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U.S. Department
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THE UNIVERSITY OF
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Science

U.S. DEPARTMENT OF ENERGY

A U.S. Department of Energy laboratory
managed by The University of Chicago

Beamlines, detectors, optics, software

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APS Upgrade Summary Workshop

August 10 - 11, 2006

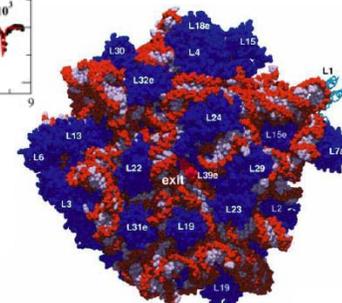
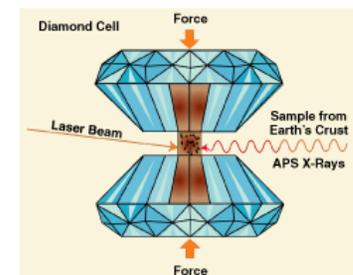
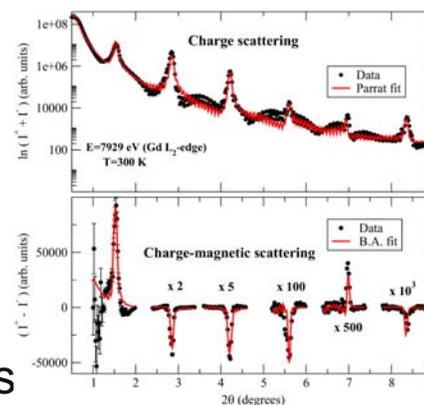
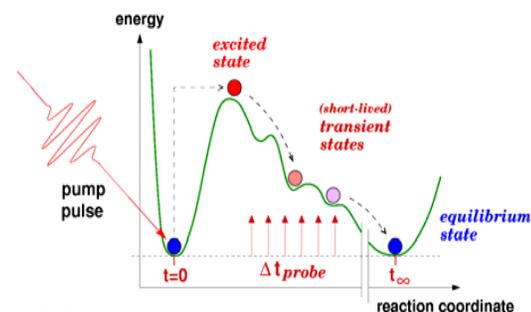
Upgrade of experimental facilities

■ Our focus is on advancing the science that can be done at the Advanced Photon Source

- Fast and ultra-fast processes
- Research under extreme conditions
- Surfaces and interfaces
- Materials, soft matter, and condensed matter physics
- Kinetics and dynamics
- Biology and life sciences
- Nanoscience

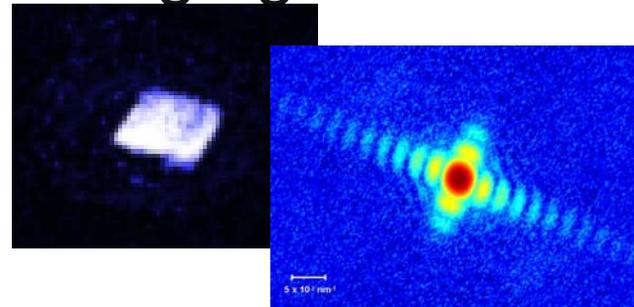
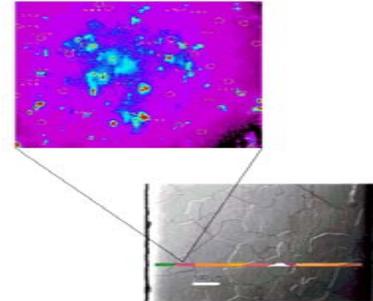
■ Future areas

- Science using high-field magnets
- Science with intermediate energy x rays



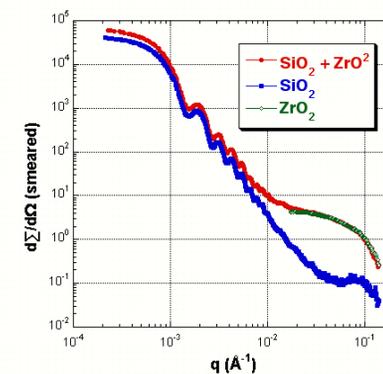
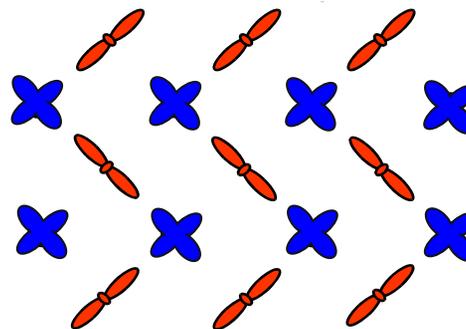
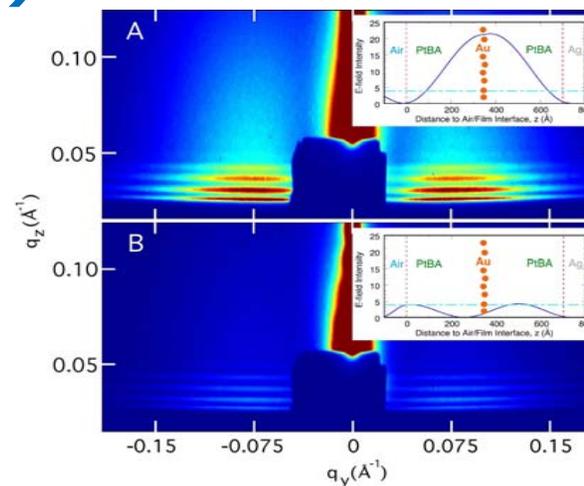
Beamlines

- Strengthen our capabilities in engineering materials science
 - High-energy x-ray diffraction
 - X-ray microscope -> x-ray nanoscope
- Expand our capabilities in the range of science disciplines served by x-ray imaging
 - Phase contrast imaging
 - X-ray tomography
 - Coherent imaging
- Upgrade our ability to characterize soft matter
 - SAXS, ultra-fast SAXS, USAXS



Beamlines (cont'd)

- Kinetics and dynamics
 - XPCS
 - Grazing incidence SAXS
- Magnetic materials
 - Diffraction in magnetic fields
 - XMCD
- Electronic structure
 - XANES
 - RIXS
 - IXS
- Surfaces and interfaces
- Structure determination
 - Diffuse scattering, diffraction and pdf
 - XAFS



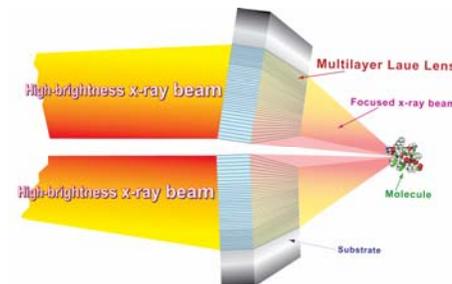
Detectors

- Phenomenal increase in brilliance of storage ring (and soon ERL) sources
 - Serious mismatch between synchrotron performance and detector capabilities
- Detector development offers an opportunity for the highest impact
 - Pixel array detectors (PAD)
 - High speed, single photon counting
 - LBL collaboration
 - Large solid angle area detectors for spectroscopy
 - Collaborate with vendors (Ortec, SII Nanotechnology)
 - APD arrays
 - 3-way collaboration: APS, ESRF, SPRing8
 - Streak cameras
 - Commercial devices

Optics

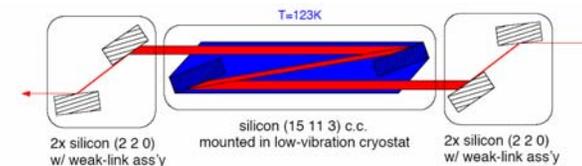
- Opportunity for gains of factors of 2 - 10 improvement in spatial resolution and energy resolution

- Multilayer Laue lens - diffractive optics
 - Nanoengineering, nanomanipulation
- Multilayer reflective optics
- Sub-meV capabilities



- Improved performance in coherence experiments

- Mirror surfaces
- Crystal surfaces



- Metrology

- Development of a bending magnet beamline

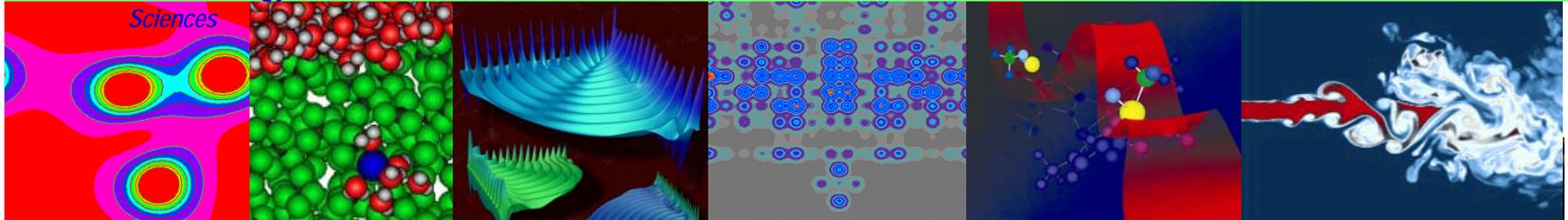
- Be windows

- High-purity, void-free, highly-polished surface

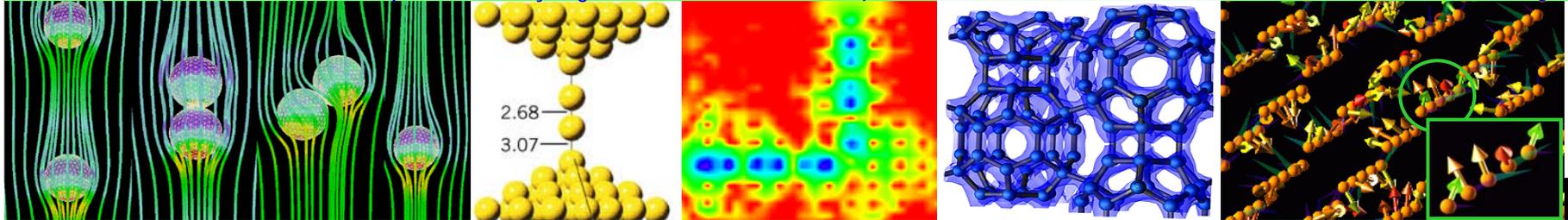
Software enables science

Office of Basic Energy

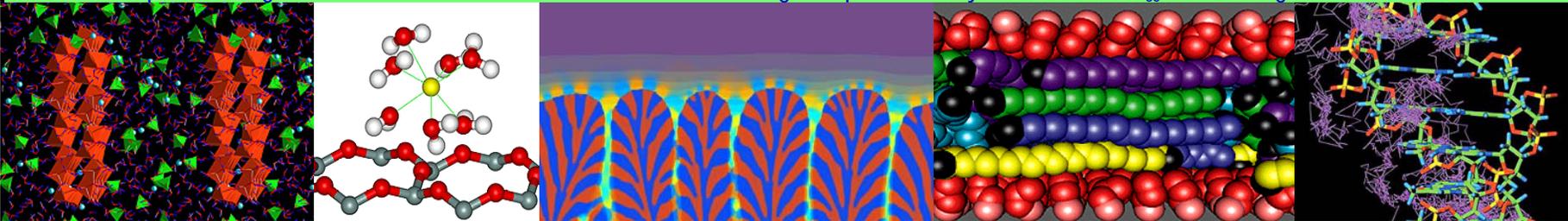
Sciences



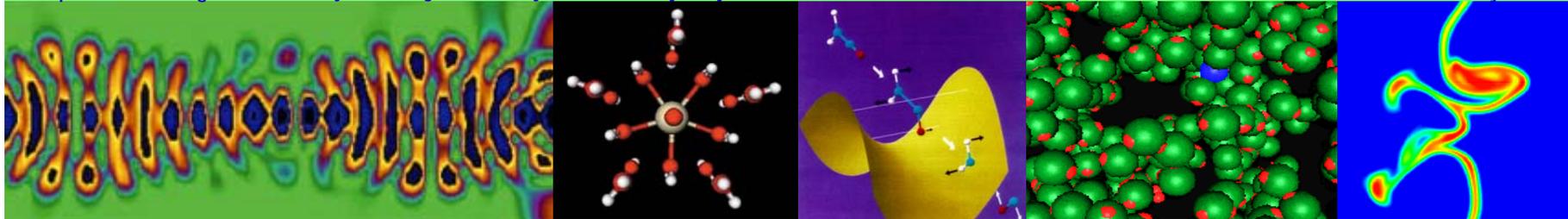
Vortices in a superfluid Cs ion transport Atomic hydrogen ionization Semiconductor-liquid interface C-H bond activation reaction Combustion turbulence modeling



Two spheres mixing in a stream Gold nanowire Waveguide optics Crystal structure for C₃₆ solid Magnetic moments in materials



Nanoparticles binding in solution Clay-mineral geochemistry Binary alloy solidification Complex fluids Na counterion mobility in DNA



Electric field in a 2D photonic crystal waveguide Uranyl in aqueous solution Dissociation of ketene Solvation in supercritical water Turbulent flame

Scientific software

- Instrument control
- Data
 - Format
 - Storage
 - Accessibility
- Archiving
- Visualization
- Treatment
- Analysis
- Simulation
- Modeling
- Doing science
 - x-ray experts
 - non-specialist
- Optimize experiments
 - experiment design
 - experiment progress
- Configure analysis
- Extract results
- Seamless access to high performance computing

Summary and conclusions

- Move forward with *beamline upgrades* and new beamline construction
- Develop and procure *x-ray detectors* that match the capabilities of the source and the experiments
- Perform forefront *x-ray optics* development to lead toward nanometer and sub-millielectronvolt capabilities
- Create a *scientific software* infrastructure that enables users to optimize experiments, inform their measurements, and interpret data.