Pacific Conference on Gravitation and Cosmology

Seoul, Republic of Korea
February,1996

LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY

PROGRESS REPORT ON LIGO

GARY SANDERS
CALIFORNIA INSTITUTE OF TECHNOLOGY

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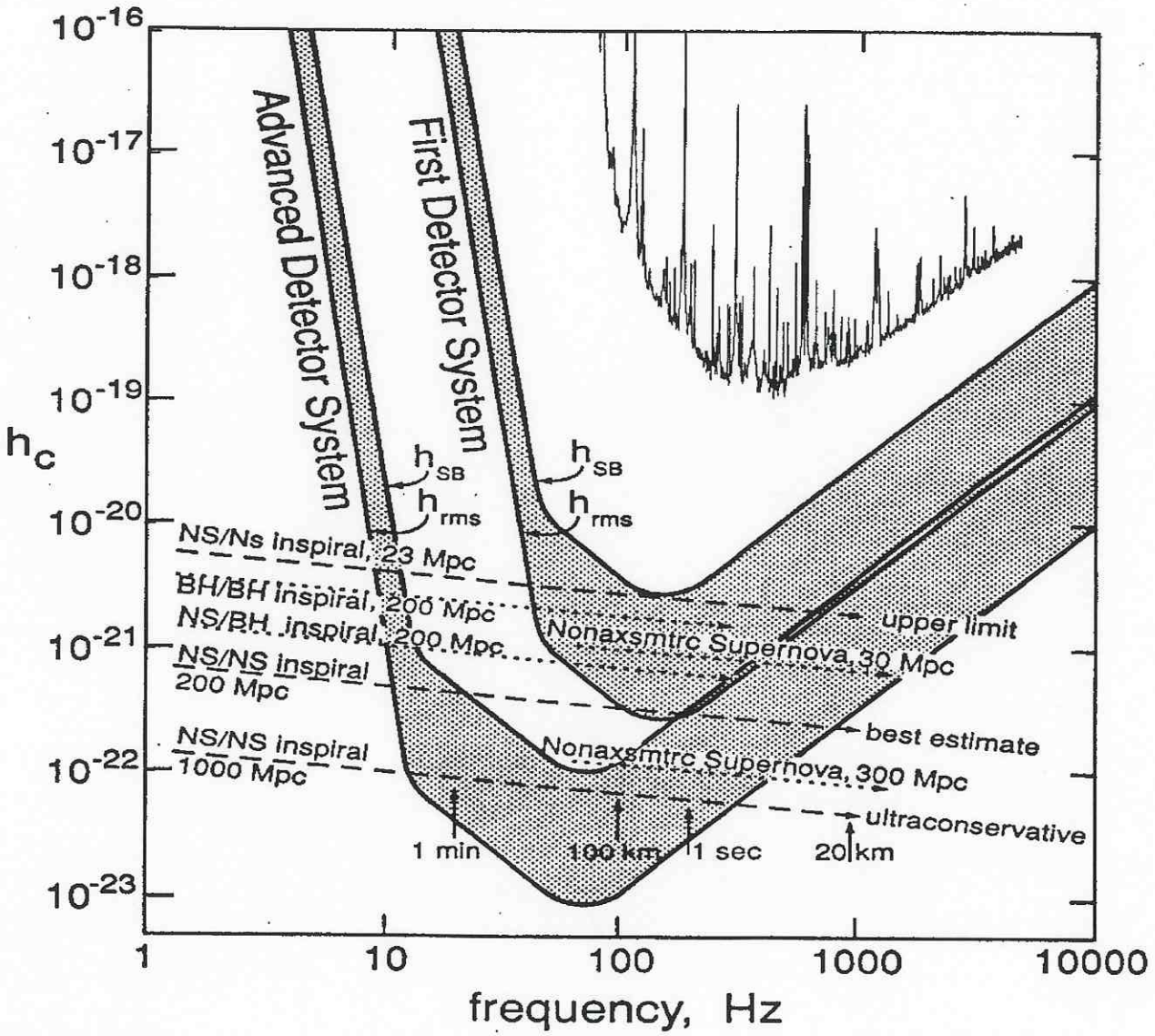
LIGO DETECTOR SPECTRAL NOISE DENSITY



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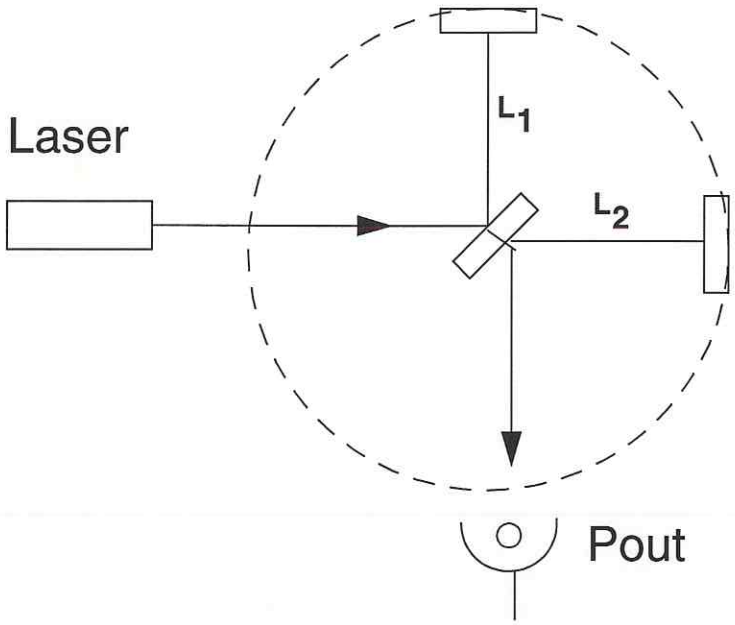
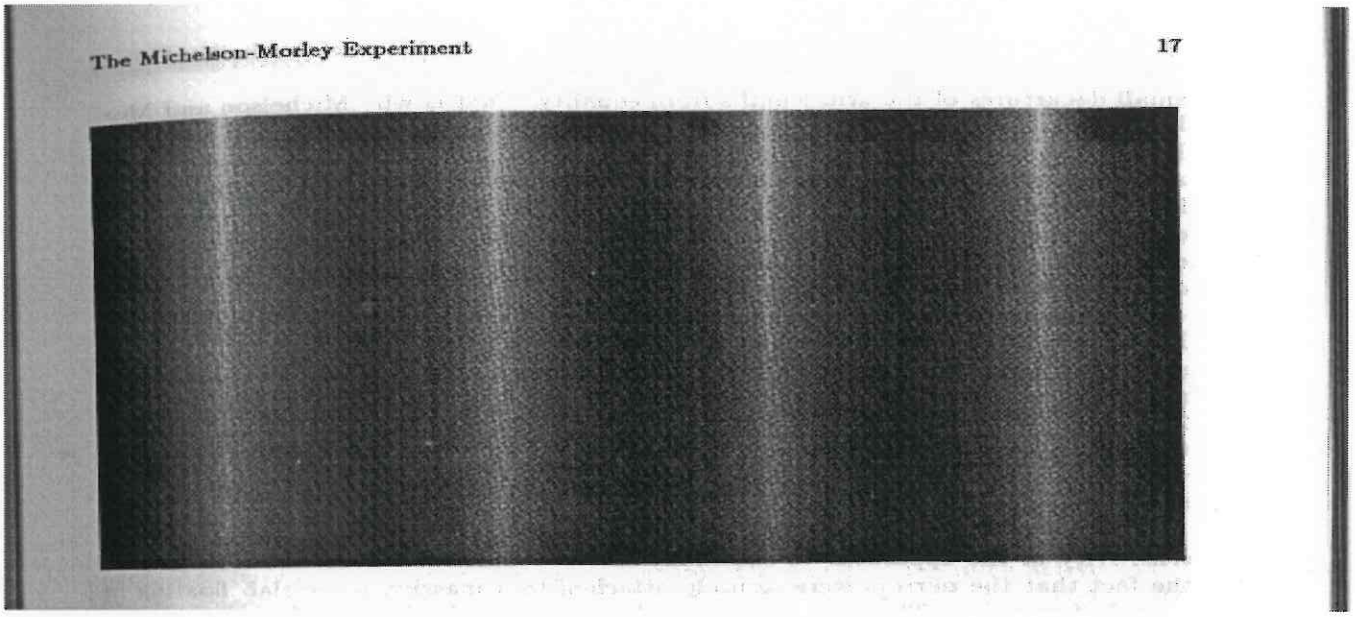
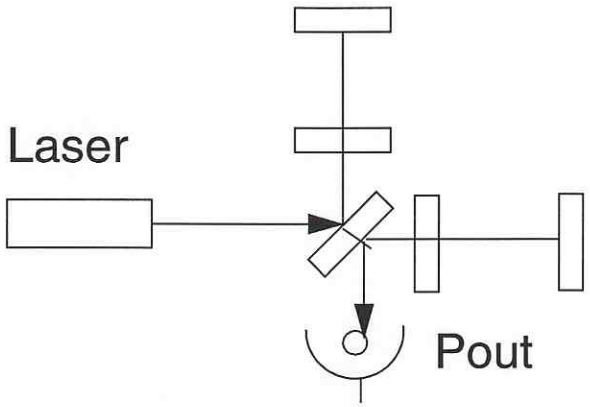
MICHELSON INTERFEROMETER





FABRY-PEROT INTERFEROMETER



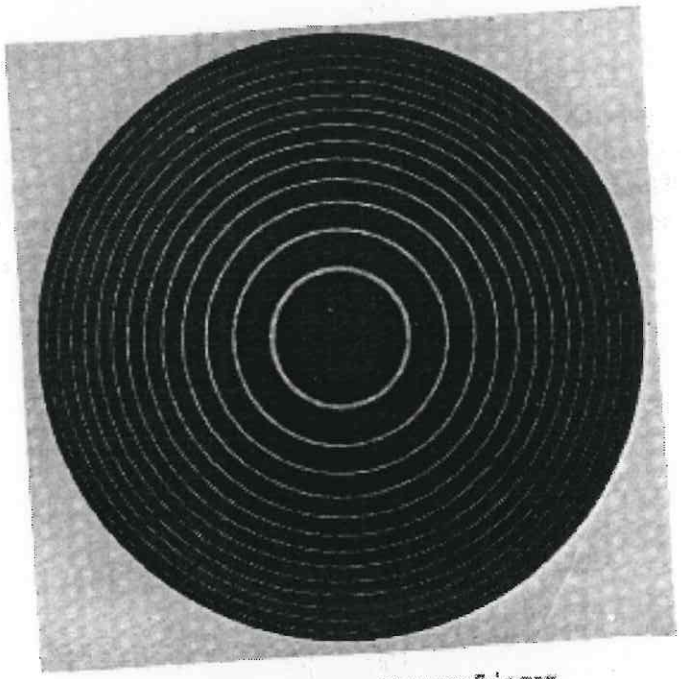
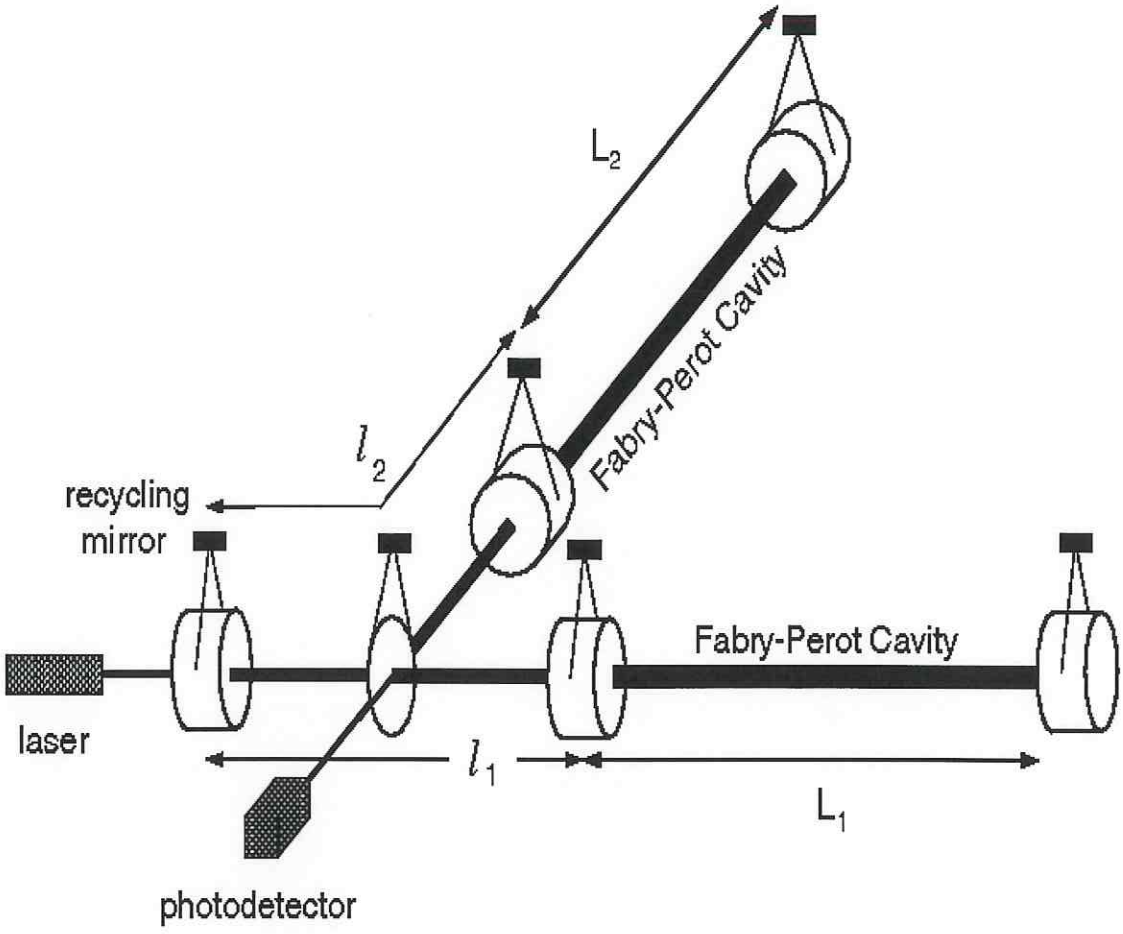


Fig. 7.60. FABRY–PEROT fringes.

LIGO INTERFEROMETER CONFIGURATION



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LIGO SITES

HANFORD, WASHINGTON

- LOCATED ON U.S. DOE RESERVATION
- TREELESS, SEMI-ARID HIGH DESERT
- APPROX. 25 KM FROM RICHLAND, WA (POPULATION :140,000)
- **TWO INTERFEROMETERS (4 KM, 2KM) LOCATED AT THIS SITE**

LIVINGSTON, LOUISIANA

- LOCATED IN FORESTED RURAL AREA
- MIXED FOREST; LOW-LYING; POOR DRAINAGE
- APPROX. 50 KM FROM BATON ROUGE, LA (POPULATION :450,000)
- **ONE 4 KM INTERFEROMETER LOCATED AT THIS SITE**

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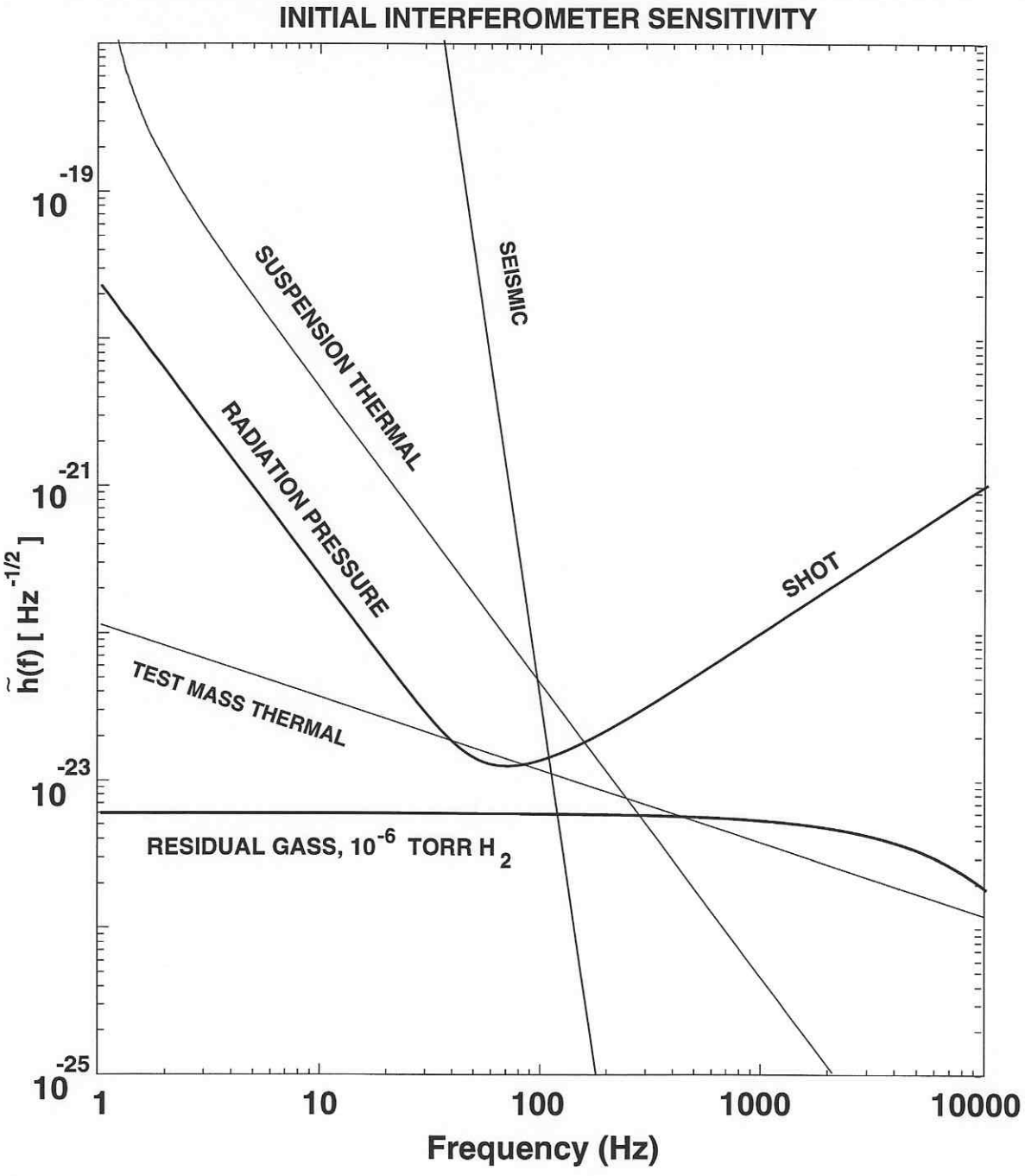
INITIAL DESIGN PERFORMANCE GOAL



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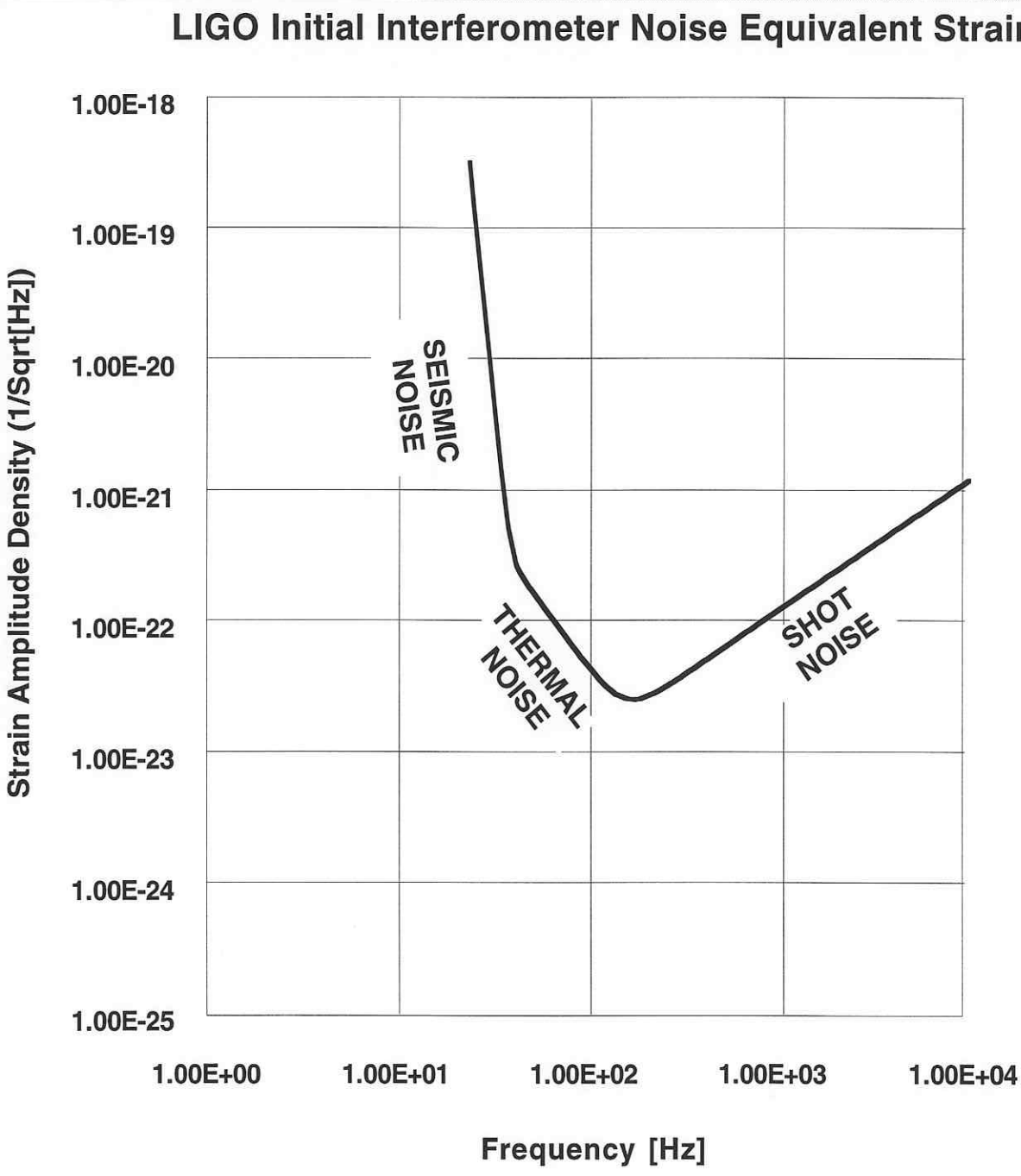
INITIAL DESIGN PERFORMANCE GOAL



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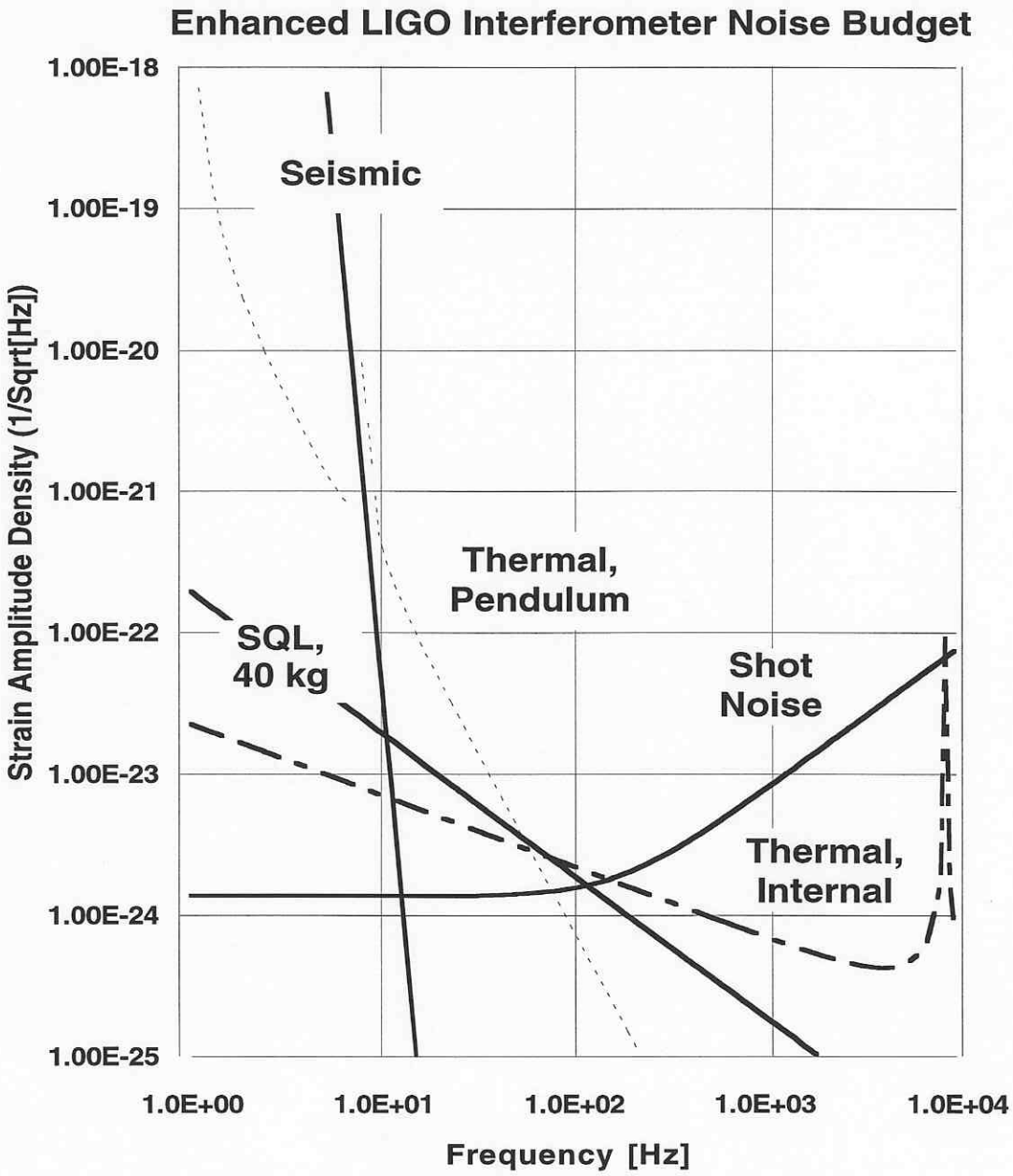
ADVANCED DESIGN PERFORMANCE GOAL



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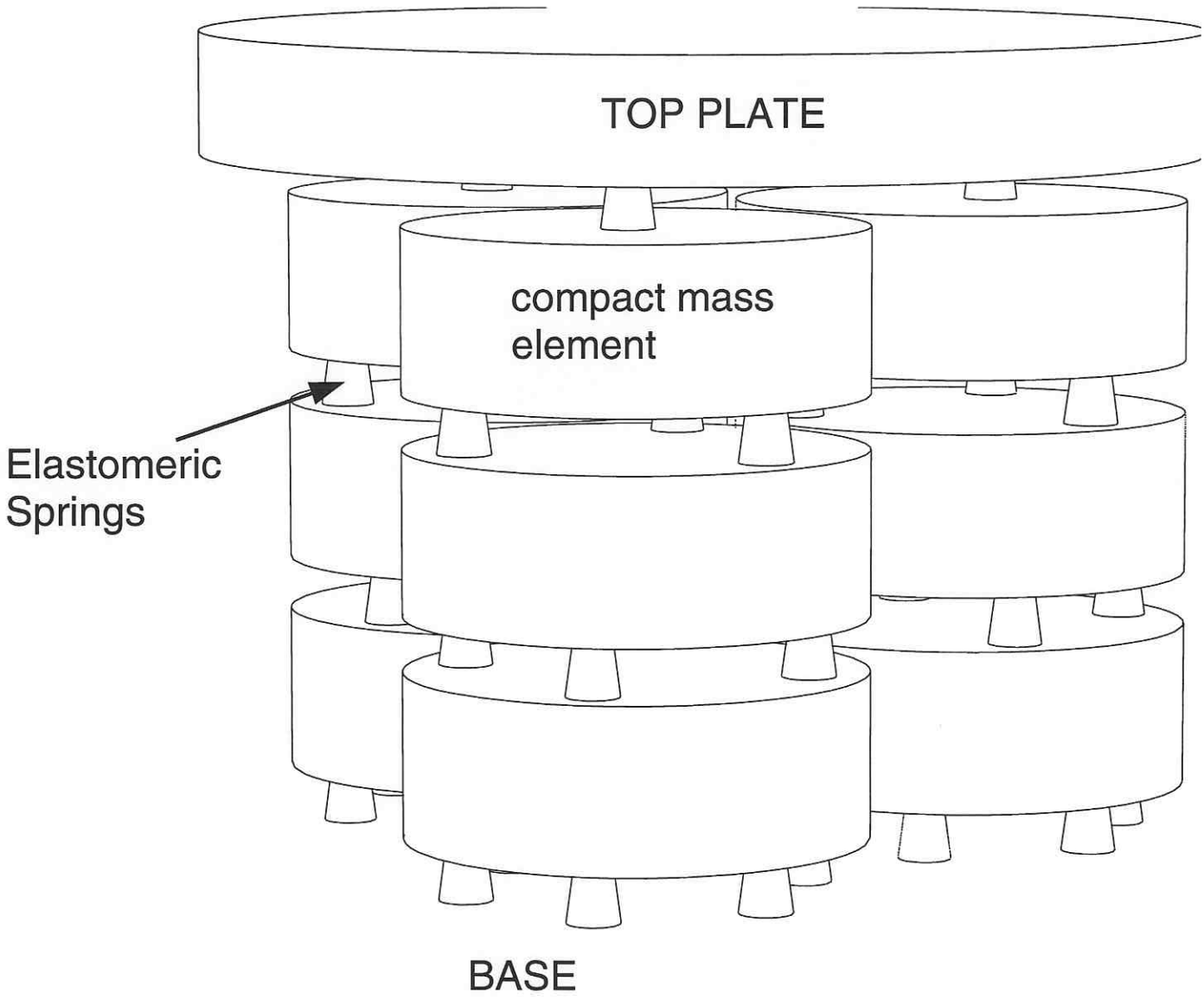
SEISMIC ISOLATION



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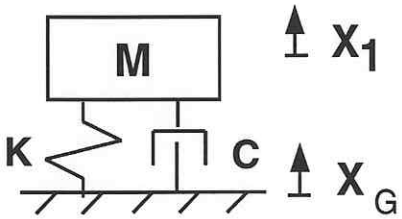
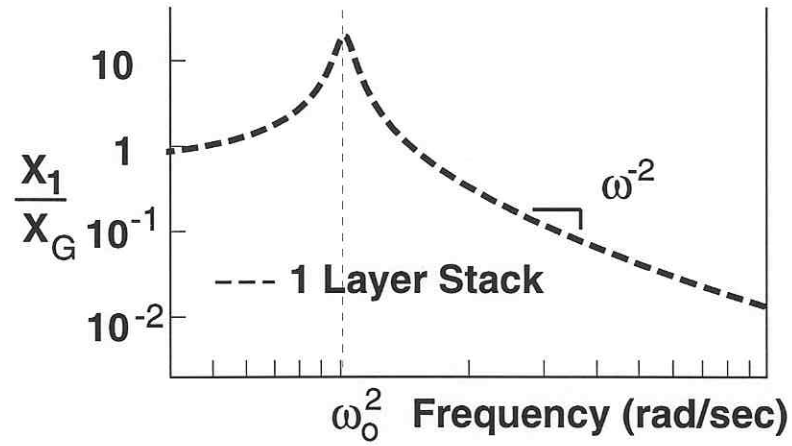
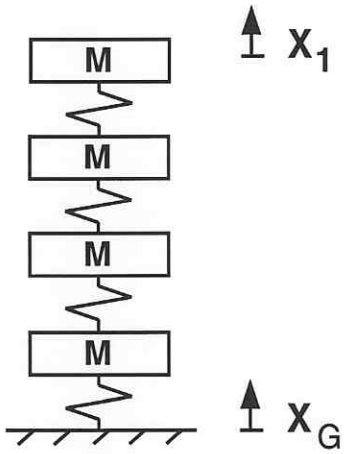
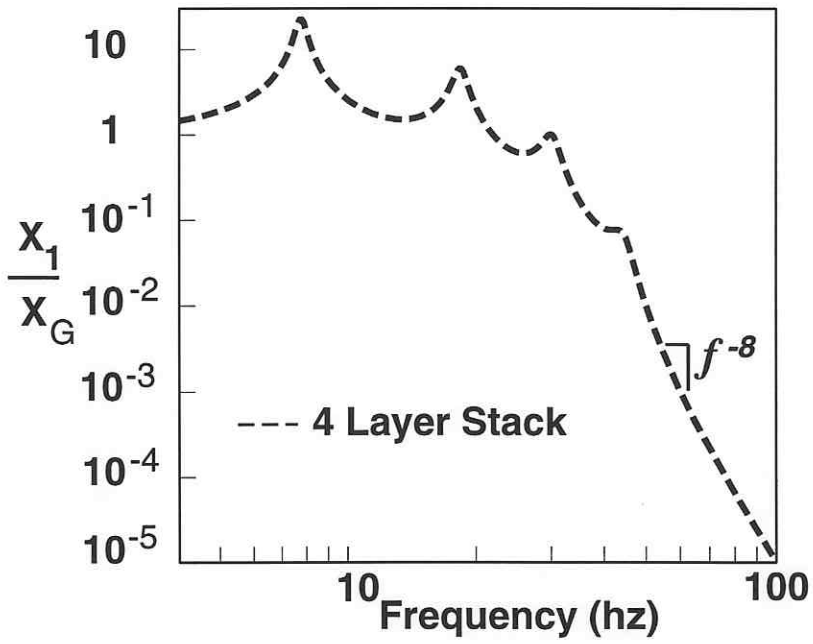
SEISMIC ISOLATION







Simple Model of Mark 2 Stack Isolation (vertical)



SEISMIC ISOLATION

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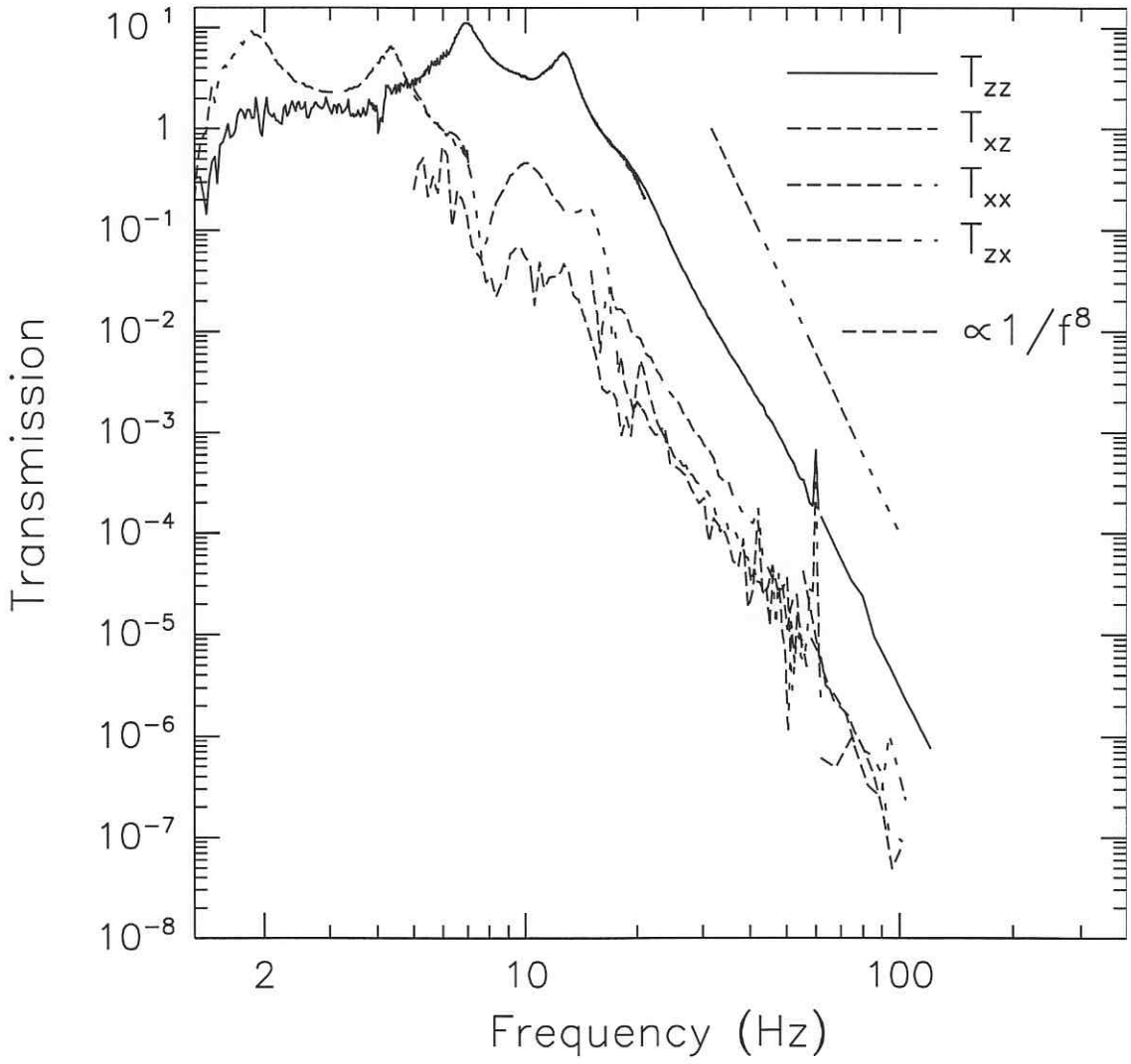
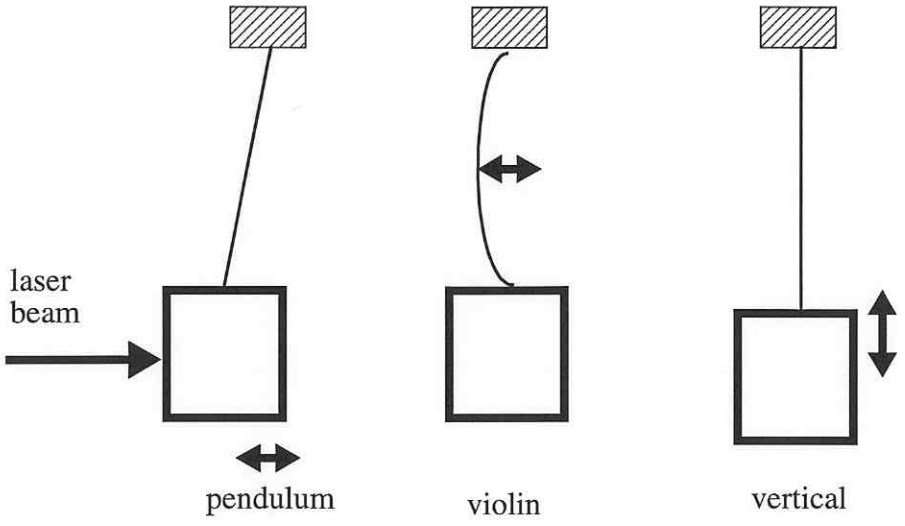
SEISMIC ISOLATION



SUSPENSION THERMAL NOISE



"EXCESS" SUSPENSION THERMAL NOISE

Moscow State

Braginsky et al.

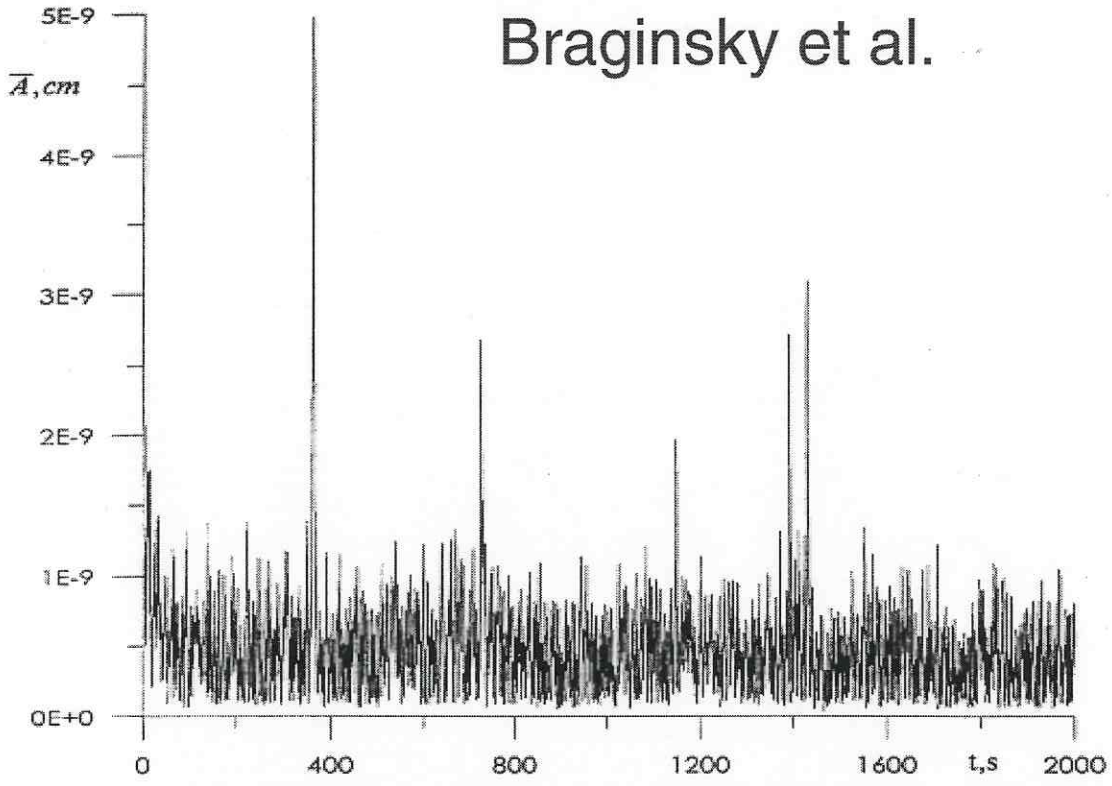
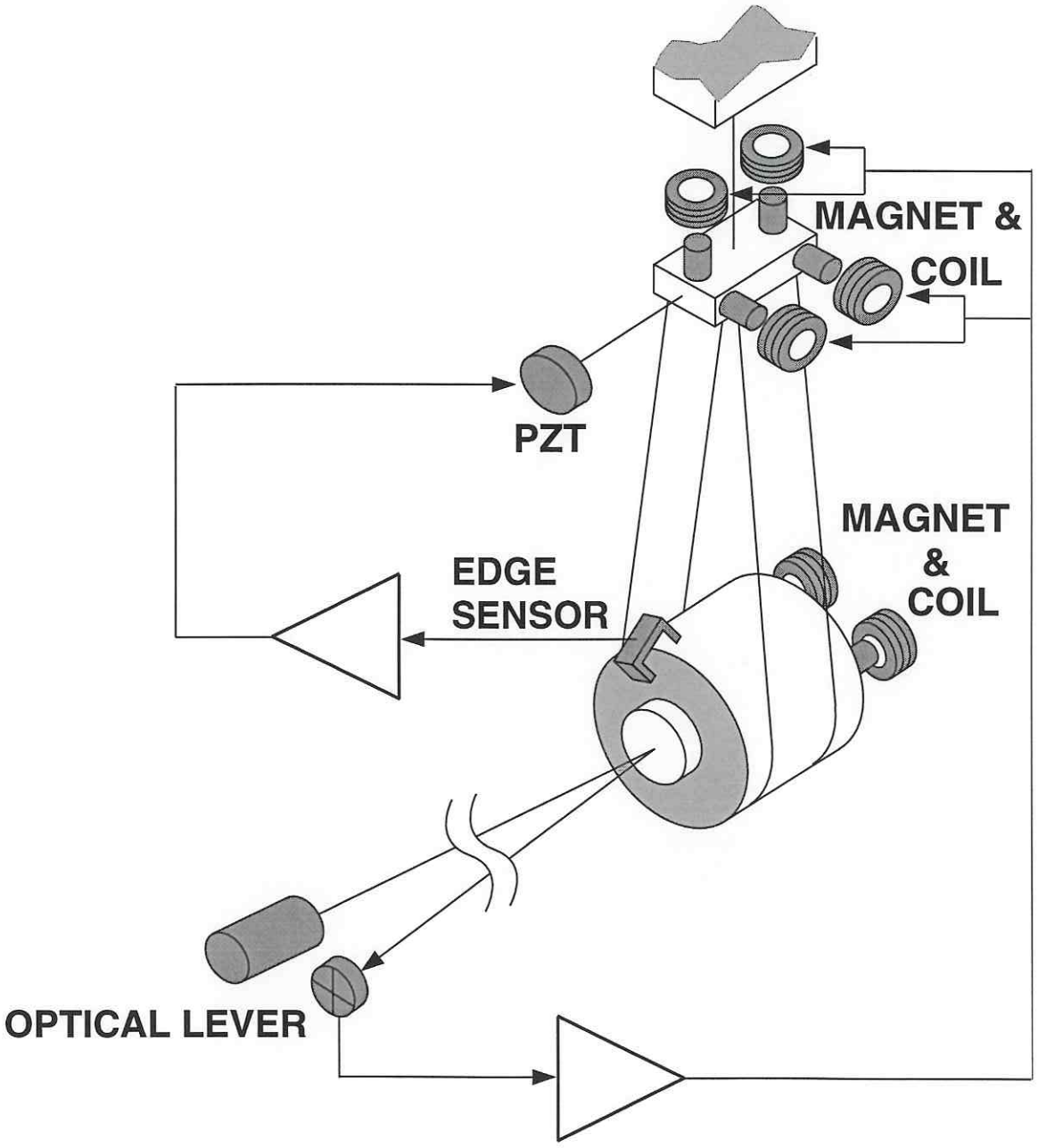


Fig. 5. Fragment of the record of noise oscillation of tungsten wire

TEST MASS SUSPENSION



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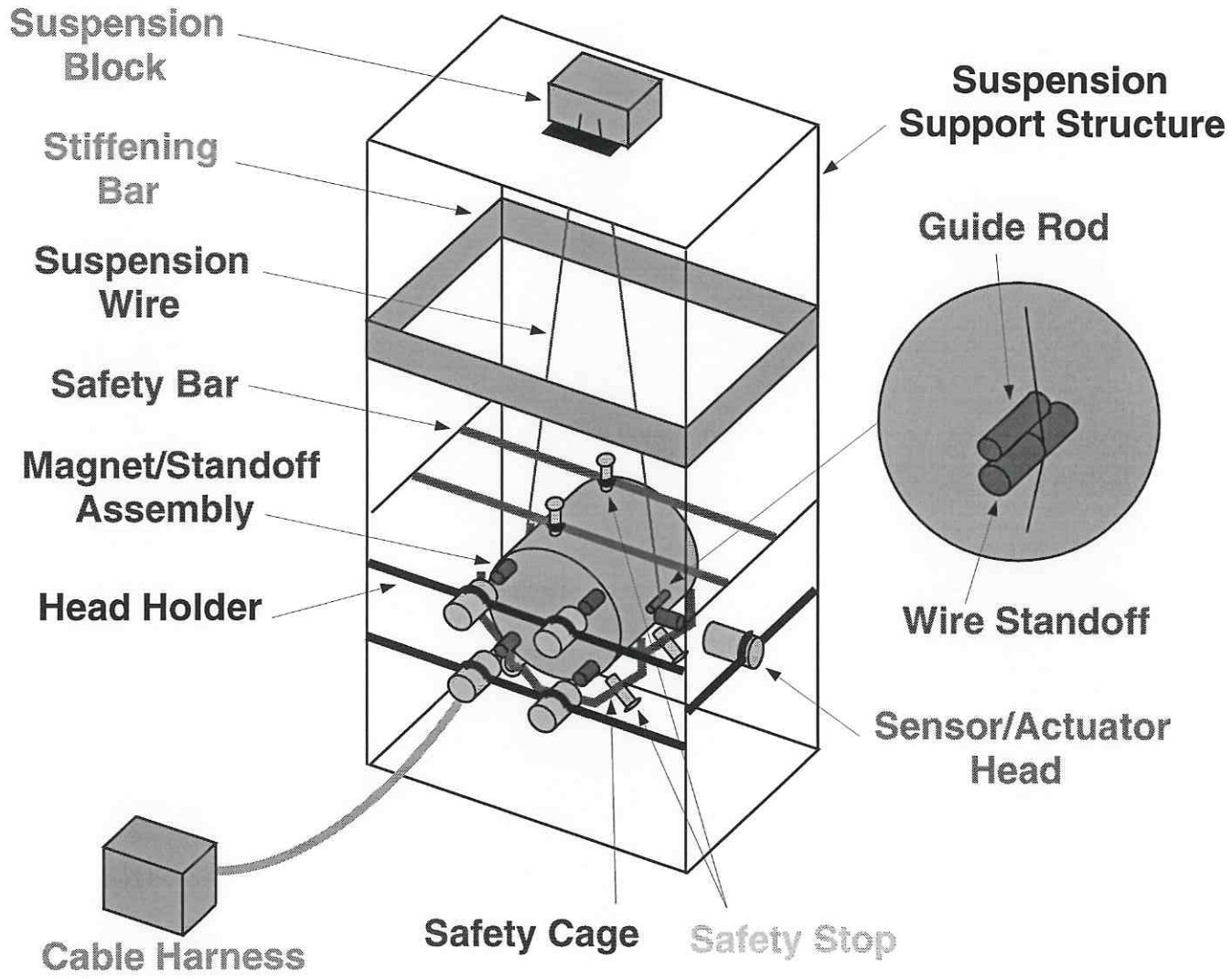
TEST MASS SUSPENSION



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40 METER AND LIGO TEST MASSES

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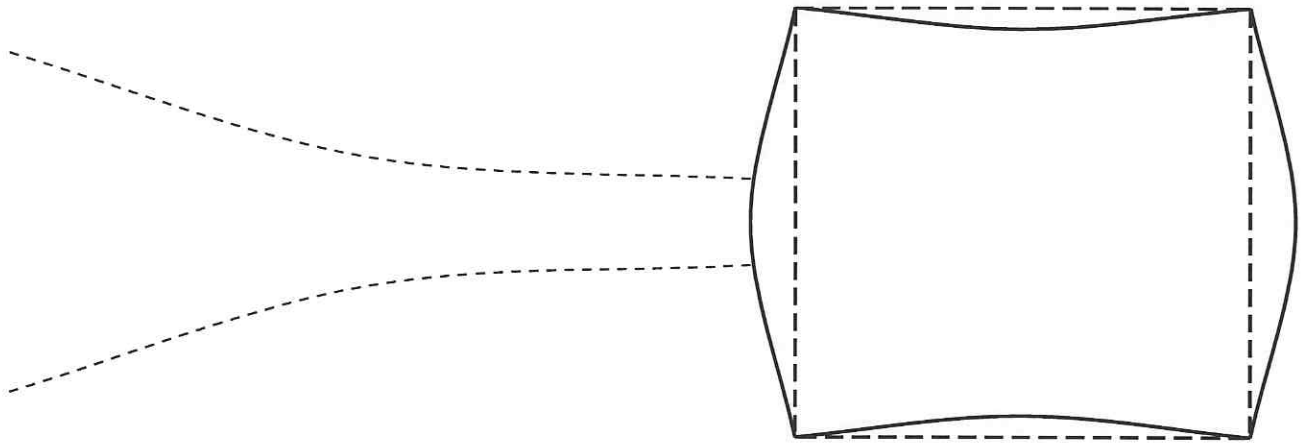
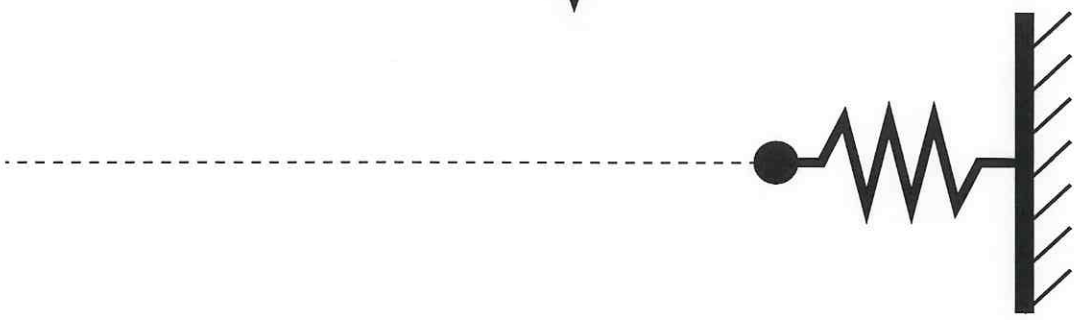
TEST MASS INTERNAL THERMAL NOISE



optical mode: $\psi(\rho,\theta,z)$
wave vector: $\vec{k}$

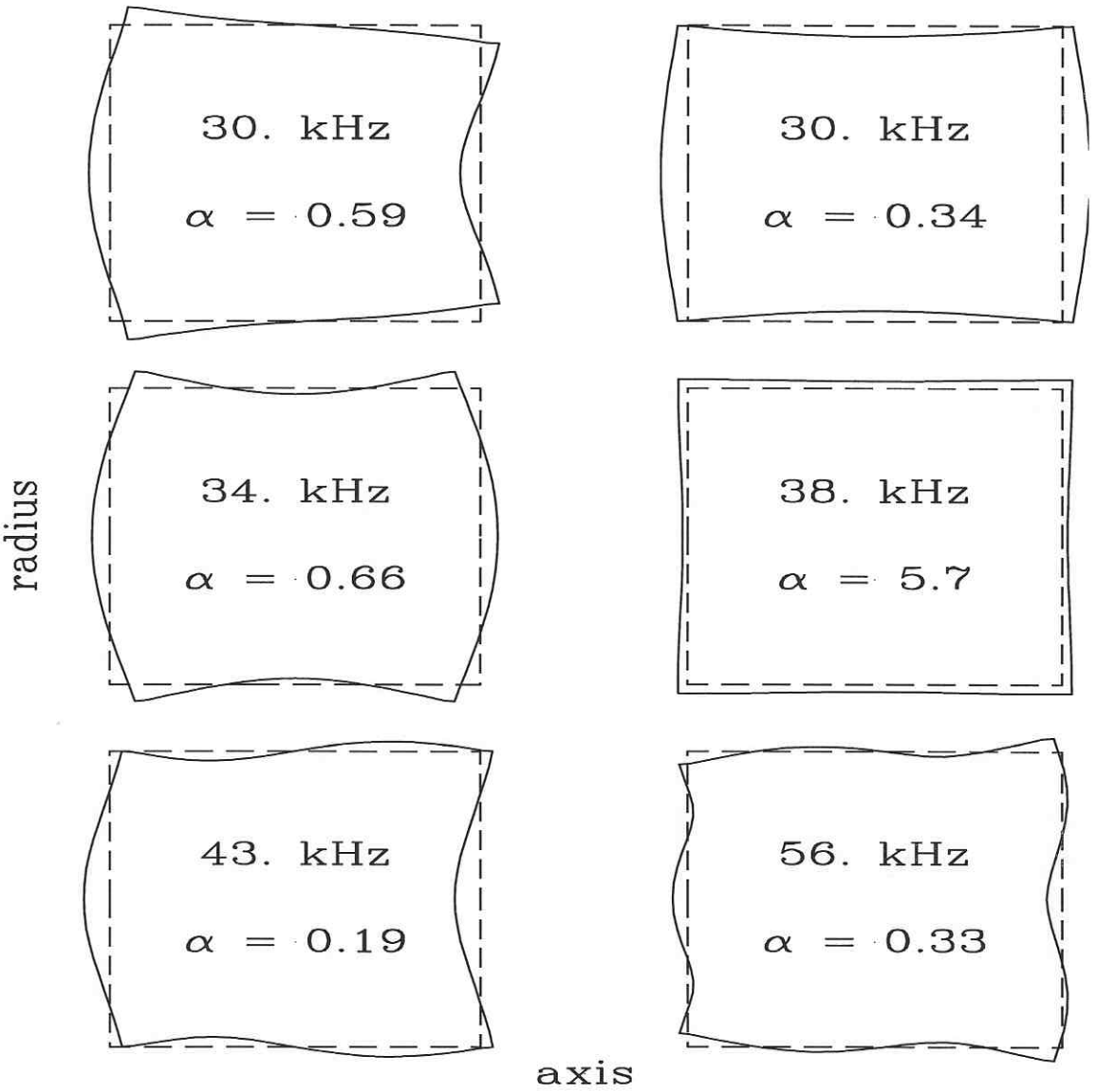
mirror mode: $\vec{u}(\rho,\theta,z)$
frequency: ω_n



one-dimensional
laser beam
wave vector: $\vec{k}$

point mass on spring
mass: $\alpha_n m$
frequency: ω_n

TEST MASS INTERNAL THERMAL NOISE



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COMPOSITE AND MONOLITHIC TEST MASSES

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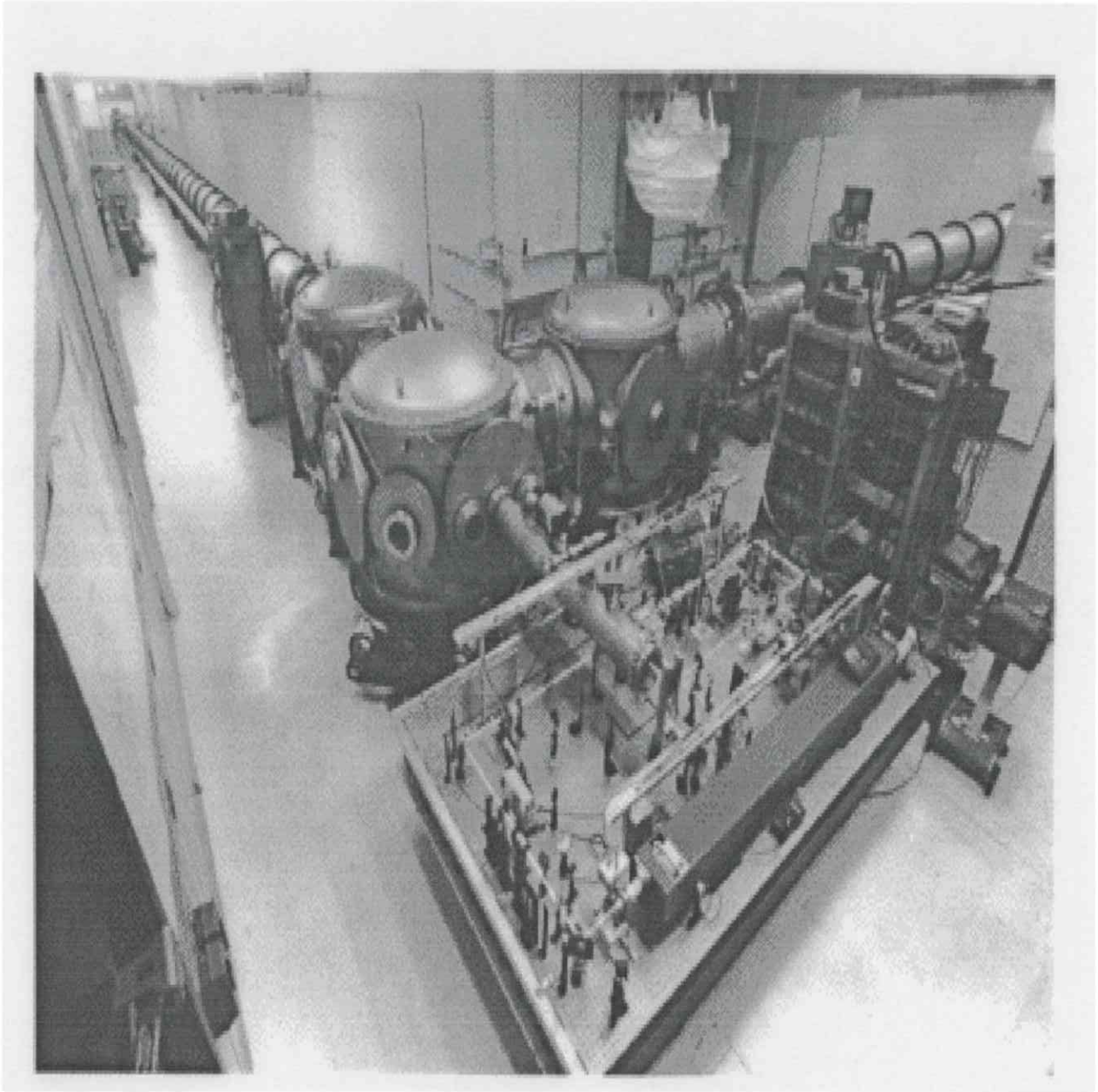
40 METER INTERFEROMETER



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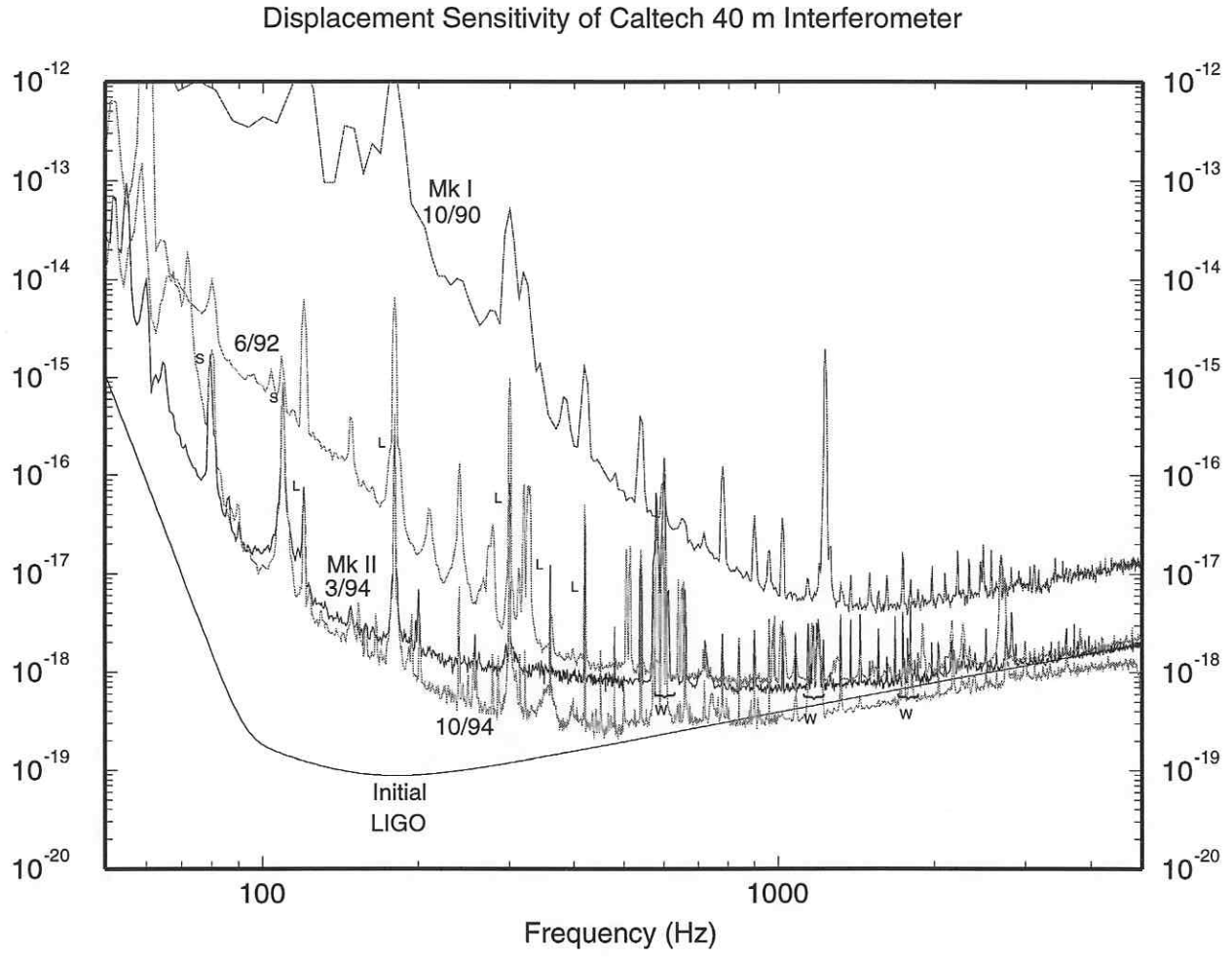
PROGRESS IN 40 METER DISPLACEMENT NOISE R&D



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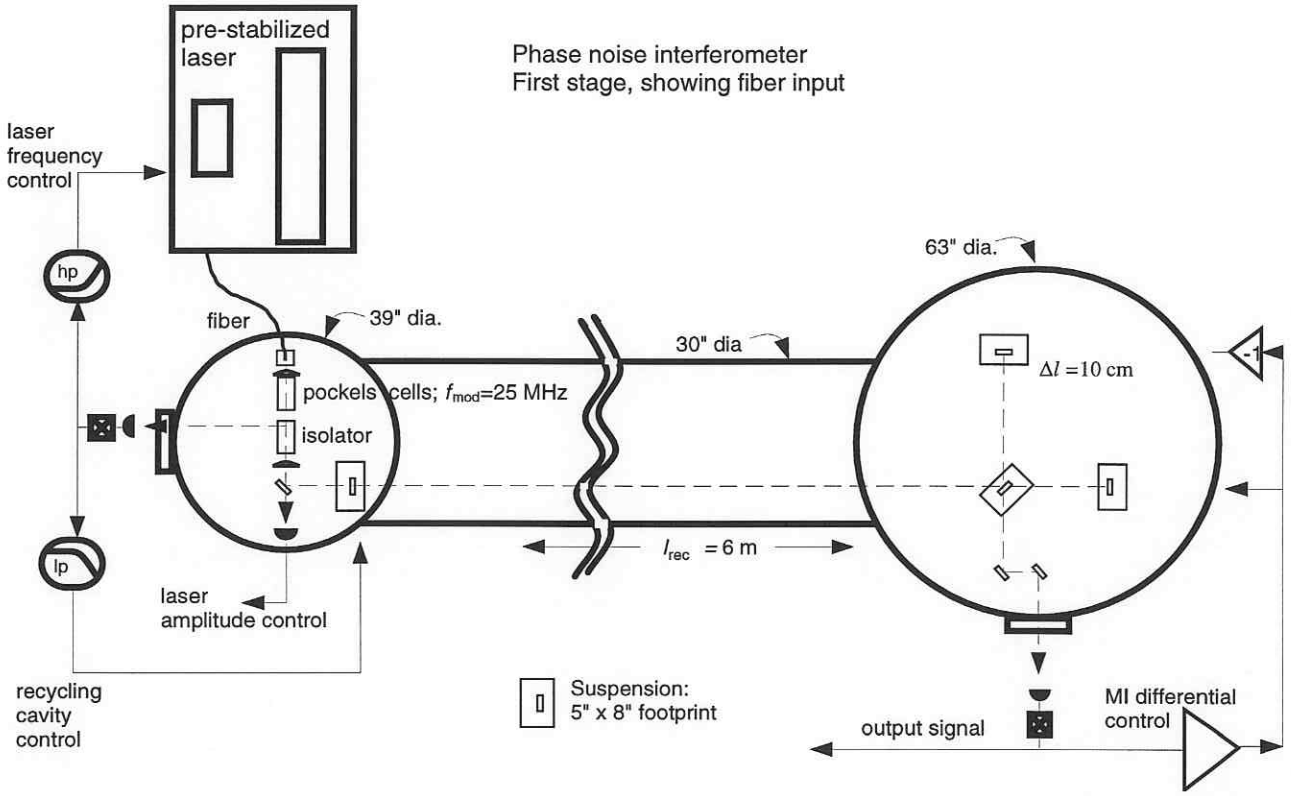
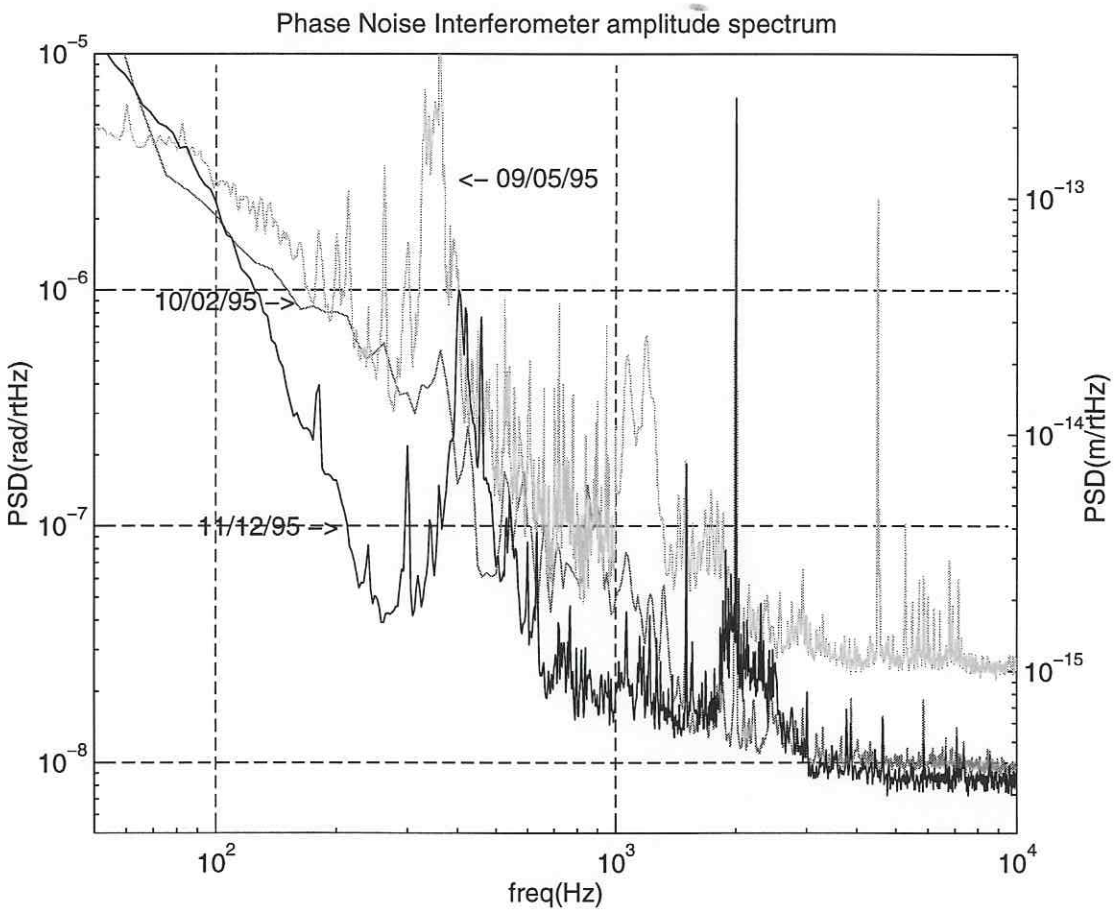
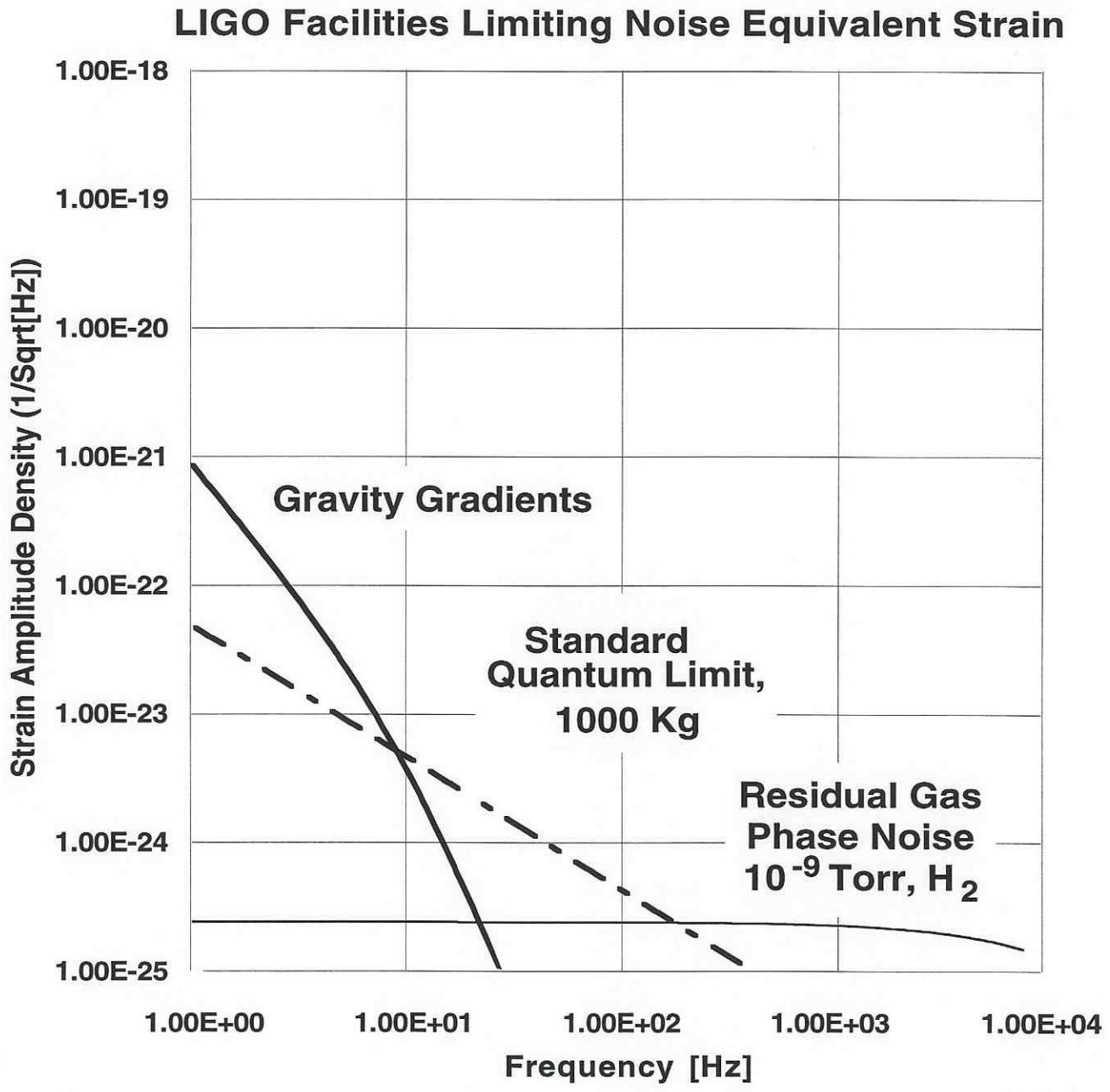
PHASE NOISE - MIT PHASE NOISE INTERFEROMETER



PHASE NOISE RESULTS TO DATE

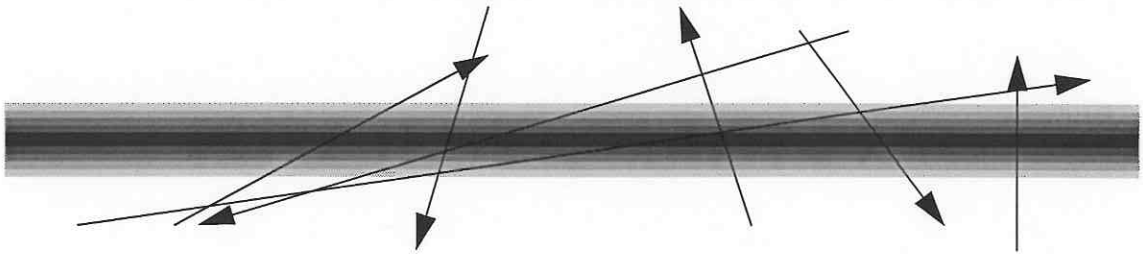


LIMITING PERFORMANCE DUE TO FACILITIES



VACUUM SYSTEM REQUIREMENTS

Light must travel 4 km without attenuation or degradation

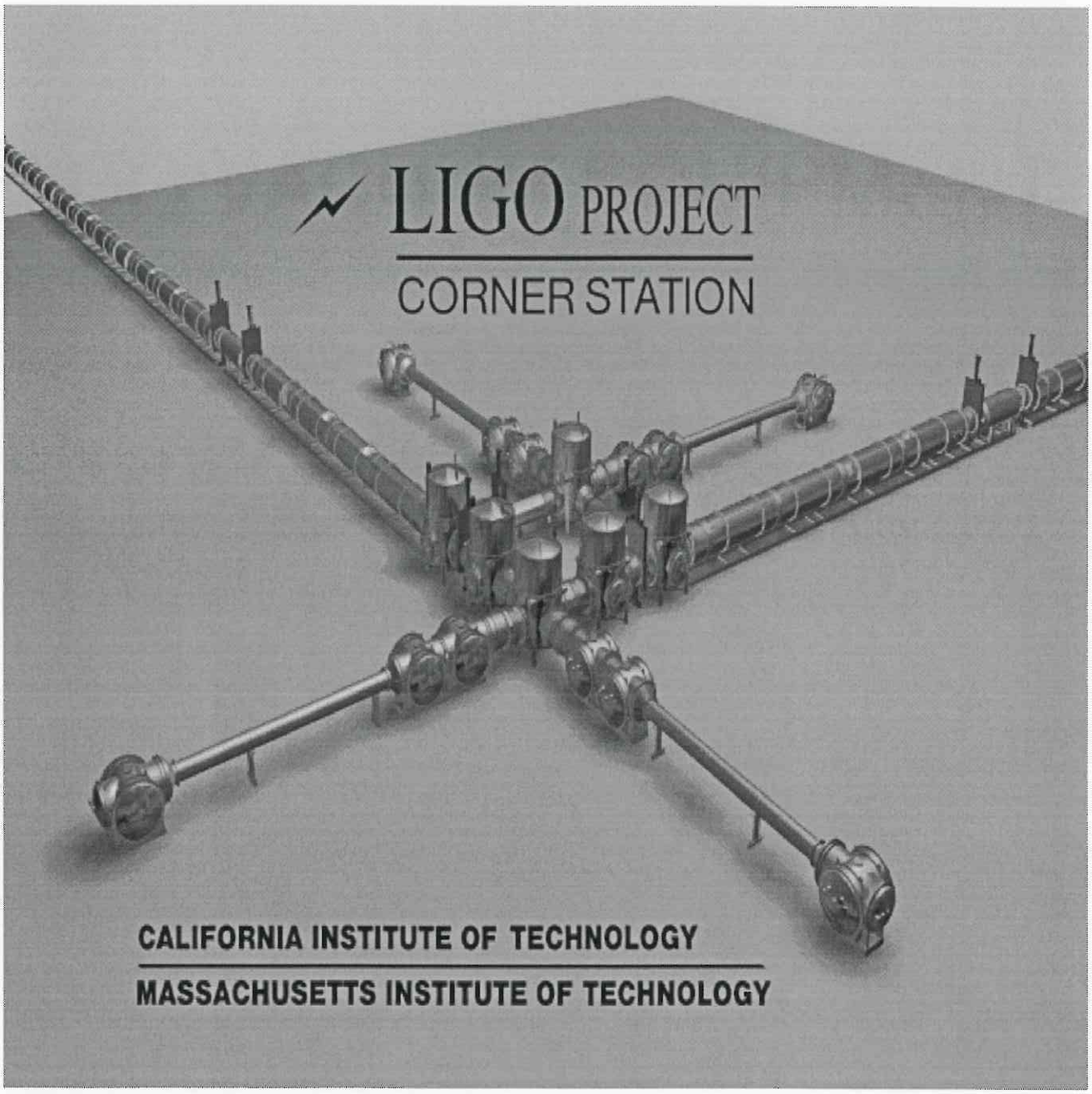


- index fluctuations in gas cause variations in optical path
  - › pressure, polarizability, molecular speed of various species
  - › light beam intensity distribution, coherence of effect

$$h(f) \approx 4\pi\alpha\left(\frac{2\rho}{v_0 w_0 l}\right)^{\frac{1}{2}}$$

- requirement for quality of vacuum in 4 km tubes from this
  - › H_2 of 10^{-6} torr initial, 10^{-9} torr ultimate
  - › H_2O of 10^{-7} torr initial, 10^{-10} ultimate
- vacuum system, 1.22 m diameter, ~10,000 cubic meters

LIGO VACUUM EQUIPMENT



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LIGO INFORMATION ON INTERNET

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LIGO SCHEDULE

- Strain sensitivity of 10^{-20} on July 4, 2000 with three operating interferometers at the two sites
- Strain sensitivity reaches 10^{-21} by December, 2001
- Enhancements and advanced interferometers after 2001