National Synchrotron Light Source II (NSLS-II)
Science Advisory Committee

Meeting Report – March 8-9, 2018

Attending: Harald Reichert (Chair), Ingrid Pickering (Vice Chair; remote), Bruce Gates, Franz Hennies, Robert Hettel (remote), Stephen Kevan, Eugene Lavely, Janet Smith (remote), Soichi Wakatsuki, Jen Bohon (representing UEC)

Regrets: Liyuan Liang, Anders Madsen, Esther Takeuchi

Preamble

The Science Advisory Committee (SAC) of the National Synchrotron Light Source II (NSLS-II) met at Brookhaven National Laboratory (BNL) on March 8-9, 2018. The SAC congratulates the whole NSLS-II team on the accomplishments and progress over the last six months. This has been achieved as a result of the expertise and dedication of all team members.

The SAC was provided with a charge by the management and was asked to provide feedback on three major aspects of the facility development, which are detailed in Sections 1-3 of the report, along with comments on the development and operations of four specific beamlines (Section 4). Suggestions of updates for future meetings are provided in Section 5.

1. Accelerator

General comments

The SAC congratulates the Accelerator Division (AD) for achieving highly reliable, high quality operation of the NSLS-II accelerator in spite of the reduction in personnel over the last several months. The AD is to be commended for cross-training staff in order to mitigate this reduction. Establishing goals for reliability, MTBF, operating current, beam stability, etc. is an effective way to motivate staff and reach high performance of the accelerator. Maintaining an appropriately funded accelerator improvement plan with associated engineering and physics challenges is critical for staff motivation and morale and for retaining the high quality skill set needed to assure the best performance of the NSLS-II accelerator complex.

Response to charge questions

1.1. Is the FY18-20 maintenance and spares program sufficient to meet our reliability goals?

The AD has made a detailed assessment of the reliability of various systems and components and has determined the most vulnerable ones. Reliability issues are being addressed with a more aggressive preventive maintenance program, periodic RF cavity and cryogenic system warm-up, component upgrades, and by procuring spares over the next 5 years. Procurement of critical spares is planned to be completed in 3 years.

The availability of funds for spares is limited by the high cost of components needed to reach 500 mA operation, including a 3rd superconducting (SC) RF cavity system and an SC high harmonic cavity (HHC) system, although a 3rd RF cavity provides redundancy and improved reliability for lower current operation as well.

Recommendation:

- If not done already, the AD should develop plans for restoring accelerator operation as quickly as possible should a critical component, for which there is no spare, fail.

1.2. Are the plans to reach the design goal of 10 pm-rad in the vertical appropriate given the performance requirements of the users?

The AD has demonstrated that operating with a vertical emittance of 10 pm or less is feasible. While the SAC was told that only 3 out of 19 beamlines report a preference of operating with 10 pm or less vertical emittance, it is those beamlines that appear to be capable of exploiting the high coherence that NSLS-II offers and operating in that mode should be justified. The drawback of low lifetime when operating in low emittance mode, which is likely to be the most significant issue for many users, should be mitigated with a future HHC.

The SAC notes that NSLS-II management could decide to have specific periods of low-emittance operation if full time operation in that mode is problematic.

1.3. Are the FY18-20 R&D plans appropriate in terms of their focus and their size?

Accelerator R&D is presently focused on developing the HHC system, improving beam position monitor (BPM) electronics, testing new undulator concepts, and exploring a future modest lattice upgrade that could reduce emittance by a factor of 3-4. These endeavors appear to be appropriate given the available resources.

Physics studies for operation at higher current with the HHC are important, challenging and interesting. The collaboration with MAX-IV on understanding their harmonic cavity problems will benefit the NSLS-II implementation. These studies could benefit other facilities as well, including the APS-U and ALS-U. The Committee notes that the time to conduct computationally intensive simulations for these studies is limited by the lack of access to a computer cluster having a high number of nodes. In principle the Accelerator Physics (AP) group could invest in such a cluster for themselves (expensive), but it would be more efficient use of the powerful computing resources provided by the BNL Computational Sciences Initiative (CSI) for these simulations. On the other the hand the AP group reports receiving rather poor support from CSI: long waiting time (few minutes to few hours) depending on the number of jobs in the queue; limited and tardy support from CSI experts; and reluctance to install and support accelerator "niche" codes.

These R&D efforts are important for preserving the physics and engineering expertise that is needed to successfully operate and improve the performance of the accelerator.

Recommendations:

- Continue to develop an accelerator improvement road-map that can provide focus for more near-term developments.
- Work with the NSLS-II Director to help resolve deficiencies in computing support from CSI.

2. Beamline Operations

2.1. Is the controls program on a path to success? Is the organizational structure appropriate for the operational needs of the facility? Are the priorities of the program clear, transparent and are there appropriate mechanisms to align them with the priorities of the facility? Is the controls program on a path to functioning as a coherent team?

The SAC commends the NSLS-II management for its high awareness of the critical role of the controls program and for making this an important topic on the SAC meeting. From discussions with staff from controls, engineering and beamlines, it became clear that various issues accumulate and result in increasing frustration. Beamline staff expressed difficulties to get controls support for these issues to a sufficient degree and in a predictable manner, but also irritation about the way organizational aspects are handled, e.g., the communication and implementation of the point-of-contact (POC) system. Crucial for an efficient organization of the controls work is the awareness by all stakeholders of strategies and procedures as well as implications for beamline outcomes and operations. However, fundamental questions of roles, responsibilities and procedures were not defined or communicated, and there was no clear sense of prioritization and the implications thereof. The SAC was particularly struck by the fact that the independent assessments of the problems, as they came up during the discussions with different groups of beamline staff and the Controls staff (Accelerator Controls, Beamline Controls and IT) were well aligned, and that none of this was part of the presentations to the SAC. The SAC takes this as evidence not only of a disconnect between management and the technical staff, but also an indication of a largely unused potential to develop a more efficient system with engagement of *all* stakeholders.

In general, the material presented to the SAC was insufficient and too unspecific. It did not offer any specific, measurable and actionable plans or processes. From the presentation, it was not possible for the SAC to understand to what extend the Controls program at current can fulfill its mission.

Information was missing about:

- the workload in the controls program in relation to available resources, in order to decide if the program is sufficiently staffed
- whether the program is able to meet the project deadlines and the needs of beamlines in operation with acceptable response times
- what fraction of the controls program resources are assigned to troubleshooting, beamline projects until IRR, beamline commissioning and continuous beamline development
- priorities of the program, in terms of balancing competing requests from beamlines, long term developments and improvements, non-essential troubleshooting, etc.
- actions that are taken in order to ease the pressure on the controls team, such as an increasing level of standardization across the facility
- the way the controls program internally processes and prioritizes incoming requests (e.g., via the ticket system), and keeps track of projects and timelines
- how the scope and specifications of controls developments are defined and the procedures for follow-up, maintenance, and documentation

The SAC was not satisfied with the presented answers to the charge questions regarding communication with beamlines and beamline groups and the setting of priorities.

From isolated comments, the SAC sensed that, where already implemented, the systems in general work in a stable manner and fulfill the needed functionality for the beamlines. Some beamline staff also expressed that they have sufficient own-access to the control systems, enabling them to contribute to development where possible. The SAC wondered about the reported difficulties with the motion control system. It is normal that motors need tuning for every specific application. However, it seems implausible that these systems need regular retuning as part of troubleshooting unless the initial tuning

was incomplete. This indicates a lack of personnel or experience or both in the controls hardware / PLC section.

The SAC observed some improvements in internal communication within the Controls program, but also found that issues of the lack of communication between different groups within the Controls program remain significant. The SAC observed a still urgent need to establish close communication channels with beamline programs and individual beamlines. While the resurrection of the issue tracking system (TRAC) is a good step forward, much more care is needed to use this technical solution in procedures that serve the needs of the beamlines, both construction of the remaining beamlines and the operation of all existing beamlines.

The SAC very much valued the meetings with the controls and beamline staff which revealed specific "facts on the floor" and a more realistic picture of the status of the controls situation. The conversations were wide-ranging, including the needs and challenges for both the controls and beamline staff, and spirited suggestions on how the situation can be improved. Many of the comments resonated with the attendees and SAC members, and the SAC believes that recognition of the talent, passion, professionalism and capabilities of the staff is essential for progress forward.

The SAC senses that the present (lack of) protocols for controls group and beamline interaction emphasizes a "point solution" approach, an effect only enhanced by the POC and "ticket" system. Meanwhile, many of the needs across beamlines share commonality, e.g., a "fly-scan" or inverse kinematics over similar sets of degrees of freedom. At current, there does not seem to be a floating intelligence or "glue" amongst beamlines and controls that could recognize common needs or have a firm grasp of prioritization and urgencies. Anchoring of controls POCs to "problems" and beamline staff to their own beamlines perpetuates inefficiencies, when, in fact, controls personnel may be more productively engaged as team members within beamlines, even if they are operating in floating capacity.

The SAC notes that the findings of the much more detailed Beamline Controls Group Review are well in line with the SAC's own observations and comments from the earlier SAC meetings. After having reviewed the Beamline Controls Group Review report, the SAC is even more concerned that none of the issues that apparently came up during that review were addressed in the material presented to the SAC.

Hence the SAC recommends involving all stakeholders from beamlines, engineering, and all divisions of controls in:

- an open evaluation of the POC system and discussion of improvements to the system
- an effort to explore commonalities between beamlines on Beamline Controls and opportunities for increasing efficiency
- developing adequate structures for defining and requesting, as well as planning and following up on Controls tasks, both short and long terms
- exploring new ways of cooperation between beamlines and between beamlines and controls in sharing development and responsibility for the controls program
- an assessment of the motion controls issue and a discussion of proper testing and tuning protocols

The value engineering effort urgently needs to include controls with a clear mandate on establishing an adequate structure, protocol and set of guidelines to address the above-mentioned issues and recommendations.

Ideas discussed by the SAC included having staff with high-level and in-depth understanding of the matter "circulate" amongst beamlines and controls to coordinate efforts, skills, and resources; and finding new ways in which solutions are documented, technical advances are shared, and working groups are established. Ultimately this could lead to advances in control science, evolution in best

practice, much needed integration between controls and beamlines, and coordination between relevant beamlines. Ultimately, this could achieve far better facility operation as well as strongly support professional development of all concerned.

The current situation is not acceptable, and the success of the controls-system is mission critical for the NSLS-II. On a positive note, there is ample expertise and understanding of the needs available in the NSLS-II organization at the beamlines and in the technical groups. A new and emergent paradigm is required, and the SAC encourages the NSLS-II Director to think "out of the box" to address these important issues involving all stakeholders.

2.2. Are the beamline operations taking advantage of all opportunities for efficiencies? Are there other opportunities we have missed?

The SAC complements the NSLS-II in managing a very diverse and rapidly growing portfolio of beamlines. Progress in commissioning new beamlines in the past year or two has been very impressive. The model for technical and science commissioning seems to be working well, though a large backlog of controls work continues to present many difficulties (see above).

NSLS-II beamline staff work very hard and offer impressive and crucial expertise. The long-term success of the facility will rely heavily on their performance. We are therefore concerned that they continue to express serious concern about decision-making processes, about how resulting decisions are communicated, about their opportunities for professional development, and about their work-life balance. We understand that these issues exist at all x-ray facilities, but that should not negate creative efforts and progress in addressing them.

We encourage NSLS-II management to develop regular communication paths with beamline and accelerator staff. In particular, this should include more inclusive decision-making processes in which staff will clearly understand constraints and will come to co-own the resulting decisions. By itself, this will be a form of professional development.

The doctoral and postdoctoral programs being developed will also provide professional development and an avenue for strong engagement of and collaboration with the user community, will train knowledgeable and more independent users, and will help develop the pool of new staff for x-ray facilities at large. However, a more complete model for sustainable beamline operations and staff work-life balance is urgently needed. In the meeting there was discussion of allowing staff not to operate their beamline on one out of nine weekends in a recent cycle. This is a good start but is clearly not adequate. Other solutions might include further development of the doctoral and postdoctoral programs, increased beamline automation, reduced change-overs on weekends, cross-training of staff on related beamlines, and operating some beamlines less than 100% of the time. The NSLS-II has an opportunity to develop new procedures and a new climate that supports the beamline staff, who play such a major role in the success of the facility.

The Computational Sciences Initiative will provide another path for beamline staff professional development, particularly concerning on-line data analysis. However, the long-term relationship is not clear, at least not to the staff. It is crucial to develop a relationship in which both sides understand and own issues related to staff development – and to user science and service, of course.

The loss of technical expertise in a recent RIF has caused serious problem with staff morale. The staff understand they cannot be completely included in decisions concerning personnel, but the rationale for losing half the technicians has not been well-explained, so this decision seems arbitrary.

Some staff commented about burdensome and ineffective safety procedures, e.g., long online courses that require rote memorization rather than developing a strong and respectful safety culture. We

have not heard this often, but it might warrant some discussion and attention, and possibly comparison with other facilities.

Finally, while we understand the financial issues faced by the NSLS-II, we are concerned that, as stated, the proposed beamline staffing model does not satisfy the BES sponsor. The model suggests direct staff support of slightly over 4 FTE/beamline, on average, with another 1.5 – 2.0 FTE of indirect staffing (e.g., user office, controls, etc.). The total remains larger than other BES-supported x-ray facilities, which is the target suggested in guidance from the recent triennial review. While we understand the complexity of this situation, it seems that the proposed model will not by itself satisfy the primary NSLS-II sponsor.

2.3. Has the beamline value engineering exercise identified concrete opportunities to reduce costs? Is the exercise on a useful path to conclusion?

The SAC was pleased to see that the value engineering exercise is laid out and understood to provide valuable input for the development of the facility during operations as much as for future beamline construction activities. The latter will soon be reduced substantially with all the major beamline construction packages being finished. Nevertheless, beamline value engineering is a very useful exercise. It has been established only late in the process, but is already beginning to show first (concrete) results. The process, as very convincingly presented by the project leader, is a good exercise in inclusiveness. It brings together all the stakeholders and stimulates exchange with the possibility to learn from past experience. Both the value engineering process itself, but also in broader strokes values of inclusiveness and appreciation of expertise, should become an everyday routine at the whole facility. Unfortunately, controls have not been included in the process so far, although controls is the area where the issues are most burning. It is also the part that has a very high visibility with users as it constitutes the interface for the use of the beamline hardware. Finally, the machine could explore a similar strategy. Ultimately, the process can deliver invaluable input for future construction, improvements of operation and strengthening of collaboration within the facility.

Beamline value engineering is a valuable tool for reaching a high level of standardization. A good example is the cryo-cooler for optical systems (monos, mirrors). Beamline value engineering at an early stage would have led to the selection of one system as a standard. Today, there are four different systems installed at the NSLS-II leading to a corresponding increase in maintenance efforts (building a stock of spares, preserve/acquire technical competence for maintenance). This has been clearly identified as a future problem by the concerned experts. The beam stability issues reported by the SMI team (see below) are another example of a problem that might have been avoided, if projects were not managed individually.

The SAC is convinced that beamline value engineering is an evolving process and should not work towards an early end. Once beamline operation reaches a steady state, maintenance, refurbishment and future upgrades provide fertile ground for further development. It also provides a forum for exchange between experts in different areas and the dissemination of skills available at the facility. Building a team spirit, where experts in one area take into account issues their choices have in other areas, e,g, the selection of mechanical components or detectors versus the efforts required to develop the necessary tools for controlling them, is another added long-term value.

3. User Program

3.1. Is the user program making appropriate progress? Are there areas of concern?

User community growth is progressing well, on track to meet or exceed the stated goals of the sponsor. There seems to be a healthy mix of new and returning users for growing a proficient user community while still enabling access for new experimenters. The SAC welcomes the instigation of the new One Stop Shop for badging and access and encourages continued consolidation where possible. The SAC is also pleased to hear that construction of additional user laboratories is expected to commence in the near future with significant progress expected prior to the next SAC meeting.

Beamline controls (section 2.1) and data access continue to be areas of concern. Complex and lengthy data access procedures, coupled with an intermittently slow or inaccessible network, were reported to create significant frustration. The SAC applauds the Single Sign-On initiative, and encourages continued efforts to streamline user interaction with data. The SAC also encourages consideration of remote access, particularly for macromolecular crystallography beamlines. The PASS proposal system continues to be difficult to use, and the SAC welcomes the efforts to investigate alternatives to this system (section 3.2).

3.2. Is the plan for the user interface with the proposal system clear and executable on the required time scale?

The proposed move to a commercial system for proposal handling, coupled with the adoption of the scheduling system already developed by ALS, has the potential to address many of the issues presented by the current PASS system. The timeline is quite reasonable (perhaps ambitious) to test this system. Movement in the direction of standardizing systems within the broader community is encouraging.

3.3. Partner User program.

The SAC is pleased to see that the Partner User Program (PUP) is gaining traction and encourages its expansion. The program provides several significant advantages, including: resources from external sources, potentially including equipment and funding; potentially innovative new science to enhance the reputation of NSLS-II as well as help attract new users; users who may be expert and productive while requiring only minimal help from beam-line staff; equipment that can extend the capabilities of NSLS-II and potentially help users other than the Partners. The Partner Users who are already engaged are clearly bringing expertise and good science to the program. The SAC encourages NSLS-II leadership to plan for eventualities such as withdrawal of Partners from the program when the capabilities they have initiated are still producing strong science and attracting users with strong proposals.

The SAC recommends watching two aspects of the PUP a little more closely, even as there is no strong indication of a major problem currently. One is the balance of GU and PU at a given end station. PUs have and should have the advantage of being able to shape the program at the respective end station, which gives them an inherent advantage. However, this should not affect the possibilities and demands of GU users, e.g., by focusing all activities too much on a specific very narrow area. The second aspect concerns expectation management, in particular in terms of staffing and resources, e.g., as needed for GU user support vs PU science, technical support from the facility, etc.

3.4. Is the proposal for the triennial review of the beamlines reasonable? Does the SAC have other suggestions for how it might be run?

The proposal put forward seems appropriate. The SAC stresses the importance of properly articulating the purpose of the reviews, in order to ensure that the reviews are a positive opportunity for growth and development. Being “reviewed” can have negative connotations causing additional stress on

a hardworking and dedicated staff. Presumably at this development stage reviews are intended to be formative, providing constructive feedback, accolades where appropriate and practical feedback of pathways to improve and new directions to follow. The reviews are an excellent opportunity for the beamline staff to self-reflect on their achievements and to undergo visioning for the upcoming years. External experts and users participate as a resource, to provide endorsement of achievements and advice where necessary. Ultimately the experience should be positive, rather than a cause for stress.

The SAC recommends that section lengths of the beamline report be given recommended boundaries, allowing enough space to articulate important points without overburdening beamline personnel. It would seem appropriate to consult beamline leads regarding which users to include in the review. Following these first reviews, feedback should be solicited both from the review committees and from the beamline personnel in order to refine the process for the next set of reviews.

4. Focus on Specific Beamlines

The SAC heard brief presentations on four of the beamlines, for each of which the SAC was asked to comment on specific aspects.

4.1. ISR (Integrated In-situ and Resonant Hard X-ray Studies, 4-ID)

- *Is the beamline on track to develop world-leading programs? If not, what should be done?*

The ISR team has achieved great progress thus far in rapidly commissioning beamline capabilities. The SAC was pleased to see science highlights already produced by the beamline despite technical challenges. The partner user activities at ISR appear to be well integrated and valuable, providing a significant increase in capabilities.

The resonant scattering program benefits from strong expertise, leadership, and advocacy from the beamline staff. The in-situ program bases on long-standing experience and expertise by NSLS staff and collaborations. However, it has come to the attention of the SAC that some basic capabilities requested by general users for the in-situ part are missing. The SAC encourages the beamline team and NSLS management to create a healthy balance between the two programs.

The SAC was not fully convinced that the solution presented for some mechanical problems (exchange of motors every 9 months after failure) is the best way of dealing with it.

- *Does the beamline have the correct mix between commissioning new capabilities and running a user program?*

The beamline presents a relatively aggressive schedule for development of new capabilities. The SAC recommends a gradual increase in GU operations from the current ratio in order to successfully integrate these new capabilities.

- *Is the user program looking healthy for this point in its development?*

User demand for ISR is strong. There were initial concerns with a significant demand from general scattering users taking up the focus of the beamline due to the presence of the sole 6-axis diffractometer at NSLS-II. These pressures are expected to be alleviated as the NIST SST beamline becomes operational with a similar capability. Here, NSLS-II management and PRP should ensure that unwanted precedents are avoided. The balance between the resonant scattering and in-situ user demand is somewhat skewed at this juncture, but this may be natural this early in beamline operations. Efforts to engage the growing in-situ community are encouraged. Notably, the beamline staff reported that the PRP routinely scored most if not all of the in-situ proposals less favorably than other types of proposals.

The SAC finds this remarkable in the light of the general development of in-situ applications. If the scoring is a true representation of the impact of the science proposed, it could reflect missing capabilities of the in-situ program at ISR and that good proposals go elsewhere. Demand for this program may increase as additional capabilities become available. In addition, it may be worthwhile to examine the composition of the panel to ensure that both programs receive representation.

- *Is the future plan for the beamline appropriate? Are there opportunities we are missing that we should go after? Conversely, is the beamline pursuing directions that it should not?*

The future plan is appropriately phased, with a realistic yet ambitious schedule. ISR may wish to reconsider capabilities planned for the in-situ program. The SAC has become aware of requests for an attenuation system to enable x-ray reflectivity measurements or the possible need of an area detector for simultaneous SAXS/WAXS measurements (perhaps the 100K area detector upgrade for the resonant scattering program could be a shared resource between the programs). Development of an in-house in-situ growth chamber is challenging, and its success will require significant expertise and resources.

4.2. SMI (Soft Matter Interfaces, 12-ID)

- *Is the beamline on track to develop world-leading programs? If not, what should be done?*

The SAC congratulates the SMI team for the successful initial operation of this new beamline. The SMI beamline has a solid scientific program addressing a potentially very large user community. A significant part of the capabilities is still in development, but beamline operations and the general user program are developing as well as can be expected. The beamline is on track, and it is too early to make adjustments before the capabilities are fully built out. Resonant scattering experiments on soft matter in the tender x-ray range, which should soon be open for the GU program, offer a particularly high potential for unique science enabled by the SMI beamline. The completion of the PLS branch is mandatory as it builds on a long history of research on liquid interfaces at BNL.

- *Does the beamline have the correct mix between commissioning new capabilities and running a user program?*

There is a large legacy in soft matter science with x-rays at BNL/NSLS. Expertise in this field is still quite high and SAC expects this science area to grow rapidly. The balance between commissioning and general user operation appears to be fine. SAC supports the request for a second full scientist to be able handle the significant amount of commissioning (still required) and a continued (rapid) ramp-up of user operation.

- *Is the user program looking healthy for this point in its development?*

The examples of early user science demonstrate that the beamline has a high potential for impactful science. The data quality is excellent, but hampered by mirror vibrations and long-term drifts in the monochromator, resulting from design issues with both optical elements.

- *Is the future plan for the beamline appropriate? Are there opportunities we are missing that we should go after? Conversely, is the beamline pursuing directions that it should not?*

The future plans are well adapted and seem to be realistic; design flaws in the optics (mirror/mono stability) must be dealt with as soon as possible. The SAC is looking forward to seeing the PLS branch built out in time (commissioning anticipated in 2019-3).

4.3. ESM (Electron Spectro-Microscopy, 21-ID)

- *Is the beamline on track to develop world-leading programs? If not, what should be done?*

The SAC complements the ESM staff in commissioning and producing early science on the ESM beamline.

Modern ARPES beamlines generally use commercial electron energy analyzers and ancillary instruments, and what often makes a particular instrument unique is the utility and user-friendliness of the control system for sample preparation, sample manipulation, and ARPES execution, the resolution and focal spot size of the beam, and the capacity for rapid visualization of multi-dimensional data sets. While the ESM complex has been well-designed and could be world-leading, the overall capability will not even be world-competitive without development of EPICS-based control systems for the Scienta analyzer and XPEEM instrument. This development will likely be useful on a few other ARPES and APXPS end stations at NSLS-II, and possibly will be useful at other facilities as well.

- *Does the beamline have the correct mix between commissioning new capabilities and running a user program?*

Expertise in the area served by ESM at NSLS-II and BNL in general is quite high, given past productivity at NSLS. For this reason, the ESM complex has been well designed and commissioning has largely proceeded smoothly (the EPICS control system being an important exception). The user program is ramping up and we expect a strong user program with continued development of capabilities.

- *Is the user program looking healthy for this point in its development?*

Yes, see above.

- *Is the future plan for the beamline appropriate? Are there opportunities we are missing that we should go after? Conversely, is the beamline pursuing directions that it should not?*

The plan for continuing development of the ESM ARPES branch is very strong. In particular, the collaboration with user groups to develop on-line growth capabilities is welcome and very important. The beamline staff might want to develop 1-2 additional partner user agreements to increase collaboration in science and in developing new capabilities.

The ability to transfer samples between the growth systems and the ARPES/XPEEM end stations is important. We encourage developing techniques to achieve sample registry between these two with micron precision. More globally, the NSLS-II should consider developing methods to achieve registry between different tools across the facility. It is important to do that now, as more microscopes are commissioned.

4.4. TES (Tender Energy X-ray Absorption Spectroscopy, 8-BM)

- *Is the beamline on track to develop world-leading programs? If not, what should be done?*

TES fills a niche in the “tender x-ray” 1-5 keV energy range that spans the traditional hard x-ray and VUV regimes; this energy range has relatively few beamlines worldwide. The beamline supports spectroscopy and spectroscopic imaging of many lighter elements including Na, Mg, Al, Si, P, S, and Cl and thus appeals to several relevant and diverse research communities. TES sets itself apart from the few tender x-ray spectroscopic imaging beamlines worldwide by combining excellent energy resolution, superb energy stability and reproducibility.

The beamline has achieved impressive performance through the sustained efforts of limited staff, most notably the lead beamline scientist. The move to the imaging group has clearly been positive, and leverages experience in common equipment, controls and software processing.

The SAC commends the effort to achieve the exquisite positional stability as a function of scanned energy. This required collaborative efforts to constrain the bend magnet horizontal position (a first for NSLS-II) and to install a novel adjustment on the mono. The resulting stability is essential for spectroscopic mapping and is a distinguishing feature of this tender x-ray range beamline.

- *Does the beamline have the correct mix between commissioning new capabilities and running a user program?*

Around 13 proposals accommodated per cycle is appropriate. The priorities and mix are commensurate with this stage of its development, with appropriate time set aside for technical commissioning and science commissioning as additional features are rolled out.

- *Is the user program looking healthy for this point in its development?*

TES has very strong General User and Partner User programs. There is a high demand for this beamline, with 32 General User Proposals in 2018 cycle 2. Demand exceeds the available beamtime by a healthy margin, close to a factor of 2 in the last two cycles. There have been excellent early results obtained from multiple communities. This is clearly a popular and well-run beamline.

- *Is the future plan for the beamline appropriate? Are there opportunities we are missing that we should go after? Conversely, is the beamline pursuing directions that it should not?*

There are several stated goals of the beamline. These include full EXAFS energy scanning; extending the energy range below 2 and above 5 keV; and pushing the beam size at the sample towards a 1 μm spot. Each of these is a very appropriate goal, needed by the user community, and achievable.

The SAC has some additional suggestions for consideration, not intended as requirements, but rather as ideas to consider.

Support for multi-modal studies would be a valuable addition, particularly for static samples. Some are already being pursued, including the ability to run the same or complementary sample both at TES and on higher energy x-ray fluorescence imaging beamlines, as well as optical imaging. Complementary FTIR imaging would leverage additional on-site expertise. Within BNL, scanning electron microscope studies of the sample at CFN also could be performed. In all of these, the availability of image registration software would be an important contribution to success.

The combined capabilities of the TES fast fly-scan stage and the monochromator fast energy scanning rates from 1 to 75 eV/s supports rapid data acquisition, and is particularly valuable for dynamical systems. This versatility is further enhanced by the large range of spatial resolutions supported i.e., ~ 1 μm to ~ 1 mm. The utility of the beamline could be enhanced even further with software algorithms were available for the user to exploit these control parameters. For example, the signal-to-noise ratio (SNR) conditions may be particularly challenging depending on the sample properties, the sample dynamic rates, the incident beam energy, and the necessary energy scan rate. In another case it may be desirable to scan a very large area of a static sample, but in a reasonable amount of time, which, again, could pose SNR challenges. Image processing software such as Bayesian image recovery with total variation or interior point methods using prior knowledge of the beam profile and Poisson statistics could address the SNR issues in a very favorable way for many users. Again, these are ideas for consideration, rather than directions to be followed.

5. Items for Future SAC Meetings

The SAC wishes to receive input on the following during upcoming meetings:

- *User Program:* Progress with the network and data access issues and the results of the PASS alternative program.
- *Controls program:* Progress on actions addressing communication and management.