NSLS-II Experimental Tools (NEXT) Progress Report

October 2012

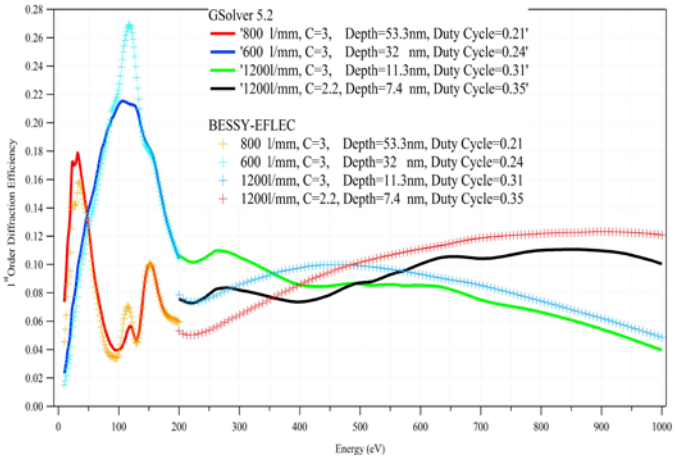

Figure 1. For the ESM beamline, calculated energy efficiencies for four gratings: 800 l/mm, 600 l/mm, and two 1200 l/mm gratings. For comparison, the calculations are performed with two different software packages (GSolver and EFLEC).

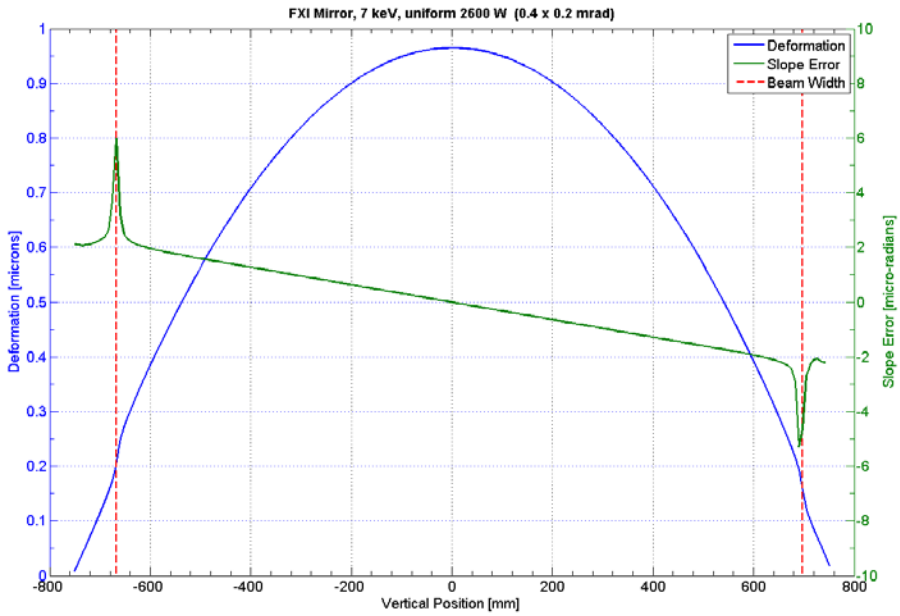

Figure 2. FEA result showing the deformation and slope error for the collimating mirror subject to twice the heat load required for the FXI beamline.

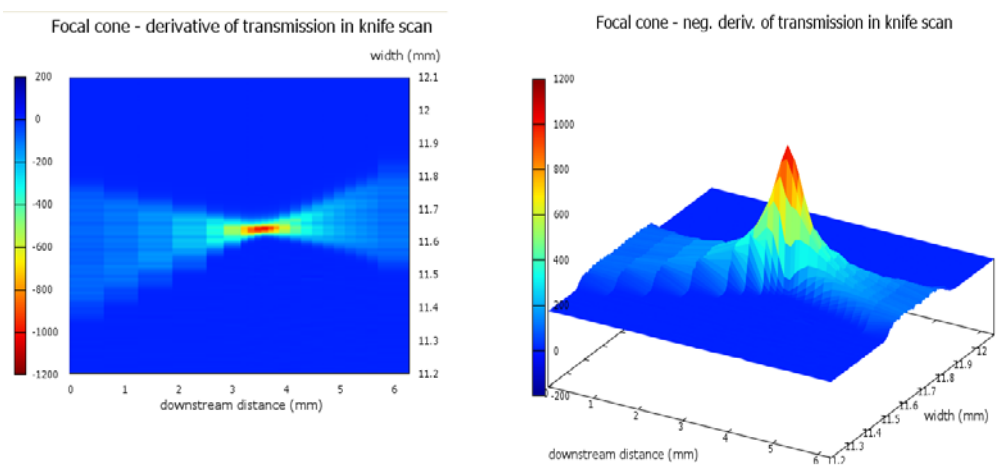

Figure 3. Measured intensity distribution of the focus cone of a commercially available poly capillary half lens for the ISS endstation spectrometer. At 10 KeV photon energy, the measured transmission of this lens is 45%, which exceeds our requirements by a factor of two. The focal spot is fully radially symmetric, has a FWHM of 25 μm, and a focal length of about 500 μm.

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OVERALL ASSESSMENT

During October, NEXT Project staff continued to address recommendations from the September DOE Review while continuing design activities. Advanced preliminary design effort has begun and the preparation of specifications and statements of work (SOWs) has started for the procurements which are scheduled to be awarded in FY13.

The cost and schedule refinement effort, including the provision of a complete basis of estimate and supporting documentation for all materials and supplies (M&S), is nearly complete. The Federal Project Director has provided active oversight of the progress of this refinement. An internal review of cost and schedule is being scheduled for mid-December 2012, with a written report to be delivered by early January 2013. In a parallel effort, the obligation profile has been revised to provide additional built-in schedule float.

ESM – ELECTRON SPECTRO-MICROSCOPY

Optimization of the grating parameters is a crucial task for the ESM beamline. On one hand, high-energy resolution is required (<1 meV below 60 eV); on the other, the highest possible photon flux is desirable for the "photon angry" photoemission technique. The grating parameters (ruling profiles) must be optimized to achieve the best compromise. Two gratings have been selected to cover the low energy (15–200 eV) portion of the ESM energy range: an 800 l/mm grating with maximum efficiency at 30 eV photon energy, and a 600 l/mm grating with high efficiency at 110 eV. The 800 l/mm grating allows the best energy resolution (sub-millivolt) and covers the energy range in which ARPES has the best angular resolution. The 600 l/mm grating covers up to ~200 eV photon energy with good energy resolution (<3 meV) and high flux. For the higher energy portion of the ESM energy range (200–1000 eV), two 1200 l/mm gratings have been selected, one optimized for the 200–400 eV range and one for 400–1000 eV.

FXI – FULL-FIELD X-RAY IMAGING

Finite element analysis (FEA) was completed for the first collimating mirror subjected to twice the expected maximum heat load (~2.6 kW). This scenario was done to consider the feasibility of a future upgrade where another TXM would be co-located on the beamline, as described in Section 9 of the Preliminary Design Report (PDR). The resulting meridional slope error is ±2.4 µrad, corresponding to an 11% calculated loss of photon flux at the sample for the FXI TXM, which is not significant. This analysis confirms that the proposed FXI future upgrade scenario is feasible. Note that in the PDR a similar conclusion was reached, based on linear scaling of a different FEA study that had ~3X higher thermal loads.

Shielded enclosure drawings, as appropriate to get the SOW started, are being generated (~80% complete). Revised preliminary designs of the white and pink beam stops have been created and are in queue for thermal analysis. It is not anticipated that there will be any thermal issues with these stops, since their thermal loads are smaller than those on the white beam slits. However, the maximum power densities which these stops can handle are being studied so that the sizes of these stops can be minimized. Preparation of detailed specifications for the double crystal monochromator also has begun.

ISS – INNER SHELL SPECTROSCOPY

Specifications of the shielding enclosures are currently in preparation. All necessary drawings of the first optical enclosure, e.g., the 3D hutch layout and the crane coverage map, have been prepared. In a second iteration process, the first-draft drawings of the endstation enclosure are being refined. A specific challenge is the implementation of a removable separation wall inside the hutch which will, if successfully implemented, allow us to use this hutch either as a single space or as two independent hutches. To minimize the risks inherent in this new hutch design concept, a safety review will be conducted as a part of the final design effort.

The endstation spectrometer design has progressed. The transmission and light distribution of two poly-capillary x-ray lenses were measured, one a commercially available lens that represents the ISS baseline device and the other being our first "homemade" lens. The transmission of the commercial lens is 45% at 10 keV photon energy, with a focal spot size of 25 µm. A plot of the light distribution around the focus is shown in Figure 3 on the cover. A full energy scan using this device was also measured, demonstrating excellent beam stability in the focus spot and the usability of these devices at ISS. The results of these tests will provide important requirements for the alignment precision of the spectrometer and its components.

SIX – SOFT INELASTIC X-RAY

As the final position of the beamline optical components is now determined, the final 3D layout of the beamline has begun. The specifications for the first mirror and the plane grating monochromator were drafted, and the calculations of the monochromator parameters have been refined accordingly. In the meantime, discussions about the manufacturing feasibility of the highest-performance gratings are ongoing with vendors, for which we regularly carry out detailed parameter calculations.

The procurement strategy for SIX has been revised to group the optical elements with their respective mounting mechanics, vacuum vessels, and stands. A similar strategy will be utilized for each of the four beamline mirrors.

ISR – IN-SITU AND RESONANT HARD X-RAY

Design refinement of the planned ISR build-out continued. One of the most important design issues of the canted build-out was resolved with the optimal location for the side-bounce monochromator determined to be at the upstream end of the FOE. This optical layout will simplify the requirements of the ISR optics because they will not need to accommodate the canted branch beam. With the optical layout finalized, hutch design refinement began.

A 10 micron-thick silicon phase plate was characterized at the APS, in collaboration with Jonathan Lang, Daniel Haskel, and Yong Choi. Dichroism of an FeRh film, shown below in Figure 4, was measured with diamond and silicon phase plates at the Rh L_2 edge (3.146 keV). While diamond is typically used for polarization control in the ~3–13 keV energy range, it cannot be used below 3 keV and therefore alternate materials are required. Our measurements indicate that silicon is a viable option. In fact, the larger flipping ratio observed with the silicon phase plate suggests a higher degree of circular polarization than that provided by the diamond phase plate. Results are still being analyzed, and future studies at absorption edges below 3 keV are planned.

Finally, the search for the ISR beamline scientist has been launched, and the next meeting of the ISR Beamline Advisory Team (BAT) is scheduled to be held on December 13.

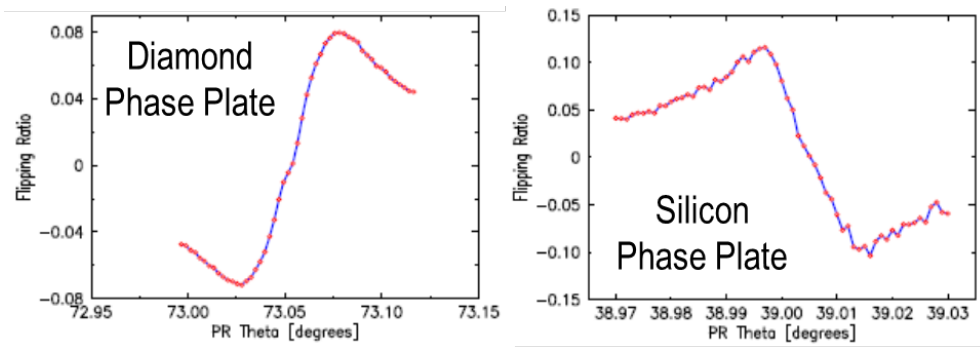
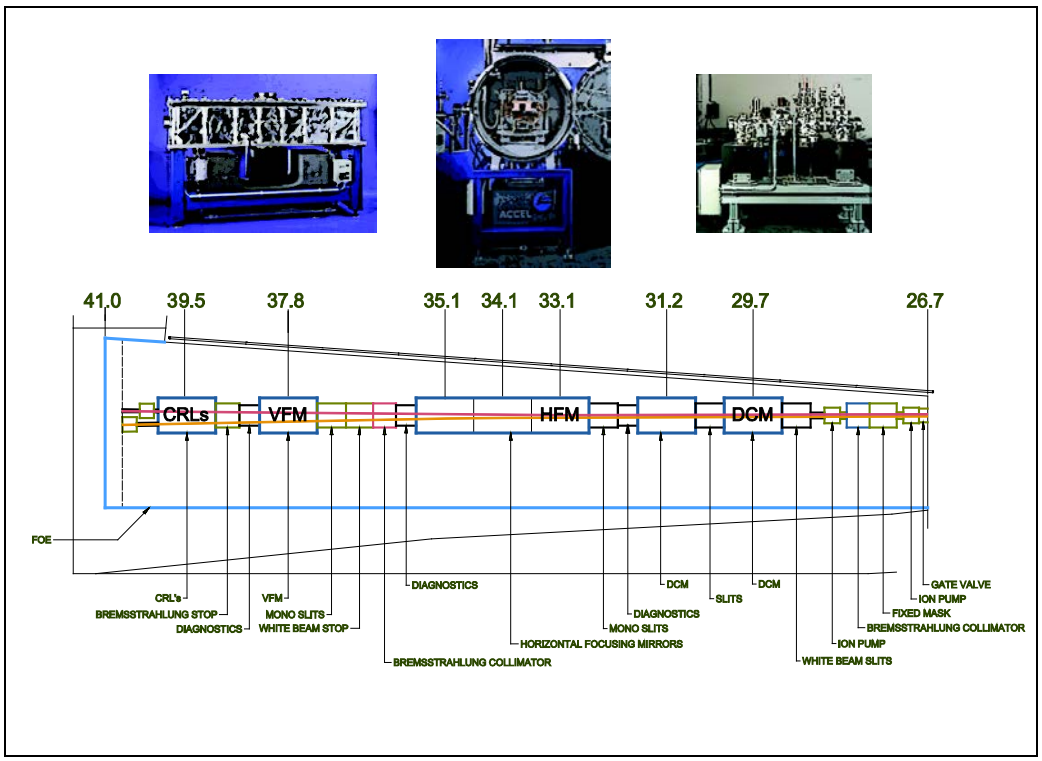


Figure 4. Dichroism of an FeRh thin film, measured at the Rh L_2 edge, using (left) diamond and (right) silicon phase plates.

SMI – SOFT MATTER INTERFACES

As the hutch specifications mature, SMI's next priority is to populate the First Optics Enclosure with realistic models of the types of instruments likely to be supplied by the vendors. Figure 5 shows the "rectangular box" layout of the SMI FOE. To make room for two canted beams, the hutch becomes crowded with instruments, allowing little space for routing bulky utilities such as cryogen lines. To ensure that all requirements are met for optics, diagnostics, and vacuum, the team must replace the generic components with models that have realistic sizes, including interfaces, and consider designs from different vendors.



Information from several vendors is being combined so that alternative model FOE layouts can be constructed for SMI. The process depends on finalizing hutch requirements for all NEXT beamlines collectively, such as those specifying cryo-cooler line geometries, air handling ductwork, and hoists within the hutch. The NEXT project team has made a high priority of tackling the common hutch specification issues, with the help of facility experts.

Figure 5. Layout of the SMI FOE: Blue outline indicates FOE walls, red and yellow lines show the two canted beams, and boxes show the conceptual component layout. The images at the top represent likely models of monochromators, mirrors, and other beamline components that need to be fitted within the layout.

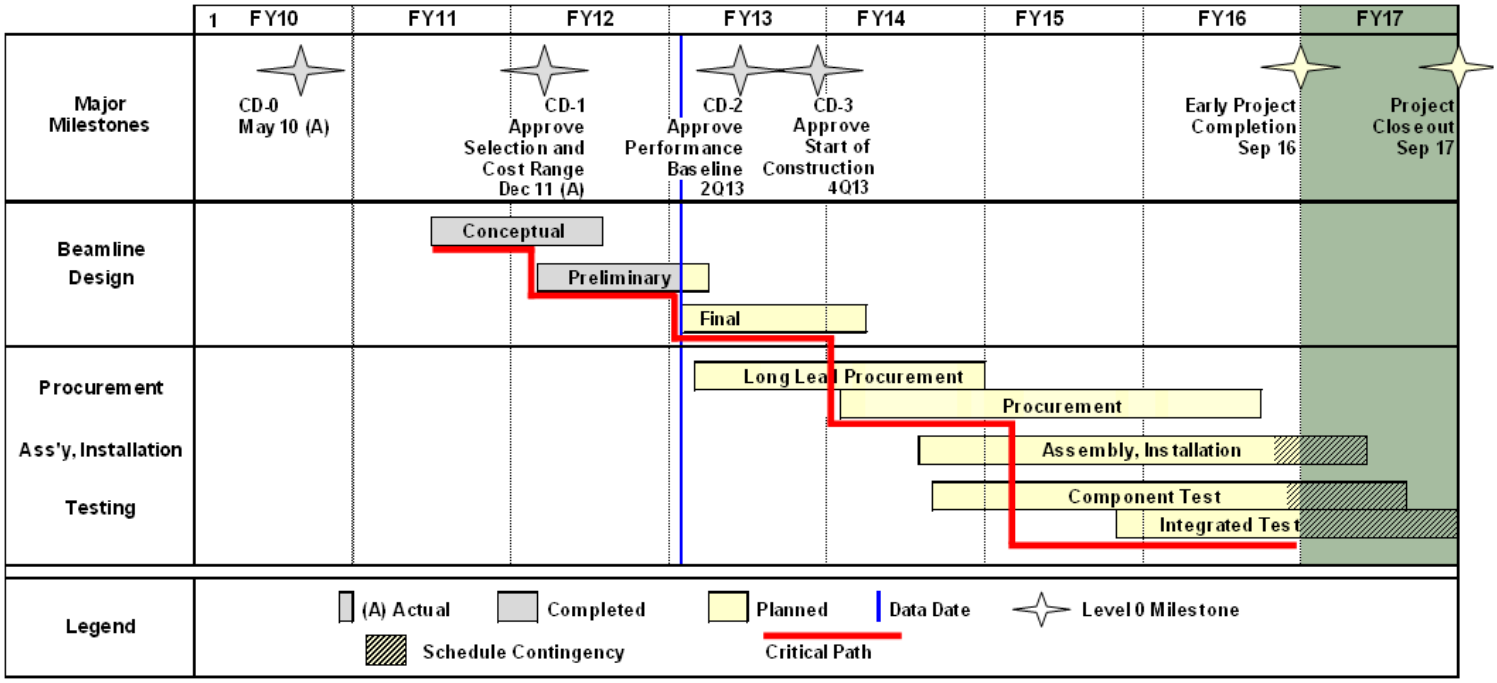
UPCOMING EVENTS

SMI BAT Meeting	Dec 10
ISR BAT Meeting	Dec 13

PROJECT MILESTONES

CD-0 (Mission Need):	Planned: 3Q10	Actual: May 27, 2010
CD-1 (Alternative Selection):	Planned: 4Q11	Actual: Dec. 19, 2011
CD-2 (Performance Baseline):	Planned: 2Q13	
CD-3 (Start Construction):	Planned: 4Q13	
Early Project Completion:	Planned: 4Q16	
CD-4 (Project Completion):	Planned: 4Q17	

PROJECT SCHEDULE



Funding Profile

Funding Type	NEXT Funding Profile ($M)						
	FY11	FY12	FY13	FY14	FY15	FY16	TOTAL
OPC	3.0						3.0
TEC		12.0	12.0	25.9	21.6	15.5	87.0
Total Project Cost	3.0	12.0	12.0	25.9	21.6	15.5	90.0

Cost and Staffing Report

As of 9/30/2012	Current Period		Cumulative-to-date	
	Planned*	Actual	Planned*	Actual
Cost	–	$298,576	–	$3,653,372
Staffing (FTE-year)	–	1.28	–	16.12

*Planned values will be included once Earned Value Management System (EVMS) tracking has begun.

Key NEXT Personnel

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NEXT Project Manager	Steve Hulbert	hulbert@bnl.gov	631-344-7570

Acronyms

APS	Advanced Photon Source
ARPES	Angle-Resolved Photoemission Spectroscopy
BAC	Budget At Completion
BAT	Beamline Advisory Team
ESM	Electron Spectro-Microscopy
ESRF	European Synchrotron Research Facility
EVMS	Earned Value Management System
FEA	Finite Element Analysis
FOE	First Optics Enclosure
FXI	Full-field X-ray Imaging
ISR	Integrated In-Situ & Resonant X-Ray Studies
ISS	Inner Shell Spectroscopy
M&S	Materials and Supplies
OPA	Office of Project Assessment
PDR	Preliminary Design Report (or Review)
SIX	Soft Inelastic X-ray Scattering
SMI	Soft Matter Interfaces beamline
TPC	Total Project Cost
TXM	Transmission X-ray Microscope