DAMPING OF STRUCTURES

STANFORD UNIVERSITY

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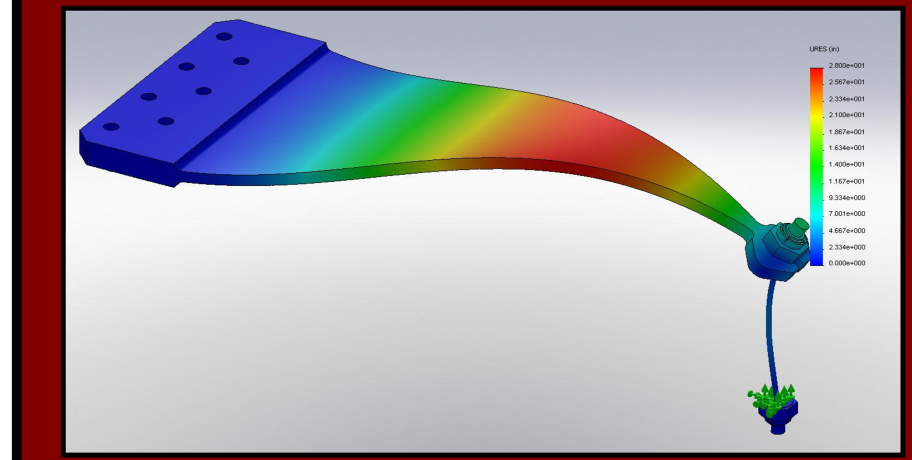
Viton and Damping

When a resonance mode of a structure is problematic, often the first reaction is to stiffen the structure to push the natural frequency of the resonance up and out of the frequency band of interest. While this is desirable, it is often not feasible. Increasing the stiffness of a structure by an order of magnitude while maintaining the same effective mass is difficult. However, decreasing the Q of a resonance by an order of magnitude might be perfectly attainable.

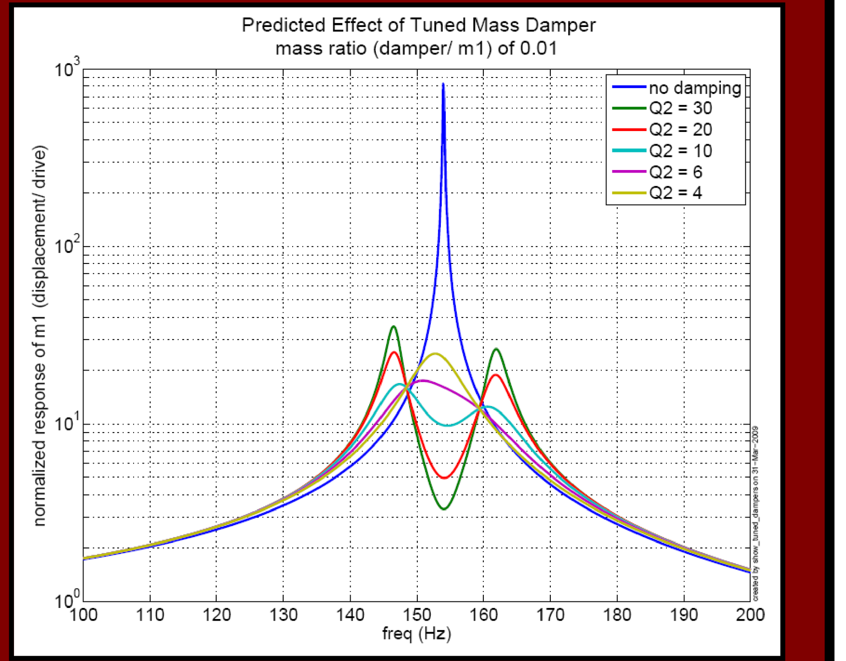
While damping cannot remove a resonance, it might reduce its effect enough to be below the noise floor or, at the least, become less significant.

Viton's is a viable damping material for LIGO, it is approved for use if procured and processed per E960050 and E960022, readily obtainable, and exhibits excellent damping properties at room temperature when placed in shear.

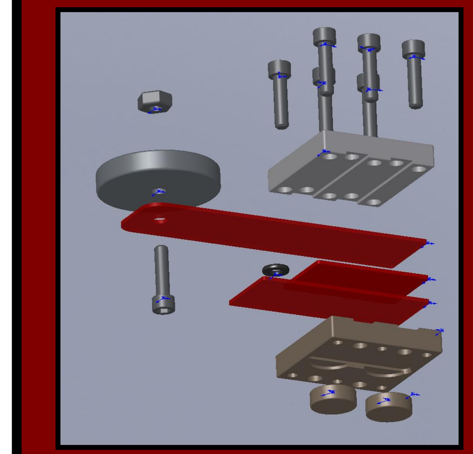
Tuned Mass Dampers



The HAM-ISI blade springs were observed to have a 153 Hz resonance mode. This was verified with FEA.

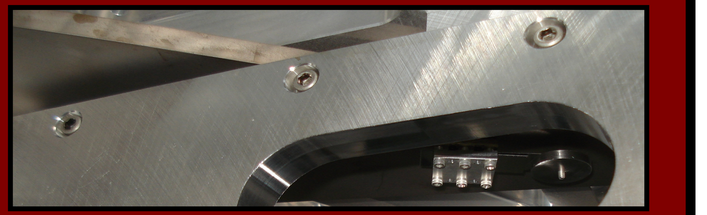


Calculations indicate that the optimal Q for the TMD is 6. This allows the best damping of the mode with a TMD mass to effective total mass ratio of 0.01.

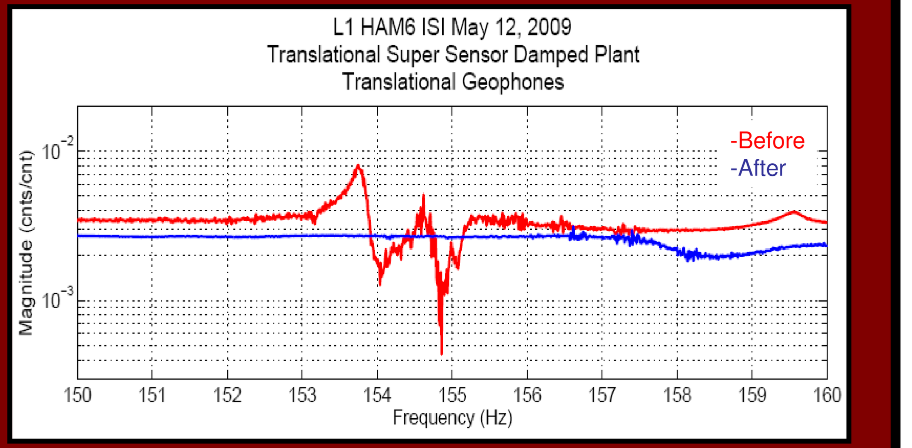


A TMD was designed and tuned to have a resonance of 153 Hz and a Q of about 6. A Viton o-ring, placed in slight shear, creates the loss. TMDs were then installed at the location of largest motion on the HAM-ISI blade springs.

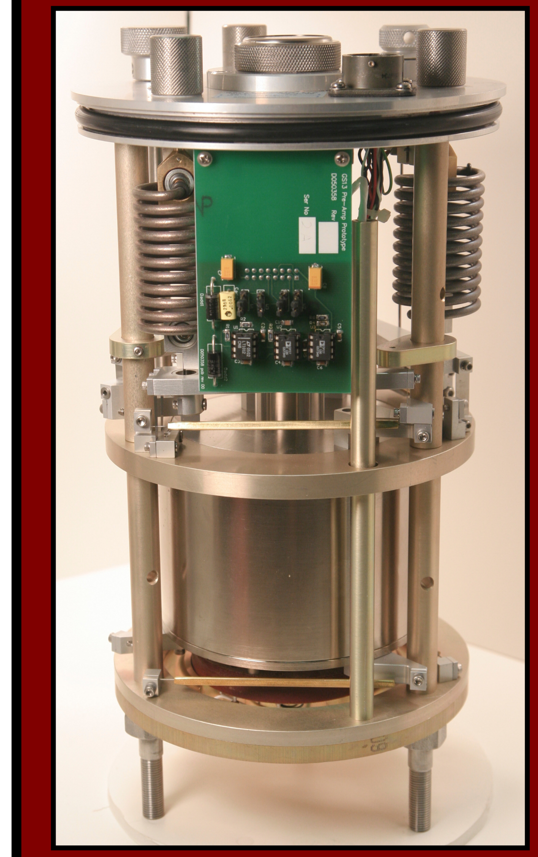
Jeff Kissel installed 3 TMDs at LLO in HAM 6. Later, 3 more were installed at LHO.



Before and after plot displays the effectiveness of the TMDs at damping blade spring resonances.



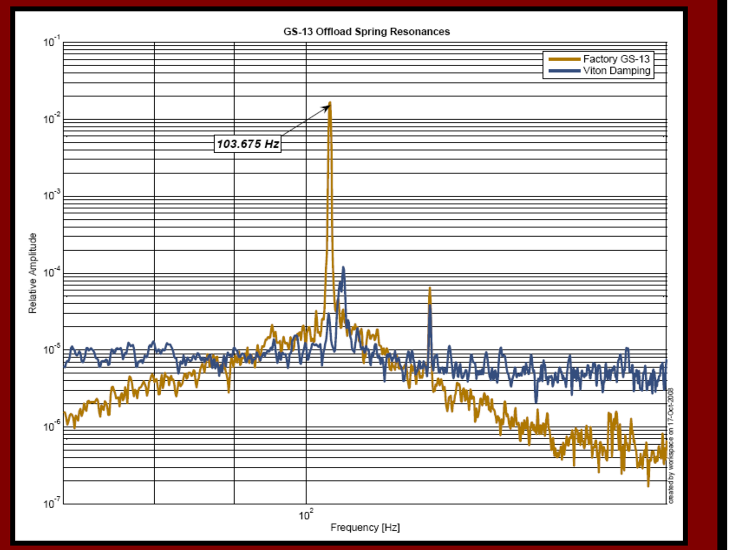
GS-13 Offload Springs

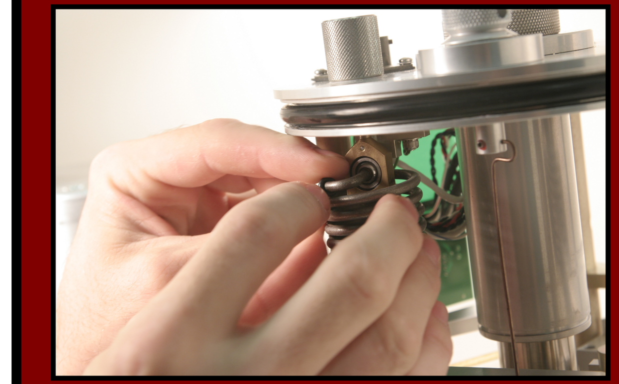


Every LIGO HAM-ISI, seismic isolation system, utilizes 6 Geotech GS-13 seismometers as sensors. A resonance in the GS-13 around 103 Hz causes a large spike in the system transfer function.

This was discovered to be a resonance mode of the three internal coil springs which offload the static gravitational force acting on the proof mass.

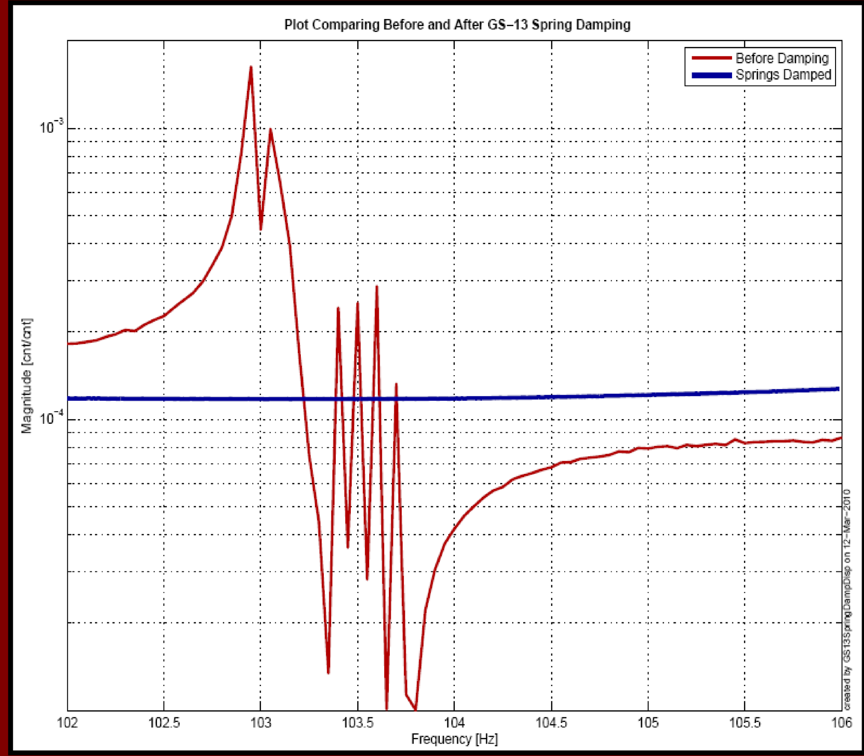
A preliminary test of plucking an offload spring while watching a laser / photo-detector output verified the resonance.



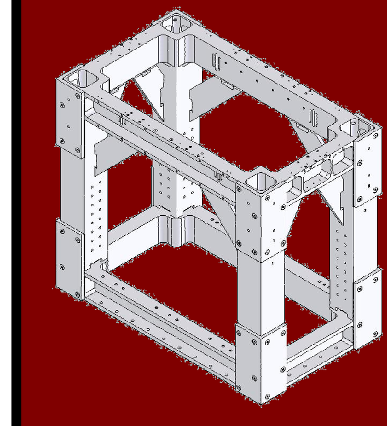


Viton o-rings were installed on all offload springs on the Stanford ETF platform's GS-13s. The o-ring was placed between adjacent coils near the fixed end.

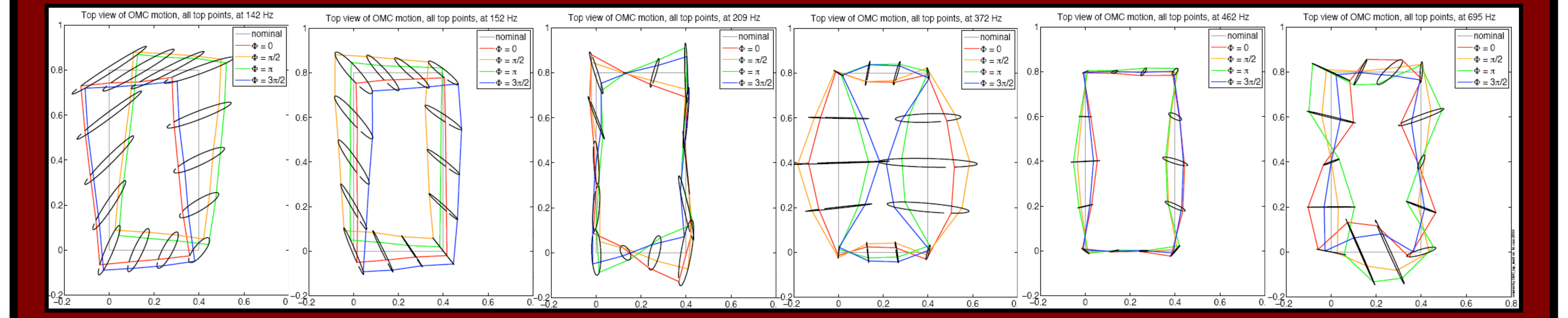
The red line in the adjacent plot displays the multiple resonances of the springs. The blue line is the result when all the springs are damped.

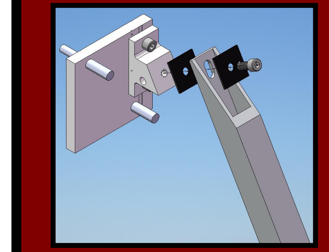


OMC Damping Struts

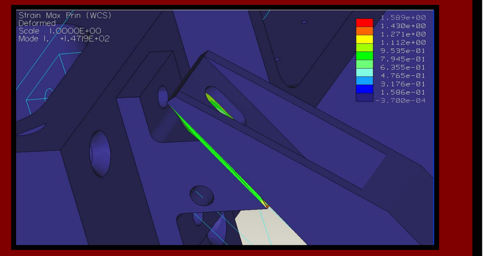


In HAM 6, the OMC cage is installed on the ISI. Two prominent resonant modes of the cage are clearly visible in the seismic isolation system transfer function. These make the control of the system more complicated. The resonances correspond with the first two translational modes of the OMC cage. The plots below show the first 6 modes of the OMC cage taken with an accelerometer and instrumented hammer. These first two critical modes are around 120 to 150 Hz – depending on the clamping method of the OMC cage to the table.



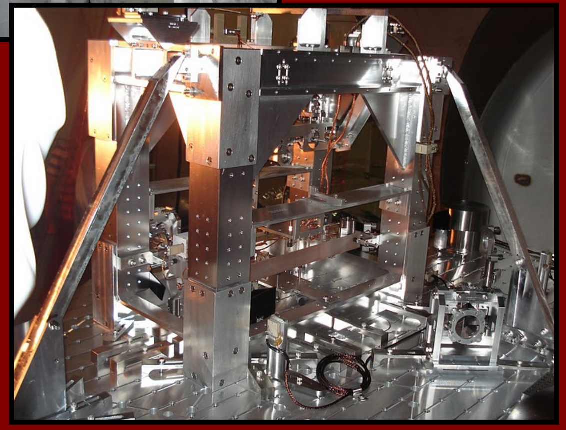


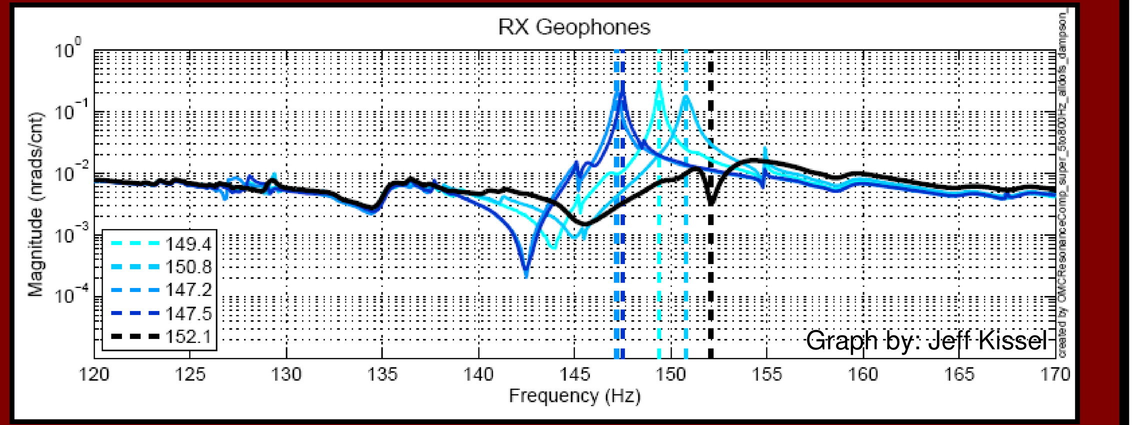
A strut was then designed which places a small pad of Viton in shear near the tip. The shear strain results were also predicted with FEA.

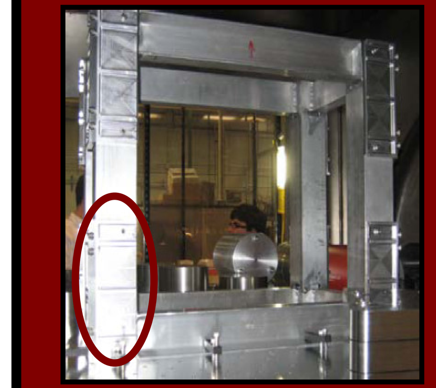


Two struts were then assembled and installed on the OMC cage in HAM 6 at LLO. To the left Brian Lantz is finishing the clean assembly with the installed struts pictured below.

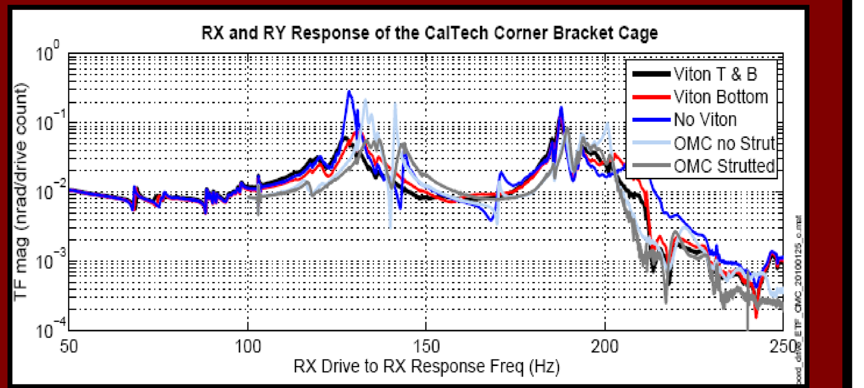
The result of the addition of the struts is an improvement in the transfer function as indicated below in the graph by the black trace. Not only was the resonance well damped, it also was increased slightly in frequency.







Kurt and Calum at CalTech also researched an alternative to struts – Viton backed corner brackets. This also is a viable option. With improved performance.



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