bnl pxrr at the NSLS

The PXRR: Macromolecular Crystallography Research Resource at the National Synchrotron Light Source, with opportunities for correlated single-crystal optical and vibrational spectroscopies.

The PXRR is a group of about 20 scientists, engineers, and technicians who provide macromolecular crystallography facilities at five beamlines at Brookhaven Laboratory's National Synchrotron Light Source. These facilities are employed by outside researchers and PXRR scientists. As part of this, three PXRR scientists provide a world-leading collaborative Mail-In program.

Funding comes roughly equally from the BER/DOE and from the NCRR/NIH . This funding is used principally for a user program, but also for beamline-development R&D, and for specialties like our growing single-crystal Vis/Raman spectroscopy station. One FTE of effort is NSLS employees; the rest are members of the BNL Biology Department.

During 2009 the PXRR served 220 projects from 110 groups at the PXRR beamlines; about 1.5M diffraction images were measured. In particular, there were over 380 Protein Data Bank (PDB) submissions and over 235 new publications supported by our suite of five active PXRR beamlines: X12-B, X12-C, X25, X26-C, and X29. Indeed, 25 of the publications were in the premier journals *Science*, *Nature*, and *Cell*. We are very proud that X29 is now the second most productive beamline in the world in PDB depositions with over 240 in 2009. The highest number is 290 from the BER-funded third-generation undulator 19ID at the APS.

This Resource also has instituted a unique and hugely successful Mail-in Crystallography program. Investigators ship cryo-cooled specimens to the scientists at BNL, and these scientists typically become collaborators in the investigators' projects. The program typically records ~15 publications each year and nearly twice as many PDB depositions. At least one BNL scientist is a co-author on most publications.

nsls IR UV X

National Center for Research Resources

For more information:
Macromolecular crystallography at NSLS, visit http://www.px.nsls.bnl.gov.

NSLS-II, visit http://www.nsls2.bnl.gov.

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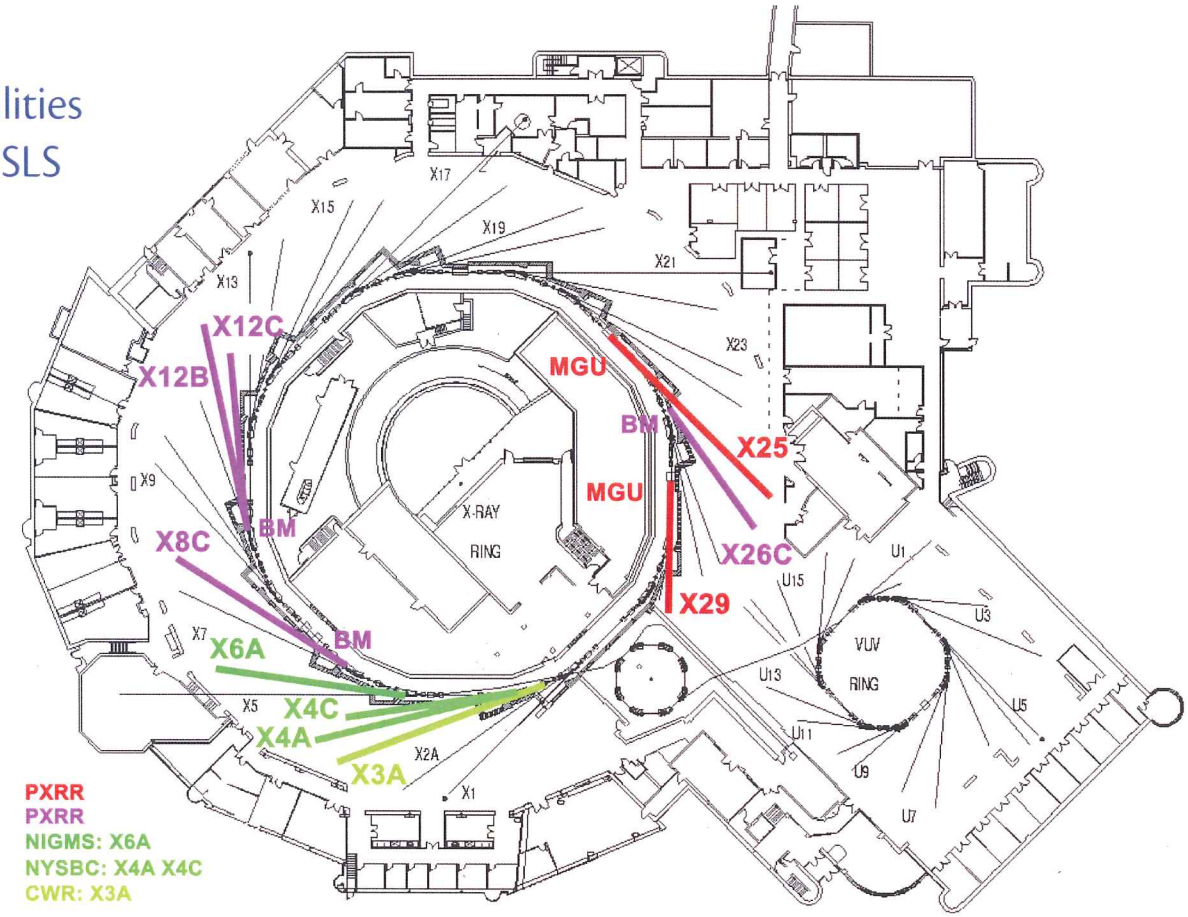
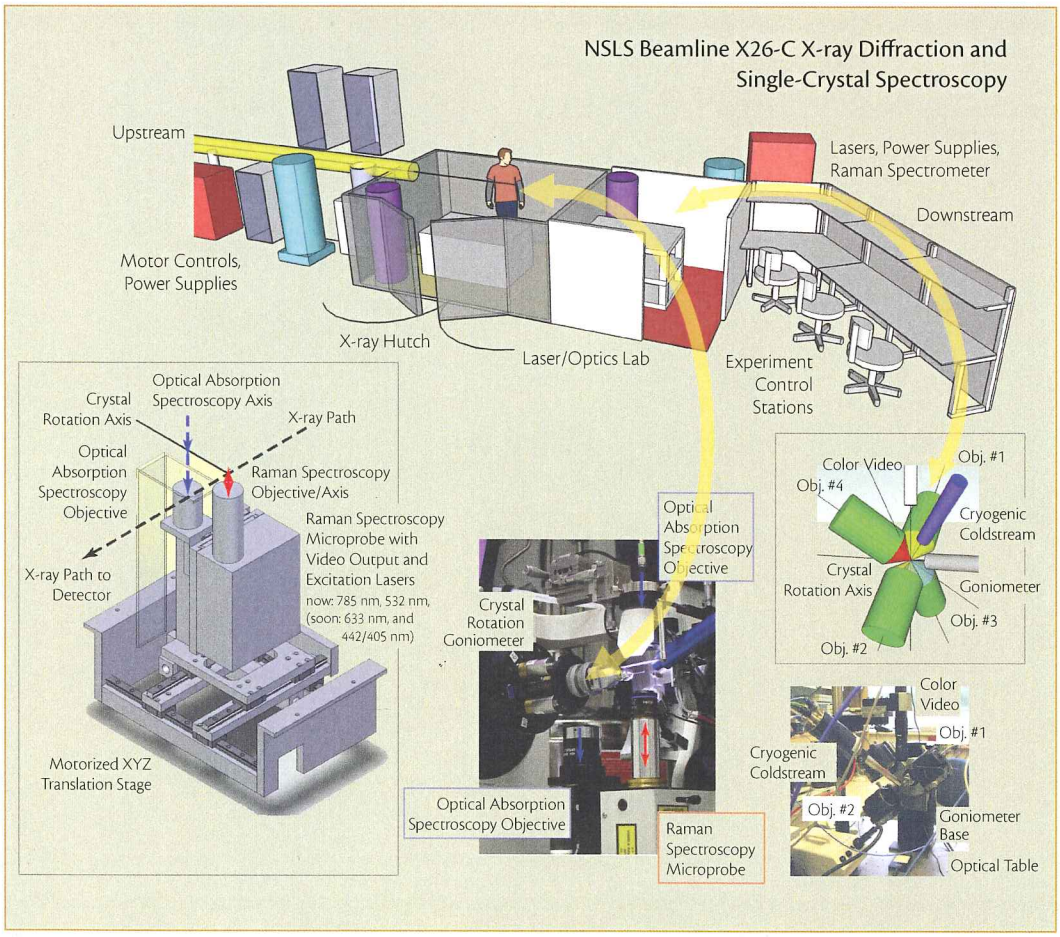
MX Facilities at the NSLS





With supplemental ARRA funding from the NIH/NCRR, we are accelerating the construction of an integrated facility at beamline X26-C of the NSLS for single crystal X-ray diffraction and spectroscopic analysis of macromolecules. This includes the simultaneous measurement of at least three types of complementary data – X-ray diffraction to high resolution, optical absorption spectroscopy, and Raman spectroscopy – from the same sample under the nearly identical experimental conditions. We are integrating the controls for these three techniques into the beamline operations. Thus, we collect correlated X-ray diffraction and single-crystal spectroscopy from a ~25μm diameter region of the crystal that intersects the X-ray beam. We are commissioning a Raman micro-spectrometer with 785nm and 532nm excitation lasers, and plan to add two more lasers in the near term (e.g. 633nm, 473/442/405nm). We also plan to add the instrumentation for single crystal steady-state and time-resolved fluorescence spectroscopy, and are building a complementary off-line single crystal spectroscopy laboratory immediately adjacent to the beamline.

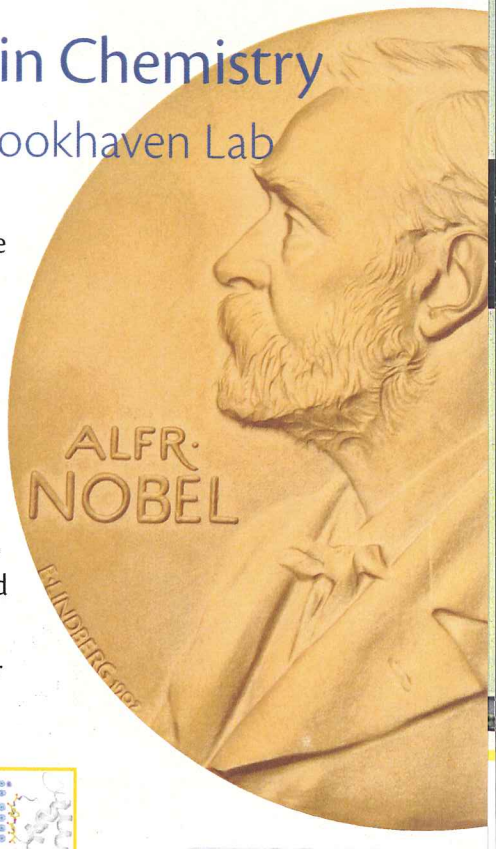
- The BER has supported macromolecular crystallography (MX) at the NSLS since 1982. We rapidly pushed technology in software and detectors: first electronic area detector in US; first GUI; first on-site data processing. We found partners and grew from one MX and one SAXS beamline to five MX lines. In the 1990s BER built labs for life science at the NSLS.
- PXRR obtained joint funding from NCRR/NIH in 1998. Established active R&D program in methods and software. Renewed twice, this cycle ends in 2013.
- We created the popular RapiData crystallography course; there are now nearly 600 alumni. We invented the PX Operators to provide overnight support for our users. We invented the "Sea of Photons" to provide users with fluid access to multiple beamlines, and to switch to a different source if it's more appropriate. This brings in users from other beamlines. We created a popular and productive Mail-In MX program – many users, many publications.
- With BER support, helped build X29, the first MX undulator at NSLS. Developed X29 into a high-productivity facility – the only MX beamline with regular scheduling of two to three research groups per day. With BER support we upgraded X25 to an undulator, every bit as hot as X29. By 2004 we began use of crystal automounters, and three are in regular use with a fourth on the way. In 2006 began development of a coordinated optical spectroscopy and crystallography station. In 2007, with BER support, purchased a microdiffractometer for X25 to begin preparation for NSLS-II. With NIH/NCRR support the PXRR ordered a high-speed and low-noise Pilatus 6M pixel-array detector to improve our overall data quality and throughput.

Background image: *Crystal structure of Proteasome from Mycobacterium tuberculosis.*
Huilin Li, Biology Department, BNL

Inhibitors selective for mycobacterial versus human proteasomes.
Lin G, Li D, de Carvalho LP, Deng H, Tao H, Vogt G, Wu K, Schneider J, Chidawanyika T, Warren JD, Li H, Nathan C.
Nature. *2009,* ***461****: 621-6.*

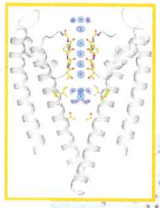
Nobel Prizes in Chemistry

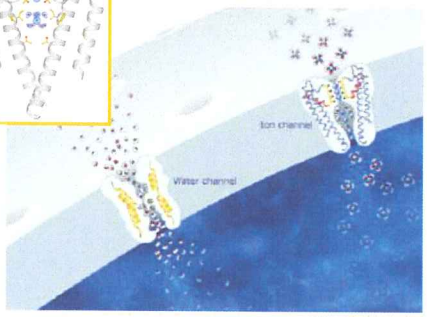
Conducted at Brookhaven Lab



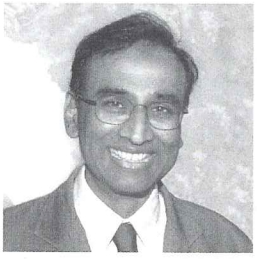
Three recent winners of the Nobel Prize in Chemistry, Roderick MacKinnon in 2003, and Venkatraman Ramakrishnan and Thomas Steitz in 2009, employed beamline X25 and other PXRR beamlines, instrumented and operated by the Resource, for significant portions of their prize-winning work.

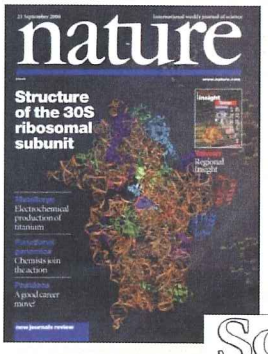
bnlbio
BIOLOGY DEPARTMENT





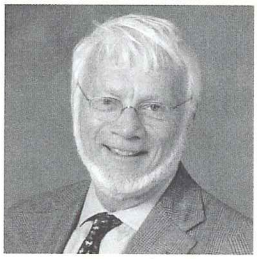
Roderick MacKinnon
For structural and mechanistic studies of ion channels in cell membranes

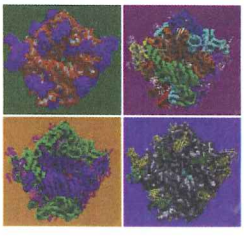




Venkatraman Ramakrishnan and Thomas Steitz

For studies of the structure and function of the ribosome.





NSLS-II at Brookhaven National Laboratory is on the horizon!

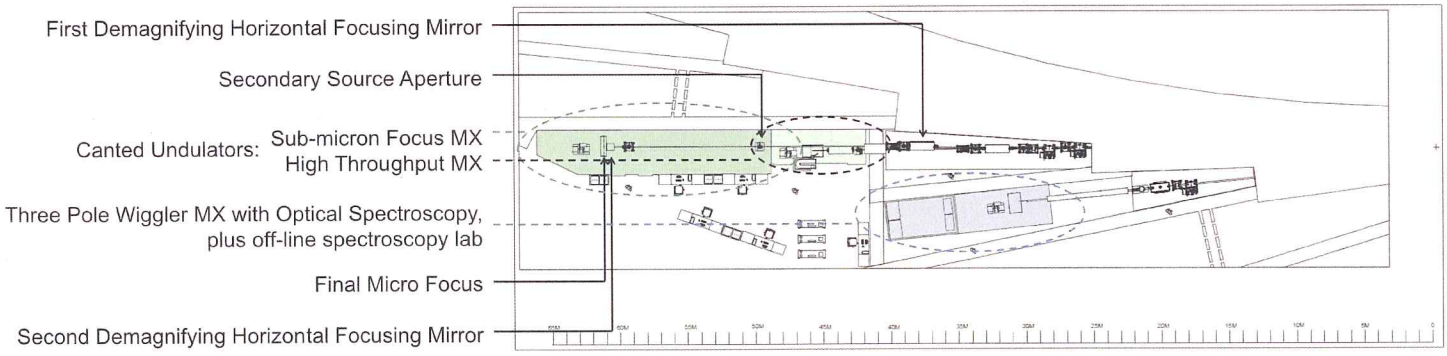
The PXRR is playing a major role in creating the opportunity for BER and NIH funding of life-science beamlines for NSLS-II. In particular, with cooperation of local users with MX interests, we have helped to lead a program to create a conceptual design for a Phase-I suite of beamlines for MX. We anticipate that the MX beamlines will help nucleate the ***Biology Village*** concept for Life Science beamlines at the NSLS-II.

We propose a two-phase construction plan to use two a pairs of canted undulators in two NSLS-II short straight sections to create a suite of state-of-the-art beamlines for macromolecular crystallography.

- Micro-beam: A down-stream station will be used to create a flexibly focused beam with dimensions in the range 0.5 - 10μm in both directions
- Mini-beam: An up-stream station will be instrumented to provide the fastest possible throughput for conventional automated crystallography, with beam dimensions in the range 5 - 200μm
- Complementary Single-Crystal Spectroscopy and MX Facility: A coordinated effort comprised of i) one undulator beamline viewing a canted pair, ii) an adjacent three-pole wiggler (3PW) beamline, and iii) an off-line laser optics lab downstream from the 3PW station to coordinate this Spec+MX facility
- The Spec+MX facility will feature X-ray beam dimensions in the range of ~10 - 300μm and will support correlated: X-ray diffraction, electronic absorption, resonance and non-resonance Raman spectroscopy, IR spectroscopy, steady-state and time-resolved fluorescence spectroscopy, and X-ray absorption spectroscopy

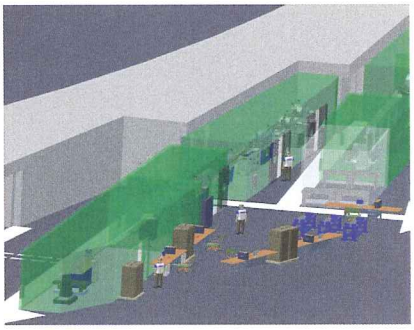
NSLS-II Characteristics:

- A new state-of-the-art storage ring
- 30 straight sections
- 60 bending magnets
- Complete by 2015
- Energy, 3 GeV @ 500 mA
- Spatial resolution of 1 nm
- Energy resolution of 0.1 meV
- Flux density $\geq 10^{15}$ ph/s/0.1%BW
- Brightness (2 keV-10 keV) $\geq 10^{21}$ ph/mm2/mrad2/s/0.1%BW



The table summarizes the horizontal beam size and divergence at particular locations along the micro-beamline This arrangement is shown in the beamline layout.

	Horizontal	
Location	**size (μm)**	**divergence (μrad)**
Source, 0 m	66	45
Front end slit 234 μm wide, 20 m	234	15
Horizontal focus mirror 3.17:1 demag, 38 m	504	15 (Incident)
Secondary-source aperture, 50 m	27	47
Second horiz focus mirror or lens 22:1 demag, 61 m	490	47 (Incident)
Final focus position, 61.5 m	1.5	1045 (Either could be smaller, depending on the setting of slits at 20 and 50 m)



Optics:

The long experimental hutch for the **micro-beamline**, where the 2nd demagnifying horizontal focusing mirror and secondary source aperture are located, permits significant flexibility in positioning these components for best performance. Note that one can easily realize a final focus width less than 1.5μm, in this two-stage optical scheme, by reducing the width of the secondary source aperture to be less than 27 μm. In a single-stage demagnification scheme, this sort of approach is possible only by reducing the width of an aperture along the beamline to define a new secondary source, discarding significant intensity in so doing since there is no secondary focal point at which this can be done. For a 1 micron beam (FWHM), we calculate that the flux will be $5x10^{11}$ - $1x10^{12}$ ph/sec with divergence of 1 mrad horizontal.

For the **mini-beamline**, intended for high-throughput performance, we calculate that flux through a 100 micron square aperture at 12 keV at the beamline will be $1x10^{13}$ ph/sec with 0.1 mrad horizontal and vertical divergence. Flux at the **MX with spectroscopy** beamline will be $1x10^{11}$ ph/sec with 1 mrad divergence.

Instrumentation:

The **micro-beamline** will have optical and manipulation systems, including an automounter, appropriate to specimens in the 1 μ size range. There will be provision for microfluidics, Rayleigh droplet streams, etc. The mini-beamline will be equipped with an automounter, and is shown with a robot to move crystal cassettes into the hutch.

The **MX with spectroscopy beamline** will have UV/Vis absorption and fluorescence plus Raman spectroscopies. A similarly equipped off-line laboratory is shown sitting beside the X-ray hutch.