

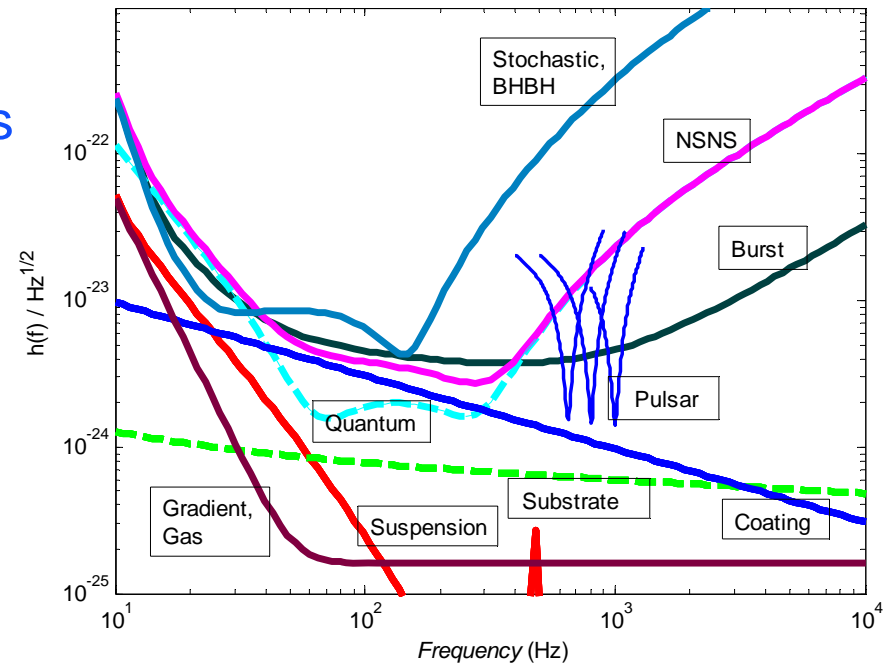


Advanced LIGO Update

David Shoemaker

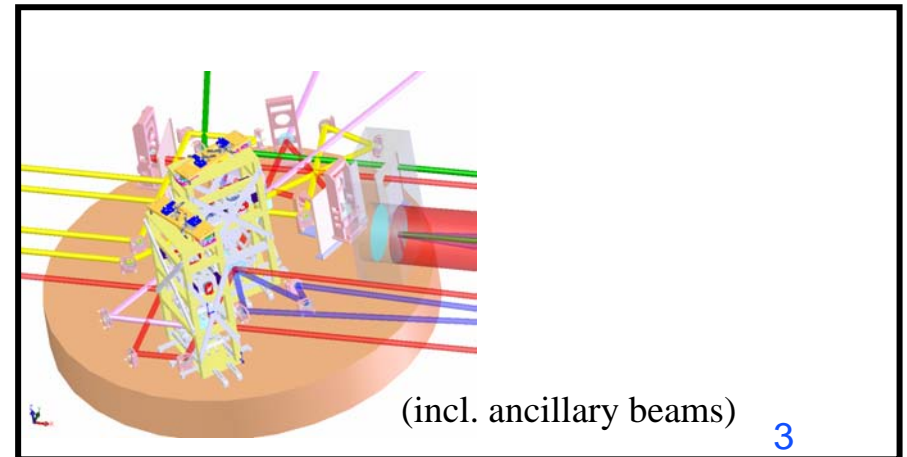
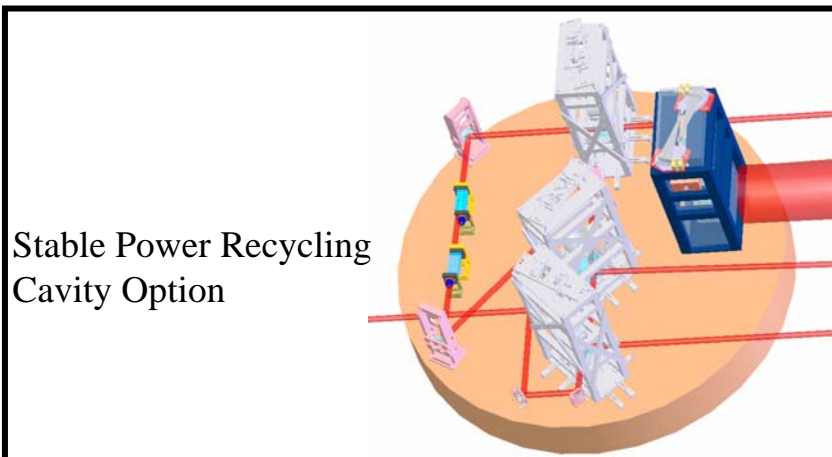
LSC/Virgo Baton Rouge March 2007

- 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
 - » Aggressive seismic isolation



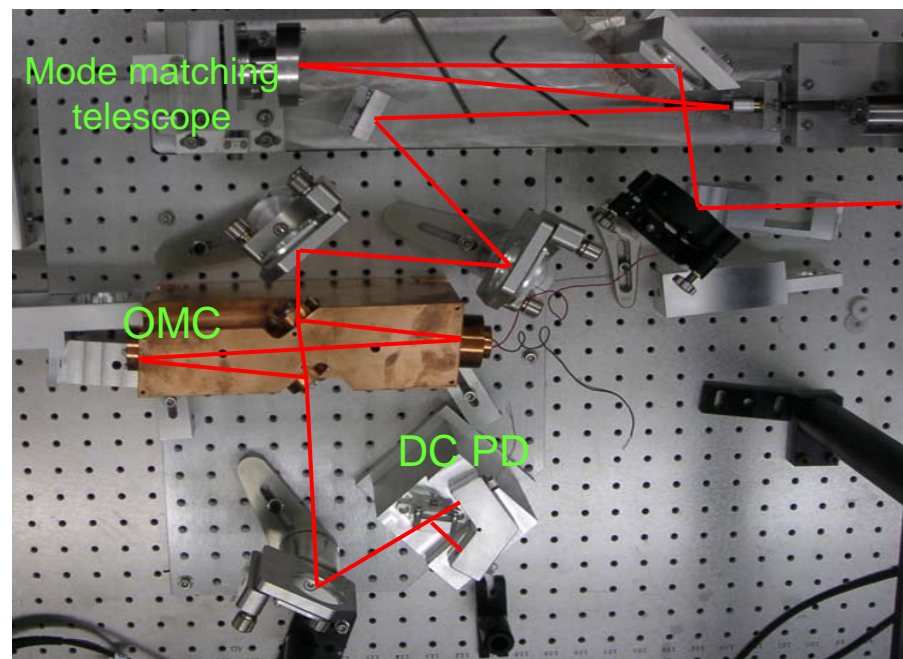
-and now: a quick run through of progress highlights and active questions

- Some systems design issues recently resolved or in process:
 - » Beam Splitter size & suspension fiber type
 - » Interferometer layout, including wedge angles & orientations
 - » Inclusion of electrostatic drive on Input Test Masses (design change made)
 - » HAM seismic system – more on this later
 - » Seismic Platform Interferometer feasibility & implementation
 - » Recycling cavity geometry
- Systems PDR in August, at which time these issues should be resolved



LIGO Interferometer Sensing and Control

- - Development of a feasible LSC modulation/readout scheme
 - » Gives a wide SRC tuning range, good enough SNR for the auxiliary length loops and operation at frequencies below ~ 60 MHz.
- Work on calculation of an ASC sensing scheme
 - » calculation of a WFS sensing matrix, doesn't yet model the feedback noise
 - » uses the aforementioned LSC modulation scheme.
- 40m testbed contributing
 - » DC readout hardware installed
 - » squeezing demonstrated on simplified interferometer
- Acquisition/Control Hardware
 - » PCIX (commodity) base
 - » Installed at 40m, LASTI; in use
 - » In-house conversion boards also being developed

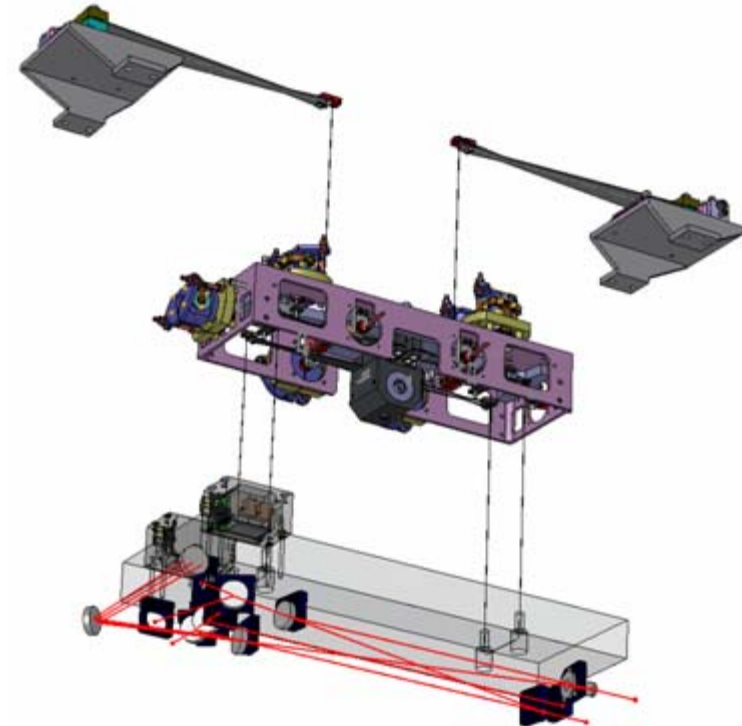
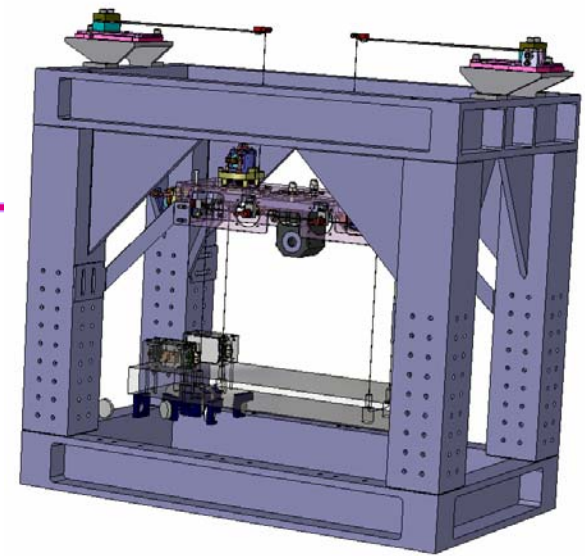


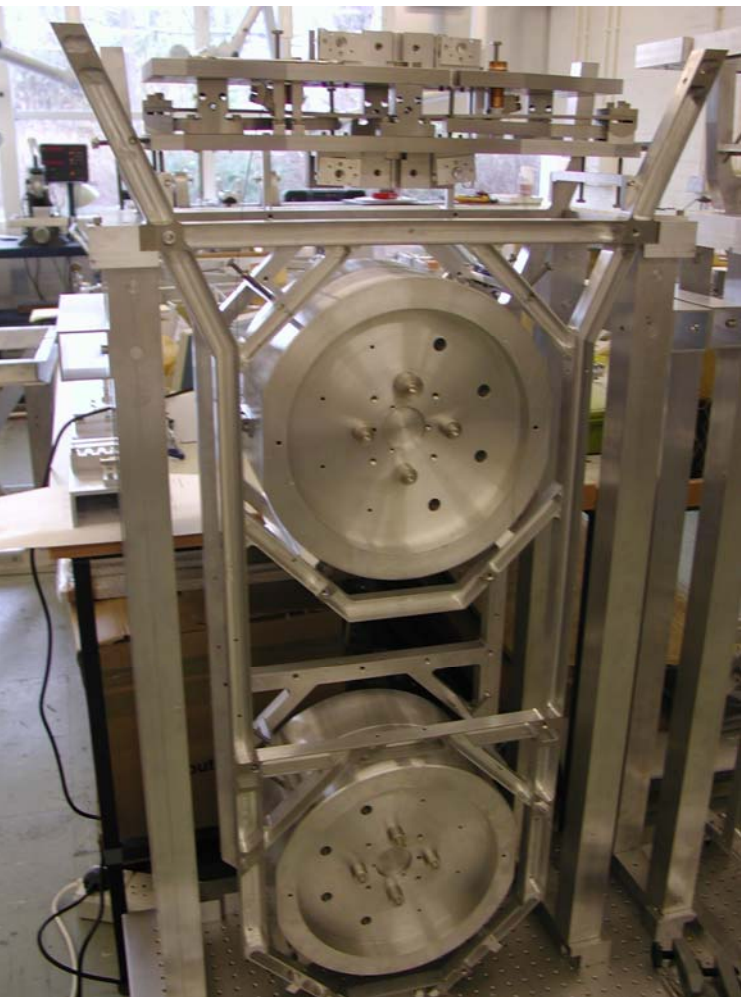
domain	Static	Stationary	Non linear Dynamic
	SIS (Static IFO Simulation)	Opticle	e2e
Model	<p>New FFT-based static field simulation which can easily</p> <ul style="list-style-type: none"> •include various effects •simulate different optical configurations 	<p>Frequency domain model with</p> <ul style="list-style-type: none"> •optical spring and •quantum noise by vacuum injection 	<p>Time domain simulation with</p> <ul style="list-style-type: none"> •dual recycled michelson •double chain quadruple pendulum
Physics studied	<ul style="list-style-type: none"> •Mirror polishing specification •Effect of BS size •Effect of thermal deformation •PI : excitation of acoustic mode 	<ul style="list-style-type: none"> •Noise of in-lock state IFO including loops of servo •Selection of sideband frequencies 	<ul style="list-style-type: none"> •Dynamics of AdvLIGO arm <ul style="list-style-type: none"> »Improvement of lock acquisition threshold velocity »ISC design strategy from unlocked to locked state
Physics to be studied	<ul style="list-style-type: none"> •Detailed requirements for AdL optics <ul style="list-style-type: none"> »ROC, TCS, finite mirror size, mode matching, ... 	<ul style="list-style-type: none"> •study of ASC •ISC servo design 	<ul style="list-style-type: none"> •Lock acquisition of the full advLIGO system

HAM chamber Suspensions

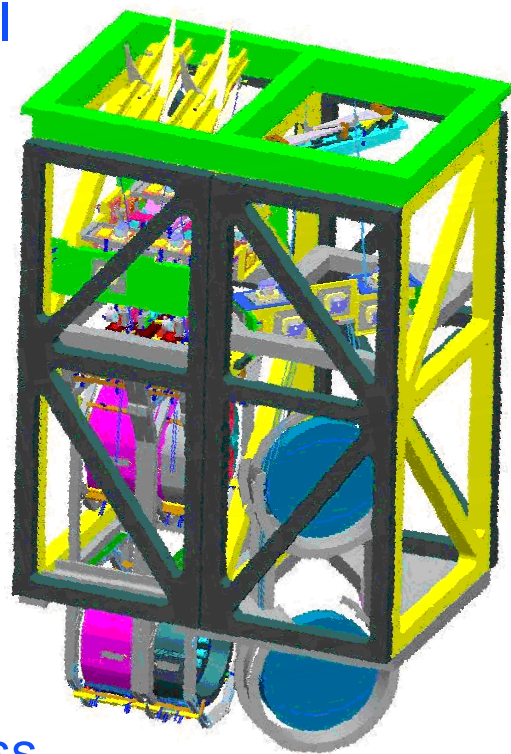
- Output mode cleaner suspension
 - » Design completed
 - » Carrying a little optical table
 - » Pushed along by ELI (Enhancements to LIGO)
 - » First assembly in May

- Interferometry using AdL suspensions
 - » Two triples with a short cavity, work completed, nice success
 - » A mode-cleaner triple facing a test mass quad suspensions set up as 10m cavity
 - » Ready to start testing



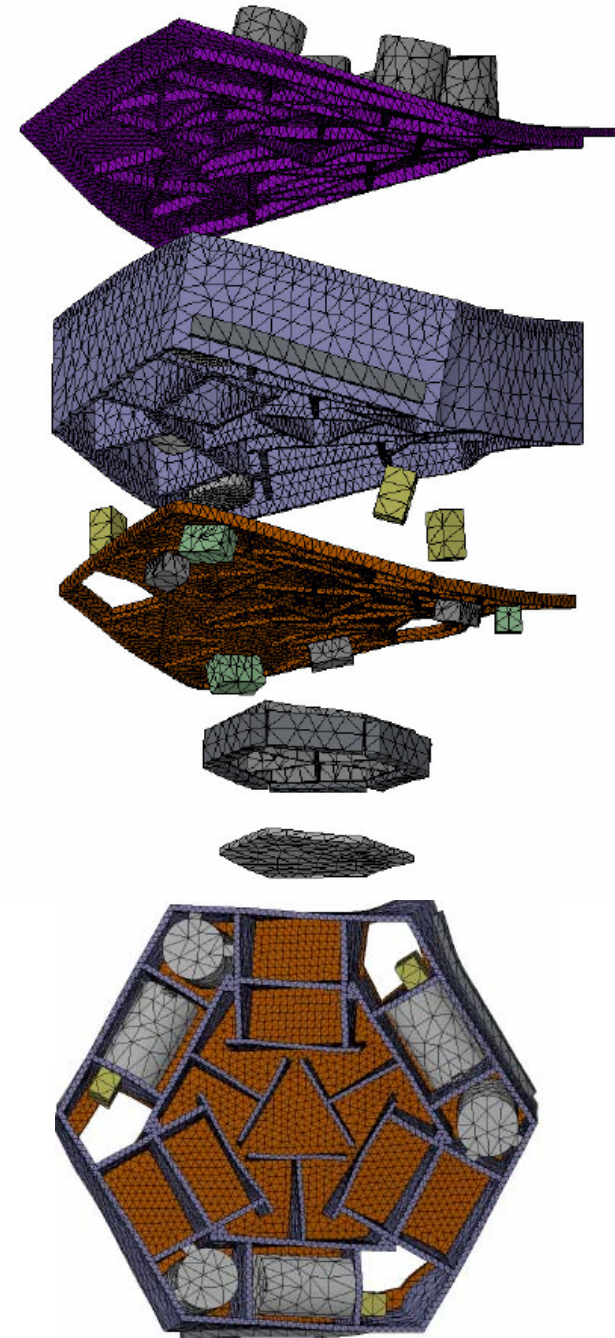


- UK has finished design, most fabrication of a ‘noise prototype’ test mass suspension; to be delivered to LASTI (MIT full-scale testbed) in April
- Production of OSEMS (sensors/actuators) for tests and for ELI underway
- Designs of other suspension variants advancing; here the combined folding mirror – test mass (for H2)

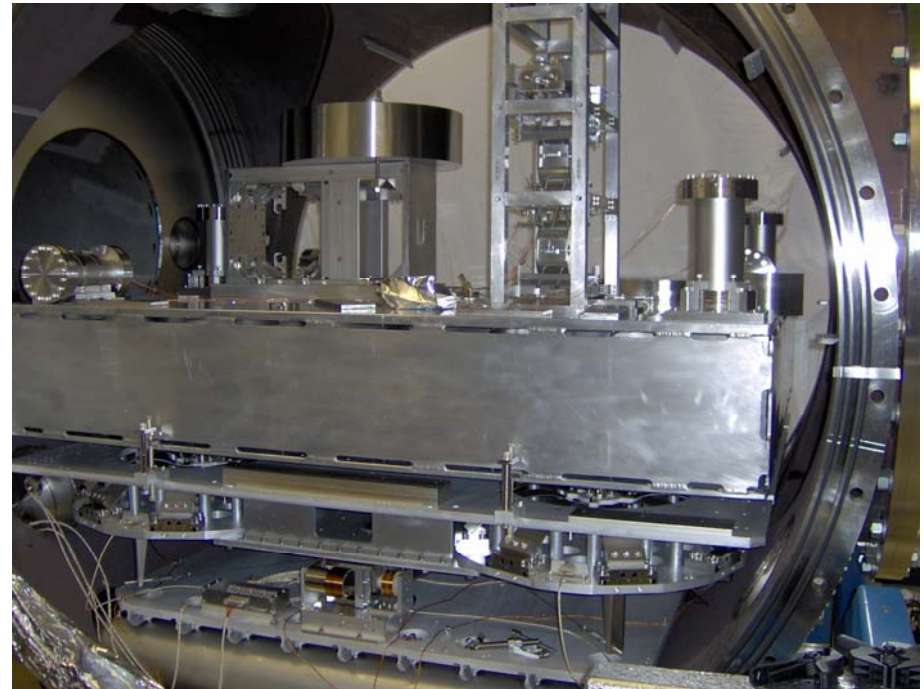


- Test Mass (BSC) isolation system initial characterization completed
 - » Mode structures, blade parameters; an iteration in alignment performed
 - » System now in dis-assembly in preparation for cleaning, installation in chamber with suspension

- Design for baseline 'stiff' HAM isolation mostly finished (HPD, Colorado)
 - » Design looks workable, buildable
 - » Final design review in mid-April
 - » Preparing to launch fabrication of 3 copies (ELI, LASTI) for Fall delivery

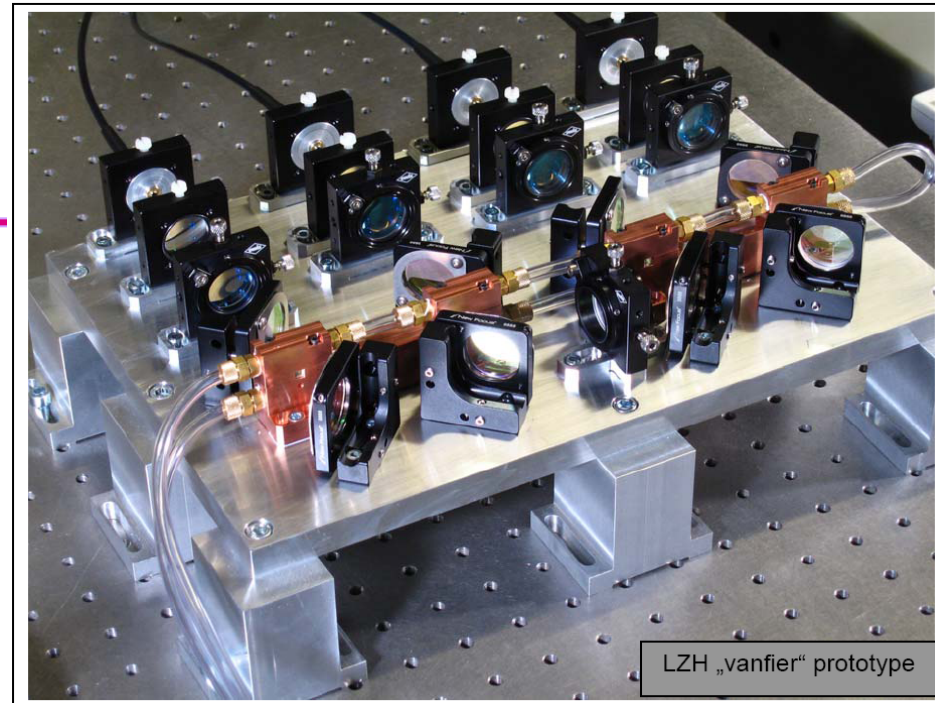


- Alternative HAM isolator using low natural frequencies (HAM-SAS)
 - » Fabricated, cleaned, assembled, installed
 - » All DOF now free and understood
 - » Tuning of natural frequencies underway
 - » Transfer functions, stability, noise to be measured
- Evaluation process underway
 - » Review committee established (Fred Raab chairing) – looking at performance, cost issues
 - » Update on baseline scheme planned also in preparation
 - » David Shoemaker to make decision in April to remain with ‘stiff’ baseline or change to HAM-SAS alternative



Pre-stabilized Laser

- Development at Max-Planck Hannover, Laser Zentrum Hannover
- First front end breadboard (NPRO, FI, EOM, AOM, Vanfier) under construction
- First 35W laser scheduled for delivery in late May, others to follow for ELI (and remain for AdL)
- High-power stage laboratory prototype in continuous operation (10h per day, since 4 weeks)
- After warm up phase (20min) stable operation over hours at 140W



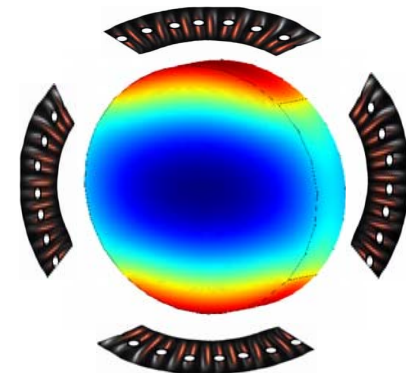
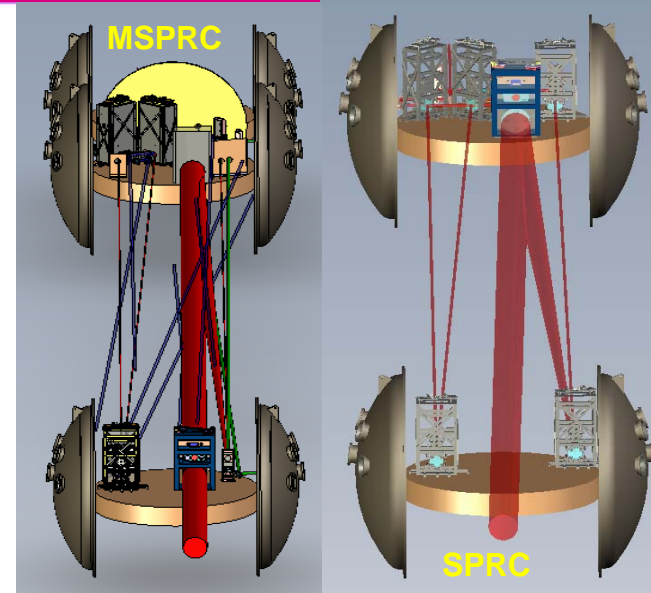
- Preliminary Design review in late March, a number of elements going into ELI
- IO layout mature
 - » For both marginally stable and stable recycling cavities



- Faraday Isolator
 - » 49 db @ 100W!
 - » Vacuum testing

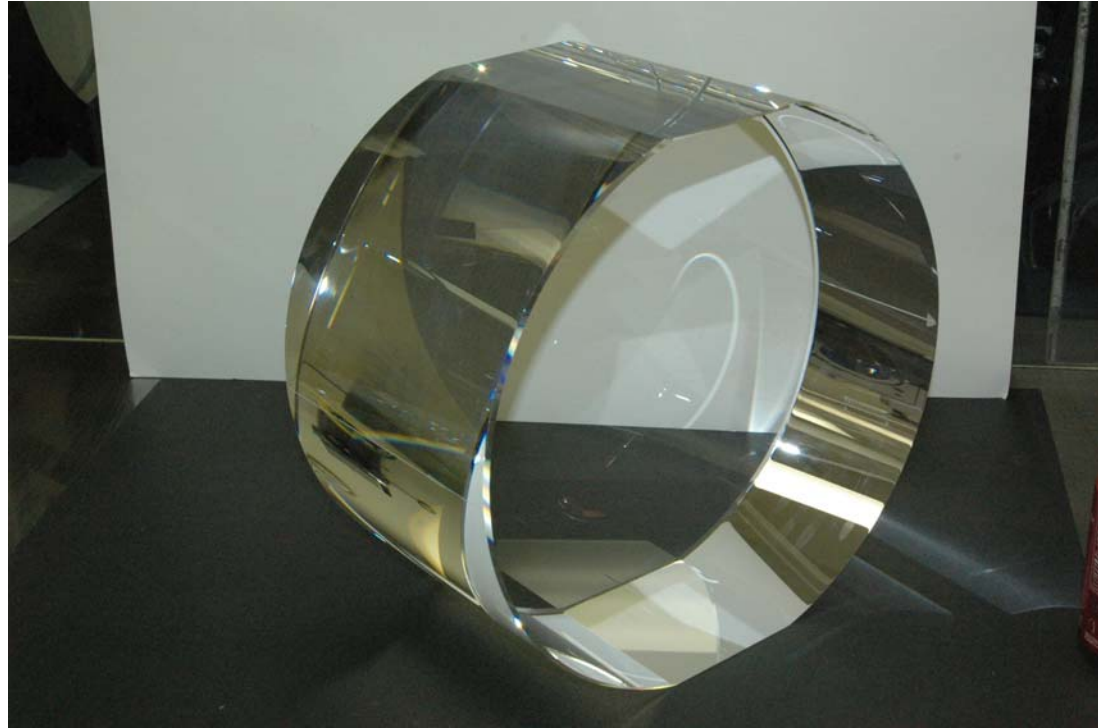
- Mode Cleaner
 - » Femlab modeling of thermal effects in the MC cavity and impact on mode matching

- Adaptive Mode Matching Telescope
 - » MMT for marginally stable (baseline) and stable PRC designed
 - » New method for adaptive compensation based on segmented ring heater on DKDP in the Faraday isolators
 - Eliminates CO2 laser heating in IO
 - Astigmatism compensation

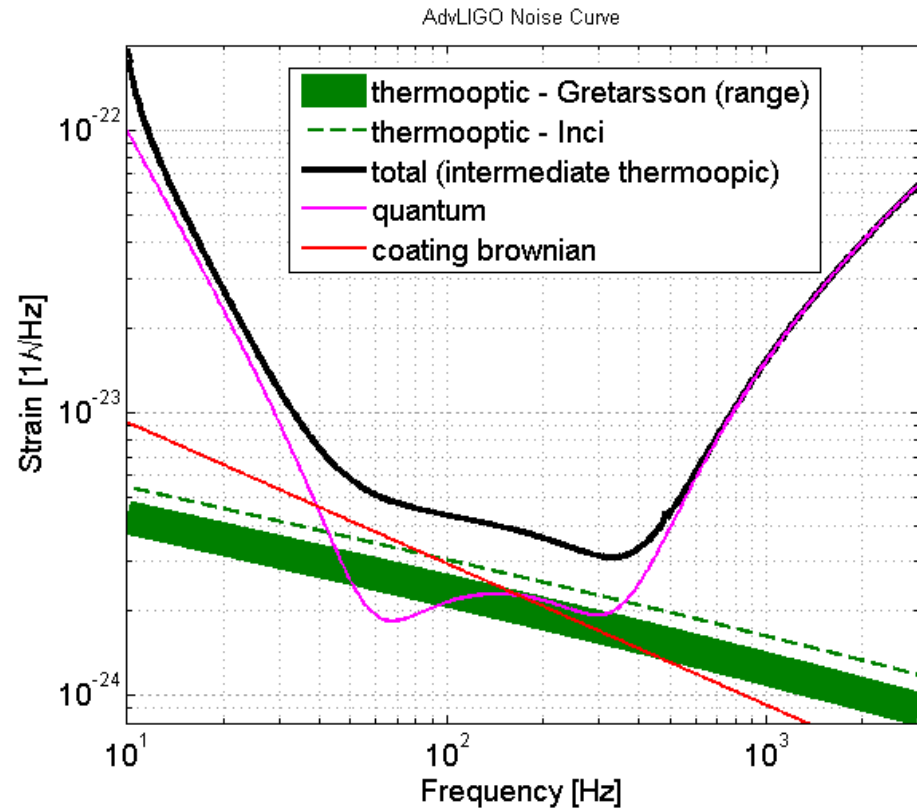


Active DKDP
segmented
heating

- Optic for integration testing; Just completed figuring, polishing
- To be joined to the UK Test Mass suspension, installed at LASTI on the BSC Seismic Isolation
- Continuing modeling/tests of parametric instability and ways to manage it
- Continuing work on both characterizing problems with initial LIGO optics (absorption, scattering), and developing techniques to maintain cleanliness (protective coverings, procedures, clean air sources)

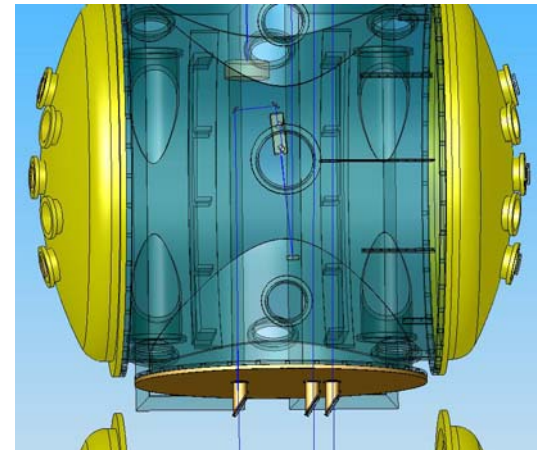
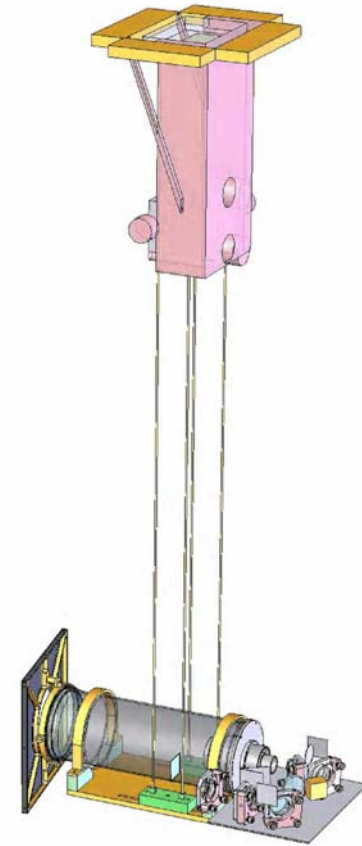
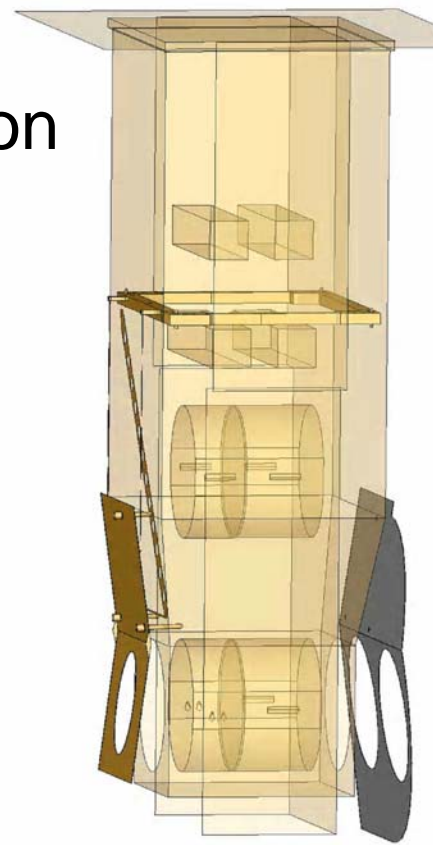


- Thermo-optic noise measurement – Gretarsson, Embry-Riddle
- Measure dn/dT for tantala layers in the multilayer coating. Use this to estimate level of coating thermorefractive noise.
- Heat coated sample to ~ 400 C. Measure reflectivity change at a wavelength right at the edge of the high-reflectivity band.
- Thermorefractive noise + thermoelastic noise (coherent sum) = thermo-optic noise.



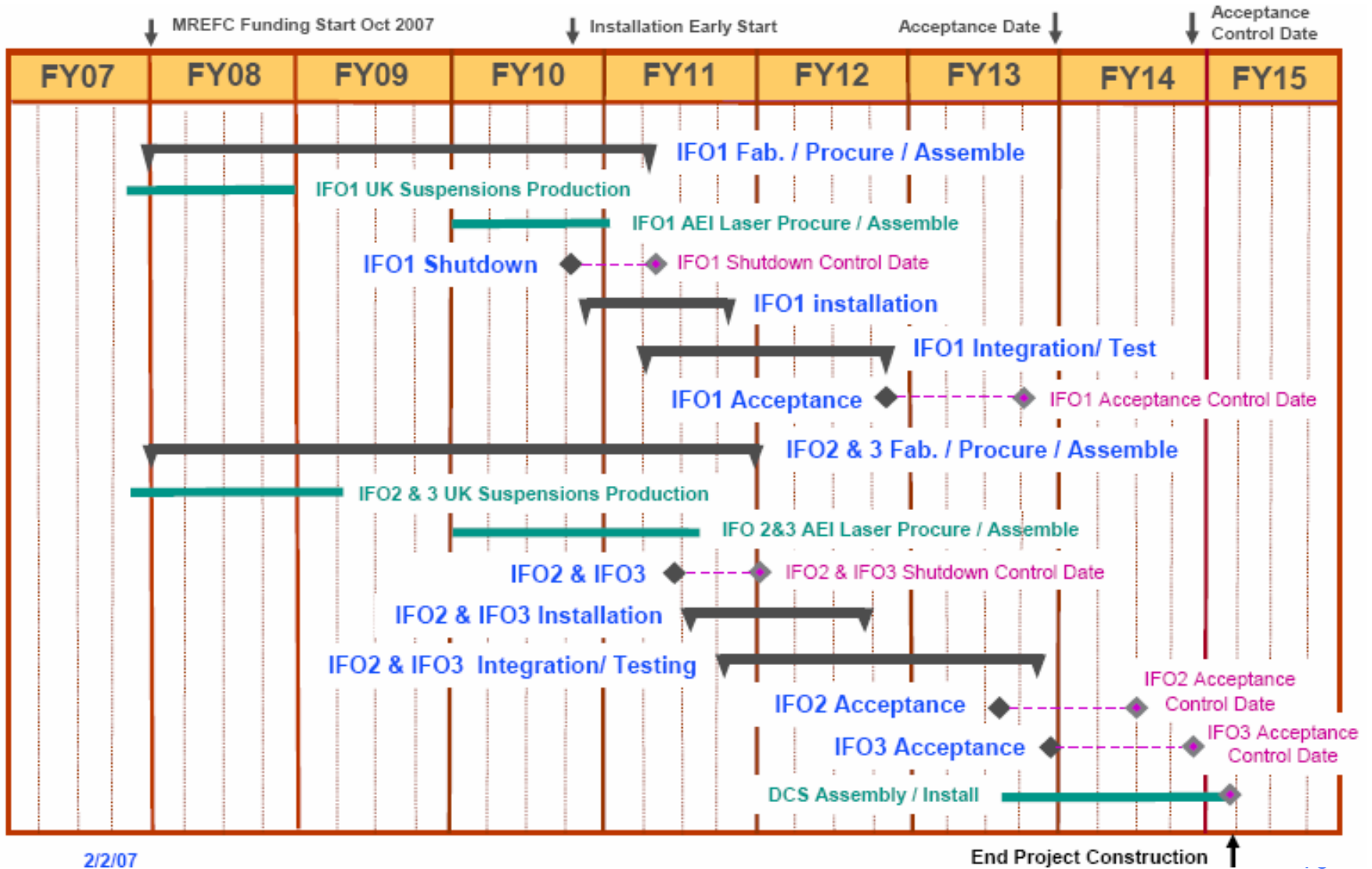
Auxiliary Optics – Thermal Compensation

- Advances in the detailed design of the output coupling, baffling
- ELI/AdL synergism – Output Mode Cleaner designs, Brewster windows to maintain separate vacuums...
- Selection of Adelaide wavefront sensor for AdL; plans to make a complete prototype demonstration of this on the suspended Test Mass at LASTI



- **Appears as the one Major Facility ‘start’ in FY2008 in the Office of Management and Budget request, with the cost and schedule that we wanted – BIG NEWS!**
- Strong support from Congress for the NSF allowed budget growth in 2007 despite the continuing resolution for the bulk of the government; no ‘traffic jam’ in major projects before Advanced LIGO
- Upcoming review on 5-6 June at NSF – confirmation of cost, schedule; April internal review not expected to show any cost/schedule/technical surprises
- Review in Fall after Congress allocates budget – one last check of situation (theirs and ours)
-Funding in ~October 2007...
- Start turning off ELI in 2010, start turning on AdL in 2013

Schedule



- Good progress on designs and prototype tests
- R&D program picking up, in some nice measure due to ELI's near-term deadlines
- Need to take our dates for completion of development seriously, because....
- **Advanced LIGO has an ever-better chance of seeing October 2007 funding!**