LIGO Renewal (2002-2006) Proposal DRAFT
Executive Summary
Campus based research activities
40 meter interferometer

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LIGO operates a 40 meter interferometer on the Caltech campus (Fig 1). This facility has been in continual operation and development for the past 15 years. Many of the key technologies used in the present LIGO detectors were developed and/or first prototyped at the 40 meter, including the vacuum envelope and controls, passive seismic isolation stacks, optics suspensions, the Fabry-Perot Michelson optical configuration, power recycling, and most importantly, the interferometer sensing and length control system. A generation of gravitational wave interferometer physicists has been trained on this facility, and many of these are key players in the construction and commissioning of LIGO. The 40 meter facility established that such a suspended mass interferometer could be locked and controlled, and that a displacement sensitivity on the order of 10^{-18} m/$\sqrt{\text{Hz}}$ could be achieved at frequencies around several hundred Hz (Fig. 2). It has achieved the best broad-band strain sensitivity of any fully instrumented gravitational wave detector (until the turn-on of LIGO).

The LIGO science program demands a major improvement in detector sensitivity. This must be preceded by a broad range of R&D work and prototyping of advanced technologies to effect those improvements reliably. The 40 meter facility will play a key role in these coordinated activities, as it has in the past. Facilities are being prepared for the testing of full-scale prototypes of Advanced LIGO seismic isolation and suspension systems (LASTI), to measure the thermal noise of candidate test masses (TNI), and other elements of the Advanced LIGO design. In order to prototype the controls and study the performance of the Advanced LIGO optical configuration, a fully instrumented suspended-mass interferometer is needed, and the 40 meter facility is ideally suited to this task. (The LIGO observatory sites would be an even better place to do this prototyping, but they will be in the midst of the LIGO science run and must be left undisturbed while Advanced LIGO is being developed).

The 40 meter interferometer vacuum envelope has much shorter arms, higher environmental noise, and less floor space and vacuum chamber volume than the LIGO observatories. In all other respects, it is entirely suitable for prototyping all aspects of the Advanced LIGO optical configuration, and the shortcomings mentioned above do not impact heavily on the fidelity and validity of the planned tests.

The 40 meter facility is being upgraded in order to perform these critical prototyping tasks. The building is being renovated at Caltech's expense, including increased space for control electronics, new electrical wiring and cable trays, and a new control room. The vacuum envelope and equipment will continue to be used, with new additions for a 12 meter mode cleaner and an output optics chamber with seismic stack. A fully

instrumented Advanced LIGO interferometer prototype (including PSL, optics, single pendulum suspensions, and all control electronics) will be assembled and tested in the years before the installation of Advanced LIGO at the observatory sites.

The development, testing, and final prototyping of an Advanced LIGO optical and control configuration at the 40 meter facility will make the installation and commissioning of Advanced LIGO at the observatory sites as smooth and quick as possible. It will benefit tremendously from the close proximity to the Caltech-resident LIGO mechanical, optical, and electrical engineering staff, as well as from the rich intellectual environment of the Caltech campus. Perhaps most importantly, it will facilitate the training of yet another generation of gravitational wave interferometer physicists, including graduate students, undergraduates, and visitors.

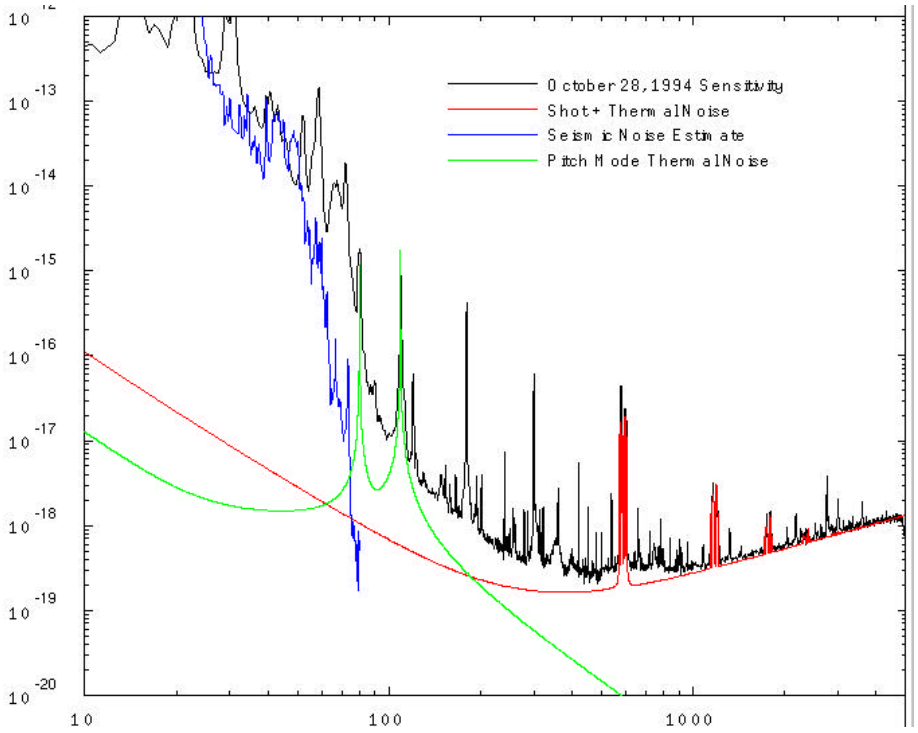

Figure 2: Displacement noise of the 40meter interferometer in recombined Fabry-Perot Michelson configuration (no power recycling), circa October 1994.