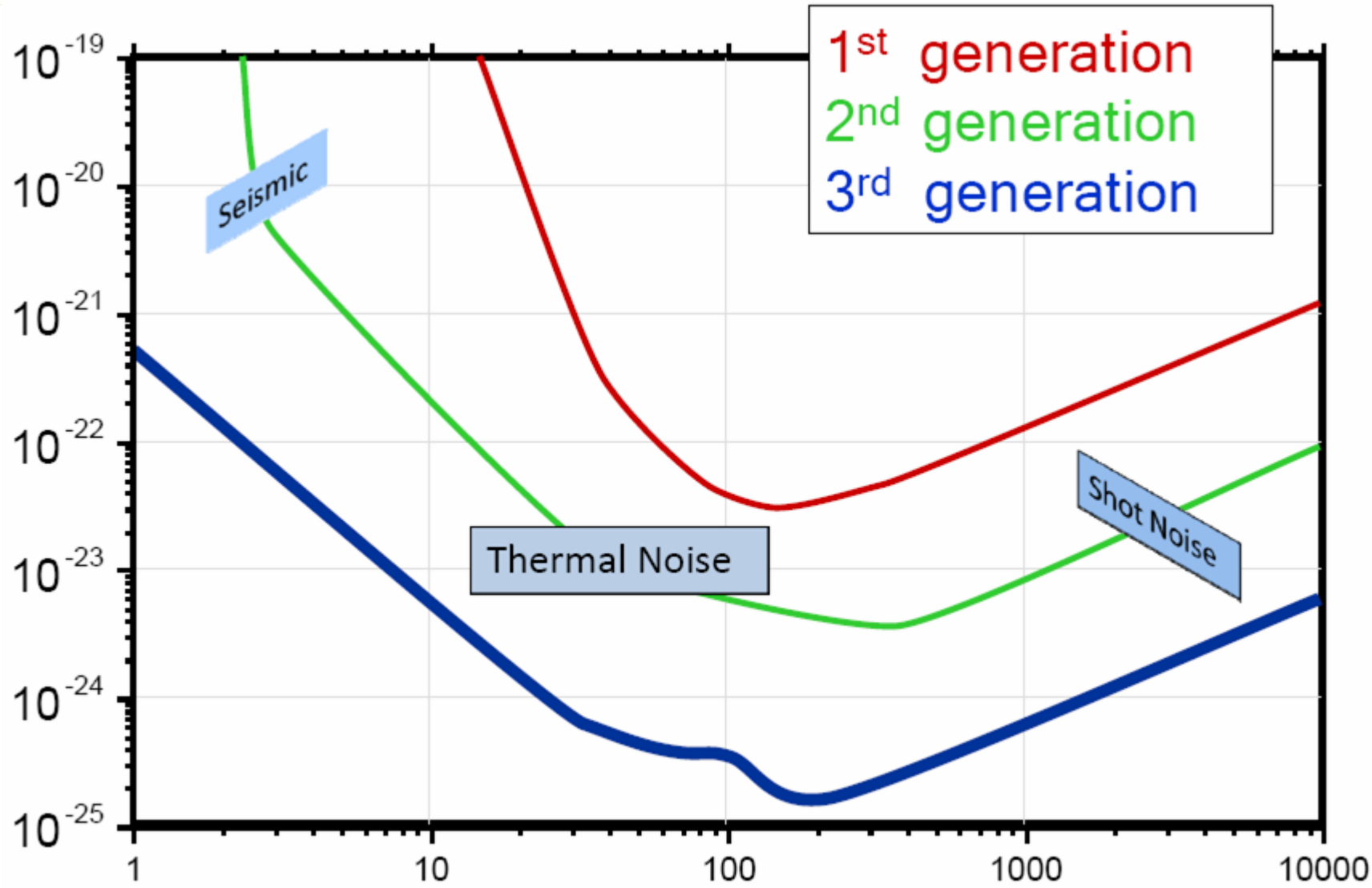
Suspension Point Interferometers?

Seismic Isolation for 3rd Generation Detectors

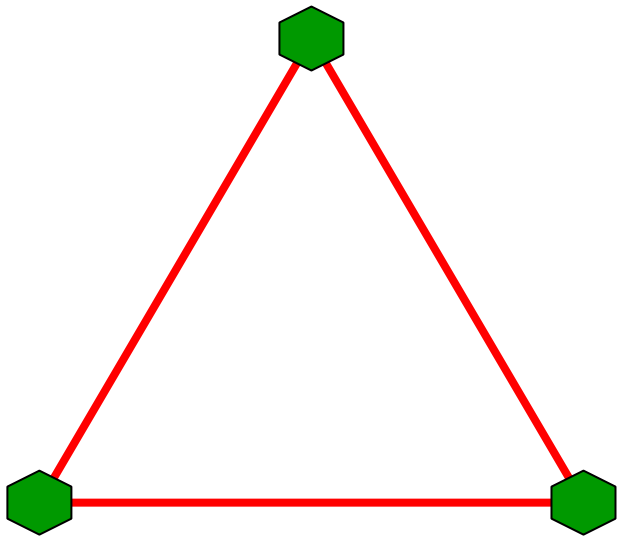
LIGO-G080526-00-Z

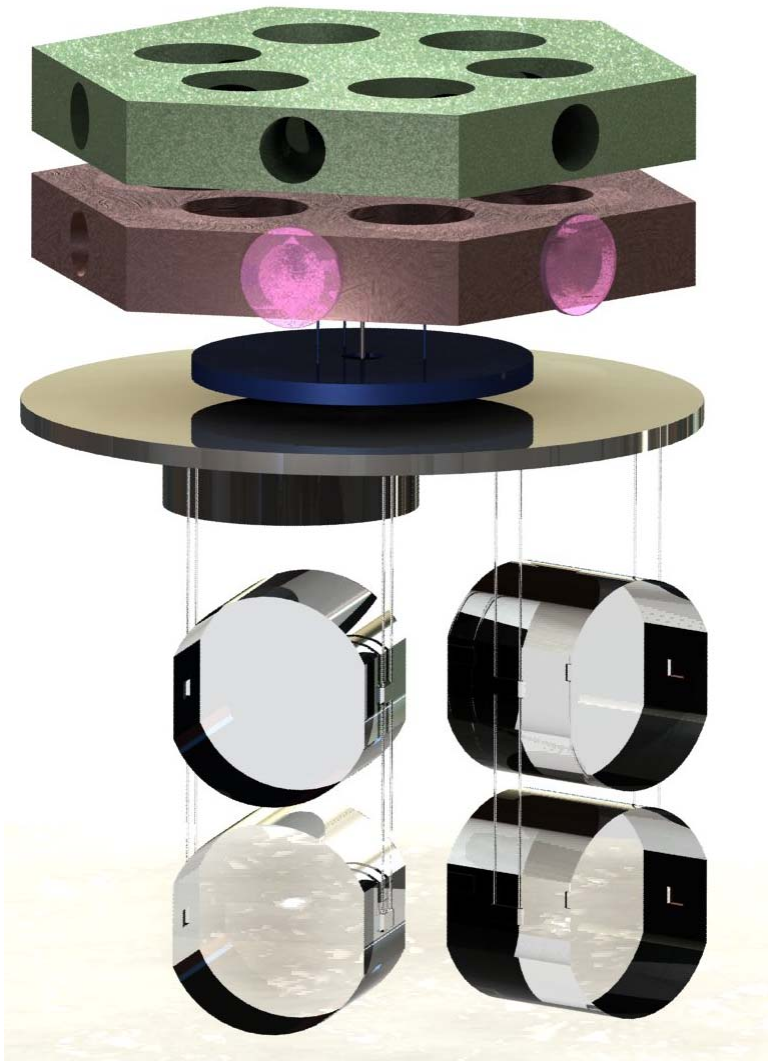
Where is the Seismic Noise?



Can we get to $10^{-18}\ m/\sqrt{Hz}$ at 2Hz?

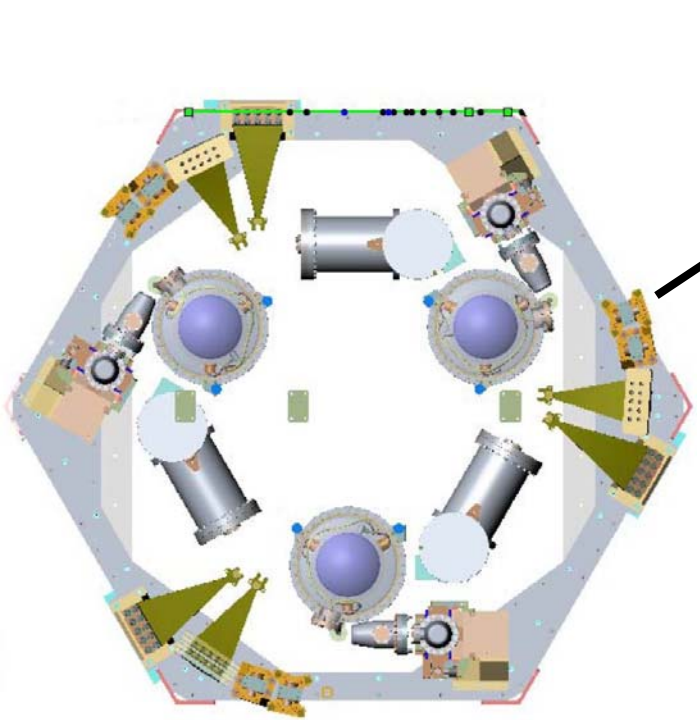
- Very difficult with all local isolation…
- With a Suspension Point Interferometer?

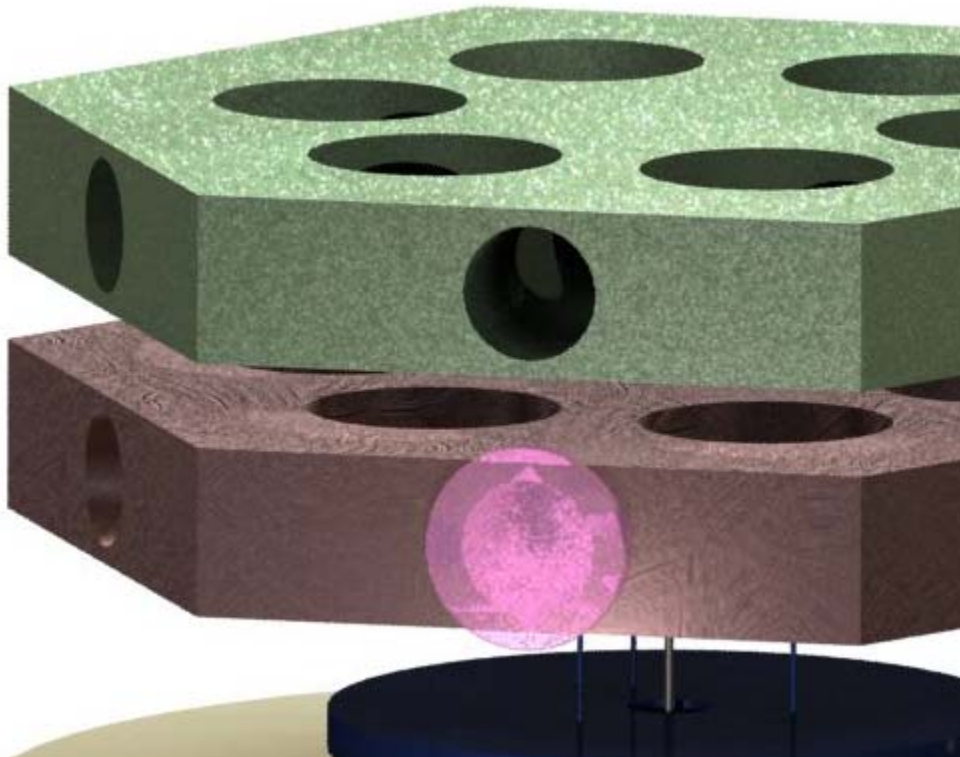




Pre-Isolation Stage

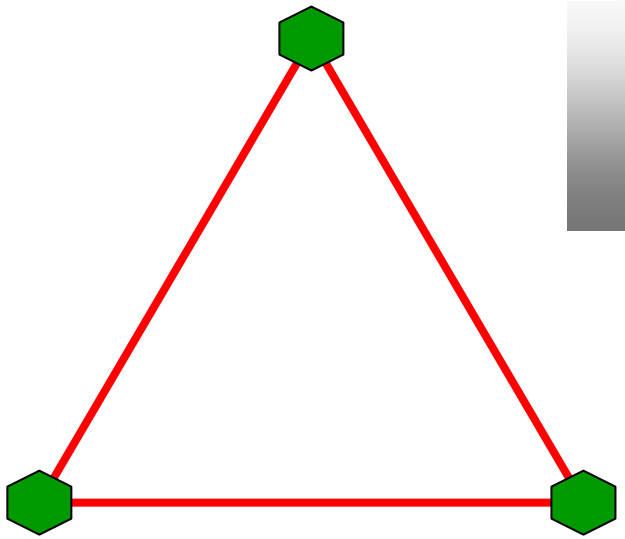
- Get to the $10^{-11} m/\sqrt{Hz}$ level
- This is working technology with the LIGO active platforms (i.e., HEPI + HAM ISI)

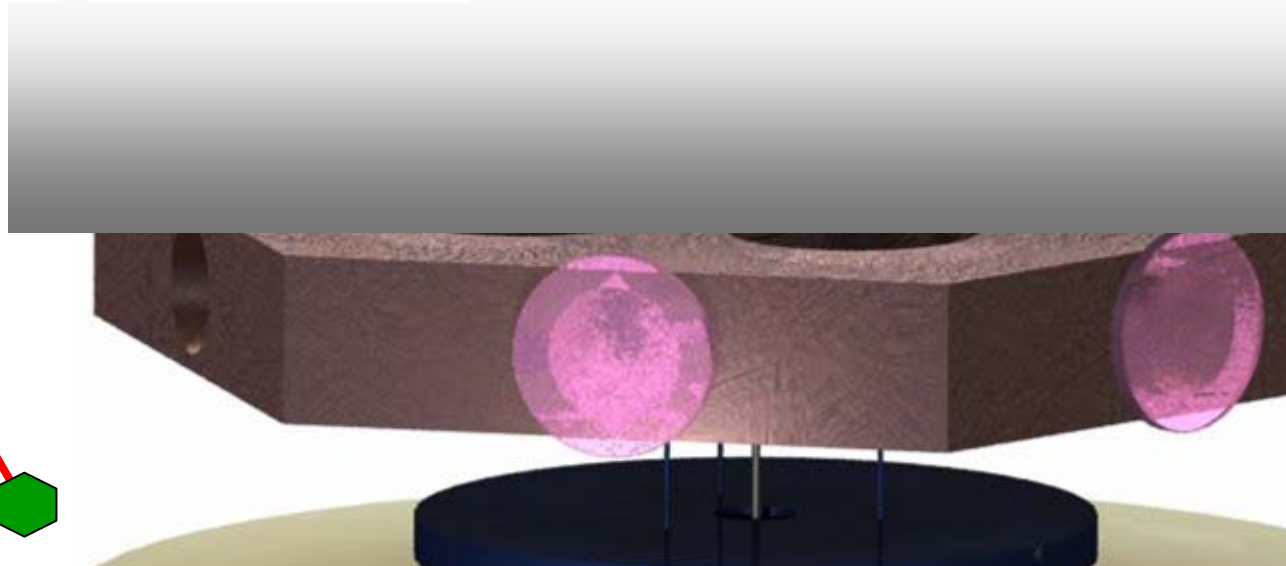




SPI Stage

- SPI made of 3 Fabry-Perot cavities
  - 10mW input power
  - Finesse of 60
  - Shot noise limited sensitivity is below
    - $10^{-16}\, m/\sqrt{Hz}$, $10^{-13}\, rad/\sqrt{Hz}$

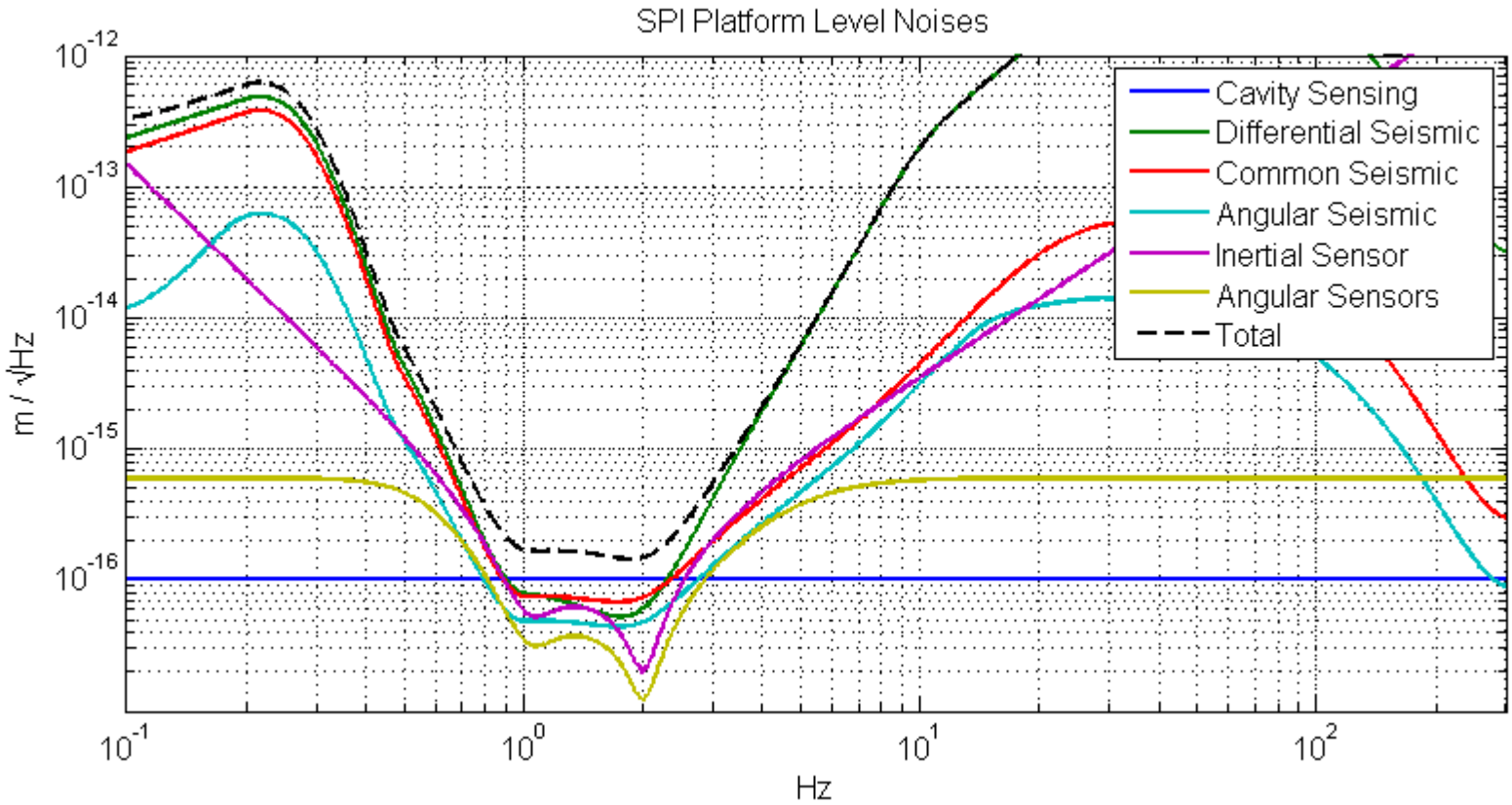




Noise at the SPI Stage

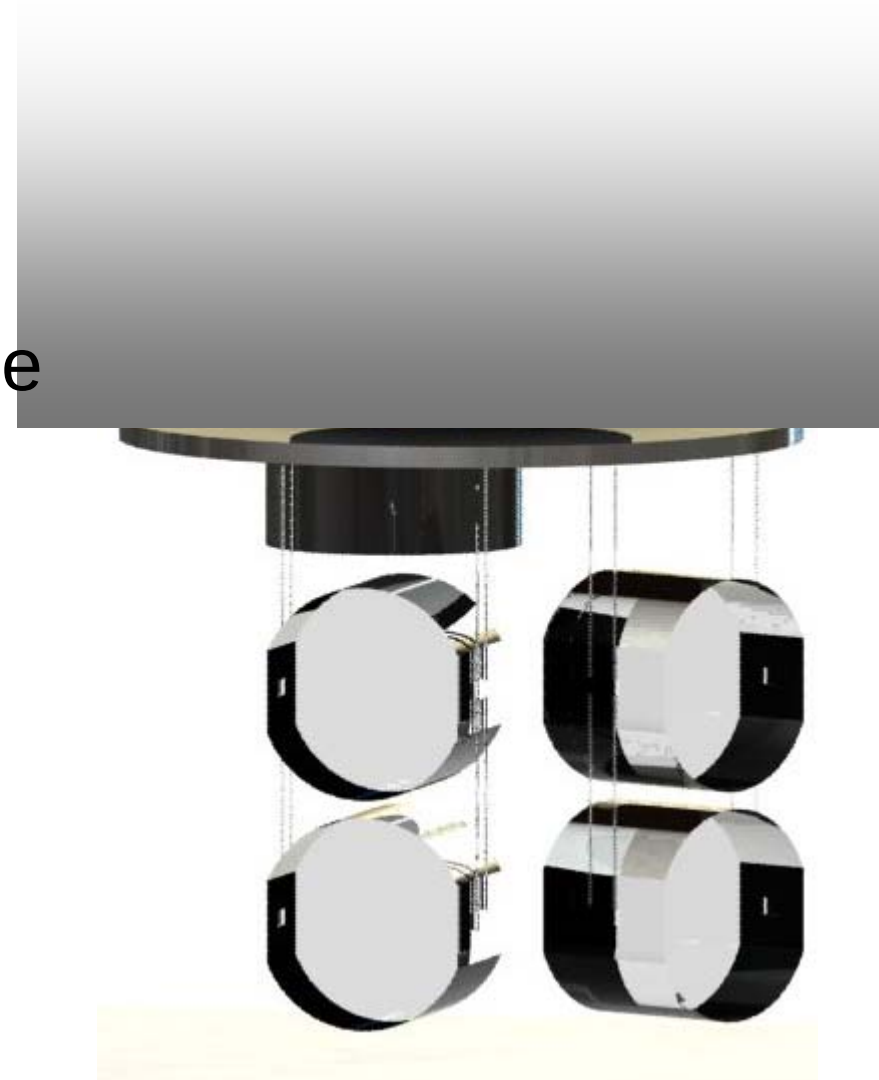
- Differential motion can be suppressed to the sensor noise level at 2Hz
  - Requires loop UGF of about 60Hz
- Common mode motion is suppressed by interferometric seismometers
  - Assume common-mode rejection of 100
- Angular motion suppressed by seismometers and SPI cavity signals
  - Assume angle to length coupling of 3mm

Noise at the SPI Stage



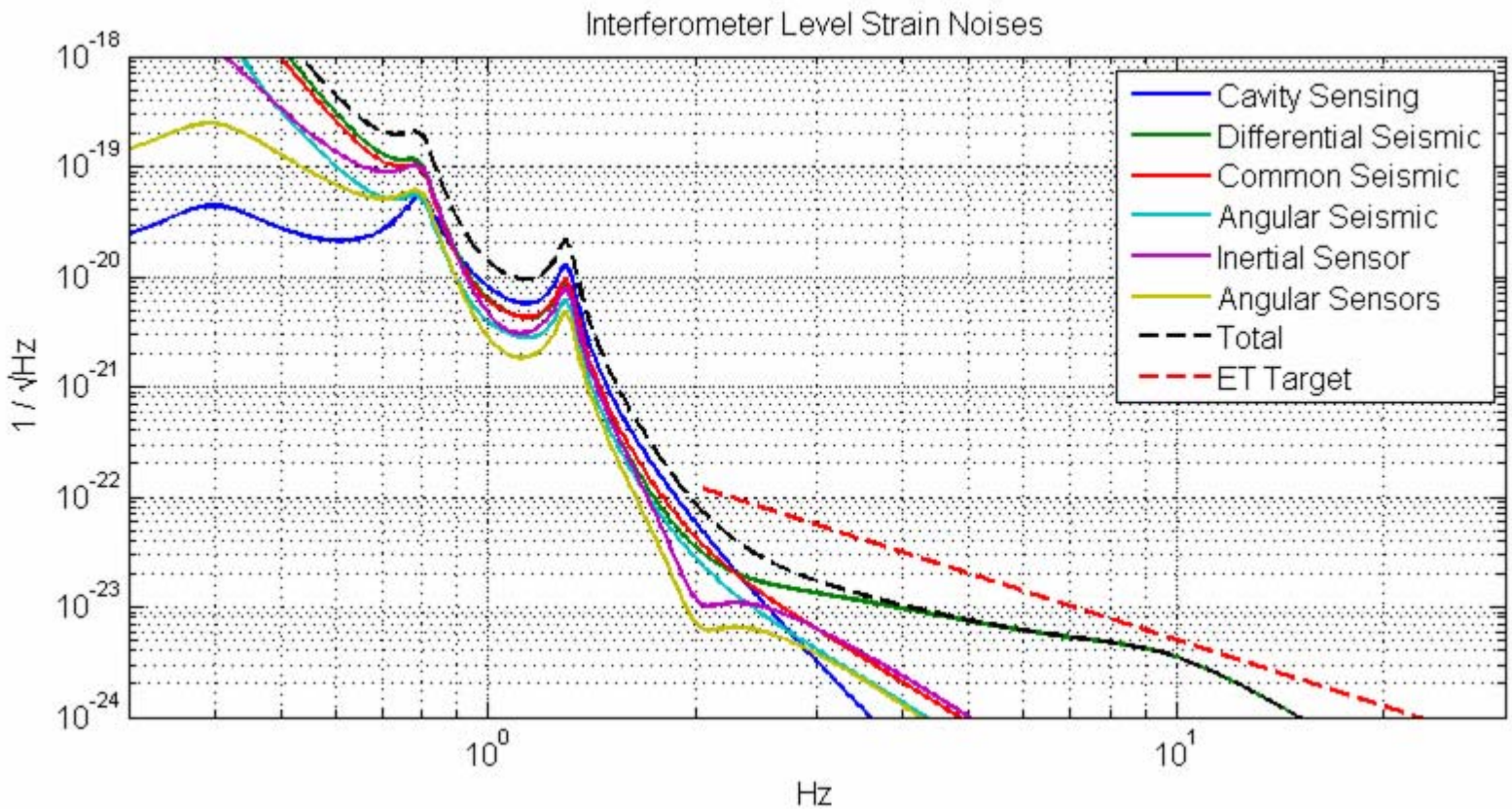
Passive Isolation

- Suspend test-masses from the SPI stage
  - From the center of the SPI stage to avoid angle to length coupling
  - At least a triple pendulum to cut-off noise increase of SPI platform above 2Hz



Noise at the Test-Mass

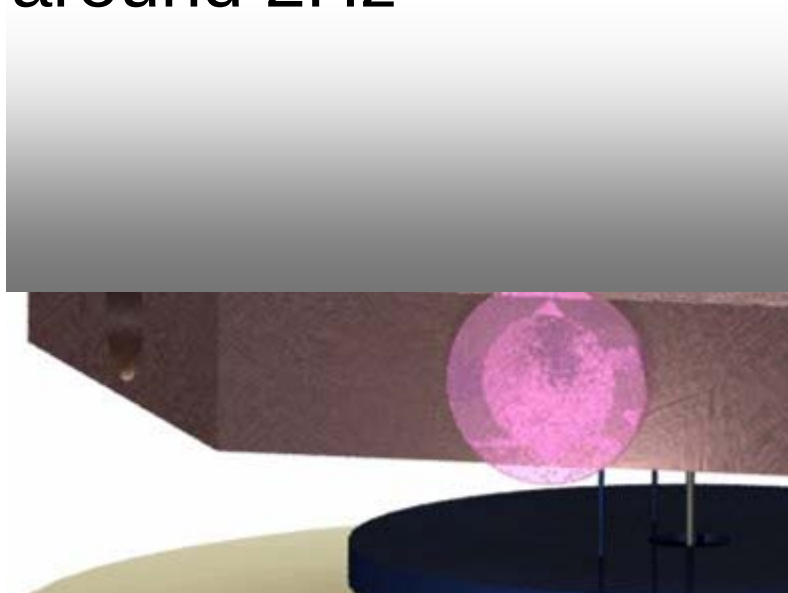
- Given 10km long arms…



But wait…
there are some hard parts.

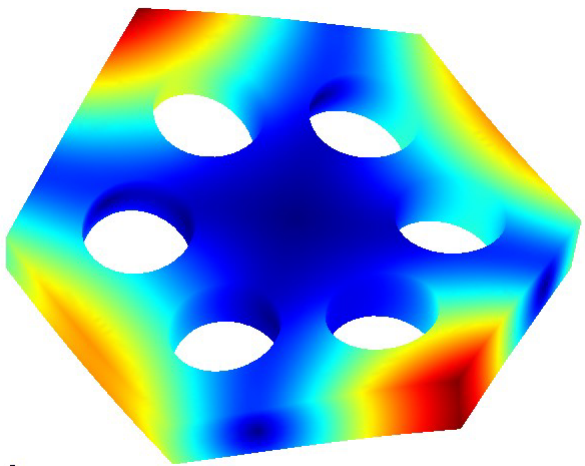
SPI Stage Seismometers

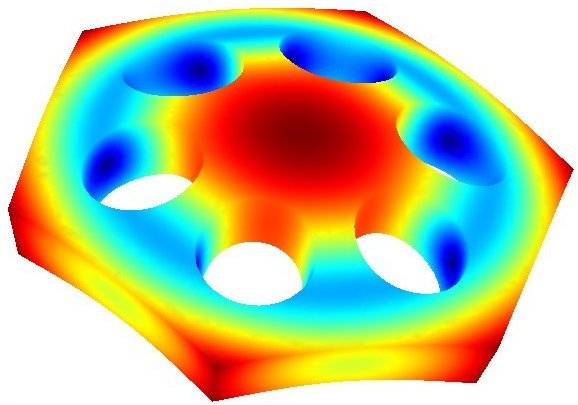
- For the vertical and tilt degrees of freedom, we will need some R&D on interferometric seismometers
  - We will need roughly $10^{-14}\, m/\sqrt{Hz}$
  - But only in a narrow band around 2Hz
    - High-Q suspensions
    - Few mW interferometer

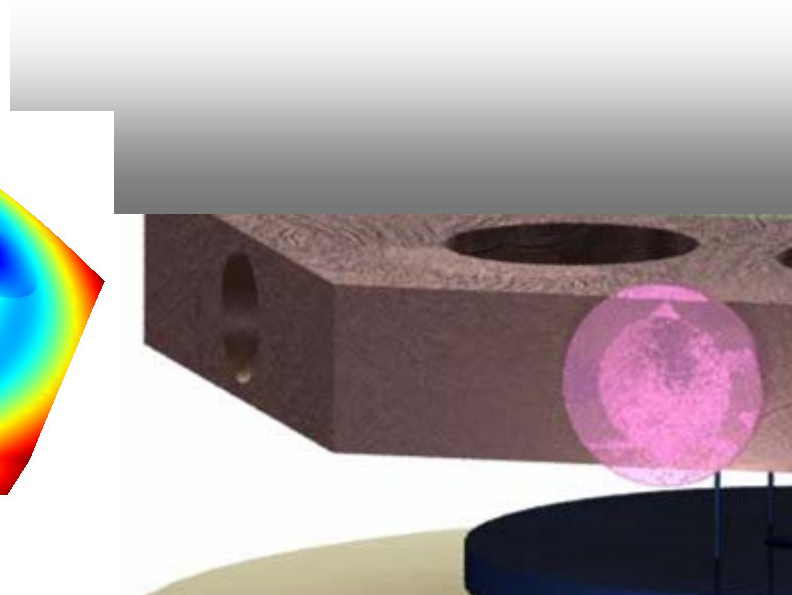


SPI Stage Mechanics

- Current LIGO active platforms have a control band-width of about 30Hz
- This is limited by mechanical resonances of the structure
  - Need a very rigid platform

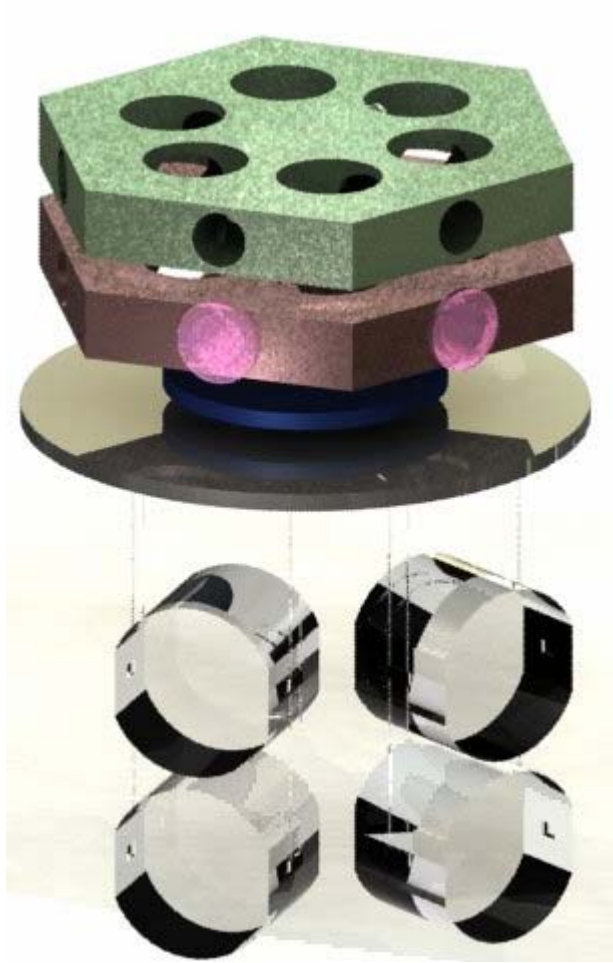




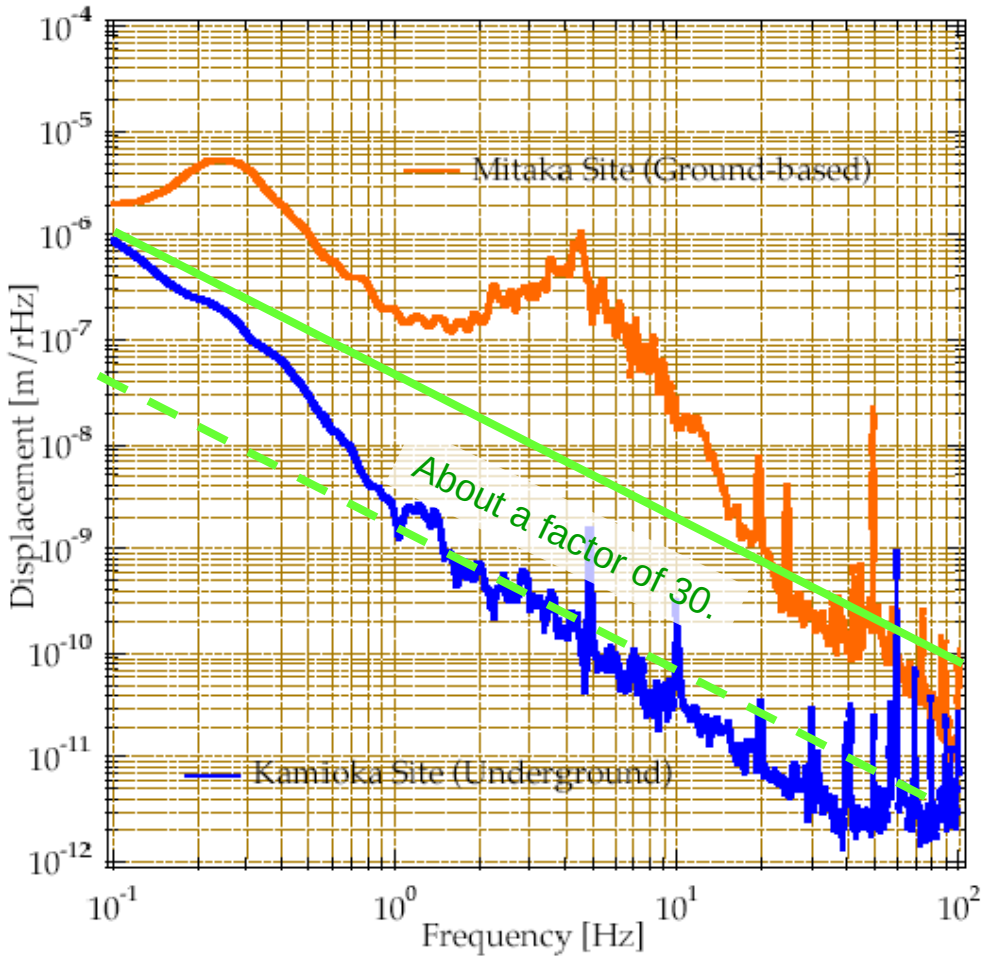


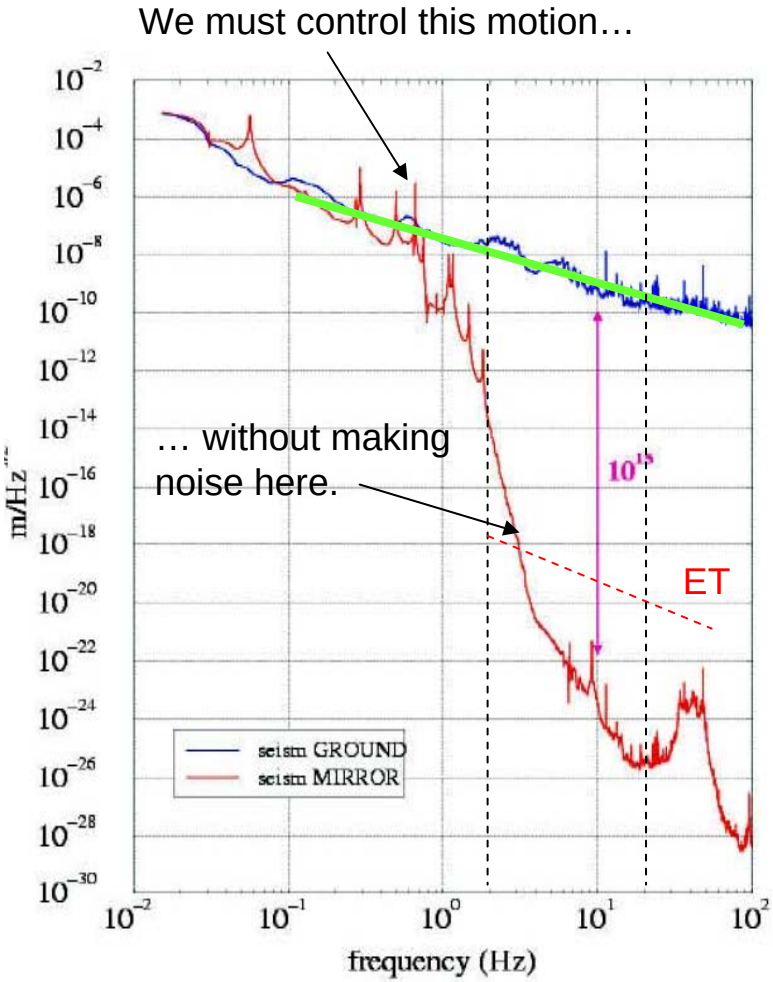
Conclusions

- The “seismic wall” can be pushed down to a few Hz
  - With proven technology,
  - some engineering,
  - … and a little R&D
- 3rd generation detectors have bigger problems than seismic noise, but it shouldn’t be forgotten



The Super Attenuator?





These plots taken from Punturo, ILIAS General meeting, Feb 2008