SRX BAT Report

October 30, 2008

This report summarizes initial findings and recommendations of the Beamline Advisory Team (BAT) for NSLS-II's Submicron Resolution X-ray (SRX) spectroscopy beamline from the first BAT meeting held at Brookhaven National Laboratory, October 30th, 2008. The BAT consists of the following individuals (asterisks denote they were in attendance at this meeting):

Peter Eng: Senior Scientist, Univ. of Chicago*
Jeffrey Fitts: Assistant Geochemist, BNL*
Keith Jones: Senior Physicist, BNL*
Antonio Lanzirotti (Leader): Senior Research Associate, Univ. of Chicago*
Lisa Miller: Biophysical Chemist, BNL
Matt Newville: Senior Research Associate, Univ. of Chicago*
Paul Northrup: Assosciate Environmental Scientist, BNL*
Richard Reeder: Professor, Stony Brook Univ.*
Mark Rivers: Senior Scientist, Univ. of Chicago*
Steve Sutton: Senior Scientist, Univ. of Chicago*
Stefan Vogt: Beamline Scientist, Advanced Photon Source*
Gayle Woloschak: Professor, Northwestern Univ.

Also in attendance were the following members of the NSLS-II project:
Qun Shen: Experimental Facilities Division Director
Andrew Broadbent: Beamline and Interface Manager
Steve Dierker: ALD for Light Sources, NSLS-II Project Director
Ray Conley:
Konstantine Kaznatcheev:

SRX BAT Meeting Agenda, October 30th, 2008

10:00 am: Welcoming remarks, presentation of Lehman CD-3 overview and discussion of comments from Lehman and EFAC reports (Lanzirotti, Shen)

10:30 am: Update of most recent NSLS-II experimental facilities plan; layout, performance, facilities, strategic plan, overall project schedule including SRX (Shen)

11:00 am: SRX BAT Executive session

- NSLS-II BAT Charter
- Role of the SRX BAT in the project
- Funding strategy for ZP branch and planning to move design forward
- Scientific mission of SRX
- SRX Staffing philosophy and needs
- Opportunities for Partner Users on SRX
- Other items

11:30 am: Presentation of SRX costing estimates (Broadbent, Lanzirotti, Northrup)

11:50 am: SRX Insertion device options (Northrup, Broadbent, Rivers)

- Is 1.5m U22 an adequate starting configuration?
- Energy range accessible and performance considerations.
- Canting considerations (minimum 2 mrad, desired 4 mrad).
- Initial performance calculations and control specifications for 1.2 m U20 (because U20 is the only device that is yet characterized for NSLS-II).
- Possibility of utilizing a cryo cooled U20 device (CPMU). This option might mitigate need for custom device for KB branch
- Optimization to consider the matrix of energy range, period, length, gap.
- Issues that will require later evaluation: gap control resolution and precision (energy tunability), parallelism control and tuning, control system and feedback if necessary, highest useful harmonic and performance of harmonics.

12:10 pm: Lunch

12:30 pm: Overview of Candidates for SRX Group Leader position and schedule for hiring staff. Discussion of candidates and BAT recommendations for staffing requirements (Shen, Lanzirotti)

1:00 pm: Signing ceremony and discussion with ALD Steve Dierker (Dierker, Shen)

1:30 pm: Discussion of Optical Layout (Eng)

- Review of raytracings, modifications required to update to current specs
- Required mirror performance and KB types that will be utilized (KB mirror types, coatings, bending or not, commercial or in-house designs)
- Mirror requirements for HFM
- Whom will take lead in optics design for SRX
- Beam stability requirements and how to implement them
- Monochromator choices and requirements

2:00 pm: Beamline Controls and Interfaces (Rivers)

- What are the best software/hardware options for interfacing beamline operations with beamline components
- What are the best choices for detector interfaces
- What insertion device and optical components need to be interfaced to beamline operations for optimal operations
- Choices for User Interfaces

2:30 pm: Experimental Station (Sutton, Lanzirotti, Fitts, Vogt)

- Sample environment requirements
- Sample stability requirements, position monitoring, table requirements
- Utilities
- Detectors
- Ancillary laboratory requirements

3:00 pm: Discussion of timeline in SRX project development and how it's incorporated into the larger project schedule

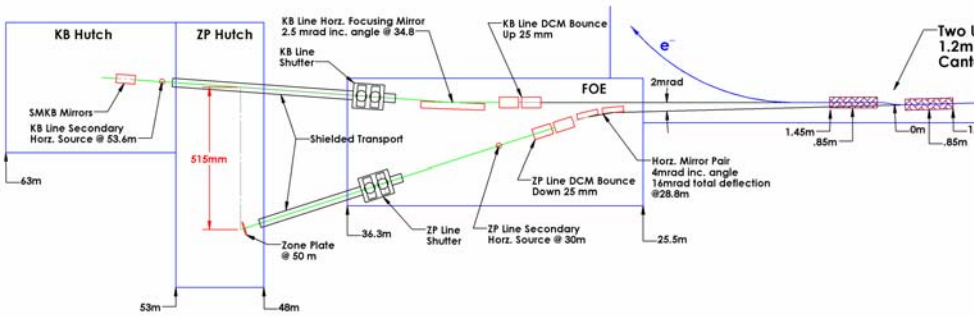
- BAT charges moving forward
- Summary and task assignments in preparing 1st BAT report

3:30 pm: Adjourn

Meeting Minutes:

Lanzirotti presents overview of LOI:

- In discussing the canting angle between the KB and ZP branch, the BAT was in agreement that 2 mrad is the minimum acceptable angle to allow enough space to accommodate both beamlines and ancillary equipment. Calculations presented in the original LOI illustrate we can achieve a separation of 515 mm between the ZP beam and the shielded transport pipe of the KB branch in the ZP hutch. It should be emphasized that the KB beam pipe must be shielded adequately so as to allow access to the ZP hutch while the KB line is in operation. Such shielding must consider placement of the ZP endstation. Even conservatively, an XRadia-type vacuum capable endstation for the ZP branch will likely require a minimal separation of roughly 0.5 m from the incident ZP beam to the inboard edge of its chamber. Thus, larger canting angles will clearly provide additional space that will translate into lower long term efforts on the part of the design team in accommodating required optics. The BAT therefore recommends that the accelerator group explore the feasibility of increasing the canting angle up to 4 mrad with respect to the IVU design and magnet spacing. The BAT would also note that it has been our experience that in retrospect the APS would have significantly benefited now from considering canting options during source design.



- The BAT still strongly feels that there is ample justification to continue to move forward in planning for the ultimate construction of the ZP branch of the SRX beamline. Primary benefits include:
    - Maximizing the use of available sources early in design, particularly given the limited number of usable straight sections at NSLS-II.
    - Access for the user community to microprobe resources optimized for the 2-15 keV range. The BAT feels it is still unlikely that a single source and optics design at NSLS-II can be optimized to access energies over the full 2-25 keV range specified in the SRX LOI.
    - While the goal of the SRX-KB branch is to ultimately achieve 100 nm spatial resolutions utilizing reflective focusing optics, we acknowledge that this requires improvements in RMS errors for silicon mirrors that are challenging by today's standards. We also feel that it's best to pursue these design goals without significantly restricting user sample requirements (i.e. maintaining long working distances, etc.) on the KB branch. The optics of the ZP branch will likely allow us to achieve the spatial resolution goals much earlier in the design. XRadia has already demonstrated they are close to achieving the stated 30 nm goal. Such

an approach ensures the highest resolution hard x-ray imaging capabilities will be available to the user community early in operations where the ZP branch will be utilized for the highest resolution applications, while the KB branch shall be used for applications where achromatic focusing and high sensitivity are required.

- Peter Eng suggests the project will benefit from a detailed interaction between the beamline design team and BAT for individual components.
- Review of the timeline shows that CDR should be finalized by Sept 2009 for all project beamlines. The project plans 2 BAT review meetings in FY09. The BAT suggests that additional collaborative design meetings would be useful but acknowledge that due to the constraints of having the CDR in hand by Sept. 2009, this may be difficult.
- The BAT wishes to see the project develop a website for collaborative interaction with the BAT from off-site. The current BNL access restrictions to the Sharepoint site are very inconvenient.
- Accelerator group will require a summary of beamline technique needs; what are we intending to do with the beam and what performance criteria do we need most to do our experiments. From an accelerator perspective the BAT makes recommendations below (see Northrup discussion).
- The BAT feels it is prudent for it to start to pursue discussions with members of the user community to allow them to prioritize potential research projects at SRX and allow them to open discussions with funding agencies to additional avenues of funding for research projects, optics, detectors and other beamline components that can be implemented at SRX.
- The BAT recommends a vigorous evaluation of beamline stability should be considered at every point of the beamline design. We foresee several potential sources of noise that may degrade the spatial resolution of this instrument and potential induce spectroscopic noise. These include:
    - Noise at 50Hz or faster that will need to be reduced by accelerator. We would like to see recommendations from the accelerator group on how these sources of noise plan to be mitigated.
    - We foresee several longer/slower instabilities that can potentially be dealt with by beamline feedback mechanisms. The BAT recommends that
        - an in depth evaluation of feedback devices be undertaken for SRX.
        - it was suggested that interferometry incorporated as part of the end-station optics will likely be required at the highest spatial resolutions to maintain positional stability on the sample.
        - that BAT members and the beamline design team explore the feasibility of conducting hard-x-ray spectroscopy in an “image stack” mode as a means of potentially minimizing the effects of sample or beam drift during spectroscopic analysis. This will require rapid stage scanning at the highest precision, likely better than 10 nm reproducibility.
        - cryogenic cooling will likely be a requirement of the SRX sample environment for many experiments given the beam intensity and we acknowledge that this may ultimately be a source of positional instability. The BAT recommends that the BAT and beamline design team interact with companies such as XRadia that have demonstrated experience in application of cryogenic cooling on x-ray microscopes and

solicit their input on technical requirements for mitigating potential instabilities.

- the hutches for the SRX beamline should be environmentally controlled to reduce thermal instabilities. At minimum we recommend the following:
    - Air temperature control (± 0.1 °C)
    - Baffled air flow to minimize air currents
    - Particulate filtering (possibly HEPA filtering for instrumentation area)
- There were suggestions from the BAT that we should begin vigorous evaluation of the feasibility of continuous scanning of the undulator gap with optical feedback from the monochromator. The BAT is confident that the SRX beamline will be an excellent facility for sub-micrometer x-ray spectroscopy. There was general consensus that an approach where scanning the monochromator without simultaneous scanning of the undulator gap will not be optimal for XAS experiments given the likely performance characteristics of the NSLS-II U20 type devices. The brightness curves for the U-20 IVU demonstrate the potential benefits of scanning the undulator gap in sync with the monochromator to keep the undulator tuned to the maximum of its emission peak in order to maximize photon statistics. An innovative monochromator design utilizing optical feedback, the potential use of interferometers to position the IVU gap and continuous scanning with lock-in could enable the next generation of XAS studies utilizing IVU sources. BAT members also noted that several APS microprobes scan undulator gap with monochromator angle for micro-spectroscopy and that it's preferred over the alternative (tapering the gap) because tapering is a big hit in brightness and flux for a micro-beam instrument. It was noted during this discussion, however, that beamline control of taper will likely be required to ensure zero taper (a critical issue when scanning gap and at higher energy).
- Matt Newville points out that for APS undulator A (with an energy width of ~100 eV) the mono energy and undulator energy can be scanned to keep a constant difference between the two. For NSLS-II, this could be done as well but the width of the undulator peak is much smaller (~5 to 10 eV??) and will likely require more frequent switching between harmonics. In this case, assuming a constant offset may not work so well, so that we may require lookup tables of undulator / mono settings.
- There is also an issue of how precisely one can move the undulator. If the NSLS-II devices claim a similar precision of about 1 micron, this would be adequate for a 100eV wide spectra (where it's no problem to be off by 10 eV), but may be too imprecise for a spectra that's only 5eV wide. This will require additional evaluation.
- Peter Eng and Matt Newville made the following suggestions for possible mechanisms for mitigating such issues:
    - The IVU could be controlled to greater precision, perhaps encoded to 50 nm. This is definitely possible with current optical encoders. Optical interferometry is another possible

approach. These schemes would require the NSLS-II accelerator group to consider the possible approaches and mechanisms that can enable high resolution control of the undulator gap in a high radiation environment.

- Either way, it's clear that a thorough evaluation of the necessary precision and reproducibility in gap control is needed (Matt Newville estimates that minimally a precision of ~1/3 of the undulator FWHM may be required). Ultimately we'd prefer to scan the gap with ~eV precision at 8 keV and maybe 0.5 eV precision at 3 keV.
- Another possibility raised is to embrace the 5 to 10 eV bandpass as a monochromatic beam, and think of a Si (111) as a 'high resolution mono'. In this mode energy scanning is primarily achieved with the undulator while the silicon mono is slaved to the undulator value. This would likely require a fast (lock in?) dithering of the mono. Scanning the undulator as the primary motion of energy has some appeal for slew scanning. In fact, it might even be preferred to do slew scanning of the undulator (probably at constant gap distance per time, which would be close to energy per time for a XANES scan) and follow along with the mono (as it can go faster).

Shen presents overview of NSLS-II Project to date:

- Qun Shen presented the BAT an overview of the NSLS-II project status to date. The following are recommendations from the BAT that are specific to his presentation.
- The BAT recognizes that the project has made very good progress in maximizing the availability of floor space for beamline sector development. However, the BAT recommends that the project consider at an early stage how property boundaries between beamlines are defined to maximize user space.
- Similarly, the spatial resolution requirements of the SRX beamline dictate the need for ancillary optical laboratory space to allow users to mount samples for analysis. Such space will be most efficient if it is immediately adjacent to the beamline.
- The BAT understands that the construction of the ZP branch may move forward if funds are available to achieve the Mature Scope (estimating that an additional $3-4M necessary, $1.3M for undulator) of the SRX project. The BAT believes that there will significant cost savings in the long run in addition to enhanced productivity in continuing to pursue the build-out of both KB and ZP branches at the outset and 50:50 operations from day one. We would thus recommend that the BAT and NSLS II move forward to develop a mature design for ZP branch so that it is ready to go when money becomes available and to outline accommodations/performance requirements. We would caution, however, that the estimate of $3-4M may be too low. Informal discussions between BAT members (Lanzirotti and Miller) and XRadia of endstation ZP instruments with the capabilities required for this branch suggest a cost of ~ $2.5 M may not be unreasonable. Thus just the IVU and end-station instruments alone approach the higher end of this cost estimate.
- Project planning foresees the following for beamline staffing: 2 scientists hired by 2010 (1 group leader), 1 engineer, 0.5 designer, 0.5 electronics/control person; 6 during

design and construction; 5 FTE during operations. The BAT generally concurs with this plan for the SRX beamline.

- The BAT recommends from experience at similar successful micro-spectroscopy beamlines at other facilities that hiring some scientific staff that have expertise in the scientific fields of the dominant user communities will increase user productivity and beamline efficiency. Chen agrees with need hire scientists with specialization in field.
- The BAT is also in agreement with the experimental facilities director that SRX would be most efficiently staffed with 3 scientists for each branch.

Lanzirotti reviews draft MOU:

- BAT members requested some consideration from the project as to what Beamline Advisory Teams generally may get in return for design and concept contributions? We understand that the scope of any potential Partner User Proposals (PUP) are being developed by the project and should be released "soon". We are eager to have input into any such documents if possible.
- The BAT requests input to hiring SRX beamline scientists. Chen agrees and the facility has asked the BAT chair (Lanzirotti, Miller has also been asked to participate) to be a member of the selection committee.
- The BAT asked about the status of the NSLS-II user access policy. The facility stated that it should be released in the next year or two. The BAT would request notice of any updates on its status.

Broadbent reviews SRX beamline costing:

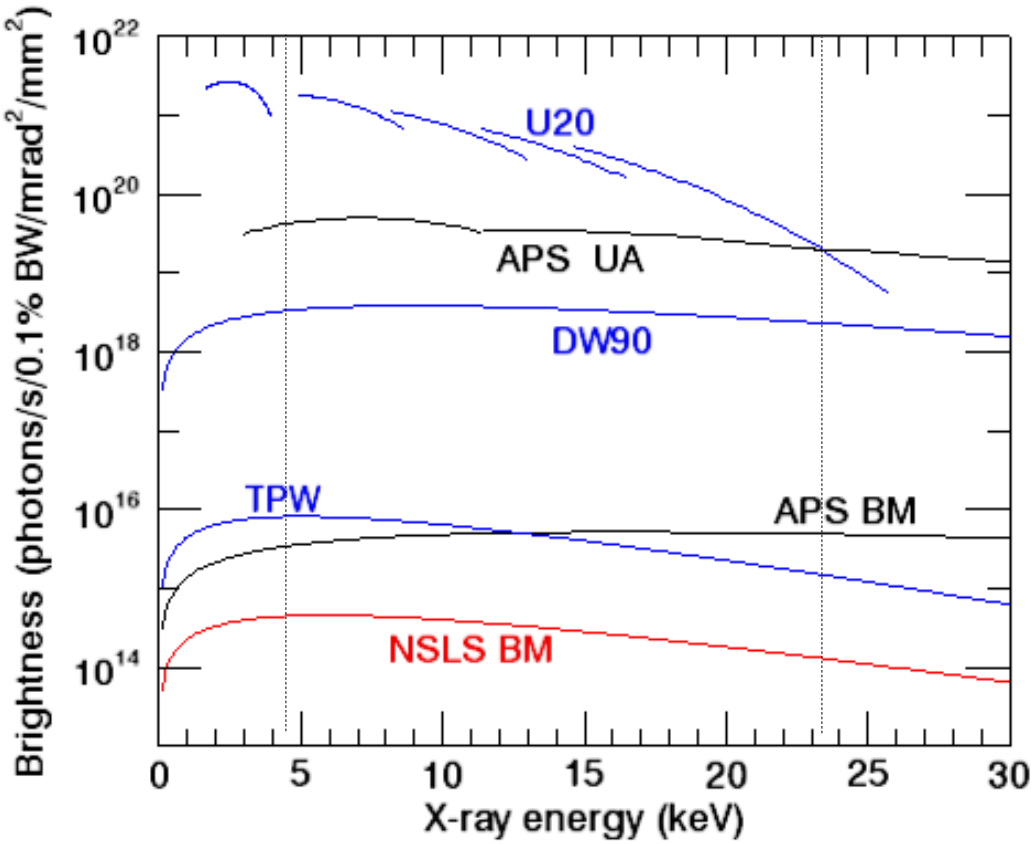
- Broadbent reviewed the beamline budget. The budget is presented in 2007 numbers with yearly adjustment.
- Beamline optics: delivering photons to the beamline – beam transport, whitebeam components, BCO ($1.7M total)
- Endstation hardware: KB mirrors $100K; FF detectors $600K;
- If we consider that the ZP branch does not get built, or that it won't be ready for some time: the BAT recommends the project consider including a zone-plate based vacuum microprobe for cryo in the budget. In this manner there is the potential to place the ZP endstation in the KB hutch for initial commissioning prior to completion of the ZP branch.

Dierker addresses BAT:

- The project director clarified the current feeling on how Partner User Proposals (PUP) might be structured for NSLS-II. He stated that contributions for consideration as a PUP will likely be very broad and cover a full range up to an entire beamline, but the majority of time (80% current number under DOE discussion) would be GU time, the amount of time allocated to PUP (up to 20% on a single beamline) agreements may include greater PUP amount but that would have to be spread on multiple beamlines.
- The BAT requests that BAT vetting will be sought on any PUP's for SRX.
- The BAT again recommended the project consider the potential of developing the ZP endstation in some intermediate state between initial and mature scope; this may be a manner in which we can bring forward the proposal for ZP endstation instrumentation earlier.

Follow-up discussion among BAT:

- The BAT recommends we secure an informal quote from X-Radia for a ZP vacuum microscope.



- The BAT would like to pursue an evaluation of how a 50:50 operations in the KB end-station utilizing such an X-Radia instrument in conjunction with the KB instrument would impact optics design in the initial scope.
- The BAT recommends that a door in the back of the ZP hutch be added (with a Kirk-key or proximity sensor). We feel this will be needed to design in capability of accessing ZP hutch while running in the KB hutch from day one.
- The preliminary costing for optics components includes two diamond windows, with the feeling this might be needed during commissioning. The BAT recommends that a well designed differential pump should mitigate this need and that since windowless operation is the plan, the beamline is best served by designing around this operational mode from the onset.
- On review of the undulator cost, the BAT expressed concern that the projected costs of the IVU's seem high. We would appreciate an update on costs for these devices as they become more firmly established.
- The BAT recommends the project investigate the potential use of interferometers and/or encoders to position the IVU gap on the KB branch. An evaluation of their performance in a high-radiation environment will likely be needed.

Northrup reviews undulator requirements:

- The BAT would like information from the accelerator group as to what is the minimum gap achievable with a U20 device (and other potentially suitable IVU devices with longer periods)? It seems to the BAT from initial calculations that reducing minimum gap by ~200 microns would appear to have substantial benefit. The project has specified a minimum gap of 5.0 mm for U20 devices. Is this a hard lower limit?
- The BAT would like information from the accelerator group as to how useful the 11th and 13th harmonic on the U20 might be; specifically how high can we go in energy and at what reduction of flux performance. We also wish to explore the flux performance at 5 keV on the 3rd harmonic and at 23 keV on 9th harmonic at various aperture (acceptance) values.
- Similarly, The BAT would like information from the accelerator group on how useful the 2nd harmonic will be. Our calculations indicate a drop in flux performance on the 2nd harmonic by 5x. Perhaps even more critically for SRX-KB, we require input on if the spatial flux distribution on this even harmonics is focusable, given the likelihood that the lowest intensity will be on axis. Can this be evaluated more fully?

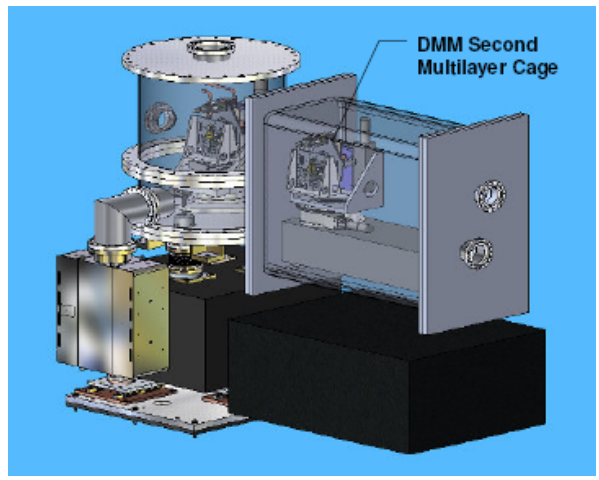
- The BAT will set out to better define the desired performance and prioritize desired characteristics; Project will calculate performance achievable. A preliminary estimate of broad requirements for SRX-KB include:
    - 4.75–23.3 keV incident photon energy range with suitable harmonic rejection. The low energy is dictated by the scientific requirement to access the Ti K edge. At the upper limit we wish to be able to use all energies up to the Rh L3 edge which is likely to be our mirror coating cut-off. The high energy cut-off should allow SRX-KB to collect XAFS spectra on actinides up to the L2 of Pu including all L edges of U.
    - Continuously variable energy range over the energy range specified with no gaps will be needed for the varied spectroscopy experiments users will wish to carry out.
    - An important consideration is also that there not be any important edges (e.g. U L3) that are caught badly in a transition between harmonics. The BAT can evaluate this more fully for specific edges when a detailed brightness curve is available for a target IVU.
    - 0.01–0.02% spectral/beam resolution (ΔE/E) for general spectroscopy. This should be achievable based on the current draft design vertical raytracing, but we recognize that if we pursue a horizontally diffracting monochromator design, it may require a horizontally collimating mirror upstream of the monochomator. This will need to be evaluated. We also would recommend an informal goal of pursuing higher resolution spectroscopy (~0.005%) in the future with Si(111). If a Si(311) lattice cut mono crystal can also be incorporated we should be able to do better than Si(111), say 0.003%.
    - Design for highest achievable flux into beams from 100 nm (small SHSA) to 1000 nm (open SHSA) in size. Our ultimate spatial resolution goal is ~100 nm for fluorescence imaging and spectroscopy on SRX-KB.
    - SRX-KB will be designed for sub-µg/g to µg/g detection sensitivity for transition metals a general requirement. This general goal will clearly depend on the element of interest, detector used and nature of the sample that is being

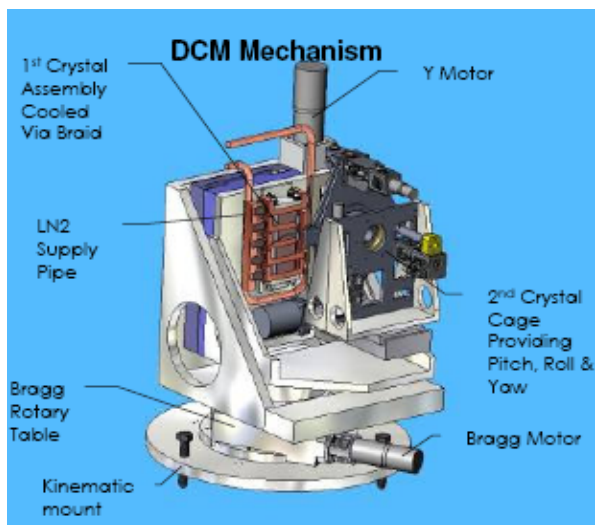
analyzed. However, we should evaluate in some detail what our likely detection limits will be and as a first step once a target IVU is identified, it would be useful for the accelerator group to provide an estimate of the likely flux performance on each harmonic.
    - Initial beam stability of <1 µm/day. Mature beam stability of < 100 nm/day as measured at the secondary horizontal source.
- The BAT feels strongly that for successful spectroscopy, some form of IVU motion control scheme with optical feedback will likely be required. Again, we recommend an evaluation of how continuous scanning of the IVU gap with lock-in from monochromator can best be achieved as an option. We need to evaluate how fast this needs to be. The BAT will explore what other facilities are doing. The accelerator group should consider that some form of hardware signal must be provided to the beamline for this purpose, possibly beyond just the constant readback of position. The BAT feels that two options should be carefully assessed:
    - for step-scanning energy the IVU will need to be integrated with beamline controls so that the gap can be adjusted every one to every few data points.
    - for slew-scanning of both IVU gap and monochromator, special mechanical considerations for IVU design and a direct lock-in synchronization to mono will be required (see above)
- The project proposes initially a 22 period, 1.5m device. They are now seeking BAT input. In consideration of reaching the Ti K edge, the placement of the U L3 edge with respect to the 9th/11th harmonics, and flux performance (throughout the range but most importantly at higher energies), a U20 with slightly smaller minimum gap and 1.2m length may be a more attractive solution. Is this feasible?

Peter Eng reviews optics design:

- The BAT notes that in initial designs, the slits are 19m from source. While the current specs for these slits specify they be capable of closing to 10x10 microns with stability/precision of 1 micron or better, it seems likely their design is such that the beam-defining portion of the aperture sees almost insignificant heatload. Yet the BAT recommends modeling the thermal expansion issues that may arise with changing the IVU gap.
- The BAT recommends vigorous evaluation of beam positioning requirements and how SRX will ultimately use these to control beam stability. The initial suite of planned BPM's seems to the BAT to be inadequate for the needs of the SRX beamline. Some suggestions that were raised in this regard during this discussion as a first pass included:
    - that a XBPM be positioned upstream from the second source.
    - another quad monitor should be considered to be placed near second source.
    - It was suggested that an edge sensing BPM be place in front of horizontally focusing mirror.
    - There was a general request that a motorized stage be designed in front of mono with various phosphors, filters and imaging devices: YAG phosphor, diamond filter, tungsten blade, pinhole.
- The BAT notes that costing envisions the use of filters for power management. The BAT recommends careful evaluation of thermal loads and suggests that these are potentially unnecessary since the horizontal mirror should mitigate the thermal load. This should be modeled using FEA.

- The BAT requests that a power budget analysis be conducted all the way down the beamline; finite element (FE) work on energy density and its effect on beam divergence.
- The BAT's experience at the Australian Synchrotron's X-Ray Fluorescence Microprobe (Microspectroscopy) beamline suggests that a similar horizontally diffracting monochromator may be suitable for SRX and should be fully evaluated including FEA. Potential advantages include:
    - No gravity effect. A constant gravitational load eliminates distortion such as crystal cage twist and sag and unwanted angular rotations of the second crystal. The gravitational benefit combined with a long second crystal that eliminates the need for longitudinal second crystal translation stage will result in a distortion free and stable instrument.
    - A properly designed horizontal DCM can be mechanically more stable particularly as energy is changed.
    - The ability to use the horizontal deflection to increase separation between the KB and ZP branches.
    - Horizontal diffraction will enable the beam defining aperture to filter out any horizontal vibration and slope errors.
    - If pursued as a design option, the crystal mounts must be fabricated to be ridged to eliminate "delta theta" type beam motion in the diffraction plane and their affect on beam stability.
    - Due to the canted geometry of SRX, the horizontal design allows us a means of potentially incorporating interchangeable lattice cuts in the monochromator that could not be accommodated otherwise due to the proximity of the canted ZP whitebeam.
    - A Si(111) DCM is likely to be the workhorse crystal for KB microscpectroscopy applications. It should achieve a resolution ($\Delta E/E$) of $1–2\times10^{-4}$, which is adequate for most spectroscopy requirements.



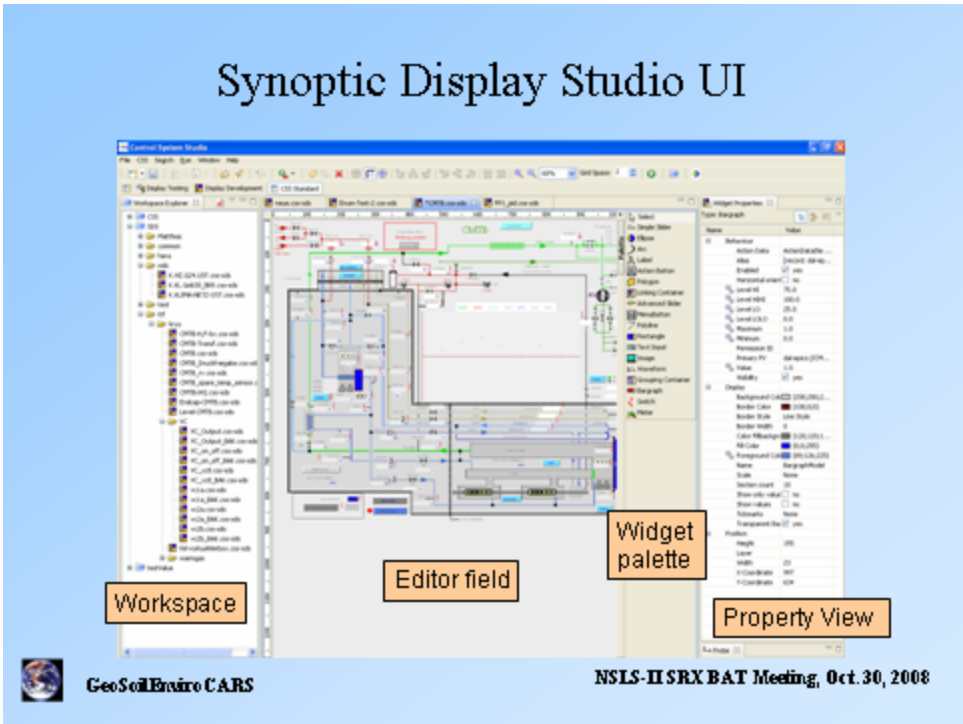


    - However with a horizontally scanning design we recommend examination of other crystals that could be interchangeable, including Si(311) DCM and DMM as potential upgrades.
    - Interchangable Si(311) crystals, for example, would more easily allow SRX-KB's energy range to be extended beyond 23 keV and higher if feasible given source, but should not be considered a replacement for the Si(111) lattice cut. The Si(111) must be designed to reach energies of at least 25 keV.
    - An inline double multilayer monochromator (DMM) with a bandpass of ~10^{-2} would allow SRX-KB to trade incident energy resolution for increased flux (estimate 10x), for example for fluorescence computed microtomography applications. We would like to see this option investigated. However, this option should be a secondary consideration given that it will require space to be reserved downstream of the monochromator for the 2nd crystal of the DMM and we must remain cognizant of the space requirements for the SRX-ZP branch. The BAT should also consider what samples would likely utilize a DMM that can withstand the increased flux and if this is a worthwhile avenue to pusue in future upgrades.
    - The BAT wishes to see calculations of the total transmitted power for these possible configurations so that the monochromator can be designed to deal with the heat load from the undulator source.
    - The BAT recommends that the first crystal be cryogenically cooled and that the project consider the potential performance benefits of utilizing dread-lock vs. braided copper cooling designs.
- Potential complications of a horizontally diffracting design that will require evaluation include:
    - The loss of intensity due to polarization losses (~60% at the closed gap energy of 4.8 keV) and reduced energy resolution resulting from the larger horizontal divergence.
    - There is a potential issue that the thermal bump may result in more significant beam divergence effects than in a vertical geometry monochromator. This needs to be evaluated fully prior to committing to the design.
- Given the likely similarity between the SRX-KB and ASP Microspectroscopy optical plan, the BAT recommends that the project potentially consider commissioning an optical design study commissioned from IDT. Having developed the optical design for the ASP instrument, IDT have unique experience in the design of that beamline. We feel this can likely be done cheaply to help move the SRX-KB design forward more rapidly prior to having full time beamline scientists on hand.
- The BAT recommends that the white beam should be slit down before the monochromator in the horizontal to increase spot stability, this will aid in mitigating the effects of noise and flux fluctuations from the source.
- The BAT acknowledges that mirror needs for SRX-KB will require improved performance as to what is currently available and encourages the project to invest resources towards achieving the stated goals. To achieve these goals a slope error of 0.2 microradians will be required. Currently 0.4 microradians achieved in Australia using Eng's bender design.
- It was suggested that spatial scanning with KB mirrors may be an option. After discussion the BAT suggests that this is too difficult because of the need to correct mirror shape as pitch changes. Pitch variations will be required to access the full range of energies at the beamline.

- The BAT recommends that the horizontally deflecting planar mirror in the beamline design incorporate a series of x-ray reflective stripes to reject higher harmonics and act as low-pass power filters where appropriate. We continue to promote the design stated in the original SRX LOI and that it is manufactured from silicon and have three stripes on its optical aperture, Rh, Pt and bare Si. This will allow much of the needed changes in harmonic rejection to be performed by simply changing stripes and negate the need to change pitch angle.
- We also recommend the project investigate the potential benefits of using this mirror as a focusing element in a compound focusing mode in the future. This would require the mirror be designed with the capability of being actively bent. This would also have a benefit of allowing for removal of thermally induced figure errors.
- The BAT recommended a goal for energy stability on SRX-KB of 0.1 eV/day and a reproducibility of 0.1 eV over 24 hours at Cu K-edge in standard DCM mode. This should be more fully evaluated, however, once target IVU and mono designs are identified.

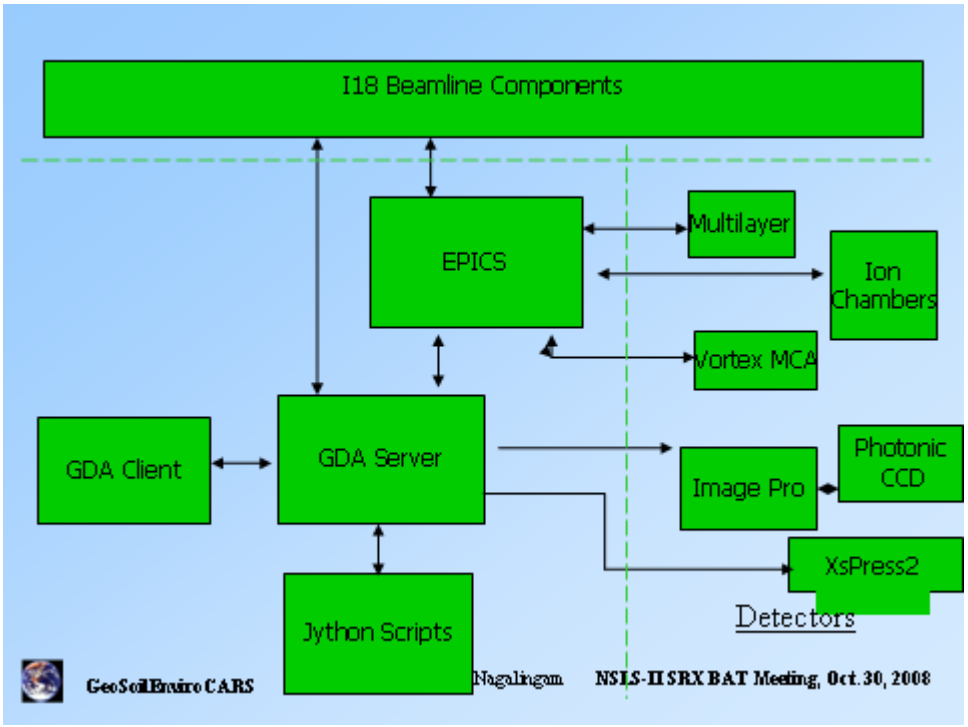
Mark Rivers reviews control systems requirements:

- The BAT recommends that EPICS should be assumed to be the underlying control system that will be used at SRX.
- However, while we can assume that much of the controls infrastructure required will be available, the devices that will be utilized at SRX-KB when in commissioning will probably be new, not existing ones.
- We also recognize that by the time of commissioning EPICS may have evolved. We thus recommend that the BAT and beamline staff examine developing systems to gauge their usefulness early. For example:
    - There are interesting developments in utilizing new Java based IOC's.
    - There are also interesting developments in user interfaces that may ultimately replace MEDM
        - Control System Studio (Eclipse-based, Java)
        - Need translation tools



- We forsee the following generic needs:
  - Hardware platform
    - VME and PCI bus architectures may be obsolete by the time SRX-KB is commissioned. The BAT and project should begin to examine hardware platforms such as Field buses (Ethernet, serial, Firewire).
    - Field buses will solve many problems, but there will be specialized high-speed devices, e.g. SIS multi-channel scaler that probably will not be compatible.
  - Motors
    - The BAT feels it's likely that the current EPICS *asyn* model will evolve to handle high-level capabilities in a generic way. This should be evaluated in planning.
  - There will be a need a good high-level GUI and scripting tool. We should assume that SPEC will be obsolete and a waste of resources in developing it for SRX. We recommend evaluating:
    - Diamond's GDK
    - Java based applications that will work with Control System Studio.
    - We see Control System Studio a potentially useful interface for developing client applications.

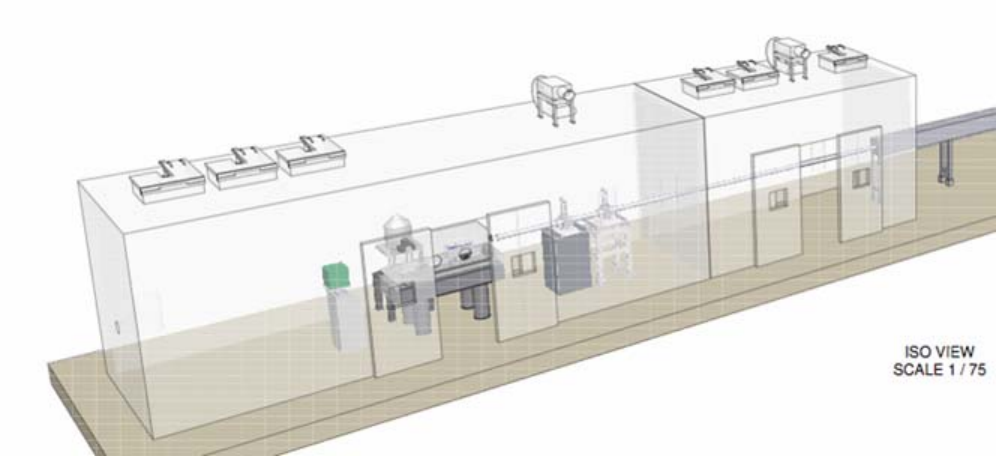
- The Synoptic Display Studio UI in CSS will provide a LabView type platform ideal for rapid beamline development.



- Undulator gap control at SRX-KB will have specific requirements to maintain beam stability and flux for sub-micron spectroscopy. We recommend that the project consider the APS model a start, but suggest that it could use improvement. For example, it is not continuously scanable with hardware synchronization.
    - NSLS-II needs very precise actuators to stay on undulator peak within 1%
    - SRX-KB will require scanning with real-time (hardware) synchronization to monochromator and detectors

Sutton reviews experimental station layout requirements (not presented in open session due to lack of time):

- The LOI and planning to date envision the first hutch reserved for ZP branch with the KB hutch containing the BPM and Secondary Horizontal Source Aperture. The specifications also envision that the stations are mono beam enclosures.

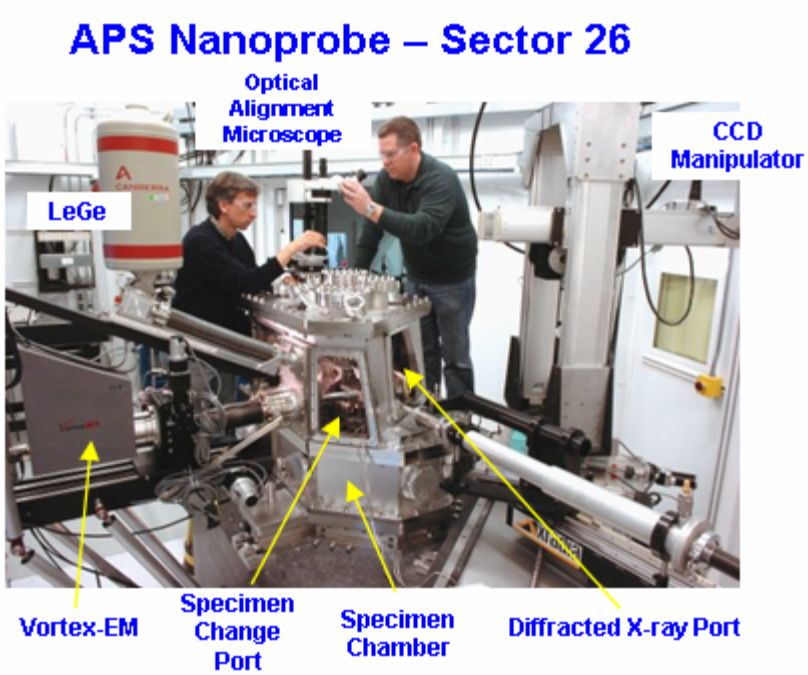


- The BAT recommends that all access to the hutches be through sliding doors which will allow them to double for equipment and personnel access.
- The BAT recommends that the roof of each enclosure be surrounded by a railing to permit safe personnel access and that there be convenient access to the roof areas via access ladders to permit equipment installations.
- For the SRX-KB endstation enclosure, we recommend the following amenities and utilities:
    - Air temperature control (± 0.1 °C; 10 nm/1 cm)
    - Baffled air flow to minimize air currents
    - Particulate filtering (possibly HEPA filtering for instrumentation area)
    - Signal patch panel (BNC, HV, RS232, ethernet, etc.)
    - Experimental gas farm and station patch panels with flowmeters (He, N_2, Ar)
    - LN_2 tap (detectors, cyro-stage)
    - Chilled water panel
    - Compressed air
    - Video monitoring
    - Crane access (mobile rather than overhead)
    - Floor fiducials
- To maintain stability requirements and control at the SRX-KB endstation, the BAT recommends the following:
    - We envision the need to maintain sample/beam stability on the sample at 10 nm level. To achieve this the BAT and project should examine the following options in depth
        - Granite as an experimental table top
        - Damping table top with vibration canceling support
        - TMC optical table top with STACIS active vibration cancellation system; effectively reduces 0.6 – 250 Hz vibration.
    - We recommend the development and utilization of an active registry system. The likely best option for this will be an active laser interferometer (2D) coupled to piezo feedback to maintain registry between mirror structure (focusing optic) and sample holder (nanometer precision). This should be capable of achieving a few nm resolution.
    - Sample motion control will need to be designed to utilize the beam resolution in both a convenient and stable manner so that points can be re-located

accurately and precisely. We recommend at minimum the following sample motion requirements and that these technologies be developed at the NSLS as test-beds so they will be ready from the onset of operations:

- A coarse-fine stack (x,y,z,θ) of stages will be required.
- The coarse stack uses high resolution linear motors (2 cm travel; 100 nm resolution)
- The fine stack uses nano-positioning devices (20 µm travel; 10 nm resolution)

- The BAT recommends the project invest resources in developing an integrated instrument including sample holder/manipulator and focusing mirrors in coupled enclosures.
- We envision that it will be preferable to use standard mounting holders wherever possible on both the SRX KB and ZP branches. The project should invest resources in developing such mounts, again preferably in collaboration with beamlines at the NSLS.
- The BAT recommends that a specialized enclosed Sample Environment will be needed for both the SRX KB and ZP instruments. Minimally we recommend:
    - A specimen compartment that should be operable in air, helium or vacuum. Detectors will need to be designed to work in all three environments.
    - Reasonable sample exchange time (~10 mins); sample cassette preferred; possible sample change antechamber
    - Cryogenic capability will be required for many samples to minimize radiation damage, probably through cold finger. Such systems are being commercially developed (e.g., Xradia) and we request quotes for such devices.
    - High temperatures may potentially be a need for some experiments but we recognize that this may be impractical. This should be investigated as a possible modular addition but should not impact the cryogenic requirements, which we see as "mission-need".
    - There may also be a need for controlled humidity within the enclosure which should be evaluated.
    - We acknowledge that it will be a challenge to optically view the specimen in such environments. We recommend that it's best to proceed under the assumption this will be needed, while evaluating the possibility of being able to adequately maneuver samples without it.



    - The APS nanoprobe design should be examined as a potential starting design for the SRX-KB specimen enclosure.
- We recommend that the following off-line equipment will be required:
    - An offline Nikon petrographic optical microscope, a Leica biomedical microscope system with UV, and a variable-zoom low magnification binocular microscope all of which require digitized stages and networked to data acquisition system for analysis point registry. These should optimally be housed in a class 100 laminar flow hood.
    - Fume hood
    - Balances
    - Glove box
    - Refrigerator
    - Cryo-storage
- We minimally envision the following detector requirements for the SRX-KB instrument:
    - Solid state fluorescence detectors required for XRF, XAFS, fCMT
        - Silicon drift (single and 4-element) similar to Vortex instruments from SII Nanotechnology
        - Large solid angle Si detector array (BNL/CSIRO development MAIA detector)
    - Bent Laue crystals
    - High resolution fluorescence analyzer crystals
    - X-ray CCD/IP for XRD, we recommend Rayonix/MAR 165/345 systems be evaluated for these applications
    - Ion chambers, likely small footprint design
    - Visible light CCD for full field imaging (e.g. Photometrics Cool-Snap)
- Given the predicted intensity of the SRX-KB instrument, the fluorescence detectors must support fast scanning or on-the-fly scanning modes. This will be critical for efficient data collection. We recommend active discussions with vendors of digital x-ray detector amplifiers in tailoring these devices to our needs (XIA and CSIRO)
- Real-time or near real-time data quantification will be vital given the predicted large datasets that will be produced for large array detectors. Users cannot be expected to have the computing resources available to them to effectively deal with the data in its raw form. We recommend these computing methodologies be developed now as a collaborative effort between NSLS-II and the NSLS. We recommend they jointly sponsor a workshop to develop these methodologies more broadly among the user community.
- Similarly, we strongly encourage the development of open-source software for data processing and visualization. We feel it is not in the best interest of the user community to require them to purchase commercial software for this purpose. We recommend again that the NSLS-II project and NSLS-management jointly sponsor and aid in the development of the software resources that will be utilized at SRX. Given that the Siddons/Ryan MAIA detector system has initially been identified as a likely detector we will utilize at SRX-Kb and that this is being commissioned and developed at the NSLS and ASP, we recommend collaboration with these efforts.
- We would encourage the beamline development team to consider as an option the development of a prototype KB instrument early, possibly at the NSLS. We envision that there would be an advantage in conducting science experiments early and evaluate potential designs. Alternatively the two systems could be developed in parallel: with the

prototype instrument in ZP station while “Phase 1” instrument being developed in KB station. In a single undulator configuration, beam might be used in either station on demand with movable backstop at end of ZP station.