Passive attenuation for the LIGO Output mode cleaner; HAM SAS

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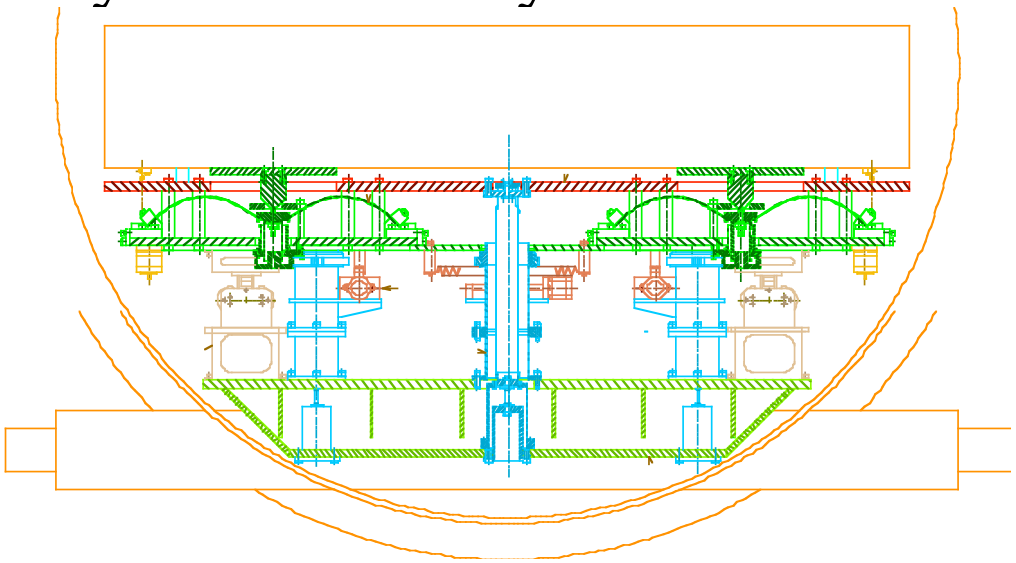
Design considerations

- Simplest possible seismic attenuation system.
  - One single stage of passive attenuation
  - Fully UHV compatible
  - Suitable for all conceivable options of OMC
  - Satisfying LIGO and Adv-LIGO requirements for all HAMS
  - Broadband attenuation performance 50~60 dB
  - Tidal correction and < rad alignment incorporated
  - Earthquake protection incorporated
  - Upgradeable to active attenuation as reserve of att. power
  - As inexpensive as possible
    - Can replace stacks even without replacing optical tables

Results

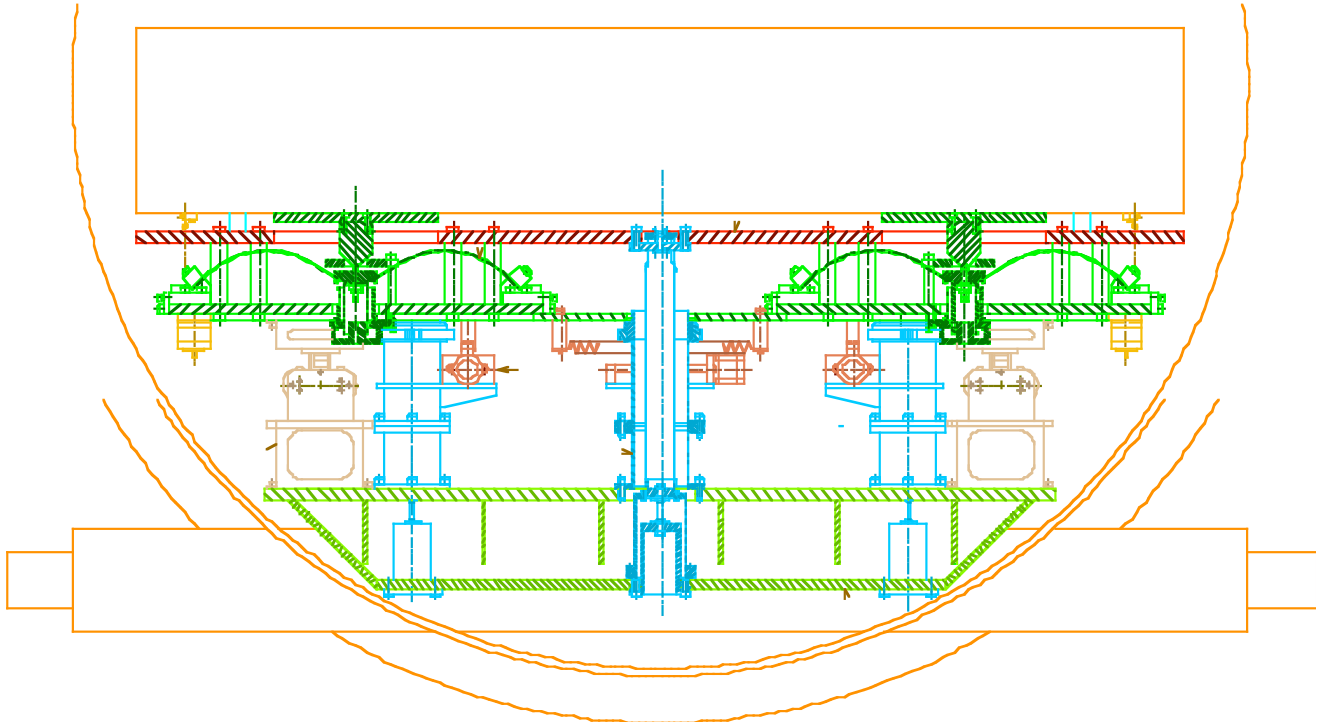
- Expected performance compatible to cumulative performance of all three layers of ad-LIGO active attenuation
- Cost of one single layer
- Less control complexity than a single layer (passive)
  - equal complexity, if upgraded, to active attenuation
- Suitable to instrument any HAM for any load



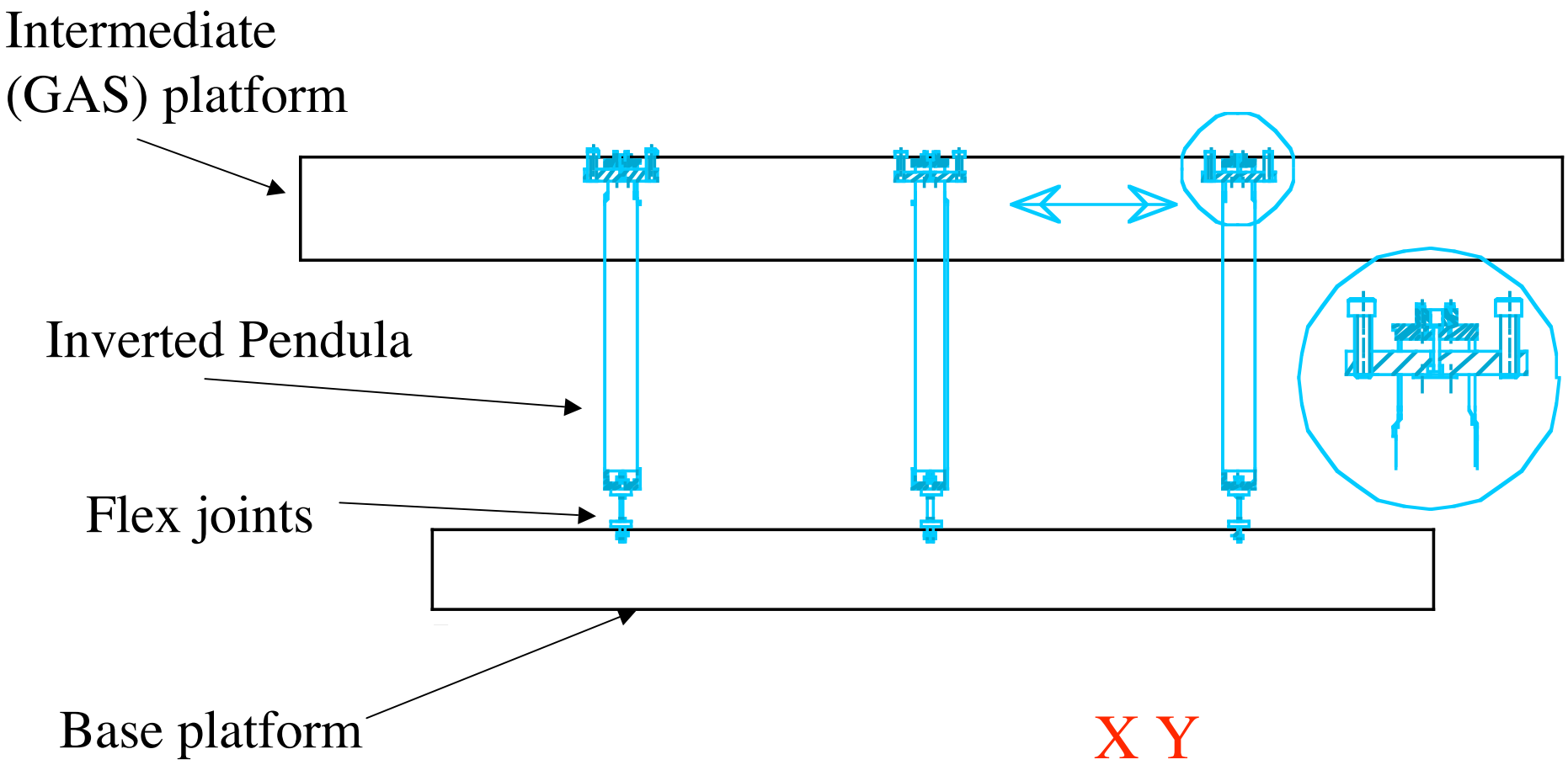
www.LIGO.caltech.edu/~desalvo/HAM-SAS

Notable characteristic

- Horizontal and vertical degree of freedom decoupled

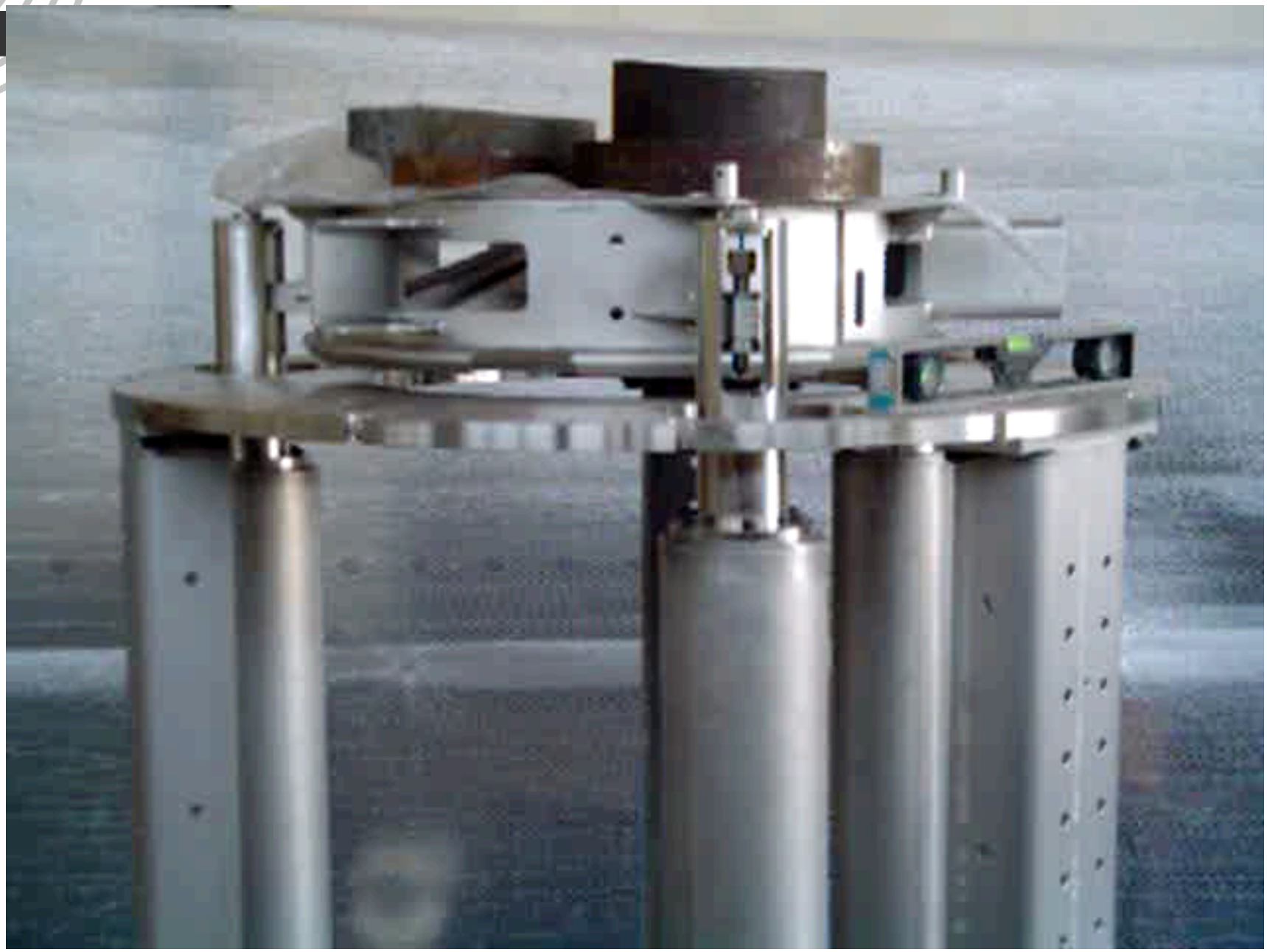


Horizontal attenuation

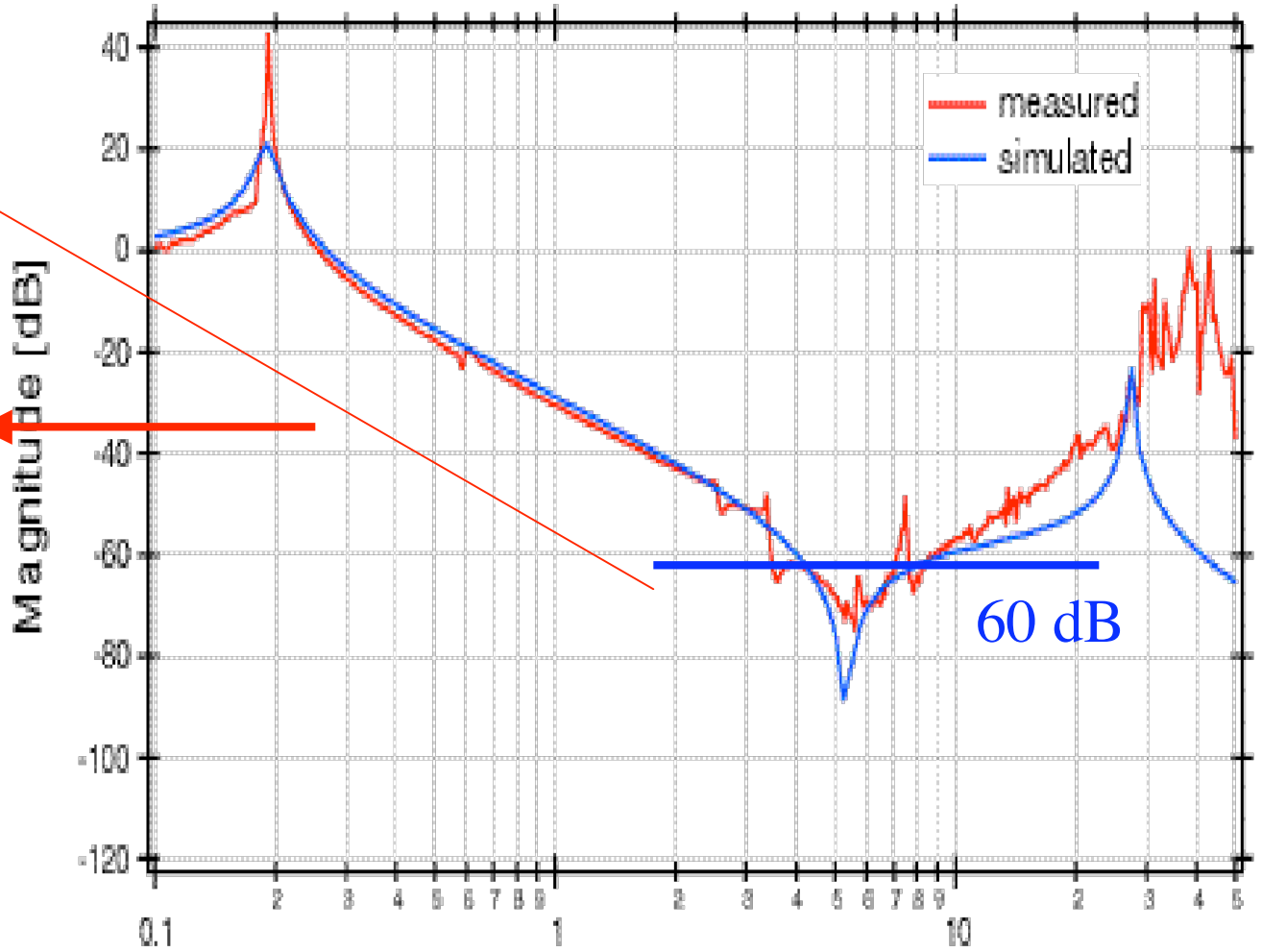


Illustrating
An IP performance

Earthquake generator
shaking tower

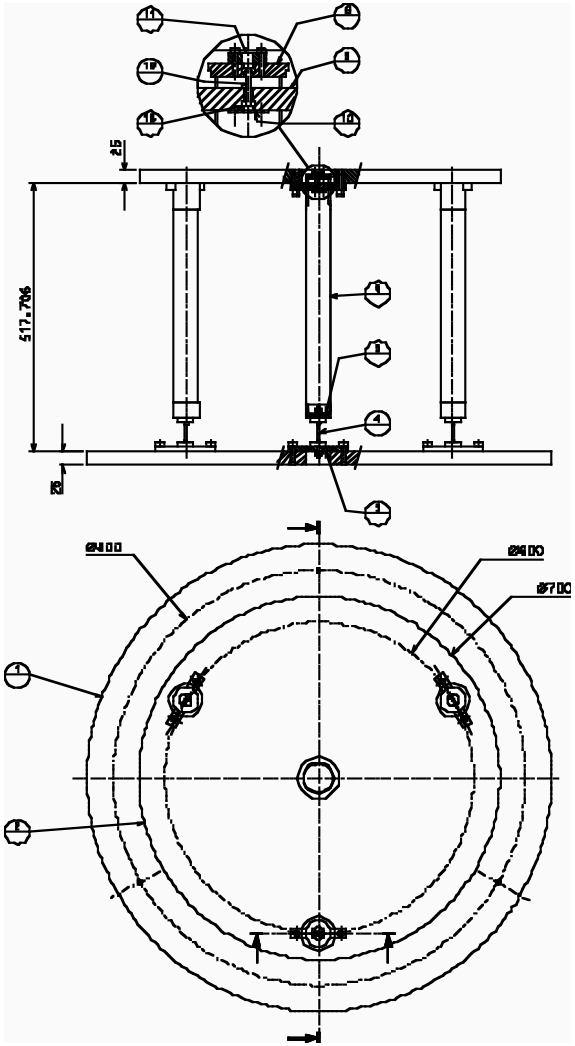


Typical IP performance

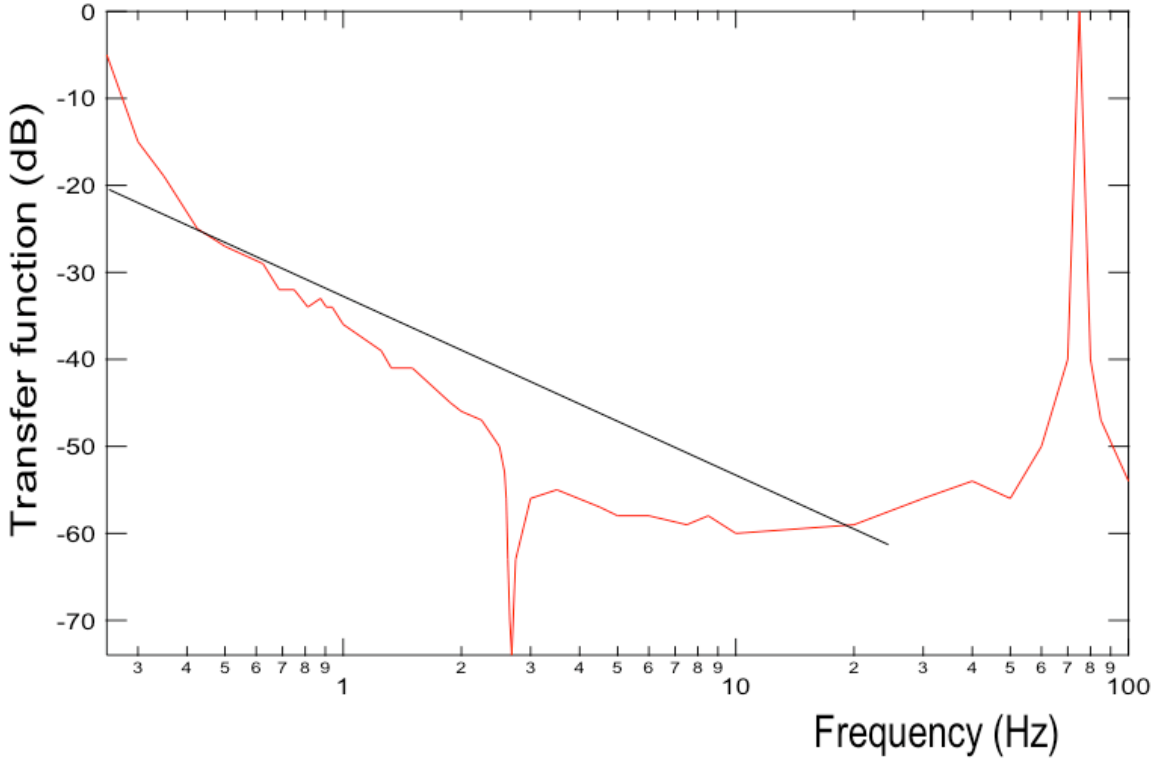


To 10 mHz resonance

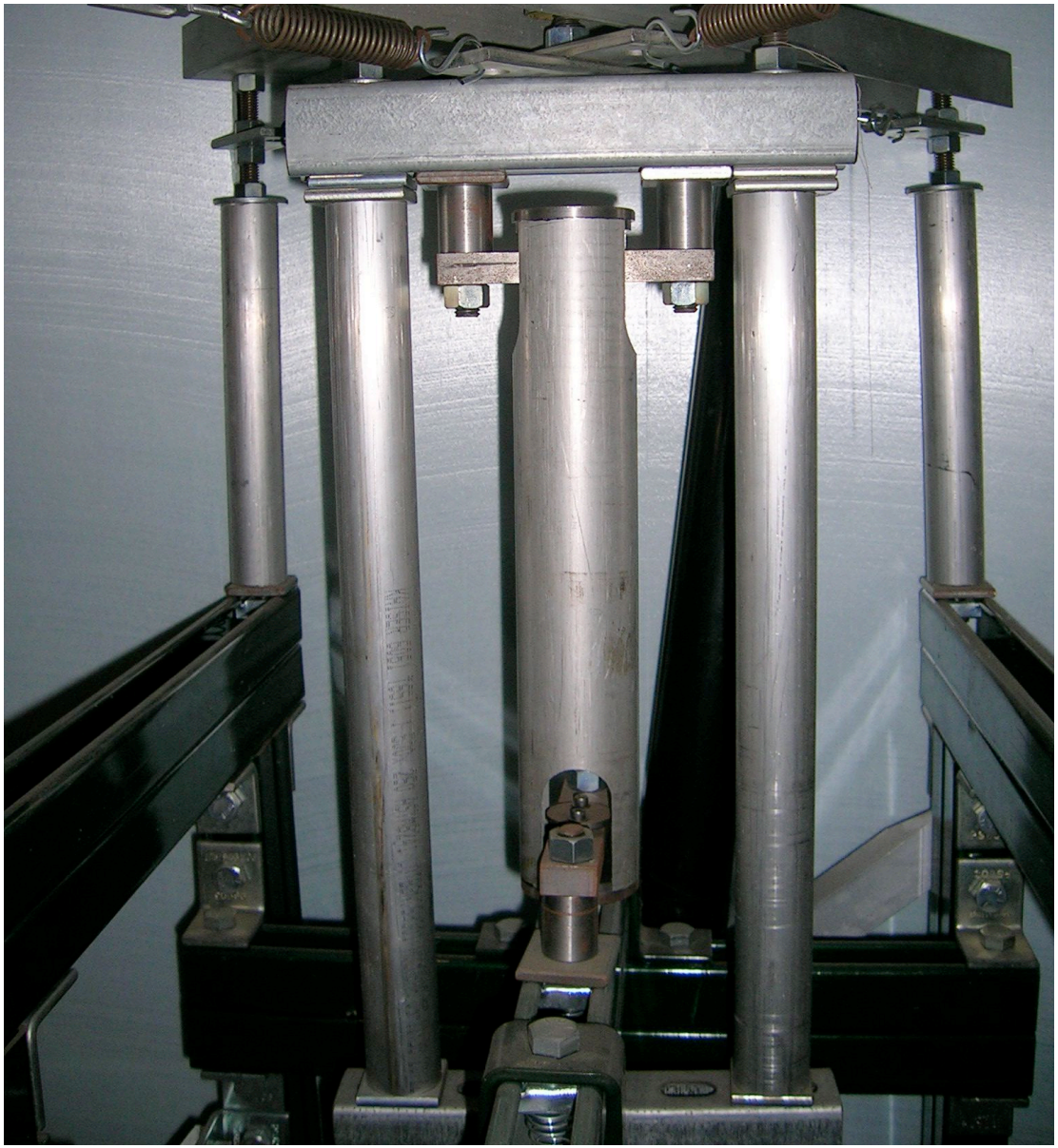
HAM IP first tests

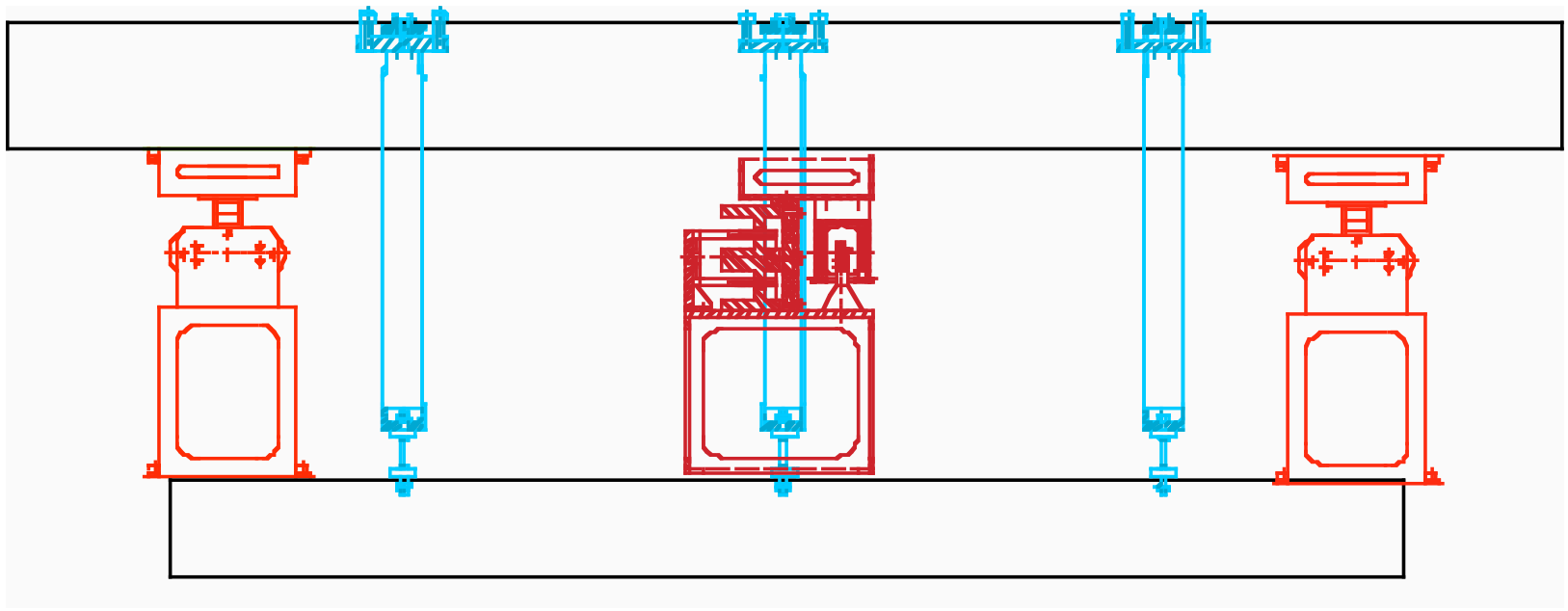


- Preliminary test results
- 60 dB achieved without CounterWeight
- 1/8 payload (8 times better at full payload)
- Further improvement with CW
- 80 Hz resonance, reducing attenuation performance, moved above 100 Hz and dampable with eddy currents



A similar IP leg



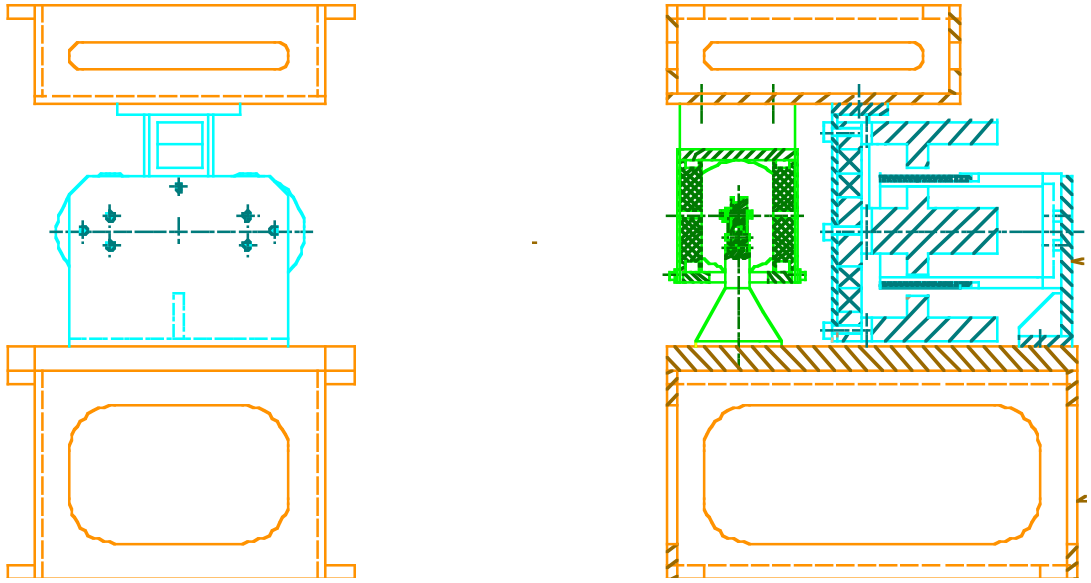


Dynamic micro-positioning

- LVDT for nanometer positioning memory
- Voice coil actuator
- Tidal corrections from global controls
- milli Watt in-vacuum power

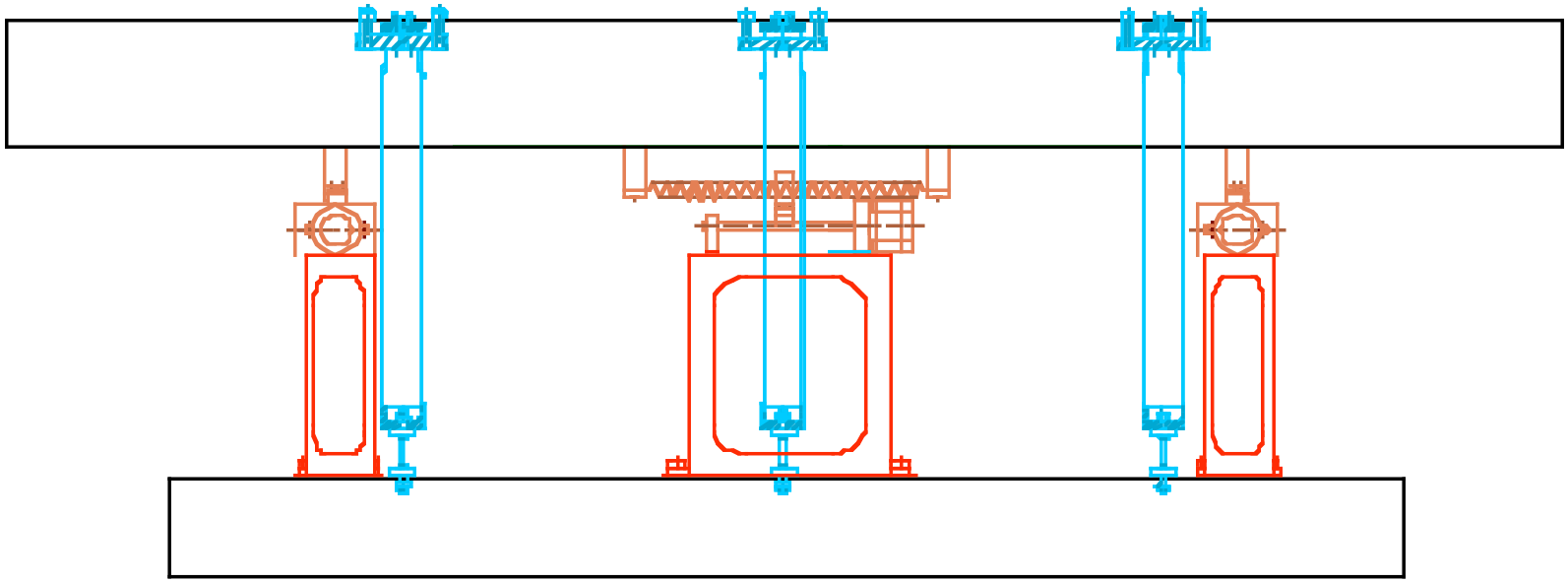
Dynamic micro-positioning

- Co-located LVDT actuator units



Static micro-positioning

- Remotely actuated springs in all d.o.f.
  - No standing currents in actuators

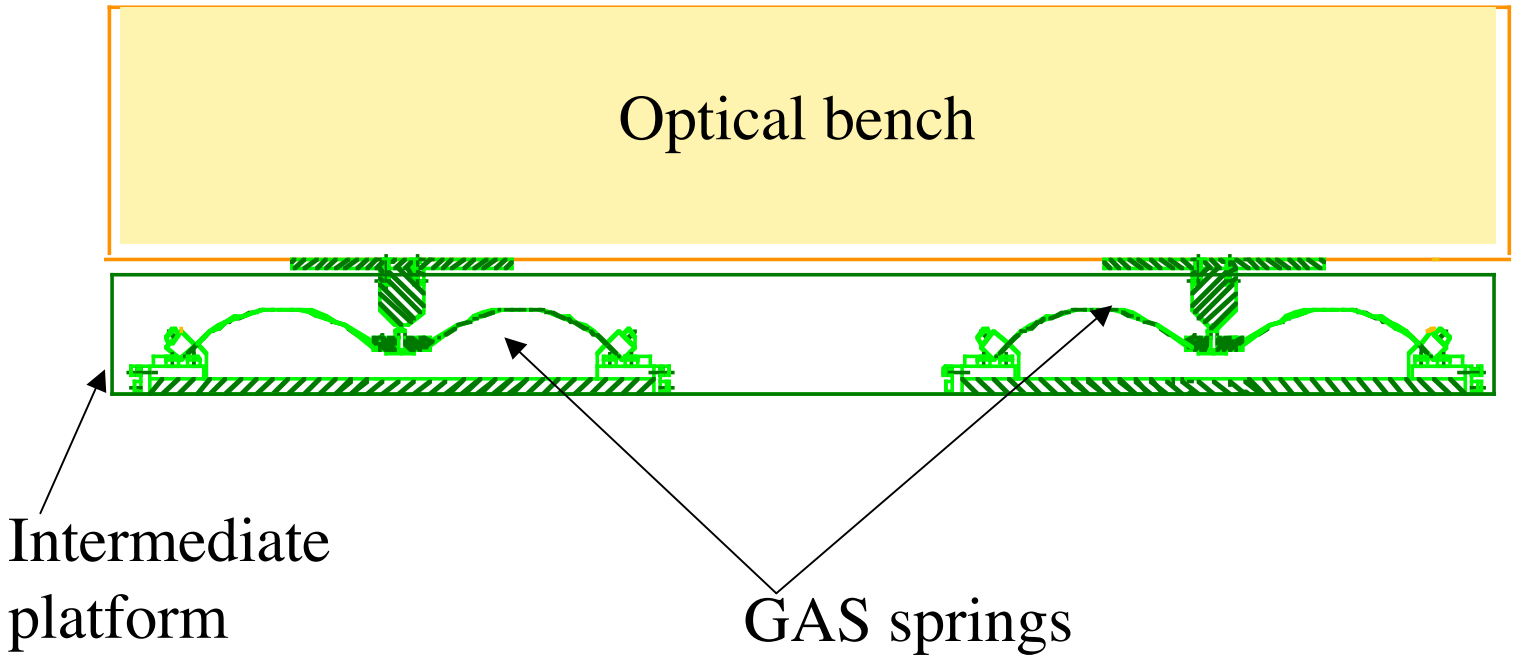


Positioning requirements/procedures

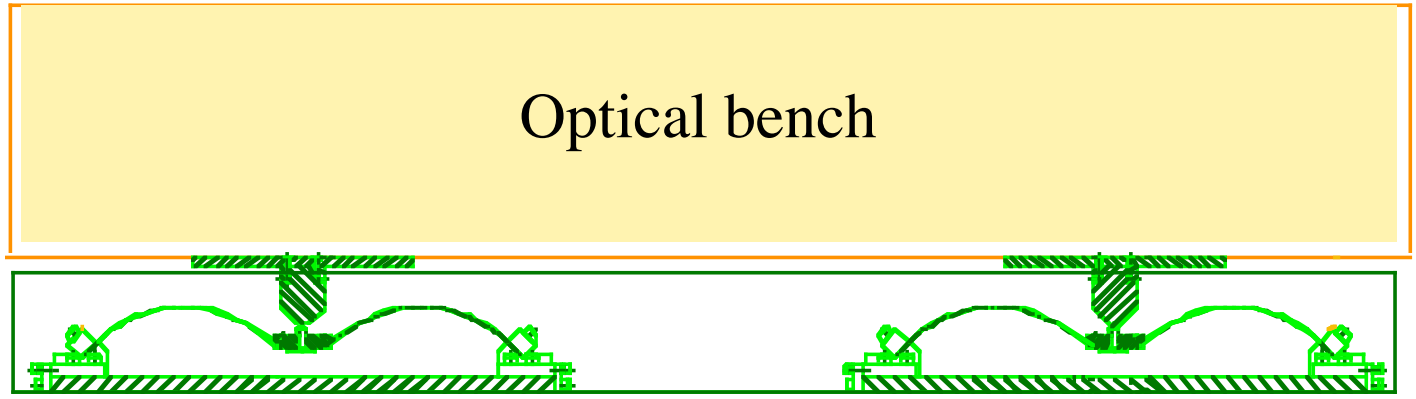
- The requirement of guaranteeing easy return of the alignment after interventions requires a set of suitable UHV compatible sensors and actuators
- The sensors will read the changes of position after interventions and either suggest changes of ballast to regenerate the previous balance, or use the actuators to return to the original table alignment
- A set of LVDT, nanometer resolution, cm range, UHV compatible position sensors are adequate for the use.
- Low power, UHV compatible voice coils are suitable actuators to deal with tidal and thermal position changes
- These sensors and actuators are available for active attenuation

Vertical direction, the GAS springs

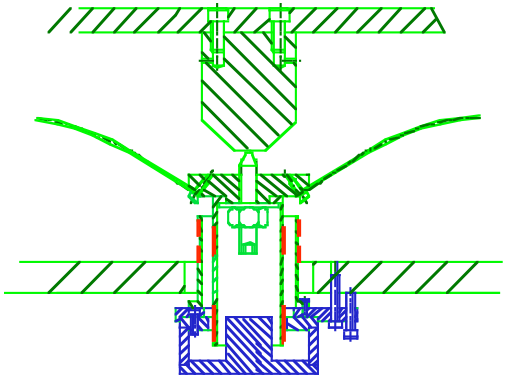
Vertical direction, the GAS springs



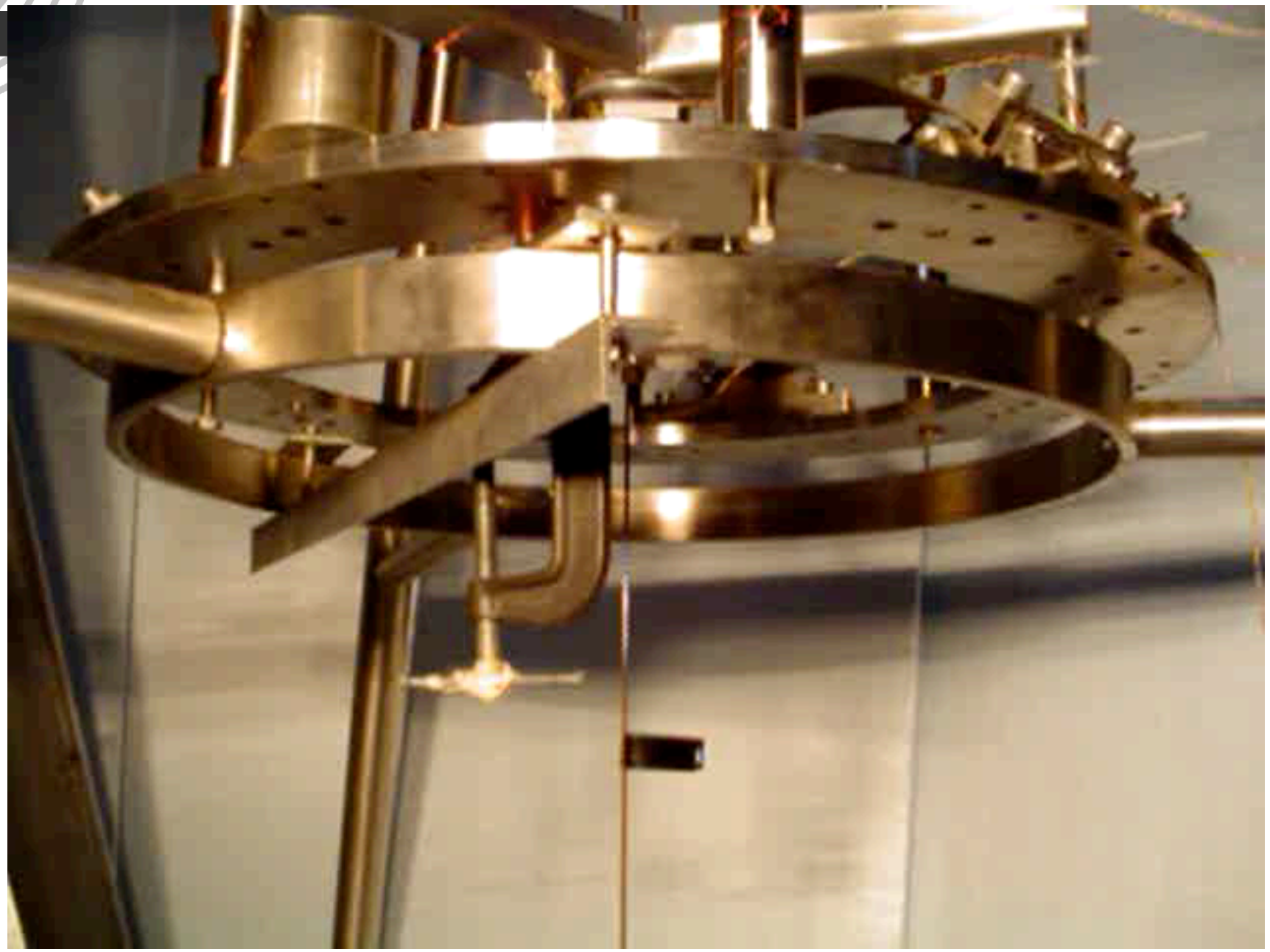
Vertical direction, the GAS springs



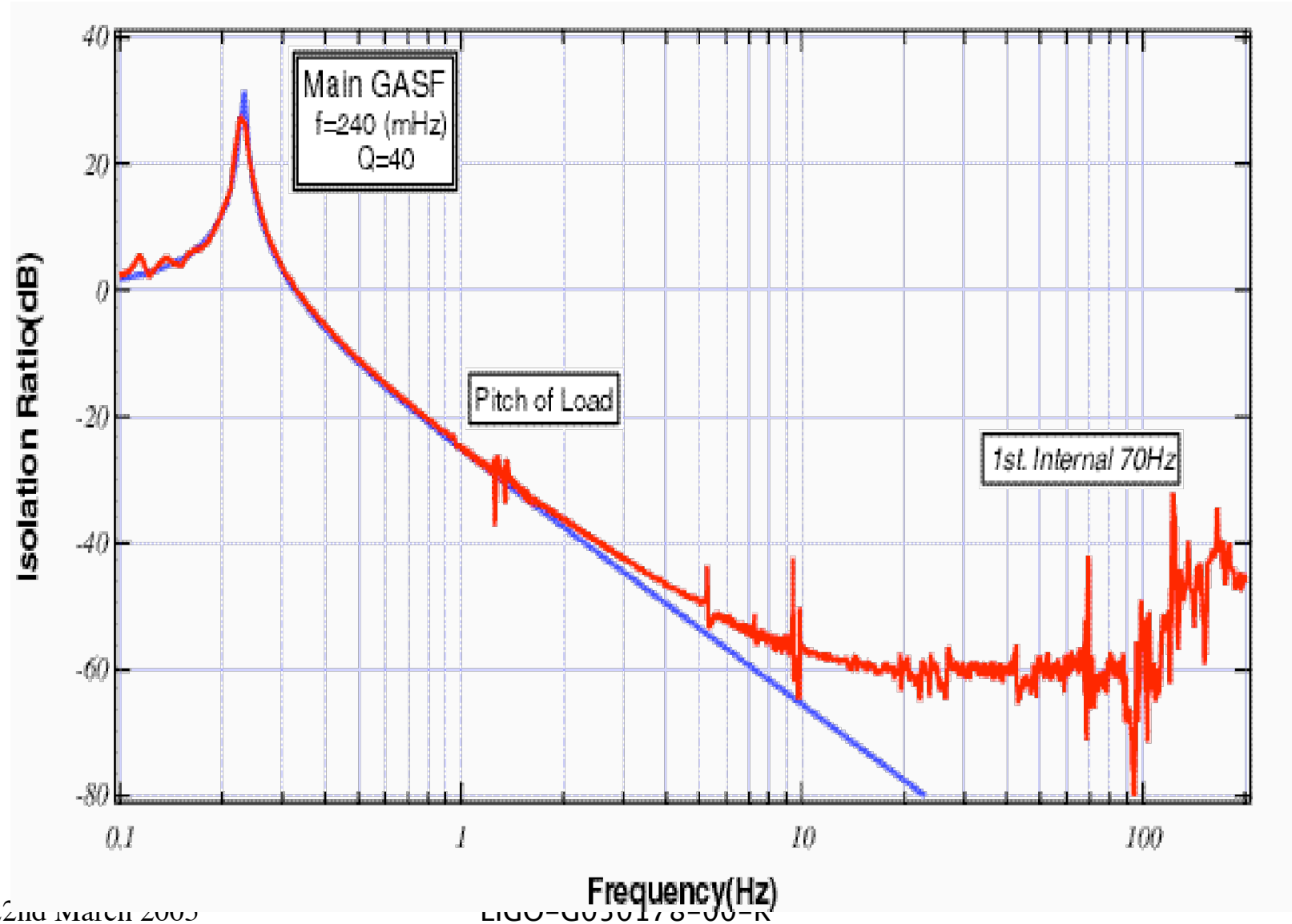
Equivalent LVDT/actuator unit implemented



Illustrating a GAS spring performance



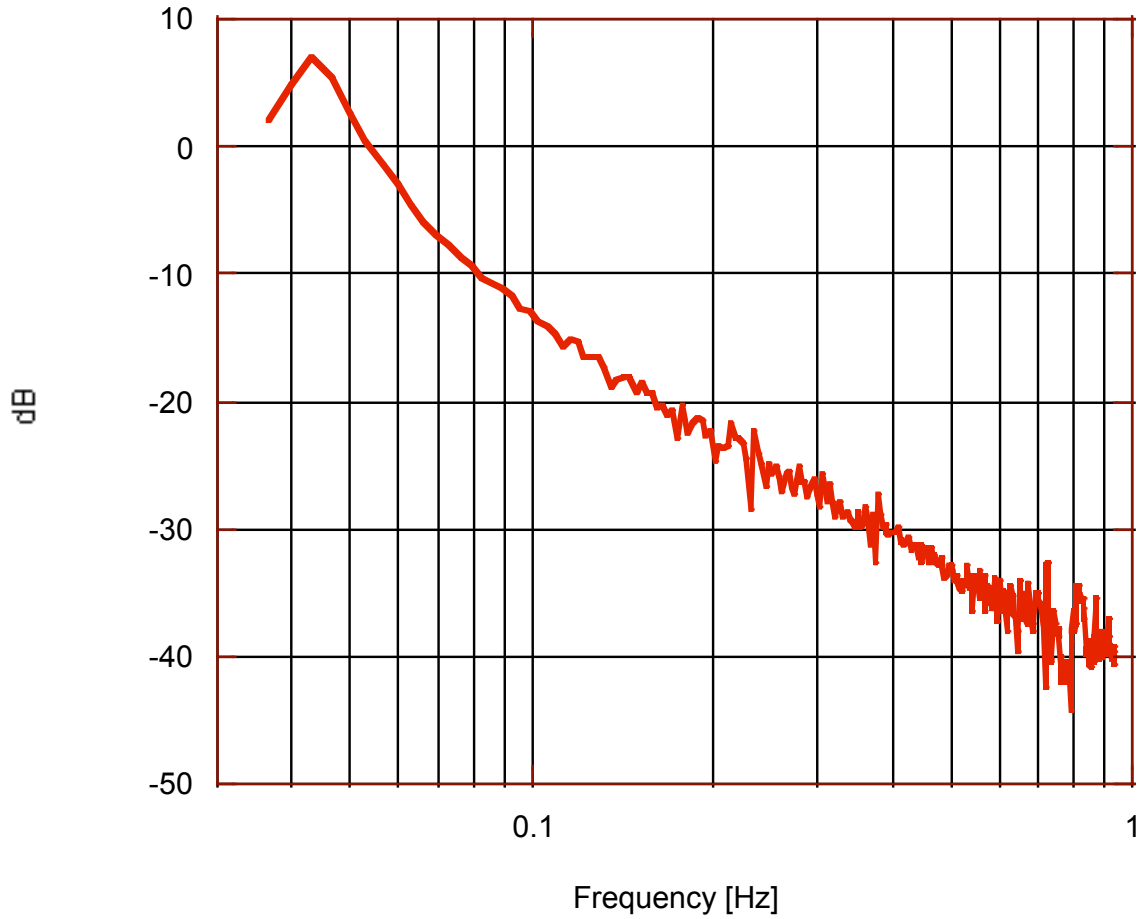
Typical GAS Passive vertical attenuation performance



Low frequency performance

•attenuation factors as large as one thousand for frequencies above 3 Hertz for LF.

• Sizeable atter

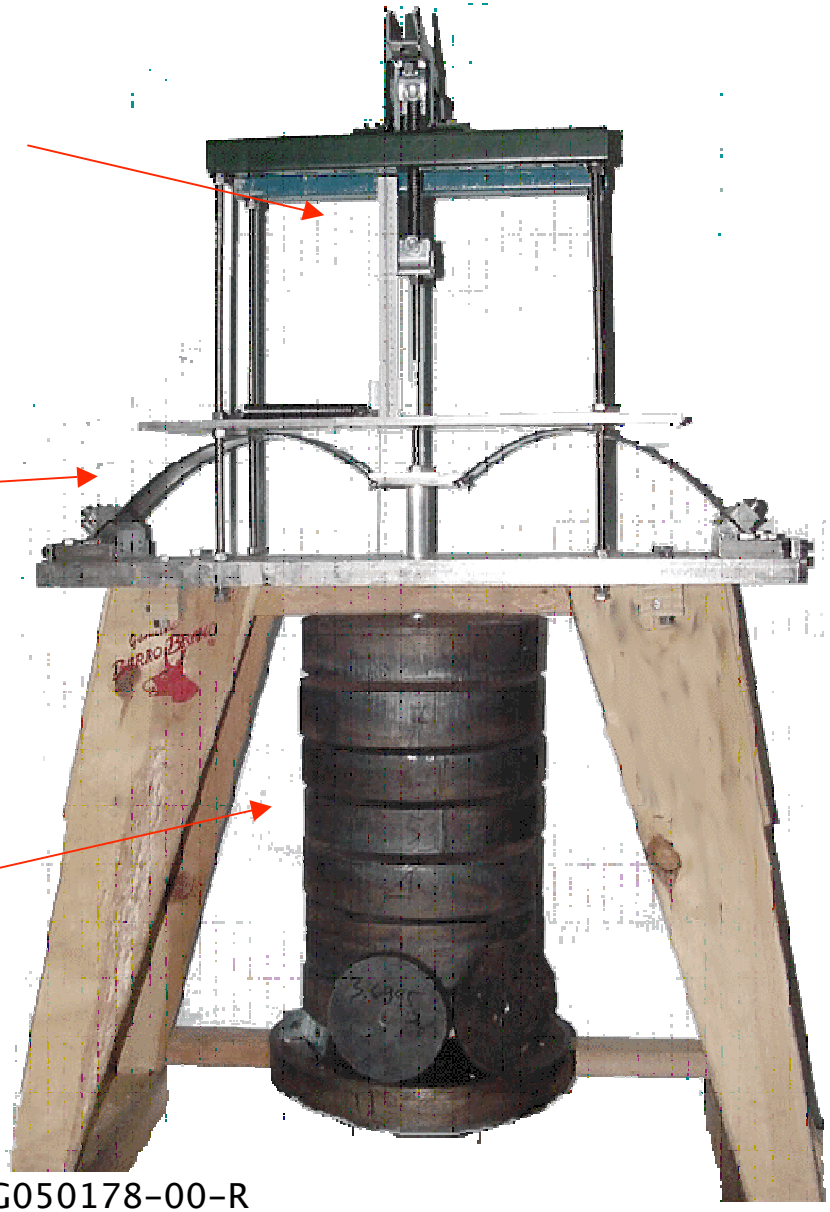


Load capabilities, DFBS prototype

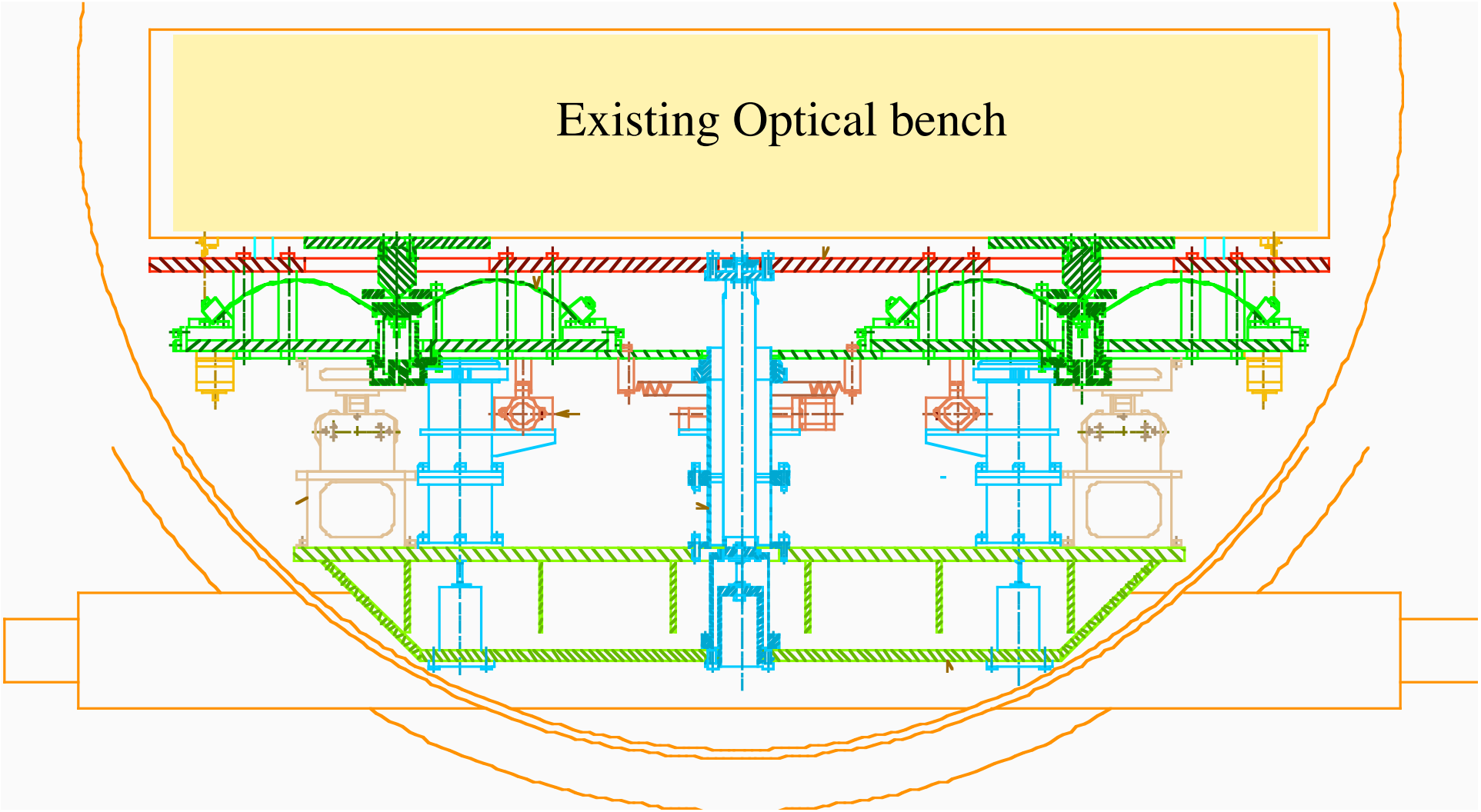
Bellow equivalent springs
(neutralized by GAS)

Two Cantilever
GAS springs

350 Kg Payload



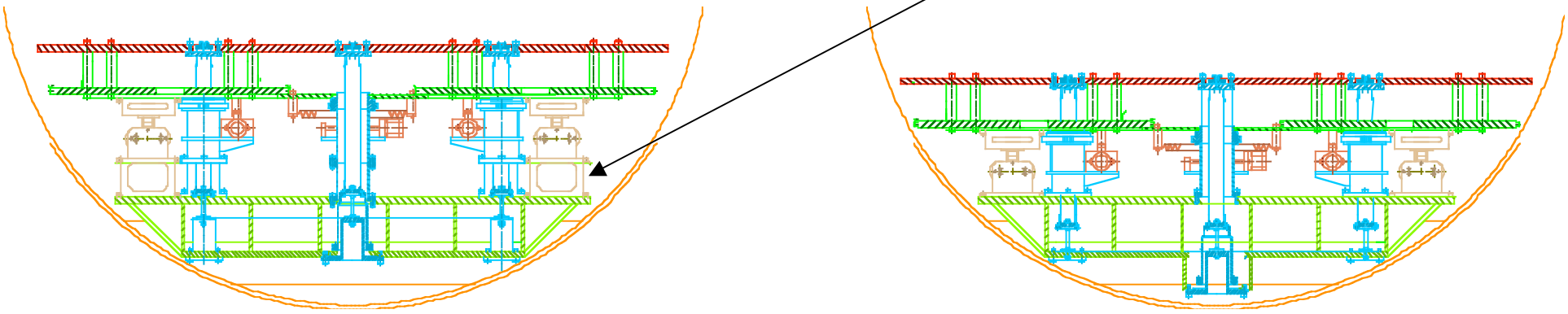
Complete SAS design for HAMs



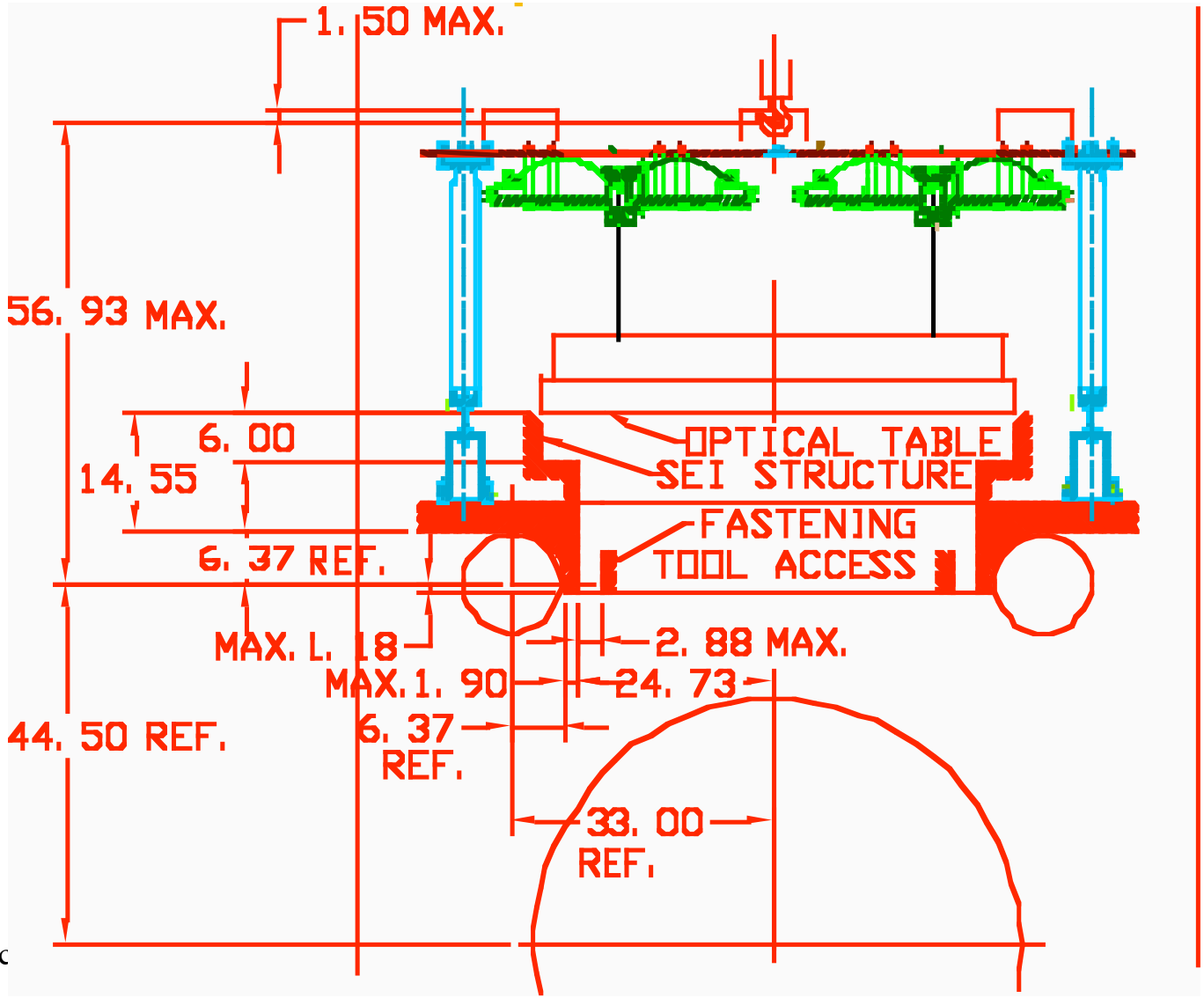
Transition from LIGO-I to Adv-LIGO

- The transition between

  LIGO and Advanced LIGO is obtained by simply eliminating a number of spacers



SAS design for BSCs



BSC SAS

- The HAM-SAS design fits in the BSC and is capable to offload the entire weight
- An additional pendulum stage, needed to reach the (lower) level required by the quad suspensions, gives a redundant safety factor in horizontal isolation

HAM and BSC SAS features

- SAS is a viable and inexpensive in-vacuum seismic attenuation candidate for Adv-LIGO (60 dB broadband)
- One passive layer can potentially replace all three stages of stiff SEI
- Upgradeable to active attenuation as reserve of attenuation power
- Fully compatible with the SUS system

HAM SAS design status

- HAM SAS design for OMC or any other HAM bench is ready for production
  http://www.ligo.caltech.edu/~desalvo/HAM-SAS and
  http://www.ligo.caltech.edu/~desalvo/HAM-SAS.doc
- Preliminary bidding indicate a cost of ~ 150K$ and production times of the order of three months
- Prototyping in LASTI, to validate the design should be considered
- Scaling of the design is possible for BSC