LIGO-G950063-00-R

'95 INTERNATIONAL SYMPOSIUM

FOREWORD

The International Symposium "Modern Problems of Laser Physics" (MPLP'95) will be held in Novosibirsk, Russia, from August 28 to September 2, 1995

The following modern aspects and recent advances in fundamental problems of modern laser physics will be discussed at this meeting :

- -new trends in high resolution laser spectroscopy;
- -femtosecond phenomena;
- -laser cooling and trapping, atomic interferometry;
- -nonlinear optical phenomena in thin films and at surfaces, harmonic generation;
- -highly stable lasers, precise physical experiments, laser detectors of gravitational waves;
- -laser sources with quantum noise level, suppression of quantum noise;
- -new laser crystals, diode pumped crystalline lasers, white laser beams;
- -physics of laser biomedicine and chemistry.

This meeting opens MPLP symposium series and we plan that MPLP symposium will be held once three years.

TECHNICAL SESSIONS

The MPLP'95 technical program will include invited talks, selected oral talks and poster section.

The opening ceremony will take place on the first day, August 28. Then, unparalleled plenary sessions will be organized for the presentation of invited and selected talks.

The official language of the Conferences is English.

COMMITTEE MEMBERS

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INTERNATIONAL ADVISORY COMMITTEE

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E.B.Alexandrov (Russia)
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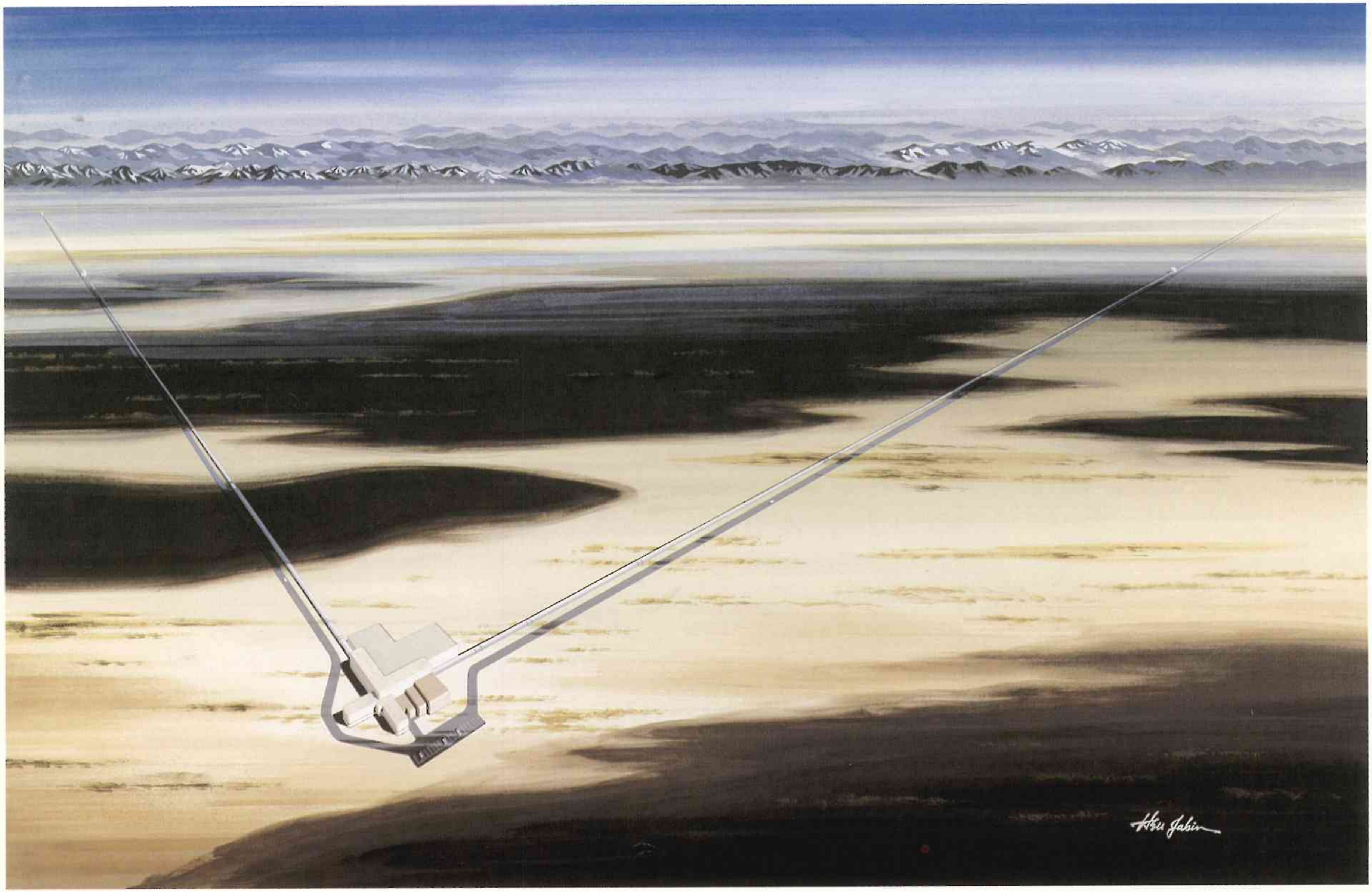
PRECISION LASER INTERFEROMETRY IN THE LIGO PROJECT

LASER INTERFEROMETER
GRAVITATIONAL-WAVE OBSERVATORY

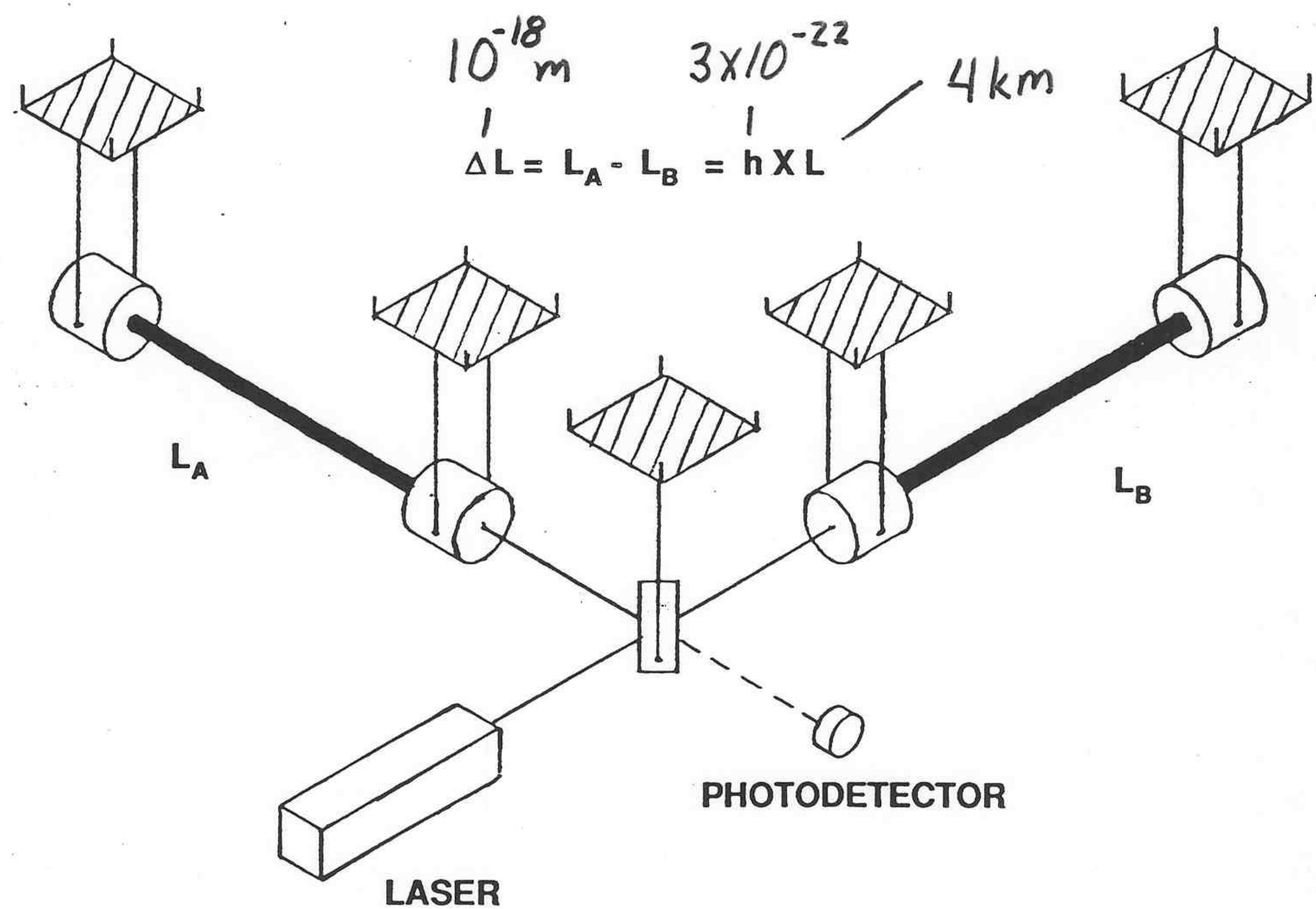
STAN WHITCOMB
(CALTECH)

** WORK DESCRIBED HERE REPRESENTS EFFORT OF ~80 CURRENT (AND ~40 PAST) SCIENTISTS, ENGINEERS, STUDENTS, TECHNICIANS, AND ADMINISTRATORS

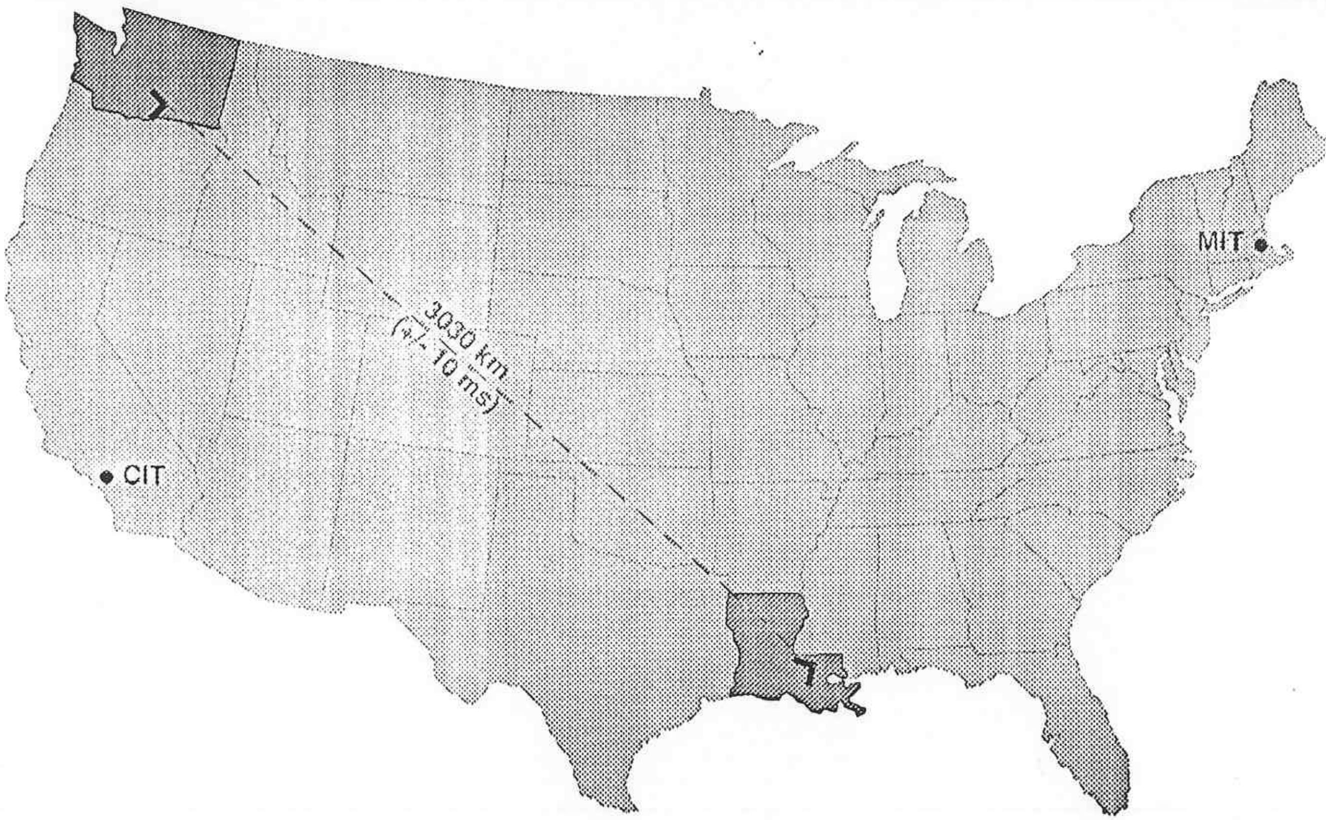
** COLLABORATION BETWEEN CALTECH AND MIT



SCHEMATIC INTERFEROMETRIC DETECTOR



LIGO SITES

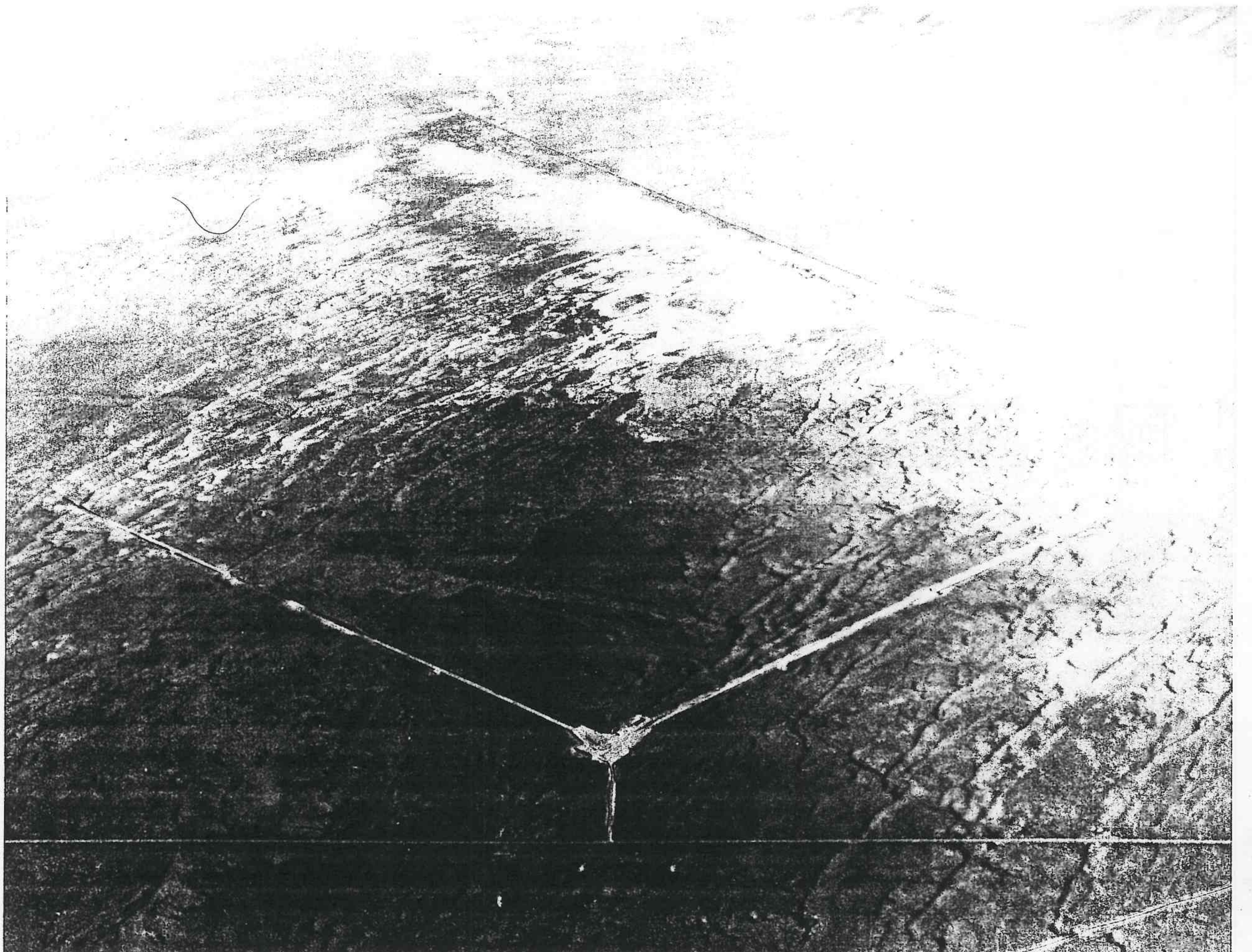


HANFORD, WASHINGTON

- LOCATED ON U.S. DOE RESERVATION
- TREELESS, SEMI-ARID HIGH DESERT
- APPROX. 25 KM FROM RICHLAND, WA (POPULATION :140,000)

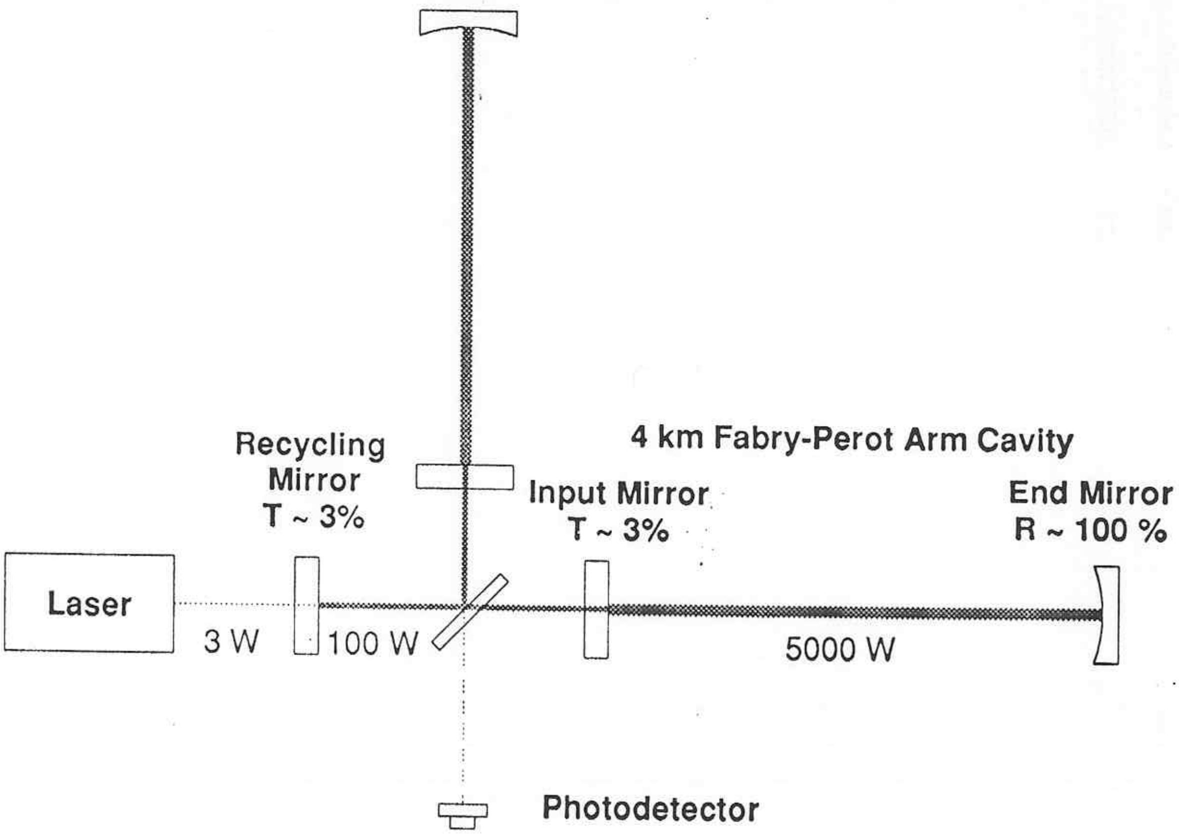
LIVINGSTON, LOUISIANA

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



PBA

INITIAL INTERFEROMETER CONFIGURATION

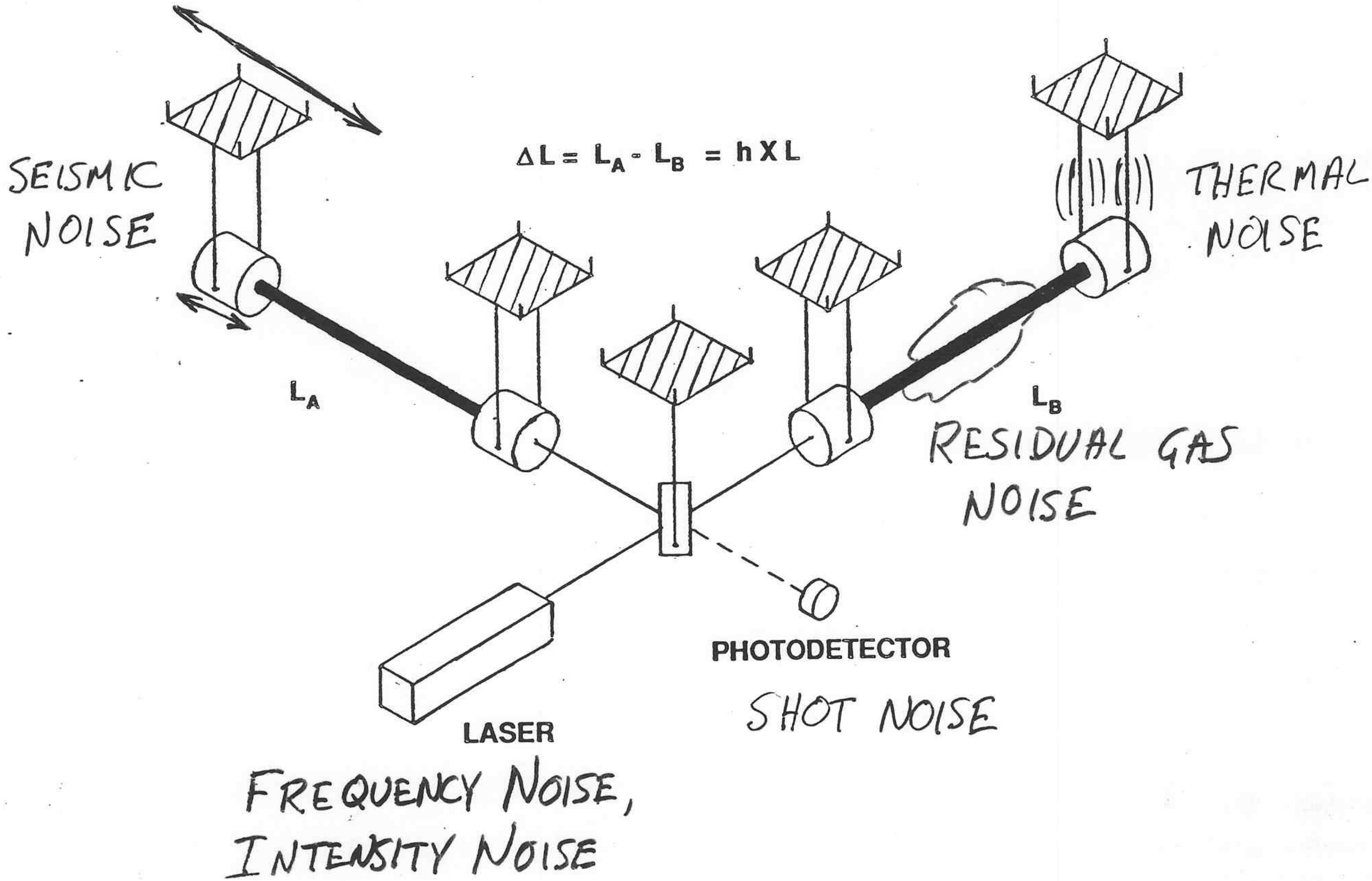


- FABRY-PEROT ARM CAVITIES
- MODEST INPUT POWER (2 - 3 w)
- INITIAL LASER: AR+ $\lambda = 0.5145\ \mu m$ POWER RECYCLING
- MODEST RECYCLING FACTOR ($\gamma \sim 30X$)
- MODEST CAVITY FINESSE ($\eta \sim 50$)

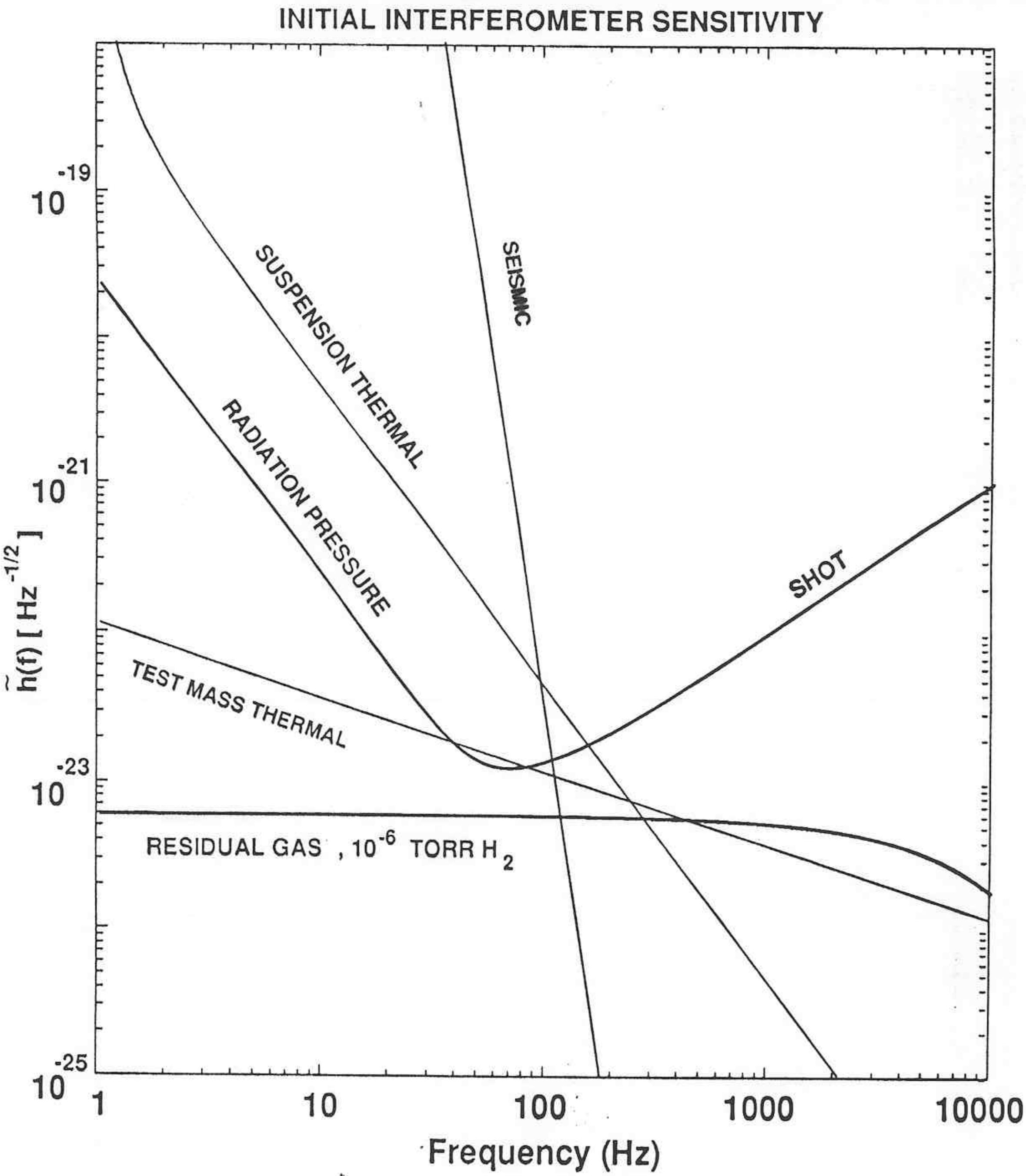
CONSIDERING CHANGE TO Nd:YAG $\lambda = 1.06\ \mu m$

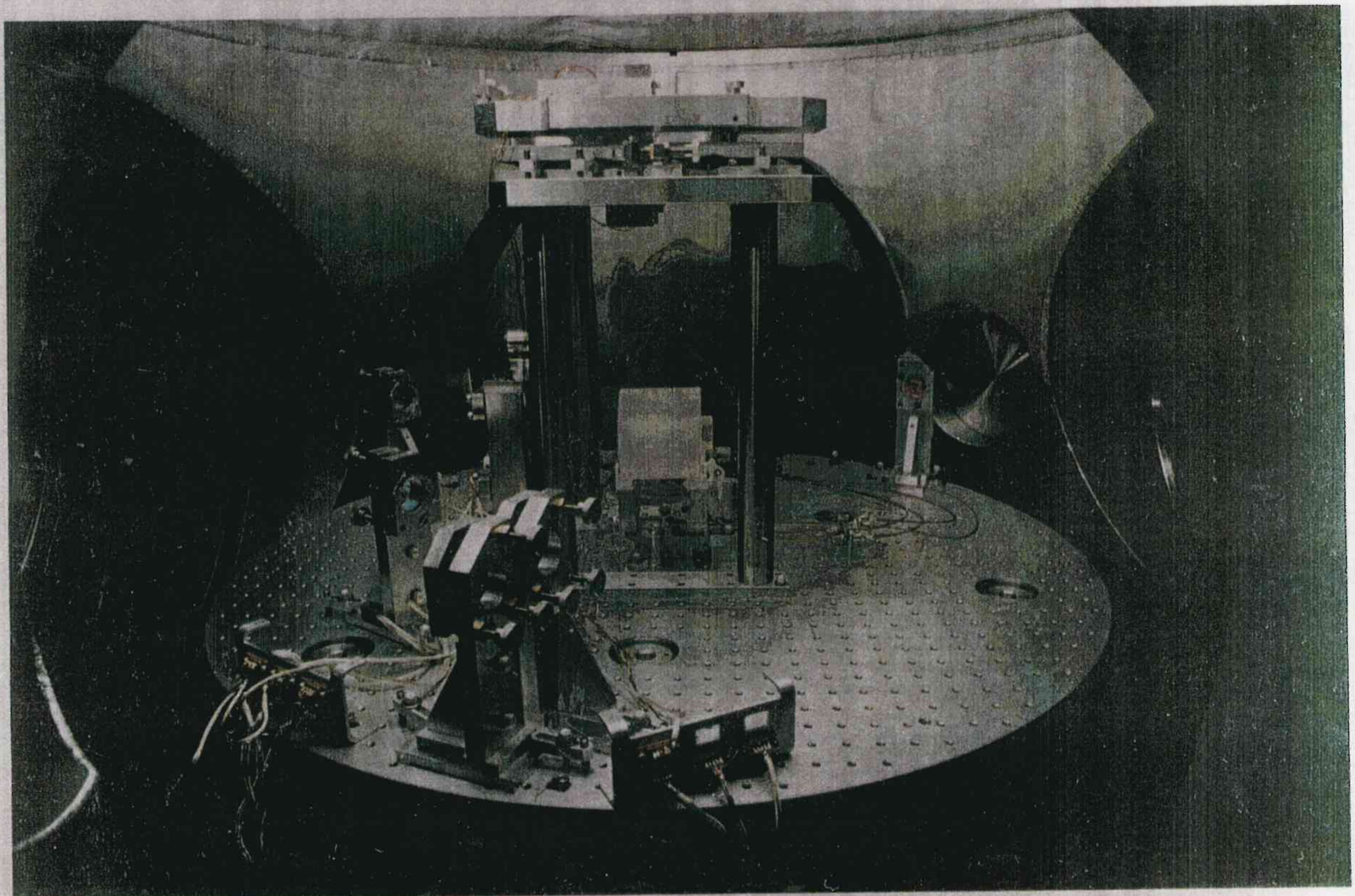
LIGO
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

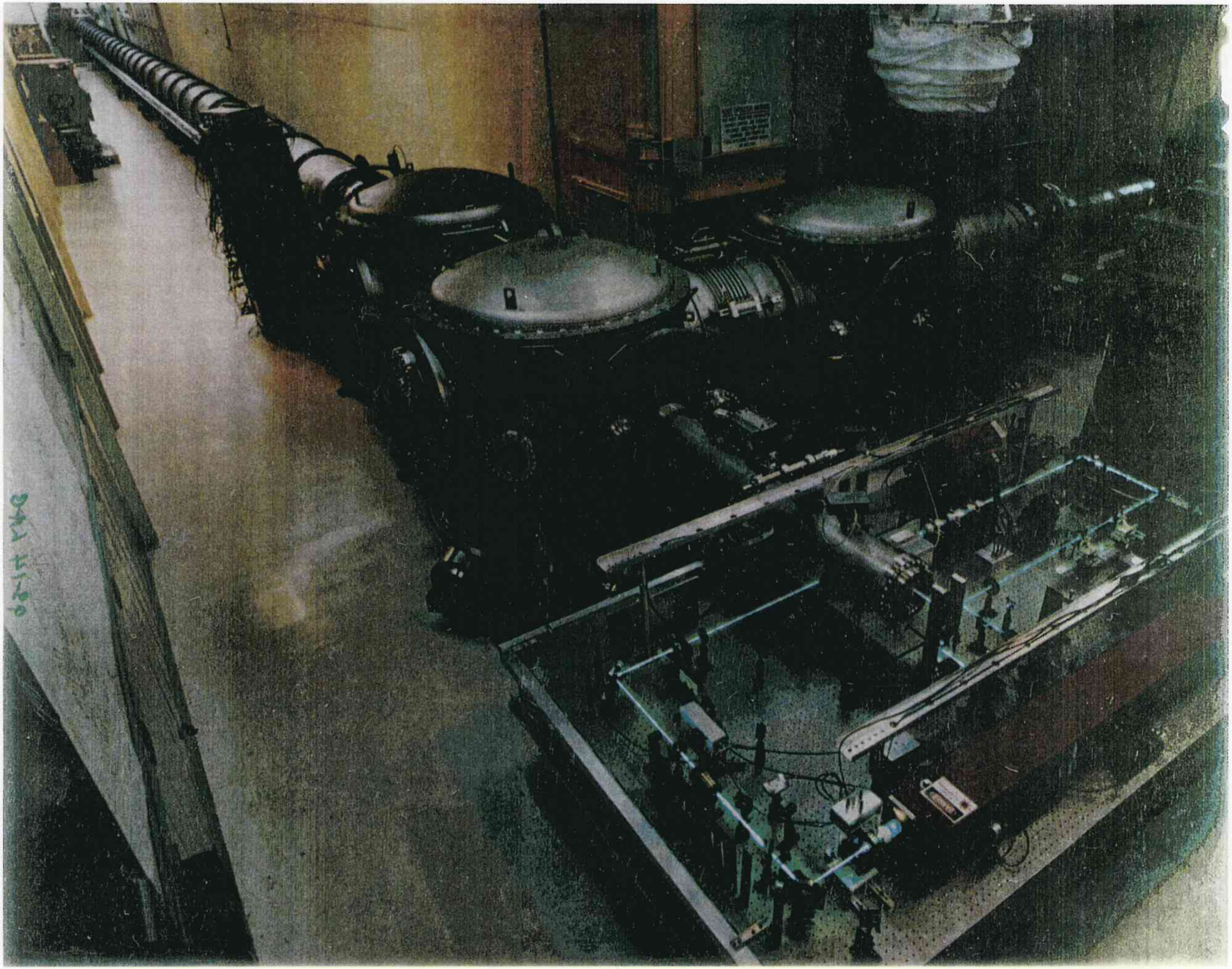
SCHEMATIC INTERFEROMETRIC DETECTOR

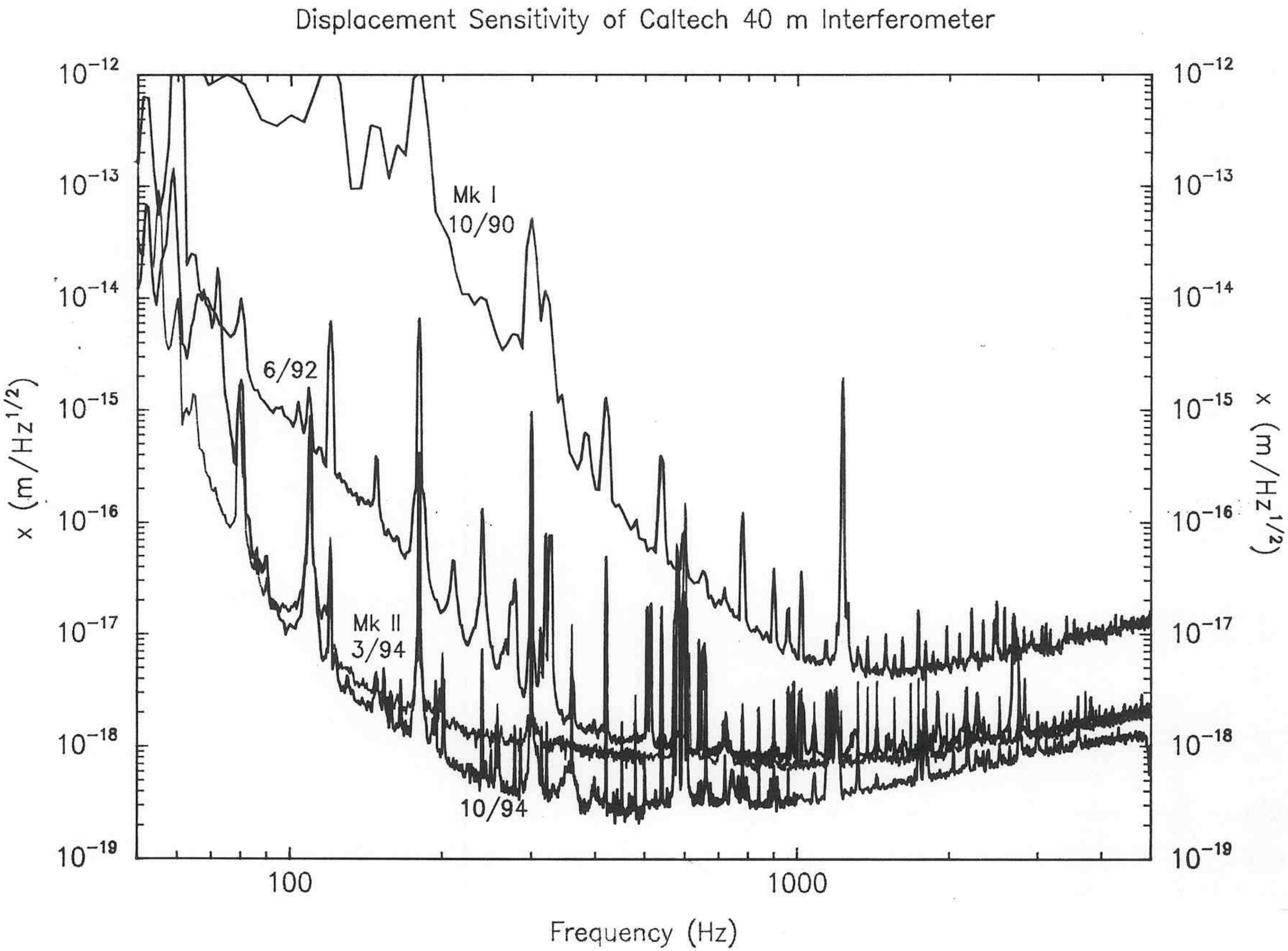


INITIAL INTERFEROMETER DESIGN PERFORMANCE GOAL





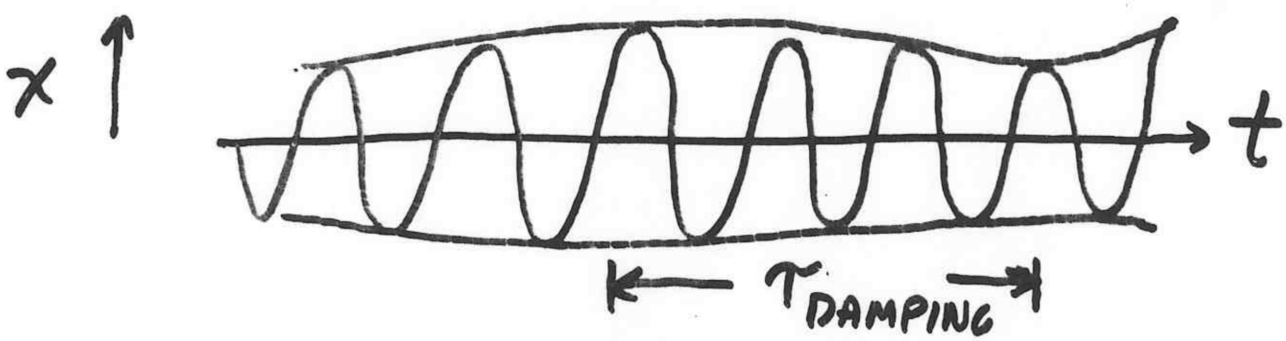



Displacement Sensitivity of Caltech 40 m Interferometer
Mk I
10/90
6/92
Mk II
3/94
10/94
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
x (m/Hz$^{1/2}$)
100
1000
Frequency (Hz)

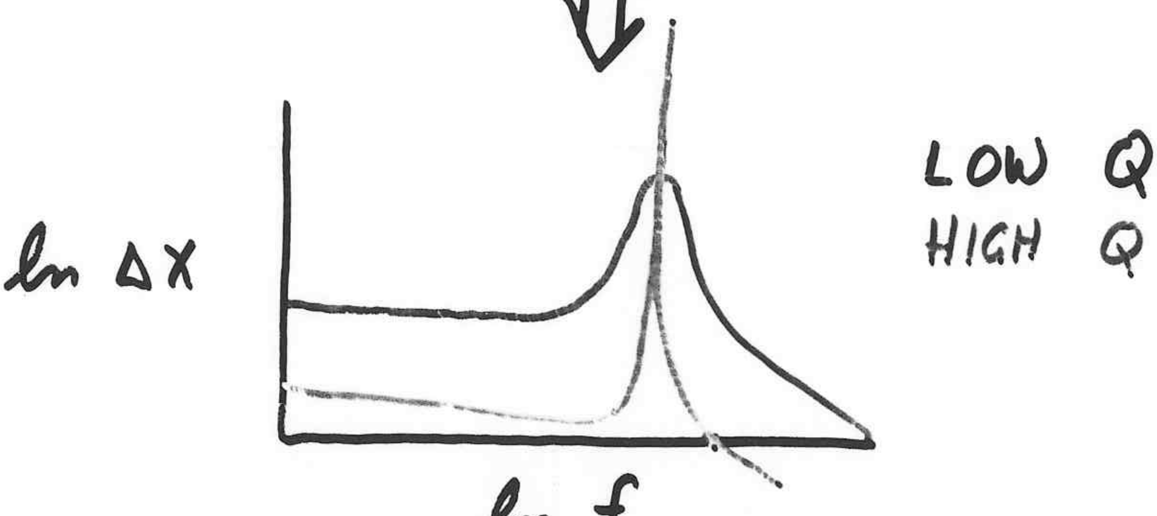
THERMAL NOISE ("BROWNIAN MOTION") IN SIMPLE HARMONIC OSCILLATOR

$$\Delta x^2 \sim \frac{kT}{m\,\omega_0^2}$$

EXCHANGE ENERGY WITH RESERVOIR



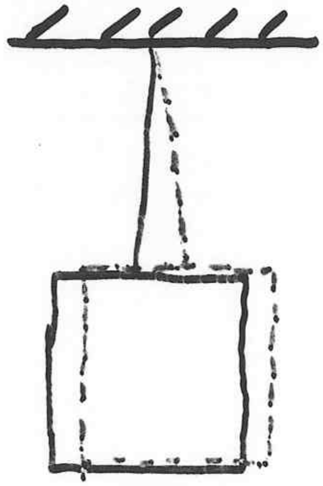
⇓



STRATEGY: 1. MOVE ω_0 OUTSIDE BAND OF INTEREST

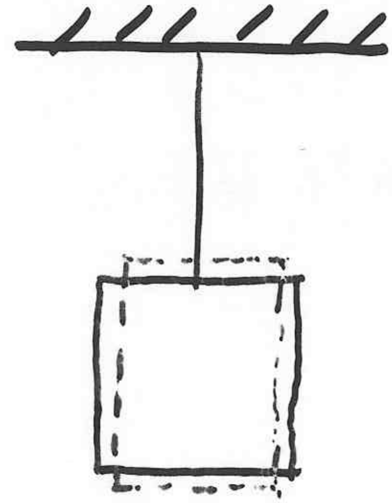
2. MAKE Q HIGH

THERMAL NOISE IN GW INTERFEROMETERS



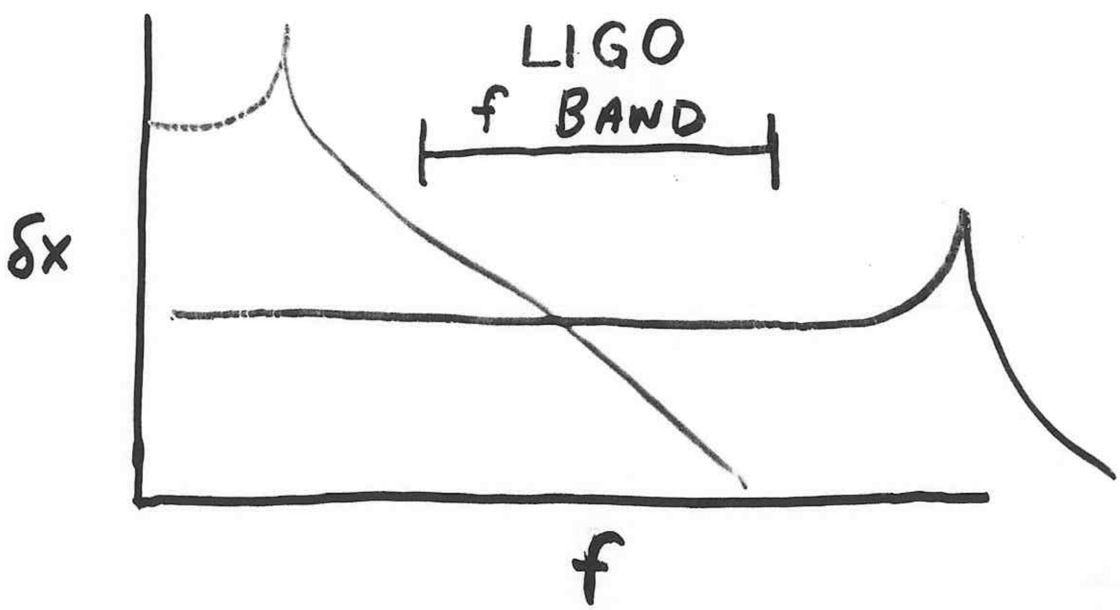
SUSPENSION MODES

$f \sim 1\ Hz$



INTERNAL MODES

$f \gtrsim 20\ kHz$



- SHAPE OF WINGS DEPENDS ON LOSS FUNCTION OF MODE $\phi_n(\omega)$

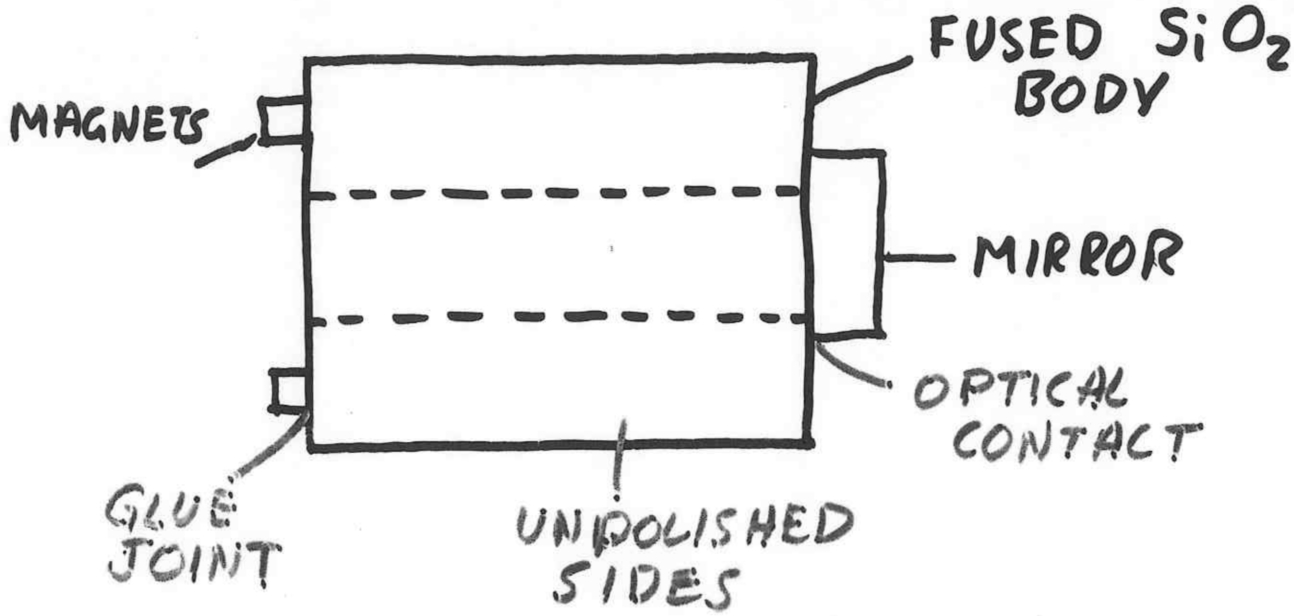
$$Q = \left[\phi_n(\omega_0)\right]^{-1}$$

- COMMON MODELS $\phi \propto \omega$ "VISCOUS"

  $\phi = $ CONST. "STRUCTURAL"

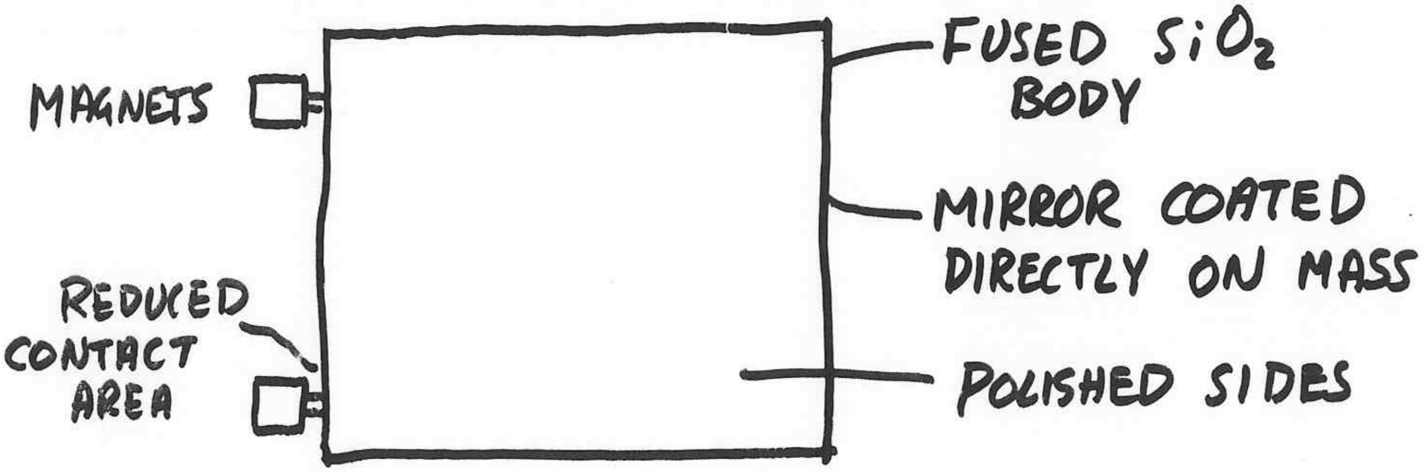
INTERNAL MODES

PRE-1994 TEST MASSES

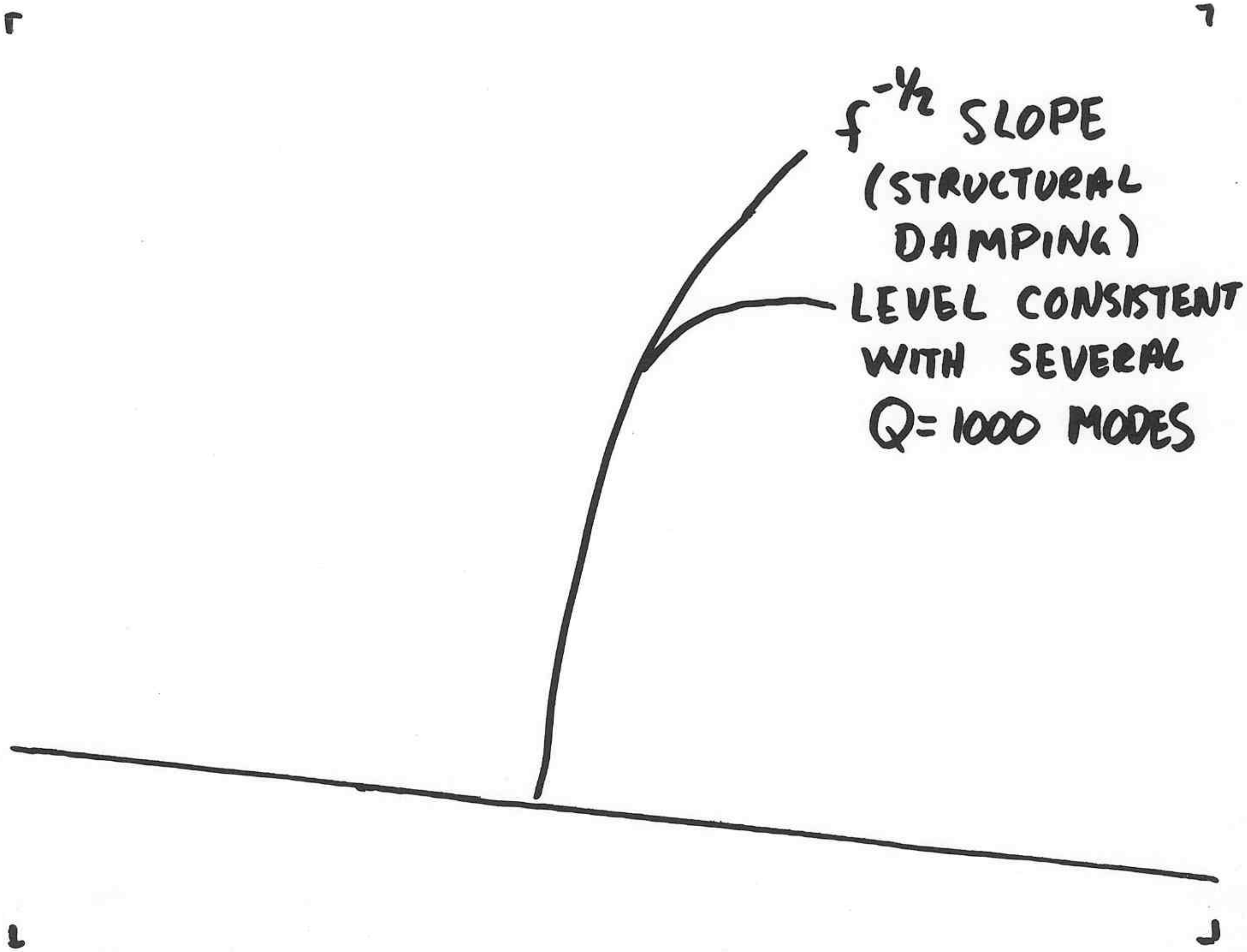


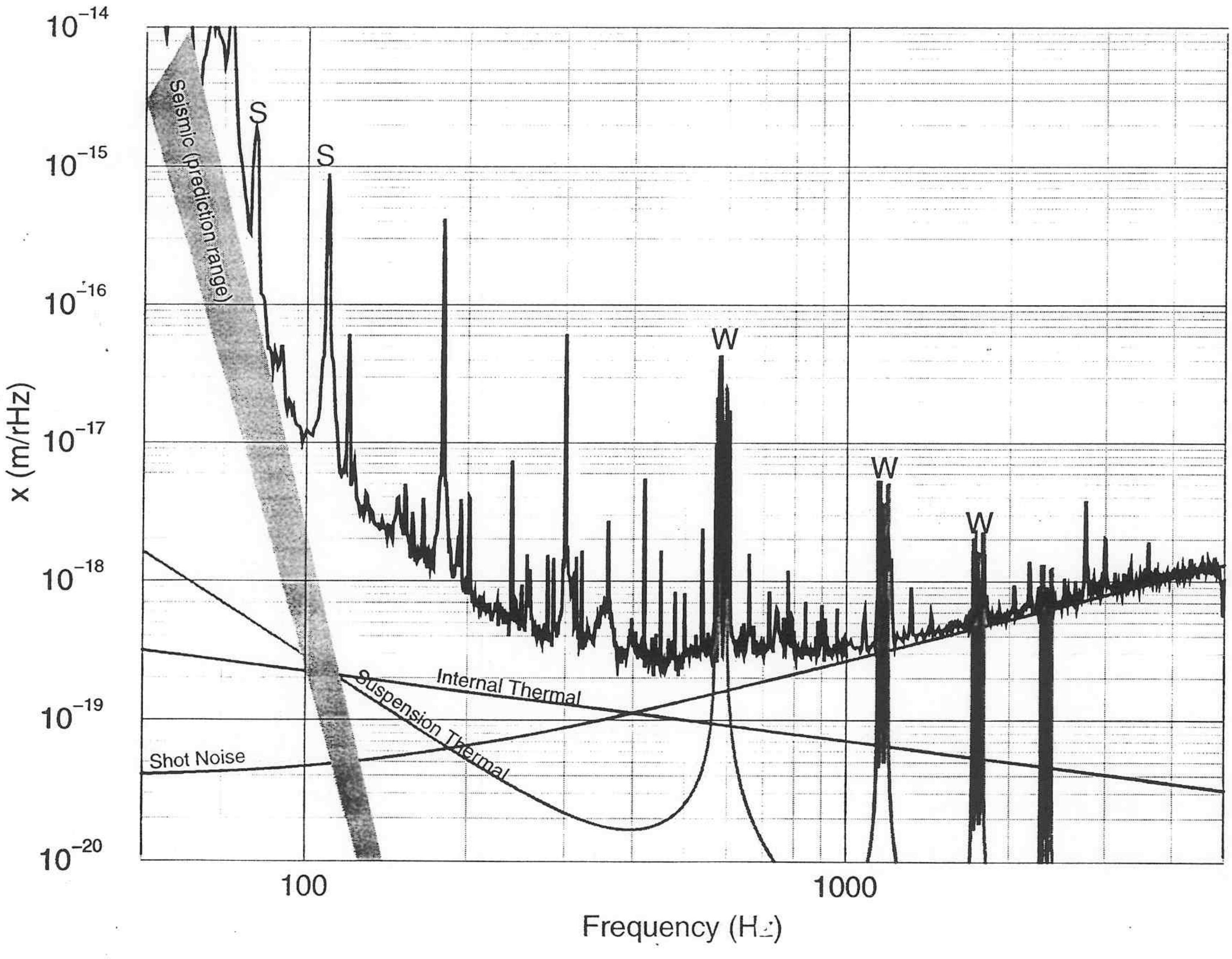
$$Q_{INTERNAL} \sim 800 - 50{,}000$$

NEW TEST MASSES INSTALLED IN 1994

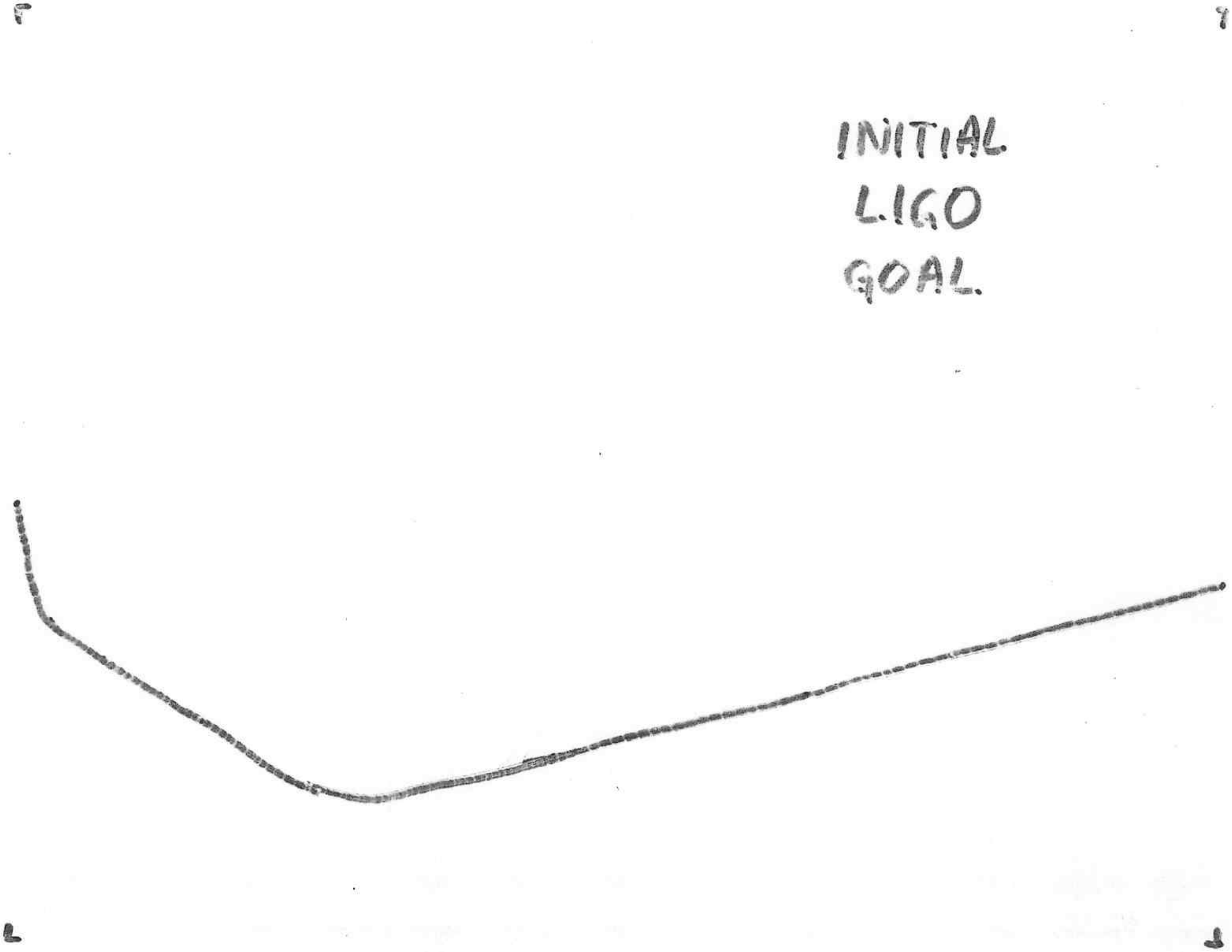


$$\phi_n (f < 5\,kHz) \leq 2.5 \times 10^{-6}$$


$f^{-1/2}$ SLOPE
(STRUCTURAL DAMPING)
LEVEL CONSISTENT WITH SEVERAL Q=1000 MODES



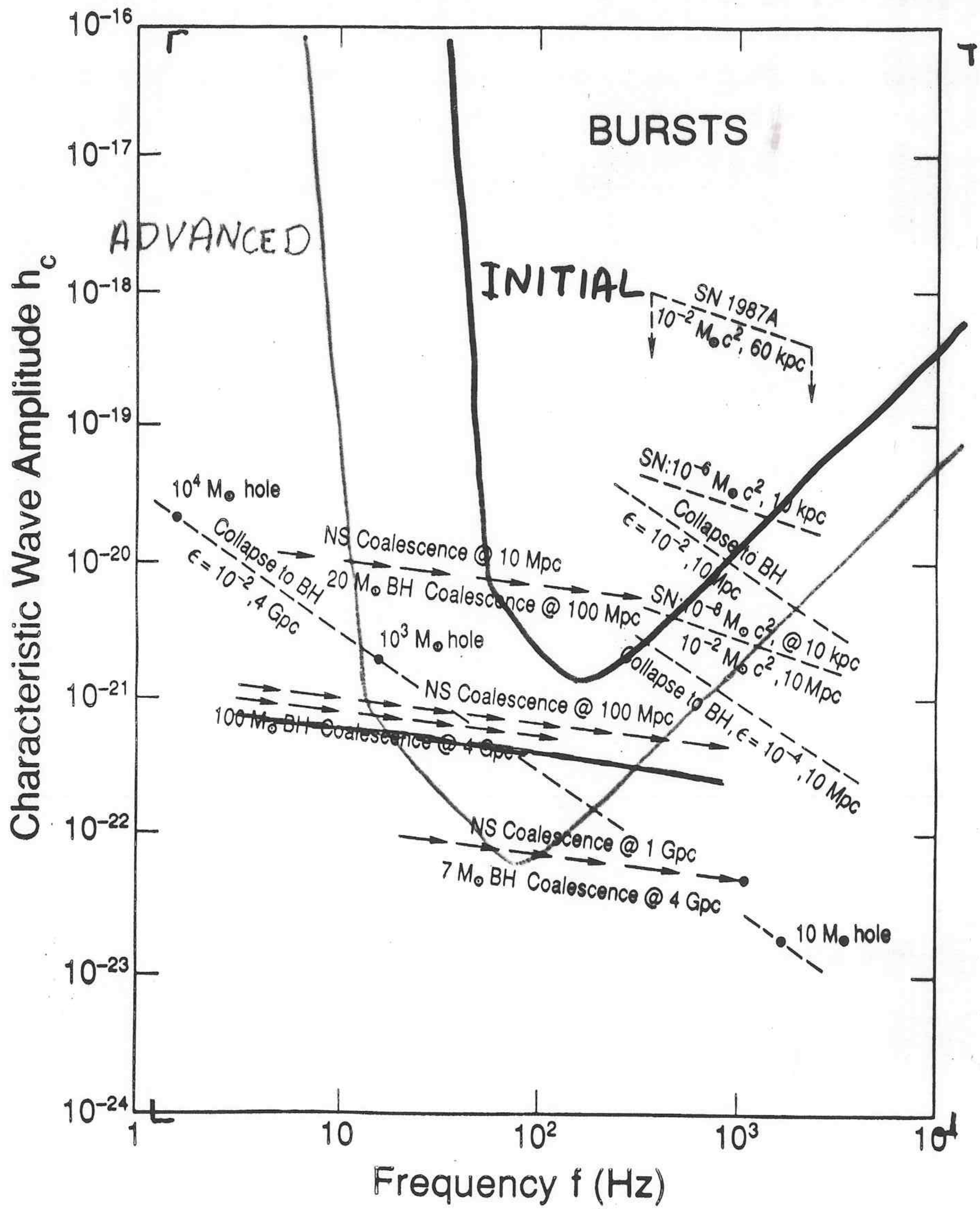
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
x (m/rHz)
Seismic (prediction range)
S
S
W
W
W
Internal Thermal
Suspension Thermal
Shot Noise
100
1000
Frequency (Hz)


INITIAL
LIGO
GOAL

THE QUESTION EVERYONE ASKS

WILL LIGO DETECT GRAVITATIONAL WAVES?

WHEN WILL LIGO DETECT GRAVITATIONAL WAVES?


BURSTS
ADVANCED
INITIAL
Characteristic Wave Amplitude h_c
Frequency f (Hz)
SN 1987A
10^{-2} $M_\odot c^2$, 60 kpc
SN:10^{-6} $M_\odot c^2$, 10 kpc
Collapse to BH
$\epsilon = 10^{-2}$, 10 Mpc
SN:10^{-8} $M_\odot c^2$, @ 10 kpc
10^{-2} $M_\odot c^2$, 10 Mpc
Collapse to BH, $\epsilon = 10^{-4}$, 10 Mpc
10^4 $M_\odot$ hole
Collapse to BH
$\epsilon = 10^{-2}$, 4 Gpc
NS Coalescence @ 10 Mpc
20 $M_\odot$ BH Coalescence @ 100 Mpc
10^3 $M_\odot$ hole
NS Coalescence @ 100 Mpc
100 $M_\odot$ BH Coalescence @ 4 Gpc
NS Coalescence @ 1 Gpc
7 $M_\odot$ BH Coalescence @ 4 Gpc
10 $M_\odot$ hole

BEYOND 2000

- LIGO FACILITIES DESIGNED TO HOUSE MUCH MORE SENSITIVE DETECTORS
- DIRECTIONS FOR FUTURE DETECTORS
  - HIGHER LASER POWER
    100 W ? 1 kW ?
  - BETTER OPTICAL COMPONENTS
    BETTER FIGURE, LOWER LOSSES
  - NEW OPTICAL CONFIGURATIONS
    SIGNAL RECYCLING? SAGNAC ?
  - QND ? SQUEEZED LIGHT ?
  - ACTIVE COMPENSATION FOR SEISMIC MOTION
  - MATERIALS AND DESIGNS FOR LOWER THERMAL NOISE

LIMITING PERFORMANCE DUE TO FACILITIES