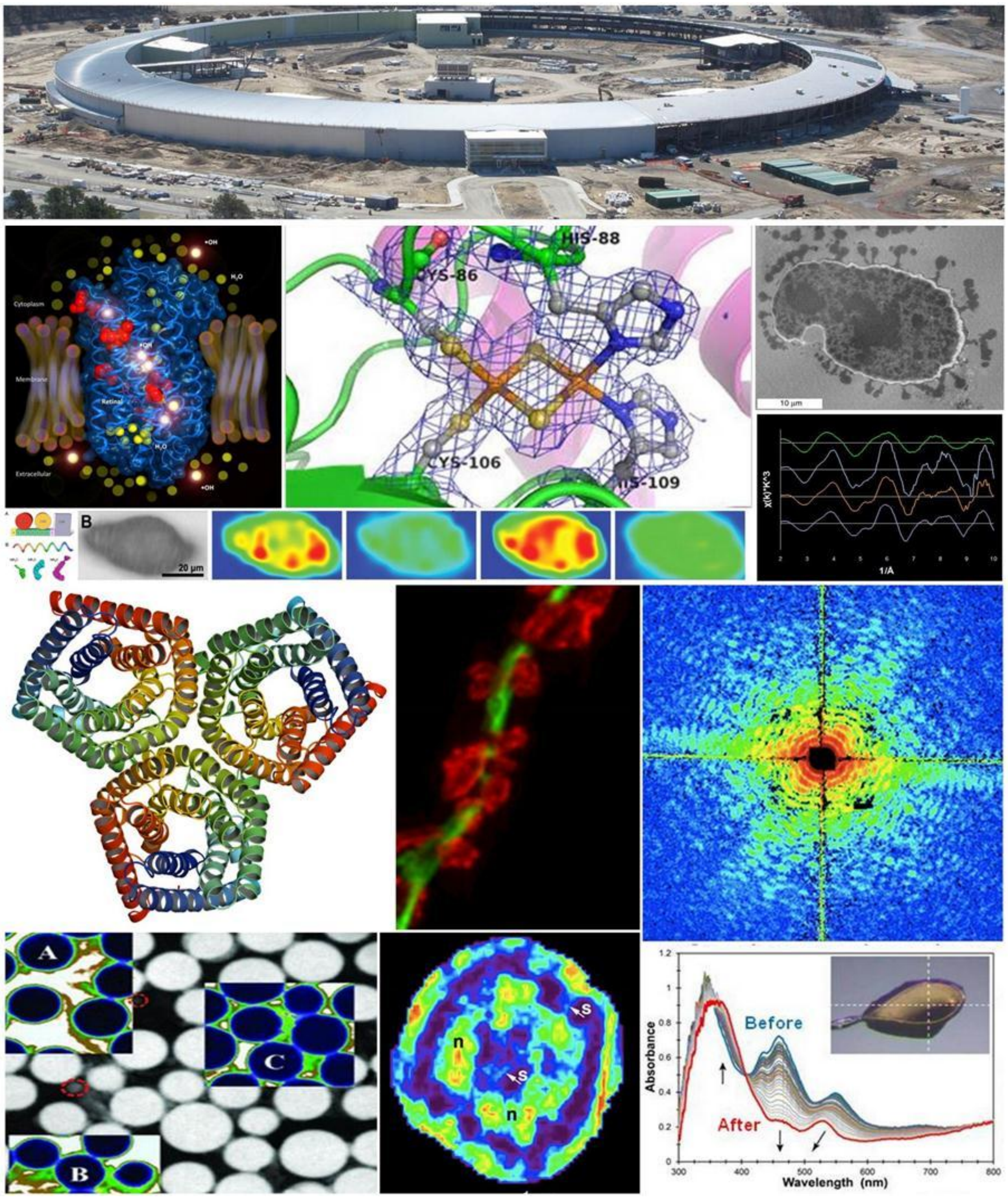
OPPORTUNITIES FOR BIOLOGICAL SCIENCES AT NSLS-II, PART A



BROOKHAVEN
NATIONAL LABORATORY

Overview of the NSLS-II Facility

The National Synchrotron Light Source-II (NSLS-II) is designed to provide a broadband source of synchrotron photons from infrared light to X-rays with a brightness unsurpassed by any synchrotron worldwide. The extreme brightness and coherence of NSLS-II will enable new techniques, such as nanoscale imaging, that are currently either in their infancy or not feasible with present sources. Moreover, NSLS-II will take widely used techniques, such as macromolecular crystallography (MX), X-ray scattering (XRS), and X-ray absorption spectroscopy (XAS), and extend them to new regimes in time- and spatial-resolution that cannot be achieved today. NSLS-II is currently under construction, now over 50% complete; and it is on track for completion in March 2014, 15 months ahead of schedule. When operational, it will replace the original NSLS.

NSLS-II under construction and ~50% completed on 25 March 2011. The new facility will produce photon beams with a brightness and coherence unsurpassed by any synchrotron worldwide, and it will support a wide range of experiments in the biological sciences as well as in the physical sciences.

The synchrotron storage ring for NSLS-II is designed to operate at 3 GeV and 500 mA such as to produce electron beams of ultra-low emittance (ε_x, ε_y = 0.6, 0.008 nm-rad). The accelerator design that reaches this emittance features a large ring (circumference 791.5 m) with relatively soft bend magnets configured in a 30 cell, double-bend achromat that holds 15 long (9.3 m) high-β straight sections and 15 short (6.6 m) straight sections, with damping wigglers in 8 of the 15 long straights. The baseline configuration implements damping wigglers in only three of the straights. The straight sections can accommodate a variety of insertion devices including undulators and superconducting wigglers, large-gap dipoles can be accommodated for IR sources, and three-pole wigglers (3PWs) can be added at bend positions to shift the critical energy into a spectrum similar to that at the NSLS bends.

NSLS-II can accommodate at least 58 independently operating beamlines, and potentially there can be many more with canted insertion devices and multiple endstations per beamline. These could comprise insertion devices on 15 low-β straights and on 12 high-β straights, including damping wigglers as potent X-ray sources, 27 bend-magnet (BM) ports for IR, UV or soft X-rays from the dipoles or hard X-rays from 3PWs, and 4 large-gap BM ports for far-IR. NSLS-II will be brighter than any other synchrotron world wide and more than 10,000 times brighter than NSLS. It is designed to enable ~1 nm spatial resolution and ~0.1 meV energy resolution and diffraction-limited coherence in the vertical at 12 keV.

The baseline construction project for NSLS-II includes six insertion-device beamlines; others are being built with additional funding from DOE-BES and other sources. A call for proposal in

2010 generated a total of 54 Beamline Development Proposals, of which 34 were approved. Calls for additional proposals will recur annually, and the recent 2011 call generated 13 Letters of Intent including resubmissions as well as new Beamline Development Proposals.

NSLS-II Beamlines for Biological Sciences

Biological sciences are prominent in the planning for NSLS-II beamlines. Four of the six project beamlines are intended to address biological research interests as well as physical and material sciences needs; 13 of the 34 approved beamlines include substantial biological applications, and biology predominates for 11 of these; and four of the new LOIs are exclusively or substantially for biology.

Acronym	Application	Spokesperson or Beamline Scientist	Source
Project Beamlines:			
CHX	Coherent hard x-ray scattering	Andrei Flueresu	U
HXN	Hard x-ray nanoprobe	Yong Chu	U
IXS	Inelastic x-ray scattering	Yong Cai	U
SRX	Sub-micron resolution x-ray spectroscopy	Juergen Thieme	U
Approved Beamline Development Proposals:			
ABS	Automated biomolecular solution scattering	Lin Yang	3PW
AIM	Advanced infrared microspectroscopy	Lisa Miller	BM
AMX	Flexible access macromolecular crystallography	Dieter Schneider	U
CDI	Coherent x-ray diffraction	Ian Robinson	U
FMX	Frontier macromolecular crystallography	Robert Sweet	U
FXI	Long beamline for full-field imaging	Jake Socha	SCW
IRI	Full-field infrared spectroscopic imaging	Lisa Miller	BM
LIX	X-ray scattering for life sciences	Lin Yang	U
NYX	NYSBC microdiffraction beamline	Wayne Hendrickson	U
SM3	Correlated spectroscopy and MX	Allen Orville	3PW
XAS	X-ray absorption spectroscopy	Mark Chance	3PW
XFM	X-ray fluorescence microprobe	Antonio Lanzirotti	3PW
XFP	X-ray footprinting	Mark Chance	DW
Letters of Intent:			
HIT	Discoveries for chemical biology	Marc Allaire	U
LAX	Low-energy anomalous x-ray diffraction	Wayne Hendrickson	U
MIT	Medical imaging and radiation therapy	Avraham Dilmanian	SCW
STX	Scanning transmission x-ray microscope	Juergen Thieme	U

BM = bending magnet; DW = damping wiggler; SCW = superconducting wiggler;
U = undulator; 3PW = three-pole wiggler

The beamlines planned now for NSLS-II are intended both to accommodate existing science programs and those that will develop in response to new opportunities. Several of the NSLS-II beamlines currently under development do address future needs of current NSLS users. In addition, however, NSLS-II brightness brings new opportunities both for these disciplines and for techniques that take advantage of the unprecedented resolutions and coherence at NSLS-II, notably in imaging. In the remainder of this document, we describe some of the features of currently envisioned beamlines. In the long run, NSLS-II will surely accommodate beamlines aiming at other applications. We group the current beamlines into four categories: Macromolecular Crystallography, Scattering, Spectroscopy and Imaging and provide a brief description of the capabilities and science areas for each beamline now under development. The divisions are somewhat arbitrary (e.g. a scattering beamline might examine crystals and an imaging or MX beamline might use spectroscopic probes), but the beamline descriptions clarify this.

Macromolecular Crystallography

FMX – Frontier Macromolecular Crystallography

This MX beamline will exploit the finest properties of NSLS-II and push the state-of-the art in X-ray optics. The tunable, one-micron, variable divergence beam handles small crystals and very large unit cells. Preserving beam coherence makes new experiments possible. Cryogenic automation at the state-of-the-art will provide convenience for users.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Structural biology. The most interesting structures are often the most difficult. This beamline will push new limits in crystal size.

Biochemistry. Knowledge of intermediates in enzymatic pathways expands our understanding of cellular and microbiological processes.

Physiology and medicine. Knowing how drugs interact with their targets is essential to development of new pharmacologically effective compounds.

FMX Beamline Capabilities:	
Source:	canted U20 undulator
Energy range and resolution:	5 – 20 keV; $\Delta E/E \approx 5 \times 10^{-4}$
Beam size:	from 1 x 1 to 100 x 100 μm^2
Diffraction resolution:	to 1 Å resolution

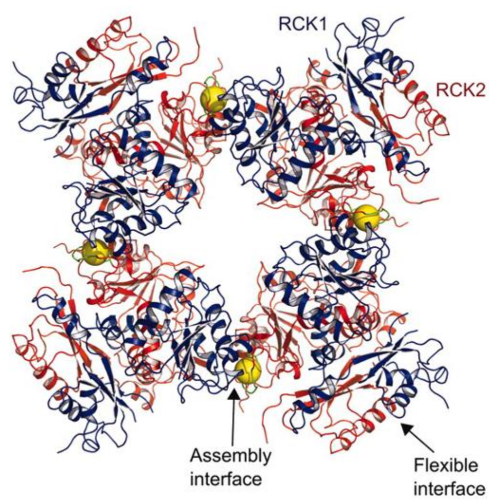
AMX – Flexible Access and Highly Automated Beamline for Macromolecular Crystallography

AMX at NSLS-II will provide structural biologists with ready access to an advanced facility for precise structure determinations at unprecedented rates; it will exploit the source characteristics and deliver a very high flux in a suitably small focused beam; and it will be highly automated to support remote access and extensive experimental studies.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Structural biology. Atomic structures of large protein and nucleic acid complexes, including membrane proteins, are prerequisites to gaining insights into their function, interaction, and dynamics, thus creating molecular movies.

Biochemistry. Structural analysis of all intermediates in



Ribbon diagram of the gating ring of the human BK channel Ca^{2+}-activation apparatus. (Yuan … MacKinnon, *Science* **329**, 182 ,2010).

entire enzymatic cycles and pathways will expand our understanding of cellular and microbiological processes.

AMX Beamline Capabilities:	
Source:	canted U20 undulator
Energy range and resolution:	5 – 20 keV; $\Delta E/E \approx 5 \times 10^{-4}$
Beam size:	from 5 µm to 300 µm
Diffraction resolution:	to 1 Å resolution

Physiology and medicine. Crystallographic studies of the interactions of drugs with their targets are essential in the development of pharmacologically effective compounds.

NYX – NYSBC Microdiffraction Beamline

This is a Type II beamline built by the New York Structural Biology Center as a Partner User. It features: (1) diffraction from micron-sized crystals and rastered scans for optimized diffraction from larger crystals of challenging biological macromolecules and complexes, (2) access to a broad range of resonant edges for anomalous diffraction (MAD and SAD) phasing, from U MV (3.5 keV) to Se K (12.7 keV) to U LIII (17.2 keV), and (3) optimization of anomalous scattering from high energy resolution for sharp transitions at resonant edges and lower energy for increased f'' with light elements (sulfur).

Homolog structure of the SLAC1 anion channel for closing stomata in plant leaves. (Chen … Hendrickson, *Nature* **467**, 1074, 2010).

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Membrane proteins. These present challenging structural problems with high relevance in neurobiology and metabolic disorders.

Macromolecular complexes. Protein-protein interactions are essential in signaling complexes and protein-nucleic acid complexes in transcription or replication.

NYX Beamline Capabilities:	
Source:	undulator on a low-β straight section
Energy range:	3.5 – 17.5 keV
Energy resolution:	down to $\Delta E/E \approx 5 \times 10^{-5}$
Beam cross section:	from 5 µ to 50 µ

Methods development. Supports efforts for methods to improve phase evaluation and enhance resolution.

SM3 – Correlated Spectroscopy and Macromolecular Crystallography

This is a unique facility for multi-disciplinary, nearly simultaneous studies of single crystals. Options include macromolecular crystallography, electronic absorption spectroscopy, fluorescence spectroscopy, Raman spectroscopy, FTIR spectroscopy, and XAS/XANES/EXAFS spectroscopy.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

SM3 Beamline Capabilities:	
Source:	three-pole wiggler
Energy range:	5 – 20 keV
Flux:	10^{13} ph/s at 12 keV

Redox state. Define redox states of metalloproteins using structures and spectroscopy from the same sample.

Mystery density. Raman spectroscopy helps assign electron density where ambiguities exist.

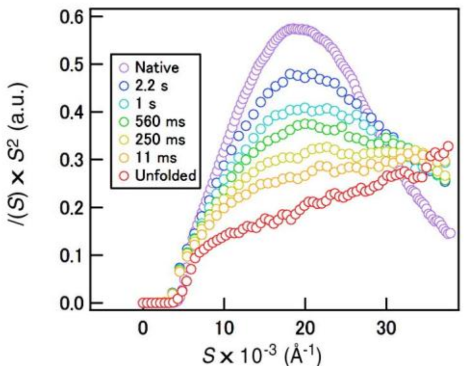
Mechanisms. Initiate and follow reactions. Trap and identify reaction intermediates.

X-ray Scattering

LIX – High Brilliance X-ray Scattering for Life Sciences

This beamline will support simultaneous small and wide angle time-resolved X-ray scattering measurements of proteins and DNA/RNA in solution using flow cells on time scales down to 10μs; it will also provide for grazing incident scattering from 2D solutions of membrane proteins embedded in near-native membranes; and it will be able to perform 1μm beam scanning probe imaging and tomography of biological tissues.

EXAMPLES OF SCIENCE AREAS AND IMPACT:



Kratky profiles from time-resolved SAXS of barnase folding dynamics. (Konuma … Takahashi, *J. Mol. Biol.* **405**, 1284, 2011)

Protein dynamics. Help understand the dynamic processes of protein conformation change (e.g. folding) and enzymatic reaction.

Membrane proteins. Resolve the structure of membrane proteins at low resolution; Reveal how the structures of these proteins change in response to external stimuli.

Tissue engineering. Help elucidate the relationship between the hierarchical structure in natural and engineered tissues and their functional properties.

<u>*LIX Beamline Capabilities:*</u>	
Source:	U23 undulator
Energy range and resolution:	2 - 20keV @ 0.01%
Q range:	0.002 - 3.0 $Å^{-1}$ @ 12 keV

ABS – Highly Automated Biomolecular Solution Scattering

This beamline will perform high throughput static solution scattering measurements at the rate of up to one sample per minute, and it will support automated data processing, including background subtraction, combining SAXS/WAXS and extraction of basic parameters such as R_g and D_{max}.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Structural biology. Complement other structural information (e.g. MX, EM, NMR) to provide a complete understanding of the structure of proteins and protein complexes in biologically relevant environment.

Structural genomics. Identify the interacting partners of genomic products.

Engineered proteins. Verify the structure of combinatorially engineered molecular machines for therapeutics and bio-energy applications.

<u>*ABS Beamline Capabilities:*</u>	
Source:	three-pole wiggler (or short undulator)
Energy range and resolution:	fixed at 12 keV @ 1% (3PW)
Q range:	0.005-3.0 $Å^{-1}$

Structure-based screening. Identify functional ligands (e.g. drug molecules) based on the structural change they induce in the target protein.

CHX – Coherent Hard X-ray Scattering

This beamline is being designed and constructed within the NSLS-II project for studies of nanometer-scale dynamics in materials using X-ray photon correlation spectroscopy (XPCS), as well as other experimental methods enabled by bright coherent X-ray beams. XPCS measures time correlation functions of the speckle fluctuations that occur when a coherent X-ray beam is scattered by a disordered sample. The CHX beamline will allow studies of dynamics ~100 times faster an on shorter length scales than ever before. Scattering geometries will include small- and wide-angle X-ray scattering (SAXS/WAXS) and grazing incidence SAXS. A versatile five-circle diffractometer will allow hosting a large selection of sample environments: cryo-furnace SAXS/WAXS chamber, micro-fluidic environments, shear cell, Langmuir-Blodgett trough, etc.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Glassy materials. Driven and out-of-equilibrium

Colloids and polymers. Nanostructured complex fluids

Biological systems and processes such as proteins, membranes, protein- and RNA-folding

Coherent diffraction imaging on near-native biological systems (frozen, hydrated).

CHX Beamline Capabilities:

Source:	U23 undulator
Energy range:	6 - 15keV
Energy resolution:	$\Delta E/E \approx 10^{-4}$ to pink beam
Coherent beam size:	10 μm x 10 μm (SAXS)
	1 μm V x 3 μm H (WAXS)
Coherent flux at sample:	2 x 10^{11} @ 10 keV

IXS – Inelastic X-ray Scattering

This beamline is being designed and constructed within the NSLS-II project to access a broader dynamic range than currently available to fill the dynamic gap between the high frequency spectroscopies, such as inelastic X-ray scattering (IXS) and the low frequency ones. A new optics concept will be implemented to achieve this goal, which involves an aggressive R&D effort that aims within the baseline scope to achieve 1 meV resolution with a sharp resolution tail and a momentum resolution better than 0.25 nm^{-1}. In the further development of the IXS beamline, the aim is to achieve an ultimate goal of 0.1 meV resolution and momentum resolution substantially better than 0.1 nm^{-1}.

IXS Beamline Capabilities:

Source:	in-vacuum undulator
Energy:	9.132 keV (1.358 Å wavelength)
Energy resolution:	1 meV
Momentum transfer:	0.5 - 80 nm^{-1}
Flux at sample:	1.6 x 10^{10} ph/s @ 1 meV

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Relaxation dynamics, sound propagation and transport properties in *disordered systems* such as *glasses, fluids and polymers*

Collective dynamics of *lipid membranes* and other *biological systems*

Spectroscopy

XFP – X-ray Footprinting

This beamline is designed for studies of X-ray mediated hydroxyl-radical footprinting (XFP). It will provide a local probe of solvent-accessibility for *in-vivo* and *in-vitro* structural studies of bio-molecular complexes and their interactions. Time-resolved XFP studies will elucidate local structural dynamics from microsecond to millisecond time scales. The high flux density and beam energy range of NSLS-II DW will provide high quality data from microliter volumes of dilute solution samples in near physiological conditions.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

In vivo studies. Real time ribosomal biogenesis in living cell, cell surface receptor-ligand interactions (drug/protein, antibody/antigen).

XFP Beamline Capabilities:	
Source:	damping wiggler
Energy range and resolution:	white beam (5 – 20 keV)

Membrane proteins. Understanding of structure and function at molecular level for ion channels, receptors (GPCR), gated pores, H+-pumps, transporters, membrane enzymes, dynamics of bound waters in pores, channels and cavities.

Mega-Dalton complexes. Protein-protein interactions are essential in signaling complexes and protein-nucleic acid complexes in transcription or replication.

Hybrid approach. XFP (local structural measures) along with SAXS (global) is important in deciphering the mechanism of biomolecular assemblies.

XAS – X-ray Absorption Spectroscopy for Biological, Environmental & Energy Sciences

This beamline will enable studies of low (<100 uM) concentration samples. It will be the #1 facility of its kind in the US and the only such facility on the East Coast (~2x flux of SSRL 9-3). It will provide continuity of service and expanded capabilities for an extensive, highly-productive user community. It will feature a sagittally focusing monochromator giving flexible beam size & tunable flux density (~0.2x0.5 to 2x10 mm, maintaining flux); and it will have multiple endstations (cryogenic, *in-situ*, high-throughput) with rapid changeover.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Biology. Study freeze-quench intermediates in metallo-β-lactamase reactions to understand antibiotic resistance.

XAS Beamline Capabilities:	
Source:	3-pole wiggler
Energy range and resolution:	4.5–25 keV/1-4 eV (ΔE/E)
Detector:	31-element Ge

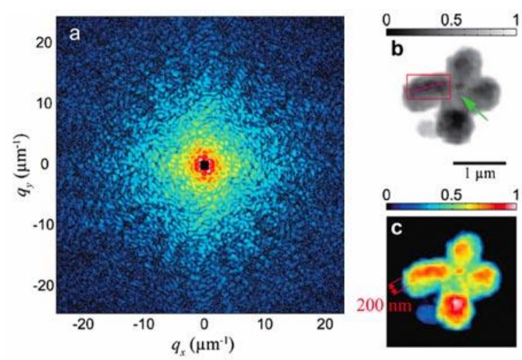
Environment. Observe Fe-TAML intermediates in the efficient catalysis of decomposition of pollutants by H_2O_2.

Energy. *In situ* electrochemical cell EXAFS to determine structure-property relationship of electroactive enzyme active sites for biological fuel cells.

Imaging

CDI – Coherent Diffraction Imaging

This beamline when ultimately configured will provide both in-line and Bragg coherent diffraction imaging (CDI) using independent undulators. It will support diffraction imaging of crystal shapes in 3D on a nm scale, diffraction imaging of cryo-frozen cells and tissues, imaging of strain fields inside crystals, time evolution of shape/strain under working conditions, and manipulation / deformation / indentation on the nm scale.



CDI imaging of a human chromosome. (Nishino … Maeshima, *Phys. Rev. Lett.* **102**, 018101, 2009)

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Ptychographic imaging for *domains in materials*.

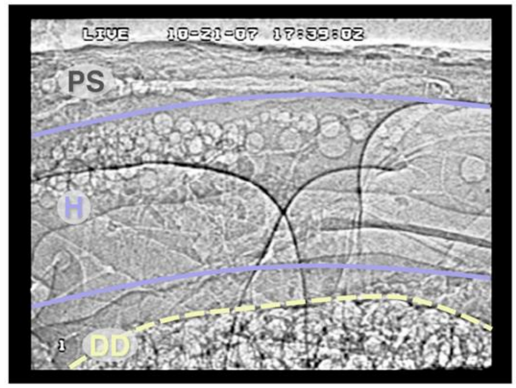
Ptychographic imaging of *biological samples* using phase contrast, dark-field and phase encoding methods.

Applications in *nanoscale semiconductor devices, strain engineering, catalysis and energy materials.*

CDI Beamline Capabilities:	
Source:	U20 undulators, low-β
Energy range:	2.5 – 20 keV (in-line CDI)

FXI – Full-field X-ray Imaging from Micron to Nanometer Scales

This beamline will host two x-ray imaging endstations. A full-field configuration will enable 2D and 3D dynamic imaging of centimeter-scale samples with micron resolution and a Transmission x-ray microscope (TXM) will achieve high-speed imaging with 30 nm resolution. The user community will be large and diverse, serving national needs and addressing fundamental issues across many fields.



Particle tracking of biological flow in a section of the tubular heart of a grasshopper. (Lee & Socha, *BMC Physiology* **9**, 2 2009)

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Paleontology. Unlocking ancient secrets in rare or fragile fossils.

Energy. Real-time imaging 3D imaging of solid oxide fuels, biofuels, and energy storage materials under real operating conditions.

Materials science & engineering. In situ imaging of functional nanomaterials and materials in extreme environments.

Biology & biomimetics. Deriving inspiration from nature, such as structural biological materials or internal flows in insects, for novel engineering solutions.

FXI Beamline Capabilities:

Source:	superconducting wiggler
Energy range and resolution:	6 - 25 keV / 1×10^{-4} at 25 keV
Spatial resolution:	10 - 30 nm V x 10 - 30 H
Flux on sample	> 5×10^{8} ph/s

HXN – Hard X-ray Nanoprobe

The hard X-ray nanoprobe beamline and endstation instruments are being designed and constructed within the NSLS-II project to explore new frontiers of hard X-ray microscopy applications with the highest achievable resolution. Currently, resolutions are limited to ~ 50 nm, which is still insufficient for probing interfacial structures critical in determining properties and functionalities of material and biological systems. The HXN beamline aims to enable X-ray experiments at spatial resolutions ranging from 10 to 30 nm with an ultimate goal of ~ 1 nm, and it will provide four modalities of X-ray microscopy: X-ray fluorescence, nanodiffraction, coherent diffraction imaging, and differential phase-contrast imaging.

HXN Beamline Capabilities:

Source:	U20 undulator
Energy range and resolution:	6 - 25 keV / 1×10^{-4} at 25 keV
Spatial resolution:	10 - 30 nm V x 10 - 30 H
Flux on sample	> 5×10^{8} ph/s

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Hierarchal relationships exist between structure and functional properties exist in nearly all classes of materials from **metals** to **biological samples**, and are a key component in furthering the development of the next generation of technological materials.

SRX – Submicron Resolution X-ray Spectroscopy

This beamline is being designed and constructed within the NSLS-II project to provide a unique combination of high spectral resolution over a very broad energy range and very high beam intensity in a sub-micrometer spot. The first branch is optimized for higher energies and uses Kirkpatrick-Baez (KB) mirrors; a second branch, optimized for lower energies from 2 to 10 keV, will use zone plate (ZP) optics to create a focal spot below 30 nm. Techniques that will be available include X-ray absorption and X-ray fluorescence imaging, X-ray tomography, X-ray fluorescence trace element mapping, XANES absorption and XANES fluorescence spectroscopy, X-ray spectromicroscopy, and X-ray microdiffraction.

SRX Beamline Capabilities (KB branch):	
Source:	undulator
Energy range and resolution:	4.65 - 25 keV / 1.5 -2.5 keV at 12 keV
Spatial resolution:	down to 60 x 60 nm at 0.6×10^{12} ph/s

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Beginning with thin sections from **geosciences** over micro and **nanoparticles** in suspension to microbial and **biological specimens**, the sample stage will be able to accommodate a great variety of samples from different scientific areas.

XFM – X-ray Fluorescence Microprobe

This beamline will provide spatially-resolved characterization of elemental abundances and speciation in "as-is" samples at μm scale with high throughput. It will be a workhorse for biological screening. It will provide optimized for microfocused Extended X-ray Absorption Fine Structure (μEXAFS) spectroscopy; 4 to 20 keV. The NSLS-II three pole wiggler is an excellent source for μEXAFS and XFM; it provides, in a 1-10 μm beam, flux densities two orders of magnitude higher than at the NSLS. This beamline will be world-leading for full μEXAFS.

XFM Beamline Capabilities:	
Source:	three-pole wiggler
Energy range and resolution:	4 to 20 keV / 1 eV
Spatial resolution:	1 - 10 μm variable

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Molecular speciation of *contaminants in the environment* at the microscale.

Genetic control of *metal ion uptake, transport and storage* in plants relevant to agriculture and bioenergy.

Biogeochemistry of *nanotoxins* in the environment.

Metal ions in health and disease.

Mineral-fluid interface reactions relevant to carbon sequestration.

Characterization of paleontological, archeological and cultural heritage *artifacts*.

IRI – Full-field Infrared Spectroscopic Imaging

This beamline will enable in-situ studies of organic composition of materials by vibrational spectroscopy. It will produce measurements from microseconds to days with micromolar detection sensitivity and sub-micron spatial resolution. It will permit the combination of the high brightness and low noise of NSLS-II with a high throughput imaging system that will be world leading.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Catalysis. In zeolite catalysis, simultaneously image reactants and products in real time for a mechanistic picture of in situ zeolite reaction chemistry.

IRI Beamline Capabilities:	
Source:	dual dipole magnets
Energy range and resolution:	500 - 4000 cm^{-1} / 1 cm^{-1}
Spatial resolution:	≈ 1 - 5 μm

Polymers. In polymer-fiber composites, image the interface morphology under sheer and stretch conditions in situ.

Microbiology. In cellulose degradation by bacteria, rapidly image reaction location, rate, and chemical intermediates for improved biofuel production.

Medicine. In Lou Gehrig's disease, simultaneously image the formation, structure, and associated cellular toxicity of intracellular superoxide dismutase aggregates.

AIM – Advanced Infrared Microspectroscopy

This beamline will enable high resolution studies of organic composition of materials by vibrational spectroscopy; it will produce measurements with sub-micromolar detection sensitivity and sub-micron spatial resolution; and it will permit the combination of the high brightness and low noise of NSLS-II with a confocal imaging system will be world leading.

EXAMPLES OF SCIENCE AREAS AND IMPACT:

Geosciences. In small particulates from earth and space, determine the composition of soil contaminants, space dust, and fluid inclusions.

Cultural heritage. In artifacts such as paint cross-sections, evaluate the chemical makeup of each sub-micron thick layer.

Microbiology. In microbe remediation of the Gulf Oil spill, determine reaction intermediates and resulting metabolites.

AIM Beamline Capabilities:	
Source:	dual dipole magnets
Energy range and resolution:	500 - 4000 cm^{-1} / 1 cm^{-1}
Spatial resolution:	≈ 1 - 5 μm (diffraction limited)

Medicine. In bone disease, image the collagen and mineral structure and composition in micro-damaged, treated, and repaired bone.

Biology Village at NSLS-II

NSLS-II is a facility, but it will also be a community. Indeed, we envision a community of villages embracing the diverse but interconnected sciences that will carry out experiments on NSLS-II beamlines. We aspire that each NSLS-II beamline should be a best-in-class facility in its own realm; and, to provide for the full range of experiments needed to address 21st century science, we have planned an accommodating user access policy and a complement of science villages. The Biology Village is a concept that emerged through the course of developing life sciences at NSLS-II since 2007 (http://www.bnl.gov/nsls2/sciOps/LifeSci/chronology.asp). We anticipate that users will have facile access to multiple beamlines that might be needed for multi-technique approaches, and we expect that an integration of techniques and scientific discourse will promote better scientific opportunities. We have elaborated such opportunities last year in a white paper for BER (http://www.bnl.gov/nsls2/docs/PDF/BER-whitepaper-Jan10.pdf).

In many respects, the concept of the Biology Village is a virtual one. It will not be possible to have all meaningful interactions for all beamlines to be physically proximate. Nevertheless, we will strive for compatible geographical placements of beamlines as much as possible. A significant aspect of physical coordination at NSLS-II will relate to the Laboratory Office Buildings (LOBs). Three of these are being built in the baseline project to house beamline staff and users and to provide laboratory resources in support of synchrotron experiments, and two of these LOBs will be fully outfitted. The remaining LOBs will be constructed and completed later. To a large extent these LOBs will serve as village centers; even though some Biology Village citizens may reside around the ring. Users and staff will have physical as well as virtual homes in their village center.