Committee Report
NSLS-II Experimental Facilities Advisory Committee Meeting
April 23-24, 2009

Members Present:
A. Baron, SPring8
M. Chance, Case Western Reserve University
P. Dumas, SOLEIL
Gene Ice, ORNL
Andrzej Joachimiak, ANL
Steve Kevan, University of Oregon
Robert Lieberman, Stony Brook University
Simon Mochrie, Yale University, Chair
Ian Robinson, University College, London
Brian Stephenson, ANL

Members Absent:
Jerry Hastings, SLAC
Mohan Ramanathan, ANL
Francesco Sette, ESRF

We congratulate the entire NSLS-II project staff for the outstanding progress achieved in the last year, including CD-3, and the recent award of ARRA funds. Notable too is that the staffing levels, which previously had been a concern of the EFAC, are now satisfactory with the addition of outstanding scientific and management staff. This is a tremendously exciting time at Brookhaven and it is clear that the hard work of the last few years has started to pay off.

In particular, we commend NSLS-II management for the appointment of a Life Sciences Director. They are further to be congratulated for the appointment of Prof. Wayne Hendrickson, whose stature augments the NSLS II biology effort tremendously.

Now that the NSLS-II project is successfully through the CD-3 milestone, and is a *bone fide* construction project, the critical challenge of how to transition from the NSLS-II construction project and NSLS operations on the one hand to NSLS-II operations on the other demands planning across the Light Sources directorate, and the EFAC is convinced that BNL's review committee structure should reflect this need.

Recommendation: We recommend that the NSLS-II Experimental Facilities Advisory Committee (NSLS-II EFAC) be reconstituted as an advisory committee charged with providing advice to the NSLS-II director, the Experimental Facilities Director and the Life Sciences director from a perspective that goes beyond the project and includes consideration of the NSLS-II project, the transition of beamlines from NSLS to NSLS-II and future NSLS-II operations.

The BATs provide a means to provide NSLS-II staff and management with expert review that can and should be more detailed than is possible by the EFAC.

Recommendations: We recommend that the charge to the BATs be clarified to explicitly include prominent review, advice and oversight roles. EFAC reviews that duplicate BAT reviews should be avoided. However, a reconstituted EFAC could certainly be productively used to evaluate each beamline/BAT on a long term basis (every 3 years, for example).

We do not recommend a BAT council at this juncture, since currently all of the beamlines are facility beamlines, managed by the NSLS-II. Instead, in the near future (within the next 12-18 months), the Light Sources Directorate should consider instituting a nascent NSLS-II Users Organization, or expanding the scope of the existing NSLS Users Organization to include NSLS-II. In this way the broader community will be drawn into NSLS-II. The current NSLS has an NSLS-II interest group which could provide a nucleus for such an organization.
Later in the development of the NSLS-II facilty, the question of a BAT council could be revisited, especially if there are a significant number of non-facility beamlines and it is desirable to improve communications among these beamlines and the facility.

We are delighted that Light Sources Directorate strategic planning has recently been started.

Recommendations: We recommend that strategic planning for what the full slate of beamlines will look like at a fully built-out NSLS-II proceed to the creation of an NSLS-II Strategic Plan as soon as possible. This document should be widely disseminated and should serve as a guideline for future LOI calls.

We recommend that NSLS-II management advertize its current thinking concerning future LOI calls and MIE proposals even before the NSLS-II strategic planning is completed, even if detailed plans have not yet been formulated. We believe that this would be very helpful in maintaining community engagement.

We commend NSLS-II management for supporting the NSLS-II scientific staff's individual research and programs

Recommendation: We recommend that support for the NSLS-II scientific staff's individual research programs continue to promote the scientific vitality of the NSLS-II organization.

Many NSLS II beamlines are ostensibly relying on Peter Siddons for detectors, and we have serious concerns about detector prioritization.

Recommendation: Key detector projects must be completed in time for operations. Thus, the priority for specific detector projects should be established immediately.

The EFAC notes that compound refractive lens are currently a key component of a number of beamlines.

Recommendation: NSLS-II should consider whether an in-house CRL effort should be added to the planned in-house optics effort.

CXS beamline

The Coherent Soft X-ray beamline staff and BAT have made good progress defining the project's scope in the past year. A preliminary conceptual design for the two undulators and beamlines has been produced. Important issues with canting and phasing two elliptical undulators remain under study and need to be understood soon so that the final design process can proceed.

The team is striving to maximize beamline flexibility. For example, it will be possible to operate the two canted undulators and beamlines independently, or alternatively to send both undulator beams down either beamline for fast polarization modulation or for the highest possible brightness (assuming the undulators can phased). This flexibility renders the existing conceptual design notably complex, since it includes two elliptical undulators, with canting and steering magnets, and two (actually two and a half) complete soft x-ray beamlines, with a total of 16 mirrors. Stationing two independent programs on one straight section will enable efficient time scheduling during operation. Despite some space constraints, this arrangement is known to be very beneficial, so long as the temptation to locate several end stations on each beamline is avoided. It is unfortunate that the canting hardware, essential for fast polarization modulation, uses space in the low-beta straight and lowers the ultimate source brightness. In that respect, co-location of these two programs is not ideal.

The NSLS-II should produce an updated cost estimate for this beamline as soon as possible to ensure that the proposed hardware remains within the scope of the budget. Clear identification of state of the art end stations for the two branches, or of resources for producing these end stations, is also necessary.

XPD-Powder Diffraction Beamline

The EFAC found the presentations by Eric Doorhee and Andy Broadbent to be comprehensive and responsive to the input from the EFAC from its May 2008 review of the original LOI [see slide #9].

The hiring of Doorhee as Group Leader was an important step and he and Broadbent have engaged the BAT in developing the beamline design. They have also engaged Peter Siddons in this process, which is highly desirable, although they must be careful not to expect Siddons to solve all problems related to detectors.

The current plan is to have two end stations, which are being designed to take advantage both of the high brightness of the NSLS II source as well as the high energies of the damping wigglers [especially between 50 and 80 keV]. We endorse this plan, as long as it does not compromise the individual station capabilities or present unreasonable stresses on the budget.

The ultimate objective of this BAT and this XPD beamine is to develop the only high-resolution instrument in the US capable of collecting data at high energies (40 keV to 100 keV) ideal for high-Q data and *in situ* and time resolved studies in environmental cells [including gas rigs, low and high temperatures, and/or high pressures]. We applaud this ambition and hope it can be achieved.

In summary, we were impressed by the progress over the past year on the planning for this beamline.

XCS Beamline

The EFAC is delighted that an XCS group leader is now appointed and that a second XCS scientist will soon arrive.

Conceptual planning for the XCS line is mature with strong BAT involvement, and a solid design is emerging.

Of critical importance to this beamline is the proposed detector. The EFAC was pleased to hear that funds for the detector are being jealously guarded by XCS staff. It is imperative for the mission of this beamline that funding for the detector must be preserved and, if possible, increased.

With regard to software – we recommend to not re-invent software that's available at APS/ESRF/PETRA

In summary, the EFAC was impressed by the progress over the past year on the planning for this beamline.

SRX beamline
EFAC is very pleased with the development of this beamline and the refinement progress of the design. A careful effort has been initiated to optimize the In-Vacuo Undulator (IVU). The recent involvement of Oleg Chubar at NSLS II project has clearly contributed to boost the optimization of the insertion device.

The choice of IVU of 1.5 m long, 21 mm period with a minimum gap of 5.5 mm provides excellent performance and matches the expectations. EFAC endorses the optimized insertion device.

The initial scope of this beamline includes one IVU and a KB station, is aiming at achieving an ultimate resolution of 100 nm. EFAC suggests to push further the KB design to reach the resolution already expected for the ZP station (30 nm). Recent achievements have proven very promising, approaching the targeted resolution of the ZP station.

EFAC is also quite pleased by the motivation, and careful report of the BAT members. Their motivation is well reflected in the numerous issues and questions addressed in the BAT report. EFAC encourages the BAT and project team to maintain their level of communication and interaction.

Despite not in the initial scope, the issue of the second branch has been raised. It is recommended to give more thought to this project, in particular in considering earlier on, the most affordable and convenient canted angle for future second branch set up, upon further funding.

EFAC is pleased to hear that Jurgen Thieme has been hired as beamline leader. Jurgen has a lot of experience in Hard X-ray microscopy for Environmental science. He should initiate quite early the cost re-examination of the beamline that is currently required.

EFAC encourages the beamline team to consider as early as possible, data acquisition and treatment, image manipulation software and user-friendly control of the beamline. Several open source programs are available that are likely adequate for the beamline needs; these should be considered quite early, as these implementations take more time and effort than originally expected. EFAC recommends also considering integration of data and treatment from other beamlines in order to contribute to a better complementary and friendliness for future users.

EFAC expresses concerns about detector development, which is a major item of the beamline. A strategy plan for detector utilization and availability should be set up, with back up options in case of late delivery.

Vigorous evaluation of beamline stability has to be initiated soon. This should be part of the stability concerns expressed by other beamlines and a common effort should be devoted to this issue. Also, issues relating to risks and stability with respect to of the spectral scanning range are currently unclear. Upon discussion at the presentations it was stated quite clearly that even near-edge spectral data collection requires gap scanning, how much and what are the implications are important issues to be researched soon. Research into and discussion with other synchrotron sources that have faced these issues should be initiated at the earliest opportunity.

The design of the monochromator is pending, and a potential candidate has been identified (from Australian Synchrotron's Xray fluorescence Microscope). It should be further evaluated, with risk and capabilities estimated (polarization losses, beam divergence…)

0.1 meV IXS Beamline

The main goal of this effort is to make it possible to do science at the NSLS-II that is "new", significantly beyond what is done at other facilities. The EFAC continues to believe that, assuming they get close to the stated goal of 0.1 meV resolution, new science is very probable. To this end, we were pleased to see the extensive improvements in infrastructure over that past year, including a group that now includes 8 persons (with one more post-doc to arrive in June), development of a beamline for optical tests at the NSLS, additional NSLS-II beamline design work, detailed consideration of collimation mirrors, tests of furnace stability, realistic, even conservative, undulator calculations, first meeting of the BAT, etc. There has been a lot of work in the year since the previous EFAC meeting.

It is now imperative that the team focus on experimentally demonstrating the potential of the optics to achieve 0.1 meV resolution, or near to 0.1 meV resolution, even in the simplest monochromator/monochromator arrangement. This is underscored by (1) the recent tests showing 10 meV resolution where 1 meV was the goal and (2) undulator calculations that suggest even with a 6m undulator, the flux (in units of photons/s/meV) will be comparable to other facilities, so that NSLS-II can not rely on increased flux as a generator for new science. This team must create new capability: improved resolution (FWHM), "small tails" of the resolution function, and, perhaps, others directions made possible by their optical scheme, the low x-ray energy, or the source brilliance. The "1 meV option" that has been discussed extensively is interesting due to the possibility of improving the tail in the resolution function, but should not be considered a high priority, except in so far as it is a step toward substantially sub-meV operation, or might generate unique capability (examples of the latter include the small tails, or taking advantage of the increased refraction at low x-ray energies to pursue surface investigations in total external reflection, or utilizing the full brilliance of the beam, with very strong focusing for exceptionally small samples.)

Count-rate estimations are suggested to help gauge the over-all feasibility of experimental goals. Such estimates were recommended in the EFAC report of 2007, the EFAC report of 2008 and the BAT report of 2008. They should be done in some of the expected and interesting experimental configurations. They should include the effects of sample thickness/transmission/environment, and desired momentum resolution. If the rates are extremely low, they might go so far as to simulate spectra and fitting. For example, if these estimates showed that even the simplest planned use of the 0.1 meV setup (where flux may be severely reduced by simultaneously requiring high resolution in energy and momentum) will have signal rates comparable with the detector noise, and so might require weeks of data collection for one spectrum, then this might significantly impact the beamline conceptual design and scientific goals.

1-nm Optics Fabrication , Theory and Test/ Nanopositioning R&D Plan and Hard X-ray Nanoprobe

Fabrication:

Progress on nano-optics fabrication, theory, tests and engineering toward a practical hard x-ray nanoprobe was presented. Since the last review there have been major advances in

staffing and in the development of in-house capabilities needed to field the world's smallest hard x-ray probe. The NSLSII can be congratulated for having put together a strong team to address the formidable challenges associated with the demonstration and fielding of a x-ray probe with 1-nm spot size. The presentation of plans for in-house fabrication of multilayer Laue lenses by Conley was particularly impressive. ***The demonstration of "through-the-middle" lenses greatly simplifies the ultimate challenges involved in achieving point focusing***. Overall, the MLL program appears to have identified the critical challenges toward achieving 1nm focal spots and is putting in place the fabrication capabilities to meet these challenges.

Kinoform optics represent an alternative path toward 1 nm focusing that was not described in this review, but which has been described in detail at previous reviews. It is not clear what priority this approach has, although kinoform or other compound refractive optics were mentioned during the review as a possible choice for collimation and/or weak focusing front-end optics on three beamlines.

Recommendation: Continued reports on MLLs and kinoform optics progress should be included in the next EFAC (or its re-incarnation) meeting.

Recommendation: Within the last year, major advances have been made in total-external-reflection and multilayer reflective optics by the Osaka group. Based on their demonstration of an 8 nm singly-focused beam it appears possible to field a 5 x 5 nm^2 probe on the time-scale of the NSLSII first light. Such a probe offers significant advantages for near-edge spectroscopy and can achieve good reflectivity efficiency. A pre-aligned Montel geometry variant of the Osaka mirrors offers a compact design with a restricted number of degrees of freedom and slightly smaller diffraction limit. The project should monitor progress in this area and consider this kind of optics for possible inclusion in the nanoprobe suite of tools.

Theory and test:

A new NSLSII effort in full-wave dynamical modeling was described. This effort has made great progress toward modeling the influence of defects. This step is essential to set goals for the optical designs and to guide alignment of nanoprobe optics. Some initial point focusing tests were also described including first tests of crossed MLLs. A far-field coherent diffraction image reconstruction of a 60 nm beam was very encouraging and provides confidence that beam focus can be characterized in-situ to aid in alignment. ***The far-field results together with the modeling results are impressive***.

Recommendations: None

Hard X-ray Nanoprobe

Given the short time Yong Chu has been on the job, the Hard X-ray Nanoprobe (HXN) beamline has made excellent progress. The EFAC appreciates that considerable innovation is already built in to the conceptual design that was presented: horizontal-

bounce monochromator, secondary focusing, long beamline, etc. EFAC commends the efforts to start advanced planning on the design of the external building from the vibration perspective. We feel the design of a "house within a house" looks correct, but would encourage the options of longer range remote control for the quietest environment. Any vibration studies that can be implemented would be welcome at this stage, particularly concerning the use of vibration-cancellation tables in the current design.

An R&D program for nanopositioning and a rough strategy for the hard x-ray nanoprobe were described. This effort is still in its infancy and is borrowing heavily (as it should) from the experience of the APS and others. The complexity of the effort was illustrated with a vibration budget diagram which estimated the vibrations in various component of a nanoprobe stage.

The EFAC generally commends the advance planning of the project, notably (i) the contract with Deming Shu, (ii) the plan to build a prototype instrument, and (iii) the plan to work with a vendor to deliver the final instrument.

Recommendation: Consider isolating the researchers from the hutch by moving the controls to the neighboring LOM.

Recommendation: Consider robotic handling of samples.

Recommendation: Simplify the degrees of freedom where possible by pre-aligning optics. The committee particularly applauds the development of
“through-the-middle” MLLs and the research on gluing crossed MLLs.

Recommendation: Pursue formal collaboration with one of the 3rd generation sources to get access to development beamtime for the prototype instrument. Diamond I-13 would be coming on line at just the time this would be needed.

Recommendation: Consider the option of a fully remote control cabin located in the LOB to optimise the vibration isolation.

Recommendation: Consider the option of a secondary horizontal slit WITHOUT upstream focusing. If the slit is close enough to the source, it will be filled with the coherent fraction of the beam without loss of coherent flux.

EFAC report on Metrology

Qun Shen reported on the current plans with regard to mirror metrology. An approximately $2M budget is proposed for metrology and mirror figure control. Plans include a laboratory with standard synchrotron mirror metrology instruments, designed to cover a wide spatial frequency distribution. A position has been advertised and good

scientists are responding. Other efforts include in-beam metrology with plans for an in-beam bend magnet beamline for far-field characterization on NSLS and eventually on NSLSII.

The EFAC commends the progress to establish a metrology lab and feels it is correct to outsource most of the polishing work. Appreciating that limited expertise means that not all technologies for extreme focussing can be investigated. We recommend building on the excellent efforts of Ray Conley's group to develop sophisticated coating methods for aberration correction, and the EFAC endorses efforts to collaborate with Rochester University. There are likely to be potential collaborations in the subjects of adaptive optics, aberration correction, and wavefront propagation, which are rather advanced for visible light.

Recommendation: Build on existing strengths of Ray Conley to develop coating methods for aberration correction.

Recommendation: Set up a metrology beamline at NSLS as an extension of the visible light in-house metrology lab.

Recommendation: Consider initiating an effort in the use of adaptive optics to engineer wavefront modification and develop methods to investigate wavefront propagation.

Recommendation: To build up a source of vendors, the NSLS II should visit J-Tec (Osaka) and Tinsley (California). A better understanding of efforts at the ESRF is also encouraged.

Recommendation: We encourage the NSLSII to become the best in the world at wavefield characterization of optics by far-field in-beam measurements.

Space allocation plan for LOBs -
We applaud the decision to work towards increasing the LOB size. This should be a high priority for usage of contingency as project risks are retired. The benchmark comparison of the current baseline LOB plan with LOM usage at APS shows that the NSLS II baseline plan does not have adequate total LOB space or lab space.

We endorse the guiding principles listed on the 4th viewgraph, although there was some discussion about the principle to have all LOB lab space shared between beamlines associated with LOB (e.g. 6 sectors, ~15 beamlines) with none dedicated to a particular beamline. This differs from APS and ESRF arrangements where labs are primarily associated with individual beamlines. Sharing will allow more efficient use and promote the 'village' concept. However, discussion indicated that some compromise may be desirable. For example, a significant fraction of the lab space should be available for allocation to medium-term or on-going projects of specific beamlines, especially in early operations. Also, if outside groups build individual beamlines, some scheme to allocate non-shared space may be needed.

The re-evaluation approach being used is sound. We concur with the conclusions, although requirements for lab space for medium-term beamline projects should be included; the analysis so far appears to be based only on user experiment needs.

The new plan resulting from the re-analysis has similar total space per sector as APS; however, it includes about 20% less lab space, and 20% more office space per sector than APS.

The new plan appears to be approximately correct, but we recommend that the project consider tweaking it to include more space that could be used for 'dry' labs or offices as needed, e.g. with appropriate electrical utilities. Since space needed by short-term users is more likely to be in labs than in offices, the extra lab space could be created by reducing cubicle space for short-term users relative to the current scheme.

In planning for management of the LOBs, the complexities of sharing labs should be considered (e.g. between about 15 simultaneous experiments as well as on going individual beamline development activities).