LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Laser SOP	**LIGO-M14000-06-v1**	Date: 2014/01/13

SOP for LLO PRC Probe Laser

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Change Log

Version	Author	Date	Summary of Changes
v1	Chris Mueller, David Kinzel	Jan 13, 2014	Original

Table 1: Change Log

Preface

Table of Documentation Hierarchy

Tier 1 = M950046 (LIGO Laboratory System Safety Plan)
Tier 2 = M960001 (LIGO Laser Safety Program)
Tier 3 = M1000228 (LLO Laser Safety Plan)(Site specific)
Tier 4 = Site-specific, laser-specific SOPs, FMEAs, and special procedures
Tier 5 = Operating, user, or other technical manuals from the manufacturer.
Tier 6 = Wiki entries instructing operators "how-to".

This document is for individuals who wish to operate the LLO PRC Probe laser which will be located on IOT2R. It describes how to safely operate the laser for use in making characterization measurements of the LLO power recycling cavity.

This is not a substitute for operating manuals or for one-on-one training. Standard operating procedures (SOPs) are site-specific, and equipment specific documents which fall under the jurisdiction of the site laser safety officer. Candidate laser operators must read and understand all site-specific laser safety plans as well as laser-specific SOPs. Candidate laser operators must understand that reading this documentation is necessary, but does not automatically qualify personnel to work on this laser equipment. neither does it clear anyone to operate identical hardware at any other LIGO facility.

1 Introduction

This document is the Standard Operating Procedure governing the operation of the PRC probe laser which will be used intermittently to characterize the higher order mode spacing of the power recycling cavity. 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.

The PRC probe laser can be found on IOT2R, the small optics table next to HAM 2, which is within the Large Vacuum Equipment Area (LVEA) nominal hazard zone. It is a class 3B infrared laser produced by Lightwave corporation with model number: M126N-1064-200. This laser is capable of producing 250 mW of light at 1064 nm, which is identical to the wavelength of the pre-stabilized laser (PSL). This beam will be injected into the vacuum system and will be used to probe the power recycling cavity for the purposes of characterization and commissioning. The 1064 nm infrared radiation is not visible without infrared viewing equipment such as IR cards and viewers.

An image of the laser head and power supply can be seen in figures 1 and 2. The power supply provides the laser head with electrical power and monitors/controls the basic performance parameters. A key switch on the front panel turns the power on and off and the standby button is pressed to control whether or not the laser is emitting light. A single LED on the front panel above the key indicates whether or not the key is switched on, and the LCD screen reads standby if the laser is not emitting light. The full parameters of the laser

can be found in the manual which is available online at the JDSU website (they purchased Lightwave), but the key parameters are listed in table 2.

Figure 1: The Lightwave 126 laser head set up in the LLO optics lab.

Figure 2: The Lightwave 126 power supply and controller.

Parameter	Value
Laser Type	Diode Pumped ND:YAG
Class	3B
Serial Number	7639
Emission Center Wavelength	1064 nm
Emission Repetition Rate	Continuous Wave
Emission Waist (Minimum)	0.38 mm
Waist Location	5 cm Outside Housing
Beam Divergence	4 mrad
Polarization	300:1 Vertical
Maximum Power Output	250 mW
Interlocked	Jumper on Power Supply
Authorized Locations	LVEA

Table 2: Laser Parameters

2 Hazards

- This laser is a class 3B laser product. Its near infrared radiation is considered hazardous to the eyes and skin. Unprotected eye exposure to the direct beam or specular radiation can lead to instant blindness
- Unprotected exposure to concentrated 250 mW radiation can lead to skin burns.
- A 110 VAC shock hazard exists if the power supplies are opened for repairs, modification, or diagnostics.
- A fire hazard is present when direct focused laser light falls onto non-fire resistant articles in the beamline.

2.1 Nominal Laser Hazard Zone

The nominal laser hazard zone for the PRC probe laser is the same as the that of the PSL whose SOP can be found at document M1100038. For reference the hazard zone and location of the laser are shown in figure 3

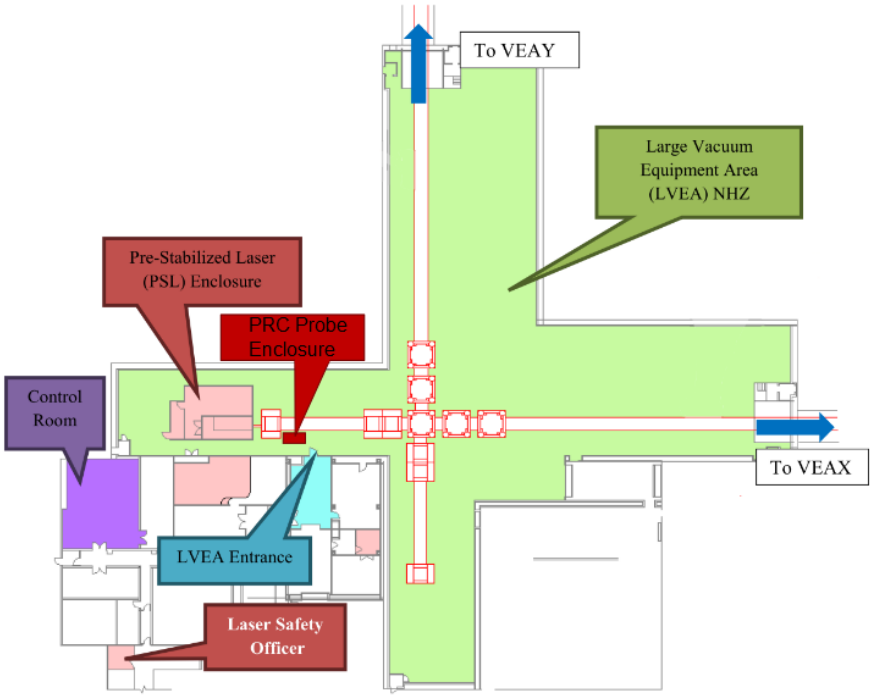

Figure 3: The nominal hazard zone and laser location are shown.

3 Controls

3.1 Access and Administrative Controls

Access to the PRC probe laser in the LVEA is controlled to ensure site personnel safety. Access to the LVEA is restricted to qualified laser operators only. These individuals gain access to these NHZs by individualized key cards and key card readers found at the entrance of the LVEA (see figure 3). Unauthorized visitors must be escorted by a qualified laser operator. Also, all operations in the LVEA must follow LIGO work permit procedures. A lighted warning sign in located at the entrance to the LVEA NHZ and indicates either a "Laser Hazard" or "Laser Safe" condition.

3.2 Physical Controls: Exposure Control

A manual shutter exists at the aperture of the laser head. This shutter can be closed at any power without risk to hardware or personnel. Beam dumps are provided in the optics lab

and may be installed around the laser as required. Lab provided clean smocks and gloves provide a limited degree of skin protection to the Lightwave's radiation.

3.3 Physical Controls: Electrical Controls

A hardware activation key on the power supply controls can turn on the device and arm the laser head. In all circumstances, this hardware activation key can shut down the laser. This key will be stored in the control room key safe when the laser is not in use to ensure that unexperienced operators can not arm the laser. There is also a jumper on the back of the power supply that can be used for the interlock.

3.4 Eye Protection

All personnel working in the LVEA NHZ while the laser is capable of being or is energized will wear protective laser safety eyewear whose optical density is specified in table 3. Laser safety eyewear can be found next to the entrance to the LVEA. Note that the maximum output power of this laser is 500 times lower than that of the PSL laser, and is at the same wavelength. This ensures that anyone complying with the eyewear policy of the LVEA NHZ is automatically in compliance with this SOP.

Wavelength (nm)	Maximum Laser Power (mW)	Minimum O.D.
1064	250	3.0

Table 3: Laser eyewear specifications.

4 Operating Procedures

4.1 Responsible Laser Operator

The responsible laser operator (RLO) coordinates tasks and informs the on-duty control room operator when work is started and completed for the PRC probe laser. The responsible laser operator is designated to be the person who removes the laser key from the laser key safe.

Access to the LVEA NHZ is handled by key card access and monitored by the status panels that are located in the control room. These panels show whether or not the NHZ is in a "Laser Hazard" or "Laser Safe" condition.

The PRC probe laser is used for short term experiments (hour timescales) with attended operation at all times, either from the control room or the LVEA. It is the responsibility of the RLO to ensure that the PRC probe laser is turned off and the key returned to the key safe before leaving the site.

4.2 Start-up Procedures

Only qualified laser operators are permitted to activate the PRC probe laser. Access cards must be used to enter the NHZ. The LVEA must be in laser hazard condition and the nominal hazard zone established before a laser may be activated.

1. Ensure that the LVEA is in the laser hazard condition as outlined in the LLO laser safety plan.
2. Make an aLog entry indicating that the PRC probe laser will be energized.
3. Retrieve the key from the control room key safe.
4. Use the key to energize the laser controller/power supply.
5. Press the standby button to instruct the laser to begin lazing.
6. Open the shutter for light as needed.

NOTE: If a laser beam with power in excess of 2 mW is found (reported by any observer), leaving the light source in an unauthorized trajectory, the PRC probe 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 working within the NHZ to ensure that LIGO and ANSI Z136.1 standards for safe laser operation are being followed at all times.

4.3 Shut-down Procedures

1. Close the laser shutter.
2. Press the standby button to have the laser cease lazing.
3. Turn the key to the "Off" position and remove it.

4. Return the key to the control room key safe.

5. Make an aLog entry indicating that the PRC probe laser is now in a safe condition.

5 Training

LIGO basic laser safety training must be completed before any individual can work around any class 3B and/or class 4 laser emission. Access to the PRC probe laser is only on an "as needed" basis for qualified laser operators. To become a qualified laser operator, an individual must complete the following requirements.

- Received LIGO basic laser safety training.
- Have a full understanding of this SOP.
- Understand emergency and safety procedures.
- Received authorization from the LIGO Livingston laser safety officer.

NOTE: Training on any specific laser system does not automatically qualify individuals for other lasers at the LIGO facilities and associated university labs.

6 Responsibilities

- **Each person** working within the LVEA NHZ is responsible for ensuring that safe laser practices are being followed at all times.
- The responsible laser operator is responsible for conducting tasks on a specific laser system in accordance with the prescribed control measures and in compliance with this SOP.
- The responsible laser operator is responsible for informing any and all assisting personnel regarding the control measures and SOP for the specific laser system.
- The responsible laser operator shall be responsible for any communications with other site personnel regarding changes in the operational status of the specific laser system.
- In case of safety incidents, contact the immediate personnel and (if necessary) emergency medical services as soon as possible.
- Any identified flaws in procedures or potential improvements that could enhance safety should be brought to the attention of the LLO laser safety officer or cognizant laser personnel.

7 References

- American National Standard for Safe Use of Lasers, ANSI Z136.1-2007 Laser Institute of America, ISBN 0-912035-65-X
- LIGO-M950046 (LIGO Laboratory System Safety Plan)
- LIGO-M960001 (LIGO Laser Safety Program)
- LIGO-M1000228 (LLO Laser Safety Plan)
- LIGO-M0900241 (Laser Safety Training for Certification and Recertification of LIGO Personnel)
- LIGO-M080368 (LLO NHZ Transition Procedures)
- LIGO-G0901007 (LIGO Basic Laser Safety Training Presentation)
- LIGO-G1000017 (LLO Addendum to Basic Laser Safety Training)