Thermal noise resulting from ring dampers used for suppression of parametric instabilities

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LIGO Seminar

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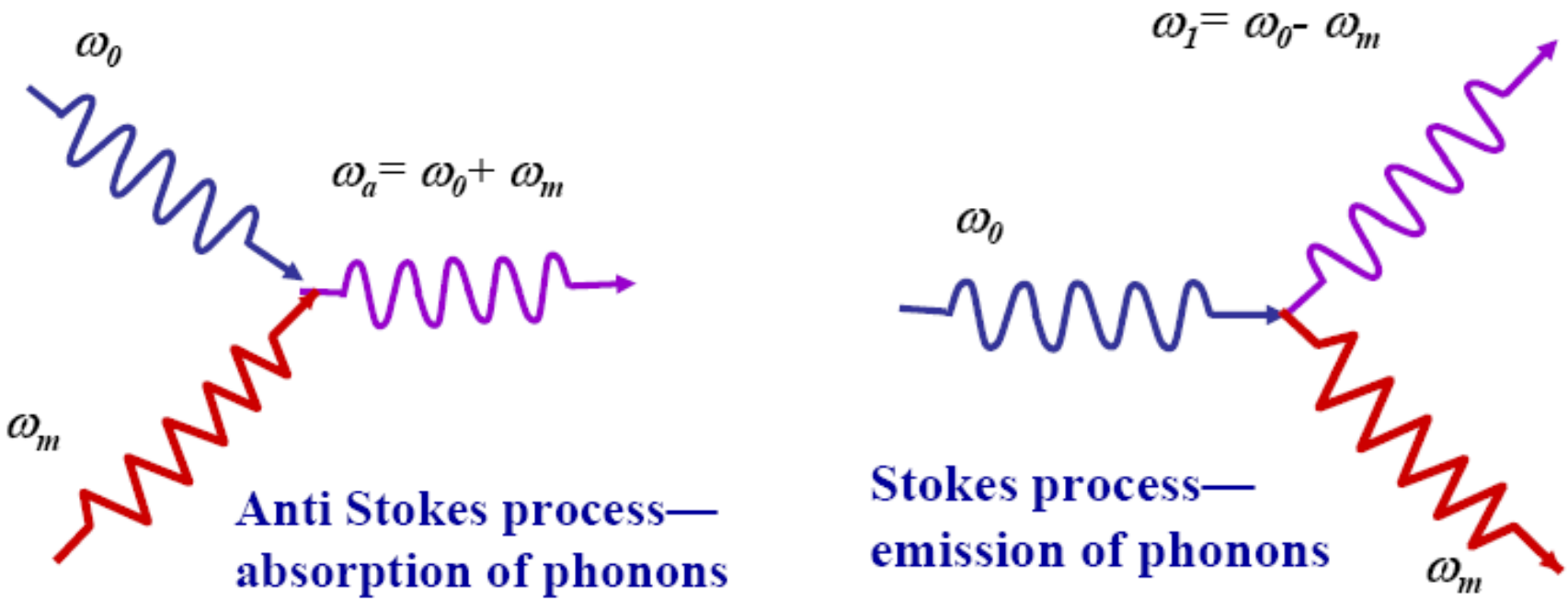
Acousto-Optic Coupling



Instability Condition

Power

Mechanical Q

Overlap factor

$$R \approx \frac{2PQ_m}{McL\omega_m^2}\left(\frac{Q_1\Lambda_1}{1+\Delta\omega_1^2/\delta_1^2} - \frac{Q_{1a}\Lambda_{1a}}{1+\Delta\omega_{1a}^2/\delta_{1a}^2}\right) > 1$$

Stokes mode contribution

Anti-Stokes mode contribution

$$\delta_{1(a)} = \frac{\omega_{1(a)}}{2Q_{1(a)}}$$

Ju, et al. G050325-00 who got it from
Braginsky, et al. Phys. Lett. A 305, 111 (2002)

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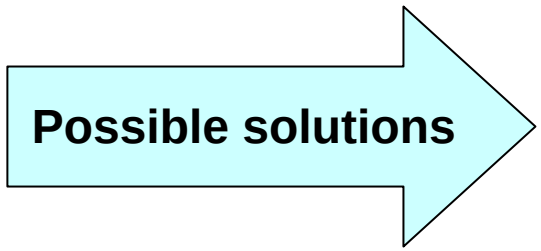
Suppress parametric instabilities

How do we eliminate parametric oscillations in AdLIGO without spoiling our low thermal noise floor?



Active feedback

Thermal detuning

Ring dampers

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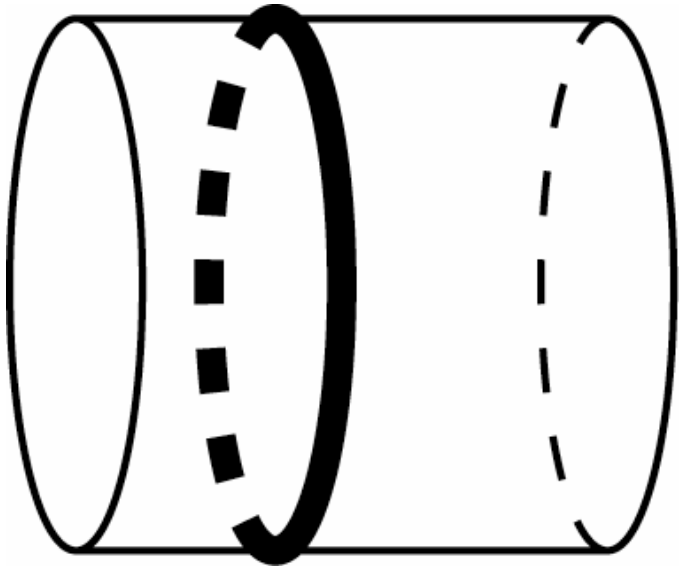
Ring Damper

IDEA:To suppress the mechanical Q's of many modes, without sensibly affecting thermal noise floor



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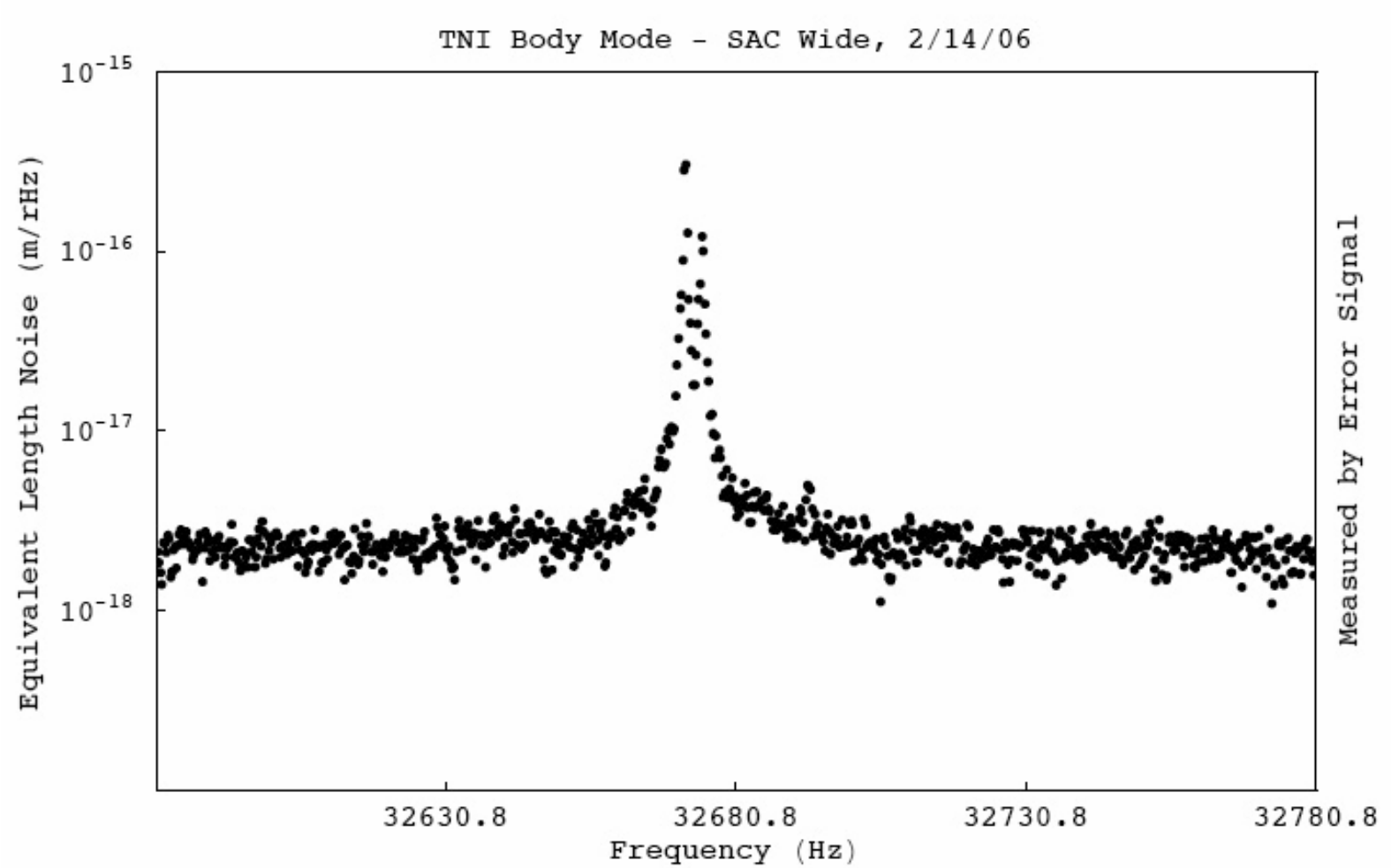
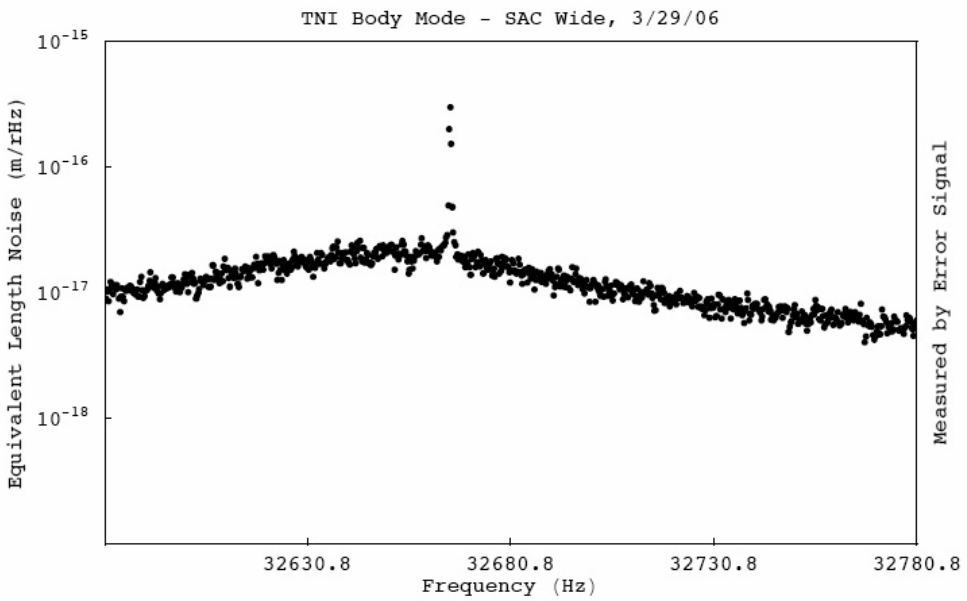
Previous results

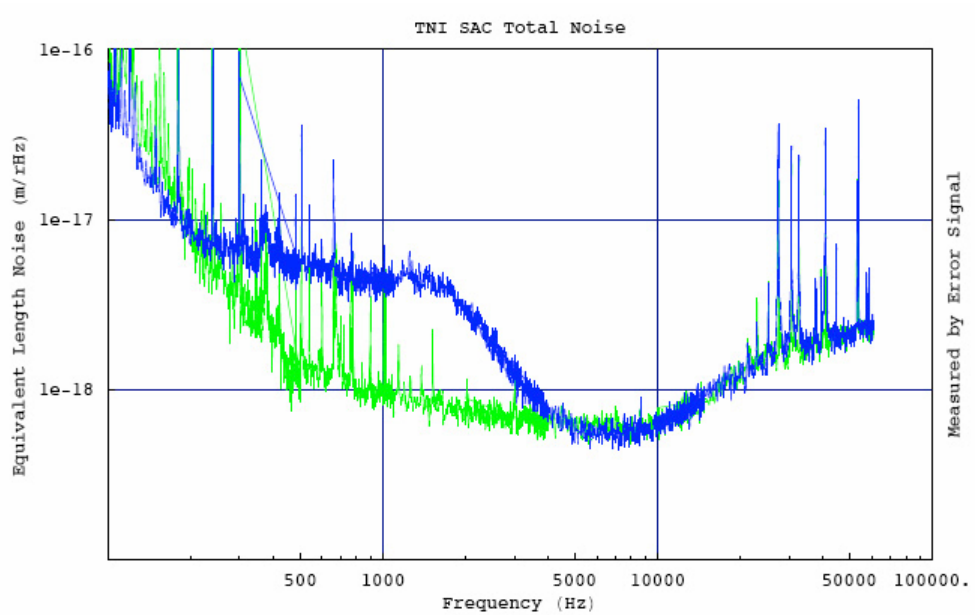
- Rubber O-Rings
  - Q's decreased
  - Broadband noise increased
- Kapton tape O-Rings
  - Q's unchanged
  - Broadband noise unchanged

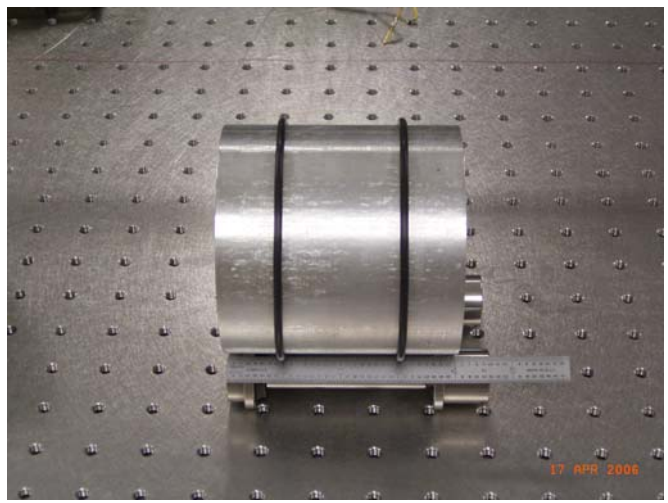
Effect of dampers on Q's



Rubber O-Rings







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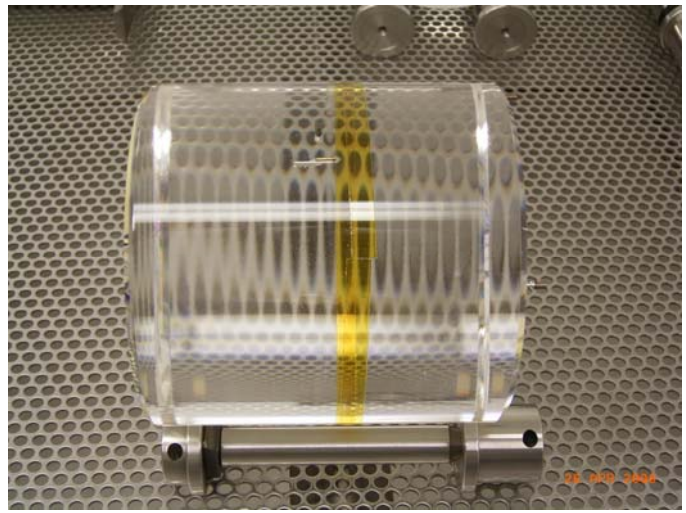
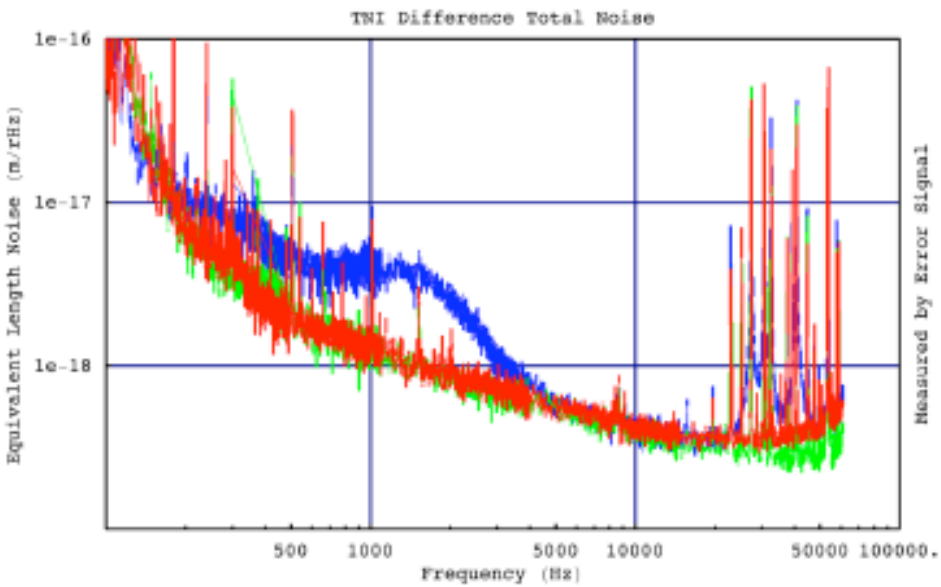
Kapton tape O-ring

No ring damper
Rubber O-Ring
Kapton tape





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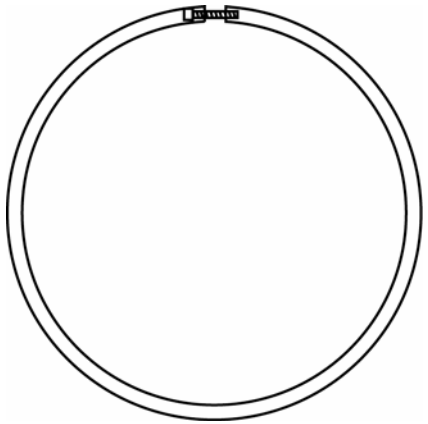
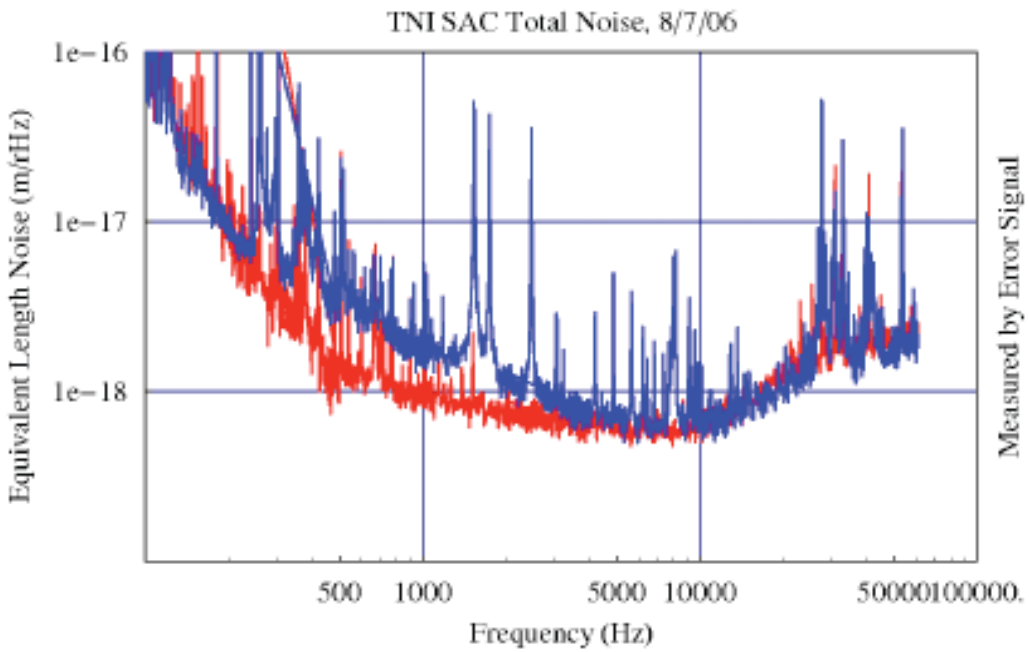
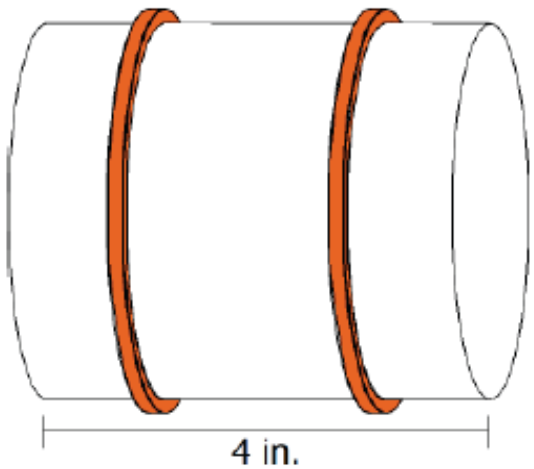
This summer's results

Copper rings with screw

- Q's decreased
- Broadband noise changed







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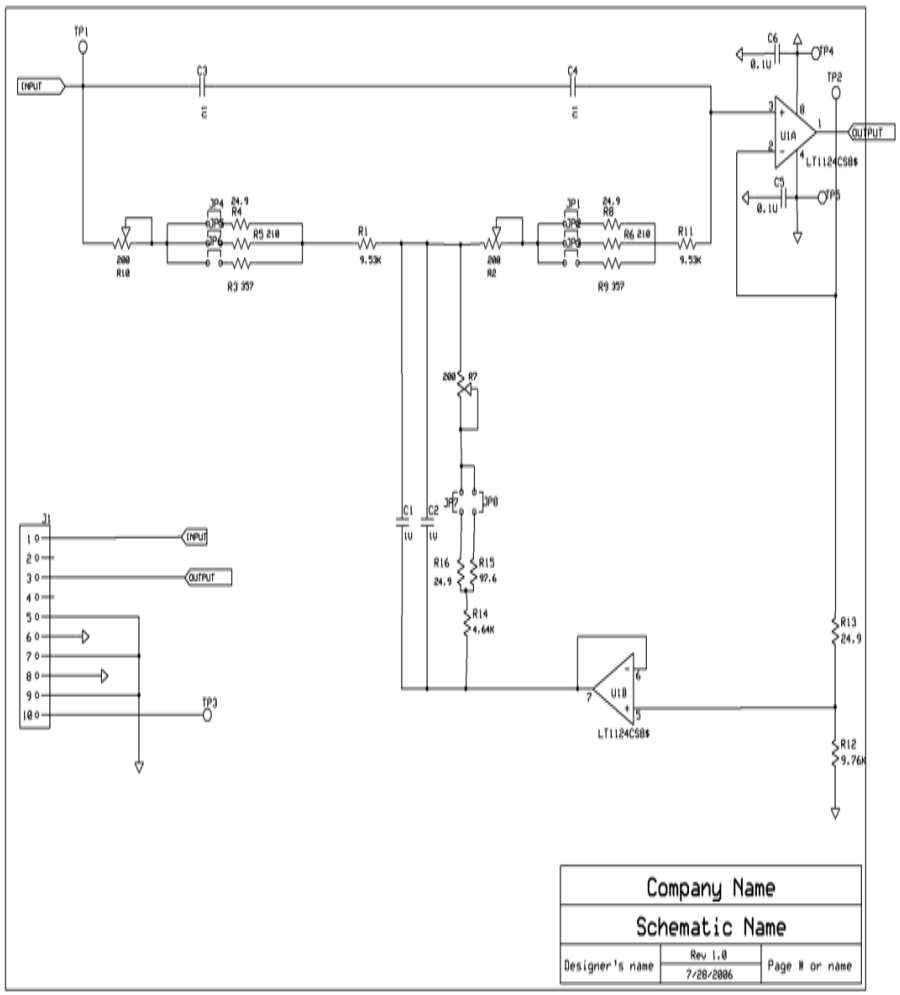
What can we do?

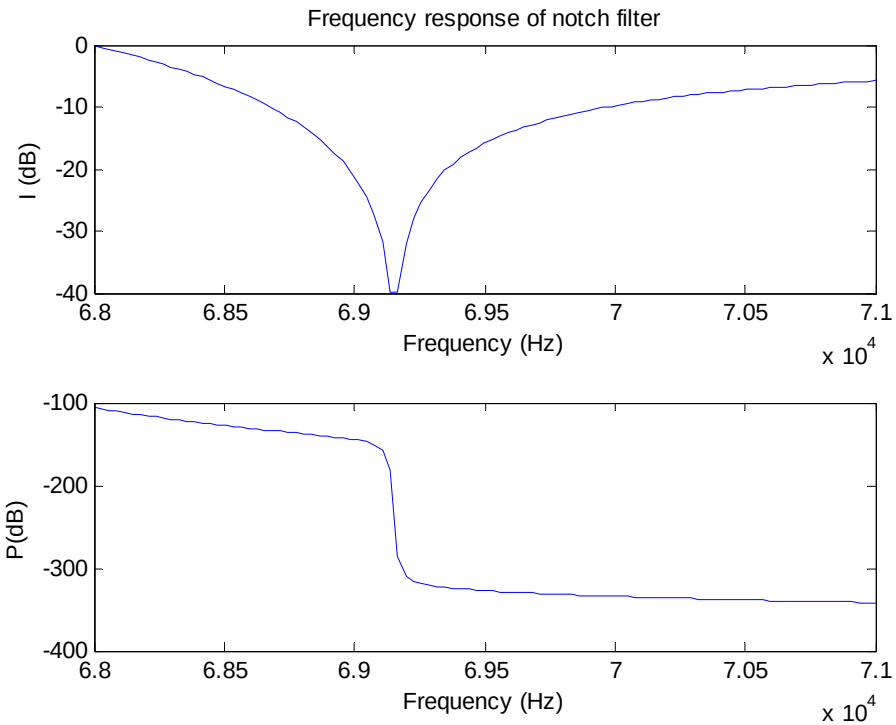
Monolithic rings

Problem: Need to eliminate screw.

IDEA: Heat rings and cool in place

Notch Filter





Flavio Nocera

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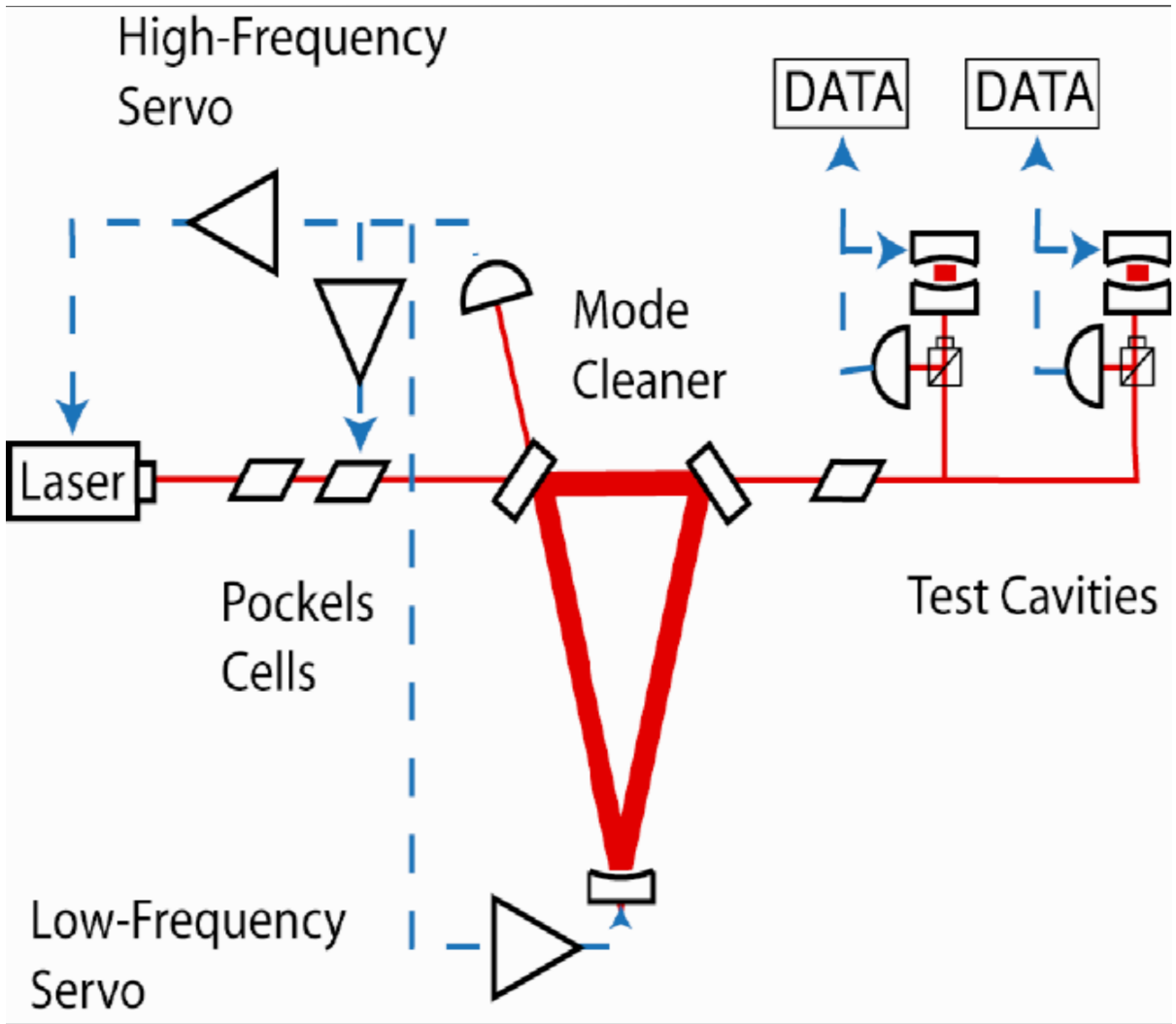
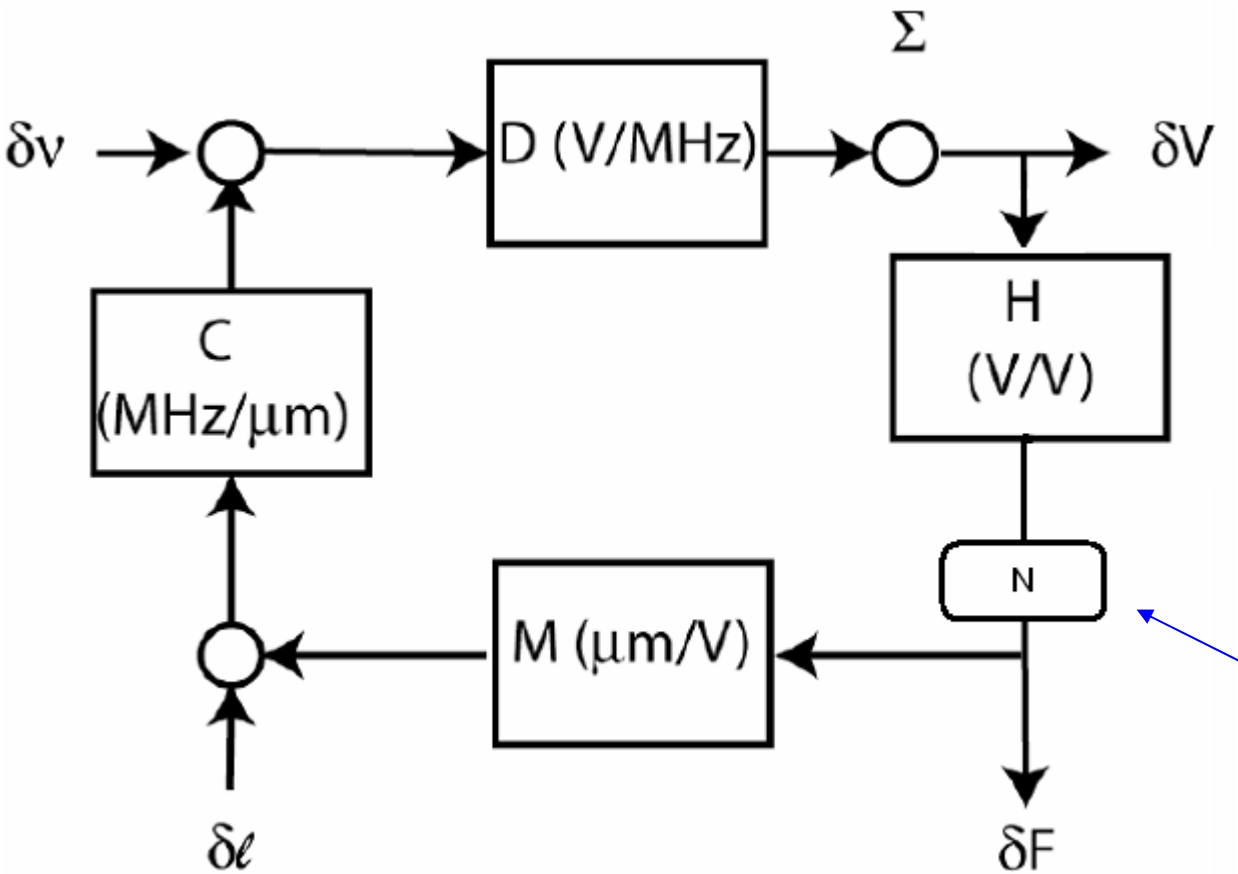
Thermal Noise Interferometer

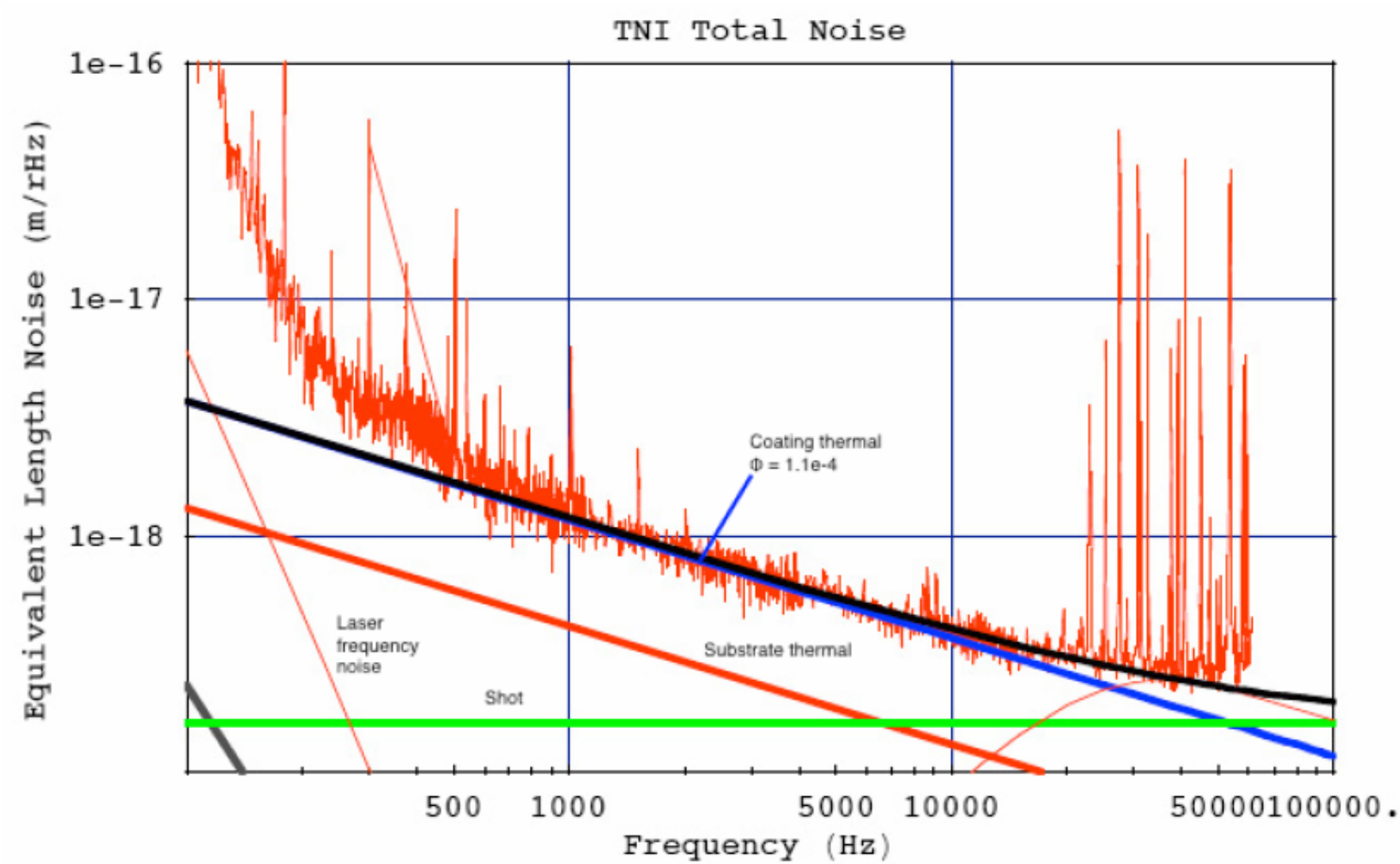


Servo Block Diagram



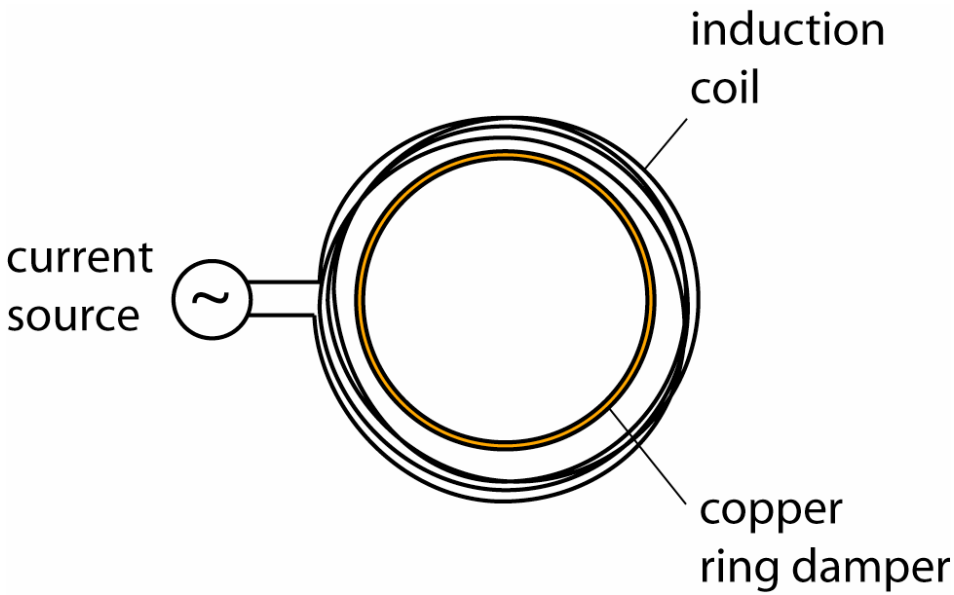
$$\delta l = \frac{1 + DHMC}{DC}\delta V$$

TNI Total Noise



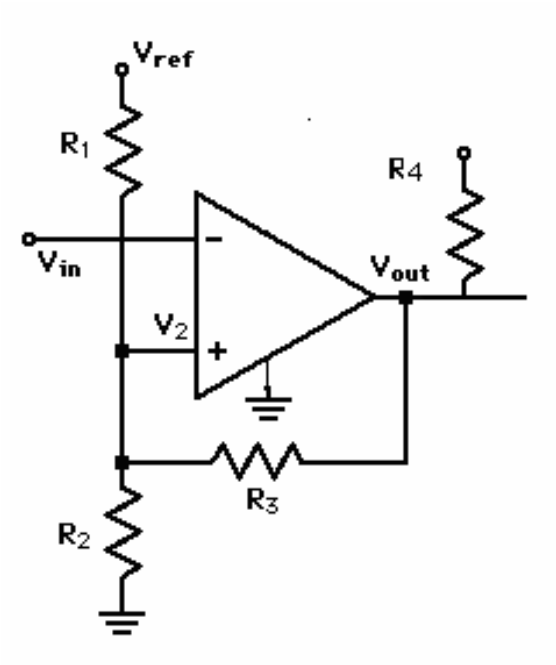
Inductive heater for installing monolithic rings

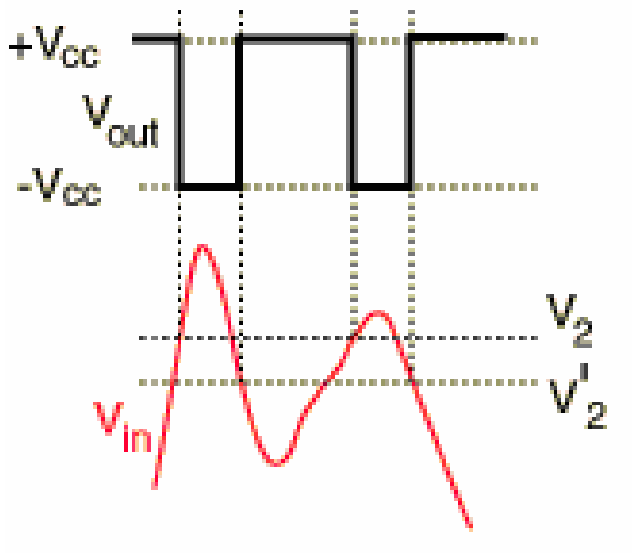
- Induction coil induces an EMF in the ring damper
- Joule heating causes the ring to expand, so it will fit over the mirror
- Upon cooling, the ring shrinks to fit the barrel of the optic



Schmitt trigger

- Comparator circuit with positive feedback
- The effect of the positive feedback is to make the circuit have two thresholds, depending on the output state
- Greater stability





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Summary

- Parametric instabilities
- Ring dampers
  - previous results
  - summer 2006 results
- My contribution
  - Notch Filter
  - Schmitt trigger

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Thanks

- Eric Black
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