The AEI Seismic Attenuation System

for the AEI 10 m Prototype Interferometer

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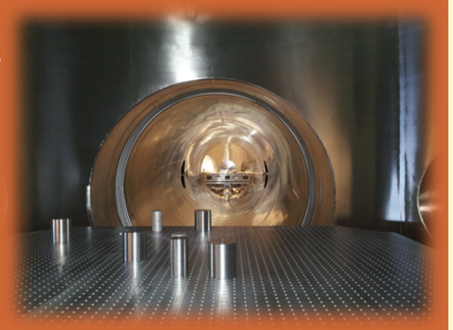
The 10 m AEI Prototype

Aims

- Developing novel techniques for future gravitational wave detectors
- High precision experiments such as measuring at the standard quantum limit (SQL)
- Required displacement noise better than 10^{-19} m/√Hz @ 200 Hz



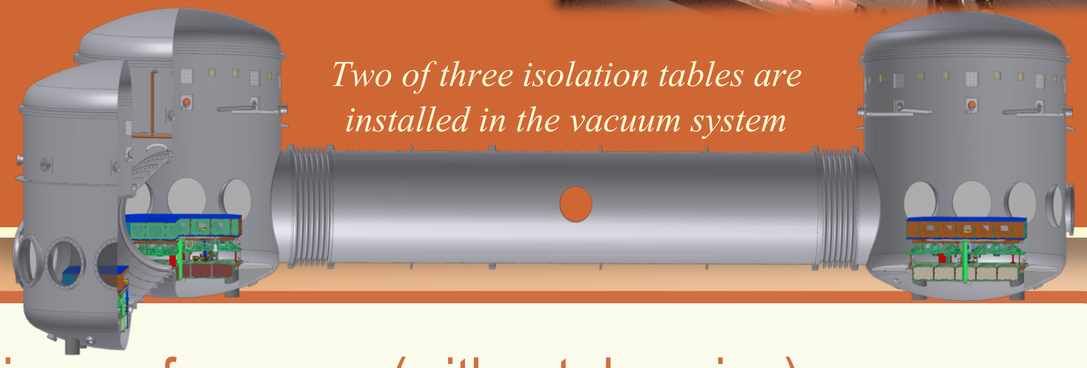
Challenges related to seismic motion

- Seismic noise: ≈ 10^{-11} m/√Hz @ 200 Hz and ≈ 10^{-8} m/√Hz @ 1 Hz
- Resonances of mirror suspensions between 1 Hz and 20 Hz couple RMS motion into the Interferometer

➔ **Seismic isolation is essential**

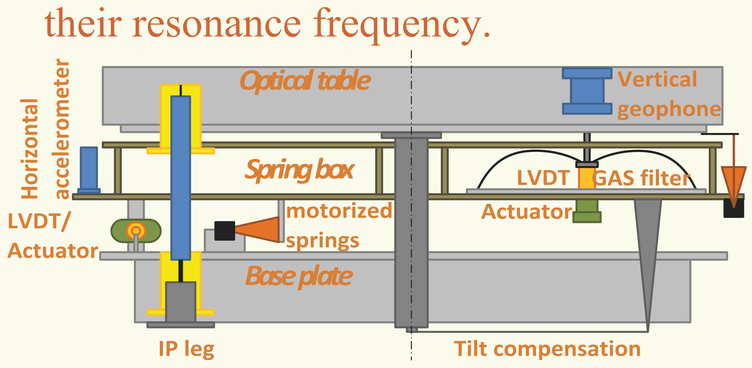
Seismic isolation for the Prototype

- One isolation platform in each of the three vacuum tanks
- Optical table with ≈ 1.75 m side length
- Ultra high vacuum compatible
- Isolation above resonance:
  - Horizontal: ~100 mHz
  - Vertical: ~250 mHz
  - Tilt: ~400 mHz
- Peak seismic isolation:
  - Horizontal: 60 dB
  - Vertical: 60 dB



Two of three isolation tables are installed in the vacuum system

The AEI Seismic Attenuation System (SAS) uses properties of harmonic oscillators, which isolate passively above their resonance frequency.



Schematic illustration of the SAS

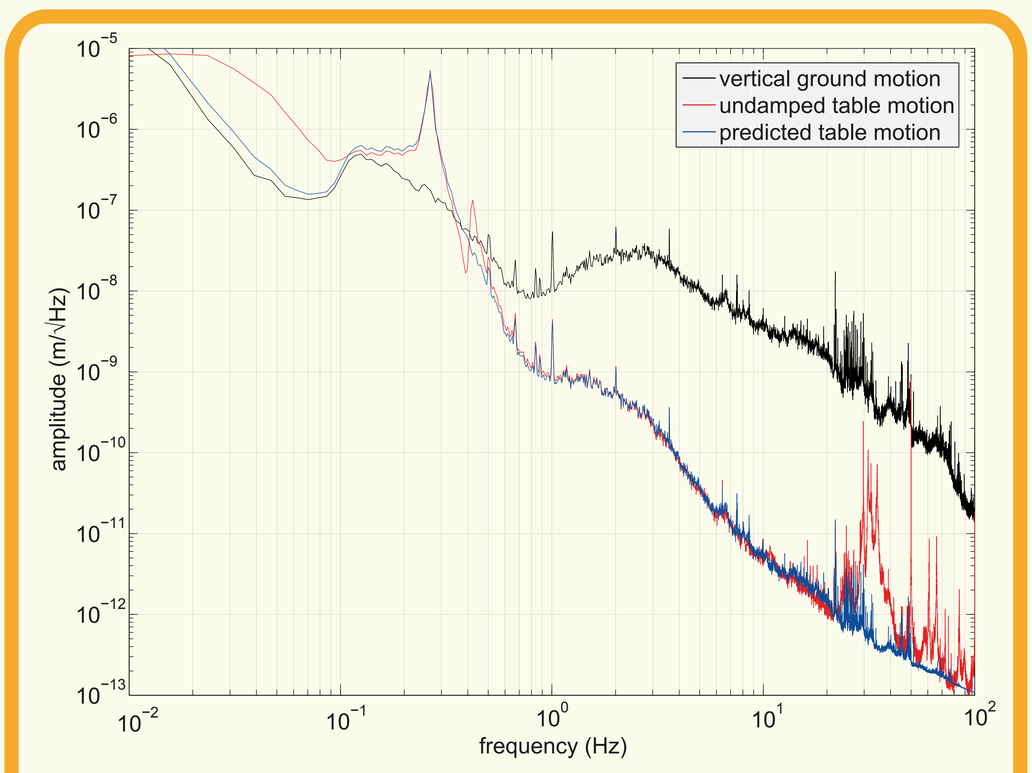
Horizontal isolation:
- Three Inverted Pendulum (IP) legs

Vertical isolation:
- Three Geometric Anti-Spring (GAS) filters

Sensing and actuation:
- LVDTs, accelerometers, geophones, coil-magnet actuators and motorized adjusters

Vertical isolation performance (without damping)

In-vacuum table inertial motion is compared with ground motion. The predicted motion is calculated using only one fitted parameter, the centre of percussion plateau. Geophone noise dominates below 0.07 Hz and above 30 Hz.



f_{res}=0.266 Hz Q=30 CoP plateau=10.5 Hz

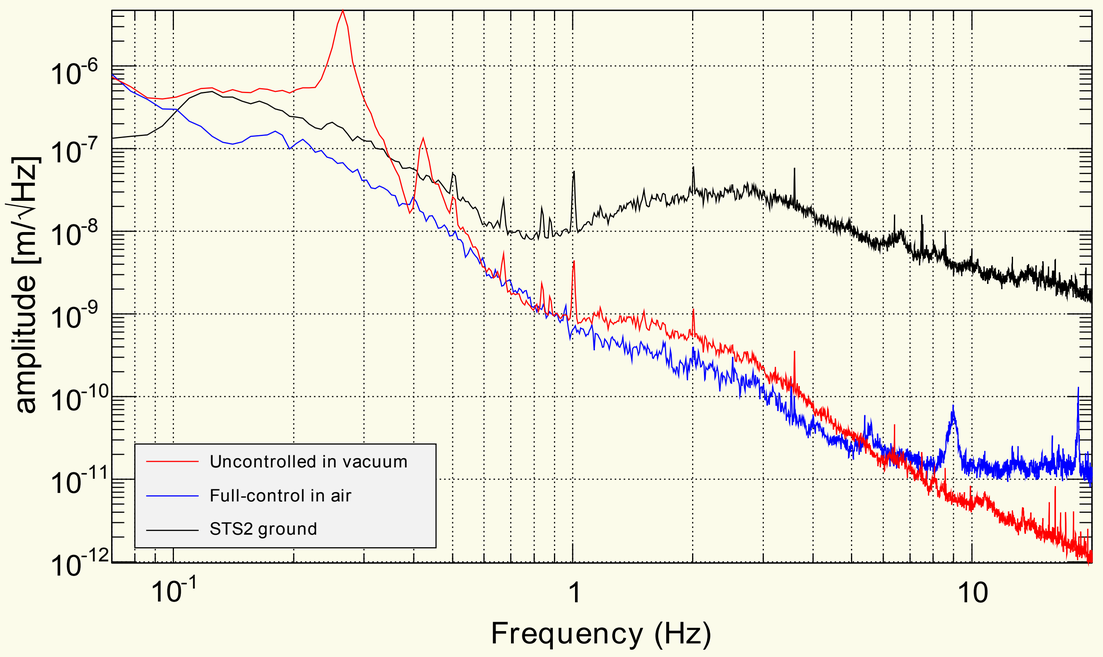
Control

Positioning 'by hand': using stepper-motors, to reduce the DC load on voice-coils

Local damping: for re-balancing the tables after optics installation, and as a 'safe mode'

Unconditionally stable: damping and slow integration

Full-control: High-bandwidth (~10 Hz UGF) using ground-motion corrected position sensors blended with inertial sensors and with relative positioning from the SPI.



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