
Update on Suspension Designs for BSC Optics

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Summary of BSC Optics

- EndTest Mass (ETM)
- Inner Test Mass ITM)
- Beamsplitter (BS)
- Folding Mirror (FM)
- Compensator Plate (CP)

These are all nominally on quadruple pendulums.
However -

- Different requirements on noise level
- Different requirements on actuation/reaction chains
- Different sizes, masses

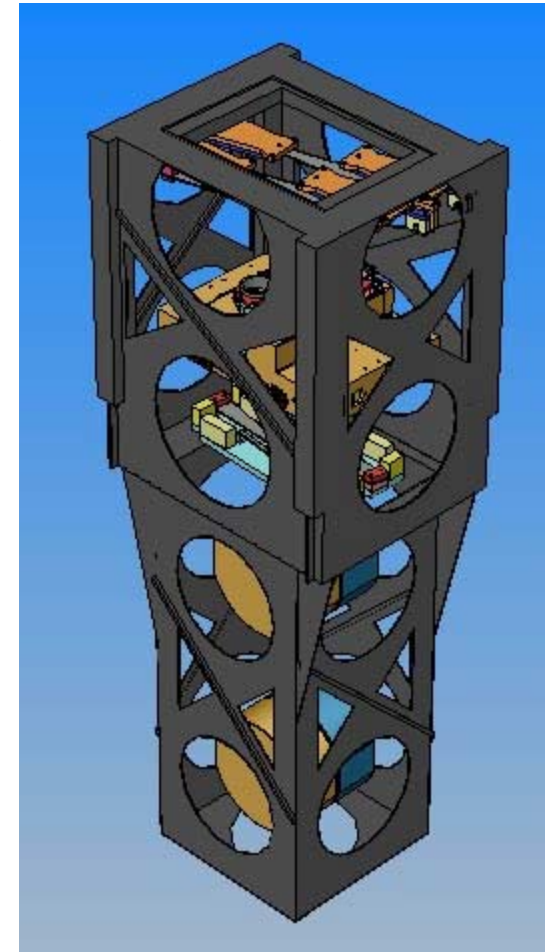
Since Hannover LSC meeting: investigations using MATLAB modelling of various design issues + key decisions/recommendations to simplify design process



ETM/ITM suspension

Changes subsequent to latest Conceptual Design Document (Oct 2003, T010103-03)

- (a) Length changes:
 - i) to increase space for catcher structure supporting penultimate and test mass,
 - ii) to ease installation at LASTI by reducing overall length
- Conclusion: shortened length (now 2.005m including structure) is acceptable
 - See "Investigation of Wire Lengths in Advanced LIGO Quadruple Pendulum Design for ETM/ITM", NAR, T040028-00-R

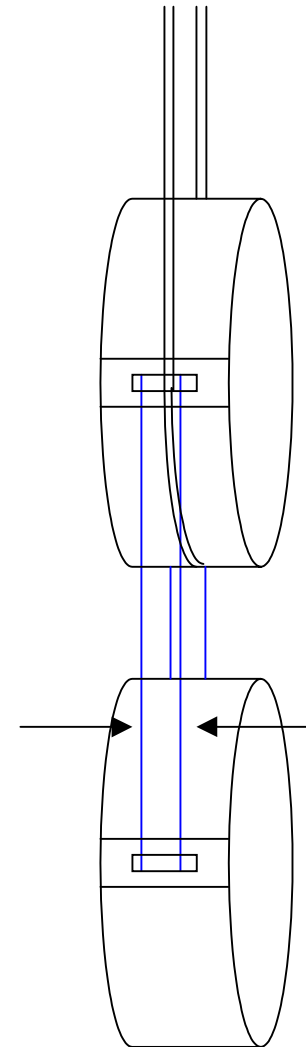


ETM/ITM suspension contd

- b) Investigate increasing spacing of ribbons/fibres (blue) in longitudinal direction:
 - To allow exploration of different ear designs
 - To ease space for the welding process
 - Range of 16 to 40 mm (full width) considered

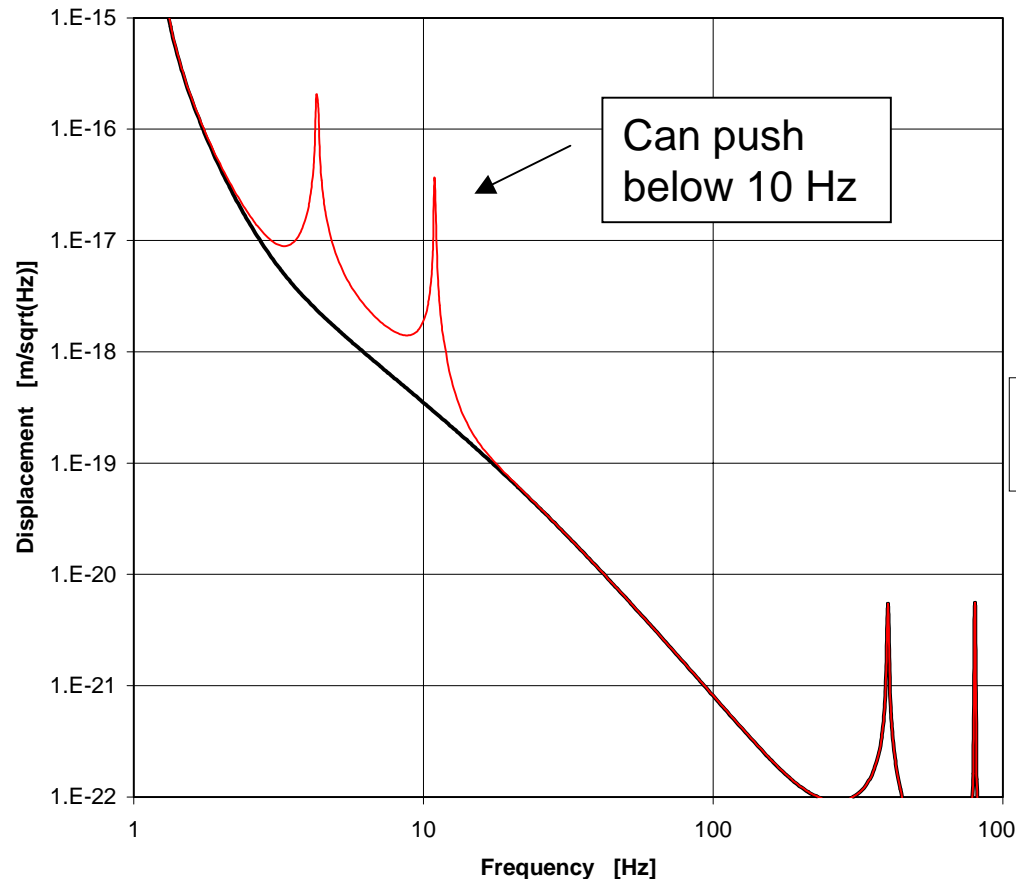
See "Investigation of Spacing of Silica Fibres in Advanced LIGO Quadruple Pendulum Design for ETM/ITM", NAR discussion document

- Frequencies, mode coupling, damping generally OK (long/pitch coupling increases: need to check control band noise level)
- Pitch thermal noise increases linearly with spacing. Estimate for 30mm spacing, ϕ of fibre $1.6e-7$, is $\sim 2e-17$ rad/rtHz at 10Hz. Fuller calculation required to verify.



Beamsplitter Design

- Analysis carried out on a preliminary design of a *triple* pendulum suspension
 - Noise requirements relaxed by x50 from ETM/ITMs
 - Vertical coupling re-estimated (D Coyne) as lower than previously considered
 - Triple is less complex design - savings in effort, time, money
 - Extensive experience of triples (GEO + MC, RM designs)
- Conclusions: design appears to satisfy noise requirements (see “Design of Beamsplitter Suspension for Advanced LIGO”, NAR, T040027-00-R)
- Further work on layout, including footprint, underway

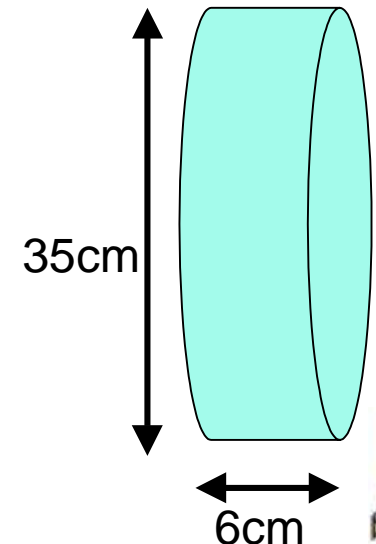


Suspension thermal noise: Black curve: longitudinal motion (no vertical coupling)
Red curve: total longitudinal motion with 0.1% vertical coupling (G Cagnoli, NAR)



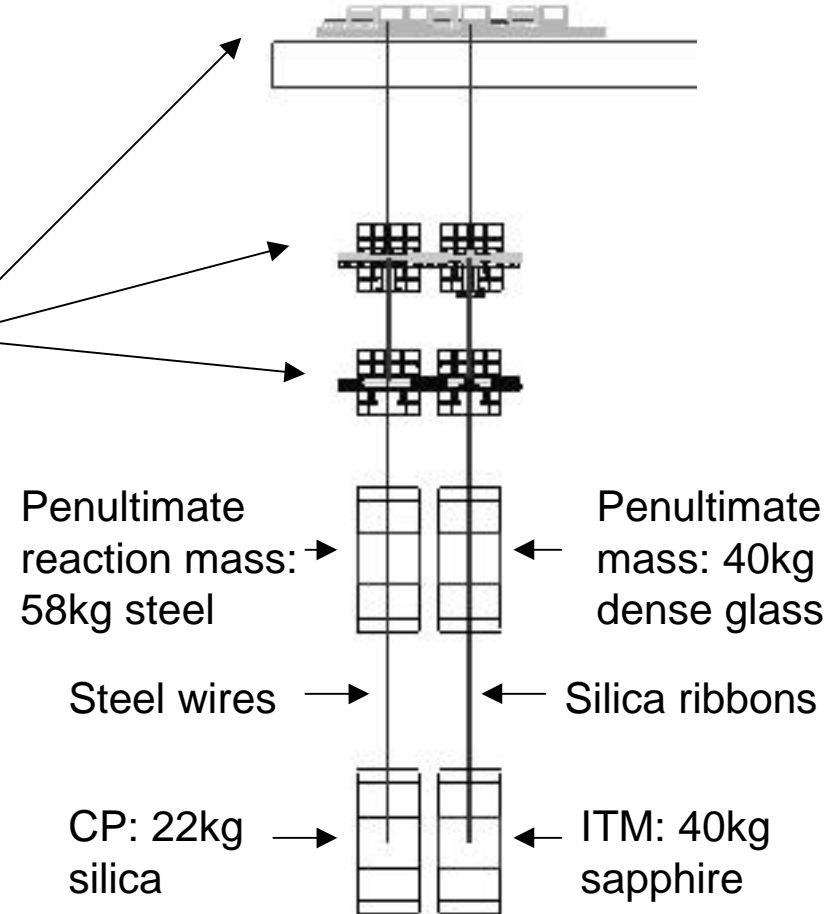
Folding Mirror (FM)

- Original design of FM - same diameter as BS, but approx twice as thick due to concern that coating strain from high reflectance coatings might warp a thinner optic
- Advantage to have FM same as BS - commonality of design and parts.
- Proposal from D Coyne:
 - adopt an FM equal in size to the BS as baseline
 - apply nominally identical coatings on both sides (the back side de-tuned from 1064 nm slightly)
 - use iterative etching and subsequently the active thermal compensation system to compensate any residual ROC imbalance
- Conclusion: A RODA (record of agreement/decision) M040006-00 has been made:-
 - FM will be same size and mass as beamsplitter
 - 35cm diameter, 6 cm thick (current numbers)



Compensator Plate (CP)

- Proposal: include CP as ultimate mass in reaction chain of ITM (noting that wide bandwidth global control not used on ITM). A RODA to this effect has been agreed (M040005-00)
- Details as shown: total load on blades and overall footprint identical to main ITM chain – gives commonality of design
- MATLAB analysis carried out to check mode frequencies, coupling of modes and damping
- Conclusion: this is a viable solution
- Refs (“Design of a suspended compensator plate” P Willems, and “Investigation of Suspension of Compensator Plate in ITM Reaction Chain”, NAR, T040038-00-R)



Summary of BSC Suspensions

- TWO main suspension designs for FIVE types of optics, thus significant savings in effort.....
 - Quad: ETM, ETM reaction chain, ITM, ITM reaction chain with CP
 - Triple: BS and FM
- Status of models/designs
 - Detailed design of ETM for controls prototype underway
 - Working design for BS/FM – layouts of blades, footprints etc being studied

→ JR + CIT presentations

