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RECENT RESULTS OF A SEISMICALLY ISOLATED OPTICAL TABLE PROTOTYPE DESIGNED FOR ADVANCED LIGO

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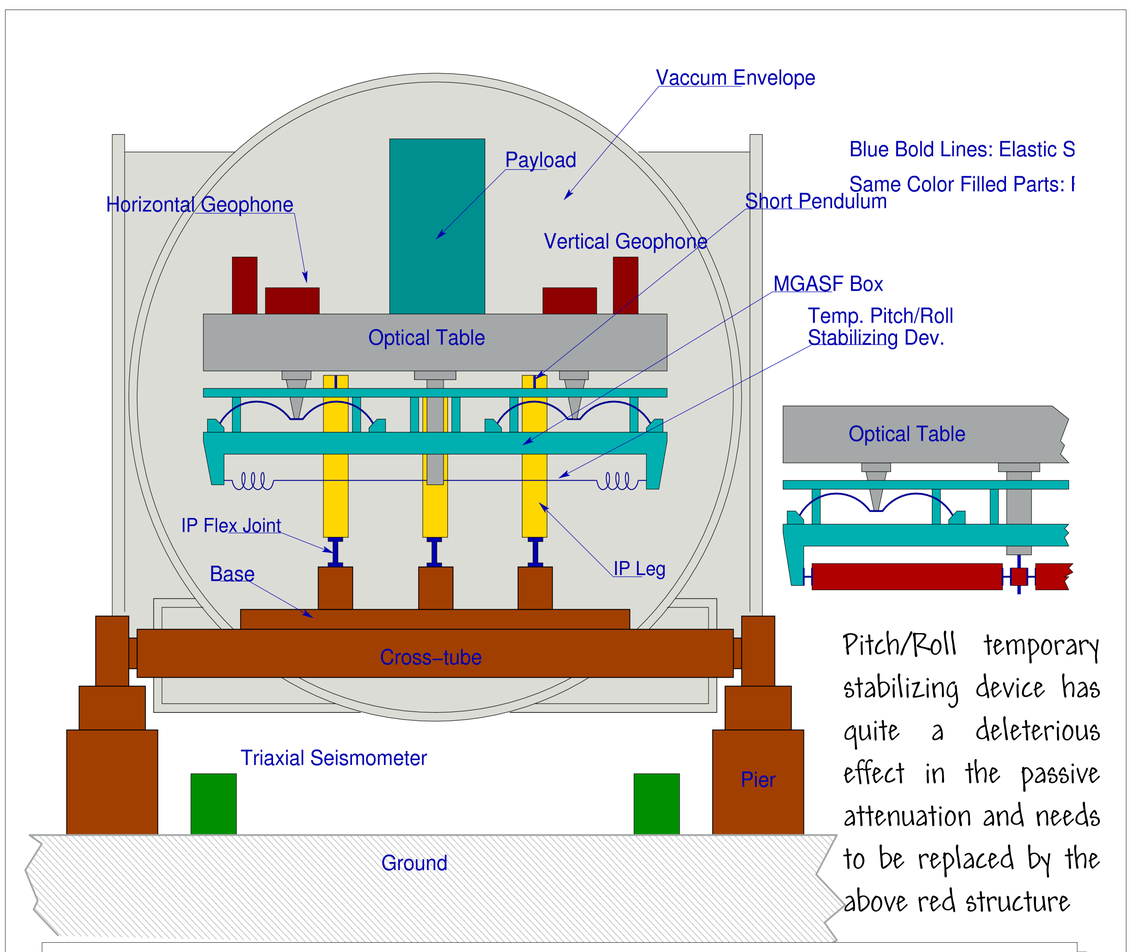
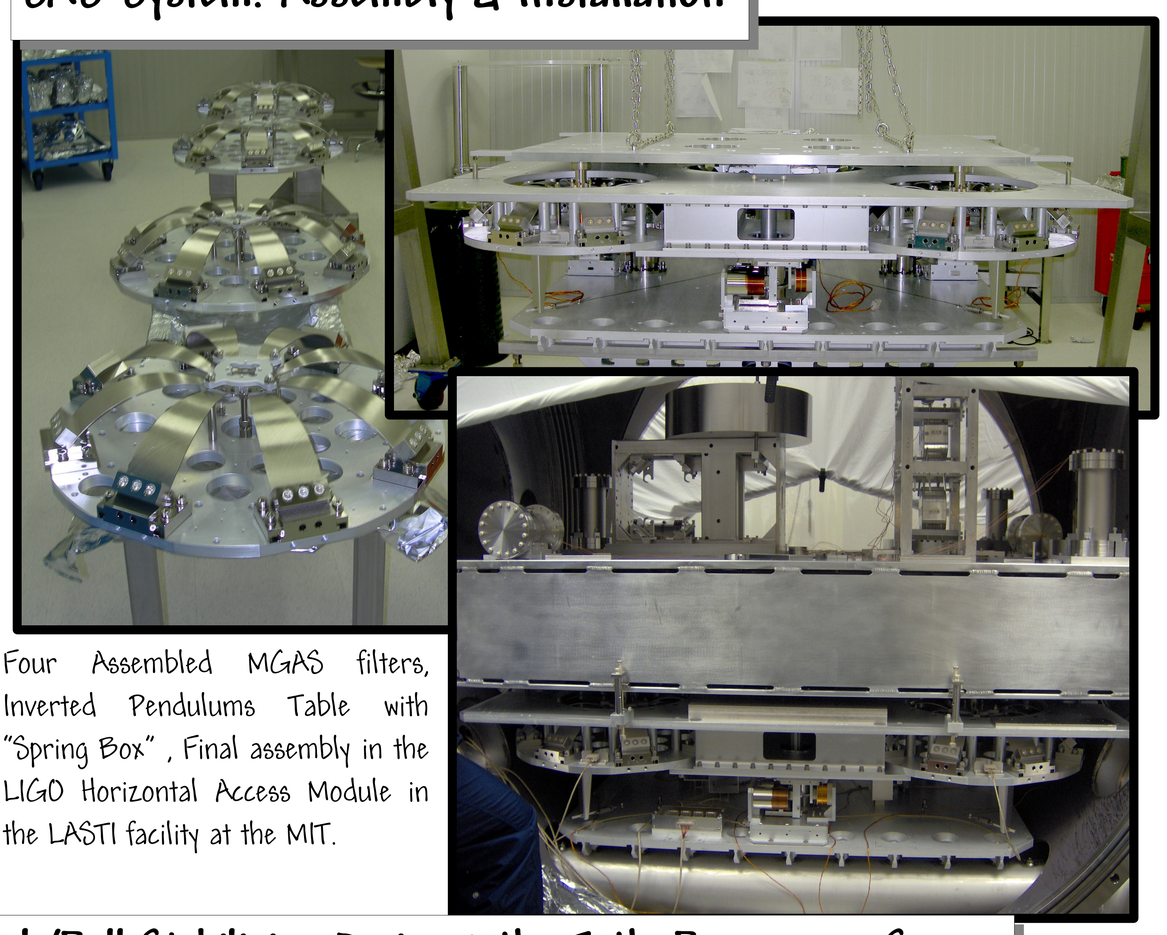
Abstract

The Horizontal Access Module Seismic Attenuation System (HAM-SAS) is a mechanical device expressly designed to isolate a multipurpose optical table and fit in the tight space of the LIGO HAM Ultra-High-Vacuum chamber. Seismic attenuation in the detectors' sensitivity frequency band is achieved with state of the art passive mechanical attenuators. These devices should provide an attenuation factor of about 70dB above 10Hz at the suspension point of the Advanced LIGO triple pendulum suspension. Automatic control techniques are used to position the optical table and reduce the low frequency rms motion. Here, we report the main results obtained from the full scale prototype installed at the MIT LIGO Advanced System Test Interferometer (LASTI) facility. Seismic attenuation performance, control strategies, improvements and limitations are also discussed.



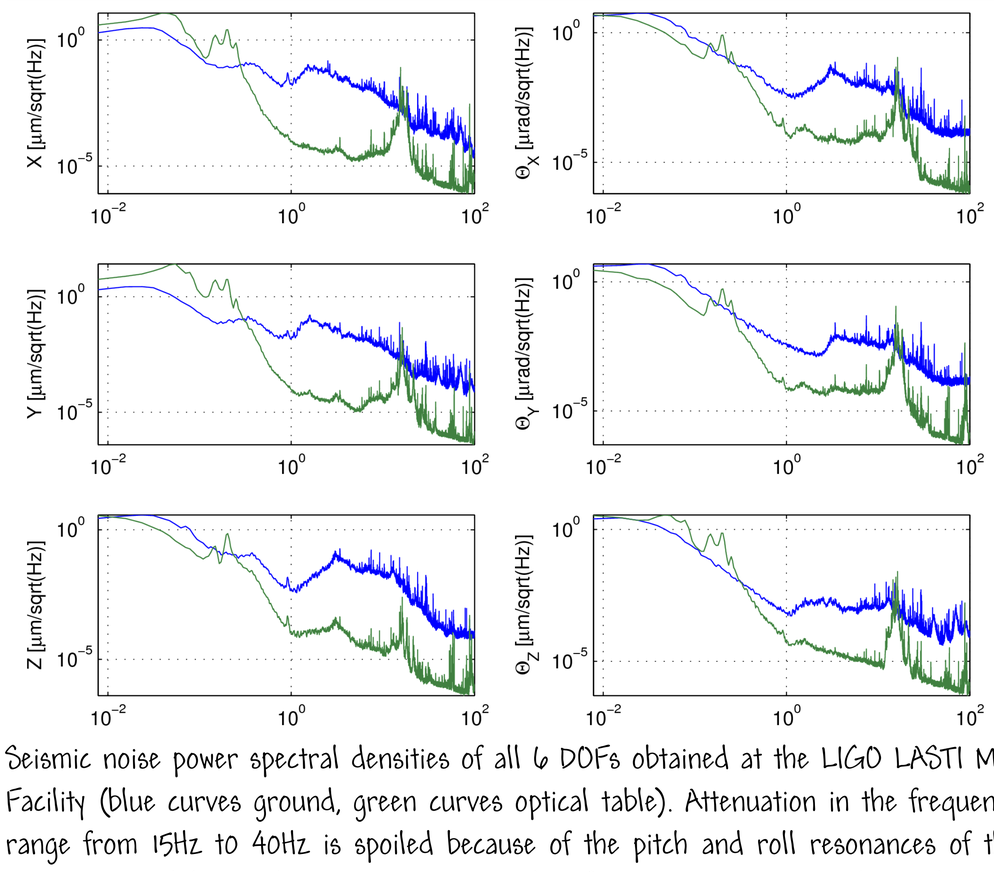
Pitch/Roll temporary stabilizing device has quite a deleterious effect in the passive attenuation and needs to be replaced by the above red structure

SAS System: Assembly & Installation



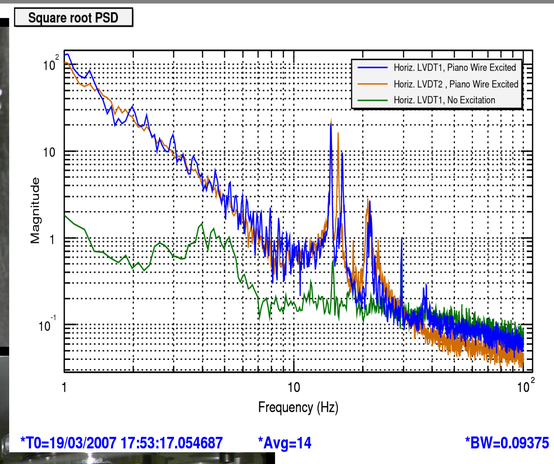
Four Assembled MGAS filters, Inverted Pendulums Table with "Spring Box" , Final assembly in the LIGO Horizontal Access Module in the LASTI facility at the MIT.

Passive Attenuation Performance: Seismic Noise PSDs

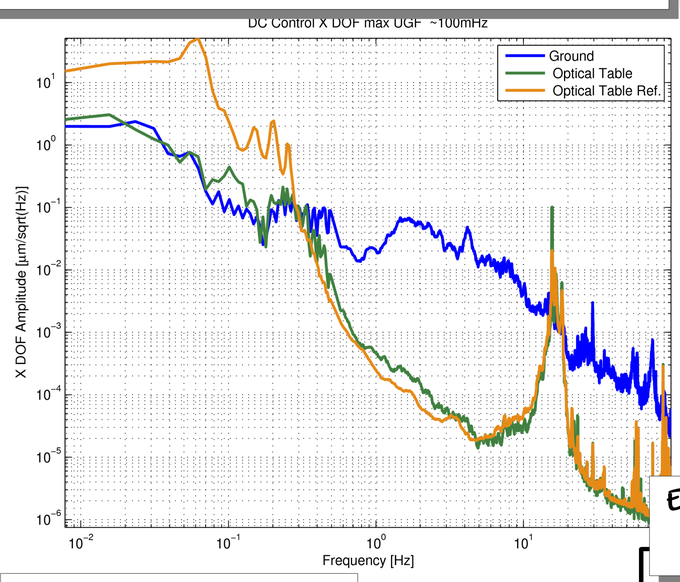


Seismic noise power spectral densities of all 6 DOFs obtained at the LIGO LASTI MIT Facility (blue curves ground, green curves optical table). Attenuation in the frequency range from 15Hz to 40Hz is spoiled because of the pitch and roll resonances of the temporary stabilizing device. Resonance in low frequency region are the undamped rigid body modes of SAS. Asymmetries in the MGAS table introduce coupling among all the DOFs.

Pitch/Roll Stabilizing Device: 10Hz-50Hz Resonances Source



DC Control Result: Horizontal DOF

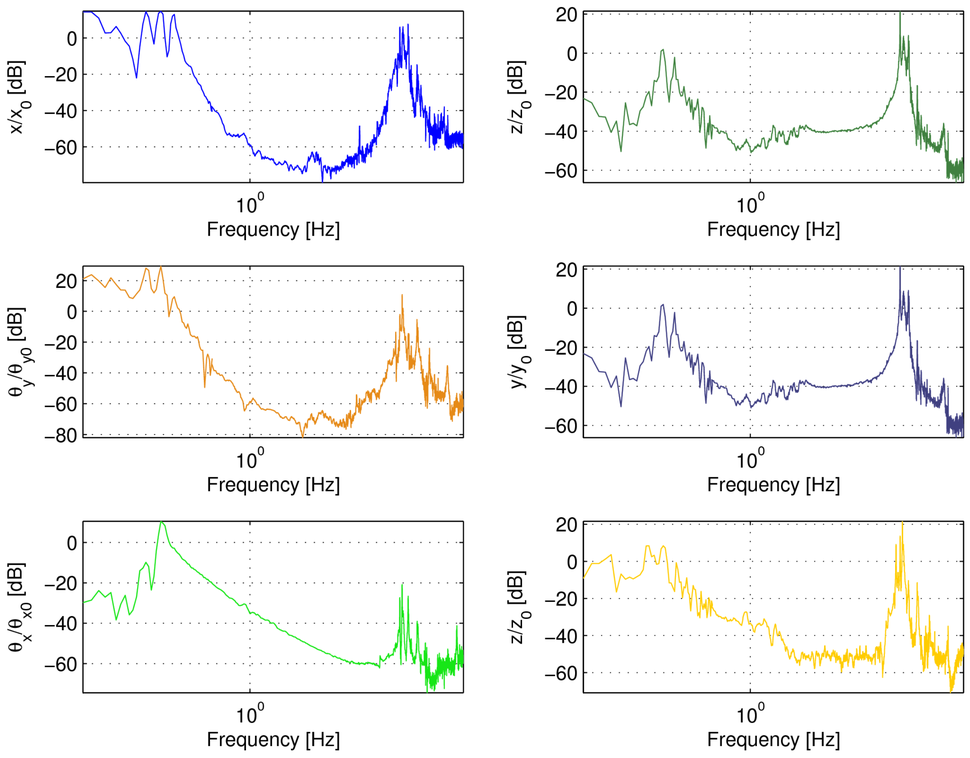


Control Strategy

- Mechanically tune all the rigid body modes close to the unstable equilibrium position ("EMAS" can be used as well).
- Apply a very low frequency relative to ground control position to recover the system to a stable equilibrium condition.
- Advantages: no resonances, minimization of control forces, maximization of passive attenuation, and minimization of the RMS Seismic Noise.

(THIS STAGE HAS NOT BEEN COMPLETED YET)

Passive Attenuation: Horizontal Transmissibility



Transmissibilities (transfer functions between ground and isolated platform kinematic variables of homologue DOFs) Attenuation of the Horizontal DOFs is more than 70dB. Resonance between 15Hz to 40Hz can be eliminated retrofitting a well designed Pitch/Roll stabilizing device.

CONCLUSIONS

Actual Performance do not completely meet the requirements. We are confident that the following modification will allow SAS to fulfill the LIGO Horizontal Access Module isolation requirements:

- Retrofit of the new stabilizing pitch/Roll device.
- Mechanical tune of ALL the modes below 80mHz or into a quasi stable equilibrium condition.
- Better tuning of the existing DC control scheme.

Possible Improvements that can increase SAS performance:

- Transmissibility saturation reduction using the "magic wands" and the IP counterweights. 10dB to 20dB of extra attenuation is expected.
- Use of the already present L4C geophones feedback to counteract the suspended optic swing during acquisition.

Example: Horizontal Direction Residual Seismic Noise Prediction at LIGO Livingston (noisiest site)