Imaging of crystals by X-ray diffraction

- Ian Robinson
- Sébastien Boutet

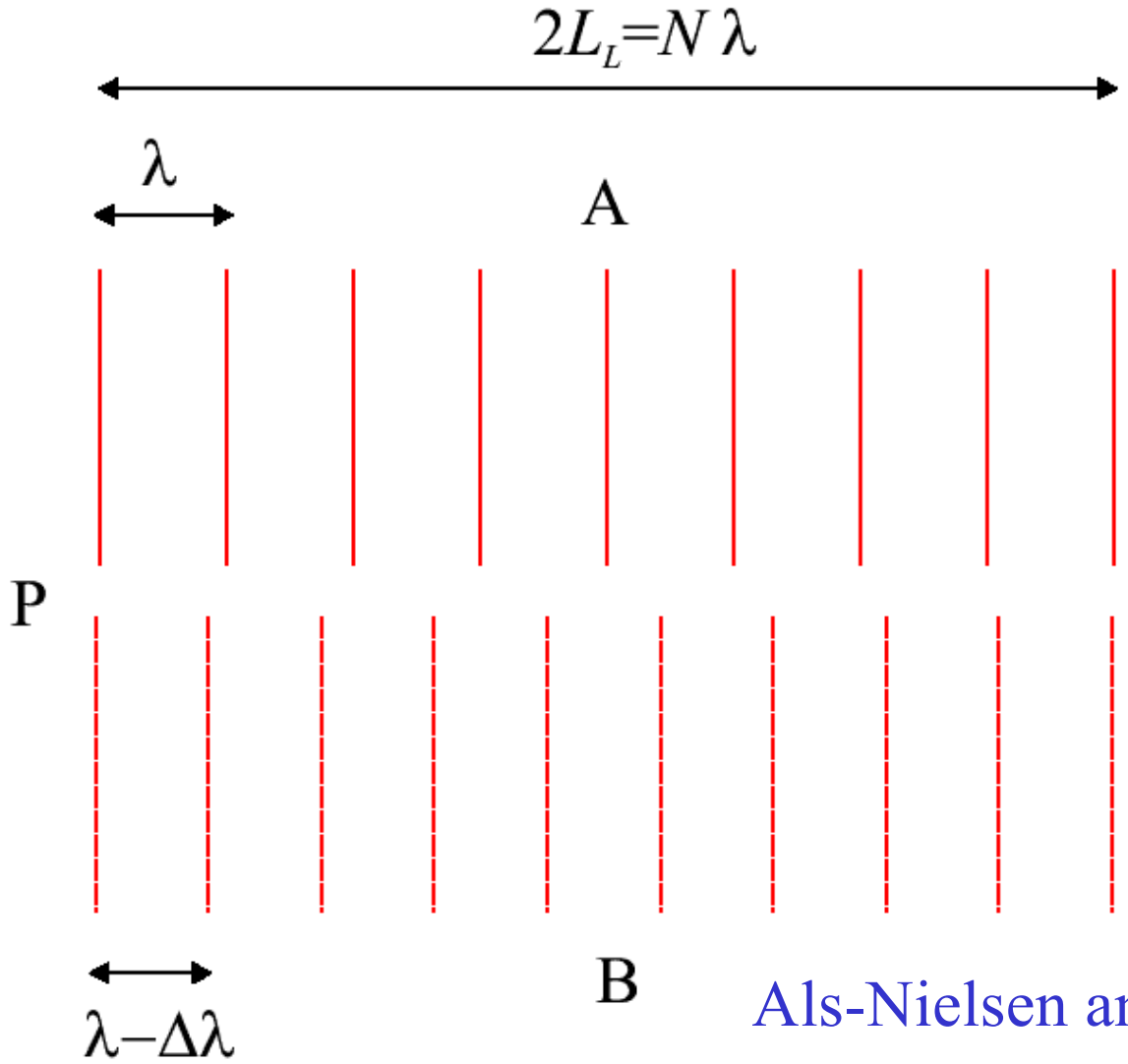
Department of Physics
University of Illinois

UIUC Physics Society
27 March 2002

Outline

- Demonstration of Coherent Diffraction
- Coherent X-ray Diffraction
- Nanocrystal Shapes
- “Lensless X-ray Microscope”
- Applications to Protein Crystallization

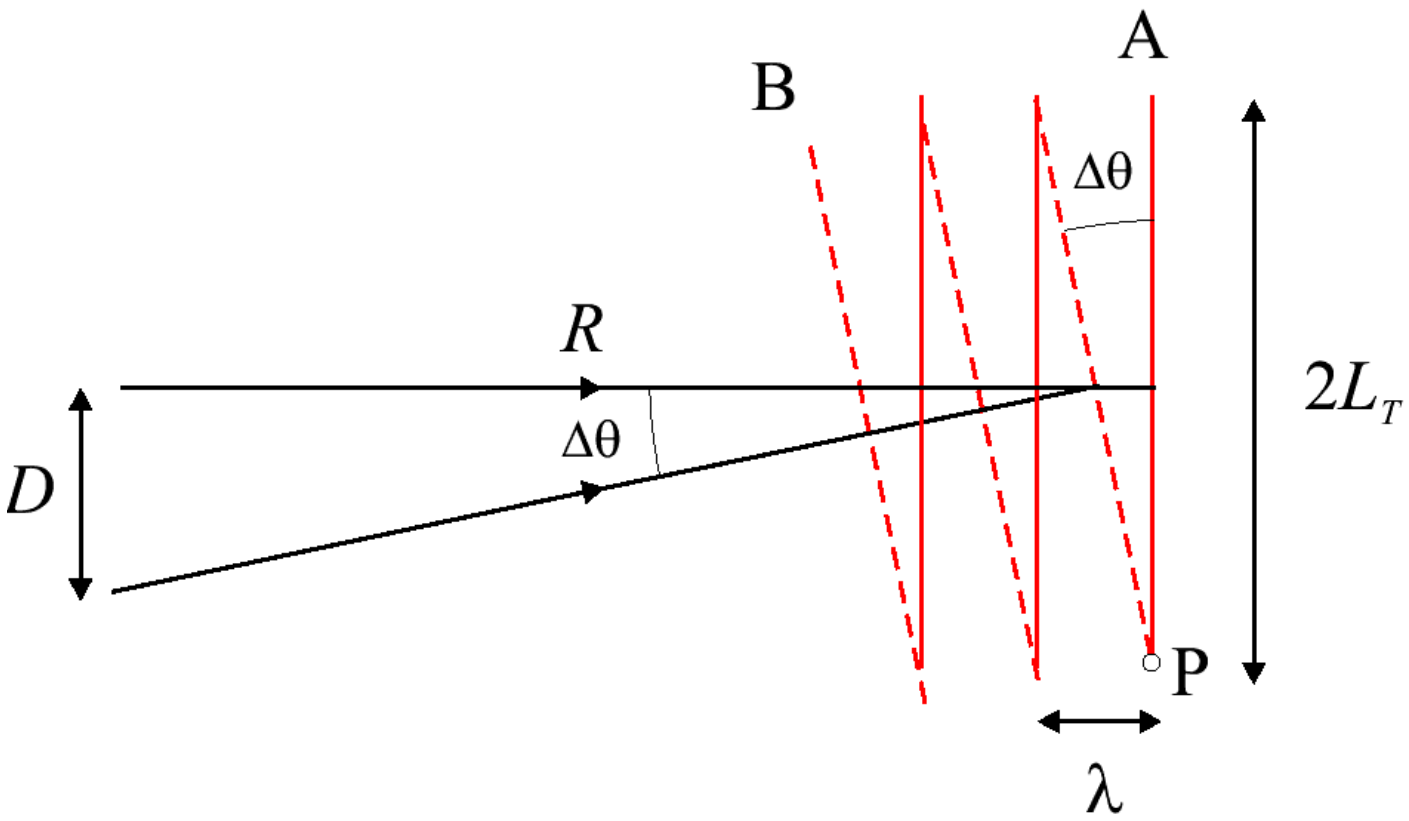
Longitudinal Coherence



$$L_L = \frac{1}{2}\frac{\lambda^2}{\Delta\lambda}$$

Als-Nielsen and McMorrow (2001)

Lateral (Transverse) Coherence

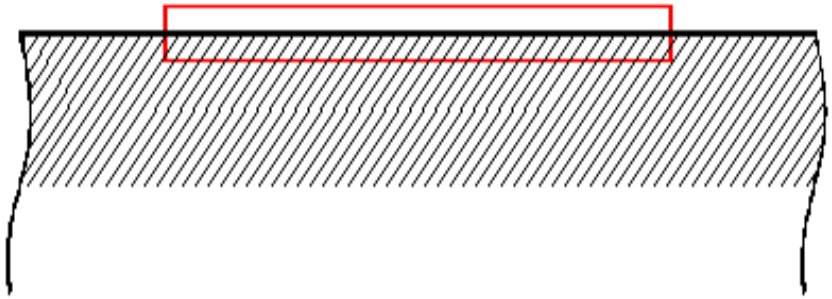


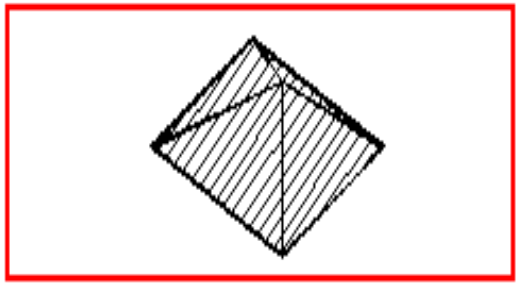
$$L_T = \frac{\lambda}{2}\frac{R}{D}$$

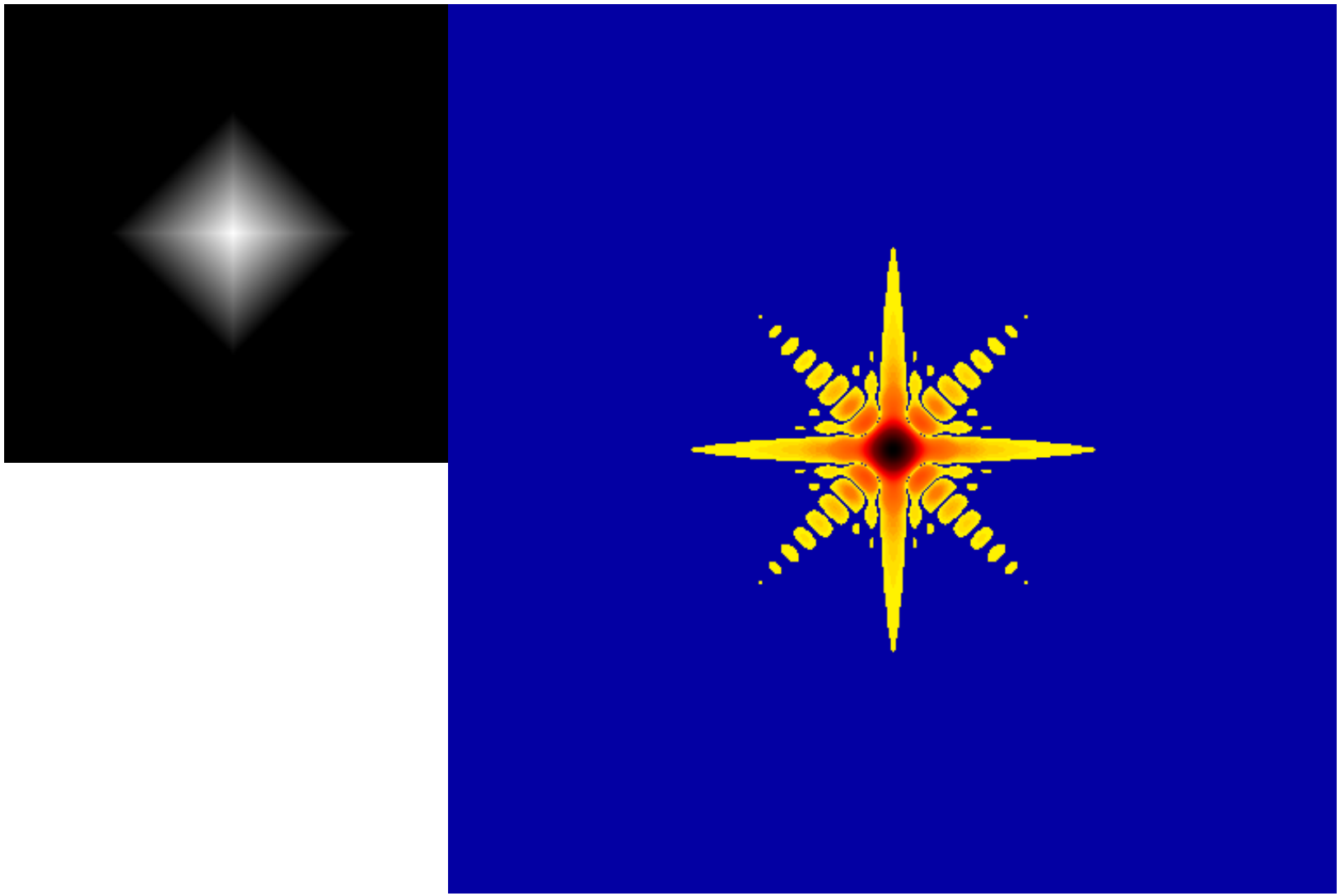
Als-Nielsen and McMorrow (2001)

Coherence at the APS

Coherence of	ξ_{VER}	ξ_{HORIZ}	ξ_{LONG}	Flux
Raw Undulator	35μm	9μm	0.004μm	2×10^{12}
Si(111) Monochromator	35μm	9μm	1μm	1×10^{10}
C(111) Monochromator	35μm	9μm	3μm	3×10^{9}







Diffraction as a Surface Integral

Die äußere Form der Kristalle in ihrem Einfluß auf die Interferenzerscheinungen an Raumgittern

Von M. v. Laue

Annalen der Physik [5] 26 55 (1936)

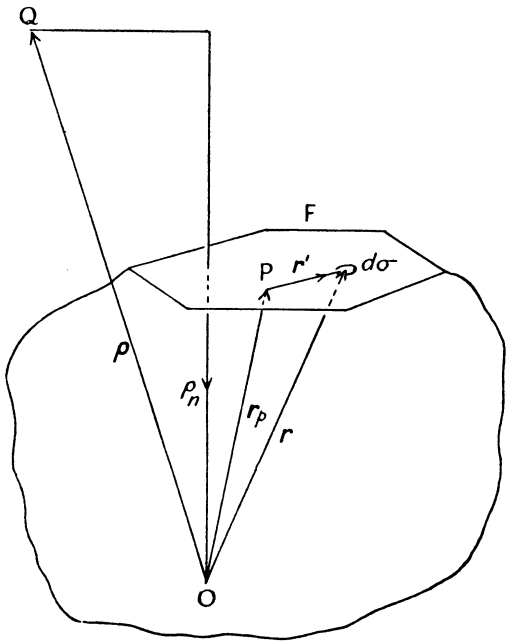
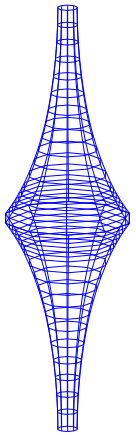
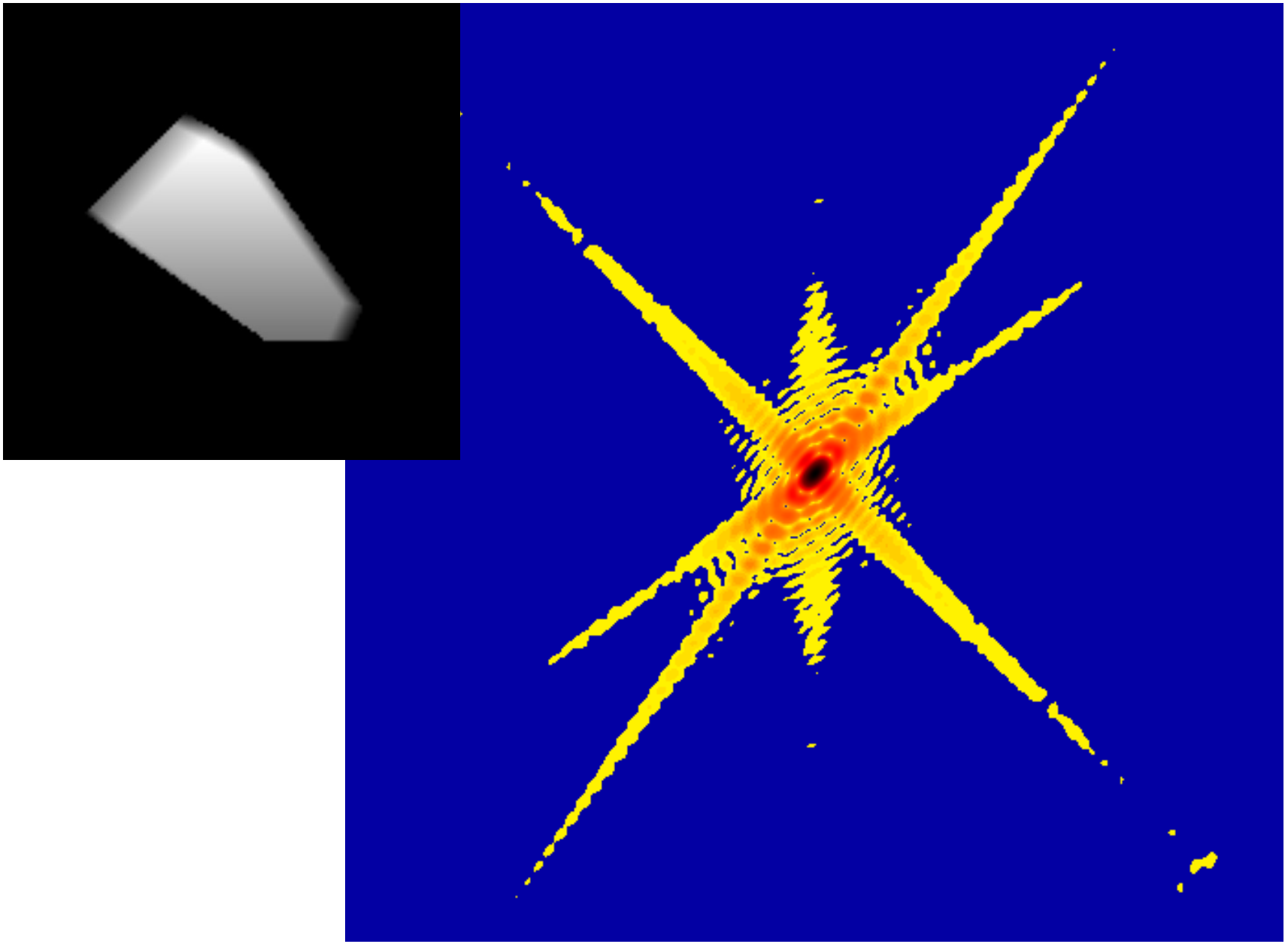


FIG. 200

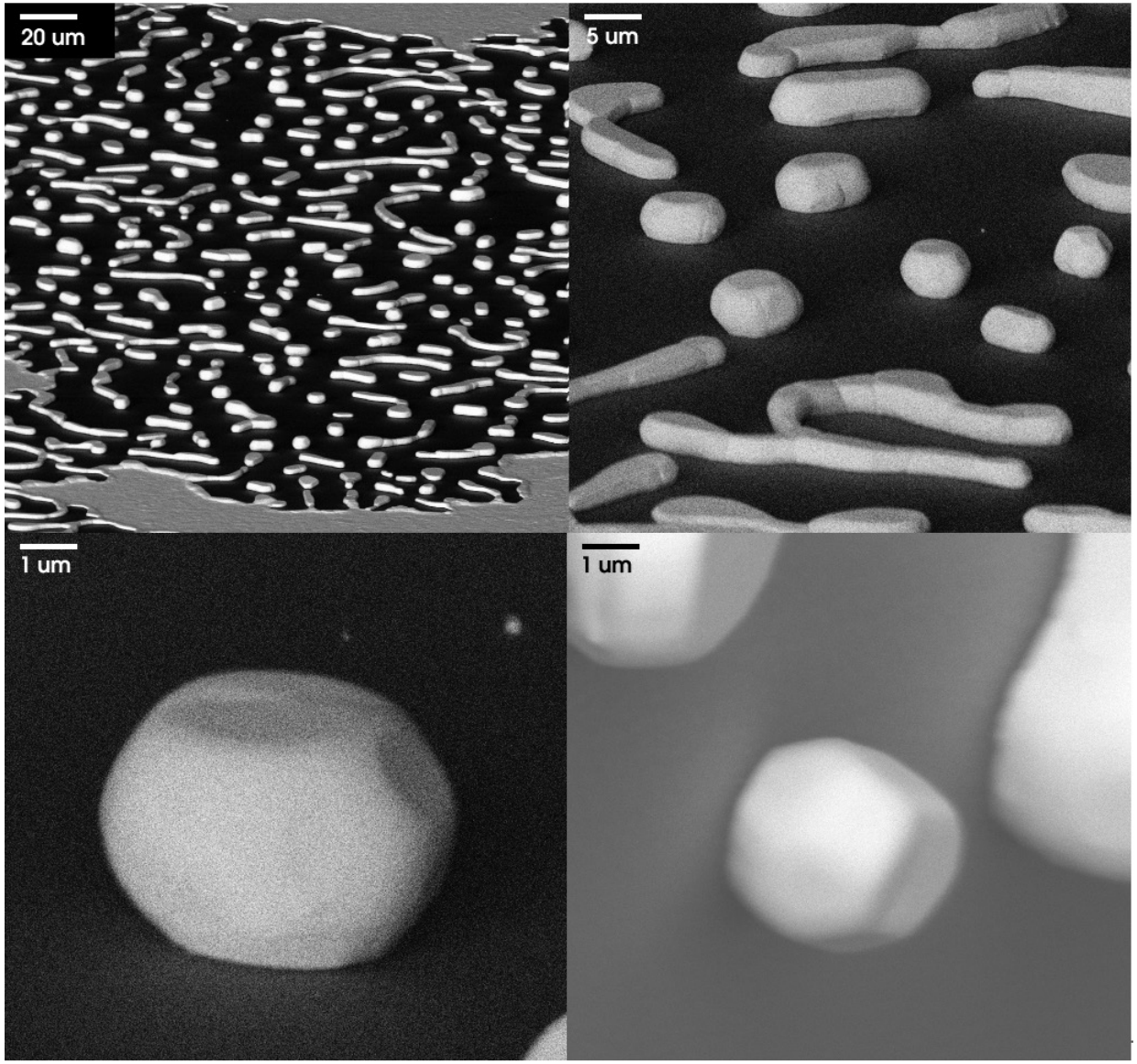


"Stacheln"

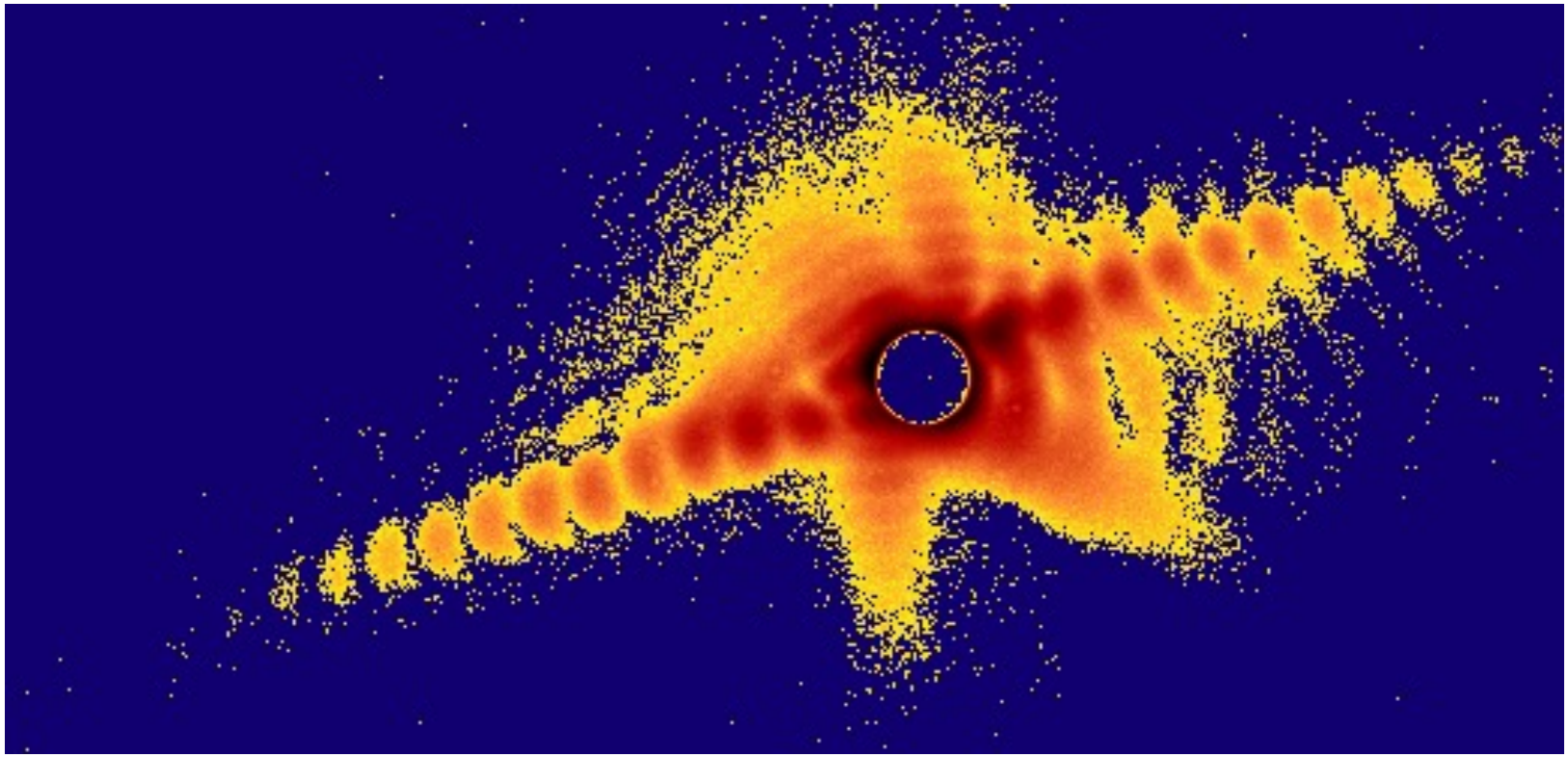


SEMS

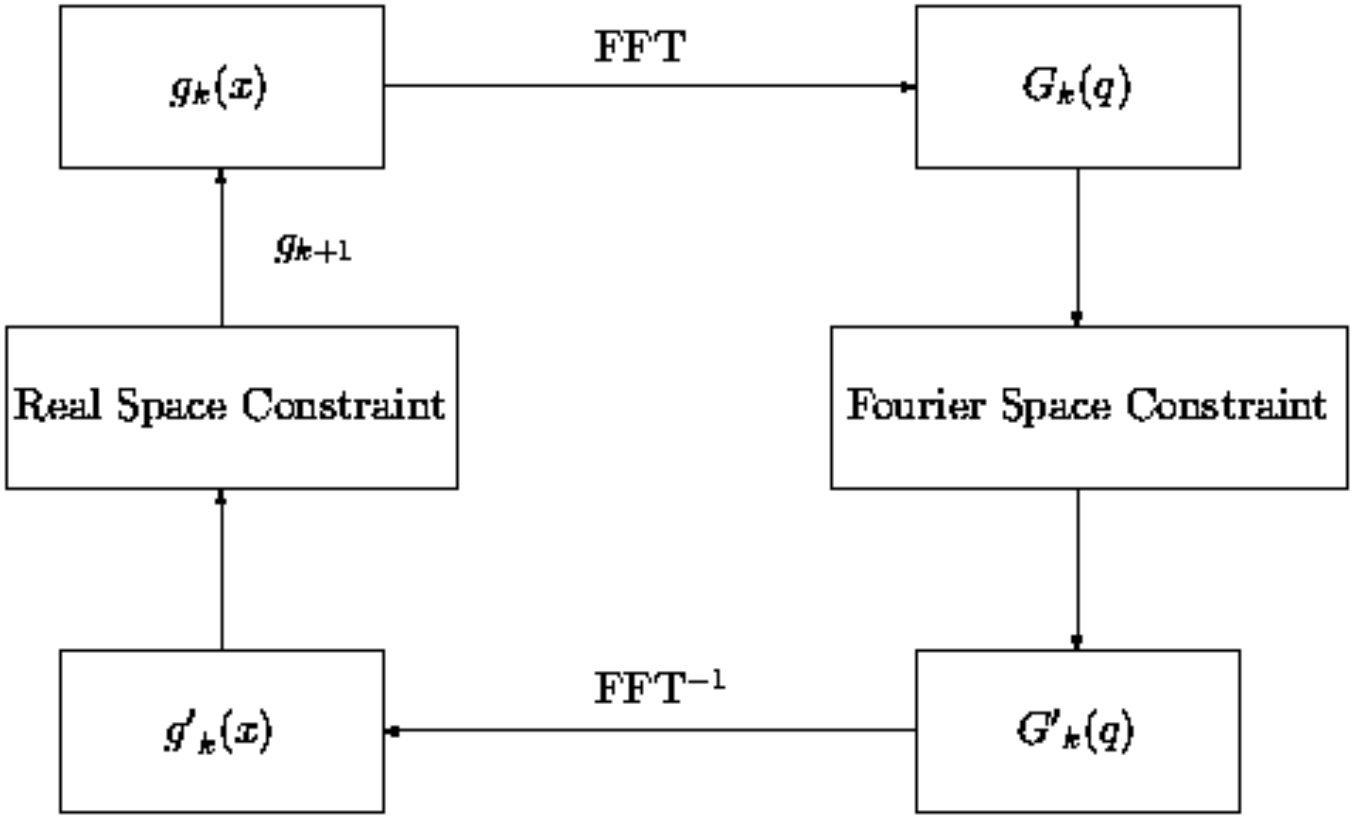
- Au blanket film
- Quartz substrate
- Annealed at 950°C for 70 hrs.



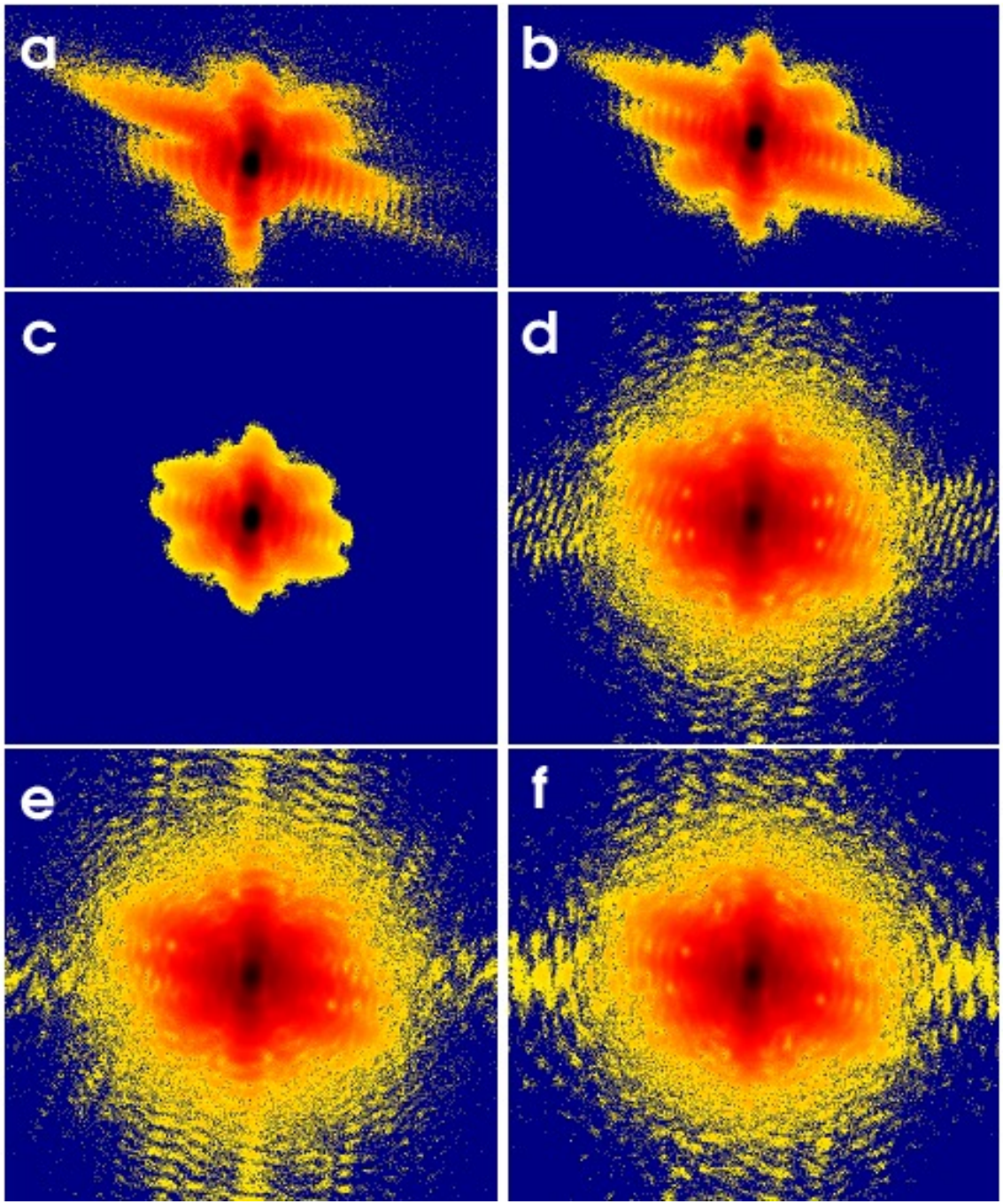
Micron-sized gold crystal: (111) Bragg reflection

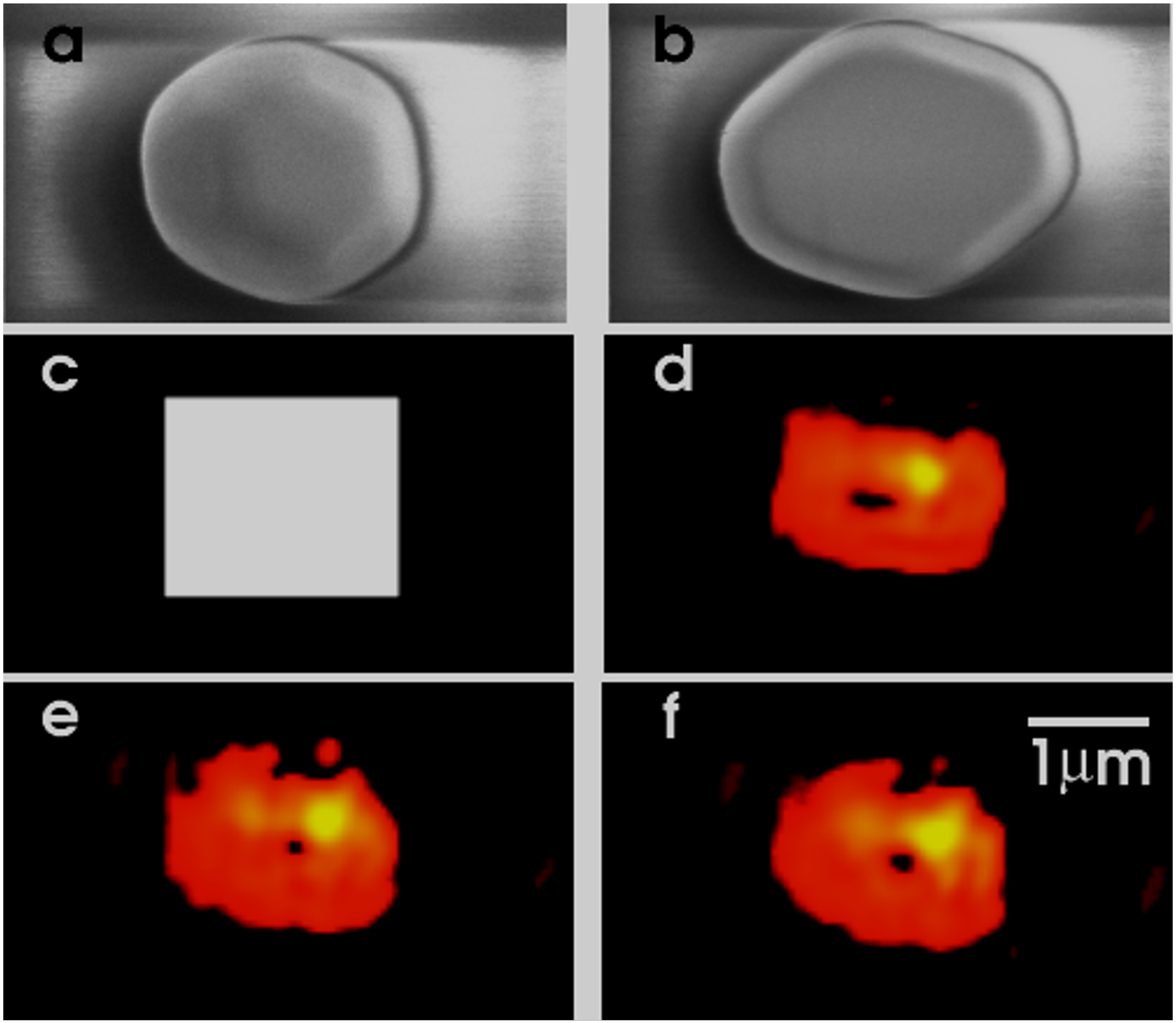


Generic "Error Reduction" method

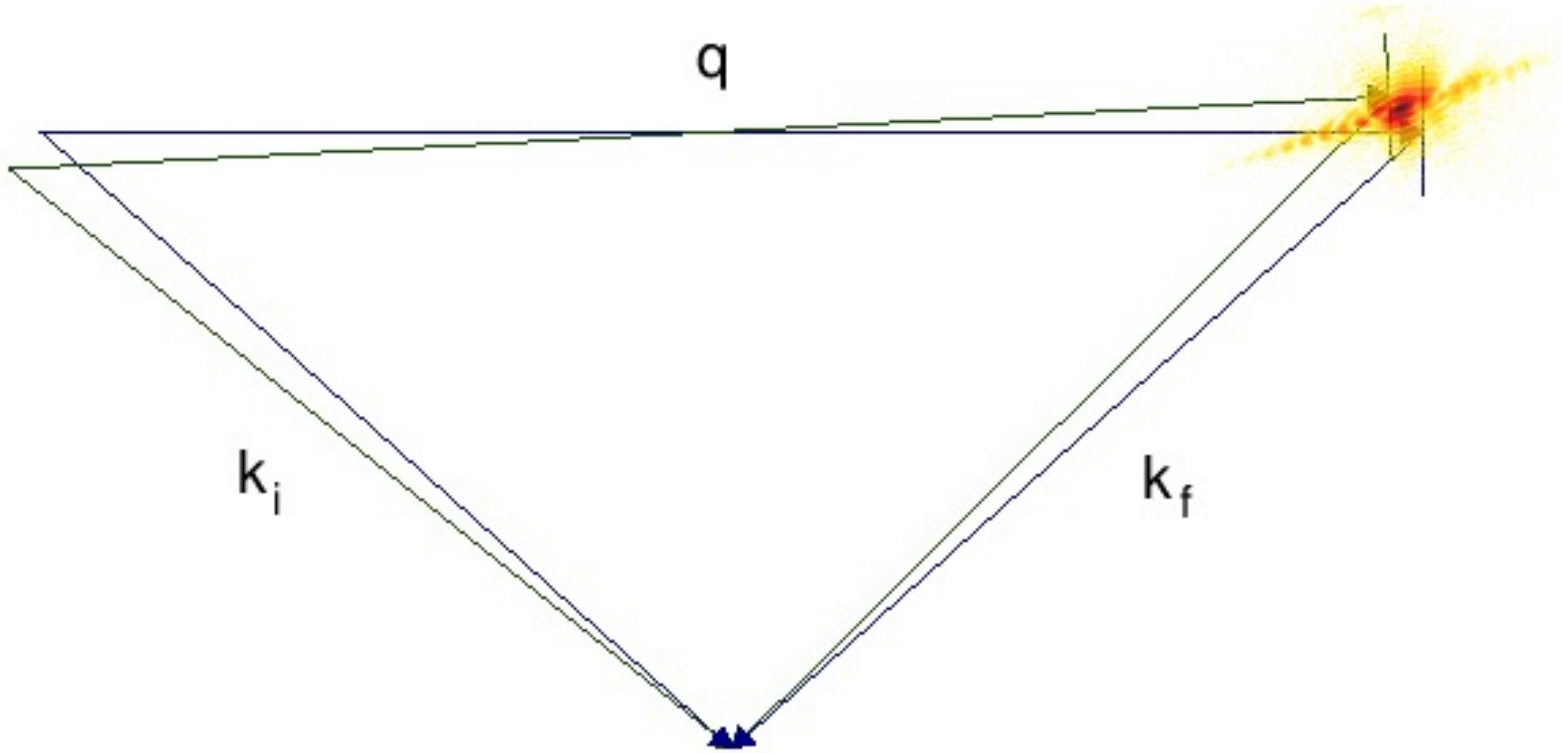


J. R. Fienup Appl. Opt. 21 2758 (1982)
R. W. Gerchberg and W. O. Saxton Optik 35 237 (1972)

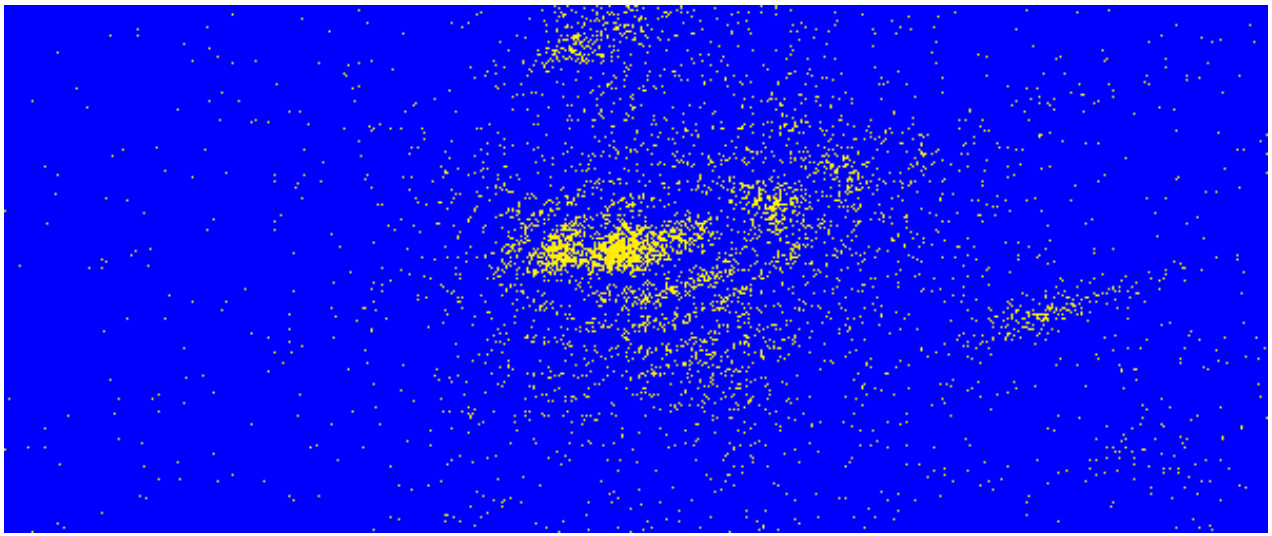

a
b
c
d
e
f


a
b
c
d
e
f
1µm

3D Diffraction Method

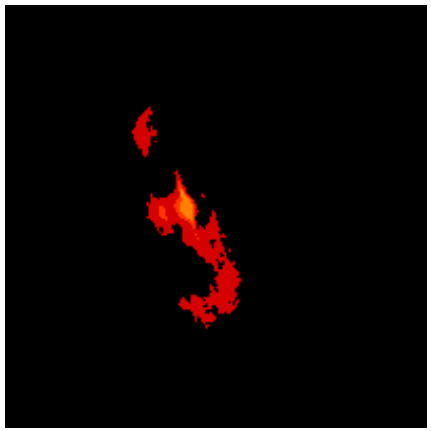


3D Diffraction Data
1 micron Au crystal

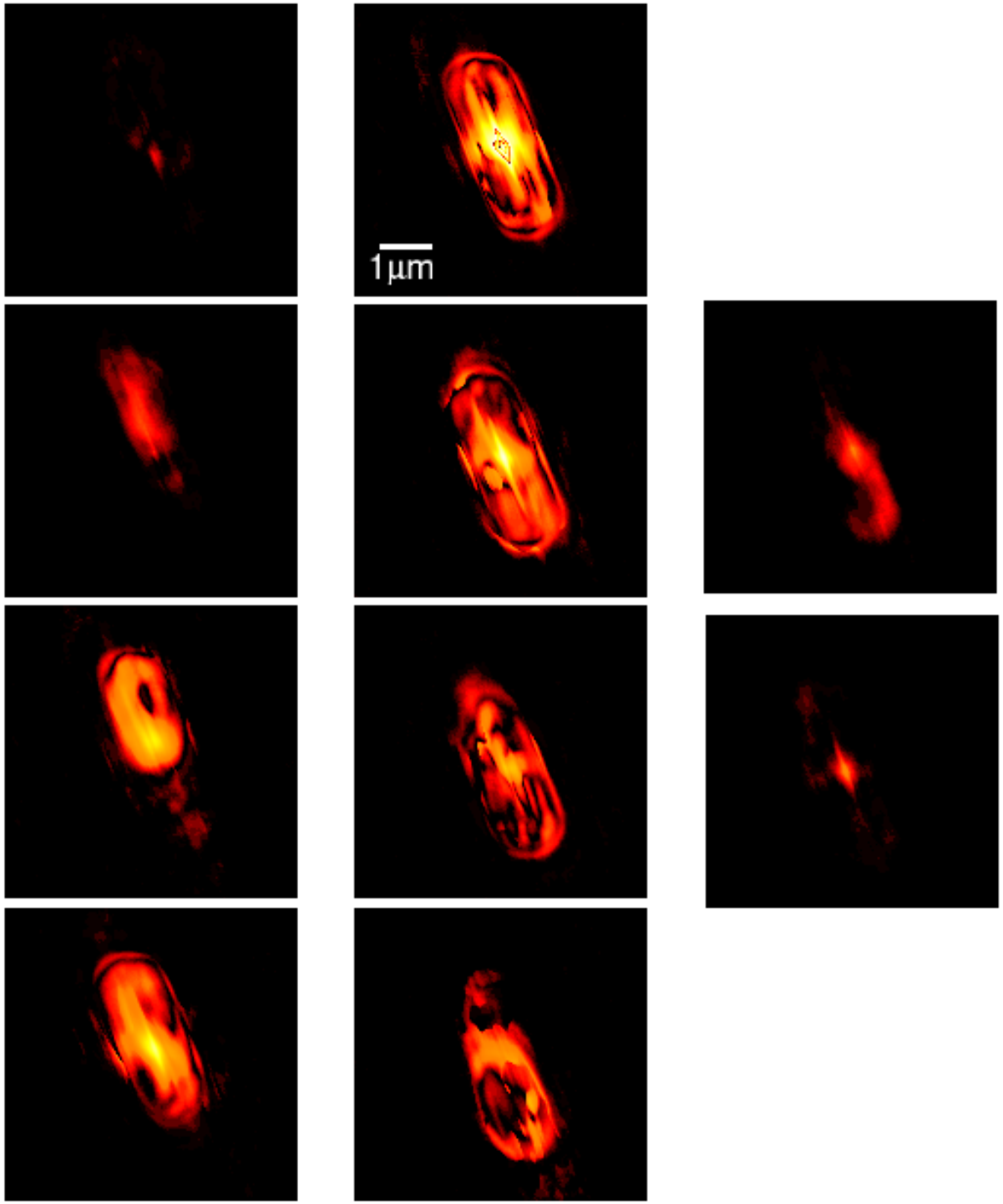


* Center is Symmetric *

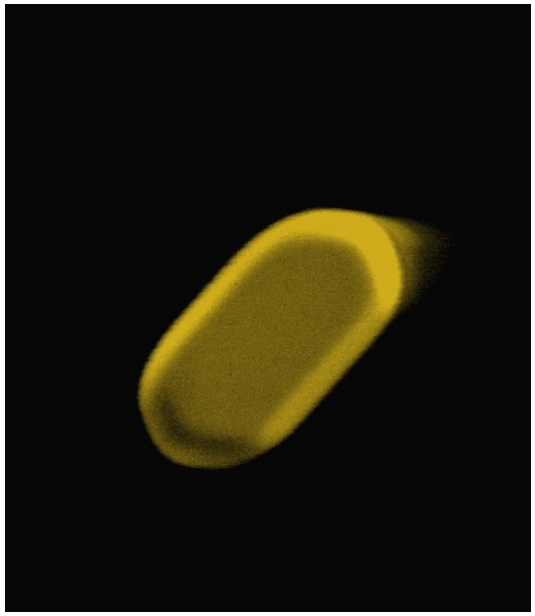
30 frames of 3D reconstruction
1 micron gold crystal



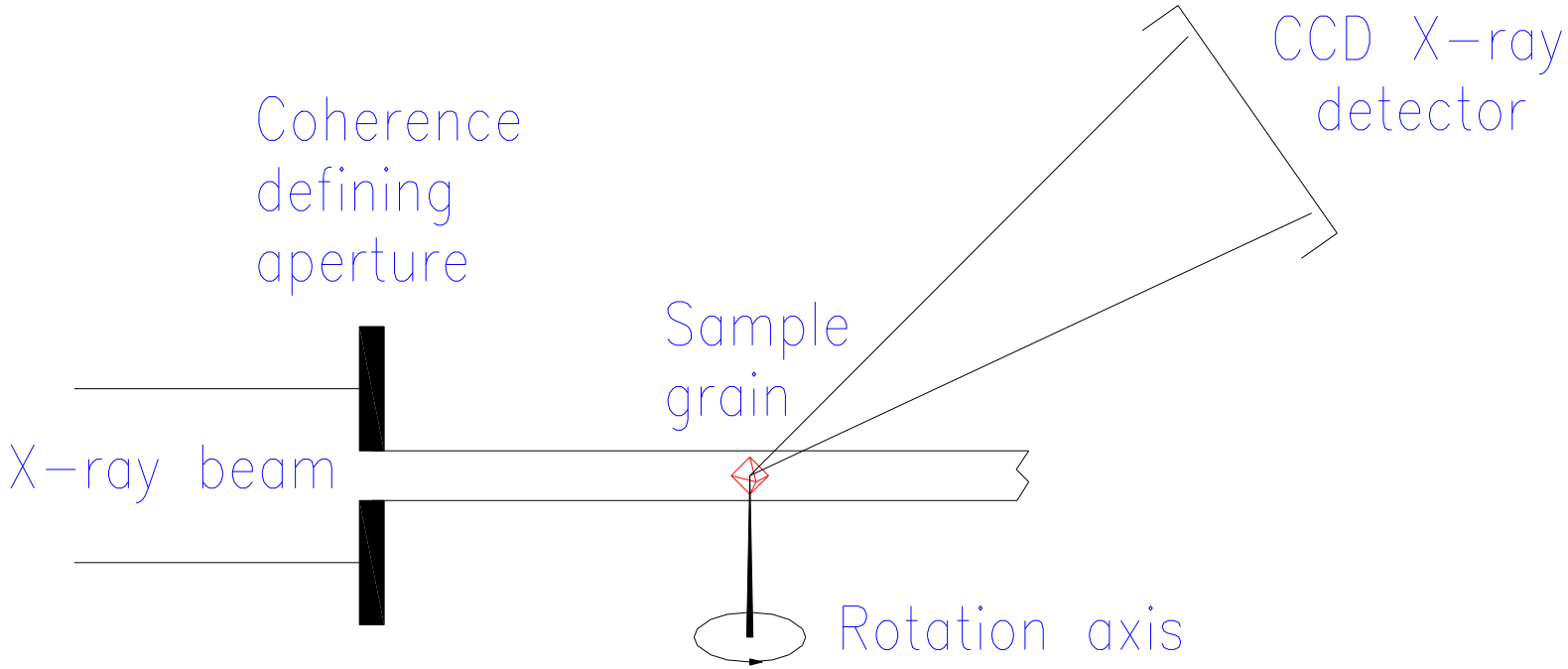
* CENTER *



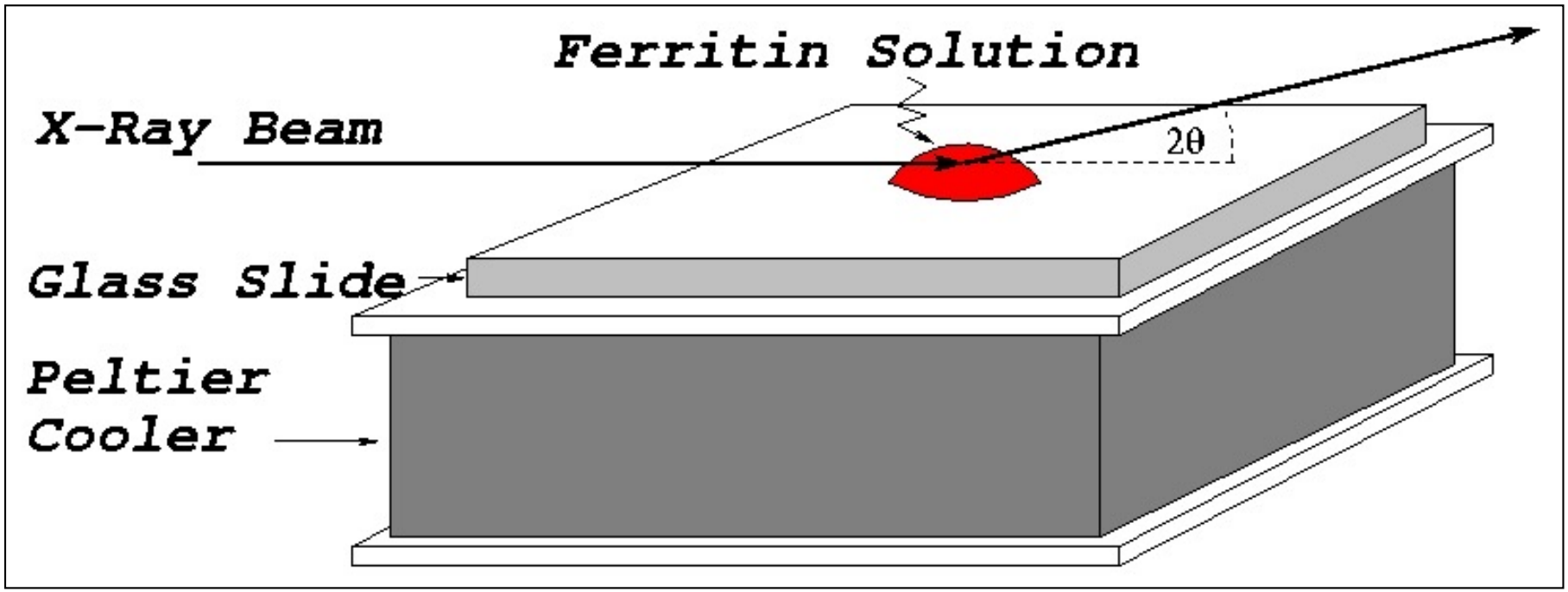
Shape is similar to plan view SEM:



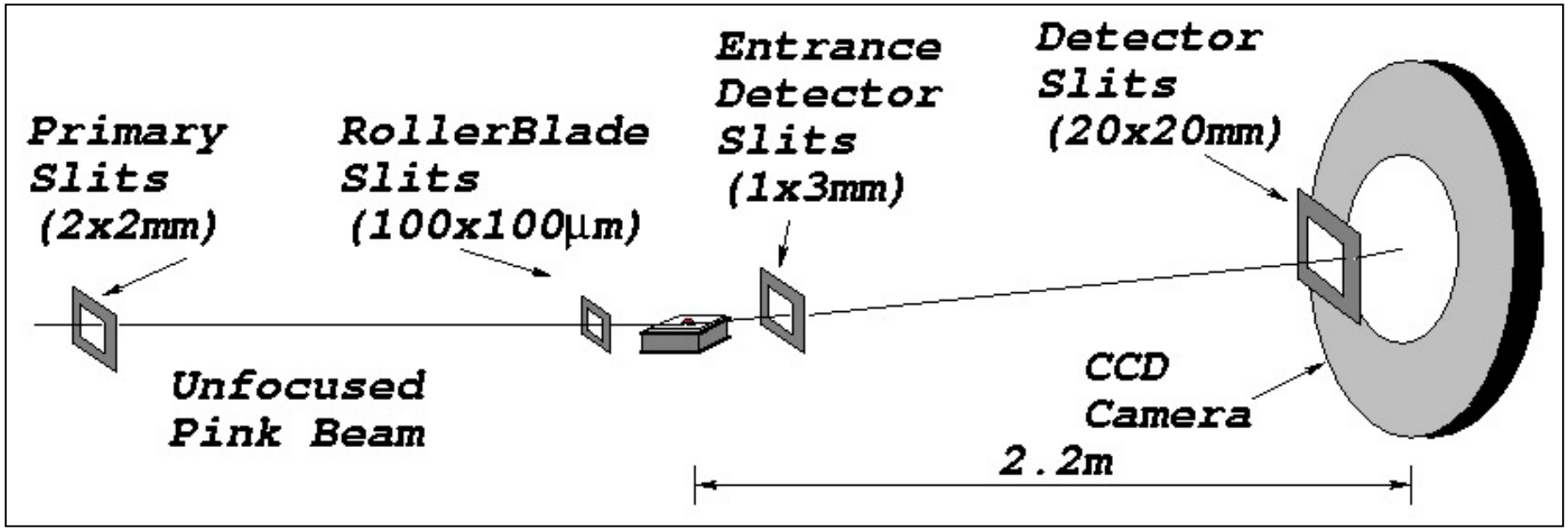
Lensless X-ray Microscope



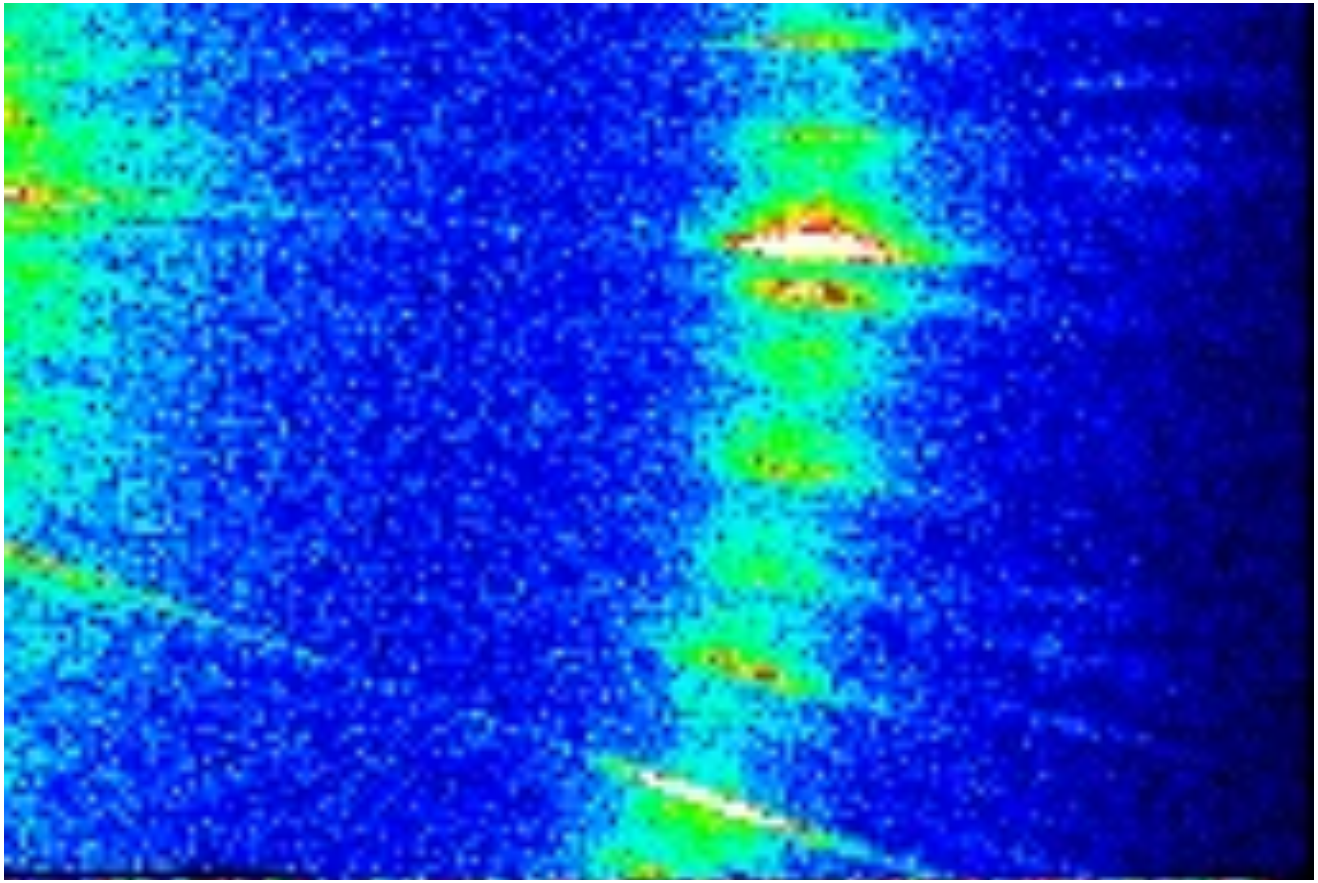
In-situ Study of Crystallization



Experiment at APS Sector 34



“Pink beam” sees CTRs



Ferritin (111) Powder Ring

- 50 frames
- 30sec exposure
- 0.3sec playback
- 150x200 pixels of 22.5μm