Overview of the LIGO Continuing Operations (FY2002 - FY2006) Proposal

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LIGO PAC9 Meeting

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LIGO Schedule at Very Top Level

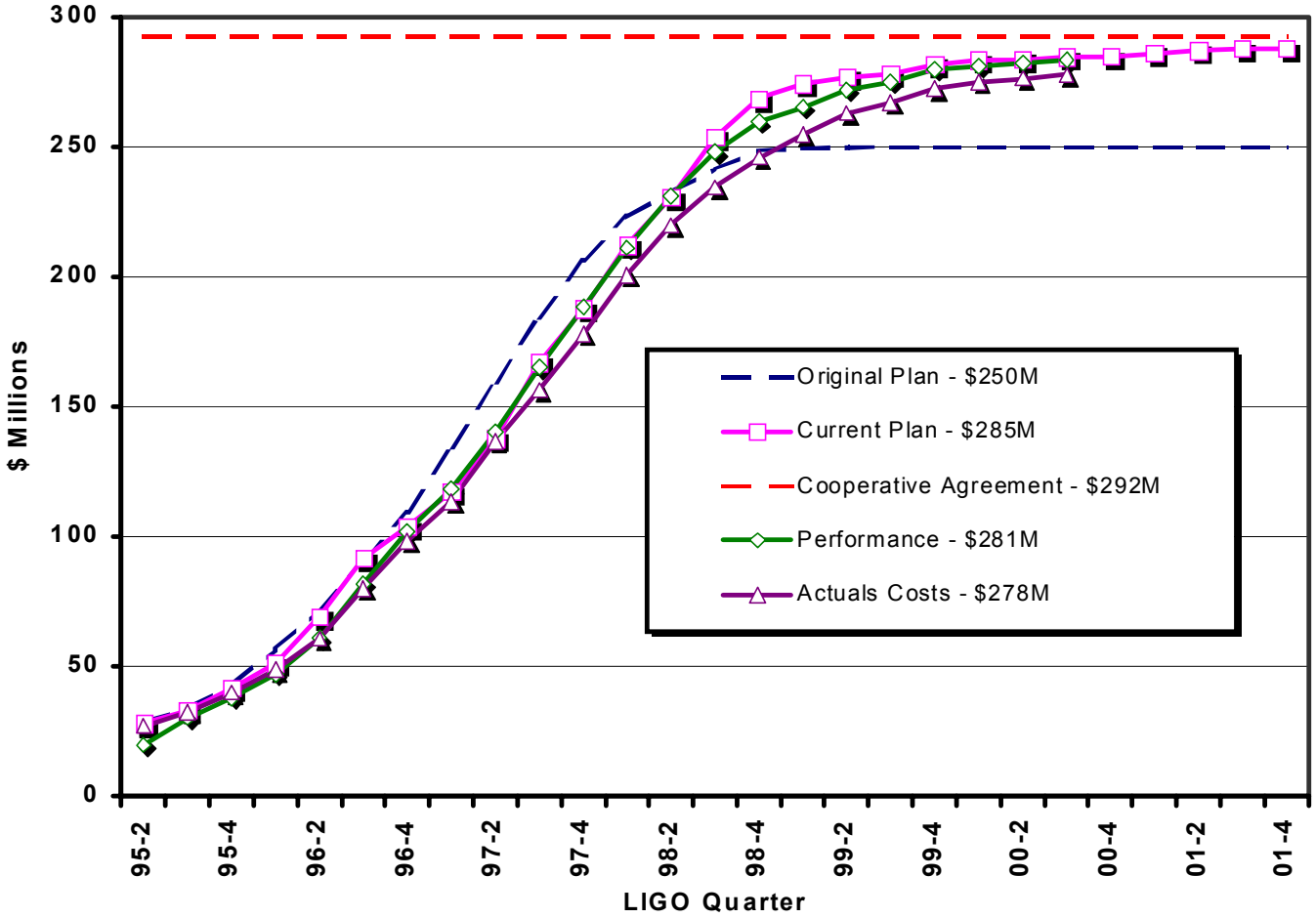
1996	Construction Underway
	» mostly civil
1997	Facility Construction
	» beam pipe and enclosure
1998	Construct Detectors
	» completion of vacuum systems
1999	Install Detectors
	» interferometers in vacuum
2000	Commission Detectors
	» first light in arms; subsystem testing
2001	Engineering Tests
	» sensitivity: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

LIGO Laboratory Funding To Date

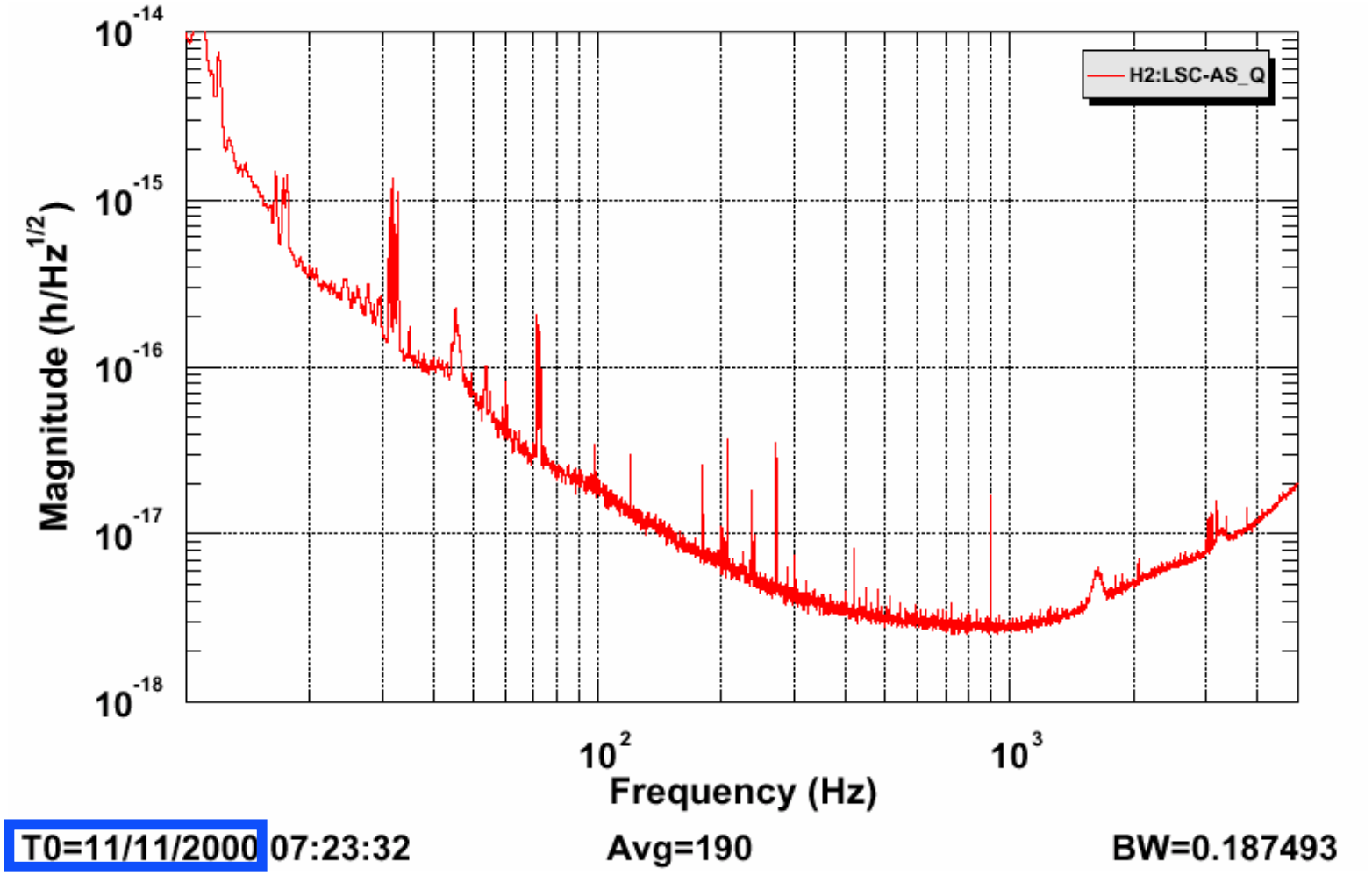
MRE

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

Construction Project Status



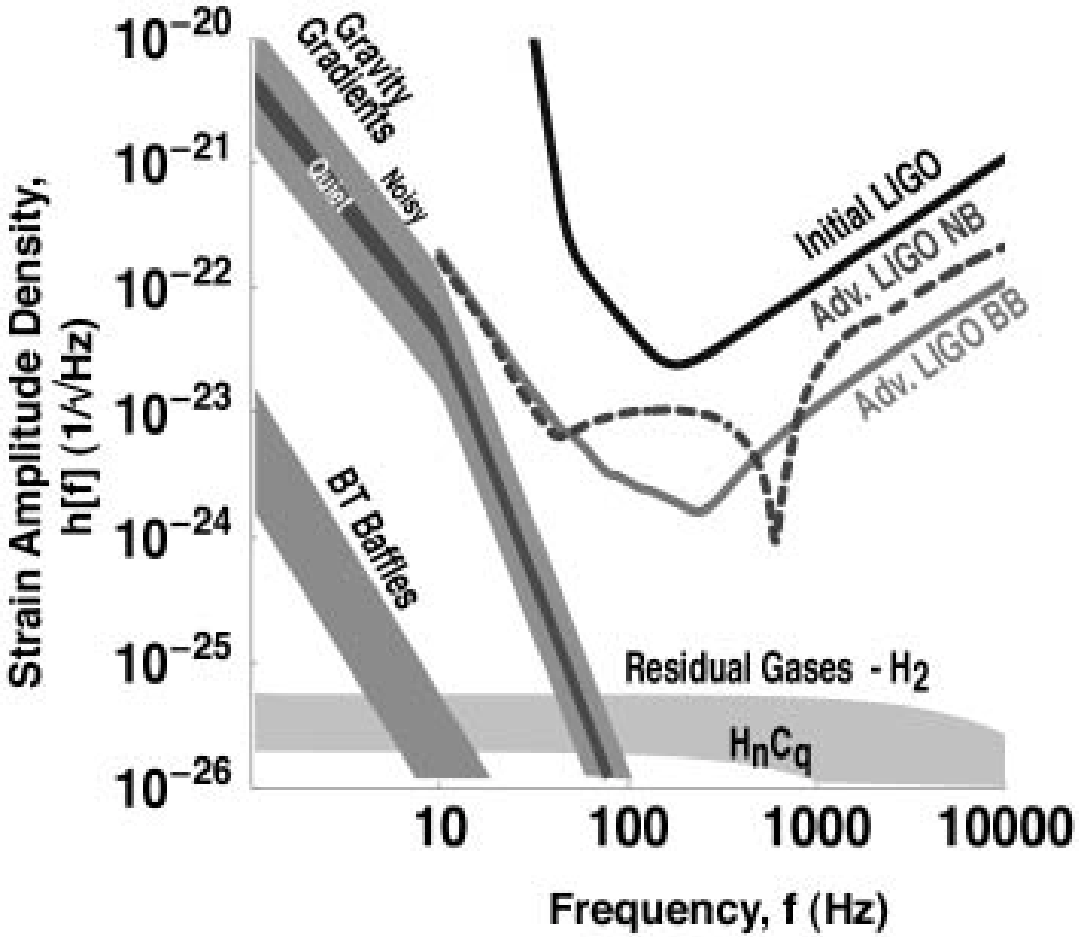
LHO 2 km Interferometer Strain Sensitivity in Recombined Mode



Results/Accomplishments

- Construction as planned nearly complete
- Installation/Commissioning well underway
- LSC formed and functioning
- LSC participating in first Engineering Runs
- Science working groups formed
- Observatory operations established at both sites
- LSC vision for future detectors is leading a vigorous development program
- International partnership/networking forming
- LIGO is source of industrial/community/education outreach

LIGO Facilities Support Detector Upgrades



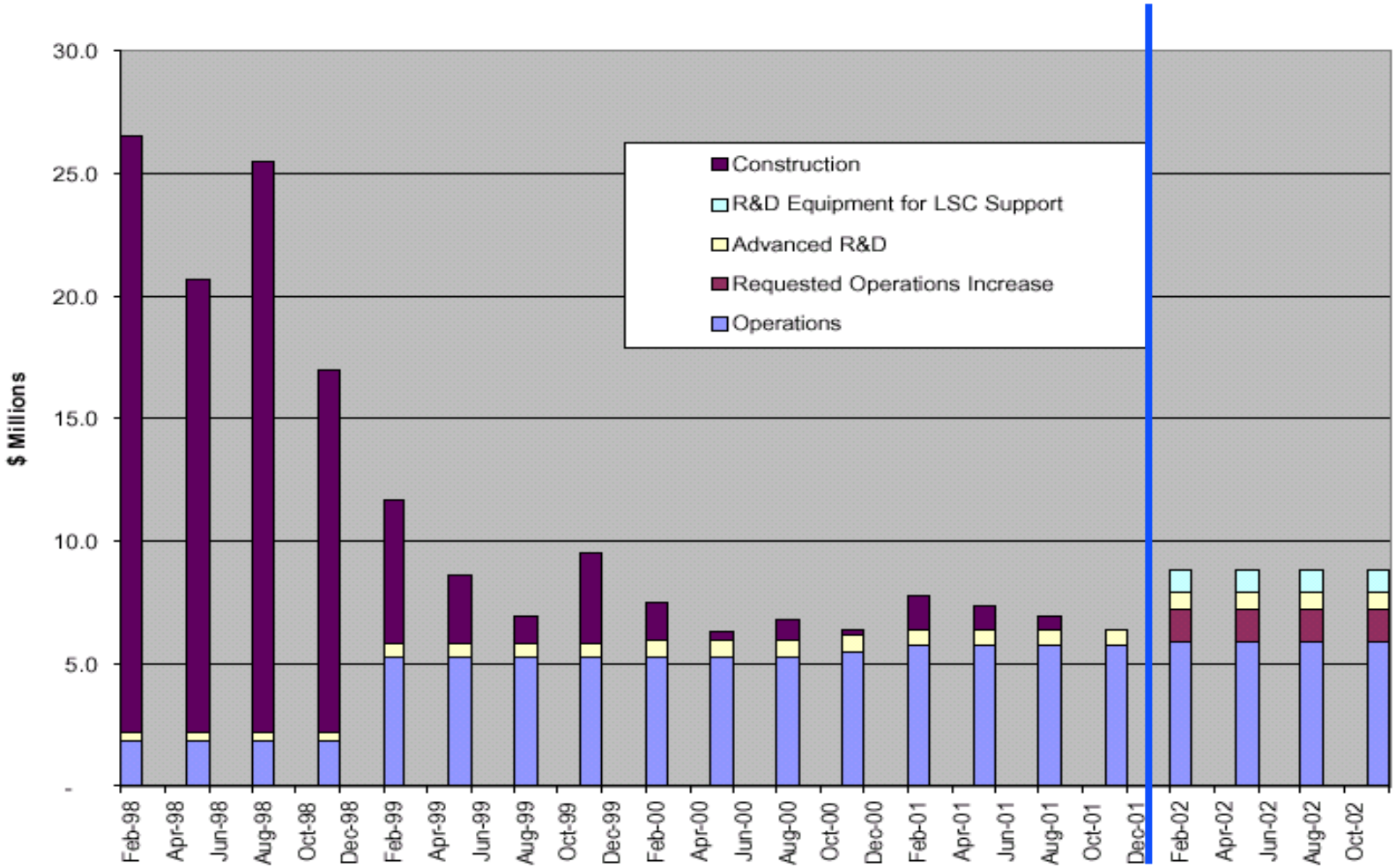
Program and Mission of the LIGO Laboratory

- observe gravitational wave sources;
- develop advanced detectors that approach and exploit the facility limits on interferometer performance;
- operate the LIGO facilities to support the national and international scientific community;
- and support scientific education and public outreach related to gravitational wave astronomy.

LIGO Proposes To:

- Complete commissioning of the initial LIGO interferometers;
- operate the LIGO interferometers for the initial LIGO Science Run;
- process and analyze the Science Run data and publish the results of the first scientific searches for gravitational wave sources;
- characterize and improve the sensitivity and availability of the operating interferometers;
- define interferometer upgrades and carry out a research and development program to underpin future upgrade proposals;
- support the development and research of the LIGO Scientific Collaboration;
- support the development of the international network of gravitational wave detectors;
- interpret the LIGO program to the public;
- leverage LIGO in educational settings;
- and address new industrial technologies and applications stimulated by the requirements of gravitational wave observation.

LIGO Funding Evolution and Proposal Request



Proposal Request

	FY 2002 $M	FY 2003 $M	FY 2004 $M	FY 2005 $M	FY 2006 $M	Total $M
Currently Funded Operations	23.63	24.32	25.05	25.87	26.65	125.52
Increase for Full Operations	5.21	5.20	4.79	4.86	4.95	25.01
Advanced R&D	2.77	2.86	2.95	3.04	3.13	14.76
R&D Equipment in Support of LSC Research	3.30	3.84	3.14			10.28
Total Budgets	**34.91**	**36.21**	**35.93**	**33.77**	**34.74**	**175.57**

Increased Operations Tasks at the Observatories

• Additional LIGO Scientific Collaboration (LSC) support at the sites. Visitor activity at the sites has increased dramatically during the Engineering runs.	$254,678
• Additional staffing and stipends to support Outreach Programs at the sites.	$249,848
• Additional staff for site Operations. This includes two FTEs at each of the sites to support seven day-per-week, twenty-four hour per day Operation of the interferometers with adequate coverage consistent with experience to date and the recommendations of our safety review panels. In addition three site FTEs are for LDAS and CDS maintenance, and two partial Post Doctoral positions are proposed in partnership with the University of Florida and Southern Louisiana University.	$558,485

Increased Hardware Costs

• Fast network connections (WAN OC3) as recommended by an NSF review panel.	$540,500
• Annual equipment maintenance and replacement. LIGO is installing nearly $4 million of computing equipment for LIGO Data Analysis and Computing. The estimate assumes a 25 percent replacement rate per year plus overhead. The missing budget was recommended by an NSF review panel.	$1,378,728
• Annual replacement and maintenance of the control room data acquisition and control hardware plus overhead. The estimated value of the computer and network infrastructure at both sites is $3 million (10 percent maintenance and replacement costs). The estimated value of the custom electronics and embedded computers is also $3 million (5 percent maintenance and replacement costs).	$513,800

R&D

- Most work supports Advanced LIGO realization
- Some far reaching research
- All work highly collaborative
- Lab coordinates program through LSC
  - » full cost/schedule planning in use
  - » monthly telecons with each working group
- Engineering and some senior effort supported from Lab Operations
- Big ticket equipment items for LSC program in Lab proposal

LIGO Increased Staffing to Support R&D and Modeling

• Increased staff in the Technical and Engineering Support and Detector Support Groups. The Caltech campus-based support to the observatories declines significantly after the Detector is commissioned. However, the increase for the R&D for an advanced LIGO (planned for installation in 2005-2006) is significant and results in a net increase.	$920,868
• Increment for engineering and technician labor (4 FTEs) at Livingston to support the LSC science team responsible for Seismic Isolation development. This effort is for two years only and is non-recurring.	$506,300
• Increased support staff for Modeling and Simulation Group. The increase was suggested by an NSF Review panel.	$282,485

R&D Effort

• Stochastic Noise. LASTI integrated system tests of the advanced seismic isolation and suspension prototypes.	$275,222
• Thermal Noise Interferometer. Direct measurement of test mass thermal noise for initial and advanced LIGO designs.	$176,697
• Advanced Core Optics including Sapphire Optics	$283,937
• Advanced Interferometer Sensing and Control including Photodetector Development	$298,779
• Stiff Seismic Isolation System Development	$46,353
• Auxiliary Optics Systems including Active Thermal Control	$366,088
• Advanced Suspensions including Fiber Research.	$208,725
• Improved Low Frequency Strain Sensitivity.	$345,637
• 40-Meter Advanced R&D. Tests of controls and electronics for a signal and power recycled configuration with the read-out scheme and control topology intended for advanced LIGO.	$235,075
• Advanced Controls & System Identification. Research on application of advanced system identification and control concepts to LIGO.	$188,677
• Advanced (highly stabilized) Input Optics Systems.	$347,423

R&D Equipment in Support of LSC Research Program

- Equipment costs for the development of advanced seismic isolation prototypes.
- Equipment costs for the development of multiple pendulum, fused silica fiber suspension prototypes.
- Materials and manufacturing subcontracts to support the development of sapphire test masses and high Q test mass materials and coatings research.
- Investment and non-recurring engineering costs for a large coating chamber and its commissioning.

Isolation Research

(STO, SUS, TNI, SEI)

FY02

Staff	Org	Adv. R&D (FTE)	LSC Support R&D	Operations (FTE)		
ISOLATION						
Sci & PD	MIT	1	0	2.4	3.4	8.1
	CIT	3	0	1.7	4.7	
UG & Grads	MIT	3	0	0	3	5
	CIT	2	0	0	2	
Eng & Techs	MIT	0	0	2.75	2.75	13.15
	CIT	0	0	6.9	6.9	
	LLO	0	0	3.5	3.5	
Totals (FTE):		9	0	17.25	**26.25**	
Equip. & Supplies ($K)		$57	$1,535	$0	**$1,592**	

N.B.: Does not include LSC research staff.

Lasers & Optics Research

(LAS, OPT, IOS, AOS)

FY02

Staff	Org	Adv. R&D (FTE)	LSC Support R&D	Operations (FTE)		
LASERS & OPTICS						
Sci & PD	MIT	0	0	0.08	0.08	4.33
	CIT	2	0	2.25	4.25	
UG & Grads	MIT	1	0	0	1	3
	CIT	2	0	0	2	
Eng & Techs	MIT	0	0	0	0	2
	CIT	0.5	0	1.5	2	
Totals (FTE):		5.5	0	3.83	**9.33**	
Equip. & Supplies ($K)		$800	$1,687	$0	**$2,487**	

N.B.: Does not include LSC research staff.

LIGO Advanced Interferometer Systems, Sensing & Control (ISC, 40m, SID, SYS)

FY02

Staff	Org	Adv. R&D (FTE)	LSC Support R&D	Operations (FTE)		
Advanced Interferometer Systems, Sensing & Control (ISC)						
Sci & PD	MIT	0	0	1.67	1.67	6.87
	CIT	2	0	3.2	5.2	
UG & Grads	MIT	1	0	1	2	5
	CIT	3	0	0	3	
Eng & Techs	MIT	0	0	0.75	0.75	10.23
	CIT	0	0	9.48	9.48	
Totals (FTE):		6	0	16.1	**22.1**	
Equip. & Supplies ($K)		$275	$0	$0	**$275**	

Total LIGO Laboratory R&D

FY02

Staff	Org	Adv. R&D (FTE)	LSC Support R&D	Operations (FTE)	Totals (FTE, $K)	
TOTAL for R&D						
Sci & PD	MIT	1	0	4.15	5.15	21.3
	CIT	9	0	7.15	16.15	
UG & Grads	MIT	5	0	1	6	14
	CIT	8	0	0	8	
Eng & Techs	MIT	0	0	3.5	3.5	25.63
	CIT	0.5	0	18.13	18.63	
	LLO	0	0	3.5	3.5	
Totals (FTE):		23.5	0	37.43	**60.93**	
Equip. & Supplies		$1,202	$3,222	$0	**$4,424**	
				MIT	14.65	
				CIT	42.78	
				LLO	3.5	