Possible Phasing Methods for Highly Strained Crystals

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Coherence Workshop
SRI-09 satellite
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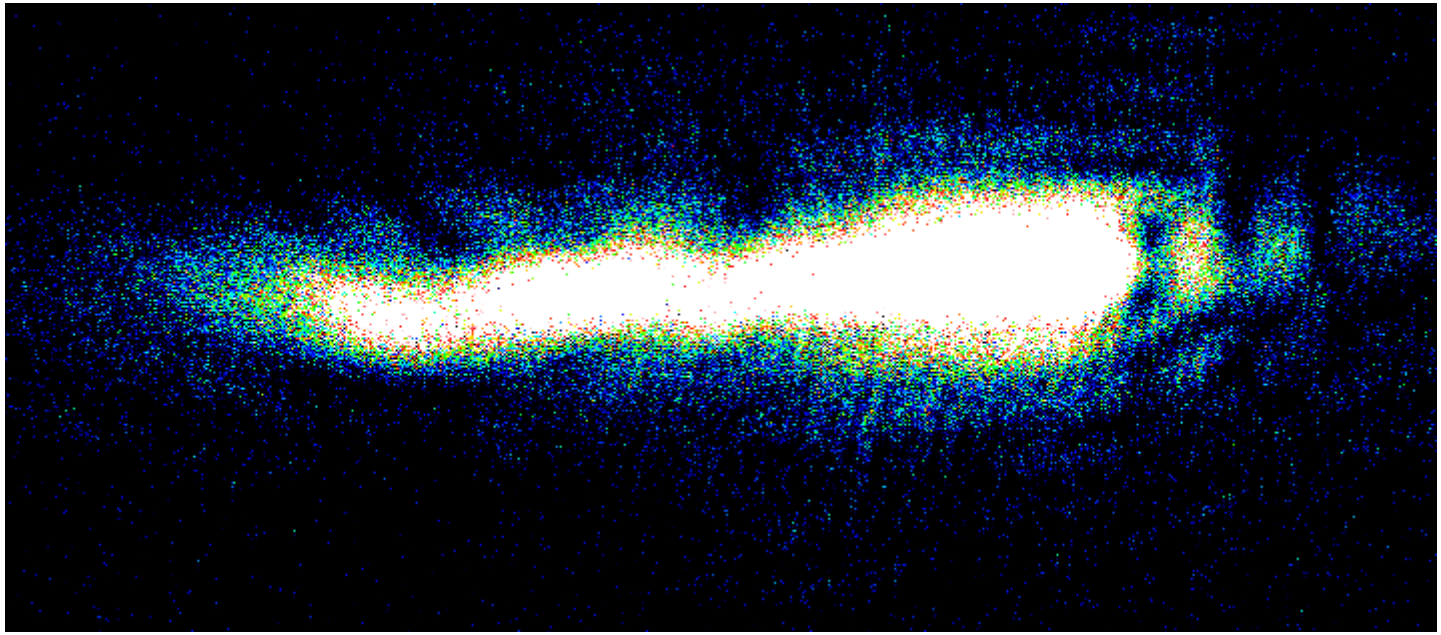
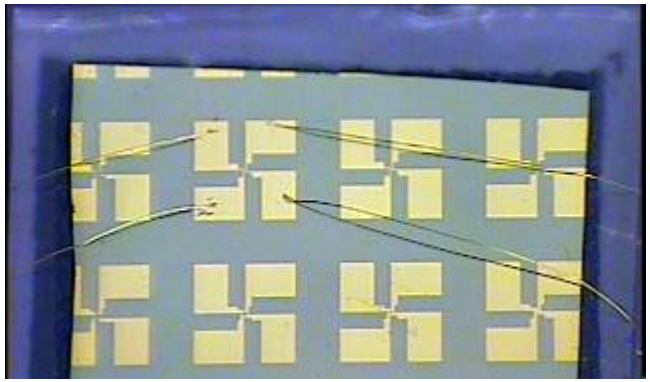
Outline

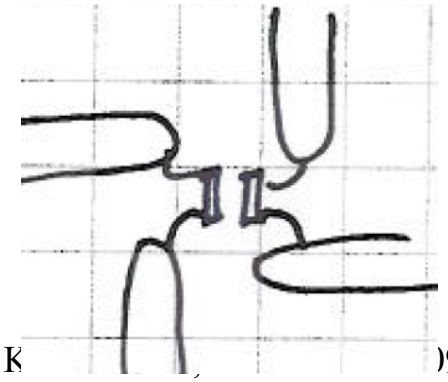
- Coherent X-ray Diffraction
- Wired ZnO experiments
- Simulation of small crystals and strain fields
- Phase-plate analyser
- Phase plate fabrication
- Preparations for XFEL

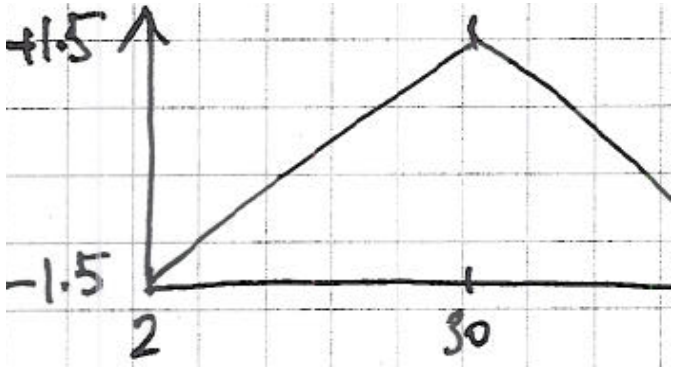
Apply Electric Field along ZnO NC

Marcus Newton. 34-ID-C zno808-18 Aug 2008

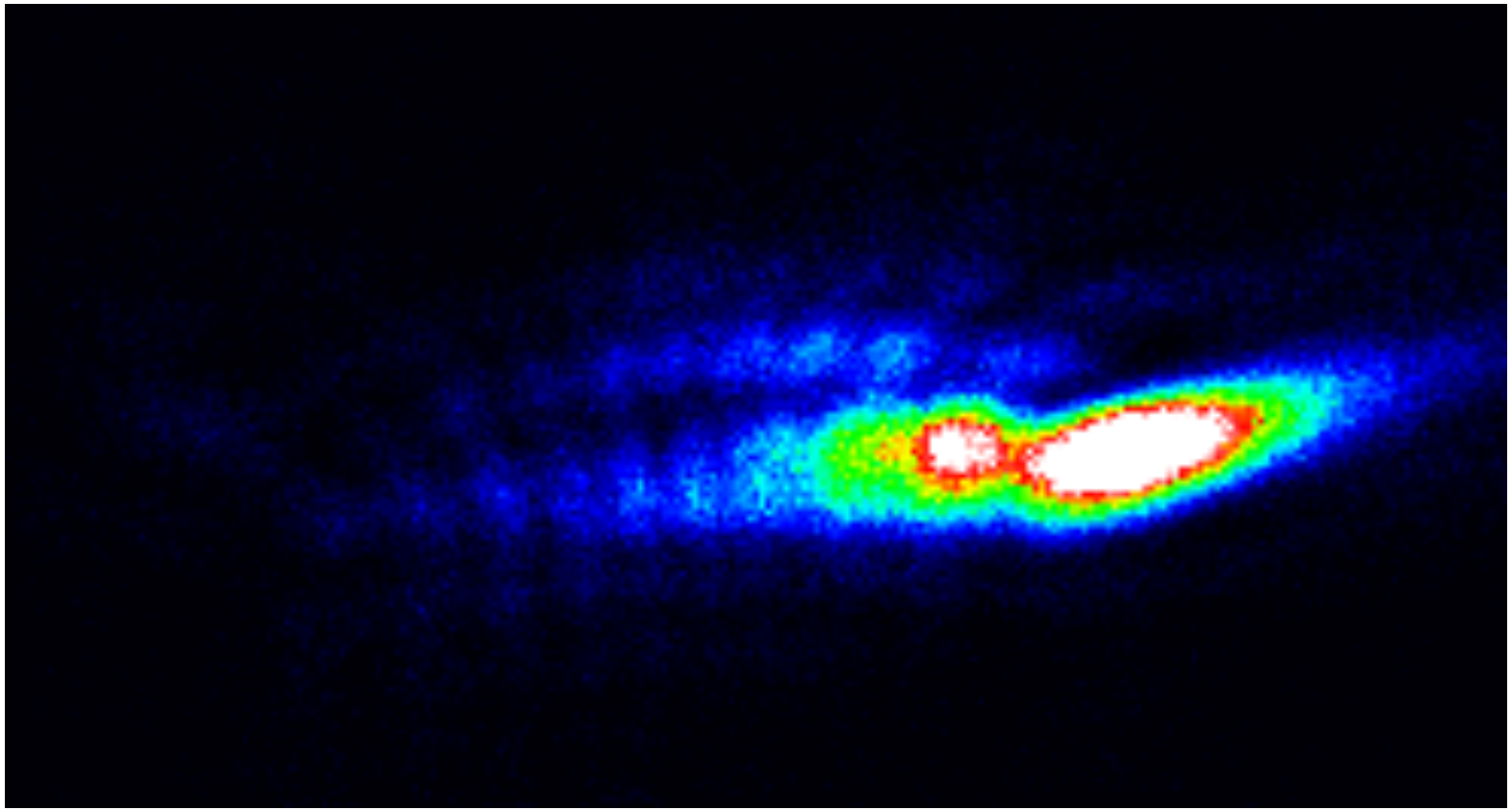








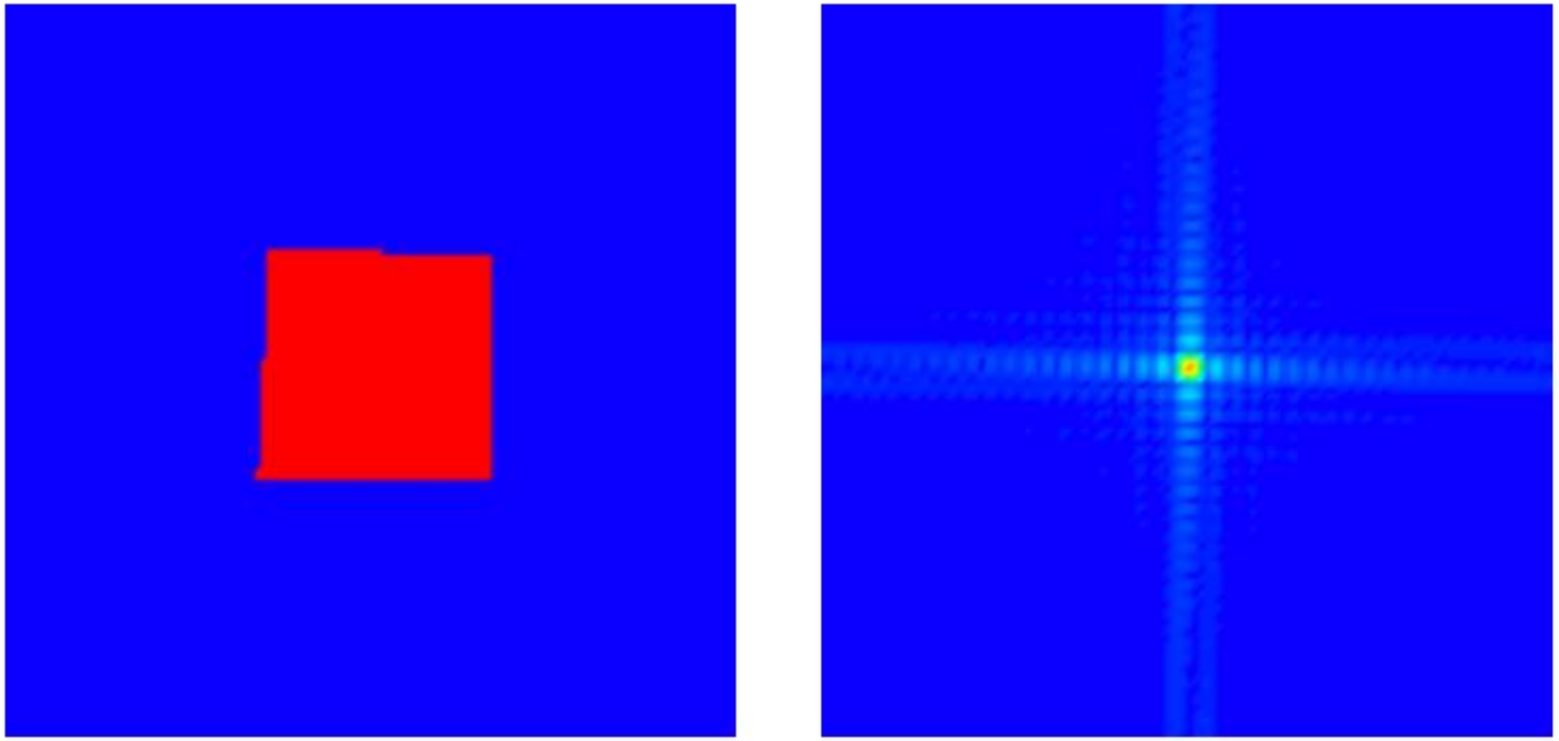
ZnO409-44 wired ZnO crystal



FFT simulations of phase objects

128x128x128 array 20x20x20 cube rotated (0.03 rad)^3

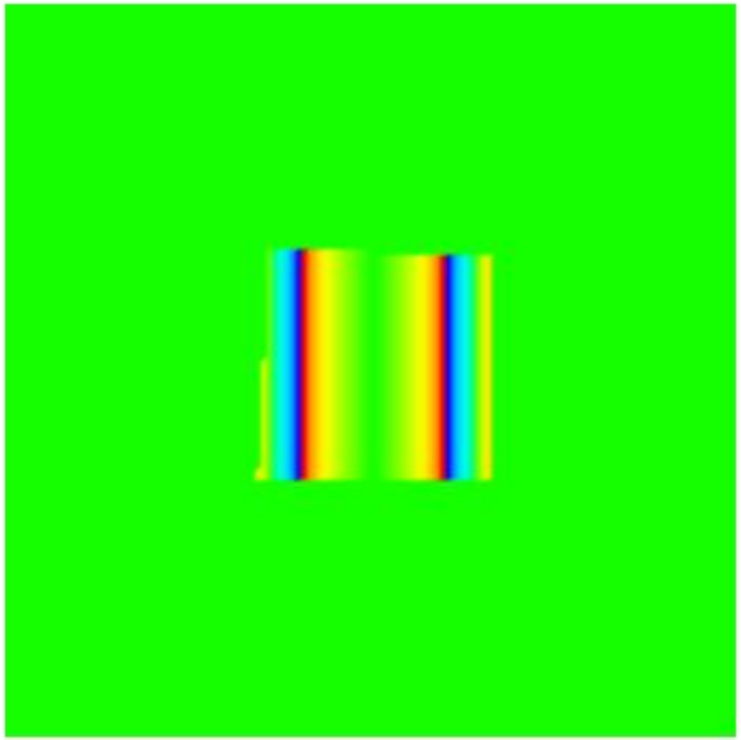
n=9 curY=0.0 curZ=0.0

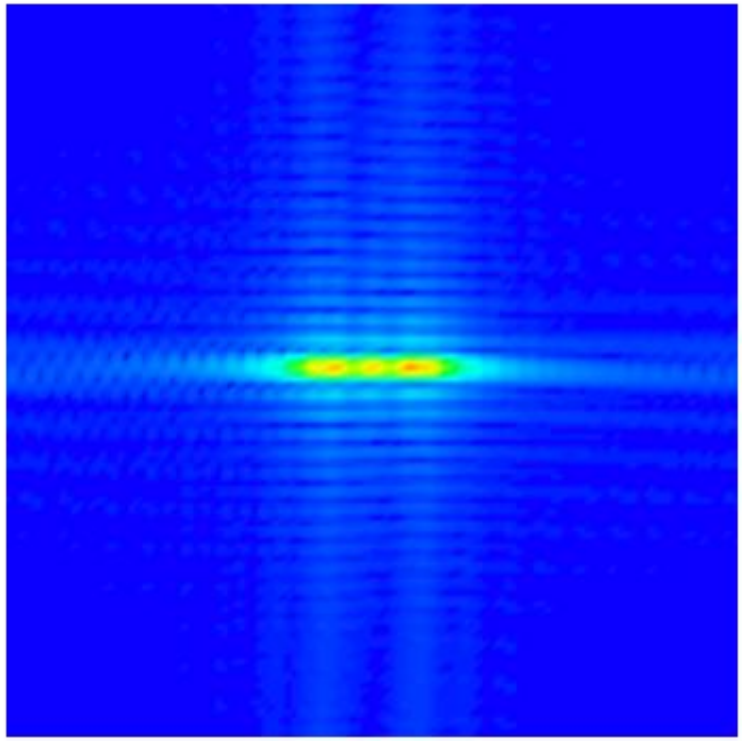


FFT simulations of phase objects

128x128x128 array 20x20x20 cube rotated (0.03 rad)^3

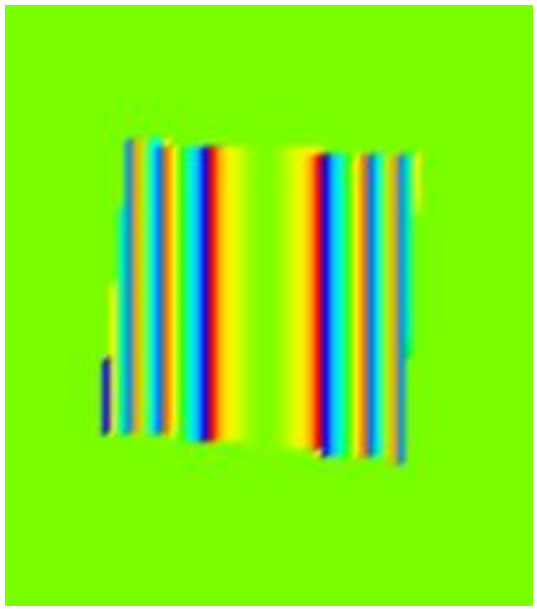
n=9 curY=0.0 curZ=0.02

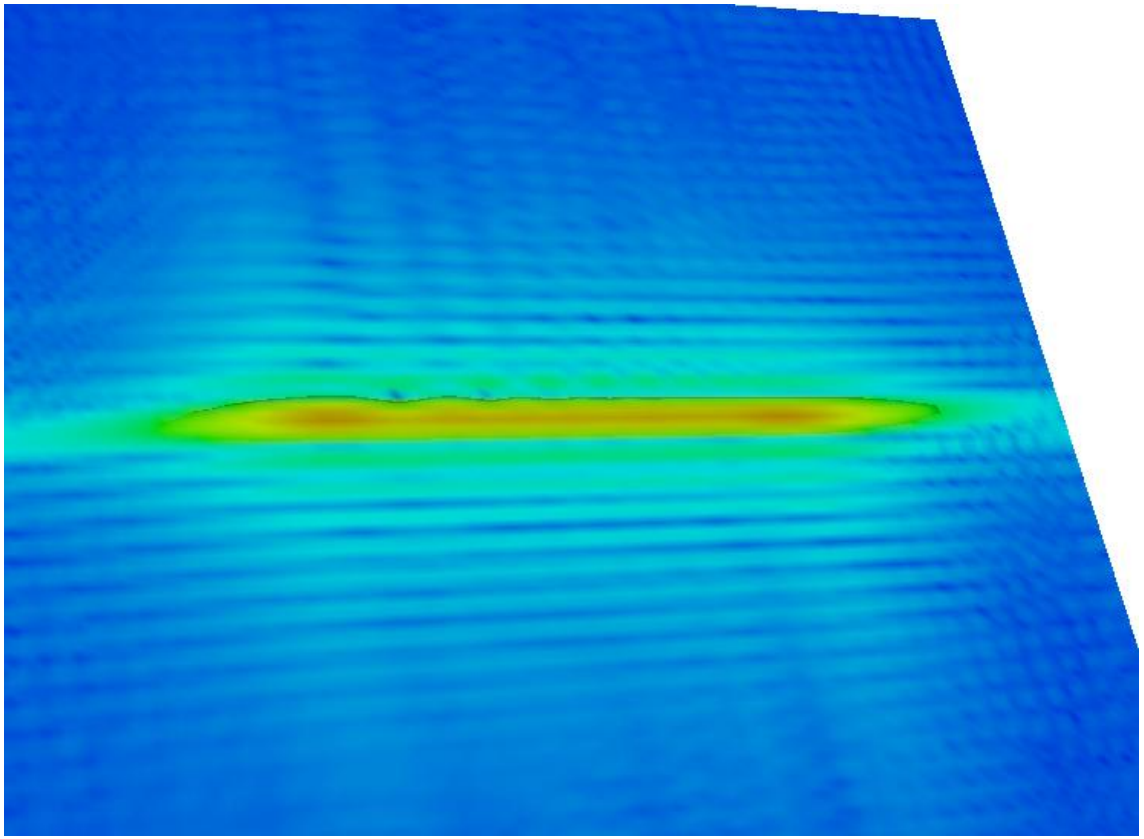




FFT simulations of phase objects

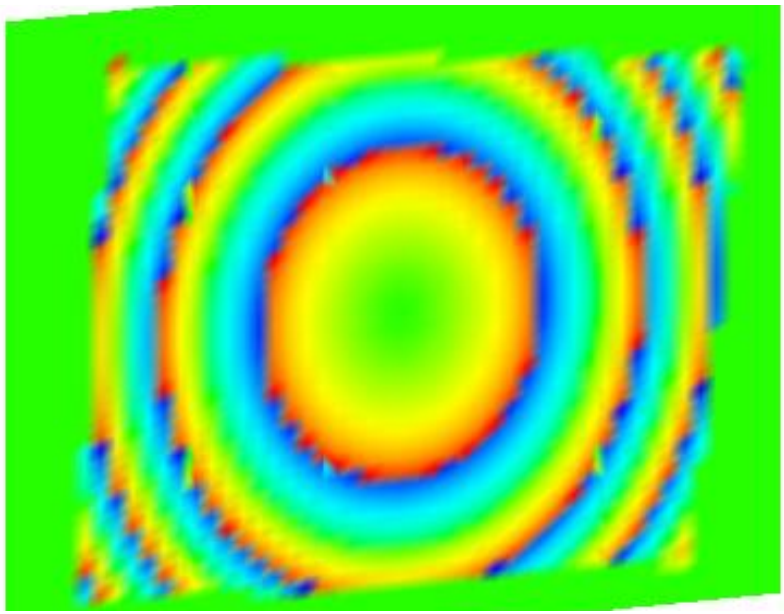
128x128x128 array 20x20x20 cube rotated (0.05 rad)^3

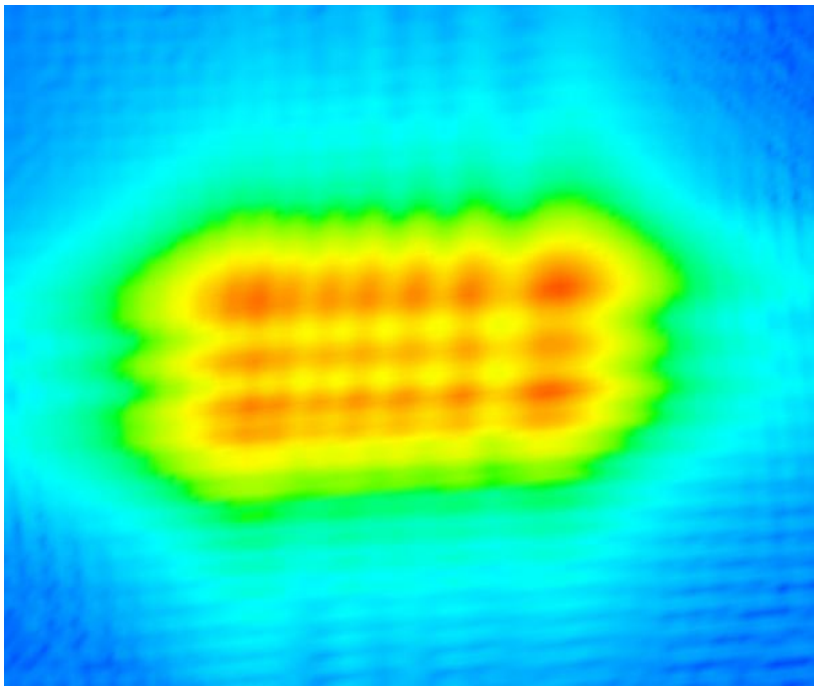




FFT simulations of phase objects

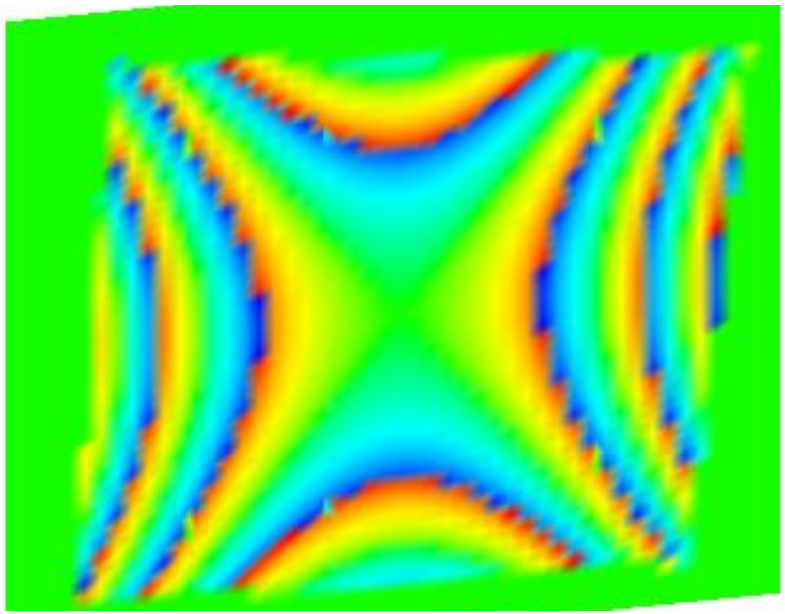
128x128x128 array 20x20x20 cube rotated (0.05 rad)^3
n=5 curX=0.03 curY=0.02

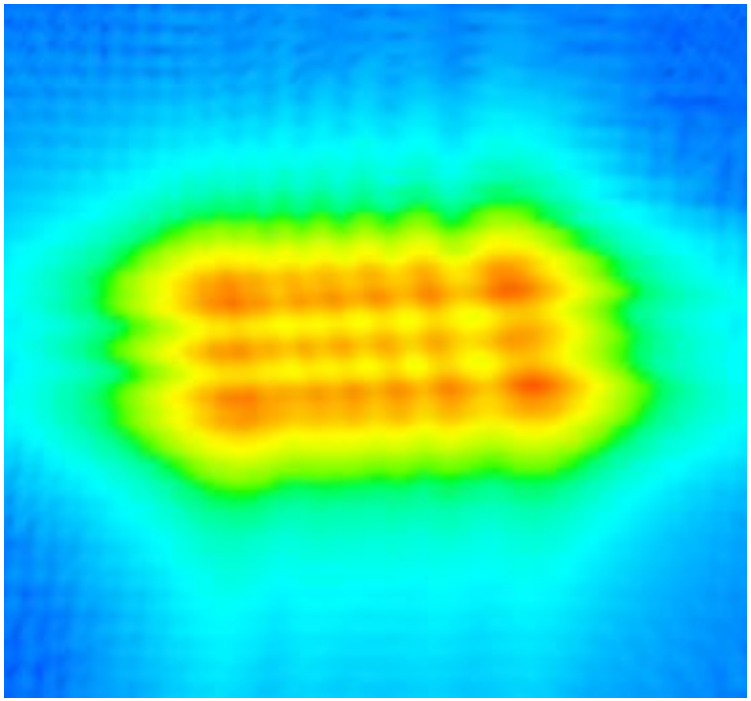




FFT simulations of phase objects

128x128x128 array 20x20x20 cube rotated (0.05 rad)^3
n=6 curX=0.03 curY=-0.02

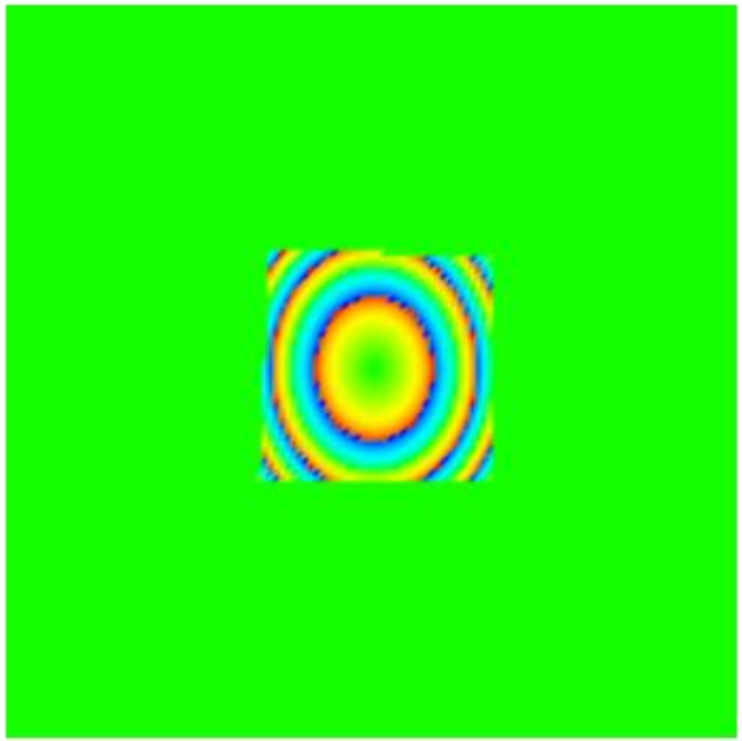


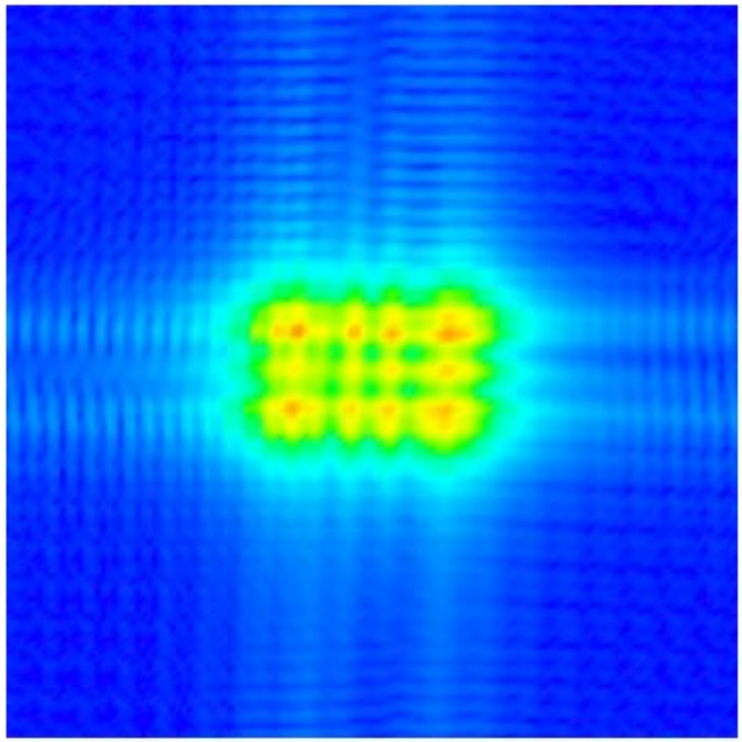


FFT simulations of phase objects

128x128x128 array 20x20x20 cube rotated (0.03 rad)^3

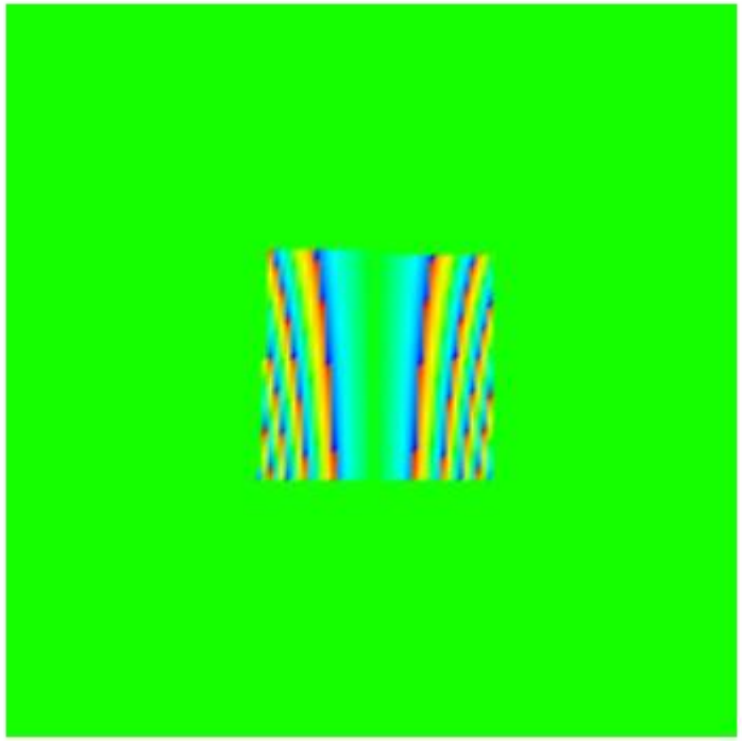
n=8 curY=0.02 curZ=0.03

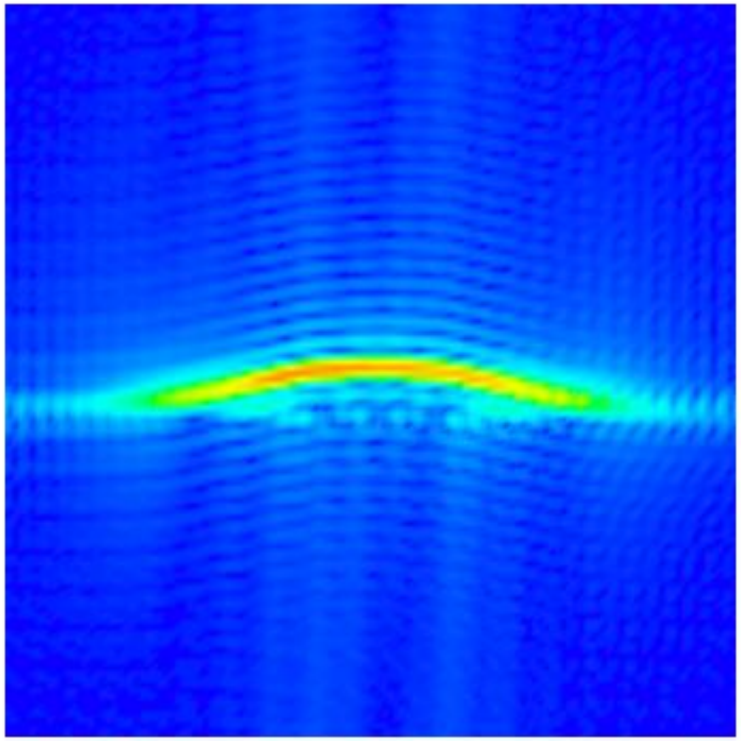




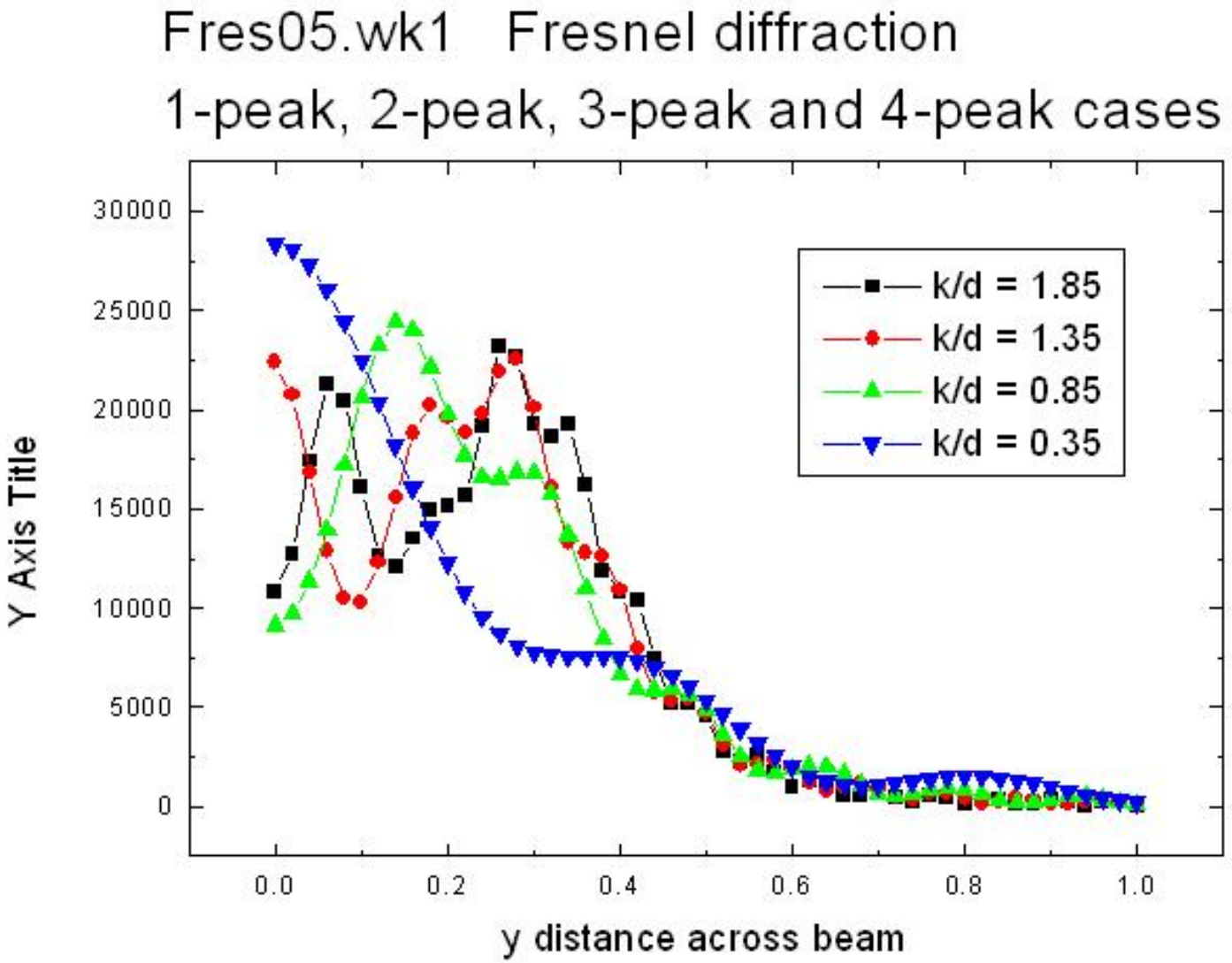
Poly_quad_ph2 curved phases

curY=50 curZ=0.001, (y-curY)*curZ*z*z





Evaluate Fresnel Integral Directly



Proposed Phasing Method (see Clare's poster)

- Estimate phase curvature in XYZ
  - Fringe counting, simple modelling
- Estimate support from fringe spacing
- On each cycle of support-based ER/HIO:
  - Offset estimated phase structure
  - Apply Fourier modulus constraint
  - Remove estimated phase structure again

Andrey Minkevich (KFA Karlsruhe)

preprint http://arxiv.org/abs/0909.4711

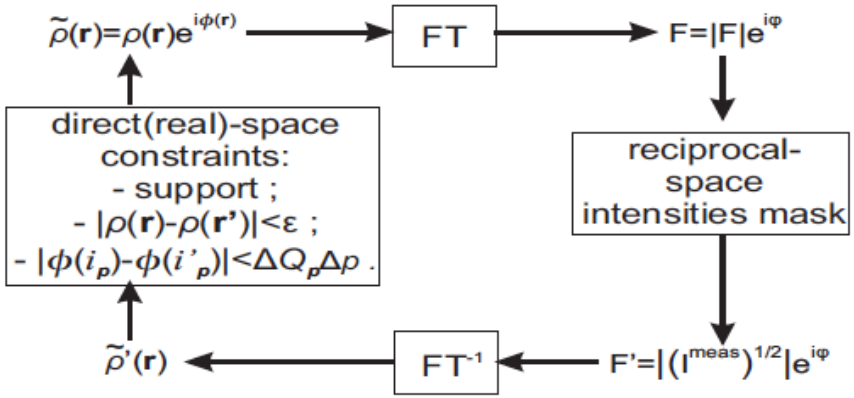
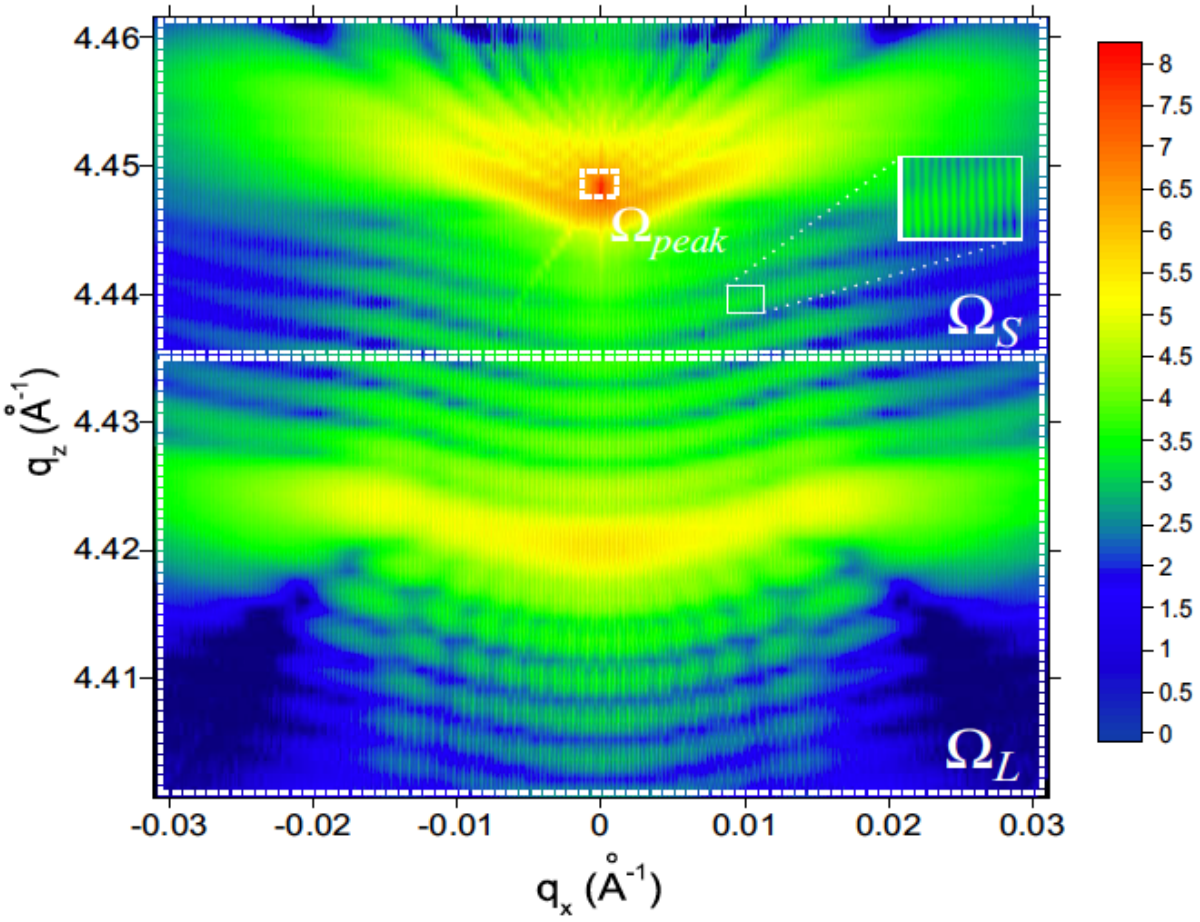


FIG. 1: Schematic diagram of the iterative loop of our phase retrieval algorithm. **r** and **r'** in "direct(real)-space constraints" box correspond to the neighbouring points within one constituent crystal and ϵ defines the threshold of electron density uniformity. i_p and i'_p are the neighbouring points along p-direction (normally lateral or vertical) and Δp corresponds to the step along this direction (achieved resolution).

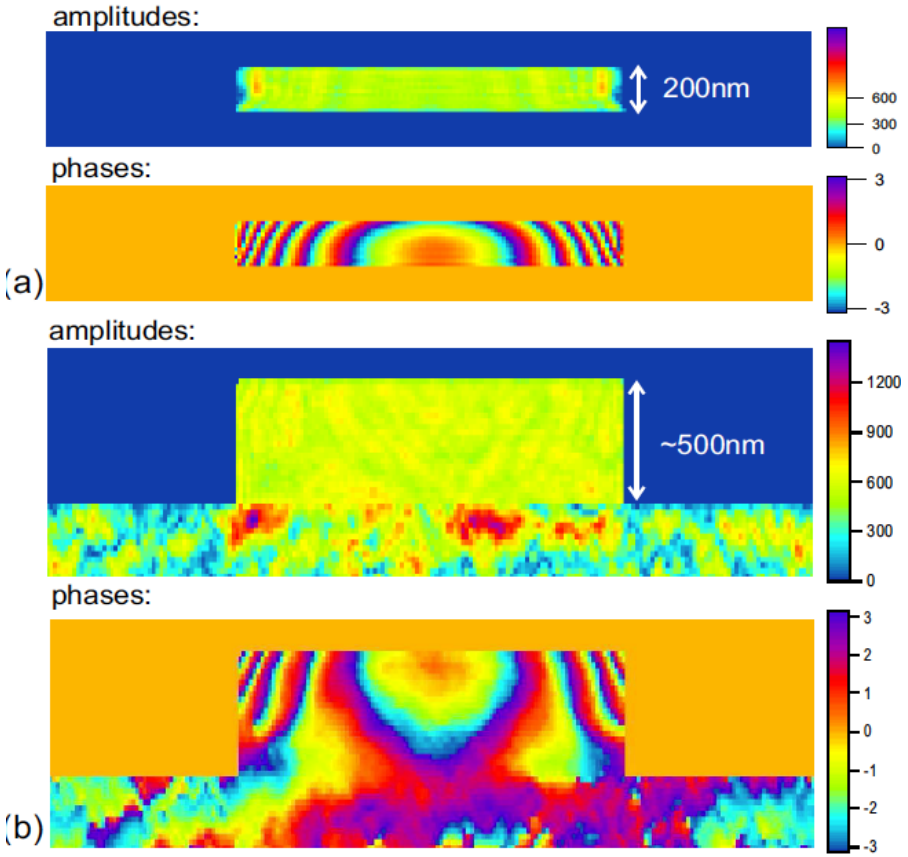
Andrey Minkevich (KFA Karlsruhe)

GaMnAs wires on GaAs



Andrey Minkevich (KFA Karlsruhe)

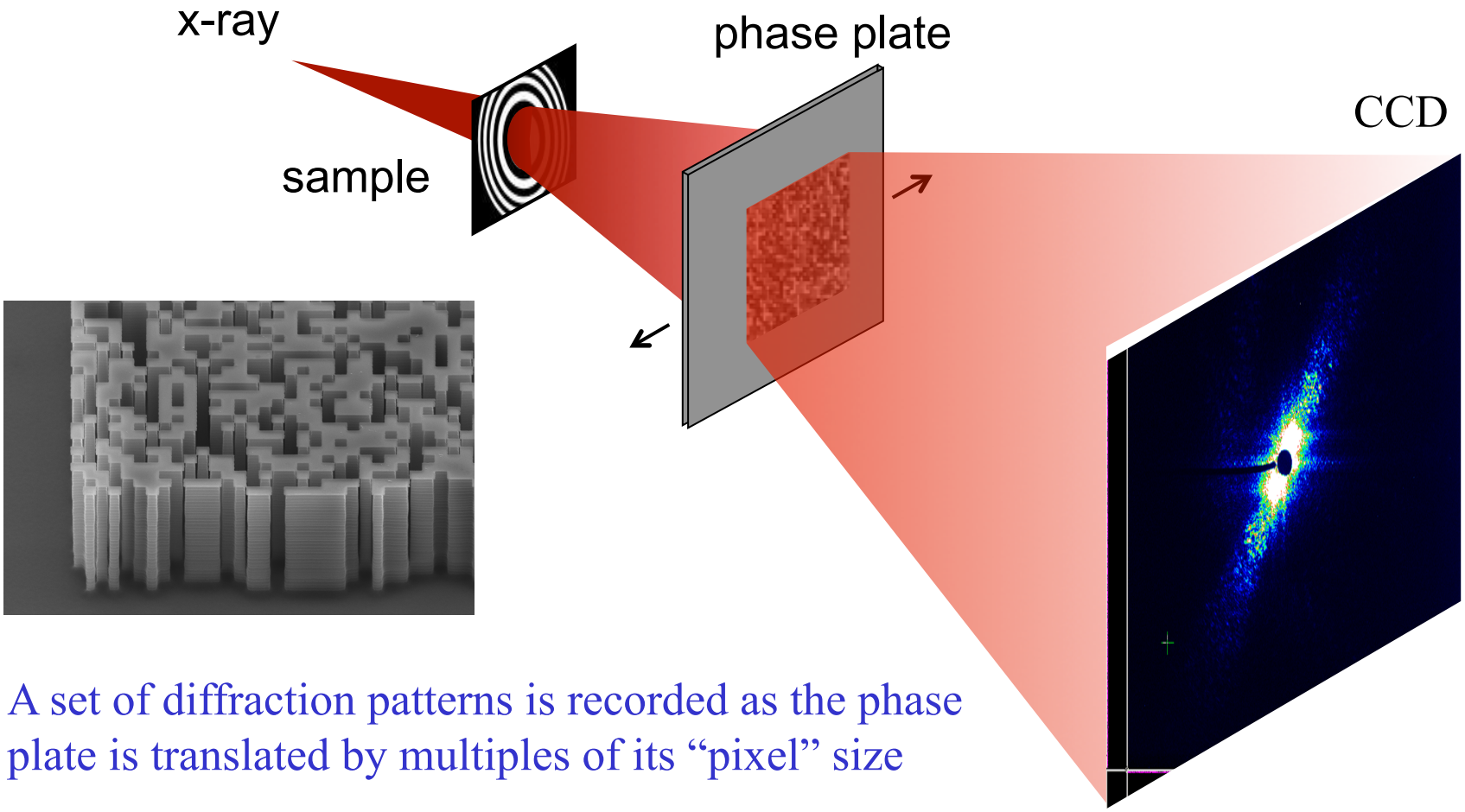
preprint http://arxiv.org/abs/0909.4711



Imaging by Wavefront Modification

F. Zhang et al., Phys Rev A 75 (2007)

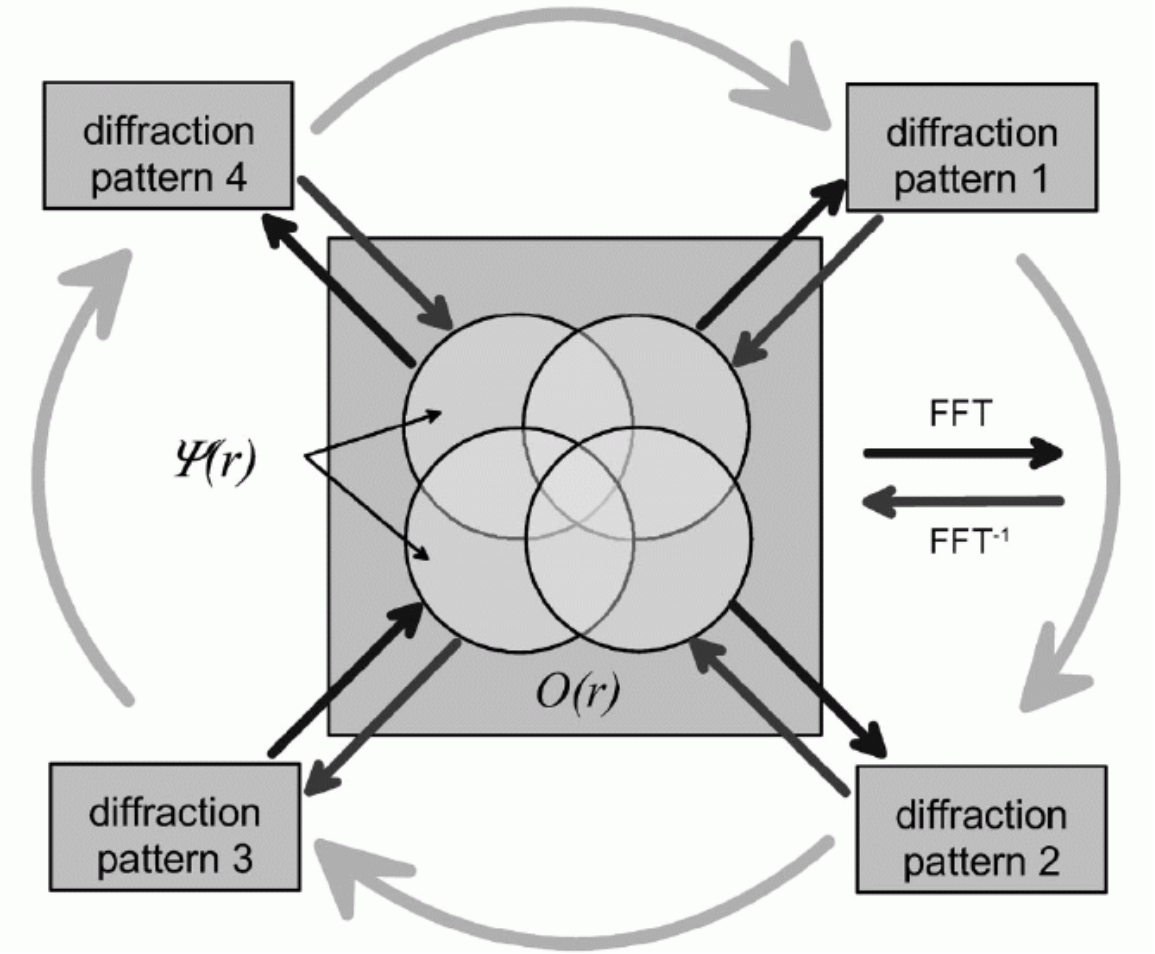
I. Johnson et al., Phys Rev Lett 100 (2008)



A set of diffraction patterns is recorded as the phase plate is translated by multiples of its “pixel” size

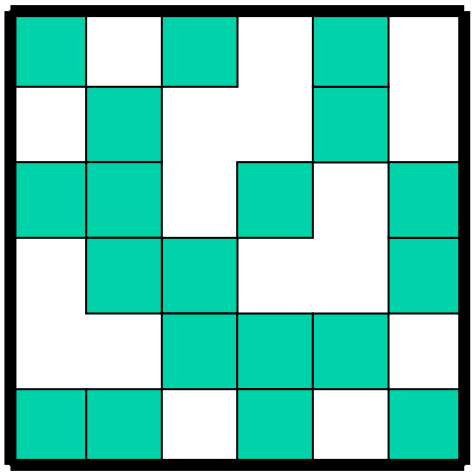
X-ray Ptychography

J. M. Rodenburg et al, Phys. Rev. Lett. 98 034801 (2007)

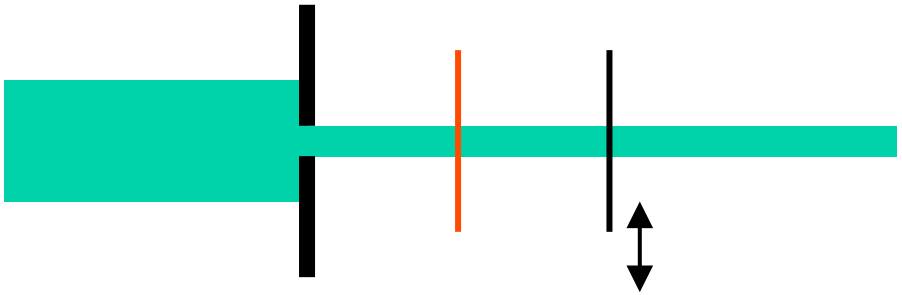


‘Random’ phase plate analyser

Joan Vila (PSI), Fucai Zhang (Sheffield)



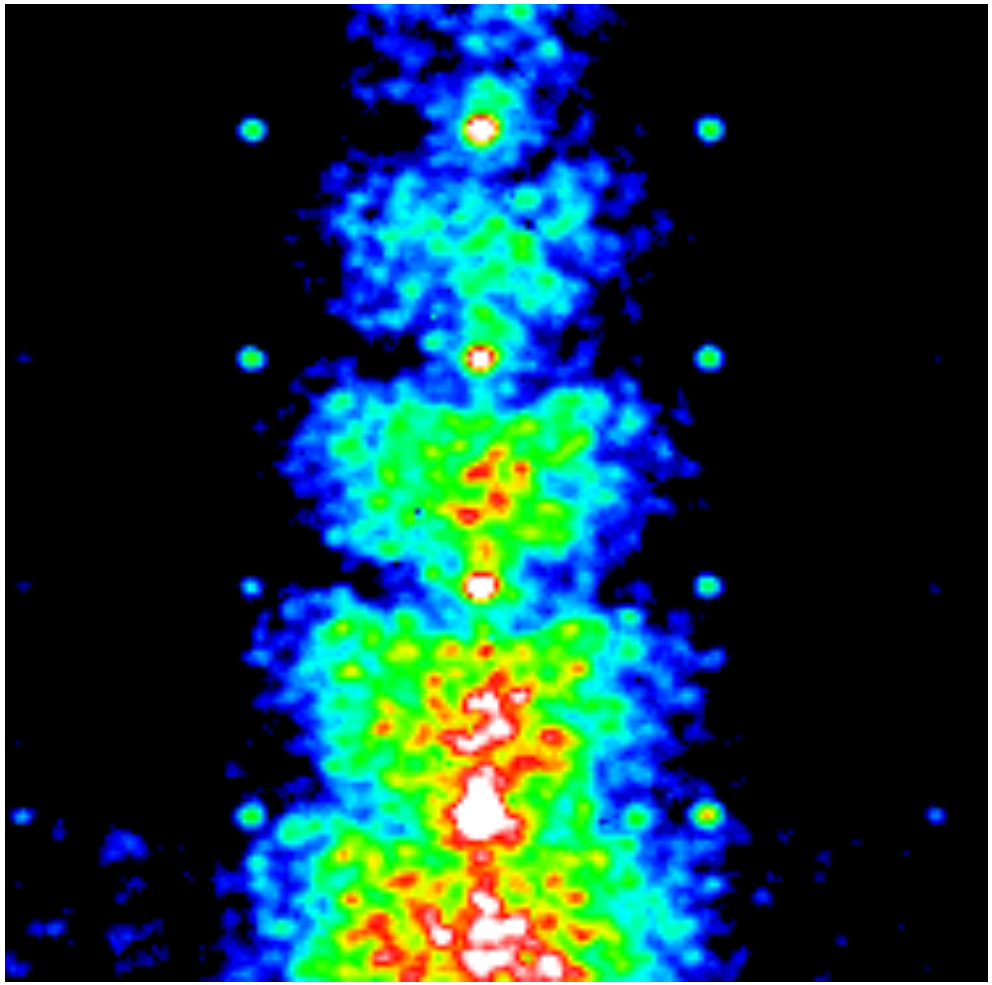
1 μm

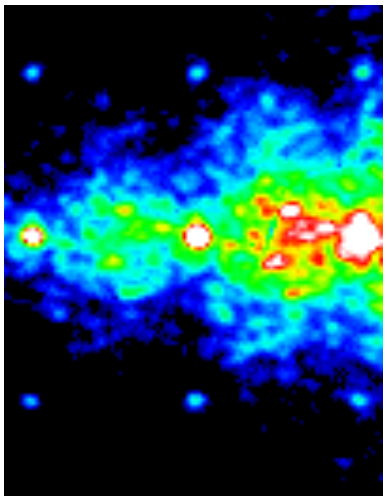


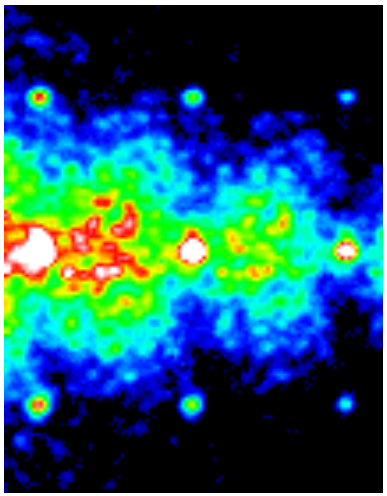
Pinhole Sample Analyser

Phase plate scan near forward direction

1μm step per frame

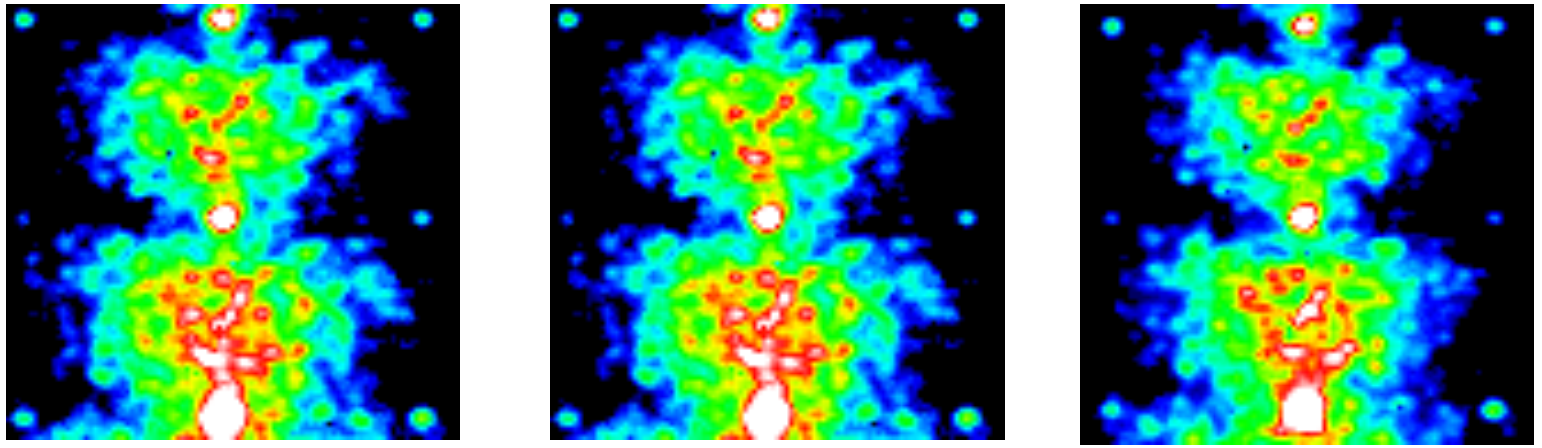






Collagen, buffer and empty cell

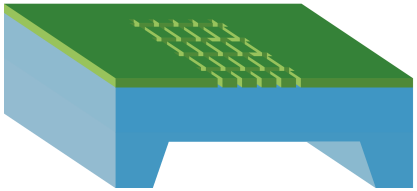
phplateFZP-236, -246 and -249



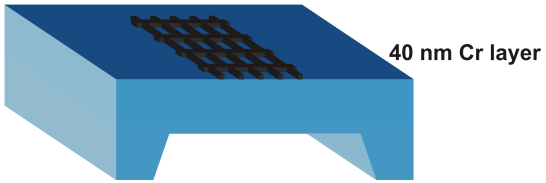
Phase plate fabrication

Joan Vila-Comamala, PSI

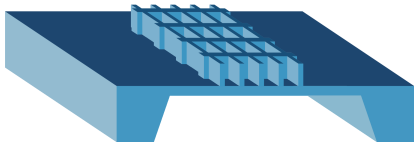
1) e-beam lithography



2) Pattern transfer to a Cr layer by evaporation and lift-off



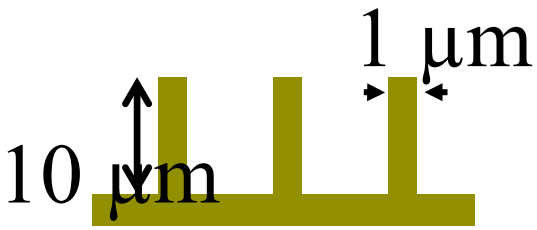
3) Pattern transfer to Si by RIE



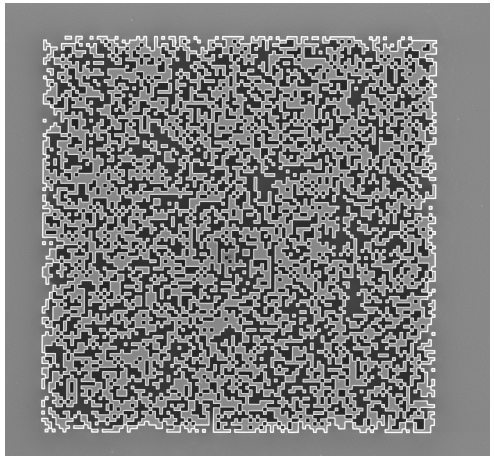
(Reactive Ion Etching)

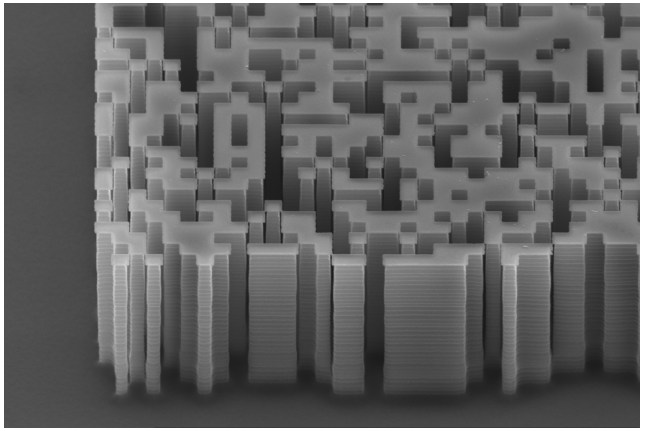
At 8.0 keV (λ=0.155 nm) → $\delta = 7.67 \cdot 10^{-6}$ **h=10.10 µm**

At 10.0 keV (λ=0.124 nm) → $\delta = 4.88 \cdot 10^{-6}$ **h=12.70 µm**

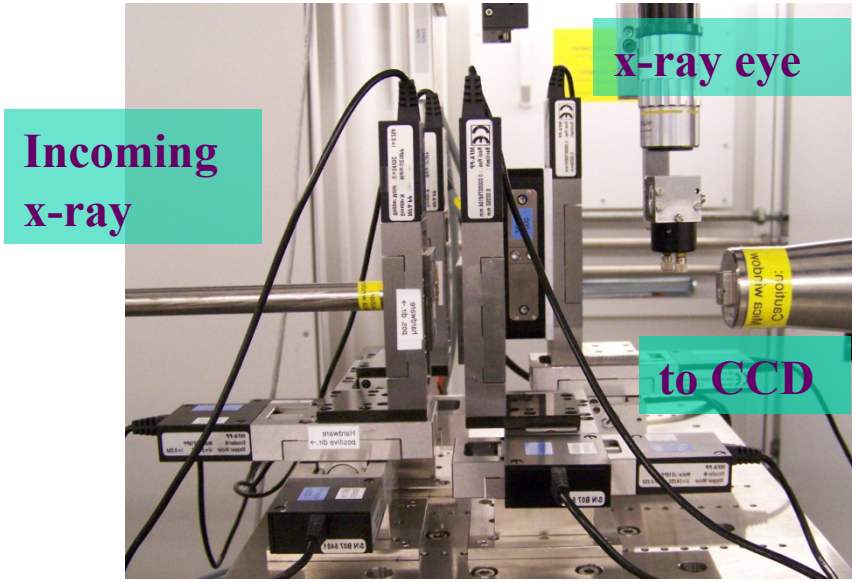


Cross section

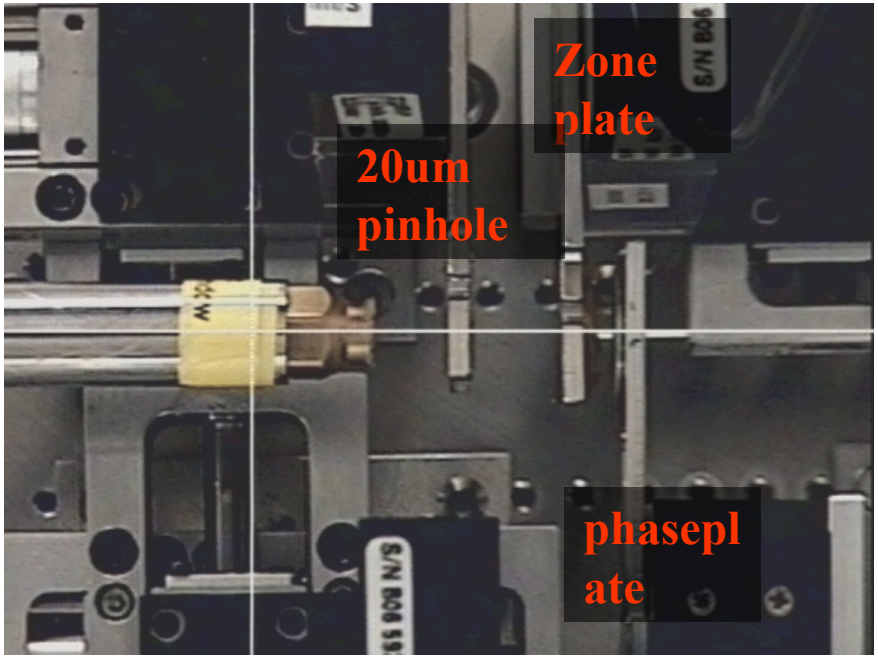




Experimental setup cSAXS (SLS)

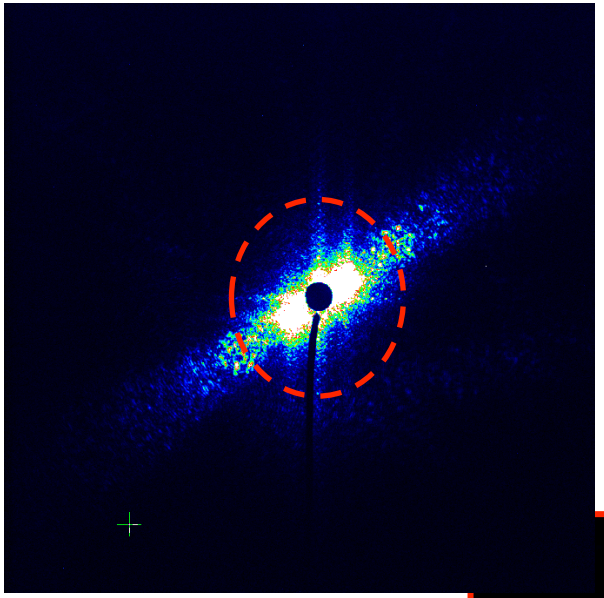


Side view

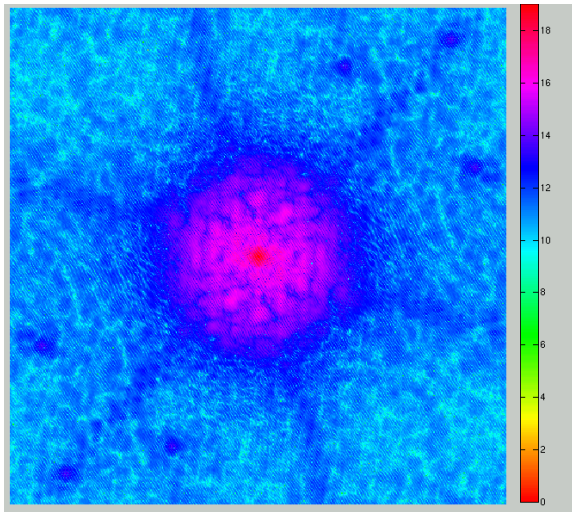


Top view (zoomed in)

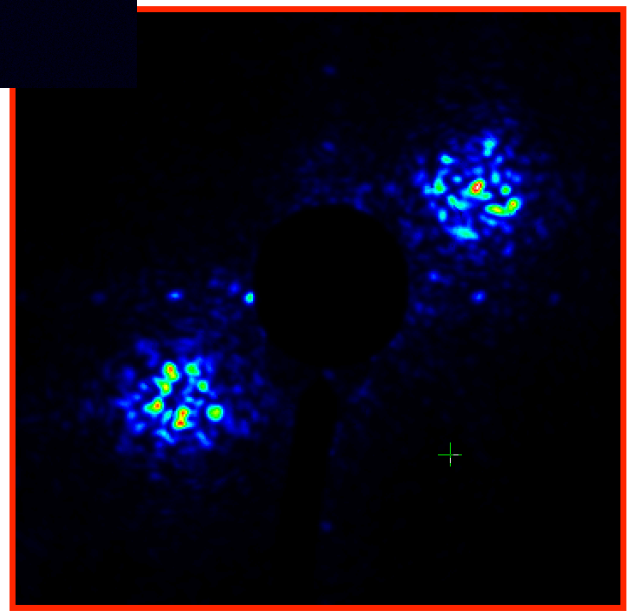
Results: Zone Plate as object



FT

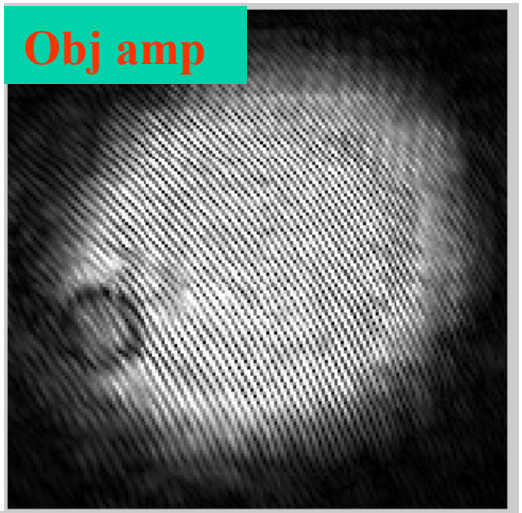


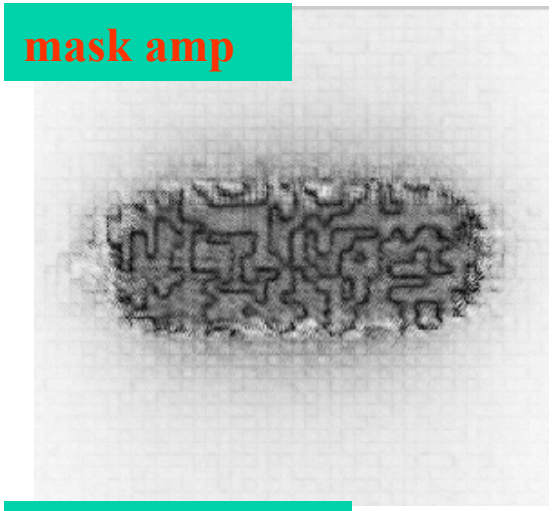
Auto correlation function

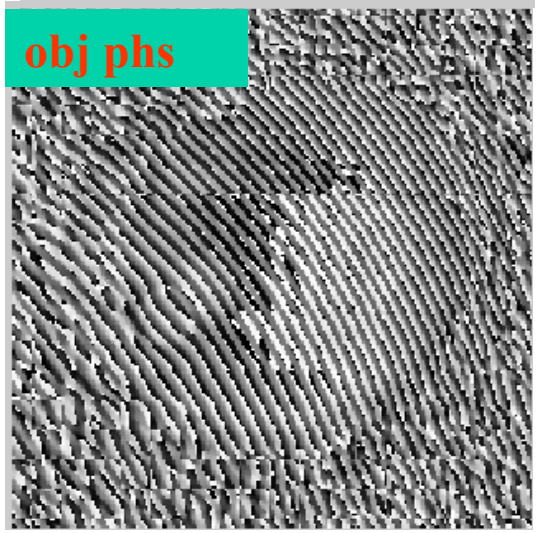


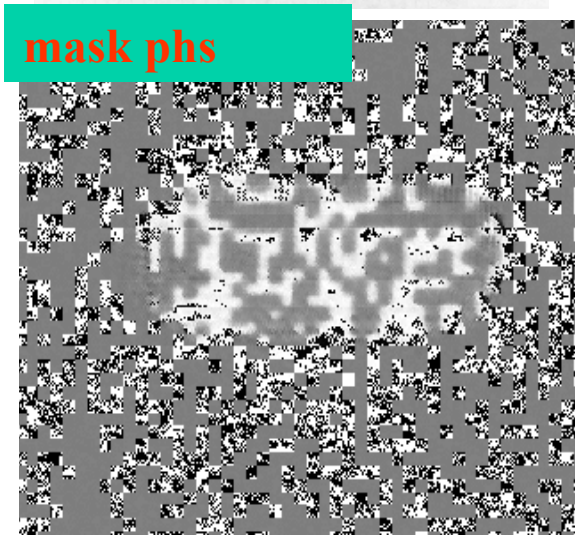
Reconstruction of Phase plate scan

1μm step per frame (512x512)



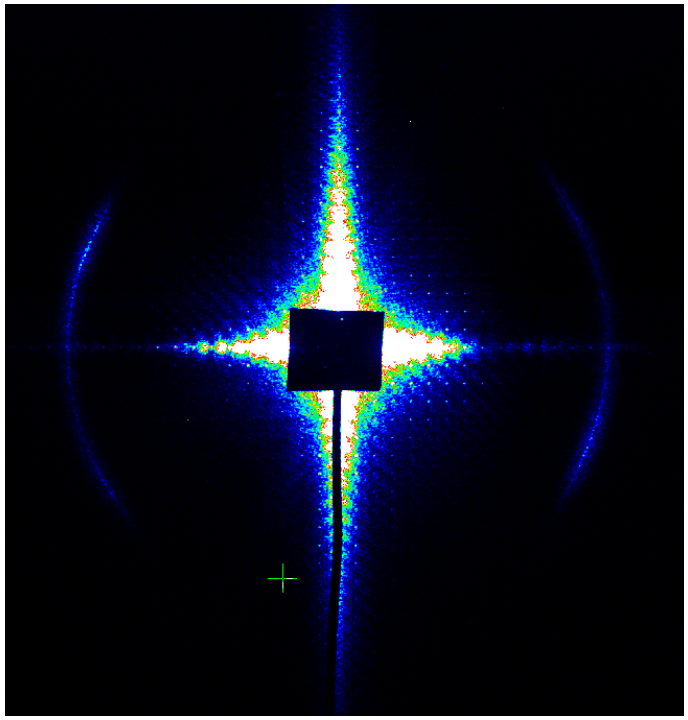


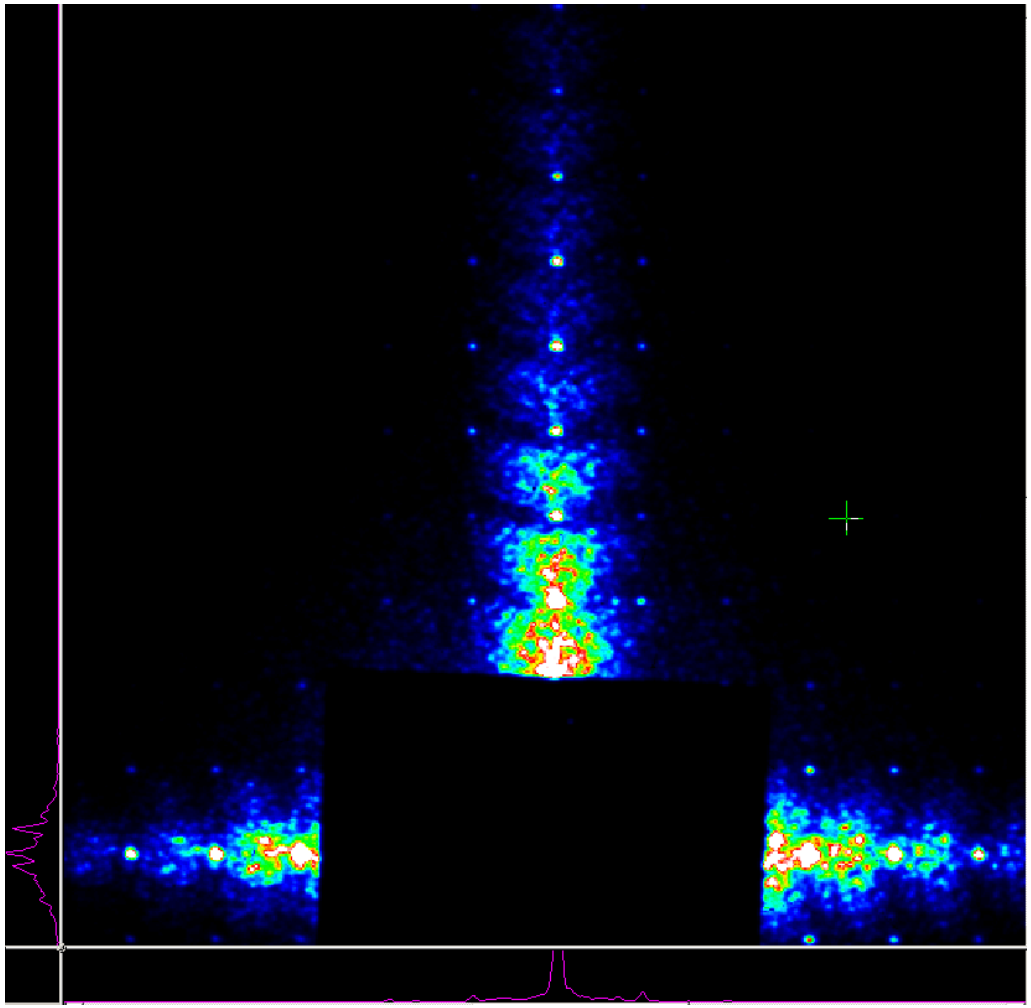




Reconstruction by F. Zhang (paper in preparation)

Collagen rat tail tendon as sample

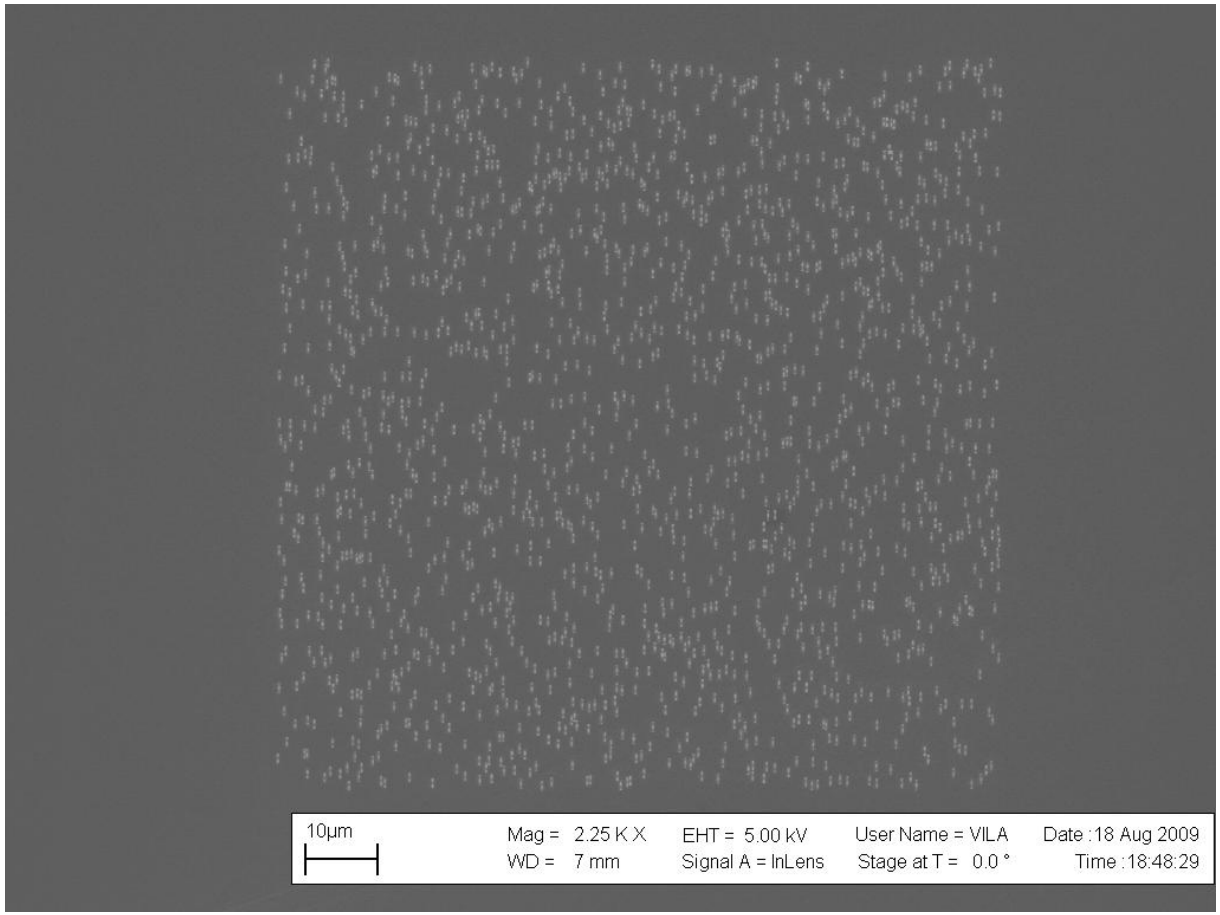




*** 0th order “repeated” in the meridian and equator**
*** Strong phase modification due to phase plate!**
*** No successful reconstruction**

New phase plate design

R. Bean and J. Vila-Comamala, PSI



Pixel size = 10 nm
Total size = 100 x 100 microns^2

Motif = 7 rectangles (200 nm x 100 nm), period of 200 nm (close to 3rd collagen diff order)

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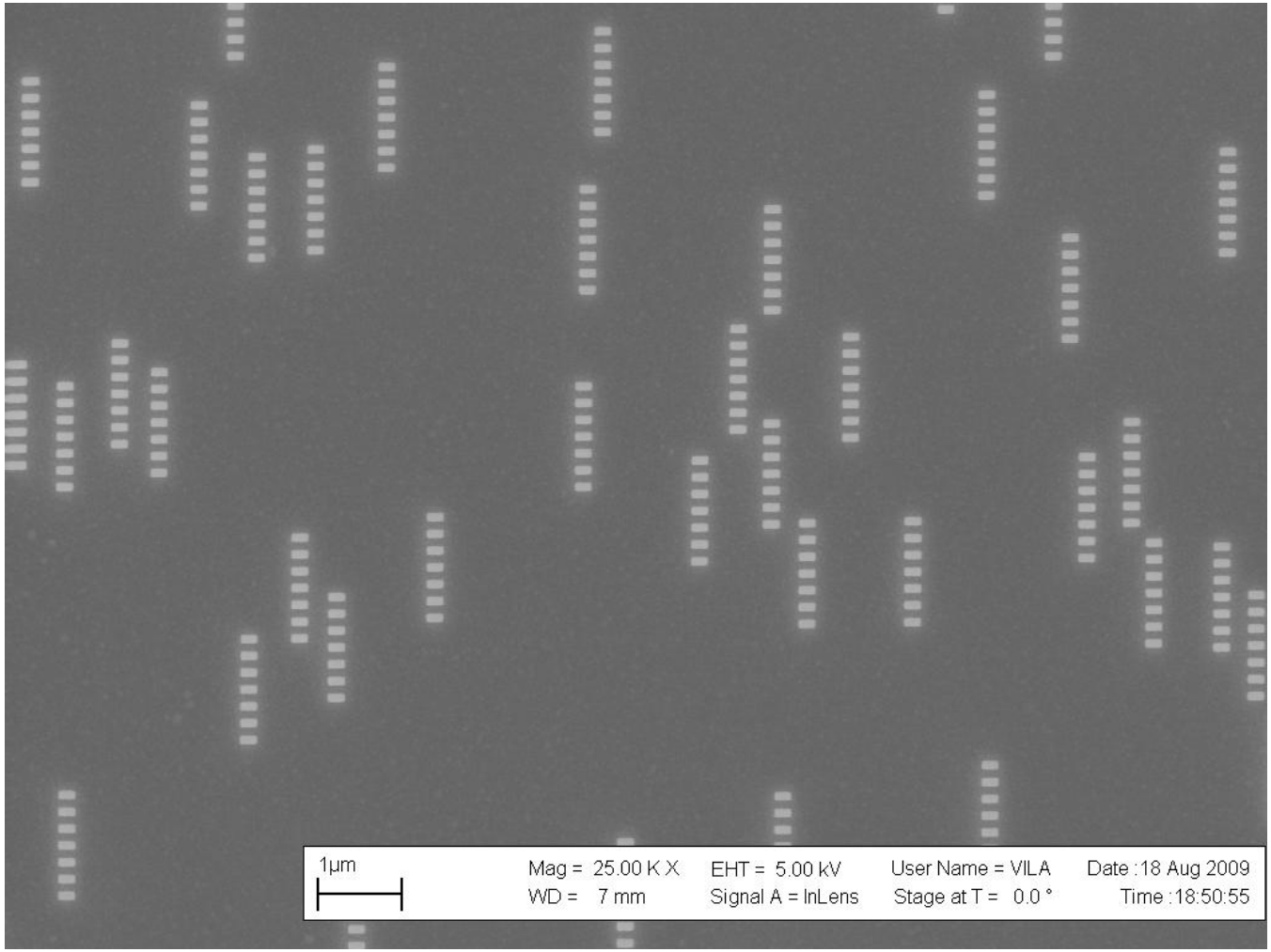
New phase plate design

R. Bean and J. Vila-Comamala, PSI



New phase plate design

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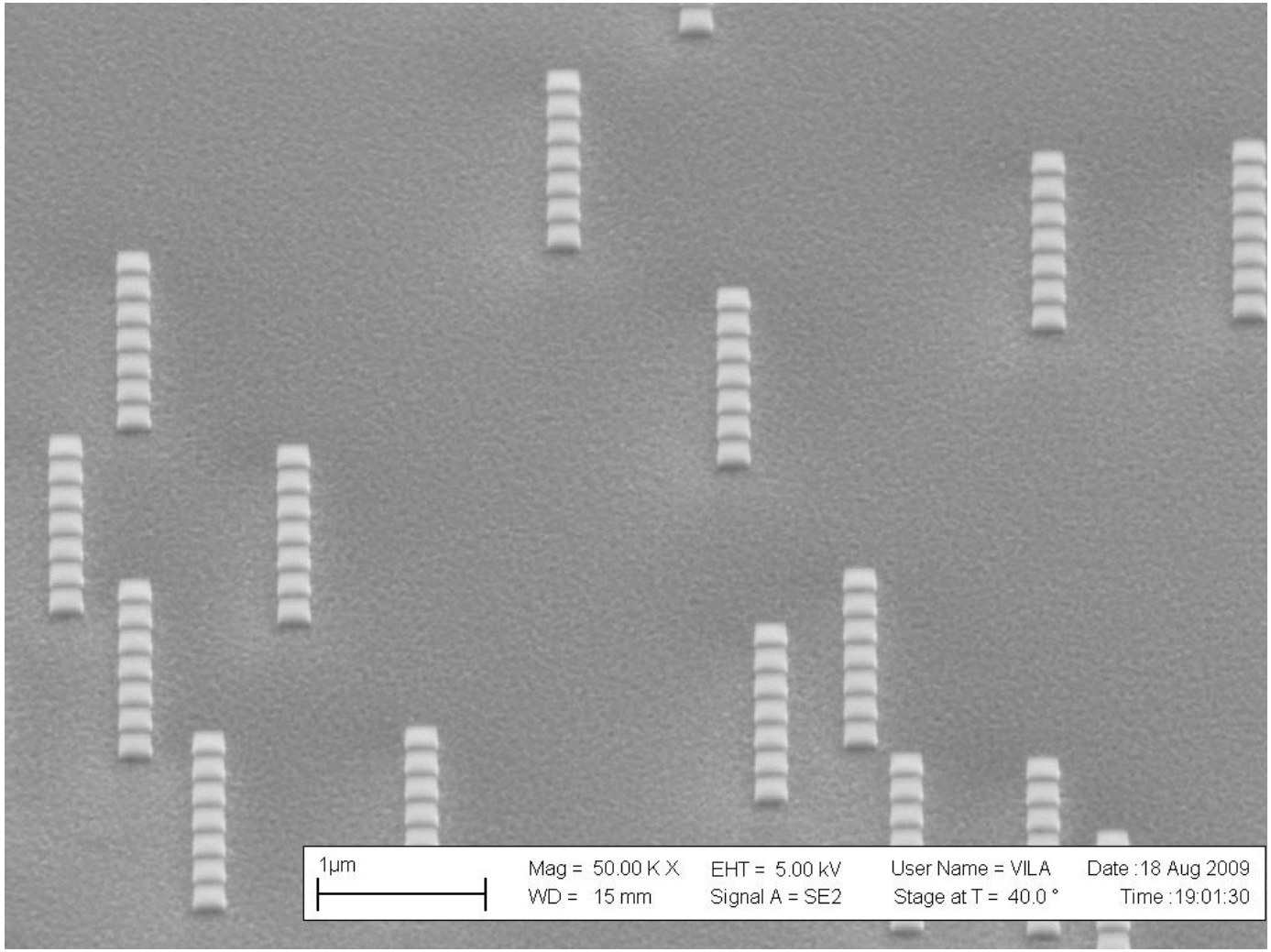

Conclusions

- Small crystal imaging
- Strains visible as real-space phase
- Ptychography reveals probe structure also
- Phase plate demonstrated
- New custom phase plates
- Preparations under way for XFEL