Committee Report
NSLS-II Accelerator Systems Advisory Committee Meeting
April 23-24, 2007

Members Present:

G. Decker, APS
D. Einfeld, ALBA
P. Elleaume, ESRF, Chairman
J.M. Filhol, SOLEIL
J. Galayda, SLAC
R. Walker, Diamond

Members Absent:

C. Bocchetta, ELETTRA
W. Decking, DESY
L. Merminga, TJNAF
D. Rubin, Cornell
C. Steier, ALS

The committee was pleased to see the progress and the active development of the project in many areas. The following summarizes its findings and recommendations in relation with each presentation.

NSLS-II Project Status (S. Dierker)

The committee takes note of the revised project schedule with start of construction in FY09, commissioning of the ring complete by the end of 2013, and CD-4b (Approve start of operations) in Dec. 2014, and believe that this gives adequate time for procurement, installation and commissioning.

The committee wishes to be presented, at the next meeting, an overall schedule of the project, highlighting the links or conflicts between the building program, the accelerator program and the beamline program.

The committee takes note of the fact that both ASAC and the DOE reviewers express recommendations in the same field of competence. The ASAC committee requests that NSLS-II management clearly identifies which of the DOE recommendations they would like the ASAC to comment upon, if any.

The committee fully supports the strategy of moving the most productive NSLS I bending magnet beamlines to three pole wigglers on NSLS-II.

Concerning the revised building program, the committee understands the need of saving money on building infrastructure but recall the importance of keeping the offices of accelerator staff (machine physicists, RF, Diagnostics,..) as close as possible to the NSLS-II control room to maximize their interaction with the operation crew.

NSLS-II Accelerator Systems (S. Ozaki)

The committee greatly appreciates the detailed answers provided by management to the points raised by the ASAC after its last meeting.

The committee is not fully convinced of the need of canting the damping wigglers and emphasizes the associated complexity.

The committee takes note of the management decision to implement a small size booster in a separate building extension with extra cost, but with an easier organization of the installation, testing and commissioning. The committee takes note of the intention to subcontract the magnet and vacuum hardware of the booster to industry but emphasizes the responsibility of the project team in the system integration and recommends substantial involvement in the lattice, magnet and hardware design of the booster.

The committee takes note that an overall unburdened and unescalated budget of 136 M$ of capital spending on the accelerator system will still need to be revised in view of the changes made since the CD-1 Review. The committee believes that this budget is low compared to similar projects scaled to the size of NSLS-II.

CD2 Lattice Improvements (S. Kramer)

The committee is pleased with the reduced number of quadrupoles in the storage ring lattice and the increased portion of the circumference dedicated to Insertion Devices. The committee wonders whether it would not be of interest to accommodate two kinds of long straight sections. Some extra long would have high horizontal beta, one of which being reserved for injection. Some others would have reduced horizontal beta functions and would be ideally fitted with damping wigglers. Such a solution would not compromise the high symmetry of the lattice, though reducing it.

The committee is not convinced of the need of the 5^{th} (or trim) quadrupole added in the center of the achromat. The committee takes note of the 10 families of sextupoles which look adequate in view of the large number of cells, but wonder if the number of sextupoles per cell (13) could be reduced. This should be clarified at the next meeting. The committee believes that the lattice could be further optimized by rising the gradient in the quadrupole to 22 T/m and by bringing the first quadrupole closer to the bending magnet. As a result of such optimization the length available to insertion devices could be further increased.

The committee fully supports the placement of the three pole wigglers immediately upstream of the second dipole of the cell.

The committee recognizes that the integration of the slow orbit correctors inside sextupoles, as done in many facilities, would enable to save space, but may introduce extra complications through the associated undesirable multipoles as well as the

nonlinear crosstalk with the main sextupolar field. It recommends a detailed study of this point.

The committee recalls that the circumference of both the storage ring and booster need to be a highly factorable number multiplied by the RF wavelength.

A 20 mm horizontal dynamic aperture at the injection point including insertion devices effects appears as a reasonable design goal. As a result, any options or tunings resulting in a shrinking of the dynamic aperture below 30 mm due to IDs or lattice errors should not be rejected (provided it is still above 20 mm). Similarly, the vertical dynamic aperture needed shall be equal to the physical aperture set by the ID gaps or vessel internal aperture.

Modeling and Guidelines (J. Bengtsson)

The committee is pleased with the experiment made in collaboration with SLS to control the non-linear lattice directly through the Lie Generator coefficient rather than through the sextupole currents of each families. The committee recommends continuing and deepening such studies which add understanding to the non-linear lattice, and give confidence in the modeling.

The various methodologies developed world-wide to simulate insertion devices in tracking codes have been well identified. It appears that detailed studies of the effects of IDs on the beam are just about to start. Whichever method is used, the committee recommends comparing it with the kick map method which is easy to implement and allows fast tracking. The committee is skeptical about the use of the Halbach-type mode decomposition for the description of the elliptically polarized undulators. The method selected must be deeply connected with the 3D magnetic design of the insertion devices.

The committee feels that the most urgent task in this area is to finalize the magnetic design of the damping wigglers and to ensure their transparency to the beam. The committee believes that the two main issues are the harmonic content along the beam axis and the sufficient horizontal width of the magnet assembly .

Injection System with a Booster in Separate Tunnel (T. Shaftan)

The committee is pleased with the injection tracking studies and recommends their continuation, including all insertion device effects and lattice errors.

From experience elsewhere, the committee is not fully convinced that the present high beta straight for injection is long enough to accommodate injection equipment, and in particular is fully compatible with state of the art top-up requirements. In order to assess the adequacy of available space, an engineering layout of the injection straight of the storage ring should be generated. It is the feeling of the committee that a longer straight for injection could easily be accommodated in the lattice (see comments above).

A possible operation at a 3.6 GeV energy was mentioned several times and the committee recalls that if NSLS-II intends to run at this energy, it should be included in the specifications of all systems such as magnets, absorbers, RF, Booster, and injection/extraction systems.

The committee recommends a horizontally movable septum magnet at the ring injection point in order to ease commissioning through a near on-axis injection configuration as well as to optimize the kicker currents in relation to the final horizontal aperture.

The Australian Light Source booster lattice design which is used as a reference design for the proposed booster lattice presents the drawback of limited flexibility in the tunes. The committee recommends the investigation of solutions which increase the accessible tune range.

The proposed lattice for the booster synchrotron is pretty tight and the committee ask for an engineering layout in order to check that there is enough space for the correctors, diagnostics, vacuum pumps, etc. The committee recommends that the space required and the positioning of injection and extraction magnets inside the booster lattice be investigated (in particular the impact of the high value of the dispersion function in the injection and extraction straights has to be evaluated as well as the low beta values).

The committee notes that there is no definite requirement yet for hybrid filling modes, but nevertheless recommends including this capability from the outset, since a need is almost certain to arise in the future.

Regarding the issue of whether or not to use a single power supply for all storage ring injection kicker magnets, the committee believes that there will inevitably be differences from kicker to kicker (due to mechanical tolerances, thickness of ceramic coating, etc.). So the committee recommends that individual power supplies be used in order to optimize the bump closure and hence minimize the disturbance of the stored beam, in view of top-up operation.

Stability Issues (S. Krinsky)

The committee is pleased to see that the project takes stability issues very seriously and encourages the continuation of the stability task force activities. Several international workshops have taken place in the past on this subject for which data and reports are available from the web, specifically at

http://acc-web.spring8.or.jp/%7Eoper/beam-stabilize-ws/index-e.html
http://www.spring8.or.jp/ext/en/iwbs2002/
http://iwbs2004.web.psi.ch/

The project is considering two kinds of bending magnets for the storage ring in order to accommodate the large aperture required by the infrared beamlines. The committee believes that implementing two independent family power supplies is preferable for beam

position stability compared to a single power supply with shunts or trim coils on the magnets.

The committee supports the recommendation of the stability workshop namely to use 20 bits (18 bits) resolution in driving the corrector dipoles (quadrupole) power supplies.

The committee recalls some of the limitations when using Xray Beam Position Monitors (XBPM) : pollution by bending magnet radiation, gap dependence, sensitivity to the type of insertion device, offset from upstream aperture. One XBPM per beamline front-end is desirable to cross-check the stability of electron BPM. Two XBPMs may be a working solution in some cases but require a placement as far apart as possible. The committee fully supports the idea of organizing a workshop on XBPMs.

Along these lines, implementation of the "Decker distortion" should be carefully considered. Use of ultraviolet radiation in a photon BPM design becomes feasible only with this lattice modification. This might also improve performance of any new hard x-ray BPM, by simplifying the radiation field patterns present in the beamline. The lattice modification is most easily included early in the design phase, and should have little impact on overall machine performances.

Multipole Girders- Alignment and Stability (S. Sharma)

It is the opinion of the committee that the proposed vibrating stretched wire set-up for aligning the quadrupoles and sextupoles on a girder has a lot of potential. A major difficulty is the large value of the sag which requires measurement and compensation. Local wire defects may introduce offsets along the wire. The committee recommends a deep study on this as early as possible in order to eliminate systematic and random errors. The committee also asks to investigate the accuracy that could be achieved by using this wire technique to correctly position the magnets roll angle (source of coupling of the beam through the associated skew quadrupole) .

The proposed girder fixation on the floor is simple but should be experimentally tested using a prototype girder as soon as possible, to determine ease and accuracy of alignment, as well as performance in terms of vibrations, reaction to thermal changes etc.

The committee approves the shift of resonant frequency of the girders above 50 Hz

SR Vacuum Systems and Front Ends (H-C. Hseuh)

The committee is pleased with the strategy to collaborate with APS for design and construction of extruded Aluminum chambers.

Beware of a possible perturbation of the BPM signals by TE modes excited by the beam inside the chamber and antechamber (reported by APS).
Beware also of the initial large offsets of the BPM readings on day one (reported by APS), that requires BBA to be done very early.

The committee was surprised by the estimated low pressure reported at the damping wiggler absorber. The graphs presented should give information on the condition of computation (accumulated dose, degassing coefficient etc.). The committee recalled that copper absorbers re-emit about 10 % of the incident power (as a rule of thumb) by fluorescence and scattering, that contributes to outgassing of the surrounding aluminum vessels.

A mirror is intended to be placed inside the bending magnet chamber to collect infrared radiation. This mirror should be safe under possible large closed-orbit distortions that will take place during machine studies. Water cooling also brings vibrations which are known to be a problem on many infrared beamlines.

In relation to the preliminary design of the front-ends, the committee believes that starting the front-end with a manual interlocked gate valve, followed by a simple fixed bending magnet radiation absorber, is in the end a cheaper solution (adopted by Soleil, Diamond, ESRF,…).

Undulator Development (T. Tanabe)

The field specifications of the damping wiggler should be finalized urgently in connection with its effect on the beam dynamics (see above) .The pole width of the damping wigglers has a strong impact on the volume of magnetic material and on the magnetic forces, and should be carefully optimized with an appropriate margin. Damping wigglers are likely to be needed early during ring commissioning in order to secure a sufficiently short damping time and allow the ramping of the current. Finalizing the magnetic and mechanical design and prototyping the wiggler should be the first well-defined task for the insertion device group.

The possible crosstalk of field integral between the three pole wiggler and the adjacent bending magnet should be studied and if needed an active or preferably passive compensation should be worked out.

Cryogenic permanent magnet undulators are a step forward in terms of peak field from in-vacuum undulators which come with additional construction costs. Significant engineering effort is required in this direction.

The committee supports the need for a proper insertion device laboratory that is compatible with the R & D needed and should include a clean room and temperature stabilization.

Storage Ring RF (J. Rose)

The committee appreciated the clear presentation and comparison of the different solutions of RF cavities for the storage ring in terms of both cost and technical performances.

The committee supports the conclusion of using superconducting cavities and agrees with the proposed strategy of purchasing a spare cavity on top of the two required for the first phase.

Radiation Shielding: Assumption and Design (R. Casey)

The committee notes that the conditions of the shielding calculations are conservative and assume worst loss conditions. The results for the proposed shielding type and thicknesses are in line with what is done in many other facilities.
The committee would like to understand the impact on the machine operation of declaring the tunnel roof, where all the power supplies and electronic cubicles are located, as a "no full-time occupancy area".

The committee recommends that detailed analysis of the radiation protection issues associated with top-up operation be started soon. While it may seem apparent that the primary failure mechanism, namely a shorted main bending magnet, is incompatible with stored beam, it is a nontrivial exercise to prove this for partially shorted magnets, e.g. shorted turns. For example, reverse particle tracking through beamline front ends and periodic validation of the location of certain accelerator components is required at the APS for top-up personnel safety. Top-up operation at the ALS has been delayed by the complexity of this type of study.

NSLS-II Footprint (F. Willeke)

The committee takes note that a future upgrade into a 15 m long straight section could double the flux and brightness for selected beamlines but believe that such a break of the lattice symmetry could impact the operation of all the other beamlines. It is also not convinced that there are many beamlines whose performance is critically determined by a factor of two improvement in flux. The committee re-iterates its opinion that it would be preferable to design the ring with a few longer straight sections from the very beginning.

Concerning a possible upgrade path to an Energy Recovering Linac (ERL), the committee found that the increased brightness at photon energies up to 30 keV did not appear large enough to justify the very high cost of such a machine. The brightness is markedly improved at photon energies near 100 keV, but this is largely as a result of the higher energy (4GeV vs. 3 GeV). Operation of NSLS-II at 3.6 GeV would close this gap.

General Comments

The committee would like to have more details on the followings items for the next meetings of ASAC:

- Magnets (design, specification, strategy of procurement, measurement) of dipoles, quadrupoles, sextupoles and correctors
- Closed orbit correction, including feedback

- More detailed presentation on front-end layout in general with a particular attention to all absorber design downstream the damping wigglers
- Diagnostics on Linac, transfer line, booster, storage ring and active machine protection system
- Control system