NOVEMBER 1994 NSLS NEWSLETTER

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The NSLS Prototype Small-Gap Undulator (PSGU): A New X-Ray Source

Peter Stefan, NSLS Beamline R&D Group

The NSLS Prototype Small-Gap Undulator (PSGU) is an example of a small-period, small-gap undulator insertion device. Such a device gives the NSLS a sample of one of the most important aspects of 3rd-generation light sources like the ESRF, APS, and SPring-8: hard x-ray photons from an undulator. The demonstration that this device can provide hard x-ray photons without affecting the beam lifetime is an important development for all synchrotron light sources, and there are now plans to install similar devices in the 3rd-generation facilities. PSGU was installed in the 1994 spring shutdown, and has been operated during studies time this summer. Results from these studies, including a measurement of the undulator light spectrum, will be presented below, together with a description of PSGU in general. First, however, it is probably worthwhile to motivate the R&D goals of the PSGU project.

Why is there all this fuss about undulators? What's so good about them? In fact it's probably true that almost any experiment could be done better with an undulator as the light source, in place of the usual bend magnet. An undulator source has all the good properties of a bend magnet source on a storage ring (high-intensity, highly-collimated, plane-polarized electromagnetic radiation, originating from a small source size, with a fast-pulsed time structure, and whose properties are stable over time) but instead of a broad continuous energy spectrum, the undulator produces very intense light at a fundamental photon energy, and a few of its harmonics. As a result, much more of the total radiated power from an undulator is useful to a typical experiment; the monochromator doesn't have to throw away almost all of a broad, continuous spectrum. But the important property of photon energy tunability is not lost. The strength of the magnetic field in the undulator determines the fundamental photon energy, and this field strength can be varied, typically by changing the separation between the two trays of permanent magnets which make up the undulator.

Well, if this is true, we should have undulators for all the users! But there is a problem. For a conventional undulator, the fundamental photon energy is often roughly 1/10 the critical energy of the bending magnets. That means that one can get ~40 eV photons from an undulator on the VUV Ring and ~500 Ev photons from one on the X-Ray Ring. The x-ray users seem to be out of luck! That, in fact, is the main motivation for the new larger storage rings: an ability to produce hard x-ray photons with a conventional undulator. The PSGU takes a different approach to the same end.

One can produce hard x-rays from an undulator in a storage ring like the NSLS X-Ray Ring in a small-period, small-gap undulator. Typically, undulators are built using two periodic arrays of magnets. If the magnetic period length in the arrays is decreased, the fundamental photon energy radiated rises. However, the strength of the magnetic field produced is only adequate if the spacing between the two arrays (the undulator magnet gap) is about the same as the magnetic period length in the arrays. So, to get high energy, small period and small gap are necessary. One can build small-period magnetic arrays, but can one get a small gap?

Fundamentally, the minimum undulator gap depends on the design of the storage ring. In most storage rings, the stored electron beam travels in an evacuated metal beam tube of roughly constant cross sectional dimensions, all around the circumference of the ring. From accelerator physics, however, the performance of the ring (e.g., beam lifetime and freedom from instabilities) should not change if some sections of the beam tube are replaced by ones of smaller dimensions. This is because when the stored beam is steered as far from the beam pipe center as it can without beam loss, in all possible ways, it will come right up against the beam tube in some locations, but only move a few mm off center in other places. In the NSLS X-Ray Ring, some of these places, where the electron beam can never move more than a few mm, are suitable for installation of insertion devices. However, while installing a smaller beam tube can permit an undulator to attain a smaller magnet gap, there are additional complications which make it hard to decide how small the beam tube should be. During injection, when the storage ring is filled, extra room is required for the electron beam. And even when the electron beam is stored and stable, there are open questions about how close the beam can get to a metal plate or tube wall before various beam instabilities and wall heating will become serious.

PSGU is designed to explore the small-aperture limit for the electron beam in the NSLS X-Ray Ring. It has a variable-aperture vacuum chamber, so that the effective beam-tube dimensions can be increased for injection, and then decreased once the electron beam is stored. In addition, it has a small-period undulator, to take advantage of whatever minimum beam aperture can be obtained with a corresponding a small magnet gap. The variable-aperture chamber is illustrated in **Figure 1**. This is a cross section, as seen along the stored electron beam direction. Deep wells, from the top and bottom flanges, extend toward the stored beam, and can be moved together or apart by means of top and bottom bellows. The central section of the chamber, between the bellows, is fastened through legs to a stage on the floor, while actuators attached to the two flanges control the electron beam aperture. The bottoms of the wells are thinned to 1 mm, and the undulator magnet arrays are inserted into the wells, up to the thinned region. The vacuum chamber is a cylindrical tank, about 460 mm in diameter, with its axis vertical. The electron beam aperture is variable between 14 mm and 3.8 mm, at present, and the small-aperture region is 104 mm wide, but only 390 mm long. The PSGU undulator magnet has a 16 mm magnetic period (vs. 80 mm period for the X-1 undulator) and is 320 mm long. It uses a special high-performance, 6-magnet-blocks/period, pure-permanent-magnet structure with NdFeB magnets. The magnet arrays are mounted on an independent drive system, which enables magnet gaps from 7.35 mm to 26 mm, at present.

In studies, PSGU has been operated at the minimum aperture, 3.8 mm, with and without the undulator magnet gap closed, with NO effect on the X-Ray Ring lifetime, even with a stored beam of 300 Ma at 2.584 GeV. Although this is certainly satisfying, it is clearly not the limit. Additional studies, performed by shifting the minimum aperture so that it is not centered about the stored electron beam, suggest that we may be able to close to 2.8 mm or even less, before the lifetime will drop. We hope to modify the PSGU vacuum chamber to allow this. A spectrum of the undulator light was taken at a magnet gap of 7.5 mm using a single-crystal spectrometer with an ion chamber detector. The result is illustrated in **Figure 2**. The experiment curve consists of two parts: Below about 4.6 keV, the spectrometer and detector were filled with He, while above 4.6 kev, a second run was made with N_2 gas. Corrections for Be window and gas absorption are made, as well as detector efficiency and Si(111) bandwidth. The theory curve comes from the "URGENT" code, and includes the electron beam emittance, and the 1 mm spectrometer slit, located about 17 m from the source. To put the vertical axes in perspective, the peak flux from X25 in its doubly-focused, white-beam mode is $5x10^{13}$ photons/sec/250mA/0.1% bandwidth, and its peak source brightness is about $1x10^{16}$, in the same units as Figure 2. At the same time, the total radiated power from X25 is about 3 kW, vs. PSGU at about 80 W, for the 7.5 mm gap. The fundamental, 2nd, and 3rd harmonics of the PSGU undulator should all be usable in experiments.

As impressive as these results may seem, small-period, small-gap undulators will not replace the undulators designed for the 3rd-generation storage rings. In general, devices like PSGU have much more limited tuning ranges: the present tuning range for PSGU is only about 3.1 kev to 3.9 kev in the fundamental for an order-of-magnitude flux decrease. For the harmonics, the flux decrease is even faster. Therefore, these undulators may not yield the wide range of tunability required at a general-purpose beamline. Nevertheless, such undulators should be able to compete successfully for a number of experimental applications, such as microscopy, x-ray scattering, etc. A further enhancement beyond PSGU is an in-vacuum undulator, in which the magnet arrays are housed inside the electron beam tube. In this arrangement, the electron beam aperture is now identical with the magnet gap. Here, smaller periods and even higher photon energies are possible, or extended tuning range, with larger period undulators.

November 1994 NSLS Newsletter

Chairman's Introduction

Denis McWhan

It has been a busy time at the NSLS since the last Newsletter. In early July the first undulator spectrum was obtained from our new prototype small gap undulator (PSGU). As discussed in the article by Peter Stefan, the first harmonic of the PSGU gives undulator radiation in the 3 KeV range and provides bright beams at the 2nd and 3rd harmonics. The success of this accelerator R&D project means that undulator radiation can be obtained at substantially higher energies for a given storage ring energy than had been thought possible, and bodes well for the third-generation sources being able to provide undulator radiation in the 100KeV range.

In the middle of July the NSLS hosted SRI'94, which was held on the campus of the State University of New York at Stony Brook. The article by Jerry Hastings and the reports from the workshop organizers tell of the success of this adventure. Over 550 attenders braved the heat and from all reports they found the conference and workshops very profitable. There was a visit to Brookhaven National Laboratory on Wednesday afternoon, and the conferees enjoyed the opportunity to visit not only the different beamlines but the X-Ray Ring tunnel, the detector program in the Instrumentation Division, the Relativistic Heavy Ion Collider (RHIC), the Magnet Factory, and the new Weather Radar Station. The NSLS and SUNY staffs did a terrific job, and I want to thank them for all their efforts at making the conference a success. We all look forward to SRI'97 which will be hosted by the SPring-8 project in Japan.

Earlier in the year the Secretary of Energy Advisory Task Force on Alternative Futures for the Department of Energy National Laboratories was formed under the chairmanship of Bob Galvin of Motorola. The committee, commonly referred to as the "Galvin Committee", visited BNL on August 19th and they toured the NSLS in addition to other BNL facilities. They had formal discussions with the Directorate and with user groups. Two of the figures presented to the Galvin Committee, which illustrate the performance of the NSLS, are shown below. **Figure 1** demonstrates the continuing increase in both the user population and publications based on work done at the NSLS. **Figure 2** shows the continuing increase in the amount of beam provided in successive years and the continuing decrease in the percentage of unscheduled downtime. Again, I want to thank the NSLS and PRT personnel along with the users who had the NSLS sparkling for the visit and who provided posters of recent work. I think that you all put on a spectacular show.

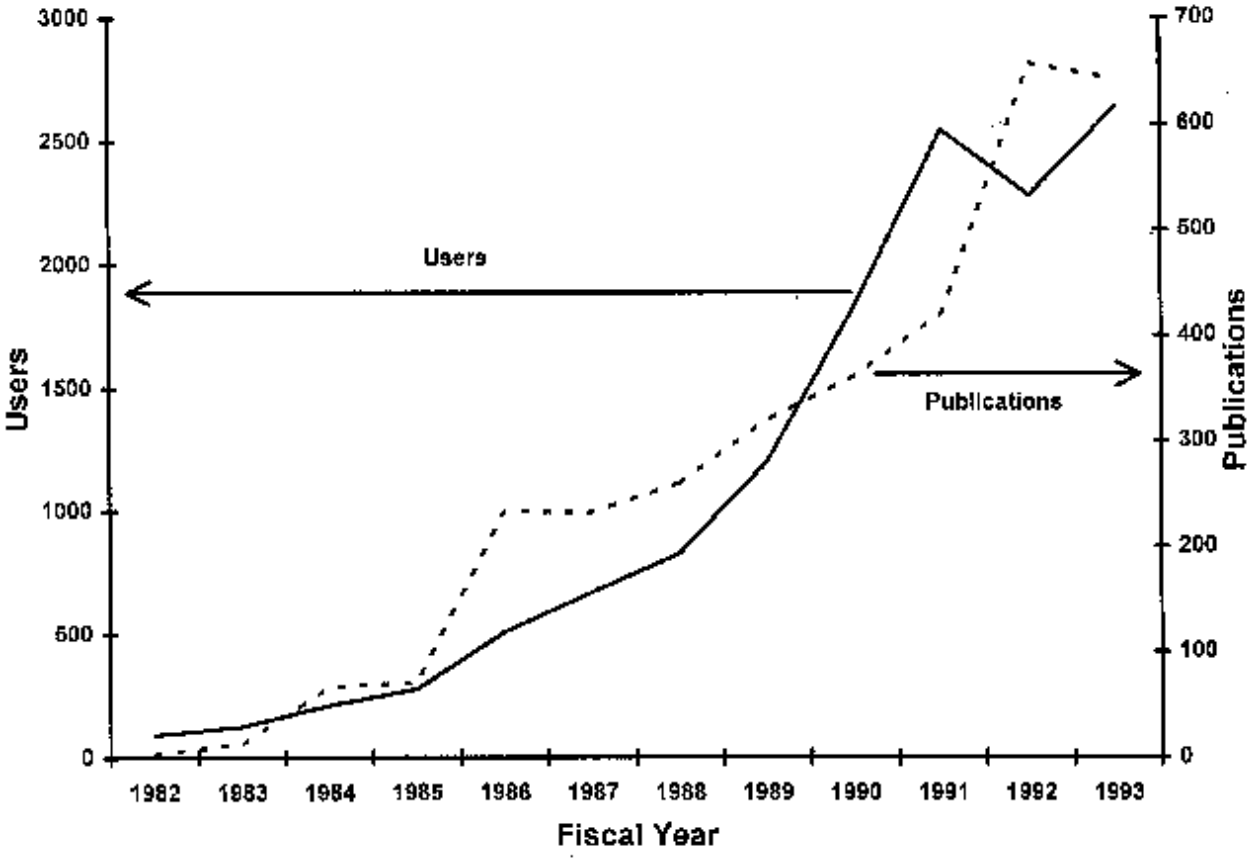
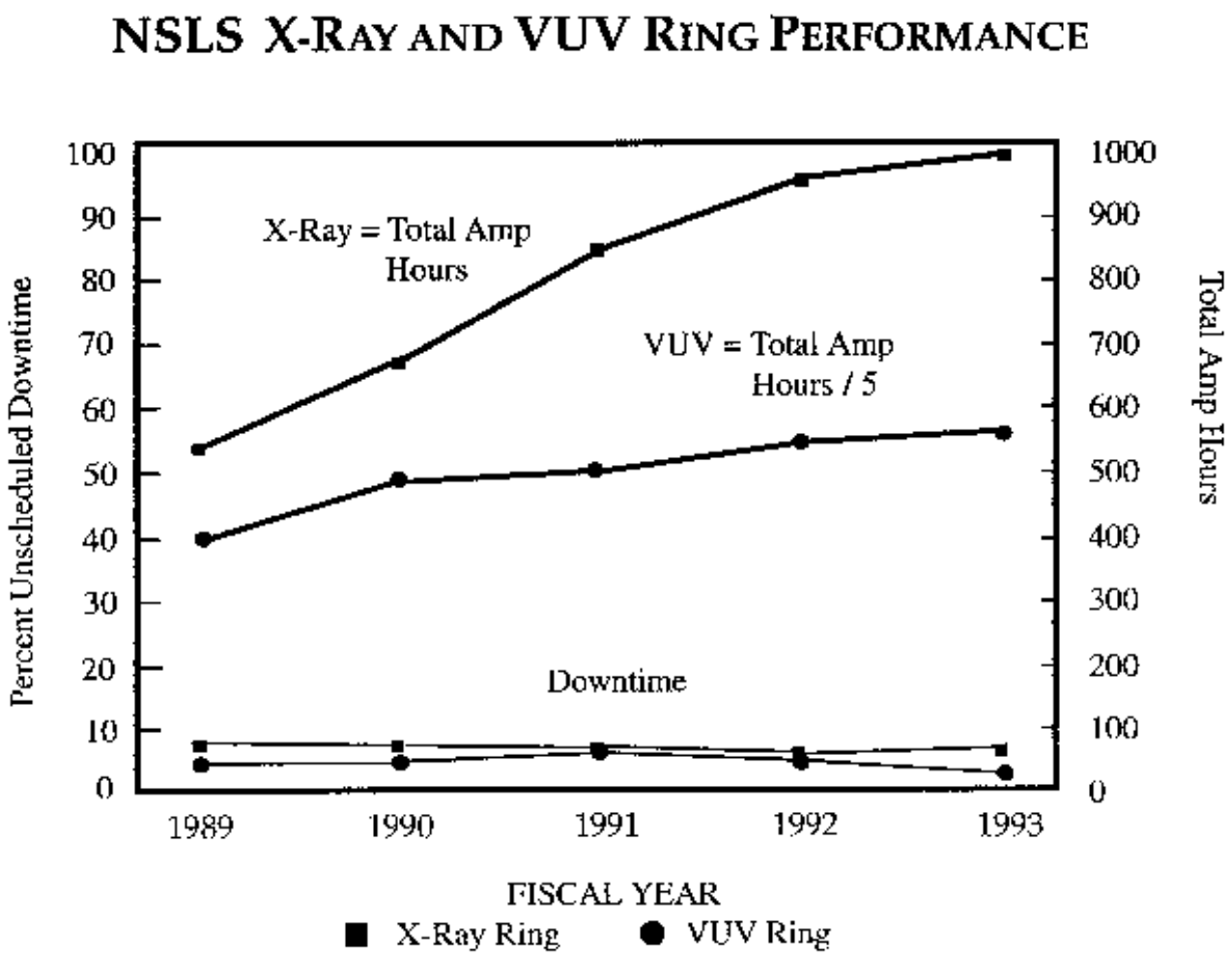


Figure 1 (Above) and Figure 2 (Below)



August and September is also the time during which we hear about the budgets for FY1995. As all of us know, the economy has not been doing well and this has been affecting science overall and the operating DOE user facilities in particular. The NSLS budget in FY1995 dollars has been decreasing for the last few years, as have the budgets of SSRL and ALS. In the light of the performance discussed above, this trend is particularly disturbing. The initial reports were that the NSLS budget for FY1995 would be 5% less than the President's FY1994 budget. This trend of decreasing operating budgets has led to a 15% reduction in staff over the last four years. Although the NSLS has been able to continue full operations and to increase the performance of the rings it has not been able to increase the beamline support to the level needed for efficient operation. Artie Bienenstock has been spearheading an attempt to have the Office of Management and Budget (OMB) look into providing a bump in operating funds for the DOE User Facilities, and the synchrotron community owes him a debt of gratitude for trying to keep all of the user facilities operating efficiently. As a result of his efforts, he and I were asked by the OMB to meet with them and the Office of Science and Technology Policy (OSTP) to show how a relatively small increase in operating and capital funds would have enormous leverage in ensuring that the DOE user facilities are fully utilized. After this meeting OSTP, DOE, and OMB asked the DOE Laboratory Directors to fill out a Facility Operations Questionnaire and to give to their principal user groups a second User Group Questionnaire to send to OMB and DOE. The UEC and the SPIGs and many of the PRTs responded within a very short time frame, and I want to thank all of you for helping to make the case for increased facility support. We tried to make the case that what is needed to increase the efficiency and to serve the ever-increasing user community is 1) to provide more user support on the floor, 2) to upgrade a number of NSLS and PRT beamlines with state-of-the-art optics, and 3) to provide travel support for young faculty and their students.

Finally, I would like to make several observations concerning the NSLS in FY2000. As illustrated by the performance history above and the strength of the scientific programs shown to the conferees at SRI'94 and to the Galvin Committee, the NSLS is a vibrant and productive user facility. With the beginning of commissioning of the APS in 1995, the United

States will have eight synchrotron sources, and this will lead to some redistribution of the existing user community.

Based on our experience when CAMD and ALS were commissioned, the principal redistribution is along geographical lines. There is a clear tendency toward regionalization with users in the south-east going to CAMD and those in the west going to ALS.

At the same time the VUV Ring at the NSLS has seen several new programs come on line. In particular, the number of infrared beamlines has gone from one to two, and a third is scheduled to come on line next year. There is a growing community of chemists including major involvement by Dow Chemical. As we upgrade U5 and U7A and bring on line the high resolution, low energy branch on the U13 undulator, the program on the VUV Ring will continue to be strong.

I have tried to get a realistic picture of the effect of the commissioning of the APS on the NSLS through extensive discussions with our Scientific Advisory Committee (SAC), the Users' Executive Committee (UEC) and many of the spokespeople for the PRTs. First, there is clearly a large number of strong programs at the NSLS which find that the NSLS is a very cost-effective facility and that it provides the quality of photons that they need to do their science. Second, there are a number of groups, especially those from Argonne National Laboratory, CARS, and midwestern universities and industries, that will move most or all of their programs to the APS.

Third, there are at least two communities of synchrotron users that are expanding rapidly: the structural biology community and the industrial community. All projections indicate that even with at least four bending magnet stations and a growing use of wiggler stations at the NSLS, along with large programs at the APS, CHESS, and SSRL, structural biology beamlines will be oversubscribed. On the industrial side, there is a growing need for rapid turn around advanced analytical capabilities, and the NSLS is working toward providing a core set of beamlines for imaging, x-ray absorption spectroscopy, x-ray powder and single crystal diffraction.

When all of these factors are put together, I estimate that there will be about a 15% reduction in the number of beamlines at the NSLS in FY2000, but that the other beamlines will be stronger and have more user support. This will represent over 50 state-of-the-art beamlines and I expect the NSLS to remain an exciting place.

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Paul Lloyd Cowan (1950 - 1994)

Our colleague and friend Paul Cowan died on August 16, 1994 after a year-long battle with cancer. He was greatly respected for his contributions to the field of synchrotron research as well as for his wisdom, thoughtfulness, and courage.

Paul Cowan received his B.S. and Ph.D. degrees in physics from Pennsylvania State University. As part of his doctoral thesis he designed and built a field ion microscope to observe the behavior of single atoms on metal surfaces. In his subsequent post-doctoral stay at AT&T Bell Laboratories he demonstrated the first use of x-ray standing waves to accurately locate surface atoms. At the same time, Paul began working in the field of x-ray and synchrotron radiation physics.

In 1980, Paul joined the Quantum Metrology Division at NIST (formerly NBS) where he was appointed to develop and instrument a soft x-ray beamline (X24A) at the new X-Ray Ring at the NSLS. His early efforts focussed on monochromator design and even to the present time, the Cowan-Golovchenko boomerang design crystal spectrometer remains the world's best spectroscopic source of x-rays in the 2 to 5 keV range. He extended the resolution of x-ray absorption and fluorescence measurements in gases, including both resonant and non-resonant fluorescence. He was a key contributor to both the observation of polarized x-ray fluorescence radiation and its interpretation in the excitation schemes of molecular gases. He pioneered the measurement of adsorbate bonds with back-reflection x-ray standing waves with sufficient resolution to observe surface relaxation for the first time. He pioneered the realization of the back-reflection standing wave method, extended the analysis of threshold phenomena in the x-ray region to include resonant inelastic scattering, and was a key contributor to the discovery and elucidation of polarization spectroscopy in the x-ray region.

Paul's dedication to physics and synchrotron radiation science was not limited to his activities on the experimental floor. He served on the NSLS X-Ray Imaging Proposal Study Panel (PSP), lending his insight and expertise to review General User Proposals. He had a gift for productive collaborative associations which was evidenced by the large diversity of co-authors on his publications. Even during his illness Paul continued to give valuable technical advice to the NSLS and the APS facilities. His advice was always thoughtful, whether about technical or non-technical matters. Though possessed of a deep intellectual knowledge, he was one of those rare scientists with a tremendous amount of modesty. Friends and colleagues alike enjoyed his company and will miss Paul Cowan for both the man and the scientist he was.

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Radiation Protection Program -- It's the Law!

William Thomlinson

Associate Chairman for User Programs and ES&H

Yes, Radiation Protection has become codified as a United States Federal Law. The U.S. Department of Energy has issued a set of guidelines for implementation of G-10 CFR 835/B1 - Rev. 0, Radiation Protection Program. The implementation guide provides an acceptable methodology for documenting the development of an occupational radiation protection program (RPP) that will comply with the U.S. Department of Energy requirements specified in Title 10 of the Code of Federal Regulations, part 835. In other words, Brookhaven National Laboratory (and thus the NSLS) must development an implementation plan or face legal consequences under the law. The schedule is for a plan of compliance by January 1, 1995 and full implementation by January 1, 1996.

BNL has established an internal committee to develop the Laboratory's plan. Tom Dickinson and I have been working with that committee to make sure that any concerns of the NSLS are properly addressed by the Laboratory. Thus far, we have not identified many serious issues since the regulations contained in 10 CFR 835 are the same as those which are already being complied with, or will be complied with under the present DOE Order 5480.11. Over the past two years, BNL and the NSLS have put in place programs to be compliant with the DOE Radiological Control Manual (better known simply as RadCon). At the present time, no one is sure just how big an impact the law will have. It is clear that, as these things usually do, the administrative burden of record keeping may explode. So much for paperwork reduction!

There are two areas that I want to mention which are certainly of interest to the User Community. The first is the set of regulations concerning recording of total yearly radiation exposure for an individual prior to being allowed access to a facility. At present, film badges are generally given out at the NSLS with no restrictions concerning the prior exposure to the individual. The new regulations will require some information about dose. We realize that most persons do not walk around with such documentation, and in fact, it may be impossible to have "up to date" information. This may put up some impediments to our "user friendly" means of issuing badges, but the Laboratory and the NSLS are working to minimize any impact.

The second major change, as we see it thus far (but stay tuned for ever developing pitfalls), is the major emphasis now placed on ALARA --As Low As Reasonably Achievable. That is the doctrine under which we have always operated with respect to radiation exposure. But now, it is law and will be mandatory in all areas of our endeavors. For example, we will have to document all ALARA actions, meetings, decisions made during facility design and constructions, monitoring, etc. We do not yet know how these strict rules will impact the user programs but we will have to be increasingly aware of the need to formally apply ALARA principles. I will keep our User Community clearly informed of the developments in this area, as well as the overall implementation of the Radiation Protection Program at the NSLS.

In the last issue of the Newsletter, I addressed our response to the TRISTAN accident. I am very pleased to bring you up to date on our efforts to establish an Electrical Safety Review Program on the NSLS Experimental Floor. During the summer, we had the pleasure of having two students from the University of Grenoble work with our staff and users to develop the program. Ms. GaNlle Corrouge and Mr. SJbastien Majoux wrote a thorough questionnaire for the review of beamlines, including most utilities as well as electrical safety. They piloted the program on four NSLS beamlines, receiving very good feedback and cooperation from the beamline staff. I would like to thank everyone who put time into the process, especially Larry Fareria, Paul Lyman, Mike Sagurton and Gwyn Williams for completing the review. Based on the outcome of these test cases, we now know the personnel resources that we must dedicate to the program in order to cover the entire facility. That will occur during the next six months. The estimate by our staff is that it takes about 8 contact hours with the beamline personnel to complete a beamline electrical safety review. In the meantime, I continue to urge each person at a beamline to be aware of any electrical hazards and to immediately address them. If assistance is needed, just contact the Operations Coordinators or any of our safety or technical personnel.

One essential part of the electrical safety reviews will be the completion of a beamport floor plan showing the location of safety related items such as the power distribution panels. The NSLS has requested a floor plan of the beamports from each of the PRTs as a part of this year's input for the SAC and Activity Report. The locations of the safety items will be added during the review. I would like to thank all of the persons who have already submitted their floor plans and look forward to receiving the remainder very soon.

On a final note, I would like to thank all of the users who have worked hard on safety and good housekeeping at the NSLS over the past few years. Each time a major review or inspection of the NSLS occurs, we issue a call to arms to clean-up. It has been noted by many of us, and the BNL Directorate, that such clean-ups are much easier now than a few years ago. That is due to the generally very high level of cleanliness and attention to safe practices at the NSLS. We can all be proud of how nice the experimental environment looks and it certainly has left a good impression on our visitors. It is also an intrinsically safer and more efficient environment for doing science.

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FELs and the NRC Report

Erik Johnson

NSLS Beamline Research and Development

The NSLS has been engaged in the development of proposals for a Free Electron Laser user oriented facility operating in the Ultra-Violet for more than five years. The Deep Ultra-Violet Free Electron Laser (DUV-FEL) conceptual design report was released in January of 1993. It details the scientific motivation, and the describes a user facility designed to meet those needs. The DUV-FEL could produce picosecond pulses of UV radiation at wavelengths as short as 75 nm and peak power of several hundred megawatts. It could also be operated in a chirped pulse mode which would produce 4 femtosecond pulses at 88 nm with peak power of 100 GW. While the DUV-FEL proposal is certainly unique, it is by no means the only short wavelength FEL proposal before the DOE. In fact the DOE has been beset by a plethora of proposals driven, at least in part, by two key developments.

First is the realization that, even as they are coming on line, the third-generation synchrotrons are inadequate for certain types of experiments. These include non-linear effects and dilute systems where higher peak power is required, or many types of intensity correlation studies where spatial coherence beyond the capabilities of existing sources is beneficial. A second driving force in the recent FEL renaissance has been the advances in many aspects of the accelerator physics.

Experiments conducted at the BNL Accelerator Test Facility (ATF) and other laboratories have demonstrated dramatic improvements in electron beam emittance in the last several years. In many respects, emittance is the figure of merit for FEL performance, and it has now developed to a state where short wavelength FELs can be realistically considered. The theoretical description of the FEL process has also advanced significantly, yielding innovative FEL designs such as the sub-harmonically seeded beam amplifier. This approach is utilized in the High Gain Harmonic Generation experiment at the ATF and is the cornerstone of the design of the DUV-FEL.

Faced with an onslaught of proposals, a large commitment to the construction of new facilities, a burgeoning demand imposed by their operation budgets, and a general paucity of ready cash for new activities, the DOE commissioned the National Research Council to perform a study of Free Electron Lasers and Other Coherent Sources of Radiation to aid in evaluating their role in DOE programs. The committee was chaired by Donald H. Levy of the University of Chicago. It started its work in November of 1993, and released its report in August of 1994.

The report, entitled "Free Electron Lasers and Other Advanced Sources of Light: Scientific Research Opportunities" had the nominal stated goal of evaluating the scientific potential of FELs relative to other sources. The body of the report is divided into five major sections. Four cover science and radiation sources by wavelength region, and the fifth addresses concerns beyond the scope of the charge to the committee. Briefly, the report recommends establishing a FEL user facility in the far-infrared and supporting the use of existing laser technology in the near-infrared and visible (located in individual investigators'laboratories). In the VUV and x-ray regions, the report recommends pursuing proof of principle experiments at existing synchrotron sources, and supporting the development of technology for FELs in these wavelength regions.

In its "General Issues" section, the report urges the DOE to take a balanced approach to support for individual investigators and major research facilities. It also recommends that FEL research should be broadly based both in its funding, and in the actual work of source development. It further states that existing synchrotron facilities should use discretionary funds to support FEL research and, prior to committing to the construction of an FEL based user facility, the DOE should explore the issue of continuing support for existing facilities or discontinuing their operation.

It remains to be seen how the DOE responds to this report but, at least with respect to the VUV section, BNL has anticipated its recommendations. Several activities were initiated during the last year known collectively as the Ultraviolet Project.

One component of this work has been supporting a major share of the operation of U11 and the construction of the U13U low energy branch line as sites for proof of principle experiments in UV science which might later be performed at an FEL facility. In this respect, the program seeds the science, and can serve as a focal point for UV based research at BNL. A second major activity has been the development of a collaboration to pursue UV-FEL R&D at Brookhaven utilizing components from other projects at BNL and elsewhere. The kernel of the collaboration was suggested in a workshop "Towards Short Wavelength Free-Electron Lasers" held at BNL in May of 1993.

One of the projects this workshop proposed was utilizing the ARPA linac at BNL (built originally for the SXLS project) with an undulator known as NISU.S. (Near Infrared Scaleable Undulator System). NISU.S. was built by STI Optronics for Boeing Space and Defense in Seattle as part of a contract with the U.S. Army Space & Strategic Defense Commands Directed Energy Weapons Program. The device is a 10 meter long undulator valued by the Army at over 8 million dollars. It has now been loaned to BNL, and will arrive in December or January for use in FEL experiments ultimately leading to a ultraviolet FEL. This part of the project, while sited at BNL, is part of a broad based collaboration involving many institutions. The Ultraviolet Project FEL (UP-FEL) does not have all of the features designed into the DUV-FEL proposal, but will ultimately provide radiation of comparable peak power and wavelength as the DUV-FEL. Although meant to be an R&D machine, the UP-FEL should provide an opportunity to explore applications (and foibles) of this type of source for research. Experience gained on this machine will be invaluable in the design of a user oriented facility.

In a parallel effort, a "white paper" is being prepared for the DOE which outlines a possible program of FEL amplifier R&D leading to the development of short wavelength FEL technology, as recommended by the NRC report. Apart from BNL, this effort includes other DOE laboratories (CEBAF, LBL, LANL, SLAC), industrial partners (Boeing, Grumman, STI-Optronics), and universities (Duke, UCLA). This program would build on the established strengths and capabilities of the participating institutions in an effort to pursue the development of what will become the "Fourth Generation" source for research.

All of this activity occurs against the backdrop of difficult times for the funding of research in the U.S., and difficult choices for the operation of its large research facilities. For BNL, one of these decisions has been to pursue FEL technology. The same motivations that lead to the creation of the NSLS drive this effort: to provide the users of its facilities with the best possible sources of radiation for their research. Hopefully this new initiative at BNL will meet with the same degree of success the NSLS has enjoyed, and form the basis for the "next generation" science.

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A User's Perspective

Jean Jordan-Sweet, IBM

Users' Executive Committee Chair

I intend to use part of this column as it's title suggests, and give some of my views on how I feel that the NSLS administration and users can work together to ensure the healthy future of this facility. The most important issue facing us is the levelling off and now decrease in DOE funds for operation of the NSLS in FY'95. With scarce resources available, it is all the more important for the user community to express it's views of how these resources should be allocated. I hope that the Administration would be receptive to suggestions from the user community and also start an open dialogue with the UEC regarding how best to set up the NSLS budget so that the effect of diminished funds does not inordinately impact PRT and General User programs. The NSLS has come a long way in improving it's "user friendliness", and it would be a shame for any of this to backslide. With upcoming competition from the ALS and APS, it is essential that the NSLS remain an attractive and reliable place to do experiments. In addition, I would like to see the NSLS view its R&D staff and the rest of the user community as more of an entity than as two separate groups, particularly in the acknowledgment of joint accomplishments.

With regard to the future funding of the NSLS, I wish, on behalf of the user community, to express our full support and appreciation to Denis McWhan in his quest for some financial relief. He and several other DOE synchrotron directors have appealed to the OSTP, OMB and DOE for an increase in operating funds. They have also been pushing for a Presidential Initiative to earmark funds for upgrades to facilities and beamlines. The UEC has played a role in this pursuit by asking SPIG representatives to fill out a questionnaire sent by DOE to "...identify potential areas in which expanding facility operations could produce tangible benefits...and examine facility user needs." Another contribution to this effort users can make on an individual basis, is to write to your Congressman! Express your appreciation for the NSLS and the extent to which you depend on it. Although New York Congressmen are aware of the NSLS, they and Congressmen from your home institution's state should be "sensitized" to the wide-ranging impact this facility has on R&D and technology transfer across the country. (Addresses for Congressmen can be found in the blue pages of your phone book).

Now I would like to report briefly on our last Town and UEC Meetings, which were held on September 8 and 9. At the Town Meeting I started things off by presenting the 1994-95 UEC membership list. Congratulations to new members Dan Fischer, Kevin Smith, and Paul Zschack. The UEC group photo and list of names (and SPIGs represented) will be posted on the bulletin board downstairs from the main entrance to the NSLS. Please make use of us!

Denis McWhan reported on the X1-9 floor expansion, which is behind schedule but expected to be completed in January 1995. There are still a couple of final finishing touches for which funds have not been found. Denis also thanked those in the audience who helped with the SRI tour and Galvin Committee visit. He showed some impressive viewgraphs which he had presented at the latter, and stated that the Committee gave him positive verbal feedback. On a more somber note, he said that because of the 5% cut in the FY'95 budget, it has become necessary for the NSLS to charge users for office space to recoup power costs. (See below for details.) Bill Foyt added that there has been a reduction in the rate for in-house electricians and A/C craftsmen. During the discussion about charges and services, it was suggested that the NSLS produce a list of services and equipment available to users, along with any associated charges. This would include such things as photocopiers, FAX machines, color printers, scanners, etc.

We had a very well-prepared report from Peggy Sutherland about the plans to have the NSLS Annual Report submissions made electronically, and for the Report to be made available via WWW and CD-ROM. Eventually all user forms also will be submitted electronically. It was suggested that the hyperlinked home page concept be seriously developed at the NSLS, with each beamline eventually having it's own home page.

Bill Foyt discussed the new NSLS video. He emphasized that although it is 6 minutes longer than the last one (24 minutes total), it's viewing fulfills requirements for GERT (General Employee Radiation Training) and is transferable to all DOE sites. GERT takes several hours when taken through normal BNL channels.

Mike Kelly brought us up to date on progress made to fight the ongoing noise battle at the NSLS. Two RF systems on the X-Ray floor have been enclosed. Sound-absorbing boards have been placed around the floor and more will be put up on the VUV mezzanine. Baffles are being put up just below the ceiling of the VUV floor. If the baffles are successful, they may be installed on the X-Ray floor in the future.

Sam Krinsky, Tom Dickinson, and Peter Stefan reported on issues related to the operation of the X-Ray Ring at high current or high energy. The ring essentially will be ready to operate in these modes in Winter '95. The Task Force on Heat Loading is still studying the effects of high power on the ring, insertion devices, and bending magnet beamlines using finite element analysis. Though there have been no surprises to date, the most complicated components have yet to be modelled. According to Dickinson, all beamlines will need more lead shielding to run at high energy. It was found that scattered radiation at beamlines is increased 20-fold in this operations mode. Because of the danger posed by straight-through beam scattering off of beamline components, the Beamline Safety Review Committee will determine whether individual reviews are needed.

During the Town Meeting users were asked to fill out an e-mail questionnaire formulated by Peter Siddons. He will be heading a committee to study the needs of users for high-speed data transfer lines and computer security issues.

At the UEC Meeting, Denis McWhan discussed the effect of the 5% FY'95 budget cut. Although no layoffs are expected at the NSLS, this is being done at the expense of putting off improvements to the facility. He then went on to describe plans for the near and not-so-near future. The small gap undulator prototype operates very successfully, and at its third harmonic (approx. 6-8 kV) puts out a beam competitive with that of the APS. Plans for the VUV floor include splitting the undulator beamline U5 into two stations, installing a 5-30 eV high resolution spectrometer at U13, reworking the U7 monochromator into an SGM, and building a second full IR beamline at U12. Denis feels that the strongest programs in the future of the X-Ray Ring will be powder diffraction, EXAFS, and single-crystal diffraction. A possibility being contemplated for the future would involve identifying and setting up small companies to build and run single-technique beamlines in a service capacity for paying customers.

Bill Foyt presented the plan for charging users for office space in 510E and the trailers. Occupants of trailers and 510E "outer" offices will be charged $5.70/sq. ft./yr. and 510E "inner" offices will be charged $3.80. The plan to charge 5 cents per page for photocopying has been tabled, and users will be encouraged to use Quick Copy Services for large jobs. Compilation of a list of chargeable services, as suggested at the Town Meeting, will require some study of the logistics involved.

Marty Blume joined the UEC for lunch and discussed the FY'95 budget and outlook for FY'96. He suggests users send letters to Senator Alfonse d'Amato (among others) stating how important the NSLS is to our research programs. He is also interested in forming a committee to study the future direction of the NSLS. Lastly, he spent some time discussing the issue of networked computer security at BNL and pointed out several possible ways to increase it. A lab-wide recommendation will be forth coming.

Bill Thomlinson reported on the Power Distribution Project. Two students from Grenoble spent the summer working with several beamlines to review electrical safety. A safety review document was developed, and the plan is to have every beamline go through the review over the next year or so. If compliance involves major improvements, an effort will be made to provide NSLS resources.

Ron Manning, head of Staff Services, made a very well-prepared presentation on improvements in the Housing Office (through Jeff Swenson), Conference Services (through Christine Ronick), and Food Services. The Housing Office added a temporary staff position this past summer to locate housing for users who could not be accommodated on site. Swenson is planning to form a "Residence Council" and intends to have some NSLS users on it. E-net and conferee terminals have been installed at Berkner Hall, but the availability of public phones remains a problem.

Gwyn Williams and Mike Sagurton (SPSC Chairs) reported detailed statistics on the End-of-Run forms collected since January 1994. The return rate was only 24%, and they have asked whether this means that most users are satisfied and have no complaints. Of the returned forms, most experiments ran at least satisfactorily, and users stated that their training and support was good. It was suggested that a higher return

rate might be achieved by using on-line forms. As a side issue, the impact of the Scientific Liaison program on NSLS R&D staff was discussed. It appears that the staff is not overwhelmed by demands from General Users and that the users are getting the support they need, from both the PRTs and NSLS staff. If you believe this is not true, please contact someone in the UEC or User Administration Office.

We next had a discussion about issues pertaining to computer networks. Peter Siddons will head a committee to determine user needs for high-speed networks, and study network congestion and computer security.

Our newly elected Vice-Chairman and head of the next Users' Meeting Organizing Committee is Paul Zschack. The 1995 NSLS Workshops and Users' Meeting will be held on May 8, 9, and 10. The next Town Meeting is scheduled for Thursday, January 19, followed by the UEC Meeting on January 20. If you have any topics you would like discussed, please direct them to me.

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5th International Synchrotron Radiation Instrumentation '94 Conference

J.B. Hastings
NSLS R&D Section Head
SRI'94 Program Committee Chair

Synchrotron Radiation Instrumentation '94 (SRI'94) hosted by the National Synchrotron Light Source was held at the State University of New York at Stony Brook, Stony Brook, New York, USA, July 18-22, 1994. This was the fifth such meeting in the series which began in 1982 in Hamburg, Germany and the size and breadth of the community has steadily increased over the period. This is reflected in the more than 550 participants from nearly twenty countries, dominated by the host with approximately 300 participants with the remainder almost equally distributed between Europe and Asia. The highlight of the meeting was the scientific program, while mother nature's influence was certainly present as we suffered through a not atypical week of July weather. The vagaries of government supported institutions were also there in the housing and building of the Stony Brook Campus, but the University staff more than compensated for difficulties beyond their control.

The format of the scientific program was altered with respect to the previous SRI conferences to reflect the evolution in the utilization of synchrotron based science. In the beginning of the field any new instrument put into operation led to new experiments. With the rapid growth of sources more and more purpose built instruments tailored to given experiments have been constructed. The program emphasized this with the plenary talks of the first two days. There was an unexpected benefit to this format in the increased quality and participation of the poster sessions matched to these general scientific topics.

The lead off speaker on Monday morning was Prof. T. Blundell, the Chief Executive of the Biotechnology and Biological Sciences Research Council, United Kingdom. He spoke about the role of x-ray scattering research in bioscience and technology with a particular emphasis on protein crystallography. This is one of the most rapidly growing fields at synchrotron sources world-wide and could easily represent more than one third of their use by the turn of the century.

Tuesday's plenary speakers, Prof. R.J. Birgeneau and Prof. G.A. Sawatzky focused on current problems in condensed matter physics from the scattering and spectroscopic viewpoints respectively. In the invited sessions following the talks there was particular emphasis on the polarization properties of the beam, i.e. how to achieve arbitrary polarizations and how to measure them. This is a clear example of the new trend. As the details of the science evolve and the source quality improves, experimenters are driven to controlling more and more properties of the incident beam.

The last three days of invited talks on sources, optics and detectors purposely did not involve parallel sessions. One of the highlights of the Wednesday sessions was the elegant presentation of the physics of accelerator based photon sources by Dr. A. Hofmann of CERN. Another bright spot was the presentation of Dr. Kitamura from KEK and the Spring8 Project in Japan on developments of insertion devices. He showed some interesting possibilities, in particular small gap undulator devices on high energy rings to get high energy photons. In Dr. Kitamura's view, if successful these new magnets would make wigglers "dinosaurs".

Thursday morning the topic was optics and here the impact of the new sources may be the greatest. The significant enhancements in brightness will open up new areas of research using small (submicron) photon beams throughout the x-ray spectrum. This was discussed by Dr. D. Bilderback of CHESS, Cornell University, Ithaca, NY and Dr. A. Snigerev of ESRF, Grenoble, France. Another interesting development is in the area of adaptive optics described by Dr. J. Susini of ESRF where he is developing adjustable optics using piezo electric bilayers with central electrodes and opposite biasing of the two piezo plates leading to optics with variable radii of curvature at the turn of a knob.

The end of the beamline was saved for the end of the meeting. The Friday morning session concentrated on

detectors. All of the presentations were reviews in nature. Harping back to the first talk on Monday emphasizing the growth industry, protein crystallography, the two talks on the present competing technologies of image plates by Dr. A. Harrison of Edinburgh University, United Kingdom and CCD detectors by Prof. S. Gruner of Princeton University USA were of particular interest. Dr Harrison discussed some of the physics of image plates that lead to insights into their true strengths and weaknesses. Dr. Gruner presented the state-of-the-art in CCD detectors and held out the possibilities of large 'mosaic' blocks of individual detectors as the wave of the future, what one might call "CCD Wallpaper".

In addition to the scientific program a full program of social events was organized. These included a concert, a play, an afternoon visit to the NSLS, a banquet and daily events for companions. There was also a large vendor show, involving thirty-seven manufacturers, including four from Europe and one from Japan, which took place during the first three days of the conference.

On the last day there were the thankyou's to the staff that organized the meeting, to which as a participant at all the previous meetings, I add mine and note the good humor of the people at Stony Brook and the NSLS in light of the adversity of the weather. Finally, it was announced that SRI'97 will be held in Japan and hosted by the Spring8 project team.

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SRI'94 Workshops

Jean Jordan-Sweet

IBM

SRI Organizing Committee (Workshops)

On Sunday, July 17, five workshops were held in the Student Union and Department of Earth and Space Sciences at SUNY Stony Brook in conjunction with SRI'94. The rooms were packed with a total of over 220 speakers and attenders, and in spite of the hot weather and World Cup Soccer Final, an exciting full day of talks, posters, and discussions was enjoyed by all. Two additional satellite meetings were held on the weekends before and after SRI'94. Reports of these workshops and satellite meetings can be found in an upcoming issue of Synchrotron Radiation News as well as the in the 1994 NSLS Activity Report (due out in May 1995). Thanks are owed to the NSLS Users' Executive Committee for providing some travel money for speakers at the five Stony Brook workshops.

X-Ray Microbeam Techniques and Applications

Organizers: Slade Cargill (Colombia University) and Don Bilderback (Cornell University)

Applications of X-Ray Standing Waves in Studies of Surfaces, Films, and Bulk Materials

Organizers: David Heskett (University of Rhode Island) and Lonny Berman (NSLS)

Technique and Experimental Method for X-Ray Absorption Fine-structure Spectroscopy

Organizer: Geraldine Lamble (NCSU)

Computed Microtomography: Techniques and Applications

Organizers: Keith W. Jones and Per Spanne (BNL-DAS)

Synchrotron Radiation at High Pressure

Organizer: Donald J. Weidner (Director of CHiPR at SUNY Stony Brook)

Thermal Management of Optical Components for Synchrotron Radiation

Satellite Meeting held at APS

Organizers: Denny Mills, Andreas Freund, and Tetsuya Ishikawa

X-Ray Science with Polarized Radiation

Satellite Meeting held at CHESS

Organizers: Qun Shen and Ken Finkelstein

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Facility Report

Mike Kelly
NSLS Building Manager

Structural Biology Addition/Control Room Expansion

As of September 29, 1994, the outside concrete walls have been poured. Steel has been erected on the Control Room/X1-X4 addition and the steel is being erected on the Structural Biology Addition. The next step is to install the steel decking, then pour the roof with lightweight concrete and then the floor slab. This is scheduled to be completed by October 15, 1994.

At this date, the schedule has slipped three months. The contractor continues to state he will finish the project the week of January 9, 1994.

VUV Ring Noise Abatement Project

The NSLS has just completed the installation of sound absorbing panels in the VUV Storage Ring. The work was done in the early evening (1730 hrs to 2130 hrs), for minimum disruption to the experimental program. An innovative idea of using the crane with a built-on scaffold made the work go very smooth and fast. Another labor saving idea was to use electrical conduit and shower hooks to support the quilted panels that hang from the ceiling. This method made possible the total installation without drilling any holes in the ceiling joist; therefore, no metal chips fell on the experimental floor.

Fiberglass sound-absorbing boards have been installed around the perimeter of the ring; these also serve as a poster boards for the neighboring beamline.

The final step was to install fiberglass sound-absorbing panels around the VUV mezzanine. That work was completed on September 29, 1994. As soon as it is possible, we will record the sound levels and compare them with the readings we recorded before the work began.

Liquid Nitrogen Fill Station

The NSLS has combined the X17 storage Dewar and the facility Dewar into one vessel to lower operating costs. When these two systems were mated the operating pressure had to be reduced to 30 psi to satisfy the X17 system. This reduction of pressure and extended length from the source has increased the filling time of 175 liter Dewars to approximately one hour. The NSLS is investigating this problem and has assigned our cryogenics engineer to this task.

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Update on FY 1995 Rates

James Desmond

NSLS Administration

In the last Newsletter some new rates were being considered. As of October 1, 1994 the space charge will be implemented. Based on budget cuts it has been decided that the NSLS can no longer afford to underwrite the power costs which we pay for the offices in buildings 510E and 728. This new charge will replace the currently existing trailer park fee, and its rate, which will be applied to the square footage occupied, has been based entirely on the historical electric power usage. The charges will be $5.70 per square foot for outside office in 510E, the trailer park and building 728, and $3.80 per square foot for inside offices in 510E. The cost per square foot is an annual cost, that will be billed quarterly. Since this is strictly for electric power no G&A will be applied to this rate.

The charge per Xerox copy has been tabled at this time. If it is deemed necessary it will be revisited at a later date, but at this time there will be no charge for copies.

Plant Engineering has made a major change to their hourly rate schedule. While there is a reduction of $3.90 per hour (FY94 $47.85 to FY95 $43.95), the major change is to departments that have assigned labor. The Light Source has assigned electricians and plumbers (AC work). If work is required of these two trades and it can be fit into our schedule, then users will be charged $35.85 an hour; otherwise, the standard rate will prevail. Fitting user work into the NSLS assigned labor schedule results in a savings of $8.10 an hour from the standard FY95 Plant Engineering rate.

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VUV Ring Improvements

Stephen Kramer, VUV Ring Manager

The VUV Ring has been running very reliably from the integrated current and beam position point of view. Users can count on the beam being available as scheduled to a greater than 98% reliability and centered vertically within photon aperture to better than plus-or-minus 40 microns. Most of the time the Global Orbit Feedback system maintains a stable beam position to better than plus-or-minus 20 microns vertically and for all frequencies less than 60 Hz. One period when this was not true was following the Nov.-Dec. 1993 shutdown, when RF beam dumps and 3 second beam fluctuations (due to AGS Booster cycling) caused a serious user problem. Work is continuing to reduce the power supply harmonic content on the RF systems. Since the last report, the filter on the main RF systems plate supply has been modified and the 50 kW tube bias has been adjusted. These improvements have reduced the RF power supply ripple by 10dB. Work will now begin on modifying the system grounds to further reduce the RF systems noise contribution to the beam. Although some of these problems could have been prevented, the lessons learned from that period will help to minimize their reoccurrence in the future. These lessons will be especially useful as budget cuts reduce the operational staff responsible for understanding and maintaining these systems. The radio frequency system in the VUV Ring has been receiving considerable attention, in order to better understand the present limitations of the bunch lengthening system. Significant progress is being made on understanding and reducing the audio frequency noise on the RF systems. Improvement has already been seen on the high frequency photon flux variations and on the lifetime jitter. Continued improvement in eliminating these sources will allow increased bunch lengthening, longer lifetimes and reduced flux variations. Along with these efforts has come a surprising disappearance of the longitudinal coupled bunch instability that prevented filling all nine RF buckets in the ring to currents above 500 mA. Stable beam fills to greater than 850 mA, with all nine RF buckets filled are now possible. However, a broad vertical halo is observed if all bunches have equal charge, possibly the result of non-linear focussing due to ions. A small charge imbalance in one of the nine bunches is sufficient to reduce this halo and yield comparable vertical beam size to the seven bunch operational fills. Operations with nine bunches has shown more than the expected (30%) lifetime increase resulting from the reduction in scattering losses (Touschek scattering) from the electron bunches. If this bunch pattern continues to remain stable, operations could benefit either from longer lifetime or higher brilliance from a reduction of the vertical beam size, while keeping the lifetime fixed.

Recent studies at higher ring energies up to 80 MeV, which are now permitted by our SRAR, have also showed significant increases in the beam lifetime. In the future even higher energy operation will require upgrading the AC transformer feeding the dipole power supply. The recent addition of high resolution Hall probes to the VUV Ring magnets will help make orbit reproducibility easier at these higher energies, since the VUV Ring will require ramping between the injection energy and the operating energy. After the improvements in the Booster dipole power supply are completed (in 1995) injection at the higher energy will make this improvement in the VUV Ring operation more reproducible, since the ring will not have to be ramped.

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X-Ray Ring Update

Norman Fewell

X-Ray Ring Manager

X-Ray ring operational performance statistics for the 1994 Fiscal Year that ended September 30, 1994, are now available, and compare very well with those of the previous year's excellent performance. The beam availability was up by approximately 3%, due mainly to running operational high current fills during portions of the scheduled study periods. Integrated stored beam (amp.hrs) was about the same as the previous year. This is now more of a reflection of user requirements (LEGS, single & five bunch fills, high brightness etc.) than of machine performance and reliability.

Electron beam fills above 250 mA with operational insertion devices await the approval of the vacuum chamber task force which is nearing the end of its thermal and stress analysis of vacuum chamber components. In response to the task force recommendations, active interlock systems are now being prepared for beam lines X1 and X13 by the NSLS diagnostics and controls group headed by Ron Nawrocky. This group has recently upgraded the pue RF receivers used on the active interlocks of X17, X21 and X25, with extended range versions that meet our performance specifications between 5 and 500 mA.

Upgrades to the orbital feedback systems are being carried out by Om Singh to increase the effective band width of the system, and Aharon Friedman, Eva Bozoki and Susila Ramamoorthy are testing a global digital feedback system.

Beamline shielding requirements for operation at 2.8 GeV are being prepared by Dean Chapman. These requirements will include beamline layout drawings which identify synchrotron beam scattering sources, installation of additional shielding, radiation surveys and approval by the NSLS Safety Officer.

Maintenance schedules for the upcoming shutdown are being prepared. Due to the amount of work and the unpredictability of its completion and machine commissioning problems, the shutdown and commissioning times have been extended. One of the major tasks during the shutdown will be the connection of the central chilled water system to our processed water systems by the Plant Engineering Division. In addition our magnet cooling water system will be modified to run with two pumps in parallel. We cannot test any of our water cooled electrical systems until those two tasks are done and performance tests are completed. Other tasks that affect the operational date of the X-Ray Ring include: installation of a new Booster to X-Ray extraction kicker, installation of a new X-Ray injection septum vacuum chamber, removal of the PSGU, installation of the Circular Polarized Wiggler and inspection of the interior of RF cavity #1. Also, the Linac upgrade includes two new Klystron amplifiers and new Klystron modulators. Testing of these and commissioning of the booster is dependent on the water system's availability. Therefore due to the X-Ray Ring vacuum breaks and the unknowns associated with the Booster extraction and X-Ray Ring injection the schedule includes two weeks of commissioning time.

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