

NSLS-II Accelerator Systems Advisory Committee (ASAC)

Report of the fourth meeting, July 17th and 18th, 2008.

Committee Members Present :

G. Decker, APS,

W. Decking, DESY

D. Einfeld, ALBA

P. Elleaume, ESRF, Chair

J.M. Filhol, SOLEIL

J. Galayda, SLAC

D. Rubin, Cornell

C. Steier, LBNL/ALS

R.P. Walker, DLS

Members Absent :

C. Bocchetta, Instrumentation Technology

Introduction

The committee is pleased and impressed to see very good progress in most areas. The project appears in good shape in view of the requirements set for the upcoming CD-3 DOE Lehman review scheduled for Late 2008.

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

Welcome and Project Status

- The expected time duration of 4.5 years between the ground breaking and the first beam in the storage ring appears reasonable in comparison with other recent facilities which required 3.5 years, some with a circumference which was significantly smaller.
- When establishing the spending profile, the committee wonders whether the payment conditions of the contracts have been taken into account, which usually spread the payment over the duration of the contract. This allows placing orders for critical items early-on while delaying the major payment after the site acceptance test. The committee encourage NSLS-II to negotiate the corresponding staged contracts with vendors
- The committee believes that the Accelerator Systems are sufficiently well advanced to be able to start procurement in the near future.

Accelerator System Overview

- The committee believes that the procurement of the linear accelerator is scheduled too late in the current project plan and recommends the placement of the contract at least 2.5 years before the planned beneficial occupancy of the linac tunnel. A similar strategy should be applied to the booster procurement.
- The committee recommends grouping the call for tenders for the linac and for the linac front-end into a single one, in order to have one single supplier responsible for the linac performances.
- The committee believes that the required single bunch and multibunch performance can be obtained from a commercially supplied linac, using the same thermionic triode gun. It is a question of a proper design of the electronics driving the cathode, grid and anode as well as a proper control system to quickly switch between optimized settings for all downstream elements. We therefore see no motivation to purchase a linac frontend separately and early. Such gun providing both single bunch and multibunch capability are in operation at ESRF, SOLEIL, DIAMOND and ALBA.
- The committee realizes that significant effort in accelerator physics had to be spent to evaluate specifications for the prototype magnets, diverting resources for the planned work on the dynamics impact of insertion devices. We believe that a thorough study of the impact of IDs is essential at this point, including an analysis and optimization of necessary correction schemes. The results should be presented at the next ASAC meeting.
- A number of recommendations were made concerning options and flexibility of the ring lattice at the previous meeting of ASAC. The committee notes that little has been done in this direction. The committee strongly recommends that the power rating of all quadrupoles and sextupoles is checked with respect to such possible lattice evolutions. In particular, the achievement of ultra low horizontal beta in the low beta ID straights requires a stronger quadrupole in the middle of the triplets located on both side of the insertion device.
- In connection with the use or not of variable gap damping wigglers, the committee would like the project team to clarify its strategy to ensure constant beam size during gap variations from the beamline users. The committee re-insists on the importance of starting an R&D program within the ID group as well as establishing an ID laboratory. This looks particularly crucial in view of some recent failures by ID vendors.
- The committee would like to see more information on the need of 10 pole correctors for the ring lattice.
- The committee realizes that previous recommendations of other committees and workshops were strongly in favor of Decker distortions. In light of the fact that XBPMs seem to be working satisfactorily in Diamond without Decker distortions, the committee suggests to revisit the

justification for the implementation of the Decker distortion scheme and report at the next ASAC. Since the dipole field is lower in NSLS-II this should make the situation easier.

- Effort should also be put into the design of improved insertion device XBPMs. This is a topic on which collaboration with other laboratories could be beneficial.
- The committee urges that the project increases the staffing in the insertion device, and diagnostic group as well as the design room. It should also be evaluated whether the very recent staffing increase in the RF group is sufficient. The committee couldn't evaluate if there are enough resources to work on injection pulsed magnets and power supplies.

Accelerator Physics

- The committee is concerned about the sensitivity of the dynamic aperture to systematic multipole errors and is not entirely convinced that the improvement gained by the high quality quadrupoles and sextupoles is required. The committee wonders if the associated gain in dynamic aperture will not disappear if one takes into account other field errors from quadrupoles, sextupoles and insertion devices.
- The committee would like to see the tracking calculations extended further. The tracking should include random non-systematic errors in the quadrupoles as well as a reasonable set of insertion devices and damping wigglers with all their nonlinearities, as well as the higher multipoles of the bend magnets and correctors. Effective correction schemes for the effects of insertion devices need to be developed and tested for robustness and ease of implementation. It should be evaluated, whether individual control of sextupoles would allow for better compensation of insertion device effects.
- From experience at Diamond (which has) and Soleil (which doesn't have), the committee recommends independent sextupole power supplies. Recent progress in beam based diagnostics makes it likely that the additional knobs can be used in the future to optimize machine performance. If individual control of all sextupoles is not possible or too costly, at least all three sextupole families presently in the short achromat straight section should be powered each with one dedicated power supply. Such a scheme will help tuning the non-linear chromaticities.
- The committee is pleased to see that the top-off requirement is taken into account very early in the project with tracking being performed in collaboration with other laboratories. The committee believes that, as was the case at ESRF, the issue could be critical only for the first or first few beamlines located immediately downstream of the injection point. However, it is also possible that all beamlines could be potentially affected, as is the case at APS, ALS, and Spear-3. The committee realizes that the studies are at a very early stage and would like to see an update at the next ASAC meeting.

Injection Systems

- The committee wonders whether including the RF system in the booster contract may not simplify the acceptance test.
- Reducing the perturbation of the stored beam in the storage ring during injection is a major and challenging issue for a successful top-off operation. In this respect, the committee suggests the study of a new injection scheme using a pulsed quadrupole or sextupole magnet (or higher order multipole) type of injection as recently achieved at KEK and being studied at BESSY.
- The committee recommends that the pumps and gauges be standardized across the storage ring, transfer lines, booster and linac.
- The committee notes that the new requirement for relatively high bunch purity in multi bunch mode presented at this review has quite significant implications for necessary beam diagnostics equipment as well as cleaning systems.

Magnet System

- The committee is impressed by the substantial design work and detailed study presented.
- Some multipole content specifications for quadrupole and sextupole amount to values as low as 0.1×10^{-4} on a 25 mm radius, which results in a field of roughly 0.03 Gauss. As mentioned above, the committee is doubtful of the justification of such requirement in view of the non-systematic multipole errors as well as contribution from the insertion devices (design and random). Even if the high quality is needed, the committee believes that laser cutting of the laminations could be sufficient to achieve the required tolerances, without high precision machining. If the need for the stringent tolerance on the 20-pole is confirmed, then other sources of such errors must be identified and addressed (including measurement strategy), such as end effects in the quadrupoles, dipoles, correctors, etc.
- Regarding the measurement of such weak multipole coefficients, the committee points out that a larger radius standard coil might be sufficient, instead of the rather sophisticated new design that was proposed. If it is decided to proceed with the latter, then the sensitivity of such a coil to fabrication errors should be checked.
- To be able to monitor the high precision mechanical tolerance of the pole positions of the quadrupoles and sextupoles, it is advisable to have flat segments at the ends of the pole profiles to assist in mechanical inspection.
- The committee looks forward to seeing results of the tests of the corrector magnet, including its dynamic performance. Because the corrector magnet power supplies comprise a potential source of beam motion, these tests should also be used to quantify power supply AC stability.

Ground Motion and Vibration Analysis

- The committee is impressed by the very comprehensive study which goes much beyond anything made so far in previous facilities. The committee concurs that the focus now should be on eliminating sources of vibration by suitable designs and specifications for support systems for the mechanical utilities.
- The committee recommends a finite element analysis of the building cross-section under variable heat load from sun and wind and to check the associated distortion of the floor of the ring tunnel. This has been a problem at the KEK Photon Factory. In this context, the committee is concerned by the proposed way the building columns are anchored with local foundation protruding under the storage ring tunnel. This could act as a lever arm, amplifying effects of heat expansion of the roof. It could also cause differential local settling of the storage ring tunnel.

Girders and Alignment R&D

- The issues have clearly been taken very seriously by the project. A number of details have already been worked out. The committee recommends continuing in this direction with high vigilance.
- The committee is impressed by the results of prototype girders showing that resonance frequencies have been shifted successfully to high values.

- The precision of alignment of the quadrupole and sextupole is linked to the straightness of the wire and the compensation of the sag. The project team has already taken this fact into account by monitoring the sag through the resonant frequency and operating the wire close to the break limit. The committee recommends checking the repeatability of the alignment with different wires (or different longitudinal positioning of the wires) and checking the possible perturbation from a damaged wire having kept memory from an accidental folding.

Vacuum System

- The committee is impressed by the progress.
- It was not clear under which extreme conditions of beam misalignment the vacuum system integrity is maintained. What is the beam position interlock threshold ? It is important to know the maximum passively safe stored beam current that can be allowed for any possible missteering condition. This may impact the commissioning plan if the value with damping wigglers turned out to be unreasonably small.
- The project team is well aware of the possible interference of BPM reading with trapped modes induced by the beam. The committee would like to see the result of such studies at some future ASAC meeting.
- A bake-out test of an APS vacuum chamber using electrical heaters instead of pressurized hot water was reported to have been successful. In view of the limited space between the sextupole pole pieces and the vacuum chamber, it is unlikely that heater and insulation jacket can cover the whole chamber. The committee recommends continuation of the tests with a realistic arrangement of heaters, insulation and magnets.
- The committee is worried about the narrow gap between the sextupole poles and the vacuum chamber. It recommends increasing it in order to have enough clearance with respect to possible positioning errors.
- Concerning the choice of RF finger design (inside the bellows), the committee recommends checking whether the reduced wake field is worth the extra cost of the outside finger design which is in use at Diamond and Soleil.
- The committee recommends the project team to study and report what is the highest vertical K value EPU compatible with the storage ring vacuum chamber design. This result could provide an important boundary condition for the design of beamlines.

Power Supply R&D and Design

- The committee appreciated the very comprehensive presentation and appreciates the centralized approach in dealing with electrical distribution and air cooled electronic cabinets.
- The 100 ppm specification for the stability of the quadrupole power supply looks insufficient.
- This seems to be generally true for other power supplies (dipoles, sextupoles, corrector magnets as well). Looking at the Preliminary Design Report , the corrector power supplies are allowed to drift by a substantial amount over a time span of only 10 seconds. This would put a big load on the orbit feedback system and would make precision accelerator studies without feedback very difficult. In user operation, the relatively poor stability specifications of all power supplies is likely to impact orbit stability, energy stability and beam size stability. State of the art technology delivers much better performance on existing synchrotron light sources. The committee

recommends working out an improved stability specification distinguishing the short, medium and long time scale requirement and to tighten the specifications to reasonable state of the art values.

- The committee advises as much standardization as possible of power supplies and their controllers and control interface across linac, booster, storage ring and transfer lines.

Diagnostics Design & R&D

- The committee recommends a careful analysis of beam induced button heating under all envisaged operating conditions.
- The committee regrets not having received any information on the planned diagnostics for the linac, transfer lines and booster. In this respect the committee recommends a close interaction with the people running the Australian Synchrotron Project booster which have reported a lack of diagnostics.
- A second pinhole camera on a bending magnet should be investigated in order to allow both energy spread and emittance to be determined. The committee realizes that the planned zone plate monitor will allow this as well, but believes that a pin hole might provide a less risky and low cost backup.
- The responsibility for the multibunch transverse feedback should be clarified.
- At least one removable fluorescent screen should be included in the storage ring injection straight.
- The recently added requirement for bunch purity in multibunch operation will require a dedicated bunch purity monitor.
- The committee would like to see a comprehensive overview of all planned diagnostic systems in LINAC, Booster, transfer lines and storage ring at the next ASAC meeting.

Overview of Ring Building and Conventional Facilities

- Most facilities operate with compressed dry air but no nitrogen inside the ring tunnel. The committee sees no need for compressed nitrogen. The committee also cautions that a centralized nitrogen gas system should not be used to vent vacuum systems to avoid potential contamination.
- Concerning the projected placement of the control room of the accelerator systems in the NSLS-I building, the committee sees no major technical difficulty and understands the goal of saving building cost. Some of the committee members are nevertheless concerned that such a solution may result in looser links with the beamlines, the experimental hall operators as well as more complex intervention in case of failure of the accelerator system or intervention linked to safety.
- From experience at other facilities, the committee would recommend implementing immediately or later a central control room located next to the ring tunnel gathering accelerator facility operators, accelerator physicists, experimental hall operators and centralizing conventional facility control (fluids, cryogenics,...) as well as safety (emergency telephone, water, fire alarm,...).
- The committee endorses the project plan to have a staged beneficial occupancy approach in the building contract. However, the committee is concerned about the currently planned order. The

linac tunnel and associated conventional facilities: electricity, fluid, compressed air,...(in a final or temporary state) should be available early-on during the building contract. This would be followed by a second beneficial occupancy of the booster tunnel followed by each pentant of the storage ring. This approach spreads the commissioning of the various accelerator systems over several years. It has been followed by many facilities world-wide and resulted in a smooth commissioning of the linac, transfer line, booster and ring while allowing further civil engineering works in other part of the building .

- The committee recommends that the complete de-ionized water system (up to the equipment manifold) should be under the responsibility of the conventional facilities people. The current proposal to have the higher stability part of the system under the responsibility of the accelerator division is unusual and may results in doubling the number of required skilled people..
- A number of facilities have suffered from problems and delays linked to dirty water pipes installed as part of the building contract. Filters with associated pressure drop monitoring should be placed in the de-ionised water system outside the ring tunnel at accessible places upstream of the accelerator systems. Ideally one such filter should be placed per cell or at least one per pentant depending on the design of the water distribution lines.
- Availability of the infrastructure utilities should be much higher than 95%. 95% is a minimum figure for the whole the facility and include both conventional facilities and accelerator systems failures. The reliability of the services feeding the cryogenic plant is especially important. This should be evaluated in the context of an overall availability budget of the facility, where individual availability goals are established for all subsystems to guarantee the overall 95% goal.

Response to the Charge :

Is the NSLS-II Accelerator Systems R&D program sufficiently advanced to support the remaining design work?

In general yes, with the exception of insertion device development.

Is the maturity of the design and development of the accelerator system consistent with the Final Design Plan and are the interfaces with the NSLS-II building and other conventional facilities sufficiently well defined for start of construction of the ring building?

The committee agrees that not all of the accelerator designs need to be finalized before making major procurements. From what has been presented and discussed, the design of the accelerator systems and their interface with the projected conventional facilities is mature enough to launch the procurement of the accelerator building.

Is the storage ring magnet system, including the planned linear and non-linear correction systems, adequate to achieve the required accelerator performance?

Concerning emittance, lifetime and injection efficiency of the bare machine (without insertion devices), the committee is confident that the planned linear and non-linear correction system is suitable to achieve the accelerator performance. Effects of insertion devices on the beam dynamics need to be studied further and correction methods need to be developed and optimized.

Do the design choices of the injector system support the anticipated storage ring performance parameters and is the preliminary layout sufficiently well defined to start the turn-key procurement process in 2009?

Yes, and the committee recommends that the order for the linac be placed early in 2009.

Alignment and stability R&D will be completed soon. Are the proposed procedures sufficient to guarantee that the tight alignment tolerances will be routinely achieved during the installation process?

All efforts that could be done at this stage have been made and should enable the tight alignment tolerances to be met during the installation process. Do not forget to test the repeatability of all alignment processes.

Are the planned diagnostic systems sufficient and adequate to allow for efficient commissioning and accelerator tune-up?

Yes for the storage ring. We have not seen the planned diagnostics for transfer lines, booster and linac.

Comment on the status of cryogenics system, electrical and mechanical utilities.

Fluid and electrical distribution seems well in hand. No information was provided concerning the cryogenic system.