# LIGO Lab ‘Stochastic Forces’ Research

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**Research that targets physical motions of the test masses**

- thermal noise
- seismic noise
- ‘excess’ noise - e.g., stress release
- control forces and hierarchies to allow interferometer ‘locking’ and operation

**Principal focus: LIGO II, ~2003**

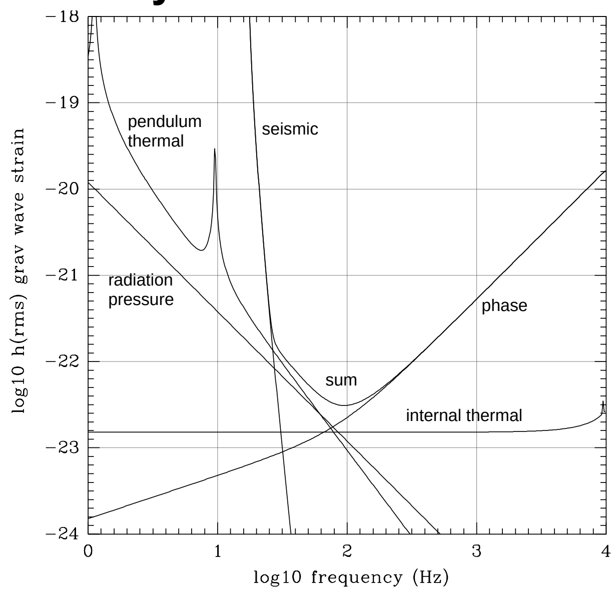
- double pendulum suspension for test mass
  - › possible changes in test mass material (sapphire??)
  - › certainly changes in fibers (probably fused quartz)
- associated changes in rest of system
  - › some damping/taming of LIGO I passive isolation
  - › active isolation, probably external to vacuum
  - › control hierarchy to get signals away from test masses

**Collaboration an important aspect of this work**

- GEO, Stanford, JILA, Syracuse, PSU, LSU, Moscow
- our plan designed to be complementary
- capitalize on LIGO experience and infrastructure

# Structure of LIGO Lab effort

**1) Approach problem from a 'systems' view**




- establish the performance requirements (baseline: 'Advanced Subsystems')
- determine the site environment, constraints from existing systems
- learn what is good in present LIGO suspension designs
- learn from collaborators what conceptual designs work

**2) Modeling**

- combine environmental info, LIGO I suspension characterization, concepts
- refine concepts; special effort to reduce/eliminate test mass actuation
- generate design questions to be answered by experiments

**3) Control and configuration prototyping:**

- build up low-performance partial suspension prototypes, in-air or bell jars
- tests for actuation, dynamics, practical questions (alignment)

# Prototype studies of thermal/excess noise

**Trial designs need noise testing at design sensitivity**

- creaking, actuator noise/coupling, and thermal noise

**Special purpose interferometer**

- targets displacement noises
- designed to suppress sensitivity to environment
- no attempt to reach phase or strain sensitivities; not a michelson

**Configuration**

- short (mm) test cavity, longer referece cavity to hold down frequency noise
- built inside single vacuum chamber, on common seismic isolation ‘stack’
- will test partial suspension systems in iterative development phase

Figure?

# Testing of Suspension Systems

### Systems are a key issue in suspension design

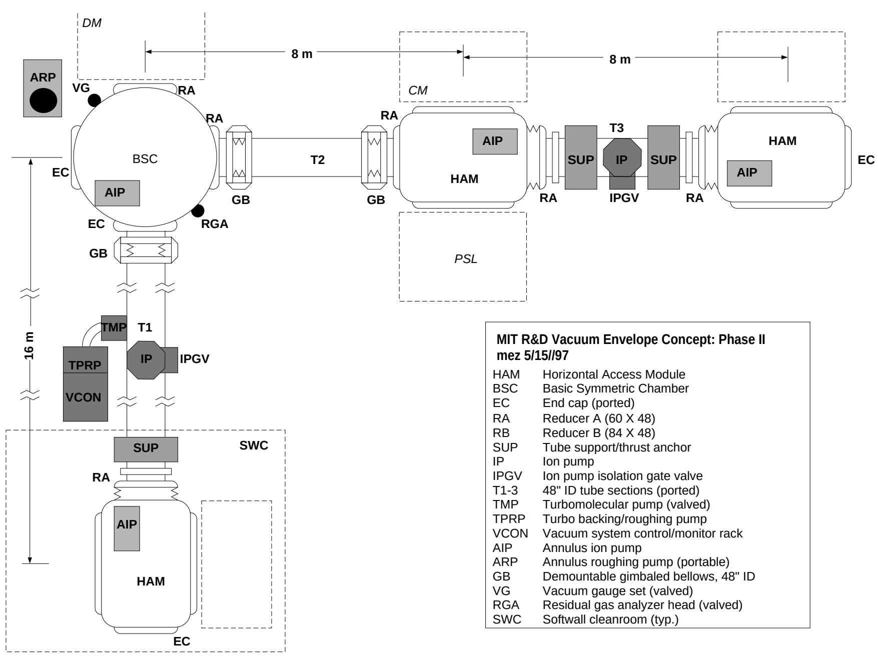
- some tests must include the dynamics of the entire isolation system
- scaling laws helpful, but actual placement of resonances, coupling critical
- need a test facility which includes all LIGO components from ground up

### Full-scale tests of prototypes

- single suspensions for actuator, control tests
- pairs of suspensions for transfer functions, pointing
- complete interferometers for end-to-end tests, including noise performance

### Pre-installation testing

- as a ‘last stop’ before LIGO
- minimize down time at the sites; practice installation and debugging



# Milestones

**Significant milestones in design process**

- establishing requirements, interfaces, design constraints (~now)
- determining the state of the art, lessons from initial LIGO
- conceptual design (1998)
- construction and test of lab prototypes of aspects of design (1999)
- initial complete prototype testing (2000)
- test of final design (2001)
- qualification of suspensions to be installed (2002)