BASELINE SUSPENSION DESIGN FOR LIGO II - UPDATE

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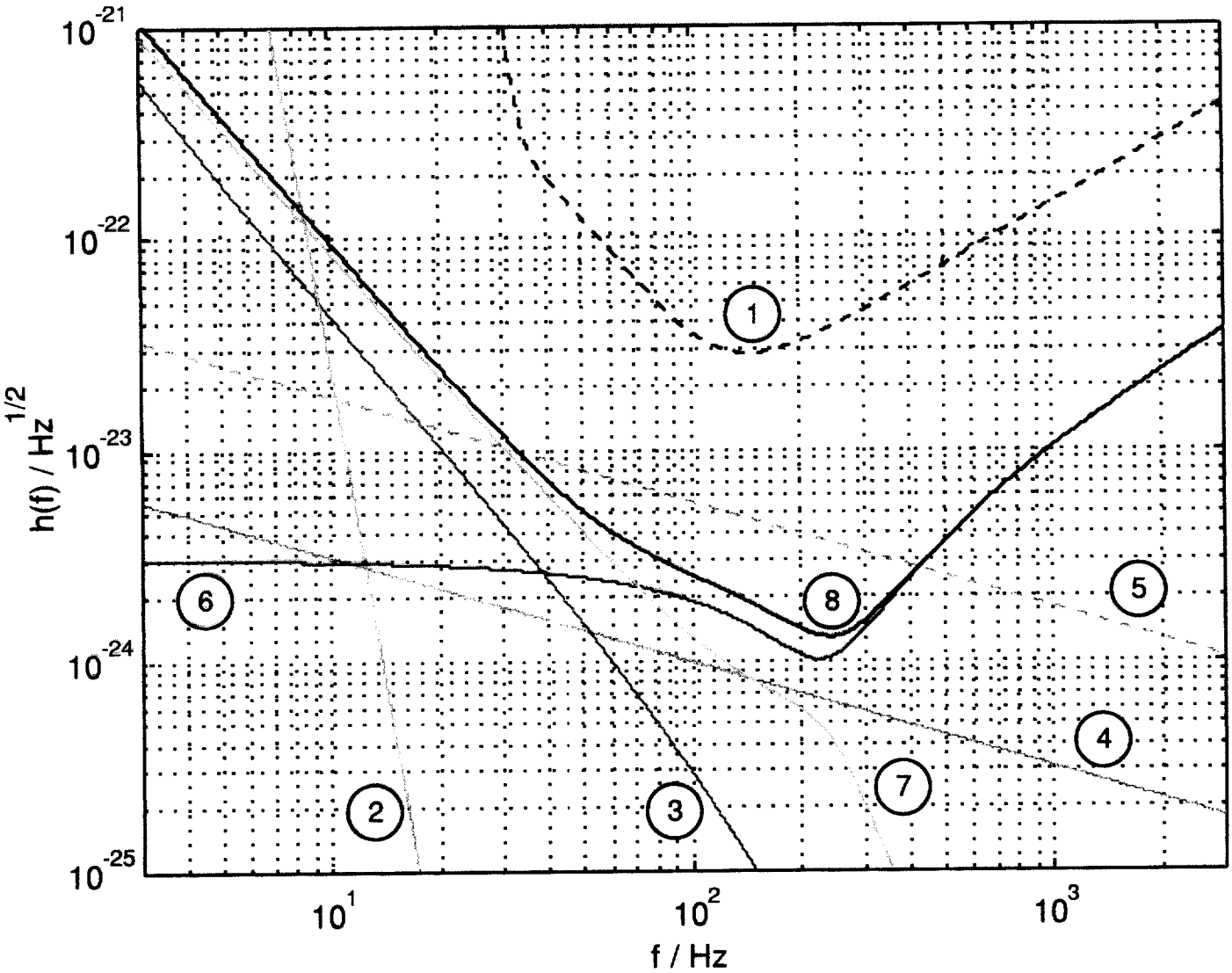
Introduction and Background

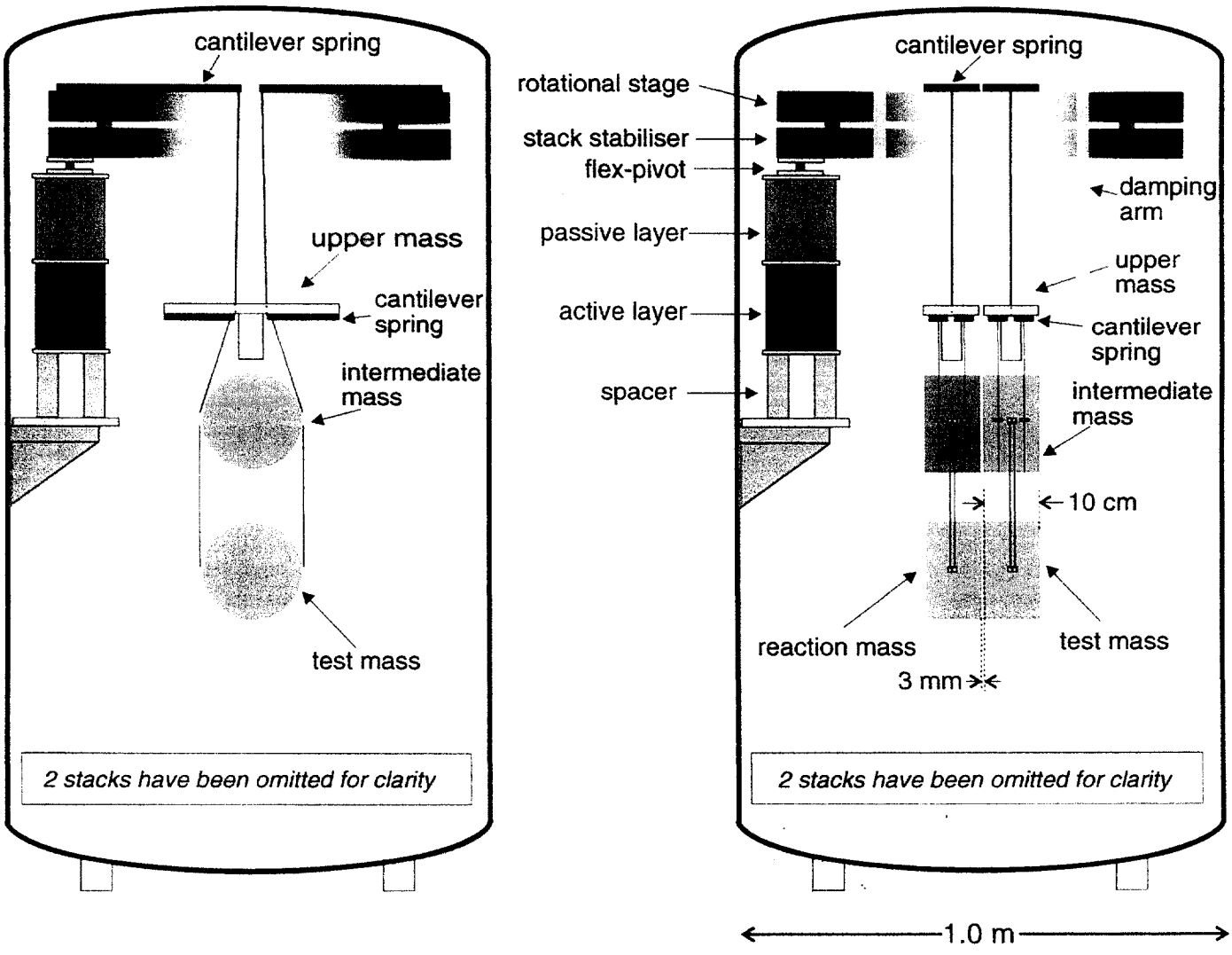
- Suspension design based on modified GEO 600 triple pendulum
- Key points in GEO design
  - **fused silica fibres for final stage suspension**
  - **local control (continuous) by 6 co-located sensors and actuators on upper mass**
  - **2 stages of enhanced vertical isolation**
  - **global control on intermediate and lower mass (electrostatic at lower) using adjacent "identical" reaction triple pendulum**

LIGO II
NOISE CURVES



1 LIGO I total
2 Filtered seismic noise
3 Suspension thermal noise
4 Internal thermal noise - sapphire
5 Internal thermal noise - fused silica (fallback)
6 Shot noise
7 Radiation pressure noise
8 LIGO II total

GEO 600 Main Suspension

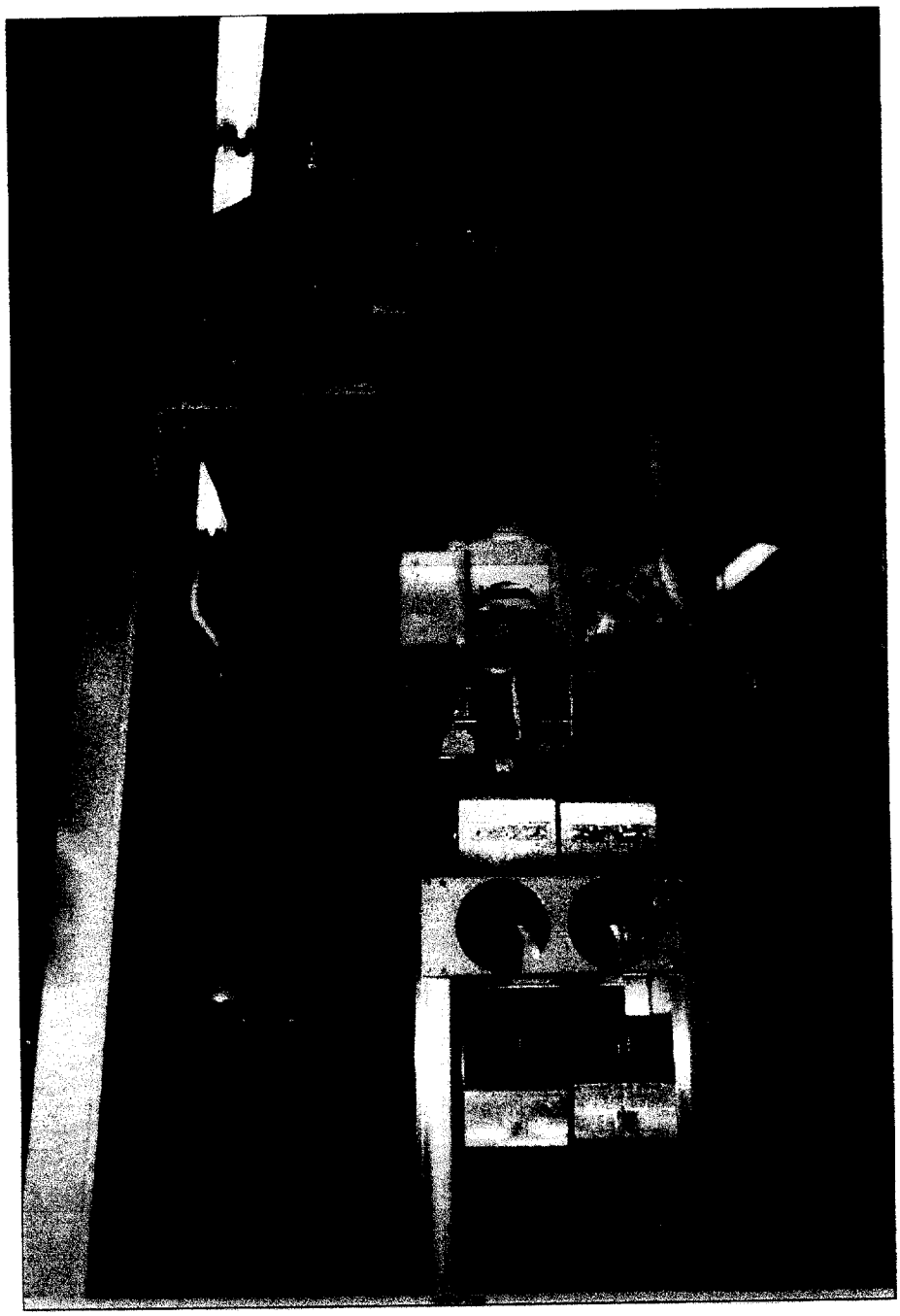


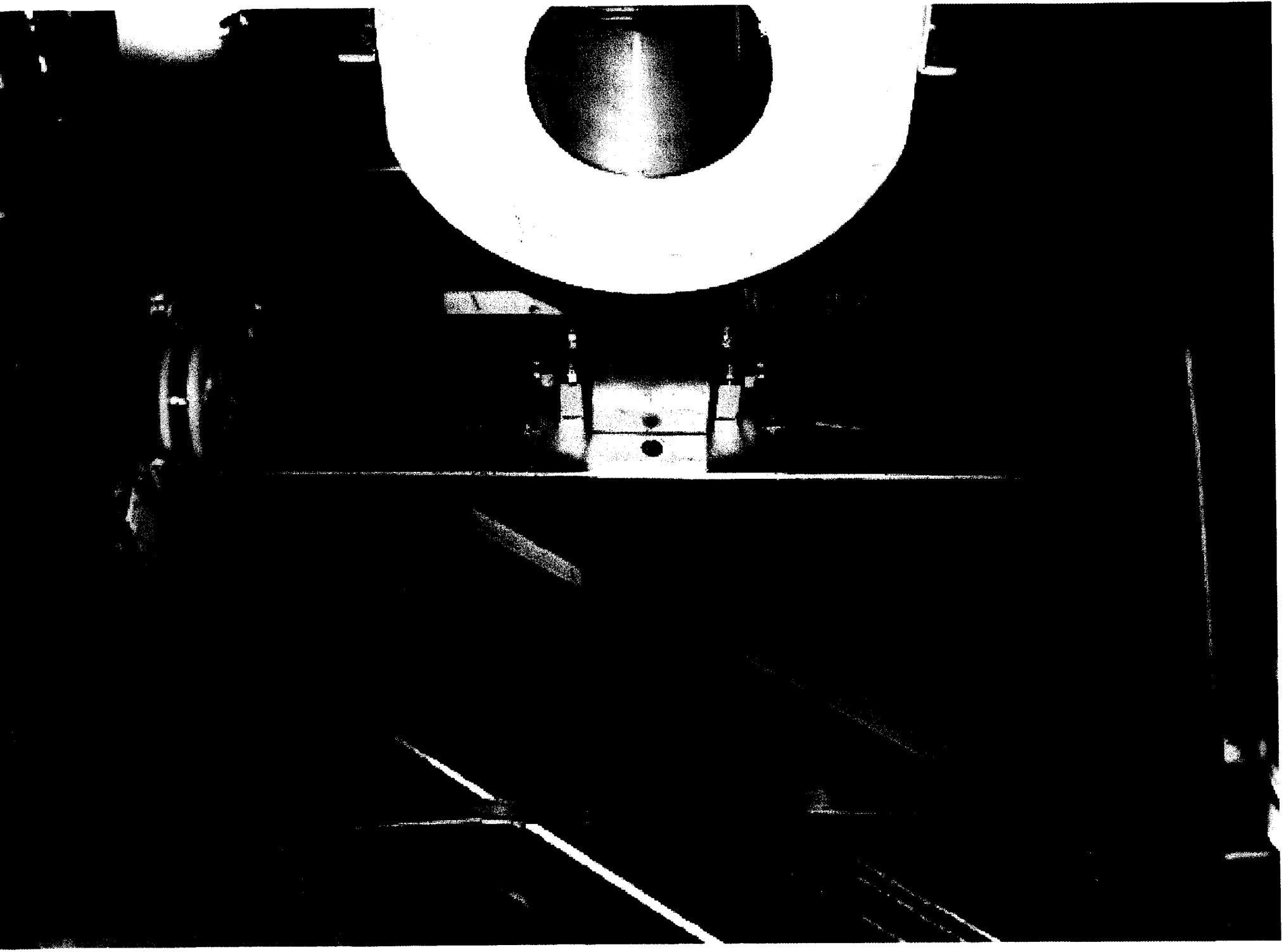
FACE VIEW

SIDE VIEW

GEO Triple Pendulum

GEO Triple Pendulum + Reaction Pendulum





GEO Suspension- further details

- Fused Silica Suspensions for Advanced GW Detectors

  S. Rowan et al, Proc. 2nd TAMA Workshop, Oct. 1999
- Suspension Design for GEO 600 - An Update

  N.A. Robertson et al, Proc. 3rd Amaldi Conf., July 1999
- Modeling of multistage pendulums - triple pendulum suspension for GEO 600

  M.E. Husman et al, Rev. Sci. Instum., June 2000
- GEO 600 triple pendulum suspension system: seismic isolation and control

  M.V. Plissi et al, Rev. Sci. Instum., June 2000

Extension of GEO Design to LIGO II

- GEO suspension requirement set by expected internal thermal noise :- test mass motion of ~7 x 10^{-20} m/rtHz @ 50 Hz
- LIGO II reference design corresponds to ~10^{-19} m/rt Hz @ 10 Hz for main optics.

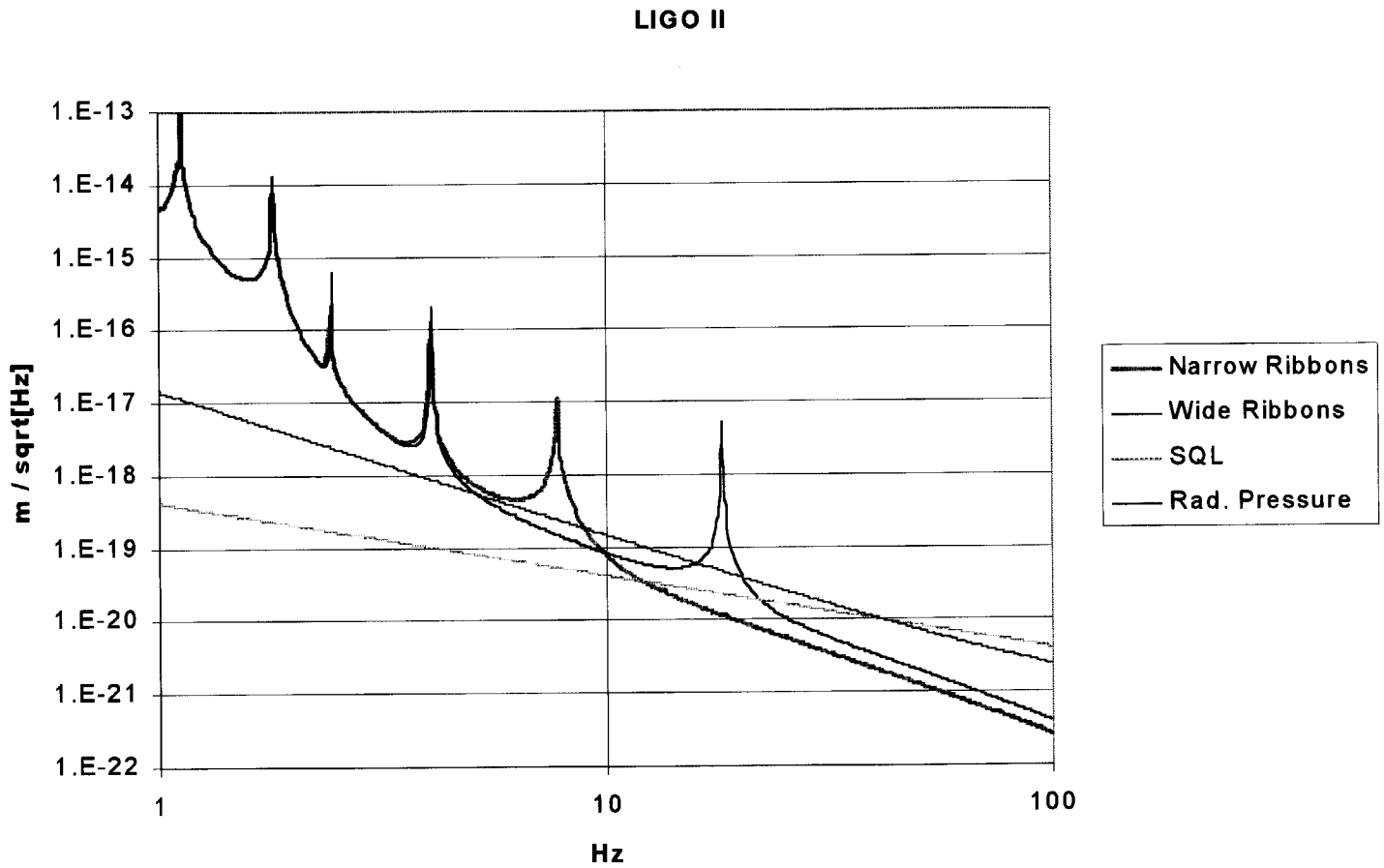
  Improvement in pendulum thermal noise, control noise (and seismic isolation) required.

Design Requirements- 1 Thermal Noise Considerations

Thermal noise performance paramount.

- main contributions from
  - dissipation in silica fibres suspending mirror
  - vertical thermal noise from flexing of lowest set of blades - coupling into horizontal
- solution - reduce by combination of
  - suitable choice of ribbon design (dimensions)
  - low frequency blade mode
  - heavy penultimate mass

Thermal Noise in BSC Suspension



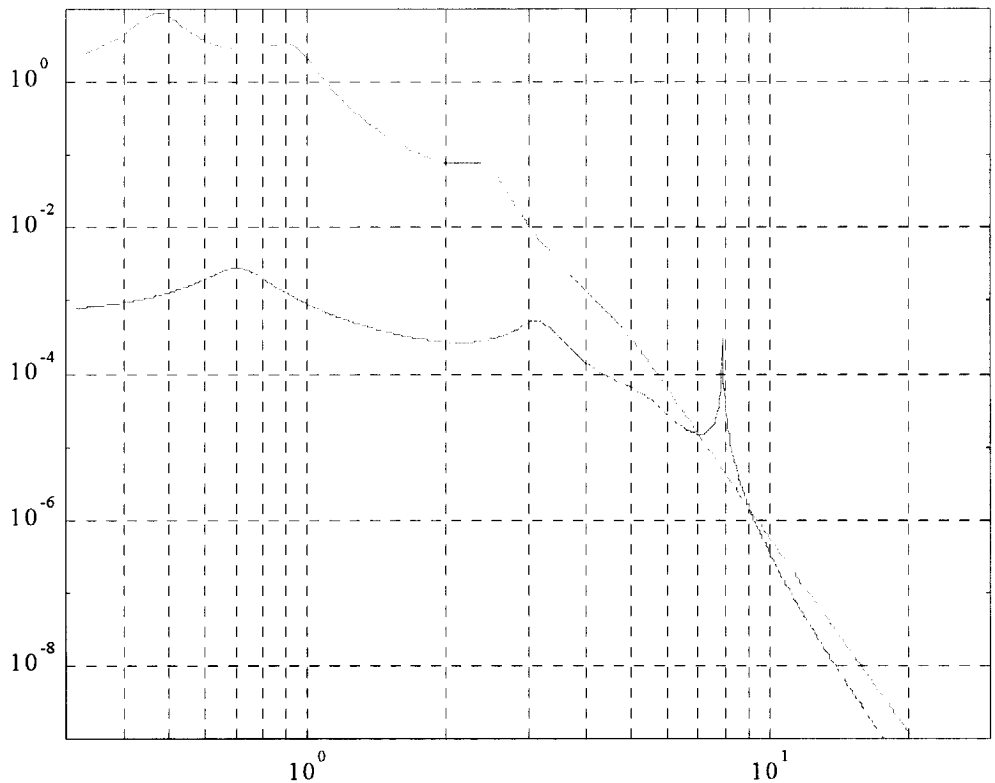
Ribbons 0.1 mm thick, 60 cm long. Wide = 5.5 mm, narrow = 1 mm.

Design Requirements- 2
Isolation and Local Control

- damping of all low freq. modes to Q ~ 10
- using working assumption of 10^{-11} m/rtHz for local control sensor noise, *quadruple pendulum* is required for BSC suspensions (longitud. pitch and yaw turned down for sensitive operation)
- lengths, masses, wire separations etc. chosen to give good coupling from uppermost mass which is damped by colocated sensors/actuators

  (possibility of using eddy current damping)

Isolation: BSC suspension

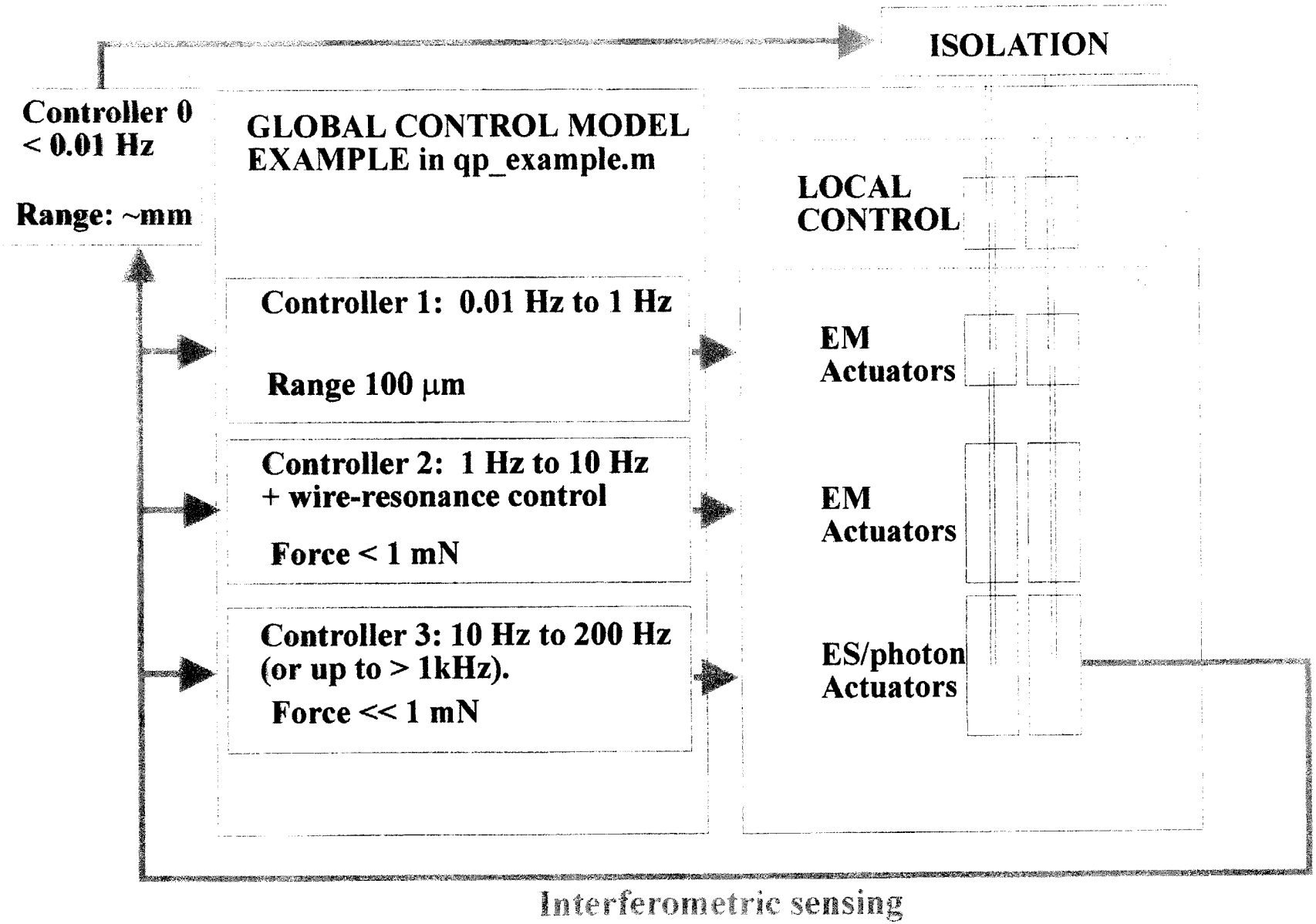


Longitudinal (red) and vertical (blue) isolation curves with local controls on, incl.cross-coupling of 0.001 in vertical. Overall length 1.7 m.

Design Requirements- 3
Global Control

- global control based on extension of GEO system (EM actuator at penultimate mass and electrostatic actuator at mirror)
- crossover frequency from isolation system to suspension system in LIGO II = 0.01 Hz

Global Control Model: Block Diagram



Summary - Baseline LIGO II Design (BSC)

- Quadruple pendulum incorporating 3 stages of enhanced vertical isolation using blades
- fused silica ribbons suspending mirror
- local control sensors/actuators (or eddy current damping) on top mass
- overall length ~ 1.7 - 2 m
- all locally controlled freqs. in range 0.4 - 5.5 Hz
- global control above 0.01 Hz, split between 3 controllers on 3 lowest stages, acting against quad reaction pendulum

Summary - Baseline LIGO II Design (HAM)

Less stringent requirements.

- triple pendulum, similar to GEO system, shorter in length : 0.6 m
- circular x-section fibres in final stage suspension

Some Developments Required for Suspensions

- Development of ribbons
  - strength and loss measurements
- Silica / sapphire bonding
  - strength, durability
- Cross-coupling
- Better sensing?

Note 1, Linda Turner, 05/09/00 01:27:51 PM
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