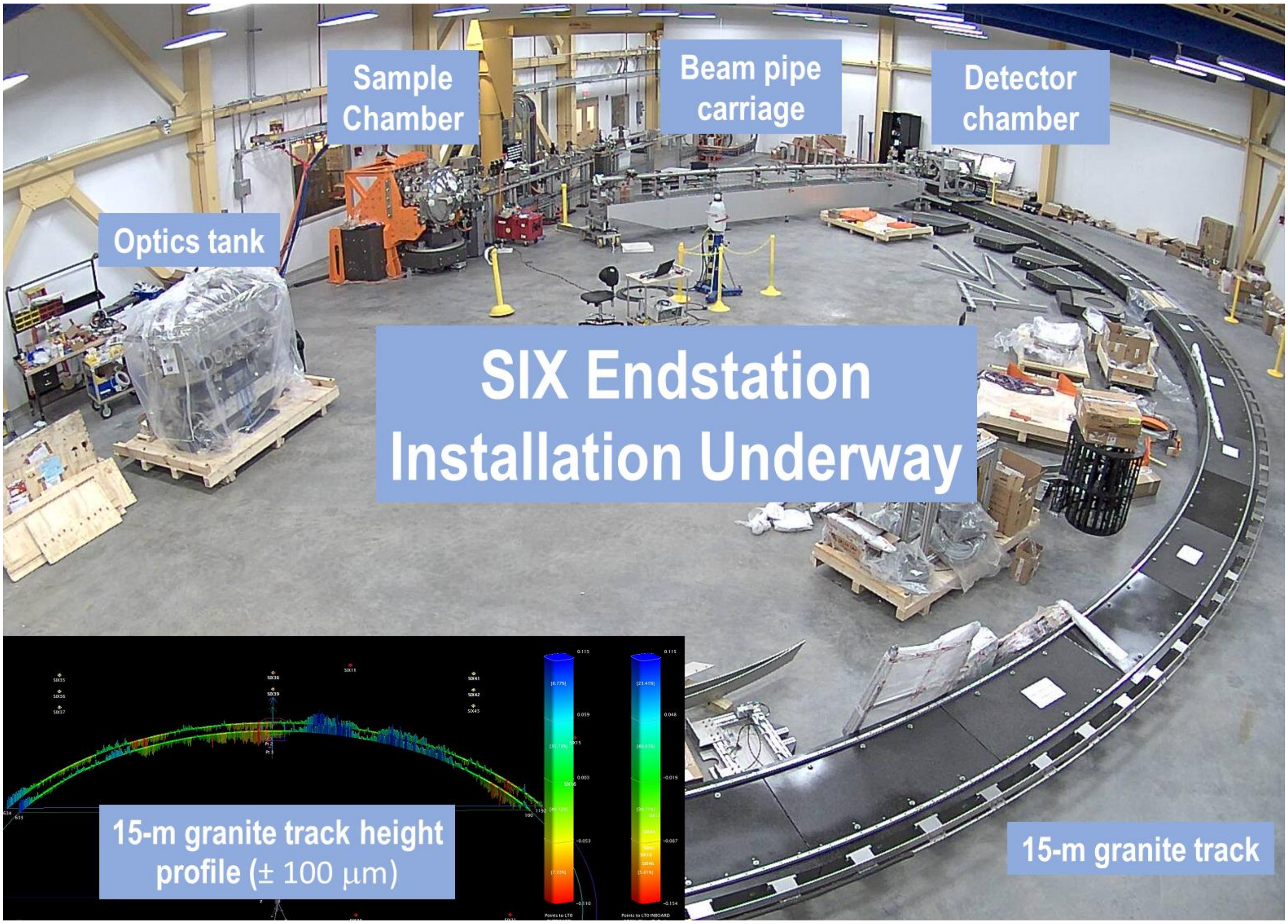
NSLS-II Experimental Tools (NEXT)

December 2016 Project Activity
Report due date: January 20, 2017



SIX endstation installation progress underway in the SIX endstation building. Principal components are labeled. Inset lower left: survey results showing the height of the detector as it moves over the 112º angular range along its 15m-radius arc. The ±100µm variation, while good, will be further improved following settling of the granite support blocks.

Steve Hulbert
NEXT Project Manager

BROOKHAVEN NATIONAL LABORATORY

OVERALL ASSESSMENT

December was a banner month for NEXT, with significant progress made on a number of fronts. SMI made another step in commissioning of its PDS, almost all remaining endstation components for ISR and SIX were shipped to BNL, and the final insertion device for NEXT was completed and installed in the NSLS-II storage ring.

SMI continued to optimize alignment, of both the source and the photon delivery system, this month. A flux level consistent with the objective KPP value has been measured.

SIX pink beam transport section modifications, to address additional shielding requirements determined in November, were vigorously pursued during December, in preparation for an IRR planned for January 2017. All SIX endstation components other than the Triple Rotating Flange (sample chamber, optics assembly, and detector assembly) were received from Bestec in December and the first week of January.

The ISR 6-circle diffractometer (Huber) was shipped this month, with receipt and installation expected in January. The phase plates and an alignment tool for the Dual Phase Plate Assembly were prepared for installation in January.

Magnetic correction and final magnetic measurements of the ESM EPU105 insertion device were completed this month. Final preparations for moving this device were completed by December 15, completing NEXT Insertion Devices (WBS 2.11) scope. The EPU105 was installed in the 21-ID straight section on December 21.

One major procurement was completed in December (ESM electron energy analyzer software update) and 7 remain: 1 (M4 mirror optics) shared between ESM and SIX, 3 for ISR (Dual Phase Plate Assembly, KB mirror optics, and 6-circle Diffractometer), and 3 for SIX (Emission Spectrometer, Sample Chamber, and Grating Rulings). Delivery of all materials for the remaining contracts is expected in January with the exception of the M4 mirrors and TRF portion of the SIX sample chamber contract.

As of December 30, 2016, the project is 97.3% complete on base scope performance earned to date. The cumulative EVMS schedule index increased by 0.01, to 0.98, while the cumulative cost index decreased 0.02, to 0.95 (accruals processed for value earned earlier).

No PCRs were processed in December and none are planned for January. BAC remained at $82.97M. Cost contingency is $7.03M, compared to $2.22M BAC work remaining.

The EAC, reported as the sum of actual cost to date (ACWP) plus the estimated cost to complete (ETC), is $88.95M, $0.02M greater than the November value (essentially flat). Details are provided in the Cost and Schedule section. As of the end of December, contingency on EAC is $1.05M, which represents 43.5% of $2.42M EAC work remaining, or 152.2% of $0.69M unobligated work to go ($1.73M of the remaining work is obligated to fixed-price equipment contracts).

ETC will continue to be assessed monthly through project completion to understand and contain costs while maintaining the good schedule performance that the project has demonstrated to date.

COMMON SYSTEMS

All Common Systems work on ISS, ESM, SMI, and ISR has been completed.

This month, installation and testing of the SIX PPS was completed and successfully certified. Reach-backs to the storage ring and linac are expected to be tested in early January. Completion of the SIX Mechanical and Electrical utilities installation work in the SIX Satellite Building is pending the delivery and installation of the endstation sample chamber and emission spectrometer. These components are expected to be ready for utilities integration in February.

BEAMLINE CONTROLS

SIX endstation controls development continues to make good progress. During December, the controls engineer assigned to the SIX beamline provided support for motion tuning and testing of the detector arm following its installation (Bestec). This engineer also continued to work closely with SIX beamline scientists regarding detailed operation of the controls for the photon delivery system, in preparation for initial commissioning following first light planned for late January.

ESM – ELECTRON SPECTRO-MICROSCOPY

The remaining ESM activities in NEXT scope are receipt and acceptance of the M4 mirror. This mirror is a focusing ellipsoid, with challenging figure error specifications, which will provide beam to the photoemission microscope in the XPEEM branch. The supplier (JTEC) is working diligently on final polish of this mirror, using their Elastic Emission Machining (water jet) polishing technique. Weekly progress updates are provided by JTEC. As of January 20, the due date for this report, delivery is expected to slip to at least February.

ISR – IN-SITU AND RESONANT HARD X-RAY

The final cross and bellows that are a part of the changeover components, which will facilitate rapid transitions among the three ISR endstations, were assembled and installed in Hutch C.

The vacuum components were successfully tested using a turbo pump. Motion testing of the in-vacuum slits, which are installed on the central stand, was also completed.

The design of the Dual Phase Plate Assembly alignment tool was completed, and drawings of the mount components (Figure 1) were released on December 5. Identical tools will be installed on the 2-theta stage of each stack, and will be used to align the chi axis with the x-ray beam. Platinum pinholes with 100 µm diameters, which will be glued to bracket 2 of each mount, were received on December 8, and the two sets of mount components were fabricated during the week of December 12. The alignment tools and phase plates will be installed in the Dual Phase Plate Assembly vacuum chamber during the week of January 23.

The modified benders and spare mirrors of the KB Mirrors package were received on December 7, and metrology in the NSLS-II Metrology Lab was carried out during December 9-16. The Fizeau interferometer was used to minimize the twist of each mirror, and the slope errors were measured using the Shack Hartmann sensor, with results from the HFM mirror shown in Figure 2. Installation of the benders and mirrors in the vacuum chamber in Hutch D was carried out by Toyama beginning on December 16, and the vacuum chamber was sealed, leak-tested, and prepared for baking (see Figure 3) by December 21.

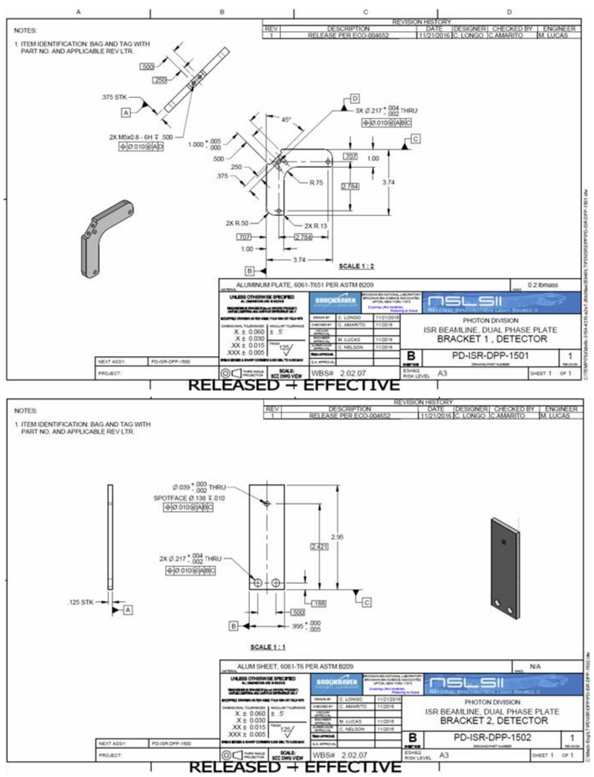


Figure 1. ISR: Drawings of the alignment tool mount components for the Dual Phase Plate Assembly.

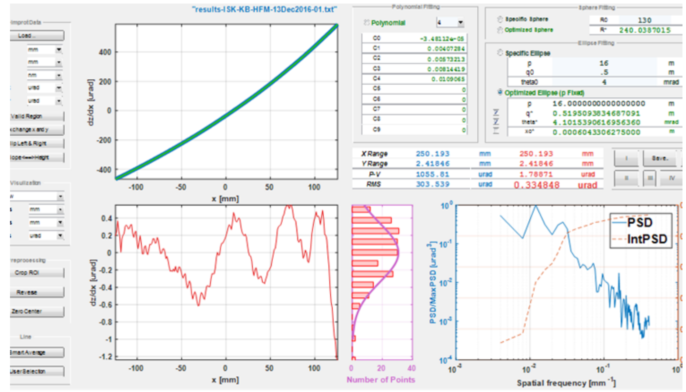


Figure 2. ISR: Metrology results for the HFM mirror of the KB pair to be installed in hutch D. The RMS deviation from the best-fit ellipse is 0.33 (±0.05) µrad and has been accepted for operation.

Figure 3. ISR: KB Mirrors in Hutch D, ready for baking.

ISS – INNER SHELL SPECTROSCOPY

The first scientific paper based on results from ISS has been accepted for publication in the Journal of the American Chemical Society. Authored by ISS users from Northeastern University and Shanghai Jiao Tong University, the manuscript is titled "Asymmetric Volcano Trend in Oxygen Reduction Activity of Pt and Non-Pt Catalysts: In Situ Identification of the Site-Blocking Effect".

SIX – SOFT INELASTIC X-RAY

The detector arm assembly, part of the SIX emission spectrometer package (Bestec), was received during the week of December 5, the detector was installed on the 15m-radius granite-supported track on December 9, and the remainder of the arm was installed by December 15. The remainder of the spectrometer system (optics tank and granite-supported track) and the sample chamber (Bestec) were shipped by sea this month and received during the first week of January 2017 (Figure 5).

Installation of these components in the satellite building is organized in two main steps, starting with the 15-m granite track and the carriage structures for the spectrometer arm pipe and detector chamber (Figure 6), and continuing with the sample chamber (Figure 7), optics tank, and 3-m granite track. The first step was completed successfully after a week of work by the Bestec crew. The flatness of the 15-m granite track was measured using a laser tracker located at the spectrometer center of rotation. Height deviations of ±100 μm were measured, and the height distribution map will be used by Bestec to improve the height deviation range to the specified ±50 μm. The second installation step is underway, with completion expected in February. It is important to mention that outstanding support from the NSLS-II rigging, survey, and technical support teams has been key to the timeliness and efficiency of all phases of the installation.

The vacuum pipe of the pink beam transport section, located between the FOE and the PGM, has been replaced with a thicker pipe which meets the NSLS-II radiation shielding recommended dose of 0.05 mrem/h on contact for a ring current of 500 mA and with the full complement of two 3.5-m EPUs in the 2-ID straight section. Delivery of the beam pipe from a local supplier (~2 weeks) and installation by NSLS-II technical staff (~1 week) were both accomplished in record time. After baking, the vacuum is in the low 10^{-9} mbar range. An update of the raytracing is being finalized for the upcoming IRR.

Figure 4. SIX: A portion of the ~20 crates containing SIX endstation components (Bestec), shown after delivery to the SIX endstation building.

Figure 5. SIX: Installation of the detector chamber carriage on the 15-m granite track.

Figure 6. SIX: Sample chamber and associated spectrometer framework (orange), shown during installation.

Figure 7. SIX: Pink beam transport section.

SMI – SOFT MATTER INTERFACES

SMI continued to optimize alignment, of both the source and the photon delivery system, this month. A flux level within a factor of two of the objective KPP value was measured at high photon energy (~19 keV), where the source output is at least a factor of 10 lower than it is at ~10 keV. Confirmation of achievement of the objective KPP value at SMI is expected in January or early February.

All fabrication and parts for the SAXS assembly, the last remaining component of the SMI endstation, have been sourced. A number of these parts were received, cleaned, and fitted during December, with others due for receipt in January.

The first SMI quad-diamond X-ray Beam Position Monitor has been installed in position downstream of the Double Crystal Monochromator (Figure 8). To enable imaging and on-axis intensity optimization of the undulator beam during commissioning, a YAG (Yttrium Aluminum Garnet) fluorescent imaging crystal (yellow plate in Figure 8, transferred to SMI from an NSLS beamline) was added beside the diamond. Fine Bragg-angle scans have been conducted for a variety of IVU gap settings, acquiring two region-of-interest intensities and a camera image of beam on the YAG at each point. The data will be compared to simulations in order to determine the causes of beam shape distortions and to provide intensity feedback to NSLS-II machine physicists as they adjust the IVU taper and/or the trim coil magnets. Once the SMI IVU is better aligned, beam orbit studies will be conducted to complete intensity optimization.

In January, the SMI team plans to bring beam into the 12-ID-C hutch, complete comprehensive radiation surveys, and begin taking diffraction data. This will be followed by commissioning and optimization of all SMI systems. SMI will accept Science Commissioning proposals for the May-August 2017 scheduling cycle, and expects to start General User operations in the Sept-Dec. 2017 cycle.

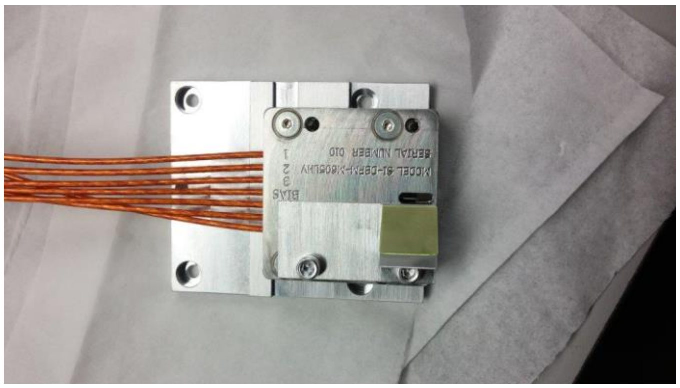
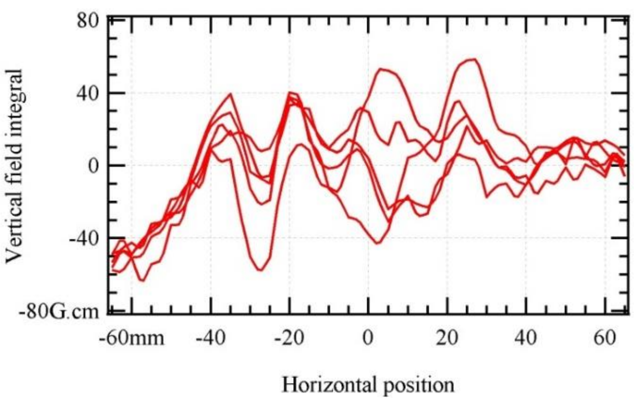


Figure 8. SMI: X-ray Beam Position Monitor (XBPM). Beam enters through the slot seen at the right, either passing through the instrumented diamond within, or over the top of the diamond. The yellow plate is a YAG imaging crystal to use for undulator beam analysis.

INSERTION DEVICES

Shimming of the ESM EPU105 insertion device was completed this month. Four successive iterations of magic finger correction were applied in order to correct the first and second field integrals of this device. Figure 9 shows the vertical and horizontal field integrals at minimum gap for five phase values.



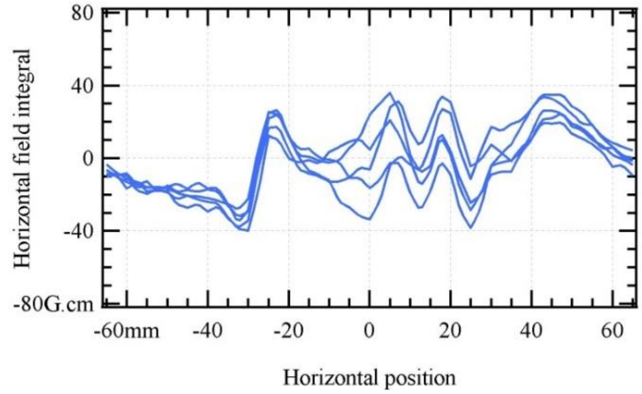


Figure 9. Insertion Devices: Vertical (top) and horizontal (bottom) field integral of ESM EPU105 at minimum gap. Curves corresponding to five EPU phase values are shown.

Introduction of the quasi-periodic magnetic field profile, which improves ESM beamline performance (see earlier activity reports), resulted in a large variation of the second field integral as function of phase. This variation cannot be corrected using magic fingers, but rather requires virtual shimming or, most efficiently, the use of external correction coils. These correction coils are fixed to the sides of the device and are used to reduce further the effect of the EPU on the electron beam dynamics. Usually these coils are not tested until the device is installed in the storage ring. Given the magnitude of the second field integral to be corrected for ESM EPU105, the coils were installed and energized in the magnetic measurement laboratory to confirm the efficiency of correction. Figure 10 shows the strength of the correction achieved with the correction coils.

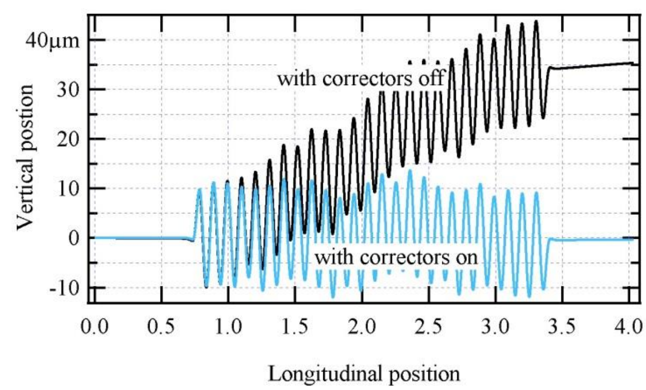


Figure 10. Insertion Devices: Vertical trajectory of a 3GeV electron in the magnetic field of ESM EPU105, with field correctors off (black) and on (blue).

Upon completion of shimming, the on-axis local magnetic field and magnetic field integral were measured over the full range of gap and phase values, for use by NSLS-II machine physicists and ESM beamline scientists. These data will be used to model the spectral performance of the EPU105 insertion device over its spectral range. Final preparations for moving the device were completed by mid-December and the device was transferred to the ring on December 19.

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
Early Project Completion:	Mar. 15, 2017	
CD-4 (Project Completion):	Sept. 29, 2017	

RECENT AND UPCOMING EVENTS

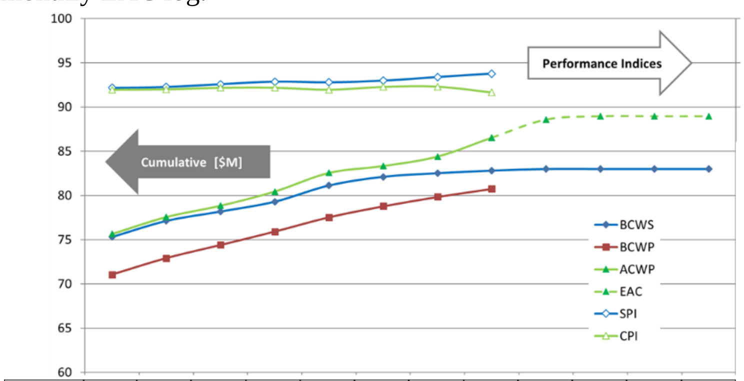
Scope Verification Review	February 2017
DOE/SC OPA CD-4 Review of NEXT	April 2017

Acronyms and Abbreviations

ACWP	Actual Cost of Work Performed
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
BSA	Brookhaven Science Associates
CAM	Cost Account Manager
CD	Critical Decision
CPI	Cost Performance Index
CV	Cost Variance
DOE	Department of Energy
EAC	Estimate At Completion
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
FE	Front End
FOE	First Optics Enclosure
FTE	Full Time Equivalent
FXI	Full-field X-ray Imaging beamline
FY	Fiscal Year
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
KPP	Key Performance Parameter
M&S	Material & Supplies
NEXT	NSLS-II Experimental Tools project
NSLS	National Synchrotron Light Source
NSLS-II	National Synchrotron Light Source II
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
RMS	Root Mean Square
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
SV	Schedule Variance
TEC	Total Estimated Cost
TPC	Total Project Cost
UB	Undistributed Budget
VAC	Variance At Completion
WBS	Work Breakdown Structure
XBPM	X-ray Beam Position Monitor
XPEEM	X-ray photoemission electron microscopy
YAG	Yttrium Aluminum Garnet

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	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17
BCWS	75.3	77.1	78.2	79.3	81.1	82.1	82.5	82.8	83.0	83.0	83.0	83.0
BCWP	71.0	72.9	74.4	75.9	77.5	78.8	79.8	80.7				
ACWP	75.6	77.6	78.8	80.4	82.5	83.3	84.4	86.5				
SPI	0.94	0.95	0.95	0.96	0.96	0.96	0.97	0.98				
CPI	0.94	0.94	0.94	0.94	0.94	0.95	0.95	0.93				
ETC									2.4	0.4	0.0	0.0

NEXT as of 12/31/2016	Current Period	Cum-to-Date
Plan (BCWS) $k	293	82,792
Earned (BCWP) $k	914	80,746
Actual (ACWP) $k	2,137	86,531
SV $k	621	-2,045
CV $k	-1,223	- 5,784
SPI	3.12	0.98
CPI	0.43	0.93
Budget at Completion $k (PMB [UB])		82,970
Planned % Complete (BCWS/BAC)		99.8%
Earned % Complete (BCWP/BAC)		97.3%
Contingency $k		7,030
Contingency / (BAC – BCWP)		316.1%
EAC $k		88,949
Contingency / (EAC – BCWP)		85.7%
(Contingency + VAC) / (EAC – ACWP)		43.5%
TPC = PMB + Contingency		90,000

The NEXT project Schedule Variance (SV) for December 2016 is +$621k, with an associated monthly Schedule Performance Index (SPI) of 3.12 (red status). The largest contributors to the current month schedule variance are provided in the table below. The cumulative SPI is 0.98 (green status), 0.01 higher than it was in November.

The NEXT project Cost Variance (CV) for December 2016 is -$1,223k, with an associated monthly Cost Performance Index (CPI) of 0.43 (red status). The significant contributors to the current month CV are provided in the table below. The cumulative CPI is 0.93 (green status), 0.02 lower than it was in November.

Leading Current Month Variances [$k], December 2016								
WBS	Title	PV	EV	AC	Schedule		Cost	
					SV	Issues	CV	Issues
2.01	Project Support	168	168	182	0	--	-14	--
2.03	Common Systems	72	110	53	38	Greater work performed than planned, especially in PPS, in order to catch up on delayed work. Utilities (WBS 2.03.01): +$7k, PPS (2.03.02): +$19k; Control Station (2.03.04): +$12k	58	Work accomplished more efficiently than planned.
2.04	Controls	3	5	32	2	--	-27	--
2.05	ESM Beamline	0	0	23	0	--	-23	--
2.07	ISR Beamline	2	223	389	221	Catch-up work this month on activities that were scheduled to be completed during prior months: changeover component installation and testing ($7k); KB Mirrors bench test, installation, and commissioning ($63k); and 6-Circle Diffractometer FAT ($152k).	-166	Accruals processed this month for work carried out and value earned in the previous month: Gas Handling System commissioning (-$21k) and 6-Circle Diffractometer FAT (-$109k).

Leading Current Month Variances [$k], December 2016									
WBS	Title	PV	EV	AC	Schedule		Cost		
					SV	Issues	CV	Issues	
2.08	ISS Beamline	29	2	1	-27	--	1	--	
2.09	SIX Beamline	2	361	1332	359	Sum of earlier-scheduled activities performed in December [spectrometer arm packaging and delivery (+$18k) and installation (+$276k), sample chamber packaging and delivery (+$19k), receipt of 5th grating ruling (+$29k), and gaskets and fittings received (+$15k)].	-971	Accruals processed this month for activities, predominantly endstation activities, which were earned earlier.	
2.10	SMI Beamline	14	42	78	28	Catch-up work on some SMI Beamline activities	-36	Material costs for SAXS endstation included in EAC (beyond BAC)	
2.11	Insertion Devices	2	2	48	0	--	-45	Labor cost for last EPU realized (within EAC) – no further cost remaining	
	Total	**293**	**914**	**2137**	**621**	**Total**	**-1223**		

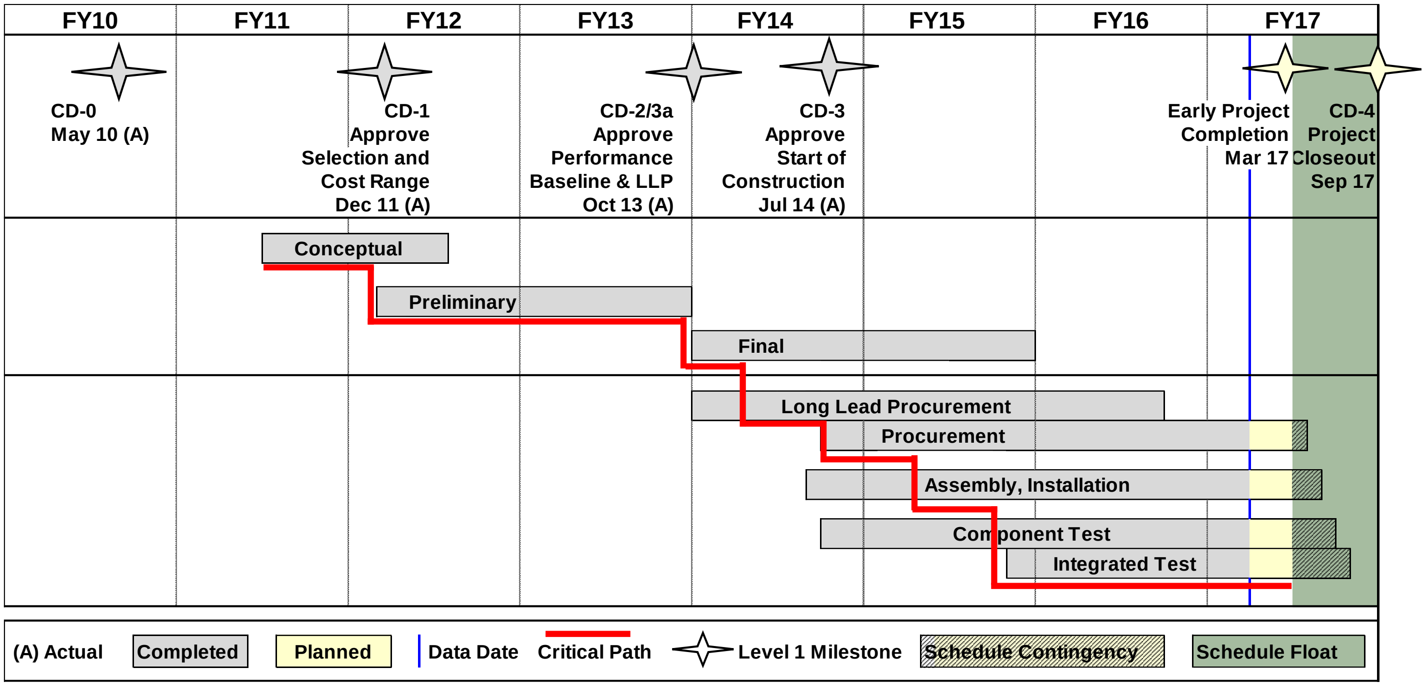
As of December 31, 2016, the project is 97.3% complete with 316.1% contingency ($7.03M) for $2.22M Budget At Completion (BAC) work remaining, based on PCRs processed and approved through December 2016. The project EAC for December is reported at $88,949k against a Performance Measurement Baseline (PMB)/Undistributed Budget (UB) of $82,970k. The Variance At Completion (VAC) is given by VAC = BAC – EAC, with EAC = ACWP + ETC. Through December 2016, the VAC (-$5,978k) is driven by the cumulative cost variance (-$5,784k), which is dominated by labor cost overage on work performed to date.

The December 2016 EAC ($88.95M) is $0.017M higher than the November value (essentially flat). As of the end of December, contingency on EAC is $1.05M, which represents 43.5% of $2.42M EAC work remaining. Outstanding commitments on fixed-price equipment contracts total $1.73M, so the $1.05M contingency on EAC represents 152.2% of $0.69M 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.

No PCRs were approved or implemented in December and no PCRs are planned for January 2017.

Milestones – Near Term		Planned	Actual	Projected
L3	ISR – Installation of Beamline Components Complete	29-Jun-16		January 2017
L3	WBS 2.04 – Beamline Control Systems Complete	14-Sep-16		January 2017
L3	SMI – Installation of Beamline Components Complete	16-Sep-16		February 2017
L3	ESM – Installation of Beamline Components Complete	29-Sep-16		February 2017
L3	SIX – Installation of Beamline Components Complete	30-Sep-16		February 2017
L3	Common Beamline Systems: EPS Installed	30-Sep-16		January 2017
L2, L3	Complete Installation of Common Beamline Systems PPS	30-Sep-16	19-Dec-16	
L2	Early Project Completion – incl. IRR	31-Jan-17		15-Mar-2017

PROJECT SCHEDULE



As of December 2016, the critical path runs through activities related to the Triple Rotating Flange, a component of the SIX endstation sample chamber (WBS 2.09.02.03, SIX Beamline Systems Endstation Equipment).

Staffing Report

Staffing as of 12/31/2016	Current Period		Cumulative-to-Date	
	Planned ** (FTE-yr)	Actual (FTE-yr)	Planned ** (FTE-yr)	Actual (FTE-yr)
WBS 2.01 Project Management and Support	0.66	0.40	41.26	36.70
WBS 2.02 Conceptual and Advanced Conceptual Design	0.00	0.00	8.74	8.74
WBS 2.03 Common Beamline Systems	0.32	0.33	32.95	19.41 *
WBS 2.04 Control System	0.23	0.20	21.91	20.83
WBS 2.05 ESM Beamline	0.00	0.00	15.75	18.52
WBS 2.06 FXI Beamline	0.00	0.00	4.77	4.60
WBS 2.07 ISR Beamline	0.13	0.17	17.67	16.11
WBS 2.08 ISS Beamline	0.00	0.00	14.96	14.92
WBS 2.09 SIX Beamline	0.84	0.73	21.29	25.21
WBS 2.10 SMI Beamline	0.24	0.18	17.40	16.27
WBS 2.11 Insertion Devices	0.16	0.30	7.74	7.20
WBS 2.12 ID & FE Installation	0.00	0.00	3.88	7.97
Total	**2.57**	**2.31**	**208.33**	**196.48**

** 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 December 2016: 92

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	a. NAME		a. NAME	a. FROM (YYYYMMDD)
Brookhaven National Laboratory	NEXT		NSLS-II Experimental Tools (NEXT) Project	2016 / 12 / 01
b. LOCATION (Address and ZIP Code)	b. NUMBER		b. PHASE	b. TO (YYYYMMDD)
	c. TYPE	d. SHARE RATIO	c. EVMS ACCEPTANCE NO X YES (YYYYMMDD)	2016 / 12 / 31

8. PERFORMANCE DATA

WBS (2) WBS (3) ITEM (1)	CURRENT PERIOD BUDGETED COST WORK SCHEDULED (2)	 BUDGETED COST WORK PERFORMED (3)	 ACTUAL COST WORK PERFORMED (4)	 VARIANCE SCHEDULE (5)	 VARIANCE COST (6)	CUMULATIVE TO DATE BUDGETED COST WORK SCHEDULED (7)	 BUDGETED COST WORK PERFORMED (8)	 ACTUAL COST WORK PERFORMED (9)	 VARIANCE SCHEDULE (10)	 VARIANCE COST (11)	AT COMPLETION BUDGETED (14)	 ESTIMATED (15)	 VARIANCE (16)
2.01 Project Management and Support	168,281	168,281	181,949	0	(13,668)	9,757,601	9,757,601	10,563,266	0	(805,666)	9,918,232	10,838,508	(920,276)
2.01.01 Project Management	73,919	73,919	56,128	0	17,791	4,527,470	4,527,470	4,151,011	0	376,458	4,598,029	4,237,558	360,470
2.01.02 Project Support	94,362	94,362	125,821	0	(31,459)	5,230,131	5,230,131	6,412,255	0	(1,182,124)	5,320,204	6,600,949	(1,280,746)
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
2.02.02 Conceptual Design and Analysis of Photon Delivery Syst	0	0	0	0	0	849,881	849,881	849,881	0	0	849,881	849,881	0
2.02.04 ESM Advanced Conceptual Design	0	0	0	0	0	101,376	101,376	101,376	0	0	101,376	101,376	0
2.02.05 FXI Advanced Conceptual Design	0	0	0	0	0	120,634	120,634	120,634	0	0	120,634	120,634	0
2.02.06 ISR Advanced Conceptual Design	0	0	0	0	0	210,700	210,700	210,700	0	0	210,700	210,700	0
2.02.07 ISS Advanced Conceptual Design	0	0	0	0	0	163,508	163,508	163,508	0	0	163,508	163,508	0
2.02.08 SIX Advanced Conceptual Design	0	0	0	0	0	179,533	179,533	179,533	0	0	179,533	179,533	0
2.02.09 SMI Advanced Conceptual Design	0	0	0	0	0	181,684	181,684	181,684	0	0	181,684	181,684	0
2.03 Common Beamline Systems	72,304	110,218	52,700	37,915	57,519	7,335,838	7,275,603	8,464,716	(60,235)	(1,189,113)	7,340,417	8,531,722	(1,191,305)
2.03.01 Utilities	0	7,131	6,951	7,131	180	4,210,031	4,183,280	4,349,187	(26,751)	(165,907)	4,210,031	4,389,631	(179,600)
2.03.02 Personnel Protection System (PPS)	67,506	86,298	36,127	18,792	50,171	1,620,824	1,594,815	2,341,688	(26,009)	(746,873)	1,620,824	2,356,497	(735,673)
2.03.03 Equipment Protection System (EPS)	0	0	1,926	0	(1,926)	680,294	680,294	949,559	0	(269,264)	680,294	949,559	(269,264)
2.03.04 Control Station	0	11,992	1,202	11,992	10,790	306,744	299,269	216,170	(7,475)	83,099	306,744	223,470	83,274
2.03.05 Common Beamline Systems Management	4,797	4,797	6,493	0	(1,696)	517,945	517,945	608,113	0	(90,168)	522,524	612,566	(90,042)
2.04 Control System	2,594	4,828	31,537	2,234	(26,710)	4,646,250	4,640,643	4,932,002	(5,607)	(291,359)	4,648,844	4,972,549	(323,705)
2.04.01 Control System Management	2,594	2,594	2,422	0	171	291,833	291,833	255,314	0	36,519	294,427	257,792	36,635
2.04.02 Control System Design & Implementation	0	1,402	26,021	1,402	(24,619)	2,929,314	2,923,707	3,326,126	(5,607)	(402,419)	2,929,314	3,364,195	(434,881)
2.04.03 Control System Equipment	0	832	3,094	832	(2,262)	1,425,103	1,425,103	1,350,562	0	74,541	1,425,103	1,350,562	74,541
2.05 ESM Beamline	0	0	23,009	0	(23,009)	9,422,464	9,350,687	10,132,222	(71,777)	(781,534)	9,422,464	10,176,240	(753,776)
2.05.01 ESM Management	0	0	0	0	0	610,744	610,744	474,027	0	136,718	610,744	474,027	136,718
2.05.02 ESM Beamline Systems	0	0	23,009	0	(23,009)	8,811,720	8,739,943	9,658,195	(71,777)	(918,252)	8,811,720	9,702,213	(890,493)
2.06 FXI Beamline	0	0	0	0	0	1,818,324	1,818,324	1,793,425	0	24,899	1,818,324	1,793,425	24,899
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	0	0	0	1,408,965	1,408,965	1,322,516	0	86,448	1,408,965	1,322,516	86,448
2.07 ISR Beamline	2,120	223,406	389,457	221,286	(166,051)	10,390,305	9,962,319	10,106,914	(427,986)	(144,595)	10,392,425	10,524,101	(131,676)
2.07.01 ISR Management	2,120	2,120	0	0	2,120	1,103,275	1,103,275	1,034,389	0	68,886	1,105,394	1,034,389	71,005
2.07.02 ISR Beamline Systems	0	221,286	389,457	221,286	(168,171)	9,287,031	8,859,044	9,072,524	(427,986)	(213,480)	9,287,031	9,489,712	(202,682)
2.08 ISS Beamline	29,215	2,120	826	(27,096)	1,294	10,470,092	10,470,092	11,236,443	(0)	(766,351)	10,472,212	11,236,443	(764,231)
2.08.01 ISS Management	29,215	2,120	0	(27,096)	2,120	836,079	836,079	681,035	(0)	155,045	838,199	681,035	157,164
2.08.02 ISS Beamline Systems	0	0	826	0	(826)	9,634,013	9,634,013	10,555,409	0	(921,395)	9,634,013	10,555,409	(921,395)
2.09 SIX Beamline	2,120	360,839	1,332,025	358,719	(971,186)	11,762,716	10,467,691	12,186,995	(1,295,025)	(1,719,304)	11,764,836	13,521,429	(1,756,594)
2.09.01 SIX Management	2,120	2,120	18,045	0	(15,925)	727,721	727,721	731,303	0	(3,582)	729,841	772,555	(42,714)
2.09.02 SIX Beamline Systems	0	358,719	1,313,980	358,719	(955,261)	11,034,995	9,739,969	11,455,691	(1,295,025)	(1,715,722)	11,034,995	12,748,874	(1,713,880)
2.10 SMI Beamline	14,205	41,942	77,608	27,738	(35,665)	9,124,717	8,973,068	9,291,332	(151,649)	(318,264)	9,126,837	9,528,639	(401,802)
2.10.01 SMI Management	14,205	2,120	0	(12,085)	2,120	803,537	803,537	706,837	(0)	96,699	805,656	708,626	97,031
2.10.02 SMI Beamline Systems	0	39,822	77,608	39,822	(37,785)	8,321,181	8,169,532	8,584,495	(151,649)	(414,963)	8,321,181	8,820,014	(498,833)
2.11 Insertion Devices	2,120	2,120	47,606	0	(45,487)	4,803,273	4,770,233	4,563,262	(33,039)	206,972	4,805,392	4,565,253	240,140
2.11.01 ESM EPU Insertion Device	0	0	44,807	0	(44,807)	4,587,795	4,554,756	4,398,606	(33,039)	156,150	4,587,795	4,398,606	189,189
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	2,120	2,120	2,799	0	(679)	98,341	98,341	94,281	0	4,060	100,460	96,272	4,188
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	1,452,960	(143)
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	847,660	(143)
Total Project Baseline	292,957	913,753	2,136,716	620,795	(1,222,964)	82,791,713	80,746,394	86,530,852	(2,045,319)	(5,784,458)	82,970,116	88,948,585	(5,978,469)
Management Reserve													
Undistributed Budget													
Performance Management Baseline (PMB)	292,957	913,753	2,136,716	620,795	(1,222,964)	82,791,713	80,746,394	86,530,852	(2,045,319)	(5,784,458)	82,970,116	88,948,585	(5,978,469)