Advanced LIGO Update

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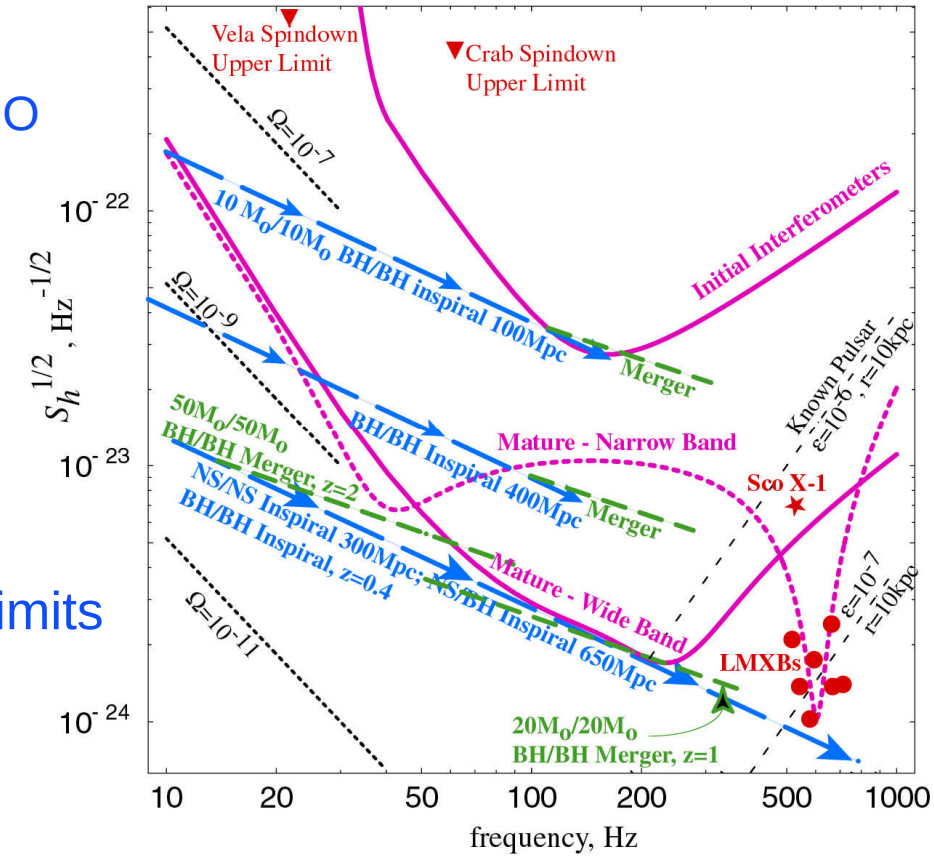
Advanced LIGO

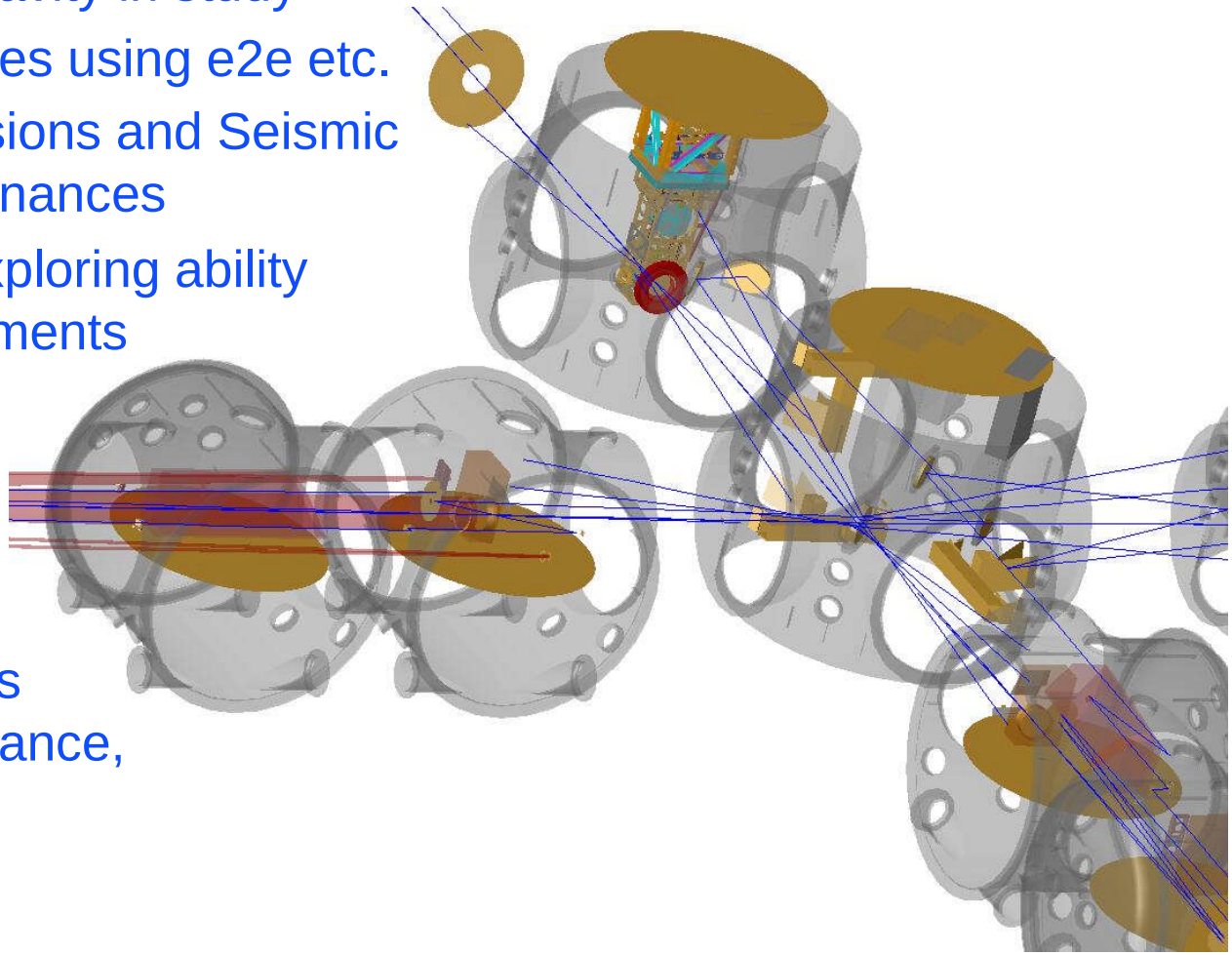
- If you have just tuned in...
  - » Second generation of detectors in LIGO
  - » ~Factor 10 in amplitude sensitivity
  - » ~Factor 4 lower frequency 'wall'
- Quantum Limited at most frequencies
  - » Recombined Fabry-Perot Michelson
  - » ~20x higher input power
  - » Signal recycling → tunable
- Gravitational gradient, thermal noise limits
  - » 40 kg fused silica masses
  - » Fused silica suspension
  - » Agressive seismic isolation



- ….and now: a quick run through of progress highlights and active questions

Systems

- May integrate seismic platform interferometer or equivalent – to reduce RMS in locking phase, possibly also used in operation
- Mode-Stable recycling cavity in study
- Locking, wavefront studies using e2e etc.
- Struts between Suspensions and Seismic may damp coupled resonances
- Layout gaining detail, exploring ability to incorporate these elements



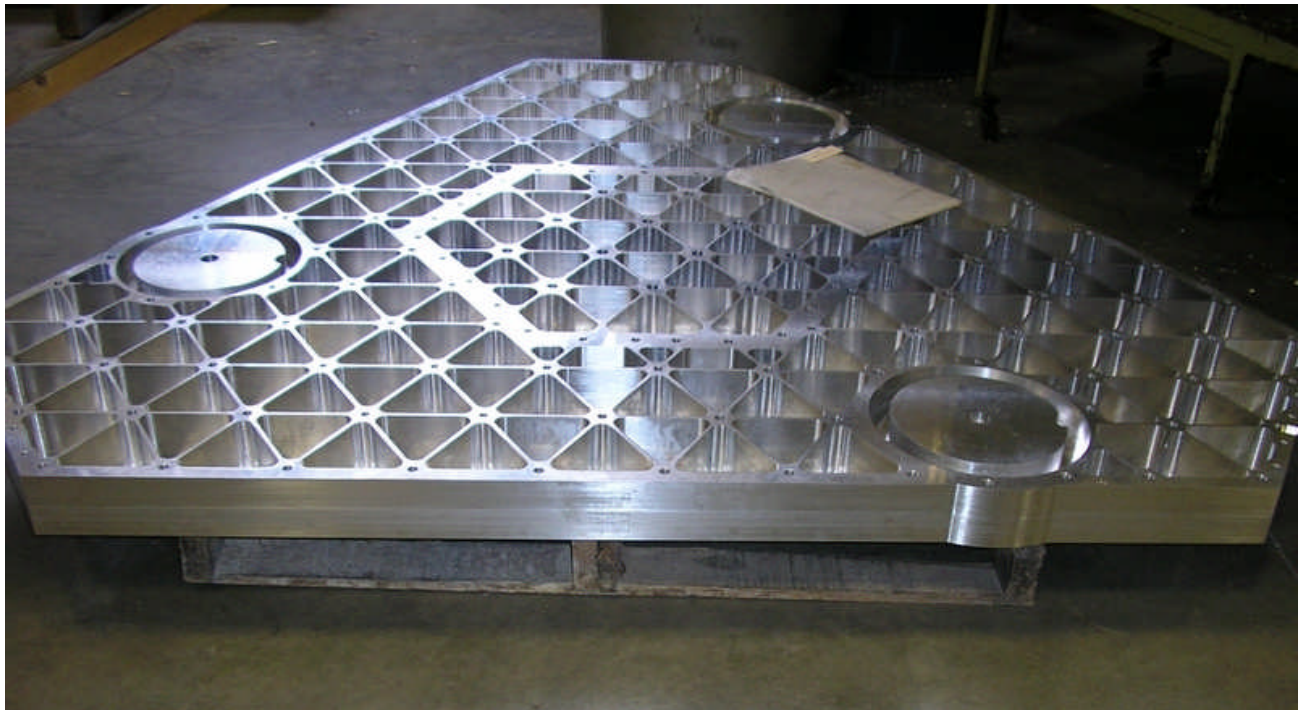
- Requirements for sub-systems growing in detail, maturity – enables optimizations of performance, cost

Suspensions

- Test Mass ‘Controls’ Quad Suspension
  - » Mass catcher or ‘cage’ from UK
  - » Spring design, mass design from Caltech
  - » Shipped to MIT LASTI, now installed under seismic ‘spacer’
  - » Some initial tests, then to be installed in BSC chamber
- Interferometry using AdL suspensions!
  - » Two mode-cleaner triple suspensions set up as short cavity
  - » For controls testing
- UK into quad ‘noise prototype’ design – contribution to AdL

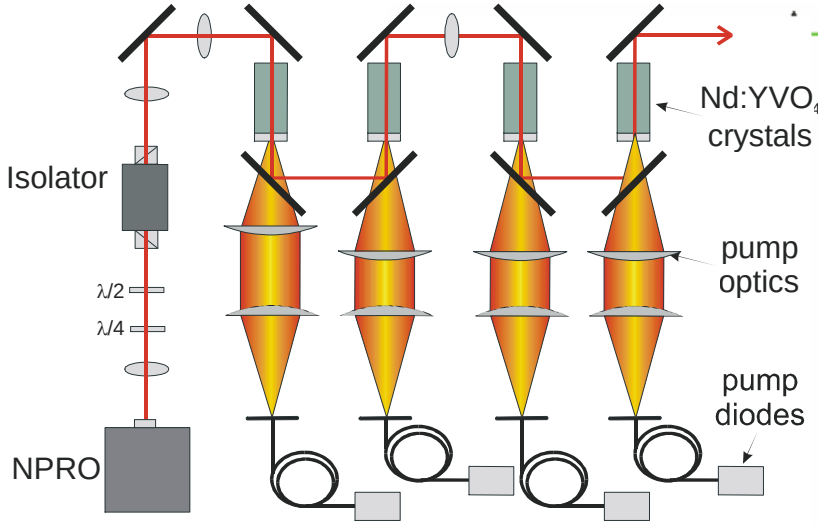
Seismic Isolation

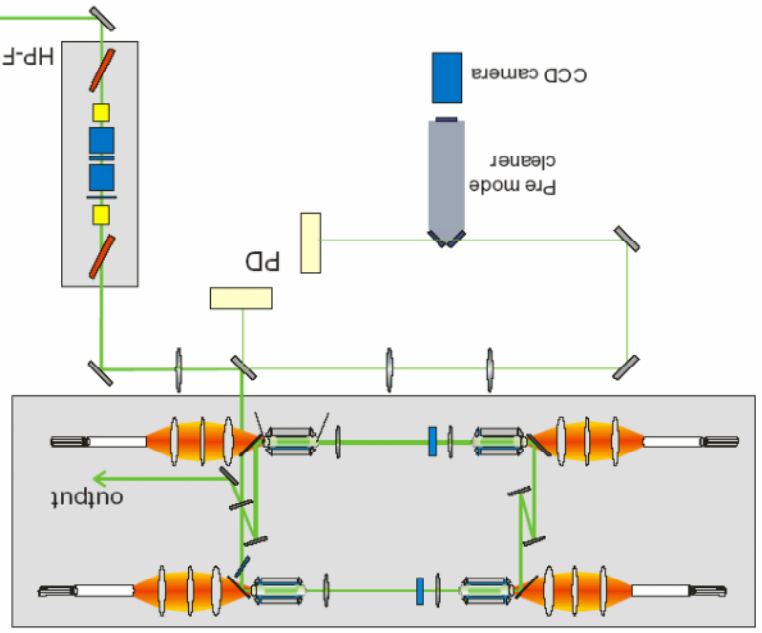
- BSC (test mass) isolation system in fabrication
- To be assembled ‘dirty’ in April, installed clean, with suspension, in Dec.
- Prototype HAM SAS (low-natural-frequency isolator) to be fabricated, tested in Sept as possible variant
- Baseline ‘stiff’ HAM design validated as 2-stage system; 1-stage system under study along with relaxed requirements



Pre-stabilized Laser

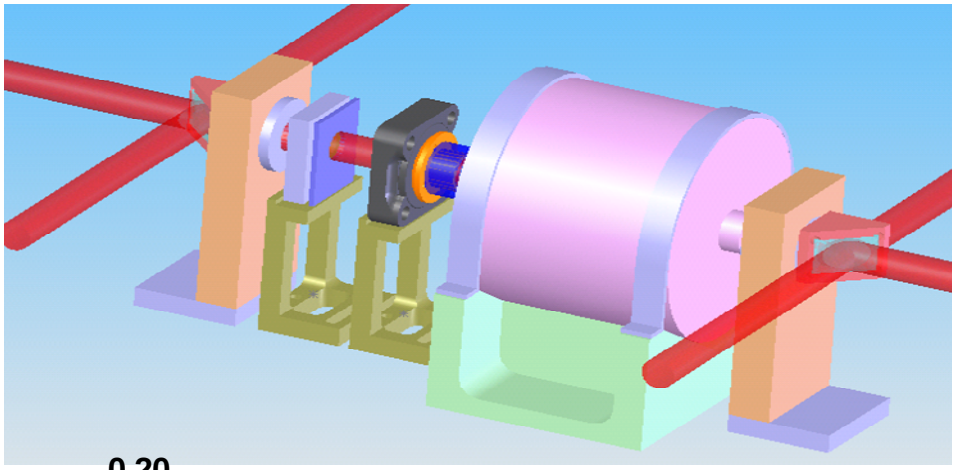
- Development at Max-Planck Hannover, Laser Zentrum Hannover
- Worked long and hard to get back to 180 W output, but now succeeded, learned lots along the way
- Have developed an alternative input system, using an amplifier rather than injection-locked cavity
- Plans forming to supply this 30W source in an AdL ‘early delivery’ for upgrades to initial LIGO

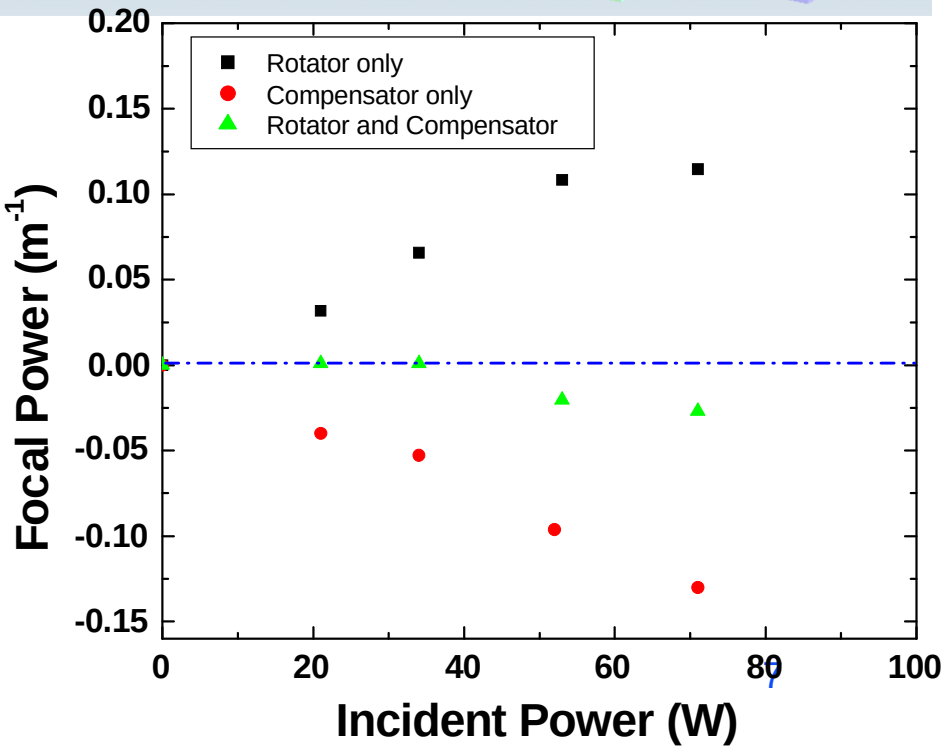




Input Optics

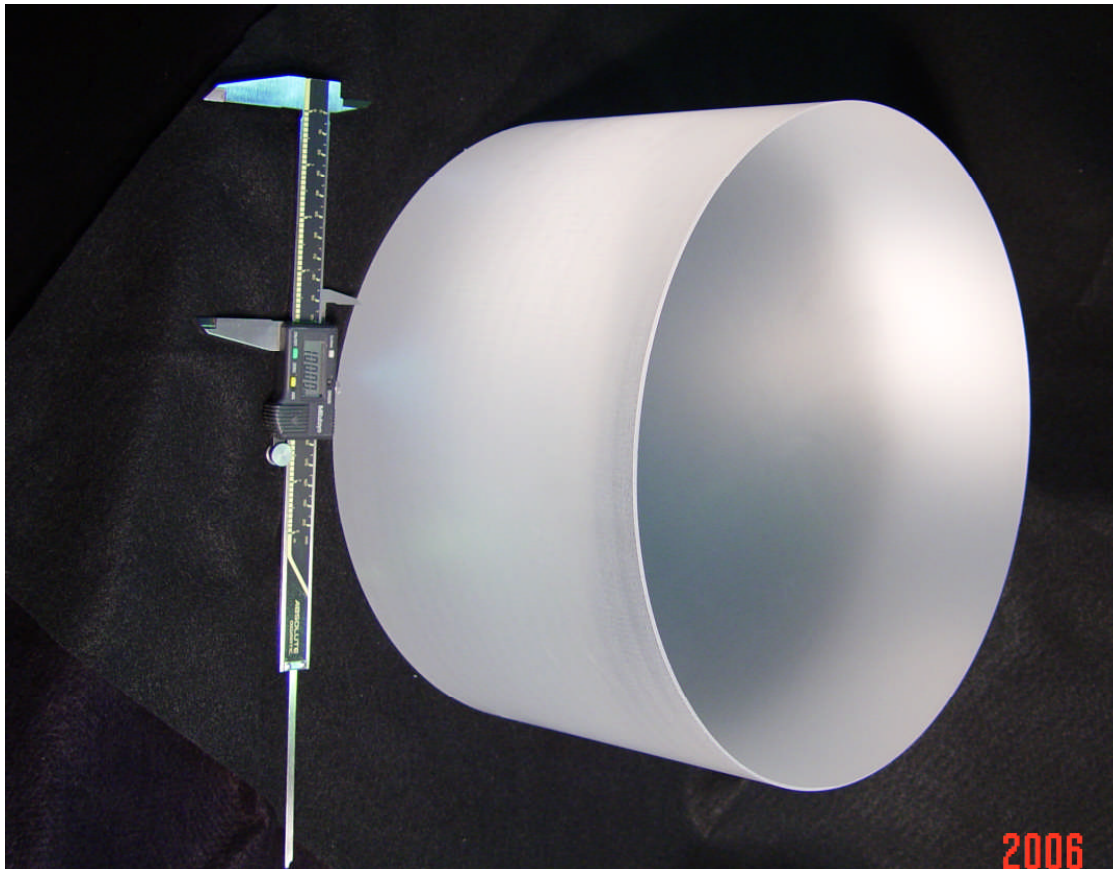
- Subsystem at U Florida
- Challenges: Faraday Isolator and modulator designs for ~200W power level
- Target designs worked through, tested at/near AdL working level
- Designs realized for upgrade of Initial LIGO isolators/modulators, ~30W power
- Yet another example of AdL hardware helping initial LIGO, which helps in testing for AdL….





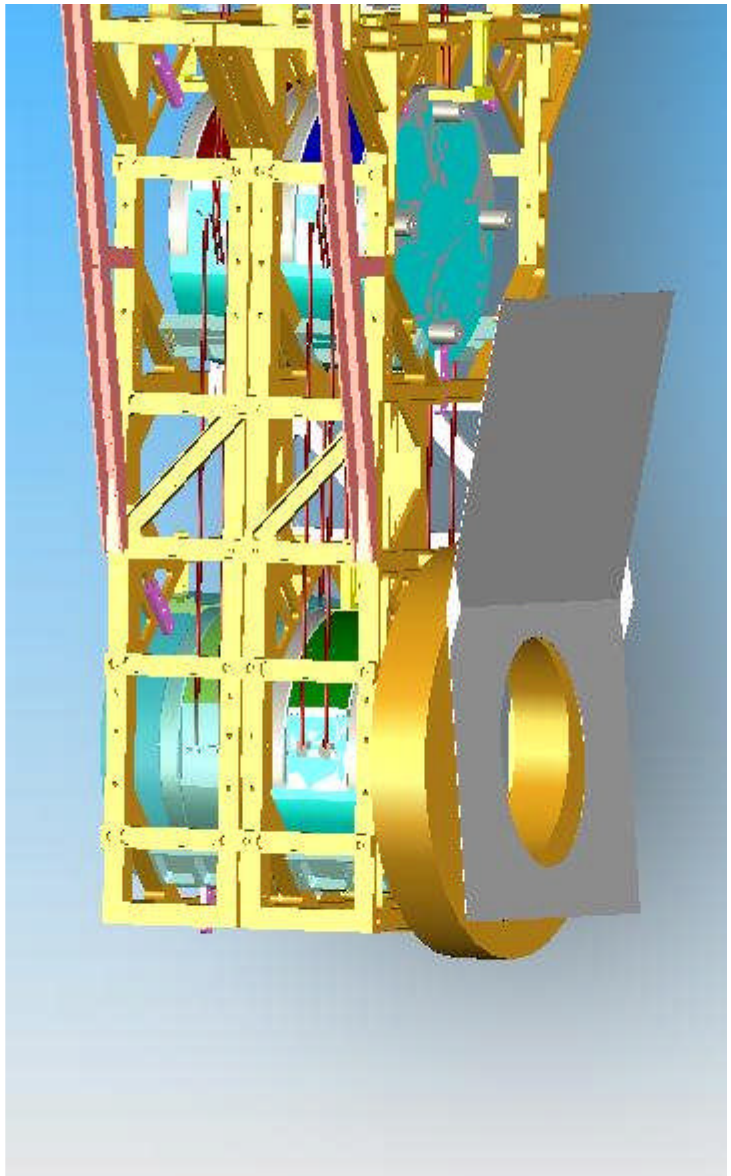
Core Optics

- First actual substrates received – Hereaus 311, contributed by UK
  - » 40 kg, 34cm x 20cm, fused silica
- To be used as a Pathfinder for polishing, coating, then installed in AdL
- This piece of glass will see inspirals daily!
- Continuing modeling/tests of parametric instability and ways to manage it
- Continuing work on coatings
  - » Working on getting the material properties with higher precision
  - » Tests of lutecium doping, does not look promising
  - » Titania-doped tantala/silica looks like our best bet just now, and a good one at that



Auxiliary Optics – Thermal Compensation

- Corrects for the focusing, and ‘bump’, due to absorption of laser light
- Thermal compensation system advancing to concrete designs
- E.g., Input Test Mass compensation via a fused-silica plate, heated with a shielded ring heater, integrated into quad suspension
- Studies of need for compensation on both reflective face in addition to substrate
- Work on identifying noise sources, e.g., acoustic modes excited by heat source fluctuations….



Experiments and prototypes

- 40m: Great agreement with models for optical transfer functions; preparing for DC readout demonstration, a side experiment on squeezing, and….recovering from being the sacrificial laser donor to LLO
- LASTI: Controlling 10 Hz BSC ‘can’ resonance (AdL, initial LIGO too); testing, integrating SUS and SEI; controls allocation work
- TNI: First measurements a ring-damped mass to verify the potential for mechanically damping a parametrically excited mechanical mode without significant thermal noise increase
- Gingin: Demonstrated thermal compensation for a sapphire-mass cavity; Setting up for tests of parametric instability
- ETF: combined SEI-SUS structural test, damping of system using a constrained-layer approach

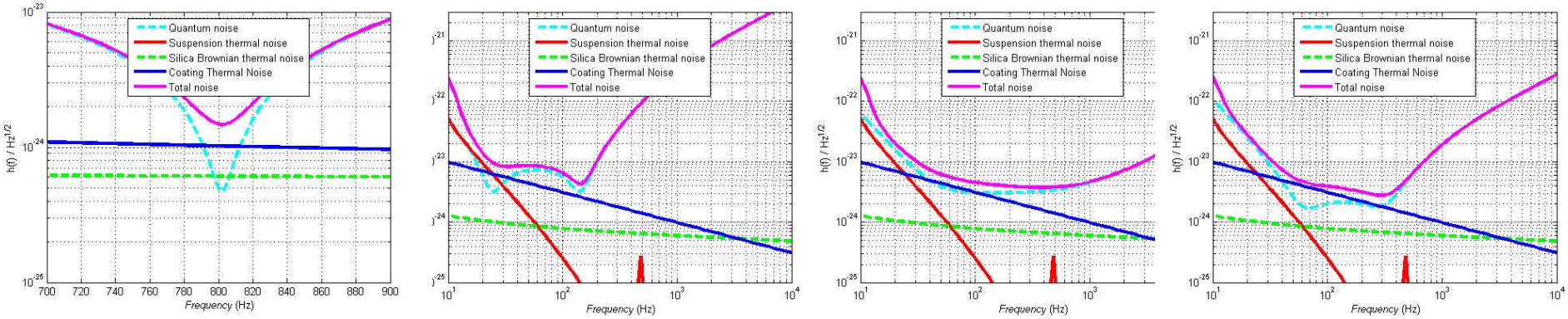
Advanced LIGO Status

- Appears as the one Major Facility 'start' in FY2008 in the President's budget and the NSF planning documents for 2007
- Needs NSB approval of budget, schedule, readiness in August 2006 to be actually included in the 2008 request
  - » Cost close to that proposed in 2003 plus inflation (199M plus UK, German contributions)
  - » Turn off first IL ifo mid-'11, turn on first AdL ifo late-'13
- Thorough 'Baseline Review' of these elements May 31 – June 2 (at MIT, right before Analysis LSC meeting)
- Intensive preparation by all the instrument folks – detailed cost and backup, schedule and its synchronization with the operation of LIGO, manpower planning, risks and fallback plans…
- Progress on S5, analysis of data to date also very important

- Looking for input on a few crucial points which mix instrument science and astrophysics

Things to think about

- How does the astrophysics we want to accomplish help us choose the starting configuration?
  - » 2, or all 3 tuned for inspirals? NSNS or BHBH? Tune the 3rd to catch the plunge, or for pulsars? Broad-band for bursts? Two identical at LHO for bursts, or stochastic?
  - » 3rd ifo is planned at 4km (more expensive to leave at 2km!) – any really good arguments to leave at 2km?
- What have we learned from the analysis process to date that is relevant to these strategic decisions?
  - » Combining data from differing instruments
  - » Correlations between the LHO detectors
  - » Non-stationary noise
  - » Duty cycle
- Do we assume we have made detections?



More things to think about

- Practical considerations
  - » commissioning identical instruments easier than different ones
  - » How easy to change configuration? NS to BH probably easy, to narrow-band probably not trivial
  - » Commissioning strategy – 2 and then the 3rd?
  - » Networking with GEO, Virgo
- What character and magnitude of ‘safety margins’ in promised sensitivity should be adopted?
- How do we best characterize the sensitivity?
  - » RMS in a band, plus examples of astrophysical sources?
- In any event: Need to stay flexible – discoveries with Initial LIGO will probably change our plans. AdL well suited to adapt.

Advanced LIGO

- Good progress on designs and prototype tests
- R&D program picking up, thanks to the S5 commissioning freeze
- Baseline review preparations setting a brisk pace for converting Advanced LIGO into a Project
- Believe Advanced LIGO has a good chance for October 2007 funding