# Managing LIGO: Lessons for a Collaboratory

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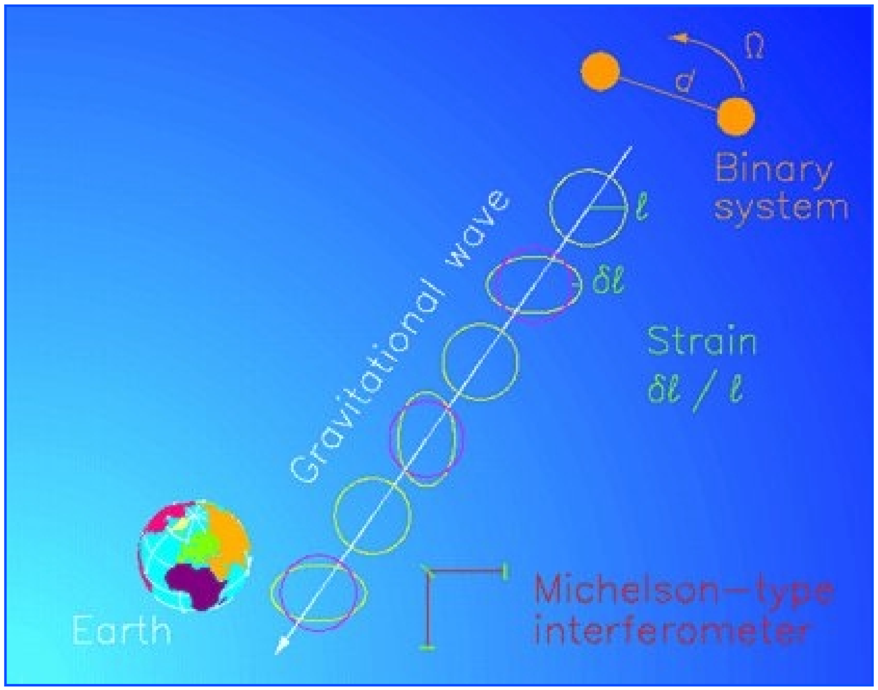
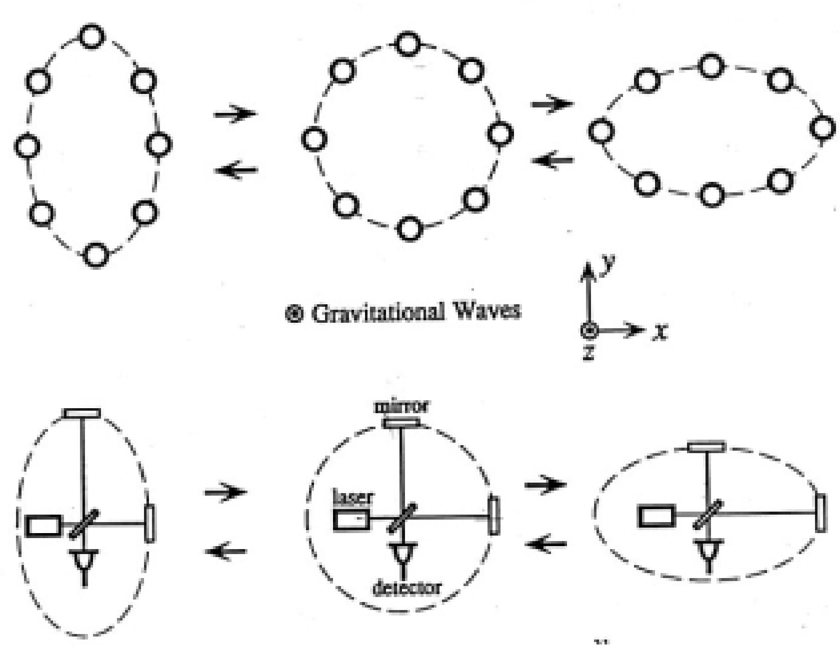
# This Talk

- Very brief overview of the LIGO project
- Observations on LIGO as a:
  - » Scientific construction project
  - » An operating central laboratory/observatory
  - » An international collaboration
- Summary comments relevant to a collaboratory

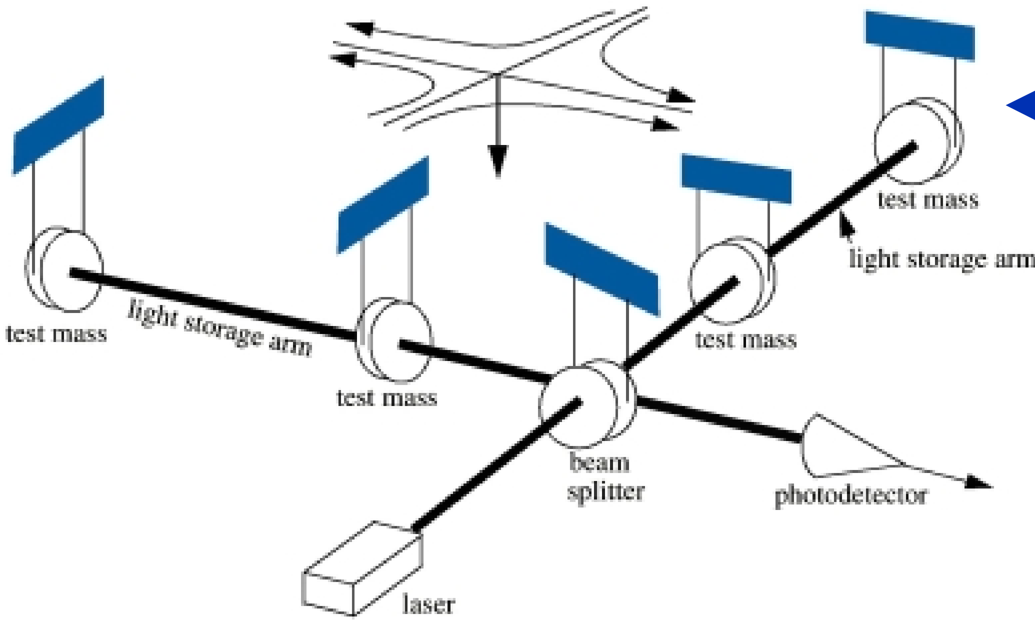
My talk to NSF “Best Practices” Workshop provided to fill in details on management of LIGO. It is available at: http://www.nsf.gov/bfa/lfp/document/sanders.ppt

# Interferometers as Detectors of Gravitational Waves



# Detection of Gravitational Waves by Interferometry




suspended test masses

**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 $10^6$ light years**

# LIGO Observatories

**LIGO (Washington)**

**LIGO (Louisiana)**

# Optics Installation

# 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
- Outside collaboration organized only as construction was nearing completion
- Collaborating community created as a new community in a new scientific field

# LIGO **Project** Work Breakdown and Organization

Work Breakdown Structure

- LIGO Project
  - Facilities
    - Civil Facilities
    - Vacuum Equipment
    - Beam Tube
    - Beam Tube Enclosure
  - Detector
    - Lasers/Optics
    - Isolation/Suspension
    - Controls
    - Env. Monitor
    - .
    - .
  - R&D
    - 40 Meter Test
    - Phase Noise Test
    - Campus Research
  - Project Management
    - Project Management
    - Cost/Schedule
    - System Engineering
    - QA/ES&H
    - Document Control
    - Computing

LIGO Project Organization

- LIGO PI and PM
  - Facilities
    - Civil Facilities
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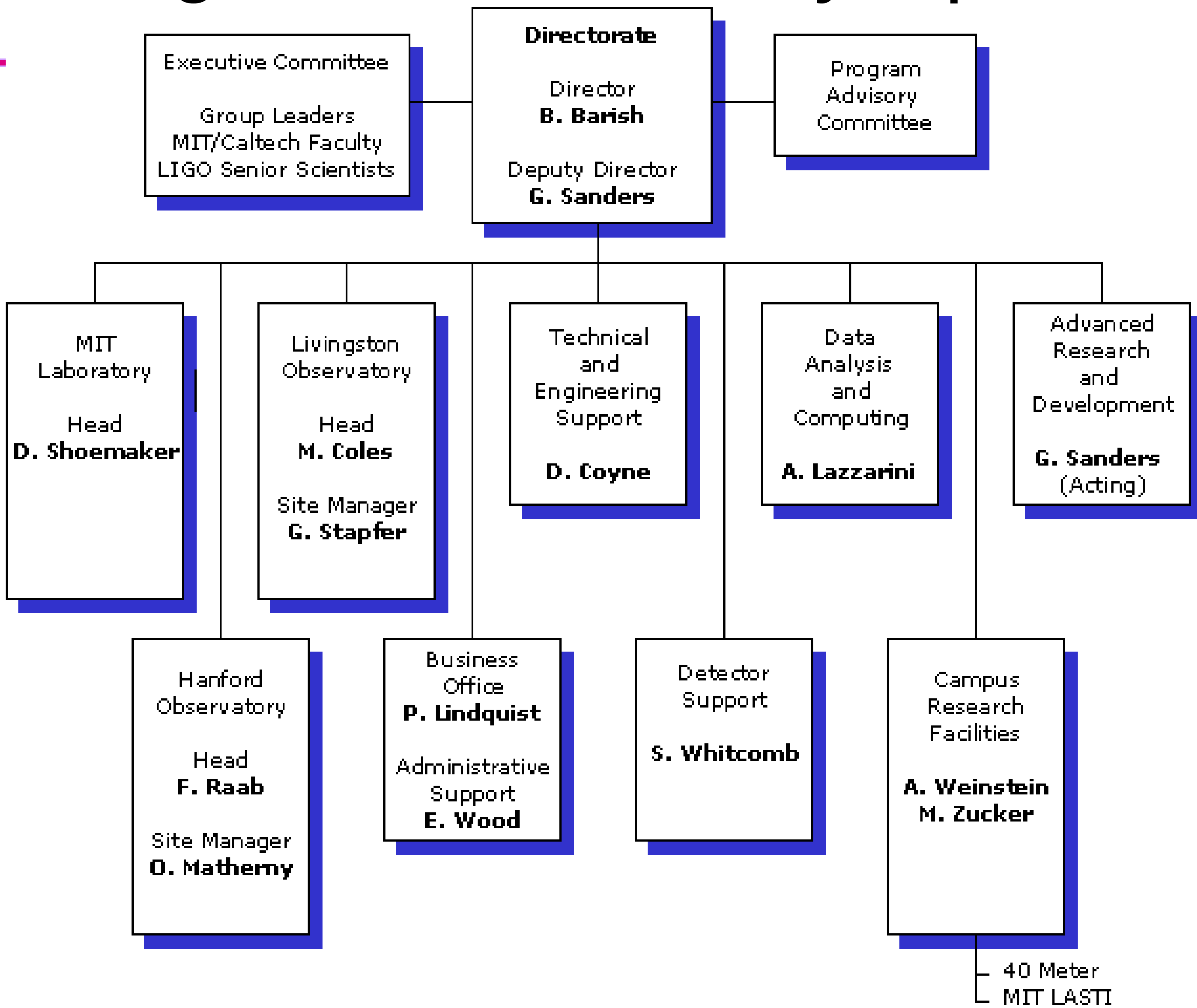
# Transitioned to LIGO **Laboratory** Organization in Early Operations



# LIGO As a Project, Laboratory and Collaboration

- LIGO construction project (1994 – 2001)
  - » Organized according to WBS deliverables, very centralized and hierarchical
- LIGO Laboratory operations (1997 - )
  - » Organized by function and observatory site, flatter organization but centralized within LIGO Laboratory
  - » LIGO Laboratory responsible for observatory operations, central data analysis infrastructure, coordination of R&D for future
- LIGO Scientific Collaboration (1997 - )
  - » 32 institutions, > 300 scientists, including LIGO Laboratory scientists
  - » LSC responsible for the science advocacy and scientific results
- LIGO global network (~2004 - )
  - » Combined observation cycles and analysis by global network of detectors
  - » Distributed and grid-based analysis leading to a laboratory without walls

# Technology Defines the Structure of Collaboration

- LIGO organized around singular and central observing detectors
  - » Leads to collaboration organized around central LIGO Laboratory
  - » Outgrowth of high-energy physics model with central accelerators and collider detectors exploited by large collaborations
  - » Only data analysis is widely distributed
- NEES, NEON organized around hierarchically similar distributed instrumentation
  - » Leads to collaboration with distributed construction, implementation and operational responsibility
  - » Central organization plays a coordinating role
  - » Central organization facilitates an integration and synthesis role

# Small Science and Big Science Measures of Succes

- Small science efforts are measured by peer review of results
  - » Intermediate process of a research group can be creative, independent, obscure and opaque
- Big Science efforts are also measured by peer review of results
  - » Intermediate process must be planned, predictable, robust, and transparent enabling ongoing assessment of progress against the plan
- Both the centralized LIGO model of collaboration, and the collaboratory model adopted by NEES, balance the big science management imperative with the imperative to support the best science driven by small investigator groups

# Final Comments

- How strong is the role of the NEES consortium principal investigator/director?
- How much will the NEES Consortium be led by consensus?
- How does funding flow and what role does the NEES director's input play in NSF program decisions?
- Enable the best science by supporting the role of consortium groups but support program effectiveness, accountability and progress by establishing a central institution.