
Exploring Suspension Loss Improvements for Enhanced LIGO

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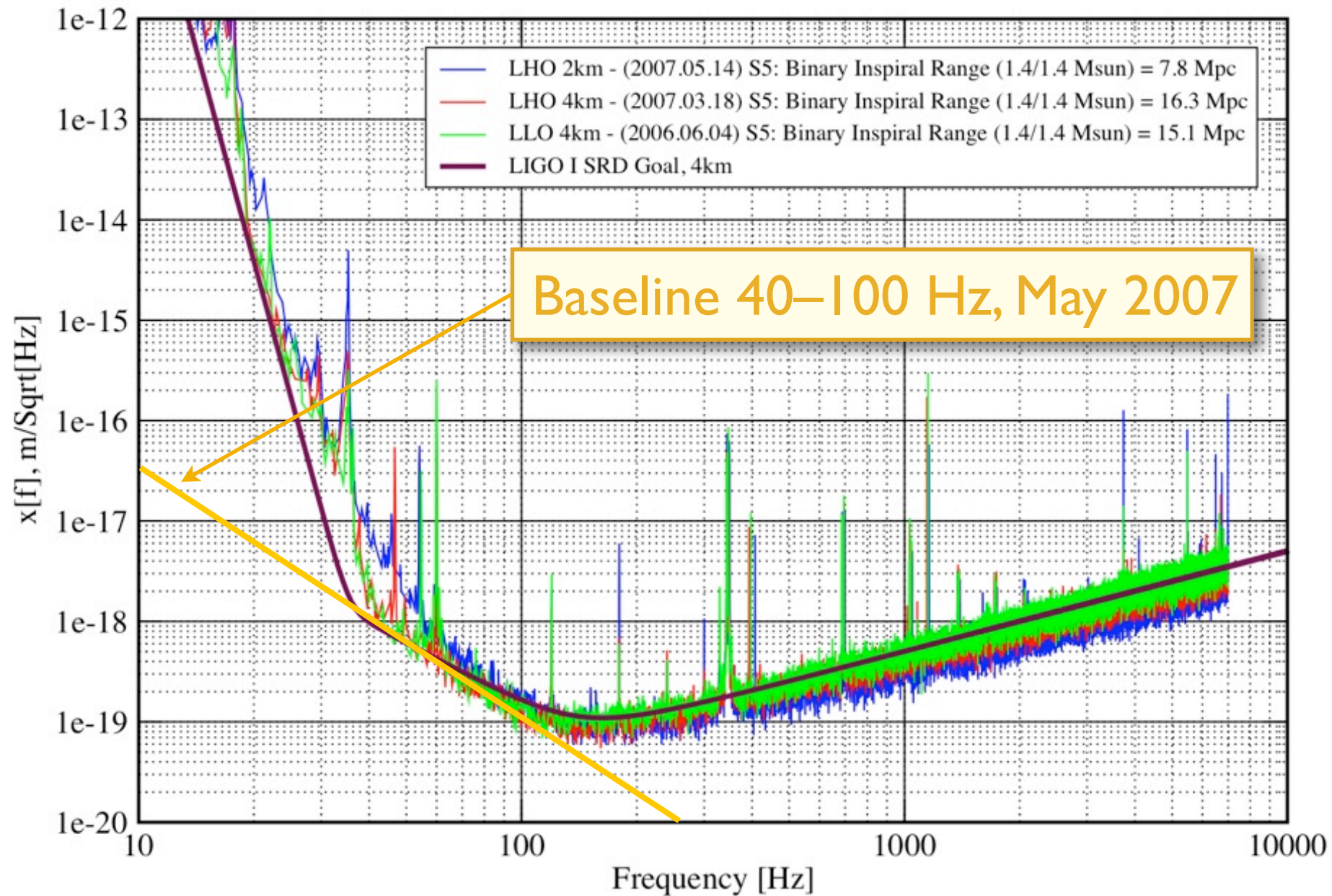
LSC Meeting - Caltech - March 2008

DCC: LIGO-G080108-00-Z

The Problem

Displacement Sensitivity of the LIGO Interferometers

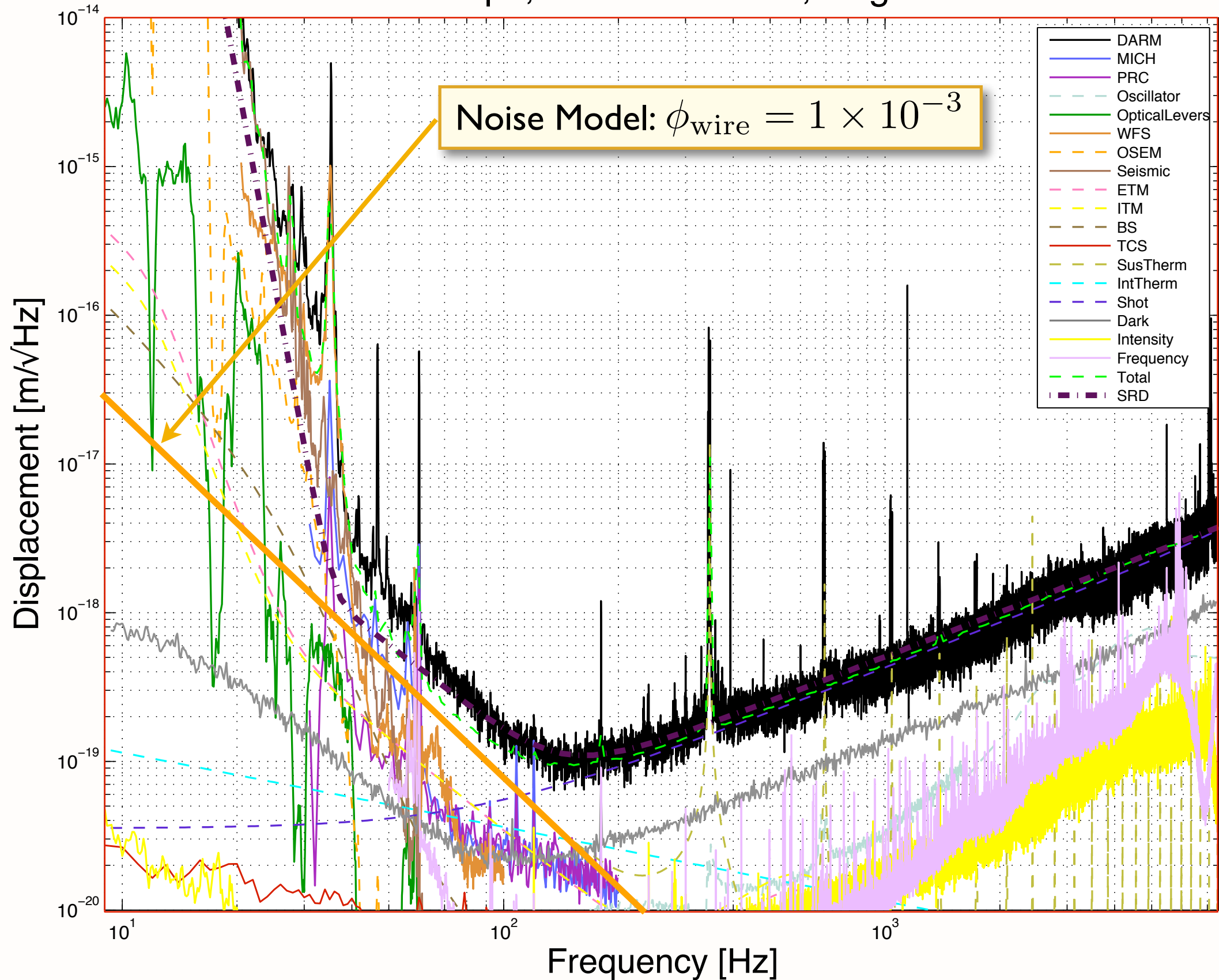
Performance for S5 - May 2007 LIGO-G070367-00-E

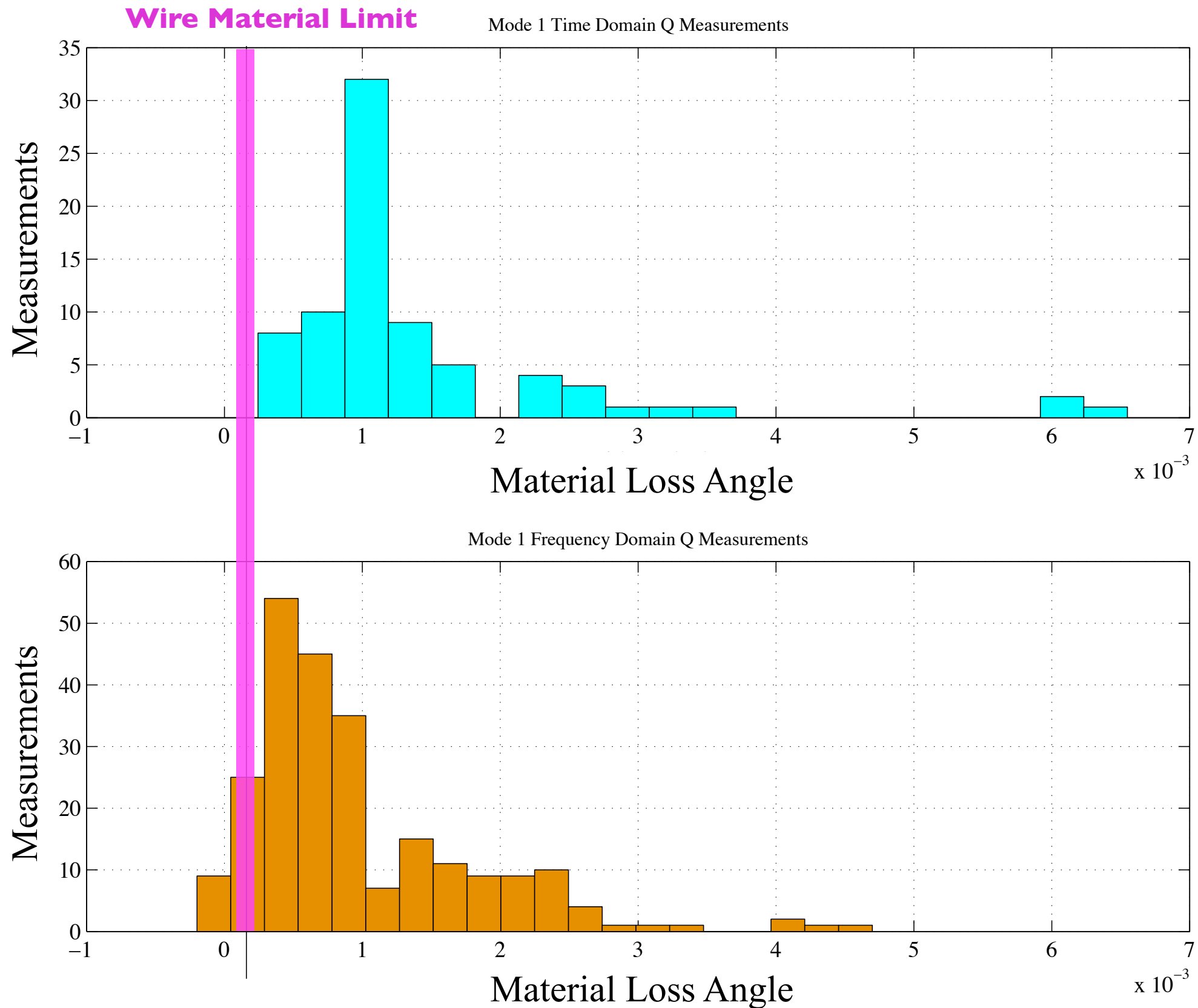


- Noise between 40 Hz and 150 Hz has slope near $-5/2$ (as does suspension noise)
- Suspension thermal noise may be contributing more than predicted by noise model
- Reducing Suspension Thermal Noise could greatly benefit enhanced LIGO

The Problem

H1: UGF = 199 Hz 13.6 Mpc, Predicted: 16.4, Aug 12 2006 01:00:00 UTC

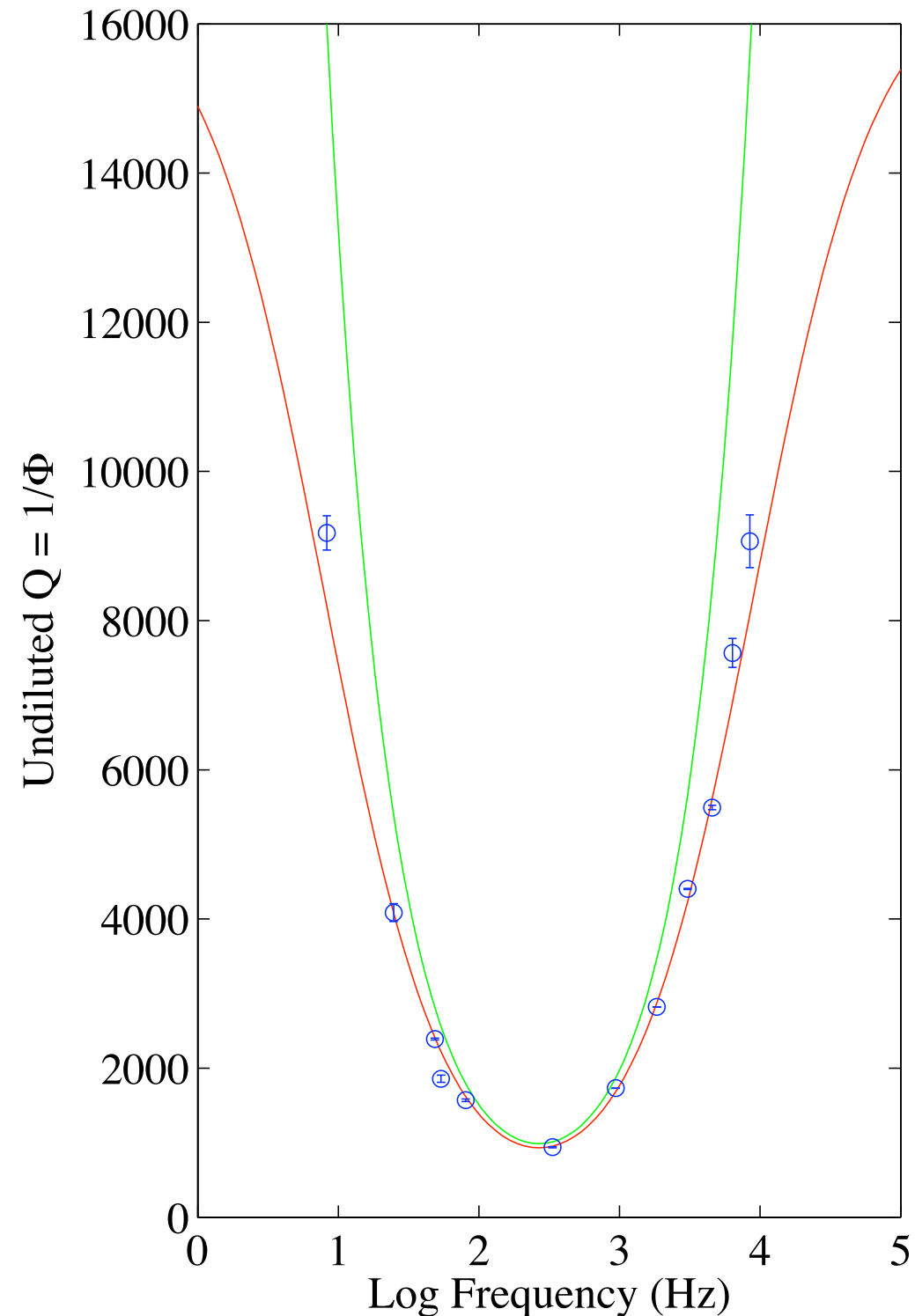
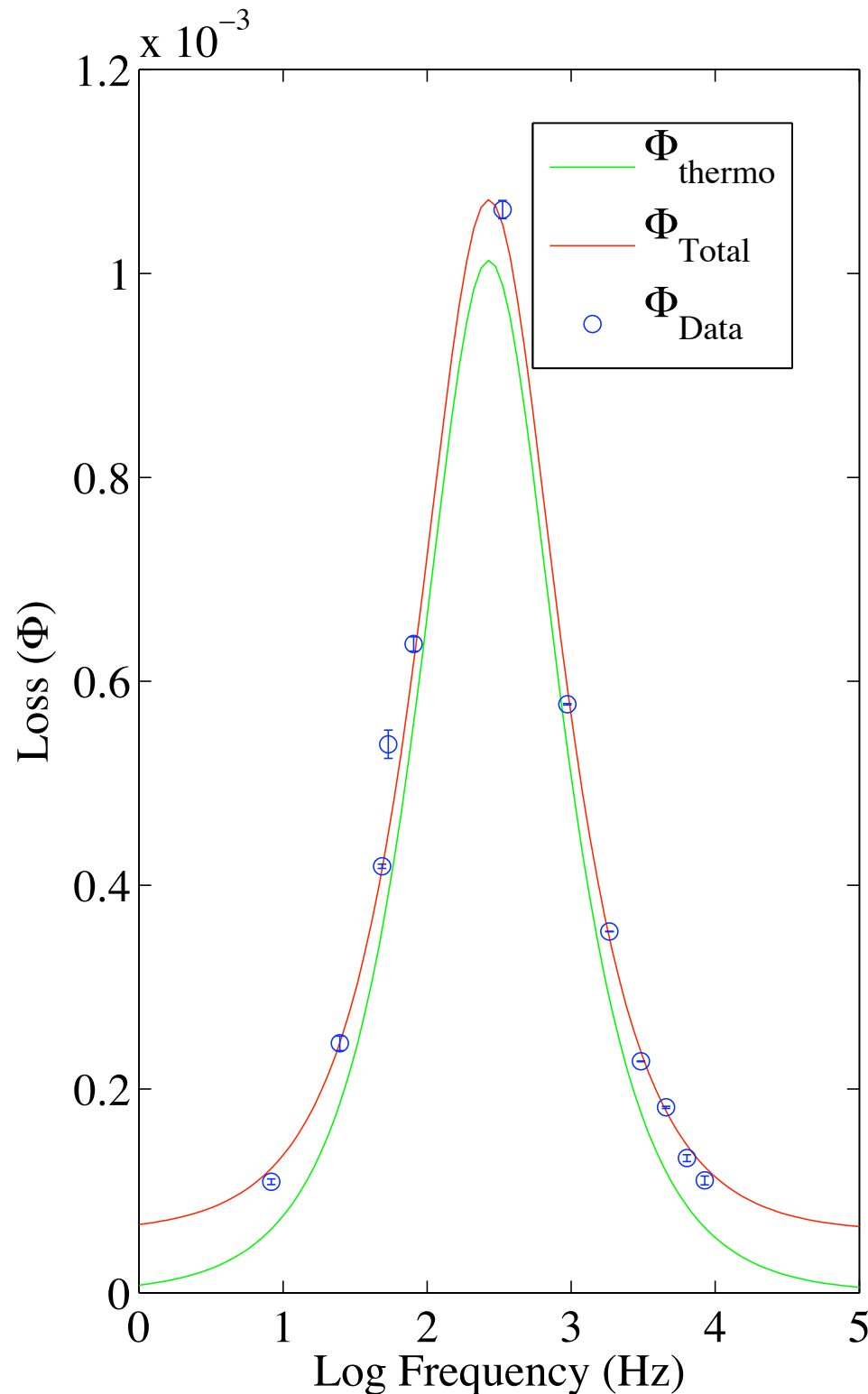




Mechanical Loss

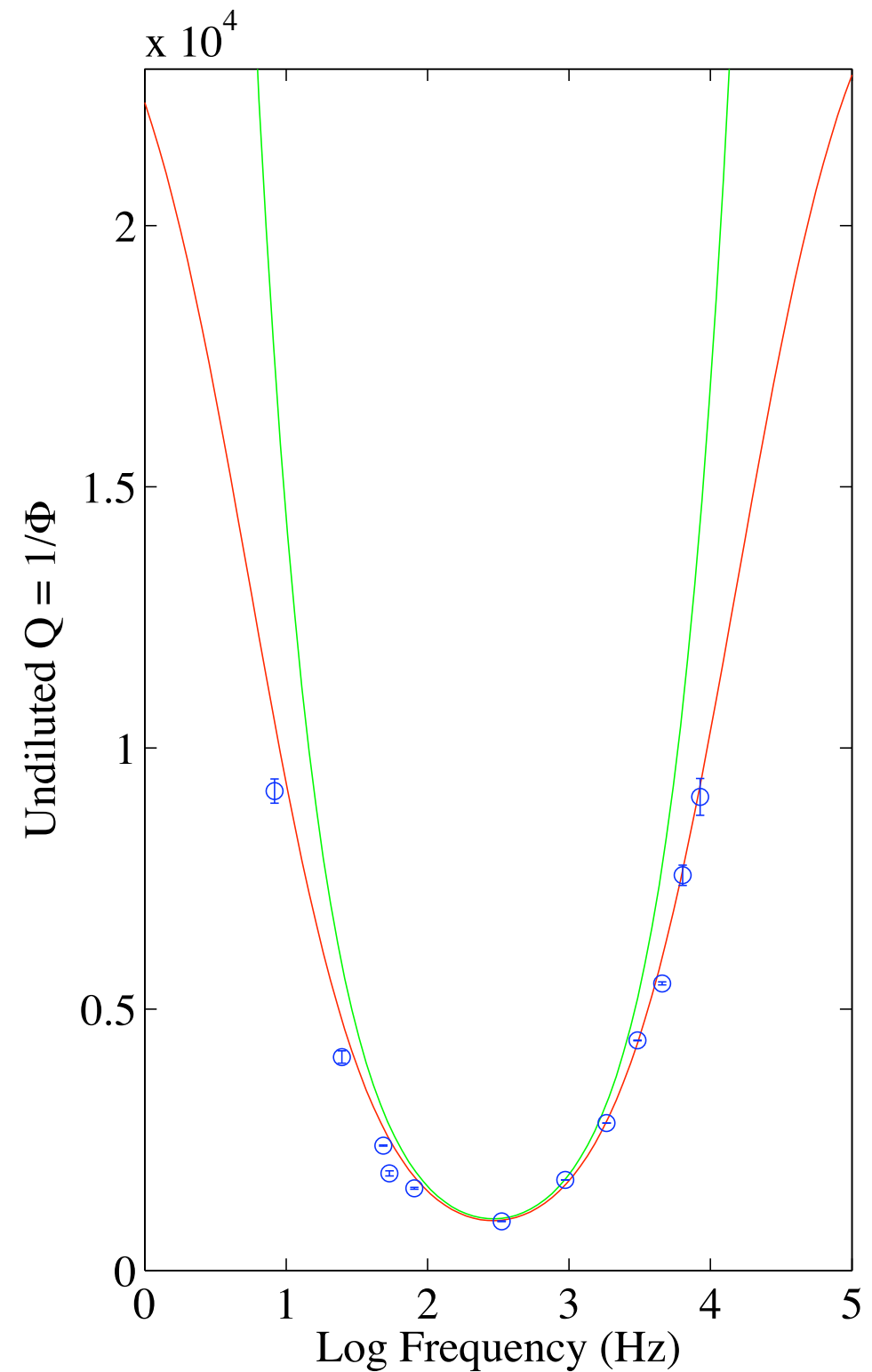
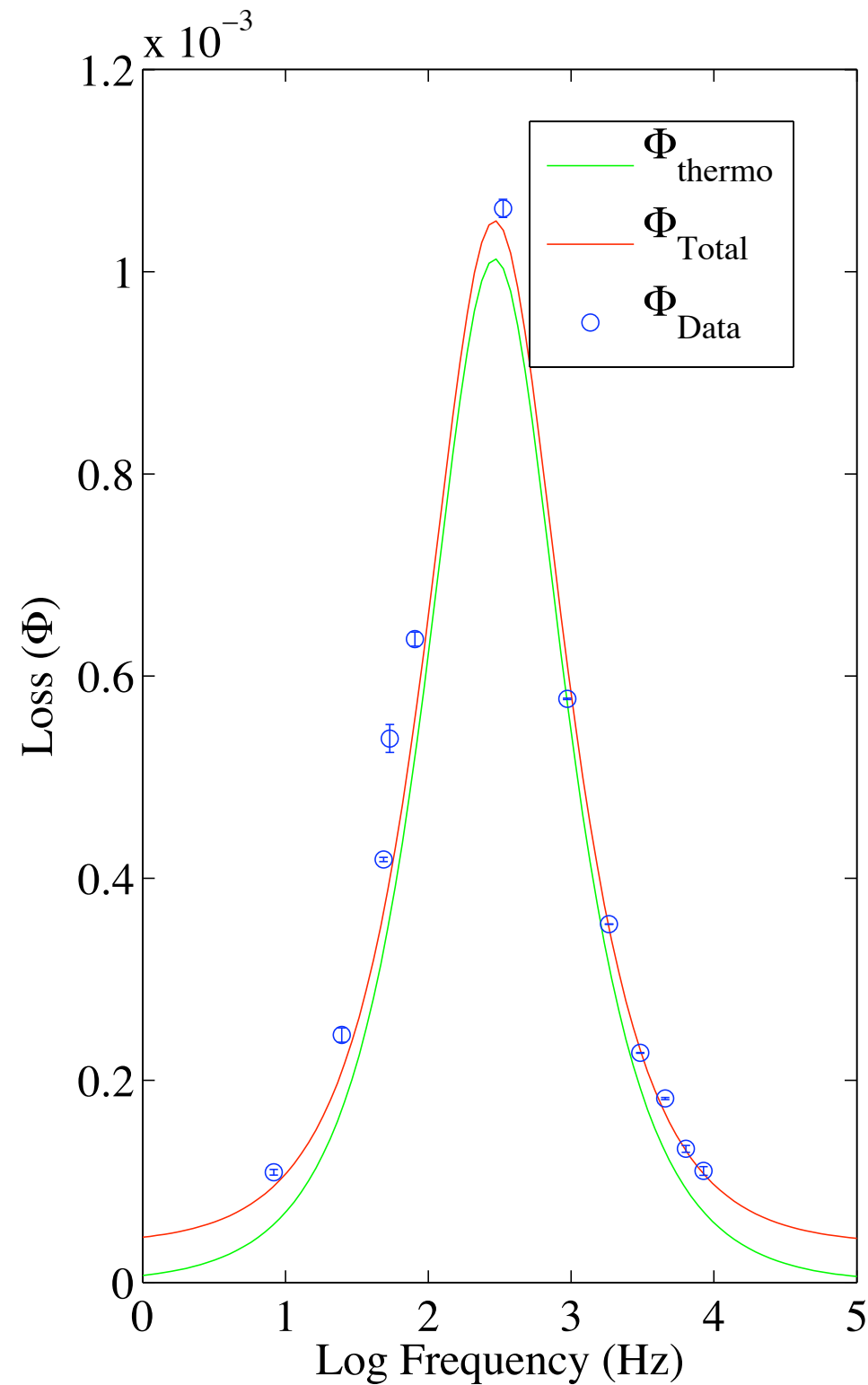
Music Wire in Virgo Clamps

$\phi_{\text{str}} = 5.9 \times 10^{-5}$ *Structural loss* \ll *Assumed design value.*



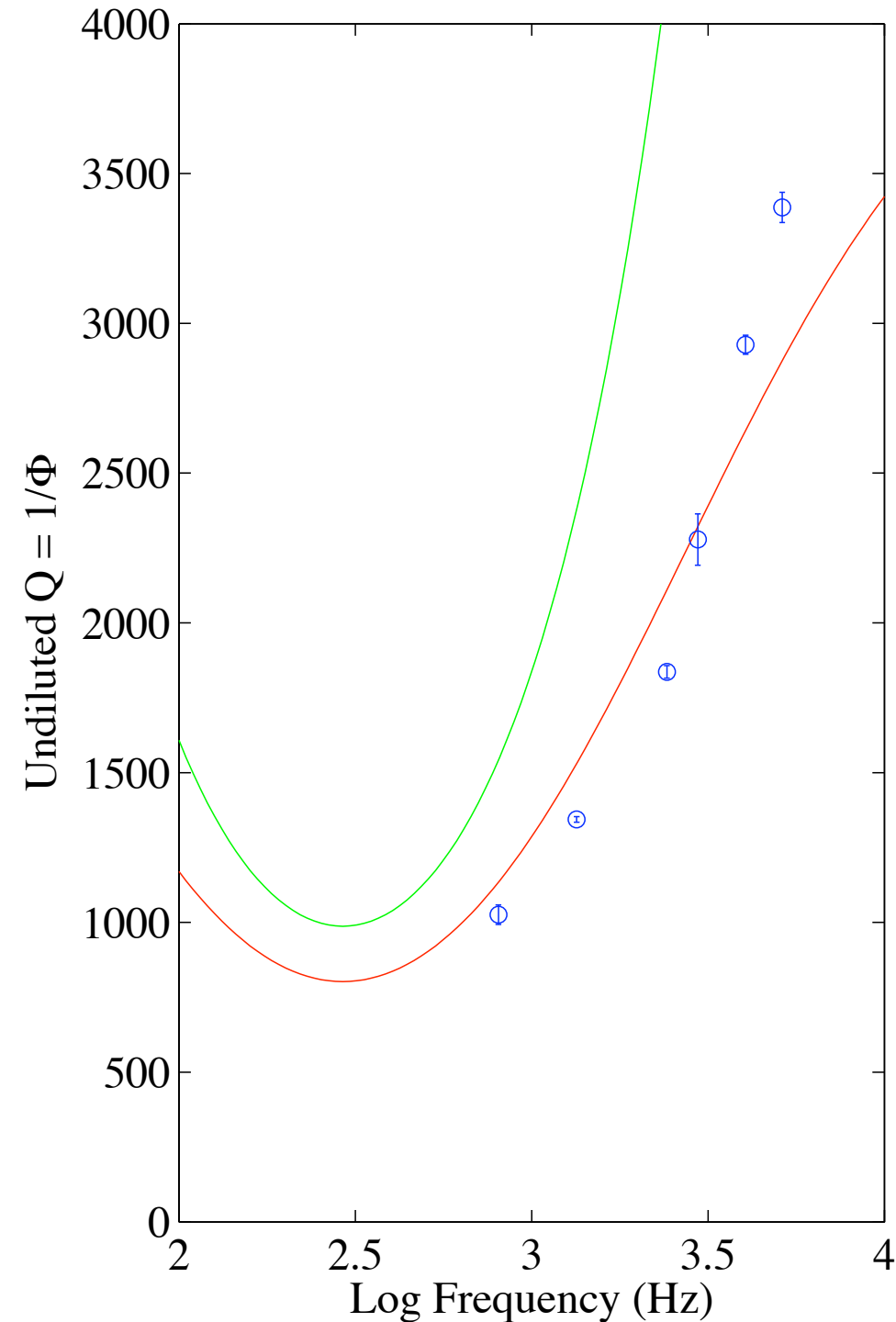
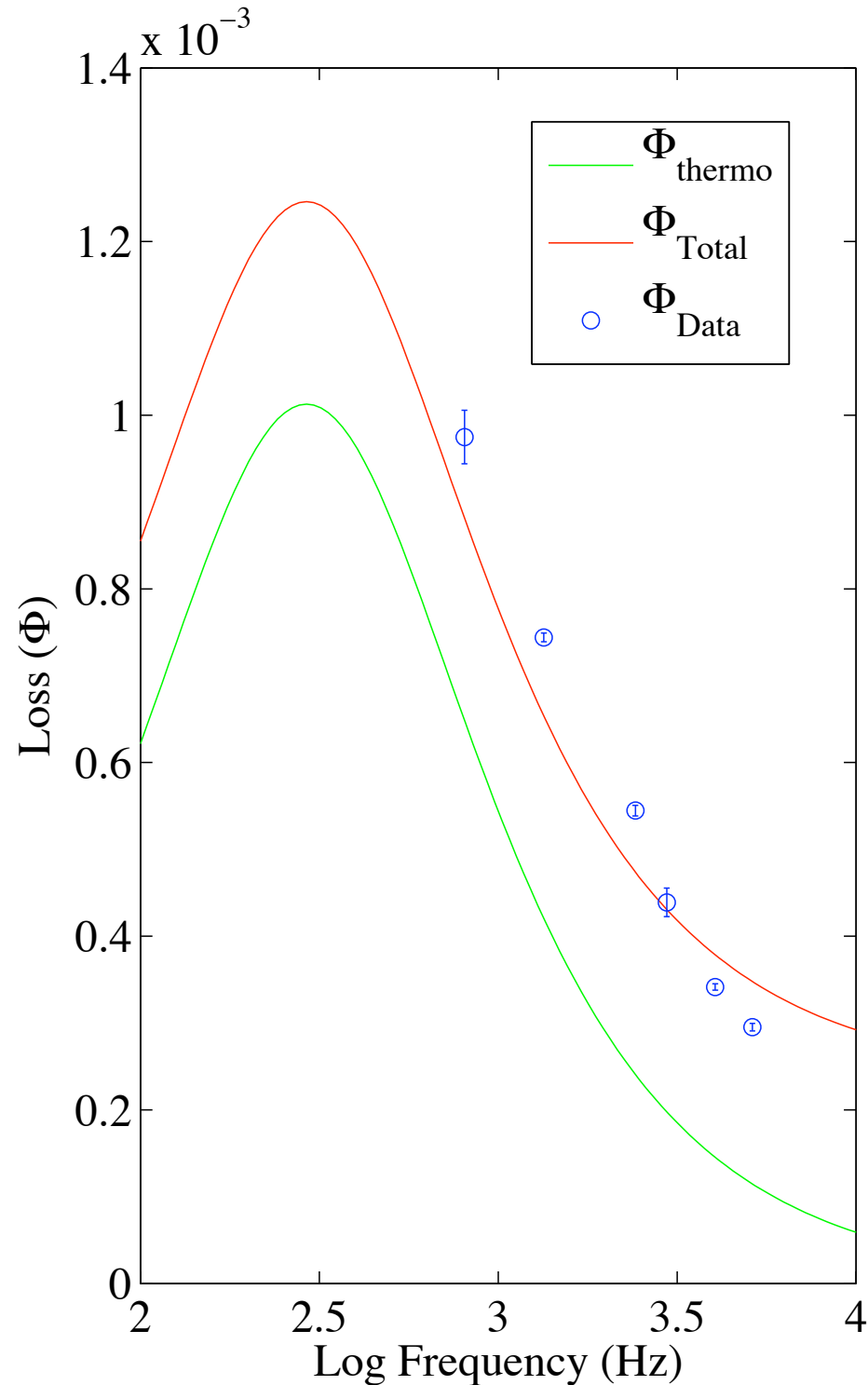
Mechanical Loss Music Wire in Virgo Clamps

Steel Wire: Thermoelastic fixed, $\Phi = 3.78\text{e-}05 \pm 3.66\text{e-}06$



Mechanical Loss Tensioned Music Wire in Virgo Clamps

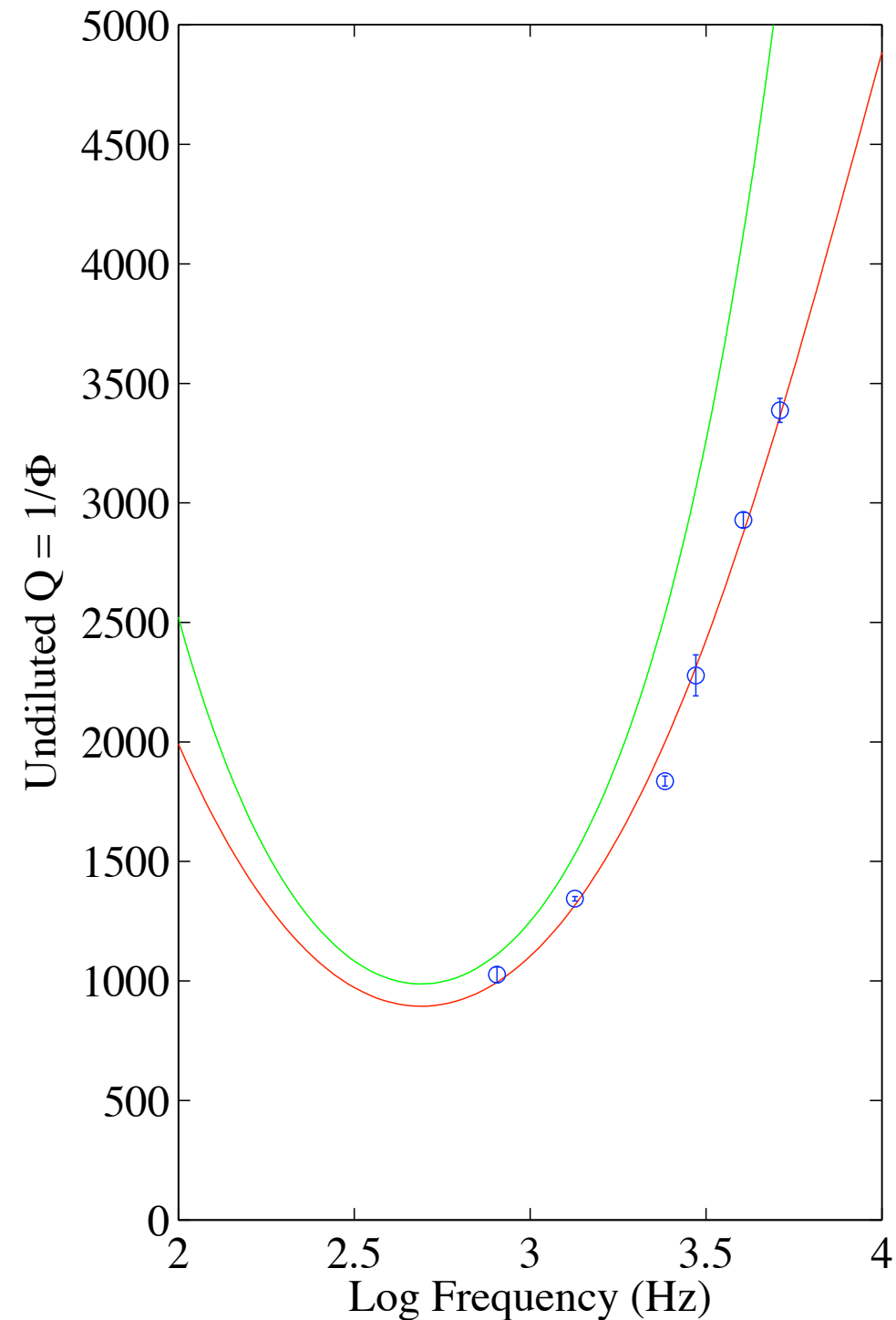
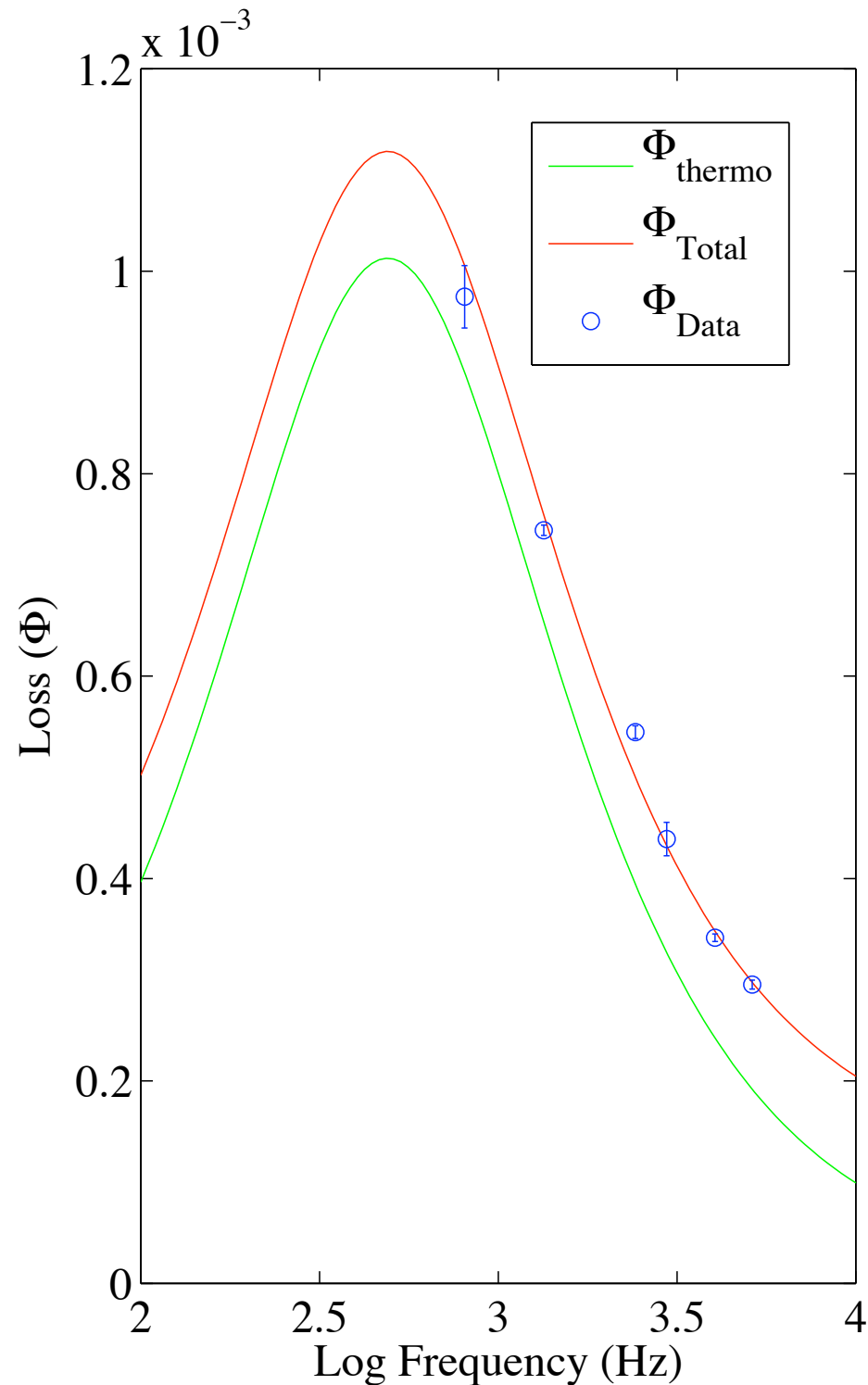
Steel Wire: Thermoelastic fixed, $\Phi = 2.33e-04 \pm 2.68e-05$



Mechanical Loss

Tensioned Music Wire in Virgo Clamps

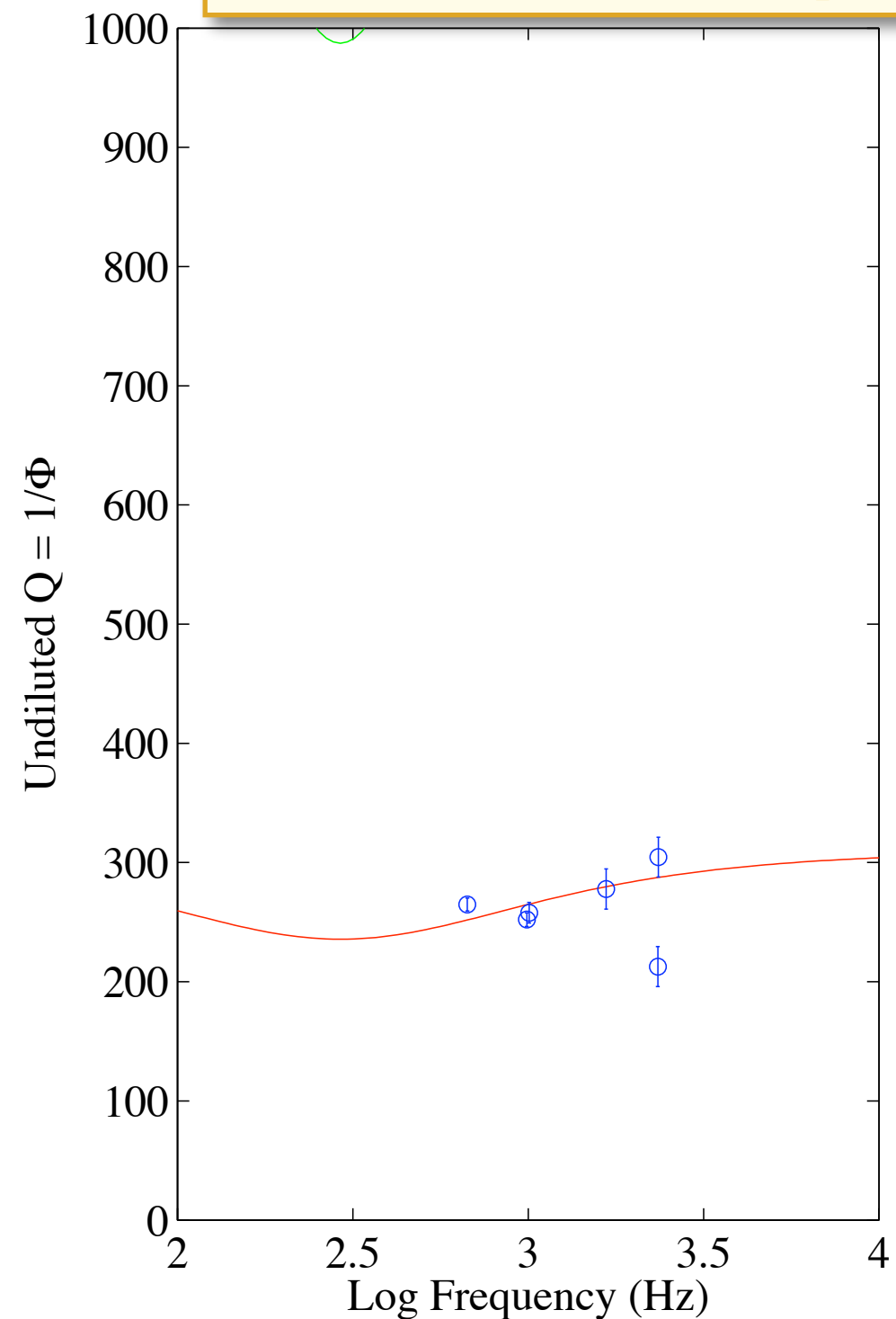
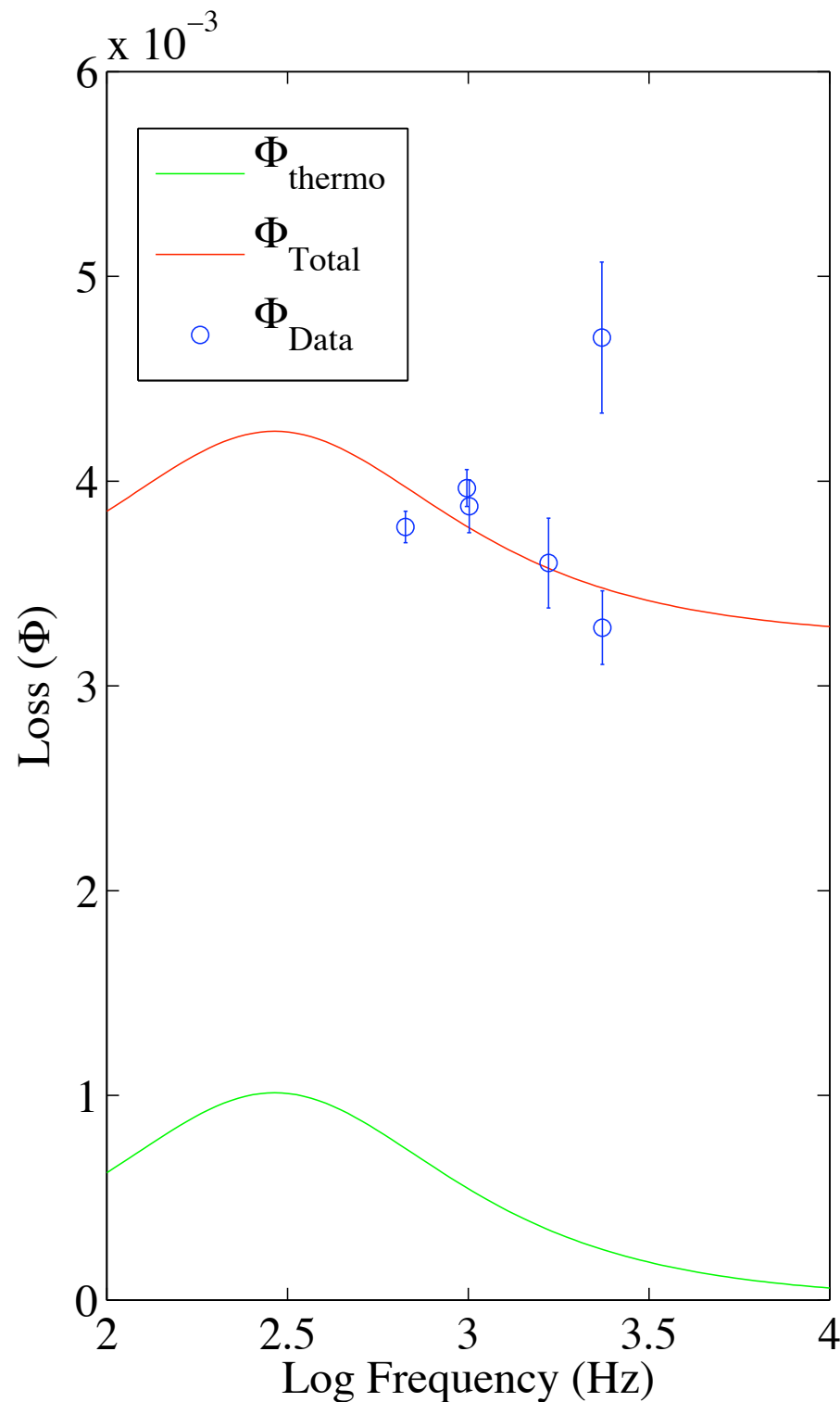
Steel Wire: Thermo. coefs = (1.00, 0.59), $\Phi = 1.06e-04 \pm 2.47e-05$



Loss from the Silica Standoff

Steel Wire: Thermoelastic fixed, $\Phi = 3.23e-03 \pm 1.07e-04$

Loss increases by 14x



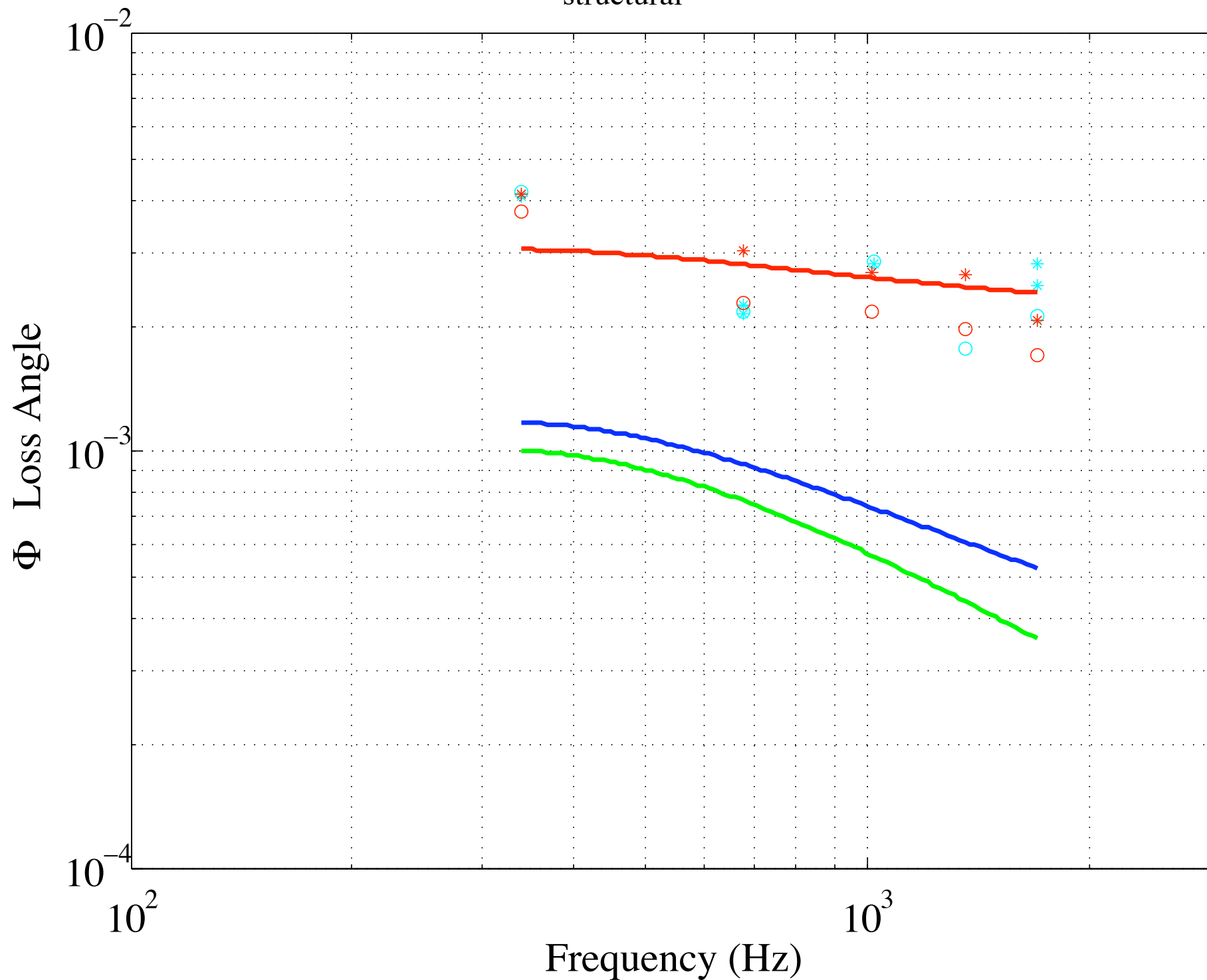


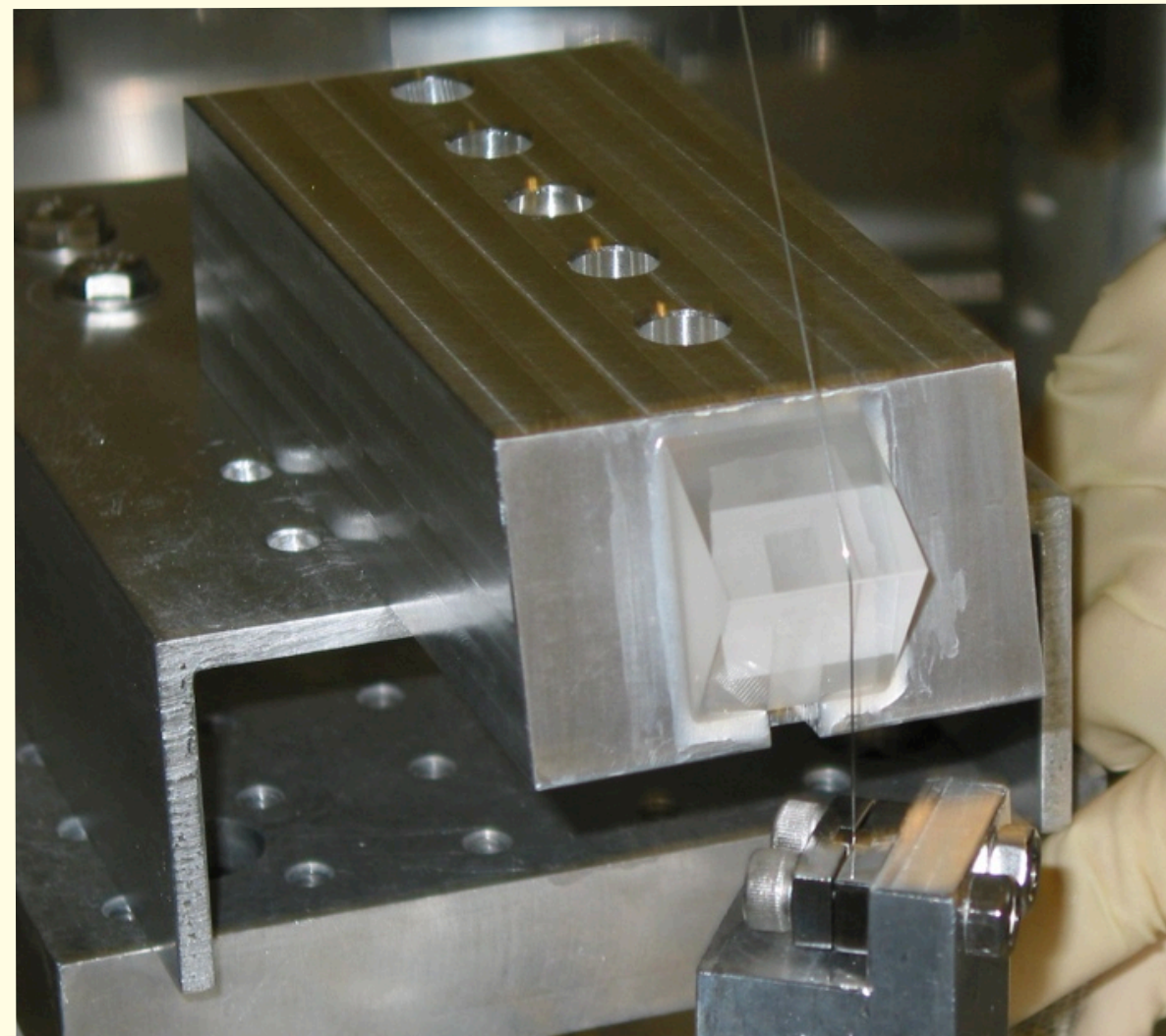
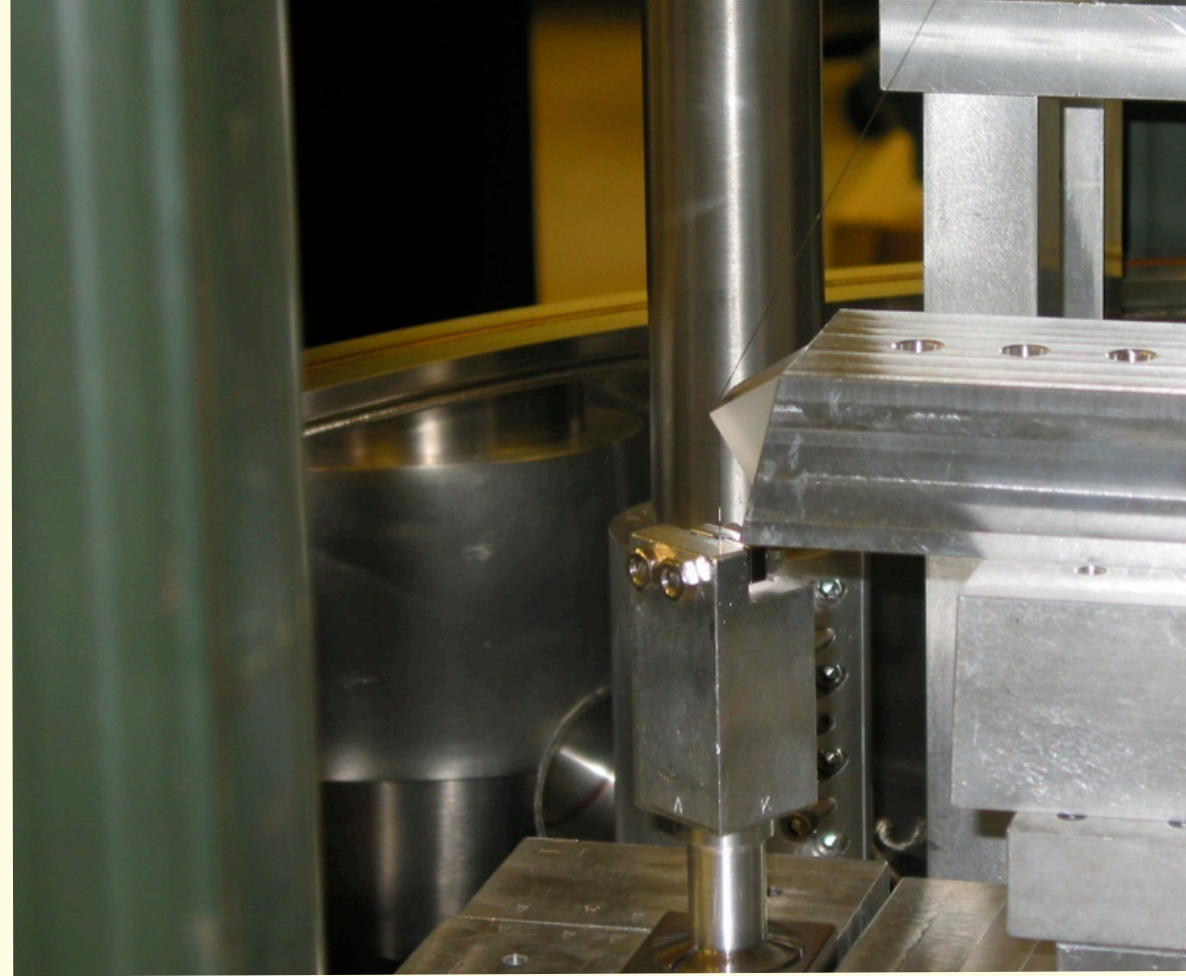
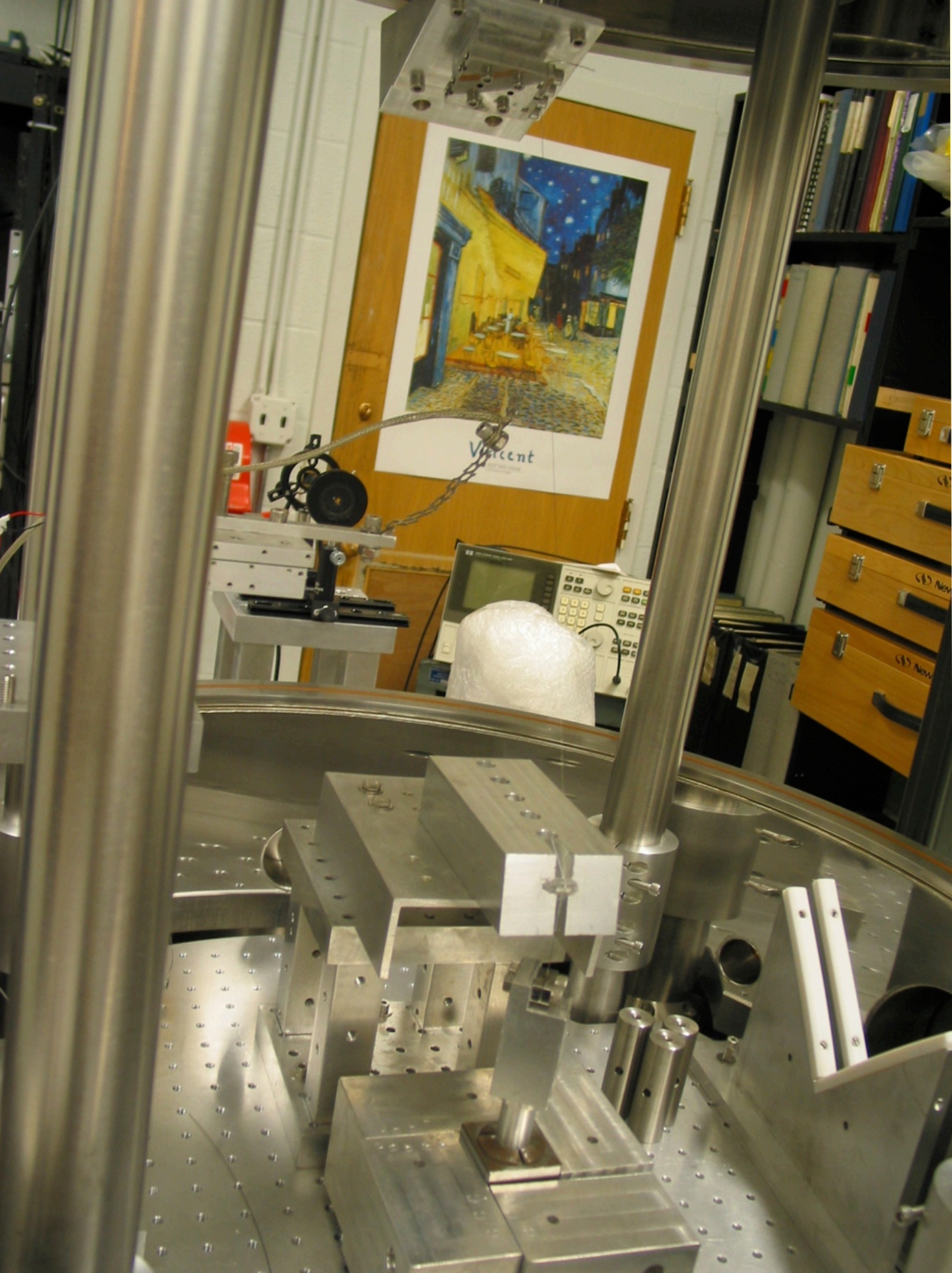
Pathfinder Optic hung in spare frame with wire from the sites. Each wire monitored by eight shadow sensors.

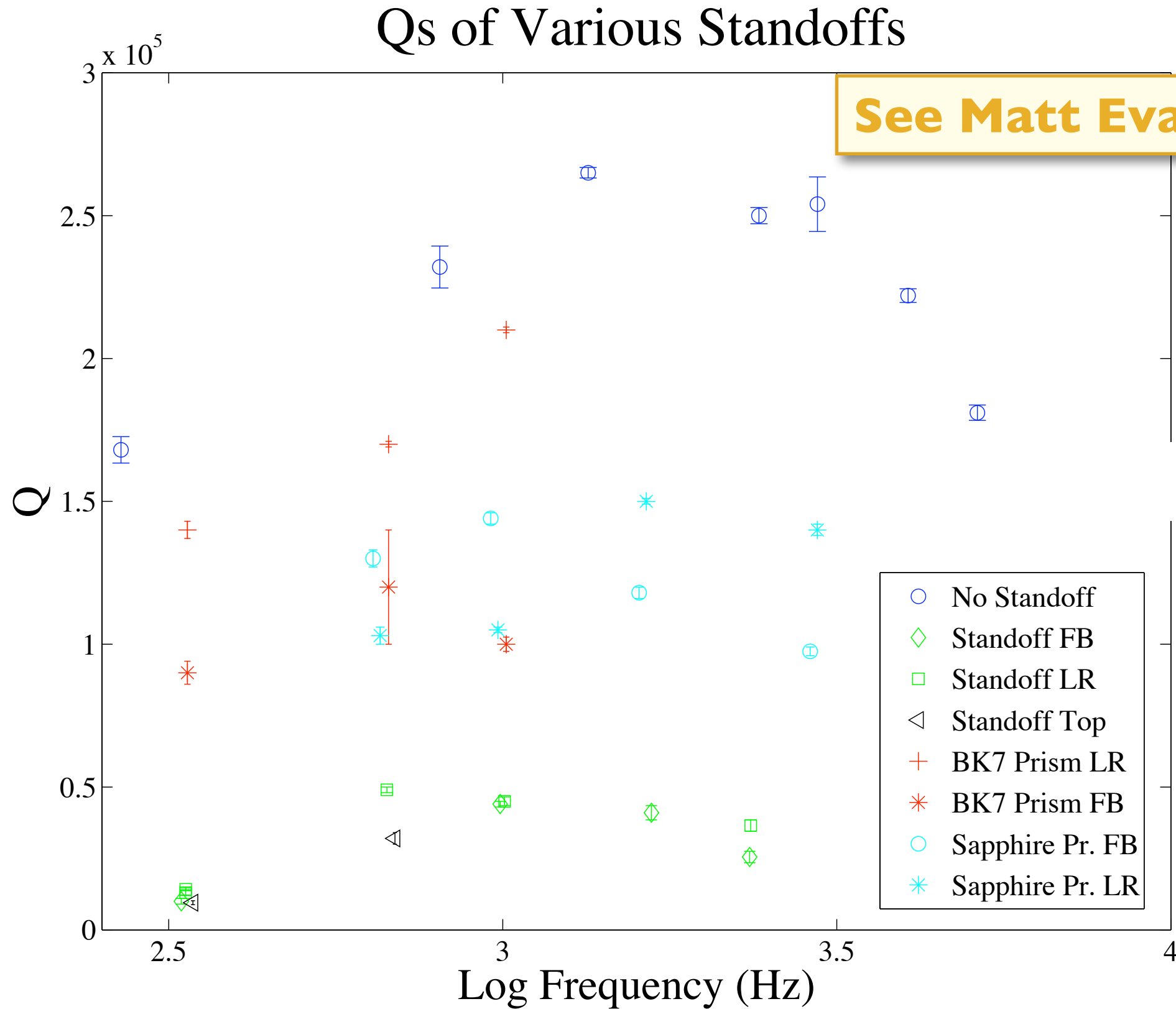


Violin Mode: Reused Clamp

$\Phi_{\text{structural}} = 2.05e-3$

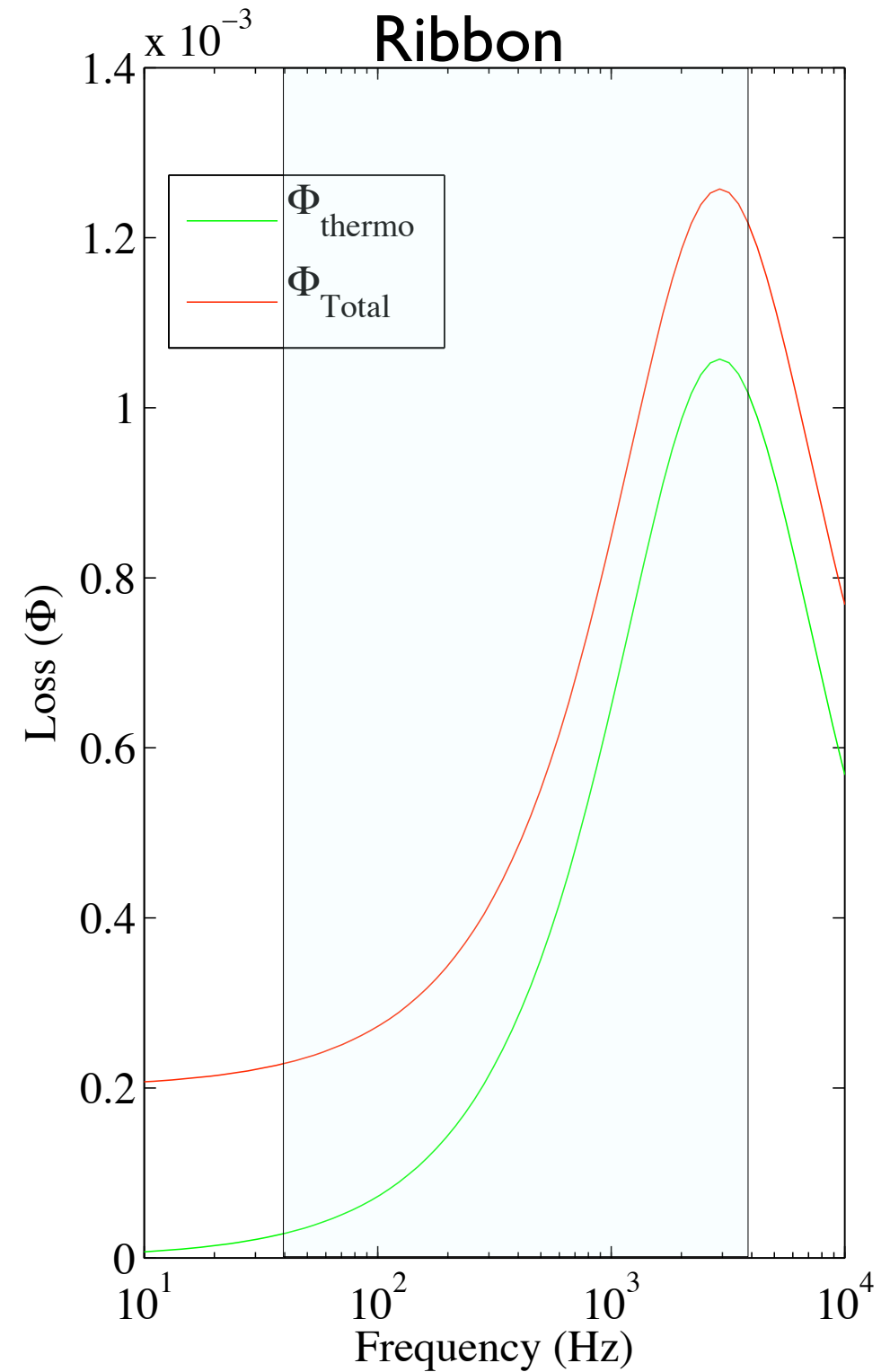
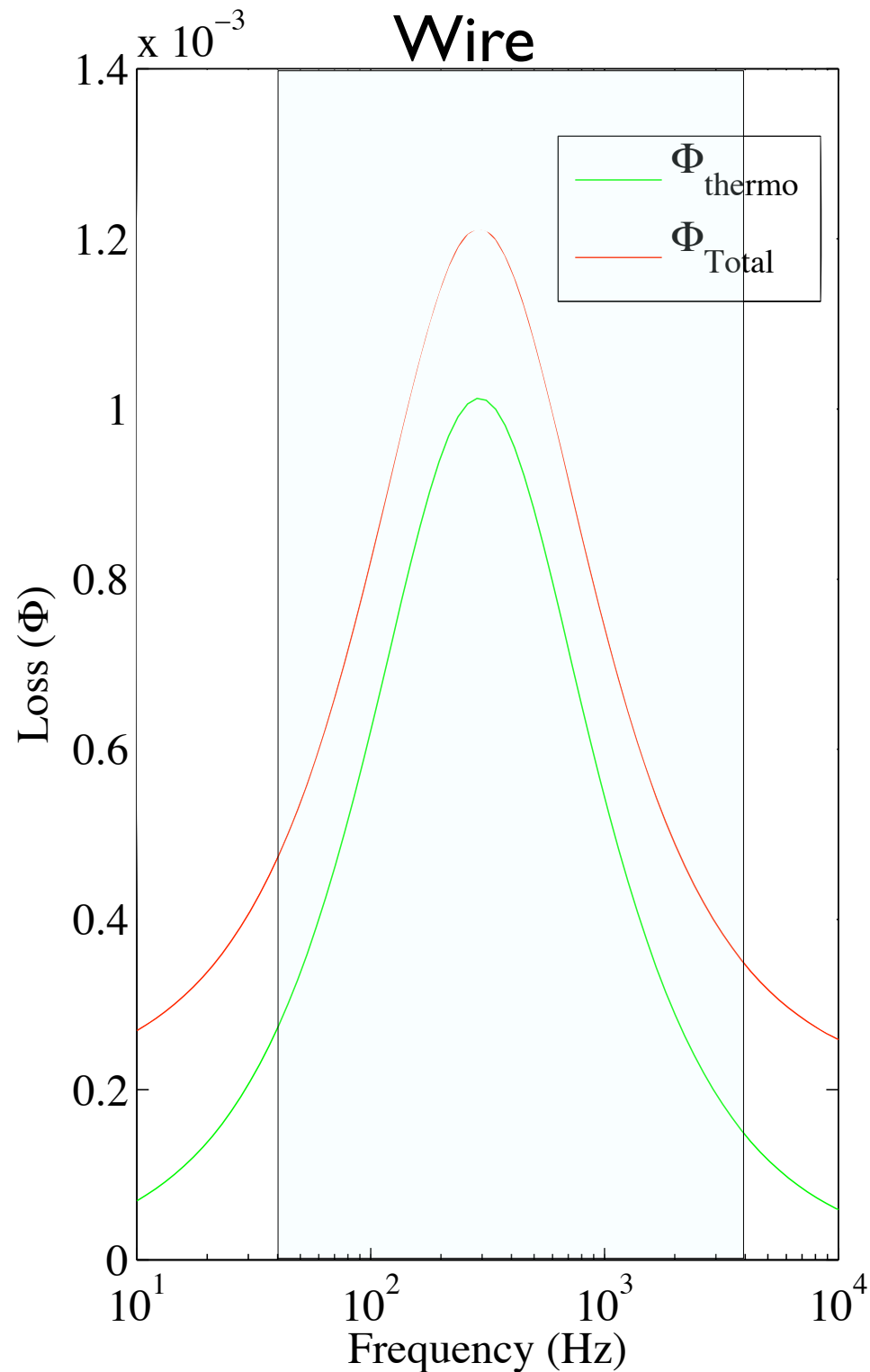






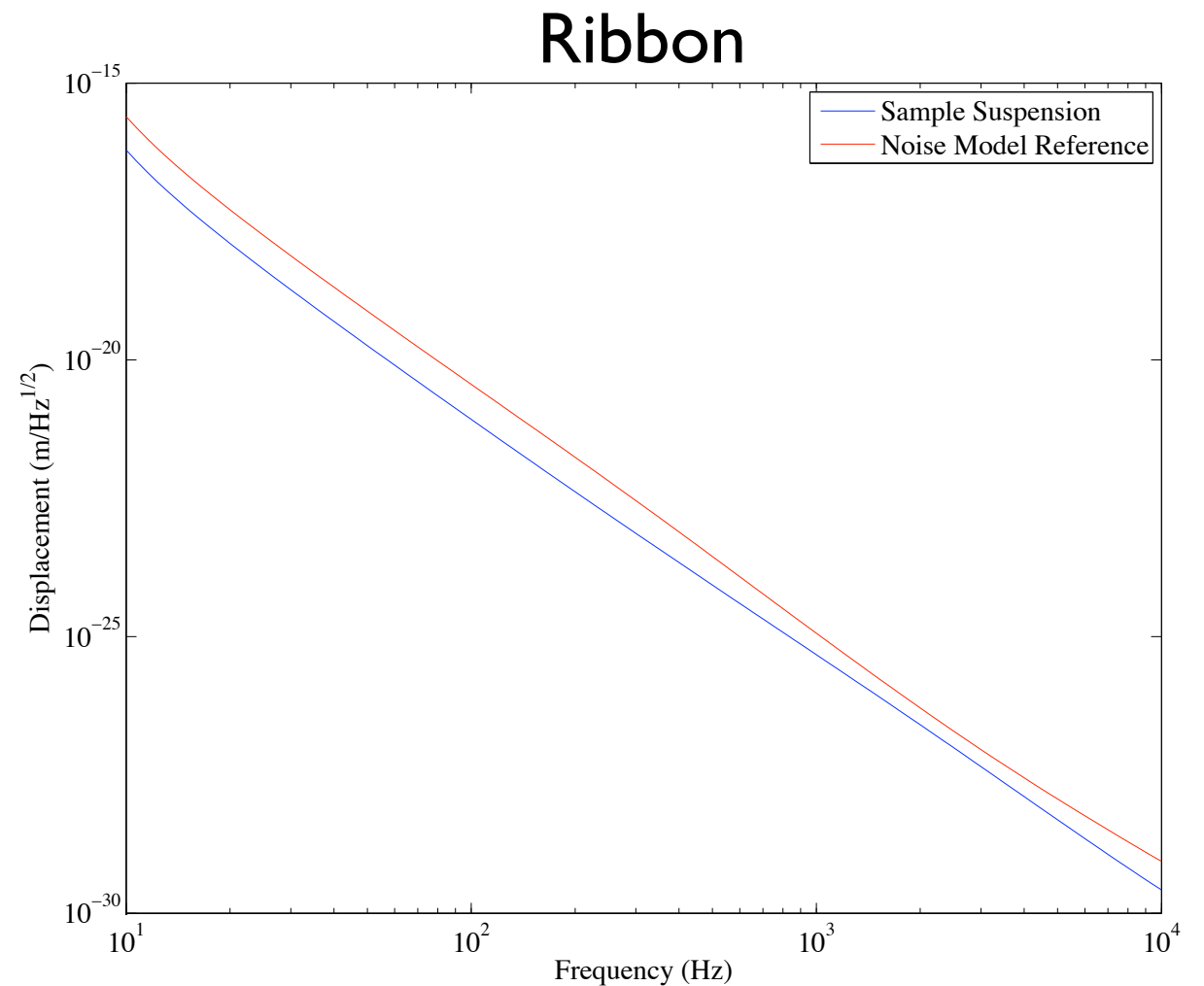
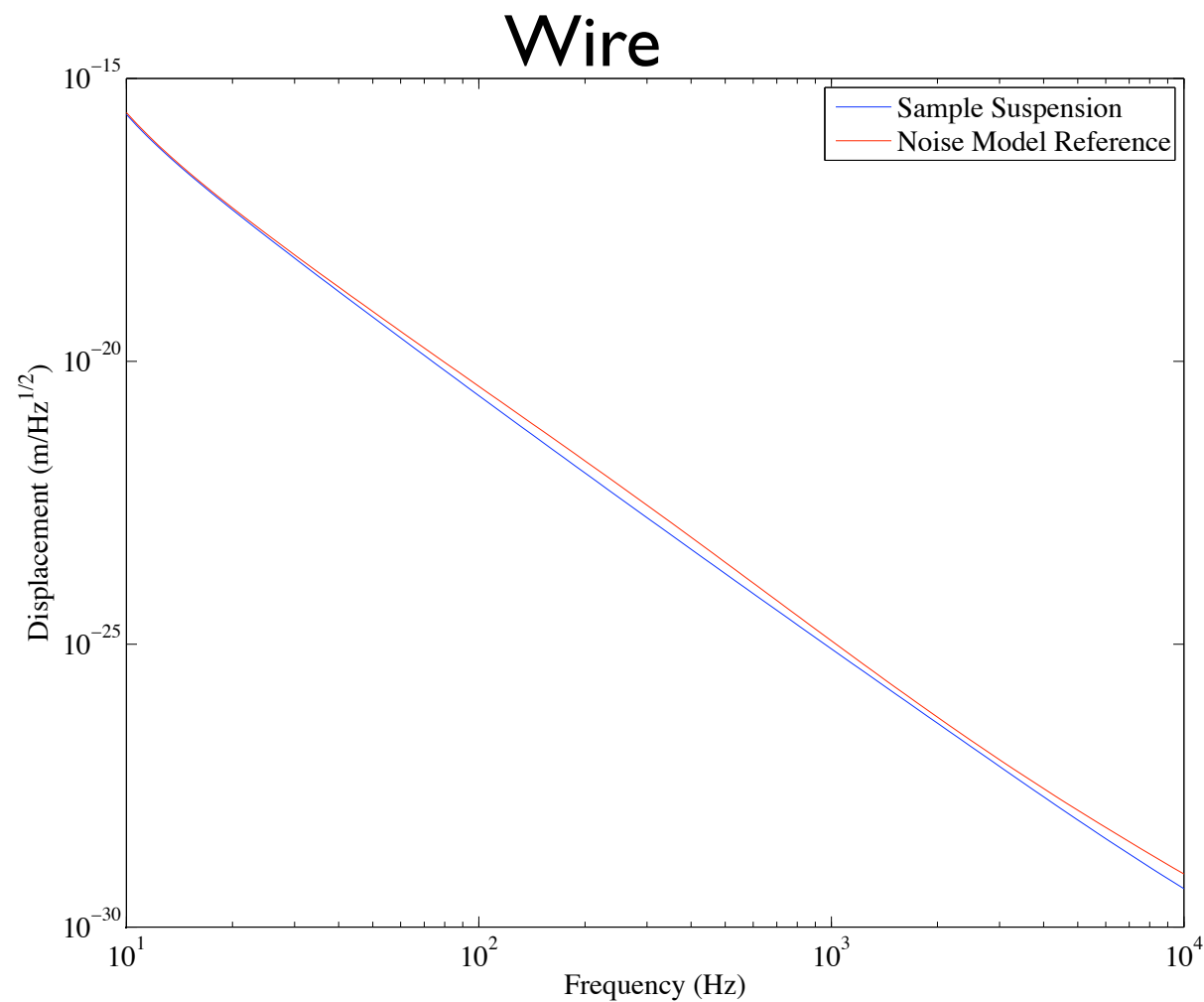
The Case for Ribbons

Thermoelastic Loss shifted from center of LIGO's sensitive region

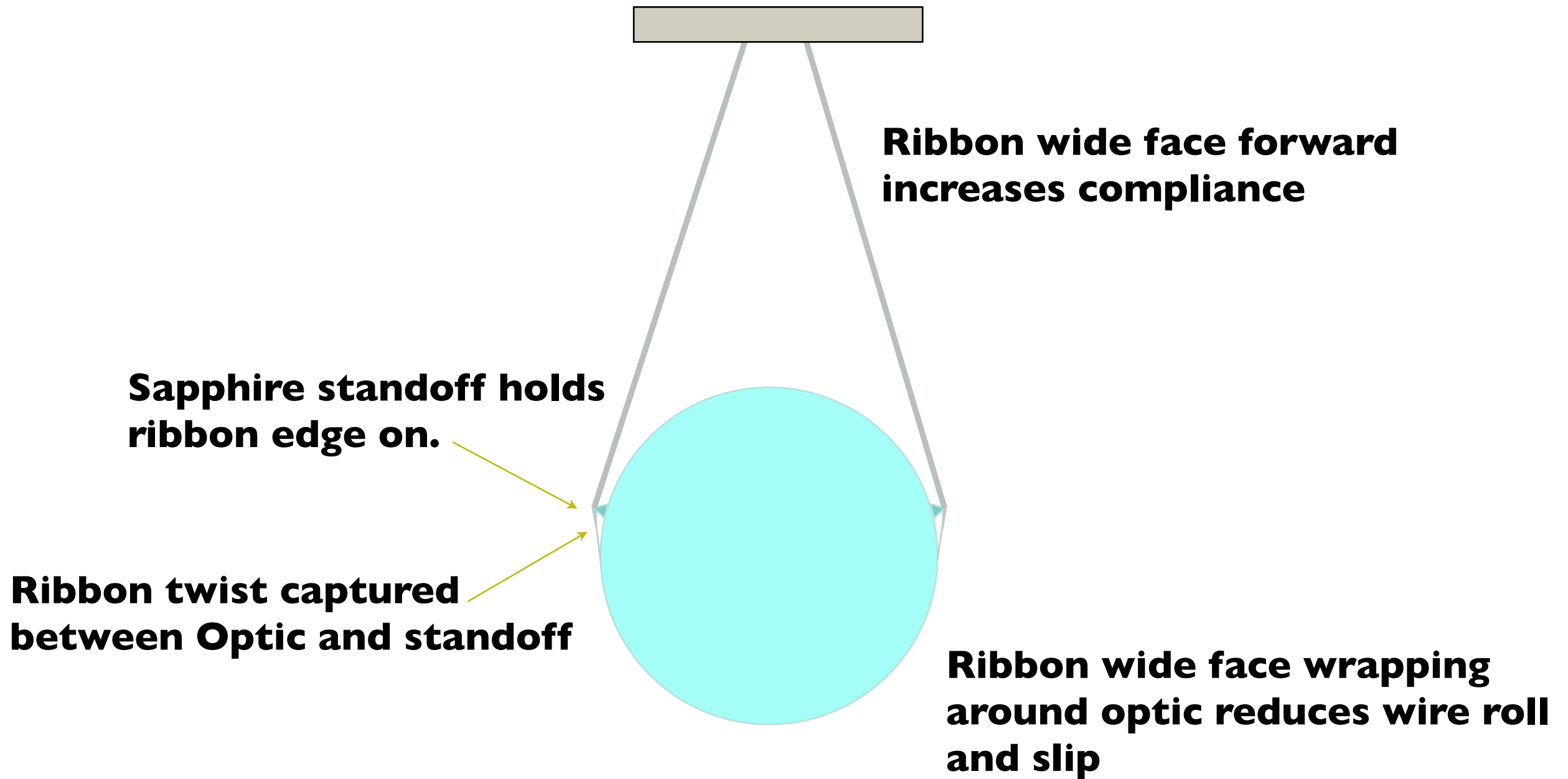


The Case for Ribbons

Displacement Thermal Noise factor of 1.86 less due to dissipation dilution



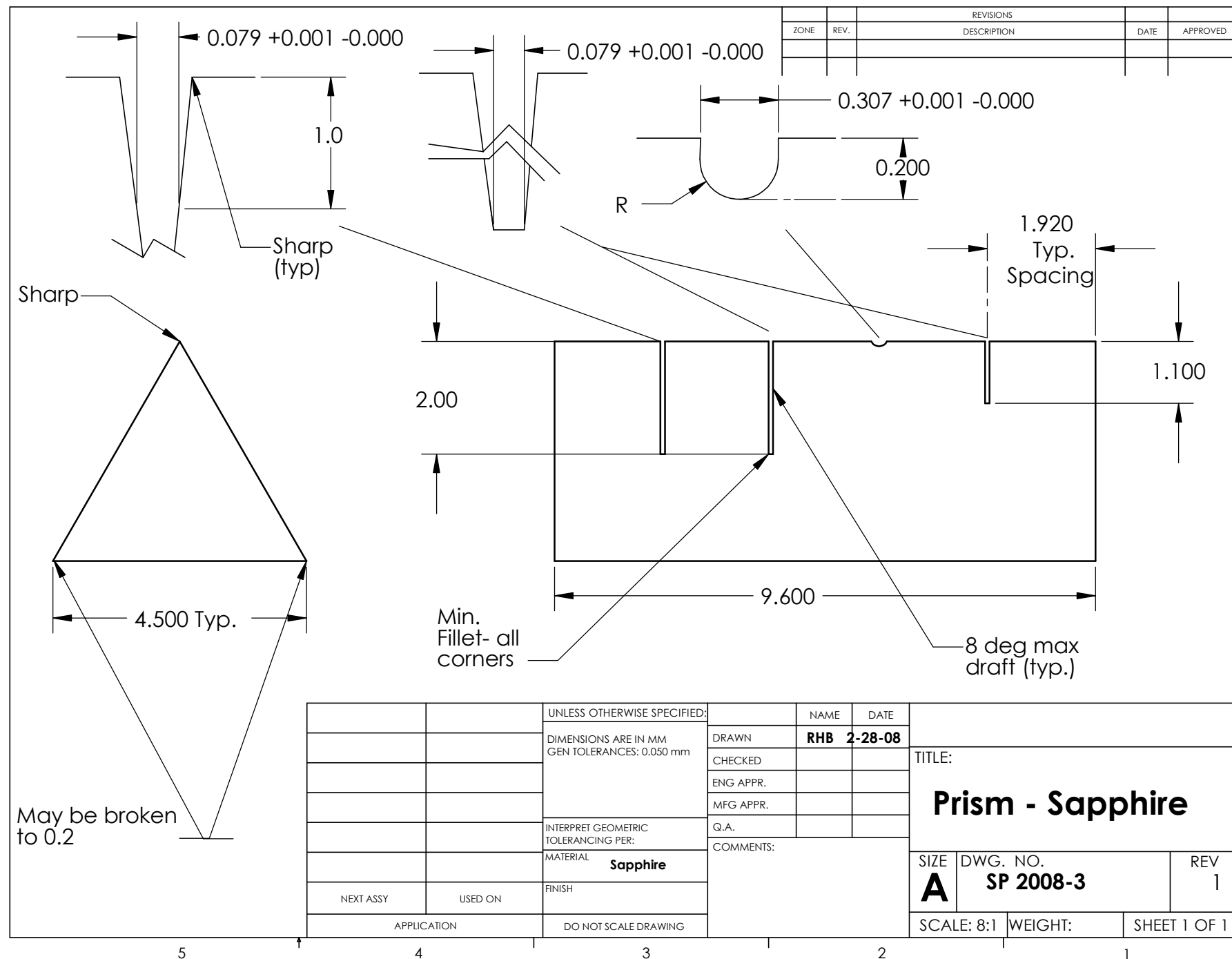
The Case for Ribbons



However, the ribbon clamps and standoffs are difficult to make well.

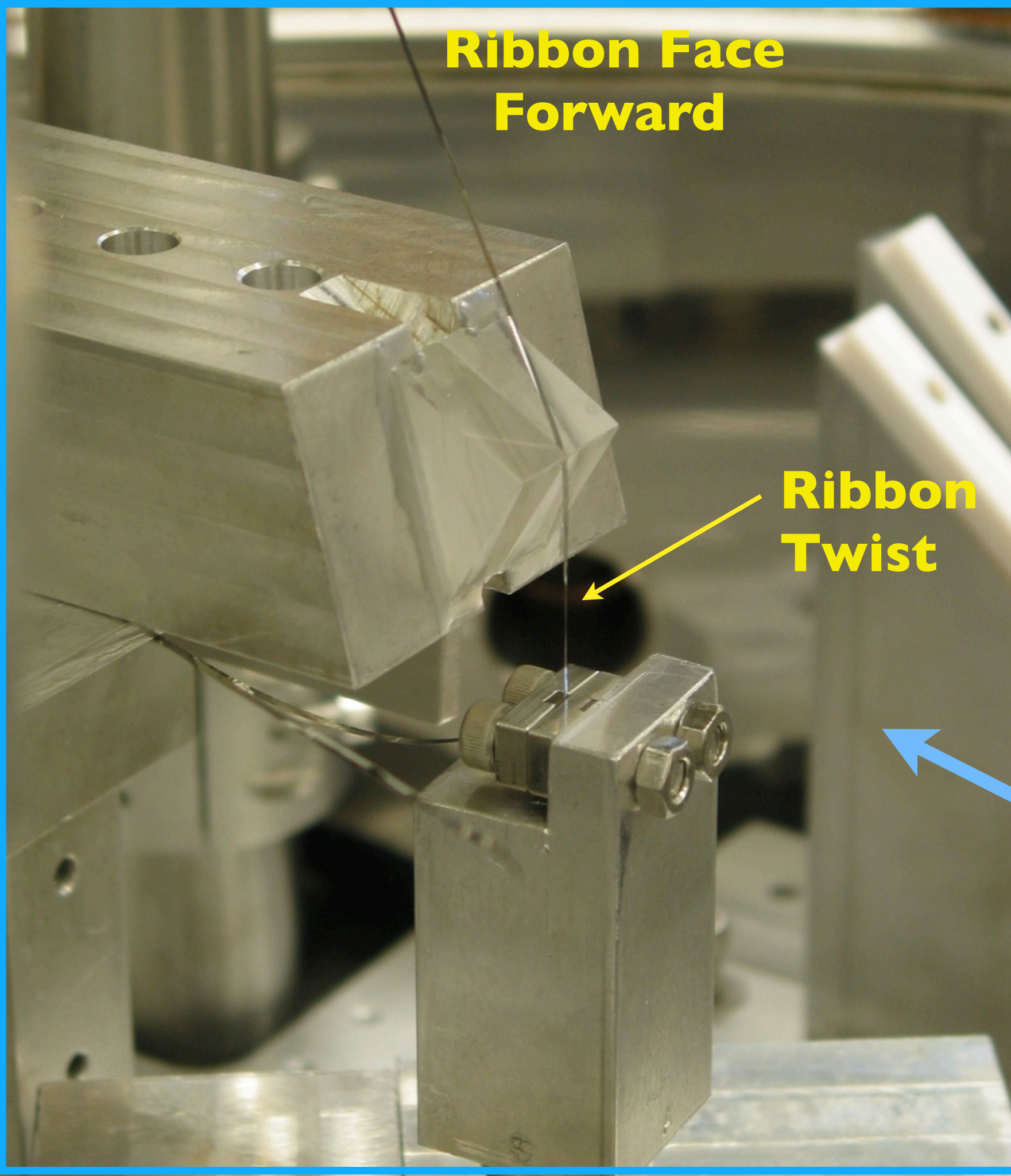
The Case for Ribbons

Excimer Laser cut Sapphire Prism with 79 micron slots
(Delivery in 7 weeks)



**Ribbon Face
Forward**

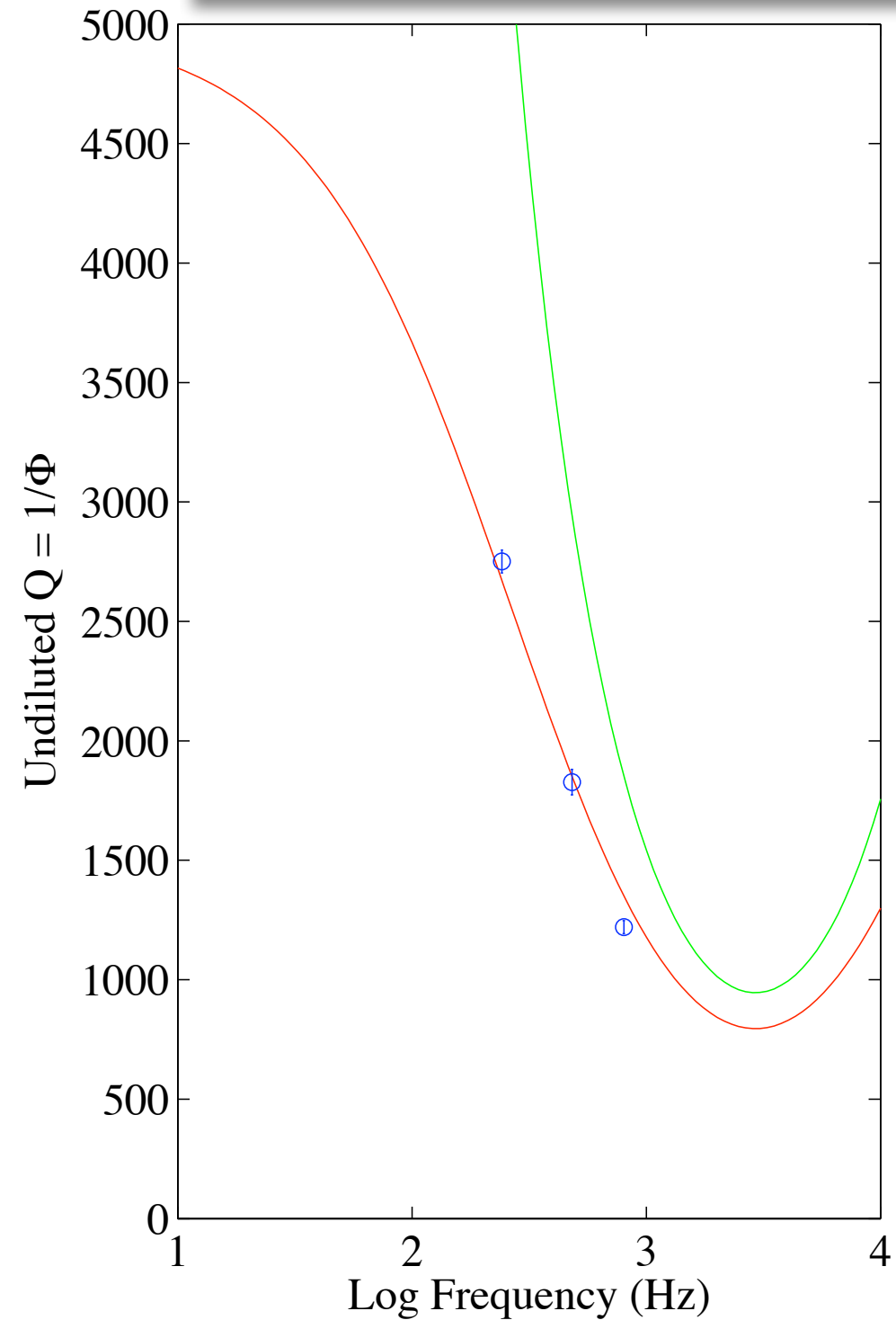
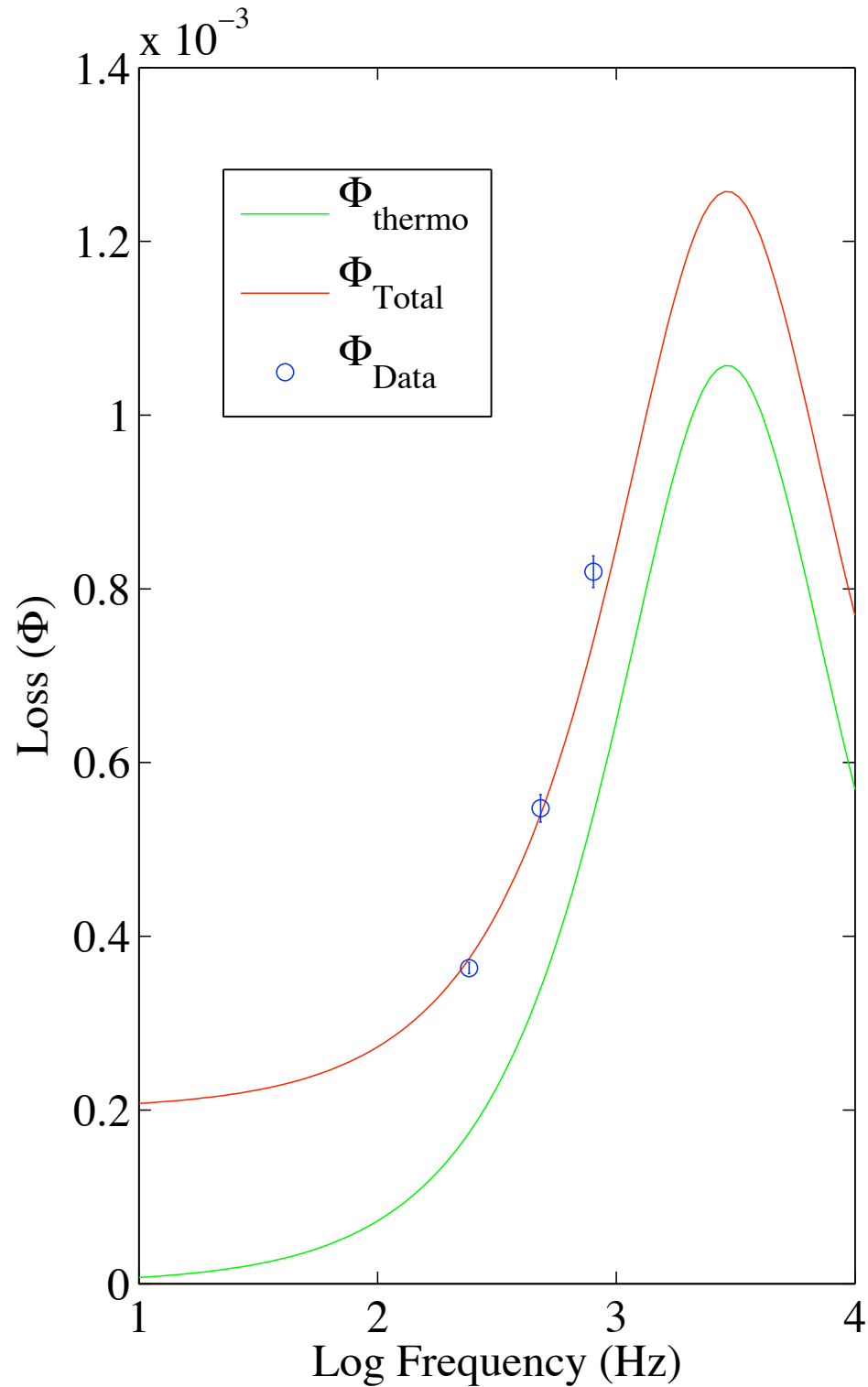
**Ribbon
Twist**



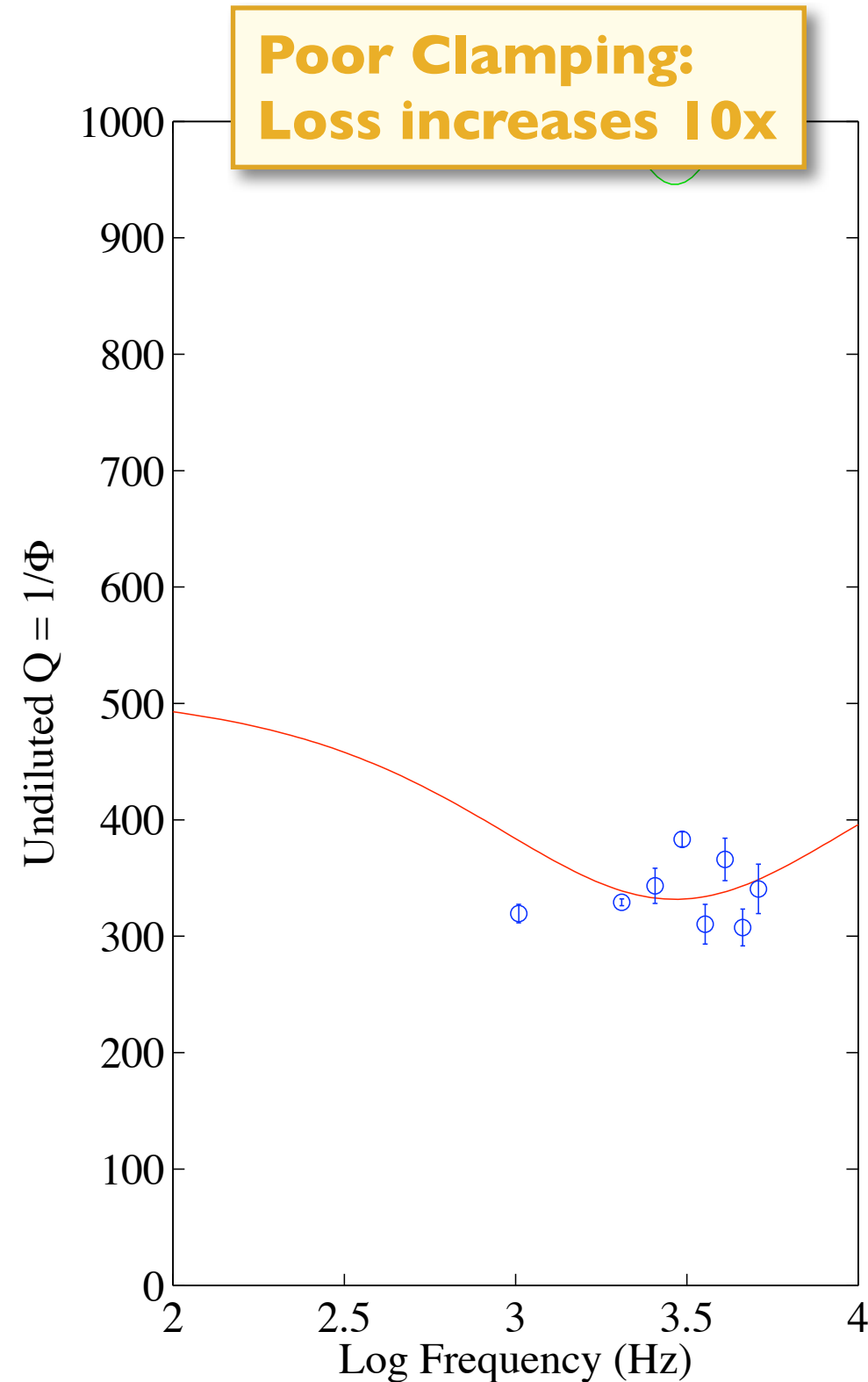
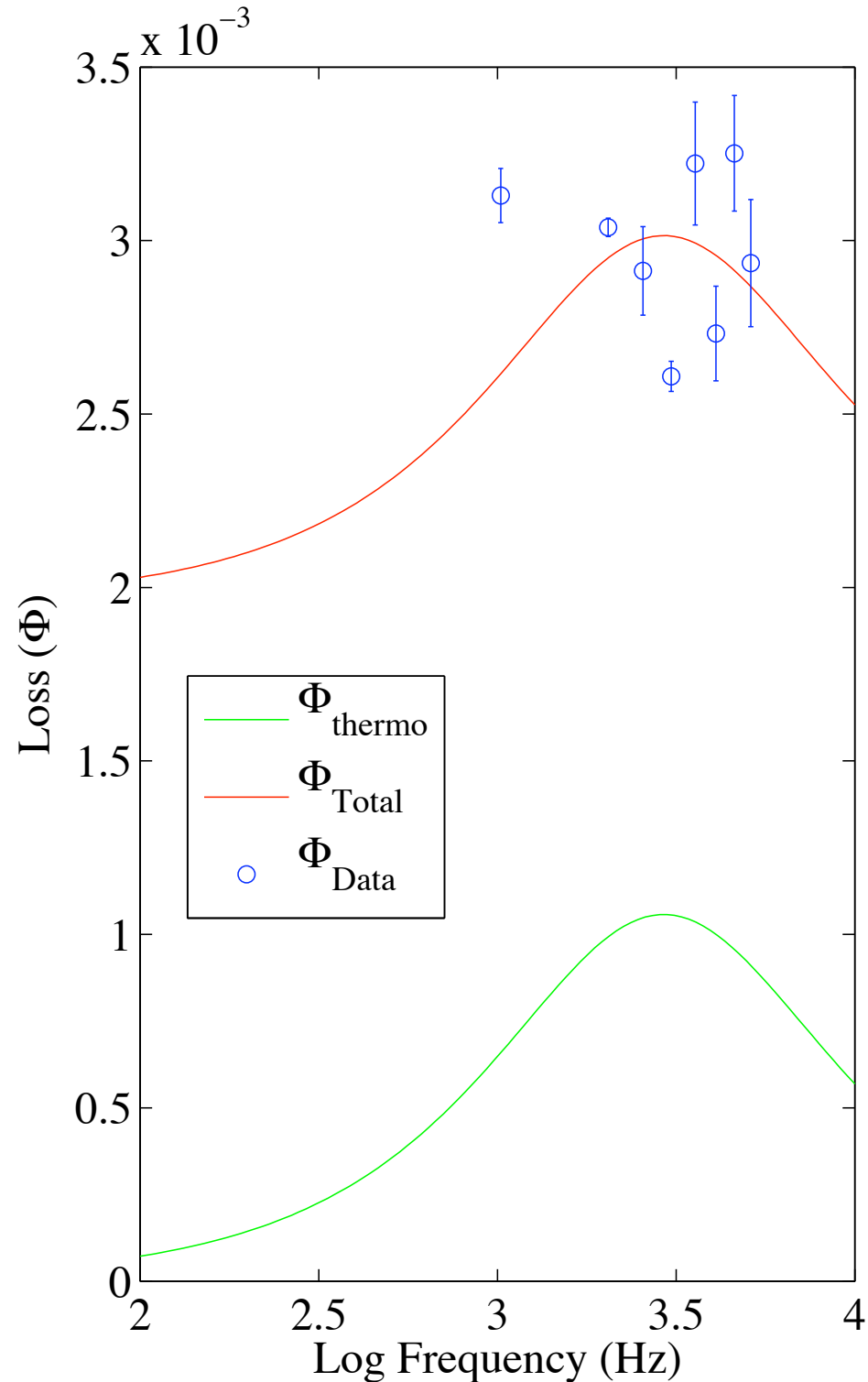
Loss in Free Steel Ribbon

Steel Ribbon: Thermoelastic fixed, $\Phi = 2.00e-04 \pm 1.87e-05$

Ribbon loss matches Wire

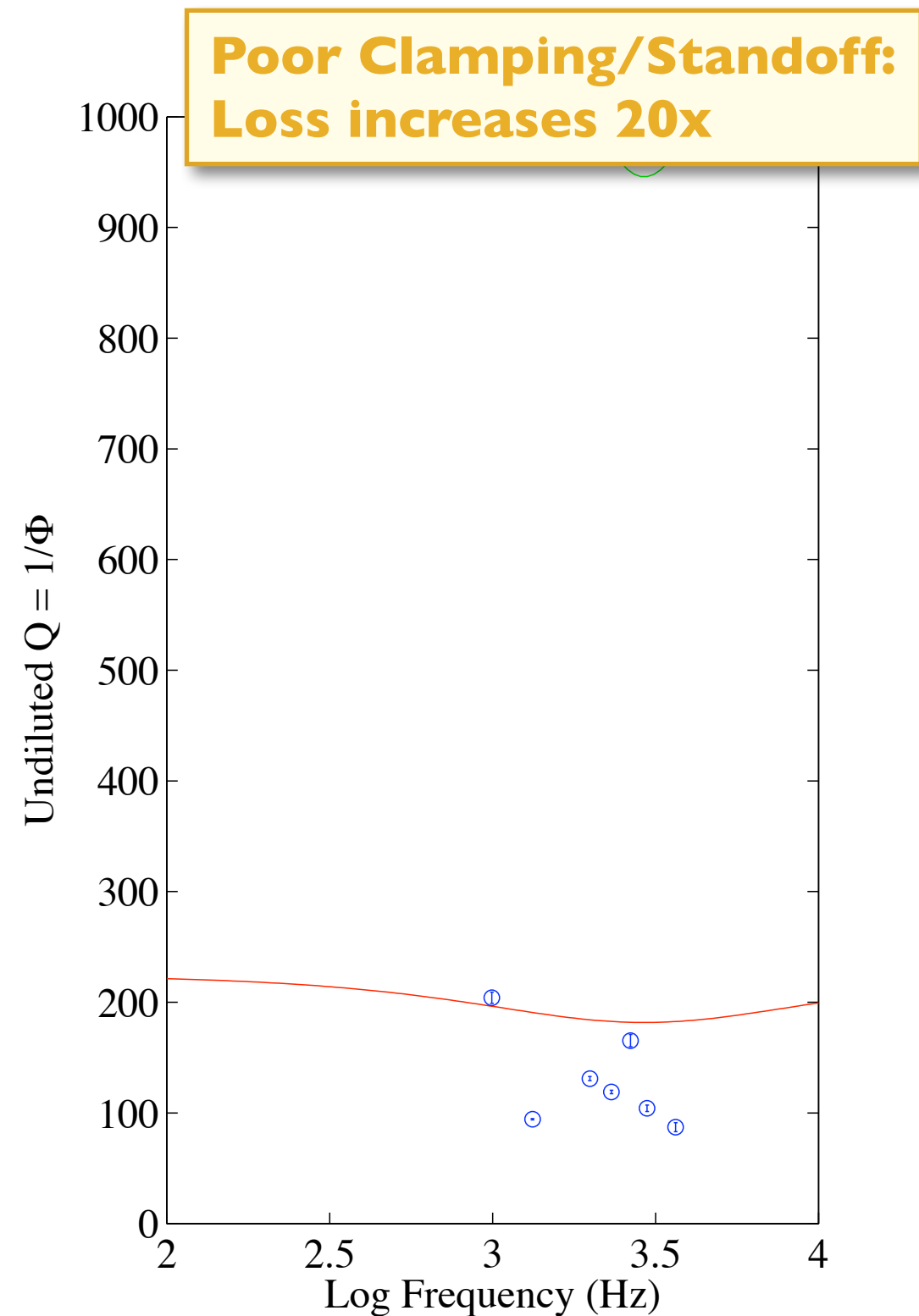
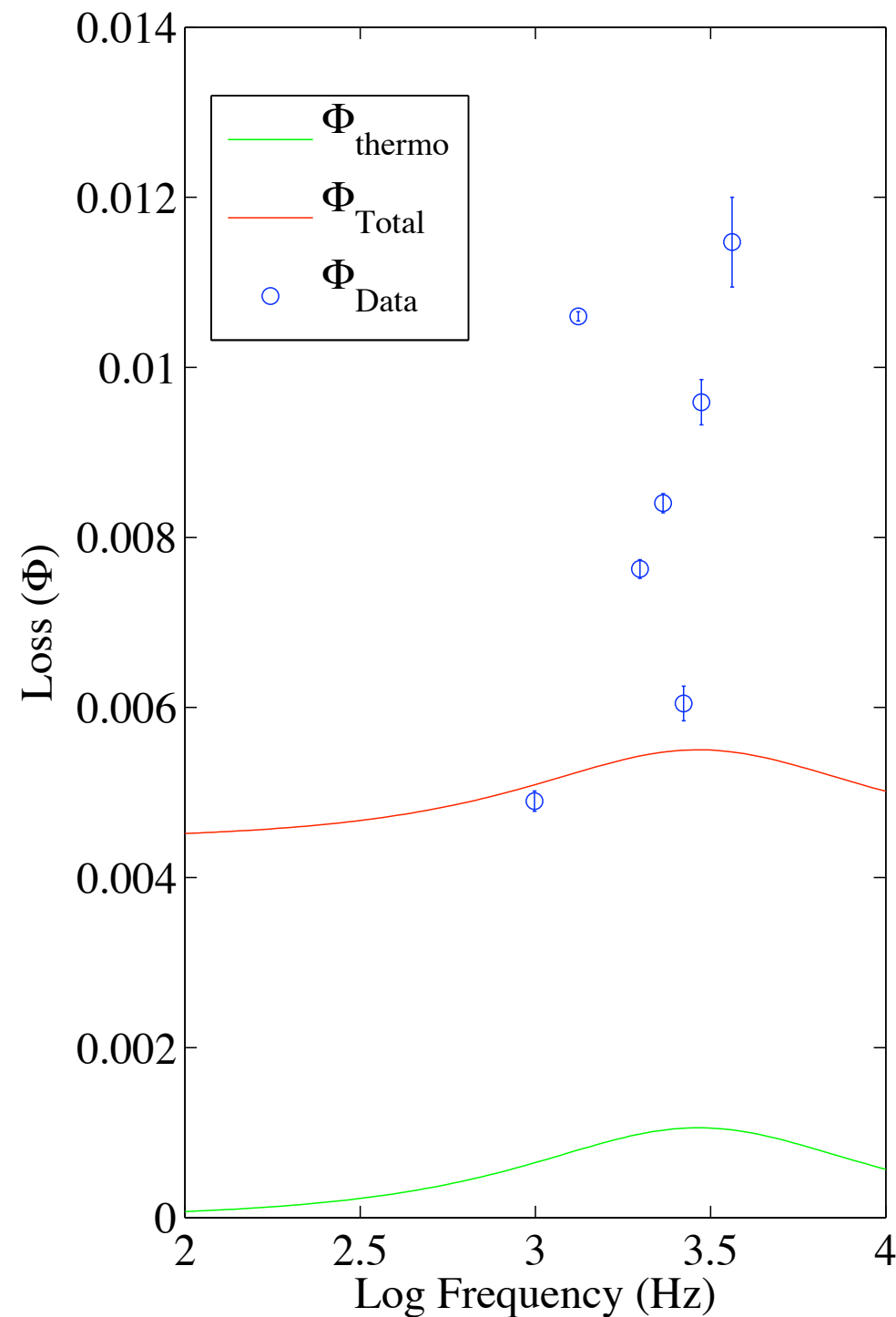


Steel Ribbon: Thermoelastic fixed, $\Phi = 1.96e-03 \pm 9.57e-05$

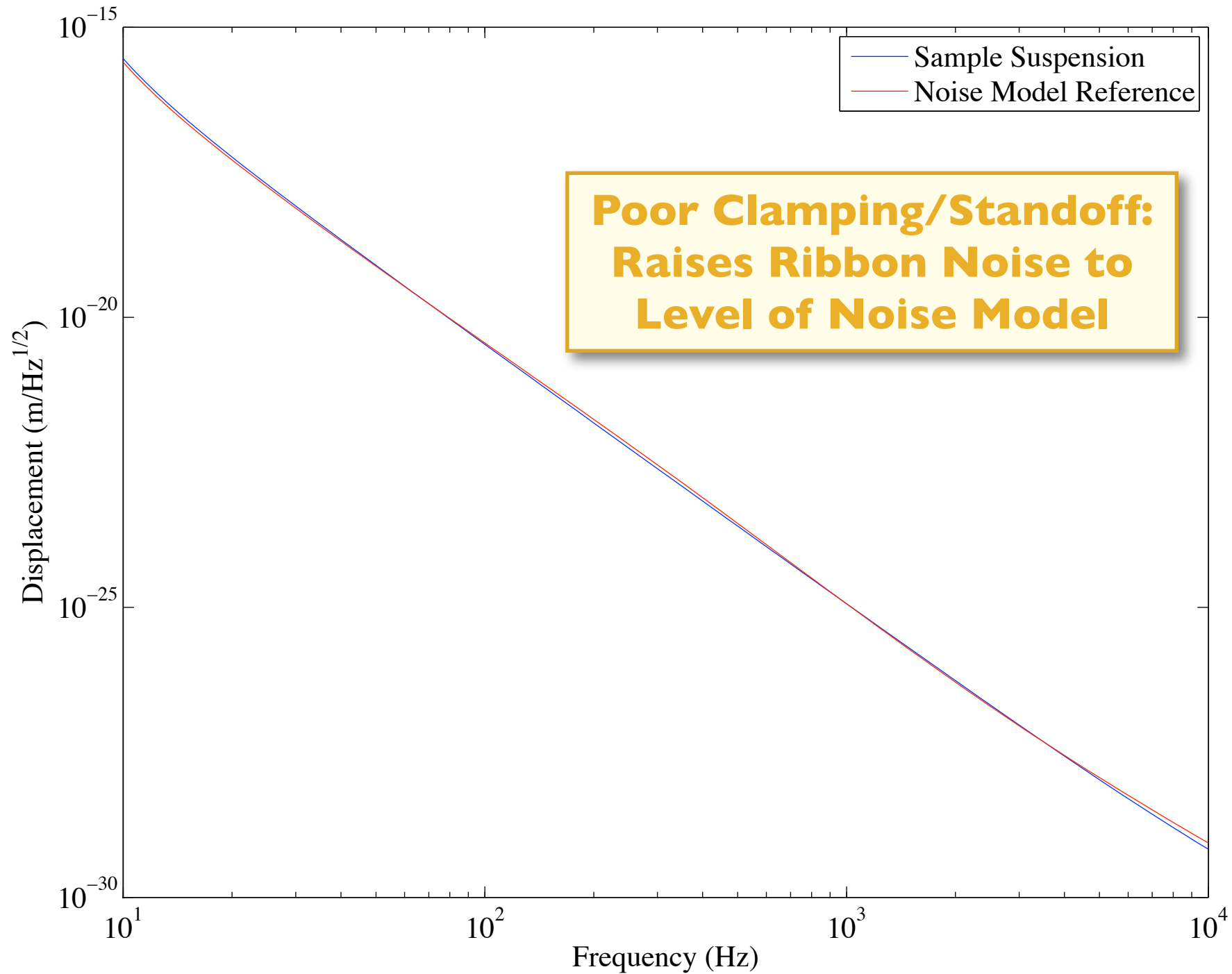


Loss in Steel Ribbon with Sapphire Prism Standoff

Steel Ribbon: Thermoelastic fixed, $\Phi = 4.45e-03 \pm 1.32e-04$



Loss in Steel Ribbon with Sapphire Prism Standoff



- Improve Ribbon Clamps.
 - Use Double Clamps as are used in LIGO
- Test new Sapphire slotted prism standoffs.
- Test Full Modified Ribbon Suspension at MIT