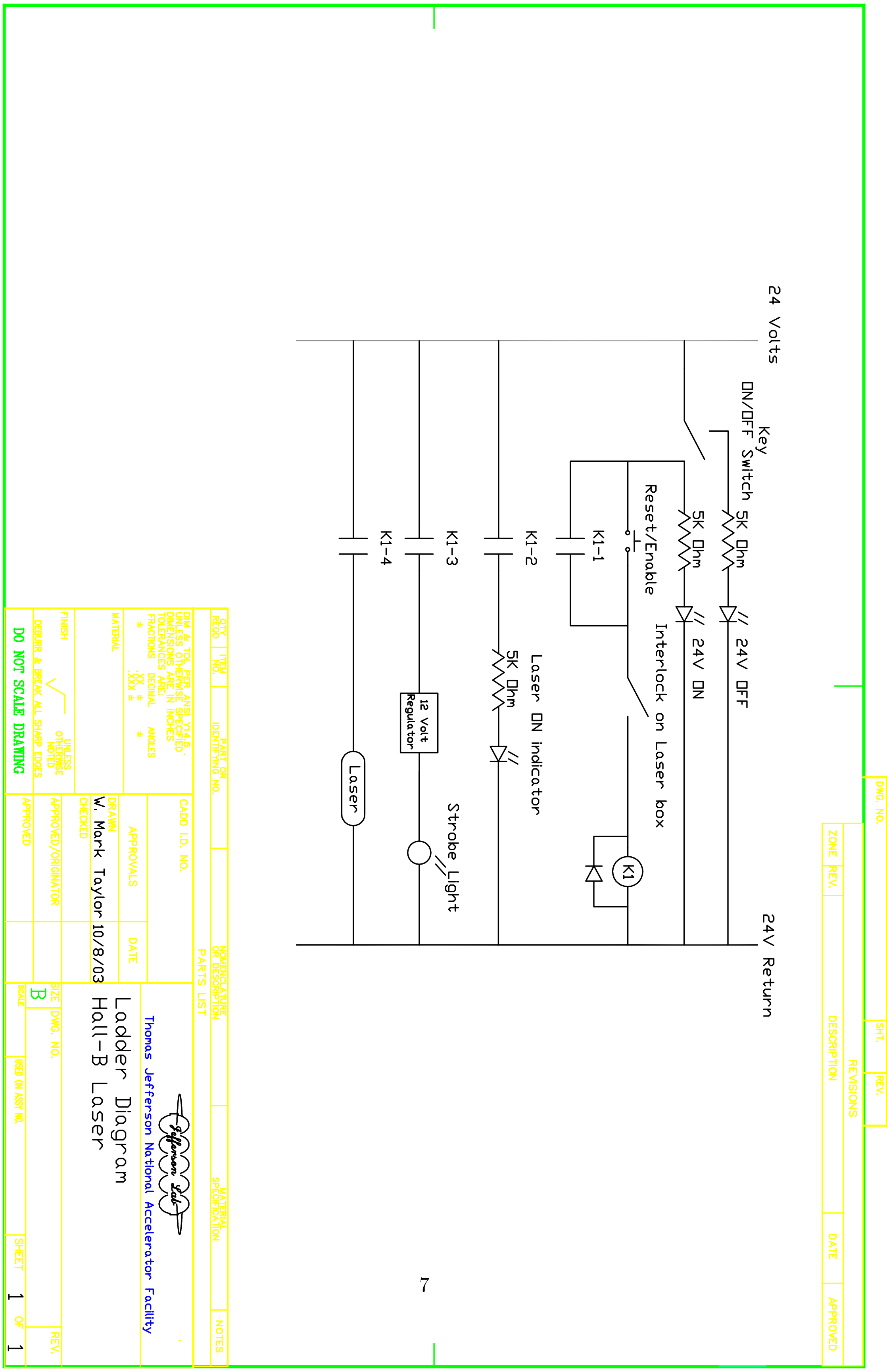

Figure 3: Controls of the inner calorimeter laser, along with interlock system.

Table 2: List of Authorized Personnel. Their signature indicates that they have read and understood the OSP for this laser.

Personnel	**Signature**	**Date**
Franck Sabatié		
Elton Smith		
François-Xavier Girod		