Use of Ptychography to detect Phase Shifts in Crystals during Diffraction

Ian Robinson
Jesse Clark
Ross Harder
Maria Civita
Laura Shemilt
Joerg Schwenke
Yusuf Mohammed
Ivan Vartaniants

London Centre for Nanotechnology
Research Complex at Harwell

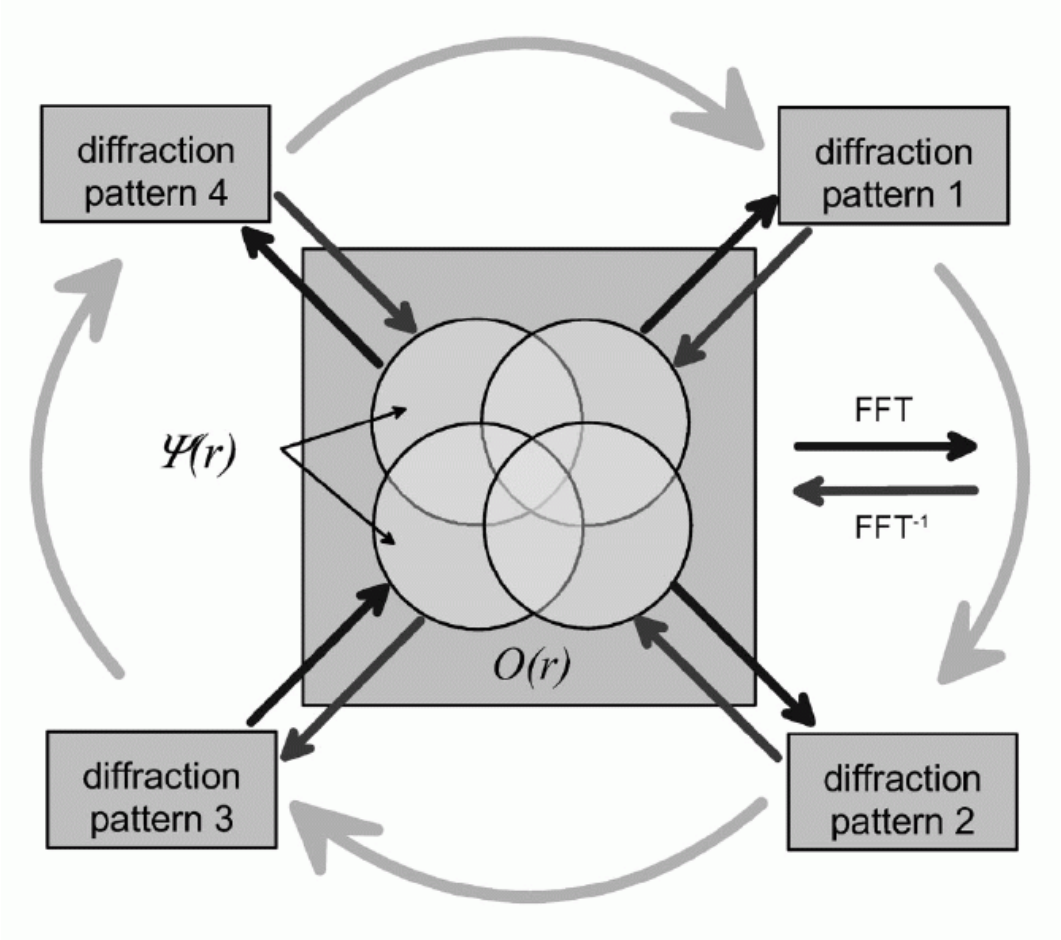
Ptycho2013,
Schloss Hohenkammer, Germany,
May 2013

Outline

- Ptychography measures phase
- Crystallographic phase
- Experiment on Au nanocrystals
- Chromosome imaging

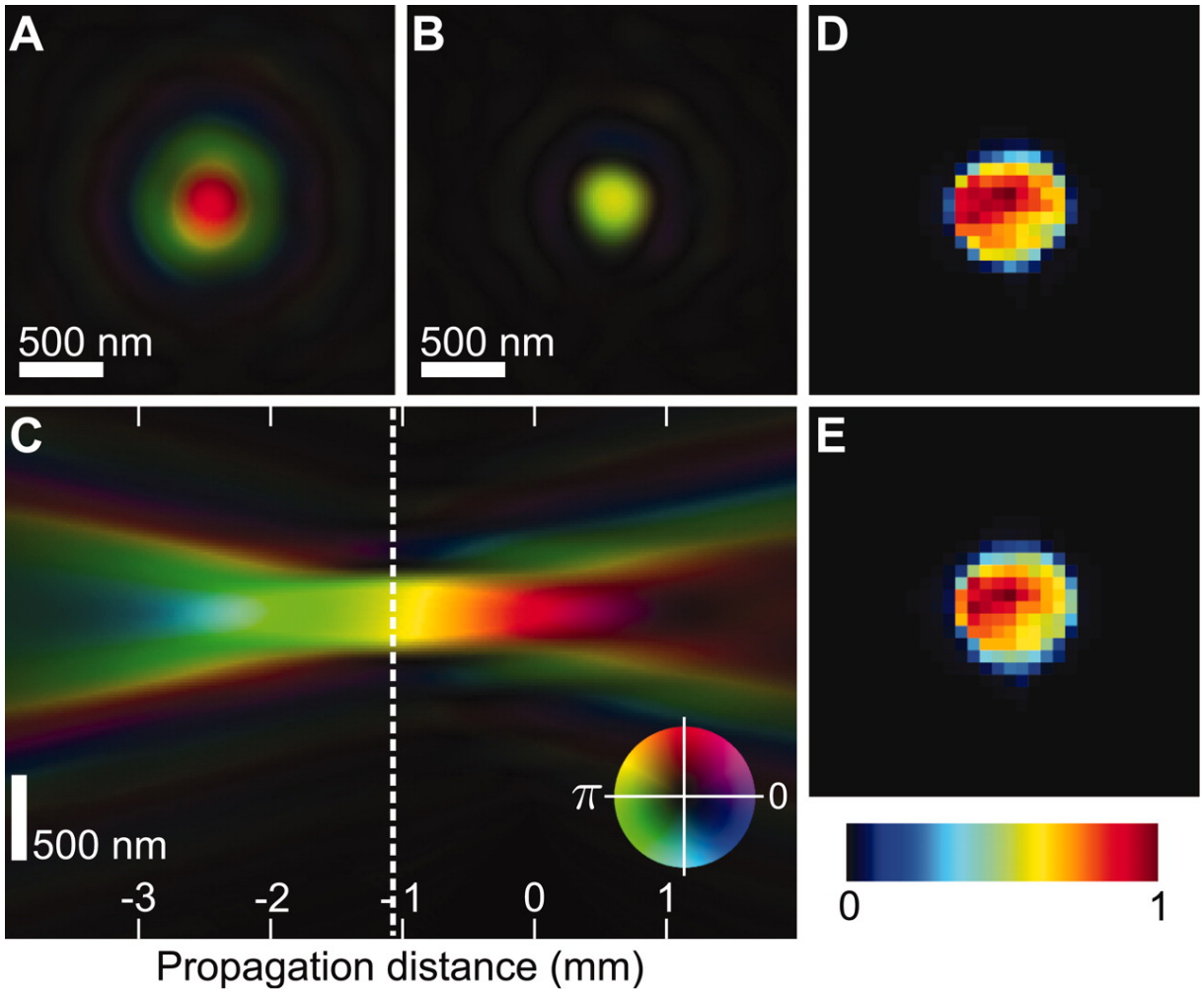
X-ray Ptychography

J. Rodenburg et al, PRL 98, 034801 (2007)



Reconstruction of Probe

P. Thibault et al, Science 321 379 (2008)



Solution of the Phase Problem in the Theory of Structure Determination of Crystals from X-Ray Diffraction Experiments

Emil Wolf*

Department of Physics and Astronomy and the Institute of Optics, University of Rochester, Rochester, New York 14627, USA

(Received 6 May 2009; published 10 August 2009)

We present a solution to a long-standing basic problem encountered in the theory of structure determination of crystalline media from x-ray diffraction experiments; namely, the problem of determining phases of the diffracted beams.

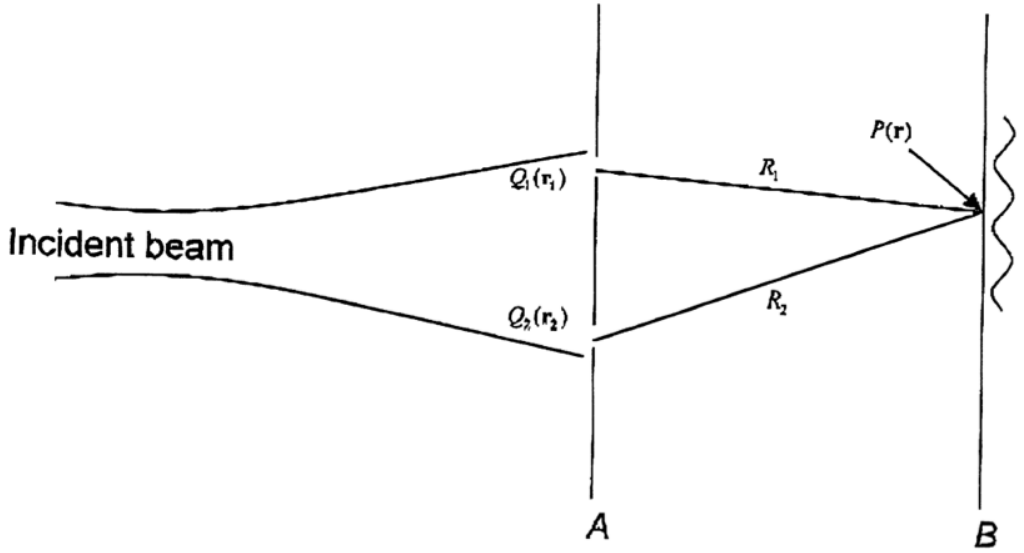
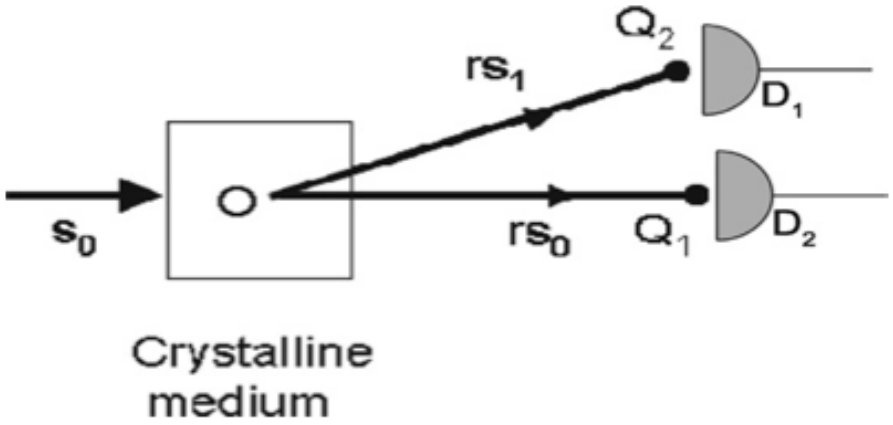


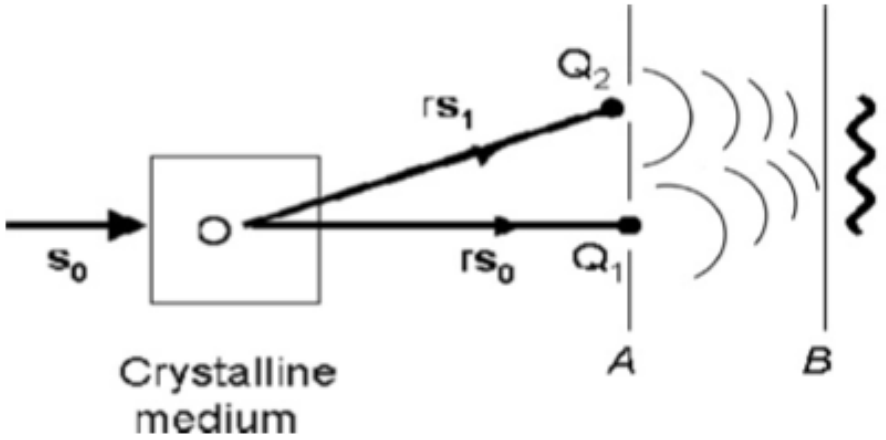
FIG. 1. Illustrating notation relating to Young's interference experiment.

Emil Wolf's Phasing Scheme

Physics Letters A 374 491 (2010)



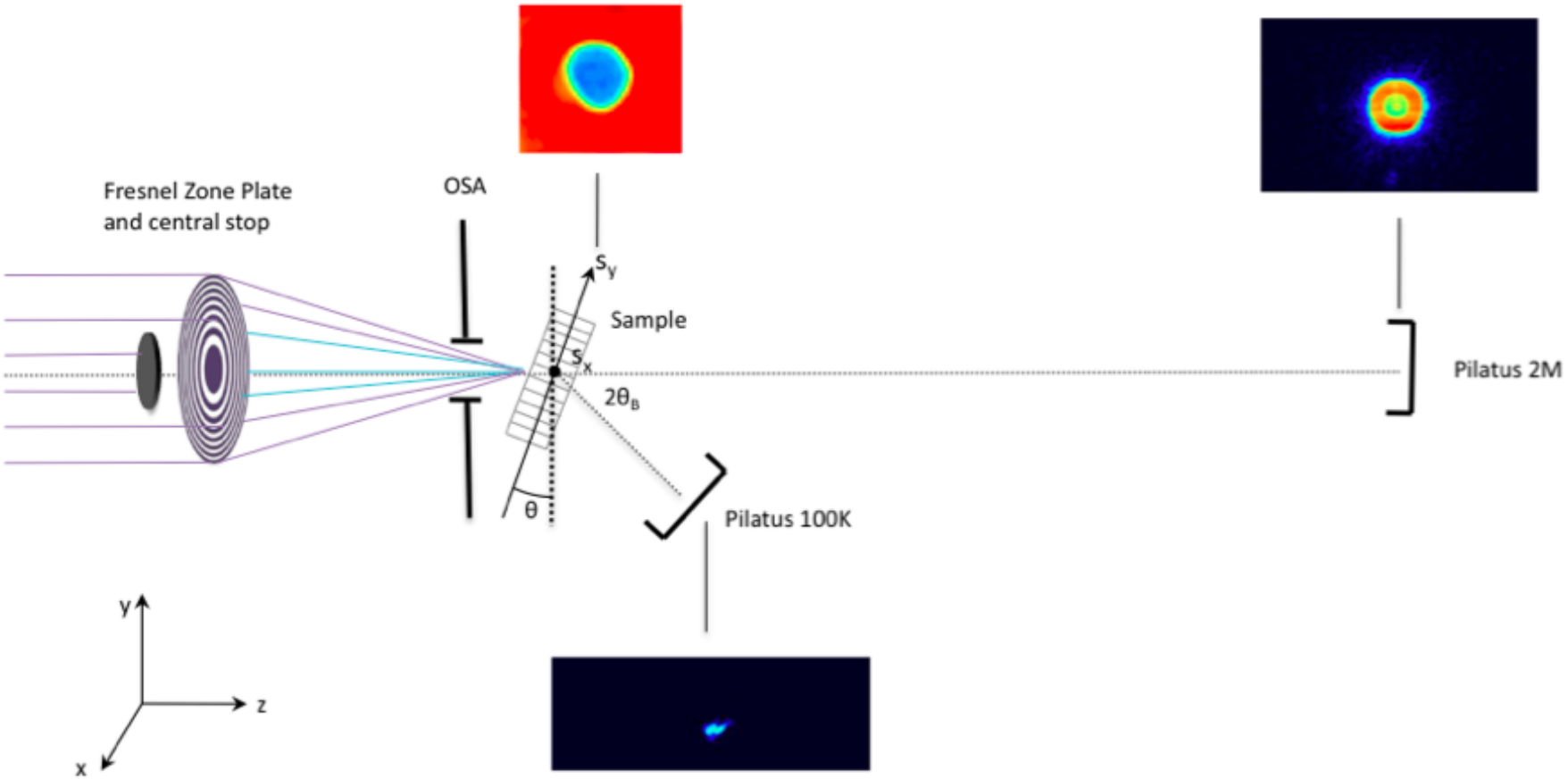
(a) In the usual technique one tries to measure *the phase difference between monochromatic beams at a pair of points* $Q_1(r\mathbf{s}_0)$ and $Q_2(r\mathbf{s}_1)$ in the far zone using detectors D_1 and D_2.



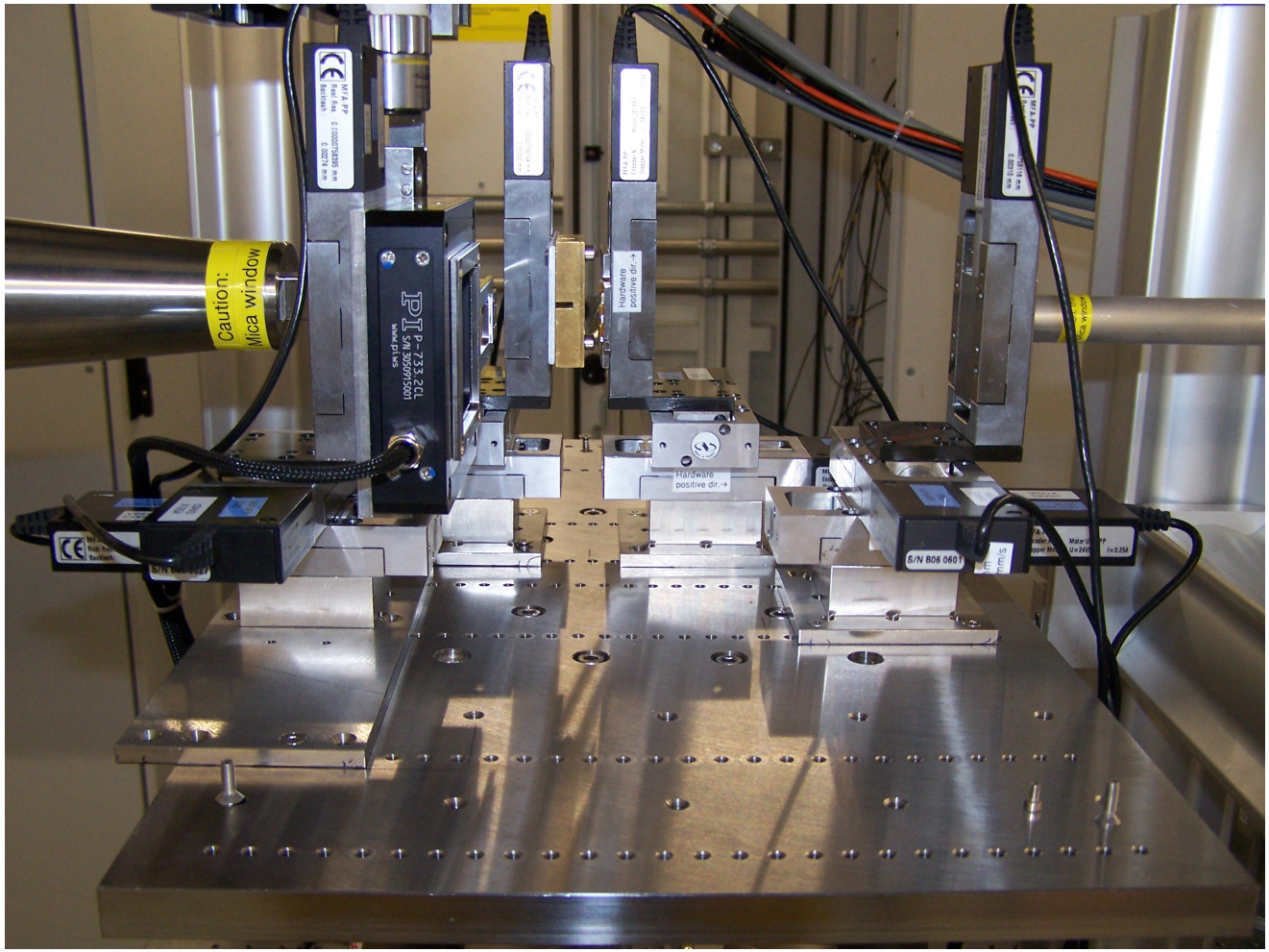
(b) In the technique described in the present Letter one would determine *the phase of the spectral degree of coherence* $\mu_{s_0}(r\mathbf{s}_0, r\mathbf{s}_1; \bar{\omega})$ at a pair of points $Q_1(r\mathbf{s}_0)$ and $Q_2(r\mathbf{s}_1)$ in the far zone from an interference experiment.

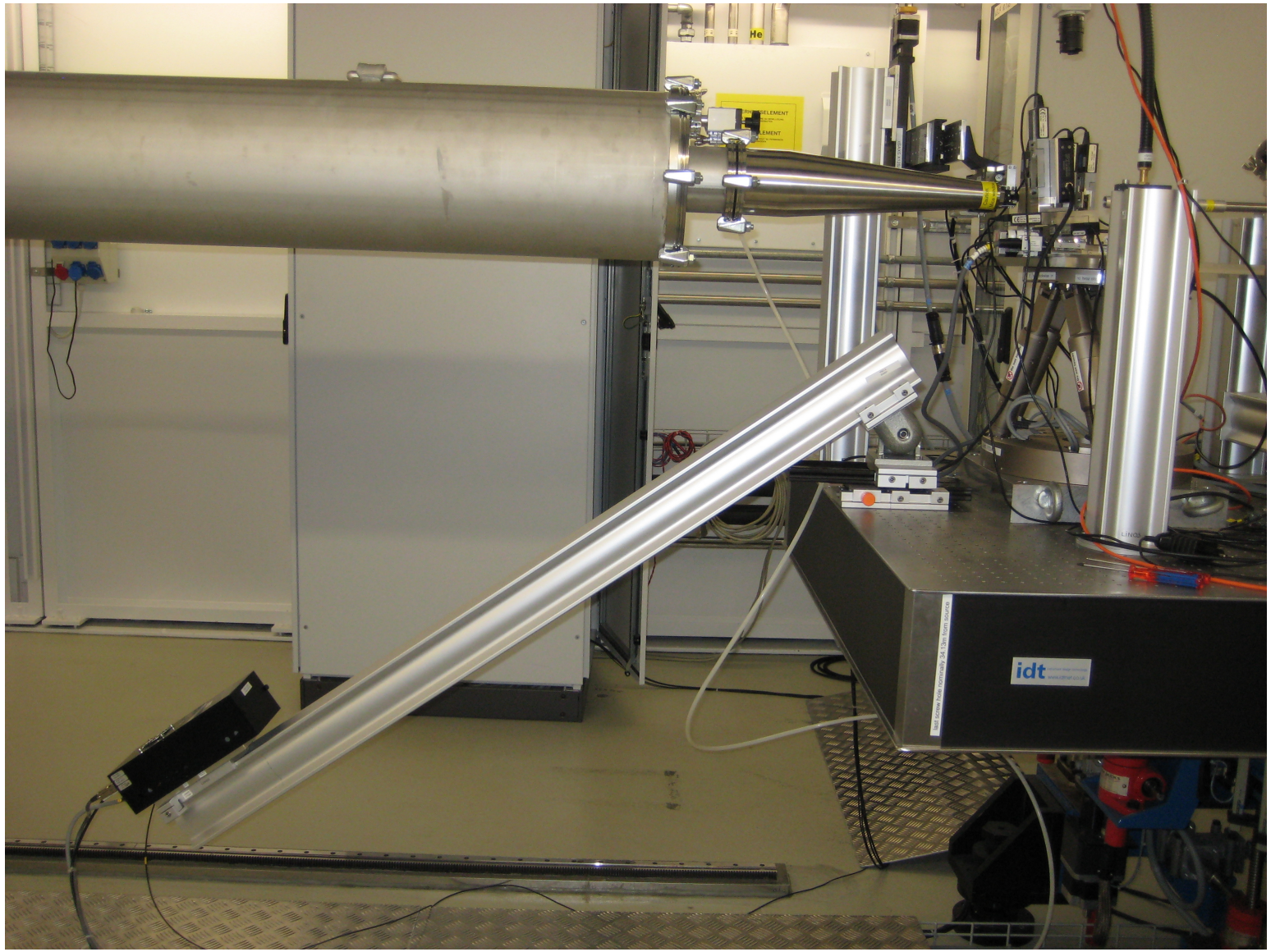
Ptychography of Gold Nanocrystals

Maria Civita, UCL, Ana Diaz, Swiss Light Source



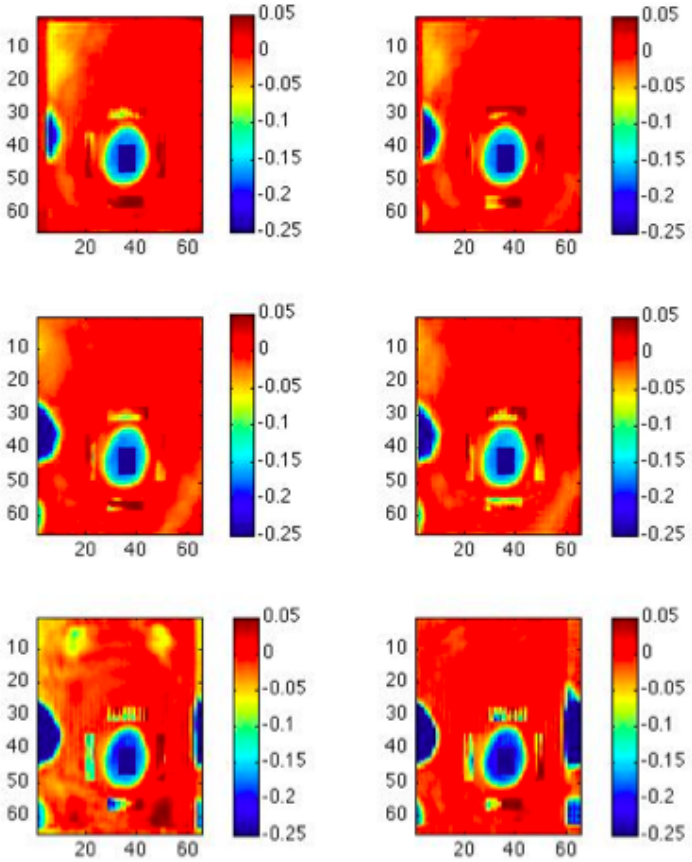
Swiss Light Source cSAXS beamline

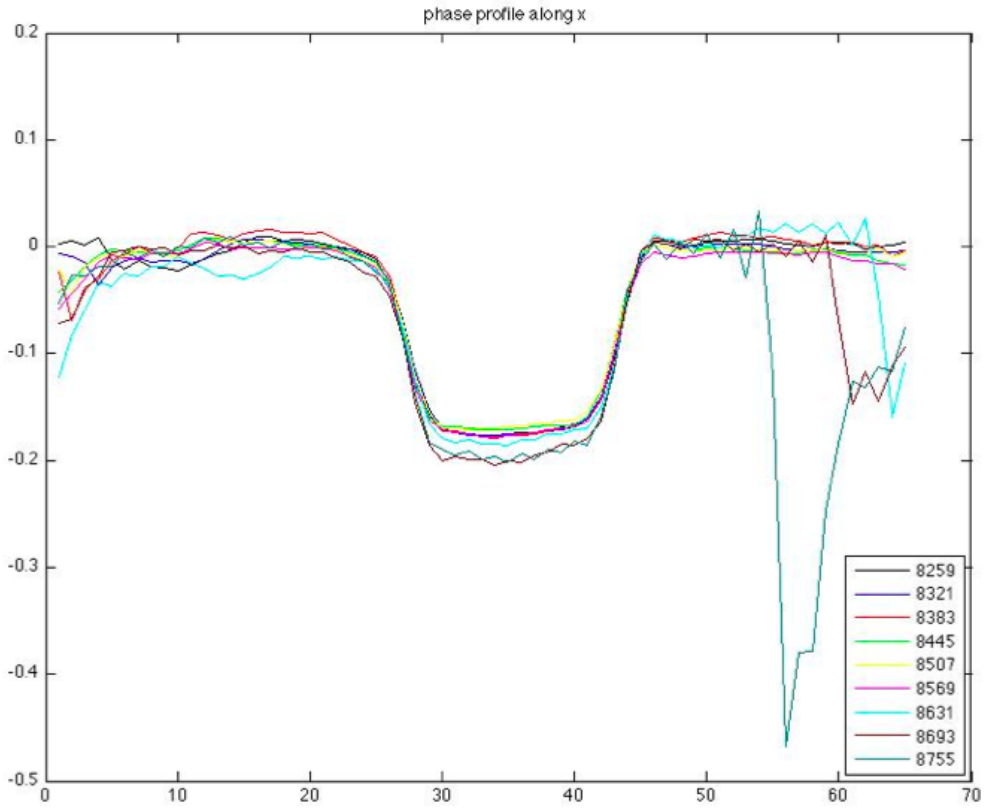



idt

Ptychography of Gold Nanocrystals

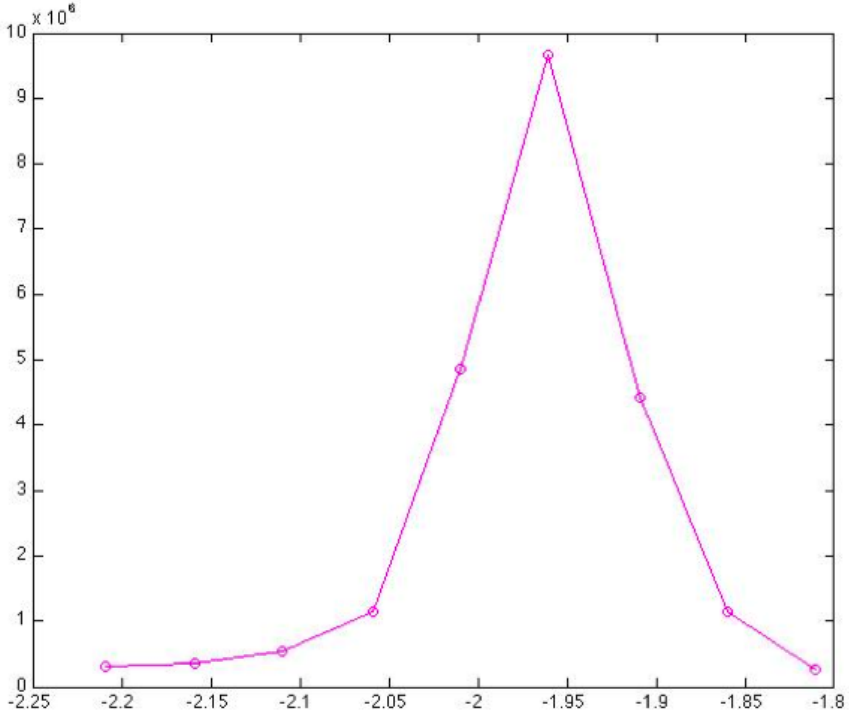
Maria Civita, UCL, Ana Diaz, Swiss Light Source

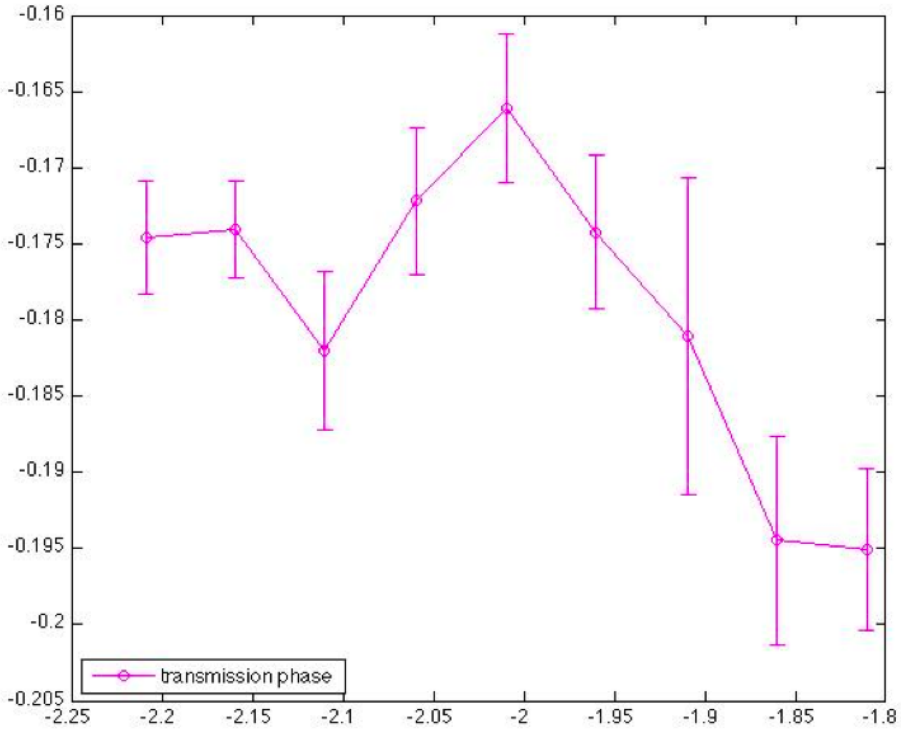




Transmitted Phase of Gold Nanocrystals

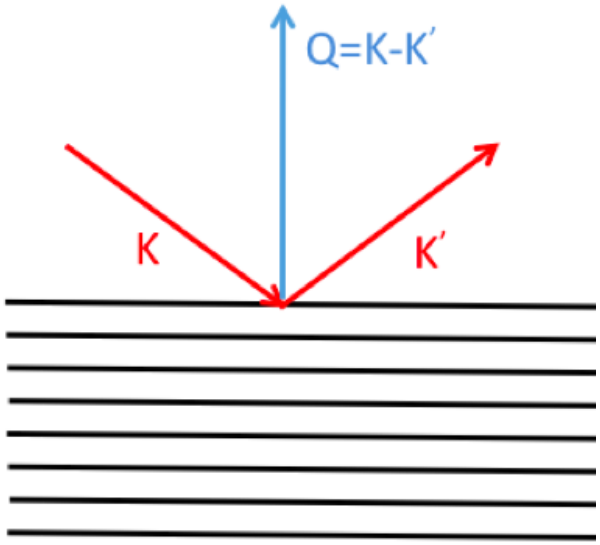
Maria Civita, UCL, Ana Diaz, Swiss Light Source

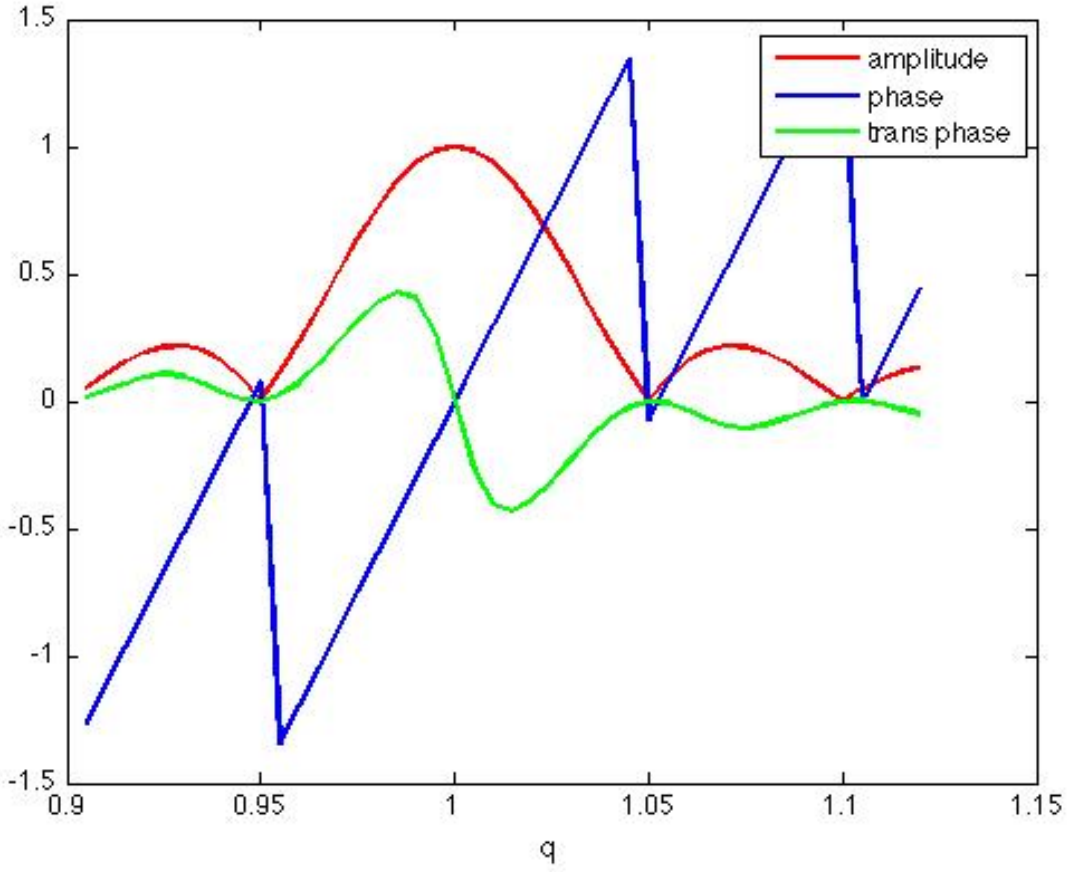




Diffraction from a Finite Slab

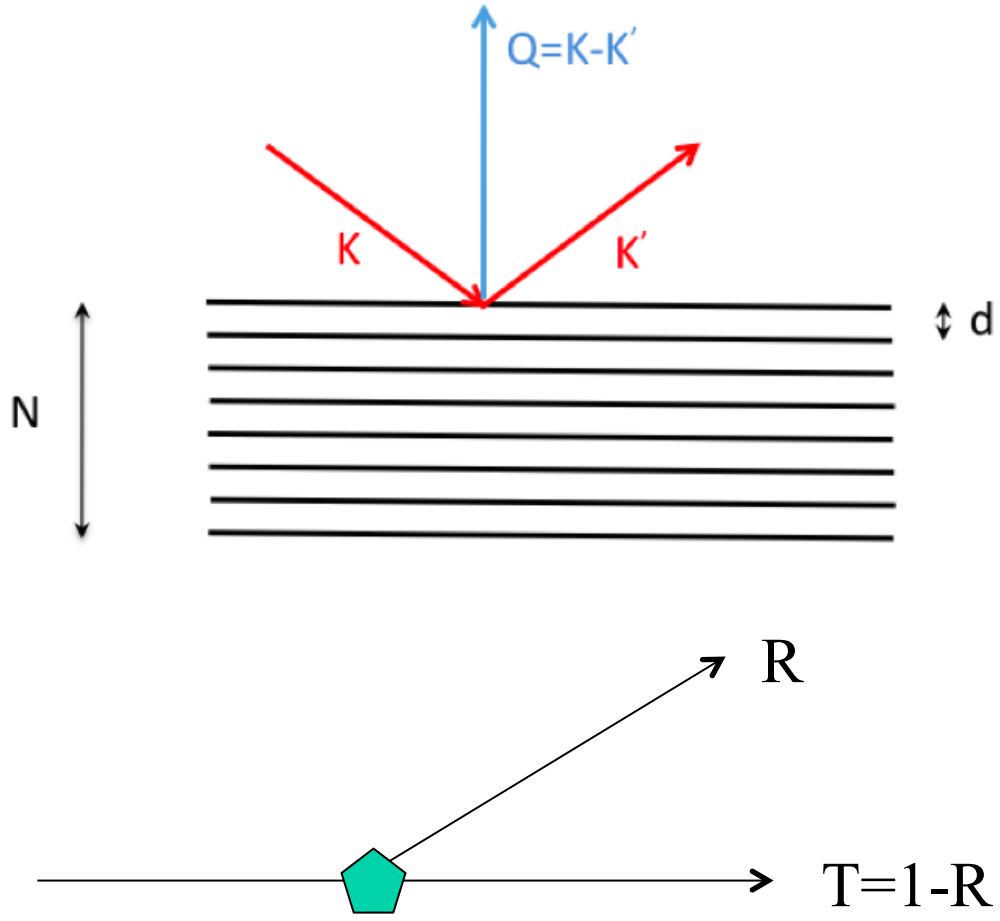
Als-Nielsen and McMorrow, "Modern X-ray Physics"

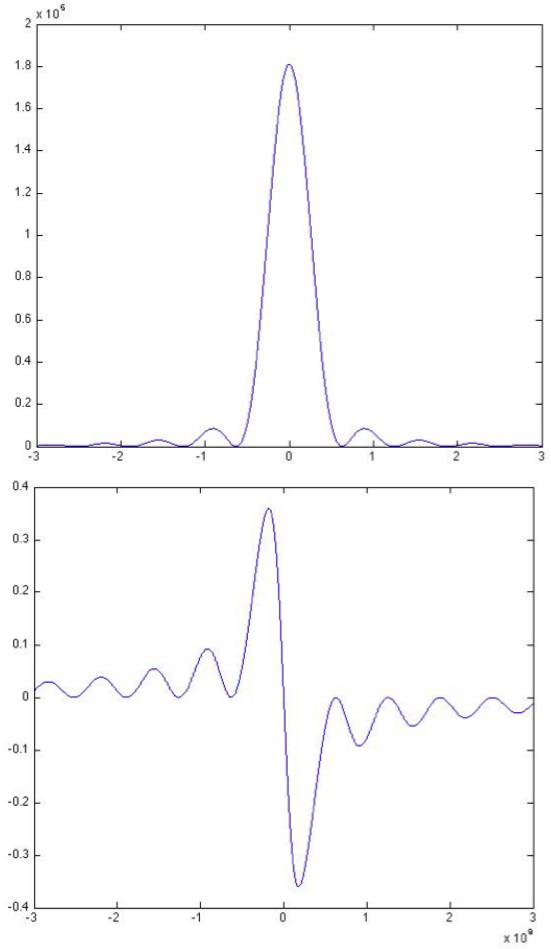




Diffraction from a Finite Slab

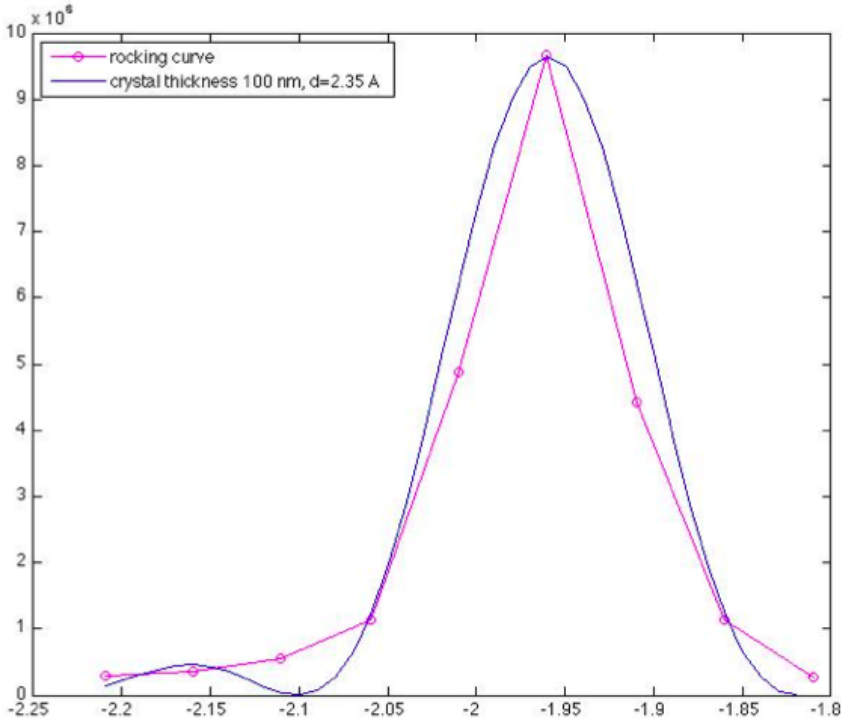
Als-Nielsen and McMorrow, "Modern X-ray Physics"

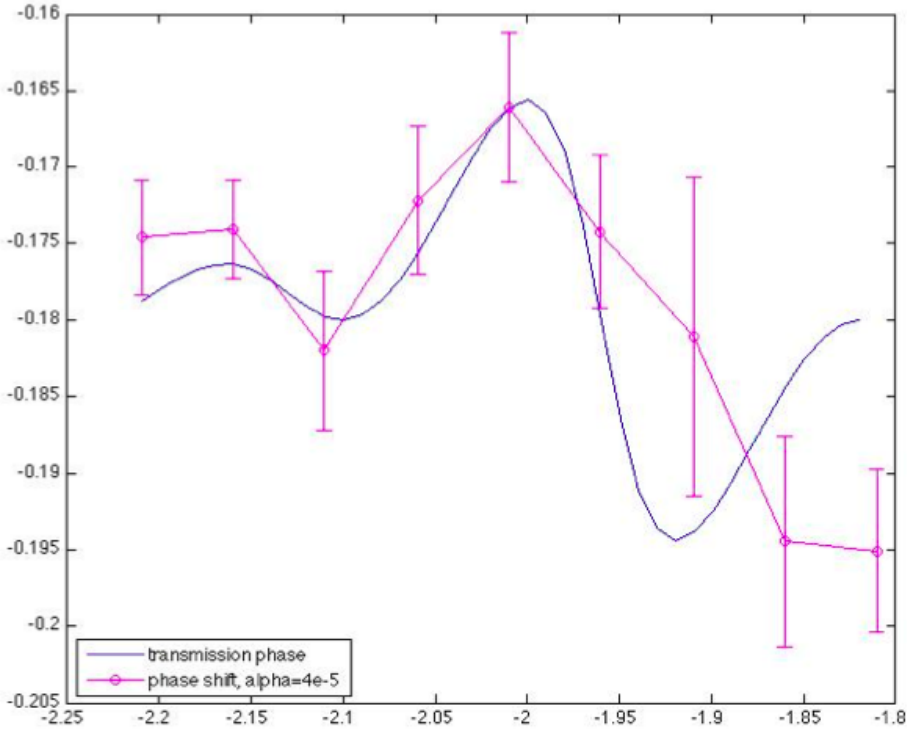




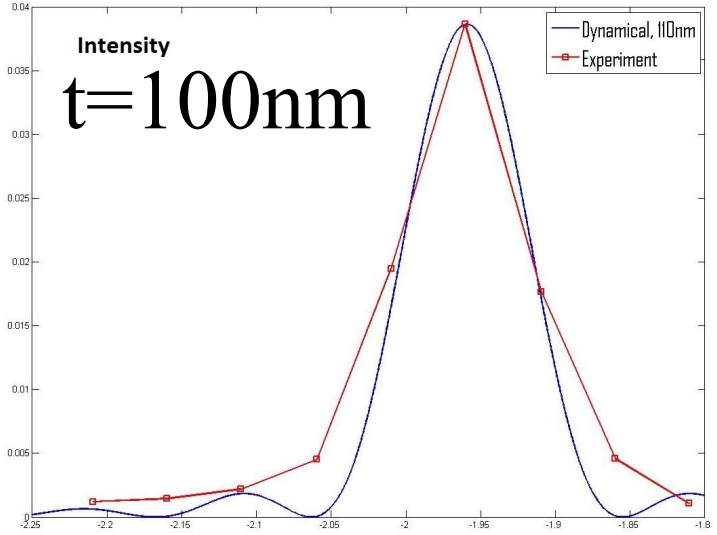
Ptychography of Gold Nanocrystals

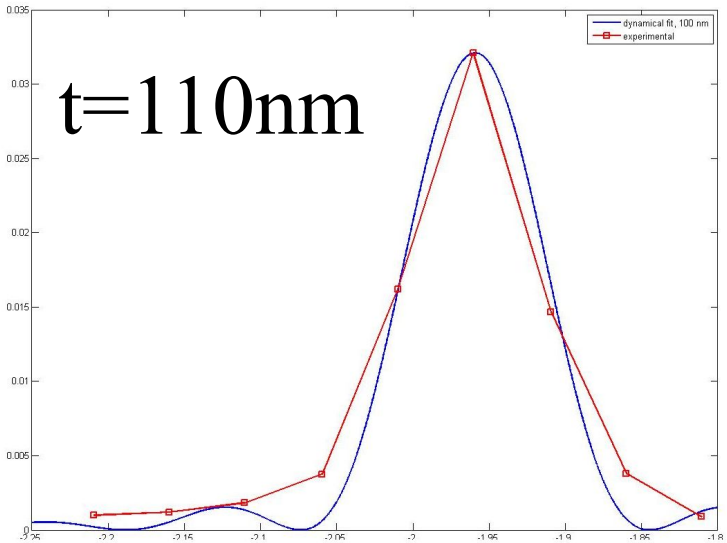
Maria Civita, UCL, Ana Diaz, Swiss Light Source

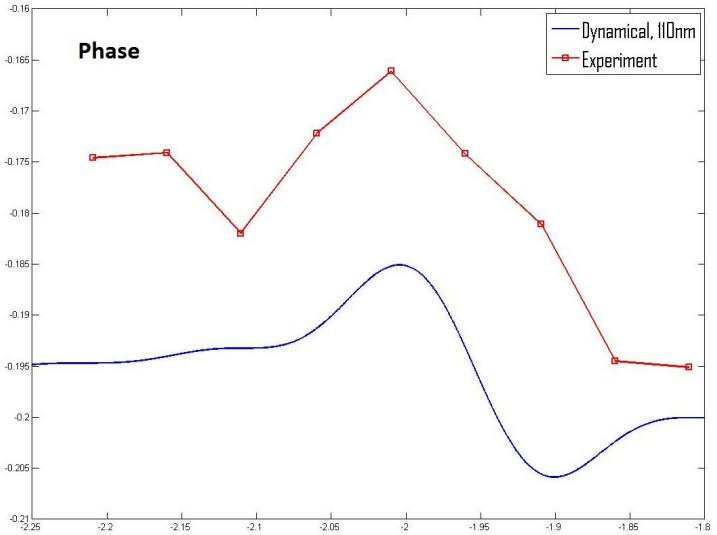


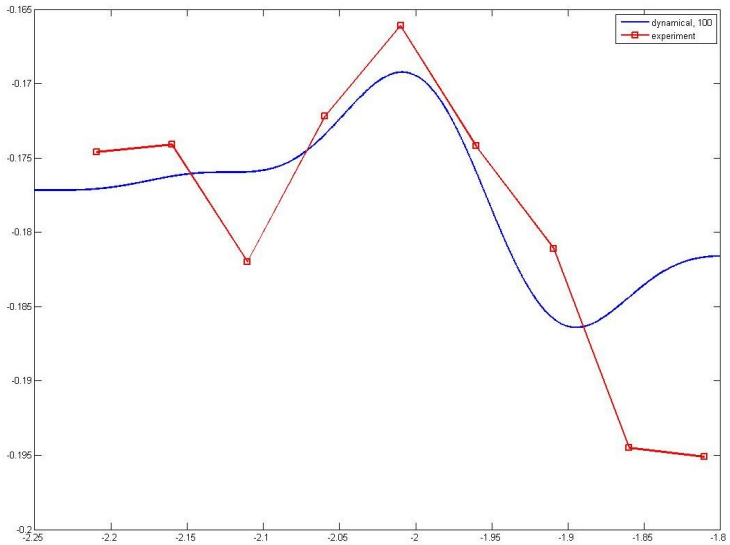


Dynamical Theory (Ivan Vartaniants)



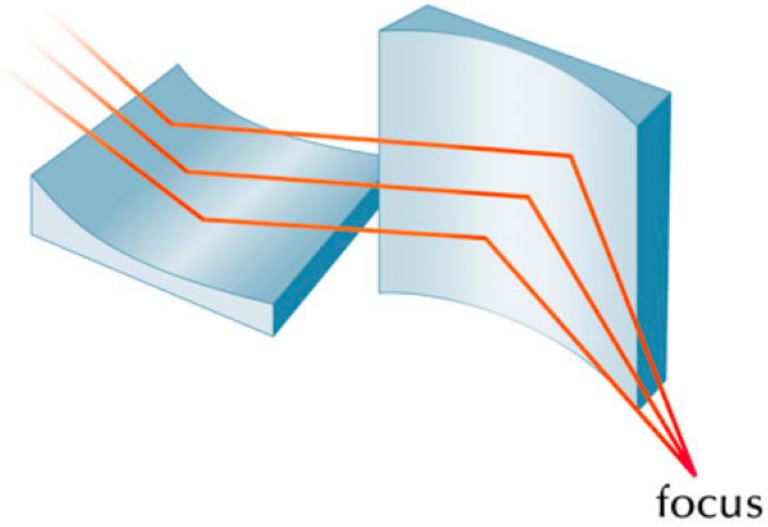


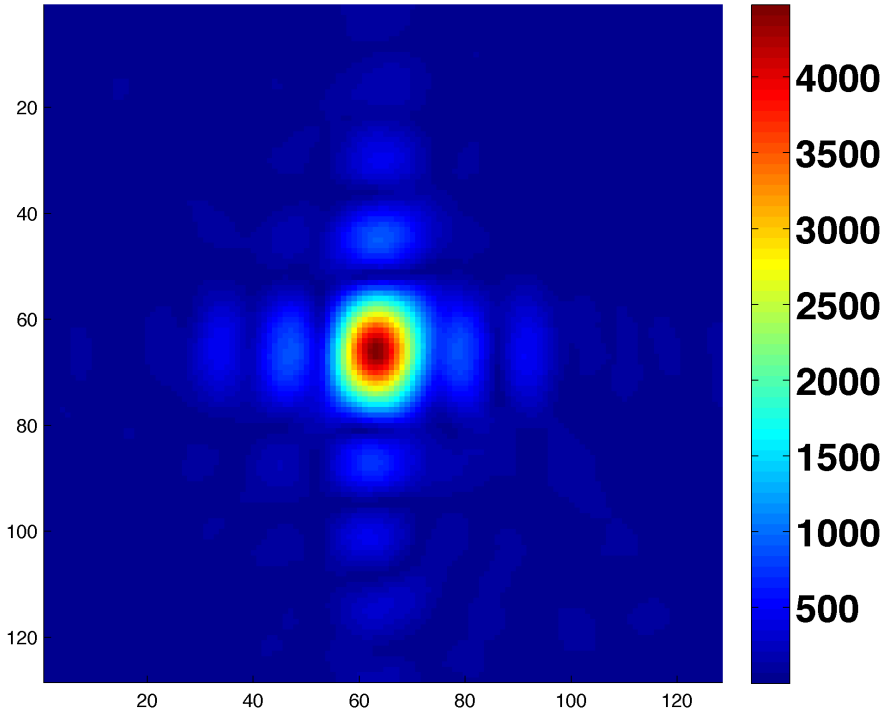




Ptychography at 34-ID-C (APS)

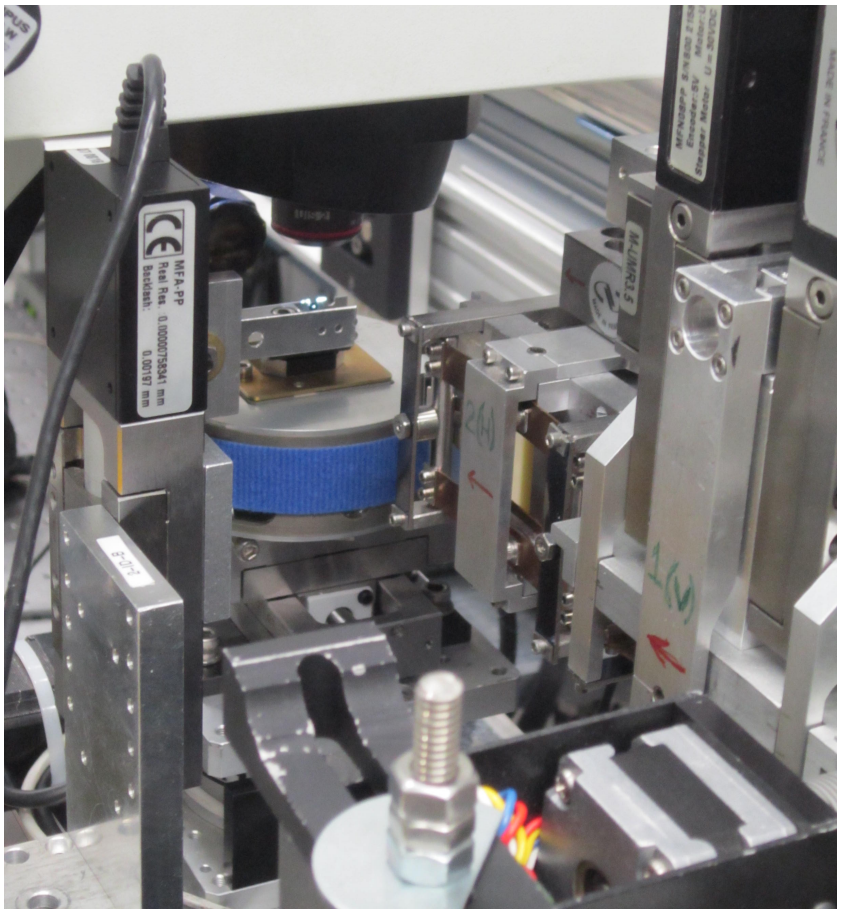
nPoint 3D scanner, Ross Harder and David Vine

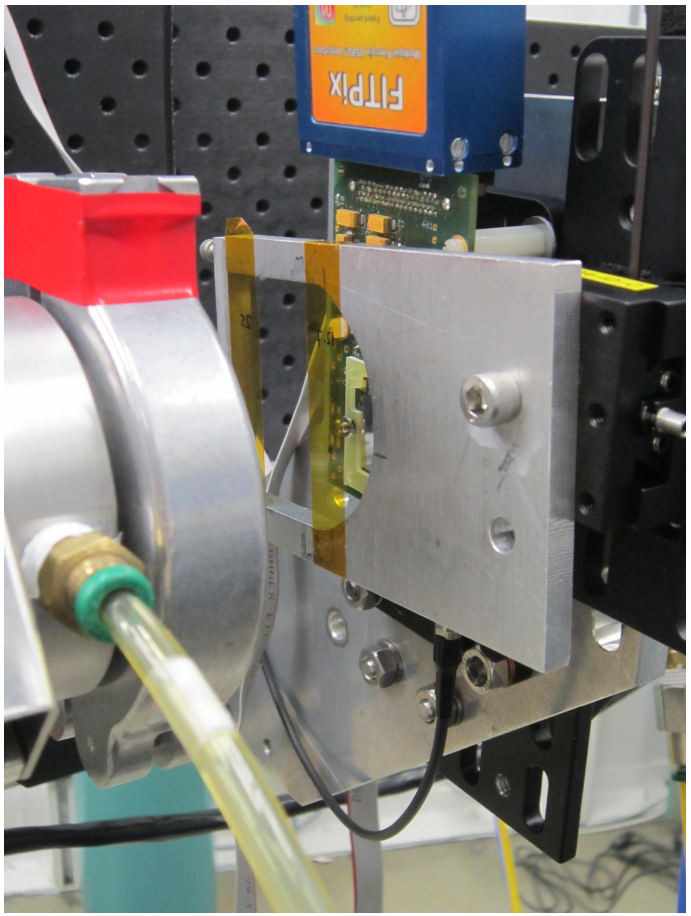




Ptychography at 34-ID-C (APS)

nPoint 3D scanner, Ross Harder and David Vine

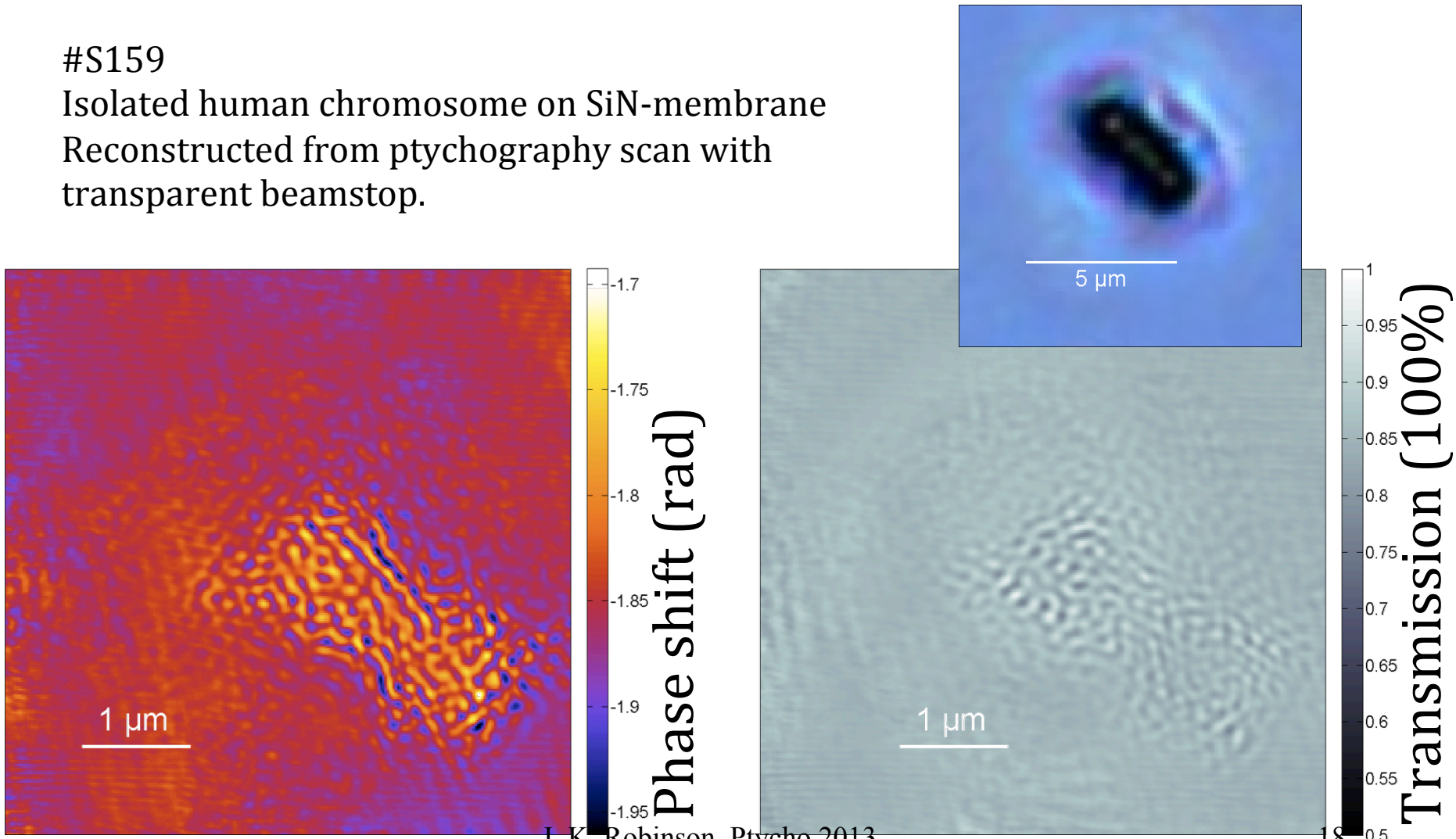




Chromosome Ptychography

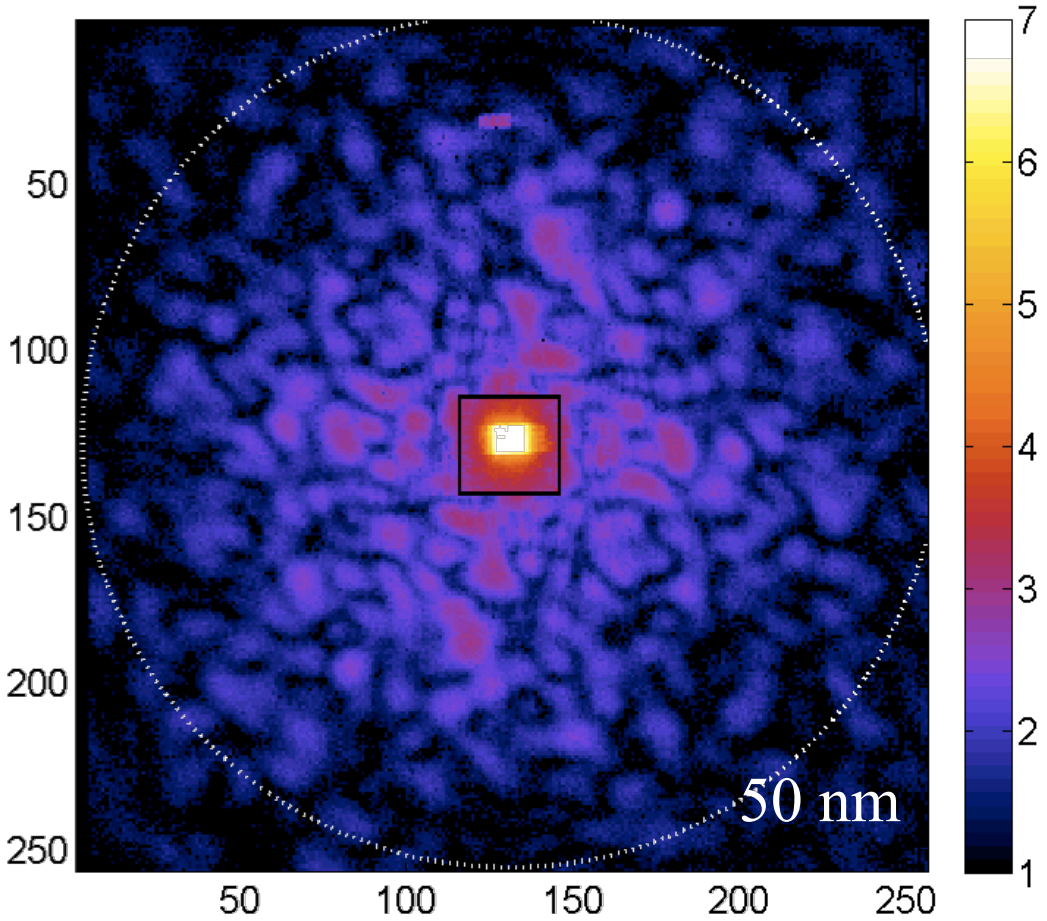
Laura Shemilt, Joerg Schwenke, Yusuf Mohammed, 34-ID-C

#S159
Isolated human chromosome on SiN-membrane
Reconstructed from ptychography scan with transparent beamstop.

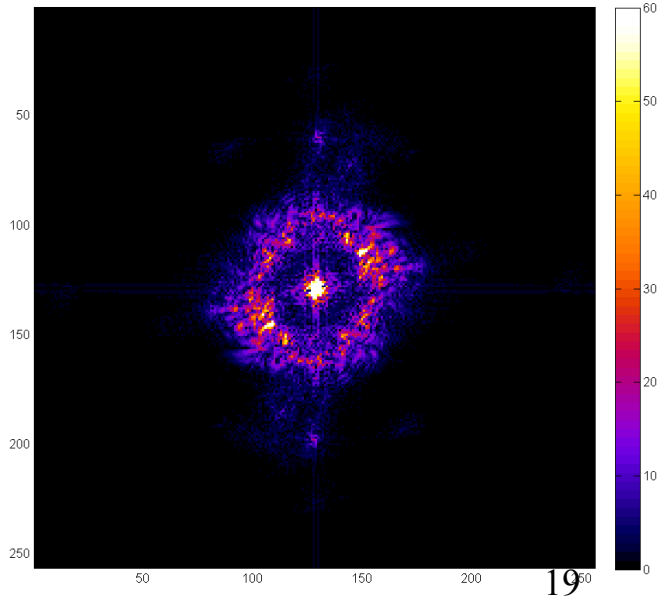


Chromosome Ptychography

Laura Shemilt, Joerg Schwenke, Yusuf Mohammed, 34-ID-C



#S152, frame 1
10s exposure
6.5 keV
Medipix2, 55 µm
1.851 m distance



I. K. Robinson, Ptycho 2013

Conclusions and Acknowledgements

- Crystallographic phase determination
- Absolute phase of Structure Factor
- Ripples in images due to beam stop?

Ana Diaz Swiss Light Source
Cameron Kewish
Manuel Guizar-Sicairos
Ross Harder Advanced Photon Source