HAM Suspensions Update

Advanced LIGO Suspensions
LIGO-Virgo Meeting
March 2009

Derek Bridges representing Advanced LIGO Suspensions team

http://ilog.ligo-wa.caltech.edu:7285/advligo/Suspensions

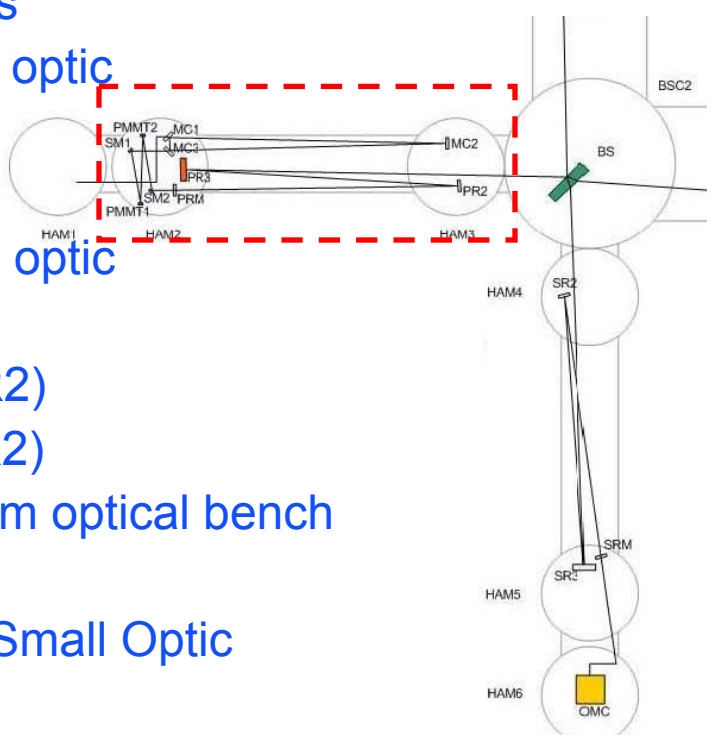
LIGO-G0900106-v1

Advanced LIGO SUS Team

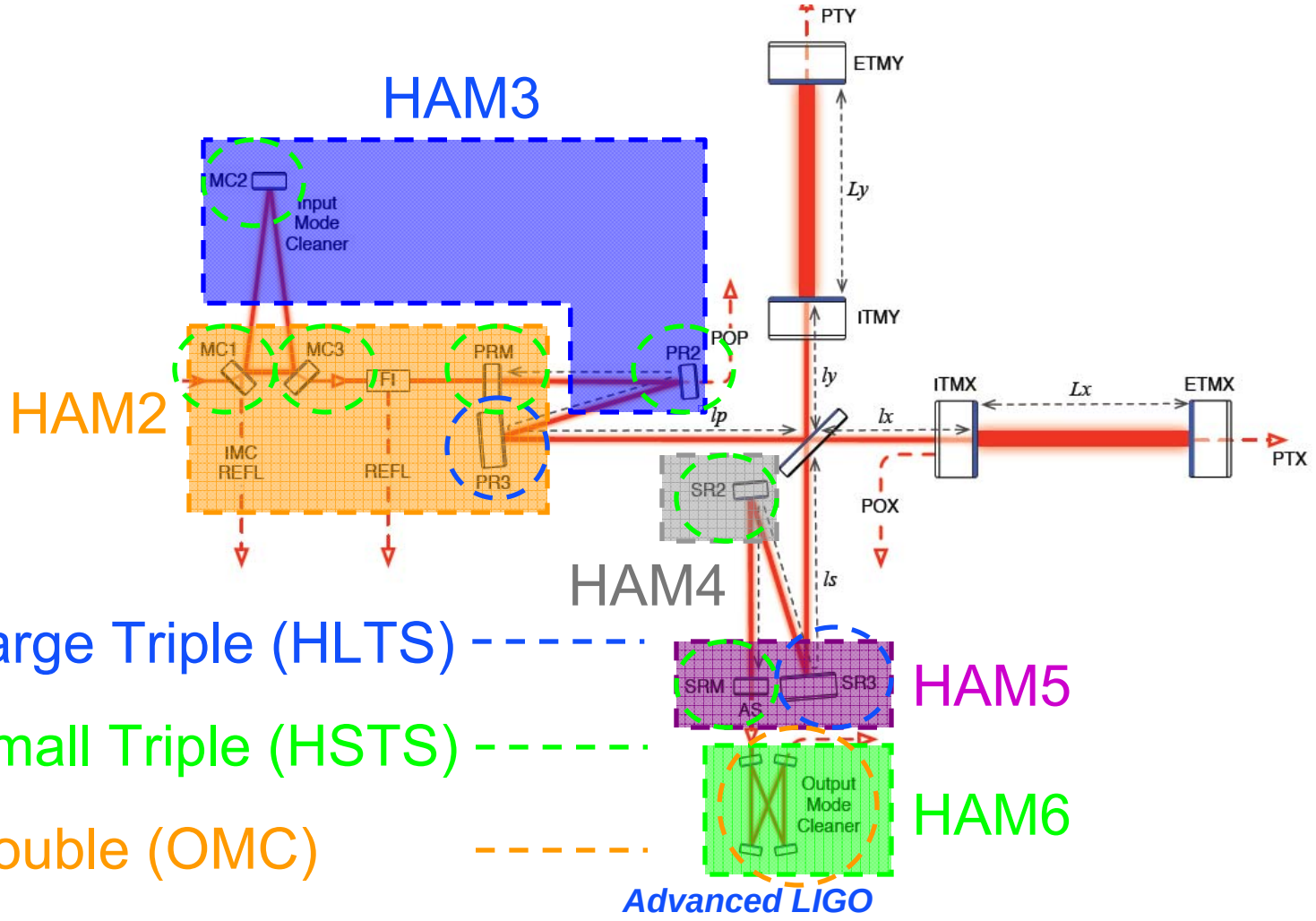
- LIGO Caltech: M. Barton, D. Coyne, J. Heefner, A. Heptonstall, K. Mailand, N. Robertson (also at Glasgow), C. Torrie
- LIGO MIT: P. Fritschel, R. Mittleman, B. Shapiro
- LIGO LHO: B. Bland, D. Cook, G. Moreno
- LIGO LLO: D. Bridges, M. Meyer, B. Moore, J. Romie, D. Sellers, G. Traylor
- University of Glasgow: C. Craig, L. Cunningham, A. Cumming, G. Hammond, K. Haughian, J. Hough, R. Jones, R. Kumar, I. Martin, S. Rowan, K. Strain, K. Tokmakov, M. van Veggel, A. Wanner
- Rutherford Appleton Laboratory (RAL): A. Brummitt, J. Greenhalgh, J. O'Dell
- University of Birmingham: S. Aston, R. Cutler, D. Lodhia, A. Vecchio
- University of Strathclyde: N. Lockerbie

HAM Suspension Overview

- Four types of suspensions sit on HAM optical tables
  - Large Triple suspension (HLTS) – 265mm dia. optic
    - Power Recycling Cavity Mirror (PR3)
    - Signal Recycling Cavity Mirror (SR3)
  - Small Triple suspension (HSTS) – 150mm dia. optic
    - Input Mode Cleaner (IMC)
    - Power Recycling Cavity Mirrors (PRM, PR2)
    - Signal Recycling Cavity Mirrors (SRM, SR2)
  - Double suspension – 450mm × 150mm × 38mm optical bench
    - Output Mode Cleaner (OMC)
  - Single suspension – 76mm dia. optic – iLIGO Small Optic Suspension (SOS)
    - Input Mode Matching Telescopes
    - Steering Mirrors

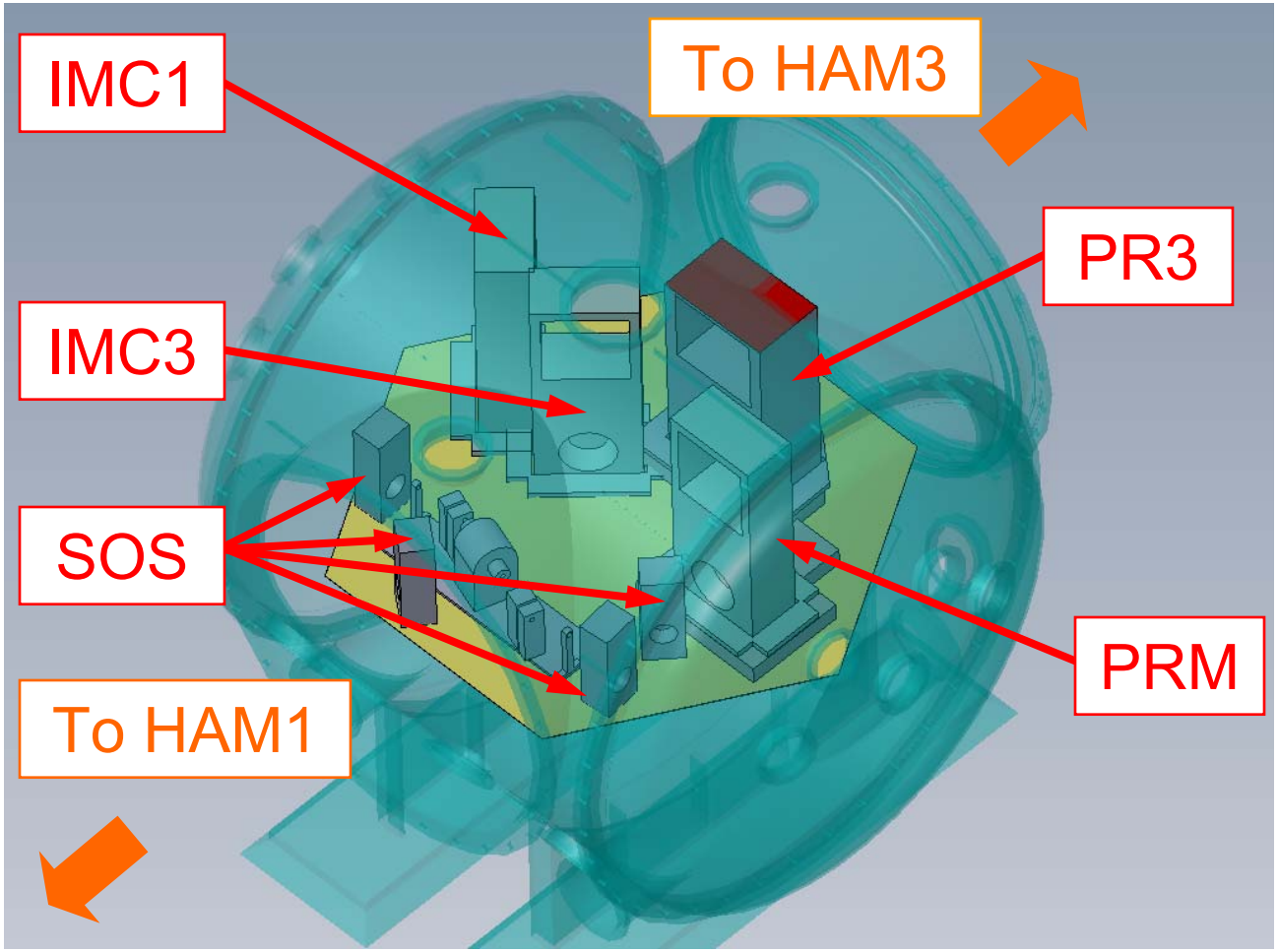


Stable Recycling Layout

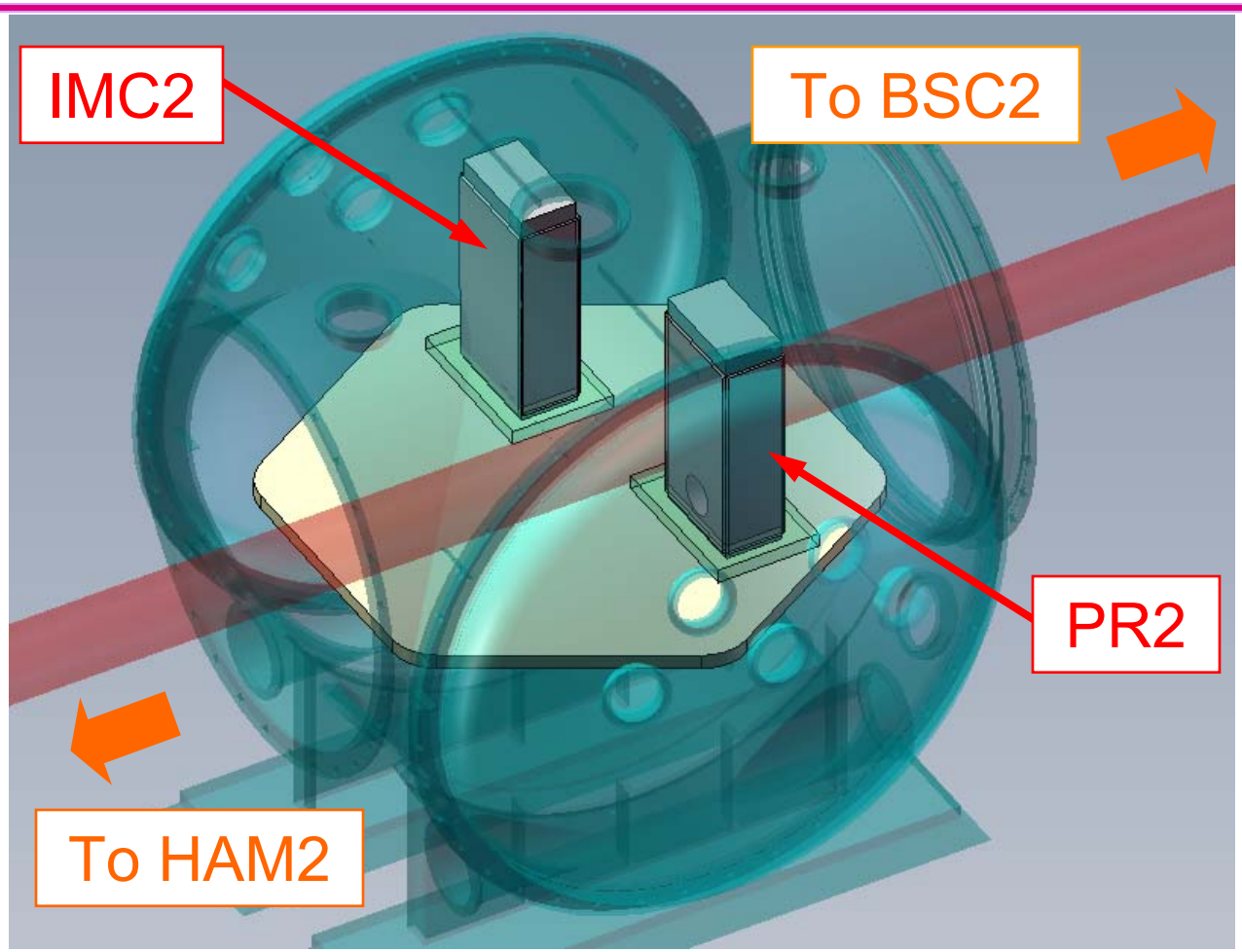


Advanced LIGO

HAM2 Layout



HAM3 Layout



HAM Suspensions Status

- Triples
  - Preliminary design review complete
  - Triples electronics
    - Design pursued by SUS-US building on SUS-UK work
    - Production by SUS-UK
  - Large Triples (HLTS)
    - Prototype being fabricated
      - Stainless steel welded structure – resonance testing done
      - Minor redesign of some parts underway
  - Small Triples (HSTS)
    - Input Mode Cleaner prototypes fully tested at LASTI
    - Upcoming triple-quad cavity test at LASTI

HAM Suspensions Status (cont.)

- Doubles (OMC)
  - Output Mode Cleaners installed, being tested and commissioned for Enhanced LIGO at LLO and LHO
  - Final design review ongoing
  - Procurement to start by May 1, 2009
- Singles
  - Baseline – reuse iLIGO SOS's (Small Optic Suspension)
  - Wires and clamps to be replaced

Triples PDR

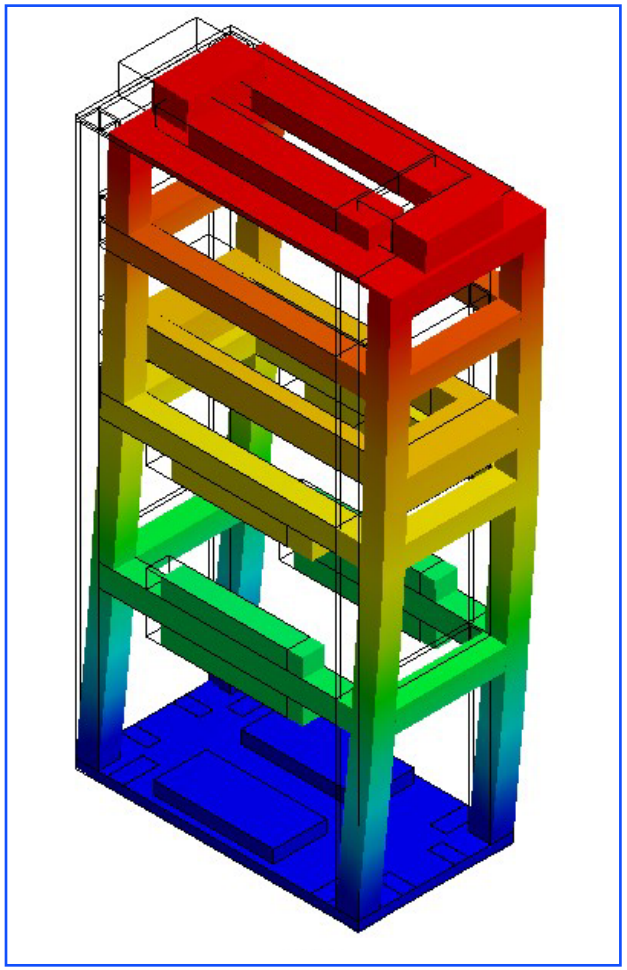
- Preliminary design review for triple suspensions conducted Nov. 2008-Jan. 2009
- Result: Proceed with final design
- Recommendations:
  - Investigate stronger/higher-stress blade springs to increase vertical isolation
  - Consider design with higher stress in wires to lower highest vertical frequency (28 Hz)
  - Collaborate with SEI – does modeling indicate coupling (at 28 Hz peak in vertical) between HAM-ISI and suspension?
  - Coordinate with SYS on max. acceptable weight based on layout
  - Separate PDR to be held for electronics

HLTS (HAM Large Triple SUS)

- Used for large optics in stable recycling cavities
- Prototype being fabricated
  - SSTL welded structure
  - Resonance test results well-correlated with FE analysis (~140 Hz)
  - Electronics test stand ready
  - Some minor redesign of parts to simplify assembly
- Prototype testing at LLO

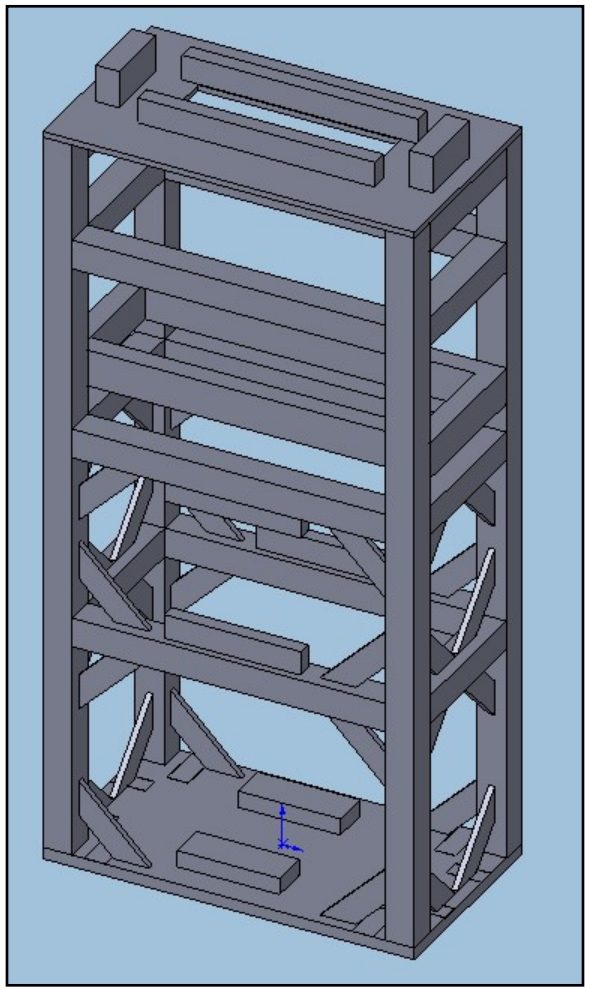
HSTS (HAM Small Triple SUS)

- Originally designed for Input Mode Cleaner
- Now also used for small Recycling Mirrors
- IMC configuration tested at LASTI
- Problem with structural resonant frequencies
  - Measured: First resonance = ~50 Hz
  - Subsequent requirement: First resonance >150 Hz (to avoid affecting HAM-ISI controls)
  - Need to increase frequency while maintaining footprint (crowding in HAM2)

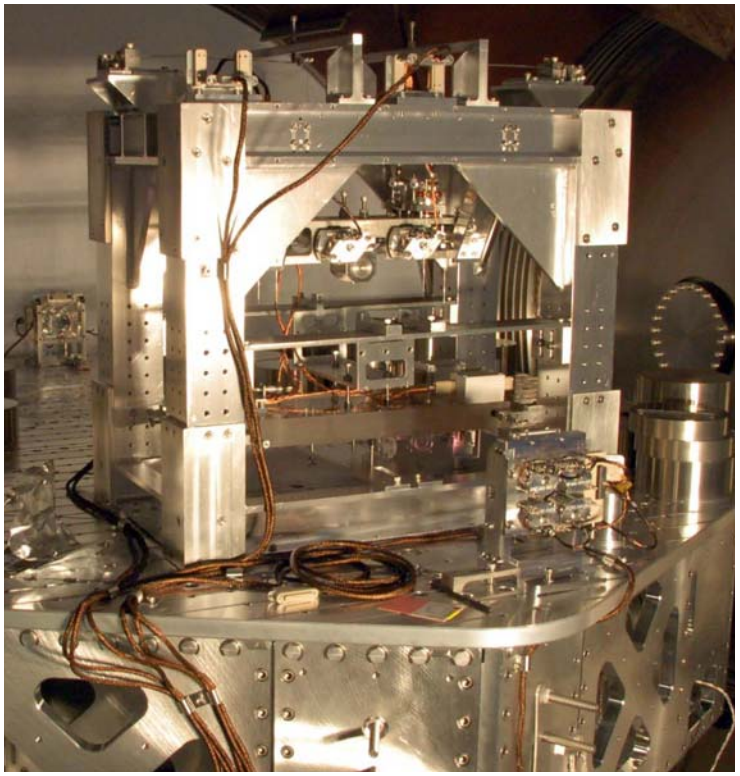


HSTS (HAM Small Triple SUS)

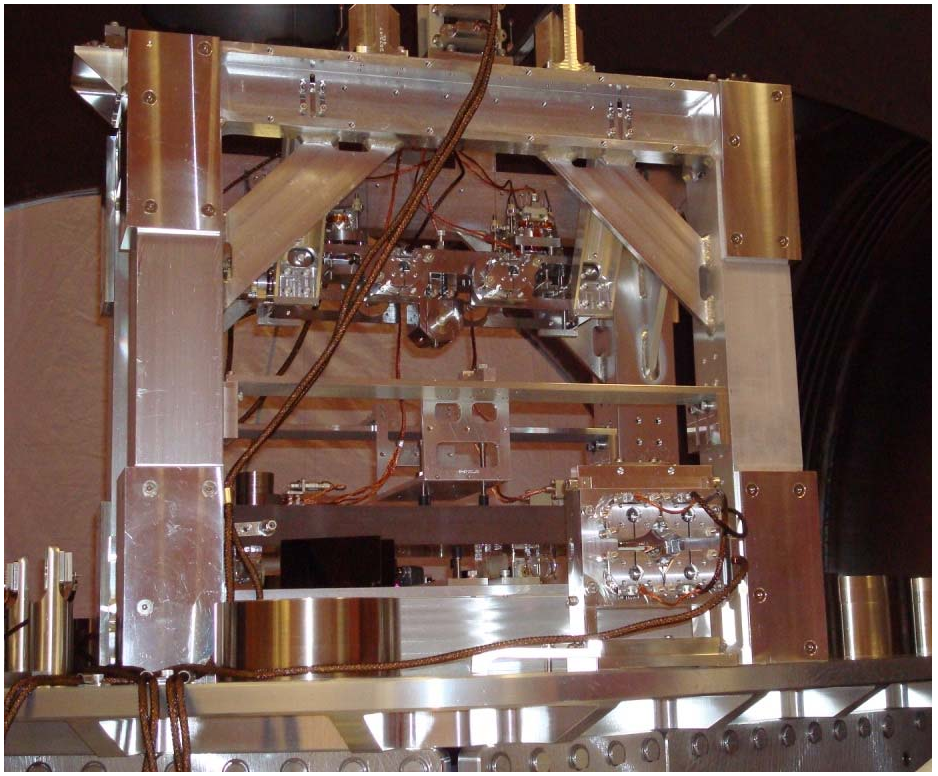
- Structural redesign (T080318)
  - Thicker base plate (1” → ~60 Hz)
  - Addition of crossmembers and gussets (~85 Hz)
  - Switch structure material from Al to SSTL
    - Heavier
    - Easier to weld
  - Reduce mass of nonsuspended items
    - Tablecloth – SSTL to Al
  - Current FEA – ~105 Hz
  - Increase size of structural members
  - Provision for struts
- Baffle design (with IO) – still in progress



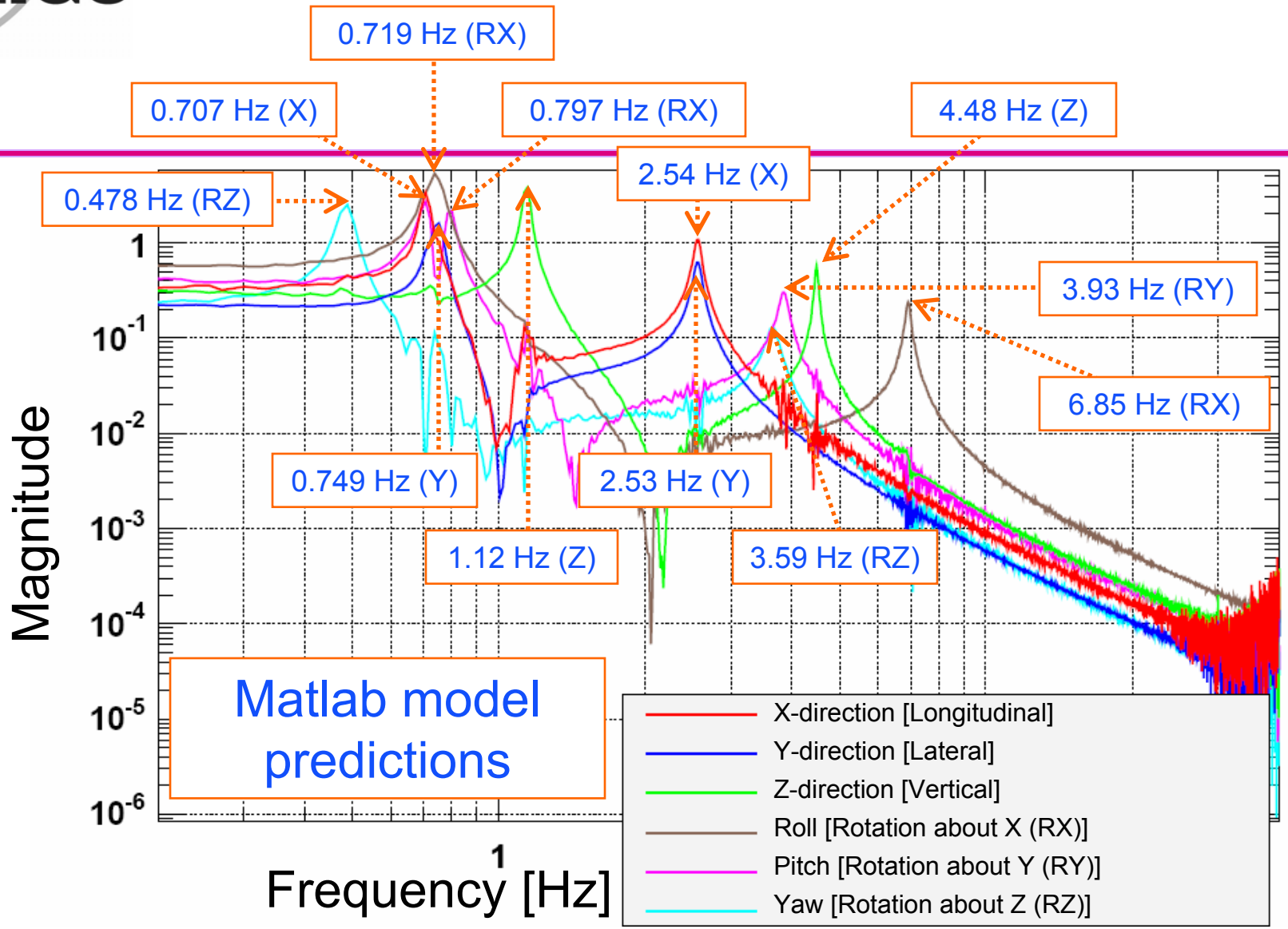
Output Mode Cleaner



LLO OMC



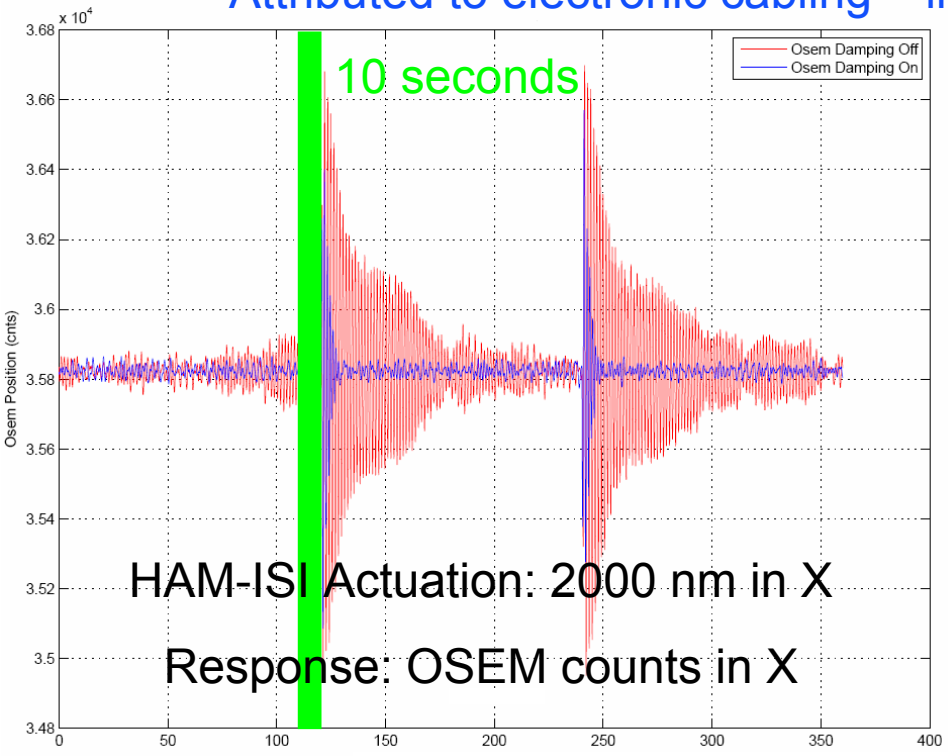
LHO OMC

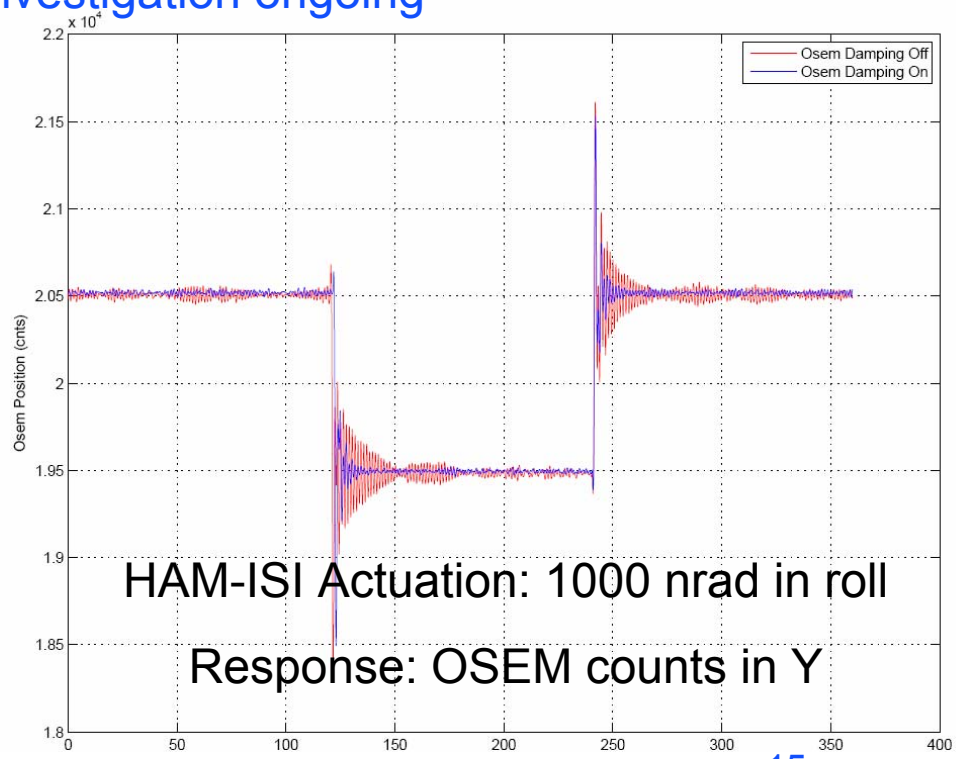


Credit: D. Bridges, T. Fricke

LLO OMC Damping Tests

- Active Damping: Requirement to damp to e^{-1} = 36.8% in <10 seconds achieved
- Passive Damping: Measured Q values – ~90 (long.), ~70 (vert.)
  - Values lower than modeled; however no requirement has been set
  - Attributed to electronic cabling – investigation ongoing





Credit: D. Bridges, J. Kissel

Maraging Steel Blade Springs

- RFQ for more prototype blades
  - Enlarge vendor pool
  - Investigate higher-stress blades
    - Thinner blades → Tighter blade curvature
    - Testing of linear behavior, overload recovery to be done
  - Electroless nickel-plating of blades now included in process specification (E0900023)
    - Prevents corrosion
    - Samples tested under multiple loadings – no flaking, no performance degradation

Misc. Engineering Improvements

- Many initiatives to streamline engineering work
  - Opto-Mechanical meetings (twice monthly) – sharing of data between engineers in SUS, SEI, SYS, AOS
  - Reinstated SUS technical meetings (weekly)
  - New Advanced LIGO drawing templates (M. Meyer, B. Moore)
  - New color coding system for materials (D. Bridges)
  - More training in SolidWorks and PDMWorks Vault (version control for models and drawings), streamlined processes for new DCC
  - New hires for drafting, logistics, clean and bake
- These initiatives support adherence to aggressive schedule
  - Final Design Reviews – HSTS (summer), HLTS (autumn)

Conclusions

- SUS teamwork continues
  - Development work through FY 2009 in parallel with project work
    - HSTS/HLTS – Design, prototyping, assembly, testing, final design reviews
    - Triple Electronics – Finish design, build prototypes, design reviews
    - OMC - Final design review actions, start production
    - iLIGO OSEMs – Complete value engineering, design review, start production
    - Quad SUS – Complete training (incl. electronics), receive production parts, start assembly