6-BM Management Plan

COMPRES

BNL Photon Sciences

Advanced Photon Source

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6-BM Beamline Management Plan

Executive Summary

This document describes the management plan for the installation of equipment and operations of the 6-BM beamline at the APS. It covers the transfer of COMPRES energy-dispersive multianvil large-volume press operations and energy dispersive diffraction (managed jointly by BNL Photon Sciences and APS) and contains the details on the beamline layout, proposed science programs, organization, information on sources of funding/support, and the user access model for the 6-BM beamline. A separate document describes the Safety Plan for 6-BM

1 Introduction and Scientific Scope

COMPRES Program

COMPRES-supported beam lines X17B2, X17B3, and X17C at the National Synchrotron Light Source have a large, active, and very productive user communities. These hard X-ray beam lines support high-pressure experimentation using large-volume multianvil presses (LVP's) and diamond-anvil cells (DAC's), providing crucial tools for Earth science research, as well as related research in materials sciences, condensed matter physics, chemistry, and planetary science. The dark period between the closing of the NSLS and the opening of NSLS-II will leave the NSLS high-pressure user groups stranded, without the necessary specialized facilities to carry out experiments. The impact on individual funded research programs, and a large number of students who depend on these facilities for carrying out their graduate research, will be severe. Synchrotron facilities with similar experimental capabilities, such as GSECARS at the APS, are already heavily oversubscribed and will not be able to accommodate the current users from COMPRES-supported beam lines at NSLS (which themselves are already heavily oversubscribed). This proposal outlines a plan to manage the NSLS dark period by utilizing a white-beam bending magnet beamline at the APS for a large-volume press, aimed at deformation, rheology, elasticity, and thermal diffusivity studies of solids at high pressures and temperatures. The effort will be led by Donald J Weidner of Stony Brook University. Through a partnership between COMPRES, Stony Brook University, and APS we see this as not only an opportunity to accommodate the current user base from X17B2, but a chance to define the state of the art in a field with growing user demand and vast potential for new and exciting science.

Energy Dispersive Diffraction (BNL- PS) Program

X17B1 is a unique national resource for EDXRD, one of a couple worldwide, optimized for in situ and operando studies of engineered materials. White beam x-rays provide the combination of penetrating power, measurement speed and spatial resolution, especially for bulk objects such as batteries and other engineered materials. Because the incident x-ray beam consists of a spectrum of photon energies, an energy dispersive detector can collect diffraction data at a fixed angle - the intersection of incident and diffracted beam slit effectively defining the spatial resolution (gauge volume). The set up at X17B1 was designed and built by Zhong (BNL), Croft, and Tsakalakos (Rutgers) about fifteen years ago for strain-mapping. Despite not having been designed for battery research, the user interest following upgrade of the facility over the past two years by the BNL-GE-Stony Brook team for this purpose has been very positive. The majority of work performed at X17B1 is now academic and industrial work on batteries.

The effort at 6-BM-A will be led by BNL's Photon Sciences (PS). Through a partnership between APS and PS, and possibly the Argonne battery hub, we see an opportunity to increase throughput significantly (a necessary condition given the ~4 X decrease in flux estimated at 6-BM compare to X17B - see Figure with spectral flux). Opening the program at 6-BM-A is not only an opportunity to accommodate the current user base from X17B1, but is also a chance to define the state of the art in a field with growing user demand and vast potential for new and exciting science and engineering.

COMPRES Science Program

Our understanding of the makeup and evolution of the Earth is strongly tied to our understanding of the materials that comprise the Earth. Pressure and temperature set the environment where these minerals and melts are found, and it is the goal of high-pressure experimental studies to probe and characterize Earth material systems. A 2008 workshop on seismological research frontiers (Seismological Grand Challenges in Understanding Earth's Dynamic Systems, 2009), funded by the National Science Foundation (NSF), considered promising research directions for the next decades and identified 10 Seismological Grand Challenge research questions including: *How do faults slip?; How does the near-surface environment affect natural hazards and resources?; What is the relationship between stress and strain in the lithosphere?; Where are water and hydrocarbons hidden beneath the surface?; How do magmas ascend and erupt?; What is the lithosphere-asthenosphere boundary?; How do plate boundary systems evolve?; How do temperature and composition variations control mantle and core convection?; and How are Earth's internal boundaries affected by dynamics?* While these questions drive the agenda of the next decade seismology research, they are also central to the research program of the multi-anvil high-pressure beamline at NSLS.

Elasticity

The most robust fingerprint of the chemical and thermal state of the Earth's interior are the elastic properties of Earth materials. Radial variations in seismic velocity point to phase transitions, melting, and general pressure increase. These transitions require a comprehensive understanding of the elastic properties of materials as a function of all of the relevant variables. The last few years has seen tremendous growth in our data base as well as our experimental tools for defining this information.

The interpretation of seismological profiles of Earth's interior has long been the principal motivation for measuring the acoustic velocities and the elastic tensors of minerals, both at ambient and high P or T conditions. As the resolution of seismological studies continues to improve, the need for more and better elasticity data, under simultaneous high pressures and high temperatures, increases.

Two specific scientific challenges that can be highlighted include: the interpretation of seismic anisotropy throughout the planet, from uppermost mantle to inner core conditions; and understanding lateral variations of compressional and shear wave velocities (∂V_p and ∂V_s) in terms of composition and/or temperature variations. These goals require the mineral physics community to provide complete characterization of elastic anisotropy, as well as aggregate acoustic velocities, in minerals, and also the variation of these properties with pressure, temperature, and composition.

Simultaneous ultrasonics + XRD investigations in the multi-anvil press permit the EoS and acoustic properties of minerals to be evaluated under high-P,T conditions. The multi-anvil beamline at the NSLS has been the pioneer of such measurements and continues to develop a wider array of possible samples for such high P-T experiments.. In principle this technique can be extended to 25 GPa and 2000K and we plan to reach this capability in the next 5 years. This program will continue at the APS bending magnet.

Rheology

The quantitative relationship between stress, strain, and time in minerals forms the basis for our view of the evolving Earth. Plate tectonics, earthquakes, volcanic eruptions all respond to these intrinsic properties of Earth materials. Thermal convection in Earth's deep interior cools the planet and in the process generates earthquakes and volcanoes, moves tectonic plates, and disturbs the uniform chemical layering of a differentiated Earth. Laboratory measurements of the relationship between deviatoric stress and deviatoric strain rate of rocks and minerals at high pressure are driven by the need to understand this circulation at depth. Current research on global geodynamics strongly suggests that the dynamics and evolution of this planet are controlled largely by materials properties under deep Earth conditions, including rheological properties, phase relationships, elastic properties and chemical properties such as the diffusivity and solubility of certain elements. For instance, the lateral and radial variation of viscosity have an important influence on the convection pattern and generation of deep earthquakes, whereas the solubility and diffusivity of elements in various phases control the chemical evolution associated with mantle convection. Also, the way in which materials are distributed or the flow pattern in Earth can, in principle, be inferred from seismological observations, but the interpretation of seismological data relies entirely on our understanding of elastic and anelastic properties of minerals under deep Earth conditions. Laboratory studies have recently made a significant breakthrough in capability for defining these properties at mantle pressures and temperatures using x-rays generated by synchrotrons at national laboratories. This progress has set the stage for new and exciting research efforts.

The rheology experiments associated with the NSLS beamline have set an entirely new range of conditions for these measurements. We can now conduct experiments uniaxial stress deformation experiments at 10 GPa and 2000K with near the precision of experiments at 0.3 GPa a decade ago. Through these developments, not only can we infer pressure dependence of mineral properties, but we can examine the properties of high-pressure mineral phases that were impossible before. The technical developments have enabled studies on the relevant properties of minerals.

The new pressure cells and measurement tools also allow a wide array of new characterizations that are still being explored including measurements of phase transition kinetics through stress oscillations with frequencies in the seismic zones, Q measurements at high P and T, thermal diffusivity at high P and T.. New science will emerge as these tools are used to study polycrystalline samples, partially molten samples, and single crystal samples. This next five years promises to be a time of great discoveries, taking the tools we have on hand and pushing our understanding of relevant materials.

Energy Dispersive Diffraction Science Program

Quantifying phase evolution and the measurement of stress-strain relationships using x-ray diffraction are critical in testing engineered systems, such as electrical storage devices. Heterogeneous system characterization has been a theme of the program at X17B1 where studies concentrate on characterization of:

1) Phase and/or chemical changes: The simplest application of EDXRD diffraction is in the rapid identification of component crystalline phases, such as phase mapping;

2) Science of the deformation of materials;

3) Rapid, high-resolution x-ray physical imaging methods.

Measurements on real devices as they operate (*operando* studies) are critical to understanding function and failure mechanisms, and to validate models that will ultimately be used to translate from short term (hours) to long-term (years) wear/failure tests. Rather than relying only on snap-shots of materials recovered from experimental runs, continuous monitoring of the processes occurring at varying conditions of stress and chemical gradients, in real time, is becoming standard operating procedure. This rationale justifies the EDXRD work carried out at NSLS X17B1 and justifies the successful beamline proposal, HEX, for NSLS-II. While the highest profile work is carried out on the GE Metal halide (Durathon®) battery, the upgraded capabilities at X17B1 that makes these experiments more productive now benefit a large community, and this community has responded by submitted competitive general user proposal that led to over-subscription. For example the upgrade to the data collection and visualization has greatly increased throughput. Upgrades to real time processing and visualization of EDXRD data provides 3-D images of the distribution of phases, and this is especially appealing to battery researchers who can correlate charge cycle, distance from current collector etc with real time changes in chemistry. These upgraded capabilities were made possible by support from New York State through its NY-BEST initiative, and the leadership of GE Global Research; we believe further modest capital investments, along with transfer of equipment, software and expertise from PS to APS will allow the next leap in capability.

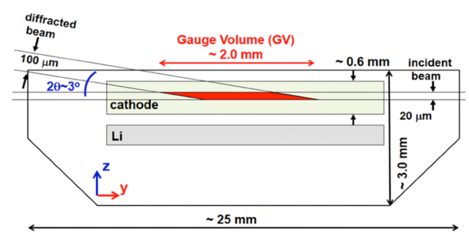


Fig. 1.1 Cell configuration in beam environment showing gauge volume of the measurement. of a typical coin cell.

Operando studies of batteries

As advanced battery technologies progress towards large-scale application, an in-depth fundamental understanding of their chemical processes, degradation pathways, and failure modes in *full-scale* cells is required. Despite tremendous technical progress over decades of research and development in battery technologies, too little is known about the evolution of microstructure (especially in the cathodes), mechanisms of charge transport, nature of the phase changes that take place during electrochemical cycling, and details of degradation and failure modes. These limitations are frequently the result of the traditional inaccessibility of the batteries' active components during cycling. Elucidating and quantifying the chemical processes that occur in full-size cells under operating conditions is key to enhanced power and energy densities, longer life, and greater safety. In-situ characterization of the cathode, separator, electrolyte, and anode materials as a function of time, state of charge, stress, temperature, etc. is now possible at X17B1.

For example GE Global Research and Brookhaven National Laboratory have a highly successful ongoing effort to study GE's sodium metal halide battery technology at X17B1. In the past two years GE-BNL-Stony Brook have partnered with New York State to equip X17B1 specifically for studying dynamic processes inside commercial battery cells. These capabilities have included hardware and software upgrades that are accessible to the broader energy storage and materials science communities. Data collection rates (i.e., time resolution and productivity) have improved.

Continued improvements of battery technology, especially that of sodium metal halide, is contingent upon a more complete understanding of the critical materials that make up the battery. In the case of the GE Durathon® sodium metal halide cell these are (see Figure of experimental set-up in section 3 "Beamline Requirements") the sodium anode, ceramic solid electrolyte, liquid electrolyte, and nickel/sodium chloride cathode. X-ray diffraction (XRD) is a powerful tool for investigating atomic structures and is most advantageous when it can be performed under the actual conditions of operation. In this way, structural changes can be directly correlated to performance. Pioneered to a large extent at BNL in the 1990's, such in-situ experiments have proven useful for the understanding of intercalation processes in lithium technologies as well, and there is increasing interest in performing operando studies on a number of commercial storage systems.

Stress-strain measurements

An EDX spectrum can be analyzed for the lattice parameters of that structure. The stability of the fixed angle scattering (with no x-ray optics motion) allows one to determine relative shifts in the lattice parameter of the structure to a relative fractional precision of better than 0.5×10^{-4}. Thus by performing EDXRD measurements on a sample that is translated in the x- y-z directions one can perform 1-D profiles, 2-D maps, or 3-D tomographs of the variation of the lattice parameter within a specimen due to internal strain fields. Such strain field mapping measurements can be used to address a host of fundamental problems in mechanics and materials science. Strain field profiles approaching surfaces or buried interfaces with resolutions approaching the 1 μm level will be possible.

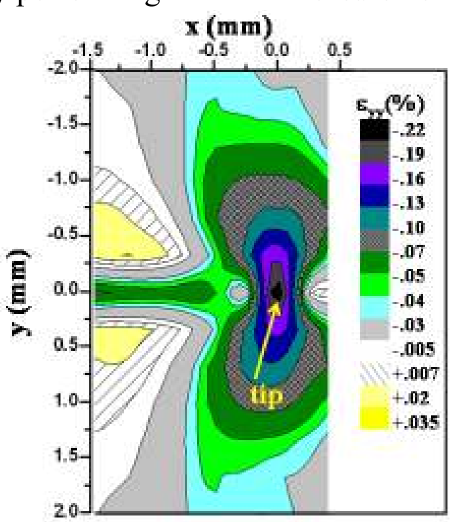


Fig. 1.2 A high spatial resolution contour plot of the ε_{yy} strain component near the crack tip of a fatigued steel specimen. These data were taken at X17B1 at NSLS.

A good example of such experimental driven advances is in the fatigue crack growth problem. Here the stress/strain fields in the vicinity of the crack tip, and the plasticity thereby produced, govern the crack propagation rate. Many years of prodigious modeling efforts in this field have been carried forth virtually without any experimental probe that could directly measure, with sufficient resolution, in the interior of a specimen, the crack tip strain fields upon which the models are based. Quantification and model based descriptions of fatigue crack growth have most certainly had empirical successes, but it has been through the resourceful exploitation of strain/stress measurements remote from the crack tip, along with other indirect and macroscopic measurements. As an illustrative snapshot of the new type of high spatial resolution synchrotron data now influencing the fatigue crack field see the figure above. The figure shows a map of the load-direction strain field component in the vicinity of a fatigue crack tip (in a steel specimen) subjected to a 100 % overload cycle.

Future applications of the EDXRD technique would involve stress/strain mapping produced by strongly nonlinear stress concentrations. Such concentrations could result from inhomogeneities (like cracks or inclusions) or required component geometrical effects. The study of fatigue crack nucleation, and growth and their interaction with the environment, for example under salt water solution, or other corrosive environments would be a natural component to the research. In all cases both the residual (zero load) and the in situ load induced strain fields would be measured. Stress corrosion cracking would be an important example of real world engineering stress/environment interactions. Of course elevated temperature environments would be part of the studies also.

Many classic and advanced materials are in fact either inhomogeneous mixtures of components or homogeneously organized mixed components. The relative strain response of the separate components in both of these cases could be monitored independently. Classic examples of inhomogeneous mixed materials are of course the two α and β phases in the aerospace Ti alloys, the competing phases in steels and the Al- matrix/precipitates in advance aluminum alloys. Ceramic coatings on metals, mixed fiberous and homogeneous materials would be examples of intentionally constructed inhomogeneities whose stress dependent response could be studied..

2 Organizational Structure for 6-BM Operations

Figure 2.1 shows the proposed organizational structure for the operations of the 6-BM- beamline. Below are the roles and responsibilities of the staff associated with 6-BM.

Roles and Responsibilities

XSD Associate Division Director – Jonathan Lang (XSD/APS)

The XSD Associate Division Director will be the APS point of contact for this beamline, coordinate activities of the APS and COMPRES/BNL-PS programs, and provide oversight for the XSD Beamline Scientist (who is directly supervised by the XSD Materials Physics and Engineering Group Leader). The XSD Associate Division Director will work closely with the 6-BM Directors to ensure safe and efficient operations of the beamline.

6-BM-A BNL-PS EDD Director – Ron Pindak (BNL- PS)

The 6-BM-A BNL-PS EDD Director serves as the point of contact for the BNL activities at the beamline. He will coordinate activities of the BNL-PS programs at 6-BM-A and supervise the BNL-PS Beamline Scientist.

6-BM-B COMPRES EDD Director – Donald J. Weidner (SUNY Stony Brook)

The COMPRES EDD Director serves as the point of contact for the COMPRES LVP activities at the beamline, will coordinate activities of the COMPRES LVP programs, provide scientific leadership for scientific and technical activities at 6-BM-B and will directly supervise the COMPRES Lead Scientist.

XSD-MPE Group Leader - Jonathan Almer (XSD/APS)

The XSD Materials Physics and Engineering (MPE) group leader will supervise the XSD-MPE beamline scientist and help coordinate the EDD experiments in the 6-BM-A station. He will work with both the XSD and BL-PS staff for installation and upgrades of energy dispersive diffraction instrumentation in the 6-BM-A station.

BNL-PS Beamline Scientist(s) - Zhong Zhong and Jianming Bai (BNL-PS)

The BNL-PS Beamline Scientist(s) will provide scientific and technical support for the energy dispersive activities at 6-BM-A during NSLS user beamtime. The BNL-PS Beamline Scientist(s) will be a BNL-PS employee(s).

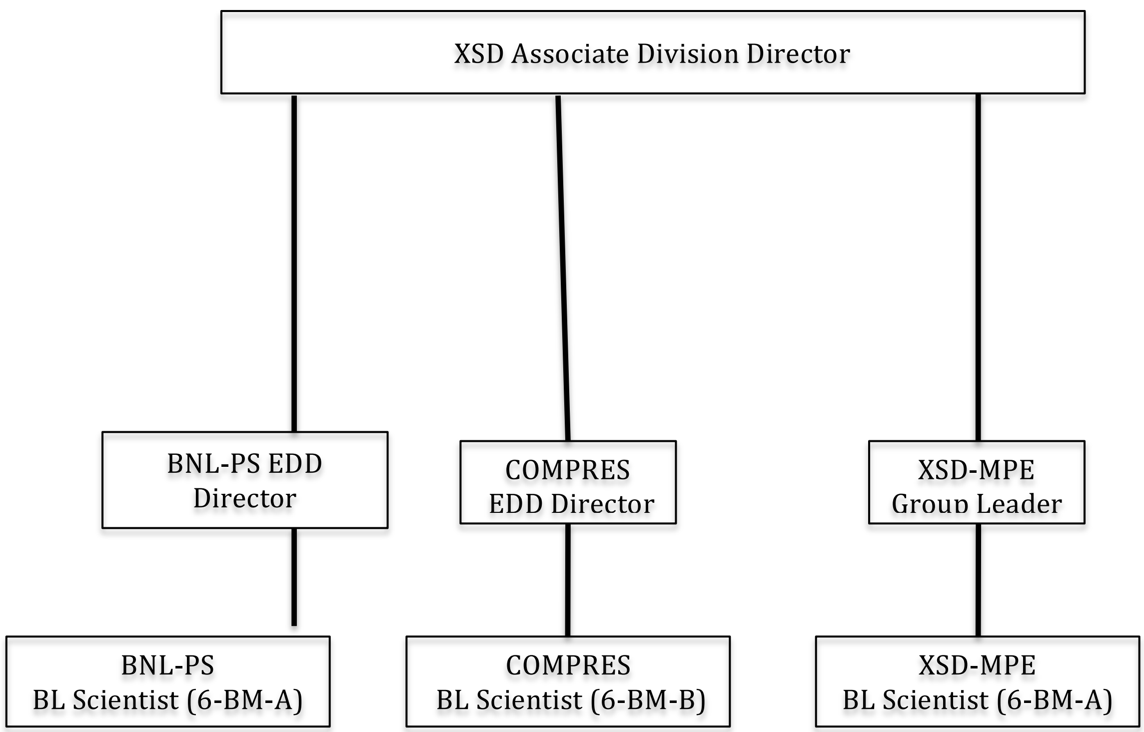


Figure 2.1 - Org Chart for 6-BM

COMPRES Beamline Scientist – Haiyan Chen *(Stony Brook, COMPRES)*

The COMPRES 6-BM-B Lead Scientist, reporting to the COMPRES EDD Director, will provide onsite day-to-day operational guidance for all scientific and technical activities on 6-BM-B. This person will be a COMPRES employee.

XSD Beamline Scientist – John Okasinski (XSD/APS)

The XSD Beamline Scientist will provide scientific and technical support for the energy dispersive activities at 6-BM-A for APS General Users. This staff will work closely with the BNL-PS Beamline Scientist to provide seamless support for the energy dispersive program. This person will be an APS employee.

3 Beamline Requirements

COMPRES Program

The intensity (intensity through a pin hole for an unfocused beam) and brightness (for a focused beam) of the APS bending magnet delivers approximately half of the total X-rays to the sample of the current wiggler at X-17 of the NSLS over the entire energy band of interest (20 kev – 100 kev). We feel that this is adequate for these experiments.

A new high-pressure deformation apparatus, called the Deformation DIA (D-DIA), made its first appearance on a synchrotron beamline at X17 of the NSLS in 2002. Over the years, its use has matured and it has achieved success beyond the initial hope. The system proposed for the APS will have a footprint of about 1.5x2 (along the beam) meters with access space for scientist set up.

Towards this beamline, the APS has committed to provide the following hardware:

White beam compatible stations with operating PSS
White beam mask
White beam slits (from 5 mm to 1 mm wide)
White beam shutter
White beam stop
Various Be windows and spool pieces
Network connections

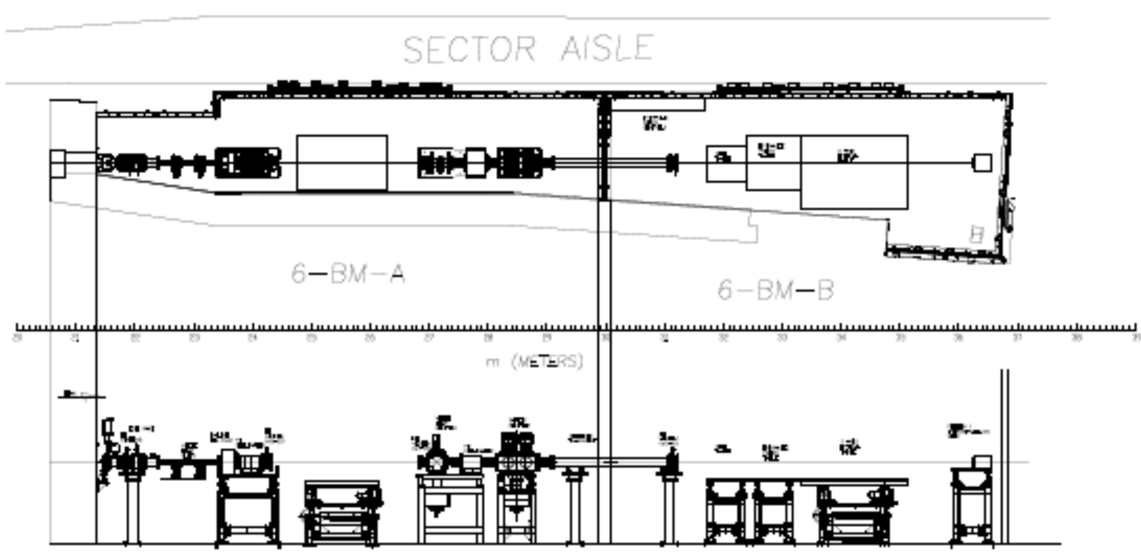


Fig. 3.1 6-BM layout showing APS-provided hardware

Space
APS will provide office space for the COMPRES beamline scientist and laboratory space for sample preparation of high-pressure sample assemblies for the LVP experiments.

Stony Brook University will provide the following instrumentation for high pressure studies in 6-BM-B:

DDIA high pressure system complete with hydraulic jacks and pumps (DDIA module on loan from UC Riverside).
Multi-element solid state energy dispersive detector, complete with electronics
Conical slit assembly
Prosilica camera, lenses, fluorescence screen, mounting system for sample imaging
Stages and motors for positioning all systems (about 10 stages, 30 motors)
VME crate and electronics for driving motors
Keithley box for data reading
4 Windows based computers with EPICS based software and 1 Unix computer.

Energy Dispersive Diffraction Program
The spectral flux is illustrated in the Figure 3.2. When distance to the source is taken into account the APS bending magnet delivers approximately four time fewer photons to the sample compared to the set-up at X17B1, including in the critical energies > 100 keV (these energies are particularly important for in-situ studies of commercial batteries such as GE's stainless steel clad halide Durathon® cells during electrochemical cycling).

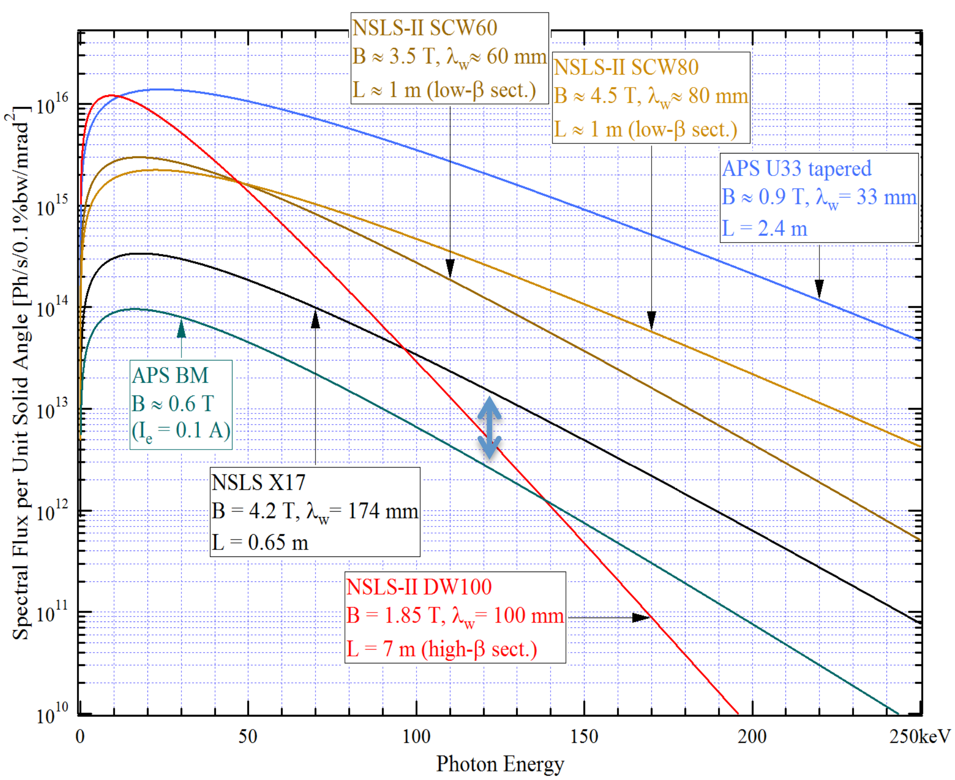


Fig 3.2 Flux comparison of various sources at high energies

Upgrading capabilities at APS

Many of the experiments carried out now at X17B1 will work quite well with a single element detector - the set up that can be transferred to APS. However, the X17B1 near real time visualization experiments are on the very edge of feasibility at NSLS. The GE Durathon® cells are by far the most demanding in terms of flux - the payoff however feeds immediately into improvements in battery technology. In order to use real GE Durathon® cells, which are ~5 cm on edge and encased in stainless steel, x-ray with E > 90 keV are needed. A move to APS 6-BM will retain operando capability and to compensate for the loss of intensity we propose installation, commissioning and operation of a multi-element detector (MED – shown below). This MED detector will be implemented at 6-BM through collaboration with the APS detector group. The EDXRD hardware, software, user base and staff expertise at X17B1 at NSLS is unique in the US-DOE complex. The NSLS application of EDXRD to engineered systems and the joint work and goodwill built up between industry (particularly GE) BNL and academic institutions at X17B1 is probably unique worldwide.

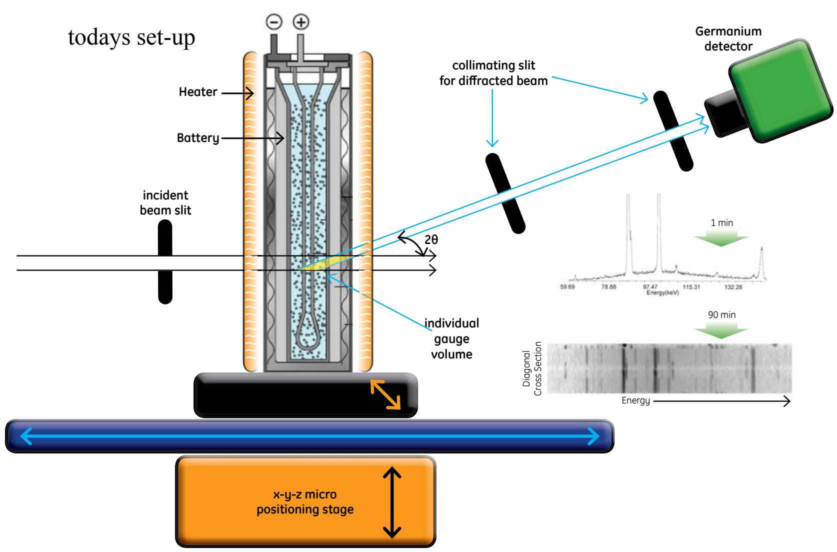


Fig. 3.3 Schematic showing the current energy-dispersive x-ray diffraction setup at NSLS beamline X17B1 at BNL. The incident high energy white beam (left) readily penetrates the 35-50 mm thick Durathon® cell. The diffracted beam (right) is collimated by slits and measured by the energy dispersive germanium detector. The cell is moved by an *x-y-z* stage to address different volumes. A single pattern is collected in 1 minute and a 90-pattern diagonal line scan takes nearly 2 hours. The detector addresses a single gauge volume, which is defined by the 2θ angle and the slit dimensions.

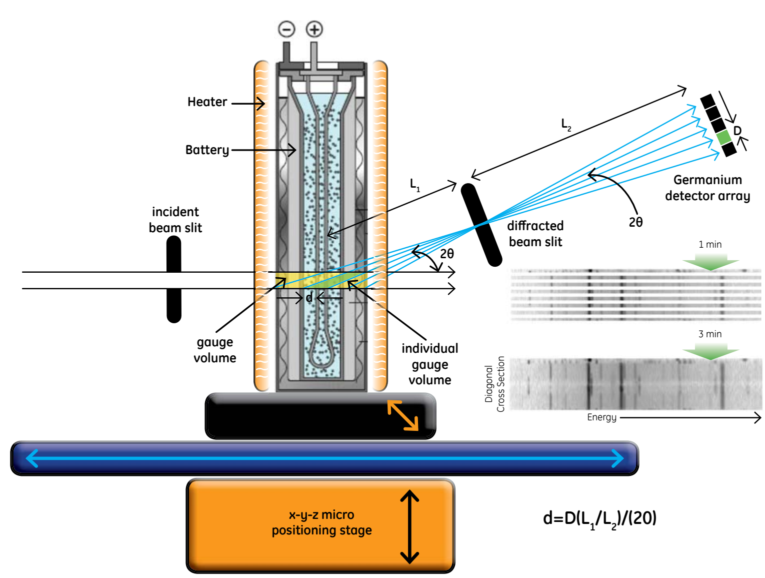


Fig. 3.4 Schematic showing the proposed new system for 6-BM-A. The 64-element Ge detector array al- lows each detector element to measure diffraction signal from a unique gauge volume along the incident beam path (cf. green detector and gauge volume). Diffraction patterns from across the entire cell width are measured simultaneously. The same 0.5mm resolution as the current setup is achieved with a 7-fold to 20-fold increase in throughput (depending on energy) compared to what is possible at X17B1.

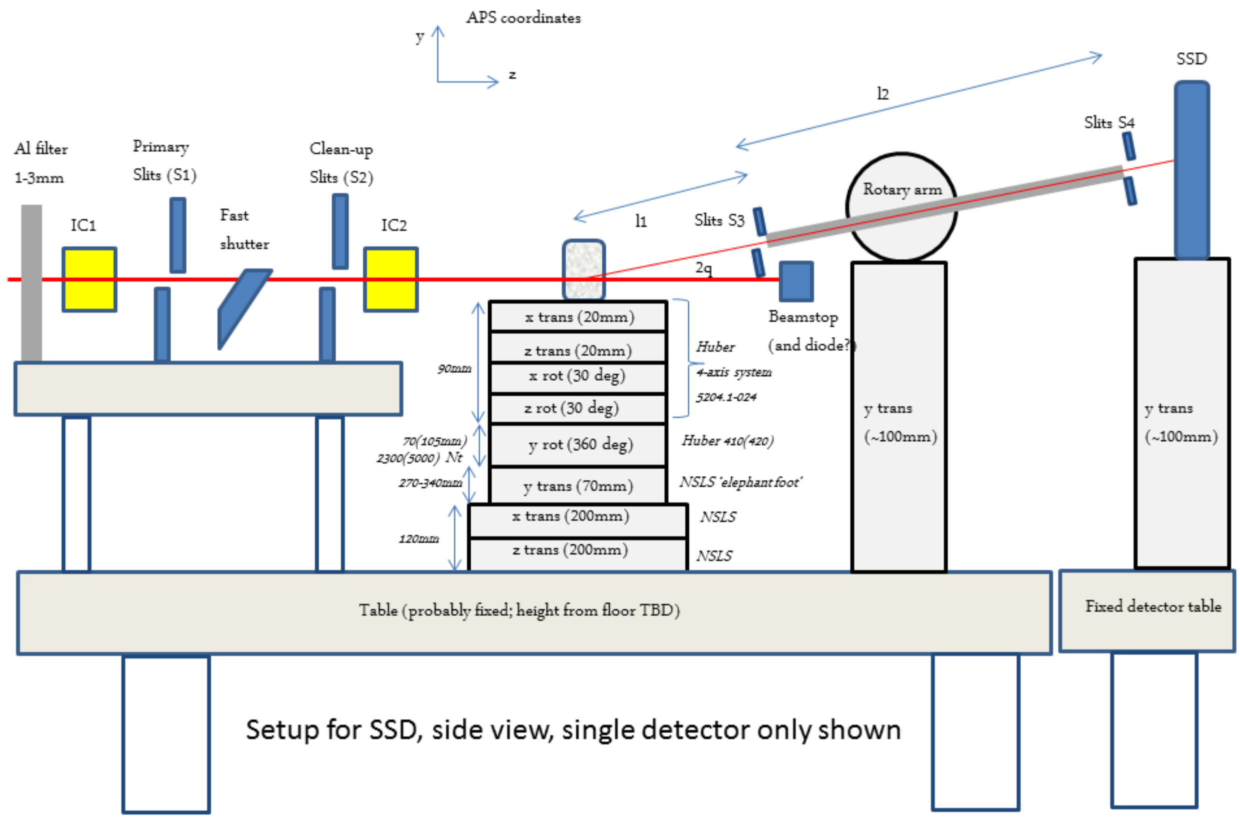
Relative to the set-up at X17B1 right now, a 7-fold to 20-fold increase in throughput (depending on energy) can be achieved, without sacrificing spatial resolution, by installing a custom-built multi-element detector (MED) array shown above. The MED that will be installed on 6-BM-A has 64 elements with a 0.5mm pitch. Utilizing the MED, diffraction data acquisition and analysis will be vastly improved to achieve near-real-time visualization and analysis of the data, even with the lower flux beam at 6-BM. A second MED is being constructed for the APS that has 384 elements with a 0.125mm pitch. When not in-use the second detector may also be made available to 6-BM-A users.

BNL-PS along with Stony Brook and Rutgers will provide the following beamline items for 6-BM-A EDD program:

Incident-beam slits (slit1, 10 mm W and slit2, 2 mm W)
Two ion chambers
Detector slits, slit3 and slit4, all 10 mm W
2 Ge detectors
4-channel XIA MCA and associated National Instrument Crate and interface card
NIM Bin with spectroscopy amplifier and 4-channel SCA, 4-channel V-F
Keithley 428 current amplifier
X-Z stage, 200 mm travel each
Z-stage, 150 mm travel
NSLS elephant foot to be used as heavy-duty Z-stage
Step-pack stepper motor driver, 16 channels
Arbin battery charger and control computer
Axis web-cam
Laser alignment system
Rotary fast shutter, 10 ms, and controller
Oscilloscope
Single-axis goniometer

The concepts for the proposed BNL-PS multiple element detector MED are mature but two further developments are needed for high-energy spectroscopy use: PCBs need to be designed and constructed to implement spectroscopy on all channels and to provide variable gain current amplifiers for all channels. It is anticipated that these required PCBs will be completed and installed by summer 2015 and the MED operations mode will take over from single detector mode (which will be kept as back-up).

The overall 6-BM-A component lay-out, with a combination of X17B1 and APS hardware, is shown on the following page.



Setup for SSD, side view, single detector only shown

4 Funding

6-BM Beamline Components
APS has agreed to provide the beamline hardware, PSS system, and network connections mentioned in Section 3 and effort costs associated with the installation of those components. APS will cover the effort and M&S costs for the XSD Beamline Scientist.

6-BM-A Instruments
The instrumentation for this station (see Section 3 - Instrumentation for EDD studies) will be provided by BNL-PS and by Stony Brook and Rutgers University with the coordinating oversight of BNL-PS. APS will provide additional instrumentation (table, slits, etc.) as necessary. Enhancements in instrumentation will be considered, in consultation between ANL and BNL-PS, particularly to ensure compatibility between imported instrumentation and APS controls. BNL will cover the effort, travel, and M&S costs for the BNL-PS Beamline Scientist(s).

6- BM-B Instruments
Instruments for this station (see Section 3 - Instrumentation for high pressure studies) will be provided by Stony Brook University with the oversight of COMPRES. COMPRES will cover the effort and M&S costs for the COMPRES Beamline Scientist.

5 Safety

COMPRES, BNL-PS, and APS are committed to ensuring that all beamline activities are conducted in a safe and environmentally sound manner. All activities at Argonne National Laboratory will conform to the requirements in the ANL Laboratory Management System (LMS) and the APS User Safety Policies and Procedures. (Information contained in ANL LMS and the APS document can be obtained by contacting Paul Rossi, XSD ES&H Coordinator.) A detailed Safety Plan for 6-BM can be found in a separate document titled 6-BM Safety Plan.

6 Operations and User Access Plan

Operations and User Program
At present we are envisioning two FTE staff to support the beamline, one FTE funded through COMPRES to support high-pressure studies, approximately 0.5 FTE funded though BNL-PS, and approximately 0.5 FTE funded though the APS X-ray Science Division to support energy dispersive diffraction. Although this is minimal support for a beamline, we will attempt to run the beamline for 100% of the scheduled user time. Based on an agreement between COMPRES, BNL-PS and APS, the allocation of beamtime will be shared as described in the table below.

Table 6.1 – Beamtime Allocation

Usage	Beamtime (percentage)	BL Scientist Responsible (percentage)
General Users	35	COMPRES (33%) & XSD (66%)
High-Pressure Earth Science Users, including Transitioned NSLS COMPRES users	38	COMPRES (100%)
Transitioned NSLS Engineering/Battery users	17	BNL-PS (100%)
XSD BL Scientist	10	XSD (100%)

We envision all users will submit general user (GU) proposals and be scored by the APS Proposal Review Panel (PRP). The General User time will be filled by the APS Beamtime Allocation Committee (BAC) based solely on the Proposal Review Panel (PRP) ratings while the time for the Earth Science users and Engineering/Battery users will be filled based on the PRP ratings supplemented with input from COMPRES Deputy Director and 6-BM Director, respectively.

The 2014-3 run cycle at the APS will be used to install and begin commissioning the instrumentation in 6-BM. Although some comissioning may continue into the 2015-1 run cycle, we expect to begin to take aome general users in 2015-1 with full operation in 2015-2.

7 Term of the Agreement

The COMPRES instruments and BNL/PS EDD equipment will remain at the APS for a minimum of two (2) years from the effective date of this Management Plan. The term shall automatically renew on a year-to-year basis after the initial two-year period. After the initial two year period, either the APS, COMPRES, or BNL-PS can withdraw from this agreement with 6 months notification to the other parties.

Qun Shen BNL-PS Deputy ALD	Jay D Bass President, COMPRES	Dennis Mills APS-PSC Deputy ALD
Ron Pindak BNL-PS EDD Director	Donald Weidner COMPRES EDD Director	Jonathan Lang XSD Assoc. Div. Dir.