NSLS-II Beamline Report for SAC Review of Beamlines

Beamline: ***Hard X-ray Nanoprobe (HXN) Beamline, 3-ID***
Report Date: September 4, 2018

Introduction

The Hard X-ray Nanoprobe (HXN) Beamline at 3-ID is designed and constructed to provide hard x-ray scanning microscopy capability with the world-leading spatial resolution. It offers a suite of analytical tools with sensitivity for visualizing morphological, elemental, chemical and crystalline details of the sample. A highly specialized instrument called nano-Mii (Nanoscale Multimodal Imaging Instrument) is developed and commissioned to provide compressive multimodal imaging measurements, by simultaneously collecting x-ray fluorescence, absorption, scattering, and diffraction signals. Significant investments in engineering efforts and infrastructure have been made to ensure excellent x-ray beam focus and high imaging stability. The HXN beamline was developed as one of the seven project beamlines, funded through Basic Energy Sciences (BES). In addition, significant R&D efforts have been made to develop ~10 nm x-ray focusing optics and an x-ray microscope.

The HXN Beamline received the first synchrotron light on Nov 14th, 2014, commissioned nano imaging capability using fly-scans in April, 2015, performed 1st user experiment (as a commissioning user) in July 2015 and received an approval for general user operation in November 2015. The general user program has been ramped up with an excellent speed with a beam time usage of ~70% since 2017-Q2 cycle and increasing number of unique users.

Beamline Overview

The HXN Beamline is a moderately long beamline with an about 120m in length. It consists of 3 radiation enclosures or hutches: 3-ID-A through C. The first hutch 3-ID-A houses the beam conditioning optics and radiation safety components. The second hutch 3-ID-B contains one of the two secondary source apertures and parasitic beam position monitor (quad diamond BPMs), which is critical to maintaining high level of beam angle stability of about 10 nrad at an 100 Hz bandwidth. The experiment hutch 3-ID-C is located within the satellite building adjacent to the experimental hall. The satellite building provides the required vibrational and thermal stability for the nanoimaging experiments. The experiment hutch is vibration-isolated from the rest of the building structure and provides a thermal stability better than 0.1°C.

The optical scheme of the HXN beamline is schematically shown in Figure 1. X-rays from in-vacuum undulator with a 20 mm period, IVU20, are conditioned by a horizontal collimating mirror and a horizontal double crystal Si(111) monochromator. The monochromator is costumed designed to meet high-level beam stability better than a 50 nrad (RMS). The monochromatic x-rays are focused at a secondary source aperture using a mirror in the horizontal direction and a set of Be CRLs (Compound Refractive Lenses) in the vertical direction. Then, the secondary source aperture (SSA) is used to define the effective x-ray source size and the degree of coherence in the transmitted x-rays. The HXN beamline has two possible SSAs. SSA1 (at Z=66 m) is located in 3-ID-B and SSA2 (at Z=96 m) in 3-ID-C. For normal user operation, SSA2 (with an effective source distance of 15 m) is used since it creates a beam size appropriate for using multilayer Laue lenses (MLL) or zoneplate as a nanofocusing optics. SSA1, with an effective source distance of 45 m, creates a much larger beam appropriate for

a pair of KB mirrors. Thus, the HXN beamline has an option to use KB mirrors as a focusing optics as well.

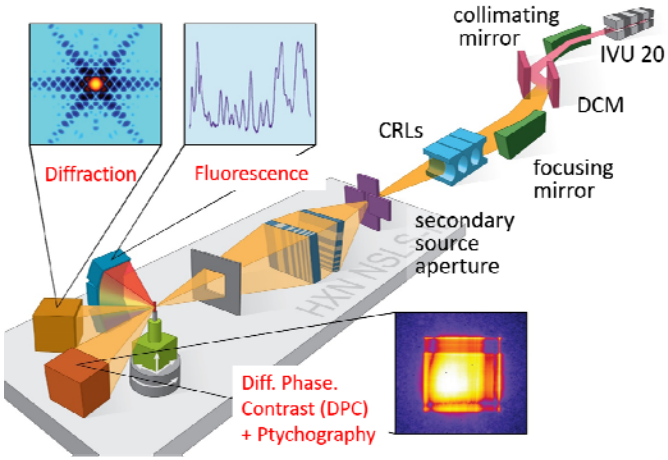

Figure 1: Schematic view of the major optical components and multimodal imaging capability of the Hard X-ray Nanoprobe Beamline

Nano-Mii, designed and constructed leveraging the NSLS-II R&D, is an in-vacuum x-ray microscope with option of using either a zoneplate or a pair of MLLs as a focusing optic. Such capability allows wide range of scientific applications by the general users. Regardless of the choice of nanofocusing optics, users can perform simultaneous multimodal imaging. The fluorescence x-rays from the sample is used to produce element maps. The transmitted x-rays are used for producing absorption and phase contrast images either using differential phase contrast (DPC) or transmission ptychography. For the crystalline samples, diffracted x-rays can be analyzed using a conventional nanodiffraction or Bragg ptychography method. Significant number of user experiments are taking advantage of multimodal imaging capability. The most common modalities are XRF and DPC/ptychography, and XRF and diffraction (conventional nanodiffraction and Bragg ptychography), both of which are carried out using a continuous fly-scan mode.

The MLLs are used for experiment requiring high spatial resolutions, typically less than 20 nm and incidence photon energy of 12 keV or higher. The limitation of the photon energy stems from the working distance of ~0.8 mm at 12 keV. Operating at lower energy further reduces the working distance, placing considerable restriction on experiments. Despite this short working distance, it is possible to perform tomography and diffraction measurements, provided that samples are prepared according to the developed methods. A zoneplate is used for experiments that require lower photon energies (i.e. XANES), larger working distances (i.e. in-situ and diffraction), and moderate resolutions (> 40 nm). The user demand for MLLs and zoneplate is reasonably balanced with small fluctuation.

Considerable efforts have been made to develop a complete workflow for tomography and ptychography (both transmission and Bragg), in order to allow the users to see 3D reconstructed data before they leave the beamline. Efforts are made in both software (user-friendly spectra fitting and image alignment) and hardware (GUP acceleration).

Currently, the HXN beamline is supported by the following labor efforts:

- Yong Chu (~0.25 FTE, lead beamline scientist/program manager)
- Hanfei Yan (1 FTE, beamline scientist)
- Xiaojing Huang (1 FTE, beamline scientist)
- Ajith Pattammattel (1 FET, postdoc)
- Petr Ilinski (0.5 FTE, scientific associate).

In addition, the beamline receives matrixed software engineer (~0.2 FTE), technician (~0.3 FTE) and mechanical engineer and designer (~0.1 FTE).

The HXN beamline users are from diverse scientific disciplines, which includes material science (49.5%), condensed matter physics (6.1%), environmental science (10.2%), geology (3.0%), biology (15.8%), optics development (11.5%), and microscopy technique development (3.9%) During the last year, the HXN beamline experienced significant growth in the number of users interested in strain imaging (either using nanodiffraction or Bragg ptychography) and XRF tomography. On the other hand, the HXN beamline experienced in decreased in proposals, requesting in-situ XRF imaging. The primary reason for this decrease is due to the limited scientific expertise among the beamline staff.

Significant ancillary capabilities exist for user operations. Mesoscale Imaging Wet Lab provides a suite of optical microscopes and bio-sample preparation methods. Environmental Wet Lab provides a range of support for handling and preparing bio/geo/soil samples. Chemistry Wet Lab has a glove box for assembling battery cells or handling Li containing samples. The most important ancillary instrument for the HXN beamline is a bench-top scanning electron microscope (SEM) located in the satellite building. This instrument is used for nano-scale sample registration for virtually all HXN experiments. Specialized sample holder and sample registration protocol are developed, so that the users can easily locate regions of interest only using the SEM or optical microscope images. In a typical XRF imaging experiment, locating a region of interest takes one coarse imaging (i.e. less than 10 minutes).

All imaging data are collected using BlueSky (https://github.com/NSLS-II/bluesky), which is a script-based data acquisition software developed at the NSLS-II. Despite its complexity, high-level commands are developed, so that users only need to know several commands to complete their experiment. All XRF spectra are fitted using PyXRF (https://github.com/NSLS-II/PyXRF), which provides high-speed fitting capability. Thus, the users can examine their data either using the real time element images (based on ROIs) and fitted element images immediately after the scan is completed. Although most of the HXN beamline users do not understand how the DPC and ptychography analysis are performed, the user-friendly GUI interfaces allow them to reconstruct the data effortlessly. The HXN beamline has its own GPU cluster and the ptychography codes are fully parallelized for high-speed computation. Presently, all the data are saved at the local data storage. We plan to move the local data to the NSLS-II Central Storage, as soon as all the data transfer infrastructure is ready.

Presently, nearly all users perform their preliminary data analysis (i.e. spectra fitting, generation of element map, DPC and ptychography reconstruction) during their beamtime and require initial training for data analysis. About 50% of the users do not have sufficient expertise to perform data analysis on their own and require significant help from the beamline scientists. All users take their data to home institutes. Thus far, only two user groups (performing Bragg ptychography) demonstrated completely independent data analysis capability.

Productivity and Impact

X-ray imaging capability of the HXN beamline provides unique nanoscale characterization solutions for a wide range of scientific problems. The followings are the primary reasons for why the users come to the HXN beamlines:

- To quantify trace amount of element distribution. This scientific need is shared by all scientific disciplines. HXN's multimodal capability for registering element distribution with the

morphological distribution (analyzed by either DPC or ptychography) provides more comprehensive understanding of the nanostructure.

- To investigate structural evolution as a function of material processing or in-situ controls. Most of the problems do not require absolute quantification but require high sensitivity of detecting change in nanostructure, composition, or oxidation state. Significant number of problems are in the field of battery research, corrosion and material processing. The HXN beamline has capability for in-situ electrochemical controls.

- To image crystalline ordering or strain within single crystalline samples. The relevant application includes nanofabrication (nanowire, quantum dots, nanoelectronics) and condensed matter physics (formation of superlattice structure due to electronic ordering or correlation).

During 2015 and 2016, most beamline users took advantage of the high-resolution fluorescence and DPC imaging capability. One of the most successful application the XRF imaging is in the field of battery research. The latest generation of battery materials take advantage of complex interfaces between electrode and electrolyte. The diversity of interfacial structure ensures multiple current paths, which can significantly promote battery performance. Zhang et. al. introduced a new concept called "self-forming" for enhancing conductivity of a solid electrolyte in a sodium battery. Self-formed (or phase-separated) secondary phase provides more robust interfacial structure, resulting in ultralong cycle life. Figure 2 shows how a self-formed $Na_3Zr_{2-x}La_x(PO4)_2$ is spatially distributed in a large volume of the sample. The amount of the self-formed phase was accurately quantified. Most importantly, nanoscale over a relative large volume (6 um x 6 um x 1 um) was used to obtain statistically significant size distribution of the self-formed phase, providing structure-functionality relation.

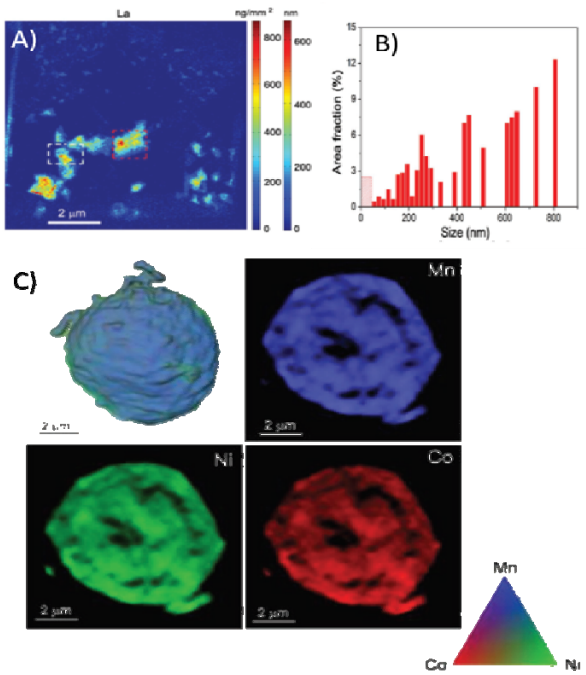

Figure 2: A) XRF image of a solid electrolyte in a Na battery material. B) Size distribution determined from element map in A). C) XRF tomography of a NCM battery material showing no detectible phase separation after heat treatment

During 2016-2017, the HXN beamline scientists focused their efforts in commissioning other imaging capabilities, which include fluorescence tomography, spectroscopic imaging and ptychography (in transmission and Bragg modes). XRF tomography found significant application in battery research, by answering an important question, "has the internal nanostructure transformed due to cycling?" Shi et. al. significantly improved the discharge voltage of NCM ($LiNi_xCo_yMn_{1-x-y}O_2$) battery material by optimizing relative concentration of the constituent elements and heat treatment. They performed XRF tomography investigation (as shown in Fig 2) to validate the structural and composition stability of their new material.

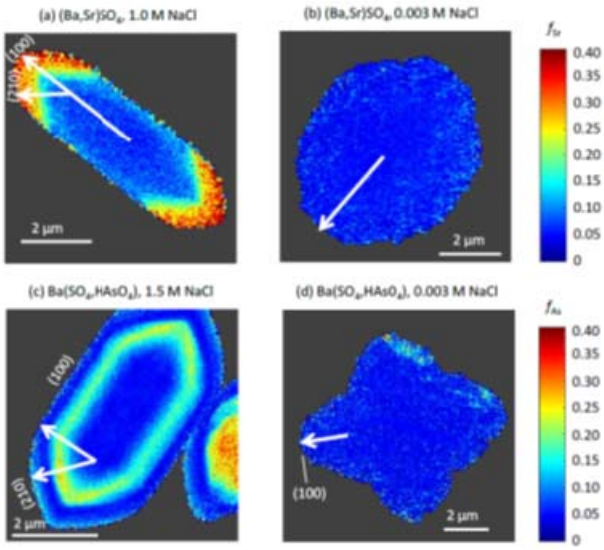

Figure 3: The fractional substitution maps showing composition zonation of As in Barite particles, precipitated from different solutions. The spatial distribution of As^V strongly depends on the growth kinetic of the Barite crystals. The arrows indicated different crystallographic directions.

The HXN capability found an important scientific application for environmental research. The primary reason for environmental experiments is to quantify element distribution and their oxidation states, in order to understand bio-availability and bio-toxicity of environment pollutants. Ling et. al. investigated how As is incorporated into Barite crystals, an important chemical reaction observed in production of waste waters from hydro-fracking. In this work, the researchers wanted to study the formation of compositionally zonated Barite particles using micro precipitates formed in dilute solutions of NaCl. Figure 3 shows the fraction substitution maps As in the (Ba, Sr)SO_4 micro particles, where the zonated As exhibited valance state of +5. This work revealed time that the incorporation of As strongly depends on the growth kinetic of the Barite particles.

The HXN is among the few nanoprobes around the world with a robust diffractometry capability, which is ideally-suited for strain imaging. Since strain imaging has considerably higher scientific risks (i.e. high rate of measurement failure) than other techniques, this capability was not offered to the general users until 2017-Q2. Presently, the Bragg ptychography investigation is the fastest growing segment of the general user proposals. Bragg ptychography with a high photon density of the HXN beamline exhibit significant potential to make important discovery in material science and condensed matter physics. Figure 4a shows how the HXN capability was used to reveal 3D strain distribution within a $In_{1-x}Ga_xAs$ nanowire with the highest reported spatial resolution of 2.6 nm. Bragg ptychography can be used to image not only strain but also staking fault, since certain reflections have high sensitivity to the stacking fault disorder, as shown in Figure 4b. High monochromatic photon density of the HXN beamline allows investigating type of crystalline ordering, producing superlattice reflections with substantially lower intensity (by a factor 100-1000) than the bulk reflections. Robinson group at BNL has been investigating charge-ordered phases in quasi-2D 1T-TaS_2 nanoflakes. Figure 4c and 4d are their preliminary data, showing both the Bragg crystalline domains and charge-ordered phase. While the charge-ordered phase does show resemblance to the Bragg domains, they reveal considerably finer structures. Successful demonstration of nanoscale imaging of the charge order phase

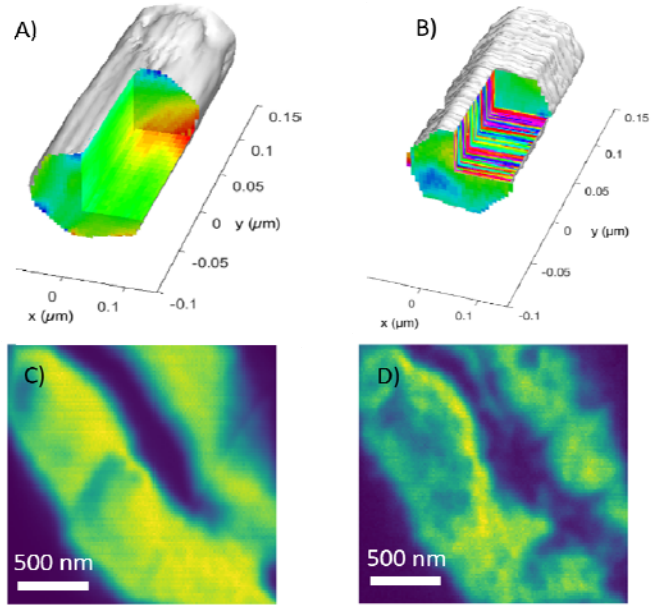

Figure 4: Bragg ptychography investigation on a single crystalline $In_{1-x}Ga_xAs$ nanowire showing A) crystalline strain and B) stacking fault disorder. Preliminary data obtained from a quasi-2D 1T-TaS_2 nanoflake showing C) bulk domains and D) charge-ordered domains.

opens new opportunities for extending this technique to other material systems exhibiting quasi-2D ordering.

The scientific impact of the HXN beamline is bridging the resolution wide gap between electron microscopy and x-ray micro/nanoprobes, providing image-based analysis tools at 5 to 100 nm range. Most of the user experiments aim at performing highest-resolution investigation in their own material system. The beamtime usage (beamtime allocated for user experiments) for the HXN beamline has been steady increasing; ~30% in 2016-Q1 to ~70% in 2017-Q2. In 2018-Q2, 87% of the beamtime was allocated for user experiment. In the middle of 2018-Q2 cycle, the HXN undulator malfunctioned and the beamline has been down since then, resulting in 28% beam time usage. While the user beamtime usage is steadily increasing, the oversubscription rate has been also increasing steadily to 3 in 2018-Q2. Additional details on the general user statistics can be found in Appendix A.

Vision for Next Five Years

The future vision for the HXN beamline is to provide imaging capability with higher resolution, higher photon density, higher measurement throughput and higher scientific productivity. In order to achieve this vision, we plan the following developments and upgrades.

1) Upgrade of nano-Mii

Nano-Mii, the HXN user microscope, uses nano positioners that were the state-of-the-art in 2012-2013. Since then, small-scale improvements have been made to enhance its positioning stability and run-out errors for the rotation stage (used for tomography and diffraction). The current bottleneck of the instrument is the accuracy of the rotation stage, which still has about ~3 um run out errors. Tomography throughput can double if the run-out errors can reduce to ~0.1 um. Incorporation of a new type of interferometer (which uses a line-focused beam) will reduce the run-out errors down to nanometers, greatly enhancing measurement throughput for both tomography and diffraction. The first step for this upgrade is already made. Evgeny Nazaretski (who designed nano-Mii) has been awarded with a special improvement project, which aim to implement new type of interferometers on a test-bed instrument. After this project is successfully completed (in about two years), we will design an upgraded version of nano-Mii.

2) Incorporation of wedged MLL into nano-Mii

The MLL optics integrated into nano-Mii is about 4 years old. Since then, significant progress has been made to achieve higher resolution and higher efficiency. Recently, we have demonstrated a 7 nm focusing using a wedged MLL. The challenge is to increase the physical aperture of the MLL, so that a sufficient working distance can be achieved. We anticipate that it will take about two years to fabricated large aperture wedged MLLs, appropriate for the user experiments.

3) Upgrade of the beam conditioning optics

In order to create a secondary source, the HXN beamline uses a horizontal focusing mirror with a slope error of 0.5 urad (RMS) and a set of CRLs in the vertical direction. When designing the HXN beamline, a set of vertical mirrors was considered to be a risk for beam stability. In comparison, the CRLs provide superb beam stability. However, its operation is rather tricky even for the experience users. In addition, it has much lower efficiency than a pair of mirrors. Replacement of the CRLs with a set of vertical mirrors and improving the slope error for the horizontal focusing mirror will result in considerable flux increase (~3X). More importantly, users can freely change beamline energies without help from the beamline staff, further enhancing user productivity.

4) Upgrade of data acquisition controls

Based on lessons learned from the previous x-ray nanoprobe developments, we began developing data acquisition for nano-Mii in 2012 and completed fly-scanning capability, long before the NSLS-II has launched data acquisition using Bluesky. Moreover, the person who developed the data acquisition left the NSLS-II. Consequently, the HXN data acquisition system has not been improved since 2014. Presently, the maximum speed of the HXN fly-scan triggering both XRF and pixel array detectors is about 30 ms/pixel, which is not high enough. The XRF detector and its data processing units (XSPRESS III) are capable of operating at 1kHz and the pixel-array detector (Merlin) can operate at 100 Hz frame rate. Once a different pixel-array detector (i.e. Eiger) is implemented, all hardware should be able to operate at a data rate close to 1kHz. However, the current data acquisition software (the EPICS interface layer below Bluesky) is incapable of operating at the maximum hardware rate. The "bottom-up" improvement of the HXN data acquisition is a non-trivial task, since this will require rewriting of the hardware controls interfaces. Nevertheless, enhancing the controls throughput is absolutely required, for the HXN Beamline to remain as the world-class microscopy beamline.

5) Development of the second Nanoprobe at the NSLS-II

The user demand for the HXN Beamline has been steadily increasing, even though the HXN beamline scientists have not actively solicited new users with a fear that the oversubscription rate will uncontrollably increase. Presently, the HXN Beamline is hosting a wide range of experiments requesting spatial resolutions from 100 nm to 5 nm. The current scientific scope of the HXN Beamline is too broad, well beyond the scientific expertise of the HXN Beamline staff. At the same time, the effective number of scientific staff has decreased from 5 (about 18 month ago) to 3.25 (now). In 2017, we had a highly capable postdoc with significant scientific expertise in battery materials, who supported in-situ investigation. In addition, we had a visiting scientist who also had significant expertise in battery and fuel cell materials with strong scientific interest in in-situ investigation. Then, Yong Chu was able to spend 100% of his effort on the HXN Beamline, which is no longer possible due to his additional duties. As a result, the HXN Beamline scientists are no longer capable of supporting in-situ experiments for battery materials or corrosion investigation.

The current trend of user subscription rate and potential growth in in-situ/in-operando imaging are two important justification for developing a second nanoprobe at the NSLS-II, operating at spatial resolution range between 50 to 200 nm. The SRX Beamline at 5-ID already has infrastructure for future canted side branch, serving as an ideal place for the second nanoporbe can be developed.
The second nanoprobe optimized for in-situ investigation (lower spatial resolution gives a longer working distance, required for in-situ cells) and operating at 50-200 nm range can effectively fill the resolution gap between the HXN and other microprobes at the NSLS-II. The second nanoprobe will also provide strong beneficial effect on the HXN in that the HXN Beamline can focus primarily on scientific problems requiring sub-50 nm resolutions.

Beamline Self-Assessment (½ pg)

The strength of the HXN Beamline is in ultrahigh resolution x-ray imaging in 2D and 3D. Its significant user base lies on investigation of hard materials. In particular, significant number of its scientific problems is on investigating interfaces: the electrode interfaces in the energy materials such as battery materials and fuel cells, and grain boundaries in complex materials. Nanoscale XRF tomography and Bragg ptychography are important tools for investigating wide range of interfacial

problems. In comparison, the HXN Beamline has fundamental limitation in biological research, since it lacks a capability for imaging biological samples under frozen-hydrated states. While the HXN Beamline will continue to investigate some biological systems, its research goal is for developing techniques (i.e. developing 3D biological imaging using La-Tag) and leverage it high resolution capability for select systems, pointing out exciting scientific opportunities.

Strain imaging capability of the HXN beamline either using conventional nanodiffraction or Bragg ptychography is truly world-leading based on both spatial resolution and detection sensitivity. In addition, the HXN Beamline occupies a rather unique position in the world-wide perspective. Furthermore, this area has significant potential for growth due to the recent scientific interests for quasi-2D systems, correlated materials and quantum information science. One of the important technical barrier in excelling in this area is to enable in-situ temperature control for the sample. Nano-Mii has such capability. However, it has not been commissioned yet. More correctly stated, there have been significantly more exciting things to do than commissioning this capability. A very wide range of scientific experiments at the HXN Beamline creates significant distraction for focused development efforts in this area. Conversely stated, the staffing level at the HXN is too thin to excel in many scientific areas simultaneously.

Appendix B: HXN Beamline User Statistics

Table B.1 summarizes the HXN Beamline user statistics. Note that the sudden decrease in the number of users in 2018-2 is due to the undulator failure. In the middle of 2018-2 cycle, the HXN undulator failed to operate. The beamline will return to operation in January 2019. The beamtime usage is defined as the fraction of the beamtime allocated for user experiments, which includes general users, science commissioning users, and beamline staff users. Typically, the fraction for beamline staff usage on the level of 5-10%. Figure B.2 shows these data in a graphic representation. Table B.2. summarizes the entire beamline users by years. By scientific disciplines, the HXN beam time were allocated to material science (51.5%), condensed matter physics (6.3%), environmental science (10.6%), geology (3.1%), biology (16.5%), optics development (12.0%), and microscopy technique development (4.0%). Table B.3. summarizes the allocated beamtime distributions to different scientific disciplines.

Table B.1: HXN Beamline user statics by beam cycle.

Beam Cycle	Proposals Submitted	Proposals Allocated	Subscription Rate	Users by Cycle	Beam Time Usage*	Users by Cycle	Unique users per CY
2015-3	16	4	4.0	34	51%	34	34
2016-1	9	5	1.80	38	30%	38	
2016-2	26	6	4.33	49	30%	49	
2016-3	17	7	2.43	51	68%	51	68
2017-1	26	10	2.60	68	72%	68	
2017-2	23	11	2.09	88	74%	88	
2017-3	27	12	2.25	35	68%	35	84
2018-1	33	14	2.36	67	87%	67	
2018-2	27	9	3.00	31	28%	31	53

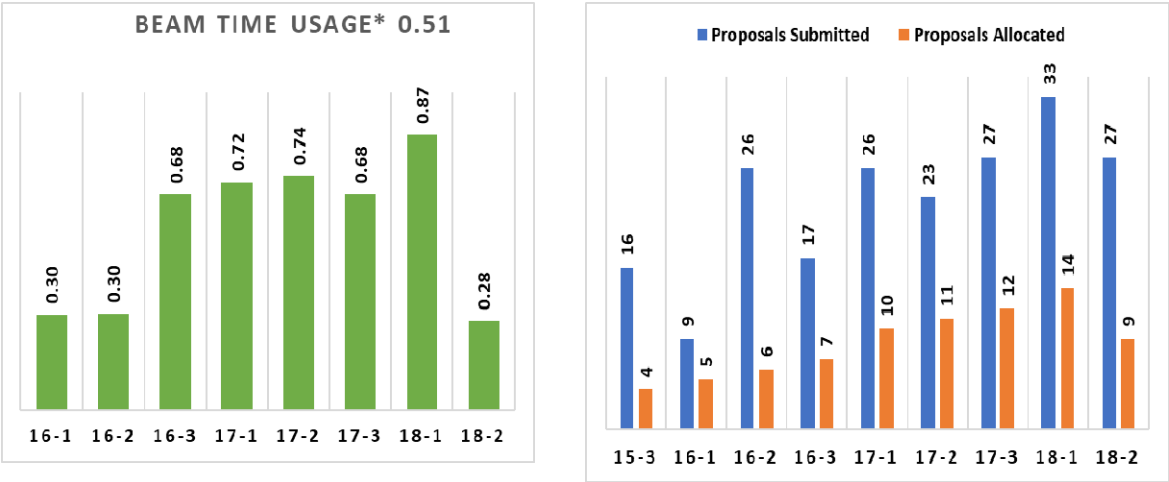

Figure B.1: Beamtime usage and proposals submitted and allocated at the HXN beamline

Table B.2: Complete list of the beamline users by beam cycle

Cycle	Last Name	First Name	Email	Affiliation
15-3				
	Acerbo	Alvin	aacerbo@uchicago.edu	University of Chicago
	Bock	David	david.bock@stonybrook.edu	SUNY @ Stony Brook
	Bohon	Jennifer	jbohon@bnl.gov	Case Western Reserve University
	Brady	Alexander	alexander.brady@stonybrook.edu	SUNY @ Stony Brook
	Campbell	Emilie	emcampbell@u.northwestern.edu	Northwestern University
	Chiu	Wilson	wchiu@engr.uconn.edu	University of Connecticut
	Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
	Cocco	Alex	alex.cocco@uconn.edu	University of Connecticut
	DeRocher	Karen	karenderocher2018@u.northwestern.edu	Northwestern University
	Flynn	George	flynngj@plattsburgh.edu	SUNY @ Plattsburgh
	Hu	Wen	wenhu@bnl.gov	Brookhaven National Laboratory
	Huang	Jianping	jianping.huang@stonybrook.edu	SUNY @ Stony Brook
	Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
	Huie	Matthew	matthew.huie@stonybrook.edu	SUNY @ Stony Brook
	Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
	Ilinski	Petr	pi15926c@gmail.com	Brookhaven National Laboratory
	Kalbfleisch	Sebastian	skalbfleisch@bnl.gov	Brookhaven National Laboratory
	Lauer	Kenneth	klauer@bnl.gov	Brookhaven National Laboratory
	Li	Jieran	jli295@uky.edu	University of Kentucky
	Li	Li	lili@bnl.gov	Brookhaven National Laboratory
	Marschilok	Amy	amy.marschilok@stonybrook.edu	SUNY @ Stony Brook
	Mead	Joseph	mead@bnl.gov	Brookhaven National Laboratory
	Muller	Erik	emuller@bnl.gov	Brookhaven National Laboratory
	Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
	Rao	William	rao@bnl.gov	University of Kentucky
	Smedley	John	smedley@bnl.gov	Brookhaven National Laboratory
	Sutton	Stephen	Sutton@cars.uchicago.edu	University of Chicago
	Unrine	Jason	jason.unrine@uky.edu	University of Kentucky
	Wirick	Sue	swirick@bnl.gov	Focused Beam Enterprises
	Wrubel	Jacob	jacob.wrubel@uconn.edu	University of Connecticut
	Xu	Weihe	weihexu@bnl.gov	Brookhaven National Laboratory
	Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
	Yin	Jiefu	jiefu.yin@stonybrook.edu	SUNY @ Stony Brook
	Zhou	Tianyi	tianyi.mse@gmail.com	SUNY @ Stony Brook
16-1				
	Acerbo	Alvin	acerbo@bnl.gov	University of Chicago
	Bak	Seongmin	smbak@bnl.gov	Brookhaven National Laboratory
	Chiu	Wilson	wchiu@engr.uconn.edu	University of Connecticut
	Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
	Cocco	Alex	alex.cocco@uconn.edu	University of Connecticut
	Damian	Peter Joseph	peter.damian@uconn.edu	University of Connecticut
	Dazas	Baptiste	baptiste.dazas@princeton.edu	Princeton University
	Feng	Huan	hfeng@bnl.gov	Montclair State University

Fitts	Jeffrey	fitts@princeton.edu	Princeton University
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Hill	Megan	meganhill2020@u.northwestern.edu	Northwestern University
Holt	Martin	mvholt@anl.gov	Argonne National Laboratory
Hruszkewycz	Stephan	s.hruszkewycz@gmail.com	Argonne National Laboratory
Hu	Enyuan	enhu@bnl.gov	Brookhaven National Laboratory
Hu	Wen	wenhu@bnl.gov	Brookhaven National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Ilinski	Petr	pi15926c@gmail.com	Brookhaven National Laboratory
Kristiansen	Paw	paw.kristiansen@gmail.com	FMB-Oxford
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Lin	Ruoqian	linruoqian@gmail.com	SUNY @ Stony Brook
Liu	Chang-Jun	cliu@bnl.gov	Brookhaven National Laboratory
Liu	Yijin	liuyijin@slac.stanford.edu	SLAC National Accelerator Laboratory
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Stephenson	Gregory	stephenson@anl.gov	Argonne National Laboratory
Tappero	Ryan	rtappero@bnl.gov	Brookhaven National Laboratory
Wrubel	Jacob	jacob.wrubel@uconn.edu	University of Connecticut
Xu	Weihe	weihexu@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
Yang	Xiao-Qing	xyang@bnl.gov	Brookhaven National Laboratory
Yu	Xiqian	xyu@bnl.gov	Brookhaven National Laboratory

16-2

Acerbo	Alvin	acerbo@bnl.gov	University of Chicago
Acerbo	Alvin	aacerbo@uchicago.edu	University of Chicago
Bouet	Nathalie	bouet@bnl.gov	Brookhaven National Laboratory
Chen-Wiegart	Yu-chen	ycchen@bnl.gov	Brookhaven National Laboratory
Chiu	Wilson	wchiu@engr.uconn.edu	University of Connecticut
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Cocco	Alex	alex.cocco@uconn.edu	University of Connecticut
Damian	Peter Joseph	peter.damian@uconn.edu	University of Connecticut
Fitts	Jeffrey	fitts@princeton.edu	Princeton University
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Gomez Gonzalez	Miguel	m.gomez-gonzalez@imperial.ac.uk	Imperial College of Science, Technology and Medicine
Goode	Angela	angelagoode@gmail.com	Imperial College of Science, Technology and Medicine
Grelet	Leo	leogrelet@wanadoo.fr	ENSEIRB-MATMECA
Hill	Megan	meganhill2020@u.northwestern.edu	Northwestern University
Hruszkewycz	Stephan	s.hruszkewycz@gmail.com	Argonne National Laboratory
Hu	Wen	wenhu@bnl.gov	Brookhaven National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Huie	Matthew	matthew.huie@stonybrook.edu	SUNY @ Stony Brook
Ilinski	Petr	pi15926c@gmail.com	Brookhaven National Laboratory
Johnson	Kyle	kylehenry@gmail.com	SUNY @ Stony Brook
Kristiansen	Paw	paw.kristiansen@gmail.com	FMB-Oxford
Lanzirotti	Antonio	lanzirotti@uchicago.edu	University of Chicago
Latsko-Hilbert	Ryan	Ryan.J.Hilbert@gmail.com	SUNY @ Stony Brook

Li	Jieran	jli295@uky.edu	University of Kentucky
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Lowery	Adam	alowery@bnl.gov	Brookhaven National Laboratory
Marschilok	Amy	amy.marschilok@stonybrook.edu	SUNY @ Stony Brook
Miller	Lisa	lmiller@bnl.gov	Brookhaven National Laboratory
Miller	Samantha	smiller3@student.sjcny.edu	St. Joseph's College
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Quinn	Paul	paul.quinn@diamond.ac.uk	Diamond Light Source Ltd
Rao	William	rao@bnl.gov	University of Kentucky
Ryan	Mary	m.p.ryan@imperial.ac.uk	Imperial College of Science, Technology and Medicine
Shen	Chenfei	chenfeis@usc.edu	University of Southern California
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Stephenson	Gregory	stephenson@anl.gov	Argonne National Laboratory
Tappero	Ryan	rtappero@bnl.gov	Brookhaven National Laboratory
Tropf	Derek	derek.tropf@gmail.com	Columbia University
Victor	Tiffany	tiffany.victor@stonybrook.edu	Brookhaven National Laboratory
Wrubel	Jacob	jacob.wrubel@uconn.edu	University of Connecticut
Xu	Weihe	weihexu@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory

16-3

Acerbo	Alvin	acerbo@bnl.gov	University of Chicago
Bajt	Sasa	sasa.bajt@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Bak	Seongmin	smbak@bnl.gov	Brookhaven National Laboratory
Bock	David	dbock@bnl.gov	Brookhaven National Laboratory
Bouet	Nathalie	bouet@bnl.gov	Brookhaven National Laboratory
Brady	Alexander	alexander.brady@stonybrook.edu	SUNY @ Stony Brook
Cama	Christina	christina.cama@stonybrook.edu	SUNY @ Stony Brook
Chapman	Henry	henry.chapman@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Gill	Simerjeet	gills@bnl.gov	Brookhaven National Laboratory
Hu	Enyuan	enhu@bnl.gov	Brookhaven National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Huie	Matthew	matthew.huie@stonybrook.edu	SUNY @ Stony Brook
Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
Isaacs	Hugh	isaacs@bnl.gov	BNL Retirees
Kashyap	Srishti	skashyap@umass.edu	University of Massachusetts @ Amherst
Lanzirotti	Tony	tonylanzirotti@gmail.com	University of Chicago
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Li	Yue Ru	Yueru.li@stonybrook.edu	SUNY @ Stony Brook
Lin	Ruoqian	linruoqian@gmail.com	SUNY @ Stony Brook
Liu	Jue	jue.liu@stonybrook.edu	Oak Ridge National Laboratory
Liu	Yijin	liuyijin@slac.stanford.edu	SLAC National Accelerator Laboratory
Lowery	Adam	alowery@bnl.gov	Brookhaven National Laboratory
Maklary	Michael	mmaklary@bnl.gov	Brookhaven National Laboratory

Marschilok	Amy	amy.marschilok@stonybrook.edu	SUNY @ Stony Brook
May	Brian	may16@uic.edu	University of Illinois @ Chicago
Miller	Lisa	lmiller@bnl.gov	Brookhaven National Laboratory
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Pelliccione	Christopher	cpelliccione@bnl.gov	Brookhaven National Laboratory
Sasaki	Kotaro	ksasaki@bnl.gov	Brookhaven National Laboratory
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Tappero	Ryan	rtappero@bnl.gov	Brookhaven National Laboratory
Tropf	Derek	dt2516@columbia.edu	Columbia University
Victor	Tiffany	tiffany.victor@stonybrook.edu	Brookhaven National Laboratory
Wolfman	Mark	mwolf22@uic.edu	University of Illinois @ Chicago
Xu	Weihe	weihexu@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
Yang	Xiao-Qing	xyang@bnl.gov	Brookhaven National Laboratory
Yu	Xiqian	xyu@bnl.gov	Brookhaven National Laboratory
Zhang	Yiman	yiman.zhang@stonybrook.edu	SUNY @ Stony Brook

17-1

Acerbo	Alvin	acerbo@bnl.gov	University of Chicago
Bock	David	dbock@bnl.gov	Brookhaven National Laboratory
Bolotnikov	Aleksey	bolotnik@bnl.gov	Brookhaven National Laboratory
Bouet	Nathalie	bouet@bnl.gov	Brookhaven National Laboratory
Calvo Almazan	Irene	ialmazn@anl.gov	Argonne National Laboratory
Cama	Christina	christina.cama@stonybrook.edu	SUNY @ Stony Brook
Camarda	Giuseppe	giuseppec@bnl.gov	Brookhaven National Laboratory
Chu	Yong	ychu@aps.anl.gov	Other
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Cui	Yonggang	ycui@bnl.gov	Brookhaven National Laboratory
Fitts	Jeffrey	fitts@princeton.edu	Princeton University
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Gill	Simerjeet	gills@bnl.gov	Brookhaven National Laboratory
Gomez Gonzalez	Miguel	m.gomez-gonzalez@imperial.ac.uk	Imperial College of Science, Technology and Medicine
Goode	Angela	angelagoode@gmail.com	Imperial College of Science, Technology and Medicine
He	Yan	heyan@sinap.ac.cn	Shanghai Institute of Applied Physics
Hill	Megan	meganhill2020@u.northwestern.edu	Northwestern University
Holt	Martin	mvholt@anl.gov	Argonne National Laboratory
Hossain	Anwar	hossain@bnl.gov	Brookhaven National Laboratory
Hruszkewycz	Stephan	shrus@anl.gov	Argonne National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Huang	Xiaoyang	xhuang@poly.edu	Polytechnic Institute of New York University
Hunter	Heather	hahunter@princeton.edu	Princeton University
Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
Koishi	Ayumi	akoishi@princeton.edu	Princeton University
Koronfel	Mohamed	mak210@imperial.ac.uk	Imperial College of Science, Technology and Medicine
Lai	Barry	blai@aps.anl.gov	Argonne National Laboratory
Lee	Tsung-Tse	lttjohn@gate.sinica.edu.tw	Academia Sinica

Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Li	Yue Ru	Yueru.li@stonybrook.edu	SUNY @ Stony Brook
Liang	Zhixiu	liangzhixiu@gmail.com	SUNY @ Stony Brook
Ling	Florence	ftling@princeton.edu	Princeton University
Marschilok	Amy	amy.marschilok@stonybrook.edu	SUNY @ Stony Brook
Miller	Lisa	lmiller@bnl.gov	Brookhaven National Laboratory
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Nietzold	Tara	tnietzol@asu.edu	Arizona State University
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Panica	Paul	paul.panica@stonybrook.edu	SUNY @ Stony Brook
Sasaki	Kotaro	ksasaki@bnl.gov	Brookhaven National Laboratory
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Takeuchi	Esther	esther.takeuchi@stonybrook.edu	SUNY @ Stony Brook
Tappero	Ryan	rtappero@bnl.gov	Brookhaven National Laboratory
Ulvestad	Andrew	aulvestad@anl.gov	Argonne National Laboratory
Victor	Tiffany	tiffany.victor@stonybrook.edu	Brookhaven National Laboratory
Wang	Jun	junwang@bnl.gov	Brookhaven National Laboratory
Xu	Weihe	weihexu@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
Yang	Ge	gyang@bnl.gov	Brookhaven National Laboratory
Zhang	Yiman	yiman.zhang@stonybrook.edu	SUNY @ Stony Brook
Zuo	Pengjian	50005958@qq.com	Harbin Institute of Technology

17-2

Acerbo	Alvin	aacerbo@uchicago.edu	University of Chicago
Assefa	Tadesse Abebaw	tassefa@bnl.gov	Brookhaven National Laboratory
Banerjee	Soham	sbanerjee@bnl.gov	Columbia University
Bouet	Nathalie	bouet@bnl.gov	Brookhaven National Laboratory
Cao	Yue	ycao@bnl.gov	Brookhaven National Laboratory
Chen-Wiegart	Yu-chen	ycchen@bnl.gov	Brookhaven National Laboratory
Chiu	Wilson	wchiu@engr.uconn.edu	University of Connecticut
Chiu	Wilson	wilsonc88@gmail.com	University of Connecticut
Chu	Yong	ychu@aps.anl.gov	Other
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Cocco	Alex	alex.cocco@uconn.edu	University of Connecticut
Damian	Peter Joseph	peter.damian@uconn.edu	University of Connecticut
Elbakhshwan	Mohamed	bakhshwan@bnl.gov	Brookhaven National Laboratory
Fitts	Jeffrey	fitts@princeton.edu	Princeton University
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Gill	Simerjeet	gills@bnl.gov	Brookhaven National Laboratory
Grelet	Leo	leogrelet@wanadoo.fr	ENSEIRB-MATMECA
Hameed	Nadia	nhameed20@yahoo.com	College at Old Westbury, The, SUNY
He	Yan	heyan@sinap.ac.cn	Shanghai Institute of Applied Physics
Hill	Megan	meganhill2020@u.northwestern.edu	Northwestern University
Hruszkewycz	Stephan	shrus@anl.gov	Argonne National Laboratory
Hu	Wen	wenhu@bnl.gov	Brookhaven National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory

Huang	Xiaoyang	xhuang@poly.edu	Polytechnic Institute of New York University
Huie	Matthew	matthew.huie@stonybrook.edu	SUNY @ Stony Brook
Hunter	Heather	hahunter@princeton.edu	Princeton University
Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
Ilinski	Petr	pi15926c@gmail.com	Brookhaven National Laboratory
Johnson	Kyle	kylehenry@gmail.com	SUNY @ Stony Brook
Kimojino	Joyce	kimojino@princeton.edu	Princeton University
Koishi	Ayumi	akoishi@princeton.edu	Princeton University
Kristiansen	Paw	paw.kristiansen@gmail.com	FMB-Oxford
Latsko-Hilbert	Ryan	Ryan.J.Hilbert@gmail.com	SUNY @ Stony Brook
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Ling	Florence	ftling@princeton.edu	Princeton University
Lowery	Adam	alowery@bnl.gov	Brookhaven National Laboratory
MacGregor	Andrew	myverybusinessemail@gmail.com	University of Massachusetts @ Lowell
Miller	Lisa	lmiller@bnl.gov	Brookhaven National Laboratory
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Panica	Paul	paul.panica@stonybrook.edu	SUNY @ Stony Brook
Peters	Catherine	cap@princeton.edu	Princeton University
Pietri	Ruth	rpietri@bnl.gov	Brookhaven National Laboratory
Shen	Chenfei	chenfeis@usc.edu	University of Southern California
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Solomon	Tunisia	15solomont@gmail.com	Farmingdale State College, SUNY
Sun	Emily Wei-Hsin	esun@princeton.edu	Princeton University
Tropf	Derek	derek.tropf@gmail.com	Columbia University
Victor	Tiffany	tiffany.victor@stonybrook.edu	Brookhaven National Laboratory
Wang	Hua	wanghua@sinap.ac.cn	Shanghai Institute of Applied Physics
Wrubel	Jacob	jacob.wrubel@uconn.edu	University of Connecticut
Xu	Weihe	weihexu@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
Zhang	Zhaohong	zhangzhaohong@sinap.ac.cn	Stanford University
Zuo	Pengjian	50005958@qq.com	Harbin Institute of Technology

17-3

Assefa	Tadesse Abebaw	tassefa@bnl.gov	Brookhaven National Laboratory
Bak	Seongmin	smbak@bnl.gov	Brookhaven National Laboratory
Calvo Almazan	Irene	ialmazn@anl.gov	Argonne National Laboratory
Cao	Yue	scottyuecao@gmail.com	Brookhaven National Laboratory
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Ge	Mingyuan	mingyuag@usc.edu	Brookhaven National Laboratory
He	Yan	heyan@sinap.ac.cn	Shanghai Institute of Applied Physics
Hill	Megan	meganhill2020@u.northwestern.edu	Northwestern University
Holt	Martin	mvholt@anl.gov	Argonne National Laboratory
Hruszkewycz	Stephan	s.hruszkewycz@gmail.com	Argonne National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Hunter	Heather	hahunter@princeton.edu	Princeton University

Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
Kim	Julie	juliejk@princeton.edu	Princeton University
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Liang	Zhixiu	liangzhixiu@gmail.com	SUNY @ Stony Brook
Ling	Florence	ftling@princeton.edu	Princeton University
Maddali Vivekanand	Siddharth	smaddali@anl.gov	Argonne National Laboratory
May	Brian	may16@uic.edu	University of Illinois @ Chicago
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Peters	Catherine	cap@princeton.edu	Princeton University
Rodkey	Nathan	nathan.rodkey@gmail.com	Arizona State University
Sasaki	Kotaro	ksasaki@bnl.gov	Brookhaven National Laboratory
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Stuckelberger	Michael	michael.stuckelberger@gmail.com	Arizona State University
Wolfman	Mark	mwolf22@uic.edu	University of Illinois @ Chicago
Xiong	Shangmin	sx2192@columbia.edu	Columbia University
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory

18-1

Ambi	Ashwin	ashwin.ambi@stonybrook.edu	SUNY @ Stony Brook
Assefa	Tadesse Abebaw	tassefa@bnl.gov	Brookhaven National Laboratory
Bajt	Sasa	sasa.bajt@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Cao	Yue	scottyuecao@gmail.com	Brookhaven National Laboratory
Chang	Guangcai	changgc@ihep.ac.cn	Institute of High Energy Physics (IHEP), Beijing
Chapman	Henry	henry.chapman@llnl.gov	Deutsche Elektronen-Synchrotron (DESY)
Chapman	Henry	henry.chapman@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Chen-Wiegart	Yu-chen	ycchen@bnl.gov	Brookhaven National Laboratory
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Fleckenstein	Holger	holger.fleckenstein@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Gao	Yuan	yuangao@bnl.gov	Brookhaven National Laboratory
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
Gomez Gonzalez	Miguel	m.gomez-gonzalez@imperial.ac.uk	Imperial College of Science, Technology and Medicine
He	Yan	heyan@sinap.ac.cn	Shanghai Institute of Applied Physics
Hill	Megan	meganhill2020@u.northwestern.edu	Northwestern University
Hruszkewycz	Stephan	shrus@anl.gov	Argonne National Laboratory
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
Koronfel	Mohamed	mak210@imperial.ac.uk	Imperial College of Science, Technology and Medicine
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Li	Yufeng	liyf@ihep.ac.cn	Institute of High Energy Physics (IHEP), Beijing
Lin	Cheng-Hung	cheng-hung.lin@stonybrook.edu	SUNY @ Stony Brook
Lin	Yu-Chung	yu-chung.lin@stonybrook.edu	SUNY @ Stony Brook
Liu	Xiaoyang	xiaoyang.liu.1@stonybrook.edu	SUNY @ Stony Brook
Liu	Yijin	liuyijin.ustc.ihep.slac@gmail.com	SLAC National Accelerator Laboratory
Michelson	Aaron	anm2172@columbia.edu	Columbia University
Minevich	Brian	bsm2124@columbia.edu	Columbia University

Mochizuki	Shogo	smochiz@us.ibm.com	IBM Research Division
Morgan	Andrew	andrew.morgan@cfel.de	Deutsche Elektronen-Synchrotron (DESY)
Murray	Conal	conal@us.ibm.com	IBM Research Division
Murray	Kevin	kevin.murray@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Poccia	Nicola	npoccia@g.harvard.edu	Harvard University
Robinson	Ian	irobinson@bnl.gov	Brookhaven National Laboratory
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Tappero	Ryan	rtappero@bnl.gov	Brookhaven National Laboratory
Thieme	Juergen	jthieme@bnl.gov	Brookhaven National Laboratory
Ulvestad	Andrew	andrew.ulvestad@gmail.com	Argonne National Laboratory
Victor	Tiffany	tiffany.victor@stonybrook.edu	Brookhaven National Laboratory
Villanueva Perez	Pablo	pablo.villanueva-perez@cfel.de	Deutsche Elektronen-Synchrotron (DESY)
Villanueva-Perez	Pablo	pablo.villanueva-perez@desy.de	Deutsche Elektronen-Synchrotron (DESY)
Williams	Garth	gwilliams@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
Zhang	Yugang	yuzhang@bnl.gov	Brookhaven National Laboratory
Zhao	Shu Yang	fzhao@physics.harvard.edu	Harvard University

18-2

Bak	Seongmin	smbak@bnl.gov	Brookhaven National Laboratory
Chu	Yong	ychu@bnl.gov	Brookhaven National Laboratory
Ge	Mingyuan	mingyuan@bnl.gov	Brookhaven National Laboratory
He	Yan	heyan@sinap.ac.cn	Shanghai Institute of Applied Physics
Huang	Xiaojing	xjhuang@bnl.gov	Brookhaven National Laboratory
Hurley	Nathaniel	nathaniel.hurley@stonybrook.edu	SUNY @ Stony Brook
Ilinski	Petr	pilinski@bnl.gov	Brookhaven National Laboratory
Jordan-Sweet	Jean	jlj@bnl.gov	IBM Research Division
Lavoie	Christian	clavoie@us.ibm.com	IBM Research Division
Li	Li	lili@bnl.gov	Brookhaven National Laboratory
Li	Luyao	Luyao.Li@stonybrook.edu	SUNY @ Stony Brook
McGuire	Scott	scott.mcguire@stonybrook.edu	SUNY @ Stony Brook
Michelson	Aaron	anm2172@columbia.edu	Columbia University
Minevich	Brian	bsm2124@columbia.edu	Columbia University
Murray	Conal	conal@us.ibm.com	IBM Research Division
Nazaretski	Evgeny	enazaretski@bnl.gov	Brookhaven National Laboratory
Ozturk	Hande	hozturk@bnl.gov	Brookhaven National Laboratory
Salvatore	Kenna	kenna.salvatore@stonybrook.edu	SUNY @ Stony Brook
Smith	Randy	rsmith@bnl.gov	Brookhaven National Laboratory
Tan	Sha	sha.tan@stonybrook.edu	SUNY @ Stony Brook
Tappero	Ryan	rtappero@bnl.gov	Brookhaven National Laboratory
Thieme	Juergen	jthieme@bnl.gov	Brookhaven National Laboratory
Williams	Garth	gwilliams@bnl.gov	Brookhaven National Laboratory
Yan	Hanfei	hyan@bnl.gov	Brookhaven National Laboratory
Yue	Shiyu	shiyu.yue@stonybrook.edu	SUNY @ Stony Brook

Table B.3: Complete list of allocated user beamtime by scientific disciplines.

Cycle	prop #	PI	shifts	sci. disciplines
2015Q3	300173	George Flynn	15.0	Geochemistry
2015Q3	300202	Wilson Chiu	17.5	Material Science
2015Q3	300289	Emmie Campbell	9.5	Biology
2015Q3	300218	Jason Unrine	14.5	Environmental
2016Q1	300565	Mingyuan Ge	12.0	Material Science
2016Q1	300202	Wilson Chiu	9.5	Material Science
2016Q1	300287	T. Lanzirotti	15.0	Environmental
2016Q1	300554	X.Q. Yang	18.0	Material Science
2016Q1	300586	H. Feng	9.5	Environmental
2016Q1	300304	S. Hruszkewycz	18.5	Material Science
2016Q2	300903	H. Yan	9.0	Optics testing
2016Q2	300554	Jason Unrine	12.5	Environmental
2016Q2	300287	T. Lanzirotti	15.0	Environmental
2016Q2	300879	L. Miller	27.5	Biology
2016Q2	300918	M. Korenfeil	9.5	Biochemistry
2016Q2	300903	H. Yan	9.5	Material Science
2016Q2	300923	A. Marschilok	14.8	Material Science
2016Q2	300918	S. Hruszkewycz	15.5	Material Science
2016Q3	300554	X.Q. Yang	15.5	Material Science
2016Q3	300923	A. Marschilok	14.5	Material Science
2016Q3	301116	Wolf	15.0	Material Science
2016Q3	300819	T. Lanzirotti	9.5	Environmental
2016Q3	301145	S. Gill	12.0	Material Science
2016Q3	300903	H. Yan	9.5	Optics testing
2016Q3	301158	X. Huang	9.0	tech. develop
2016Q3	300879	L. Miller	9.0	Biology
2017Q1	300879	L. Miller	18.0	Biology
2017Q1	300287	T. Lanzirotti	15.0	Environmental
2017Q1	300903	H. Yan	14.5	Optics testing
2017Q1	301304	Stueckelberg	12.0	Material Science
2017Q1	301600	S. Gill	9.0	Material Science
2017Q1	300918	M. Korenfeil	9.5	Biochemistry
2017Q1	301545	X.Q. Yang	9.0	Material Science
2017Q1	301567	S. Hruszkewycz	15.0	Material Science
2017Q1	301370	Chu	15.5	Material Science
2017Q1	300923	A. Marschilok	14.5	Material Science
2017Q2	301370	Chu	12.0	Material Science
2017Q2	301304	Stuecheklberger	9.0	Material Science
2017Q2	301239	Wilson Chiu	9.5	Material Science
2017Q2	301632	Cao	8.5	Condensed Matter
2017Q2	301567	Hruszkewycz	15.5	Material Science
2017Q2	301793	Yan	5.5	Optics testing

2017Q2	301158	Huang	9.0	tech. develop
2017Q2	301884	Miller	15.5	Biology
2017Q2	302009	Fitts	9.0	Environmental
2017Q2	301600	Gill	3.5	Material Science
2017Q2	301894	Li	15.0	Biology
2017Q3	302190	Huang	12.0	tech. develop
2017Q3	301512	H. Yan	9.5	Optics testing
2017Q3	302009	Fitts	11.5	Environmental
2017Q3	302361	Liming	8.0	Biology
2017Q3	301884	Miller	14.5	Biology
2017Q3	302005	Yang, X-Q	12.0	Material Science
2017Q3	302317	Gill	12.5	Material Science
2017Q3	301370	Chu	8.0	Material Science
2017Q3	301632	Cao	12.0	Condensed Matter
2017Q3	301882	Wolf	17.5	Material Science
2017Q3	302166	Ulvestad	15.0	Material Science
2017Q3	302169	He	9.0	Material Science
2017Q3	301793	Yan, H	11.5	Optics testing
2018Q1	302083	Murray	18.0	Material Science
2018Q1	302396	Liu	17.5	Geology
2018Q1	302769	Chen-Wiegart	14.5	Material Science
2018Q1	302784	Cao	12.0	Condensed Matter
2018Q1	301924	Koronfel	11.5	Biochemistry
2018Q1	302176	Poccia	10.0	Condensed Matter
2018Q1	302361	Liming	14.0	Biology
2018Q1	302250	Hruszkewycz	15.0	Material Science
2018Q1	302755	Bajt	12.0	Optics testing
2018Q1	301793	Yan	9.0	Optics testing
2018Q1	302703	Ozturk	9.0	Optics testing
2018Q1	302362	Zhang	11.5	Material Science
2018Q1	302508	Michelson	11.5	Material Science
2018Q1	301884	Miller	11.3	Biology
2018Q2	302571	Wong	15.0	Material Science
2018Q2	303294	Jordan-Sweet	12.0	Material Science
2018Q2	302508	Michelson	9.0	Material Science
2018Q2	303030	Huang	12.5	tech. develop
2018Q2	302769	Chen-Wiegart	15.0	Material Science
2018Q2	302755	Yan	12.0	Optics testing
2018Q2	302755	Bajt	12.0	Optics testing
2018Q2	303069	Paiella	15.5	Material Science
2018Q2	302784	Cao	14.5	Condensed Matter
2018Q2	302638	Xu	12.0	Material Science
2018Q2	303028	gorobtosov	9.0	Condensed Matter
2018Q2	303071	Syed	12.5	Optics testing
2018Q2	303278	He	20.5	Material Science

Appendix B: HXN Beamline Publications

2018

Submitted

- Z. Dong, Y.-L. L. Fang, X. Huang, H. Yan, S. Ha, W. Xu, Y.S. Chu, S. Campbell and M. Line, "High-Performance Multi-Mode Ptychography Reconstruction on Distributed CPUs", Submitted*
- Ghulam Ali, Mobinul Islam, Deu S. Bhange, Seong-Min Bak, Xiao-Qing Yang, Young-Hwa Jung, Mingyuan Ge, Yong S. Chu, Kyung-Wan Nam, Hun-Gi Jung, Kyung Yoon Chung, "Self-standing mixed metal $Co_{2.4}Sn_{0.6}O_4$ nano-rods as a high performance anode material and its application in sodium-ion full cell against layered $NaNi_{2/3}Bi_{1/3}O_2$ cathode", Submitted*
- Wen Chu, Yan He, Huanhuan Sheng, Haiying Qin, Weihao Lin, Liang Meng, Xiaojing Huang, Hanfei Yan, Yong S. Chu and Jiabin Liu. "High-performance anion exchange membranes with dispersed Cu(OH)2 nanoclusters", Submitted*
- Jieran Li, Ryan V. Tappero, Alvin S. Acerbo, Hanfei Yan, Yong S. Chu, Greg V. Lowry, and Jason M. Unrine, "Effect of surface functional groups on subcellular distribution of CeO2 nanomaterials in plnats revaled using hard X-ray nano- and microscopectroscopy, submitted*

Accepted

- Nathalie Bouet, Albert T. Macrander, Jörg Maser, Yong S. Chu, Juan Zhou, Evgeny Nazaretski, Hanfei Yan, Xiaojing Huang, and Ray Conley, "Large Aperture and Wedged Multilayer Laue Lense for X-ray Nanofocusing", Accepted in J. Nanoscience and Nanotechnology*
- E. Nazaretski, W. Xu, H. Yan, X. Huang, D. S. Coburn, M. Ge, W.-k. Lee, Y. Gao, W. Xu, M. Fuchs, and Y. S. Chu, Microscopy Instrumentation and Nano-Positioning at NSLS-II: Current Status and Future Directions, Synch. Rad. News, accepted*

Published

1. T. W. Victor, L. M. Easthon, M. Ge, K. H. O'toole, X. Huang, H. Yan, K. N. Allen, Y. S. Chu, L. M. Miller, "X-ray Fluorescence Nanotomography of Single Bacteria with a Sub-15 nm Beam", Sci. Reports, 8, 134115 (2018)*.
2. F. T. Ling, H. A. Hunter, J. P. Fitts, C. A. Peters, A. S. Acerbo, X. Huang, H. Yan, E. Nazaretski, and Y. S. Chu, "Nanospectroscopy Captures Nano-scale Compositional Zonation in Barite Solid Solutions", Sci. Rep., **8**, 13041 (2018)*
3. M Stuckelberger, T Nietzold, B West, T Walker, C Ossig, M Kahnt, F Wittwer, J Deng, J Maser, et al., Challenges and Opportunities with Highly Brilliant X-ray Sources for multi-Modal in-Situ and Operando Characterization of Solar Cells, *The 14th International Conference on X-ray Microscopy*, Vol 24 (S2), p. 434, sponsored by Canadian Light Source (2018).*
4. H Yan, X Huang, E Nazaretski, N Bouet, J Zhou, W Xu, P Ilinski, Y Chu, Imaging Capabilities, Performance and Applications of the Hard X-ray Nanoprobe Beamline at NSLS-II, *The 14th International Conference on X-ray Microscopy*, Vol 24 (S2), p. 194, sponsored by Canadian Light Source (2018).*
5. X Huang, H Ozturk, H Yan, Y He, M Ge, Z Dong, M Lin, E Nazaretski, P Ilinski, et al., High-Resolution and High-Throughput Ptychography with Depth Sensitivity Using Multilayer Laue Lenses, *The 14th International Conference on X-ray Microscopy*, Vol 24 (S2), p. 28-29, sponsored by Canadian Light Source (2018).*
6. H Feng, Y Qian, J Cochran, Q Zhu, C Heilbrun, L Li, W Hu, H Yan, X Huang, et al., Seasonal differences in trace element concentrations and distribution in Spartina alterniflora root tissue, *Chemosphere*, **204**, 359-370 (2018).*
7. W Hu, X Huang, H Yan, Dynamic Diffraction Artefacts in Bragg Coherent Diffractive Imaging, *J. Appl. Cryst.*, **51**, 167-174 (2018).
8. J Shi, D Xiao, M Ge, X Yu, Y Chu, X Huang, X Zhang, Y Yin, X Yang, et al., High-Capacity Cathode Material with High Voltage for Li-Ion Batteries, *Adv. Mats.*, **30**, 1705575 (2018).*

9. M Hill, I Cavalo-Almazan, M Allain, M Holt, A Ulvestad, J Treu, G Koblmuller, C Huang, X Huang, H Yan, Measuring three dimensional strain and structural defects in a single InGaAs nanowire using coherent x-ray multi-angle Bragg projection ptychography, *Nano Lett.*, **18**(2), 811-9 (2018).*
10. S Bajt, M Prasciolu, H Fleckenstein, M Damaracky, H Chapman, A Morgan, O Yefanov, M Messerschmidt, Y Du, et al., Achieving focusing with efficient high-NA multilayer Laue lenses, *Light: Science and Applications*, **7**, 17163 (2018).*
11. H Yan, N Bouet, J Zhou, X Huang, E Nazaretski, W Xu, A Cocco, W Chiu, K Brinkman, et al., Multimodal hard x-ray imaging with resolution approaching 10 nm for studies in material science, *Nano Futures*, **2**, 11001 (2018).*
12. H Ozturk, H Yan, Y He, M Ge, Z Dong, M Lin, E Nazaretski, I Robinson, Y Chu, X Huang, Multi-slice ptychography with large numerical aperture multilayer Laue lenses, **5**(5), 601-607 (2018).*
13. S. Cheng, W. Xu, K. Mueller, "ColorMapND: A Data-Driven Approach for Mapping Multivariate Data to Color," IEEE Trans. on Visualization and Computer Graphics (TVCG), 2018.*

2017

14. D Gursoy, Y Hong, K He, K Hujsak, S Chen, M Ge, L Miller, Y Chu, C Jacobsen, et al., Rapid Alignment of Nanotomography Data Using Joint Iterative Reconstruction and Reprojection, *Sci. Rep.*, **7**(1), 11818 (2017).*
15. H Feng, Y Qian, J Cochran, Q Zhu, W Hu, H Yan, L Li, X Huang, Y Chu, et al., Nanoscale Measurement of Trace Element Distributions in Spartina Alterniflora Root Tissue During Dormancy, *Sci. Rep.*, **7**, 40420 (2017).*
16. I Robinson, X Huang, X-ray Imaging: Reaching the Third Dimension, *Nat. Mater.*, **16**, 160–161 (2017).*
17. J Durham, A Brady, C Cama, D Bock, C Pelliccione, Q Zhang, M Ge, H Yan, X Huang, et al., Electrochemical (de)lithiation of Silver Ferrite and Composites: Mechanistic Insights From Ex Situ, In Situ, and Operando X-ray Techniques, *Phys. Chem. Chem. Phys.*, **19**, 22329-22343 (2017).*
18. X Huang, W Xu, E Nazaretski, N Bouet, J Zhou, Y Chu, H Yan, Hard X-ray Scanning Imaging Achieved with Bonded Multilayer Laue Lenses, *Opt. Express*, **25**(8), 8698-8704 (2017).*
19. H Yan, X Huang, N Bouet, J Zhou, E Nazaretski, Y Chu, Achieving diffraction-limited nanometer-scale X-ray point focus with two crossed multilayer Laue lenses: alignment challenges, *Opt. Express*, **25**(21), 25234-25242 (2017).*
20. H Öztürk, X Huang, H Yan, I Robinson, I Noyan, Y Chu, Performance Evaluation of Bragg Coherent Diffraction Imaging, *New J. Phys.*, **19**, 103001 (2017).
21. M Highland, S Hruszkewycz, D Fong, C Thompson, P Fuoss, I Calvo-Almazan, S Maddali, A Ulvestad, E Nazaretski, et al., In-situ Synchrotron X-ray Studies of the Microstructure and Stability of In2O3 Epitaxial Films , *Appl. Phys. Lett.*, **111**, 161602 (2017).*
22. X Huang, H Yan, M Ge, H Ozturk, E Nazaretski, I Robinson, Y Chu, Artifact Mitigation of Ptychography Integrated with on-the-fly Scanning Probe Microscopy, *Appl. Phys. Lett.*, **111**, 023103 (2017).*
23. E Nazaretski, H Yan, K Lauer, N Bouet, X Huang, W Xu, J Zhou, D Shu, Y Hwu, Y Chu, Design and Performance of an X-ray Scanning Microscope at the Hard X-ray Nanoprobe Beamline of NSLS-II, *J. Synch. Rad.*, **24**, 1113-1119 (2017).*
24. D Shu, Y Chu, High Precision Detector Robot Arm System, US Patent No. US 9,557,282 B1 (2017).
25. O Chubar, M Rakitin, Y Chen-Wiegart, Y Chu, A Fluerasu, D Hidas, L Wiegart, Main Functions, Recent Updates, and Applications of Synchrotron Radiation Workshop Code, *SPIE Optical Engineering + Applications*, Vol 10388, p. 1038805, sponsored by SPIE (2017).
26. L Li, H Yan, W Xu, D Yu, A Heroux, W Lee, S Campbell, Y Chu, PyXRF: Python-based X-ray fluorescence analysis package, *SPIE Optical Engineering + Application*, Vol 10389, sponsored by Sutter Instrument Corp. (2017).*
27. F Tsui, B Collins, Y Chu, X-ray Technique for Determining Chemical Disorders in Complex Alloys, *SPIE News room*, sponsored by SPIE (2017).
28. W Xu, N Schlossberger, W Xu, H Yan, X Huang, Y Chu, E Nazaretski, High resolution tip-tilt positioning system for a next generation MLL-based x-ray microscope, *Meas. Sci. Technol.*, 28, 127001 (2017).

29. G. Williams, O. Chubar, L. Berman, Y. S. Chu, and I. Robinson, Optical Design and Simulation of a new Coherence Beamline at NSLS-II, *Conference 10388: Advances in Computational Methods for X-Ray Optics IV*, p. 10388-14, sponsored by SPIE.Optics & Photonics (2017).

2016

30. M Lin, H Xin, Y Chu, H Yan, R Tappero, J Thieme, W Lee, J Smart, K Jones, V Titarenko, Towards a Portable Open-source Tomography Toolbox: Containerizing Tomography Software with Docker, *International Conference on X-ray Optics and Microanalysis (ICXOM23)*, sponsored by AIP (2016).
31. E Nazaretski, H Yan, K Lauer, X Huang, S Kalbfleisch, H Yan, L Li, N Bouet, J Zhou, et al., Nm-scale Spatial Resolution X-ray Imaging with MLL Nanofocusing Optics: Instrumentational Requirements and Challenges, *ICXOM23: International Conference on X-ray Optics and Microanalysis*, sponsored by DOE (2016).*
32. J Fitts, A Lanzirotti, A Acerbo, Y Chu, B Dazas, X Huang, E Nazaretski, G Rogers, R Tappero, et al., Salinity Effects on Arsenic Incorporation During Barite Precipitation Treatment of Idealized Shale Gas Wastewaters, *American Chemical Society National Meeting & Exposition*, Vol 252, sponsored by American Chemical Society (2016).*
33. A Lanzirotti, S Sutton, M Newville, J Fitts, E Head, High Energy Synchrotron X-ray Microspectroscopy for Geochemical Characterization of Terrestrial and Extraterrestrial Samples, *Geological Society of America Annual Meeting*, Vol 48, p. 35-2, sponsored by Geological Society of America (2016).*
34. R Conley, N Bouet, Y Chu, X Huang, H Kang, A Macrander, J Maser, E Nazaretski, G Stephenson, H Yan, Multilayer Laue Lens: A Brief History and Current Status, *Synch. Rad. News*, **29**(4), 16 (2016).*
35. E Nazaretski, W Xu, N Bouet, J Zhou, H Yan, X Huang, Y Chu, Development and Characterization of Monolithic Multilayer Laue Lens Nanofocusing Optics, *Appl. Phys. Lett.*, **108**, 261102 (2016).*
36. Z Zhang, Q Zhang, J Shi, Y Chu, X Yu, K Xu, M Ge, H Yan, W Li, et al., A Self-Forming Composite Electrolyte for Solid-State Sodium Battery with Ultralong Cycle Life, *Adv. Energy Mater.*, **7**(4), 1601196 (2016).*
37. J Weker, X Huang, M Toney, In Situ X-ray-based Imaging of Nano Materials, **12**, 14-21 (2016).
38. E Nazaretski, W Xu, N Bouet, J Zhou, H Yan, X Huang, Y Chu, Development and Characterization of Monolithic Multilayer Laue Lens Nanofocusing Optics, *Appl. Phys. Lett.*, **108**, 261102 (2016).*
39. H Yan, E Nazaretski, K Lauer, X Huang, U Wagner, C Rau, M Yusuf, I Robinson, S Kalbfleisch, et al., Multimodality Hard-x-ray Imaging of a Chromosome with Nanoscale Spatial Resolution, *Sci. Rep.*, **6**, 20112 (2016).
40. Flynn, G. J, Keller, L. P., Wirkick, S., Hu, W., Li, L., Huang, X., Nazaretski, E., Lauer, L. and Chu, Y. S. "High-Nickel Iron-Sulfides in Anhydrous, GEMS-Rich CP IDPs", Metrortics & Planetary Science, Volume: 51, Pages: A258-A258, Supplement:1, Special Issue SI, Published: Aug. 2016.*
41. Meifeng Lin, Huolin Xin, Yong Chu, Hanfei Yan, Ryan Tappero, Juergen Thieme, Wah-Keat Lee, David Biersach, James Smart, Keith Jones, and Valeriy Titarenko, "Towards a portable open-source tomography toolboxk: Containinerizing tomography software with docker. AIP Conference Proceedings, 1764, 030008 (2016)
42. Lee, Wah-Keat, Reininger, Ruben, Loo, William, Gambella, Richard, O'Hara, Steven, Chu, Y. S., Zhong, Zhong, Wang, Jun, "FXI: a full-field imaging beamline at NSLS-II", Proceedings of SPIE, Volume 9592, Article Number UNSP 959209, 2016.
43. Oleg Chubar, Yong S. Chu, Xiaojing Huang, Sebastian Kalbfleisch, Hanfei Yan, Timur Shaftan, Guimei Wang, Yong Q. Cai, Alexey Suvorov, Andrei Fluerasu, Lutz Wiegart, Yu-chen Karen Chen-Wiegart, Juergen Thieme, Garth Williams, Mourad Idir, Toshiya Tanabe, Paul Zschack and Qun Shen, "Initial Performances of First Undulator-Based Hard X-Ray Beamlines of NSLS-II Compared to Simulations", AIP Conf. Proc., 1741, 040002 (2016)*

2015

44. X. Huang, K. Lauer, J. Clark, W. Xu, E. Evgeny, R. Harder, I. Robinson, Y. Chu, Fly-scan Ptychography, *Sci. Rep.*, **5**, 9074 (2015).

45. X. Huang, W. Yang, R. Harder, Y. Sun, M. Lu, Y. Chu, I. Robinson, H. Mao, Deformation Twinning of a Silver Nanocrystal under High Pressure, *Nano Lett.*, **15**(11), 7644-7649 (2015).
46. W. Xu, K. Lauer, H. Yan, V. Milanovic, M. Lu, E. Nazaretski, Performance and Characterization of a MEMS-based Device for Alignment and Manipulation of X-ray Nanofocusing Optics, *AIP Adv.*, **5**, 037137 (2015).
47. N Burdet, X Shi, D Park, J Clark, X Huang, S Kevan, I Robinson, Evaluation of partial coherence correction in X-ray ptychography, *Opt. Express*, **23**(5), 5452-5467 (2015).
48. X Huang, R Conley, N Bouet, J Zhou, A Macrander, J Maser, H Yan, E Nazaretski, K Lauer, et sl., Achieving Hard X-ray Nanofocusing Using a Wedged Multilayer Laue Lens, *Opt. Express*, **23**(10), 12496-12507 (2015).*
49. B Collins, Y Chu, L He, D Haskel, F Tsui, Structural and Chemical Ordering of Heusler Co_xMn_yGe_z Epitaxial Films on Ge (111): Quantitative Study Using Traditional and Anomalous X-ray Diffraction Techniques, *Phys. Rev. B: Condens. Matter*, **92**, 224108 (2015).
50. E Nazaretski, K Lauer, H Yan, N Bouet, J Zhou, R Conley, X Huang, W Xu, M Lu, et al., Pushing the Limits: An Instrument for Hard X-ray Imaging Below 20 nm, *J. Synch. Rad.*, **22**(2), 336-341 (2015).
51. C Zhu, R Harder, A Diaz, V Komanicky, A Barbour, R Xu, X Huang, Y Liu, M Pierce, et al., Ptychographic X-ray Imaging of Surfaces on Crystal Truncation Rod, *Appl. Phys. Lett.*, **106**(10), 101604 (2015).
52. J Kim, N Habekorn, E Nazaretski, R da Paula, T Tan, X Xi, T Tajima, R Movshovich, L Civale, Strong Magnetic Field Dependence of Critical Current Densities and Vortex Activation Energies in Ananisotropic Clean MgB2 Thin Film, *Solid State Commun.*, **204**, 56-60 (2015).
53. Y Chu, H Yan, E Nazaretski, S Kalbfleisch, X Huang, K Lauer, N Bouet, Hard x-ray nanoprobe Facility at the National Synchrotron Light Source II, SPIE prepared for SPIE (2015).*
54. J Clark, M Trigo, T Henighan, R Harder, B Abbey, T Katayama, M Kozina, E Dufresne, H Wen, et al., Lensless Imaging of Nano- and Meso-Scale Dynamics with X-rays, *Microscopy and Microanalysis*, Vol 21, p. 1081, sponsored by Microscopy Society of America (2015).
55. H Ozturk, H Yan, J Hill, Correlating Sampling and Intensity Statistics in Nanoparticle Diffraction Experiments, *J. Appl. Cryst.*, **48**(4), 1212-1227 (2015).

***** Papers published using the x-rays produced at the HXN Beamline.