

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
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SOP	LIGO-M000330-B-L	8/30/01
Standard Operating Procedure IOT/ISC Table Operation in LLO LVEA		
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1 PURPOSE AND SCOPE

This document is a supplemental Standard Operating Procedure (SOP) for Registered Laser Users of LIGO-M990151-L, *SOP: LIGO 10-W Laser for the 4k Interferometer Operating in the LVEA (with Laser Area Enclosure)*, LIGO-M000005-L, *SOP: ISC Table Infrared Alignment Laser Operation in LLO LVEA and Optics Lab* and LIGO-M000324-D, *SOP: Modulated 980 nm RF Detector Test Laser Operating at LLO*. Registered Users of these lasers may need to access the IOT/ISC tables in the LLO Laser and Vacuum Equipment Area (LVEA). This SOP is designed to ensure the safety of all personnel and equipment in and around the area where the 4k Ifo. LIGO 10-W Laser beams exit the vacuum envelope through windows in Hams 1, 3 and 4 in the LVEA (Figure 2). Its role within the overall laser safety plan is described in LIGO-M990148-L, LIGO Livingston Laser Safety Plan.

This SOP contains the essential procedures required for the safe operation of the 4k IOT and ISC tables, and must be approved by both the LIGO Livingston Observatory (LLO) Laser Safety Officer and the LLO Site Safety Officer.

2 LVEA LAYOUT

There is a single LIGO 10-W Laser in the LVEA, for the four-kilometer-long (4k) interferometer. It is located in the LVEA as shown schematically in Figure 1 and is labeled *4k Laser*. The dashed lines denote the locations of the vacuum equipment in the LVEA. This SOP addresses the operation of the 4k IOT and ISC tables shown schematically in Figure 2.

3 LASER DESCRIPTION

The LIGO 10-W Laser is Class IV Nd³⁺:YAG laser. It is a model 126 MOPA laser system manufactured by Lightwave Electronics Corp. The output from this laser is in the near-infrared region of the electromagnetic spectrum and is therefore not visible to the human eye. This laser emits radiation from two apertures: the main output beam and a sample beam. The relevant operating parameters for the LIGO 10-Watt Laser are:

MAIN BEAM

- 1064 nm wavelength
- 12 W max. power output
- continuous wave output
- 6.1 kW/cm² intensity at output aperture

SAMPLE BEAM

- 1064 nm wavelength
- 70 mW max. power output
- continuous wave output
- 36W/cm² intensity at output

4 HAZARDS

A Class IV laser is a hazard to the eye or skin from the direct beam, may be a hazard from a diffuse reflection, and may also be a fire hazard. Infrared lasers such as the LIGO 10-W Laser pose an additional hazard because the output radiation is not visible to the unaided human eye.

After conditioning by the PSL optics, the beam propagates through the IOO optical components mounted on the IOO/PSL Optical Table, then exits through an aperture in the IOO/PSL Optical

Table Enclosure. The beam then propagates through a window in HAM-1 adjacent to the IOO/PSL Optical Table to the IOO optical components mounted inside the vacuum envelope on HAM tables 1 and 2. After conditioning by the IOO in-vacuum optical components, the laser radiation propagates through the Core Optics (COC) optical components, and therefore throughout the entire vacuum enclosure, including the vacuum equipment located in the End-stations. There are nine potentially dangerous output beams from the LIGO 10-W Laser used for interferometer sensing and control. Seven of the output beams exit the vacuum envelope in the LVEA through windows in Hams 1, 3 and 4 (Figure 2) and are indicated in **RED**. The remaining two output beams exit the vacuum equipment through windows in BSCs 4 and 5, one in each End-station.

5 CONTROLS

Controls for operation of this laser shall conform to guidelines provided in ANSI Z136.1 for lasers used without protective housings, in research and development environments, and by highly trained personnel.

5.1. Administrative Controls

For the purpose of laser safety, two conditions have been defined for the LVEA: LASER HAZARD and LASER SAFE.

The LASER HAZARD condition shall exist any time the 4k Ifo. LIGO 10-W Laser is capable of operating and emitting a beam of laser light outside the Laser Area Enclosure in the LVEA.

The LASER SAFE condition shall exist only when a) the 4k Ifo. LIGO 10-W Laser power supply has been locked and tagged out in accordance with LIGO-M990190-L, *LOCKOUT-TAGOUT PROCEDURE* and is therefore incapable of being energized or b) the 4k Ifo. IOO/PSL Optical Table Enclosure Output Aperture is closed and locked and tagged out and the Laser Area Enclosure laser warning sign (see Section 5.2., below) has been energized.

Individual VEAs may be in the LASER SAFE condition when the LVEA is in the LASER HAZARD condition only if a 48 inch diameter gate valve in the beam line between the VEA and the LVEA is in the closed position and locked and tagged out.

5.2. LIGO 10-W Status Controls

The procedure for transitioning to the LASER HAZARD condition is in *Procedure for Transition to the LASER HAZARD Condition* (LIGO-M990152-L). The procedure for transitioning to the LASER SAFE condition is in *Procedure for Transition to the LASER SAFE Condition* (LIGO-M990153-L).

The keyswitches that control the illumination of the laser warning signs are located on the housings of the warning signs. They are switched to the LASER HAZARD position when transitioning to the LASER HAZARD condition.

The power supply for the laser is locked and tagged out in the “off” position or the 4k Ifo. IOO/PSL Optics Table Enclosure Output Aperture Shutter is locked and tagged out in the “closed”

position when transitioning to the LASER SAFE condition. This is described in more detail in the procedures referenced above.

5.3. LIGO 10-W Emergency OFF Switches

Emergency OFF switches are located as follows: one in the control room, one at the entrance to the 4k Ifo. Laser Safety Enclosure, and one near the laser warning sign at the entrance of the LVEA. Activation of any Emergency OFF switch shuts down the laser. Emergency shutdown from the End-stations require communication with the control room via telephone or radio.

5.4. IOT/ISC Table Warning and Access Controls

Two portable laser warning signs will be placed in visible locations on or near the IOT/ISC table under work. The warning signs will be powered from dedicated AC power lines, which are connected to the Emergency OFF switches (see below). The portable laser warning signs are to have a Lock and Tag boot installed by the laser Safety Officer prior to opening the doors of and working within the IOT/ISC tables. The portable laser warning signs will be energized by the LLO Laser Safety Officer or the LLO Site Safety Officer. It is the responsibility of the persons working on the IOT/ISC tables to visually check for proper operation of portable laser warning signs during the course of their work.

5.4.1. Restricted Area

A restricted area (Figure 2) will be created by placing a portable laser partition near the IOT/ISC table under work, and located so as to act as a block should a beam exit the IOT/ISC table enclosure. The area between the IOT/ISC table and the laser partition must be roped off with safety tape, and not used as a passageway. In the case of IOT-1 the laser partition cannot be used because of the adjacency of the LVEA wall. The area between IOT-1 and the LVEA wall will be a Restricted Area whenever IOT-1 is open. Access to this area will be restricted to Registered Laser Users of LIGO-M990151-L, *SOP: LIGO 10-W Laser for the 4k Interferometer Operating in the LVEA (with Laser Area Enclosure)*, LIGO-M000005-L, *SOP: ISC Table Infrared Alignment Laser Operation in LLO LVEA and Optics Lab* and LIGO-M000324-D, *SOP: Modulated 980 nm RF Detector Test Laser Operating at LLO*. The master list of Registered Laser Personnel is found on the LIGO Livingston Observatory Laser Safety website at:

http://www.ligo-la.caltech.edu/laser/registered_laser_personnel.pdf

Only Registered Laser Users are authorized to open, and work upon the IOT/ISC tables.

The safety of the IOT/ISC tables also relies on:

- Enclosure doors which are always locked. The keys are kept in the LLO Control Room.
- A number of physical barriers and beam dumps.
- Training.- Personnel must be a Registered Laser User for LIGO-M990151-L, *SOP: LIGO 10-W Laser for the 4k Interferometer Operating in the LVEA (with Laser Area Enclosure)*, LIGO-M000005-L, *SOP: ISC Table Infrared Alignment Laser Operation in LLO LVEA and Optics Lab* and LIGO-M000324-D, *SOP: Modulated 980 nm RF Detector Test Laser Operating at LLO* in order to work on the IOT/ISC tables.
- A written and approved LLO Work Permit.

- A copy of this SOP is to be on hand when the IOT/ISC table enclosures are open.

5.5. IOT/ISC Table Mechanical Controls

The IOT/ISC tables are provided with safety enclosures. These enclosures consist of a number of panels secured by machine screws, as well as two hinged doors secured with keylocks. The keys to these doors must always be kept in the keycabinet in the Control Room, except when the Registered Laser User removes them to unlock and lock the tables. Normal access to the tables will be by the two keylocked doors.

Connecting the IOT/ISC tables with their adjacent HAMs are rigid aluminum tubes, covered with flexible, lighttight fabric bellows. Within the IOT/ISC tables are physical beam-blocks. These beam-blocks, particularly those backing the upper periscope mirror near eyeheight, must never be removed without an approved LLO Work Permit and a waiver from the LLO Laser Safety Officer or the LLO Site Safety Officer. Likewise, the panels secured by machine screws must not be removed without an approved LLO work permit and a waiver from the LLO Laser Safety Officer or the LLO Site Safety Officer. The Responsible Operator (Section 7) must see to it that the enclosure doors are shut when work is not being actively performed on the table, and that the doors are locked when the tables are unattended.

5.6. Eye Protection

Required protective eyewear for work within the IOT/ISC enclosures must be **LASER SAFETY GLASSES**, and have an optical density (OD) of greater than 5.0 for 1064 nm wavelength radiation. Particular care must be taken to ensure that the **sideshields of the laser glasses are properly fitted to your face**. Plastic protective eyewear is designed for protection from diffuse scattered radiation, and does not provide sufficient protection to direct exposure of the LIGO 10-W beam. The output beams of the LIGO 10-W laser exit the vacuum envelope into the interior IOT/ISC table enclosures at **eye level** and extreme caution must be exercised by Registered Laser Users working in the table enclosures.

6 GENERAL WORKING GUIDELINES

To the maximum extent practicable, persons working in the IOT/ISC Table Enclosures should strive to reduce the possibility of particulate or hydrocarbon contamination introduced by themselves, their clothes, or items that they transport into area

6.1. Portable Clean Room Enclosures

An ISC Portable Clean Room Enclosure (Green) has been provided and must be placed over the IOT/ISC tables whenever the doors of the table enclosure are open. The fans for the HEPA filters in the Portable Clean Room Enclosures are to be running whenever practicable. *Frock*, *Bouffant Cap*, and *Overshoe Covers* are required at all times. *Facemask* and *UHV Gloves* are required when handling contamination-sensitive components, particularly optics.

7 OPERATING PROCEDURES

1. A current LLO Work Permit must be obtained.
2. The PSL power into the mode cleaner must first be reduced to less than 100 mW.
3. The motorized waveplate on the PSL table (volume control) must be unplugged from its controller using the RJ-12 connector, and the cable locked and tagged.
4. A restricted area (Figure 2) will be created by placing a portable laser partition near the IOT/ISC table and located so as to act as a block should a beam exit the IOT/ISC table enclosure. The area between the IOT/ISC table and the laser partition will be roped off with safety tape, and not used as a passageway.
5. In the case of IOT-1 the laser partition cannot be used because of the adjacency of the LVEA wall. The area between IOT-1 and the LVEA wall is a Restricted Area whenever IOT-1 is open and must be roped off with safety tape. It must not be used as a passageway.
6. Upon opening a IOT/ISC Laser Table Enclosure, the Responsible Laser Operator must scan the optical table and enclosure with an infrared viewer or other suitable beam-finding device for stray beams.
7. Any time one or more people will be working within an IOT/ISC Laser Table Enclosure, ONE person shall be designated the “Responsible Operator.”
8. The “Responsible Operator” shall coordinate activities on or in the vicinity of the IOT/ISC Laser Table. Multiple independent activities involving manipulation of the laser beams shall not occur simultaneously. 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.
9. All persons manipulating the laser beams, e.g., by placing objects such as mirrors, lenses, power meters, or beam dumps, into or near the laser beam paths, must remove all jewelry such as wrist watches and rings.
10. Immediately after inserting, removing, or making significant adjustments to any optical component, the IOT/ISC optical table and enclosure shall be scanned with an infrared viewer or other suitable beam-finding device to ensure that all stray beams are dumped.
11. Scattering of laser light 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.
12. Temporary and diagnostic devices, e.g. quad-cells and power meters must be securely fastened to the optical table. Special care must be taken to secure power and signal cables to the table so that they do not interfere with the beampath. Cables MUST NOT be routed so that the enclosure doors cannot be closed and locked. Cable passthroughs are provided on both sides of each enclosure.
13. Upon completion of the work the IOT/ISC Laser Table enclosure will be locked and the key returned to the Control Room.
14. In the case of extended work (commissioning) the enclosure must be kept closed and locked as much as is practicable.
15. The enclosure must always be locked when unattended.

It is the responsibility of each person working within the LVEA and VEAs (NHZ) to ensure that LIGO standards for safe laser operation are being followed at all times

APPENDIX 1 APPLICABLE DOCUMENTS

ANSI Z136.1-1986, *American National Standard for the Safe Use of Lasers*
American National Standards Institute (1986)

LIGO-M960001-P, *LIGO Laser Safety Program.*

LIGO-M990148-L, *LIGO Livingston Laser Safety Plan.*

LIGO-M990151-L, *SOP LIGO 10-W Laser Operating in the LVEA*

LIGO-M990152-L, *Procedure for Transition to the LASER HAZARD Condition*

LIGO-M990153-L, *Procedure for Transition to the LASER SAFE Condition*

LIGO-M000005-L *SOP: ISC Table Infrared Alignment Laser Operation in LLO LVEA and Optics Lab*

LIGO-M000324-D, *SOP Modulated 980 nm RF Detector Test Laser Operating at LLO*

LIGO-Dxxxxxx-D, *ISC Layout Drawing, Corner Station, Livingston Site*

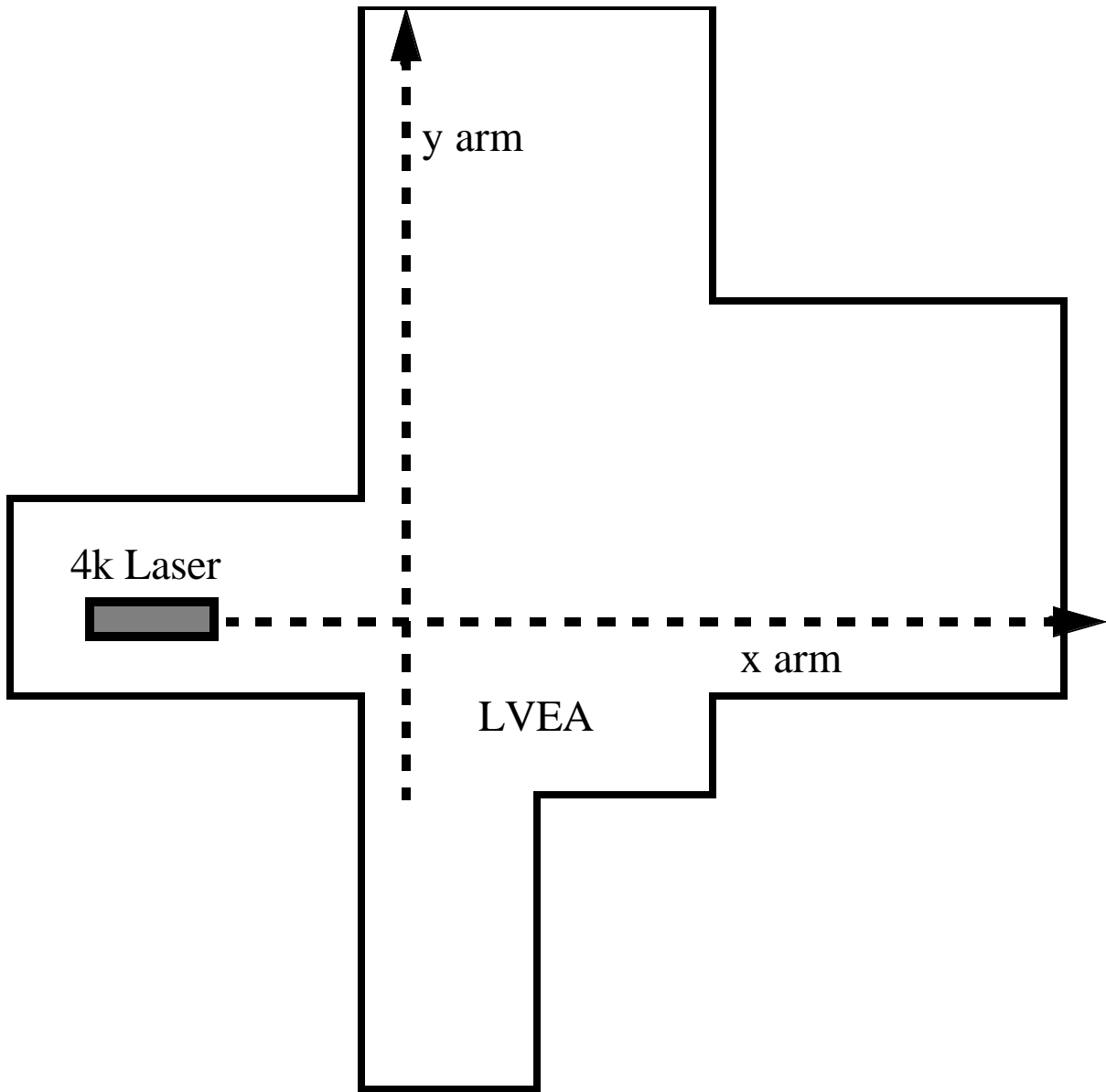


Figure 1: Layout of the laser and vacuum equipment area (LVEA) showing the location of the LIGO 10-W laser

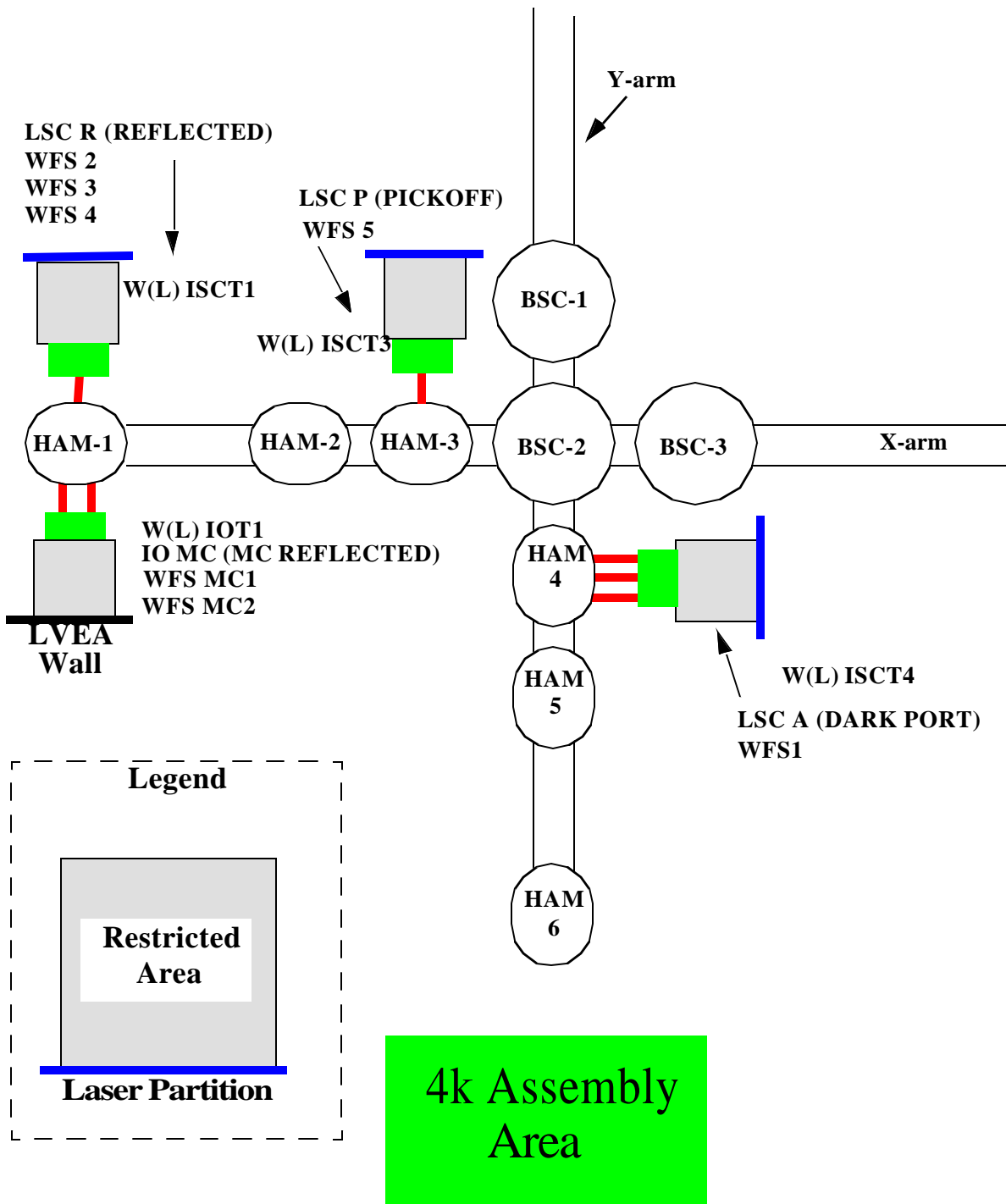


Figure 2: Seven output beams exiting the vacuum envelope shown in **RED**.
 Three from HAM-1, one from HAM-3 and three from HAM-4