The Photon Sciences Directorate operates the National Synchrotron Light Source (NSLS) and is constructing the National Synchrotron Light Source II (NSLS-II), both funded by the Department of Energy’s Office of Science. These facilities support a large community of scientists using photons (light) to carry out research in energy and environmental sciences, physics, materials science, chemistry, biology, and medicine, and other disciplines.

**NSLS-II MILESTONES**

- **Mission need approved**
  - July 2010
- **Alternative selection and cost range approved**
  - August 2009
- **January 2008**
  - Performance baseline approved
- **January 2009**
  - Start of construction approved
- **February 2009**
  - Award for ring building
- **May 2010**
  - Award for booster systems
- **June 2010**
  - NEXT mission need approved
- **August 2010**
  - LLO contract awarded
- **October 2010**
  - “Topping out” ceremony – closing of the ring
- **March 2011**
  - Beneficial occupancy of 1st section of ring building
- **October 2013**
  - Start accelerator commissioning
- **June 2015**
  - Approve start of operations

**REFLECTIONS ON THE YEAR**

This is an exciting time for photon science at Brookhaven National Laboratory. It is also a time of unprecedented growth for the Photon Sciences Directorate, which operates the National Synchrotron Light Source (NSLS) and is constructing NSLS-II, both funded by the Department of Energy’s Office of Science.

Reflecting the quick pace of our activities, we chose the theme “Discovery at Light Speed” for the directorate’s 2010 annual report, a fiscal year bookended by October 2009 and September 2010. The year began with the news that NSLS users Venu Ramanathan of Cambridge University (also a former employee in Brookhaven’s biology department) and Thomas A. Steitz of Yale University were sharing the 2008 Nobel Prize in Chemistry with Ada E. Yonath of the Weizmann Institute of Science.

Every research project has the potential for accolades. In 2010, NSLS users and staff published close to 900 papers, with about 170 appearing in prestige journals. These are impressive stats for a facility nearly three decades old, testament to the highly dedicated team keeping NSLS at peak performance and the high quality of its user community. Our NSLS users come from a worldwide community of scientists using photons, or light, to carry out research in energy and environmental sciences, physics, materials science, chemistry, biology, and medicine. All are looking forward to the new capabilities enabled by NSLS-II, which will offer unprecedented resolution at the nanoscale. The new facility will produce x-rays more than 10,000 times brighter than the current NSLS and host a suite of sophisticated instruments for cutting-edge science.

Some of the scientific discoveries we anticipate at NSLS-II will lead to major advances in alternative energy technologies, such as hydrogen and solar. These discoveries could pave the way for:

- catalysts that split water with sunlight for hydrogen production
- materials that can reversibly store large quantities of electricity or hydrogen
- high-temperature superconducting materials that carry electricity with no loss for efficient power transmission lines
- materials for solid-state lighting with half of the present power consumption

Emphasis about NSLS-II is evident in many ways, most notably the extraordinary response we had to the 2010 call for beamline development proposals for the anticipated 60 or more beamlines that NSLS-II will ultimately host. A total of 54 proposals were submitted and, after extensive review, 34 were approved. Funding from both the Department of Energy and the National Institutes of Health has already been secured to support the design and construction of a number of these beamlines.

FY11 is a challenging and exciting year for the NSLS-II Project as we reach the peak of our construction activities. We remain on track to complete the project by March 2014, a full 15 months ahead of schedule and with even more capabilities than originally planned. The Photon Sciences Directorate is well on its way to fulfilling our vision of being a provider of choice for world-class photon sciences and facilities.
Made by accelerating electrons to 99.99 percent of the speed of light, photon help scientists illuminate wide-ranging scientific mysteries, from the inner workings of batteries and the composition of comet dust to the atomic structure of proteins vital for human life. As U.S. Department of Energy’s Brookhaven National Laboratory, scientists perform this work and move at the National Synchrotron Light Source (NSLS) and are preparing to extend their research at the National Synchrotron Light Source II (NSLS-II), now under construction. The 2010 Annual Report of the Photon Sciences Directorate, which oversees NSLS and NSLS-II, details a spectrum of recent achievements made by direc executive staff and the large user community supports. This companion piece highlights our activities for the fiscal year, from October 2009 through September 2010.

View the full report at: www.bnl.gov/pa/annualreport

A BEAM OF PHOTONS IS A POWERFUL TOOL

Nobel for “Pictures” of Protein Factories
Two recipients of the 2009 Nobel Prize in Chemistry have strong ties to NSLS. Yuki Tanihara, a former employee in Brookhaven’s biology department and long-time NSLS user, now at Cambridge University, and Thomas A. Steitz of Yale University, also a long-time NSLS user, shared the prize with Ada E. Yonath of the Weizmann Institute of Science for their work on the structure and function of the ribosome. In the late 1990s, Tanihara and Steitz used protein crystallography at NSLS and other light sources to solve the high-resolution structures for two ribosome subunits crucial to understanding everything from how the ribosome achieves its amazing precision to how different antibiotics bind to it.

Bringing NSLS Into the Classroom
A K-12 program launched at Brookhaven lets high school teachers and their students conduct experiments they devise with a major piece of scientific equipment: NSLS. The program, dubbed InSynC for introducing Synchrotrons into the Classroom, allocates time on the multi-million-dollar machine to classrooms through a competitive, peer-reviewed proposal process.

Moving Into Production for Accelerator Hardware
We had 16 goals for the year and checked off 11, with “in progress” noted on the design work. Design work on the complex hardware for NSLS-II accelerator systems was completed in 2010. This includes superconducting magnets, RF power sources, vacuum systems, power supplies, magnet systems and motion devices. In addition, we started the fabrication and assembly of aluminum vacuum chambers, finishing roughly 20 percent of them by year’s end. Orders for all vacuum pumps were placed, and about 50 percent of the pumps were delivered.

Boom Gives Birth to Photon Sciences Directorate
Since 2005, the number of employees in the directorate has increased from 130 to more than 450 as our portfolio has expanded from operating NSLS to also design and constructing NSLS-II. Designing and constructing additional beamlines for NSLS-II and, in coming years, transitioning to NSLS-II operations. To better manage this rapid growth, the Light Source Directorate spent much of the year planning for a reorganization. To better manage this rapid growth, the Light Source Directorate spent much of the year planning for a reorganization.

IN THE SPOTLIGHT

We Called, You Answered
A remarkable 54 NSLS-II beamline development proposals were submitted in 2010 by nearly 700 proposal team members from around the world, representing both existing and new user communities in a variety of scientific fields. Each proposal was reviewed first by one of seven Science Advisory Committee (SAC) Study Panels and then by the full SAC. More than half — 34 — were approved.

Closing the Ring
Just days into FY11, the structural frame of NSLS-II became a complete, nearly half-mile ring as the final steel beam was bolted into place. The “topping out” ceremony collected the signatures of nearly 700 proposal team members from around the world, representing both existing and new user communities in a variety of scientific fields. Each proposal was reviewed first by one of seven Science Advisory Committees (SAC) Study Panels and then by the full SAC. More than half — 34 — were approved.

Getting to the Action
At NSLS-II, all the science action will take place at two 60 beamlines, each consisting of a suite of scientific instruments where experiments are carried out. Six beamlines are being built by the NSLS-II Project. Preliminary designs for these six “project” beamlines by our basic design team at the front end, where the light is directed to the target and the beam is focused, and at the end of the beamline, where the research is done. Procurement will begin soon on major equipment such as high-precision mirrors and gratings. Planning also is under way for additional beamlines. The U.S. Department of Energy’s CD-11 (approval of mission need) for a Major Items of Equipment Project, known as “NSLS-II Experimental Facilities,” or NEXT. NEXT will design and construct 5-6 beamlines.

NSLS User Wins Kavli Prize
For his pioneering advances in the field of DNA nanotechnology, New York University chemist Nadrian C. (Ned) Seeman took home the 2010 Kavli Prize in Nanoscience. Seeman, who shared the $1-million prize with Donald Eigler of IBM’s Almaden Research Center, uses NSLS to determine the atomic structure of the specific DNA components he creates. With the help of NSLS, Seeman made a significant breakthrough — the creation of 2D DNA structures.

Websites in the Spotlight
Two of BNL’s top five papers of the year targeted the tuberculosis (TB) industry. Targeting the system that delivers unwanted proteins to the TB bacteria’s “recycling center” could inhibit the bacteria and thwart TB. The circulatory system that drives this similar protein-recycling system that could also be leveraged by other TB drug companies. Research in this project led to multiple science news stories.

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NSLS-II Construction
Targeting the Tuberculosis "Recycling Center" TB (Mycobacterium tuberculosis) injects a third of the world’s population. Targeting the system that delivers unwanted proteins to the TB bacteria’s “recycling center” could inhibit the bacteria and thwart TB. The circulatory system that drives this similar protein-recycling system that could also be leveraged by other tuberculosis drug companies. Research in this project led to multiple science news stories.

NSLS-II lab-office building

TWO OF BNL’S TOP FIVE PAPERS OF THE YEAR

Protecting Platinum for Better Fuel Cells
Platinum is one of the most efficient metals used to drive reactions in fuel cells for electric cars. But during charging and go-driving, the precious platinum quickly degrades. With help from NSLS studies, scientists developed a new membrane that can greatly enhance the practicality of fuel cell vehicles.