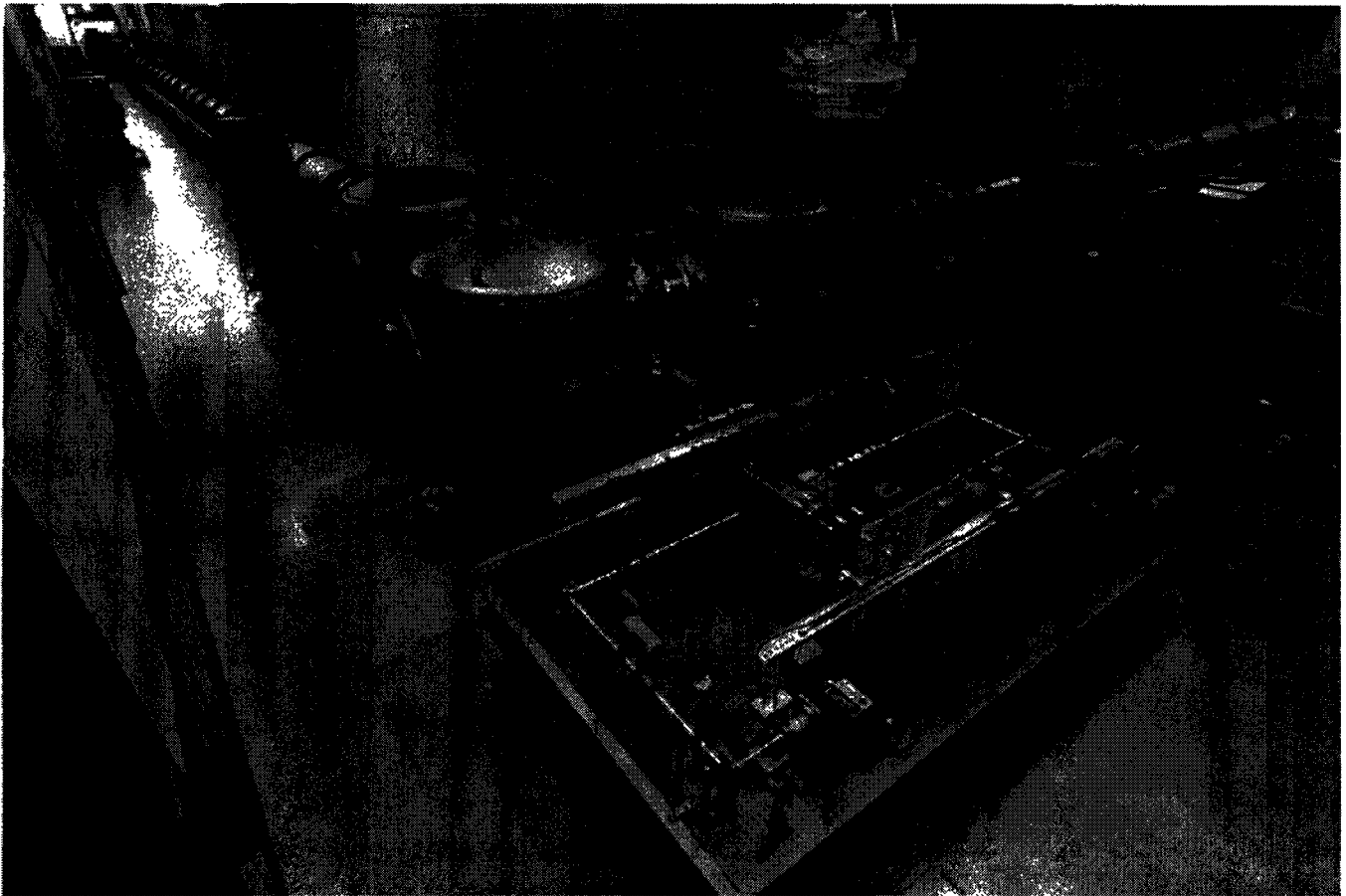


Recent Research on the LIGO 40m Interferometer

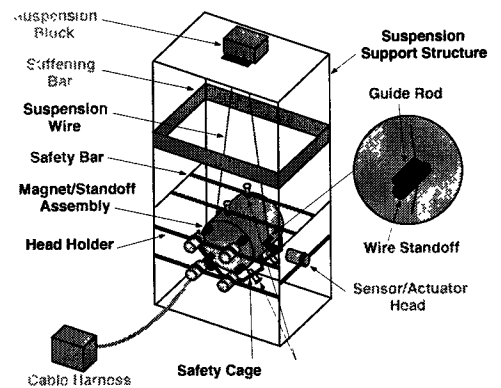


**Seiji Kawamura
(LIGO, Caltech)**

Recent Developments

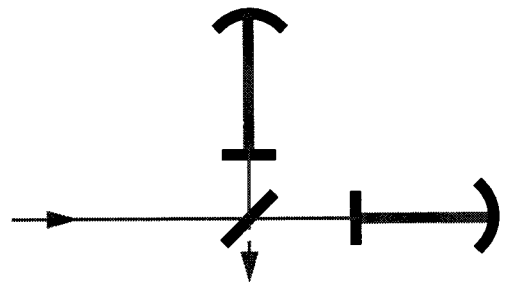
- New Suspension Prototype

- ›› Installed and tested



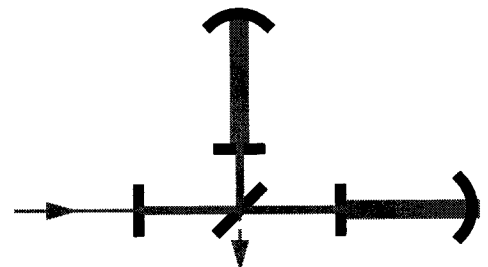
- Recombination

- ›› Completed



- Recycling

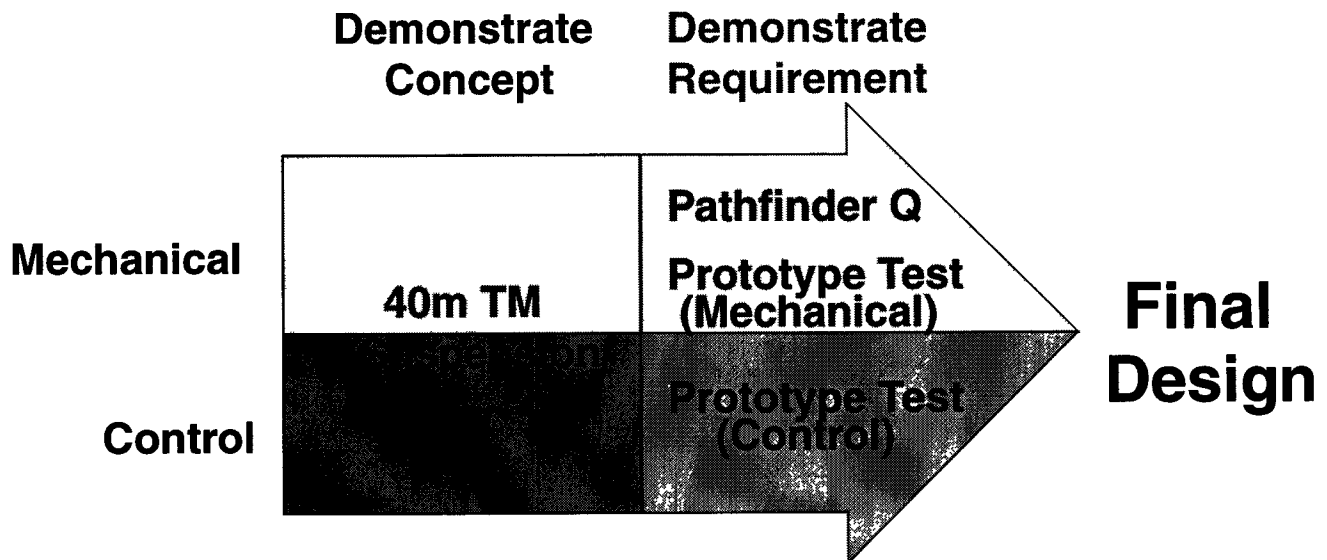
- ›› Started



Significance of 40m TM Suspension Test

LIGO Large Optics Suspension

(Test Mass, Beamsplitter, Recycling Mirror, Folding Mirror)

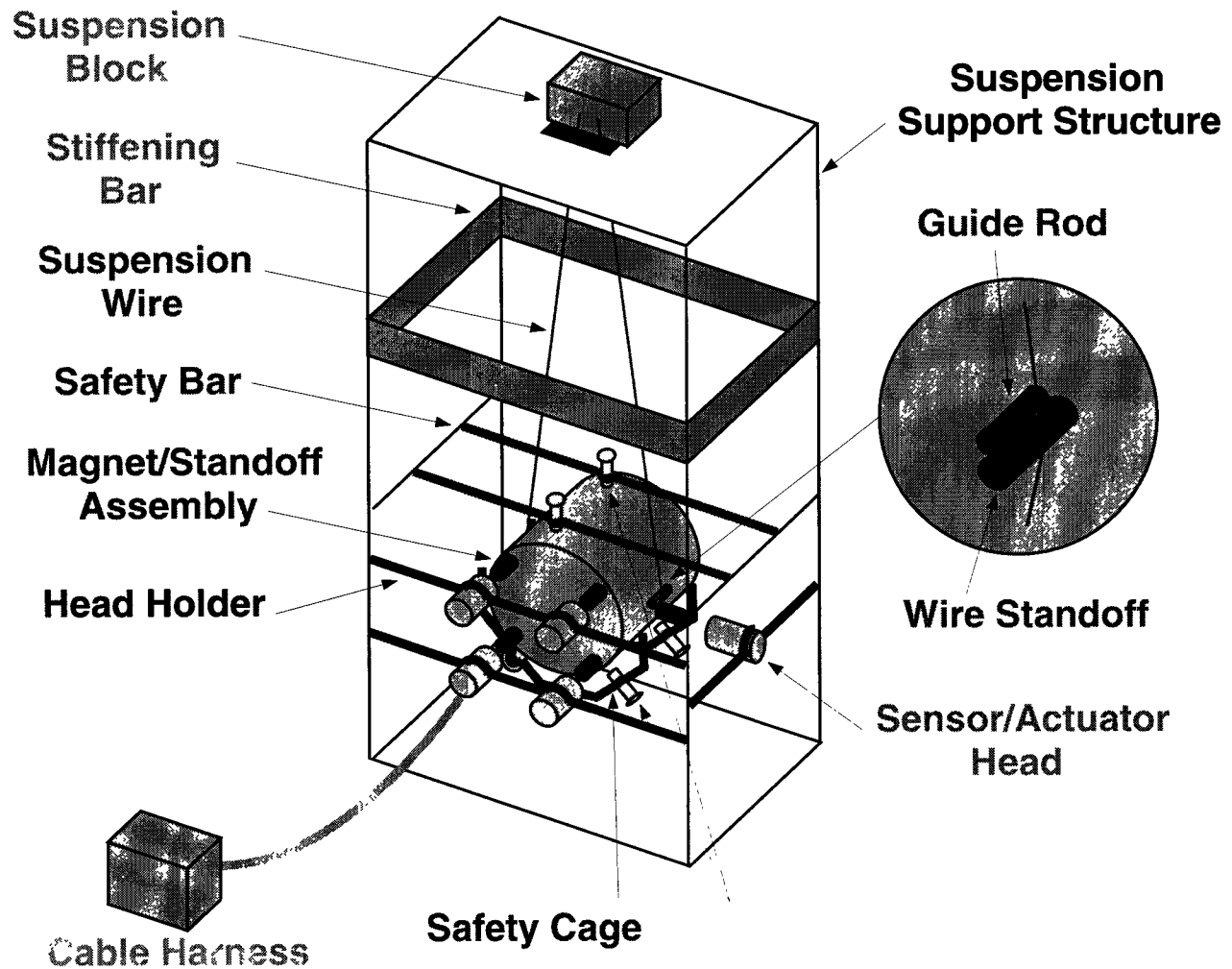


40m Test Mass Suspension

- One prototype was designed, fabricated, installed in the 40m, and characterized.
- New mechanical design worked.
- New control design worked.
- General performance was satisfactory.
- 40m was locked using the LSC (Length Sensing Control) input of the controller.
- 40m sensitivity with the prototype was NOT degraded with and without the LSC input.

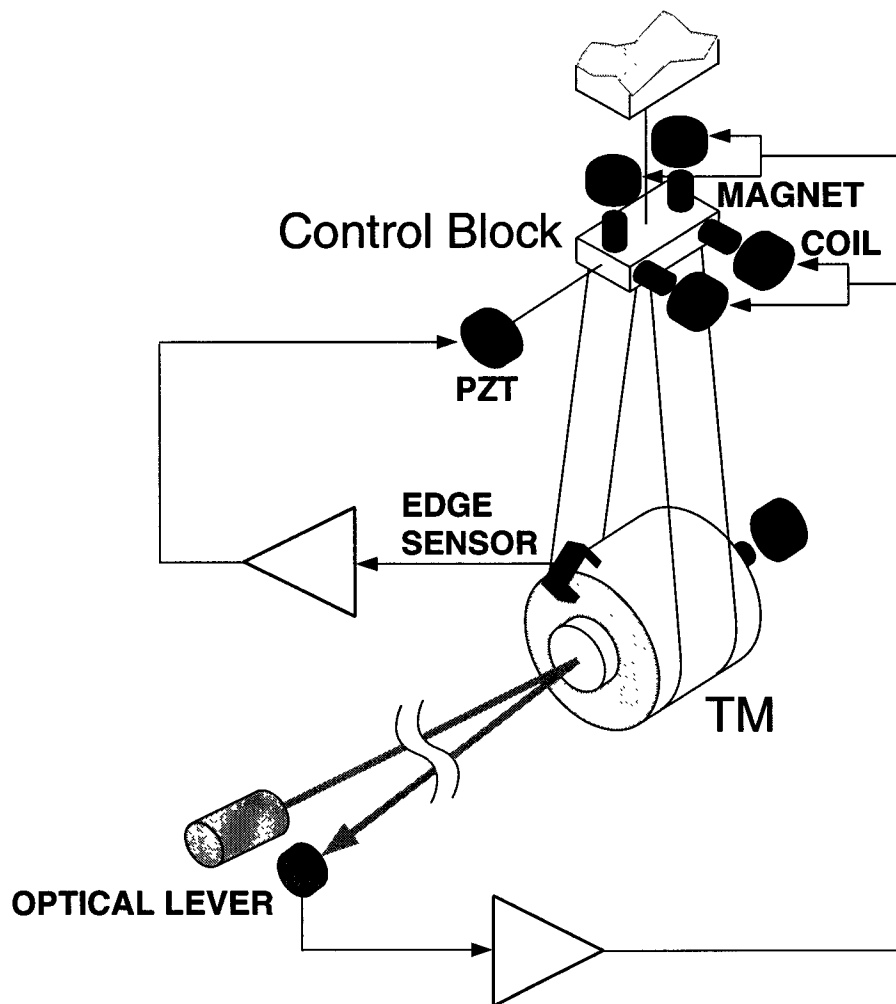
Mechanical System

- Single loop wire
- Modular support structure



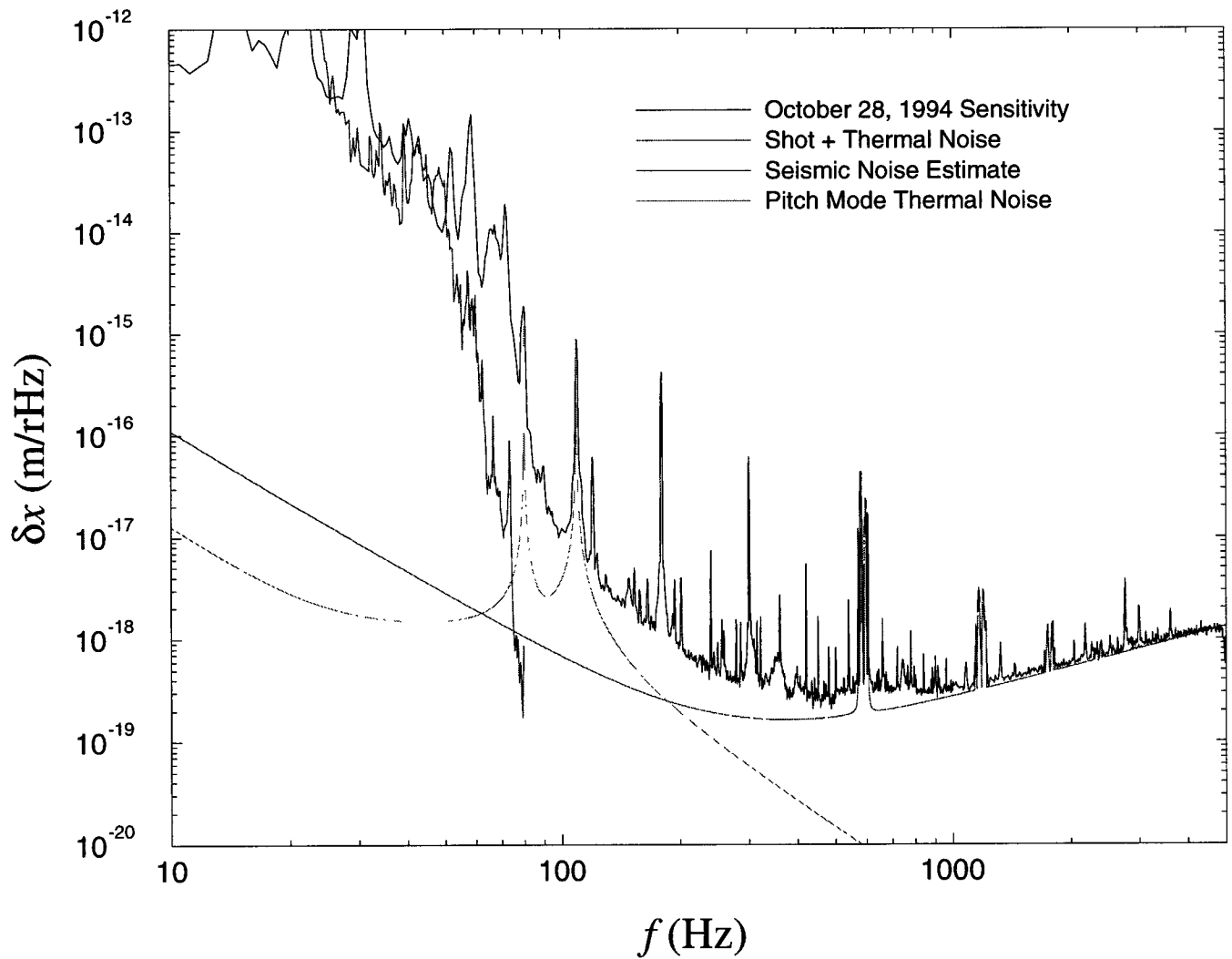
Double Loop Wire Configuration (Old 40m TM Suspension)

- Too complicated mechanical design
- Pitch and yaw mode thermal noise



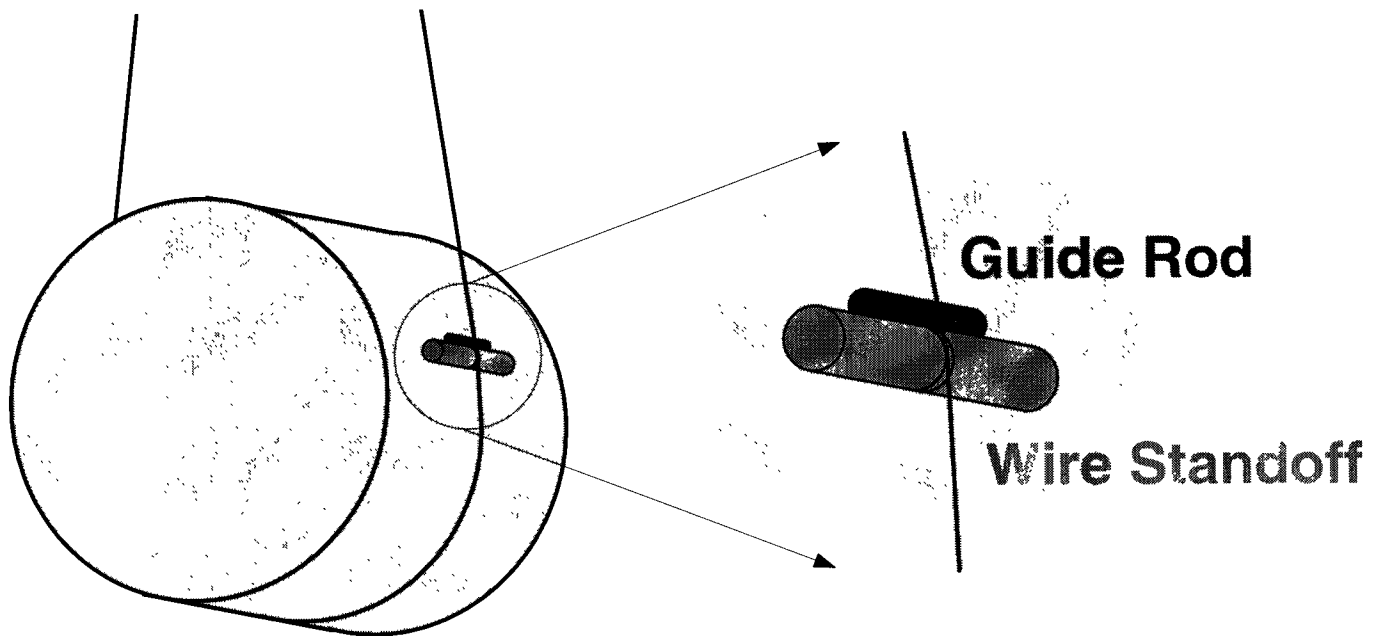
Pitch Mode Thermal Noise

- Measured Q: 2,000 - 3,000

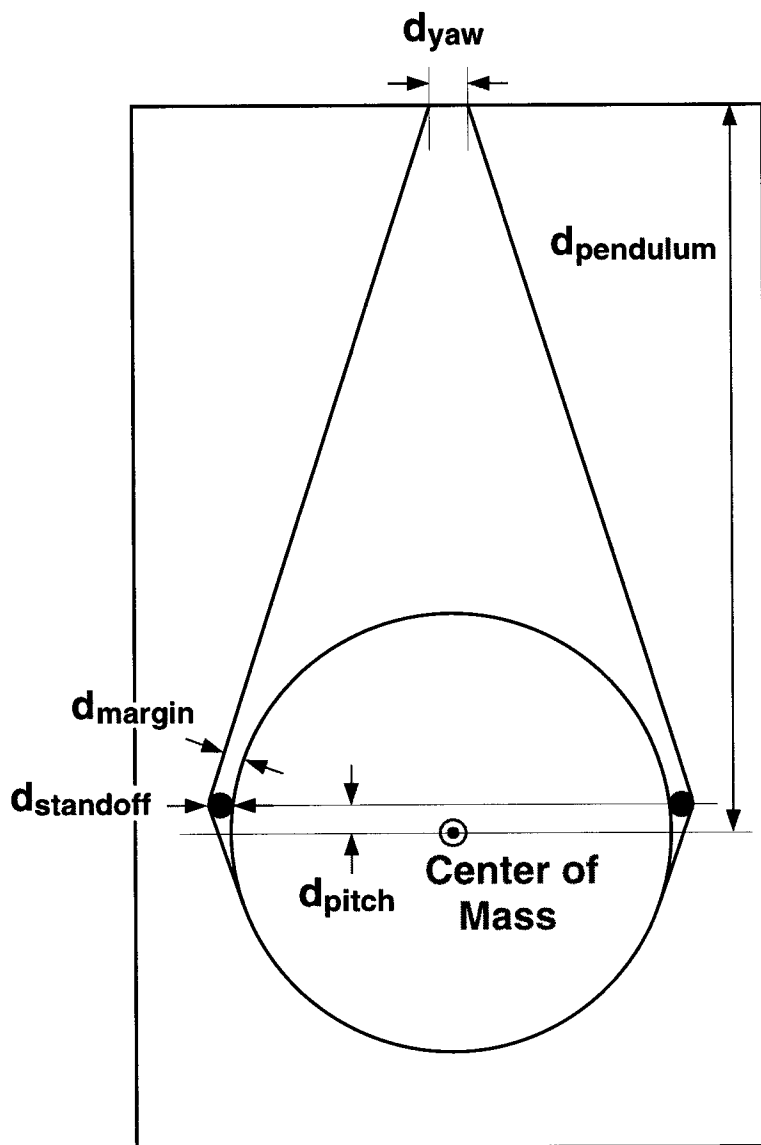


Balancing Test Mass with Single Loop Wire

- Balanced using guide rods and wire standoffs with groove
- Negligible Q degradation due to attachments



Suspension Configuration



$$f_{pendulum} = 0.84 \text{ Hz}$$

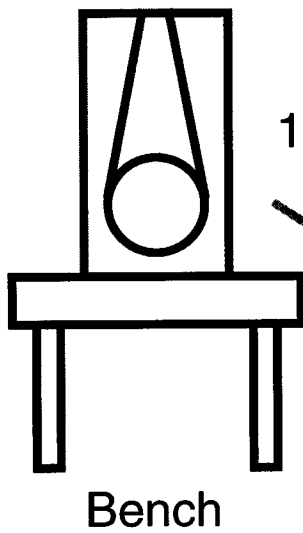
$$f_{pitch} = 0.50 \text{ Hz}$$

$$f_{yaw} = 0.60 \text{ Hz}$$

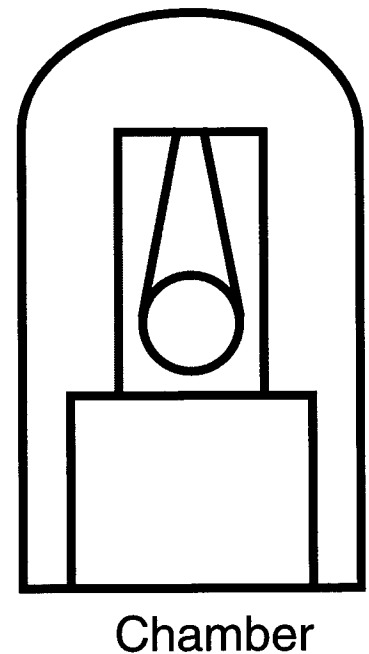
$$f_{violin} = 548 \text{ Hz}$$

$$f_{vertical} = 11.1 \text{ Hz}$$

Assembly on Bench, Then Transfer into Chamber

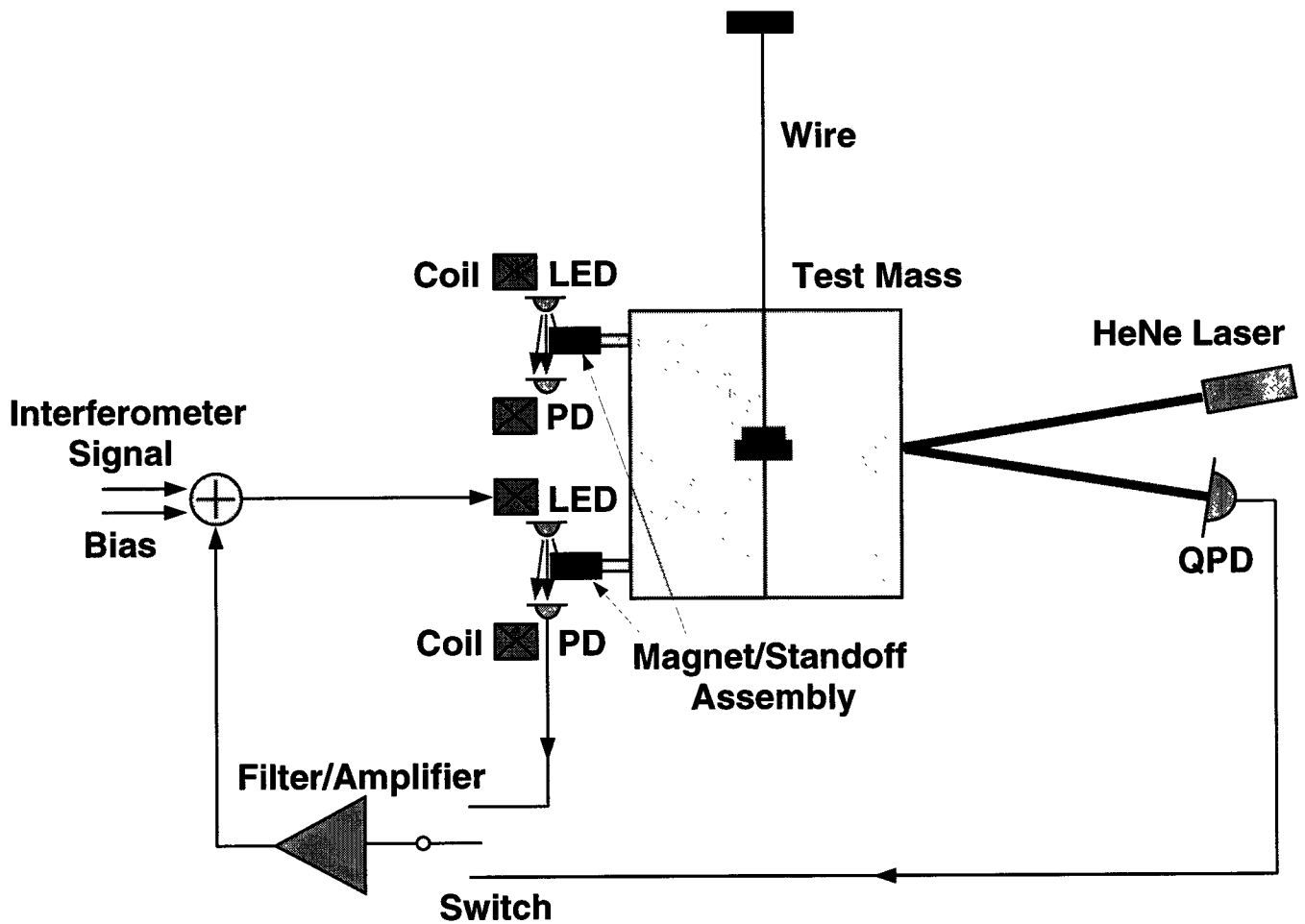


1. Assemble and Balance
2. Clamp TM
3. Transfer



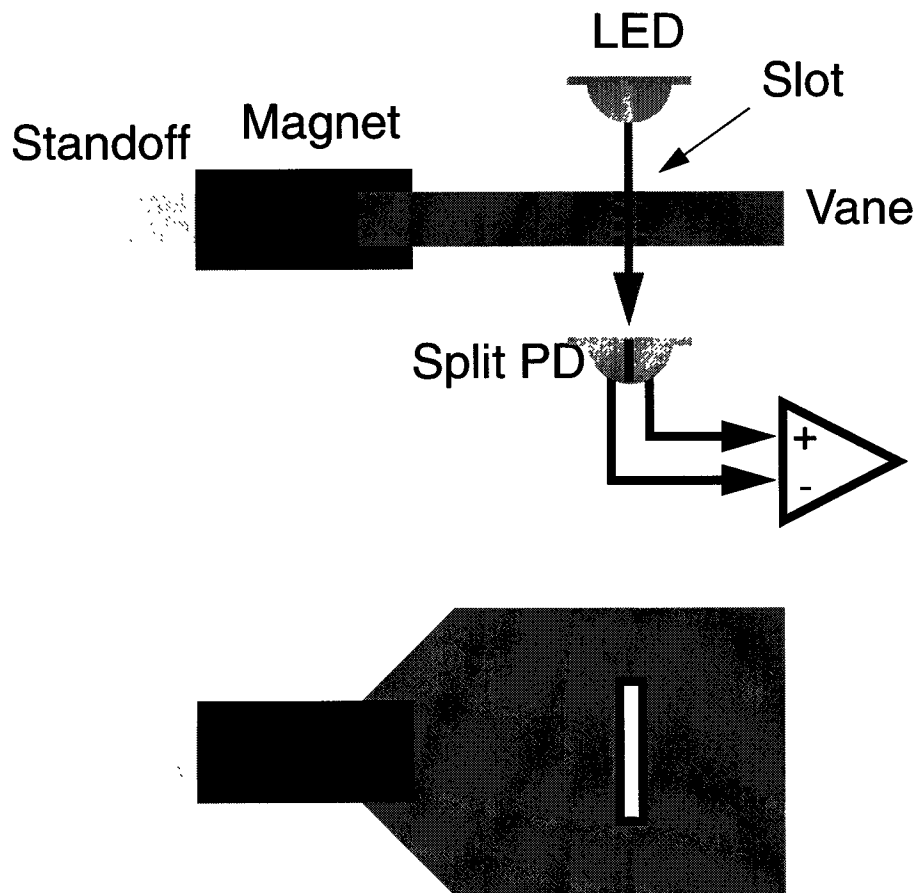
Control System

- Simple edge sensor
- Current-source type driver



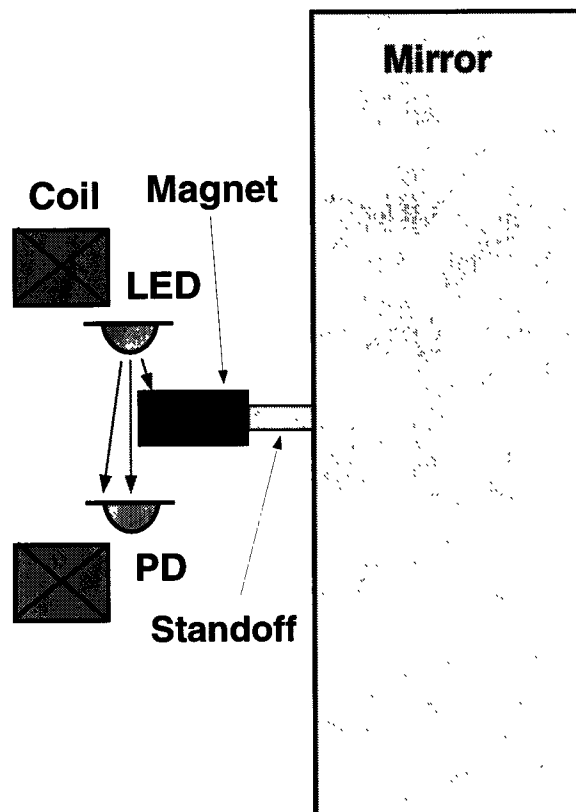
Slot Sensor with Vane (Old BS Suspension)

- Resonant frequency ~ 1 kHz due to the big vane
- Q degraded due to the big vane
- Complicated electronics



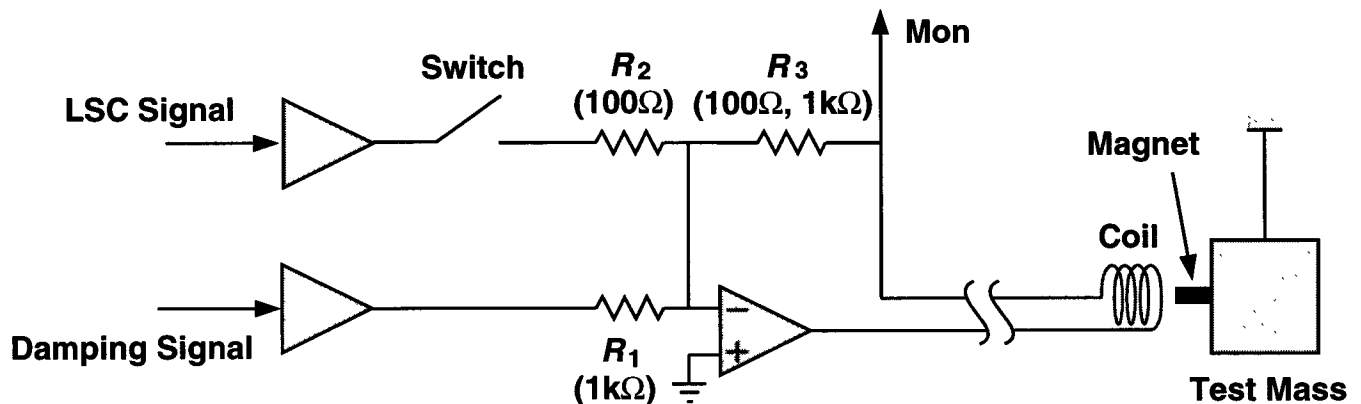
Edge Sensor without Vane

- Resonant frequency ~ 8 kHz
- Reasonable Q
- Simple electronics



Current-Source Type Driver

- No pick-up current into the coil
- Monitor signal free from pick-up.
- No eddy current dragging.
- Switchable between the acquisition mode and operation mode without gain change



Extrapolation to the LIGO

Large Optics Suspension

Items	40m TM Suspension or Pathfinder Q measurement	Extrapolated to LIGO	LIGO Requirements
Residual Q when damped	< 3	< 3	< 3
Internal Mode Loss	3×10^{-7}	3×10^{-7}	$< 4 \times 10^{-7}$
Pendulum Mode Loss	2×10^{-5} (Violin Mode)	7×10^{-6}	$< 7 \times 10^{-6}$
Actuator Range ($f < 0.15$ Hz)	44 μ mp	8 μ mp	> 80 μ mp
Driver Noise (at 40 Hz)	6×10^{-19} m/ $\sqrt{\text{Hz}}$	9×10^{-20} m/ $\sqrt{\text{Hz}}$	< 5×10^{-20} m/ $\sqrt{\text{Hz}}$
Sensor Noise (at 40 Hz)	4×10^{-20} m/ $\sqrt{\text{Hz}}$	4×10^{-20} m/ $\sqrt{\text{Hz}}$	(Option) < 5×10^{-20} m/ $\sqrt{\text{Hz}}$

Next...

40m BS&RM Suspension

LIGO Small Optics Suspension

(Mode Cleaner Mirror, Steering Mirror)

