LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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SOP for TCS Prototype Carbon Dioxide Laser

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LIGO Scientific Collaboration

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1 Signature Page

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Caltech Laser Safety Officer

2 Introduction

This document is the Standard Operating Procedure (SOP) for the TCS prototype carbon dioxide lasers at Caltech. The purpose of this document is to ensure the safety of all personnel and equipment in and around the area where the TCS prototype carbon dioxide laser is operating. Its role in the overall laser safety plan is described in LIGO-M960001, LIGO Laser Safety Program. This document replaces the previous SOP for this laser, LIGO-M070109-01-R, to reflect the move of the TCS prototyping activities from rooms 17 and 19 Lauritsen/Downs.

The two TCS prototype carbon dioxide lasers reside in room 058F West Bridge, on the Caltech campus. A diagram of the room with the location of the laser identified is shown in Figure 1. Entrance to the room is through a small 'goggle chamber,' in which goggles are stored and can be put on by personnel before entering further into the room. The entire room beyond the goggle chamber is designated as a Nominal Hazard Zone.

The TCS prototype carbon dioxide laser is a Synrad 48-2 carbon dioxide laser operating at 10.6 μm. It is a Class 4, FIR laser. The output of this laser is in the far infrared region of the electromagnetic spectrum and is therefore not visible to the human eye. At the output aperture, its beam diameter is 3.5 mm and its beam divergence is 4 mrad. Its specified output power is 25 W CW minimum; measurements in the laboratory show this laser to produce 35 W CW maximum.

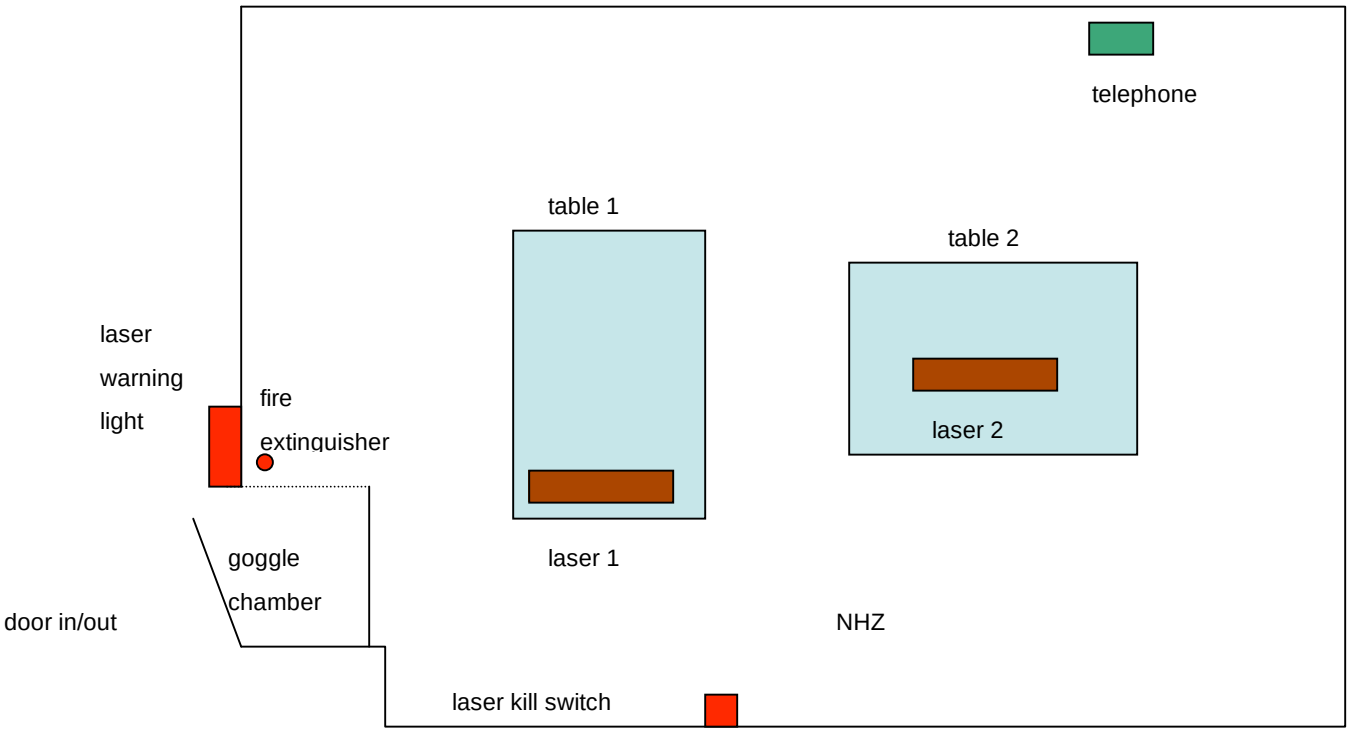

Figure 1: Layout of Room 058F West Bridge.

Normal operation of these lasers as TCS prototypes will always be in CW mode. As built, the lasers are capable of pulsed operation, and in practice this is the most convenient way of reducing the laser power to safer levels during alignment of the TCS optics. The pulses have a repetition rate of 5 kHz and pulse lengths from 0-200 μs. The output power is then 35 W multiplied by the duty cycle of the pulse width modulation.

The LIGO thermal compensation system projects an infrared beam of suitable power and spatial profile onto optics inside the LIGO vacuum system at the sites. The TCS prototype laser beams will generally stay on the TCS prototype laser tables and are used to test techniques of intensity stabilization and spatial profiling. There will be times when it is necessary to project a laser beam over a distance of a few meters to test its spatial profile in the far field. In such cases the beam may be projected between table 1 and table 2. When this is done the beam will travel from table to table within an enclosure.

3 Hazards

A Class 4 laser is a hazard to the eye and skin from the direct beam, and may be a hazard from a diffuse reflection. Far infrared lasers pose an additional hazard because the output radiation is not visible to the unaided eye. This laser is capable of burning skin and is a fire hazard if beams are not properly dumped.

The TCS prototype lasers operate from 30V, 14A power supplies and present the electrical hazard typical of laboratory bench electronics. The lasers could potentially both operate simultaneously. One example of such simultaneous operation would be one laser operating continuously for several hours or days during a long term power drift measurement while the other laser is being tuned for improved spatial profile or used to test infrared components. The beam paths on the tables will change as different aspects of the prototyping are tested. The beam paths will not point directly at the door.

4 Controls

4.1 Access Controls

- An illuminated Laser Safety Warning sign with the message "DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION- AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION" is mounted at the entrance to room 058F West Bridge. It shall be switched on whenever either or both lasers are on.
- A schematic of Room 058F West Bridge showing the location of the TCS prototype carbon dioxide lasers and PMA in Case of Emergency placard identifying contact people are posted near the laser safety warning sign.
- A signed copy of this SOP is posted at the entrance to Room 058F West Bridge.

4.2 Electrical Controls

Each TCS prototype carbon dioxide laser is powered by a power supply that can be switched on and off by means of a switch on its power outlet strip. Additionally, both lasers have safety interlock connectors that are wired to a single 'kill switch' that can shut down both carbon dioxide lasers simultaneously. Each laser has a control key that must be inserted and turned to the 'on' position before the laser will operate. These controls are the same for the two lasers. The Laser Safety Warning sign is not interlocked to the lasers and must be switched on by the responsible laser operator.

4.3 Eye Protection

- Required protective eyewear for the TCS prototype carbon dioxide laser must have an optical density (OD) of greater than 3.4 for 10.6 μm wavelength radiation.
- The laser safety eyewear is never intended for intra-beam viewing. (OD is calculated for intra-beam viewing for 1 minute at the laser aperture diameter.)
- A warning sign with wavelength and eye protection OD requirement is posted in the goggle chamber.

5 General Operating Procedures

- When shutting down a TCS prototype laser after normal operation, first close the laser aperture using the lever at the front of the laser, then switch the laser control key to 'OFF'. Then, de-energize the laser power supply. The procedure above is conducted in reverse to switch on the laser. If there is any uncertainty whether the optics downbeam of the TCS prototype laser are properly aligned, position a firebrick in front of the laser output to collect the beam before opening the laser aperture.
- When either TCS prototype carbon dioxide laser is operating the Laser Warning Sign must be energized and all persons in the Laser Controlled Area are required to wear eye protection as described in Section 3.3 above.
- Prior to powering up either TCS prototype carbon dioxide laser, the Responsible Laser Operator (the person actively in charge of the laser) shall ensure that all persons on the NHZ are aware of his/her intent to power up the laser and that they are in compliance with all laser safety requirements, eye protection in particular.
- Anytime one or more people will be working within the Laser Control Area or the laser will be running unattended, ONE person shall be designated the "Responsible Laser Operator." The name of the Responsible Laser Operator shall be posted near the Laser Controlled Area laser warning sign.
- The Responsible Laser Operator shall coordinate activities on or in the vicinity of the laser optical table. Multiple independent activities involving manipulation of the laser beams from one or both lasers simultaneously shall only occur when the Responsible Laser Operator deems it safe to do so.
- Any time the laser beams will be manipulated, e.g. by inserting, removing, or adjusting optical components, persons not directly participating in the beam manipulation activity will move to a safe location until the activity is completed.
- Before and during insertion or removal of any optical component, the power of all affected laser beams shall be reduced to the lowest working power setting or be blocked upstream by an appropriate device, such as a firebrick.
- All persons manipulating the laser beams, e.g. by placing objects such as mirrors, lenses, power meters, or beam dumps into or near the beam paths, must remove all jewelry such as wrist watches and rings.
- The acrylic barrier around the optical table is not intended to provide positive containment of errant 10.6 micron radiation. If a high power beam is incident on the barrier, it will melt

a hole through the acrylic in less than half a minute. The smell of melted acrylic provides a warning to the operator of the existence of a high power errant beam, and he/she should shut down the laser immediately.

- Immediately after inserting, removing or making significant adjustments to any optical component, the vicinity of the optical table shall be scanned with a suitable beam-finding device (e.g., thermal imaging camera) to ensure that all stray beams are dumped. There is a thermal imaging camera stored in a cabinet in the NHZ.
- Scattering of laser power shall be kept to a minimum at all times by maintaining proper alignment of optics, utilization of beam dumps, and ensuring that optics are securely fastened.
- If it is necessary to project a beam between table 1 and table 2, the space between the two tables shall be barricaded to prevent personnel from entering the vicinity of the beam. The barricades will be clearly marked as to their purpose by the Responsible Laser Operator.
- Each time the laser will left running unattended, the vicinity of the optical table shall be scanned for stray beams immediately prior to vacating the Laser Control Area. The "unattended" status of the laser shall be clearly posted near the name of the Responsible Laser Operator in the goggle chamber.
- If a laser beam is found (reported by any observer) leaving an optical table, except in the specific manner described to project beams between tables 1 and 2 above, both lasers shall be shut down by the Responsible Laser Operator, the incident reported to the LIGO Safety Officer, and the lasers shall remain "off," until start up authorization is received from the LSO and Albert Lazzarini (LIGO Project Deputy Director).

6 Training

Any personnel who will serve as the Responsible Laser Operator for the TCS prototype laser or work on the TCS prototype system while the laser is on shall first receive Basic Laser Safety Training. In addition, they shall be instructed in the use of beam finding and dumping techniques for the TCS prototype laser by Phil Willems or Aidan Brooks. There is no separate class of maintenance or repair personnel for the TCS prototype laser.

7 Responsibilities

The Cognizant Laser System Engineer for the TCS prototype laser is Phil Willems. In an emergency he can be contacted at x3883 during normal business hours or at (626) 437-9879 at other times. The back-up emergency contact is Aidan Brooks. He can be contacted at x2005 during normal business hours or at (626) 200-5961 at other times.

8 Miscellaneous

Any visitors to the NHZ must wear the eye protection mentioned above when the TCS prototype laser is in operation. In case of an accident, shut down the TCS prototype lasers by use of the 'kill switch.'