# National Synchrotron Light Source II

# Project Progress Report

## January 2011

January 31: Work continues through the winter weather.

report due date:
February 20, 2011

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BROOKHAVEN
NATIONAL LABORATORY

## OVERALL ASSESSMENT

The National Synchrotron Light Source II project continued to make excellent progress in January despite record-setting snowfalls and temperatures well below average. The project is 48% complete with 30% of contingency and management reserve for the remaining cost to go. The cumulative schedule index is 0.97 and the cumulative cost index is 1.02, both well within the acceptable range. The current-month schedule variance is negative due to conventional construction being slowed by weather and the delivery of production magnets falling further behind schedule.

Construction of the ring building is still on schedule despite the laboratory being closed down five times in January due to harsh winter weather. Construction is on track to conduct the phase I beneficial occupancy readiness evaluation (BORE) on February 1, then turn over the first section in late February. Construction of the Lab–Office Building (LOB) also made excellent progress, with concrete foundations and steel fabrication being underway as scheduled. The project continued to proactively manage the construction site to ensure that sitewide safety goals are met. Both the chilled water plant and the electrical substation expansions are nearing completion.

Excellent progress continued in the production of girders, vacuum chambers and pumps, linac, booster, controls, power supplies, and electrical utilities for Accelerator Systems. A proposal for the cryogenic refrigeration system and three proposals for the Elliptically Polarized Undulator (EPU) were received, and the Request for Proposal (RFP) for the RF cavity was issued. Despite intensive effort, magnet production continues to progress slowly. Careful cost–benefit analysis and formulation of the schedule mitigation plan will continue over the next few months. The projected early completion date is expected to fluctuate during this adjustment period.

Excellent progress continues on the final designs of six beamlines and the technical specifications and statements of work for key procurement components. Preliminary specifications for the hutches were released and the engineering design of endstations and R&D activities continued to advance at good pace, as extensively described in this report.

The projected early completion date of March 2014 and the critical path remain the same as in December. Activities funded by the American Recovery and Reinvestment Act (ARRA) continued to be on schedule and on budget.

## UPCOMING EVENTS 2011

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|---|---|
| Budker Institute of Nuclear Physics (BINP) Final Design Review | Feb 7–11 |
| Project Advisory Committee (PAC) meeting | Feb 8–9 |
| DOE Mini-Review of NSLS-II Project | Feb 25 |
| SRX Beamline Advisory Team (BAT) meeting | Feb 28 |
| IXS BAT meeting | Mar 16 |
| CSX BAT meeting | Mar 29 |
| Science Advisory Committee (SAC) meeting | Apr 4–5 |
| Accelerator Systems Advisory Committee (ASAC) meeting | May 10–11 |
| DOE Review of NSLS-II Project | June 21–23 |

## ACCELERATOR SYSTEMS

**Accelerator physics.** Studies have been carried out to better understand the effect on dynamic aperture of the breaking of lattice symmetry. A study is nearing completion to determine whether a superconducting wiggler can be placed off-center downstream in a short straight. This would allow for a diagnostic stripline to be placed in the upstream portion of the straight. An important issue for the top-off safety analysis has been recognized. Quadrupole and sextupole power supplies have been designed with the capability to provide significant margin above the stated maximum current. Simulations are underway to determine the controls required to ensure safe top-off operation, taking into account this increase in the potential field strength in the quadrupole and sextupole magnets. Analysis has shown that safe top-off operation can be accomplished with the inclusion of proper horizontal aperture either at the crotch or downstream of it. Work to determine the better approach is proceeding.

**Magnet systems.** Further first article magnets have been received. Two short and one long quadrupole were received from Budker Institute of Nuclear Physics (BINP). From TESLA, a quadrupole with a double coil and the first large aperture quadrupole were received. The second batch of 14 production sextupoles was delivered to BNL. The crew in Bldg. 902A was busy performing acceptance and magnetic measurements on the magnets. Most of the magnets perform well and the field error is below or near the specified limits.

**Vacuum.** The production of Al vacuum chamber continued, with about 35 vacuum chambers completed by the end of the month. The last multipole extrusions were received and are being measured. The last batch of dipole extrusions are being inspected at the vendor. Six S3 dipole chambers were completed and shipped from APS. Nine more chambers were assembled, baked, vacuum certified, and ready for girder integration, with a total of 35 chambers available. Production S4A extrusions were produced and sent to vendors for chamber fabrication, with a prototype expected in early March. LBT B3 and B4 chambers were made and are being measured. Gussets may be added to B1 and B2 chambers to reduce deflection. The orders for 10 prototype synchrotron radiation absorbers and 10 so-called crotch absorbers were submitted for approval. Sixty more titanium pumps were delivered this month, bringing the total available to 110. A total of 136 ion pump controllers are also in-house and most have been tested. Orders for vacuum gauges and controllers were placed with the low bidder and the first articles are expected in early March. Two prototype RF bellows were cycle-tested, and the procurement should start in February. The draft specification for front end gate valves is being reviewed. The chemical cleaning facility was delivered in mid January, and the second containment is being installed in Bldg. 945.

**Power supplies and electrical utilities.** The power supply controller (PSC) chassis order has been placed. Production test fixtures have been designed for all PSC cards and they are in the process of being constructed. First units of the power

supply interfaces (PSIs) are available for software development and for BINP to start on the overall software integration. Production test fixtures have been designed for all PSI chassis and they are in the process of being constructed. Mechanical design work and printed circuit board layout continues on the design of the different power amplifiers needed for the low-current fast corrector and high-current slow corrector power supplies. One-wire temperature sensor testing is taking place at NSLS, where the shielded new sensors have performed without failure. The production one-wire interface chassis procurement has been placed. The power converter procurement is progressing. An initial meeting with the vendor has taken place, along with a meeting to review the final design report. There were only very minor issues with the design report; these will be cleared up within a week's time. First article inspection at the vendor's facility is scheduled for March 7. Full production testing of DCCTs is continuing, with more than 1,600 units already tested. Almost all of the units exceed their specifications by a factor of 2. The first output cables have started to arrive and the rest should be in house next month. All the engineering is done for the one-line diagram for the injector complex AC power. We believe the information on the power supply AC mains requirements from BINP and the linac manufacturer is now complete. The new details required us to rearrange the equipment layouts to allow for placing the larger booster dipole power supplies and slightly larger equipment enclosures. The order for the AC power connection cable has been placed. This is the cable for almost all the power connections located on the storage ring mezzanine and in the injector service building. Some of the cables for large loads still need to be ordered but we are awaiting final details. The low-precision temperature control panels order has been placed, as well as the order for a long-lead component for the high-precision temperature controller chassis. The first articles for the uninterruptible power supplies (UPS) have been delivered and are ready for installation. All UPSs needed for the first pentant are available.

**Insertion devices**. Proposals for the EPU from four vendors have been received and examined and questions were sent to each vendor. The contract for the in-vacuum measurement system is ready to be placed. All the design issues for the integrated field measurement system have been resolved, except for knobs attached to motors. The Clean Room in Bldg. 832 is fully operable, and the high-precision Hall probe measurement bench is being commissioned.

## EXPERIMENTAL FACILITIES

XFD activities in January focused on the technical specifications and statements of work (SOW) for long-lead-time procurement beamline components (including the larger beamline optics packages). The SOW and specs documents for the experimental hutches are now with the procurement team. Draft specifications were sent to potential offerors for review and comment; we estimate that the RFP will be released to potential suppliers around March 15. Bid responses for motion controllers are being evaluated.

Collaborating with the optics metrology group, the inelastic x-ray scattering (**IXS**) team has studied optical specs for the KB focusing mirrors. Initial vendor feedback indicates that these specifications can be met. Further work will focus on finalizing the specs and SOW in the coming weeks. Compilation of the technical specs for the first optical enclosure (FOE), including the high-heat-load double crystal monochromator, is progressing well.

In high energy-resolution optics R&D, components for the second version of the high-precision mechanical stages for testing the CDW optics were completed, assembled, and sent to the SPring-8 synchrotron for beamtime in early February (Fig. 1). This will be the first experimental test of the NSLS-II design at a third-generation synchrotron source. The results will provide valuable feedback on the mechanical design, crystal quality, and overall performance of the optical system. In collaboration with the optics fabrication group and the ESRF crystal fabrication lab, two sets of C, D, and W crystals have been made. In addition, another set of CDW crystals has been procured from reputable vendors. Plans are to test all these crystals using the coming beamtime at SPring-8 and elsewhere.

Figure 1. The new CDW–CDW mechanical system mounted on the high-resolution optics table of the BL12XU beamline at SPring-8.

The hard x-ray nanoprobe (**HXN**) team concentrated on technical specs for the beamline optics and components. The monochromator design was modified to ensure the highest level of angular stability. In addition, there was steady progress in nanopositioning R&D. After ~0.3 nm sensitivity was achieved last month, systematic measurements were made to characterize the operating range of the fiber optic interferometers, investigating their long-term electronic stability by cooling the cavity to the temperature of liquid nitrogen (Fig. 2). Over a 2-hour period, a stability of ~0.55 nm was achieved, with better than 1 nm achieved after 40 hours.

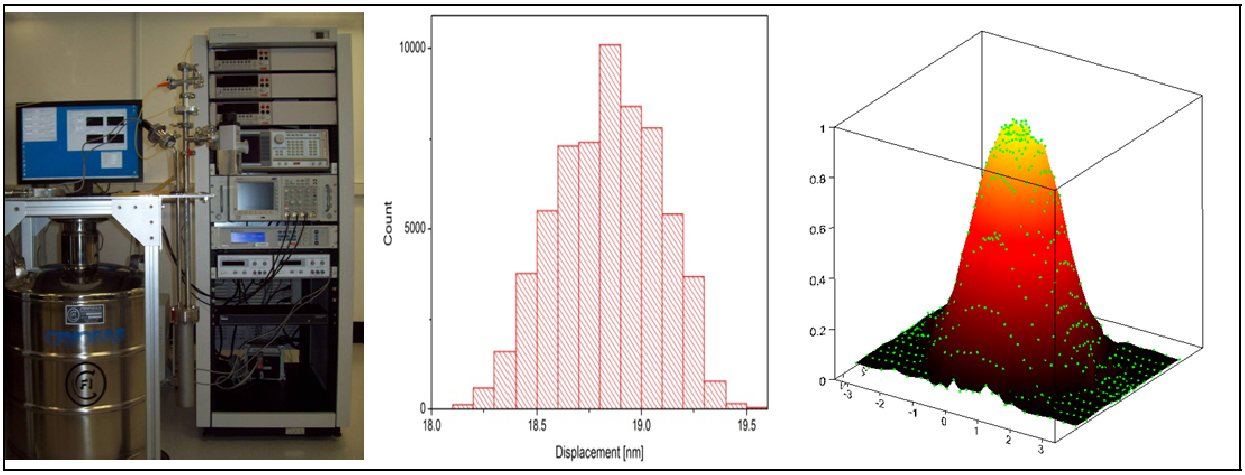


Figure 2: Left: Experimental setup for measuring long-term stability of the laser interferometers. Middle: Measured stability over 2 hrs with the FWHM of 0.55 nm. Right: Measured interferometer signal strength over 2D angular tilts. The FWHM width of the angular range is ~2°.

In addition, this investigation demonstrated an extremely encouraging property of the fiber-optic interferometer: the angular range (2°) is substantially larger than that of conventional interferometers. The large angular range is extremely useful for implementing these interferometers for the MLL x-ray optics, which require ~1° angular adjustment for proper focusing. The empirical verification of a large angular operating range is an important breakthrough in nanopositioning R&D.

The **CHX** team continued its focus on finalizing technical specs for the beamline optics through detailed interactions with potential vendors. Particular attention is being paid to the two main optical components: the white beam horizontal deflecting mirror and a pseudo channel-cut double crystal monochromator (DCM). Both instruments will be designed to achieve an unprecedented stability of 50 nrad over a wide range of time scales. To achieve this level of stability in the vertically deflecting DCM, novel solutions exclusively based on flexure coupling for the motions inside the crystal cage and flexible braid cooling are being carefully evaluated (Fig. 3).

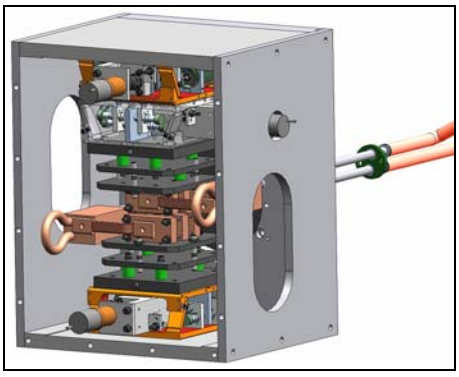

Figure 3: Design of a pseudo channel-cut monochromator crystal cage featuring flexure couplings for the roll and pitch crystal motions and thermal contact to the liquid nitrogen circuit via flexible braids.

The team for the coherent soft x-ray (**CSX**) beamline began detailing the beamline's final design. Procurement packages for the grating substrates and the internally water-cooled mirrors are progressing steadily and the CSX beamline team will meet regularly with experts in x-ray optics over the next weeks to complete the specs for the toroidal mirrors. A strong collaboration has been established with the ASD insertion device team; the EPU design was approved for procurement, and the specifications document for the phaser magnet located between the EPUs is nearing completion. The CSX team progressed on the beamline FOE and utilities procurement packages. There are parallel efforts to elucidate the degree of coherence to be delivered by the CSX high-coherence flux branch (wave front analysis). Expectations are very high and results will be available soon.

For the x-ray powder diffraction (**XPD**) beamline, specs and SOW documents for procuring the Double Laue Monochromator are being written. The layout for the lead hutches (one FOE, three end stations) was completed and is ready for handover to the procurement team. Discussions were carried out with potential vendors regarding ongoing development of a CdTe-based pixel array detector. This technology is particularly promising for XPD, combining a high-efficiency sensor, large area, high resolution, high dynamic range, and high framing rate. The specification for the XPD 1.3 m long, Pt-coated mirror was also discussed internally within a dedicated working group. Discussions are ongoing with ESRF regarding a custom design of the filtering stage.

The main task of the submicron resolution x-ray spectroscopy (**SRX)** beamline group in January was to continue working on specifications for the FOE optics package. Wave propagation calculations were made to verify SHADOW raytracing results. The first results affirmed an obtainable spatial resolution well below 50 nm. These calculations continue. To match the expected high spatial resolution, a model for highly accurate stages has been designed: hybrid stages move the sample from coarse to medium-fine, and an extremely accurate piezo stage moves the sample in very fine steps as well as compensates for any errors of the hybrid stages (Fig. 4). This is work in progress.

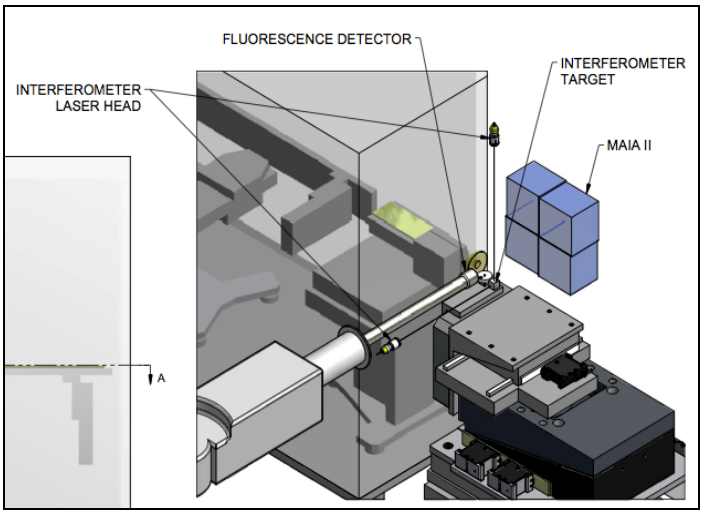


Figure 4: Model of sample stages for the SRX beamline end station.

The optics fabrication group has initiated chemical-mechanical polishing of silicon. A first test on oriented silicon using 40 nm colloidal silica (pH of approximately 10.5) was found to result in zero scratches or pits, with a roughness under 4 nm RMS. Further work to obtain a polishing quality lower than 1 nm RMS is planned. Manual multilayer sectioning and thinning by dicing and polishing was initiated as a backup plan for reactive ion etching. Multilayer thinning down to a thickness of 20 microns was successful. The BNL Office of Commercialization and Technology Transfer filed a provisional patent with the US Patent and Trademark Office on Feb. 11, 2011, "Technique for etching $WSi_2$ and Si based materials," which discloses the process for $SF_6/O_2$ and $CHF_3/Cl_2/O_2$ reactive ion etching of MLs to a trench depth of 40 microns. Work on nitrogen mixing for stress-reduced multilayer growth continues, with reflective multilayers grown using 9% nitrogen showing no degradation or loss of performance compared to multilayers grown only with argon.

The CHX and XPD beamline preliminary designs and some recent applications of x-ray photon correlation spectroscopy were summarized in an invited presentation at a workshop on "Dynamic Phenomena under Extremes," held during the week of January 24–28 at the University of Texas, Austin.

## PROCUREMENT ACTIVITIES

The proposal for the Cryogenic Refrigeration System was received and is in evaluation, with award expected by late February or early March. Proposals for the Three-Pole Wiggler and the Elliptically Polarized Undulator have been received and are in evaluation; awards are expected in late February and early March, respectively. The RFP for the RF Cavity was issued with a closing date of February 25, 2011; competition is expected. Award was made for the Corrector, Transport Line, and Multipole Power Supplies.

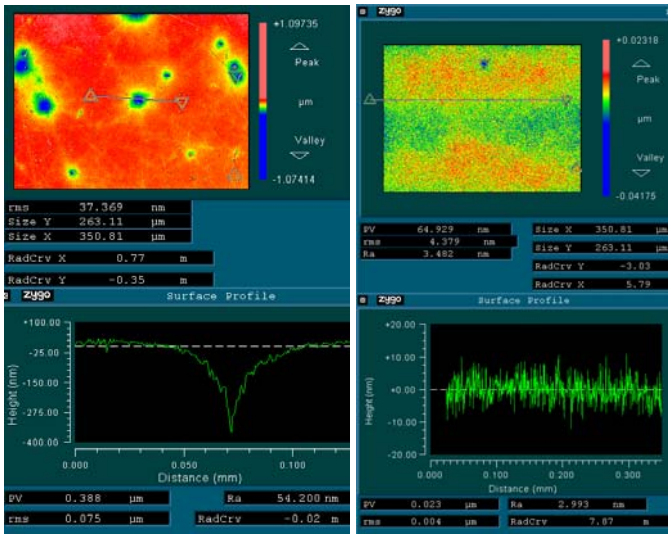


Figure 5: The optical metrology group continued working on specifications for the nanoradian measuring system. In addition, they progressed with the optical head pre-design and the measuring station using a Fizeau interferometer, measuring optical components (silicon polished crystal, mirror for the NLSL UV).

## CONVENTIONAL FACILITIES

Despite record snowfall for January and temperatures well below average, construction of conventional facilities continued to progress well, albeit at a pace slower than planned. Despite the weather, construction is on track to turn over the first section of the ring building in late February, provided more typical winter conditions prevail in the coming weeks.

Utility systems are being commissioned and going through startup under the oversight of the commissioning contractor, with the participation of operations and maintenance staff. Electrical systems are now energized into pentant 1 and being utilized for equipment testing. The steam system also is energized and available in pentant 1. Mechanical systems in service building 1 are being readied for final testing and control system startup (Fig. 6).

Figure 6: NSLS-II Lead Mechanical Engineer inspects contractor work.

Difficult weather has had the greatest impact on exterior envelope productivity. Some detail items required for final enclosure in pentant 1 have been delayed but are now on track for completion in February. Much of the building envelope work in subsequent phases was ahead of schedule and thus is

not expected to be delayed as winter conditions subside and full-scale roofing and siding installation resume.

Figure 7: Lobby exterior siding and curtain wall near completion in January.

Interior finish work in pentant 1 (Figs. 8–10) is nearing completion, aided by the installation of temporary heating systems and temporary closure walls to maintain necessary interior temperatures for spackling and painting.

Figure 8: Painting of structural steel in pentant 1 is nearly complete.

Interior mechanical, electrical, and plumbing continues to progress around the ring. Mechanical and electrical systems are being installed in the service buildings, mezzanine, and experimental floor areas. The work includes HVAC ductwork, equipment placement and installation, fire protection, heating and cooling system piping, compressed air, nitrogen and other utility services.

Concrete work on the storage ring tunnel slab and walls in the pentant 5 area is complete and the tunnel roof and experimental floor in this area and the ground floor slab in the booster building are the only significant concrete work that remains. They are being readied for final concrete pours in the February–March time frame.

The chilled water plant expansion is nearing completion of the startup and testing phase but is awaiting some components for the chiller motor starters. These components are expected in mid-February and will enable completion of chiller startup several months earlier than the added chiller capacity is needed. The underground chilled water piping installation has been completed and is ready to convey chilled water to the NSLS-II site from the central chilled water plant.

The electrical substation expansion is also nearly complete. Switchgear and cabling work is done, and permanent power is being delivered to the NSLS-II site. The 20 MVa transformer requires only some punchlist items before startup. With some cooperation from the winter weather it will be available during February 2011, more than 1 year earlier than needed.

Figure 9: Lamps shrouded for paint protection illuminate the work area.

The LOB contractor has employed winter concrete techniques to continue foundation installation for LOBs 1 and 2 during January. A significant portion of the steel shop drawings have now been approved and steel fabrication is underway. The delivery of steel and the start of steel erection for LOB 1 are on track to begin early this spring. Work planning among the ring building and LOB contractors continues to proceed cooperatively and without impact on the pace of each contractor's work.

## RECENT HIRES

Eric Blum – Sr. Physics Associate, Injector Systems, ASD

William Wahl – Mechanical Engineer, Mechanical Engineering, ASD

## COST/SCHEDULE BASELINE STATUS

The cumulative Cost Performance Index (CPI) is 1.02 and the cumulative Schedule Performance Index (SPI) is 0.97, both well within the acceptable range. The project is 48% complete, with 29% of contingency and management reserve remaining, based on EAC work remaining.

The current-month CPI is 1.05, green status; the current-month SPI is 0.79, red status. This negative current-month schedule variance is due primarily to weather-related conventional construction delays affecting the installation of mechanical piping, electrical work, and steel stairs in pentant 1, and delays in electrical and mechanical installation in pentant 2 and the RF building. However, conventional construction maintained a slightly net-positive cumulative schedule variance of $6M. The current-month accelerator systems' schedule performance was negative due primarily to delays in magnet production and deliveries of multipole power supplies and vacuum chambers.

The critical path for the project (see p. 8) remains the same and includes RF cavity procurement lead-time to delivery, along with the delivery of the storage ring production magnets. The critical path runs through accelerator magnet deliveries; RF cavity contract award and fabrication; girder assembly, installation, survey, and alignment; then accelerator installation, integrated testing, and commissioning. Within 2 to 3 months of the critical path are vacuum chambers/components; the storage ring RF cryogenic system; and booster vendor production, assembly, and testing. The projected early completion date for the project is March 2014. There are 15 months of float between the project early completion milestone and CD4, with approximately 28% schedule contingency.

## ENVIRONMENT, SAFETY, AND HEALTH (ESH)

The beneficial occupancy readiness evaluation (BORE) for phase I will be conducted on February 1. This includes pentant 1 and the vehicle tunnel. Any pre-occupancy items identified will be completed so the installation of technical equipment can begin.

The drafts of the Linac Commissioning Safety Assessment Document and Accelerator Safety Envelope have been completed and will be reviewed by the Photon Sciences Directorate on February 24. Following resolution of any comments, the documents will be formally reviewed by the BNL ESH Committee.

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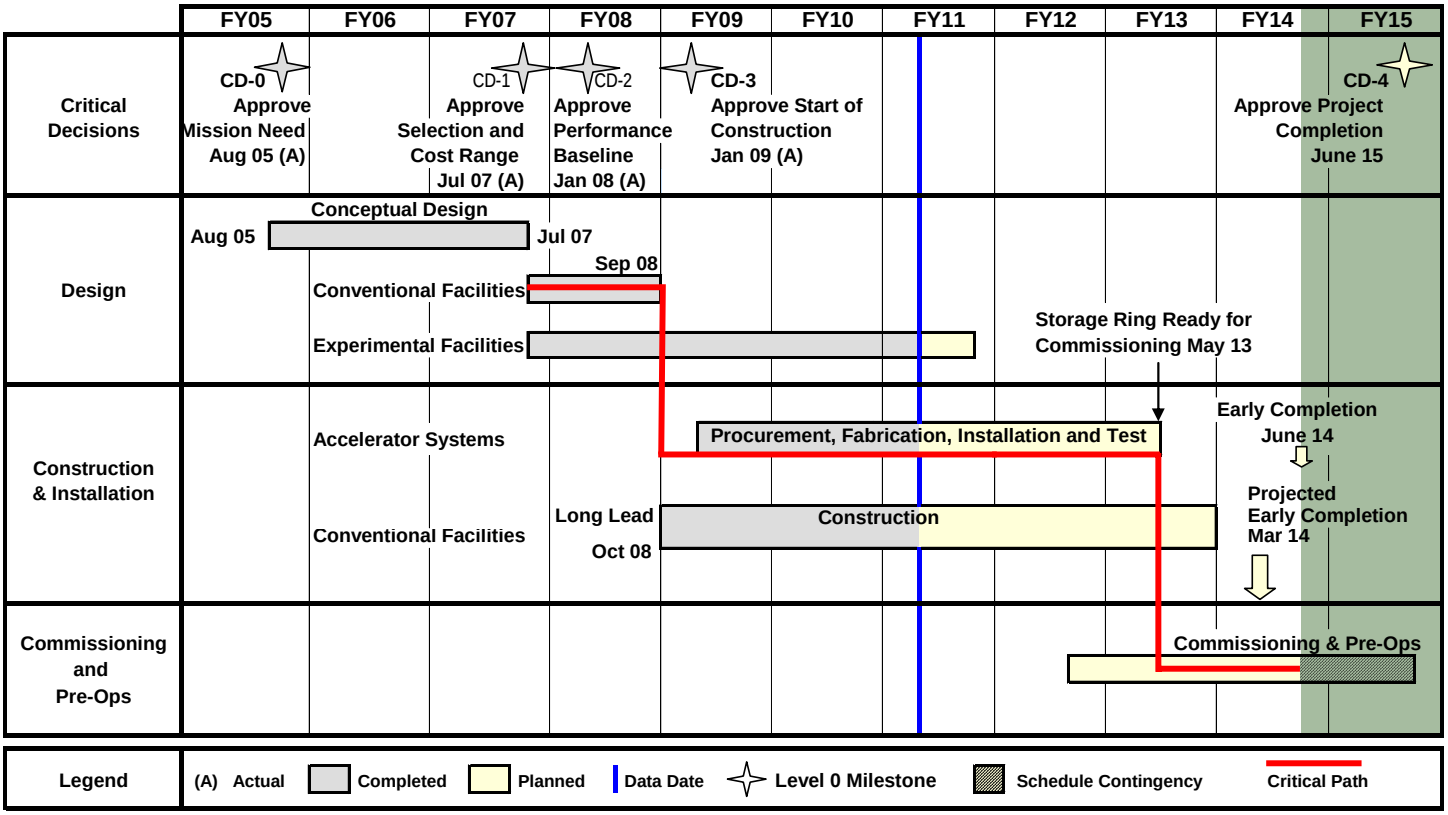
Figure 10: Different view of work underway in the lobby of the ring building.

The NSLS-II project is being carried out to design and build a world-class user facility for scientific research using synchrotron radiation. The project scope includes the design, construction, and installation of the accelerator hardware, civil construction, and experimental facilities required to produce a new synchrotron light source. It will be highly optimized to deliver ultra-high brightness and flux and exceptional beam stability. These capabilities will enable the study of material properties and functions down to a spatial resolution of 1 nm, energy resolution of 0.1 meV, and with the ultra-high sensitivity necessary to perform spectroscopy on a single atom.

## DOE Project Milestone Schedule




### Funding Profile

| | NSLS-II Funding Profile ($M) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Topic | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 | TOTAL |
| R&D | | | 3.0 | 20.0 | 10.0 | 2.0 | 0.8 | | | | | 35.8 |
| OPC | 1.0 | 4.8 | 19.0 | | | | | | | | | 24.8 |
| PED | | | 3.0 | 29.7 | 27.3 | | | | | | | 60.0 |
| Construction | | | | | 216.0 | 139.0 | 151.6 | 151.4 | 46.9 | 26.3 | | 731.2 |
| Pre-Ops | | | | | | | 0.7 | 7.7 | 24.4 | 22.4 | 5.0 | 60.2 |
| Total NSLS-II Project | 1.0 | 4.8 | 25.0 | 49.7 | 253.3 | 141.0 | 153.1 | 159.1 | 71.3 | 48.7 | 5.0 | 912.0 |

The NSLS-II Project Progress Report is prepared monthly for submission to the Department of Energy.
This condensed version is available to the public at the NSLS-II website in PDF format. For questions or comments, contact the editor, Kathleen Robinson, at krobinson@bnl.gov,
or via mail at: Room 37, Bldg 830M, Brookhaven National Laboratory, Upton, NY 11973.