NSLS-II Experimental Tools (NEXT) Progress Report

August 2012

Each month, graphics related to three of the six NEXT beamlines are shown below and discussed in the reports.

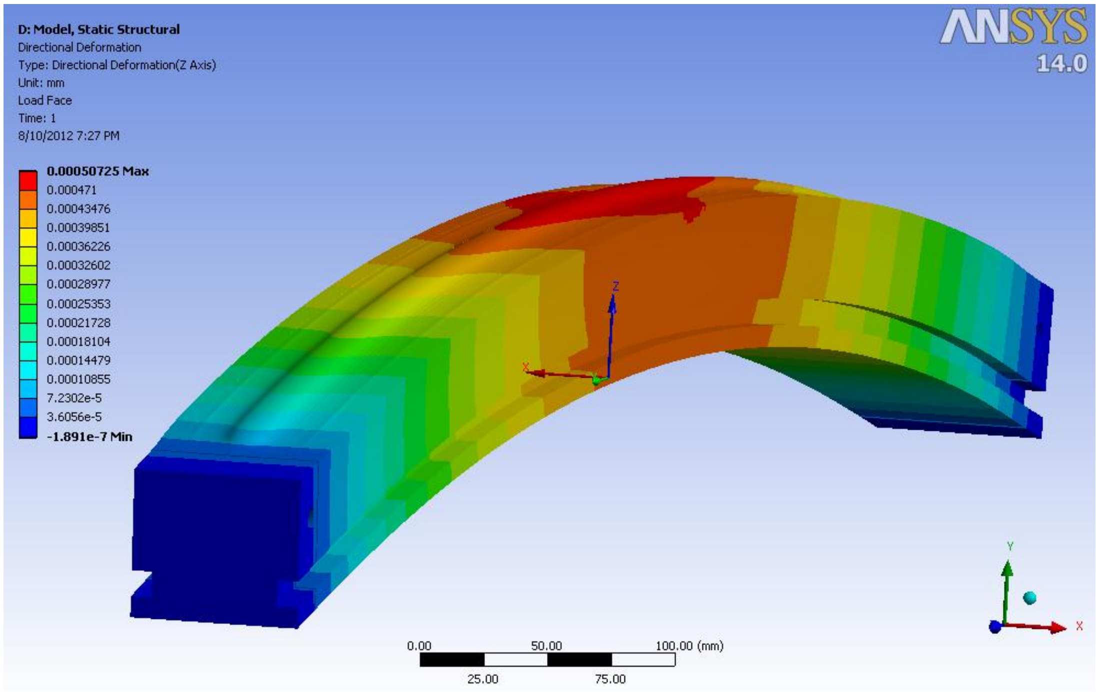

Figure 1. FXI. Finite-element analysis of the collimating mirror. Mirror is subject to white beam with a thermal load of 1757W. The tangential slope error over the beam footprint is ±1.2 μrad.

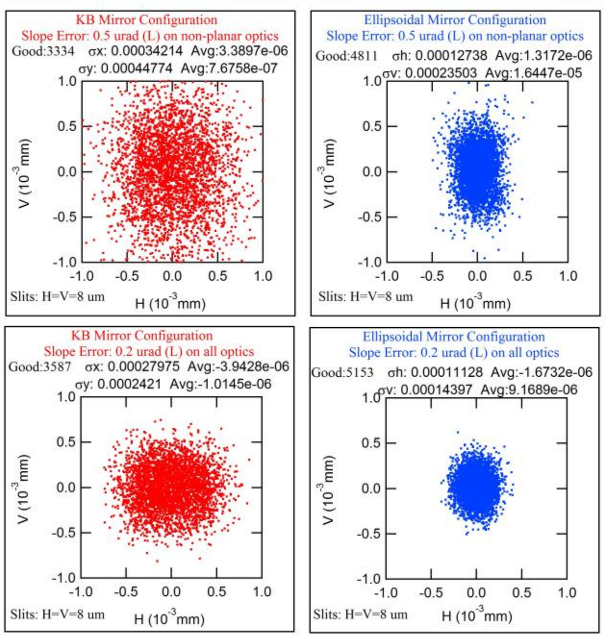

Figure 2. ESM. Comparison of spot size at the sample obtained with the KB refocusing mirrors (red, left panels) and with a single ellipsoidal refocusing optic (blue, right panels). The calculations are performed for the same slit settings and with 0.2 μrad (bottom) and 0.5 μrad (top) slope errors in the longitudinal (meridional) direction. The sagittal slope errors are set to 5 times the longitudinal values.

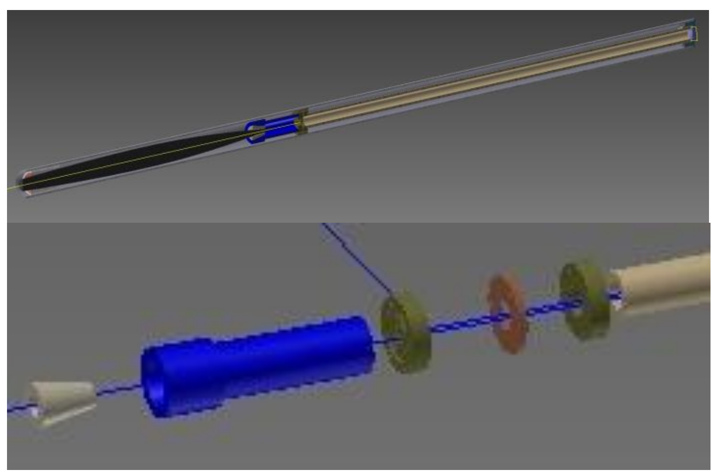

Figure 3. ISS. (Upper) X-ray emission analyzer lens assembly, showing the pre-collimation and collimation lenses. (Lower) Details of the lens assembly showing pre-collimation lens alignment cone, lens holder, adapter flange centering the lens inside the vacuum tube, Be window, and adapter flange with following double-tube fixture carrying the collimation lens. This design will allow the pre-collimation lens to be cooled by the exchange gas of the sample volume, permitting extreme sample temperatures.

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OVERALL ASSESSMENT

The NSLS-II Experimental Tools (NEXT) Project team finalized and posted all documents and presentations for the DOE Office of Project Assessment (OPA) Review scheduled for September 11–13.

The proposed project baseline scope and associated cost and schedule cover the design of six beamlines and the construction of five beamlines. The proposed total project cost (TPC) of $90M includes $68.1M Budget At Completion (BAC) and 32% contingency. The proposed early project completion is Sept. 2016; the CD-4 milestone is Sept. 2017.

A team of external technical experts, led by Mohan Ramanathan (APS/ANL) and appointed by the Associate Laboratory Director for Photon Sciences, conducted a preliminary design review of NEXT on August 7–9. The 34 recommendations from this review were addressed and the corresponding changes to CD-2 documents were made prior to posting in late August.

The Earned Value Management System (EVMS) tracking of NEXT cost and schedule, which began with the May 2012 data, will continue as an internal exercise until CD-2 approval is received. We expect to include a Cost Performance Report with the report due in October, covering activity through September.

The search for a fifth mechanical engineer is underway. The top-rated candidate has been selected.

The first Beamline Advisory Team (BAT) meeting for the SIX beamline has been scheduled for October, 4, 2012.

FXI – FULL-FIELD X-RAY IMAGING

We began raytracing work in the first optics enclosure (FOE) to determine the location of the beam and brehmsstrahlung stops so the FOE layout can be finalized. Figure 1 (p. 1) shows the results of finite element analysis (FEA) on the collimating mirror.

SIX – SOFT INELASTIC X-RAY

Optical component requirements have been sent to mirror vendors, and discussions about the feasibility of the optics fabrication are underway. Discussions with the Linac Coherent Light Source (LCLS) and others are ongoing regarding proper methods of mechanically mounting the optics so as to not affect their state-of-the-art slope error values.

ESM – ELECTRON SPECTRO-MICROSCOPY

A crucial aspect of the ESM beamline optical design is the final section, which determines the quality of micro-focused x-ray spot size. The goal is to prepare a beam with 1 µm spot size over the entire 20–2000 eV photon energy range. This can be achieved by imaging two separately located objects (horizontal and vertical slits) into a single spot using a pair of elliptical cylinder mirrors. This is the classical KB configuration. A different solution consists of modifying the upstream optical parameters to create a common horizontal and vertical focus at a single location, which is then imaged onto the sample with a single ellipsoidal mirror. The second solution has the advantage of requiring one less reflection and of producing an asymmetrical spot, which is beneficial in non-normal-incidence measurements as are typical in photoemission experiments. The manufacturing of an ellipsoidal mirror surface profile is, however, more demanding than the elliptical cylinder profiles needed for the KB stages. A comparison of the two approaches is shown in Figure 2. Determination of the optical design to utilize for ESM will be made during the final design phase.

ISS – INNER SHELL SPECTROSCOPY

As a starting point of the final design phase, we defined the interface documents for the individual packages of the photon delivery package. The controls group and the Common Beamline Systems Cost Account Manager (CAM) are currently reviewing these documents.

Technically, we focused on the challenges of the x-ray emission analyzer design. The conceptual design for this analyzer has been presented at various conferences to a broad international spectroscopy community. Building on the expert feedback received, we have developed a preliminary design, shown in Figure 3, which is based on a triaxial concept, fully separating the vacuum shroud and mechanical support of the analyzer from the lens assembly. This cost-efficient design provides for precision alignment of the lens assembly while ensuring long-term mechanical stability. We are now developing the first design of a lightweight crystal goniometer stage using a direct encoder, which will enable closed-loop control.

SMI – SOFT MATTER INTERFACES

We completed a detailed FEA study of the heat load deformations of the SMI monochromator. The crystal surface was modeled with power incident through large and small apertures, with direct cooling geometries having channels parallel to and transverse to the beam, and with an indirect side-cooled model. The team learned that the total power load must be kept below 85 W for these geometries to be viable, and that the resulting surface profiles in this scenario are similar for direct and indirect cooling. Figure 4 shows the surface deflections expected at 2.05, 3.6, 10.8, and 20.4 keV x-ray energies (upper to lower images) for direct (left) and indirect (right) cooling.

The lower panels show the slope errors along the centerline. These profiles will be used for raytracing the beam profile.

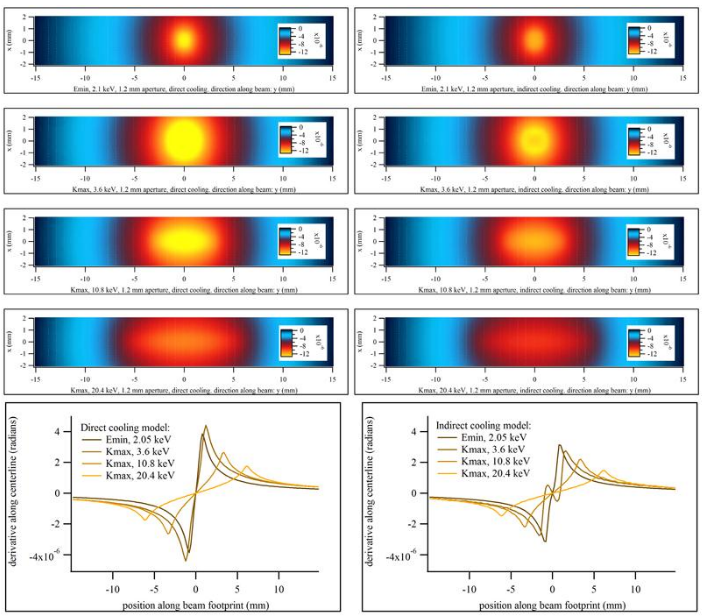


Figure 4. Results of Finite Element Analysis to determine SMI monochromator crystal deformation under heat load. IVU23 radiation was simulated in a 1.2 mm x 1.2 mm aperture 30 m from the source. Left: directly cooled model. Right: side cooled model. False color images: surface height deflection in mm, for 2.05, 3.6, 10.8, and 20.4 keV (top to bottom). Graphs show derivatives calculated along the centerline in radians.

ISR – IN-SITU AND RESONANT HARD X-RAY

In order to determine the constraints on the planned ISR build-out, which will require the installation of experimental hutches in the downstream floor space of the neighboring Materials Physics and Processing (MPP) beamline, the ISR team worked with the MPP team to evaluate optical designs for the MPP beamline. A preferred optical design was chosen, and its impact on the planned ISR build-out as well as the detailed design of the ISR FOE is now being determined.

The location of the ISR in-vacuum undulator (IVU) within the straight was reconsidered. By shifting the IVU toward the center of the straight, a gap between the first and third harmonics, which includes the important uranium $M_{4,5}$ absorption edges, is eliminated. FEA was carried out to determine the effects of the increase in power that arise due to this shift. The increase in total power can be effectively mitigated by reducing the size of an upstream aperture, while still accepting the central cone, and the peak power density on the monochromator is found to increase only slightly. Raytracing analysis that includes the FEA results suggests that indirect cooling of the monochromator, which is preferred for operational ease, remains feasible. While the bump-within-a-dip of the thermally-deformed monochromator surface (Fig. 5a) results in a bimodal beam shape, the vertical focusing mirror can be used to correct this and produce well-behaved, unimodal beam spots at the ISR endstations (Figs. 5b and 5c).

Finally, three days of beam time at APS for Si(111) phase plate characterization, which is development work required to provide polarization control in the important 2.4–3 keV energy range, has been scheduled for late October 2012.

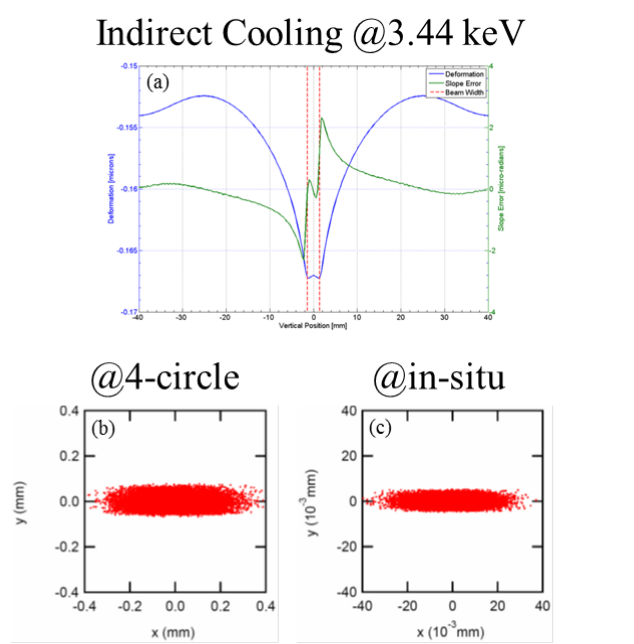


Figure 5. (a) FEA results of monochromator surface deformation and slope errors with indirect cooling at the thermally-worst-case energy of 3.44 keV. Beam spots at the (b) 4-circle and (c) in-situ endstations after correction of the thermal deformation of the monochromator. Note the 10-fold difference in scale between (b) and (c).

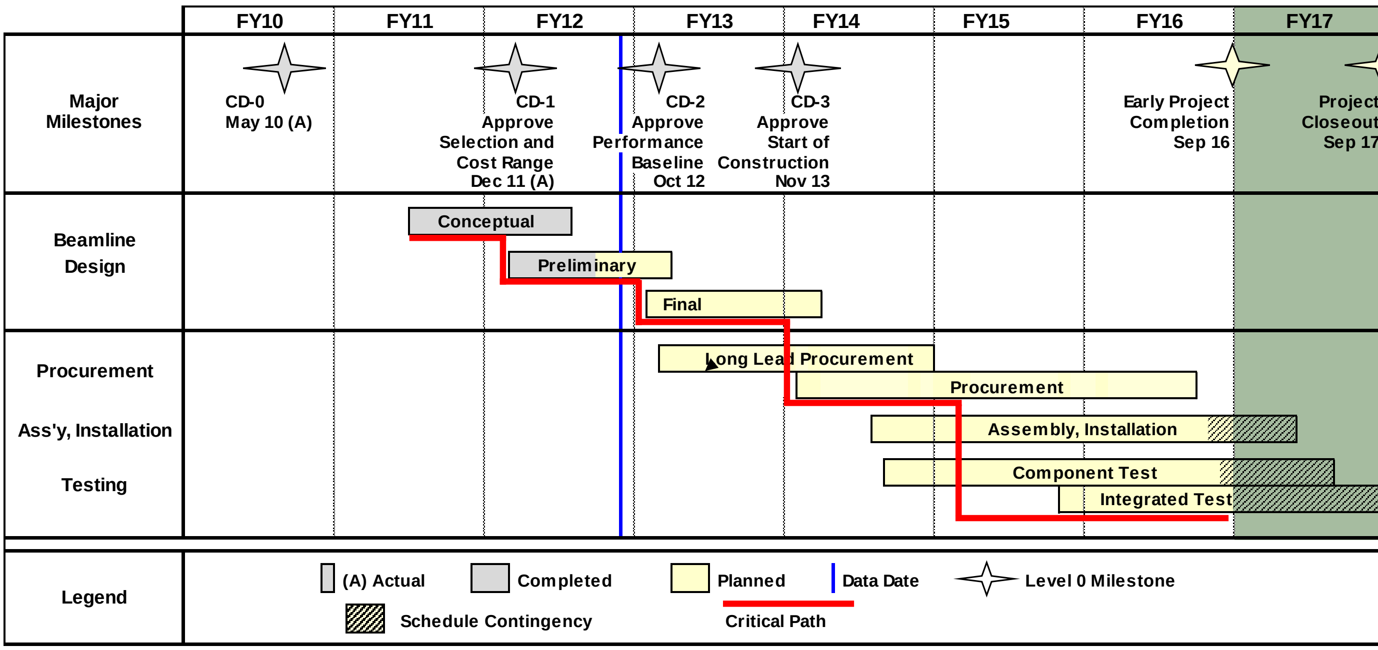
PROJECT MILESTONES

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: 1Q13	
CD-3 (Start Construction):	Planned: 4Q13	
Early Project Completion:	Planned: 4Q16	
CD-4 (Project Completion):	Planned: 4Q17	

UPCOMING EVENTS

ALD's Preliminary Design Report (PDR) Review	Aug 7–9
DOE CD-2 Review of NEXT Project	Sep 11–13
ESM Beamline Advisory Team (BAT) Meeting	TBD
SIX BAT Meeting	Oct 4

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

	Current Period		Cumulative-to-date	
As of August 2012	Planned*	Actual	Planned*	Actual
Cost	–	$326,389	–	$2,923,797
Staffing (FTE-year)	–	1.40	–	12.80

*Planned values will be included once EVMS tracking has begun.

Key Personnel

Title	Name	Email	Phone
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NEXT Project Manager	Steve Hulbert	hulbert@bnl.gov	631-344-7570

Glossary of Acronyms

ALD	Associate Laboratory Director
ANL	Argonne National Laboratory
APS	Advanced Photon Source
BAC	Budget At Completion
BAT	Beamline Advisory Team
CAM	Cost Account Manager
ESM	Electron Spectro-Microscopy (beamline)
EVMS	Earned Value Management System
FEA	Finite Element Analysis
FOE	First Optics Enclosure
FXI	Full-field X-ray Imaging (beamline)
ISR	Integrated In-Situ & Resonant X-Ray Studies (beamline)
ISS	Inner Shell Spectroscopy (beamline)
IVU	In-Vacuum Undulator
KB	Kirkpatrick-Baez
LCLS	Linac Coherent Light Source
MPP	Materials Physics and Processing (beamline)
OPA	Office of Project Assessment
PDR	Preliminary Design Report (or Review)
SIX	Soft Inelastic X-ray Scattering (beamline)
SMI	Soft Matter Interfaces (beamline)
TPC	Total Project Cost