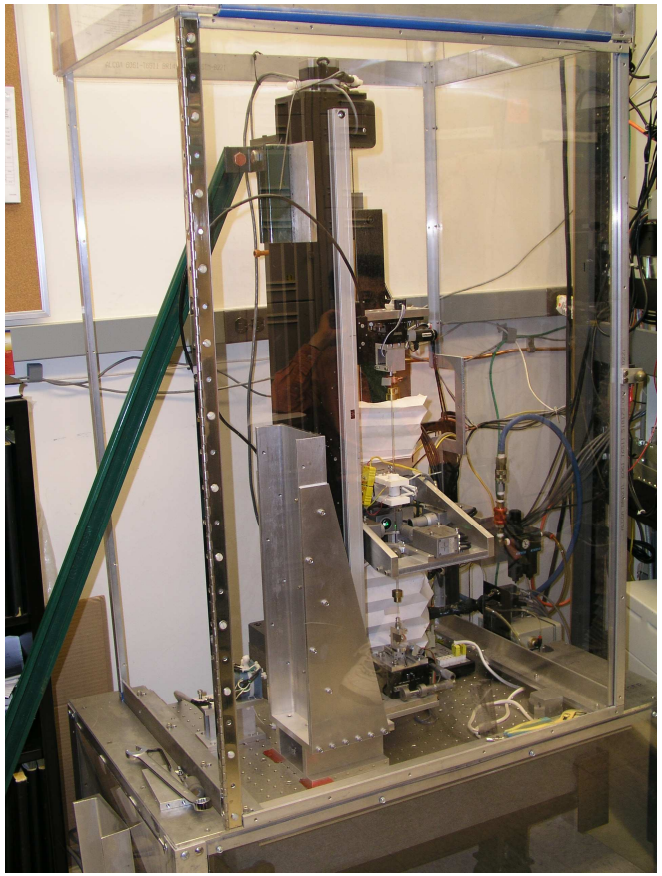
Vibration Reduction in X-ray Capillary Optic Fabrication

CHESS & LEPP



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[1]Cornell High Energy Synchrotron Source,
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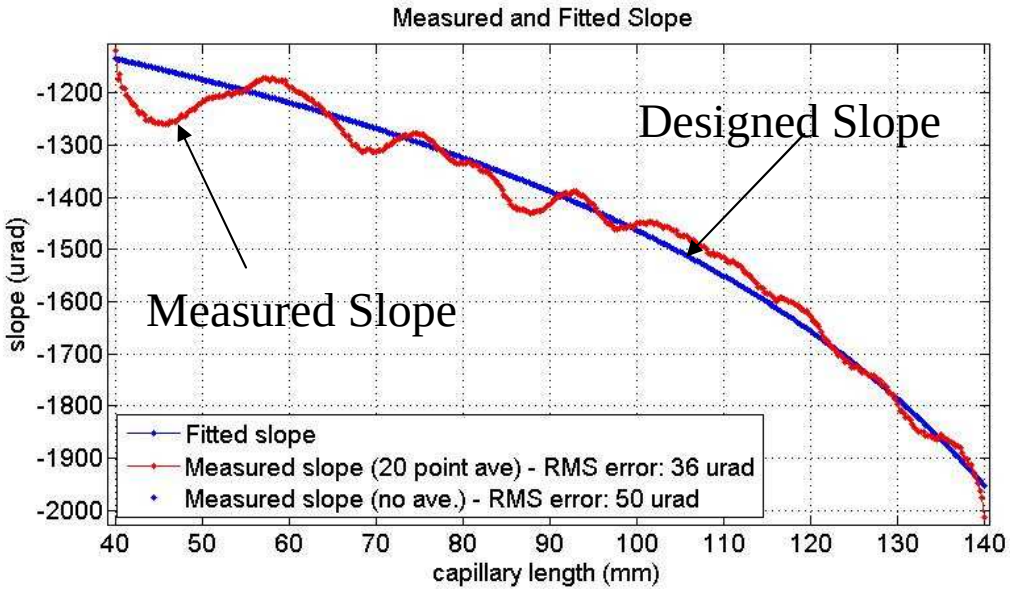
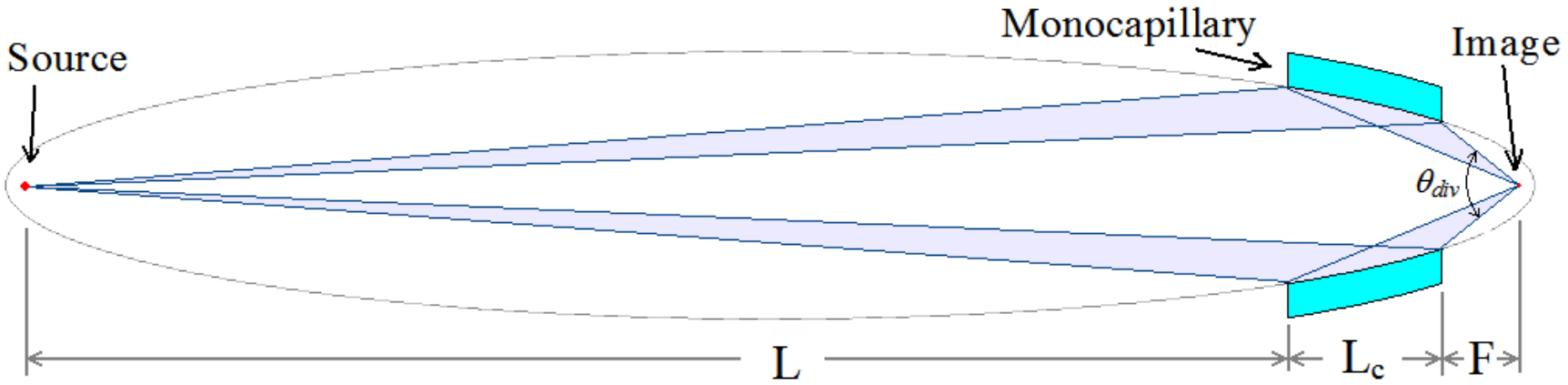
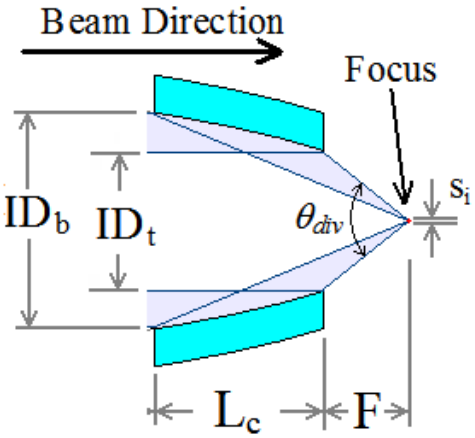
[1,2]Cornell University, Ithaca, New York,
[3]Departement of Physics, Rhodes College, Memphis, Tennessee
email: hugjl@rhodes.edu



Capillary Optics

CHESS & LEPP





Advantages:

- Work with any X-ray Energy
- Optically & Mechanically Robust
- Efficient

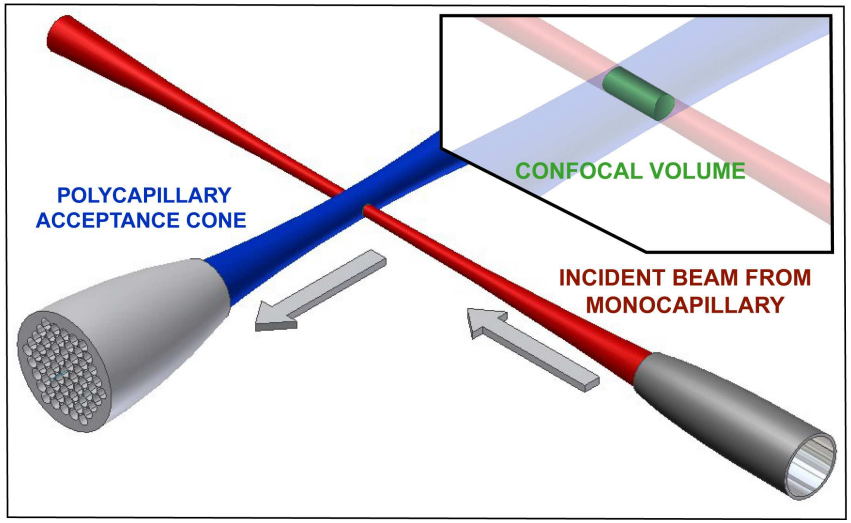
Disadvantages:

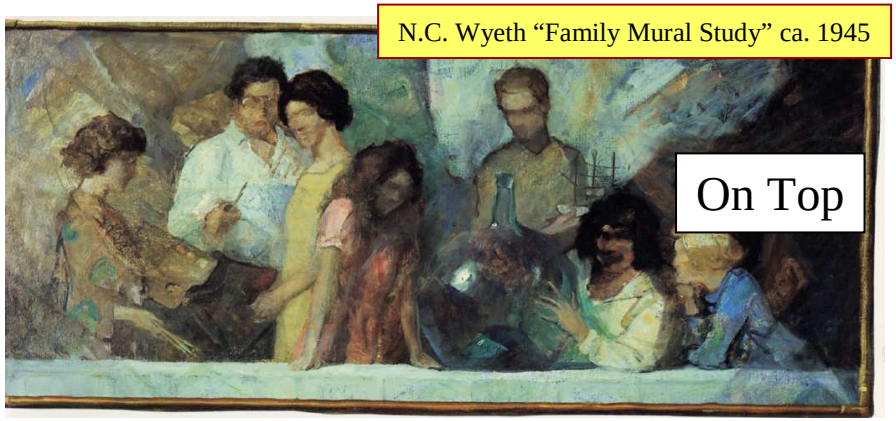
- Not Imaging Optics

X-ray Science Application: Art History

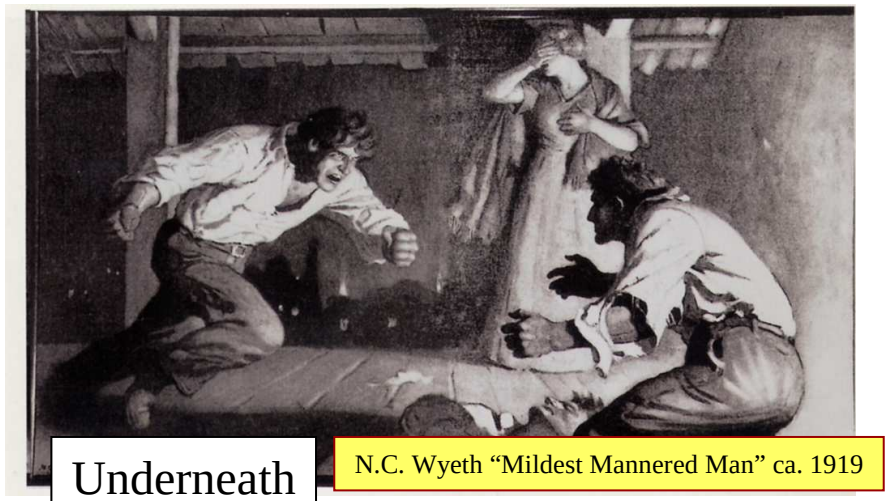
CHESS & LEPP

Confocal X-ray Fluorescence: Analyze Buried Layers Non-Destructively





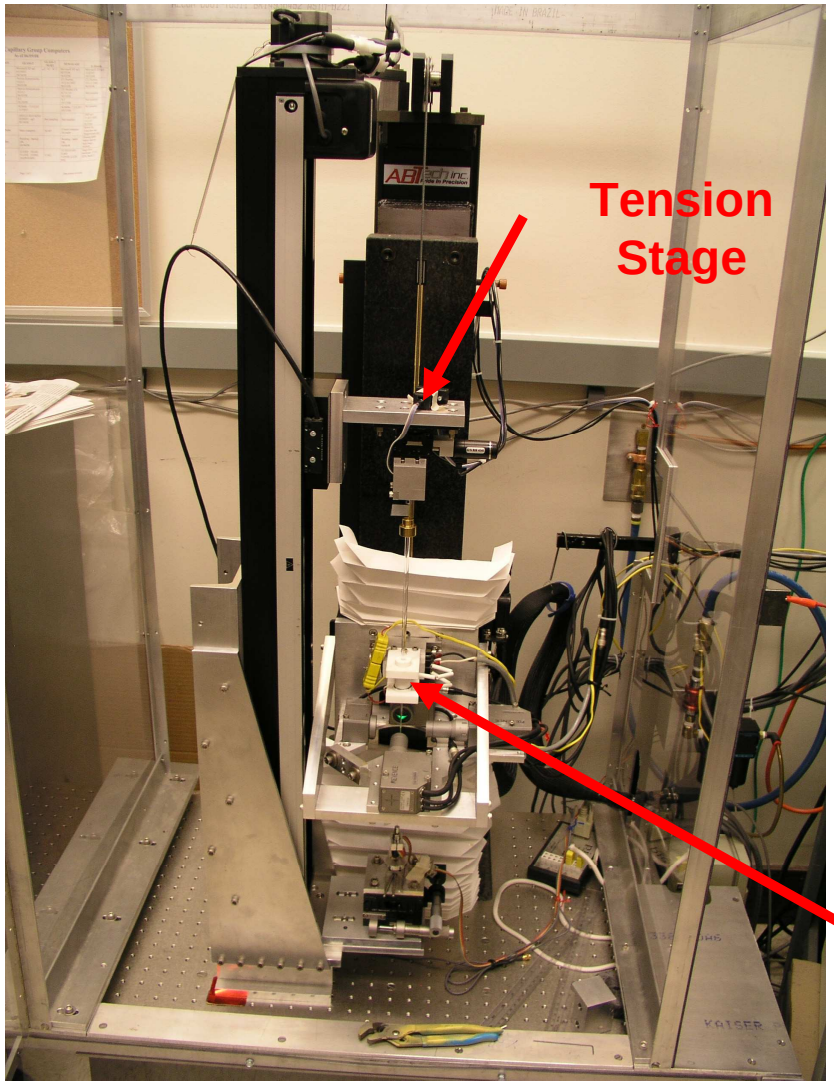
N.C. Wyeth "Family Mural Study" ca. 1945

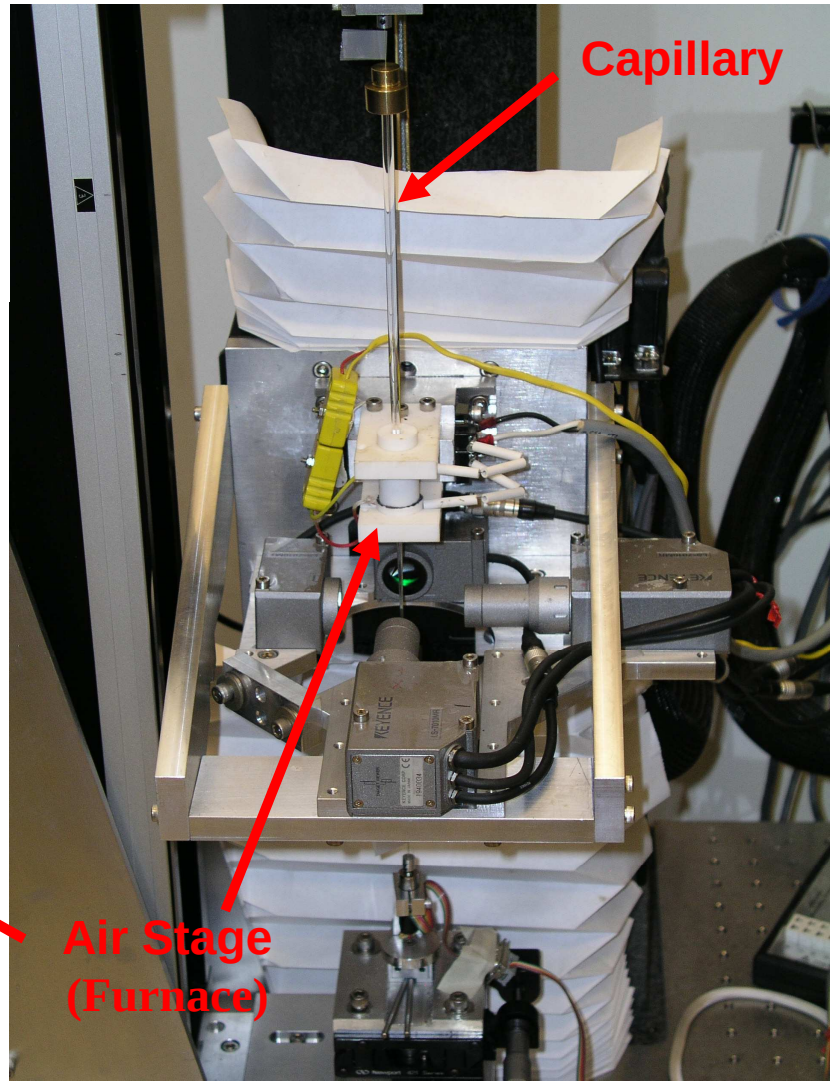


N.C. Wyeth "Mildest Mannered Man" ca. 1919

Capillary Puller

CHESS & LEPP

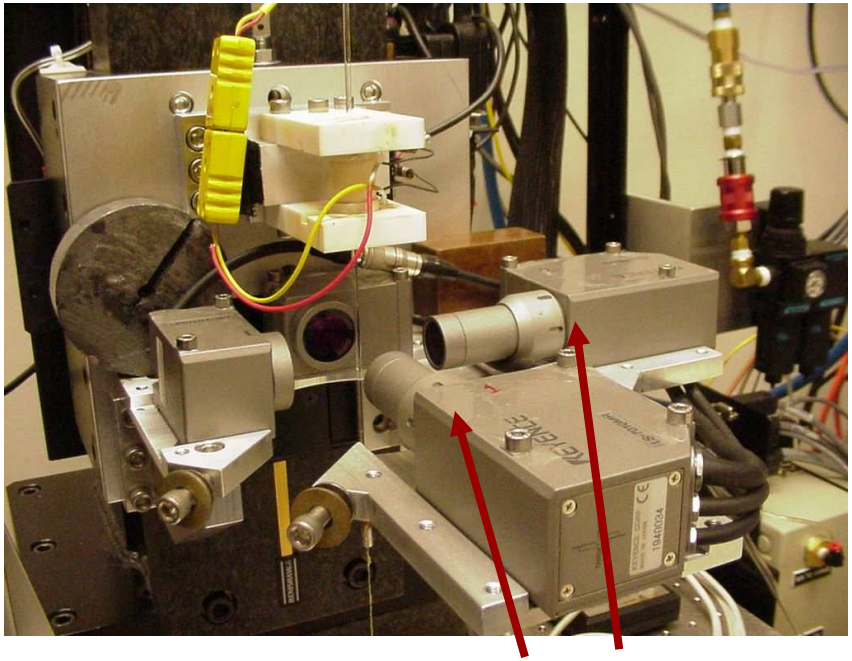




Capillary Evaluation

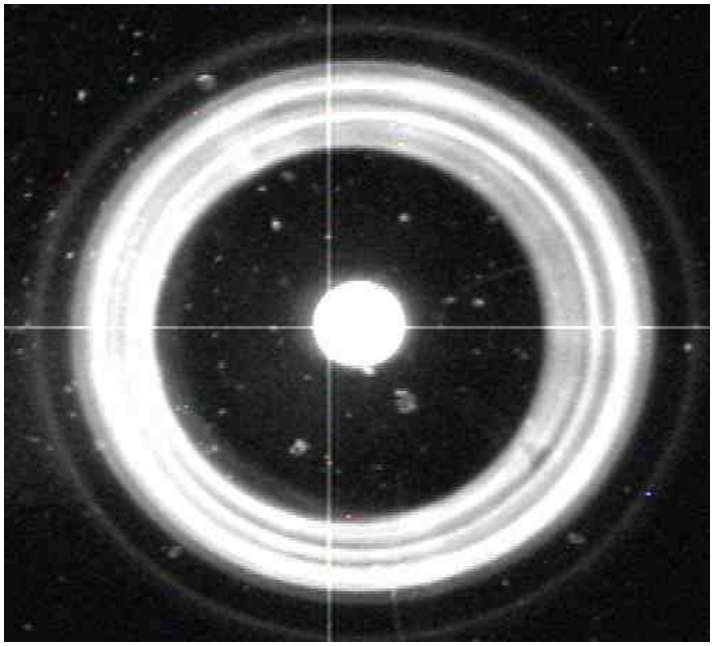
CHESS & LEPP

Optical Metrology



Optical Micrometers

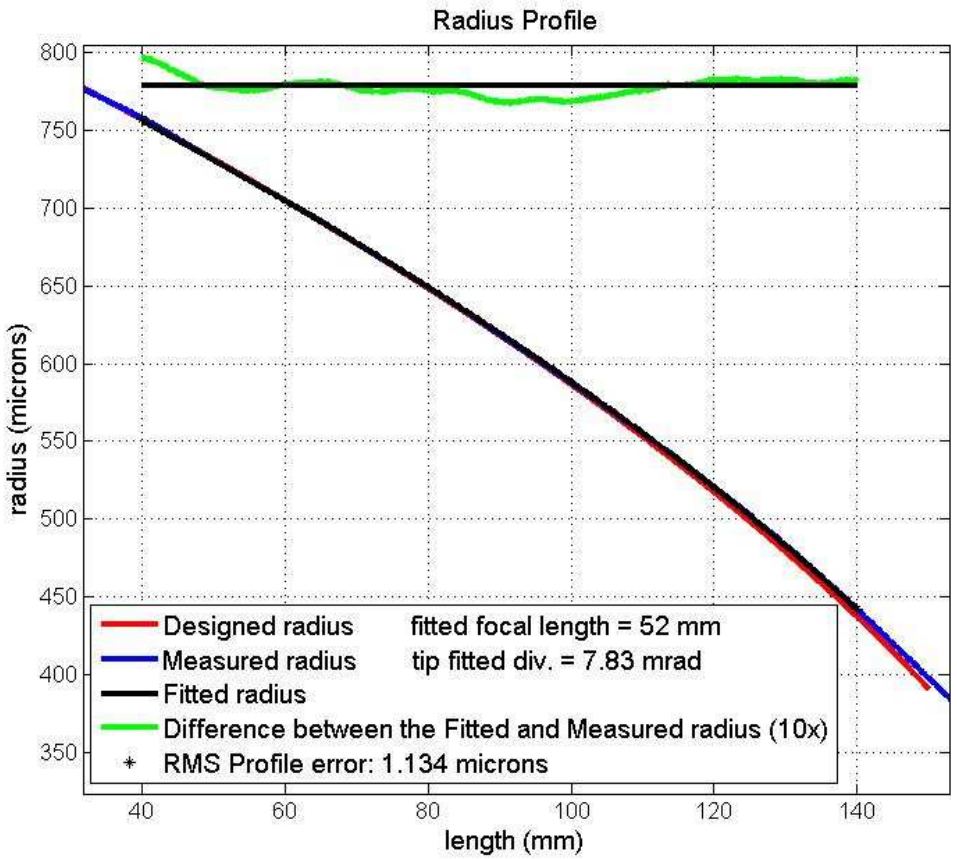
Beam Line Evaluation

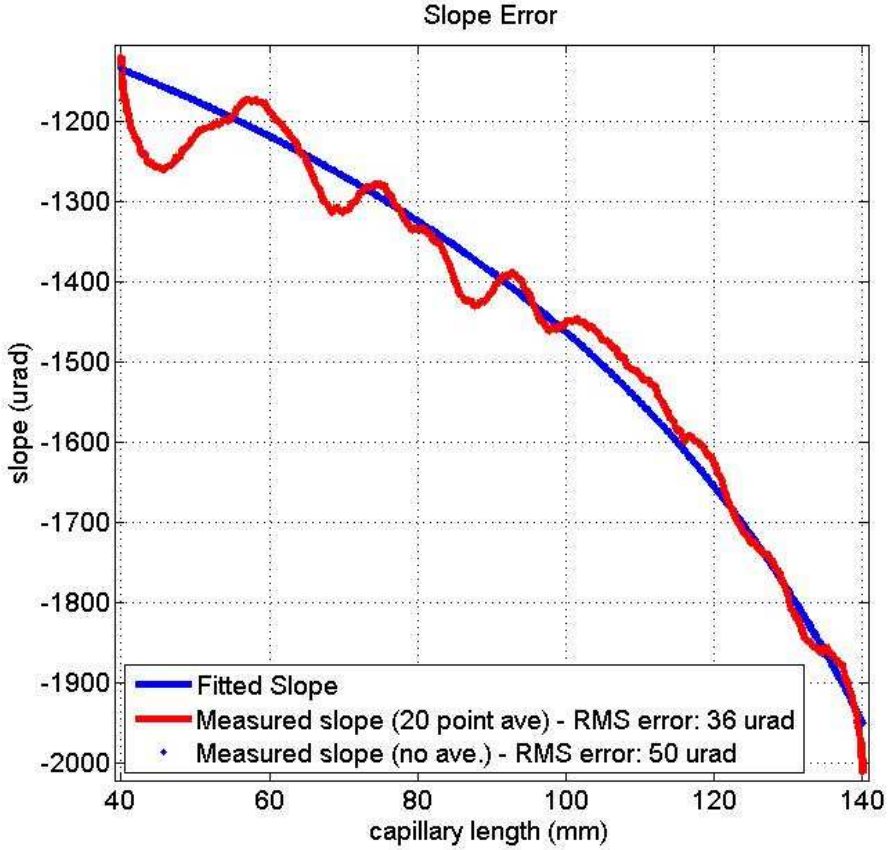


Far Field X-ray Image

Status of Capillary Fabrication Quality

CHESS & LEPP

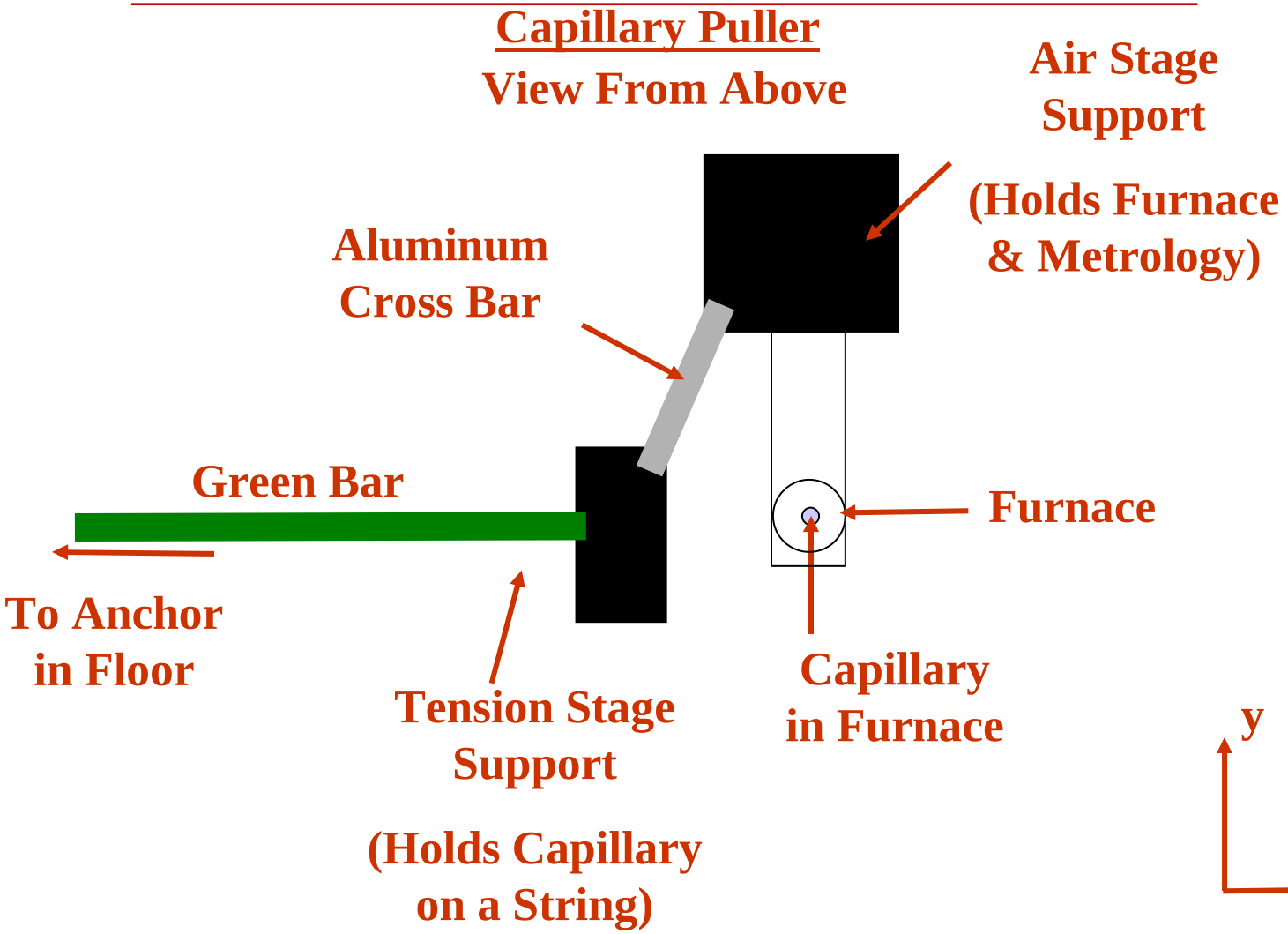




Profile Errors: 0.5-2 μm rms
Slope Errors: 20-80 μrad rms

Structural Bracing

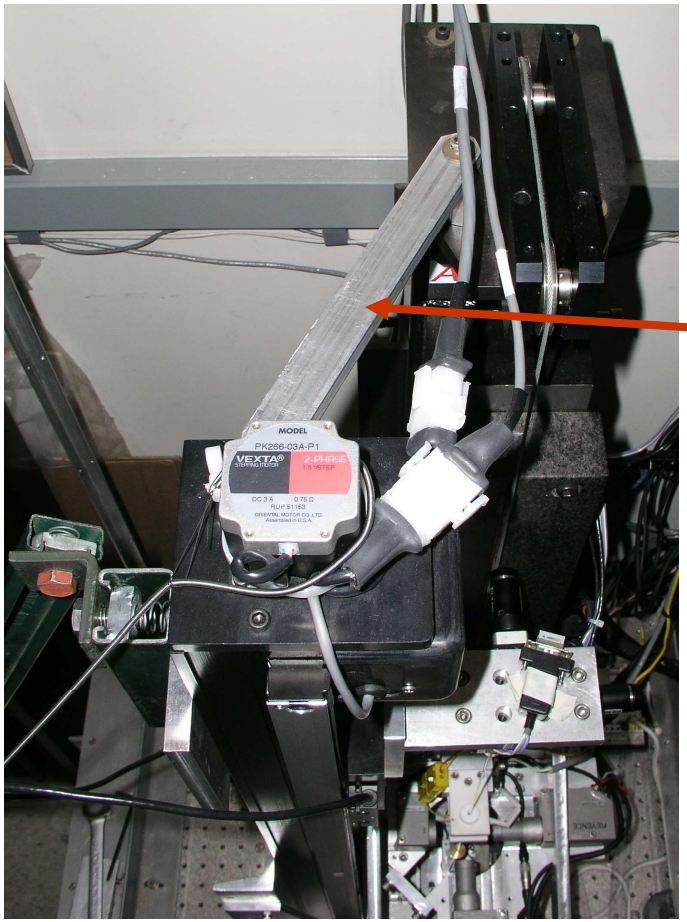
CHESS & LEPP



Structural Bracing, Continued

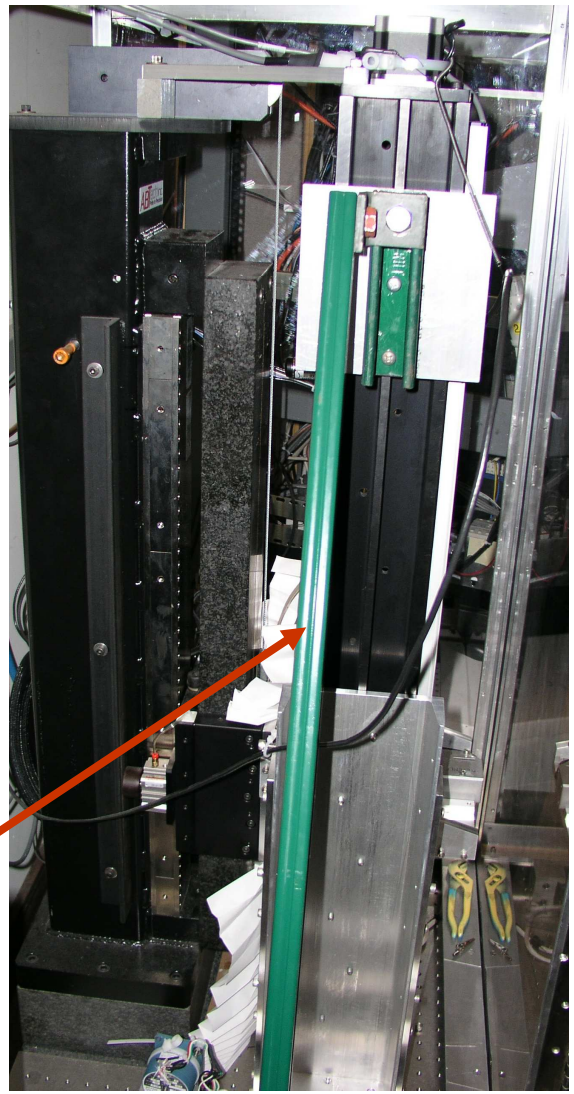
CHESS & LEPP

Improved Puller Structural Bracing



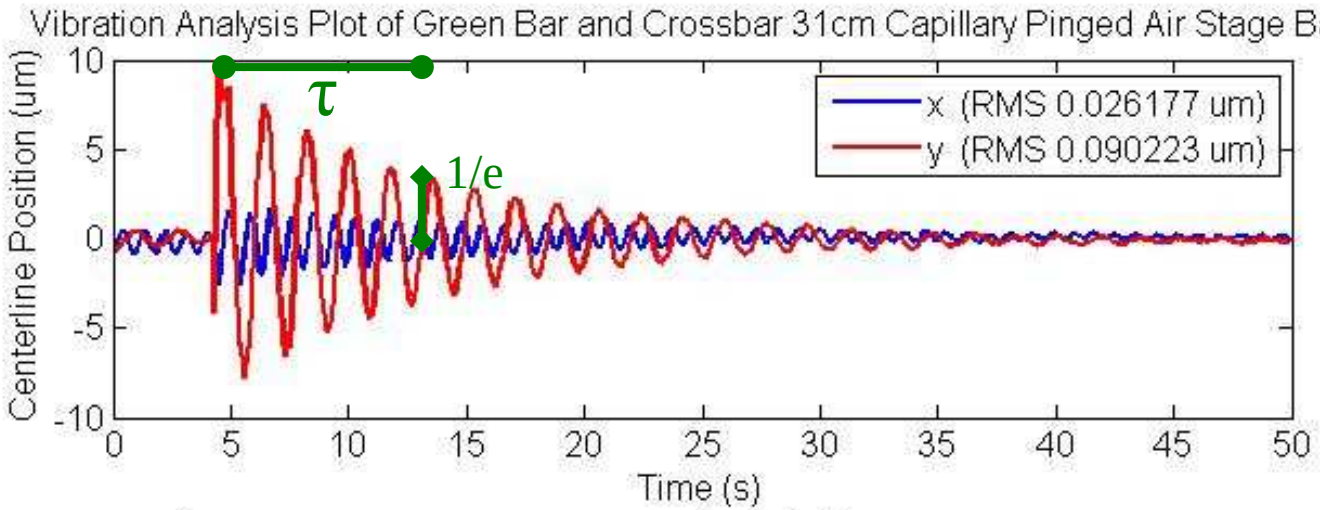
Aluminum Bar

Steel Unistrut



“Ping Tests in Y-direction”

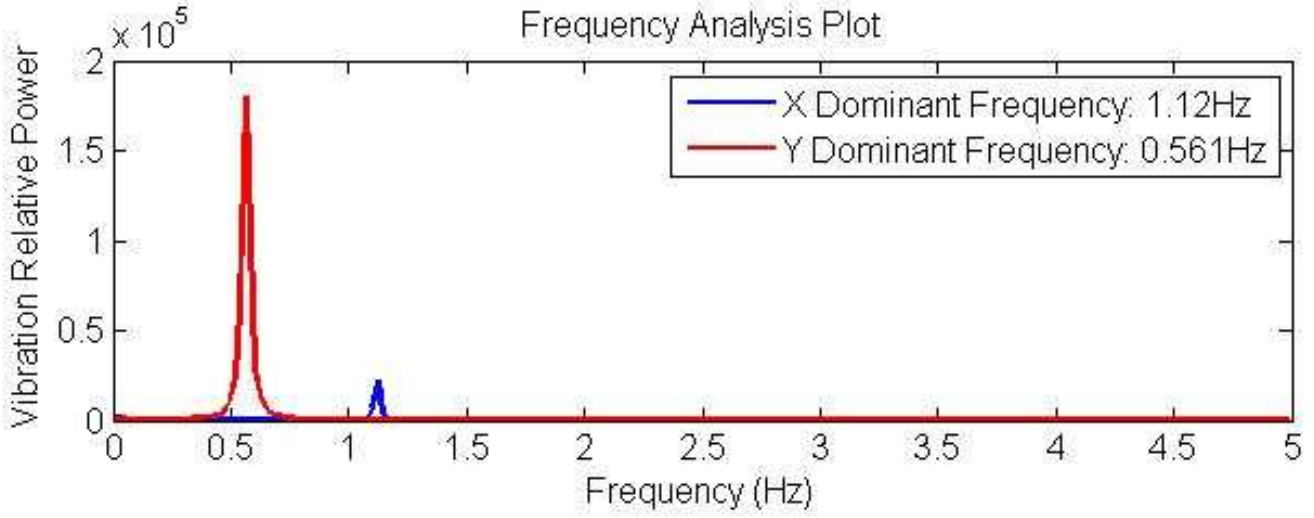
CHESS & LEPP



τ_y = 13 s

In General:

τ ~ 10s



“Ping Tests” Continued

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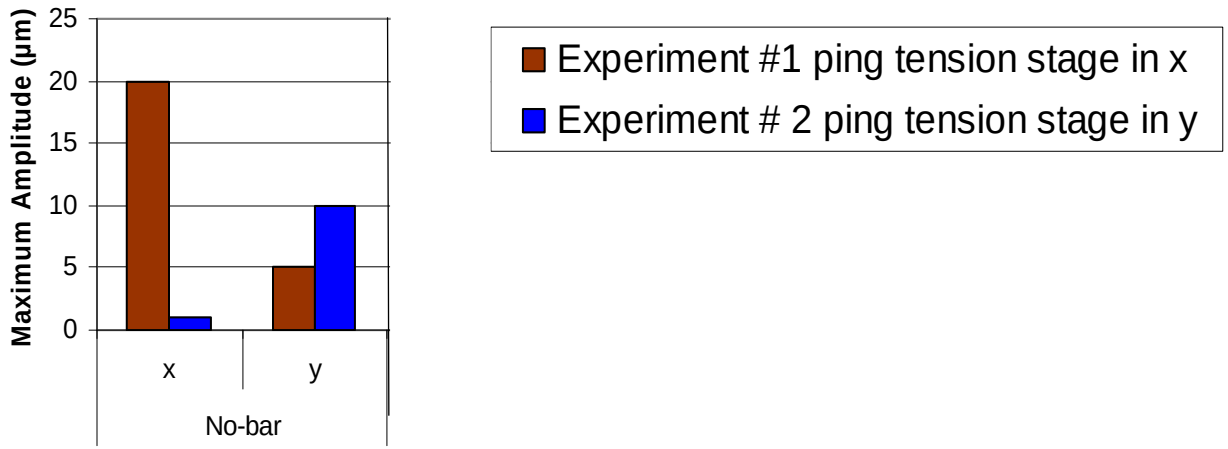
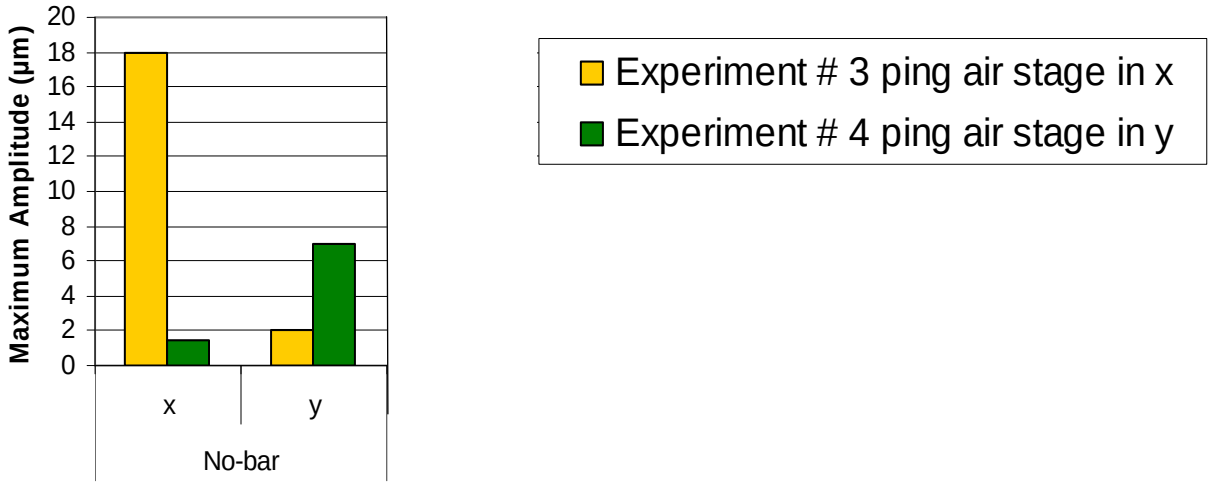
Pinged Tension Stage Amplitudes

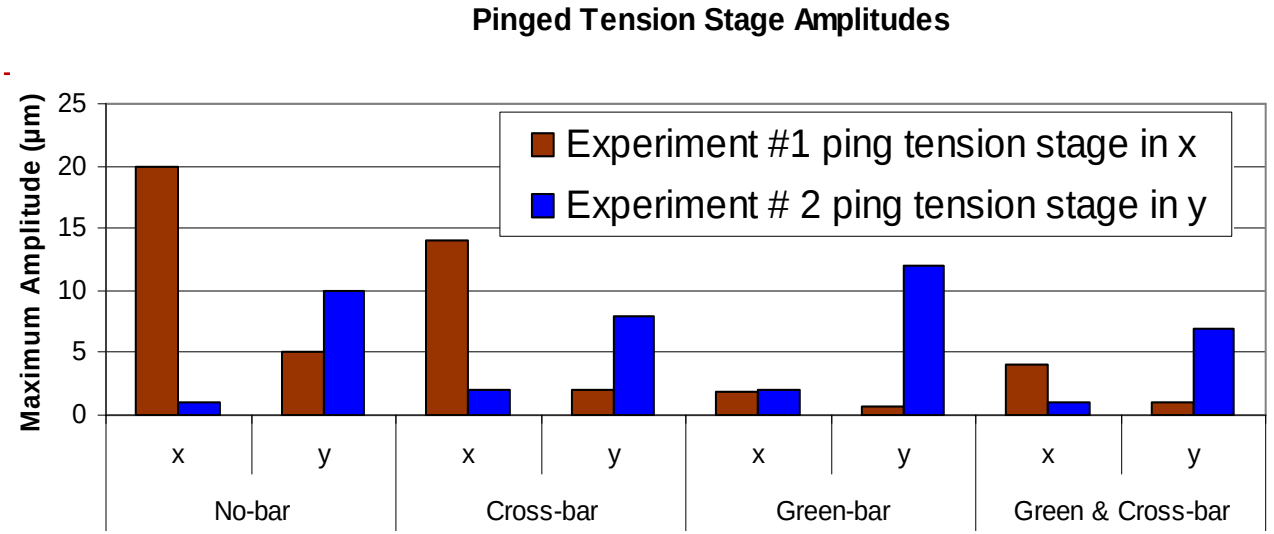


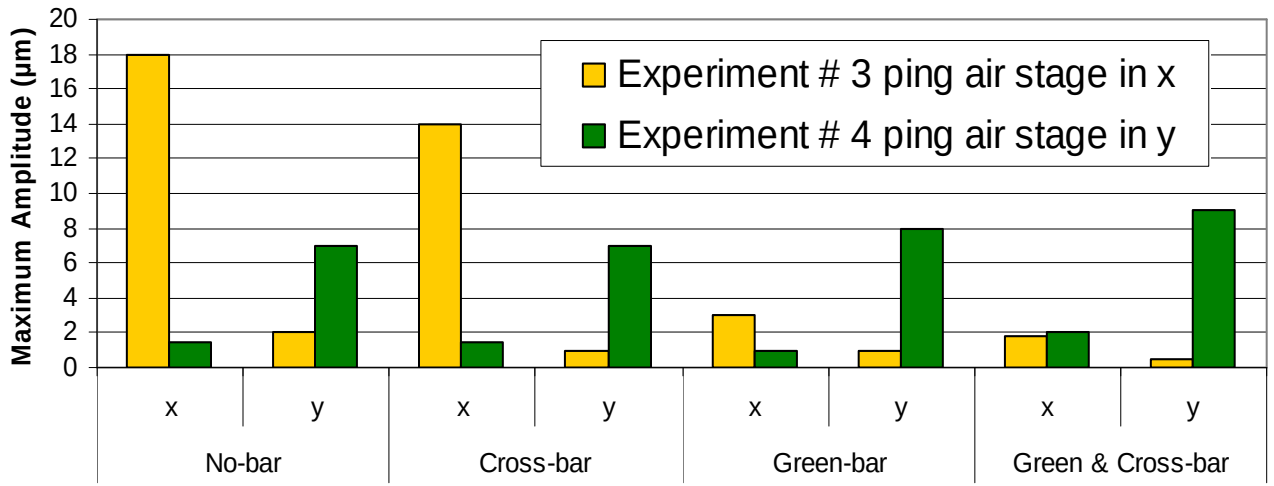
Pinged Air Stage Amplitudes



“Ping Tests” Continued

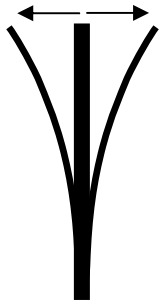
CHESS & LEPP





Fundamental Frequency Cantilever Prediction

CHESS & LEPP



$$f_n = \frac{\kappa_n^{\,2}}{2\pi}\sqrt{\frac{EI}{\rho A L^4}}$$

Air Stage: f_1 = 100 Hz

Tension Stage: f_1 = 45 Hz

Capillary as a String: f_1 = 30 Hz

$$I = \frac{bd^3}{12}$$

$$\kappa_1 = 1.875$$

Predictions v. Observations

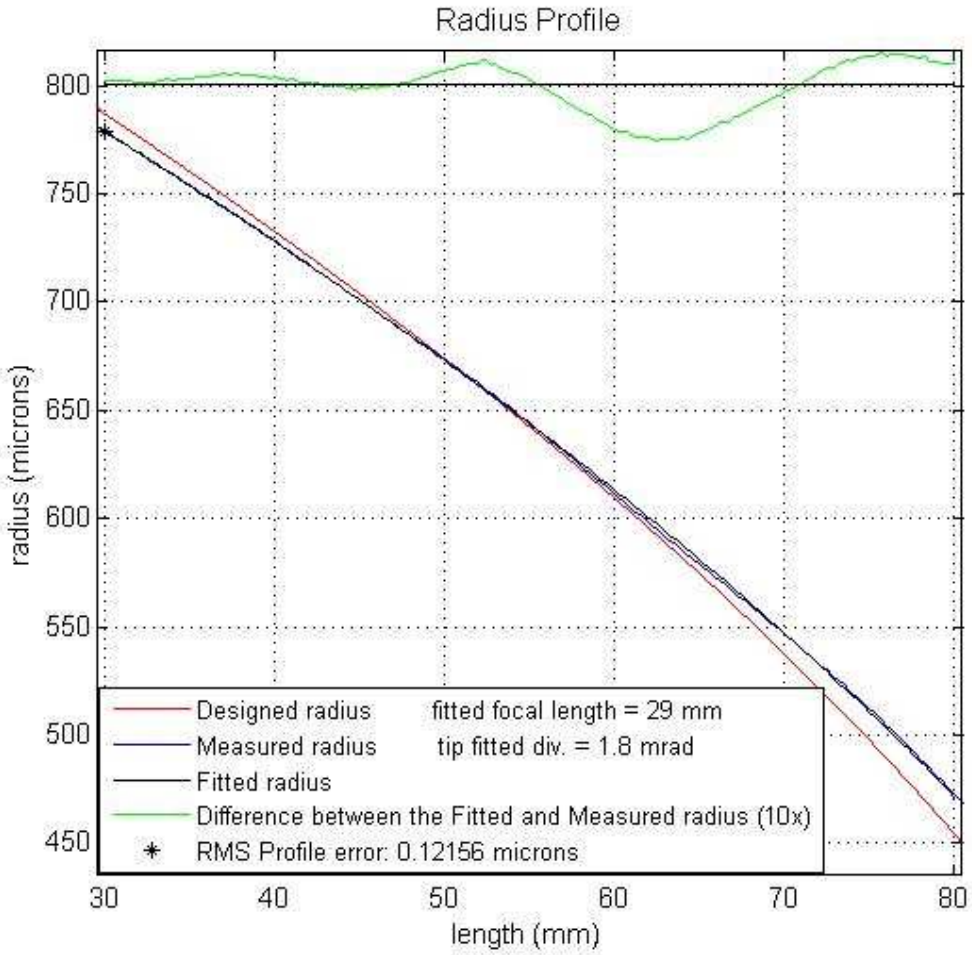
CHESS & LEPP

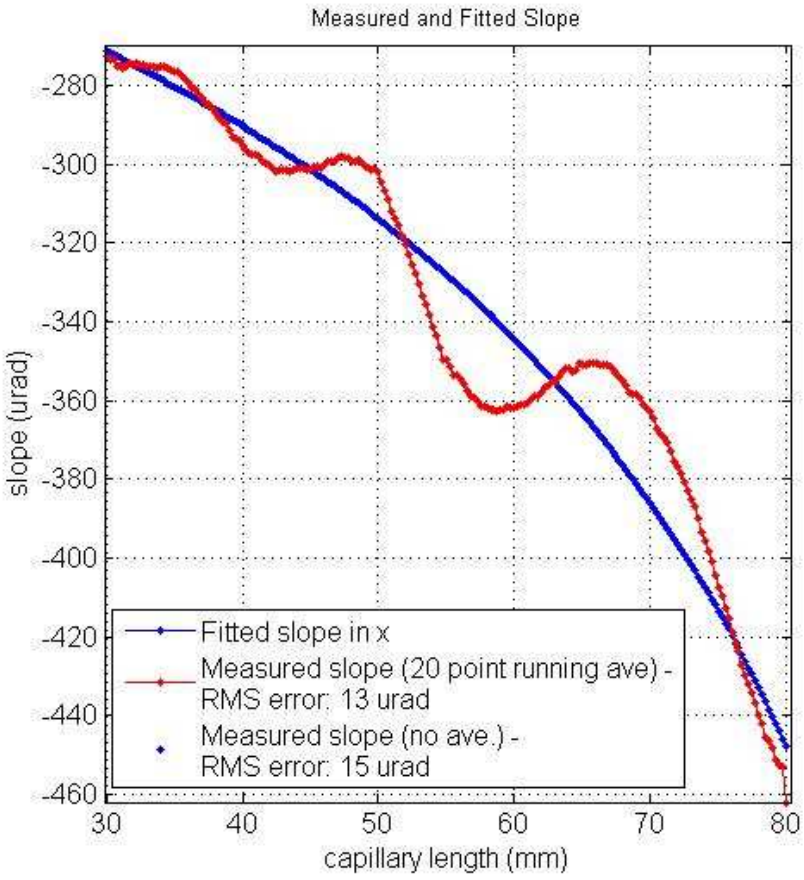
- Predicted Frequencies Too High
- Maximum Measurable Frequency 5 Hz
- Source of Vibrations Not Air or Tension Stage Supports

Cornell University
Cornell High Energy Synchrotron Source

Present Capillary Status

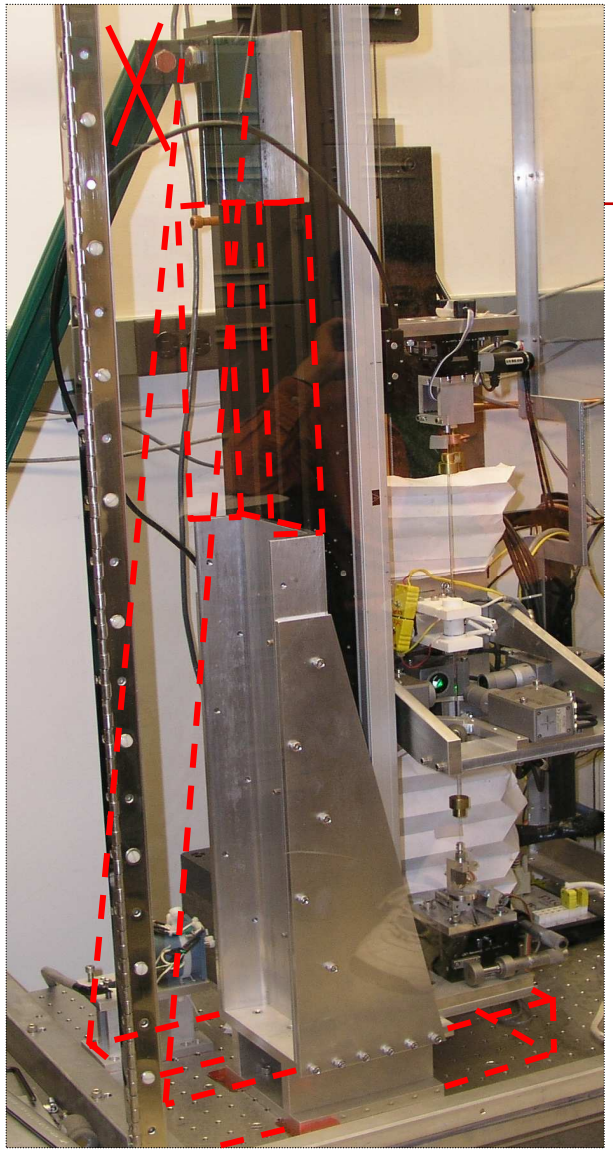
CHESS & LEPP





Suggestions for Further Improvement

CHESS & LEPP



New Structural Bracing

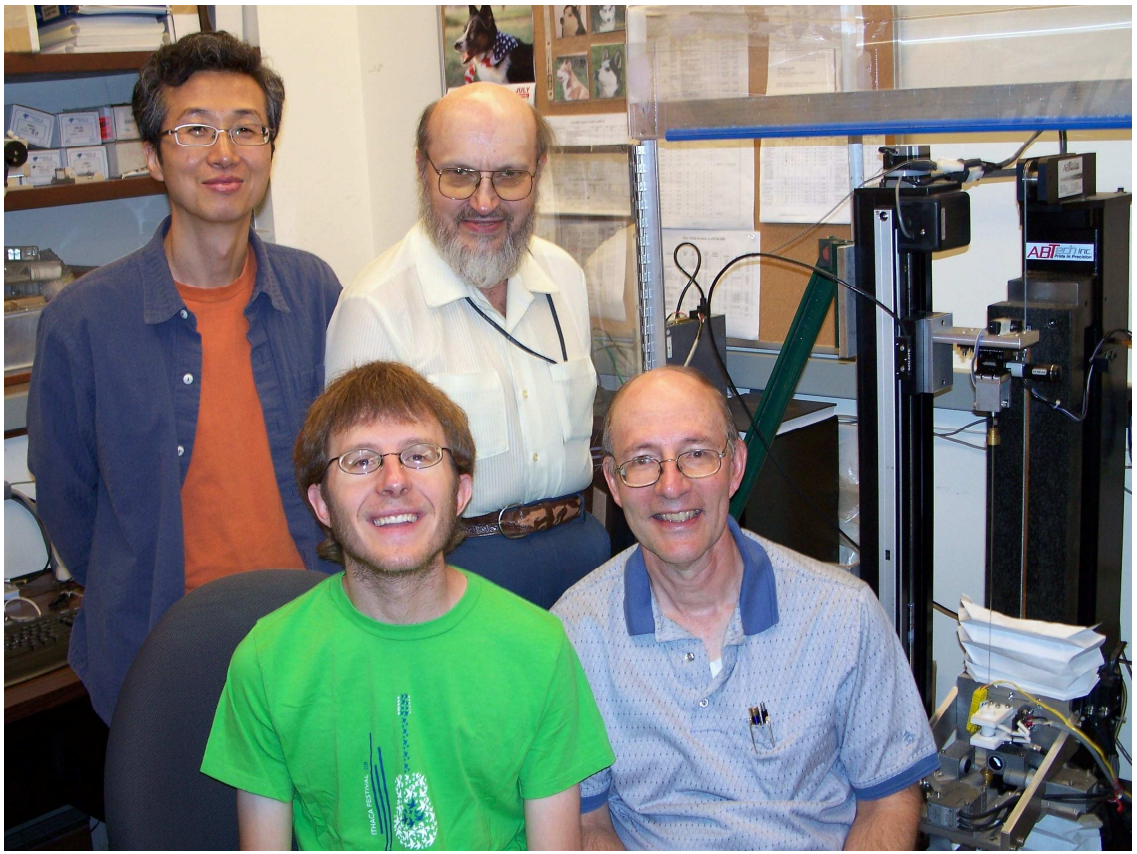
- Further stiffen the mechanical stages against vibrations
- Does 'string mounting' of capillary amplify the vibrations?
- Need improved metrology—
  Need more sensitive on-board optical equip.
  Off-line viewing of Capillary Interior profile?

Acknowledgments

CHESS & LEPP

Sterling Cornaby

National Science Foundation



Heung-Soo Lee, Tom Szebenyi (top)
Justin Hugon, Don Bilderback