LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO-T070105-00-W *Enhanced LIGO* 05/08/07

Revised 5/18/07

eLigo and AdvLigo PSL Pump Diode Room Design Requirements and Conceptual Design

Rick Savage, Anamaria Effler

Distribution of this document:
LIGO Science Collaboration

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW17-161
175 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

1 Introduction

The purpose of this note is to describe the requirements and a strawman design for the new rooms that will contain the pump laser diodes, including power supplies and thermo-electric coolers, for the 35W enhanced Ligos laser and for the 200W Advanced Ligo lasers.

The requirements and design were developed during several telecons of the Advanced LIGO PSL working group and a meeting at LLO in March 2007. This document is intended to serve as a framework for more detailed design work that will be carried out at each site in response to local building practices.

2 Requirements

2.1 Room Location

In order to preserve the high-bay space in the LVEA and because the fiber optic coupling facilitates remote location of the laser diode room, it is to be located outside the LVEA high-bay area (from SYS).

2.2 Room Size

For each interferometer, the PSL pump laser diodes, including fiber couplers, power supplies, and thermo-electric coolers will occupy two standard 19”-wide, full-height equipment racks (approximately 24” wide x 31.5 deep, x 79” high). Thus there will be four racks at LHO and two at LLO. The racks require access both in front and behind. A portable HEPA filtered flow bench and support platform will be positioned in front of the rack for making the fiber coupling connections.

The ceiling height must be sufficient to allow a cable tray for the fiber bundles to be installed and accessed between the top of the racks and the ceiling.

An ante-room, designated the Change Room in the conceptual design, is required to maintain cleanroom conditions, for gowning, and for laser safety.

2.3 Cleanliness

Coupling the laser diodes to the fibers requires class 100 working conditions. The diode room must thus be constructed using clean room practices commensurate with a class 10,000 cleanroom. The portable flow bench will provide the final stage of dust filtering. The air flow to the room should be variable so that it can be reduced when the room is not occupied to reduce acoustic noise and vibrations from the HEPA filter fans. This may require adjustable exhaust louvers in order to maintain over-pressure inside the diode room.

Note that variable speed control that utilizes SCRs may not be suitable due to EMI concerns.

2.4 Heat load

Most of the heat generated by the power supplies and thermo-electric coolers will be removed via water. The residual heat load from the electronics is estimated to be 1.5 kW per interferometer

(thus 3 kW at LHO and 1.5 kW at LLO). This does not include the load from lighting and personnel during times when work in the room is ongoing.

2.5 Electrical

The eLigo lasers are the intermediate power stages for the AdvLigo lasers. The eLigo pump laser diodes and associated thermo-electric coolers will utilize two power supplies requiring 600 W each of 110 V, single-phase power. For AdvLigo, the high power stages will add an additional four power supplies requiring 1505 W each of 110 V, single-phase power.

Thus the total anticipated 110V power requirements for the equipment in the racks is approximately 7.2 kW per interferometer.

Convenience outlets are required in the diode room and the ante-room for diagnostic equipment and for operation of the portable HEPA bench in the diode room.

2.6 Lighting

Overhead lighting is required in both the diode room and the ante-room for typical working conditions.

2.7 Fiber optic access

A room penetration is required for the fiber optics that will transport the pump light to the PSL locations in the LVEA

2.8 Cooling water piping access

A room penetration is required for the hoses or piping for the chilled water required to cool the thermo-electric coolers. This could share the fiber optics penetration, but would need to be arranged such that leaks or condensation on the cooling lines would create a significant risk of getting the fiber optic bundles wet.

2.9 Laser safety/access control

Laser warning signs and access control equipment as required by the LIGO laser safety plan. This will likely indicate a electrically-activated striker on the diode room or ante-room access door.

2.10 Monitoring and services

Continuous dust level sensor in the diode room with monitoring via the CDS system.

Continuous temperature sensor with monitoring via the CDS system.

Webcam monitoring of the diode room via the CDS system.

Telephone connection in both the diode room, and the ante-room.

CDS network connection in the diode room.

3 Strawman design

3.1 Room location

The laser diode rooms are located in the north-east corner of the mechanical equipment rooms as shown in Figure 1 for LHO, and Figure 2 for LLO, below. This location will allow access to the laser diode room during "science mode" operation and should serve to reduce coupling of acoustics noise, vibrations, and EMI to the interferometers. The CDS vacuum control rack that is presently situated in this location will have to be moved. We plan to utilize part of the cable tray for the CDS rack for the fiber optic bundles.

Note that the mechanical room at LLO is approximately 20 ft. narrower in the E-W direction. Also, there several electrical panels mounted in or on the wall that separates the mechanical room from the LVEA both at LHO and LLO. The LHO panels are shown in Figure 3, below. Placement of the room will have to take into consideration access to the panels from inside the ante-room or diode room or relocation of the panels.

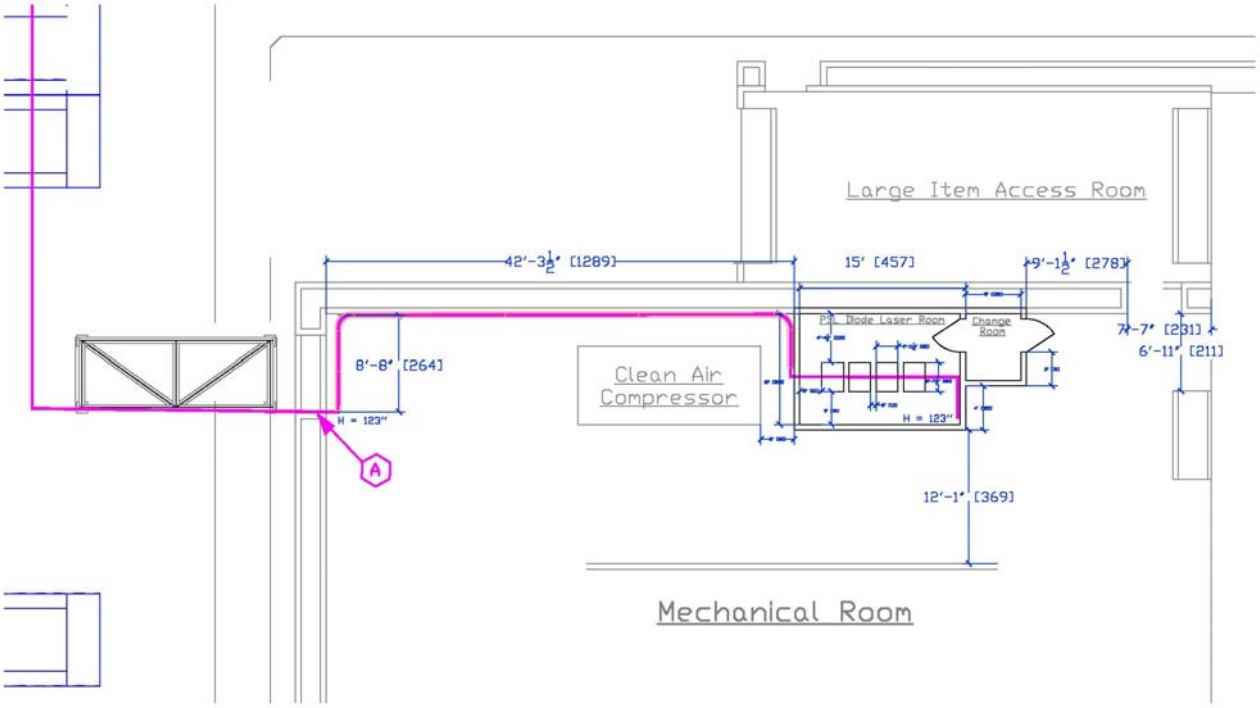

Figure 1 Laser diode room located inside the mechanical equipment room at LHO. The magenta lines show the fiber optics routing toward the H1 and H2 PSL areas in the LVEA.

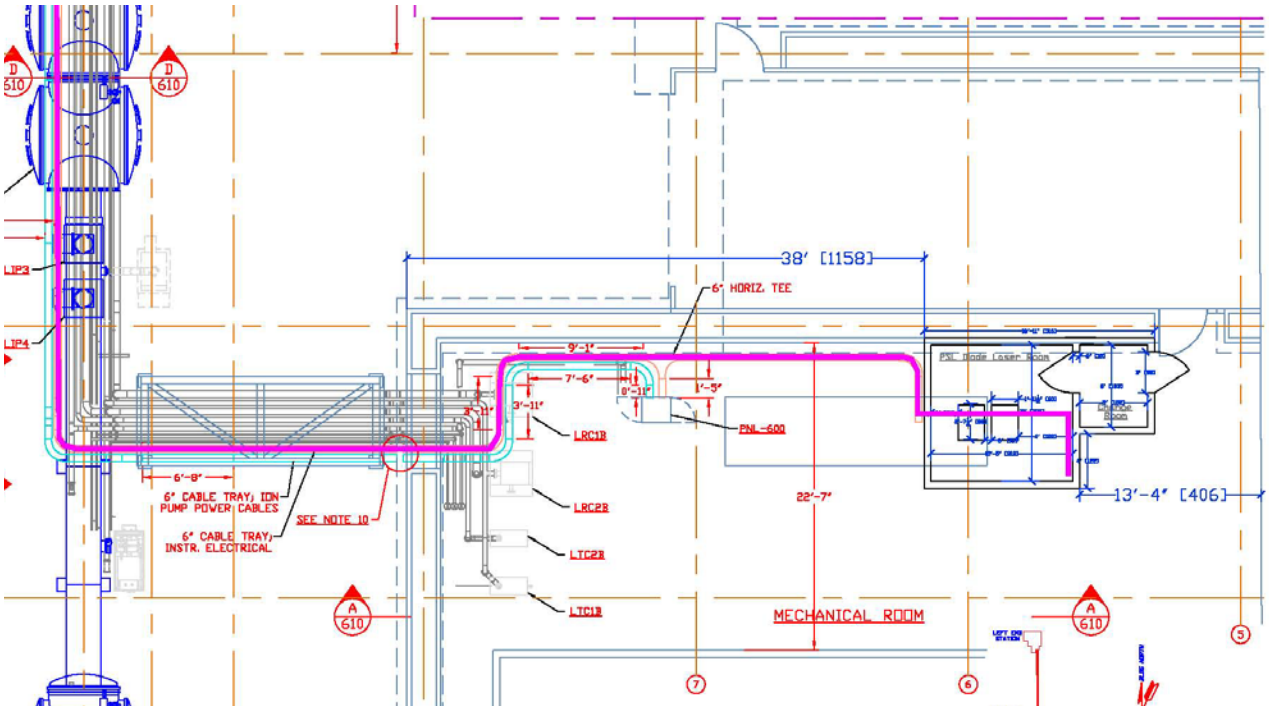

Figure 2 Laser diode room located inside the mechanical equipment room at LLO. The magenta lines show the fiber optics routing toward the PSL area in the LVEA.

Figure 3 Electrical panels on wall separating Mechanical Room from the Large Item Access Area at LHO. The black tape on the wall (circled in blue) marks the location of the wall at

the entrance to the ante-room (right circle) and the wall separating the ante-room and the diode room (left circle).

3.2 Room configurations

Plan views of the laser diode rooms are shown in Figure 4 for LHO and in Figure 5 for LLO.

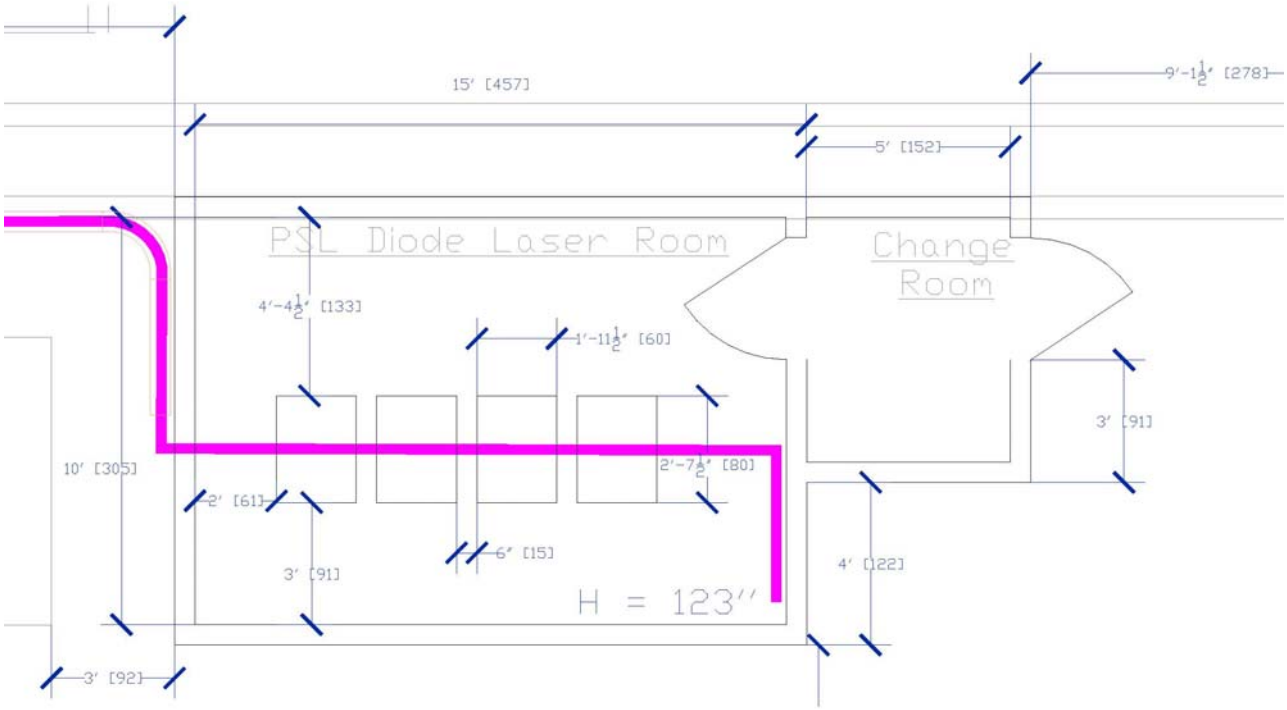

Figure 4 LHO laser diode room layout. The room is sized for two interferometers (2 racks per interferometer) for AdvLIGO. As drawn, the room incorporates the wall adjacent to the Large Item Access Area.

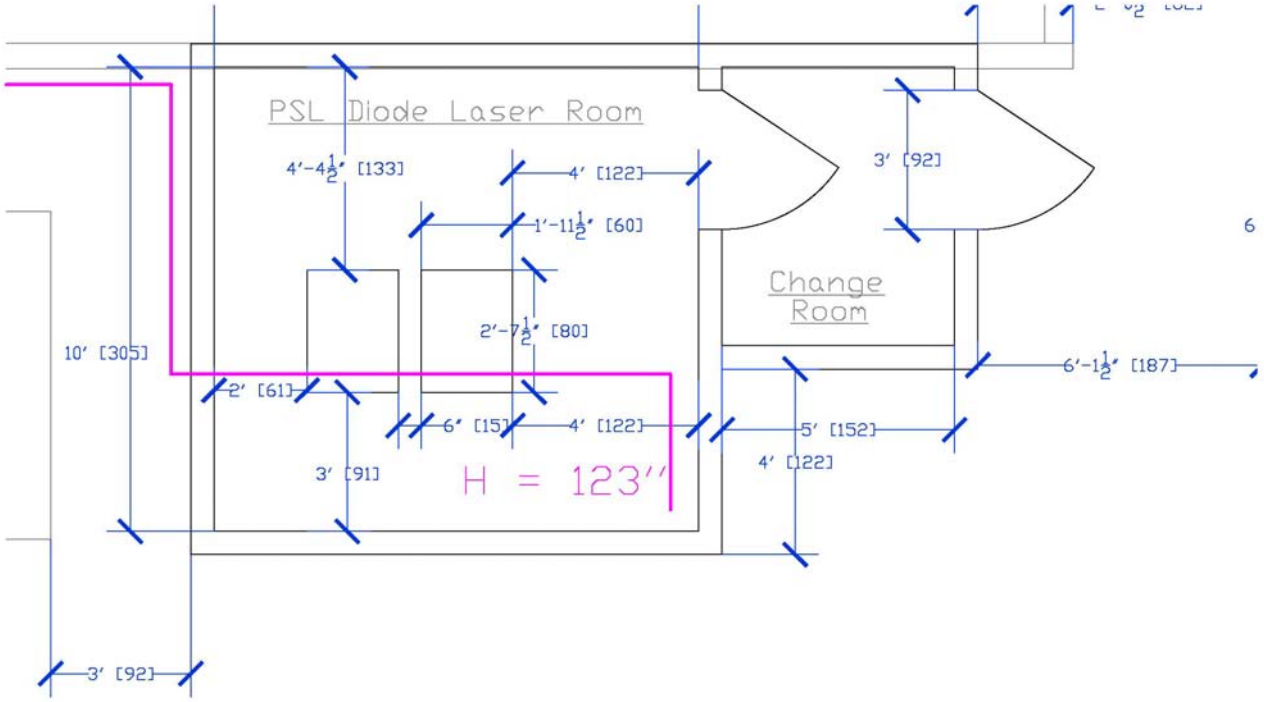

Figure 5 LLO laser diode room layout. The room is sized for one interferometer (2 racks) for AdvLIGO. As drawn, the room incorporates the wall adjacent to the Large Item Access Area.

3.2.1 Features and considerations

1) The size of the Change Room has been reduced to increase access to the Mechanical Room for large items such as air handler fans via the roll-up door in the East wall of the Mechanical Room.
2) The Change Room door opens to the outside to increase the space available for gowning in the change room. It swings away from the electrical panels on the wall adjacent to the Large Item Access Area so that it doesn't block access to the panels when open.
3) The door to the Laser Diode Room swings into the room, again to maximize space in the Change Room. Because the Laser Diode Room is expected to be maintained in an over-pressure condition, some type of adjustable louver may be required in the door to relive the pressure when opening the door.
4) We have attempted to allow three feet of clearance between the Laser Diode Room and the clean air compressor, but exact placement of the room will likely be dictated by maintaining access to the electrical panels on the wall adjacent to the Large Item Access Area. Thus the clearance may be reduced to less than three feet.
5) In Figure 4 and Figure 5, above, the rooms are shown incorporating the wall adjacent to the large item access area. This is not a requirement, rather one option for allowing access to the existing electrical panels on the wall. In a stand-alone design, some kind of window would be required for access to the electrical panels.

6) The ceiling height is 96". If we decide to utilize the iLigo equipment racks (84" high on wheels, 32" wide, 36" deep) we have only 12" between the top of the racks and the ceiling. This may be just workable assuming a cable tray height of approximately 6". Lighting and HEPA panels would have to be located so that they don't interfere with the cable trays.

7) This conceptual design incorporates four 2 ft. x 4 ft. HEPA panels with variable flow rate fans mounted in the ceiling of the Laser Diode Room. Exhaust air louvers, manually adjustable, are installed near floor level. A combination of fan flow adjustment and louver adjustment should facilitate maintaining over-pressure when work is ongoing inside the Laser Diode Room and when it is not, likely with reduced air flow.

8) A single 2 ft. x 4 ft. HEPA panel with variable flow rate fan is mounted in the ceiling of the Change Room. A manually-adjustable exhaust air louver is installed near floor level.

9) Flooring is a continuous (welded where necessary) sheet of linoleum.

10) Walls are painted with semi-gloss paint compatible with clean room construction.

11) There is no active heating or cooling of the air inside the laser diode room. The temperature is maintained by the flow of air from (and back into) the Mechanical Room. There is a temperature monitor with constant monitoring via the CDS system.

12) An opening in the West wall of the Laser Diode room near ceiling height and on the rack centerline admits the cable tray (~ 4" high x 8" wide) for the fiber optic bundles. The cooling water pipes or hoses may also be admitted through this opening, then drop to floor level so that they don't pass over the top of the racks.

13) Convenience outlets (110V) are installed along the walls in the Laser Diode Room and Change Room at standard intervals.

14) The Laser Diode Room is under constant surveillance via a webcam on the CDS network.

15) CDS network connections are installed in the Laser Diode Room and the Change Room.

16) Telephone jacks are installed in both the Laser Diode Room and the Change Room.

17) Clean room compatible fluorescent light fixtures are utilized in both the Laser Diode Room and the Change Room.

18) A dust monitor is installed in the Laser Diode Room and continuously monitored via the CDS system.

3.3 Chillers

The chillers will probably be placed on top of the air handler plenum, and then have pipes and/or hoses running both to the Laser Diode Room and to the PSL tables. The water cooling systems are currently being designed at LZH.

3.4 Cable Trays

There are cable trays in place, running to the CDS vacuum controls rack which now occupies part of the floor space where the rooms will be located. These racks will be moved. We utilize the existing cable tray along the North wall of the Mechanical Room for the fiber optic bundles. The

trays will be extended to the opening in the Laser Diode Room and across the room above the equipment racks.

3.5 Laser Safety and Access controls

Laser warning lights, signs, and an access card reader are installed on West wall of the Change Room to the left of the door to the Laser Diode Room. The door to the Laser Diode Room has an electrically-actuated striker that is part of the access controls system. The signs and access control are in this location rather than on the door to the Change Room in order to allow access to the electrical panels on the wall adjacent to the Large Item Access Area without invoking laser safety-related access controls.