Coherent Diffraction using X-ray Optics

- Ian Robinson
- Meng Liang
- Ross Harder

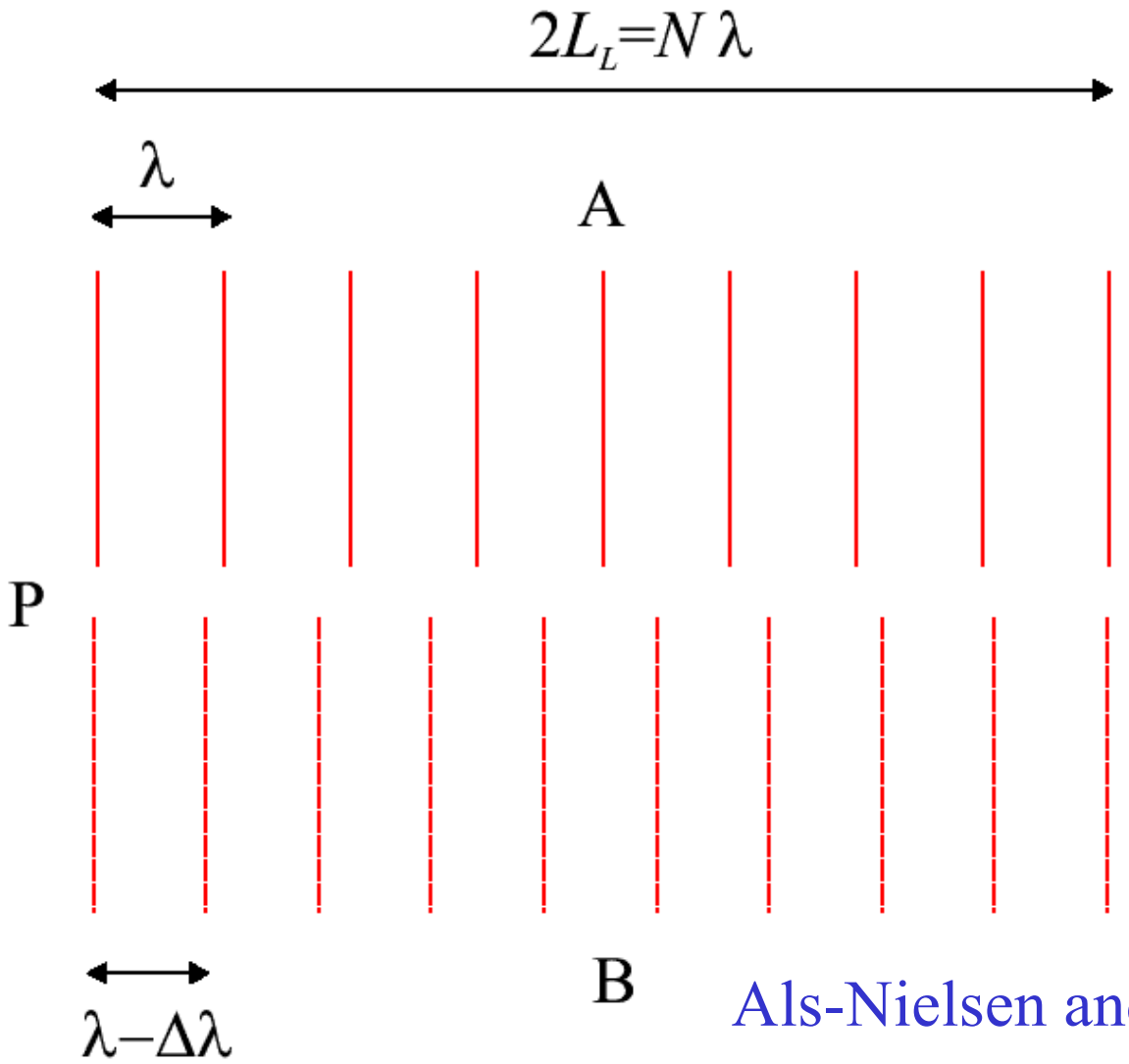
Department of Physics
University of Illinois

APS Lunch Seminar
July 2005

Outline

- Coherent Diffraction
- Nanocrystal Shapes
- Effect of Optics
- Coherence Studies

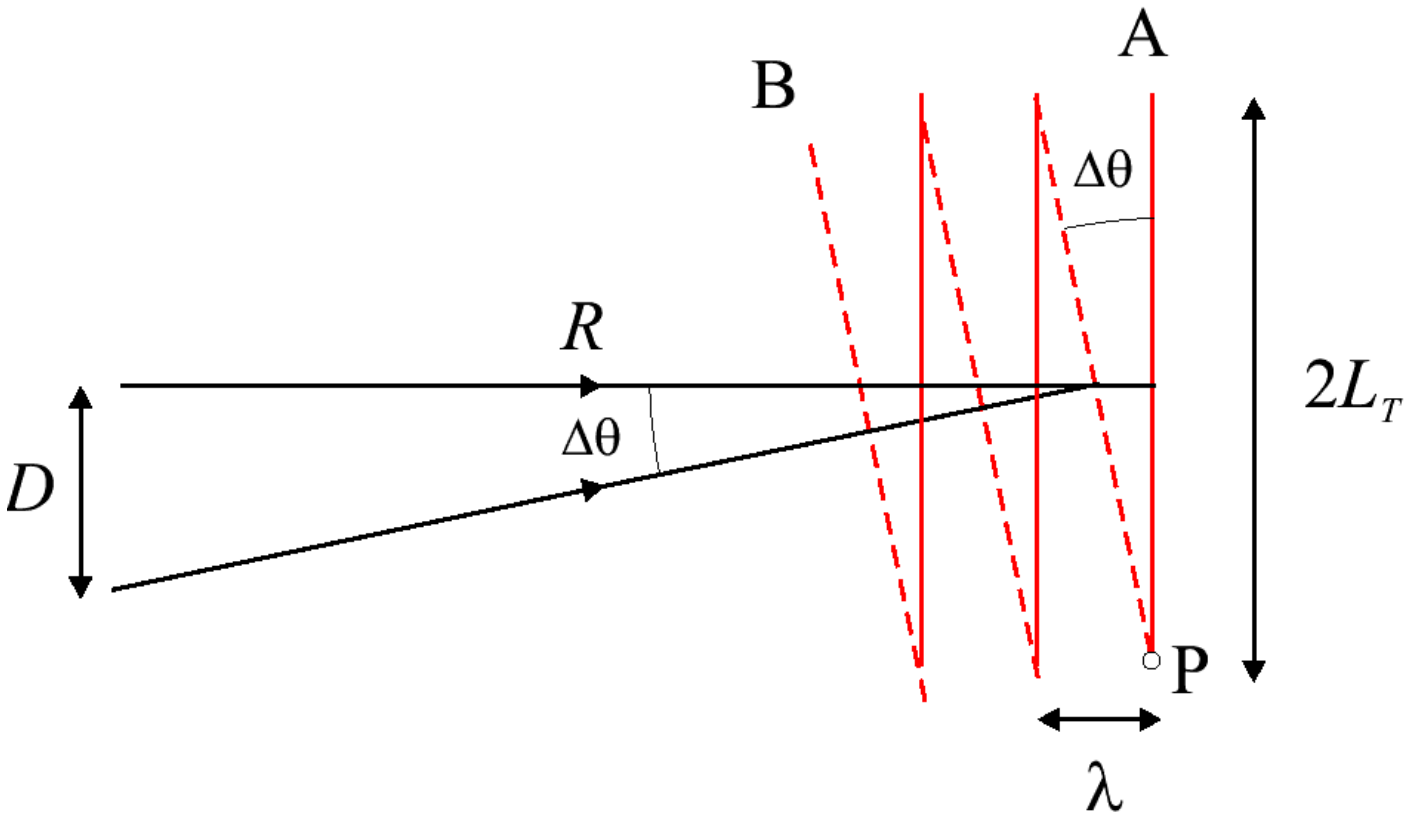
Longitudinal Coherence



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

Als-Nielsen and McMorrow (2001)

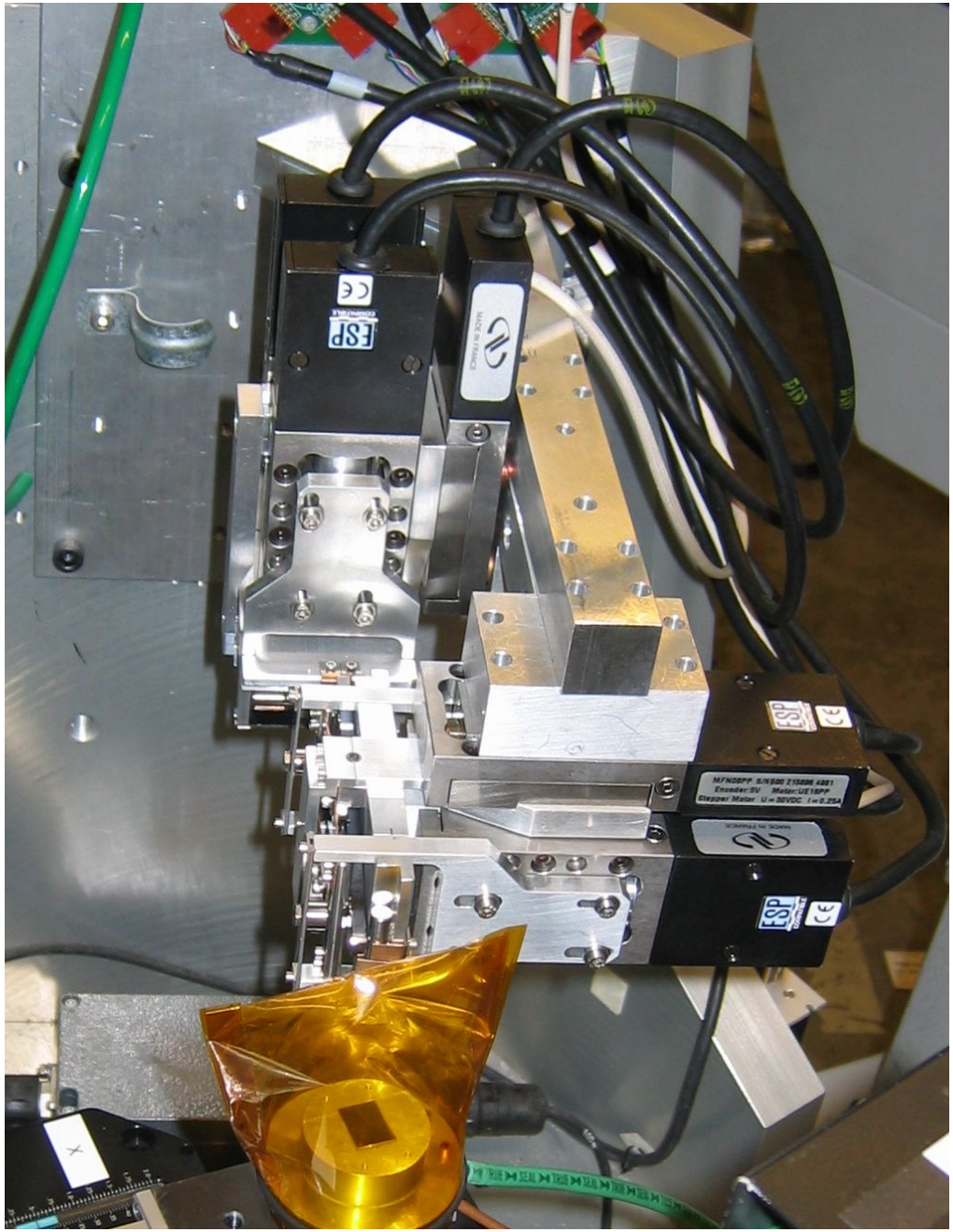
Lateral (Transverse) Coherence



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

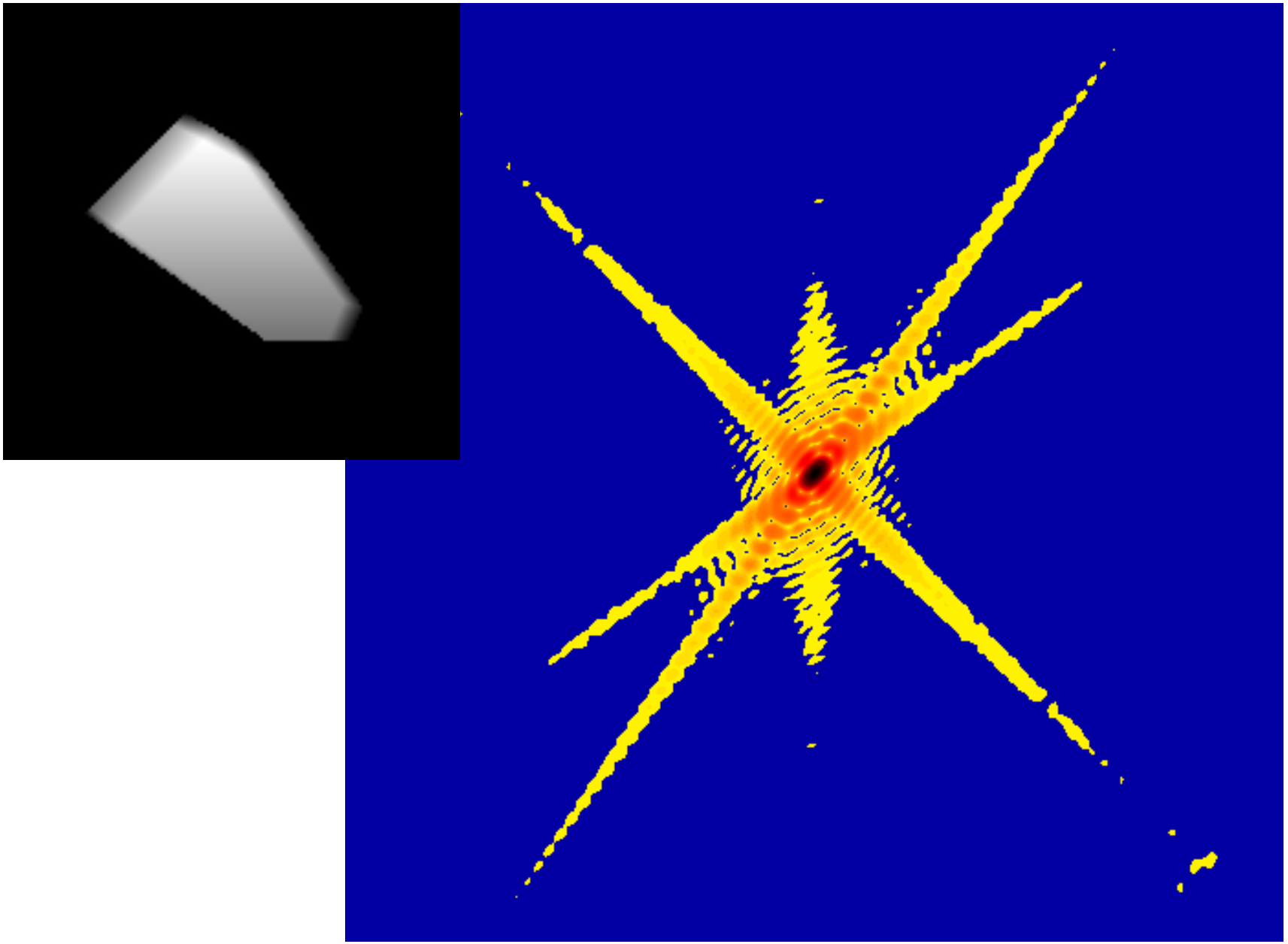
Als-Nielsen and McMorrow (2001)

KB mirrors at 34-ID-C

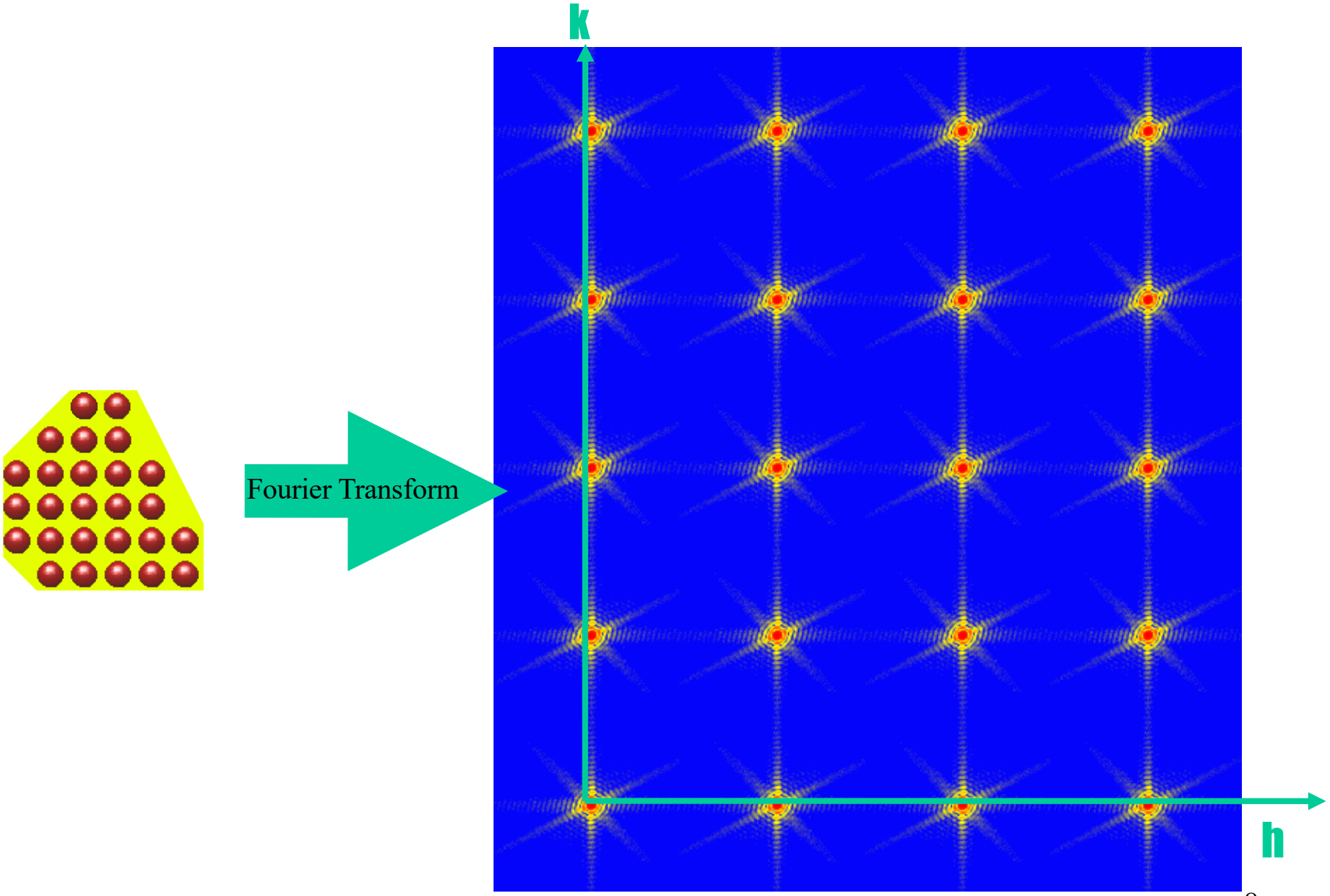


Ideal Focusing Optics

- Smaller beam, more flux on sample
- Increased divergence by Liouville theorem
- Proportionately reduced coherence length
- Coherent: Cylindrical or spherical wave
  - Curved wavefront = phased plane wave
- Incoherent: Smearing of information
  - Loss of resolution
  - Fringe contrast (definition of partial coherence)

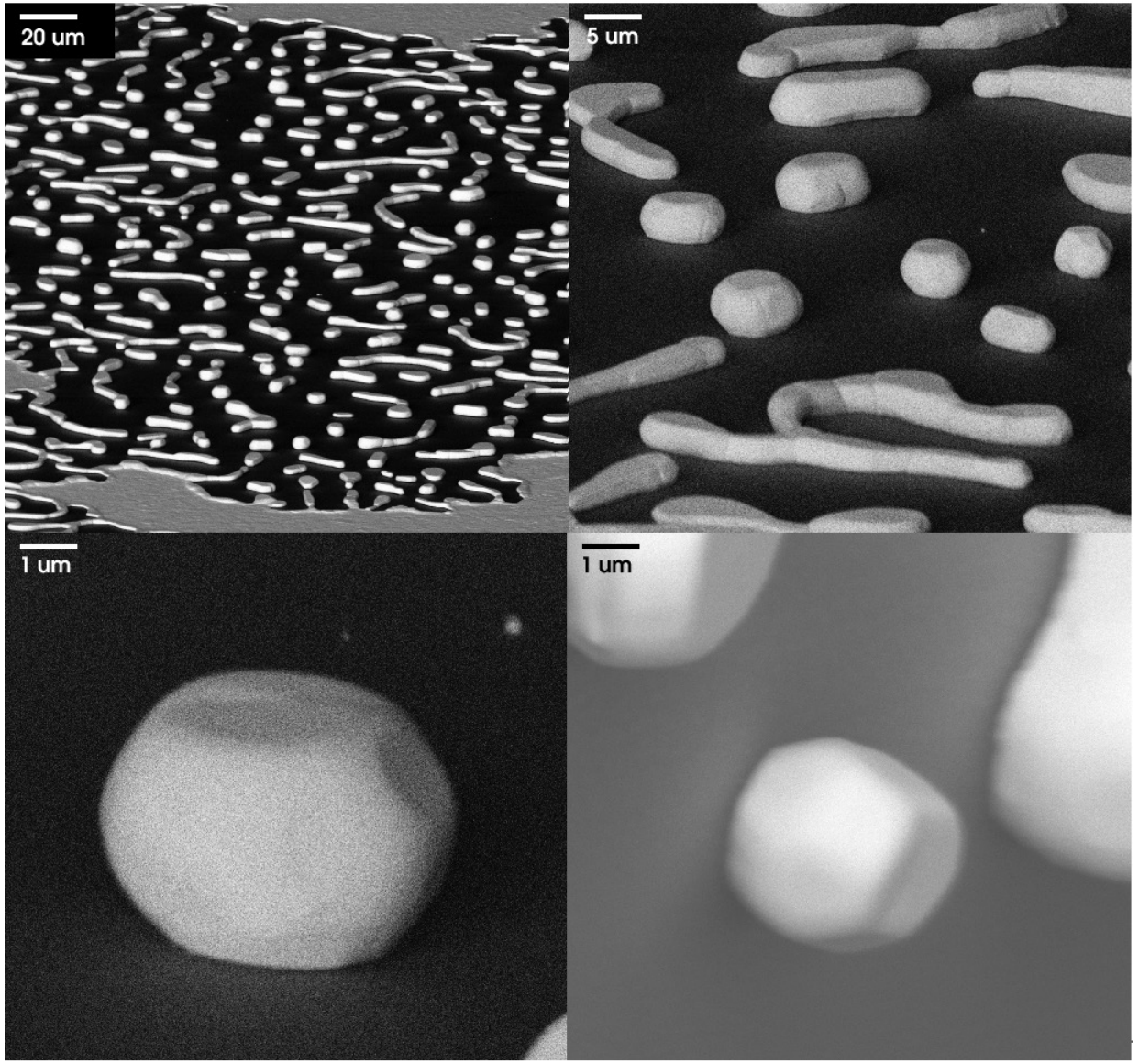


Coherent Diffraction from Crystals

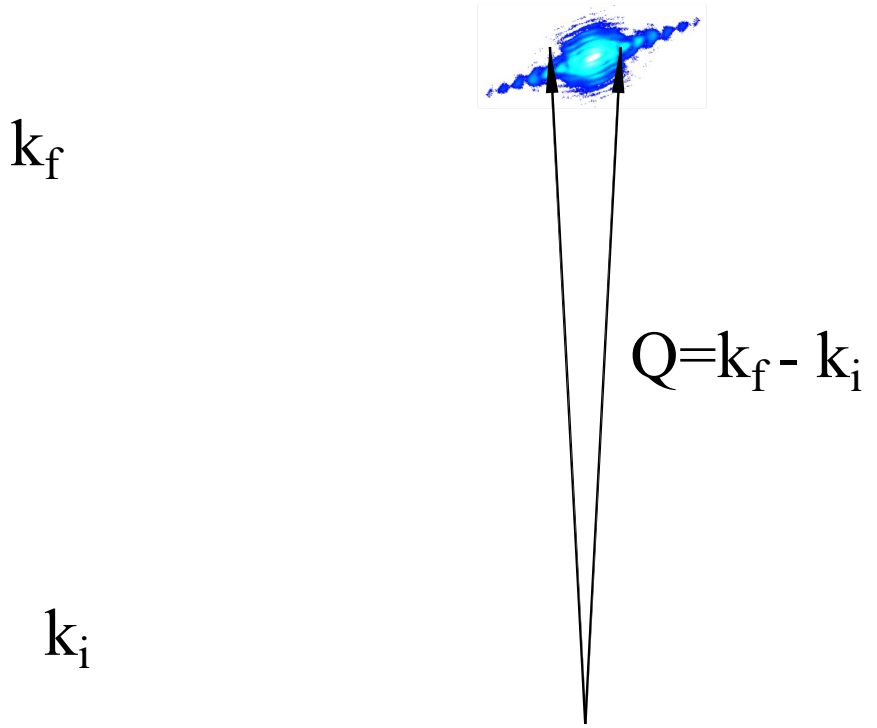


SEMS

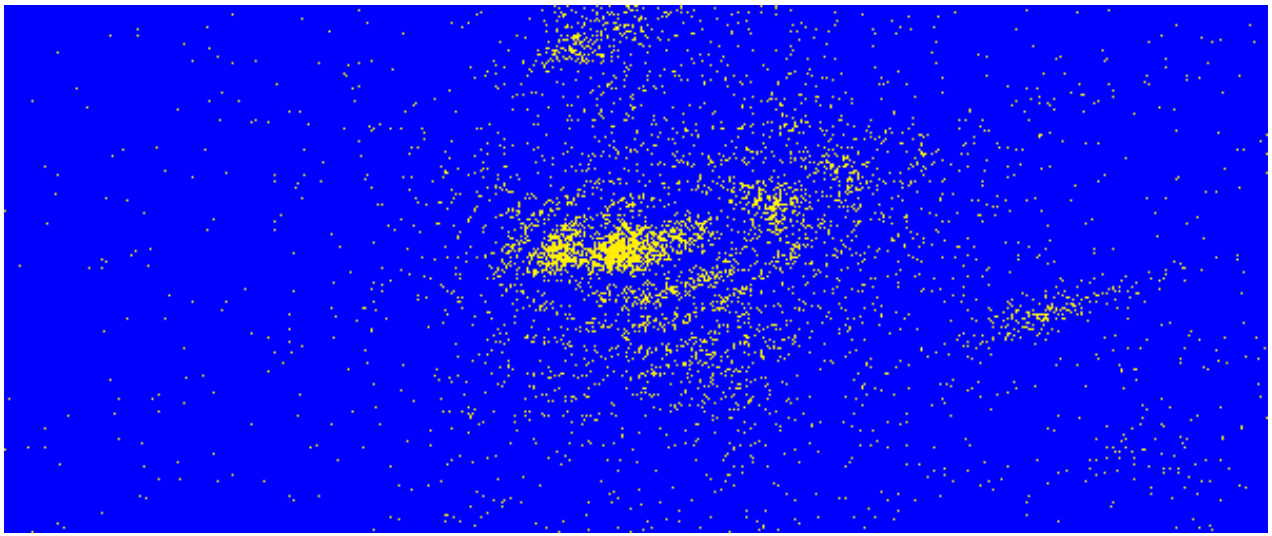
- Au blanket film
- Quartz substrate
- Annealed at 950°C for 70 hrs.



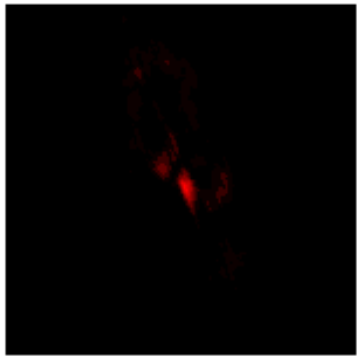
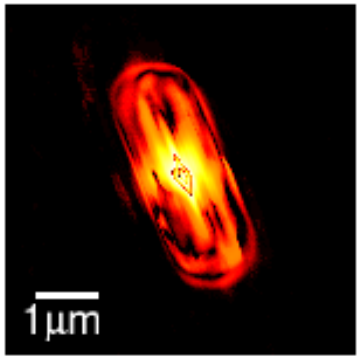
3D Diffraction Method

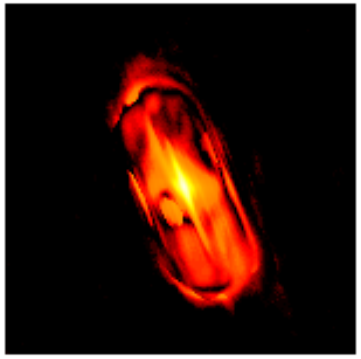
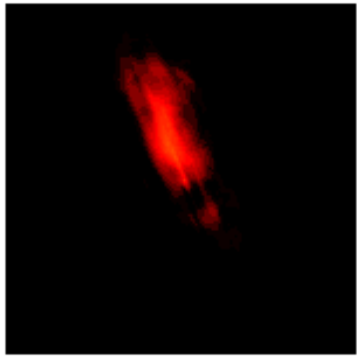
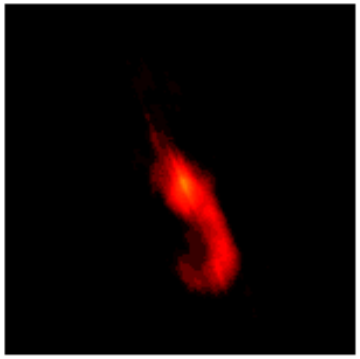
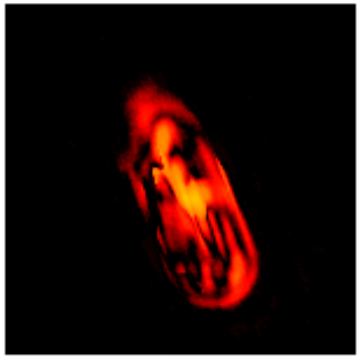
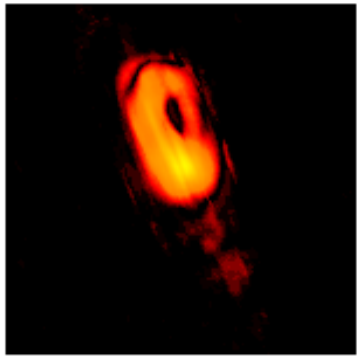
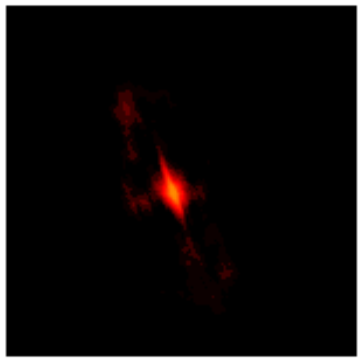
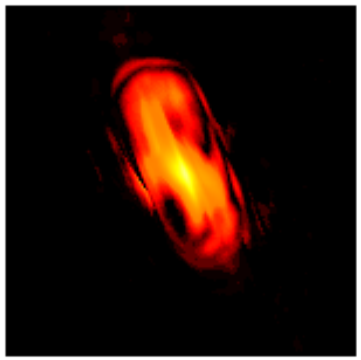
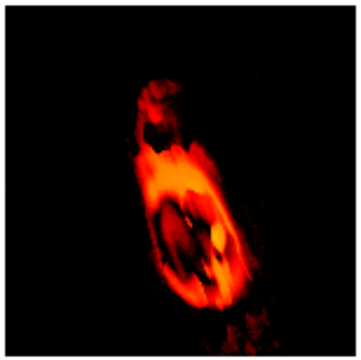
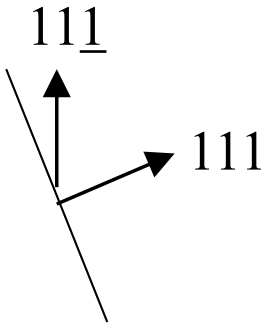


3D Diffraction Data
1 micron Au crystal

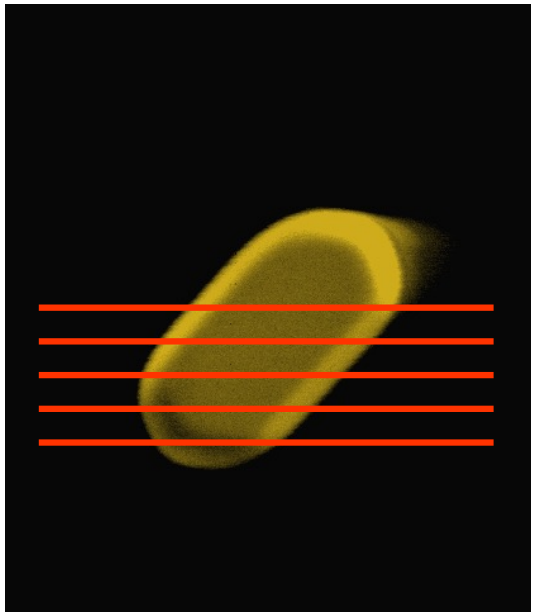


* Center is Symmetric *

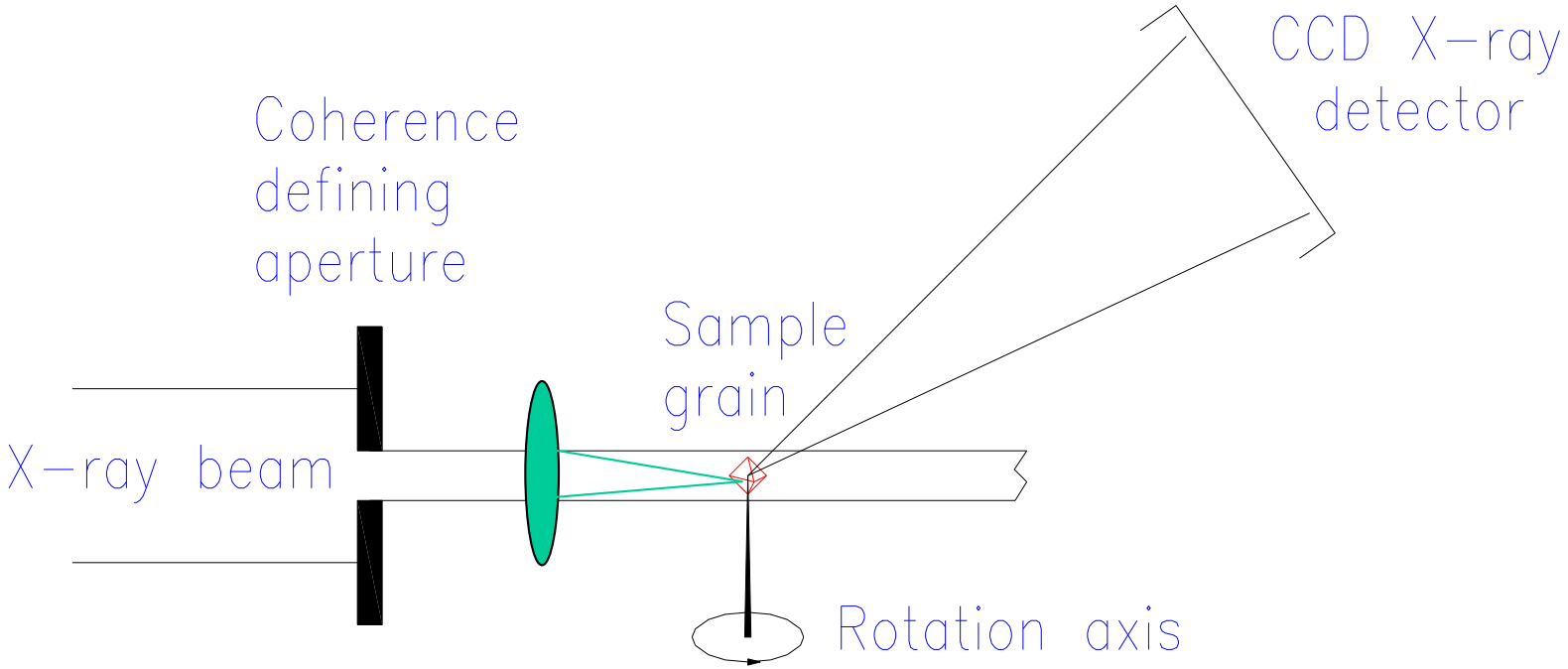



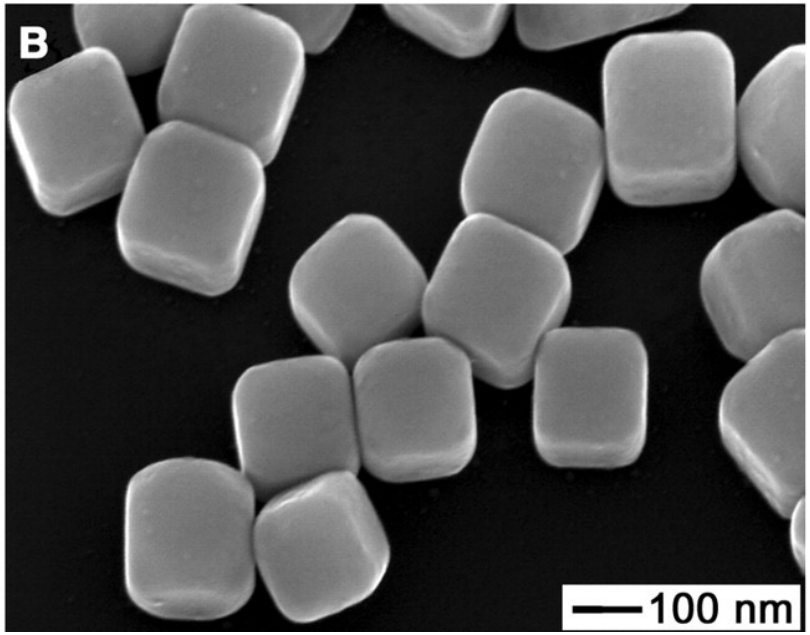
Slices through plan view SEM:

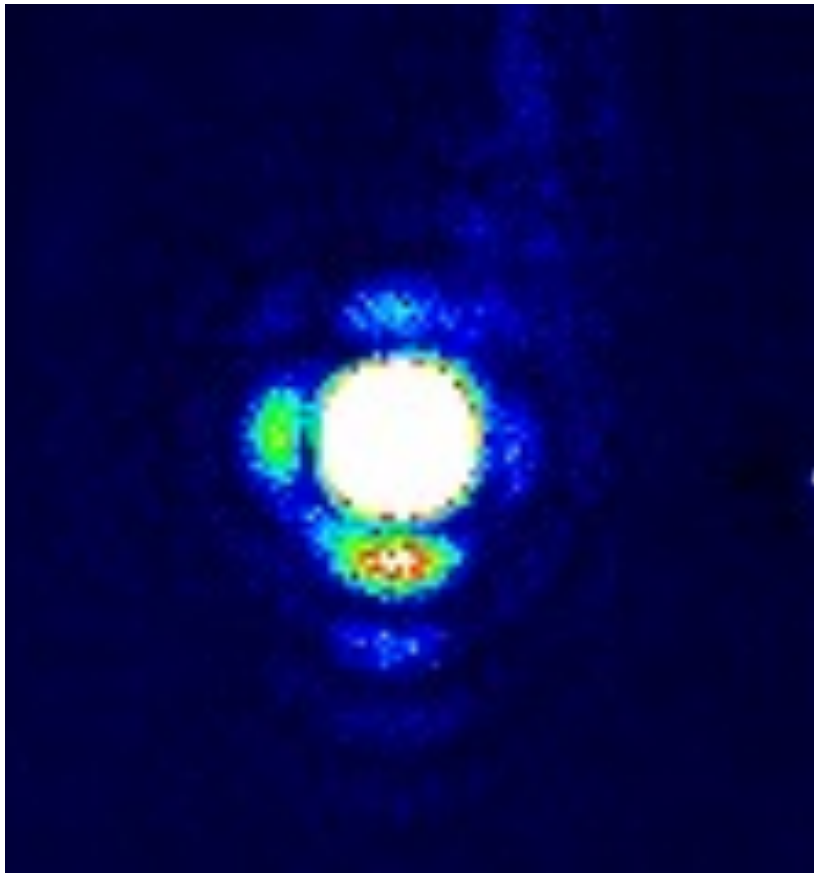


Lensless X-ray Microscope



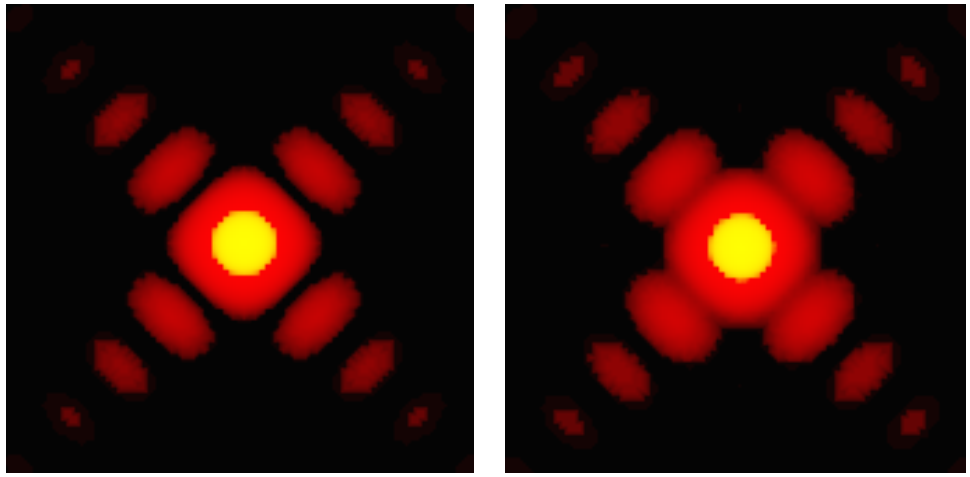
CXD from Silver Nanocubes





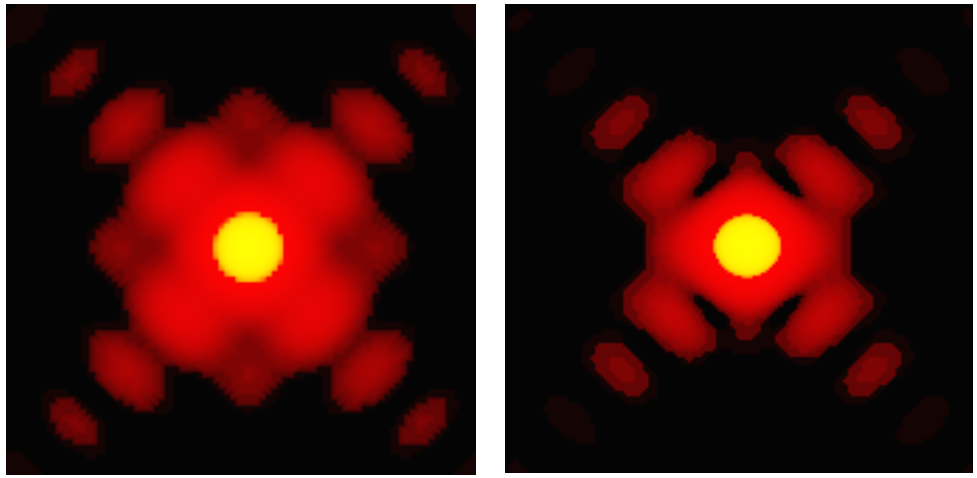
Yugang Sun and Younan Xia,
Science 298 2177 (2003)

Spherical and cylindrical waves



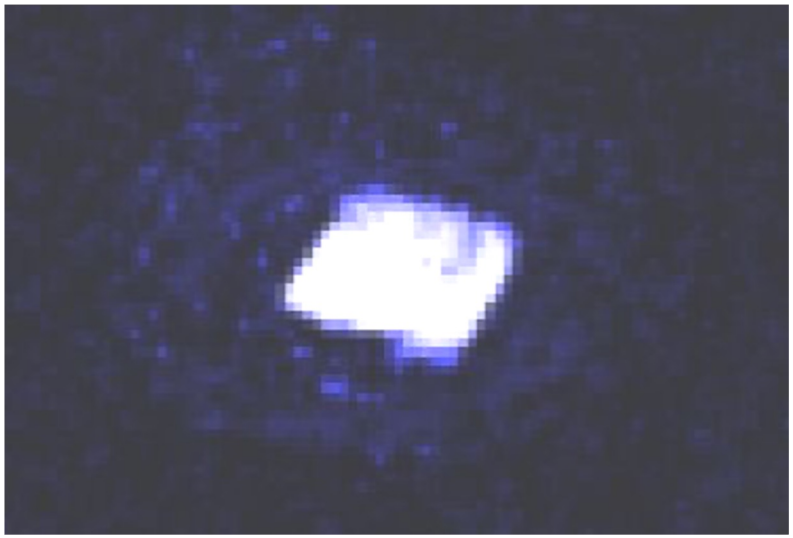
π/4

π/2

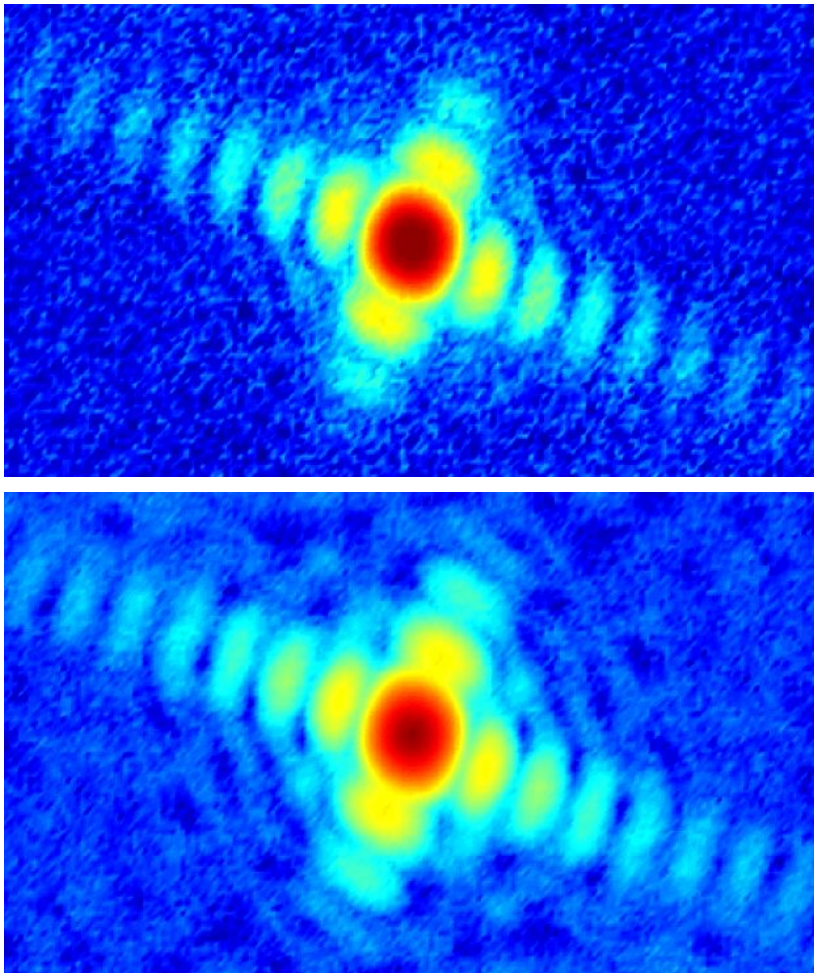


π/4 (x)

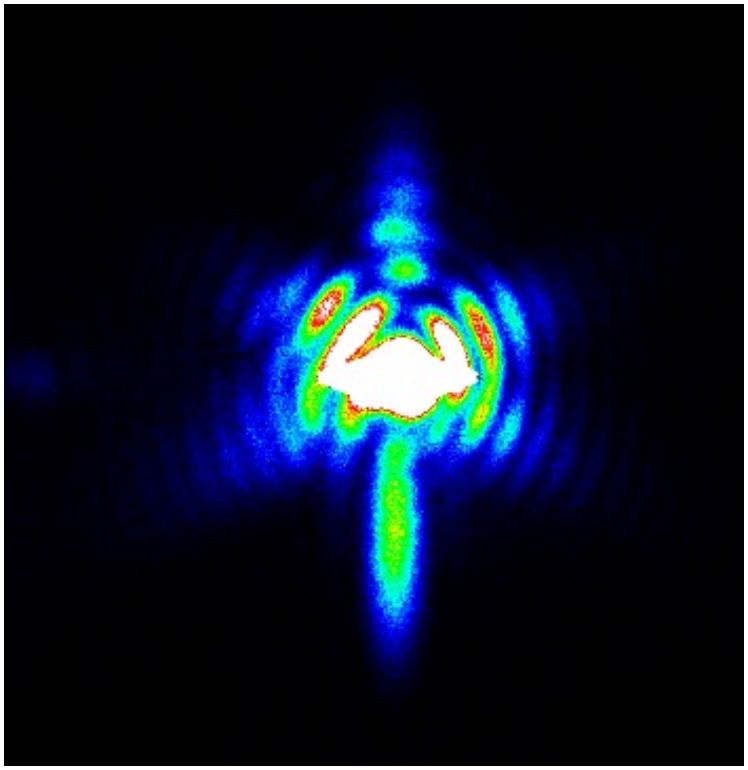
Reconstruction of Ag Nanocrystal



200nm



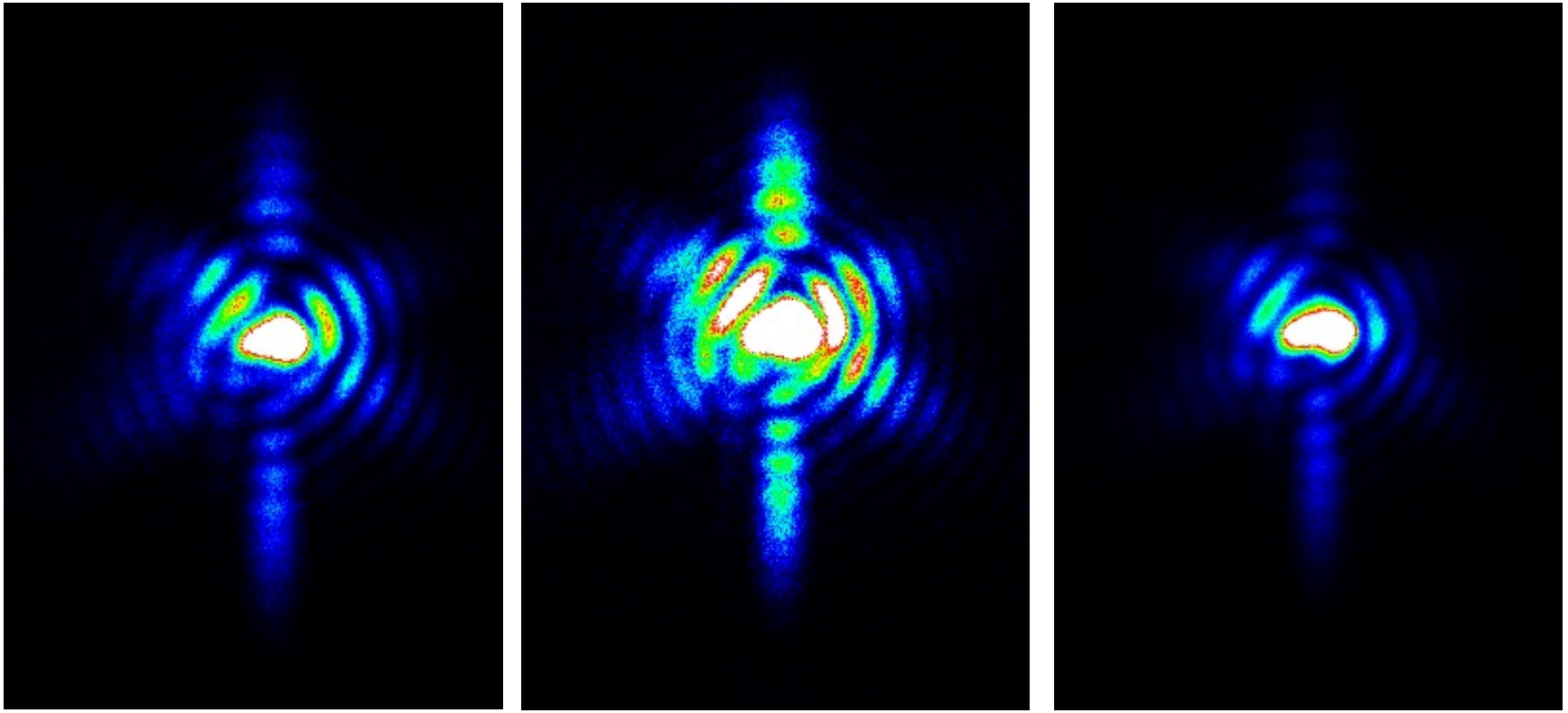
Vary vertical aperture before KB



10 micron steps from 10 to 100 microns

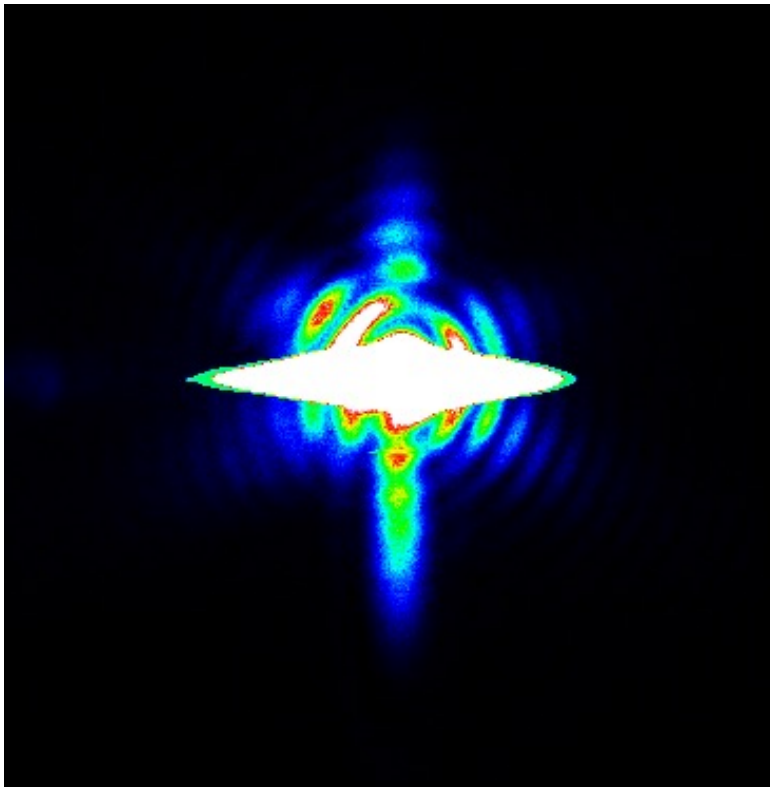
Insert diffuser before sample

all with 50 micron entrance slit



-138, none -140, 50mm -141, 15mm

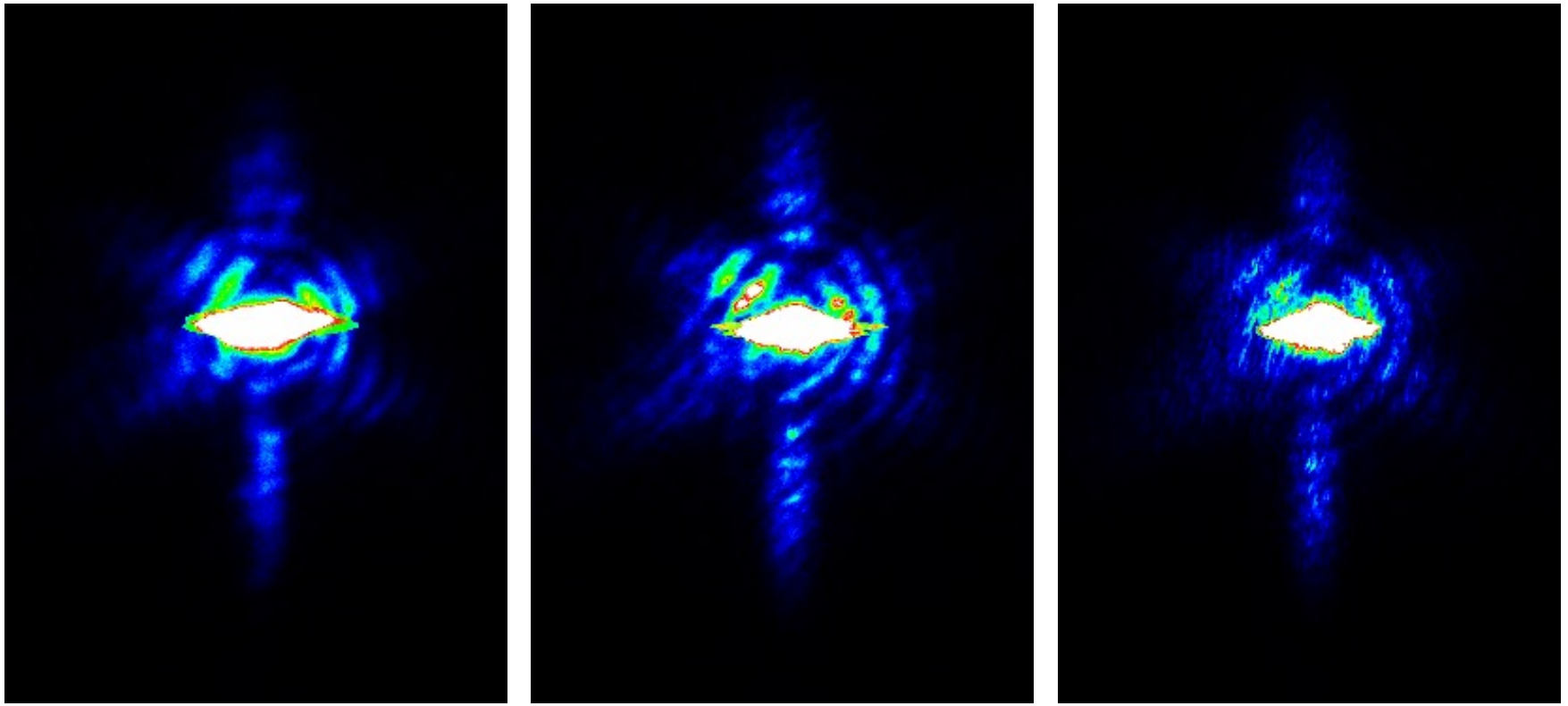
Diffuser added 15mm before sample



10 micron steps from 10 to 100 microns

Add diffuser after sample

all with 50 micron entrance slit



-142, 10mm -143, 37mm -144, 250mm

Conclusions and Outlook

- Inversion of CXD demonstrated
- Internal structure of Au Nanocrystals
- Modification of coherence upon focussing
- Diffuser can cause severe interference
- Potential for phasing methods