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MEMORANDUM

DATE: October 26, 2009

TO: Seiji Kawamura
FROM: Stan Whitcomb, on behalf of the Evaluation Committee
SUBJECT: Review of Study Report on the LCGT Interferometer Observational Band

The external evaluation committee was assembled to review the reports and recommendations of two special LCGT working groups. Each working group was assigned the task of addressing a specific question concerning the LCGT design and producing recommendations for the LCGT leadership. The members of the evaluation committee are

Stan Whitcomb (Chair)
Stefan Ballmer
Hartmut Grote
Benoit Mours
Peter Shawhan

The charge to this committee (email dated 6/26/2009 from Seiji Kawamura) is to:

"Make recommendation to the reports of the two special working groups."

This report summarizes our assessment of the Interferometer Observational Band Report. The evaluation committee was supplied with the report via email, and each member read it and provided comments to the chair and the other committee members. These were discussed via email, and the chair assembled the contributions into a draft report. This report was circulated among the committee and iterated to this final version, which all members of the committee support.

Overall Assessment

The question of the interferometer optical configuration, which includes the observational bandwidth, is a complex one. The committee commends the special working group on its careful analysis and report.

The report contains two major recommendations. The first is to choose VRSE as the optical configuration for LCGT. The evaluation committee strongly supports this recommendation. The case is well reasoned and the arguments for this course are strong.

The second recommendation is to choose VRSE-D for early observation with a change to VSRE-B after the first detections. This may be a good course of action, but the reasons for this choice over simply beginning with VSRE-B do not seem as strong. The difference in observation time to early detection (the factor cited as most important supporting this choice) is not large, and this apparent difference could easily be overturned by the commissioning time to make VRSE-D work. In this case, we recommend staying flexible on this question, continuing to carry the option of starting with either VRSE-D or VRSE-B, until the information to make a clear choice is available.

Finally, the first two lines of the executive summary indicate an over-arching goal was to make recommendations on the optical configuration. The observational bandwidth is an important part of the optical configuration but it is only one part. In particular, the optical geometry of the recycling cavities is a key design issue. Other projects have found themselves working with awkward constraints because of the physical layout of chambers, etc. This issue has a strong impact on the infrastructure and we recommend that it be given attention now.

Additional Comments and Suggestions

As shown in Figure 2, the differences in the expected time to a first detection among the different configurations are not very large, and are probably smaller than the uncertainties in the required commissioning times for the different configurations. Thus, this factor should not be the dominant one in determining the final choice of bandwidth and optical configuration. Instead, we recommend that the decision between VRSE-D and VRSE-B be made based on which scheme is easier to implement and commission. This is a difficult question and it may not be possible to answer at this point. If this proves to be the case, then maintaining flexibility to implement either scheme, until there is enough information to make the decision is wise. A likely scenario for the commissioning progress would be to have a locked detector with ever increasing sensitivity, which takes science data from time to time, rather than having a detector which is declared 'ready' at some point, and then takes many months of data.

The choice of VRSE looks reasonable at this point of the investigation, but certainly more simulations/calculations are required as the optical configuration design proceeds.
Points of further work that we see include:

- The arm-cavity finesses are high (about 1500) for VRSE and BRSE.

-Is there experience with losses on cryogenic mirrors? What is the safety margin on the mirror losses here? What would happen to the control scheme and range, if the specs are not met?
-If the finesse is high, differences in the losses play a more important role. In particular this is true for DC readout and the freedom to choose the homodyne phase. Some quantitative estimation seems essential here. (As the authors also propose in section B.2.4.)
-We assume that one of the main driving forces was the expected substrate loss of 20ppm/cm in sapphire (compare to 0.25ppm/cm for Suprasil 3001 silica glass). The considerations that went into the choice of finesse for Advanced LIGO are summarized in "Arm Cavity Finesse for Advanced LIGO" (http://www.ligo.caltech.edu/docs/T/T070303-00.pdf). In particular, the BS coupling is inverse proportional to the finesse and sets a lower limit on the finesse, but there is also a SRM coupling through radiation pressure that is proportional to finesse times arm build-up. For AdvLIGO, this suggested picking a finesse below ~625 (driven by the SRM suspension thermal noise.)

- SR cavity control signal

-Planning for an offset on the SR control signal for detuning the SR cavity obviously raises the question of laser power noise coupling. This should be considered.
-Did you consider the possibility of tuning f_1 frequency as a means to detune the SR cavity (and using only one f_1 sideband to generate the error signal)?

- Alignment control noise

-As far as we can tell, this has not been addressed by the LCGT team yet. However, it is expected to be the dominant noise source for (at least some configurations of) Advanced LIGO at low frequencies. In particular the detuned mode is sensitive here, as the alignment control bandwidth might need to be high in order to control optical spring effects. We consider it wise to include an alignment noise budget in the LCGT configuration design soon.

- Noise couplings:

- The behavior of the SRM loop noise coupling seems counter to our experience, as it actually decreases below ~10Hz going from VRSE-B to VRSE-D. But the length control system of LGCT is different from the AdvLIGO one, and this may explain the difference.
- RF Oscillator phase noise will have a worse coupling in VRSE-D (compared to VRSE-B). It effectively generates intensity noise on both carrier and sideband as soon as the two see a different optical filtering. Note that it can't be suppressed by an intensity stabilization loop with a sensing PD that samples the input light only.
- In general, the discussion of technical noises is too short. Reaching 5 $x10^{-24}$ at 50Hz is a challenge. Is it possible to guess the dominant technical noises at low frequency, perhaps by looking at LIGO/Virgo noise budget there, add such extra noise in a somehow arbitrary way, and see if it changes the result for choosing VRSE-D versus VRSE-B.