Report of 1st Meeting of the NSLS-II Experimental Facilities Advisory Committee
October 19-20, 2006

Present:
P. Dumas, SOLEIL
G. Ice, ORNL
S. Mochrie, Yale, Chairman
I. Robinson, University College London

Absent:
R. Lieberman, Stony Brook University
F. Sette, ESRF

The NSLS-II EFAC met on October 19 and 20, 2006 and heard presentations concerning the proposed accelerator systems, experimental and conventional facilities. Presentations also described possible hard and soft x-ray undulator beamlines, the latter with unique polarization-switching capabilities, damping-wiggler beamlines, bending-magnet beamlines (including IR beamlines), and an excellent R&D component. The R&D goals are broadly focused on developments that efficiently utilize the source brilliance and allow for new scientific capabilities. Specific goals include beamlines with 1 nm spatial resolution, and 0.1 meV energy resolution, the development of mega-channel, fast, “smart” detectors, the development of state-of-the-art undulators, including superconducting undulators, and metrology capabilities to guide new mirror fabrication efforts and to provide quality assurance that vendor mirrors satisfy the stringent requirements of NSLS-II. These efforts will benefit not just NSLS-II but the whole synchrotron radiation community.

We also heard about the “trust fund” concept, which assigns a definite, protected budget for beamline implementation, amounting to nearly 10% of the project construction budget, in order to ensure that there are functioning beamlines as soon as possible after the start of ring operations. The trust fund will permit about 5 state-of-the-art beamlines to be implemented. We also heard that, beyond the initial NSLS-II project budget, it is anticipated that further build-out of beamlines will be funded via Major Items of Equipment (MIE) funding. We also heard ideas for leveraging a high level of involvement at the NSLS-II by selected university faculty.

Overall, the presentations were impressive and we wish to commend the NSLS-II team for excellent progress on the project. Further highlights that emerged from the presentations include: ground-breaking beamline plans, meeting the project demands and advancing the technical side of synchrotron radiation development; close coordination of the machine design and the beamline needs, such as wide bending magnet vessels for IR development, and optimized beta-functions for coherence utilization; and professional project management.

The EFAC strongly endorses the strategy of using the trust fund, and later on MIEs, to develop word-leading beamlines, that are uniquely suited to exploit the high brilliance of NSLS-II, such as the 0.1 meV-resolution inelastic x-ray scattering line, the x-ray photon correlation spectroscopy line, the 1 nm resolution nano-focus line, the hard and soft x-ray coherent imaging lines, and the soft x-ray scattering line. Beyond these DOE funded NSLS-II facility beamlines, it is reasonable to expect there will be externally-funded Beamline Development Teams (BDTs) that, for example, will be established to develop beamlines for biomedical research, which should be held to the same state-of-the-art standard, and we endorse the suggested BDT approval process. Nevertheless, a consequence of the strategy described in the last paragraph, and strongly endorsed by us, could be that early NSLS-II operations would only involve a small number of beamlines. In view of the existing large NSLS user community, and particularly with the projected short period of simultaneous NSLS and NSLS-II operations, we therefore recommend proactive planning for the possible transfer of beamlines from the NSLS to NSLS-II bending magnet beamlines close to the start of NSLS-II operations, offering the prospect of a larger number of beamlines in operation and users at the NSLS-II soon after the start of operations. Specifically, we recommend that consideration be given to the criteria for deciding whether a beamline is suitable for transfer to NSLS-II, which beamlines should transfer, what the associated costs will be, and in favorable cases when such a transfer should be scheduled. Because this process involves two organizations, it clearly will be a delicate process, and will benefit from early consultations and considerable planning. We would like to see a proposed plan at the next EFAC meeting.

With regard to the synchrotron itself, we generally approve of what is being proposed. Cognizant of the fact that brighter is invariably better, we recommend that the trade-offs, in terms of performance versus cost, involved in going from 3 GeV to somewhat higher energies (3.6 GeV) should be investigated and considered carefully. We also recommend that the possibility of 2 or 3 collinear undulators in one straight section (with refocusing in between, if required on the accelerator side) be very seriously considered, because such an arrangement offers the possibility for a factor of 2 or 3 increase in brilliance at relatively little cost.

Similarly, it is imperative to understand the trade-offs involved in decisions about beamlines and optics. Specifically, we recommend that, in developing plans for standard optics, NSLS-II staff consider carefully and realistically how beamline optics will be used; real case use rather than hypothetical worst-case scenarios should guide designs. As an example, we may inquire whether the choice to use a mask that passes 4σ of the central undulator cone is the most appropriate one. Would 2σ be preferable? Going from 4σ to 2σ would decrease heat load by a factor of 4 and would decrease central cone by 32%, but this loss could be more than made up by using 2 undulators (with focusing between) or by doubling the ring current, either or both of which would yield one half the heat load on downstream optics, but would yield a delivered beam of 1.4 times greater brightness to the experiment! Another example concerns canted damping wigglers. The rationale (in terms of flux to an experiment) for canted wigglers, rather than collinear wigglers with offset masks, needs clarification. By contrast, canted wigglers may introduce considerable complications on the accelerator side. Horizontal mirrors for beam separation (and for alleviating heat load) on wiggler beamlines should be considered as simpler, effective alternatives to canted wigglers. However, especially in the likely scenario that the initial mix of beamlines in the trust fund will all be undulator beamlines, the EFAC recommends an initial focus on the optics for undulator beamlines, since we are concerned that a separate development effort for damping-wiggler-heat-load capable components could be a distraction from the key task of developing undulator-beamline optics. An initial alternative permitting the wiggler spectrum to be made available at an early stage, for EXAFS experiments for example, is to simply use a mask/slits to limit the power to what an undulator-capable monochromator can handle.

In general, the EFAC believes that a single experimental station per undulator is preferable. In some cases, such as the coherent diffraction beamline and the XPCS beamline, both of which are brightness-limited experiments and use only the coherent portion of the beam, splitting the photon beam from the undulator(s) and two experimental stations per undulator may be reasonable. However, in the case of the proposed IXS stations, for each of which it is undesirable to split the beam spatially for signal-to-noise reasons, more than one station per undulator may make less sense – unless it becomes possible to cleverly split the beam in energy and employ different energies in different stations. Each example should be decided on a case-by-case basis.

NSLS has been leading the field of synchrotron infrared spectroscopy and microscopy since the early 90's; it leads this field both in scientific activity and technical innovation. NSLS-II should be in position to preserve this leadership. The request for large opening angles to provide the world's leading flux, well down into the THz range, is fully compatible with the production of high flux, high brightness beams in the far- to near- infrared region. The high energy of the storage ring imposes an innovative design of a modified dipole chamber, where a very unique arrangement is proposed, which is very much appreciated, and requires a detailed R&D. The proposed modified dipole chamber includes a toroid mirror, as the first mirror, followed, in the same dipole vessel by a flat mirror to bounce back the beam outside the dipole chamber toward a diamond window. It clearly appears that design of such chamber should consider the alignment issue, and introduce the necessary ports during the design stage of such dipole chambers. The alignment strategy and procedure and should be carefully considered before designing the dipole chamber. Moreover, the first focusing optics will have to cope with a heat load of up to 30 W/mm^2, mainly distributed around +/- 1.5 mrad at the center of the mirror (which is , however, less that the power load at NSLS). An option of introducing a partially slotted toroid mirror, should be considered, since it opens up the possibility of exploiting the central beam, passing through the slot of the first infrared mirror for an additional, higher-energy beamline. The symmetrical distribution of IR dipole chambers around the storage should be justified, as it could impact in the total cost of the storage ring construction, and on the efficient coupling between complementary techniques. Finally, the effect of top-up mode on the IR source and possible associated beam perturbations should be addressed. Collaboration with synchrotron facilities using this injection mode is encouraged at an early stage.

With regard to the proposed R&D efforts, the EFAC supports all the efforts described. We especially recognize the importance and innovation of developing highly-capable, special-purpose x-ray detectors in order to fully exploit the unique brilliance of NSLS-II. Indeed, the proposed detector R&D projects may represent a new "smart" detector paradigm. Detector development has long lagged far behind the accelerator and optics portions of a synchrotron experiment, and we applaud the NSLS-II for taking a lead in this area and encourage a faster ramp-up of this program if at all possible, even if that involves additional resources.

Achieving an energy resolution of 0.1 meV is a key goal for NSLS-II, and the EFAC was impressed by the clever scheme devised for the IXS spectrometer to achieve this, using multiple, asymmetrically-cut monochromator crystals, and a linear detector. We look forward in the future to understanding the details of this scheme better. Specifically, in the next EFAC presentation on this topic, we ask for a detailed explanation of how the throughput and energy resolution varies with x-ray energy, even for small variations about exact backscattering -- to answer the question of whether this novel setup could also serve as a useful 1 meV resolution spectrometer -- and a detailed explanation of whether or not there are gains to be made by detecting x-rays that are further out of the scattering plane than currently is being considered.

Another critical goal for NSLS-II is to achieve a useful focused 1 nm-sized x-ray beam. To this end, we heard about two possible routes to be pursued as R&D efforts at the NSLS-II: kinoform lenses and multi-layer Laue (MLL) lenses. Kineform lenses appear to have many attractive attributes. Specifically, the technology to manufacture silicon kinoform lenses seems relatively simple and very much in-place. However, we learned that an existing calculation indicates that the minimum focal spot achievable, even with a sequence of silicon kinoform lenses, is limited to 2 nm, although this calculation was criticized. We strongly urge that the focusing properties of sequences of kinoform lenses be the subject of proper, detailed theoretical exploration immediately. The smallest x-ray focus achieved to-date, however, has been achieved with MLL lenses, Nevertheless, the successful development of MLL lenses capable of focusing to 1 nm presents a number of major materials growth challenges, including the precise engineering of the layer thicknesses, which vary over a wide range through the growth process and the precise engineering of the layer tilt, i.e. step density, which also varies through the growth process. We look forward at the next EFAC meeting to learning of the progress in both kinoform and MLL approaches, especially concerning the kinoform-lens calculation described above, and in more detail about how to meet the materials challenges involved in MLL lens fabrication.

In addition to these three R&D thrusts, we also are supportive of the proposed undulator R&D efforts, involving superconducting undulators and new magnetic materials, and the R&D efforts necessary for mirror quality control. Undulator quality is key to x-ray brilliance- particularly for hard x-rays with medium energy rings. We are impressed by the at-temperature measurement plans for characterizing the undulator fields and strongly support this effort. We encourage the staff to engage with other rings around the world that are currently planning on the use of advanced undulator designs to optimize the performance of medium energy rings.

We are also supportive of the plans for enhanced metrology for the NSLS-II. Dr. Takacs pioneered the use of facility-specific and x-ray optics appropriate metrology to improve mirrors at the NSLS. His efforts have influenced the scientific productivity of beamlines around the world. If anything the committee was under whelmed by the modest proposed advances in metrology. Specific concerns are that extraordinary measures may be needed to accurately characterize ultra-precise surfaces. For example, no plans were described for special clean room, or for thermally controlled or vibration isolated environments. Approaches to measure optics at wavelength may be essential as are methods to understand the effects of heat loads, vibrations and thermal drifts on actual optical performance.

With regard to the initial NSLS-II facility beamlines, either implemented using the trust fund or later MIEs, each beamline will be developed by a Beamline Access Team (BAT), envisaged as a bona fide collaboration among both external researchers and NSLS-II staff. In order to make their investment of time in such a collaboration sufficiently attractive to external scientists, instead of the proposed external BAT member share of the beamtime being 50% in the first year after declaring the beamline in question operational, 35% in the second year, and 0% thereafter, we recommend that 21.25% of the beamtime be assigned to external BAT members in each of the first four years. This is the same amount of BAT time in aggregate, but it reflects the likelihood that even after declaring operational, a beamline will probably only achieve its full potential after a couple of years. From one perspective, the BAT is simply the first (set of) Contributing Users and so it seems sensible to us to make an award of beamtime to BAT external users that is temporally distributed similarly to what may be expected for a CU proposal.

With regard to conventional facilities, the EFAC generally approves what is proposed. Because the experimental floor is where users will spend the overwhelming majority of their time while at NSLS-II, we appreciate the efforts made so-far, and encourage additional efforts, to ensure that the experimental floor is as pleasant a working environment as possible. In particular we encourage efforts to make it as quiet an environment as possible.