CSX BAT meeting January 8th 2009

Meeting attendees (alphabetical order, * indicates CSX - BAT members): *Harald Ade, *Darío Arena, Andy Broadbent, *Steve Kevan, Konstantin Kaznatcheev, John Hill, *Steve Hulbert, *Yves Idzerda, Rubén Reininger, *C. Sánchez-Hanke, Qun Shen, Paul Steadman, George Rakowsky, Toshi Tanabe and *Stuart Wilkins.

The attached agenda was distributed to all BAT members.

MORNING SESSION

Ruben Reininger contribution: The meeting started with a short contribution from Rubén Reininger (RR) related to the need of the CSX BAT, or the CSX beamline scientist, to contact the BESSY beamline, particularly with F. Senf, regarding their new intention to accomplish fast-switching polarization at that beamline using a chopper. The problem at the BESSY beamline is the difficulty to make both beams overlap "completely" in the sample plane.

Action item: Contact F. Senf to find out the latest results regarding the alignment of the beamline at BESSY.

Qun Shen contribution: In his introduction, Qun provided remarks r.e. the importance of the NSLS-II project, the NSLS, and JPSI for the future of BNL. He also described the NSLS-II construction plan, specifically the ring building itself, office and laboratory space, and the possibility to find space for long beamlines with endstations outside of the main building.

Action item: Provide input on CSX-related lab requirements for the LOB

Qun Shen con'd: Qun Shen also provided us with an NSLS-II project schedule timeline from and where beamline construction will fit into it. Conceptual design (50% of the total design, includes completed beamline layout – source, front end, beamline components) by end of FY2009. Preliminary design (drawings completed) by January 2011. Beneficial occupancy will be in Feb. 2012, at which time beamline construction can start. It is planned that the first beam for beamlines will happen in June 2014, at a target current of 25mA (or higher). There will be one year of commissioning for the beamlines, concurrent with ring commissioning (June 2015 is start of NSLS-II operations). One major problem is that the project timeline shows installation of the insertion devices later than first beam, leading to the question: How will the beamlines proceed with commissioning without their IDs in place and functioning?

Action item: XFD must interface with accelerator group, to agree/arrange for installation of the ID's prior to June 2014 (first beam). The ID gaps can always be opened for ring commissioning, but having them in place is essential to timely commissioning of the beamlines.

Qun Shen con'd: Qun Shen also showed the funding profile of the entire NSLS-II project, without details about the beamlines. This year (2009) there is 27 $M from DOE,

but more will be needed to proceed with award of the construction project after the contractor has been selected.

Early operation funds are planned to start in 2012, at the same time that funding for the (first) MIE (Major Item of Equipment) beamlines should begin. One stated (by NSLS-II (Dierker) and DOE (Montano, Klaffky)) use of early operations funding is for the upgrading and moving (transferring) of ~20 beamlines from NSLS to NSLS-II.

Non-BES (Life Sciences and other) beamline are also being proposed, looking for ID and floor space, and seeking funding.

Action item: Determine if CSX beamline requires R&D and, if so, does any NSLS-II funding exist, or could it be requested?

Action item: It is essential to find or determine the specifications for soft x-ray photon beam position monitors.

Action item: Request vibration analysis (dynamical FEA of the effect of mechanical vibrations) for the CSX beamline floor space and all beamline and endstation components that "handle" the photon beam.

Action item: CSX BAT recommends that the NSLS-II Project dedicate funds for optics metrology R&D, to develop and implement the next generation of optics metrology tools in order to be able to verify the specified quality of optical elements (mirrors, gratings) needed for achieving design performance of the CSX beamline, a performance that matches the brightness of the NSLS-II soft x-ray EPU source. This development should be performed in collaboration with the optical industry. For example, we recommend procure prototype state-of-the-art optics and measure them with the state-of-the-art metrology tools, thereby establishing an iterative process of optics quality improvement. Also, join forces with other NSLS-II beamline group leaders and BATs to push for optics metrology R&D.

Problem in the synchrotron grating fabrication industry: The grating division at ZEISS is on the verge of going out of business, and it is not clear what other company or group can produce the next generation of ultra-high-quality gratings for synchrotron radiation beamlines. Other potential grating bidders include Shimatzu (Japan) and Bach Research (Denver, USA).

Rubén Reininger reported a possible plan to form a synchrotron grating group from the principal personnel from the Zeiss grating division, funded by BESSY (Berlin) and DESY (Hamburg), and set up in an open section of the Petra-III very stable floor.

Action item: Rubén to establish a connection between NSLS-II (Qun Shen, CSX group leader, and CSX BAT) and F. Senf (BESSY) regarding the formation of the synchrotron grating group and the involvement of NSLS-II in this endeavor. We recommend that NSLS-II work with the new grating group to specify gratings that are needed by the CSX beamline and are technically feasible for production. The CSX beamline may need at least six super-high-quality diffraction gratings (possible cost increase item).

Mirrors: Zeiss, In-Sync, and JenOptic are potential bidders for the CSX mirrors, as well as Horiba/Jobin-Yvon and [Japan EEM company]. Zeiss already has the ability to fabricate the mirrors needed by the CSX beamline (planes (0.1 microradian up to 150mm length), cylinders (0.5 microradian), and bent ellipsoids (0.5 microradian).

Konstantine Kaznatcheyev contribution

Proposition:

Direct imaging: Scanning diffraction microscopy – measure complete diffraction pattern at each point in STXM scan. Spot size is 30 nm: Ptychography, CDI + STXM: Thibault et al., Science 321 (2008).

NSLS-II proposal: combine STXM with diffraction via three detectors. One on straight thru beam (fast detector), one on SAXS (a 2D CCD) one on two theta arm (1D strip detector to accept all chi). If doing diffraction contrast imaging, sit on the brightest part of the peak and scan sample. Only have theta degree of freedom on the sample.

Steve Kevan pointed out that some aspects of the proposed endstation are going to happen in any case, somewhere, before the construction of the CSX beamline. As for any proposed project, the proposers need to stay aware of relevant developments worldwide.

It is proposed to integrate the capability proposed by Kon in the coherent diffraction endstation on the coherent scattering branch, pending cost and real-estate considerations. Consideration of making this a new endstation on a separate beamline branch (as was proposed by Kon), is not being considered, for real-estate and cost reasons. In fact, Kon showed how tight the real-estate is at the CLS STXM beamline.

Action item: Need to look at real-estate, optics, layout, and cost for adding STXM/diffraction/scattering hardware behind the coherent branch endstation (aka "Stuart's chamber") – distances, etc. Investigate the feasibility to switch between the two experiments, the impact of one experiment on the operation of the other, how to isolate them in order to work on one while the other is taking data, etc.

Ruben Reininger contribution

All calculations shown are for EPU with 45 mm period, 4m long. The fast-polarization-switching branch has not changed since the CD-2 design: 88.75 degree incident angles on the mirrors, 10 micron exit slit opening. Note that it is possible to achieve the specified photon energy resolution for this branch using optics presently available on the market. Grating efficiency calculations use the latest Neviere code. Rubén Reininger stated that the best method of rejecting undulator harmonics is using the quasi-periodic EPU (QEPU) design. Toshi Tanabe stated that he is willing to consider the engineering of a QEPU, possibly one with adjustable pole position (TT says this is technically feasible) to be able to change from QEPU to standard EPU.

Action item: discuss EPU designs, specifically QEPU, with the NSLS-II insertion devices group and, now that he is here, Oleg Tchubar. Involve the beamline design (Rubén Reininger) in this discussion, so that realistic on-sample quantities are calculated.

RR reported that SLS uses QPUs and their spectra are very clean; the price to pay is some reduction in first-order photon flux on sample.

Rubén also explained the need for 3 front mirrors on the polarization control branch, one for each of two canted (switched) undulator beams, and one for accepting the beam from the two undulators operating as a single ID. Alignment, stability and reproducibility of the two mirrors for polarization switching is an important issue, and involves photon energy matching (between the two beams) and stability since the grating chamber and exit slit are located downstream of these mirrors.

Question from Steve H.: Is real time monitoring of figure of mirror feasible? Answ. from Ruben: Design exists for a gas phase time-of-flight instrument to measure the beamline resolving power and polarization , which could be used for this monitoring. One could also measure the spot sizes using a Shack Hartmann wavefront analyzer (Imagine Optic).

Action item: include instrument to measure the resolving power, polarization, etc. (example Jens Viefhaus prototype at Petra III), to be located downstream of the exit slit (possible cost increase item).

Coherent branch

Spring 2008 design, based on ALS COSMIC design (see RR report for the LOI): Design concept is based on the idea to have the lowest number of reflections as possible (two). (1) toroidal mirror located inside the shield wall, horizontally deflecting, focusing meridionally at the entrance slit and sagittally at the exit slit, (2) SGM (4.3m) grating, horizontally dispersing, focus (varying) near the exit slit. In summer 2008, a suggestion was made (by Q. Shen) to move the toroidal mirror outside the shield wall to reduce heat load and make for easier access to this mirror. Rubén verified that this resulting coherent branch would still fit in the available beamline floor space. However, the most serious problem with this design, for the NSLS-II source, would be the insurmountable heat load effects on the entrance slit/aperture, as well as on the grating.

The solution to the heat load problem, while also providing greater degree of flexibility in resolving power and exit slit size, is to use the focusing VLS PGM (F-VLS-PGM) design (see report and talk from Rubén).

Question to Rubén: has roughness of the optics has been included in the calculations? Answ.: not yet, will be done, and will affect higher photon energies more than low.

Action item: need to calculate high order/harmonic content for both branches (Neviere code can take into account the real (measured) groove shape, although the result is likely similar to the answer obtained for ideal groove shape with inclusion of an rms surface roughness in the reflectivity input.

Steve K. suggested that the figure of the first mirror on the coherent branch should be ellipsoidal rather than toroidal. Rubén's reply: I understood we are looking at a F-VLS-PGM. The first mirror is a plane. I think that Steve was questioning the idea of having the sample very close to the exit slit instead of at the focus of the ellipsoidal mirror.

Request of Rubén: cost estimates to change monochromator handedness. An alternative is to simply interchange the two branches.

Question from Rubén: what is the user requirement for the figure of merit for circular polarization when using third harmonic, which is elliptically polarized, not pure circular.

Action item: all BAT members interested in using the 3rd harmonic for polarization-sensitive experiments should provide either (a) their requirements for the degree of polarization or (2) describe their figure of merit, from which their requirement can be deduced.

Rubén's answers to questions from conference call (December 2008)

Is it possible to have one less reflection? Answer: No

Why 3.5 degrees deflection angle? Answer: because of energy range (the upper limit is 1.6 keV, c.f. 2 keV on scattering branch) and to provide physical separation between the coherent and polarization branches.

Is it possible to have a smaller spot on exit slit? Yes, can gain a factor of two by moving things closer, although this has real estate implications.

Darío: regarding with the cost of the beamline, suggested consider returning to a previous beamline design with a single monochromator, splitting the exit arm to two branches after the grating chamber. The tradeoffs are in flexibility and independence of operation of the two branches, and possible impact on performance.

ID phasing: this needs to be achieved, for coherence. The method can be mechanical or magnetic, the latter solution suffering from real estate problems in the straight section. Realistic calculations of the brightness gain by phasing two EPUs needs to be performed: the answer is somewhere between 2 and 4, but the more precise value is important information.

George Rakowsky: ESRF Apple-II EPU magnetic design includes end poles that reduce the usable length of the EPUs. Usable EPU length is clearly the important user parameter. Question: does ESRF include phasing magnets (or other scheme) between multiple EPUs in one straight?

Action item: check with other SR sources regarding the design of their EPU straight sections and experience with their EPU ID phasing schemes.

Action item: comparison of the coherent branch performance with the ALS coherent beamline, both for the current ALS accelerator parameters and after the upgrade. S. Kevan thinks that ALS will ultimately be 20x brighter than today.

Steve Hulbert contribution

EPU45 vs EPU55: the tradeoffs must be considered now and a recommendation by the CSX BAT made soon.

Toshi contribution (to help the BAT to decide the EPU period length): see Toshi's talk.

Action item: Look at undulator-undulator angular overlap for the various operating modes (as a function of energy).

Action item: should the lower energy limit of the coherent branch be raised (from 250 eV to 500 eV, for example) to ease the heat load issues in linear mode?

Action item: the CSX BAT should convey their recommendations for photon energy range and polarization of the CSX beamline. At present, the stated requirements are being able to reach 275eV minimum photon energy for both circular and linear (sigma and pi) polarizations. This action should be completed in Feb. 2009.

Action item: The CSX BAT asks the NSLS-II ID group (TT) for drawings and calculations for the ID period, in the 46mm to 49mm range, to see what are the tradeoffs and compromises. 47 mm period appears to be a good candidate value as per Toshi's drawings; calculations are needed to be sure. We would like to have flux, brightness, and all polarizations (circular, linear horiz., linear vertical, and 45-degree linear) vs. undulator period.

There was a question about the minimum degree of circular polarization at the high end of the CSX beamline range, i.e. above pure helical range (~1000eV max) and the high energy cutoff of the beamline (~2200eV). The consensus was: no less than 70% circular polarization.

During the meeting, there were conversations about the polarization requirements for the coherent branch, in particular how quickly it needs to be changed.

AFTERNOON SESSION

Paul Steadman's contribution

Some initial parameters for the BLADE beamline at Diamond

Insertion device: helical undulator, period length 47 mm, with fast polarization switching via kicking the electron beam, requirement on polarization: 0-180 degree linear polarization as well as pure circular. Number of periods >42 for each EPU, length of each EPU 2m. Gap 15mm.

Reasons for fast switching: white noise error floor in measurements (this statement generated much conversation). S. Kevan: XPCS is a good technique to measure noise; results show that mechanical and thermal are the largest sources and that the problematic region is below 100 Hz.

Noise reduction by fast switching, using lock-in technique, with signal-to-noise ratio down to 10^-4 or better to see induced magnetization in non-magnetic elements.

Data in the hard x-ray range show the magnetic moment induced on gold particles. Not conclusive comparison between data collected with and without lock-in.

Five polarization switching modes: (1) static, dual beam, (2) dynamic, single beam (kicker magnets), (3) mechanical motion of EPU gaps, (4) electromagnetic device, and (5) crossed undulator scheme with lambda/4 "plate" in between -- very difficult.

Discussion and brainstorming continued (from Jan. 7) r.e. novel switching mode ideas, including using weak E-M coils to kick the emission of the EPU outside the bandpass of the monochromator.

Action item: Solicit Oleg Tchubar's assistance in analyzing the polarization switching schemes.

Need for Si steel laminations for the kicker magnets.

Action item: Talk to beamline scientists at BESSY, SLS, ESRF and find out why they went away from fast switching in each case. What would they do differently if they began again with a fresh start.

Action item: request that the SLS polarization-switching beamline staff provide the detection limit that they can achieve using slow polarization switching (SW).

Dynamic switching has limitations regarding the type/material required for the ID chamber. There is a lot of work at Diamond trying to implement this switching system, including changes in the straight section and using real estate outside the nominal straight section (for steering/switching magnets).

Action item: Find out if it is possible to change the design of the straight section at the NSLS-II. Study the present EPU ID straight section layout and compare with the elements that BLADE is going to use and see if the BLADE elements fit into the NSLS-II straight section in order to accommodate the static, dynamic, or both switching methods. Trade off of switching capability vs. reduced EPU length.

Question: Should we reconsider long straights to gain real estate for switching?

Answ.: Spectra8.1 says that the brightness of long (high beta) straights, for the same length EPU, falls by factor of ~2 compared to short (low beta) straight. But you can put longer EPUs in a long straight section. If this is still a subject of interest, we should calculate beamline performance (esp. spot size) for high-beta (long) straights.

Action item: what are the trade offs in coherence and beamline optical design (incl. heat load issues) if CSX moves to a long (high beta) straight section? The achievable spot size on sample will surely be larger, but it may not be so large as to have strong negative implications. We request that the NSLS-II accelerator group assess dynamic aperture effects, which may reduce the length of the ID in the long straights.

Paul Steadman comments that the current CSX beamline design will require ID phasing of the EPUs. And that he thinks that the static polarization switching method may work, based on the CSX design not having horizontal optics prior to the exit slit.

Diagnostics for the BLADE beamline: BPM's are the same as for hard x-rays (Paul, pls. confirm this)

Action item: investigate BPM design for soft x-rays at other sources such as SLS, ALS, or soft x-ray beamlines on higher energy machines.

Yves I. request: perform calculations for how misalignment of the first mirrors, especially those in the full polarization control branch, will affect the performance of the beamline in terms of energy shift and the overlap of the two beams on the sample.

Action item: Error analysis in the polarization control branch to see when there will be an observable energy shift between the polarizations by having the first mirrors (with 6 degrees of freedom each of them) "detuned" and when the "detuning" will affect having the possibility to have both beams overlapping on the sample. Analysis and report to be completed in 3 months. Mechanical vibrations should be included in this analysis.

Action item: do we want to have an FEA analysis of mechanical vibrations of the CSX beamline, as has been performed for the nanofocus beamline?

There has been also the discussion about the zone plate (ZP) needs of the coherent branch: what size is required, operating distances between the ZP and sample, and between sample and detector.

Action item: Study the ZP needs for the coherent branch, including the stages to control the position of the ZP and sample.

Action item: Discuss detector requirements for the two branches.

Action item: the CSX BAT strongly recommends that NSLS-II arrange with RR a new contract, for finalizing the CSX beamline optical design.

Action item: BAT scheduling for the rest of the year (CSH).