Optimizing Monocapillary Optics for Synchrotron X-ray Applications

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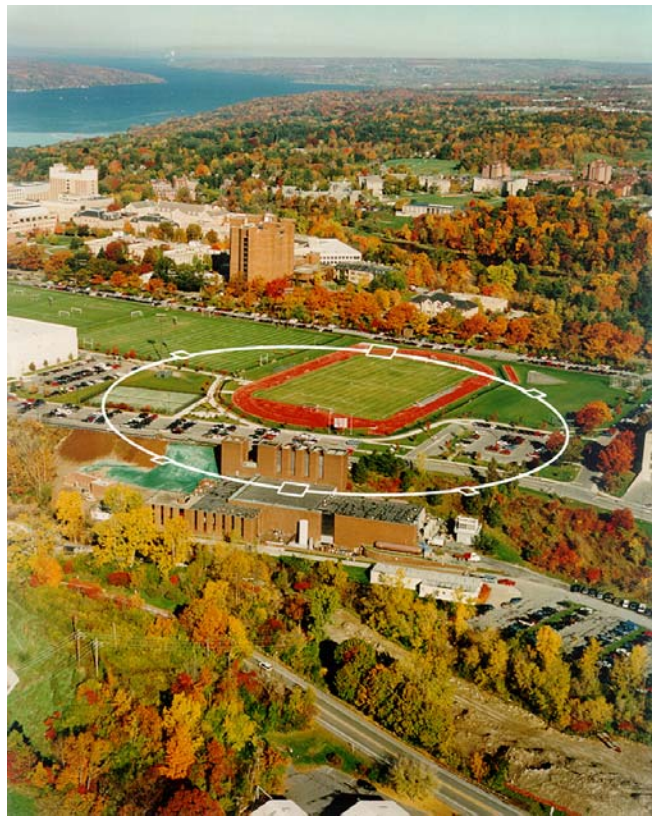
Donald Bilderback[1,2], Sterling Cornaby[1], Tom Szebenyi, Heung-Soo Lee[1,3]
[1]Cornell High Energy Synchrotron Source, [2]School of Applied and Engineering Physics,
[1,2]Cornell University, Ithaca, New York,
3Pohang Accelerator Laboratory, South Korea
email: dhb2@cornell.edu

1. **Introduction to monocapillary optics**
2. **Elliptical focusing one-bounce geometry**
3. **CHESS applications experience**
   a) **Fluorescent imaging of fish ear stones**
   b) **Confocal x-ray microscopy of historic paintings**
4. **Conclusions**



What can optics do?

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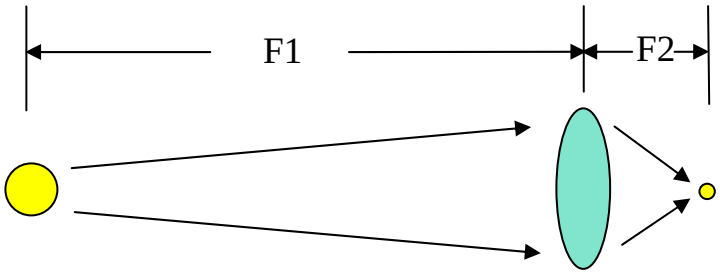

sun

magnifying
glass of diameter, D

optics exchange divergence for size

lens transmission is around 100%

Magnification=F2/F1; Divergence ~ D/F2 ~ 0.5° (9 mr)

Introduction to Monocapillary Optics

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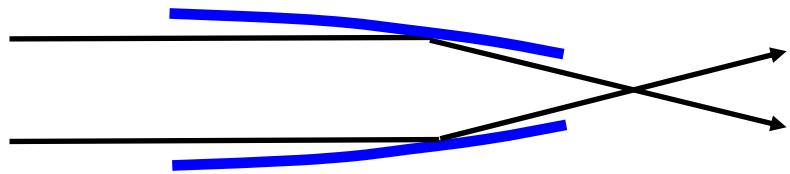
Why do we need a capillary ?

To make small beams and to increase the x-ray beam intensity (flux/μm^2)

What kind of capillaries we are talking about ?



One-Bounce Glass Capillary

Large working distance (cm scale); Good
•Near 100% transmission; Good
•Divergence controlled by making ideal mathematical shape; Good
•More difficult to make small focal spot, (such as 1 μm); Challenge!

Life History from Fish Ear Stones

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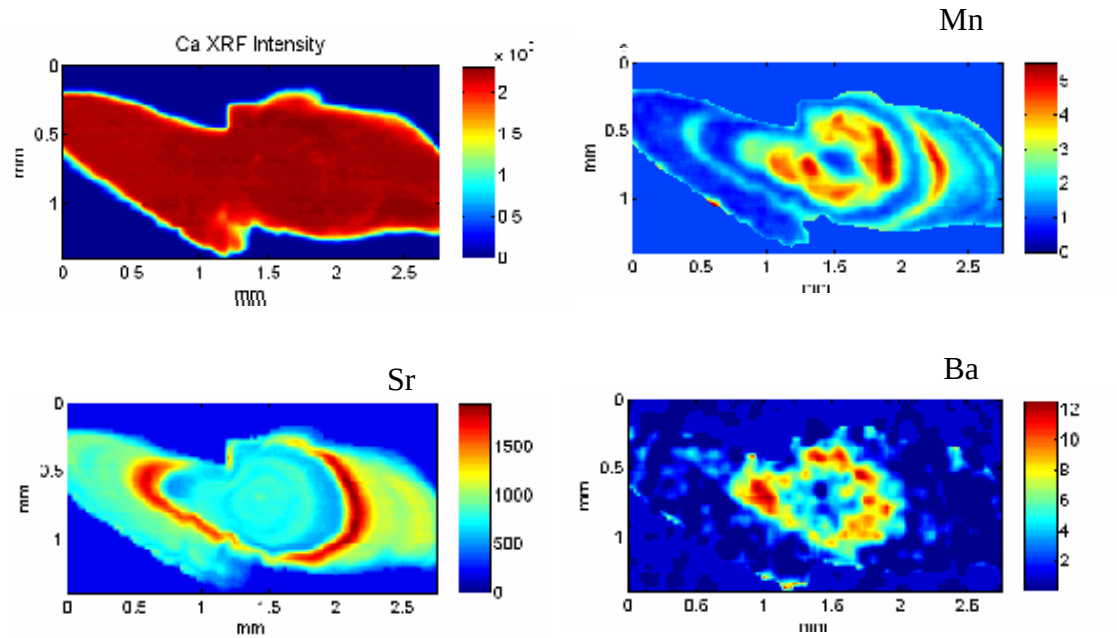
Optical image of an otolith of blueback herring captured in the Mohawk River at Rome, NY

Barium is present only in the interior, corresponding to the first season's growth. The high Sr ring is consistent with going out to sea. The three tracers confirm that the fish life began in the Mohawk, spent one winter out at sea and then returned to a lower estuary.



"Fish otolith trace element maps: new approaches with microbeam X-ray fluorescence", K. Limburg, R. Huang, and D. Bilderback in print, X-ray Spectrometry (2007).

New Tool for Art History

Arthur Woll. D. Bilderback, S. Gruner. CHESS: R. Huang, U. Chicago;
N. Gao, X-ray Optical Systems; C. Bisulca, J. Mass (U. Delaware, Winterthur Museum)

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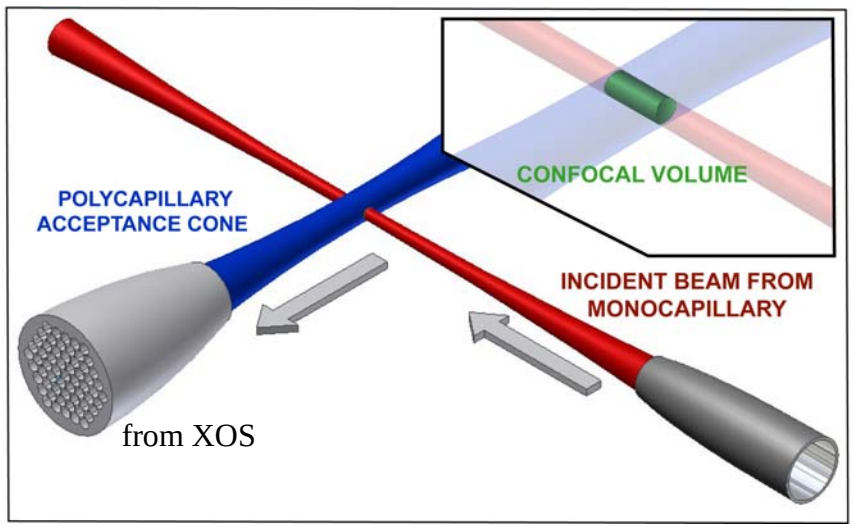
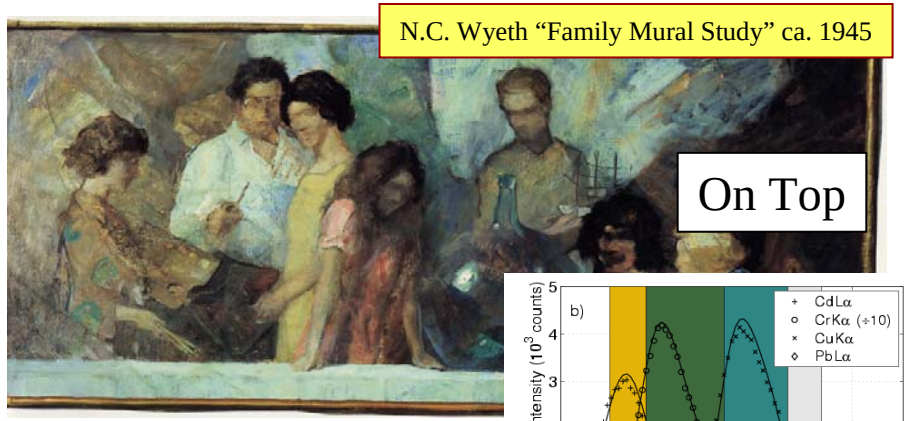
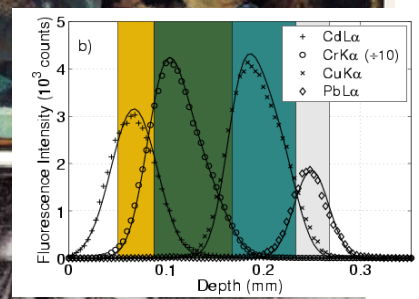
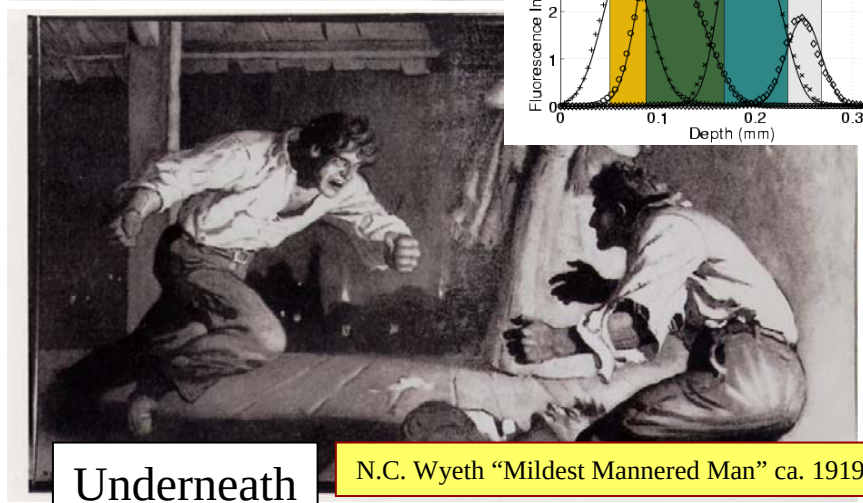
Confocal x-ray fluorescence microscope analyzes buried layers non-destructively



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







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

UNIQUE PROGRAMS → unique facility combining x-ray and art scientists (NSF IMR grant)

IMPACT → demonstrates state-of-art quantitative analysis

Cornell University
Cornell High Energy Synchrotron Source

New and Improved DB3 glass puller

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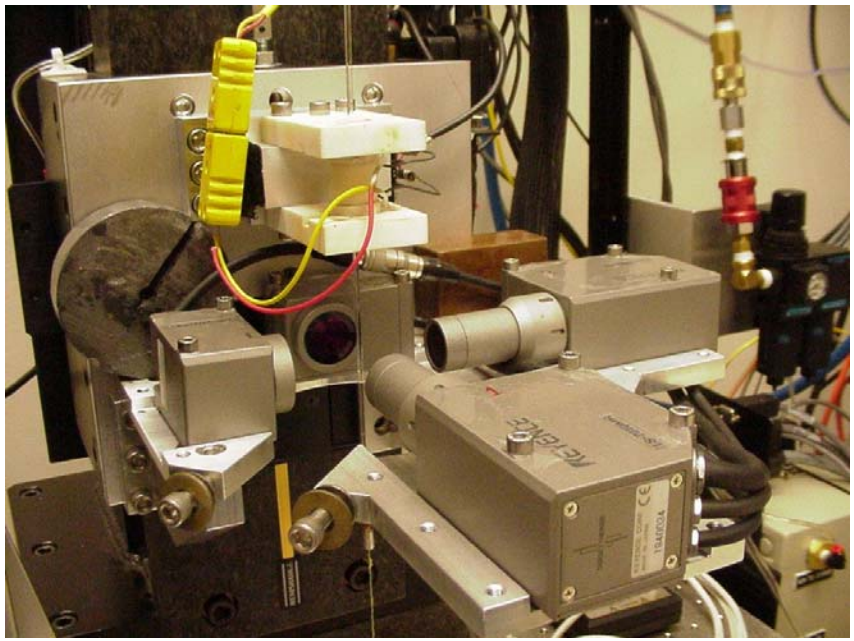

ABTech linear air bearing
under test with dual-Keyence profilers
for fast figure analysis.

Goal: highly automated puller with fast optical profile analysis to be used in conjunction with web-based capillary design program (developed by Rong Huang)

New puller design team: Don Bilderback, Tom Szebenyi, Sterling Cornaby and Aaron Mauer

Furnace translation: linear air bearing with 0.1 micron readout

Strain gauge/tensioning method with .02 gram resolution at 100g (force) of total tension.

New furnace and temperature controller control to 0.3 C

Velmex tensioning stage pulls upward as glass yields to maintain a constant tension

LabView operating under WinXP controls the equipment

Keyence dual-axis Optical Micrometer measures the outer glass profiles either before or after drawing