Gravitation and Cosmology Group

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Point of departure

- Strong continued commitment to LIGO installation, commissioning, operations, management
- R&D program to help advance the field
- Growing Data Analysis initiative
- LIGO Lab plans on ~20 full-time-equivalents at MIT long-term (~present size)

Operations: Installation

Initial Alignment

- Complete at LHO 2k interferometer
- in progress for LLO 4k
- to be done for LHO 4k

Length and Alignment Controls

- IO controls tests near completion
- 2km cavity system test to start late Nov. ‘99 (analog controls)
- full interferometer tests in early spring ‘00 (digital controls, coupled cavity acquisition)

Installation general support

- 1.0 Evans, 0.25 Kruzel, other staff as needed when at Observatories

Our principal manpower commitment

- continues through early 2000
- 0.9 Zucker, 0.5 Fritschel, 0.9 Mason, 1.0 Macinnis, 0.75 Smith, 0.75 Daw, 0.25 Burgess

Operations: Shakedown/Commissioning

Physics Environmental Monitor

- environment thoroughly monitored: mechanical motion, acoustical input, electric and magnetic fields, muons, trend data (tilts, meteorological input)
- many individual sensors, throughout detector and facility
- installation near completion, start of exploitation
- 0.25 Smith, 1.0 Chatterji

Global Diagnostics

- system of software/hardware to exploit wealth of information
- goal is to characterize instrument
- requires on-line software to give operator ‘feel’ to interferometer
- test points for stimulus/response
- 0.25 Daw, 0.15 Fritschel

System Test

- inter-subsystem test, optimization
- will grow to 0.5 Fritschel, 0.25 Shoemaker

Operations: top-level and cross-system

Integration:

- facility completion, shakedown, characterization
- detector troubleshooting, independent critique, and help
- Weiss

Detector organization

- reviews, reports, presentations, internal communications
- resolution of specific problems
- Shoemaker, 0.5
- (MIT group organization/finances/etc.: Shoemaker 0.25, Holder 1.0)

Summary:

- Construction, Installation, Shakedown, and Commissioning is the overwhelming priority and commitment for the coming years of the present group
- >3/4 of the total MIT LIGO group budget, >3/4 of the manpower
- ~1/4 of our staff at observatories on average

Research and Development

Imperative to maintain a significant research activity on campus

- principal connection to academic environment, education
- creation of next generation of GW scientists
- infrastructure/expertise to jump on problems found in the field

Near-term R&D activity must be secondary to LIGO I

- the schedule (and our hearts) demand it
- must not lose critical minimum level of effort

Group interest/expertise broad

- veterans of many large and small interferometry development programs
- tabletops, MIT 1.5m, MIT 5m, Garching 30m, Caltech 40m, LIGO 4km
- configurations, optics/lasers, suspensions/isolation, controls/systems

R&D focussed on LIGO II:

- coordination of LSC activities
- study and selection of readout or sensing system for signal recycled interferometer, photodiode development
- development of technique for thermal lensing correction
- development of 'stiff' seismic isolation system as candidate
- **establishing infrastructure and background experiments to enable development and test of full-scale mechanical systems for LIGO II**

LSC coordination

Weiss: Spokesperson

- in ‘98, focussed on establishing structure, Technical Working Groups
- ‘99: focus on Data Analysis Working Groups, White Paper

Shoemaker: Suspension/Isolation Working Group chair

- development of shared vision of suspension
- continuing effort to build consensus on best isolation design
- coordination of work on LIGO II concept, ‘99 Technical White Paper

Anticipate both of these roles to continue

- as LIGO II evolves, find the correct ‘managed R&D’ and project roles

Sensing systems for LIGO II

Motivations for a different scheme

- mirror at interferometer output requires positioning to ~lambda/100
- present LIGO I system has high sensitivity to laser light defects

Several schemes under experimental test

- Caltech, ANU, University of Florida: tabletops
- Garching: simple suspended interferometer

Interesting option: simple offset from dark fringe

- greater sensitivity to some noise sources
- simplicity may lead to this option
- (figure of some readout scheme)

Activity of Interferometer Configurations Working Group

- Peter Fritschel taking LSC lead in selecting a sensing scheme, organizing group to evaluate and recommend

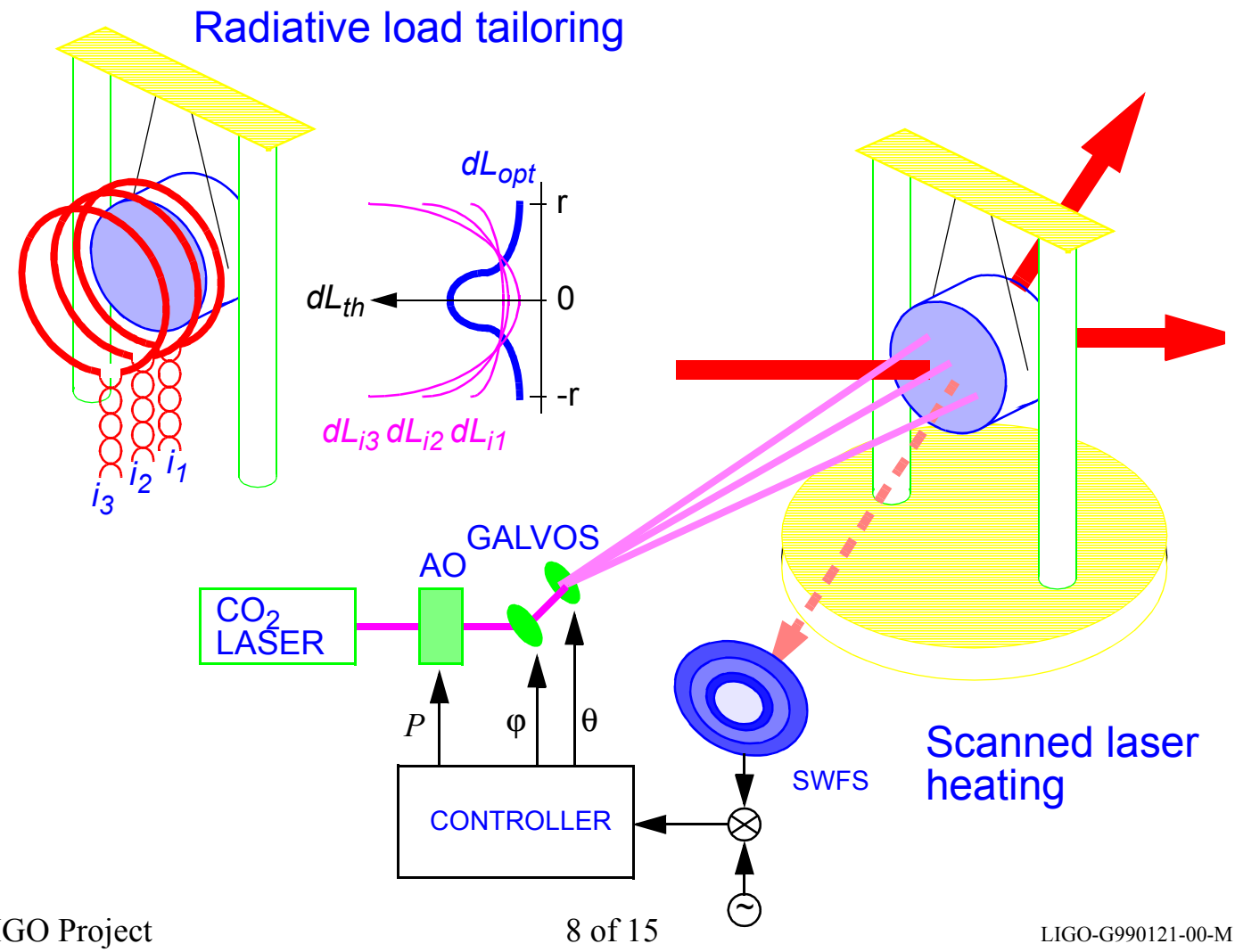
Sensing 'Sensor': Photodiodes

- increased power implies much increased photodetector demands
  - › light power handling
  - › dynamic range
- continued collaboration with Stanford on back-illuminated system
- Adhikari (G) with Zucker

Adaptive Optics

Thermal focussing due to substrate and coating absorption

- Several thermal effects foreseen:
  - › cavity mode distortion --> poor coupling
  - › differential cavity mode mismatch --> contrast defect
  - › recycling cavity sideband loss for power-recycled Schnupp scheme
- LIGO I sees thermal effects at 10 W laser power; 180 W for LIGO II
- Complementary heating approach under test by Ryan Lawrence (G)



‘Stiff’ Seismic Isolation

The servo-control lover’s approach to quiet platforms

- low-noise sensors mounted on each of two nested stages
- voice-coil actuators to apply forces
- digital multiple input/output servo system
- performance limited by sensor noise

Risks

- less well developed than the alternative VIRGO-like design
- prototypes to date not ‘robust’ or carefree (required hand-trimming etc.)
- noise performance, product of servo gains, and configuration all near or at limit of specifications and experience

Advantages

- flexible; attenuation can be modified after-the-fact (outside of vacuum) for operational modes, suspension transfer/control complexities, etc.
- provides quiet table for flexible placement of optics
- has high stiffness: ease in installing, aligning optics; allows reaction forces from suspensions to be exerted; allows multiple non-interacting loads
- similar designs for HAM and BSC chambers possible, saving design effort

‘Stiff’ Seismic Isolation

Prototype in development

- MIT taking lead for servo design and test
- JILA leading development of mechanical structure

Sensors

- Streckeisen 3-axis long-period seismometers in procurement

Actuators

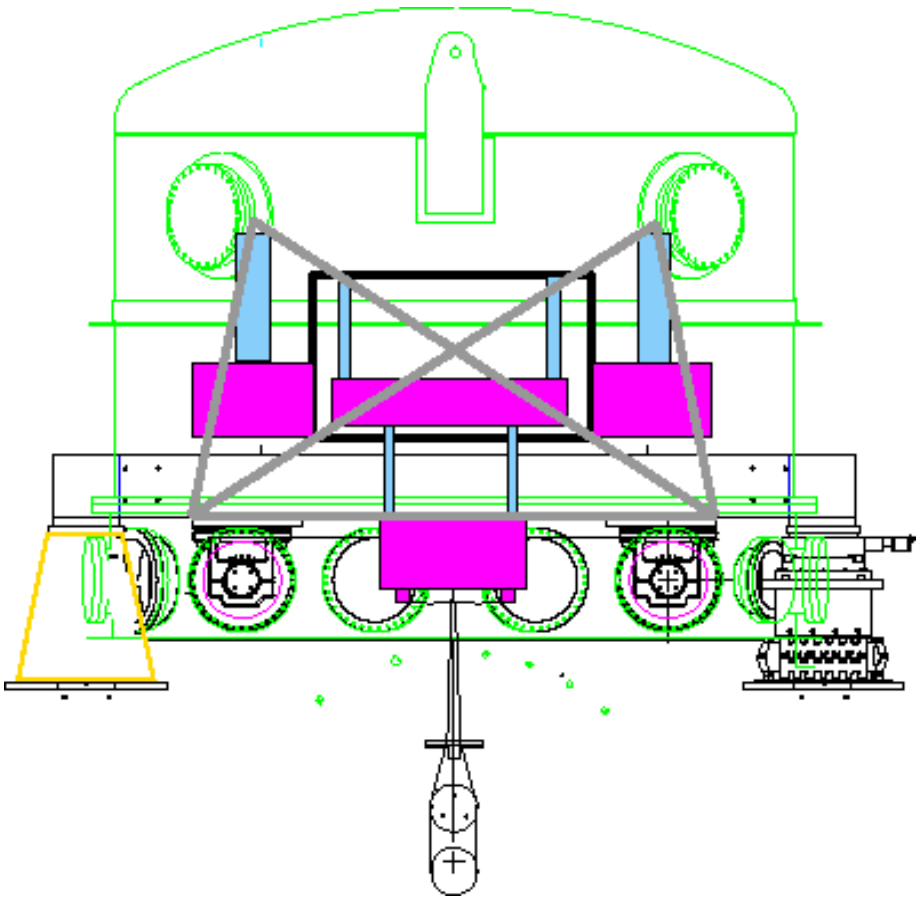
- in discussion with BEI for vacuum-compatible voice-coil systems

Controllers

- ‘d-SPACE’ system (Matlab-interfaced real-time servo controller)

Modeling/Design

- Sam Richman, Jon How (to join MIT Aero/Astro faculty) in concert with LSU, Stanford



Seismic Isolation/Suspension Test

LIGO **A**dvanced **S**ystem **T**est **I**nterferometer

- Opportunity, Responsibility
- tests of both isolation and suspension systems for LIGO II
- capability of supporting development of these systems
- need to provide infrastructure

LASTI role in the LSC Working Group development plans

- the one place where full-scale prototype tests are possible

LASTI role in the Lab development/installation plans

- first article tests, tests of installation hardware, training of installation staff

LIGO II more aggressive in performance; impact on LASTI

- greater sensitivity requires more capable sensing system
- test mass chambers (BSC) and multipurpose chambers (HAM) require similar isolation -- and test
- complete replacement of the in-vacuum isolation system planned
- time scale for development/test short for scale of planned changes

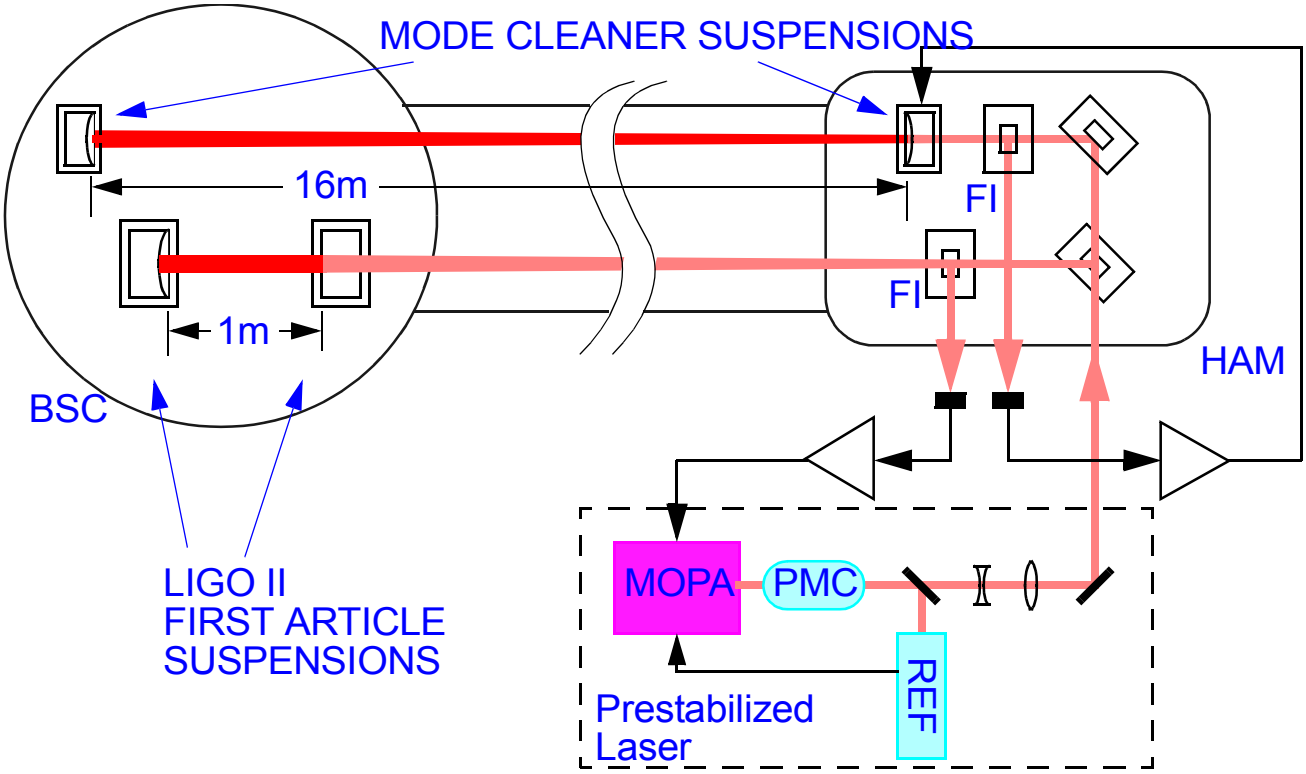
What does this mean?

- thrust in MIT group to get infrastructure designed and installed
- focussed request for additional R&D funding for LASTI
- greater importance of direct LSC participation (FTEs, not encouragement!)

LASTI Isolation/Suspension tests

Functions

- tests of HAM, BSC isolation systems
- tests of Mode Cleaner, Test Mass suspensions
- test of hierarchy of mechanical control from test mass outward
- as little optics/interferometry as is needed



Concept

- long cavity - short cavity approach used in Thermal Noise Interferometer (and elsewhere)

LASTI Status/Schedule

Status

- vacuum chambers in place (Just Downstairs!)
- pumping system in assembly, completion/test in ‘99
- external seismic structures received, installation to start once pumped
- internals (support beams, HAM tables) in fabrication

Schedule as per LSC 99 White Paper, LIGO Lab Concept

- 4Q99: envelope commissioned
- 1Q00: external structures installed
- 2Q00: infrastructure design review
- 3Q01: infrastructure complete
- 1Q02: prototype installation complete
- 3Q02: servo controls locked
- 1Q03: controls test review
- 2Q03: noise prototype installed
- 3Q03: noise performance test review
- 1Q04: final test review
- 1Q04: first article installation starts
- 3Q04: first article tests complete

Research and Development

LASTI the principal focus

- will ultimately bring all expertise of group together
- final system tests of advanced isolation will require displacement sensitivity of LIGO II
- any configuration issues appropriate also can be tested

Parallel developments on smaller scales

- thermal focus compensation central to LIGO II design
- development of higher current photodetectors on horizon
- configuration studies to complement experiments

New faculty will contribute/complement plan

- may find interests match and can play considerable role in LASTI
- may add new interests which give new dimension to lab

Collaborative effort necessary and desirable

- significant contributions from all of LSC needed to carry out plan

Data Analysis

New faculty central to plan in this domain

- present efforts are in characterization of the instrument
- connection with astrophysics to come from new appointment

Staff to get started

- looking for postdoc and scientist; Daw and Sylvestre (G) working on issues

Scenario for evolution of data analysis in first years of operation:

- Gaining a detailed understanding of the instrument performance
  - › **what is the quality of the data coming out of the instrument?**
  - › establishing the stationary noise, and the slow variations
  - › **what kinds of impulsive events are generated in the instrument?**
  - › catalog of transients
  - › statistics & rates of transients
  - › correlations with auxiliary channels; vetoes
  - › explanation of the noise behavior: performance connected to known noise sources through modeling of the system
- Searching for anomalies (detection!) in the data
- Progress towards 'reduced data sets'– learning what data is necessary to store; what can be stored based on triggers

Initially, technical analysis (present expertise) and scientific analysis (desired activity) will be indistinguishable