Diamond Update: Surface and Interface Beamlines

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Diamond Light Source

Argonne SIS group pizza lunch
21 April 2009

Outline

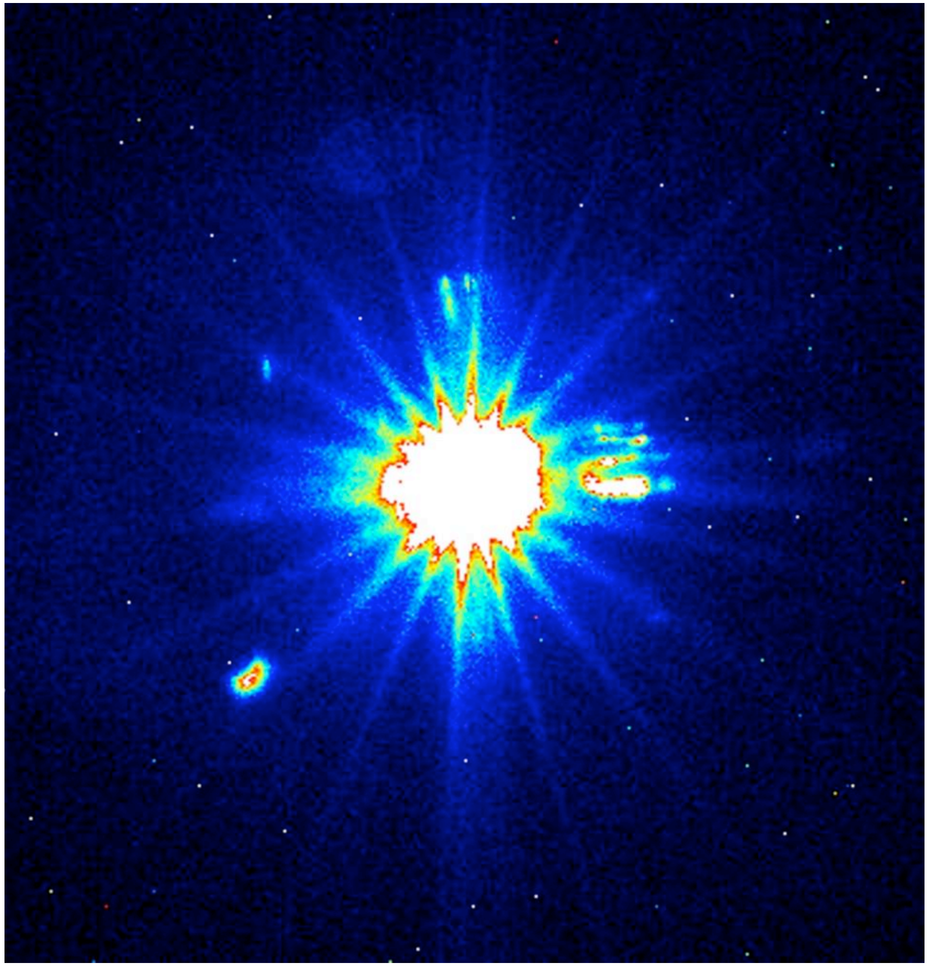
- Coherent X-ray Diffraction
- Imaging of small crystals and strain fields
- Domain speckle patterns
- X-ray Ptychography
- Pulsed field experiments

Diamond Light Source (RAL)

Last Girder – March 2006

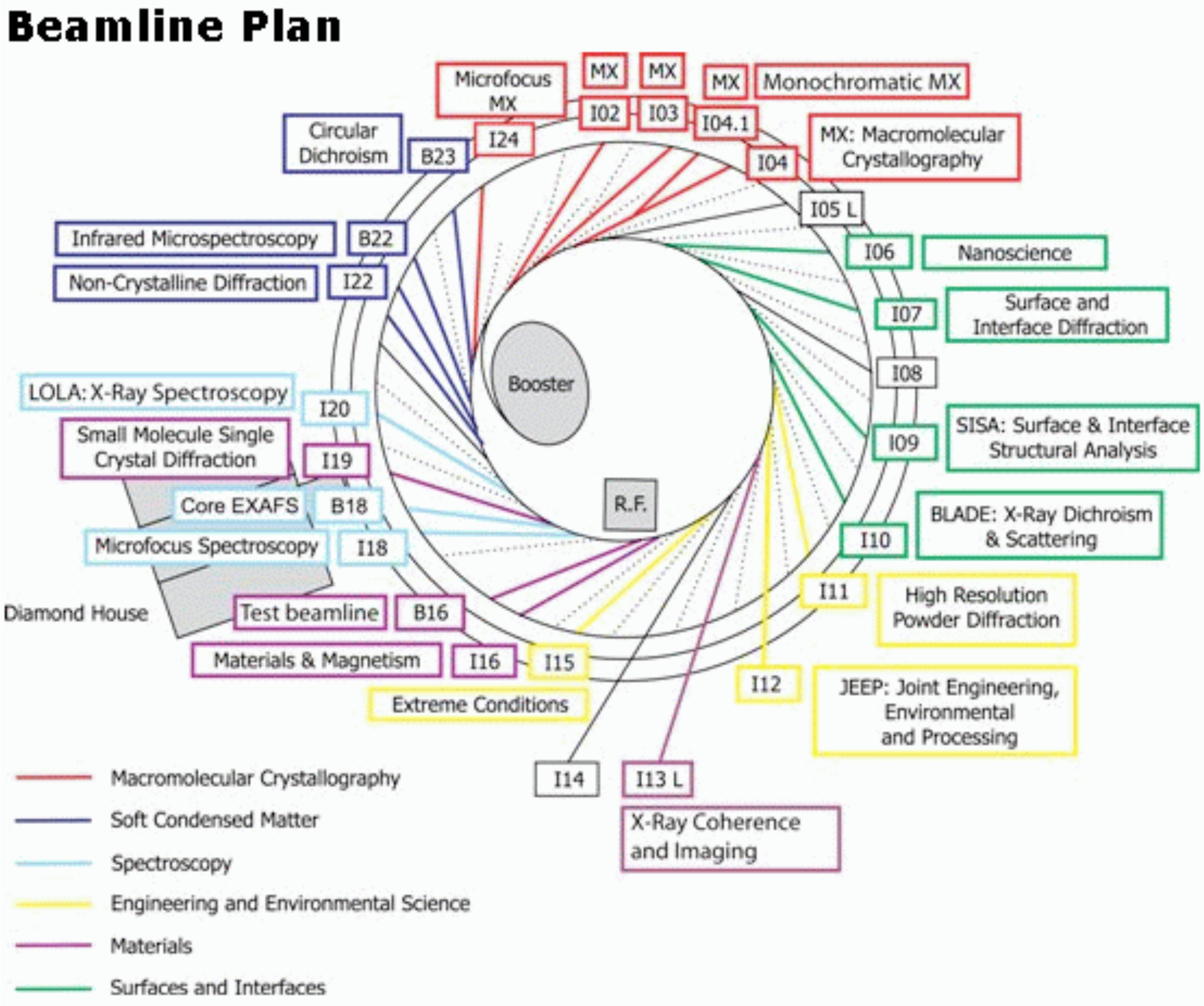
“First Light” - May 2006

ramped to 3GeV – Sept 2006



Diamond in-vacuum X-ray Undulator

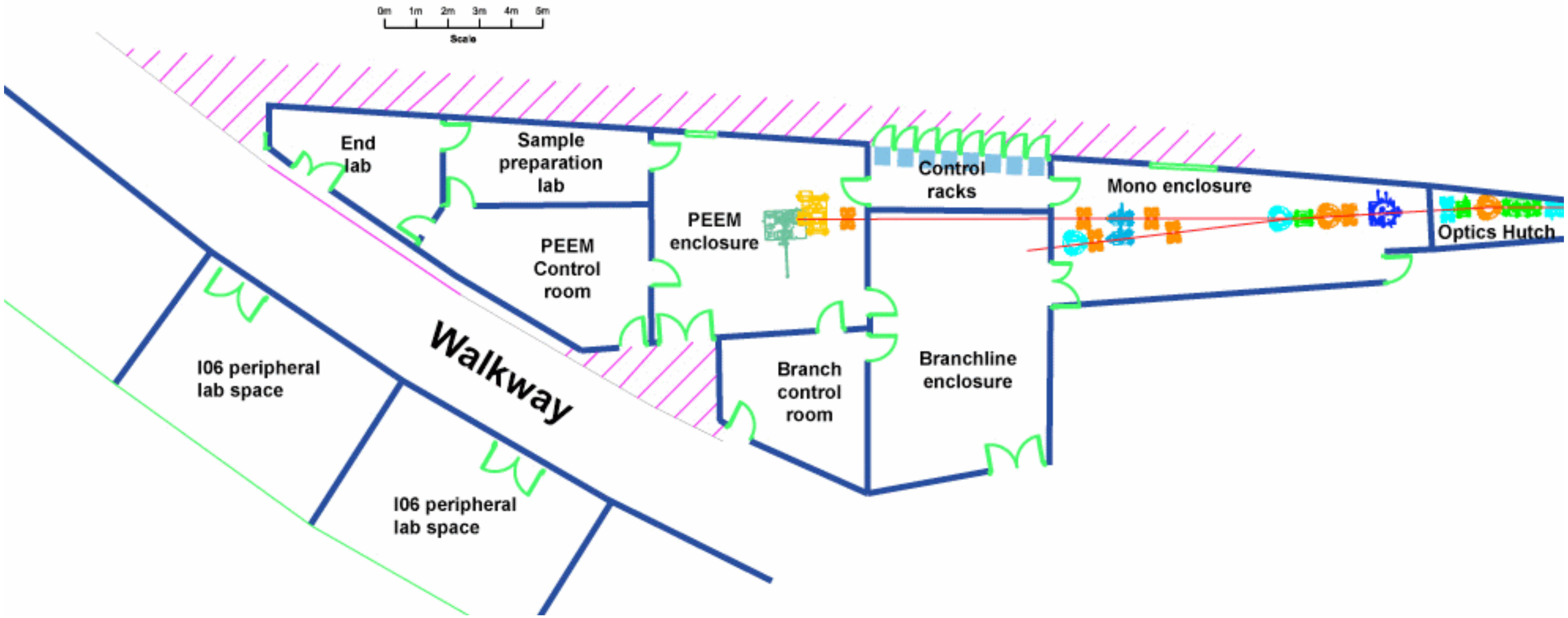
Diamond Floor plan



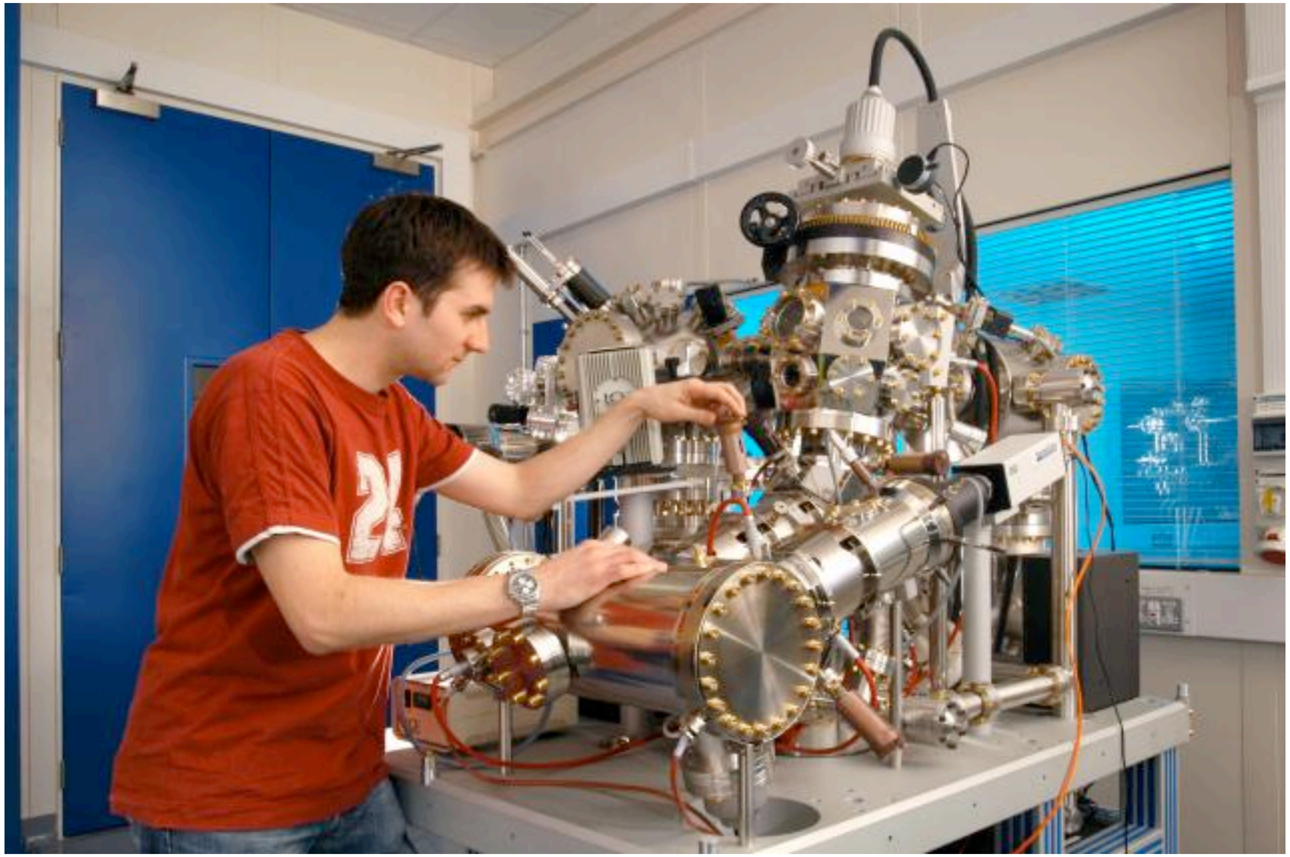
Surface and Interface Village

- I-06 (1/2007) Nanoscience, Sarnjeet Dhesi
- I-07 (10/2009) SIXRD, Chris Nicklin
- I-09 (4/2011) SISA, Tien-Lin Lee
- I-10 (10/2010) BLADE, Paul Steadman

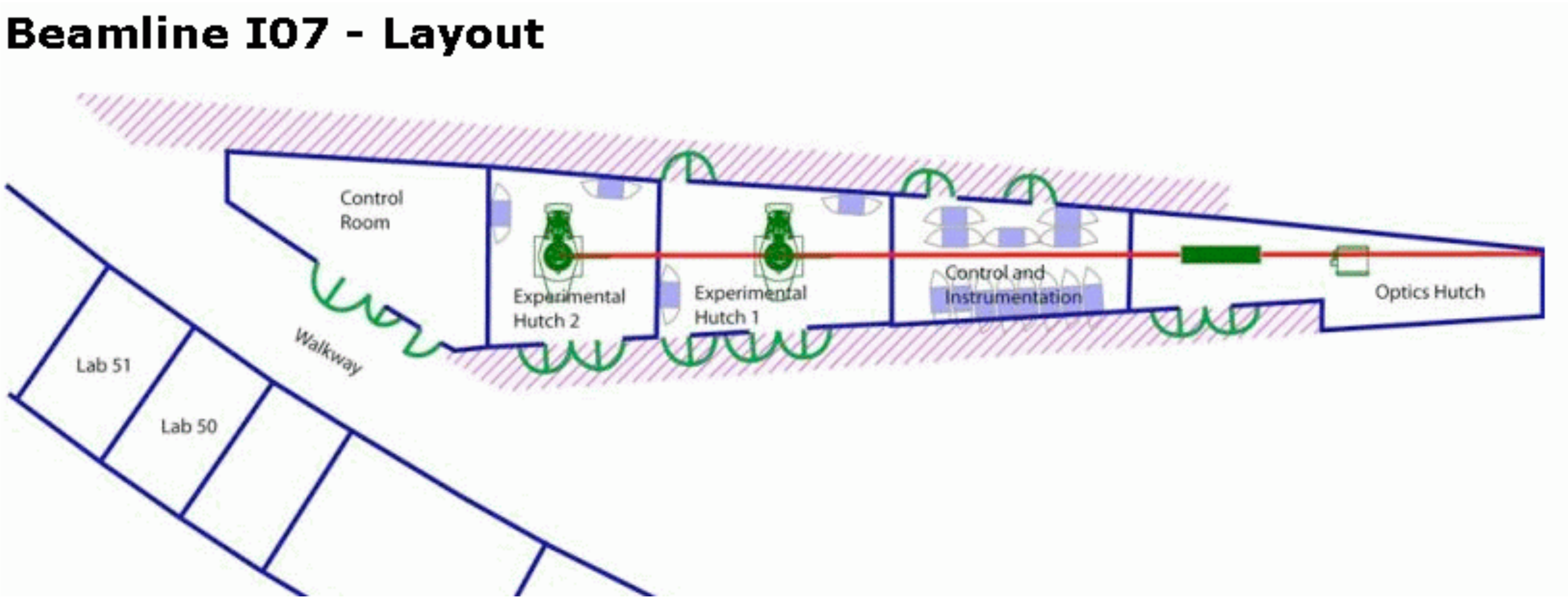
I-06 Nanoscience layout



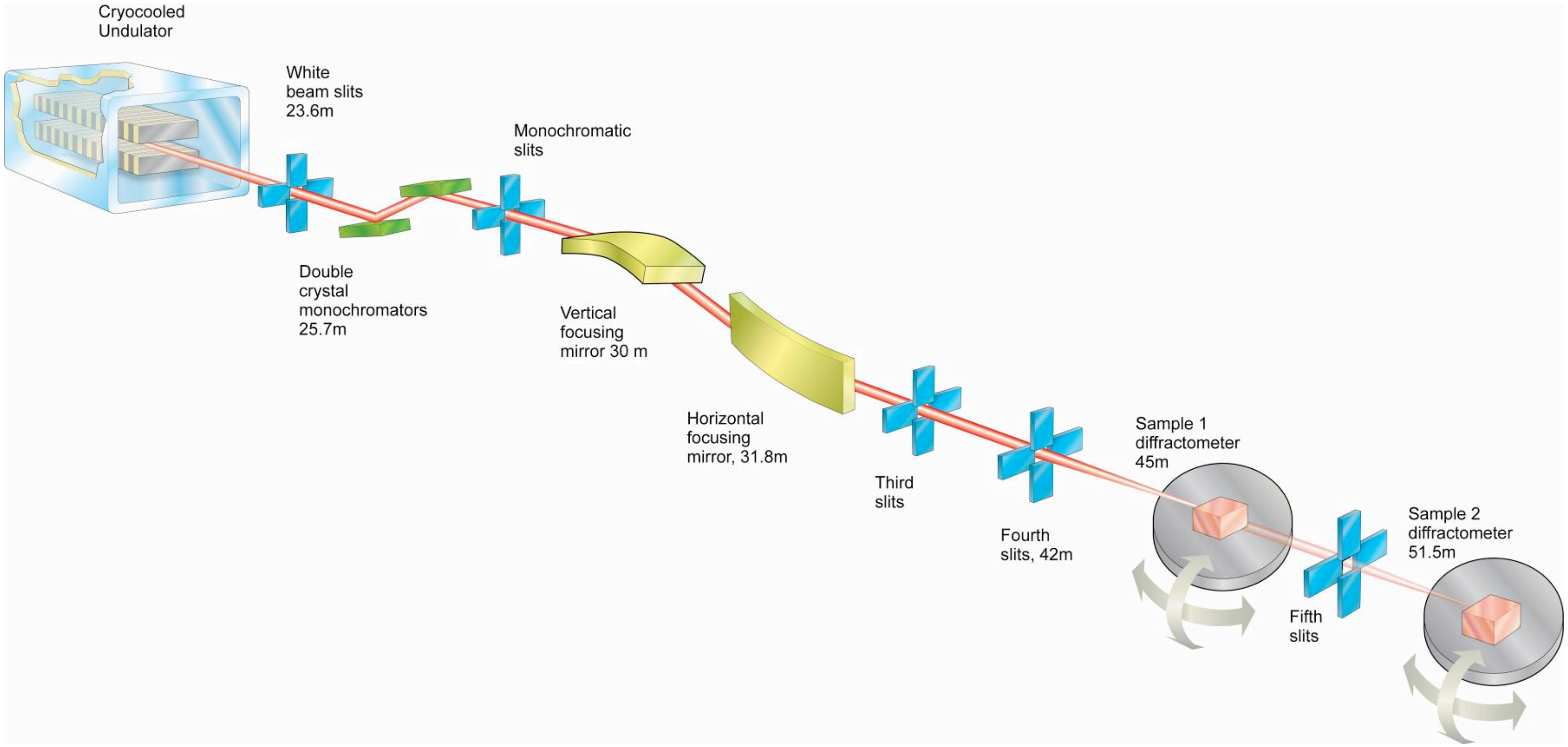
I-06 Nanoscience PEEM instrument



I-07 Surface-Interface XRD



I-07 Surface-Interface XRD optics



I-07 experimental Hutch 1

- Hexapod or Eulerian cradle (load capacity: <50kg vertical mounting; <200kg horizontal mounting)
- Horizontal or vertical scattering geometry
- Scattering from liquid surfaces, Qz <1Å-1
- Ultrahigh vacuum baby chamber
- Closed cycle cryostat (10 - 800 K)
- Controlled atmosphere environments
- Furnace (300 – 1500K)
- Electrochemical and solid-liquid cells
- Liquid and Langmuir troughs

I-07 experimental Hutch 2

- 2+3 Circle Diffractometer
- Hexapod sample stage
  Vertical Scattering Geometry
- Large ultrahigh vacuum sample chamber (removable)
  - Ability to mount other ‘large’ chambers
  - In situ preparation and characterisation using standard surface science techniques.
  - Sample heating up to ~1800K

I-07 supporting Lab

- Nima Langmuir Trough
- Nanofilm Imaging Spectroscopic Ellipsometer (incorporating Brewster angle microscopy)
- Kruss Drop Shape Analysis Tensiometer
- Laurell Spin Coater
- UV-Ozone cleaner
- Veeco Atomic Force Microscope
- Offline UHV chamber inc, STM, LEED, XPS, etc.

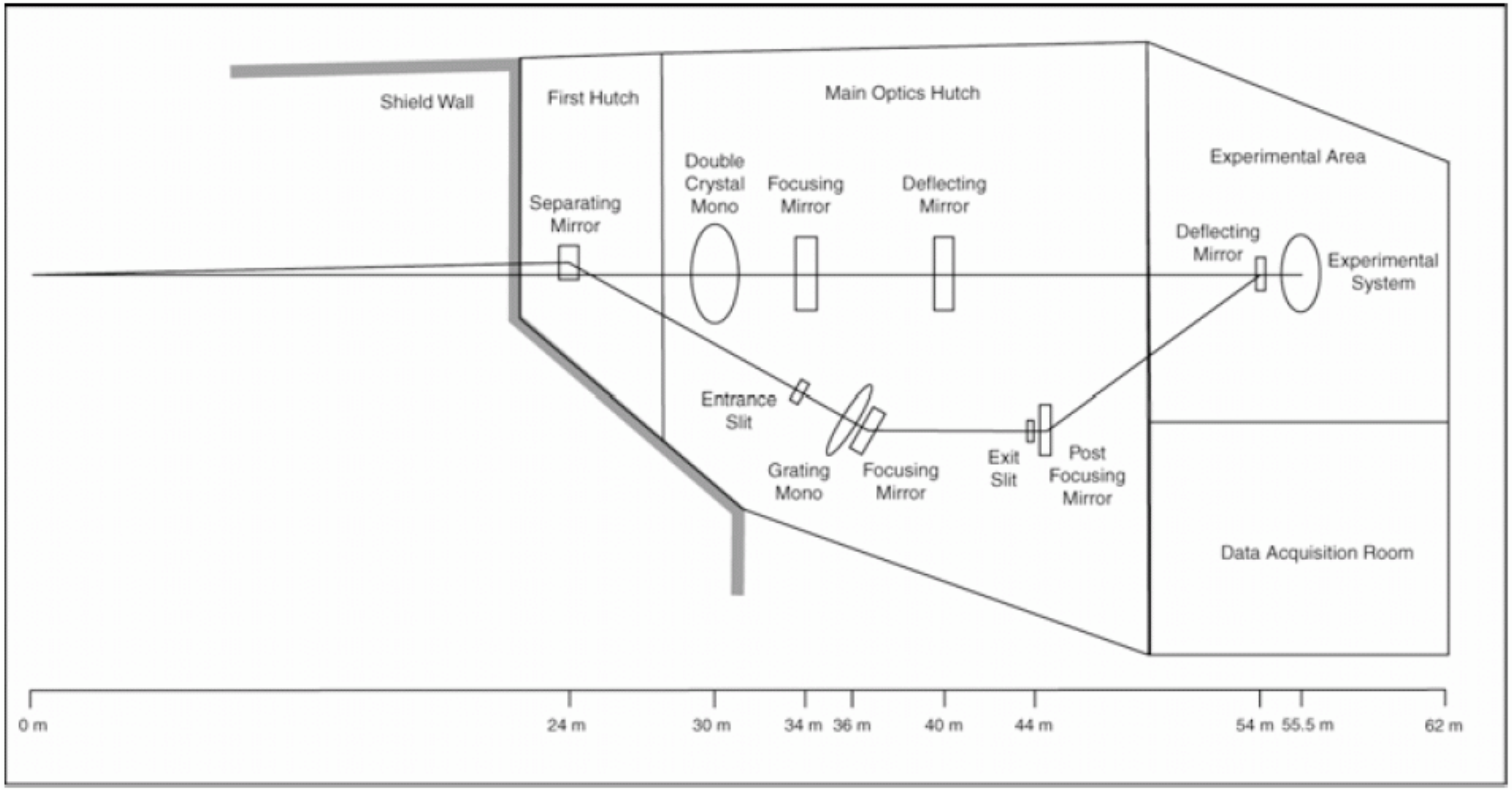
I-07 Surface-Interface XRD

I-09 SISA capabilities

- Core Techniques
  - Near Edge X-ray Absorption Fine Structure (NEXAFS) (also called XANES)
  - Photoelectron Diffraction (PhD)
  - X-ray Standing Wave (XSW)
  - Normal Incidence X-ray Standing Wave (NIXSW)
  - X-ray reflectivity
- New Techniques
  - Depth Profile NIXSW, SEXAFS, XSW and NIXSW
  - Variable Period X-ray Standing Wave (VPXSW) analysis

I-09L SISA floor plan

2 beams on sample, Canted undulators



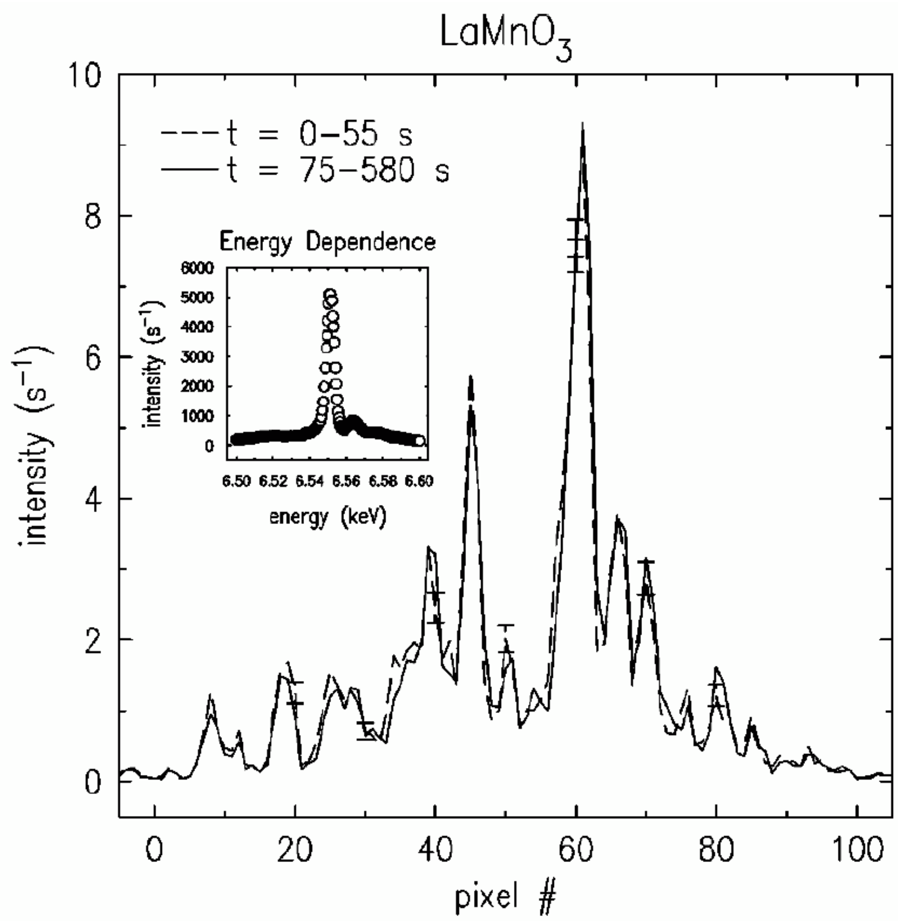
I-10 BLADE

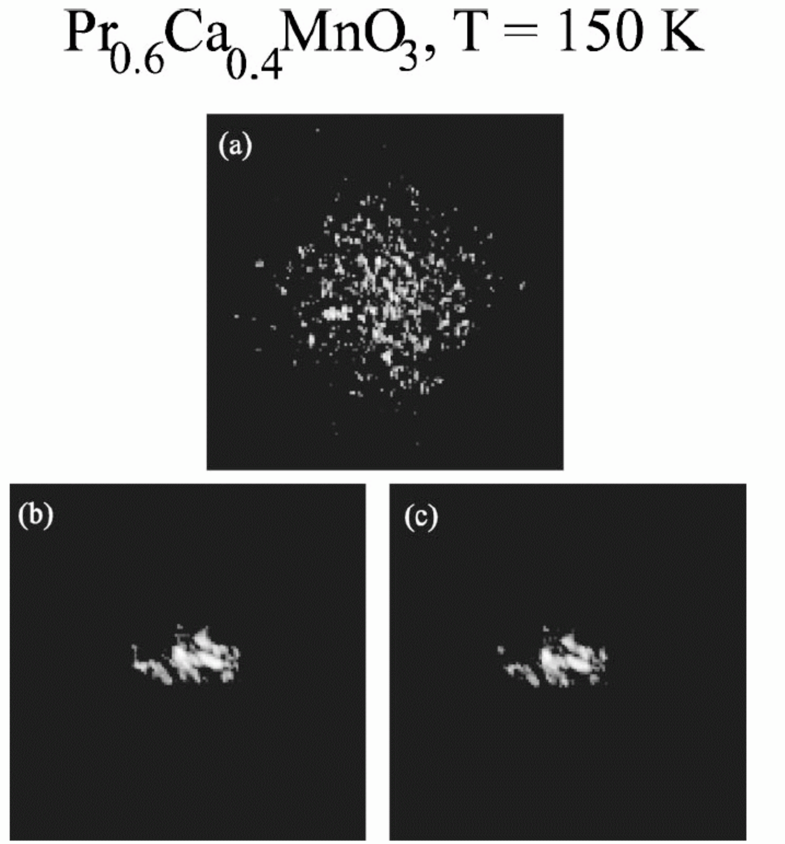
BeamLine for Advanced Dichroism Experiments

- variable linear and circular polarized x-rays
- energy range 0.4 to 2 keV
- soft x-ray resonant scattering
- multi-circle UHV diffractometer (XRMS)
  - liquid helium cooling
  - sample magnetization
- 9 T magnet with UHV environment (XMCD)
- time resolved studies and coherent radiation.

$LaMnO_3$ and $Pr_{0.6}Ca_{0.4}MnO_3$ speckle

C. S. Nelson, J. P. Hill, Doon Gibbs, F. Yakhou, F. Livet, Y. Tomioka, T. Kimura and Y. Tokura, PRB 66, 134412 (2002)

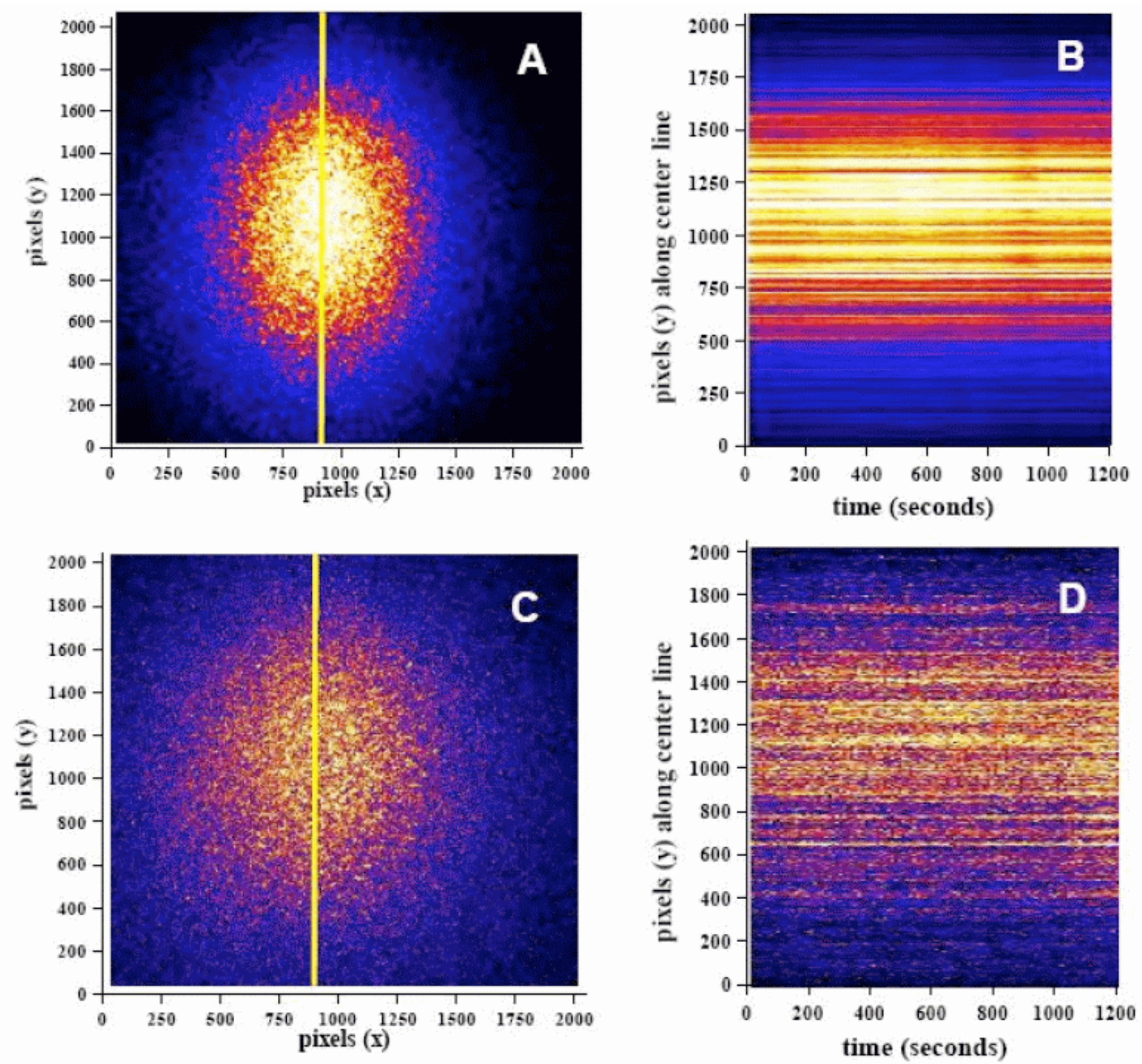




. Images of orbital (a) and charge (b), (c) order

$Pr_{0.5}Ca_{0.5}MnO_3$ at MnL_{III} edge (650 eV)

J. J. Turner et al, New Journal of Physics 10 053023 (2008)

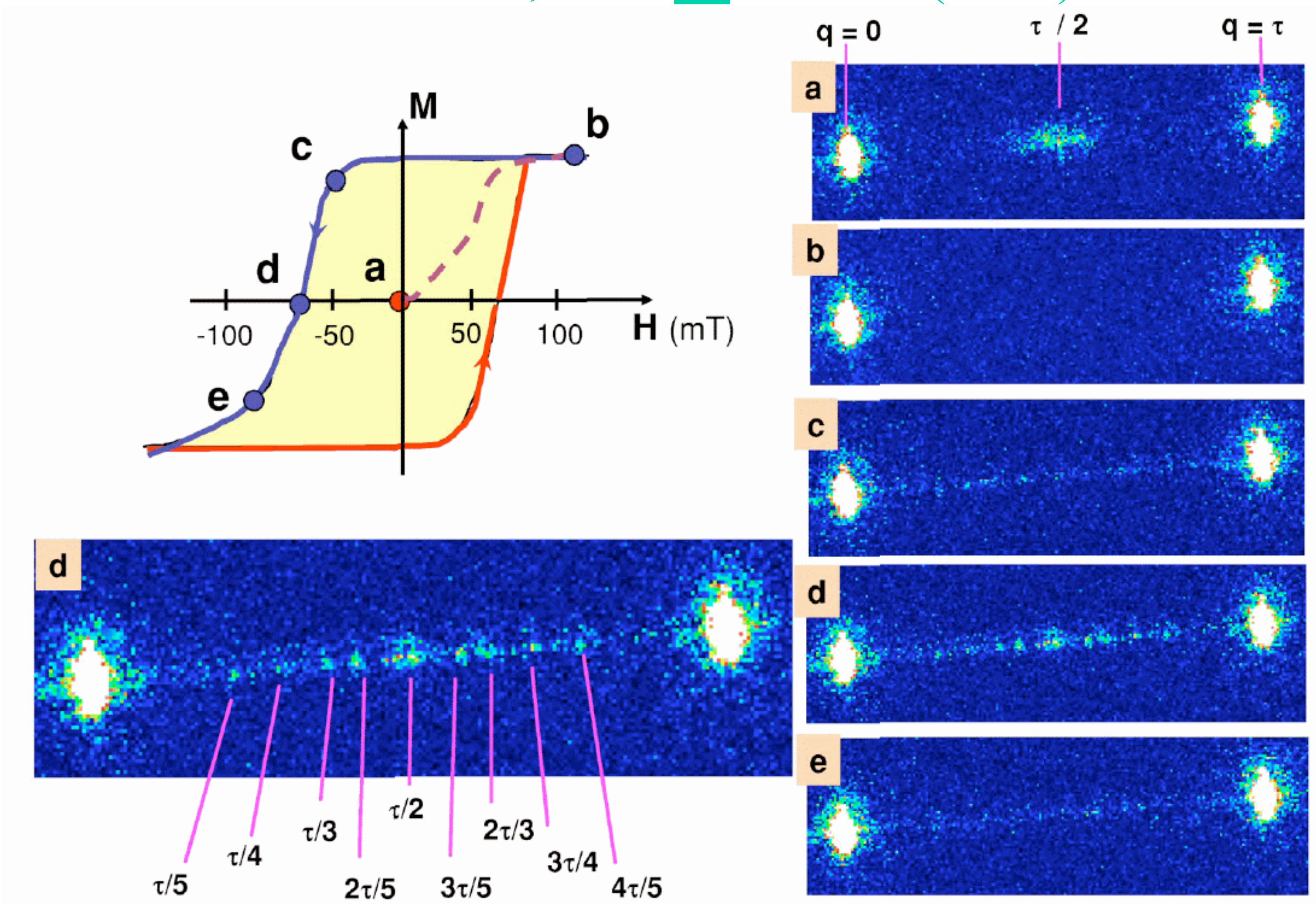


(0, ½ , 0)
Orbital ordered
T=205K

(0, ½ , 0)
Near phase transition
T=232K

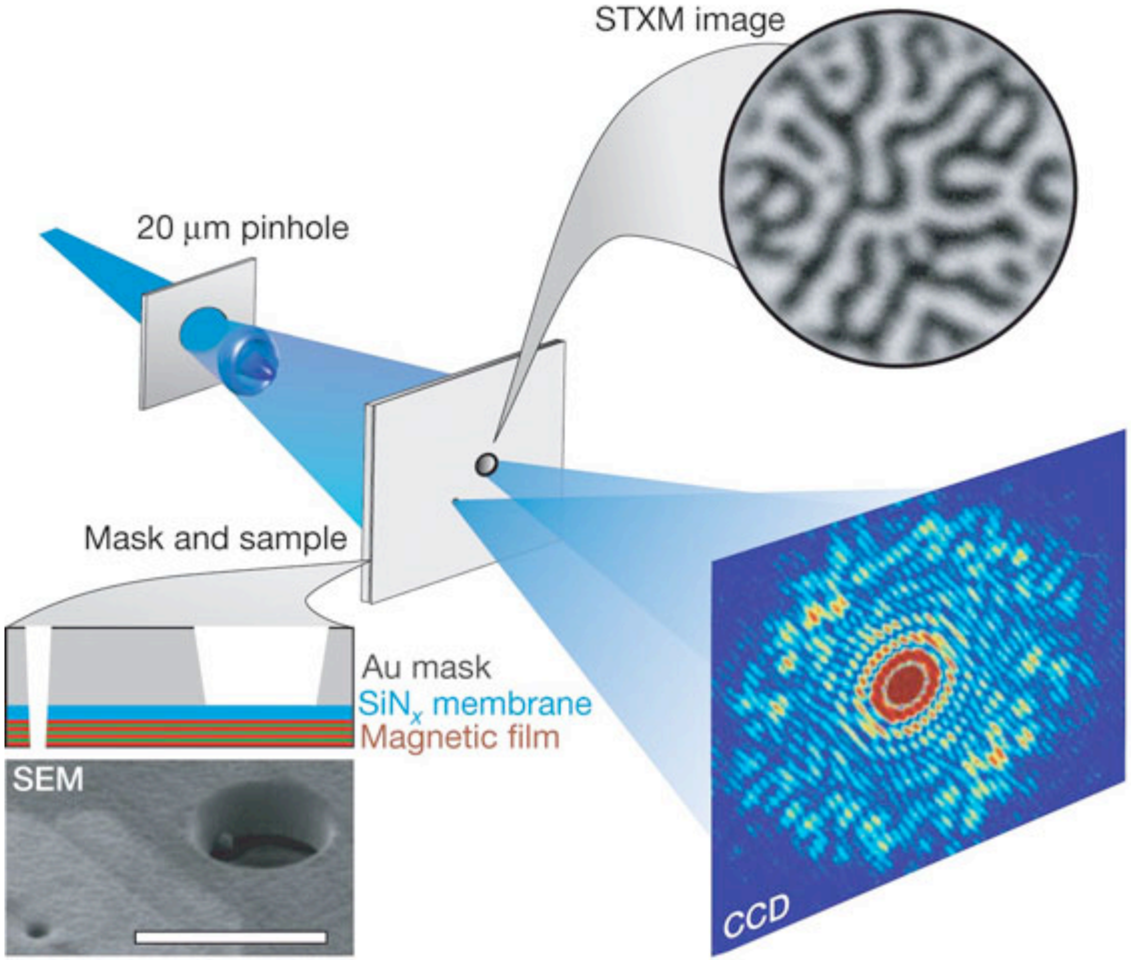
Co/ Pt multilayer line grating at 780eV

K. Chesnel et al, PRB <u>70</u> 180402 (2004)



X-ray Holography of Pt/CoML Domains

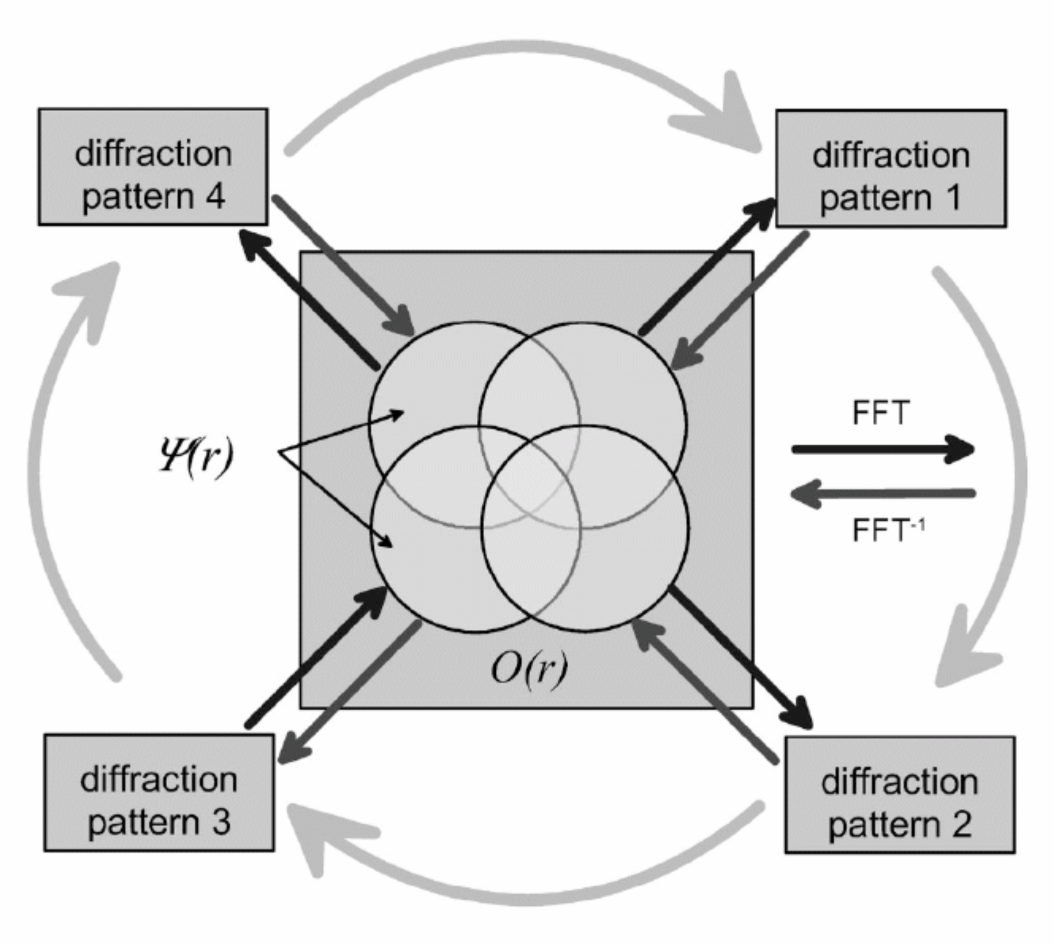
S. Eisebitt et al. Nature 432 885 (2004)



Field of view 1.5 μm

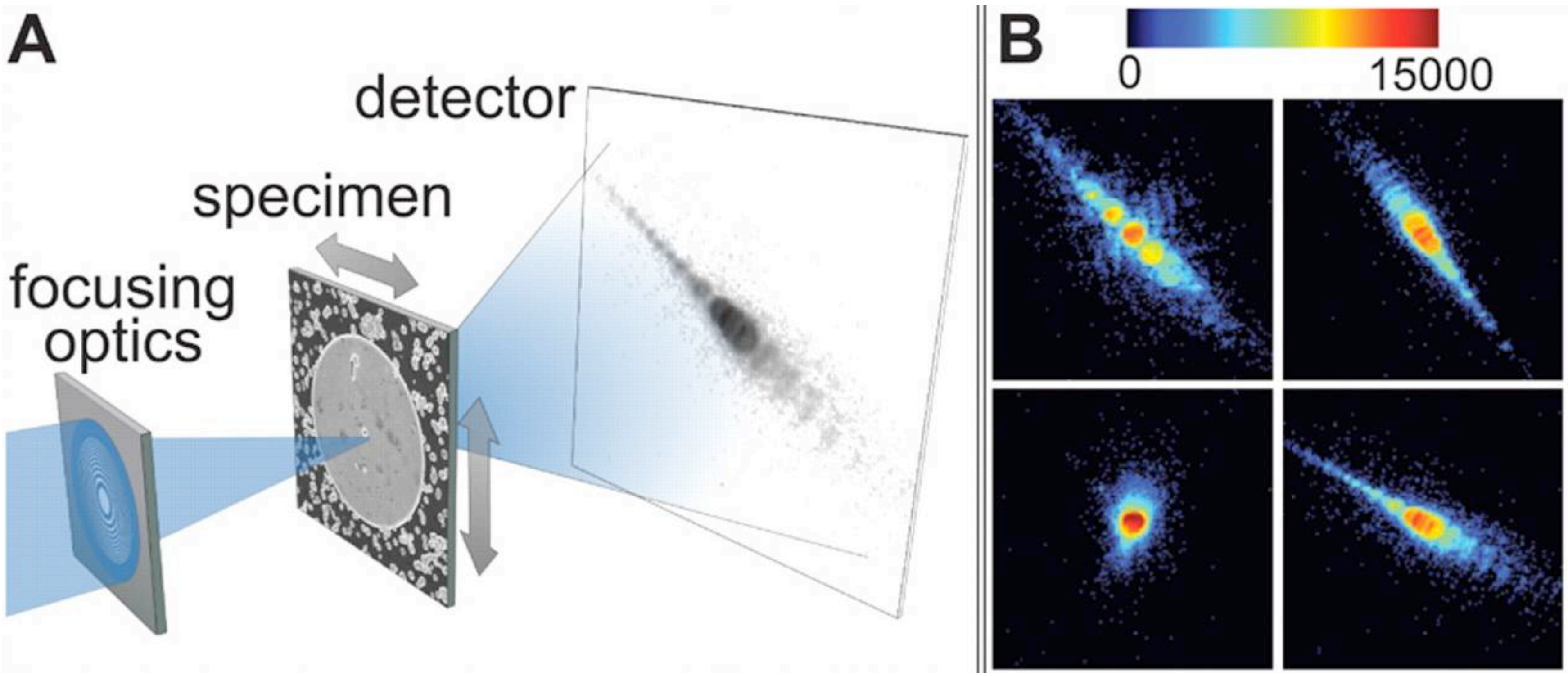
X-ray Ptychography

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



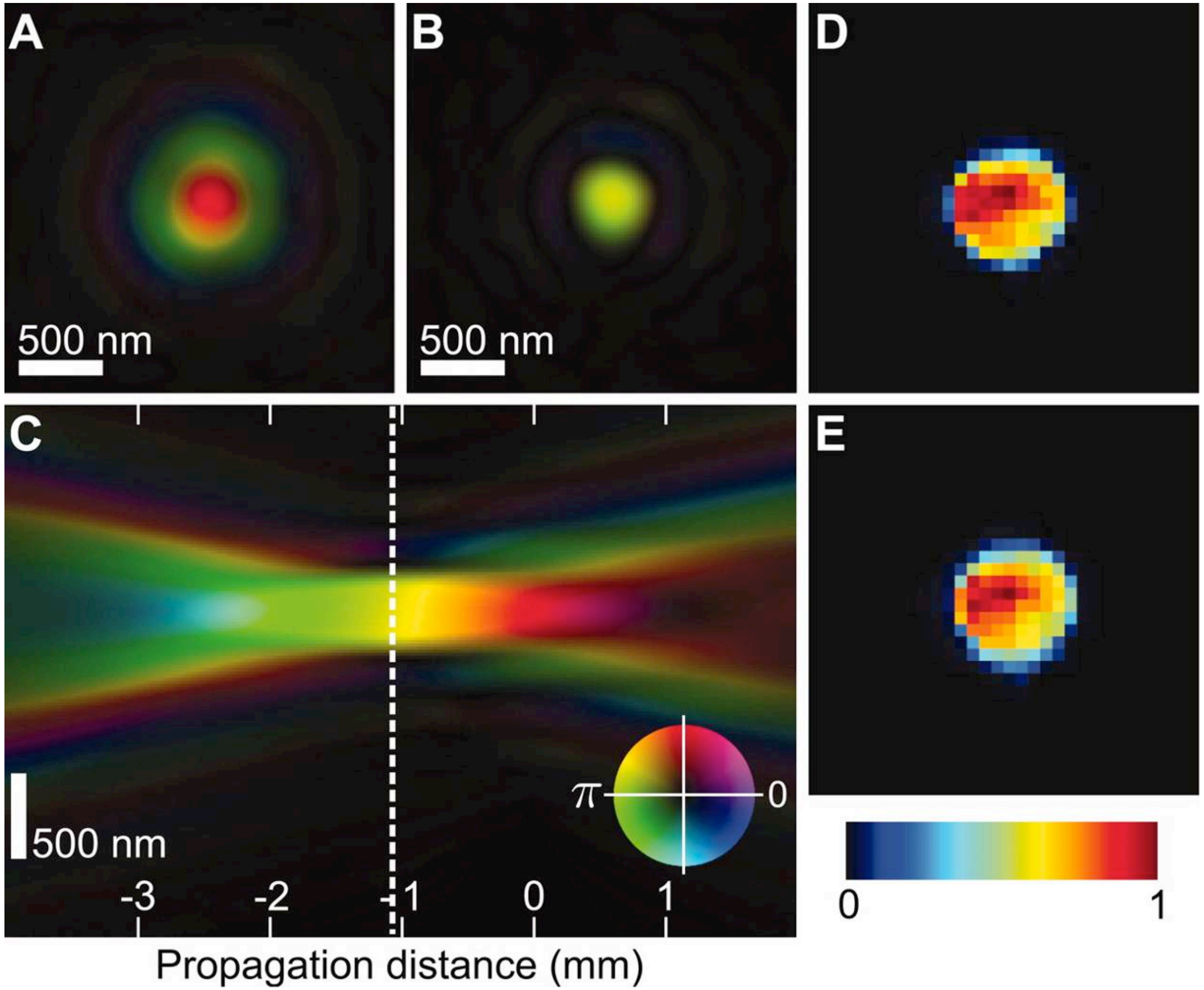
X-ray Ptychography

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



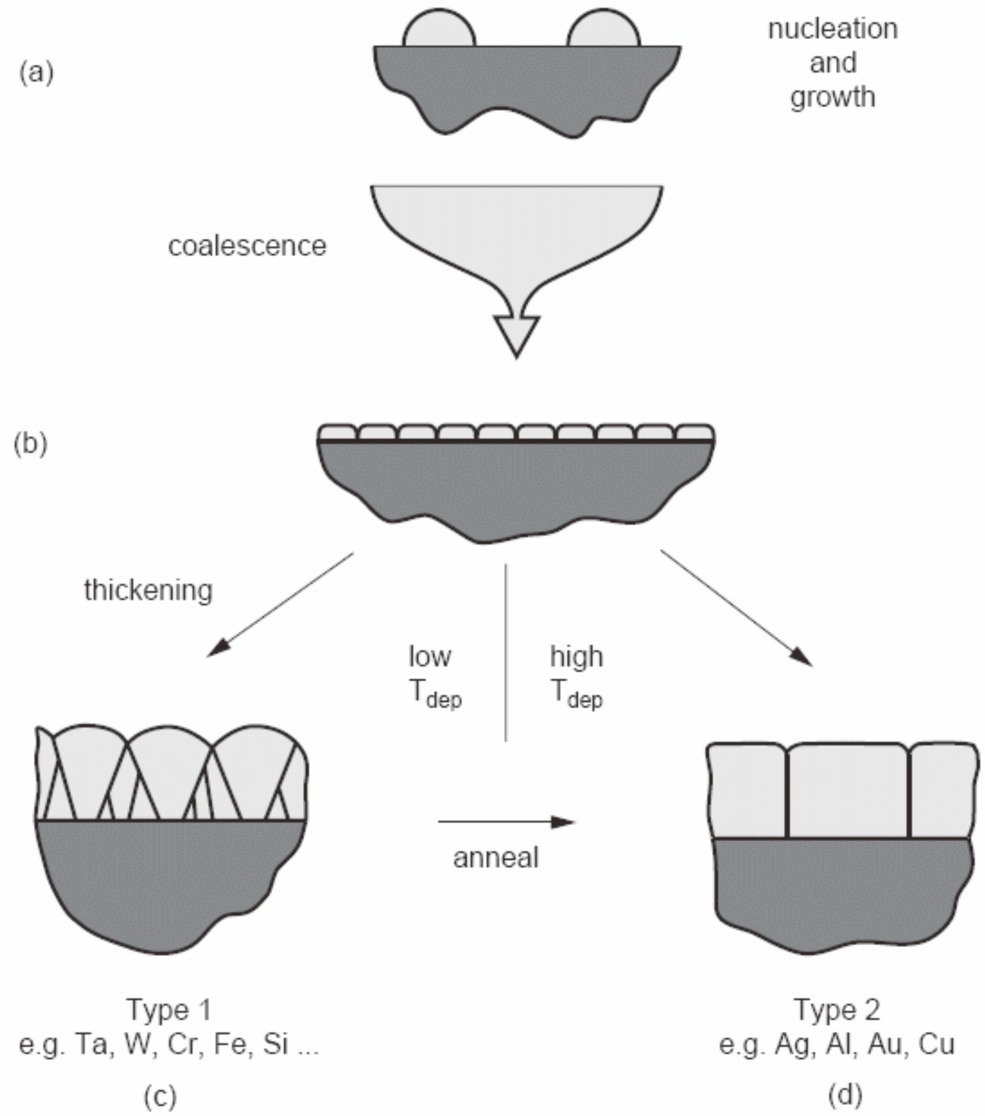
Reconstruction of Probe

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

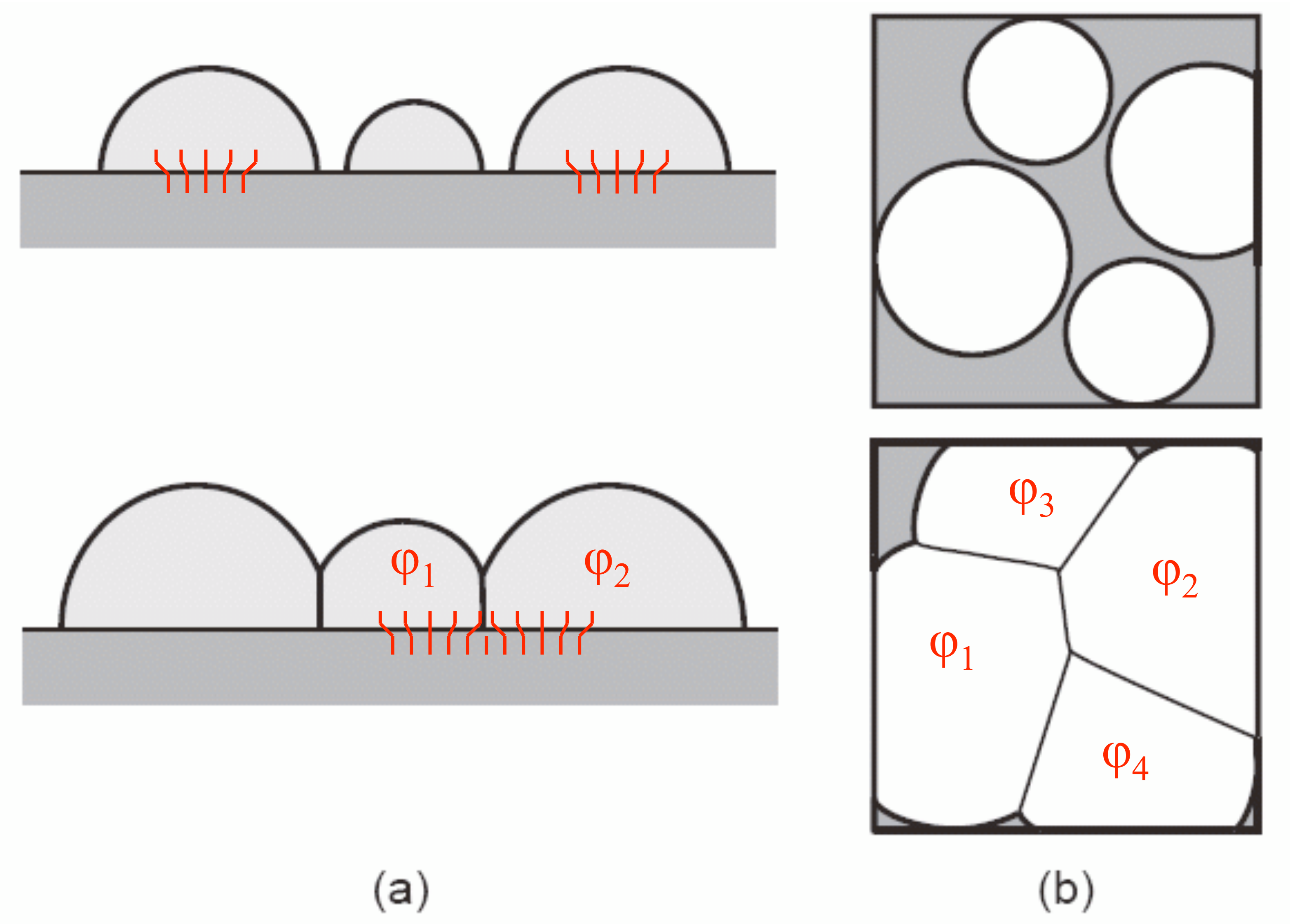


Thin film growth after deposition

C. V. Thompson, Annu. Rev. Mater. Sci. 2000. 30:159–90

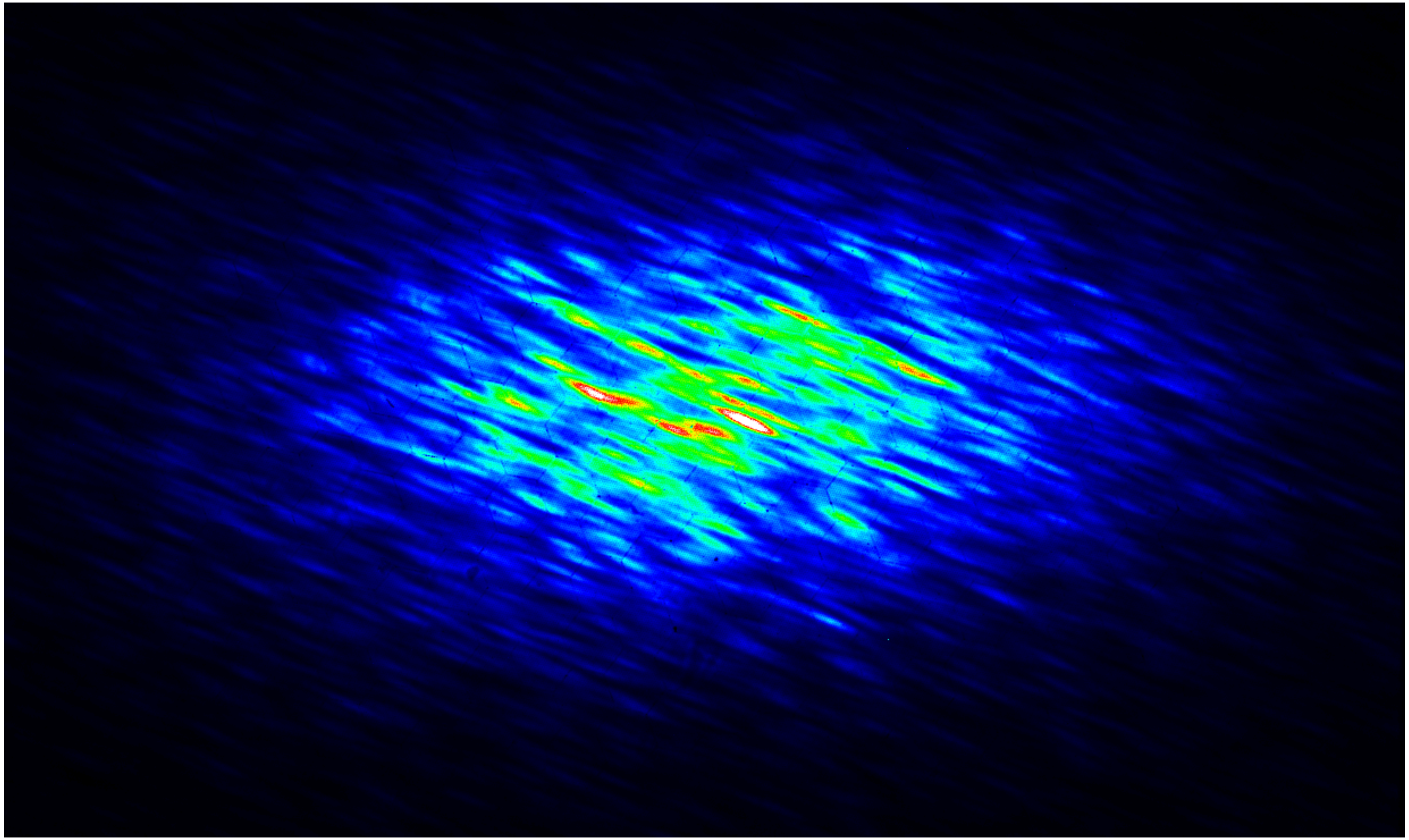


Epitaxial growth effects



Niobium (110) Thin Film Grains

Richard Bean, I-16, Nb110-35 Jan 2009



FeAl antiphase domains (001)

Lorenz Stadler, PhD dissertation, TU Wien (2005)

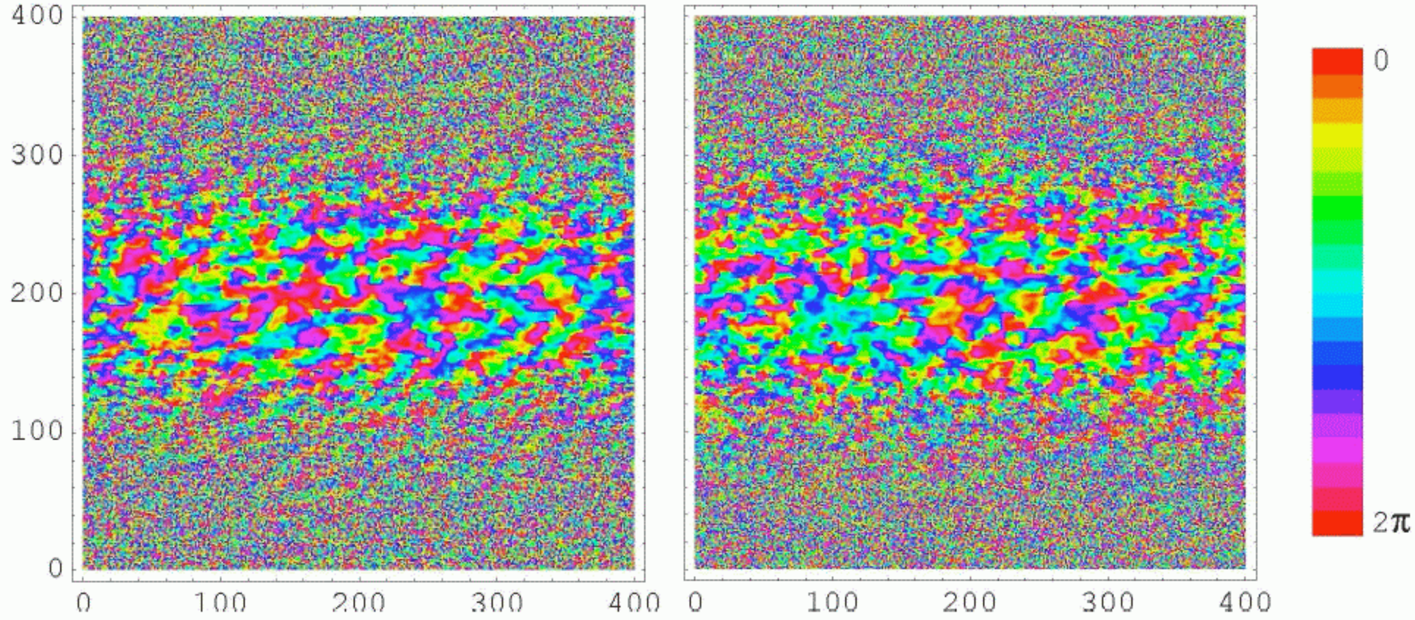
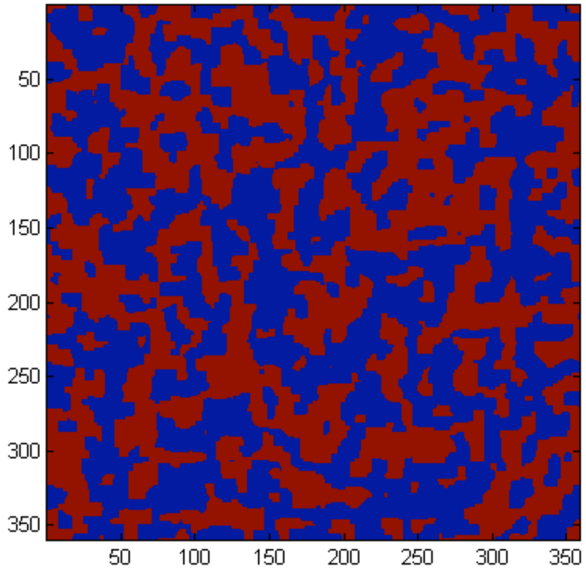


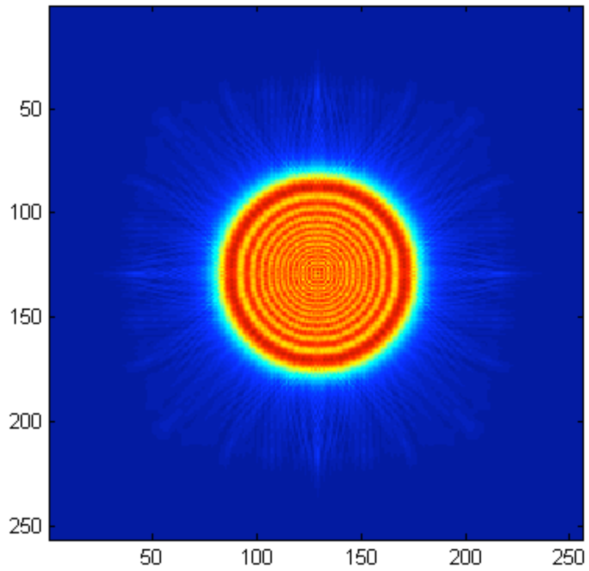
Figure 7.11: Typical reconstructed phases from runs with different combinations of algorithms and supports derived from the 2D Gaussian fit of the illumination function. Numbers in brackets denote how many iterations of the particular algorithm were done each cycle. Graphs on the left are from reconstruc-

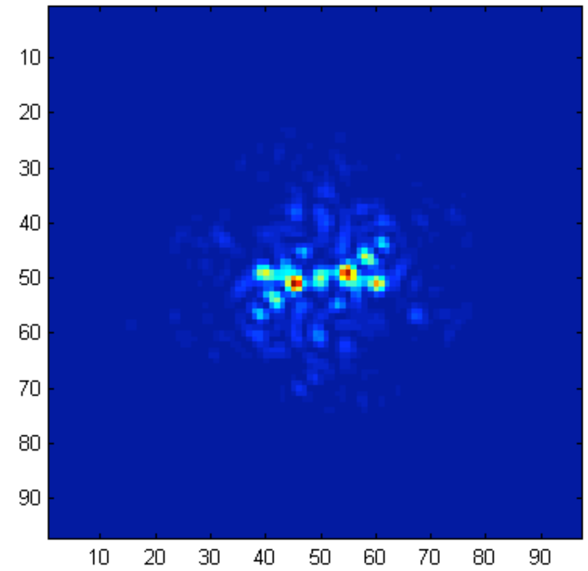
Ptychography phasing tests

Diffraction patterns computed from i) simulated domain array ii) propagated pinhole function with an overlap of ~80% between adjacent positions.

Richard Bean, UCL, Jan 2009

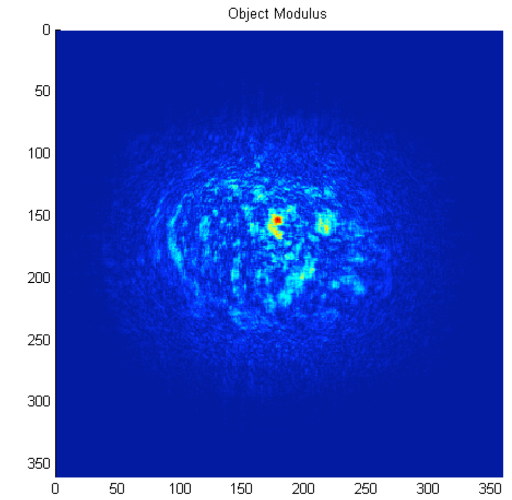


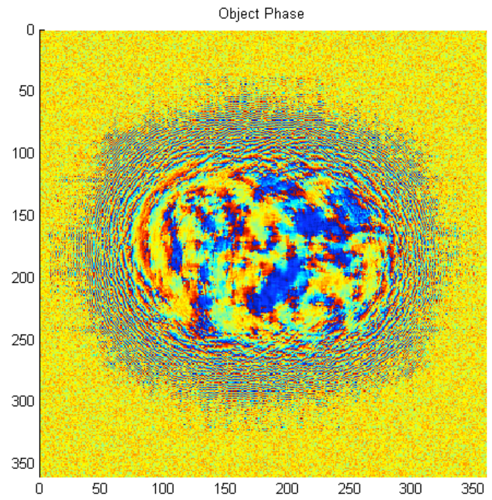




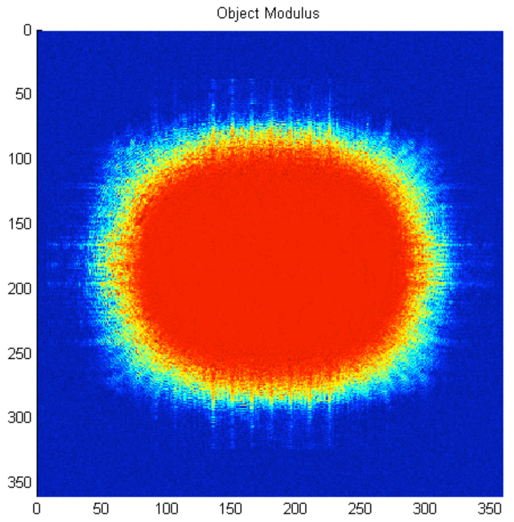
Ptychography phasing tests

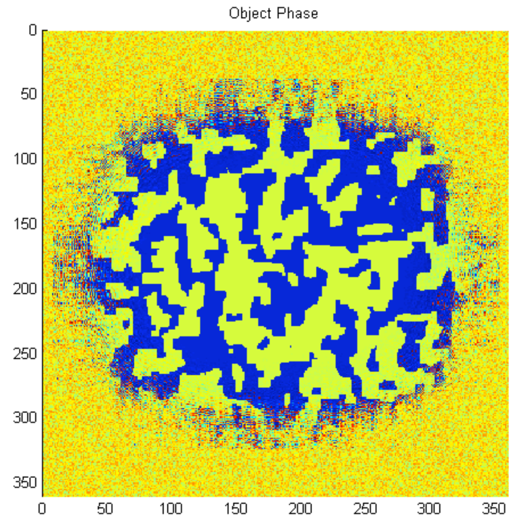
Sheffield Ptychography algorithm starting with an array of random numbers in both amplitude and phase. 7x3 array. Richard Bean, Jan 2009





Amplitude and phase after 1 iteration.

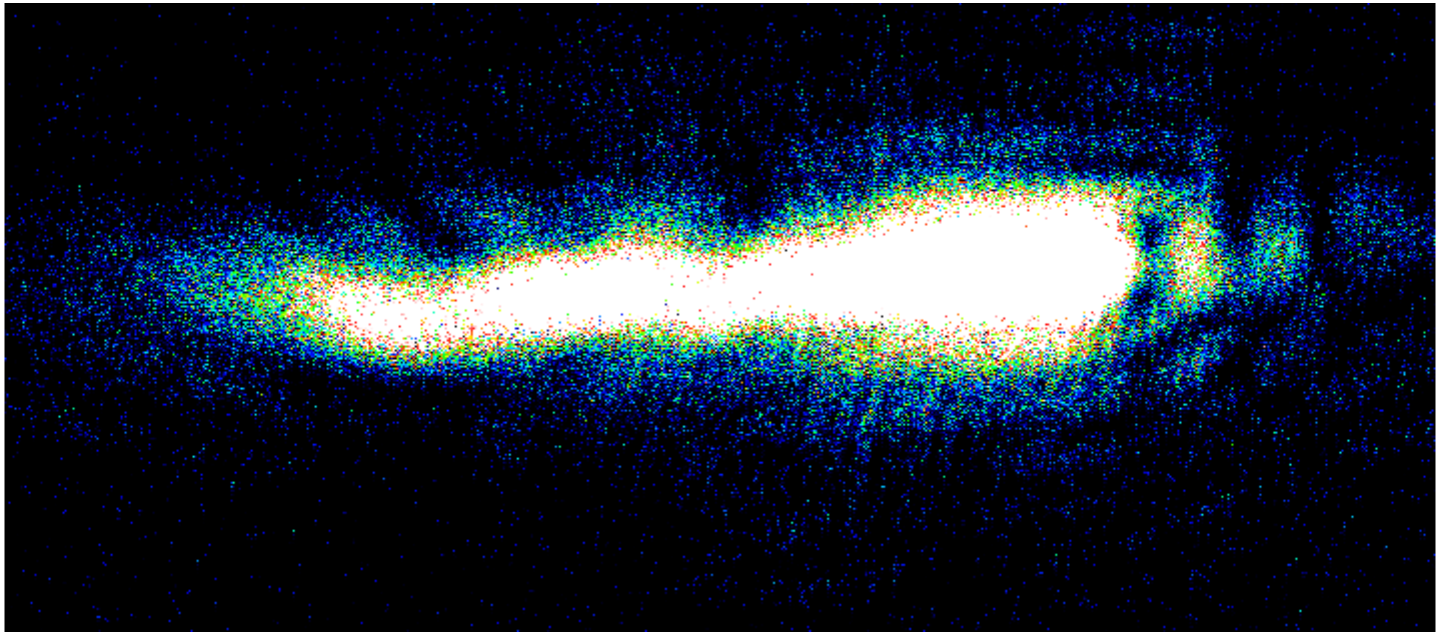


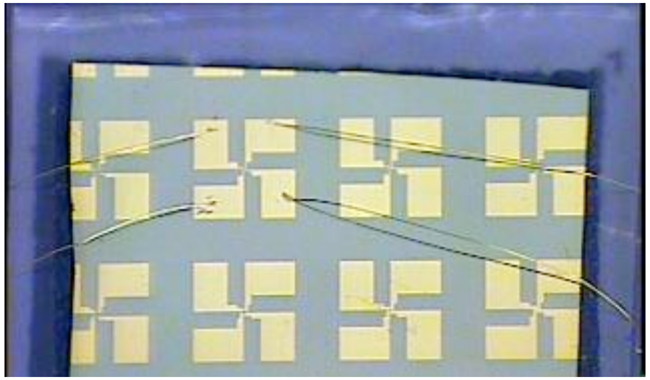


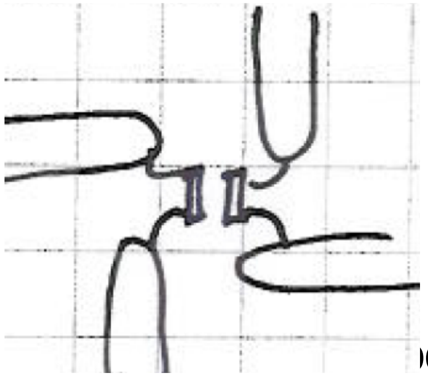
Amplitude and phase after 20 iterations.

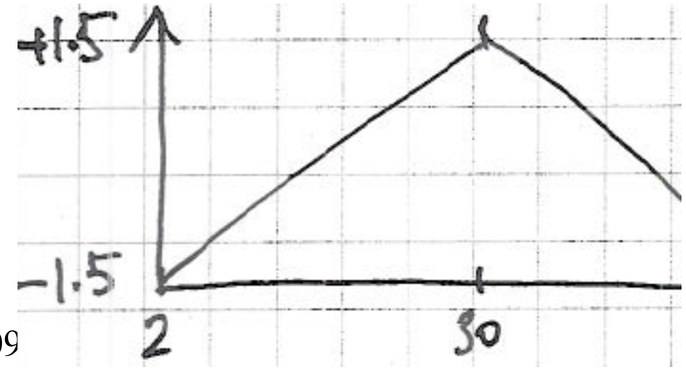
Apply Electric Field along ZnO NC

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









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- Ross Harder 34-ID-C beamline
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- Marcus Newton, Steven Leake ZnO
- Moyu Watari, Loren Beitra Au
- Richard Bean, Felisa Berenguer Nb

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