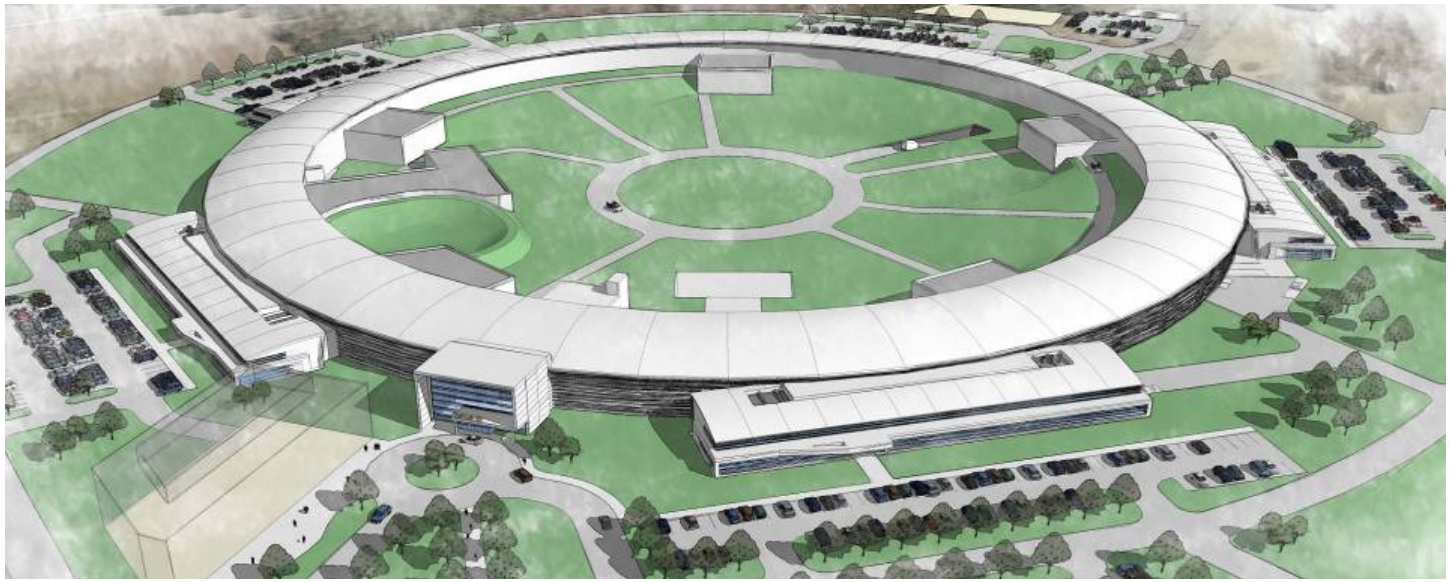
National Synchrotron Light Source II



Coherent X-Ray Diffraction Beamline
Letter of Interest (due March 30th)

Ian Robinson

CXD workshop, March 14th, 2008

U.S. Department of Energy

Office of Science

The FY 2009 Budget Request: A New Era for Science

World-Leading Facilities

Driving transformational science and U.S. innovation

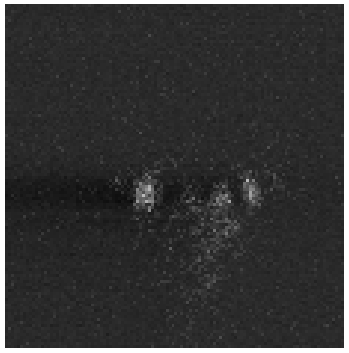
- **Spallation Neutron Source** ($177.6M) and the **High Flux Isotope Reactor** ($58.8M), together provide capabilities unavailable anywhere else in the world for study of the position and motion of atoms in materials – from liquid crystals to superconducting ceramics, from proteins to plastics, and from metals to cell walls.
- **Four Synchrotron Light Sources** – Extraordinary tools for determining protein structures, probing the physical properties of new materials, and studying chemical reactions
  - **Advanced Light Source** ($51.1M)
  - **Advanced Photon Source** ($116.5M)
  - **National Synchrotron Light Source** ($40.1M)
  - **Stanford Synchrotron Radiation Laboratory** ($33.0M)
- **Five DOE Nanoscale Science Research Centers** ($101.2M) – providing unmatched capabilities for fabrication, synthesis, and characterization of matter at the nanoscale

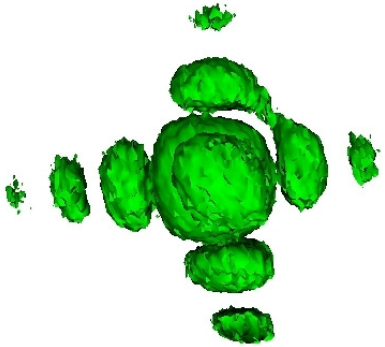
Next Generation Tools

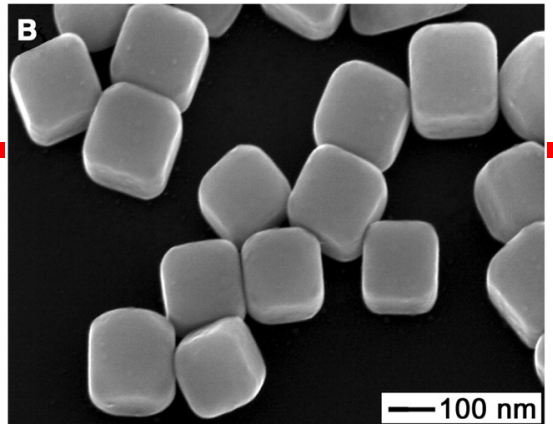
- **Linac Coherent Light Source** ($56.0M) – a revolutionary x-ray free electron laser that will allow probing of chemical and biological structures and examination of chemical reactions in real time at the single molecule level
- **National Synchrotron Light Source-II** ($103.3M) – a state-of-the-art light source for x-ray imaging, capable of nanometer resolution of structures and features of individual atoms, molecules, and crystals

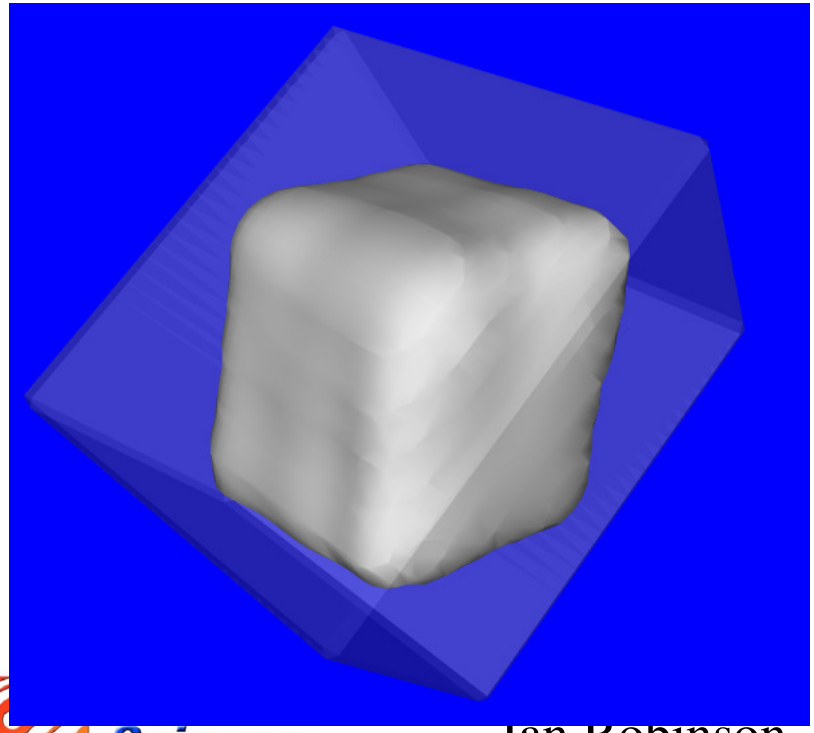
LOI scientific case for the beamline

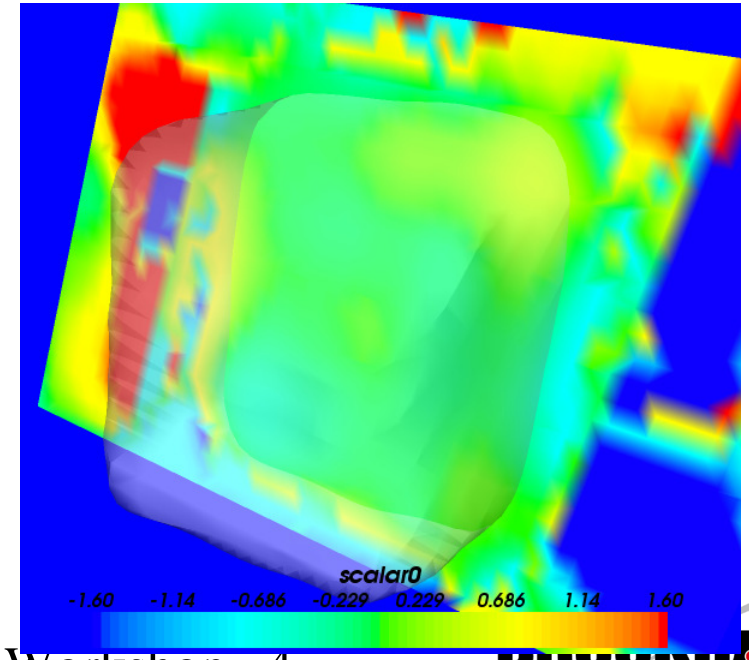
- Imaging of crystal shapes in 3D on nm scale
- Imaging of strain fields inside crystals
- Evolution of shape/strain under working conditions
- Manipulation/deformation/indentation on the nm scale
- Ptychographic imaging for extended objects
- Ptychographic imaging of biological samples using phase contrast
- Serial crystallography for single molecule imaging
- Applications in nanoscale semiconductor devices, strain engineering
- Applications to catalysis





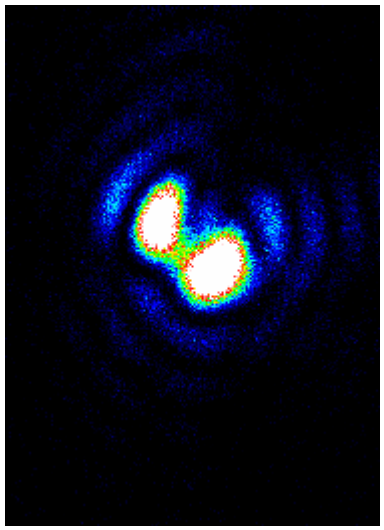


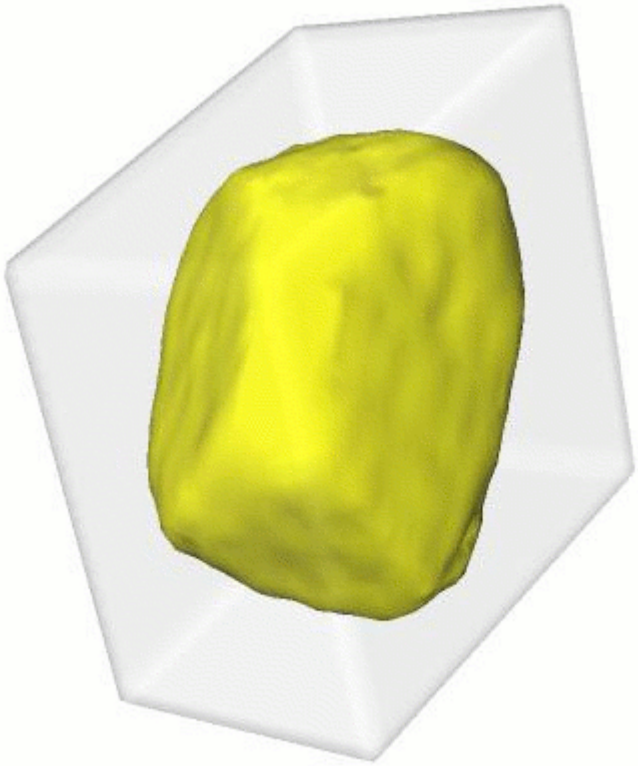




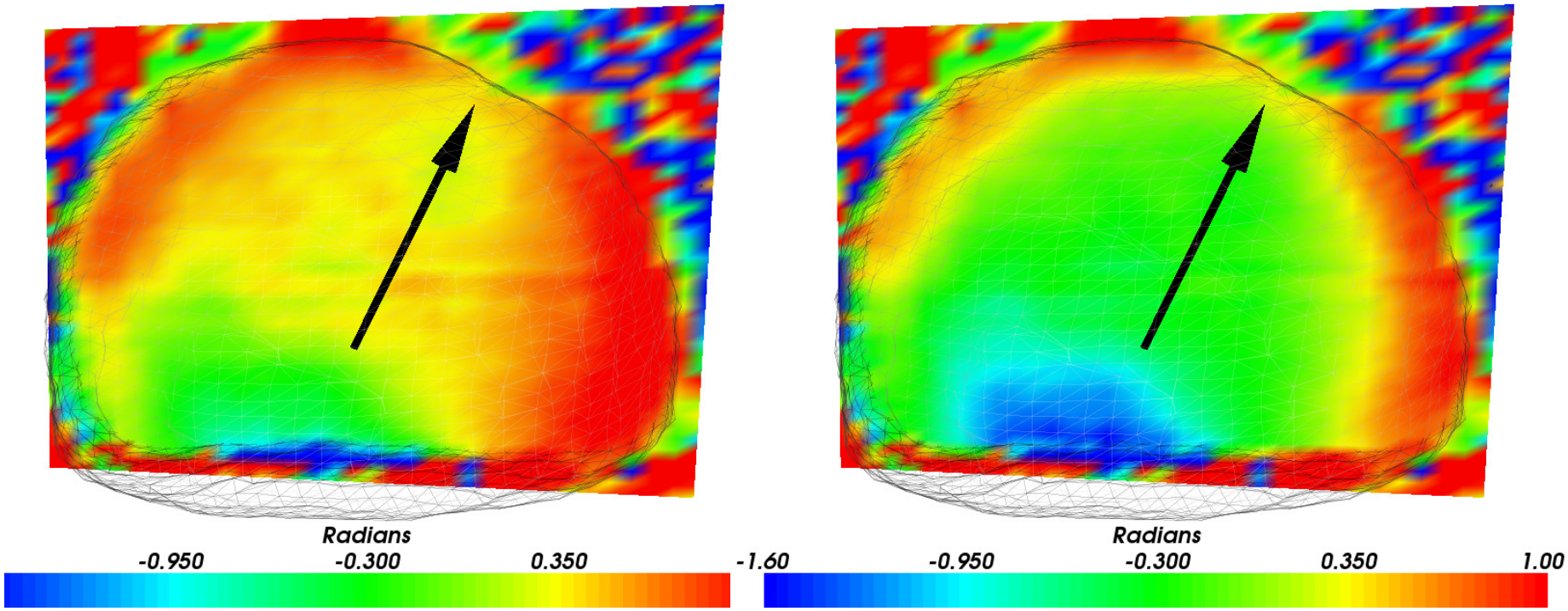
Gold nanocrystal reconstruction

showing support used for 20 HIO followed by 10 ER

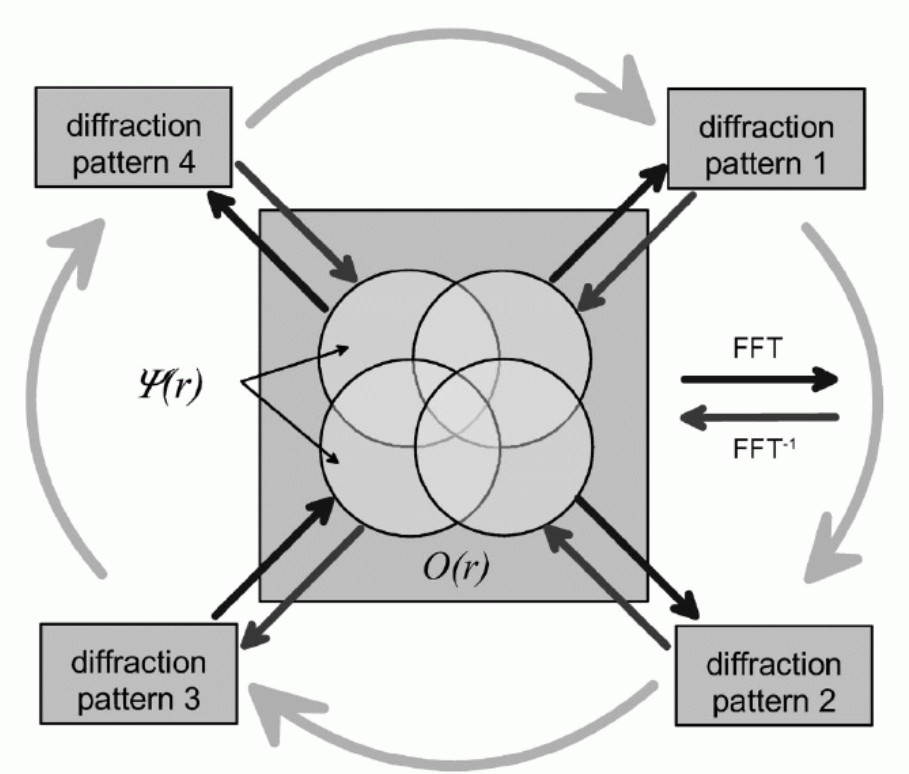


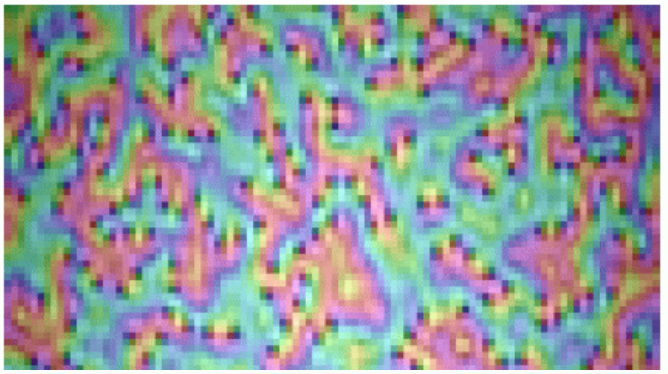


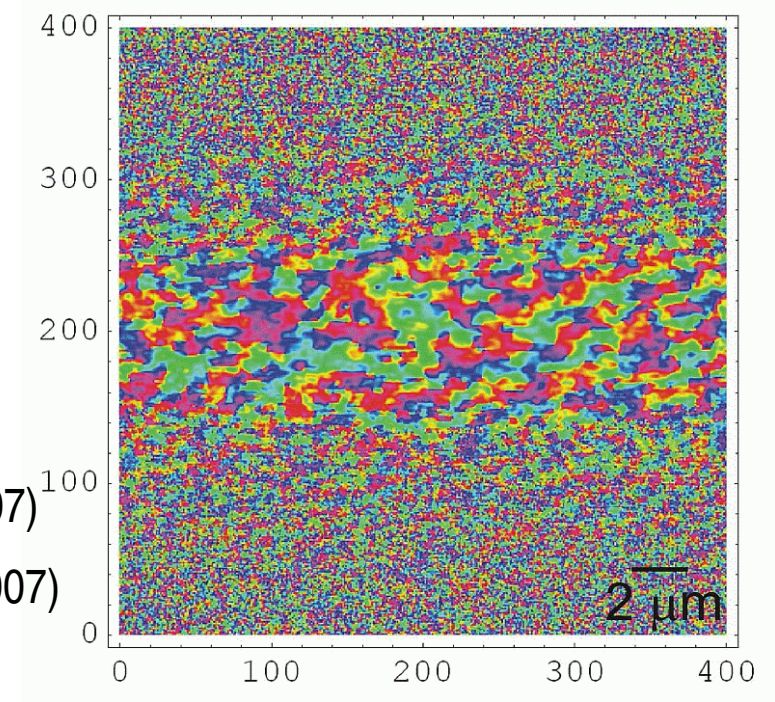
Phase Maps before and after Correction



X-ray Ptychography



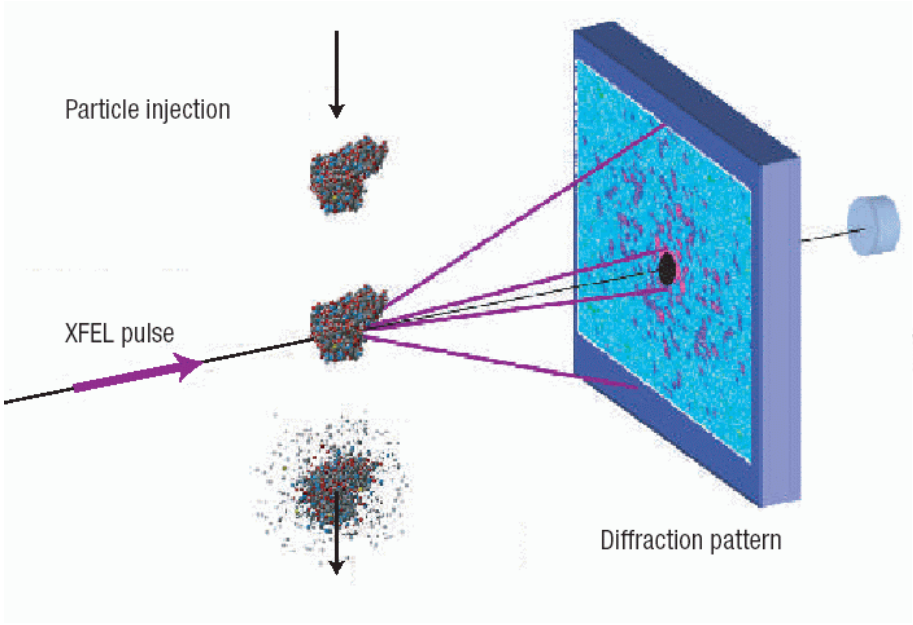




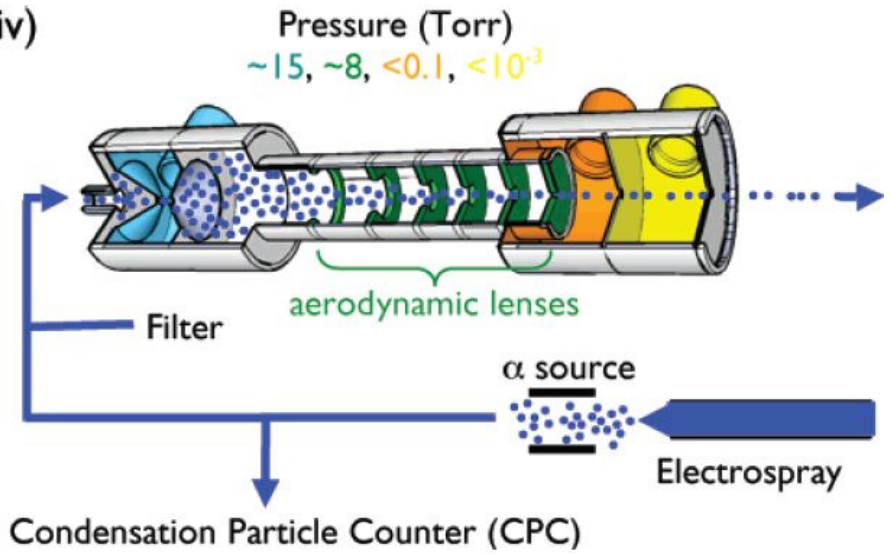
J. M. Rodenburg et al, Phys. Rev. Lett. 98 034801 (2007)

$Fe_{65}Al_{35}$: L. M. Stadler et al, Phys. Rev. B 76 014204 (2007)

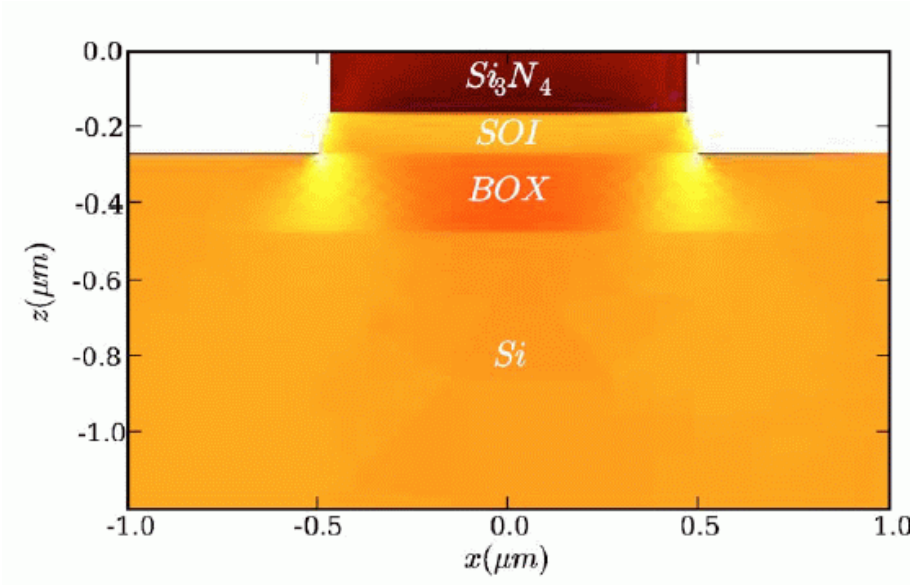
Serial Crystallography



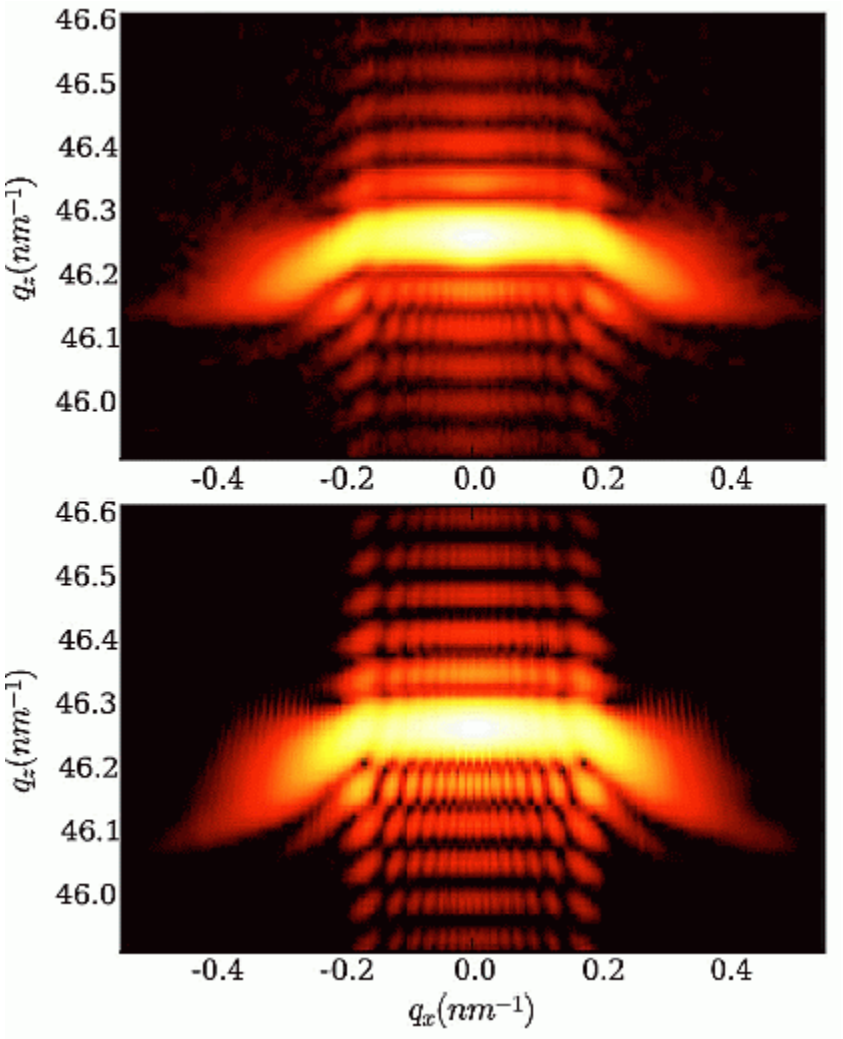
iv)



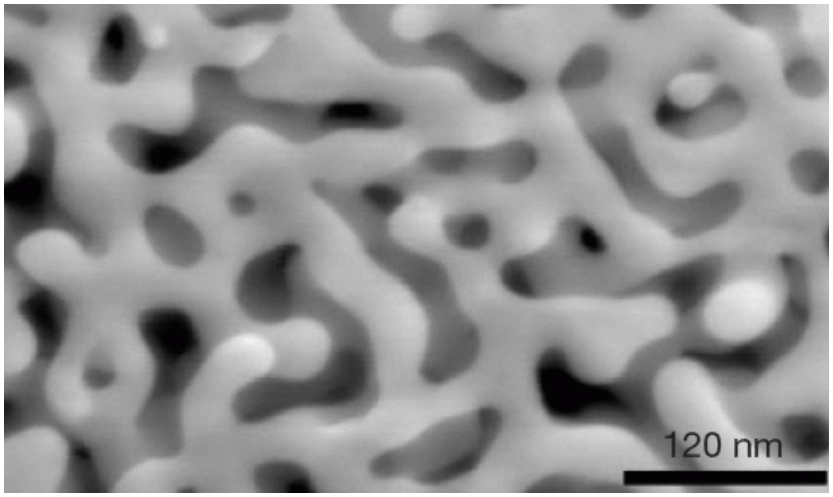
Strain Engineering



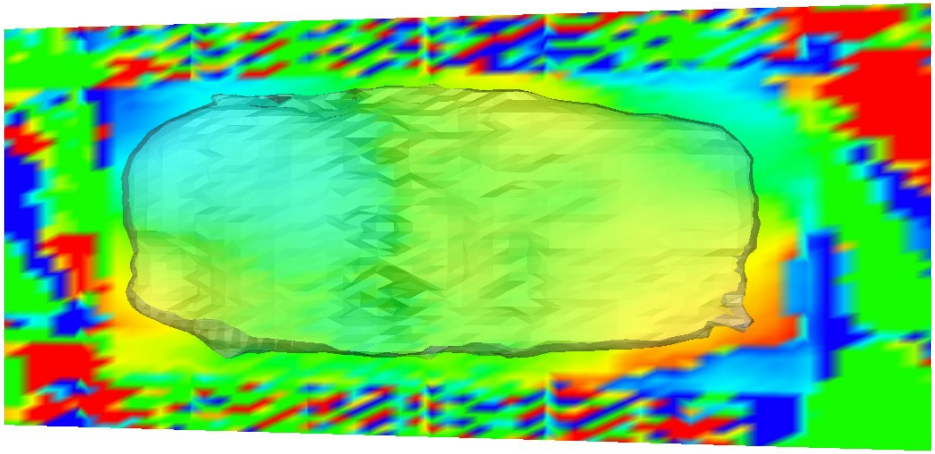
Strain field in silicon on insulator lines using high resolution x-ray diffraction, Gailhanou M, Loubens A, Micha JS, Charlet B, Minkevich AA, Fortunier R, Thomas O, Appl. Phys. Lett 90 111914 (2007)



In-situ Chemical Reactions / Catalysis



Jonah Erlebacher, Aziz MJ, Karma A, Dimitrov N, Sieradzki K, “Evolution of nanoporosity in dealloying” Nature 410 450 (2001)



3µm ZSM-5 crystal. [Unpublished work done by Hyunjung Kim and K. B. Yoon at Sogang University]

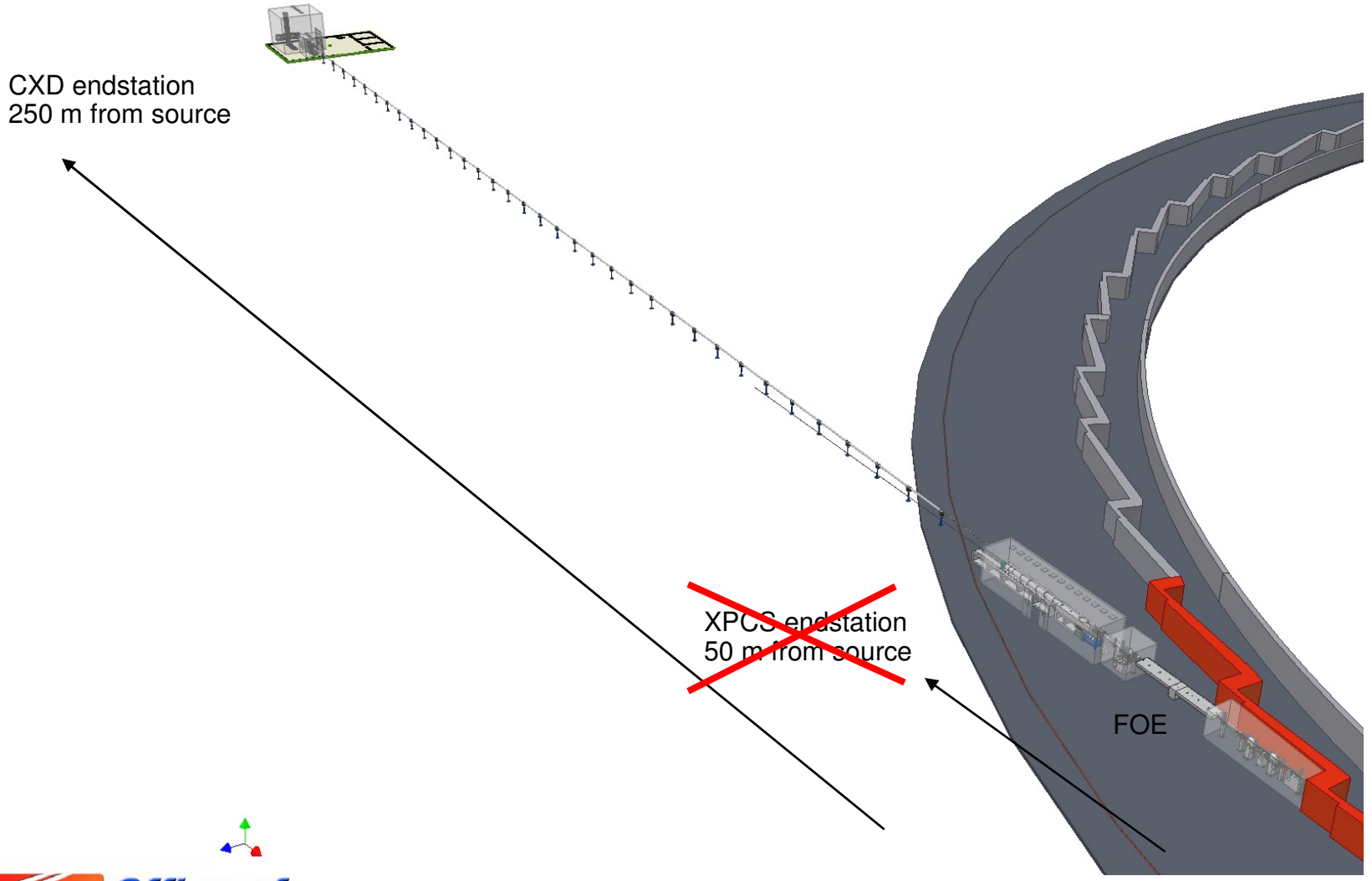
LOI technical requirements and specifications

- Low-beta undulator with single branch
- Long beamline (200m) for maximum demagnification
- Monochromatic beam 8-25keV
- Stable optical bench in far hutch
- Ultra-high precision position stage for sample and optics in controlled environment
- Full angle range (3 degrees of freedom) for access to reciprocal space points
- Long detector arm, mechanically isolated from sample
- High dynamic range, quantum efficient area detector, probably based on MAPS technology.

Workshops on CXD (last 4 years)

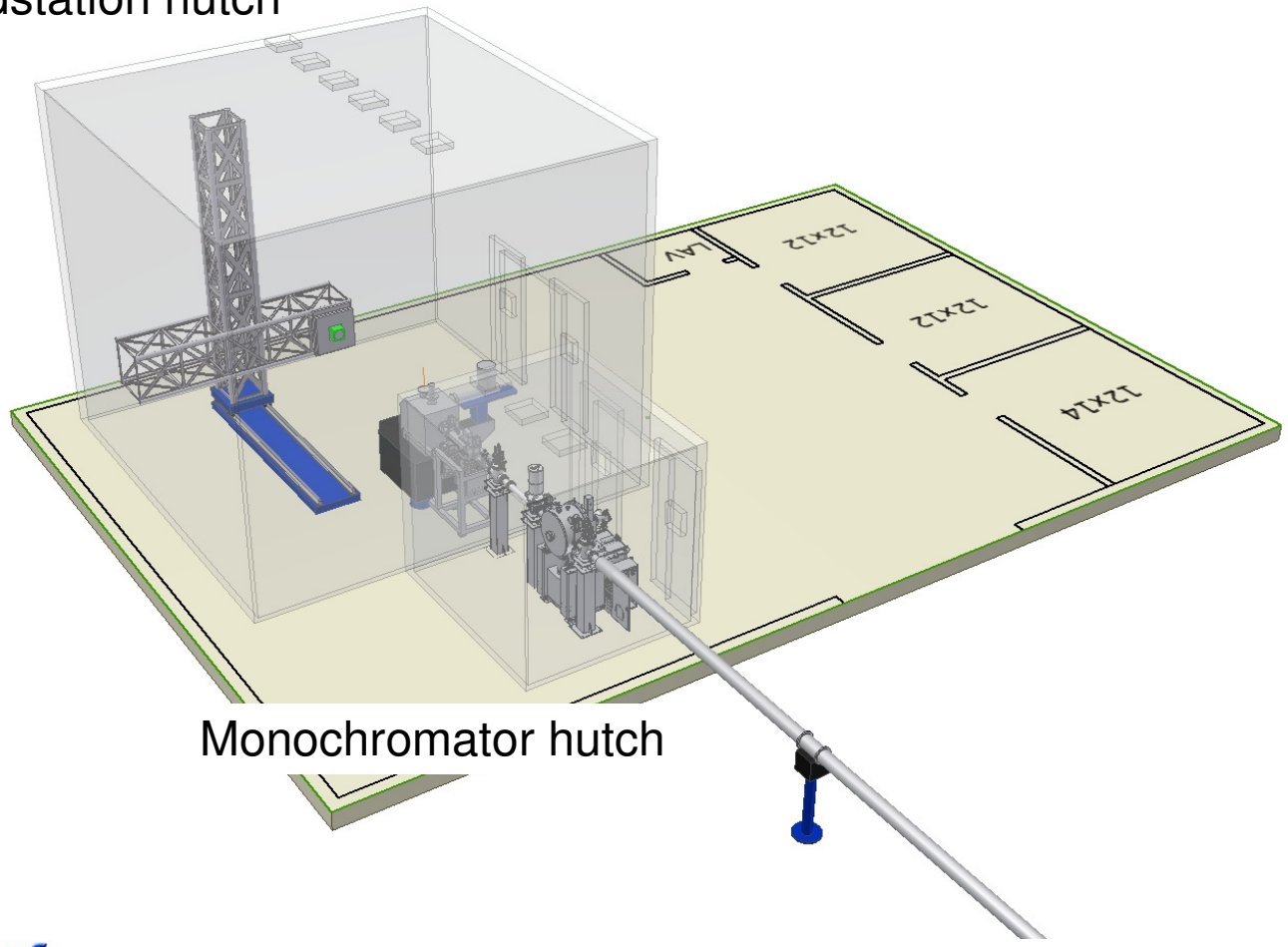
- Diamond Light Source Workshop on Coherence, 22 March 2004
- Workshop on emerging new directions of synchrotron research with soft X-rays VUV and Infrared, SRC, Madison, September 2004
- Journée Scientifique sur Diffraction et Diffusion des X Coherents, CNRS Grenoble, October 2004
- BESSY Coherence Workshop, Berlin, December 2004
- Phase Retrieval and Coherent Scattering, Isle Porquerolles, France, June 2005
- Workshop on Diffraction, Crystallography and Imaging at the European XFEL, Hamburg, Germany, October 2005
- ERL workshop, Cornell University, New York, June 2006
- Coherence/Imaging Planning Meeting, Advanced Photon Source, July 2006
- Symposium on Nanoscience, Diamond Light Source Users Meeting, September 2006
- SLS-Soleil Workshop on *The Full Spectrum*, Villigen, September 2006.
- Workshop on coherent x-ray microscopy (APS Users Meeting), 8-9 May 2007
- ESRF *Science at the Nanometre Scale* Workshop, 24 October 2007
- Workshop on Coherent X-ray Diffraction at NSLS II, Brookhaven, 14 March, 2008
- Heraeus Seminar *Matter in Coherent Light*, Bad Honnef, Germany, 17-20 March, 2008

Overall Beamline Layout



CXD Beamline Layout

CXD endstation hutch

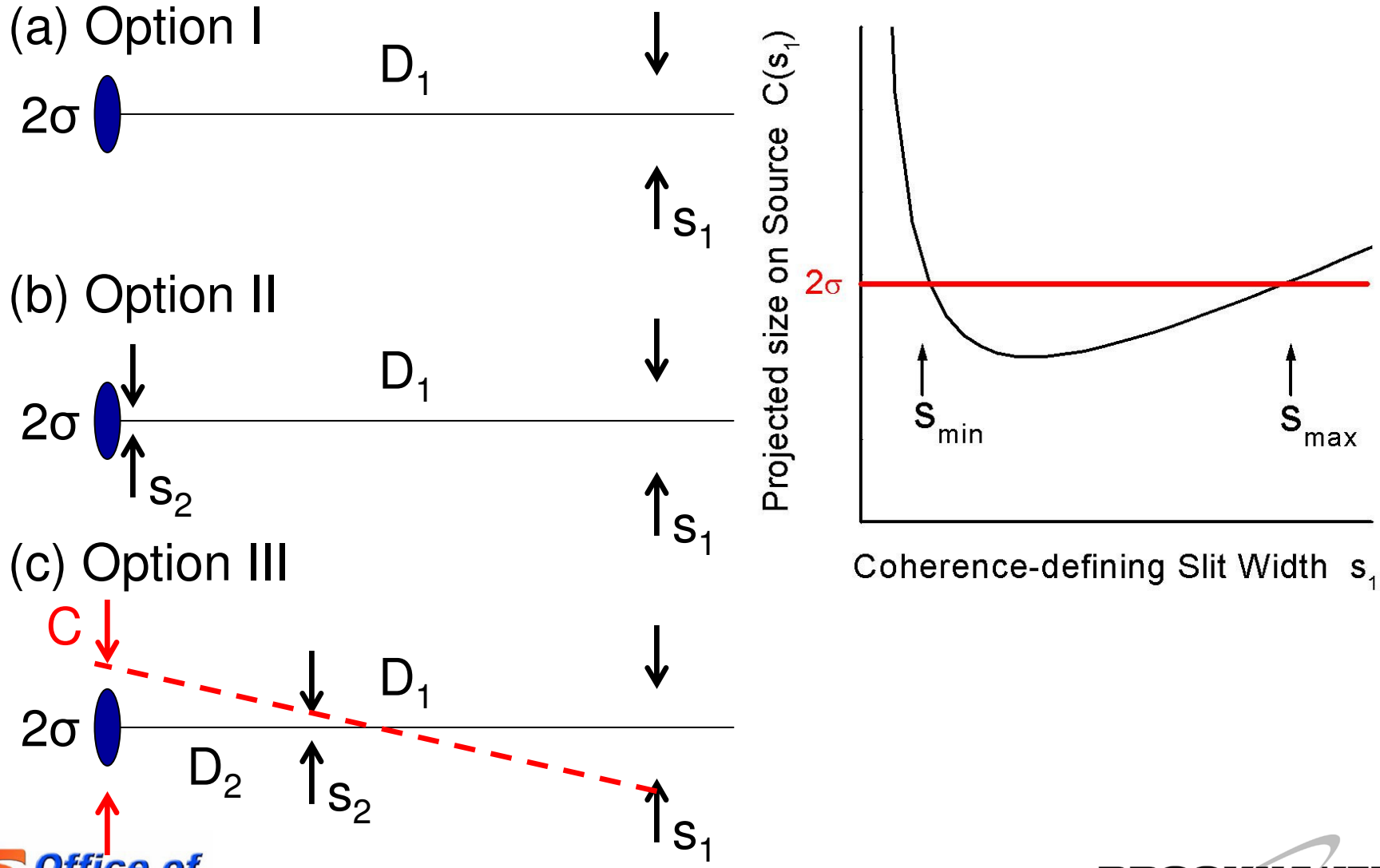


Monochromator hutch

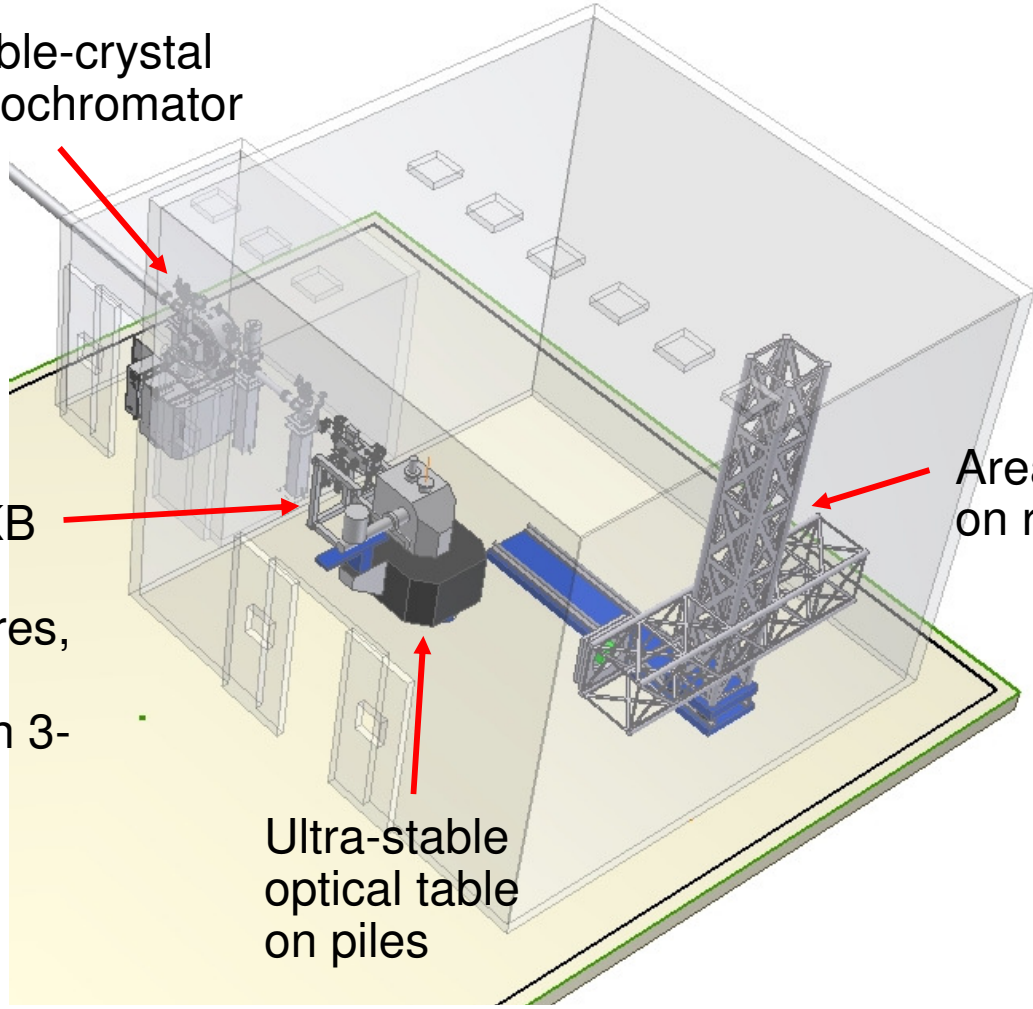
CXD Beamline Optical Components

- Water-cooled (?) silicon mirror in FE optics hutch, coated (?), to remove harmonics and Bremstrahlung
- White-beam slit as (optional) secondary source
- Water cooled double-crystal monochromator, Si(111), channel-cut style
- Concrete 'bunker' construction of beam transport and hutches to reduce cost
- Separate piles for isolation of granite optical table in experimental hutch.

Horizontal Secondary Source Option



CXD Endstation



Revised NSLS-II Site Plan