Summary Report of Visit to LIGO, Caltech: October 18th - November 17th 2004

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This document summarises the work completed during a recent visit to California Institute of Technology. The purpose of this visit was to assist with the continued collaborative design work being undertaken by the Advanced LIGO Suspension Team. The work displayed in this document is both work that I did on my own (primarily with interaction/input from Calum Torrie) and work done by my LIGO colleagues, in which I was involved.

The aims of the visit were:

- To follow my design for a Controls Prototype ETM Top Mass, interact with workshop staff to ensure the accurate manufacture, and to receive and build the assembly in the laboratory in which the initial build of the ETM Quad pendulum will be suspended.
- To work closely on the design of the C-Ptype ETM structure with Tim Hayler (Rutherford Appleton Labs [RAL]), Calum Torrie and Janeen Romie (both Caltech).
- To interact on issues related to the detailed design of the C-Ptype ETM Upper Intermediate Mass with members of the LIGO, Caltech Suspension team to bring it towards manufacture ready for an initial build early next year.
- To work closely on the design of C-Ptype ETM assembly fixtures and top mass tablecloth with Ian Wilmut (RAL), Calum Torrie and Janeen Romie

I would like to thank Dennis Coyne, Janeen Romie and Calum Torrie for inviting me to come and work with them on this visit and for their help and assistance during my trip both inside and outside of work. Furthermore, I would like to thank Cindy Akutagawa and Irene Baldon for co-ordinating the necessary arrangements to get me over to Caltech on the visitors programme and associated travel arrangements.

Top Mass Manufacture and Build

FIGURE 1: C-Ptype ETM Top Mass Build October 2004 – Left View: Top half and bottom half with blades; Right View: Top half above bottom half prior to blades being flattened.

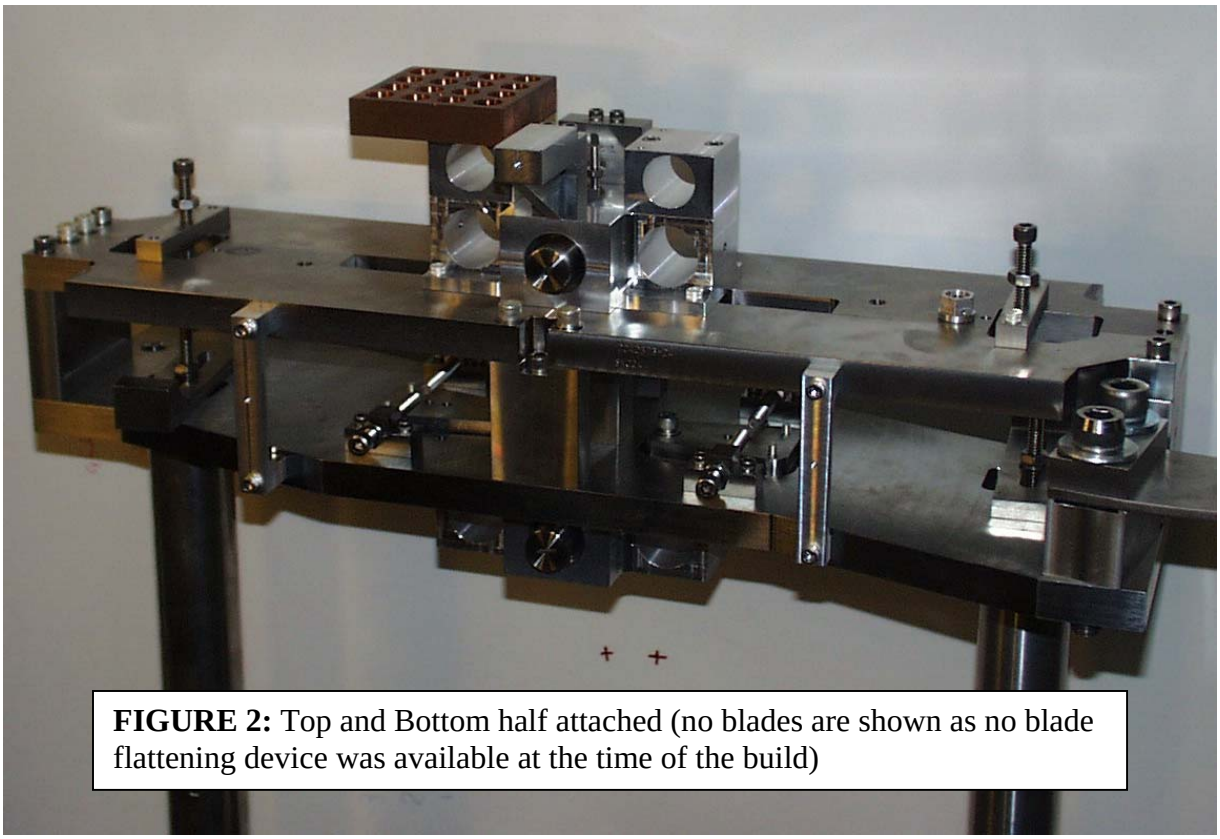

FIGURE 2: Top and Bottom half attached (no blades are shown as no blade flattening device was available at the time of the build)

We completed the build of the Top mass towards the end of my visit thanks particularly to Mike Gerfen of Central Engineering Services (CES) working overtime to get the key parts of the assembly to us. The build allowed an initial assessment of the real scale and weight of the assembly and allowed us to identify a couple of minor modifications which were quickly dealt with and sent back to CES.

ETM Structure - Development of Concepts

At the beginning of my visit, I crossed over with the end of Tim Hayler's three week visit. The focus of his trip, being new to the project, was on getting up to speed on aspects of suspension design, the ETM Structure design, and understanding the organisational structure of the project. For one day of our discussions we also had the benefit of Norna Robertson's expertise and knowledge of future designs in which Tim would be involved in the design of (e.g. the ITM and Beam Splitter).

Our initial discussions reviewed where Calum and Tim had reached with respect to the design of the Top Structure, the newly designed Implementation Ring (the interface between upper and lower structure) and the structure that would eventually surround the U-I mass. During our time together, we decided to go ahead with a box/u-section construction for the Top Structure as opposed to a 'stretched-skin' or 'chest of drawers' construction. As I had a good knowledge of the U-I Mass Design it was deemed useful that I took on the design of the U-I Mass Structure and its development into an integrated lower structure following the completion of the U-I Mass design.

U-I Mass Detailed Design

The visit allowed some concentrated effort to be spent on the detailed design of this suspension component. A number of additional requirements had been suggested or become apparent since it was last worked upon it in August. These were:

- The addition of a pitch adjuster able to rotate the test mass by >1 mrad
- The addition of split top plates to allow easier access to attach blade clamps, blade wire clamps and suspended-mass wire clamps.
- Consideration for the interface with respect to the '3 and 1' assembly technique
- Inclusion of an adapted coil holder/adjuster design
- Inclusion of a simplified adjustable magnet-flag-spacer assembly
- Addition of a blade damper

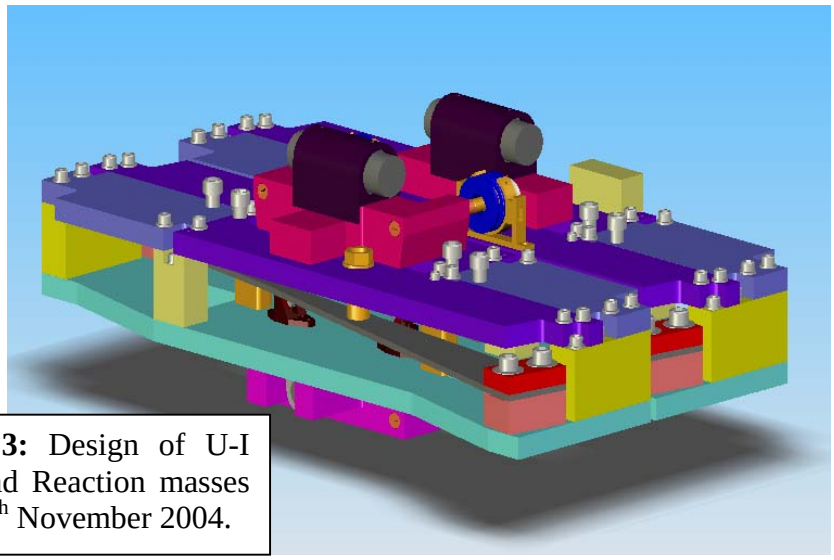

Figure 3: Design of U-I Main and Reaction masses as of 17th November 2004.

ETM Wire Testing

At the tail end of my visit, I also overlapped with the first week of Ian Wilmut's visit to Caltech. Amongst discussing interface issues of aspects of the Top and U-I Masses and their respective assembly fixtures, one of the key areas we analysed was the use of drum-end wires within the ETM suspensions.

Having completed experiments which demonstrated that the traditional GEO-style bolted wire clamps were not suitable for the 1mm Top wire just prior to Ian's visit, we then conducted further experiments on the top and U-I wires to check the feasibility of using these throughout the suspension. As the wire slipped prior to breaking in all tests, we concluded that the Top Wires definitely could not be used in a traditional clamped set-up. However, the U-I Wire could still be manufactured the

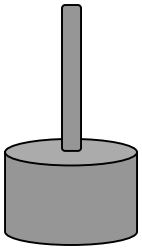

Figure 4: Example of Drum-Ended Wire

traditional way (although it would be useful to look at the possibility of using a drum-ended wire at this stage).

After several discussions with Riccardo Desalvo and Virginio Sannibale who have experience with drum-end wires from their time at VIRGO we were able to conclude that the drum-end wires would be the best way forward at all stages should the geometry of interfacing parts allow for this. At the Top Wire stage this was not a problem, however at the U-I wire the lack of space at the U-I mass meant that a comprised wire loop and clamp would need to be used. The clamp would be required to define the break-off (and position appropriately to take in to account the flexure point position)

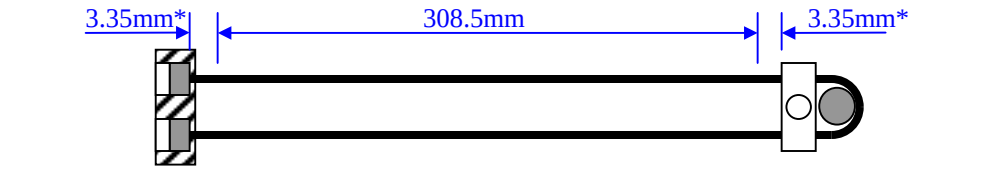

Figure 5: Example of Drum-ended wire for U-I Wire stage

NOTE: * = Distance to Flexure Point as per calculation in D040183

ETM Assembly fixtures

During my overlap with the visit of Ian Wilmut; Calum, Janeen, Ian and myself discussed the assembly fixtures for Top Stage, Top Mass and U-I Mass These included various jigs for aligning blades on masses, flattening blades, mechanical fingers, etc. Many of which were drawn up as concepts in SolidWorks or Pro/E and/or concepted and bench tested on similar components.

Top Mass Tablecloth

I was involved in discussions on the Tablecloth design with Calum Torrie and Janeen Romie so that design could be further evolved from the initial layout. The critical interface elements and the required access areas for components on the Top Mass were clarified so that the layout design (of the tablecloth) could be developed and detailed ready for manufacture early in the New Year.

SUS SolidWorks Webpage

Further details were added to the Suspension SolidWorks Webpage (accessible from the side bar on Calum Torrie's webpage at LIGO: www.ligo.caltech.edu/~ctorrie/) including instruction on the current version of SolidWorks the team are using and information on the use of 'Joined Parts' in SW Assemblies.

Revision Notes:
Rev 01- includes comments by Calum Torrie