



Management of the LIGO Project

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Presented to the Committee on Programs
and Plans of the National Science Board

August 9, 2001

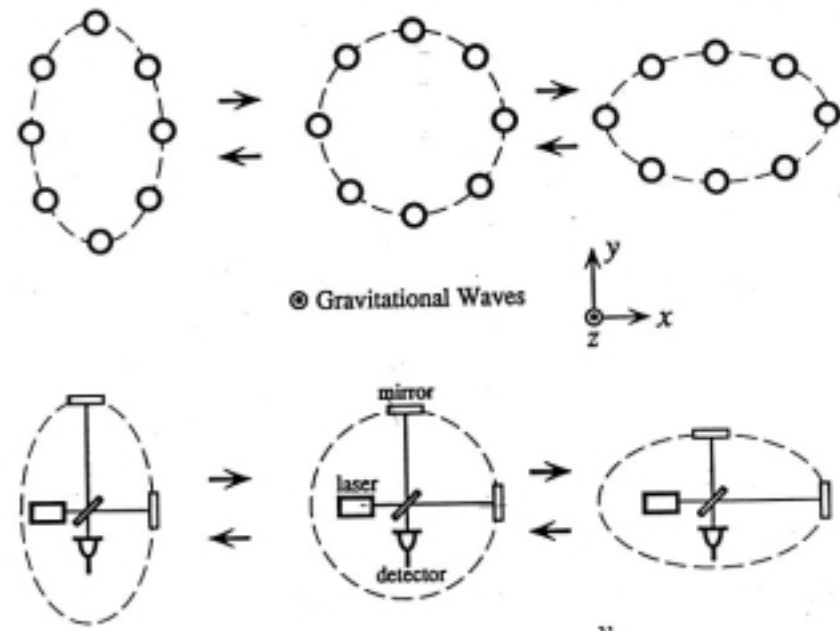
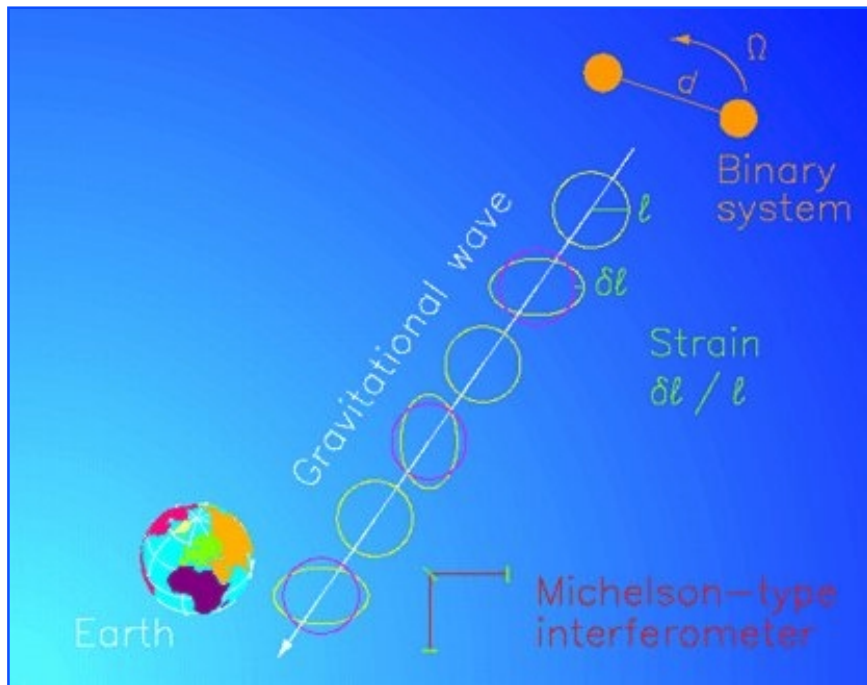


This Presentation

- Introduction to LIGO
- How we have managed LIGO
- How NSF has managed LIGO
- Status of LIGO today

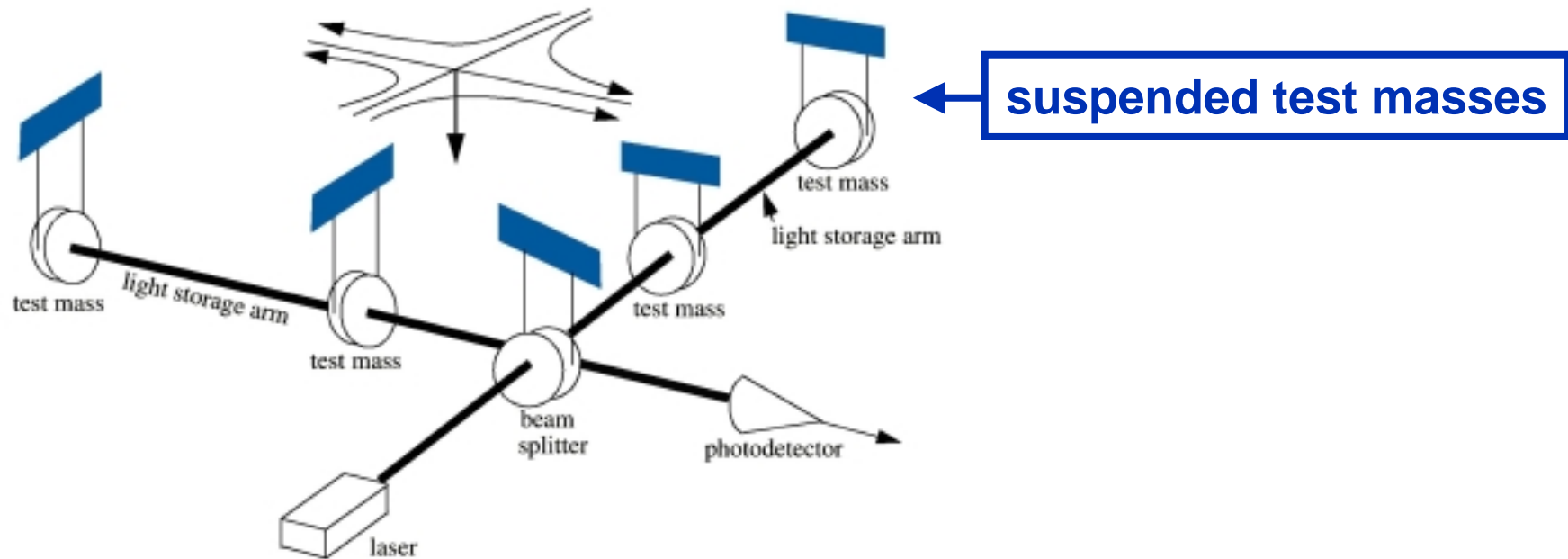


Interferometers as Detectors of Gravitational Waves





Detection of Gravitational Waves by Interferometry



LIGO (4 km), stretch (squash) = 10^{-18} m will be detected at frequencies of 10 Hz to 10^4 Hz. It can detect waves from a distance of $600 \cdot 10^6$ light years

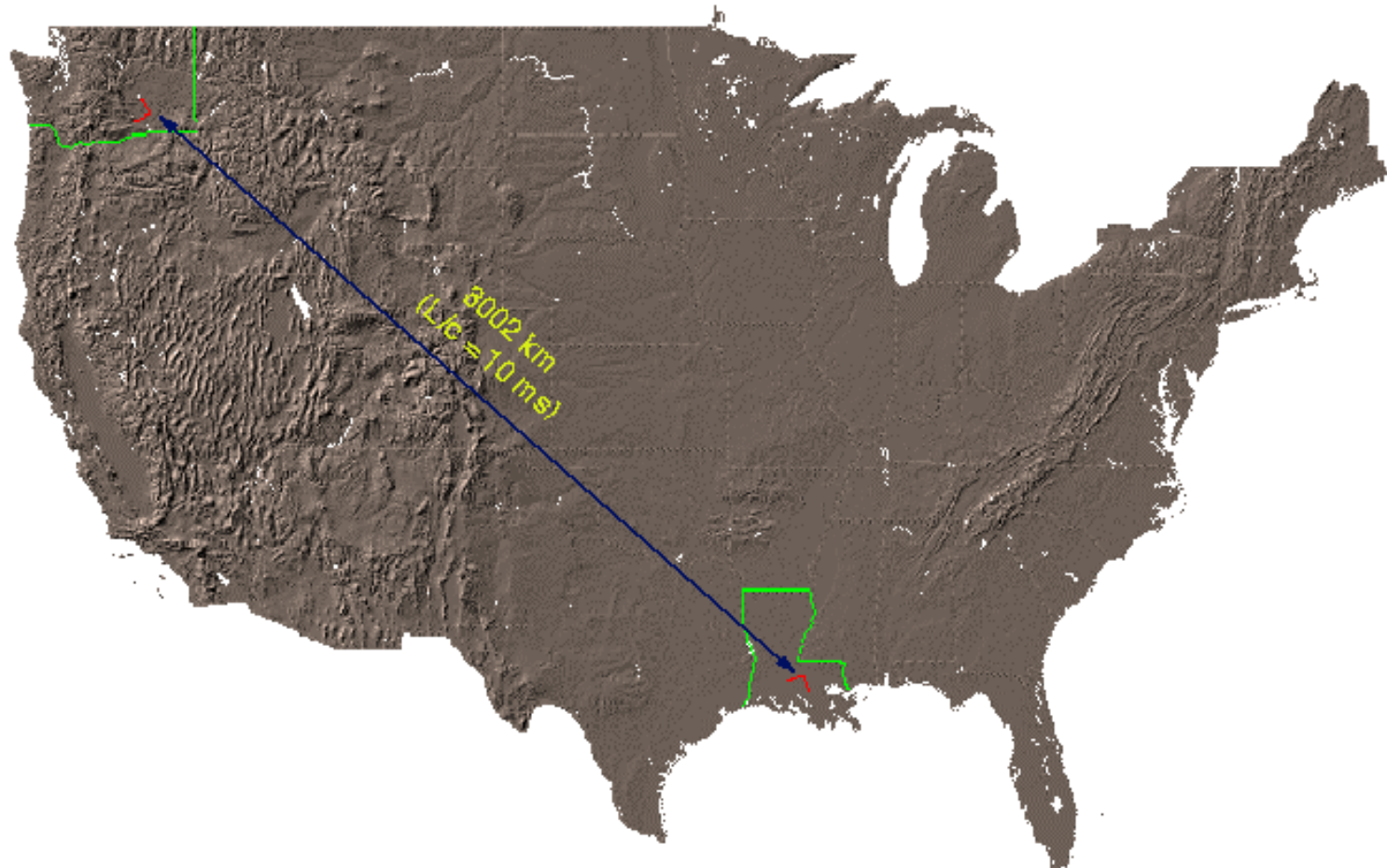


LIGO Scope and Costs

- The Laser Interferometer Gravitational Wave Observatory (LIGO) is:
 - » a joint project of Caltech and MIT
 - » construct and operate two observatories with 4 km interferometers
 - » detect gravitational waves
 - » initiate ground-based gravitational wave astronomy
- LIGO has been supported through the NSF Division of Physics/Gravity Program
 - » Construction cost \$292 million (Major Research Equipment + R&D)
 - » Commissioning, early operations and R&D cost \$79 million
 - » This funding covers 1994 - 2001



Two Observatories - Long Baseline





LIGO Observatories

LIGO (Washington)



LIGO (Louisiana)





LIGO Vacuum System



LIGO-G010262-00-M



LIGO 4 km Beam Tubes



LIGO-G010262-00-M



Optics Installation



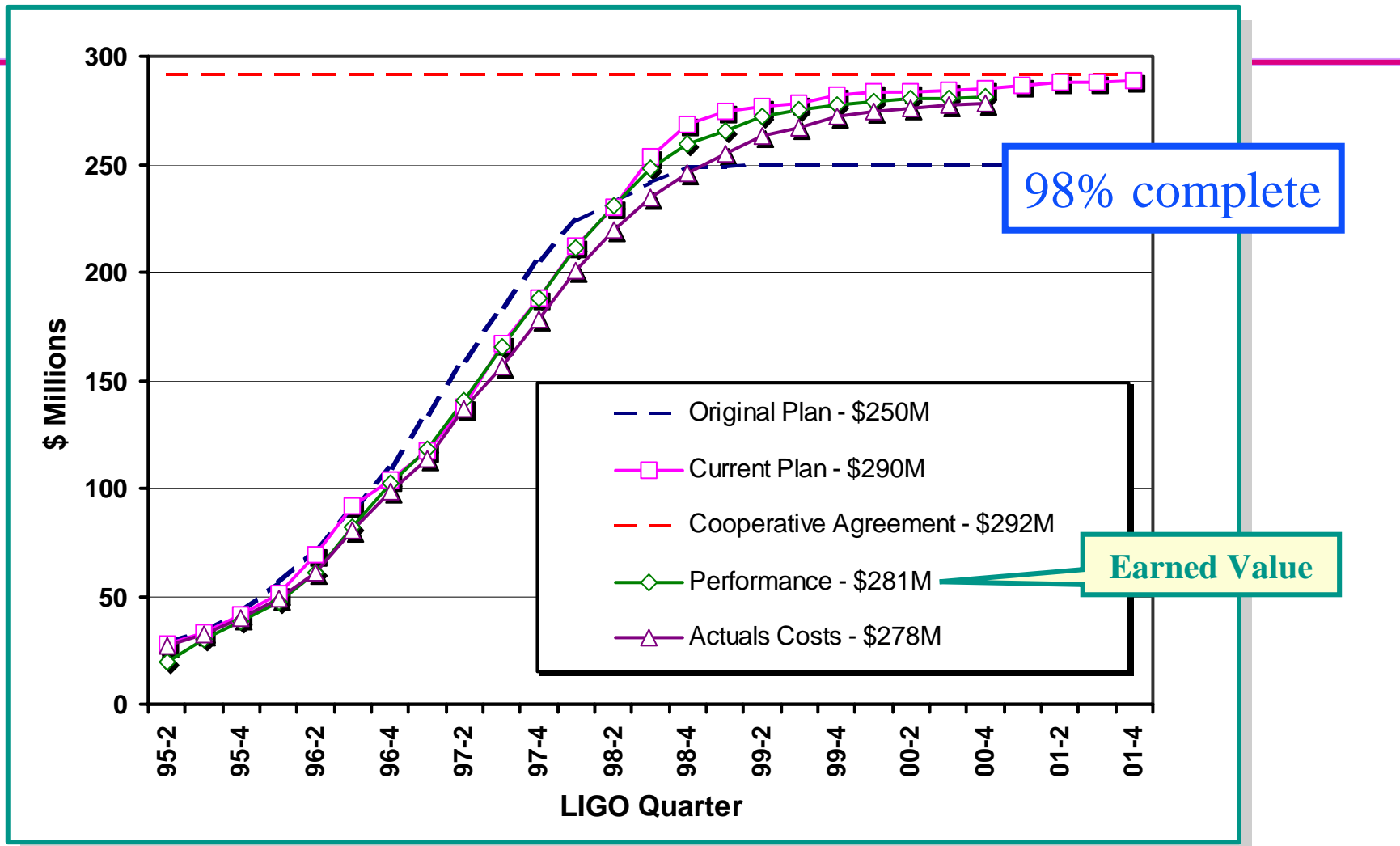


LIGO Schedule

1996	Construction Underway (mostly civil)
1997	Facility Construction (vacuum system)
1998	Interferometer Construction (complete facilities)
1999	Construction Complete (interferometers in vacuum)
2000	Detector Installation (commissioning subsystems)
 2001	Commission Interferometers (first coincidences)
2002	Sensitivity studies (initiate LIGO I Science Run)
2003+	LIGO I data run (one year integrated data at $h \sim 10^{-21}$)
2006+	Begin 'advanced' LIGO installation



Construction Cost Schedule Performance





LIGO

Features of the LIGO Construction Project

- University (Caltech+MIT) managed, no national laboratory
- Two green field sites
- Carried out as two major subprojects
 - » 2/3 of the project constructs buildings, clean labs, vacuum system designed for ultimate terrestrial detectors
 - » 1/3 of project constructs initial detectors
- NSF funding provided when scheduled, leading to a technically limited project



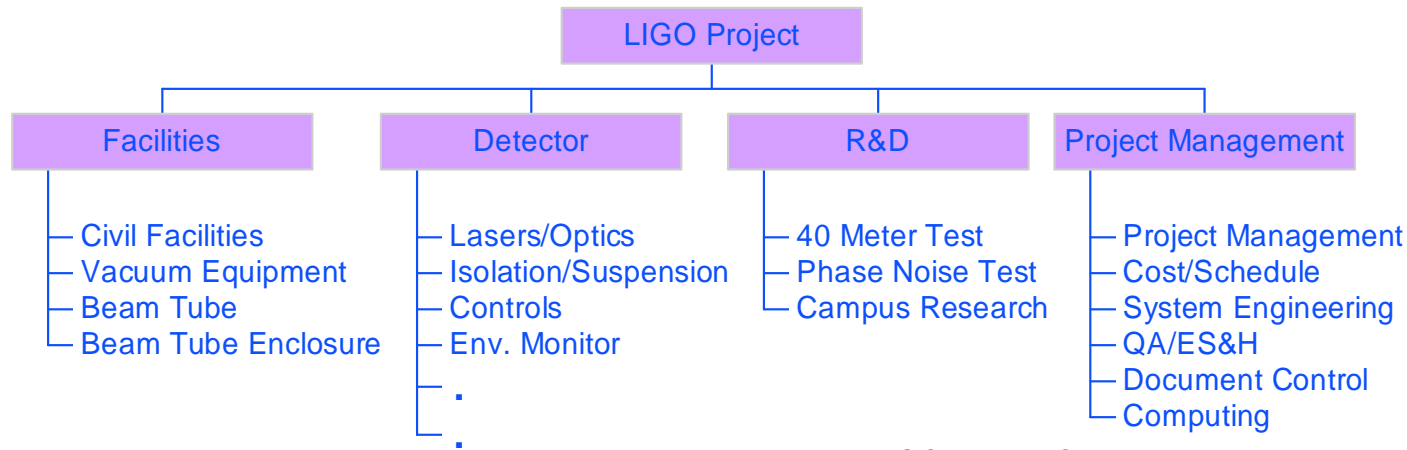
Features of the LIGO Construction Project

- Organized and executed like a bridge building project
 - » Product oriented Work Breakdown Structure (WBS)
 - » Scope and technical configuration defined and controlled
 - » Cost and schedule integrated into a performance measurement baseline with earned value analysis
 - » Contingency funds managed centrally through a Change Control Board
 - » Organization matches WBS
 - Subsystem managers responsible to deliver products
 - » Subcontractors managed rigorously
 - » Scientists fully integrated and aware of Voltaire's maxim "**le mieux est l'ennemi du bien**"
 - Scientists did not destabilize project but were also the source for project repair and workaround
- Big Science culture new to NSF and to Caltech/MIT scientists

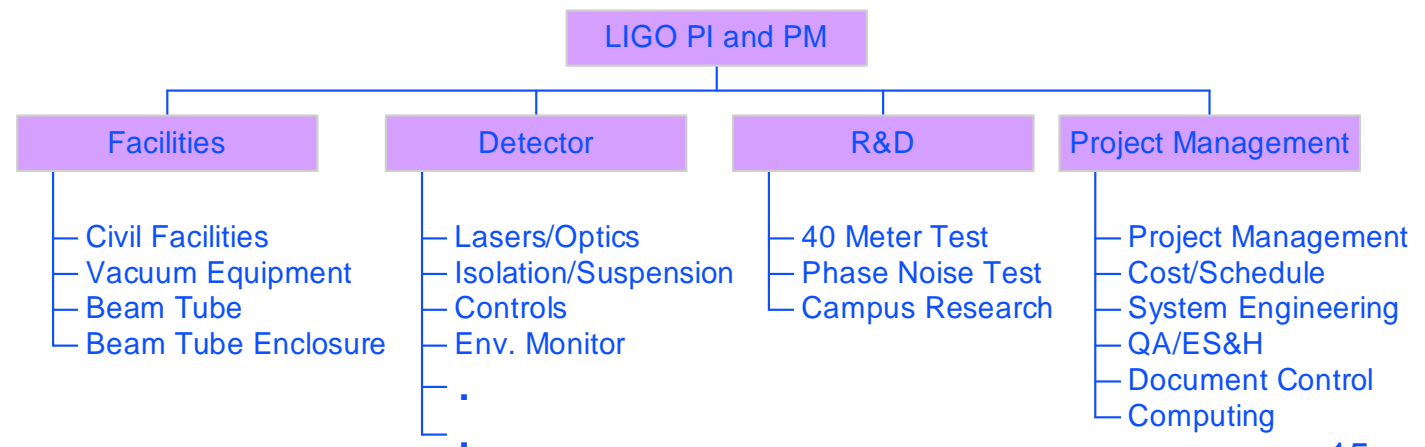


LIGO Project Work Breakdown and Organization

Work Breakdown Structure

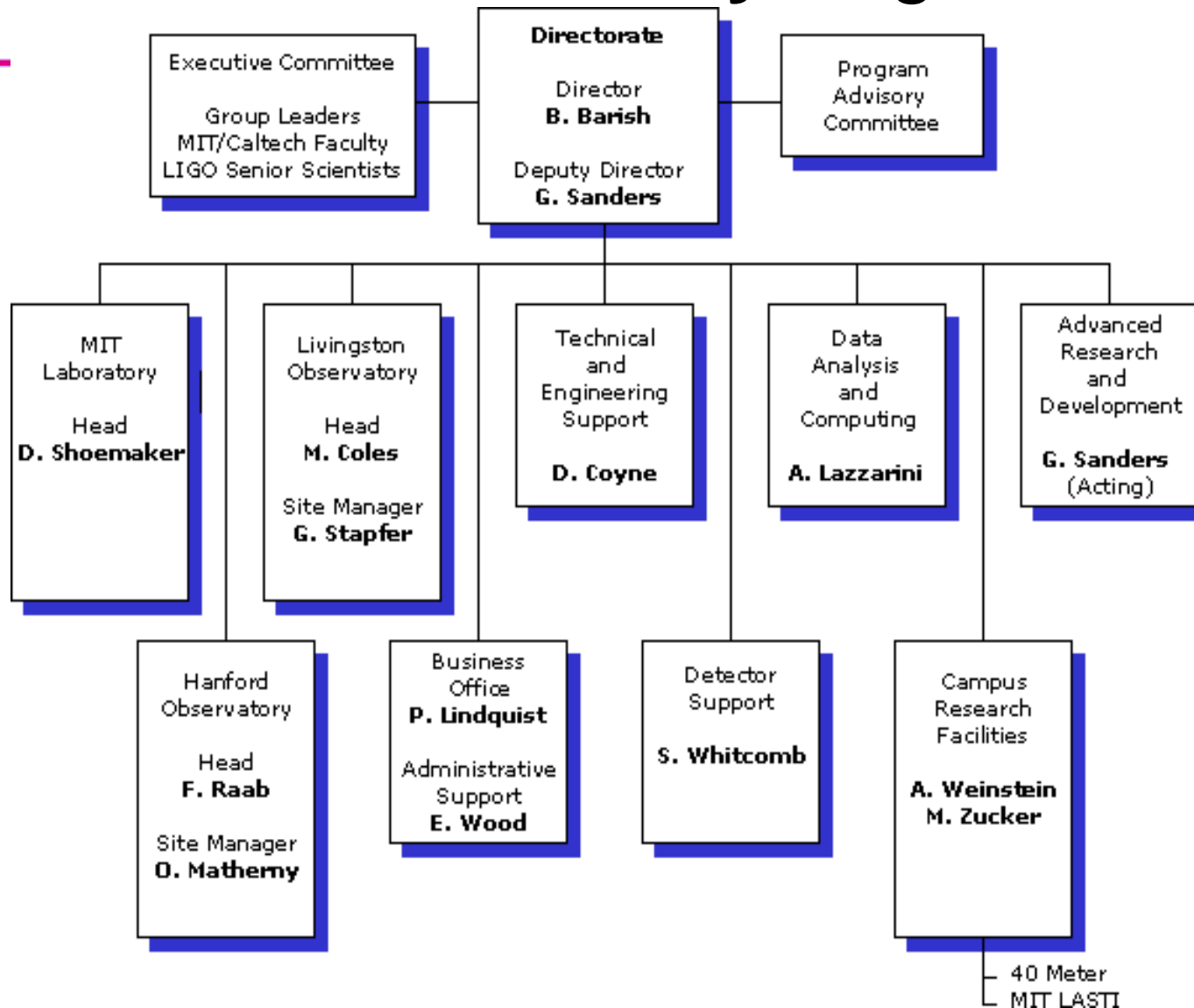


LIGO Project Organization





LIGO Laboratory Organization





Post Construction

- Operating as a scientific program has been initiated
- Organized LIGO Scientific Collaboration (LSC)
 - » a ~30 institution, ~300 scientist international collaboration to carry out the
 - observational science and
 - advanced R&D
 - » LSC includes LIGO Laboratory scientific staff

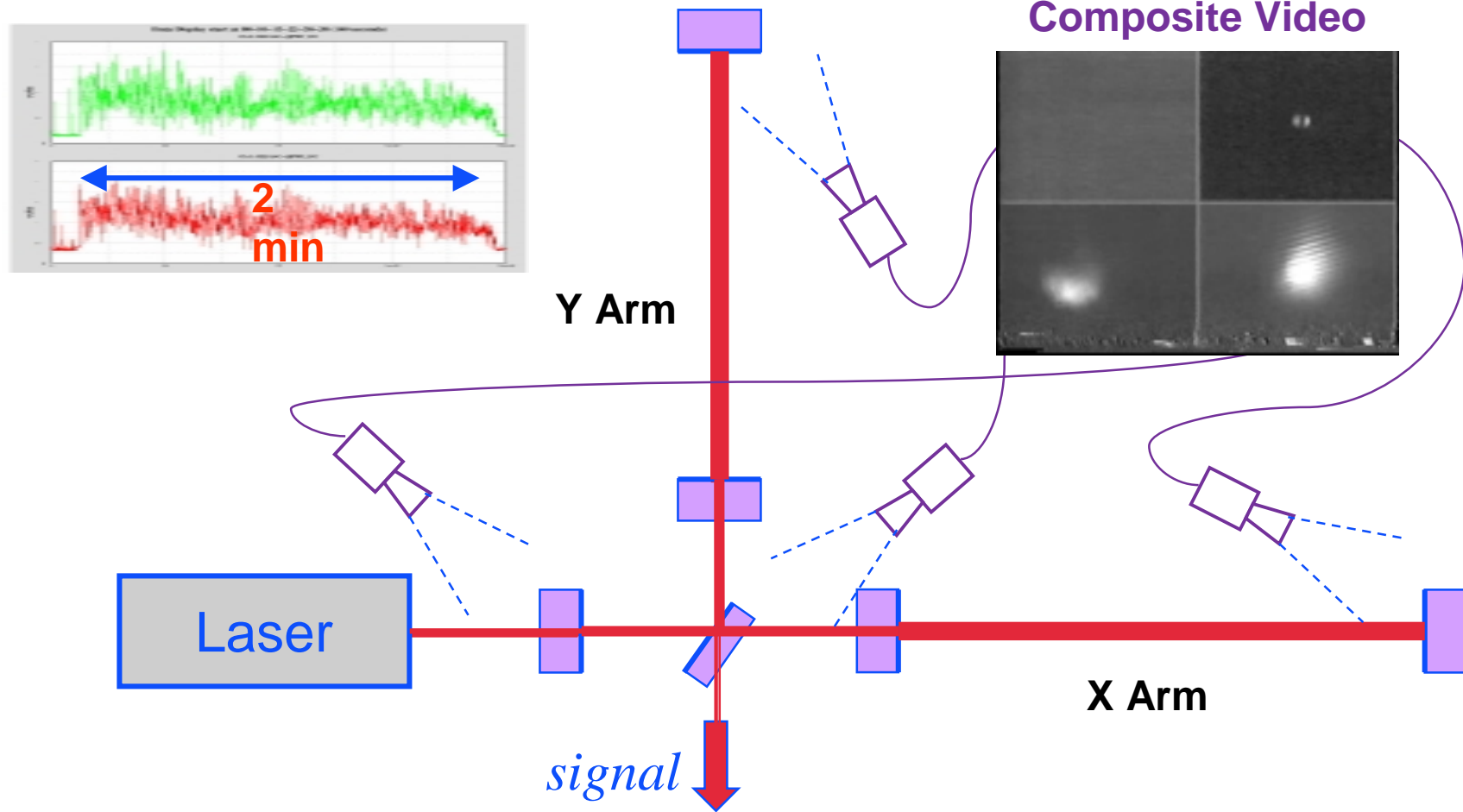


What NSF Has Done

- Through the Gravity Program, NSF has created an oversight function for LIGO
- Cooperative Agreement and Project Management Plan created the formal framework
- A **dedicated** program officer led the oversight and structured NSF review
- Semiannual project reviews during construction used a **standing** committee with slowly varying membership to provide review of progress
- Program officer employed an internal multidisciplinary team to coordinate NSF reviews and approvals with periodic meetings
 - » Gravity program, grants and agreements, legal, public affairs, government affairs, property management, budget,...



LIGO "First Lock"





LIGO Status

- Hanford 2 kilometer interferometer commissioned in final optical configuration
- Livingston 4 kilometer interferometer commissioning in recombined configuration
- Hanford 4 kilometer interferometer laser and mode cleaner commissioned with arms about to be illuminated
- Engineering runs and mock data challenges carried out
- Coincidence studies later this year
- Scientific running commences in 2002