Committee Report
NSLS-II Accelerator Systems Advisory Committee Meeting
October 8-9, 2007

Members Present:

C. Bocchetta, Instrumentation Technology
G. Decker, APS,
W. Decking, DESY
D. Einfeld, ALBA
P. Elleaume, ESRF, Chair
L. Merminga, TJNAF
D. Rubin, Cornell
C. Steier, LBNL/ALS

Members Absent:

J.M. Filhol, SOLEIL
J. Galayda, SLAC
R. Walker, Diamond Light Source

Introduction

The committee is pleased and impressed to see very good progress in all areas. The project appears in good shape in view of the requirements set for the upcoming CD-2 DOE Lehman review scheduled for November 2007.

The committee is pleased to see the appointment of F. Willeke as Division Director for the Accelerator Systems. The committee expects that his broad experience and expertise will have a great impact on the success of the project. The committee also would like to congratulate outgoing Accelerator Systems Director S. Ozaki for his outstanding work that has guided the project up to this point.

The committee deeply regrets that none of the presentations were available on the web site sufficiently in advance of the meeting. The committee would like to emphasize that the availability of electronic versions of the presentations (either in final or in draft form) on the NSLS-II web site or by mail at least two days before the date of the ASAC meeting is essential to allow a detailed evaluation of the progress of the project. Fulfilling this request can only result in more accurate and valuable recommendations.

The following sections summarize the committee's findings and recommendations in relation to each presentation.

Welcome and Recent Project Developments (S. Dierker)

The committee takes note of the schedule showing procurement starting early in 2009, ring commissioning starting in October 2013, and beam availability to the beam lines in

June 2014. The present schedule includes 15 months of total schedule contingency. The committee regrets that the schedule for construction and commissioning of the NSLS-II facility is not limited by technical or project execution reasons but rather by the expected funding profile from DOE over the coming years.

Regarding the limited office space in the various NSLS-II buildings, the committee recalls that once commissioning is finished a close interaction between engineers, accelerator physicist and the operation group as well as beamline scientists is essential. The experience of many other facilities is that this is facilitated by locating the groups in close proximity. Locating accelerator physics and facility staff away from NSLS-II would make optimal cooperation more difficult.

The cost of the accelerator systems and conventional facilities including contingencies but excluding "burden costs" are in line with the associated cost of the Diamond facility scaled to the ring circumference within the uncertainty in the costing method, which differs between US and UK.

Charge and Response to last ASAC (F. Willeke)

The committee takes note of the numerous reviews that have taken place since the last meeting of ASAC and is pleased by the presentation of the major recommendations from each review.

The ASAC would like to comment on some of the cases where the previous technical reviews resulted in conflicting recommendations.

"Integrate or separate fast and slow orbit correction." The committee believes that the signals from all beam position monitors should be available for both slow and fast orbit correction. It would be highly desirable that all steerers involved in the orbit correction have a large dynamic range as well as large frequency bandwidth. Engineering constraints may result in using different type of correctors with either large range or large frequency bandwidth which could break the integration of the fast and slow orbit correction. Such a break while undesirable is not a major problem, provided it is supplemented by sufficient dynamic simulations for the final configurations to be used. However, as mentioned later all corrector magnets used by the fast feedback system should be identical (including the vacuum chamber they are mounted on).

"Variable or fixed gap damping wiggler."
The committee believes that a variable-gap damping wiggler is the most flexible and desirable solution. In the long term, when a large number of insertion devices will be in operation, the committee believes that it will be necessary to vary the field of one or a few wiggler sections in order to maintain the beam size constant as the users change their gap settings on all undulators. The experience of many other light sources is that excellent beamsize stability is of very high importance.

The only argument against a variable gap damping wiggler is the cost and the space constraints inside the tunnel. The cost involves the design, purchase and control of a multi-ton variable gap support structure as well as the field shimming process. Multipole field errors coming from permanent magnet block positioning errors and non-uniform magnetization are largely gap dependent. Shimming the multipole field errors of a high field wiggler at a fixed gap is considerably simpler (and therefore cheaper) compared to correcting the multipoles for all gap values.

Accelerator System Overview (F. Willeke)

The committee takes note of the multiple appointments of F. Willeke: as Director of Accelerator System Division, leader of the Accelerator Physics Group, and coordinator of the storage ring. The committee wonders whether this may not be too heavy a load for a single person.

The committee recommends a fast ramping of the staff complement in the Accelerator System Division with urgent staff recruitment in the vacuum, controls, diagnostics and Radio Frequency areas. The committee takes note of the concern raised by several presenters that the envisioned staff increase might not be achievable within the required time scale.

Concerning RF, the committee takes note of the proposed initial procurement and operation with only two Cornell type superconducting RF cavities and one klystron-based transmitter. The committee endorses the planned study of alternatives based on IOTs and/or solid state. If the klystron solution is kept, the committee recommends the immediate purchase of a spare klystron tube as well as a complement of spare parts for the single transmitter.

NSLS-II Lattice (S. Kramer and J. Bengtsson)

The committee is pleased to see and endorses the reduction of the number of quadrupoles with a total of 10 quadrupoles and 10 sextupoles per cell. .

Before freezing the quadrupole and sextupole strength and position, the committee recommends the following numerical investigations:

- Small distributed dispersion for reduction of the bare lattice emittance (the parameter to optimize is of course the effective emittance)
- Ultra-small horizontal beta (< ~0.5 m) in a symmetric subset (up to half) of the ID straight sections.
- Implementation of a few (1, 3, 5, …) Longer ID straights of high beta by using doublets instead of triplets and if the study is successful, try to implement them from the beginning.

The committee realizes that there might not be good lattice solutions to those requests and that they can present new problems. However, since each of those changes might provide significant performance improvements for users and the baseline lattice now seems to be in good shape, the committee feels that the opportunity can be taken to study

the limits of the flexibility of the chosen lattice by exploring the above mentioned options.

The committee is pleased to see the progress in the investigation of the impact of insertion devices on the beam dynamics. The committee agrees with the proposed future study of numerical estimation of the dynamic aperture and Touschek lifetime including a full set of insertion devices with their intrinsic nonlinearities, engineering tolerances, corrections, and an accurate model of the physical aperture.

Some committee members expressed their concern about indications in some frequency map plots of diffusive areas in the amplitude space at $x < 10$ mm. There might be a necessity to re-optimize the baseline lattice to allow for better compensation of insertion device effects or to find better compensation schemes within the existing lattice.

The committee recalls that the impact of the Insertion Devices on the dynamic acceptance and therefore the injection efficiency combined with the mandatory topping-up constitutes a major issue. In this respect, the committee warns of the potential severe impact of large period and high field EPUs.

Impedance Calculations (A. Blednykh)

Extensive impedance computations have been performed and an impedance model has been derived. The committee recommends to carry on and extend the simulations to predict the instability threshold as function of the chromaticity. The committee also recommends to review and possibly integrate similar studies carried out at other facilities. A major source of impedance is the gap between flanges which should be minimized. Some projects have adopted special flange designs with small gap or have filled the gap. A full simulation using “gdfidl” is recommended

The committee advises to look at the fast ion instability. Studies performed for the ILC damping rings could be helpful.

The committee recommends to identify besides the nominal 500 mA multibunch mode of operation a typical multi-single bunch mode of operation (such as the 2 bunch mode of ALS or 16 bunch mode of ESRF) to derive the most severe wake field conditions and check that the hardware is compatible (RF-fingers , ceramic chambers, BPMs, HOM absorbers…)

Beam Orbit Stability and Stability Control (L-H. Yu)

The committee is impressed by the detailed simulation of a fast global orbit feedback based on a model of the quadrupole and BPM noise. These studies permit to derive the power supply specifications for the steerer magnets. The committee recommends extending these studies to take into account of the girder stiffness and modes of vibration, latency, noise in BPM electronics, etc. Some of those studies might benefit from numerical simulations of systems with just a few BPM/corrector channels. Extending the

studies will allow to identify which parameters are ultimately limiting the feedback performance such as update rate, BPM latency time, BPM noise, network latency time, corrector DAC resolution, power supply voltage limits, vacuum chamber cut off frequency, etc. This will allow to prioritize the further development program and detailed engineering of the feedback system.

The committee recommends to not limit the required beam stability to 10% of the rms size but make all reasonable effort to reach the smallest figure keeping in mind that a few highly demanding beamlines will always find the beam not stable enough. Several of the existing 3rd generation light sources achieve a short term orbit stability of significantly better than 10% (of course at larger beamsizes), with some user experiments still asking for better stability.

The committee reminds that a beam energy feedback has to be integrated properly into the slow orbit feedback.

The design of the proposed fast corrector magnets is unique, and as such the dynamics of these magnets and their impact on the performance of a global closed orbit correction system needs to be carefully considered. Dynamic magnet measurements of the fast correctors, including the effects of the vacuum chamber should be conducted on a prototype prior to issuing any large procurement of these magnets.

Diagnostic and Feedback System Update (O. Singh)

The committee endorses the proposal for diagnostics. As the measured ring current will be heavily used by a number of beamlines and for the lifetime diagnostic, the committee recommends the implementation of a spare current transformer sometime after commissioning, which implies reserving the space for the associated ceramic chamber in some diagnostic straight section.

The committee recommends the hiring of a scientist/engineer competent in visible and x-ray imaging to take care of the various visible imaging set-ups and pinhole camera in the injector, transfer line and storage ring.

The committee recommends the development of a permanently operating high-resolution imaging set-up in view of accurately monitoring the electron beam dimensions. The proposed pinhole camera set-up can be considered as a standard robust imaging system that could be used initially, but it will have a limited resolution in the vertical plane. The resolution of the pinhole camera grows with the energy of the X-ray radiation, and as a result the pinhole should preferably be installed on a three pole wiggler rather than on a bending magnet and for many reasons not on an insertion device.

The committee recommends that a reasonable effort be made to implement a stable stand for ID BPMs. Monitoring the mechanical position of BPMs with high precision might be a cost effective alternative to improve the performance of the stable stand further, but is not trivial to incorporate into the orbit feedback.

The committee recommends that the absolute accuracy be clearly distinguished from the resolution required for each diagnostic. The committee believes that the resolution required for many of the measurement devices will be much better than the absolute accuracy requirements presented.

Preliminary Design of Injector Complex (T. Shaftan)

The proposed pre-injector consists of a 200 MeV linear accelerator with three klystrons with design based on the Soleil and ALBA linac produced by Thales. While a lower energy and therefore cheaper linear accelerator could be used, the committee welcomes the proposed 200 MeV which, in case of klystron or modulator failure, will provide adequate redundancy for the continuous top-off operation.

The booster lattice is largely derived from the Australian Light Source Booster design, built and commissioned by Danfysik. An additional family of quadrupoles has been added to increase the range of tune variation. The committee is of the opinion that it is a sound design. One member of the committee thinks that the lattice can be further optimized with the use of smaller gradient magnets and shorter damping times.

The project team intends to purchase the booster with injection / extraction magnets but without RF from a single vendor. The committee endorses this strategy and advises the project team to benefit from the experience from other facilities which have made similar decisions.

The committee was not convinced of the practicality of the additional weak kicker in the storage ring injection straight. The committee recommends a manually movable septum magnet for ring injection in order to allow on-axis injection during initial commissioning, and lifetime optimization later on once the beam based alignment is completed and the lattice is fully corrected. For the next meeting the committee asks for a detailed presentation of all booster components

The committee takes note of the plan to potentially stack beam at injection energy in the booster. This will likely have a significant effect on injection elements and detailed injection tracking studies should be performed.

Vacuum System and Front-End Preliminary Design (H. Hseuh)

The committee recommends that the project team defines the maximum ring current that can be operated safely without active machine protection system during commissioning. The proposed 0.5 mm interlock threshold for triggering the machine protection system looks somewhat small and may result in a number of unnecessary beam trips.

Large periods and high field EPUs generate radiation in a large vertical angle which may require a local change of the bending magnet as well as crotch chamber design. The

committee notes that the case with highest heating on the vertical aperture can be close to circular polarization (rather than vertical polarization).

Permanent magnet protection in the front-end of the beamlines to resolve potential radiation safety issues with top-off operation appears as a promising concept but requires further study. Issues such as a potential need for horizontal masks as well as a possible demagnetization of the magnet material exposed to X-rays must be looked at. Enough space has to be allocated early on in the front end and beamline design and safety experts have to be fully involved.

For in-air insertion devices, it is proposed to use the APS type ID chamber with NEG strips in a wide antechamber. Several members of the committee believe that the ESRF type flat chamber with NEG coating implemented in many facilities is cheaper to produce, will provide less volumetric constraints for the insertion devices and could also have a cost saving impact for the damping wigglers.

The committee recommends to qualify the thermo-mechanical designs of absorbers using temperature as well as stress or strain criteria.

Based on the experience on existing light sources the committee is not convinced that TiN coating is needed in the vacuum chamber in order to reduce the desorption. The committee believes that this could have a serious impact on the planning and cost of the vacuum system.

Progress in preliminary magnet design and Prototyping (J. Skaritka)

The committee is impressed by the level of engineering and prototyping progress for the storage ring magnets.

The committee recommends to use a single type of corrector magnet for fast orbit correction. If the correctors are placed above the bellows, the influence of the RF fingers on the field penetration has to be taken into account.

The committee endorses the proposed strategy of building the magnets to spec. with a baseline reference design in order to make best use of the expertise of the selected company.

The committee believes that a curved dipole magnet is the best solution considering the significant length of the dipoles.

A test on a 6 m vibrating wire has shown a resolution of 5 microns in the positioning of a quadrupole. As the method of alignment proposed is quite innovative and aims at precision positioning much improved compared to conventional methods, the committee recommends to investigate all sources of errors in detail: wire sag and wire defects. One should also assess the repeatability of the magnet positioning following a replacement of the wire.

The Procurement plan looks reasonable

Recent Changes and Results in Insertion Device Design (T. Tanabe)

The wedge pole wiggler magnet design is known to be more expensive than straight magnet and pole design. In addition, for reasons of patenting, the adoption of such a design will prevent the issue of a competitive call for tender. The committee recommends studying an alternative straight magnet design with side magnets.

For a fixed gap structure, the free parameters for damping wigglers are the spatial period and the peak field. Complexity and costs of the magnetic structures of the damping wigglers increase drastically above some peak field (for a fixed period) and below some period (for a fixed field). Both parameters have different effects on the ultimate equilibrium emittance. The committee recommends the optimization of the peak field and period performed in a global manner including cost and efficiency in the emittance shrinking taking into account of all sources of emittance growth.

Once the accelerator facilities will be completed, further improvements of the source will mostly be possible through the improvement and refurbishment of insertion devices. As a result the committee recommends the development of a solid in-house expertise in insertion device technology. To do so, a dedicated insertion device laboratory should be created and the production or the purchase of up-to-date magnetic measuring benches should be carried out. Several vendors can provide such tools including the processing software. Even if the heavy workload and the lack of resources may force the purchase of some insertion devices or damping wigglers from industry, it is strongly desirable in order to develop the expertise that one or a few devices are built in house. In this spirit, many recently built synchrotron radiation facilities have built all or most of their insertion devices in-house. In case of industrial procurements, the committee recommends to build to spec and to provide a baseline reference design.

The committee does not see the need to remotely align the vertical position of in-air undulators or wigglers while having this capacity for small gap in-vacuum undulators could be envisaged to compensate for alignment error and ground settlement.

3 meter long in-vacuum undulators are proposed with a 3-4 m long rectangular flange parallel to the beam in order to perform magnetic field measurement without detaching the main vacuum vessel. While there are many different engineering paths to solve the same technical problems, the committee would like to emphasize some of the difficulties to be met in this new approach. Long rectangular flanges have shown a poor record of compatibility with UHV. A worry is a leak opening during baking. The field measurement apparatus cannot be suspended from the flange which is likely to deform under vacuum.

Control System (B. Dalesio)

The committee endorses the plan of selecting EPICS and the Matlab middle layer toolkit for both of which a large experience exists in the US. The committee also recommends to continue the already started collaboration with other laboratories within the US that have significant expertise in state of the art FPGA systems (for RF control, fast orbit feedbacks, multibunch feedbacks) but also to keep an eye on commercial systems now becoming available.