



Date:	2 October 2008
Refer to:	L080112-00-D
Subject:	PSL Preliminary Design Review (PDR) report
From:	PSL PDR review committee: Rich Abbott, Rana Adhikari, Mick Flanagan, Peter Fritschel (chair), Eric Gustafson, Guido Mueller, David Nolting, Dave Reitze, Rick Savage
To:	Benno Wilke, Peter King, and the PSL team
Cc:	Dennis Coyne, David Shoemaker, Carol Wilkinson

Background

A preliminary design review (PDR) of the Advanced LIGO Pre-stabilized Laser (PSL) has been completed. The review committee reviewed the design documentation found on the PSL preliminary design review page of the Advanced LIGO wiki.¹ Questions on the documentation and design were generated by the committee and sent to the design team in early September 2008. Some questions were answered in writing, and some were addressed in the review meeting on September 23, 2008. The former (Q&A) are appended to this document.

Recommendation

We find that the Pre-Stabilized Laser (PSL) has successfully completed the preliminary design. We also find (subject to items 6 and 7 in the Findings) that the 35 W front end laser and the diagnostic breadboard are sufficiently developed to approve the production of these two elements of the PSL. Committee recommendations for actions to pursue in the final design phase are given in the Findings section below.

Findings

1. Design requirements. There is one area where we find the requirement should be changed, in the direction of tightening it up: laser amplitude noise in the RF band. Currently the requirement says: for frequencies above 9 MHz, the broadband PSL

¹ http://ilog.ligo-wa.caltech.edu:7285/advligo/Preliminary_Design_Review_Documents

amplitude noise must be less than 3 dB above the shot-noise in an average photocurrent of 50 ma. Because the ISC design calls for shot-noise limited light at 9 MHz and 100 ma of photocurrent, this requirement should be revised to: at 9 MHz and higher frequencies, the broadband amplitude noise must be within 1 dB of shot-noise with a photocurrent of 100 ma.

Except for a few performance numbers that are not quite consistent, we find the other design requirements to be appropriate and complete. The inconsistencies are not terribly significant and can be cleared up in the final design phase; they pose no risk to the PSL design. Finally, the requirements document should include more references, where appropriate, to the sources of information found in it.

2. Control & monitoring electronics. The team proposes to implement a LIGO real-time linux system for control and monitoring of the PSL. We have some question as to whether this is the best choice from a cost and robustness standpoint, as there appears to be no channels needed in real-time. This choice should be re-examined in the final design phase.
3. There is a possibility of training LIGO personnel on the laser build procedures when the Reference system is built at LZH. The PSL team should inform the AdLIGO project leader when this takes place (with a few month lead time), so that LIGO has time to consider and plan for this.
4. The PSL subsystem will need to supply a wavemeter at each site, for wavelength measurements of spare laser diodes (new scope). The team should present the choice of wavemeter at the final design.
5. The spares policy should be revisited during the final design phase. It may not make sense to have a fully functional PSL spare at each site, but instead have spares for the elements that have potential to fail. The team should present the full PSL spares plan at the final design.
6. We recommend there be a method for removing the laser box lid without having to shut down the laser (currently an issue for the 35 W front end, potentially for the high power stage). For example, a key-actuated interlock defeat, or just plan to remove the interlock once the laser is received.
7. Look into a method for remotely engaging/disengaging the NPRO noise-eater, to be able to remotely diagnose its functionality.
8. The PSL team should learn about the ISS upgrades/changes that have been made for the Enhanced LIGO 35 W lasers, and incorporate them into their design if appropriate.
9. The suspended-cavity outer loop ISS test should be revisited. It may not be worthwhile, given that the in-air intensity stabilization has already achieved performance very close to the requirements. The committee does not consider a suspended-cavity outer loop ISS a requisite for the final design.
10. PMC filtering. Given the change in RF noise requirement detailed above, additional PMC filtering will be needed. This can be with an increase in finesse, an increase in the cavity optical path length, or both. Space constraints were mentioned at the

review as potentially limiting the PMC size, but the committee suspects that more space could be found. The PSL team should communicate with the IO group about the potential for getting more space on the PSL table.

11. PMC longevity. Given the experience with initial LIGO PMCs, the committee is concerned about longevity (at high throughput) of the PMCs. We wonder if tighter contamination control in this assembly will be needed. We urge the PSL team to begin long-term testing of a PMC under optical load as soon as possible.
12. The PSL subsystem needs to supply instrumentation to monitor the servo gains of the FSS and ISS.
13. Special load handling requirements for PSL installation in the Laser Area Enclosure should be communicated to the FMP leader.
14. QA issues are to be followed up with Mick Flanagan in the final design phase.
15. We make the general comment that the high power performance of the PSL will not be needed at the outset of Advanced LIGO. The PSL should keep this in mind as they prioritize the remaining R&D and the installation.

To: PSL PDR committee
From: AdvLIGO PSL team
Re: Questions on PDR documentation
Date: 17 September 2008
Review committee: Peter Fritschel (chair), Rich Abbott, Rana Adhikari, Eric Gustafson, Guido Mueller, Dave Reitze, Rick Savage, Mick Flanagan (AdLIGO QA), David Nolting (AdLIGO Safety).

Response to the questions that can be discussed outside of the main review meeting:

1. DRD, Page 4, Table 1: Typo in the polarization row, comment col.
corrected

2. DRD. Table 3 gives the RIN requirement and the corresponding induced motion in the 0.1-10 Hz band, but Table 2 gives the seismic motion only in a limited part of this band, so it is not clear how consistent these are. Then sec 5.2 of the PDD gives a different set of control band requirements. So this all needs to be made consistent.
we should discuss at the review how this could best be done

3. DRD. Figure 3: the caption says 'see text for explanation', but there is nothing in the text.
"see text for explanation" was deleted, we do not remember what was supposed to be said in the text

4. Long term frequency stability. The DRD says 100 kHz for time scales longer than 100 sec, but the PDD (sec 3.2) says 1 MHz. The former appears to be too stringent (1 micron of equiv. arm length), and the latter makes better sense (also stated that it is no worse than iLIGO); make them consistent. Practically, this means we should plan on improving the thermal isolation of the L1 ref cav, so that it is like H1.
we changed DRD to "1MHz or no less stable than the InL PSL, whichever is more stringent, TBM)",

5. DRD, sec 2.4. Include a reference to the appropriate IO design doc for the filtering factor of 250.
reference added "LIGO-T060269-02-D, p. 57"

6. DRD, sec 2.5. You can explicitly say that the iLIGO control is adequate, so maintaining/reproducing that is good enough.
deleted the word "essentially" in "The requirements for these inputs are essentially the same as for initial LIGO,..."

7. PDD, section 1.1. For consistency, the 'does not include' list should include the interferometer input power level (IO scope). For clarity, the wording in the included list should change from 'Overall power control ...' to 'GW-band power stabilization ...' or something like that.
PDD changed following your suggestions

8. Pointing spec (p8 DRD and Table 5 PDD); the formula should use beam size and $\theta = \lambda/\pi/\omega$, instead of waist and far field divergence angle.

we inserted $\theta = \lambda/\pi/\omega$ but we do not understand why we should change “beam waist” to “beam size”, maybe you can explain at the review

9. Do you have any vendor data on the pump diode lifetime when operated at two thirds power?

we called Jenoptics: they would expect about 30.000h (instead of 20.000h which is the specification for nominal power),

lifetime definition: duration for which the diode delivers its full power and for which the pump current does not need to be increased by more than the allowed 15% to keep the output power constant

10. The DBB PDD says it can accept a wide range of beam parameters, but some numbers would be good to have here.

- the input power needs to be $120\text{mW} < P < 150\text{mW}$,
- two modematching lenses can be positioned between $60\text{mm} < x < 440\text{mm}$ from the breadboard input aperture, to match the incoming beam into at mode with $190\mu\text{m}$ waist radius located 804mm downstream of the breadboard input
- the focal power and the position of the two lenses can be adapted to the beam under test

11. PDD, p43. Where is the Attachment: Pointing Requirements ... ?
is now available on the Wiki, sorry

12. PDD. Is the last sentence on p45 complete?

No, in the Word document it reads: Such camera views are already installed at LIGO Livingston and have become useful for monitoring and status checking. These cameras should be located such that the zoom and panning features cover most of the area in question.
somehow this was not converted into the pdf.

13. PMC diagnostics. Consider adding a camera to monitor scattered light from one or more of the mirrors. Consider adding a pressure monitor to the chamber.

we will consider the camera,

concerning the pressure monitor we need more experiences and have to decide if we seal the container against pressure fluctuations or not

14. PMC servo. Some performance target should be set for this – unity gain frequency, or gain at some frequency.

added row in table Table5 PDD:

“PMC length control loop : unity gain frequency $> 1\text{kHz}$ ”

15. If we understand correctly some subset of the Beckhoff channels are made available to EPICS. What is the process for making more channels available to EPICS later, if desired?

the channel name needs to be added to a OPC database and the OPC service needs to be re-started

16. FYI on cameras: We are planning on using GigE-interfaced digital video cameras in other places in the interferometer, and we think the PSL monitoring should go the same way and use the same camera type. The system will allow easy storage of reference images.

we will test these cameras during the final design phase and adopt them if they perform well

17. FYI on RF oscillators. There will be a standard crystal-based RF oscillator design for AdLIGO, being developed by CDS/ISC.

we will try to incorporate that design into the PSL electronics

18. We understand the 35 W stage amplifier power monitors have not been reliable in the EnLIGO lasers; has this problem been resolved?

No. We will try to make them more reliable by an intensity reduction on the pump light photodiodes. Tests are underway at LZH.

If it turns out that the 1064nm power monitors are unreliable we will use them only for maintenance purposes.

19. Water cooling. Is there a reason/need to monitor the quality of the cooling water? We recently had a leak on the H2 PSL water cooling; consider adding a leak detector (humidity sensor) to the PSL tables.

we will check if a humidity sensor can be fitted into the laser box

20. FSS bandwidth. Keep in mind that the PMC will add a high-frequency pole to this loop; OK if it is at 7 MHz, but we might want to make it a little lower (see below).

What is the effect of (propagating through) the oscillator stage on this loop?

We will wait for the outcome of the discussion on the PMC bandwidth at the review.

We have not measured the effect of the 200W oscillator on the FSS bandwidth yet but will do so in summer 2009 when the first 200W system will be integrated into the full PSL setup at the AEI. We expect only a little phase delay (<10deg) at 600kHz.

21. RF modulation frequency for oscillator PDH locking (p19 of PDD). Given the potential for higher order modes in the 30-50 MHz region, it seems prudent to choose something outside that band (ie, not 35.5 MHz). Perhaps 25 MHz, since we use that in iLIGO.

The modulation frequency can only be decided on once the resonator design of the 200W oscillator is frozen. What would be the advantage of using one of the iLIGO frequencies?

22. Enclosures and such. Where is the gowning area in Fig 41 of the PDD? What's the plan for deciding whether to include acoustic enclosures for the PSL tables?

Regarding reuse of existing laser table enclosures: is the (laminated) wall material still adequate given the higher power beams?

There is no specific PSL gowning area. We envision to put on the clean room clothes before entering the LVEA. We should discuss the acoustic enclosure question at the review.

The laminated walls are fine as they do not serve as beam dumps and should not see any high power beam.

23. Low power mode. Somebody is going to come up with a reason to want more than 16 W. Consider a way to make the full MOPA power (35 W) available.

We do not see an easy way to do this. We will discuss this topic at the review.

24. There is no data on the performance of the iLIGO frequency pre-stabilization in the control band. Consider making a two reference cavity comparison experiment to get such data.

We will have a chance to do such a comparison at the AEI during the final design phase. Furthermore such experiments are planned at several other places in the LSC.

25. Higher crystal doping, sec 2.5.5 of PDD. If you go with higher doping, presumably the pump diode wavelength would need to be shifted away from the absorption peak to get the same thermal loading. But then the pumping would be more sensitive to pump wavelength variation. Is this a concern?

No. The absorption profile varies only little with wavelength around 802nm. The variation is actually less than at 808nm.