LIGO Data Analysis System and Simulation Updates

8th Meeting of the LIGO PAC

Caltech

Pasadena, California

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Albert Lazzarini

LIGO Laboratory Caltech

These talks

- **Pending LDAS HW procurement planning**

- **LDAS SW Status (Kent Blackburn)**

- **LDAS Data Archive Status (Stuart Anderson)**

- **LDAS Database Access (Peter Shawhan)**

- **End-to-End Simulation Environment (Hiro Yamamoto)**

LIGO Data Analysis System Hardware Procurement Overview

- LDAS hardware consists of:

  » PCs for parallel computation
  » Unix(Sun/linux) workstations for users (on private LDAS LANs)
  » RAID (HW & SW) systems for data caching, staging, storage
  » Data Servers (Sun 60, 450, 420)
  » Hierarchical Storage Management system (HSM) for main archive
  » Smaller robotic tape archives for sites
  » Networking switches

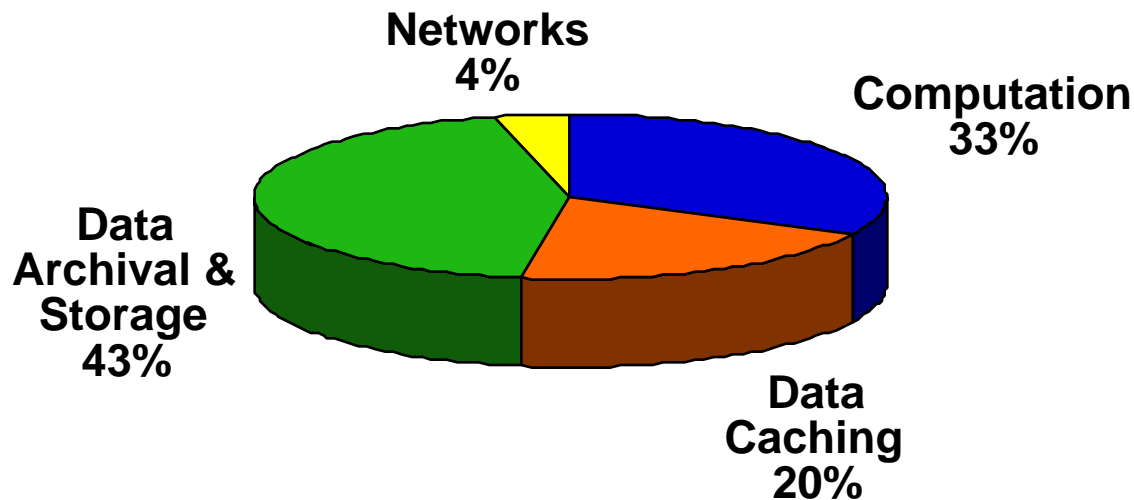- Amount budgeted from LIGO Project Construction for this procurement: $5M.

LIGO Data Analysis System Procurement Strategy

- **Consider only commercial products ("catalog items")**
  - » Multiple vendor quotes for identical (or similar) configurations
  - » Select best value (reliability, warrantee, cost, service, …)

- **Maintenance**
  - » Bundle multi-year service contracts with purchase of major (unique, costly) equipment -- saves operations costs
    - – ATM, Ethernet switches
    - – Servers
    - – RAID
  - » "Self insure" for commodity units (PCs) through:
    - – Redundancy, spares
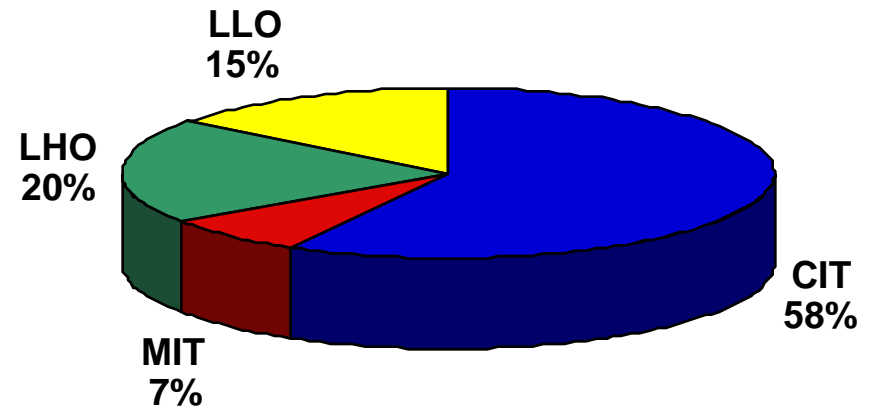   - – Prepaid multi-year service/replacement contracts

LIGO Data Analysis System Hardware Procurement Overview

LDAS Procurement By Function

Networks
4%

Computation
33%

Data
Archival &
Storage
43%

Data
Caching
20%

LDAS Procurement By Site

LLO
15%

LHO
20%

CIT
58%

MIT
7%

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Networking Technology

- **LDAS uses heterogeneous mixture of networking technologies:**

  » Ethernet (100BT and 1000BT) for compute clusters, LANs

  » ATM (OC3, OC12) for connection to internet, databases, server-server, etc. for high BW, point-to-point high priority connections
  - LAN Emulation (LANE)
  - Large (16 x OC12) switches connect databases & servers to compute clusters, local users

  » Fibre channel for disk systems (where needed)

CPU Technology
Servers, Workstations, Compute Clusters

- Servers used for relational database and to distribute framed time series data to users
    - » DBMS
    - » Network file systems
    - » LDAS software modules

- e.g.:
    - » Unix/linux for users
    - » Linux (Intel) for compute clusters
    - » Enterprise class or equivalent servers (SMP)

CPU Technology
Servers, Workstations, Compute Clusters

- ## Sun & Linux machines (Intel):

Component	Qty	Comments
Compute clusters 1GHz CPU; 512 MB RAM 1x72GB IDE; 100 Mbps	336	linux/Intel commodity PCs for parallelized beowulf MPI analysis
Beowulf server 4x1GHz CPU; 4GB RAM 2x72GB IDE; 1000 Mbps	5	master nodes
Data Conditioning PCs 4x(Xeon CPUs); 512MB RAM 1x72GB IDE; 100 Mbps	8	For regression analysis, calibration, pre-processing of data
Control & Monitoring PCs 1 CPU; 256 MB 2x18 GB IDE; 100 Mbps	5	control room monitors; log file servers; software mirrors
Intel Workstations 1 CPU; 512 MB 1xGB IDE; 100 BT	16	Commodity PCs; for work within LDAS LAN
Sun Workstations 1 CPU; 512 RAM 1x36GB SCSI; 100 Mbps	16	For work within LDAS LAN

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Mass Storage Technology

- ## Comparative scale of LIGO I needs

Program	Top Level Requirements
LIGO I	• 100 TB total storage • 0.2 TB per day growth • <1 TB per day transfer • 10^6 files • 5 concurrent transfers @ 1-10 MB/s • Availability > 95 % (up-time)
ASCI	• 5 PB total storage • 10 TB per day growth • 50 TB per day transfer • 10^9 files • 4 concurrent transfers @ 2 GB/s • Availability ?
LIGO II	• 750 TB - 1 PB total storage • Other requirements TBD • Availability > 95%

Major impetus for HPSS development →

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Mass Storage Technology

- **Hierarchical Storage Management**

- **Large volume robot at Caltech**
    - » **100 TB - 200 TB after 2 - 3 years**
    - » **Target: HPSS (likely on Sun)**
    - » **Dedicated HSM disk cache (1 TB)**
    - » **Data movers(servers) & tape controllers**

- **Smaller volume robots at each of two sites**
    - » **20 TB max,**
    - » **Non-HPSS (initially for LIGO I)**
    - » **Same tape drive technology as at Caltech**

- **Miscellaneous small robots (~ 1 TB max)**
    - » **User access to reduced datasets**
    - » **AIT-2 (Sony, Cybernetics)**
    - » **30 x 50 GB tapes**

Mass Storage Technology

- ## HPSS System for LIGO I (IBM baseline*):

Component	Qty	Comments
SP2 rack with backplane switch	1	
4-way PCI nodes	5	Tape head servers, HPSS metadata server
High performance gateway node (HPGN)	1	High BW service to disk cache, users, PC cluster, etc.
High BW tape drives (STK 9840 or later, or equivalent)	8	High BW, high volume tape casettes for archive
Misc. disk storage	~200GB	HPSS metadata
SSA RAID disk cache	1 TB	Intermediate disk cache for R/W tape transfers

Baseline configuration shown is for IBM HW for budgeting purposes; attractive second option is to install equivalent Sun configuration

Disk systems

- **RAID systems (file servers, e.g. NetApp 720)**
  - » 1500GB across 4 installations
  - » High BW access:
    - – SCSI or fibre channel
    - – Hostless, network-attached
  - » Metadata servers

- **Disk cache for frame data**
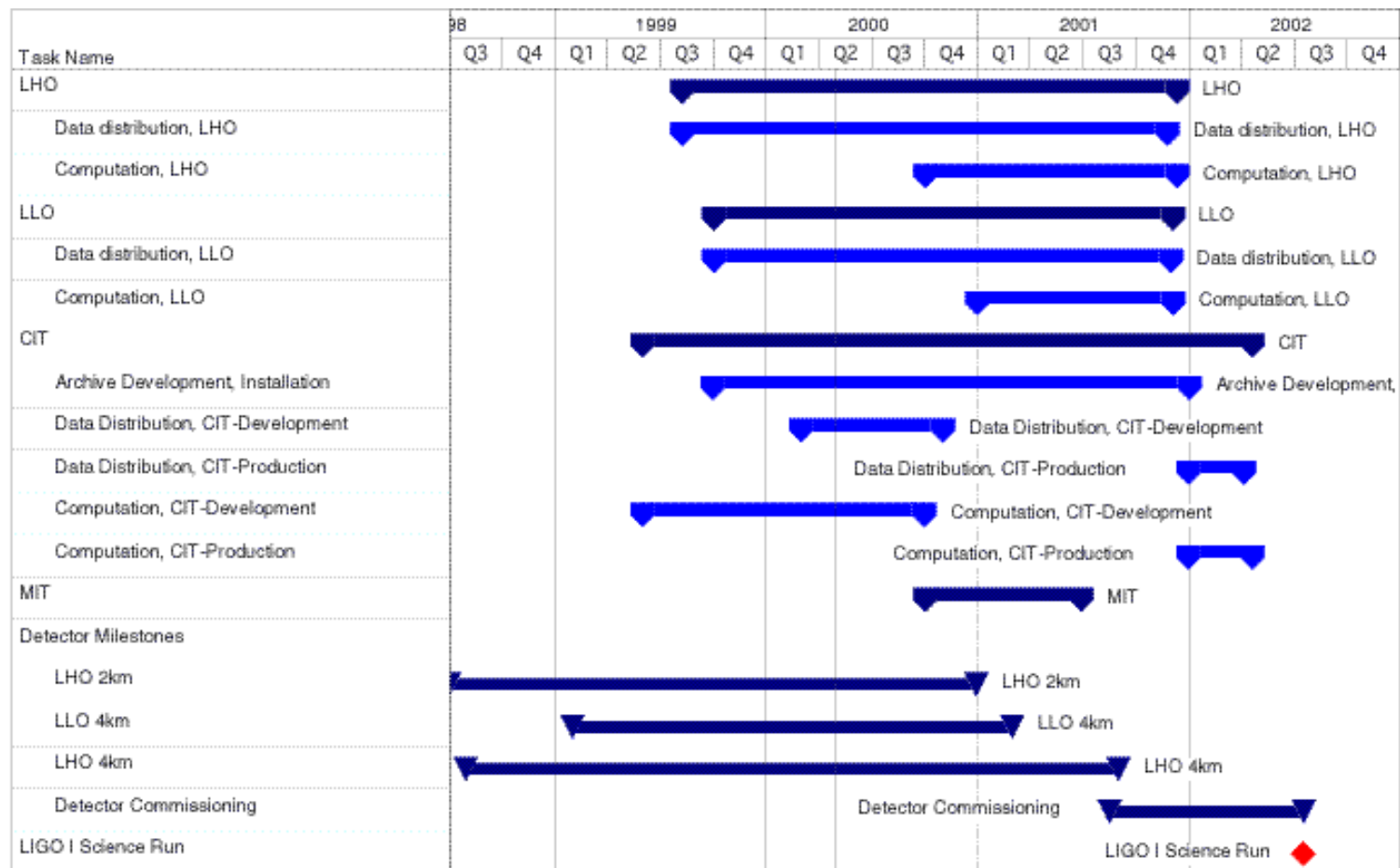 - » 2850GB across 4 installations
  - » RAID 0+1, plus servers

Disk systems

- **Disk cache systems:**

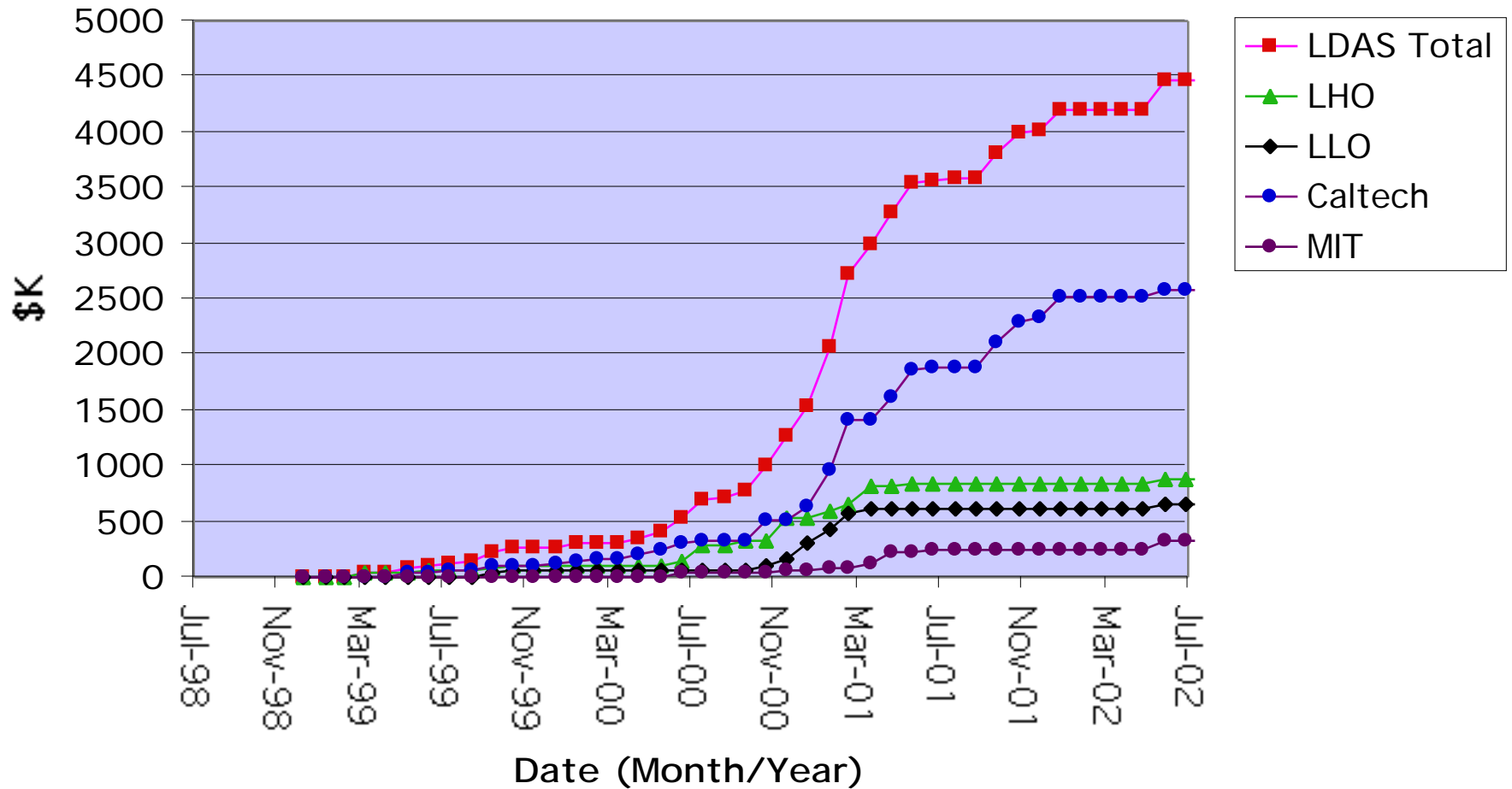| Use	Qty (GB)	Comment
Framed data at observatories	1000/500	LHO/LLO
Metadata (DBMS)	750/150/300/300	CIT/MIT/LHO/LLO
LDAS caches	1250/250/500/250	CIT/MIT/LHO/LLO

LDAS Procurement Timeline

LDAS Expenditure Profile

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LIGO Data Analysis System Summary

- This is the final major procurement for the LIGO Construction Project

- Procurement Plan follows from the requirements of LIGO I data analysis

- Procurement will ramp up during 2Q & 3Q 2000
  » Mounting pressure/need from the detector characterization activities to archive, analyze data
  » Procurements will be phased to match demand
  » Select the most cost effective options at each phase

- Design is extensible
  » Allows for expansion, upgrades to support LIGO II when needed