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X-Ray Light Sources and Neutron Sources at the DOE National Laboratories

Dennis Mills

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X-RAY LIGHT SOURCES AND NEUTRON SOURCES AT THE DOE NATIONAL LABORATORIES

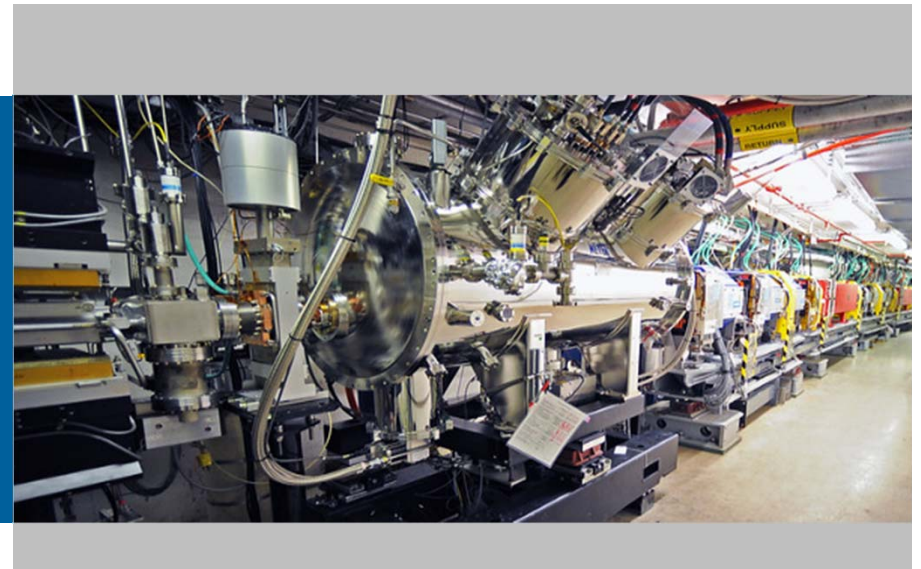
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&

DEPUTY DIRECTOR, ADVANCED PHOTON SOURCE

National Lab Day
October 8 & 9, 2019



DOE/BES LIGHT SOURCES

4 Storage Ring Sources (SR)

- Advanced Light Source (ALS)
- Advanced Photon Source (APS)
- National Synchrotron Light Source II (NSLS II)
- Stanford Synchrotron Radiation Lab (SSRL)

1 X-ray Free Electron Laser (XFEL)

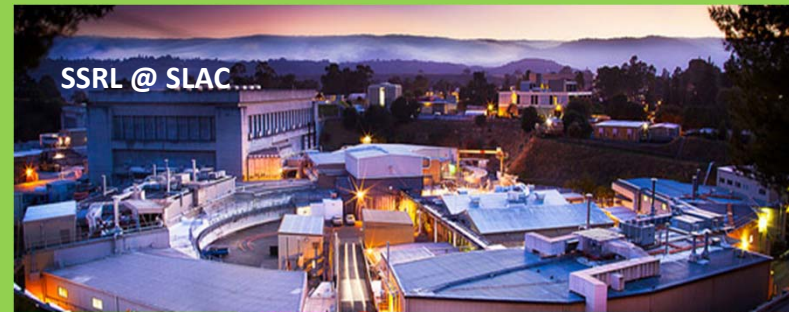
- Linac Coherent Light Source (LCLS)



APS @ ANL



ALS @ LBNL



SSRL @ SLAC...



NSLS II @ BNL



LCLS @ SLAC

Future Design

Sectors 10-20 of
Linac (1 km)
(with modifications)
Bypass LCLS Linac
In PEP Xport Line
(extended)

New Beam Transport
Hall

SXR, HXR Undulators

X-ray Transport
Optics/Diagnostics

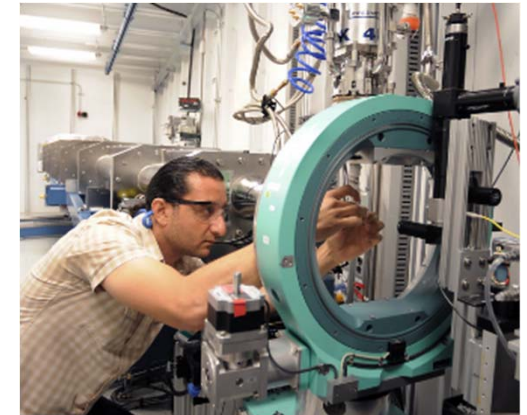
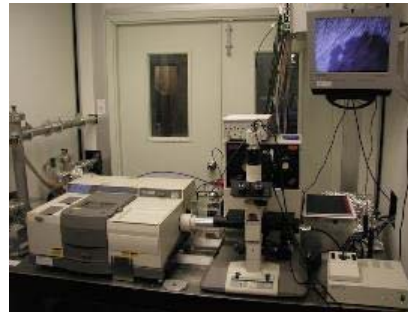
A SUITE OF SOURCES COVERS A WIDE RANGE OF PHOTON ENERGIES AND PULSE DURATIONS

- The storage ring sources covers the **spectral range from vacuum ultra-violet (10's of eV) to very hard x-rays ($E > 100$ keV)** in addition to several infra-red beamlines.

LCLS Undulator Hall



Infrared Spectromicroscopy at the ALS



Hard X-ray Inelastic Beamline at the APS

- Storage ring sources have **pulse durations of 100's of picoseconds** and repetition rates in the MHz range.
- The free electron laser at SLAC covers an energy range of 250 eV to 20 keV but can generate x-ray pulses in the **few femtosecond range**, currently with repetition rates of about 100 Hz.

DOE/BES NEUTRON SOURCES

Neutrons provide an alternative window into matter and have similarly important applications to materials, chemistry, and biology. The DOE Office of Science has two different neutron sources at ORNL:

- Spallation Neutron Source (SNS)
- High Flux Isotope Reactor (HFIR)



SNS @ ORNL



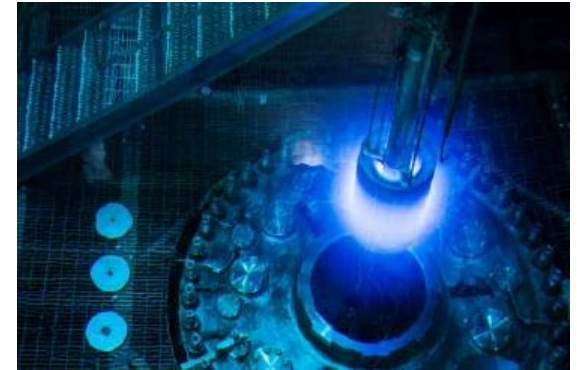
HFIR @
ORNL

SNS is the most powerful pulsed neutron source in the world for materials research.

Operating at 85 MW, HFIR provides one of the highest steady-state neutron fluxes of any reactor in the world for materials research.

A REACTOR SOURCE AND A SPALLATION SOURCE

- The HFIR facility is the United States' highest flux reactor-based neutron source, and is a major neutron scattering user facility as well as the world's leading source of elements heavier than plutonium for research, medicine, and industrial applications.
- The primary mission of HFIR is providing **thermal and cold neutron beams** and instruments for neutron scattering research.



Refueling at the High Flux Isotope Reactor

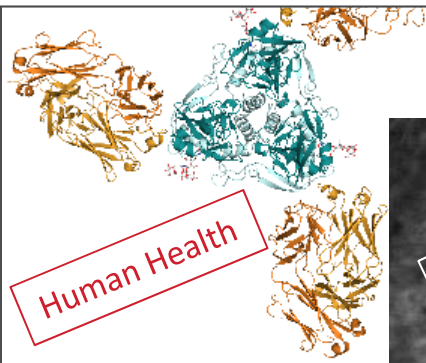
64,000-pound inner reflector plug being lowered into position at SNS



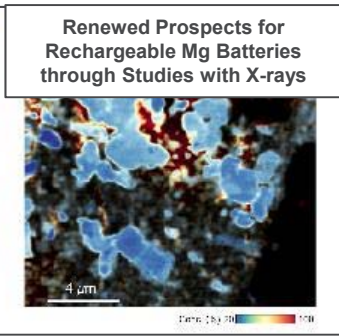
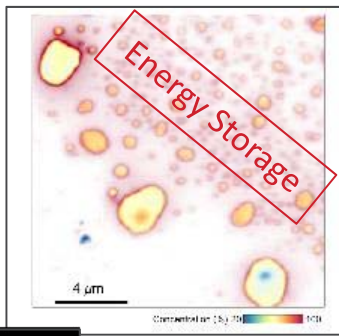
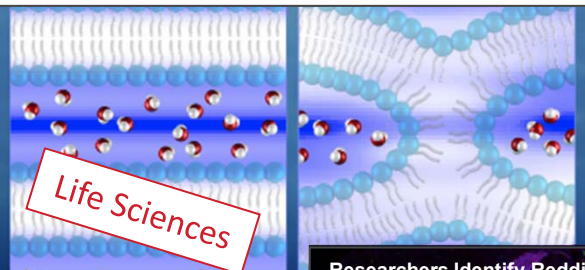
- The SNS is a next-generation spallation neutron source for neutron scattering that is currently the most powerful neutron source in the world.
- **Pulsed thermal neutrons** are particularly well suited for measuring the positions as well as the fluctuations in the positions of atoms, the structure of atomic magnetic moments in solids, and magnetic excitations. Such studies lead to understanding phenomena such as correlated electron effects, magnetic order, and superconductivity in a variety of materials.

THE SCIENCE IS WIDE RANGING

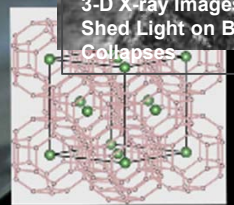
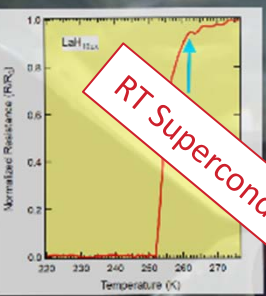
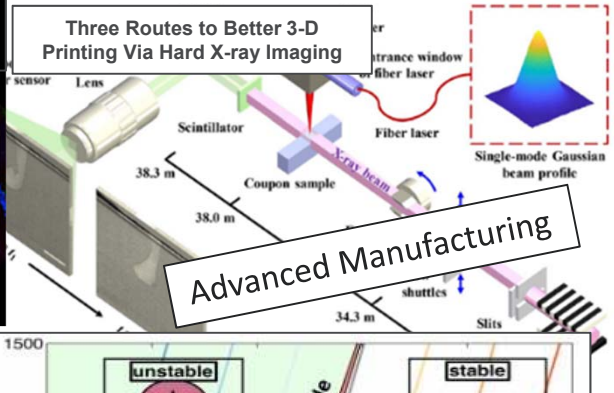
Toward a Universal Therapy against Ebola Virus with X-ray Macromolecular Crystallography



First Direct 3D Maps of Water During Cell Membrane Fusion Using Neutrons

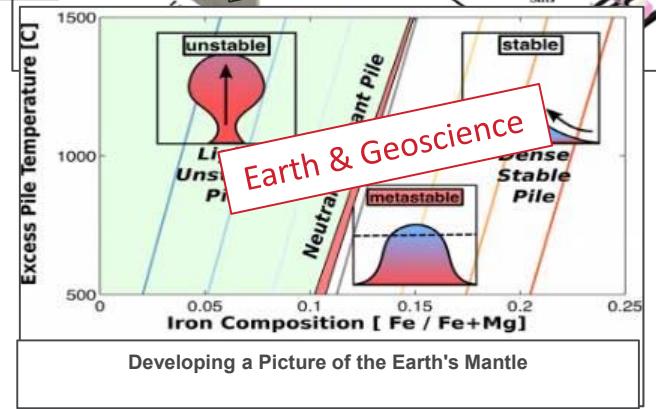
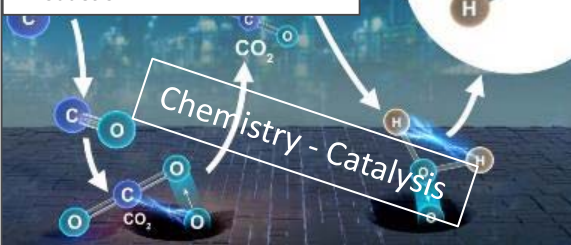


Researchers Identify Reddish Coloring in an Ancient Fossil – a 3-Myr-old Mouse



The First Observation of Near-Room-Temperature Superconductivity Confirmed Using X-rays

Neutrons Shed Light on Industrial Catalyst for Hydrogen Production



OFFICE OF SCIENCE/BES IS INVESTING IN THE FUTURE

Linac Coherent Light Source Upgrade Project – LCLS II (in progress)

- LCLS II will provide a major jump in capability – moving from 120 pulses per second to 1 million pulses per second

Advanced Photon Source Upgrade Project – APS-U (in progress)

- replacement of storage ring for 100 to 1000 fold increase in brightness ensures the US will remain a leader among the world's hard x-ray light sources

Advanced Light Source Upgrade Project – ALS-U (in progress)

- replacement of storage ring resulting in an increase in the coherent soft x-ray flux beyond any storage-ring-based light source operating, under construction, or planned

Spallation Neutron Source Proton Power Upgrade – PPU (in progress)

- double the proton beam power capability of the SNS and upgrade the first target station to accommodate beam power up to 2 MW, and deliver a 2 MW qualified target

Spallation Neutron Source Second Target Station – STS (in progress)

- pulsed source to produce an order of magnitude higher brightness cold neutrons than previously achievable

NSLS II Experimental Tools II – NEXT II (new for FY2020)

- continue the phased build-out of beamlines at the National Synchrotron Light Source II at BNL

TAKE AWAY MESSAGE

- Light Sources and Neutron Sources support:
 - Physical sciences
 - Live sciences
 - Geosciences, Planetary sciences, Environmental sciences
 - Applied/Industrial research
- Beamline scientists are available to:
 - Discuss potential experiments
 - Provide guidance on proposal submission
 - Assist in experiment set-up, data collection, and data analysis
- Some beamlines have a mail-in service for "routine" experiments
 - Powder diffraction
 - Small molecule crystallography
 - Macromolecular crystallography (MX)
 - Ultra-small angle x-ray scattering (USAXS)



Shipping containers for MX samples maintained at LN2 temperature



Powder diffraction sample holder