



Final Report
for
NSLS-II Comprehensive
Design Review
at
Brookhaven National Laboratory

September 11-13, 2007

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Executive Summary

On September 11-13, 2007 a Comprehensive Design Review of the NSLS-II project was held at Brookhaven National Laboratory. The NSLS-II project is being carried out to design and build a world-class user facility for scientific research using synchrotron radiation. It will be highly optimized to deliver ultra-high brightness, flux and exceptional beam stability to enable the study of materials properties and functions down to a spatial resolution of 1 nm and energy resolution of 0.1 meV with sensitivity to single atoms. The objective of the NSLS-II Comprehensive Design Review was to assess the status and adequacy of the overall NSLS-II preliminary design effort.

The review team had twenty members and included technical experts in accelerator science, experimental facility operation, and conventional facility design from several of the world's leading synchrotron light source facilities and national laboratories. In a series of talks and discussions the committee saw evidence of a sound preliminary design and a sound approach towards a detailed design, based on specifications derived, or in some cases being derived, from the scientific requirements.

The project has built upon a quite advanced conceptual design report prepared last December. Design work has continued since then at an accelerating pace. There is a well-established organization in place and it is growing rapidly. The project team is very knowledgeable and enthusiastic and has strong support from the Laboratory. The team is built from existing expertise at BNL along with new appointments. However, it has not yet reached full strength and recruiting is continuing.

The critical path for the project and the dominant cost drivers are the Conventional Facilities and Accelerator Systems. The designs for these are the most advanced.

The Accelerator System consists of a linac and booster injection system and a storage ring ~ ½ mile in circumference. The 3GeV beam energy and 500mA beam current provide for broad spectral coverage along with high brightness and flux. The lattice design along with several novel and challenging features will produce these beams of exceptionally small size and low emittance. The girder and support systems are designed for high stability and low cost. The vacuum system is based on extruded Al as a conservative approach. A large number of beam lines can be made available for users spanning a very large range of the wavelength spectrum. A recent series of technical reviews has affirmed the design, which is well advanced, while suggesting a few changes. The accelerator system also plans for staffing increases as it moves towards final design.

The Conventional Facilities System includes improvements to land and the construction of a new Ring Building and Operations Center along with service buildings and Laboratory/Office Buildings (LOBs) to house beamline staff and users. A Title I conventional facilities design package near 90% complete has been prepared by HDR Architects & Engineers working with the project design support team. In some cases further details and specifications are needed and that work is underway. The design process included visits to several of the world's major operating light source facilities. A contract for the management of preconstruction services is in place with LIRO/Gilbane.

Several construction contracts, all fixed price, best value awards, are planned to deliver the conventional facilities.

The Experimental Facilities System will deliver an initial suite of 6 beamlines and instruments. Ultimately these facilities will be capable of hosting at least 58 beamlines. The design is at the conceptual level and is not as advanced as the accelerator and conventional facilities designs. Outside engineering firms have been contracted to help carry out the work. An appropriate amount of contingency should be allocated for those aspects of the experimental facilities where significant R&D remains. Design studies and cost estimates for the 6 beamlines are due this month. The design team is already working closely with the user community in planning for a transition to operations and has hosted a recent workshop attended by 450 potential users.

Increased attention is being paid to interfaces within and across the project's major systems. The project appears to be developing a sound approach that includes new Interface Managers in the project organization. The review team was provided a draft of the project's configuration management plan describing change control including engineering change requests. This issue needs further attention.

Outside advice is sought and responded to. Many design reviews have been completed. Value engineering is an integral part of the continuing design effort and a Value Engineering Workshop is scheduled in the near future for the conventional facilities. A set of standing committees advises the project and laboratory on technical and management matters.

A Preliminary Design Document (PDD) which includes updates to the technical components from the CDR and the completed Title I Facility Design Package is being prepared over the next few months. The PDD will be finalized after the series of internal advisory committee meetings this fall and the DOE reviews in November.

The review team identified no new serious risks and judges the risks and associated mitigation plans already identified by the project to be acceptable. Nevertheless the committee includes many comments and recommendations in this report that it hopes will be helpful. The project is planning very aggressive staffing increases. Those will be difficult to achieve.

Overall, this committee feels that the NSLS-II design for the accelerator and conventional systems is sound, is progressing well, and will soon be of sufficient detail to support a baseline cost estimate and schedule and should continue from the current preliminary stage to final design.

The design for the experimental facilities system is, understandably, not yet as advanced, but is also progressing well. It will need increased staff and resources in order to succeed.

1.0 Introduction

A NSLS-II Comprehensive Design Review was held on September 11-13, 2007 at Brookhaven National Laboratory. The objective of this review was to assess the status and adequacy of the overall NSLS-II preliminary design effort. The charge included a list of topics and specific questions to be addressed as part of the review. The assessment of the Review Committee is documented in the body of this closeout report.

The sections in this closeout presentation are generally organized by Findings, Comments and Recommendations, which are defined as follows:

- Findings are statements of fact that summarize noteworthy information presented during the review.
- The Comments are judgment statements about the facts presented during the review and are based on the reviewers' experience and expertise. The comments are to be evaluated by the project team and actions taken as deemed appropriate.
- Recommendations are statements of actions that should be addressed by the project team.

Reference materials for this review are contained in the Appendices. The Charge for this review is shown in Appendix A. The review was conducted per the agenda shown in Appendix B. The Reviewer's assignments are noted in Appendix C and their contact information is listed in Appendix D. Appendix E is a table that contains all the recommendations included in the body of this report.

2.0 Accelerator Systems

Findings

- Significant and thorough studies have been performed to design an outstanding 3rd generation light source.
- On many items, the accelerator program is closer to a detailed design than a conceptual design.
- The review committee did not hear a presentation of the final staff plan to be reached. There does not appear to be a coherent staffing plan to go from design to commissioning to pre-operations and finally to steady-state operations.
- Many groups, and management as well, voiced concern over the required ramp-up in staff. This staffing seems to be a serious problem that may create a schedule risk over the construction period.
- Main technical risks or cost risks have been identified and their mitigation is under preparation.
- Value engineering efforts and the R&D program are at an adequate level for such a challenging project.

Comments

- Documentation: the CDR is not up to date and there is a need to update and reference the latest design documents, once they are approved.
- There seem to be mechanisms in place for documenting interfaces, but it was not clear who takes ownership of such issues. *Somebody* must feel responsible for a particular item or things will not happen.
- It was not clear how the “budget” for achieving tight specifications is allocated. In general, a successful solution will involve “sharing the pain.”
- It was stated that the accelerator group was responsible for the de-ionized water system. This seems ill-advised. Such an approach requires duplicating plumber/cooling skills within the accelerator division, in addition to the ones that will exist for the conventional facility. There is probably a more cost-effective approach.
- The magnet group needs to decide on water circuitry for the magnets, but the interface typically is a manifold on the girder that has only a supply and return line. The group that builds the distribution system to provide the water should be the experts—the same group that provides other “house” water systems. Similarly, the vacuum group should decide on its water system internal plumbing, but have a simple return and supply interface to the house water. Though it is probably obvious, care must be taken to keep the copper and aluminum water

systems separated. Especially in the vacuum area, where both types of system are present in close proximity, there is a danger. Such aids as color coding or different fitting sizes should be considered.

- The tight temperature control specification, while achievable, may well involve some trial and error to get it right. It might be prudent to assume a looser tolerance for initial commissioning and operation of the facility.
- One way to augment staff without a major and lengthy recruiting effort is to collaborate with other laboratories on some elements of the facility design and fabrication. There is some loss of control this way, but there is a compensating gain in intellectual strength and there are many recent examples of successful collaboration. If a competent group takes responsibility for delivering some component or subsystem, there is a good chance that they will complete the task well. The NSLS-II vacuum group is already collaborating with the APS vacuum group, and this mode of operation should be encouraged where beneficial and appropriate.
- Consideration should be given to providing such services as data storage and data acquisition support centrally, as a facility activity. Having many different kinds of backup systems, uninterruptible power supplies, and the like is rather inefficient.
- Installation of accelerators, commissioning of the linac and even the booster are planned to start before the end of the building construction. From recent experience at other facilities, this is a major schedule risk.
- With the very short lifetime, compensated by top-up injection, there will be significant radiation production inside the tunnel. The review committee did not hear a presentation on how this will be managed with respect to collecting the electron losses, localizing the induced radiation, and minimizing the activation of components inside the tunnel. This has to be considered as a key issue.

Recommendations

1. Deepen the analysis of the impact of staffing shortage on the overall project schedule.
2. Consider collaborating with other institutions as a way to augment staff in key areas quickly.
3. A plausible (not detailed or fully accurate at this stage) staffing plan for the life of the project should be developed. The benefits and needs, if any, for recommendation 2 will become more obvious by doing this.
4. Make a detailed scheduling of design review meetings with the relevant people before launching any major procurement.

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5. Reconsider the division of responsibilities between accelerator and conventional facility divisions

2.1 Lattice, Accelerator Physics and Stability

Findings

- The lattice work to date has been well done. The tools to evaluate the relevant beam dynamics issues are in place and the people to use them are capable and knowledgeable.
- The main issues to study are well understood and have mostly been looked at, but not for the latest incarnation of the lattice. One exception is to examine the need for a beam abort system, which is conspicuously absent from the design.

Comments

- Most of the challenging issues (beam dynamics, energy acceptance, position stability) are being well addressed.
- Off-momentum dynamic aperture still looks a bit marginal. Touschek scattered particles often have large betatron amplitude to go along with their large momentum offset, and these particles will not survive at $\delta p/p = 3\%$. This is understood by the lattice group, and presumably the situation will be improved with suitable design changes. Tracking with the effects of the Landau cavities will ultimately be needed, as was noted in the presentation by Krinsky.
- The effects of an electron cloud on the electron beam have not been explored. Recent evidence from CESR is that such effects may exist, and could well be relevant in the low emittance regime to be used at NSLS-II.
- It is not clear that higher-order mode (HOM) power has been considered adequately. Especially if there is no third-harmonic cavity, the bunch length is short and the peak current will be large. Every little opening in the vacuum chamber, such as the gap between a bpm button and the chamber wall, is a site for potential heating and every shape discontinuity is a site for possible trapped modes.
- Required bpm resolution is beyond the state-of-the-art right now.

Recommendations

6. Look carefully for places where HOM power could be trapped and develop mitigation techniques.
7. NSLS-II staff should try to work proactively with industry to see if the project needs for bpm resolution can be met. The proposed workshop is good idea as a way of developing and documenting the need for such performance.
8. Evaluate and document the need for an abort system. If it is needed, provide a location in the lattice for it and design the required hardware and beam dump.

2.2 Injectors and Injection Systems

Findings

- The injection system is based on modest changes to existing turn-key designs. The linac is based on the 100 MeV SOLEIL design, upgraded to 200 MeV. The booster is based on the 3 GeV ASP booster with some modest design changes to the lattice. 1 Hz repetition frequency was chosen for the Booster.

Comments

- Due to the very short lifetime, top-up injection is mandatory for the operation of NSLS-II. Therefore, there should be some additional margin available in the injector performance to compensate for a shorter than expected lifetime.
- The planned total charge (15 nC) accelerated by the linac is 50% higher than that achieved at SOLEIL. However, if injection efficiency falls below 50%, or storage ring losses are higher than projected, less than ideal top-up scenarios need to be used.
- The top-up requirements, especially bunch-to-bunch charge uniformity, and the response to possible injection inefficiencies and storage ring loss rates, need to be refined, as these affect the possible solutions that may need to be considered in the injector operation.
- The design with a single IOT for driving two PETRA 5-cell cavities and handling the beam loading is at the limit of performance of an IOT. The investigation of possible alternatives that were outlined by the group is encouraged.

Recommendations

9. The consequences of top-up injection with degraded performance should be assessed and remedies should be investigated together with the Experimental Facilities Division.

2.3 RF Systems

Findings

- The proposed RF system for the storage ring, consisting ultimately of 4 CESR-B superconducting cavities each with a 310 kW klystron amplifier, is well-suited to NSLS-II requirements.

Comments

- The RF group demonstrates good knowledge of the issues in the detailed design of these RF systems, and is continuing to review possible improvements to this basic design.
- In the overview of risks, a significant R&D program was presented. Some of the R&D items would need a long time to produce results.
- Because of the severe criteria on RF phase and voltage stability, the cavity phase and voltage have to be monitored with a sufficient accuracy. For example, cross talk of the directional coupler in the high power RF may cause a dominant phase error (in the case of SCRF, the range of the reflected power from the cavity changes its level from 0 to 100%).
- As designed, the CESR-B cavity has no high frequency tuner, such as the piezo tuner of the KEKB cavity. Thus, voltage fluctuations due to mechanical vibrations must be compensated by the feedback of additional RF power. Estimation of the additional power will be needed.

Recommendations

10. The need for spare cavities for the storage ring should be assessed, especially considering the implications of catastrophic contamination of the SC cavities.
11. Since the 3rd harmonic cavity is required at the start of operation, work needs to be done to confirm the baseline design choice, and the means (financial, internal manpower) to procure that system.
12. Estimation of the SR power into the SC cavity should be made. The SR power from the bending magnet hits the edge of the taper section and heats it up. This causes outgassing and discharging in the cavity. To avoid this problem, shielding masks should be designed.
13. On the cryogenics, not only the refrigeration capacity but the cooldown procedure should be considered carefully. It would be helpful if the cavities could be warmed up and cooled down independently.
14. The relationship between the schedule of the RF R&D and the total project schedule should be made clear.

2.4 Magnetic Elements and Girders

Girder System : Findings

- A low-precision machining concept with no built-in precision alignment mechanism to adjust the magnetic components on the girder has been chosen. High precision alignment of the magnetic axis of each magnetic element on the girder is achieved with a vibrating wire method.
- The magnets are supported at their mid-planes. A method of tightly fastening the magnets onto the girder without changing the “null-position” defined by the vibrating wire still has to be developed

Girder System : Recommendations

15. The long-term stability of this rigid support has to be shown. Any influence of the girder transport methods on maintaining accurate magnet positions has to be mitigated.
16. Extensive alignment, vibration and thermal tests of the complete girder system have to be performed.

Magnetic-Elements : Comments

- Field quality requirements for the quadrupoles and sextupoles ask for very precise and stable mechanical solutions.
- Fringe field effects have to be compensated by a proper chamfer design.
- Cross-talk between neighboring magnetic elements on the girder will be investigated

Magnetic-Elements : Recommendations

17. Despite the very tight time schedule, prototype magnets of each type should be built and measured to prove the required field quality over the dynamic range of excitation before mass production starts.
18. High current densities, up to 10 A/mm^2 in the magnet coils, are not recommended to avoid local heating of the magnet yoke and problems with water circuits.
19. Consider the vibrations that could be caused by water-cooling circuits on individual quadrupole and sextupole magnets.

2.5 Power Converter & Electrical Infrastructure

Findings

- The magnet dc power system design and requirements are well documented and understood. No unusual issues arose. No details on pulsed magnets were given. Few details on the AC feed were given.
- Specification requirements and enumeration were presented for the ring power supplies. The requirements were said to have been developed in collaboration with the beam physics staff and the magnet designers. The requirements for power and stability are within the range of values commonly found in particle accelerators and should not present unusual challenges. All supplies are of the switching type except for the main dipole string power supplies, which are of SCR type (12-phase 60-Hz switching). A 20% margin is added to the current/voltage requirement to ensure the supply can support normal machine tuning and magnet tolerances.

Comments

- It didn't show up clearly how the PS specifications correspond to the machine physics requirements.
- It is not obvious whether the addition of margin has been scrutinized at a high enough level to avoid duplication of margins.
- The maximum voltage to ground (650 V) of the dipole string may approach a boundary where special safety precautions are needed for tunnel access or working on the magnets.
- There may be a value-engineering opportunity in reducing the number of control modules from 2 to 1 per power supply.
- Sensitivity to line voltage variation was not shown or specified.

Recommendations

20. Consider using a switching type power supply for the dipole string. Switchers are less susceptible to tripping on line fluctuations, they avoid introducing line noise and minimize noise on the magnets, and they allow broader bandwidth regulation.
21. Establish a schedule of design reviews for the various kinds of supply to be procured as well as for the cable plant design.

2.6 Vacuum Systems, Absorbers, Collimators, Shutters

Findings

- Design team is very experienced and is well along with a good design concept. Design concepts for most chambers are available now.
- No provision has been made for coating of chambers.
- Impedance considerations are being taken into account, except possibly for HOM power issues.
- DOE is considering defining vacuum chambers as “pressure vessels.”
- The pressurized hot water bake-out system is considered to be a big technical risk for the vacuum system.
- Cross sections for the Al extrusion were shown. Atlas flanges to be used for the connections should perform well. Synchrotron rays are being traced, the power deposition is being evaluated, and absorber locations are being defined to absorb the power.
- The design of the components at the interface between the electron and x-ray beams is much advanced. Thermal calculations have been shown. Except for the damping wiggler absorber, the heating is not very critical.

Comments

- Absorbers, collimators and shutters have been built for similar bunch length and beam currents before. It is known what one has to look out for.
- Technical data have been shown for the collimators, absorbers and shutters that show they will likely not be damaged by the beam. It was however not specified why their dimensions are what is needed.
- The absorbers and collimators do not seem to have been included in the impedance budget. They might overheat because of wake fields. Possible impacts of electron clouds have not been investigated
- The design of the vacuum system is in an early stage, but the approach taken should fulfill the requirements. A significant amount of detail work is still to be done. The committee supports the decision to eschew NEG coating as a major means of pumping, in favor of NEG strips in the antechambers. The review committee does recommend, however, TiN coating of the beam channel as a means of reducing the secondary emission, as evidence at other labs (Cornell) suggests that e-cloud issues may arise even in electron rings. This could be a potential limiting issue for achieving low vertical emittance.

- Chambers with BPMs need to be supported such that relative motion between BPM and associated quadrupole and/or sextupole is minimized. This is of paramount importance for consistently achieving low vertical emittance.
- Present plan calls for replacing an entire girder if a magnet coil fails. This may be a burden for vacuum conditioning and seems quite undesirable from the vacuum perspective. A means to split a magnet for repair without breaking vacuum would be highly desirable if it can be made compatible with alignment needs.
- HOM power in BPM housings, bellows, and the like is a serious concern and should be monitored carefully at the design stage. Adding numerous thermocouples to the chamber is worthwhile and should be included in the design if not already there.
- Bellows design is critical and needs to be developed and tested early.
- Defining all vacuum chambers as pressure vessels could have a major impact on all accelerators, present and future. Helping to find a good and sensible compromise will be a help to the NSLS-II project and a service to the entire accelerator community. The vacuum group is commended for taking this issue seriously.
- An alternate technical solution for the bake-out system should be explored. If the primary goal of an *in situ* bakeout is simply to remove water vapor, the alternative of flushing the chambers with warm dry nitrogen gas—a “desert breeze” in effect—is workable, and probably much safer.
- There is concern that staffing will not keep up with the requirement to support the schedule.

Recommendations

22. Consider including TiN coating of the beam channel in the design.
23. Establish a schedule of design reviews for the various vacuum components to be designed and built.
24. Wakefield heating of the various absorbers could become a critical issue and they should be included into the impedance budget.
25. Develop a robust bellows design, considering dust generation and HOM power.
26. Consider BPM position reproducibility after bake-out.

2.7 Diagnostics

Findings

- It has been clearly specified what will be measured and what precisions these measurements will need to have. In most cases, it also became clear which x-ray goal drives the precision. Only in the case of bunch charge uniformity was it not clear if there is a real x-ray need for the high uniformity that is specified.

Comments

- Regulating the fill pattern to 1% can likely be done, but is not easy and cannot be guaranteed.
- 1mm dispersion measurement is not easy, but should be possible.
- It is proposed initially to only have vertical but no horizontal feedback, this will not allow filling of 500mA.
- It could be quite valuable to have the metrology beamline to measure beam size and beam divergence at an ID early on, possibly for commissioning, rather than after the 6 initial beamlines, as currently planned.
- The x-ray physics motivation for diagnostics requirements were stated well, except in the case of 1% fill-pattern regularity.
- Many of the diagnostics are either commercially available, in which case documentation will be provided, or have been operated similarly in other laboratories, in which case documentation can be and might already have been obtained. But the presentation was too short to show such documentation.
- The diagnostics components are considered to not have a large risk associated with them, but team-building for the diagnostics group is needed, and the main risk seems to be that no sufficiently qualified staff can be found.

Recommendations

27. Prioritize the diagnostics that are essential from day 1 to achieve the commissioning of the 3 accelerators (Linac, Booster and Storage Ring).
28. Clarify with the Experimental Facilities Division the requirement for 1% filling uniformity, as well as the bunch-purity requirement in the time-structure mode.
29. Optimize the design of the BPM buttons with respect to the RF power that will be deposited inside the feed-throughs, which could result in overheating.

2.8 Controls and Infrastructure

Findings

- A comprehensive control system design based on EPICS and mostly commercial components was presented.
- To avoid risks associated with sole source systems, an open source device control scheme based on FPGAs is proposed to be compatible with the commercial systems. The commercial systems would be a backup.
- An operational NSLS-II simulation will be implemented to aid in development of control and physics applications.
- A global relational database for all controls, feedback, data archiving and physics application support will be implemented to provide uniform configuration control across the project.

Comments

- The approach taken is based on experience and well established hardware and software where possible, and is reasonable and adequate for this stage of the project.
- Requirements are reasonably clear. Gathering timely information from other systems is always a challenge for control system designers.
- Risk assessment and mitigation is well thought out. Difficulty in assembling the required staff is the most significant risk to the schedule.

Recommendations

30. The number of FTEs stated to develop the control system seems to us to be inadequate. There will be conflicting requirements of resources between the accelerator and experimental division as commissioning time approaches.
31. There should be clear definitions of what is absolutely required on the control system to start the commissioning of the 3 accelerators.

2.9 Insertion Devices

Findings

- Many different IDs to be ready for Day 1 (DW, EPU, U19, 3PW,...).

Comments

- Major and critical issues are well identified.
- There is a good follow-up of the state-of-the-art ID technology at various labs by the ID group.
- Some highly performing IDs (cryogenic undulators, etc.) are being considered, and correspond to what the NSLS-II project deserves.

Recommendations

32. The review committee supports the principle of variable gap for damping wigglers. It will ease Day 1 commissioning and will enable going back to the bare lattice later on.
33. Implement an ID lab as soon as possible to start the R&D program.
34. Clarify with the Experimental Facilities Division the ID specifications (period, gap, flux, energy range,..) taking into account the technical specifications of the beamlines (defining slits, power load,..).

2.10 Accelerator Safety Systems

Findings

- The PPS will be implemented using redundant PLC systems, one safety-rated, for radiation protection in the linac, booster, storage ring, and active user stations.
- The system will be monitored by the EPICS control system.
- Labeling of cables and components and a rigorous configuration control system will minimize the likelihood of accidental alterations to the system.

Comments

- General objectives and implementation philosophy are based on experience at other laboratories. However, the safe operation of the facility depends on the details of implementation.
- It is planned that controlled access to the tunnels will require re-searching the areas before restarting the beam. This may be cumbersome during the early commissioning phase.

Recommendations

35. A detailed plan for implementation, function, testing, and administrative controls of the PPS should be thoroughly reviewed in the near future, taking into consideration the specific requirements of the top-up injection.
36. Don't use the dipole power supply as a second beam abort device in addition to the RF. This may require a long time to recover stable beam conditions. At other places, either a gate valve or a beam killer is inserted, some quadrupole power supplies are tripped, or a beam abort system is implemented.

3.0 Experimental Facilities

Beamlines, Sources, Utilities, and Ancillary Systems

The Experimental Facilities Subcommittee is favorably impressed with the breadth and depth of the planning performed by the beamline design team, given the current staffing level available for this area.

Findings

- The plan to construct the SR tunnel with a different floor height than the experimental hall has ramifications for front-end access and safety. The inability to use existing insertion device designs and components due to the shorter floor/beam height will have cost implications as well.
- Out-sourcing of the design and construction of the first six beamlines may adversely impact standardization of components and control systems.
- As described, the plan to maintain electrical power to critical beamline and computer resources in the event of interruption appears inadequate.
- The planned small (few degrees) temperature differential between the SR tunnel and experimental floor will help minimize thermal instability between these systems.
- Requirements for standardized controls and data acquisition systems were not defined.
- The benefit (apart from cost) of combining the hard x-ray XPCS and coherent diffraction beamlines in the same straight section is not clear, whereas there are known disadvantages of only 250 mm separation between the two beamlines and sharing an undulator.
- It is not clear that the medium-energy (7–30 keV) powder diffraction beamline benefits from a damping wiggler source.
- Handling the unprecedented thermal load (8 kW) posed by the damping wiggler sources was discussed but a clear solution was not presented.
- The potential impact of LEED certification standards on the experimental floor was not discussed. This may have large impacts (i.e., limitations) to x-ray experimental facilities and needs to be spelled out early in planning.
- The utilities available to the experimental beamlines, and associated interface issues with conventional facilities, were not spelled out.

- It is not clear which group will develop high-resolution x-ray BPMs with suitable resolution for either storage ring position feedback or experimental alignment. It is also not clear which group will develop x-ray flux monitors.
- A strong case for developing the cryo-permanent magnet undulator (CPMU) was not presented. While it closes the gap for harmonics in the 4-6 keV range, it wasn't shown that there is strong need in this energy range, despite the high brilliance of NSLS-II in this range. No effort estimates (FTE loads) were presented for the insertion device projects.
- It was not clear that the beamline plans presented all needed the same undulator or whether they might be better served by a choice of undulators optimized for a particular science driver and beamline.
- The quality of mirror surfaces will have a direct, detrimental affect on the performance of the XPCS and coherent x-ray diffraction beamlines. Because mirror development, fabrication and/or metrology are not in the project scope, it is not possible to declare that these two beamlines will achieve the necessary performance.
- The planned time structure for the storage ring fill pattern (~1000 filled out of ~1320 buckets) offers a good tradeoff for lifetime vs. top-up frequency, but appears to negate the possibility of time-resolved experiments without use of extremely fast choppers. If time resolved programs take on a significant role, the issue of bunch filling uniformity could become important.
- The locations of the long beamlines are affected by multiple issues such as proximity to the booster (potential EMI/RFI source), vibration sources (e.g., building utilities), preferred beta values in the straight sections, and the variable earth grade. However these choices also impact the concrete pouring schedule.

Comments

- An overriding concern is how the key performance goals of 1 nm and 0.1 meV will be met in the mature phase of the project. For the construction phase, the question is what strategy will be employed to ensure sufficient technical resources will be available and what long-term investments are being made to meet these goals. It may be useful to define specific intermediate range milestones in order to assess progress towards these final goals.
- The committee sensed some reluctance both to embrace the opportunity and to take on the challenge of building long beamlines at NSLS-II. NSLS-II offers a unique opportunity to build long beam lines with revolutionary capabilities in the US. This is particularly the case for the CXD beamline. Taking full advantage of this opportunity should be encouraged by making the commitment to build long beamlines, starting with the CXD beamline, early on the project design.

- Whether it is better to maintain a level storage ring and align beamlines to it, or to let the ring settle and follow it with the beamlines over time was not obvious, but this should be decided soon.

Recommendations

37. Alternative solutions to the differing floor heights should be considered, such as concrete pedestals for the girder sections alone. The 1-meter below-beam allowance will constrict insertion device options and drive up costs in this area.
38. The benefits of out-sourcing beamline construction (rapid response, multiple ideas, cost competition) should be weighed carefully with regard to standardization of technical systems and full utilization of facility staff. At this point each beamline seems to have invented its own design process and its own cost basis without oversight as to commonality and scale. The committee feels strongly that standardization will be extremely important to achieve overall project cost containment and minimize maintenance and operational costs (spares, staff training, documentation, etc.). In addition, the long term benefits of operation and maintenance should be considered at this early stage.
39. Availability of limited emergency power backed by UPS to each beamline is essential to maintain key elements of the beamlines. Investment in much larger UPS systems for critical beamline and computing facilities should therefore be considered. It is more cost effective to include this in the original Conventional Facilities planning than to add it later on a case-by-case basis.
40. Keeping the SR tunnel and experimental floor temperatures within a few degrees will help minimize thermal instability between these systems. Maintaining both a few degrees cooler than the planned 25.5/23.8 C would improve equipment longevity and the personnel work environment. The relative humidity should also be evaluated in these decisions as it impacts certain experiments as well as personnel comfort.
41. An integrated approach across the whole facility should be taken for the controls, data acquisition, and safety interlock systems. In addition, the computing needs for the beamlines have to be addressed early on. Specifically the benefits of centralizing the data storage and archiving should be weighed in. In this regard the availability of data between beamlines can be an important issue for centralization. As EPICS is the control system of choice, there should be complete transparency between the controls for the beamline, the accelerator, and, if possible, the conventional facilities.
42. Separating the hard x-ray XPCS and coherent diffraction beamlines by putting them on different undulator ports will give them full independence and eliminate the concerns of having the two transport pipes in close proximity. The scientific impact of these two programs is significant and may warrant the additional cost of dedicating an extra port and the additional financial burden of undulator, front end and FOE. (~\$2–3M). In addition, given the risks of splitting the beam using

mirrors, the cost savings of sharing an insertion device and front end do not seem justified.

43. The medium-energy (7–30 keV) powder diffraction beamline would probably be served better by a bending magnet and 3-pole wiggler rather than by a damping wiggler. There is an opportunity to optimize the powder diffraction beam line for the energy range above 40 keV using transmission focusing optics. Experience at the APS is that such a beam line would be highly desirable. Given the ease with which lower energy powder diffraction needs can be met with one of the 3-pole wiggler beam lines, there is a strong case to be made for not adding complexity to the powder diffraction line by including the lower-energy capability.
44. The use of a damping wiggler as a source in the initial phase should be carefully weighed. Unless the science requires the higher energies and the high brilliance, it might be advisable to make use of a 3-pole wiggler source for early operation. This has an added advantage of allocating resources, in terms of not handling all the challenges at the same time. If, after consideration, a damping wiggler source is still justified, a thorough thermal analysis of how the optics will handle such a source is needed.

Organizational Priorities and Interfaces

Findings

- A plan to provide the necessary mechanical and technical support for beamline construction was not articulated. At this point, staff are shared or supervised from other divisions inside NSLS-II or BNL at-large. It is not clear that the proposed aggressive design schedule can be met by matrixed talent.
- The formation of capable controls and personnel safety systems groups appears immature.
- There does not appear to be a technical specification for the beamline cooling needs (process water system).
- Several powerful tools for tracking WBS elements and interface issues were described. However, it is not clear whether these are being effectively implemented, or how they will incorporate the project priorities to meet performance goals.
- A common set of measurement units and coordinates in use by all facilities (CFD, ASD, EFD) is not evident. This may adversely impact project efficiency, especially concerning contracts with outside vendors.

Comments

- The importance to the project of building up capable controls and personnel safety systems groups at an early stage should not be underestimated. Formation of these

groups to support experimental and accelerator facilities on an equal basis should be undertaken at the earliest opportunity.

Recommendations

45. Prioritization for constructing the Nanoprobe and Inelastic Scattering beamlines should include the necessary mechanical and technical support. These beamlines are beyond the current state-of-the-art and will require long-term R&D. Each of the beamlines should have its own set of goals, milestones, and metrics to maintain focus and momentum. Each beamline will need cost containment that can only be done in concert with economies of scale achieved by sharing non-recoverable engineering design with other facility beamlines. In particular, strong leadership will benefit the hard x-ray nanoprobe beamline design in reaching the ambitious project goal of 1 nm resolution.
46. Accelerator and experimental facilities should develop a common technical specification for a centrally supported process water system designed and built by conventional facilities.
47. The approach to effective identification and resolution of interface issues, and how they will incorporate the project priorities to meet performance goals, should be clarified. In particular, the staff training (and expectations) to use the proposed on-line database WBS tracking system was not discussed.
48. A common set of measurement units and coordinates should be adopted by all facilities at the earliest opportunity.
49. A consistent system for survey and alignment of both the storage ring and beamlines should be adopted.

Personnel and Staffing

Findings

- Plans for hiring new staff and using existing staff are immature at this point. In particular, the hiring plan is very ambitious given the available pool of talent.
- The segue from the Construction to the Operations phase is not clearly defined, particularly with regard to staffing.
- As described, the plan to develop Beamline Access Teams appears partly to engage key scientists and collaborators, but does not go far enough to encourage full participation and long-term buy-in.

Comments

- It is not evident what the role of the Beamline Manager is to the project and his/her relationship to the Interface Managers.

Recommendations

50. A detailed schedule for effective hiring and utilization of staff to meet the performance objectives is needed.
51. The plan to maintain staffing continuity through the Construction phase to the Operations phase should be clarified.
52. A detailed plan for developing the future Beamline Access Teams and Partner Users should be articulated. This is essential to encourage productive, long-term scientific programs for NSLS-II.

4.0 Conventional Facilities

Findings

- The design team has done an excellent job of leveraging the experience of other light sources. At this stage they have thoroughly developed a coherent overall design concept for the facility.
- For the 90% Title I stage, the Architectural/Civil/Structural drawings and specification are reasonably complete and well developed for the various buildings and systems. The presentations were very organized and were of substance. The Project Team (NSLS-II Conventional Facilities staff and HDR) have been proactive and sought to benefit from “lessons learned” at other light sources, including visits, measurements and organizing workshops, etc.
- The Conventional Facilities team lead by Marty Fallier has established a design team including BNL employees, HDR and Colin Gordon to develop the NSLS-II Civil design. A 90% complete Preliminary Design Report (PDR), preliminary design drawings, and specifications have been developed and were provided to the reviewers.
- A Construction Management firm and a Commissioning agent are planned to be added to the team in the near future.
- The current base scope includes 419,000 gross square feet of floor with an alternate expansion of the Ops center and two LOBs to increase the building to 477,000 gsf.
- The cost estimate for conventional facilities is approximately \$235 million which includes approximately 33% of contingency.
- Construction is planned to begin in early 2009 and be complete in early 2013. The duration of the construction has been stretched to try to match the current FY budget guidance.
- The review committee was provided with a risk list from the Conventional Facilities team including 27 currently identified risks.

Comments

- At the 90% Title I stage, some fundamental information should be compiled and formalized that delineates all mechanical equipment anticipated for the project. While this list would be preliminary in nature and subject to change it should provide a place holder for every major piece of equipment required for the project and its associated electrical power requirements. It was not apparent that such a list exists at this time. Accompanying and preceding this equipment list should be a comprehensive “Project Design Criteria” document that not only defines design parameters but includes a list of definitions of acceptable equipment types and manufacturers.

- The 90% design Specifications have not been sufficiently edited for the project. Some mechanical equipment listed in the specification is of a commercial grade that may not be able to meet the vibration and performance criteria required for the facility. This includes water pumps and exhaust fans.
- The NSLS-II facility will be relying on chilled water from the BNL central plant, which will be expanded to accommodate the new facility. The chilled water source is a predominant variable that will affect the ability to meet temperature stability throughout the facility. Since the NSLS-II will undoubtedly be the largest single chilled water user at BNL, and will impose the strictest demand on the stability of the system, some effort should be made to ensure that water flow and temperature control are maintained within the required specifications. In review of the drawings, it does not appear that any type of local dedicated chilled water pumps or mixing valves are being provided to insure flow and supply water temperature.
- The 90% Title I drawings have various flow diagrams but they lack sufficient development of terminal temperature control. A typical temperature control diagram should be included for every type of space to be constructed; this should as a minimum include office, laboratory, high bay, and hutches. Schematics to explain the operation of terminal temperature control devices and to flesh out the details of the water and air distribution systems, are needed.
- Sufficient staffing for the BNL Conventional Facilities Group will be essential for the successful execution of the design and construction activities. At this juncture, it appears that the current plans do not anticipate a large enough staff, with too much reliance being placed on outside consultants to fulfill this function.
- An operation and maintenance organization should be developed before the completion of the design phase. Particularly, staff planning and operating costs should be included to check that they are compatible with the design requirements.
- It will also be beneficial to describe the support group's organization. Presently, it seems that they will be part of the Accelerator System. This will need an appropriate priorities management system to provide all divisions the support they will need to deal with their own priorities.
- Preliminary building sections and elevations appear to indicate some potential obstructions to future beam line utility extensions and to future build-out of the experiment hall. Specifically, drawing A-301 indicates a vertical process piping rack and adjacent hazardous exhaust duct that appear to partially block horizontal passage of any future utilities. Additional consideration should be given to the proposed location of main distribution ductwork and piping for future beamline build-out. Ductwork now shown nested into the building structure should be reconsidered and lowered as much as possible to enhance accessibility. Careful

attention should be placed on location of electrical panels since the cost of future build-out will be strongly affected by length of conduit and wire runs.

- Drawing A-303 shows rooftop air handling units: Consideration should be given to the implication of future maintainability for this arrangement.
- The design of the heat recovery system shown on drawings M-701 and M-702 needs some more development and clarification. Direct utilization of process water waste heat should be given consideration in lieu of the heat pump system shown on drawing M-701.
- The design effort for the DI (process) water system has been delegated to the Accelerator group. While delegating this work to that group in itself is not of concern, the creation of bid construction documents and the execution of this construction effort may be a challenge. This type of work is usually better suited to the Conventional Facilities engineers.
- A set of drawings and design guidelines that clearly describe how users connect hutches and other enclosures to the building infrastructure has not yet been prepared. This document should be available for review by the user community and be updated and maintained throughout the life of the design, construction, and operation of the facility.
- The communication between the accelerator controls and the building management temperature controls needs to be more fully described, such that information and data can be transferred from the building management system to the accelerator data logging and alarm system.
- Selection of the location of the emergency generators needs to consider outside air intakes for air handlers to avoid entrainment of exhaust vapors.
- Supply and return fans are stated as being belt-driven. Consider direct drive for reduction of vibration due to the equipment.
- Specifications need to be clear regarding slab on grade requirements (e.g., flatness, if required) as well as the preferred construction sequence for the pentants. Initial efforts on this sequencing were shown and these efforts are a good start.
- NFPA 70E should be specifically referenced in the design requirements document for arc-flash requirements.
- Galvanized steel is stated as being used for all lab main exhaust ductwork and stainless steel for all exposed branch ductwork. Dialogue with the users is recommended regarding acids planned on being used in the labs that could create issues, especially with the galvanized ductwork.

- No overhead crane exists in the experimental hall so a method of building beamlines needs to be clear, especially how to build a beamline in amongst 2 existing beamlines and how large pieces of beamline equipment can be delivered and installed. This could be especially problematic adjacent to raised peripheral walkways.
- Schemes to protect the underpass from flooding need further development.
- The shrink/swell behavior of the sand as the water table varies by 1.5 ft is deemed not to be significant. The final height of the facility is still to be set and this should be resolved soon with the storage ring slab founded on virgin soil around the whole circumference.
- Good evidence was presented on the modeling and measurement of the vibration performance of floor slabs and across joints. These findings were being put into effect by separating the peripheral walkway and the service building slabs. What is less clear is how radial slotting of the experimental hall floor slab will be achieved and what effect it could have. This needs more detailed study before implementation and perhaps should not be implemented until the performance of the installed slab is measured.
- The vibration presentation made the recommendation to use suspended structural floor on the lower level of the Service Building, (instead of slab on grade). This is counterintuitive and needs to be reviewed and verified by an independent qualified expert.
- An earlier recommendation was made during the stability workshop to validate the analytical FE model and its various parameters (especially soils). It should reasonably replicate the measurements taken where the mechanical vibration from NSLS-I machinery was detected at the CFN, several hundreds of feet away. It seems that this still needs to be completed.
- Detailed work has been carried out that underpins the shielding design. More detail is required on the actual routes for cables and pipes penetrating the tunnel spaces. An important question was raised regarding utilizing the personnel access routes as equipment routes and whether this conflicted with fire escape regulations.
- An EMI policy should be established as soon as possible and applied across beamlines and accelerators. This policy should include requirements on extensive bonding and cable segregation as well as the requirements for screening and glanding of cables.
- More information is required on the planned developments of the central plant facilities (chilled water and electrical) as these will be essential for the successful delivery of the conventional facilities.

- The level of technical information on the conventional facilities appeared to be adequate for this stage, but it was acknowledged by the team that they had only received the information a few days ago and needed a first review themselves.
- A coordinate system should be developed across machine and beamlines and a system of measurement units adopted across the project.
- A more developed contract management strategy of how client and various consultants and contractors interact is needed. This will help identify risks associated with delivering the conventional facilities and refine the strategy early in the next phase.
- The current staffing plan appears to halve the CF team in year 2 which was not understood.
- Establishing a schedule of design and procurement specification reviews would help maintain the program and ensure the necessary people are booked to attend and achieve sign-off.
- The contribution of conventional facilities to achieving a 1nm resolution was not entirely clear and the design is proceeding on a best efforts basis with an appreciation of the key factors influencing the outcome.
- An estimate of the liquid helium consumption by the beamlines should be done to determine if a recovery system is appropriate or not (taking into account costs and sustainable design, even if the process is not within the scope of LEED).
- The amount of information on the LN₂ and LHe cryogenic systems needs more development. Apparently an experienced team from RHIC is assisting in this area. One or two centrally located tanks are foreseen for the liquid nitrogen distribution. Attention should be paid on the heat loads along the distribution pipes, and an appropriate gas exhaust system should be included along the distribution pipes (capacity, number...), particularly during the beamline construction phase when the consumption will be much lower than the nominal one.
- Temperature stability in EXPH is expected to be $\pm 1^\circ\text{F}$; this has both technical and cost consequences. It may be fruitful to modulate the set point slowly according to seasons or to have steps during shutdowns, without disturbance for beamlines or accelerators. More study should be given to the limits of the temperature stability that will be achieved with the current storage ring system design.
- Different services will be provided by BNL, such as a data center and facilities management—operation and maintenance, chilled water, main power, etc. An exhaustive review of these services should be done and analyzed with regard to NSLS-II requirements.

- Limit position for long beamlines to avoid too much flexibility constraining building design. The design team confirmed the external columns will miss long beamlines.
- On Civil drawings of existing conditions, it will be helpful to show the outline of NSLS-II.
- Structural Design Live Loads: all slabs on grade and Ring roof slab should be 250 psf (or higher) and fork lift capable (2 or 5 tons).
- Security and access control (Card Key?) is still not defined.
- The vibration presentation shows that dynamic response at high frequencies (above 50Hz) may still be significant (e.g., see slide 17 of vibration presentation). Conventional Facilities needs to share this with the scientists.
- Concrete specifications should place more emphasis on measures to produce low shrinkage concrete mix (low W/C ratio, fly ash, larger size aggregates, etc.).
- Attempt to secure a variance to allow installing the hutches without sprinklers (similar to APS).
- More formal involvement by the maintenance staff (not just the mechanical/electrical engineers) is encouraged in the development of the design. Priorities should probably be identified to determine whether the design can be operated and maintained in a satisfactory way (high MTBF for facilities vs. investment costs, duration of the maintenance shutdowns vs. reliability of the components, balance between investment and operating costs, human resources vs. automatic and remote controlled systems...).
- The 90% electrical drawings do not show high-to-medium voltage transformers or switchgear. In addition, the current electrical drawings do not include isolation transformers on the experiment circuits. This information should be included in the final PDR drawings.
- The electrical section of the PDR should include a table of technical electrical loads that form the basis of the civil design. The table should include at a minimum the machine component name, peak power required and average power required.
- There was not sufficient time to review the civil cost estimates and schedule in detail. The team needs to include adequate time after the completion of the PDR drawings to update cost and schedule prior to the CD-2 review. In addition, the team needs to revise the schedule to fit the current funding profile.
- While it is clear that the team has identified interfacing (integration) and communication requirements as very important between the three divisions, the

review committee is concerned that the use of different tools may cause miscommunication in the future. The review committee believes it would be better to adopt a single program to manage integration and communications.

- The NSLS-II team is in the process of establishing a technical requirements/parameters list. The review committee recommends establishing a controlled parameter requirements document that is approved and accepted by all divisions prior to the CD-2 review and EIR.
- The risk registry is currently being developed. A comprehensive set of risks with mitigations should be prepared prior to the CD-2 review. The impact and probability of the risks should help form the basis of the contingency.
- Attach radiation shielding guidance to the PDR to defend the reinforced concrete enclosure floor, wall and slab thicknesses. It should be mentioned in the structural section of the PDR that the thickness of structural concrete is driven by radiation shielding requirements and not gravity loads.
- It is important to finalize technical requirements including beamline (storage ring) element location and lattice prior to the beginning of the title II design. Changes in technical requirements after the beginning of Title II will have significant impact on the cost and schedule for design and construction
- Isolation of mechanical systems was discussed as a potential solution to reducing vibration sources. The cost estimates must be updated to include these potentially rather expensive isolation components.
- The Conventional Facilities team presented potential scope that may achieve the LEED gold certification. It is important to update the PDR drawings with this new scope and revise the estimate to reflect this increase in cost. Extra operating costs linked to this investment should be added to these, to have a better cost breakdown within the next 10–20 years.
- The architectural drawings at this stage appear technically adequate.
- No Personnel Safety System development and its impact on conventional facilities was evident. This system will have significant installed equipment and cable containment and will require service coordination.
- No controls system development and its impact on conventional facilities was evident. Again this will have an impact on installed containment and services, for example routing and installation of fiber optics.
- No Survey and Alignment group is in the project team and this is seen as important to interact with the main contractor in accurately delivering the shield wall. Some guidance has been gained from the APS to inform the building design at this stage. The overall alignment strategy for the storage ring needs to be

discussed further across relevant groups. For example, if regular access to the 8 bolts holding a girder down is required for alignment, then M&E services need to be coordinated with this.

- The cost information and construction schedules that were presented were based on the 50% PDR drawings with some recent modifications. Some effort will be required to update the cost and schedule to match the final PDR drawings.
- It was stated that the Commissioning Agent (CA) will be brought online prior to the completion of preliminary design. It is strongly suggested that this process is expedited to gain the CAs input as early as possible in the design process.
- A review of Conventional Facilities manpower should be performed with regard to staffing requirements during design and construction.
- Since all the buildings are fed from the potable water system, there is a need to have backflow preventers at each lab sink, or to split the supply into two water systems at each building.

LOB Specific Comments:

- The review committee suggests combining two small shared office rooms (column 8) into a large central conference room with a center divider. Side conference rooms next to the Experiment Hall can be converted to offices, labs or storage.
- There is only one loading dock. What about access for forklifts and other vehicle into the Experimental Hall, especially when long beam lines are built? Are the receiving rooms adequate for that purpose? Will it be feasible to replace overhead doors with large double swing doors?
- Consider having at least one BioSafety enclosure/lab and cold room in one of the LOBs.
- How will heavy items required for maintenance be placed in the LOB Mechanical Mezzanine? A roof or floor hatch may be needed.
- Are the two open stairs to the Mechanical Mezzanine necessary? Check the code to whether one is enough, maybe with a door to the roof.
- It appears that the shop walls are not solid all around; does it need to have fire rated walls?
- The wedge between the LOB Mezzanine and the Experimental Hall is costly and inefficient (extra surface of expensive siding). Consider elongating the Mezzanine close to the ends (near columns 1 & 15), similar to first floor. This will add more space at low cost.

- The rooms between columns 4 to 11 next to the Experimental Hall can follow the Hall boundary, giving, more usable space at no cost.
- The storage space seems to be insufficient, and attention is needed as design progresses in the area of records storage (archival, M&O info, etc).
- The office and laboratory HVAC and temperature control concepts are not sufficiently clarified at this point. Also, it was not apparent that a comprehensive preliminary list of mechanical equipment and associated electrical requirements has been compiled.
- Good effort by NSLS-II and HDR covered a lot of ground, especially the most sensitive areas, (e.g., vibration, EMI, and acoustics). The system put in place to document any observations or concerns, track them, and post their resolution or response, is a positive action that is commended.
- It appears that two separate air handling systems are being provided for each LOB. Since the laboratories and the office are the same code occupancy type, these two units could be consolidated into one unit to reduce construction cost.
- LOB laboratory exhaust fans appear to be centrifugal utility type with extended fan stacks. Experience has shown that, in comparison to induced dilution fans with wheels rotating in the horizontal plane, vibration levels induced by the fans can be dramatically reduced and the large stacks eliminated.
- Consider the use of an energy-efficient VAV design for the chemical fume hood system, as a constant volume design is described in the Preliminary Design Report.

Storage Ring Specific Comments:

- Underfloor drains should preferably be placed at elevation lower than Ring floor elevation.
- Requirements for the vehicle tunnel (VT) need to be finalized: single lane vs. two lane (cost vs. stability vs. other considerations). The entire VT box needs to be constructed as one of the early activities so the effect of the resulting soil disturbance can stabilize before the beamline is commissioned.
- Carefully plan for VT construction; this will disturb a large area and needs to be done early on, so the soil below the ring will have adequate time to stabilize. The method of construction will have an impact on cost.
- Why not integrate the infield pier and footing with the ring wall? The massive size is likely to eliminate wind effects.
- The interface between the ring and the infield, especially at the backfilled area, continues to be a source of concern (thermal variation, vibration transmission

from superstructure). It should be a priority to perform the required analysis to settle this concern and incorporate any engineering details into the design drawings. The analysis should investigate making the short piece of concrete (Grade beam) between the ring and infield siding skin to be monolithic cantilever from the ring roof slab (this may be beneficial by eliminating differential settlement there and the dynamic impulse when moving objects from the service buildings). The current scheme of supporting the infield steel columns is very awkward, and may result in unintended consequences. It may be worth it to investigate supporting the infield steel columns on a monolithic concrete pilaster extension of the ring infield wall; the ring enclosure is so massive that the roof weight and wind effect may not adversely affect the ring floors when compared with the detail shown on the drawings. An analysis needs to be performed to investigate if this is a better solution from settlement and vibration transmission prospectives. Another alternative would be to mount the inner ring columns on separate piles to isolate the building from the storage ring.

- Consideration should be given to placement of insulation in front of the grade beam.
- Given the step at the ring, are all the ratchet shield doors really necessary? NSLS-II may need to revisit this and attempt to reduce them. Are these doors manual or motorized?
- The drawings do not show any access (stairs) between the Exp. Hall and the ring roof slab.
- The design of the storage ring air handling system is predicated on the basis that the components in the ring will operate primarily in a steady state condition and that the HVAC system will not be stressed. This has resulted in a relatively low flow system with a minimum of number of discrete temperature control zones. Given the extremely tight temperature controls requirements of 0.2°C peak-to-peak variation, it is essential that this assumption be confirmed. This should be the result of thermal modeling efforts. These are underway and should continue.
- The installation of the racks on the SR tunnel roof requires more development, especially the detail of how to cool the racks and control the noise contribution to the hall.
- The current PDR drawings do not clearly show the lateral force resisting system in the ring building. The lateral force resisting system in the transverse direction for the ring building must be designed and shown adequately on the PDR drawings.
- From the shielding presentation, it appears that shield walls at certain areas (at the Linac) may need to be thickened. In lieu of that, it may be advantageous to use a heavy weight concrete band within the center portion of the wall with normal weight concrete below and above (used occasionally in APS).

Service Buildings Specific Comments:

- Clarify relationship between air intakes and exhaust stacks.
- Overhead doors have been troublesome at APS, consider oversized swing doors or air lock.
- Is there an alternative to the use of the huge labyrinth, which is basically a pipe and duct chase? In the APS there are smaller straight penetrations in the infield walls for pipes and ducts. Large ducts for NSLS-II can be formed with a shielding step in the concrete wall, which should be considered.

Recommendations

53. Complete a standalone, controlled, facility design criteria/technical parameter requirements document, approved and accepted by all divisions, prior to the CD-2 review. This document should include the basis of design, including a list of design limits for flow velocities, pressure drops, materials of construction, diversity factors, electrical load requirements, etc. This should be a living document that is maintained and updated and will act as a vehicle to insure uniformity of the design for all Mechanical Electrical Plumbing (MEP) systems.
54. Complete the title I design drawings to bring the level of detail up to that required for pricing and the commencement of the title II design. This includes the central plant upgrades (chilled water and electrical), which need to be at the same level of design and specification as the rest of the conventional facilities prior to the CD-2 review for the purposes of obtaining accurate cost and schedule estimates. In addition, expedite technical completion and resolution of the infield detail (column, thermal and wind effects, etc.) and vibration studies.

5.0 Charge Questions

10.1 Is the design technically adequate, i.e. is the design likely to meet the facility technical requirements?

The design is consistent with the facility requirements. Work remains in bringing the detailed technical requirements into the civil construction package. The experimental facilities are at the conceptual design stage.

10.2 Are the physics requirements clearly stated and documented? Have these physics requirements been translated into technical performance requirements and specifications?

The physics requirements are understood and NSLS-II is still in the process of documenting the technical requirements. This information should be more clearly presented at future reviews.

10.3 Can the design be constructed, inspected, tested, installed, operated and maintained in a satisfactory way?

The design is headed in the right direction and the major technical risks are identified and understood.

10.4 Is there adequate supporting documentation to detail the design?

The committee saw evidence of adequate design detail in much of the supporting documentation, but not all. More work is needed here.

10.5 Are the risks (on technical, cost, and schedule basis) of the selected design approach understood and are appropriate steps being taken to manage and mitigate these risks?

Yes, the significant technical and costs risks are understood and mitigation is either completed or underway. The committee identified no new, serious risks.

10.6 Is the project organization clearly defined and sufficient to ensure the successful engineering and design of the project, including the interfaces between the Accelerator Systems, Experimental Facilities, and Conventional Facilities groups?

There is a clear, existing project organization. The acquisition of additional staff is a critical factor. Interfaces appear to be managed differently within the different divisions, but plans were presented for improving interface coordination.

10.7 Is there a reasonable plan in place for implementing configuration management to ensure changes to the technical requirements/specifications are controlled and communicated to all affected groups?

Configuration management plan was made available during the review but the plan is not yet fully implemented. The plans include the new interface manager positions within each of the technical divisions along with a documented configuration and change control procedure.

Issued 09/25/07

Appendices

Charge

Agenda

Report Outline and Reviewer Writing Assignments

Reviewers' Contact Information

Table of Recommendations

Appendix A

Charge**NSLS-II Comprehensive Design Review
Brookhaven National Laboratory
September 11-13, 2007**

The objective of the NSLS-II Comprehensive Design Review is to assess the status and adequacy of the overall NSLS-II preliminary design effort. The NSLS-II preliminary design is expected to provide the depth and detail required to convert the conceptual design to a design appropriate for establishing the NSLS-II Performance Baseline. Design completion is expected to be roughly twenty percent of the total design effort but will depend on the area of the project with the conventional facilities and accelerator designs more advanced than beamlines. The specific elements of the charge are as follows:

- Is the design technically adequate, i.e. is the design likely to meet the facility technical requirements?
- Are the physics requirements clearly stated and documented? Have these physics requirements been translated into technical performance requirements and specifications?
- Can the design be constructed, inspected, tested, installed, operated and maintained in a satisfactory way?
- Is there adequate supporting documentation to detail the design?
- Are the risks (on technical, cost, and schedule basis) of the selected design approach understood and are appropriate steps being taken to manage and mitigate these risks?
- Is the project organization clearly defined and sufficient to ensure the successful engineering and design of the project, including the interfaces between the Accelerator Systems, Experimental Facilities, and Conventional Facilities groups?
- Is there a reasonable plan in place for implementing configuration management to ensure changes to the technical requirements/specifications are controlled and communicated to all affected groups?

Appendix B
Agenda

**NLS-II Comprehensive Design Review
 Brookhaven National Laboratory
 September 11-13, 2007**

Tuesday, September 11, 2007 - CFN Seminar Room

08:15 – 08:45	Executive Session	G. Bock
08:45 – 09:15	NLS-II Welcome and Project Overview	S. Dierker
09:15 – 09:45	Construction Project Baseline & CD-2 Expectations	J. Yeck
	<u>Accelerator Overview and Design Requirements</u>	
09:45 – 10:15	Accelerator Overview	F. Willeke
10:15 – 10:45	Requirements and Interfaces	E. Johnson
10:45 – 11:15	<i>Break</i>	
	<u>Conventional Facilities Overview and Design Requirement</u>	
11:15 – 11:45	Conventional Facilities Overview	M. Fallier
11:45 – 12:10	Requirements and Interfaces	O. Dyling
12:10 – 12:45	Presentation of the 90% Title I Design	HDR
12:45 - 01:45	<i>Lunch at CFN</i>	
	<u>Experimental Facilities Overview and Design Requirements</u>	
01:45 – 02:15	Experimental Facilities Overview	J. Hill
02:15 – 02:45	Requirements and Interfaces	L. Miceli
02:45 – 03:15	<i>Break and Move to Breakout Rooms</i>	
03:30 – 04:30	Breakout Sessions (review plans for day 2)	
04:30 – 05:30	Executive Session	G. Bock
06:00	Reception and Dinner – Berkner	All

Wednesday, September 12, 2007 (See Breakout Agendas)

08:30 – 03:45	Breakout Sessions	
12:00 – 01:00	<i>Lunch at CFN</i>	
04:00 – 06:00	Executive Session	G. Bock/Committee

Thursday, September 13, 2007 – CFN Main Conf. Room

08:30	Executive Session	G. Bock/Committee
12:00	Close-out	All

- Notes:
1. Overview presentations should include a slide that responds directly to the charge to the review committee.
 2. Presentations on both days should include time for questions and discussion

Wednesday, September 12, 2007 (1/3 of each presentation time must be reserved for questions)**Accelerator Systems Breakout Session – CFN Seminar Room**

08:30 – 09:00	Risk Factors, Value Engineering, Test Plans	F. Willeke
09:00 – 09:30	Lattice, Accelerator Physics and Stability	S. Krinsky
09:30 – 10:15	Injectors and Injection Systems	T. Shaftan
10:15 – 10:45	Magnetic Elements	J. Sakritka
10:45 – 11:15	<i>Break</i>	
11:15 – 11:45	Power Converter & Electrical Infrastructure	G. Ganetis
11:50 – 12:15	Vacuum Systems	H. Hseuh
12:15 – 12:45	RF Systems (separate RF breakout session in afternoon)	J. Rose
	<i>Lunch</i>	
01:45 – 02:15	Girder, Absorber, Collimators, Shutters	S. Sharma
02:15 – 02:40	Diagnostics	I Pinayev
02:40 – 03:00	Controls and Infrastructure	B. Dalesio
03:00 – 03:25	Insertion Devices	T. Tanabe
03:25 – 03:45	Accelerator Safety Systems	S. Buda
01:45 – 03:45	RF Parallel Session (Bldg 817)	J. Rose

Experimental Facilities Breakout Session – Conference Room A

08:30 – 09:15	R&D Plans and Laboratory Infrastructure	J. Hill
09:15 – 09:45	Insertion Devices	T. Tanabe
09:45 – 10:30	Hard X-ray Nanoprobe Beamline	K. Evans-Lutterodt
10:30 – 11:00	<i>Break</i>	
11:00 – 11:45	Inelastic X-ray Scattering Beamline	Y. Cai
11:45 – 12:30	Hard X-ray Coherent Beamline	L. Berman
	<i>Lunch</i>	
01:30 – 02:15	Soft X-ray Coherent Beamline	C. Sanchez-Hanke
02:15 – 03:00	Powder Beamline	J. Alblett
03:00 – 03:45	XAFS Beamline	P. Northrup

Conventional Facilities Breakout Session – Conference Room B

08:30 – 09:15	Vibration & Beam Stability	N.Simos
09:15 – 09:45	Sustainable Design & LEED “Gold”	HDR
09:45 – 10:15	Utility Services - Building & Beamlines	O. Dyling
10:15 – 10:45	<i>Break</i>	
10:45 – 11:30	Thermal Stability	C. Channing
11:30 – 12:15	Acoustic Noise Mitigation	H. Amick
	<i>Lunch</i>	
01:15 – 02:00	Radiation Shielding	R. Casey
02:00 – 02:45	Geotechnical Conditions & Structural Stability	T. Joos
02:45 – 03:15	Value Engineering Opportunities – Interactive Session	M. Fallier
03:15 – 03:45	<u>Open Time for Discussion</u>	

Report Outline and Reviewer Assignments

NSLS-II Comprehensive Design Review Brookhaven National Laboratory September 11-13, 2007

Executive Summary	<u>Greg Bock</u>
1.0 Introduction	<u>Dean Hoffer</u>
2.0 Accelerator Systems	<u>Jean-Marc Filhol</u> , Mark DeJong, Takaaki Furuya, Georg Hoffstaetter, David Rice, Klaus Sinram, Uli Wienands, Michael Zisman
3.0 Experimental Facilities	<u>Ian McNulty</u> , Sean Brennan, Ernest Fontes, Mohan Ramanathan
4.0 Conventional Facilities	<u>Jeff Pitman</u> , Emmanuel Braus, Jim Kay, Marvin Kirshenbaum, John Sidarous, Jeffrey Sims
5.0 Charge Questions	
5.1 Is the design technically adequate, i.e. is the design likely to meet the facility technical requirements?	
5.2 Are the physics requirements clearly stated and documented? Have these physics requirements been translated into technical performance requirements and specifications?	
5.3 Can the design be constructed, inspected, tested, installed, operated and maintained in a satisfactory way?	
5.4 Is there adequate supporting documentation to detail the design?	
5.5 Are the risks (on technical, cost, and schedule basis) of the selected design approach understood and are appropriate steps being taken to manage and mitigate these risks?	
5.6 Is the project organization clearly defined and sufficient to ensure the successful engineering and design of the project, including the interfaces between the Accelerator Systems, Experimental Facilities, and Conventional Facilities groups?	
5.7 Is there a reasonable plan in place for implementing configuration management to ensure changes to the technical requirements/specifications are controlled and communicated to all affected groups?	

- Note underlined names are the primary writer.

Appendix D

Reviewers' Contact Information**NSLS-II Comprehensive Design Review****Brookhaven National Laboratory****September 11-13, 2007**

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* Chairperson

** Assistant Chairperson

Appendix E

Table of Recommendations

**NSLS-II Comprehensive Design Review
Brookhaven National Laboratory
September 11-13, 2007**

#	Recommendation	Assigned To	Status/ Action	Date
	1.0 Accelerator Systems			
1	Deepen the analysis of the impact of staffing shortage on the overall project schedule.			
2	Consider collaborating with other institutions as a way to augment staff in key areas quickly.			
3	A plausible (not detailed or fully accurate at this stage) staffing plan for the life of the project should be developed. The benefits and needs, if any, for recommendation 2 will become more obvious by doing this.			
4	Make a detailed scheduling of design review meetings with the relevant people before launching any major procurement.			
5	Reconsider the division of responsibilities between accelerator and conventional facility divisions			
	2.1 Lattice, Accelerator Physics and Stability			
6	Look carefully for places where HOM power could be trapped and develop mitigation techniques			
7	NSLS-II staff should try to work proactively with industry to see if the project needs for bpm resolution can be met. The proposed workshop is good idea as a way of developing and documenting the need for such performance.			

#	Recommendation	Assigned To	Status/ Action	Date
8	Evaluate and document the need for an abort system. If it is needed, provide a location in the lattice for it and design the required hardware and beam dump.			
	2.2 Injectors and Injection Systems			
9	The consequences of top-up injection with degraded performance should be assessed and remedies should be investigated together with the Experimental Facilities Division.			
	2.3 RF Systems			
10	The need for spare cavities for the storage ring should be assessed, especially considering the implications of catastrophic contamination of the SC cavities.			
11	Since the 3 rd harmonic cavity is required at the start of operation, work needs to be done to confirm the baseline design choice, and the means (financial, internal manpower) to procure that system.			
12	Estimation of the SR power into the SC cavity should be made. The SR power from the bending magnet hits the edge of the taper section and heats it up. This causes outgassing and discharging in the cavity. To avoid this problem, shielding masks should be designed			
13	On the cryogenics, not only the refrigeration capacity but the cooldown procedure should be considered carefully. It would be helpful if the cavities could be warmed up and cooled down independently.			
14	The relationship between the schedule of the RF R&D and the total project schedule should be made clear.			
	2.4 Magnetic Elements and Girders			
	Girder System Recommendations			
15	The long-term stability of this rigid support has to be shown. Any influence of the girder transport methods on maintaining accurate magnet positions has to be mitigated.			

#	Recommendation	Assigned To	Status/ Action	Date
16	Extensive alignment, vibration and thermal tests of the complete girder system have to be performed.			
	Magnetic-Elements Recommendations			
17	Despite the very tight time schedule, prototype magnets of each type should be built and measured to prove the required field quality over the dynamic range of excitation before mass production starts.			
18	High current densities, up to 10 A/mm ² in the magnet coils, are not recommended to avoid local heating of the magnet yoke and problems with water circuits.			
19	Consider the vibrations that could be caused by water-cooling circuits on individual quadrupole and sextupole magnets.			
	2.5 Power Converter & Electrical Infrastructure			
20	Consider using a switching type power supply for the dipole string. Switchers are less susceptible to tripping on line fluctuations, they avoid introducing line noise and minimize noise on the magnets, and they allow broader bandwidth regulation.			
21	Establish a schedule of design reviews for the various kinds of supply to be procured as well as for the cable plant design.			
	2.6 Vacuum Systems, Absorbers, Collimators, Shutters			
22	Consider including TiN coating of the beam channel in the design.			
23	Establish a schedule of design reviews for the various vacuum components to be designed and built.			
24	Wakefield heating of the various absorbers could become a critical issue and they should be included into the impedance budget.			
25	Develop a robust bellows design, considering dust generation and HOM power.			

#	Recommendation	Assigned To	Status/ Action	Date
26	Consider BPM position reproducibility after bake-out.			
	2.7 Diagnostics			
27	Prioritize the diagnostics that are essential from day 1 to achieve the commissioning of the 3 accelerators (Linac, Booster and Storage Ring).			
28	Clarify with the Experimental Facilities Division the requirement for 1% filling uniformity, as well as the bunch purity requirement in the time-structure mode.			
29	Optimize the design of the BPM buttons with respect to the RF power that will be deposited inside the feed-throughs, which could result in overheating.			
	2.8 Controls and Infrastructure			
30	The number of FTEs stated to develop the control system seems to us to be inadequate. There will be conflicting requirements of resources between the accelerator and experimental division as commissioning time approaches.			
31	There should be clear definitions of what is absolutely required on the control system to start the commissioning of the 3 accelerators.			
	2.9 Insertion Devices			
32	The review committee supports the principle of variable gap for damping wigglers. It will ease Day 1 commissioning and will enable going back to the bare lattice later on.			
33	Implement an ID lab as soon as possible to start the R&D program.			
34	Clarify with the Experimental Facilities Division the ID specifications (period, gap, flux, energy range,..) taking into account the technical specifications of the beamlines (defining slits, power load,..).			
	2.10 Accelerator Safety Systems			

#	Recommendation	Assigned To	Status/ Action	Date
35	A detailed plan for implementation, function, testing, and administrative controls of the PPS should be thoroughly reviewed in the near future, taking into consideration the specific requirements of the top-up injection.			
36	Don't use the dipole power supply as a second beam abort device in addition to the RF. This may require a long time to recover stable beam conditions. At other places, either a gate valve or a beam killer is inserted, some quadrupole power supplies are tripped, or a beam abort system is implemented.			
	3.0 Experimental Facilities			
	Beamlines, Sources, Utilities, and Ancillary Systems			
37	Alternative solutions to the differing floor heights should be considered, such as concrete pedestals for the girder sections alone. The 1-meter below-beam allowance will constrict insertion device options and drive up costs in this area.			
38	The benefits of out-sourcing beamline construction (rapid response, multiple ideas, cost competition) should be weighed carefully with regard to standardization of technical systems and full utilization of facility staff. At this point each beamline seems to have invented its own design process and its own cost basis without oversight as to commonality and scale. The committee feels strongly that standardization will be extremely important to achieve overall project cost containment and minimize maintenance and operational costs (spares, staff training, documentation, etc.). In addition, the long term benefits of operation and maintenance should be considered at this early stage.			

#	Recommendation	Assigned To	Status/ Action	Date
39	Availability of limited emergency power backed by UPS to each beamline is essential to maintain key elements of the beamlines. Investment in much larger UPS systems for critical beamline and computing facilities should therefore be considered. It is more cost effective to include this in the original Conventional Facilities planning than to add it later on a case-by-case basis.			
40	Keeping the SR tunnel and experimental floor temperatures within a few degrees will help minimize thermal instability between these systems. Maintaining both a few degrees cooler than the planned 25.5/23.8 C would improve equipment longevity and the personnel work environment. The relative humidity should also be evaluated in these decisions as it impacts certain experiments as well as personnel comfort.			
41	An integrated approach across the whole facility should be taken for the controls, data acquisition, and safety interlock systems. In addition, the computing needs for the beamlines have to be addressed early on. Specifically the benefits of centralizing the data storage and archiving should be weighed in. In this regard the availability of data between beamlines can be an important issue for centralization. As EPICS is the control system of choice, there should be complete transparency between the controls for the beamline, the accelerator, and, if possible, the conventional facilities.			

#	Recommendation	Assigned To	Status/ Action	Date
42	<p>Separating the hard x-ray XPCS and coherent diffraction beamlines by putting them on different undulator ports will give them full independence and eliminate the concerns of having the two transport pipes in close proximity. The scientific impact of these two programs is significant and may warrant the additional cost of dedicating an extra port and the additional financial burden of undulator, front end and FOE. (~\$2–3M). In addition, given the risks of splitting the beam using mirrors, the cost savings of sharing an insertion device and front end do not seem justified.</p>			
43	<p>The medium-energy (7–30 keV) powder diffraction beamline would probably be served better by a bending magnet and 3-pole wiggler rather than by a damping wiggler. There is an opportunity to optimize the powder diffraction beam line for the energy range above 40 keV using transmission focusing optics. Experience at the APS is that such a beam line would be highly desirable. Given the ease with which lower energy powder diffraction needs can be met with one of the 3-pole wiggler beam lines, there is a strong case to be made for not adding complexity to the powder diffraction line by including the lower-energy capability.</p>			
44	<p>The use of a damping wiggler as a source in the initial phase should be carefully weighed. Unless the science requires the higher energies and the high brilliance, it might be advisable to make use of a 3-pole wiggler source for early operation. This has an added advantage of allocating resources, in terms of not handling all the challenges at the same time. If, after consideration, a damping wiggler source is still justified, a thorough thermal analysis of how the optics will handle such a source is needed.</p>			
Organizational Priorities and Interfaces				

#	Recommendation	Assigned To	Status/ Action	Date
45	<p>Prioritization for constructing the Nanoprobe and Inelastic Scattering beamlines should include the necessary mechanical and technical support. These beamlines are beyond the current state-of-the-art and will require long-term R&D. Each of the beamlines should have its own set of goals, milestones, and metrics to maintain focus and momentum. Each beamline will need cost containment that can only be done in concert with economies of scale achieved by sharing non-recoverable engineering design with other facility beamlines. In particular, strong leadership will benefit the hard x-ray nanoprobe beamline design in reaching the ambitious project goal of 1 nm resolution.</p>			
46	<p>Accelerator and experimental facilities should develop a common technical specification for a centrally supported process water system designed and built by conventional facilities.</p>			
47	<p>The approach to effective identification and resolution of interface issues, and how they will incorporate the project priorities to meet performance goals, should be clarified. In particular, the staff training (and expectations) to use the proposed on-line database WBS tracking system was not discussed.</p>			
48	<p>A common set of measurement units and coordinates should be adopted by all facilities at the earliest opportunity.</p>			
49	<p>A consistent system for survey and alignment of both the storage ring and beamlines should be adopted.</p>			
	<p>Personnel and Staffing</p>			
50	<p>A detailed schedule for effective hiring and utilization of staff to meet the performance objectives is needed</p>			
51	<p>The plan to maintain staffing continuity through the Construction phase to the Operations phase should be clarified.</p>			

#	Recommendation	Assigned To	Status/ Action	Date
52	A detailed plan for developing the future Beamline Access Teams and Partner Users should be articulated. This is essential to encourage productive, long-term scientific programs for NSLS-II.			
	4.0 Conventional Facilities			
53	Complete a standalone, controlled, facility design criteria/technical parameter requirements document, approved and accepted by all divisions, prior to the CD-2 review. This document should include the basis of design, including a list of design limits for flow velocities, pressure drops, materials of construction, diversity factors, electrical load requirements, etc. This should be a living document that is maintained and updated and will act as a vehicle to insure uniformity of the design for all Mechanical Electrical Plumbing (MEP) systems.			
54	Complete the title I design drawings to bring the level of detail up to that required for pricing and the commencement of the title II design. This includes the central plant upgrades (chilled water and electrical), which need to be at the same level of design and specification as the rest of the conventional facilities prior to the CD-2 review for the purposes of obtaining accurate cost and schedule estimates. In addition, expedite technical completion and resolution of the infield detail (column, thermal and wind effects, etc.) and vibration studies.			