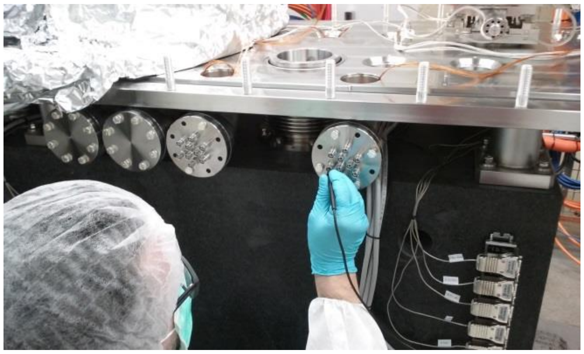
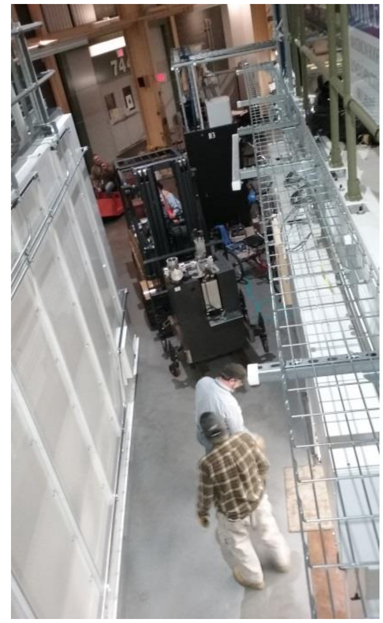
NSLS-II Experimental Tools (NEXT)

March 2016 Project Activity

Report due date: April 20, 2016





SMI: Photon delivery system installations during April (Cinel)

Steve Hulbert
NEXT Project Manager

OVERALL ASSESSMENT

$3.5M worth of work was performed in March, which is largest monthly earned value of the NEXT project to date. The greatest amount of work was performed in the ISR ($825k), SMI ($748k), and ISS ($521k) beamline WBS elements, primarily for photon delivery system (PDS) installations.

Installation of the ISS PDS and all utilities, controls, and safety systems needed for IRR were completed by mid-month. Required documents were completed in advance of the ISS PDS IRR, which was held on March 24. No pre-start actions were identified by the IRR and first beam was planned for the studies period on April 5.

Monitoring and management of contractor progress on the 28 remaining major procurement contracts are important ongoing activities that are crucial to maintaining project schedule.

As of March 31, 2016, the project is 81.6% complete based on base scope performance earned to date. The cumulative EVMS schedule and cost indices are both 0.95.

One PCR was approved during March, a zero-cost amendment to the ISS Spectrometer System Contract.

BAC remained flat in March at $82.3M, with cost contingency at $7.7M, which is 50.8% of $15.2M BAC work remaining. The EAC, reported as the sum of actual cost to date (ACWP) plus the estimated cost to complete (ETC), is $86.01M, $0.27M greater than the February value. The increase consists of added utilities for the SIX beamline, additional installation coordination effort, and labor overage on work performed. As of the end of March, contingency on EAC is $3.99M, which represents 25.9% of $15.4M EAC work remaining, or 60.6% of $6.6M unobligated work to go ($8.8M of the remaining work is obligated to fixed-price equipment contracts). ETC will continue to be assessed monthly through project completion to contain costs while maintaining the good schedule performance that the project has demonstrated to date.

Looking ahead, all five NEXT beamline PDSs will be substantially installed by June and remaining cost contingency should be sufficient to consider scope enhancements at that time.

COMMON SYSTEMS

Mechanical and electrical utilities finishing work continued in March, primarily in the SIX satellite building. Cable trays are now installed in that building, ready for cable installation scheduled to start by the end of April. Installation of fire suppression plumbing for the gas handling systems in the ISR 4-ID-D and ISS 8-ID-B endstation hutches began in March and is expected to be completed by mid-April.

PPS design, development, and installation continued to make significant progress this month. PPS installation continued at ESM and ISR, and PPS software and integrated testing were started. The ISR and ESM beamline PPSs are scheduled to be certified during the May 2016 maintenance period.

The EPS team is continuing to receive EPS requirements for each beamline, and their efforts are being directed to where major beamline component installations are underway or soon will be taking place. At ISS, EPS installation was completed in support of the PDS IRR. Later in March, EPS installation work started at ESM. At SMI, EPS technicians installed two temperature sensors for the white beam stop. Integration of LN2 control valves into the ISR EPS was completed. EPS installation in the ISR hutches began in March as Toyama completed installation of PDS components. EPS installation activities at ESM resumed in March following installation of remaining beamline components by Bestec, which is expected to continue in April.

Control station configurations for all NEXT beamlines have been approved by the Light Source Safety and Operations Council (LSSOC), and remaining control station furniture at ISR and ESM is expected to be procured in April. Integration of AC power and network cables for all NEXT control stations is planned to occur over the next few months, once the control station partitions are received and installed.

BEAMLINE CONTROLS

Controls engineers continued to support optics installations at all NEXT beamlines during March. The ISS controls engineer was fully occupied with controls integration effort in advance of the successful ISS beamline IRR at the end of the month. For ISR, in addition to supporting PDS optics installation by Toyama, the controls engineer participated in the FAT of the Dual Phase Plate system at Huber X-Ray during the first week of March. This system includes ~20 motors which the controls engineer tuned during the FAT using a standard NSLS-II Delta Tau motion controller. For the SMI beamline, cable pulling and terminations for endstation equipment were accomplished in March, along with installation of additional motion controllers and power supplies for the SMI endstations.

EPS logic design work and cable studies for the ESM and SIX endstations continued during March. The controls engineer for these beamlines devoted effort to motion testing of the PGMs and exit slits at these beamlines, including detailed comparison of measured PGM motions against specifications. During this testing, it was discovered that the following error of some of the angular motions is 5-10 times worse than the specified values. Further diagnostics to determine the root causes of these motion problems, either from electronics noise issues or mechanical vibrations, or both, will be further studied in the coming months.

ESM – ELECTRON SPECTRO-MICROSCOPY

ESM construction activities continued at 21-ID during March. The main accomplishment this month was completion of installation of all optics in the VLS PGM: the M2 mirror and the four diffraction gratings. Considerable progress was also made in installation of the ARPES endstation.

The monochromator is the heart of the ESM beamline. It is a sophisticated instrument, covering a wide energy range (from 15 to 1500 eV) with high energy resolution (10^5-10^4 resolving power) and flux (10^{10} - 10^{12} photons/sec). The large energy range, an advantageous feature of the PGM design, is provided by the long (~600 mm) variable-angle planar M2 pre-mirror which illuminates the gratings. Furthermore, the use of four gratings (300, 600, 800, and 1200 lines/mm) introduces sufficient flexibility to optimally balance flux and resolution over the entire energy range. Installation of the ESM monochromator is therefore a complex and lengthy process, involving the installation and precision alignment of these five optical elements. First, optical metrology was carried out on all optics, first as free pieces received from the suppliers, and then as mounted in their holders. The latter is an iterative process, with adjustment of the clamping forces introduced by the holders until the measured surface figure is as close to the free value as possible. Then the optical surfaces were pre-surveyed with respect to the holders, with fiducials established. Fiducials are essential to permit alignment of the optics inside the Monochromator, where the optical surfaces cannot be accessed directly. Finally, the optics are installed inside the vacuum tank, connected to the cooling system, and aligned. All of this work was successfully completed in March.

Also during March, the support structure for the ARPES endstation was installed and assembly of the endstation equipment on this structure began. The endstation features two main sections: the analysis chamber, and the sample preparation chamber. Both sections were mounted on the supporting structure table this month (Figure 1). The analysis chamber, located between the refocusing optics chamber and the preparation chamber, house two main components: the Scienta analyzer, which will be mounted on the large rotatable flange shown in Figure 1, and the microscanning stage, which will be installed on a Ti column directly connected to the granite base that supports the refocusing optics. The preparation chamber hosts a set of e-beam evaporators, each of which is mounted on a linear motion feedthrough and can be replaced without venting the entire system. Also visible in Figure 1 is a sputter gun and the LEED. All of the endstation equipment will be remotely controlled. Initial endstation assembly is expected to be completed in April, followed by integrated testing.

Looking forward, the M3A and M3B mirrors are planned to be installed in the M3 vacuum vessel during April. This will complete optical installation of the ARPES branch. At that point, the entire beamline will be under vacuum except two short sections inside the FOE which host the white and pink beam masks. These masks are in fabrication and expected to be delivered in May.

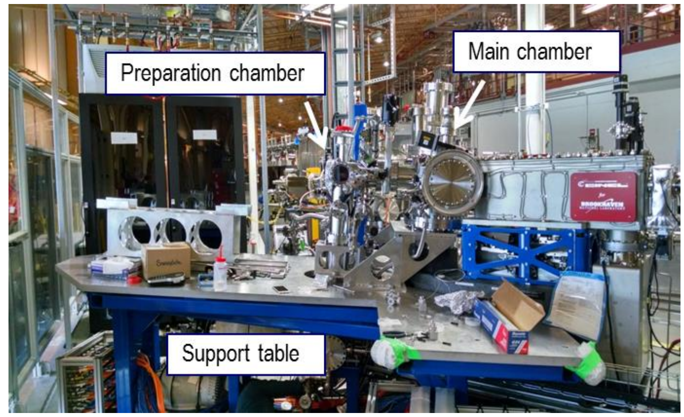


Figure 1: ESM: View of the ARPES endstation. The large flange on the main chamber is the port for the electron spectrometer. The Al structure on the left, featuring three large through holes, is the support for the long sample manipulator.

ISR – IN-SITU AND RESONANT HARD X-RAY

The second (final) monochromatic beam mask, diamond window (Figure 2), and laser curtain were received during March. Installation of the curtain in the outboard doorway of Hutch 4-ID-D began.

The motion testing component of the FAT for the Dual Phase Plate Assembly was held at Huber on March 3-4 (Figure 3). Out-of-vacuum motors and the in-vacuum motors of both stacks were tested using the Delta Tau Geo Brick motion controller. The diameter of the sphere of confusion of each stack was measured to be 30-35 microns using a dial gauge during chi rotation, which is acceptably close to specification. On March 22, the results of the vacuum testing of the chamber were received, and the final pressure, leak rate, and residual gas analysis results were found to be satisfactory. The chamber was prepared for shipment from Pink (the chamber subcontractor) to Huber in order to test the mechanical fit of the full assembly, which is anticipated to take place in early April. The chamber, granite support with out-of-vacuum stages, and stand will then be shipped to BNL for mid-April installation, while the stacks undergo baking at Pink. Installation of the stacks at ISR is anticipated in May.

The two silicon flat mirrors for the Double Harmonic Rejection Mirror (DHRM) system arrived on March 8. Surface figure measurements by the NSLS-II optical metrology laboratory on March 21-22 were consistent with the inspection report from JTEC, the subcontractor for the mirror fabrication, with tangential slope errors meeting the specification of <0.25 μrad for both mirrors. Installation in the DHRM vacuum chamber is scheduled to be performed by Toyama in early May.

Installation of the exhaust system in Hutch 4-ID-D by Blake Sheet Metal, the subcontractor for the Gas Handling System, commenced in early March. Connections between the exhaust labyrinth in the roof of the hutch and the two gas cabinets were completed by March 19, followed by a two-week beamline PPS testing period, during which time no installation work could be performed. Completion of the Gas Handling System installation, including hutch sprinklers and exhaust connections to the gas cabinets, mixing box, and laser enclosure, is expected during April.

The KB Mirrors table and five degree-of-freedom table arrived on March 8 and were assembled and tested by Square One on March 15-17 (Figure 4). The KB Mirrors vacuum chamber will be mounted on the KB Mirrors table by Toyama in early May, after which the mirrors and benders will be installed.

The first phase of Toyama's installation of the FOE Optical Components Package, the DHRM, the Secondary Source Aperture, and the Shielded Beam Transport System continued through March 19. All stands, except for BPM2, which must follow installation of the Dual Phase Plate Assembly, were installed and surveyed into place. Two pumps were installed in the ion pump enclosures, which are a part of the Shielded Beam Transport, and vacuum sections were flanged off and successfully leak-tested. Prior to their departure, Toyama technicians prepared the HFM, VFM, and DHRM vacuum chambers for baking. ISR technicians began gentle (80˚C) bakes of the HFM and VFM vacuum chambers (Figure 5) on March 23, which continued through the end of the month. The DHRM vacuum chamber and as many vacuum sections as possible will be baked before Toyama returns on April 25.

In preparation for PPS testing, the NSLS-II mechanical utilities group conducted flow tests of the water-cooled PPS components (two masks and two beam stops). When connected in series in a single DI water circuit, the maximum measured flow rate was 1.85 gallons/minute, slightly lower than the calculated (Toyama) need for 2 gallons/minute flow. To reach the required flow rate, the two masks and two stops were separated into two DI water circuits.

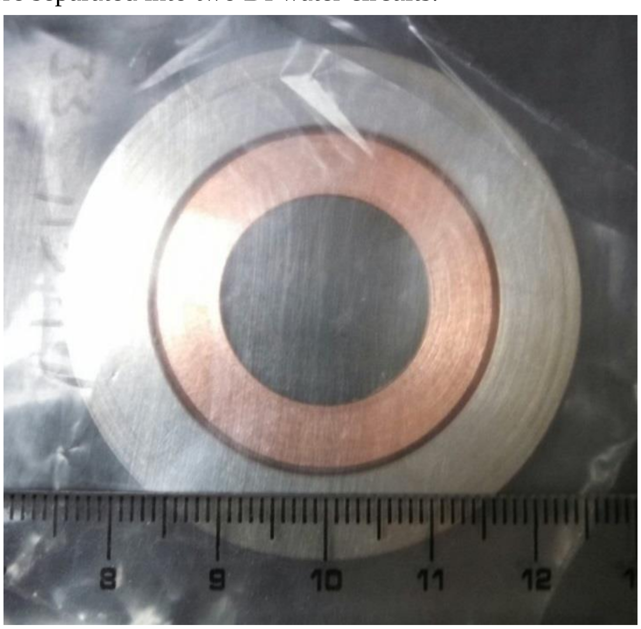


Figure 2: ISR: Diamond window fabricated by Applied Diamond, Inc.

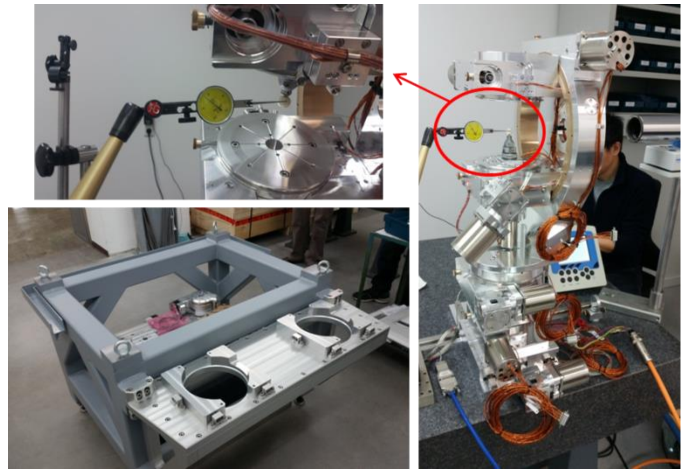


Figure 3: ISR: Dual Phase Plate Assembly undergoing Factory Acceptance Testing at Huber. Clockwise from right: motion testing of in-vacuum stages of one stack, stand with out-of-vacuum stages and ion pump support, and close-up of sphere-of-confusion measurement using a dial gauge during chi rotation.

Figure 4: ISR: Testing of the five degree-of-freedom table by Square One.

Figure 5: ISR: VFM vacuum chamber being baked at 80˚C.

ISS – INNER SHELL SPECTROSCOPY

The Instrument Readiness Review (IRR) of the ISS photon delivery system (PDS) was held on March 24. No pre-start items were identified, allowing the start of commissioning with beam in April.

ISS and matrixed staff for utilities, controls, EPS, and PPS systems were focused on completion of installation, documentation, and testing of all PDS components included in the IRR. In addition, Job Training Assessments (JTAs) for ISS beamline staff were performed and all training requirements fulfilled. No self-identified pre-start items existed prior to the IRR and no pre-start items were identified during the review. Consequently, the ISS operations authorization memorandum was signed by facility director John Hill on March 25. Several post-start items were identified, each of which is being tracked in the BNL Action Tracking System (ATS). The ISS beamline is now ready for commissioning with beam, which is scheduled to begin on April 5.

Endstation installation progress was also made during March. Installation of the fire suppression system began, all motor drivers were installed, motor and encoder cables were terminated, and additional hardware for the timing system was installed. Finally, the higher harmonic rejection mirror (HHRM) system was delivered, installed, and commissioned by Axilon.

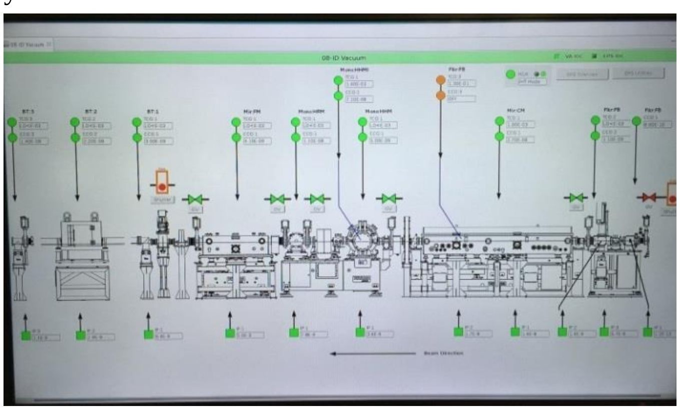


Figure 6: ISS: EPS screen showing the vacuum status of all PDS components. At the time this screen shot was taken, all PDS gate valves were open, while the photon shutter and GV2, the gate valve separating front end vacuum from beamline vacuum, were closed. All PDS components have reached vacuum specifications.

SIX – SOFT INELASTIC X-RAY

During March, work continued on final design of the SIX sample chamber and spectrometer arm (Bestec). A production release meeting was held on March 22 to approve the start of production of the sample chamber, and of the mechanical components of the arm downstream of the optics tank, which include the arm bridge structure, beam pipe, detector granite base, and cooling head support structure. A rendering of the detector chamber area is shown in Figure 7. In order to mitigate the vibrations generated by the cryogenic cooling head, the linkage between the head and the detector sensors is kept soft through a bellows coupling and the detector is rigidly connected to the large underlying granite base through the cage-like support structure. Materials of different impedance will be used in the assembly of the cage-like structure in order to attenuate the acoustic waves via absorption and scattering at the interfaces between these different materials.

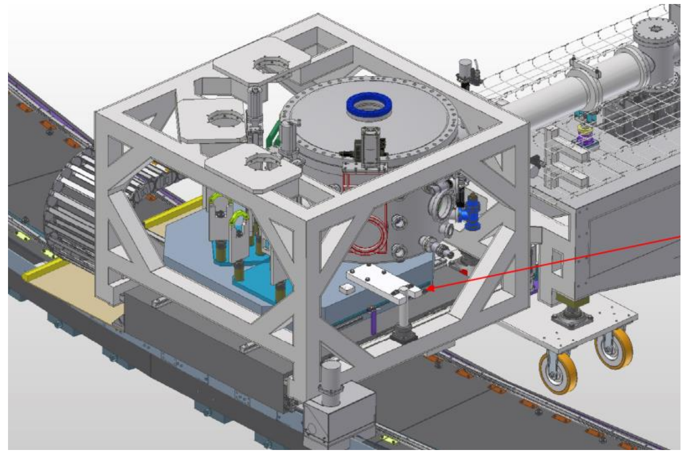


Figure 7: SIX: Rendering of the final design of the detector chamber area of the SIX spectrometer.

On March 7, the final design of the in-vacuum sample diffractometer was reviewed by phone with the supplier, SmarAct, and approved by the SIX team. Production of long lead items had already begun prior to this design review with approval from the SIX team, and production of the remaining components commenced immediately following this review. The FAT is scheduled for May 23-24, and will include interferometric measurements of the vibration performance.

The Bestec installation crew visited NSLS-II for two weeks during March to install the M4 mirror system, the last remaining SIX PDS optical component (Figure 8). The M4 mirror system was installed and surveyed in place, followed by vacuum pumping, baking, and testing. Delivery of the M4 ellipsoidal mirror from JTEC Corp. has been delayed to June, which is still ahead of the SIX need date.

In the experimental area of the SIX satellite building, installation of power and network cables for cameras was completed. Conduits were also installed for cables for the arm motion interlock system, and boxes for the search-out buttons.

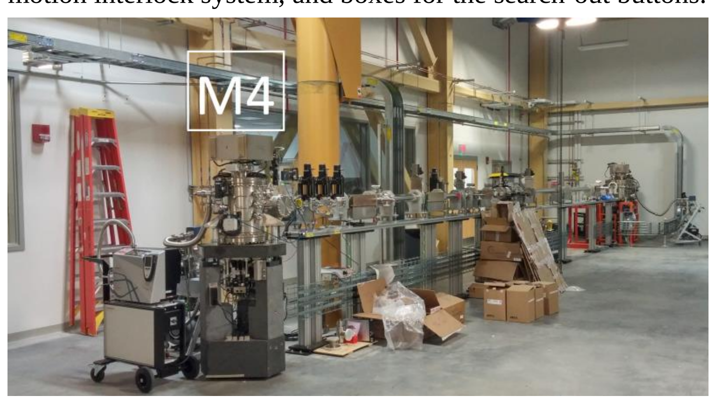


Figure 8: SIX: M4 mirror system installed by Bestec at the downstream end of the photon delivery system.

SMI – SOFT MATTER INTERFACES

Following installation of the CRL Transfocator early in March, controls activities for this system began. All motor axes were tested by the SMI controls engineer using a portable Delta-Tau controller. A few items were found to be out of compliance, such as limit switches wired with opposite sense, and quickly set right. During installation of the lens vessel in this system, one wire seal found to be inadequate was replaced by the SMI lead mechanical technician, eliminating a potential schedule delay. Following installation, NSLS-II crews began terminating cables for this system. Figure 9 shows the CRL Transfocator operating on its ion pumps and with significant progress on cabling. SMI also commenced an aggressive schedule for user-friendly controls in a collaborative effort between SMI Associate Physicist Misha Zhernenkov and controls group members. The first of two CRL control screens, for control of the physical axes including position, orientation, and lens cartridge positions, is shown in Figure 10. The second control screen will incorporate the equations relating these process variables to the beam focus position.

Figure 9: SMI: CRL Transfocator, installed and bench tested, with completed limit switch rewiring, cable tray installation, and operation under ion pumps. Cable terminations are well underway. The floor plate, framed and awaiting grout, for the Vacuum Sample Chamber immediately downstream is visible in the foreground at left.

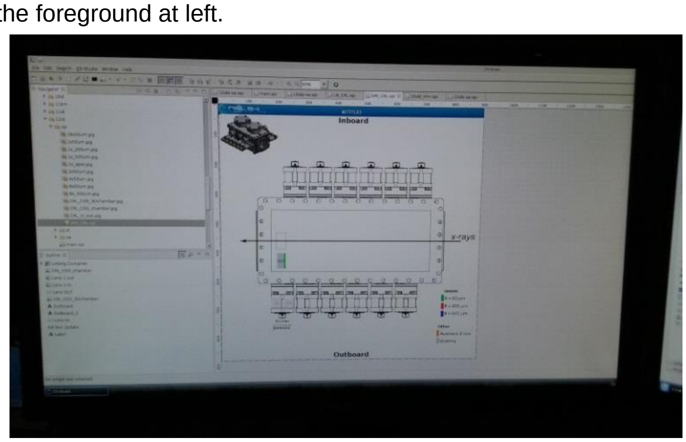


Figure 10: SMI: Edit screen in progress for the first of SMI's two CRL Transfocator Control Panels.

As Figure 9 shows, the grout plate for the SMI Vacuum Sample Chamber has been installed, surveyed, and framed. The next step is grouting (by masons) followed by installation of the WAXS granite base and Vacuum Sample Chamber (by riggers), both of which are staged nearby. Installation of this chamber will enable a major chain of activities including setup of the WAXS Goniometer and the Pilatus 300K-W detector, both also received and awaiting further work. The final large SMI deliverable is the SAXS Beam Chamber. Manufacturer GNB has made excellent progress with fabrication. Photos from their 5 April monthly status report show the tube rollup sections received, flanges being welded, and square tubing for the frame stacked and ready for the cut list. Numerous small parts have been received for other items as well (e.g. XBPM and SAXS/WAXS mechanics); the SMI group members have been added to the experimental safety envelope for a setup lab in LOB3 to commence work assembling and prototyping small parts. Finally, SMI has articulated specifications for a beam stop mechanism and assigned engineering time to this item.

In a meeting attended by NEXT and Insertion Device Group members, SMI obtained an update on the IVU23 control system. A revised development plan described by the assigned controls engineer includes initial use of simpler controls for the NEXT IVU23's (for SMI and ISR). SMI staff expressed the desire to incorporate readback of all four real girder axes, rather than "Gap" and "Elevation" virtual axes. It was agreed that this would be implemented. The controls group aims to deploy the new control software during the May maintenance period if possible.

On March 3rd, the weekly NEXT meeting hosted one of two Health Physicists, who presented an outline of the process leading to radiation shielding calculations performed using Fluka and Stac8 code. She clarified the manner in which monochromator bandwidth and focusing mirrors affect flux numbers for the high harmonics most likely to penetrate shielding. At the time of this meeting, four beamlines, from NEXT, Partner, and BDN projects, were scheduled for radiation shielding calculations ahead of SMI, and it was projected that the calculations for each beamline take up to several weeks to complete. To avoid being held up by limited resources closer to the scheduled IRR, SMI began planning work on Fluka input files. A mechanical designer experienced in this process has been assigned to work on SMI's beamline raytracing. By the end of March, tracing of the bulk of the geometric rays and the first step of the mirror excursion analysis had been completed. The second step awaits installation of the H-V focusing mirrors and the associated survey of mirror limit ranges. Design of the PPS Aperture mask was also completed in March. This mask will include apertures for both inboard and outboard branches of SMI from Day One.

INSERTION DEVICES

The 3.5m-long EPU57 for SIX was delivered to BNL on March 1. Insertion devices of this length and mass cannot be move by forklift, but instead require rigging as follows: first, the top of the container is removed using a forklift, then the truck with the container is backed into the receiving bay of the Magnetic Measurements Laboratory (Bldg. 832) where the top of the EPU crate is removed to expose eyebolts affixed to the device. Then, using the 18 Ton crane in Bldg. 832, the EPU crate is lifted vertically by ~20cm from the container and the truck drives away with the container, leaving the EPU crate free to be lowered smoothly to the floor by the crane. Some of the EPU unloading steps are shown in Figure 11. The process of unloading an Insertion Device from the delivery truck requires some attention during its design. Per BNL SBMS, any lift above the center of gravity of any heavy, sensitive, or expensive equipment needs to be accompanied by a Critical Lift Evaluation Form (CLEF) that is approved by BNL ES&H prior to delivery. This also requires advance planning in collaboration with the supplier, as obviously the container and crate must have removable covers. Such lifts have been performed for a number of NSLS-II insertion devices, such as the long, heavy damping wigglers.

Figure 11: Insertion Devices: Delivery of the SIX EPU57 insertion device to Bldg. 832 at BNL.

After being unwrapped in Bldg. 832, the SIX EPU57 was cabled and connected to its electronics rack. The SIX EPU57 was located near the ESM EPU57 in order to allow the use of both devices during the training session organized with Kyma from March 14-18. During this training session, performed by Luka Belingar (Kyma control system engineer), Insertion Device group members were trained to perform basic operations on these devices such as changing the gap and phase, as well as more advanced operations such as the procedure for homing and replacement of an encoder. In addition to the training, Luka repeated the Final Control Acceptance Test of the SIX EPU57 device using the NSLS-II controls system and witnessed by Insertion Device and Controls group staff.

During the March 14-18 training session, oil was found at two locations on the device that should not have oil present: on the support for the upper girder phase drive system and on the lower magnet array (Figure 12). The oil leak was reported to Kyma, who are investigating the origin of the leak(s).

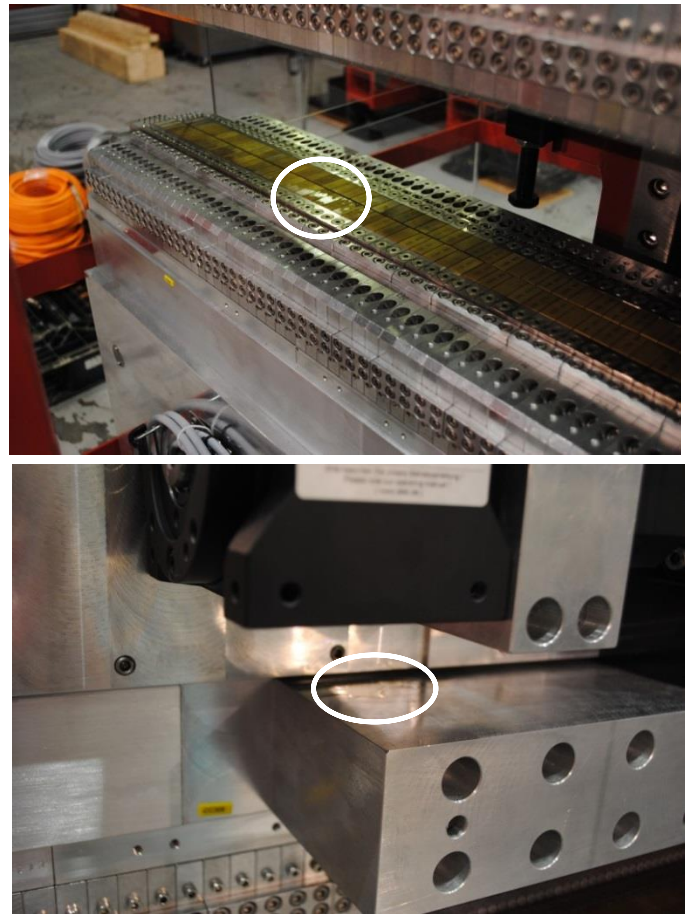


Figure 12: Insertion Devices: Oil was found at two locations on the SIX EPU57: on the lower magnet array (top) and on the base of the phase drive of the upper moveable girder (bottom).

The remaining activities by the EPU contractor (Kyma) at their site are all related to completion of the ESM EPU105 insertion device, the last NEXT EPU to be delivered to BNL. During March, Kyma completed assembly of the ESM EPU105 magnets into 46 M3 modules and 46 M5 modules. The average magnetic field integral measurements of all M3 and all M5 modules are shown in Figure 13. These modules are now ready for the magnetic sorting and shimming steps, which will be performed by NSLS-II Insertion Devices Group staff following delivery to BNL and completion of the contract with Kyma.

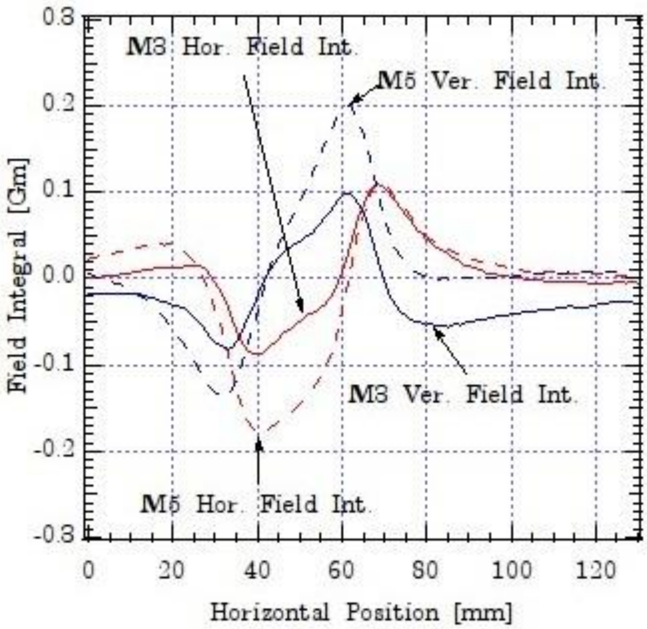


Figure 13: Insertion Devices: ESM EPU105: Horizontal (red) and vertical (blue) average field integral of M3 (continuous line) and M5 (dashed line) module populations.

PROJECT MILESTONES

Milestone	Planned	Actual
CD-0 (Mission Need):	May 27, 2010	May 27, 2010
CD-1 (Alternative Selection):	Sept. 30, 2011	Dec. 19, 2011
CD-2 (Performance Baseline):	Dec. 31, 2013	Oct. 9, 2013
CD-3A (Long Lead Procurement):	Dec. 31, 2013	Oct. 9, 2013
CD-3 (Start Construction):	Mar. 31, 2014	Jul. 7, 2014
Internal Early Project Completion – Beamlines	Jan. 13, 2017	
Early Project Completion:	Jan. 31, 2017	
CD-4 (Project Completion):	Sept. 29, 2017	

RECENT AND UPCOMING EVENTS

EVMS Desktop Review (BNL)	April 1, 2016
DOE OPA Status Review of NEXT	August 30-31, 2016
DOE OPA EVMS Review (BNL)	October 2016

Acronyms and Abbreviations

AC	Alternating Current
ACWP	Actual Cost of Work Performed
ARPES	Angle-Resolved PhotoElectron Spectroscopy
ATS	Action Tracking System
BAC	Budget at Completion
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BDN	Beamlines Developed by NSLS-II
BNL	Brookhaven National Laboratory
BPM	Beam Position Monitor
CAM	Cost Account Manager
CD	Critical Decision
CLEF	Critical Lift Evaluation Form
CPI	Cost Performance Index
CRL	Compound Refractive Lens
CV	Cost Variance
DCM	Double Crystal Monochromator
DI	De-Ionized
DOE	Department of Energy
DHRM	Double Harmonic Rejection Mirror
EPS	Equipment Protection System
EPU	Elliptically Polarizing Undulator
ES&H	Environment, Safety & Health
ESM	Electron Spectro-Microscopy beamline
ETC	Estimated Cost to Complete
EVMS	Earned Value Management System
FAT	Factory Acceptance Test
FDR	Final Design Review
FE	Front End
FOE	First Optics Enclosure
FTE	Full Time Equivalent
FXI	Full-field X-ray Imaging beamline
FY	Fiscal Year
GV	Gate Valve
HFM	Horizontal Focusing Mirror
ID	Insertion Device
IRR	Instrument Readiness Review
ISR	Integrated In-Situ and Resonant X-ray Studies
ISS	Inner Shell Spectroscopy beamline
IVU	In-Vacuum Undulator
JTA	Job Training Assessment
KB	Kirkpatrick Baez
LEED	Low Energy Electron Diffraction
LOB	Lab Office Building
LN2	Liquid Nitrogen
LSSOC	Light Source Safety and Operations Council
M&S	Material & Supplies
NEXT	NSLS-II Experimental Tools project
NSLS	National Synchrotron Light Source
NSLS-II	National Synchrotron Light Source ll
OPA	Office of Project Assessment
OPC	Other Project Costs
PCR	Project Change Request
PDS	Photon Delivery System
PGM	Plane Grating Monochromator
PMB	Performance Management Baseline
PPS	Personnel Protection System
SAXS	Small Angle X-ray Scattering
SC	Office of Science
SIX	Soft Inelastic X-ray Scattering beamline
SMI	Soft Matter Interfaces beamline
SPI	Schedule Performance Index
SSA	Secondary Source Aperture
SV	Schedule Variance
TEC	Total Estimated Cost
TPC	Total Project Cost
UB	Undistributed Budget
VAC	Variance At Completion
VFM	Vertical Focusing Mirror
VLS	Varied Line Spacing
WAXS	Wide Angle X-ray Scattering
WBS	Work Breakdown Structure
WS	Working Schedule
XBPM	X-ray Beam Position Monitor

COST AND SCHEDULE STATUS

Cost and schedule progress is being tracked using an Earned Value Management System (EVMS) against the cost and schedule baseline established on October 1, 2013. All baseline changes are being controlled through the NEXT Change Control Board. Cost and schedule revisions are being managed using Project Change Control procedures. From June 2015 forward, EAC is reported as the sum of actual cost to date (ACWP) plus the estimated cost to complete (ETC), at the individual activity and resource level, with account-level cost corrections applied as needed to account for the difference between the Earned Value and accrual schedules. ETC values are shown in the final row of the EVMS table below, and all EAC changes are captured in the monthly EAC log.

Cum $M	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16
BCWS	48.7	51.7	54.9	58.3	61.5	64.3	66.4	70.7	73.0	75.6	77.5	79.3
BCWP	47.0	50.2	52.8	55.9	58.6	61.2	63.7	67.2				
ACWP	50.7	54.3	56.1	59.8	62.4	64.9	67.2	70.6				
SPI	0.97	0.97	0.96	0.96	0.95	0.95	0.96	0.95				
CPI	0.93	0.93	0.94	0.93	0.94	0.94	0.95	0.95				
ETC								15.4	11.2	8.3	5.7	3.8

The NEXT project Schedule Variance (SV) for March 2016 is -$895k, with an associated monthly Schedule Performance Index (SPI) of 0.79 (red status). The largest contributors to the current month schedule variance are provided in the table below. The cumulative SPI is 0.95 (green status), 0.01 lower than it was in February.

The NEXT project Cost Variance (CV) for March 2016 is +$55k, with an associated monthly Cost Performance Index (CPI) of 1.02 (green status). The primary contributors to the current month CV are provided in the table below. The cumulative CPI is 0.95 (green status), the same as it was in February.

Leading Current Month Variances [$K], March 2016					
WBS	Title	Schedule		Cost	
		SV	Issues	CV	Issues
2.01	Project Support	0	--	26	--
2.03	Common Systems	-98	Delayed PPS installation effort resulting from prioritization of BDN and Partner beamline PPS	-128	Combination of under-reported EV in utilities and generally greater labor costs than estimated
2.04	Controls	46	EV for Motor and encoder cable, scheduled in earlier months	-14	--
2.05	ESM Beamline	121	EV for PDS and endstation activities scheduled in earlier months	-39	Installation labor higher than estimated for March
2.06	FXI Beamline	0	--	-1	--
2.07	ISR Beamline	-833	Late receipt and installation work for FOE Optics and Mirrors packages	-86	Accruals and payments for work earned in earlier months
2.08	ISS Beamline	-236	Sum of scheduled work performed earlier (collimating mirror, -$307k) and work performed early (IRR preparation, +$71k)	124	Costs for installation and IRR preparation effort less than estimated for March
2.09	SIX Beamline	273	Net effect of a number of activities performed in March that were scheduled in earlier months	8	--
2.10	SMI Beamline	-27	--	356	EV for the H-V mirror package that will be invoiced in April
2.11	Insertion Devices	-141	EPU and power supply activities scheduled for March, some performed earlier, some later	-191	Accruals on EPU contracts in March for work performed in earlier months
	Total	**-895**	**Total**	**55**	

As of March 31, 2016, the project is 81.6% complete with 50.8% contingency ($7.7M) for $15.2M Budget At Completion (BAC) work remaining, based on PCRs processed and approved through March 2016. The project EAC for March is reported at $86,010k against a Performance Measurement Baseline (PMB)/Undistributed Budget (UB) of $82,305k. The Variance At Completion (VAC) is given by VAC = BAC – EAC, with EAC = ACWP + ETC. Through March 2016, the VAC (-$3,705k) is dominated by the cumulative cost variance (-$3,464k), which is in turn dominated by labor cost overage on work performed to date.

The March 2016 EAC ($86.01M) is $0.27M higher than the February value. The increase consists of utilities additions for the SIX beamline ($60k), additional installation coordination effort ($30k), and labor overage ($180k). As of the end of March, contingency on EAC is $4.00M, which represents 25.9% of $15.4M EAC work remaining. Outstanding commitments total $8.8M, so the $4.00M contingency on EAC represents 60.6% of $6.6M unobligated EAC work to go. ETC will continue to be assessed monthly through project completion to contain costs while maintaining the good schedule performance that the project has demonstrated to date.

One PCR was approved and implemented in March.

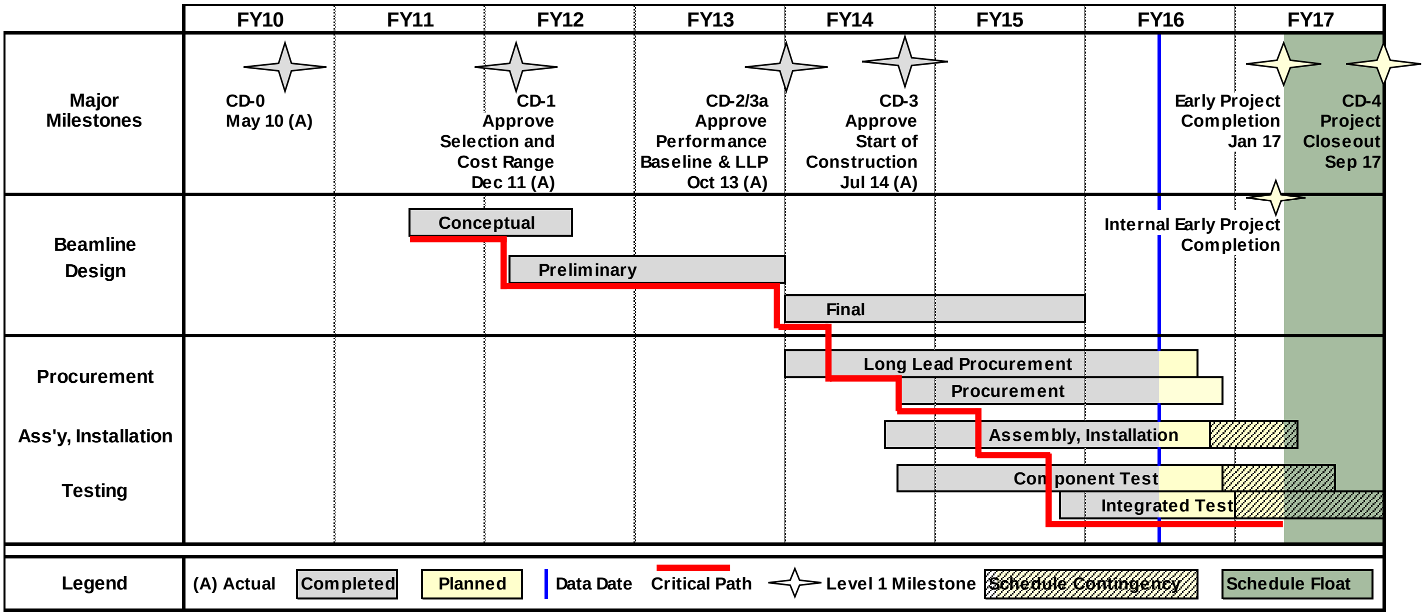
PCR	PCR Level	Baseline Change [$]	Description
16-113	L3	0	ISS Spectrometer System Contract Amendment

Two PCRs are planned for April: PCR_16_114, a Level 3 PCR in WBS 2.05.02 (ESM Beamline Systems) and WBS 2.09.02 (SIX Beamline Systems), will implement contract amendments. PCR_16_115, a Level 3 PCR in Common Systems, will implement discrete EAC increases identified in WBS 2.03.02 (PPS) and WBS 2.03.05 (Common Systems Management).

NEXT as of 3/31/2016	Current Period	Cum-to-Date
Plan (BCWS) $k	4,346	70,724
Earned (BCWP) $k	3,452	67,154
Actual (ACWP) $k	3,397	70,618
SV $k	-895	-3,570
CV $k	55	-3,464
SPI	0.79	0.95
CPI	1.02	0.95
Budget at Completion $k (PMB [UB])		82,305
Planned % Complete (BCWS/BAC)		85.9%
Earned % Complete (BCWP/BAC)		81.6%
Contingency $k		7,695
Contingency / (BAC – BCWP)		50.8%
EAC $k		86,010
Contingency / (EAC – BCWP)		40.8%
(Contingency + VAC) / (EAC – ACWP)		25.9%
TPC = PMB + Contingency		90,000

Milestones – Near Term		Planned	Actual
L3	ISR - Bench test of Dual Phase Plate Assembly complete	24-Feb-16	4-Mar-16
L3	SIX - Testing Monochromator and Slits complete	1-Mar-16	Expect May
L3	ESM - Photon Delivery System Ready for Integration	7-Mar-16	1-Mar-16
L3	ISR - Installation of DCM Monochromator complete	15-Mar-16	Expect May
L3	Common Beamline Systems: Electrical Utilities Installed	29-Apr-16	
L3	ESM - Testing Monochromator and Slits complete	12-May-16	Expect April
L2	Complete Installation of 1st Beamline Components	25-May-16	30-Mar-16
L2, L3	Common Beamline Systems: Mechanical Utilities Installed	31-May-16	
L3	Insertion Devices - SIX EPU Received	6-Jun-16	2-Mar-16
L3	SMI - Installation of CRL Focusing Optics Complete	17-Jun-16	24-Mar-16
L3	ISR – Installation of Beamline Components Complete	29-Jun-16	
L3	ISS - Testing Collimating Mirror complete	7-Jul-16	26-Feb-16
L2	Receive EPUs for ESM and SIX	12-Aug-16	
L3	Insertion Devices - ESM EPU105 Received	12-Aug-16	
L3	SIX - Testing of Spectrometer Detector Complete	23-Aug-16	
L3	WBS 2.04 – Beamline Control Systems Complete	14-Sep-16	
L3	ISS – Installation of Beamline Components Complete	14-Sep-16	30-Mar-16
L3	SMI – Installation of Beamline Components Complete	16-Sep-16	
L3	ESM – Installation of Beamline Components Complete	29-Sep-16	Expect June
L3	SIX – Installation of Beamline Components Complete	30-Sep-16	
L3	Common Beamline Systems: EPS Installed	30-Sep-16	
L2, L3	Complete Installation of Common Beamline Systems PPS	30-Sep-16	
L2	1st Beamline Available	30-Sep-16	13-Apr-16
L2	Early Project Completion – incl. IRR	31-Jan-17	

PROJECT SCHEDULE



As of March 2016, the critical path runs through PPS design, software development, testing, and integration for the SIX beamline (WBS 2.03.02, Common Systems PPS).

Staffing Report

Staffing as of 3/31/2016	Current Period		Cumulative-to-Date	
	Planned ** (FTE-yr)	Actual (FTE-yr)	Planned ** (FTE-yr)	Actual (FTE-yr)
WBS 2.01 Project Management and Support	0.75	0.51	35.09	32.21
WBS 2.02 Conceptual and Advanced Conceptual Design	0.00	0.00	8.74	8.74
WBS 2.03 Common Beamline Systems	1.26	1.27	24.86	12.62 *
WBS 2.04 Control System	0.74	0.51	17.12	16.2
WBS 2.05 ESM Beamline	0.50	0.76	14.03	15.06
WBS 2.06 FXI Beamline	0.00	0.01	4.77	4.59
WBS 2.07 ISR Beamline	0.49	0.63	13.77	12.57
WBS 2.08 ISS Beamline	0.51	0.55	13.27	13.00
WBS 2.09 SIX Beamline	0.49	0.43	16.04	18.83
WBS 2.10 SMI Beamline	0.48	0.49	13.30	12.49
WBS 2.11 Insertion Devices	0.05	0.22	4.39	4.15
WBS 2.12 ID & FE Installation	0.00	0.00	3.88	7.97
Total	**5.27**	**5.38**	**169.27**	**158.43**

** Based on the NEXT working schedule

* A large fraction of utilities installation has been performed by contractors (M&S) rather than staff as originally planned

Number of individuals who worked on NEXT during March 2016: 135

Funding Profile

Funding Type	NEXT Funding Profile ($M)						
	FY11	FY12	FY13	FY14	FY15	FY16	Total
OPC	3.0						3.0
TEC – Design		3.0	2.0				5.0
TEC – Fabrication		9.0	10.0	25.0	22.5	15.5	82.0
Total Project Cost	**3.0**	**12.0**	**12.0**	**25.0**	**22.5**	**15.5**	**90.0**

Key NEXT Personnel

Title	Name	Email	Phone
Federal Project Director	Robert Caradonna	rcaradonna@bnl.gov	631-344-2945
NEXT Project Manager	Steve Hulbert	hulbert@bnl.gov	631-344-7570

COST PERFORMANCE REPORT

CONTRACT PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

FORM APPROVED
$ OMB No. 0704-0188

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME Brookhaven National Laboratory	a. NAME NEXT	a. NAME NSLS-II Experimental Tools (NEXT) Project	a. FROM *(YYYYMMDD)* 2016 / 03 / 01
b. LOCATION (Address and ZIP Code)	b. NUMBER	b. PHASE	b. TO *(YYYYMMDD)* 2016 / 03 / 31
	c. TYPE / d. SHARE RATIO	c. EVMS ACCEPTANCE X YES	

WBS (2) WBS (3) ITEM (1)	CURRENT PERIOD BUDGETED COST WORK SCHEDULED (2)	 WORK PERFORMED (3)	 ACTUAL COST WORK PERFORMED (4)	 VARIANCE SCHEDULE (5)	 COST (6)	CUMULATIVE TO DATE BUDGETED COST WORK SCHEDULED (7)	 WORK PERFORMED (8)	 ACTUAL COST WORK PERFORMED (9)	 VARIANCE SCHEDULE (10)	 COST (11)	AT COMPLETION BUDGETED (14)	 ESTIMATED (15)	 VARIANCE (16)
2.01 Project Management and Support	191,699	191,699	164,906	0	26,793	8,209,860	8,209,860	8,950,996	0	(741,136)	9,918,232	10,556,909	(638,677)
2.01.01 Project Management	82,312	82,312	55,329	0	26,983	3,859,785	3,859,785	3,590,987	0	268,797	4,598,029	4,334,730	263,299
2.01.02 Project Support	109,386	109,386	109,576	0	(190)	4,350,075	4,350,075	5,360,009	0	(1,009,933)	5,320,204	6,222,180	(901,976)
2.02 Conceptual Design and Advanced Conceptual Design	0	0	0	0	0	1,807,316	1,807,316	1,807,316	0	0	1,807,316	1,807,316	0
2.03 Common Beamline Systems	232,163	133,867	261,708	(98,295)	(127,840)	5,986,869	5,798,057	7,172,225	(188,813)	(1,374,168)	7,212,607	8,729,917	(1,517,310)
2.03.01 Utilities	3,133	35,560	96,116	32,427	(60,556)	4,194,048	3,843,794	4,069,218	(350,254)	(225,424)	4,209,423	4,521,661	(312,239)
2.03.02 Personnel Protection System (PPS)	140,110	53,931	86,936	(86,179)	(33,005)	843,247	871,631	1,699,321	28,383	(827,690)	1,523,306	2,337,989	(814,683)
2.03.03 Equipment Protection System (EPS)	57,860	32,321	54,431	(25,540)	(22,111)	393,840	466,249	747,026	72,409	(280,777)	680,294	1,002,220	(321,926)
2.03.04 Control Station	22,182	4,069	14,811	(18,113)	(10,742)	115,282	179,491	127,386	64,209	52,105	306,744	255,080	51,664
2.03.05 Common Beamline Systems Management	8,877	7,987	9,414	(890)	(1,427)	440,451	436,892	529,273	(3,560)	(92,382)	492,840	612,967	(120,126)
2.04 Control System	117,358	162,936	176,531	45,577	(13,596)	4,009,745	4,043,438	4,120,099	33,693	(76,661)	4,558,236	4,693,420	(135,184)
2.04.01 Control System Management	5,673	5,673	7,479	0	(1,806)	253,205	253,205	231,952	0	21,253	294,427	273,183	21,244
2.04.02 Control System Design & Implementation	111,685	94,860	124,809	(16,825)	(29,949)	2,406,317	2,448,517	2,621,792	42,200	(173,275)	2,913,586	3,145,375	(231,789)
2.04.03 Control System Equipment	0	62,403	44,243	62,403	18,160	1,350,223	1,341,717	1,266,355	(8,507)	75,361	1,350,223	1,274,862	75,361
2.05 ESM Beamline	100,682	221,716	260,672	121,034	(38,956)	9,034,189	8,537,832	9,017,633	(496,356)	(479,800)	9,289,079	9,671,521	(382,442)
2.05.01 ESM Management	15,192	15,192	4,150	0	11,042	509,512	509,512	445,565	0	63,948	626,650	553,069	73,581
2.05.02 ESM Beamline Systems	85,490	206,524	256,522	121,034	(49,998)	8,524,676	8,028,320	8,572,068	(496,356)	(543,748)	8,662,429	9,118,452	(456,023)
2.06 FXI Beamline	0	0	1,090	0	(1,090)	1,818,324	1,818,324	1,792,636	0	25,688	1,818,324	1,792,636	25,688
2.06.01 FXI Management	0	0	0	0	0	409,359	409,359	470,908	0	(61,549)	409,359	470,908	(61,549)
2.06.02 FXI Beamline Systems	0	0	1,090	0	(1,090)	1,408,965	1,408,965	1,321,727	0	87,237	1,408,965	1,321,727	87,237
2.07 ISR Beamline	1,658,177	825,419	911,387	(832,758)	(85,968)	8,555,356	7,443,311	7,647,336	(1,112,045)	(204,024)	10,361,410	10,475,236	(113,827)
2.07.01 ISR Management	31,439	31,439	24,722	0	6,717	894,847	894,847	884,351	0	10,496	1,105,394	1,040,784	64,610
2.07.02 ISR Beamline Systems	1,626,738	793,980	886,665	(832,758)	(92,685)	7,660,509	6,548,465	6,762,985	(1,112,045)	(214,520)	9,256,015	9,434,452	(178,437)
2.08 ISS Beamline	756,725	521,100	397,358	(235,624)	123,743	9,450,368	9,338,636	9,799,987	(111,732)	(461,351)	10,472,212	10,954,657	(482,445)
2.08.01 ISS Management	14,774	85,742	7,442	70,968	78,300	621,765	749,173	600,522	127,408	148,651	838,199	689,571	148,628
2.08.02 ISS Beamline Systems	741,950	435,359	389,916	(306,592)	45,443	8,828,603	8,589,463	9,199,466	(239,140)	(610,002)	9,634,013	10,265,086	(631,073)
2.09 SIX Beamline	120,059	393,048	385,159	272,989	7,889	9,054,895	7,756,647	8,314,501	(1,298,247)	(557,854)	11,572,208	12,288,975	(716,767)
2.09.01 SIX Management	20,827	20,827	6,236	0	14,591	596,083	596,083	599,658	0	(3,576)	729,841	733,087	(3,246)
2.09.02 SIX Beamline Systems	99,233	372,221	378,923	272,989	(6,701)	8,458,812	7,160,565	7,714,843	(1,298,247)	(554,278)	10,842,367	11,555,888	(713,521)
2.10 SMI Beamline	774,810	748,028	392,161	(26,781)	355,867	7,821,383	7,455,150	7,209,265	(366,233)	245,885	9,108,910	9,133,498	(24,587)
2.10.01 SMI Management	12,861	12,861	21,459	0	(8,598)	659,787	659,787	580,347	0	79,440	802,179	721,912	80,267
2.10.02 SMI Beamline Systems	761,948	735,167	370,702	(26,781)	364,465	7,161,596	6,795,363	6,628,918	(366,233)	166,445	8,306,731	8,411,586	(104,855)
2.11 Insertion Devices	394,812	253,900	445,846	(140,913)	(191,946)	3,522,898	3,492,822	3,333,182	(30,075)	159,641	4,733,509	4,453,173	280,336
2.11.01 ESM EPU Insertion Device	391,867	250,954	444,430	(140,913)	(193,476)	3,329,761	3,299,685	3,189,931	(30,075)	109,754	4,515,912	4,285,458	230,454
2.11.02 SIX EPU Insertion Device	0	0	0	0	0	117,137	117,137	70,375	0	46,762	117,137	70,375	46,762
2.11.03 Insertion Devices Management	2,946	2,946	1,416	0	1,530	76,000	76,000	72,876	0	3,124	100,460	97,341	3,119
2.12 ID & FE Installation & Testing	0	0	0	0	0	1,452,816	1,452,816	1,452,960	0	(143)	1,452,816	1,452,816	(0)
2.12.01 ID & FE Installation & Testing Management	0	0	0	0	0	20,739	20,739	20,739	0	0	20,739	20,739	0
2.12.02 ID Installation & Testing	0	0	0	0	0	584,560	584,560	584,560	0	(0)	584,560	584,560	(0)
2.12.03 FE Installation & Testing	0	0	0	0	0	847,517	847,517	847,660	0	(143)	847,517	847,517	0
Total Project Baseline	**4,346,485**	**3,451,714**	**3,396,817**	**(894,771)**	**54,896**	**70,724,019**	**67,154,212**	**70,618,135**	**(3,569,807)**	**(3,463,924)**	**82,304,860**	**86,010,075**	**(3,705,215)**
Undistributed Budget													
Management Reserve													
Performance Management Baseline - PMB	**4,346,485**	**3,451,714**	**3,396,817**	**(894,771)**	**54,896**	**70,724,019**	**67,154,212**	**70,618,135**	**(3,569,807)**	**(3,463,924)**	**82,304,860**	**86,010,075**	**(3,705,215)**