Radiometry and Metrology –
Synchrotron Beamlines to Serve a Diverse Community

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OVERVIEW

X-ray instrumentation calibration and metrology plays a critical supporting role as an "enabling" science, making possible successes in many diverse dependent scientific fields. Radiometry specifically seeks to provide absolutely calibrated detectors, optical components, and complete instruments at the synchrotron for application to a wide variety of laboratory and astrophysical light sources which are, in themselves, of scientific interest.

SCIENTIFIC NEEDS OF SPECIFIC COMMUNITIES

1. High Energy Density (Plasma) Physics, Inertial Confinement Fusion, and National Security.

This community consists largely of NNSA efforts at LLNL, SNL, LANL. These groups currently utilize roughly 60% of the available beamtime at NSLS U3c and X8a to enable publications in premier scientific journals such as Physics Review Letters, including at least four over the past three years. The scientific motivation is as follows:

LLNL: National Ignition Facility, Campaigns 1, 4, and 10. Absolutely-calibrated X-ray spectrometers ("DANTE") are used for critical determination of radiation temperature for short-lived (sub ns) plasmas with temperatures equivalent to several hundred eV. In this sense, the calibrations are a required part of the core functionality of the facility. Component calibration accuracy of 5-10% is required to achieve radiation temperature determination within a few percent. Components are calibrated using highly monochromatic x-rays with energy ranging from 0.08 to 20 keV, and standard reference detector with 2-5% absolute calibration accuracy. The Dante spectrometers maintained for the National Ignition Campaign support both NIF and Omega (at LLE), and require annual calibration of more than 700 components over the 0.08 to 6 keV photon energy range. This workload is projected to increase by a factor of 2 or more beyond 2012. Additional component calibrations at higher energies (up to 30 keV) are also desirable.

LANL: The LANL need has three essential components for National Security.
<u>Test Readiness</u>: Although underground nuclear weapons testing is currently banned by international treaty, the ability to conduct such tests within roughly 2 years remains a requirement of national security. Maintaining x-ray diagnostics calibrations capability is therefore a requirement of DOE considered by LANL.
<u>National Ignition Campaign, Science Campaigns 1, 4, and 10</u>: A large part of the thrust of the work at NIF, Omega and the Z machine is to develop accurate models of plasma behavior relevant to predicting inertial confinement fusion and weapons performance. Indirectly-driven fusion experiments use x-ray blackbody radiation emitted within "hohlraums" to ablatively compress capsules containing fusion fuels such as deuterium and tritium. The behavior of the time-dependent thermal flux is critical to achieving optimal fusion implosions, and thus blackbody temperature measurements require high precision radiation flux measurements (2-6% or better). Similarly, experiments use the radiation flux diagnostics for a variety of purposes, including broadband spectroscopy for verification and validation of weapons physics codes. The predictive capability afforded by these codes replaces underground testing to enable continued weapons performance assessments. The component calibrations required to meet these objectives include Dante-like equipment, spanning photon energies 0.05-8 keV, through at least 2012. In addition, Bragg mirrors, transmission grating spectrometers, and diagnostics for high energy (up to 70 keV), including imaging systems will require calibrations extending to at least 2017.
<u>Satellite-based detonation monitoring</u>: Absolute calibration and characterization of x-ray sensors provides the quantitative measures required for this initiative. Over the past decade the U3C and X8A beamlines at the NSLS have been used to calibrate more than 100 sensor elements found

aboard the Combined X-ray and Particle Dosimeter (CXD) instruments aboard GPS satellites. The LANL NUDET program has a long-term, continuing need for calibrations up to at least 30 keV. These measurements are critical to the ability to characterize the sensors deployed in operational satellite systems. With these systems being fielded through 2030 and the impending closure of the NSLS, a dedicated, post-NSLS calibration capability is clearly needed.

SNL: The National High Energy Density Physics (HEDP) calibration report specifies need out to at least 2012 for x-ray diode array spectrometer components (similar to Dante), from 0.1 to 5 keV, at roughly 140 components per year. These diagnostics support the operation of the Sandia Z machine as an ICF test facility.

LLE (Laboratory for Laser Energetics): LLE plays a key role in the National Ignition Campaign (NIC) and Stockpile Steward Program (SSP) by operating the OMEGA laser facility. Calibrated x-ray diagnostics are required for meeting the objectives of indirect and direct drive ignition, as well as target diagnostics and target diagnostics calibrations systems, and supporting technology development. The LLNL Dante array components on OMEGA are calibrated at NSLS beamlines U3C and X8A. LLNL is responsible for Dante calibrations and coordinates this effort with Dante's planned usage on OMEGA. LLE seeks to increase its utilization of synchrotron-based calibrations for a wide range of x-ray diagnostics, including various direct exposure X-ray films, flat and curved mirrors, transmission gratings, filters, X-ray crystals, direct exposure CID detectors, direct exposure CCD detectors, Diamond PCD's, and XRD's. OMEGA EP (to be completed in FY08) will be a source of X rays with energies greater than 100 keV, so new higher energy X-ray diagnostics will be needed, and synchrotron x-ray sources from 1 keV to > 100 keV will greatly enhance LLE's ability to calibrate existing and future diagnostics for use on OMEGA, OMEGA EP, and NIF (to be completed in FY09).

AWE (Atomic Weapons Establishment, UK): Diagnostics team members from the Plasma Physics Group responsible for characterization of X-ray components at the laser facilities of AWE have been using NSLS beamlines X8A and U3C periodically for over a decade. Over the next two years a set of diagnostic instruments being developed for experiments at the Orion laser facility, is scheduled for commissioning. These diagnostics, requiring full X-ray characterization, consist of 2 new Dantes, a transmission grating spectrometer, an X-ray microscope, an XUV grating spectrometer, and a hard X-ray spectrometer. There is also an additional NIF Dante being developed by another AWE group. The major components (filters, photocathodes, CCD cameras, gratings, mirrors) from these diagnostics will require calibrations at NSLS beamlines. Approximately three months of beamline time over the next 2 years is needed for these measurements. After these components are fully calibrated, periodic re-calibrations will be conducted in subsequent years and anticipated to continue beyond 2012.

2. Astrophysical applications (x-ray astronomy, solar physics, planetary science, etc.).

This community supports space science, and is currently represented at NSLS by users at several beamlines. For example, high-energy x-ray multilayer mirrors for space physics are developed using NSLS X17b1 via general user access, and mirror coatings for the Chandra x-ray space telescope were tested at the U3a beamline via contributing user / PRT collaboration access.

In addition, soft x-ray detectors for NASA lunar missions, and diamond photoconductive detectors for LANL space physics are presently being developed with support by U3c. The scientific motivation is as follows:

NASA: X-ray metrology and development needs for a wide range of NASA scientific missions include calibration and characterization of both x-ray detectors and x-ray optics for astronomy applications. Several types of instruments have been identified as requiring at-wavelength x-ray calibration. Historically, large space-based x-ray telescopes, such as Chandra, that are comprised of a few reflecting surfaces have relied on the 500 m long X-ray Calibration Facility at Marshall Space Flight Center for reflectivity and image quality calibration. Going beyond Chandra to missions such as Con-X and Gen-X involves large-area (100 m^2) and high-angular-resolution (0.1 arcsec) grazing-incidence x-ray collecting mirrors for soft to 15 keV x-rays, with new technology including lightweight Wolter I and adaptive control. A major challenge for such an endeavor is the metrology of possibly thousands of individual mirrors to far greater accuracy than this (0.01 microradian), to ensure that finished assemblies meet the target resolution. This accuracy is beyond the reach of standard optical metrology techniques and necessitates the urgent development of at-wavelength metrology methods to keep pace with these planned developments in the field. Synchrotron-based x-ray metrology offers an easily accessible and versatile test station capability that is expected to fill a growing need for accessible metrology to advance these scientific efforts. In addition, high energy (2-100 keV) x-ray polarimetric imaging of celestial objects will require development of new types of instruments that will need precise calibration of detector and optical systems. Also, lunar and planetary atmospheres, as well as solar wind observations will be made possible using large-area (1 m^2) spectroscopic soft x-ray (0.3-15 keV) detectors, presently under development for future space missions.

Space Optics in General: Broadly speaking, NSLS has historically enabled fundamental research on the interaction of soft x-ray and extreme ultraviolet (EUV) radiation with surfaces, detectors, and reflective and diffractive optics. More recently, development and calibration of spaceflight optics and instrumentation have been undertaken on behalf of NASA, LANL, NOAA, and ESA. These efforts enable otherwise impossible space-based observational science in astronomy and solar physics. Characterization and radiometric calibration of future devices such as spaceflight instrument components, detectors, gratings, crystals, mirrors and filters will be required. NASA contractors that have developed multilayer coating technologies in the soft x-ray range are being asked to extend the range into the hard x-ray region, beyond 20 keV. Development of coatings for this energy range is hampered by lack of good information about the optical properties of materials in this energy range. Access to photons for mapping reflectivity and coating uniformity on full size mirror optics is essential for successful development of these coatings.

3. Materials science and materials optical properties.

This community supports materials science by studying defects in single crystal materials and measuring optical properties of bulk and structured objects. These needs are currently represented at NSLS by roughly 50% utilization of beamline X19c by SUNY-Stony Brook, as well as significant fractions beamtime at other NSLS beamlines. The scientific motivation is as follows:

SUNY-Stony Brook: Several x-ray diffraction topography techniques have become the specialization of this group in the study of crystallographic defects. The scientific goal, broadly speaking, is to provide defect configuration and density data which, when correlated with crystal production parameters, enables improved understanding of the origins of defect configurations observed in single crystals and single crystal devices, with a view to control the nucleation and propagation of the various defects. The topography measurements may be static, dynamic (in situ), or make use of reticles to measure strain distributions. All such studies require close collaboration between the crystal grower and the X-ray topographer. Some example outcomes include helping growers identify strategies to minimize thermally induced stress during growth. In situ techniques are hoped to provide real-time observation of defect nucleation and propagation during the crystal growth process, changes in defect microstructure experienced during phase transformations, dislocation propagation under applied stress, and behavior of defects during the operation of semiconductor devices.

NSLS: Several needs of the materials science community (in particular magnetic materials and soft x-ray spectroscopy) have been stated in terms of required development and metrologic testing of many instrumentation components, including spectroscopic and polarimetric detectors, improved-efficiency detectors for fluorescence photons and photoelectrons, as well as improved-performance optical components such as mirrors, gratings, and polarizers. Detector development relevant to beamline materials science in particular is something currently undertaken by groups at several beamlines. In addition, since many beamlines make extensive use of materials science in the form of accurately measured optical properties of materials (relevant to common beamline components such as mirrors), measuring these optical materials properties is undertaken by several beamlines presently, and these measurement efforts are expected to benefit from the improved brightness and stability of NSLS-II.

4. X-ray (at-wavelength) optical metrology of optics and detectors for high-brightness light sources.

No dedicated beamlines presently exist at NSLS for at-wavelength testing of optics. A dedicated beamline for at-wavelength testing of synchrotron optics and instrumentation would be a welcome asset to the metrology community nationally. The scientific motivation is as follows:

High-performance optics for NSLS-II and other domestic synchrotron light sources: All users of synchrotron beamlines benefit scientifically from developments made possible due to metrology and radiometry efforts in the testing and development of synchrotron instrumentation. These applications broadly speaking include both materials and biological sciences. Most NSLS-II beamlines will utilize x-ray optics and detector systems that will need at-wavelength testing and calibration in order to reach their stated objectives. High-brightness synchrotron light sources such as NSLS-II are expected to require exceptionally high-performing (“brightness-preserving”) optics in order to bring both brightness and flux to the experimental stations, and ultimately, to meet the stated targets for the facility of 0.1 meV energy resolution and 1 nm imaging resolution at 10 keV photon energy. Achieving these goals will require significant efforts in instrumentation development, made possible only by close interaction between optics fabrication and metrology.

The need for dedicated beamlines is made clear whenever improvements are desired. For example, currently, to investigate the suitability of a new mirror technology for an application at NSLS or APS, a new mirror must replace an existing mirror in a fully subscribed beam line. Since the scientific program of the existing beam line takes precedence over engineering tests, it is extremely difficult to perform the necessary testing and calibration to investigate new mirror technology. Then, once the mirror is installed, it is again practically impossible to remove it to make changes to the system or to assess possible damage effects to the surface. Dedicated test beamline(s) will provide a test bench for at-wavelength metrology, to ensure that only fully qualified and stable optics are installed into other user beamlines.

Specific synchrotron optics instrumentation which is expected to need access to at-wavelength metrology includes nanofocusing optics (zone plates, multilayer Laue lenses, kinoforms and K-B mirrors), coherence-preserving optics (both reflective and transmissive), and other beamline optics with less strict requirements on coherence performance but which may have other metrics for the particular scientific application, such as flux, beam uniformity, harmonic purity, etc. Some methods for these tests are outlined in a later section.

Other light source facilities, and accelerator diagnostics: The growing need for testing and calibration of coherence-preserving x-ray optical elements is relevant not only to high-brightness synchrotrons but also to high-brightness, high peak power x-ray light sources, such as FELs. Examples of such sources include the LCLS FEL at SLAC (0.08-25 keV), FLASH (operating 0.04-0.2 keV at DESY), and other European and Japanese X-ray FELs which will soon be on line. For LCLS, in addition to nearly-perfect soft and hard x-ray beam steering optics, the facility requires x-ray optics such as K-B mirrors to support focusing and imaging for the experiments downstream. The quantity of optical elements required for these applications is expected to be high, owing to expected damage and to continuous development of mirrors with improved performance. The extremely high peak pulse power (instantaneous dose) from the LCLS beam is expected to melt most mirror substrate and coating materials, with the exception of a few low-Z materials. Therefore, extensive work is currently underway towards investigating the most robust materials and coatings for these applications. Since LCLS mirrors are also required to preserve the coherence properties of the incident beam, it is crucial to test the coherence properties of these mirrors at-wavelength, to verify that the substrate figure, the coating uniformity, and the overall efficiency of these mirrors meet the wavefront preservation and flux requirements. At-wavelength calibration of multilayer refocusing mirrors in support of imaging experiments at FLASH using 32.5 nm wavelength has already been performed at NSLS. The LCLS is the first x-ray FEL of its kind in the world. Despite several models and studies, no one has a definite understanding of how the x-ray optics are going to perform and degrade under the unique LCLS conditions. Therefore, there is a great amount of progress to be made in optics development in the near future, and the metrology opportunities represent enormous upward scientific potential.

UPGRADE AND TRANSITION PLANS OF EXISTING BEAMLINES

[Note: Programs which are not currently on dedicated NSLS beamlines nevertheless remain active and intend to grow as NSLS-II approaches. Drawing these into the group of Metrology stakeholders is part of the ongoing effort of this community. See the following section for further description of those programs and their scientific goals.]

NNSA: Beamlines U3c and X8a (30 eV – 6 keV) are currently operated for NNSA, and additional high energy x-ray calibrations are performed at beamline X15a (up to 30 keV). Additional needs for even higher energy x-rays are expected to become more important in the coming years. Beamline upgrades in progress at U3c and X8a include new endstations, additional automation hardware and software (sample positioning and monochromator control, plus vacuum hardware for all three beamlines), and an improved order sorter. Future further upgrades may include acquisition of a cryogenic calorimeter and/or transmission grating spectrometer. Evaluation of "post-NSLS options" for this group is currently underway; critical issues in this evaluation are access to and control of beamline configuration and scheduling. Presently NNSA groups use roughly 60% of the available beamtime at U3c and X8a, and this utilization is projected to increase to as much as 80% in the coming years. NNSA funding is being sought for new beamlines but this may or may not go to NSLS-II depending on control, access and funding concerns. The core need of this community lies in the soft x-ray range, so at a minimum, 60-80% utilization will continue to be required on one beamline covering the existing capabilities of U3c. Ideally, this beamline might utilize a VLS-PGM on a soft bend of NSLS-II, spanning 30-3000 eV. It is important for the radiometry application that harmonics are strongly rejected, so a bending magnet source may be ideal since there is little flux beyond the critical energy. Funding and access permitting, a second beamline would be useful for extending the radiometric calibrations capability to higher photon energies. This is presently envisioned to be a Si(111) DCM installed on a 3-pole wiggler (wavelength shifter) source of NSLS-II. Since the existing X8a beamline already has a silicon monochromator and collecting mirror, it may be possible to move all or parts of this beamline to NSLS-II and thereby cover the 2.1 to 30 keV range. Ideally, the collecting mirror could be adjusted to filter out higher harmonics as needed (for the low energies) and then be removed when white light is needed. Additionally, asymmetric silicon crystals and/or convex bimorph mirrors may be useful for providing spatially extended beams. Since the NNSA need is less (projected ~ 50% utilization) for the higher energies, a future beamline for this range could in principle be shared with groups with similar technical needs (such as metrology, radiometry, space optics, or topography). In addition, some additional future needs exist for access to higher energy x-rays (up to 100 or 200 keV).

SUNY-Stony Brook: At beamline X19c, the topography group uses white light from a bending magnet on the NSLS X-ray ring to produce topographs. Future plans include utilization of monochromatic x-rays (requiring high flux) and development of in-situ and reticle-based methods. At NSLS-II, the group desires a high energy white and monochromatic source in 6-100 keV range, possibly utilizing a 2T, 3-pole wiggler (insertion device). This source is anticipated to provide monochromatic beam, extending the range of dislocation density measurements from the 10^6 to the 10^8 /cm^2 range by means of increased image contrast. Spatial resolution improvement should likewise be afforded by moving to a brighter source (smaller source size) and longer beamline. Additionally, beam size will be helpful in the collection of topographs from large wafers. Projection of utilization, based on current activity is roughly 40%; partnering with the synchrotron instrumentation metrology effort may be a fruitful option for this group.

ADDITIONAL TRANSITION STAKEHOLDERS

In addition to the existing NSLS beamline owners (PRT organizations NNSA and SUNY), there are three other classes of important stakeholders in the enterprise of metrology beamlines at NSLS and/or NSLS-II. The first is the sponsorship and collaborators base for existing programs. This includes organizations such as NASA, NOAA, and materials industrial partners of various types, all of which are expected to increase their participation with the visibility of potential NSLS-II beamlines.

The second is the Light Source itself (NSLS & NSLS-II), and its peers: metrology is needed for the continued and future success of these facilities, mainly in the field of beamline optics. This need extends to support of other DOE light sources (APS, ALS, LCLS) as described above. APS and ALS metrology experts advise us that having dedicated beamlines capable of measuring the performance of beamline optics and detectors is critical to the timely success of the scientific missions of the facility. In particularly, the challenging instrumentation needs to achieve 1 nm focusing and 0.1 meV resolution inelastic x-ray scattering, will demand an active x-ray optics development program that involves crystals with a perfection of better than one part per 10^8, graded multilayers, crossed-zone-plates with sub-nanometer alignment capability, and large focusing mirrors with sub-microradian slope errors. All of this indicates that, in addition to beamlines with access to large energy range, additional facilities will need to be established. These include standard metrology labs with x-ray and visible optics, crystal preparation labs for orientation, cutting, lapping, polishing, and etching, as well as on-line and off-line topographical characterization capabilities. Trained personnel, under the direct control of scientists, are also needed for a healthy instrumentation development effort. Storage ring accelerator physicists may find partners with photon metrology as well. On the positive side, NSLS-II has an advantage in that a metrology-based effort already exists at the current NSLS, which is active both in soft and hard x-ray regions. Thus, starting from the needs of the NNSA and space optics communities, the NSLS-II project should be able to build up an attractive program to serve the needs of new communities.

The third is the national and international community of standards. The metrology effort for NSLS-II will benefit itself and the standards community by extending its reach to other institutions like NIST, and build bridges with the international community. Collaboration and partnership with organizations like NIST, and other synchrotron metrology capabilities worldwide will ensure that methods and instrumentation are state of the art. NIST (photon physics) may extend its metrology and radiometry capabilities beyond the EUV (250 eV) into the x-ray range, as a partner user or collaborator at NSLS or NSLS-II, in order to better support space science, and potentially even NNSA or DOE-BES metrology needs, possibly via NIST's National Voluntary Laboratory Accreditation Program. Developing partnerships with NIST's photon physics group could help build an infrastructure to benefit all. However, this group is presently pursuing a "compact light source" facility for Gaithersburg and anticipates being only a minor player in x-ray radiometry for the foreseeable future; efforts at NIST presently seem more focused on serving EUV lithography development at SURF-III. While some attempt is being made currently to invite NIST to participate more fully in the x-ray metrology field, partnerships with other radiometry and metrology groups such as PTB at BESSY-II and the metrology group of SOLEIL are also being pursued. Opportunities for collaboration and interaction with PTB have are presently under development.

WORLD STANDING

While several synchrotrons worldwide host dedicated beamlines for at-wavelength metrology and radiometry, many do not. Some examples of successful metrology beamlines include ALS 6.3.2/5.3.1 (mostly soft x-rays), ESRF BM05 (6-100 keV), Spring8 BL29XUL (4.4-37.8 keV), PTB beamlines at BESSY-II (spanning IR through 60 keV) and MLS (UV/VUV/EUV, started this year), and NIST's SURF-III (radiometric up to 0.25 keV). Absent from this list are the APS and NSLS, which have no dedicated metrology beamlines. Other non-SR facilities (limited flux and tunability) include NASA's X-ray Calibration Facility at Marshall Space Flight Center (XRCF) and a similar facility at the Max Planck Institute in Munich. The NSLS and NSLS-II community as a whole can expect to benefit from dedicated, facility-supported metrology and radiometry beamline capabilities.

New beamlines for radiometry developed with NNSA are likely to be world-class, taking advantage of exceptional stability and coherence of NSLS-II to provide unsurpassed beam uniformity and positional stability, in concert with continuing development of radiometry methods such as cryogenic calorimetry, photoconductive and wide-bandgap detectors, soft x-ray dispersive detectors, and source-based techniques for dispersive detectors. The existing and future NNSA beamlines are recognized as unique nationally in their capability to provide absolute detector responsivity calibrations with high accuracy, and NNSA intends to further this status by investing in NIST's accreditation program.

Beamlines for X-ray Topography exist at several synchrotron facilities around the world. In the US, the only current effort that is dedicated to X-ray topography is at beamline X-19C at the NSLS. At the APS, approximately 7-8% of the beamtime on beamline 33-BM-B is dedicated to X-ray topography although the future of this effort is in question. The partial effort that existed at the SSRL is no longer in existence. In other countries, there is a significant effort at beamline ID-19 at the ESRF in Grenoble, France and a smaller effort at beamline F1 at DORIS III, HASYLAB, DESY, Hamburg, Germany.

CHALLENGES AND METHODS

In order to meet the needs of optics development for next-generation light sources (e.g. NSLS-II, FEL/ERL sources), potential metrology activities can be quite extensive, and include at-wavelength testing of reflective, refractive, and diffractive optics (transmitted wavefront quality of windows for coherence preservation, phase retrieval intensity measurements, Talbot grating interferometry, edge-scanning techniques for PSF measurement, mirror bender tuning, and development of active/adaptive x-ray optics), reflectometry (optical properties of materials, especially beyond 30 keV, multilayer coating characterization), heat load studies (crystal monochromator distortion, cooling techniques, and in-situ profilometry), materials damage studies, and detector development. A significant quantity of new test equipment, including positioning systems, interference gratings, and imaging and monitoring detectors will be required. Beamline(s) supporting these methods must span 2-100 keV, utilizing both Bragg (possibly asymmetric) and Laue silicon monochromators, and providing white light from a wiggler source.

In addition, specific issues raised by NSLS/NSLS-II beamline scientists so far which require metrology support include polarimetry, soft x-ray spectroscopic detectors, temperature control of cryo-cooled crystal optics, heat load effects, materials damage, and crystal slope errors and effect of adaptive correction (in bimorph mirrors). In addition, new equipment requiring characterization and development at existing PRT beamlines may include a new order sorter and optics for U3c, a cryogenic radiometer for NNSA, and a reticle system and monochromator for topography.

PROPOSED SUITE OF NSLS-II BEAMLINES FOR METROLOGY AND RADIOMETRY

Spanning 30 eV – 100 keV or wider, these beamlines are expected to produce uniform, tunable monochromatic or white light x-ray beams for at-wavelength testing of optics, detectors, and crystals in support of the science described above. The photon energy range may be extended in either or both directions.

1. Soft x-ray VLS-PGM (grating) type monochromator, spanning 30-3000 eV photon energy, located at a "Soft" bending magnet at NSLS-II. This beamline, with appropriate harmonic rejection and endstation design could support radiometry (60-80% NNSA), as well as reflectometry, and detector development for space physics and materials science.

2. Hard x-ray Si(111) DCM monochromator, spanning 2.1-30 keV, located at a 3-pole wiggler (wavelength shifter) source of NSLS-II. This beamline, with appropriate harmonic rejection and endstation design, could support reflectometry and radiometry of space optics and detectors for high-energy density physics, astronomy, materials science, and at-wavelength metrology of beamline instrumentation. White light operation on this beamline should also be available, and also may include an asymmetric cut silicon monochromator for applications requiring wide beams. In principle, parts of NSLS beamline X8a may be able to be moved to NSLS-II to make up a significant fraction of this beamline's hardware. Depending on utilization and technical feasibility, it may be possible for this mirror and monochromator to support an upstream (serial) end station of the high energy beamline proposed below.

3. High energy beamline utilizing Laue-type silicon monochromator on 2 T or greater wiggler to span 30-100 keV or higher. This would be useful for topography, as well as for high-energy radiometry and metrology for NNSA and space optics. The bendable Laue monochromator is considered to be particularly useful for providing variable interchange of flux and bandwidth. The white light option should be available for this beamline, and asymmetric cut silicon monochromator should be considered for the topography application. Depending on utilization, a second, upstream DCM monochromator hutch may be an important consideration for lower energy (2.1-30 keV) work.

TRANSITION & INFRASTRUCTURE CONCERNS

Transition concerns include access, downtime, and space for office, setup, and storage. Block access or rapid access for programmatic or other special user needs should be discussed. Dark period for beamlines moved should be minimized, by coordination with the facility as well as similar beamlines.