Cryogenic Systems for Future LIGO Detectors - G1400940

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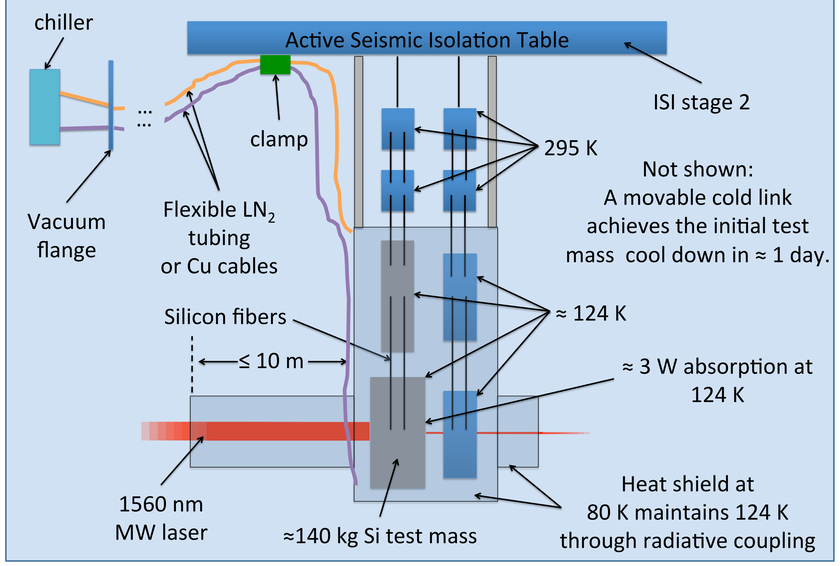
LIGO III Cryogenic System

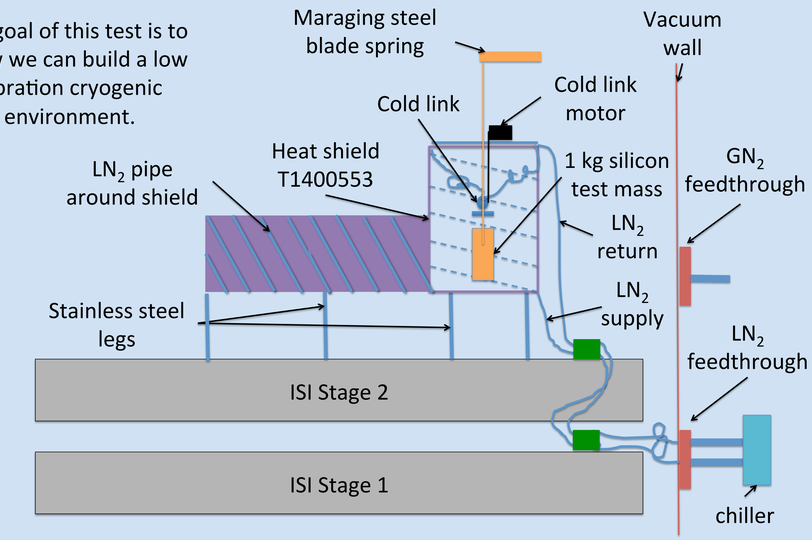


This poster explores the details of a cryogenic system for the ITM and ETM suspensions in 3rd generation LIGO observatories. Cold silicon test masses improve thermal noise and thermal lensing issues. The poster follows the Blue Team description in the Instrument Science White Paper T1200199.

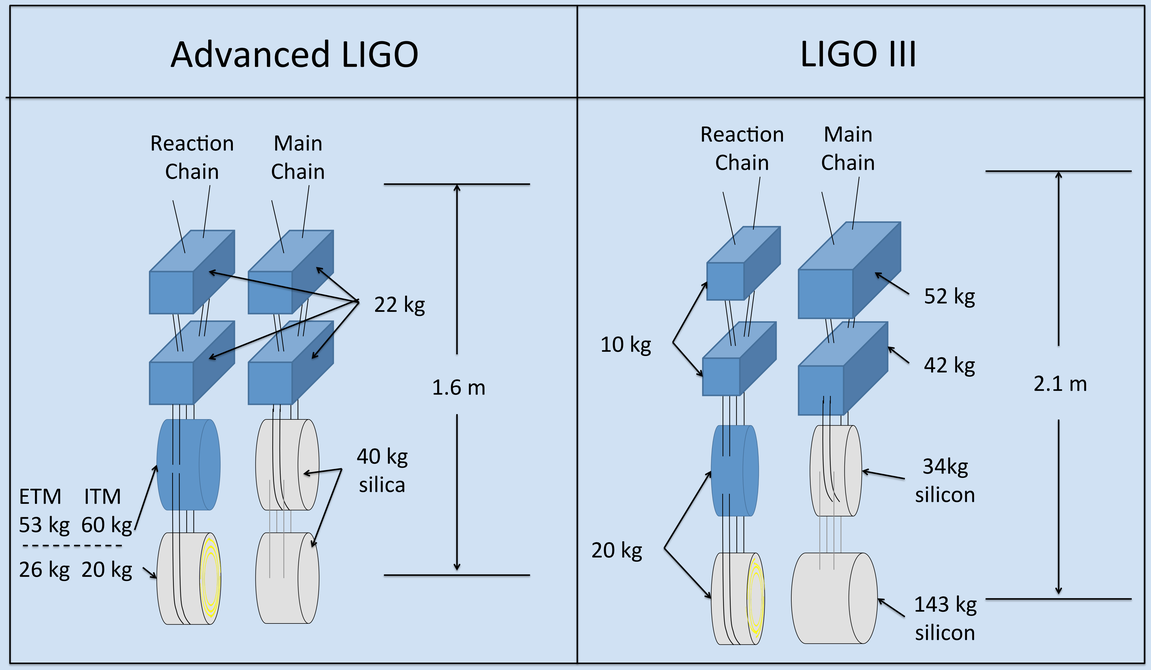
The figure on the left illustrates an overview of what such a system may look like for one of the test mass suspensions. The figure on the right is a planned test at the Stanford facility integrating as many of these components as possible.

Integrated System Test Beginning at Stanford

The goal of this test is to show we can build a low vibration cryogenic environment.



Quadruple Suspension Redesign



One of 3 conceptual designs for a LIGO III quad suspension discussed in T1300786. The test mass is silicon rather than fused silica, with an increase in weight. Silicon is useful at cryogenic temperatures for its low loss and high thermal conductivity. The remaining stages are optimized in terms of mass and wire length. This particular design assumes the test mass hangs from silicon springs at the penultimate mass. However, T1300786 also considers designs without these springs, at the expense of some increase in noise.

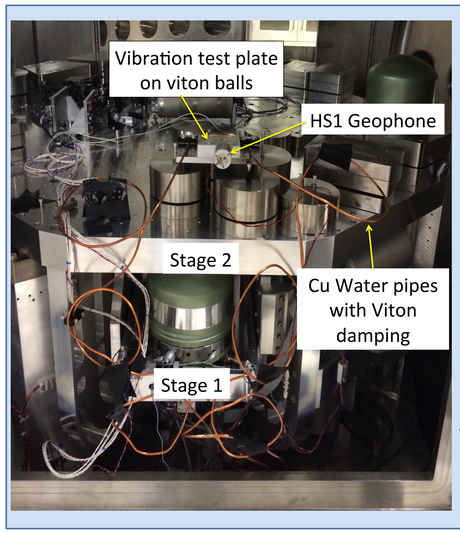
Cooling with Cu cables or Liquid Nitrogen (LN_2) Pipes?

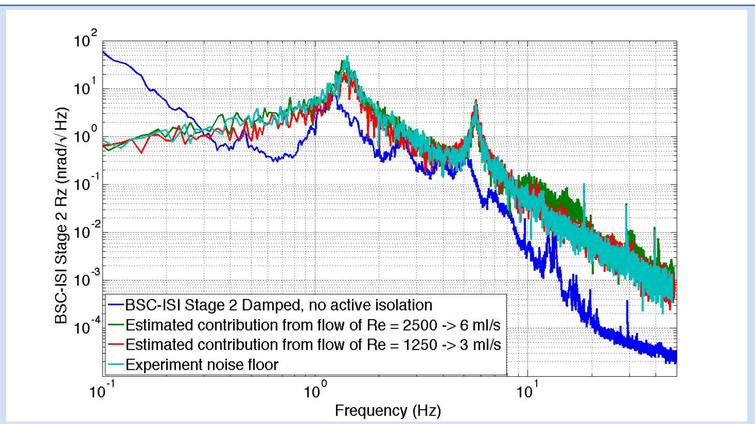
	Heat Transfer	Added weight	Seismic shorting	System Complexity	Vacuum leaks
Cu cables					
LN_2 pipes			?		

Good | Fair | Risky | Show stopper

LN_2 has more cooling power, and can be pumped where needed, but it is unknown how much noise its flow will generate. The LN_2 is pre-cooled so it does not boil.

The figures below show a recent measurement of the magnitude of vibration induced by flowing fluids. The experiment uses water for its ease of use and similarity to LN_2 in terms of density and viscosity. So far the measured vibration is low enough it is difficult to distinguish from noise. More work is required.





The measured vibration for reasonable flow rates is difficult to distinguish from the experiment noise floor. This noise floor, projected onto BSC-ISI stage 2 Rz motion (the 'quietest' ISI DOF), is more than the seismic noise.