



---

# Suspensions Update: the View from Caltech

Phil Willems  
LIGO/Caltech

Livingston LSC Meeting  
March 17-20, 2003

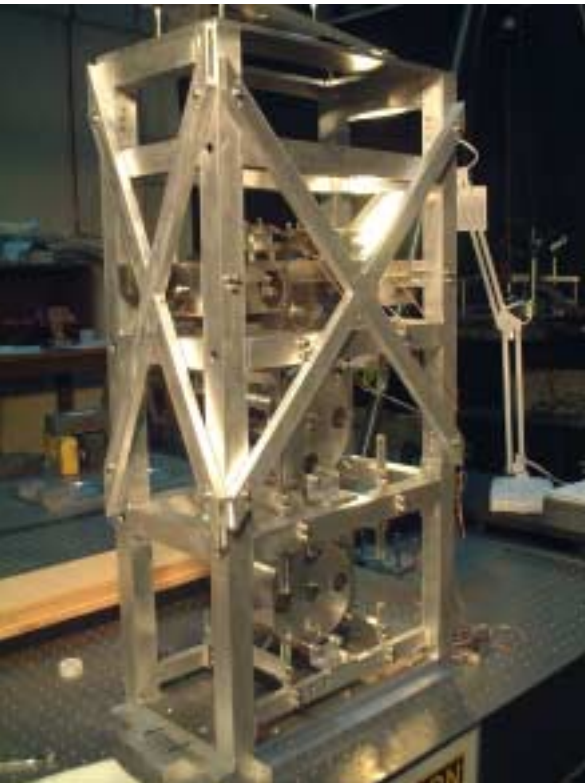
# Progress in Prototypes: Mode Cleaner Suspension

- Successes
  - » Constructible
  - » Modes of suspension are as predicted
- Challenges:
  - » Stainless steel coil formers are made ferromagnetic by wire EDM machining
  - » Structure resonant frequencies are low and need to be pushed higher
  - » Sensor noise (about which more later)



# Mode Cleaner Milestones

- MC design completed summer 2002
- Refined adjustable eddy current dampers in prototype



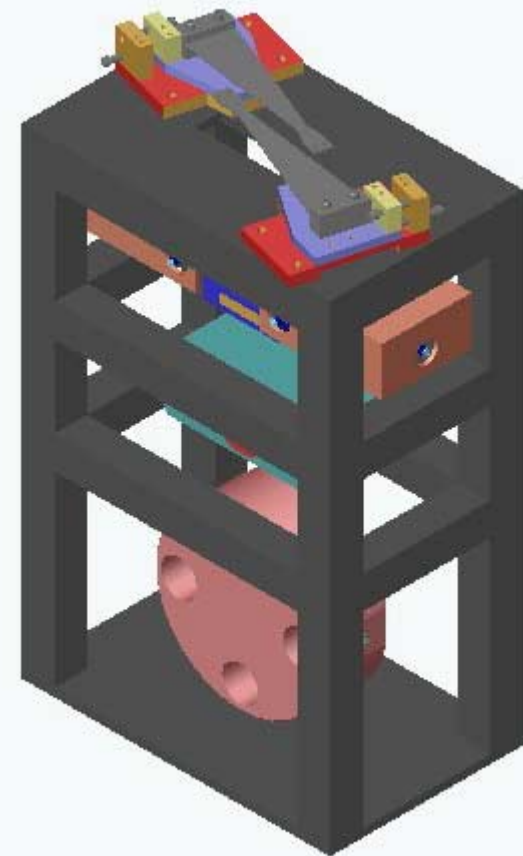
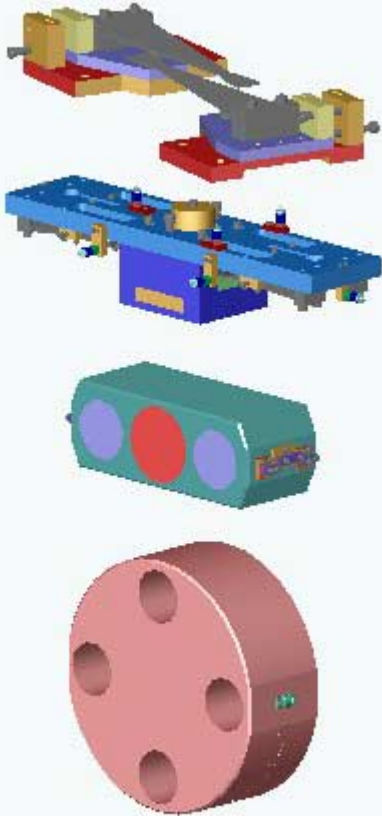
- Hybrid LIGO/GEO OSEM design for local damping
- Design does not include reaction chain
- Refinements to clamps and blades
- Refined yaw, pitch adjustments
- Installation fixtures

# Progress in Prototypes: Recycling Mirror Suspension

Design progressing well,  
just beginning production  
now.

Some departures from  
GEO design

- » As with mode cleaner, no reaction chain
- » Truncated intermediate mass allows for shorter design, better fit in HAM chamber
- » Intermediate mass and suspension wires are metallic to take advantage of relaxed thermal noise requirements for recycling mirrors



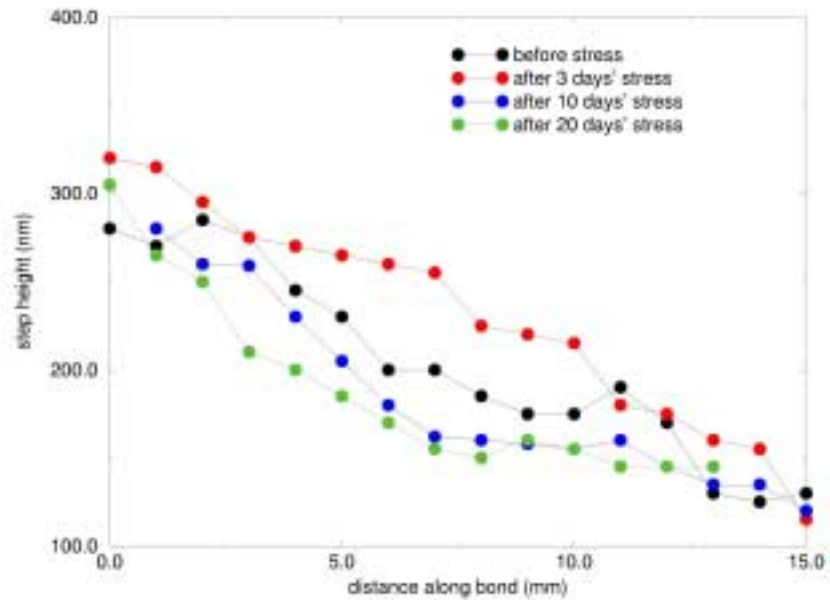
# Silicate Bonding: Latest Results

- Creep measurement: bonds with a known substrate misalignment are put under AdLIGO shear for 10 days and the misalignment remeasured.
- Attempts to measure creep in silicate bonds have all yielded null results so far:
  - » Silica/silica bonds:  $dx/dt < 6 \times 10^{-14} \text{m/s}$
  - » Silica/sapphire bonds:  $dx/dt < 5 \times 10^{-13} \text{m/s}$
- Early attempts to make strong silica/SF4 bonds have so far not proven very successful- about half fail.
  - » Interesting observation- glass always pulls from the SF4 substrate
  - » Maybe an improved recipe will solve the problem

## How We Measure Creep



Creep Test of Silica/Silica Bond



# Some Zits that Need Picking

---

- Payload requirements
- Electromagnetic interactions with SEI
- Space constraints within the full interferometers
- Actuator noise within the active band needs to be lower
- Requirements need to be set for thermal compensator plates

# Payload Requirements

- Initial assumption: 800kg limit for all platforms
  - “Seismic Isolation Subsystem DRD,” LIGO-E990303-03-D
- But this is much too much for HAMs, much too little for BSCs. Current SEI platform maximum payload estimates:
  - » HAM: 581kg (HAM4, with SRM, output MC2, periscopes, counterweights, etc)
  - » BSC: 1080kg (BSC1, with ITM, thermal compensator, counterweights)
  - » But note the contingencies: we have not designed the output MC, and the payload for the ITM+FM (BSC7 & BSC8) in the folded IFO will likely be even larger
- SEI design will likely change to reflect actual payloads, perhaps even with specific design for BSC7 & BSC8
- SUS design will likely change to reduce weight, especially for quads
- Currently a subject of intense effort

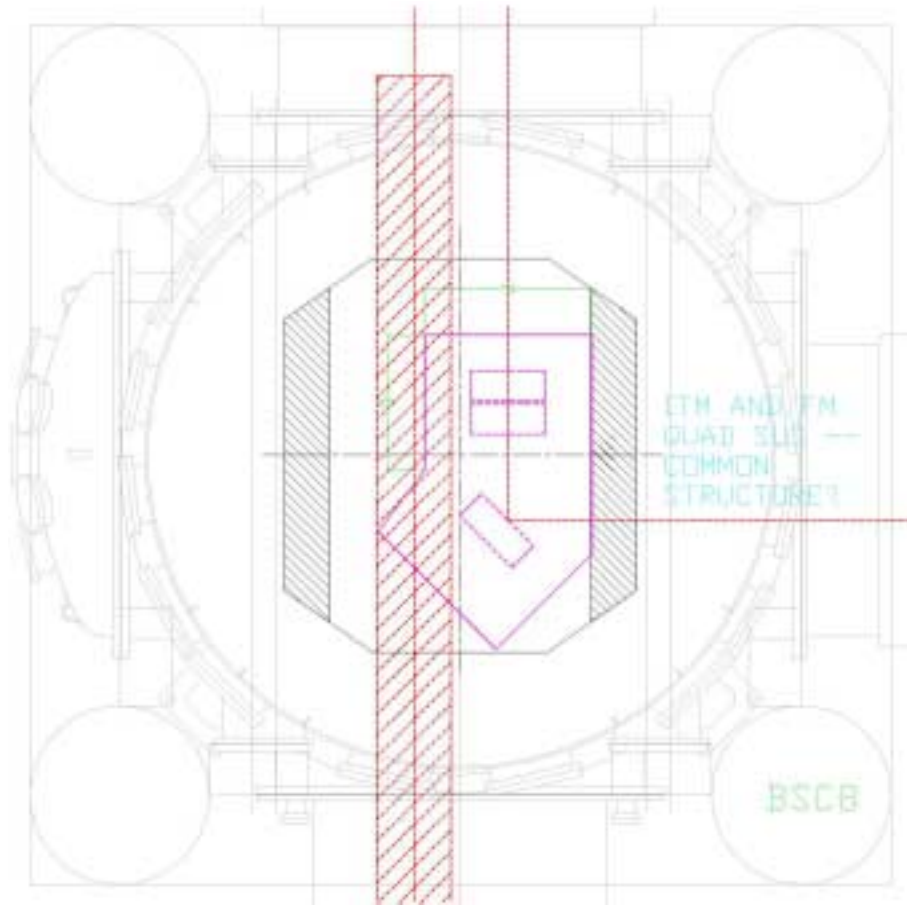


# Sensor Noise

- Available motion sensors with 1mm range have  $10^{-10}$  m/rt(Hz) noise in the 1-10Hz band where suspension resonances lie- this noise cannot be filtered away.
- The SEI platform will provide  $10^{-11}$  m/rt(Hz) at 1Hz, falling to  $2 \times 10^{-13}$  m/rt(Hz) at 10Hz
- Thus with any significant gain in the local damping servoes the actuator noise will undo much of the benefit of the seismic isolation, increasing RMS motion
- Eddy current damping appears promising for triples but insufficient for heavier quads without exotic (cryogenic) upgrades
- Less damping can help, but how little is too little?
- Noise above 10Hz may be reduced using Losurdo technique (see Norna Robertson's talk)

# Space Constraints on Suspensions Keep Getting Tougher

- Space constraints within the BSC chambers
  - » “All suspensions and suspension structures within the BSC chambers shall reside within a zone of 111cm width centered on the global axis. “
  - » “The suspensions for the folded IFO shall not obstruct the 4K IFO beams. “
  - » This will require much thought for the folding mirrors.



# Space Constraints Continued

- “Stay clear” zones under the support beams complicate thermal compensator installation.

