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Sagittal Focusing of High-Energy Synchrotron X-Rays with Asymmetric Laue Crystals

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X-rays below 20 keV can be focused easily with doubly curved x-ray mirrors. Sagittal focusing of x-rays within the energy range of 5- to 30- keV is also routinely achieved using sagittally bent Bragg crystals, first proposed by Sparks et al, 1980. For x-rays with energy above 30 keV, due to the decreased Bragg angle, the beam's footprint on the crystal increases. Large crystals approximately 100-mm long must be used, making the control of anticlastic bending difficult (Yamaoka et al, 2000). Also, at high x-ray energies, the energy-bandwidth of the monochromatic beam created is dominated by the vertical opening angle of the beam, which is of the order of a few tenths of milliradians. Due to these difficulties, sagittal focusing of high-energy x-rays has rarely been attempted. Instead, to focus high-energy synchrotron x-rays, crystals were curved in their meridional plane (scattering plane) and diffracted horizontally. Single-bounce meridionally-bent Laue crystals have been used for polychromatic focusing (Schulze et al, 1998). Laue-Bragg crystals were employed to construct meridional-focusing fixed-exit monochromators (Lienert et al, 1998). These approaches limit the magnitude of acceptable horizontal x-ray divergence due to the difficulty in controlling the uniformity of large bent Bragg crystals, and the coupling between the divergence and energy in meridionally-focusing Laue crystals.

Recently, sagittal focusing with asymmetric Laue crystals has been proposed (Zhong et al, 2001). **Figures 1**a and b illustrate the mechanism of such focusing and depict the change of the direction of the diffracted x-rays in real- and reciprocal- space. Two parallel x-ray beams with wave vector $\mathbf{k}_0$ are considered. The first beam hits the center of the crystal and is diffracted by the diffraction vector $\mathbf{H}_1$ into a direction $\mathbf{k}_1=\mathbf{k}_0+\mathbf{H}_1$. The second beam is in the same horizontal plane as the first one. At the point where it meets the crystal, the crystal's diffraction vector, $\mathbf{H}_2$, precesses around the axis of sagittal bending. This causes a change of the direction of the diffracted x-rays of the second beam ($\mathbf{k}_2=\mathbf{k}_0+\mathbf{H}_2$) with respect to that of the first beam. The sagittal focal length is $F_s = \pm R_s/(2\sin\theta_B \sin\chi)$, where θ_B is the Bragg angle, χ is the asymmetry angle and R_s is the sagittal bending radius. The

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upper sign is used if the diffraction vector is on the same side of the crystal as the center of the sagittal bending, hereby focusing the x-rays (**Figure 1** corresponds to this case). F_s is negative if the diffraction vector is on the convex side of the crystal, causing further divergence of the horizontal x-rays. Compared with the focal length of a sagittally focusing symmetric Bragg crystal, the focal length of a Laue crystal is a factor of $1/\sin\chi$ larger. The sagittal focal length is infinite when χ is zero. Thus, a symmetrical Laue crystal does not have any sagittal focusing effect. This can be understood by considering the diffraction vectors, $\mathbf{H}_1$ and $\mathbf{H}_2$, in **Figure 1**. They all would point along the bending axis of the crystal, making no change to the direction of the diffracted x-rays in the sagittal plane.

For synchrotron x-ray beamlines, it is desirable to have a double-crystal monochromator to keep the beam's direction horizontal. For Bragg crystals, anticlastic bending causes deviation from parallelism between the first and second crystals, and, if not controlled to within the Darwin-width of the crystal's diffraction (which is a few micro-radians for hard x-rays) over the extent of the beam's footprint, it degrades the efficiency of the monochromator (Sparks et al, 1982). Methods to minimize the anticlastic bending includes cutting stiffening ribs in the crystal (Sparks and Ice, 1982, Batterman and Berman, 1983), and using an array of weak-links in the crystal (Mills et al, 1986, Matsushita et al, 1986). With two Laue crystals, instead of trying to minimize anticlastic bending, we can take advantage it by realizing the non-dispersive setting in the meridional plane, while using both crystals for sagittal focusing. This is achieved in the meridional plane by having both crystals diffract in the inverse-Cauchois geometry.

Figure 2 shows schematically this configuration. The first crystal diffracts up, and is curved sagittally upward so that the diffraction vector is on its concave side. The second crystal's diffraction vector points down, but since it is curved in the opposite way to the first crystal, the diffraction vector still is on the concave side of its sagittal bending. Thus, both crystals contribute to the sagittal focusing. Ignoring the small distance between the two crystals, the overall sagittal focal length, f_s, of the two-crystal assembly is $1/f_s=1/F_{s1}+1/F_{s2}$, where $F_{s1}=R_{s1}/(2\sin\theta_B\sin\chi_1)$, and $F_{s2}=R_{s2}/(2\sin\theta_B\sin\chi_2)$ are the sagittal focal length of the first and second crystal, respectively.

In the meridional plane, the non-dispersive arrangement is used (Suortti et al 1992, Ren et al 1999). The first crystal is arranged in inverse-Cauchois geometry, with the source on its Rowland circle at a distance of $F_1=R_{m1}\cos(\chi_1+\theta_B)$ from it, where R_{m1} and χ_1 are the meridional-bending radius (as a result of anticlastic bending) and asymmetry angle, respectively, of the first crystal. Consequently, a virtual-image point is formed on its Rowland circle at a distance of $R_{m1}\cos(\chi_1-\theta_B)$ from the crystal. The second crystal is bent so that the virtual-image point of the first crystal is on its Rowland circle at a distance of $R_{m2}\cos(\chi_2+\theta_B)$ from it. Ignoring the small distance between the two crystals, we have the following relationship between the bending radii and asymmetry

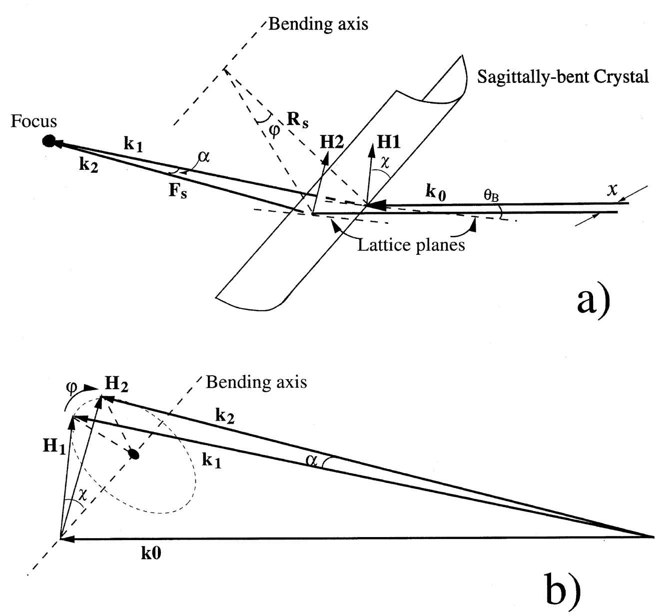

__Figure 1.__ The mechanism of the sagittal focusing with an asymmetric Laue crystal. a) Real-space diagram showing two parallel incident x-ray beams being monochromatized and sagittally focused. b) Reciprocal-space diagram showing the precession of the diffraction vectors around the axis of sagittal bending, and the resulting angle between the diffracted beams.

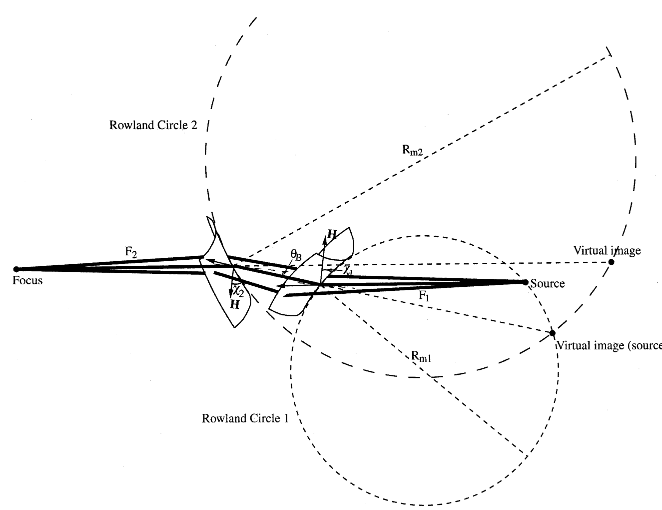

__Figure 2__. Constructing a monochromator using two sagittally bent Laue crystals. Both crystals contributed to focusing the x rays sagittally. They were cut from (001) silicon crystal wafers and bent to the same sagittal bending radius.

angles of the two crystals $R_{m2}/R_{m1}=\cos(\chi_1-\theta_B)/\cos(\chi_2+\theta_B)$. If the same asymmetry angle is used on both crystals, R_{m2}/R_{m1} is close to unity at typical asymmetry angles (for small Bragg angles corresponding to high-energy x-rays). The easiest approximation is two crystals of the same asymmetry angle and bending radius. Then, the two crystals are approximately non-dispersive in the meridional plane. The reflectivity would remain close to ideal since the intrinsic diffraction width (of the order of 100 micro-radians, due mostly to the anticlastic bending) is much larger than the errors (about 10 micro-radians) introduced by the crystals not being exactly non-dispersive.

Depending on the coupling between the meridional-bending and the sagittal-bending ($R_s/R_m=\nu C$), the asymmetric angle of the crystal must be chosen to achieve simultaneously inverse-Cauchois geometry in the meridional plane and sagittal focusing. The condition imposed on the asymmetry angle of each crystal in a double-crystal monochromator is $\sin(2\chi)\sim(\nu C)/(2\sin\theta_B)(1+F_1/F_2)$ (Zhong et al, 2001).

Experiments were performed at X15A and X17B1 beamlines of the NSLS. Two identical 0.67-mm thick (001) silicon crystals, 40-mm high and 100-mm wide, were bent to the same sagittal radius of 760 mm, using similar four-bar benders (Zhong et al, 1997). The resulting meridional bending radius was 18.8 meters. The crystals were put together in the fashion depicted in **Figure 2**. The [111] reflection (asymmetry angle is 35.3 degrees) of both crystals was used to diffract the x rays. A synchrotron x-ray white beam, 50-mm wide (divergence ~ 3 milliradians) and 3-mm high was incident across the middle of the first crystal. The height of the second crystal was adjusted so that the beam diffracted by the first crystal struck the middle of it. When the second crystal's angle was adjusted, a phosphor screen put in the path of the diffracted beam (off the second crystal) showed that the beam appeared and disappeared uniformly across its width.

Since the focal length of the crystal assembly depends on the Bragg angle of the reflection, the angle of both crystals were adjusted by the same small amounts to maintain their parallelism, till a sharp focal spot was obtained on the phosphor screen at the end of the hutch. The x-ray energy selected was about 15.8 keV, at a Bragg angle of 7.2 degrees. With the second crystal tuned to the peak of its rocking curve, film and image plate exposures were taken at the end of the experimental hutch at 3.2 meters from the second crystal, and in the path of the diffracted beam at 2.0 meters from the second crystal. **Figures 3** shows the results of the exposures. The beam in **Figure 3**b is uniform horizontally, except at the upper left corner, and its vertical profile is consistent with the vertical-intensity profile of the incident synchrotron radiation. These indicate parallelism between the two crystals across the footprint of the 3-mm by 50-mm beam. The missing intensity at the upper left corner is probably due to the local distortions in the lattice planes of one of the crystals as a result of defects in the crystal or irregularity in the bending bar. The focal spot in **Figure 3**c has a width (FWHM of the linear intensity, measured with an image plate) of 0.4 mm and a height of 4 mm.

A focal length of 2.69 meters was calculated from the distance between the focal spot and the crystal assembly, and the distance between the synchrotron radiation source and the crystals. Using the experimentally determined Bragg angle of 7.2 degrees, when the best focus was achieved, a focal distance of 2.62 meters was calculated using $f_s = R_s/(4\sin\theta_B\sin\chi)$, where R_s and χ are the sagittal bending radius and asymmetry angle, respectively, of the two identical crystals. The agreement between the two values is within 3%.

Figure 4 shows the rocking curve measured by an ion chamber as the crystal's angle was changed, with the first crystal set to diffract 30 keV x-rays. Also shown is the intensity measured simultaneously, by an ion chamber placed in the path of the beam diffracted by the first crystal and transmitted through the second crystal. When the second crystal was tuned to the peak of its rocking curve, the ion chamber (in the beam transmitted through the second crystal) measured less than 10% of the detuned intensity, indicating a high diffraction efficiency by the second crystal.

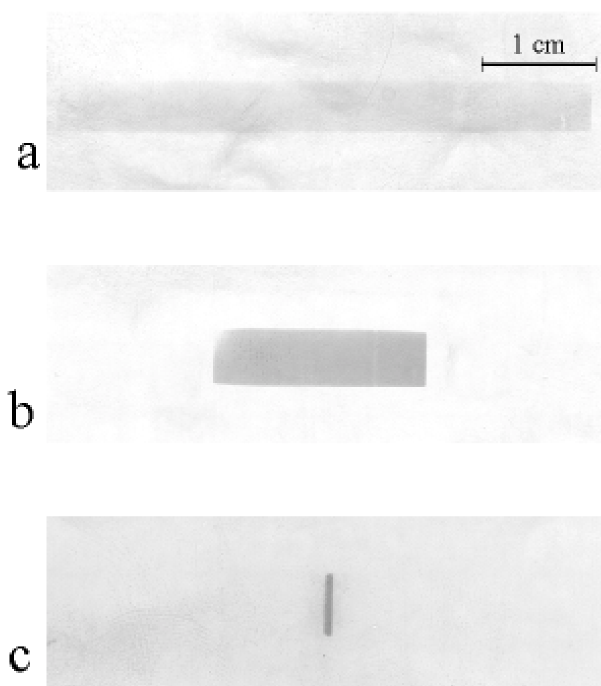

***Figure 3**. Film exposures of the sagittally focused beam. Exposures were taken a) just behind the second crystal, at 0.1 meters from it, b) at 2.0 meters from it, and c) at the end of the experimental hutch at 3.2 meters from the second crystal. A white beam, 3-mm high and 50-mm wide, was incident on the first crystal.*

The second crystal's rocking curve is roughly triangular, with a FWHM of about 0.007 degrees (120 microradians). This is consistent with the convolution of two box-shaped intrinsic rocking curves of sagittally bent crystals, measured with a parallel monochromatic beam (Zhong et al, 2001). Also, the FWHM of the rocking curve was reduced only slightly as the incident beam's vertical height was reduced to 0.5 mm. These observations confirm that the matching of the two crystal's meridional-bending radii was good, thus putting them in approximate non-dispersive (parallel) mode in the meridional plane.

The flux of the diffracted beam was measured by an ion chamber in its path, at different energies between 15 and 50 keV. The measured flux density was compared with the calculated average intensity of a 4-mm high beam produced by a [111] prefect Bragg crystal using the same filtering. There is a gain in flux density of a factor of six hundred to eight hundred by sagittal bending at energies above 25 keV, when the attenuation by the Laue crystal is small. This is explained by a gain of about a factor of a hundred due to focusing, a gain of about a factor of ten from the increase in integrated reflectivity, due mostly to the expansion of the rocking-curve's width, and a loss of about a factor of two to the reflectivity of the second crystal.

Two advantages of sagittal focusing by Laue crystals are noted: First, the transmission geometry renders the length of the beam's footprint small, reducing the control of the crystal's bending profile from a two-dimensional problem to a one-dimensional one. Second, the Laue geometry allows us to tailor the crystal's thickness and asymmetry angle to take advantage of anticlastic bending. Therefore, in addition to gains in focusing, we can achieve an order of magnitude increase in the monochromatic x-ray intensity without broadening the energy bandwidth of the diffracted beam, compared to using Bragg crystals. The disadvantage is that use of the Laue geometry limits the device to high-energy x-rays that can penetrate the crystal. With the Laue crystal's wide choice of asymmetry angle, some control (through the orientation of the crystal and bender design) over the extent of coupling between the meridional and sagittal bending radii, and reduced beam footprint, we feel that there is ample room for progress and innovation in using Laue crystals for sagittal focusing of x-ray beams.

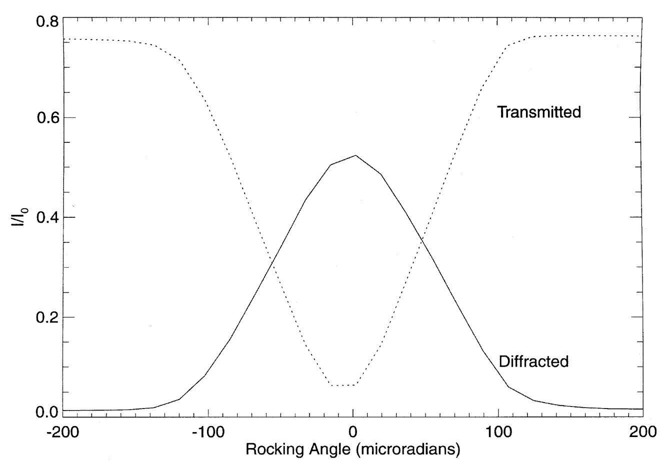

***Figure 4**. Reflectivity of the beam diffracted by the second crystal (solid line) and the normalized intensity of the beam transmitted through it (dashed line), versus the rocking angle of the crystal, measured at 30 keV.*

Acknowledgments

This work was supported by US Department of Energy, DE-AC02-76CH00016. We would like to thank Lonny Berman, Wolfgang Caliebe, Dean Chapman, Erik Johnson, and William Thomlinson for helpful discussions, and Shu Cheung, Richard Greene, and Anthony Lenhard for modifying the benders.

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Chairman's Introduction: Source Development at the NSLS

Samuel Krinsky
Interim Chairman

While running the facility at the highest levels of reliability and stability, the NSLS is actively engaged in enhancing the capabilities we provide for our users. The upgrade of beamlines on the VUV Ring, carried out over the last few years, has resulted in a revitalization of the user program. During the upgrade, 6 new IR beamlines and 4 upgraded soft x-ray beamlines were brought into operation, and a new 5-30 eV beamline was established at U13. These innovations have produced new state-of-the-art capabilities and have enhanced the scientific program as evidenced by increasing numbers of users and publications.

Samuel Krinsky, Interim Chairman of the NSLS

There is now an initiative to improve the insertion device beamlines on the X-ray Ring. A new high-resolution monochromator has been procured for the soft x-ray undulator beamline X1B. The superconducting wiggler beamlines at X17 are being reconfigured to increase the experimental throughput. On X21, photon beam transport is being provided to bring x-rays into the back hutch to establish a new end station for materials science. A new cryogenically cooled monochromator and a state-of-the-art 9-cell CCD detector have been purchased for X25. In addition, we are building new in-vacuum undulators to be installed in the RF straight-sections at X29 and X9, increasing the number of insertion devices on the X-ray Ring to eight.

In the life sciences, a consortium of protein crystallography beamlines has been formed with NIH funding. The result has been a major increase of user support in this area and a dramatic increase in productivity. This suggests that consortia should be developed targeting other scientific disciplines. If funding can be acquired, the advantages of coordinating the activities of groups of beamlines and providing enhanced user support could have a very positive impact on the experimental program.

In the area of novel source development, the high-gain harmonic-generation (HGHG) experiment at the BNL Accelerator Test Facility (ATF) successfully demonstrated the proof-of-principle for a new approach to free-electron lasers. In HGHG, a seed laser imposes a coherent density modulation on an electron beam. When this bunched electron beam passes through a long undulator magnet, coherent radiation is produced at harmonics of the seed laser. The high peak power output is both spatially and temporally coherent. It is planned to extend the success achieved at the ATF in the infrared to shorter wavelengths at the Deep Ultraviolet Free Electron Laser (DUV-FEL) now being installed in building 729 adjacent to the NSLS.

A very exciting subject of R&D at the NSLS is the possibility of a future upgrade to the facility utilizing a Photo-injected Energy Recovery Linac (PERL). At the present time, most synchrotron radiation research is carried out on electron storage rings. In such devices, the electron beam's transverse emittance, bunch length and energy spread are determined by an equilibrium between the quantum fluctuations arising due to the emission of discrete photons and the damping resulting from the average energy loss. Storage ring sources have been optimized in recent years to provide high brightness, stability and reliability. It is now a good time to consider what type of accelerator future synchrotron radiation sources should be based upon. One apparent limitation of storage ring sources is that no practical scheme has been put forward to provide very short electron bunches with duration below a few ps. It is known that short electron bunches of duration down to 100 fs can be obtained using linear accelerators.

Linear accelerators are quite widely used as drivers of free electron lasers because of the high peak currents and small emittances that are achievable. In the last few years several research groups including BNL, Cornell, Jefferson Lab, LBNL, and BINP, Novosibirsk have been considering the potential of using linac sources for providing incoherent synchrotron radiation. On reason this is not commonly done is that achieving high average currents, on the order of a few hundred mA, has been common place in storage rings but has not yet been achieved in linacs. Recent developments at Thomas Jefferson National Accelerator Facility have made it seem much more likely that average currents of a few hundred mA can be achieved in linacs with energy recovery. The result is that PERLs have the potential to provide electron beams of 3-6 GeV, with average currents of 100 mA, emittances on the order of 0.1 nm-rad and bunch lengths of 100 fs. Therefore, PERLs have great potential for serving as the driver for the next generation of synchrotron radiation sources at BNL.

NSLS Annual Users' Meeting, May 21-24, 2001

Simon Bare
User Meeting Chair, UOP

The NSLS Annual Users' Meeting is a forum, organized by the NSLS Users' Executive Committee, for reporting new research results and advances in experimental capabilities that utilize synchrotron radiation. The meeting brings together scientists from many diverse disciplines to share their recent accomplishments and visions of the future. It also provides them with the opportunity to visit with old friends and to forge new relationships.

Because the focus of our meeting is on the science produced at the NSLS, we especially encourage the infrequent or new synchrotron user to attend. Through workshops, invited talks, the poster session, and the informal interactions, there will be numerous opportunities to learn about new frontiers in synchrotron-based experimentation and how these will impact your research interests.

The Users' Meeting is an ideal time to interact with the wide variety of scientists who make the NSLS a most productive user facility. Below are brief descriptions about each workshop. Full details about the meeting and workshops (including speakers and their topics), and ***all the latest information***, can be found at the following website: **nslsweb.nsls.bnl.gov/nsls/users/meeting**. We hope to see you at this year's meeting, May 21-24.

Schedule for the Meeting

Monday May 21

7:30 – 9:00 a.m. Forum on Advanced Detector Development for Synchrotron Radiation

9:00 a.m. – 5:00 p.m. Workshops (see details below)

5:30 – 8:00 p.m. Welcome reception, Poster session, Vendor exhibit

Tuesday May 22

8:00 a.m. – 5:00 p.m. Main Users' Meeting (see details below), Poster session, Vendor exhibit

6:30 – 10:00 p.m. Hawaiian Luau

Wednesday May 23

8:30 a.m. – 5:00 p.m. Workshops (see details below)

Thursday May 24

8:30 a.m. – 5:00 p.m. Hands-on Workshops (see details below)

Poster Session

All scientists, researchers, post docs and students are encouraged to submit posters exhibiting their research at the NSLS for the Poster Session to be held during Annual Users' Meeting. Multiple entries by the same author are permitted. In addition, post docs and students may enter their poster(s) in the Poster Contest. Cash prizes will be awarded and the winning posters will be exhibited in the NSLS Lobby after the close of the Users' Meeting and Workshops. Deadline for poster registration is April 30. http://nslsweb.nsls.bnl.gov/nsls/users/meeting/2001/postersession.htm

Main Meeting

We will have a full day of both scientific talks and updates from numerous funding agencies. Our keynote speaker will be Dr. Jane "Xan" Alexander (DARPA). Confirmed speakers from funding agencies include: Dr. Pat Dehmer (DOE), Dr. Thomas Weber (NSF), and Dr. Judith Vaitukaitis (NIH-NCRR). Moreover, we have a tentative acceptance from Congressman Felix Grucci. We will have a BNL update from Dr. Marburger, and a BES update from Dr. Osgood. Also, there should be a facility update from a new NSLS chairperson! As with all details regarding the meeting please check nslsweb.nsls.bnl.gov/nsls/users/meeting http://nslsweb.nsls.bnl.gov/nsls/users/meeting for the latest information!

About the Workshops

May 21, **Environmental Molecular Sciences** (organized by Richard Reeder/SUNY Stony Brook and Tony Lanzirotti/Univ. of Chicago). Synchrotron radiation sources provide a unique and powerful set of tools in the field of environmental sciences that is revolutionizing our understanding of environmental processes at the molecular scale. The superior intensity and spectral properties of synchrotron radiation, ranging from the infrared to the hard x-rays, enhance the potential of spectroscopy, microscopy, and diffraction methods far beyond the limits set by conventional radiation sources. Although the physics, materials science, and biological communities have made extensive use of synchrotron facilities, the use of synchrotron radiation for environmental studies is still relatively new. There is thus a clear need for ongoing interaction between interested researchers to promote the exchange of new ideas, attract new environmental researchers to these facilities and provide a forum to stimulate innovations in techniques and methodologies. The "Environmental-Molecular Sciences Workshop" is an effort to fill this niche with an emphasis on advances in instrumentation and techniques and on innovative environmental studies.

May 21, **Catalysis Research using Synchrotron Radiation** (organized by Jiangguan Chen/Univ. Delaware). The objective of the workshop is to increase the awareness and to expand the future utilization of synchrotron facilities for catalytic studies. The Speakers, from academic, industrial, and national laboratories, will present their recent results on the in-situ and time-resolved capabilities of the synchrotron techniques for a wide range of catalytic studies. Also planned is a round-table discussion, with invited representatives both from NSLS and government funding agencies, to explore ways to attract more beamline users from the catalysis community.

May 21, **Frontiers in Structural Biology at High-Brightness X-Ray Sources** (organized by Mike Becker & Lonny Berman/BNL). This symposium will focus on (a) evolving X-Ray structural methods in biology (single particles, monolayers, macromolecular folding, and other time-dependent phenomena) that depend on current high-brightness synchrotron sources, and that may be expected to undergo even greater advances with future potential higher-brightness, pulsed X-ray sources, such as hard X-Ray Free Electron Lasers or Photoinjected Energy Recovering Linacs, and (b) new or recent structures of some extremely important membrane proteins by current X-Ray methods, which typically require synchrotron beamlines for satisfactory structure solution, and which are a class of proteins that are notoriously difficult for overall structure determination by any method.

May 23, **Advanced Methods and Tricks of EXAFS Data Modeling** (organized by Anatoly Frenkel/Univ. Illinois). With the development of the *ab initio* theories and data analysis techniques, EXAFS is evolving into a routine materials characterization method, on a par with other well established structural techniques. The goal of this workshop is to demonstrate how to make the most use of the experimental EXAFS signal via smart modeling (beyond the first-shell analysis) and yet not to over interpret the data. In addition, many common mistakes in the data analysis and some common examples of unphysical interpretations of the data, which are often overlooked, will be discussed. The workshop is intended for the broad audience of synchrotron users from all fields of materials science, physics, chemistry, biology, environmental science, engineering etc. who specialize in EXAFS.

May 23, **Nanotechnology: Opportunities in Synchrotron Radiation** (organized by Peter Johnson/BNL Physics and Chi-Chang Kao/BNL NSLS). Nanoscience and technology have attracted considerable attention recently. Indeed they are thought by some to be engine driving the next industrial revolution. The wide range of experimental tools at the NSLS has been extremely valuable in the characterization of bulk samples, and will certainly play an important role in nanoscience and technology. The goal of the workshop is to bring together researchers in nanoscience and experts in synchrotron techniques to explore this exciting opportunity. The scope of the workshop includes synthesis of novel nanomaterials, characterization of nanomaterials with synchrotron and other techniques, and the study of the growth of nanomaterials. In addition, there will be a session at the end of the workshop for participants to discuss their plans in nanoscience, to promote collaborations, and to identify the critical areas in synchrotron technique development.

May 23/24, **IR Micro-Spectroscopy: A Molecular Probe with Micron Resolution** (organized by Larry Carr and Lisa Miller/BNL NSLS). Synchrotron light provides an excellent infrared source for micro-spectroscopy because of its high brightness and broadband nature. Using synchrotron IR micro-spectroscopy, high quality spectra can be collected at the diffraction limit, which is 2-20 microns in the mid-infrared region. This workshop will focus on the benefits of using synchrotron radiation for infrared micro-spectroscopy in many fields of research, including medicine, biology, chemistry, geology, the environment, polymers, and material science. In addition, new techniques for improving spatial resolution will be presented that take advantage of the high brightness of the synchrotron IR source. The NSLS has 6 infrared beamlines, with 3 operating IR microscopes, which will be available for the 2 days that follow the workshop. So if you have a sample you'd like to examine, bring it along!

May 24, **XAFS data reduction and analysis using WinXAS** (organized by Thorsten Ressler, the developer of WinXas/Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin) is a hands-on EXAFS analysis session in the Use of WinXAS. The workshop will focus on the use of the WinXAS software for XAFS data reduction and analysis. Emphasis is put on the graphical user interface to perform both conventional data reduction and advanced data analysis (PCA, higher shells refinement). Examples will be demonstrated step-by-step "on line" (laptop and "beamer") and come from the research areas of materials science, inorganic chemistry, and heterogeneous catalysis. Participants may bring their own laptops and follow the given examples (hands-on, software and data provided). Specific user questions will also be addressed. The workshop is intended for all XAFS users (beginners and experts) who seek convenient and rapid reduction of piles of experimental data and value graphically aided data analysis.

Register online for the
NSLS Users' Meeting and Workshops at
http://nslsweb.nsls.bnl.gov/nsls/users/meeting

Registration Deadline April 30, 2001

First Demonstration of Staged Electron Laser Acceleration (STELLA)

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Introduction

At the BNL Accelerator Test Facility (ATF), an important first demonstration was achieved in the area of laser acceleration. As way of background, intense research is being conducted around the world to find ways to generate high-energy electrons using much higher acceleration gradients than currently possible with microwave accelerators. This is needed for future elementary particle research where >100 TeV electron energies are desired and for enabling the development of more compact and less expensive accelerators for applications such as industrial processing, medical therapy, and materials research. These latter applications would benefit from an accelerator with 100's MeV to ~1 GeV electron energies, which might fit within a small room.

Lasers have demonstrated the ability to accelerate electrons with gradients >100 GeV/m[1], which is over 1,000 times greater than possible from microwave sources. Indeed, at the ATF routine laser acceleration has been achieved using inverse Cerenkov acceleration (ICA)[2] and inverse free electron laser (IFEL)[3] acceleration. Until now the laser acceleration process has been only over limited distances and no one has demonstrated that the laser can repeatedly accelerate the electrons in a staged fashion as is done in microwave accelerators. Staging is necessary if high net energy gain is to be achieved. In a proof-of-principle experiment, the Staged Electron Laser Acceleration (STELLA) Experiment at the ATF is the first to demonstrate that such staging is possible. This experiment involved the collaboration between BNL, industry, and universities.

Three critical requirements were necessary for this staging demonstration. First, electrons in the electron beam (*e*-beam) produced by the ATF microwave linear accelerator (linac) had to be organized into a train of very short bunches whose lengths are a fraction of the laser wavelength. STELLA used the ATF high-power CO_2 laser (l = 10.6 μm); hence, these short bunches, called microbunches, needed to be ~1 μm or less in length. Traveling at nearly the speed of light, they are equivalently only several femtoseconds in length.

Second, the staged laser accelerator system had to be designed to minimize lengthening out of the microbunches (referred to as bunch smearing) while traveling through the system. Bunch smearing can be caused by electrons within the microbunch traveling different path lengths and by electrical repulsion forces (space-charge) causing the electrons to spread apart.

Third, staging requires femtosecond accuracy in the control and stability of the microbunches as they travel through subsequent laser acceleration stages in order to stay properly synchronized with the laser wave inside the stages. This process is called phase synchronization where the electrons are confined to a limited portion of the laser wave. The phase delay, mentioned later in this article, refers to the time delay measured in degrees of the laser wave length between the laser beam and microbunches arriving in the second stage.

Description of Experiment

The first laser accelerator stage in STELLA served the function of generating the train of microbunches and is called a prebuncher. The prebuncher is an IFEL using a permanent magnet wiggler designed and built by STI Optronics. A photograph of the wiggler is shown in **Figure 1**. The wiggler consists of a planar array of uniformly-spaced magnets with a period of 3.3 cm and a total length of 33 cm through which the *e*-beam and CO_2 laser beam copropagate. The electrons take oscillatory trajectories through the wiggler, which introduces a transverse velocity component in the same direction as the linearly-

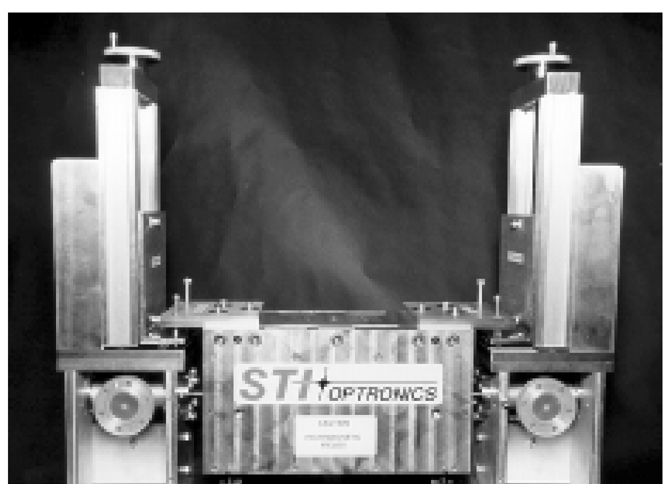

***Figure 1**. Photograph of permanent-magnet wiggler used in the STELLA IFEL.*

polarized laser field aligned to the electron wiggle plane. At resonance, the electrons stay synchronized with the optical field and continuously acquire net energy exchange.

To create the microbunches, the prebuncher modulates the energy of the incoming electrons by approx. 0.5%. The *e*-beam pulse coming from the ATF linac (set at 45.6 MeV for STELLA) is 3 ps long, which is short compared with the laser pulse (180 ps), but long compared with the laser field oscillating every 35 fs. This means in the prebuncher some of the electrons experience accelerating fields, some decelerating fields, and some little field. If allowed to drift downstream from the prebuncher, the accelerated electrons catch up with the decelerated ones, thereby forming microbunches. (Note, this particular scheme permits a maximum of 50% of the electrons grouped into the microbunch. The rest are distributed over all phases of the laser wave.)

The second laser accelerator stage in STELLA is another IFEL using an identical wiggler as the prebuncher. It is located 2.3 m downstream of the prebuncher at the drift distance where the electrons form into microbunches after leaving the prebuncher. In between the prebuncher and second stage are three quadrupole magnets (called a triplet or *e*-beam focusing lenses) for focusing the *e*-beam into the second stage. A schematic of the STELLA beamline showing these major components is given in **Figure 2**. The *e*-beam energy spectrum is measured using a special wide-energy acceptance spectrometer designed by the ATF.

The pulsed ATF CO_2 laser beam is split into two beams with approx. 24 MW peak power sent to the prebuncher and approx. 200 MW peak power sent to the second stage. An adjustable optical delay stage in the laser beam transport to the second stage provides gross phase delay control and a rotating delay plate (not shown) provides fine control. Mirrors located inside the vacuum pipe reflect the focused laser beams inside the wigglers. A central hole in these mirrors transmits the *e*-beam.

Sample Experimental Results

Figure 3 shows raw data from the energy spectrometer where energy increases from left to right. **Figure 3**(a) shows the *e*-beam with the laser off. It indicates the *e*-beam has an intrinsic energy spread of approx. 0.04%. In **Figure 3**(b), the laser is on and the phase delay has been adjusted to achieve maximum energy gain. We see an intense signal to the right in the figure indicating the acceleration of the microbunch electrons. (The rest of the spectrum are electrons outside the microbunch that are interacting with the laser field in the second stage.) In **Figure 3**(c) the phase delay is set 180° from **Figure 3**(b), which should cause the microbunches to experience a decelerating laser field and, indeed, a strong signal is seen to the left.

Figure 3 shows our ability to create the microbunches and phase synchronize the microbunches with the laser field in the second stage, thereby demonstrating the crucial features of staging.

It is possible to extract more details of this process by comparing the energy spectrum with a 3-D computer model developed for STELLA. The model includes all major effects including 1-D longitudinal space-charge, *e*-beam emittance, and possible misalignment of the *e*-beam and laser beams along the beamline. The model results, shown shortly, used 5,000 electrons.

Figure 4 compares the model results with the data for the case of maximum acceleration of the microbunch. **Figure 4**(d) is the raw output from the spectrometer and is also plotted in **Figure 4**(c). Overlaid on the data spectrum is the model energy histogram where the areas under the curves have been made equal. This energy histogram originates from the phase-space plot [**Figure 4**(a)] generated by the model, which tracks the evolution of the 5,000 electrons and provides detailed information on the coordinates of each electron along the system. In **Figure 4**(a), each electron is represented by a point in a pair of conjugate coordinates; in this case, energy and time (or energy and phase) measured relative to a reference energy and phase. Projecting this plot onto the energy axis produces the energy spectrum measured by the spectrometer. Projecting **Figure 4**(a) onto the phase axis gives the electron distribution in the longitudinal direction [**Figure 4**(b)]. Since 2π of phase corresponds to the laser wavelength (i.e., 10.6 μm), this longitudinal distribution corresponds to the microbunch length. Indeed, **Figure 4**(b) indicates the bunch length is ~0.6 μm (full width at half maximum) or ~2 fs.

Further Discussion

The microbunch electrons seen in **Figures** 3(b) and **Figure 4** are still immersed within the background of elec-

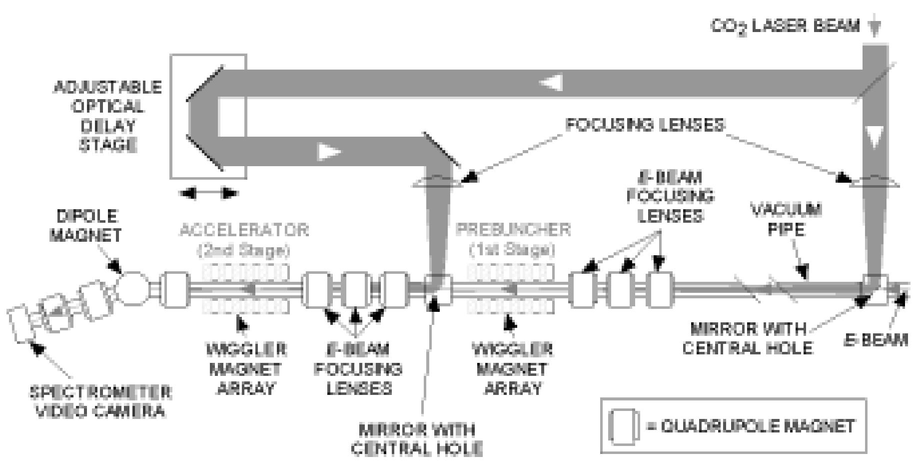

***Figure 2**. Schematic layout of STELLA experiment on Beamline No. 1 of the ATF.*

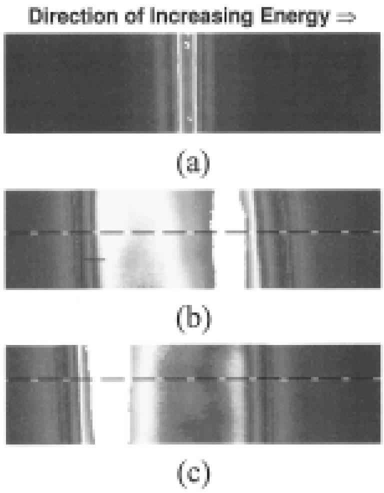

Figure 3. *Raw video images from electron energy spectrometer. (a) Laser off. (b) Laser on and phase delay adjusted for maximum acceleration. (c) Laser on with phase*

trons not part of the microbunch. In a practical laser accelerator linac it will be important to separate the microbunch electrons from the background ones so that monoenergetic laser acceleration occurs, i.e., the microbunches are separated and have narrow energy spread. This separation is not possible with the untapered wiggler used in STELLA. Using a tapered wiggler, in which the gap between the magnet array decreases along the wiggler, and using higher laser power will allow this separation to occur while maintaining narrow energy spread.

The wiggler length is also too short to permit oscillation of the microbunch electrons within a confined phase and energy range (so-called synchrotron oscillation). This means the microbunch electrons are not trapped in the second stage, but the phase synchronization we demonstrated shows that trapping should be possible.

The data shows a high degree of repeatability in which the phase delay can be adjusted back and forth over a period of many minutes. This demonstrates our ability to maintain stable phase control on the few femtosecond level. This is quite remarkable in light of the fact the laser beam injection points for the prebuncher and second stage are separated by 6 m, optical elements are on separate supports, the transport lines are not evacuated nor tightly enclosed, and no active phase stabilization is used. It is important to note that the relatively long wavelength of the laser helped reduce the precision needed for phase control and the stability requirements. A shorter wavelength laser, such as 1.06 μm, would have 10 times more stringent requirements for phase control and stability.

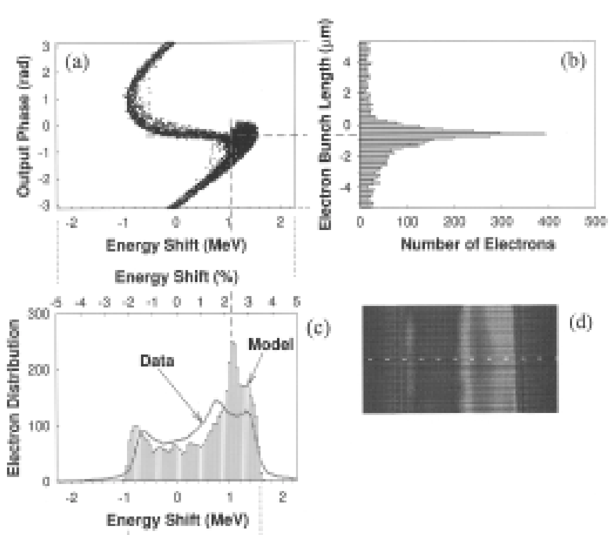

Figure 4. *Comparison of staging results with model for phase delay corresponding to maximum acceleration. (a) Model-predicted electron output phase versus electron energy. (b) Model-predicted electron bunch length. (c) Electron energy spectrum. (d) Raw spectrometer output for data plotted in (c).*

The maximum acceleration gradient observed during STELLA is a modest approx. 7 MeV/m; however, it was not the primary purpose of STELLA to demonstrate high acceleration gradients. Gradients of ~100 MeV/m are possible with 1 TW laser power and using a tapered wiggler. The ATF is in the process of upgrading their CO_2 laser to eventually produce 1 TW. However, in the near-term, proposed future experiments on STELLA will concentrate on demonstrating monoenergetic laser acceleration at moderate acceleration gradients.

Conclusion

STELLA accomplished a number of firsts including first demonstration of a laser-driven prebuncher staged with a laser-driven second stage; first direct measurement of ~2-fs microbunches produced by a laser external to a wiggler; first demonstration of laser-generated microbunch acceleration with phase control stable over periods of many minutes; and first demonstration of laser-accelerated microbunches where a large portion of the electrons receive maximum energy gain. This last achievement is noteworthy because laser acceleration experiments to date typically only accelerate a small number of electrons within a narrow energy spread.

Acknowledgement

The authors wish to acknowledge the helpful support of Dr. Xijie Wang and the staff at the ATF. This work was supported by the U.S. Department of Energy, Grant Nos. DE-FG03-98ER41061, DE-AC02-98CH10886, and DE-FG03-92ER40695.

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About Radiation Badges . . .

Wear your Radiation Badge as shown at the left. . .

which means it must be . . .

- ✳ fully visible (not covered)
- ✳ between your neck and belt
- ✳ with the yellow or blue color bar facing out

Always wear your radiation badge when working in a Controlled Area.

For Temporary Radiation Badge users: If you are working at the NSLS over a badge exchange weekend, go to User Admin. or the NSLS Control Room to return your old badge and sign out a new one. When your experiment is finished and before you leave, always put your radiation badge in any “Returned Badge” box located near the badge boards.

Reminders About User Obligations ....

Pre-Register for Every Visit: All NSLS Users are required to pre-register with NSLS User Administration prior to each visit so that BNL gate security personnel is notified of your arrival. To access the online pre-registration form, go to URL: http://nslsweb.nsls.bnl.gov/nsls/dbforms/user-regis.asp. Please provide this information at least 7 days prior to your arrival at BNL.

Foreign Nationals: All foreign nationals must file Form IA-473. Go to URL: http://nslsweb.nsls.bnl.gov/nsls/users/procedures/foreign.htm.

First-Time Users and Those with Expired Appointments: First-time users and users whose appointments or training have expired are requested to arrive at NSLS User Administration Monday through Friday before 3:00 p.m. to allow ample time to register and receive training. Thank you.

BNL Weekend Food Service ....

The Cafeteria now serves breakfast foods and sandwiches from 7:30 a.m. until 2:00 p.m., both Saturdays and Sundays.

BNL Onsite Shuttle and Courtesy Van for Users and Staff....

An onsite shuttle is available weekday mornings from the apartment area to onsite facilities and door-to-door from 8:45 a.m. to 4:15 p.m. For more information, see their website: http://www.bnl.gov/bnlweb/shuttle.html

X-Ray Ring Status

Jeff Rothman,
X-Ray Ring Manager

During the year 2000 winter shutdown, the mechanical group replaced stainless steel fast valve blades with molybdenum blades due to the higher current and energy in the X-ray Ring. The beam is now intense enough to melt through the stainless steel blades in a short period of time. A new water-cooled mask was installed at X6 in preparation for the new N.I.H. beamline. The experimental water system was upgraded with new high flow water spigots with the option of adding additional connections, and polyflow tubing was replaced with copper pipe to improve reliability and reduce maintenance. In order to reduce downtime, air solenoids were moved outside of the ring so repairs can be made without breaking ring security. Control and monitoring of the air system was upgraded from pneumatic to digital units. An interlock was added to the air system to reduce moisture when the system switches over to site air.

The RF group modified the output transmitters that drive the RF cavities. The tuning plate assembly, designed by the vendor, provided poor RF contact, causing arcing and subsequent transmitter failure. The RF group increased the tuning plate thickness to ¼", improved the sliding contacts, and added cooling channels. These upgrades allow the transmitters to operate at higher power with less heating, increasing output power from 125kW to 150kW. One of the difficulties associated with adjusting these transmitters is that the tuning of the output stage is temperature dependant and can induce beam instabilities if the heating is excessive. Reducing the operating temperature simplifies maintenance and improves reliability.

In addition to preventative maintenance, the diagnostics group completed wiring for the digital feedback system. Studies and commissioning of the system can now proceed for both horizontal and vertical planes. Cables and mounting hardware for the loss monitors were installed and additional test stands for LVDTs were installed to monitor beam pipe motion. R&D is underway to improve the beam position monitors. We are investigating a low noise front end with the potential of improving the resolution by a factor of 10, giving a 2.4uM resolution in a 2kHz bandwidth. We are also working on a data acquisition/control card for the power supplies that will allow the supplies to automatically flag fault conditions and capture waveforms.

Other work included improved read-backs for the X-ray defocusing quadrupole supply and the installation of Programmable logic controllers (PLCs) to improve diagnostics, interlocking, and control of power supplies. The original hand-wired interlock boards at X12 have been replaced with printed circuit boards.

The X29 vacuum exit chamber could not be installed due to a tight schedule and delays acquiring the 2219 aluminum alloy used in fabrication. Installation of the chamber has been postponed until the 2001 winter shutdown. This chamber is identical to the ones planned for installation at X9 and X13, incorporating exit ports at 0°, 3.5°, and 10°. Installation of the new IVUNs can begin after these chambers are installed.

Since vacuum was not broken in the ring, commissioning proceeded smoothly and lasted only two weeks. The first week of commissioning focused on equipment start-up and the second week was dedicated to machine conditioning. Operators turned the beam over to users one week early.

VUV Ring Status

Stephen Kramer
VUV Ring Manager

The VUV Ring came back on schedule from the winter shutdown. Unfortunately some of the major work was not accomplished due to problems in the spare ceramic gap construction. The manufacturer welded two monel transition metal rings instead of one monel and one stainless steel ring. This error was only detected when the BNL shop was unable to weld to the monel ring. A major effort has begun to obtain new spare ceramic gaps, not an easy task since there are few companies able to perform these welds. Since the ceramic gap couldn't be replaced, the vertical stripline, in the same period of the ring, was also not replaced. However, the connector was removed from the bad electrode of this stripline, without creating a vacuum leak. The connector was destroyed by arcing of the outer conductor, creating a high impedance to ground from the melted metal. The beam induced currents caused this connector to heat up, created an unknown impedance on the beam. Fortunately, there was enough clean metal on the center pin of this connector that the forward power port of the stripline could be shorted to ground. This reduced the potentially dangerous impedance on the beam but still prevented the stripline from being used in the longitudinal feedback system. At present, the plan is to replace the ceramic gap and vertical stripline during the May shutdown. This will require almost a month of maintenance and will mean there will not be beam until the User Workshops.

The horizontal stripline was replaced during the shutdown and has been working as part of the longitudinal feedback system. The higher order mode damping antennae were inspected and although no major problems were found, the picket fence instability threshold has been increased significantly. This should allow timing experiments to be performed with higher beam current. Other work performed during the shutdown, was an improvement in diagnostics on the BPM's and trim magnets that will allow measurements of fast beam motion and glitches that occur during operations.

Focus On . . User Administration

Mary Anne Corwin
User Administrator

So, what's new in User Administration? Many changes in staffing, office configuration, and electronic office automation have taken place this past year and several other changes related to training and guest services are in progress.

Staffing

User Administration staffing took on significant changes this year with Linda Feierabend moving over to a new position at Physics and Eileen Pinkston retiring after 20 years at the lab. We all wish Linda and Eileen well in their new endeavors.

In October, Gretchen Cisco joined our staff having provided administrative support to the Reactor Division and to the Department of Energy Brookhaven Group while working for DOE contractors prior to her arrival. Wendy Spaeth is new to the laboratory and joined our staff in December.

NSLS User Administration Office Staff. Top row (left to right): Gretchen Cisco, Mary Anne Corwin, Lydia Rogers. Bottom row (left to right): Nancye Wright and Wendy Spaeth.

The new staffing changes provided an opportunity to increase productivity and improve services by reorganizing the functions and responsibilities within the office. In Lydia Roger's new role as Deputy User Administrator, she supervises and trains other staff, coordinates the annual Users' Meeting and the Users' Executive Committee and Town Meetings, and will be working directly with PRTs concerning progress reports, agreements, MOUs and tenure reviews. She will continue to hold the anchor role for the abstract system.

Nancye Wright continues to be the Production Assistant and primary contact for the Activity Report, publication references, the NSLS Newsletter, the Community Directory, and the Operations Directory. Nancye is also the Users' Meeting Vendor and Exhibit Coordinator.

Gretchen has a very important role as General User Proposal Program Coordinator, working with users, PRT members, the Proposal Study Panel and the Allocation Committee to manage the proposal program. She also serves as primary contact for proprietary use of the NSLS, email lists and summer housing for users.

Wendy's position was modified to better serve users and to provide more continuity and less interruption throughout the office. Her principal role is to assist users in user appointments, registration, training, badging and user agreements. She maintains the BLOSA and Safety Approval Form data. Her accounting background will benefit the office in generation of reports.

Office Renovation and Training

Another significant change has been the office renovation that took place during this winter's shutdown. Oddly, several staff members and users have commented, "So, what's changed?" While it may appear at first glance that little has changed, a very important goal was achieved—the training room is considerably larger and will now accommodate eight users for registration and training. Training will no longer be accomplished by viewing a video and reading the Users' Guide. All training is PC-based (mainly web). Several other modifications were made to increase functionality of the office.

On the subject of training and the Users' Guide, Section 6 of the Users' Guide will be removed. The official training documentation will be contained on the web. One final anticipated goal for training this year is to open it to offsite web access.

Office Openings and Closures

To improve the efficiency of our office and to remove some of the burden on the Operations Coordinators, the User Administration office will be staffed on those holidays on which we are in operations (Martin Luther King Jr. Day, Presidents' Day and Veterans Day). To improve user services, the User Administration office will close each Wednesday (except during weeks when operations begin on a Wednesday or Thursday) from 2:00 to 2:30 for staff meeting.

NSLS Website and Office Automation

The NSLS website took on a new look this year, a new home page and a new web address. Be sure to bookmark our new site at nslsweb.nsls.bnl.gov. Most of the files have been moved from our older server to the new one. This project is near completion.

The new server and software have given us capabilities only previously available by hiring a consultant or through BSD. It is now possible to create online forms with many applications. Electronic office automation in the User Administration office continues to move forward. Online submissions forms were completed and put into production for publications references and abstracts. The new abstract system now uses Word and is much more simple to use.

With the new move to the PC-based webserver, each beamline has been given a website of their own so that information about the beamline can be maintained more effectively. Completion of the beamline web project will take place mid-year.

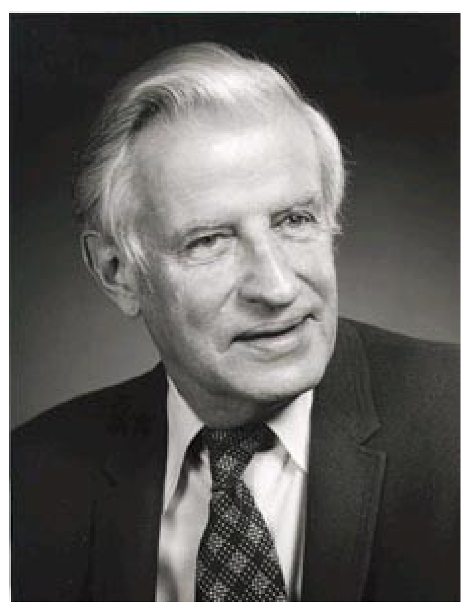
BNL has implemented a new guest information database which allow users to register for their appointment online, offsite. Though the NSLS has had its own database for nearly a decade, we have been asked to link up to BNL's databse. Our database, however, has considerable Light Source specific information and the link up is not quite so simple. The initial framework has been completed and we anticipate to be fully operational in the Spring.

FTP Site

A FTP site has been set up for users to transfer research data files back to their institution that were created while performing experiments at the NSLS. No special access is needed and you log on anonymously. For more information, speak with a beamline staff member or contact NSLS User Administration.

John Blewett 1910-2000

Accelerator pioneer John Blewett died on 7 April, just a few days short of his 90th birthday. Born and educated in Toronto, he completed his PhD at Princeton in 1936. After a postdoctoral year at the Cavendish Laboratory in Cambridge, in the twilight of the Rutherford era, Blewett worked at General Electric's Research Laboratory from 1937 until 1946. There, in 1945, he calculated that the energy of a beam of circulating electrons should lose energy through the dissipation of radiation, resulting in a tiny reduction in the radius of the electron orbit. Following this prediction, "synchrotron radiation" was duly observed at General Electric in 1947.



John Blewett 1910-2000

Meanwhile, in 1946, Blewett had moved to Brookhaven, where he stayed for the remainder of his long and active career. He contributed to the development and construction of a series of major machines at Brookhaven - the Cosmotron, the Alternating Gradient Synchrotron (AGS) and the Light Source, as well as working for the Isabelle collider. Blewett proposed applying the principle of strong focusing to linear accelerators immediately after the invention of this principle for synchrotrons in 1952.

From 1953 until 1954, at the invitation of CERN machine pioneer Odd Dahl, Blewett worked with the small group designing CERN's Proton Synchrotron. US Cosmotron experience and the design approach for the new AGS were thus integrated into European thinking. In 1993 Blewett was awarded the American Physical Society's Robert R Wilson Prize.

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Safety & Compliance: Cryogens in the Hutches

Andrew Ackerman and Bob Chmiel

Many of you may have heard or read about a researcher who was overcome by an oxygen-deficient atmosphere in a New York City hospital last year. Boil-off from a liquid nitrogen system accumulated in a small room and when the person entered the area, he became unconscious and ultimately died. This incident prompted us to consider the risk presented by use of liquid helium and liquid nitrogen in our X-ray beamline hutches. Both these cryogens are in common use on our experimental floor and, occasionally, dewars, cryostats, or superconducting magnets are brought into the hutches. The hutches are essentially small rooms isolated from the large volume of the experimental hall. So, do they provide sufficient containment for an inert gas boil off from a spill or leak to create an oxygen-depleted atmosphere?

There is certainly adequate cryogen volume in some of these systems to push all the air out of an average hutch if the liquid rapidly expands to gas. However, the hutches are not sealed, most have fans, and all of the liquid will not instantly boil off. Since oxygen concentrations in the hutch will depend on evaporation and ventilation rates, and the size of the hutch, more information is needed to answer the question.

Let's make a few assumptions. Suppose a dewar fails or a magnet quenches and 100 liters of cryogen are released over 20 minutes into the hutch. We did a quick survey of our hutches to see how big they are and to check if they are equipped with a fan. They vary, but most have a volume of about 23 cubic meters and most have 10-inch fans on their roofs, which have rated outputs of 17 cubic meters per minute. All the hutches have ample openings to allow good airflow. The 100 liters of liquid cryogen will become about 80 cubic meters of gas. If the boil-off really occurs in just twenty minutes, the hutch will fill at a rate of about 4 cubic meters per minute. If the fan is on, drawing air through the hutch at 17 cubic meters per minute, there is no asphyxiation hazard. If the fan is off, the oxygen concentration is more likely to be affected. With helium, any reduced oxygen concentrations will not be sustained for long. With nitrogen, the risk is greater. Cold nitrogen gas will tend to accumulate around the release point. It will mix with the surrounding air. The small air movements always present from the building ventilation system and personnel movement will help, but the volume of the hutch could become oxygen depleted while the release is occurring and for some time after. Exactly how low the levels will go and how long that will be sustained is difficult to estimate.

Oxygen deficiency risks must be respected. Ensuring that the hutch fan is operating before moving cryogens into a hutch and opening the hutch door during a release will significantly reduce the risks. An interesting fact to note is that exposure to low oxygen atmospheres often presents no warning to the individual exposed. Depending on the concentrations, you can become confused and lose consciousness very quickly and never know what happened. A person breathing an oxygen deficient atmosphere will not experience any choking feeling and may have no clue that things have gone bad.

Here are a few points to keep in mind: if you experience a rapid release inside a hutch or other enclosed space, do not enter alone. Call Operations for help, ventilate the area, and wait for good mixing and for the cryogen supply to deplete. Operations has a handheld oxygen meter that can help. In most cases we can easily blow the inert gas away and avoid any injury. Also be sure to identify the use of cryogens in hutches on your safety approval form. There may be situations where special precautions will be needed.

Safety & Compliance: Magnetic Fields

Nicholas Gmür

Magnets are used in many types of equipment at the NSLS, ATF and SDL. These devices typically generate strong magnetic fields within their working volumes and may also produce significant fringe fields. Personnel with medical electronic devices should be particularly aware of areas where fringe fields can be 5 gauss or greater, e.g. in the corridor near the klystrons opposite the NSLS Control Room. This location and all doors leading into the NSLS, ATF and SDL experimental areas are posted:

CAUTION
Electric or Magnetic Fields
May Affect Cardiac Pacemakers
Or Other Medical Implants

Higher fringe fields may require additional postings or controls, such as the use of non-magnetic tools, to protect against hazards. For this reason, any magnetic devices being used for experimental purposes must be fully detailed in your Experimental Safety Approval Forms.

Examples of equipment at the NSLS, ATF and SDL where one might find fringe magnetic fields are: klystrons, ion pumps, wigglers and undulators, ring magnets (dipoles, quadrupoles, sextupoles, etc.), and superconducting magnets for dewars and experimental use.

BNL procedures provide industrial safety guidance for posting magnets so as to alert personnel to the presence and magnitude of these external fringe fields.

Contact NSLS ES&H staff for magnetic field surveys, postings or other guidance.

Note: If you are giving a tour, always ask the members of your group if any of them have medical electronic devices. "Magnetic Fields" are called out on the Visitor/Escort forms.

Facility Update

Frank Terrano

Assistant to the Chairman

User Offices in Building #535

It's happening! The much awaited office/lab spaces in Building #535 are finally becoming available for NSLS Users. The original plan to move our users from their offices on the third floor of Building #510 to Building #535 is still in effect. Delays caused by difficulties in finding adequate space for the groups moving out of #535, were further complicated by having to refurbish some of those spaces before the moves could take place. We sincerely regret any inconveniences that these delays may have caused to our users, but we are also happy to announce that the process has begun, and several offices in #535 have already been turned over to us. As many of you know, Building #535 is connected via tunnel to the NSLS experimental floor. This should make for a much more convenient location for our users, and bring the community back into one main area again.

The plan is to ultimately move all of our users from #510, including those who were temporarily located in Building #129, into Building #535. Spaces in #535, originally assigned to individuals or organizations moving into the building, will remain in effect. Some adjustments have been necessary, for people who have come and gone since the room assignments were originally made. Naturally, we will make all the necessary arrangements to have belongings, telephone and network connections, etc., moved from the old offices to the new ones, and our users will be exempt from any costs associated with this move.

BNL has committed to have the bulk of the rooms in #535, made available to NSLS Users between now and the end of June. Users affected by the moves will be contacted throughout this period as their offices become ready for occupancy. If you have any questions regarding this move, please contact either Frank Terrano at extension 3963, e-mail terrano@bnl.gov, or Gerry VanDerlaske at extension 3476, e-mail gerryv@bnl.gov.

We thank those of you involved, for your patience, and hope you will enjoy your new locations.

Library/User Lounge Upgrades

In response to suggestions from a recent User survey, equipment in the NSLS Library/User lounge, on the experimental floor, has been upgraded. A new computer was installed, with Windows NT (so that programs will remain consistent), and the copier and fax machines have been replace with one unit that does both, and will provide copies and faxes at a faster rate. Ethernet connections are also provided for laptops, on the platform in the front of the room as well as in the rear alcove by the computer.

New General User Lab

In response to the growing demand for laboratory facilities on the experimental floor at the NSLS, construction of a new General User Laboratory in room 1-110 began in the early fall of 2000. Equipped with standard lab furnishings, including fume hood, sinks and de-ionized water, the new laboratory is slated for completion around March 2001. Room 1-110, which was previously used for short term storage, is located in the northeast corner of the experimental floor, adjacent to the NSLS Library/User Lounge. This will bring the total up to five General User labs available to our research community in Building #725.

Sound Abatement

As part of our ongoing sound abatement effort, over the past year we have installed some 550 sound absorption panels throughout the X-ray and VUV experimental areas. Panels have been affixed to sawtooth walls and outer walls behind the beamlines as well as atop and below the cable trays radiating out from the rings between the beamlines. They have also been attached to hutches and wherever else we found large flat sound reflective surfaces. Approximately fifty remaining panels have been earmarked for installation around the newly renovated hutches in the X6-A&B and X20-A/B/C areas. User feedback has been quite positive thus far, and we will continue our efforts wherever we determine improvements can be achieved.

Credit Cards for Users

During the past year the “Electronic Mall” was established at BNL to provide an on-line vendor to carry stationary items, which had been discontinued in BNL's central stockroom. On- line vendors for electronics are slated to follow shortly. In response to NSLS User requests, BNL began issuing credit cards to Users, to allow for ordering stationary via on-line catalogs, as well as other materials directly from vendors. The process generally takes only a few days to get a credit card, after completing the mandatory training that all credit card holders are required to have. Users wishing to have a BNL credit card must have an established account at BNL, before a card can be issued. BNL credit cards are required to use the new on-line catalogs, however, users with credit cards from their home institutions may still continue to make direct purchases with outside vendors, on their own cards, as before.

Lobby Upgrades

During the December shutdown, upgrades were made to the video wall in the main lobby of Building #725. The original matrix of nine 25” CRT video screens, used for displaying highlights of the facility, machine parameters for the X-ray & VUV Rings, video presentations and events telecast from Berkner Hall, has been replaced with new flat screen technology. The new system is PC driven which also enables us to display Web based images and information, as well as CD-Roms. The lobby touch screen directory located to the left when entering the front entrance is slated for the next upgrade.

User Convenience

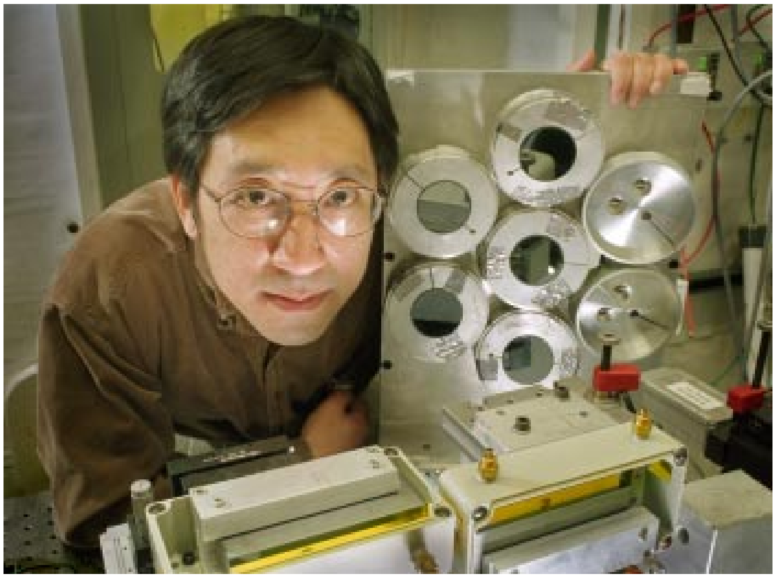
A new coffee machine and a new food vending machine have been added in the main lobby area of Building #725. These machines will compliment the existing food and coffee machines on the (opposites) north end of the experimental floor, by the room #129 kitchen area.

Mimicking Conditions at the Center of the Earth

Diane Greenberg, Brookhaven National Laboratory/Public Affairs

At the National Synchrotron Light Source (NSLS), researchers are using a newly modified instrument C a diamond anvil with a beryllium gasket C to exert high pressure on transition metals, such as iron, cobalt, and chromium, to study their electronic structure. To understand the geophysics of the earth, the scientists hope to mimic the conditions at the center of the earth, where such transition metals are under extremely high pressure.

Chi-Chang Kao, a physicist in the NSLS Department, explained this research in more detail in the Brookhaven Lecture on Wednesday, January 31, at Berkner Hall. The title of the lecture was AA Softer X-Ray View Into the Diamond Anvil Cell: Electronic Structure of Materials Under High Pressure.



Chi-Chang Kao, NSLS, studies the electron structure of transition metals using a newly modified instrument C a diamond anvil with a beryllium gasket.

David Mao of the Carnegie Institute invented the diamond-anvil method in the 1960s, but, until this time, only high-energy x-rays or lasers were used for light source studies. With Mao, Kao recently designed a beryllium gasket for the anvil. Then, Kao and James Ablett, University of London, developed microfocusing optics to focus the x-rays into the diamond anvil cell.

These modifications to the diamond anvil enabled Kao to use softer x-rays for x-ray spectroscopy studies, thus enabling him to determine the electronic structure of the transition metals under high pressure.

A month after earning his Ph.D. in chemical engineering from Cornell University in 1988, Kao started as a postdoctoral research associate at BNL. He became an assistant physicist in 1990, associate physicist in 1992, and physicist in 1994. He was awarded tenure in 1997.

The Frontier: A Workshop on Nanoscience and Technology

Peter Johnson, Brookhaven National Laboratory/Physics Dept.

The discoveries of the 20th Century allow the engineering of a whole range of new materials at the atomic level. As such, it is widely anticipated that nanoscale materials will be one of the cornerstones of technology in the 21st Century. In response to this, and to the increased call for research proposals in the area of nanoscience, a workshop was recently held at Brookhaven to bring together interested parties in the North East. Organized by Peter Johnson of the Physics Department, this one day event held in December brought together researchers from BNL and from Columbia, Princeton, Rutgers, Stony Brook and Connecticut Universities. Lucent Technologies and IBM were also represented.

The speakers, who included Stan Wong (Stony Brook), Kostya Likharev (Stony Brook), Chi-Chang Kao (NSLS), Chris Jacobsen (Stony Brook), Horst Stormer (Columbia/Lucent), Emilio Mendez (Stony Brook), Bill Russel (Princeton), Irving Herman (Columbia), and Chuck Black (IBM), covered a range of topics from the fabrication of nanoscale systems through to the potential application in a arnge of areas including magnetic storage, catalysis and electronic devices. The attendees were introduced to the capabilities existing at the different institutions and also made aware of the user facilities available at BNL. In particular the NSLS was highlighted in talks from Chi-Chang Kao and Chris Jacobsen.

The NSLS is expected to play a particularly important role in any future plans for Nanoscience at BNL. Indeed a proposal has been submitted to the DOE for a completely new building providing fabrication and characterization facilities for nanoscale systems. This building will be constructed immediately adjacent to the NSLS with direct access to the relevant beamlines.

The speakers and session chairmen shown in the photograph include (Front Row from left) Stan Wong, Joe Budnick (U.Conn), Kostya Likharev, Chi-Chang Kao, Rick Osgood (Director's Office), (Middle Row) Chris Jacobsen, Horst Stormer, Emilio Mendez, Louis Brus (Columbia), (Back Row) Bill Russel, Irving Herman, Andy Millis (Rutgers University) and Chuck Black. Sitting in the foreground is Peter Johnson the organizer of the workshop. In the background is an architectural drawing of the proposed Nanocenter to be sited at BNL.

BNL's Science & Technology Awardees Honored

BNL's Science & Technology Award recognizes distinguished contributions to the Lab's science and technology mission over one or more years. Among this year's winners were Ilan Ben-Zvi (NSLS/ATF) and Peter Johnson (BNL/Physics and a user of the NSLS)

Ilan Ben-Zvi

Ilan Ben-Zvi, National Synchrotron Light Source and Collider- Accelerator Departments, is recognized internationally for his outstanding leadership and technical innovation in the construction and operation of BNL's Accelerator Test Facility and its user program. His contributions include the development of high-brightness electron beams and advanced diagnostics for their characterization, the development of the BNL photocathode radio frequency electron source, the measurement of the emittance of time-slices of the electron bunch, and the tomographic measurement of electron phase-space distributions.

Peter Johnson

Peter Johnson, Physics Department, an internationally recognized leader in surface science and photoemission spectroscopy, heads the Physics Department's Electron Spectroscopy Group. His contributions include developing experimental techniques for inverse photoemission and spin-polarized photoemission, and the application of angle-resolved photoemission spectroscopy to the study of high- temperature superconductivity. Johnson and his group were the first to demonstrate that a new type of analyzer developed by SCIENTA can be operated to allow parallel collection of data as a function of both electron momentum and energy, substantially improving the energy resolution and data-collection rates.

BNL Award recipients Charles Springer, Peter Johnson, Ilan Ben-Zvi, Toshi Sugama, and Thomas Roser

Users' Perspective

Mark Chance
Albert Einstein Coll. of Medicine & UEC Chair

As this goes to press we have just had a Town Meeting on February 7, serving as our regular forum for user concerns. A number of important and interesting issues were presented and discussed. As always, the Users Executive Committee wants to make sure that user's concerns are transmitted to NSLS and BNL management and staff and, where possible, resolved. Please feel free to contact me (mrc@aecom.yu.edu) or the Vice-Chair, Simon Bare (srbare@uop.com) at any time to voice your ideas and concerns.

The meeting started with a report from NSLS management provided by Erik Johnson, Head of the Experimental Systems Division. Dr. Johnson outlined the continued growth in the user base that occurred in 2000, with 2551 users active in the year. The numbers indicate the continued increases in Life Science users (+8%) to over 950 but encouragingly also shows a increase in Materials Science users (+3%). Other categories showing strong growth from modest bases are Geosciences and Ecology (+20%) and various physics categories (+17%). Dr. Johnson also provided a breakdown of user categories in terms of beam-days used, experiments performed, and publications. This showed that Materials and Chemical sciences, the bread and butter focus areas of DOE's Basic Energy Sciences program, utilize 52% of the beam-days and account for 54% of the publications. Clearly, these programs are central to the NSLS's activities. Breakdowns in terms of user's funding for their experiments also showed a plurality of experimenters had DOE funding (37%), while about 15% had funding from NSF and about 10% had funding from either NIH or industry. These statistics are part of a self-evaluation leading to an upcoming DOE review of the NSLS that is to take place this summer. The user community will be playing an important part in this review.

Dr. Johnson also presented an overview of the NSLS strategic plan (formerly called Phase III). He pointed out the significant progress made in a number of areas despite the lack of funding increases over the last five years. Two areas that have not received attention up to this point concerned beamline control systems and user office space. The latter is being addressed with substantial funds from BNL to build out part of the second floor to provide needed space. In addition, the long awaited moves of users to office spaces promised in the adjacent building 535 are beginning immediately and are likely to be completed this year. As usual, the Space Committee will review user space needs and should be consulted directly by users.

In terms of beamline control systems, the news is less encouraging. CAMAC based control systems are rapidly losing support from the vendor community. A recent survey of beamlines conducted by Steve Ehrlich shows that nearly 150 E-500 motor indexers are in use with about 30 spares existing around the rings. Thus, the user community is still dependent on these systems. The UEC and NSLS management will try to help in several ways. First, current information on servicing or availability of spare components can be solicited in any of the weekly user meetings (X-ray or UV). Second, the NSLS has developed VME/EPICS based control systems that provides a possible upgrade path for users wishing to replace CAMAC based systems. In future Town Meetings or other forums, the UEC will provide further information on these systems and continue to assist the user community in maintaining their beamlines.

Dr. Richard Osgood, Associate Director for Basic Energy Sciences gave a presentation on NSLS, BNL and DOE initiatives, including the DOE "Nano" Initiative. This includes a possible nanotechnology center adjacent to (and connecting to) the NSLS. This center would include labs and facilities with capabilities in the following areas: nano-materials fabrication, materials synthesis, TEM microscopy, user oriented proximal probes, and ultra-fast sources. DOE is contemplating five centers around the country as a "package." Funding for nanotechnology within DOE will also include competitive university based grants as well as competitive proposals from the National Laboratories. In terms of NSLS initiatives, Dr. Ilan Ben-Zvi, presented the case for PERL or Photocathode based Energy Recovery LINAC as a novel source technology that is under both study and active development at BNL. Dr. Ben-Zvi will give a talk on this work at the annual user meeting in May and a recent "brown" paper has been forwarded to DOE for their evaluation.

The town meeting ended with a brief continuation of discussions relating to changes in computer security. BNL has shown responsiveness to user concerns and can exempt limitations on access on a case-by-case basis where need is demonstrated. The chief of cyber-security, Carl Eyler (eyler@bnl.gov) can be directly contacted when problems arise.

*The **NSLS Newsletter** is printed on paper containing at least 25 percent recycled materials, with 10 percent post-consumer waste.*

Call for NSLS General User Proposals

For Beam Time in Cycle September - December 2001	Deadline is: Thursday, May 31, 2001

Prior to Submitting a Proposal

You must contact the beamline personnel responsible for the beamline(s) selected in order to verify technical feasibility on the beamline(s) and discuss any special arrangements for equipment. Your chance of getting beam time is improved by being able to use more than one beamline.

Preparing Your Proposal

The same form is used for both new proposals and beam time requests against existing proposals. Follow the instructions on the information sheet and complete and submit all the required sections. Type or print all information legibly. MAIL OR FAX ONE COPY of the proposal form and any attachments to the NSLS User Administration Office. Only one copy is required - do not mail a hard copy if you have already faxed one.

Macromolecular Crystallography (PX) Requirements

New Proposals: The proposal represents a two-year program. Provide an overall plan for your research according to the instructions on the proposal form. If you can, estimate the number of crystals you plan to measure over the two years. If you require the use of an insertion device beamline like X25, be sure to indicate your need for the enhanced performance. New proposals must also include your plans for the upcoming cycle for which you are requesting time (below).

Beam Time Requests: Be specific about what you plan to study in the upcoming cycle. Submit PX Forms only for the crystals you plan to study in that cycle. Answer all the questions, use the back of the form if you need more space. Be clear about what crystals you already have, which you expect to have, and how you would use the beam time you requested if you were unable to obtain the planned crystals in time (i.e., other crystals described in your program).

Proposal Deadline

The complete proposal package must be received by the User Administration Office on or before 5:00 p.m. Eastern Standard Time on the above date to be considered for beam time in this cycle. The fax machine is always extremely busy on the deadline date. Do not rely on faxing the proposal successfully on the deadline date. New proposals should be sent by mail or fax prior to the deadline. Beam time requests for active proposals will be accepted after the deadline, but will be allocated beam time only after requests received on time have been allocated. Late requests are not eligible for a rating upgrade if beam time could not be allocated to them.

Each proposal will receive a prompt preliminary review to verify that it is complete and legible. If there is a problem with the proposal, you will be contacted immediately. Submitting your proposal well in advance of the deadline date assures that the User Administration Office has time to reach you and that you will have enough time to correct any deficiencies.

Proposal Forms and Additional Information

Blank proposal forms and instructions are available on the World Wide Web. From the home page at http://www.nsls.bnl.gov, go to User Information, then Forms. The PX form must now be completed online. A guide to the NSLS beamlines and more information about the General User Program can be found through our homepage, http://www.nsls.bnl.gov or by contacting E. Pinkston or L. Rogers in the NSLS User Administration Office. Office hours are Monday through Friday, 8:00 a.m. to 5:00 p.m. Eastern Standard Time (EST). Contact information is on the back page of this Newsletter.

Safety Approval Form

Safety Approval Forms (SAFs) are required for every experiment. Your SAF must be submitted online **at least one week before** your scheduled beam time. Do not send in SAFs with your proposal. Be sure to include the birthdates of each experimenter so that the final SAF will provide accurate training information. Go to URL:

http://130.199.76.52/safety/

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Important Upcoming Dates

April. 10, 2001	Deadline for submissions, July Newsletter
April 22-27, 2001	Rapid Data 2001 Course, "Rapid Data Collection and Structure Solving at the NSLS: A Practical Course in Macromolecular X-Ray Diffraction Measurement"
April 30, 2001	Deadline to register for the NSLS Users' Meeting
May 7, 2001	Deadline to submit entry for Poster Session for NSLS Annual Users' Meeting
May 21-24, 2001	NSLS Annual Users' Meeting and Workshops
May. 31, 2001	Deadline for General User Proposals (Sept-Dec 2001)
October 1, 2001	Deadline to submit Publication References for FY2001 (The system doesn't close!)
October 31, 2001	Deadline to submit Abstracts for FY2001 (Submit soon! The system is always open!)

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Mary Anne Corwin, Editor
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For additional information about the NSLS (including this Newsletter in electronic format) see the NSLS Home Page on the World Wide Web at

http://nslsweb.nsls.bnl.gov

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