

# **Advanced LIGO Seismic Isolation Status**

LVC Meeting Rome 2012

Céline Ramet, for the **Seismic Isolation** team

September 11th, 2012

# Overview

- Different aLIGO Seismic Isolation Systems
- Assembly & Installation Status
  - LIGO Livingston (LLO), LIGO Hanford (LHO), LIGO India (Assembly only)
- Commissioning Status
  - BSC-ISI & BSC-HEPI (LHO), HAM-ISI (LLO), HAM-HEPI (LASTI)



# DIFFERENT ALIGO SEISMIC ISOLATION SYSTEMS

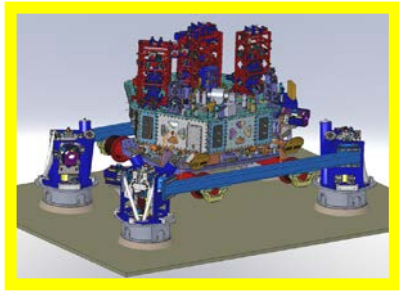
# Different aLIGO Seismic Isolation Systems

- From the ground to the optical table
- Passive isolation (mass-spring) systems with **active** control (in contrast to iLIGO)
- Sensing loops made of blended inertial and capacitive/inductive position sensors (super sensors)
- Goal : Isolating optics + provide positioning & alignment
- 1 Pre-Isolator (present under all chambers)
  - HEPI
- Two in-vacuum Seismic Isolation systems (ISI)
  - HAM-ISI
  - BSC-ISI

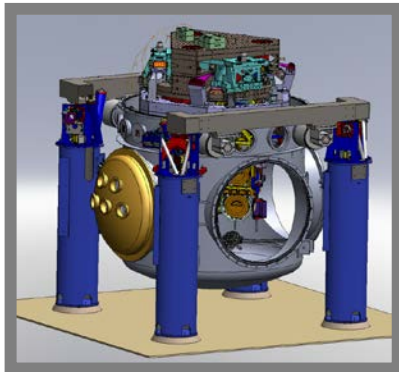
# LIGO

## LIGO Livingston (LLO)

6 HAM Chambers:  
6 HEPI, 5 ISI

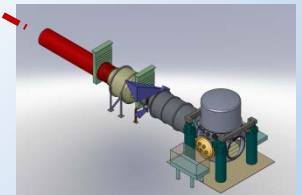
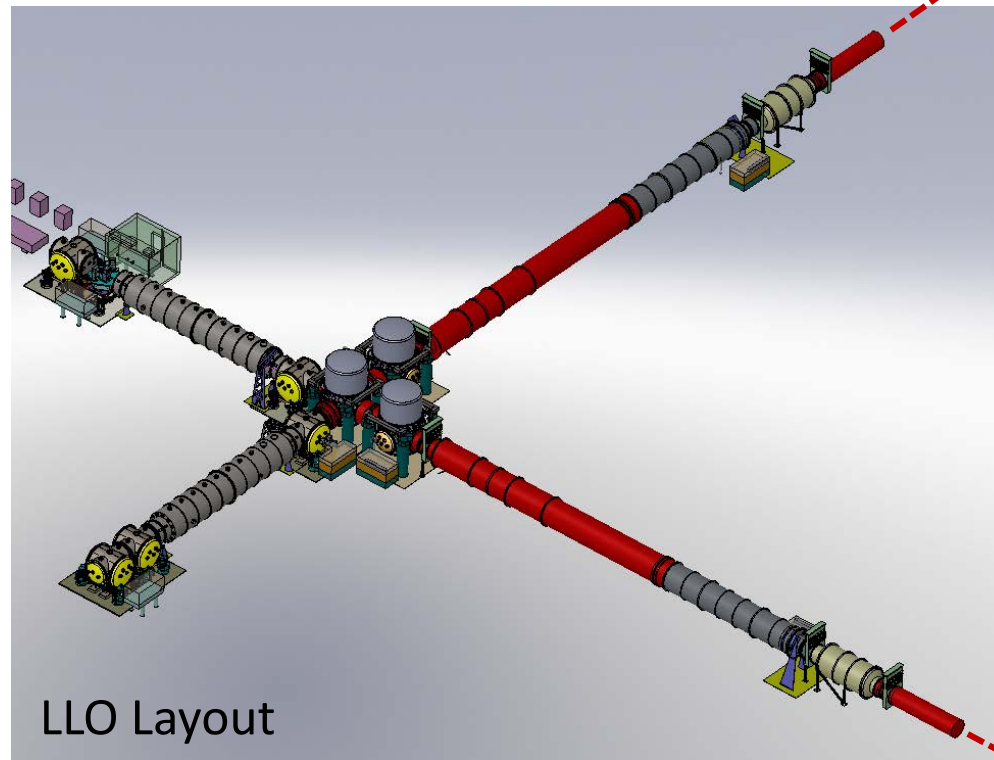
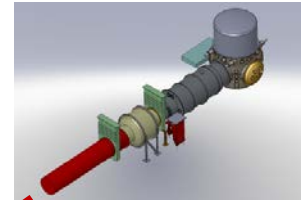


5 BSC Chambers:  
5 HEPI, 5 ISI



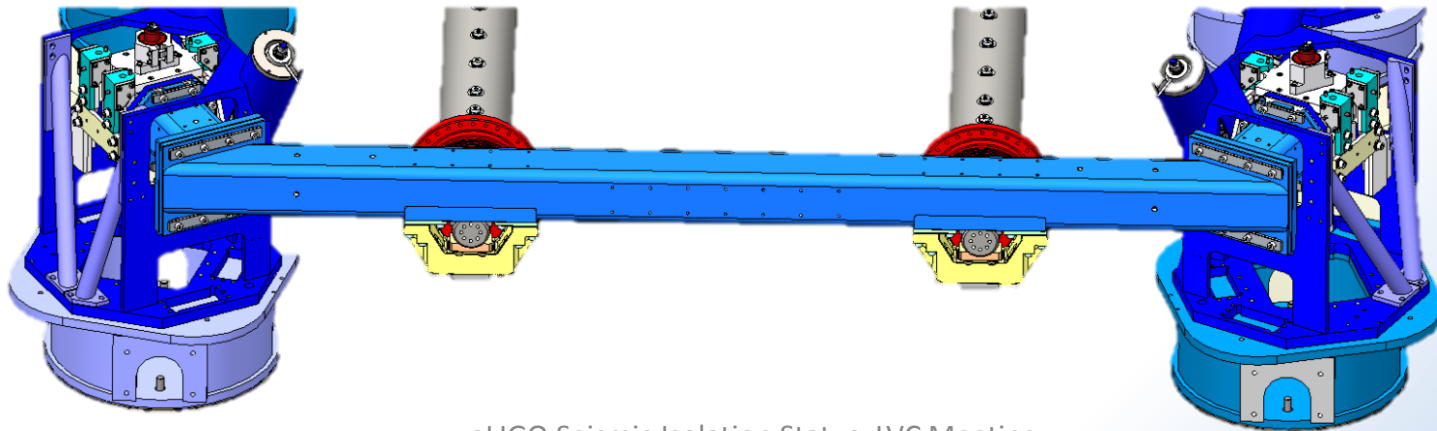
Courtesy: F. Matchard

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- One stage of isolation
- Isolation from 0.1 Hz to  $\sim 10$  Hz
- Out of vacuum
- 16 sensors
- Divided in 4 piers, connected by the support tubes
- Hydraulic actuation





## HAM-HEPI

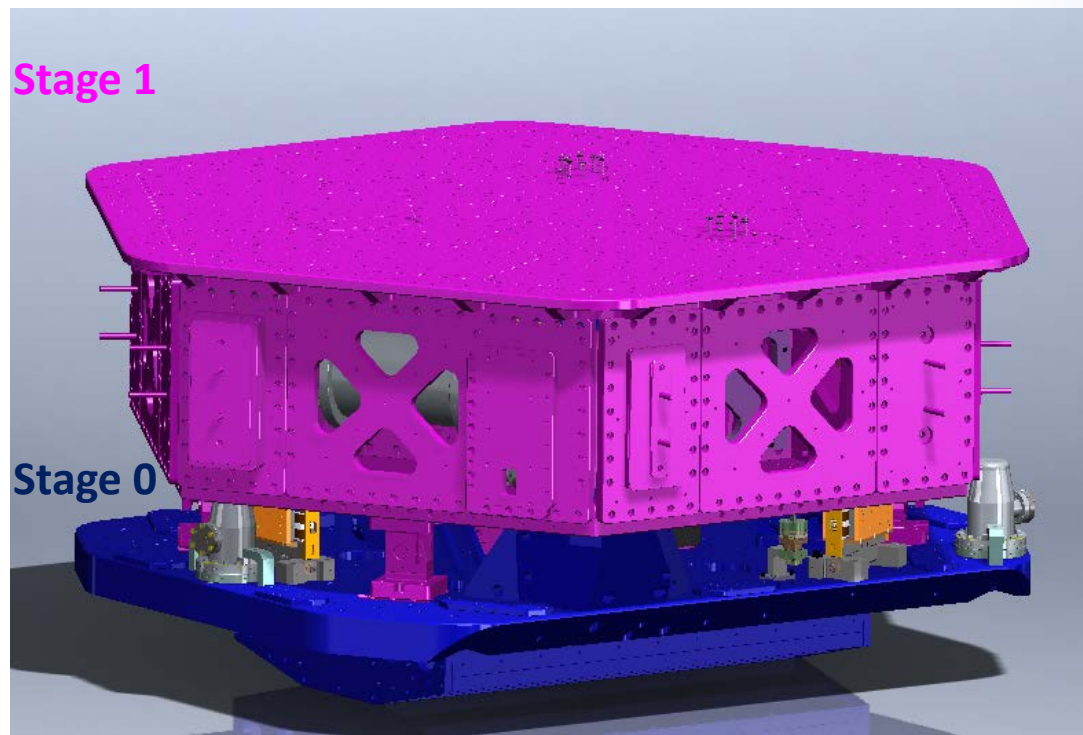


## BSC-HEPI



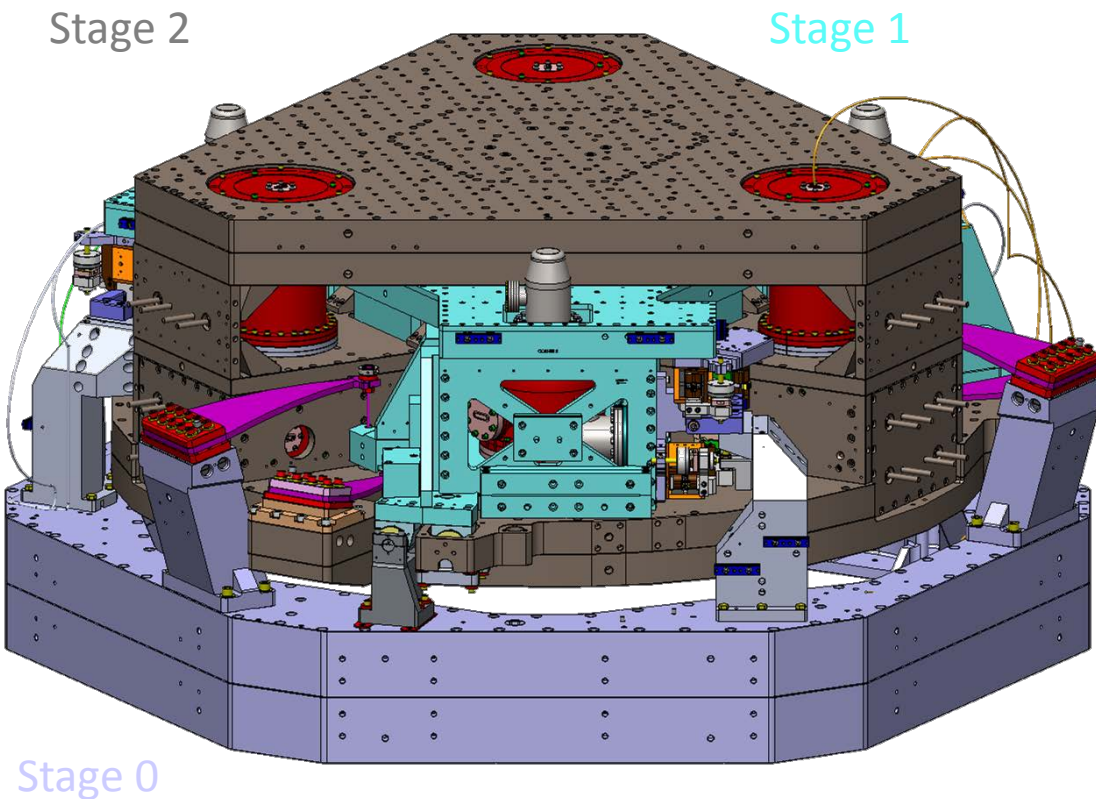
## HAM-ISI

- One stage of isolation
- Effective  $> \sim 0.2$  Hz
- In Vacuum
- 12 sensors
- 2 per IFO have additional sensors on Stage 0 for feed-forward
- Optical table facing up
- Carrying Auxiliary Optics



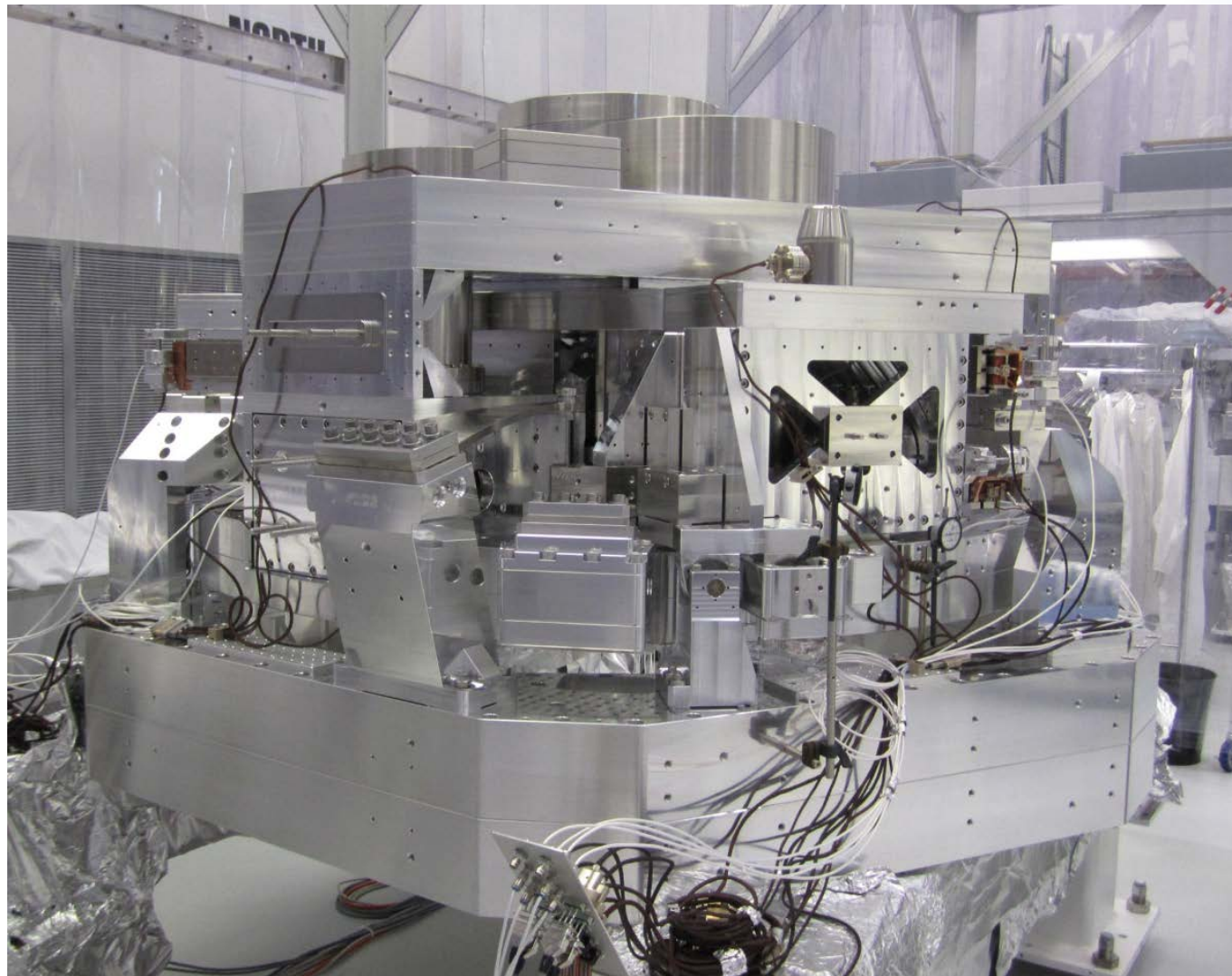






- Two stages of isolation
- Effective  $> 0.2$  Hz
- In vacuum
- 33 sensors
- Optical table facing down
- Carrying Core Optics





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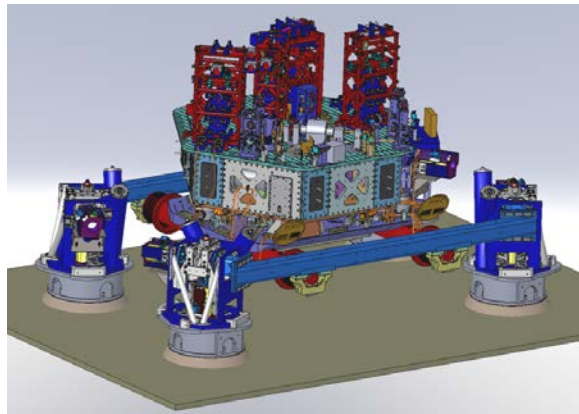
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LIGO Livingston (Louisiana, USA), LIGO Hanford (Washington St, USA),  
LIGO India

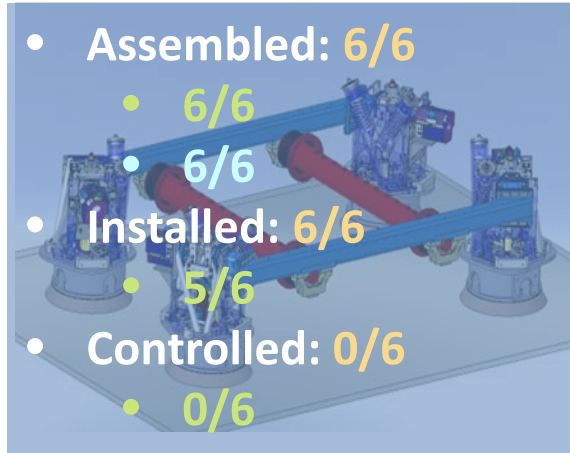
# **ASSEMBLY & INSTALLATION STATUS**

H  
A  
M



## ■ HEPI

- Assembled: 6/6
  - 6/6
  - 6/6
- Installed: 6/6
  - 5/6
- Controlled: 0/6
  - 0/6

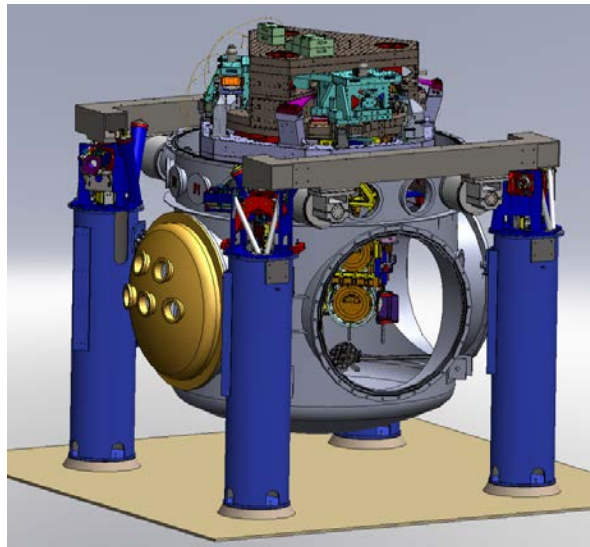


## ■ ISI

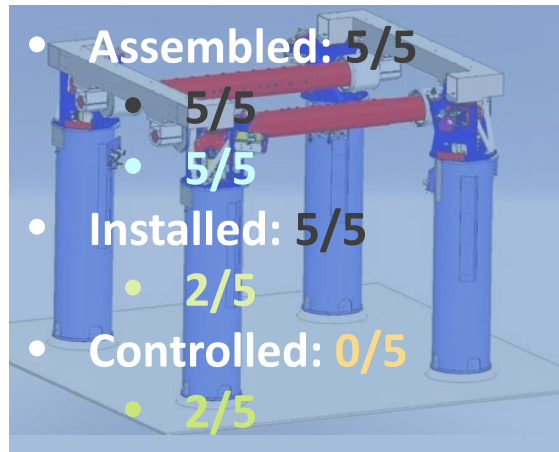
- Assembled: 5/5
  - 5/5
  - 3/5
- Installed: 5/5
  - 3/5
- Controlled: 4/5
  - 0/5



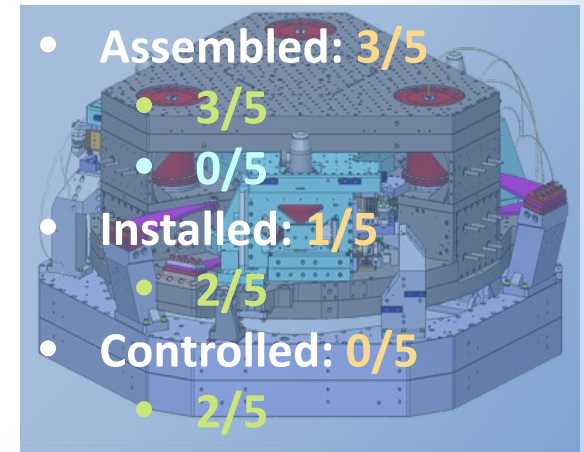
B  
S  
C



- Assembled: 5/5
  - 5/5
  - 5/5
- Installed: 5/5
  - 2/5
- Controlled: 0/5
  - 2/5

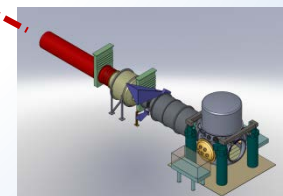
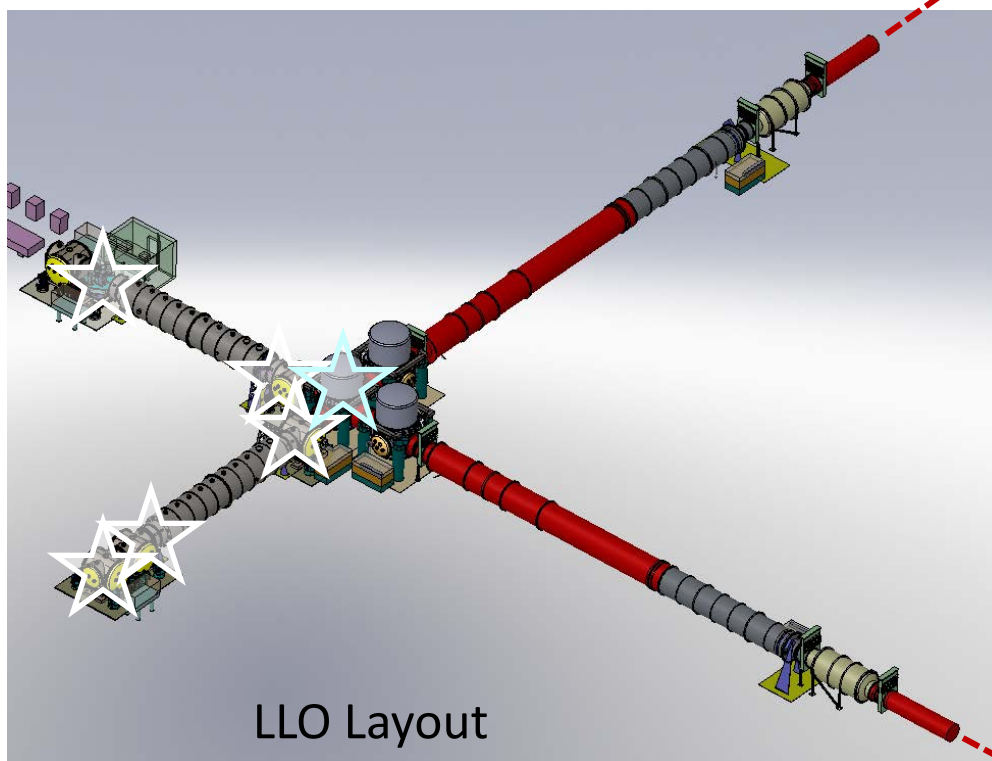
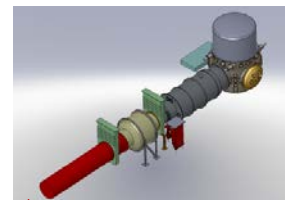


- Assembled: 3/5
  - 3/5
  - 0/5
- Installed: 1/5
  - 2/5
- Controlled: 0/5
  - 2/5



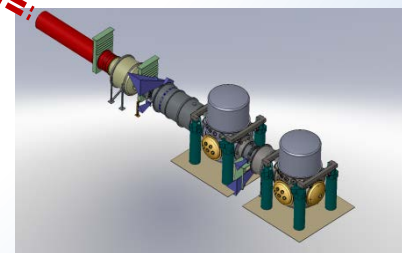
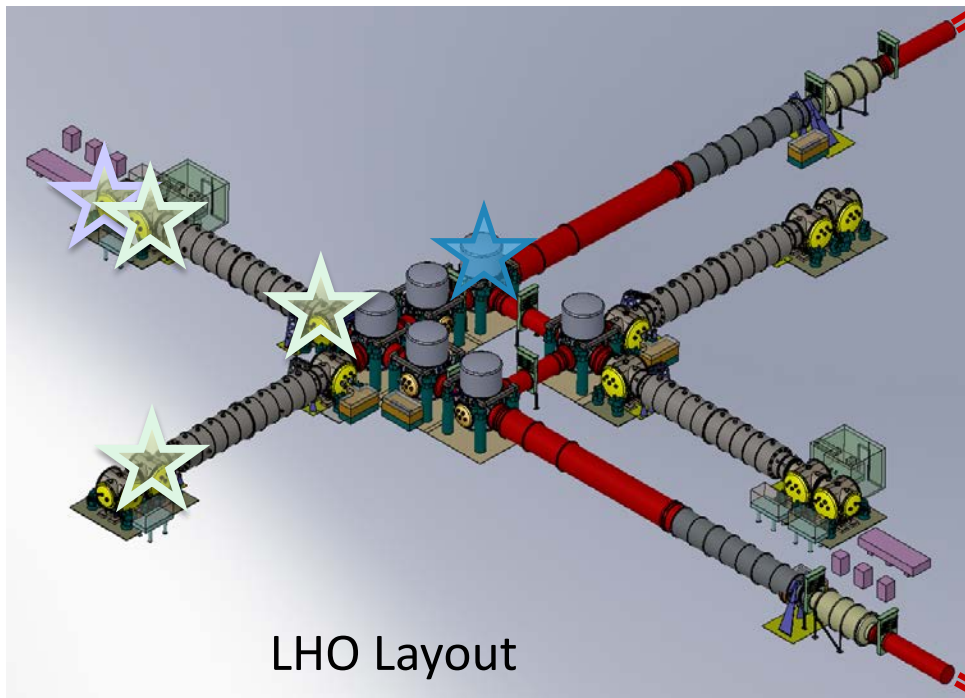
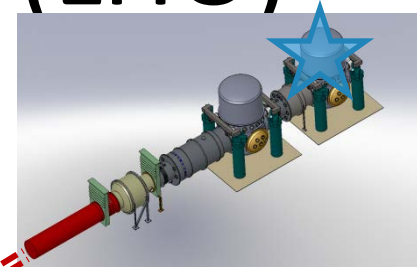


represent ISI+HEPI assembly & installation complete





★ represent ISI+HEPI assembly & installation complete



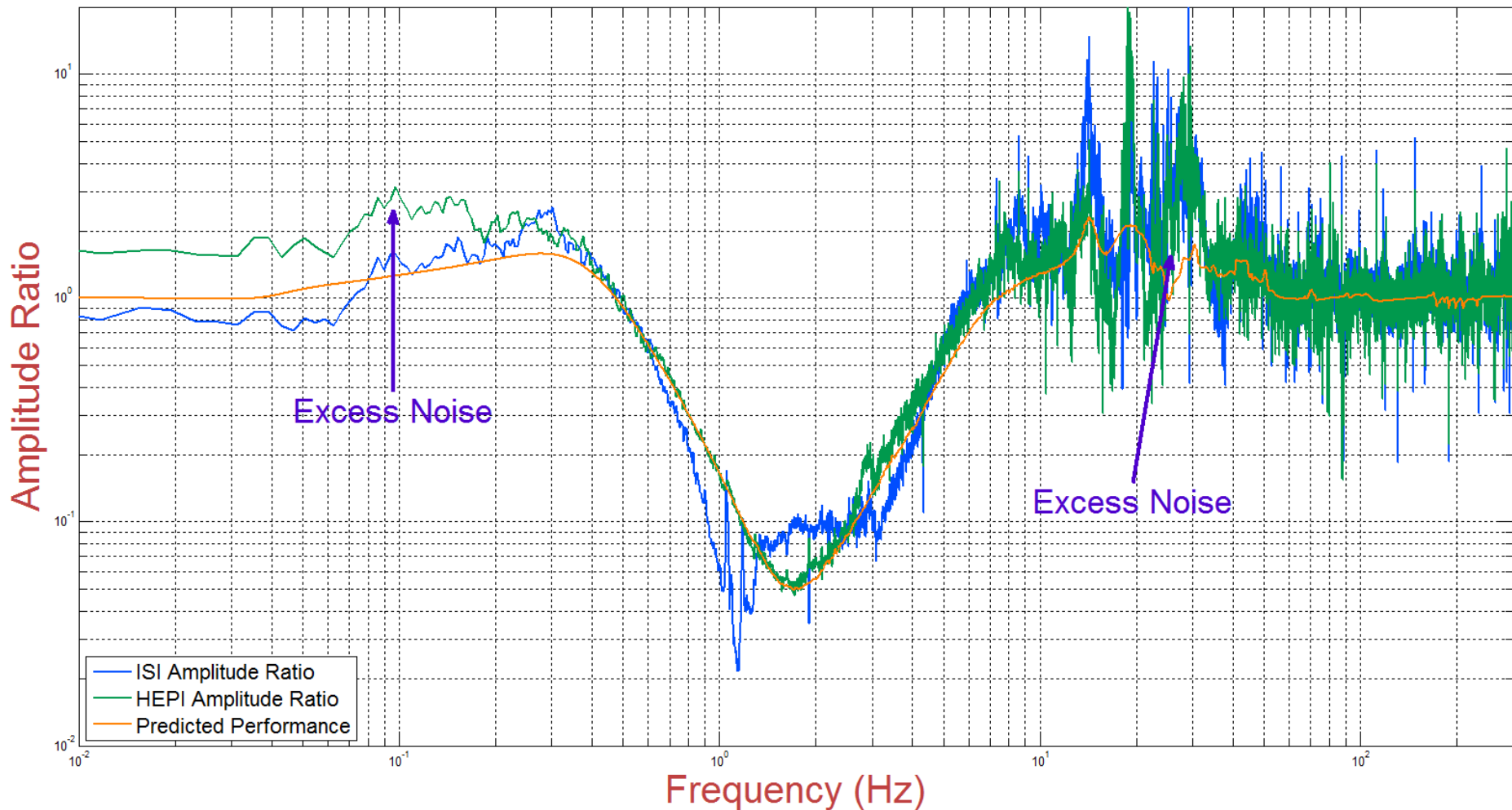


LIGO Livingston, LIGO Hanford, LIGO (Cambridge, Massachusetts, USA)

# COMMISSIONING

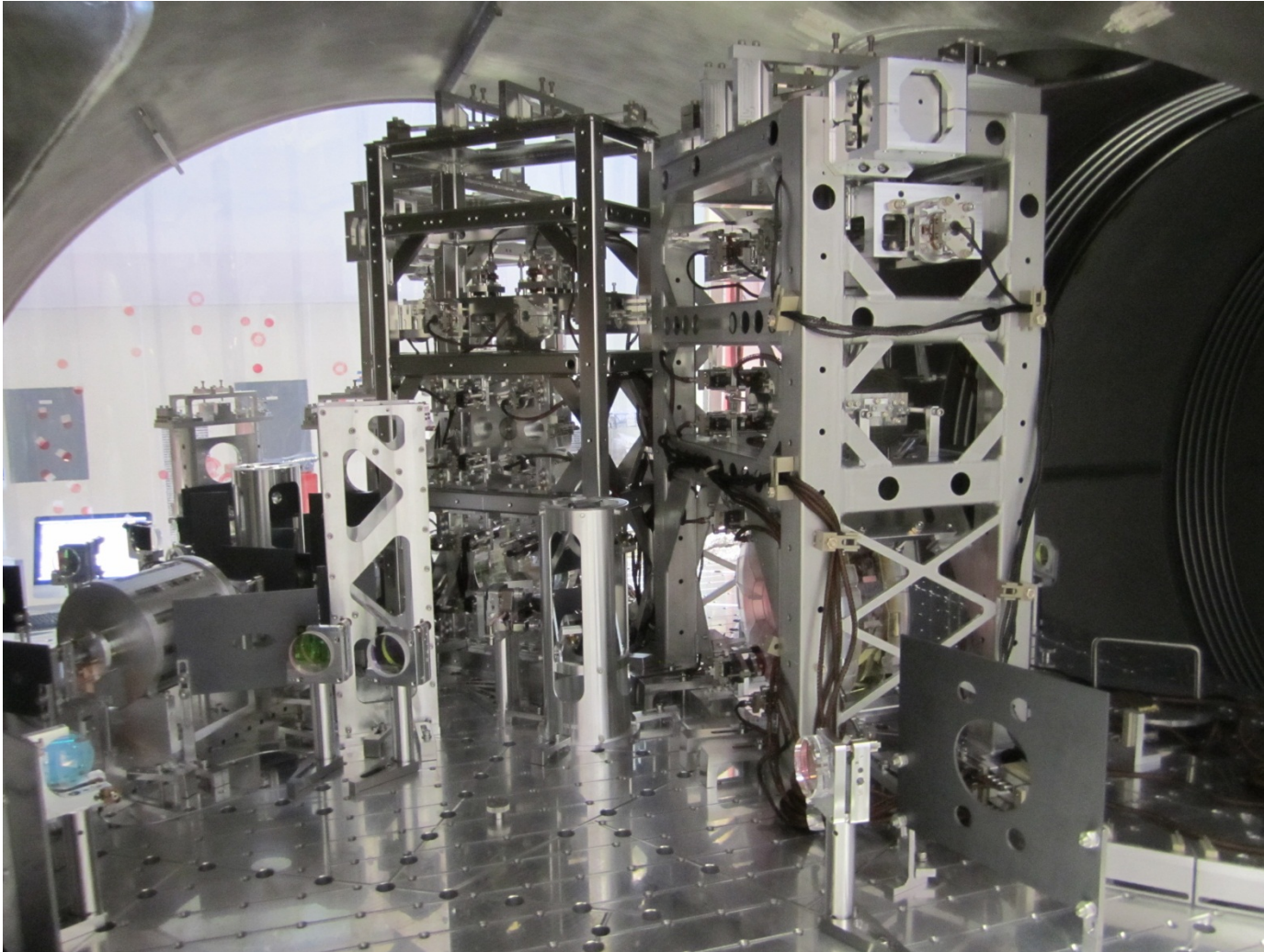
Courtesy: R. Mittleman

Y direction performance (cavity axis)



# LIGO Tracking HAM-ISI Evolution (LLO)

## L1-HAM 3 Story



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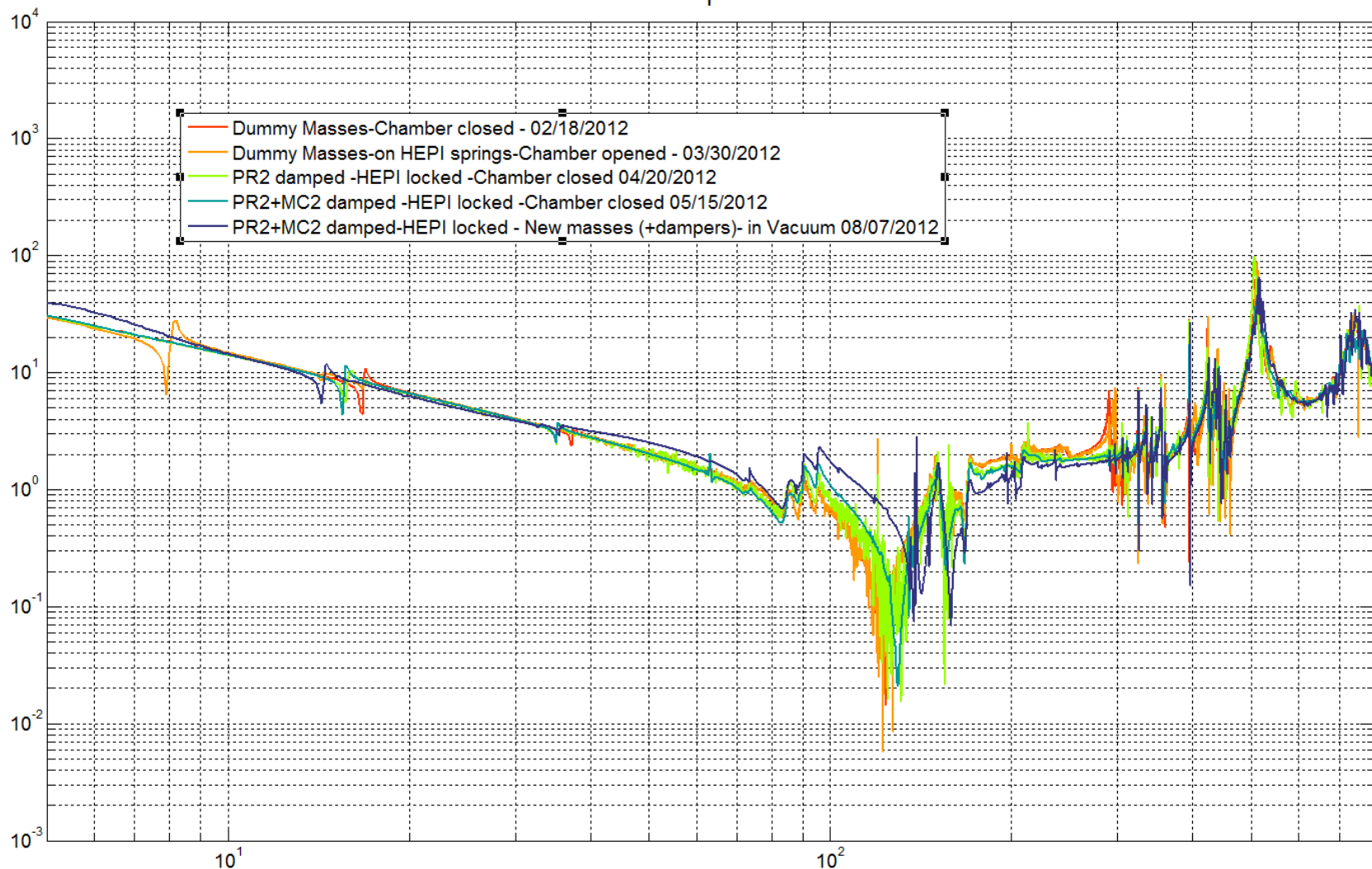
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# Tracking HAM-ISI Evolution (LLO)

## L1-HAM 3 Story

HAM-ISI - L1 -HAM 3 - GS-13 Transfer Functions Comparison Spring 2012- In air

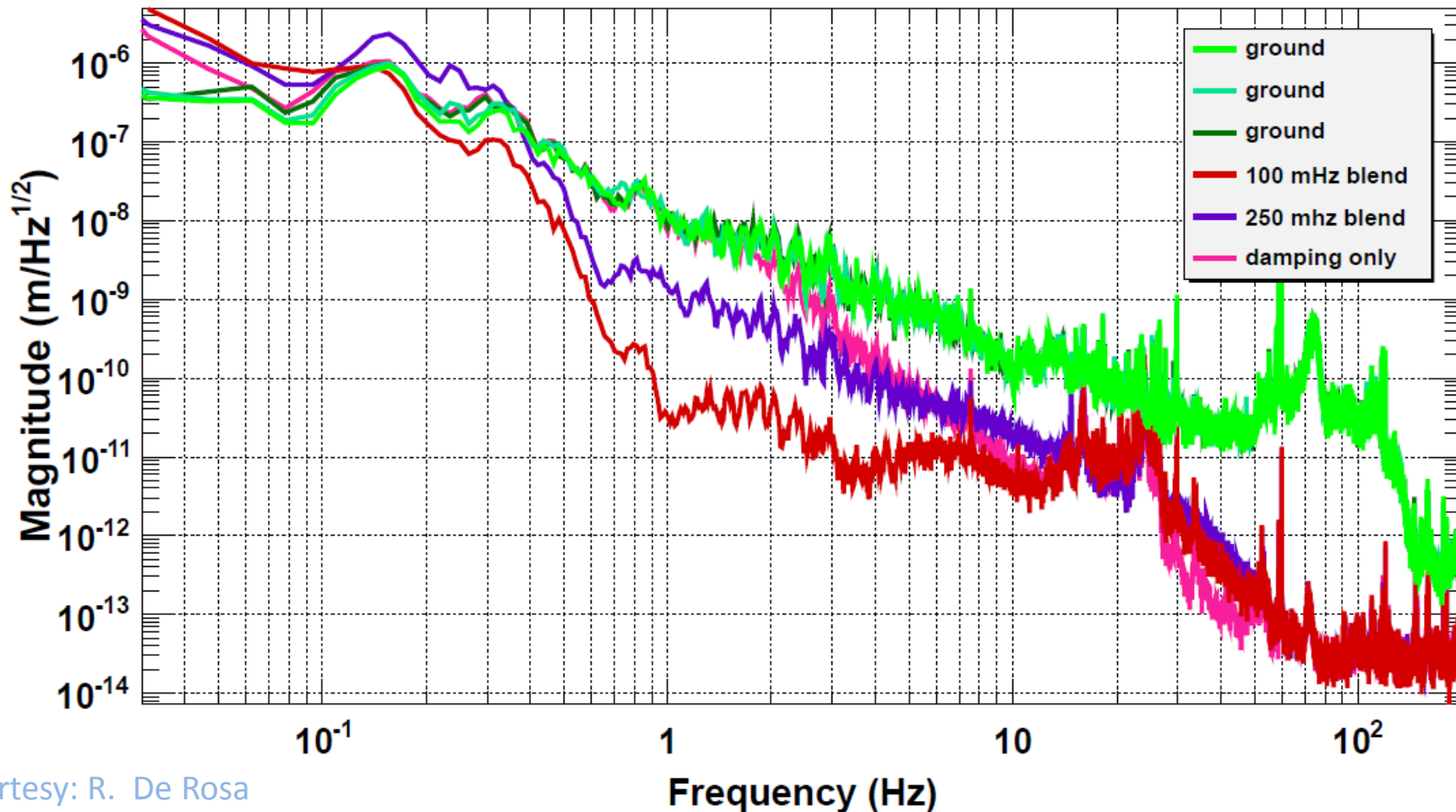
Y





# LIGO HAM-ISI Commissioning (LLO)

X motion (cavity axis) as seen by GS-13's



Courtesy: R. De Rosa

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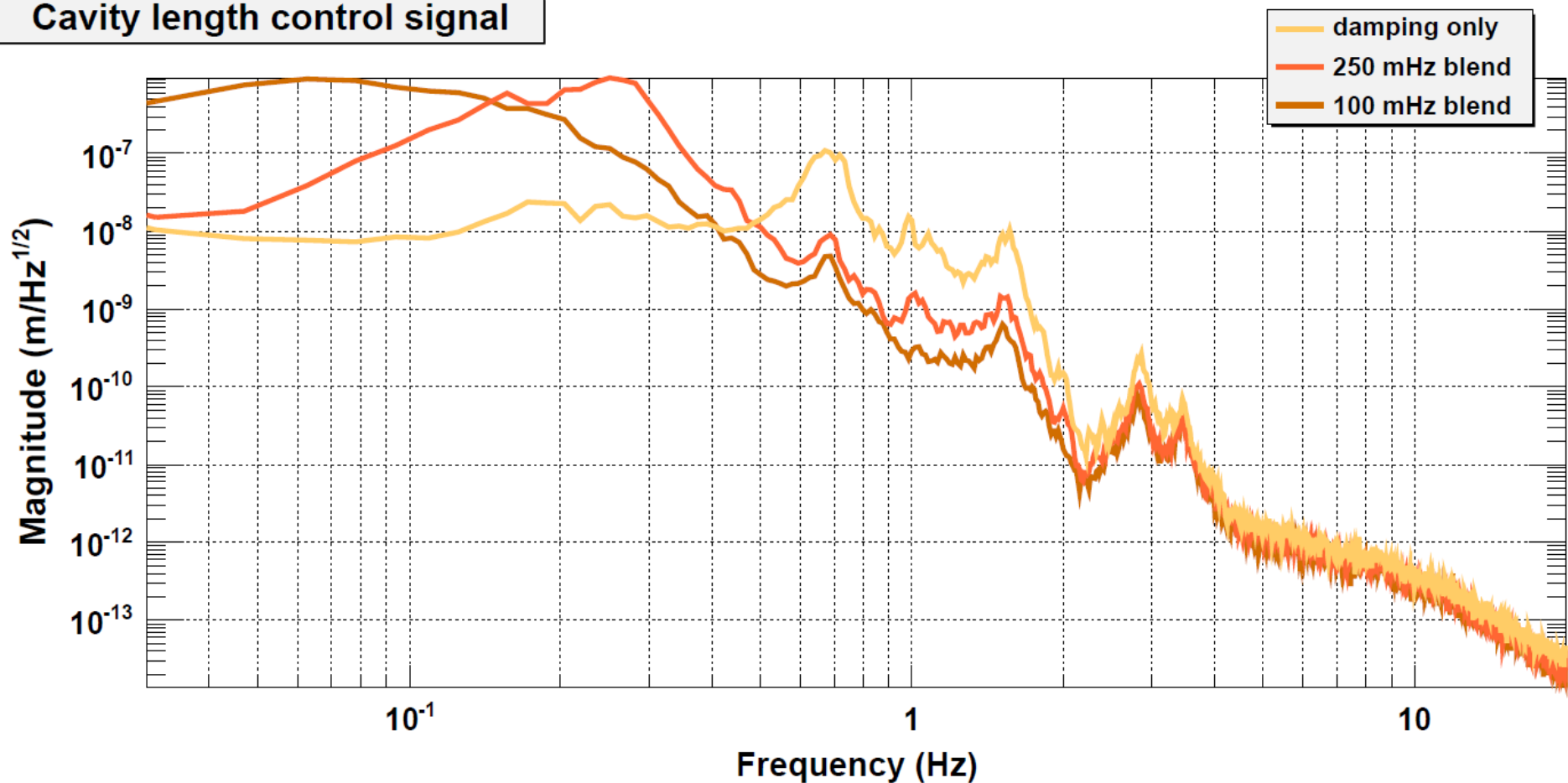


# IMC Commissioning (LLO)

Courtesy: R. De Rosa

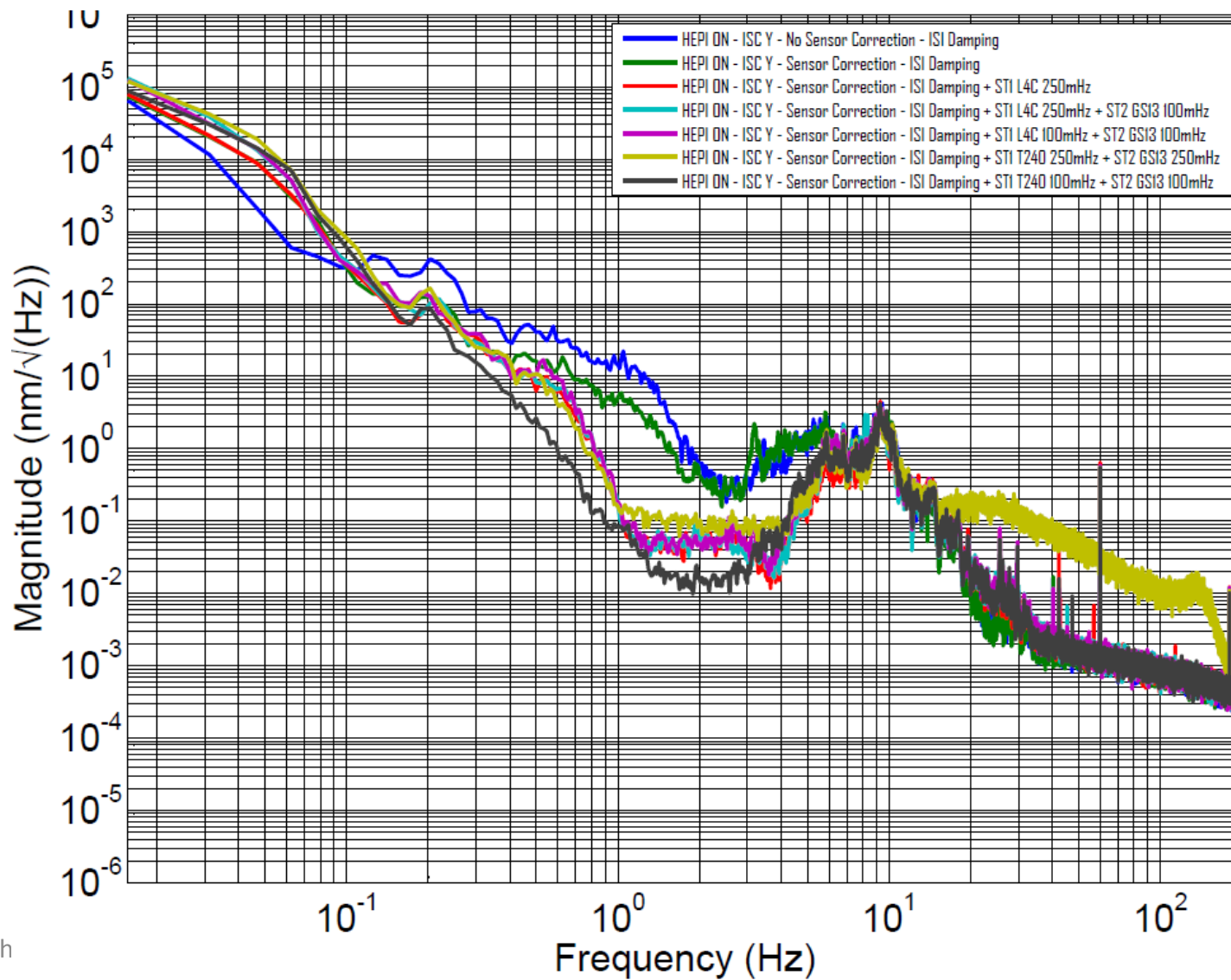
Input Mode Cleaner

Cavity length control signal

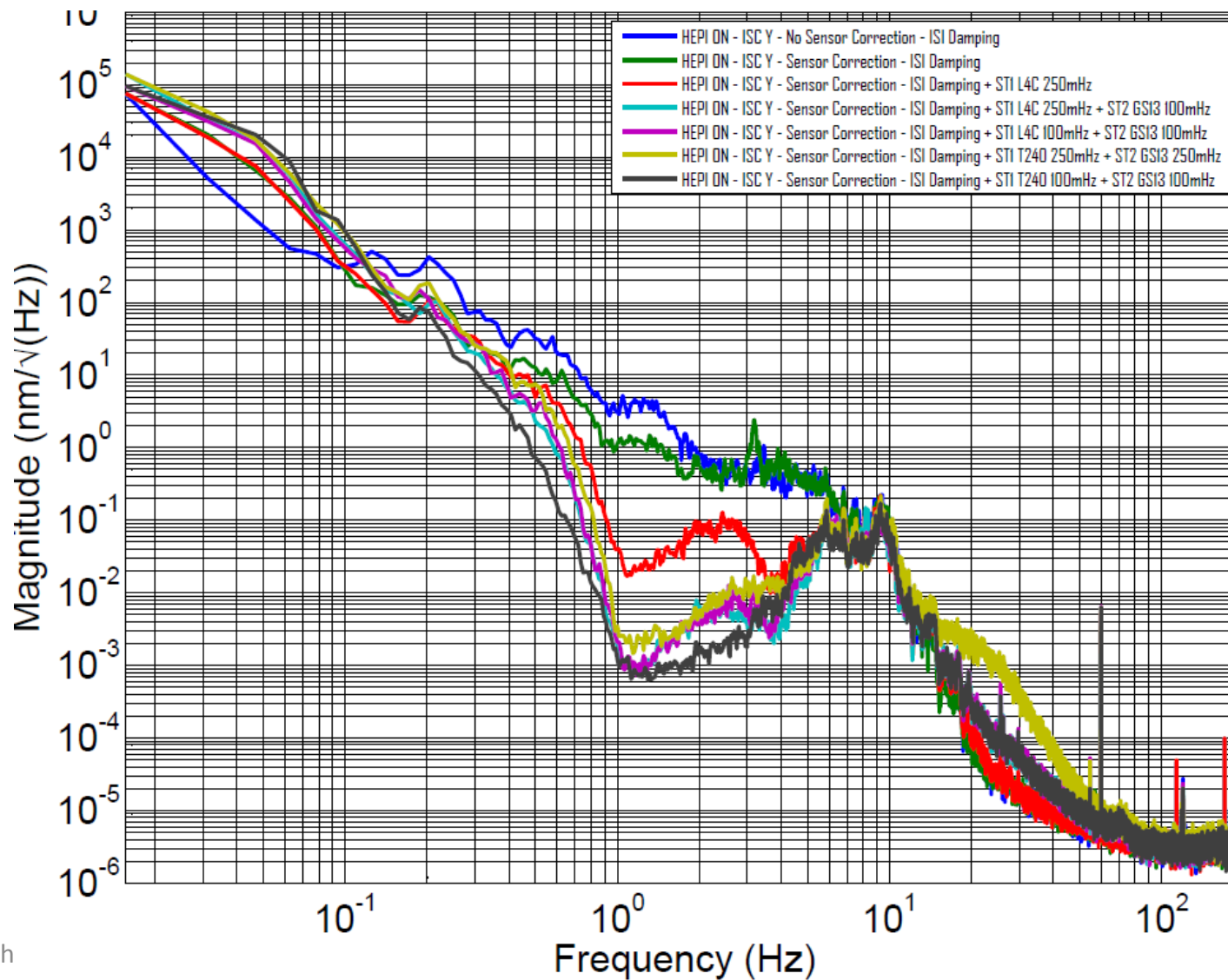


Courtesy: V. Lhuillier

## Stage 1



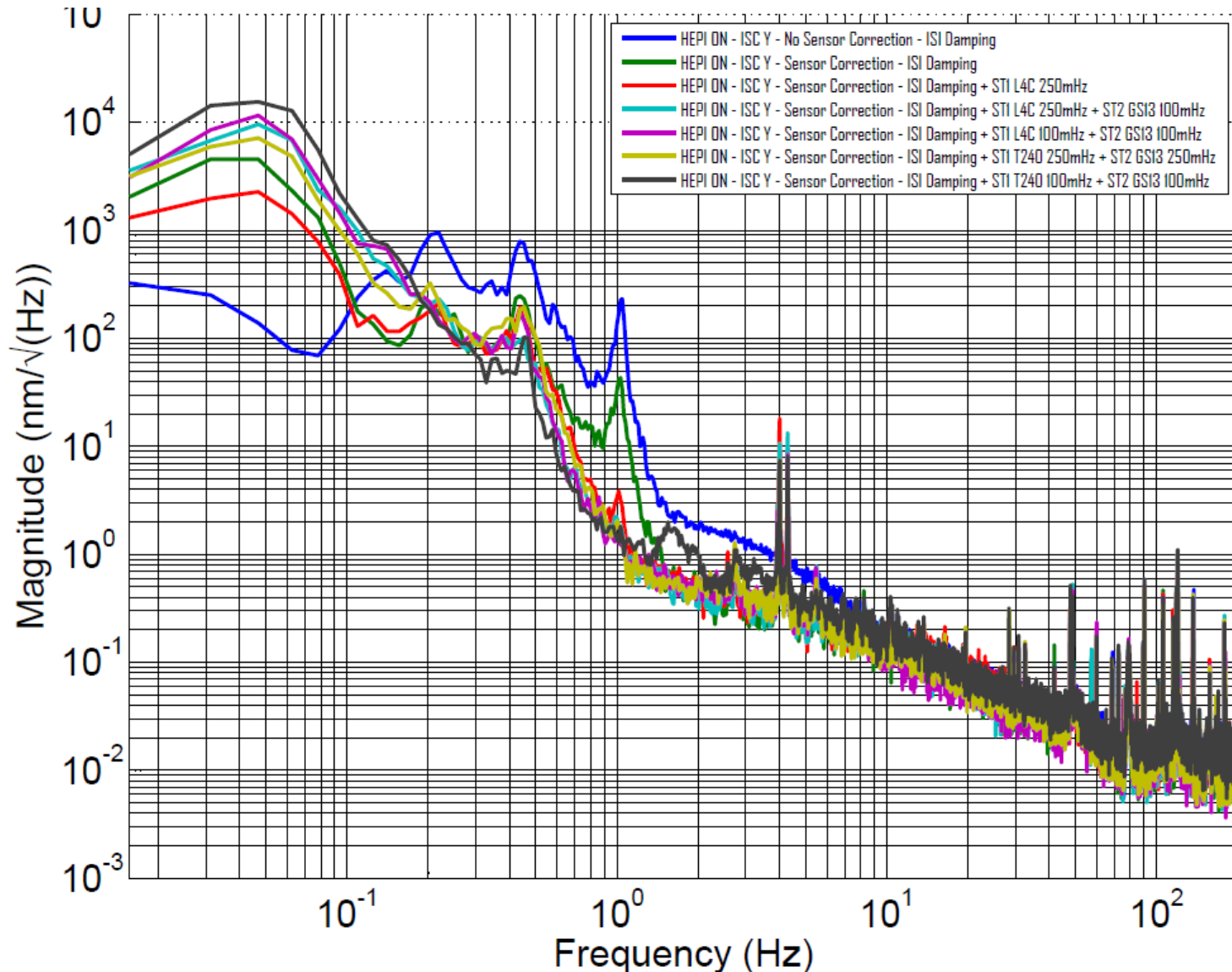
## Stage 2



# Single Arm Commissioning (LHO)

Courtesy: V. Lhuillier

## Cavity length control signal



# Conclusion

- Currently 63% of aLIGO SEI in vacuum components and 100 % of pre-isolators are built
  - 1/3 of all components will not be installed until India is ready.
- Several of each different system (HAM-ISI, BSC-ISI, HAM-HEPI, BSC-HEPI) are installed and under control at either LHO, LLO or LASTI.
- About to approve chambers to go through OPS control
- Still learning!!!... But closing in on aLIGO requirements

## Thanks / Grazie

- All Seismic team at LLO, LHO, LASTI, Stanford, Caltech
- Fabrice Matichard, Vincent Lhuillier, Richard Mittleman, Hugh Radkins, Ryan DeRosa
- LLO team:



- Y'all

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# Questions ?



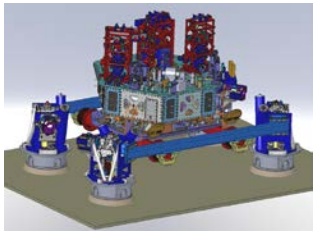
# EXTRA SLIDES



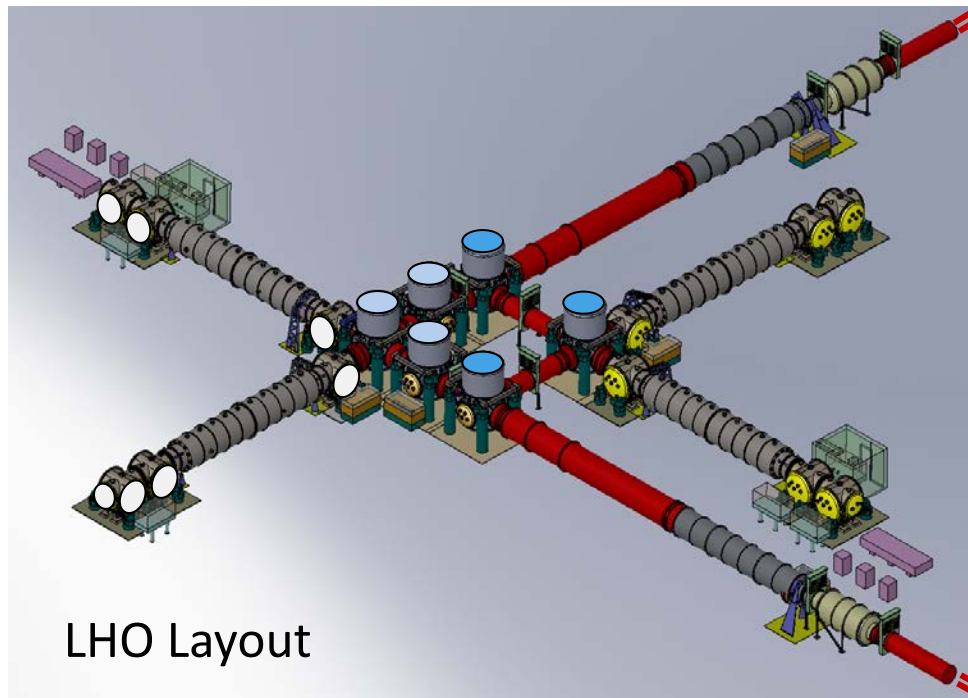
# LIGO Hanford (LHO)

Courtesy: F. Matichard

Auxiliary Optics:  
10 + 2 Chambers



- H1 HAM Chambers
- H1 BSC Chambers



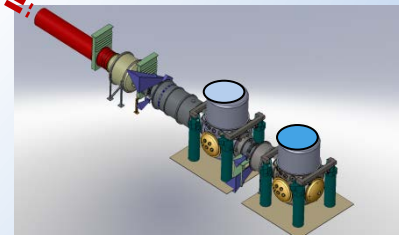
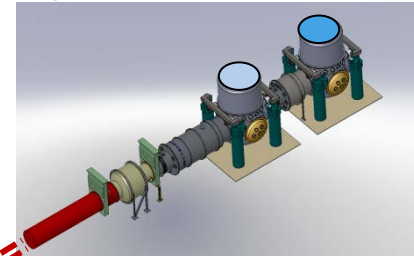
LHO Layout

- H2 HAM Chambers
- H2 BSC Chambers

Core Optics:  
10 Chambers

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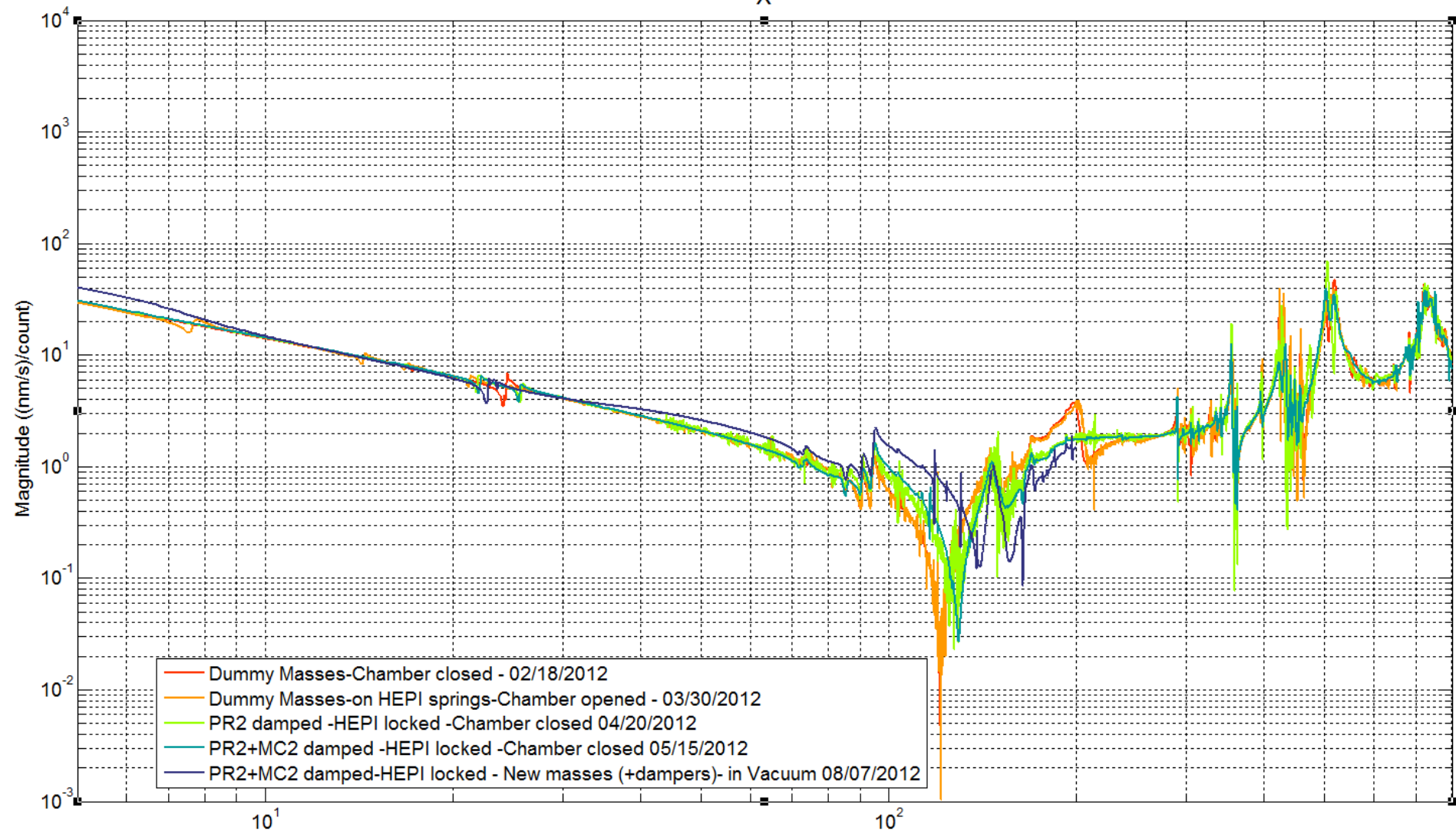


# Tracking HAM-ISI Evolution (LLO)

## L1-HAM 3 Story

HAM-ISI - L1 -HAM 3 - GS-13 Transfer Functions Comparison Spring 2012- In air

X



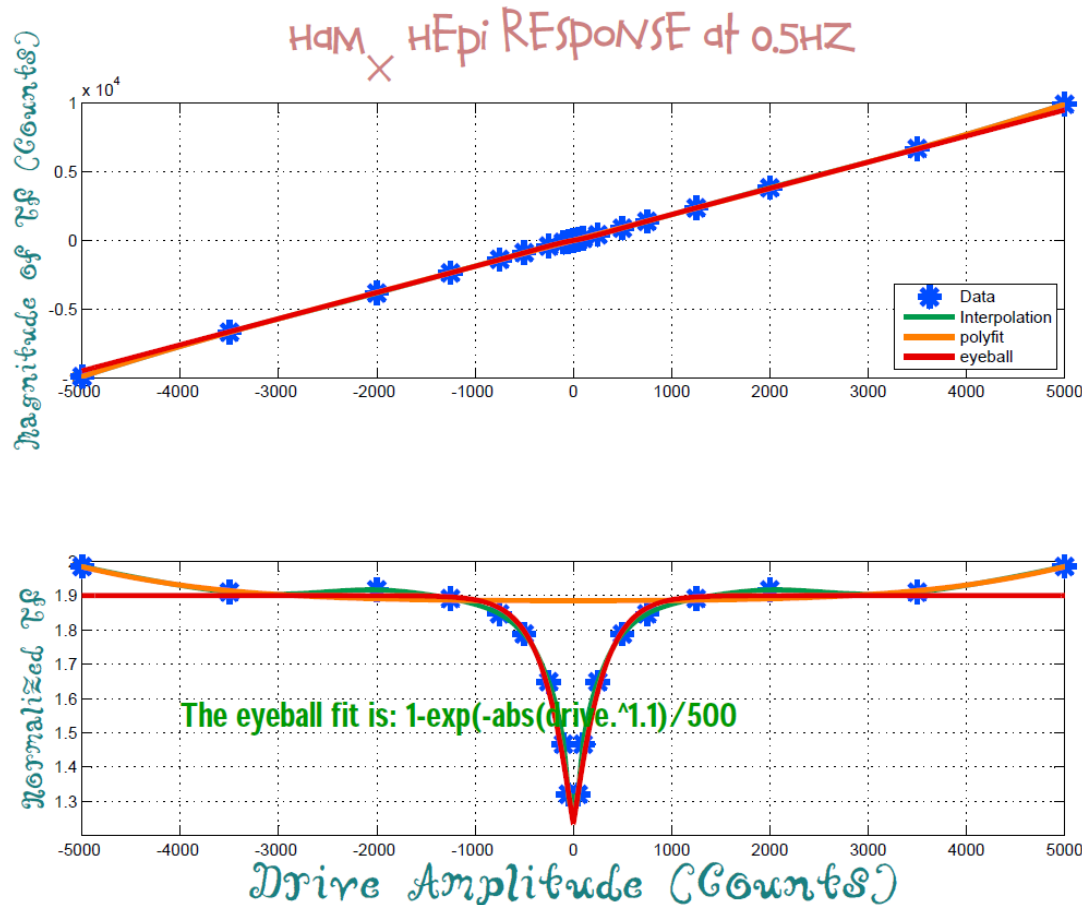


# LIGO HAM-ISI Commissioning (LLO)

- HAM-ISIs without pre-isolation (HEPI not running yet)
  - Starts right after testing after install is approved
- Damping (only with seismometer signals)
- Blend filters
- Isolation
  - Level 1 (identical to all chambers and sites)
  - Level 2 (minor adjustments for actual resonances)



- HEPI limitation?... Non linearity of low amplitude drives



Courtesy: R. Mittleman

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