LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Procedure	**LIGO-M1100040-v7**	**22 August 2012**

SOP for Arm Length Stabilisation Setup in LVEA (East Bay) and VEA at LHO

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1 PURPOSE AND SCOPE

This document is the Standard Operating Procedure governing the operation of the ISC Arm Length Stabilisation laser at LHO during the initial setup in the LVEA East Bay and during their operation in the VEAs. This SOP is designed to ensure the safety of all personnel and equipment in and around the experiment while it is operating. Its role falls within the overall laser safety plan is described in LIGO-M960001, LIGO Laser Safety Plan.

In addition, the post eLIGO squeezer will be sharing the same space during testing. Further detail with regards to the squeezer SOP can be found in LIGO-M1200008.

2 LHO LVEA LAYOUT

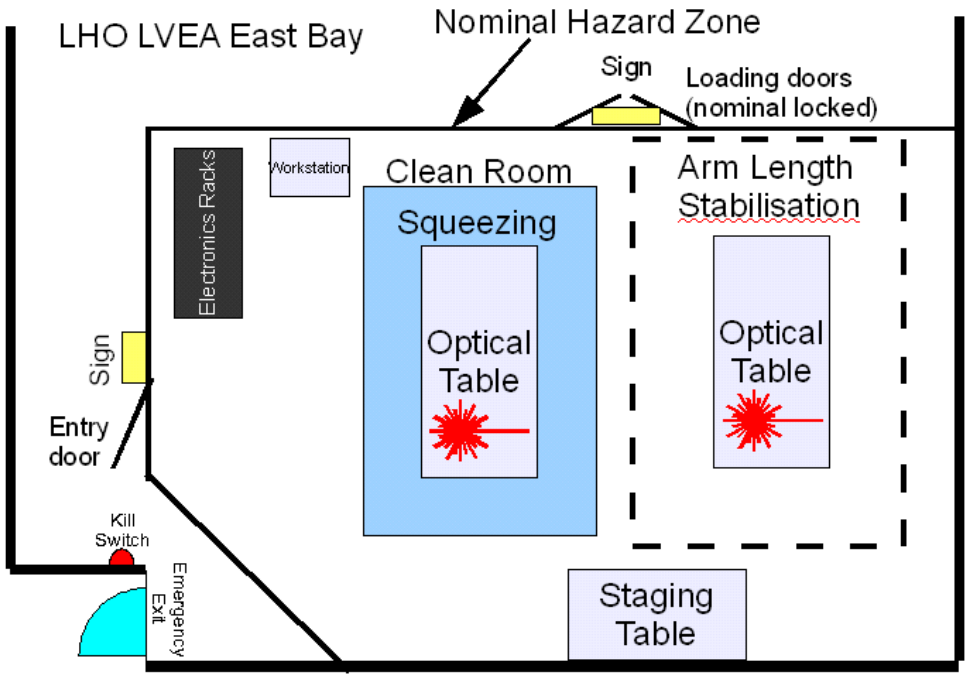

Figure 1: Nominal Hazard Zone in the East Bay of the LVEA at Hanford. The Arm Length Stabilisation area is on the right of the squeezer.

The ALS optical table (ISCTEY) will be located next to the squeezer experiment in the East Bay of the LVEA, as shown in figure 1. The ISCTEY is a 8'x4' optical table with an enclosure mounted on top of the table. The nominal hazard zone (NHZ) is an area approximately 14' x 14' in the East Bay, with modular walls of aluminum and sheet rock separating it from the LVEA at large. Entrance/egress to the NHZ is through a single door on the south side of the enclosure. Double doors on the west side will be locked and left closed except when heavy equipment is to be moved and the lasers deactivated.

When completed, ALS optics tables will be moved from this location to their respective locations in the end-station VEAs.

2.1 LHO End Station VEA LAYOUT

The ISCTEY1/2 and ISCTEX1/2 tables will have the final location next to the BSCs in the end-station, as shown in figure 2. The tables will have their own enclosure isolating the tables from air current and other disturbances. In addition it will prevent any unintentional laser light from leaving the table. A HEPA filter unit is mounted on top of the enclosure and will provide an overpressure on the table when working on the table is required.

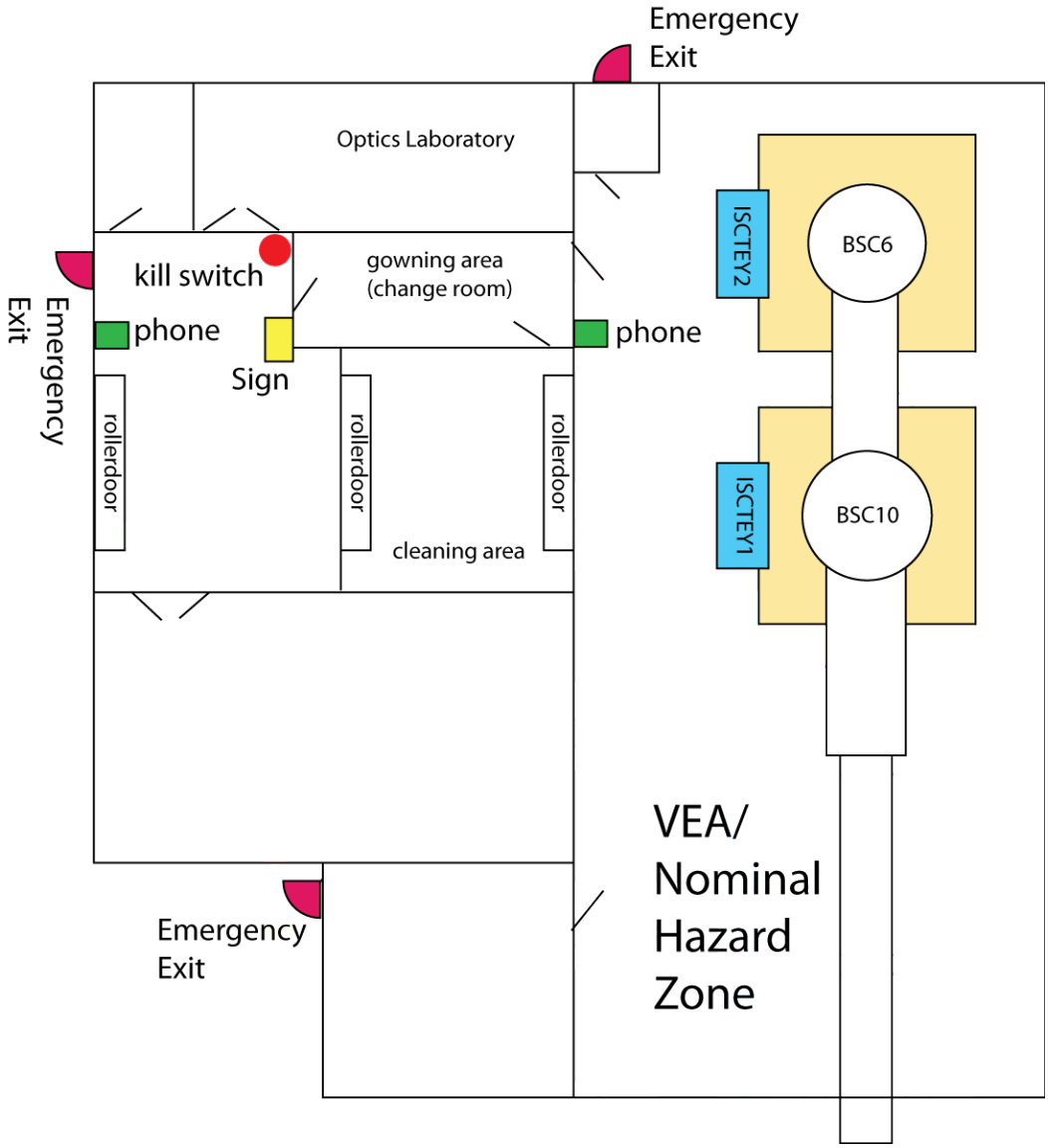

Figure 2: LHO Y-End Station layout (D960260-02/D0901467), illustrating the locations of the ISCTEY1/2 tables, kill-switch, emergency exits, phones and the nominal hazard zone.

The green laser beam will be directed into the vacuum via a viewport, as shown in figure 3. In addition an optical fiber from the PSL will be directed on to the table (via a patch panel mounted into the table enclosure).

Even with the enclosure mounted on top of the table, during normal laser operations the VEA will be a nominal hazard zone. The entrance to the NHZ will be through the gowning (change room) area, through which access is controlled by a card access system.

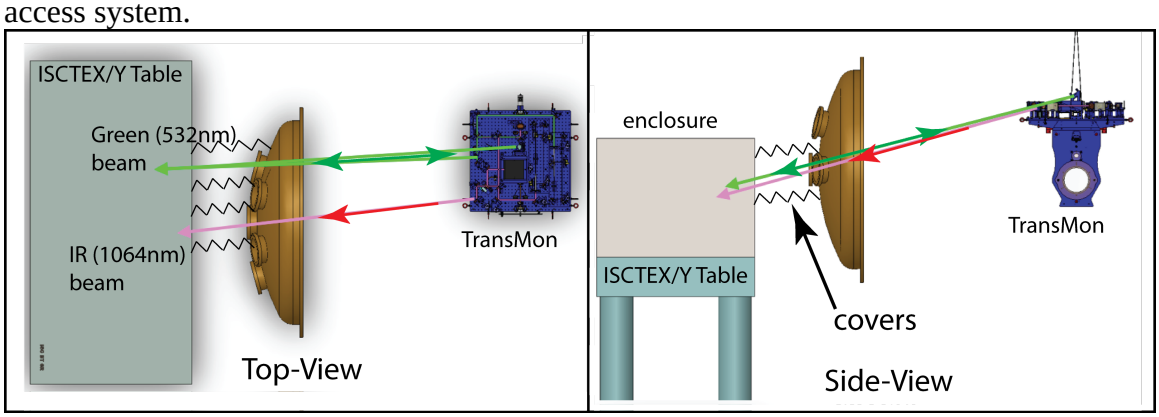

Figure 3: Layout of the interface between the ISCTEY/X and the vacuum (Transmon). The ISC table will be fully enclosed, with no beams exiting the enclosure other then through the viewports (with light covers) as indicated in the figure. Note that this beam is at eye height, although fully enclosed.

When the VEA is in laser hazard and the roll-up door is opened, that area becomes laser hazard as well until the door is again closed.

3 LASER DESCRIPTIONS AND LOCATIONS

The setup includes an InnoLight Prometheus 50NE, located on the ISCTEX/Y tables. Which will produce Class 3B 50 mW of doubled Nd:YAG at 532 nm (visible), and Class 4 1.5 W of ND;YAG at 1064 nm (infrared), making the area a Class 4 laser hazard.

Laser will be located inside NHZ as shown in section 2. Light will not leave the NHZ.

A fiber optic line running from the reference cavity in the OSB optics lab to the optical table within the NHZ will transmit less than 2 mW of 1064 nm light (see T1000555, section 3), making it a Class 3R hazard and not requiring regulation in this document. It is potentially hazardous to the eye only under intentional intra-beam exposure.

4 HAZARDS

Class 3B lasers are hazards to the eye via direct exposure and/or specular reflection. The 532 nm light benefits some from being visible and thus more easily detected by the human eye, triggering an aversion response.

Class 4 lasers are hazards to the eye via direct exposure, specular reflection, and potentially diffuse reflection. Class 4 lasers are also capable of burning skin and causing fires if not properly controlled and dumped. The 1064 nm light poses an additional hazard as it is infrared and not visible to the unaided human eye.

The Prometheus laser emits simultaneously and continuously both 532nm and 1064nm wavelength during operations.

5 CONTROLS

5.1 Access Controls

In the LVEA: NHZ is allowed to operate in laser hazard while the rest of the LVEA is in laser safe. NHZ is accessed through one of two doors ("entry door") in modular aluminum walls. The other door ("loading door") is locked while NHZ is in laser hazard. There are lighted signs above both of the doors.

In the End stations: The VEA has an Entry and Exit proximity reader installed and is part of the Access System. There is a laser hazard sign by the entry door. The Entry reader unlatches the entry door to allow access to the Laser Control Area. The Changing Room and the entire VEA is part of the Laser Control Area and is considered to be NHZ. Access controls, alarms and all transactions for this area are recorded and monitored in the Control Room.

5.2 Electrical Controls

In the LVEA: The lasers will be plugged into the LVEA laser kill circuit via twist lock outlet, and in the event of an emergency may be deactivated by one of the 'emergency kill' buttons located around the LVEA and in the control room. The laser will be otherwise strictly locally controlled from within the NHZ.

In the End stations: The lasers will be plugged into the VEA laser kill circuit via twist lock outlet, and may be deactivated by one of the `emergency kill' button located around the end-station VEA.

5.3 Eye Protection

*Required protective eyewear for the LHO LVEA NHZ will have an optical density of **2.9 at 1064 nm** (1.5 W) and **3.0 at 532 nm** (330 mW). For LHO and LLO VEA NHZs, the requirement is **2.9 at 1064nm** (1.5 W) and **2.1 at 532nm** (50 mW). These values may be revised when other operating lasers occupy the NHZ.* This eyewear is ***never*** intended for intra-beam viewing. (OD is calculated for intra-beam exposure of 0.25s for visible and 10s for IR at laser aperture diameter.) This type of eyewear is new for LHO and LLO, and **laser glasses previously used in the LVEA/VEA during normal operation are not adequate for this setup**. Appropriate laser glasses are available at the entrance of the NHZ.

6 GENERAL OPERATING PROCEDURES

1. When any of the ALS setup laser sources are capable of being energized (power is being supplied), the laser warning sign must read "LASER HAZARD", and all persons entering the NHZ are required to wear protective eye wear as described in section 5.3 above.
2. Prior to powering up the laser, the Responsible Laser Operator (RLO, the person actively in charge of the laser) shall ensure that all persons in 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.
3. When work is required in the ALS NHZ, the RLO is the person who activates the laser(s). If they are already activated on entering, those present should decide who will assume the role of RLO.
4. The RLO shall coordinate activities on or in the vicinity of the laser optical table. Multiple independent activities involving manipulation of the laser beams shall only occur simultaneously when the RLO deems it safe to do so.

5. On conclusion of work with the lasers active, the table itself will either be fully enclosed or the lasers deactivated. The lasers will not be allowed to run uncovered and unattended.
6. All eyewear must be compatible for all laser systems running concurrently. When in doubt, check with the Laser Safety Officer. When multiple lasers are being used, the governing SOP must consider safety compatibility.
7. Any times 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.
8. 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 ceramic wand.
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 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 optical table shall be scanned with a thermal imaging camera 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. If a laser beam with power in excess of 2 mW is found (reported by any observer) leaving the optics table, the laser will be shut down by the LSO and will remain OFF, until start up authorization is received.

It is the responsibility of each person with within and in the vicinity of the NHZ to ensure that LIGO standards for safe laser operation are being followed at all times.