



LIGO Laboratory Operations

Plan for the Data Analysis & Computing Group

NSF Review of the LIGO Operations Proposal for FY2002 - 2006

*LIGO Hanford Observatory
Hanford, Washington
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Outline

- Data analysis & computing group organization, functions
- Staffing
- Budgets



Data and Computing Group Roles

- Throughout Engineering & Science Runs, the Laboratory's Data Analysis & Computing Group fulfills the following roles:
 - » LIGO science, data analysis: scientific staff are actively engaged in the astrophysics searches
 - » Simulation & Modeling: detector support, data analysis
 - » Continuous management and movement of large volumes of data
 - » Maintaining pipeline analyses running, archive running
 - » Software maintenance/improvements/enhancements
 - » LSC support, visitors
 - » LIGO Laboratory-wide IT support



Data and Computing Group: Organization

- Three subgroups:
 - » LIGO Data Analysis System Group (LDAS)
 - » Modeling and Simulation Group
 - » General Computing Group (IT support)



Data & Computing Group Activities

Example LIGO Data Analysis System Group Activities

- Early upper limit searches
 - » Acquire, archive, process data from early engineering runs to set observational upper limits on gravitational wave source rates and strengths, etc.
 - » Complete software environment for pipeline analyses through mock data challenges (MDCs) jointly within LSC
- LIGO I Science Run astrophysical searches
 - » Data analysis will become a key “business” of the Laboratory across all sites
 - Participation by LIGO scientists in astrophysical searches through the LSC, including use of multiple interferometer data streams (detector network)
 - Database, archive use & maintenance
 - Pipeline analysis SW and HW maintenance
 - Continued R&D into algorithms, new technologies

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LIGO Data Analysis & Computing Group

LDAS FTE allocation for activities during operations

		<i>LDAS Staffing Plan</i>						
Personnel	FTE	LIGO Science Run; Algorithm Perf. Mon	LIGO Science Run; HW Perf. Mon	LIGO Science Run; Data Archival	LIGO Science Run; Data Analysis & Research	Operations: DB Mgmt	Operations: Sys. Admin	SW Dev & Maint.
Graduate Student	2				2			
Postdoctoral Scholar	3	0.45	0.33	0.25	1.97			
Sci.	3.8	1.38	0.2	0.45	1.24			0.53
Sw. Eng	3.8	1.42						2.38
<i>Contract SW Eng.</i>	<i>1</i>							<i>1</i>
<i>Contract DB Admin</i>	<i>1</i>			<i>0.5</i>		<i>0.5</i>		
<i>Contract HPSS Admin</i>	<i>1</i>			<i>0.5</i>			<i>0.5</i>	
<i>Contract LDAS-SysAdmin</i>	<i>1</i>						<i>1</i>	
<i>CIT Totals -></i>	<i>16.6</i>	<i>3.25</i>	<i>0.53</i>	<i>1.7</i>	<i>5.21</i>	<i>0.5</i>	<i>1.5</i>	<i>3.91</i>
Caltech Personnel Classifications	Students				2			
	Postdoctoral	0.45	0.33	0.25	1.97			
	Scientists	1.38	0.2	0.45	1.24			0.53
	SW Eng.	1.42						3.38
	SysAdmin			1		0.5	1.5	
LHO Sci*	1	0.2	0.2	0.2	0.2		0.2	
LLO Sci*	1	0.2	0.2	0.2	0.2		0.2	
LHO Eng..*	1			0.5		0.2	0.3	
LLO Eng..*	1			0.5		0.2	0.3	
LIGO Lab Totals ->	20.6	3.65	0.93	3.1	5.61	0.9	2.5	3.91

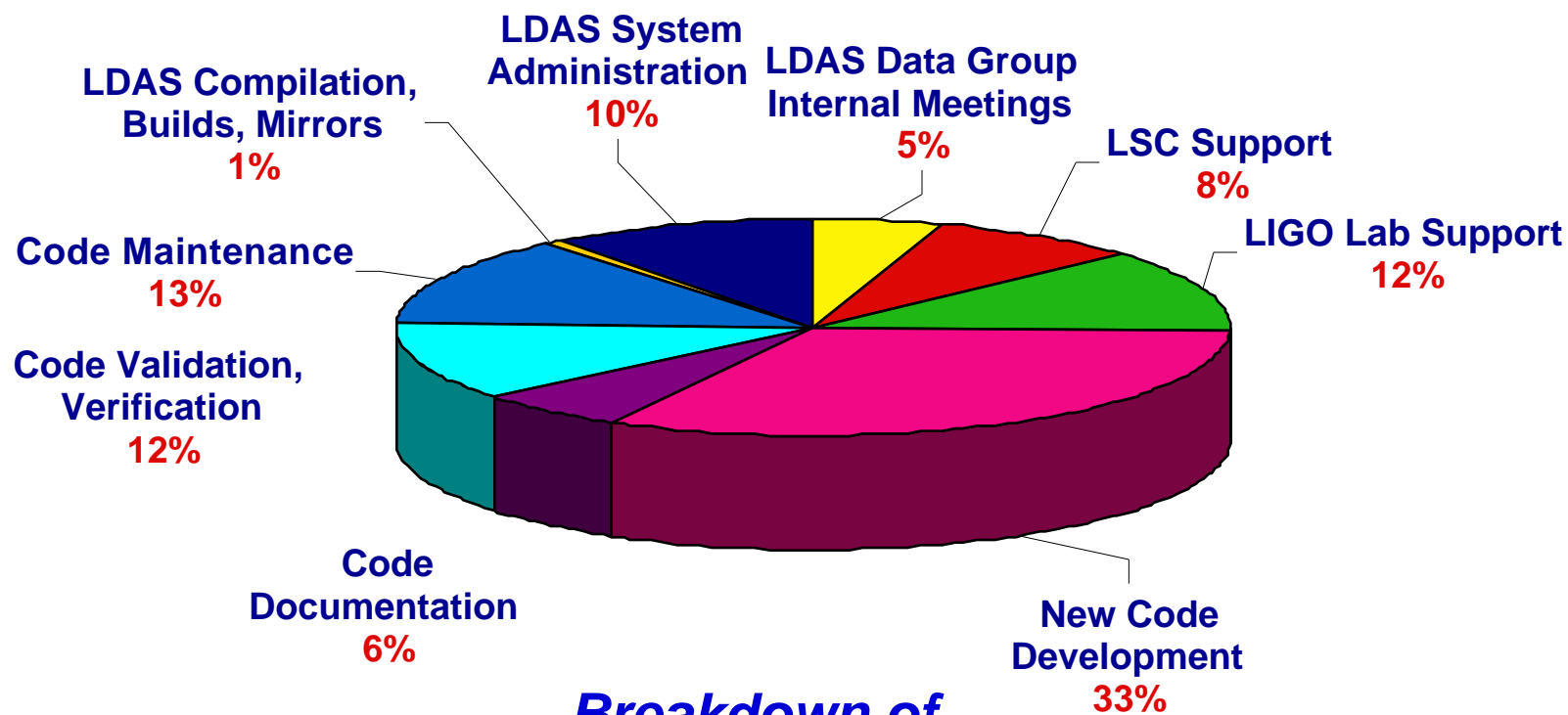
* NOTE: LHO and LLO personnel are in the budgetary proposals from the respective sites

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LDAS Operations

Statistics derived from historical data



***Breakdown of
LDAS Workforce Activities***



Data & Computing Group Activities

Example Modeling & Simulation Group Activities

- LSC science search participation
 - » Simulated data for data analysis, Monte Carlo simulation of detection efficiencies, etc.
- Commissioning support
 - » Provide realistic simulations to assist in improving interferometer performance up to and during science run
- Development of physics models
 - » Improvement of physical optics and mechanical systems models
- Code improvement & optimization
 - » Parallel computing, client-server model, etc
- Improvement of the User Interfaces
 - » Simplify the setting up of simulation sessions and viewing of results



Data Analysis & Computing Group

Modeling & Simulation FTE activities during operations

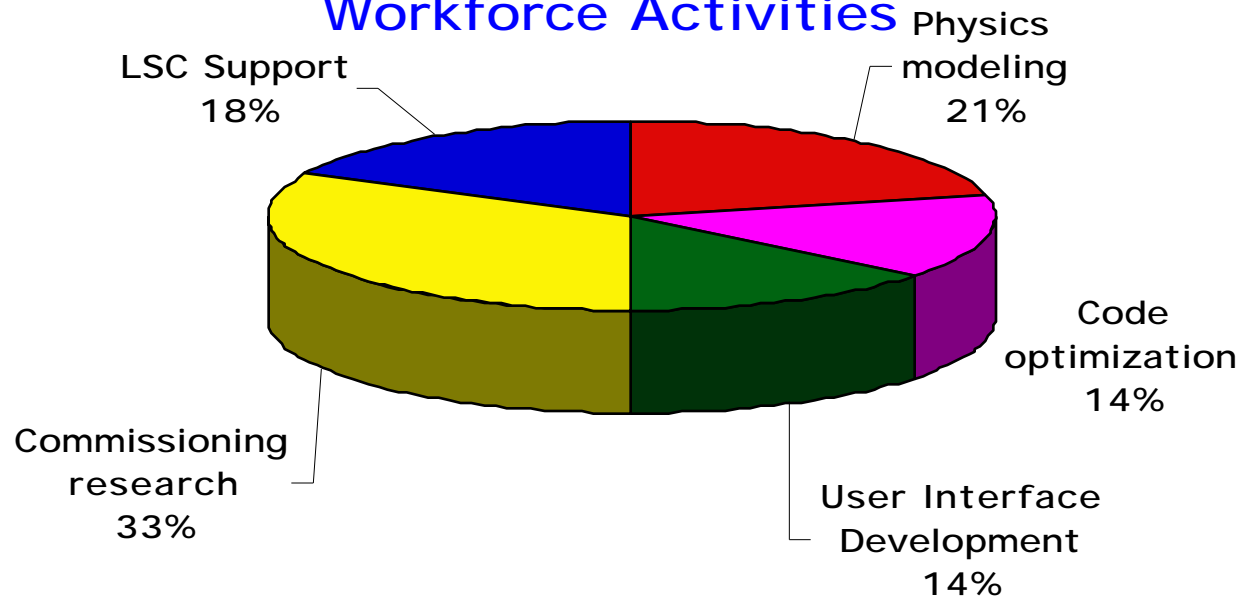
		<i>Modeling & Simulation Staffing Plan</i>					
Personnel	FTE	Code environ.		Code environ.		Detector Performance Modeling	Data Analysis Simulation
		Development: Architecture	Development: EM Fields, Optics	Development: Mechanical systems	Development: Code environ. GUI Develop.		
Graduate Student	2					1	1
Postdoctoral Scholar	1			0.5		0.5	
Sci.	2	0.25	0.75			0.75	0.25
Sw. Eng	1				1		
<i>Contract SW Eng.</i>	<i>1</i>	<i>0.75</i>		<i>0.25</i>			
<i>CIT Totals -></i>	7	1	0.75	0.75	1	2.25	1.25
Caltech Personnel Classifications	Students					1	1
	Postdoctoral			0.5		0.5	
	Scientists	0.25	0.75			0.75	0.25
	SW Eng.	0.75		0.25	1		



Modeling and Simulation Operations

Statistics derived from historical experience

Breakdown of Simulation & Modeli Workforce Activities





Data & Computing Group Activities

Example General Computing Group Activities

- System Administration Duties Performed by the GC group:
 - PC and PC server support: 75+ PCs, 5 NT servers
 - Unix systems support: 75+ Sun workstations
 - Unix Server support: 2 Enterprise servers, 6 smaller servers
 - Network Administration LSN (Caltech) and WAN (Laboratory-wide)
 - WEB administration for Laboratory and LSC functions
 - User and application support - 300+ user accounts backed up, maintained, Application licensing for unix servers, PCs, etc.
 - Meetings support (visitor workstations, DHCP, A/V equipment etc.)
 - Purchasing of all hardware, software for laboratory subgroups at Caltech
 - Document Control Center archive
 - Leadership and guidance to other Laboratory sites for IT support



Data Analysis & Computing Group

Principal General Computing activities during operations

		<i>General Computing Staffing Plan</i>				
Personnel	FTE	Server & Data Systems	Desktop Workstations	LAN & WAN Administration	Telecommunications Administration	Web & DB Administration
Student Asst.	0.4		0.4			
www, DB Admin	0.5					0.5
Sci.	0.1			0.1		
Sr. Sys. Admin	1	0.2	0.15	0.3	0.35	
Asst. Sys. Admin	1	0.3	0.6	0.1		
<i>Contract Sys. Admin.</i>	<i>1</i>	<i>0.25</i>	<i>0.75</i>			
<i>CIT Totals -></i>	4	0.75	1.9	0.5	0.35	0.5
Caltech Personnel Classifications	Students		0.4			
	DB Admin.					0.5
	Sci.			0.1		
	SysAdmin	0.5	0.75	0.4	0.35	
<i>MIT Sys Admin*</i>	<i>1</i>	<i>0.3</i>	<i>0.6</i>	<i>0.1</i>		
<i>LHO Sys Admin*</i>	<i>1</i>	<i>0.15</i>	<i>0.5</i>	<i>0.1</i>	<i>0.13</i>	<i>0.12</i>
<i>LLO Sys Admin*</i>	<i>1</i>	<i>0.15</i>	<i>0.5</i>	<i>0.1</i>	<i>0.13</i>	<i>0.12</i>
<i>LIGO Lab Totals -></i>	7	1.35	3.5	0.8	0.61	0.74

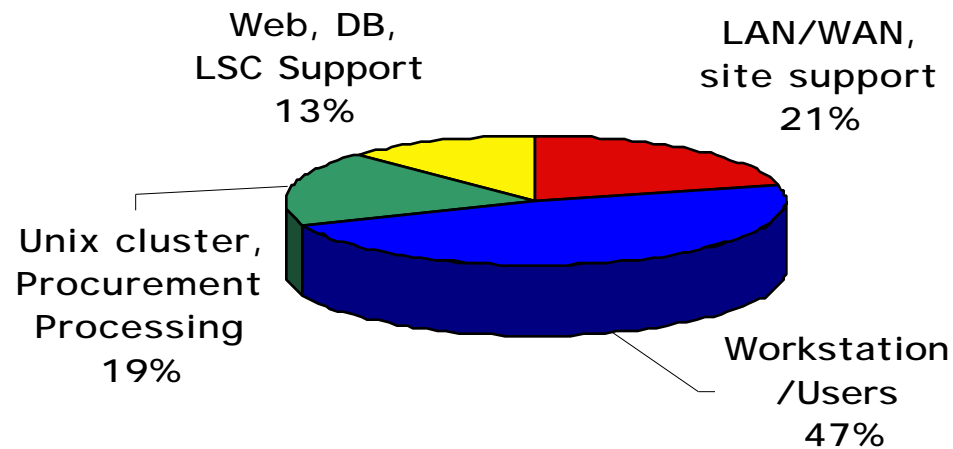
** NOTE: MIT, LHO, and LLO personnel are in the budgetary proposals from the respective sites*



General Computing Operations

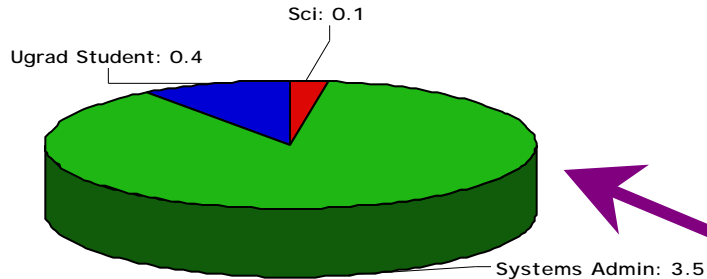
Statistics derived from historical experience

Breakdown of General Computing Workforce Activities



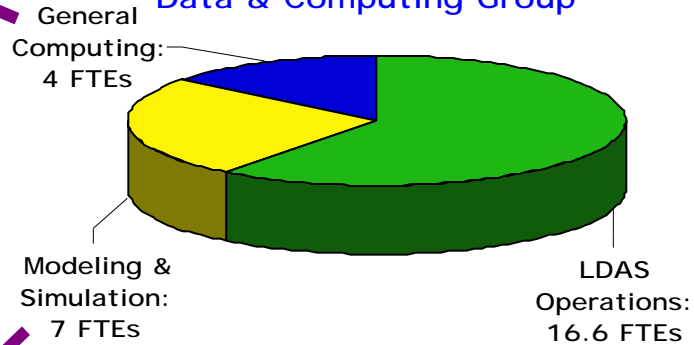


General Computing FTE Makeup

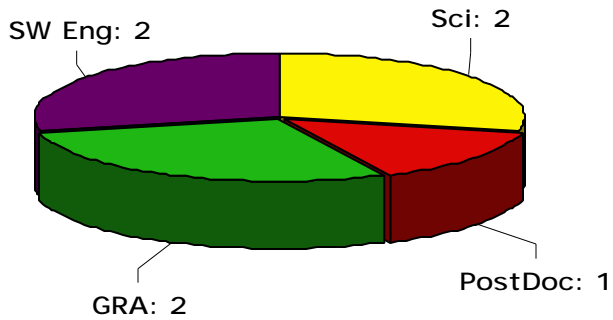


*** Does not include MIT, LHO, LLO Gen. Comp. FTEs**

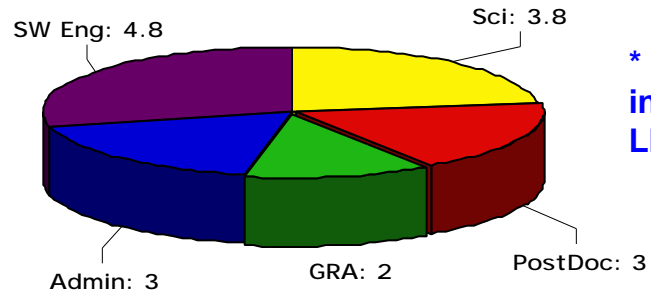
Breakdown of FTEs in Data & Computing Group



Modeling & Simulation FTE Makeup



LDAS FTE Makeup



*** Does not include LHO, LLO LDAS FTEs**



Increase for Full Operations

Budget Category	Increase	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
Basic Operations						
* CDS Hardware Maintenance		513,800	502,434	517,507	533,032	549,023
* LDAS Maintenance		1,378,728	1,378,728	1,322,235	1,303,163	1,303,163
Outreach		249,848	257,343	265,063	273,015	281,206
Site Operations		558,485	575,240	592,497	610,272	628,580
* Telecommunications / Networking		540,500	542,200	542,200	539,500	539,500
Staff for Site LSC Support		254,678	262,318	270,187	278,293	286,642
Basic Operations Totals		3,496,039	3,518,263	3,509,689	3,537,275	3,588,114
Operations Support of Advanced R&D						
Seismic Development		506,300	434,574			
Engineering Staff		920,868	948,494	976,949	1,006,257	1,036,445
* Simulation & Modeling Staff		282,485	293,949	305,614	317,772	330,617
R&D Total		1,709,652	1,677,017	1,282,562	1,324,029	1,367,062
Grand Total		5,205,691	5,195,280	4,792,252	4,861,304	4,955,176

* Need recognized by NSF Review Panel

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LIGO Laboratory at Caltech



LIGO Data Analysis System

LDAS Hardware Investment

- LIGO Laboratory is establishing a distributed network of data analysis installations covering all sites
 - » Managed/maintained by LDAS group (not a general computing function)
 - » 10+ enterprise class SMP unix (sun) servers for data distribution
 - » 5+ PC linux SMP servers for pipeline data preprocessing
 - » 500TB robotic archive based on HPSS
 - » 30TB - 60TB RAID disk farms for data caching
 - » 5 separate linux PC clusters for parallel (MPI) pipeline analysis -- total of 350+ PCs
 - » Gigabit/fast ethernet switches, fibre channel switches
- Total plant investment will be ~\$4M (with educational/GSA discounts, etc.)

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LIGO Laboratory at Caltech



Data & Computing Operations Budget

LDAS Hardware Maintenance Budgetary Estimate

From Procurement Plan C90755-A

Hardware Class	Procurement Expense	Maintenance @ 30%/yr *
HPSS	\$1428.0K	\$428.4K
Servers	\$272.0K	\$81.6K
Switches	\$163.0K	\$48.9K
HW RAID, Small Robots	\$735.0K	\$220.5K

Subtotal for major hardware **\$779.4K**

Hardware Class	Procurement Expense	Maintenance @ 15%/yr
Workstations, small switches, disks	\$1387.0K	\$208.1K

Totals, per year-> **\$3985.0K** **\$987.5K****

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* Major equipment obtained at deep (educational, GSA) discounts carries non discounted maintenance fees; normal maintenance of 15% of list price becomes ~30% of discounted purchase price for LIGO

<i>Skew towards maintenance during first half: FY2002 - FY2004</i>	<i>Skew towards replacement during second half: FY2005 - FY2006</i>
Maintenance, per year \$779.4K	Maintenance, per year \$428.4K
Replacement Equipment \$208.1K	Replacement Equipment \$559.1K

Total, per year	\$987.5K	\$987.5K
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** Net maintenance costs for LDAS equipment are 25% per year of purchase price



Data & Computing Operations Budget

LDAS Hardware Maintenance Budgetary Estimate

- Maintenance and replacement budget allocated to each site in order to take advantage of different tax and overhead structures among LIGO Laboratory sites.
 - Caltech+MIT: \$866k (includes \$295k OH)
 - LHO : \$314k (includes \$59k OH)
 - LLO: \$199k (includes \$37k OH)
- \$1379k



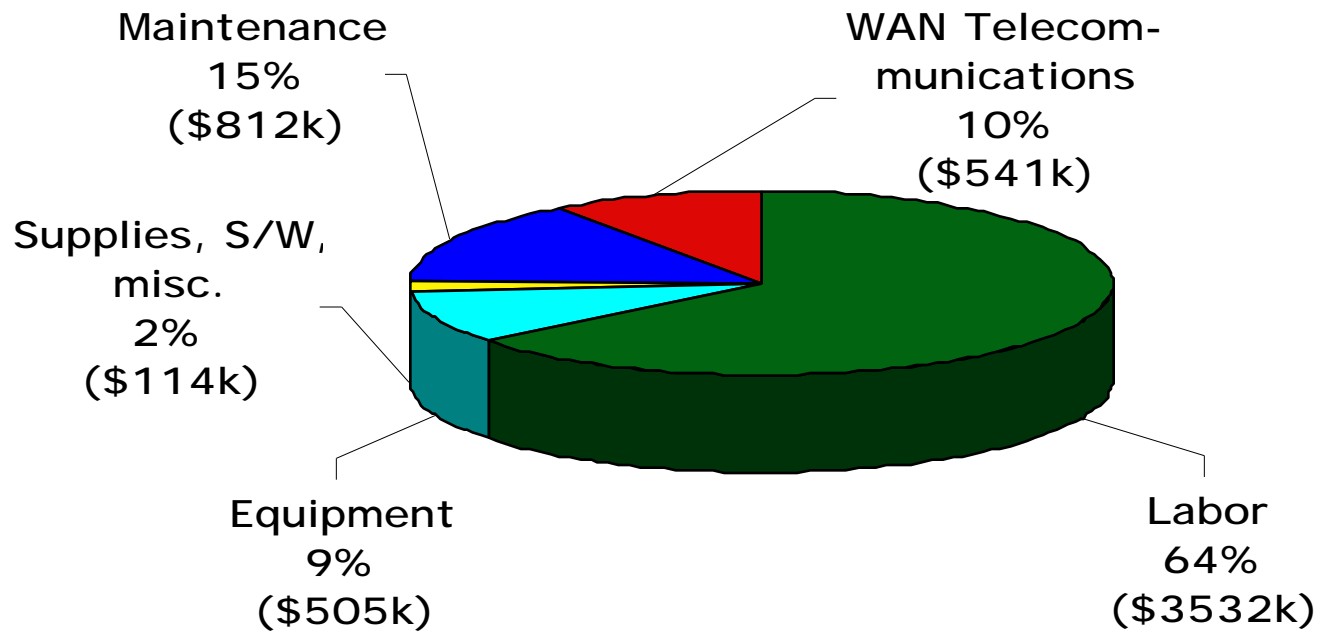
LIGO WAN

- LIGO is working with DOE, PNNL, Internet2, and Abilene to establish a high bandwidth WAN (OC3) across the laboratory
 - » Caltech & MIT are already accessible
 - » LHO uses Esnet via PNNL for present internet access
 - Established through an MOU between DOE and NSF in 1999
 - Present MOU accommodates up to 4xT1 bandwidth
 - Have begun move to OC3 via and ATM-ATM switch link between LHO and PNNL in Richland
 - Estimated costs for OC3 operations from LHO-PNNL-Seattle: **\$340k/year**
 - » LLO uses LANet via LSU for present internet access
 - Established through affiliation of LSU and LIGO at Livingston
 - Present service accommodates up 1xT1 bandwidth
 - Have had several meetings with State & BellSouth representatives to discuss move to OC3
 - Estimated costs for OC3 operations from LLO-Baton Rouge: **\$200k/year**
 - » Total estimated WAN operations costs for LHO + LLO: **\$540k/year**



LIGO Data Analysis & Computing Budget Breakdown

Data & Computing Group FY2001 Budget Breakdown





Summary

- LIGO Laboratory on threshold of transition to scientific observatory:
 - » Participation in astrophysical searches by the Laboratory scientists through the LSC
 - » Data analysis will become a key “business” of the Laboratory across all sites
 - Database, archive use & maintenance
 - Pipeline analysis SW and HW maintenance
 - Continued R&D into algorithms, new technologies
 - » Collaboration within LSC requires continuing support by the Laboratory
 - » Simulation & modeling of interferometers needed to support detector understanding, data analysis
 - » LIGO WAN management crucial to daily operations