LIGO

Advanced LIGO Update

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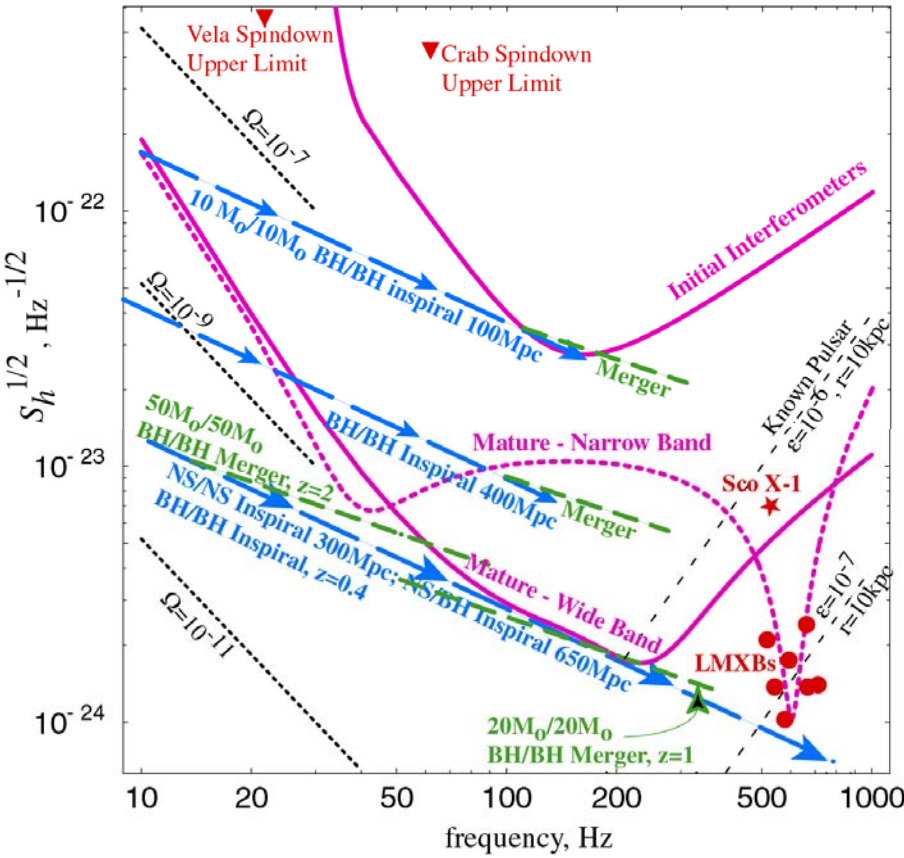
LSC LHO August 2004

Advanced LIGO

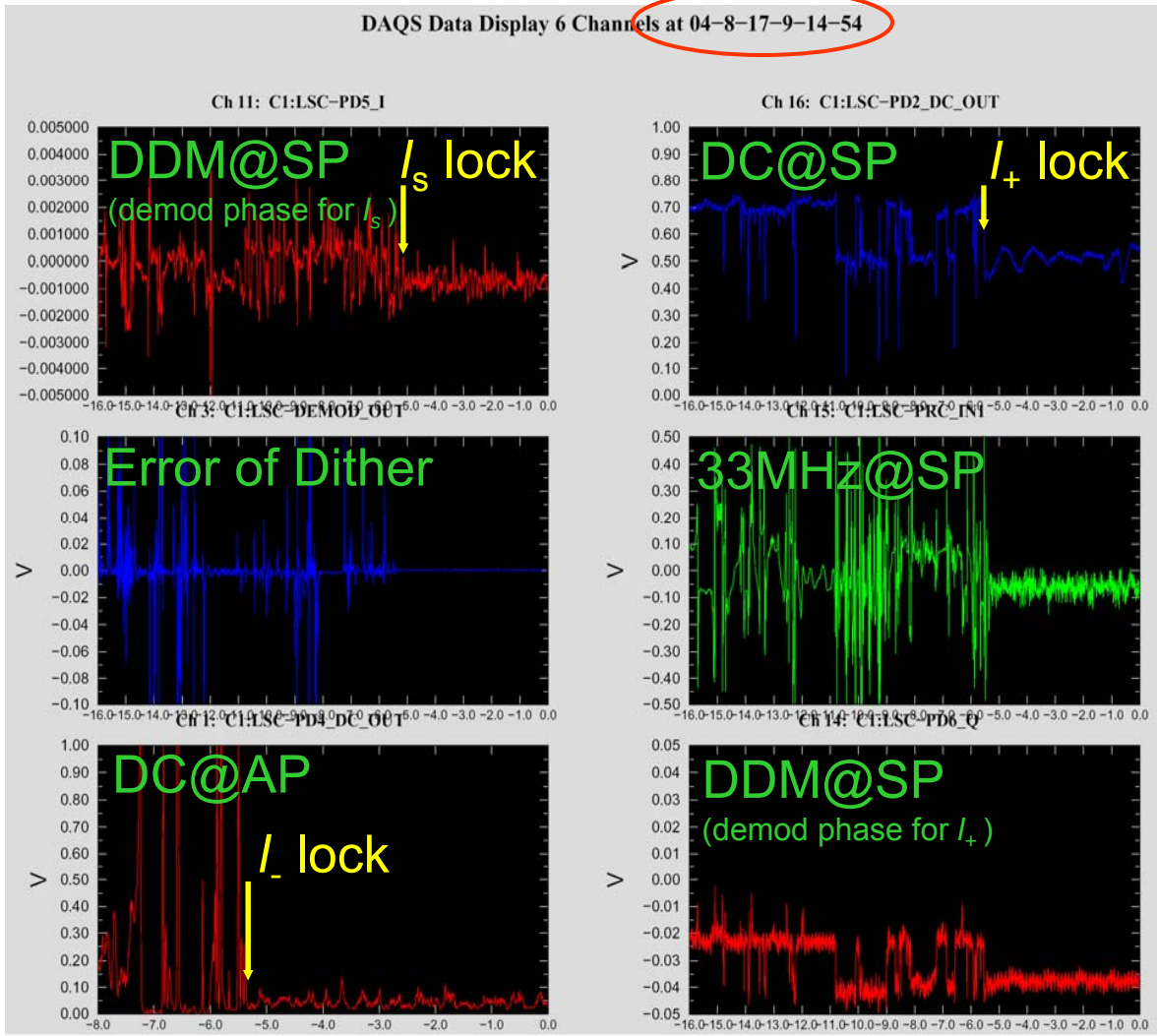
- If you have been on Mars...
  - ~Factor 10 in amplitude sensitivity
  - ~Factor 4 lower frequency
  - Tunable
- Recombined Fabry-Perot Michelson
  - Signal recycling
  - ~20x higher input power
  - 40 kg masses
  - Fused silica suspension
  - Active seismic isolation, quad pendulum suspension



- Proposal in to NSF, requested funding in FY2005
  - Past date for funding in 2006 – looking at 2007 (Oct 2006)
  - First instrument into commissioning in early 2011
- Here and now: a quick run through of progress highlights and active questions

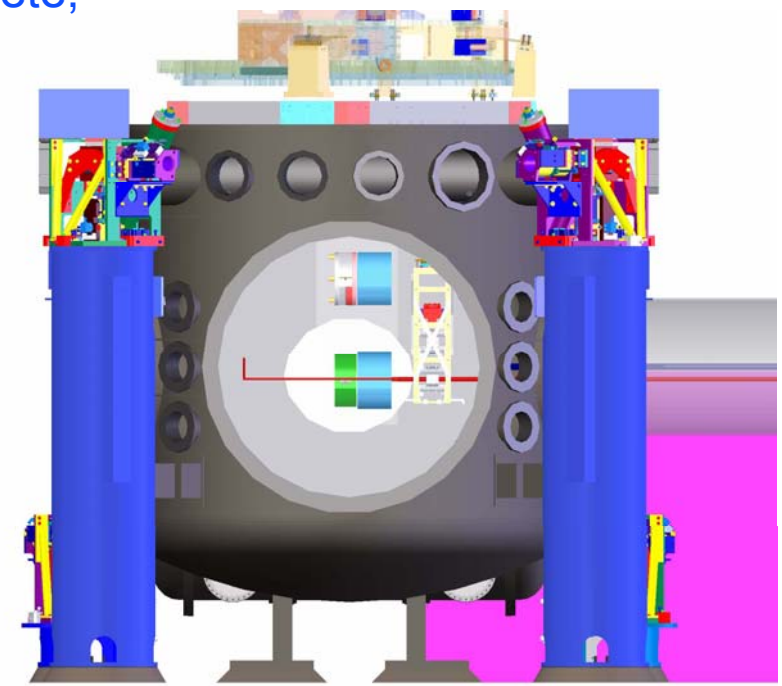
Systems

- e2e for Adv.LIGO: All ingredients to build Adv.LIGO model ready (or very close)
  - » fast simulation code of Dual Recycling Michelson Cavity : scalar case formulation done, module = soon to be delivered.
  - » Mechanical System Simulation: State Space using ABCD matrix is supported.
  - » Radiation Pressure : supported
- 40m experiment now teaching us things about Length Controls
  - » First Lock of dual recycled Michelson this morning!

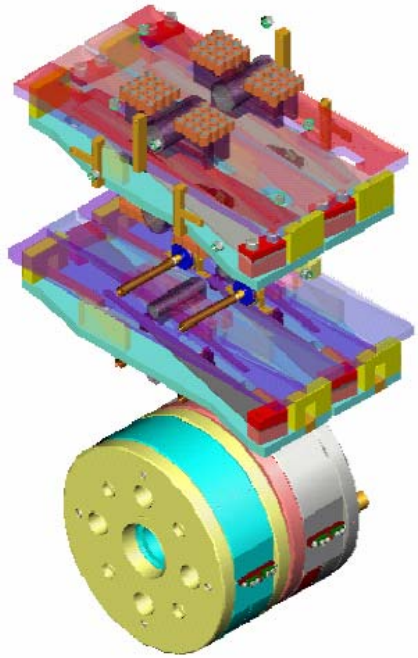


Systems

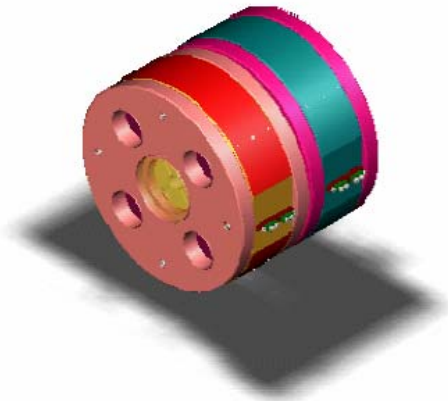
- Combined Suspension-Isolation mechanical models, trades
- LASTI finishing HEPI role, moving toward Seismic-Suspension integration
- Substrate Downselect wrapping up
- Cost and Schedule systems warming up
  - » New bottom-up estimate for R&D complete, for construction underway

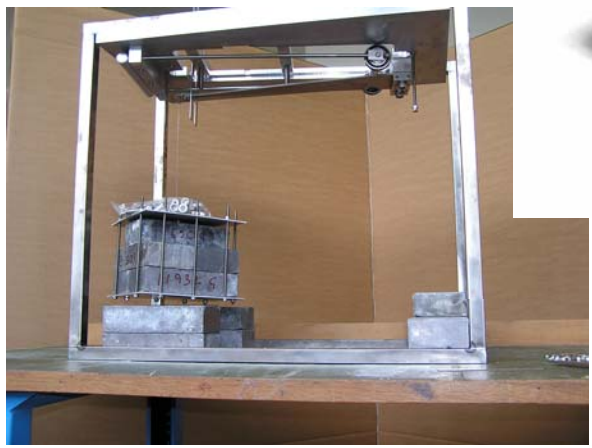


Suspensions



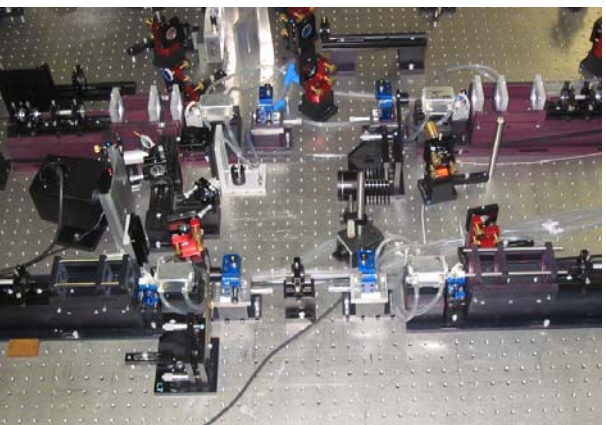
- CO2 pulling, welding of fibers in development
  - » Greater control, cleaner process
- Thermal Compensation plate: common with suspension
- Test Mass Quad Pendulum design
  - » Mass catcher or ‘cage’
  - » Spring design – and prototype tests
- OSEM designs
  - » Developed – including a nifty interferometric one
  - » Selected – upgraded ‘occultation sensor’
- Triple transported
  - » Installed in LASTI
  - » Testing underway
  - » Will use HEPI as a shake table

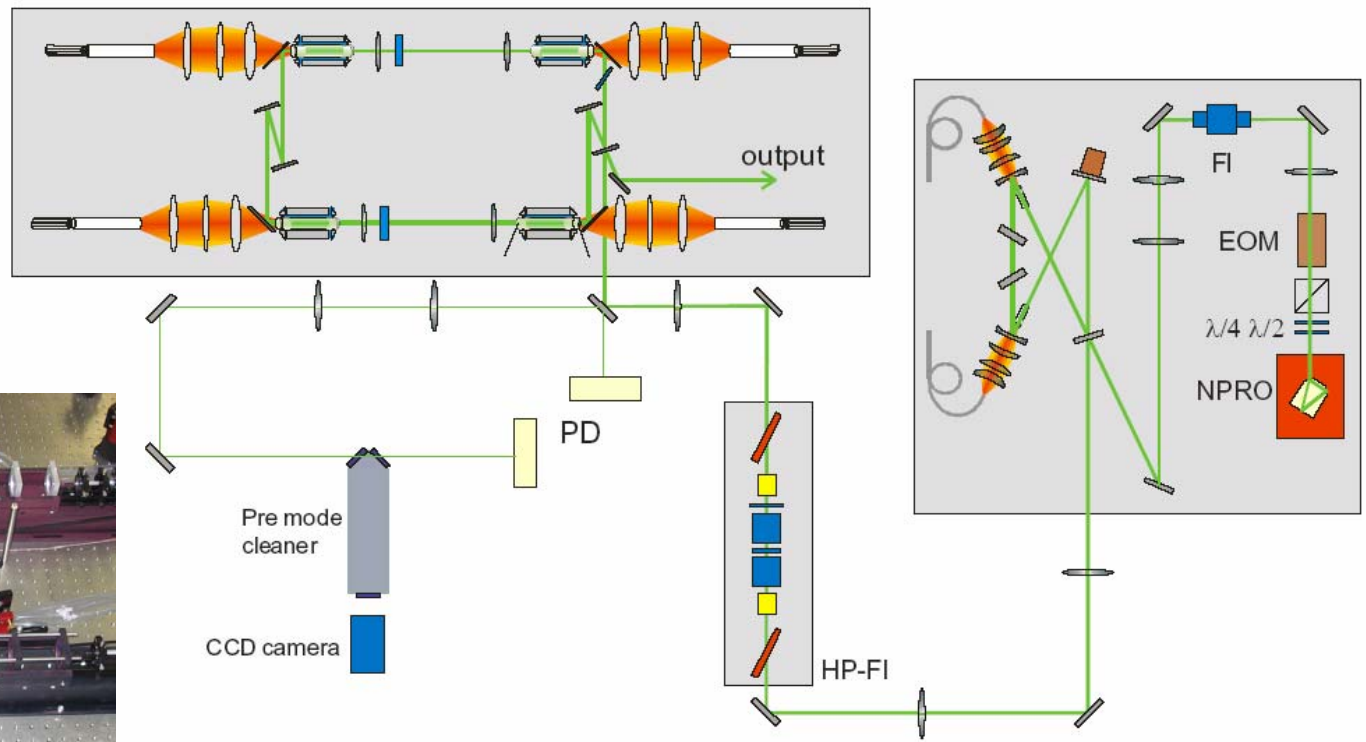




Pre-stabilized Laser

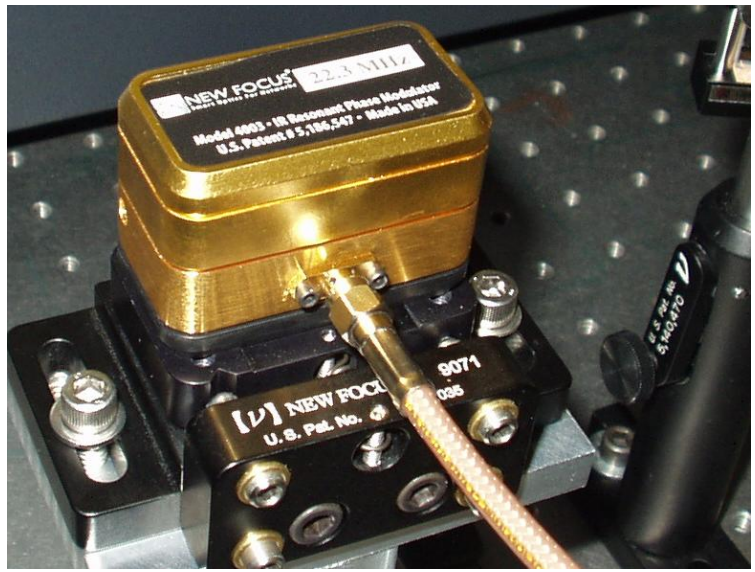
- Injection locking of the power laser (LZH, AEI)
- Measurement to characterize spatial and temporal behavior under way
  - » 170 W single frequency, Linearly polarized, No free oscillating higher modes, Relock time < 400 ms, First test: stable for > 8h





Input Optics

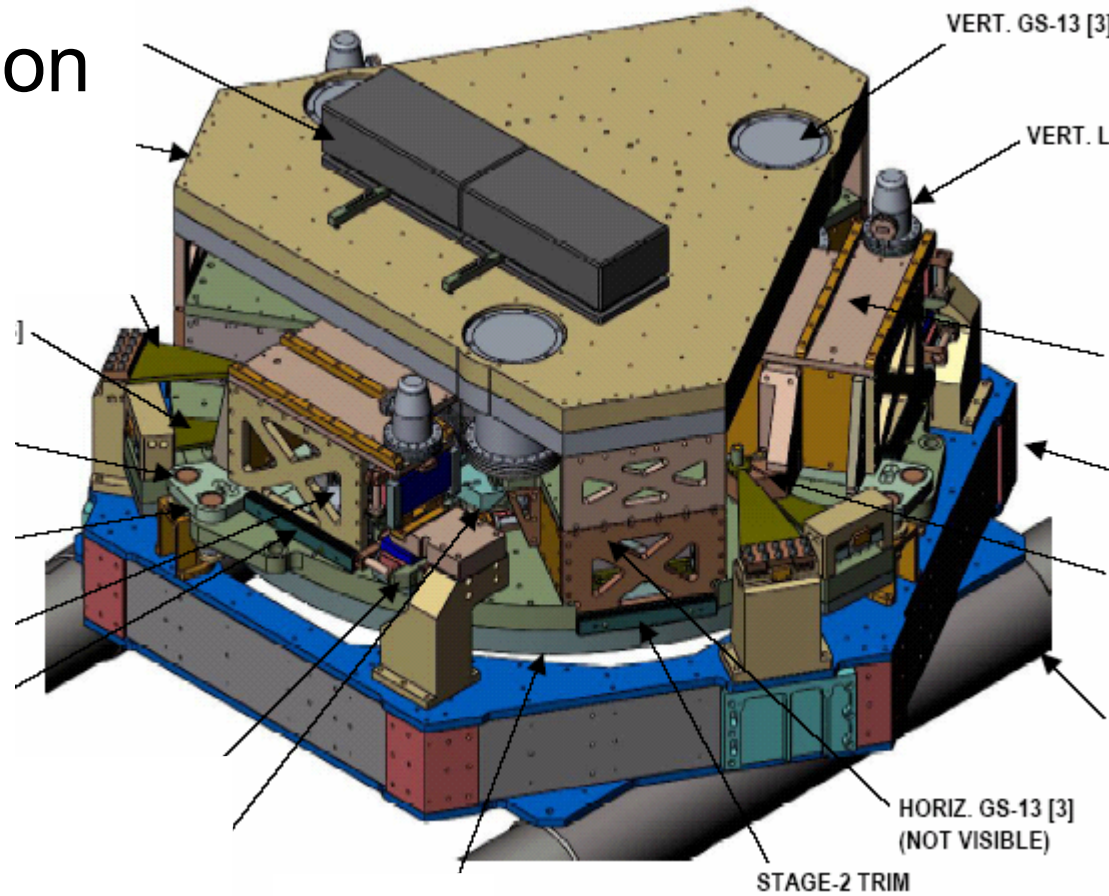
- Prototype RTP modulator – UF/New Focus design (serial number?)
  - » High power design, RTP active medium
  - » 4 mm clear aperture
- Prototype tests
  - » RFAM < 10-5
  - » negligible thermal lensing at 50 W
  - » damage testing underway



- Faraday Isolator
  - » 20 mm aperture (uncompensated) FI installed in H2
  - » 10 mm full compensated FI being tested at LZH for AdL high power laser – ok at 120 W!

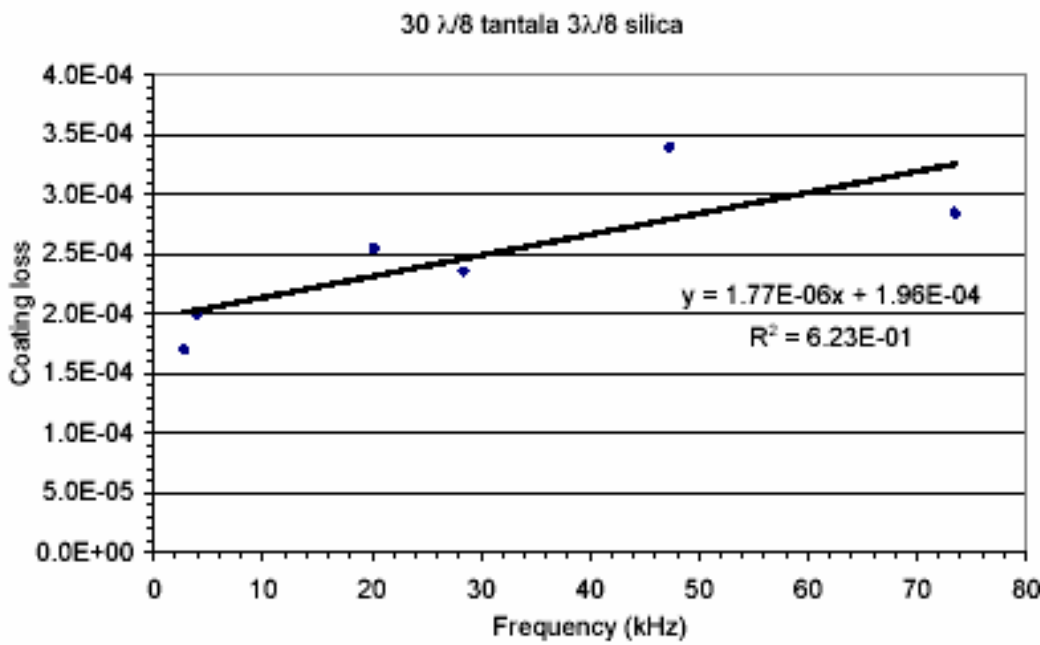
LIGO Seismic Isolation

- Principal focus on HEPI; lots of travel to LLO
- Installation of (more) HEPI at MIT
- Adaptive feed-forward techniques developed at MIT
  - » Studied for possible application at LLO
- Preparation for pumpdown of Stanford Tech Demo



- Most of the design of the BSC system complete (image from ASI's Critical Design Review)
  - » Scaling prototype fabrication etc. to manage costs – a real challenge
- Attention to interface between Suspension and Isolation
  - » Coupled (more than we'd like) through resonant frequency requirements

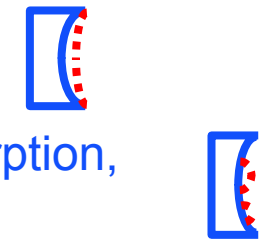
Coatings



- Goal: ~10x reduction
  from 5 10^{-4} to 5 10^{-5} loss angle
  - » Brings coating noise down below substrate Brownian noise
- Progress on several fronts:
- Evidence of frequency dependence of coating mechanical loss
  - » Coating loss lower at lower frequencies
- Increasing Titania dopant reduces mechanical loss (LMA)
  - » So far, from a loss angle 2.7 10^{-4} to 1.6 10^{-4} ; may be the limit
- Secondary ion-beam bombardment reduces loss (CSIRO)
  - » So far, from a loss angle 4.4 10^{-4} to 3.2 10^{-4}
- Both still require tests for optical properties, optimization, checks if compatible and if both work at lower losses
- Sense is that we can get pretty close with such incremental improvements

Thermal Compensation

- To be integrated into suspension – fused silica element as final mass in reaction chain for input test masses; conceptual design well along
- Careful study of the various effects needing compensation, and consequences
  - » Basic substrate focussing, effects on arm cavities and on sidebands – and noise introduced by compensation heating fluctuations
  - » Basic deformation of the TM surfaces
  - » Effects due to variability in substrate absorption, and variability in coating absorption



- Silica and Sapphire each have their (dis)advantages, and once we get over the overall difficulty of either, thermal compensation may be the key ingredient in choosing a substrate

Core Optics

- Focussed on substrate selection
- Lab work – annealing, characterization, coatings, etc.
- Analysis and organization of data – thermal compensation, thermal noise, optical performance, vendor quotes, etc.
- Many ingredients – astrophysics, implementation, risks

	Sapphire	Silica
NS-NS 1.4 Ms	191 Mpc	191
BH-BH 10 Ms	923	1052
Pulsar h/√Hz	7×10^{-24}	12×10^{-24}
Omega	1.7×10^{-9}	1.2×10^{-9}

- Intend to make selection in coming weeks
- Important to get LSC input at this meeting, In particular, on Astrophysics –
- Please make SURE you express your thoughts:
  - » Technical plenary, Wednesday, 11-12
  - » Informal discussion, Thursday, 8-9
  - » In the hallways

Advanced LIGO R&D

- Good progress on designs and prototype tests
- See again how valuable the ‘advanced’ R&D is to initial LIGO
- Working to fit a robust R&D Lab program in the available funds, available manpower
- Exciting to see that the interface to Astrophysics is becoming more immediate with the substrate selection; would like to see that link grow
- Anticipating an NSF review in early Spring of Advanced LIGO as a Project – certainly a milestone for us
- No quotable news from the NSF, but believe Advanced LIGO has a good chance for October 2006 funding