



News from LIGO Laboratory

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Caltech LIGO Laboratory

LSC-Virgo Meeting

Orsay, France

9 - 12 June 2008

Since Jay's last update in March

- *LIGO operations renewed !*
- *Advanced LIGO was approved and has started !*
- Astrowatch is under way
- eLIGO is progressing well
- A new proposal for H1 post-S6 and pre aLIGO
- Outreach activities



Very Good News

LIGO Laboratory Operations for FY2009 - 2013

- On 26 March ...

RESOLVED, that the National Science Board authorizes the Director at his discretion to approve the award to the California Institute of Technology for LIGO Laboratory operations and maintenance for an amount not to exceed \$150,000,000 for 60 months. If progress is acceptable based on reviews made pursuant to the Internal Management Plan, the awardee will be invited to submit a renewal proposal for an additional 60 months.

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- Funding of LIGO laboratory during next 5 years assured
- Level of funding \$10M less than requested
 - Has led to a descoped program of operations
 - Travel
 - Visitors
 - Outreach augmentations
 - Other reductions
- Funding profile over the 5-year period is not uniform
 - Leading to lean and less lean years as Operations meshes onto Advanced LIGO Project



More Very Good News

Advanced LIGO Project has been authorized to begin!

- Also on 26 March

• • •

RESOLVED, that the National Science Board authorizes the Director at his discretion to approve the award to the California Institute of Technology for the Advanced LIGO construction project for an amount not to exceed \$205,120,000 for 84 months.

- **April 1 2008** official start date
 - **\$205M approved** for 2008-2015 total Project
 - **\$32M for the first year**, as requested
- Now: parallel efforts in Development and Project.



Other news:

- Also part of the approval resolution ...

WHEREAS, the NSF management shall report back to the National Science Board within 12 months of this award what efforts have been undertaken and what provisions have been implemented to make the data obtained under this award available and useable to the broader research community;

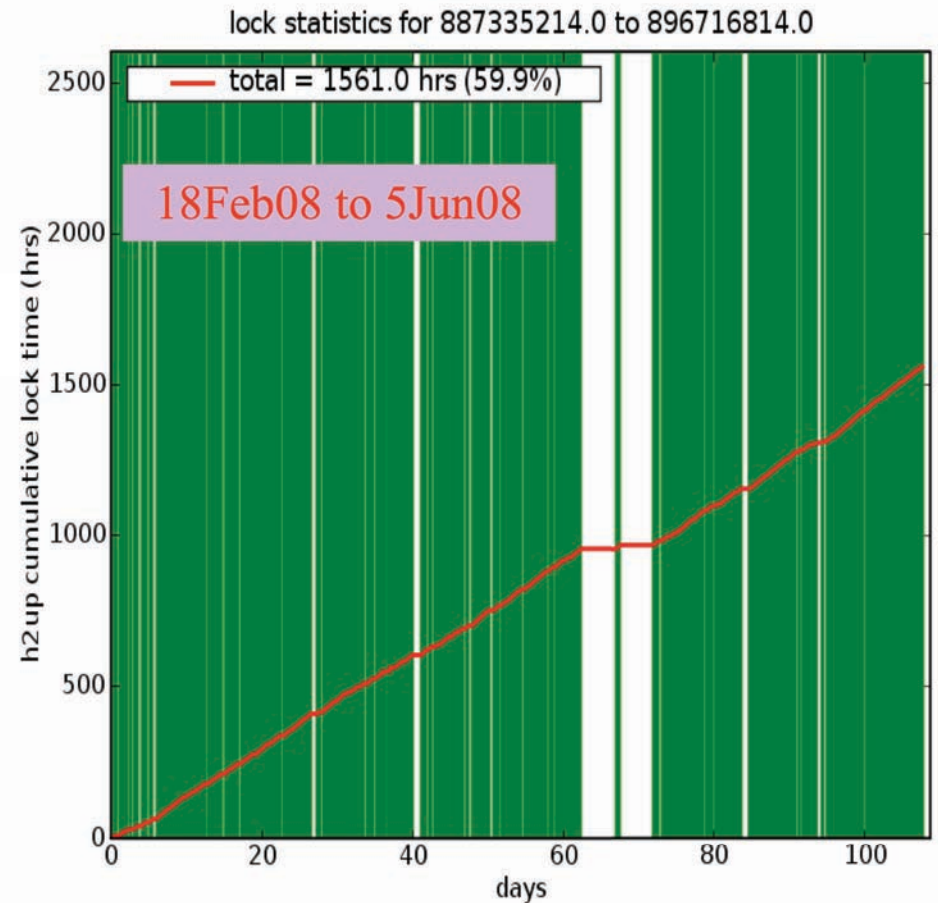
- This is a directive to the NSF (not LIGO or the LSC at this point)
- The model under which we launched the LSC in 1996 may no longer be a valid one in 2009+ ...
- LIGO Directorate are considering options prior to NSF making a request to the LIGO Laboratory
 - Take the initiative to consider what the Lab and the LSC would like to see happen given that there are changes coming ...
 - There will be plenty of time to discuss within the LSC as strawman options come into sharper focus ...



AstroWatch

H2 at LIGO Hanford Observatory

- A5 began 18 Feb 2008
- Run led by LSC grad students
 - Good training for students
 - Frees up most experienced labor for eLIGO work on H1
 - Expect 50% AstroWatch duty; 50% for thesis work
 - Lab provides apt + carpool
 - 1 daily night shift when 6 students in residence + interventions as available
- Successfully running:
 - Science mode up time ~34%
 - Total up time ~60%
 - Saving 12-20 hrs of data/day





AstroWatch

LSC graduate students who have enrolled for AstroWatch A5 duty

Berit Behnke (AEI)	Philip Roberts (Andrews)
Evan Goetz (Michigan)	Jacob Slutsky (LSU)
Pinkesh Patel (Caltech)	Junyi Zhang (Michigan)
Szymon Steplewski (WSU)	Matt West (Syracuse)
Adam Mullavey (ANU)	Satya Mohapatra (U. Mass. Amherst)
Llucia Sancho de la Jordana (U. de les Illes Balears)	Miquel Trias (U. de les Illes Balears)
Jericho Cain (U. Miss)	

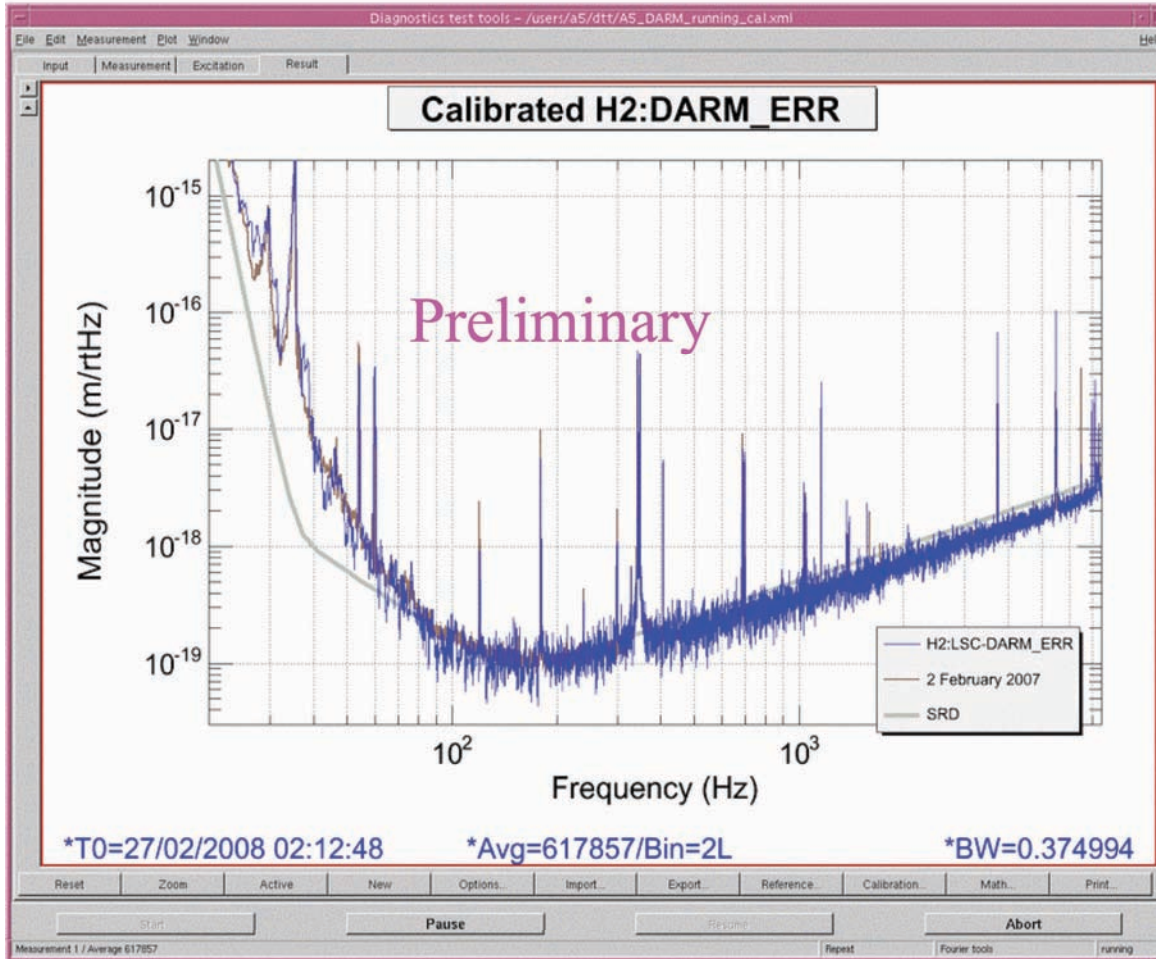
Already served

Scheduled to arrive



AstroWatch

H2 running well, considering...

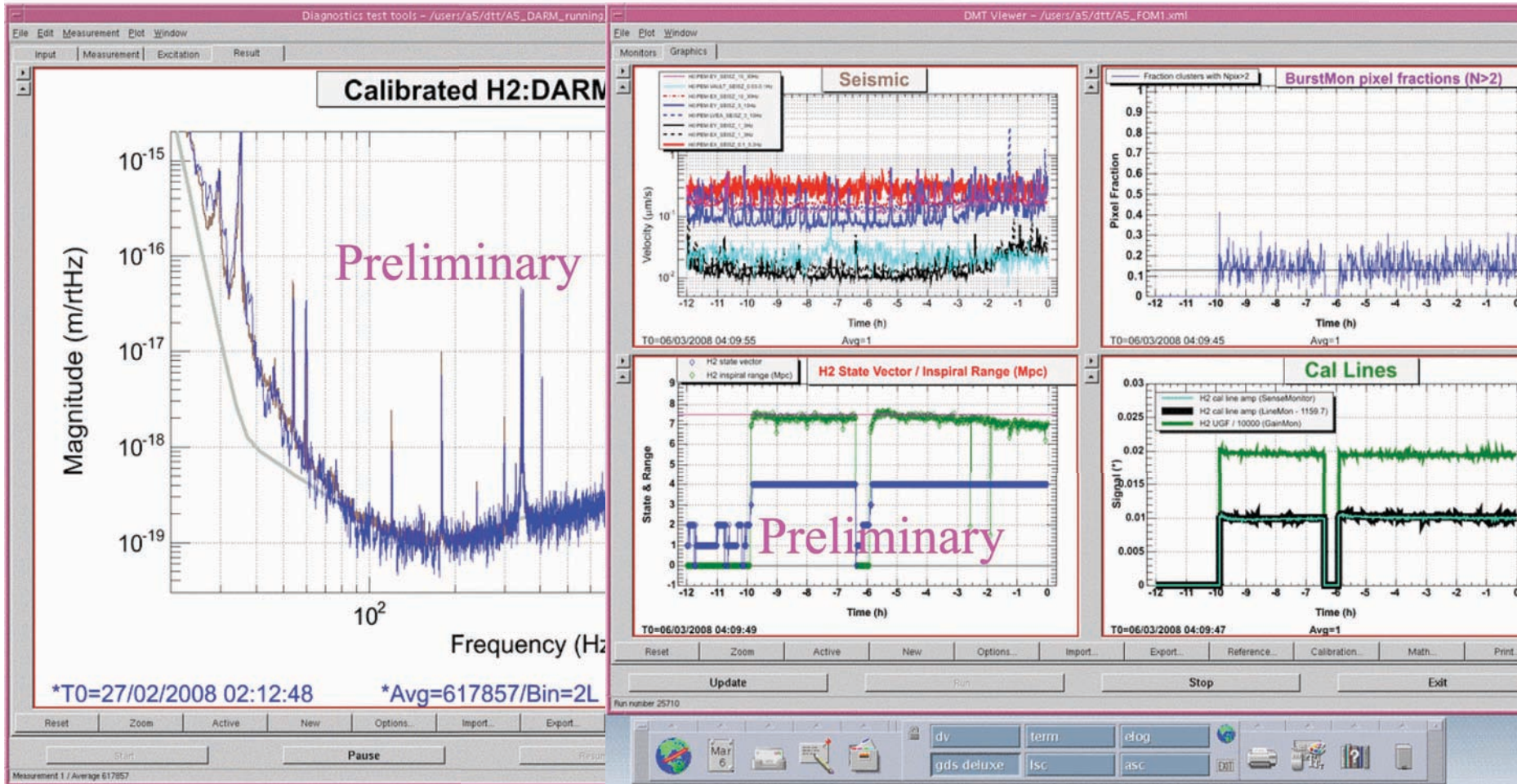


- H2 range varies 6-7.5 Mpc, depending on eLIGO activity & hardware installation.
- Compares well to H1 range during SGR1806-20 (2004.12.27) of ~5.7 Mpc.



AstroWatch

H2 running well, considering...



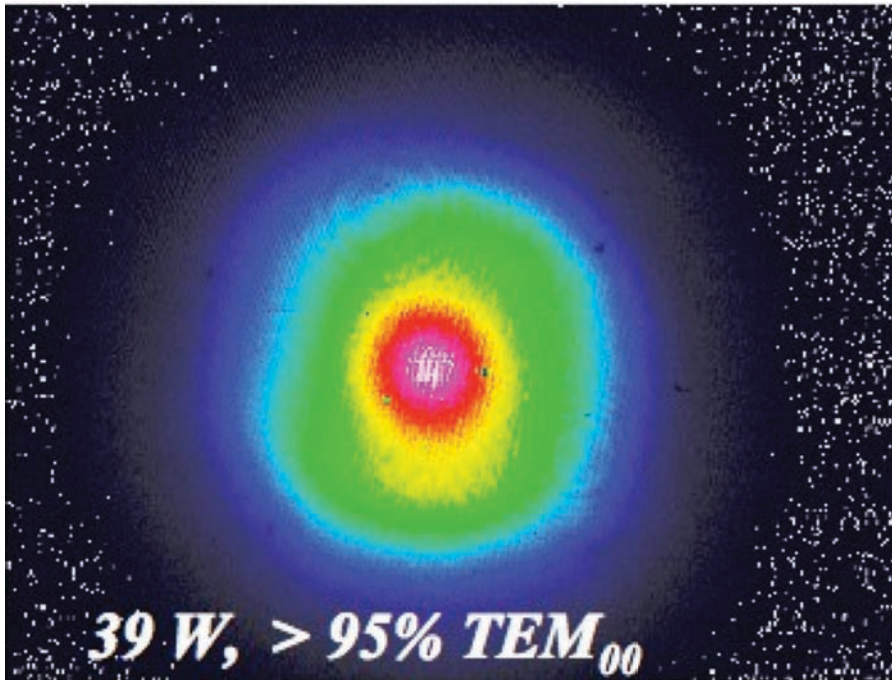
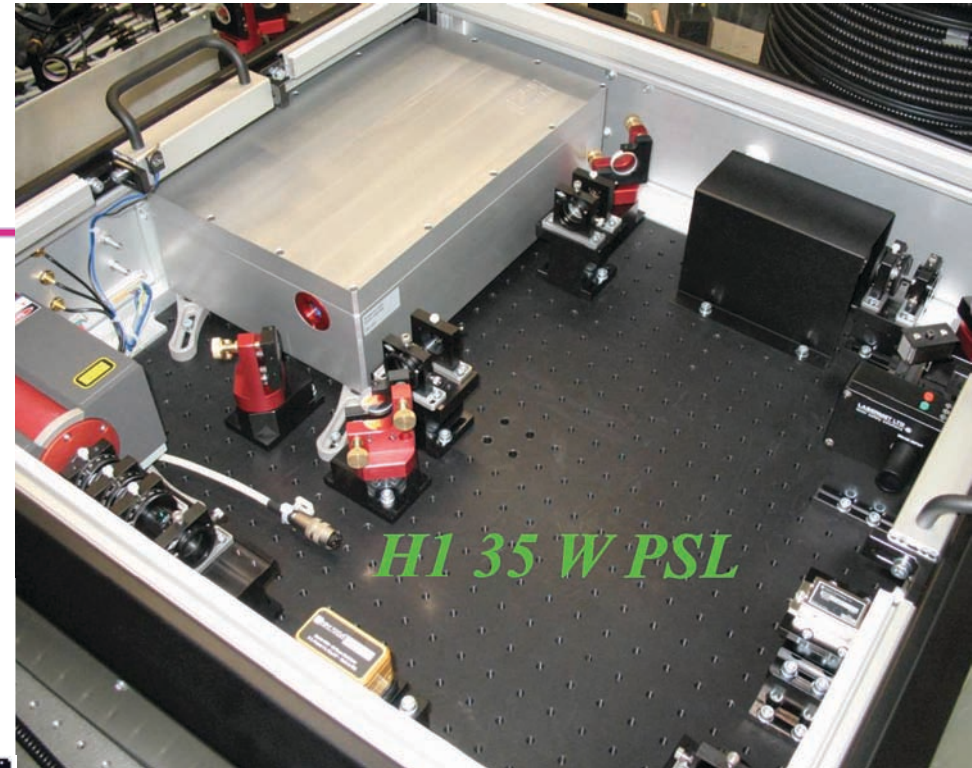
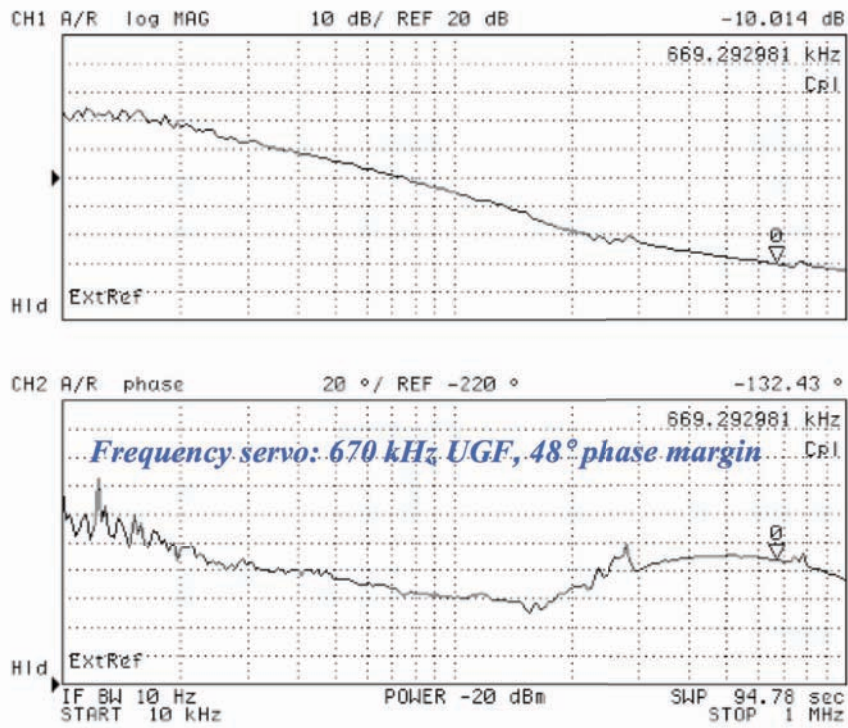
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eLIGO

Latest news

- Hardware > 95% complete
- Installation > 85% complete
 - ✓ IO Faradays installed, modified input beamlines on H1 and L1
 - ✓ SiO₂ EQ stops on H1, H2 ITMs & ETMs and on L1 ITMs
 - ✓ NdFeB magnets replaced with SmCo on H1 ETMs
 - ✓ Septa, windows and new readout beamlines on H1 and L1
 - ✓ HAM ISI installed on both H1 and L1
 - ✓ 35 W eLIGO/aLIGO Laser and EOM on H1
 - ✓ OMC suspension, OMC cavity, and DC readout on L1
- ... and H2 is up, running Astrowatch
- Now in “Commissioning” mode at both sites:
 - L1: DC readout is operational !! Rapid progress to improve sensitivity
 - H1: “High power” testing, ISI control loop development
- Remaining installation scope:
 - Scattered light baffles for both L1, H1
 - High-power TCS for both L1, H1
 - SmCo magnet swap (and SiO₂ EQ stops) on L1 ETMs
 - OMC suspension, OMC cavity, DC readout electronics for H1
 - 35 W laser and EOM, activate HAM ISI controls on L1

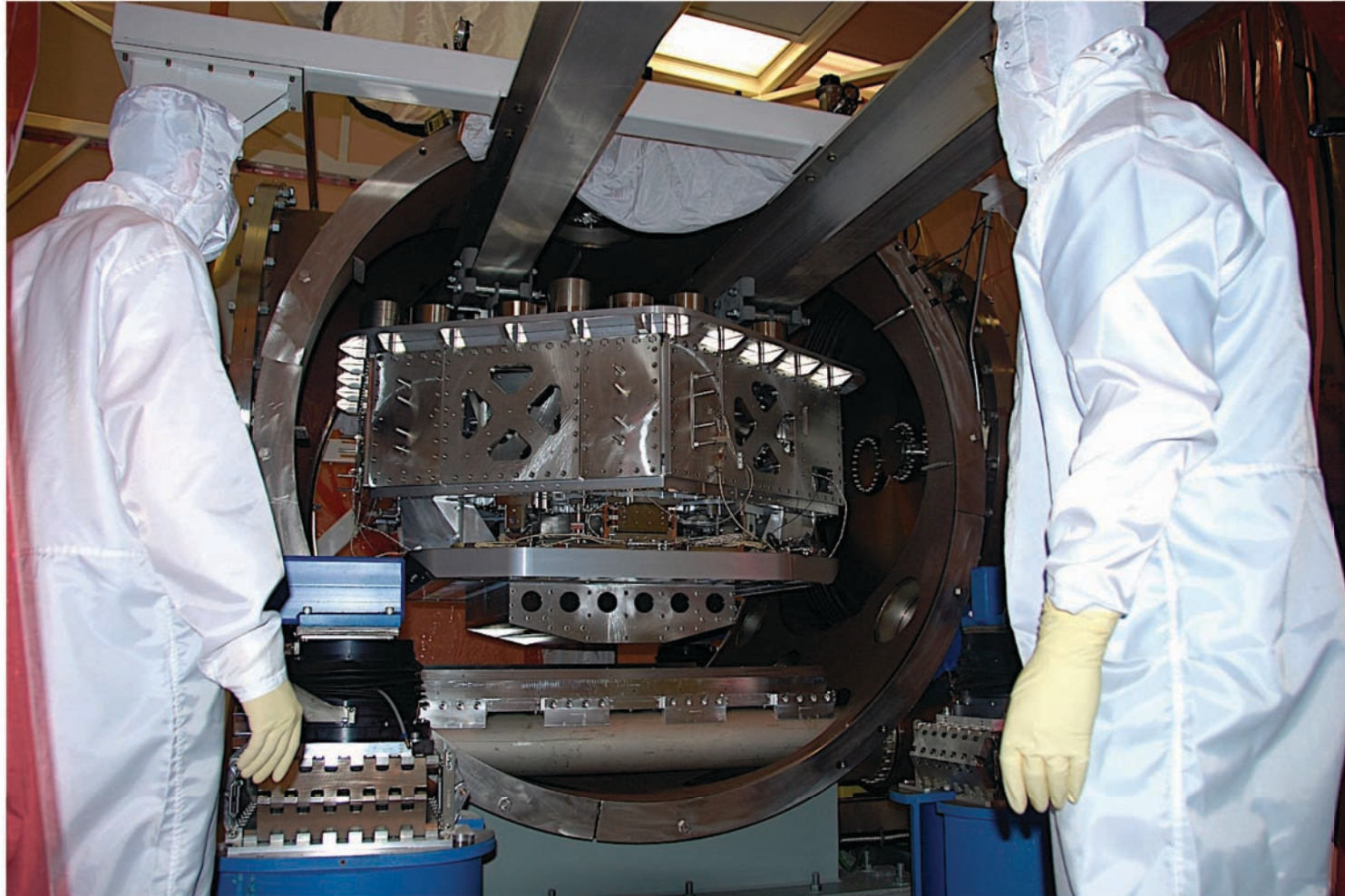


Pump diodes housed in new remote lab



eLIGO

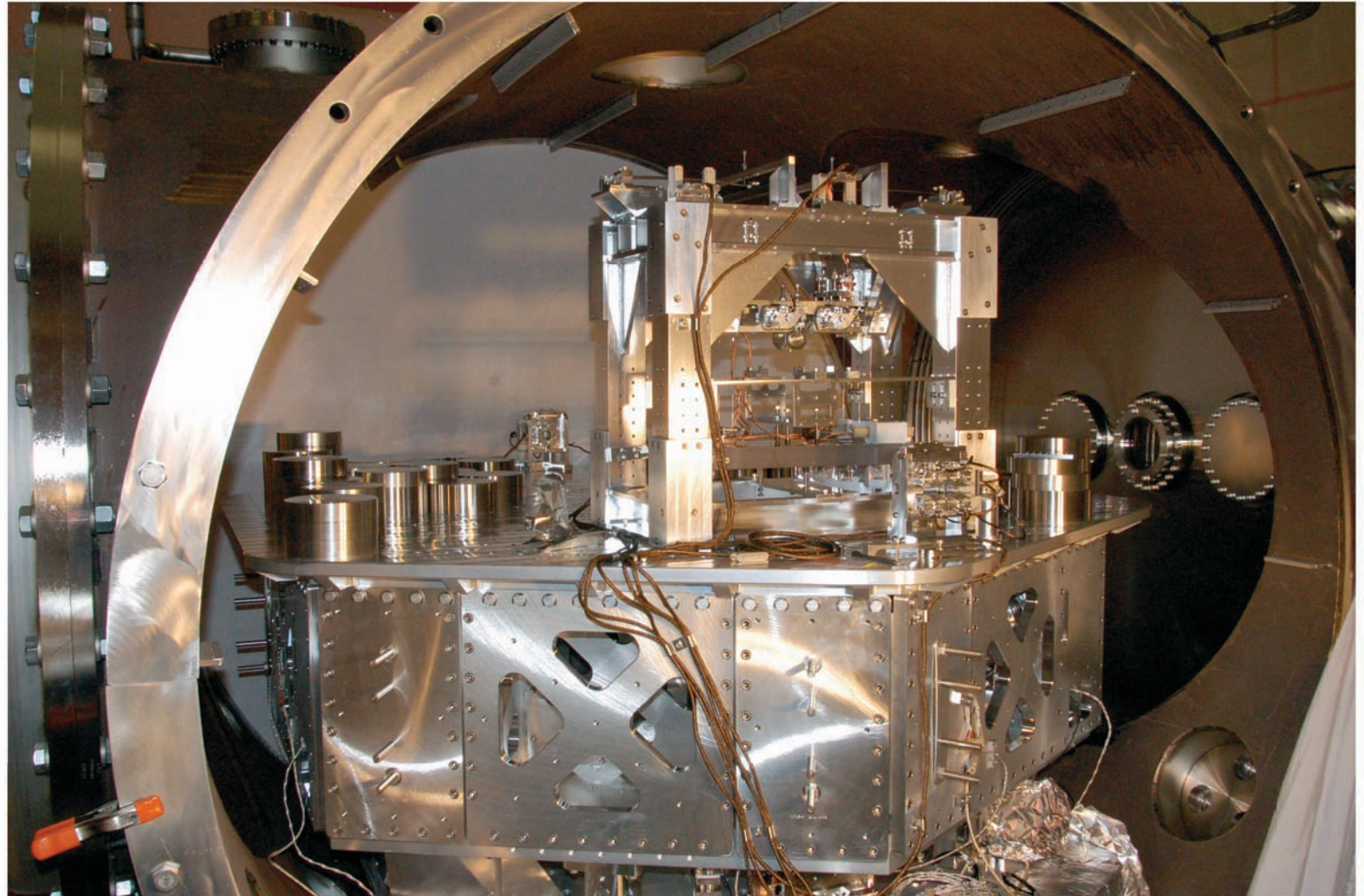
L1 HAM-ISI Seismic System Installation





eLIGO

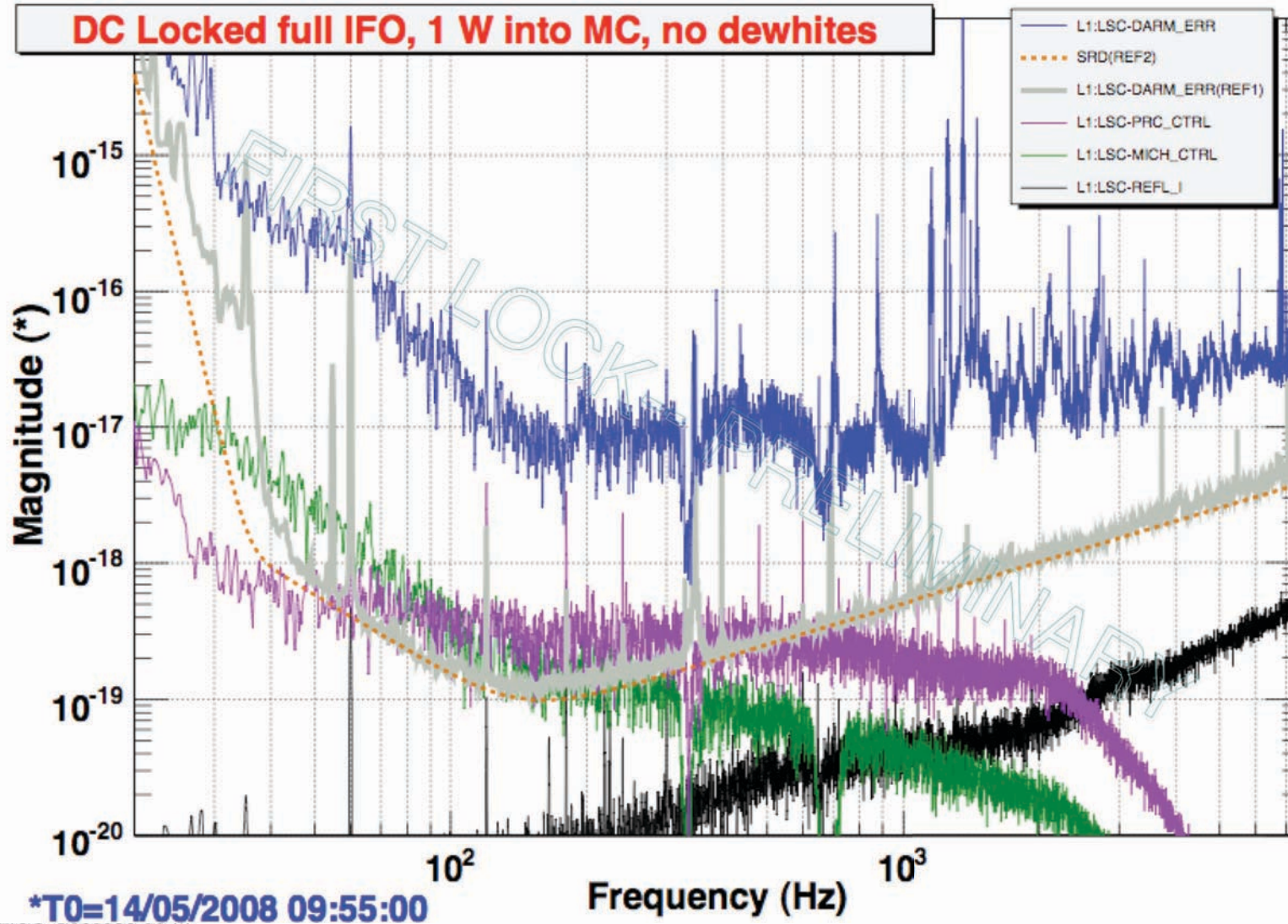
L1 HAM-ISI Seismic System + Output Mode Cleaner (OMC)





eLIGO

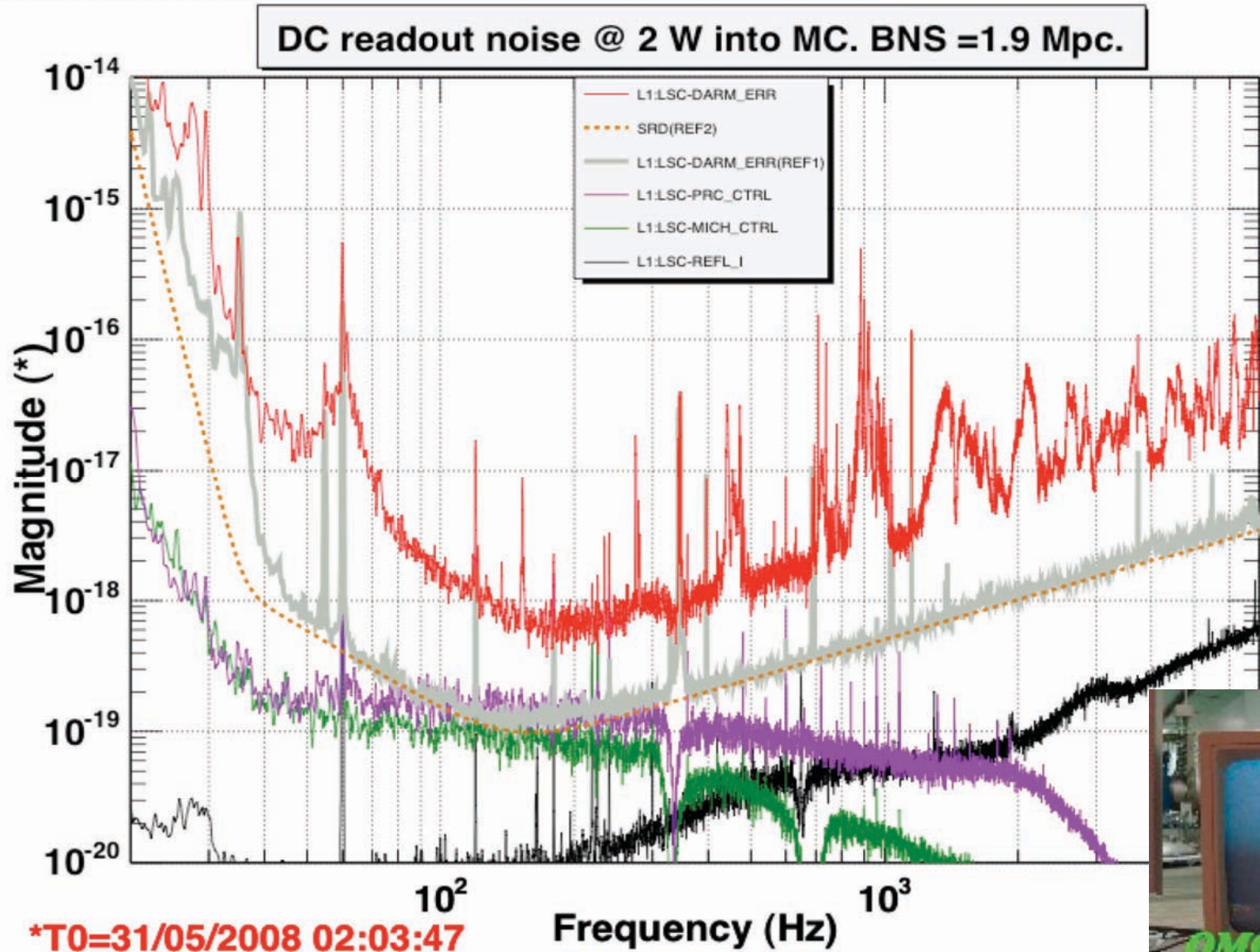
L1 on DC Readout !!





eLIGO

L1 on DC Readout !!





eLIGO

The Road to S6

- June-July: **Finish component commissioning**
 - L1: \Rightarrow Low noise (@ modest power) on DC readout
 - H1: IO & arm cavity stability at 35 W, robust ISI control laws
- July-August: **Synchronize H1 & L1 hardware**
 - L1: 35 W PSL; ETM magnets; SEI activation; TCS; stray light baffles
 - H1: OMC & DC readout; TCS; stray light baffles
 - ***Both machines synchronized to nominal S6 configuration***
- September-January '09: **Tag-team commissioning push**
 - Power up, noise reduction, duty factor
 - Task division: two teams, identical hardware, complementary tests
- Feb '09; Prepare for S6
 - Optimum S6 strategy depends on commissioning progress, AdL ETA, LSC/Virgo community, Virgo+, GEO, AstroWatch...
 - Possible variant: short S6A, ***commissioning break*** (review lessons learned), longer S6B



H1 Squeezing Experiment

Motivation

- High power operation in future detectors
 - Biggest remaining technical risk (after DC readout)
 - Squeezing allows for lower laser power
- Squeezer technology now ready
 - 7 dB of squeezing down to 10 Hz
 - Has been demonstrated on a bench and on interferometers (40m)

Missing: Low frequency noise demonstration

- Planned Experiments
 - GEO600: prototype for long baseline interferometers
 - Hanford H1: low noise demonstration



H1 Squeezing Experiment Time Line



- Complete proposal to LIGO lab: August 2008
 - Approval (hopefully): September 2008
- Construction
 - Build breadboard by fall 2009
 - Testing and characterization by mid 2010 → send to LHO
- Experiment on H1: Feb 2011 to Sep 2011



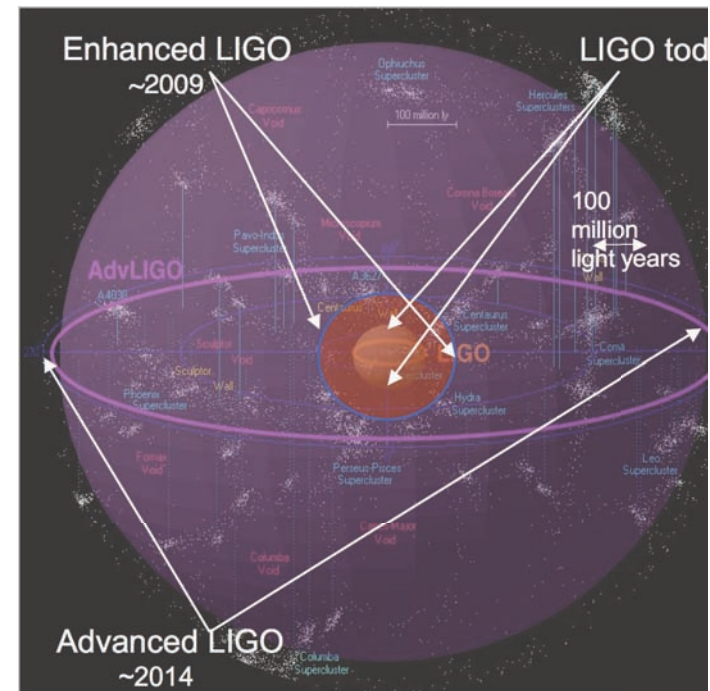
H1 Squeezing Experiment Progress

- Directorate has appointed a review committee to consider proposal, make recommendations to Laboratory management
 - Chaired by Fred Raab
 - Timeline
 - Review: late summer
 - Follow progress of experiment preparation, S6, Advanced LIGO schedule through 2009/2010
 - Make final decision to proceed with experiment in late 2010
- Most technical questions addressed
 - OPA configuration, SHG topology, auxiliary lasers, fiber stabilization, in-vacuum Faraday modifications, physical setup at H1, concepts for electronics, scattering, etc.
- Preliminary layout available
- Working on a budget
- Schedule/workload: next
- Wiki: <http://baikal.mit.edu/sqwiki/H1Squeezer>
 - Email list: <http://mm.ligo.caltech.edu/mailman/listinfo/squeezer>

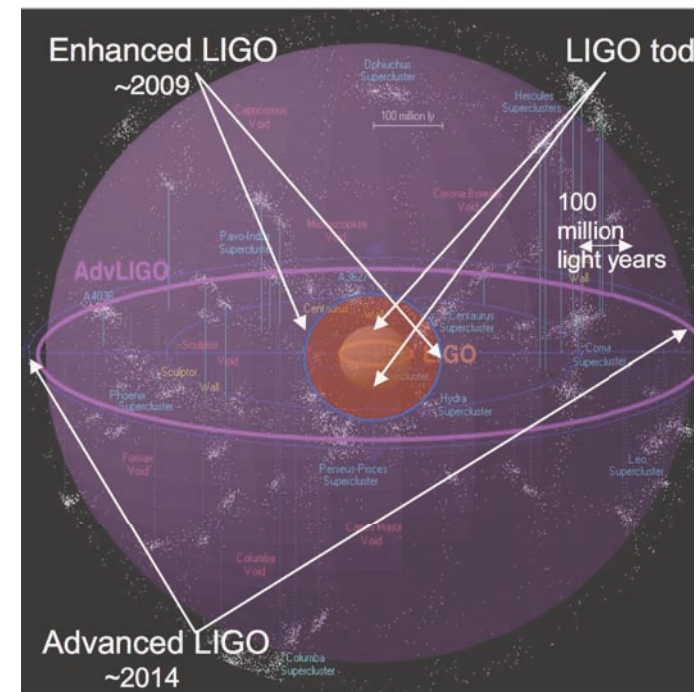
Squeezing is an exciting new technology!
Could be crucial to the success of aLIGO

Status of Advanced LIGO

- Baseline Review in November 2007
 - Review committee gave us (you all!) high grades
 - “The panel is unanimous that AdLIGO is ready for a new construction start. We were extremely impressed with the thoroughness of their preparation and the soundness of the design.”
- Construction start awaits the end-March meeting of the National Science Board
 - They received the package a few weeks ago...
- Anticipate Project Start in April 2008
 - Expect robust funding
- Planning and hoping for continued broad LSC participation – adding value during Project, digging into post-Project tuning and testing



- The Project has started!



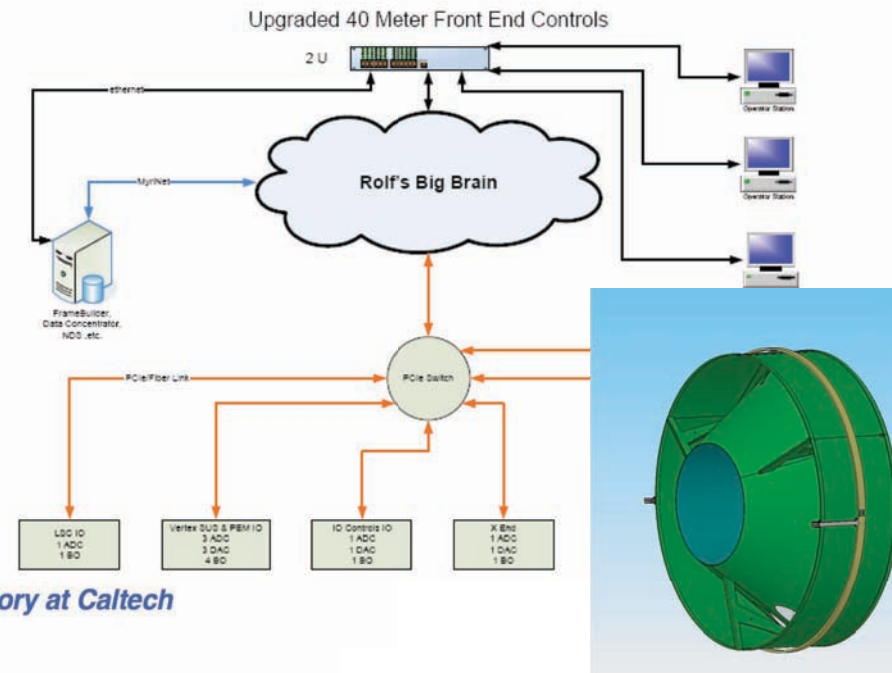


Advanced LIGO Development

- The eLIGO prototype testing you have just heard about is central to many of the subsystems –
 - HAM seismic isolation
 - Output Mode Cleaner suspensions
 - DC readout
 - Thermal Compensation System
 - Tests of ADC/DAC/real time computing/timing
 - Input Optics modulators, isolators
 - Pre-Stabilized Laser 'front end'
 - ...and lots of valuable familiarity and formal training

LIGO Advanced LIGO Development

- Testing of the Test Mass Quad Suspension and the BSC Seismic Isolation at LASTI – installed in the vacuum chamber with start of servo controls work
- Start of demonstration of length sensing and controls at the Caltech 40m – design firmed up, starting fabrication; progress on selecting a pre-lock length stabilization system
- Lots of detailed design work, and many reviews, to bring efforts to the procurement phase

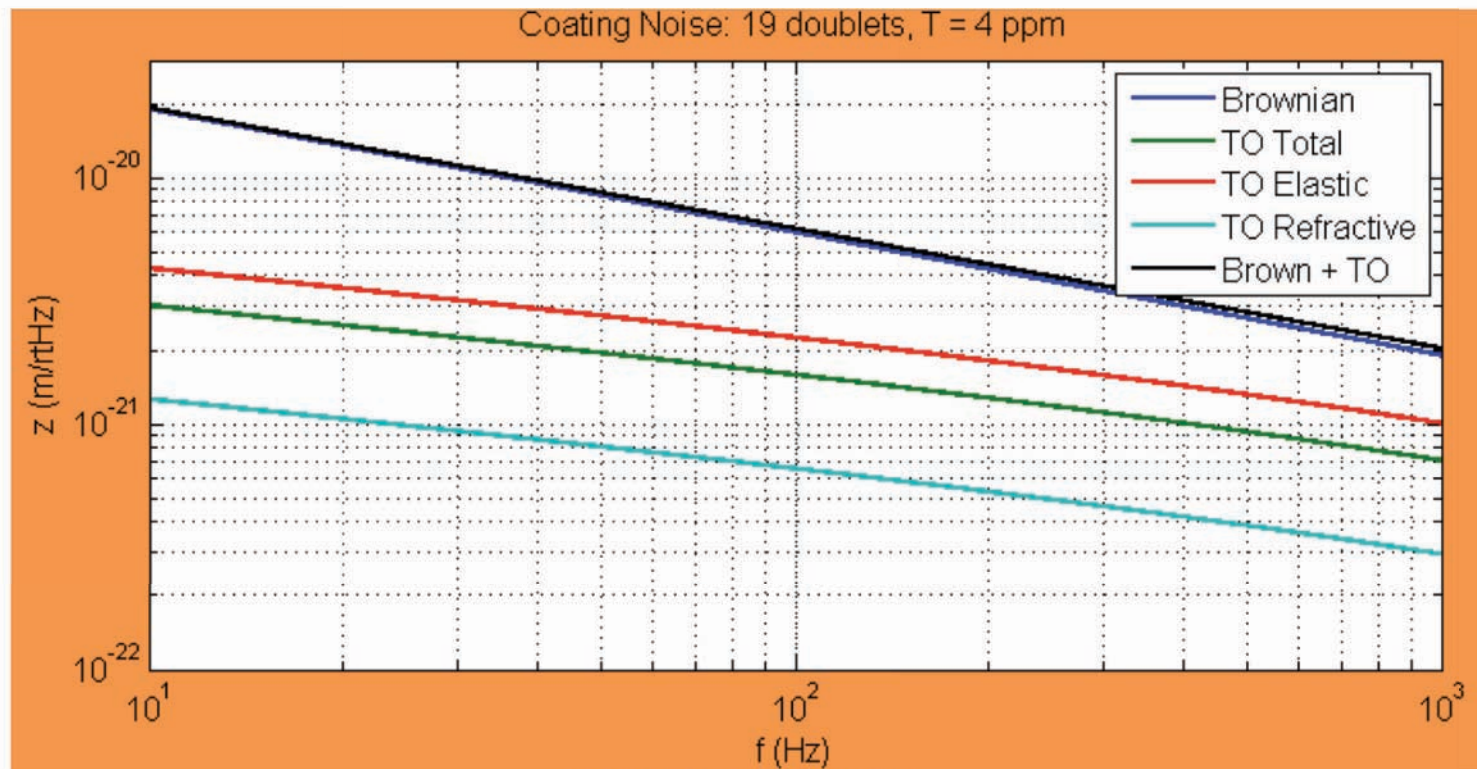


LIGO Laboratory at Caltech



A recent discovery: Coating thermo-optic noise

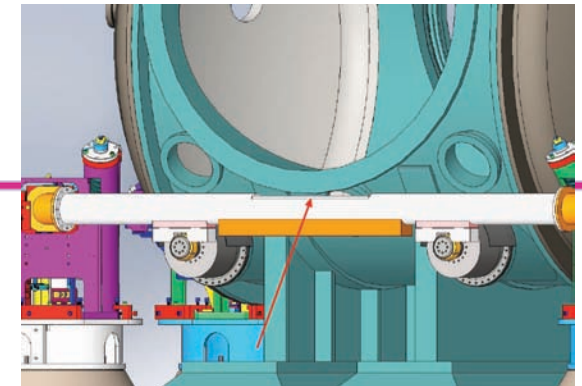
- A sign error found in the coating noise calculation; it appears that thermo optic noise will be much lower than anticipated (Matt Evans)
 - Thermo-elastic and thermo-refractive coherent, but out-of-phase -- subtract, not add
 - May result in aLIGO NS-NS range > 200 Mpc, helps also at high frequencies





Advanced LIGO Project

- HEPI (Hydraulic External Pre-Isolator) being readied for production for the Hanford site (already installed at Livingston)
- Procurement process for Core Optics (test masses etc.) moving forward
- Test Mass Quadruple Suspension (UK effort) into production for selected elements
- Preparing spaces at observatories for assembly

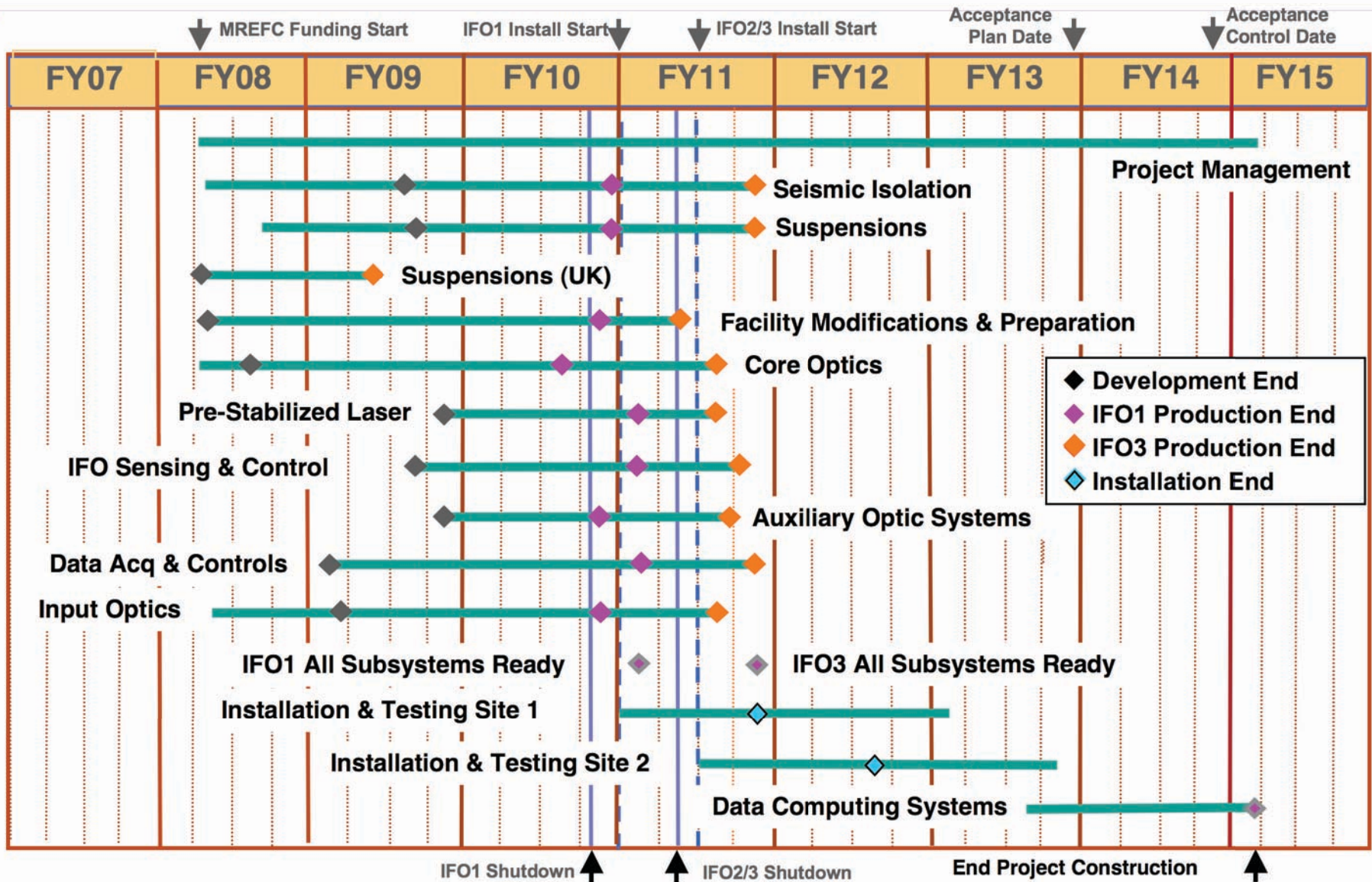


Assembled BOSEMS at testing station



Advanced LIGO Subsystem Summary

(Showing Development and Project Production Early Milestones)





Teacher professional development programs at both sites draw heavily on local and regional education partnerships

- The SEC served 34 teacher professional development programs between 1/07 and 5/08, 14 of which were Math Science Partnerships
- LHO serves as a partner on a local Math Science Partnership that features a two-week summer graduate course for teachers on the nature of scientific inquiry.



- The LHO - WSU Tri-Cities professional development partnership has resulted in a publication in the science education literature. A similar collaboration is underway between LLO and Tulane.



The new LSC Outreach Working Group seeks to improve coordination and collaboration on outreach across the LSC

- Chaired by Marco Cavaglia, University of Mississippi
- Front-burner projects include participation in the June meeting of the Astronomical Society of the Pacific and in the 2009 World Science Festival in New York City. Additional projects will be considered for the 2009 International Year of Astronomy.





Summary

- Funding for LIGO Laboratory Operations is assured for next 5 years.
- Funding for Advanced LIGO is assured
 - 7 year construction project
- Astrowatch is progressing well
- eLIGO is nearing construction/installation completion
 - Commissioning is ongoing at subsystem level
 - On target for early 2009 S6
- aLIGO is ramping up - major procurements starting
- Squeezed light experiment under serious consideration by LIGO Laboratory for the interim period between end of S6 and start of aLIGO installation at LHO
- Outreach activities continuing robustly, with substantial (and growing) LSC participation