National Synchrotron Light Source II

Project Progress Report

February 2011

Midday, midway through February.

report due date:
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OVERALL ASSESSMENT

The National Synchrotron Light Source II project made good progress despite unusually extreme winter weather that continued in February. The cumulative cost and schedule indices are 1.02 and 0.96 respectively, both within the acceptable range. The current-month negative schedule variance of $4M is mainly due to conventional construction being slowed by weather, delayed delivery of production magnets, and lagging status reports on some accelerator components by production vendors. Close attention is being paid to all elements of the project which contributed to this negative schedule variance. Overall, the project is 49% complete with 31% of contingency and management reserve for the remaining cost to go.

The DOE Independent Project Review (IPR) was conducted by the Office of Science on February 25 and the committee concluded that the technical, cost, and safety performance is excellent but the magnet production schedule needs continued attention.

Construction of conventional facilities continued to make excellent progress despite unceasing harsh winter weather. The ring building is still on schedule and a successful beneficial occupancy readiness evaluation (BORE) was held on February 1, which will enable occupancy of pentant 1 by mid March. Construction of the Lab–Office Building (LOB) made substantial progress, with concrete foundations and steel fabrication being underway as scheduled. In anticipation of the ramp-up of accelerator installation activities, management of the construction site and site access process have been further strengthened and refined in order to ensure that sitewide safety goals continue to be met.

Accelerator Systems progress continued with successful delivery of most production components and preparations for installation at the ring building. Magnet production continues to improve but slowly, and the schedule mitigation plan is being cautiously implemented. Excellent progress continues on the final designs of six beamlines, and the preparation of procurement packages 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. Activities funded by the American Recovery and Reinvestment Act (ARRA) continued to be on schedule and on budget.

UPCOMING EVENTS 2011

Event	Date
IXS BAT meeting	Mar 16
CHX BAT meeting	Mar 18
CSX BAT meeting	Mar 29
Science Advisory Committee (SAC) meeting	Apr 4–5
Earned Value Management System (EVMS) training	Apr 13–14
Accelerator Systems Advisory Committee (ASAC) meeting	May 10–11
DOE Review of NSLS-II Project	June 21–23
Internal NEXT CD-1 Review	June 28–30
DOE NEXT Project CD-1 Review	Aug 30–Sep1

ACCELERATOR SYSTEMS

The **accelerator physics** group determined the beam acceptance phase space area in the dipole magnet for the final design of the equipment protection system. An outline for the top-off safety document, which will serve as the basis for safety review, has been produced. Work on high-level applications for storage ring commissioning has been started. Accelerator physics also completed a study of nonlinear beam dynamics with a strong superconducting wiggler situated downstream in a short straight section.

Injector. The final booster design review at the beginning of the month went very well. Only minor issues were raised, and these were resolved during the month so that prototyping for the booster began. Contracts for the transfer line diagnostic have been placed.

Magnets. The magnet group was busy in February with acceptance measurements for the 28 Danfysik production magnets that were received in the two preceding months. Acceptance measurements performed on magnets delivered by Budker Institute of Nuclear Physics (BINP) and Tesla showed acceptable to excellent quality. As a consequence, BINP was given the go-ahead to produce two types of quadrupoles, and Tesla and IHEP were approved for the production lamination and magnet yokes. Meanwhile, BINP has already produced the laminations and the yokes for more than 25 magnets. Magnet production was 12% complete at the end of February.

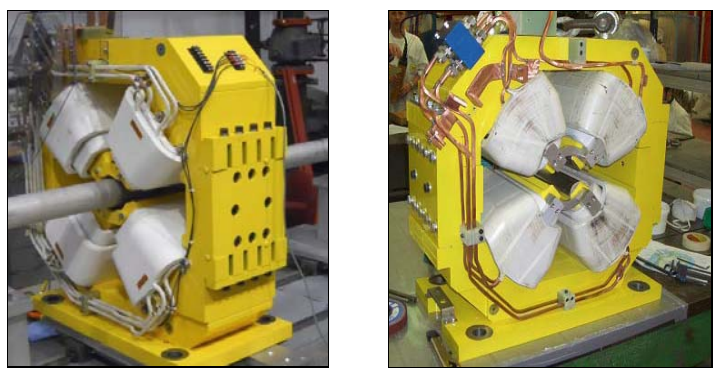


Figure 1: First article quadrupole magnets from BINP (left) and Tesla (right).

Vacuum. Ten additional chambers were assembled, baked, vacuum certified and are ready for girder integration, making a total of 45 vacuum chambers (30%) available. Machining orders for special diagnostic multipole chambers and for even, straight sections were placed. Three of the delayed short S4A chambers were completed at the vendor and have been tested. The first transfer line vacuum chambers were completed and passed inspection. The procurement process for the absorber system has begun. Orders for thirty prototypes of three types of absorbers have been placed with an outside vendor. One-hundred-ten ion pumps were received, which corresponds to one-third of the entire production. The order for the beam transfer line ion pump was placed. Forty titanium pumps were delivered this month, bringing the total delivered to 150, which is 50% of the entire production. One-hundred-sixty ion pump controllers are in house. First article titanium pump power supplies (PS) were received and are being tested. The fabrication of first-article RF-shielded bellows has started at BNL Central Shops. The specification of front end gate valves was released. Layout of the PLC chassis for injectors was produced for review by BINP colleagues. In summary, most vacuum parts are in or close to mass production. A significant fraction of the production is in house and ready for installation.

Power supplies and electrical utilities. The production of components is picking up speed: first articles for all the power supply controller (PSC) boards and chassis have been received and have been tested with no issues found, so full production can begin. First units of the power supply interface (PSI) were also delivered and tested and will be sent to BINP for integration into the booster PS system.

Some first article AC mounting hardware and power modules have been received and reviewed, with only minor issues found. Production testing of DCCTs with 1,825 units is finished. All PS instrumentation and output cables have been delivered. The contractor has started work on the cable trays in the tunnel and mezzanine. The AC power connection cables for almost all the power connections located on the storage ring mezzanine and injector service building have been delivered. The first articles for the low-precision temperature control chassis have been delivered. The uninterruptible power supply (UPS) units needed for the first pentant have been delivered and are ready for installation.

Mechanical utilities. The installation of DI water piping in the accelerator tunnel has started. The survey group has started to install secondary survey monuments in the tunnel.

Insertion devices. Evaluation of the technical proposals for the EPU has been completed, and the alignment base for the calibration magnet has been fabricated. A layout model of the 3 m IVU-22 has been developed. The award for the Three-pole-Wiggler has been made. House water for the cooling of the calibration dipole has been connected to the chiller. Optical stages are prepared for mounting on the Hall and NMR probes.

RF. Construction of the higher harmonic has been completed; the contract for the cryogenic plant has been placed.

BPM development work has been progressing quite well. All four major subsystems (AFE, DFE, chassis, and junction box) are in advanced stages of prototyping or pre-production testing. The production procurement cycle is planned to start in April, with a contract award in June for the injector and in September for the SR BPMs. The second iteration analog front end (AFE spin-2) board was integrated into the BPM assembly with successful results, both in the laboratory and at ALS at LBL. Long-term stability of 200 nm was demonstrated, as well as the single-turn revolution of 400 nm. The AFE layout with upgraded components selection has further improved the overall BPM performance. The final design of the digital part with the latest generation FPGA electronics is well advanced and is expected to be available in early March.

EXPERIMENTAL FACILITIES

XFD activities in February continued to focus 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 and will be released to vendors in mid March. The best-value evaluation process for motion controllers has been completed and we are proceeding with the award of this contract.

One of the major activities of the **IXS** team in February was the first experimental test of the new high-precision mechanical stages for the CDW optics at the BL12XU beamline at SPring-8. Within the 5 days of available beamtime, we were able to complete the commissioning and testing of the entire mechanical system and the alignment of CDW monochromator and analyzer. One of the main improvements of the new design is the separation of the C and W crystals from the previous monolithic design, making it possible to improve the individual crystal surface quality. The C crystal reflectivity as measured was close to 80%, a factor of 2 or more better than previous crystals. The rapid alignment of the entire CDW–CDW scheme was made possible thanks to a refined alignment procedure by the recent theoretical effort of Yuri Stetsko, making use of multiple beam diffraction (Fig. 2) and the substantial experience gained at NSLS beamline X16A. A full set of C, D, and W crystals from one vendor was tested. They yielded an energy resolution of ~4 meV and efficiency of ~2.2%, comparable to those obtained at NSLS. Some mechanical issues were identified in the system and are now being addressed.

At NSLS, trouble at the X16 front end has prevented the operation of X16A since January. Repair requires venting the NSLS storage ring and is scheduled for the May maintenance period. Meanwhile, the IXS team began work to implement monochromatic beam topography capability at X19C. This will provide critical characterization capability for the crystal fabrication effort.

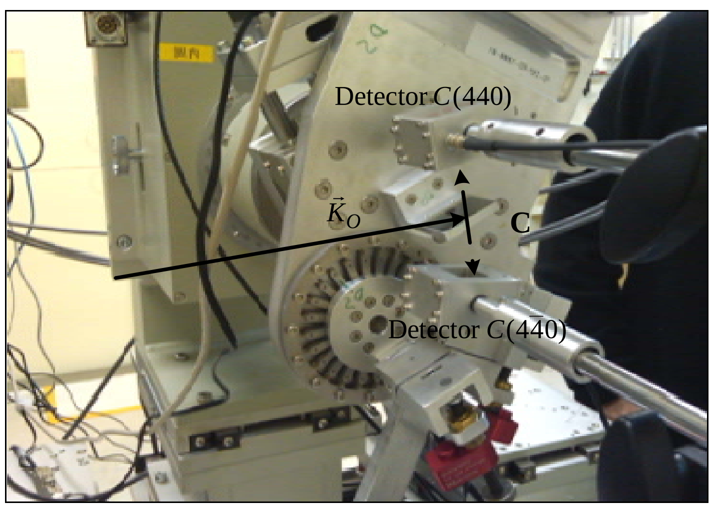


Figure 2. Scheme showing the use of multiple beam diffraction from the C crystal in setting the correct energy for the CDW.

The **HXN** team is continuing to finalize the specification documents for procuring the beamline components. After a thorough performance evaluation of the nanopositioning R&D, a decision was made to expand the current laser interferometer capability from three axes to twelve. Thermal stability investigations were carried out on three types of commercially available piezo scanning systems; two types of piezo scanners meet the criterion for in-vacuum application. For the 1 nm x-ray optic R&D, all piezo scanners used for the prototype MLL microscope are now configured in EPICS. In addition, the overhead time associated with controlling these stages has been reduced significantly. Now, the identical 2D scans can be carried out more than five times faster.

The first major procurement for the **CHX** beamline, an optics package containing most of the major components, is progressing steadily. The procurement schedule has been carefully planned to avoid possible conflicts with other activities. The team worked on finalizing a first publication describing the beamline conceptual design and simulations of the beamline performance using the "Synchrotron Radiation Workshop" (SRW) software by Oleg Chubar et al. While the work will likely continue over the next several months, the team is encouraged to see simulated partially coherent beams that exceed, by more than an order of magnitude, the flux available today at other instruments. This will enable studies of dynamics on time scales 100 times faster than what is achievable today.

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. The CSX beamline team will meet regularly with experts in x-ray optics over the next weeks to complete the specifications 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, the technical specification document for the XPD double-Laue monochromator (DLM) is close to completion. A draft version was internally reviewed at a formal meeting and has been submitted to potential manufacturers for comments and feedback. The document covers the specification and requirements for all components of the DLM, including the first article and the final production unit. The first article is a subset of the DLM and includes crystal 1, its mounting, all relevant translations/rotations, the cooling system, and the vacuum vessel. Its purpose is to demonstrate that specifications for crystal 1 are met. The first article is designed for integration in the final DLM unit, though that is not required. The final production unit consists of the support structure, the vacuum vessel, the crystals, and their assembly ready for integration in the XPD beamline. The current specifications assume a single vessel housing both crystal stages. An alternative configuration is to allow the option for dedicated vessels for each of the two crystals (interconnected). The group is examining whether this option might be beneficial for positioning accuracy, stability, reliability, vacuum integrity, and cleanliness.

The XPD team recently submitted an article for publication in the *Journal of Applied Crystallography*: "Surface curvatures and diffraction profiles of sagittally bent Laue crystals." This article covers part of the experimental and theoretical work on Laue optics carried out over the past months. The experimental measurements were done with an x-ray beam at the NSLS X15A beamline and used the Newview 6000 surface profiler at the NSLS-II optical metrology lab.

A critical parameter for high-quality spectroscopy on the **SRX** beamline will be the control of the undulator IVU21. Calculations show that changes in the undulator gap must be controlled with an accuracy of ~1 µm to achieve a maximum intensity change of 1%. An inquiry about experiences at other storage rings showed a gap change of ~1 µm is feasible.

The SRX hutch design has been finalized. Due to the position of the secondary source aperture outside the large endstation hutches for the KB and ZP branches, a mini-hutch has been designed. This results in hutches numbered from 5-ID-A for the first optical enclosure down to 5-ID-D for the KB endstation hutch.

The KB endstation was modified, allowing even more versatility. The two sets of KBs have been separated into two vacuum vessels using a micro- and a nano-stage, for high flux and high resolution experiments, respectively. The sample area for high flux experiments can now handle much larger samples and has more room for sample manipulation.

The **optics fabrication group** moved the x-ray crystal orientation system from Bldg. 535 to the 703 Optics Lab. Orientation capability will be available once the machine has been approved by BNL ES&H. Surface roughness, profile, and white-beam topography studies have been completed on a set of three different crystals that will be used in an upcoming experiment involving two-step gaseous surface silicon removal for strain reduction. As a backup optic for the March beamtime, a new MLL has been grown in the large deposition system with 21 µm total growth thickness, 4 nm outmost zones, and ~2,600 layers. The next MLL growth is targeted for almost 60 microns total thickness and will act as a first test of nitrogen reactive sputtering for stress reduction.

CONVENTIONAL FACILITIES

Challenging winter weather continued through February, with temperatures well below average and substantial precipitation. Construction of conventional facilities continued to make excellent progress despite the conditions, but at a slower pace than planned for the period. A review of pentant 1 readiness for beneficial occupancy was conducted in February. The action items identified and attendant startup and commissioning of systems in pentant 1 are nearly complete and should enable beneficial occupancy of the building in mid March.

Figure 3: Pentant 1 floor being prepped for the application of floor sealer.

Work on the LOBs and the electrical substation also made substantial progress during February, and overall progress is still ahead of schedule.

Building systems in pentant 1 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 energized and the HVAC and process cooling water systems in pentant 1 are being placed in operation to enable overall system testing and calibration. Life safety systems such as fire protection and detection and building egress lighting are all being readied for final acceptance. Final architectural details and building signage needed for life–safety egress are in place and being readied for final verification prior to building occupancy.

Figure 4: Signage installed, final paint touch-up on the pentant 1 mezzanine.

The difficult February weather had the greatest impact on exterior envelope progress. Rain, snow, wind, and extreme cold have substantially impacted the ability to work on the roofing and siding. With the advent of milder weather in March and beyond, building envelope productivity is expected to regain the momentum lost during the winter months. Since much of the building envelope work in subsequent phases was previously ahead of schedule, this momentary setback will not affect the overall schedule. In fact, the ring building contractor is projecting completions of the final phases of the building several months early.

Even with significant focus on completing items required for occupancy of pentant 1, work on other systems continues to progress around the ring. Interior mechanical, electrical, and plumbing are in progress in each of the remaining pentants and service buildings. The work includes HVAC ductwork, equipment placement and installation, fire protection, heating and cooling system piping, compressed air, nitrogen, and other utility services.

The concrete storage ring tunnel is now complete around the entire ring, as the last section of tunnel roof was placed in February. The injection service building floors were also placed in February, enabling the start of injection building enclosure and equipment installation. Remaining concrete work is limited to a section of the experimental floor and access corridor slabs in pentant 5 (Fig. 5) and a section of floor slab in service building 5.

Figure 5: Preparations in pentant 5 for pouring the experimental floor.

The chilled water plant expansion is nearing completion of the startup and testing phase. Components required for the chiller motor starters were received in February and, when installed in March, will enable final commissioning of all systems and 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 also is nearly complete. Switchgear and cabling work is done, and permanent power is being delivered to the NSLS-II site. The 20 MVa transformer punchlist work has been completed, and start-up of the main transformer is scheduled for the first week of March, enabling full power availability to the site more than 1 year earlier than needed. Closeout of the electrical substation upgrade contract is anticipated by the end of March.

The LOB contractor continued to employ winter concrete techniques to continue foundation installation for the LOBs (Fig. 6). Most 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 this April. The LOB contractor's final schedule has also been approved and they are making excellent progress on all submittals. Work planning between the ring building and LOB contractors continues to proceed cooperatively and without impact on the pace of each contractor's work.

Figure 6: LOB 2 site being prepped for pouring the floor slab.

ENVIRONMENT, SAFETY, AND HEALTH (ESH)

The beneficial occupancy readiness evaluation (BORE) for phase I was conducted on February 1. NSLS-II and Contractor staff have been working to complete all pre-occupancy items identified by the BORE committee. All items are expected to be completed by mid March, allowing occupancy by installation staff.

The drafts of the Linac Commissioning Safety Assessment Document and Accelerator Safety Envelope have been completed. They were reviewed by the Photon Sciences Directorate and are now being reviewed by the BNL ESH Committee. Following the resolution of any comments, the documents will be submitted to DOE's Brookhaven Site Office for review and approval. Approval of these documents is a critical step in the process of commissioning the linac.

Engineering designs based on the shielding calculations for different linac shielding components have been completed. Final shielding designs for the two beam dumps, energy slit, and safety shutter are available and ready for procurement. A paper, "Radiation safety implications of top-off operation at synchrotron light sources," has been submitted for publication in the journal *Nuclear Instruments and Methods A.*

COST/SCHEDULE BASELINE STATUS

The cumulative Cost Performance Index (CPI) is 1.02 and the cumulative Schedule Performance Index (SPI) is 0.96, both well within the acceptable range. The project is 49% complete, with 30% of contingency and management reserve remaining, based on EAC work remaining.

The current-month CPI is 1.08, green status; the current-month SPI is 0.80, red status. This negative current-month schedule variance is due primarily to weather-related conventional construction delays affecting the installation of thermal and moisture protection on the building exterior and roof, and mechanical and electrical equipment installation in pentant 2, the injection building, and the RF building. However, conventional construction maintained a slightly net-positive cumulative schedule variance of $4M. The current-month accelerator systems' schedule performance was negative due primarily to late delivery of equipment racks in electrical utilities, continued late delivery of magnets and vacuum chamber components, and delays in work on the damping wiggler insertion devices.

The critical path for the project (see p. 7) remains the same as last month and includes RF cavity procurement lead-time to delivery, as well as 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; storage ring RF cryogenic system; booster vendor production, assembly, and testing; procurement of instrumentation components; and various conventional construction activities in pentants 3, 4, and 5. 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 29% schedule contingency.

PROCUREMENT ACTIVITIES

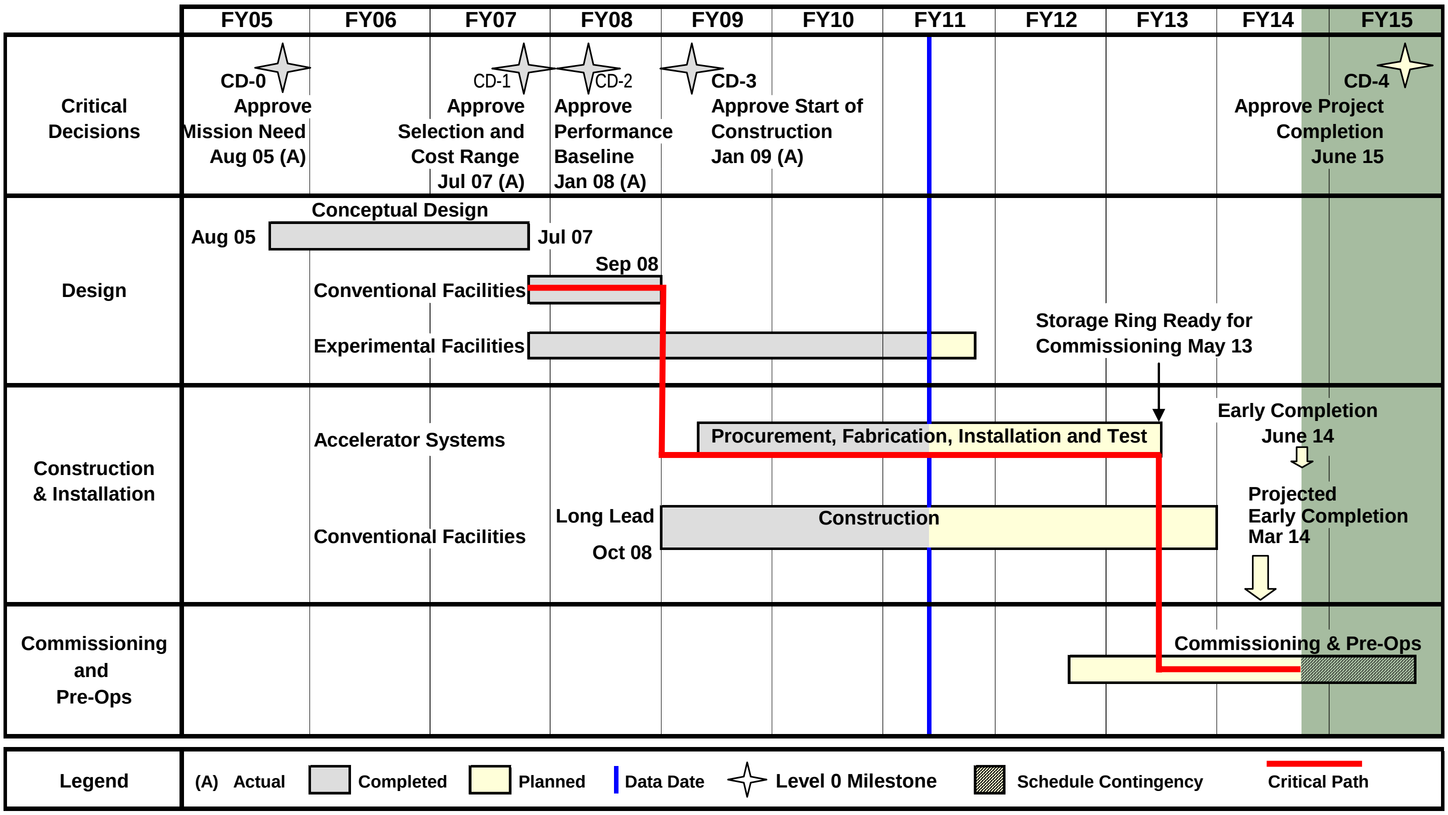
The cryogenic refrigeration system contract has been awarded to Linde Cryogenics, a division of Linde Process Plants, Inc. Awards were made for the in-vacuum magnetic measurement system (IVMMS), network hardware, transport line beam imaging screen, and the linac front end test stand. Proposals for the 3PW and the EPU have been received and are in evaluation; awards are expected in late March. Two proposals were received for the RF cavity. The proposals are in evaluation and award is scheduled to be made in early May. Proposals for the motion controllers have been received and evaluated, with award expected by late March.

RECENTLY HIRED

Aubrey Anderson – Mechanical Engineer, Vacuum Group, ASD

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

Topic	NSLS-II Funding Profile ($M)											
	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.