Delivering Bright X-Ray Beams to Hundreds of Scientific Experiments

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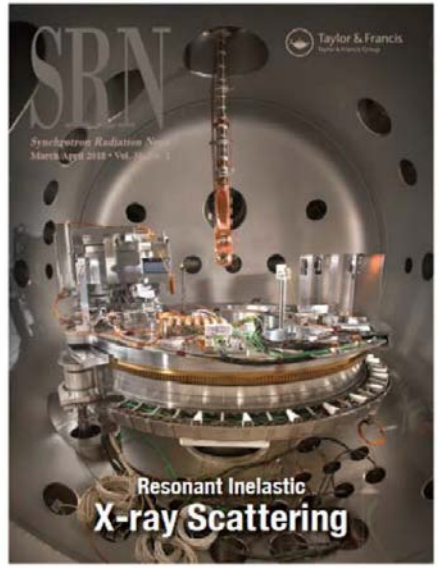
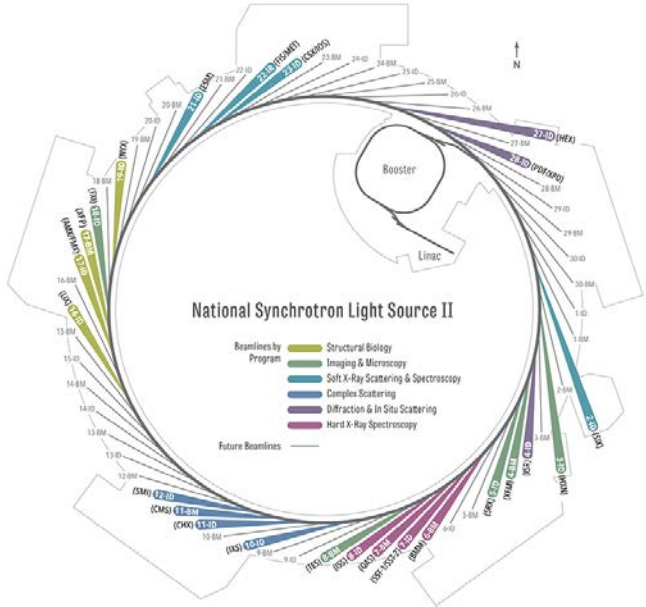
U.S. DEPARTMENT OF ENERGY | Office of Science
BROOKHAVEN NATIONAL LABORATORY

National Synchrotron Light Source II

- World brightest synchrotron light source
- 28 beamlines covering InfraRed to Hard X-ray range of ph spectrum
- 1300 experimenters per year
- 792 meters in perimeter
- National scientific facility, science, industry, education





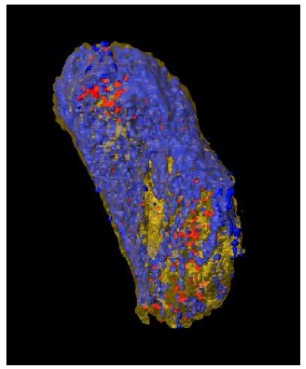
The need for light

- NSLS-II Mission

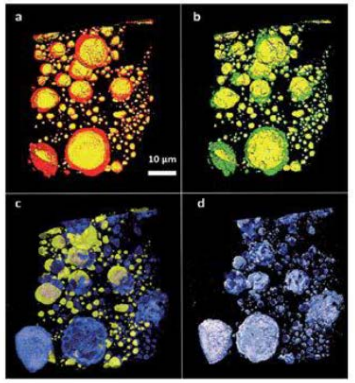
To develop and operate a premier user facility that embraces diversity to safely and efficiently deliver high-impact and cutting-edge science and technology for the benefit of society

- Strategic Partnerships
  - Biological and Environmental Research
  - Nanoscience
  - Industrial Research
  - Materials in Radiation Environments
  - Interagency Advanced Manufacturing Initiative
  - National Security

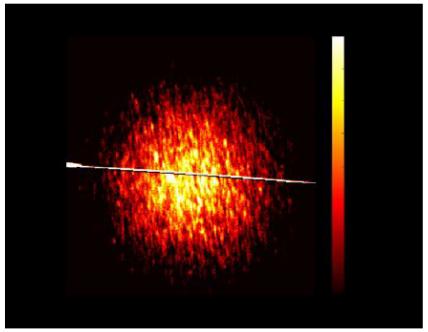
HXN – Hard X-ray Nano-probe
World-leading resolution for hard x-rays (~13 nm)



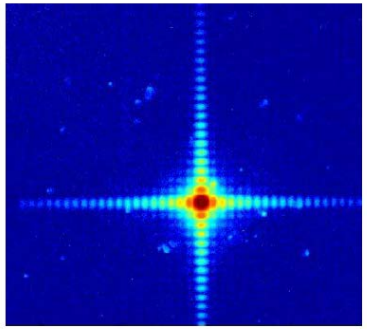
FXI – Full-field X-ray Imaging
World's fastest transmission X-ray microscopy beamline



CSX-1 – Coherent Soft X-ray Scattering
World leading soft coherent capabilities: $5x10^{13}$ ph/s coherent flux

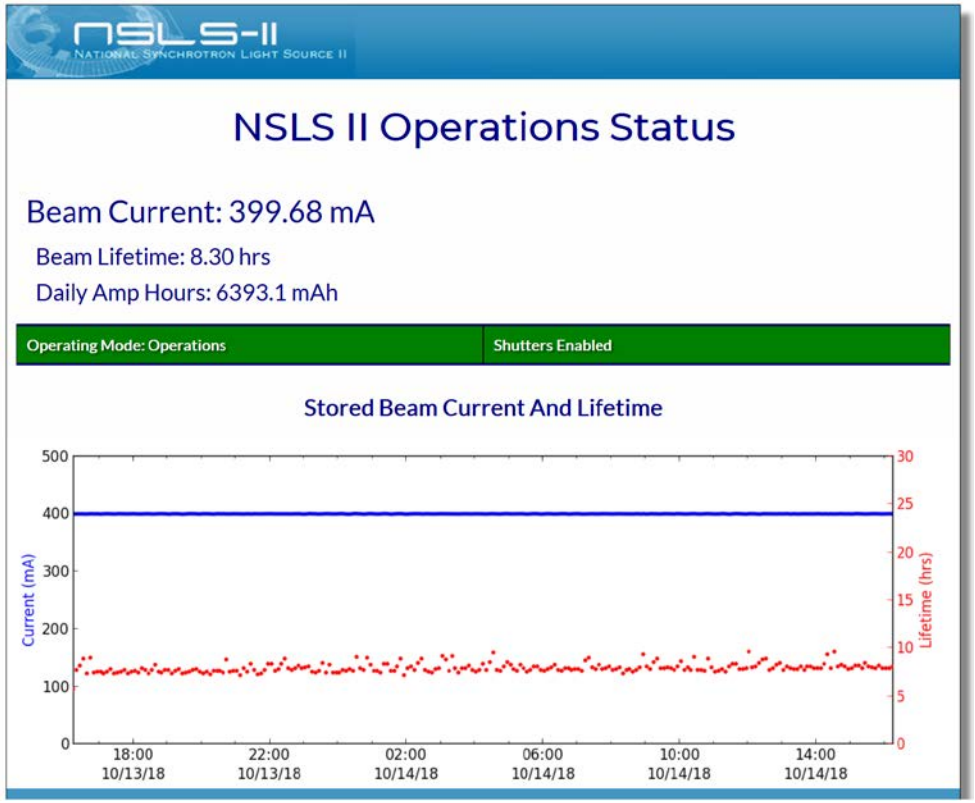


CHX – Coherent Hard X-ray Scattering
XPCS with highest available brightness in the 6-16 keV range to access usec timescale



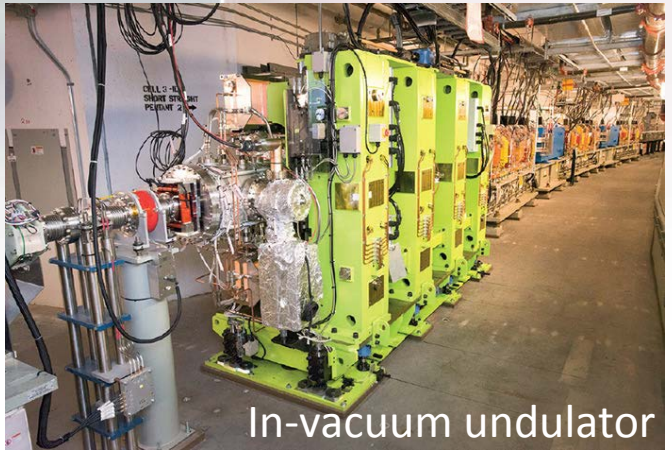
5000 hours of Operations per year

- Priorities of Light Source Operations
  - Reliability: 97%
  - Stability: 1 micron
  - Intensity: 400 mA
- 20…30 experimental programs running simultaneously
- Week to 2 week long runs with 1-day maintenances and 1 month shutdowns
- 400 kW of emitted radiation



Particle Accelerators: NSLS-II

- 30 m long 200 MeV Linear RF accelerator
- 158 m long Booster-Synchrotron
- 792 m long 3 GeV Storage Ring
- Inject 2 mA every 2 minutes to maintain 400 mA in the Storage Ring
- Accelerator Power Consumption 3 MW


In-vacuum undulator

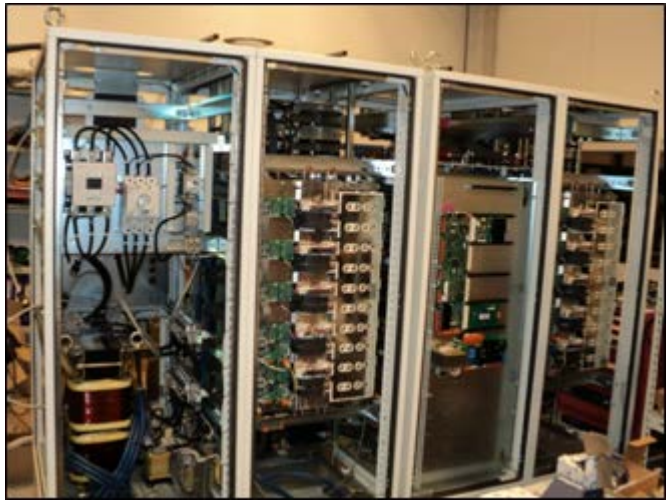

3-GeV booster ring


200 MeV linac

High Power Electronics

- 800 switch mode power supplies in 600 T-controlled racks
- From 10V / 10A to 700V / 500 A
- DC and ramping supplies
- 1000 ppm to 10 ppm of relative accuracy
- EPICS (Experimental Physics and Industrial Control System) controls with 1,000,000 digital signals (PVs)

Multiple low-voltage power supplies



0.5 MW ramping power supply

High Voltage Electronics

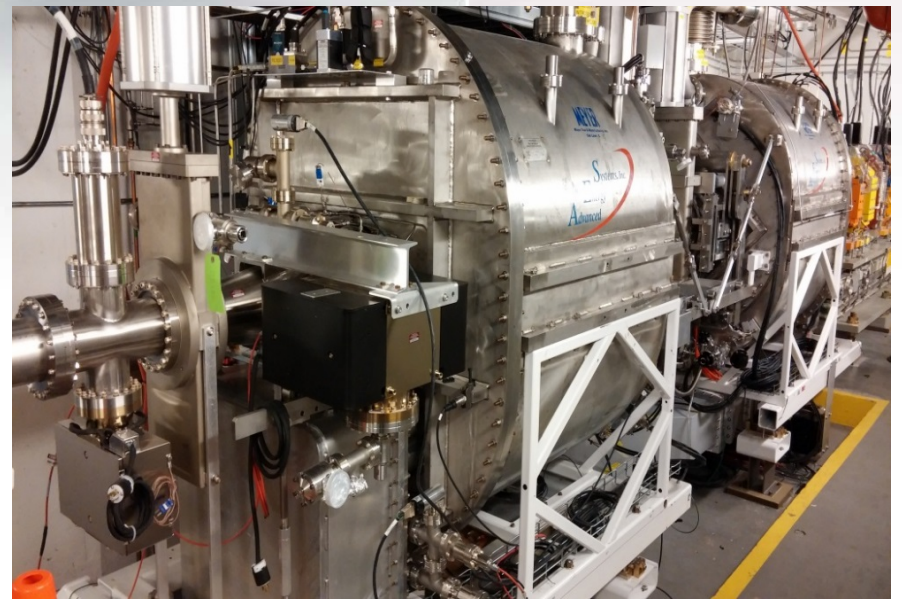
- Short pulse kickers: 100 ns rise/fall time, 25 kV
- Septa magnets: 2.6 microseconds pulse, 6 kV / 6 kA
- 500 MHz gun electronics, 100 V, flexible pulse structure, 100 kV DC bias
- Thyrotrons, SCR, IGBT, MOSFET technology
- Intelligent Control System

Pulsed septum 6 kV, 6 kA

500 ns 20 kV pulse generator

RF Electronics

- Pulsed RF klystrons, 3 GHz, 45 MW, 3 microsecond pulsed at 10Hz
- Inductive Output Tube, 500 MHz, 1 MV
- 500 MHz DC RF klystrons, 310 kW
- Electron Gun broadband electronics, 100 kV DC power supply
- 2 MV Superconducting cavities, 500 MHz 300 kW RF transmitters



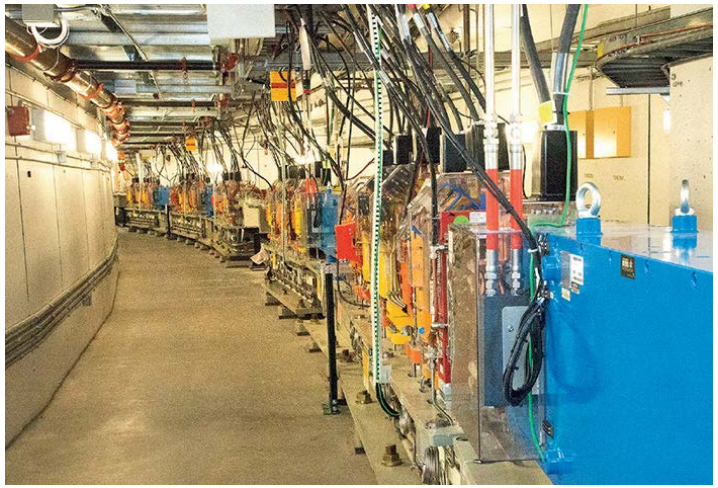
Superconducting RF cavities

Solid-state klystron modulator

Scientific / Industrial Facilities of Tomorrow

- High-brightness synchrotron light sources covering photon energy range from meV to 100 keV
- Free Electron lasers delivering femtosecond X-ray pulses at MHz rep rate
- “Table-top” X-ray sources for universities
- Small proton machines for cancer therapy

- Directions for R&D in power electronics
  - Ultra-stable DC power supplies
  - Low-voltage broadband amplifiers for feedback systems
  - High current and voltage switches
  - High-power klystrons
  - Solid-state amplifier technology



NSLS-II, Brookhaven National Lab

THANKS for your Attention

QUESTIONS?