
Status of the LIGO Project

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LSC Meeting

University of Florida - March 4, 1999



LIGO Schedule at Very Top Level

- 1996 Construction Underway
 - » mostly civil
- 1997 Facility Construction
 - » beam pipe and enclosure
- 1998 Construct Detectors
 - » completion of vacuum systems
- 1999 Install Detectors
 - » interferometers in vacuum
- 2000 Commission Detectors
 - » first light in arms; subsystem testing
- 2001 Engineering Tests
 - » sensitivity: engineering run
- 2002 LIGO I Run Begins
 - » $h \sim 10^{-21}$



Project Status

- Project is on its budget and close to schedule
- Facility construction is complete
- Vacuum equipment delivered and accepted at both observatories
- Beam Tubes accepted at both observatories
 - » Bakeout is 75% complete at Hanford
- Detector design complete
- All major detector fabrication contracts in place
 - » Many items delivered daily
- Detector installation underway at Hanford and imminent in Livingston



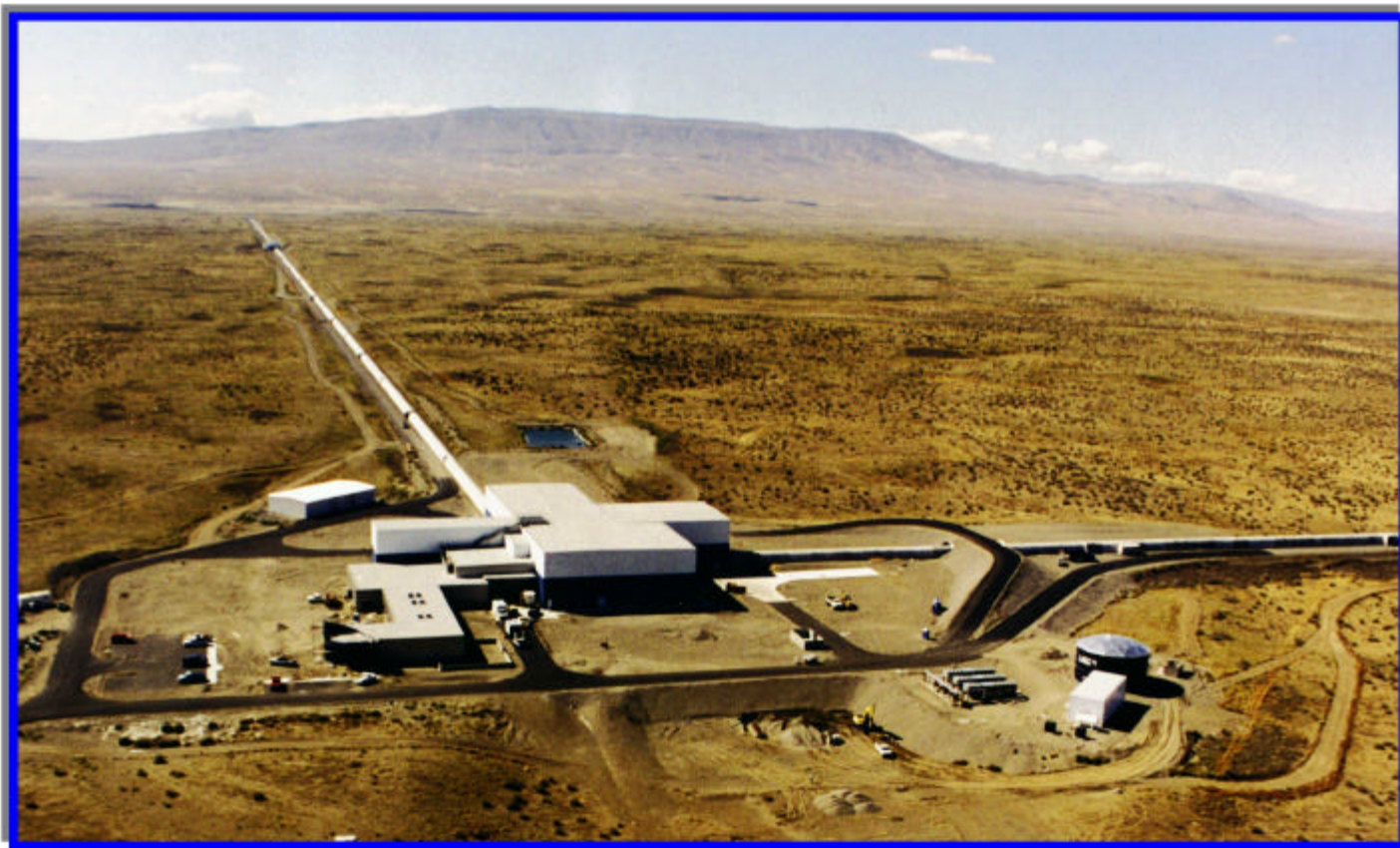
LIGO Hanford Observatory (LHO) 2km IFO Detector Installation Schedule

ID	Task Name	Duration	Start	Finish	1998												1999												2000											
					J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A										
1	1 2km PR Near-Michelson	575.9 days	7/1/97	10/14/99																																				
2	1.1 Setup Labs	22 days	6/1/98	7/1/98																																				
7	1.2 Accept Vacuum Equipment	96 days	3/11/98	7/27/98																																				
16	1.5 PEM System Installation	252 days	7/1/98	7/1/99																																				
34	1.6 Install SEI Phase 1	91 days	7/1/98	11/6/98																																				
55	1.7 Cable Tray Installation	75 days	9/29/98	1/20/99																																				
61	1.8 In-Vacuum Cable Assembly	75 days	10/5/98	1/26/99																																				
68	1.9 Cleaning	341 days	7/1/97	11/5/98																																				
75	1.10 Viewport & Feedthru Installation	113 days	8/3/98	1/18/99																																				
84	1.11 SEI/HAM Phase 2&3 Installation	137.9 days	7/10/98	1/29/99																																				
129	1.12 PSL INSTALLATION	153 days	4/13/98	11/16/98																																				
130	1.12.1 Setup	16 days	4/13/98	5/4/98																																				
135	1.12.2 PSL Installation	50 days	9/8/98	11/16/98																																				
144	1.13 IO Installation & MC Lock	192.95 days	7/22/98	4/28/99																																				
145	1.13.1 IO Deliveries	77 days	7/22/98	11/9/98																																				
152	1.13.2 Install Input Optics (IO)	74.95 days	10/6/98	1/27/99																																				
163	1.13.3 IO ISC Table Installation (IOT7)	91.95 days	10/9/98	2/24/99																																				
168	1.13.4 Input Optics Commissioning	165.95 days	8/28/98	4/28/99																																				
180	1.14 SUS Assembly	229 days	4/15/98	3/15/99																																				
181	1.14.1 SUS/COC Deliveries	209 days	4/15/98	2/16/99																																				
204	1.14.2 SUSPEND Small Optics	75 days	8/10/98	11/23/98																																				
210	1.14.3 SUSPEND MMT3	72 days	9/1/98	12/14/98																																				
216	1.14.4 SUSPEND Recycling Mirror (RM)	21 days	11/30/98	1/4/99																																				
221	1.14.5 SUSPEND Fold Mirror Y (FM-Y)	21 days	12/28/98	1/27/99																																				
226	1.14.6 SUSPEND Fold Mirror X (FM-X)	29 days	12/11/98	1/27/99																																				
231	1.14.7 SUSPEND Inner Test Mass-Y (ITM-Y)	29 days	1/5/99	2/12/99																																				
236	1.14.8 SUSPEND Beam Splitter (BS)	34 days	12/10/98	2/2/99																																				

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					J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A												
241	1.14.9 SUSPEND Inner Test Mass X (ITM-X)	20 days	1/28/99	2/24/99							◊																															
246	1.14.10 SUSPEND End Test Mass Y (ETM-Y)	29 days	2/3/99	3/15/99							◊																															
251	1.14.11 SUSPEND End Test Mass X-Arm (ETM-X)	29 days	2/3/99	3/15/99							◊																															
257	1.15 Install RM & MMT3	137.25 days	8/7/98	2/26/99	█							◊																														
290	1.16 SEI/BSC Phase 2&3 Installation	183.2 days	8/27/98	5/21/99	█							◊																														
359	1.17 Install & Align CO	123.9 days	10/6/98	4/6/99																																						
420	1.18 INSTALL COS	115.9 days	1/4/99	6/15/99																																						
485	1.19 ISC Installation	80.9 days	3/15/99	7/7/99																																						
508	1.20 Vertex Michelson Shakedown	70 days	7/7/99	10/14/99																																						
510	1.20.2 Align/Lock Vertex Michelson	4 wks	7/7/99	8/4/99																																						
512	1.20.4 Characterize Vertex Michelson	10 wks	8/4/99	10/14/99																																						
516	2 LIGO 2k PRM with F-P Arms	423.9 days	12/28/98	8/24/00																																						
517	2.1 Install Detector in X-Arm Mid-Station	147.2 days	12/28/98	7/27/99																																						
554	2.2 Install Detector in Y-Arm Mid-Station	178.2 days	1/11/99	9/21/99																																						
589	2.3 Shakedown 2k PRM w/ F-P Arms	220 days	10/14/99	8/24/00																																						
591	2.3.2 Align/Lock 2k IFO	16 wks	10/14/99	2/10/00																																						
593	2.3.4 Characterize 2k IFO	28 wks	2/10/00	8/24/00																																						

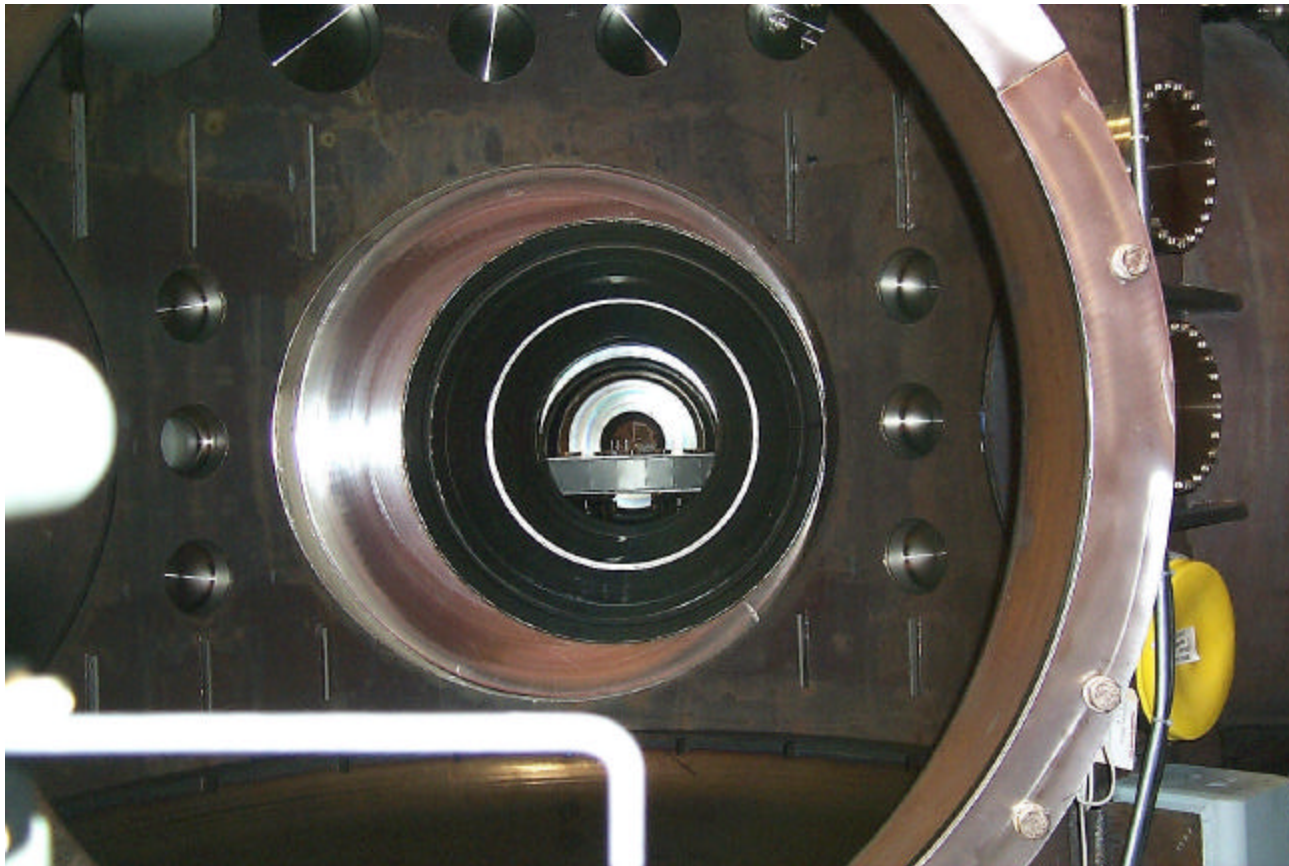
Hanford Aerial View



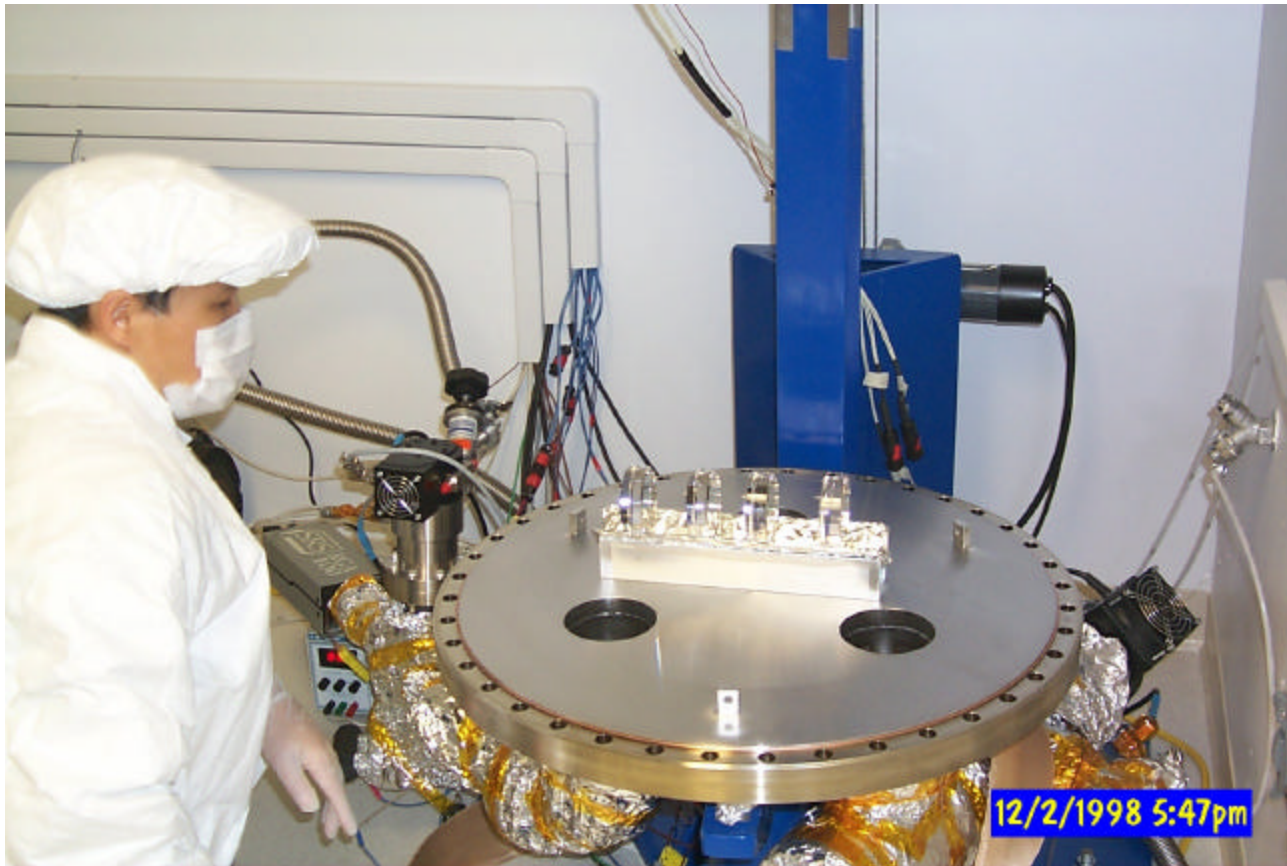
Installation Getting Off the Ground



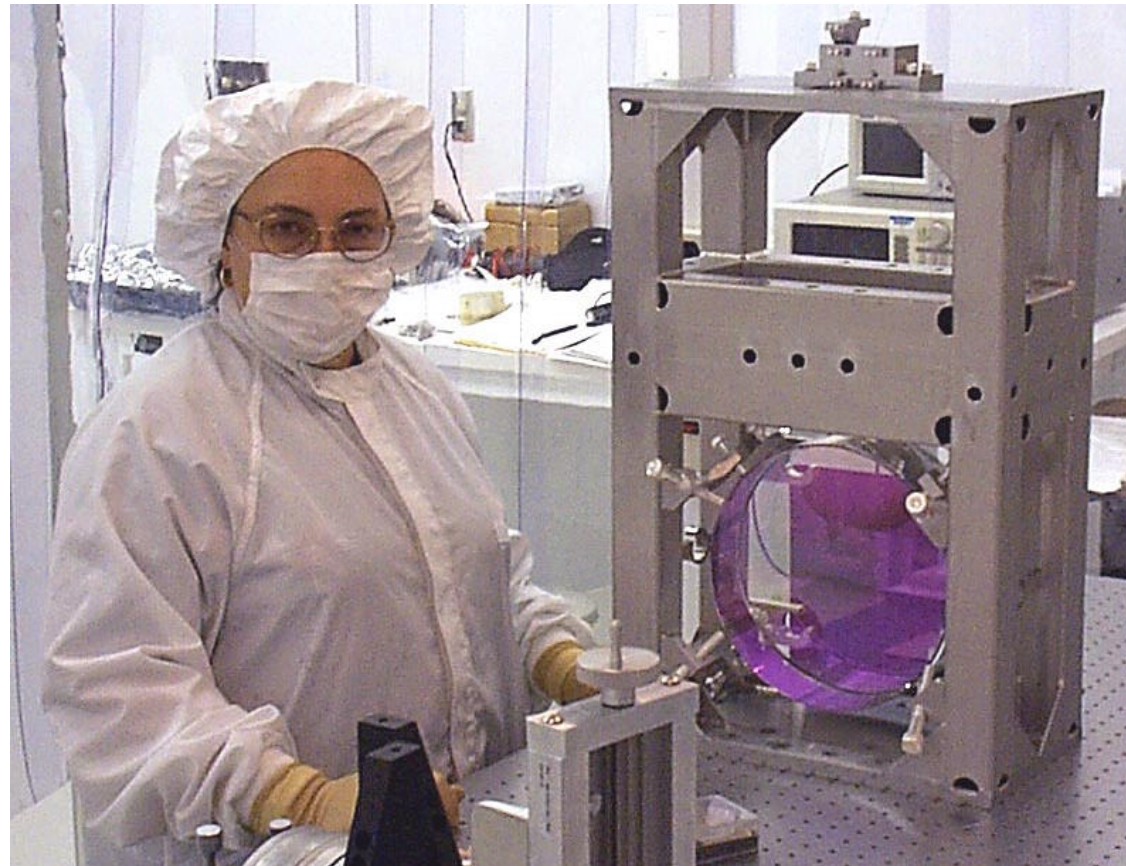
From the Input Test Mass to the Mode Cleaner



Baking IO Optics



Large Optics Preparation



Trial Installation of MMT3 Large Optic



MMT3 Leveling in HAM 7



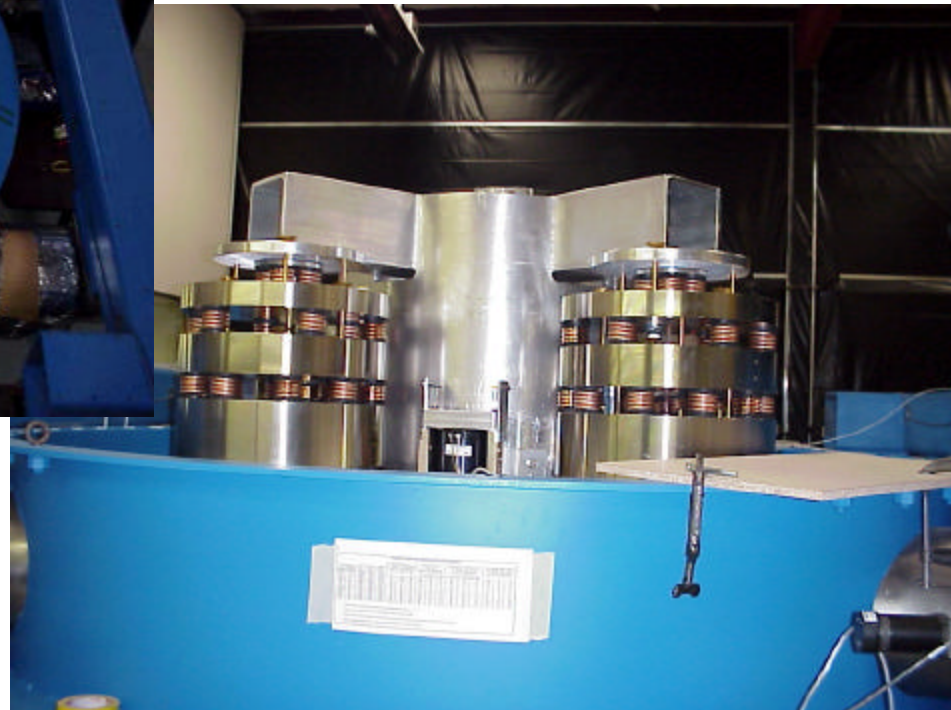
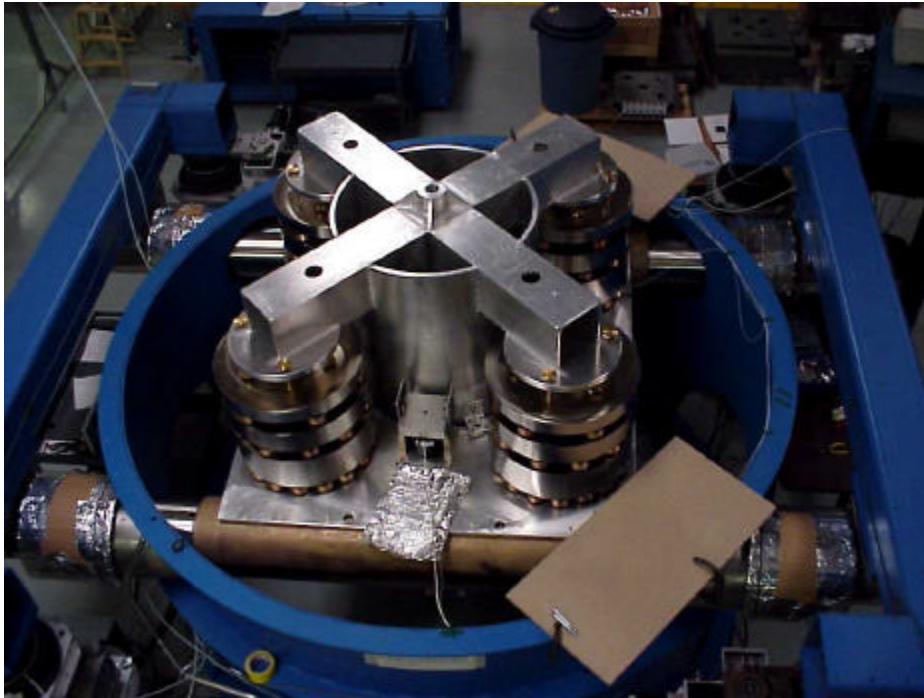
David Adjusting Recycling Mirror Alignment



Installing the BSC8 Downtube



BSC Stack Assembly in HYTEC 1st Article



LIGO Livingston Observatory



Livingston Facilities Complete



Livingston Preparing For Seismic Installation



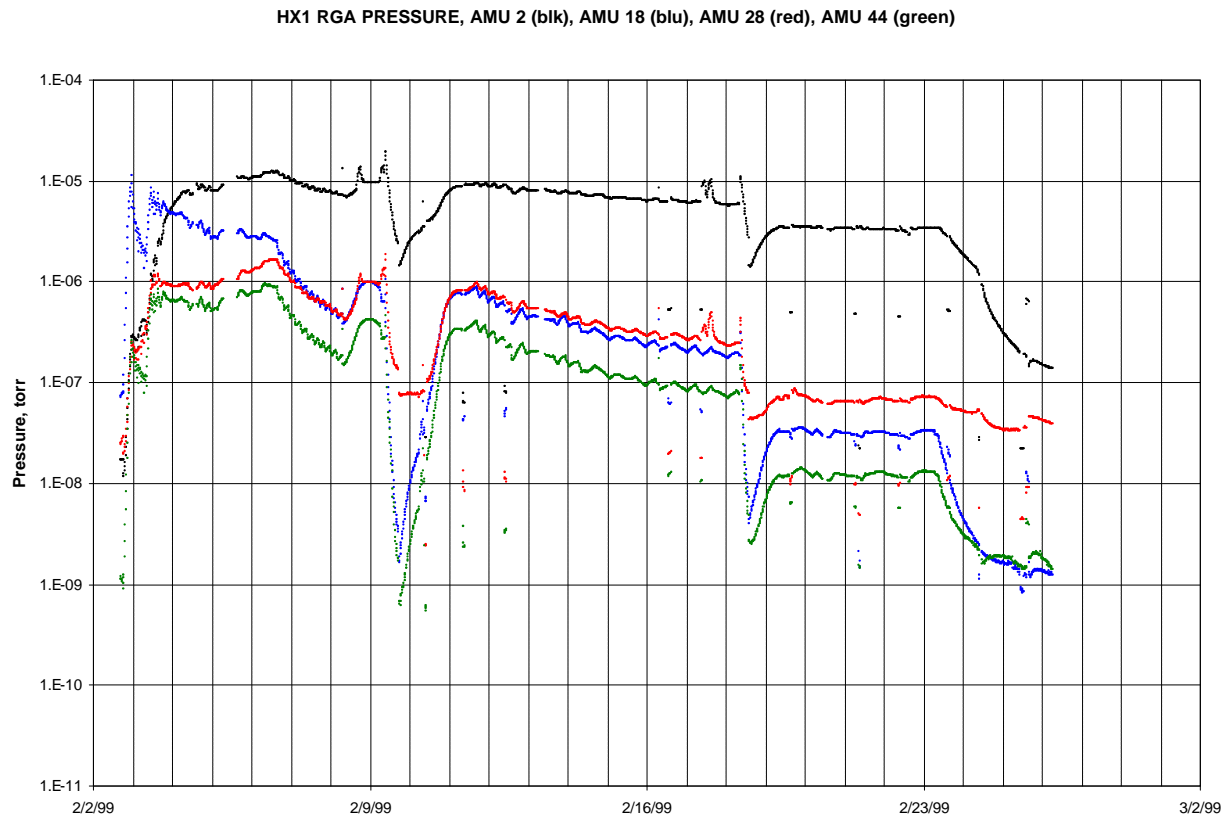
Bakeout of Hanford 2 Kilometer Beam Tube Module X1



Mobile Beam Tube Bakeout Power Supplies

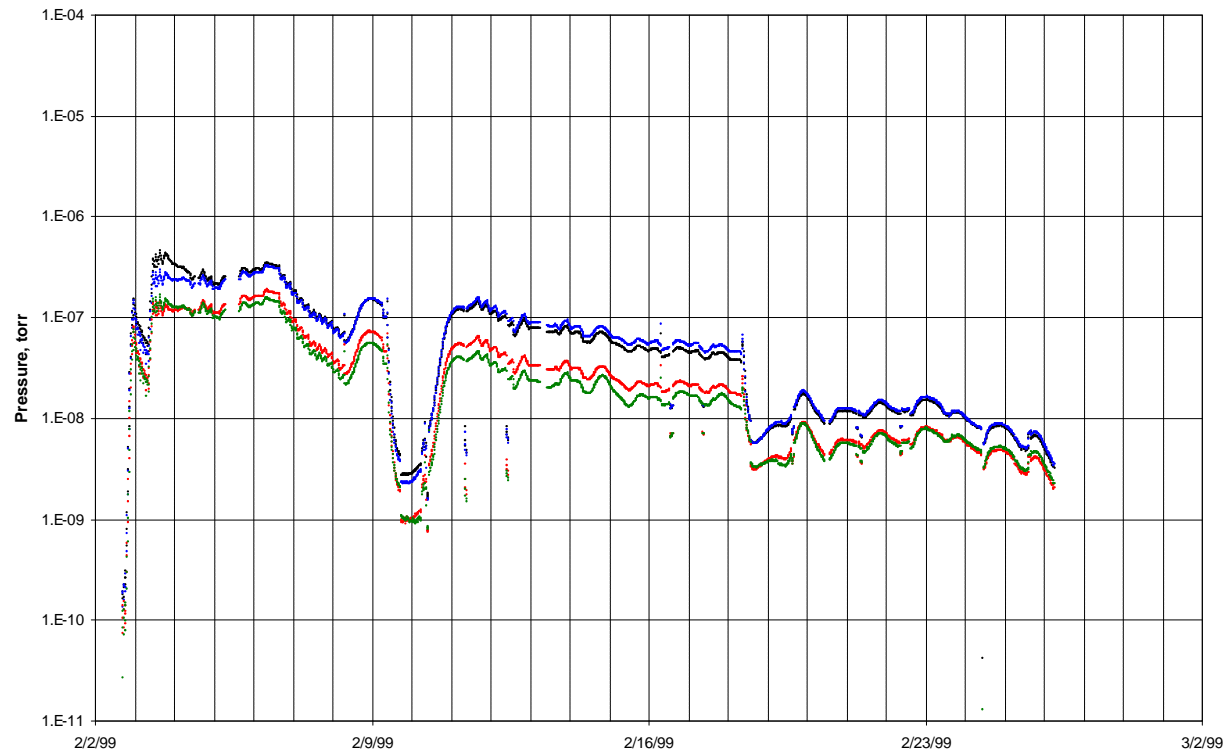


RGA Plot From X1 (2/26/99) of LOW AMU



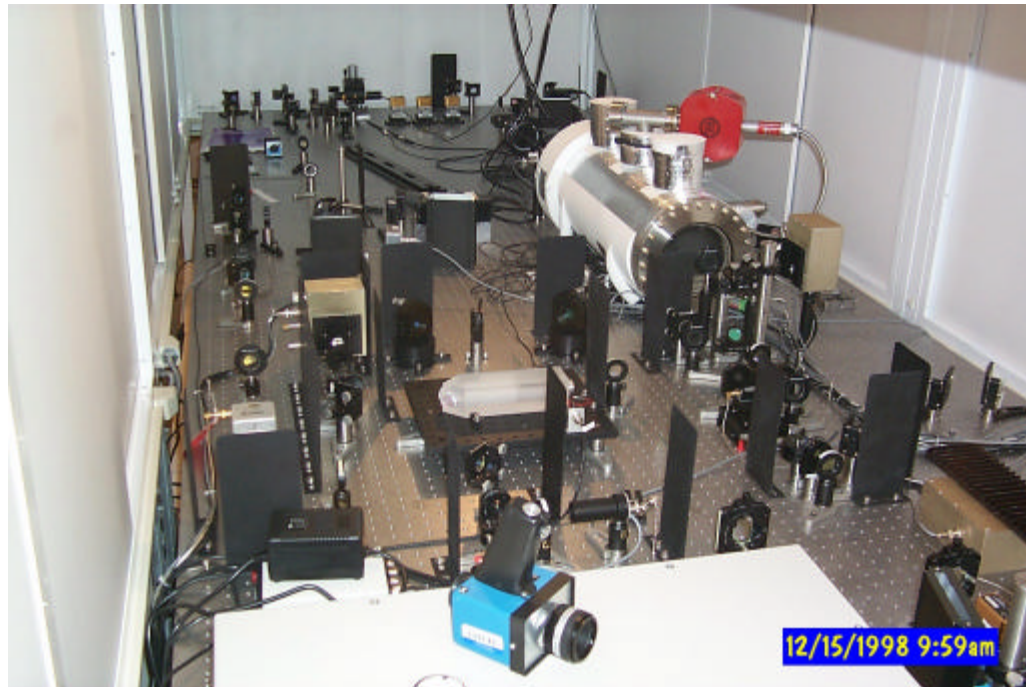
... and High AMU

HX1 RGA PRESSURE, AMU 41 (blk), AMU 43 (blu), AMU 55 (red), AMU 57 (green)



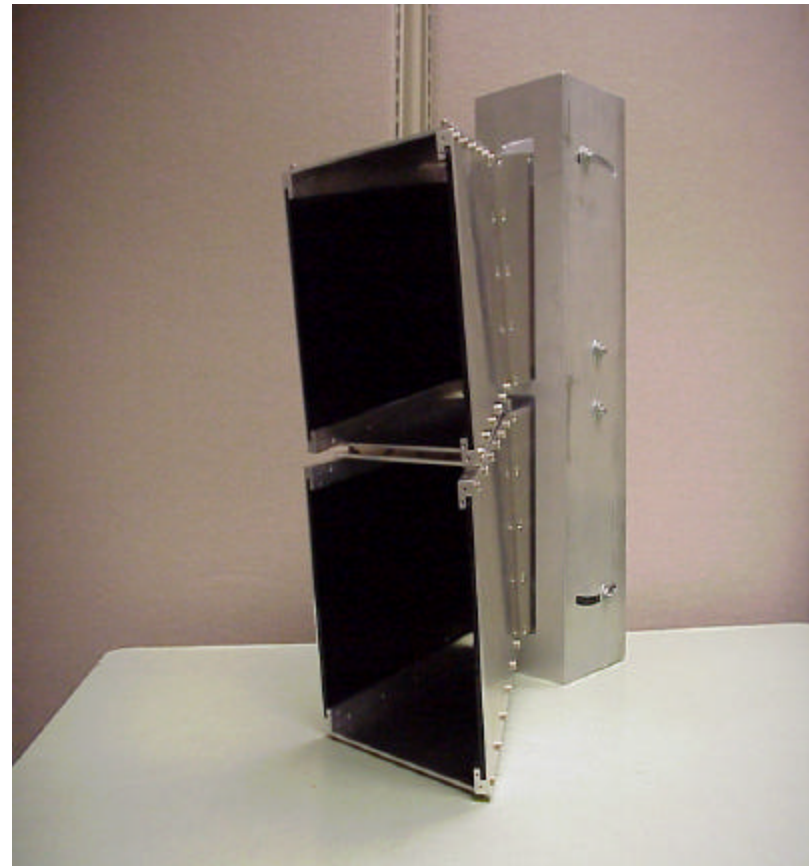
Detector Subsystems

- Prestabilized Laser
 - » Hanford 2 km IFO PSL installed and meets requirements
 - In use by Input Optics group
 - Has run for weeks at a time
 - » Next PSL being assembled at Caltech April delivery to Livingston



Detector Subsystems (cont'd)

- Input Optics
 - » Univ. of Florida team actively installing in Hanford PSL enclosure and in 2 km IFO vacuum system
 - MMT3 large optic installed in HAM7
 - mode cleaner, small optics and in-air installation in progress
- Core Optics Support
 - » First baffles installed in Hanford IO vacuum chambers



Detector Subsystems (cont'd)

- Seismic Isolation

- » Isolation systems installed in three HAM chambers at Hanford
 - First BSC Chamber system began installation at Hanford last week

- Suspensions

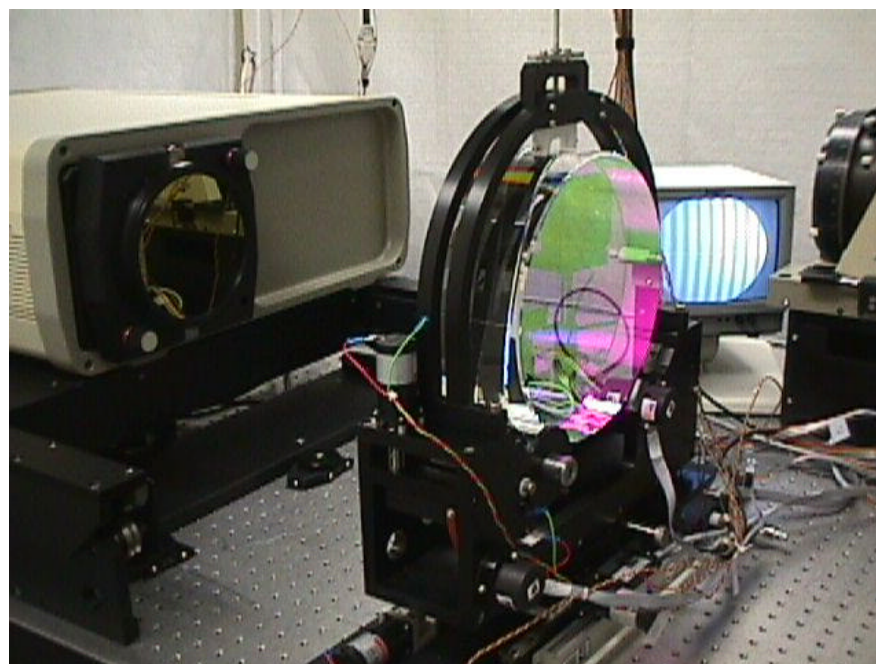
- » Large Optics and Small Optics Suspensions in production
 - Several installed in Hanford chambers



Detector Subsystems (cont'd)

- Core Optics

- » Recycling Mirror, Fold Mirror, Input Test Mass at Hanford with metrology complete
- » Metrology of coated optics continues at Caltech on Beam Splitter, Fold Mirror, Input Test Masses for second arm
- » Input Test Masses for 4 km interferometers in polishing and coating

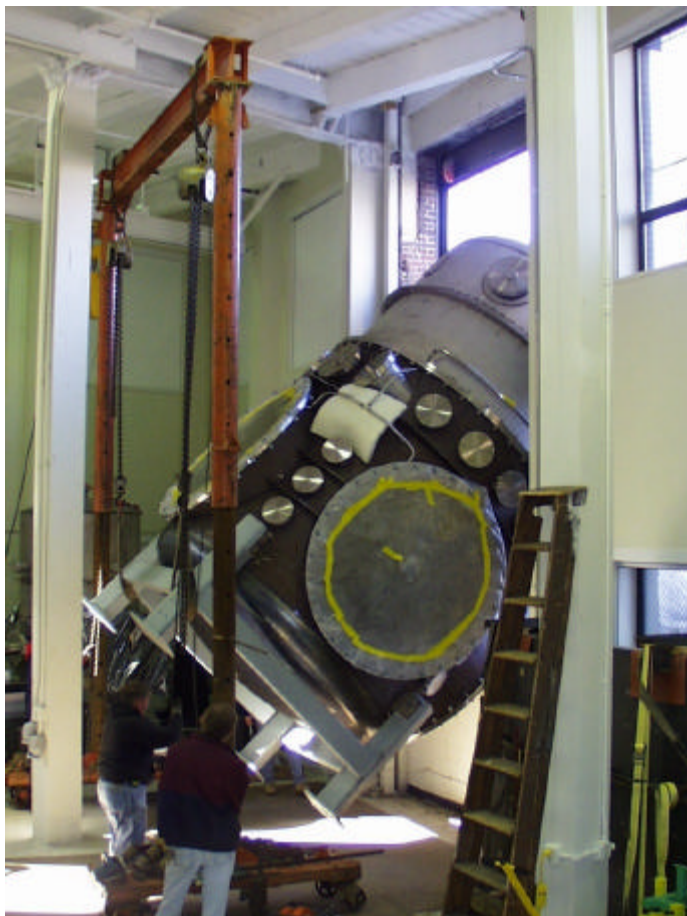


Detector Subsystems (cont'd)

- Alignment System
 - » First alignment tests performed by MIT and Hanford staff
 - » First elements of system operating
- ISC
 - » First sensing table installed at Hanford
- PEM
 - » RGA's, weather stations, microphones, magnetometers, shakers, tilt meters, accelerometers in use at Hanford and Livingston
- GDS
 - » Viewing tools, diagnostics tools, data monitoring tool in preparation for use quite soon



LASTI at MIT



LDAS and Simulation

- LDAS

- » LIGO-LSC technical information exchange meeting held 26 February at Caltech
- » Implementation
 - PDR to be held at Caltech week of March 8 1999
 - Software development proceeding as planned (more or less)
 - Planning to provide initial (Phase 1) LDAS availability to support vertex Michelson integrated tests

- Network

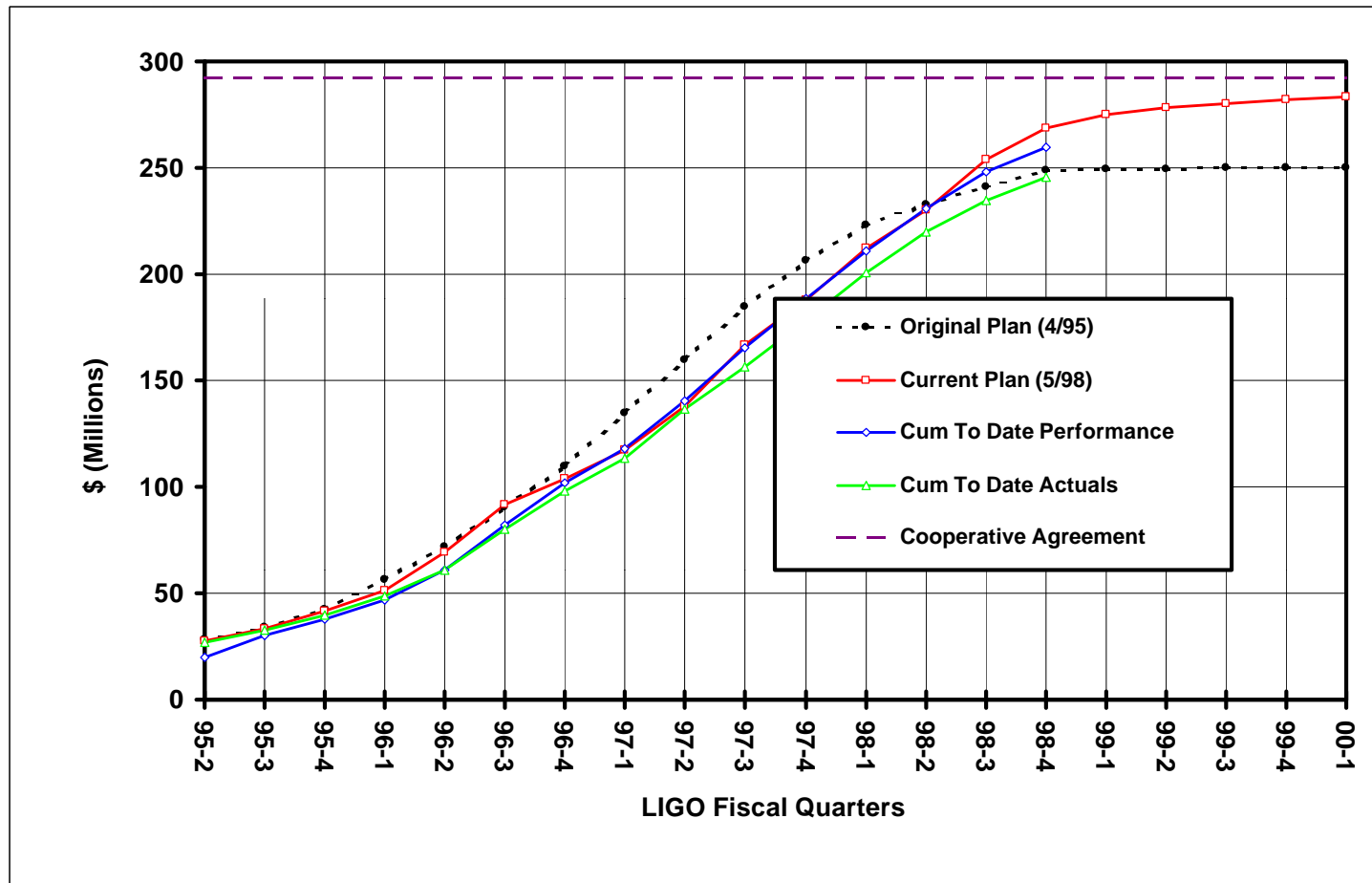
- » Met 22 Feb. with LSU/Bell South to discuss vBNS wide area network extension to Livingston Observatory
- » New options emerging at Hanford

- Simulation

- » First release of end-to-end model will be timed to support vertex Michelson integrated tests



End of FY1998 LIGO Project Status



LIGO Funding by NSF Task and By Year

1999 Level Restored

Fiscal Year	Construction	R&D	Operations	Advanced R&D	Total
Through 1994	35.9	11.2			47.1
1995	85	4			89
1996	70	2.4			72.4
1997	55	1.6	0.3	0.8	57.7
1998	26	0.9	7.3	1.6	35.8
1999	0.2		20.9	2.5	22.5
2000			21.1	2.6	23.7
2001			19.1 (10 months)	2.7	22.9
Total	272.1	20	68.7	10.2	371.1



Operations Funding Level Restored

- At time of last LSC meeting, internal NSF Budget for FY1999 did not support the Cooperative Agreement level of \$20.9 million providing only \$19.8 million
- LIGO Laboratory provided Impact Statement to NSF
 - » delay of 6 - 8 months in completion of third interferometer
 - » stretchout of 40 Meter Interferometer refit for signal-tuned configuration research (LSC meeting made a difference!)
- NSF restored funding level
- LIGO Laboratory has now organized an effort to refit 40 Meter
- IFO installation schedule is restored



Other Issues of Interest to LSC

- Livingston access road
- Livingston bullet damage to buildings
- Control of chemicals at sites
- Laser safety
- Control of lasers brought to sites
- Funding support to build LSC collaboration
- Increased support by LIGO Laboratory in supporting the MOU/Attachment process
- LIGO II baseline cost estimate ?



Livingston Observatory Entrance Road Condition



Livingston Bullet Incident



Roads and Bullets

- Livingston access road is currently a construction road
 - » Departure of construction contractors, road maintenance dropped
 - » State is completing top level of road now
 - “speed of light is slower in Louisiana” - State Highway official
 - » Design is expected to be inadequate
 - » NSF and LIGO are in discussion about possible road improvement
- 10 - 15 bullet holes in end station building
 - » 9 on one weekend believed to be a single incident
 - » local sheriff, FBI, NSF IG have looked at situation
 - » LIGO Lab now planning strengthened security patrol and possible “hardening” of buildings
- Community relations important !



Contamination and Laser Safety

- Control of chemicals at sites

- » All chemicals and clean room materials at sites are governed by an approved list
- » Do not bring chemicals or cleaning materials to sites without coordinating with site management PRIOR to arrival
 - Our isopropyl alcohol is not “rubbing” alcohol with lanolin

- Laser safety

- » laser eye exams, laser goggles of approved type are required
 - Hanford LVEA is now in **laser hazard** mode at times

- Control of lasers brought to sites

- » ALL lasers brought to sites must be approved by site representative
- » All red beams should be 5 mw or less! Or review required
- » All class IIIB and above lasers require written and approved SOP's



Building an LSC: Funding

- As a community we must get smarter about writing proposals
- NSF structure and process driven strictly by expert review
- This continues to make it difficult for entrance of new groups and recognition of “apprenticeship” and future promise
- Overlap with LIGO installation continues to be an issue



MOU/Attachment Process

- MOU's and Attachments are how the LIGO Laboratory organizes its collaborative activities
 - » inside and beyond LSC
- These are key arrangements within the LSC
- We are “overwhelmed” by success in growth of collaborative activities
- LIGO Laboratory views the process that we have followed to date as “practice”, a learning experience
- We are adding support of this process by adding professional contractual support and eventual Web-based interactivity



LIGO II Scope ?

- When are we ready to document a strawman LIGO II configuration, with well-defined options?
- LIGO Laboratory is ready to support the LSC in laying out a schedule and cost baseline
- NSF is already engaged in long term planning for construction of upgrades
- This meeting might consider this as we work towards revisions in White Paper



This Meeting

- R&D progress and discussion
- Data stream will appear this year
 - » Detector Characterization
 - » Astrophysical Signatures
 - » Validation/Detection Confidence
- New MOU's, Attachment revisions, Progress Reports
 - » Updated attachments from March '99 to August '99
- New members of LSC
- Action on Nomination Committee recommendations
- New funding proposals to NSF

