The Thermal Noise Interferometer

Measuring Displacement Noise in Advanced Suspended Interferometers

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Objectives:

- ↓ Characterize Advanced Detectors
  - Verify Design Specifications
  - Measure Noise Sources
  - Measure Non-thermal Noise Properties
- ↓ Physics of Fundamental Noise Sources
  - Noise Physics, Statistics
  - Reach (and Exceed) the SQL

LIGO-G000268-00-D

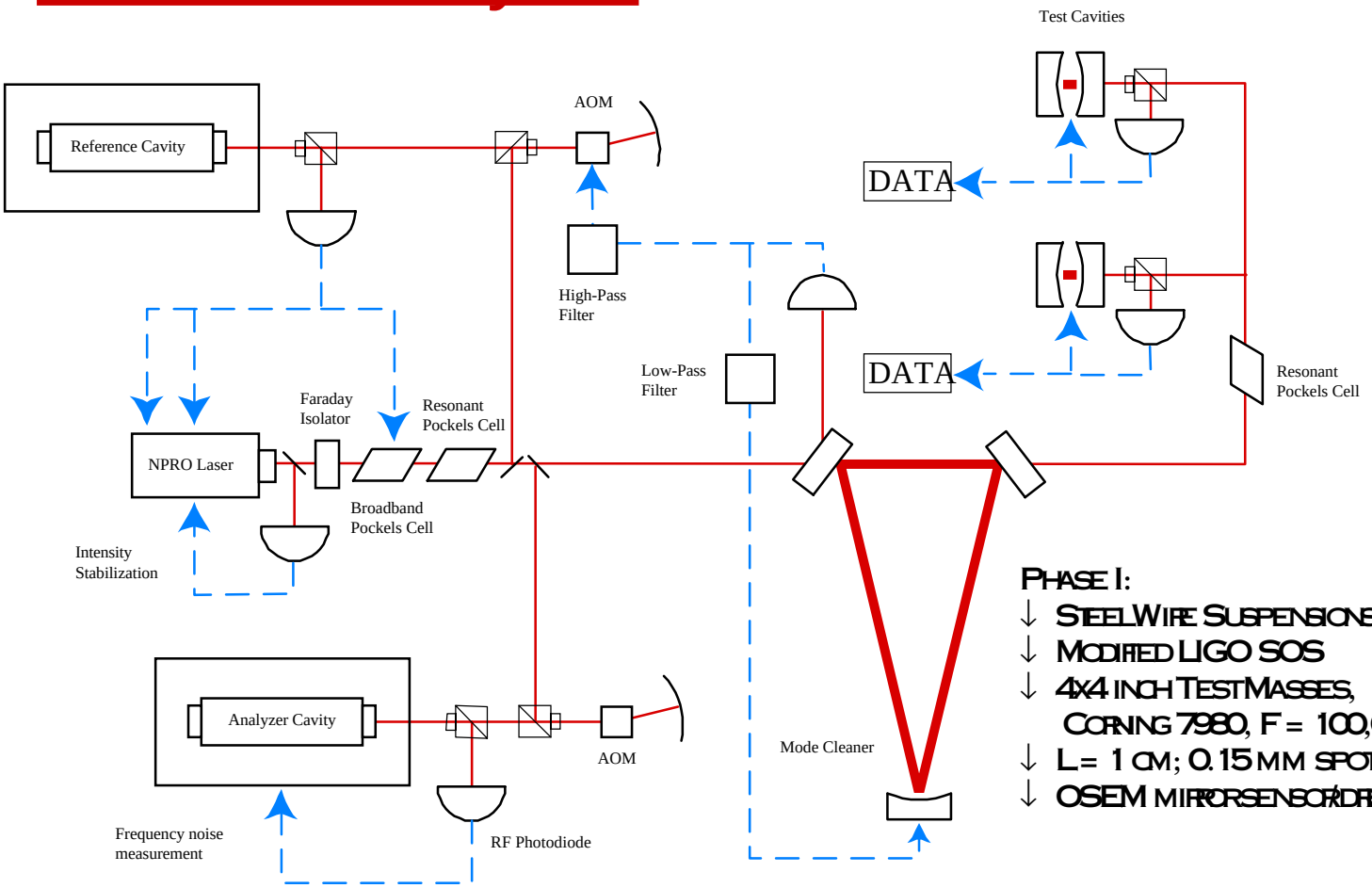
TNI Design Elements

The many advantages of using a short cavity length (L λ 1cm)

- ↓ Short Cavity Storage Time
  - υ Use High Finesse Cavities
  - υ No Power Recycling
- ↓ Independent Cavities
  - υ No Recombination
  - υ Independent Controls
- ↓ Reduced Optical Pointing Requirements - no WFS
- ↓ Reduced Laser Stability Requirements
- ↓ Common Support for Test Masses
  - υ Reduced Seismic Noise
  - υ Lower Suspension Recoil Thermal Noise

But…Smaller laser spot size υ Higher Internal Thermal Noise

TNI Initial Layout

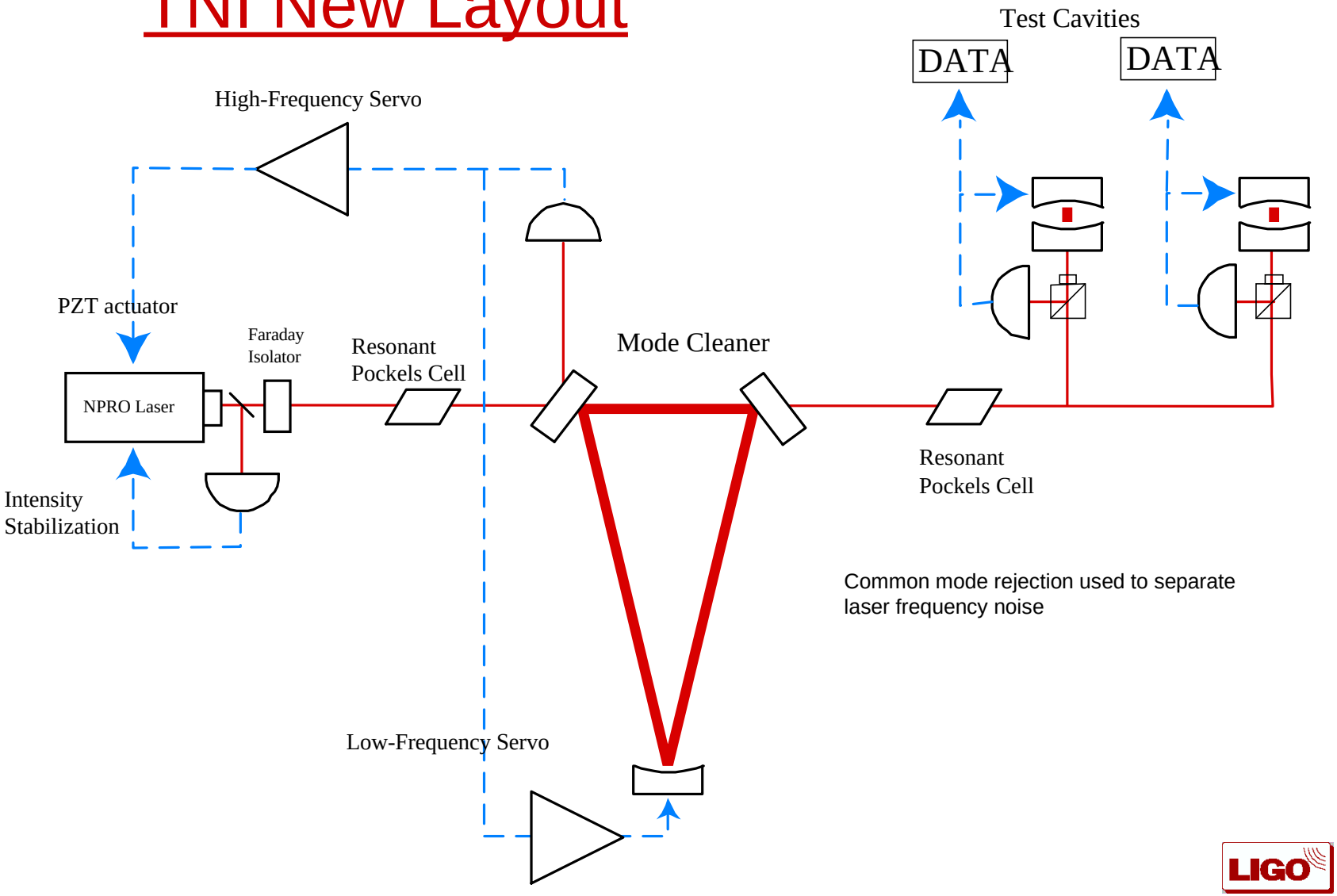


PHASE I:

- STEEL WIRE SUSPENSIONS
- MODIFIED LIGO SOS
- 4X4 INCH TEST MASSES, CORNING 7980, F = 100,000
- L = 1 CM; 0.15 MM SPOT SIZE
- OSEM MIRROR SENSOR/DRIVERS

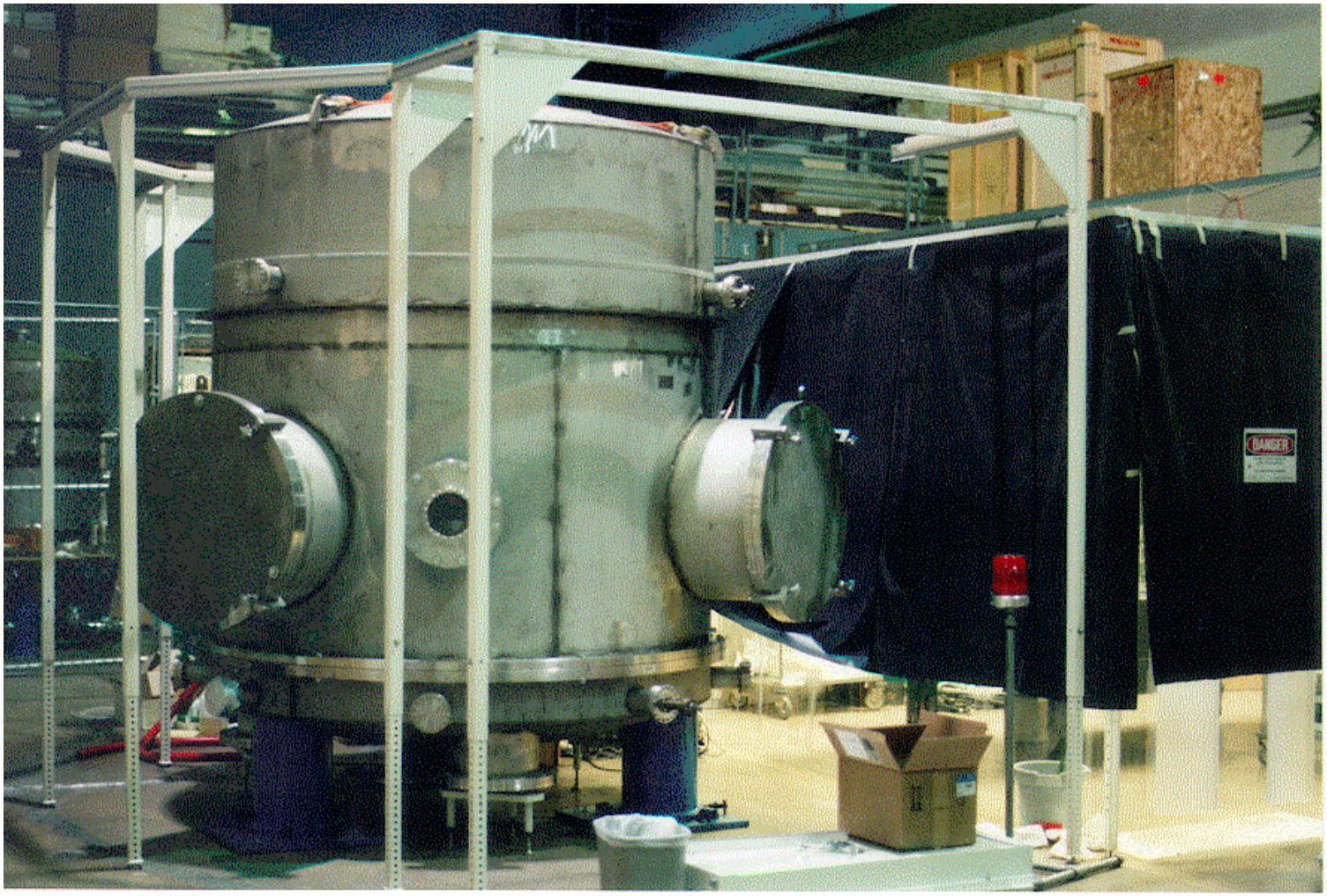
LIGO PSL copy

TNI New Layout



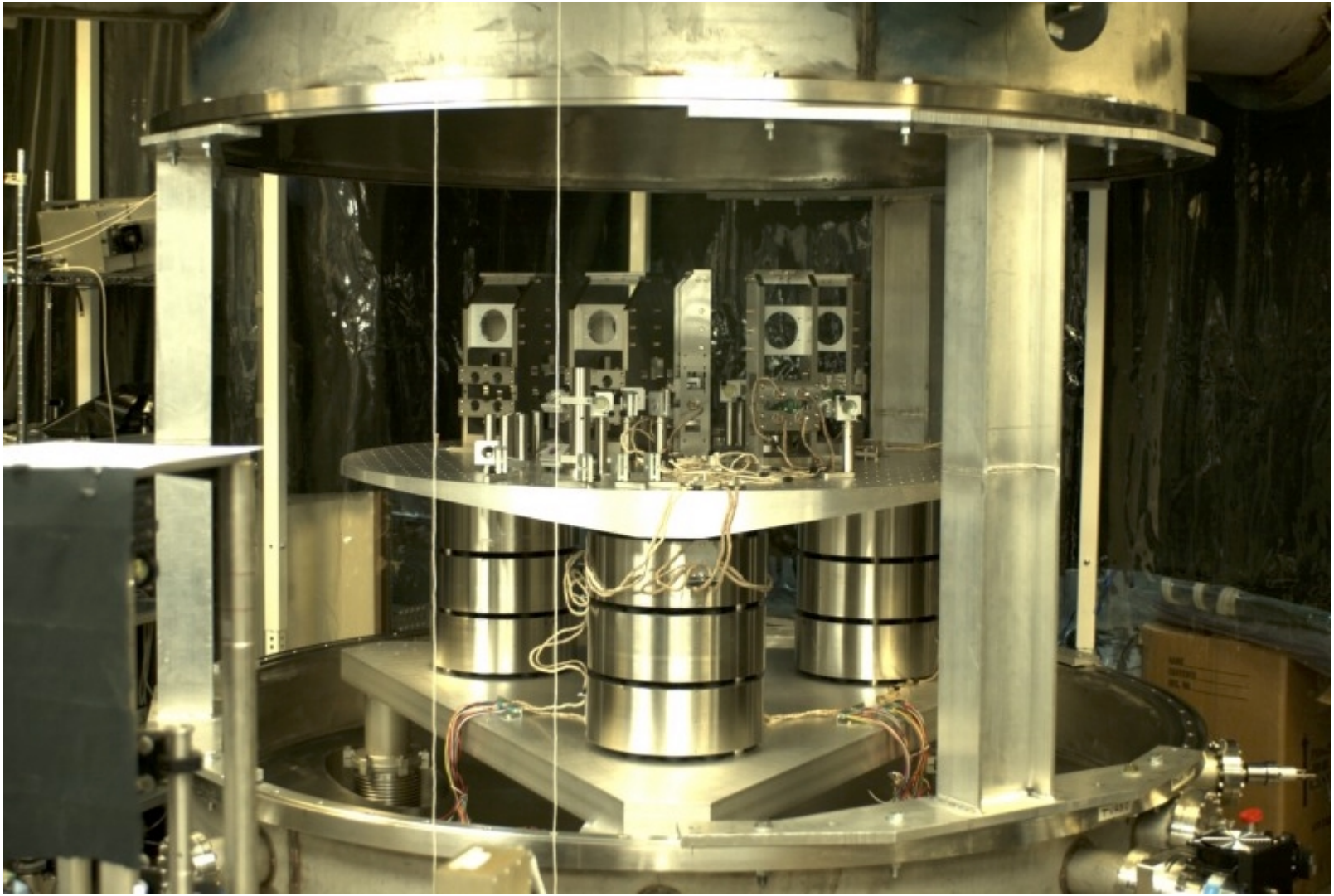
Common mode rejection used to separate laser frequency noise

TNI Outside View

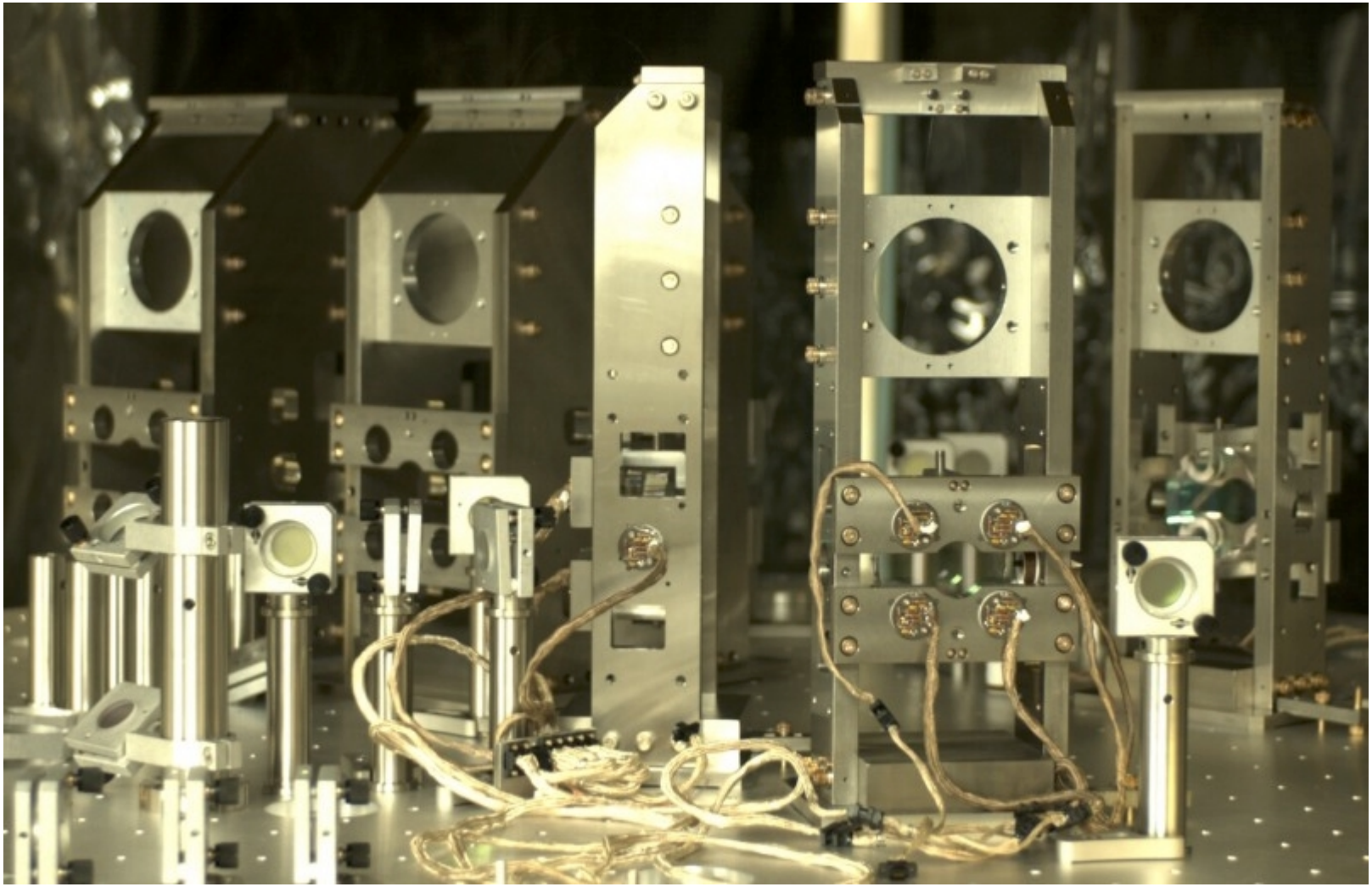


…before clean-room cover around vacuum chamber

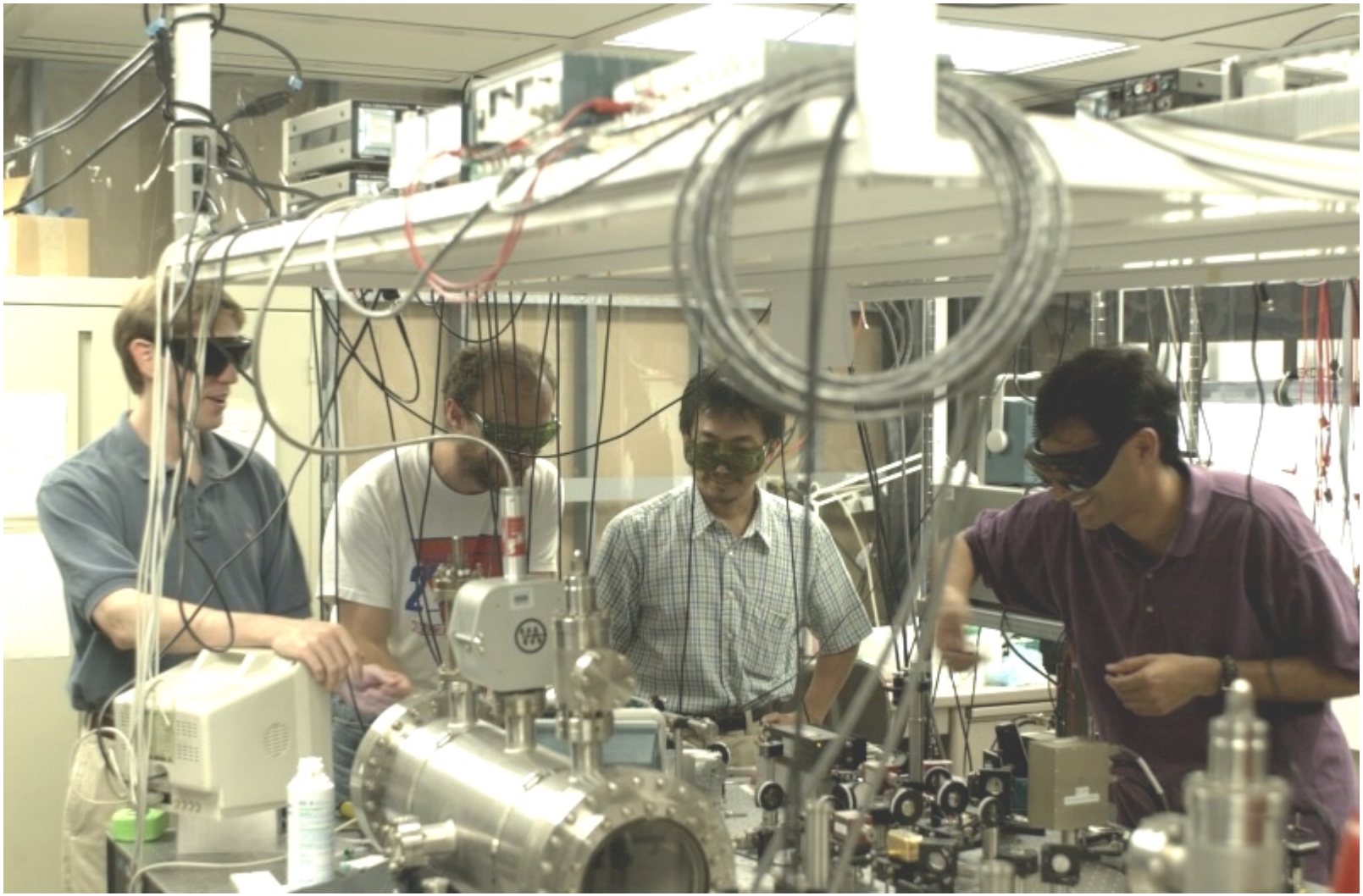
TNI View inside vacuum chamber



TNI View inside vacuum chamber



The TNI crew



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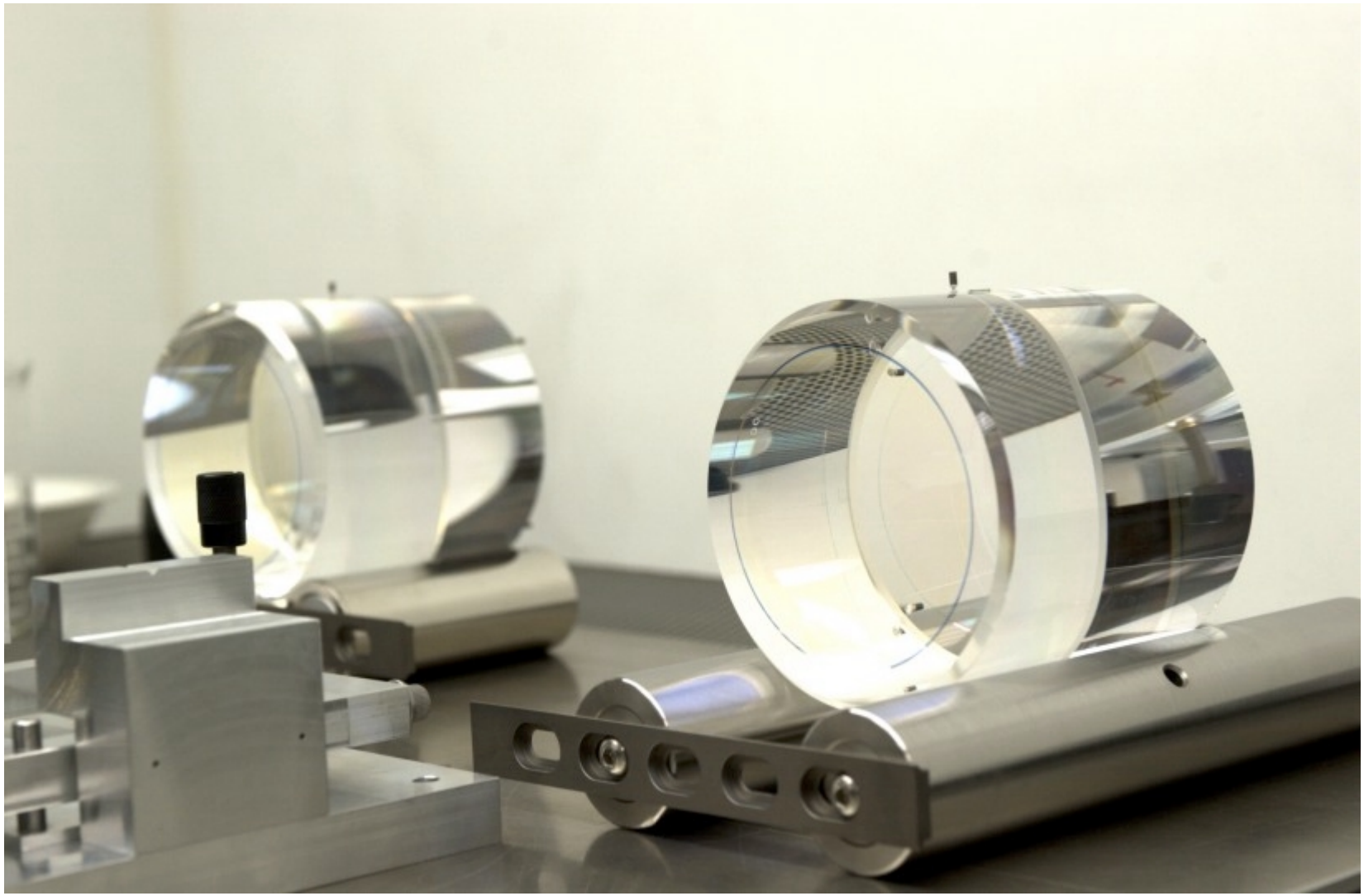
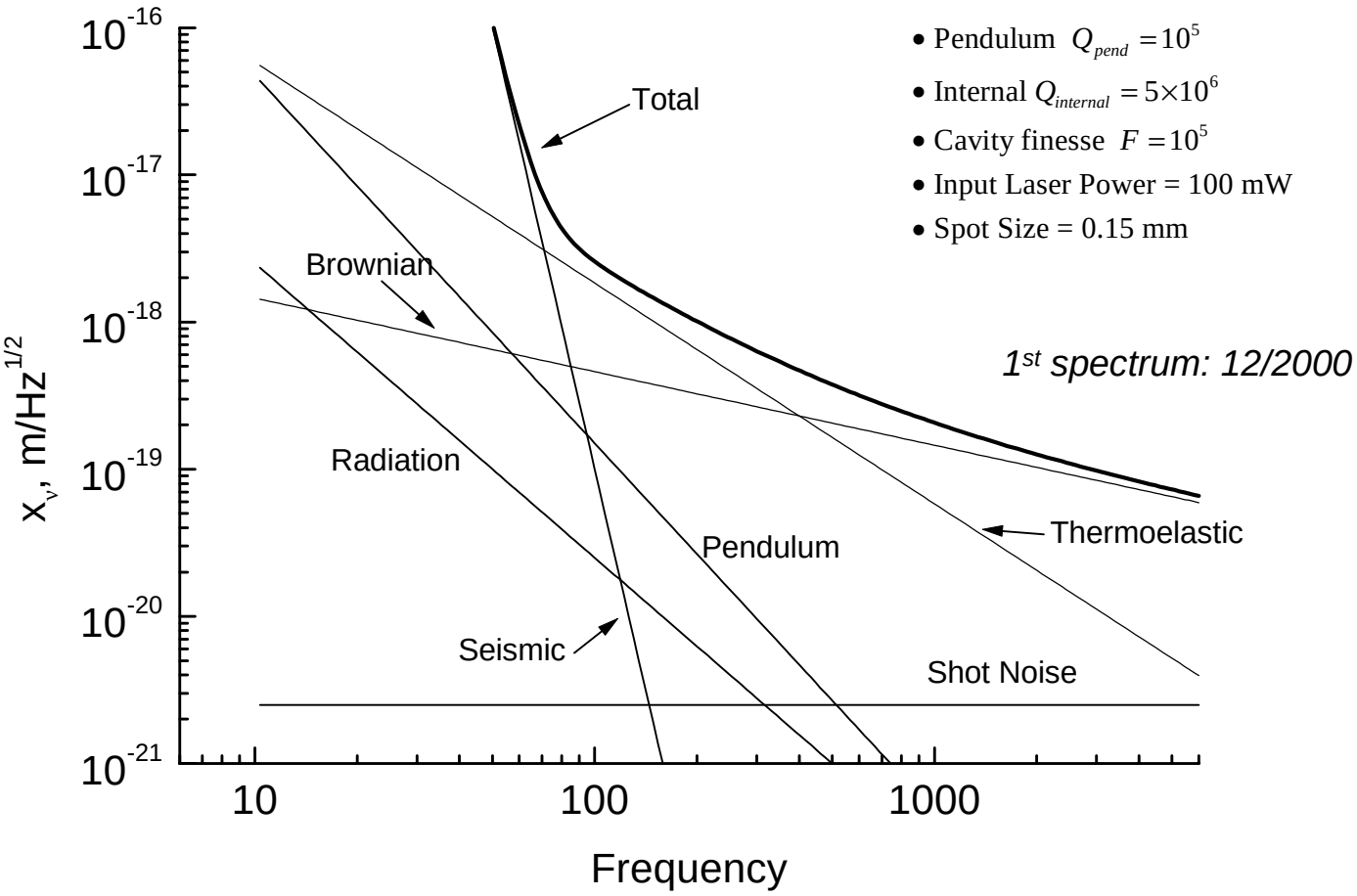
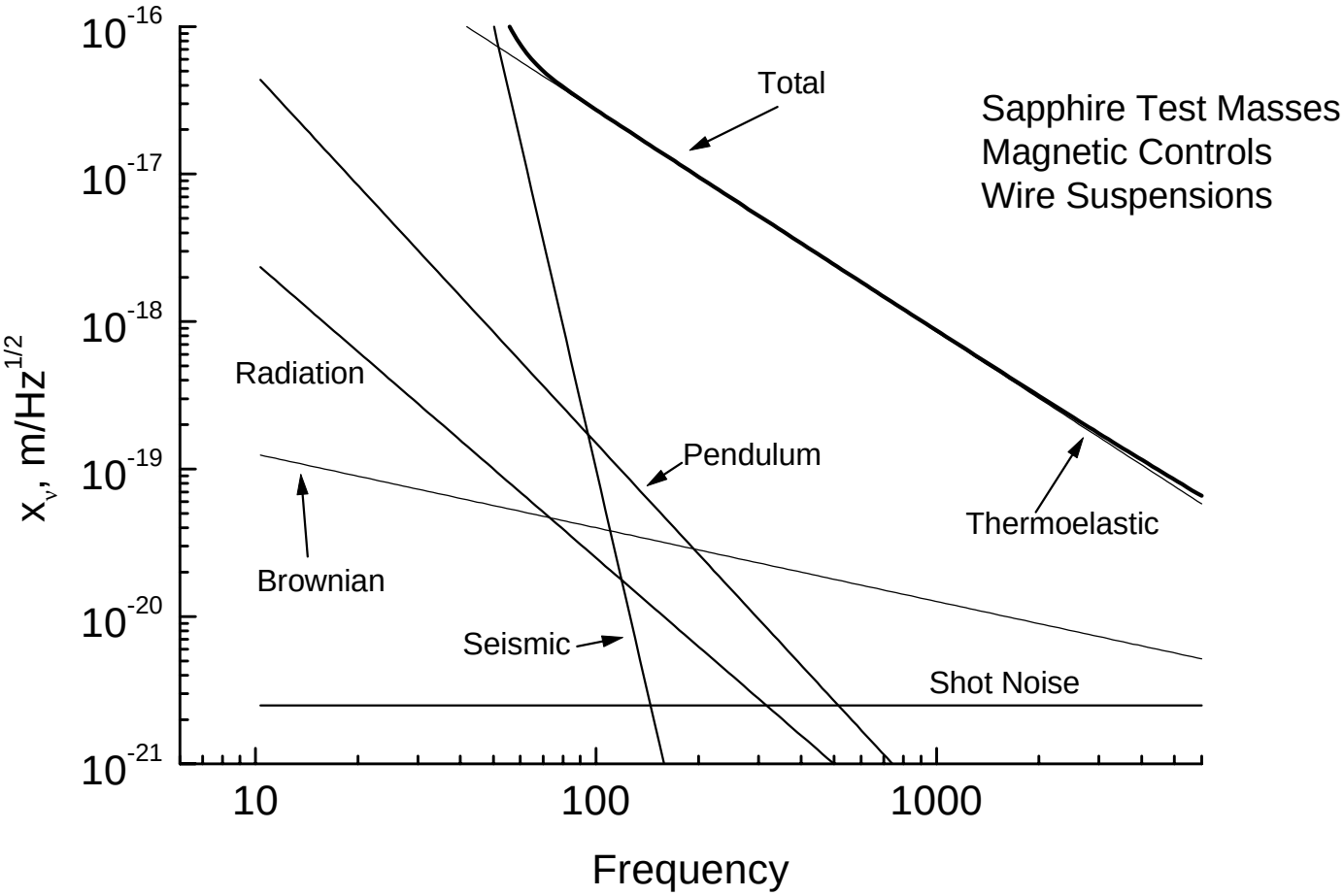
TNI Phase I Test Masses



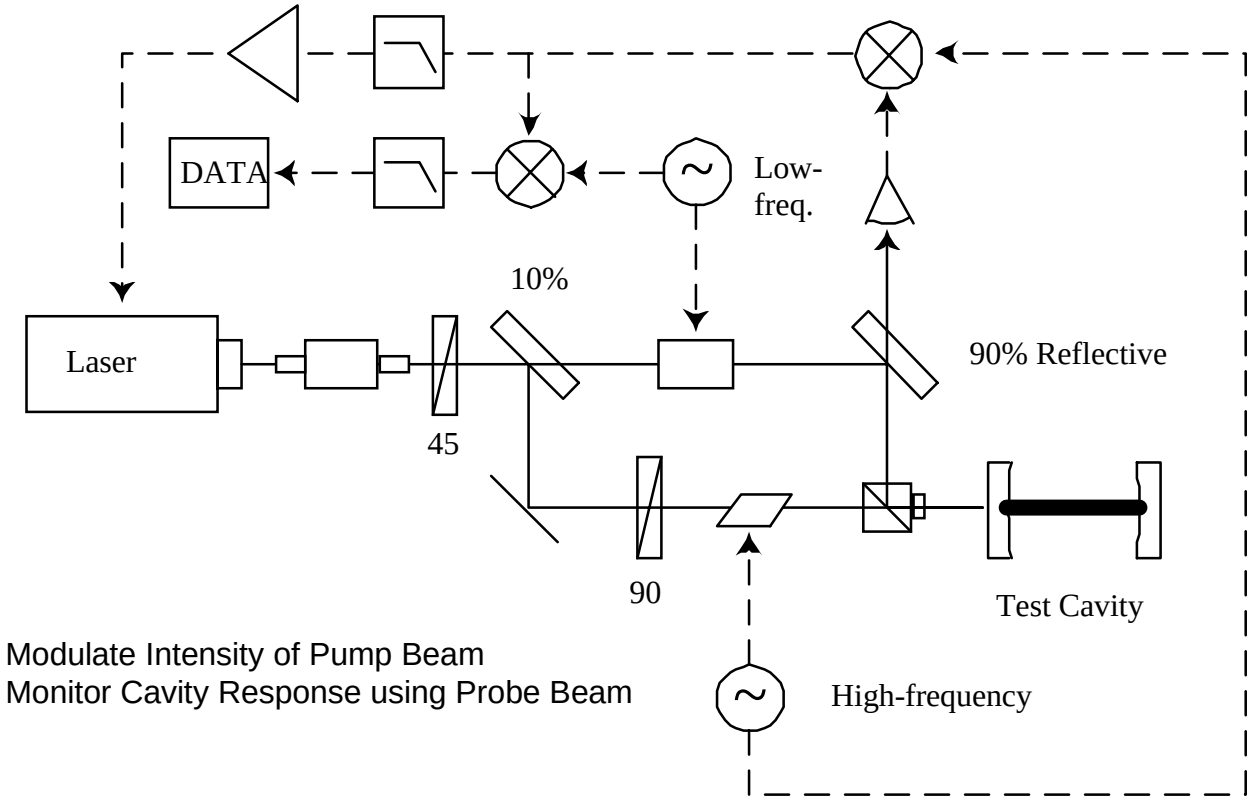
TNI Phase I Expected Spectrum



TNI Phase II Expected Spectrum



PhotoThermal Noise Measurement



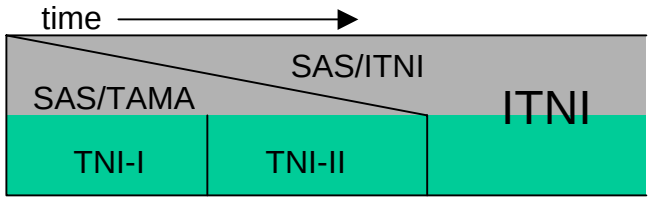
Modulate Intensity of Pump Beam
Monitor Cavity Response using Probe Beam

The International Thermal Noise Interferometer (ITNI)

Principal Objective:

Examine Fused Silica Suspension Noise

- Pendulum Thermal Noise not yet measured
- Non-Gaussian events probably dominate data analysis
- Physics not well understood
- Determine optimal stress in fibers



Experiment Upgrade:

- Push to Lower Frequencies
- Combine SAS and TNI, plus collaborators

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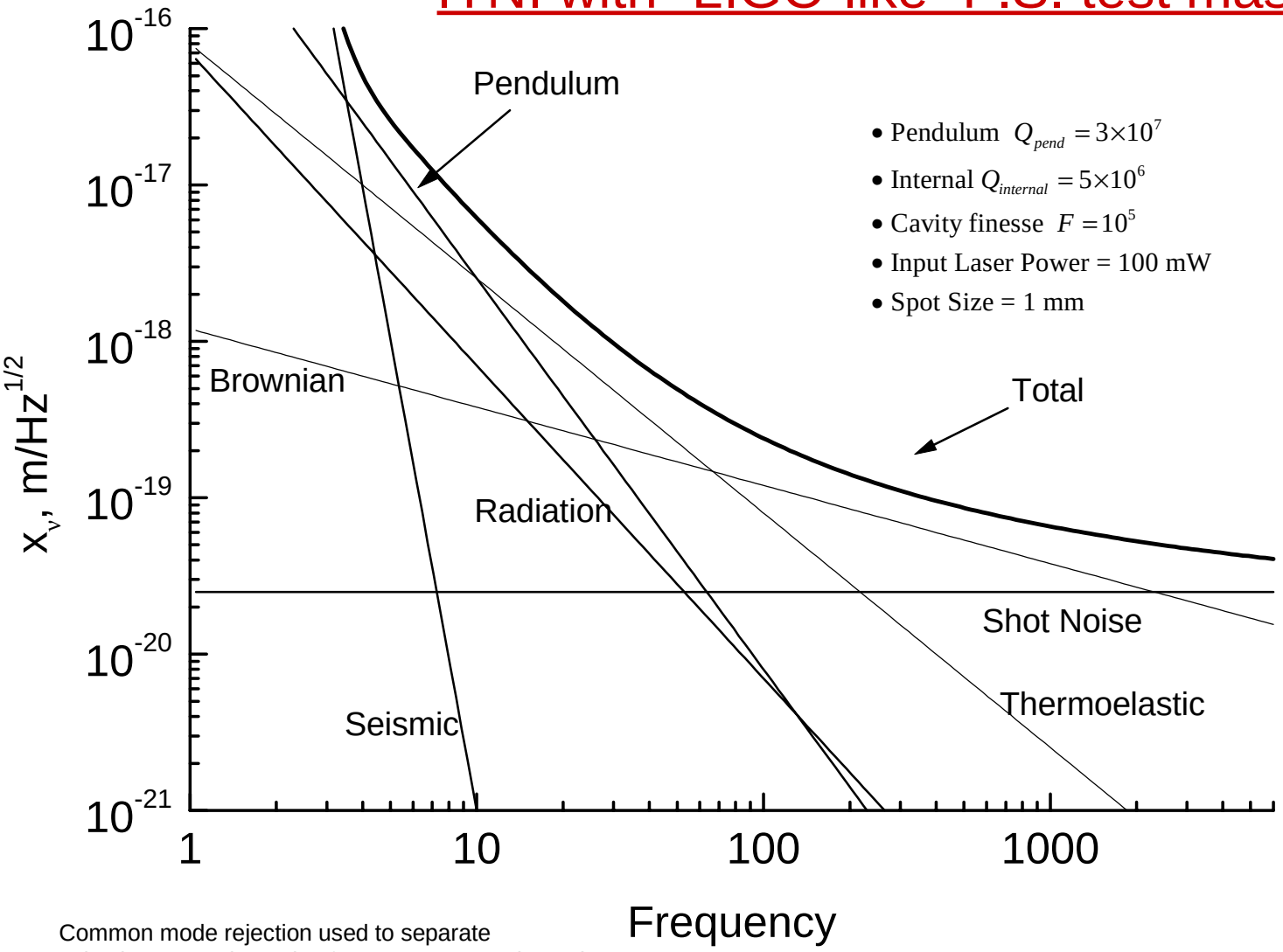
ITNI with “LIGO-like” F.S. test masses



- Pendulum $Q_{pend} = 3\times10^7$
- Internal $Q_{internal} = 5\times10^6$
- Cavity finesse $F = 10^5$
- Input Laser Power = 100 mW
- Spot Size = 1 mm

Common mode rejection used to separate seismic suspension noise from F.S. suspension noise

ITNI with flat/flat cavities