

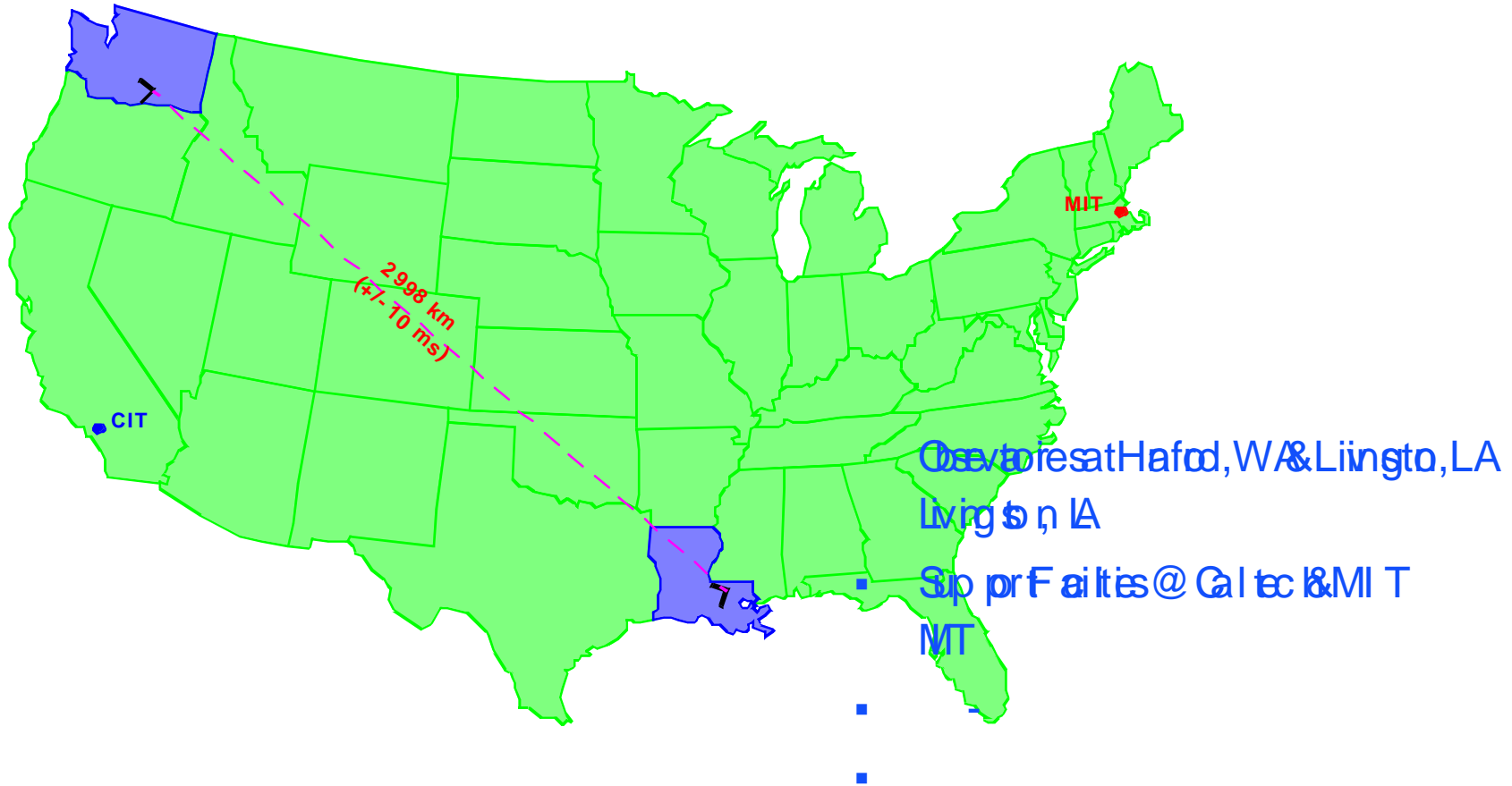


Status of LIGO Installation and Commissioning

Frederick J. Raab, LIGO Hanford Observatory



The Four Corners of the LIGO Laboratory





Aerial Views of LIGO Facilities



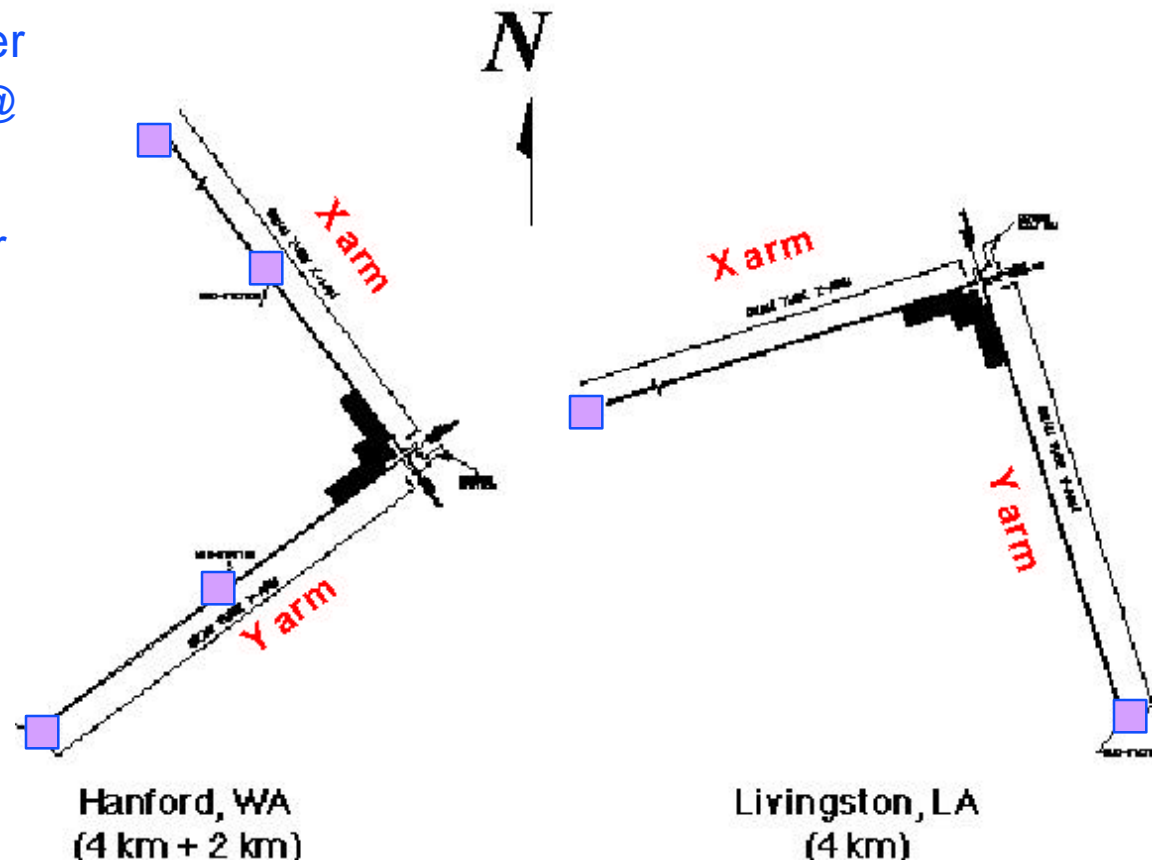
LIGO Hanford Observatory

LIGO Livingston Observatory



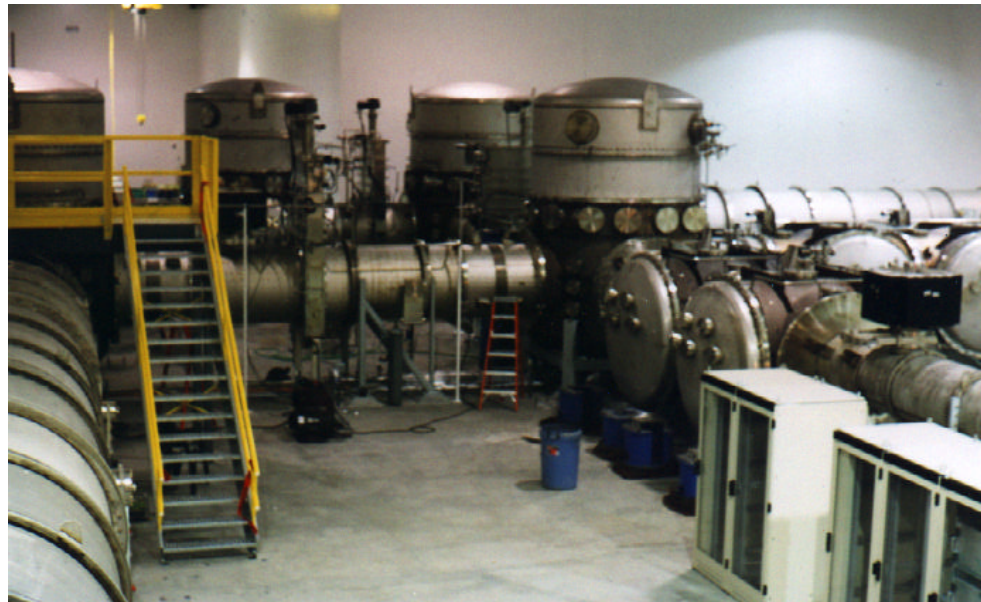
Configuration of LIGO Observatories

- 2-km & 4-km laser interferometers @ Hanford
- Single 4-km laser interferometer @ Livingston



Observatory Facilities Mostly Completed

- Hanford and Livingston Lab facilities completed 1997-8
- 16 km beam tube with 1.2-m diameter
- Beam-tube foundations in plane ~ 1 cm
- Turbo roughing with ion pumps for steady state
- Large experimental halls compatible with Class-3000 environment; portable enclosures around open chambers compatible with Class-100
- Some support buildings/laboratories under construction



Beam Tube Bakeout

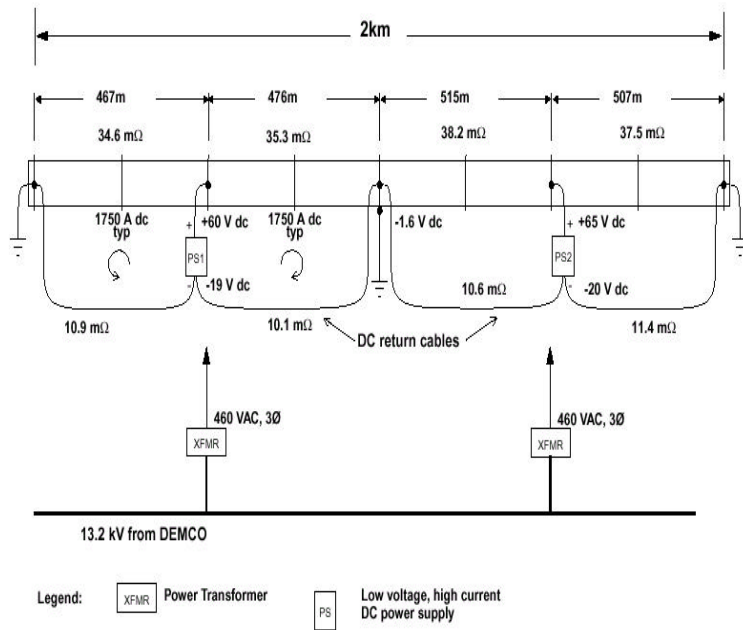
- Method: Insulate tube and drive ~2000 amps from end to end



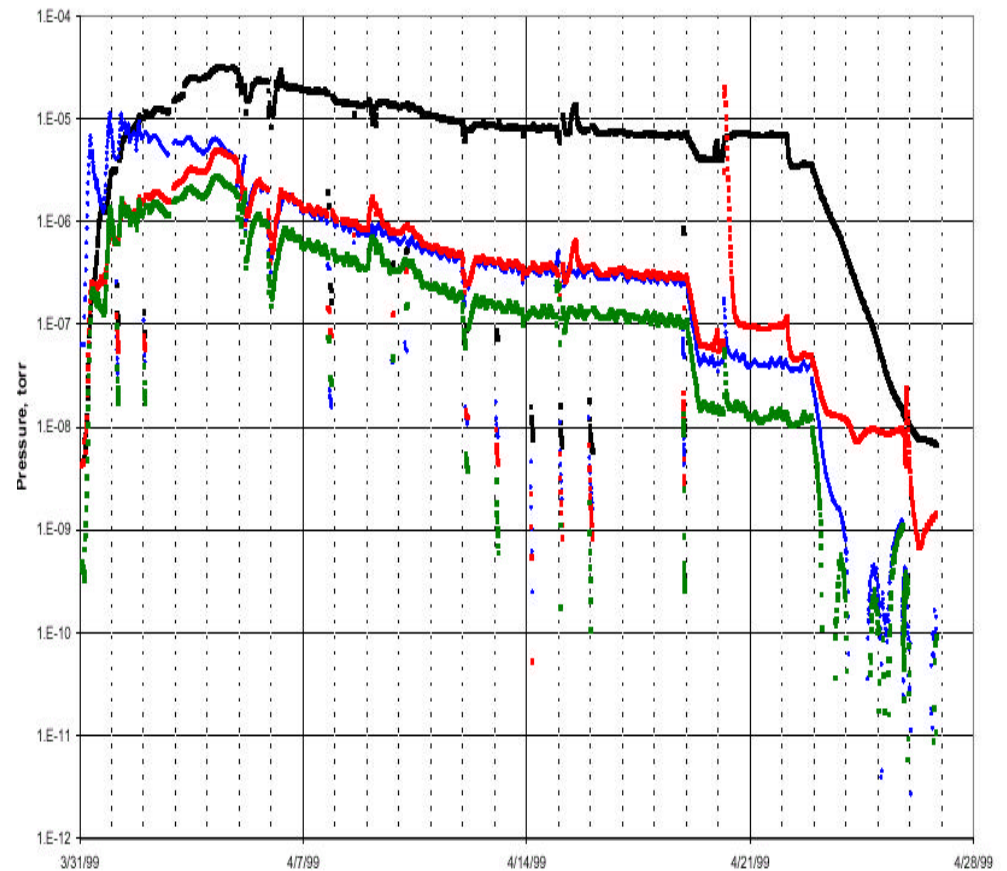


Beam Tube Bakeout

BEAM TUBE BAKEOUT ELECTRICAL HEATING POWER



HX2 RGA PRESSURE, AMU 2 (blk), AMU 18 (blu), AMU 28 (red), AMU 44 (green)





Beam Tube Bakeout Results

Postbake measurements of module X1 at Hanford

March 11-12, 1999

Table 1: Results from gas model solution of 16.9 hour postbake accumulation ending March 12, 1999 at 10:00AM .

molecule	Outgassing rate @ 10C	pressure@ 10C	outgassing rate @ 23C	pressure@ 23C
	torr liters/sec/cm ²	torr	torr liters/sec/cm ²	torr
H ₂	1.6 x 10 ⁻¹⁴	1.0 x 10 ⁻⁹	5.2 x 10 ⁻¹⁴	3.4 x 10 ⁻⁹
CH ₄	< 2 x 10 ⁻²⁰	< 3.4 x 10 ⁻¹³	< 8.8 x 10 ⁻²⁰	< 1.5 x 10 ⁻¹²
H ₂ O	< 3 x 10 ⁻¹⁹	< 5.2 x 10 ⁻¹³	< 1.3 x 10 ⁻¹⁸	< 2.3 x 10 ⁻¹²
N ₂	< 9 x 10 ⁻¹⁹ **	< 1.5x 10 ⁻¹³		
CO	< 1.3 x 10 ⁻¹⁸	< 1.7 x 10 ⁻¹³	< 5.7 x 10 ⁻¹⁸	< 7 x 10 ⁻¹³
O ₂	< 1.2 x 10 ⁻²⁰	< 2.3 x 10 ⁻¹⁴		
A	< 2.5x 10 ⁻²⁰	< 3.6 x 10 ⁻¹⁴		
CO ₂	< 6.5 x 10 ⁻²⁰	< 1.2x 10 ⁻¹³	< 2.9 x 10 ⁻¹⁹	<5.2 x 10 ⁻¹³

Detector Installation and Commissioning

- Proceeding on 3 interferometers at 2 sites at this time
- Strategy: learn by doing, one interferometer at a time
- Start with 2-km @ Hanford, then 4-km @ Livingston, end with 4-km @ Hanford
- Focus on earliest shakedown for each subsystem
- Resident staff working with commuting members of design & fabrication teams





Installation Status

- All seismic isolation systems installed for all three interferometers
- Prototype Pre-Stabilized Laser (PSL) for 2-km interferometer @ Hanford operational since Dec 98
- All in-vacuo installation of 2-km interferometer @ Hanford completed; both 2-km arms have been aligned and locked; length/alignment servos for complete interferometer now being installed
- Livingston 4-km PSL, Injection Optics installed; main mirrors (Core Optics) being installed



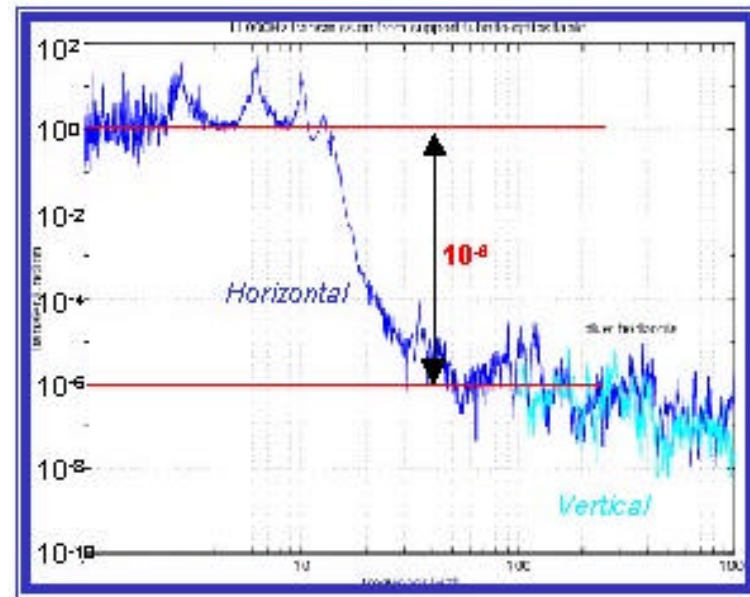
Seismic Isolation Installation Completed





Subsystem Commissioning: Seismic Isolation

- First-article tests and in-air transfer functions
- In-vacuo transfer functions begun @ Livingston, ongoing @ Hanford, using in-vacuum accelerometers
- Fine actuator transfer functions measured using 2-km Fabry-Perot





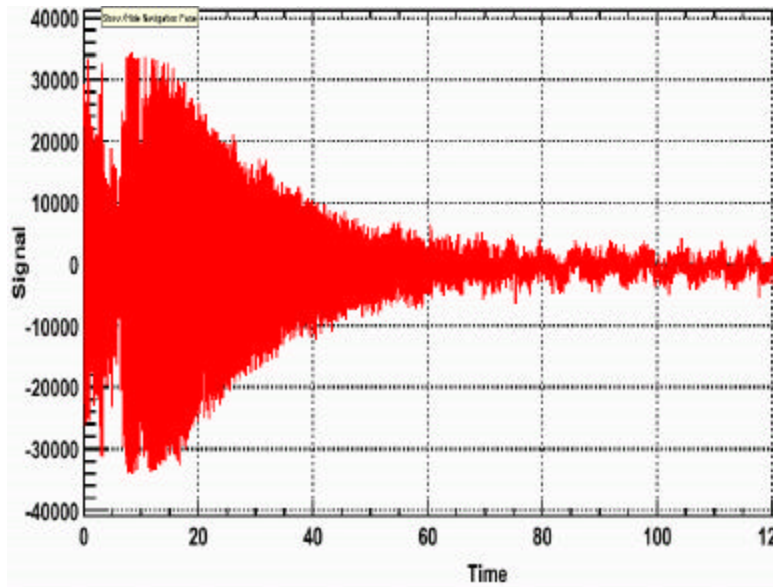
Suspension Installation & Commissioning

- Solved conflicts between bonding and cleaning procedures
- Developed reliable fixturing and alignment procedures on the job
- Installation is now smooth
- Mechanical Q's measured for mirror and pendulum modes look on target, but some instances of low Qs need follow-up
- Developed tuning procedures to minimize “cross-coupling” in shadow sensors/drivers

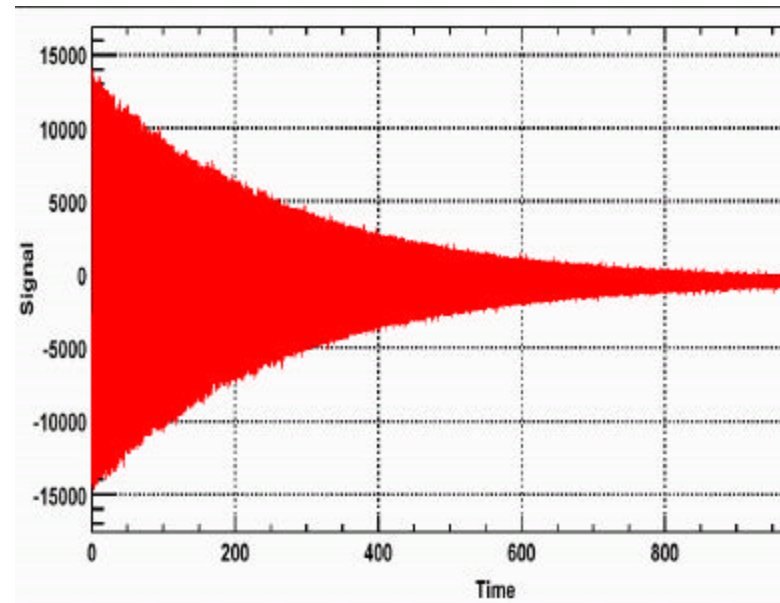




ITMx Internal Mode Ringdowns



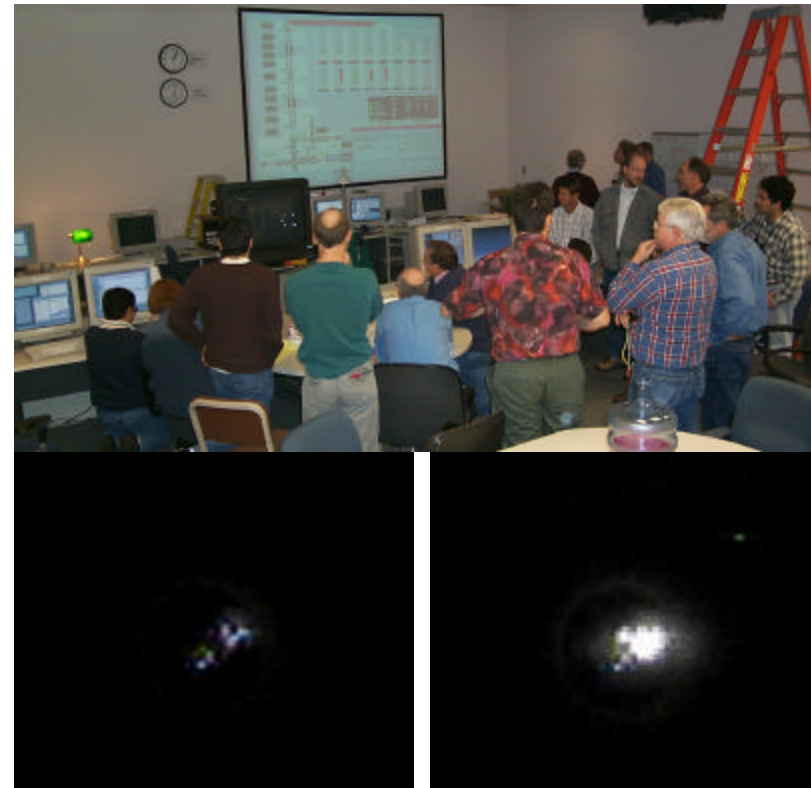
9.675 kHz; $Q \sim 6e+5$



14.3737 kHz; $Q = 1.2e+7$

Single-Arm Tests

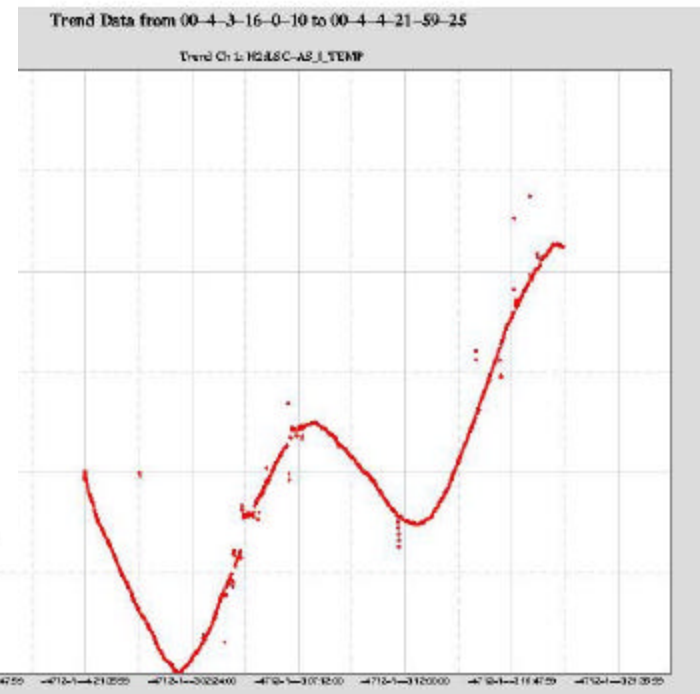
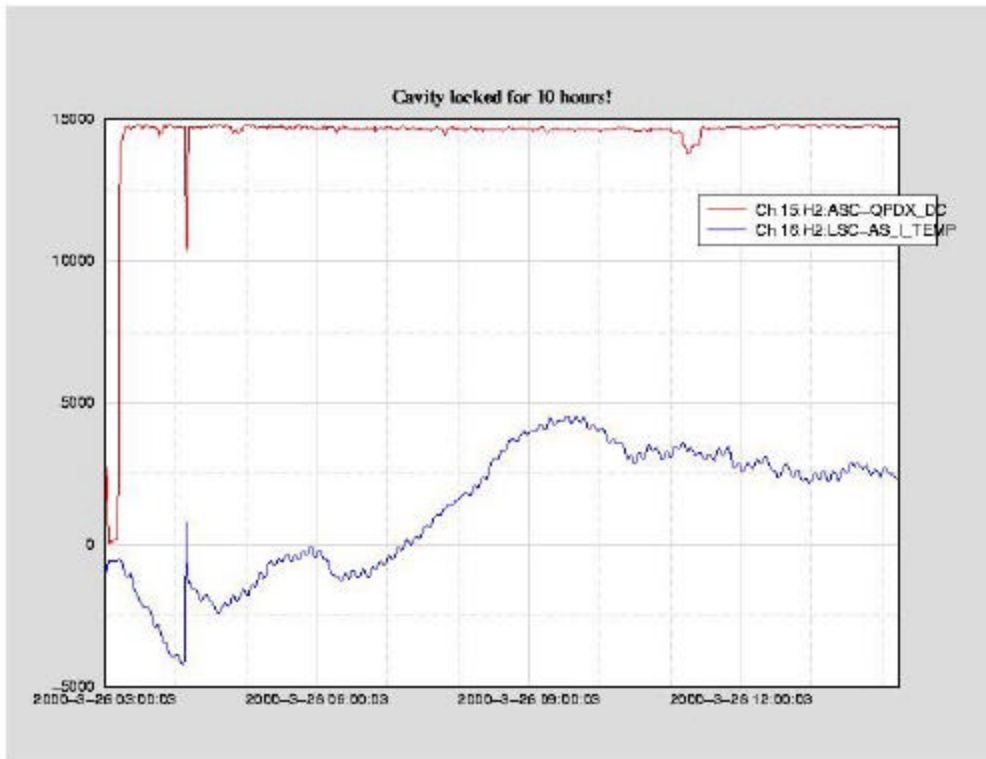
- Alignment of 2-km arms worked for both arms!
- The beam at 2-km was impressively quiet
- Stable locking was achieved for both arms by feeding back to arms
- Measured optical parameters of cavities
- Characterized suspensions
- Characterized Pre-Stabilized Laser & Input Optics



Swinging through 2-km arm fringes



Data From Locked Stretch on Hanford 2-km Y Arm





Initial Results From Single Arm Tests

- + It works!
 - + Optical parameters consistent with lab metrology
 - + Refined methodologies for aligning, tuning, mode-matching
 - + RMS motions dominated by microseism as expected
 - + Drifts consistent with earth tides in magnitude
 - + Auto alignment system improved fringe alignment
- ⇒ Shadow sensor redesign to improve scattering sens.
 - ⇒ PSL/IO mount redesign to improve microphonics
 - ⇒ Alignment & mode matching redone on input optics
 - ⇒ Needed strong frequency noise suppression to deal with 350 Hz arm line width
 - ⇒ Electronics saturates easily
 - ⇒ “Butterfly” mode of mirror required “notching”



Present & Future

- Currently preparing to lock power-recycled Michelson in corner station for Hanford 2-km interferometer
- Follow with full 2-km interferometer configuration by year end
- Livingston coming on line with some what improved systems a few months later than Hanford
- Hanford 4-km interferometer will integrate lessons learned previously at Hanford & Livingston
- Science runs will start in 2002



LIGO, Built to Last

