LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Statement of Work: Change of Modulation Frequency at the 40m

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1 OBJECTIVES / SCOPE

As a step towards changing the topology of the 40m from recombination to recycling it is necessary to change the modulation frequency from its present 12.3 MHz to 32.7 MHz. This is due to the nature of the signal extraction scheme to be employed in the recycling experiment [1]. The task will compromise of

- installing a new in-vacuum Pockel Cell and matching resonant circuit
- installing new RF photodiodes and employing the new RF reference source [2]
- confirming that the 40m still operates satisfactorily as a recombined interferometer

2 PROCEDURE

Since the system will be vented, advantage will be taken to carry out a few other auxiliary tasks in the system as noted below. For clarity each individual task is outlined in full. Note that in fact some of this work will be carried out in parallel for more efficient use of time. The dovetailing of tasks is dealt with in section 3 of this document.

2.1. Preparation at 40m (1/2 day)

- disable HV sources inside vacuum envelope
- vent beam tube and annulus lines
- set initial pointing monitor as a reference for laser pointing
- set globals for BS, EV and SV masses

2.2. Installation of New Pockel Cell and Matching Circuit (2 days)

- remove door(s) from the side chamber
- disconnect present matching circuit and place into storage
- remove present Pockel cell together with its carriage to the clean bench on the south arm
- replace present Pockel cell with new one which has been fully vacuum prepared
- reinstall carriage on optical rail
- use main laser beam to align - some alignment of the optical rail may be necessary. NB As always low power should be used and caution is to be exhibited since there are rejected beams from Faraday cells, which are also mounted on this rail. Care must be taken that these rejected beams remain blocked during any motion of the rail.
- install new matching circuit
- connect up new RF source
- verify that the tuning circuit is indeed correctly tuned (actual tuning procedure will be done off-line prior to venting the 40m).

2.3. Installation of new RF photodiodes (few hours)

- testing of photodiodes carried out prior to the vent
- when the interferometer is aligned in air (see below) position new RF diodes in place of the present ones at the symmetric and antisymmetric ports

- check that the correct form of error signal is produced by free running fringes

2.4. Auxiliary Tasks

The 40m has suffered some recent earthquake damage. In particular the EV mass has lost a magnet and the SV suspension has almost no range in its position bias. These problems will be rectified during this vent.

When the present beamsplitter was installed, all the teflon stops were changed for steel screws. This change was made since unacceptably large changes in BS alignment were caused by making small adjustments to the position of the stops. This was thought to be due to the effects of electrostatic charging. Since teflon stops are currently the choice for LIGO further investigation of this phenomenon is required.

2.4.1. East Vertex (7 days)

The recommendation of the suspension group is that all six magnet and stand-off assemblies be replaced. The procedure for this is as follows

- open the EV chamber
- clamp the test mass in place using the safety stops
- mark the position of the EV tower using shims that butt up against the tower base
- removing the EV tower and transport to the south annex
- place several counterweights on the EV table top to minimise stack drift
- remove the test mass from its suspension
- remove the remaining magnet and stand-off assemblies
- using the appropriate fixtures glue new magnet stand-off assemblies to the test mass using Vac-seal. This will be left for ~ 24 hours to cure
- the test mass will then be baked for 48 hours and RGA scanned
- note that changes made to the EV controller will be left in place until it is finally verified after pump down that they are no longer required
- following this the test mass will be resuspended (the previous guide-rods and standoffs will still be attached to the mass). It is intended that the same suspension wire be used, although new cleaned and baked wire will be on hand if required
- balance the mass using an optical lever as a guide and a PZT buzzer to gently move the wire
- clamp the mass in place using the safety stops
- reinstall the tower in the chamber
- conduct standard tests carried out to check the leveling and behaviour of the whole assembly (e.g. see EV vacuum chamber check out list)
- final alignment carried out with green beam

2.4.2. South Vertex (~ few hours)

- open SV chamber
- make turntable adjustments to bring the operating bias point for this mass to the centre of the range. This is done by using the global laser as a rough guide i.e.
    - change test mass bias, keeping global on its photodiode, to bring bias back towards the centre of its range

    - using the turntable adjustment, reorient mass in order to bring the global back to centre on the photodiode.
    - continue this process until the bias is back in mid-range with the global centred on its photodiode
- use green beam for final alignment

2.4.3. Beamsplitter (~ 1 day)

- open BS chamber
- retrieve an equivalent teflon stop from the laminar flow bench in the south annex - minimise handling of the screw and take particular care not to touch the screw tip
- set up BS global and note position of reflected beam when transmitted beam is well centred
- remove one of the front facing stops from the suspension - verify BS global is still well centred
- install the teflon stop
- look for any sign of BS deflection by observing the BS global (checking that the transmitted beam remains centred)
- if deflection is observed, remove teflon screw and brush with prepared copper brush [3]
- reinstall screw
- again look for deflection - if any is observed, try repeating above process
- if no deflection is observed (either on initial installation or after brushing) the teflon screw will be left in place.

2.5. Coarse Alignment of Interferometer (~ 2 days)

- check beam centring on test masses
- align each arm for green fringes
- align all locals and globals
- carry out standard chamber checkouts
- replace chamber doors

2.6. Pump Down (1 day)

- after chamber inspections are completed and 40m resealed, pump down

3 DOVETAILING OF TASKS

- following vent, remove EV suspension to allow off-line work to commence
- carry out electrostatic tests on beamsplitter whilst EV magnets are being removed and new magnets glued on.
- carry out Pockel cell changeover whilst EV mass is being baked
- carry out SV adjustments whilst EV mass is being scanned and suspended
- re-install EV suspension
- align interferometer and install RF diodes
- carry out chamber checkouts

- close system up and pump down.

4 VERIFICATION OF RECOMBINED CONFIGURATION

- re-set all phase shifters and check gains
- lock interferometer
- take spectra and confirm that shot noise is at expected level

5 STARTING CONDITIONS

- completion of all other on-going investigations at the 40m as agreed by Jennifer Logan, Robert Spero, Mark Coles and other involved personnel
- all relevant components are baked and ready to be installed.

6 WORKFORCE

• Task leader	Jennifer Logan
• Pockel cell and tuned circuit work	Brent Ware
• EV Suspension work	Seiji Kawamura
	Janeen Hazel
• BS electrostatic tests	Janeen Hazel
• Other Key Workers	Robert Spero
	Nergis Mavalvala
	Dick Gustafson
	Anatoli Arodzero
	Bill Kells
	Mark Coles
• Electronics support	Jay Heefner (EV controller)
	Dale Ouimette (RF diodes)
	Rich Abbot (RF source)
• Lab support	Denise Durance
• Vacuum and technical support	Steve Vass
	Karthik Naidu
• Baking	Yehuda Kommemi

References

[1] M.W. Regehr, “Signal Extraction and Control for an Interferometric Gravitational Wave Detector”, PhD Thesis, California Institute of Technology, 1995.

[2] R.S. Abbot, “40 meter Reference Source System”, LIGO - T960071-00-C

[3] “Small optics Suspension Specification”, LIGO - E970037-00-D