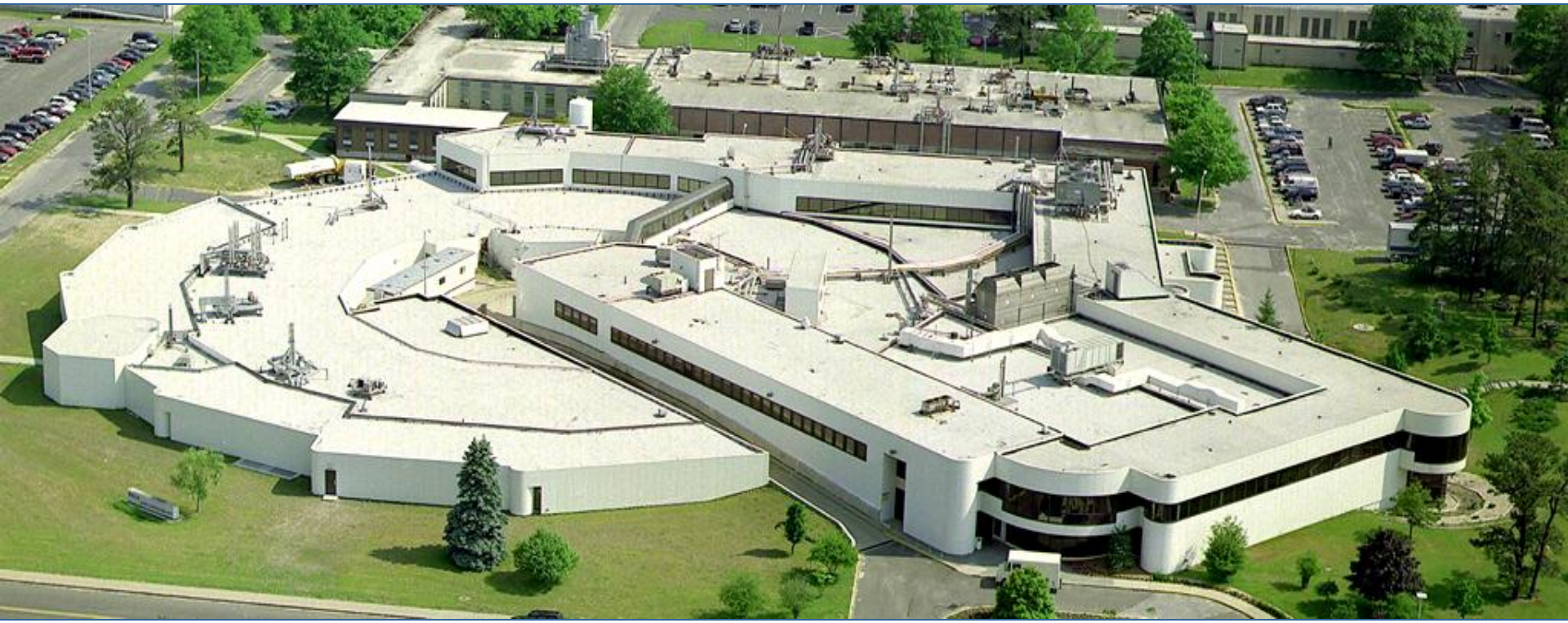
Introduction to the NSLS



Chi-Chang Kao
Chair NSLS

DOE EPSCoR Program Review, July 20-23, 2009

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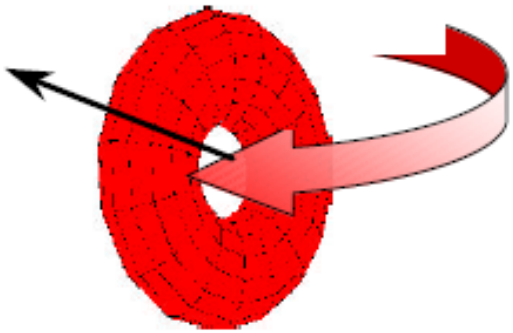
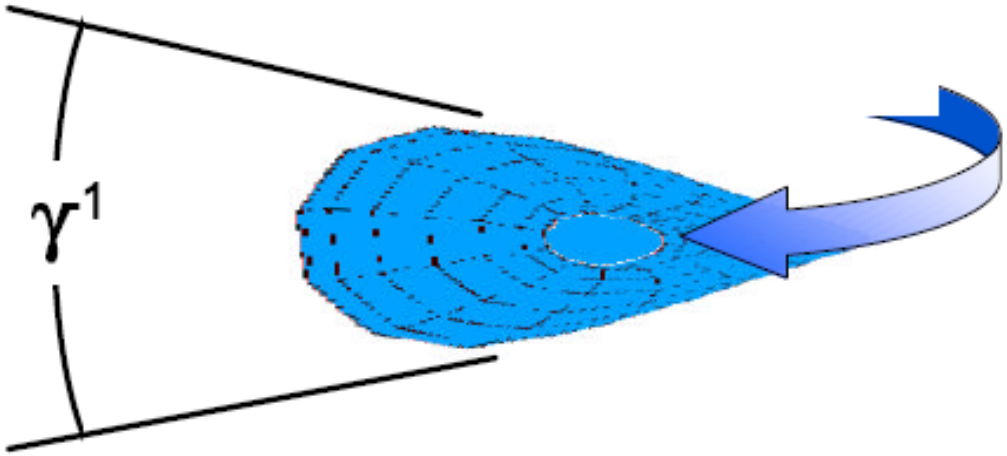
Synchrotron Radiation

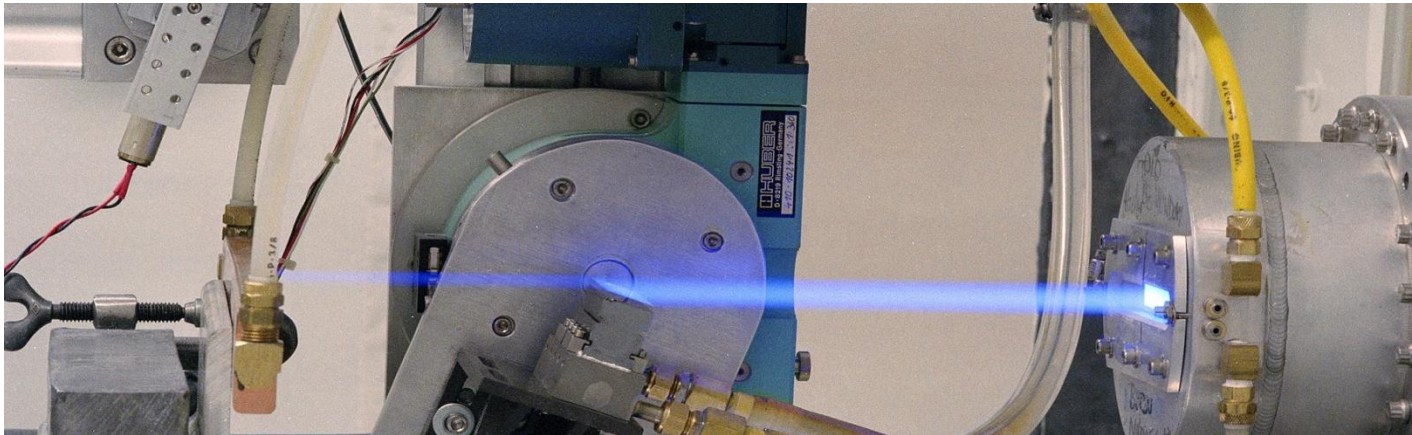
Dipole Radiation



Relativistic Energy



$\gamma = E / m_0C^2$ (Energy/Elec. rest mass)



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National Synchrotron Light Source

VUV Storage Ring:

51 m circumference

E = 0.808 GeV

I= 1.0 A

7 bunches

Orbital Period = 170 ns

Pulse Width = 320 ps

X-Ray Storage Ring:

170 m circumference

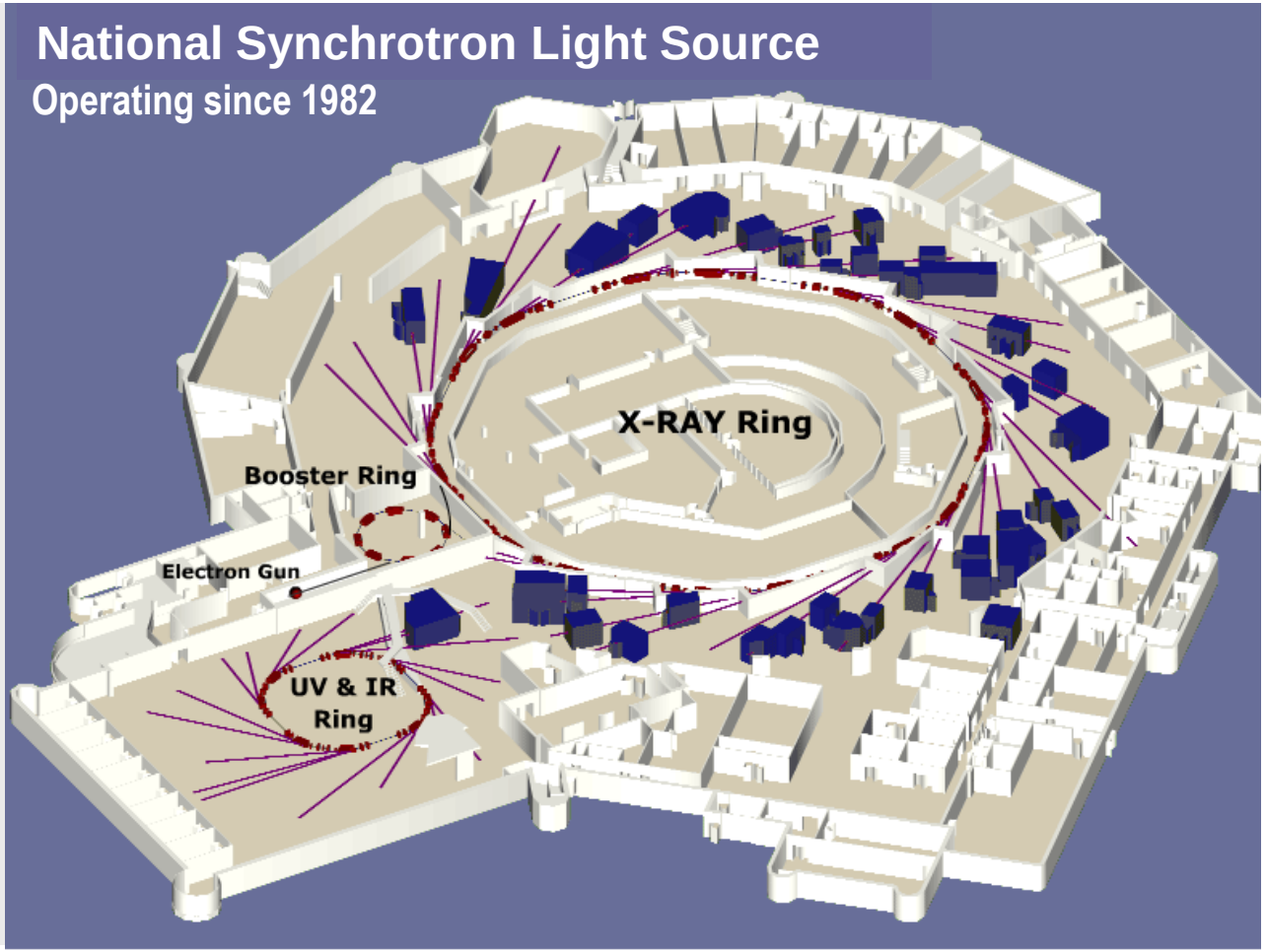
E = 2.8 GeV

I = 280 mA

25 bunches

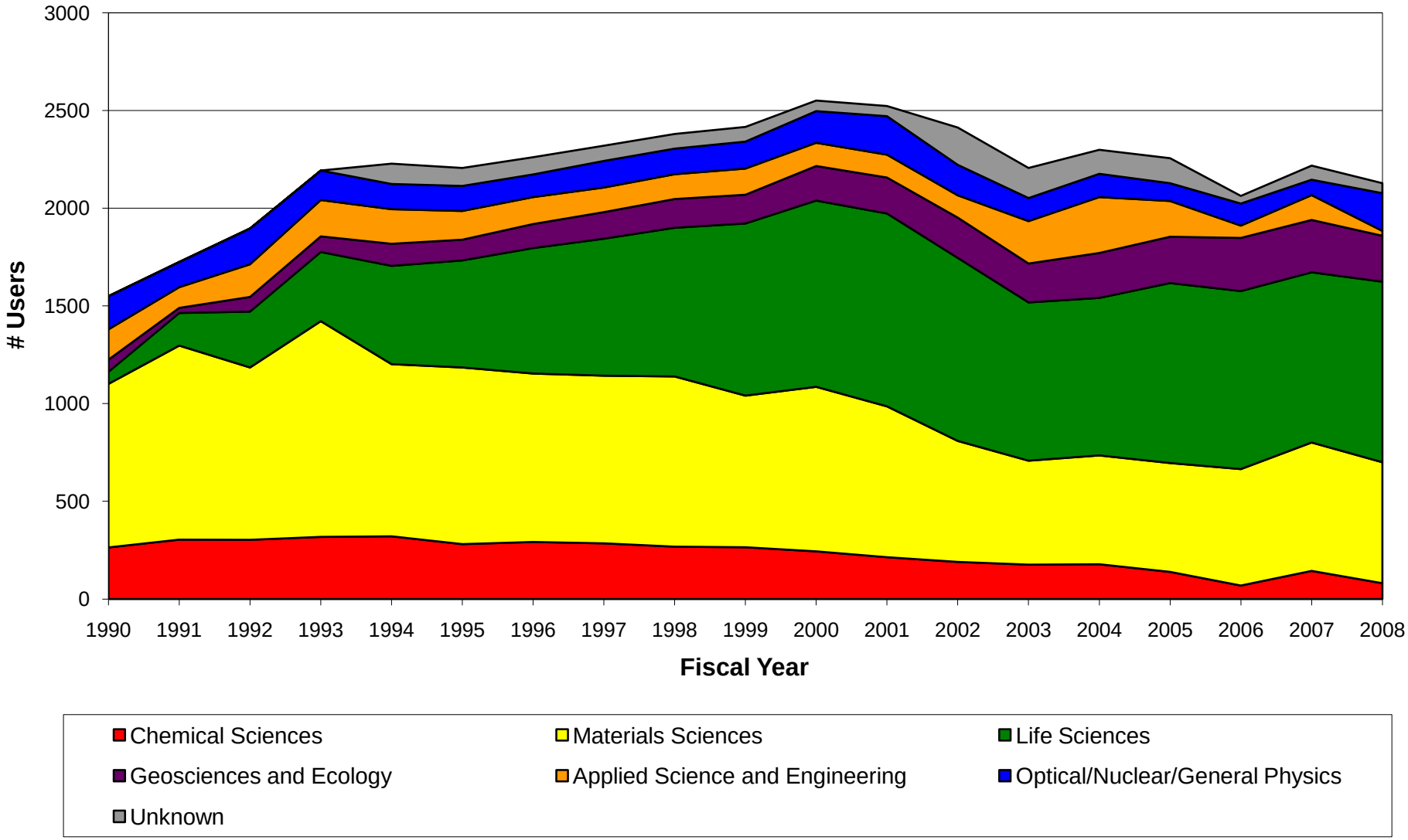
Orbital Period = 567 ns

Pulse Width = 290 ps

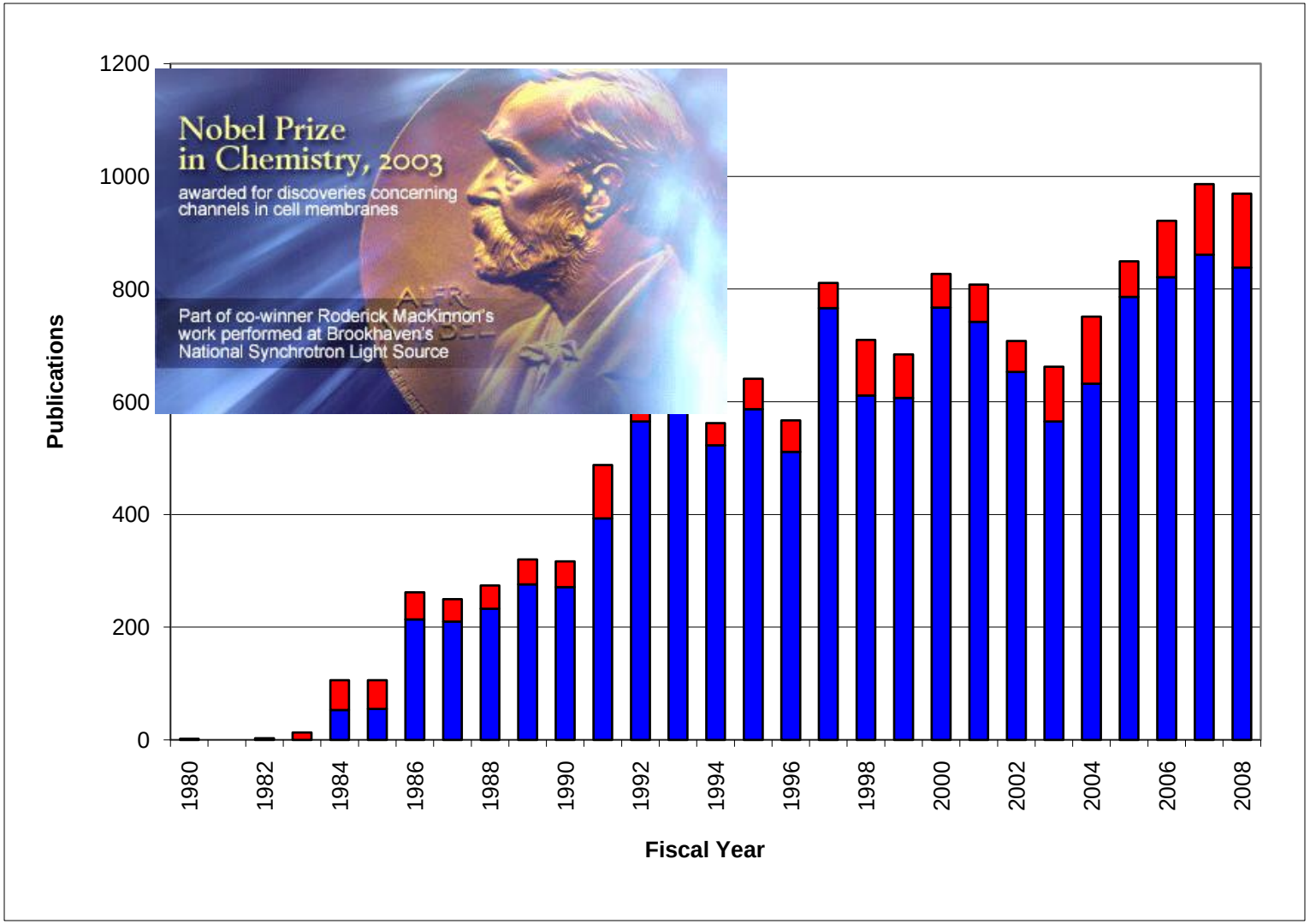


- 65 operational beamlines from far-IR to >100 keV X-rays

NSLS User Statistics



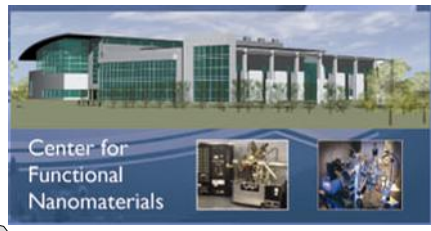
NSLS Publication

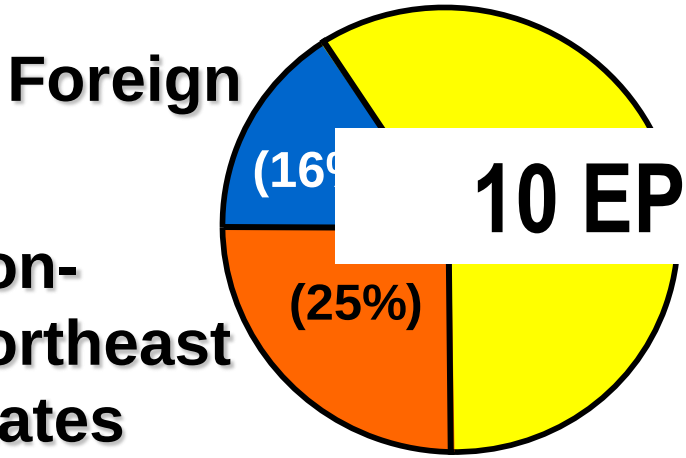


NSLS: A Crucial Resource for the Northeast

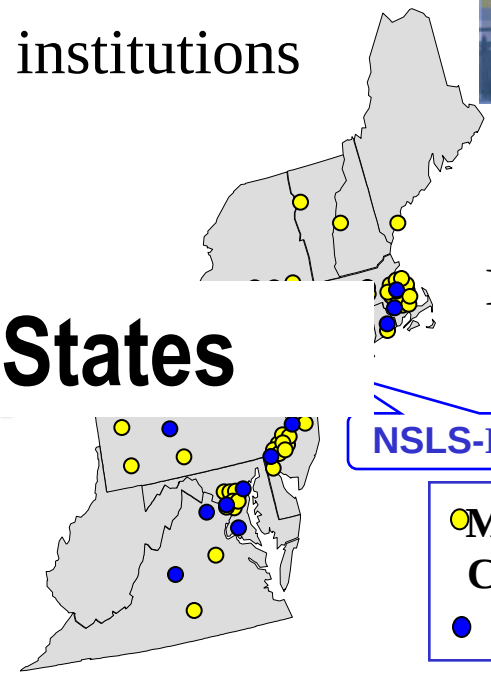
2200 Users/year

> 400 academic, industrial, government institutions





10 EPSCoR States



Home Institutions of Users

NSLS-II & CFN

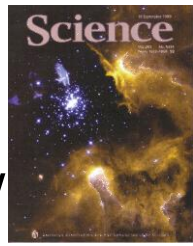
- **Macromolecular Crystallography**
- **Nanoscience**

Vital resource for university, industrial and government labs:

Industry: IBM, ExxonMobil, GE, Pharmaceuticals, others

NIST: Center for Synchrotron Measurement Science & Technology

BNL: CFN, Catalysis Center, Structural Biology, Environment



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Major Techniques and Research Fields

SPECTROSCOPY
- Infrared spectroscopy
- Photoelectron spectroscopy
- X-ray absorption spectroscopy
- X-ray emission spectroscopy

DIFFRACTION/SCATTERING
- Protein crystallography
- Small molecule crystallography
- Powder diffraction
- Small-angle x-ray scattering
- X-ray microdiffraction
- High momentum resolution x-ray scattering

IMAGING
- Infrared microspectroscopy
- Soft X-ray scanning microscopy
- Hard X-ray microprobe
- X-ray microtomography
- Diffraction-enhance imaging

OTHER
X-ray footprinting

MATERIALS/CONDENSED MATTER PHYSICS
- Strongly Correlated Electron Systems
- Surface and Interface Science
- Small Molecule Crystallography
- Magnetism Magnetic Materials
- Soft Matter

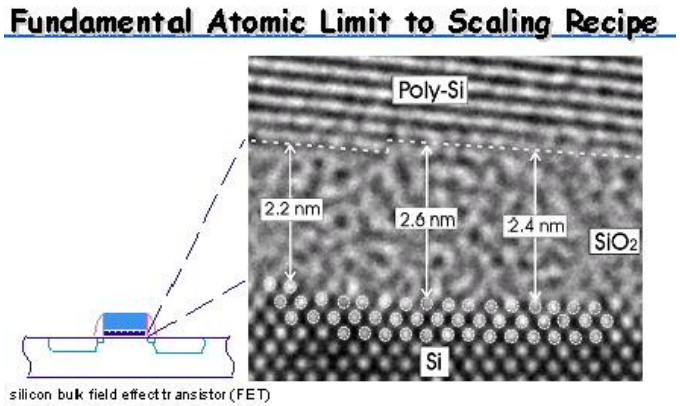
CHEMICAL SCIENCES
- Catalysis
- Materials Synthesis
- Electrochemistry
- Polymer Science

EARTH, PLANETARY, ENVIRON. SCIENCES
- Geophysics and high-pressure Science
- Environmental Science

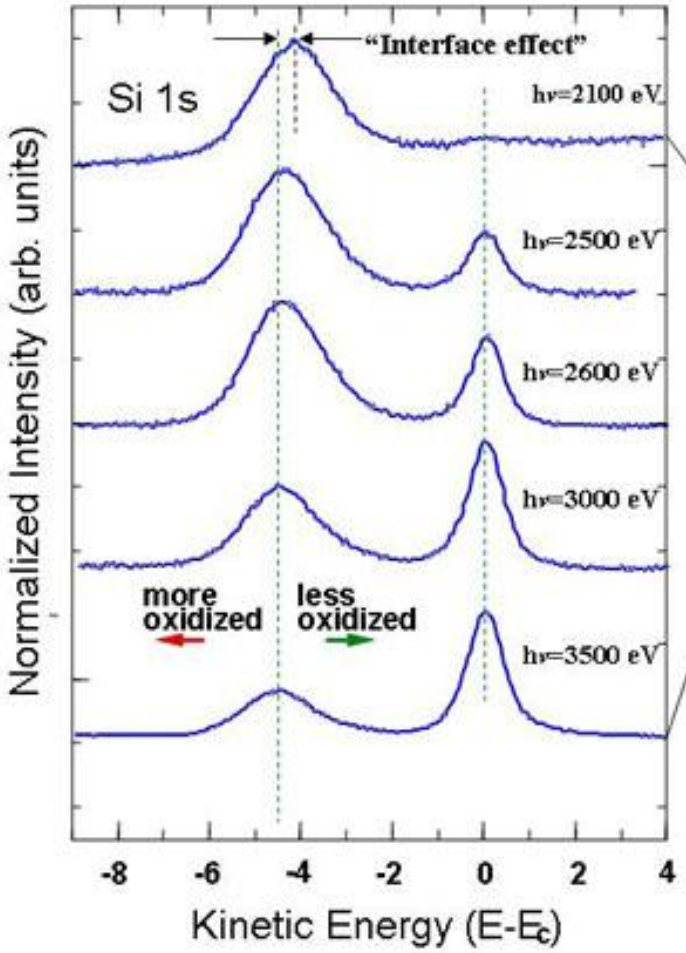
BIOLOGY
- Protein Crystallography
- Scattering from Biomolecules
- Bio-Medical Imaging

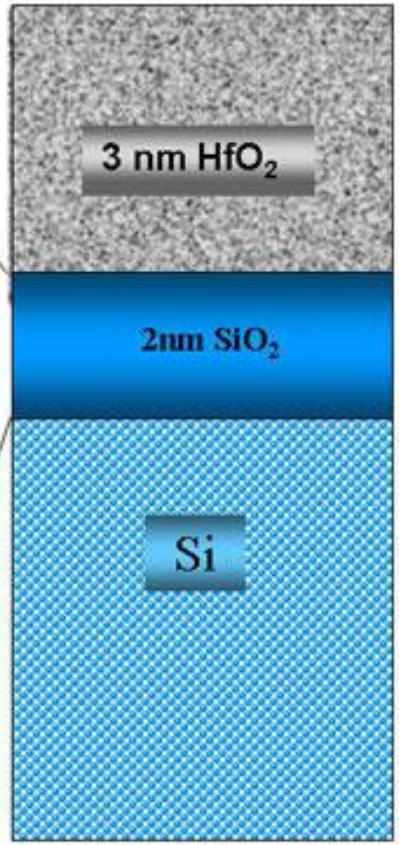
Variable High Energy Photoemission: Probing buried interfaces

High K dielectric in field-effect transistor



- High leakage current for <2nm SiO2
- Hf based oxides are promising, but not good enough
- Modifying of Hf oxides thin film to optimize their properties





SEMATECH and NIST

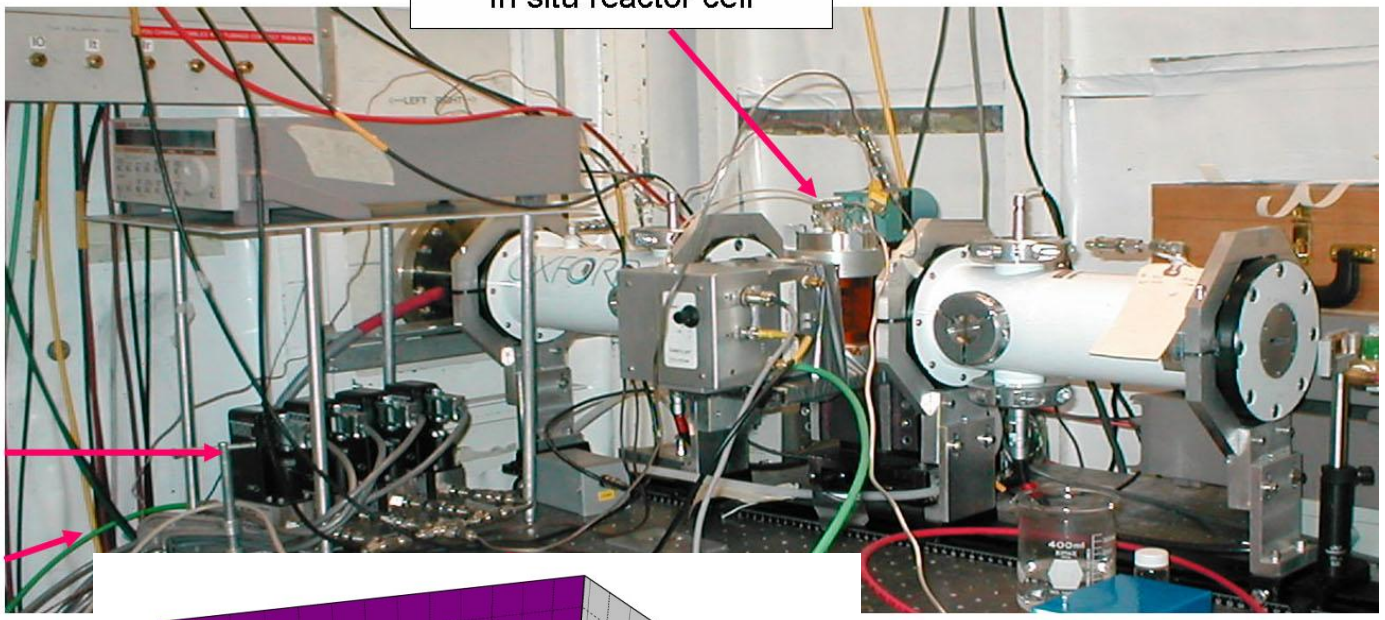
In-situ X-ray Absorption Studies of Catalytic Reactions

Flow control electronics, gas cylinders (outside the hutch)

Flow controllers

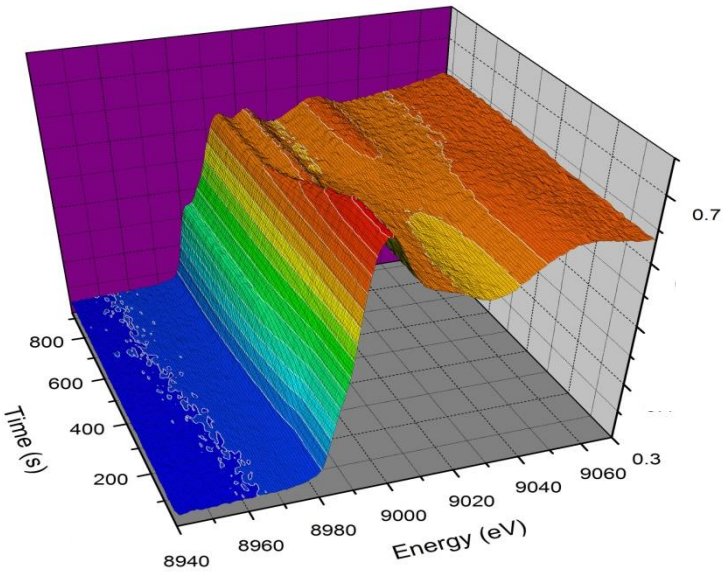
Gas inputs

In situ reactor cell



RGA (MS and GC): Inside the hutch

reduction of Cu/ceria catalyst with 5% H2 at 300C



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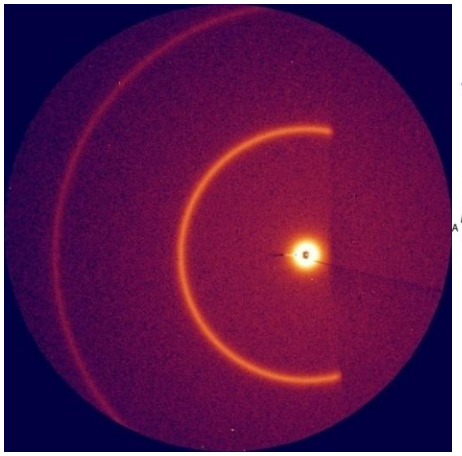
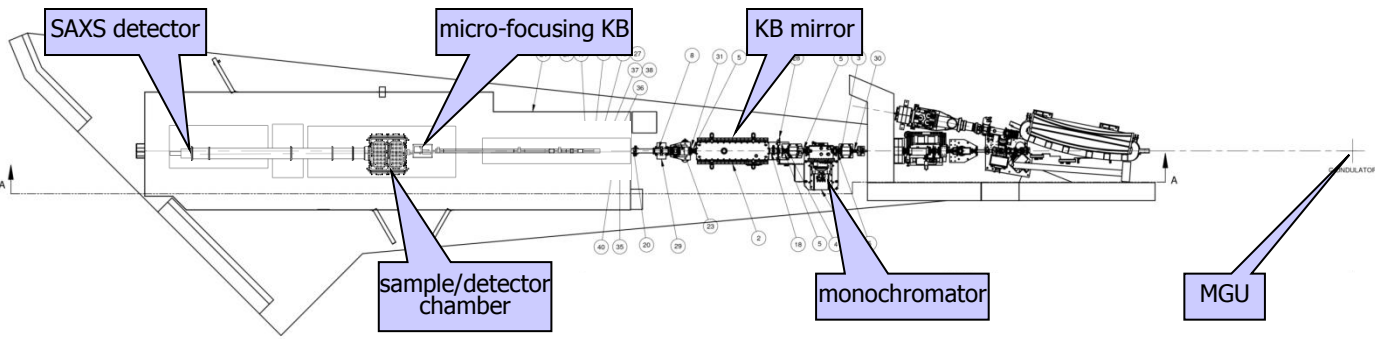
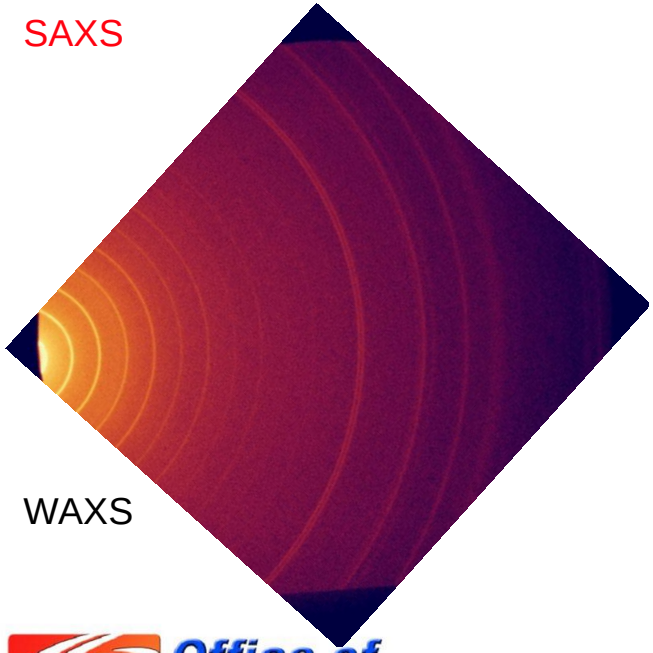
Undulator Beamline for Small Angle X-Ray Scattering

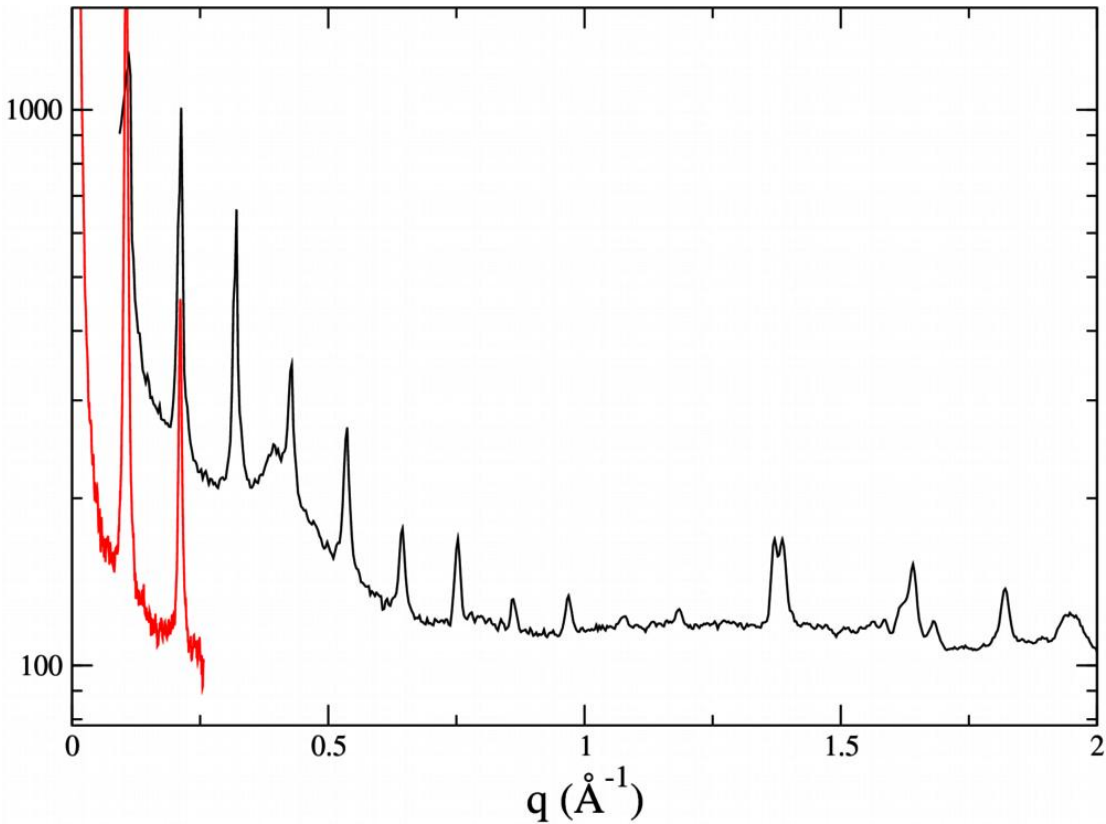




SAXS



WAXS



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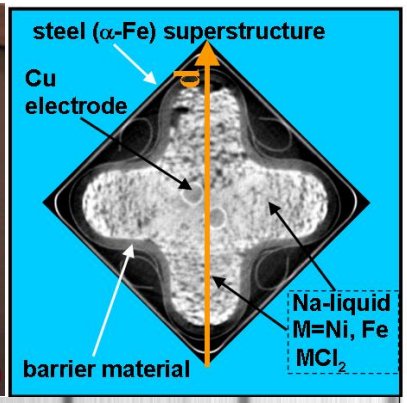
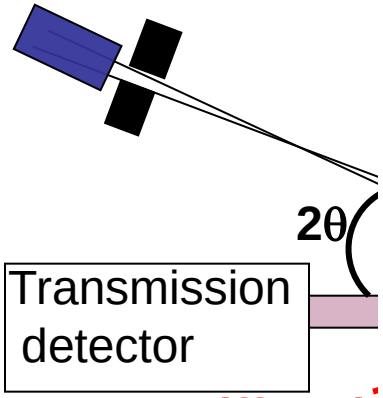
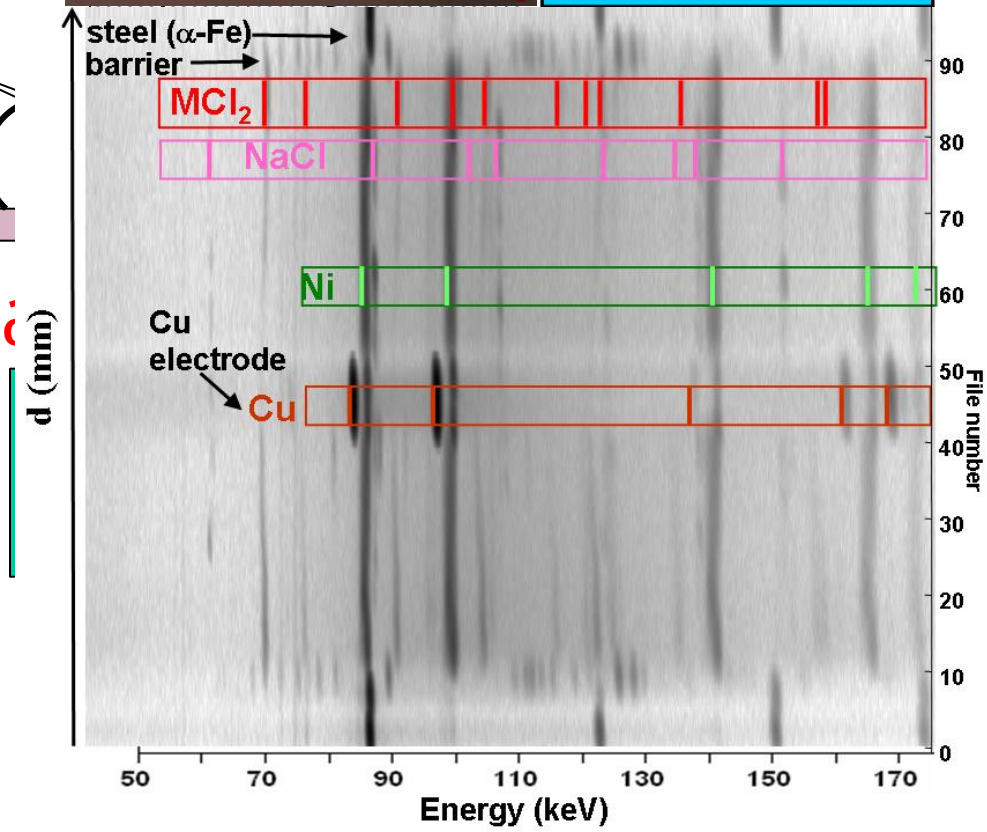
High Energy X-ray Diffraction

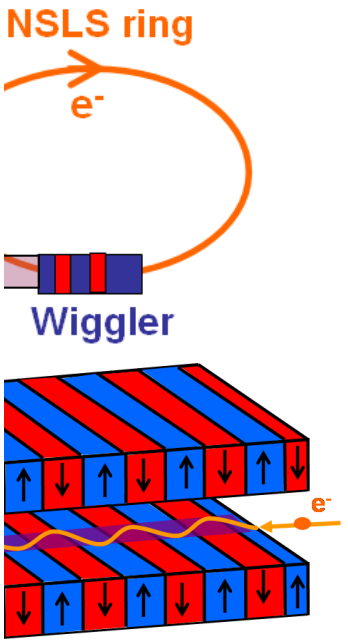
"Wh [illegible] Mode





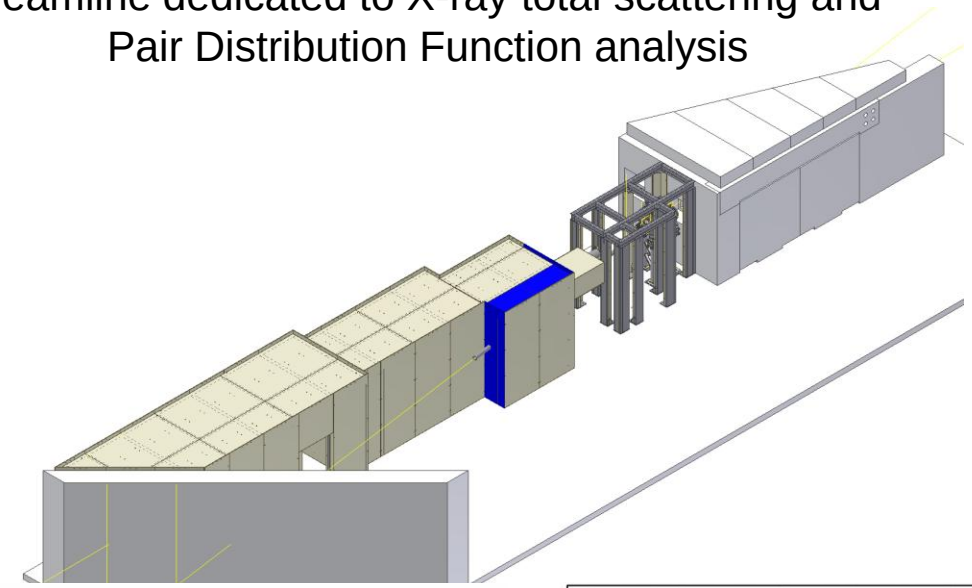
Diffracti[illegible] volume

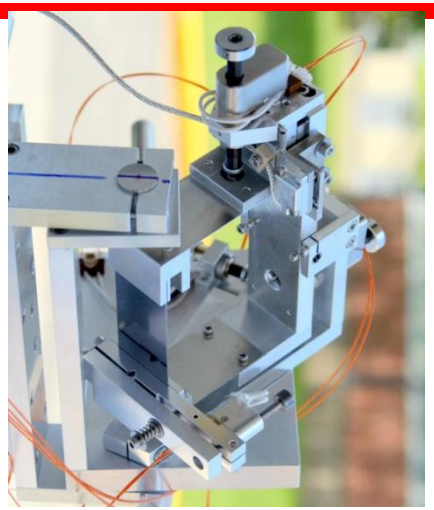




High Energy X-ray Scattering

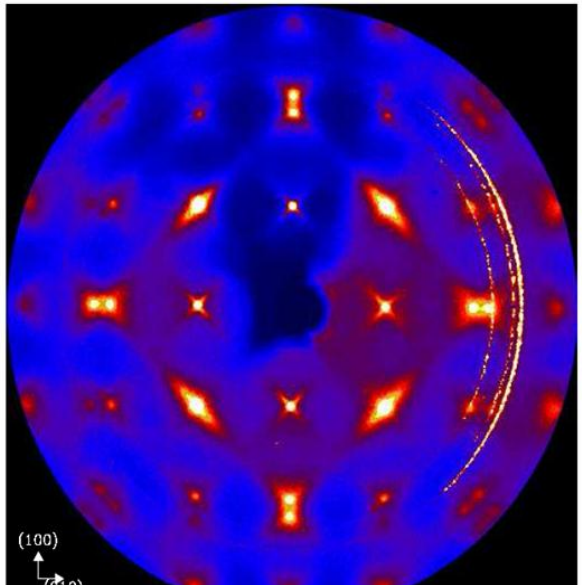
Beamline dedicated to X-ray total scattering and Pair Distribution Function analysis

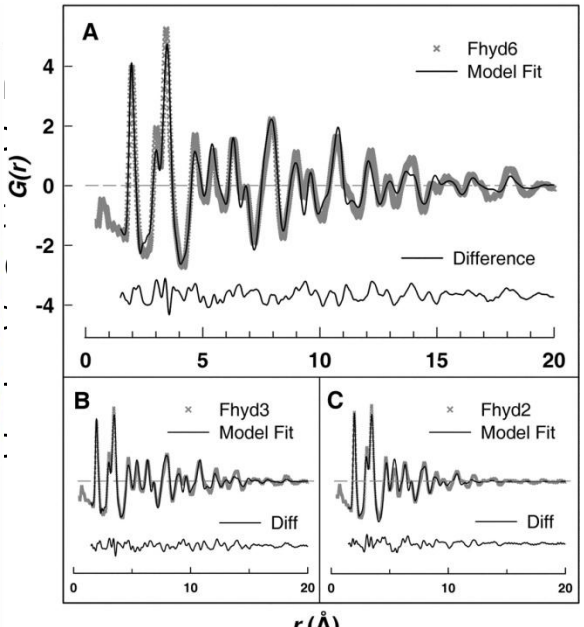




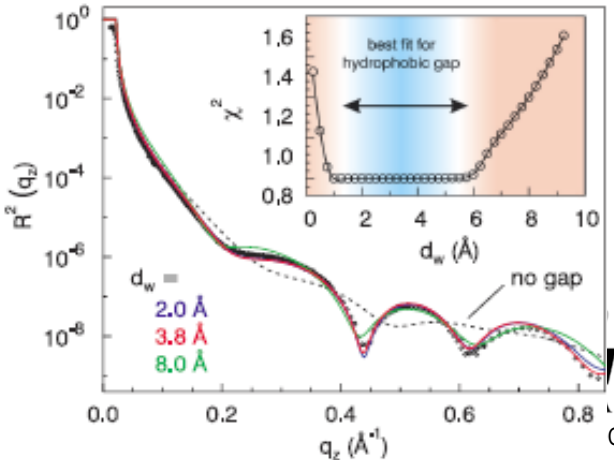
Fixed energy at 75 keV selected by a side-scattering (511) silicon Laue monochromator

PZN–8PT T=200 K

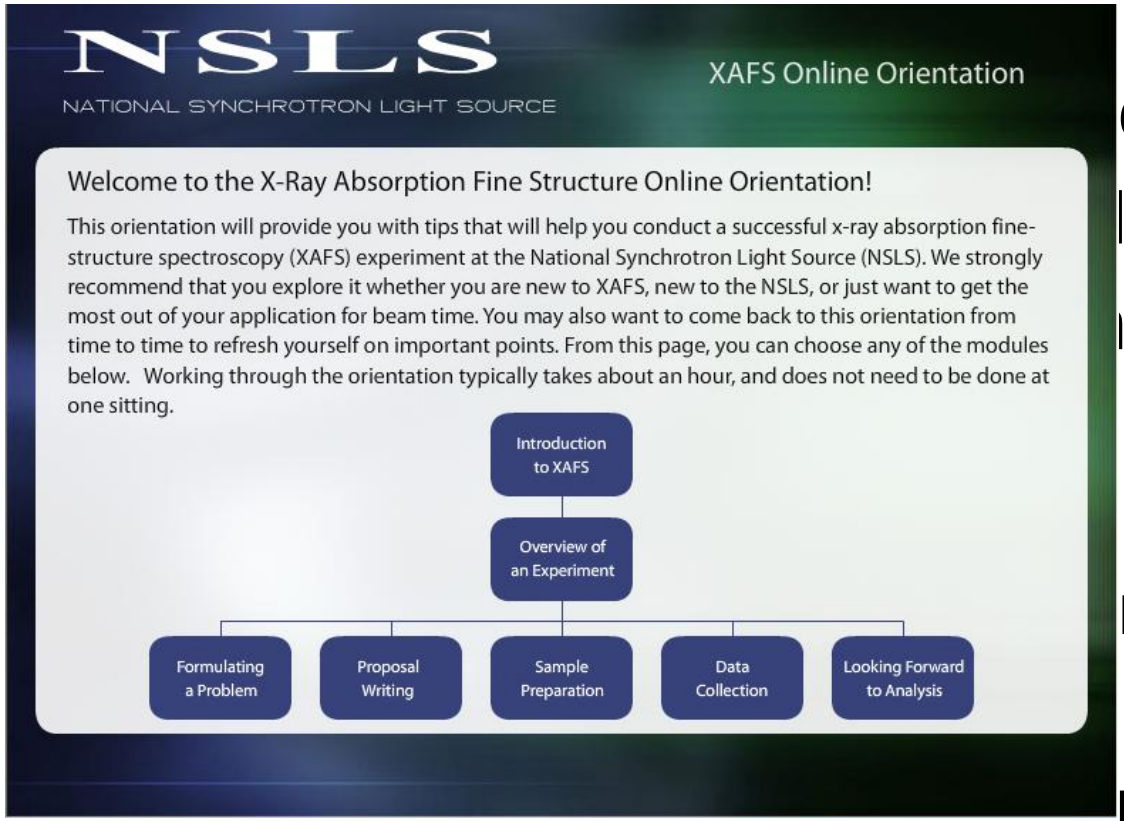




Design of bending mechanism for 2D focusing is progressing well



New Training Initiatives : XAFS



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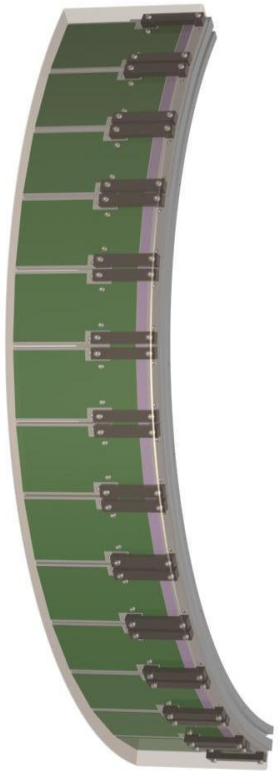
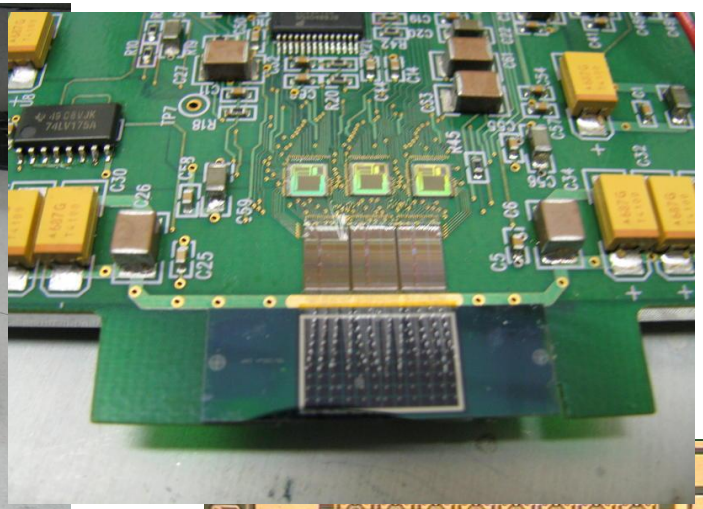
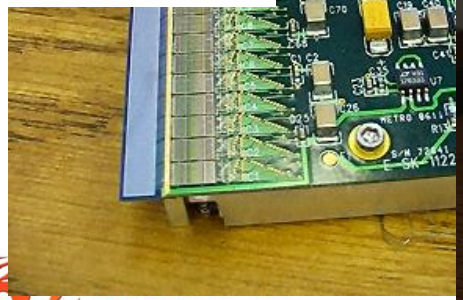
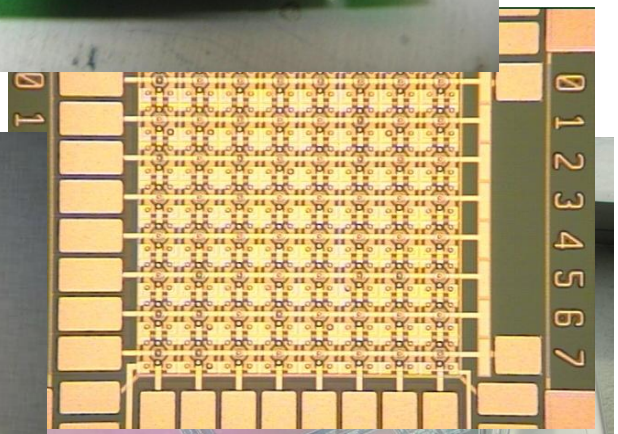
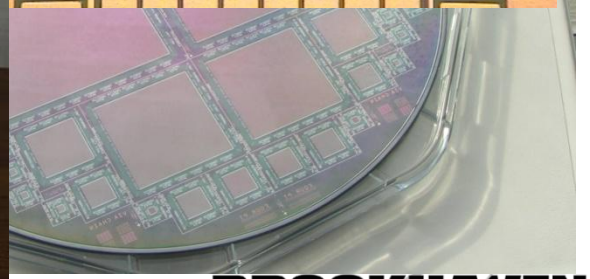
NSLS Detector Development Program











Science
U.S. DEPARTMENT OF ENERGY

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NATIONAL LABORATORY
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Industrial Research Initiative

- A newly created position: Industrial Program Coordinator
  - Work closely with industrial users as well as beamline staff
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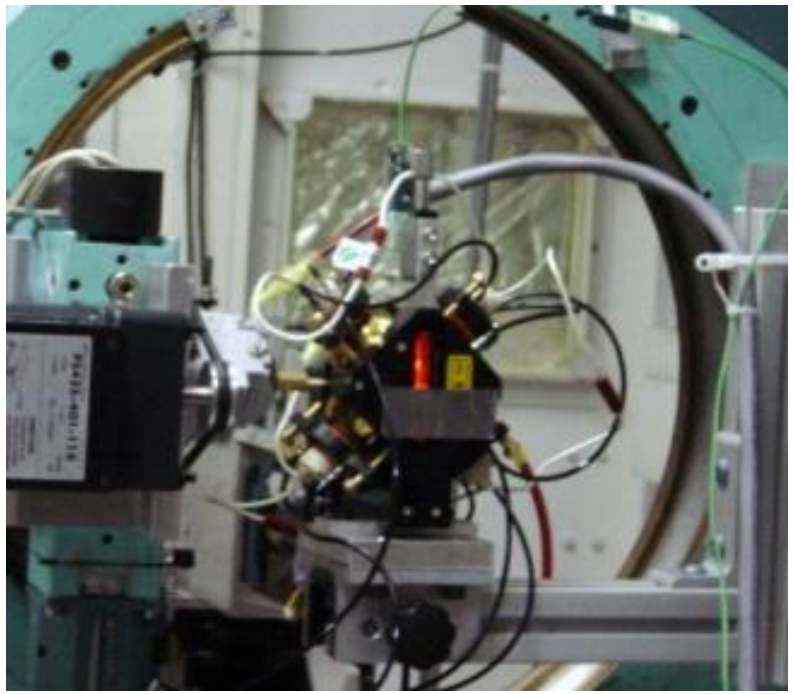
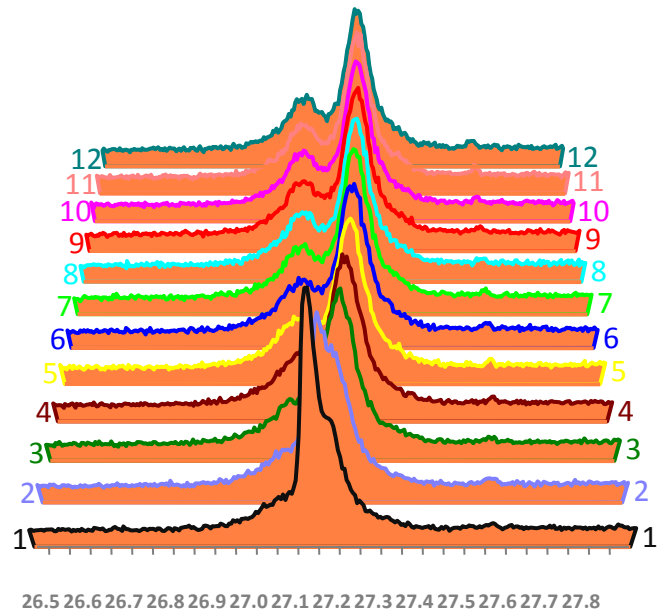


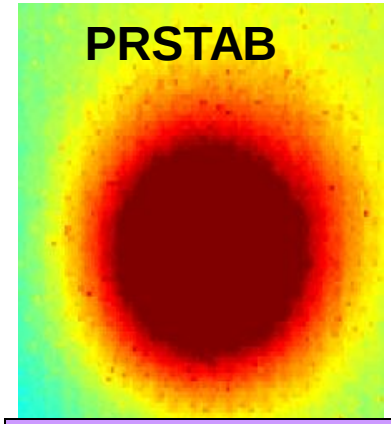
New ambient-atmosphere high-temperature furnace mounted on diffractometer at NSLS X14A.



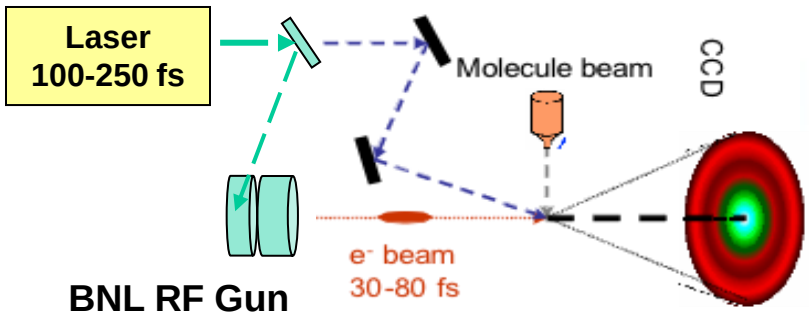
Time resolved XRD of YSZ: 10 sec /scan, T = 1500°C. Gao (GE), Bai (ORNL), and Wang (NSLS).

ng

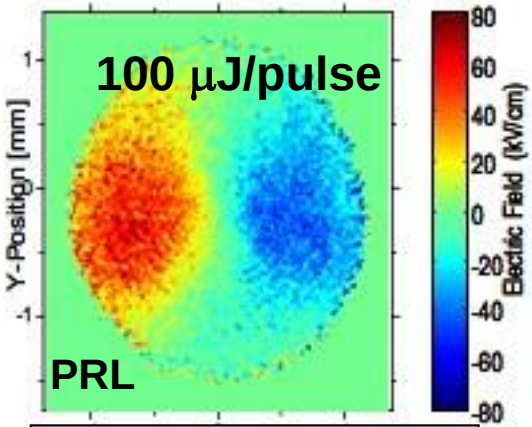
NSLS Source Development Lab (SDL): Frontier FEL & Bright Electron Beam R&D



HGHG & Laser Seeded FELs



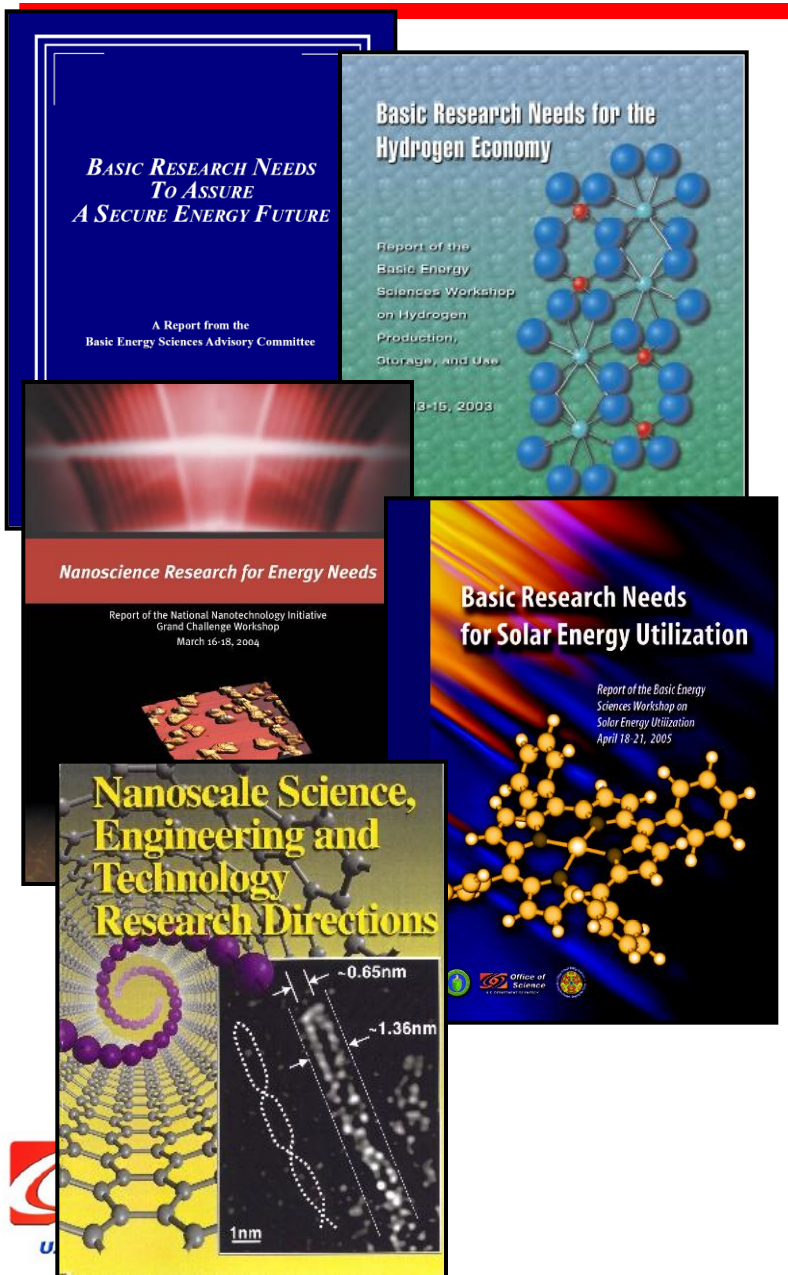
Ultrafast Electron Diffraction



High Intensity THz

NSLS-II Project

The Mission Need for NSLS-II

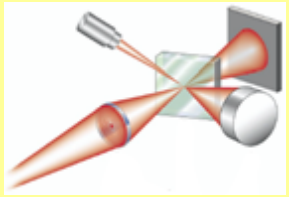


- Major studies by BESAC, BES, and the National Nanotechnology Initiative have reassessed the research and the scientific tools needed to advance energy technologies.
- A common conclusion is that the development of nanoscale materials – as well as the methods to characterize, manipulate and assemble them – is critical for the development of future energy technologies.
- The remarkable tools that were developed over the past 30 years for visualizing the nanoworld – in particular, the synchrotron radiation light sources – helped launch the nanorevolution; ; however, none of today's light sources (anywhere in the world) were designed to probe materials with 1 nanometer spatial resolution and with 0.1 meV energy resolution (equivalent to ~1 K).

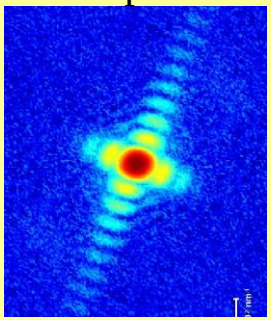
"Light sources with even more advanced capabilities than the best available today are needed to address the challenges put forward in these and other reports."

High Level Description of NSLS-II

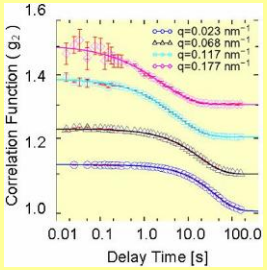
New Capabilities



Nanoprobes



Diffraction Imaging



Coherent Dynamics

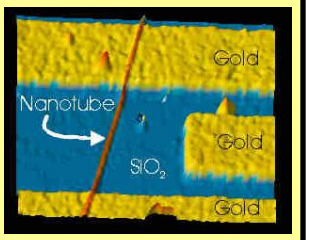
A highly optimized x-ray synchrotron delivering:

- very high brightness and flux;
- exceptional beam stability; and
- a suite of advanced instruments, optics, and detectors that capitalize on these special capabilities.

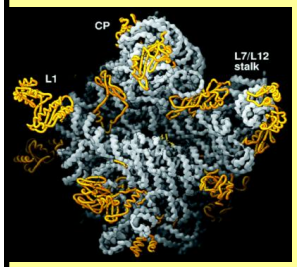
Together, these will enable:

- ~ 1 nm spatial resolution,
- ~ 0.1 meV energy resolution, and
- single atom sensitivity.

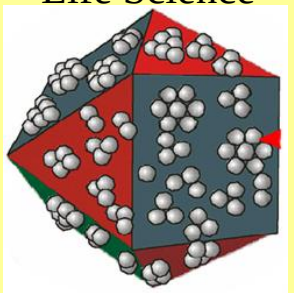
New Science



Nanoscience



Life Science



Nanocatalysis

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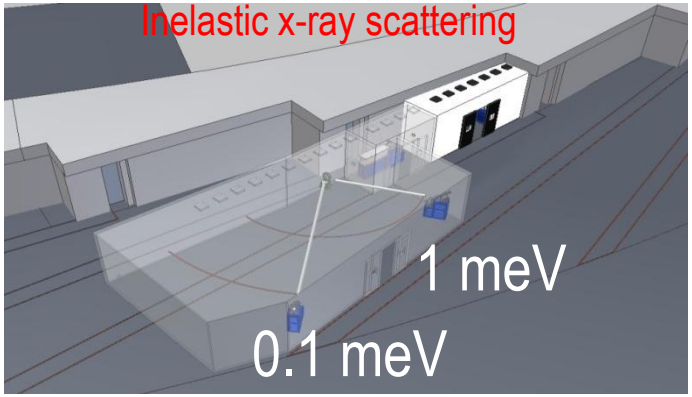
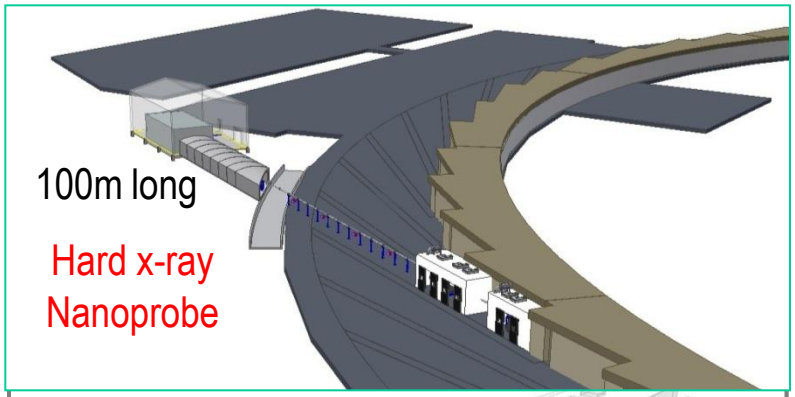
BROOKHAVEN SCIENCE ASSOCIATES

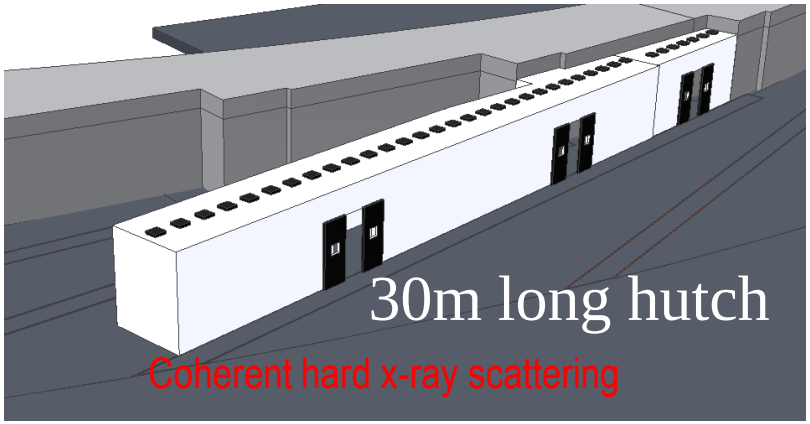
Key Project Milestones

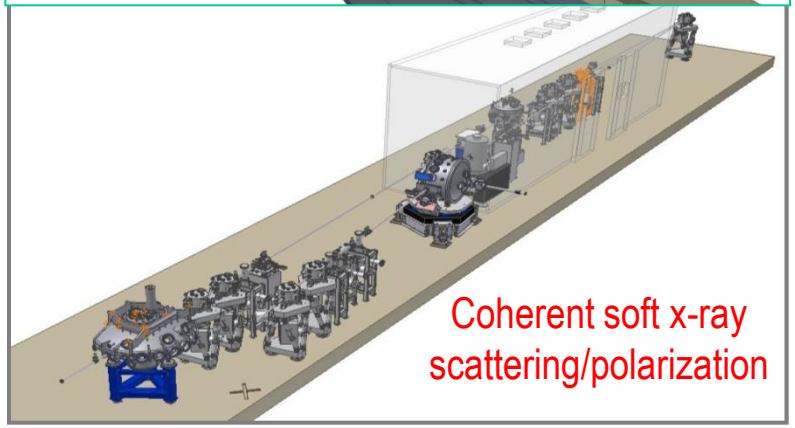
Aug 2005	**CD-0**, Approve Mission Need (Complete)
Jul 2007	**CD-1**, Approve Alternative Selection and Cost Range (Complete)
Jan 2008	**CD-2**, Approve Performance Baseline (Complete)
Dec 2008	**CD-3**, Approve Start of Construction (Complete)
Feb 2009	Contract Award for Ring Building (Complete)
Aug 2009	Contract Award for Storage Ring Magnets
Mar 2010	Contract Award for Booster System
Feb 2011	1st Pentant Ring Building Beneficial Occupancy; Begin Accelerator Installation
Feb 2012	Beneficial Occupancy of Experimental Floor
Oct 2013	Start Accelerator Commissioning
Jun 2014	Early Project Completion; Ring Available to Beamlines
Jun 2015	**CD-4**, Approve Start of Operations

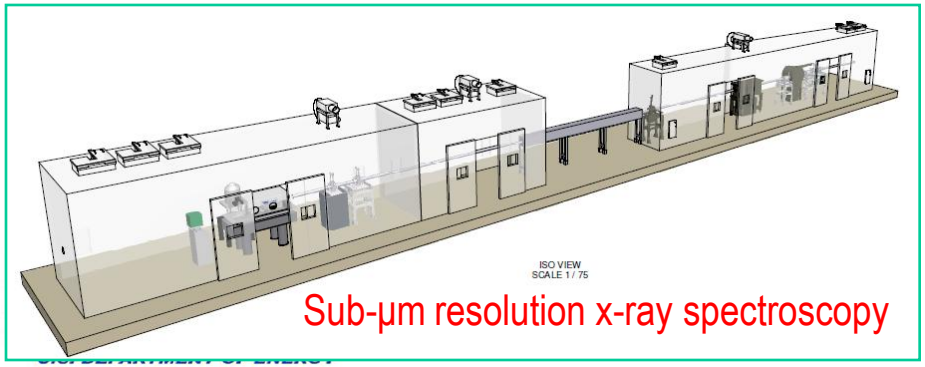
Six Project Beamlines at NSLS-II

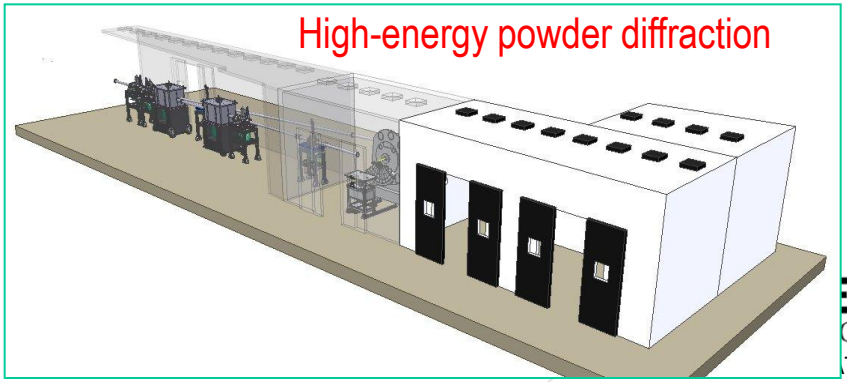












Summary

We will work with you to:

- Use the wide range of capabilities at NSLS for your research program
- Enhance your research program by collaborating with NSLS staff and the large users community at the NSLS
- Participate in research teams to develop new instruments or experimental techniques for NSLS-II