Status of LIGO

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NSF Review

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This Talk

- Status of Installation/Commissioning
- Revised plan for completing commissioning and initiating Science Run
- LIGO Financial Status
- LIGO Data Analysis System (LDAS) Status and Plan

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
	» $h \sim 10^{-21}$

Future Scenario: Planning Beyond the Previous Horizon

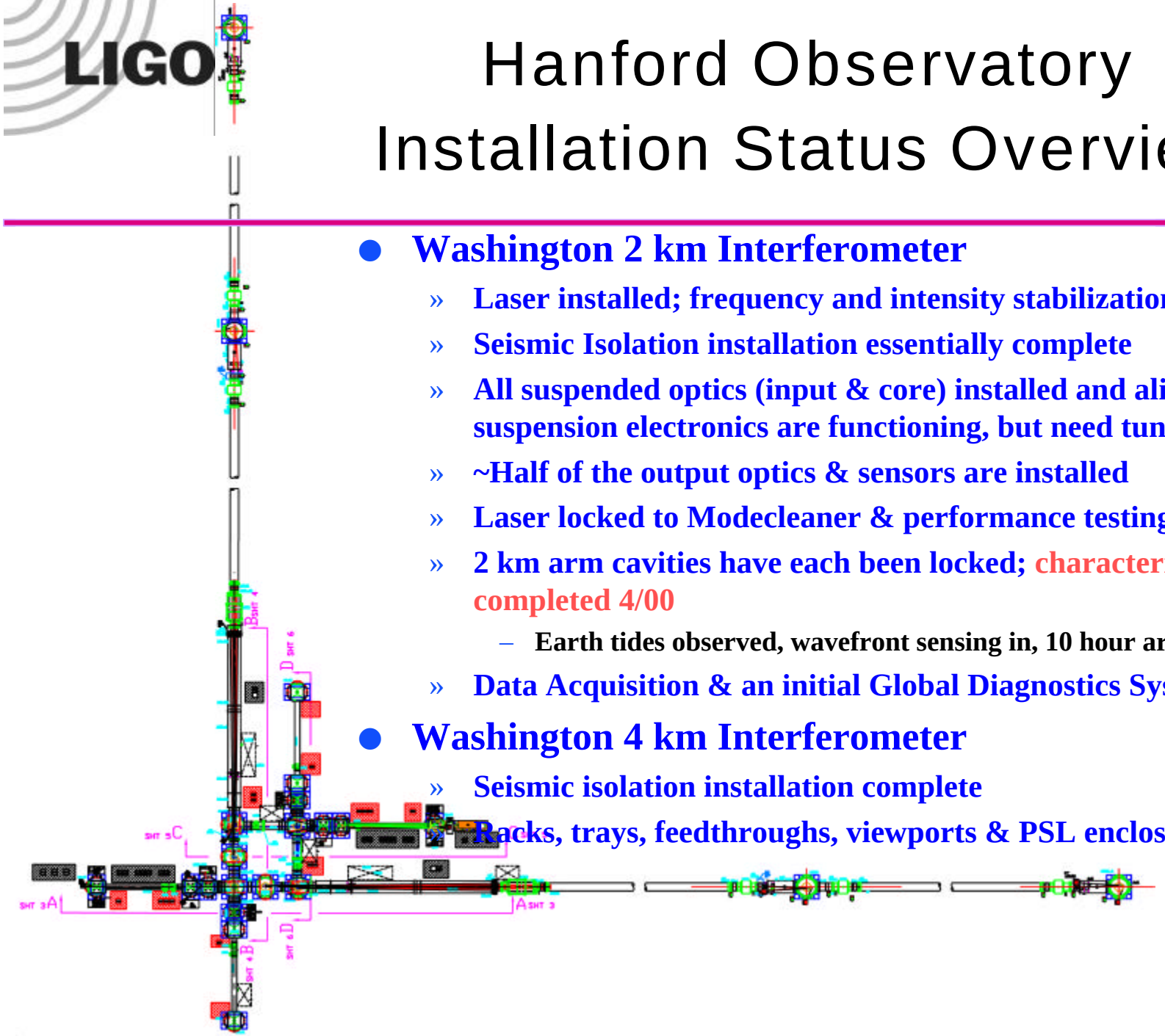
YEAR	LIGO I	LIGO II
2000	Installation and commissioning	R&D
2001	Installation and commissioning	R&D
2002	Science run starts	MRE/R&D funds start, R&D, design, long lead items
2003	Science run	R&D, design, fabrication
2004	Science run	Fabrication, on-site assembly
2005	LIGO I interferometers removed	Fabrication, on-site assembly, installation into vacuum system
2006		Installation and commissioning

Construction Project Status

- 97.5% complete
- Construction will finish on the budget
- Hanford buildings essentially complete, including support buildings
- Livingston essentially complete except for erosion control and support building construction
- 7 of the 8 beam tube modules (2 km each) baked

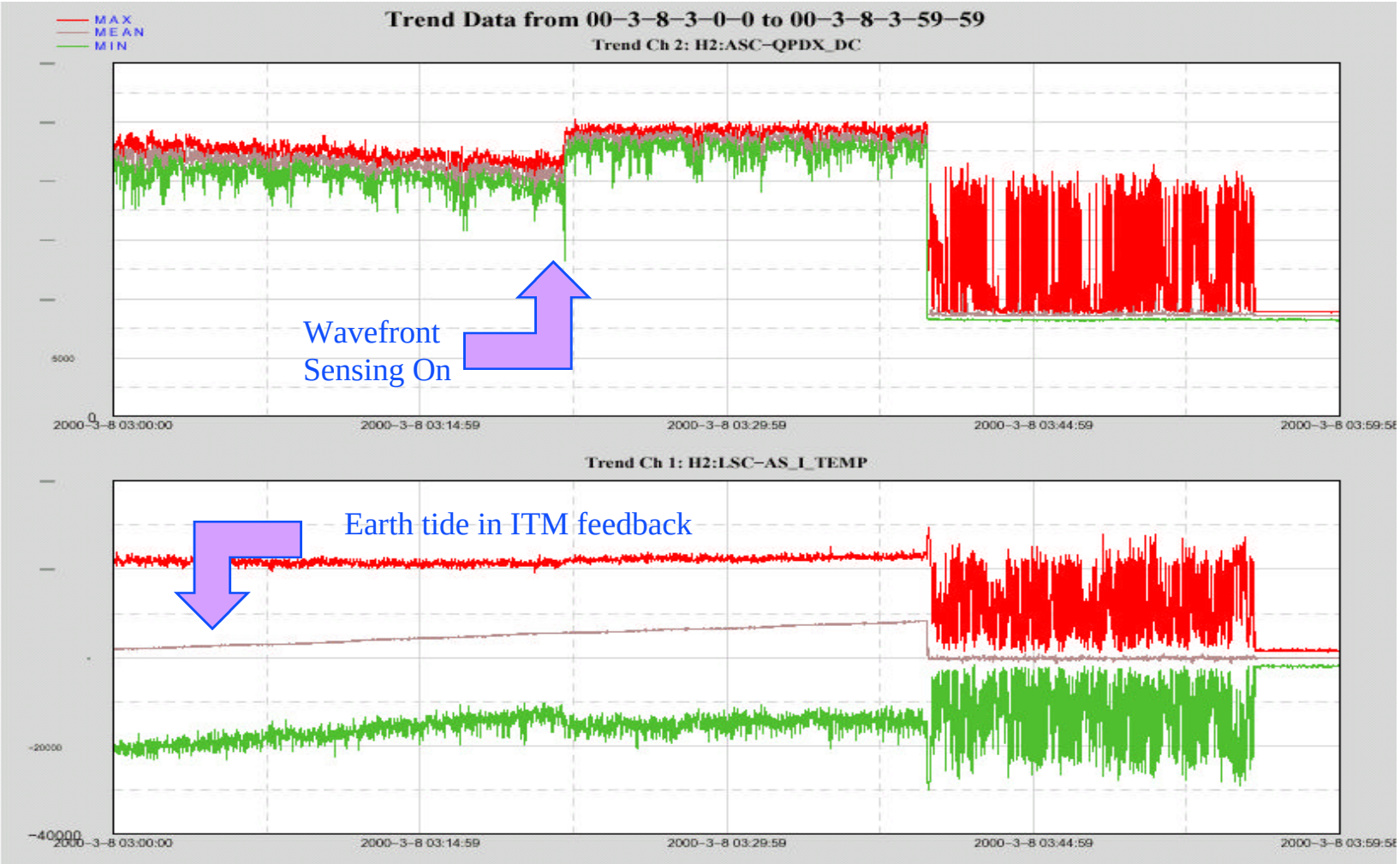
No more bullet holes in Livingston, but in Hanford...

Hanford Observatory Installation Status Overview



- **Washington 2 km Interferometer**
  - » **Laser installed; frequency and intensity stabilization operational**
  - » **Seismic Isolation installation essentially complete**
  - » **All suspended optics (input & core) installed and aligned; suspension electronics are functioning, but need tuning**
  - » **~Half of the output optics & sensors are installed**
  - » **Laser locked to Modecleaner & performance testing in progress**
  - » **2 km arm cavities have each been locked; characterization completed 4/00**
    - – **Earth tides observed, wavefront sensing in, 10 hour arm lock!**
  - » **Data Acquisition & an initial Global Diagnostics System installed**
- **Washington 4 km Interferometer**
  - » **Seismic isolation installation complete**
  - » **Racks, trays, feedthroughs, viewports & PSL enclosure in place**

LHO 2 km Arm Cavity Lock With Wavefront Sensing



Progress...

Date	Duration of lock
1 Dec 99	Flashes of light
9 Dec 99	0.2 sec
14 January 00	2 minutes
19 January 00	60 seconds
21 January 00	5 minutes (other arm!!)
12 February 00	18 minutes
26 March 00	10 hours

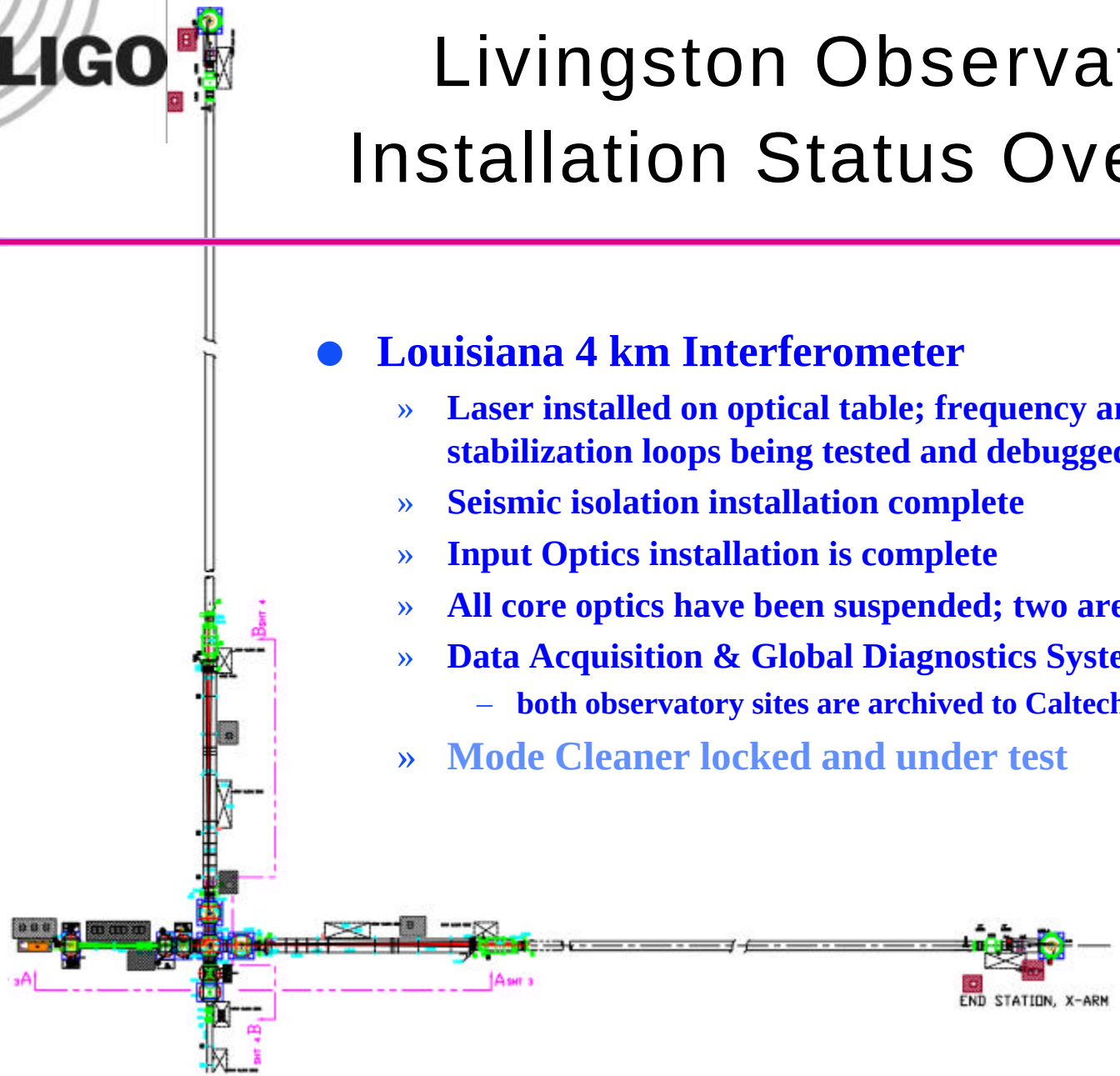
Software tools for Diagnostics

- Data acquisition system
  - » site-wide, synchronized, flexible
  - » reduced data sets for later study
- Time series viewing tools
  - » multiple time series, trends
- Diagnostic analysis tools
  - » Fourier transforms, coherence, etc.
- Change of paradigm for LIGO:

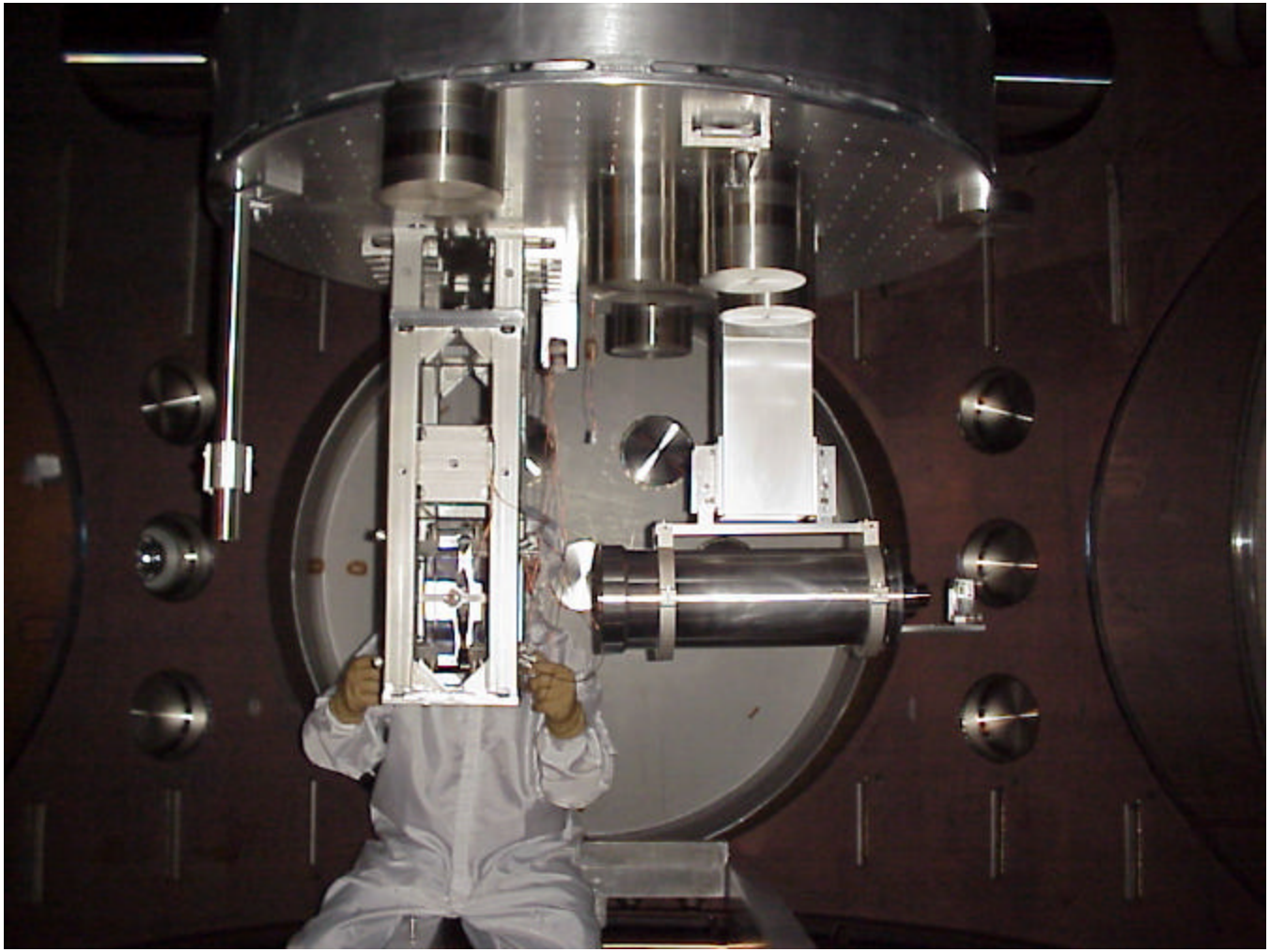
Research performed in the control room

Livingston Observatory Installation Status Overview

- **Louisiana 4 km Interferometer**
  - » **Laser installed on optical table; frequency and intensity stabilization loops being tested and debugged**
  - » **Seismic isolation installation complete**
  - » **Input Optics installation is complete**
  - » **All core optics have been suspended; two are installed**
  - » **Data Acquisition & Global Diagnostics System being installed**
    - – **both observatory sites are archived to Caltech every night**
  - » **Mode Cleaner locked and under test**



LLO End Test Mass Installation



Readonly Access to Log Books is Public!

- Livingston
  - » http://abundance.ligo-la.caltech.edu/ilog/
- Hanford
  - » http://blue.ligo-wa.caltech.edu/ilog/

Progress Against Schedule?

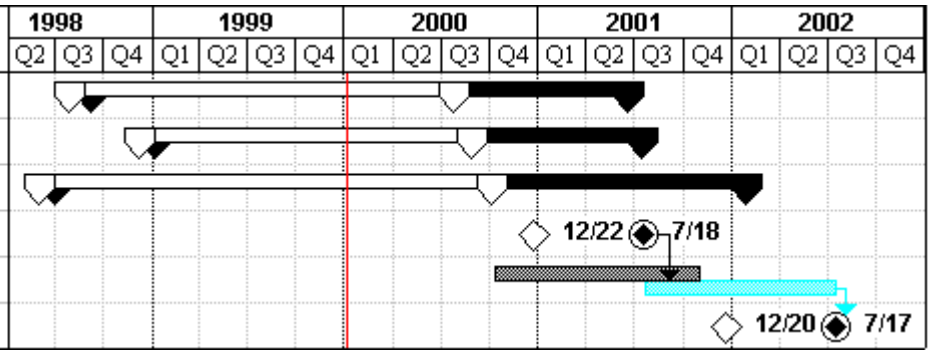
- Installation and commissioning of the interferometers have been progressing and preliminary results are encouraging
- However, there have been delays and problems:
  - » seismic isolation slow early production pace (discussed in October 1998 review)
  - » magnet/standoff assembly adhesion to the optics (discussed in April 1999 review)
  - » transport fixture problems for suspension assemblies (discussed in April 1999 review)
  - » flourel component stock lost in tornado (possible elastomer contamination discussed in April 1999 review)
  - » re-baking of the flourel spring seats (and associated seismic stack rebuild) to mitigate water load on the vacuum system (newer issue)
    - – water load is now an operational constraint

Strategy Evolving: Look Over the Original Planning Horizon

- Slow the installation into 3rd interferometer (LHO 4-km) to permit use of reworked components
  - » recognize different role for each interferometer (first article, detailed characterization, reworked implementation)
- Move to coincidence running as soon as 2 interferometers are at useful sensitivity
  - » makes coincidence data stream available earlier than waiting for triple coincidence
- Path to Science Run should be smoother with this approach
  - » 3 interferometer Science Run begins mid-2002
- No additional funds required for this revised plan

Top Level Schedule

ID	Task Name
1	LHO 2km IFO
14	LLO 4km IFO
30	LHO 4km IFO
44	Coincidence Engineering Run starts
45	Observatory Operations & improvements
46	Science Run starts



LIGO I Science Run

- Begins with reliable and calibrated coincidence data on three interferometers and stable configuration
  - » Formally recognized by LIGO Laboratory
  - » “Ownership” of running then guided by LSC science
- Improvements to reach final design goals in sensitivity and reliability will be alternated with data running
  - » Scientific running experience informs detector development
- Commitment is to obtain at least one year of integrated sensitivity at $h \sim 10^{-21}$ before initiating LIGO II

Future Scenario: The Next 5 Year Plan

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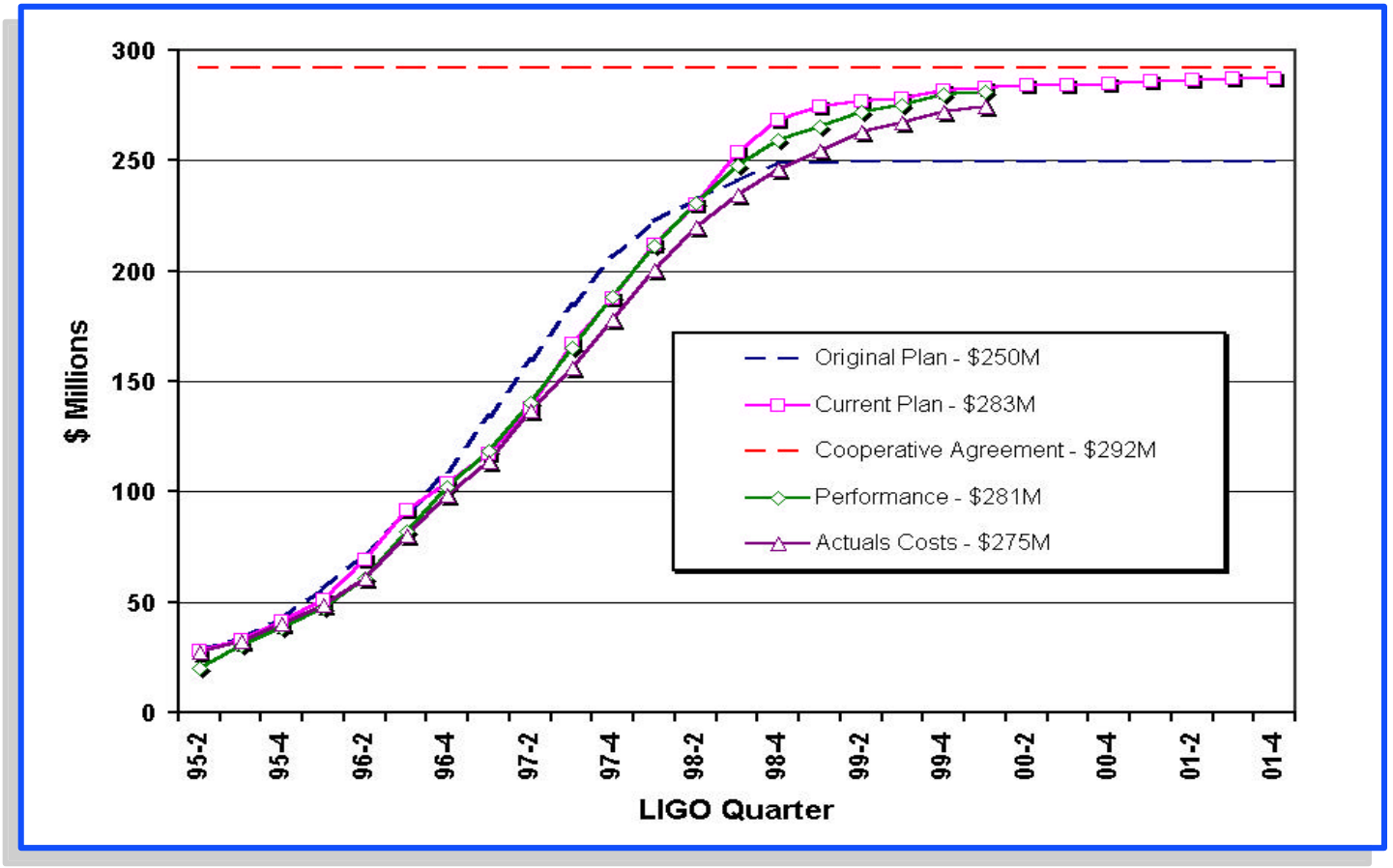
LIGO II: LIGO Lab's Plan

- Full LIGO II Proposal to be submitted near end of 2000, with LSC and GEO participating
- Request R&D $ increment for 2002
- Request construction $ for 2003
- Plan first installation in vacuum system in 2005
- LIGO II development/proposal effort is putting pressure on LIGO I commissioning

LIGO Cost and Schedule Performance
(End of February 2000)



LDAS Procurement Plan

- 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: $5.0M.

Caltech Commitment to CACR

Shared and LIGO Owned Resources at CACR

- Computer science and high performance computing are a high priority for Caltech.
- Caltech needs a forum in which cross-disciplinary research and computational science meet.
- CACR serves that purpose. Examples include:
  - » NPACI
  - » ASCI program
  - » Digital All Sky Survey (prototyped at CACR and then launched as an astronomy initiative, Virtual National Observatory -- VNO)
  - » LIGO

Caltech Commitment to CACR

Shared and LIGO Owned Resources at CACR

- Caltech is committed to the long-term support and success of CACR.
  - » CACR is supported by several CIT budgets and these are not changing.
  - » CACR will remain a campus-wide and open facility.
- CACR has high bandwidth access to Internet2 independent of the Caltech backbone in order to support NPACI collaborators at remote sites.
  - » This access will be expanded in the future and will be a available to access the LIGO archive.

LIGO Opportunity at Caltech

Shared and LIGO Owned Resources at CACR

- LIGO Laboratory requires an archive for its science run.
  - » LIGO personnel who develop, manage the archive are at Caltech.
  - » LIGO's coordination of this effort with CACR makes synergistic use of Caltech resources:
    - – Space & infrastructure
    - – Hardware resources
    - – Highly skilled people (!)
    - – NSF provides partial support for CACR-- leverage this support at Caltech to the benefit of LIGO and the LSC.
  - » Both local users and those from outside (LSC, MIT) have identical (readonly) accounts on HPSS. There is no hurdle for users off campus.

Conclusions...

- Installation/Commissioning have been progressing and early commissioning of two PSL's, two mode cleaners, a short-arm Michelson, and two 2-km arm cavities has been encouraging
  - » many key elements of the design have been validated
- Delays in installation/commissioning have led to a replanning exercise
- Revised plan improves transition to early coincidence data taking, efficiency in incorporating rework, and initiation of the full Science Run

...Conclusions...

- LDAS Procurement Plan is matched to the requirements of analysis
- The Plan identifies up-to-date technologies for each requirement
- The basis for the costs is an example system with real market choices
- Our procurement schedule will be phased to the growth in our demand to a full system
- Our procurement will seek the most cost effective sources at the time of each procurement

...Conclusions

- In order to meet our operational needs, our plan utilizes the existing Caltech CACR capabilities for:
  - » hosting archival storage,
  - » sharing space and resources,
  - » sharing expertise and administration,
  - » sharing licenses,
  - » and sharing existing large bandwidth.
- Caltech's commitment to CACR/CALREN2 is firm and reflects important institutional imperatives